February 9, 1930.

Dear Dr. Leighton:

I am submitting herewith the manuscript of the report on the "Geology and Mineral Resources of the Havana quadrangle", consisting of contents and illustrations, 6 chapters and 3 appendices, with three tubes of separate illustrations containing plates, figures and tables. I am also submitting the photographs and negatives taken in connection with the Havana work, the note book, with the notes typed and indexed, the drill records for the area, and other maps, diagrams and notes pertaining to the Havana work.

The manuscript is essentially complete, with the following exceptions:

Drafting Room file

Dr. Mac –

(1) List of Pennsylvanian fossil invertebrates to compose table 4 of Appendix A, Part I.

(2) List of Pennsylvanian fossil plants, to compose table 5 of Appendix A, Part II, and three or four text references to the correlation suggested by fossil floras for certain beds.

(3) The names of trees represented by wood in certain localities in the Kansan, Yarmouth and Wisconsin deposits to be inserted in text discussions of these deposits.

(4) Foot note references to Dr. Weller's paper on Cyclical sedimentation, and my report on the Alexis quadrangle, pages to be inserted when these reports are issued.

The fossil invertebrates have been examined cursorily, and a partial fauna of about 100 species has been listed, but there is a large amount of material which has not yet been gone over, which will doubtless add to the present temporary list. The material represents about 73 collections from about 20 or 25 stratigraphic horizons. The fossil plant collections are with Professor Noé, who has verbally promised a report on them about March 1st. The Pleistocene wood has not yet been submitted to an expert for identification. The amount is not large, and the identification can probably be made in a short time when submitted. I spoke with Professor Hottes about it, and he thought no one in the botany department here would be qualified to make the identification. The material can be prepared for shipment to any one you may select within a short time.

The report is long, and may include certain material which you do not consider it necessary to publish. I have worked on the principle suggested by Dr. Ekblaw that a report can be better edited down, omitting material presented, than adding desired material which is not present in the manuscript. The materials composing Appendix C should be mentioned especially. Part I consists of the deep drillings in the Havana and adjacent quadrangles which have been used in constructing three cross sections and 7 structure contour maps. Similar material was used in the Alexis report in the same way. Part II consists of well records not used in these sections and maps. Because of the small number of these wells, they add comparatively little to the report. Part III contains 57 coal test borings selected from the 500 or more in the quadrangle. These coal tests extend to the No. 2 coal in regions well within its line of outcrop, and to the Rock Island No. 1 coal in many places in the Havana quadrangle and a narrow strip of the Canton quadrangle within 1½ miles of the Havana. These sections have been drawn up graphically in one of the section sheets submitted along with the manuscript. It is possible to correlate many of these with the formational units proposed, and they afford much information relative to the variations of the Pottsville in that part of the area where it is concealed by younger strata. These records were near all confidential at the time when they were obtained (mostly 1917-1920), when considerable interest was shown in the No. 1 coal in this region. The compan which drilled the holes have ~~mostly~~ suspended operations in the region, and present interest is almost wholly concentrated in possible strip lands in the Springfield (No. 5) coal. I have carefully omitted sections supplied by the strip companies now operating in the area, as they are , of course, strictly confidential, and it is important that they be kept so. If these deeper records should be used, permission for their use should be obtained from the companies furnishing them, principally the Saline County Coal Corporation, the Star Coal Company, and Wm. Scripps. Dr. Ekblaw has suggested that if these records are not used, the stratigraphic data presented in them might be shown in graphic ### sections of the records, with the statement tha the records might be consulted at the survey by persons interested. Most of the sections have been drawn up, and all could be drawn from the sections and correlations given in this part of the appendix. Three or four partial logs from these borings are here used in the text to illustrate certain parts of the Pennsylvanian section. Should the whole records be published, these sec- tions could be omitted, and reference made to the appendix.

The locations of points mentioned, the description and thicknesses of members of stratigraphic sections, ### the names and authorities of Pleistoce fossils (appendix A, Part III) and foot note references to the literature hav been checked against the original sources after the completion of the manu- script.

Parts of the ###### manuscript dealing with the Pennsylvanian have been revised so that they are in accord with the stratigraphic conclusions reache during the field season of 1929 in ##### areas adjacent to the Havana quadran

In the treatment of the Pennsylvanian stratigraphy, I have followed the plan outlined in the summary statement of the field work of 1929. I have considered the groups or suites of sediments there considered separately as formations, and have designated them by names. The basal boundary has been placed at the base of the sandstone where a sandstone is present. In those formations which locally lack a basal sandstone, the boundary has been placed at the contact of the underclay below the coal of the overlying form- ation and the ### evenly laminated shale, the limestone, or coal bed of the underlying formation. Coal beds occur in each formation designated. There is appended here a statement #### regarding the meaning of each of the new formational names proposed, together with the names applied to 5 members of formations. The names Pottsville, Carbondale and McLeansboro are used throug out the report with their standard definition, parallel to the new classifi- cation, but are termed series,

(See P. 3, para. 4)

Very sincerely yours
Harold R. Wanless

P. S. The outcrop map, Plate I, shows the Pleistocene units colored and with accompanying legend. The legend shows two alternative possibilities for coloring the Pennsylvanian (1) 3 units, the Pottsville, Carbondale, and Mc-Leansboro, and (2) 6 units, with the new formations and groups of them as units. The outcrops are not colored, because of uncertainty as to which of the two classifications is to be followed. Reference can be made to the accompanying photolithographic (office) map, on which the outcrops are colored according to the first classification. If the second classification is to be followed it will be necessary for me to draw boundaries within the outcrops for this purpose. This will not be as accurate a map as that first presented, as the data for it will have to be obtained from field notes, rather than done in the field. The errors in boundaries would not be as much as 20 feet in most places, I should think.

NEW NAMES PROPOSED IN THE HAVANA QUADRANGLE MANUSCRIPT

(1) Babylon formation. This name is proposed to designate# the sediments formed during the second cycle preceding the deposition of the Rock Island (No. 1) coal. The typical outcrop is a high cut bank on the west side of Spoon River in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 14, T. 7 N., R. 1 E. (Lee twp.) ½ mile N. of in the Avon quadrangle. At this type outcrop a 2' coal considered the Rock Islan No. 1 outcrops high on the bank below sandstone, below this underclay, sandy shale and sandstone, then a ######## cycle comprising shale, limest coal and underclay, and below this the strata assigned to the Babylon formation, namely

Shale, gray, darker above, with Lingula 1'9"
Limestone, gray, concretionary, with root traces 5"
Shale, gray, micaceous, unfossiliferous 5"
Limestone, pyritic, unfossiliferous 1-2"
Shale, black, fissile, hard and soft 3'11"
Cannel coal $5\frac{1}{2}$"
Coal, not cannel $1\frac{3}{4}$"
Black coaly shale 2"
Sandy clay, light gray, 4'
Sandstone and sandy shale, some Stigmarian, some coarser than othe Pennsylvanian sandstones and more recrystallized, partly concealed. 8'9" exposed.

There is some uncertainty as to whether this is the oldest formation or cycle in the western Illinois district so far studied. There is, in a few localities, indication that an older group of beds exists. These have not yet been differentiated or named.

(2) Pope Creek formation. This name is proposed to designate the sediments formed during the first cycle preceding the deposition of the Rock Island (No. 1) coal. The type outcrop selected is a high cut bank on the south side of Pope Creek in the NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 33, T. 14 N., R. 2 W. (Greene t in the Alexis quadrangle. This section is described as geologic section 4 in the Alexis quadrangle report, the beds assigned to the Pope Creek being beds 10-3. They include gray shale, fossiliferous limestone, black shale, coal, underclay and sandstone from top to bottom, a typical sedimentary cycle.

(3) Seville formation. This name is proposed for the sediments including th Rock Island (No. 1) coal (called Suite II in the Alexis manuscript). The location selected is Worthen's type for the No. 1 coal in western Illinois the high cut bank on the southwest side of Spoon River in the SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 23, T. 6 N., R. 1 E. (Harris twp.) (Vermont quadrangle). The strata here consist of:

Limestone, blue gray, fossiliferous (Parks Creek limestone of Savage 4'
Shale, dark blue gray to black 2'10"
Clay, #### rusty yellowish brown (clod) 3"
Coal (Rock Island No. 1) # 3'2"
Underclay 2'
Sandstone 4'+

#Near the southern end of the cut a higher sandstone, probably the Bernadotte, replaces all strata down to the coal, and part of it, a relation mentioned, I believe, by Worthen, and later by Savage. This type of cut out is typical of this formation in many places in western Illinois.

(4) Bernadotte formation. The name is proposed for the sediments formed during the first cycle after the Rock Island (No. 1) coal. The type locality is the southeast bank of a ravine in the southern edge of the village of Bernadotte just south of the center of sec. 19, T. 5 N., R. 2 E. (Bernadotte twp.) in the Vermont quadrangle. This is Savage's type exposure of the Bernadotte sandstone. The term is not used in the same sense as by Savage in his A.J.S. paper (which apparently limits the term to the basal sandstone) or in the Vermont manuscript, in which the term Bernadotte is extended to include beds here designated as the overlying "Brush Creek" formation. The beds placed in this ########### formation are:

Shale, dark gray and black 1'11"
Coal 4'2" in one outcrop, 4" and $\frac{1}{4}$" in other outcrops nearby
Underclay, very sandy,########## thin or absent
Sandstone, hard, ledge forming, recrystallized in upper portion, Stigmarian (Bernadotte sandstone of Savage) 3'6"+

The variations in the development of this formation here are typical of its variations elsewhere in western Illinois, including the Alexis and Havana quadrangles.

(5) "Brush Creek" formation. This is a tentative name applied to sediments above the Bernadotte formation including the variegated clays of many quadrangles. The type outcropsfrom which the name is taken (the name is unavailable because of ### its application to a persistent Conemaugh limestone in Ohio) ## are (1) along #the south side of Brush Creek in the SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 5, T. 9 N., R. 2 E. (Chestnut twp.) and (2) the south bank of this creek in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 9 of the same township. The strata assigned to this formation include gray shale, with one or two thin limestone or ironstone bands 1'10", dark to black shale 4-5", and 4 coal beds ranging from $\frac{1}{4}$" to 3" separated by gray shale or clay $1\frac{1}{2}$" to 18" thick. No basal sandstone occurs here, but it has been found near Bernadotte, and at other localities. This has been mentioned as the "4 coal" zone by Workman in the Monmouth quadrangle. The conditions of deposition## of this formation appear to be somewhat different from those of most of the others#, in the presence of several coals, and further south, unusually thick underclay.

(6) Seahorne formation. This name is proposed for the sediments including the "Pottsville knobby" limestone, of wide distribution in western Illinois. The type exposure is along the south side of Seahorne Branch and its side gullies in the S. $\frac{1}{2}$ SE. $\frac{1}{4}$ sec. 5, T. 3 N., R. 3 E. (Kerton twp.) in the Havana quadrangle. The names Vermont, Ray and Aylesworth have been previously proposed for this limestone by Savage and Searight. The names Vermont and Ray are unavailable, because previously used. The limestone is unfossiliferous apparently along Aylesworth Branch, while it is very fossiliferous along Seahorne Branch, so the latter name is preferred. The strata of the type exposure are described in the Havana manuscript in geologic section 15 , beds 2-6 . They comprise a fossiliferous limestone, a thin coaly streak usually 1-2 below the limestone, underclay, and a basal sandstone, light colored and very fine grained.

(7) Wiley formation. This name is proposed for the dark shale, coal and underclay ## immediately above the Seahorne limestone. The type outcrop is a cut bank on the south side of a ravine near the center of the east line of sec. 18 and #### the adjacent part of sec. 16, T. 7 N., R. 2 E.(Deeffield twp.) in the Avon quadrangle. The outcrop is about 1 mile northwest of the Wiley school from which the name is taken. This exposure shows coal 16" and underclay 2'3" above the Seahorne limestone and below the underclay of the Greenbush formation. In many exposures a few inches of dark shale overlie the coal.

(8) Greenbush formation. This name is proposed for the first suite or group of beds below that including the Colchester (No. 2) coal, including typically gray to olive gray shale, limestone concretions or a thin limestone containing marine fossils in a few outcrops, and underclay. In a few exposures coal to a maximum thickness of 6", dark shale, and basal sandstone, to a maximum thickness of 3 or 4 feet also occur in the formation. The name is taken from Greenbush ######### township, T. 8N., R. 1 W., in the Avon quadrangle. The typical outcrops are in secs. 23 and 24, 1 and 2 miles west of Avon, in ravines, road cuts, and a high cut bank of Swan Creek just northeast of the Sailer School. The name Avon was proposed for this member as a shale by Savage in his A.J.S. paper, and for this combined with the Wiley and Seahorne formatinns in the Vermont quadrangle manuscript. The name has been previously used, so is not available.

(9) Liverpool formation. This name is proposed for the suite or group of beds including the Colchester (No. 2) coal. The name is taken from exposures (1) exposures on the north side of the ravine in the NE. ¼ sec. 20 and the NW. ¼ sec. 21, (2) the ravine in the N. ½ NW. ¼ sec. 17, T. 5 N., R. 4 E. (Liverpool twp.). These sections show a basal sandstone (Isabel), underclay, coal (Colchester N0. 2), gray shale (Francis Creek), black hard shale with concretions, a succession of thin fossiliferous limestones and dark shales (Oak Grove member) and a thick gray shale (Purington). Excellent exposures of the unconformity between this formation and the overlying Pleasantview sandstone are also found in secs. 20 and 29 of Liverpool township. Typical sections in this township are described in the Havana quadrangle.

(10) Summum formation. This name is proposed to include the Pleasantview sandstone, the coal between the Springfield and Colchester, and associated marine beds. The type exposure is in the ravine northeast of Summum in the N. ½ sec. 3, T. 3 N., R. 2 E. (Woodland twp.) and the S. ½ sec. 34, T. 4 N., R. 2 E. (Pleasant twp.). The strata here include a thick basal sandstone (Pleasantview), underclay, locally with nonmarine limestone, coal varying from 3-4" to 6' (Kerton Creek), black shale with large smooth black fossiliferous concretions. A gray marine limestone (Hanover) belonging with this formation, does not appear to be present at Summum, extending from near Pleasantview southward to or nearly to St. Louis. An unconformity in this formation causes the coal locally to cut out its underclay and the nonmarine limestone, and truncate the upper beds of the Pleasantview sandstone.

(11) St. David formation. This name is proposed for the beds associated with and including the Springfield (No. 5) coal, long mined at and in the vicinity of St. David. The type outcrop, in the SE. ¼ sec. 17, and the NE. ¼ sec. 21, T. 6 N., R. 4 E.(Buckheart twp.) about 1 mile west of St. David, is described in the Havana manuscript as geologic section 32, beds 9-22. The beds typically composing this are a thick shale #### (Canton) with one persistent limestone or limestone concretion band, calcareous shale or "clod", limestone (St. David), black to gray hard and soft shale, with concretions, coal (Springfield No. 5), underclay, and 1-3 bands of unfossiliferous limestone or septarian limestone concretions. The name St. David has been applied by Savage to the dark shale and limestone in his A.J.S. paper and to the shale alone in the Vermont manuscript.

(12) Brereton formation. This name is proposed for beds associated with and including the Herrin (No. 6) coal. The type locality is a high cut bank on the east side of Middle Copperas Creek in sec. 1, T. 7 N., R. 4 E. (Canton twp.) about 1 mile east of the village of Brereton. Here, and in a road cut and ravine exposure nearby, the formation includes gray shale# (Copperas Creek), calcareous fossiliferous shale, limestone(Brereton), black shale, coal with blue band (Herrin No. 6) underclay, with fresh water limestone or concretions, and sandstone (Cuba). Near Cuba a marine limestone and gray shale between the basal sandstone and fresh water limestone above are also referred to this formation for the time being.

New member names.

(1) ###Seahorne limestone. The limestone member of the Seahorne formation, named from the same exposure.

(2) Isabel sandstone. The basal sandstone of the Liverpool formation, name from the high cut bank in the NW. ¼ NE. ¼ sec. 16, T. 4 N., R. 5 E. (Isabel twp.) described in geologic section 20, in the Havana manuscript. The channel phase of this sandstone has been called the Browning member by Searight in the Beardstown manuscript.

(3) Oak Grove member or marine member. This name is applied to the dark shales and thin limestone bands with persistent marine faunas between the Francis Creek shale and Purington shale. The type outcrop is in a ravine back of the Oak Grove school in the SW. ¼ SE. ¼ sec. 6, T. 5 N., R. 3 E. (Lewistown twp.) in the Havana quadrangle. The type outcrop is shown as fig. 31 in the Havana manuscript. ##### It is not quite certain whether the black hard pimply shale with associated large concretions at the base of this member should or should not be included as a part of it. It is not present at the Oak Grove locality, but has a wide distribution in western Illinois. It would be better to exclude it in many ways, as the Oak Grove would then become approximately equivalent to the limestone member of most cycles, but it would then leave this thin unnamed unit between the Oak Grove and Francis Creek ####### members.

(4) Purington shale. Name previously used by Poor, but not in quite the same sense, as he included the Pleasantview sandstone and underclay above, assigned here to the Summum formation. The type locality is the shale pit of the Purington paving brick co. at East Galesburg, Galesburg quadrangle. The term is used here for the thick gray shale between the highest limestone bed of the Oak Grove member and the Pleasantview sandstone.

(5) Kerton Creek coal. This name has been previously proposed by Searight in the Beardstown manuscript, but in a ######### slightly different sense. It is here limited to the coal of the Summum formation. The type outcrop is on the North side of Kerton Creek in the NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 15, T. 3 N., R. 2 E.(Pleasant twp.), ########### in the Beardstown quadrangle, the outcrop in an abandoned mine drift entrance, where the coal rests with angular unconformity on the underlying Pleasantview sandstone. The term seems to me more desirable for the coal alone, rather than in combination with the dark shales above, as other coals are separately designated.

RECORD SHEET OF EDITING

Author: Wanless, H.

Title: GEOLOGY AND MINERAL RESOURCES OF THE HAVANA QUADRANGLE

Submitted, Feb. 9, 1930; Accepted, 2-12-30 - D.E.G.

~~Date submitted~~ __________

Pleistocene and Physiography, read by

__________ Date __________

Structural Geology, Oil and Gas, read by

__________ Date __________

Non-fuel Products, read by

__________ Date __________

Entire report, with special reference to bedrock stratigraphy and historical geology, read by

__________ Date __________

Other readings by:

__________ Date __________

__________ Date __________

Report amended by author

__________ Date __________

Prepared for publication __________

Requisition No. __________

Ms. returned from printer __________

Illustrations returned __________

Cuts returned __________

Date of distribution __________

Editor __________

Manuscript on

GEOLOGY AND MINERAL RESOURCES OF THE HAVANA QUADRANGLE

Harold R. Wanless.

Submitted February, 1930.

CONTENTS

Tables

Illustrations

Chapter I. Introduction.

Location and Extent

The Havana quadrangle is situated in the west central part of Illinois, about 30 miles southwest of the city of Peoria. It includes the southeastern part of Fulton County and a small area in western Mason County (See fig. 1) The map (Plate I) is published on a scale of approximately one mile to the inch. It is part of a large topographic map of the United States which the United States Geological Survey is preparing. For convenience, in most areas in Illinois and adjacent states, this large map is divided into units of ## quadrangles 15' of latitude by 15' of longitude. The Havana quadrangle lies between parallels 40° 15' and 40° 30' N. and the meridians 90° 00' and 90° 15' W. The area of the quadrangle is approximately 224 square miles, with a north-south length a littl over 17 miles and an east-west width of approximately 13 miles.

Purpose of the report

This report is designed to present an interpretation of the past hist of the area studied, in language which will be intelligible to the educate layman. The data assembled regarding the coal beds and other mineral resources of the area should enable operators to proceed economically with th development of these resources. The many excellent exposures of the coal bearing strata in the area throw additional light on the physical conditions which prevailed during the Pennsylvanian period when these strata were accumulated, ~~and~~ The exposures of the surficial deposits present a record of the events ofeach of the glacial and interglacial epochs which compose the Pleistocene period, and of changes in the region since the beginning of recent time. The area also contains a record of the activities of man during pre-Columbian time in the mounds built by the mound builders.

Previous work in this area

~~A. H. Worthen~~

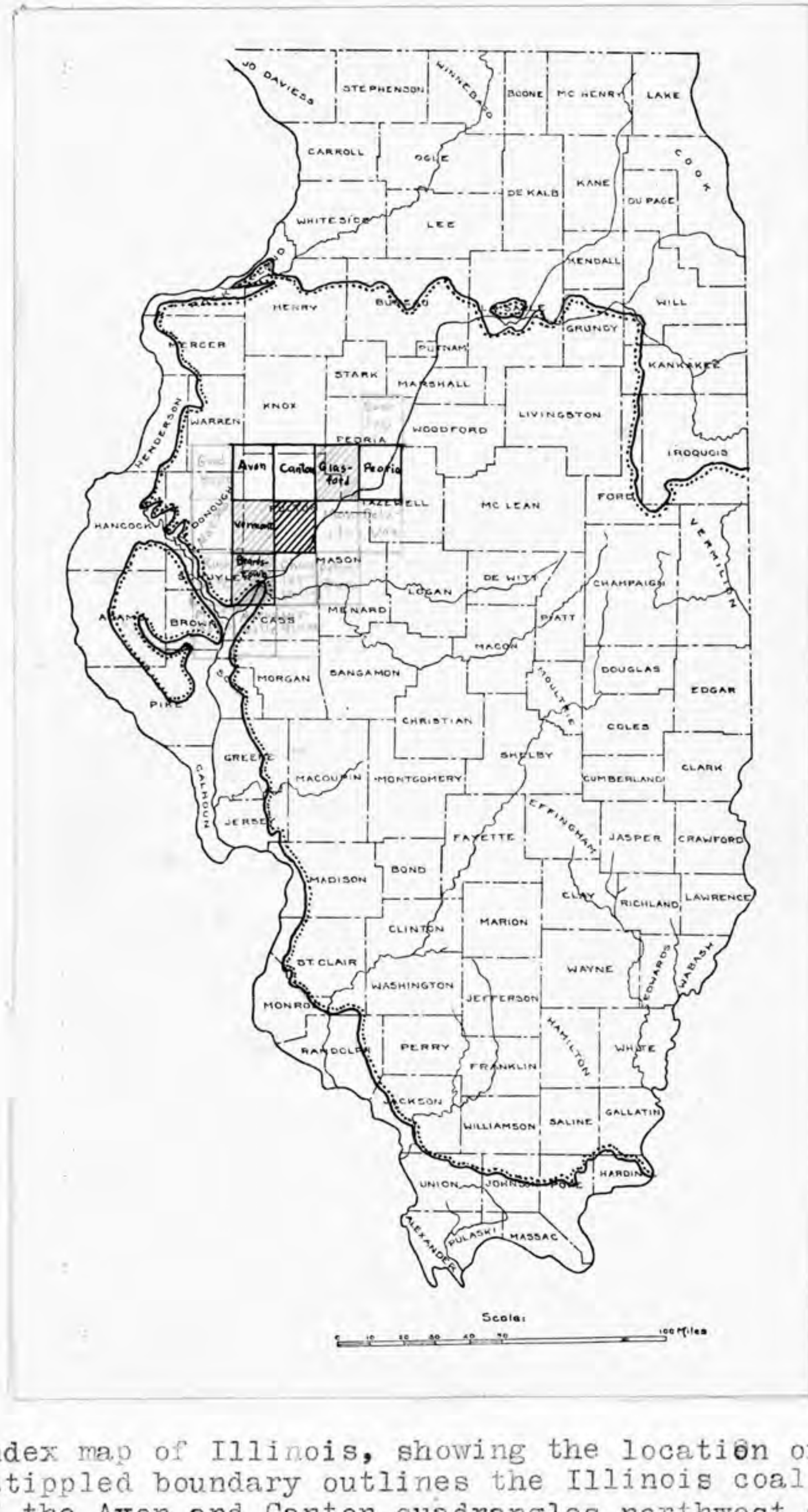


Fig. 1 . Index map of Illinois, showing the locati0n of the Havana quadrangle (shaded). The stippled boundary outlines the Illinois coal ~~boundary.~~ field. The geology of the Avon and Canton quadrangles northwest and north of the Havana is described in Bulletin 38 ~~of the~~ Illinois State Geological Survey. The geology of the Peoria quadrangle is described in Bulletin 506 of the United States Geological Survey. The Vermont quadrangle, west of the Havana, ~~has also been geologically surveyed~~, the Glasford to the northeast, and the Beardstown to the southwest, have also been geologically mapped by the State Geological Survey.

A. H. Worthen, in 1870,[1] published a brief report on the Geology of

[1] Worthen, A. H. Geology of Illinois, vol. IV. Fulton County, pp. 90-110, Geol. Survey of Illinois, 1870.

Fulton County, in which he made the section of Pennsylvanian strata expose there the type or standard section for the correlation of the "Coal Measure strata in the central and western parts of the state. He found in this reg seven coal beds, to which he applied consecutive numbers, beginning with no. 1 at the bottom. The coals which he numbered 4 and 5 respectively in this region are now known to be the same bed, and some error in interpretat was involved in the bed called no. 3. Otherwise the numbers here applied have been retained and applied to coal beds in all parts of the state~~s~~.

Areas adjacent to the Havana quadrangle on the north and west have been mapped by Dr. T. E. Savage[2]. ~~and~~ The coal resources of the eastern

[2] Savage, T. E. Geology and Mineral Resources of the Avon and Canton Quadrangles. Illinois State Geol. Survey, Bull. 38, 1921.
___________. Geology and Mineral resources of the Vermont quadrangle. Illinois State Geol. Survey, Unpublished manuscript.

PART OF Fulton County, including the northern part of the Havana quadrangle are included in a report on District IV,[3] while the coal resources of

[3] Cady, G. H. Coal Resources of District IV. Illinois State Geol. Survey Cooperative Mining Series Bull. 26, pp. 76-105, 1921.

the western and southern parts of Fulton County are included in a report on District III.[4] The coal stripping possibilities in this area have also

[4] Culver, H. E. Coal Resources of District III (Western Illinois). Illinois State Geol. Survey, Cooperative Mining Series, Bull. 29, pp. 44-50, 1925.

been studied[5].

5/ Culver, H. E. Preliminary Report on Coal stripping possibilities in Illinois, Illinois State Geol. Survey, Coop. Mining Series, Bul. 28, pp. 21-25, 1925.

Field work and acknowledgments

The field work upon which this report is based was done, principally during the summer of 1927, with Mr. H. B. Willman as assistant. ###

The author is indebted to various members of the Illinois State Geological Survey for contributory suggestions and for criticisms; especially to Dr. M. M. Leighton, Chief, who visited important Pleistocene exposures, and has developed the principle of the profile of weathering in the interpretation of the record of interglacial time; to Dr. G. H. Cady, in charge of coal studies for the Survey, who visited important Pennsylvanian exposures in the area, and has aided in the interpretation of its Pennsylvanian history; to Dr. J. M. Weller, who has aided in the identification of the Pennsylvanian fossils, and has contributed the idea of recurrent cycles in Pennsylvanian sedimentation, here used as a basis for classifying the Pennsylvanian formations. ## Mr. F. C. Baker, Curator of the Natural History Museum of the University of Illinois identified the Pleistocene fossils, and furnished information regarding the environments ~~under~~ in which the fossil-bearing strata were deposited. Dr. A. C. Noé, of the University of Chicago identified the Pennsylvanian plants collected in this area. Mr. J. E. Lamar has offered valuable suggestions regarding the development of the non-fuel mineral resources of the area. Mr. H. B. Willman prepared a thesis on the subject "An attempt to correlate the Pennsylvanian sandstones of the Havana quadrangle by the composition and structure of their grains", from which the author has used information regarding the sandstones. Mr. H. C. Spoor, Jr. ran precise levels to 150 outcrops of coal beds for use in the preparation of the structure map. Mr. J. L. B. Taylor, formerly engineer in charge of indian mound investigations for the University of Illinois gave the author the opportunity to examine several pits made during the exploration of mounds in this area. Mr. A. W. Waldo and Mr. J. R. Griffin assisted in the field work part of the time. Members of the Department of Geology of the University of Illinois offered many helpful suggestions.

The cordial dooperation and hospitality of the residents of the region, especially those engaged in coal mining, is gratefully acknowledged.

Fundamental Geologic Processes[6]

---

[6] This section has been adapted from the report on the Geology and Mineral Resources of the Kings Quadrangle, by J. H. Bretz, State Geological Survey Bull. 43, pp. 211-217, 1923.

A mere description of the rocks of a region and a discussion of their economic uses does not constitute a geological report. Geology, in a broad sense, is the history of the earth - the record and the interpretation of the changes it has incurred. The earth is not a finished product; under our observation agencies are everywhere changing its surface at the present time, though the rate of such changes is very slow compared with the rate of progress of human events. These agencies have been operative throughout the past, and some of their results have been nothing short of revolutionary. Once or repeatedly areas now land were below the sea for long ages; regions now of gentle relief were the site of lofty mountains; some districts where now there is fertile farming land were the scenes of volcanic eruptions, and others were buried beneath thousands of feet of glacial ice; areas now frigid supported palms, fig trees, magnolias, and other subtropical plants.

Many of the events of earth history are recorded in the rocks; that is, the rocks are the products of past conditions. The present environment represents the cumulative result of the past environments. Consequently an appreciation of the geology of any region as it is today involves an adequate comprehension of the geological history of that region. By studying the rock formations and interpreting their features as nearly as possible in accordance with current phenomena, geologists have worked out a considerable portion of the past history of the earth. They have subdivided geologic time into significant intervals, each of which is characterized by a suite of conditions that is reflected in the rocks that represent the interval. The major subdivisions are eras and periods.

(Table 1). The transition from one to the other of these major subdivisions was marked by some momentous change that had worldwide effects. Some, but not all of these great changes are recorded within the area of the Havana quadrangle.

Running water, ground-water, wind, and man constitute the agencies that are now actively engaged in creating geological changes in the Havana quadrangle. Their results are gradational and tend to bring the surface of the whole area and adjacent areas to an accordant level. Degradation, or wearing away, is everywhere occurring on the slopes and uplands, and aggradation, or building up, is in progress to some extent on the lower tracts.

Work of Running water

The average annual rainfall in this region is 37 inches, of which more than a third, perhaps a half, flows down the slopes and converges in the definite water courses. Most of the smaller streams are intermittent and exist only during and immediately after rains and the melting of snow. Others are permanent and persist with a greater or less flow throughout the year. The larger rivers, Spoon River and Illinois River, are subject to great variations in volume, as each carries the water draining from over a thousand square miles. The streams, whether intermittent or permanent, are generally more or less muddy, and when in flood they carry sand in suspension and roll pebbles along their bottoms. Such action, continued through centuries inevitably lowers the surface of the region by removing loose material and abrading more substantial deposits.

Measurements of the rate of flow of many Illinois rivers indicate that the run-off per square mile of their drainage basins averages nearly 700,000 tons of water per year. If in its course to the permanent streams this run-off descended a slope averaging 50 feet to the mile, it would produce an average of nearly four and one-half horsepower operating on every square mile of surface. After the water is concentrated in streams, its work is even more pronounced and conspicuous. The adequacy of running water to wear down the land through long intervals of time is thus apparent.

Work of ground-water.

The portion of the precipitation that sinks into the ground constitutes ground-water. All but the uppermost portion of soils and porous rocks is continually saturated. The upper limit of the saturated rock and soil is called the water-table. In general it is nearer the surface in valleys than on hills. The bottoms of many valleys are below the water-table, in which instances springs and seeps may issue at or below the water-table ~~in which instances springs and seeps may issue~~ along the lower parts of the valley-slopes and the streams that occupy the valleys will be permanent. Depressions whose bottoms are below the water-table will be occupied by lakes or swamps. Wells must be dug or drilled below the water-table in order to assure a permanent source of water. Most quarries, mines, and other excavations that extend below the water-table fill with water unless pumps are constantly operated to remove it.

Ground-water rarely produces mechanical effects like those which result from surficial run-off, because generally it only seeps slowly through pores and cracks in the rocks. ~~But~~ It effects ~~other~~ changes by other means, chief of which is solution. The ground-water which issues as springs or seeps, or is obtained from wells, frequently carries in solution great quantities of mineral matter ~~which it has~~ obtained from the rocks through which it has passed. It# is this dissolved material which makes water "hard When precipitated it constitutes the mineral deposits around springs and forms the scale in teakettles, steam-boilers, and water-pipes. Calcium carbonate, the dominant constituent of limestone, is the chief substance dissolved by the ground-water.

Ground-water also reacts on the rocks by means of three chemical processes - hydration, oxidation, and carbonation -- all of which tend to disintegrate the solid rocks and reduce them to soil. The three processes are chemical combinations of water, oxygen, and carbon dioxide, respectively, with some minerals or their constituent elements. The oxygen and carbon dioxide are adsorbed from the air by the falling rain#. Oxidation is best revealed by the rusting of iron-bearing minerals in rocks and their eventual development as reddish-stained soils. Carbonation first produces calcium carbonate, which is dissolved by the ground-water.

Work of stagnant water.

Plant debris may be preserved from decay only when it accumulates in expanses of standing water, such as lakes and marshes, where the material gradually becomes peat or muck. Such deposits are now being formed in undrained depressions in the recently glaciated areas of norhteastern Illinois, northern Michigan, Wisconsin, Minnesota, and southern Canada. Swamp deposits of peat and muck that were developed in ancient geologic epochs were buried beneath other sediments, and subsequent compression has changed them into beds of coal, such as those which form the principal source of mineral wealth of the Havana area.

The organic acids that result from the decay of plant material leach and deoxidize the underlying soil of its more soluble and more highly oxidized minerals, so that a white or light gray clay is formed. Such clays are found underlying most coal beds. They are called underclays or "fire clays", as most of them when burned, form brick which is especially resistant to high temperatures (fire-brick).

Work of wind.

Wind, which is simply air in motion, produces only mechanical changes. When it is bearing loose material it acts like a sand-blast and wears away exposed surfaces of indurated rock. It removes loose material from one place (erosion or degradation) and deposits it in another (aggradation). The material borne by the wind under ordinary conditions must of necessity be composed of small particles - dust and sand - but under unusual conditions fine gravel and even larger fragments may be moved. Soil may be blown away from areas in which the moisture or vegetation is insufficient to hold it. Sand will accumulate in the lee of any obstacles and there form sand dunes like those in the southeast part of the Havana quadrangle. The finer constituents may be carried as suspended dust for miles and may be deposited as a widespread mantle of loess.

The geological changes above outlined are known to have occurred in this region intermittently in the past, as well as in the present. Other gradational changes, of which ~~three~~ two will be outlined in the following topics, alternated with them.

Glaciation

Most of the non-indurated rock, commonly called the subsoil, in the upland area of the Havana quadrangle west of the Illinois River, is non-stratified stony clay. It contains boulders and pebbles of rocks utterly unlike the subjacent bedrock. Granites (~~[illegible]~~) and fine-grained lavas which have solidified from a former molten state; gneisses whose twisted and gnarled structures tell of tremendous pressures and movements in the throes of mountain-making; red quartz porphyry (an igneous rock consisting of a red, microcrystalline ground-mass in which are set crystals of glassy quartz and pink-to-red feldspar) whose parent ledges are probably north of lakes Superior and Huron; an immense amount of limestone and dolomite; and a great variety of other types of rock foreign to the region are represented in the surficial gravel of road cuts and stream beds (see fig. 8).

These rocks have been introduced by an agency which carried and deposited particles of all sizes, from huge boulders to the finest clay, in intimate association. Further, it has dragged them under great pressure, because they are beveled, planed, polished, and scratched and the surface of the bed rock has been smoothed, grooved, and marred with long, parallel scratches that show the direction in which the debris was moved. Neigher wind or water can do this. There is but one gradational agent which does these things, and that is glacial ice. The stony clay which it deposits is known as till, or sometimes as drift.

Marine sedimentation

The indurated rock, or bedrock, of the region is stratified and consists of sandstones, shales, limestones and coal beds. Records of wells and other borings reveal that these rocks extend to a depth of more than 2200 feet at least. Originally these formations were unconsolidated sands, muds, ### calcareous ooze and decayed vegetation, most of which ### were deposited in layers on strata at the bottoms of shallow seas that opened into oceans which then surrounded the continent of North America. When the sands were deposited the shores of the ancient seas were not far inland from this region. The currents created by waves and tides were strong enough to carry the sand grains along the bottom for some distance from the land from which the material was derived. When the calcareous ooze was deposited the shores were perhaps farther inland from this region, and the water was probably a little deeper and surely much clearer and less disturbed by waves and currents. The ooze consisted largely of the shells and other hard parts of marine animals living in the seas, with which organic debris only mud fine enough to be carried in suspension far from the land was mingled.

Subsequent to the deposition of these marine sediments, the originally incoherent materials have become indurated, partly by compression but largely by cementation. The cement consists of mineral matter which was introduced in solution in ground-water and was precipitated between the grains of the unconsolidated material.

The consolidated formations can rarely be traced continuously between two places where they may be exposed. The identification or correlation of scattered outcrops must be based on certain features or criteria, which are unique to the formation, and which are widely distributed in it.

One reliable criterion for correlation is fossils, which are the impressions or petrifactions of plant or animal organisms that lived in the region while the sediments were being deposited. The existence of fossils has been known for many centuries, but the fact that each of the different formations in one region contains different assemblages of such forms, and that any one formation contains the same or a similar assemblage wherever it may occur was first recognized in England about 125 years ago. This fact is now established as one of the most important of geological principles. After careful study of the embedded fossil forms, sedimentary formations may be correlated across great gaps, perhaps some hundreds of miles wide, in which no outcrops of these formations occur.

Diastrophism.

The stratified bedrock, with its entombed marine fossils, is undisputable evidence that several times in the past the Havana quadrangle was inundated by embayments of the oceans. The region now stands several hundred feet above sea level. These two facts indicate that since the last strata were deposited the region has been raised, the sea-level has been lowered, or both movements have taken place, to create a differential approaching, if not attaining, a thousand feet. Movements in the body of the earth, manifested by warpings of its exterior, explain such changes in altitude. Downwarp of the ocean basins would draw off the waters; upwarp of the continent, or a part of it, would convert areas covered by shallow water into land. Such movements constitute diastrophis

Should the region as it now exists be again submerged beneath the sea, mud, sand, or calcareous materials would again be deposited, and these would rest on the present irregular surface. The contact between the new deposit and that already deposited would be as irregular as the present topography.####### Such contacts are termed unconformities. If marine strata occur both above and below an unconformity, the following succession of events is recorded: (1) the presence of the sea over the region and marine deposition; (2) the withdrawal of the sea and the action of degradational agents; and (3) the return of the sea and the renewal of marine deposition.

Weathering

The sum total of all unobtrusive processes by which solid rock is reduced to an unconsolidated condition is known as weathering. In addition to the processes and agencies already mentioned, the following are worthy of note: (1) differential expansion and contraction of solid rock from daily changes in temperature; (2) expansional force of the freezing of water in ### pores and crevices; (3) wedge work of plant roots growing in cracks in the rock; and (4) the burrowing of animals. It is obvious that any rock, however firmly indurated, must slowly disintegrate as a result of the attack of these varied agents during the passage of years. Thus a mantle of unconsolidated material - physically and chemically unlike the parent rock - is formed on all outcrops of indurated rock, save those too steep to retain it. This loose material is appropriately termed mantle-rock. Its upper portion, ##### with which is mingled the carbonaceou matter of decayed plant tissues, forms the soil.

Chapter II.

Physiography

Drainage

The Havana quadrangle is entirely drained by tributaries of Illinois River, which crosses the southeastern part of the quadrangle. Illinois River has a flood plain 3 to 4½ miles wide. Its principal tributary in this quadrangle is Spoon River, which enters from the west nearly opposite Havana. This streams follows a very meandering course through a flood plain ½ mile to 2 miles ~~in width~~ wide. The last four or five miles of its course is across the Illinois River flood plain. Other large streams are Big Creek, with a flood plain one eighth to three eighths of a mile wide, which drains most of the northwest quarter of the quadrangle and Otter Creek, which drains a large part of the southwestern portion of the quadrangle. Buckheart Creek, Big Sister Creek and Little Sister Creek, tributary to Illinois River, and Stuart Creek and Tater Creek, tributary to Spoon River are other large streams west of Illinois River. The only tributaries on the east side of the river are Quiver Creek and White Oak Creek, which receive much of their water from drainage ditches dug in poorly drained areas in Mason County.

The upland west of Illinois River is ~~accomplished~~ drained by hundreds of small tributary ravines and gullies of each of the larger streams mentioned. The interstream areas are, with few exceptions, a mile or less in width. The Chicago Burlington and Quincy Railroad and State Highway 31 follow one of the interstream divides between St. David, Bryant and Lewistown. The Toledo, Peoria and Western railroad follows another level divide through Cuba.

The area east of the flood plain of Illinois River is deficient in surface drainage, because of the porosity of the dune sand and sandy loam, the principal surface materials of this area. The concentration of fine material in depressions formed by winds or other agencies has formed numerous small surface reservoirs in which water collects after heavy rains. Because of this, rain water stands in and near roads in several places. A large temporary lake formed in this manner is situated in the SW. ¼ sec. 8, T. 21 N., R. 8 W. (Havana twp.), crossed by two wagon roads and the Illinois Central Railroad. This is indicated on the topographic map by a depression contour. The extreme southeastern part of the quadrangle is very level except for a few sand dunes, forming an irregular ridge in secs. 16, 20 and 21, T. 21 N., R. 8 W. (Havana twp.) This district is drained by a system of ditches connecting with White Oak Creek, as it possesses no natural drainage outlet.

The flood plains of Illinois and Spoon Rivers and some other large streams are poorly drained and subject to frequent overflow. Large areas of these lands have been reclaimed by the construction of levees and drainage ditches. Several flood plain lakes, of which Thompson Lake was the largest and best known, have been converted into arable land by drainage and levee protection. Fig. 3 shows ~~the~~ Illinois River valley as it was before the establishment of the present drainage districts. Fig. 2 shows the drainage districts in ~~the~~ Illinois River valley. Several of these districts were flooded during the fall and winter of 1927-28, under the pressure of the highest water stage in the past century. The most disastrous of these breaks inundated the Langellier ~~########~~ and Lacey districts, about six square miles in area. Fig. 116 shows one of the levees and drainage ditches. Drainage ditches and levees have not been constructed in Spoon River valley, but a survey has been made, showing desirable locations for levees, with suggestions for straightening the course of this meandering stream[1]. Fig. 4 shows the changes recommended in this valley.

---

[1] Harman, J. A. Report and plans for reclamation of lands subject to overflow in ~~Spo~~ the Spoon River Valley. Illinois State Geol. Survey, Bull. 32, 1916.

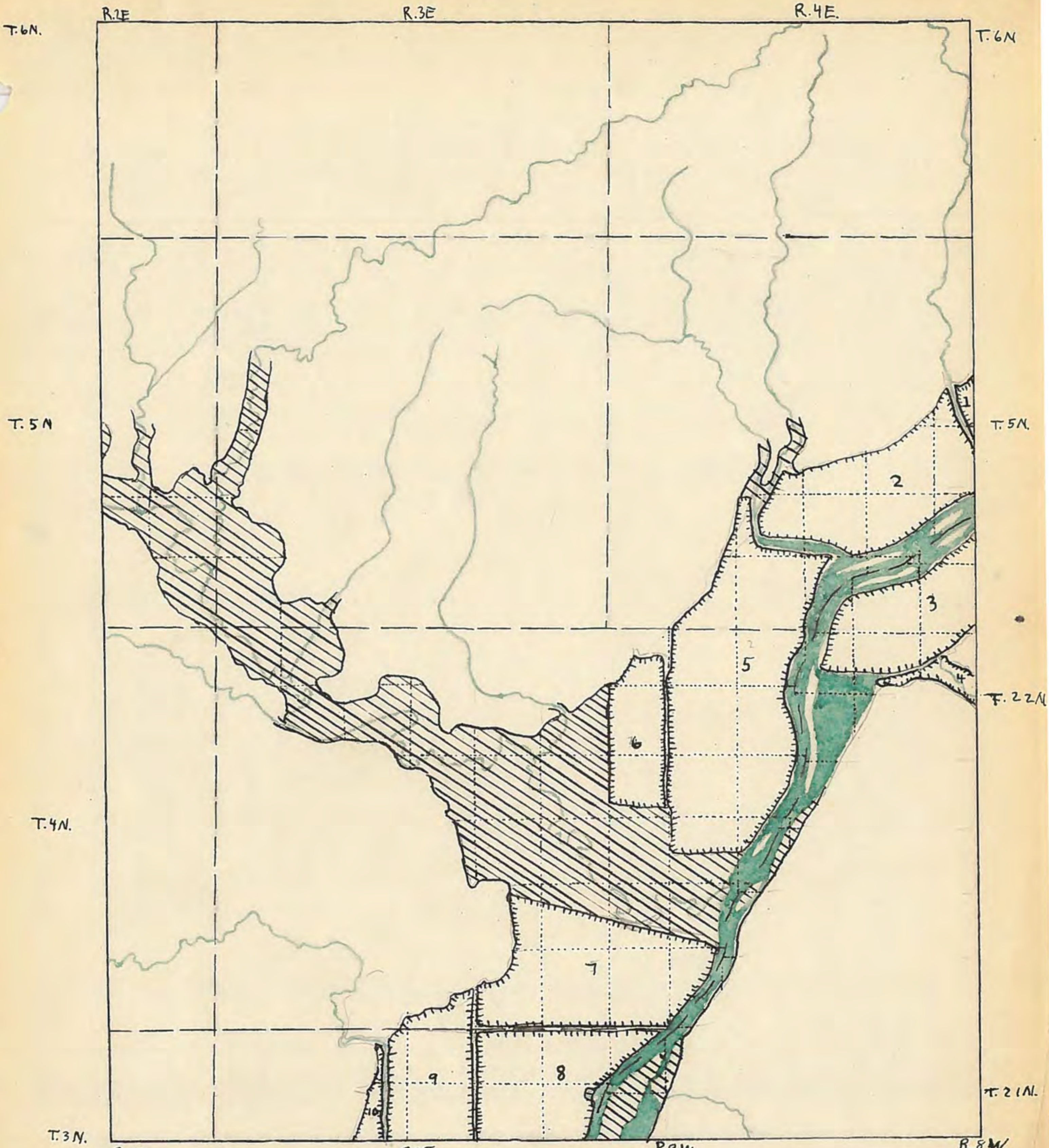


Fig. 2 . Title on 3a.

Fig. 2 . (on p. ~~5a~~ 3).

Map of Havana quadrangle showing bottom lands which are subject to overflow ~~######~~ (diagonal shading) and bottom lands which are protected by levees in the following drainage districts:

(1) East Liverpool Drainage and Levee District
(2) Liverpool Drainage and Levee District
(3) Chautauqua Drainage and Levee District.
(4) Quiver Creek Drainage District
(5) Thompson Lake Drainage and Levee District
(6) Crabtree District
(7) Lacey Drainage and Levee District.
(8) Langellier Drainage and Levee District
(9) Kerton Valley District
(10) Seahorne District

During the floods of ~~the~~ Illinois River of 1926-27 districts (1), (3), (6), (7), (8), (9), and (10) were flooded. Districts (2) and (5) were not flooded at this time but were flooded when levees broke during April, 1922. The data for this diagram are taken from "Engineering and Legal Aspects of Land Drainage in Illinois, by G. W. Pickels and F. B. Leonard, Bull. 42 (First Revised Edition) Illinois State Geological Survey, ~~(1929).~~ Map and pp. 122-125, 1929.

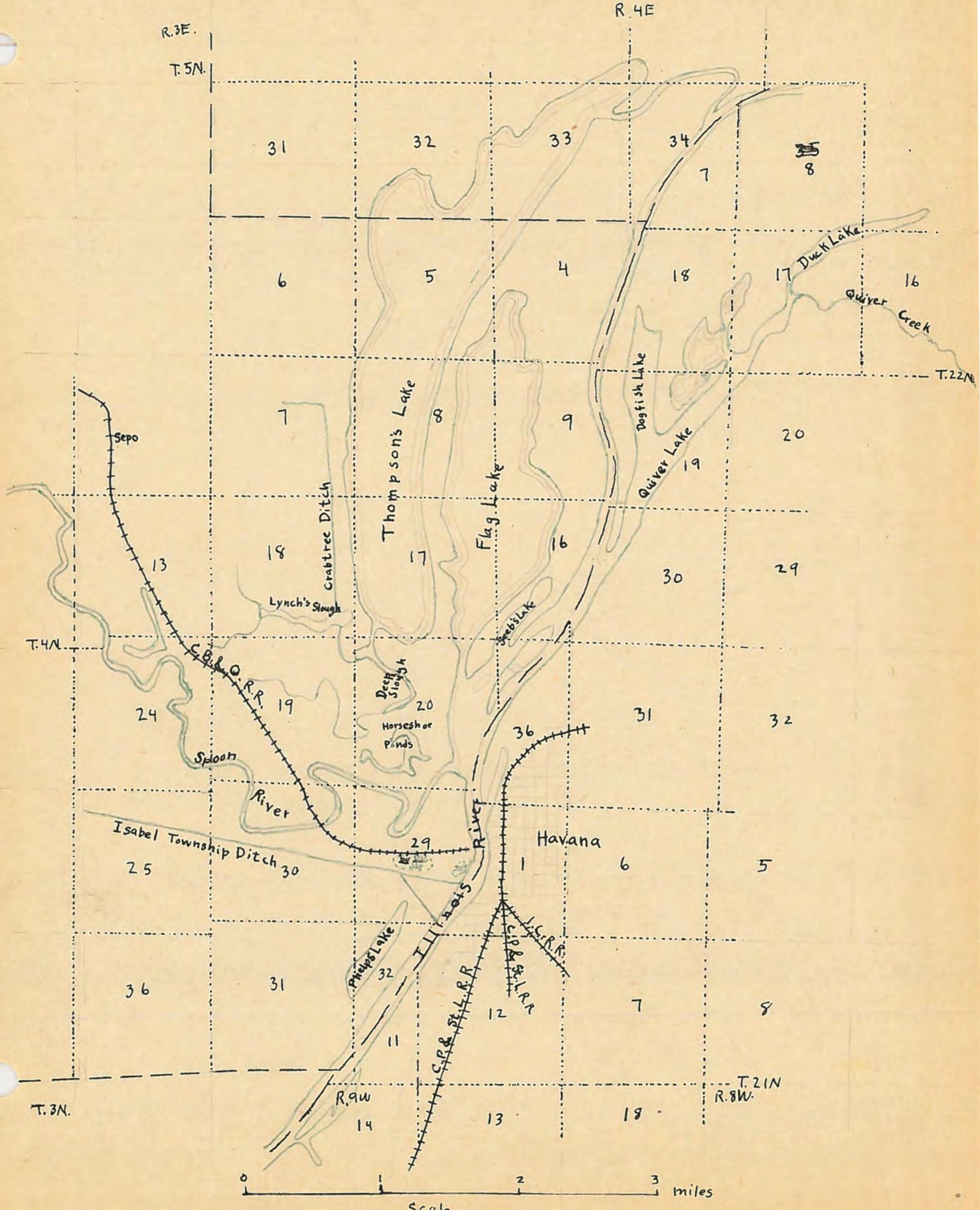


Fig. 3 Title on 4a

Fig. 3 . (on ~~5c~~ 4) Map of Illinois River bottomlands near Havana showing flood plain lakes before the construction of the levees of the Thompson Lake and Chautauqua Drainage and Levee Districts. (compare with figure 11 ~~on p. 5a~~). After map prepared by Richardson of Natural History Survey about 1914.

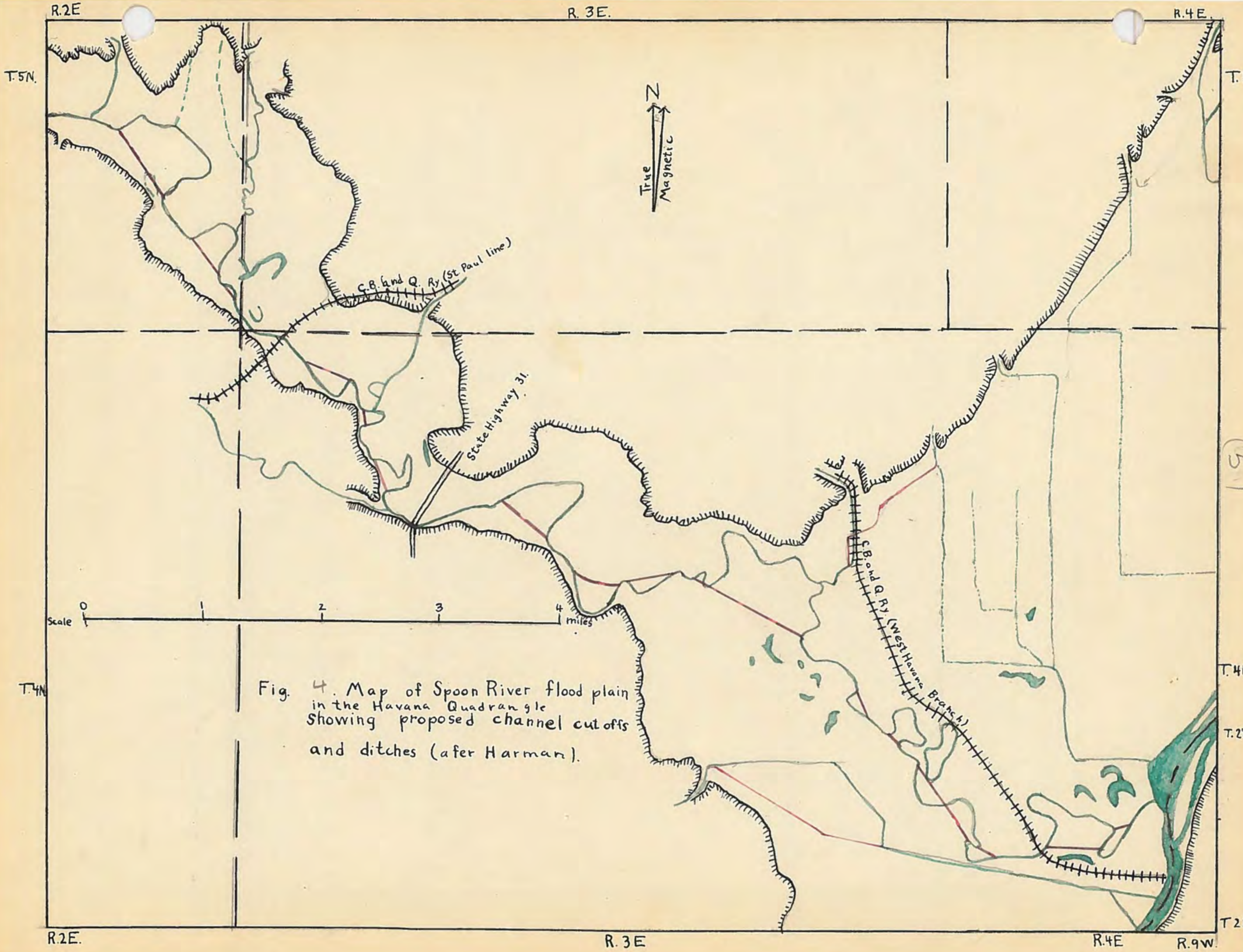


Fig. 4. Map of Spoon River flood plain in the Havana Quadrangle showing proposed channel cut offs and ditches (after Harman).

The drop in mean water level in Illinois River in crossing the Havana quadrangle is about 3 feet. The distance is 12.7 miles, giving a gradient of about 0.25 feet per mile. The drop of Spoon River in its 21.4 miles across the the quadrangle to its junction with Illinois River, is 32 feet, a gradient of 1.5 feet per mile. Big Creek has an average gradient of 6.7 feet per mile# in 16.1 miles, and Otter Creek a gradient of 4.8 feet per mile in 9 miles. All of these streams are subject to overflow.

The natural drainage has been disturbed by strip mining operations southeast of Cuba, and small ponds have collected in depressions in the debris piles, where the coal has been removed.

Relief.

The Havana quadrangle lies entirely within the Interior Glaciated Plains Province.[2/] Altitudes in the quadrangle range from 686 feet at Cuba to 427 feet, the water level of Illinois River at the southern edge of the quadrangle, a total relief of 259 feet. The quadrangle is naturally

---

2/ Fenneman, N. M., Physiographic divisions of the United States: Annals of the Association of American Geographers, vol. 6, pp. 19-98, 1916.

---

divided into three distinct regions: (1) the uplands, west of Illinois River, separated into two districts by the broad flood plain of Spoon River; (2) terrace lands, situated principally southeast of Illinois River, but including also narrow strips one ~~half~~ mile or less in width along the margins of Illinois and Spoon River valleys; and (3) flood plains of Illinois and Spoon Rivers. The upland area north of Spoon River including the flood plains of smaller streams is approximately 106 square miles in area, 47.1% of the total area; that south of Spoon River is approximately 33 square miles, 14.7%; The total upland area thus constitutes approximately 61.8% of the quadrangle. The terrace area includes approximately 32 square miles or 14.3% of the area, and the flood plains include approximately 53 square miles, or approximately 23.9% of the total area. Fig. 5 or 5a shows the distribution of these areas in the quadrangle. Fig. 6 shows profile sections across the quadrangle.

The uplands.

The level of the upland surface declines from the vicinity of Cuba toward the bluffs of Illinois River. The altitude near Cuba is 680 to 686 feet, near Lewistown about 595 feet, and along the tops of the bluffs 565 to 575 feet. From Cuba the surface also declines westward toward the valley of Spoon River. Slight irregularities on this upland surface bear some suggestion of weak morainic ridge topography. ~~but~~ The places where this is recognized might as well be preglacial divide ridges partially obscured by ~~thicker~~ deposits of drift thicker in the valleys than on the ridges. A ridge of this type is seen along State Highway 31 in secs. 20, 21 and 29, T. 6 N., R. 4 E. (Buckheart twp.) between Bryant and St. David.

The valleys of the upland area exhibit all stages in valley development, from newly carved gullies on deforested or formerly cultivated slopes (fig. 101), through steep walled V-shaped ravines (fig. 100), to regularly meandering streams with narrow valley plains, ~~which are still actively eroding their valleys~~, like Sepo Creek (fig. 7), and larger streams which meander irregularly on a wider flood plain ~~and~~ frequently inundat~~e~~ing much or all of this plain during high water. ~~in these streams or in Illinois or Spoon Rivers.~~

Many streams whose courses run principally toward the east or west have distinctly unsymmetrical valleys. These streams ~~follow~~ flow close to the southern bank, and at frequent intervals cut bank exposures are found on this side. This bank is usually much steeper and often more wooded than the opposite side of the valley. The north margin of the valley has a longer and gentler slope, in grass land rather than forest, ~~and~~ cut by many gullies.

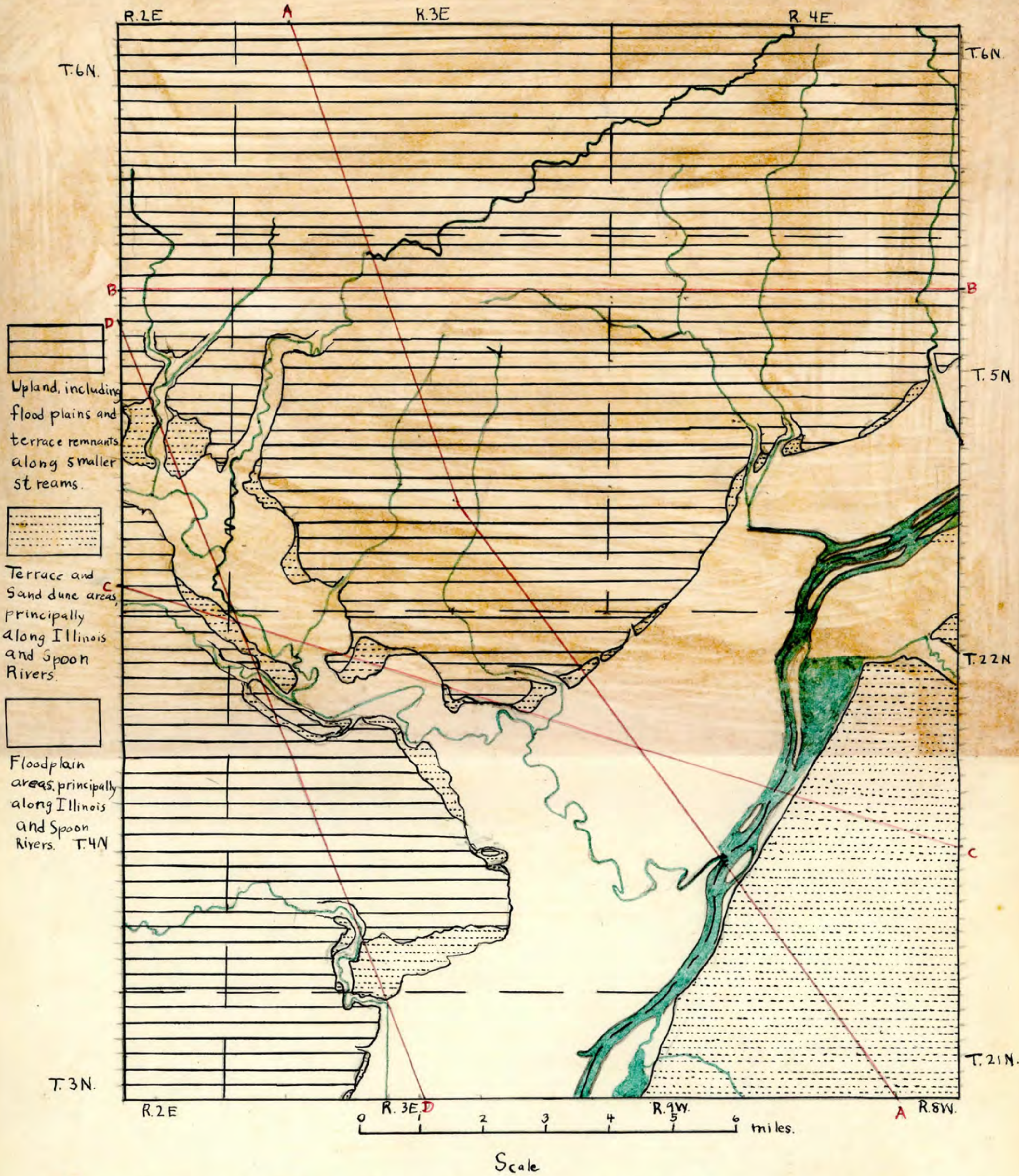


Fig. 5 . Sketch map, showing the approximate distribution of upland, terrace and sand dune, and flood plain areas in the Havana quadrangle, Illinois.
Lines AA,-DD are lines of profiles in fig. 6.

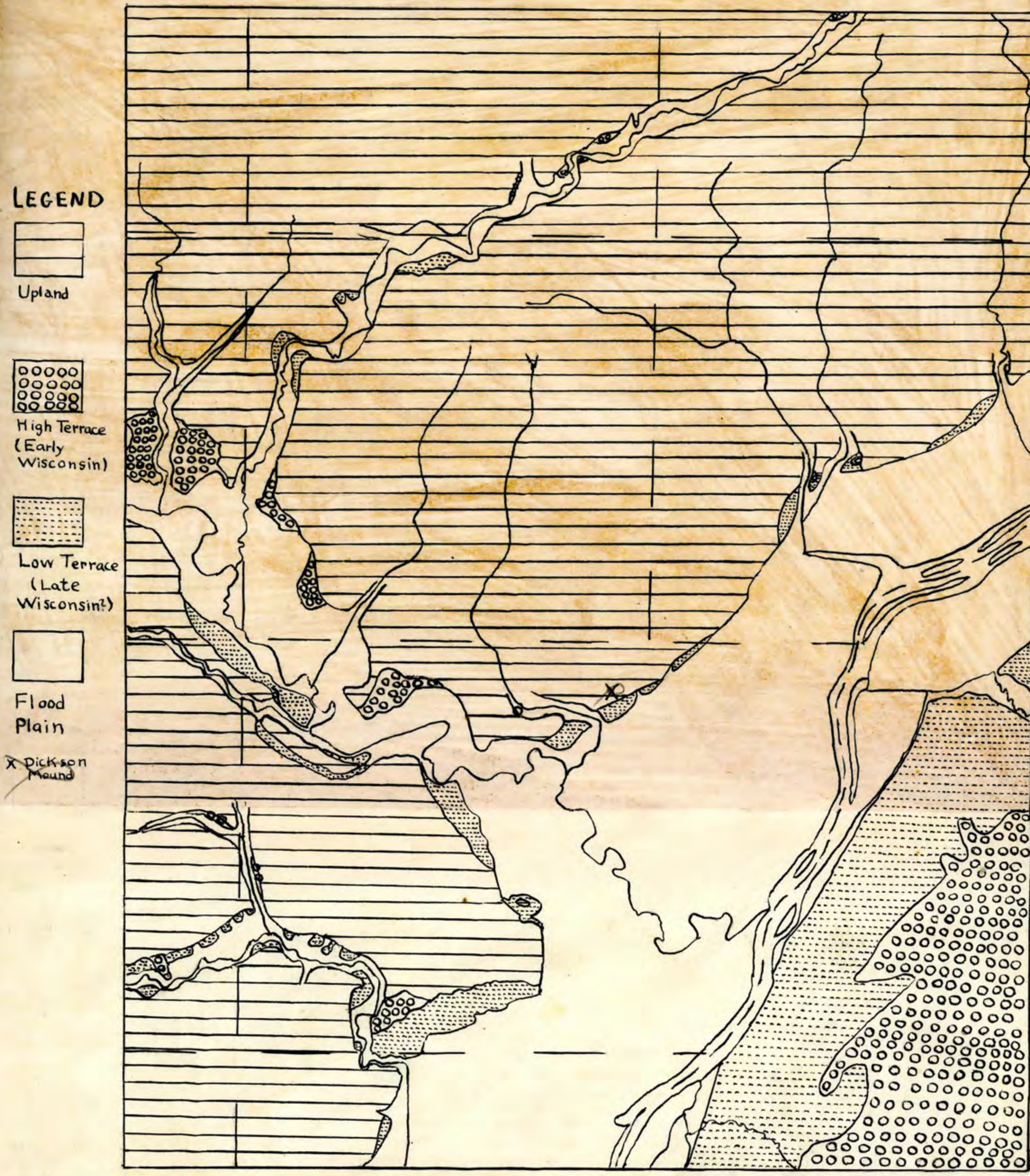


Fig 5a Physiographic diagram of the Havana quadrangle, Illinois

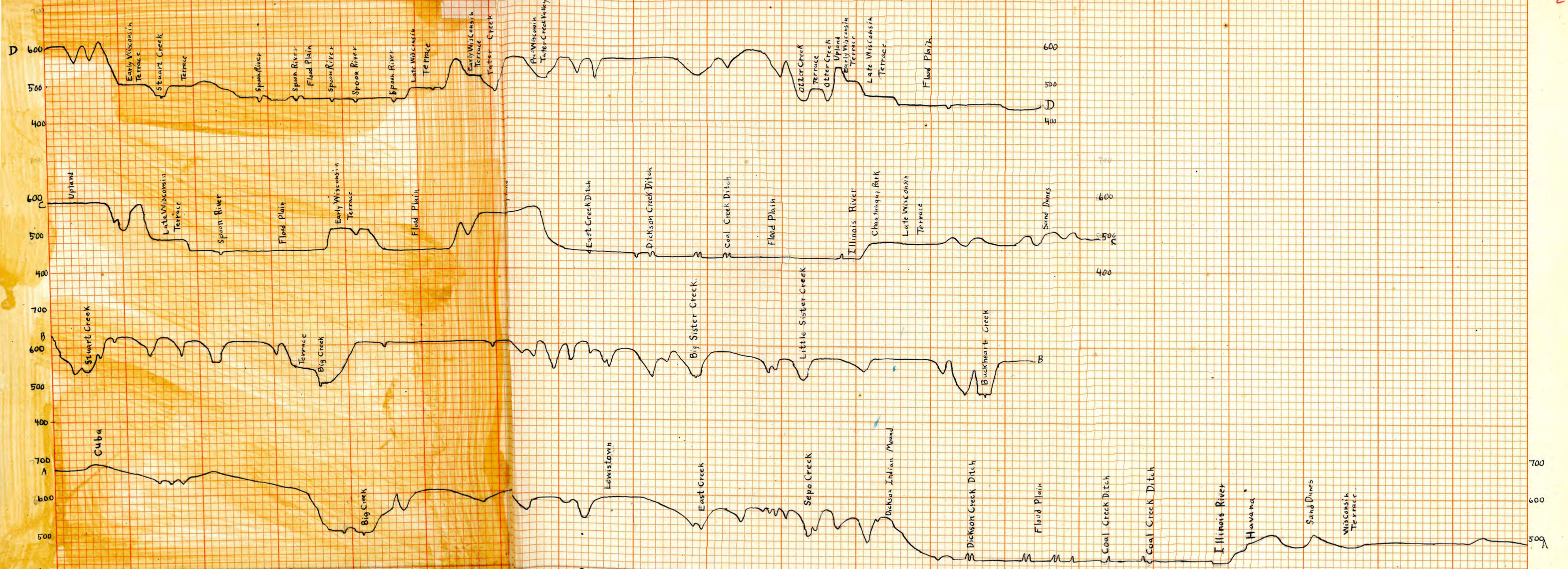


Fig. 6 . Profile Sketches across the Havana Quadrangle, Vertical Scale 1 inch = 200 feet Horizontal Scale $\frac{1}{62500}$

Fig. 1. The ~~V~~alley of Sepo Creek, a regularly meandering stream with a narrow valley plain in the NW. $\frac{1}{4}$ sec. 36, T. 5 N., R. 3 E. (Lewistown twp.). In the area shown in this picture this stream crosses the valley 5 times, cutting each side of the valley in three places. It occupies a valley of pre-Illinoian age, as the cutting is in Illinoian till, whereas ~~while~~ the lateral tributary ravines on both sides cut through the Pleasantview sandstone at levels higher than that of the main stream.

The tributaries on the south side are shorter, with steeper gradients than most of those on the north side of the valley. This difference in form has been explained as the result of the greater exposure of the north slope of the valley to the sun, with consequent greater drying ~~out~~ of the soils and erosion than on the south slope, which is more shaded, ~~with~~ and has moister soil.[3] This valley form is well illustrated by the North Branch of Otter

---

[3] Knappen, R. S. Geology and mineral resources of the Dixon quadrangle. Illinois State Geol. Survey, Bull. #49 , pp. 102-104 , 1926 .

Creek in sec. 24, T. 4 N., R. 2 E. (Pleasant twp.)

The smaller valleys are commonly floored with large fragments of rock foreign to this area, derived by erosion from glacial till (fig. 8). In areas of outcrop of the Pleasantview sandstone member of the Carbondale series, the hardness of the sandstone retards erosion so that the bed of the stream is commonly free from debris. This relation is seen in a hundred or more of the small streams excavated in this sandstone. (fig. 9) Thin limestone or sandstone beds of the Pennsylvanian form small ledges in many streams, causing small waterfalls (fig. 23)

Slumping is seen on the slopes of many valleys, as the result of heavy rains, like those of the winter 1926-27 (fig. 105). Drainage is obstructed by the slumping, forming marshy areas on the slopes.

Slumping or caving has also affected areas from which coal has been removed by underground mining operations. This is noticed in small undrained depressions on the surfaces, or in actual sinks in the beds of streams which drain into abandoned underground mine workings. (Fig. 10) ~~shows a sink in the bed of a ravine which occurred during the field season of 1927.~~

Debris, consisting of shale, limestone, glacial till and loess, has been piled up over several hundred acres southeast of Cuba as a result of strip mining operations. Drainage systems have been deranged, and the

Fig. 8. A ravine in the NE. $\frac{1}{4}$ sec. 5, T. 3 N., R. 3 E. (Kerton twp) showing the bed of boulders and coarse gravel characteristic of smaller streams cutting in Pleistocene deposits. These fragments are concentrated from the glacial till which has been cut away by the stream.

Fig. 9. A ravine in the SW. $\frac{1}{4}$ sec. 36, T. 4 N., R. 2 E. (Pleasant twp.), excavated in the Pleasantview sandstone member of the Carbondale series, which forms the bed of the ravine. Streams excavated in this sandstone commonly flow directly on bed rock.

30

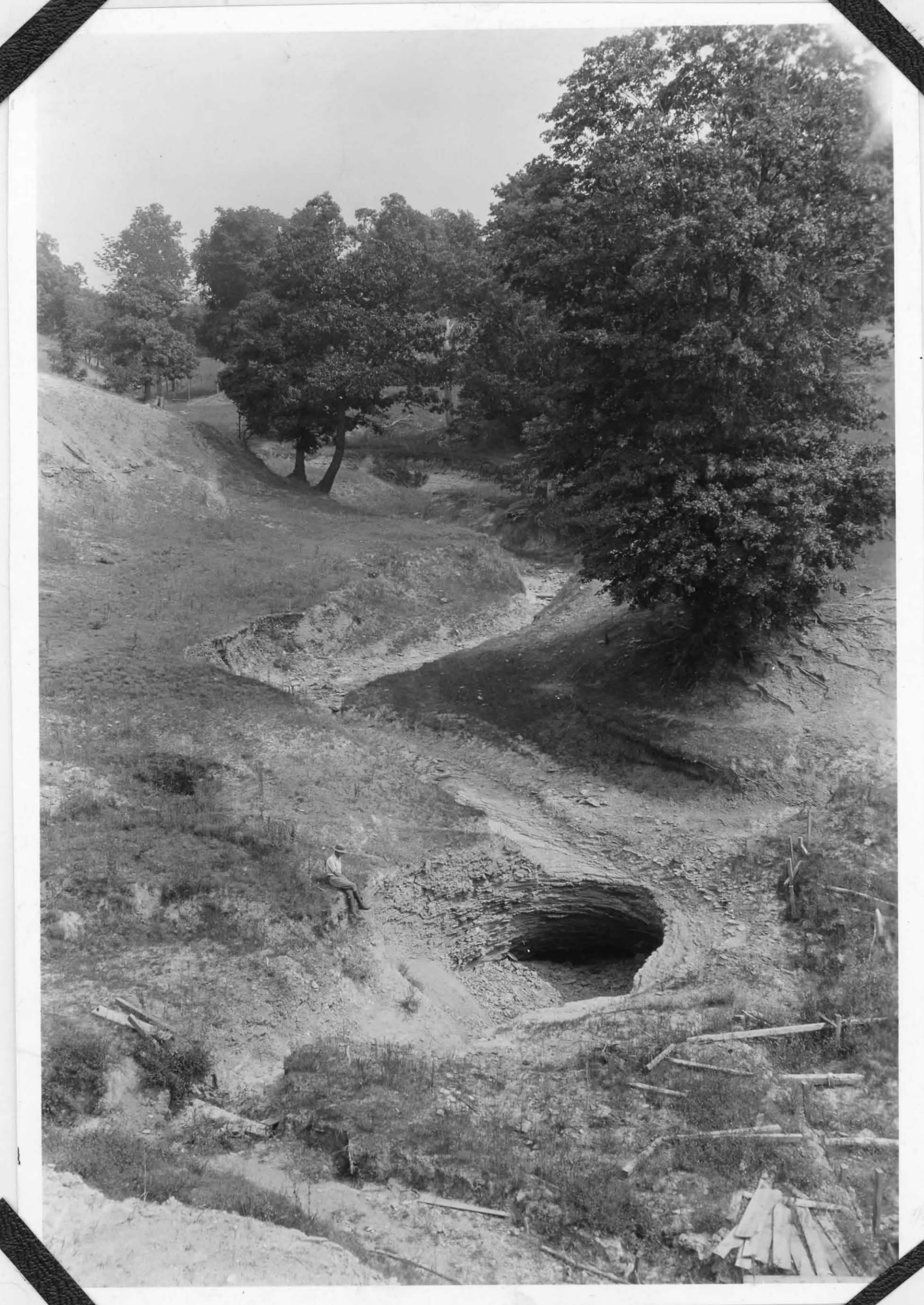


Fig. 10. A cave-in or sink in the bed of a ravine in the NE. ¼ SW. ¼ sec. 23, T. 6 N., R. 3 E. (Putman twp.), resulting from the removal of the Springfield (No. 5) coal by underground mining. This cave-in took place in July or August 1927, during the field season spent in this area. The strata exposed in the sides of the cave-in belong to the Canton Shale member of the Carbondale series. The Springfield coal is 15 to 20 feet below stream level in this locality.

surface soil intimately mixed with unweathered rock.

Certain valleys have been abandoned due to drainage changes in the streams which formed them. The largest abandoned valley is that formed by Tater Creek in secs. 7 and 8, T. 4 N., R. 3 E. (Isabel twp.), abandoned at the time of the building of the 500 foot terrace during Early Wisconsin time (fig. 96). A valley which was abandoned later is in secs. 22 and 23, T. 4 N., R. 3 E. (Isabel twp.) near the Mound Chapel. The level of this abandoned valley is near that of the lower terrace of Later Wisconsin age, 475 feet.

The bluffs of Illinois and Spoon Rivers are quite uniformly steep throughout the quadrangle, the slopes ranging from 15 to 20° in most places. The western margin of Illinois River valley seems to alternate in direction between about N. 8° E. and N. 70° E. The valley is widened at three places where the bluffs bend toward an east-west direction. These ~~three~~ places are (1) near ~~those where Illinois and Spoon River~~ the mouth of Big Sister Creek, (2) near Sepo, where Illinois and Spoon River valleys meet, and (3) near Enion, where Otter Creek enters the Illinois River flood plain. Each of these angles may represent old meander scars of the river, probably previous to Later Wisconsin time. It is significant that in each of these angles wider remnants of the terraces of Early and Later Wisconsin age are preserved than elsewhere along the valley. This relation suggests that the valley margins were swept by a torrent of water from the breaking of the dam of a glacial lake. This torrent scoured the valley from bank to bank except where the valley widened ~~appreciably,~~ as in these reentrant angles, where the velocity of the torrent was somewhat decreased. This interpretation fits with the preservation of more extensive terrace remnants in the valleys of tributary streams than along Illinois valley. The straight margin of the valley may have resulted from erosion by this torrent. Fig. 11 shows a typical view of the bluffs and the reentrant angle near Enion.

Fig. 11. Typical view of the bluffs of ~~the~~ Illinois River in the NE. ¼ sec. 33, T. 4 N., R. 3 E. (Isabel twp.). At the right is seen one of the reentrant angles in the western valley margin, near the mouth of Otter Creek. The cultivated lowland surface in this picture is the lower or late Wisconsin terrace, with an altitude of 475 feet, 30 to 40 feet above the flood plain of ~~the~~ Illinois River. The terrace remnant is here about one half mile ~~in~~ wide. A remnant of the higher terrace of early Wisconsin age is preserved back of the hill at the right of the picture.

Terraces and sand dunes.

Remnants of terraces are preserved along nearly all of the larger streams in the quadrangle. These terrace remnants range in altitude from about 530 feet or higher to 458 feet. Two distinct terrace levels are recognized north of Enion, with levels of 500 feet and 470 feet, and at several other places. ###

The principal terrace area is situated in the southeast part of the quadrangle in Mason County, This terrace is about 30 square miles in area. The part of the terrace near ## Illinois River is 460 to 475# feet above sea level, with several dunes 20 to 30 feet high on it. There is a belt with sand dune and blow out topography ## averaging a mile in width about one and a half miles back from the margin of the flood plain. Beyond this sand dune belt there is another level terrace, with an average altitude of 485 to 495 feet. Scattered dunes and dune ridges are also present on this terrace. This higher terrace is 10 to 15 feet lower than the higher terrace west of the river, but it may be approximately equivalent to it in age. The terrace is slightly undulating in most places, because some sand has been removed by wind and accumulated in minor dune ridges. The boundaries between the terrace and dune areas on the map outline the principal sand dune tracts, but do not show small low dunes three or four feet #high. Fig. 104 shows a typical blow-out in a sand dune area. The vegetation of the sand dune area includes some forms not found elsewhere in ~~this part of~~ central Illinois, notably the prickly pear cactus (Opuntia polyacantha) which is the most characteristic plant of this part of the quadrangle. (Fig. 12)

Flood plains

The flood plain of Illinois River ranges in altitude from 427 feet near water level in the southern part of the quadrangle to 446 feet near the outer margin of the valley. The higher altitude is probably due to sediment

Fig. 12. Sand dune and blow-out region near the SE. ¼ corner sec. 5, T. 21 N., R. 8 W. (Havana twp), about two miles east of Havana, showing the characteristic sand dune vegetation. The prickly pear cactus shown at the left is abundantly distributed through the sand dune areas east of ~~the~~ Illinois River. Miniature dunes are formed around the grasses in the right foreground. Forests in the sand dune area consist principally of oaks.

washed from the slopes. The position of Illinois River in its flood plain is largely determined by the distribution of alluvial fans and other materials brought into the valley by tributary streams. The principal stream erosion in this area takes place on the west side of the valley, and as a result the river follows quite close to the southeast bank of the flood plain. It is farthest from the edge of the flood plain near the mouths of Quiver ~~Creek~~ and White Oak Creeks, its only tributaries on the east side.

Before the reclamation of the flood plain lands by drainage ditches and levees, much of the flood plain was covered by lakes and marshes. The largest lake was Thompson Lake, two or three miles northwest of Havana (fig. 3). Two large flood plain lakes remain, Quiver Lake, north of Havana, and Matanzas Lake, near the southern margin of the quadrangle. Another similar smaller lake is Mud Lake, near Liverpool. These lakes lie east of the channel of the river. Quiver Lake has been reduced in size by the construction of a levee along its northern margin. Fig. 13 shows a view of Quiver Lake from Baldwin Beach, three miles northeast of Havana. The larger flood plain lakes in this area are not ox-bow lakes, formed by cutting across of meandering streams, isolating portions of the old channel as crescent shaped lakes, although some lakes of this type are present in the valley of Spoon River. Lakes like Quiver and Matanzas Lakes have been explained [4]

---

[4] Barrows, H. H. Geography of the Middle Illinois Valley. Illinois State Geol. Survey, Bull. 15, p. 55, 1910.

---

as the result of a break of the river from its partially filled channel in flood time, to follow a slightly lower line through the adjacent bottoms.

The comparative straightness of Illinois River channel is probably due to its very low gradient, as more sediment is accumulating in its valley

Trim photo

Fig. 13. Quiver Lake, the largest of the flood-plain lakes in the valley of ~~the~~ Illinois River, at Baldwin Beach, three miles northeast of Havana. The shores of this lake and Matanzas Lake are used for bathing beaches and the sites for summer cottages at Baldwin Beach, Quiver Beach, Chautauqua Park and Matanzas Beach, just south of the quadrangle.

(Trim this picture with sky line straight) than it is carrying away. Streams with very low gradients do not ordinarily possess the power to cut much on# the outer sides of curves in their channels, and thus they do not usually become more meandering with the passing of time. Spoon River~~, on the other hand,~~ has a somewhat higher gradient, and it has developed a very meandering course across the## quadrangle, flowing $21\frac{1}{2}$ miles in a distance which is less than 12 miles in a straight line. Changes in course are common in this stream, and oxbow lakes in its valley indicate that such changes have taken place in the past.

Culture

Indian mounds

Evidences of the ancient occupation of the margins of Illinois River valley by the mound builders are abundant. Indian mounds are principally found along the later Wisconsin terrace, near the river bank, north and south of Havana, along the top of the bluff on the west side of the river, and along low terrace remnants along the western side of the valley. Fig. 14 shows the locations of some of the known Indian mounds in this quadrangle. The mounds range from one or two feet to 25 or 30 feet in height. They are discussed further on pages 28.4-294, Chapter III

Population

The Havana quadrangle includes the city of Havana,########, the county seat of Mason County, with 3614, the city of Lewistown, the county seat of Fulton County, with 2279, Cuba, with 1484, Saint David, with 1189, Bryant with 482[5/] and several smaller communities, namely ~~Bryant,~~ Dunfermline,

---

5/ Populations #from census of 1920. The present populations of St. David and Bryant are much smaller than those given, because of the abandonment of mines since 1920.

Liverpool, Duncan Mills, Sepo and Enion. In addition, there are summer resorts north of Havana at Chautauqua Park, Quiver Beach and Baldwin Beach, which have only a small## permanent population. The topographic map shows 1211

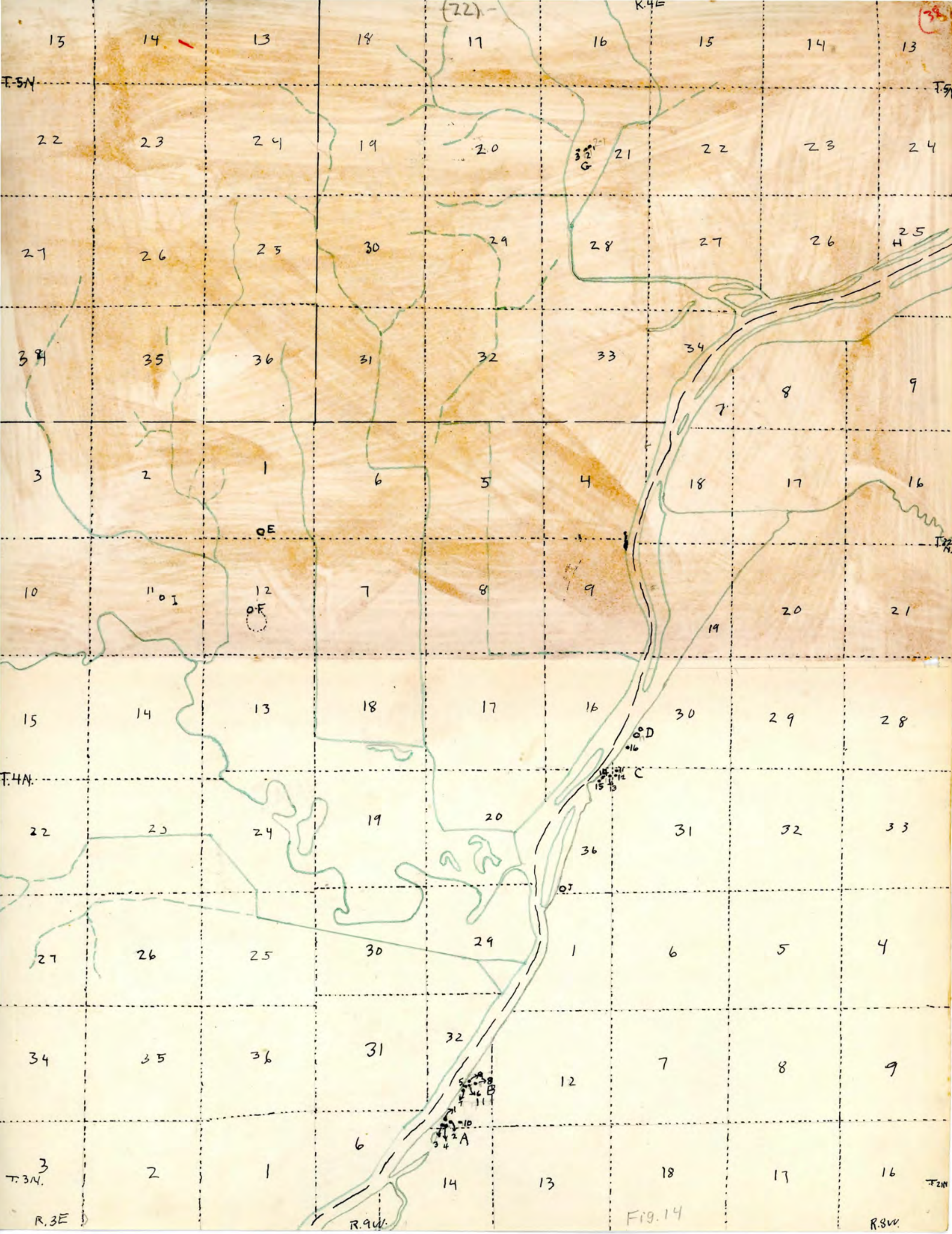


Fig. 14

39

Fig. 14 . (on 20a) Map of a portion of the Havana quadrangle showing the locations of some Indian mounds 6/

6/ Most of the locations shown are described in "The Cahokia Mounds" by W. K. Moorehead and J. L. B. Taylor. Univ. of Illinois Bull. Vol. 26, no. 4, Appendices B and C, pp. 155-170, 1928.

A 1-4, 10. Mounds of Havana group, University of Illinois explorations, centering around Bird Mound (2), in SW. ¼ SE. ¼ sec. 11, T. 21 N., R. 8 W.
Havana group, University of Illinois explorations
B 5-9, Mounds near the southern edge of Riverside Park at the south end of Havana, explored by University of Illinois. Mounds 7 and 9 are large mounds each about 25 feet in height. Mound no. 6 between these mounds, contained several skeletons buried on beds of large chipped flint flakes, and several earthenware pots. Mound no. 5 contained an extensive accumulation of fresh-water shells, interpreted as a kitchen midden deposit.

C 11-16. ~~###~~ Havana group, University of Illinois explorations. Mounds in and near Chautauqua Park. Mound 11 contained several skeletons, bone and copper implements, and slabs of Pottsville sandstone. Studies of hard pan zones in the mounds were made in mounds 11, 13 and 16, and hard pan ~~#####~~ below the base of the mound was ~~#############~~ studied in mound 16.

D Two large mounds between Chautauqua Park and Quiver Beach which have not been explored.

E. Dr. Don Dickson's mound builders burial ground where over 200 skeletons and a great number of implements have been uncovered (fig. 109)

F. Ogden Mound, containing skeletons buried in log tombs and a ceremonial pyramid of earth, and a group of 25 or more small mounds which are situated near this. (Fig. 110)

G. Mounds 1-3, Liverpool group, explored by University of Illinois party.

H. Log tomb burials at Liverpool in 3 mounds along river bank, exact locations not known

I. Mound at top of bluff of Illinois River. Not explored.

J. Mound in City Park in northern part of Havana. Not explored.

In addition to the mounds shown there are known to be many other mounds along the bluff crests of the west side of the Illinois River valley and the terrace margin of the eastern side of the valley.

rural houses, with an estimated rural population of 6055. The total popu-lation of the quadrangle is estimated as ~~about~~ 15,103.

Industries

Although the Havana quadrangle is situated in central Illinois, near the center of the corn belt, the many types of surface included in it cause its industries to be unusually diversified. Lewistown is the market town for a large number of the farmers in the western part of the quadrangle. Havana is somewhat less an agricultural market town, and has several manufacturing industries, producing metal wheels, gas and gasoline engines and plough shares. Cuba is partly an agricultural town, but because of its proximity to the strip mines it is the home of many people engaged in coal mining. Bryant, St. David and Dunfermline were ~~have all been~~ established around large underground coal mines, now ~~which have all been~~ abandoned. The last two named are distinctly coal miner's communities at the present time, with a population consisting ## principally of foreign born residents or residents with foreign born parents. Liverpool is a port for river steamers on ### Illinois River. It is a fishing center and a resort ### of duck hunters in the fall and winter.

~~Agriculture~~

Corn is the principal crop grown on the upland and the terrace areas west of Illinois River. It has also been extensively grown in areas reclaimed from the flood plain of Illinois River. Wheat, clover, oats and timothy are other crops extensively grown on the upland. The sloping sides of valleys west of the river are largely given to pasture land or forest. ## Where they have been cultivated and later abandoned, the slopes have been extensively gullied and the top soil eroded. Experiments have been made on rice cultivation in the Thompson Lake Drainage district, northwest of Havana. 1/

1/ Bohannon, F. C. Rice growing in the upper Mississippi valley. Trans. Ill. State Acad. Sci., vol. 20, p. 234, 1928.

Coal mining is and has been the principal mineral industry of the area.

In the past ~~The~~ mining was ~~formerly~~ largely by underground methods, entering the coal by horizontal drifts on its outcrop or by shafts. The horizontal drifts are mostly those of local wagon mines which entered the outcrop of the coal and were extended back 200 to 500 feet and then abandoned. Large underground mines have been operated near Cuba, St. David and Dunfermline, and northwest of Bryant at the Cripple Creek mines. Fig. 117 shows the approximate areas from which the coal has been removed by mining. The coal has been stripped from small areas where its outcrop was near the surface of stream valleys for many years. Stripping operations on a large scale were started in the region in 1923 by the United Electric Coal Co., southeast of Cuba. During 1927 this coal company had four large electric shovels engaged in stripping the overburdgn from the coal and more coal was being removed by this method in 1927 and 1928 than by all the underground mines in the area.

Some gravel has been dredged from the channel of Illinois River near Havana.

The marshes and lakes of ### Illinois River valley are used extensively for duck hunting during the fall and early winter. Havana is one of the principal resorts for hunters along the valley. During the summer months quite a large summer population is attracted ~~to the district~~ to the bathing beaches and summer cottage resorts north and south of Havana. A small resort with swimming pools has been established at Depler Springs in the valley of Big Creek in sec. 8, T. 5 N., R. 3 E. (Lewistown twp.), using the water from a strongly flowing artesian well to fill the pools.

Transportation

The area west of Illinois River is served by two lines of the Chicago, Burlington and Quincy Railroad; one branch from Galesburg to West Havana passes through Cuba, Lewistown and Sepo and ends at West Havana; the other from Canton to Vermont passes through St. David, Bryant and Lewistown.

The Toledo, Peoria and Western Railroad ~~line~~ from Peoria to Keokuk passes through Cuba and the northwestern portion of the quadrangle. The area east of Illinois River is served by the Chicago and Illinois Midland Railroad (shown on the map as Chicago, Peoria and St. Louis) ~~line~~ from Peoria to Springfield. The Havana and Jacksonville Railroad runs south from Havana. A line of the Illinois Central Railroad runs southeast from Havana to Mason City, Lincoln, Clinton and Champaign. An electric interurban line, the Illinois Central Traction Company, was formerly operated ~~a line~~ from Lewistown to Bryant, St. David and Canton, but service was discontinued in 1929.

The area is crossed by several paved roads. State Highway 31 from Canton to Quincy crosses the quadrangle from northeast to southwest ~~passing~~ through St. David, Bryant, Lewistown and Duncan Mills. State Highway 43 runs from Havana east to Mason City. State Highway 95 runs from Lewistown to Cuba, and State Highway 98 runs from Duncan Mills west to Ipava and Table Grove. Most of the country roads are graded, but most of these west of Illinois River are nearly impassable after heavy rains. East of Illinois River most of the roads are in sand or sandy loam. They are usually rough, but can be travelled at all times. Communication between the east and west sides of Illinois River is made by three roads west from Havana, to Sepo, Duncan Mills and Enion. These roads were covered by water nearly continuously for 8 months during the winter of 1926-27. They are frequently impassable after heavy rains. A higher levee across the valley is being constructed for a state highway to connect Havana with the west side of the river.

Chapter III - Descriptive Geology

Introduction.

Strata ~~representing~~ of the Ordovician, Silurian, Devonian, Mississippian and Pennsylvanian systems of the Paleozoic group and deposits representing the Pleistocene and Recent systems of the Cenozoic group (Table 1) ### are penetrated by wells or other borings, or are exposed at the surface (Appendix C# and #### Figs. 124, 125 and 126.) The oldest rocks known in the quadrangle belong to the St. Peter formation of the Ordovician system, ~~are~~ are penetrated in the city well of Cuba, and an oil test ###### well in the NW. ¼ sec. 31, T. 22 N., R. 9 W. (Havana twp.). The deepest drilling in the quadrangle, an artesian well ### at Depler Springs, in the NE. ¼ NE. ¼ sec. 8, T. 5 N., R. 3 E. (Lewistown), extended to a depth of 2245 feet. No accurate log of this well was kept, but a ~~by~~ comparison with other wells in the area it shows ~~appears~~ that this well penetrates strata of Cambrian age to a depth of between 200 and 300 feet. ############### The rocks from the base of the St. Peter formation to the base of the Croixan series of the Cambrian system ## are probably similar to ### rocks of the same age in other parts of western Illinois.1/ The pre-Cambrian sedimentary rocks, where ~~ver they are~~

1/ Wanless, H. R. Geology and Mineral Resources of the Alexis Quadrangle. Illinois State Geol. Survey Bull. 57, Appendix C, 20, 1930.

exposed, are intensely metamorphosed, sharply folded, and intruded by igneous rocks, and presumably they have the same character in Illinois. The oldest rocks exposed at the surface belong to the Pottsville series of the Pennsylvanian system.

The interpretation of the Pennsylvanian record has been facilitated by about 500 records of coal test borings in the northern part of the Havana quadrangle and about 50 in the southern part of the Canton quadrangle adjacent to the Havana quadrangle.

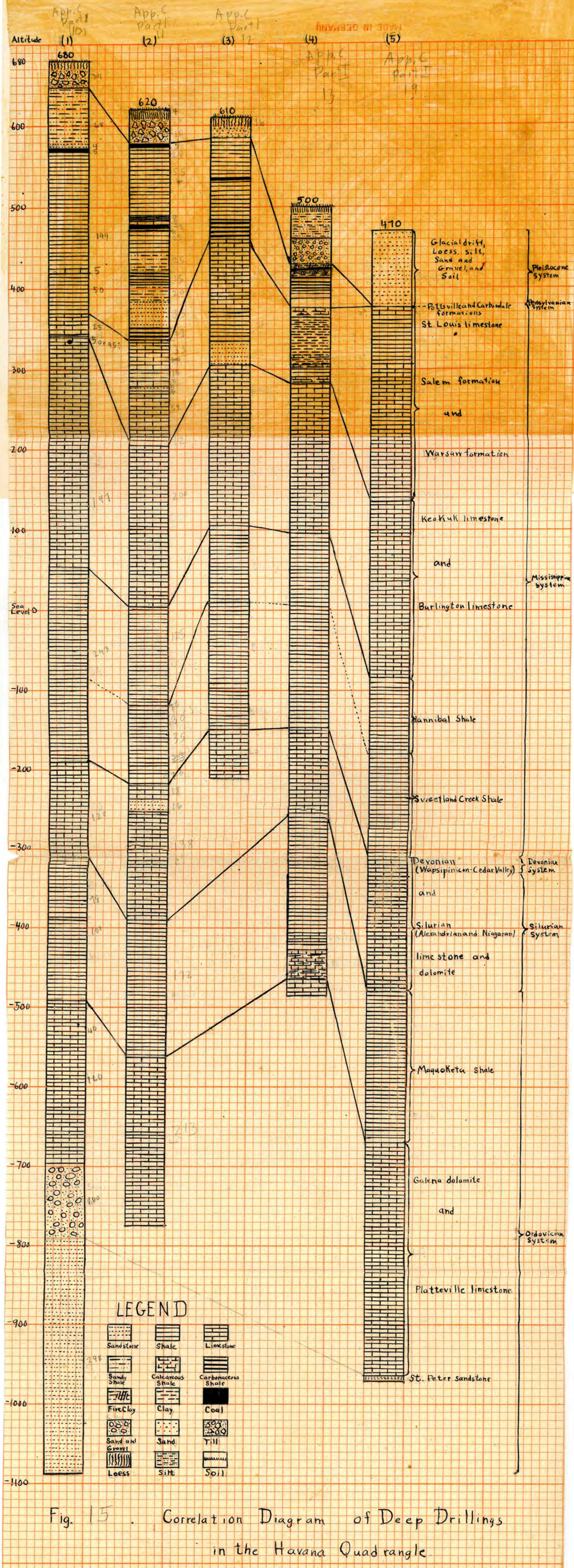


Fig. 15 . Correlation Diagram of Deep Drillings in the Havana Quadrangle

1. City Well, Cuba
2. Oil test drilling, SW. ¼ sec. 29, T. 6 N., R. 4 E. (near Bryant)
3. Oil test drilling, NW. ¼ sec. 12, T. 5 N., R. 2 E.
4. Oil test drilling, SW. ¼ sec. 24, T. 5 N., R. 2 E.
5. Oil test drilling, NW. ¼ sec. 31, T. 22 N., R. 9 W. (near Havana)

Ordovician system

Introduction

The name Ordovician refers to the Ordovices, an ancient tribe, who at the time of the Roman empire lived in Wales, ~~at the time of the Roman empire,~~ where the rocks of the system are typically exposed.2/

2/ Lapworth, C., On the tripartite classification of the lower Paleozoic rocks: Geol. Mag., London, new ser. vol. 6, pp. 12-14, ~~1897~~ 1879.

The Ordovician rocks of northern Illinois and adjacent states are divided into three subsystems:- Lower Ordovician, which is represented by the Prairie du Chien series; Middle Ordovician, represented by the Mohawkian series, which contains the St. Peter, Glenwood, Platteville, Decorah, and Galena formations; and Upper Ordovician, which is represented by the ~~Maquoketa~~ Cincinnatian series. which contains the Maquoketa formation

Prairie du Chien series

The name Prairie du Chien was introduced 3/ to replace the old name

---

3/ Bain, H. F., Zinc and lead deposits of the upper Mississippi Valley: U. S. Geol. Survey Bull. 294, p. 18, 1906

Grant, U. S., and Burchard, E. F., U. S. Geol. Survey Geol. Atlas Lancaster-Mineral Point folio (No. 145), page 3, 1907.

"Lower Magnesian" that had been originally used to designate the strata ~~that lie~~ between the Croixan series and the St. Peter sandstone. The name is derived from the town of Prairie du Chien, Wisconsin. ~~because~~ Near that town typical exposures of the series occur along the bluffs of the Mississippi River valley.

The series presumably underlies all of Illinois, as many deep wells encounter it, but it crops out only along Illinois River east of La Salle and in a few other northern Illinois localities. In the Havana quadrangle it was penetrated in the Depler Springs well, but there is no information as to its character. A few miles north of the quadrangle, at Canton (Appendix C, 5) 393 feet of dolomite, limestone, shale and sandstone are assigned to this series.

The Prairie du Chien series is probably separated from the overlying St. Peter sandstone by an erosional unconformity, as such a relationship is exposed at some ~~####~~ localities in Illinois[4] and at many places in Wis-

4/ Knappen, R. S., Geology and mineral resources of the Dixon quadrangle: Illinois State Geol. Survey Bull. 49, p. 47, 1926.
Cady, G. H., Geology and mineral resources of the Hennepin and LaSalle quadrangles: Illinois State Geol. Survey Bull. 37, p. 36, 1919.
Sauer, C. O., Geography of the Upper Illinois valley and history of development: Illinois State Geol. Survey Bull. 27, pp. 38-39, 1916.

consin,[5] and is supported by the correlation of records of numerous wells in both states. This unconformity represents an erosional interval during

5/ Thwaites, F. T., Stratigraphy and geologic structure of northern Illinois with special reference to underground water supplies: Illinois State Geol. Survey Rept. of Inv. No. 13, p. 22, 1927.

which relief of several hundred feet was locally developed.[6]

6/ Fisher, D. J., Geology and mineral resources of the Joliet quadrangle: Illinois State Geol. Survey Bull. 51, p. 20 and Pl. III, 1925.

The Prairie du Chien series is usually correlated with the Beekmantown (Lower Ordovician) of New York.

Mohawkian Series

St. Peter formation

The St. Peter formation was originally named by D. D. Owen[7] because

7/ Owen, D. D., Preliminary report of the Geological Survey of Wisconsin and Iowa: U. S. Gen. Land. Off. Rpt. 1847 (U. S. 30th Cong. 1st Sess. Sen. Ex. Doc. 2) pp. 160-173, 1847.

he saw good exposures of it along St. Peter's (now Minnesota) River, near St. Paul, Minnesota. It has been penetrated by many deep wells in Illinois and probably underlies all of the state, but it crops out in limited areas only.[8] Typical exposures accur along ~~the~~ Illinois River between LaSalle

8/ Lamar, J. E., Geology and economic resources of the St. Peter sandstone of Illinois: Illinois State Geol. Survey Bull. 53, pp. 14-18 and Pl. II, 1928.

and Ottawa, along Rock River in Lee and Ogle counties, and along Mississippi River in Calhoun County. It underlies all of the Havana quadrangle, and it has been penetrated in two wells in the quadrangle and several in adjacent areas.

The St. Peter sandstone is reported to be white to light gray, medium-to fine-grained quartz sand composed of clear, well rounded grains.

The thickness of the ##.formation in and adjacent to the Havana quadrangle ranges from 235 to 298 feet in six wells which have penetrated all or nearly all of it. (Appendix C)#

The St. Peter formation rests unconformably on the strata of the Prairie du Chien series in many places in Illinois. The erosion surface below this unconformity in many places shows a relief of 100 feet or more. The drill records in and near the Havana quadrangle afford little information regarding this surface.

The sandstone is correlated with the typical St. Peter formation in # Minnesota because they are similar in stratigraphic position and nearly identical in lithologic characteristics. On the basis of its fossil content ~~content~~ the St. Peter sandstone of Minnesota is correlated with the upper Chazy (Ordovician) series# which is exposed at Chazy, near Lake Champlain, New York.

Glenwood formation

The name Glenwood #9/ is applied to a greenish sandy shale which

9/ Calvin, Samuel, Geology of Winneshiek County: Iowa Geol. Survey, vol. 16, pp. 60-61 and 74-75, 1906.

overlies the St. Peter sandstone in many parts of northern Illinois, Wisconsin, Iowa and Minnesota. No shale is reported between the St. Peter sandstone and the Platteville limestone in wells in the Havana quadrangle and the surrounding area, so the Glenwood formation is probably

47

absent or quite similar in lithologic character to the adjacent strata in this region.

Platteville formation.

The name Platteville was adopted for this formation, because its full thickness is typically exposed along Little Platte River west of Platteville, Wisconsin.[10]

[10] Bain, H. F., Zinc and lead deposits of northwestern Illinois: U.S. Geol. Survey Bull. 246, pp. 18-19, 1905.

The formation is a more or less dolomitic limestone, rather thin bedded, and it generally contains some shale layers. Its thickness is not easily determined in the Havana area, as it is not sharply differentiated from the overlying Decorah or Galena formation. In most places where it is exposed it is 90-100 feet in thickness. It ~~appears to~~ may be about 100 feet thick at Cuba and ~~perhaps~~ 110 feet at Canton.

The Platteville has been correlated with the Upper Stones River series in Tennessee, and the Chazy-Lowville series in New York. Formerly it was correlated with the Trenton formation in New York, but later it was discovered that the Platteville formation was not the exact equivalent of the Trenton horizon.

Decorah formation

The name Decorah is applied to shaly or sandy limestone beds occurring between the Platteville and Galena formations from typical exposures in and near the city of Decorah, Iowa.[11] Thin shales reported at or near the top of

[11] Calvin, Samuel, Geology of Winneshiek County: Iowa Geol. Survey, vol. 16, pp. 60-61 and 84-85.

the Platteville formation in drill records in western Illinois are commonly referred to the Decorah, although they may not be identical in age. The Decorah shale is not distinguished in the records of drillings in the Havana quadrangle and vicinity. It is correlated with the Lowell Park limestone in the Dixon, Illinois, area,[12] and with the Black River formation

[12] Knappen, R. S., Geology and mineral resources of the Dixon Quadrangle: Illinois State Geol. Survey Bull. 49, p. ## 60, 1926.

in New York.

Galena formation

The Galena formation was so named[13] because it was #### the principal source of lead in the upper Mississippi Valley. The lead was derived from the mineral galena. Like the Platteville formation, it underlies all of

[13] ####Foster, J. W., and Whitney, J. D., Geology of the Lake Superior Land District Part 2: 32d Cong. spec. sess., Senate Doc. 4, p. 146, 1851.

northern Illinois except small areas from which it has been removed by erosion.

The Galena formation is a relatively massive, gray, cherty, coarsely crystalline magnesian or dolomitic limestone, which weathers to a yellow color and a sandlike texture. It can be most readily distinguished from the subjacent Platteville limestone by the more shaly structure ###### and thinner bedding of the latter, although the two are frequently confused in drill records. #

The thickness of the Galena formation in the Havana region averages between 185 and 200 feet. The combined thickness of the limestones and dolomites between the St. Peter and Maquoketa formations (Galena-Platteville) varies only between 270 and 300 feet in the drillings in this area.

In northern Illinois an erosional unconformity of small relief has been reported at the base of the Galena formation.

The Galena dolomite is regarded as the equivalent of the Trenton limestone of New York.

###Cincinnatian series

Maquoketa formation

The Maquoketa formation is named from exposures along the Little Maquoketa River in Iowa.[14] It underlies most of northern Illinois, and is reported in 4 drill records in the Havana quadrangle and several in the surrounding territory.

14/ White. C. A., Geology of Iowa. vol. 1, p. 181. 1870.

The Maquoketa formation consists of blue gray, light gray, greenish gray, and brownish shale, with one or more thin limestone layers. Some of the shale is sandy, some calcareous, and some contains pyrite; The limestone is usually in the lower part of the formation and occurs in one or more layers # 15 to 30 feet thick.

The thickness of the Maquoketa formation in the Havana quadrangle and vicinity ranges from 172 to 220 feet, the greater thickness being reported to the north and east of the quadrangle at Glasford and Canton. (Appendix C). The thickness is about the same as that reported in other nearby areas in western Illinois.

In typical exposures in eastern Iowa and northwestern Illinois, the Maquoketa ## formation rests conformably on the Galena ##### formation.

The Maquoketa formation here is recognized by its stratigraphic position and lithologic character, as a shale between two massive dolomites, the Galena below and the ######## Niagaran above. The upper part of the Maquoketa formation of Iowa and northwestern Illinois is correlated with the lower Richmond (Fernvale and Waynesville) of Indiana and Ohio on the basis of fossil evidence.[15]

50

15/
Savage, T. E., Richmond Rocks of Iowa and Illinois: Amer. Jour. Sci., 5th ser., vol. 8, pp. 411-427, 1924.

Silurian system

Introduction

The name Silurian, which is applied to a system of rocks that occur below the "Old Red Sandstone" (Devonian) is derived from Silures, the Roman name for a Celtic tribe who formerly inhabited a region that now includes parts of both England and Wales, where the system is typically exposed.16/ At first the system was divided into the Lower and Upper Silurian subsystems, but the lower division was subsequently recognized as a distinct system and named Ordovician.

16/
Murchison, R. I., On the Silurian system of rocks: London and Edinburgh Philos. Mag. and Jour. Sci., 3d ser., vol. 7, pp. 46-52, July, 1835.

The Silurian rocks in Illinois are divided into two series, the Alexandrian and the Niagaran, and a third series, the Cayugan, may be represented.

Alexandrian series

The Alexandrian series is named from typical exposures in Alexander County, Illinois.17/ ~~#########~~ It consists of limestones, dolomites and shales.

17/
Savage, T. E., ~~Alexandrian rocks of northeastern Illinois and eastern Wisconsin: Bull. Geol. Soc. America, vol. 27, pp. 305-325, 1916.~~ On the lower Paleozoic stratigraphy of south western Illinois Amer. Jour. Sci., Vol. 25, p. 434, 1908

The Alexandrian series is represented in the Plymouth-Colmar oil field in McDonough county by a sandstone of local distribution at the base of the Silurian. It occupies depressions in an erosion surface on the Maquoketa formation, and is absent from higher points on this surface. It is named the Hoing sand,[18] and is correlated approximately with the Edgewood formation of the Alexandrian series. The Hoing sand has not

---

18/ Blatchley, R. S., The Plymouth oil field: Illinois Geol. Survey Bull. 23 (extract) p. 51, 1914.

---

been reported in drillings in or closely adjacent to the Havana quadrangle. If dolomites of Alexandrian age are present in this region they have not been distinguished from the overlying Niagaran dolomites.

Niagaran series

The name Niagaran was adopted to designate this series because Niagara Falls, which is produced by the passage of Niagara River over a precipitous ledge of the limestone rocks of the series, exhibits the greatest natural development of the series in New York State.[19] Rocks of Niagaran age outcrop extensively in northeastern, northwestern, and southwestern Illinois and in

---

19/ Hall, James, Report of the Survey of the fourth geological district: Natural History of New York, part 4, Geology of New York, vol. 4, p. 80, 1843.

---

adjacent parts of Wisconsin, Iowa and Missouri. They underlie most of the state, being absent only where they have been eroded after diastrophic elevation exposed them at the surface. They are present under all of the Havana quadrangle and the surrounding area.

The Niagaran series consists principally of massive tan, brownish or gray dolomite or dolomitic limestone, containing much chert and some pyrite. The limestone and dolomite of this region is unconformably overlain by the Wapsipinicon limestone of the upper Devonian. The Devonian limestone is usually distinguishable from the underlying Niagaran in samples taken from drillings, but the two limestones are not commonly separated in drillers' logs. The character of the Niagaran series is shown in detailed logs in Appendix C, Pt I.

The combined thickness of the Niagaran and Wapsipinicon limestones in the Havana quadrangle ###### and vicinity ranges from 250 feet to 66 feet. The thickness is greatest northeast of the quadrangle at Glasford, Peoria County, and least #####west of the southern part of the quadrangle at Vermont, Fulton county. The thickness diminishes fairly regularly from east to west, and less rapidly from north to south. (See graphic sections in figures 124, 125 and 126). The boundary between the two limestones is not distinguished in the majority of the wells in the area. The variation in thickness may be due to#one or more of the following causes:

(1) Regional variation in original thickness of either the Niagaran or the Wapsipinicon limestone.

(2) Erosion of the Niagaran series before the deposition of the overlying Wapsipinicon formation.

(3) Erosion of the Wapsipinicon formation, as well as some of the Niagaran series before the deposition of the Sweetland Creek formation.

The Niagaran series is separated from both the underlying Maquoketa formation and the overlying Wapsipinicon formation by ######o######## erosional unconformities.

The Niagaran series in the upper Mississippi valley are assigned to the Lockport subseries and have been divided into the Joliet, Waukesha, Racine, and Port Byron formations,[20] but these formations cannot be satisfactorily differentiated in well records.

20/ Savage, T. E., Silurian rocks of Illinois: Bull. Geol. Soc. America, vol. 37, pp. 513-534, 1926.

Devonian system

Introduction

The name Devonian was proposed for this group of rocks because they are typically exposed in Devonshire, England.[21] The term was substituted for a

 55

21/ Sedgwick, Rev. A., and Murchison, R. I., Geol. Soc. London Proc. vol. 3, No. 63, pp. 121-123, abstract, 1839.

________________, On the physical structure of Devonshire, and on the subdivisions and geological relations of the older stratified deposits, etc: Geol. Soc. London Trans., 2d ser., vol. 5, pt. 3, pp. 701-702, 1840. (Read April 24, 1839).

---

much older name, "Old Red Sandstone", because rocks other than sandstone were discovered to be its equivalent in many localities.

Except in localities where they have been removed by erosion, Devonian rocks are presumed to underlie all of that portion of Illinois that lies south of Green River (Rock Island to La Salle) and southwest of a line drawn southeast from La Salle through Danville. They are probably ~~are believed to~~ underlie most ~~all~~ of the Havana quadrangle and its immediate vicinity, although they may have been locally removed by erosion before the deposition of the earliest Mississippian sediments.

The Devonian system has been divided into Lower, Middle, and Upper Devonian subsystems. The Devonian rocks of northwestern Illinois, which are well exposed along both banks of Mississippi and Rock Rivers in the vicinity of Rock Island, Illinois, belong to the Upper Devonian subsystem 22/

#12/ Savage, T. E., Devonian formations of Illinois: Amer. Jour. Sci., 4th ser., vol. 49, pp. 181-182, 1920.

---

and are divided into two formations, the Wapsipinicon and the Cedar Valley. 23/

23/ Savage, T. E., and Udden, J. A., The geology and mineral resources of the Edgington and Milan quadrangles: Illinois State Geol. Survey Bull. 38C, pp. 24-28, 1921, Bull. 38, pp. 136-140, 1922.

The Devonian rocks of the Havana quadrangle are much thinner than they are near Rock Island, and they are believed to represent only the Wapsipinicon formation, although some of the higher beds may belong to the Cedar Valley.

Senecan series

Wapsipinicon formation

The Wapsipinicon formation was named from exposures along the Wapsipinicon River in Iowa.[24] ####

---

[24] Norton, W. H., Notes on the lower strata of the Devonian series in Iowa: Iowa Acad. Sci. Proc. 1893, vol. 1, pt. 4, pp. 22-24, 1894.

The Wapsipinicon formation is composed of limestone, which is commonly thinner bedded, darker in color and less dolomitic than the Silurian. The log of an oil test drilling in the SE. ¼ SW. ¼ sec. 29, T. 6 N., R. 4 E. (Buckheart twp.) (Appendix C, no. 11), reports 16 feet of "sand" below 18 feet of limestone and above 138 feet of limestone. The #"sand" may be granular limestone which accumulated on the erosional surface formed on the Silurian limestone. If this interpretation is correct, the Devonian is represented by 34 feet and the Silurian by 138 feet in the above drilling. In a few other wells west and north of the quadrangle (Appendix C, nos. 3, 6, 7, 8 and 9) the Wapsipinicon formation ranges from 41 to 63 feet in thickness. In the other wells penetrating this formation it is not differentiated from the underlying Niagaran series.

The Wapsipinicon formation is separated by erosional unconformities from the underlying Niagaran series and the overlying Sweetland Creek formation in parts of western Illinois. It is correlated with the Tully formation of New York,[25] the lowest formation of the Upper Devonian subsystem. The fauna of this limestone indicates that the Devonian series in this area were connected with the Arctic and Pacific oceans, probably by way of McKenzie River and the northern Great Plains.

---

[25] Savage, T. E., and Udden, J. A., Idem.

55

Mississippian system

Introduction

The term Mississippian was proposed and is used by most North American geologists as a geographical designation for this system of rocks because they are so largely developed in the basin of## Mississippi River.[26]

---

[26] Winchell, A., On the geological age and equivalents of the Marshall group: American Philos. Soc. Proc. vol. 11, No. 81, p. 79, 1869; No. 83, pp. 245 and 385, 1870.

The name Carboniferous, which means "Coal-bearing", has been long used ##[27]

---

[27] Conybeare, W. D., and Phillips, W., Outlines of the geology of England and Wales, pp. 278 and 320-364, 1822.

---

and is retained as a system term by some American and by European geologists, who refer to rocks equivalent to the Mississippian system as "Lower Carboniferous".

The Mississippian system, like the Devonian, is distributed over those parts of Illinois lying south and southwest of a line drawn east from Rock Island to La Salle and thence southeast to Danville from which it has not been removed by erosion. It is divided into two subsystems: The Lower Mississippian,# which includes the Kinderhook, Osage, and Meramec series; and the Upper Mississippian, which consists of the Chester series. The Upper Mississippian subsystem is not represented in the Havana quadrangle.

Kinderhook series

The name Kinderhook was proposed to include the beds lying between the "Black Slate" and the Burlington limestone because the series as such was first examined at Kinderhook, Illinois[28].

---

[28] Meek, F. G., and Worthen, A. H., Geol. Survey of Illinois, vol. 1, Geology, p. 111, 1866.

The series underlies all of the Havana quadrangle and the adjacent area. In southwestern Illinois it has been divided into five formations - the Grassy Creek shale, the Saverton shale, the Louisiana limestone, the Hannibal formation, and the Chouteau limestone[29], but farther north

[29] Moore, R. C., Early Mississippian formations in Missouri: Missouri Bureau of Geol. and Mines, 2d ser., vol. 21, pp. 33-76, 1928.

the Louisiana and Chouteau limestones disappear and the Grassy Creek and Saverton shales become a single unit designated the Sweetland Creek shale. The Sweetland Creek and the Hannibal formations only are present in the Havana quadrangle.

Sweetland Creek formation

The Sweetland Creek formation is so named because its relations are well exhibited along Sweetland Creek, Muscatine County, Iowa.[30] It is present throughout the Havana quadrangle. It is characteristically a

[30] Udden, J. A., Geology of Muscatine County: Iowa Geol. Survey Ann. Rept. 1898, vol. 9, p. 291, 1899.

#__________, The Sweetland Creek beds: Jour. Geol., vol. 7, p. 67, 1899.

brownish gray to dark gray shale. In many layers it contains the tiny spores of a fern-like plant, known as Sporangites huronense, in such abundance that many of these undecomposed spore cases may be found in every cubic centimeter of the shale.

The average thickness of the Sweetland Creek formation in the Havana quadrangle and vicinity is about 120 feet. It ranges from 95 to 130 feet in 8 wells in which it is distinguished from the overlying Hannibal shale. The Sweetland Creek shale is ordinarily recognized in drill samples by its color, which is brownish, while the Hannibal shale is commonly greenish-gray. The two shales are not ordinarily distinguished in drillers' records.

The Sweetland Creek shale follows the line of an erosion surface of some irregularity. It is reported to overlap the Devonian limestone, Silurian limestone and even locally the Maquoketa shale in eastern Missouri and western Illinois [31]. The variation in thickness of the Silurian and

---

[31] Krey, F., Structural reconnaissance of the Mississippi Valley Area from Old Monroe, Missouri to Nauvoo, Illinois. Illinois State Geol. Survey Bull. 45, p. 34, 1924

Devonian limestones in the Havana region may be related to this unconformity.

The Sweetland Creek formation in the Havana quadrangle is directly correlated with the type Sweetland Creek formation in Iowa, on the basis of similar stratigraphic position and lithologic character. It has been also considered the equivalent of the Grassy Creek shale in northeastern Missouri; the Mountain Glen shale in Union County, Illinois; the Chattanooga shale in Kentucky and Tennessee; and the "Chattanooga" shale in southwestern Illinois, southern Missouri, and Arkansas. Formerly these deposits were considered to belong to the Chautauquan series of the upper Devonian. The marked unconformity between these shales and the upper Devonian limestone below and the absence of marked unconformity between them and the Hannibal gray shale above, combined with other evidence has led many geologists recently to consider them as early Mississippian [32].

---

[32] Moore, R. C., op. cit., including numerous citations to other authors.
Mylius, L. A., Oil and gas development and possibilities in east-central Illinois: Illinois State Geol. Survey Bull. 55, pp. 53-57, 59-65, 1927.

Swartz, Joel H., The age of the Chattanooga shale of Tennessee: Am. Jour. Sci., 5th ser., vol. 7, pp. 24-30, January, 1924.

__________, The age of the Big Stone Gap shale of southwestern Virginia: Am. Jour. Sci., 5th ser., vol. 12, pp. 512-531, December, 1926.

__________, Chattanooga shale in eastern Tennessee and Virginia (abstract) Bull. Geol. Soc. America, vol. 39, No. 1, p. 201, March, 1928.

__________, Devonian-Mississippian boundary in Virginia and Tennessee (abstract): Bull. Geol. Soc. America, vol. 40, no. 1, p. 93 , 1929.

Hannibal formation

The name Hannibal was applied to this formation because typical outcrops of it occur near Hannibal, Missouri.[33] The formation underlies all parts of the Havana quadrangle and adjacent areas.

---

[33] Keyes, C. R., The principal Mississippian section: Bull. Geol. Soc. America, vol. 3, pp. 283-300, 1892.

In its type locality the Hannibal formation consists of sandstone ("Vermicular") and shale, and elsewhere in Iowa, Missouri and Illinois it includes a magnesian limestone member[34], but as reported in ~~####~~ drill records

---

[34] Moore, R. C., Op. cit., pp. 20-24, 33, 50-60.

---

in and near the Havana quadrangle it is a light, blue, or greenish-gray soft shale without hard layers. It may be most easily distinguished from the underlying Sweetland Creek formation by its difference in color, and by the presence of the fossil <u>Sporangites huronense</u> in the latter.

The Hannibal formation ranges in thickness from 95 to 160 feet in those wells in which it is distinguished from the Sweetland Creek formation. The combined thickness of these shales in all wells in and near the Havana quadrangles ranges from 223 to 255 feet in all except one well in which it ~~appears to~~ may be only 150 feet. (Appendix C, Part I no. 20).

The Hannibal formation apparently overlies the Sweetland Creek formation conformably, but is separated from the overlying Burlington limestone by a disconformity.

The Hannibal shale in the Havana quadrangle is correlated with the typical Hannibal shale on the basis of its stratigraphic position between the dark Sweetland Creek shale ~~##~~ and the massive crinoidal Burlington limestone.

Osage series

 59

The name Osage was proposed to designate one of three major paleontological subdivisions of the Mississippian system [35], and presumably

[35] Williams, H. S., Correlation papers - Devonian and Carboniferous: U. S. Geol. Survey Bull. 80, p. 169, 1891.

refers to Osage River in southwestern Missouri, which cuts through the series. The series includes four formations - Fern Glen, Burlington, Keokuk, and Warsaw. The typical Fern Glen formation has not been recognized in the Havana quadrangle, although it may be present.

Burlington formation

The Burlington formation is named because of excellent exposures at Burlington, Iowa. [36] It underlies all of western Illinois south of

[36] Hall, James, Observations upon the Carboniferous limestones of the Mississippi Valley: Am. Jour. Sci., 2d ser., vol. 23, p. 190, 1857.

Mercer County, ##### including the Havana quadrangle and vicinity.

The Burlington formation is a gray, coarsely crystalline, cherty, fossiliferous ######### limestone. Fragments of crinoids constitute such a large proportion of the calcareous material composing the limestone, that it has been long recognized as the "Crinoidal" or "Encrinital" limestone. It contains much chert in concretions and discontinuous bands. The ### characteristics of this limestone in the drillings which have penetrated it are given in Appendix C, Part I. The overlying formation, the Keokuk, is also a cherty limestone, and it cannot be distinguished from the Burlington in the available drill records. The combined thickness of these formations ranges from 187 to 240 feet in and near the Havana quadrangle. The thickness ~~appears to be~~ is greater southwest of the quadrangle than to the northeast. The lower 100 to 140 feet of limestone probably belong to #####the Burlington formation.

The Burlington limestone ~~appears to~~ overlies the Hannibal shale conformably, and its contact with the Keokuk is also conformable.

The formation is correlated with the typical Burlington limestone on the basis of its identical stratigraphic position and lithologic character.

Keokuk formation

The name Keokuk was originally applied to cherty limestone at the base, the "encrinal" limestone or "Lower Archimedes Limestone" and the overlying geode-bearing shales which are well exposed at Keokuk, Iowa.[37]

---

[37] Hall, James. Geology of Iowa, vol. I, part I, p. 94, 1858.

Subsequently the geode-bearing shales ~~have been~~ were referred to the overlying Warsaw formation. The Keokuk formation underlies all parts of the Havana quadrangle and most of the adjacent area, although northeast of the quadrangle the upper part of it may have been removed by post-Mississippian, pre-Pennsylvanian erosion (Appendix C, nos. 1 and 2). The thickness of this formation at its typical exposure is about 70 feet, and ## this is approximately the thickness in the Havana quadrangle and vicinity. It cannot be readily distinguished from the underlying Burlington formation in drill records. The combined thicknesses of the Burlington and Keokuk limestones are given above.

The Keokuk limestone rests conformably on the underlying Burlington and is overlain conformably by the Warsaw. The Keokuk limestone in the Havana quadrangle is correlated with the typical Keokuk formation on the basis of similarity in stratigraphic position.

Warsaw formation

The Warsaw formation was originally defined[38] as consisting of ap-

---

[38] Hall, James, Op cit., p. 97.

proximately forty feet of interbedded shale and limestone, typically developed near the town of Warsaw, Hancock##### county, western Illinois. Subsequently the underlying Geode# bed has been transferred to this formation from the Keokuk formation.[39] The Warsaw formation was originally

[39] Van Tuyl, F. M., The Stratigraphy of the Mississippian formations of Iowa: Iowa Geol. Survey, vol. 30, p. 185, ### 1922.

considered the basal formation of the Meramec series, but more recently it has been commonly referred to the Qsage Series[40]. The Warsaw

[40] Mylius, L. A., Oil and Gas development and possibilities in east-central Illinois. Illinois State Geol. Survey Bull. 54, p. 66, 1927.
Moore, R. C., Early Mississippian formations in Missouri: Missouri Bureau of Geol. and Mines, 2d ser., vol. 21, pp. 33-76, 1928.

formation underlies all of the Havana quadrangle, but thins and disappears north and northeast of the quadrangle, as a result of post-Mississippian, pre-Pennsylvanian erosion. It consists ## predominantly of ##### blue gray, calcareous shale, interbedded with relatively thin beds of limestone and calcareous sandstone. It is impossible to distinguish the Warsaw formation from the overlying Spergen formation in drill records. The combined thickness of the two formations in the Havana quadrangle and vicinity ranges from 16 to 115 feet. Where the thickness is less than 60 feet the upper part was removed by erosion before the deposition of the overlying Pennsylvanian strata. Detailed sections of the Warsaw and Spergen formations in drill records are given in Appendix C, Part I nos. 3, 6, 7, 11, 12, 13,16, 17, 19, and 21.

The Warsaw formation is reported to rest conformably on the Keokuk formation at its typical locality. In some parts of Iowa the Spergen and Warsaw formations are separated by an# unconformity.

The Warsaw formation in the Havana area, is correlated with the typical Warsaw formation because of its similar lithologic character and stratigraphic position.

6.2

Meramec series

The Meramec series was named to include the Warsaw, Spergen ~~####~~ and St. Louis formations which outcrop along the Meramec River in Missouri.[41]

41/ Ulrich, E. O., Zinc and Lead Deposits of Northern Arkansas: U. S. Geol. Survey, Prof. Paper 24, table opp. p. #90, 1904.

In the reports of the Illinois State Geological Survey the Warsaw formation is considered the upper formation of the Osage series, and the Ste. Genevieve formation has been transferred to the Meramec series from the Chester series of the upper Mississippian subsystem. The names Spergen Hill and Salem have been used by some authors for the beds designated the Spergen.[42]

42/ Cumings, E. R. The use of Bedford as a formational name. Jour. Geol. vol. 9, pp. 232-233, 1901.

The Spergen and St. Louis formations ~~###~~ underlie nearly all of the Havana quadrangle and most of the adjacent area south and west of the quadrangle, but they are absent north and east of the quadrangle. The Ste. Genevieve formation is not present in this area unless some of the upper limestone and white shale layers reported in an oil test boring in sec. 31, T. 22 N., R. 8 W. (Havana) (Appendix C, Pt I no. 19) which are assigned to the Pottsville formation may be of Ste. Genevieve age.

Spergen formation

The name Spergen is applied to highly fossiliferous limestones at Spergen Hill, Indiana.[43] In western Illinois and eastern Iowa the Spergen

---

43/ Ulrich, E. O. Op. cit.

---

formation consists of crinoidal limestone, dolomitic limestone, shale and fine grained bluish sandstone. The strata grade from one type to another laterally as well as vertically, suggesting deposition near the old shore line. The Spergen formation cannot be separated from the underlying

Warsaw formation in the records of drillings. The thickness of the formation where it is exposed in western Illinois and eastern Iowa ranges from 5 to about 35 feet. The thickness in the Havana area is probably similar.

The Spergen formation is separated from the overlying and underlying formations in eastern Iowa by disconformities.

St. Louis formation.

The St. Louis formation is named from the city of St. Louis, Missouri, where it is typically exposed.[44] It underlies nearly all of the Havana

44. Swallow, G. C. Geological ~~of Missouri~~ survey of Missouri. First and second Ann. Repts. pp. 93-95, 1855.

quadrangle, but it is absent from most of western Illinois north of the Havana quadrangle, as it was eroded before the deposition of the earliest Pennsylvanian strata from this area. At Glasford, northeast of the Havana quadrangle the Pennsylvanian strata rest on the Burlington or Keokuk formation; at Canton, north of the quadrangle, they rest on the Warsaw formation; and in the northern part of the Havana quadrangle on the St. Louis.

The St. Louis formation is, for the most part, a very fine grained, dense, white to light gray limestone, with few fossils, containing a little chert. In many places it possesses a brecciated structure. It is exposed along Spoon River near Bernadotte and near Seville in the Vermont quadrangle, a few miles west of the Havana, and along tributaries to ~~the~~ Illinois River in the Beardstown quadrangle southwest of this quadrangle. It is not exposed at any place in the Havana quadrangle, but it may be covered only by alluvial deposits at some places in the valleys of Spoon River or Illinois River.

The thickness of the St. Louis formation in and near the Havana quadrangle ranges from 85 feet to 25 feet. The variation in thickness is probably due ~~only~~ to the thickness of the limestone which escaped erosion before the deposition of the basal Pennsylvanian strata.

In southeastern Iowa, where the St. Louis limestone is well exposed, a disconformity is reported at ~~the~~ its base ~~of the St. Louis limestone~~. The St. Louis limiestone is the ~~#######~~ youngest Mississippian formation in this area, and it is overlain unconformably in all parts of the area by the Pottsville series of the Pennsylvanian system.

The St. Louis limestone in the Havana quadrangle is correlated with the limestone exposed in other parts of western Illinois, because it is similar in lithologic character and stratigraphic position. The nearby exposures of the St. Louis limestone are correlated with the type exposures by the presence of a fossil coral Lithostrotion canadense, which is limited to this formation.

Pennsylvanian system.

Introduction

The term Pennsylvanian was proposed as a synonym for the terms "Upper Carboniferous" and "Coal Measures", 45/ because excellent exposures of the coal-bearing rocks were first thoroughly studied in the State of

45/ Williams, H. S., The geology of Washington County: Arkansas Geol. Survey Ann. Rept. for 1888, vol. 4, p. xiii, 1891.

Pennsylvania. Like the term Mississippian, it has been recognized only as a series term by the U. S. Geological Survey and it has not been generally adopted in Europe.

Rocks of the Pennsylvanian system underlie all except the north part, west border, and south end of Illinois and occupy what is familiarly known as the "Illinois Coal Basin" (fig. 1). They underlie all of the Havana quadrangle, unless they have been entirely removed from some parts of ~~the~~ Illinois or Spoon River valleys. No ~~############~~ strata older than the Pennsylvanian are exposed ~~in the Havana quadrangle~~ here.

The rocks of the Pennsylvanian system in the Havana quadrangle consist of shales, sandstones, underclays, coal beds, limestones and conglomerates, in the order of abundance ~~nated~~ noted.

Thickness

The maximum composite thickness of Pennsylvanian strata in the Havana quadrangle is about 330 feet, according to available information. This is a composite of strata above the Springfield (No. 5) coal exposed in secs. 25 and ~~27~~ 36, T. 6 N., R. 4 E. (Buckheart); and strata from the Springfield (No. 5) coal to the base of the Pennsylvanian from a coal test boring at the center of sec. 22, T. 6 N., R. 3 E. (Putman). The aggregate thickness of the members in the generalized section below is about 400 feet. This greater thickness is the result of the inclusion in the generalized section of certain sandstones which attain considerable thickness only ~~in those places~~ where they truncate other strata which are also placed in the generalized section.

Stratigraphic relations

The basal Pennsylvanian strata rest unconformably on the strata of the Meramec series of the Mississippian system. A short distance north and northeast of the quadrangle, the Pennsylvanian strata overlap the Warsaw, Keokuk and Burlington formations of the Osage series, but in the quadrangle itself, they probably rest on the Spergen or St. Louis formations in all places (See figures 124, 125 and 126). The surface upon which the Pennsylvanian strata were deposited ~~appears to have~~ possessed a relief of 80 to 100 feet, and the oldest sediments are found in basins or low places on this surface.# Figures 118 and 134 show the general distribution of relief of this surface in the quadrangle and in the surrounding territory. The early Pennsylvanian strata of the Pottsville series are thicker in the southern part of the Canton quadrangle, north of Cuba, than in the Havana quadrangle, indicating that this was a lowland area at the beginning of Pennsylvanian sedimentation. This lowland probably corresponds to the area in which the Pennsylvanian rests on the weak Warsaw shale.

There are several unconformities within the Pennsylvanian system in this area, which are discussed in connection with the strata involved.

The Pennsylvanian strata are separated from the overlying Pleistocene and ###### recent sediments by a great erosional unconformity in all parts of the area.

Subdivisions

The Pennsylvanian strata of Illinois are divided into three series, (considered formations in most previous reports of the survey), named respectively, beginning with the oldest, the Pottsville, Carbondale and McLeansboro. These three series are considered the approximate equivalents of the Pottsville, Allegheny and Conemaugh formations of Pennsylvania. The boundary between the Pottsville and Carbondale ##### series is placed at the base of the Murphysboro (No. 2) coal, of which the probable equivalent in western Illinois is the Colchester coal. The boundary between the Carbondale and McLeansboro series ~~is~~ placed at the top of ~~the~~ the Herrin coal of southern Illinois, which is equivalent to the No. 6 coal of western Illinois. Both the Colchester coal and the No. 6 coal are exposed in the Havana quadrangle, as well as strata respectively below and above these coals. On this basis the Pennsylvanian rocks in the quadrangle have been divided into the three series. ~~These three ser~~

A further subdivision is made as the result of studies by the author and other workers in western Illinois and elsewhere in the state. These studies revealed that a more or less consistent suite of sequence of beds is successively repeated within the Pennsylvanian system and that each suite is demarcated by unconformities both below and above it.# These suites appear to be natural divisions of the Pennsylvanian strata and supplement the present three-fold classification.

The succession of strata which seems to constitute the normal complete suite or sequence consists of (1) basal sandstone, (2) sandy shale, (3) fresh water limestone in several suites, but not in all, (4) underclay,

(5) coal or carbonaceous strata, (6) laminated carbonaceous shale, often containing calcareous or pyritic concretions, (7) limestone, or an alternation of thin limestones and fossiliferous laminated calcareous shales, and (8) laminated shale#, usually gray, and often containing ######### scattered calcareous or ferruginous concretions. The ############ sequences recur more regularly and the members are somewhat thicker in the Carbondale series than in the Pottsville.

Members (1)to (5) appear to have been deposited under# terrestrial or fresh water conditions, and members (6) to (8) usually contain evidence of their marine origin. Thus each recurrent sequence marks an advance and a retreat of the shallow sea across the area. Member (1), the basal sandstone, is ~~known to~~ separated from the shales or other strata of the underlying suite or sequence by erosional unconformity in many places. The suite or sequence ## thus # represents fairly continuous sedimentation, separated from adjacent suites by diastrophic activity. When these persistent suites were recognized during the course of the Havana field work there was little information available regarding the areal extent of these units. During the field season of 1929 the writer had the opportunity to study exposures of Pennsylvanian strata in most of western Illinois north of Beardstown and southwest of# a line connecting Peoria, Galesburg and Rock Island. This study revealed the wide areal extension of many of the ###### suites which had been recognized in the Havana quadrangle. Members which #are missing from their proper place in the suite in the Havana quadrangle appear in other localities where the suites ### are exposed. The# suites, then, seem to constitute geological formations as this term is commonly used, and they are here designated formations. In the areas so far studied in western Illinois there appear to be 15 suites or formations in the Pennsylvanian system. Of these 15 suites the lower 12 are believed to be exposed in the Havana quadrangle.

68

The changing physical conditions which led to the recurrent cycles of sedimentation in the Pennsylvanian are considered on p. 15-18, ~~in the~~ chapter V ~~dealing with the geological history of the quadrangle, and~~ they have been recently summarized.46/

46/ Weller, J. M., Cyclical sedimentation in the Pennsylvanian Jour. Geol., vol. ## 38, pp. , 1930.

The correlation of the lower part of the Pottsville strata exposed in the southern part of the Havana quadrangle with equivalent strata penetrated in numerous coal test borings in the vicinity of Cuba and St. David and in the southern portion of the Canton quadrangle (appendix C, Pt III) is not entirely certain. ## The most easily recognized succession in many of the drill records is a thick coal with a limestone cap rock which is correlated with the Rock Island (No. 1) coal of western Illinois. No similar succession is exposed in the southern part of the quadrangle, due either ### to the fact (1) that ####### these beds are unexposed below the principal drainage lines, or (2) that equivalent strata are exposed, but are not easily recognized because of difference in lithologic character and stratigraphic succession. The former explanation seemed correct ########### until exposures in adjacent areas were studied during 1929, when the differences were found to result from lateral variations in the character of the strata and to unconformities.

The general# section of Pennsylvanian strata exposed in the Havana quadrangle, AND the correlation of these strata ~~is~~ are presented in the following section:

Generalized section ~~Complete classification~~ of Pennsylvanian strata in Havana quadrangle

Member No.		Thickness Feet	Inches
#	McLeansboro series		
	Brereton formation		
79.	Limestone, gray, subcrystalline, #### with 1½ inch clay parting 4 inches from the base, fossiliferous, with Fusulinella girtyi (Girtyina ventricosa) (Brereton limestone)	# 1	10
78.	Shale, carbonaceous, black to dark blue-gray, light gray in upper 2 inches	2	4
	Carbondale series		
77.	Coal, with partings as follows: Light shale band 2 inches thick, 1 foot 8 inches from top of coal, one half inch dark shale, 2 feet 3 inches from top of coal, one inch light gray shale 2 feet 10 inches from top of coal; and large black concretions, 3 feet 6 inches wide and 8 inches thick near top of coal (Herrin or No. 6# coal)	4	11
76.	Shale, carbonaceous, hard, distinctly laminated		3
75.	Clay, gray in upper portion, rusty in lower portion, blocky fracture; containing at some localities irregular shaped slightly ~~slightly~~ septarian limestone concretions, which grade laterally into a non-marine limestone bed	6	
74.	Shale, gray, soft, well laminated, very local in distribution	10	
73.	Limestone, pinkish gray, weathering brown, fossiliferous, local in distribution		5
72.	Sandstone, gray to buff, fine grained, thin to thick bedded, with millstone shaped concretions in upper portion, locally absent or grading into sandy shale (Cuba sandstone)	# 20	
	St. David formation		
71.	Shale, sandy, buff, micaceous, locally absent	5	
70.	Shale, gray, even bedded, with some ironstone concretions	20	
69.	Limestone, blue gray, commonly forming a discontinuous band of concretions, locally a persistent band, slightly fossiliferous		7
68.	Shale, gray, even bedded, with some calcareous or "ironstone" concretions (members 68-71 constitute Canton shale)	7	6
67.	Clay or shale, calcareous, consisting principally of flattened and broken fossils, such as crinoid stems, brachiopods, etc.	1	3
66.	Limestone, gray, massive, in one bed fossiliferous, weathering buff (St. David limestone)	1	5
65.	Shale, black, or black and gray mottled, soft		11
64.	Shale, carbonaceous, black, hard, finely laminated, fossiliferous, locally containing large calcareous and pyritic fossiliferous concretions	1	10
63.	Coal, without bedded shale partings; in many places cut by clay veins and "horsebacks" (Springfield or No. 5 coal)	4	10

Carbondale series (cont.)
St. David formation (cont.)

No.	Description	Ft.	In.
62.	Underclay, light gray, blocky fracture; contains numerous large calcareous concretions, locally septarian, about 1 foot 6 inches from top of underclay; concretions grade into continuous bed of fresh water limestone	4	6
	Summum formation		
61.	Shale, gray to dark gray, distinctly bedded	1	8
60.	Shale, black, #### soft, thin bedded	1	
59.	Shale, dark gray, thin bedded; contains large round## or oval shaped dark gray limestone concretions, which are slightly fossiliferous; laminae of shale bend around concretions	1	
58.	Coal or coaly shale, commonly 2-4 inches, locally much thicker, with numerous clay partings (Kerton Creek) ~~or~~	2	
57.	Sandstone, white, hard, in one bed, very local in distribution; either replaces or immediately underlies coal		5
56.	Underclay, white to light gray, blocky fracture; contains large calcareous concretions, which are somewhat septarian, and unfossiliferous	3	
55.	Limestone, silty or sandy, blue gray, unevenly bedded, with irregular upper surface, ###unfossiliferous	3	
54.	Shale, slightly sandy, gray# to buff, medium bedded, not persistent	5	
53.	Sandstone or sandy shale, buff to gray, fine grained, basal portion (about 1 foot) contains pebbles to 4 inches diameter; thin bedded in upper portion and more massive beds below; strongly cross-bedded in some places; lower portion contains Cordaites and other plant impressions; carbonaceous ### streaks and partings abundant, locally forming thin lenticular coaly streaks; large calcareous concretions in upper portion; lower portion locally ## replaces 50-80 feet of underlying beds in channel areas; thickness varies from about 3 feet to 80-100 feet (Pleasantview or Vergennes sandstone)	50	
	"Liverpool" formation		
52.	Shale, gray, soft, evenly laminated, with polygonal jointing in upper portion and rectangular jointing in lower 5-10 feet; upper beds sandy in some exposures; contains several bands of calcareous and "ironstone" concretions, especially in lower 10 feet; absent in southern part of quadrangle (Purington shale)	50	
51.	Clay, gray, calcareous, containing flattened impressions of pelecypods and gastropods		1½
50.	Limestone, gray, ######## in one bed; fossiliferous, the fossils outlined in whitish casts		4
49.	Shale, gray, soft, with three persistent layers of calcareous and ironstone concretions, which are slightly fossiliferous	2	7
48.	Limestone, dark blue gray, abundantly fossiliferous, weathering brown		4
47.	Shale, black, soft, thinly laminated, fossiliferous, <u>Aviculopecten rectilaterarius</u> especially abundant; weathers reddish brown; locally contains discontinuous band of dark gray limestone concretions, fossiliferous. ~~wt~~ containing mainly Pelecypod shells	~~1~~ 1	~~3~~ 3

	Carbondale series (cont.)		
	"Liverpool" formation (cont.)		
46.	Shale, calcareous, dark gray, harder than above, with band of nearly white shells of *Chonetes mesolobus* and one or two other species		1
45.	Shale, dark gray to black, slightly gritty, somewhat fossiliferous, with *Marginifera muricata*, etc.	1	9
44.	Limestone, argillaceous, or clay, ######## calcareous, consisting largely of partly crushed shells of gastropods, pelecypods and crinoid stems		4
43.	Cone in cone layer, not continuous		4
42.	Limestone, light gray; locally a series of septarian concretions instead of a solid limestone bed; fossiliferous, weathering yellow or buff	1	
41.	Shale, gray, slightly fossiliferous		5
40.	Limestone or limestone conglomerate, gray; locally sub-crystalline; contains small black rounded limestone pebbles and crinoid stems; in western portion of quadrangle black platy limestone with pelecypod fauna occurs at this horizon; and near eastern margin of quadrangle massive brownish gray limestone with brachiopod and bryozoan fauna occurs at or near this horizon, thickness varies from 3 inches to	2	6
39.	Shale, gray, calcareous, with discontinuous thin limestone concretion bands (beds 39-51 constitute Oak Grove marine member)	# 1	
38.	Shale, carbonaceous, black, hard; thinly laminated; very slightly fossiliferous; upper 4 inches contains small calcareous concretions giving a "pimply" appearance to the shale; contains a band of black platy limestone concretions near middle, which are very slightly fossiliferous; present only in northeastern part of quadrangle	3	
37.	Shale, slightly silty or sandy in upper 5 feet, gray, evenly bedded; some thick beds show a regular spheroidal weathering; contains some fossil plants in lower 1-2 feet (Francis Creek shale)	35	
36.	Coal, without bedded clay impurities, widely persistent (Colchester or No. 2 coal)	2	6
	Pottsville series		
35.	Underclay, light gray, with irregular fracture; contains some large calcareous concretions; somewhat septarian	2	
34.	Sandstone, gray to buff, mottled with brown iron stains; thin to massive beds, locally cross bedded (Isabel sandstone)	6	
	Greenbush formation		
33.	Shale, gray, soft, evenly bedded	5	
32.	Limestone, gray, sublithographic, very slightly fossiliferous; in some places irregularly bedded or concretionary; weathers reddish to buff	1	
31.	####Underclay, gray, with blocky fracture; locally contains trace of coaly clay at top and large limestone concretions in lower portion	1	6
	Wiley formation		
30.	Shale, black, soft, finely laminated, not persistent		2
29.	Coal, with partings of bony coal		10
28.	Underclay, light gray, blocky fracture; contains large limestone concretions, somewhat septarian	3	

	Bottsville series (cont.)		
	Seahorne formation		
27.	Limestone, blue gray; massive bed, with very uneven or "knobby" upper and lower surfaces; brecciated structure; fossiliferous, with numerous gastropods, especially Naticopsis altonensis and Trachydomia sp. (Seahorne or Aylesworth limestone) (absent in northern part of quadrangle)	3	
26.	Clay or shale, gray, indistinctly bedded, not persistent	1	
25.	Shale, coaly, locally a thin band of coal		2
24.	Underclay, light gray; blocky fracture; contains large septarian calcareous concretions, which locally form a persistent limestone layer	3	6
23.	Sandstone, locally shaly, light gray, fine grained, sugary texture, due to recrystallization of grains; thin bedded	2	
	Brush Creek formation		
22.	Clay or shale, with uneven fracture, not distinctly bedded	3	
21.	Shale, gray, evenly bedded	2	
20.	Underclay, dark blue gray to light gray, blocky fracture, locally containing one or more thin coaly layers	5	3
	Bernadotte formation		
19.	Shale, gray, evenly bedded	5	
18.	Limestone concretion band		2
17.	Shale, dark gray		4
16.	Coal, locally present	1	
15.	Underclay, gray, with blocky fracture	2	6
14.	Sandstone, buff to gray, very hard, massive bedded, especially in upper portion, quartzitic texture; locally thin or absent, reaching maximum thickness of 9 feet (Bernadotte sandstone)	9	
	Seville formation (see additional members reported in drill records)		
13.	Coal (Rock Island or No. 1), thicker in some drill records	1	6
12.	Underclay, dark blue to light gray, blocky fracture	3	6
11.	Clay, blackish, may be a coaly streak		2
10.	Underclay, light gray, blocky fracture	2	3
9.	Sandstone, somewhat concretionary in upper portion, quartzitic in texture, not persistent	1	2
	Pope Creek formation		
8.	Shale, dark gray, carbonaceous		3
7.	Coal	1	3
6.	Underclay, gray, with blocky fracture	1	6
	Babylon formation		
5.	Shale, gray, with two 2 inch ironstone concretion bands	5	10
4.	Limestone concretions, septarian, large, locally distributed	2	
3.	Shale, ##### slightly sandy, gray, evenly bedded	2	6
2.	Shale, black, hard, finely laminated		5
1.	Shale, sandy to micaceous, blue gray, soft, papery bedding, with large concretions	10	

The development of the three lowest formations in the vicinity of Cuba, as reported in drill records in that vicinity, is quite different from that in the southern part of the quadrangle. The following table presents a tentative correlation of the earlier Pottsville strata in the vicinity of Cuba:

Geological section 1

	Thickness Feet	In.
Pottsville series		
Seville formation		
Limestone, blue gray, hard, variable in thickness and locally distributed, maximum 31 feet (Parks Creek limestone of Savage)	16	
Shale, black, hard, finely laminated, variable in thickness, locally distributed	6	
Coal, with some clay partings; variable in thickness	4	8
Shale, bituminous, black		2
Underclay, light gray	2	
Sandstone, white, hard	2	
Coal		3
Sandstone, hard	1	3
Pope Creek formation		
Clay, "fire clay"	2	6
Shale, dark	6	6
Coal		8
Underclay	4	
Shale, dark	2	5
Underclay	1	8
Shale, dark	2	9
Sandstone, hard		10
Babylon formation		
Shale, dark	6	4
Shale, gray	4	
Clay, "fire clay"	3	
Shale, light	1	8
Shale, sandy, light	2	7
Shale, dark gray	10	

The ~~##~~ lower part of the general section above may represent more than the two formations named if the strata have been described correctly by the drillers.

Figure 16 shows a graphic representation of the strata ~~###########~~ described in the foregoing generalized sections.

Description of outcrops and drill records

Pottsville series

The name Pottsville was first applied to the basal conglomeratic series of the Pennsylvanian strata.[47] The name presumably was derived

[47] Platt, W. G., and Platt, F., Report on progress~~##~~ in the Cambria and Somerset district of the bituminous coal fields of Western Pennsylvania: Part I, Cambria: Second Geol. Survey of Pennsylvania, Report of Progress H H, p. ~~104~~ XXVI, 1877.

from the town of Pottsville, Pennsylvania. In Illinois it has been used as a formation name for the lower part of the Pennsylvanian system, which consists principally of sandstones, shales, conglomerate and underclays, and in which coal beds are few and of minor commercial value. With the recognition ~~of the recognition~~ of the recurrent sequences ~~############~~ within the Pennsylvanian as formations, the Pottsville is classed as a series.

Pottsville strata underlie~~s~~ all parts of the Havana quadrangle unless they have been removed by post-Pennsylvanian, pre-Pleistocene erosion from some parts of ~~the~~ Illinois and Spoon River valleys. They are well exposed in the southern part of the quadrangle along tributaries of Spoon River, Otter Creek and Seahorne Branch, and in the northern part of the quadrangle along the lower portions of Big Creek, Big Sister Creek, and other smaller tributaries of Illinois and Spoon Rivers. They are penetrated by ~~#######~~ about ~~54~~ 56 coal test borings in the northern part of the Havana quadrangle and the adjacent southernmost portion of the Canton quadrangle, (Appendix C - Pt III) where they are buried beneath younger Pennsylvanian strata.

The Pottsville series is divided into 8 formations and part of a ninth in this report (See general section of the Pennsylvanian, p.)

Babylon formation

The Babylon formation is so designated from an exposure in the west bank of Spoon River one half mile north of Babylon, Fulton County, Ill. (NE. ¼ sec. 14, T. 7 N., R. 1 E. (Lee twp.). At the typical exposure it consists of sandstone, underclay, coal (including some canneloid coal), dark shale, limestone concretions and gray shale.

The Babylon formation is believed to outcrop in the Havana quadrangle only in the south bank of Spoon River at the village of Duncan Mills. The strata exposed represent only the upper part of the formation, if ~~it is~~ correctly correlated with the typical exposure. A limestone bed was reported ~~to have been struck~~ at the base of the pier at the south side of the Spoon River bridge of State Highway 31, at Duncan Mills. If ~~This~~ is ~~probably~~ the St. Louis limestone of Mississippian age, ### ~~and if~~ so, the lower portion of the Babylon formation must be only a few feet below water level ~~at this place~~. The following section was measured at this place:

<u>Geologic section 2.- Outcrops along the south bank of Spoon River at Duncan Mills, near center of sec. 8, T. 4 N., R. 3 E. (Isabel twp.)</u>

	Thickness Feet	Thickness Inches
Pleistocene system		
15. Terrace deposit	(not measured)	
Pennsylvanian system		
Pottsville series		
Seville formation		
14. Sandstone, buff to gray, hard, massively bedded	3	
Pope Creek formation		
13. Coal	1	4
12. Underclay, light gray, with blocky fracture	2	
11. Covered	2	
Babylon formation		
10. Shale, gray, soft	3	
9. Ironstone concretion band		2
8. Shale, gray, soft	1	6
7. Ironstone concretion band		2
6. Shale, slightly sandy, gray		10
5. Ironstone concretion band		2
4. Limestone concretions, gray, large, with septarian structure, irregularly distributed	2	
3. Shale, gray, micaceous, slightly gritty, thinly bedded	2	6
2. Shale, black, hard, finely laminated		5
1. Shale, blue gray, soft, papery, to base of exposure	12	

Coal in the Babylon formation is not exposed in the Havana quadrangle, but thin coal beds reported in test borings in the northern part of the quadrangle may belong to this formation. The following partial logs reveal the# general character of the Babylon and overlying formations

76

in the northern portion of the quadrangle:

Geologic section 3. Partial log of coal test boring at the middle of the west line of sec. 21, T. 6 N., R. 3 E. #

(Putman ~~t#w####p~~.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Pottsville series		
Seville formation (?)		
21. Coal (Rock Island or No. 1?)	4	
20. Shale, "fissile"		3
19. Underclay	1	9
18. Shale, soft		4
17. Shale, sandy	2	6
16. Limestone (possibly concretion)		4
15. Sandstone	3	3
Pope Creek formation (?)		
14. Shale, gritty	1	
13. Shale, "fissile"	2	
12. Limestone		2
11. Shale, "fissile"		3
10. Fire clay (?)	2	
9. Shale, dark gray	3	6
8. Limestone		2
7. Shale, dark gray, "fissile", with streaks of mudstone	9	4
6. Underclay	3	
5. Sandstone and shale	3	
Babylon formation (?)		
4. Shale, black, "fissile"	7	
3. Coal	2	2
2. Shale, black, "fissile"	1	
1. Sandstone, with chips of hard shale	2	10

The base of the Pennsylvanian probably lies less than 20 feet below the base of the a bove drilling.

Geological section 4. Partial log of coal test boring in the NW. ¼ NW. ¼ sec. 2, T. 5 N., R. 3 E.(Lewistown twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Pottsville series		
Seville formation (?)		
20. Coal (probably equivalent to Rock Island or No. 1 coal)		8
19. Underclay, sandy	4	2
18. Shale, gray, sandy	11	8
Pope Creek formation (?)		
17. Limestone, hard		5
16. Shale, gray, sandy	7	5

		Feet	Inches
		#	
15.	Coal		10
14.	Shale, gray		2
13.	Underclay, sandy	1	10
Babylon formation (?)			
12.	Shale, dark, soft	7	2
11.	~~######~~ Coal		7
10.	Shale, light gray	6	9
9.	Shale, sandy, light	3	5
8.	Sandstone, light		9
7.	Limestone, blue, hard	1	
6.	Sandstone, gray, soft	2	
5.	Shale, gray, "~~fissile~~" hard	5#	11
4.	Limestone, blue, hard		9
3.	Shale, gray, "~~fissile~~" hard	11	2
2.	Shale, light gray	1	3
1.	Fire clay, sandy		4

The strata above included in the Babylon formation may represent more than one cycle of sedimentation. If so, they should constitute two formations instead of one, but such division does not appear advisable at present.

Geological section 5. Partial log of coal test boring in the SE. 1/4 SW. 1/4 sec. 8, T. 5 N., R. 3 E. (Lewistown twp.)

		Thickness Feet	Thickness Inches
Pennsylvanian system			
Pottsville series			
Seville formation (?)			
13.	Coal (Probably horizon of Rock Island (No. 1) coal	1	1
12.	Shale, dark		8
11.	Underclay	1	2
10.	Sandstone, light	21	6
Pope Creek or Seville formation (?)			
9.	Sandstone, light, with streaks of coal	2	6
8.	Underclay	2	8
Babylon formation (?)			
7.	Shale, mixed	2	7
6.	Shale, gray	11	9
5.	Shale, light	1	2
4.	Sandstone, light	7	6
Mississippian system			
Meramec series			
St. Louis formation			
3.	Limestone, very hard	5	1
2.	Shale, calcareous		5
1.	Limestone, very hard	61	7

In the foregoing section the thick sandstone (No. 10) referred to the Seville formation may truncate all of the normal strata of the Pope Creek formation, or a trace of the coal and underclay (8 and 9) may not have been eroded.

Geological sections 2, 3, 4 and 5 show marked lateral variation in the character of the Babylon formation. These variations may be due to:

(1) features of relief on the erosional surface upon which the first Pennsylvanian sediments were deposited;

(2) variations in the amount and character of clastic material supplied to various parts of the area; or

(3) the erosion of a part or all of the Babylon formation before the deposition of the overlying Pope Creek formation.

The Babylon formation is unconformable upon the Mississippian formations below, and it ~~appears that it~~ may rest upon some older Pennsylvanian strata which have not ~~yet~~ been designated as one or more formations, especially in the northern part of the Havana quadrangle, and the southern part of the Canton quadrangle, where the pre-Pennsylvanian surface consisted of the weaker Warsaw or Spergen formations. The Babylon formation is also separated from the overlying Pope Creek formation by an unconformity in some places, but the break is apparently one of very minor importance.

The Babylon formation is correlated with the lower part of the Spoon River sandstone and shale[48] which also includes the Pope Creek formation and the lower part of the Seville formation.

Marine fossils were not found in the shales of this formation exposed in

---

[48] Savage, T. E., Significant breaks and overlaps in the Pennsylvanian rocks of Illinois: Am. Jour. Sci., vol. 14, 1927, fig. 2, p. 309.

____________ Geology and Mineral Resources of the Vermont quadrangle: Illinois State Geol. Survey, Unpublished manuscript.

---

the Havana quadrangle, and the few marine fossils collected from it at its type locality ~~and elsewhere~~ do not permit its correlation with Pennsylvanian strata elsewhere than in western Illinois.

 77

Pope Creek formation

The Pope Creek formation is so named from an exposure in the south bank of Pope Creek near the middle of section 33, T. 14 N., R. 2 W. Greene# township, Mercer County, Illinois.[49] At the typical exposure

---

[49] Wanless, H. R., Geology and Mineral resources of the ~~######~~ Alexis quadrangle Illinois State Geol. Survey, Bull. 57, Geological section 4, beds 3-10. P.___ 1930.

---

the formation consists of sandstone, underclay, coal, black shale, fossiliferous limestone and gray shale containing "ironstone" concretions. In the Havana quadrangle strata including the first coal horizon below the Rock Island (No. 1) coal are referred to the Pope Creek formation.

The Pope Creek formation is exposed in a few places along Spoon River and Tater Creek west of Duncan Mills, and ~~along~~ Otter Creek near Enion. Its character is also revealed in coal test borings near Cuba and elsewhere in the northern part of the Havana quadrangle (See geologic sections 2, 3, 4 ~~and~~ 5, 8 and 9.)

The expsures of the Pope Creek formation in the Havana quadrangle consist only of a thin black shale, a coal bed averaging 1½ to 2 feet thick, with one or more clay partings, and the underclay of the coal bed. Drill records in the northern part of the quadrangle show in addition to these, limestone and shale above the coal and sandstone below the coal.

The Pope Creek formation is separated from the Babylon formation by an unconformity of minor importance. The basal sandstone of the Seville formation truncates the upper portion of the Pope Creek formation ~~in the places~~ where the contact is exposed, and it may replace the whole formation in some places (Geological section 5).

The Pope Creek formation in the Havana quadrangle is correlated with the typical exposure because it is similarly located, relative to the Rock Island (No. 1) coal. Strata of similar age and character were found in several adjacent quadrangles during the field season of 1929.

80

Seville formation

The ~~###~~ Seville formation is named from an exposure in the west bank of Spoon River about one mile southwest of Seville, Fulton County, which Worthen made the type exposure of the No. 1 coal in western Illinois.[50]

[50] Worthen, A. H., Geology of Illinois, vol. IV, Fulton County. p. 94, 1870.

At the typical outcrop the Seville formation includes a sandstone, underclay, coal, black hard shale, and a limestone which has been named the Parks Creek limestone.[51] In the southern part of the cut the limestone

[52] Savage, T. E., Significant breaks and overlaps in the Pennsylvanian rocks of Illinois: Am. Jour. Sci., vol. 14, 1927, fig. 2, p. 309.
A

and hard dark shale and part of the coal are cut out by a channel sandstone. The exposures of the Seville formation in the Havana quadrangle ~~########~~ resemble the southern portion of the cut in the absence of the limestone, but this bed is reported in numerous drill records in and near the Havana quadrangle.

Strata belonging to the Seville formation underlie nearly all parts of the quadrangle, except where they have been removed by post-Pennsylvanian, pre-Pleistocene erosion. They are exposed at several places along Tater Creek west of Duncan Mills, and in a few places along Otter Creek. The~~##~~ character of the Seville formation in the northern part of the~~##~~ Havana quadrangle and the southern part of the Canton quadrangle is quite well known, because about 54 coal test borings were drilled in that area ~~for the purpose of~~ to obtaining information about the Rock Island (No. 1) coal, ~~the coal~~ of this formation.

The following partial log shows the general character of this formation in the southern part of the Canton quadrangle:

(SE 1/4, NE 1/4)

Geological section 6. Partial log of coal test boring in sec. 7, T. 6 N., R. 3 E. (Putman twp.)

	Thickness Feet	Inches
Pennsylvanian system		
Pottsville series		
Seville formation		
6. Shale	2	8
5. Limestone, dark ("Parks Creek")	21	
4. Shale, hard, "~~fissile~~" (probably black)	7	8
3. Shale, soft, black ("clod")		4
2. Coal (Rock Island or No. 1)	4	5
1. Shale, sandy		7

There are 11 drill records in the section from which the above partial log was taken, ~~and~~ 7 they exhibit remarkable variations in the thickness of the members of the Seville formation. The dark limestone varies from 3 feet 9 inches to 31 feet 2 inches, and is not reported ###### in two of the drillings. The coal is not reported in two of the drillings, and reaches a maximum thickness of 4 feet 6 inches. Sandstone is reported immediately above the coal in one of the drillings. The variation of the strata of this formation in sec. 7, T. 6 N., R. 3 E. (Putman twp.) which is about 1½ miles northwest of Cuba, illustrated the nature of the variation in this formation in various parts of the Havana quadrangle and in other areas in western Illinois. Figure 17 shows the variation in succession of beds of the Seville formation north of Cuba in east-west and north-south ##### sections.

The coal is less than 2 feet thick in nearly all places where it is not overlain by the limestone cap rock. Areas in which thick coal and limestone have been reported in drillings in and near the Havana quadrangle are in sections 5, 6, 7 and 8, T. 6 N., R. 3 E. (Putman twp.), in the Canton quadrangle, sec. 32, T.6 N., R. 3 E. (Putman twp.), sec. 16, T. 6 N., R. 4 E. (Buckheart twp.), sec. 4, T. 4 N., R. 4 E. (Waterford twp.), near Sepo in sec. 12, T. 4 N., R. 3 E. (Waterford twp.), near the Mound Chapel, sec. 23, T. 4 N., R. 3 E. (Isabel twp.). Thick coal apparently without the limestone cap rock is also reported in secs. 30 and ~~34~~ 31, T. 4 N., R. 3 E. (Isabel twp.) and secs. 25 and 26, T. 4 N., R. 2 E. (Pleasant twp.)

81a

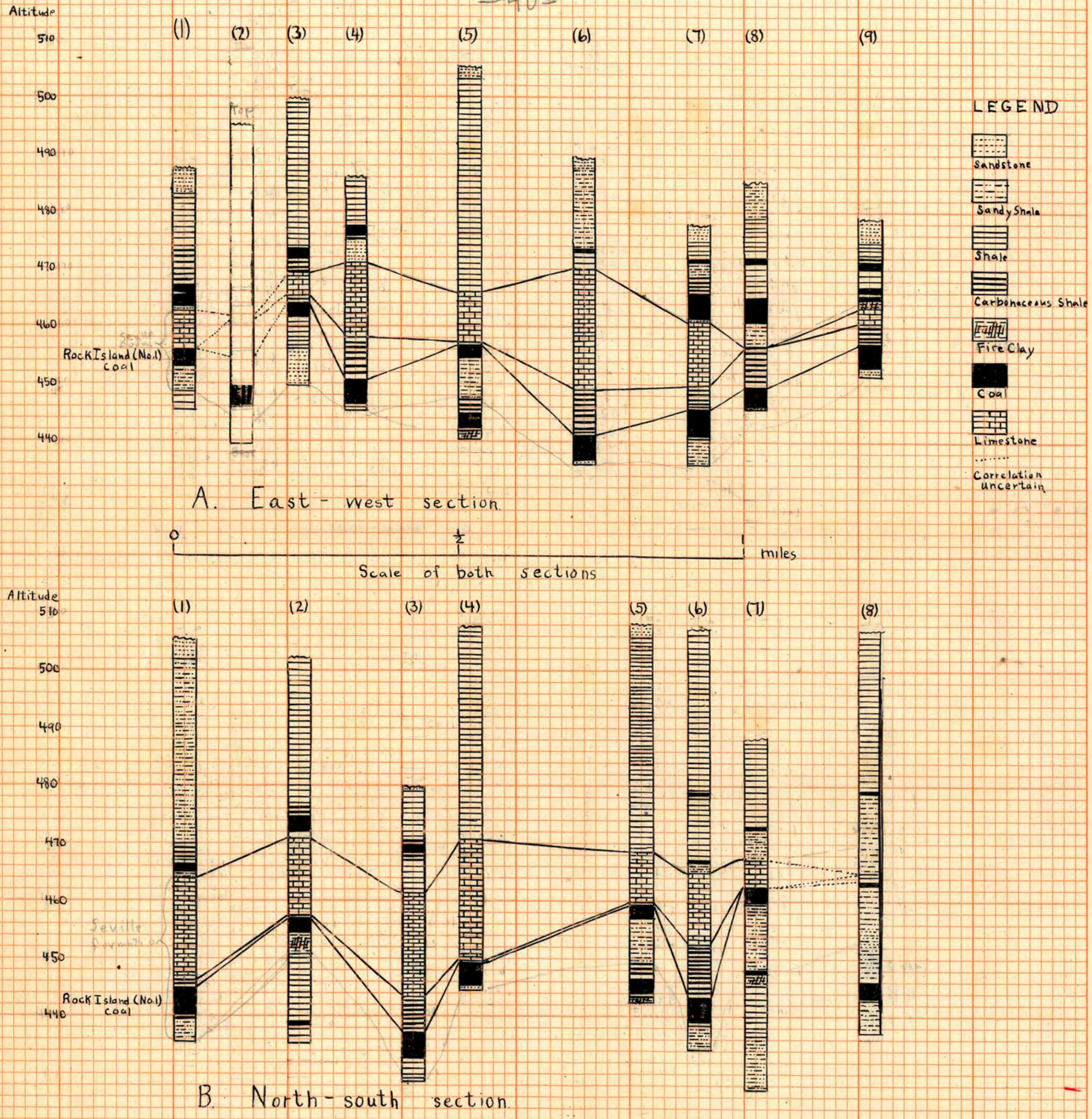


Fig 17. Cross sections showing variations in thickness and altitude of Rock Island Coal and associated strata about 1½ miles north of Cuba, based on coal test borings.

82

The thickest exposure of coal which appears to belong to the Seville formation is in a local strip pit along the west bank of a ravine near the center of the SE. ¼ sec. 25, T. 4 N., R. 2 E. (Pleasant twp.), where the following section was measured:

Geological section 7. Outcrop in local strip mine near the center of sec. 25, T. 4 N., R. 2 E. (Pleasant twp).

	Thickness Feet	Thickness Inches
Pleistocene system		
16. Loess and drift	Not measured	
Pennsylvanian system		
Pottsville series		
Seville formation (?)		
15. Shale, gray	8	
14. Coal, dull, containing much clay		1½
13. "Ironstone" concretions		2
12. Shale, gray	1	8
11. Coal		2½
10. Clay, light gray, blocky fracture		6½
9. Coal		2
8. Clay, black		½
7. Coal		9
6. Coal, dull, bony		¼
5. Coal, dull		11¼
4. Clay, dark gray above, lighter below, blocky fracture	1	11
Seville or Pope Creek formation (?)		
3. Coal, dull, bony		7
2. Clay, light gray, blocky fracture		5
1. Coal (base not exposed)	2	6

The coal here may belong wholly in the Seville formation, or it may include coal belonging either to the Bernadotte formation above or the Pope Creek formation below, separated from the Rock Island (No. 1) coal only by partings of clay.

The best exposure of the Seville formation, showing its relation to the overlying and underlying formations is on the south side of Tater Creek, about one mile west-northwest of Duncan Mills, described in the following section. (Figure 18).

Geological section 8. Cut bank on south side of Tater Creek in the NW. ¼ NE. ¼ sec. 7, T. 4 N., R. 3 E. (Isabel twp.)

Figure 18. Exposure of Pottsville strata in a cut bank on the south side of Tater Creek in the NW.~~######~~ $\frac{1}{4}$ sec. 7, T. 4 N., R. 3 E. (Isabel), showing the Bernadotte sandstone at the top, and the two "Duncan Mills" coals in the lower portion. The sandstone above the lower coal appears to have been partially disintegrated during a prolo#nged interval of weathering, and the clay above this sandstone may be the product of disintegration of a considerable thickness of the sandstone. See text, P. ___.

	Thickness Feet	Inches
Pennsylvanian system		
Pottsville series		
Bernadotte formation		
13. Underclay, ~~###~~ gray to dark gray, blocky fracture	3	
12. Sandstone, gray to buff, massive, fine grained, very hard, quartzitic in texture from secondary enlargement of quartz grains (Bernadotte sandstone)	1	6
Seville formation		
11. Coal (Rock Island or No. 1?)	1	6
10. Underclay, dark blue gray, not distinctly laminated		8
9. Underclay, light gray, blocky fracture	2	10
8. Clay, black, carbonaceous, ~~############~~ coaly		2
7. Clay, light gray, blocky fracture	2	3
6. Sandstone, irregularly bedded, upper surface uneven, as though partially disintegrated into isolated fragments	1	2
Pope Creek formation		
5. Clay, carbonaceous, somewhat laminated		3
4. Coal		5
3. Clay, gray		1
2. Coal		8
1. Underclay, gray, blocky fracture	1	6

In an exposure about half a mile west of the section above, the succession is similar, but the intervals between the coals is less and the coals and sandstones are thinner. The strata exposed in this outcrop are described here: (Figs. 19 and 20)

Geologic section 9. Cut bank on south side of Tater Creek in the NW. ¼ NW. ¼ sec. 7, T. 4 N., R. 3 E. (Isabel twp.)

	Thickness Feet	Inches
Pleistocene system		
20. Loess and drift	Not measured	
Pennsylvanian system		
Pottsville series		
Seahorne formation		
19. Sandstone, light gray, massive, fine grained	1	6
"Brush Creek" formation		
18. Covered (a little underclay showing)	3	
17. Shale, gray	2	
16. Shale, dark blue gray and underclay, mottled	1	3
15. Underclay, gray and covered	4	
Bernadotte formation		
14. Shale, gray	3	
13. Shale, blue gray	2	
12. Limestone band, hard		2
11. Shale, dark gray		4

		Ft.	In.
10.	Sandstone, buff to gray, fine grained, in one bed, quartzitic in texture from secondary silicification, rises and thins somewhat toward east end of cut (Bernadotte sandstone)		8
	Unconformity		
Seville formation (?)			
9.	Coal, dull, bony		2
8.	Coal, with some pyrite nodules, thinning toward east end of cut, and disappearing near middle of cut, apparently cut out by sandstone above (Rock Island (No. 1 coal?))		8½
7.	Underclay, light gray, blocky fracture	2	
6.	Coal, in western part of cut, disappears toward east		2
5.	Sandstone, white or light buff, hard, persistent throughout cut; rises toward east end		3
	Unconformity		
Pope Creek formation (?)			
4.	Coal, with two pyritic bands near middle, thickest near west end of cut, thinning out near middle and disappearing, probably cut out by sandstone above; at east end of cut 3 inches of dark hard calcareous sandstone occupy position of this coal in western part of cut		4
3.	Underclay, light gray, blocky fracture	3	6
2.	Underclay, dark blue gray, blocky fracture		2
1.	Underclay, light gray, blocky fracture (base covered)	4	

Figure 19 shows a detail of the western part of this cut bank where both coal beds are present and figure 20 shows a generalized sketch of the stratigraphic relations ~~of the strata~~ in this cut bank.

Stratigraphic relations.

The Seville formation rests unconformably upon the Pope Creek formation, and the basal sandstone of the Seville formation appears locally to replace all of the upper portion of the Pope Creek formation. In other parts of western Illinois, an angular unconformity has been reported between these two formations.[53] A number of drill records showing the Rock Island

[53] Wanless, H. R., Geology and mineral resources of the Alexis quadrangle: Illinois State Geol. Survey, Bull. 57, p. ___, 1930.

(No. 1) coal and its limestone cap rock were plotted with the Colchester (No. 2) coal as the datum of correlation. This graphic section shows a variation in the interval between the Colchester coal and the top of the limestone cap rock from 52 to 67 feet in 17 records. In the same records

Figure 19 Exposure of Pottsville strata in the western part of a cut bank on the south side of Tater Creek in the NW. ¼ NW. ¼ sec. 7, T. 4 N., R. 3 E. (Isabel) showing the "Bernadotte" sandstone, where hammer is located, and the ~~"Duncan Mills"~~ coals of the Seville and Pope Creek formations ~~beds~~ below. Note that the wavy lower surface of the "Bernadotte" sandstone truncates the upper part of the coal bed. This coal thins out and disappears about 50 feet east of this point. Note thin light sandstone above lower coal bed and thin coal above the sandstone at the right side of the cut. See text, p. 44, for description of this outcrop, and figure 20 for diagrammatic representation of it.

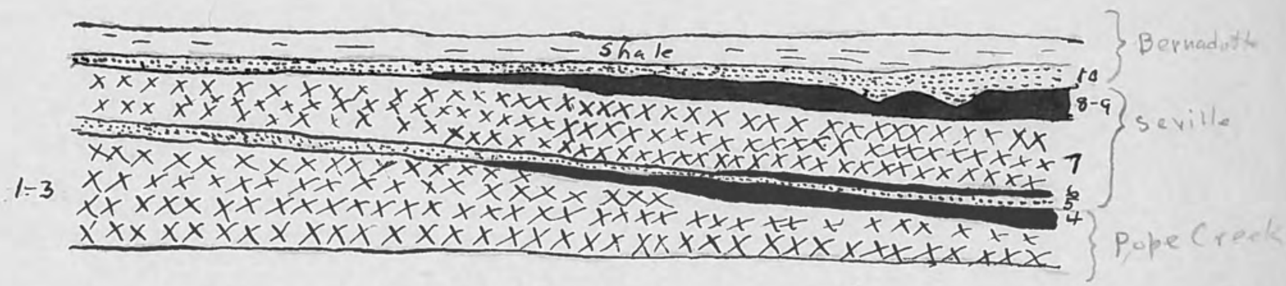


Fig. 20. Diagrammatic sketch of cut bank on south side of Tater Creek in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 7, T. 4 N., R. 3 E. (Isabel twp.) showing Pottsville strata including and below the "Bernadotte" sandstone, (no. 10). Strata are numbered as in text. Fig. 19 is a photograph of the western (right) portion of this cut.

the interval between the Colchester (No. 2) coal and the top of the Rock Island (No. 1) coal varies from 62 to 91 feet. The variation in interval between the two coals is approximately twice the variation between the upper coal and the top of the limestone. The coal was probably accumulated on an uneven surface, and the thick limestone was deposited only in the lower portions of this surface.

The Seville formation is separated from the Bernadotte formation by an erosional unconformity, in which all of the marine beds above the coal ############### have been removed from a large part of the area (if they were formerly present), and the coal has also been cut out locally.

Correlation

The Seville formation in the northern part of the Havana quadrangle is correlated with the typical exposure at Seville because no other thick #### coals with thick limestone cap rock# are known in the Pottsville of western Illinois, and because they occupy the same stratigraphic position. The development of the Seville formation in the southern part of the quadrangle, as reveaaled in natural exposures is so different from the typical sequence near Seville, that the two were not considered identical when the field work in the Havana quadrangle was done. Study of the Seville formation in a number of adjacent quadrangles has shown that the marine limestone cap rock is absent from a larger area than that in which it is present in western Illinois, and the coal, less than 2 feet thick, is much more widely extensive than the limestone. The No. 1 coal of Seville, Fulton County, was later correlated with the principal coal bed of Rock Island County and northern Mercer county, and the name (Rock Island or No. 1) coal has been applied to it.

The limestone cap rock of the coal has been named the Parks Creek limestone,[54] presumably from exposures near Seville, Fulton County,

---

[54] Savage, T. E. Op. Cit.

84

(although the name Barker Creek is applied to the# creek near the typical outcrop on the Vermont quadrangle topographic map.) This limestone is very fossiliferous. It has been approximately correlated, because of its fauna, with the Lower Mercer limestone of the Pottsville formation of Ohio. No fossils were found in the Seville formation in the Havana quadrangle.

Bernadotte formation.

The Bernadotte formation is named from typical exposures along a ravine in the southern portion of the village of Bernadotte, Fulton County, Illinois. (sec. 19, T. 5 N., R. 2 E. (Bernadotte twp.)). At the type exposure the formation consists of sandstone, underclay, coal and dark shale. The basal sandstone there truncates ## three or four feet of black hard shale #### belonging to the Seville formation. The overlying "Brush Creek" formation is locally initiated by a basal sandstone, which is not notably unconformable on the strata of the Bernadotte formation.

In the Havana quadrangle the Bernadotte formation is quite widely distributed. Its basal sandstone and some of the overlying strata are exposed in the same general regions where the Seville formation is exposed. This formation is not easily ############ separated from the overlying "Brush Creek" formation, as the basal sandstone of the latter formation is absent in most of the area. The character of this formation north of its outcrop is revealed in the records of coal test borings near Cuba and St. David. (appendix C. Part III)

The characteristics of the Bernadotte formation are shown in geological sections 8 and 9, and in the following sections:

Geological section 10. Exposure in east bank of artificial cut of channel into which stream was diverted by C. B. & Q. Ry. in NE. ¼ SE ¼ sec. 32, T. 5 N., R. 3 E. (Lewistown twp.) (see figure 21).

"Liverpool"
Green bush
Wiley
Seahorne
"Brush Creek"
Bernadotte

Figure 21. Exposure of Pottsville strata on east bank of artificial cut of channel into which stream was diverted by ~~###~~ C. B. & Q. Ry., in the NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 32, T. 5 N., R. 3 E. (Lewistown), showing strata from ~~##~~ below the Colchester (No. 2) coal to the top of the Bernadotte sandstone, which appears at the base of the picture at the extreme right. The hammer marks the position of the ~~10 inch~~ coal of the Wiley formation 20 feet below the Colchester coal and the man is standing at the horizon of the Seahorne ~~"Ray or Astoria~~ limestone . The prominent hard bed about two feet below the man is the sandstone ~~with "sugary texture~~ at the base of the ~~5th sequence.~~ Seahorne formation

		Thickness Feet	Thickness Inches
Pennsylvanian system			
Carbondale series			
Summum formation			
33.###	Sandstone, buff to gray, micaceous, in scattered outcrops at top of bank	5	
"Liverpool" formation			
32.###	Covered interval, including Colchester (No. 2) coal and 2 feet or less of the Francis Creek shale	4	
Pottsville series			
31.###	Underclay, light gray, blocky fracture, exposed at top of cut	2	
	################################		
30.###	Shale, sandy, greenish gray, micaceous, thinly laminated, with irregular iron coated laminated masses of sandstone	4	6
29.###	Sandstone, brown, massive, hard, forming ledge (Isabel sandstone)	2	
28.###	Shale, sandy, gray		6
27.###	Sandstone, light brown, fine grained, iron coated, forming ledge, not persistent	1	
Greenbush formation			
26.###	Shale, sandy or sandstone, shaly, greenish gray and light yellow, micaceous, with numerous iron coated limestone nodules around which laminae of shale bend; upper part sandy, with some concretions of sandstone	3	10
25.###	Limestone, dark brown, iron saturated		5
24.###	Clay, ##### carbonaceous, dark gray, not laminated		6
23.###	Limestone, light brown, dense, nodular, with iron coated knobby surface	1	6
22.###	Limestone concretions, light brown, not continuous, maximum thickness	2	6
21.###	Underclay, gray, blocky fracture, lower 6 inches dark gray	2	9
Wiley formation			
20.###	Shale, black, hard, finely laminated, not persistent		2
19.###	Coal		10
18.###	Underclay, gray, with gypsum crystals	1	3
Seahorne formation			
17.	Limestone concretions, gray, massive, iron coated, representing Seahorne limestone, not persistent		10
16.	Underclay, gray enclosing concretions	1	9
15.	Sandstone, white to light gray, soft to ledge forming, fine grained, with "sugary" texture	1	6
"Brush Creek" formation (?)			
14.	Shale, gray, sandy		11
13.	Sandstone, gray, "sugary" texture		9
12.	Shale, gray, soft	1	
11.	Sandstone, ############ soft, iron stained		6
10.	Shale, ################## gray, soft	#	#03
9.	Sandstone, forming ledge	##	#04
8.	Shale, sandy, light gray	1	10
7.	Sandstone		2
6.	Shale, sandy, gray		$9\frac{1}{2}$
5.	Sandstone		1

Bernadotte formation			
4.	Shale, slightly sandy, light gray	2	10
3.	Shale, blue gray to dark (coal horizon)	1	6
2.	Underclay, light gray, ~~##########~~ blocky fracture	3	2
1.	Sandstone, buff to gray, hard, somewhat crossbedded, quartzitic texture due to secondary enlargement of quartz grains (Bernadotte sandstone) to water level	3	

The relation of the Bernadotte formation to the underlying Seville formation in the vicinity of Cuba is shown in the accompanying partial log of a coal test boring:

Geological section 11. Partial log of coal test boring in the NW. ¼ sec. 8, T. 6 N., R. 3 E. (Putman ~~##~~ twp.)

		Thickness Feet	Thickness Inches
Pennsylvanian system			
Pottsville series			
"Brush Creek" formation (?)			
15.	Sandstone, light	4	
Bernadotte formation (?)			
14.	Shale, light	#2	
13.	Shale, dark, "~~fissile~~" hard	1	
12.	Coal, dirty	1	5
11.	Shale (probably clay, not bedded), light	3	3
10.	Coal		9
9.	"Rock", probably pyritic concretion in coal		10
8.	Coal		6
7.	Underclay		9
Seville formation			
6.	Limestone	1	
5.	Limestone, dark	2	6
4.	Shale, sandy, dark, "~~fissile~~" hard	3	3
3.	Coal and "sulphur" (pyrite)		6
2.	Coal (Rock Island, ~~or~~ No. 1)	3	3
1.	Sandstone	1	6

The ~~##########~~ basal sandstone of the Bernadotte formation is absent in the preceding section. The assignment of the coals 8, 10 and 12 to the Bernadotte formation may be incorrect, as the uppermost coal may belong to the "Brush Creek" formation.

The basal sandstone of this formation was given the name Bernadotte[55]

[55] Savage, T. E., Significant breaks and overlaps in the Pennsylvanian of Illinois, Amer. Jour. Sci., vol. 14, p. 309, 1927.

from the #### exposure which is here considered the type ~~exposure~~ of the formation. The Bernadotte sandstone is well exposed at several places along Spoon River, Tater Creek and Otter Creek and their tributaries. It is commonly massively bedded and hard. It varies from 5 inches to ? feet in the exposures examined ~~The upper portion of it, where it is thick, forms one thick ledge forming layer.~~ It is gray to brown, very fine grained, and contains a considerable percentage (27-50 per cent) of grains the size of silt. A fresh surface of the sandstone is distinctly glassy. It is composed largely of clear, small, uniform grains of quartz with crystal faces. All of the samples examined are noncalcareous, but the lower portion is ~~known to be~~ slightly calcareous in some places where it is thick. The upper one or two feet of the sandstone ~~where it is thick,~~ is commonly more resistant to weathering and more quartzitic in appearance than the lower beds, a character which is shown in figure 22. The sandstone is well exposed in the bed of Seahorne Branch at the margin of the alluvial plain of ~~the~~ Illinois River. ~~in the SW. ¼ SW. ¼ sec. 4, T. 3 N., R. 3 E. (Kerton twp.).~~ The sandstone here is white to light gray, and impressions of the roots of a Pennsylvanian tree (St#igmaria ficoides) are common on its irregular upper surface. The following section was measured ~~at this place~~:

Geologic section 12. Exposure along the south bank of Seahorne Branch in the SW. ¼ SW. ¼ sec. 4, T. 3 N., R. 3 E. (Kerton twp.)

	Thickness Feet	Thickness Inches
Pleistocene system		
14. Loess and drift	(Not measured)	
Pennsylvanian system		
Pottsville series		
Seahorne formation		
13. Limestone, light gray, fine grained, fossiliferous; loose boulders mark its position; (Seahorne limestone)	2	
12. Covered	5	

Fig. 22. Bernadotte sandstone exposed in the northeast bank of Otter Creek in the SW. ¼ SW. ¼ sec. 28, T. 4 N., R. 3 W. (Isabel). The upper three feet of the sandstone are more resistant to weathering because of the secondary enlargement of the quartz grains, giving a quartzitic texture to the rock. The lower portion ### is softer sandstone and has been undercut by the stream. Alluvial ###### deposits of Otter Creek are deposited against this sandstone in the lower part of the picture. Notice the continuation of this sandstone ledge in the woods in the right background.

"Brush Creek" formation			
11.	Clay, dark gray, soft, blocky fracture	1	
10.	Clay, light gray, blocky fracture	2	6
9.	Clay, dark, indistinctly bedded		6
8.	Shale, sandy	1	
7.	Clay, light gray, blocky fracture	6	
6.	Shale, dark blue gray, thin bedded	3	
5.	Clay, blue gray, blocky fracture	2	6
4.	Clay, light gray, soft, blocky fracture	1	6
Bernadotte formation			
3.	Coal, rather bony		6
2.	Shale, carbonaceous, dark gray, hard		3
1.	Sandstone, light gray, very hard; uneven upper surface; containing impressions of Stigmaria; exposed in bed of creek (Bernadotte sandstone)	3	

The coal bed one or two feet above the Bernadotte sandstone is exposed in several places and varies from 2 inches to ~~one~~ 1 foot in thickness. It is commonly an impure coal with rather dull luster. Above the coal in some exposures ~~there occurs~~ dark finely laminated ~~fissile~~ shale is found, followed by lighter gray shale, with one or more layers of calcareous or ironstone concretions.

Stratigraphic relations

The Bernadotte sandstone at the base of this formation ~~appears to~~ rests unconformably on the Rock Island ~~or~~ (No. 1) coal in most of the exposures in the quadrangle. The records of drillings in the quadrangle and exposures in nearby areas show that this sandstone was deposited on an erosional surface with a relief of at least 20 or 30 feet.[56] Such relations are reported in the

[56] Savage, T. E., Significant breaks and overlaps in the Pennsylvanian of Illinois. Am. Jour. Sci., vol. 14, p. 310, 1927.

[57] Wanless, H. R., Geology and mineral resources of the Alexis quadrangle: Illinois State Geol. Survey, Bull. 57, pp. , 1930.

Vermont and Alexis quadrangles.[57] There is little evidence of unconformity at the top of the Bernadotte formation, although the shale above the coal varies somewhat in thickness and is locally absent.

Correlation

No fossil remains were found in the strata composing the Bernadotte formation except Stigmaria ficoides, which ranges through the entire

Pennsylvanian system. It is correlated with the typical exposure at Bernadotte, because of similar lithologic character and stratigraphic position. The coal and sandstone of this formation have also been found in the Avon, Galesburg, Monmouth, Alexis, and other quadrangles in western Illinois.

"Brush Creek" formation.

This formation is typically exposed along Brush Creek in the Galesburg quadrangle in secs. 5 and 9, T. 9 N., R. 2 E. (Chestnut twp.). At its typical exposure it consists of 3 or 4 coal beds one half inch to two inches thick, separated by underclay. In one of the exposures dark shale and limestone overlie the uppermost coal, but in the other the sandstone of the overlying formation truncates these beds. In that district this "three coal" or "four coal" zone is fairly widespread and easily recognized. Further south the thin coals disappear and their combined underclays make up most of the formation. This underclay is in several places marked by more variation in color than the underclays of most of the formations. The colors pale pink, greenish blue, purplish gray and rusty are all found in this clay. The basal sandstone of this formation is much less extensive than the underclay, but it has been recognized in a few places, as at Bernadotte, at the type section of the Bernadotte formation.

In the Havana quadrangle not more than one thin coal bed has been found in this formation. This bed is locally 2-5 inches thick and is exposed at several places along Otter Creek and Tater Creek and their tributaries. It is not present in all exposures of the formation. The lithologic character of strata of the "Brush Creek" formation in the Havana quadrangle is described in geological sections 9, 10 and 12 and the two following sections, which show the thin coal bed of the formation.

Geological section 13. Cut bank on south side of Tater Creek, near the NW. corner sec. 7, T. 4 N., R. 3 E. (Isabel twp.)

	Thickness Feet	Thickness Inches
Recent system		
13. Slump and soil	2	
Pennsylvanian system		
Pottsville series		
Greenbush formation		
12. Limestone concretion band		3
10. Underclay, gray, with blocky fracture	3	
Wiley formation		
#9. Coal, weathered at outcrop		5
8. Underclay, gray, blocky fracture		10
Seahorne formation		
7. Limestone concretions, gray, with septarian structure, not a persistent band (horizon of Seahorne limestone)		8
6. Underclay, gray, blocky fracture, weathering buff	4	
5. Sandstone, gray or buff, forming a massive ledge, fine grained, iron stained, especially on joint surfaces	1	5
"Brush Creek" formation		
4. Shale, gray, evenly bedded	4	6
3. Coal, bony, mixed with shale		3
2. Coal		2
1. Underclay, gray		8

Geological section 14. Cut bank on south side of Otter Creek, NE. ¼ NE. ¼ sec. 35, T. 4 N., R. 2 E. (Pleasant twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Pottsville series		
"Liverpool" formation		
20. Sandstone	2	
Greenbush formation		
19. Shale, gray, thin band of ferruginous septarian concretions, and underclay	3	
Wiley formation		
18. Coal		6
17. Underclay, gray	2	
Seahorne formation		
16. Limestone, light gray, hard, knobby upper surface, fossiliferous (Seahorne limestone)	2	
15. Underclay, gray	2	
14. Coal, bony		2
13. Underclay, gray	3	4
12. Sandstone, light gray, "sugary" texture	2	
"Brush Creek" formation		
11. Underclay, gray	4	6
10. Shale, carbonaceous, black, slightly coaly		5
9. Shale, dark gray		8
8. Underclay, light gray		6
7. Shale, carbonaceous, dark gray		2
6. Underclay, gray		8
5. Sandstone, weathering brownish	1	10

########

98

Bernadotte formation (?)

		Ft.	In.
4.	Underclay, light gray		11
3.	Shale, gray, light in upper portion, darker below, with ferruginous concretions	5	6
2.	Shale, carbonaceous, black (coal horizon)		2
1.	Underclay, dark gray		6

The last four members of the preceding section may also belong to the "Brush Creek" formation, but the correlation suggested seems more probable.

Stratigraphic relations.

There is little or no evidence of an erosional break between the "Brush Creek" and Bernadotte formations, although the variation in the succession of the latter, especially in the strata above the coal suggests the removal of a slight thickness of beds between the deposition of the two formations. In one or two places in western Illinois a sandstone which appears to be the basal sandstone of the "Brush Creek" formation truncates 10 feet or more of the underlying strata. This formation differs from others in the Pennsylvanian of western Illinois in the predominance of underclay over the other members of the sequence and in the presence of more than one coal horizon. The variegated underclay of this formation has a distribution over at least several counties, but the other members of the formation are much less persistent. The explanation of the underclay as the result of weathering when the area was neither receiving sediments nor being eroded, seems to account for the wider distribution of that member than of the others. There is little or no evidence of unconformity at the top of this formation, but the basal sandstone of the overlying #Seahorne# formation is fairly widespread, and its basal contact is sharp in most places.

Correlation

No fossil remains ########################## were found in the exposures of the "Brush Creek" formation in the Havana quadrangle. The underclay of this formation may constitute ### a part of the clay horizon to which the name "Cheltenham" clay has been applied in the St. Louis district.

The formation is also equivalent to the upper part of the beds which were designated the "Bernadotte" member in the Vermont quadrangle.[58]

58/ Savage, T. E. Geology and Mineral resources of the Vermont quadrangle: Illinois State Geol. Survey. Unpublished manuscript.

Seahorne formation.

This formation is typically exposed along the south bank of Seahorne Branch in the S. ½ SE. ¼ sec. 5, T. 3 N., R. 3 E. (Kerton twp.). At its typical locality (Geological section ~~14~~ 15), it consists of a fine grained sandstone, underclay, a thin coaly streak, clay and massive light gray brecciated fossiliferous limestone, with an uneven upper surface. This succession of beds is fairly persistent through the southern part of the quadrangle, though the coaly streak is not everywhere present. In the northern part of the quadrangle the limestone grades into a discontinuous bed of limestone concretions, and further north disappears entirely. There the clay below the limestone is in contact with the underclay belonging to the overlying Wiley formation and the boundary cannot be distinguished. The sandstone and limestone of this formation can also be recognized in some coal test borings in the vicinity of Cuba.

The characteristics of the strata composing the Seahorne formation are described in geologic sections 10, 12, 13 and 14 and in the following section of the typical exposure of the formation.

<u>Geological section 15. Cut bank on the south side of Seahorne Branch ~~SW.~~ SE ¼ SE. ¼ sec. 5, T. 3 N., R. 3 E. (Kerton twp.)</u> (Fig. 25)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Pottsville series		
Wiley formation		
8. Coal		11
7. Underclay, light gray, with blocky fracture, and covered	2	6
Seahorne formation		
6. Limestone, light blue gray, compact, not bedded, brecciated, fossiliferous, with irregular upper and lower surfaces	3	6
5. Clay, gray, with blocky fracture, containing some large irregular shaped gray calcareous concretions	2	2

F Fig. ~~25~~ 23. Pottsville exposure on the south side of Seahorne Branch near the SE. cor. SW. $\frac{1}{4}$ sec. 5, T. 3 N., R. 3 E. (Kerton) twp, showing the ~~10 inch~~ coal ~~horizon~~ of the Wiley formation in the upper right part of picture, underlain by 3 feet of light gray irregularly fracturing underclay. The latter rests on the wavy upper surface of the "~~Astoria or Ray~~ Seahorne" limestone. Notice that although this surface is generally smooth numerous small knobs rise above the general surface, giving a knobby appearance to the top of this limestone, which is characteristic of most of its exposures.

USE ANOTHER PRINT WHICH WILL BRING OUT FOREGROUND D
DETAIL BETTER THAN THIS ONE DOES

Seahorne formation (cont.)

4.	Coal		1½
3.	Underclay, gray, with blocky fracture	4	
2.	Sandstone, light gray, fine grained, thin bedded	2	
"Brush Creek" formation			
1.	Clay, gray, with blocky fracture	1	6

The thickness of the Seahorne formation in the section described above is about 12 feet. From this locality, near the southern margin of the quadrangle the thickness decreases rather regularly, to 6 or 8 feet near Duncan Mills and 4 or 5 feet along Big Creek west of Lewistown. The thinning is especially notable in the limestone member, which thins from a maximum of 6 feet 6 inches along Seahorne branch to disappear in the northern part of the quadrangle. Figure 24 shows a number of graphic sections of the Seahorne and Wiley formations arranged to show their variations in a north-south direction across the quadrangle.

Sandstone

The basal sandstone of the Seahorne formation is locally massive, but in many exposures in the northern part of the quadrangle, it is thinly bedded and shaly. It is very fine grained and white, with a sort of sugary texture on fresh fractures. Minute limonitic specks can be seen with a hand lens. In many outcrops the weathered surface of this sandstone is partly stained by limonite which is more reddish than in the other sandstones of the Pennsylvanian. Microscopic examination shows that many of the limonite specks have centers of unaltered pyrite surrounded by limonite stained grains of quartz. The grains of quartz are comparatively uniform in size, consisting of about 52% grains of silt texture, 25% ~~grains~~ of very fine sand, 18% ~~grains~~ of clay and 5% ~~grains~~ of fine sand. Some of the quartz grains show secondary enlargement, but this is not as common as in the Bernadotte sandstone, hence the sandstone is less tough and weathers more easily. The sandstone is noncalcareous. It is well shown in the lower part of figure 25, an exposure in a ravine north of Otter Creek, where the following section was measured:

Fig. ~~23~~ 25. Exposure of Pottsville strata in the bed of a ravine ~~north~~ of Otter Creek, near the center of the SW. $\frac{1}{4}$ of sec. 28, T. 4 N., R. 3 E. (Isabel twp.). The upper ledge forming stratum is a local ~~non~~unfossiliferous limestone about 2 feet below the horizon of the ~~"Astoria or Ray"~~ Seahorne limestone. The reentrant face below this is soft irregularly fractured clay, and the laminated rock forming the lower ledge is thin bedded white sandstone, with "sugary" texture, the basal bed of the ~~fifth sequence.~~ Seahorne formation

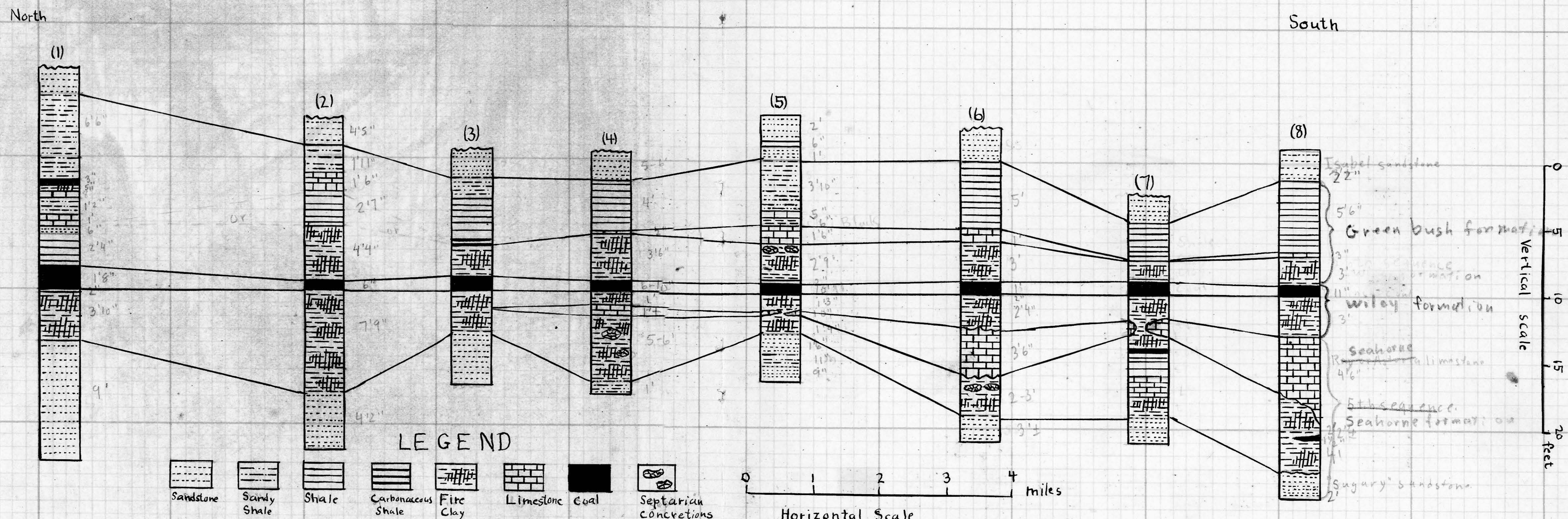


Fig. 24 North-south section across the Havana Quadrangle illustrating variations in ~~the 5th and 6th sequences of Pennsylvanian strata.~~ Seahorne ~~and~~ Wiley and Greenbush formations. Note the persistence of the coal, and the disappearance to the north of the ~~Ray or Astoria~~ Seahorne limestone

(1) Coal test boring, NW. cor. sec. 24, T. 6N., R. 3E.
(2) Coal test boring, NE. cor. SE. ¼ sec. 32, T. 6 N., R. 3E.
(3) Outcrops, NW. ¼ sec. 8, T. 5N., R. 3E.
(4) Outcrops, NE. ¼ sec. 19, T. 5N., R. 3E.
(5) Outcrops, NE. ¼ sec. 32, T. 5N., R. 3E.
(6) Outcrop, NE. ¼ sec. 16, T. 4N., R. 3E.
(7) Outcrops, SW. ¼ sec. 28, T. 4N., R. 3E.
(8) Outcrops, SE. ¼ sec 5, T. 3N., R. 3E.

Geologic## section 16. Exposure in a ravine north of Otter Creek, near the center of the SW. ¼ sec. 28, T. 4 N., R. 3 E. (Isabel twp.)

	Thickness Feet	Inches
Pennsylvanian system		
Pottsville series		
"Liverpool" formation		
12. Sandstone, gray, thin bedded to massive	5	
Greenbush formation		
11. Shale, dark gray, and covered	3	
10. Shale or clay, light gray	1	6
Wiley formation		
9. Shale, black, hard, finely laminated		2
8. Coal	1	
7. Underclay, light gray, with blocky fracture	1	6
Seahorne formation		
6. Shale, gray, with nodules of blue gray, conglomeratic, knobby, fossiliferous limestone 1 foot 6 inches thick	4	
5. Coaly parting		1
4. ########### Clay or shale, gray	2	
3. Limestone, brown, dense, unfossiliferous, weathering reddish	1	6
2. Underclay, sandy light gray, soft, ## with blocky fracture	1	6
1. Sandstone, light gray, thinly bedded, sugary texture	2	

The sandstone overlies shale or underclay with a sharp break in many exposures, but in some, as in geologic section 10, there is an alternation of sandstone and argillaceous strata for a thickness of 2 or 3 feet. The sandstone of the Seahorne formation is recognized in 28 exposures in the central and southern parts of the quadrangle and 12 coal test borings in the vicinity of Cuba. In these records it varies from 1 foot 6 inches to 8 feet in thickness. The higher thicknesses are from drill records and they may include some argillaceous beds. There is no evidence of an erosional surface below this sandstone in the Havana quadrangle.

Coal and underclay.

The underclay ##### is as widespread as the sandstone, but the thin coal parting in it is less persistent, appearing in only 4 records of about 40 which show the clay. It does not exceed two inches in thickness in any of the exposed sections. In the upper part of the clay large irregular calcareous concretions without traces of fossil remains are common. A number of these directly below the limestone member are shown in figure 26.

Wiley

Seahorne

Fig. 26. Pottsville exposure in the east bank of a ravine south of Spoon River in the NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 16, T. 4 N., R. 3 E. (Isabel), showing the lower part of the Seahorne ~~knobby "Astoria or Ray"~~ limestone projecting irregularly down into the plastic ~~irregular~~ unbedded underclay. Several large calcareous unfossiliferous concretions are shown in the underclay. (Fig. 28 shows the strata above this in the same cut bank up to the Pleasantview sandstone).

In the northern part of the quadrangle, where the Seahorne limestone is absent, this clay is continuous with the clay above the limestone, and clay occupies the whole interval between the coal of the Wiley formation and the basal sandstone of the Seahorne formation.

Seahorne limestone

The limestone of the Seahorne formation is a blue gray, fine grained, sublithographic limestone, with conglomeratic or brecciated structure locally. A sample of the limestone treated with hydrochloric acid was found to contain 88.18% soluble material ($CaCO_3$, etc.), 9.50% yellowish clay, 1.62% silt and 0.70% fine sand. The silt and fine ########## sand consist principally of hardened clay aggregates. The limestone# is everywhere massive or irregularly bedded and has a very uneven lower surface projecting downward into the soft plastic underclay below (Fig. 26). The upper surface is also characteristically knobby and wavy (Fig. 23). The thickness of the limestone varies from 6 inches to ~~three~~ 3 feet within a hundred yards or less, suggesting an unconformity above the limestone. The limestone was probably at one time continuous over the whole quadrangle, as scattered concretions are found in some exposures in the northern part of the quadrangle, and limestone is reported at this position in 6 of 43 coal test borings in the vicinity of Cuba. Calcareous concretions in the underclay may have been confused with this limestone in these drill records.

The limestone is very fossiliferous in some exposures, although it appears to be wholly without fossils in others. The fauna is ~~characterized~~ marked by an abundance of gastropods, of which many species have not been found in other limestones in the Havana quadrangle or elsewhere in western Illinois. The most characteristic species of gastropods are Naticopsis altonensis, Naticella americana, and Trachydomia sp. The fossils collected at 4 exposures of this limestone are listed in Appendix A, Pt. I.

Correlation

The limestone, the most easily recognized member of this formation has been described from exposures near Bernadotte in the Vermont quadrangle [59]

[59] Savage, T. E. Geology and Mineral Resources of the Vermont quadrangle. Ill. State Geol. Survey. Unpublished manuscript.

where the name Aylesworth limestone is applied to it, and from Mill Creek, Schuyler County, in the Beardstown quadrangle, [60] where the name Ray limestone

[60] Searight, W. Geology and Mineral resources of the Beardstown quadrangle. Illinois State Geol. Survey. Unpublished manuscript.

is applied to it. It is one of the most easily recognized Pottsville members from the middle of the Havana quadrangle south and west about 50 miles, because of its ~~characteristic~~ knobby upper surface and gastropod fauna. The name Seahorne is proposed for the limestone and formation because all of the members of the formation are well exposed along Seahorne ~~formation~~ Branch, and the limestone is very fossiliferous there. The limestone is unfossiliferous along Aylesworth Branch and the name Ray has already been applied to another formation

Wiley formation.

This formation is typically exposed 1½ miles northwest of the Wiley School in the Avon quadrangle in sections 16 and 17, T. 7 N., R. 2 E. (Deerfield twp.). At its typical exposure It consists of ~~coal and~~ underclay and coal. The coal is the second coal horizon below the Colchester (No. 2) coal, and the first above the Seahorne limestone at the typical exposure. Elsewhere a few inches of dark gray or black shale overlie the coal. Similar strata in a similar stratigraphic position in the Havana quadrangle are correlated with the typical exposure. The character of the beds of the Wiley formation in the Havana quadrangle is indicated in geological sections 10, 13, 14, 15, 16, 17, 18 and 20, and in figure 24. The coal and underclay are exposed in all parts of the Havana quadrangle except where they have been removed by erosion or where they are buried beneath younger strata. They are known to continue north of their line of outcrop, for the coal and underclay are reported in all of the deeper coal test borings in the vicinity of Cuba ~~which were drilled in search of the Rock Island (No. 1) coal~~.

The underclay averages about 2 feet i~~n thickness~~ where it rests on the Seahorne limestone. In the northern part of the quadrangle where this limestone is absent the underclay is continuous with the clay below the limestone, and locally reaches a thickness of 4 or 5 feet.

The coal is present in all exposures and drill records and outcrops showing its horizon, averaging 20 feet below the Colchester (No. 2) coal and ranging from 15 to 25 feet below it. It averages 10 inches i~~n thickness~~ in 42 drill records and 48 outcrops. It ranges from 1 foot 10 inches in a drill record near Cuba to 4 inches in a few outcrops and drill records. In its typical exposure in the Avon quadrangle it is 16 inches thick. The thickness appears to diminish from the north toward the south in and near the Havana quadrangle. In most exposures it is fairly hard coal, without bedded impurities.

The roof of the coal in most exposures is one to two inches of thin bedded black shale, but this is locally absent and underclay belonging to the Greenbush formation directly overlies the coal. No fossil remains have been found in the roof shale of this coal.

The Wiley formation rests unconformably on the Seahorne limestone, as indicated by the uneven knobby surface and discontinuity of this ~~the Seahorne~~ limestone, but the unconformity is probably of minor importance. It is apparently conformable with the overlying Greenbush formation.

Correlation

The coal of the Wiley formation has been mentioned as widely distributed in Fulton County [61]. Similar strata have also been found in parts of Knox,

[61] Cady, G. H., Coal Resources of District IV. Illinois State Geol. Survey, Coop. Mining Series Bull. 26, pp. 81-82, 1921.

Warren and McDonough counties.

Greenbush formation

This formation is typically exposed in secs. 23 and 24, T. 8 N., R. 1 W. (Greenbush twp.), along Swan Creek and its tributaries one to two miles west of Avon. At the typical exposure it consists of sandstone, underclay, a thin coaly streak, black, ~~shale~~ and olive to gray shale. Elsewhere a thin limestone band or band of limestone concretions intervenes between the black shale and the gray or olive shale. In the Havana quadrangle strata between the Wiley formation and the first sandstone below the Colchester (No. 2) coal are referred to the Greenbush formation. The usual succession of strata of the Greenbush formation in the Havana quadrangle is shown in the following described section. (Fig. 27)

Geologic section 17. Cut bank on the east side of Turkey Branch about 400 feet north of the road in the NE. ¼ SE. ¼ sec. 31, T. 4 N., R. 3 E. (Isabel twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Carbondale ~~Pottsville~~ series		
Summum formation		
12. Sandstone, buff, thinly to massively bedded, micaceous (Pleasantview sandstone)	3	
"Liverpool" formation		
11. Coal (Colchester ~~or~~ No. 2) and covered — Pottsville series	3	
10. Underclay, light gray, with blocky fracture, containing calcareous concretions	3	6
9. Shale, sandy, gray	3	
8. Sandstone, buff, mottled with brown spots on fresh surfaces, moderately hard, thinly to massively bedded, micaceous	5	
Greenbush formation		
7. Shale, gray, soft, evenly bedded	4	6
6. Shale, gray, with two levels of calcareous ironstone concretions	1	
5. Limestone, gray, weathering brown, fine grained, unfossiliferous		3
4. Underclay, light gray, with blocky fracture, with numerous large irregular shaped calcareous concretions	3	
Wiley formation		
3. Shale, carbonaceous, black, hard		1½
2. Coal		8
1. Underclay, exposed to bed of creek	2	

"Liver-pool"

Green bush

wiley

Fig. 27. Exposure of upper Pottsville strata in a cut bank on the east side of Turkey Branch in the NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 31, T. 4 N., R. 3 E. (Isabel). The Colchester (No. 2) coal appears as a black blossom about one half inch below the top in the center of the picture. Below it is ~~the~~ underclay, deeply rilled with small drainage furrows. Below this is the Isabel sandstone at the base of the ~~seventh sequence~~ "Liverpool" formation, forming a smooth face, with few laminations, and separated sharply from the more closely laminated shale below. At the base of the gray shale, which forms the central part of the picture, a small ledge is formed by a 3 inch band of unfossiliferous limestone. Below this limestone the clay is not laminated and contains large calcareous concretions, several of which are shown. The 8 inch coal bed and its underclay show at the base of the picture.

The base of this exposure is just above the Seahorne limestone. This formation is also well exposed in the ### outcrop described as geologic section 20.

The basal sandstone of the Greenbush formation is exposed at several places in the Avon, Vermont and Galesburg quadrangles, but appears to be missing from all parts of the Havana quadrangle. The underclay rests directly on the coal or overlying shale of the Wiley formation. Large irregularly shaped calcareous concretions are common in it, as shown in figure 27. This underclay is overlain by coal at several places outside the Havana quadrangle. ~~but~~ Coal was found in only two exposures in the ~~Havana~~ quadrangle, where 1 and 2 inches ~~of coal~~ occur between the underclay and the overlying limestone band. The thin limestone band is absent in some exposures, as in the following exposed section:

Geologic section 18. Exposures along the lower part of a ravine north of Big Creek in the NW. ¼ SW. ¼ sec. 8, T. 5 N., R. 3 E. (Lewistown twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Pottsville series		
"Liverpool"formation		
9. Sandstone, #### buff, with brown spots from limonite stains	1	
8. Covered, including shaly sandstone	3	6
7. Sandstone, mottled brown and buff, like (9), massively bedded	1	6
6. Shale, sandy, unevenly bedded, with concretions	1	6
"Liverpool" or Greenbush formation		
5. Shale, slightly sandy, gray, lower beds darker in color than upper beds; micaceous, thin bedded; containing # carbonaceous streaks and indistinct impressions of Cordaites, fern leaves and other plants; and lenticular ironstained calcareous concretions with irregular shape	3	
Greenbush formation		
4. Shale, black, soft, finely laminated, unfossiliferous		6
3. Underclay, gray, with blocky fracture	2	3
Wiley formation		
2. Coal		10
1. Underclay, gray, with blocky fracture, to base of exposure	1	

In this exposure the thin################ limestone ~~appears to~~ may be replaced by the soft black shale, or cut out by the micaceous plant bearing shale above.

The thin limestone band of the Greenbush formation is commonly light gray or buff on fresh surfaces, but ~~it~~ may be stained a deep reddish brown on weathered surfaces. It is fine grained and almost lithographic in texture, and is unfossiliferous in all exposures in the Havana quadrangle, except one, where Ambocoelia planoconvexa was found. Outside the Havana quadrangle marine fossils are known in this limestone band in only a few exposures. In several ~~exposures~~ places in the northern part of the quadrangle this limestone layer is very irregularly bedded, suggesting a mass of ferruginous limestone concretions. A sample ~~of this limestone~~ treated with dilute hydrochloric acid contains 90.62% soluble material ($CaCO_3$, etc.) The residue includes 5.23% buff clay, 3.58% silt and 0.57% fine sand. The silt and fine sand consist principally of brownish gray micaceous silt, hardened aggregates of the same material, and a few larger flakes of mica to 0.2 mm. diameter.

The shale, which is the highest member of the Greenbush formation, is an even bedded olive gray to bluish gray clay shale in most of the southern part of the quadrangle. Flattened elliptical calcareous or ferruginous concretions are common in the lower foot of the shale. In the northern part of the quadrangle the shale is more micaceous and sandy and the contact between the top of the shale and the overlying basal sandstone of the "Liverpool" formation is not clearly marked, thin sandstones and shales alternating for one or two feet (See geological section 10, members 26-29). Traces of fossil plants were found in this shale in the exposure described in geological section 18. Fossil plants are also found in a shale about 20 feet below the Colchester (No. 2) coal in a cut bank on the west side of Kerton Creek in the NW. ¼ NW. ¼ sec. 24, T. 3 N., R. 2 E. (Woodland), about 1¼ miles south of the quadrangle. This shale may belong to the Greenbush formation, but the writer believes it to be a shale of the same age as the basal sandstone of the "Liverpool" formation filling a channel excavated in underlying strata. The plants collected from this shale are listed in Appendix A. Pt. II.

The Greenbush formation appears to overlie the Wiley formation conformably, as the coal of the latter formation is present throughout the quadrangle. The "Liverpool" formation overlies the Greenbush unconformably, ~~and~~ Channels 60 or 80 feet ~~in depth~~ deep were excavated ~~into the underlying strata~~ before the basal sandstone of the "Liverpool" formation was deposited just south and southwest of the Havana quadrangle, as well as in other parts of western Illinois. In the Havana quadrangle itself, the irregularity of the surface beneath the sandstone is not more than 5 or 6 feet, as none of the major channels excavated at this time appear to traverse this quadrangle.

Correlation.

The name Avon member has been applied to strata corresponding to the Seahorne, Wiley ~~and~~ Greenbush and the lower part of the "Liverpool" formations 62/ from exposures near Avon, Fulton

---

62/ Savage, T. E., Geology and Mineral resources of the Vermont quadrangle. Illinois State Geol. Survey. Unpublished manuscript.

__________ Significant breaks and overlaps in the Pennsylvanian rocks of Illinois. Amer. Jour. Sci. vol. 14, p. 309, 1927.

County.

9986

"Liverpool" formation.

The "Liverpool" formation is named from exposures in secs. 7, 8, 16, 17, 20 and 21, T. 5 N., R. 4 E. (Liverpool twp.), in the Havana quadrangle where all the strata composing this formation are exposed. The formation consists of a basal sandstone, underclay, coal, gray shale, black hard shale, a succession of thin persistent limestone beds separated by dark fossiliferous shales and a thick gray shale. The sandstone and underclay are the uppermost strata of the Pottsville series and the other strata belong to the Carbondale series. This formation is widely distributed in exposures and drill records in the Havana quadrangle. In the southern part ~~of the quadrangle~~, the Pleasantview sandstone truncates all of the strata of this formation down to the coal or the lower part of the overlying gray shale. Thus the higher members of the formation are exposed and reported in drillings only in the northern half ~~of the quadrangle.~~ The formation is so thick that it is not entirely exposed in any one outcrop. ~~in the quadrangle.~~ The complete sequence of strata composing the formation is penetrated in a coal test boring ~~###~~ in the Blacksby school yard ~~in the northern part of the quadrangle.~~

Partial log of
Geologic section 19. Coal test boring in the Blacksby school yard at the NW. cor. sec. 24, T. 6 N., R. 3 E. (Putman twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Carbondale series		
Summum formation		
10. Shale, sandy (Pleasantview sandstone)	25	
"Liverpool" formation		
9. Shale, gray (Purington shale)	47	
8. Limestone (Oak Grove member)		7
7. Shale, dark (Oak Grove member)	6	
6. Shale, black, "~~fissile~~" hard	2	
5. Shale, gray, soft (Francis Creek shale)	11	7
4. Coal (Colchester ~~or~~ No. 2)	2	6
Pottsville series		
3. "Fire clay" (underclay)	1	6
2. Shale, gray	3	4
1. Sandstone (Isabel) ~~sandstone~~	5	

~~####################~~

Isabel sandstone member

The basal sandstone of the "Liverpool" formation is well exposed in many parts of the quadrangle. The best exposure is in a high cut bank on the east side of a ravine south of Spoon River in the ~~NE.~~ NW. ¼ NE. ¼ sec. 16, T. 4 N., R. 3 E. (Isabel twp.) which shows strata from the Pleasantview sandstone to the clay of the Seahorne formation (Fig. 28). The name Isabel is applied to ~~this~~ the sandstone from this exposure.

Summum

"Liverpool"

Green-
bush

Wiley

Seahorne

Fig. 28. Exposure of Pennsylvanian strata in high cut bank on east side of ravine south of Spoon River in the ~~NE.~~ N.W. ¼ NE. ¼ sec. 16, T. 4 N., R. 3 E. (Isabel top). The PleasantView sandstone shows in the upper right corner. The man near the center is sitting on the ~~horizon~~ level of the Colchester (No. 2) coal, here covered by slump from above. The underclay of the coal extends down to the massive cross bedded ledge forming Isabel sandstone at the middle of the cut. Below this sandstone, ~~the basal bed of the Colchester sequence~~ "Liverpool" formation, is a shale, a thin limestone, and a nonbedded clay with concretions, (Greenbush formation) a succession which can be distinguished at the edge of the shaded area to the right of the center. The ~~10 inch~~ coal shows below this and ~~its~~ underclay of the Wiley formation and the irregular surfaced fossiliferous Seahorne ~~"Ray or Astoria"~~ limestone. Just above the stream level the nonbedded clay below this limestone with its large calcareous concretions is visible.

Geological section 20. Cut bank of ravine south of Spoon River in the ~~NE~~ NW ¼ NE. ¼ sec. 16, T. 4 N., R. 3 E. (Isabel twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Carbondale series		
Summum formation		
14. Sandstone, buff, thinly to massively bedded (Pleasantview sandstone)	12	
"Liverpool" formation		
13. Shale, gray (Francis Creek)	3	
12. Coal (Colchester ~~or~~ No. 2), poorly exposed	2	6
Pottsville series		
11. Covered, principally underclay	6-8	
10. Sandstone, buff, ~~spotted~~ with brown spots of limonite, hard, massively bedded and crossbedded, forming a projecting ledge near middle of bank (Isabel sandstone)	8-10	
Greenbush formation		
9. Shale, gray, soft, well bedded	5	
8. Limestone, gray, unfossiliferous, weathering buff	1	
7. Underclay, light gray, with blocky fracture, containing irregular shaped calcareous concretions	3	
Wiley formation		
6. Coal	1	
5. Underclay, dark, not distinctly bedded		2
4. Underclay, light, with blocky fracture	2	4
Seahorne formation		
3. Limestone, blue gray, fine grained, with knobby upper surface, and lower surface projecting irregularly down into the underlying clay (Fig. 26)	3	6
2. Underclay, light gray, with blocky fracture, containing numerous large limestone concretions	3	
1. Sandstone, white or light gray, upper beds hard, weathering buff, exposed about 200 yards downstream from cut bank	3	

The Isabel sandstone is commonly massive. In some exposures it is thinly bedded and cross bedded. The grain ### is somewhat coarser than that of other Pennsylvanian sandstones in this area. It is almost everywhere light brown, with a great abundance of large, dark brown, limonitic specks. The average of six mechanical analyses of samples ~~of this sandstone~~ shows 22% fine sand, 32% very fine sand, 16% silt and 30% clay. In the other persistent Pennsylvanian sandstones the ~~percentage of~~ fine sand does not exceed 5%. In contrast with the sandstones of the Bernadotte and Seahorne formations, this ~~sandstone~~ contains a considerable quantity of calcareous cement. It rests with a sharp contact on the strata below in exposures in the southern part of the quadrangle. In one or two exposures the lamination of the shale beneath has been destroyed to a depth of about 2 feet below the contact, and the upper three or four inches is a black or dark gray clay somewhat resembling an old soil. This suggests that the surface was exposed for some time after the deposition of the shale ~~#########~~ and before the deposition of the ~~#######~~ sandstone. In the Havana quadrangle the underlying strata are not truncated to a depth of more than two to six feet. The sandstone ranges from three to about ten feet~~in thickness~~. In the Beardstown quadrangle sandstone and shale corresponding to the Isabel sandstone fill a channel excavated 60 feet or more into the underlying strata. The name Browning member has been applied to this channel sandstone.[63] The ###

---

[63] Searight, W. Geology and mineral resources of the Beardstown quadrangle. Illinois State Geol. Survey. Unpublished manuscript.

---

plant bearing shale described on page 71 is believed to be a part of the filling of this ~~shale~~ channel.

Underclay.

The underclay of the Colchester coal is two to six feet ~~in~~ thick~~ness~~. It contains large calcareous concretions similar to those found in the underclays of other coal beds. The results of tests made on a sample~~s~~ ~~of this clay~~ are tabulated in Appendix B, Part II.

Carbondale series

The Carbondale series is so named because it is well exposed in the vicinity of the town of Carbondale in Jackson County, Illinois.[64] It

---

[64] Shaw, E. W., and Savage, T. E., U. S. Geol. Survey Geol. Atlas, Murphysboro-Herrin folio (No. 185), p. 6, 1912.

COMPRISES the strata between the base of the Murphysboro (No. 2) ~~coal~~ and the top of the Herrin (No. 6) coal, and consists of shales, sandstones, thin limestones and most of the important coal beds of Illinois. It includes most of the "Liverpool" formation, all of the Summum and St. David formations, and the lower part of the Brereton formation. It has been considered a formation in previous publications of the Survey, but ~~is considered as~~ a series in this report.

Colchester (No. 2) coal.

The Colchester ~~or~~ (No. 2) coal is the most widely recognized member of the Pennsylvanian system in the Havana quadrangle. Because of its uniform dis- distribution ~~tribution~~ It has been used as a key horizon for# mapping the structure of the Pennsylvanian strata (Fig. 135 or Pl. II.). It is remarkably uniform in thickness, averaging two feet six inches in all the outcrops and drill records available. It ranges from two feet #### two inches to three feet. Bedded clay bands are absent in this coal, but pyrite is distributed through it in small bands or nuggets or irregularly. The cleavage faces are marked with thin platy films of calcite or calcite and pyrite mixed. The coal and associated strata are well exposed in a cut bank on the south side of Tater Creek near the western margin of the quadrangle (Fig. 29).

Geologic# section 21. Cut bank on the south side of Tater Creek near the SW. cor. SE. ¼ sec. 35, T. 5 N., R. 3 E. (Bernadotte twp.).

	Thickness Feet	Inches
Pennsylvanian system		
Carbondale ###### series		
Summum formation		
11. Sandstone, ############ somewhat shaly, buff to brown, fine grained, medium to thinly bedded (Pleasantview sandstone)	15	
###		
"Liverpool" formation		
10. Shale, sandy		5
9. Coal (Colchester or No. 2)		6
8. Pyrite concretion band, discontinuous		1
7. Coal	1	
6. Pyrite concretion band, discontinuous		1
5. Coal		8
Pottsville series		
4. Underclay, soft, gray, not bedded		6
3. Underclay, gray, with blocky fracture, more sandy in lower portion, with some calcareous concretions	6	
2. Sandstone, buff, hard (Isabel sandstone)	1	
1. Sandstone, soft	3	

In some mines the pyrite is reported as concentrated at the base of the coal.

Summun

"Liverpo

Fig. 29. Exposure of Pennsylvanian strata ~~i~~on the south bank of Tater Creek in the SE. ¼ sec. 35, T. 5 N., R. 2 E. (Bernadotte Twp.). The thin# bedded strata in the upper part of the picture ~~are~~ belong to the ~~fine~~ly ~~laminated~~ Pleasantview sandstones. The Colchester ## (No. 2) coal ~~unconformably~~ underlies this sandstone unconformably in the middle of the picture. The contact between the two is even. The underclay below the coal rests on a thin to massive bedded buff sandstone (Isabel) upon which the man is standing. The coal here is about 2 feet 3 inches thick.

Francis Creek shale member.

The usual roof of the Colchester coal is a soft bedded gray shale, which is dark gray in the lower 1 to 2 feet. ~~and~~ That portion of the shale in some places contains well preserved impressions of ferns and other fossil plants. It has been named the Francis Creek shale[65] from exposures along Francis Creek

[65] Savage, T. E., Significant breaks and overlaps in the Pennsylvanian of Illinois, Amer. Jour. Sci., vol. 14, p. 309, 1927.

about two miles west of Bernadotte, in the Vermont quadrangle, where ~~this shale~~ it is 42 feet thick. The shale is evenly bedded, and without calcareous or ferruginous concretions in most places. It is commonly slightly micaceous, and the upper 5 to 10 feet is slightly sandy in many ~~places,~~ exposures. The bedding surfaces suggest~~ing~~ wash marks along a shore line, made by advancing and retreating waves. The shale, where exposed in high banks, exhibits a spheroidal weathering, curved laminae of shale shelling off as from an iron-stone concretion or from an exfoliated granite boulder. This structure seems to be characteristic of the thicker beds, and laminae cannot commonly be seen cutting the curved exfoliating fragments. The Francis Creek shale varies in thickness from a maximum of 45 feet to a feather edge. In the southern part of the quadrangle the Pleasantview sandstone cuts out the calcareous strata above this shale and in many places cuts it out ~~this shale~~ entirely. In the part of the quadrangle south of Spoon River the interval between the top of the coal and the unconformity at the base of the Pleasant-view sandstone varies between ~~15~~ 20 feet and zero (Figs. 29 and 43). In the northeastern part of the quadrangle, the black ~~fissile~~ hard shale at the base of the calcareous beds above the Francis Creek shale occurs only a short distance above the Colchester coal. ~~and~~ In one drill record it is reported to rest directly on the coal. Figure 43 shows cross section diagrams of the strata between the Colchester coal and the Pleasantview sandstone in north-south and east-west directions across the quadrangle. The best complete

~~################~~ exposure of the Francis Creek shale is in a high cut bank on the south side of a large ravine just west of the junction of this valley with that of Big Creek. (Fig. 30).

Geologic section 22. Cut bank on south side of ravine in the SW. ¼ NW. ¼ sec. 4, T. 5 N., R. 3 E. (Lewistown twp.)

	Thickness Feet	Inches
Pennsylvanian system		
Carbondale series		
"Liverpool" formation		
5. Limestone, gray, fossiliferous, weathering yellow-brown, poorly exposed	1	
4. Shale, ~~####~~ slightly sandy, gray, with spheroidal weathering (Francis Creek shale)	43	
2. Coal, (Colchester ~~or~~ No. 2), base not exposed in western part of cut, rising toward east end, where base of coal is exposed	2	
3. Shale, dark gray, thin bedded, containing well preserved fossil plants	1	6
Pottsville series		
1. Underclay, dark to light gray, not bedded, exposed at east end of cut	2	

The fossil plants collected from bed 3 of the foregoing section, identified by Professor A. C. Noe are listed in Appendix ~~A~~, Pt. II.

Oak Grove marine member

The interval between the two thick shale members of the "Liverpool" formation, the Francis Creek below and the Purington above, is occupied by a succession of dark ~~fissile~~ shales, soft or hard, thin limestones or limestone concretions and gray shales with limestone concretions. These include beds 39-51 of the general section of the Pennsylvanian. The succession of these beds is not entirely persistent over the quadrangle, but certain of the beds are very persistent in this quadrangle and other parts of western Illinois. The intervals between some of the limestone bands vary only two or three inches in exposures 10 to 20 miles apart. The name Oak Grove marine member is proposed for these shales and limestones, as the succession is typically exposed in the ravine north of the Oak Grove school in the SW. ¼ SE. ¼ sec. 6, T. 5 N., R. 3 E. (Lewistown twp.), and fossil collections were made from most of the beds at this locality. (Fig. 31.)

Liverpool

Fig. 30 . Exposure of Carbondale strata of the "Liverpool" formation on the south bank of a large ravine in the SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 4, T. 5 N., R. 3 E. (Lewistown twp.), showing the gray fossiliferous limestone near the top of the cut (indicated by line) over the Francis Creek shale here about 45 feet thick. ~~and~~ The upper part of the Colchester coal shows just above the stream level. The dark colored shale beds above the coal contain well preserved fossil plant remains.

Fig. ~~40.~~3) Exposure of Carbondale strata in a ravine north of the Oak Grove School, in the SW. ¼ SE. ¼ sec. 6, T. 5 N., R. 3 E. (Lewistown twp.), showing the fossiliferous limestone bands above the Colchester Coal and associated carbonaceous and calcareous shales forming the Oak Grove marine member. The outcrop of the gray septarian limestone forms the waterfall in the foreground. The dark shales between this limestone and the dark gray brown weathering limestone are shown at the left of the fall, the latter limestone forming another water fall in the middle distance. The highest of the fossiliferous limestone bands outcrops on the spur in the distance, where the man is seated. The shale above this band is the basal part of the Purington ~~shale~~ member. This exposure furnishes excellent opportunities to collect fossils from this succession of fossiliferous beds.

The strata of the Oak Grove member are not exposed at any point south of an east-west line drawn through the southern part of Lewistown across the quadrangle, as they are cut out by the Pleasantview sandstone, ~~in the southern half of the quadrangle.~~

The sequence of these beds is well exposed in a cut bank on the east side of Buckheart Creek.################## (Fig. 31).

Geologic section 23. Cut bank on the east side of Buckheart Creek in the SW. ¼ SW. ¼ sec. 1, T. 5 N., R. 4 E. (Liverpool twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Carbondale series		
Summum formation		
## ####		
11. Sandstone, buff, thinly to medium bedded, with unconformable lower contact,# cutting more deeply into underlying strata in northern part of cut (Pleasantview sandstone)	3	
"Liverpool" formation		
Purington member		
10. Shale, gray to dark, evenly bedded	5	9
Oak Grove member		
9. Limestone, gray, fine grained, fossiliferous		3
8. Shale, ###### gray, with one or two discontinuous levels of calcareous oval concretions	4	
7. Limestone, dark blue gray, ########## very fossiliferous, weathering brown		3
6. Shale, black, ~~fissile~~, soft, fossiliferous	2	3
5. Limestone concretions, fossiliferous, not continuous		4
4. Limestone, gray, fine grained, fossiliferous, forming a ledge		6
3. Shale, dark gray, with three fairly persistent levels of calcareous and pyritic concretion bands, slightly fossiliferous	7	
2. Limestone, gray, sandy, apparently unfossiliferous		4
1. Limestone, dark blue gray, fine grained, ######## ############## very hard, forming ledge in Buckheart Creek, slightly fossiliferous	1	5

The beds numbered 4-9 in the above section are generally persistent throughout the quadrangle, but the lowest limestone (1 and 2) is present only in a small area ~~part~~ in ~~of~~ the northeastern part of the quadrangle in the drainage systems of Buckheart, Big Sister and Little Sister Creeks. Its equivalent is probably a black limestone exposed in the valley of Stuart Creek near the western

Fig. 34. Exposure of Carbondale strata on the east side of Buckheart Creek, in the SW. ¼ SW. ¼ sec. 1, T. 5 N., R. 4 E. (Liverpool twp.), showing the Pleasantview sandstone at upper left over 8-10 feet of Purington shale. A band of dark shale near the center of the picture lies between the brown weathering fossiliferous limestone and a gray septarian fossiliferous limestone. The hard limestone forming a ledge across the stream in the foreground is the lowest of the limestone bands.

(IF USED, A LIGHTER PRINT SHOULD BE MADE, TO BRING OUT MORE DETAIL IN THE DARK LEFT PORTION OF THE PICTURE)

 125

margin of the quadrangle. Below the base of ~~lowest in~~ the above section are one or two other members ~~which are~~ found in the eastern part of the quadrangle. This lower sequence of beds is well exposed in the north bank of a ravine draining northeast into Buckheart Creek in ########## sec. 11, T. 5 N., R. 4 E. (Liverpool twp.), about one half mile southeast of the exposure described in geologic section 23. (Fig. 33).

Geologic section 24. Exposure in the north bank of a ravine in the NE. ¼ NE. ¼ sec. 11, T. 5 N., R. 4 E. (Liverpool twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Carbondale series		
"Liverpool" formation		
Oak Grove member		
4. Limestone, gray, dense, slightly fossiliferous	2	6
3. Shale, carbonaceous, black, hard, finely laminated, containing large hard black limestone concretions near the middle, and small calcareous concretions less than one half inch in diameter in the lower portion, the thin laminae of the black shale bending around these small concretions, giving a wavy or pimply surface to the bedding plane	2	6
2. Shale, black, soft, finely laminated		3
Francis Creek member		
1. Shale, gray, soft	2	

Bed no. 4 in the above section corresponds with bed no. 1 in geologic section 23.

The black hard shale, (3) of the above section is nearly as widespread as the Colchester (No. 2) coal in much of western Illinois. ~~but~~ In the Havana quadrangle it is restricted to ### part of the northeast quarter ~~of the quadrangle~~. It is absent south of Cuba where the Francis Creek shale reaches its maximum thickness, but ~~it~~ is present in the lower valleys of Buckheart, Little Sister and Big Sister Creeks, where the Francis Creek shale is less than 20 feet thick. In the vicinity of St. David, 8 drill records in sections 9, 16, 20 and 21, T. 6 N., R. 4 E. (Buckheart) twp (Appendix C P.) show this hard shale directly on the Colchester coal in 4 drillings, and 2 to 7 feet of the Francis Creek shale between the coal and the hard shale

Fig. 33. Exposure of Carbondale strata on the northwest bank of a large ravine west of Buckheart Creek in the NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 11, T. 5 N., R. 4 E. (Liverpool top), showing a massive dark gray fossiliferous limestone in upper portion, over black ~~fissile~~ hard shale, containing numerous small calcareous concretions (whitish specks) in the lower portion, giving a wavy or pimply surface to the laminae of the shale. The soft bed at the base is the top of the gray Francis Creek shale. The black shale with small concretions shown here is widely distributed in western Illinois, either directly above the Colchester (No. 2) coal, or 5-~~30~~ 50 feet above it.

in the other 4 drillings.

The hard ~~fissile~~ shale splits easily into laminae $\frac{1}{4}$ to $\frac{1}{2}$ inch ~~in~~ thick~~ness~~. The large cleavage sheets are slightly elastic. In addition to the small calcareous concretions in the hard shale shown in fig. 33, there are locally large flattened oval concretions in the middle or lower portion of ~~the shale~~. These concretions are dark blue gray to black in color, very hard and unfossiliferous or slightly fossiliferous. Fig. 34 shows a number of these concretions washed out in the bed of a branch of Little Sister Creek. In a few exposures along Big Sister and Little Sister Creeks at the horizon of the black hard shale there are large masses of apparently brecciated limestone and hard black shale including masses of the large calcareous concretions, the black ~~fissile~~ shale and septarian limestone concretions thoroughly cemented together. The fragments of hard black shale are tilted at various angles as though they were detached after they had become quite thoroughly consolidated. The maximum diameter of these brecciated masses observed is 12 feet, and the maximum thickness 4 feet 6 inches. The fossils collected from the black shale and the concretions in it are listed in Appendix A, Pt. I.

The lowest of the limestone bands of the Oak Grove member is a finely laminated black fossiliferous limestone, which is well exposed along Stuart Creek in the SE. $\frac{1}{4}$ sec. 35 and the NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 36, T. 6 N., R. 2 E. (Cass twp.). The fossils in this bed are somewhat flattened, showing that it has been ~~somewhat~~ thinned during consolidation. The relation of this bed to the other limestone bands of the Oak Grove member is best shown in a cut bank on the east side of the east Branch of Stuart Creek (Fig. 35.)

Geologic section 25. Cut bank on the east side of the east branch of Stuart Creek near the SW. cor. NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 36, T. 6 N., R. 2 E. (Cass twp.)

	Thickness Feet	In.
Pennsylvanian system Carbondale series "Liverpool" formation		

Fig. ~~33~~ 34. Large flattened oval black calcareous concretions from the black hard ~~fissile~~ shale above the Francis Creek Shale ~~Colchester (No. 2) coal~~ washed out in the bed of an east tributary of Little Sister Creek in the SW. ¼ SE. ¼ sec. 10, T. 5 N., R. 3 E. (Liverpool twp.). about 100 feet east of the north-south mid-section line road. The black shale is exposed in the opposite bank of the creek.

Fig. 35. ~~Cut bank on ea~~ Carbondale exposure in a cut bank on the east side of the east branch of Stuart Creek, showing the Oak Grove limestone bands and dark shales between the Francis Creek and Purington shales. The hammer marks the base of the Purington shale. ~~and~~ The gray shale in the foreground is the top of the Francis Creek shale. The four limestone bands shown are nos. 3, 5, 8 and 10 of the accompanying described section.

	Thickness Feet	Inches
Pennsylvanian system		
Carbondale series		
"Liverpool" formation		
Purington member		
11. Shale, dark gray, soft, with many levels of discontinuous ferruginous and calcareous concretions and three bands of limestone 2 to 3 inches thick in the lower two feet	~~18~~ 21	
Oak Grove member		
10. Limestone, pyritic, gray, fossiliferous, weathering brown, with most fossils preserved as external and internal casts		3
9. Shale, black, soft, with a little gray shale, containing three 1 inch bands of limestone concretions, slightly fossiliferous	1	6
8. Limestone, dark blue gray, fossiliferous, weathering chocolate brown		2½
7. Shale, black, soft, fossiliferous, containing flattened impressions of Aviculipecten rectilaterarius, etc.	1	8
6. Limestone, ~~######~~ shaly, black, fossiliferous		4
5. Limestone, gray, fossiliferous, somewhat concretionary, weathering light brown, with abundant Marginifera muricata		8
4. Shale, sandy, dark gray, fossiliferous	1	
3. Limestone, dark blue gray, very compact, slightly fossiliferous		3
2. Shale, gray, fossiliferous, with a great abundance of crinoid stems		2
Francis Creek member		
1. Shale, sandy, dark blue gray	2	

The limestone band, no. 3 in the above section is the equivalent of the ~~fissile~~ platy limestone in sec. 35, about three quarters of a mile west of this outcrop, where this bed is 10 inches thick. East of this exposure this band disappears unless it is represented by an impure finely laminated unfossiliferous black to dark gray limestone in a stream cut on the southeast side of Big Creek near the center of the NE. ¼ sec. 35, T. 6 N., R. 3 E. (Putman twp.) about 5½ miles east of the above exposure. In the eastern part of the quadrangle, especially along the lower part of the valley of Buckheart Creek in secs. 1 and 11, T. 5 N., R. 4 E. (Liverpool twp.) ~~#~~ and along the bluff of Illinois River in sec. 22 of the same township, a massive dark blue slightly sandy fossiliferous limestone occurs in approximately the same position as that occupied by the limestone along Stuart Creek. The two may be equivalent in age, but representing ~~a~~ different facies, as the limestone along Stuart Creek contains mainly pelecypods (Cardiomorpha missouriensis, etc.) and goniatites, and the limestone in the eastern part of the quadrangle mainly brachiopods. In the intervening area many excellent exposures in the drainage basin of Big Creek show a sandy shale or fine grained sandstone with a few fossils, mostly Marginifera muricata, and numerous wave marks, in the approximate position of the limestone beds along Stuart and Buckheart Creeks. In secs. 33 and 34, T. 6 N., R. 3 E. (Putman twp.), ~~numerous~~ exposures along ravines north of Big Creek show a crinoidal limestone or a limestone conglomerate containing fragments of crinoid stems and rounded limestone pebbles 1 foot or 1 foot 6 inches below the gray septarian limestone horizon and just above the sandy shale with wave marks, in nearly the position occupied by the massive limestones east and west of this area. Fig. 36 shows the relations of ~~between~~ the various limestone and shale beds between the gray septarian limestone and the Francis Creek shale across the quadrangle from east to west.

A sample of the black fissile limestone from Stuart Creek which was tested with dilute hydrochloric acid contains 89.95% calcium carbonate and other soluble material, 3.17% clay, 6.00% silt and 0.87% fine sand. The silt and fine sand consist principally of small subangular grains of quartz 0.05 to 0.1 mm in diameter, a few subrounded grains of quartz to 0.3 mm. diameter, flakes of mica to 0.2 mm. diameter, dark gray micaceous silt containing some carbonaceous matter and hardened aggregates of silt. The fossils collected from this limestone ~~####~~ are listed in Appendix A, pt. I. Limestone of similar lithologic character and stratigraphic position is exposed along the road from the village of Marietta to Marietta station on the T. P. & W. railroad in the Vermont quadrangle and in various parts of the Beardstown quadrangle.

The sandy limestone with brachiopod fauna is best exposed in a small ravin along the bluff of Illinois River about 50 feet west of a secondary north-south road along the mid section line of sec. 22, T. 5 N., R. 4 E. (Liver-

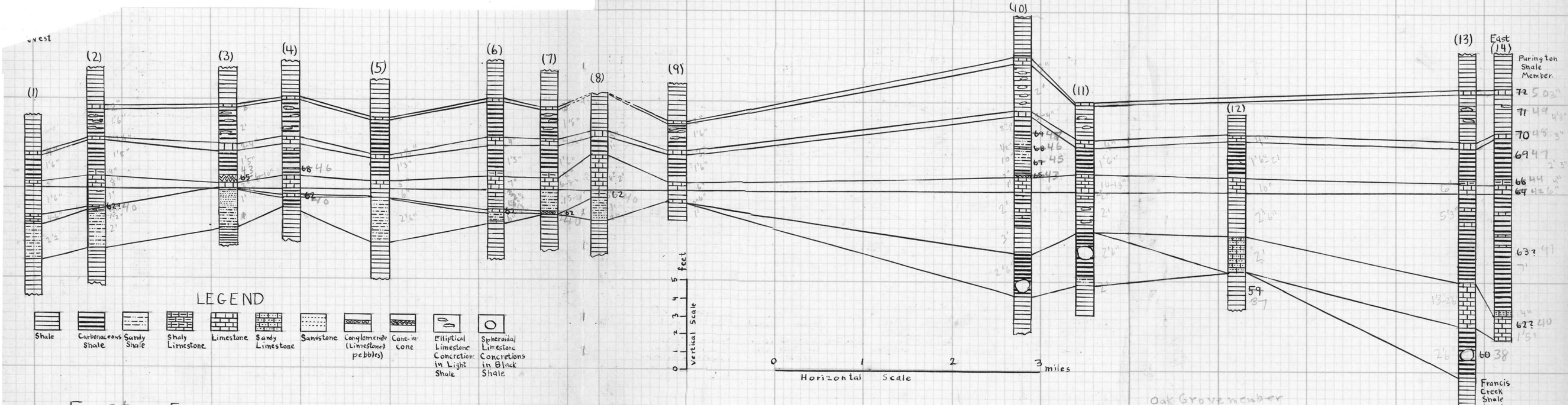


Fig. 3b. East-west cross section of the Havana Quadrangle illustrating variations in the limestone bands and dark shales of the ~~7th~~ Oak Grove member sequence of ~~Pennsylvanian strata~~ (nos. ~~60-73~~ 39-54 in generalized section). The strata are correlated on the base of the gray septarian limestone, (~~no. 64~~ no. 42) the most persistent of the limestone bands. Nos. correspond with numbers in general section. Note the marked uniformity in strata above the gray septarian limestone, which ~~is marked~~ in all parts of the quadrangle where these strata are exposed. No. ~~62~~ 40 is typically a crinoidal limestone or conglomerate as in (7) and (8). In (1) and (2) the limestone in this position is different both in lithology and fauna. In (12), (13) and (14), the limestone correlated with ~~62~~ 40 is different from each of the other limestone. The fissile black shale (no. ~~60~~ 38) in (10), (11), and (13) is widely distributed in western Illinois, but locally ~~distributed~~ in this Quadrangle. Fig. 43 shows the relation of this zone to the Colchester (No. 2) coal below and the Pleasantview sandstone above.

pool twp.). This secondary road is not shown on the topographic map.

Samples of the crinoidal limestone and crinoidal conglomerate mentioned above were tested with dilute hydrochloric acid. The limestone ######## is 87% soluble in the acid ($CaCO_3$, etc.), and contains 4.1% clay, 4.95% silt and 3.95% sand.########### The silt and sand consist principally of hardened aggregates of micaceous silt and a few flakes of muscovite and grains of# quartz to 0.1 mm. diameter. The crinoidal conglomerate ######## is 88.08% soluble in the acid, and contains 7.3% clay, 2.97% silt and 1.65% sand. The coarser residue consists principally of hardened aggregates of muscovite and quartz particles about 0.02 to 0.05 mm. diameter. The pebbles in the conglomerate are black limestone ~~pebbles which are~~ well rounded, and commonly range from $\frac{1}{4}$ to $1\frac{1}{4}$ inches in maximum diameter. As the conglomerate is not known to overlie the black fissile limestone of the Stuart Creek region it is possible that these pebbles are derived from that bed. ########### The fossils collected from the crinoidal limestone and conglomerate are listed in Appendix A, pt I. Crinoid stems and the bryozoan <u>Rhombopora</u> <u>lepidodendroidea</u> are the commonest forms.

Above the crinoidal limestone horizon there is commonly 15 to 18 inches of dark gray shale with more or less continuous calcareous concretion layers. Fossils are present in the shale and concretions, but they are not as abundant or as well preserved as in the limestones above and below.

Above the gray shale is the gray septarian limestone ########, the most persistent member of the limestone bands in this quadrangle. This is a rather light blue gray limestone forming one or locally two benches 6 inches to 1 foot 6 inches thick. It is normally a continuous band, but is locally concretionary with a septarian structure. This limestone weathers a light yellow brown. It is well exposed in the bed of a ravine west of Big Sister Creek where the following section was measured: (Figure 37).

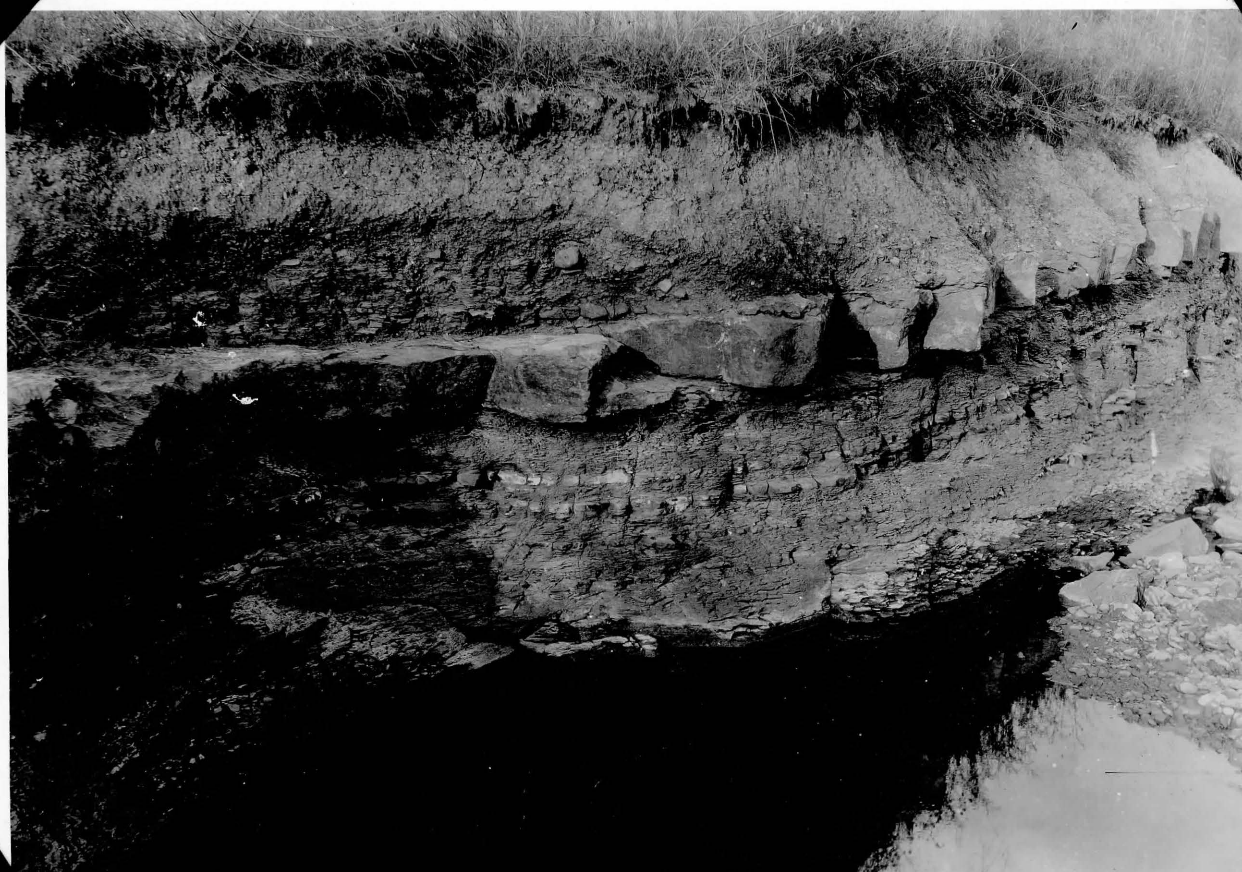


Fig. 367. ~~Carbondale~~ Exposure of Carbondale strata in north bank of ravine tributary to Big Sister Creek near the NE. cor. NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 17, T. 5 N., R. 4 E. (Liverpool twp.), showing the gray fossiliferous limestone about 20 feet above the Colchester (No. 2) coal and associated beds. See ~~described~~ geologic section ~~on p.~~ 26. Cone-in-cone ~~structure~~ is developed on the upper surface of this limestone near the center of the picture. Two thin limestone bands are shown below the prominent band

Geologic section 26. Exposure in a ravine near the NE. cor. NW. ¼ NW. ¼ sec. 17, T. 5 N., R. 4 E. (Liverpool twp.)

	Thickness Feet	Inches
Pennsylvanian system		
Carbondale series		
"Liverpool" formation		
Oak Grove member		
12. Shale, #### slightly sandy, dark gray, medium bedded		6
11. Shale, black, forming nearly a solid band of shells of Chonetes mesolobus, with some Derbya crassa, Leda bellistriata, etc; shells are white		1
10. Shale, calcareous, dark gray, similar to 12	1	2
9. Shale, black, soft, fossiliferous		4
8. Limestone, light gray, ######### slightly fossiliferous, weathering yellowish or buff, with cone-in-cone on upper surface (gray septarian limestone horizon)		8
7. Limestone, gray, fossiliferous, with abundant Marginifera muricata; weathering brownish		4
6. Shale, dark gray		10
5. Limestone, shaly, dark gray, slightly fossiliferous		2
4. Shale, dark gray		2
3. Limestone, shaly, dark gray		2
2. Shale, dark gray		7
1. Shale, light blue gray	1	4

Cone-in-cone structure is quite characteristic of the upper surface of this limestone, and ~~it~~ is found in many separate exposures, but shows much variation. ############ In the NE. ¼ NE. ¼ sec. 12, T. 5 N., R. 2 E. (Bernadotte twp.) the cone-in-cone is on the upper surface of this limestone in some exposures and on the lower surface of the dark brown weathering limestone 1 foot 6 inches higher in other exposures. Cone-in-cone has also been reported at this horizon in the vicinity of Galesburg, Knox County.[66]

[66] Poor, R. S., Geology and mineral resources of the Galesburg quadrangle. Illinois State Geol. Survey. Unpublished manuscript.

The cone-in-cone is typically shown in figure 38.

Septarian concretions are abundant at this horizon in some outcrops, locally giving a hummocky appearance to the surface of the limestone, and in other places the horizon may be represented by a discontinuous band of concretions. A typical septarian concretion from this horizon is shown in

Fig. 38. Cone-in-cone structure from the upper surface of the gray septarian limestone above the Colchester (No. 2) coal in a ravine in the SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 34, T. 6 N., R. 3 E. (Putman twp.). The cone-in-cone here is 8-10 inches thick.

A DARKER PRINT SHOULD BE USED TO BRING OUT THE DETAIL OF THE STRUCTURE MORE CLEARLY figure 39.

Fossil remains are abundant in this limestone, but the species Marginifera muricata greatly exceeds others ~~species~~ in abundance. In one exposure at the mouth of a small ravine along ~~the~~ Illinois River valley in the NW. 1/4 NE. 1/4 sec. 29, T. 5 N., R. 4 E. (Liverpool twp.) (Geologic section 29) this limestone has a much larger fauna than at other exposures in the quadrangle, ~~The fauna here~~ including a large number of pelecypods and gastropods. The fossils collected from the gray septarian limestone are listed in Appendix A, Pt. I.

This limestone is the most widely distributed of the limestone bands of the Oak Grove marine member, and it has been recognized in several adjacent areas.[67]

---

[67] Savage, T. E. Geology and mineral resources of the Avon and Canton quadrangles. Illinois State Geol. Survey, bull. 38, pp. 230-235. 1922.
Savage, T. E. and Nebel, N. L. Geology and mineral resources of the Good Hope and La Harpe quadrangles. Illinois State Geol. Survey, Bull. 43, pp. 49-51, 1921.
Savage, T. E. Geology and mineral resources of the Vermont quadrangle. Illinois State Geol. Survey. Unpublished manuscript.
Poor, R. S. Geology and mineral resources of the Galesburg quadrangle. Illinois State Geol. survey. Unpublished manuscript.
Wanless. H. R. Geology and mineral resources of the Alexis quadrangle. Illinois State Geol. Survey. Bull. , pp. , 1930.
Workman, L. E. Personal communication (Monmouth quadrangle)
Cox, B. B. Personal communication (Liberty quadrangle)

Strata between the gray septarian limestone and the dark gray brown weathering limestone

The interval between the gray septarian limestone and the next prominent limestone band above is normally 1 foot 5 inches to 2 feet in the Havana quadrangle. Immediately above the gray limestone there is commonly a ferruginous shaly limestone or calcareous shale. The shale contains well preserved fossils which weather out in large numbers along the outcrop of the bed. Gastropods of the Bellerophon type are especially abundant and characteristic. The species collected from this bed are listed in Appendix A, Pt. I

The shale above this calcareous shale is dark gray and slightly fossil-

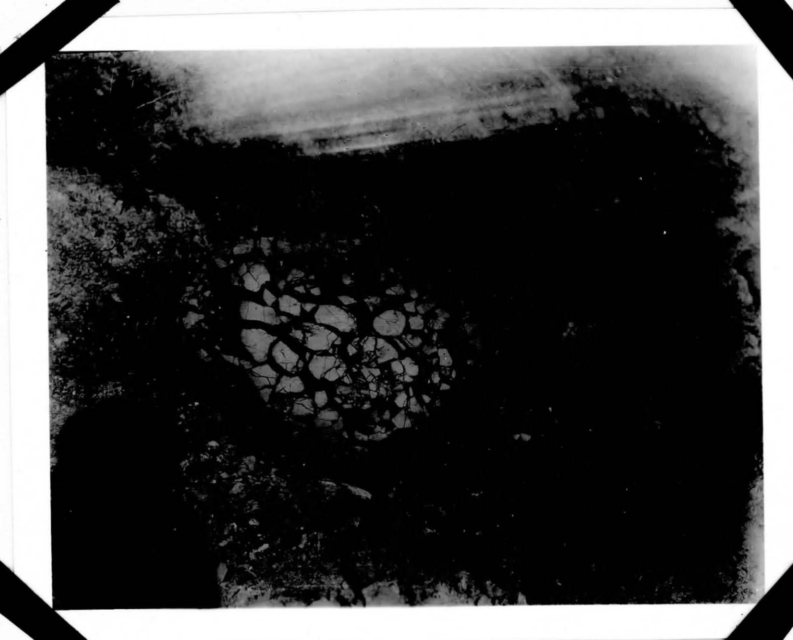


Fig. 39. Septarian limestone concretion from the gray septarian limestone horizon about 20 feet above the Colchester (No. 2) coal along the bluffs of ~~the~~ Illinois River near the center of the west line of the NW. ¼ NE. ¼ sec. 29, T. 5 N., R. 4 E. (Liverpool twp.).

iferous, with Marginifera muricata as the most abundant species. It is 8 to 10 inches thick.

About 10 inches above the gray septarian limestone there is a widespread band of white shells of Chonetes mesolobus and a few other species, which can be easily recognized. It has been reported from several other quadrangles, although it is only about 1 inch thick. The species collected from this band are listed in Appendix A, Pt. I.

Above the Chonetes mesolobus band is black soft shale, 8 or 10 inches thick, without calcareous concretions except a discontinuous band of brown weathering concretionary limestone in the lower part of this shale. ~~The shale is 8 or 10 inches thick.~~ It is crowded with the flattened impressions of Aviculipecten rectilaterarius, and it contains a few specimens of Lingula umbonata, ~~and~~ Orbiculoidea missouriensis, and one or two other forms. Like the persistent limestones above and below this shale is known to extend over 8 or 10 quadrangles ~~or more~~ in western Illinois, and throughout this area the bedding surfaces are crowded with the impressions of Aviculipecten rectilaterarius.

The brown weathering concretionary limestone contains abundant well preserved uncrushed shells of pelecypods, especially Cardiomorpha missouriensis and Chaenomya sp. The fauna of this limestone band is almost wholly different from the gray septarian limestone below and the dark gray brown weathering limestone above, as well as the adjacent shales. A sample ~~of this limestone~~ was tested and found to be 83.50% soluble in dilute hydrochloric acid, and to contain 11.25% clay, 1.37% silt and 3.87% sand. The coarser insoluble residue contains some pyrite which forms internal casts of many of the pelecypod shells. The species collected from this pelecypod limestone band are listed in Appendix A, Pt. I.

Dark gray brown weathering limestone

The next persistent limestone band above the gray septarian ~~limestone~~ is a somewhat thinner band of dark blue gray limestone, which weathers to a dark reddish brown. It is about 1 foot 6 inches to 2 feet above the gray limestone, and commonly ranges from 3 to 6 inches, ~~in thickness~~. It is practically as widely distributed as is the lower band, and is also known to occur west, southwest and northwest of the quadrangle as far as Liberty, Adams County, and Viola, Mercer County, each 60 miles or more distant. A sample of this limestone which was tested is 86.58% soluble in dilute hydrochloric acid, and contains 6.75% clay, 4.05% silt and 2.62% sand. The coarser insoluble residue consists principally of aggregates of very fine dark gray micaceous silt, abundant small nodules of pyrite, some as large as 0.2 mm.; a few grains of quartz (0.2-0.3 mm. diameter) much larger than the surrounding grains, fairly well rounded and frosted; a number of fragments of silicified hollow spines, possibly small Productus spines; and numerous silicified and pyritized shells and shell fragments of minute gastropods. The larger rounded quartz grains are probably wind deposited. Figure 40 shows a typical exposure of this limestone band. It ~~This limestone~~ is everywhere very fossiliferous, with Ambocoelia planoconvexa and Productus cora, var. as the most conspicuous fossils. The species collected ~~from this~~ limestone ~~band~~ are listed in Appendix A, Pt. I

Above this limestone band there is commonly a dark blue gray or black shale approximately 2 feet thick, containing two or three discontinuous bands of ferruginous limestone concretions, with ~~containing~~ a few fossils, principally gastropods. The fossils in these concretions are similar to those in the thin limestone band just above this shale interval. Fossil traces are also present in the shale, but not in abundance except in the uppermost 2 or 3 inches, ~~of the shale,~~ just below the thin limestone band. The species collected from this shale are listed in Appendix A, Pt. I.

The highest of the persistent bands of fossiliferous limestone is situated about 2 feet above the dark gray brown weathering limestone. It is brownish gray in color, and commonly ranges from 2 to 3½ inches, ~~in thickness~~. It is very fossiliferous, and the fossil remains are ~~######~~ uncrushed, but the actua

Fig. 39 . Carbondale exposure in the ravine north of the Oak Grove School in the SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 6, T. 5 N., R. 3 E. (Lewistown twp.), showing the dark gray brown weathering limestone band and associated calcareous shales locally warped into a sharp fold. ~~probably as a result of ice shove~~.

shells are largely dissolved away or at least partially leached, with chalky white calcite remaining on the internal part of the shell. The external and internal dasts of pelecypod and gastropod shells preserve the minute details of sculpture more distinctly than ~~they are preserved~~ in any of the other fossiliferous beds in the quadrangle. A sample of this limestone which was tested is 81.35% soluble in dilute hydrochloric acid, and contains 12.7% clay, 1.8% silt and 4.15% sand. A considerable part of the coarser insoluble residue consists of shells or shell fragments of gastropod shells of the species ___ which are silicified. The species collected from this limestone band are listed in appendix A, Pt. I.

Purington shale member

Above the highest limestone band of the Oak Grove member there occurs a widespread gray soft clay shale, similar to the 2 feet of shale immediately below this limestone band. There are numerous levels of flattened oval calcareous and ferruginous concretions occasionally containing marine fossils similar to those in the limestone band below, in the lower 5 to 10 feet of the shale. In the upper part of the shale such concretion levels are less frequent and marine fossils have not been discovered. ~~in them~~. The lower 5 to 10 feet of the shale has ~~is characterized by~~ a rectangular system of joints, while the upper portion usually shows a polygonal jointing, suggesting a mud crack or desiccation pattern. This jointing is well shown in fig. 41. The shale is exposed in many places in the northern half of the quadrangle, but it is absent in the southern half, ~~of the area~~, where the Pleasantview sandstone cuts it out completely. The average thickness of the shale, where it is not truncated by the overlying sandstone, is 35 to 50 feet. A typical exposure of the shale is in a high cut bank on the west side of the ravine followed by the West Havana branch of the Chicago, Burlington and Quincy Railroad where the following section was measured:

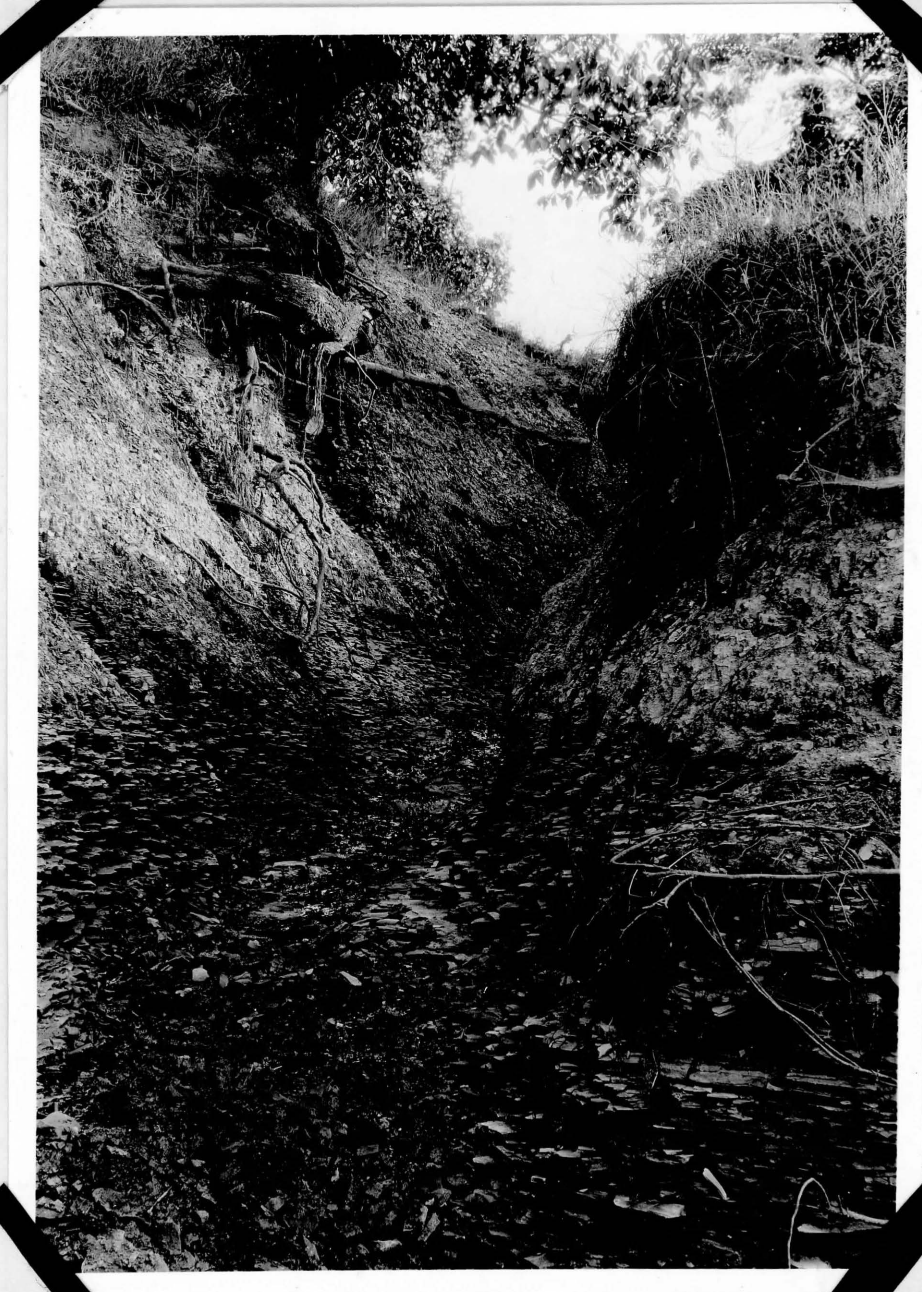


Fig. 41. Exposure of Carbondale strata in a small gully south of east-west section line road in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 17, T. 5 N., R. 4 E. (Liverpool twp.), showing the Purington gray shale with characteristic polygonal weathering.

Geologic section 27. Exposure in cut bank on west side of ravine in the NE. ¼ NE. ¼ sec. 31, T. 6 N., R. 3 E. (Putman twp.)

		Thickness Feet	Thickness Inches
Pennsylvanian system			
Carbondale series			
"Liverpool" formation			
Purington shale member			
10.	Shale, sandy, gray	6	
9.	Shale, gray, soft, grading into slightly sandy shale in upper part	22	
8.	Concretion band, calcareous and ferruginous, discontinuous		2½
7.	Shale, gray, soft	1	6
6.	Concretion band, calcareous and ferruginous, discontinuous		2
5.	Shale, gray, soft	1	3
4.	Concretion band, gray, calcareous and ferruginous, discontinuous		3
3.	Shale, gray, soft	2	7
2.	Concretion band, gray, calcareous		3
1.	Shale, gray, soft, to base of exposure	3	

This exposure shows all but the lower 10 to 12 feet of this shale and is typical of many exposures.

Fossil invertebrates are present only sparingly in the concretion layers near the base of the Purington shale. Fossil plants were not found in this shale except in one exposure of a rather sandy shale which belongs near the top of this member or represents a shaly phase of the overlying Pleasantview sandstone. This plant bearing shale is exposed in a cut bank along the southeast side of a large ravine north of Big Creek near the SW. cor. SE. ¼ SE. ¼ sec. 24, T. 6 N., R. 3 E. (Putman twp.) The leaves and stems of ferns and other plants are abundantly and excellently preserved in this shale. The species of plants collected ~~from this shale~~ are listed in Appendix A. P.T. II

Because there is no sandstone ~~above~~ between this plant bearing shale and the Springfield coal above, and ~~because~~ plant remains have not been found elsewhere in the Purington shale, ~~####~~ this shale seems more likely to belong to the Pleasantview than the Purington member.

A thick shale occurs above the gray septarian limestone and the other limestone bands in the Avon and Canton quadrangles, 68/ and the shale in the

Sa

 145

68/ Savage, T. E. Geology and mineral resources of the Avon and Canton quadrangles. Illinois# State Geol. Survey, Bull. 38, p. 236 . 1921.

pits of the Purington Paving Brick Co. of East Galesburg, Knox County, ~~has been found to~~ occupies ~~occupy~~ the same position. The name Purington shale was proposed from this locality.69/

69/ Poor, R. S. Geology and mineral resources of the Galesburg quadrangle. Illinois State Geol. Survey, Unpublished manuscript.

Stratigraphic relations of the ########## "Liverpool" formation.

The strata of this formation rest unconformably on the strata of the # Greenbush formation, although in the Havana quadrangle the unconformity is not important. A stratigraphic break within the formation is suggested by the variation in thickness of the Francis Creek shale from 45 feet south of Cuba to a feather edge near St. David. This variation in thickness may be the result of erosion or nondeposition, although the latter appears the more probable. Figs. 42 and 43A ####### show the relations in an east-west section across the quadrangle. The higher members of the formation are truncated by the Pleasantview sandstone, the basal member of the Summum formation, in many parts of the quadrangle. This unconformity is discussed more fully in connection with the ## Summum formation.

Paleontology and correlation.

The lists of fossil plants and invertebrates collected from the "Liverpool" formation are given in Appendix A, Pls. I and II. The ######### Oak Grove marine member is marked by the extreme abundance of Chonetes mesolobus and Marginifera muricata. A similar zone is recognized in the Pennsylvanian in many other parts of the country. It has been correlated with the lower part of the Allegheny formation of Ohio, and is approximately equivalent to the Putnam Hill limestone, a widespread limestone with similar fauna. Comparison with

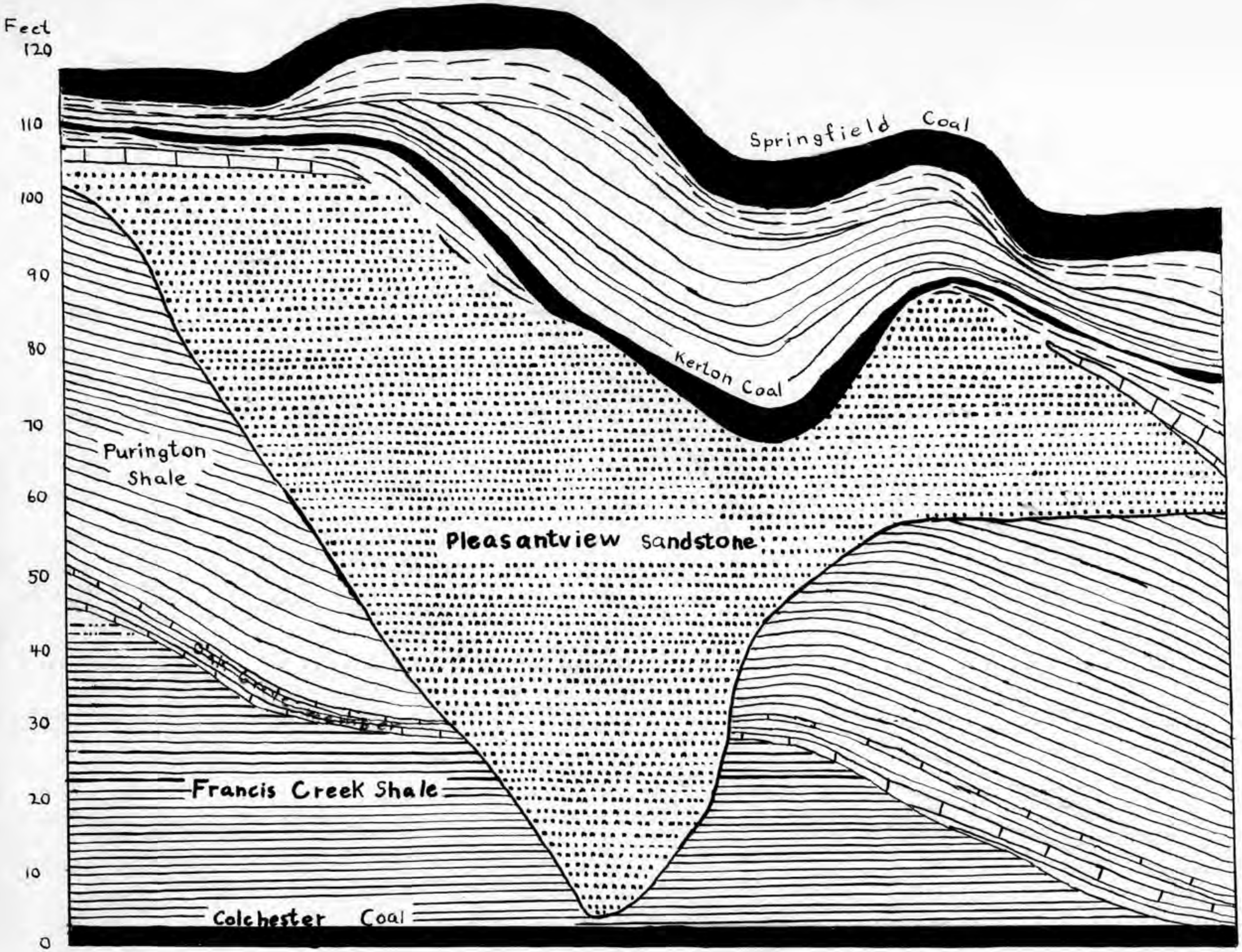


Fig. 42 Generalized Cross Section showing relations of Springfield (No. 5) Coal, Pleasantview sandstone and Colchester (No. 2) Coal between Cuba and St. David, Fulton County, Ill.

fossil lists from Missouri indicates that the calcareous beds are probably equivalent to those over either the Bevier or Mulky coal beds in the upper part of the Cherokee shale. In Texas the Chonetes mesolobus zone is situated in the Mineral Wells formation. The fossil plants collected from this sequence indicate

Summum formation

The Summum formation is so named because the strata composing it are well exposed in a ravine northeast of the village of Summum in sec.34, T. 4 N., R. 2 E. (Pleasant twp.) and sec. 3, T. 3 N., R. 2 E. (Woodland twp.) This exposure is about one mile west of the Havana quadrangle. At the type exposure the formation consists of a basal sandstone, sandy shale, fresh water limestone, underclay, coal, and dark shale containing large concretions with a few marine fossils. ~~At the type locality~~ Here, and at some other places there is an unconformity below the coal which may cut out the intervening beds and rest on the basal sandstone. S~~trata corresponding to~~ all of those mentioned ~~the~~ above ~~mentioned strata~~ are exposed in the Havana quadrangle. This formation is widely distributed in all parts of the quadrangle, but through most of the southern half, all of the strata younger than the basal sandstone ~~of this formation~~ have been removed by post-Pennsylvanian erosion.

Pleasantview sandstone and sandy shale.

The basal member of the Summum formation is a thin bedded fine grained micaceous shaly sandstone alternating with beds or lens shaped masses of more thoroughly cemented massive sandstone. It exhibits great lateral variation in lithologic character and thickness. In the vicinity of Cuba it is represented by 5 to 10 feet of thin bedded sandy shale with one to two feet of soft thin bedded micaceous sandstone. It is there not sharply separate from the underlying Purington shale, which grades up into this more sandy material. In the southern~~#~~ part of the quadrangle it attains a thickness of 60 to 80 feet, and consists of thin bedded soft sandstone with a few hard and massive layers. Its typical appearance in this area is shown in fig. 44.

~~##############################~~
This sandstone is named the Pleasantview because it is excellently exposed in Mill Creek north of the village of Pleasantview, Schuyler County, in the Beardstown quadrangle.10/

10/ Searight, W. Geology and mineral resources of the Beardstown quadrangle. Illinois State Geol. Survey, Unpublished manuscript.

The color of the Pleasantview sandstone ranges from buff and yellowish ~~##~~ brown to gray and locally nearly black. Carbonaceous material is more abundantly distributed through the thinner layers of this sandstone than in any of the other sandstones exposed in this quadrangle. The lower two or three feet are ~~especially~~ marked by the concentration of plant debris. Stem impressions of Cordaites, Lepidodendron, Sigillaria and Calamites make up the greater part of this zone in some localities. Thin streaks of coaly material resulting from the carbonization of logs of driftwood are also ~~not un~~common in this layer. The lower~~most~~est portion is also locally conglomeratic, with pebbles to two or three inches diameter. These pebbles commonly consist of gray calcareous concretions without marine fossils resembling the concretions in the Purington shale. One fragment of dark gray brown weathering fossiliferous limestone from the Oak Grove member was found at the outcrop of this sandstone south of Spoon River, apparently a pebble which had weathered out of it. No pebbles of quartz, chert, or igneous or metamorphic rocks were observed in the sandstone, and no pebbles were observed higher than two or three feet above its base.

Fig. 44 . Carbondale exposure in the west bank of a ravine south of Otter Creek in the NW. ¼ SW. ¼ sec. 36, T. 4 N., R. 2 E. (Pleasant twp.), showing the ~~#######~~ alternation of thin shaly beds and lenticular massive beds characteristic of the Pleasantview sandstone.

Cross bedding is very characteristic of this member, and the inclination of the foreset beds locally reaches 15-20°. The direction of inclination of the foreset beds is variable, although within a single ravine most of the beds may exhibit approximately the same direction of inclination. The thin bedded micaceous beds show cross bedding more commonly than the more massive layers. Ripple marks are also commonly developed on certain surfaces, especially of the more massive layers. Fig. 45 illustrates a ripple marked surface of this sandstone. The upper portion of the sandstone ~~characteristically~~ contains large concretionary masses of sandstone, consisting of the same type of clastic material# as the rest of the sandstone, thoroughly cemented with a calcareous cement. The bedding planes pass from the sandstone into the concretions instead of bending around them. In several places these concretions are 4 or 5 feet thick# and 10 to 18 feet in diameter. Fig. 46 illustrates large concretions of this type.

Examination of the sandstone under the binocular microscope shows that it consists of scattered larger grains of# quartz, which ###### not uncommonly show crystal faces, set in a matrix of fine material which gives the appearance of poor sorting. Muscovite is abundant and is principally concentrated along bedding planes. Feldspar grains are found, but many of these are clouded by weathering, and in ## no specimen examined are they abundant enough to consider the rock an arkose. In some specimens limonite specks are abundantly distributed through the sandstone. All ~~of the specimens~~ are calcareous, but there is great variation in the calcareous content. Mechanical analysis of 10 samples showed great divergence in the percentgages of fine sand, very fine sand, and clay. The average of the ten analyses shows 3% fine sand, 46% very fine sand, 27% silt and 24% clay. This ## is similar to only one of the ten analyses. Five samples should be classed as very fine sandstones and five as siltstones or sandy shales. In most respects the samples ~~of this sandstone~~ closely resemble those from the Cuba sandstone of the Brereton formation, but carbonaceous matter is more abundant in the Pleasantview. Heavy minerals are

Fig. 45 Detached fragment of a massive phase of the Pleasantview sandstone along east bank of valley in the SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 19, T. 6 N., R. 4 E. (Buckheart twp.), showing a ripple marked surface of this sandstone.

Fig. 46. Carbondale exposure in the north wall of a ravine east of Big Creek in the NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 19, T. 5 N., R. 3 E. (Lewistown twp.), showing large calcareous concretions in the upper part of the Pleasantview sandstone.

present in all samples, but do not constitute more than 1% of the grains in most ~~samples~~. Zircon and tourmaline are the most abundant heavy minerals ~~in this sandstone~~, and garnet is also fairly common.

Stratigraphic relations

The basal surface of this sandstone is one of marked irregularity, with a total relief of 70-80 feet. The sandstone normally rests on the soft gray shale of the Purington ~~shale~~ member, with no evidence of a break. The silt content of the shale increases upward, it becomes more micaceous, and about 5 feet above the normal gray clay shale is found a fine grained sandstone, representing this member. Elsewhere the upper beds of the Purington shale are absent and the break is sharp, a massive sandstone bed resting directly on the clay shale of the Purington member. ## From this position the basal surface of the Pleasantview sandstone truncates the various limestone beds and carbon## aceous shales ~~b#####################~~ of the Oak Grove member, and the upper part of the Francis Creek shale. In many exposures in the southern half of the quadrangle the Francis Creek shale is entirely absent and the sandstone rests directly on the Colchester (No. 2) coal (Fig. 29). Elsewhere the sandstone is reported to truncate this coal and to rest on Pottsville strata, but in the Havana quadrangle no exposures were found where the coal was absent. Information regarding this irregular surface is available from outcrops and drill records at 423 places quite uniformly distributed throughout the Havana quadrangle. Examination of these records shows that in 208 places the Pleasantview sandstone rests on the Purington shale either in apparent conformity on the upper layers or in apparent unconformity on the middle and lower layers, and in 215 places it rests on strata older than the Purington shale. The data regarding this surface are plotted graphically on fig. 47. This figure shows # that the basal surface of this sandstone member is comparatively level on the Purington shale in the northeastern part of the quadrangle west to a line running from one quarter mile west of the Blacksby school near the north border to

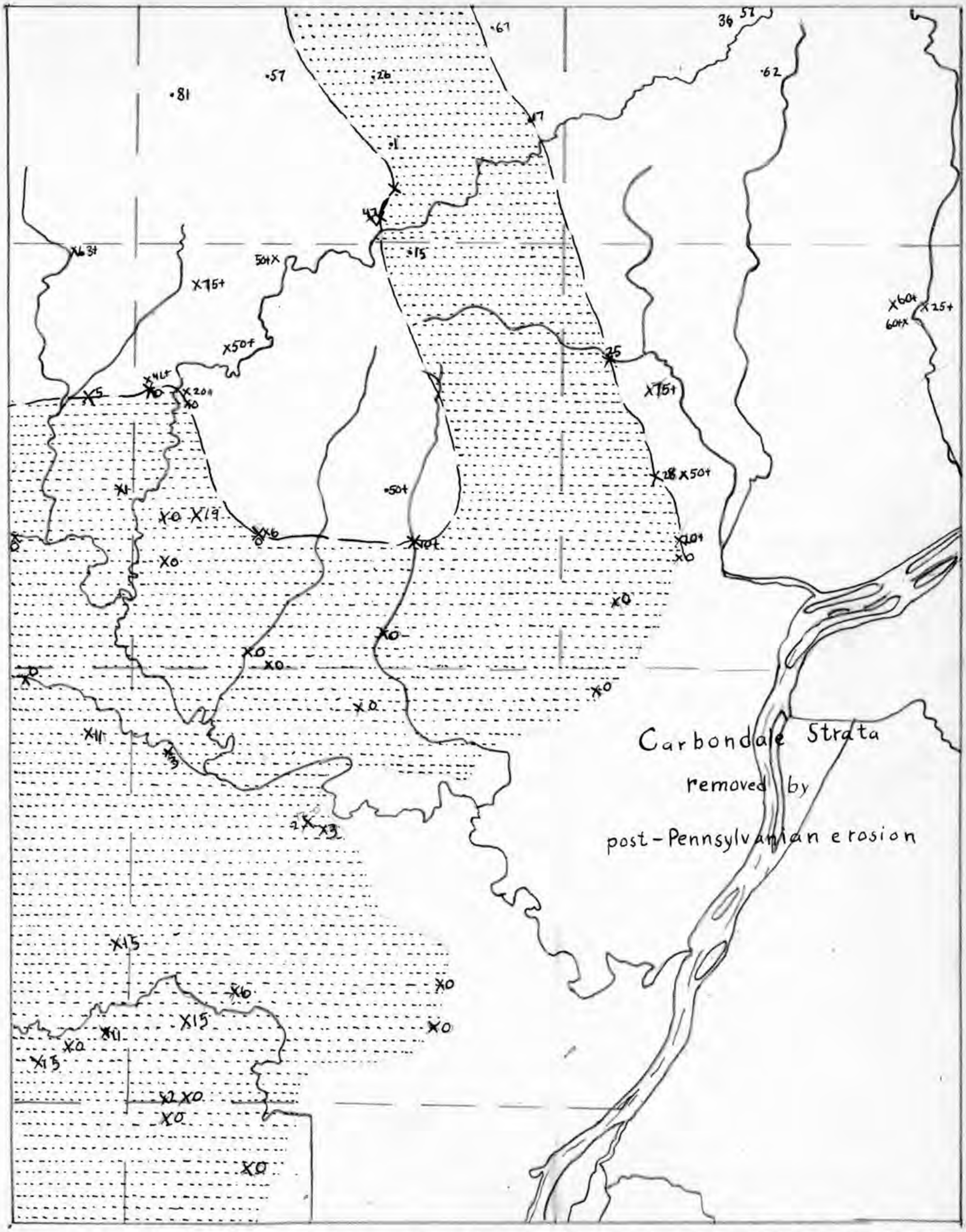


Fig. 47 . Map showing distribution of uplands (plain) and valleys or lowlands (dotted) eroded before the deposition of the Pleasantview sandstone. X indicates exposures showing the margins of valley areas and exposures where the approximate thickness of strata between the Colchester (No. 2) coal and the Pleasantview sandstone can be measured. A dot indicates a drill record showing the thickness of strata between the Colchester coal and the Pleasantview sandstone. The boundary is not projected across ~~the~~ Illinois River valley, as Carbondale strata have been removed from that area by post-Pennsylvanian erosion.

the Mt. Pleasant school near the bluffs of ### Illinois River. Similar relations exist in the northwestern portion of the quadrangle east to about one half mile east of Cuba and Lewistown, and south to the southern edge of Lewistown and a winding border extending north and west to the margin of the quadrangle in sec. 11, T. 5 N., R. 2 E. (Bernadotte twp.). The basal surface rests on strata older than the Purington shale south of this line in the entire southern half of the quadrangle, and in a belt approximately 2½ miles wide trending about north-northwest to south-southeast between the two areas mentioned above. The boundaries between these areas are in several exposures sharply defined by steeply inclined basal surfaces. Fig. 48 illustrates such an exposure in the NE. ¼ NE. ¼ sec. 34, T. 6 N., R. 3 E. (Putman twp.), where a soft thin bedded phase of the Pleasantview sandstone truncates the middle part of the Francis Creek shale member with its basal surface sloping about 20° toward the east. As similar steep slopes are observed on both sides of the 2½ mile belt in the northern part of the quadrangle it seems to represent a stream valley cut into the lower Carbondale strata before the beginning of the deposition of the Pleasantview sandstone. A continuation of this valley northward has been traced two-thirds of the way across the Canton quadrangle. The sandstone in this area may then be a channel phase. Mechanical analyses ~~which were~~ made, were too few to show the difference in texture between the sandstone in this belt and in the adjacent belts, but field examination shows that sandstone of coarser texture is more commonly in areas of the channel type. Fig. 49 shows the Pleasantview sandstone resting directly on the gray septarian limestone of the Oak Grove member along one of the valley margins in the NE. ¼ SW. ¼ sec.20, T. 5 N., R. 4 E. (Liverpool twp.).

In the southern portion of the quadrangle the sandstone varies ~~ranges~~ from ### ########## 15 feet above the Colchester coal to direct~~ly in~~ contact with it. In a few exposures one or two inches of the top of the coal seems to be truncated by the sandstone, and in one exposure a small mass of the sandstone

Fig. 48 . Exposure along the south bank of a ravine in the NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 34, T. 6 N., R. 3 E. (Putman twp.) showing the unconformable contact of ~~the~~ shaly sandstone belonging to the Pleasantview sandstone member on horizontally bedded Francis Creek shale at the western margin of a channel eroded before the deposition of the Pleasantview sandstone.

Fig. 49 . Exposure of Carbondale strata along the south bank of a ravine in the NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 20, T. 5 N., R. 4 E. (Liverpool twp.), showing the Pleasantview sandstone member resting unconformably on the gray septarian limestone band about two feet above the top of the Francis Creek shale, which is seen in the lower part of the picture. This exposure is situated along the eastern border of the "valley" of pre-Pleasantview erosion trending south-southeast across the northern part of the quadrangle. Eastward from this exposure 30-35 feet of Purington shale overlie the septarian limestone band below the Pleasantview sandstone.

extends diagonally down~~ward~~ into the top bench of the coal about six inches. (Fig. 50). In certain mines in the Colchester (No. 2) coal in this portion of the quadrangle the sandstone is said to rest uniformly on the coal for distances of 100 to 200 feet, without truncating it, and then rise two to five feet above the coal for a similar distance, the interval being occupied by the gray Francis Creek shale. Both of these relations are prevalent in all parts of the southern half of the quadrangle.

In some localities within the pre-Pleasantview "channel" in the northern part of the quadrangle the interval between the Springfield (No. 5) coal and the Colchester (No. 2) coal or the gray septarian limestone of the Oak Grove member is ~~appears to~~ be unusually small. This is because a portion of the channel was only partly filled by the Pleasantview sandstone, or because some of the sandstone was eroded later. Such exposures are situated along the ravine in the NW ~~NE.~~ ¼ sec. 20 ~~29~~, T. 5 N., R. 4 E. (Liverpool Twp.) ~~and the NW. ¼ sec. 20 of the same township~~, and in two small ravines along the bluff of Illinois River in the NW. ¼ NE. ¼ sec. 29, T. 5 N., R. 4 E. (Liverpool twp.) about 1¼ miles southeast of the first ~~same~~ exposure. In one exposure here the interval between the gray septarian limestone and a coal which is either the Springfield (No. 5) coal or the Kerton Creek coal ~~of the Summum formation~~ is only 17 feet. ~~In this same section (sec. 20),~~ Farther east in sec. 20 the exposed interval between the Colchester (No. 2) coal and the gray septarian limestone is 27 feet, making a total interval between the two coals of not more than 45 feet. In the vicinit of St. David this interval is 96 feet and near ~~in the vicinity~~ of Cuba it is 120 to 125 feet. In an exposure on the north side of the ravine about 400 yards south of the NW. cor. sec. 20, the upper surface of the Pleasantview sandstone is inclined 20° or more toward the west, ~~and~~ Above a clay approximately 2 feet thick, a coal bed 3 feet 2 inches thick slopes toward the west with an inclination similar to that of the upper surface of the Pleasantview sandstone. Fig. 51 shows a generalized section of this exposure. The upper

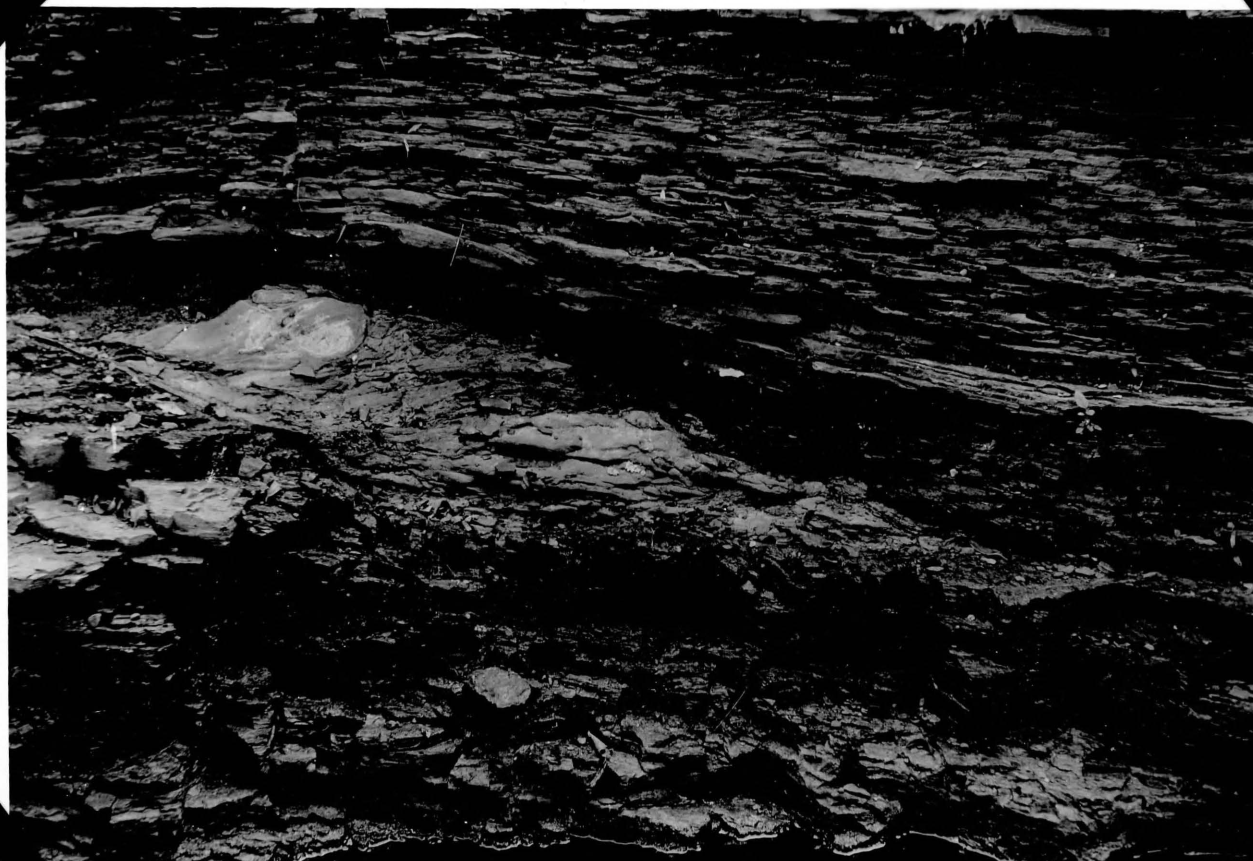


Fig. 50. Exposure of Carbondale strata in the south bank of the west fork of a ravine in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 12, T. 4 N., R. 2 E. (Pleasant Twp.), showing the Pleasantview sandstone resting directly on the Colchester (No. 2) coal, with a mass of sandstone, presumably belonging to the Pleasantview, projecting obliquely downward into the upper portion of the coal. The mode of deposition of this mass of sandstone is not entirely clear.

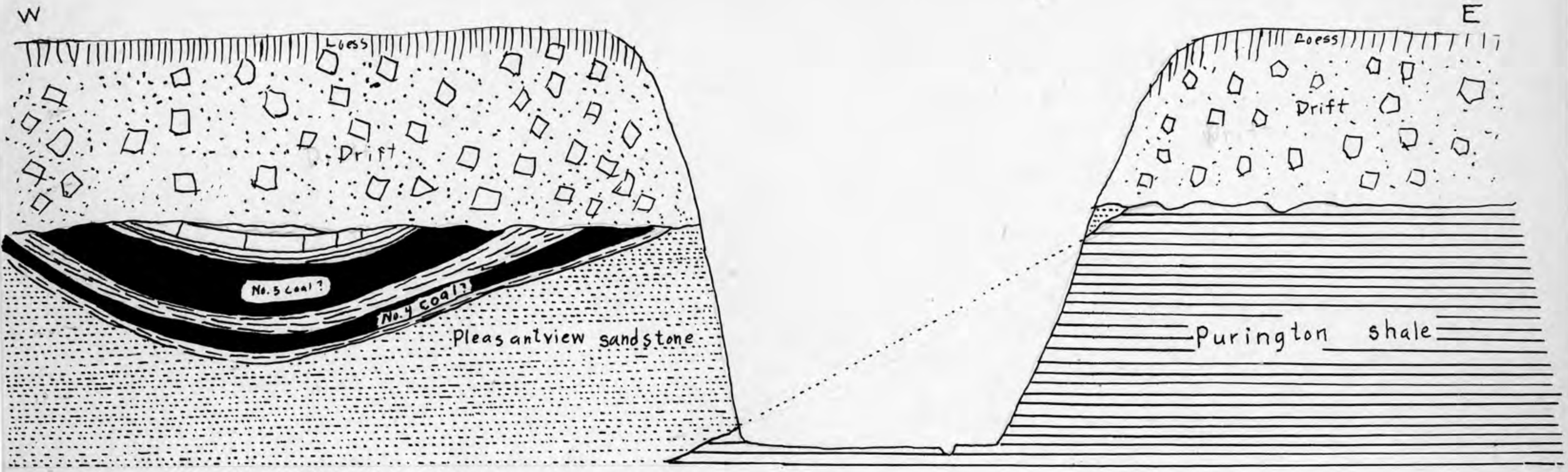


Fig. 51. Generalized cross section of the north side of the large east flowing ravine in the NE. 1/4 sec. ~~20~~ 19 and the NW. 1/4 Sec. 20, T. 5 N., R. 4 E. (Liverpool twp.) at the junction with the large north tributary near the section line, showing the eastern margin of a channel eroded before the deposition of the Pleasantview sandstone and two coal beds, possibly ~~nos.~~ the Kerton Creek and Springfield (No. 5) ~~4 and 5~~, which seem to occupy an erosional depression or channel in the top of the Pleasantview sandstone.

Vertical scale approximately 1 inch = 20 feet.

surface of the Pleasantview sandstone here is light yellowish gray, and fine grained and contains the impressions of ferns and other coal measures plants in considerable abundance. The same plant bearing layer of the top of the Pleasantview is exposed on the opposite side of this ravine about 100 yards southeast of this exposure. The following section was measured in a short gully on the south side of this ravine about 300 yards east of the west line of sec. 20:

Geologic section 28. Exposure in a short gully on the south side of a ravine in the SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 20, T. 5 N., R. 4 E. (Liverpool twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Carbondale series		
Summum formation		
14. Coal blossom, only the lower part exposed below glacial drift	1	6
13. Concretion band, clay ironstone		2-3
12. Shale, blue gray, finely laminated, weathering brownish on bedding surfaces	4	
Pleasantview member		
11. Sandstone, blue gray, massive, micaceous, somewhat cross bedded, mottled with iron stains, with an uneven lower surface	3	
10. Shale, dark blue hard, finely laminated, containing Cordaites, weathering to dark chocolate brown	10	
UNCONFORMITY		
"Liverpool" formation		
Oak Grove member		
9. Limestone, dark gray, fossiliferous, with *Ambocoelia planoconvexa* as most characteristic fossil, weathering brown, seen in float on cut bank on south bank of main ravine, apparently absent in small gully		
8. Shale, dark gray, fossiliferous, with *Chonetes mesolobus*, *Marginifera muricata*, etc., mostly covered by slump	1	10
7. Limestone, gray, fossiliferous, locally septarian		5
6. Shale, gray, weathering brownish	2	
5. Conglomerate, carbonaceous, hard, weathering brownish		5
4. Shale, sandy, calcareous and micaceous, massive, forming a ledge, fossiliferous, surface covered with irregular branching tubules resembling worm trails, with *Marginifera*, *Chonetes*, etc.	1	3
3. Sandstone, shaly and micaceous, blue gray	2	6
2. Concretions, calcareous, large, flattened, oval	1	6
Francis Creek member		
1. Shale, blue gray, soft, exposed to water level	3	6

In the above exposure the limestone bands of the "Liverpool" formation are well exposed, the Purington shale is absent, and the Pleasantview sandstone is represented by a maximum of 13 feet, only about one third the average thickness of the Purington shale. The coal at the top is probably the coal of the Summum formation, described below.

The exposure along the bluff of Illinois River is situated in two small gullies back of a farm house about 300 yards south of the north line of sec. 29, T. 5 N., R. 4 E. (Liverpool twp.). The following section was measured in the northern ~~of the two~~ gulli~~es~~: (See Fig. 53, D)

Geologic section 29. Exposure in small gully along bluff of Illinois River in NW. ¼ NE. ¼ sec. 29, T. 5 N., R. 4 E. (Liverpool twp.)

	Thickness Feet	Thickness Inches
Pleistocene and recent systems		
6. Glacial drift and regolith	Not studied	
Pennsylvanian system		
Carbondale series		
~~########################~~		
Summum or St. David formation		
5. Coal blossom, badly weathered, directly below drift	4	5
4. Underclay		10
Summum formation		
Pleasantview member		
3. Sandstone, gray, thinly bedded, weathering buff	3	6
Unconformity		
"Liverpool" formation		
Oak Grove member		
2. Limestone, gray, with many large septarian concretions (see fig. 38), very fossiliferous, with large fauna of brachiopods, pelecypods and gastropods (see Appendix A, Pt. I)	1	6
Francis Creek member		
1. Shale, ~~######~~slightly sandy, gray, weathering buff	3	

Tracing the coal bed (no. 5 above) up into this small gully it appears to thin sharply toward the west. ~~and~~ In an outcrop 50 feet distant from that described 4 inches of coal are seen between beds of sandstone, apparently representing this bed. In a small gully on the south side of the large ravine about 200 yards north of this exposure a coal bed three or four feet thick is exposed at the same level, but in the next ravine to the south of that described above the limestone (no. 2) the Pleasantview sandstone is about 20 feet thick, well exposed, and contains no coal bed. In a ravine about one quarter of a mile south of the one described the Pleasantview sandstone is 2 feet above the Colchester (No. 2) coal and separated from it only by the Francis Creek shale. Fig. 53 shows a generalized north-south section across these four outcrops. The outcrops showing the thick coal are situated along the eastern margin of the pre-Pleasantview "valley" ~~in the northern part of the quadrangle~~ which has been mentioned above. The coal beds may represent local accumulations in bayous along the margins of this valley in an abandoned channel. ##

In several exposures ~~beds of~~ thin bedded shaly sandstone which ~~are~~ is considered a part of the Pleasantview ~~are~~ is sharply truncated by more massive layers which are not parallel with the beds below. These contacts resemble unconformities and may represent the scouring by a stream of Pleasantview time of deposits formed earlier by the same stream. Such channeling is characteristic of meandering streams. Fig. 52 shows such a contact in a ravine west of Slug Run in the SE. ¼ NW. ¼ sec. 27, T. 6 N., R. 3 E. (Putman twp.)

The contact between the Pleasantview sandstone and older strata is distinct in most parts of the southern half of the quadrangle, where it rests on the Francis Creek shale, or the Colchester (No. 2) coal. ~~but~~ In one exposure, on the south side of Turkey Branch, in the SW. ¼ SE. ¼ sec. 31, T. 4 N., R. 3 E. (Isabel twp.) there is an apparent interbedding of clay shale with sandstone and the lower limit of the Pleasantview member is not entirely clear. The following section was measured here: (Figs. 54 and 55).

##

Geologic section 30. Exposure on the south side of Turkey Branch in the SW. ¼ SE. ¼ sec. 31, T. 4 N., R. 3 E. (Isabel twp.)

	Thickness Feet	Inches
Pennsylvanian system		
Carbondale series		
Summum formation		
Pleasantview member		
8. Sandstone, gray, micaceous, largely massive, with a few thin bedded layers, conglomeratic in basal 6 inches, with hard iron saturated nodules and thin		

Fig. 52. Exposure of Carbondale strata near the junction of two small branches of a ravine west of Slug Run and immediately southeast of the margin of the stripmined area in the SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 27, T. 6 N., R. 3 E. (Putman twp.), showing an angular contact resembling an unconformity between massive beds of the Pleasantview sandstone and a thin bedded shaly phase of this sandstone. The massive sandstone is probably the filling of a channel excavated in alluvial sediments formed earlier in Pleasantview time.

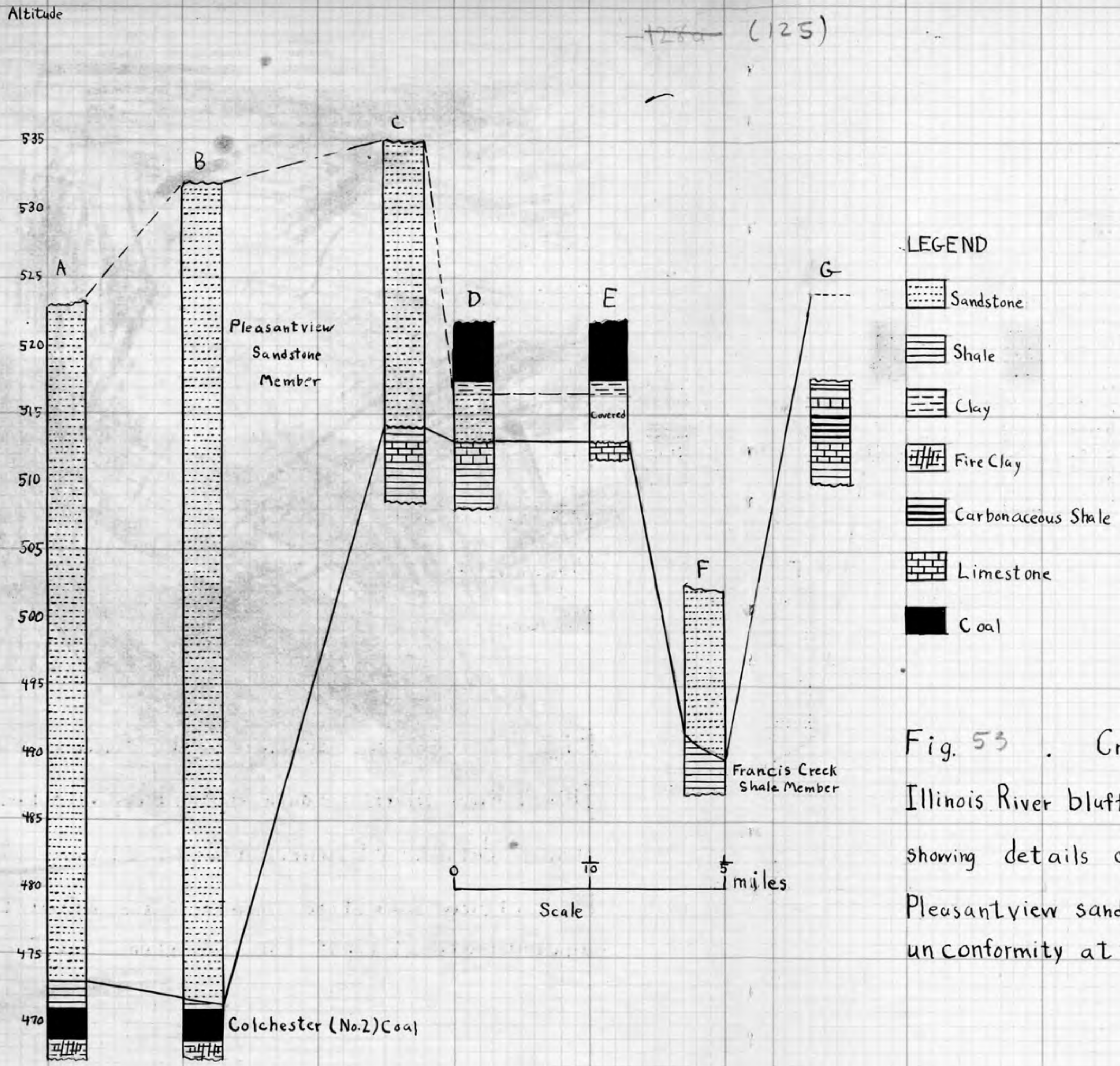
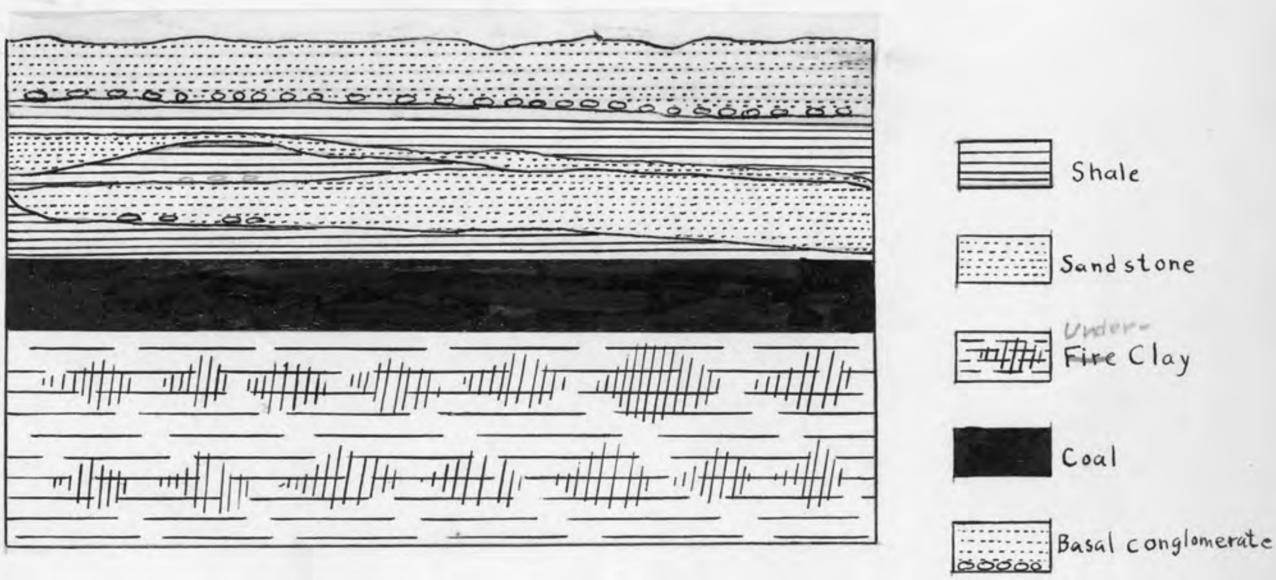


Fig. 53. Cross section of exposures along Illinois River bluffs south of Mt. Pleasant School, showing details of unconformity at base of Pleasantview sandstone member and apparent unconformity at top of this sandstone in C, D and E.

Fig. 54 . Exposure of Pottsville and Carbondale strata along the south bank of Turkey Branch in the SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 31, T. 4 N., R. 3 E. (Isabel twp.) illustrating an abnormal alternation of shale and sandstone beds immediately above the Colchester (No. 2) coal. The typical Pleasantview sandstone occupies the upper fourth of the picture and below it in succession are a clay shale, a lenticular bed of sandstone re~~presenting~~sembling the Pleasantview, a lenticular mass of clay shale, another bed of sandstone resembling the Pleasantview, which forms a prominent light band just above the center of the picture, a gray clay shale, which is probably the Francis Creek, the Colchester (No. 2) coal, here 2 feet 10 inches thick, and its underclay, the highest Pottsville stratum. A pseudolamination characteristic of the top of the underclay is seen just below the coal. The relations between the beds figured is shown in diagram in fig. 55 .



Scale. Coal bed is 2 feet 10 inches thick.

Fig. 55. Diagram illustrating the abnormal alternation of shale and sandstone above the Colchester (No. 2) coal illustrated by photograph in fig. 54. ~~Neg. 2031.70~~

168

coal seamlets representing carbonized logs; impressions of stems of Cordaites, etc. abundant, lower surface uneven	10	
7. Shale, gray, soft, clay	1-2	
6. Sandstone, gray, massively and thinly bedded, with coal seamlets 1/8 inch thick		3-6
5. Shale, gray, soft		0-7
4. Sandstone, gray, massive, except upper 4 inches, which is conglomeratic; contains thin coal seams		2-36
Unconformity (?)		
"Liverpool" formation		
Francis Creek member		
3. Shale, gray, soft, in medium to thick beds		19-39
Colchester member		
2. Coal	2	10
Pottsv##le series		
1. Underclay, light gray, not distinctly bedded, with a darker gray ~~gray~~ zone showing pseudolamination in the upper 4 inches	4	

In this exposure no. 8 is typical Pleasantview sandstone, and no. 3 is typical Francis Creek shale, but the reference of beds 4-7 to the Pleasantview sandstone member may be erroneous.

Paleontology and correlation

The remains of carbonized logs or stem impressions are characteristic of the Pleasantview sandstone, especially in the lower two or three feet, and in its channel phases. Locally fine silts of the upper part of the Pleasantview member contain well preserved leaf and stem impressions. Species collected from silts ~~at the locality described in geologic section~~ at the top of the Pleasantview in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 20, T. 5 N., R. 4 E. (Liverpool## twp.) are listed in Appendix A, Pt. II. The fossil plants listed as occurring in a micaceous phase of the Purington shale in sec. 24, T. 6 N., R. 3 E. (Putman twp.) may represent a very shaly backwater phase of the Pleasantview member, as no sandstone is exposed between the Purington shale and the Springfield (No. 5) coal at this locality.

Fossil invertebrate remains were not found in the Pleasantview sandstone except in a few pebbles in the basal one or two feet. These fossils were apparently derived ~~principally~~ from concretions in the lower part of the Purington shale and the limestone bands below it.

The Pleasantview sandstone in the Havana quadrangle is correlated with the typical exposure of this sandstone, because they are similar in lithologic character and stratigraphic position. This sandstone is exposed in several adjacent areas and the name Summum sandstone has been proposed from the exposures in the ravine here considered the type of the Summum formation.[71] This sandstone has been previously correlated

---

[71] Savage, T. E. Geology and mineral resources of the Vermont quadrangle. Illinois State Geol. Survey. Unpublished manuscript.

---

with the Vergennes sandstone of Jackson County, in southern Illinois[72], ~~but~~ there is some doubt regarding the age equivalence of these sandstones, which have not yet been traced through some parts of the intervening area, so it

---

[72] Savage, T. E. Significant breaks and overlaps in the Pennsylvanian of Illinois. Amer. Jour. Sci. ~~####~~ Vol. 14, pp. 312-313, 1927.

---

seems best to use this name based on a western Illinois locality until its equivalence with the Vergennes can be more definitely proved. It is also believed to be approximately equivalent to the Vermillionville and Waupecon sandstones of La Salle and Grundy counties in northern Illinois, since the relations of these sandstones to the La Salle (No. 2) coal is similar to that of the Pleasantview sandstone to the Colchester (No. 2) coal.

Field evidence shows conclusively that the Purington shale and the limestone bands of the Oak Grove member were removed from an area in the northern part of the Havana quadrangle before the beginning of Pleasantview sand deposition, as the successions on both sides of the Pleasantview channel area are virtually identical. Because of the complete absence of any trace of the Purington shale and the limestone bands ~~############~~ from the southern half of the quadrangle, there may be some doubt that they were deposited in this area and subsequently eroded. South of the area from which the shale and limestone are absent similar beds appear in the Beardstown, Rushville and Liberty quadrangles. The sequence in these areas is so nearly identical with that in the Havana quadrangle that it points strongly to an original continuity of the beds across the area from which they are now absent. It is difficult to explain why pre-Pleasantview erosion should have so nearly completely removed the material above the Colchester (No. 2) coal over areas of several square miles ~~in area~~ without cutting out the coal itself in some places. The coal, where it immediately underlies the sandstone is no more weathered than it is where it underlies the Francis Creek shale. If it had lain exposed while the shale was being stripped from adjacent areas, one would expect it to be somewhat weathered. There are unconformities or sharp contacts resembling them within the sandstone in many places in the southern part of the area. ~~It is possible that~~ Some of the lower material in the Pleasantview sandstone in the southern part of the area may have been ~~was~~ formed during the time of deposition of the upper Francis Creek shale, the Oak Grove member or the Purington shale in the the northern part of the area, then somewhat modified by erosion during the pre-Pleasantview erosion interval, and the higher portion of the Pleasantview sandstone deposited at the same time that it was formed in the northern part of the area. Fig. 56 illustrates an exposure along a branch of Tater Creek which might be interpreted in this way. A compilation of all outcrop and drill record data regarding the basal surface of the Pleasantview sandstone from a group of quadrangles in western Illinois, would furnish more data regarding the nature of the drainage pattern at this time, and would aid in explaining the unusual relations of this sandstone to the coal in the southern part of the Havana quadrangle.[13]

---

[13] Such a study is now being carried on by Mr. S. E. Ekblaw.

The fossil plants indicate that the probable age of this sandstone is

Fig. 56. Exposure of Carbondale and Pottsville strata on the north side of the west branch of Tater Creek just south of the tracks of the C. B. & Q. Ry. in the SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 2, T.4 N., R. 2 E. (Pleasant Twp). The Colchester coal and its underclay are shown in the lower part of the picture. The laminated material on the coal is a dark gray brownish weathering micaceous sandy shale with carbonaceous streaks ~~commonly~~ distributed through it, typical of the shaly phases of the ~~Vergennes~~ Pleasantview member. The massive material at the top is a sandstone, typical of the massive phases of the Pleasantview. The even contact of the shaly material on the coal suggests that this may be a sandy phase of the Francis Creek clay shale rather than a shaly phase of the Pleasantview sandstone.

Kerton Creek coal and associated strata.

The strata above the Pleasantview sandstone have been designated the Kerton Creek beds because the coal and other strata are well exposed along Kerton Creek in sec. 15, T. 3 N., R. 2 E. (Woodland twp.),[74] about 1 mile southwest of the Havana quadrangle. This name will be used here for the coal bed of the Summum formation.

The strata of the Summum formation above the Pleasantview sandstone are well exposed in the lower part of the large ravine south of Big Creek in the NW. ¼ SE. ¼ sec. 35, T. 6 N., R. 3 E. (Putman twp.). (Fig. 57).

Geologic section 31. Exposure along ravine in the NW. ¼ SE. ¼ sec. 35, T. 6 N., R. 3 E. (Putman twp.)

	Thickness Feet	Inches
Pennsylvanian system		
Carbondale series		
St. David formation		
13. Limestone, gray, fossiliferous, one massive bed (St. David limestone)	1	5
12. Shale, gray, soft	1	5
11. Shale, black, soft		9
10. Shale, black, hard, fossiliferous		8
9. Coal (Springfield ~~or~~ No. 5)	5	
8. Underclay, gray, with blocky fracture, containing some gray, septarian limestone concretions, unfossiliferous	2	
7. Covered	3-5	
Summum formation		
6. Shale, sandy, gray	3	

[74] Searight, W. Geology and mineral resources of the Beardstown quadrangle. Illinois State Geol. Survey. Unpublished manuscript.

Fig. 57. Exposure of Carbondale strata in a small gully on the southwest side of a ravine south of Big Creek in the NW. ¼ SE. ¼ sec. 35, T. 6 N., R. 3 E. (Putman twp.), showing the "Kerton Creek" coal and associated strata. The underclay contains a large irregular shaped calcareous septarian concretion showing in the lower part of the picture. The coal is broken by a normal fault with a displacement of about 18 inches, marked by the hammer near the center of the picture. The dark and light shales above the coal and the ~~characteristic~~ cannon ball shaped concretion to the right of the center are characteristic of this horizon over a wide area in the northern portion of this quadrangle.

5.	Shale, black, soft	1
4.	Shale, gray, not distinctly bedded, containing many large round and oval gray limestone concretions, which cut through the gray and black bands of shale, and in places extend down into the coal below, fossiliferous	1
3.	Coal, fairly hard, no bedded impurities, cut by several faults and horsebacks (Kerton Creek)	2 average
2.	Underclay, ~~###########~~very sandy and micaceous blue gray, with large septarian limestone concretions reaching a diameter of 5 by 6 feet, unfossiliferous	3
	Pleasantview member.	
1.	Sandstone, dark gray to brown, thin bedded or shaly, with numerous carbonaceous partings, to base of exposure	15

The Kerton Creek ~~coal~~ is the most variable ~~of the~~ coal~~s~~ above the Pottsville in this region. Its horizon is commonly represented by a thin band of coal 2-6 inches in thickness, or a thin streak of black shale. It is recognized as a thicker coal bed only in secs. 26, 27 and 35, T. 6 N., R. 3 E. (Putman twp.) and probably in secs. 19 and 20, T. 5 N., R. 4 E. (Liverpool twp.). Its outcrop, where it is a thin coaly streak, can usually be detected by its position below the large black spheroidal or oval concretions, like those in no. 4 of the foregoing section. Strata from 24 feet above the Springfield coal to the Pleasantview sandstone are exposed in the ravine north of Big Creek where the following section was measured:

<u>Geologic section 32. Exposures along the ravine in the SE. ¼ SE. ¼ sec. 17, T. 6 N., R. 4 E. (Buckheart twp.) and the northern part of the NE. ¼ NE. ¼ sec. 21, of the same township.</u>

		Thickness Feet	Thickness Inches
	Pennsylvanian system		
	Carbondale series		
	St. David formation		
22.	Shale, gray, with many small ironstone concretions (Canton shale)	10	
21.	Shale, black, soft, finely laminated	1	
20.	Limestone concretions, blue gray, very slightly fossiliferous, forming a nearly continuous band		8
19.	Shale, black, soft	1	
18.	Shale, calcareous ("clod", hard, fossiliferous)		1

17.	Shale, black, soft	1	
16.	Shale, gray, soft	6	
15.	Limestone, gray, forming one massive bed, fossiliferous (St. David limestone)	1	4
14.	Shale, #### gray, soft		8
13.	Shale, black, soft	1	
12.	Shale, black, hard, finely laminated	1	
11.	Earthy layer, black ("draw slate")		1
10.	Coal (Springfield ~~or~~ No. 5)	5	4
9.	Underclay, with blocky fracture, containing gray septarian limestone concretions, ranging up ############to 1 foot in diameter	4	
Summum formation			
8.	Shale, gray	5	
7.	Clay, light gray, containing large smooth calcareous concretions, black to dark gray, unfossiliferous or slightly fossiliferous		6
6.	Shale, black, soft		6
5.	Coaly streak, soft (Kerton Creek)		3
4.	Underclay, gray, with blocky fracture	3	
3.	Limestone, blue gray, with very irregular bedding, somewhat nodular, sandy or silty, weathering brown	2-3	
2.	Underclay, not distinctly bedded grading down into gray shale	4	
Pleasantview member			
1.	Sandstone, brownish gray, thinly bedded, to base of exposure	6	

The coaly streak and shale with large concretions above it are evidently similar to the coal and concretions described in geologic section 31. The impure limestone, no. 3, is widespread between the underclay of the Kerton Creek coal and the Pleasantview sandstone, where the coal is only a thin streak, but it has not been found in exposures where the coal bed is two feet or more in thickness. The significance of the absence of this limestone is discussed below, in connection with the stratigraphic relations of the Summum formation. The limestone is probably of fresh water origin, as marine fossils have not been found in it, and its lithologic character and stratigraphic position with reference to the coal bed ###are similar to fresh water limestones which are widespread in the upper Pennsylvanian of Ohio.[15] There the marine and

---

[15] Stout, W. Origin of coal formation clays, in Geol. Surv. of Ohio, Bull. 26, Fourth series, pp. 538-539, 1923.

BRACKISH water limestones, with few exceptions lie on or not far above the

 176

coal beds, whereas the fresh water limestones occur below the underclays ~~clays which~~ of ~~underlie~~ the coals. A specimen# of this limestone which was tested is 72.74% soluble in dilute hydrochloric acid, and contains 9.80% clay, 14.38% silt and 3.08% sand. The residue is very light in color and glistening from the minute crystals of pyrite contained in it. The coarser residue consists of about 75-80% very fine angular quartz grains and 20% of minute pyrite crystals and aggregates or rosettes of pyrite to 0.5-0.7 mm. A few flakes of muscovite to 0.3 mm. are also present.

An exposure which shows a coal possibly equivalent to the Kerton Creek coal is in a meander cut on the west side of Slug Run, described in the following section:

Geologic section 33. Outcrop in cut bank on west side of Slug Run in the NE. ¼ N W. ¼ sec. 27, T. 6 N., R. 3 E. (Putnam twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Carbondale series		
Summum formation		
7. Coal, weathered at top under regolith	2	6
6. Clay band, gray		3
5. Coal	1	6
4. Shale, gray, bedded	1	
Pleasantview member		
3. Sandstone, shaly, thin bedded, with abundant carbonaceous partings or laminations, containing some impressions of ferns, etc.	5	
2. Concretionary layer, black, hard, not persistent, containing a few plant impressions		1
1. Sandstone, gray to buff, in beds 3-6 inches thick, to base of exposure	4	

This coal cannot be positively identified as the Kerton Creek coal, because its roof is not exposed. Coal beds 2 or 3 feet in thickness have been found in the Pleasantview sandstone in a few places. Such coals have no underclay and a roof of sandy shale. The coal bed described above is 37 feet below the entrance to a nearby mine drift in the Springfield (No. 5) coal, but the intervening strata are covered by regolith. Fossil plants collected from beds 2 and 3 above are listed in appendix A, Pt. II.

In two exposures southeast of Cuba a fine grained light colored sandstone occurs near the horizon of the Kerton Creek coal. This sandstone was at first considered ~~##~~ the basal sandstone of the overlying St. David formation, but in one exposure it is clear that it occurs between the underclay of the Kerton Creek coal and the marine shale above the coal horizon. No coal is present in this outcrop, ~~and~~ so the relation to the coal cannot be ascertained. Sandstone has been observed in a similar position in two exposures in the southern part of the Canton quadrangle. The following is a section of the best exposure showing ~~###~~ this sandstone bed.

Geologic section 34. Exposures along the ravine in the NE. ¼ SE. ¼ sec. 21, T. 6 N., R. 3 E. (Putman twp.) and several of its side gullies.

	Thickness Feet	Thickness Inches
Pleistocene system		
Peorian, Sangamon and Illinoian series		
23. Loess, soil and till	15	
Pennsylvanian system		
Carbondale series		
Brereton formation		
Cuba member		
22. Sandstone, buff, fine grained, thin bedded	8	
St. David formation		
Canton member		
21. Shale, sandy, buff, thin bedded and micaceous	5	
20. Shale, gray, with some small flattened oval clay ironstone concretions in discontinuous layers	18	
19. Limestone, blue gray, concretionary, slightly fossiliferous, discontinuous		10
18. Shale, gray, soft	9	
St. David member		
17. Shale, calcareous, gray, consisting principally of flattened and somewhat weathered crinoid stems, corals, brachiopods, etc., not persistent in all outcrops		8
16. Limestone, light blue gray, buff weathering, forming one massive bed, varying in thickness, absent in one gully on north side of ravine	1	6
15. Shale, black to dark gray, soft in upper foot, hard and finely laminated in lower 18 inches, containing occasional large calcareous and pyritic concretions in the lower portion	2	6
14. Coal, without bedded impurities (Springfield ~~or~~ No. 5)	5	
13. Underclay, light gray, not distinctly bedded, noncalcareous in upper 11 inches, lower part calcareous, containing large irregular shaped septarian calcareous concretions about 18 inches below base of coal	4	

178

Summum formation

No.	Description	Ft.	In.
12.	Clay, similar to above, containing small pellet like nodules of ~~###############~~ light gray limestone, a few of which contain marine fossils or fossil fragments	1	
11.	Limestone, dull brownish gray, with fragments of petrified wood, fish spines and teeth, and abundant <u>Orbiculoidea</u> <u>missouriensis</u>		1-1½
10.	Clay dark gray		½
9.	Clay, light gray		½
8.	Clay, dark gray		¼
7.	Sandstone, white, hard, very fine grained, calcareous, in one massive bed, locally present in two or three gullies on north side of ravine near east line of section		5
6.	Underclay, gray, poorly exposed	3	
5.	Calcareous concretions, dark gray, somewhat septarian, not continuous	1	6
4.	Clay and shale, gray, poorly exposed	6	
3.	Limestone, blue gray, impure, very irregularly bedded, with uneven upper and lower surfaces projecting into adjacent clay	1-2	
2.	Covered	2	6
1.	Sandstone, gray to buff, thin bedded and silty in upper 10 feet, massively bedded below, in parts of ravine strongly crossbedded, with foreset beds dipping southwest (Pleasantview sandstone)	16	

A sample of the sandstone, no. 7 of the foregoing section, was examined. It is white to light gray, very fine grained, composed of quartz from the grade of silt to very fine sand and muscovite, including some flakes to 0.5mm. diameter. The quartz grains may be slightly recrystallized. There is no calcareous cement.

The horizon of the Kerton Creek coal is probably near members 8-10 in the section above. The nodules of light gray fossiliferous limestone in the clay in member 12 above resemble a limestone which appears above the Kerton Creek coal horizon near Pleasantview, Schuyler County, and extends southward nearly to St. Louis, Missouri. The name Hanover ~~limestone~~ has been proposed for this limestone, from exposures near the Hanover school in the ~~Brighton (?)~~ Roudhouse quadrangle, Illinois.[76] ~~As~~ since this limestone occurs

---

76/ Weller, J. M. Personal communication

---

in the same stratigraphic position as the nodular limestone above, the two are probably of the same age.

Stratigraphic relations of the Summum formation

The ~~###~~ unconformity at the base of the Pleasantview sandstone has been discussed in connection with that member. There is no evidence of unconformity between the marine beds over the Kerton Creek coal and the underclay of the Springfield (No. 5) coal. There is good evidence of an unconformity within the Summum formation at the base of the Kerton Creek coal. Where this coal is two feet or more in thickness the clay beneath ~~it~~ is not typical underclay, more like a normal shale. The thicker coal is very locally restricted to small parts of the "channel" areas excavated before the deposition of the Pleasantview sandstone. In these areas both in and ~~###~~ near the Havana quadrangle, the contact between the coal and the Pleasantview sandstone is markedly unconformable, the coal truncating the eroded surface of the sandstone. This relation is well shown at the typical outcrop of the Kerton Creek coal in the northeastern part of the Beardstown quadrangle.[1]

---

[1] Searight, W. Geology and mineral resources of the Beardstown quadrangle. ~~#####################~~ Illinois State Geol. Survey, unpublished manuscript.

Paleontology and correlation.

Marine fossils have been found in a very few places in the black smooth flattened oval concretions over the Kerton Creek coal, in the brownish gray limestone (member 11, geologic section 34), ~~and~~ fragments of Derbya crassa and other marine fossils were found in the nodules of light gray limestone in member 12 of the same section. The fossils collected from these beds are listed in Appendix A, PtI. A few plant impressions have also been found in concretions over the Kerton Creek coal.

The Kerton Creek coal in this quadrangle is correlated with the typical exposure ~~of this coal~~ because of similar position and stratigraphic relations with adjacent beds. The large smooth black concretions over this coal have been found to extend into the Beardstown, Vermont, Canton, Manito and Galesburg quadrangles. The Hanover limestone, whose attenuated margin appears to lie in the Havana quadrangle is a persistent member in western Illinois in and south of Schuyler County. The irregularly bedded nodular fresh water limestone beneath the underclay also persists over several quadrangles in western Illinois.

St. David formation.

This formation is so named because it is well exposed in the vicinity of St. David, and because the coal of this formation, the Springfield (No. 5) coal has been mined for years ~~in the vicinity of the town of St. David~~ near this town. The black shale and limestone above the coal were named St. David [18], and the name is here extended to cover the whole formation. The type exposure is in the ravine on the north side of Big Creek about 1 mile west of St. David described as geologic section 33. Geologic section 34 shows the entire thickness of strata composing this formation, as they are exposed near Cuba. The formation normally consists of (1) an underclay containing limestone concretions or persistent bands of unfossiliferous limestone; (2) the Springfield coal, (3) black hard shale with large pyritic and calcareous fossiliferous concretions, containing marine fossils both in the shale and the concretions; (4) marine limestone (the St. David), (5) clay consisting principally of loose fossil shells, and (6) an evenly bedded clay shale interrupted by one level of fossiliferous limestone concretions (the Canton shale). This formation is widely distributed in the northern part of the quadrangle, and very well exposed in the artificial cuts of the strip mines southeast of Cuba. In addition to over 190 outcrops of the Springfield (No. 5) coal and associated strata, the writer has had access to about 500 drill records from the northern part of the Havana quadrangle and the southern 1½ miles of the Canton quadrangle which penetrate this coal. The Springfield (No. 5) coal and associated strata are present northeast of the village of Summum in the extreme southeastern part of the Vermont quadrangle, about three quarter

[18] Savage, T. E. Significant breaks and unconformities in the Pennsylvanian of Illinois. Amer. Jour. Sci. vol. 14, p. 309, 1927.

of a mile west of the Havana ~~quadrangle~~, and they may underlie parts of the level upland in sec. 35, T. 4 N., R. 2 E. (Pleasant twp.) and secs. 1, 2 and 12, T. 3 N., R. 2 E. (Woodland twp.), but there are no outcrops or drill records indicating their presence in this district. Elsewhere in the southern part of the quadrangle these strata were removed by pre-Pleistocene erosion.

The underclay of the coal normally varies between 2½ and 5 feet in thickness. It contains large masses of concretionary limestone which are commonly septarian. These concretions are in some places as large as 3 feet by 3 feet by 1 foot in dimension, and they are very irregular in outline. In a few places these concretions seem to form nearly a solid ledge of light gray limestone. In the Canton and Glasford quadrangles, north and northeast of the Havana there are commonly two or three persistent bands of limestone below the underclay instead of isolated concretions. No fossils have been found either in the concretions or these limestone bands. A sample of ##### one of the concretions which was tested is 84.08% soluble in dilute hydrochloric acid and contains 12.10% yellowish brown clay, 2.57% silt and 1.70% fine sand. The coarser residue consists principally of small aggregates of brownish gray micaceous silt; nodular masses with pyritic centers surrounded by concentric bands of limonite formed from the pyrite; and ~~a~~ fairly well rounded grains of quartz to 0.3 mm. diameter. The uppermost part of the underclay in some exposures is dark ## gray or black in color, and shows a lamination resembling that of the upper #### part of the ~~soil~~ profile of weathering. Material of the character of the underclay also fills the "horsebacks" and clay [illegible] in the coal, which are discussed in connection with the coal.

Springfield (No. 5) coal

This coal bed is widely distributed in all parts of the Havana quadrangle from which it has not been removed by pre-Pleistocene erosion. All of the exposures are situated in T. 6 N., R. 3 E. (Putman twp.), T. 6 N., R. 4 E. (Buckheart twp.), and T. 5 N., R. 4 E. (Liverpool twp.), except for three small outcrops in sec. 13, T. 5 N., R. 3 E. (Lewistown twp.). It normally contains no bedded impurities, and averages 4 feet 10 inches to 5 feet in thickness in the outcrops and drill records in this area. It is the thickest persistent coal bed in the quadrangle. Pyrite and calcite are principally distributed as thin films along the vertical partings in the coal. Much pyrite is commonly mixed with the coal in the basal $1\frac{1}{2}$ inches ~~of the coal,~~ which normally adheres to the underclay. It is also found as discontinuous bands of small concretions 1 to 2 inches in diameter, especially in the upper half of the coal. In the strip mines, the upper surface ~~is seen to~~ contain small pits or depressions 1 to 3 inches deep in which pyrite is sometimes concentrated. The following section of the coal and the beds immediately above and below was measured in the strip mine southeast of Cuba.

Geologic section 35. Exposure in strip mine in the SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 27, T. 6 N., R. 3 E. (Putman twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Carbondale series		
St. David formation		
St. David member		
11. Limestone, gray, massive, fossiliferous, in one bed		10
10. Shale, dark gray, mottled with light gray spots, finely laminated, rather soft	1	7
9. Shale, black, hard, finely laminated, splitting into thin sheets, with occasional large fossiliferous concretions	1	
Springfield member		
8. Coal		6
7. Pyrite concretion band, not persistent		$\frac{1}{4}$-$\frac{1}{2}$
6. Coal		$9\frac{1}{2}$
5. Pyrite streak, not continuous		$\frac{1}{2}$
4. Coal		$10\frac{1}{4}$
3. Pyrite streak		$\frac{1}{4}$
2. Coal	1	11
1. Underclay, only upper surface exposed		

Excellent natural exposures of this coal are situated along the banks of the ravine in the SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 13, T. 6 N., R. 3 E. (Putman twp.), where the coal bed dips downstream at about the same slope as the gradient of the stream ~~so as to~~ making a continuous exposure nearly a quarter of a mile along banks of the ravine. Fig. 58 shows the Springfield coal along this ravine, with its underclay and finely laminated black shale roof, and a "horseback" or clay seam in the coal filled with gray clay forced up from below. Horsebacks are of common occurrence in this coal. They vary from 6 inches to 2 or 3 feet in thickness and may cut out the coal in almost any direction. Figs. 59 ~~and~~ 60, and 133 illustrate a horseback in the coal along the ravine exposure mentioned above. About 6 horsebacks cross the coal in the exposure along this ravine. Small faults of about 6 inches displacement are also found in the coal. Along the edge of a horseback exposed in the strip mine southeast of Cuba a large nodule of brown calcareous rock consisting principally of fossilized plant material was found in the coal. This resembles a coal ball in appearance and mode of occurrence. The plant material in this nodule was identified as .

An outlying exposure of this coal and associated strata which is abnormal in succession is situated in sec. 20, T. 5 N., R. 4 E. (Liverpool twp.)# (Fig. 51), (See Geologic Section 2-8)

<u>Geologic section 36. Exposure near the junction of two principal forks of a ravine near the west line of the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 20, T. 5 N., R. 4 E. (Liverpool twp.)</u>

	Thickness Feet	Inches
Pennsylvanian system		
Carbondale series		
St. David formation (?)		
6. Limestone, gray, fossiliferous, shale, black, finely laminated, fossiliferous, containing large pyritic and calcareous fossiliferous concretions, seen in dumps around small mine drifts, but not exposed		
5. Coal, with two or three thin shale partings	5	6
4. Underclay and covered, average	~~5~~ 3	
Summum formation		
3. Coal, reported from drilling and abandoned workings, not exposed	3	2½
2. Underclay, sandy, not distinctly bedded, average		6
Pleasantview member		
1. Sandstone, thin bedded, with fossil fern impressions on upper surface, average	10	

Fig. 58. Exposure of Carbondale strata along a ravine in the SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 13, T. 6 N., R. 3 E. (Putman twp) showing the Springfield (No. 5) coal and its overlying black ~~fissile~~ hard shale and its light gray underclay. The coal is cut near the center of the picture by a horseback or clay seam, along the line of which a small gully has been excavated.

Fig. 59. Exposure of the Springfield (No.5) coal on the bank of a ravine in the SW. ¼ SE. ¼ sec. 13, T. 6 N., R. 3 E. (Putman twp.) showing a horseback cutting nearly through the coal. The material filling this space is a gray clay, somewhat similar to, but lighter ~~gray~~ than most of the underclay. Small fragments of coal detached from the walls during the time of upward movement of the clay are seen entirely surrounded by the light gray clay. Fig. 60 shows the distribution of coal, and light and dark gray clay in this horseback.

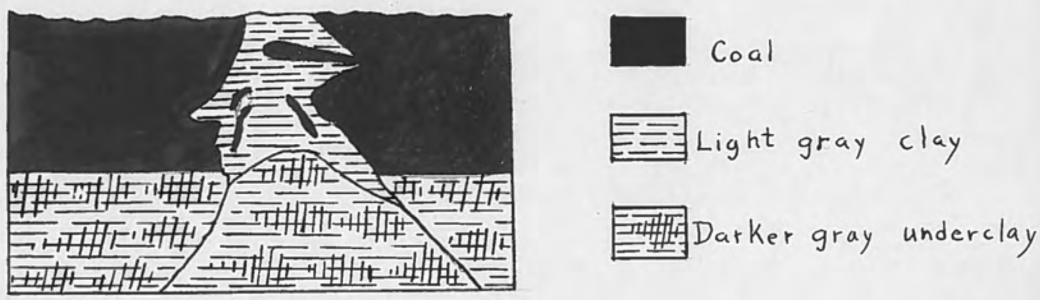


Fig. 60. Diagram of horseback in the Springfield (No. 5) coal illustrated by photograph in fig. 59. ~~The coal is shown by solid black, the light gray clay filling the fissure by white color and the darker gray underclay of the coal by an X pattern.~~

Notes: Fulton 1213.62 (Second diagram)

The upper coal is probably ~~appears to be~~ the Springfield (No. 5) ~~coal~~, as the marine strata above it resemble those over this coal. The coal only 2 or 3 feet below it may be the Kerton Creek ~~coal~~, although no trace of the marine strata normally occurring above it was found. This exposure is situated along the eastern margin of the pre-Pleasantview valley of the northern portion of the quadrangle, where the interval between the Springfield and Colchester coals is not more than 50 feet. This unusual position may account for the abnormal sequence of beds.

In an exposure along a small ravine in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 25, T. 6 N., R. 3 E. (Putman twp.) about 300 yards south of the secondary road at the north line of this section the Springfield coal has been burned for about 30 feet along its outcrop to a red clinker. The dark shale overlying the coal is here converted into a material which looks like thin slabs of red brick. This is the only instance of natural combustion of a coal bed seen in the quadrangle.

Black shale and concretions

The immediate roof of the Springfield coal in this quadrangle, as in other portions of the Springfield-Peoria district is a black finely laminated carbonaceous shale, which is somewhat pyritic and calcareous. This shale contains large flattened oval or irregular shaped concretions which are principally calcareous, but contain much more pyrite in the outer ~~portion~~ than in the central portion of the concretion. These are locally 2 feet in maximum diameter and in some places extend down into the upper 5 or 6 inches of the coal. The lower portion of the shale is hard and splits into sheets one inch or less in thickness, which are slightly flexible. A rectangular or rhomboidal system of joints is commonly found in this hard shale, and the calcareous concretions are found only in this part. The lower surface of the hard shale in some places is ~~appears to~~ be cemented to the coal by pyritic concentrations in the base of the coal. Fossil remains are common in the hard shale and in the concretions ~~in it~~. The fossils in the shale are similar to most of the commonest species in the concretions, but the shells are crushed and flattened ~~extremely~~, or preserved only as impressions on the bedding surfaces of the shale. The distribution of fossils and concretions in the shale is sporadic. In some areas the shale is entirely barren of fossils, or contains scattered impressions of Lingula unbonata, Lingula ___ or Orbiculoidea missouriensis, while in other localities the bedding surfaces of the shale are crowded with impressions. In some localities the concretions and the fossil remains preserved in them are much more pyritic than elsewhere.

The upper part of the shale ranges from black and soft to black mottled with dark gray masses, which suggest seaweed or other organic impressions. Recognizable fossils are not found in the upper part ~~of the shale~~. The upper surface of the shale is commonly irregular, with knobs of the overlying gray limestone projecting down 1-2 inches into the shale. Fig. 62 shows the typical section of this shale and its relation to the Springfield (No. 5) coal below, and the St. David limestone above. There are 45 available records of outcrops and drillings showing the thickness of both the hard and soft shales. The hard shale ranges from 8 to 42 inches in these records, averaging 18-24 inches. The soft shale ranges from 6 to 36 inches, averaging about 12 inches. In 89 other records the combined thicknesses of these shales, not differentiated, ranges from 12 to 72 inches, averaging 30-36 inches. Fig. 61 shows the general regional variation in thickness in the Springfield coal, the shale and the St. David limestone.

The most abundant and characteristic species of fossils in the black shale are Orbiculoidea missouriensis, Lingula unbonata, Lingula ________, Marginifera muricata, Productus cora, and Solenomya trapezoides. The list of species collected from this shale is given in Appendix A, Pt. I.

#152a- (149)

189

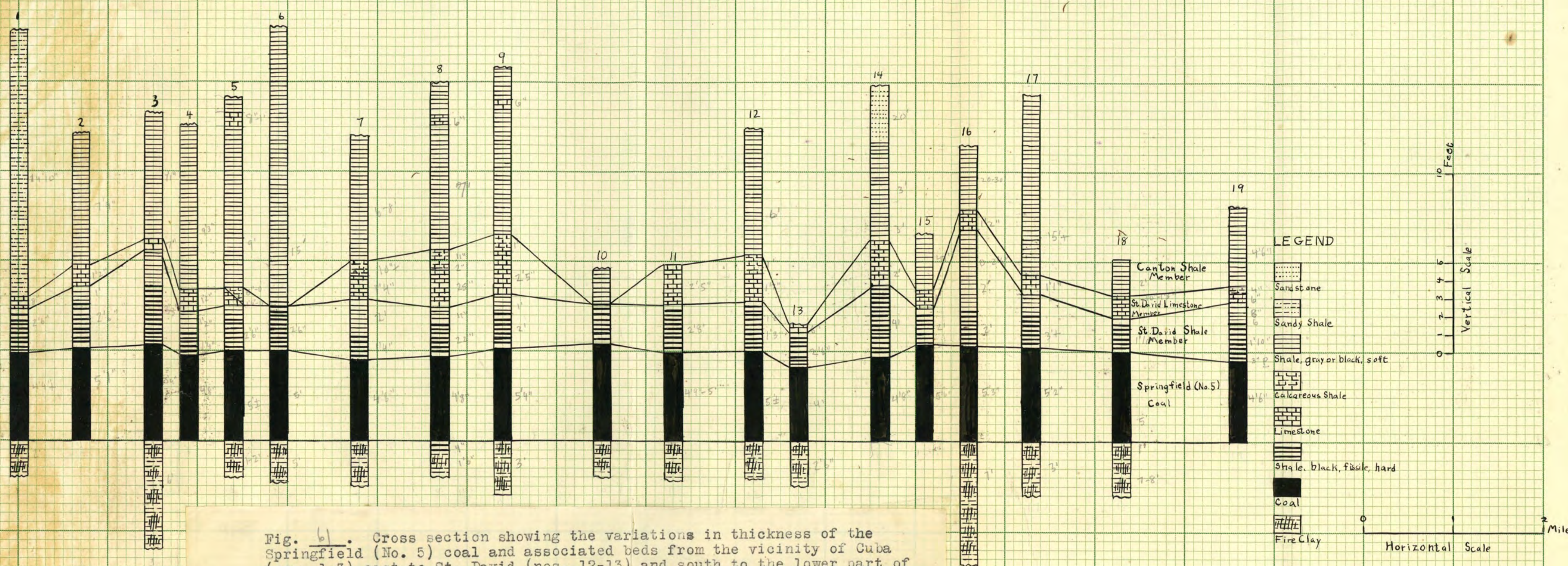


Fig. 61. Cross section showing the variations in thickness of the Springfield (No. 5) coal and associated beds from the vicinity of Cuba (nos. 1-3) east to St. David (nos. 12-13) and south to the lower part of Buckheart Creek valley (no. 19). This section shows variations in thickness of the coal, ~~fire~~ clay, roof shales (miner's slate) and limestone cap rock (St. David limestone) locally, but does not indicate a regular change in thickness of any of these beds in any direction. The following coal test borings and outcrops furnished the data for this section:

(1) Coal test boring, NW. ¼ sec. 30, T. 6 N., R. 3 E.
(2) Coal test boring, SW. ¼ sec. 20, T. 6 N., R. 3 E.
(3) Coal test boring, SE. ¼ sec. 20, T. 6 N., R. 3 E.
(4) Coal test boring, SW. ¼ sec. 21, T. 6 N., R. 3 E.
(5) Outcrops, SE. ¼ sec. 21, T. 6 N., R. 3 E.
(6) Outcrop, SW. ¼ sec. 22, T.6 N., R. 3 E.
(7) Outcrops, NW. ¼ sec. 23, T. 6 N., R. 3 E.
(8) Outcrops, NW. ¼ sec. 24, T. 6 N., R. 3 E.
(9) Outcrops, SE. ¼ sec. 24, T. 6 N., R. 3 E.
(10) Coal test boring, SE. ¼ sec. 19, T. 6 N., R. 4 E.
(11) Coal test boring, NE. ¼ sec. 20, T. 6 N., R. 4 E.
(12) Outcrops, NW. ¼ sec. 21, T. 6 N., R. 4 E.
(13) Coal test boring, SE. ¼ sec. 21, T. 6 N., R. 4 E.
(14) Coal test boring, SE. ¼ sec. 22, T. 6 N., R. 4 E.
(15) Coal test boring, NE. ¼ sec. 27, T. 6 N., R. 4 E.
(16) Outcrops, SNE. ¼ sec. 26, T. 6 N., R. 4 E.
(17) Outcrops, NE. ¼ sec. 35, T. 6 N., R. 4 E.
(18) Outcrops, NW. ¼ sec. 1, T. 5 N., R. 4 E.
(19) Outcrops, NW. ¼ sec. 12, T. 5 N., R. 4 E.

Fig. 62. Exposure of Carbondale strata in the west branch of the ravine in the SW. ¼ NW. ¼ sec. 24, T. 6 N., R. 3 E. (Putman twp.), about 500 yards south-southeast of the Blacksby school, where the Springfield coal had been stripped for local use, showing the upper part of the Springfield (No. 5) coal,## the hard ~~fissile~~ black shale which forms its immediate roof, grading up into softer black and mottled dark gray and black shale, and the limestone cap rock of the Springfield coal. The hammer head marks the top of the coal. Notice the prominence of vertical jointing in the hard ~~fissile~~ shales over the coal and the irregular knobs of limestone projecting downw~~ard~~ into the upper part of the shale.

The concretions in the shale, when they are freshly exposed to the air, are very hard and can be broken only with a sledge hammer. When they have been exposed ~~to the air~~ for 8 to 15 years they are weathered to such a state that they readily fracture, usually around the edges of fossil shells. In some localities the fossils in the concretions are preserved as pyritic impressions, but in others the concretions are principally calcareous. In the pyritic concretions the fossils belong principally to the species Orbiculoidea missouriensis, Solenomya trapezoides and Clinopistha radiata, var. laevis. In the calcareous concretions the fauna is much more diverse, and while the species mentioned above are numerous, Composita argentea, rare or absent in the pyritic concretions, is the commonest form in the calcareous. One concretion about 2 feet in diameter probably contained 800-1000 shells of this species. The largest fauna found in these concretions is from the east slope of a ravine west of a farm house in the NE. 1/4 SW. 1/4 sec. 26, T. 6 N., R. 3 E. (Putman twp.). The list of fossils collected from these concretions is given in Appendix A, Part I. A sample of one of the calcareous concretions which was tested is 90.45% soluble in dilute hydrochloric acid, and contains 2.57% clay, which is highly carbonaceous, 0.92% silt and 6.05% coarser material, including several pyritized fossil shell fragments. Pyritized wood is also present in these concretions.

St. David limestone

The gray limestone which immediately overlies the dark shale of this formation consists of one bench which is commonly 12 to 18 inches thick. In 105 outcrops or drill records which show the horizon of this limestone, it is absent or discontinuous in 22 localities. Its absence in some places is due to its truncation by the overlying Cuba sandstone, the basal member of the Brereton formation. In other places it shows much local variation in thickness, ranging from 20 ~~inches~~ to 3 or 4 inches within 100 yards. The limestone is light blue gray when fresh, somewhat similar in color and texture to the gray septarian limestone of the Oak Grove member. Its weathered surface is stained buff or light yellowish brown. Although it appears to be very hard when freshly exposed, large blocks of this rock ~~which had been~~ exposed in the dumps of strip mines for 4 years or less were so disintegrated that they readily broke into fragments 2 or 3 inches in diameter. A sample of this limestone which was tested is 87.13% soluble in dilute hydrochloric acid, and contains 10.35% clay, 1.12% silt and 1.20% coarser fragments. The silt and coarser fragments consist principally of small irregularly shaped nodular masses of pyrite, numerous pyritized bryozoa (Rhombopora sp.), pyritized and silicified hollow spines, probably small Productus spines, light gray micaceous clay and a few rounded quartz grains.

The lower surface of this limestone is normally covered with irregularly shaped knobs 2 to 4 inches in height which project down into the underlying dark shale, as illustrated in figure 62. The upper surface is in contact with the calcareous shale or "clod" which immediately overlies the limestone. Fig. 63 shows the limestone, with the overlying calcareous shale and the lower part of the Canton shale. This limestone is everywhere fossiliferous. It is well exposed in the high piles of debris which have been thrown up in the strip mining ~~of the Springfield (No. 5) coal~~ southeast of Cuba. On the upper surface of this limestone and extending up into the basal part of the calcareous shale are numerous large slightly pyritized shells of large nautilids. The most characteristic fossils in addition to the nautilids are Chonetes mesolobus, var. euampygus, Chonetes verneuiliana and Productus semireticulatus. The two varieties of Chonetes are rare or absent in the Pennsylvanian strata of this quadrangle below this limestone. The fossils collected ~~from this limestone~~ are listed in Appendix A, Part I,

T

Fig. 63 Exposure of Carbondale strata near the head of a ravine in the NE. 1/4 SW. 1/4 sec. 21, T. 6 N., R. 3 E. (Putman twp.) showing the gray limestone cap rock of the Springfield (No. 5) coal (St. David limestone), the gray fossiliferous calcareous shale or clod immediately above it (the dark laminated material above the massive bed ~~below~~) and the lower part of the Canton shale.

The name St. David shale and limestone was proposed[19] to include the black hard shale above the Springfield coal, the dark soft shale, the limestone cap rock and the calcareous shale or clod immediately above this limestone, from exposures near St. David, in the northeastern

[19] Savage, T. E. Significant breaks and unconformities in the Pennsylvanian of Illinois. Amer. Jour. Sci. vol. 14, p. 309, 1927.

part of the Havana quadrangle.

Calcareous shale or "clod"

Above the ~~gray~~ St. David limestone there occurs a dark gray shale 8 inches to 1 foot thick, which consists largely of crinoid stems and other fossil remains. This bed usually adheres to the limestone below, and it is consequently best exposed on the surfaces of large blocks of the limestone on some of the debris piles associated with the strip mine southeast of Cuba. Where these blocks have been subjected to weathering about 1 year the calcareous shale is so decomposed that the fossils may be picked up loose from its surface. ~~The list of fossils collected from this shale is given in Appendix A.~~ The species most abundant in, and characteristic of this shale are crinoid stems, Eupachycrinus tuberculatus, Chonetes mesolobus, var. euampygus, Chonetes verneuiliana, Chonetes granulifer, Spiriferina kentuckyensis, Hustedia mormoni, and Composita argentea. The list of species collected from this shale is given in Appendix A, Part I.

Canton shale and associated beds.

The strata of the ~~######~~ St. David formation above the calcareous shale fossiliferous horizon are principally shales. The lower part ~~of the shale~~ is ~~They are~~ typically exposed in the strip mine cut described here:

Geologic section 37. Exposure in strip mine cut in the SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 28, T. 6 N., R. 3 E. (Putman twp.).

	Thickness Feet	Thickness Inches
Pleistocene system		
Peorian, Sangamon, and Illinoian series		
7. Loess and till	16	11
Pennsylvanian system		
Carbondale series		
St. David formation		
Capron member		
6. Shale, light gray, soft, containing small iron-stained calcareous concretions, at various levels in discontinuous bands	7	
5. Shale, dark blue gray, soft, slightly fossiliferous		1½
4. Limestone~~#~~ concretions, blue gray, not persistent, slightly fossiliferous, with Productus cora as ~~####~~ commonest fossil		7
3. Shale, light gray, soft, with small ironstained calcareous concretions, similar to (6)	7	6
St. David Member 2. Shale, dark blue gray, calcareous, very fossiliferous	1	3
1. Limestone, gray, in one massive bed (~~St. David limestone~~)		9

~~The band of small calcareous concretions~~

The band of fossiliferous concretions and associated sparingly fossiliferous shale (nos. 4 and 5) are widely distributed in the area of exposure of ~~the~~ Canton shale, and they are also known to occur in the Canton and Glasford quadrangles north and northeast of the Havana ~~area~~. The concretions range from a solid band of limestone about 6 inches thick ~~very locally~~ to concretions in the shale several feet apart. Locally they are more persistent than the St. David limestone below and ~~####~~ in such places the~~#~~ concretion band is the first limestone horizon above the Springfield (No. 5) coal. The interval between this concretion horizon and the St. David limestone varies from 3 to about 10 feet in the exposures observed. A sample of one of these concretions ~~which was~~ tested, is 72.02% soluble in dilute hydrochloric acid. It contains 16.84% clay, 10.70% silt and 0.44% sand. The residue is black in color and mostly very fine in texture. The coarser residue consists of fine angular quartz particles stained dark gray and small pyrite crystals. A few large well formed pyrite crystals up to 1.5 mm. diameter, a few small flakes of muscovite and a few hollow siliceous spines or tubes of organic origin are also present.

These concretions are slightly fossiliferous in some exposures. The ~~following~~ species ~~were~~ collected from the concretions and the associated calcareous shale in the strip mine cut described above (Geological section 37), beds 4 and 5 are listed in appendix A, Part I.

In some exposures two to three feet of the shale immediately below this concretion horizon is darker gray in color than the rest of the shale.

In most exposures there is no difference in texture between the gray shale above this concretion layer and that between it and the St. David limestone. Small calcareous concretions are present in both parts of the shale. The thickness of the gray shale above the concretions ranges from 18 to 25 feet in numerous exposures, averaging about 22 feet ~~in exposures~~ where it is not truncated by the overlying Cuba sandstone. The upper 4 or 5 feet ~~of this shale~~ is micaceous and slightly sandy in texture, and is so evenly laminated that in exposures it resembles a pile of boards one to two inches ~~in~~ thick~~ness~~. The lower part of the shale is nearly indistinguishable from the Purington ~~shale~~, except that the concretions are somewhat smaller than in the Purington. Fig. 64 shows a typical exposure of the upper part of the shale.

The name Canton ~~shale~~ has been applied to the shale above the St. David ~~shale and limestone~~[80], from exposures in the western part of

---

[80] Savage, T. E. Geology and mineral resources of the Avon and Canton quadrangles. Illinois State Geol. Survey, Bull. 38, p. 240, 1921.

Canton, Fulton County, where this shale is used in brick manufacture. The shale in the Havana quadrangle is similar in position and lithologic character to the Canton shale, and may be correlated with it. ~~The Canton shale~~ This is the highest member of the St. David formation.

Stratigraphic relations.

The strata of the St. David formation overlie those of the Summum ~~formation~~ with no apparent unconformity in any part of the quadrangle. The basal sandstone of the overlying Brereton formation rests unconformably on the upper members of ~~this formation~~ the St. David, locally truncating all strata above the hard black shale above the coal. This unconformity is discussed further in connection with the Brereton formation.

Correlation

Fig. 64 . Exposure of Carbondale strata in the west fork of a ravine in the NE. ¼ SW. ¼ sec. 23, T. 6 N., R. 3 E. (Putman twp.), showing the upper portion of the Canton shale, which is an evenly stratified, slightly micaceous and sandy shale. ~~Notice that~~ The ravine has abandoned a valley flat at the level from which the picture was taken and incised itself into the soft shales below its alluvial deposit in the meandering course which it developed while ~~it was~~ building the valley flat. Such recently incised streams are common in many parts of the quadrangle, and are believed to be partly the result of the change of regimen of the streams following the deforestation of the ~~stream~~ banks and other activities of man in the region.

The coal bed of the St. David formation is correlated with the Springfield ~~or~~ (No. 5) coal of Sangamon and Peoria counties, on the basis of similar stratigraphic position and lithologic character of its associated strata. Worthen first applied numbers to the coal beds of western Illinois from the exposures in Fulton County, ~~and~~ Apparently he considered the Springfield coal in the vicinity of Cuba, where it is only about 30 feet below the Herrin coal, a different bed from the Springfield coal in the vicinity of Canton, where it is about 65 feet below the Herrin coal. 81/ He applied the number, 4, to the Springfield coal with the greater

---

81/ Worthen, A. H. Fulton County. Geology of Illinois. Vol. IV, pp. 98-100. 1870.

Cady, G. H. Coal resources of District IV, Illinois State Geol. Survey, Coop. Mining Series, Bull. 26, p. 33, 1921.

---

interval below the Herrin coal and the number, 5, to the coal near Cuba. As the two beds have been found to be continuous, and the difference in interval the result of an erosional unconformity between the Herrin and Springfield coals the number 5 is now applied to all outcrops, ~~of this coal~~. ~~This coal~~ It has been tentatively correlated with the Harrisburg coal of Saline county in southern Illinois, and it is believed to be approximately equivalent to the Lexington coal of Missouri, the highest coal of the Cherokee shale formation. The calcareous members of this formation are probably approximately equivalent to the limestones of the lower part of the Henrietta formation of Missouri and Kansas, notably the Fort Scott limestone, as the species Chonetes mesolobus, var. euampygus is ~~most~~ abundant in both of these limestones.

Brereton formation.

The Brereton formation is so named because the entire formation is well exposed in a cut bank on the east side of Copperas Creek in the NE. ¼ sec. 1, T. 7 N., R. 4 E. (Canton twp.), about one mile east of the village of Brereton, Fulton County, and near At the typical exposure, it consists of a basal sandstone, underclay, coal, with a persistent clay parting, black shale, limestone, calcare~~ous~~ shale, and clay shale. The formation is represented in the Havana quadrangle by similar strata, although the calcareous shale and clay shale were removed from all parts ~~of the Havana quadrangle~~ by preglacial erosion. In the Havana quadrangle there is also found a fresh water limestone below the underclay, and a locally distributed marine limestone and clay shale between the basal sandstone and the underclay. ###### The coal of the Brereton formation is called the Herrin or No. 6 coal,## and by definition it is the highest stratum of the Carbondale series. The strata above the coal are thus the basal strata of the McLeansboro ########## series.

The Brereton formation is exposed only in small portions of T. 6 N., R. 3 E. (Putman twp.), T. 6 N., R. 4 E. (Buckheart twp.) and sec. 12, T. 5 N., R. 4 E. (Liverpool twp.). The succession of beds in the eastern part of the quadrangle is somewhat different from the succession in the vicinity of Cuba, where the basal sandstone truncates several feet of strata of the St. David formation.

An exposure about one half mile east of Cuba in the upper portions of two forks of a ravine in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 21, T. 6 N., R. 3 E. (Putman twp.) is difficult to correlate with the exposures of the formation elsewhere, as a marine limestone (bed 73) and an overlying gray shale (bed 74) have not been found elsewhere in the Havana or adjacent quadrangles.

<u>Geologic section 38. Exposure in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 21, T. 6 N., R. 3 E. (Putman twp.)</u>

	Thickness Feet	Inches
Pennsylvanian system		
Carbondale series		
Brereton formation		
9. Limestone, blue gray, hard, weathering brown, unfossiliferous, exposed only in float, probably 1 foot in thickness		

Brereton formation (?)

8.	Shale, gray, soft, like Canton shale (bed 74 94)	4
7.	Covered	4
6.	Shale, gray, soft, like (8) (bed 74)	3
5.	Limestone, pinkish or purplish gray, fossiliferous, with abundant Productus cora, weathering light yellow brown (bed 73)	4
4.	Shale, gray, soft	4
3.	Sandstone, light gray, hard, forming ledge	2-3
2.	Sandstone, light gray, thinly bedded, softer than above, grading down into sandy shale (Cuba sandstoné ?)	6

St. David formation

Canton member

1.	Shale, slightly sandy in upper 3 or 4 feet, grading down into gray clay shale, base not exposed	18

The abnormal feature of the succession in this outcrop is the presence of a marine limestone almost directly above a sandstone without an underclay, coal horizon or carbonaceous shale intervening. Three different interpretations of this succession are suggested:

(1) The limestone (5) represents a very brief incursion of the sea after the cessation of sand deposition within what is in all other cycles the non-marine part of the cycle. The invasion did not reach further to the northeast than this exposure and the record of the invasion west of the exposure has been destroyed by post-Pennsylvanian erosion.

(2) The limestone (5) represents the marine member of a cycle of short duration. Although the underclay, coal and carbonaceous shale members of the cycle are not present in this exposure they may be found in other exposures of strata of the same geologic age. If this is the correct interpretation beds ~~94-96~~ 72-74 constitute a distinct sequence between that including the Springfield coal and that including the Herrin coal. Coal beds have been mentioned between the No. 5 and No. 6 coals in southern Illinois and they may belong to the same sequence as beds ~~94-96~~ 72-74 here. If these beds constitute a distinct sequence there is no known sandstone member of the sequence to which the Herrin (No. 6) coal belongs. However, in many exposures the Cuba sandstone appears to be the basal sandstone of that sequence.

(3) The sandstone (2 and 3) is a lenticular ~~sandstone~~ in the shale (Canton) and the thin marine limestone (73) is stratigraphically equivalent to the blue-gray concretionary limestone in the lower part of the Canton shale (bed ~~91~~ 69 of the general section). If this interpretation is correct the Cuba sandstone is absent here, the limestone is different in color and lithologic character from its normal appearance and about 25 feet above the Springfield (No. 5) coal instead of 5-10 feet, its usual interval.

The first and second interpretations seem to be more plausible than the third. As the limestone layer is not now known at any other outcrop the data do not warrant the establishment of a distinct formation to include beds ~~95~~ 12 93 and ~~96~~ 94. ~~They should be placed in such a formation if the~~ The lithologic character ## and paleontology of the limestone are described on p. 170 .

Cuba sandstone.

The basal sandstone member of this sequence is more widely exposed than the higher members. It is well shown in a number of ravines east and west of Buckheart Creek in secs. 25 and 36, T. 6 N., R. 4 E. (Buckheart twp.) where a local syncline or basin carries the Springfield (No. 5) coal below drainage. The sandstone is there 20 to 25 feet thick. The lower beds ~~of the sandstone~~ follow the slightly sandy beds of micaceous shale of the Canton ~~shale~~ member in apparent conformity. The sandstone consists of some hard and massive beds alternating with beds 1 to 2 inches in thickness. The lower beds of this sandstone are normally very uniform, exhibiting little cross bedding. A typical exposure of the lower part of the sandstone is shown in fig. 65 . The upper surfaces of some of the more massive beds are ripple marked and cross bedding is more common in them than in the thinner beds. The upper 5 or 6 feet of this sandstone contain some large calcareous concretions, 4 or 5 feet in diameter similar to those in the upper portion of the Pleasantview ~~sandstone~~. The sandstone is light brown with abundant dark limonite specks about the size of a small pin head. Carbonaceous mat-

Fig. 65. Exposure of Carbondale strata in the south#### bank of a ravine west of Buckhear t Creek ## in the NE. 1/4 SW. 1/4 sec. 25, T. 6 N., R. 4 E. (Buckheart twp.), showing the typical board-like weathering of ### the lower part of the Cuba sandstone. At the left of the picture the strata have been deformed into a small fold, probably as a result of overriding by the continental glacier.

ter is not as common in the Cuba sandstone as it is in the Pleasantview. Many of the larger quartz grains show crystal faces. They are set in a matrix of fine material which gives the appearance of poor sorting. Mica is abundant and irregularly distributed through the mass, showing no uniform parallelism of the flakes to the bedding. All samples examined are calcareous, but there is wide variation in the calcareous content of different samples. The average composition of 5 samples of this sandstone is 7% fine sand, 36% very fine sand, 39% silt and 8% clay. The samples range from very fine sandstones to siltstones, and show much variation. The coarsest sample examined represents the "channel" phase of this sandstone in the vicinity of Cuba. It contains 36% fine sand and 35% very fine sand, 14% silt and 15% clay. This sandstone resembles the Pleasantview in the variation between thick and thin beds, in the poor assortment of material, and in the proportions and degree of rounding of the heavy minerals present. It is most easily distinguished by the smaller amount of carbonaceous matter present. It also resembles the Pleasantview sandstone in that each contain ~~presence of~~ large calcareous concretions in the ~~its~~ upper portion, and each ~~in its~~ occurrences in two phases, a channel phase, ~~in which it~~ sharply truncating the marine and brackish water strata below, and a phase in which there is a gradual transition from shale through sandy shale and shaly sandstone to the typical fine grained sandstone. Fossil plant and invertebrate remains were not found in the exposures of this sandstone in the Havana quadrangle. The following is a composite section of the strata between the Springfield (No. 5) and Herrin (No. 6) coals in the valley of Buckheart Creek.

Geologic section 39. Composite section of exposures in the S. ½ sec. 25 and the N. ½ sec. 36, T. 6 N., R. 4 E. (Buckheart twp.)

206

	Feet	Thickness Inches
Pennsylvanian system		
Carbondale series		
Brereton formation		
13. Coal (Herrin or no. 6)	2	6
12. Clay, gray		3
11. Coal	1	
10. Clay, gray, not persistent		2
9. Coal		5
8. Underclay, gray, with blocky fracture	6	
7. Sandstone, thinly to medium bedded, with a prominent band of calcareous concretions 6-8 feet from top, includes some beds of shaly sandstone (Cuba sandstone)	18-25	
St. David formation		
6. Shale, gray, micaceous or slightly sandy in upper 3-5 feet, containing some calcareous concretions at various levels (Canton shale)	18-30	
5. Shale, gray, calcareous, fossiliferous	1	
4. Limestone, gray, in one massive bed, fossiliferous (St. David limestone)	1	2
3. Shale, gray, mottled and black, soft	4	6
2. Shale, black, hard, finely laminated, fossiliferous	2	
1. Coal (Springfield or No. 5)	5	3

In the foregoing section the maximum interval between the coals is approximately 70 feet, which is normal for much of Fulton County, where this sandstone is not in channel fillings.

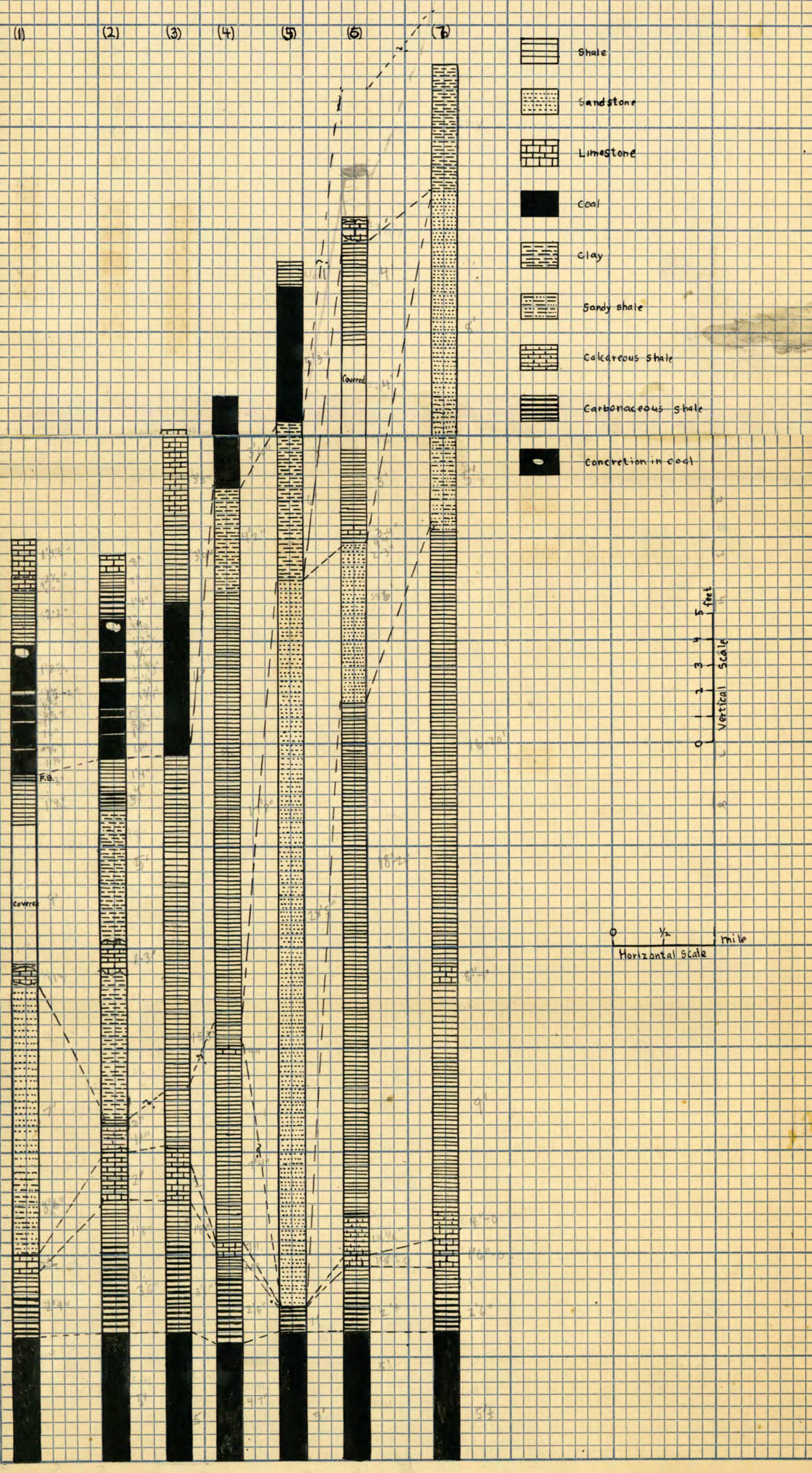
In the vicinity of Cuba the interval between the two coals is much less than 70 feet and some or all of the shale and limestone beds below the sandstone are truncated by it in some exposures (Fig. 66). The sandstone itself is here reduced rather than increased in thickness in some exposures. ~~and~~ It is reported that in one drill record and abandoned mine entry in sec. 10, T. 6 N., R. 3 E. (Putman twp.), northeast of Cuba,[82] coal which

[82] Savage, T. E. Geology and mineral resources of the Avon and Canton quadrangles, Ill. State Géol. Survey, Bull. 38, p. 242, 1921.

is locally 10 feet thick consists of the Herrin (No. 6) coal in direct contact with the Springfield (No. 5) coal, all the intervening strata being absent. The interval between the coals in two outcrops and 4 drill records in the vicinity of Cuba ~~in the Havana quadrangle~~ ranges from 19 to 35 feet. In three of these records the interval between the

Fig. 6 . Cross section from west to east showing the variations in the thickness and succession of strata between the Springfield (No. 5) coal and the Herrin (No. 6) coal south and southeast of Cuba. The following test borings and outcrops furnished the data for this section:

(1) Outcrops in the SW. ¼ SE. ¼ sec. 19, T. 6 N., R. 3 E. and the NW. ¼ NE. ¼ sec. 30, T. 6 N., R. 3 E.
(2) Outcrops in the SW. ¼ SW. ¼ sec. 20, T. 6 N., R. 3 E.
(3) Coal test boring at the SW. cor. SE. ¼ NW. ¼ sec. 20, T. 6 N., R. 3 E.
(4) Coal test boring near the SE. cor. SW. ¼ NE. ¼ sec. 20, T. 6 N., R. 3 E.
(5) Coal test boring near the SE. cor. NE. ¼ NE. ¼ sec. 20, T. 6 N., R. 3 E.
(6) Outcrops in the N. ½ NW. ¼ sec. 21, T. 6 N., R. 3 E.
(7) Outcrops in the E. ½ SE. ¼ sec. 21, T. 6 N., R. 3 E.



coals includes no sandstone, and in the other the thicknesses of sandstone are respectively 7 feet, 7 feet 6 inches and 28 feet 5 inches. This illustrates the extreme variability in this interval in the vicinity of Cuba. The following exposure shows nearly the entire interval between the two coals in the southern edge of the town of Cuba.

Geologic section 40. ~~#########~~ Exposure in a cave-in over abandoned mine workings in the Springfield (No. 5) coal in the SW. ¼ SW. ¼ sec. 20, T. 6 N., R. 3 E. (Putman twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Carbondale series		
Brereton formation		
8. Interval below base of Herrin (No. 6) coal	1	
7. Shale, gray, soft, bedded	1	4
6. Shale, black, finely laminated, with coaly fragments		3
5. Shale, light gray, bedded		5
4. Clay, ~~#####~~ gray, not bedded, soft, upper foot dark gray, containing a discontinuous band of large gray sublithographic limestone concretions with indistinctly preserved fossil traces about 5 feet from the top	8	
3. Clay, dark to light gray, soft, not distinctly bedded	4	1
St. David formation		
2. Shale, dark gray, soft, bedded		2
1. Shale, calcareous, blue gray, abundantly fossiliferous (shale above St. David limestone)		11

The Springfield coal is reported to lie 4 feet or less below the base of this exposure.

Another exposure of this same interval is in a ravine about one half mile south west of the ~~exposure~~ above section. The top ~~of the exposure~~ is 6 feet below the base of the Herrin (No. 6) coal, which outcrops in the road cut just north of it.

Geologic section 41. Exposure in a ravine just south of road along north line of section, near NW. cor. NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 30, T. 6 N., R. 3 E. (Putman twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Carbondale series		
Brereton formation		
5. Limestone, brownish gray, sublithographic, concretionary, unfossiliferous, apparently embedded in blue gray clay		11
4. Sandstone, shaly, gray, micaceous, thinly bedded (Cuba sandstone member)	7	
St. David formation		
3. Shale, slightly sandy, blue gray (Canton shale)	3	6
2. Limestone, gray, in one bed, weathering buff, fossiliferous (St. David limestone	2	
1. Shale, gray, soft, base concealed		2

The base of this exposure is about 3 feet above the Springfield coal. The Canton shale is probably represented only by $3\frac{1}{2}$ feet of slightly sandy shale, whereas in the preceding section (geol. section 40) both the Canton shale and the Cuba sandstone are ~~apparently~~ absent. The unfossiliferous concretionary sublithographic limestone (no. 5 in the foregoing section) is equivalent to the limestone in no. 4, ~~in~~ geological section 40. ~~This limestone is also found in adjacent parts of the Canton quadrangle.~~ Fig. 66 shows the relations of the strata between the Springfield and Herrin coals in the vicinity of Cuba.

~~concretionary limestone is of later date than the Cuba sandstone, similar to No. 5 in the second section desdribed, and in the first exposure the Canton shald and the Cuba sandstone members are absent. Fig. (~~64~~ 66 ~~171a)~~ shows ~~######~~ the relations of the strata between the Springfield and Herrin coals in the vicinity of Cuba.~~

The sandstone above the Canton shale has been named the Cuba sandstone[83]

---

[83] Savage, T. E. Significant breaks and overlaps in the Pennsylvanian of Illinois. Amer. Jour. Sci., 5th ser., vol. 14, p. 309, 1927.

---

from exposures about 1 mile north of Cuba in the Canton quadrangle where this sandstone truncates the underlying strata down to the black ~~fissile~~ hard shale above the Springfield (No. 5) coal. The relations of the Cuba sandstone to the ~~fissile~~ hard shale and coal ~~######~~ near its type locality are shown in fig. 67 . The sandstone in this vicinity occurs in more massive beds, and is somewhat coarser grained than in its exposures in the Havana quadrangle. It represents a channel phase of the sandstone.

Strata between the Cuba sandstone and the Herrin (No. 6) coal.

~~The local marine limestone (member 95) described above~~

A sample of the local marine limestone (member ~~95~~ 73) described above is 86.00% soluble in dilute hydrochloric acid, and contains 9.67% clay, 2.75% silt and 1.57 % sand. The coarser residue consists principally of very small quartz grains and a few scattered grystals of selenite to o.4 mm., flakes of muscovite, larger subangular to rounded quartz grains and small pyrite crystals. A few small bean shaped white siliceous masses suggesting casts of ostracods are the only organic fragments in the residue. The ~~following~~ species of fossils ~~were~~ collected from the exposure of this limestone about one half mile east of Cuba are listed in Appendix A, Part I,

Cuba
St. David

Fig. 67 . Exposure of Carbondale strata near the SW. cor. SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 8, T. 6 N., R. 3 E. (Putman Twp.), about $1\frac{1}{4}$ miles north of Cuba in the Canton quadrangle showing the Cuba sandstone, the massive bedded and thin bedded light colored rock in the upper part of the picture resting unconformably on the dark ~~fissile~~ hard shale (St. David) above the Springfield (No. 5) coal, which shows in a mine pillar near the center of the picture. This is at or near the type locality of the Cuba sandstone.

The gray shale ~~(96)~~ 74 which overlies the limestone east of Cuba is not known elsewhere, but sandy shale, and alternations of clay and shale make up most of the interval between the Cuba sandstone and the Herrin coal. The layer of concretionary limestone (Figure 25) described in geological sections 40 and 41 is quite persistent in exposures near Cuba in the Havana and Canton quadrangles. It is also present north of Fairview in the Canton quadrangle, where it reaches a thickness of 8 or 10 feet. It is found in some exposures in the Peoria and Glasford quadrangles. It is probably of fresh water origin, as marine fossils have not been found in it. The underclay of the Herrin (No. 6) coal resembles the underclays of the other coal beds. The name Big Creek shale has been proposed for strata between the Cuba sandstone and the Herrin (No. 6) coal in the Canton quadrangle.[84] As the interval includes

84/ Savage, T. E. Op. cit. P. 309.

underclay, fresh water limestone and marine limestone, as well as shale, it seems unwise to designate it as a shale member.

Herrin (No. 6) coal.

This coal ~~is exposed only in very limited areas~~ has a very limited distribution in the Havana quadrangle. It is exposed or reported in drill records in a small area south of Cuba in secs. 19, 20, and 30, T. 6 N., R. 3 E. (Putman twp.), and immediately under Pleistocene deposits at the heads## of three small gullies on the west side of Buckheart Creek in the SE. $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 25, T. 6 N., R. 4 E. (Buckheart twp), 11 to 12 miles east of the outcrops near Cuba. This coal differs from the Colchester and Springfield coals in that it contains several bedded partings of clay, ironstone and pyrite, dividing the coal into separate benches. The total thickness ~~of the coal~~ in 4 measured exposures ranges from 4 feet 6 inches to 5 feet 6 inches, and the bedded impurities range from 5 to 11 inches ~~in these exposures~~. The best exposure of this coal and the shale and limestone above it is in the central fork of a small ravine in the SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 19, T. 6 N., R. 3 E. (Putman twp.) (Figs. ~~69~~ 68 and ~~70~~ 69).

Geologic section 42. Exposure in small ravine 300 feet north of east-west road at south line of section in SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 19, T. 6 N., R. 3 E. (Putman twp.).

	Thickness Feet	Thickness Inches
Pleistocene system		
Peorian and Illinoian series		
17. Loess and glacial drift	Not measured	
Pennsylvanian system		
McLeansboro series		
Brereton formation		
16. Limestone, gray, fossiliferous, with abundant Fusulinella girtyi, and other fossils (Brereton)	1	$4\frac{1}{2}$
15. Clay, soft, bedded		$1\frac{1}{2}$
14. Limestone, gray, massive, fossiliferous		4
13. Clay, light gray		2
12. Shale, dark blue, rather soft, containing a few fossil traces	2	2
Carbondale series		
Herrin coal member		
11. Coal, with large black calcareous and pyritic concretions reaching a horizontal # diameter of 3 feet 6 inches, extending down into the coal as far as 8 inches	1	8
10. Shale, light, with clay ironstone band below center		2
9. Coal		5
8. Shale, dark gray		$\frac{1}{2}$
7. Coal		$6\frac{1}{2}$
6. Shale, light gray		1
5. Coal, with thin white veins of calcite on parting faces	1	

Fig. 68. Exposure of McLeansboro and Carbondale strata in the SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 19, T. 6 N., R. 3 E. (Putman twp), about 1 mile southwest of Cuba, showing the ~~best exposure of the~~ Herrin (No. 6) coal and the overlying shale and limestone (Brereton), the basal beds of the McLeansboro series. Large calcareous and pyritic concretions in the upper bench of the coal are visible to the left near the center of the picture. The benched character of the coal, with its clay bands is shown in the exposure in the foreground at the right. Fig. ~~70~~ 69 is a more detailed picture of the coal in this exposure.

D

10

8

6

Fig. ~~109~~ 87 Exposure of the Herrin (No. 6) coal 1 mile southwest of Cuba (see fig. 68 for exact location), showing the division of this coal into benches by persistent clay bands. A persistent band of gray shale is seen above the middle of the picture (No. 10 of described section), and two thinner beds of shale (nos. 8 and 6) are indicated at edge of picture.

		Feet	Inches
4.	Shale, black, coaly		$\frac{3}{4}$
3.	Coal		$11\frac{1}{4}$
2.	Shale, black, finely laminated, hard		3
1.	Shale, black, soft, weathering gray	1	9

Fig. 68 shows beds 5-16 of the foregoing section and fig. 69 shows the coal and its bedded impurities in greater detail. The number and positions of many of the bedded impurities do not appear to be constant in the 4 sections of the coal measured. The coal is also well exposed in abandoned local strippings west of the C. B. & Q. Ry. track near the southern corporate limits of Cuba. Here the coal contains a larger number and greater thickness of bedded impurities than in the foregoing section.

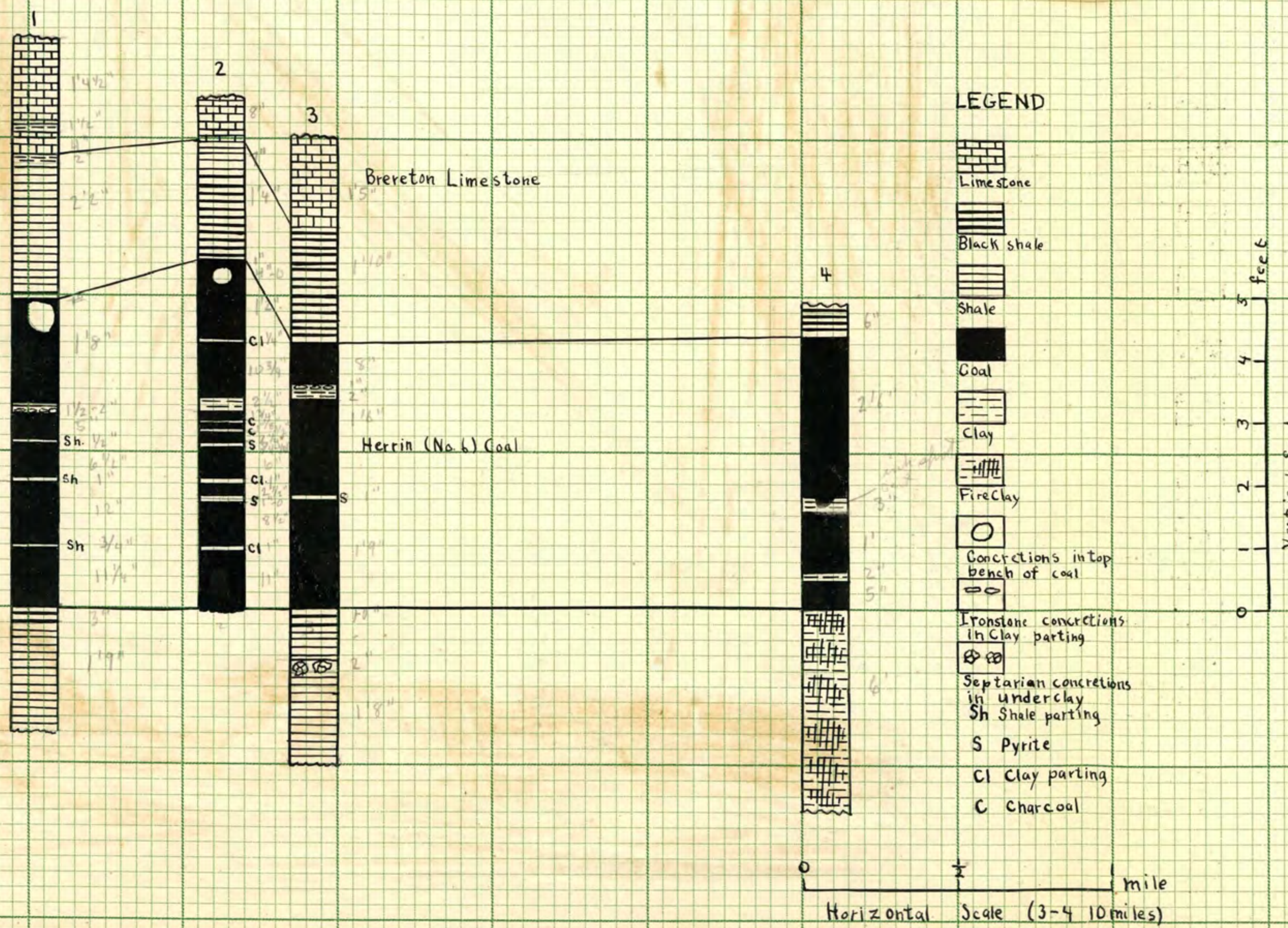
Geologic section 43. Exposure in abandoned local stripping in the NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 20, T. 6 N., R. 3 E. (Putman twp.).

		Thickness Feet	Thickness Inches
Pennsylvanian system			
McLeansboro series			
Brereton formation			
22.	Limestone, gray, fossiliferous, with Fusulinella girtyi (Brereton limestone)		8
21.	Shale, brownish		7
20.	Shale, black, soft, weathered	1	4
Carbondale series			
Herrin coal member			
19.	Coal, soft, weathered		1
18.	Concretions, pyritic, black, hard, with some calcite bands, not persistent, in upper bench of coal		4
17.	Coal, including the concretions above	1	2
16.	Clay, gray		$\frac{1}{4}$
15.	Coal		$10\frac{3}{4}$
14.	Clay, blue gray		$2\frac{1}{2}$
13.	Coal		$1\frac{3}{4}$
12.	Charcoal parting, not persistent		1/8
11.	Coal		1
10.	Charcoal parting		$\frac{1}{2}$
9.	Coal		$2\frac{1}{4}$
8.	Pyrite concretions, black		$\frac{1}{4}-\frac{3}{4}$
7.	Coal		6
6.	Clay, gray		1
5.	Coal		$2\frac{1}{2}$
4.	Pyrite concretions, not persistent		1
3.	Coal		$8\frac{1}{2}$
2.	Clay, gray		1
1.	Coal, to base of exposure, probably within 1 inch of base of coal		11

Fig. 70 shows graphic sections of this coal in the 4 exposures measured.

Fig. 5-10. Graphic sections of the Herrin (No. 6) coal and associated strata in the vicinity of Cuba (1-3) and along Buckheart Creek southeast of Dunfermline (4). These sections show bedded impurities in the coal in all outcrops. ~~It is probable that~~ Certain bedded partings in the coal are locally persistent in the sections near Cuba. The exposures on which the sections are based are:

(1) Outcrop along ravine in the SW. ¼ SE. ¼ sec. 19, T. 6 N., R. 3 E.
(2) Abandoned local strip mine south of Cuba cemetery in the NW. ¼ SW. ¼ sec. 20, T. 6 N., R. 3 E.
(3) Outcrop along ravine in the SE. ¼ SW. ¼ sec. 20, T. 6 N., R. 3 E.
(4) Outcrop in small gully west of Buckheart Creek in the SE. ¼ SW. ¼ sec. 25, T. 6 N., R. 4 E.



This coal is correlated with the No. 6 coal, which was first numbered from exposures in eastern Fulton County and in the vicinity of Cuba.[85]

[85] Worthen, A. H. Fulton County. Geology of Illinois, vol. IV. Pp. 100-101, 1870.

The No. 6 coal of Fulton County has been subsequently correlated with the Herrin coal of Franklin and Williamson counties in southern Illinois, and ~~this coal~~ is called the Herrin (No. 6) coal. It is usually recognized by the presence of a persistent blue band or clay parting about 1½ inches thick, which commonly occurs 15 inches above the base of the coal.[86] In the exposures measured, there is more than one shale or clay parting, and the blue band cannot be certainly recognized.

[86] Cady, G. H. Coal resources of District IV, Illinois State Geol. Survey, Coop. Mining series, Bull. 26, p. 86, 1921.

McLeansboro series

The McLeansboro series is named from McLeansboro, ~~White~~ Hamilton County, Illinois, where a deep drilling gives a good section of these strata.[87] It includes Pennsylvanian strata above the Herrin or No. 6 coal. The only strata exposed in the Havana quadrangle belonging to the McLeansboro series are dark shale and limestone above the Herrin (No. 6) coal, ~~which are~~ exposed in secs. 19 and 20, T. 6 N., R. 3 E. (Putman twp.), south and southwest of Cuba. The three exposures measured in these sections show from 2 feet 5 inches to 4 feet 2 inches of McLeansboro strata. The~~se exposures~~y are described in geologic sections 42 and 43 and shown graphically in fig. 70.

[87] DeWolf, F. W. Studies of Illinois Coal. Introduction. Ill. State Geol. Survey, Bull. 16, p. 181, 1909.

The lower member is dark soft finely laminated shale, containing a few large calcareous and pyritic concretions. Fossil remains are very uncommon and poorly preserved in this shale and its concretions. It is much softer than the corresponding black shale over the Springfield (No. 5) coal.

Brereton limestone

The upper member is gray limestone, which commonly occurs in two benches separated by a parting of clay. A sample of this limestone which was tested is 91.64% soluble in dilute hydrochloric acid, and contains 2.70 % clay, 5.14% silt and 0.52% fine sand. The coarser insoluble residue consists of nearly equal proportions of aggregates of minute pyrite crystals, ~~and~~ hardened aggregates of ferruginous clay, and numerous grains of quartz, 0.4 mm. or less in diameter, rounded to subangular in shape. No well preserved traces of fossils are present in the insoluble residue. This limestone is everywhere fossiliferous, and ~~it~~ is marked especially by the abundance of the small fusulinid Fusulinella girtyi, formerly called Girtyina ventricosa. It ~~This fossil~~ is so abundant and characteristic ~~of this limestone~~ that this ~~it~~ has been called the "Girtyina" limestone. Its presence in abundance in a limestone cap rock of a coal has been used to recognize the Herrin (No. 6) coal in various parts of Illinois. ~~but~~ Recent studies have shown that this fusulinid is not limited to the Brereton ~~this~~ limestone, and that other species of fusulinids from other horizons have been confused with it. The diagnostic internal characters of Fusulinella girtyi have been recently described.[88]

---

[88] Dunbar, C. O. and Condra, G. E. The Fusulinidae of the Pennsylvanian system in Nebraska. Nebraska Geol. Survey, Bull. II, 2nd. ser., pp. 76-78, 1927.

The brachiopod Squamulária perplexa is , next to Fusulinella girtyi, the most abundant fossil in this limestone. The species of fossils collected ~~from this limestone~~ are listed in Appendix A, Part I.

The name Brereton ~~limestone~~ has been recently proposed for this limestone from exposures along a branch of Copperas Creek east of the village of Brereton ~~####~~ in the Canton quadrangle.[89] Exposures in this

[89] Savage, T. E. Op. cit. P. 309.

vicinity are here ~~####~~ considered the type ~~exposures~~ of the Brereton formation.

Stratigraphic relations of the Brereton formation

The basal sandstone ~~of the Brereton formation~~, the Cuba, ~~sandstone~~, locally truncates some or all of the strata between the top of the Canton shale and the Springfield (No. 5) coal. In some exposures this truncation ~~##~~ or unconformity is present, but shale or poorly bedded clay, rather than sandstone, is the first stratum above it. The limited area affected by these unconformable relations in the Havana quadrangle does not prove clearly whether or not this truncation occurs along the channel of a stream excavated before the deposition of the Cuba sandstone. Relations between the Cuba sandstone and underlying strata in the Canton, Glasford and Peoria quadrangles suggest the presence of stream channels in ~~##~~ which the coarser and thicker ~~Cuba~~ sandstone was deposited ~~in those areas~~. The stratigraphic relations of the thin marine limestone above the Cuba sandstone are discussed on p. 162. The Brereton limestone is conformably overlain by gray shale in the Canton quadrangle. This shale has been named the Copperas Creek ~~shale~~. It is not exposed in the Havana quadrangle, having been completely removed by pre-Pleistocene erosion. The Brereton formation is everywhere unconformable overlain by Pleistocene materials.

Correlation.

The Herrin (No. 6) coal is the top of the Carbondale series in Illinois. It is ~~probably~~ the approximate equivalent of one of the coals in the upper part of the Allegheny formation of Ohio and Pennsylvania, probably the Middle Kittanning or Upper Freeport coal. This coal and associated strata

are approxim

are probably equivalent to the upper part of the Henrietta formation or the lower part of the Pleasanton formation of Missouri and Kansas.

Post-Pennsylvanian pre-Pleistocene deposits.

No materials accumulated in the later Pennsylvanian or Permian periods of the Paleozoic era, during the Mesozoic era, or during the Cenozoic era previous to the Pleistocene period have been found in this quadrangle. Rounded pebbles of quartz and chert, which are of common occurrence in the glacial drift deposits, are similar to those occurring on the Lancaster peneplain of southwestern Wisconsin, a region which was not glaciated. These pebbles may have come from similar deposits which formerly occurred in this region, but were later worked over and incorporated in the Pleistocene glacial deposits. The pre-glacial surface may be considered the principal product of this long unrecorded time when erosion predominated over deposition in this region.

Preglacial surface

The general character of the pre-glacial surface may be determined from the altitudes of contact between the Pleistocene and Pennsylvanian deposits. The surface thus outlined is, however, complex, as the oldest Pleistocene deposits in various places belong to different stages of the Pleistocene, and erosion during the interglacial stages removed locally not only the deposits of the preceding glacial stage, but some ~~the~~ pre-Pleistocene materials as well.

The altitudes of the preglacial surfaces ranged from about 660 feet above sea level in the vicinity of Cuba to about 380 feet under parts of the Illinois River flood plain and the sandy terrace around Havana. The maximum known relief is thus approximately 280 feet. The altitudes of the present surface range from 636 feet at Cuba to 427 feet at water level in the Illinois valley in the southern part of the quadrangle, a relief of approximately 260 feet. The character of this surface, as determined from outcrops or drill records is plotted graphically in Plate III. The more important features shown on this contour map are briefly discussed here.

(1) Northwestern part of the quadrangle. The bed rock surface ~~#####~~ seems to decline gradually or abruptly west of the area of highest altitude near Cuba. The two streams near the northwest ~~#####~~ corner of the quadrangle are cut to levels of about 580 and 620 feet and show no bed rock. The bed rock level along the head tributaries of Stuart Creek is 580 to 600 feet, but this declines to the south in sec. 2, T. 5 N., R. 2 E. (Bernadotte twp.) to 540 feet, and south of this no exposures are found along the banks, bed or tributaries of the creek. An oil test boring in sec. 24, T. 5 N., R. 2 E., on the terrace north of Spoon River and east of Stuart Creek shows a bed rock altitude of 430 feet, 110 feet lower than the lowest exposure along Stuart Creek. An area of several square miles in the northeast part of the Vermont quadrangle and the southeast part of the Avon quadrangle adjacent to the northwest part of the Havana quadrangle has a bed rock surface lower than the beds of ravines at 500 to 480 feet. This area seems to be the location of the pre-Illinoian or perhaps pre-Kansan valley of Spoon River. This valley may have had a width of two or three ~~#######~~ miles, while the present valley of Spoon River between Bernadotte and Seville in the Vermont quadrangle is bounded by rock exposures not more than one half mile apart in several places. The lack of well data in this area makes it impossible to map the exact limits of this old valley.

(2) Slug Run valley east of Cuba. Several small buried valleys have been detected in secs. 15, 16, 21 and 22, T. 6 N., R. 3 E. (Putman twp) in connection with coal mining operations and ~~#####~~ test borings in the Springfield (No. 5) coal. These seem to be occupied at least in some places by weathered gravels of pre-Illinoian age (see fig. 80). Such gravels continue south along Slug Run to its junction with Big Creek and upstream about 2 miles along the valley of Big Creek. Similar gravels have been found along Big Sister Creek in sec. 8, T. 5 N., R. 4 E. (Liverpool twp.), but none have been found along the lower part of Big Creek valley.

This distribution suggests that during preglacial or early interglacial time a valley may have crossed Big Creek and united with one of the branches of Big Sister Creek, probably the branch heading in the SE. ¼ sec. 36, T. 6 N., R. 3 E. (Putman twp), as there are no outcrops of the bed rock along this branch.

(3) Little Sister Creek valley. A preglacial valley is reported to cross the divide between Little Sister Creek and Big Creek near St. David, cutting below the Springfield coal. This valley seems to meet the valley of Big Creek near the point where it curves from a southerly to a southwesterly direction, and suggests that in preglacial or pre-Illinoian time the drainage of upper Big Creek continued south past St. David into the drainage basin of Little Sister Creek. The bed rock altitudes along Little Sister Creek are lower than along Big Sister or Buckheart Creeks, indicating that Little Sister Creek had the largest preglacial valley of the three.

(4) Drainage changes south west of Lewistown. The large ravine west of Lewistown has a bed rock level lower than 510 feet in its upper part, just west of Lewistown. In the lower mile ## this valley is bounded by rock walls rising to 550 or 560 feet. The lower part of the valley appears ~~thus~~ to be of more recent origin than the upper ~~part~~, as the rocks ~~of that part of the valley are not known to be more resistant than those of the other part~~ are about equally resistant in both parts. It seems likely that the drainage of the upper part of the valley was carried across the present divide southwest of Lewistown to a southeast flowing tributary of East Creek, as shown on the contour map. The date of this drainage change is not known as pre-Illinoian deposits were not found along either of these valleys.

(5) Valley of Coal Creek. The valley of Coal Creek is pre-Kansan in age, at least in part, as Kansan drift is found in this valley, and the bed rock appears at much higher levels along its lateral tributaries on both sides.

(6) Valley near Mound Chapel, Isabel township. The east flowing stream in secs. 20, 21 and 22, T. 4 N., R. 3 E. (Isabel twp.) has no rock outcrops west of the point where its valley merges with that of Spoon River. ~~That of Spoon River~~ This suggests that this stream follows the line of a preglacial valley between Spoon River and Otter Creek. It may have carried the drainage of the North Branch of Otter Creek above the sharp bend in this stream in the NW. ¼ sec. 19, T. 4 N., R. 3 E., and the south flowing portion of the North Branch may have been a pirating branch of Otter Creek.

(7) Steep slopes of Illinois River rock valley. Very steep slopes along the margin of ~~the~~ Illinois River valley are indicated in the straight sections of the valley in secs. 26 and 35, T. 4 N., R. 3 E. (Isabel twp), secs. 29, 31 and 32, T. 5 N., R. 4 E. (Liverpool twp) and secs. 14, 22 and 23 of the same township. The straightness and steepness of these portions of the valley wall are probably the result of the torrential flow of water which occupied this valley at the time of the drainage of Lake Illinois, or during one of the later times when the valley was occupied by a torrent of glacial waters.

(8) Spoon River valley at Duncan Mills. A steep south wall for Spoon river is indicated at Duncan Mills, where the south end of the highway bridge rests on bed rock and the north end of the bridge rests on 60 feet of valley fill.

(9) Flood plains of Illinois and Spoon Rivers and the terrace area east of ~~the~~ Illinois River flood plain. The level of the rock floor of ~~the~~ Illinois and Spoon Rivers is indicated by these datum points.

(a) Spoon River at Duncan Mills, 400 feet.
(b) Spoon River terrace in sec. 24, T. 5 N., R. 2 E. (Bernadotte twp.) 430 feet.
(c) Illinois River valley at and near Sepo (from 5 coal test borings) 430, 406, 409, 406 and 398 feet.
(d) Illinois River valley in sec. 4, T. 4 N., R. 4 E. (Waterford twp) 403 feet.
(e) Illinois River terrace at Havana. Bed rock not reached at 410 feet.
(f) Illinois River terrace in sec. 31, T. 22 N., R. 8 W. 381 feet.

The foregoing data indicates an average altitude of the bed rock surface of 400 feet or a little lower. The level of the ~~######~~ rock floor of the terrace east of the river appears not to be higher than that of the flood plain. Variations in the rock level near Sepo are probably due to the entrenchment of the preglacial valley of East Creek into a rock terrac along the margin of the valley~~#~~ of ~~the~~ Illinois River.

(10) Strip mining area southeast of Cuba. The bed rock topography of parts of secs. 27, 28, 33 and 34, T. 6 N., R. 3 E. (Putman twp.) has been contoured from the data supplied by several hundred closely spaced and accurately levelled coal test borings. The contouring~~#~~ of this surface reveals many minor irregularities such as doubtless occur in all parts of the quadrangle. These minor irregularities can be shown only where the datum points are very closely spaced, as in the strip mining area.

HAVANA QUADRANGLE (Part B.)

Pleistocene system

Introduction

The term Pleistocene was introduced in 1839,[30] but the original

[30] Lyell, C., Elements of Geology, French translation, appendix, pp. 616-621, Paris, 1839.

__________, Charlesworth's Magazine of Natural History, vol. 3, p. 323, footnote, 1839.

stratigraphic application of the term was revised and defined in its present status in 1846.[31] The Pleistocene system in America is divided into five

[31] Forbes, Edward, On the connection between the distribution of the existing fauna and flora of the British Isles, and the geological changes which have affected their area, especially during the epoch of the Northern Drift: Great Britain Geol. Survey Memoir, vol. 1, pp. 402-403, 1846.

glacial and four interglacial series. (See table, p. 14.) All of these series occur in Illinois, but the Havana quadrangle contains glacial deposits belonging only to the Nebraskan, Kansan and Illinoian series. Interglacial deposits belonging to each of the interglacial series are present in the Havana quadrangle. Valley train, slack water and wind deposits belonging to the Wisconsin, and probably also to the Iowan glacial stages are present ~~in the Havana area~~. The Pleistocene deposits overlie the Pennsylvanian strata unconformably.

Pleistocene deposits cover the entire surface of the quadrangle, except locally where postglacial erosion has exposed the bed rock. The entire area was mantled with glacial deposits of Illinoian age, and the record of the older stages of glaciation is preserved in isolated localities where the older drifts are separated from the Illinoian drift by loess, peat beds or lacustrine silts, and where the older drifts show a profile of weathering,[32] beneath unweathered Illinoian drift. Localities

[32] discussion of profile of weathering, pp. 224-231.

where the deposits of pre-Illinoian age are exposed beneath Illinoian drift are shown in fig. 71.

Nebraskan and Aftonian series
Insert p. 188a

Two glacial drifts older than the Illinoian were recognized in two ravines in the southern part of the Havana quadrangle. The lower and older of these drifts is referred to the Nebraskan, the earliest known epoch of glaciation, and the upper to the Kansan, the second known glacial stage.[97]

---

[97] Wanless, H. R. Nebraskan till in Fulton County, Illinois. Trans. Ill. State Acad. Sci. vol. 21, pp. 273-282, 1929.

One of these exposures is in the largest ravine in the NE. ¼ sec. 5, T.3 N., R. 3 E. (Kerton twp.).

Geologic section 44. Cut bank on north side of ravine near center NE. ¼ sec. 5, T. 3 N., R. 3 E. (Kerton twp.)

	Thickness Feet	Thickness Inches
Pleistocene system		
Illinoian series		
8. Till, calcareous, light gray	12	6
Yarmouth series		
7. Calcareous concentration, white, in clay		1
6. Silt, calcareous, bluish to dark blue gray, compact; fossiliferous (containing a loess ? or terrestrial fauna); not distinctly bedded; contains numerous iron stained concretions of irregular shape as large as one foot 6 inches diameter; weathers to dark chocolate brown; smoothed upper surface due to glacial erosion; shows a lenticular mass of noncalcareous Kansan till thrust into it (fig. 73). For fossil list from this silt, see Appendix A, Part II	6	
Kansan series	2 or 3	
5. Till, noncalcareous, gray (~~B or C~~ horizon of buried profile of weathering); includes three foot lenticular mass thrust into Yarmouth silt	6	6
4. Till, calcareous, rusty colored (horizon 4 of buried profile of weathering		6
3. Till, calcareous, dark blue gray, to stream level	3	3
Aftonian series (?)		
2. Sand, calcareous, yellow brown, exposed at east end of cut	2	
Nebraskan series		

See p. 253? for fossils

The Nebraskan series was originally called sub-Aftonian, because ## drift of this age was discovered below the Aftonian gravels of western Iowa.[93] Subsequently the name was changed to Nebraskan from typical ex-

---

[93] Chamberlin, T. C. Nomenclature of glacial formations. Jour. Geol. vol. 4, pp. 872-876, 1896.

---

posures along the Missouri River in eastern Nebraska and western Iowa.[94]

---

[94] Shimek, B. Aftonian sands and gravels of western Iowa. Bull. Geol. Soc. Amer. vol. 20, p. 408, 1909.
__________. The Pleistocene of the Missouri Valley. Science, N. S., vol. 31, pp. 75-76, 1910.

The Aftonian series is named from exposures of gravels between two drift sheets near Afton Junction, Iowa. The gravels were at first considered ~~to be~~ younger than the drift of the Kansan epoch,[95] but it was later dis-

---

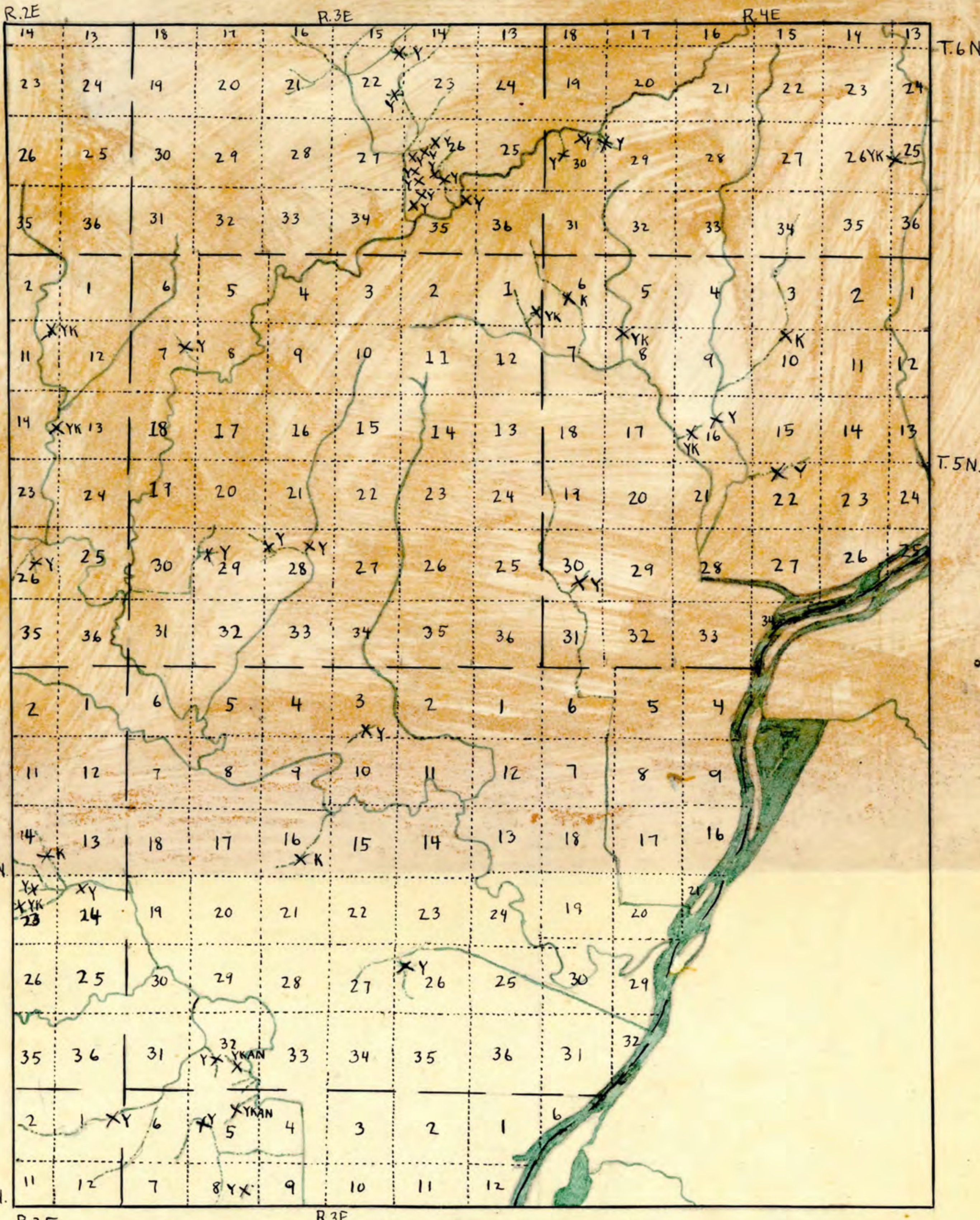
[95] Chamberlin, T. C. The classification of American glacial deposits. Jour. Geol. vol. 3, p. 272, 1895.

---

covered that the overlying drift is of Kansan age.[96]

---

[96] Chamberlin, T. C. Nomenclature of glacial formations. Jour. Geol. vol. 4, pp. 873-874, 1896.



Y Yarmouth Gravel, Sand, Silt, Loess ~~and~~ or Soil

K Kansan Till or Gumbotil

A Aftonian Sand, Loess, or Soil

N Nebraskan till or Sand.

Fig. 71 . Sketch Map of Havana Quadrangle showing Location of Exposures(X) of Buried pre-Illinoian glacial and interglacial deposits.

Fig. 12. Diagram of cut bank in the NE. ¼ sec. 5, T. 3 N., R. 3 E. (Kerton) [illegible] showing Illinoian till overlying Yarmouth fossiliferous loess and Kansan till. Due to ~~######~~ glacial overriding of this surface a wedge shaped mass of leached and oxidized Kansan till has been thrust into the Yarmouth loess from the east. In the lower right partion of the cut bank is a mass of ~~######~~ oxidized calcareous sand of Kansan or Aftonian age, and near the water level at the base of the cut is a rolled mass of brown oxidized calcareous till ~~##~~ surrounded by blue gray unoxidized till. This mass is interpreted as a rolled ~~pellet~~ inclusion from the upper surface of weathered Nebraskan till in this vicinity which was incorporated in the Kansan till.

-186

8pt

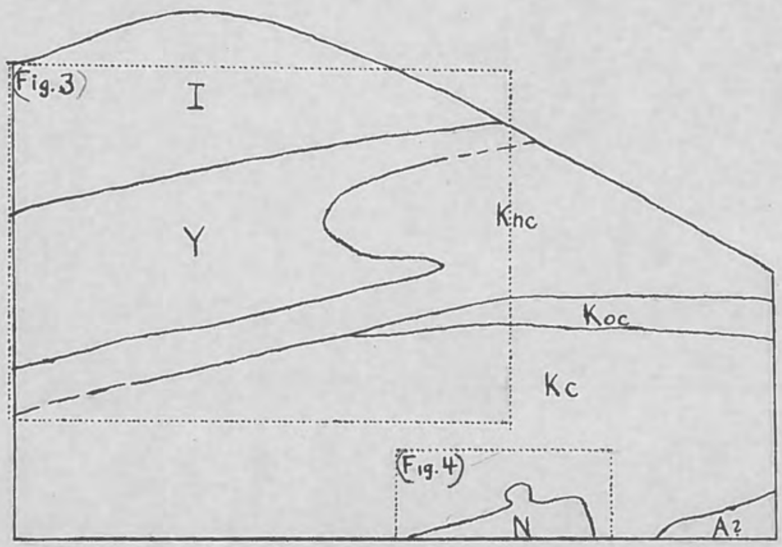


Figure 2. Diagram of cut bank on north side of ravine near center of NE. $\frac{1}{4}$ sec. 5, ~~T.~~ 3 N., R. 3 E. (Kerton twp.). Areas included in figures 3 and 4 outlined with dotted lines.

I	Illinoian till, calcareous
Y	Yarmouth fossiliferous loess
Knc	Kansan till, noncalcareous
Koc	Kansan till, calcareous, oxidized
Kc	Kansan till, calcareous
A?	Aftonian? sand, calcareous oxidized
N	Nebraskan till, calcareous oxidized

Fig. 13. Upper portion of cut bank sketched in fig. 12, showing dark compact fossiliferous late Yarmouth loess, lying between calcareous Illinoian till above and noncalcareous till below. The Yarmouth ~~silt is~~ loess is outlined.

1. Till, calcareous, oxidized, brown; a rounded ball with projecting knob, surrounded by dark blue gray unoxidized till. (figs. 72 and 74)

About 200 yards east of the above cut, yellow-brown, calcareous Aftonian (?) sand is exposed above brown oxidized calcareous till, like the rolled ball of the Nebraskan ~~till~~ incorporated in the Kansan ~~till.~~ Fig. 72 is a generalized sketch of the relations in this cut bank. These exposures were studied in August, 1927. When revisited in June, 1928, extensive slumping of loess and soil from the upper part of the slope had covered the Nebraskan and most of the Kansan till.

The other exposures of Nebraskan and Aftonian deposits are in a ravine about one half mile north-northwest of the ##### exposure described in geologic section 44. In this ravine the Pleistocene succession is a composite of (a) a sharply cut gully on the west side of the ravine, (b) outcrops along the ravine about 150 yards below the gully, and (c) a high cut bank on the southwest side of the ravine at the lower end of the main ravine outcrop. The top of the exposure is 22 feet below the adjacent level upland.

Geologic section 45. Exposures in a ravine west of Otter Creek in the ~~N~~SW. ¼ SE. ¼ sec. 32, T. 4 N., R. 3 E. (Isabel twp.)

	Thickness Feet	Thickness Inches
Pleistocene system		
Peorian series		
17. Loess, noncalcareous, gray, buff above; with reddish spots along joints and root canals	3	4
16. Loess, calcareous, gray; some ferruginous concretions and a few kindchen	7	6
Sangamon series		
15. Loess, noncalcareous, reddish; some carbonized wood fragments; lower surface dips north	3	3
Illinoian series		
14. Silt, slightly calcareous (probably around local centers such as root canals); pink and gray laminated; pebble concentrate at top; thins and disappears to north	1	
13. Till, noncalcareous, brownish-gray (horizon 2 of buried ~~soil~~ profile of weathering).	2	9
12. Sand and gravel, noncalcareous	2	6
11. Till, slightly calcareous above, more calcareous below; reddish brown; (lower part of horizon 3 and horizon 4 of buried profile of weathering)	1	6

Fig. 74. Detail of lower portion of cut bank sketched in fig. 72, showing rolled mass of calcareous oxidized Nebraskan till incorporated in unoxidized calcareous Kansan# till. The Nebraskan till pellet is outlined.

10. Till, calcareous, light gray — 15

Yarmouth series

9. Silt or loess, calcareous, gray, unfossiliferous, not persistent — 1
8. Sand, noncalcareous, yellowish, very fine; gravel concentrate at top — 6-8
7. Gravel, noncalcareous, brownish; including some beds of coarse reddish sand — 15 6

Kansan series

6. Till, calcareous, dark gray, bouldery; deformed into sharp folds (by shove of Illinoian glacier, see fig. 76); containing the following kinds of inclusions; (1) numerous large blocks of well preserved wood (fig. 75); (2) large blocks of thoroughly leached and oxidized till (Nebraskan); (3) ~~numerous~~ blocks of blue gray calcareous fossiliferous loess (Aftonian); and (4) ~~numerous~~ blocks of dark forest soil, with small fragments of carbonized wood; in cut bank on southwest side of ravine lower surface is very uneven and inclined to west — 12

Nebraskan series

5. Till, noncalcareous, brownish gray; including a large mass 2 feet 6 inches thick, projecting toward east into sand below; separated by sharp contact from till above (figs. 77 and 78) — 1-1½
4. Sand, noncalcareous, light buff; somewhat crossbedded; foreset beds dip east; includes several lens-like masses of weathered coal — 2
3. Gravel, noncalcareous, lenticular — 1
2. Sand, noncalcareous, to base of cut — 4
1. Till, noncalcareous, brownish; exposed by digging; may be lenticular — 6

The sections along this ravine were measured in August, 1927. In June, 1928, when the ravine was revisited the exposures ~~along the ravine~~ were buried to quite an extent by silt and sand wash of the ravine, so that the contorted till, including blocks of Aftonian loess and pre-Kansan soil could not be found easily. The log in the Kansan till figured, had been carried away by the stream and the high cut bank had slumped extensively, exposing the brown oxidized noncalcareous Yarmouth gravel in the upper portion. This had been covered, by soil and slump previously. The Nebraskan till and sand were buried with debris from above.

Pebble counts were made of the Illinoian, Kansan, and Nebraskan tills in these two ravine exposures to determine, ~~if possible~~, ~~if~~ whether certain types of rocks were characteristic of a certain till either by their abundance in one ~~till~~ and rarity in others, or by their presence in one ~~till~~

Fig. 75. Log of coniferous ? wood in Kansan till in bed of ravine in SW. ¼ SE. ¼ sec. 32, T.4 N., R. 3 E. (Isabel twp.).

Fig. 16. Kansan till contorted into sharp folds by overriding Illinoian ice, in bank of the same ravine as shown in fig. 15.

Fig. 11. ~~####~~ Diagram of exposure in a cut bank on the southwest side of a ravine in the SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 32, T. 4 N., R. 3 E. (Isabel twp.), showing calcareous Kansan till overlying noncalcareous Nebraskan till and sand, which has been locally contorted so that one mass of till is surrounded by the sand.

Fig. 78. Photograph of cut bank shown by diagram in fig. 77, showing Kansan and Nebraskan till. The hammer marks the contact between the tills.

and rarity in the other two. A pebble count is made by lining out an area of one or two square feet and picking up all pebbles larger than the size of a pea on the surface within this area. This gives representative proportions of the different kinds of rocks incorporated in the till.

Fresh till in this region is calcareous. A noncalcareous till has been leached of all of its limestone and dolomite pebbles, ~~and~~ many sandstone and shale pebbles have also become disintegrated, hence its pebbles consist principally of the rocks which are most resistant to weathering, such as quartz, chert, igneous and metamorphic rocks. The Nebraskan till is noncalcareous in the only exposure found, while the other tills are calcareous where pebble counts were made from them.

The proportions of different kinds of rocks in the pebble counts made is shown graphically in fig. 79.

A sample of the noncalcareous sand from below the Nebraskan till in the second ravine described was examined. It is principally quartz sand from 0.1 mm. to 1 mm., with a few grains of chert, feldspar, muscovite, granules of quartz, granite and greenstone. The larger quartz grains are rounded or subrounded, but many of the smaller grains are angular.

The wood included in the Kansan till in this ravine (fig. 75) was identified as ##### . This wood is probably of early Kansan age, representing forests which occupied this region when the Kansan glacier covered it ~~the region~~.

The blocks of loess included in the Kansan till contain a few fossils, but the preservation of these is poor, as the loess was greatly compacted and crushed first by the overriding Kansan glacier and later by the Illinoian ~~glacier~~. The three species identified from the loess are listed in Appendix A, Part III. They are all land shells and characteristic of loess deposits. The loess is probably of late Aftonian age.

240

200

Fig. 74

Omit

BECKLEY-CARDY CO., CHICAGO

 24?

98/

Kansan series

98/ Chamberlin, T. C., in Geikie, James, The Great Ice Age, pp. 753-764, 1894.

The term Kansan was proposed for this series of glacial deposits because it has wide surficial distribution in the State of Kansas, where it is free from complication with other drifts. 99/

99/ Chamberlin, T. C., The Classification of American Glacial Deposits: Jour. Geol., vol. 3, pp. 270-277, 1895.

The Kansan series is represented by dark blue gray till in a few exposures in the quadrangle. It is distinguished from the overlying Illinoian till only in exposures where a weathered zone of till or interglacial deposits of Yarmouth age were preserved above it. Kansan till has been recognized with more or less certainty at thirteen exposures in the Havana quadrangle. In six of these exposures it is separated from the overlying Illinoian till by interglacial loess or waterlaid silt or soil of Yarmouth age; in four exposures it is separated by oxidized and leached sands and gravels of Yarmouth or late Kansan age, in one exposure it is separated by ##### one band of Yarmouth fossiliferous loess, several feet of sand and gravel, and a band of Yarmouth fresh water silt which is also fossiliferous. ~~and~~ In the other two exposures it is distinguished from the Illinoian ~~only~~ by a weathered zone developed on the Kansan till underneath calcareous and unoxidized Illinoian till.

The relation of the topography of Kansan time to the places where Kansan till is preserved is well illustrated in outcrops along Coal Creek in the SW. ¼ sec. 30, T. 5 N., R. 4 E. (Liverpool twp.) where the Kansan till is limited to a belt closely paralleling the creek valley. In the upper portions of lateral tributaries the Pleasantview sandstone, the bed rock of this area is exposed at altitudes higher than those where the Kansan till is preserved nearer the valley. The preservation of Kansan till here is probably related to the trend of this valley, which drains about S. 60° E., while the direction of Illinoian ice advance was approximately N. 60° E., nearly at right angles to the trend of this valley.

The exposures described in geologic sections 44 and 45 show typical sections of the Kansan drift under fossiliferous Yarmouth loess in section 44 ~~the first ravine described~~ and under weathered sand and gravel in section 45. It is noteworthy that the Kansan till immediately below the fossiliferous loess has been considerably weathered, with the development of a profile of weathering, while the Kansan till below the weathered gravel is comparatively fresh. The significance of this difference will be mentioned further in determining the ages of various Yarmouth deposits.

The best exposures showing Kansan till directly beneath Illinoian till are in several branches of a ravine south of Spoon River, described in the following section.

Geologic section 46. Exposure in the east branch of a ravine in the NE. 1/4 SW. 1/4 sec. 16, T. 4 N., R. 3 E. (Isabel twp.), about 100 feet above its junction with other branches of the ravine.

	Thickness Feet	Inches
Pleistocene system		
Illinoian series		
3. Till, calcareous, dark blue gray	8-10	
Kansan series		
2. Till, noncalcareous, brownish gray, clayey, with polygonal fracture, containing a few pebbles of chert and dense igneous rocks, nearly a gumbotil in texture	1	6
1. Till, noncalcareous, reddish brown along fracture surfaces, bluish gray in centers of fragments bounded by fracture planes, hard, exposed to level of creek	2	6

The Kansan till here probably represents horizons 2 and 3 of the profile weathering developed during Yarmouth time. In other forks of the ravine the exposure differs from that described in that the reddish brown till (1) immediately underlies the calcareous Illinoian till. Pebble counts which were made here from the Kansan and Illinoian tills are ~~present~~ shown graphically in fig. 79.

From the small number of pebble counts made, ~~it appears that~~ the Kansan till ~~in this quadrangle~~ appears to contain more chert, ~~more~~ shale, and much more sandstone than the Illinoian till and nearly as much limestone.

The thickness of the Kansan drift in the exposures in which it was recognized does not exceed 15 feet, but the original thickness was probably much greater. Thicker sections may now be exposed which are not separated from the Illinoian till by a weathered zone or by interglacial deposits.

Yarmouth series

The name Yarmouth was proposed for this interglacial series because it was first recognized in a well near Yarmouth, Des Moines County, Iowa[100].

---

[100] Leverett, Frank, The weathered zone (Yarmouth) between the Kansan and Illinoian till sheets: Proc. Iowa Acad. Sci., vol. 5, pp. 81-86, 1898; Jour. Geol., vol. 6, pp. 237-243, 1898.

The strata belonging to the Yarmouth series in the Havana quadrangle are ~~deposits of~~ sand and gravel, water laid silt, loess, some of which is fossiliferous, buried swamp soils containing some wood, and ~~certain~~ silts of uncertain origin. In addition to the deposits representing the Yarmouth series, this interglacial epoch is represented by profiles of weathering developed upon the underlying Kansan drift and an erosional surface, indicating that the Kansan till was removed from much of the area before the beginning of Yarmouth deposition.

The profiles of weathering which were developed upon the Kansan till during the Yarmouth interglacial epoch were subsequently so modified by the pressure of the Illinoian glacier that the various zones are less easily detected than more recent profiles of weathering, formed since the last glacial invasion of the region. The profiles of weathering are discussed more fully in connection with Sangamon interglacial materials on pp. 229-231.

 246

See also geologic sections 44 and 46.

Yarmouth deposits have been recognized in 39 or more exposures in the Havana quadrangle. The most complete record of this stage is afforded in an exposure in a cut bank on the east side of Big Sister Creek. (Fig. 81).

Geologic section 47. Cut bank on the east side of Big Sister Creek, NW. ¼ NW. ¼ sec. 8, T. 5 N., R. 4 E. (Liverpool twp.)

	Thickness Feet	Thickness Inches
Pleistocene system		
Illinoian series (profile of weathering)		
Horizon 1		
13. Silt, noncalcareous, grayish brown to dark gray, loose	1	
Horizon 2		
12. Gumbotil, noncalcareous, brownish gray, with dark brownish stains on fracture surfaces, containing scattered quartz and chert, and a few igneous pebbles, mostly small	8	
###		
Horizons 3 and 4		
11. Till, noncalcareous to slightly calcareous, rusty brown along fracture surfaces, bluish gray in centers of larger masses	1	8
Unweathered		
10. Till, calcareous, gray	7	
9. Sand, ######## calcareous, reddish or yellowish	1	6
8. Silt or fine sand, calcareous, blue gray	1	4
Yarmouth series		
7. Silt, carbonaceous and calcareous, dark bluish gray, with numerous carbonized wood fragments, earthy or bituminous odor (late Yarmouth soil)	1	6
6. Silt, ########## calcareous, dark gray, brownish gray below, slightly fossiliferous, with a loess fauna	1	3
5. Sand, ########## slightly calcareous, yellowish to reddish brown, ################ fine grained in upper foot, grading down into coarser sand	6	
4. Gravel, ############ calcareous, reddish brown, thickening toward north end ### of cut from 2 ~~feet~~ to 4 feet	2-4	
3. Silt, calcareous, blue gray, laminated, (marly) fossiliferous, with a typical fresh water fauna, compact, standing out as a hard ledge on face of cut bank, thickening from 2## feet 6 inches near center of cut to 5 feet at northern end, wavy lower surface	2½-5	
2. Sand, calcareous, reddish, grading into gravel, partly cemented, with uneven lower surface	5	
################		
Kansan series		
1. Till, calcareous, dark blue gray, bouldery, with uneven upper surface, exposed to water level	5	

(see geol. sec. 49)

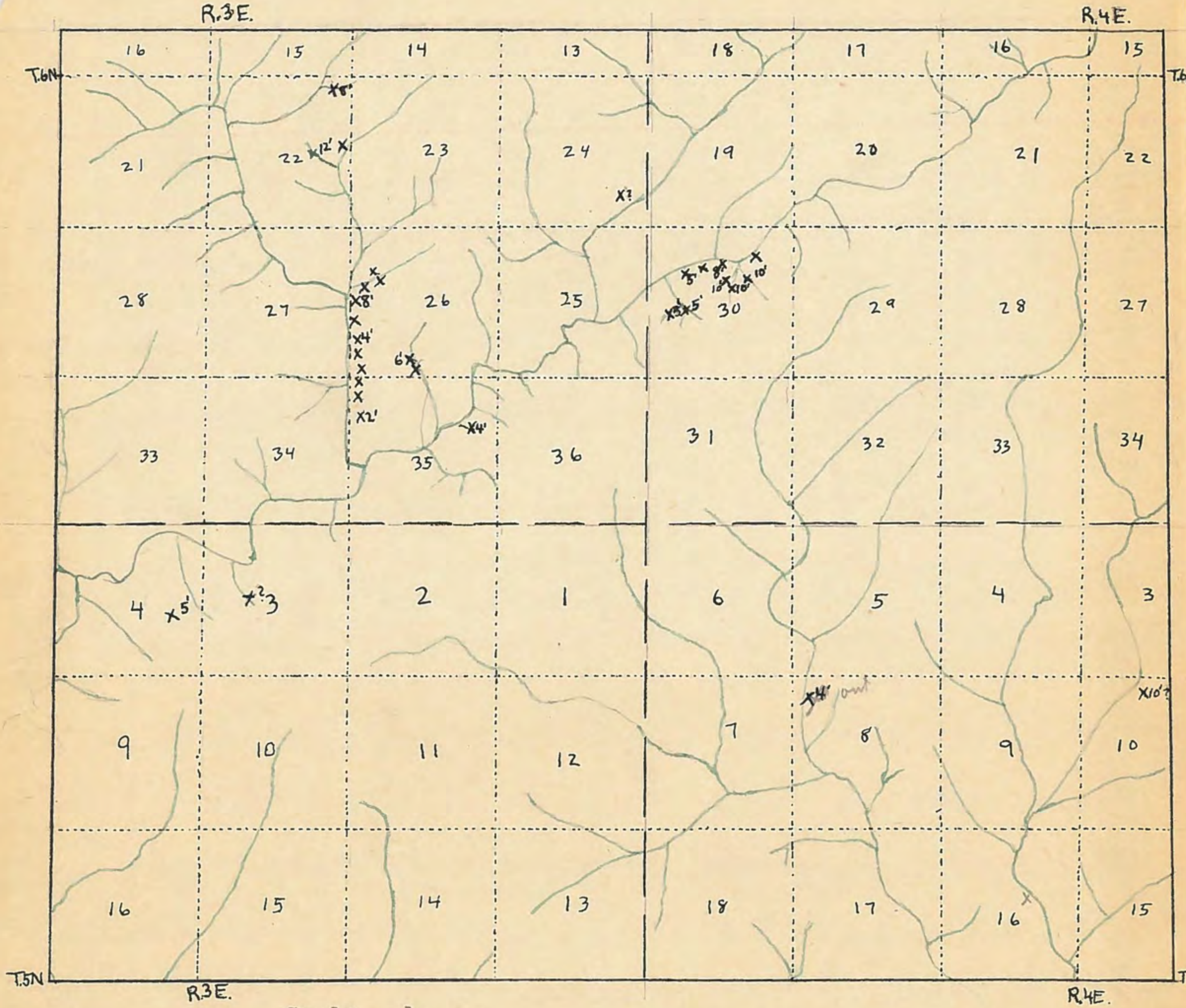
Fig. 80. Cut bank on the east side of Big Sister Creek in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 8, T. 5 N., R. 4 E. (Liverpool twp.), showing Illinoian till in the upper part of the cut overlying Yarmouth deposits, with Kansan till exposed near the water level at the lower right. The prominent Yarmouth beds are two bands of silt which stand out as harder ledges in this cut bank. The upper one, at the ~~layer~~ level of the pick, near the center of the picture, is a loess deposit of late Yarmouth age, and the lower one, well shown in the right half of the picture is a water laid silt of early or middle Yarmouth age. Note the ~~########~~ wavy lower surface of this lower band of silt. See section on p. 204.

The fossils collected from members 2 and 6 in the foregoing section are listed in Appendix A, Part III.

The Yarmouth record in this section includes a sand and gravel deposited shortly after the melting away of the Kansan glacier from this area, as the surface of the Kansan till is unweathered. The accumulation of fine silts in a pond or a stagnant part of a river channel followed, when the climate had become sufficiently mild to permit the return of life to the area. This water laid deposit was later buried by coarse gravel, probably formed in a stream channel, which ~~gradually~~ later deposited fine sand as its flood plain was aggraded. The surface was finally mantled with loess. The loess formed the surface soil long enough to permit the concentration of much carbonaceous matter or humus in the soil. The position of this surface was probably near the level of the water table, for the loess and soil were not leached of calcareous material. The surface was finally buried by silt and later by sand, probably advance outwash material in front of the Illinoian glacier. This cut affords a nearly continuous record of the events of the long Yarmouth epoch.

Brown, oxidized and leached gravel is exposed in 15 or 20 outcrops in the north central and northern parts of the quadrangle. It varies from 2 to 10 feet in thickness. It is commonly overlain by two to ten feet of bluish gray silt or fine sand. This sequence underlies calcareous Illinoian till and overlies Pennsylvanian strata directly in ~~nearly~~ all exposures. The gravels appear to be stream channel deposits formed during early or middle Yarmouth age, which were oxidized during later Yarmouth time. Fig. 80 shows the distribution of exposures of this material. The relations of these gravels to adjacent strata are well exhibited in a road cut section east of Slug Run.

Geologic section 48. Road cut east of Slug Run near the middle of the west line of sec. 26, T. 6 N., R. 3 E. (Putman twp.)



Scale $\frac{1}{62500}$

Fig. 81 . Sketch map of part of the Havana quadrangle showing the location of exposures of brown weathered gravels buried below ~~the~~ Illinoian drift. These gravels are probably of early Yarmouth age. The approximate thicknesses of the gravels are indicated where these were determined

250

	Thickness Feet	Inches
Pleistocene system		
Peorian series		
5. Loess	12	
Illinoian series		
4. Till, gray, weathered in upper portion	37	
Yarmouth series		
3. Silt, noncalcareous, gray, weathering buff	2	
2. Gravel, noncalcareous, brownish, deeply weathered at surface, consisting of concretions from Pennsylvanian, chert fragments, and a few pebbles of pre-Cambrian rocks, locally cemented to a conglomerate	8	
Pennsylvanian system		
Carbondale series		
Summum formation		
1. Sandstone, buff, thinly bedded (Pleasantview sandstone)	16	6

Dark humus soil occurs between two bands of fossiliferous Yarmouth loess in an exposure in a ravine along the bluff of Illinois River just north of the south end of the quadrangle.

Geologic section 49. Exposures in a ravine in the NE. ¼ SE. ¼ sec. 8, T. ~~4~~ 3 N., R. 3 E. (Kerton twp.).

	Thickness Feet	Inches
Pleistocene system		
Peorian and Sangamon series		
12. Loess	11	
Illinoian series		
11. Gumbotil, brownish gray	1	9
10. Till, reddish brown and gray	10	
9. Sand, calcareous, yellow	1	6
8. Silt, calcareous, blue gray, unfossiliferous	8	
7. Covered	6	
6. Silt, gray, similar to (8)	4	
5. Till, calcareous, gray	15	
Yarmouth series		
4. Loess, calcareous, gray, not laminated, fossiliferous, containing pipe stem concretions	5	8
3. Silt, not generally calcareous, dark gray, containing many fragments of carbonized wood and some small gastropod fragments; somewhat laminated; resembles horizon 1 of profile of weathering; has bituminous odor, like humus		9
2. Loess or silt, calcareous, gray, interbedded with some sand and gravel, slightly fossiliferous	3	6
Pennsylvanian system		
Pottsville series		
Seahorne formation		
1. Limestone, gray, fossiliferous (Seahorne ~~limestone~~)		

Fossils collected from beds 2 and 4 in the foregoing section are listed in Appendix A, Part III. All the species from both horizons are land mollusks typical

251

of loess deposits.

Yarmouth strata are also well exposed under Peorian, Sangamon and Illinoian deposits in the cut bank described in the following section. (Fig. 82)

Geologic section 50. Cut bank on the east side of the ravine in the SW. ¼ NW. ¼ sec. 26, T. 4 N., R. 3 E. (Isabel twp.)

	Thickness Feet	Thickness Inches
Recent system		
9. Soil, dark gray	1	
Pleistocene system		
Peorian series		
8. Loess, noncalcareous, light brownish	1	8
7. Loess, calcareous, gray, fossiliferous, especially in lower portion; containing calcareous concretions or kindchen	5	
Sangamon series		
6. Loess, noncalcareous, pinkish in upper portion, gray in lower 6 inches	2	8
Illinoian series		
5. Gravel concentrate at top of till	½-1	
4. Till, calcareous, gray	5	8
Yarmouth series		
3. Silt, carbonaceous, noncalcareous, dark gray to black, full of fragments of carbonized wood including recognizable stem fragments; cut out by Illinoian till in northern portion of cut bank		6
2. Sand# and gravel, noncalcareous, brown, a lenticular mass in central and southern part of cut, absent in northern portion		8
1. Silt, noncalcareous, bluish, micaceous, rising toward north end of cut, where it directly underlies Illinoian calcareous till, with very uneven upper surface	2	

The bluish noncalcareous silt at the base of the Yarmouth section is similar to material found in other exposures where the overlying dark soil is noncalcareous. A sample of it ~~which was~~ examined was composed principally of grains of quartz from the size of silt particles to very fine sand grains, fresh flakes of muscovite from silt size to 0.5 mm. diameter, and numerous smaller flakes of a dark greenish to black micaceous mineral, probably chlorite.

Along this same ravine about 100-200 feet upstream Yarmouth silt, with numerous gastropod shells and fragments of wood, exposed under Illinoian

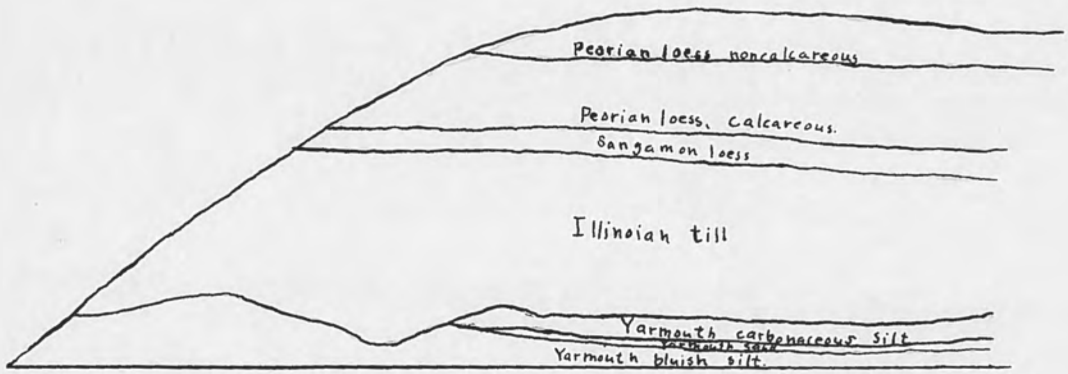


Fig. 82. Diagram showing the relations of Pleistocene deposits in a cut bank on the east side of a ravine in the SW. ¼ NW. ¼ sec. 26, T. 4 N., R. 3 E. (Isabel twp.). The basal surface of the Illinoian drift cuts unevenly into the thin Yarmouth members below. Compare the section of Peorian, Sangamon and Illinoian deposits here with those ~~in described~~ Geologic section ~~on p.~~ 59, from exposure about 300 yards south.

till. It may correspond in part to the dark soil in the exposure described in geologic section 50, but it is calcareous instead of being leached. The gastropods collected from this silt are listed in Appendix A, Part III. The species are all land mollusks typical of loess deposits, hence the surface where it accumulated was probably a somewhat forested area near the margin of a flood plain in which the sand and gravel of the cut bank described above were deposited.

Fragments of wood ranging from the size of sticks a fraction of an inch in diameter to logs 6-8 inches in diameter are not uncommon in the Yarmouth dark soil. The specimens collected have been identified as follows:

On the bedding surface of a fine Yarmouth silt ~~of~~ ~~age~~ exposed in a ravine in the NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 23, T. 4 N., R. 2 E. (Pleasant twp.) about one quarter mile east of the margin of the Havana quadrangle, imperfectly preserved traces of fern leaves were exposed.

Fossil collections were made from fossiliferous #loess along the banks of the ravine described in geologic section 44, member 6. These are listed in Appendix A, Part III. The gastropods are all land shells, except the ############ species Pomatiopsis scalaris and Fossaria parva tazewelliana, which are amphibious and breathe air. They are found in loess deposits. ~~There were found in addition to the gastropods~~, ~~8~~ Six pelecypod shells representing Pisidium abditum and Pisidium concinnulum in this deposit. These are typical fresh water forms and ~~they~~ must have been introduced into this deposit by foreign agencies.

In the bed and banks of a deep narrow ravine north of Spoon River in the ## SE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 3, T. 4 N., R. 3 E. (Waterford twp.), from five to eight feet of light blue gray calcareous Yarmouth silt, many specimens of a fresh water gastropod Stagnicola caperata were collected, along with 2 specimens of Succinea ovalis pleistocenica and 1 specimen of Strobilops virgo, both of which are land shells typical of loess deposits. This deposit lies ~~only~~ about 5 feet above the present flood plain of Spoon River, and probably started as a lacustrine deposit in a ~~#####~~ flood plain of the ancestral Spoon River, which was later drained or silted up, becoming the site of lowland loess deposition.

Fossiliferous loess of Yarmouth age is exposed in two cut banks on the south side of a ravine east of Coal Creek in the SE. ¼ SW. ¼ sec. 30, T. 5 N., R. 4 E. (Liverpool twp.). In one of the exposures the loess underlies oxidized Illinoian till, and in the other it overlies greenish till of Kansan age. The species collected from this loess, which are listed in Appendix A, are all land shells except Fossaria parva tazewelliana, which inhabits stagnant wooded pools.

In many exposures the Yarmouth deposits rest directly on the Pennsylvanian strata. In others they rest on Kansan till, and in several others their base is not exposed. The Kansan till was removed completely from a large portion, probably half or more, of the region, before the accumulation of the late Yarmouth sediments. Many of the longer ravines were ~~probably~~ partly excavated at this time, as Illinoian till completely fills some valleys and the lower portions of tributary valleys, while it is much thinner in the upper portions of these tributaries. Sepo Creek in the NW. ¼ sec. 36, T. 5 N., R. 3 E. (Lewistown twp.) is probably ~~typical of~~ such a Yarmouth valley.

Yarmouth silts and soils are normally very compact, and the fossil remains in them somewhat crushed, as the result of their later burial by the Illinoian glacier. The upper surface of the Yarmouth deposits is smooth or slightly wavy, and in a few exposures the Yarmouth silts have been contorted into small folds ~~as a result of their burial by the glacier~~.

Illinoian series

The name Illinoian, which was first used in 1896,[101] was assigned

---

[101] Chamberlin, T. C., Editorial: Jour. Geol. vol. 4, pp. 872-876, 1896.

---

to this series of glacial deposits because it is most extensively exposed and best developed in the state of Illinois.[102]

---

[102] Leverett, Frank, The weathered zone (Yarmouth) between the Kansan and Illinoian till sheets: Proc. Iowa Acad. Sci., vol. 5, pp. 81-86, 1898; Jour. Geol., vol. 6, pp. 237-243, 1898.

The Illinoian series is represented in the Havana quadrangle by till, sand and gravel, bedded silts and finely laminated sand and silt probably representing varve deposition.

Illinoian till underlies all parts of the quadrangle in Fulton County, west of the bluff of Illinois River, except the valleys of streams from which it has been removed by post-Illinoian erosion. It may underlie parts of ~~the~~ Illinois River flood plain and the terrace and sand dune region of Mason County, but in those ~~regions~~ districts it is entirely covered by Wisconsin and recent deposits.

The thickness of the Illinoian deposits ranges from about 6 ~~feet~~ to 80 or 90 feet in the available records. The thickness may be greater than this maximum in some of the forested slopes adjacent to Illinois or Spoon Rivers where the relief is 120 to 140 feet and no Pennsylvanian exposures are seen. The minimum thickness of the till is well shown in the vicinity of Cuba, a pre-Illinoian ridge which was but slightly veneered with till by the Illinoian glacier.

The Illinoian deposits ~~seem to~~ represent (1) outwash ~~deposits~~ in front of the advancing ~~Illinoian~~ glacier, (2) ~~glacial~~ deposits formed by this glacier during its first advance over the region, (3) deposits formed in streams and perhaps lakes during a temporary recession of the glacier, (4) ~~glacial~~ deposits formed during a second advance ~~of the glacier~~, (5) and outwash deposits in streams and lakes formed during the final recession ~~of the glacier~~.

In addition to the deposits formed during the Illinoian epoch,(1) the compacting of the underlying Kansan and Yarmouth deposits, (2) local warping of the pre-Illinoian loess, silt and till, and of Pennsylvanian strata, and (3) in one exposure a striated surface on the underlying Pennsylvanian, ~~strata~~ record this glacial epoch. The drainage pattern of the quadrangle also seems to be related to the glaciation during the Illinoian epoch and the drainage courses of streams supplied by the melting ice.

Glacial striae are preserved on the surface of Cuba sandstone above a local mine drift on the southeast bank of a large ravine in the SE. ¼ SE. ¼ sec. 24, T. 6 N., R. 3 E. (Putman twp.) The striae indicate a local direction of ice movement from N. 60° E.

Sand and gravel deposits probably formed in front of the advancing Illinoian ice are well exposed in three cut banks on the south side of the North Branch of Otter Creek in the NE. ¼ NW. ¼ sec. 24, T. 4 N., R. 2 E. (Pleasant twp.), Here coarse cross-bedded gravel and sand including a few small masses of till ~~sharply~~ truncate loess, soil and silt of Yarmouth age. The relations shown in one of these cut banks is illustrated by sketch in fig. 83. The gravel bed ~~########~~ which rests directly on stratified sand and under Illinoian till is shown in fig. 84.

Much sand and gravel below the Illinoian till and interbedded with it is exposed in the west central portion of the quadrangle. Exposures of such sand and gravel are principally found in secs. 12, 13 and 14, T. 5 N., R. 2 E. (Bernadotte twp.) and secs. 7 and 18, T. 5 N., R. 3 E. (Lewistown twp.). The sand is calcareous in most exposures except where the overlying till has been removed by erosion, and ranges from gray or buff to reddish brown in color. In ~~an~~ exposures in ~~a~~ small ravines east of Stuart Creek in the SE. ¼ NE. ¼ sec. 14, T. 5 N., R. 2 E. (Bernadotte twp.) the following section was measured:

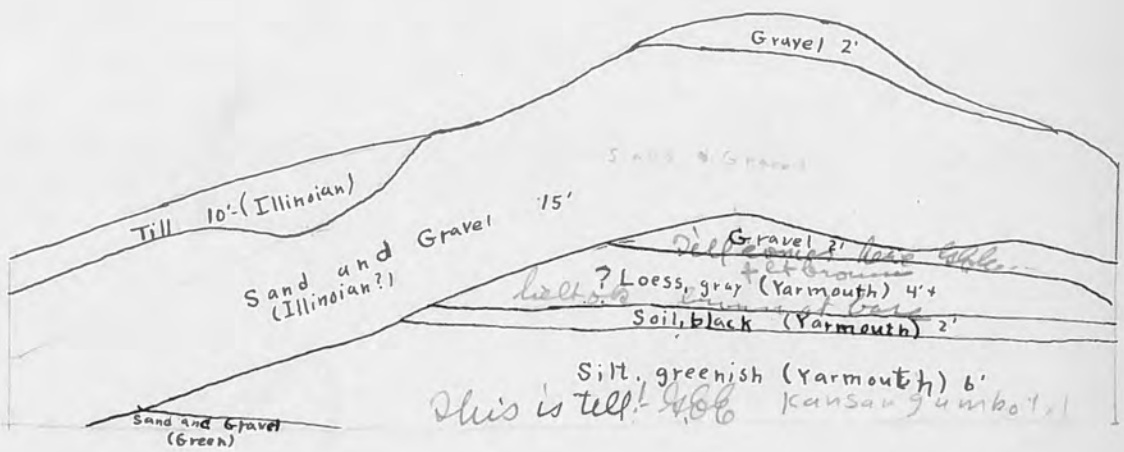


Fig. 83 . Sketch of cut bank on south side of North Branch of Otter Creek in the NE. ¼ NW. ¼ sec. 24, T. 4 N., R. 2 E. (Pleasant) showing sand and gravel which are probably outwash deposits formed in advance of the Illinoian glacier resting unconformably on loess, soil and silt of Yarmouth age. Sand and gravel of similar age underlying Illinoian till in a cut bank a short distance east ~~of this cut bank~~ is shown in fig. 84 ~~(p. 211)~~).

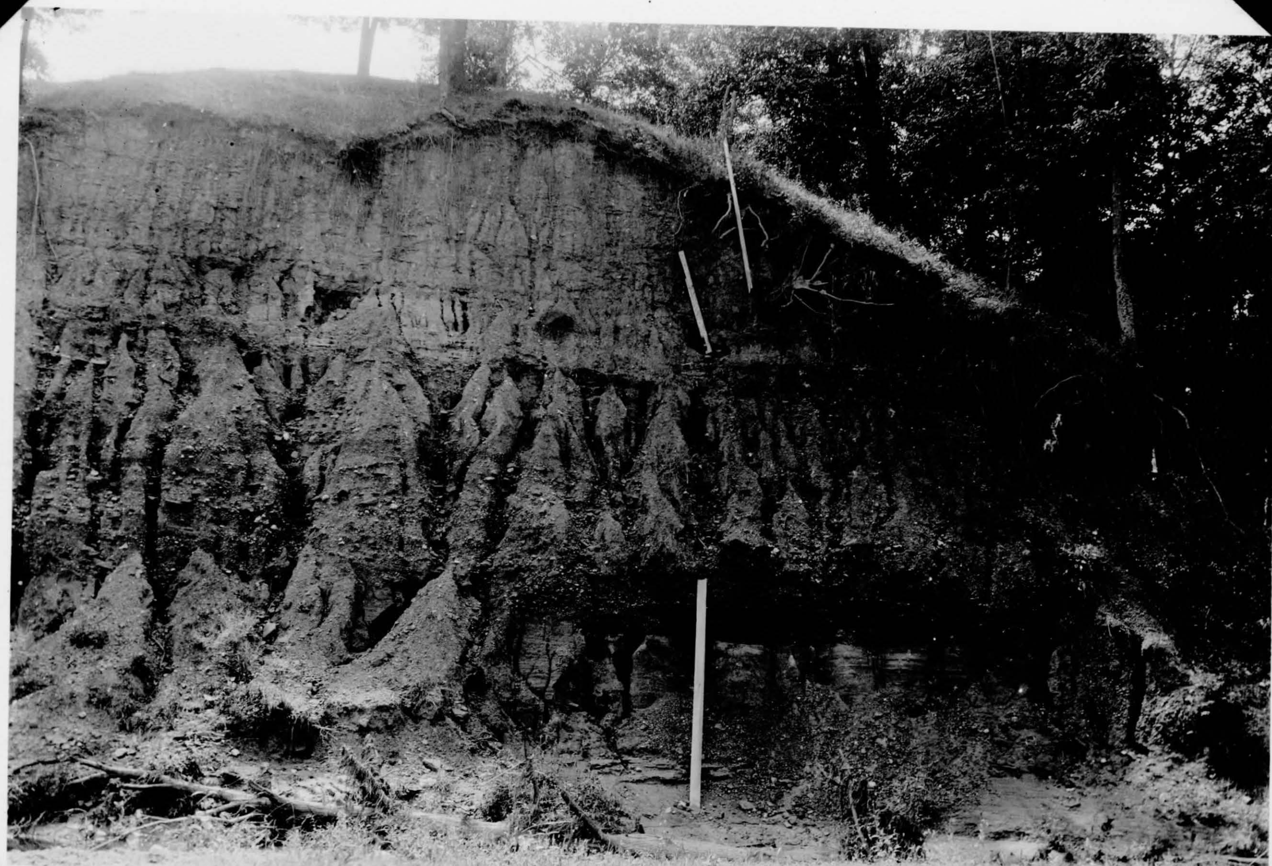


Fig. 84. Exposure in a ~~#####~~ cut bank on the south side of the North Branch of Otter Creek in the NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 24, T. 4 N., R. 2 E. (Pleasant twp), showing Illinoian till in upper third of cut overlying roughly assorted gravels in central portion of cut, overlying ~~sands~~ crossbedded sands, containing numerous fragments of coal, in the lower portion of the cut, The sand and gravel are interpreted as outwash deposits formed in advance of the Illinoian glacier in a channel cut during late Yarmouth time. In an outcrop about 200 feet west of this one similar sands truncate late Yarmouth soil and silt as at the edge of a channel (See fig. 83.)

Geologic section 51. Exposures in small ravines east of Stuart Creek in the SE. ¼ NE. ¼ sec. 14, T. 5 N., R. 2 E. (Bernadotte twp.)

	Thickness Feet	Thickness Inches
Pleistocene system		
~~##########################~~		
Peorian and Sangamon series		
5. Loess, noncalcareo s, pinkish to gray	15	
Illinoian series		
4. Till, basal portion calcareous, reddish, with some sand lenses, gravel concentrate at top	15	
Illinoian (?) or Yarmouth series		
3. Sand, noncalcareous, reddish, containing some small pebbles, upper surface uneven	3	6
2. Gravel, ~~############~~ calcareous, with large concentration of cobbles, partially cemented	5	6
Illinoian (?) or Kansan series		
1. Till, calcareous, gray		$7\frac{1}{2}$

In other exposures in the vicinity of these ravines the reddish sand is calcareous below the upper till, suggesting oxidation by ground water ~~or~~ during a brief period ~~during~~ of the Illinoian glacial stage when the area was freed from ice, but the leaching of the sand in the foregoing section may furnish evidence that the sand and gravel were outwash deposits from the Kansan glacier ~~which was~~ covered later by Illinoian till.

The best exposure of interbedded till and masses of sand and gravel is in a high cut bank along a ravine east of Stuart Creek. (Fig. 85).

Geologic section 52. Exposure in a high cut bank on the south side of a ravine in the NE. ¼ NW. ¼ sec. 13, T. 5 N., R. 2 E. (Bernadotte twp.)

	Thickness Feet	Thickness Inches
Pleistocene system		
Peorian series		
17. Loess, noncalcareous, buff	6	
Sangamon series		
16. Silt, noncalcareous, reddish brown, with numerous carbonized plant traces	2	6
Illinoian series		
15. Till, noncalc reous, grayish brown, not plastic, with pitted surfaces and blackish coatings on joint surfaces; pebbles few and small, consisting of chert and quartz (horizon 2 of well drained ~~####~~ profile of weathering)	3	6
14. Till, noncalcareous, yellowish brown (horizon 3 of profile of weathering	4	6
13. Silt, very slightly calcareous, buff (horizon 4 of profile of weathering)	1	6
12. Till, strongly calcareous, gray, sandy at top	5	

Fig. 85. Exposure of Pleistocene deposits in cut bank on south side of ravine in NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 13, T. 5 N., R. ~~3~~ 2 E. (Bernadotte twp.), showing Illinoian till interbedded with sands and gravels. The man is standing at level of B horizon ~~zone~~ of ~~soil~~ profile of weathering developed on Illinoian till.

11.	Sand, strongly calcareous near top, slightly calcareous below, yellowish, with 1 foot gravel band near base, including fragments of calcareous till	2	6
10.	Sand, yellowish, almost entirely free from gravel, distinctly bedded	3	8
9.	Coal concentrate at base of sand		2
8.	Gravel, well assorted, slightly cemented	6	
7.	Till, calcareous, gray	4	
6.	Gravel, calcareous, with some lenticular masses of sand	10	6
5.	Sand, calcareous, white	2	
4.	Sand and silt, blackish, iron stained		6
3.	Sand, reddish brown	3	
2.	Till, calcareous, gray, with limestone pebbles, lenticular, not persistent	3	
1.	Gravel, calcareous, coarse, to base of exposure	8	

In the foregoing section the oxidation of sand and gravel lenses may have been accomplished by ground water after the deposition of the overlying till, although the even bedding of certain of the sand lenses suggests channel deposition during a period when the region was freed from ice. Part of the sand and gravel may be of subglacial channel accumulation, and the blocks of till may have been detached from the banks of such a subglacial stream. The distribution of sand between tills in several ravines in the vicinity suggests that a drainage line here was largely filled with sand and silt during a temporary recession of the Illinoian ice, and obliterated when the area was again covered ~~by ice~~. This drainage line may have discharged into Spoon River.

The Illinoian till is commonly lighter gray in color than the Kansan. It is also less compact, and shows no evidence of contortion such as was described in exposures of Kansan and Yarmouth deposits. Summaries of pebole counts are given in fig. 79# in comparison with those from the Kansan and Nebraskan tills. Large blocks of Pennsylvanian rocks are found in several places in this drift. The commonest rocks represented by these fragments are the Brereton limestone, the Lonsdale limestone from the McLeansboro formation in the Peoria district, and in the southern part of the quadrangle the Seahorne limestone from the Pottsville series. The largest fragment incorporated in the till observed in the quadrangle is a block of coal 4 feet thick and 15 feet long, attached to some black hard shale roof, which is somewhat tilted ~~in the till~~. The coal is evidently from the Springfield (No. 5) coal. This block ~~of coal~~ is exposed along the north side of a ravine in the NW. ¼ NW. ¼ sec. ~~28~~ 23, T. 6 N., R. 2 E. (Cass twp.), near the northwest corner of the quadrangle, about 2½-3 miles west of the outcrop line of the Springfield coal. Many fragments of coal, black hard roof shale and over a dozen large calcareous concretions from the roof shale of the Springfield (No. 5) coal are exposed in till which is probably Illinoian in the bed of a ravine near the center of the SW. ¼ sec. 6, T. 5 N., R. 4 E. (Liverpool twp.). Among the rocks which are foreign to this vicinity the following types were recognized: (1) Niagaran dolomitic limestone probably from northeastern Illinois, (2) limestone beds from the Maquoketa or Richmond shale, (3) amygdaloidal basalt, (4) quartz porphyry, and (5) jasper conglomerate. The last named rock is probably derived from the Lorraine quartzite (Huronian) from the vicinity of Cobalt, Ontario, northeast of Lake Huron.

Evidence that the Illinoian glacier receded from this area for a time and later readvanced across it is afforded by a rather widespread blue gray calcareous laminated silt between two masses of calcareous till. The exposures of this silt are principally in the southern part of the quadrangle, in secs. 5 and 8, T. 3 N., R. 3 E. (Kerton twp.) and sec. 24, T. 4 N., R. 2 E. (Pleasant twp.). Two or three exposures in the northern part of the quadrangle seem to represent the same silt, but there is a possibility that this may have been confused with the late Yarmouth ~~silt~~. The Illinoian silt is calcareous in all exposures, and no fossil remains were found in it. It is well exposed along the south bank of Seahorne Branch where the following section was measured: (Figs. 86 and 87).

<u>Geologic section 53. Cut bank on south side of Seahorne Branch just southwest of the sharp bend in this stream in the SW. ¼ NW. ¼ sec. 5, T. 3 N., R. 3 E. (Kerton twp.)</u>

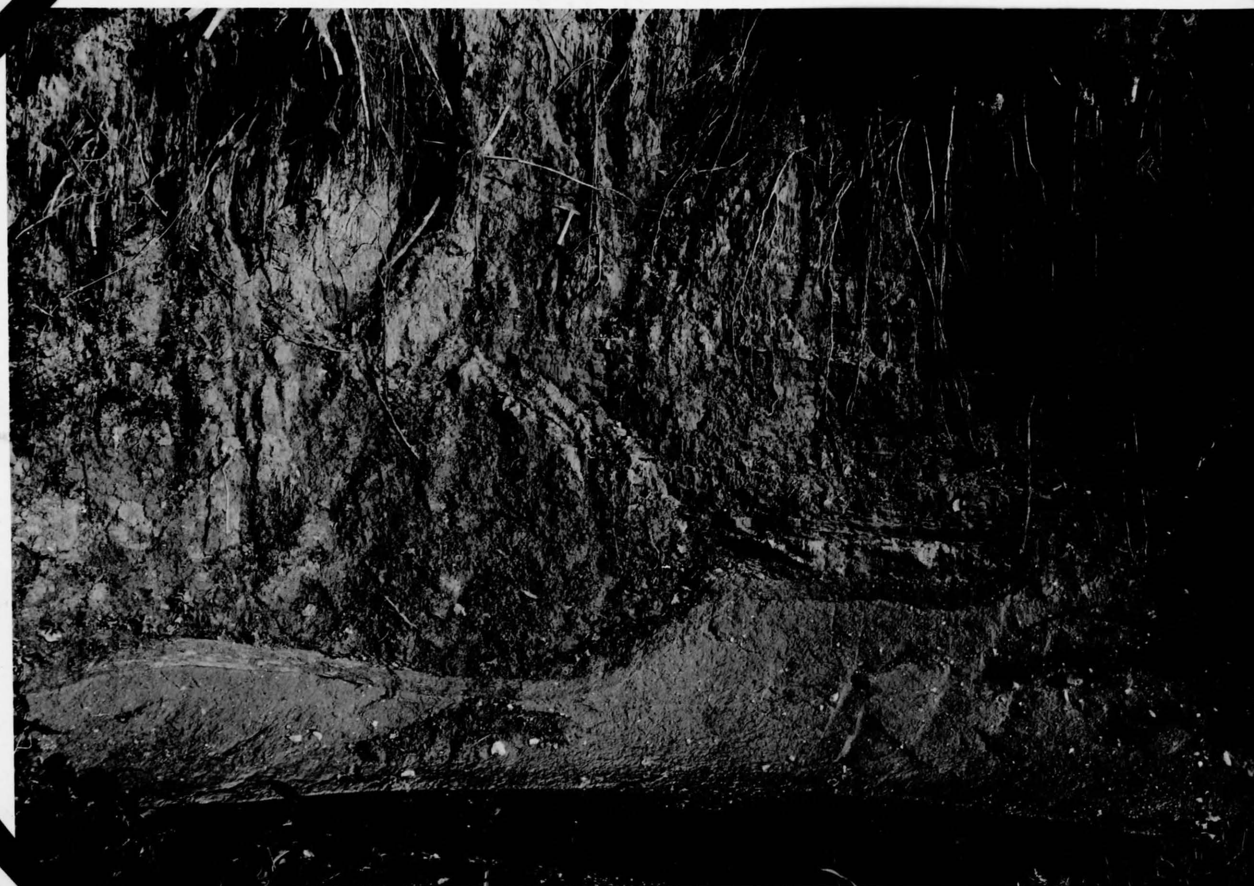


Fig. 86. Exposure of Illinoian deposits along the southeast bank of Seahorne Branch,# near the west border of sec. 5, T. 3 N., R. 3 E. (Kerton twp.), showing calcareous laminated silt, and a lenticular mass of sand lying between an upper and a lower part of the Illinoian till. The hammer marks the top of the laminated silt, and the prominent undulating surface marks the top of the underlying till. The thin band of darker till along this line is oxidized but calcareous. This silt ########## was accumulated during a temporary recession of the Illinoian glacier from this region. It is rather widespread in the southern part of the Havana quadrangle.

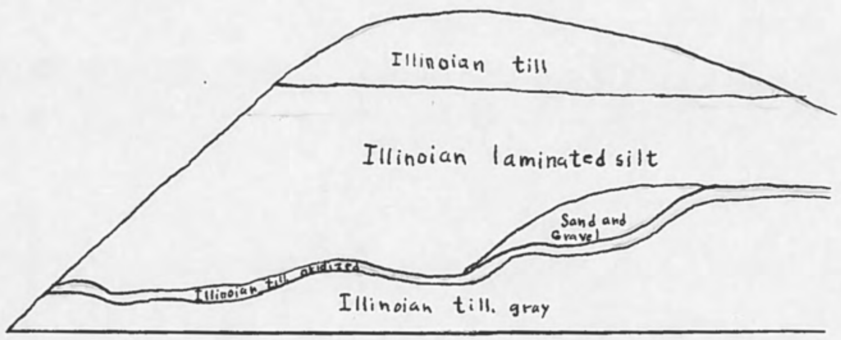


Fig. 87. Diagram of cut bank shown by photograph in fig. 86.

	Thickness Feet	Inches
Pleistocene system		
Illinoian series		
5. Till, calcareous, blue gray	5	
4. Silt, calcareous, blue gray, laminated, weathering yellowish brown on surface	6-10	
3. Sand and gravel, calcareous, lenticular, in small pocket, which seems to be a depression in the surface of the underlying till	0-1	
2. Till, calcareous, reddish brown, oxidized, uniform in thickness on uneven surface		6
1. Till, calcareous, gray	3-4	

In exposures about 300 yards east of this cut bank the lower till (1) of the foregoing section, 11 feet thick, rests on a glaciated surface of compact brownish gray Yarmouth loess. The silt reaches a thickness of 18 feet in a ravine along the bluff of Illinois River near the south edge of the quadrangle described in geologic section 49, beds 6-8. The presence of an oxidized zone in the till under this silt and the irregularity of its lower surface, suggests a short period of erosion and weathering between the two advances of the Illinoian glacier over the Havana region. In areas where the till is thin and no such silt is present, the till may represent only the second advance of the glacier. A deposit formed in a lake during the recession of the ice after its first advance or preceding the second advance appears to be exposed in the following outcrop in a strip mine cut, now destroyed by mining operations:

Geologic section 54. Strip mine cut near the middle of the west line of sec. 28, T. 6 N., R. 3 E. (Putman twp.).

	Thickness Feet	Inches
Recent system		
9. Soil, dark gray	1	
Pleistocene system		
Peorian series		
8. Loess, noncalcareous, buff	4	4
7. Loess, calcareous, gray	1	6
Sangamon series		
6. Silt or loess, noncalcareous, brownish gray, with numerous carbonized fragments of wood	2	6
Illinoian series		

 266

		Feet	Inches
5.	Silt, brownish gray, gumbo-like, plastic (horizon 2 of poorly drained profile of weathering)	2	
4.	Till, slightly calcareous, yellow brown (horizon 3 of profile of weathering)	3	8
3.	Till, calcareous, brownish gray (horizon 4 of profile of weathering)	2	
2.	Sand# and gravel, calcareous, reddish brown	1	11
1.	Silt, calcareous, blue gray and sand, buff, finely laminated, suggesting seasonal or varve deposition in a lake, base concealed	5	10

No difference in color, texture or constituent rocks is noted between the upper and lower till members of the Illinoian, and the two cannot be distinguished where they are not separated by a silt.

The final recession of the Illinoian glacier from the region is represented by outwash sands and gravels in numerous exposures, and by laminated sands and silts accumulated in a lake in at least one locality.

The beds of sand and gravel# resemble those formed during the Illinoian glacial stage and during the temporary recession of the Illinoian ice in coarseness, cross bedding and ~~the~~ lenticular character of most beds. In several places large fragments of coal 10-50 times the mass of the other larger pebbles are embedded in the gravel. Fig. 88 shows such a block of coal 2½ feet long and about 15 inches thick. Such fragments were probably ice floated from the margin of the glacier. The fragments of coal are relatively unweathered and have been extracted and burned by farmers# in the vicinity.

A finely laminated deposit of silt and sand overlying beds of crossbedded sand and gravel seems to represent annual deposition of glacial outwash in a small pond or lake. This is exposed in a ravine north of Big Sister Creek, described in the following section: (Fig. 89)

<u>Geologic section 55. ######## Cut bank on east side of ravine in the NW. ¼ SE. ¼ sec. 8, T. 5 N., R. 4 E. (Liverpool twp.)</u>

	Thickness Feet	Inches
Pleistocene system		
Peorian series		
3. Loess, noncalcareous, buff	6	

Fig. 88. Exposure along the ~~sou~~ west bank of a ravine north of Big Sister Creek in the NW. ¼ SE. ¼ sec. 8, T. 5 N., R. 4 E. (Liverpool twp.), showing crossbedded ~~sand and~~ gravel, an outwash deposit from the Illinoian glacier including a fragment of coal 2 feet 6 inches long by 1 foot 3 inches thick embedded in the gravel at the left. The dark cavity at the ~~left~~ right is a place where a larger fragment of coal than this has been partly removed. Such fragments of coal are not uncommon in the Illinoian outwash deposits. They were probably ~~floated on ice cakes~~ carried to their present position on floating cakes of ice.

Fig. 89. Exposure in a cut bank on the east side of a ravine north of Big Sister Creek in the NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 8, T. 5 N., R. 4 E. (Liverpool twp.) showing finely laminated silt and sand overlying Illinoian outwash gravels at the base of the cut and underlying Peorian loess at the top. The sands and silts probably represent annual accumulations of winter and summer layers in a lake or pond a few miles from the ice front. Three laminae of thicker sand, $2\frac{1}{2}$ feet, $1\frac{1}{4}$ feet and 3 inches in thickness respectively are shown near the center of the picture and in the upper portion of the cut. These probably represent seasons of unusually rapid melting. The base of the pond was irregular at first, but was filled to nearly an even beds by the first two thick sand laminae. The section shows 234 alternations of sand and silt or annual varves.

Illinoian series

		Feet	Inches
2.	Silt, gray to brownish gray and sand, yellowish, fine, finely laminated, with regular alternation of sand and silt, total number of laminae counted 234; average thickness of laminae $\frac{1}{4}$-$\frac{3}{4}$ inch#; lowest 54 laminae dip## ~~down~~ into depression in gravel surface near base of cut; above these occurs 2 feet 6 inches of sand in one lamina in northern part of cut, thinning to less than 1 inch near south end of cut; above this sand ~~lamina~~ 10 laminae dip slightly toward center of cut, overlain by another sand lamina about 15 inches thick at a maximum, thinning toward both ends of cut; above this a laminae are nearly horizontal, giving a board like structure to this cut bank; 123 laminae above the last mentioned sand lamina# 2-3 inches thick	13	6
1.	Sand and gravel, crossbedded, to base of exposure	6-8	

The laminae of silt and sand are interpreted as ##### alternate winter and summer deposits in a lake supplied in part by glacial outwash. The # three thick laminae mentioned probably represent years of unusually rapid melting of the ice, supplying much coarse sand. The fine silts represent finely divided silt and colloidal matter which would settle ~~out~~ during the winter months. This record points to a period of at least 234 years during which the melting ice discharged into the ancestral Big Sister Creek. The present drainage divide at the head of the valley is about 4 miles north of this exposure, but the drainage conditions at this time may have been spmewhat different.

Certain drainage changes seem to have resulted from the occupation of this region by the glacier. The glacial striae mentioned above indicate a local direction of ice movement #from N. 60° E. in the northern part of the quadrangle. A number of the streams ~~of the quadrangle~~ flow in a direction nearly parallel to that of ice advance. The most important of these streams is Big Creek, but the east branch of Stuart Creek and several smaller streams are nearly parallel ~~to it~~. In the southern part of the area a general parallelism between the direction of streams such as Turkey Branch and the south fork of Seahorne Branch to the bluff of ### Illinois River suggests that the ice movement here may have been about N. 30° E. In the west central portion of the quadrangle a number of small streams flow nearly east or N. 80° E. These may be related to the movement of the Illinoian ice, but the evidence is not clear. Fig. ~~131~~ 137 shows stream courses which seem to have been determined by the direction of the Illinoian glacial advance over this area.

Sepo Creek, which flows from N. 20° W. to straight south, a direction not parallel to the local direction of ice movement, is evidently pre-Illinoian, ~~in age,~~ ~~for~~ Illinoian deposits fill its valley in some parts of its course, and bed rock appears at higher altitudes in its lateral tributaries on both sides. Evidence has been mentioned of the pre-Kansan age of a part of the valley of Coal Creek, another stream whose course is not parallel to the direction of Illinoian glacial advance. It appears ~~that~~ many of the larger streams whose courses are at a considerable angle to the direction of Illinoian ice advance belong to an earlier period of stream erosion than those with courses ~~which~~ paralleling the direction ~~of ice advance~~. The area in which pre-Illinoian leached gravels are located in the northern part of the quadrangle may ~~appears to~~ be related to the direction of the present Slug Run, but not definitely ~~related~~ to the direction of Big Creek. ~~It is probable that~~ The stream in which these gravels formed may have crossed the present valley of Big Creek and joined one of the branches of Big Sister Creek, draining through it to Illinois River.

The development of a profile of weathering on the Illinoian till occurred after the withdrawal of the Illinoian ice from the region, and ~~it will be~~ is discussed in connection with the Sangamon series.

Sangamon series

The name Sangamon was proposed for this interglacial series because it was first described from Sangamon County, Illinois,[103] and has its most

---

[103] Worthen, A. H., Geology of Sangamon County: Geological Survey of Illinois, vol. 5, pp. 306-319, 1873.

 271

conspicuous development in the drainage basin of Sangamon River.[104]

---

[104] Leverett, Frank, The Illinois glacial lobe: U. S. Geol. Survey Monograph 38, p. 125, 1899.

The Sangamon series is represented in the Havana quadrangle (1) by the weathered zone on the underlying Illinoian till, (2) by deposits of loess in many places, (3) by a ~~deposit of~~ water-laid silt in at least one place, and (4) by the formation of a profile of weathering on the Sangamon loess in late Sangamon time. Fossil remains were found in the water-laid silt, but not in the loess. Sangamon deposits are distributed over most of the quadrangle west and north of the edge of ~~the~~ Illinois River alluvial plain. The thickness of Sangamon deposits does not exceed 11 feet in any observed outcrop. The maximum thickness of ~~the~~ Sangamon loess ~~observed~~ is 7½ feet.

The formation of a profile of weathering is the result of (1) chemical changes ~~brought about~~ accomplished by the soil water and substances dissolved in it, ~~acting on the materials of the soil and subsoil~~, combined with the (2) mechanical changes brought about by the transfer of material of the soil, or products of chemical change to new positions by descending waters and (3) the changes brought about by bacteria living in the soil and subsoil. The results of these processes are different according to (1) the porosity of the soil, (2) the composition of the mineral and rock fragments composing it, (3) the topographic position of the soil with reference to drainage by soil waters, and (4) the length of time during which weathering has taken place. The principle of the profile of weathering has been ~~recently~~ applied to the weathered zone on the Illinoian till over an extensive area ~~in Illinois~~.[104a] Several exposures in the

---

[104a] This study has been carried on by Dr. M. M. Leighton, who has explained the principles involved to the writer and aided in the interpretation of the sections described here.

Havana quadrangle illustrate the development of the profile of weathering under different conditions. The profile ~~of weathering~~ is divided into 4 zones or horizons, the characteristics of which are ~~here~~ separately described:

Horizon 1. The top soil. This is the zone of accumulation of humic compounds from the decay of vegetation. It is dark gray to black where the surface is level, and the soil waters are deficient in oxygen necessary to oxidize# it ~~this material~~. Where drainage conditions are good, much of the carbonaceous matter is removed by oxidation, and the color is light gray or pinkish. The texture of the silt in this zone is friable. The upper part commonly shows a fine horizontal lamination suggesting stratification.#### The lower portion of this zone seems to be composed of minute granules, and there is no lamination apparent.

Horizon 2. The zone of silicate decomposition. In horizon 2 the ground waters have leached out all of the calcium carbonate and other soluble compounds present, and organic acids have caused the decomposition of many silicate fragments. ############ In profiles ~~Where~~ formed on glacial till the pebbles are almost entirely leached, except for some pebbles of quartz, chert, quartzite and dense# igneous rocks. The texture of this horizon varies greatly according to the nature of the ground water drainage. Where the drainage is poor, fine silts and colloidal material carried down from above are concentrated in this zone, making it plastic and sticky when wet. The name gumbotil is applied to such material formed on glacial till, and corresponding names gumbosand, gumbogravel and gumboloess have been applied to this #### horizon developed on sand, gravel and loess. Where the drainage is good, the colloidal material is removed from this zone, and ~~it~~ has a loose and friable texture like Horizon 1. The name silttil is applied to such material formed from glacial till, because of its resemblance to ##### silt or loess. The name mesotil is applied to horizon 2 formed from glacial till under intermediate drainage conditions. The color is commonly brownish gray. When broken it shows minutely pitted surfaces. ######Joint faces are commonly coated with blackish or brownish films of some iron compound. Small concretions of limonite and of calcium carbonate are commonly found in the lower portion of horizon 2. Around the edges of root canals some calcium carbonate has ~~also~~ bee#n precipitated. The silttil may be distinguished from true loess or silt by the presence of small pebbles of chert and quartz scattered along the line of its outcrop, Pebbles ~~which~~ are absent from loess deposits.

Horizon 3. Oxidized and leached. Below horizon 2 in a profile of weathering formed on glacial till, the number of pebbles showing along the outcrop increases markedly. Limestone pebbles are absent, except for ### some largely decomposed pebbles in the lower part of this horizon. Silicate pebbles are common, but coarse grained pebbles of granite and related rocks may be somewhat decomposed. The color, especially of the upper portion of horizon 3, is rusty brown.

Horizon 4. Oxidized and calcareous. This zone is altered only by the oxidation of the iron compounds, especially along the edges of joint blocks. Pebbles of calcium carbonate in it are comparatively fresh and the matrix is calcareous. The color# is buff or mottled buff and gray.

Horizon 4 grades down into the unaltered material, which in glacial till is light to dark gray and strongly calcareous. The contact between horizon 4 and the unaltered ##### till is not sharp because oxidation has proceeded to a greater depth along joints than in the mass of the till.

The profile of weathering on the Illinoian till is considered a part of the Illinoian ~~till~~, since the materials were deposited at that time, but the alteration by weathering occurred during the Sangamon interglacial epoch.

The limits of the upper zones of the profile of weathering on Illinoian till cannot be easily determined where the overlying Sangamon loess is noncalcareous and the subsurface drainage is good. The Sangamon loess includes a calcareous zone in only one outcrop in the quadrangle. In many other exposures the upper part of the profile on the Illinoian till grades up without apparent break into the overlying Sangamon loess. The profile on the Illinoian till underlying an incomplete profile on Sangamon loess and a# ########## profile on Peorian loess is excellently exposed in the road cut of State Highway 31 south of Otter Creek. (Fig. 90).

<u>Geologic section 56. Road cut on east side of State Highway 31 on the south side of Otter Creek, near the center of the SE. ¼ sec. 30, T. 4 N., R. 3 E. (Isabel twp.).</u>

	Thickness Feet	Thickness Inches
Pleistocene system		
Peorian series (profile of weathering)		
Horizon 1		
11. Silt, brownish, not compact	1	
Horizon 2		
10. Silt, noncalcareous, brownish, compact, gumbo-like, sticky, breaking into irregular polygonal blocks	1	7
Horizon 3		
9. Silt, noncalcareous, reddish brown, less fractured than horizon 2	2	6
Horizon 4		
8. Loess, calcareous, gray# to yellow gray, weathering with a smooth surface, only slightly gullied, somewhat fossiliferous	9	9
Sangamon series (profile of weathering)		
Horizon 1		
7. Silt, noncalcareous, mottled gray and buff, distinctly laminated, containing numerous root canals which are calcareous and iron stained	1	
Horizon 2		
6. Silt, noncalcareous, brownish, more compact than horizon 1, with whitish markings on fracture surfaces; small subspherical lime concretions generally less than 3/8 inches, some attached to rootlet canals, lined with calcium carbonate. Also some irregular concretions, ranging from elongate to complexly ramifying and united, root canals. Near the base of horizon 2 in a few places minute pellets of iron oxide are found. In some places these are broken up and oxidized to reddish pellets, but they are not numerous enough to affect the color of the loess	3 appr.	
Horizon 3		
5. Silt, noncalcareous, brownish, more loosely aggregated than horizon 2, showing less numerous fractures	1	6

########

Fig. 96. Exposure of Pleistocene deposits on the east side of the cut of State Route 31, south of Otter Creek in #### the SE. ¼ sec. 30, T. 4 N., R. 3 E. (Isabel twp.), showing ~~soil~~ profiles of weathering developed on the Peorian# ######### loess, Sangamon loess, and the Illinoian till.

 276

Illinoian series (profile of weathering)

Horizons 1 and 2

4. Silt, noncalcareous, brownish red in upper part, brighter red in lower, a few small pebbles scattered throughout, the siliceous type only, comparable in size and lithology to those of the gumbotil. One large granite boulder on the west side of the road cut is completely disintegrated and granules are falling around its edges. Large concretions of lime, especially in the lower part up to $2\frac{1}{2}$ inches across, most of them irregular and etched. Upon breaking open they show rootlet canals, and the material is pinkish red calcium carbonate. Shoulders of horizons 1 and 2 ~~zones~~ begin about 2 feet 6 inches below the shoulder of late Sangamon loess. Texture of material is silty, open and granular with some clay. In the base of ~~the~~ horizon 2 and the top of ~~the~~ 3 occur pebbles and cobbles which are being decomposed. Some of them can be broken up with the hand, others readily with the hammer — 5 appr.

Horizon 3

3. Till, noncalcareous, buff to yellowish, with limestone pebbles leached, otherwise normal till, with large and small pebbles promiscuously scattered and much more numerous than in horizon 2. The lower 3 feet of horizon 3 is leached sand and gravel, which account for ~~###~~ greater leaching than in most well drained profiles on Illinoian till. The gravel is rusty in color. In the lower end of the cut horizon 3 is much more plastic and tenaceous than the overlying horizon 2, resembling in this respect gumbotil, but the pebbles are of normal size for horizon 3, and apparently some colloidal material has been concentrated here. This part fractures on the surface like gumbotil — 5 appr.

Horizon 4

2. Till, partially oxidized and calcareous, reaching a thickness on the downhill end of the cut of 10 feet, mottled and cut to some extent by vertical and horizontal seams of calcium carbonate — 10

Pennsylvanian system

Carbondale series

Summum formation

1. Sandstone (Pleasantview ~~sand-tone~~)

The illustration of this road cut section shows that horizon 2 of each of the three profiles forms the top of a shoulder. ~~The profile on the~~ the Illinoian till shows typically a well drained profile, as this road cut is here through a slope toward a ravine lying west of the road.

A somewhat similar succession of profiles of weathering is shown in a road cut north of East Creek, where the following section was measured:

Geologic section 57. Road cut on north-south road north of East Creek, in the SE. ¼ SW. ¼ sec. 2, T. 4 N., R. 3 E. (Waterford twp.)

	Thickness Feet	Thickness Inches
Pleistocene system		
Peorian series (profile of weathering)		
Horizon 1		
9. Silt, dark gray, with some humus	2	
Horizons 2 and 3		
8. Silt, buff, noncalcareous	3	
Horizon 4		
7. Loess, calcareous, gray, containing 2 inch iron stained band 10 inches from base which cuts across the bedding and slopes toward a gully east of the road, cutting into the Sangamon loess below	17	7
Sangamon series (profile of weathering)		
Horizon 1		
6. Silt, pinkish, loosely aggregated		6
Horizon 2		
5. Silt, noncalcareous, pinkish, compact, with numerous whitish markings on bedding and joint surfaces		11
4. Silt, noncalcareous, pinkish, compact, without whitish markings		9
Horizon 3		
3. Silt, noncalcareous, pinkish, calcareous around root canals, which are also iron stained	2	
Illinoian series (profile of weathering)		
####		
Horizons 1 and 2		
2. Silt, noncalcareous, pinkish, containing small fragments of carbonized wood in upper portion, and occasional pebbles of quartz and chert	5	
Horizon 3		
1. Till, noncalcareous, reddish, with abundant pebbles on the surface of outcrop	6-8 exposed	

The profile of weathering above is also formed under good drainage conditions since it is on the north slope of the valley of East Creek. Profiles of## weathering developed under conditions of poor drainage are exposed in many places, especially well in some of the cuts in the strip mines southeast of Cuba, which are in the level upland. The following section was measured in a strip mine cut (since destroyed):

Geologic section 58. Strip mine cut near the SW. cor. NW. ¼ sec. 27, T. 6 N., R. 3 E. (Putman twp.)

	Thickness Feet	Thickness Inches
Pleistocene system		
Peorian series (profile of weathering)		
Horizon 1		
8. Silt, dark gray, with some humus	1	
Horizons 2 and 3		
7. Silt, noncalcareous, buff	3	2
Horizon 4		
6. Silt, calcareous, mottled and gray	2	8
Sangamon series (profile of weathering)		
Horizon 1		
5. Silt, noncalcareous, pinkish gray, loosely aggregated, with root canals		10
Horizon 2		
4. Silt, noncalcareous, brownish gray, plastic, gumbo-like, possibly representing lower part of Sangamon loess profile of weathering and upper part of Illinoian till profile	1	7
Illinoian series (profile of weathering)		
Horizons 1 and 2		
3. Gumbotil, noncalcareous, brownish gray, plastic, weathering to gumbo-like surface, containing small pebbles of chert and quartz, shows minutely pitted surfaces when fractured	5	8
Horizon 3		
2. Till, noncalcareous, reddish brown, containing a few deeply weathered limestone pebbles and abundant silicate pebbles	2	10
Pennsylvanian system		
Carbondale series		
St. David formation		
1. Shale, gray (Canton shale)		

This exposure is typical of a profile of weathering developed under conditions of poor drainage. It is located on the pre-glacial upland near Cuba, which was only thinly veneered with Illinoian till, and Sangamon and Peorian loess, in contrast with geologic sections 56 and 57, which are nearer the bluffs of Illinois River, in areas of thicker depositio

Sangamon loess is widely distributed through the quadrangle. It is invariably thin, ranging from 2 feet to 7 feet 6 inches in 18 measured sections. It is commonly pinkish, in contrast with the overlying Peorian loess which is gray where it is calcareous, and buff where it is leached. The distinction of this loess from the underlying Illinoian till is more difficult, especially where a #### profile of weathering has been formed on the latter under good drainage conditions. The loess is of middle to late Sangamon age, because its deposition followed the development of a profile of weathering on the Illinoian till, a process requiring more time than that which has elapsed since the deposition of the early Wisconsin till. The loess is noncalcareous in all except one of the exposures studied ~~sutided~~. It is thickest in the area near the junction of Spoon and Illinois River valleys, and ~~it~~ is believed to have been supplied by winds from these flood plains. The thickest measured section shows 3 feet of calcareous loess at the base, suggesting that all the loess was calcareous when it was deposited. Because of its slight thickness it was completely leached in most exposures before it was buried by younger loess during the Peorian epoch. The thickest exposure of the Sangamon loess is in a gully ~~which has~~ recently ~~been~~ deeply entrenched, with nearly vertical walls partly due to recent slumping (fig. 91).

Geologic section 59. Exposure in small east draining gully southeast of a farm house near the west line of the SW. ¼ NW. ¼ sec. 26, T. 4 N., R. 3 E. (Isabel twp.)

	Thickness Feet	Thickness Inches
12. Interval between top of exposure and level upland	18	
#######		
Pleistocene system		
Peorian series (profile of weathering)		
Horizon 1		
11. Soil, dark, moist, loessial		6
Horizons 2 and 3		
10. Silt, noncalcareous, buff	2	3
Horizon 4 and unweathered material		
9. Loess, calcareous, mottled, grayish yellow in upper 18 inches, gray below, very fossiliferous, with limestone kindchen	8	9
Sangamon series (profile of weathering)		
Horizon 1		
8. Silt, noncalcareous, grayish brown, fine, sandy, loose		#2

Fig. 91. A small gully on the west side of the ravine in the SW. 1/4 NW. 1/4 sec. 26, T. 4 N., R. 3 E. (Isabel twp.), just east of a farm house which shows in the center background. The large grass covered flat near the center of the picture is a mass which slumped toward the gully from the upland on the right. This occurred several years before the picture was taken, as the slump escarpment had already been extensively dissected by gullies. The upper part of the walls of this gully is Peorian loess. The lower part, represented by the darker area on the face of the slumped block in the center foreground is Sangamon loess, here $7\frac{1}{2}$ feet thick, with a well developed ~~soil~~ ~~weathering~~ profile of weathering.

Horizon 2

7. Silt, noncalcareous, sandy, pinkish, fine, compact, with root canals having limonitic discoloration, massive structure, having band of carbonized fragments one inch from top — 10

6. Silt, noncalcareous, drab colored, fine sandy, root canals with limonite coloration; secondary concentration of calcium carbonate along root canals — 8

Horizon 3

5. Silt, ########### noncalcareous, sandy, gray, fine, with streaks of pale pink, canals with limonite coloration, few concretions and segregations of calcium carbonate along canals — 4

Horizon 4

4. Silt, calcareous, light gray, fine, sandy, with some secondary concentration of calcium carbonate along root canals, ~~along~~ with limonite coloration, unfossiliferous — 1 9

3. Silt, rusty brown, noncalcareous, except for calcium carbonate along tubules, contains fragments of carbonized wood — 6

2. Silt, calcareous, pinkish, fine sandy, loessial, with tubules and canals with rusty coloration — 1

Illinoian series (profile of weathering?)

###################

Horizons 1# and 2

1. Silt, pinkish in upper 4 feet, changing to grayish in lower part, noncalcareous except for concretions of calcium carbonate in one part of cut bank, contains a few scattered small pebbles of chert, quartz, rhyolite and feldspar up to ½ inch, with plant tubules and canals throughout and some some carbonized plants and wood — 6

The lowest silt exposed in the foregoing section may be horizon 2 of a well drained profile on the till, or it may be reworked Illinoian till which had formed a layer of washed silt on the lower slopes. The Sangamon loess section showed distinctly a break in loess accumulation a short time after the deposition of the first loess, during which it became weathered to a depth of 6 inches. This material, included above in horizon 4, really has the character of ## imperfectly developed horizons 1 and 2.

The Sangamon loess is much thinner in the northwestern part of the quadrangle, near Cuba and Bryant, than in the foregoing section. It is there commonly weathered to a dark soil. This is well shown in cuts along an abandoned railroad northwest of Bryant.

Geologic section 60. Cut ~~####~~ along abandoned railroad track ~~leading~~ northwest of Bryant, near the NW. cor. SW. ¼ SW. ¼ sec. 30, T. 6 N., R. 4 E. (Buckheart twp.)

	Thickness Feet	Inches
~~P##########~~		
Pleistocene system		
Peorian series		
6. Soil, dark, loessial	1	
5. Loess, noncalcareous, dark brown	2	6
4. Loess, calcareous, gray, with iron stained pipe stem concretions; no fossils present	#5	
Sangamon series		
3. Silt, noncalcareous, banded dark brown and black, with light gray, loessial silt; abundant small fragments of carbonized wood in dark brown silt; apparently a soil interbedded with loess	3	3
Illinoian series		
2. Gumbotil, noncalcareous, gray, very fine silt, with polygonal fracture, plastic, containing a few pebbles	4	6
1. Till, slightly calcareous, reddish brown, base concealed	2	

In a ravine east of Buckheart Creek near the north line of sec. 1, T. 5 N., R. 4 E. (Liverpool twp.) near the east line of the quadrangle, numerous large fragments of wood and a slightly indurated femur of an animal were found in a dark brown silt or soil apparently underlying Peorian loess. Although this exposure did not clearly show the relation of this material to the overlying loess, it seemed to represent a swamp forest soil or peat bed of Sangamon age.

A fresh water silt apparently of late Sangamon age is exposed along the northern edge of the valley of Spoon River, as described in the following section:

Geologic section 61. Road cut on west side of State Highway 31, # just north of Spoon River flood plain in the NE. ¼ NE. ¼ sec. 8, T. 4 N., R. 3 E. (Waterford twp.)

	Thickness Feet	Inches
Pleistocene system		
Peorian series		
4. Soil, dark, loessial	1	

	3. Loess, noncalcareous, light brown to buff, ### becoming mottled with gray loess toward base	4	8
	2. Loess, calcareous, gray, fine sandy, with a fracture showing a semblance of lamination, abundantly fossiliferous, with a typical loess (terrestrial) gastropod fauna	14	6
Sangamon (?) series			
	1. Silt, strongly calcareous, light pinkish more clayey and compact than loess above, fossiliferous, with a fresh water, rather than a terrestrial fauna; contains a few chert pebbles in lower portion	10	8

The road cut deseribed here extends from the 500 foot (early Wisconsin) terrace down to the flood plain of Spoon River. Immediately west of the road an isolated hill rises to 560 feet altitude. The hill is mantled with Peorian loess. The road cut appears to be against the lower slope of the hill, rather than on the terrace. The fauna collected from the upper loess contains species whihh are not known to have survived to a later date than the Peorian, and the pinkish fresh water silt is thus #### assigned to an age earlier than the early Peorian. It may be of earliest Peorian, late Iowan or Sangamon age. As loess deposition is known to have started during the late Iowan in many places and continued without interruption into the early Peorian, it seems more likely that this water laid deposit is of late Sangamon age, perhaps equivalent to the late Sangamon loess, which it resembles in color. The fossils collected from the silt are listed in Appendix A, Part III. They are all fresh water forms, but the ##### species Fossaria parva tazewelliana and Stagnicola caperata are amphibious and sometimes live in damp meadows where loess may accumulate. The calcareous character of this silt indicates that it was not exposed to weathering, but remained at or below the level of the ground water table. Similar reddish silts have been found at other localities underlying early Wisconsin fresh water silts. They may be similar only in color and texture, or they may be late Sangamon silts of flood plain origin, not buried by later sediments until the early Wisconsin.

The record of the later part of the late Sangamon in the Havana quadrangle is one of weathering and erosion, rather than of deposition. The Sangamon loess is absent in many exposures, and the Peorian rests on Illinoian till. The profile of weathering on the late Sangamon loess is also of this age. The climatic changes during the Sangamon epoch are discussed in connection with its history, p. 42, 43, Chapter V.

Iowan and Peorian series.

The name Iowan was proposed for the fourth glacial series of the Pleistocene system because it has its best known expression in eastern Iowa.[105]

---

[105] Chamberlin, T. C., in Geikie, James, The Great Ice Age, pp. 753-764, 1894

____________, The classification of American glacial deposits: Jour. Geol. vol. 3, pp. 270-277, 1895.

The name Peorian was proposed for the subsequent interglacial deposits because they are best displayed in the vicinity of Peoria, Illinois.[106]

---

[106] Leverett, Frank, The Peorian soil and weathered zone: Jour. Geol., vol. 6, pp. 244-249, 1898.

Loess deposited during late Iowan and early Peorian time, mantles the uplands and gentler slopes in all parts of the Havana quadrangle west of the bluffs of Illinois River. It is not exposed east of Illinois River, where the surface materials are of later age.

The loess ranges in thickness from 5 feet in the northwest part of the quadrangle, to 30 or 35 feet near the Mound Chapel in the angle between the valleys of Spoon ~~River~~ and Illinois Rivers. The thickness is greatest within a mile or less of the margins of these ~~Illinois and Spoon Riv~~er valleys, the probable source of much of the loess.

The loess lies on an uneven surface. It was observed on the Sangamon loess and soil, Illinoian till and Yarmouth loess. It may overlie the Pennsylvanian strata directly in some places, but such a contact was not found. The basal surface of the loess slopes toward the larger valleys, especially ~~the~~ Illinois River, Spoon River, Otter and Big Creek ~~valley~~s. Fig. 92 shows the loess sloping toward the valley of Otter Creek overlying Sangamon loess.

The loess is a fine silt, which commonly shows no sign of stratification It is somewhat coarser in texture where it is thicker near the bluffs of Illinois River than in exposures several miles from the river. Tests of two samples showed that the percentage of silt passing the 200 mesh sieve ranges from 95.46 to 99.84. The coarser material in the first sample consists principally of hollow tubes lined with calcite to which aggregates of silt adhere, a few grains of quartz sand to 0.3 mm., and a few flakes of muscovite and biotite, and grains of pyrite. The loess is composed principally of subrounded to subangular quartz grains about 0.05 mm. diameter

Although the loess is not cemented to any considerable extent it stands easily in steep ~~or nearly vertical~~ faces, and ~~it~~ possesses a distinct vertical jointing. The topography of the loess is best exhibited in road cuts ~~through the~~ loess in the southern part of the quadrangle, where its thickness ## is 20-30 feet (Fig. 93).

The loess is calcareous when unweathered. Much of the calcium carbonate is in fine particles. When a specimen of loess is tested with hydrochloric acid the evolution of carbon# dioxide causes the loess to swell quite noticeably. Numerous large calcareous concretions or kindchen##### which are very irregular in shape and may be several inches in length are also found in the loess. The cavities formed around root canals ~~also~~ have some secondary calcium carbonate. Small concretions of limonite are ~~also~~ present, but principally in the weathered zone of the loess.

Fresh loess is yellowish gray in color or mottled gray and buff. When weathered it changes to a light yellowish brown in most exposures, although it ~~is~~ may be reddish brown ~~in a few exposures~~ on the slopes of large

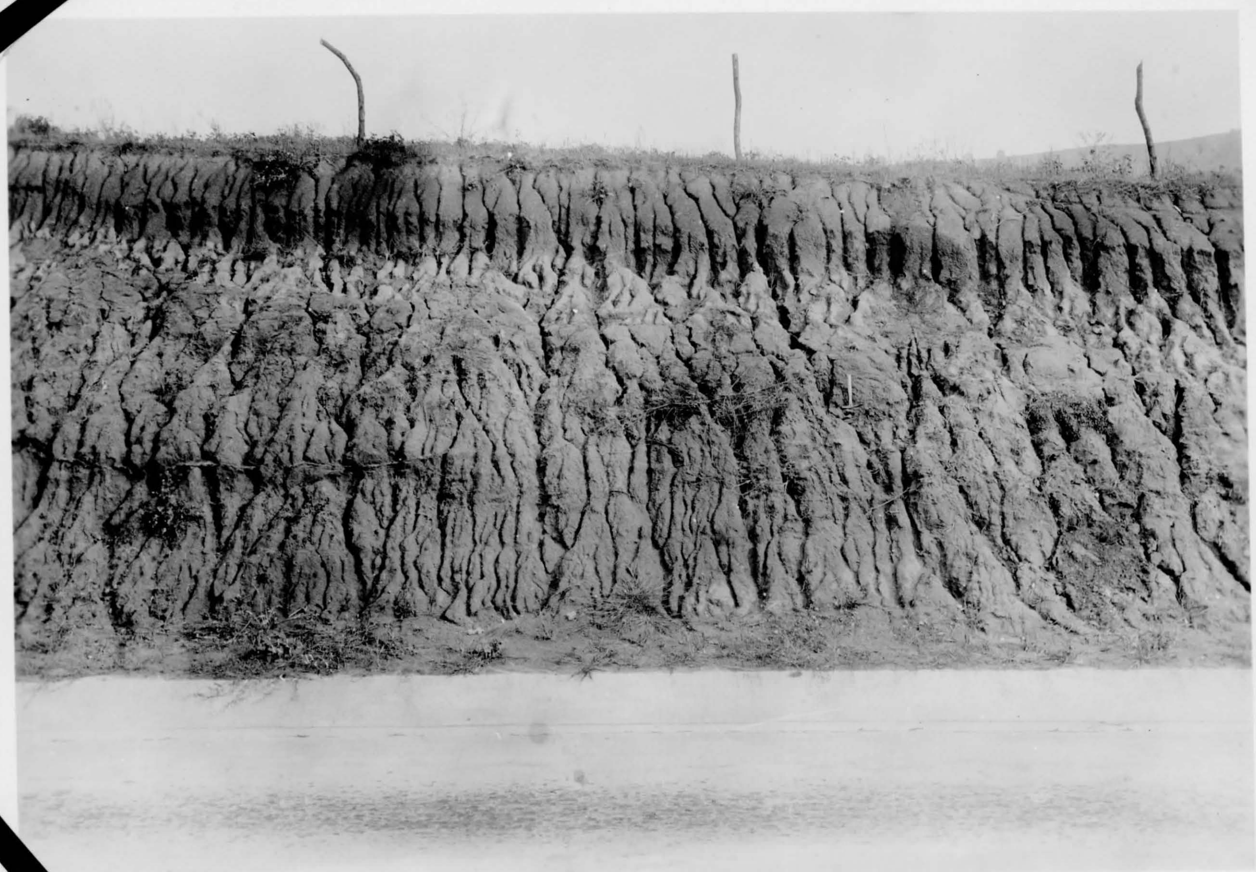


Fig. 92. Road cut section on the east side of State route 31, on the north side of Otter Creek near the center of the NW. $\frac{1}{4}$ sec. 29, T. 4 N., R. 3 E. (Isabel twp) showing Peorian loess overlying Sangamon loess and Illinoian till. The Peorian loess lies on a surface sloping toward the valley of Otter Creek about 1 foot in 8 in this picture. The light gray zone above the center of the picture is the calcareous loess, ~~or D zone of the soil profile,~~ the vertically furrowed zone just above this is the horizon 3 ~~C zone~~, and the comparatively smooth surface above this is the horizon 2. ~~B zone~~. The Sangamon loess is here less eroded by gullies than the Peorian loess above. Its thickness is less at the right than at the left, showing that it is partly ~~cut#~~ out by pre-Peorian erosion.

Fig. 93. Road cut exposure along north south road just south of the Otto school and State Highway 31, in the SE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 30, T. 4 N., R. 3 E. (Isabel twp.) showing calcareous Peorian loess in the lower part of the cut under noncalcareous Peorian loess above. The typical smooth ~~vertical~~ faces of the loess, the vertical jointing, and the absence of any semblance of ~~horizontal~~ stratification are brought out in this picture.

valleys where the weathering has taken place under conditions of good drainage. Profiles of weathering developed on Peorian loess are described in geologic sections 56, 57, 58 and 59.

Examination of samples of Peorian loess under the binocular microscope show that it is composed principally of subrounded to subangular quartz grains, about 0.05 mm. in diameter, with a small number of grains of muscovite and pyrite.

Calcareous Peorian loess is fossiliferous in many places, and fossil remains are abundant in some localities. The fossils collected from the loess at 11 localities are listed in Appendix A. They species are all terrestrial gastropods except three ~~species~~, Stagnicola caperata, Fossaria parva tazewelliana and Pomatiopsis scalaris. These species inhabit moist meadows which are covered by water during some seasons, and where loess might accumulate at other seasons. They are common in the loess in many exposures. Three of the species, Columella alticola, Vallonia gracilicosta, and Succinea grosvenori are now found only in the drier western states, Utah, Colorado, Wyoming, Nevada and Arizona, suggesting that the Peorian loess in Illinois was deposited under semiarid climatic conditions. The fauna affords little information regarding the temperature prevailing during loess deposition. The early part of the Peorian was probably colder than the later part.

All of the fossil collections were made from localities within 2 miles of the bluffs of Illinois and Spoon Rivers. Fossil remains are not commonly found at distances greater than 3½ miles from the river bluffs in this area. The exposures from which collections were made include loess deposited on uplands, valley slopes and along the margins of valleys. The amphibious species Stagnicola caperata and Pomatiopsis scalaris are limited to those collections made on lower slopes adjacent to valleys, but the other amphibious species Fossaria parva tazewelliana occurs abundantly in collections from all of ~~the~~ types of localities.

 289

The later part of the Peorian epoch is not recorded in this area by sediments. It was probably marked by the beginning of the weathering of the loess, as an exposure in East Bureau Creek, near Princeton, Illinois, shows leached Peorian loess underlying till and gravel of Early Wisconsin age.[107]

[107] Leighton, M. M. Personal communication

Wisconsin series

The name Wisconsin was applied to this series because glacial drift of this age is well exposed in eastern Wisconsin. The name East Wisconsin was at first proposed, but it was later abbreviated ~~to Wisconsin~~.[108]

[108] Chamberlin, T. C. in Geikie, A. The Great Ice Age, pp. 773-774, 1894.
____________. Classification of American glacial deposits. Jour. Geol. vol. 3, pp. 270-277, 1895.

No glacial deposits of Wisconsin age occur in the Havana quadrangle, as the glaciers did not reach this area during the Wisconsin invasion. ~~The~~ Illinois River carried a great deal of outwash from the glacial margin during the Shelbyville and Bloomington stages, when the Wisconsin glacier extended down ~~the~~ Illinois River valley to Peoria, about 35 miles northeast of the Havana quadrangle. ###Spoon River carried outwash from the Bloomington stage of the glacier from the ice front in eastern Stark County. The deposits formed during this part of the Wisconsin glacial epoch are called Early Wisconsin. They now form terraces which are widely distributed throughout the quadrangle. Other ~~and~~ lower terraces are referred to the Later Wisconsin stage of glaciation. The sediments of the Wisconsin series in this area were formed in# streams, on flood plains, in lakes, and on land where loess deposits and dune sands accumulated.

Early Wisconsin subseries

The outwash ######## and slackwater deposits of Early Wisconsin age form a terrace averaging 500 feet in altitude in this region. This terrace has been preserved along Big Creek, ##### Otter Creek, Spoon River and many smaller valleys.## It seems to have been largely removed from the edge of Illinois River valley, as though by torrential scour. The deposits in the smaller streams are slackwater deposits, formed because of the silting up of Illinois River valley with glacial outwash. The deposits composing this terrace are well exposed along East Creek (Fig. 94)

Geologic section 62. Cut bank ############ against terrace on southeast side of East Creek in the NW ¼ NE ¼ sec. 11, T. 4 N., R. 3 E. (Waterford twp.)

	Thickness	
	Feet	Inches
Pleistocene system		
Wisconsin series		

Fig. 94. Cut bank on the southeast side of East Creek in the NW. ¼ NE. ¼ sec. 11, T. 4 N., R. 3 E. (Waterford twp.), in early Wisconsin terrace deposits. The section exposed includes three distinct members, an upper gray loess, showing in the upper left portion, a middle laminated fresh water silt and sand, and a lower red fresh water silt which is not laminated. The boundary between the lower and middle members is shown below the middle of the picture. Fossils are present in the loess and middle laminated silt in abundance, but are rare in the lower silt.

3. Silt, calcareous in lower portion, upper portion inaccessible, blue gray, massive, slightly laminated, resembling loess, lower surface uneven, fossiliferous, with terrestrial gastropods typical of loess fauna 8
2. Sand and silt, calcareous, consisting of laminae of bluish gray sand and brick red silt, and some bands of gravel; some laminae show cross bedding in coarser materials; distinct alternation of colors suggestive of seasonal deposition; contains fauna of fresh water gastropods and pelecypods 9 6

Wisconsin series (?)

1. Clay or silt, calcareous, brick red, not distinctly bedded; contains a few poorly preserved fossils 7 6

In this exposure the lower silt or clay seems to be a lake or flood plain deposit, not clearly related to outwash of the Wisconsin glacier. The middle silt and sands were accumulated in a sluggish stream or lake during a period of marked seasonal temperatures, probably at the time of the melting of the Bloomington stage of the Wisconsin glacier at Peoria. The upper silt is evidently a loess formed after the recession of the glacier from the Bloomington moraine.

The fossils collected from the loess (3) in the foregoing section, are listed in Appendix A, Pt. III. The most abundant forms, Fossaria parva tazewelliana and Pomatiopsis scalaris, are amphibious in habit, suggesting that the loess accumulated on a flood plain occasionally inundated by the stream. The middle laminated silts contain a fauna of 6 fresh water species, 3 amphibious species and 5 terrestrial species, listed in Appendix A, Pt. III. The fresh water and amphibious species exceed the terrestrial species in abundance of individuals, suggesting that this locality was a flood plain commonly inundated during the period of deposition of the silts and sands. The small number of terrestrial shells present were either washed into the deposits, or invaded the area during short periods when it was free from water.

The exposure described in the foregoing section is along East Creek about half a mile back from Illinois River valley. The ~~####~~ sedimentation here was related to that in Illinois River valley, because a similar succession is found in other ~~smaller~~ stream valleys back from Illinois River. The following section, measured along Otter Creek, about 5½ miles southwest of the section above, illustrates this parallelism.

Geologic section 63. Cut bank in 500 foot terrace on southeast side of Otter Creek in the NW. ¼ SW. ¼ sec. 33, T. 4 N., R. 3 E. (Isabel twp.)

	Thickness Feet	Thickness Inches
Pleistocene system		
Wisconsin series		
4. Silt or loess, noncalcareous, brownish gray, grading up into soil	5	
3. Silt or loess, calcareous, gray, not laminated, no fossils seen	10	
2. Sand, gray and silt, pink, calcareous, in alternating bands with thicknesses ranging from one quarter to several inches; some bands of the sand are coarse with numerous pebbles; gray bands are commonly fine silt and reddish bands clay; slightly fossiliferous; lamination is suggestive of seasonal deposition	10	
Wisconsin series (?)		
1. Silt, calcareous, reddish, very fine grained, not bedded, fossiliferous, base concealed	6	

The middle laminated layer in this outcrop and the lower unlaminated reddish layer have nearly the same thicknesses as the corresponding beds have in geologic section 62. The greater thickness of the upper loess may be due to erosion of the former exposure. The East Creek terrace remnant is about 490 feet in altitude, while that on Otter Creek is about 500 feet. The fossils collected from lower red silt are listed in Appendix A, Pt II. They are all fresh water species, except Stagnicola caperata, an amphibious ~~##########~~ species, indicating that the bed was deposited under water. This lower reddish bed resembles closely the reddish calcareous silt underlying Peorian loess which was referred to as Sangamon silt in geologic section 61, member 1. Reddish silt underlying Wisconsin laminated silt outcrops only ~~############~~ three quarters of a mile northeast of the exposure described as Sangamon silt, and at the same altitude.

Geologic section 64. Road cut of secondary east-west road near the center of the east line of the SW. ¼ sec. 4, T. 4 N., R. 3 E. (Waterford twp.).

294

	Thickness Feet	Thickness Inches
Recent system		
4. Soil		8
Pleistocene system		
Wisconsin series		
3. Loess or silt, noncalcareous, brownish	2	3
2. Silt, ###### calcareous, gray, not well stratified, containing a few calcareous kindchen, very fossiliferous, with fresh water gastropods and pelecypods	12	3
Wisconsin series (?)		
1. Silt, ############ calcareous, brownish red, unstratified, slightly fossiliferous, containing principally fresh water gastropods	9	

The fossils from beds 1 and 2 in the foregoing section are listed in Appendix A, Pt. III. Those from the gray silt are all fresh water forms, including 5 species of pelecypods of the genus Pisidium. ############### The fauna is typical of quiet bodies of water such as flood plain lakes or slack water deposits. The fauna from the lower reddish silt includes three fresh water #######, #### two amphibious and two terrestrial species. This fauna might have lived along the margins of a flood plain often inundated, into which land shells were washed from the slopes of the valley, or else during occasional low water stages the land species invaded the area. Similar conditions of deposition are indicated for the reddish Sangamon (?) silt three quarters of a mile southwest of this locality, so the lower bed here may be of Sangamon, rather than Early Wisconsin age. Other unstratified reddish calcareous silts exposed in terrace remnants may then also be of Sangamon age. The absence of leaching of this silt, if it is of Sangamon age, can be explained because it was adjacent to the river valley, and below the water table. The presence of gravel# and sand near the base of the laminated silt above the red silt may indicate that it is the first outwash material from the Wisconsin ice front deposited in this region.

In the upper portions of some of the streams ponded by outwash in ~~the~~ Illinois River valley, part of the terrace material was probably contributed by wash from the streams themselves, as coarse sediment is commoner here than in the lower portions of these streams. This is illustrated in the following exposure along East Creek , about $1\frac{1}{2}$ miles upstream from the terrace cut desctibed in geologic section 62.

Geologic section 65. Cut bank against terrace remnant on southwest side of East Creek, in the NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 3, T. 4 N., R. 3 E. (Waterford twp.)

	Thickness Feet	Thickness Inches
Recent system		
7. Soil	1	
Pleistocene system		
Wisconsin series		
6. Loess, noncalcareous, buff	#1	#
5. Silt or loess, calcareous, gray, not laminated, weathered into vertical faces, fossils uncommon	4	6
4. Sand and gravel, stratified, slightly fossiliferous	3	3
3. Silt, calcareous, pinkish, laminated, with fine sand, containing some kindchen	1	3
2. Silt, calcareous, gray, #### stratified, with some pebble bands	2	6
1. Silt, calcareous, gray and sand, buff to gray, in alternate beds; some pebbles scattered through the sand; fossiliferous	7	

In the exposure further down this creek described in section 62 the laminated silt (member 2) is $9\frac{1}{2}$ feet thick, with very little gravel. In the foregoing section corresponding beds are 14 feet thick and are much coarser in texture. The species collected from the lower silts and sands here are listed in Appendix A, Pt III They include 3 fresh water #######, 2 amphibious and 7 terrestrial species. This mixed assemblage is probably representative of a flood plain, where the channel frequently shifted its position. The interbedding of sand and silt in the section is ~~also~~ typical of flood plain accumulation.

Another terrace exposure which contains abundant fresh water shells is in a large ravine north of Spoon River, described here:

Geologic section 66. Cut bank on south side of south branch of large ravine tributary to Spoon River, 75 feet east of junction of main forks of this ravine, near middle of west line of sec. 29, T. 5 N., R. 3 E. (Lewistown twp.)

	Thickness Feet	Thickness Inches
Pleistocene system		
Wisconsin series		
3. Silt or loess, noncalcareous, brownish	4	6
2. Silt, calcareous, gray and yellowish brown mottled, chiefly gray in upper portion and yellowish below, fossiliferous in lower yellowish portion; upper portion may be calcareous loess overlying fresh water flood plain silt	22	
1. Silt, calcareous, dark blue gray, with numerous small fragments of carbonized wood, fossiliferous, with fresh water fauna similar to that of (2) above, base concealed	3	

The species collected from beds 1 and 2 are listed in Appendix A, Pt. II. The fresh water species greatly predominate over amphibious and terrestrial ~~species~~ forms. The terrestrial shells may have been washed into the deposit from adjacent valley slopes ~~which are~~ covered with Peorian loess.

The sediments of the 500 foot terrace are excellently exposed along the west side of the North Branch of Otter Creek near the center of the SW. ¼ sec. 19, T. 4 N., R. 3 E. (Isabel twp.). Here fossiliferous Wisconsin loess with a terrestrial fauna overlies fossiliferous fresh water silt, containing fresh water and amphibious gastropods and pelecypods.

The most extensive remnants of a terrace at about 500 feet are ~~situated~~ north of Spoon River on each side of the channel of Stuart Creek, about 5 miles west of Lewistown. The following section describes an exposure on this terrace, near the western line of the quadrangle:

Geologic section 67. Cut bank on east side of small ravine in the NE. ¼ SW. ¼ sec. 14, T. 5 N., R. 2 E. (Bernadotte twp.)

	Thickness Feet	Inches
Pleistocene system		
Wisconsin series		
8. Silt, noncalcareous, brownish, sandy	8	
7. Sand, noncalcareous, yellowish brown, fine	5	
6. Sand, calcareous, bluish gray to brown, finely laminated, suggesting seasonal deposition, brownish in irregular streaks and around root canals	3	8
5. Silt, calcareous, brownish, sandy		2
4. Silt, calcareous, blue gray, slightly sandy, light brown along joint fractures and root canals, containing scattered pebbles of quartz and chert to one half inch diameter, and poorly preserved fossil gastropods, and some small calcareous concretions in the basal portion	6	
Wisconsin series (?)		
3. Silt, light gray, plastic, brownish in small spots along root canals, with 1 inch band of brown highly calcareous silt with abundant calcareous concretions at top, underlying silt very slightly calcareous, effervescing only after repeated treatments with acid	3	7
2. Silt, noncalcareous, pink, slightly sandy, containing fragments of carbonized wood and in basal portion scattered pebbles to ¾ inch diameter, thickening from 2 feet at north end of cut to 3 feet at south end	2-3	
1. Silt, noncalcareous, dark bluish gray, sandy, with numerous pebbles, absent at south end of cut	2	

The members of the foregoing section cannot be easily correlated with the widespread terrace sequence described in sections 62, 63 and 64. No. 4 is probably equivalent to the laminated silt and sand carrying a fresh water fauna in the other exposures. The material above this silt is coarser in texture than most of the loess elsewhere. It may be of eolian origin, like the loess, but nearer the source of sand. Noncalcareous silt below calcareous silt and sand is not found in the other terrace sections. Members 1-3 may be interpreted as fluviatile deposits of Spoon River formed during the late Sangamon or early Peorian, or during the Iowan glacial stage, which were weathered before the deposition of the overlying Wisconsin silts. It is not possible to determine which of these stages is represented.

A somewhat different type of Early Wisconsin deposit is exposed in a ravine just north of ~~the~~ Illinois River bluff, described here: (Fig. 95)

Fig. 95
Exposure in the southeast bank of east fork of ravine in the NE. $\frac{1}{4}$ sec. 33, T. 4 N., R. 3 E. (Isabel twp.), showing early Wisconsin terrace materials. The upper part of the section shown consists of well rounded gravels and sands, which have washed down the slope to some extent, appearing mixed with wood at the right. Below these gravels and sands is a concentration of logs apparently driftwood, embedded in silt containing terrestrial fossils. The log at the left is about 6 feet in ~~length~~ diag. and is a

Geologic section 68. Cut bank on southeast side of east fork of largest ravine in the NE. ¼ sec. 33, T. 4 N., R. 3 E. (Isabel twp.)

	Thickness Feet	Inches
Recent system		
6. Soil, noncalcareous, black to brownish gray		7
Pleistocene system		
Wisconsin series		
5. Gravel and sand, slightly calcareous in upper portion, strongly calcareous below	8	
4. Silt, calcareous, carbonaceous, gray, with many small fragments of carbonized wood, and some gravel	2	6
3. Gravel, lenticular masses, containing fragments of wood	2-0	
2. Silt, calcareous, gray, surrounding concentration of logs (fig. 95), including logs over 6 feet in length and 9 inches in diameter; silt contains fauna of terrestrial gastropods	1	6
1. Silt, calcareous, gray, interbedded with gravel, containing fragments of wood and blocks of calcareous till, bituminous odor	1	

This exposure is in a small ravine just north of the bluff of Illinois River, which had been only slightly excavated before the alluviation of this portion with terrace deposits. Illinoian till is exposed a short distance upstream from this outcrop and some of the gravel may have been derived from the erosion of this till. The wood may have been drifted into this valley from the river during times of high water and become embedded in the fine flood plain silts here. The wood is identified as

The fossil gastropods and pelecypods collected here are listed in Appendix A, Pt III. They include 12 terrestrial, 1 amphibious and 1 fresh water species. Some of the species of land shells may have been washed down from the adjacent slopes to this deposit, or this flood plain may have been inundated only occasionally.

A Wisconsin terrace deposit of somewhat different character is exposed in the central branch of this ravine, about 200 yards north of the preceding exposure.

Geologic section 69. Exposure in central branch of ravine in the NE. ¼ Sec. 33, T. 4 N., R. 3 E. (Isabel twp.)

	Thickness Feet	Inches
Pleistocene system		
Wisconsin series (Profile of weathering)		
Horizon 1		
9. Soil, dark, with laminations		11
8. Soil, dark gray, granular		5
Horizon 2		
7. Soil, dark gray, compact	1	3
6. Silt, dark gray, compact, with iron coatings on many faces, grading down into	1	
5. Silt, noncalcareous, saturated with limonite, brownish to dark blue gray, becoming more deeply iron stained at base, probably a bog limonite deposit	1	6
Horizon 3 (?)		
4. Gravel, yellowish brown		3
Horizon 4		
3. Gravel, calcareous, buff to gray		4
2. Silt, calcareous, gray, slightly fossiliferous, with carbonized wood fragments, black at base, mixed with gravel	3	5
Illinoian series		
1. Till, calcareous, gray, base concealed	3	

The foregoing profile of weathering may have been developed on a loess, but it was probably developed under marsh conditions. The silt saturated with limonite has the appearance of a low grade bog iron ore.

The alluviation of the many tributaries to Illinois River valley with slack water deposits during the filling of the main valley, resulted in the checking of erosion by even the minor tributaries. In some places the present flood plain is nearly at the level of the early Wisconsin terrace, and in other ~~cases~~ places the entrenchment below this surface is so recent that both the level surface in the streams and the sloping surfaces extending up lateral tributaries are apparent. The North Branch of Otter Creek illustrates various phases of terrace development. In the SW. ¼ sec. 19, T. 4 N., R. 3 E. (Isabel twp.) the terrace remnants are about 30 feet above the present flood plain and are discontinuous. Further up the stream in the NE. ¼ sec. 24, T. 4 N., R. 2 E. (Pleasant twp.) the terrace remnants are only 5-10 feet above the present narrow flood plain and are more extensive. In the NW. ¼ of the same section the broad flood plain seems to be at the same level as the 500 foot terrace, still undissected. The sloping plain of a tributary joining this terrace surface is shown in fig. 96. This tributary has recently entrenched itself into unconsolidated sand of Illinoian age so rapidly that some of its side gullies now enter it as hanging valleys.

In exposures along the north side of Big Creek and the west side of Slug Run in the eastern portion of sec. 34, T. 6 N., R. 3 E. (Putman twp.) the terrace remnants are narrow and locally almost entirely cut away, but the former existence of a terrace is clearly shown by high level alluvial fans at the mouths of several gullies. The outer edges of some of these fans have been somewhat dissected since the erosion of the terrace. Similar high dissected fans are found at some places along the edges of Illinois and Spoon River valleys.

An interesting drainage change related to Early Wisconsin alluviation in this region is exhibited in the southern parts of secs. 7 and 8, T. 4 N., R. 3 E. (Isabel twp.), just south of the ~~new~~ paved road west of Duncan Mills (State highway 98). This is a wide flat floored valley approximately 70 feet below the surrounding uplands which is not now occupied by a stream. The eastern part of the valley is drained eastward toward Spoon River, and the western part ##### northward to Tater Creek. Fig. 97 shows this relation. Tater Creek evidently flowed through this valley before the formation of the 500 foot terrace, entering Spoon River valley near the eastern edge of section 8. The silting up of the valley to the 500 foot level diverted the lower part of Tater Creek through a low col in the divide in the NE. ¼ NW. ¼ sec. 7 to the valley of Spoon River, abandoning its former valley.

The early Wisconsin terrace materials of the west side of Illinois River valley have been largely removed by erosion by the main stream, but they are preserved extensively on the east side of the valley. The terrace

Fig. 96. A southern tributary of the North Branch of Otter Creek in the NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 24, T. 4 N., R. 2 E. (Pleasant twp.) in which the graded slope related to the early Wisconsin (500 foot) terrace has been recently abandoned by the entrenchment of the stream. Remnants of this surface form the grass covered slope above the cut bank at the left. The North Branch, which shows in the background is here entrenched ~~about~~ 8-10 feet below this 500 foot terrace. ###

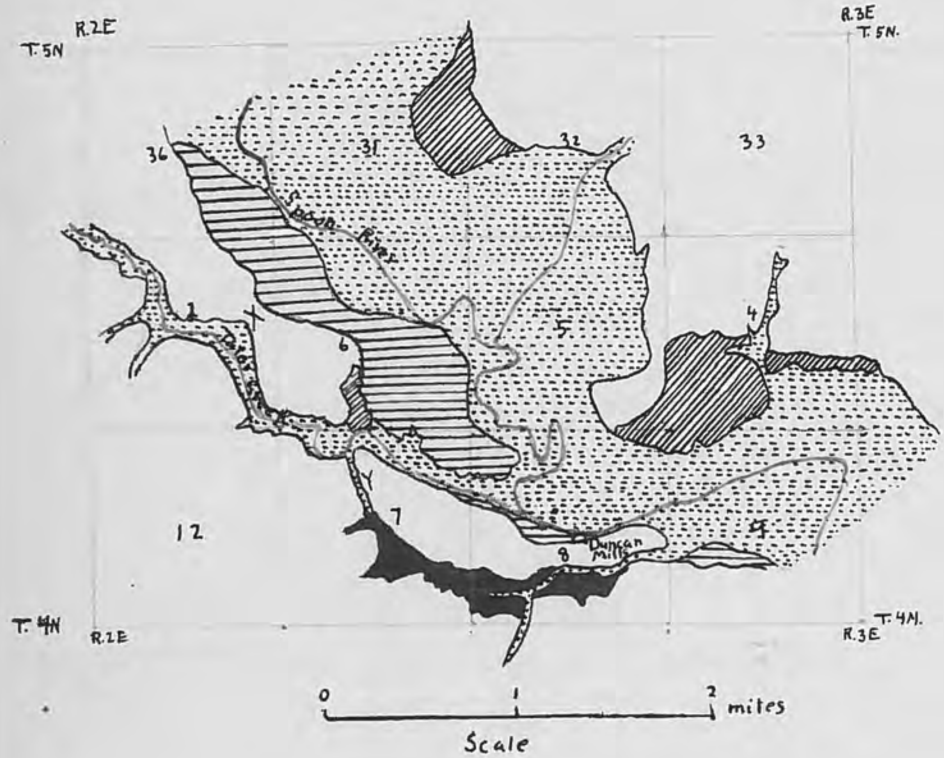


Fig. 97 . Sketch map showing abandoned valley of Tater Creek south of Duncan Mills formed by the diversion of the waters of Tater Creek through a low col in the divide between the creek and Spoon River at the time of the aggradation of Spoon River v lley to the 500 foot level and the formation of the early Wisconsin terrace. The map shows another ~~#######~~ col further upstream through which diversion would have taken place had the valley of Spoon River become aggraded to a level 40 feet above that of the high terrace of the early Wisconsin. The abandoned valley is now being degraded to some extent by the waters of some tributaries on the south side of the valley.

area on which Havana is built is lower than this terrace and is of later date. A large area in the southeastern part of the quadrangle in secs. 4, 7, 8, 9, 16, 17, 18, 19, 20 and 21, T. 21 N., R. 8 W. (Havana twp.) is level, and ranges in altitude from 485 to 494 feet. Numerous sand dunes rise to altitudes over 500 feet in this area. The surface soil here is sandy loam, which may be equivalent in age to the loess which commonly caps the 500 foot terrace in Fulton County exposures. There are no natural cuts in the terrace materials in this area.

Later Wisconsin subseries

The record of the Later Wisconsin in the Havana quadrangle consists in (1) certain terrace ~~terrace~~ remnants along the west bluff of Illinois River, along Spoon River, Otter Creek, and other smaller streams, 15-30 feet lower in altitude than the 500 foot early Wisconsin terrace; (2) a broad terrace area along the east side of Illinois River, averaging 2-2½ miles in width, upon which the city of Havana is situated; (3) sand dune deposits on this terrace, between it and the higher terrace in the southeastern part of the quadrangle, and on the higher terrace; and (4) a terrace area in sections 15 and 22, T. 4 N., R. 3 E. (Isabel twp.) about 458 feet in altitude, 15 to 20 feet lower than the other areas of Later Wisconsin terrace, and probably later than them.

The Later Wisconsin terrace is well exposed along the south side of Spoon River valley across the quadrangle to within 2 miles of the western edge. The village of Duncan Mills is situated on this terrace, which has an average altitude of 475-480 feet there. It is partly a terrace of erosion, as Pennsylvanian strata are exposed almost continuously along this terrace east and west of Duncan Mills, very thinly veneered with alluvial silts.

Two terrace levels are preserved adjacent to each other in several places in the quadrangle. The best exposure of this sort is north of the hamlet of Enion, in sec. 33, T. 4 N., R. 3 E. (Isabel twp.). Here the upland is about 560-570 feet in altitude, the higher terrace a few feet over 500 feet, the lower ~~terrace~~ 465-~~480~~ 470 feet and the flood plain of Illinois River 445-450 feet. The preservation of a wide terrace area here seems to be related to the situation behind the projecting point of the bluff of the river in sec. 35. This ~~situation~~ may have caused this to be a somewhat sheltered bay where the river would be widened and decreased in velocity during floods.

Another place where two terrace levels are preserved adjacent to each other is north of Tater Creek along the road in the SE. ¼ SW. ¼ sec. 6, T. 4 N., R. 3 E. (Isabel twp.). Here the upland is about 560 feet in altitude, the higher terrace 506 feet, the lower ~~terrace~~ 495 feet and the flood plain of Tater Creek 460 feet.

Along the north side of Otter Creek 2 terrace levels are represented in the SE. ¼ sec. 26, T. 4 N., R. 2 E. (Pleasant twp.), about one half mile east of the quadrangle line. The level of the upland here is about 585 feet, the upper terrace 530 feet, the lower terrace 495 feet and the flood plain 481 feet.

Two terraces are preserved ~~also~~ at several places near the mouths of Big Sister, Little Sister, and Buckheart Creeks.

The lower terrace in many places appears to be almost entirely a surface of erosion, with the Pennsylvanian strata exposed under a thin veneer of terrace materials. Inspection of the map shows many outcrops of the Pennsylvanian in road scrapings along the edges of this terrace. Elsewhere ~~the erosion has been marked by the erosion of~~ the upper portion of the early terrace materials, has been eroded the silts remaining containing a mixture of fresh water and terrestrial mollusks suggesting a concentration of shells from the overlying loess during this erosion period. This is# illustrated in the faunal assemblage collected from silts in the lower terrace along Dickson Creek in the SE. ¼ SE. ¼ sec. 1, T. 4 N., R. 3 E. (Waterford twp.), about 200 yards north of the east-west road bridge across this stream. The fauna collected here, consisting of 5 terrestrial, 1 amphibious and 5 fresh water species, is listed in Appendix A. Pt. III

It appears possible to discriminate between deposits of Early Wisconsin and Late Wisconsin age in exposures along a sharply entrenched ravine, cutting across the lower terrace (altitude 471 feet) for a distance of about one quarter mile along the east edge of the SE. ¼ NE. ¼ sec. 34, T. 4 N., R. 3 E. (Isabel twp.). (Fig. 98)

Geologic section 70. Exposure along ravine at the east edge of the SE. ¼ NE. ¼ sec. 34, T. 4 N., R. 3 E. (Isabel# twp.)

	Thickness Feet	Thickness Inches
Pleistocene system		
Wisconsin series		
Later Wisconsin subseries		
7. Silt, noncalcareous, yellowish, fine, bleached surface soil	1	
6. Silt, noncalcareous, dark gray, with humus, and a few pebbles	1	2
5. Silt, noncalcareous, buff, with scattered pebbles, not distinctly bedded	3	4
4. Silt, calcareous, yellowish gray, slightly fossiliferous	2	7
Early Wisconsin subseries		
3. Silt, noncalcareous, brownish gray, dark, with some humus, showing some lamination, as in horizon 1 of profile of weathering		9
2. Silt, slightly calcareous in upper portion, strongly calcareous below, yellowish gray, containing a mixture of terrestrial and fresh water mollusks	3	
1. Sand, calcareous, with some beds of gravel, fossiliferous	5	6

In this exposure it seems probable that the noncalcareous silt (3) ###### is a weathered zone developed during a brief period of mild climate between the time of the formation of the higher terrace and the deposition of later silts on the lower terrace level. Fossil remains are abundant in the silt and sand below this weathered ~~silt~~ zone (1 and 2) in

Fig. 18. Exposure along sharply cut south flowing ravine near the SE. cor. SE. ¼ NE. ¼ sec. 34, T. 4 N., R. 3 E. (Isabel twp.), showing terrace silts and sands of Wisconsin age. The terrace is of late Wisconsin age, and has an altitude of 471 feet. The upper 5½ feet ~~of the terrace~~ is composed of noncalcareous silts, underlain by 2 feet 7 inches of calcareous silt, with some fossils. The base of this silt is marked by the hammer head to the left of the center. Below this level is nine inches of brownish gray noncalcareous silt, apparently the upper part of a ~~soil~~ profile of weathering, underlain by calcareous fossiliferous silts and sands. The weathered zone mentioned is interpreted as the upper surface of early Wisconsin deposits overlain by late Wisconsin silts

the southern part of this ravine, but rare and poorly preserved in the bed above ~~this silt~~ (4). In the northern part of the ravine cut an extremely fossiliferous silt occurs within 1-2 feet of the top of the terrace in that position. This is probably a continuation northward of the later Wisconsin silt described in the foregoing section, although the weathered zone was not observed there. If this interpretation is correct, both Later and Early Wisconsin silts are very fossiliferous in this ravine.

The Early Wisconsin fauna from the lower part of the ravine contains 19 terrestrial ~~fresh water~~, 1 amphibious and 4 fresh water species. The Later Wisconsin (?) silts from the upper part of the ravine contain 17 terrestrial, 1 amphibious, and 2 fresh water species. The fossils collected in this ravine are ######### listed in Appendix A, Pt. III.

The interpretation of these deposits is confused by the presence of a mixture of fresh water, amphibious and terrestrial shells. The situation may have been the marginal postion of the flood plain, which was inundated only during seasons or years of unusually high water. At other times loess may have accumulated here. The mixture of terrestrial and fresh water forms in the lower beds may have resulted from the reworking of the silts during the erosion of the high terrace. The species listed as later Wisconsin #### in age are characteristic of these deposits elsewhere, except Fossaria parva tazewelliana and Polygyra multilineata wanlessi, which have not heretofore been reported in deposits younger than the Early Wisconsin. Thus the age of this upper deposit is not clearly determined by the fauna.

Sandy deposits which are apparently of later Wisconsin age are preserved along the outer margin of this terrace about 1¼ miles southwest of the ravine section described in geologic section 70, where they are exposed in a road cut~~ting~~ near the middle of the east line of the SE. ¼ sec. 33, T. 4 N., R. 3 E. (Isabel twp.)

A terrace area several hunderd acres in extent occurs north and northwest of Wild Goose school in secs. 15 and 22, T. 4 N., R. 3 E. (Isabel twp.) The levels of this terrace range from 456 to 458 feet. The adjacent flood plain is 441 to 448 feet, and the later Wisconsin terrace a short distance west is about 475-480 feet. There are no exposures of the ~~terrace~~ materials of this, which is apparently a younger terrace. There are three terraces along Illinois River near Peoria, and this may be equivalent to the lowest of the three terraces there.

The area east of the flood plain of Illinois River in this quadrangle is largely a terrace area correlated with the lower (or middle) terrace on the west side of the river. Sand dunes are present on some parts of this terrace. The altitudes ~~of the terrace~~ ~~east of the river~~ range from 459 to 479 feet. This occupies a belt ## two to three# miles wide between the higher terrace to the southeast and the flood plain of the river. Along the inner border ~~of this terrace~~ there is a belt of sand dunes ranging from one half mile to one and a half miles in width. This ~~sand dune~~ belt is continuous across the quadrangle# except for one break near the diagonal road southeast from Havana in ### sec. 7, T. 21 N., R. 8 W. (Havana twp.) The surface material of this terrace area is commonly sandy loam, but it is locally sand. ~~Besides the dunes at the inner border of this ### terrace~~ There are also scattered dunes or dune ridges on the higher terrace in the southeast corner of the quadrangle and on the lower terrace near Illinois River. Such a dune ridge or branching ridge passes through the eastern part of Havana. Undrained depressions in which water gathers after periods of heavy rain are also found in this terrace. A large depression of this sort became filled with water, forming a lake following the heavy rains of 1927-28. This lake is in the SW. ¼ sec. #8, T. 21 N., R. 8 W. (Havana twp.), including the intersection of two roads and the right of way of the Illinois Central Railroad.

Sieve analyses of (A) the surface sandy loam from the level terrace, (B) ~~of~~ sand from the top of a dune, and (C) ~~of~~ compact sandy silt from an undrained depression in the dune area, are shown graphically in fig. 99.

On the surface of the low terrace in the SE. ¼ sec. 36, T. 23 N., R. 8 W. (Quiver twp.), about two miles east of the quadrangle, a granite boulder is exposed, surrounded by sandy silt. A smaller boulder lies near the larger one. These boulders are probably ice floated, as no others are known from the surface of this terrace.

The two terraces which are recognized along both sides of Illinois River in this quadrangle are probably equivalent in age to two terraces along Illinois River in the Peoria quadrangle.[109]

---

[109] Udden, J. A. Geology and mineral resources of the Peoria quadrangle, Illinois. U. S. Geol. Survey Bull. 506, pp. 60-61, 1912.

The earlier terrace is probably composed of fresh water silt and sand accumulated as outwash and slack water deposits at approximately the time of the building of the Bloomington moraine in the Peoria region and near the headwaters of Spoon River. The outwash deposits at this time are known to have formed a great dam at Peoria across the Illinois valley, ~~resulting in the~~ formation of a lake extending over 100 miles up ~~the~~ Illinois River. This ~~lake~~ has been named Lake Illinois.[110] The loess deposits on the

---

[110] Leighton, M. M. Unpublished paper presented before National Academy of Sciences at Urbana, October, 1927.

---

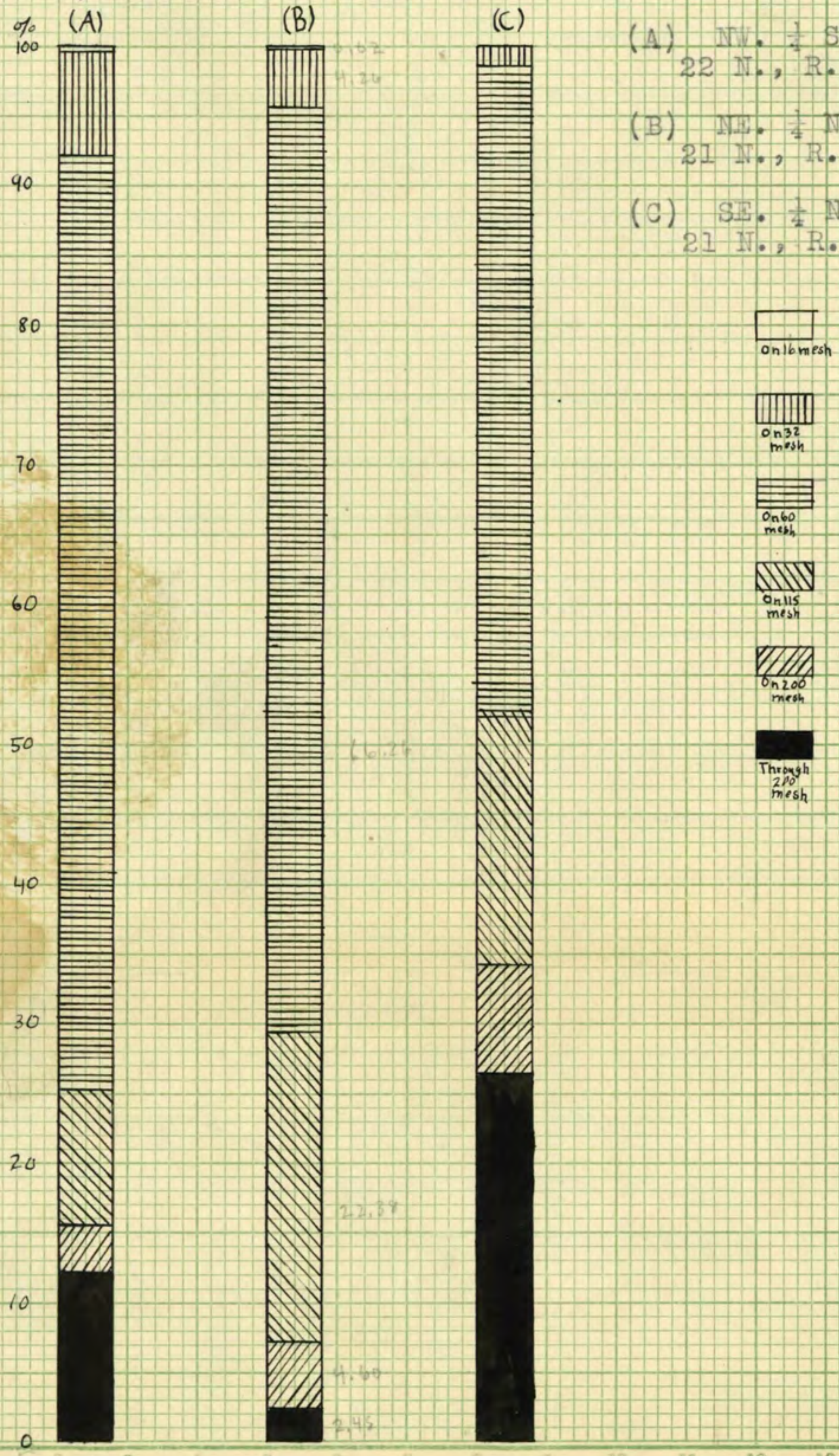
higher terrace may have accumulated during the low water stage when the waters of Illinois River were confined by this dam. There is Abundant evidence ~~exists~~ in the physiography of Mason and Tazewell Counties that the Mackinaw River, which now enters the Illinois from the east near Pekin (see fig. 123) formerly discharged its waters through a wide valley southwest-

Fig. 99 . Sieve analyses of (A) sandy loam from level part of later Wisconsin terrace, (B) sand from top of sand dune and (C) sandy loam from the bottom of a poorly drained depression enclosed by sand dunes to show the relation between topographic position and the concentration of the fine silts (through 200 mesh) in the surface soil.

(A) NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 30, T. 22 N., R. 8 W.

(B) NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 5, T. 21 N., R. 8 W.

(C) SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 5, T. 21 N., R. 8 W.



~~ward~~ into ### Sangamon River, and it seems likely that Illinois River itself may have occupied this valley at some time previous to the building of the outwash dam at Peoria holding in Lake Illinois. If this is the case the breaking of the dam which finally drained Lake Illinois may have diverted the waters into drainage channels other than that occupied previous to the building of the dam. The altitudes of towns in the broad valley connecting the Sangamon and Mackinaw are near 500 feet, an altitude corresponding to the early Wisconsin outwash deposits in Fulton County, suggesting that this valley was abandoned after the building of the outwash dam. The flood of waters from Lake Illinois must have occupied most of the present flood plain area of Illinois River and the lower terrace areas adjacent to it. Other channels may also have been occupied at this time, as Quiver Creek valley and other level valley areas east of Illinois River form a somewhat anastamosing drainage pattern, obstructed in places by sand dune ridges. The greater part of the sand deposits in the Mason County area may be derived from the outwash dam, as deposited by torrential streams from Lake Illinois. The age of the many dunes along the eastern margin of the low terrace along the Illinois valley# and other drainage lines of this period may be the low water stage following the ######### draining of Lake Illinois. This low water stage may perhaps be equivalent to the time when the upper Illinois River was held in by a dam formed by the Marseilles moraine at Marseilles, La Salle County. During this time the smaller valleys formed by the torrential streams from Lake Illinois were blocked at many places by sand dune barriers. The abandonment of the lower terrace by Illinois River seems to be related to another torrential flow of water, because of the comparative straightness of the margins of this terrace. This ~~torrent~~ may have been the Kankakee torrent,[12] which drained

---

12/ Ekblaw, G. E. and Athy, L. F. Glacial Kankakee torrent in Northeastern Illinois. Bull. Geol. Soc. Amer. vol. 36, pp. 417-428, 1925.

a glacial lake formed by the Marseilles moraine barrier across Illinois River. The level of Illinois River valley at this time probably about 400 feet or lower, as alluvial deposits are reported 30 feet or more ~~thick~~ in various parts of the flood plain. The age of the sand dunes on the low terrace surface near Havana may thus be subsequent to the Kankakee torrent, or perhaps subsequent to the time when Illinois River served as a drainage outlet for Lake Chicago. A part of the alluvial deposits underlying the present flood plain may be of Later Wisconsin age, formed during the Lake Chicago stage, but these cannot be easily distinguished from the recent flood plain deposits. Gravels which are dredged from the channel of Illinois River may be of late Wisconsin age, as the present gradient of the river is too low to permit the transportation of gravel except during flood times.

Recent system.

The deposits formed since the close of the Wisconsin glacial epoch are referred to the recent system. ############ Postglacial time is recorded in the Havana quadrangle by (1) erosion by the smaller streams, (2) the formation of profiles of weathering on the surface materials of the area, (3) the deposition of alluvial fans and slope wash along the margins of most of the streams, (4) the deposition of flood plain deposits along Illinois River and other larger streams, (5) the formation of ### some of the sand dunes of the Mason County area. Indians inhabiting this area before its settlement by white people built numerous mounds along the margins of Illinois River flood plain on both sides. Drainage ditches and levees have been constructed for land drainage and flood control. Strip mine debris covers many acres near Cuba, and the area is increasing annually. Natural surface drainage has been obstructed in some places by the slumping after ~~of the surface following~~ the removal of coal by underground mining.

The extensive outcrops of Pennsylvanian strata indicate that large amounts of Peorian loess and Wisconsin terrace deposits have been eroded since the close of Wisconsin time. Many small gullies show exposures of 50-75 feet of pre-Peorian deposits. Fig. 100 shows a gully typical of the many small gullies along the bluff of Illinois River. New gully systems have developed on deforested slopes of some of the stream valleys, with a corresponding formation of alluvial fans along the lower slopes (Fig. 101).

Along some ~~the margins~~ of the larger valleys like Illinois and Spoon Rivers alluvial fan and piedmont alluvial deposits formed against the margin of the lower terrace are still preserved, although the terrace has been cut away from these portions. These remnants resemble narrow terraces, and may be confused with them. Such a fan is situated along Illinois River bluffs east of the center of sec. 26, T. 4 N., R. 3 E. (Isabel twp.).

Profiles ~~#####~~ of weathering formed on Peorian loess are exposed in many road cuts and stream banks. The formation of these profiles is largely of postglacial time, as the Peorian is only slightly weathered where it underlies Wisconsin till. In the Havana area the loess is weathered to a depth of 6-8 feet. Wisconsin terrace deposits are also leached to depths ranging from 5 to 13 feet in the early Wisconsin terrace silts and to 5½ feet in the later Wisconsin silts. The sandy terrace and sand dune accumulations east of Illinois River are leached and oxidized to a depth of 10-15 feet where subsurface drainage conditions are good. The finer silts have largely been removed from the sandy loam in ~~sand~~ dunes and carried by ground waters toward the centers of depressions, where a compact plastic mixture of sand and clay accumulates. The following succession is desdribed from an auger boring near the center of an undrained depression in a sand dune area:

Geologic section 71. Auger boring in undrained depression near the SE. cor. NE. ¼ sec. 5, T. 21 N., R. 8 W. (Havana twp.) (fig. 102)

Fig. 100. Sharply entrenched gully along the bluffs of ~~the~~ Illinois River in the SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 14, T. 5 N., R. 4 E. (Liverpool twp), eroded into the Purington shale member of the Carbondale series. This is typical of the steep walled gullies adjacent to the larger streams eroded in post-Peorian or post-Wisconsin time.

Fig. 101. East slope of the North Branch of Otter Creek in the SW. ¼ sec. 19, T. 4 N., R. 3 E. (Isabel twp), showing the development of new systems of gullies on deforested slopes adjacent to streams. The lower slopes below the gullies are mantled with alluvial fans, composed of debris brought down by these gullies. They ~~gullies~~ are excavated in loess and Illinoian till.

~~Use another print because of scratch in upper part of this one.~~

317

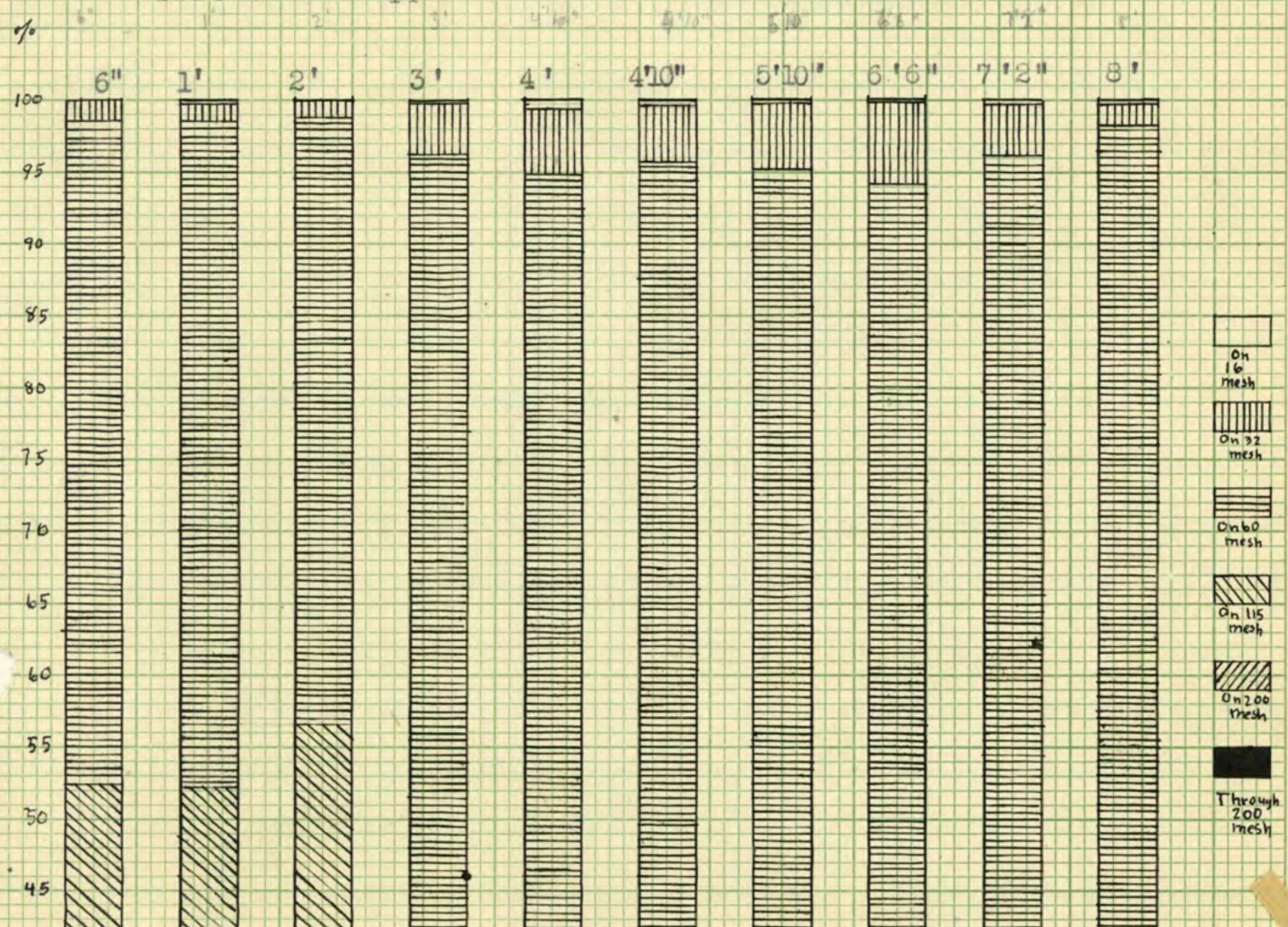
	Thickness Feet	Thickness Inches
Pleistocene system		
Wisconsin series		
4. Loam, noncalcareous, sandy, dark brown, plastic, with considerable clay, clay concentrate# increasing slightly with little color change to about 3 feet, slightly lighter color from 3 feet to 4 feet 10 inches	4	10
3. Sand, noncalcareous, reddish, moist, less clay than above	2	2
2. Sand, noncalcareous, mottled yellowish and reddish brown, lighter colored than above, less clay than (4)		6
1. Sand, yellow to light brown, soft, without clay, caving easily, to base of auger boring		8

The upper member probably corresponds to horizons 1 and 2 of the profile of weathering. The rest of the boring belongs to horizon 3, as the sand is noncalcareous to the base of the hole. The compact silt near the surface holds the water in these depressions after rains, forming small lakes and marshes. Fig. 103 shows a plant succession in a small blow out in a sand dune district, illustrating the effect of concentration of clay near the center of the depression in holding the water near the surface. On the more level portions of the sandy terrace there is commonly a zone of concentration several feet below the surface. Along the outer edge of the terrace about 1½ miles south of Havana the depth to this compact zone is 4 feet 6 inches, and the sand is so tightly compacted with clay that it can hardly be penetrated with an auger. An auger boring near the north end of Chautauqua Park on this terrace level shows marked concentration of fine silt and clay at a depth of 8½ to 9 feet. This auger boring is described as geologic section 73, p. 291.

Years of very heavy rainfall like 1926 and 1927 have caused extensive slumping on the slopes of stream valleys. This causes the slopes to be ~~more~~ poorly drained, with standing water trapped here and there along them. Fig. 104 shows the result of such slumping along the margin of a large valley.

Fig. 102

Sieve analyses of samples from an augur boring in a poorly drained depression between sand dunes in the SE. ¼ NE. ¼ sec. 5, T. 21 N., R. 8 W., showing the concentration of silt in the upper 3 feet of the hole. Depths:



319

Fig. 103. A blow out or wind excavated depression in a sand dune district in the NE. $\frac{1}{4}$ sec. 16, T. 21 N., R. 8 W. (Havana twp). The presence of a hard pan or clay concentrate# in the sand holds the water near the center of the depression giving rise to a growth of mosses and other plants growing only in moist places. Around this center the water is farther from the surface, as indicated by bands of vegetation of drier habitats, until the borders where scattered stems of bunch grass are alone able to grow. The outer slopes of this blow out are completely devoid of vegetation.

Fig. 104. Northeast slope of a ravine in the SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 2, T. 5 N., R. 4 E. (Liverpool twp.) showing the effects of slumping. The bare white area along the middle of the slope is an exposure of the Purington shale member of the Carbondale series formed by the slumping away of the soil cover from the lower slopes.

Flood plain deposits have been formed in the valleys of Illinois and Spoon Rivers and many smaller streams. Records of borings in the flood plains of Illinois and Spoon Rivers show depths to bed rock ranging from 22 to 40 feet or more. These deposits are ~~probably~~ mostly postglacial in age. The deposits of fine silts which stand on the flood plains until they are dried out become extensively mud cracked. Fig. 105 shows a surface in the flood plain of Spoon River showing cracks formed after two stages of inundation. Fig. 106 shows the same part of Spoon River valley during a flood in July, 1929.

The highest flood level of Illinois River in recent years was approximately 447 feet, 17 feet above low water stage at Havana. This was during the winter and spring of 1926-29. The flood waters reached the western bluff of Illinois River at one place, in the SW. ¼ NW. ¼ sec. 35, T. 4 N., R. 3 E. (Isabel twp.). This high stage is recorded by a wave cut notch one to two feet high along the edge of the bluff and by masses of driftwood piled against this beach. (Fig. 107) Similar cuts along the sandy terrace east of the river are found at several places, notably Baldwin Beach, 3 miles north of Havana. Along the margin of the terrace in sec. 10, T. 22 N., R. 8 W. (Quiver twp.) driftwood has accumulated to a depth of 2 feet (Fig. 108)

Where the natural forest cover has been destroyed in the sand dune areas in Mason County renewed drifting of the sand has formed low sand dunes and blow outs. This has also happened where crops have been grown in sand dune areas and the cultivated fields subsequently abandoned. Piles of sand 1 to 3 feet high are common along many of the hedges ~~at~~ along the ~~edges of~~ roads. These piles have been collected by wind from the roads and cultivated fields.

322

Fig. 106. A low portion of the flood plain of Spoon River just east of State Route 31, near Duncan Mills, where the overflow waters remain until they are evaporated. Two sets of desiccation cracks are shown here, the larger ones formed ~~by/d~~ after overflow in the spring of 1927, and the smaller ones after one or two days of inundation in the fall of ~~1927~~ the same year.

Fig. 106. Spoon River valley in flood stage north of Duncan Mills, July, 1929. Mud cracks formed in this same locality after a flood are shown in fig. 105.

Note. Another flood picture of Spoon River showing the river, as well as the flood plain is available.

321

Fig. 103. The edge of the bluff of ~~the~~ Illinois River in the SE. ¼ NW. ¼ sec. 35, T. 4 N., R. 3 E. (Is bel twp), where the flood waters of ~~the~~ Illinois River extended to the bluff. A scarp or notch one to two feet in height was cut by the waves at this time and boards and drift logs were piled up ~~######~~ along the beach of this flood area.

Fig. 108. Edge of the late Wisconsin sandy terrace in sec. 10, T. 22 N., R. 8 W. (Quiver twp.). The flood waters of ~~the~~ Illinois River extended to this bank and the great masses of driftwood shown were piled here by this# flood. The bark is absent from the lower partsof the tree trunks up to the high water mark.

(Trim out black in corners.)

Indian mounds.

Records of the activities of the mound builders, predecessors of the modern Indians in ~~the~~ Mississippi and Illinois River valleys are abundantly distributed through the quadrangle. Indian mounds are found in many places along the outer margin of the late Wisconsin terrace, north and south of Havana, and along the bluffs of ### Illinois River near Sepo. Other mounds are reported along the bluffs of Illinois and Spoon Rivers from Mound Chapel southward. The position of some of the mounds is shown in fig. 14. The larger mounds are 20 to 25 feet in height and 100~~# feet~~ to several hundred feet in diameter. Large mounds are situated along the edge of the terrace between Chautauqua Park and Quiver Beach about $1\frac{1}{2}$ miles north east of Havana.

Interest in the exploration of Indian mounds in this area was greatly increased in the spring of 1927 by the discovery of a burial mound with several hundred skeletons and an abundance of implements and ornaments on the bluff of Illinois River near the SE. cor. SW. $\frac{1}{4}$ sec. 1, T. 4 N., R. 3 E. (Waterford twp.) about 300 feet northeast of the East Waterford school. The excavation of this mound has been undertaken by Dr. Don F. Dickson of Lewistown, who has ~~built a~~ erected building over the excavation and opened it to the public. This is the largest ~~single~~ known burial of the mound builders ~~known~~, so far as the writer is aware. Fig. 109 is a view of part of this excavation.

Fig. 109. View of the interior of the excavation of the Dickson Mound Builders Tombs, one half mile north of Sepo. A family burial is seen to the right in the background, the skeleton of a child, between two adults. In the foreground the skeleton was removed and another skeleton underlying it was excavated, then the upper skeleton was replaced on a piece of plate glass, which is seen in the foreground. The pieces of pottery shown by the skeletons are placed ~~exactly~~ where they were ~~it was~~ discovered. ~~Photo~~

(other pictures are available as substitute for this.

Another ~~interesting~~ mound burial is that in the Ogden mound, (fig. 110 (picture from survey collection)) a flat topped mound about 20 feet high, situated near the outer edge of a low alluvial fan apparently built by East Creek at the margin of the present flood plain of ~~the~~ Illinois River. It is in the NE. ¼ SW. ¼ sec. 12, T. 4 N., R. 3 E. (Waterford twp.) in the southern part of the village of Sepo. ~~It is about 20 feet high, flat topped and~~ A residence was constructed on the top of the mound 25 or 30 years ago. The flat top is said to be the result of levelling at the time the residence was constructed. Only one skeleton was found under this mound, and it was in a log tomb. A necklace composed of several hundred shell beads was twined about the neck. A large mound of clay under the center of the mound was interpreted by the excavators as a ceremonial pyramid. The materials for the mound are mostly derived from the adjacent fan and flood plain. The mixing of materials from various depths in the soil and subsoil gives a mottled appearance to the mound clay. The shape of the mound suggests that a definite plan was followed in its construction. There are 15 to 20 low mounds within 400 feet of this large ~~mound~~ one.

During the late fall of 1927 and the spring of 1928 excavations were made in 16 mounds along the margin of the late Wisconsin terrace within $1\frac{1}{2}$ miles north and south of Havana by the University of Illinois under the direction of Mr. W. K. Moorhead and Mr. J. L. B. Taylor. These included a group of 9 mounds in the S. $\frac{1}{2}$ of sec. 11, T. 21 N., R. 9 W. (Havana twp.) all within 300 feet of the river bank and a group of 7 mounds in the vicinity of Chautauqua Park. The~~se~~ ~~mounds~~ were explored by lines of auger holes along the north-south and east-west axes of the mounds, and by a series of pits along these axes where objects were found. Fig. 111 shows the pits excavated along the north-south axis of mound 13, in the south part of Chautauqua Park. Skeletal remains were found in several of the mounds and copper, flint and bone implements and pottery or pottery fragments in others ~~some mounds~~. In a mound southwest of Havana several skeletons were buried on flat chipped slabs of flint averaging 7 x 10 x 1 inches, ~~in dimension~~. No rock of this type is known in the Havana quadrangle or its vicinity, nor are large boulders of it ~~this type~~ found in the glacial drift. In a mound near this ~~one~~ a layer of river clam shells surrounded by charcoal seems to represent a kitchen midden deposit. In one of the mounds in Chautauqua Park several large fragments of sandstone of Pottsville age, representing the basal sandstones of the Seahorne and "Liverpool" formations of the Pennsylvanian were found. These rocks outcrop along the west bluff of Illinois River about 4 miles west of here, and they were probably brought from that vicinity. The excavators noted a zone of very compact sandy loam or hard pan in many of the mounds explored, and a similar compact material below the mound in one excavation. The writer was given the opportunity to examine several of the mound trenches to determine whether ~~or not~~ this compact zone ~~of the mound~~ was equivalent to a compact zone in horizon 2 of a profile of weathering, formed since the building of the mound, or whether it was simply more compact material used in constructing part of the mound.

Fig. 111. An Indian mound (no. 13 of those explored by the University of Illinois in the spring of 1928) in the southern part of Chautauqua Park. This shows the mode of exploration used in these mounds. Augur holes were sunk along the north-south and east-west axes of the mounds, and where these showed the presence of buried implements, pottery, or human remains, a series of pits was sunk along each of these axes to the mound base, and lateral entrances from these pits were used to excavate ~~any~~ skeletons ~~or~~ and other remains thus found. This mound is approximately 10 feet in height and 80 by 100 feet in dimension.

The most significant excavation bearing on the antiquity of the mounds was that in Mound 16, just north of Chautauqua Park. The following section was measured in the deepest pit made, just southwest of the top of the mound:

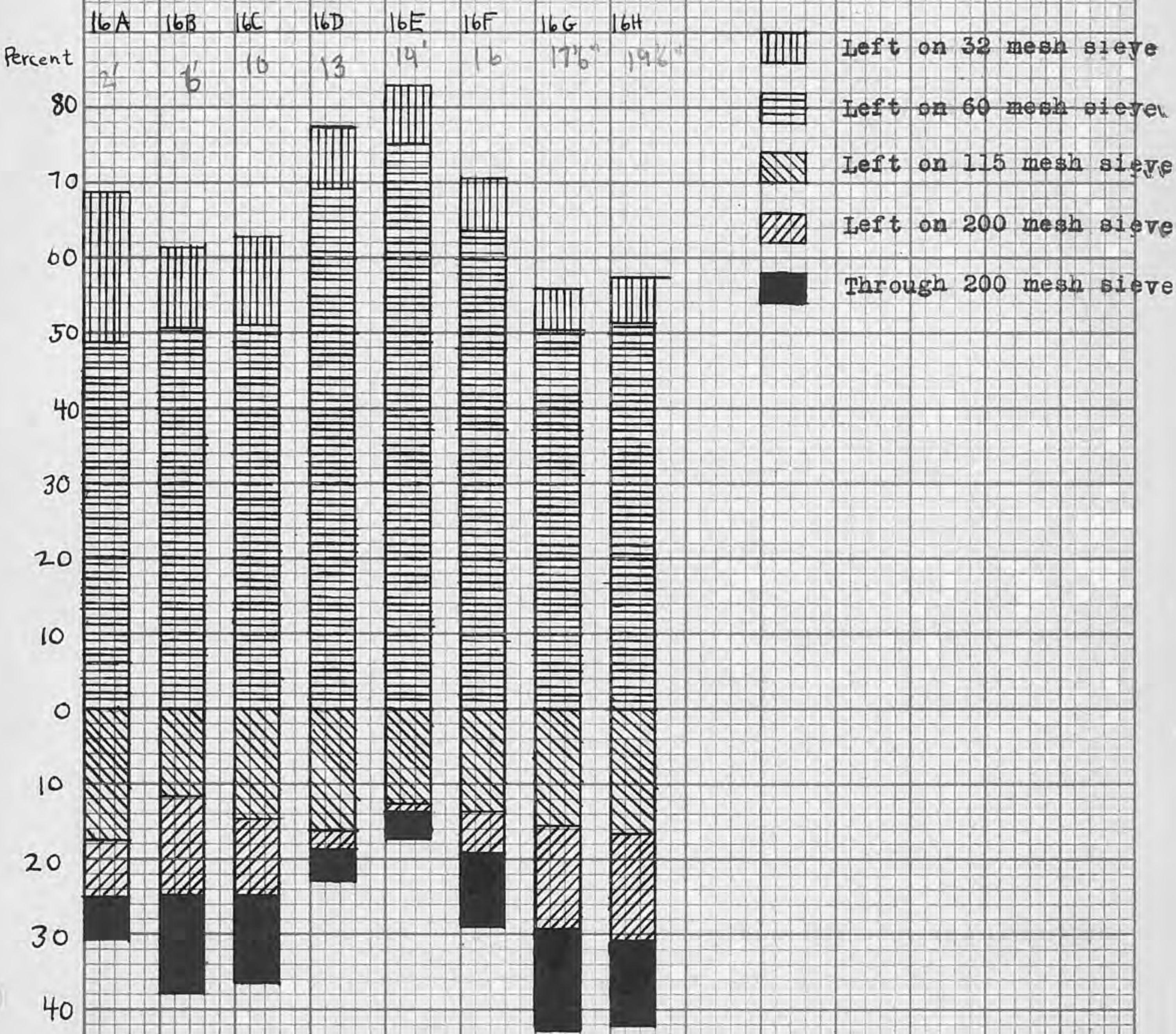
Geologic section 72. Section of pit face in Mound 16, 50 feet north of Chautauqua Park and 250 feet west of road along east# edge of park, in the SW. ¼ sec. 30, T. 22 N., R. 8 W. (Havana twp.)

	Thickness Feet	Thickness Inches
Recent system (Mound material)		
7. Soil, with leaf mould		6
6. Silt, noncalcareous, sandy, brownish gray and dark gray, loose to slightly compacted, moist, with a few scattered bits of pottery	4	8
5. Silt, noncalcareous, sandy, dark gray, dry, compact, with scattered bits of charcoal	6	6
4. Ash bed, noncalcareous, very loose, with scattered weathered clam shells in upper portion, ### human skeletal material below upper part of ash, fragments of sandstone in upper portion; basal layer of mound	1	6
Pleistocene system		
Wisconsin series		
Later Wisconsin subseries (Terrace material)		
3. Sand, noncalcareous, gray to yellowish, very loose at top, grading down into more compact at base	3	4
2. Sandy loam, noncalcareous, reddish brown, compact, ##############, plastic when wet	1	8
1. Sandy loam, noncalcareous, light yellow, rather loose, poorly assorted, to base of pit	1	6

Sieve analyses were made of 4 samples from the mound and four samples from the terrace materials below the mound base. The results of these analyses are given in fig. 112. These analyses show a concentration of silt and clay 6 to 10 feet below the top of the mound and approximately 3½ feet below the base of the mound. Each ~~of these~~ seems to represent horizon 2 of a profile of weathering, but the amount of concentration below the mound is greater than that in the mound itself. The proportion of silt and clay in the zones of concentration is higher than that indicated, because many of the fine sand particles consist of tightly compacted aggregates of clay and silt. The very loose sand just below the mound base may have been a wind blown deposit, for the topography in the vicinity

Mound 16, Havana group.

Depth of sample below top of mound. Last four samples below mound base



Graphical representation of ~~mechanical~~ sieve analyses of samples from Mound 16, Havana group, SW. $\frac{1}{4}$ sec. 30, T. 22 N., R. 8 W., Mason County. Drawn with correlation of samples at base of major size grade, 60 mesh, to emphasize effects of concentration.

shows a faint suggestion of dune forms, and the mound may have been started on a low dune. The compact zone in the mound may be the result of (1) concentration in the formation of profile of weathering, ~~or the result of~~ (2) compacting of a part of the mound surface before another part was added, or (3) ~~the result~~ the use of materials differing in compactness in constructing different levels of the mound.

An augur boring was made about 50 feet east of the mound to compare the profile of weathering under the mound with the profile developed on the terrace away from the mound. (See fig. 113)

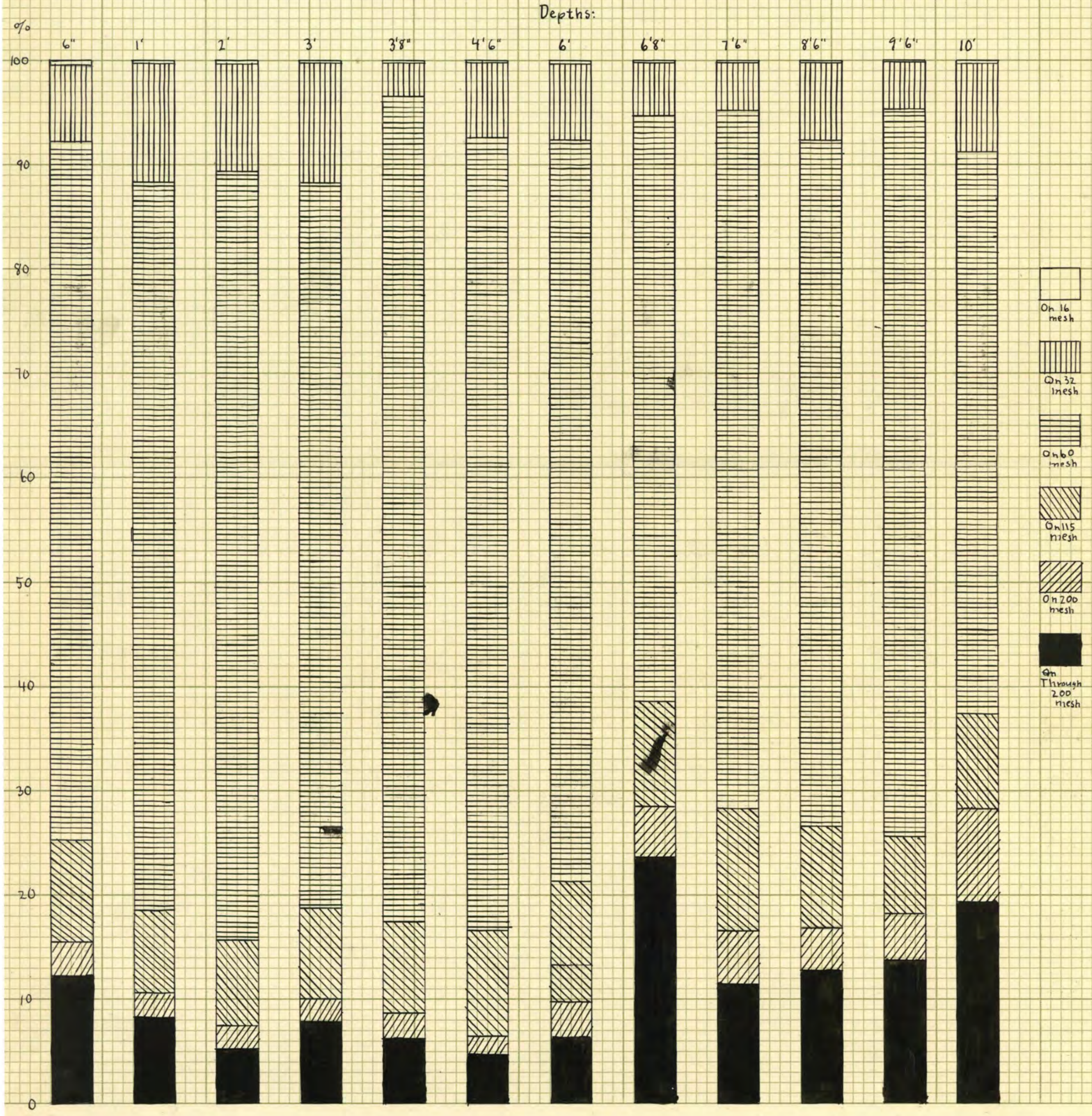
<u>Geologic section 73. Record of augur boring on late Wisconsin terrace about 50 feet east of Mound 16, Chautauqua Park.</u>

	Thickness Feet	Thickness Inches
Pleistocene system		
Wisconsin series		
Later Wisconsin subseries (profile of weathering)		
Horizon 1		
9. Soil, dark, loose, with stems, leaves, etc.		10
8. Sandy loam, chocolate brown, loose, changing to light brown at depth of 3 feet 8 inches, and increasing slightly in plasticity	3	11
7. Sand, yellowish, in streaks through reddish brown sandy loam	1	3
6. Sandy loam, light yellowish brown, more compact than above, more clay		4
5. Sand, light yellow, looser than above		4
4. Sand, yellowish brown, loose, almost no clay		4
Horizon 2 (?)		
3. Sand, darker than above, more plastic		11
2. Sandy loam, yellowish brown, compact, plastic, with more clay than any level above	1	6
Horizon 3		
1. Sand, yellowish brown, looser than above	4	10

This boring shows the zone of greatest plasticity at 6 feet 8 inches to 8 feet below the surface, while in the section below the mound it is only about 3½ feet below the surface on which the mound was built. This may indicate a considerably longer time than the time of formation of the sub-mound profile. Several mounds show evidence that pits were cut into the top or sides ~~of the mound~~ at some time and subsequently filled with looser sand. Fig. 114 shows such a section in mound 13, in Chautauqua Park.

Fig. 118

Sieve analyses of samples from an augur boring on the lower terrace near Mound 16 of the Havana group. NW.¼ SW.¼ sec. 30. T. 22N., R. 8W. (Havana). Note the concentrations of silt at and below 6 feet 8 inches.



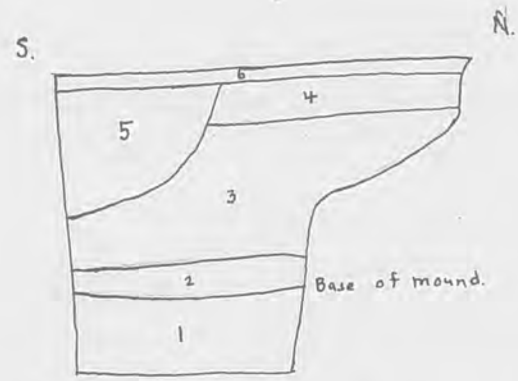


Fig. 14. Section of trench pit about 15 feet north of the center of Mound 13 (University of Illinois explorations) in Chautauqua Park showing sand (5) which was apparently ########## placed in a pit previously excavated in the upper part of the mound. This may have been done by the mound builders, but it is more likely of recent origin. The materials shown in the diagram are described here:

6. Sod, loose, reddish sandy loam 4 inches
5. Sand, loose, reddish, with some pebbles to 3/4 inch diameter, with very little silt and no clay
#4) Sandy loam, reddish, loose, containing no clay or charcoal
3. Sandy loam, reddish brown, containing bits of charcoal, carbonized roots, and irregular shaped masses of bluish gray to black clay or fine sand; more compact than overlying layers; has a spotty appearance which is probably due to the mixing of materials during mound construction 4 feet 3 inches to 3 feet.
2. Sandy loam, reddish, without clay and charcoal 1 foot to 1 foot 4 inch
Base of Mound.
1. Sand, loose, yellow, noncalcareous, containing some gravel, surface material of the low terrace on which the mound is constructed.

No. 2 may be the soil formed on the low terrace materials, slightly worked over during the beginning of mound construction. The materials for 3, especially the dark ~~material~~, was probably taken from the black soil of undrained depressions in the vicinity. Nos. 4 and 5 are much more recent additions, and contain no charcoal. No. 6 may be the soil formed after the addition of the last material to the mound.

The hard pan or compact zone in the mound itself is lenticular in shape, thinning to a feather edge near the ~~edge~~ border of the mound, but its presence in many mounds both north and south of Havana, makes it seem probable that it is not a different material used during different stages of the mound building, but the result of a compacting of the mound surface during its construction, or a concentration brought about by soil waters.

Summarizing the evidence regarding the age of this mound building culture, ##### the surface on which the mounds are built is a sandy terrace, formed perhaps at the time of the draining of Lake Illinois during the earlier part of the later Wisconsin. Subsequent to the deposition of the terrace sands, sand dunes were accumulated by wind on some parts of the terrace, as some of the mounds are on low dunes, and the terrace materials were leached ~~of calcareous material~~ to a depth of several feet. A zone of concentration was formed by soil waters on the sandy loam terrace deposits, which probably represents ~~half or more than~~ at least half of the time since the beginning of weathering of these sands. This weathering and concentration of clay and silt was probably not started to any extent until postglacial time, because of the cold winters during the time of recession of the glacier. Hence the indian mounds examined in this area are not likely to be more than 10,000 years in age, and they are probably much younger.

The Indian mounds on the west side of the River are on Peorian loess (Dickson mound) and the outer edge of an alluvial fan of East Creek of postglacial age (Ogden mound and other small mounds near it).

Drainage ditches, levees, mine dumps, etc.

The larger tributaries of Illinois River are drained across its flood plain through drainage ditches protected by levees on each side. Fig. 116 shows one of these drainage ditches about 3 miles west of Havana. The road from Duncan Mills to Havana is on the levee on the left side. Spoon River is just the other side of this levee near here. Fig. 2 shows the

Fig. 115. A drainage ditch and levees about three miles west of Havana. The road from Havana to ~~###~~ Duncan Mills is on the levee at the left, and Spoon River is to the left of this road. A large tract of land southwest of Havana was flooded in the fall of 1926 when the waters of Spoon River broke across the road into this drainage ditch in the area shown by this picture, and the combined waters caused a break in the levee to the right, flooding all of the Langellier and Lacey drainage districts.

distribution of drainage ditches, levees and drainage districts.

A large acreage of land in the vicinity of Cuba has been recently covered with strip mine debris. ##(Figs. 116 and 117). This consists of high piles of loess and glacial drift, the surface materials of this area, with fragments of the Canton shale and the St. David limestone and shale. Some of the fragments of the latter are 6 to 8 feet in diameter. Weathering of these piles is so rapid that some vegetation grows on them in the second year after they are made, and in four or five years they are mantled with a fairly complete cover of grasses and weeds of various kinds. (~~See discussion on p. __.~~)

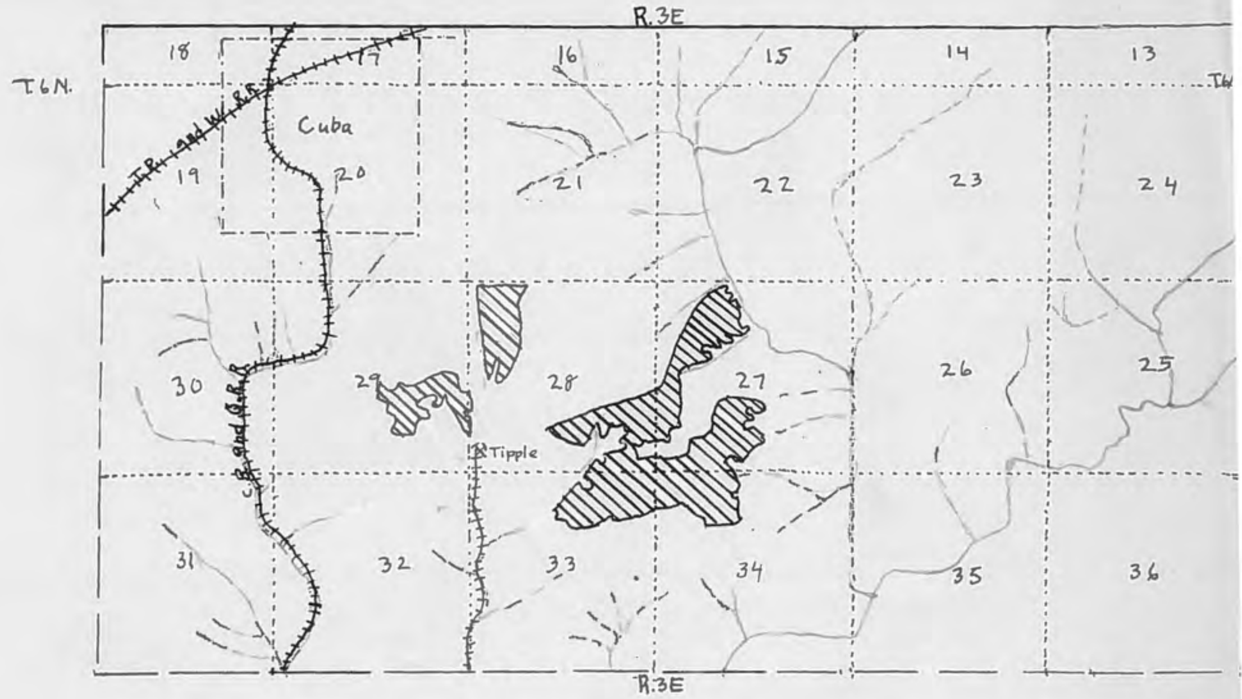


Fig. 116. Map of T. 6 N., R. 3 E. (Putman twp.) in the Havana quadrangle, showing the area from which the Springfield (No. 5) coal has been stripped in Mine No. 9 of the United Electric Coal Company southeast of Cuba. (Data from map furnished by the company, shows area mined to September, 1928)

Fig. __. Piles of strip mine debris in the SW. ¼ sec. 27, T. 6 N., R. 3 E. (Putman twp-). An area from which the coal has not been removed is seen in the middle distance. The strip piles behind this area were made during 1927, the year the picture was taken. The piles in the background to the right, and in the immediate foreground were made during 1925 and 1926 and have become partially covered with vegetation.

CHAPTER IV

STRUCTURAL GEOLOGY

General Statement.

Structural geology is the phase of geologic science that treats with the ~~of~~ ~~concerned with~~ determination of the attitude of rock strata ~~the determination, representation,~~ and the interpretation of ~~rock~~ structural features ~~which~~ as related to ~~results~~s ~~from~~ earth movements.

Rock structures may be determined in one of several ways by the field geologist. In regions of considerable folding, measurements of the amount and direction of maximum dip or slope of the rocks may be made at numerous points, and the structure determined from those data. If the rock beds have been disturbed only slightly, the structure is determined best by using surveying methods to obtain the location and elevation of outcrops of rock beds of known stratigraphic position. With these data, supplemented by observations of local dips, it is usually possible to determine the structural features with considerable accuracy. In many regions, such as the greater part of Illinois, however, outcrops are few, and the geologist must supplement data from them by use of records of wells, test borings and shafts. As the depth ~~of~~ to any bed recognizable in drill records subtracted from the altitude ~~elevation~~ of the ground of the bed at that point is the altitude of the bed, it is a relatively simple matter to make use of this type of data if the records are accurate, and distinctive beds are penetrated by the wells.

The geologic structure may be represented on maps by symbols showing the direction and amount of dip, or by contours showing the elevation of the key bed or key ~~beds~~ used.

The interpretation of structure maps is important, both in determining the nature and time relations of geologic processes active in the past, and in providing information for the development of mineral resources. From such maps it is possible to determine the depth to water bearing beds, the probable location and extent of coal beds, localities favorable for testing for oil and gas, and data on other mineral resources which may be present.

In the Havana quadrangle key horizons for structure mapping are the widespread coal beds of the Pennsylvanian, which outcrop in many places and have been penetrated in many coal test borings ~~at many places~~ where they are not exposed, and the contacts between strata of different lithologic character which have been penetrated in wells in this and adjacent areas.

~~### Pre-Pennsylvanian~~ Structures of pre-Pennsylvanian Rocks.

The Pennsylvanian strata, the oldest exposed in the Havana quadrangle, were deposited after the older rocks had been ~~######~~ elevated above sea level, folded and deeply eroded. The structure of the Pennsylvanian ~~rocks~~ is therefore different from that of the older rocks. In the Havana quadrangle there are 5 wells with available records ~~which~~ have penetrated these older strata to considerable depths, ~~of which records are available~~. To determine ~~For the study of~~ the structure of the pre-Pennsylvanian strata, these records have been studied along with 17 wells ~~those~~ in adjoining ~~##########~~ areas, ~~and~~ cross sections 1, 2, and 3 (Figs 118-120) and the structure contour maps shown in figs 121-127 have been prepared. The surfaces which are most easily recognized in drill records ~~in this area~~ are (1) the top of the St. Peter sandstone, (2) the top of the Galena dolomite, (3) the top of the Maquoketa shale, (4) the top of the Devonian (Wapsipinicon) limestone, ~~and~~ (5) the base ~~top~~ of the Burlington limestone ~~Hannibal shale~~, (6) and the top of the Keokuk limestone. All ~~of these surfaces~~ are surfaces of contact of limestones or dolomites with shales or sandstones.

~~General structure.~~

The general structure of all the pre-Pennsylvanian surfaces ~~studied~~ is dominated by a regional dip to the southeast~~, of 20 to 25 feet per mile~~. A syncline whose axis pitches to the southeast or east crosses the northern part of the Havana quadrangle. Some of the maps ~~#######~~ suggest an anticline with an axis pitching to the southeast north of the quadrangle, ~~#####~~ on the basis of variations in altitude in 5 closely spaced wells in the city of Canton.

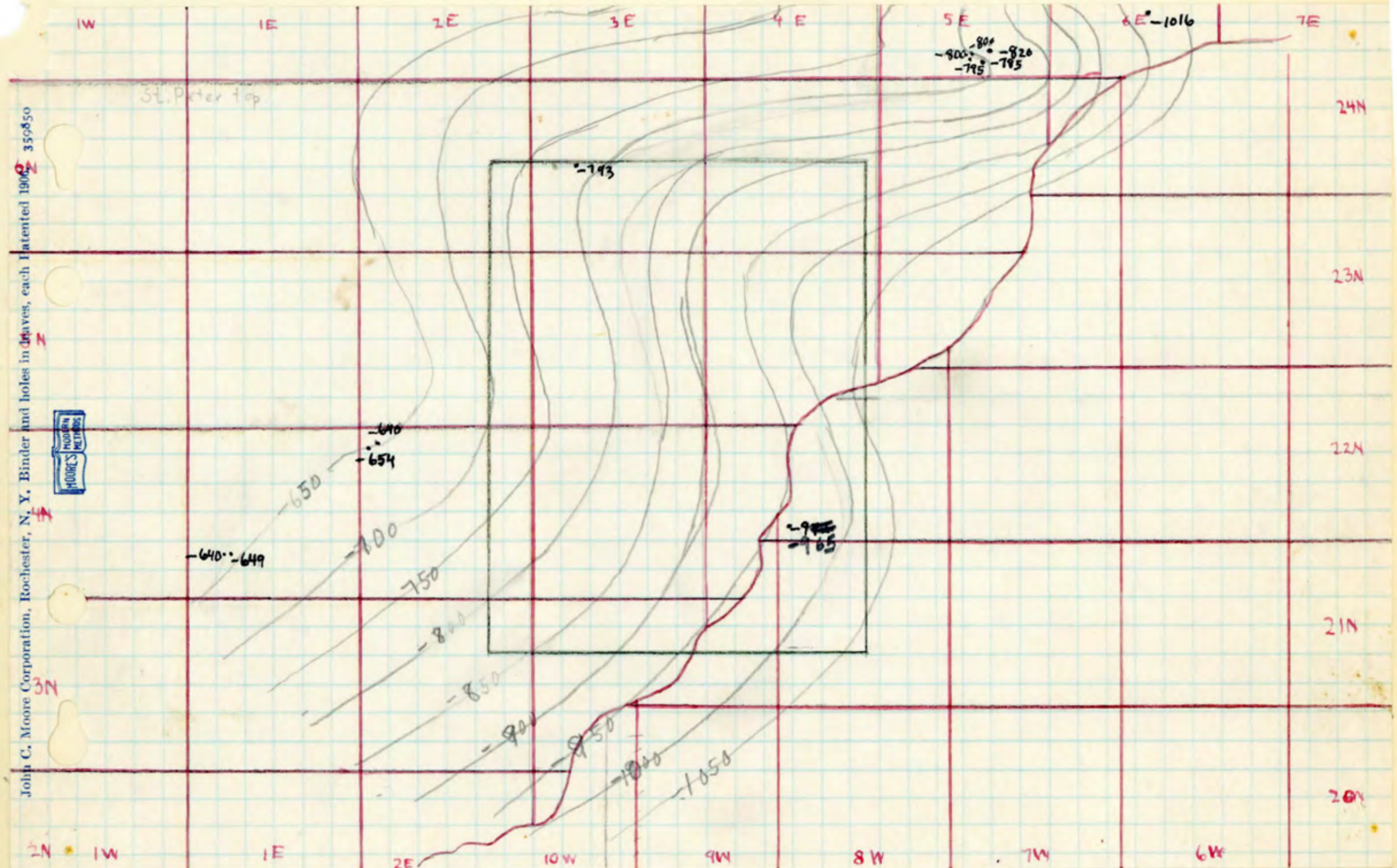


Fig. 12 . Structure contours on the top of the St. Peter sandstone (Ordovician) in the Havana quadrangle and vicinity, drawn from the records of 12 drill holes which have penetrated this horizon. Contour interval 50 feet

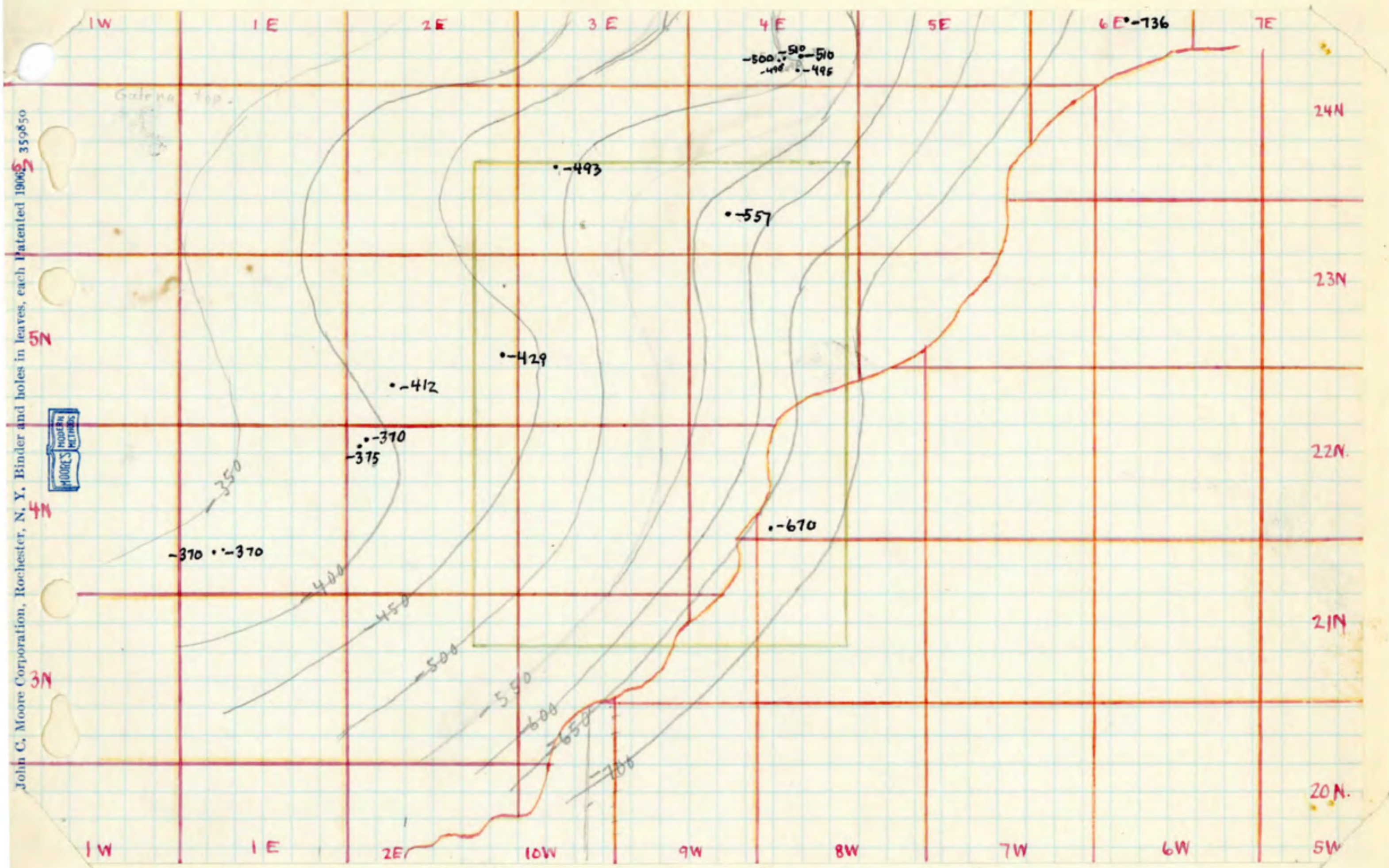


Fig. 122. Structure contours on the top of the Galena dolomite (Ordovician) in the Havana quadrangle and vicinity drawn from the records of 15 drill holes which have penetrated this horizon. Contour interval 50 feet.

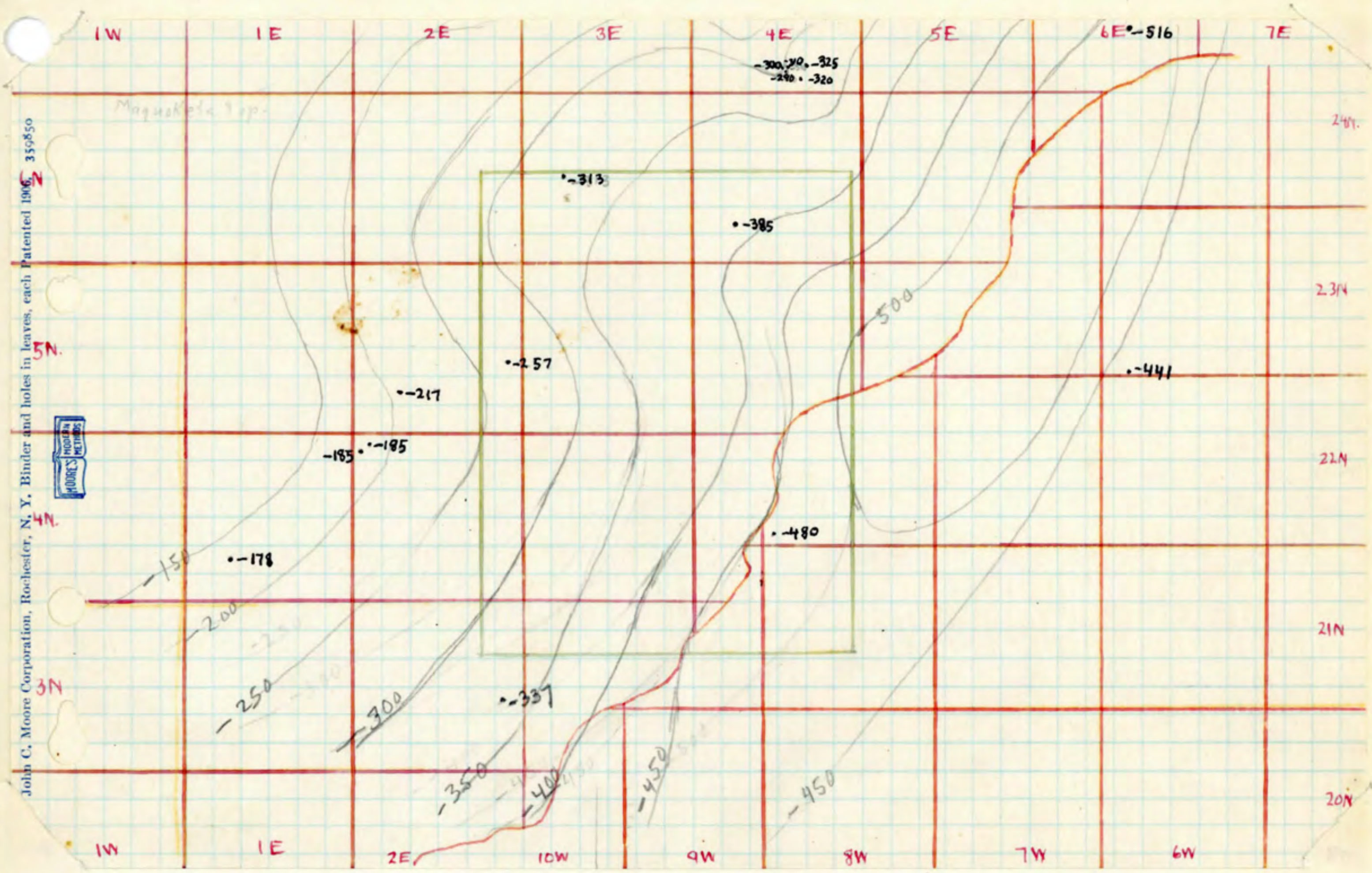


Fig. 123 . Structure contours on the top of the Maquoketa shale (Ordovician in the Havana quadrangle and vicinity drawn from the records of 15 drill holes which have penetrated this horizon. Contour interval 50 feet

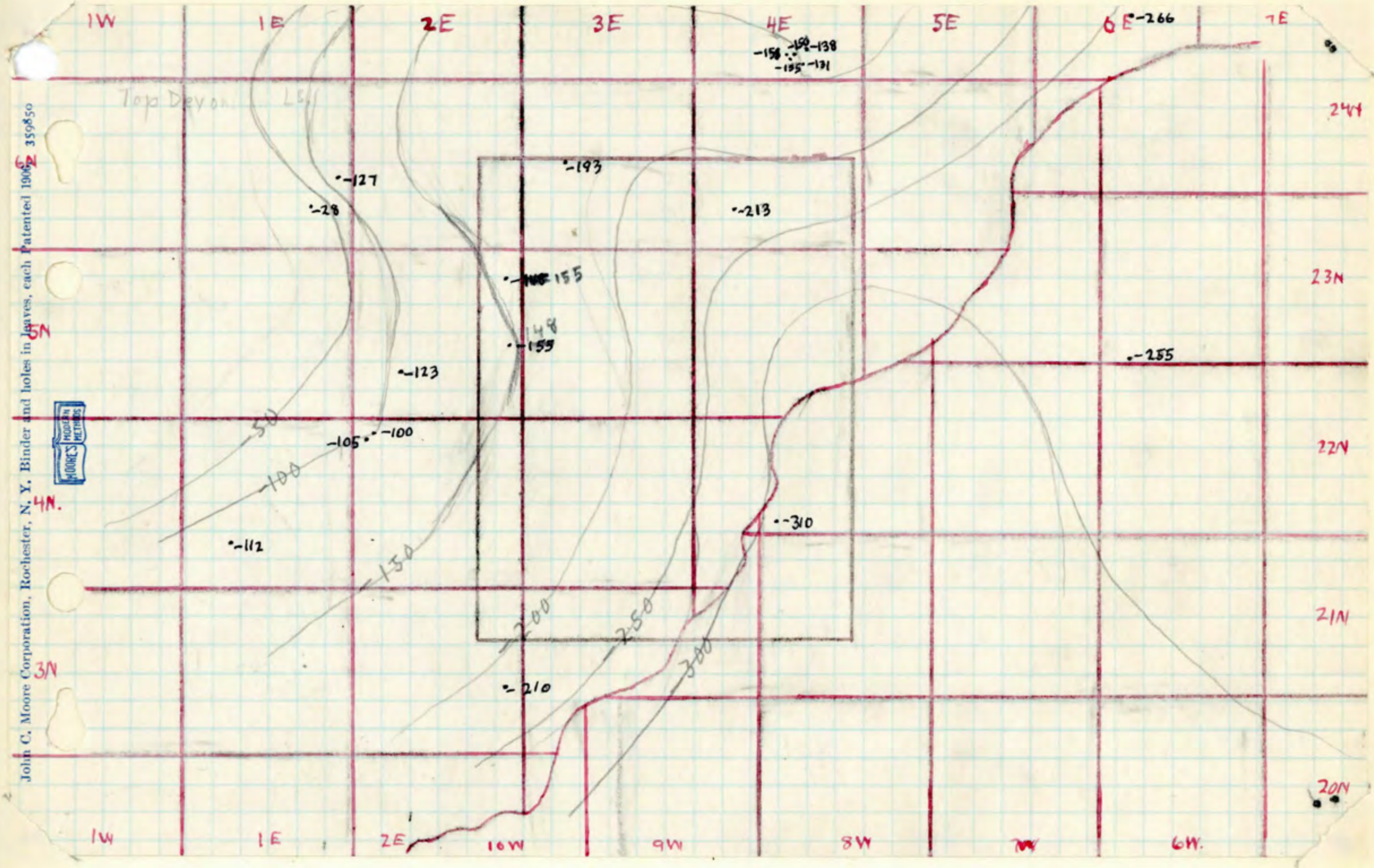


Fig. ~~130~~ 124 . Structure contours on the top of the Wapsipinicon limestone (Devonian) in the Havana quadrangle and vicinity drawn from the records of 19 drill holes which have penetrated this horizon. Contour interval 50 feet.

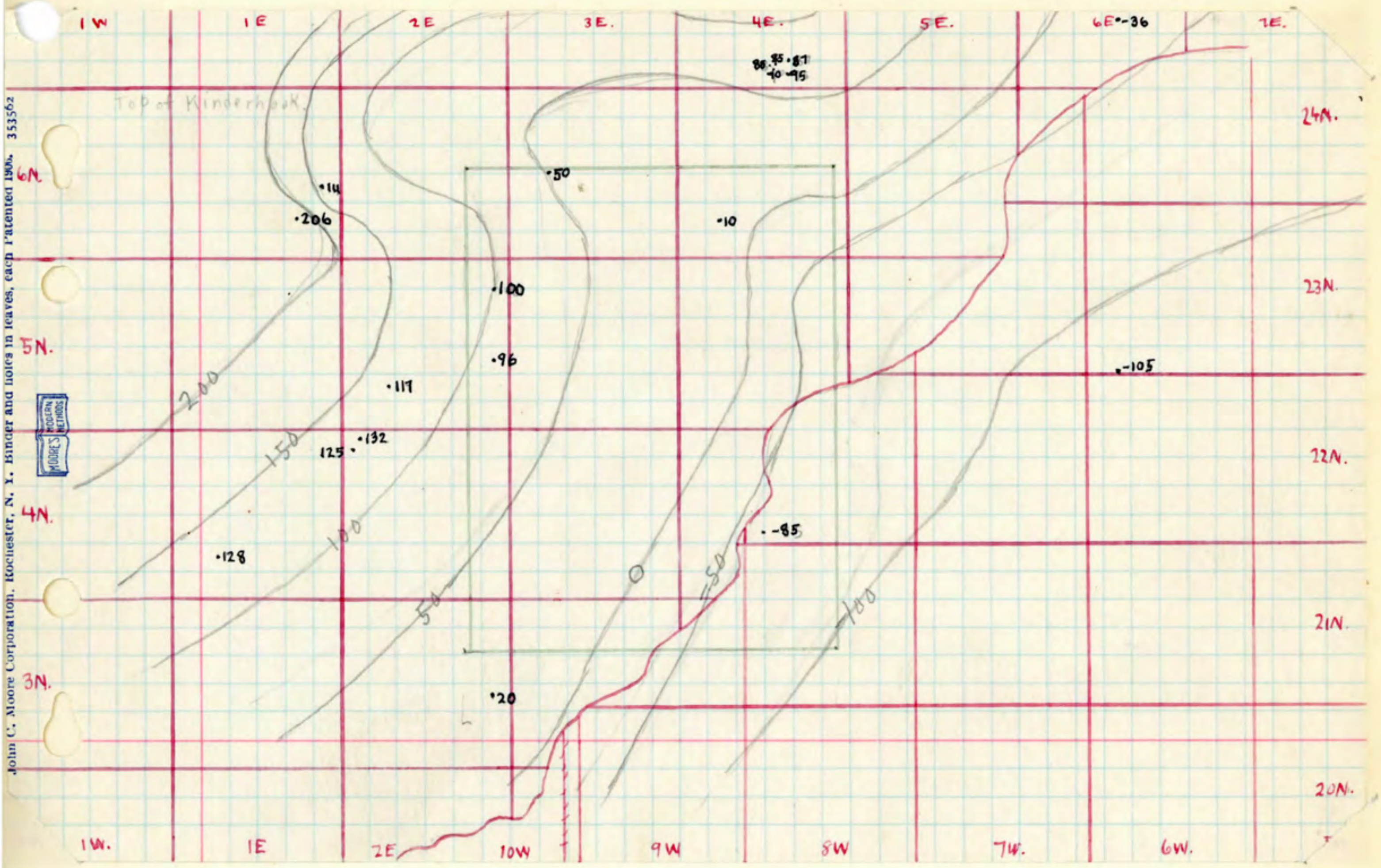


Fig. 25. Structure contours on the ~~###~~ base of the Burlington limestone (Mississippian) in the Havana quadrangle and vicinity drawn from the records of 19 drill holes which have penetrated this horizon. Contour interval 50 feet.

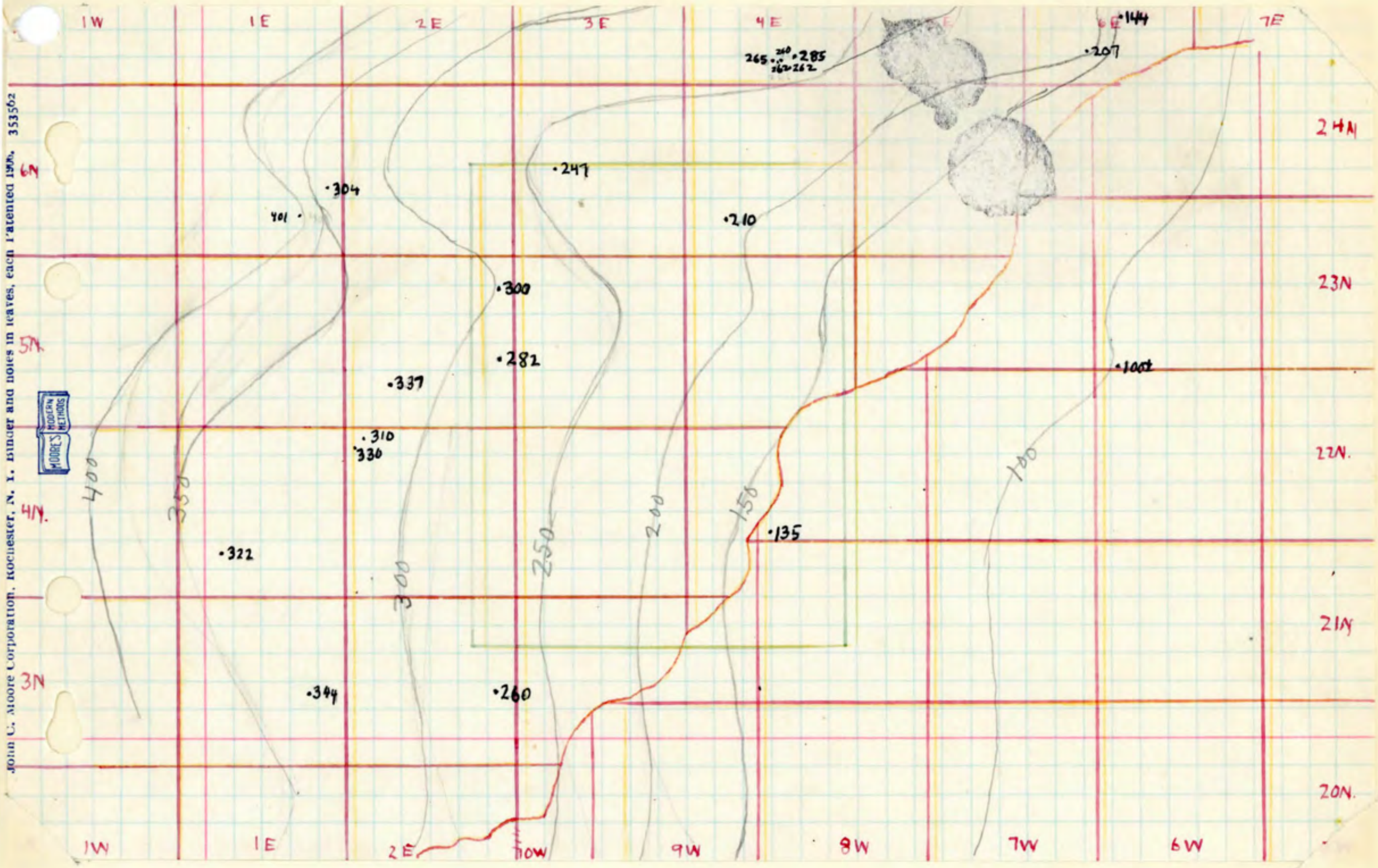


Fig. ~~122~~ 126 . Structure contours on the top of the Keokuk limestone (Mississippian) in the Havana quadrangle and vicinity drawn from the records of 21 drill holes which have penetrated this horizon. Contour interval 50 feet.

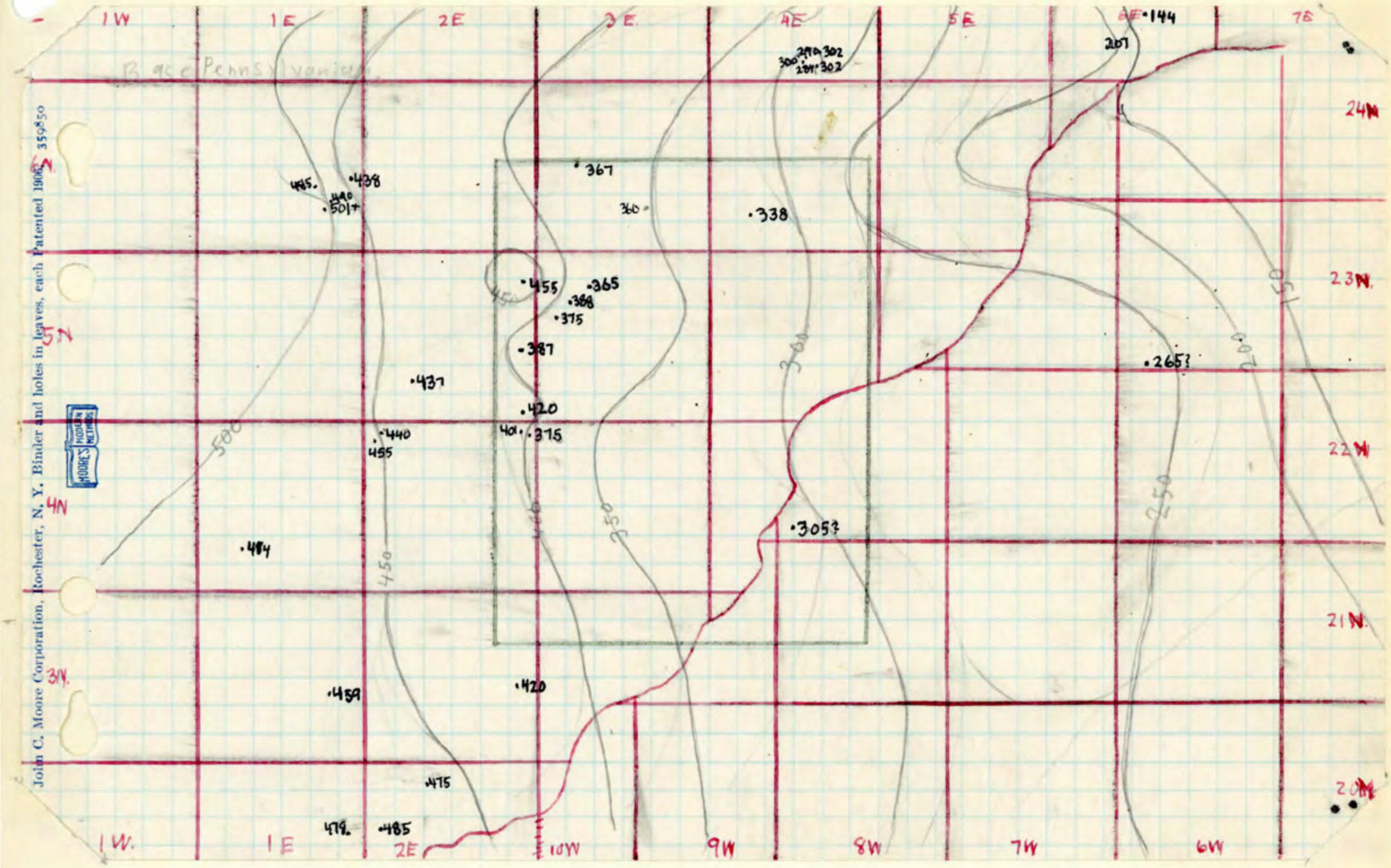


Fig. 123/21. Contour map of the base of the Pennsylvanian system in the Havana quadrangle and vicinity, drawn from the records of 26 drill holes and outcrops where the contact is exposed. which have penetrated this horizon. Contour interval 50 feet. Note that the surface contoured here is an erosional surface, as the Pennsylvanian strata rest on the St. Louis, Spergen, Warsaw and Keokuk formations of Mississippian age in various parts of the area. Note also that the position of the Pennsylvanian-Mississippian boundary is uncertain ~~###~~ in the two drill holes southeast of ~~the~~ Illinois River. If it is higher than ~~boundary~~ altitude given the strata designated as lower Pennsylvanian may be Mississippian strata younger than the St. Louis formation.

The small number of records of the older strata permits ~~the~~ drawing ~~of~~ only the more general features of structure. Minor ~~variations~~ structures ### within small ~~areas~~ are suggested by variations in ##### the altitudes of key strata in ~~the~~ 5 wells in Canton north of the quadrangle and ~~the~~ two in Ipava west of it.

Differences in the structure of the various are Pennsylvanian key beds is due principally to the regional variations in the intervals between two adjacent key horizons. The intervals between the top of the St. Peter sandstone and the top of the Galena dolomite and from the top of the Galena to the top of the Maquoketa vary less than 50 feet in the records studied, and the structures of these three surfaces are ~~thus~~ very similar. The interval between the top of the Maquoketa and the top of the Wapsipinicon limestone varies from 120, 89 and 66 feet in the westernmost ######## records on the three cross sections to 250, 176 and 175 in the easternmost records on these three sections. This interval thus decreases from east to west and,#somewhat less rapidly, from north to south. This variation in interval may be the result of (1) variation in original thickness of the deposits of Niagaran or Wapsipinicon time, ~~to~~ (2) erosion of the Niagaran strata before the deposition of the Wapsipinicon limestone, ~~or~~ ~~to~~ (3) erosion of the Wapsipinicon limestone before the deposition of the Sweetland Creek shale, or ~~to~~ a combination of these factors. The intervals between the top of the Wapsipinicon limestone and the base of the Burlington and between the base of the Burlington and the top of the Keokuk# limestone show variations of 50 feet or less in the area studied, and thus the structures of these three surfaces are nearly ######## the same. The interval between the top of the Keokuk limestone and the base of the Pottsville varies from zero in the northeastern part of the area to 170 feet or more in the southern part ~~of the area.~~ This variation is the result of pre-Pennsylvanian erosion which removed all or parts of the St. Louis, Spergen and Warsaw formations from the northern portion of the area.

As the thickness of the Silurian-Devonian limestones increases to the east, the regional southeast~~ward~~ dip of the surfaces above these limestones is less than the dip of lower surfaces. The change in dip is from about 20 feet to about 12 feet per mile. Because of the irregularity of the Pennsylvanian basal surface the eastward trending syncline is less marked on the map of this surface than on any of the older surfaces.

Structure of Pennsylvanian rocks.

The Pennsylvanian strata exposed in the Havana quadrangle have ~~in most places~~ dips too low to be measured with a clinometer except ~~.~~ locally ~~high dips are seen ###### and the rocks~~ where they are buckled into small folds (fig. 31). These folds may be caused by a differential shrinkage of these beds during compacting after their deposition, ~~but many of them are due~~ or to deformation of the beds by overriding glacial ice. Certain sandstone layers commonly have dips as high as 10^{o}-15^{o}, ~~but~~ These inclinations are not due to deformation, but are original, and ~~they~~ represent the angle of slope of the surface upon which the sand was deposited. The sandstone possessing such high dips is said to be crossbedded. These sandstones afford no information upon the structures of the Pennsylvanian strata. Coal beds are ~~most~~ satisfactory for a structure map of Pennsylvanian ~~strata~~, as they are most commonly reported in the records of drillings and the map indicates the approximate depth to the coal in all parts of the area. The Colchester (No. 2) and Springfield (No. 5) coals were used as key horizons for structure contours in this quadrangle.

Structure of the Colchester (No. 2) coal.
(Plate II) or fig. 128

The data upon which this map is based consist of 65 outcrops of the coal which were accurately levelled by plane table and telescopic alidade traverse, 1/ 3 coal shafts in which the depth to the coal is known,

1/ These levels, and those to other key horizons were determined by Mr. H. C. Spoor, Jr.

and 15 coal test borings in which the altitude of the coal was determined. The altitude of the ~~Ray (Pottsville)~~ Seahorne limestone was determined in 5 localities where the Colchester coal had been ~~removed by~~ eroded and the altitude of the coal was estimated at 20 feet above this limestone, the normal interval in this region. In the northern part of the quadrangle where the Colchester (No. 2) coal is below drainage, the altitude of the gray septarian limestone (member ~~64~~ 42 of the general section) was determined at 30 localities. This limestone is 35 to 50 feet above the coal in the western part of the quadrangle and 5 to 20 feet above it in the northeastern part. The altitude of the coal as estimated at these localities. These 118 datum points cover most of the quadrangle ~~which is~~ underlain by this coal except the valley of Buckheart Creek. In this creek ### valley the structure of the Springfield (no. 5) coal is very irregular and it is probable that the Colchester (no. 2) coal is more extensively deformed than elsewhere. The altitudes of the coal range from 546 feet above sea level in sec. 1, T. 5 N., R. 2 E. (Bernadotte twp.) to 449 feet (##### estimated from gray septarian limestone) in sec. 11, T. 5 N., R. 4 E. (Liverpool twp.). The interval between the Colchester and Springfield coals ranges from 99 to 124 feet in 6 test borings which passed through both coals. If the interval is as much as 100 feet along Buckheart Creek the altitude of the Colchester coal is probably 390 to 395 feet in parts of secs. 25 and 36, T. 6 N., R. 4 E. (Buckheart twp.) and 385 feet in part of sec. 12, T. 5 N., R. 4 E. (Liverpool twp.). These low altitudes have been assumed in the contouring. The regional dip is toward the east and southeast, but there are several reversals of dip. There seems to be a shallow syncline whose axis pitches to the east-southeast ## ##### along Slug Run east of Cuba to Bryant ### and Maples Mill. A low anticline or dome is southwest of Lewistown and another southeast of Duncan Mills. A dip of 1° amounts to 92 feet per mile. This is a higher dip than that of the Colchester coal in the Havana quadrangle at any point, unless its dip is this much near ~~the structural low places along~~ in this coal Buckheart Creek. In mines the difference in altitude is ~~not~~ commonly ~~more~~ less than ~~5~~ 10 feet.

Structure of the Springfield (no. 5) coal.

Although the interval between the Colchester and Springfield coals ###### averages 100-125 feet, there are a few places where it is known to be much less than this. The causes for variation in the interval between the Springfield and Colchester coals are: (1) the variation in thickness of the Francis Creek shale from 50 feet to 0; (2) the unconformity at the base of the Pleasantview sandstone below which 80-100 feet of strata are locally cut out; and (3) the variation in thickness of the Pleasantview sandstone from 5 feet to 70 or 80 feet, due to (a) the irregularity of the surface upon which it was deposited, (b) and the partial filling of channels in which it was deposited (c) or an erosion interval after its formation, during which these channels were partially reexcavated. The existing parallelism between the coals ~~which exists~~ is remarkable considering these causes for a lack of parallelism.

The area underlain by the Springfield coal is much less extensive than that underlain by the Colchester coal, but because a greater number of test holes have been drilled to this coal its structure can be more accurately determined. The structure map (fig. ~~86~~ 129) is based on 46 outcrops of the coal, whose altitude was determined by instrument, 29 outcrops, whose altitudes were estimated from the topographic map, 272 coal test borings, whose altitudes had been instrumentally determined and 20 coal test borings whose altitudes were estimated from the topographic map. ~~In addition~~ The coal has been contoured on mine maps of the Big Creek Coal Company's Mine no. 2 at St. David and part of Mine no. 8 at Dunfermline with a contour interval of 2.5 feet, This shows the structure of the coal for these areas much more accurately than it could be drawn from the records of test borings and outcrops.

The altitude of the Springfield coal varies from 645 feet above sea level in the SW. ¼ sec. 16, T. 6 N., R. 3 E. (Putman twp.) to 486 feet in the SW. ¼ sec. 12, T. 5 N., R. 4 E. (Liverpool twp.), a difference of elevation of 159 feet, about the same as that of the Colchester coal.

The main structural features shown on the contour map of this surface are (1) a regional dip toward the southeast, (2) a syncline pitching toward the east in sections 25 and 36, T. 6 N., R. 4 E. (Buckheart twp) and (3) an anticline apparently pitching toward the east south of this syncline in sections 1 and 2, T. 5 N., R. 4 E. (Liverpool twp.). The coal dips from an altitude of 572 feet south of the center of sec. 35, T. 6 N., R. 4 E. to 495 feet just north of the center of section 36 of the same township, a distance of a little over 1 mile. In the greater part of the map the ~~########~~ ~~###############~~ surface of the coal consists largely of round or irregular shaped hills separated by irregular small depressions. The distribution of relief does not seem to correspond to any axes of folding, and it is probably older than the regional folding of the coal. The contour map of mine No. 2 of the Big Creek coal company (Fig. 130) shows the character of this surface better than the contour map of the quadrangle, because of the wide spaces intervening between altitude datum points in the latter. ~~rest of the quadrangle.~~ The surface suggests the knob and kettle surface topography of a glacial moraine or ~~###~~ an area of karst topography. The total relief shown in the map of mine no. 2 is 47.5 feet. The map of a part of Mine No. 4 of the Big Creek Coal Company (Fig. 131) shows a relief of 35 feet within the same quarter section (SE. ¼ sec. 27, T. 6 N., R. 4 E. (Buckheart twp).

In addition to the structural features of the Springfield coal shown on the contour maps ~~of its surface~~ there are ~~found~~ occasional faults, rolls, horsebacks, cut outs and clay veins.

The faults in the coal are commonly normal ~~faults~~ with a displacement of one foot or less. In many places the coal is separated at the fault line by clay which has been forced up from the underclay zone below. These clay veins are not found in all fault planes (see fig. ~~134~~ 132) and they are found in some places where the coal beds do not seem to have been faulted.

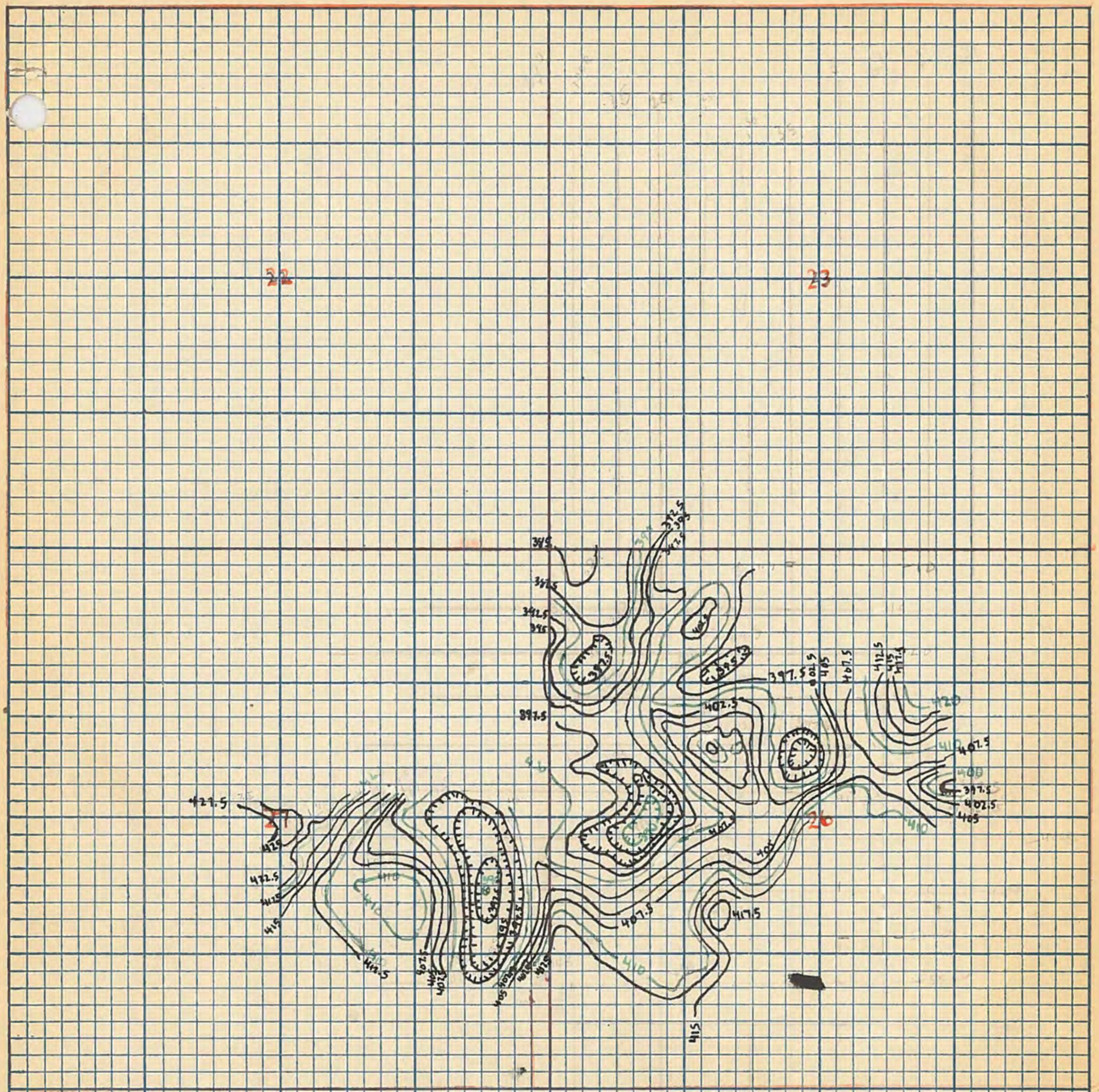


Fig. 61 Structure contour map of Springfield (No. 5) coal in southern part of Mine No. 4, Big Creek Coal Co., at Dunfermline, secs. 22, 23, 26 and 27, T. 6 N., R. 4 E. (Buckheart) Fulton County.

Scale 4 in. = 1 mile

Contour interval 2.5 feet. Company O datum = 145 ft. above sea level.

\# 376 8 x 8

Fig. 132. Exposure of the Springfield (No. 5) coal in the SE. $\frac{1}{4}$ sec. 13, T. 6N., R. 3 E. (Putman twp) showing a normal fault in the coal (along hammer) with a displacement of about 1 foot along the fault plane

Horsebacks are commonly associated with rolls in the roof and floor. The upthrow side of a fault in the floor is called a roll in the floor and the downthrow side of a fault in the roof is called a roll in the roof. The stringers of clay extending into the overlying coal above the horsebacks are called clay veins. Horsebacks and clay veins in the coal are shown in figs. 59 and 133 .

Cutouts are places where the coal ends abruptly on account of faulting, squeezing or erosion. In the Havana quadrangle all the known cut-outs are the result of erosion, although the name "fault" is sometimes applied to them by miners. Most of the cutouts are preglacial channels which have been obliterated by being filled with drift. The coal near St. David is cut out by such a preglacial channel which seems to cross the divide between Big Creek and Little Sister Creek. Several small cutouts of the coal in the SE. $\frac{1}{4}$ sec. 16 and the NE. $\frac{1}{4}$ sec. 21, T. 6 N., R. 3 E. (Putman twp.) are shown on mine maps of Mine No. 3 of the Big Creek Coal Company at Cuba.

Fig. 133 . Horseback (left) and clay vein (right) in the Springfield (No. 5) coal along a ravine in the SE. $\frac{1}{4}$ sec. 13, T. 6 N., R. 3 E. (Putman twp.)

(See also fig. 59)

Chapter V. Geologic History

Introduction

The geologic history of an area is recorded in the rock formations, the surficial deposits, and the existent topography of that area. The character of the rock formations, their attitude, and their relations reflect the conditions under which they were deposited and the alterations which they have subsequently undergone. From these data geologists are enabled to read the geologic history.

Through all ages continental land masses have been sources of oceanic sediments. Gravel, sand, silt, clay , and mineral matter in solution have been transported, worked over and assorted, and deposited beneath the seas, the coarser material being generally deposited near the shore and the finer farther out. After consolidation by compaction and cementation, gravel becomes conglomerate, sand becomes sandstone, silt becomes siltstone, clay becomes shale, and chemical precipitates and organic secretions of calcium carbonate become limestone, or dolomite if mixed with magnesium carbonate.

Cross-bedding, ripple and rill marks, channel fills, etc., record water movements, and together with sun-cracks, rain-drop impressions, and worm borings they record ~~th~~ shallow-water conditions. Widespread limestone formations indicate that the continents adjacent to the sea in which the limestone was deposited were low or distant; coarse clastic sediments indicate that the continents were high or near the sea.

Warped, folded, or faulted strata record earth movements. Erosion between two epochs of marine deposition is recorded by irregular contacts between the formations deposited during those epochs, by evidences of weathering in the upper part of the older formation, by residual detritus in the base of the upper formation, or by the occurrence in the younger formations of fossils of organisms more advanced in their evolution than those in the older formation. The history of life development may be traced by the changes in life forms as revealed by their fossils in successively younger generations.

The geologic history of Illinois is read partly from rock outcrops and partly from records of wells and borings and is supplemented by knowledge derived from similar data in adjacent regions. Similarly, the geologic history of the Havana quadrangle as interpreted from the local bedrock formations which are exposed or are penetrated by borings may be supplemented by facts gleaned from studies of adjacent areas, because processes which were operative within the quadrangle were generally also operative over considerable areas outside. The record of the earlier part of the Paleozoic era must be drawn largely from other nearby areas, where the rocks formed during these periods are exposed, as in the Havana quadrangle these rocks are known only as they are reported in the records of deep wells.

Pre-Paleozoic Eras

An involved series of sedimentary periods interspersed with epochs of diastrophism, vulcanism, and igneous intrusion and separated by erosional epochs is recorded in the pre-Cambrian rocks where they are exposed. A similar series of events presumably occurred in Illinois during those eras. A long period of erosion, during which the pre-Cambrian peneplain that is known to occur in Wisconsin was developed [1] immediately preceded

[1] Weidman, S., and Schultz, A. R., Water supplies of Wisconsin: Wisconsin Geol. and Nat. Hist. Survey Bull. 35, Pl. I, 1915.

Knappen, R. S., Geology and mineral resources of the Dixon quadrangle, Illinois State Geol. Survey Bull. 49, p. 34, 1926.

the Paleozoic era. The present southward tilt of this peneplain surface may be due partly to its original slope, but it is probably due largely to subsequent diastrophic movements.

Paleozoic Era

The Havana quadrangle lies within an area that is frequently designated as the Eastern Interior Basin. During the Paleozoic Era this basin was always a low-lying area and was frequently submerged by epi-continental seas. The alternate depression and elevation of the area relative to the level of the sea created alternate epochs of deposition and erosion, and the strand line changed radically many times and probably varied constantly in minor degree. The sediments deposited in the seas were derived from highland areas to the north in the vicinity of Lake Superior, from the Ozark highland area to the southwest, and sometimes from the Appalachian highland to the east. Some of the breaks in deposition reflecting changes in conditions are marked by discordant or unconformable strata, but others are marked only by a change of the fauna which is revealed by the fossils in the rocks.

Cambrian Period.

The upper Mississippi valley region remained above sea level and was undergoing erosion through the early and middle Cambrian epochs, as no formations of those series are known in this region. During the later Cambrian epoch the lowland surface was submerged and materials that now form the Croixan series were deposited. The fact that the series is thickest at the south and thins to the north suggests that the sea in which it was deposited advanced from the south, and the off-shore phases that occur to the south show that the open sea was in that direction. The variable character of the rocks in the series shows that conditions were neither stable nor precisely the same over large expanses, although the formational divisions of the series which can be recognized in regular succession over wide areas shows that generally the gross conditions were similar. So many factors, such as the rate of weathering and erosion on land, in turn due to climatic conditions, diastrophic movements, amount of rainfall, etc.; the depth, extent, temperature, and clarity of the sea; the relative position and configuration of the strand-line; and the number and size of streams, enter into the conditions affecting sedimentation that the alteration of no one condition or set of conditions can be definitely ascribed as the cause of the change in character of rocks. The earlier sediments ### deposited in this sea were principally sands, derived from the deeply weathered mantle rock of the old land. As the sea continued to encroach further upon the land finer sediments were deposited in Illinois, and after a time calcareous muds, derived partly from the secretions of marine organisms, predominated over clastic material. The Late Cambrian sea continued to cover Illinois and adjacent states for a very long time, as 1480 feet of sediments formed during this epoch have been penetrated at Dixon, ~~Illinois~~. 2/ The sediments

2/ Knappen, R. S. Geology and mineral resources of the Dixon quadrangle: Illinois State Geol. Survey Bull. 49, p. 38, 1926.

that were deposited constitute the Mt. Simon sandstone, the Eau Claire sandstone and shale, the Dresbach sandstone, the Franconia dolomite, sandstone and shale, the Mazomanie glauconitic sandstone, the Trempealeau sandy dolomite and dolomitic shale, and the Jordan sandstone.

In this region the Cambrian period was terminated by emergence of the land above sea-level, during which the Madison and Mendota formations that occur in Wisconsin were completely eroded, if they had been deposited, in Illinois, and the Jordan formation was so eroded that only an irregular thickness of it remains.

Ordovician period

Early Ordovician epoch

The Ordovician period was inaugurated by an invasion by the sea. The sea was clearer than during Late Cambrian time, for the sediments formed were largely limy muds which have been subsequently altered into the dolomites of the Prairie du Chien series. About the middle of this epoch some sands were carried into Illinois, probably from the north, and distributed widely, although not continuously, over the sea bottom, forming the "New Richmond" sandstones. It is not known whether or not such sands were deposited in the Havana quadrangle ~~or not~~. After this brief interruption, the deposition of limy muds was resumed and continued until the end of this epoch. The calcareous deposits were also subsequently altered to dolomites, forming the Shakopee formation. Ripple-marks, mud-cracks, and breccia in Shakopee dolomite exposed near Franklin Grove, Lee County, Illinois, indicate that it was deposited in shallow water and was frequently exposed on tidal flats.3/

3/ Knappen, R. S., Geology and mineral resources of the Dixon quadrangle; Illinois State Geol. Survey Bull. 49, pp. 82-85, 1926.

The Early Ordovician marine inundation was closed by an emergence of the whole region and a prolonged period of erosion. Valleys of considerable width and several hundred feet depth were locally developed,4/ and in some parts of northern Illinois all of the Prairie du Chien series was eroded during this erosion interval.5/

4/ Fisher, D. J. Geology and mineral resources of the Joliet quadrangle: Illinois State Geol. Survey Bull. 51, p. 20 and Pl. III, 1925.

5/ Thwaites, F. T., Stratigraphy and geologic structure of northern Illinois Illinois State Geol. Survey Rpt. Inv. No. 13, pp. 22-23, 1927.

Middle Ordovician epoch

Early in the middle Ordovician epoch the sea again advanced over the area, which had been sculptured into hills and valleys during the long period of emergence. The marine invasion came from the south. The sands which form the St. Peter sandstone were deposited in this sea. The excellent assortment of the sands, their purity and the rounded character of the grains have led many students of this sandstone to believe that it been long worked

 36

over by wind, as in the dunes of an arid land, or along wind swept beaches. The actual deposition of the sand must have taken place after the return of the sea, as there are found in it marine worm borings and some other marine fossils, and oscillation ripple marks, such as are formed in standing water. 6/ This sand filled the depressions in the old land surface and buried the hills as well. It is reported to be 298 feet thick in the well at Cuba, which is more than its average thickness in northern Illinois.

After the deposition of the St. Peter sand the land was again elevated above sea level, and there followed an erosion interval, during which some of the St. Peter sand was removed. This interval was probably of short duration, for the St. Peter sandstone is separated by the overlying formation by an erosional unconformity in some places, and at other places there seem to be transition beds, showing continuous deposition from the St. Peter to the Glenwood stages.

After a brief period of erosion, the sea again covered the area and sediments which now form the Glenwood, Platteville, Decorah and Galena formations were deposited. The sea at first was not very favorable for life, as fossils are nearly absent in the Glenwood shale. Sand from the St. Peter surface was worked over and mixed with clay and silt, which were newly imported into the area. Some unique environmental factor was present to cause the green color typical of the formation. After a time less clastic material was carried in, and marine life flourished in a clear warm sea, while the Platteville limy muds were being deposited.

6/ Dake. C. L., The problem of the St. Peter sandstone; Univ. of Missouri School of Mines and Metallurgy Bull., technical series, vol. 6, No. 1, 1921.

Lamar, J. E., Geology and economic resources of the St. Peter sandstone, of Illinois: Illinois State Geol. Survey Bull. 53, pp. 26-30, 1928.

In some parts of Illinois a thin layer of mud was spread over the sea floor after the Platteville stage, forming the Decorah shale. The water soon cleared, however, and 200 to 300 feet more of limy muds were accumulated in a clear sea inhabited by numerous gastropods, corals and sponges. ~~###~~ These muds have been altered to form the Galena formation. As the Platteville formation is thin-bedded and compact and the Galena formation is porous and thick-bedded, it is believed that the dolomitization of the Platteville limestone took place before its consolidation and that of the Galena dolomite may have taken place after consolidation[7]. The sea withdrew after the deposition of the

---

[7] Knappen, R. S., Geology and mineral resources of the Dixon quadrangle: Illinois State Geol. Survey Bull. 49, pp. 89-90, 1926.

Galena sediments, and erosion and weathering prevailed for a time.

Late Ordovician epoch#

During the Waynesville stage of the Late Ordovician or Richmond epoch, the sea again covered much of Illinois, including the Havana quadrangle. It advanced over this area from the south. The sea was muddy, and in it about 200 feet of sediment, mainly mud alternating with thin beds of limy mud and a little fine sand were deposited. This sediment now constitutes the Maquoketa formation. The sea supported a varied fauna, among which brachiopods and bryozoa were most conspicuous. The principal limy beds were deposited at about the middle of this epoch, but thin limy beds are also found rather commonly in other parts of the formation. After the deposition of these sediments the sea again withdrew from Illinois, and with this emergence the Ordovician period terminated.

Silurian Period

Alexandrian epoch

After an erosion interval of considerable duration, Illinois was largely submerged during the Early Silurian or Alexandrian epoch by seas

368

which advanced from the Gulf of Mexico.[8/] In some parts of western Illinois

8/ Savage, T. E., Silurian rocks of Illinois: Bull. Geol. Soc. America, vol. 37, pp. 513-534, 1926.

a "sand" was formed in the depressions of the erosional surface before the entire area was submerged. This is the Hoing sand of the Colmar-Plymouth oil field about 30 miles west of the Havana quadrangle. Sand has not been reported in this position in wells in the Havana quadrangle, so there is no positive evidence that it was submerged. It is possible (1) that Alexandrian strata occur in the quadrangle and have not been distinguished from overlying Niagaran strata, (2) that Alexandrian strata were deposited in the quadrangle, but were eroded during the interval between Alexandrian and Niagaran epochs, or (3) that the quadrangle remained a land area during the Alexandrian epoch. The erosional unconformity that occurs between the Alexandrian and the Niagaran series at some localities in the state shows that there was an erosional interval between the two epochs, although at other localities there is apparent only a disconformity in strata and a notable difference in fauna to mark the interval.

Niagaran epoch

The sea again covered Illinois during the middle Silurian or Niagaran epoch, the invasion coming this time from the north or the Hudson Bay region. The water must have been warm and clear, for the deposits formed in this sea were mostly limy muds. There is very little clastic material, and this is all mud or fine silt. Conditions were favorable for marine life, as indicated by the abundance of such types as corals, crinoids and long straight cephalopods (Orthoceras) in the rock. Before the consolidation of this limy mud dolomite seems to have replaced a considerable part of the calcite, as the rock is now generally a dolomite. The chert, which is widespread in the Niagaran dolomite was formed in part by precipitation from circulating ground-waters subsequent to the consolidation of the sediments, and in part by direct chemical precipitation from the sea-water at the time of the deposition.[9] The Niagaran marine invasion of Illinois was terminated by uplift, and the area remained a land during the Late Silurian epoch.

---

[9] Fisher, D. J., Geology and mineral resources of the Joliet quadrangle: Illinois State Geol. Survey Bull. 51, pp. 41 and 44, 1925.

Devonian Period

Although the southern part of Illinois was inundated during the Early Devonian epoch, the central and northern parts were land areas high enough to be undergoing some erosion during this epoch and also much of the middle Devonian. During the later part of the Middle Devonian (Hamilton stage) the seas spread further northward into Illinois, and during the Late Devonian epoch they submerged nearly all of western Illinois, including the Havana quadrangle. The record of this marine invasion in the Havana area is difficult to separate from that of the Niagaran epoch, as the sediments form two adjacent limestone formations, which are usually combined in well records. In many parts of western Illinois a "sand" horizon, usually consisting of reworked grains or crystals of dolomite from the weathered underlying Silurian dolomite, occurs at the base of the Devonian. Such a "sandstone" is reported in a deep well near Bryant, with only 16 feet of limestone above it. If this sandstone truly represents the base of the Devonian it indicates either that the Devonian seas covered this area for a much shorter time than they did the areas north and northwest of here, where 100 to 200 feet limestone were deposited, or that the deposits formed during this inundation were eroded during the next period of emergence. The Devonian sea which covered this area was probably clear and warm, as limy muds were the principal sediments formed, and where the rocks are exposed near Rock Island they are crowded with fossil corals, brachiopods and other marine forms.

The sediments formed in the Late Devonian sea constitute the Wapsipinicon and Cedar Valley limestones in Iowa and the Rock Island district of Illinois. The sediments in the Havana area probably represent only the earlier of these formations, the Wapsipinicon.

After this relatively brief marine incursion, the sea again drained away from the area, and erosion may have removed the greater part of the sediments formed during the preceding invasion. There is some question as to whether the deposition of the dark Sweetland Creek shale started in the later Devonian or the early Mississippian. Because it is separated from the Devonian limestone by a marked erosional unconformity, and not sharply separated from the overlying Hannibal shale (Mississippian), it is usually placed in the Mississippian system.

Mississippian period

Early Mississippian epoch.

Western Illinois was again invaded by the sea during the Early Mississippian epoch. This sea was probably so enclosed as to be nearly devoid of currents, and as a result of its stagnation the waters became fouled and bottom life ceased to exist. The dark carbonaceous muds containing numerous spores of Sporangites huronense (a lycopod plant of the fern group) which now form the Sweetland Creek shale accumulated in this sea. After 100 feet or more of these muds had accumulated the waters cleared, perhaps because of the opening of a strait connecting this sea with the ocean, causing currents to form and sweep the decaying organic matter from the sea floor. The sea floor continued to be muddy after the black muds had ceased to form, but some bottom living marine forms were able to live, as their remains are preserved in the gray or greenish gray Hannibal shale which was accumulated at this time. At the close of the Kinderhook stage the waters cleared, and the sea had submerged a greater part of the continent, so that muds were no longer washed into it.

The sediments formed during the Burlington were clear, and the deposits were principally calcareous ooze. The sea must have been very favorable for bottom living organisms, for some beds consist almost wholly of the segments of stems and plates of crinoids, and brachiopods are abundant and large. The alteration of the limestone after its consolidation has produced layers and irregular nodules of chert, in which many of the fossils exist only as molds and casts, the shells having been dissolved.

The climax of the early Mississippian marine invasion came during the deposition of the Burlington limestone, after which it gradually contracted, although it was still extensive during the later Osage when the sediment forming the Keokuk limestone was deposited. During the later part of this time muds began to be washed into the seas again, and limestones alternate with thin shales in the deposits of the later Keokuk. The Early Mississippian marine invasion came from the south. As the seas gradually contracted, beginning in the Keokuk stage and continuing into the earlier part of the Maramec stage, the strand line oscillated across this region. Thus muds alternated with sands and limy muds in the deposits formed during the Warsaw and Spergen stages. Some of these beds exhibit marked lateral variations in western Illinois and eastern Iowa, showing that these areas were close to the source of clastic sediments. The sea bottom still remained sufficiently clear for marine life to flourish in some abundance, although some beds contain very few fossil remains, indicating less favorable conditions for bottom life. During the St. Louis stage the sea was probably more extensive, as shale is less prevalent here than in the Warsaw and Spergen. The water was clear enough to allow the formation of coral reefs of the colonial coral Lithostrotion, which is widespread in the St. Louis. Some of the beds of the St. Louis are commonly brecciated, showing that the bottom where it accumulated was sufficiently agitated to break up the limestone when it was but partially consolidated.[10] The beds exhibiting this brecciated structur

---

[10] Van Tuyl, F. M. The Stratigraphy of the Mississippian formations of Iowa. Iowa Geol. Survey, Vol. 30, pp. 233-236, 1923.

probably underlie parts of the Havana quadrangle, as they outcrop in the Beardstown quadrangle, about 15 miles to the southwest.

The Mississippian sea probably continued to cover the area of the# Havana quadrangle during the later part of the Meramec stage when the St. Genevieve formation was deposited further south and west in the state, and it may have been inundated during ### part of the Later Mississippian or Chester epoch, but if so, the deposits formed during such inundations were entirely removed during the erosion interval which followed the# final withdrawal of the Mississippian sea. The later Mississippian epoch was probably marked in this region by the withdrawal of the sea, and the warping of the Mississippian and older rocks into a series of folds in Illinois and adjacent territory. The most notable fold in Illinois is the La Salle anticline, trending north-northwest and south-southeast across the state. The greatest amount of warping of this fold probably took place at this time. #### In western Illinois the greatest amount of uplift at this time was probably to the north, and a series of minor folds were also formed in this region. The more elevated surfaces of the land area formed by this folding after the withdrawal of the sea were most deeply eroded, so that the deposits of the Pennsylvanian period rest on rocks varying in age from later Mississippian to Middle ##### Ordovician in various parts of Illinois. In the northeastern part of the Havana region the surface rock exposed on this erosion surface was shale and limestone of the Warsaw and Spergen ###### formations, while further to the west and south the St. Louis limestone formed the surface.

Pennsylvanian period

Pottsville epoch

Although the sea continued to cover the southeastern part of the Appalachian region from the later Mississippian into the earliest Pennsylvanian, or early Pottsville, sedimentation was not renewed in Illinois until the middle Pottsville, and in west central Illinois probably not until early in the late Pottsville. Erosion thus continued here longer than it did further south, and the Mississippian strata were consequently more deeply ~~######~~ denuded. The cycle of erosion may have reached maturity or late maturity, but the surface was not reduced to ~~the character of~~ a low featureless plain. The higher elevations on this erosion surface were probably capped by the more resistant members of the Mississippian system and the valleys or lowlands were carved principally in the weaker beds. This erosional surface, as known from some drill records in the Havana quadrangle ranges from about 340 feet above sea level in the northeastern part to about 470 feet in the west central part (See fig. ~~118~~ 34). The few altitude records available show the highest elevations in a north-south belt along the western margin of the quadrangle, with rather abrupt slopes to the east, locally amounting to about 50 feet within half a mile. The St. Louis limestone occurs in the bed of Spoon River at Bernadotte at about 470 feet ~~feet~~, and outcrops southwest of Seville (both in the Vermont quadrangle) at an altitude of about 480 feet, and near Pleasantview in the Beardstown quadrangle at about 430 feet. It seems possible that a broad upland lay along the western edge of this area, and a wide valley or lowland lay to the east of this. Part of the difference in elevation of various parts of this surface may be due to deformation of the strata after Pennsylvanian time. The shales of the Spergen and Warsaw formations may be confused with those of the Pottsville in some well records, and the altitude of this erosion surface may not be correctly identified.

Pennsylvanian sedimentation started earlier in the lowlands ~~areas~~ of this erosion surface, and the thickness of Pottsville strata at any locality should indicate whether that point was in an upland or valley portion, ~~of this erosion surface.~~ The total thickness of the Pottsville strata in Schuyler County, about 20 miles southwest of this quadrangle is reported

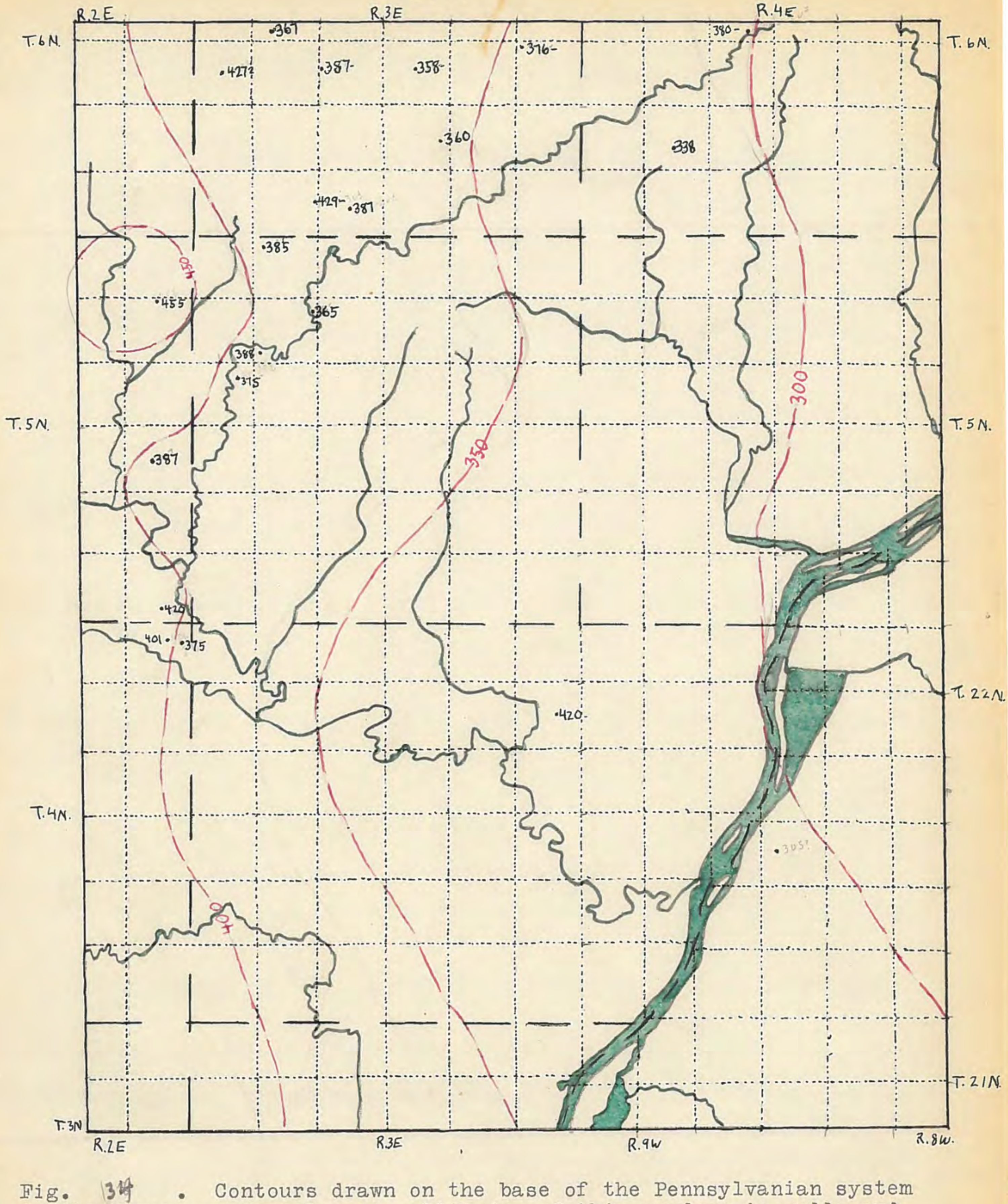


Fig. 34 . Contours drawn on the base of the Pennsylvanian system in the Havana quadrangle and altitudes of this surface in wells and coal and oil test borings.

 37

as 45 feet,10a while a coal test boring about three miles northeast of Cuba

10a Culver, H. E. Coal Resources of District III (Western Illinois), Illinois State Geol. Survey Coop. Mining Series Bull. 29, p. 106, 1925.

shows approximately 185 feet of Pottsville. The elevation of the Mississippian ###### surface in the Schuyler County area is about 475 feet, and north of Cuba about 305 feet, suggesting a close relation between thickness and altitude.

Conditions of formation of Pennsylvanian sediments.

The sediments formed during the Pennsylvanian period in this area differ from those formed earlier in the Paleozoic in that the# older sediments are almost wholly marine, whereas the Pennsylvanian contains many sediments formed in ~~other than~~ non marine environments. The Pennsylvanian sediments form ### much thinner units than those of the older systems, indicating either(1) that they represent the record of a diversified surface, upon which a record of river channel and flood plain, lake, marsh, and shallow sea sedimentation was being formed simultaneously, or (2) that they record a monotonously level surface which alternately rose above the sea and was depressed beneath it, so that the thin beds are persistent over a wide area. The latter hypothesis is in accordance with the distribution of the thin units in the Havana and adjacent quadrangles. ###### Only a small portion of the Pennsylvanian sediments contain marine fossils, and ~~many~~ some other members contain plant remains or other traces of terrestrial or fresh water material, suggesting that they were formed on land or in fresh waters. The principal types of sediments are clay shales, calcareous shales, carbonaceous shales, underclays, sandstones and sandy shales, limestones, coal beds, various types of concretions, and local and discontinuous conglomerates. Most of the calcareous shale, carbonaceous shale, clay shale and limestone contain evidence that they were deposited in marine waters, but some limestones and one clay shale may have been ## formed in fresh water. The coal and underclay were formed in fresh water or on land, and most or all of the sandstone, sandy shale and conglomerate ~~appear ### to~~ may be of fresh water origin.

The arrangement of the sediments in repeated cycles, and the interpre#tation of these cycles has been recently described.[11]

---

[11] Weller, J. M., Sedimentation cycles in the Pennsylvanian
Jour. Geol. Vol.

Marine fossils are absent from all sandstones and sandy shales except the slightly sandy beds at the top of the Franois Creek shale. Some of the sandstones contain casts of logs, stems, leaves and indistinguishable particles of carbonized plant material in such abundance as to indicate their local derivation. Many of the sandstones are micaceous, a characteristic which has been cited as evidence of non-marine origin.[12] The surfaces

---

[12] Lahee, F. H. Field Geology (2nd. ed.) Pp. 36, 95, 96. 1916.

---

upon which they rest are in many places erosion surfaces. Strongly marked cross bedding in many different directions suggests deposition in the shifting currents of streams. Most of these characteristics are more marked in the Pleasantview and Cuba sandstones than in those of Pottsville age.

The underclays of the coal beds do not contain any traces of marine organisms, and they were probably formed partly (1) by the weathering of the sandstone, shale or limestone which formed the surface rock during the periods when the area stood above the water level and partly (2) by the accumulation of the ash of vegetation which decayed during this period of emergence, as has been suggested by Stout.[13] Septarian limestone

---

[13] Stout, W. Coal formation clays of Ohio. Geol. Surv. of Ohio, 4th ser., Bull. 26, pp. 550-563, 1923.

---

concretions which are present in several of the underclays may be (1) weathered fresh water limestones # or (2) chemical or bacterial precipitates in the soil.

The coal beds were probably all accumulated in situ, with the possible exception of the Kerton Creek bed, which in some places does not rest on an underclay.

The carbonaceous shales were ~~accumulated~~ deposited in marine waters, in most cases just after the accumulation of vegetable matter had ceased. The seas in which these shales were deposited were probably shallow and there was no free circulation of water, but there was some bottom life, as marine fossils are found in some of the dark shales.

The limestones were nearly all marine, ## as most of them contain marine fossils. The seas in which they were deposited varied in depth and clearness of water. Some muds were drifted into the lime depositing seas, and grains of sand and silt were probably blown in by winds. During the accumulation of the Oak Grove marine member the sea bottom alternated several times between clear and muddy bottoms, forming the widespread alternation of thin limestone and shale bands.

The clay shales may have been formed in shallow seas or estuaries, which cleared at times long enough to permit the formation of thin limy layers or limestone concretion bands in which some marine shells are found. The estuaries must have been near enough to the shore lines at times to permit vegetation to float from the nearby shores and become preserved in the mud. The water level may have been lowered at times, so that parts of the estuaries or lagoons were exposed to the air, as mud cracks are seen in some of the beds of shale. Fossil remains are absent or uncommon in most of the clay shales, so the exact conditions which prevailed during their accumulation are difficult to determine.

The concretion layers are of several kinds, some of them formed #### while ##### the sediments ####were being deposited and others at some later time.

Some of the calcareous concretion layers may result from the fact that there was not enough calcareous material to form a stratum, when it was collecting on bottom, so it collected into spheres.[14]

---

[14] Twenhofel, W. H. Treatise on sedimentation, p. 507, 1926.

Pottsville sedimentation

The first Pottsville sediments formed in this area were probably deposited in the north central or northeastern part of the quadrangle. These oldest sediments, as reported in coal test borings consist of sandstone, underclay, gray and dark shale, thin coal beds, and locally thin limestones. As these layers are not exposed, it is impossible to determine whether the sea invaded this area earlier than the time of deposition of the Rock Island ~~or~~ (No. 1) coal. Part of western Illinois was covered by marine water in which limy mud was deposited before the formation of the Rock Island coal.[15]

---

[15] Wanless, H. R. Geology and mineral resources of the Alexis quadrangle: Illinois State Geol. Survey Bull. 57 , p. , 1930.

The basal Pennsylvanian bed in some drill records is reported as clay or shale, and in others as a hard sandstone. Some of the clay may be a residual soil formed on the Mississippian limestone, and not subsequently eroded. The thicker sandstone beds were probably deposited in channels excavated during short periods of emergence.

The ~~exposed~~ shale of the Babylon formation (the oldest exposed stratum in the quadrangle) may have been formed in a shallow marine area, although marine fossils were not found in it. After it was deposited, the area was elevated at least slightly, and the underclay of the Pope Creek formation was formed during this period of emergence. After the formation of the underclay the area was depressed slightly and swamp vegetation accumulated, forming the peat which was later changed to the coal of the Pope Creek formation. The marsh in which this coal accumulated was not as extensive ~~##########~~ as other marshes later in the Pennsylvanian, as the coal is not persistent throughout the area. Some oscillation of the water level during the deposition of this coal is indicated by a clay parting in some exposures. The sea may have invaded the region for a short time after the deposition of the marsh vegetation, but if so the marine sediments were eroded during the period of emergence which soon followed.

A considerable area in western Illinois was sufficiently elevated to be somewhat eroded after the deposition of the Pope Creek formation. In the Havana quadrangle all beds down to the coal of this formation were locally eroded, and the coal itself may have been thinned ~~###########~~ or cut out in some places. Upon this erosion surface sand was deposited in the valleys of streams. In some places in western Illinois this sandstone ~~##~~ contains numerous impressions of Stigmaria, ~~########~~ the roots of Lepidodendron trees. After a short period of exposure to processes of weathering and soil formation, during which a thin ~~########~~ underclay was locally formed, the level of the water table rose to such a height that vegetable material accumulated under standing water. ~~#################~~ The vegetation which accumulated has since been changed to form the Rock Island ~~or~~ (No. 1) coal. The marshes in which this vegetation accumulated appear to have been restricted to ~~elongate~~ narrow belts several miles long, but rarely more than one mile wide, resembling in shape the valleys of rivers. Elsewhere some vegetation accumulated, but after compression it formed a much thinner bed of coal. Certain of the large marshes were situated in and near the Havana quadrangle, for the thicker coal is found (1) at Seville, a few miles west ~~of the quadrangle~~, and reported (2) a little over a mile north of Cuba, ~~as well as~~ (3) in the vicinity of St. David, (4) under the Illinois River alluvium near Sepo, and (5) in a few places in the southern part of the quadrangle. The data available do not permit the mapping of this marsh area. The water level ~~in this marsh~~ changed several times, as the coal is now separated into benches by partings of clay in some places. The clay may represent the ash of vegetation which was oxidized during stages of low water level, or it may be clastic material carried into the area by wind or water during temporary stages of unusually high water ~~level~~. This swamp forest was killed by the rise of sea level, which caused the water to become first brackish, and later truly marine. The sea appears to have invaded the area along the lines previously marked by thick coal accumulation, perhaps older drowned valleys. Other parts of the region evidently stood high enough above the marsh so that they were not reached by the marine waters, or were reached only at the close of the inundation, as the marine shales and limestones above the Rock Island coal are restricted to about the same areas as those in which the coal is 4 feet or more thick. At first the mud imported by the invading sea was spread across the marsh and mixed with enough carbonaceous matter to give it a black color, but soon the water cleared and the deposition of limy mud was begun. This marine inundation lasted for a long enough time to ###### accumulate 20 to 30 feet of limy muds in the area north of Cuba. These ~~limy muds~~ have been consolidated into the member known as the Parks Creek limestone The sea was clear and warm enough to support a diverse fauna of bryozoa, crinoids, brachiopods, etc., which are abundant in this limestone at### its type locality, near Seville, a few miles west of the Havana quadrangle. The great variability in thickness and distribution of this limestone may be due to (1) the irregularity of the surface over which the sea advanced, and (2) its removal by erosion during the period of emergence after the deposition of the highest beds of the Seville formation . (See fig. 17). The deposition of limy mud may have been followed locally by the deposition of clay, but the land emerged soon after the cessation of limestone deposition. The direction from which this marine invasion reached the Havana area has not been determined, but it may have been from the west or northwest, as the limestone continues in that direction through Knox, Warren and Mercer counties. It is absent or thin in Schuyler County to the southwest, as this area seems to have remained a highland until a later time in the Pennsylvanian. The sea may have come around this highland to the east or to the west.

During the erosion interval which followed the deposition of the strata now forming the Seville formation, the older Pennsylvanian strata were cut ## to various depths in different areas. The marine strata of the Seville formation ~~above the Rock Island coal~~ were cut out entirely in places, the coal was cut out or thinned in others, and all the Pottsville strata formed up to this time may have been locally removed. 16/ In the southern part of the Havana quadrangle the erosion appear to have been rather uniformly checked at ### or near the top of the Rock Island coal. In the vicinity of Cuba some channels were apparently cut into the Parks Creek limestone (fig. 17, A2 and B8). After a rather prolonged tim of erosion sands were imported into this area, and accumulated in channels,

---

16/ Savage, T. E. Significant breaks and overlaps in the Pennsylvanian rocks of Illinois, Amer. Jour. Sci., vol. 14, pp. 310-311, 1927.

Wanless, H. R. Geology and mineral resources of the Alexis quadrangle, Illinois State Geol. Survey, Bull. 57 , pp. , 1930.

---

and later ~~was~~ distributed widely over the land surface. These sands now form# the Bernadotte sandstone, the basal member of the Bernadotte formation. This sandstone is rather evenly bedded, but no evidence of marine life has been found in it. The impressions of Stigmaria are, however, fairly common ~~in it~~. Some parts of the surface on which this sand was deposited were later depressed, forming a swamp in which vegetable matter accumulated. This swamp was not very extensive, nor did it persist for as long a# time, as the swamps in which the coals of the Pope Creek and Seville formations were accumulated. After the deposition of the Bernadotte sands much silica was precipitated around the grains of sand, as most of them show secondary crystalline growth, and the rock in some exposures has the texture of a quartzite. The conditions under which this crystalline growth took place are imperfectly understood, but some recent sedimentary quartzites have formed on rather dry sandy plains in which ground water is drawn to the surface by capillarity and evaporated, precipitating its dissolved silica around the grains of sand.[17] The crystalline growth may be related to ### a

[17] Bucher, W. Personal communication.

period of weathering after the deposition of the sand, and preceding the inundation by swamp waters. No marine sediments deposited immediately after the coal of the Bernadotte formation have been found in the Havana quadrangle, so there may or may not have been #### an inundation at this time. In some areas near the Havana quadrangle, and perhaps in it, evenly bedded gray muds were deposited at this time in fresh ##### or marine waters.

The conditions which prevailed during the deposition of the "Brush Creek" formation in the Havana area are rather difficult to determine. The area may have been elevated above the level of ground water shortly after the deposition of the coal of the Bernadotte formation. Sands, silts and muds were imported by streams, or in some other manner. In adjacent areas there appear to have been three or more periods of weathering of greater or less duration resulting in the formation of as many zones of underclay. Each of these periods of weathering in adjacent areas was followed by subsidence of the land of short duration, ## resulting in the accumulation of three or four thin beds of coal. The water level probably oscillated during this time in the Havana quadrangle, but only one of the thin coal beds has ~~have not~~ been found. Sandy material appears to be more abundant in this formation in the northern part of the quadrangle than in the southern part. This may indicate either (1) that the area in that direction was more elevated and the sediment was derived ### by erosion from land# in that direction, or # (2) that the channel of a river crossed this region from east or west, and most of the ######### coarser clastic material was deposited near the channel of the river. After the deposition of the last sediments of the "Brush Creek" formation the area probably rose to a

~~slight~~ ne
#######

sl
slight elevation above the ground water table, so that it suffered weathering, but little erosion.

After this brief period of emergence sand was deposited. # This sand, which is the basal member of the Seahorne formation, may have reached a slightly greater thickness in shallow channels excavated during the short period of emergence preceding than elsewhere. The sand is thicker and more continuous in the southern part of the quadrangle than in the northern part, where it is replaced in some exposures by sandy shale, so a channel in which this sand was transported may have crossed the southern part of the quadrangle. The surface upon which it was deposited may have been exposed under conditions favorable for the secondary growth of quartz crystals, but if so, these conditions prevailed for a shorter time than when the secondarily enlarged grains in the Bernadotte sandstone were formed, for a smaller proportion of the grains show this characteristic. After the deposition of sand had ceased the area ### may have received finer sediments for a time, and freshwater ponds may have existed on some parts of the surface. Local lenticular masses of unfossiliferous limestone may have been deposited in such ponds. Then the area again rose above the water table, and weathering ~~and soil formation~~ led to the ~~formation~~ production of the underclay of the Seahorne formation. The area may have passed through the state of a marsh after the underclay had been nearly formed, and a very small amount of vegetation may have been deposited in this marsh locally, forming thin lenses or streaks of coal. After a time the submergence continued, and the waters of the sea again entered the area. The land had been subjected to weathering for such a long time that the area had become a very level plain, and the marine waters were relatively free from clastic material. Marine life flourished in the waters of this sea, and a fine light colored limy mud accumulated. This has been subsequently consolidated to form the Seahorne limestone. Bottom conditions were especially favorable fpr gastropods, which are more conspicuous elements of this fauna than of other Pennsylvanian faunas of this region. The sea probably advanced from the southwest across the area, as the limestone extends across Schuyler County ~~to point~~s to the west and southwest ~~of it~~. The residual highlands of pre-Pennsylvanian time which seem to have affected the distribution of the earlier Pottsville sediments in that area were apparently destroyed by this time. The Seahorne limestone does not appear to extend further to the north or the northeast than the middle of the Havana quadrangle. This may signify either that the Havana quadrangle is situated at the margin of the sea in which this limestone was deposited, or that the land was elevated to a greater height north of this area and the limestone was eroded or weathered during the next period of emergence. Before the limestone had become completely consolidated, it was somewhat broken, either by waves or by desiccation, producing a brecciated structure, which has also been reported in Schuyler County.[19] After the deposition of the Seahorne limestone, the sea withdrew.

[19] Culver, H. E., Coal resources of District III, Illinois State Geol. Survey Coop. Mining Series, Bull. 29, p. 106, 1925.

During the ensuing period of emergence the limestone was weathered and eroded. This is evidenced by (1) the characteristic uneven upper surface of the limestone, (2) the frequent changes in thickness from a few inches to two or more feet, and (3) the representation of the limestone in some exposures by scattered concretions with uneven nodular surfaces. During or following the period of weathering of the limestone underclay collected above it. The water level rose again, converting the region into an extensive marsh, which covered all of the Havana quadrangle, and much adjacent territory, especially to the west and northwest. The vegetation which accumulated in this marsh has been subsequently compacted and altered, to form the coal of the Wiley formation. There is no evidence that the sea flooded the area after the formation of this coal bed. It is probable that the water level was again lowered, so that weathering, but very little erosion ensued.

The formation of a soil or weathered zone initiated the next sedimentary cycle, during which the Greenbush formation was deposited. After a time the water level rose again, remaining for a brief period at such a level that marsh vegetation accumulated, then rising to admit the open waters of the sea. The featureless plain provided little clastic sediment, and limy muds were accumulated during the brief marine incursion of this cycle. The bottom of the sea appears to have been unfavorable for bottom life, as only one brachiopod, Ambocoelia planoconvexa was found in the limestone formed at this time. Marine fossils are known to occur in a limestone of the same age in a few localities outside the Havana quadrangle. The direction of marine invasion cannot be determined. The limestone continues in outcrops to the west and northwest of the Havana quadrangle, more than it does to the south and southwest. The shallow sea became more shallow and muddy, or the water may have become brackish or fresh, and the mud forming the shale of the Greenbush formation was deposited. Fern leaves in some of the upper beds of the shale suggest their formation in a lake or lagoon near low lying forest covered shores. The area was again elevated above water level after the deposition of this mud.

The elevation after the ~~formation~~ deposition of the shale of the Greenbush formation was more extensive than any since the beginning of the Pennsylvanian. It was followed by a relatively long period of erosion during which some channels several miles in width and ~~#######~~ 50 feet or more in depth were eroded. In areas south and southwest of the Havana quadrangle these channels extended to the base of the Pennsylvanian. The Havana quadrangle seems to have been situated largely between the main drainage lines of this erosion interval, and the older Pottsville strata here suffered very little erosion. Sands were imported to the region ~~by~~ thru the channels, and after these were approximately filled the sands were distributed over the surrounding territory. These sands have since been consolidated to form the Isabel sandstone member of the "Liverpool" formation. #### The reductio in relief of the area supplying the sands, or climatic change , finally brought to a close this period of sand deposition. Finer silts were deposite for a time and then deposition ceased, allowing the surface of the sandstone to become weathered, with the formation of soil, the underclay of the Colchester coal. This event closes the record of the Pottsville epoch.

Carbondale epoch.

After a long period of soil formation the water level rose ######### and converted all of the Havana quadrangle, as well as most of west central Illinois into a vast marsh. Forest vegetation flourished in this marsh, and the products of its decay now form the Colchester or No. 2 coal. The accumulation of this vegetation was not interrupted by elevation or subsiden as there are no bedded clay partings in the coal. The marsh appears to have persisted for about the same length of time in all parts of the area, but the waters which finally drowned it ##### were admitted to some parts earlier than to others. At first it was inundated by fresh water, perhaps a series of lakes or lagoons near the sea coast. The longer axis of one of the lakes passed westward from the vicinity of Lewistown to Bernadotte and Table Grove in the Vermont quadrangle and Colchester, McDonough County. ####### Along this line 40 to 50 feet of clay accumulated, while the thickness is less both to the north and south of this line. The lands were for a time so close that the delicate# branches of tree ferns were floated out and buried in the muds without being cut to pieces by waves. An enclosed or stagnant sea seems to have existed in part of western Illinois at about this time. This sea appears to have gradually spread until it invaded the area of the fresh water lakes. The sea ~~seems~~ first ~~to have~~ reached the region around St. David in the Havana quadrangle, and gradually spread southward and westward from there. The bottom life in this sea was restricted to a few types of mud loving brachiopods such as Lingula and Orbiculoidea. After a time the water of the sea cleared, first in the eastern part of the quadrangle, later spreading across to the western portion. The clearing of the water permitted the immigration of many other types of bottom living species. It was in this sea that the limestones and shales of the Oak Grove marine member were deposited. ~~The character of the sea bottom changed frequently, not only in the Havana quadrangle, but over the greater part of western Illinois, because this larger area records the same succession of environments as does the Havana quadrangle.~~ The ~~various~~ different types of sea bottom were suitable habitats for various assemblages of marine invertebrates, so each of these thin zones is marked by a typical, but distinct fauna. These oscillations in the sea were regional, rather than local, for ~~a similar~~ the same succession of thin beds, with typical faunas extends north, northwest, ~~###~~ west and southwest 60 to 80 miles beyond the quadrangle. South and southeast of Cuba one of the basal marine beds is a conglomerate of small subrounded of limestone pebbles like ~~those~~ that formed during the earlier stages of the inundation east and west of that district. This conglomerate, ~~combined~~ together with the absence of lower members of the marine sequence in that region, suggests either (1) that the area southeast of Cuba was the last to be inundated and that the conglomerate was a shore deposit formed during the overlap by the sea, or (2) that during one of the stages of lower sea level this area stood high enough to permit the erosion of the first limestone beds formed there. The general invasion of the region probably came from the southwest or west, although this cannot be determined with certainty. The oscillation of sea level continued for some time, but the stages of clear water suitable for the deposition of limy mud became less frequent and shorter in duration, as they are represented in the earlier stage by thick continuous layers of limestone, later by thinner continuous layers, and finally by scattered concretions. The ~~bottom~~ sea became less suited for bottom living animals as it became more muddy. The mud, which now forms the thick Purington shale, must have been supplied by the elevation of some land area in or near western Illinois. 40 or 50 feet of mud were deposited. The absence of this shale from the southern part of the quadrangle is interpreted as the result of erosion rather than nondeposition, for the shale reappears in southern Schuyler ~~###~~ County and Brown County, beyond the area where it is ~~appears to bb~~ cut out. The cycle in which the "Liverpool" formation was deposited was terminated by a considerable elevation of the land.

Erosion started at once upon this exposed land surface and a system of valleys was formed. These valleys were ~~appear to have been~~ cut to a depth of 80 to 100 feet into the underlying strata. The approximate distribution of valleys and uplands in this erosion surface is shown in fig. 47. The principal features of this drainage are (1) a valley or lowland about 2 miles wide trending ~~about~~ S. 10° E. from the northern margin of the quadrangle, ~~about~~ one half mile east of Cuba to the bluffs of Illinois River, where the eastern margin of this lowland intersects the bluffs about 1/4 mile southeast of the Mt. Pleasant School in sec. 29, T. 5 N., R. 4 E. (Liverpool twp.). The valley mentioned seems to unite with a larger valley, the northern margin of which is ~~situated~~ in the central part of the Havana quadrangle, and the southern margin about 15 miles south of the quadrangle. The course of this lowland across the southeastern part of the Havana quadrangle cannot be ~~##~~ determined, since all Carbondale strata have been eroded from that area. In much ~~a considerable part~~ of the valley area in the southern part of the Havana quadrangle, and ~~in~~ adjacent localities in the Vermont and Beardstown quadrangles all of the strata down to the Colchester (No. 2) coal were removed. After the cessation of erosion sands were imported into the valleys. The sands, which now form the Pleasantview sandstone, were derived from outside this region, because the strata eroded were principally shales and limestones. In some parts of the "channel" area pebbles of impure limestone several inches in diameter, and logs of Lepidodendron, Cordaites, Calamites, etc. were deposited abundantly, locally forming a basal conglomerate. These materials were locally derived. As they are much larger than the matrix in which they are embedded, they were probably floated by blocks of river ice, or more likely ### floating trees or rafts of vegetation, such as are now carried in the larger rivers during their flood stages. The more delicate branches and leaves of plants were not preserved in this sand during the earlier stages of ## channel filling. Deposition of sand continued in the channels and lowland areas until they had been nearly or entirely filled and then for a short time fine sands, silts and clays were spread over the whole region. The waters were now less agitated by waves and currents, and the fronds of ferns ~~were~~ preserved in the finer sediments, which perhaps collected in lakes or slackwater areas near the borders of the flood plain. During the aggradation of the valleys, local channels were cut ~~frequently~~ into the sands already deposited. The main lowlands appear to have been entirely aggraded and for a short time the finer sands and silts were distributed over the interstream areas. The sediment became gradually finer until silt and clay replaced sand. Then an extensive fresh water lake ~~seems to have~~ extended over a large part of the area. A nodular fresh water limestone bed was formed in ~~this~~ the lake. The area then emerged above the water table and weathering led to the formation of another underclay. This period of weathering was marked by some erosion, as ~~some~~ channels were excavated into the Pleasantview sandstone through the fresh water limestone and sandy shale. The ##### area was then submerged and locally fresh water marshes ~~were~~ formed, permitting the accumulation of plant debris. This plant debris now forms the Kerton Creek coal. It rests on an underclay in some places, but is unconformable on ### sandy beds of the Pleasantview sandstone elsewhere, #### as in the Beardstown quadrangle,[19] and in sec. 20, T.

[19] Searight, W. Geology and mineral resources of the Beardstown quadrangle. Illinois State Geol. Survey, Unpublished manuscript.

5 N., R. 4 E. (Liverpool twp.) The coal bed is much thicker in certain linear areas which seem to have been lowlands or valleys, into which the vegetation may have been washed, than elsewhere. It is there interrupted by several clay partings. Conditions suitable for the accumulation of vegetation prevailed for a shorter time in the uplands away from stream channels. The swamp was terminated by a brief marine inundation, during which carbonaceous and calcareous muds were deposited. The circulation of the sea water was probably limited, and the bottom was inhabited only by a few mud loving types of marine animals, such as small goniatites, brachiopods such as Lingula and Orbiculoidea, and certain pelecypods. Marine fish were also present, as their spines are occasionally preserved in the calcareous concretions representing this inundation. The sea probably invaded from the south for in Schuyler County and southward toward St. Louis a relatively pure fossiliferous limestone, the Hanover ~~limestone~~ occurs in this position. A few scattered nodules of light gray fossiliferous limestone in one outcrop east of Cuba suggests that a feather edge of this limestone may have reached the Havana region, or it may at one time have covered all of the area, to be weathered away before the deposition of the overlying strata. This marine invasion ## was closed by the deposition of a little clay, perhaps in brackish or fresh water, and another period of emergence.

There is no good evidence of erosion during the emergence after the deposition of the Summum formation. A slight subsidence soon permitted lakes to form in the lower parts of the region. Calcareous ########## muds were deposited in these lakes north of the# Havana quadrangle, forming two or three beds of fresh water limestone. The limestone forms only scattered concretions in the clay in the Havana area, either because it never covered all of this region, or bedause it was reduced by weathering to these condretions. The water table was lowered again and the underclay below the Springfield (No. 5) coal was formed. The whole region was again

d

depressed, forming an extensive swamp in which vegetable debris accumulated. This swamp ### endured for a longer time than any previous swamp in the region during the Pennsylvanian, giving rise to a thicker bed of coal. The swamp condition was not interrupted by general emergence or submergence, for there are no partings in the coal. After a long time the submergence continued, finally admitting the waters of an enclosed sea to spread across the area. For a time mud was mixed with plant debris from the swamp and the shells of marine mud living animals, forming the dark marine shale above the Springfield coal. The circulating waters deposited much pyrite and marcasite in this shale, locally forming large concretions. Some logs, floating into the sea from a nearby land, became embedded in the sulphurous mud, where they are now mixed with the marine fossils and pyrite. After the deposition of the mud, it was greatly compacted and the fossil shells in it were flattened ~~out~~. Those parts of the mud which had become sufficiently consolidated before burial to form the pyritic and calcareous concretions, were not compacted, the fossil shells in them are uncrushed, and the layers of## shale bend around them. The mud imported into the sea was less and less mixed with carbonaceous material, and so it changes from black to gray ######## $1\frac{1}{2}$ to 2 feet above the coal. The continued deepening of the sea water or the reduction by erosion of nearby lands caused a clearing of the water, permitting the deposition of limy mud, which now forms the St. David limestone, and the repladement of the mud loving bottom fauna, by clearer water types, such as the brachiopods <u>Productus semireticulatus</u>, <u>Chonetes mesolobus euampygus</u>, crinoids and large nautilids. The direction from which this sea invaded cannot be determined, but the St. David limestone is #### 5 feet thick, near Pleasantview, Schuyler Co., near Cuba and Canton one or two feet, and near Peoria and Galesburg thinner and discontinuous. This suggests that clear water conditions prevailed southwest of the# Havana quadrangle longer than in it, and that the sea invaded from the southwest. Lowering of sea level, or the elevation of nearby lands caused an increase in the mud imported into the region.

The sea bottom became less suitable for marine bottom living forms, as fossils are usually absent in the Canton shale. The water cleared once long enough to permit the formation of a thin limy bed of band of limestone concretions, and marine life reached the area ~~sea~~ while this bed was being deposited. Soon more mud was imported and its deposition continued until about 20 feet had been laid down. The land was again raised, or sea level lowered, and erosion started ~~again~~, closing the cycle in which the St. David formation was deposited.

During the erosional interval after the deposition of the Canton shale, valleys were cut into the underlying strata. One of these valleys north of Cuba extended down to the black shale immediately above the Springfield coal. The course of this valley is not known. In the vicinity of Cuba it is about a mile west of the valley in which the Pleasantview sandstone was deposited. After erosion had ceased sand was imported into this valley, eventually filling and spreading fine sand over lands adjacent to the valley. This sand, which now forms the Cuba sandstone member, is usually freer from traces of vegetation than the Pleasantview sandstone, but no remains of marine invertebrates were found in it, so it is probably of fresh water origin. In one locality, just east of Cuba, in sec. 21, T. 6 N., R. 3 E. (Putman twp.) there is a record of a brief marine invasion just after the deposition of sand had ######### ceased. In this sea limy muds were deposited, and the sea was favorable for bottom living types such as large brachiopods, crinoids and foramenifera (Fusulinella). After the deposition of these limy muds the sea bottom became more muddy and 8 to 10 feet of clay (shale) was deposited. The direction from which this marine invasion came is unknown, as the record of it is found in but one locality. If this marine invasion was followed by emergence and erosion, the Cuba sandstone may have been eroded from some localities near Cuba ~~at this time~~. Such erosion might account for the diminished interval between the Springfield (No. 5) and Herrin (No. 6) coals in the vicinity of Cuba. A fresh water lake came into existence shortly after the deposition of the marine mud, in the vicinity of Cuba, permitting the accumulation of limy muds for a short time. The area was then elevated and weathering proceeded for a long enough time to permit the formation of the underclay of the Herrin (No. 6) coal. Then the area was depressed, and a widespread swamp covered it ~~nearly all of the area~~. A swamp forest supplied vegetable debris for a long time, but the swamp condition was interrupted for short periods of time by inundation or lowering of the water table, with the result that thin mud bands were interbedded with the layers of vegetable debris, which have since been consolidated to form the Herrin coal. The deposition of this coal brought the Carbondale epoch to a close.

McLeansboro epoch

The coal swamp was finally terminated by a marine inundation in which ~~###~~ carbonaceous mud was deposited for a short time. The sea soon cleared, and limy mud was deposited. Marine life flourished, and the bottom was especially favorable for foramenifera of the genus Fusulinella, which are very abundant in the Brereton limestone, formed during this inundation. The Havana quadrangle affords no record of Pennsylvanian sedimentation later than the Brereton limestone, as all later strata were removed by post-Pennsylvanian pre-Pleistocene erosion. The cyclic alternation of (1) emergence with erosion, (2) subsidence with sand deposition, (3) weathering with underclay formation, (4) swamp conditions and coal formation, and (5) marine invasion with limestone and shale deposition probably continued for some time, as the Glasford quadrangle, northeast of the Havana, contains the records of three such cycles later than that in which the Brereton limestone was deposited. These cycles, including (1) the no. 7 coal, (2) the Lonsdale limestone, and (3) the No. 8 coal, were probably originally distributed over the Havana region. The invasions of marine waters which reached the Glasford region probably crossed the Havana area, if they came from the southwest.

Post-Pennsylvanian, Pre-Pleistocene Interval

This interval includes the Permian period of the Paleozoic era, all of the Mesozoic era, and all of the Cenozoic era except the Pleistocene and Recent periods. Since the withdrawal of the sea in late Pennsylvanian times the Upper Mississippi Valley appears to have been a land area, subjected to continuous erosion and intermittent uplift so that at least two recognizable peneplains have developed. In southwestern Wisconsin and adjacent parts of Illinois, Iowa, and Minnesota (the district known as the "driftless area"), a high-level peneplain, called the Dodgeville peneplain,[20] possibly represents

[20] Trowbridge, A. C., The erosional history of the driftless area, Pt. II: Univ. of Iowa Studies in Natural History, vol. 9, No. 3, pp. 55-127, 1922.

erosion to the Cretaceous period. Following uplift, this peneplain was largely reduced to another peneplain at a lower level, known as the Lancaster peneplain,[21] so that by the Pliocene period the region stood in low relief

[21] Grant, U. S. and Burchard, E. F., U. S. Geol. Survey Geol. Atlas, Lancaster-Mineral Point folio (No. 145), p. 10, 1907.

with remnants of the Cretaceous peneplain rising above the general level. As the Havana quadrangle was glaciated three times, the topographic character of these old erosion surfaces was largely obscured, but polished and rounded pebbles of quartz and brown chert, commonly found in the drift, are similar to the gravels which collected on these peneplains, and were probably derived from them.

During the early part of the Cenozoic era the Mississippi River had a different course from that of the present time, as it turned eastward a few miles south of Clinton, Iowa, and with the preglacial Rock River entered the valley of Illinois River, near the "big bend" at Hennepin. It ~~followed~~ flowed along or near the present Illinois River valley to its mouth. This old course of the Mississippi is indicated (1) by the low altitude of its rock floor near Princeton, (2) by the extraordinary width of the middle and lower Illinois River valleys, and (3) by the position of the present drainage divide between ~~the~~ Illinois and Mississippi Rivers in western Illinois, which is much closer to the Mississippi than the Illinois. The western part of this preglacial Mississippi valley crosses the Havana quadrangle in the southeastern quarter and extends beyond the borders of the quadrangle so far that in central Mason County this lowland has a width of 18 miles (Fig. 123). This valley was also occupied by Mississippi River during the early Pleistocene, perhaps until the Illinoian glacial invasion.

A marked elevation of the land relative to sea level occurred at the close of the Pliocene Period. As a result streams were rejuvenated, and cut valleys into the Pliocene peneplain as much as 50 feet lower than the present main valleys. The Havana quadrangle was drained at this time, by a large river which closely paralleled the present valley of Spoon River, but was more extensive than the present river, and by other streams flowing directly into the ancestral Mississippi.

Cenozoic Era.

Pleistocene period

At ~~the~~ beginning of the Pleistocene period the temperature was lowered and climatic conditions favored the accumulation of continental glaciers. During the Pleistocene the Mississippi ~~valley was affected by five glacial invasions, which were separated from each other by long periods of mild~~

World-wide climatic changes at the close of the Pliocene period caused snow and ice to accumulate over large areas in the northern hemisphere. These accumulations began as continental ice caps in the higher latitudes but eventually increased in size and thickness and moved outward in all directions from the centers of accumulation. The continental glaciers which affected North America are known to have spread from three principal centers: (1) the Labradorean center, in the highlands of eastern Quebec and Labrador; (2) the Keewatin center, west and southwest of Hudson Bay;

(36)


MERCER
Toulon
STARK
MARSHALL
Galesburg
KNOX
Monmouth
WARREN
PEORIA
WOODFORD
Peoria
TAZEWELL
FULTON
Canton
McDONOUGH
Lewistown
Havana
MASON
LOGAN
SCHUYLER
Rushville
MENARD
BROWN
CASS
Virginia

Fig. 136

and (3) the Cordilleran center, in the Canadian Rocky Mountains (Fig. ~~115~~ 135). The northern Mississippi Valley was invaded five times by glaciers advancing from either or both the Keewatin and Labradorean centers, each invasion being followed by an epoch of milder climate during which the ice sheets melted away. (See table I, p. 1A, Ch. III).

Nebraskan ~~glacial~~ epoch

The first known glacial invasion of the Havana area occurred during the Nebraskan ~~glacial epoch~~, the first known glacial epoch of the Pleistocene. The record of this invasion in the Havana area is so limited that ~~####~~ it throws little light on the direction of glacial invasion, original distribution and thickness of the drift, and other problems. Nebraskan glacial deposits have been discovered near Winchester[22] and the pre-Illinoian drift

[22] Bell, A. H. and Leighton, M. M. Nebraskan, Kansan, and Illinoian tills near Winchester, Illinois. Bull. Geol. Soc. Amer. vol. 40, pp. 481-490, 1929.

~~OF SOUTHEA~~stern Illinois has tentatively been assigned to the Nebraskan glacial invasion[23] with the suggestion that the Nebraskan glacier came

[23] McClintock, P. Unpublished paper presented before Illinois State Academy of Science at Bloomington, May, 1928.

from the Labrador center of glaciation. As the Nebraskan glacier advanced over the area of Pliocene peneplanation, it removed much of the quartz and chert gravel from the surface of this peneplain, incorporating them in its deposits.

Aftonian ~~interglacial~~ epoch.

The first interglacial epoch, the Aftonian, is recorded in the Havana quadrangle in (1) the oxidation and leaching of the surface of the Nebraskan drift, (2) the deposition of loess, probably during the later Aftonian, (3) the formation of humus soil, and (4) the growth of vegetation, to be preserved in the Kansan drift. The restricted distribution of the Nebraskan glacial drift in the region seems to indicate that it was completely eroded from much of the area during the Aftonian.

Kansan ~~glacial~~ epoch

The Aftonian epoch was closed by a return to cold climate and the formation of glaciers. A glacier originating in the Keewatin center spread southward through central Minnesota and north-central Iowa into Missouri as far as the present valley of Missouri River, and expanded radially eastward into Illinois. The distance which it extended into Illinois has not been determined, but it has been reported in Rock Island, Mercer, Warren, McDonough, Knox, Fulton, Peoria, La Salle, Schuyler and Morgan Counties, so it appears that most of Illinois west of Illinois River and the preglacial Mississippi were covered during this glacial invasion. The glacier incorporated fragments of soil, loess, weathered till and wood from the Aftonian and Nebraskan deposits below in its load. It crossed an extensive area of outcrop of the Mississippian limestones in western Illinois and Iowa, and fragments of these limestones are common in its deposits. The deposits ~~######~~ left by the glacier form a heterogeneous mixture of clay, sand, gravel, and boulders. The clay, which consists not only of the older soil but also of material derived by the pulverization of most of the soft rocks and some harder rocks, serves as a matrix in which larger fragments of the harder rocks, both of distant and of local origin are scattered. The Kansan epoch was terminated by milder climatic conditions during which the ice melted ~~away~~, and with which the Yarmouth epoch was introduced.

Yarmouth epoch

The Yarmouth ~~interglacial interval~~, which was probably the longest of all the interglacial epochs, was marked through most of its time by a mild and humid climate in Illinois. While the Kansan glacier was wasting ~~###~~ away gravels were deposited in streams near the margins of the ice sheet. Some such deposits are still preserved in the Havana quadrangle, but the direction of flow of the streams in which the deposits were made is not clear. These gravels cannot be distinguished in all places from gravels deposited in stream beds later in the Yarmouth epoch, as the latter rest on Kansan drift in some exposures and on the bed rock (Pennsylvanian) in others. If the Kansan drift sheet formerly covered all of the quadrangle, as seems probable, Yarmouth gravels which rest on the bed rock were probably formed sufficiently late in Yarmouth time to permit the Kansan drift to have been eroded from such areas. The surface of the Kansan drift was deeply weathered during the earlier part of the Yarmouth epoch, and a well developed profile of weathering was formed on it, including a gumbotil in level areas with poor subsurface drainage. Fresh water silts were deposited in streams during the early Yarmouth, and perhaps in other parts of the district in the later Yarmouth also. Some of the gravels deposited as outwash from the Kansan glacier, or in streams during the early or middle part of the Yarmouth epoch were completely leached of their calcium carbonate content, oxidized to a deep brown color, and locally cemented with dissolved material carried down from above during the later Yarmouth. Some of the fresh water silts or loess deposits were also completely leached before they were buried under Illinoian glacial deposits. The climate became cooler during the later Yarmouth, and a dark gray or black humus soil was formed in areas with poor drainage. This soil may have formed during the time when the Illinoian glacier was accumulating in the Labrador center. The latest Yarmouth event seems to have been the deposition of a widespread mantle of loess over the surface. The loess may have been silt blown from the river valleys, when the temperature there had become too low to cover the surface with vegetation, or it may have been material carried in streams from the advancing Illinoian glacier and redistributed by winds during the dry or cold seasons. The temperature at the time of loess deposition was probably cool, as it is calcareous, and the land surface during the later Yarmouth was probably deficient in calcareous material. The climate was not so cold but that air breathing gastropods inhabited the surface abundantly. After the deposition of the loess the climate became progressively cooler, so the surface of the loess was not appreciably weathered before it was buried by drift of the Illinoian glacier. In a few poorly drained surfaces a black calcareous soil formed on top of the loess, although in other places the formation of black soil preceded the last loess deposition.

Illinoian epoch

The long Yarmouth epoch was terminated by the recurrence of glacial conditions which inaugurated the Illinoian epoch. A glacier originiating in the Labradorean center spread southwest~~ward~~ across Quebec, southern Ontario and Michigan, and expanded radially into Illinois and Indiana. The basins of the Great Lakes were probably not as completely formed as they are now, and they may not have had an important influence on the shape of the ice front. The glacier, advancing into Illinois, spread more rapidly down the broad valley of ~~the~~ Mississippi (present Illinois) river than elsewhere. It was probably at this time that ~~the~~ Mississippi River was forced ~~away~~ from its old channel through Illinois, and for a time it flowed through Iowa around the margin of the Illinoian glacier. Fig. 120 shows the area affected by Illinoian glaciation, and the position of the Havana quadrangle. The sand and gravel washed out in front of the advancing Illinoian glacier which were subsequently buried by the glacier itself are preserved in a few places. The direction from which the glacier advanced is indicated by glacial striae at one place as N. 60° E. This direction is nearly paralle with the bluffs of Illinois River. It is also parallel with a number of stream valleys, as shown in fig. ~~121~~ 137a, and most of these valleys are believed to be post-Illinoian in age. Several buried valleys, which run at various angles to this, especially from northwest to southeast, seem to have been important drainage lines of Yarmouth time, abandoned because they were

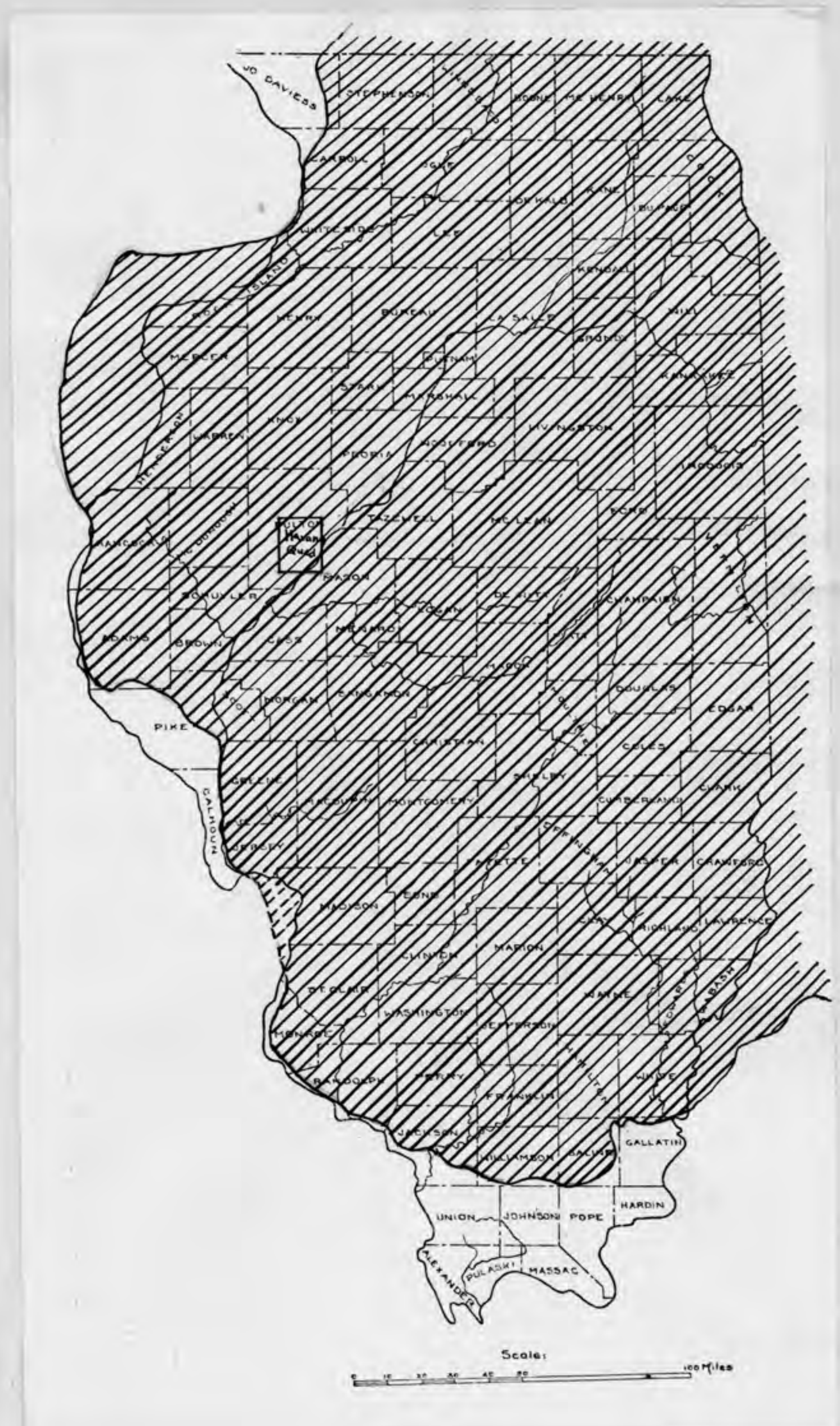


Fig. 137. Map of Illinois showing area covered by the continental glacier during the Illinoian glacial invasion (diagonal shading) in relation to the Havana quadrangle. (after Leverett)

filled with Illinoian glacial drift.

No relief features such as morainic ridges, eskers, kames or drumlins have been recognized in the Havana quadrangle, so the whole area appears to belong to the ground moraine of the Illinoian glacier. The glacier covered the area for a time, depositing ~~glacial~~ drift, then retreated, exposing all or parts of the area, and later readvanced ~~across the area~~, depositing more ~~glacial~~ drift. During the brief time of emergence outwash gravels were deposited near Spoon River in the west central part of the quadrangle, and fine laminated silts were probably deposited in undrained depressions or temporary lakes. The period of exposure was not long enough to allow the weathering of these water deposits, or the climate was too cold ~~to permit weathering to take place~~. The extent of deglaciation during this interval has not been determined. When the glacier finally withdrew from this area, outwash gravels were deposited in the valley of Big Sister Creek, and were followed by laminated silts and sands which were probably deposited in a temporary lake. The number of alternations of sand and silt indicates that glacial drainage reached this temporary lake for at least 234 years.

The recurrence of a milder climate caused the Illinoian glacier to melt ~~away~~ slowly, and brought in the Sangamon interglacial epoch.

Sangamon epoch

The Sangamon epoch was shorter than the Yarmouth ~~epoch~~, because the Illinoian till was not weathered as deeply during the epoch as was the Kansan till during the Yarmouth ~~epoch~~. As in the Yarmouth epoch, (1) vegetation flourished, (2) a rich dark soil was formed everywhere, (3) gumbotil was developed on surfaces of low relief where the subsurface drainage ~~conditions~~ was poor, (4) a reddish or rusty colored zone in the upper part of the drift was produced nearer the valleys of the larger streams where the subsurface drainage ~~conditions~~ was ~~were~~ better, and (5) stream erosion progressed. During the middle Sangamon or ~~the~~ early part of the later Sangamon there was a climatic change marked by increasing cold or decreased humidity or both. At this time silt was blown from the broad valley of Illinois River over the adjacent uplands. On the west side of the valley, in the Havana quadrangle, the silt is several feet thick within a mile or two of the bluffs, but decreases rapidly to the northwest ~~of the bluffs~~, so that at a distance of 8 or 9 miles it cannot be easily distinguished from the weathered till below. In the northwestern part of the quadrangle where the accumulation of loess was slower ~~less rapid~~ it was mixed with decaying vegetation to form a dark gray to black soil. Calcareous silts seem to have been deposited in the valley of Spoon River during the later Sangamon. These may have been water laid silts or wind deposited silts which settled on the wet flood plain of this river. During the latest Sangamon, the climate was warmer or moister, or both, so that the loess deposits formed a little earlier, were weathered. This loess was entirely leached where it was less than four feet thick, but the lower part of it was not leached in a few exposures near the bluffs of Illinois River.

Iowan epoch

The Sangamon interglacial epoch was terminated by a recurrence of conditions favorable for the accumulation of glaciers during the Iowan Epoch. A glacier from the Keewatin center pushed southward through central Minnesota into northern and central Iowa, where its terminal position was ~~is~~ near Iowa City, ~~Iowa~~,[24] and a glacier from the Labrador center is believed to

[24] Alden, W. D. and Leighton, M. M. The Iowan Drift, A review of the evidences of the Iowan stage of glaciation. Iowa Geol. Survey, vol. 26, p. 122, 1915.

have extended westward in the valley of Green River in north central Illinois beyond the Wisconsin drift margin into Lee and Whiteside Counties.[25]

[25] Knappen, R. S. Geology and mineral resources of the Dixon quadrangle, Illinois State Geol. Survey, Bull. 49, pp. 70-73, # 96, 1926.

The climate in the Havana quadrangle was probably so cold that erosion was materially retarded, but the only changes which may have occurred in the area during the Iowan epoch are a slight amount of erosion and weathering. The epoch was probably shorter than either the Kansan or the Illinoian ~~epoch~~, as the Iowan drift is thinner and covers a smaller area than either of the others. At the close of the Iowan epoch (1) the main# streams were lower in altitude than ~~they are~~ at present, (2) the longer tributaries were present, but not as deeply entrenched as ~~they~~ now ~~are~~, (3) the drainage system was simpler, and (4) the interstream divides were more extensive than at present.

Peorian epoch

Another epoch of milder climate, the Peorian, terminated the Iowan glacial epoch. When the Iowan glacier began to waste away the climate became more arid and ### from the newly exposed drift plains and the broad valleys of rivers like the Illinois and Mississippi vast quantities of silt were blown to the adjacent uplands by winds. This loess-forming condition was similar to those prevailing when the loess of the late Aftonian, late Yarmouth, and late Sangamon were deposited, but it persisted for a longer time, or the climate was more arid, so that a thicker and more widespread deposit of loess was formed than during any of the other loess forming ~~periods~~ epochs. The deposition of the loess began during the late Iowan while the glacier was melting ~~away~~ and continued through the earlier part of the Peorian epoch. All parts of the Havana quadrangle were probably buried under loess at this time, but east of Illinois River and in the larger flood plains it has been either eroded or buried beneath more recent deposits. The Havana quadrangle is at least 100 miles from the nearest Iowan drift plain, so most of the silt here was derived from the flood plain of Illinois River. The loess is thicker, and slightly coarser texture near the flood plain than several miles away from it. During the later Peorian the weathering of the loess began. The amount of weathering accomplished during the Peorian in the in the Havana quadrangle cannot be ascertained, because the weathering was renewed during post-Wisconsin time. The extent of late Peorian weathering of the loess in northern Illinois has recently been revealed in an exposure along East Bureau Creek in Bureau County, where the Peorian loess has a weathered zone and is overlain by early Wisconsin drift.[26]

---

26 Leighton, M. M. Personal communication.

Wisconsin epoch

The brief Peorian epoch was terminated by a recurrence of glacial conditions, so that great ice-sheets once more formed in the three centers of accumulation. During this epoch Illinois was invaded only by a Labradorean glacier which extended southwestward until it had covered most of northeaster Illinois, reaching within 25 miles of the Havana quadrangle near Peoria. Fig. ~~122~~ 138 shows the relation of the Havana quadrangle to this glacial invasion The glacier formed a series of prominent morainic ridges, of which the Shelbyville and Bloomington were nearest to the Havana quadrangle. Part of the old Mississippi-Illinois River valley was obliterated east of Peoria and Pekin by morainic deposits of this glacial invasion. ~~The~~ Illinois River received a great flood of water from the melting glacier during the Shelbyville and Bloomington stages, and vast quantities of gravel and sand were distributed in the valley outside of the margin of the Wisconsin glacier. ~~The~~ Illinois river probably flowed ~~#####~~ in a channel along the eastern side of the old Illinois-Mississippi valley when the ice front of the Wisconsin glacier stood near Peoria, rather than along the western side of the valley, where it now flows. The great deposit of gravel and sand outwash ~~which was deposited~~ in ~~the~~ Illinois River valley in front of the Bloomington moraine at Peoria formed a dam ~~which held~~ holding in the glacial waters in a great temporary lake which persisted until the ice front had receded to Marseilles, over 100 miles up ~~the~~ Illinois River. The level of the barrier which formed

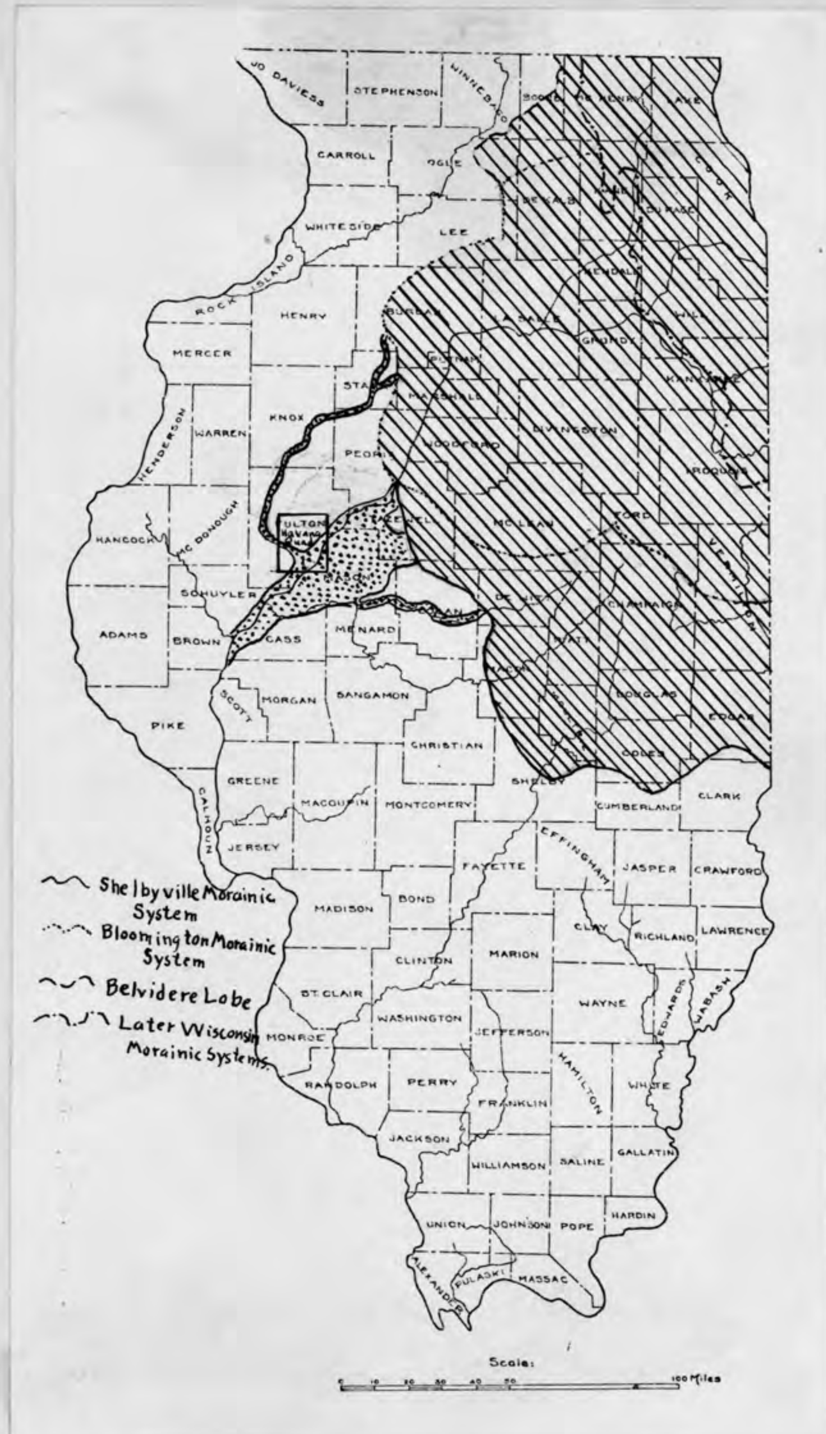


Fig. 138. Map of Illinois showing area covered by the continental glacier during the Wisconsin glacial invasion (diagonal shading) in relation to the Havana quadrangle. The outer boundaries of the principal morainic systems are shown. ~~by~~(see explanation above), and the drainage lines darrying waters from the Wisconsin glacier to the Havana quadrangle through the valleys of Spoon and Illinois rivers are shown (dotted shading).

this lake at Peoria is about 600 feet above sea level, ~~##~~ 164 feet above the present level of Illinois River at Peoria. This lake has been recently named Lake Illinois.[27] During its ~~the~~ existence ~~of this lake~~ comparatively little

[27] Leighton, M. M. Unpublished paper presented before National Academy of Sciences, at Urbana, October, 1928.

WATER FLOWED IN ~~THE~~ Illinois River valley below the lake, and sand and silt may have been blown about extensively by winds from the broad valley. Sand dune ridges are common along the eastern margin of the old Illinois valley and dune sand extends to some distance beyond the bluffs on that side ~~of the vall~~ The slack water deposits which were formed in the Havana quadrangle during the time of flooding of the Illinois Valley with outwash are commonly mantled with a sheet of loess, which was probably formed during the existence of Lake Illinois. The prevailing westerly winds would cause the coarser sands to be carried principally toward the eastern margin of the valley. After Lake Illinois had reached a length of over 100 miles a breach occurred in its dam, probably near the western side ~~of the valley~~, and torrents of water from the lake swept down the valley. The main flow seems to have been along the western side of the valley, but other parallel channels ~~within the valley~~ were probably ~~also~~ filled. One of these channels may have been that which enters ~~the~~ Illinois River in Quiver Creek in the Havana quadrangle During this torrential flow much of the gravel and sand which had formed the dam at Peoria was swept away and distributed downstream along the flood channels. After the lake had become practically drained the smaller channels were abandoned, as they had not been eroded to as low an altitude as the main channel, ~~### which was by this time situated along the western margin of the valley~~. The old channel ~~######~~ along the eastern side of the valley was probably abandoned now ~~by this time~~, as its altitude is about 500 feet, while the lower terrace at Havana, which probably represents the valley floor at this time is about 465 feet. The subsiding of the waters was followed by the renewal of wind distribution of sand and silt from the various channels which had served as drainage ####### lines for Lake Illinois. The dune belt one to three miles east of Havana, and the linear belts of dunes extending several miles east of there were probably formed shortly after the drainage of Lake Illinois.

After the ice front of the Wisconsin glacier had receded up ### Illinois River as far as Marseilles another #large moraine was built across the valley, the Marseilles moraine. This constricted the outlet for the glacial waters for a time, and later a torrential flow of glacial waters from the Saginaw Bay, Lake Erie and Lake Michigan lobes ~~of the glacier~~ passed through the Kankakee River valley. This flow has been named the Kankakee torrent.[28] This

[28] Ekblaw, G. E. and Athy, L. F. Glacial Kankakee Torrent in northeastern Illinois. Bull. Geol. Soc. Amer. vol. 36, pp. 417-428, 1925.

Athy, L. F. Geology and mineral resources of the Herscher quadrangle. Illinois State Geol. Survey, Bull. 55, pp. 89-94, 1926.

flood entered ~~the~~ Illinois River and continued down it. Its effect upon the river in the Havana quadrangle has not been determined, but it was probably confined to the approximate limits of the present valley and may have degraded the valley 10 or 15 feet, to an altitude of 450 to 460 feet. The terrace remnant in secs. 15 and 22, T. 4 N., R. 3 E. (Isabel twp.), with an elevation of about 458 feet, (~~about~~ 10 or 15### feet above the present level of the flood plain) may be of this age. After the decline of this flood more sand may have been piled up by wind along the margins of the valley, and the dunes in the city of Havana, ~~which are~~ on the lower terrace east of the river, may be of this age.

~~At a~~ Later, ~~time~~ Illinois had become entirely freed from its cover of glacial ice, but the northern part of the basin of Lake Michigan was still occupied, so that the glacial waters were ponded, forming glacial Lake Chicago. This lake drained southwest through ### Chicago River and the vall now followed by the Chicago Sanitary Canal into ~~###~~ Desplaines River and the Illinois. This flow of water was probably rather clear, as the glacial sediment had been deposited in the basin of Lake Chicago. Therefore the river which served as an outlet of Lake Chicago eroded the valley quite vigorously. In the Havana region the volume of water was probably adequate to completely fill the present flood plain of Illinois River and to cut away remnants of older and higher terraces which may have projected ~~out~~ into the valley. The steepness of the bluff, the absence of terraces at its base in many places, and the partial removal of the mantle of Peorian loess in some places suggests that the face of the bluff was actively eroded by the waters ~~in some places~~. Where the valley has greater width, as near Enion, in the southern part of the ~~###~~ quadrangle, the velocity of flow was diminished, and the terrace remnants protected by projecting bluffs upstream escaped this erosion. The valley was probably degraded at this time to the rock floor, which is about 25 feet below the present flood plain, or about 405 feet in altitude. Lake Chicago had several levels, ~~which were~~ caused by barriers in the outlet river, but the distance of the Havana quadrangle from the Lake Chicago outlet is too great to distinguish the results of changes in size of this lake. For a time the Illinois-Chicago Outlet River ~~####~~ carried the drainage of most of the present lakes Michigan, Huron and Erie, but the continued slow recession of the Labrador ice sheet finally exposed a lower outlet to the east, and the direction of drainage of Lake Chicago was reversed. After ~~the~~ Illinois River ceased to serve as an outlet for Lake Chicago, the influence of the Wisconsin glacier upon the Havana region was at an end.

RECENT PERIOD.

Post-glacial time.

The succession of glacial torrents which had occupied ~~the~~ Illinois River valley had reduced its channel to an extremely low gradient, and the small river which occupied this channel after the Lake Chicago stage did not possess the power to further degrade its bed. Its tributaries were cutting through loess and glacial drift, both of which are easily eroded, and it received a greater load than it could dispose of, so it has become an aggrading, rather than a degrading stream. The alluvial fill of the present flood plain has been formed since the beginning of the present Illinois River. The aggradation is greater near the channel than in other parts of the valley, and from time to time the stream has shifted its channel during a flood stage to a new channel essentially parallel to the old one, leaving the old channel as a flood plain lake, like Quiver Lake and Matanzas Lake and the recently drained Thompson Lake, northwest of Havana. The river did not inherit a meandering course from its predecessor, the Chicago Outlet River, and its low gradient has prevented its developing an extensive meander system by scouring its banks. Its position in the valley is determined to a considerable extent by the points of discharge of tributary streams ~~which~~ bringing sediment into its valley. As most of the stream erosion in the Havana quadrangle takes place on the west side of the valley, the river follows the opposite, or east bank through most of the area, but it flows near the middle of the valley at the mouth of Quiver Creek, which contributes more sediment than any other tributary on the east side of the valley.

The tributary streams in the Havana quadrangle have degraded their valleys toward the various levels reached by ~~the~~ Illinois River, but the smaller streams have lagged somewhat behind in their cutting, and some of them seem to be flowing at about the same level ~~occupied~~ as they did during the Wisconsin glacial epoch. The abandoned flood plains of the larger streams are still preserved as terraces along their valley margins. A number of streams show two distinct terrace levels, which suggests that they adjusted their valleys along with the Illinois at the times of the Lake Illinois torrent and ~~the time~~ of the Chicago Outlet River. Spoon River has become an aggrading stream in its course across the Havana quadrangle, and has a postglacial valley fill nearly as thick as that of ~~the~~ Illinois River.

Erosion of the upland areas of the quadrangle has continued in postglacial time, and the region has advanced to late youth in the erosion cycle. A renewal of erosion in some of the smaller streams has been caused by the deforestation and cultivation of their slopes. This has resulted in the abandonment of narrow flood plains in some places, in the active dissection of formerly smooth slopes, and in the increased amount of load carried by these smaller streams to the rivers into which they drain, forming alluvial fans.

The transfer of sand by the wind and its accumulation in dunes continues on the terrace area east of Havana wherever the protecting cover of soil and vegetation has been broken, as by cultivation of the land. ~~but~~ The greater part of the dune area is stabilized by vegetation. ~~and~~ Most of the dune ridges were formed during the low water periods following the various floods which occurred in the valley during the later Wisconsin.

The weathering of the loess deposits which was started in the later Peorian, and interrupted during the Wisconsin glacial invasion, has been continued since the withdrawal of the Wisconsin glacier, and the surface of the loess is weathered to a depth of 6 to 10 feet over all of the area where erosion has not been more rapid than weathering. The sandy deposits of Wisconsin age have also been leached and oxidized since the beginning of recent time.

Human occupation of the Havana quadrangle and its effects.

The Illinois Valley has been occupied by man since long before the appearance of European man in America. The aboriginal races ~~of man~~ left a splendid record of their activities in the series of mounds which line the valley of the Illinois on both sides. The actual time of the first appearance of man in ~~in~~ this region cannot be definitely ascertained, but it was probably after the recession of the Wisconsin glacier from Illinois, and long enough after this to permit the outwash deposits and dune sands formed during the later Wisconsin to be weathered to a depth of several feet.

The aboriginal races ~~of men~~ who inhabited this valley carried on extensive trade with tribes in other parts of the country. This is revealed by the presence of marine mollusk shells of gulf coast species ~~in some abundance~~ in some of the burial mounds and large flattened chipped pieces of flint, which are foreign to this part of the valley. The local Pottsville sandstones probably served some purpose for the mound builders, as numerous fragments of such sandstones as are common on the south side of Spoon River between Duncan Mills and the Mound Chapel are present in some of the mounds on the east side of the river in Chautauqua Park, north of Havana. ~~The~~ Illinois River was probably the principal route of travel, as indicated by the distribution of the mound builders' settlements along both sides of the valley.

(~~Discussion of early French travel through this valley.~~)

Since the settlement of this part of Illinois early in the nineteenth century, many changes have been wrought by man. The flood plain of the river has been protected from floods by a system of artificial levees; some of the flood plain lakes have been drained, and the land formerly occupied by them converted into farm land; the clearing of lands on the sandy terrace areas near Havana has ~~have~~ started anew the formation of dunes and blow outs in that region; the deforestation of slopes has caused a renewal of erosion in the loess and till areas west of ~~the~~ Illinois River valley; the underground mining of coal has been followed by the caving ~~in~~ of the surface above the coal bed, obstructing natural drainage lines in some districts; and the recent mining of coal by stripping has resulted in the accumulation of great debris piles over several square miles near Cuba.

CHAPTER VI ~~Mineral~~ Economic Geology

Mineral resources

The mineral resources of the Havana quadrangle which have been developed, or which may be of value at some future time, are coal, sand and gravel, clay and shale, limestone, and natural gas. Several wells have been drilled in search of petroleum, but no ~~ne~~ oil has yet been discovered. The water resources and the soil are of great importance, for it is upon these ~~resources~~ that the prosperity of the district principally depends.

Coal.

Nine coal beds are more or less persistent in the section of Pennsylvanian strata exposed in the Havana quadrangle (fig. 16). One or more beds older than the oldest exposed may underlie some parts of the quadrangle. Several of the beds are of no value, as they are too thin to be worked. Other beds are thick enough to be worked in part of the area, but they are too variable in thickness or too discontinuous to be of present value. The coal beds of greatest ~~value~~ importance are the Rock Island (No. 1), the Colchester (No. 2), the Springfield (No. 5) and the Herrin (No. 6). Workable coal beds are distributed in practically all of the quadrangle west of Illinois River valley, and some parts of the valley are probably underlain by coal beds.

Coal beds below the Rock Island (No. 1) coal.

A coal bed belonging to the Pope Creek formation is exposed at several places along Tater ~~Creek~~ and Otter Creeks. This coal attains a maximum thickness in exposures of 2 to 2½ feet. It is separated from the Rock Island coal above by less than 5 feet of clay and sandstone. Several coal test borings in the northern half of the quadrangle penetrate strata 30 to 50 feet below the Rock Island coal. In some of these one or two coal beds are reported. The greatest thickness reported for such coals in these drillings is 2 feet 2 inches, a short distance east of Cuba. The coal bed which possesses this thickness is probably 20 to 25 feet below the horizon of the Rock Island coal. It may be the correlative of the coal mentioned along Tater Creek. It does not appear to be sufficiently widespread to merit testing.

Rock Island (No. 1) coal.

The Rock Island coal is known to occur at many localities in western Illinois, widely separated from each other. In certain localities it is so thick that it has been mined for many years, and is of much importance. Between such areas the coal is found to be notably discontinuous, variable in thickness, and to contain such a thickness of bedded impurities as to render it practically worthless. Recent stratigraphic work has shown that a relatively thin bed of coal, without the overlying marine strata usually associated with the Rock Island coal, occurs at about the stratigraphic position of the latter coal. Coal of this character and position is exposed at several places in the southern part of the Havana quadrangle. This coal, in most of its exposures, along Otter Creek and Tater Creek ranges from one to two and a half feet in thickness. It is commonly overlain by the Bernadotte sandstone, the hardest of the Pennsylvanian sandstones. This should furnish a satisfactory roof for mining if it overlies coal of sufficient thickness at any place. A local drift has been opened in this coal along the bank of Tater Creek about 1 mile northwest of Duncan Mills. A coal, referred tentatively to the Rock Island, is exposed on the west side of a ravine south of Otter Creek in the SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 25, T. 4 N., R. 2 E. (Pleasant twp.) (Geologic section 7). The coal here totals 5 feet $3\frac{1}{2}$ inches, but it is in 6 benches, with a total of 4 feet 9 inches of shale, clay and ironstone concretions intervening. The lowest bench, $2\frac{1}{2}$ feet thick, is being stripped locally.

Twenty six wells and coal test borings have been extended to the horizon of this coal in the northern part of the Havana quadrangle. The coal is reported in 9 of these wells. About $1\frac{1}{2}$ miles north and northwest of Cuba, in the southern part of the Canton quadrangle, the coal has been tested more systematically by drilling than at any locality in the Havana quadrangle. The thicker coal in this district, with a thick limestone cap rock, terminates to the southeast along an irregular northeast-southwest trending line crossing sections 5, 8 and 7, T. 6 N., R. 3 E. (Putman twp.), (fig-7) Variations in the coal and associated strata in this area are shown in fig. 18. The thick coal appears to be absent northeast of Cuba. Thick coal has been reported in drillings in sec. 4, T. 4 N., R. 4 E. (Waterford twp) # and sec. 12, T. 4 N., R. 3 E. (Waterford twp.) in the Illinois River flood plain near enough to the surface to be stripped profitably if it is sufficiently thick and extensive and free from clay partings. The data available here suggest that it occurs in a rather narrow belt trending north east and southwest. Thick coal which probably is the Rock Island has also been reported in the flood plain of Otter Creek in secs. 25, 26, 35 and 36, T. 4 N., R. 2 E. (Pleasant twp.) and sec. 30, T. 4 N., R. 3 E. (Isabel twp.), at such a depth that it might be stripped if ~~it is~~ of suitable quality and thickness.

The coal has a hard black shale roof in some places, a limestone roof in other~~s places~~, and shale or sandstone roof in other localities. The limestone and black shale ##### make satisfactory roofs in mining this coal by the room and pillar method in other parts of western Illinois, but there is no information regarding them in this area, as there are no mines operated in this coal.

The principal obstacle in the development of the Rock Island coal in the Havana quadrangle is the great irregularity in thickness and distribution. It will probably not be mined extensively until the other and more continuous beds of the region have become exhausted.

Coal beds between the Rock Island (No. 1) and the Colchester (No. 2) coals.

Thin coal beds or coaly streaks occur in the "Brush Creek", seahorne and

Greenbush formations in a few outcrops. Coal in the Bernadotte formation reaches a maximum thickness of about one foot, but it is not widely persistent. The coal of the Wiley formation is widely persistent through the quadrangle. It averages 10 inches in thickness, but reaches 1 foot 10 inches in the vicinity of Cuba, as reported in drill records. None of these coals are thick enough to be of present or future economic importance.

Colchester (No. 2) coal.

This coal bed underlies all of the Havana quadrangle except those parts from which it has been removed by post-Pennsylvanian erosion (Fig. 139). Its thickness is quite uniformly $2\frac{1}{2}$ feet, and it ranges from 2 feet to nearly 3 feet. It is commonly free from clay partings, although pyrite occurs in it in small concretions which form a nearly continuous bed in some places. (An analysis of this coal is given in Table 2.) The roof of this coal is either soft gray shale, the Francis Creek ~~shale~~, or thin bedded fine grained sandstone, the Pleasantview ~~sandstone~~. The shale roof is found in most of the north half of the quadrangle, and the sandstone roof in most of the area south of ### an east-west line drawn through the southern part of Lewistown.

The Colchester coal has been mined by shafts, drifts along the outcrop, and by local stripping of the beds of ravines in which it outcrops. The shaft mining is principally in the vicinity of Lewistown, where the coal lies at a depth of 50 to 90 feet. Most of this coal is sold# locally. Drift mines are situated in nearly all of the ravines in which the coal outcrops, but most of them were abandoned when the field work was done in this quadrangle. The coal is commonly mined out to a distance of about 100 feet from the outcrop at the drift entrance, the drift then abandoned, and a new one opened a short distance up or down the ravine. Fig. ~~142~~ 140 shows ### the side of a ravine with six abandoned drift entrances along the outcrop of the Colchester coal. Hundreds of such drifts have been operated, but comparatively little of the coal has been mined.

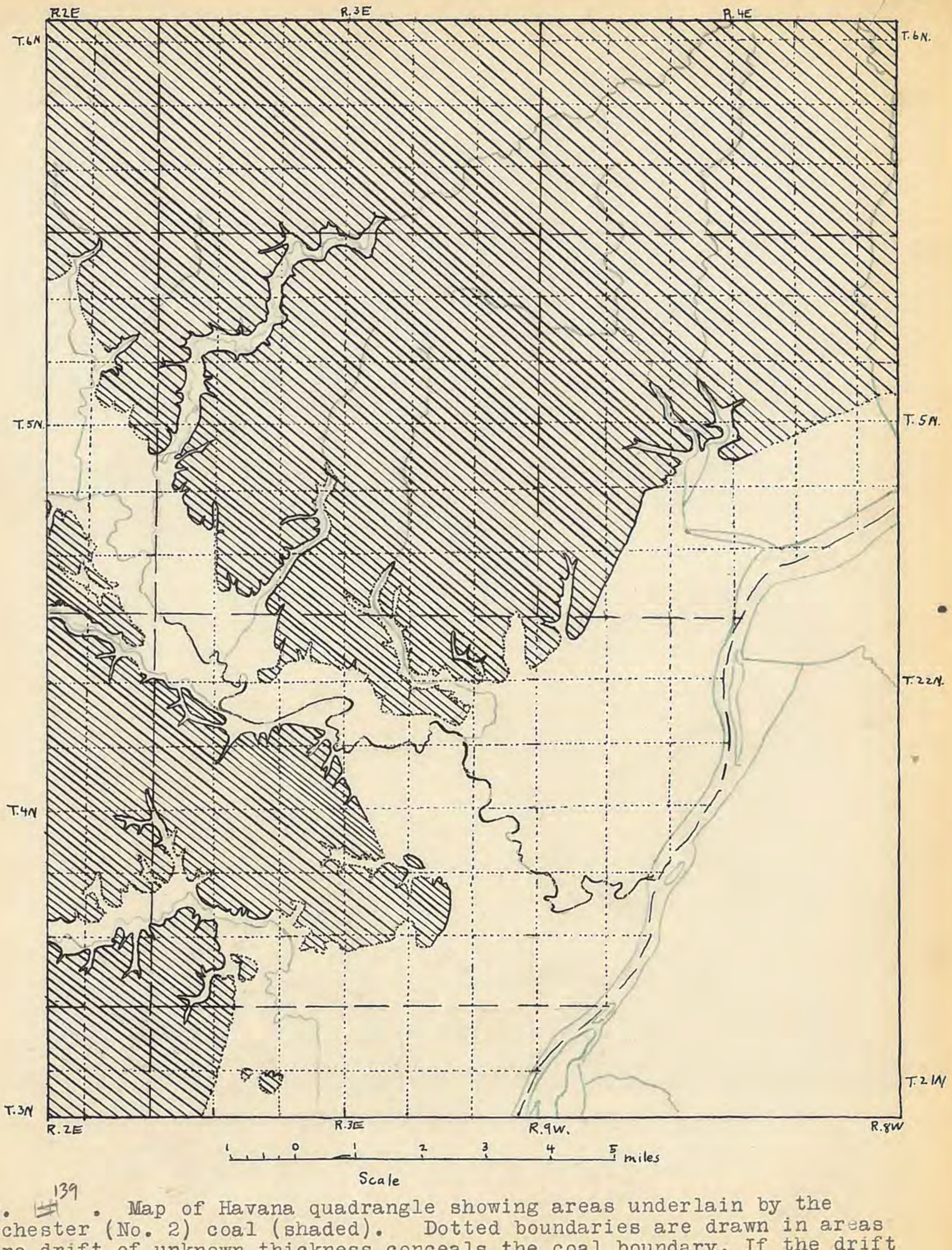


Fig. 139 . Map of Havana quadrangle showing areas underlain by the Colchester (No. 2) coal (shaded). Dotted boundaries are drawn in areas where drift of unknown thickness conceals the coal boundary. If the drift is thick in these places the boundary may be further away from the nearest drainage line than it is drawn.

Fig. 14D. Southeast wall of ravine in the SE. ¼ sec.32, T. 5 N., R. 3 E. (Lewistown) twp. showing debris piles at 6 abandoned mine drift entrances in the Colchester (No. 2) coal. This method of mining the coal a short distance in from the outcrop and then abandoning the mine and opening another has been commonly practiced with the Colchester coal in this quadrangle.

Data regarding the Colchester coal in two mines, one with shale roof, and the other with sandstone roof, are given in Appendix B, Part I.

The Colchester coal does not appear to be near enough the surface over any large area to permit strip mining on a large scale, and its thickness is too small to permit underground mining by modern methods, unless part of the underclay is removed along with the coal, but it is as thick as important coal beds in some adjacent states, and may be mined on a larger scale when the Springfield (No. 5) coal is more nearly exhausted in this part of Illinois.

Kerton Creek coal.

The only coal bed between the Colchester (No. 2) and the Springfield (No. 5) coals in the Havana quadrangle is the coal bed in the Summum formation, which is here called the Kerton Creek coal from exposures on Kerton Creek in the northeastern part of the Beardstown quadrangle. Thin lenticular masses of coal are found in the Pleasantview sandstone ~~####~~ in a few places. The Kerton Creek coal is much more limited in distribution in this quadrangle than the Colchester ~~coal~~. Its distribution seems to be closely connected with the "channel" in the northern part of the quadrangle which was cut before the Pleasantview sandstone was deposited. East and west of the channel, the horizon of the Kerton Creek coal is represented by 4 to 6 inches of coal or less, but in the channel area it is locally much thicker, and several local drifts and strip mines have been opened in it. The coal is known to be of minable thickness only in parts of secs. 27 and 35, T. 6 N., R. 3 E. (Putman twp.) and secs. 19 and 20, T. 5 N., R. 4 E. (Liverpool twp.). In the NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 27, T. 6 N., R. 3 E. (Putman twp.) the coal is 4 feet thick with a 3 inch clay parting $2\frac{1}{2}$ feet below the top, and 37 feet below the Springfield coal. About $1\frac{1}{4}$ miles southeast, in sec. 35 of the same township, it is 2 feet thick and 12 feet below the Springfield coal. The following section was measured in another part of sec. 35:

Geologic section 74. Exposure in small gully south of Big Creek in the SW. ¼ sec. 35, T. 6 N., R. 3 E. (Putman twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Carbondale series		
Summum formation		
14. Shale, gray, soft		8
13. Coal, hard		4
12. Shale, black, coaly, with some thin beds having coaly fracture		10
11. Coal, tough, without fracture		3
10. Shale, gray and black		2
9. Coal		5
8. Mixture of noncontinuous bands of coal, black shale and gray clay	3	2
7. Pyrite, not persistent		1
6. Coal, hard		6
5. Charcoal parting		¼
4. Coal, hard		5½
3. Charcoal parting		¾
2. Coal, hard	1	4½
1. Underclay		6

The total thickness of coal in the foregoing section is about 3½ feet, but it is so separated by clay partings as to have little value. In a small area near the middle of the east line of the NE. ¼ sec. 19, T. 5 N., R. 4 E.# (Liverpool twp.) and in the adjacent part of sec. 20 of the same township, a coal which is believed to be equivalent to the Kerton Creek coal is 3½ feet thick and only about 3 feet below a coal referred to the Springfield horizon. This coal is so variable in thickness and so restricted in distribution that it is unlikely that it will ever be mined except in local drift or strip mines near its outcrop, as it has been mined up to the present time.

Springfield (No. 5) coal.

This coal bed is found only in the northern half of the quadrangle, but it has been much more extensively mined than any of the other coal beds. In the past it was ~~mined~~ worked in a number of large underground mines, as well as small drift and shaft mines and local stripping operations. Since 1923 strip mining of this coal has been carried on more extensively, and at the present time it has nearly supplanted other methods of mining the coal.

The approximate area underlain by this coal, and the areas from which it has been mined in large mining operations (as indicated on mine maps) are shown in fig. ~~130~~ 129. The locations of the entrances to local mines are also indicated.

The thickness of the Springfield coal in 61 outcrops and 377 records of coal test borings ranges from 3 feet 6 inches to 6 feet. 52 of the records show coal less than 4 feet 6 inches, 367 show coal between 4 feet 6 inches and 5 feet 4 inches and 19 records show coal from 5 feet 5 inches to 6 feet. Several other drill records report coal less than 3 feet 6 inches thick, but most of these records show that the drilling penetrated a clay seam or "horseback" in the coal, or that it was situated so near the outcrop of the coal that it had been thinned by preglacial weathering or erosion, so these lesser thicknesses do not represent the true thickness of the coal. Some of the records showing less than 4 feet 6 inches may be on clay seams or the outcrop line. The average thickness of the coal in the 438 records is about 4 feet 9½ inches.

The coal is fairly free from bedded impurities, as it is in other parts of western Illinois. In the vicinity of Cuba the lower 1½ inches of the coal is mixed with much pyrite, and this layer, which is called "false bottom", usually adheres to the underlying clay and is left in the mine. Pyrite occurs in small concretions scattered through the coal, especially in its upper part. The most important impurities in the coal are the "horsebacks" or clay seams which are widely distributed through it. These are composed of clay similar to the underclay, which has been forced up into cracks in the coal. These "horsebacks" commonly occur along faults ~~in the coal~~. The displacement of the faults varies from a few inches to 1½ feet. They are commonly branching and much coal adheres to them both between and outside of the branches, so they are a cause of much loss of coal and trouble in mining. They are not uniformly distributed ~~in the coal~~, and where present ~~they~~ seem to run in all directions. In some places there is much pyrite as well as clay along the horsebacks, and in others ~~there are found~~ brownish masses of silicified or calcified wood are found. Such material also occurs as floor "boulders" in some mines and causes trouble. Sections of the coal are given in fig. 14.

The floor is clay, which shows little tendency to heave. Large calcareous septarian concretions commonly occur in the clay about 1 foot below the coal, but these have little effect upon mining.

The roof is hard finely laminated black shale, averaging 1 to 1½ feet in thickness, overlain by a softer black or black and gray shale about 1 foot thick, locally called "clod" by the miners. Both of these beds of shale are variable in thickness. Large pyritic and calcareous concretions are found in the black hard shale immediately above the coal. These concretions are not uniformly distributed in the shale but are present in nearly all parts of the quadrangle underlain by the Springfield (No. 5) coal. The lower part of the shale sometimes falls when the coal is removed, and the large concretions or "niggerheads" in the shale also cause some roof falls. When the lower part of the shale has fallen, and the upper softer shale is exposed to the air, the whole shale may fall away from the limestone cap rock (St. David limestone), which is 2½ to 4 feet above the coal. In general the hard shale forms a satisfactory roof for underground mining.

The large underground mines in the Springfield coal were ~~all~~ closed at the time field work was done in the Havana quadrangle, but notes on these mines were obtained from the survey files and a published report.[1]

[1] Cady, G. H. Coal resources of district IV, Illinois State Geol. Survey, Coop. Mining Series, Bull. 26, pp. 87-104, 1921.

Detailed notes on these mines and on the large strip mine of the United Electric Coal Company (fig. 14) are given in Appendix A, Part I.

(Title fof figure)

Fig. 14½. Sections of the Springfield (No. 5) coal in the Havana quadrangle.[2]

1. Mine No. 2, Big Creek Coal Company, St. David.
2. Same Mine, face main haulage entry.
3. Same mine, 2200 feet northwest of drift mouth.
4. Same mine, 2500 feet west of drift mouth.
5. Same mine, entry face, 7th west, 4500 feet from opening.
6. Same mine, entry face, 15th north, 6000 feet from opening
7. Same mine, entry face, 11th north, 6000 feet from opening.
8. Same mine, entry face, 7th east, 5000 feet from opening.
9. Same mine, entry face 14th east, 5500 feet from opening.
10. Same mine, room 3, 18th east, 6000 feet from opening.
11. Mine No. 4, Big Creek Coal Company, Dunfermline, face main south entry.
12. East Cuba coal mining company's local mine no. 1, room 1, off 2nd east off 1st south off main west.
13. Applegate and Lewis mine, Cuba, face room 2 off 7th south.
14. Cripple Creek Coal Co. Mine no. 1, face of 5th north, 4000 feet north of no. 3 portal.
15. Cripple Creek Coal Co. Mine no. 1, 1st west off 5th north, 1000 feet north and 2300 feet west of no. 1 portal.
16. Cripple Creek Coal Co. Mine no. 1, face of main back west, 2700 feet west of no. 1 portal.
17. Star Coal Co. Mine no. 3, Cuba, temporary north entry.
18. United Electric Coal Company, Mine no. 9 (strip), 1400 feet west and 970 feet north from SE. cor. sec. 28, T. 6 N., R. 3 E.
19. Same mine, 510 feet west and 130 feet south from NE. cor. sec.33, T. 6 N., R. 3 E.
20. Same mine, about 2700 feet north and 500 feet north of SW. cor. sec. 28, T. 6 N., R. 3 E.
21. Same mine, about 500 feet north and 300 feet east of center of west line sec. 27, T. 6 N., R. 3 E.
22. Outcrop on north side of ravine in NE. ¼ NW. ¼ sec. 21, T. 6 N., R. 3 E.
23. Outcrop along ravine in SW. ¼ NW. ¼ sec. 24, T. 6 N., R. 3 E., near Cripple Creek Coal Company Mine.
24. Outcrop in ravine in NW. ¼ NW. ¼ sec. 25, T. 6 N., R. 3 E.

---

[2] Sections 3, 4, 5, 6, 7, 8, 9, 10, 12 and 17 are ~~published~~ taken from Cady, G. H. Coal Resources of District IV, Ill. State Geol. Survey, Coop. Mining series, Bull. 26, pp. 93, 96 and 101, 1921.

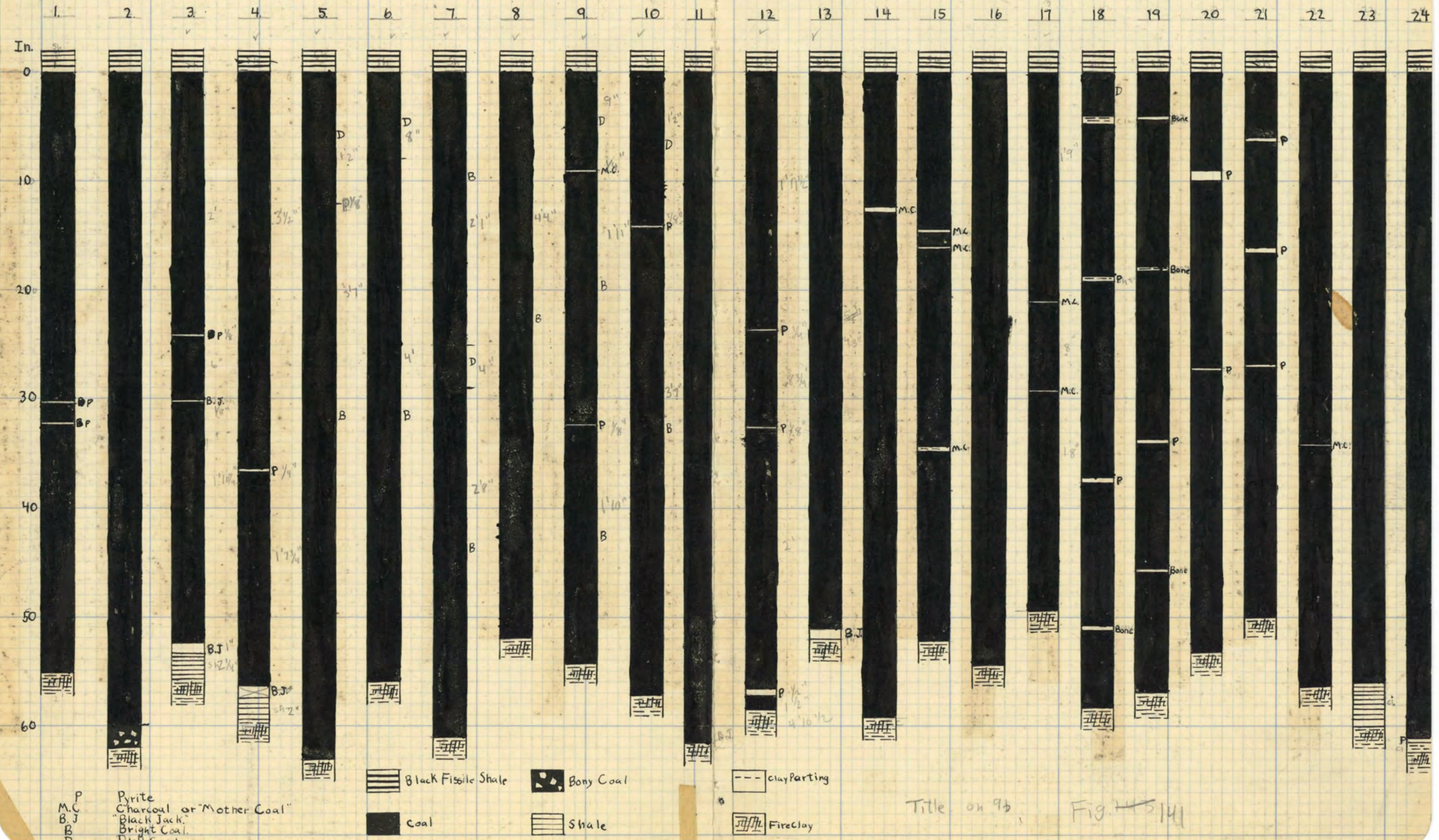
Fig. 102. General view of a stripping face of the United Electric Coal Company's Mine no. 9 southeast of Cuba in the SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 27, T. 6 N., R. 3 E. (Putman Twp.). The strip face at the left is about 30 feet high, consisting of about 19 feet of loess and drift and 11 feet of shale and limestone. Several large blocks of the St. David limestone are seen in the debris piles at the right.

Chemical analyses of the Springfield coal.

The following table shows analyses of the Spgingfield coal from the Havana quadrangle.

Table 2. (~~P. 19a~~)

In ~~According to~~ the analyses given the Colchester coal is somewhat lower in moisture and ash content than the Springfield coal, but the number of analyses of the former from this ~~####~~ quadrangle prevent a clear determination of the comparative fuel values of the two coals. The Springfield coal has a rather high content of ash and moisture and CO_2, as compared with the coals of southern Illinois. The sulphur content is about the average for Illinois coals. The CO_2 occurs as calcium carbonate along the joint faces of the coal, and when abundant, ~~it~~ is an undesirable impurity, ~~in the coal.~~ In rank, the coals of the Havana quadrangle are rather low grade bituminous ~~coals~~.



Title on 9b

Fig. ~~45~~ 141

Table 2. Analyses of mine samples taken in and near the Havana quadrangle.
Not exactly indicative of commercial output

Laboratory No.	File No.└	Date	Coal Bed	Proximate Analysis of Coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO_2	B.t.u.	Unit Coal
				Moisture	Volatile Matter	Fixed Carbon	Ash				
				Colchester (No. 2) Coal							
338	1722	9/08	2	10.90 Dry			7.52 8.56				
1811	1722	9/08	2	15.37 Dry	29.40 34.72	48.84 57.73	6.39 7.55	3.11 3.67		11475 13558	14889
				Springfield (No. 5) Coal							
340	1116	9/08	5	15.42 Dry			10.60 12.52				
5283	1116	8/12	5	15.18 Dry	37.17 43.82	35.17 43.82	12.48 14.73	3.45 4.07	1.70 2.00	10201 12026	14444
5285	1116	8/12	5	18.42 Dry	34.98 42.88	37.66 46.15	8.94 10.97	2.33 2.85	.86 1.06	10270 12587	14377
5296	1116	8/12	5	16.82 Dry	37.28 44.81	33.45 40.23	12.45 14.96	2.84 3.42	1.69 2.02	10580 12038	14479
5298	1116	8/12	5	16.52 Dry	37.17 44.52	36.54 43.78	9.77 11.70	3.91 4.69	.80 .97	10394 12451	14409
5341	1116	8/12	5	17.37 Dry	35.71 43.22	37.86 45.82	9.06 10.96	2.34 2.83	1.14 1.38	10420 12610	14397
5345	1116		5	15.27 Dry	32.91 38.84	41.46 48.93	10.36 12.23	3.01 3.55			
4346	1116		5	15.67 Dry	31.43 37.28	43.10 51.11	9.80 11.61	2.99 3.55		10620 12593	14519
1808	1116	9/08	5	15.49 Dry	35.66 42.20 ~~37.50~~	37.50 44.37	11.35 13.43	3.22 3.81		10448 12364	14596
1856	1217a	9/08	5	15.44 Dry	35.88 42.42	38.35 45.36	10.33 12.22	3.52 4.17		10711 12666	14741
343	1219	9/08	5	12.72 Dry			11.66 13.36				
4388	1220	8/11	5	14.04 Dry	36.14 42.04	39.28 45.69	10.54 12.27	3.46 4.02	.56 .65	10721 12472	14515
4387	1220	8/11	5	12.03 Dry	36.30 41.27	39.67 45.08	12.00 13.65	3.35 3.81	.72 .82	10779 12254	14506
2651	1220a	8/09	5	14.35 Dry	34.48 40.25	36.98 43.18	14.19 16.57	4.44 5.19		10324 12053	14881
84409	1224	3/22	5	13.5 Dry	34.4 39.8	38.8 44.8	13.3 15.4	3.5 4.1		10410 12040	14240
14619	1228	9/24	5	13.75 Dry	36.59 42.42	37.38 43.34	12.28 14.24	~~3.11~~ 2.92 3.38		10560 12243	14589
14620	1233	9/24	5	12.36 Dry	36.69 41.87	40.90 46.67	10.05 11.46	3.00 3.42		11194 12773	14697

└ Analyses having the same file number are for the same mine. Attention is called to the fact that much greater dependence can be placed on these analyses where there are at least three for a given mine than where only one is available.

Recommendations for further exploration.

The Springfield coal has been removed from large areas in the Havana quadrangle by the three mines of the Big Creek Coal Company, (1) at St. David, (2) Dunfermline and (3) Cuba, (4) in the strip mines of the United Electric coal Company near Cuba, (5) in the Cripple Creek mines northwest of Bryant, and (6) in a large mine south of Big Creek in secs. 21, 28, 29, and 32, T. 6 N., R. 4 E. , about which no information is available in the survey files.

Fig. 129 shows the approximate outcrop of the Springfield coal, its structure, ~~###~~ the areas from which the coal has been removed according to available mine maps, and the locations of the mine entrances of mines of which no maps have been obtained. Most of ~~these~~ the latter are local ~~mines~~, and the acreage of coal removed in each is ~~###~~ probably small.

The areas from which the coal has not been mined may be classified as strip coal land or underground mining land according to the average thickness of the overburden. As the coal averages nearly 5 feet thick it can be profitably mined by stripping at a depth of 50 feet, although no territory would probably be stripped where the overburden averaged as much as 50 feet. The coal has not been mined to its outcrop line in the underground mines, in some places because the roof was too thin to permit this type of mining, and in other places because of the weathered condition of the coal at its outcrop beneath the glacial drift. The outcrop line may be much more uneven than ~~it~~ is indicated in some places, and the area of coal still unmined may thus be much less than ~~is indicated~~ shown.

Buckheart township, T. 6 N., R. 4 E.

In secs. 13 and 24, near the northeast corner of the quadrangle, there is a considerable area from which the coal has not been removed, east of Buckheart Creek, extending east beyond the quadrangle line. The area is well dissected by streams and under the level upland the depth to the coal varies between 50 and 75 feet. The coal outcrops along the ~~bluffs~~ banks of several streams here. There is also an area of coal unmined, except in local drifts about ¼ to 1/3 mile in width west of Buckheart Creek and east of the workings of the Dunfermline mine of the Big Creek Coal Company in secs. 13, 23, 24, 25, and 26. This block of coal ~~would be~~ is divided into several separate areas by ravines tributary to Buckheart Creek on the west and by local mines. The depth to the coal would be too great for strip mining in some parts ~~of this area~~.

In secs. 25, 26, 35 and 36 the coal dips sharply toward the east from 569 feet altitude in the SW. ¼ sec. 26 to about 490 feet in the south central part of sec. 25. The coal is below the level of Buckheart Creek in the south half of sec. 25, and it might be stripped in the narrow flood plain of this creek in a part of this section. The depth to the coal west of Buckheart Creek would be too great to permit stripping in most of the area east of the workings of the Dunfermline mine.

The position of the ######## outcrop of the coal across secs. ###### 33, 34, and 35, between Little Sister and Buckheart Creeks has not been clearly ascertained. Coal is reported in a farm well in the SE. ¼ SE. ¼ sec. 34 at a depth of about 40 feet, appendix C, Part II. This is about 1 mile south of the southern margin of the Dunfermline mine workings, and if the coal underlies all of the intervening territory, a considerable ~~territory~~ area would be available, part of it at a depth suitable for stripping.

Little Sister Creek seems to occupy ### a preglacial channel deep enough to have removed the Springfield coal. ##### This channel extends north through St. David and reappears north of Big Creek in the southern part of the Canton quadrangle, where it has been spoken of as the St. David fault. There seems to be 1/8 to 1/2 mile of coal between this preglacial channel and the Dunfermline workings in secs. 15, 22, and 27, and the coal reaches a depth of 60 feet ## near the center of sec. 22. The margins of this preglacial channel are probably so steep that the coal is not well situated for stripping over any considerable part of this area.

West of Little Sister Creek and south of Big Creek the coal has been mined from most of secs. 20, 21 and 29 and small parts of secs. 28 and 32. ########## Between this mined area and the coal outcrop line to the south there is a considerable area including the east $\frac{1}{2}$ of the NW. $\frac{1}{4}$ sec. 28 and the SW. $\frac{1}{4}$ of the same section, the W. $\frac{1}{2}$ of the NW. $\frac{1}{4}$ sec. 33, the S. $\frac{1}{2}$ of the SE. $\frac{1}{4}$ sec. 29, the N. $\frac{1}{2}$ of the NE. $\frac{1}{4}$ sec. 32 and part of the SW. $\frac{1}{4}$ of the same section, where the depth to the coal is from 19 to 45 feet. Most of this area where the coal is not weathered along the outcrop would be available for coal stripping. There has been ~~some~~ rather extensive mining in secs. 30 and 31, but no mine map is available, and there are no drill records ######### showing the depth to the coal, nor its extent in these sections. If there should be any considerable body of coal remaining in these sections it probably lies near enough to the surface to permit stripping.

North of Big Creek the coal has been mined from all the area east of the ravine in the SE. $\frac{1}{4}$ sec. 17. No extensive mining has been carried on in the ###### strip of land west of this ravine between Big Creek and Eveland Branch (not named on the topographic map), the large ravine which crosses sections 17, 18 and 19. This area is nearly divided by a preglacial valley draining southeast across sections 18, ## and 20 which seems to be a continuation of the present southeast flowing valley in the south half of sec. 18. This valley is said to have rather steep sides and to cut at least 20 feet below the coal. There is, however, a good acreage north and south of this valley which is available at a depth suitable for stripping. The coal has not been mined except locally from #### the parts of secs. 18 and 19 northwest of Eveland Branch, but its depth here averages 50 feet or more, and it would probably not be suitable for stripping.

Liverpool township, T. 5 N., R. 4 E.

The Springfield coal underlies most of the level upland in this township between Buckheart Creek and the east line of the quadrangle in secs. 1 and 12. The coal varies gre tly in altitude and depth in the## parts of these sections in the Havana quadrangle. It is 504 feet at the north line of sec. 1, appears to be cut ##out about ¼ mile south, 537 feet at the middle of sec. 1, 494 feet near the north line of sec. 12 and about the same to the bluff of ~~the~~ Illinois River. These altitudes are ###### in outcrops along Buckheart Creek or its tributaries. Its depth probably varies between 25 and 75 feet in these sections. In combination with some of the territory just east of the Havana quadrangle a block of coal large enough to be profitably stripped may be found.

The coal has a limited exposure west of Buckheart Creek along the bluffs of ~~the~~ Illinois River in the NE. ¼ sec. 14, but seems to rise rapidly to the west. The continuation of this coal to the north into sec. 11 is not known, as no drill records are available ~~in this area~~. This area does not appear to be very promising for exploration.

A coal which is probably the Springfield coal and another bed 3 feet thick 3 feet lower are exposed along the large east flowing ravine near the middle of the east line of the NE. ¼ sec. 19. If this coal should continue far to the north or south of this ravine its altitude would probably make it available for stripping. It has been locally stripped a short distance north of the ravine mentioned. It is improbable that this coal continues far east of the south flowing ravine at the corners of sections 17, 18, 19, and 20. It may, however, continue toward the northwest toward an outcrop of the Springfield coal in a ravine near the SW. cor. NW. ¼ sec. 18. The coal is probably so near the surface over much or all of this area that it has been extensively weathered and eroded before it was buried with glacial till.

~~#########~~ Putman township, T. 6 N., R. 3 E.

The Springfield coal has not been mined except locally from the NE. ¼ sec. 24 northeast of Cripple Creek Mine no. 2 workings and the part~~#~~ of sec. 13 ~~which is~~ on the Havana quadrangle. The depth to the coal in most of this area is 60 to 75 feet, which would make stripping impossible. The area might be mined by underground mining, however, if this is later resumed in the Havana region on an extensive scale. ~~######~~ According to available information the coal is also unmined and available in most of the north half of sec. 23 and the part of sec. 14 on the Havana quadrangle, but at too great a depth to permit stripping. This is north of the workings of the Cripple Creek Mine~~ing Company's mines~~ nos. 1 and ~~no~~. 2.

Many small mines have been opened in the ~~small~~ area between Eveland Branch and Big Creek in secs. 24 and 25, and most of the coal remaining there is too deep to make~~#~~ stripping possible. There is a considerable acreage in secs. 25 and 26 west of Eveland Branch ~~#########~~ between ~~of~~ the Cripple Creek Mine no. 1 workings and the outcrop of the coal north of Big Creek, but it is not certainly determined whether or not the coal is present under all of this area ~~or not~~.

In secs. 15 and 22 the coal is much reduced in area by two or more wide preglacial channels which are not related to the present drainage. There are two small areas in the southern half of sec. 22, east of Slug Run shown on the map where the coal lies from 25 to 55 feet below the surface. Local stripping is now being carried on in the southern of these ~~two~~ areas. North of Slug Run in the northernmost part of sec. 22 and the part of sec. 15 on the Havana quadrangle there is a considerable acreage of unmined coal. The coal dips ~~######~~ quite regularly toward the north here, dropping from 619 to 580 feet in about half a mile. The southernmost part of the area may be underlain by coal near enough the surface for stripping, but such an area would be small.

West of Slug Run in ### sec. 16 and the northern part of sec. 21 most of the available coal has been removed in ### Mine No. 3 of the Big Creek Coal Co. The coal here was cut by several preglacial channels and the area still remaining unmined may also possess such channels. The coal has been mined only locally in ########### sec. 21, except the northwest quarter, and a large acreage of coal remains there. The surface altitude is high here and most of the coal is more than 50 feet deep, rendering it unsuitable for stripping. The ~~###########~~ roof conditions ~~here~~ are probably similar to those in the Big Creek Coal Company's Mine No. 3 northwest of here, and the coal should be available for underground mining. No data are available regarding the amount of coal removed ~~here~~ in local mines. Most of the coal in secs. 27, 32 and 34 has been mined by the United Electric Coal Company, or will soon be removed. A large part of sec. 28 has not yet been mined, but it will ##### probably be stripped when the coal with # thinner overburden nearby has been mined out.

The map indicates quite a large acreage of coal unmined south of Cuba in secs. 20, 29 (north half) and 30 (NE. ¼) ###### but much coal has been removed ~~here~~ in mines of which no maps are available. The ######## area of unmined coal remaining ~~here~~ is not known, but it is probably much smaller than indicated on the map.

The southern part of sec. 19 is underlain ### in part by the Herrin (No.6) coal, and the Springfield Coal is about 15-20 feet below it. A considerable acreage of the Springfield coal may remain unmined ~~here~~ at a depth of 50-70 feet. The position of the coal boundary west and southwest of Cuba in secs. 18 and 19 has not been ascertained. It is probably cut out rather sharply in the western parts of these sections, as the drift seems to thicken ~~here~~ within about a mile west of Cuba.

There is not much of the Springfield coal south of Big Creek in this township. The coal has been mined locally, and outcrops in the SE. ¼ sec. 25, and it may extend south into sec. 36, but no information regarding the coal boundary in this section is available. It appears in a few ravines in the southern part of sec. 35, but does not seem to be continuous ~~here~~. Its outcrop line in this section is probably more irregular than ~~is~~ indicated on the map.

Lewistown township, T. 5 N., R. 3 E.

The only part of this township known to be underlain by the Springfield coal is in the NE. ¼ sec. 13, where the coal outcrops in the two branches of the principal ravine. It is thinner than ~~it is~~ in most parts of the quadrangle, averaging less than 3 feet in the two exposures. It is separated from the overlying drift by only three or 4 feet of overlying black shale, and ~~it~~ may have been thinned by preglacial weathering. This exposure may be continuous with that in sec. 18, Liverpool township, but this is doubtful.

Woodland Township, T. 3 N., R. 2 E.

The Springfield outcrops along ravines north of Summum in the Vermont quadrangle, about 1 mile west ~~north~~ of the quadrangle line, and it may extend eastward to underly some of the higher upland in sec. 2. The coal is not exposed in this part of the Havana quadrangle, and no attempt has been made to draw a coal boundary here. If present, the coal is probably near enough the surface to be profitably stripped.

Herrin (No. 6) coal.

The highest coal bed in the Havana quadrangle is the Herrin or No. 6 coal at the top of the Carbondale formation. It was probably deposited over the entire area of the quadrangle, but was removed by preglacial erosion from nearly all of the area. The thickness of the coal in 4 exposures and 3 drill records ranges from 3 feet 10 inches to 6 feet. The lower thickness is not normal, as the coal there immediately underlies the glacial drift, and was probably thinned by preglacial erosion. The coal underlies a part of the southern half of sec. 19, T. 6 N., R. 3 E. (Putman twp.) and probably extends a short distance into section 30 of the same township. It also outcrops in the SW. ¼ sec. 20 and has been penetrated in drillings in the NE. ¼ and NW. ¼ of sec. 20, in the same township. It is not present in 5 drillings in the SE. ¼ of sec. 20. The coal also outcrops on the west side of Buckheart Creek in part of the SE. ¼ SW. ¼ sec. 25, T. 6 N., R. 4 E. (Buckheart twp.). In the exposures here it lies immediately below the glacial drift, and is probably too much weathered to have any value.

The coal lies near enough to the surface to be easily stripped south of Cuba, but it ~~the coal~~ would not be suited for large scale strip mining on account of the abundance of bedded impurities. The coal is known in many parts of the state to possess a "blue band", but near Cuba there are commonly 3 to 5 partings of shale, clay or pyrite. In the upper bench of the coal there are large concretionary masses of siliceous and pyritic material which seem to be petrified wood. These extend down as far as 8 inches into the coal, and would be a cause of much trouble in mining. Fig. 68 shows sections of this coal in its outcrops in the Havana quadrangle.

In the vicinity of Cuba the Springfield coal has been mined out in some places beneath the Herrin coal, leaving the latter, and there seems to be little present interest in this coal. It may be mined more extensively later after the Springfield coal is more nearly exhausted in this region. No analyses of the Herrin coal in the Havana quadrangle are available.

LIMESTONE

There are 12 limestone beds in the Pennsylvanian succession exposed in the Havana quadrangle. The highest of these, the Brereton ~~limestone~~, is ### near the base of the McLeansboro, 9 are in the Carbondale, and 2 in the Pottsville. The greatest thickness attained by any of these limestones is 6 feet, the thickness of the Seahorne limestone (Pottsville) along the south bank of Seahorne Branch in part of the SE. ¼ sec. 5, T. 3 N., R. 3 E. (Kerton twp.). The average thicknesses of most of the limestones is less than one foot, so it is unlikely that any of them will be of economic importance except for local use in competition with the thicker and purer Mississippian limestones of other parts of western Illinois.

The percentage soluble in dilute hydrochloric acid ($CaCO_3$, etc.), in typical specimens of each of the 12 limestones is given here: (The member numbers refer to the general Pennsylvanian section, pp. 27-30)

Member No.	Local name	% $CaCO_3$, etc.
79	Brereton (Cap of No. 6 coal)	91.44
73		86.00
69		72.02
66	St. David (Cap of No. 5 coal)	87.13
55		72.74
50		81.35
48		86.58
44		73.63
42		81.28
40		88.08
32		90.62
27	Seahorne	88.18

The impurities in the limestones are principally clay, minute grains of quartz, clay particles cemented into small concretions by silica or iron oxides, pyrite crystals, and silicified or pyritized shell fragments. Most of the limestones contain enough iron to weather to a brown color.

In the strip mining of the Springfield (No. 5) coal near Cuba the St. David limestone (No. 66), the cap rock of the coal, is commonly removed in large blocks and piled on the spoil banks (fig. 142). Although this limestone averages only about 1 foot in thickness it could probably be separated during the stripping of the coal if there were any local demand for limestone, as for agricultural limestone. Its recovery from the spoil banks themselves would be difficult, because of the uneven topography of the stripped areas.

SAND AND GRAVEL

The supply of these materials in the Havana quadrangle comes entirely from Pleistocene and recent deposits. Gravel is not plentiful, and no large production may be expected from this quadrangle, but sand is very abundant in the broad terrace east of Illinois River near Havana.

Gravel

Some gravel has been dredged from the channel of Illinois River near Havana for use in constructing a concrete wall around Beardstown, to protect it from floods. Gravel also occurs in the Illinoian and Yarmouth deposits in parts of the quadrangle.

The Yarmouth gravels are principally exposed along Big Creek and Slug Run in secs. 22, 25, 26 and 35, T. 6 N., R. 3 E. (Putman twp.) and sec. 30, T. 6 N., R. 4 E. (Buckheart twp.) and along Big Sister Creek in sec. 8, T. 5 N., R. 4 E. (Liverpool twp.). (See fig. 80). This gravel ranges from 4 to 15 feet in thickness. It was exposed to weathering for a long time after its deposition before it was buried by Illinoian glacial drift and is therefore oxidized to a brown color, some of the pebbles are largely decomposed, and it has been locally cemented into a conglomerate. All of these qualities would detract from its value as a gravel resource. In addition it is not favorably exposed for development, as it is commonly covered ~~overlain~~ by an overburden of 20-35 feet of loess and drift.

The Illinoian gravels were deposited either in front of the advancing ice sheet, which later buried them, under the ice in subglacial channels, during a temporary recession of the ice from the area, or as outwash deposits in front of the receding ice sheet. The conditions of their deposition did not, in most places lead to a good assortment of the fragments according to size, and changes in the rate of melting of the ice and the consequent change in the velocity of flow of glacial waters, caused frequent variations in the size of the materials deposited, from coarse gravels or boulder deposits to sands. Sands and gravels deposited under these conditions are especially abundant in the west central part of the quadrangle along Stuart Creek and its tributaries in secs. 13 and 14, T. 5 N., R. 2 E. (Bernadotte twp.) ### along a tributary of Big Creek in sec. 7, T. 5 N., R. 3 E. (Lewistown twp.) and along the North Branch of Otter Creek in sec. 24, T. 4 N., R. 2 E. (Pleasant twp.) The greatest thickness of gravel of Illinoian age is exposed in the high cut bank on the south side of a tributary of Stuart Creek in the NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 13, T. 6 N., R. 2 E. (Bernadotte twp.) described in geologic section 52 and pictured in fig. 85. The total amount of gravel in this cut is $24\frac{1}{2}$ feet. The overburden consists of 8 to 10 feet of 10ess, $14\frac{1}{2}$ feet of till and $6\frac{1}{2}$ feet of sand. The layers of gravel and sand in this cut seem to be lenticular and the proportions given here may change a short distance back from the outcrop. The gravel and ~~the~~ sand are fairly well assorted, and have not been ~~much~~ weathered. The locality is, however, about 4 miles from the nearest railroad, so it could ## probably be developed only for local use.

Secondary concentrations of gravel are found in bars in streams flowing ####### past exposures of Pleistocene gravels, and gravels may be concentrated by streams out of the glacial drift (Fig. 8). ~~Small~~ Supplies of rather well washed gravel for local use in road construction or repair might be obtained from such concentrations in the smaller streams in many parts of the quadrangle.

Sand

The soil and surficial deposits in the terrace east of Illinois River near Havana are nearly all sandy, but the level terrace areas are underlain by a more impure sandy loam than the hills, which are principally well assorted dune sand. The principal dune areas are shown on the geologic map (Plate I). The thickness of sand here is not known, but the Havana city wells penetrate about 75 feet of sand and gravel. Several of the dune areas are situated near railroad lines and sand pits could be opened easily near such transportation. In the NW. ¼ sec. 7, T. 21 N., R. 8 W. (Havana twp.) there is a dune area near the Illinois Central and Chicago and Illinois Midland (shown on map as Chicago, Peoria and St. Louis) railroads. A dune ridge continues south through sections 7, 18, and 19 of the same township just west of the Chicago and Illinois Midland railroad. This railroad also crosses a small dune area in the NE. ¼ NE. ¼ sec. 33, T. 22 N., R. 8 W. (Havana twp.), ~~This area~~ adjoin~~s~~ing the most extensive dune tract in the quadrangle. State Highway 43, east of Havana, crosses a sand dune belt nearly 2 miles in width in secs. 4 and 5, T. 21 N., R. 8 W. (Havana twp.) Some of the sand dune areas might also be accessible to the proposed Illinois River deep waterway.

The results of sieve analyses of six samples of sand are shown in fig. 143. The ####### sands from the terrace show a somewhat poorer assortment than those from dune areas on the terrace and the shore of Quiver Lake at Quiver beach. Some small pebbles from 3-8 millimeters in diameter are found in most of the sands of the terrace. Concentrations of these pebbles are ~~not un~~commonly found in blowouts in sand dune areas where the finer grains have been blown away. The sand grains of the terrace and dune deposits are principally composed of quartz with subordinate amounts of gray, white and brown chert, jasper, feldspar, magnetite, and small fragments of dense igneous rocks such as basalt. The quartz grains in most of the dune sand samples are well rounded to subrounded with a small proportion of subangular grains. In many of the dune sands there is a considerable admixture of dust particles of much finer size than most of the grains. These are probably of more recent origin and have been washed down into the sands.

The uses of sands have been recently summarized 3/. The dune and

---

3/ Lamar, J. E. Geology and Economic Resources of the St. Peter Sandstone of Illinois. Ill. State Geol. Survey Bull. 53, pp. 99-142, 1927. The reader is referred to this paper for specifications for sand used for each of the purposes named here.

---

terrace sands of the Havana quadrangle seem to be adapted to the following uses:

(1) Sand for asphalt pavements
(2) Ground sand for asbestos shingles
(3) Sand bedding for stock cars
(4) Core sand
(5) Cutting and sawing sand
(6) Engine sand
(7) Sand for a fertilizer filler
(8) Sand as a filler for rubber, paper, soal and linoleum
(9) Filter sand
(10) Friction sand
(11) Grinding and polishing sand
(12) Common molding sand
(13) Sand for plasters
(14) Sand for railroad fills
(15) Sand for sandbags (as for levee protection)
(16) Scouring sand.
(17) Sweeping sand
(18) Tumbling sand

(128)

442

Fig. 143.

Results of sieve analyses of Wisconsin (Pleistocene) and recent sands from Havana quadrangle and vicinity.

Locations on 31b.

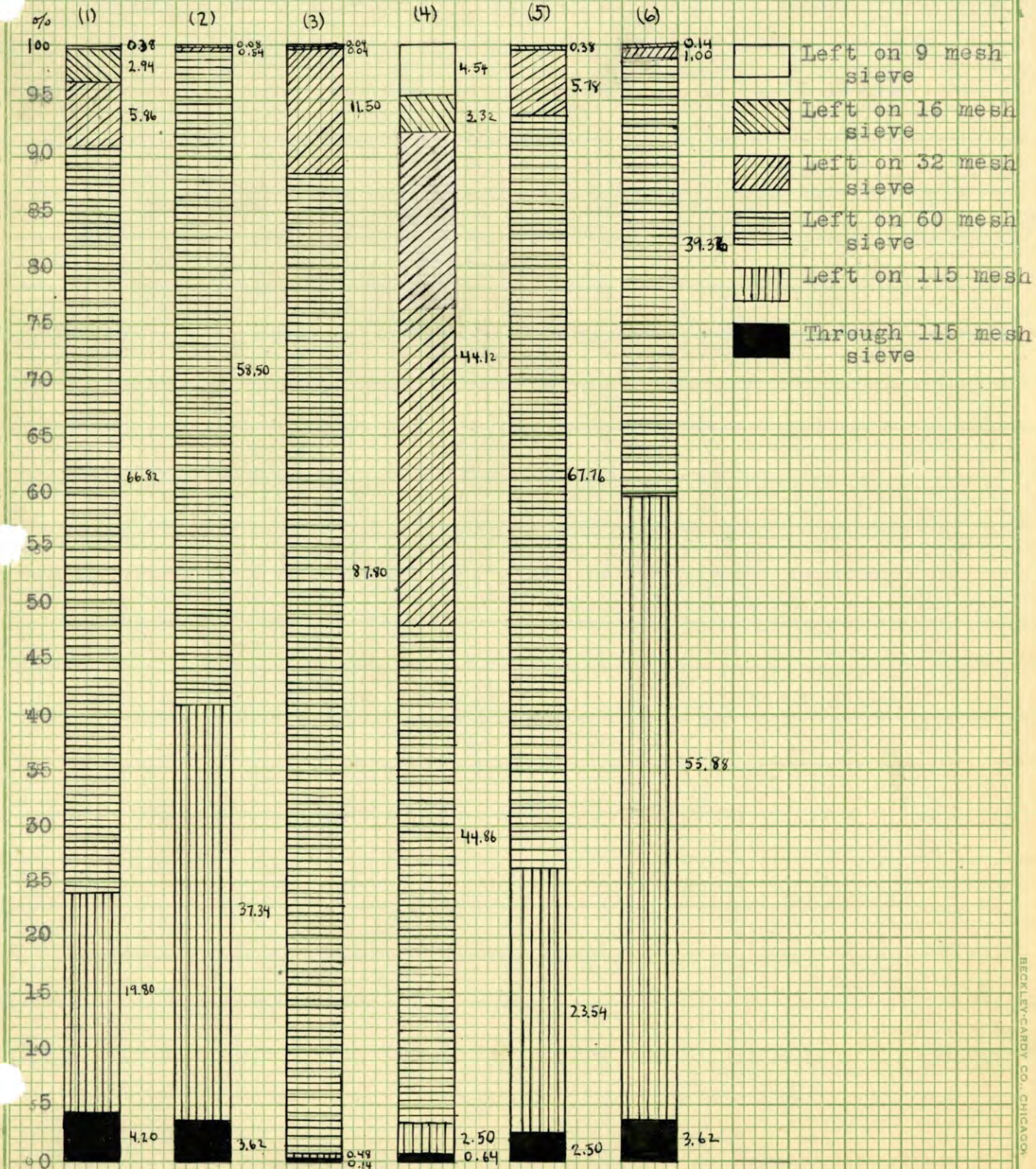


Fig. 143. Results of sieve analyses of Wisconsin (Pleistocene) and recent sands from Havana quadrangle and vicinity. (on ~~31a~~ 28)

(1) Dune sand from NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 33, T. 22 N., R. 8 W. (Havana) typ typ!

(2) Dune sand from ~~SW.~~ SE. $\frac{1}{4}$ ~~SW.~~ SE. $\frac{1}{4}$ sec. 11, T. 21 N., R. 9 W. (Havana)

(3) Sand from lower terrace at Quiver Beach, NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 30, T. 22 N., R. 8 W. (Havana) typ, somewhat worked over by recent wave action during high water stages

(4) Sand from low terrace below base of Indian mound ~~##########~~ at south end of Chautauqua Park, about 200 feet from bank of Quiver Lake, near NW. corner sec. 31, T. 22 N., R. 8 W. (Havana) typ

(5) Dune sand from top of dune 80 feet high in sec. 21, T. 23 N., R. 7 W. (Quiver) typ in the Manito quadrangle.

(6) Sand from lower terrace, NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 34, T. 4 N., R. 3 E. (Isabel) typ

Clay and Shale

Clay and shale are abundant in the Pennsylvanian strata exposed in the Havana quadrangle. Excluding the carbonaceous, calcareous and sandy shales there are 10 shale members (6 in the Carbondale and 4 in the Pottsville and 11 underclay members (3 in the Carbondale and 8 in the Pottsville). Clay is also an important constituent of the glacial drift, loess and water-laid silts of the Pleistocene system.

The underclays are much thinner than the shales, and unless they are sufficiently refractory for the manufacture of fire brick and other refractory materials their use would be less satisfactory than that of the shale. The underclays also contain large calcareous septarian concretions scattered through them and some pyrite and gypsum, which would be undesirable impurities.

The shales which are thickest and could be most easily dug are the Canton ~~shale~~ (members 68 and 70) about 28-30 feet thick, with a thin limestone concretion band (member 69) about 8 feet from its base, the Purington ~~shale~~ (member #52) about 30-50 feet thick and the Francis Creek shale (member 37) which varies from 18-20 feet in the east central part of the quadrangle to 45-50 feet in the west central part.

Four samples of clay and one of shale were collected and burning tests were made upon them by the Department of Ceramics of the University of Illinois. The beds sampled are those ~~the beds~~ numbered 20, 22, 28, 35, and 70 in the generalized section of the Pennsylvanian (Ch. II). The sections from which the samples were collected are described here, and the results of the tests are given in Appendix B, part 2.

Two samples, nos. 118 and 119 were collected in the ravine exposure just west of State Highway 31 south of the bridge over Otter Creek. (fig. 144)

Green-bush

Wiley

Sea-horne

"Brush Creek"

Fig. 144 Exposure of Pottsville strata in the small ravine south of Otter Creek just west of State Highway 31 in the NW. ¼ SE. ¼ sec. 30, T. 4 N., R. 3 E. (Isabel twp.). Clay samples 118 and 119 were taken from this exposure, no. 118 from the lowest bed exposed ~~here~~, shown at the lower right, and no. 119 from the clay or shale below the ledge of sandstone which forms a waterfall in the middle distance. The man is standing at the horizon of the ~~Ray~~ Seahorne limestone, which is separated from the sandstone below by a layer of clay containing gypsum crystals.

Geologic section 75. Exposure in lower part of ravine west of State Highway 31 in the NW. ¼ SE. ¼ sec. 30, T. 4 N., R. 3 E. (Isabel twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Pottsville series		
Greenbush formation		
15. Clay, gray, with large septarian calcareous concretions	1	6
Wiley formation		
14. Coal		8-10
13. Underclay, gray	3	
Seahorne formation		
12. Limestone concretions, fossiliferous, not persistent here, but forming a limestone ledge 3 feet thick about 300 feet further up ravine (Seahorne limestone)	1	
11. Clay, gray, with large calcareous concretions	2	
10. Coal parting		1
9. Underclay, gray, with large unfossiliferous calcareous concretions and gypsum crystals	2	6
8. Coal parting		1
7. Underclay, gray, with gypsum crystals	3	
6. Sandstone, fine grained, hard		4
5. Sandstone, thinly bedded	5	
"Brush Creek" formation		
4. Shale, gray, or clay, indistinctly bedded (Sample 119)	4	6
3. Shale, dark gray		2
2. Coal		1½
1. Underclay, gray, with blocky fracture (Sample 118)	3	

Samples 117 and 120 were collected along the ravine south of the C. B. & Q. R. R. in sec. 1, T. 4 N., R. 2 E. (Pleasant twp.).

Geologic section 76. Exposure along ravine south of C. B. & Q. R. R. in the NW. ¼ SW. ¼ sec. 1, T. 4 N., R. 2 E. (Pleasant twp.)

	Thickness Feet	Thickness Inches
Pennsylvanian system		
Carbondale series		
Summum formation		
15. Sandstone, thinly to massively bedded, with uneven basal surface (Pleasantview sandstone)	60	
"Liverpool" formation		
14. Shale, gray (Francis Creek ~~shale~~)	8-11	
13. Coal (Colchester ~~or~~ No. 2)	2	6
Pottsville series		
12. Underclay, gray (Sample 120)	4	
11. Sandstone (Isabel ~~sandstone~~)	4	
Greenbush formation		
10. Shale and nonbedded clay	5	
Wiley formation		
9. Coal		6-10
8. Underclay, gray (Sample 117)	1	6
Seahorne formation		

447

7.	Limestone, blue gray, fossiliferous (Seahorne ~~limestone~~)	1	
6.	Underclay, with blocky fracture	5	
5.	Sandstone, white to light gray, coarse, granular	1	3
"Brush Creek" formation			
4.	Shale, gray	6	
3.	Shale, black		4
2.	Coal		1
1.	Underclay	5	

Samples 118 and 119 were collected from beds corresponding to nos. 1 and 4 respectively in the outcrop above.

Sample 116 was collected from the Canton shale (Fig. 10)

Geologic section 77. Exposure along a ravine in the NE. ¼ SW. ¼ sec. 23, T. 6 N., R. 3 E. (Putman twp.)

	Thickness Feet	Inches
Pennsylvanian system		
Carbondale series		
Brereton formation		
3. Sandstone, thinly and thickly bedded very fine grained (Cuba ~~sandstone~~)	20	
St. David formation		
2. Shale, slightly sandy, evenly bedded	5-6	
1. Shale, gray (Canton ~~shale~~) (Sample 116)	25+	

The Canton shale has been used in the vicinity of Canton for the manufacture of paving, building and sidewalk brick, hollow block and drain tile 4/ and it could probably yield equally satisfactory products in

4/ Savage, T. E. Geology and mineral resources of the Avon and Canton quadrangles, Illinois State Geol. Survey, Bull. 38, p. 262, 1921.

~~THE~~ Havana quadrangle.

Purington shale

No samples of this shale were collected for tests, as similar shale in the same stratigraphic position has been used for many years at East Galesburg, Knox County, in the manufacture of Paving Brick. 5/

5/ The results of tests of a sample of this shale collected at East Galesburg is published in "Clay Materials in Illinois Coal mines", by R. T. Stull and R. K. Hursh, Illinois State Geol. Survey, Coop. ~~######~~ Coal Mining series, Bull. 18, p. 37, 1917. It is stated that it is suitable for common, front, and paving brick and hollow tile.

The Purington shale is well exposed along the ravine followed by the West Havana line of the C. B. & Q. R. R. in the NW. ¼ sec. 32, and the NE. ¼ NE. ¼ sec. 31, T. 6 N., R. 3 E. (Putman) top. ~~###########~~ and in the NW. ¼ sec. 33 of the same township along the ravine in which the railroad line leading to the United Electric coal company strip mine is situated. In both of these places pits could be opened close to railroad transportation.

Francis Creek shale.

No samples of the Francis Creek shale~~, the roof shale of the Colchester (No. 2) coal,~~ were collected for tests. This ~~shale~~ is in some places slightly more sandy than the Purington and Canton shales, but in most places it could be used for the same uses as those to which these shales have been put at ~~##########~~ East Galesburg and Canton. ~~This shale~~ It is well exposed along the tributary of Big Creek which flows east across sec. 5, T. 5 N., R. 3 E. (Lewistown) top. which is followed by the West Havana branch of the C. B. & Q. R. R. It is also exposed along East Creek in the SE. ¼ sec. 22, of the same township just east of the city of Lewistown. The mantle of drift ~~#######~~ here is somewhat thicker than in the first named locality, so conditions would not be so favorable for pit mining.

Summary.

Tests of the clays and shales of theHavana quadrangle and their equivalents elsewhere, show that there are abundant deposits suitable for ordinary brick and tile and other nonrefractory clay products. The only clay tested which is refractory is a clay in the Pottsville series in the "Brush Creek formation" ~~4th sedimentary sequence~~ (bed ~~42~~ 20 of the general section) which is locally 5 feet thick, and is probably the approximate stratigraphic equivalent of the Cheltenham clay of the St. Louis district. No development of the clay and shale resources of the Havana quadrangle has yet been undertaken.

OIL AND GAS

(1st paragraphs from Herschel's report)

Oil

Several factors determine whether or not oil may occur in a given area. It is not necessary that prospectors be able to recognize all of them, but they are instrumental in the formation and accumulation of the oil.

First of all there must be a source-bed in which the oil was formed. Any bed which once contained a large amount of organic matter buried in such a way that it was preserved and metamorphosed through physical, chemical and bio-chemical processes into petroleum, is a source-bed. Such a bed is usually shale or limestone, but frequently it is impossible to recognize the source-bed ########## from which an oil came because the reservoir-bed in which the oil occurs may not be the source bed. The presence of a probable source-bed in an area is no indication that oil is sure to occur but assurance that no source-beds are present in the vicinity would eliminate the area from favorable consideration. It is not necessary to find the source-bed in oil prospecting if the reservoir-bed is known to have yielded showings of oil. Recognition of the source-bed is important, however, for other areas in which it is known to occur should be studied for the favorable occurrence of reservoir-beds, cap-rock, and structure. If conditions are right, such areas should be tested ~~for oil~~.

A second requisite for oil accumulation in commercial amounts is the presence of a suitable reservoir-bed, such as a porous sandstone or a porous, cavernous or fissured limestone. Oil that is widely disseminated through an impervious rock cannot be pumped out in commercial quantities. The rock must be of such a character that the oil is free to flow readily under pressure.

Another requisite is that there be cap-rock, that is a shale or an impervious stratum, over the reservoir-bed to prevent the upward migration and dissemination of the oil.

A fourth necessary condition is the presence of rock structure suitable for the accumulation of oil. As oil is usually associated with water and

~~as there is~~ an a

as there is an active circulation of the underground waters, the structures must allow the oil to accumulate above the water or in places where it may be trapped out of the course of the circulating waters. The most common structures which satisfy the conditions are domes or anticlines and terrace structures on monoclines. The oil would be expected to accumulate on the high part of the structure in the Illinois region.

In most regions, such as the Havana area, drilling need not be carried on blindly because the formations in the area are known and those which carry oil in other localities are also known. Furthermore, drill records show the quantity of oil encountered.

No oil has been produced in the Havana quadrangle up to the present, but the discovery of oil near Colmar and Plymouth, McDonough County, about 35 miles west of the Havana quadrangle, in 1914 has led to the drilling of several wells in the Havana quadrangle in search of oil.

The formations ~~##########~~ in and near the Havana quadrangle which are known to contain oil elsewhere in Illinois are (1) the Pennsylvanian (especially Pottsville) sandstones; (2) the Silurian (Niagaran) dolomite; (3) the Hoing sand at the base of the Silurian (not known to be present in the Havana area; and (4) the Galena dolomite.

The Pennsylvanian sandstones are reservoir rocks for oil in parts of the oil fields of southeastern Illinois. In the Havana quadrangle they lie at such shallow depths and have been penetrated in so many drillings without the discovery of traces of oil that it is very improbable that oil is present in these sandstones.

The Silurian dolomite is a reservoir rock for gas and a little oil in Pike County, about 100 miles southwest of this quadrangle. In the Havana quadrangle it is reported that a strong flow of salty water comes from this formation, but no oil has been reported.

The Hoing ~~sand~~ 6/ is a thin sand consisting of well-rounded quartzitic

6/ Hinds, H., Colchester-Macomb Folio, Illinois. U. S. G. S. Geological Atlas Folio 208, p. 12, 1919.

grains occurring in lentils on the top of the Maquoketa shale and commonly under Silurian dolomite. It accumulated in depressions on the top of the Maquoketa and was reworked by the Silurian sea, so that its age is Silurian. Owing to the conditions under which it was deposited and in part to subsequent erosion the Hoing sand is irregularly distributed and is absent in many districts; in its largest productive area in McDonough County it ranges from 5 to 30 feet and averages 14 feet in thickness. The horizon of the Hoing sand has been penetrated in at least six wells in the Havana quadrangle, but sandstone has not been reported in the records of any of these wells. There is then no sure indication of its presence in any part of the Havana area.

The Galena dolomite is of approximately the same age as the Kimmswick (Trenton) formation which ######## yields a commercial supply of oil in the Waterloo and Dupo fields in Monroe and St. Clair Counties in southwestern Illinois. No oil show has been reported from it in the Havana area.

Results of previous exploration.

Six of the seven deep wells in the quadrangle were drilled in search of oil. The available information concerning these tests is here briefly summarized:

(1) Well at Depler Springs, sec. 8, T. 5 N., R. 3 E. (Lewistown twp.). Depth 2245 feet. No record of strata available. A letter from Mr. Depler of Lewistown states that a ###### flow of very sulphurous water was struck at 600 feet (probably in the ######################### Silurian or Devonian limestone) and at 1100 feet, near the base of the Galena dolomite a flow of 1500 gallons per minute was obtained. No show of oil was reported.

(2) F. W. Harrison well. S. of the center of SW. ¼ sec. 29, T. 6 N., R. 4 E. (Buckheart twp.). Depth 1395 feet, ending near the base of the Galena-Platteville. (See record 10, Appendix C (Part I)). Gas was reported in sufficient quantity below 200 feet to burn continuously. This is near the ~~base~~ middle of the Pottsville formation. No oil show was reported.

(3) Robert Zempel well. NE. cor. NW. ¼ sec. ~~24~~ 12, T. 5 N., R. 2 E. (Bernadotte twp.). Depth 820 feet, ending in the Silurian or Devonian limestone. (See record 12, Appendix C (pt. I).) No showing of oil or gas was reported from this well.

(4) Brock well. SW. ¼ sec. 24, T. 5 N., R. 2 E. (Bernadotte twp.). Depth 929 feet, ending in the upper part of the Galena dolomite. (See record 13, appendix C (Pt I)). Nearly fresh water was reported from a depth of 257 feet, near the top of the "big lime" (Keokuk-Burlington) ~~limestone~~. A flow of salty and sulphurous water was reported from the "second lime" (Silurian-Devonian) at about 648 feet. The well now flows from this level. Another strong flow of water said to have been fresh, but with a "flat" taste was encountered at 965 feet in the upper part of the Galena dolomite. No oil show was reported.

(5) Miller well. NW. ¼ SE. ¼ sec. 19, T. 5 N., R. 3 E. (Lewistown twp.). Depth 1045 or more feet. No record of the well is available. During 1928 water was flowing from the top ~~of the well~~.

(6) Hahn well. NW. ¼ sec. 31, T. 22 N., R. 8 W. (Havana twp.). Depth 1442 feet, ending near the top of the St. Peter sandstone. (See record 19, Appendix C (Pt I)). Flows of water were reported from limestones of the St. Louis, Warsaw, Burlington, Devonian (Wapsipinicon), Silurian ("Niagaran") and Galena formations. The flow of water from the "Niagaran" limestone is reported to be mineralized. The flow amounted to 5000 barrels a day when the well was completed. No oil show was reported.

Recommendations.

No tests for oil need to be carried below the base of the Galena-

Platteville dolomite and limestone, as oil is not known to occur in older strata. The depth to this horizon varies from about 1400 feet in the western part of the area to about 1650 feet in the southeast part of the quadrangle.

The strong flow of water obtained from most of the possible oil bearing horizons indicates that these strata are saturated with water under pressure, and if any oil is present it must be on the higher parts of structures.

The structures of the Springfield (No. 5) and Colchester (No. 2) coals and seven pre-Pennsylvanian horizons are contoured in figs. 121-129. The predominant structures are a general southeast~~ward~~ dip and a shallow east~~ward~~ pitching syncline which crosses the northern part of the Havana quadrangle. Weak anticlinal structure with two or more small enclosed domes is indicated south of this syncline on the structure map of the Colchester coal, but the slopes of these structures are so gentle as to be unfavorable for the migration and concentration of oil. If the steeper dip of the Springfield (No. 5) coal along certain parts of the valley of Buckheart Creek and its tributaries continues down into the deeper strata, an anticline pitching east~~ward~~ may lie in sections 1 and 2, T. 5 N., R. 4 E. (Liverpool). No drill records are available in this immediate vicinity.

As no reservoir bed is known to contain oil under any part of the Havana quadrangle, and as no structures particularly favorable for oil accumulation are known, the chance of finding oil in commercial quantities in the area is not believed to be particularly good.

Gas in the glacial drift

Small quantities of natural gas are encountered in some wells at or near the base of the glacial drift. This gas is formed from the decay of plant material in old soils or peat beds of interglacial or preglacial age. The distribution of these materials is rather sporadic, as they were removed from most of the area by the Illinoian glacier. They are somewhat more likely to be preserved in the bottoms of preglacial valleys which were filled with drift, as the ########### glacier performed less erosion in the smaller valleys than it did on the divides between ~~them~~. Gas is reported in the well of a farm in the SW. ¼ SE. ¼ sec. 35, T. 6 N., R. 3 E. (Putman twp.). The gas pressure is so low in most ######## wells in the glacial drift that the flow varies with the atmospheric pressure. The zones from which the gas is formed are thin and the total amount of gas present is small.

WATER

The Havana quadrangle is well supplied with water, both surface and underground. The surface waters are little used, except where dams have been built across small ravines and reservoirs for watering stock have been made. The water of ~~the~~ Illinois River is not suitable for human consumption here, as it ~~here~~ carries much of the sewage of Chicago and Peoria.

A part of the rain water ~~of rains~~ sinks into the ground and moves slowly downward through the soil and subsoil until it reaches ~~top of the~~ the zone which is already saturated with water, the upper surface of which is ~~or~~ the water table. When wells are sunk below ## the water table the surrounding water ~~water~~ flows toward the well, ~~and may be pumped.~~ The altitude of the water table is not constant at any place, as it is varies with ~~dependent upon~~ the amount and nature of rainfall, the ~~east with which~~ the permeability of the surface soil, ~~admits the water of rains,~~ ############ and the amount of water which is ~~may be~~ withdrawn ~~from it~~ in wells. The water table is usually nearer to the surface in #### level areas than in a hilly country, and it is nearer the surface in the valleys of the larger streams than in level uplands away from the streams. The water table is also nearer to the surface in places where there is an impervious layer of some sort at a shallow depth, which holds the water above it. Where such impervious layers outcrop along the sides of valleys the water may reach the surface as springs or a line of seepage along the outcrop.

Where the strata are inclined, ### water may enter a porous stratum along its line of outcrop and move along this stratum in the direction in which it is dipping to a ################ depth of several thousand feet below the surface and a distance of several hundred miles. If there is a change in the direction of dip and the porous layer passes beneath a nonporous layer like a shale formation the water may accumulate in the lowest part of the structure until it ########### is under considerable pressure or "head". When a well is drilled penetrating water which is under such a "head" the water will rise in the well, and if the head is sufficient, the water will flow to the surface. The name artesian is used for such wells whether the water flows at the surface or simply rises some distance above the top of the stratum in which it occurs. There are several #### artesian wells in the Havana quadrangle.

The chemical character of underground water depends largely upon the distance which it has traveled after entering the soil and the chemical character of the rocks through which it has passed. Thus water from limestone formations is commonly "hard" because some of the limestone has decomposed in the ### water forming the soluble bicarbonate of calcium. As much finely ground limestone is present in glacial drift and loess, water from these materials is also ~~commonl~~y hard. ## Marine sediments ######### commonly contain some salt which may be dissolved ~~out~~ by water passing through them. Coal beds and associated strata contain much iron sulphide, either pyrite or marcasite. This is decomposed by underground water and soluble sulphates may be carried away in waters which have passed through such strata. Thus waters from Pennsylvanian strata in many places contain too much ###### dissolved sulphate to be satisfactory for domestic use. Waters from deep wells in many places are more highly mineralized than waters at shallower depths, although some deep water bearing strata yield water with a low content of dissolved solids.

When a deep well is drilled water is commonly encountered in several strata. The water pumped from the well may not, thus, be typical of any one of the water bearing formations, but a mixture of all. The total yield of a well may be increased by making use of all of this# water, but if the water from any of the strata contains an undesirable quantity of dissolved solids it is desirable ~~well~~ to case the well through such strata.

Most of the farms in the Havana quadrangle obtain water from the loess or drift, or alluvial deposits, or from the top of the bed rock. A few wells obtain water from the Pennsylvanian and Mississippian formations. The city of Cuba obtains water from the St. Peter sandstone of the Ordovician system.

City and village water supplies.

Havana, Lewistown and Cuba have ~~city~~ public water supplies. ### Analyses of samples of water from these ci~~ty supplie~~s ## are given in table 3, p. 43. 7/

7/ Analyses and some other data on these water supplies are taken from Habermeyer, G. C. Public Ground Water Supplies in Illinois, Illinois State Water Survey, Bull. 21, pp. 159-161, 280-281, and 353-355, 1925, supplemented by later information from the officials in charge of water supply in these cities.

The city water of Havana in 1927 was drawn from 4 driven wells 75 feet deep and 1 drilled well 77 feet deep, sealed at the base. No log of these wells was obtained, but they passed through sand and well rounded stream gravels, but no loess, till or rock. The base of the wells is probably within 10 or 15 feet of the ## base of the valley fill. ######## The water in a ~~new~~ well drilled in November, 1927 stood 19½ feet from the surface before pumping. The level of water i~~n the well~~s varies somewhat according to the level of ~~the~~ Illinois River. The average daily amount of water pumped in November, 1927, was 260,000 gallons. In 1921 the average amount of water used was estimated at 350,000 gallons. It #is said that 3,000,000 gallons has been pumped in 24 hours. The water has a mineral content of 197, a total hardness of 165 and an iron content of 0.2 parts per million in a sample# collected ~~on~~ September 23, 1921.

Table 3. Analyses of well waters of the Havana Quadrangle.

	Havana	Lewistown	Cuba	Depler Springs	Sec. 31, T.22 N., R.8 W.
Laboratory number	46148	46149	49558	12808	46611
arts per million of—					
otassium	1.9	3.0	106.1		52.7
odium	4.5	30.1	474.2		654.6
Ammonium	0.0	0.0	36.1		1.5
Magnesium	15.0	33.8	95.7		42.9
Calcium	41.8	74.8	137.3		106.7
Iron	0.2	0.0	0.8		0.0
Alumina	2.0	1.0	7.1		3.0
Nitrites					
Nitrates	8.0	1.8	1.4		1.1
Chloride	6.0	9.0	392.0	467.5	585.0
Sulphate	27.0	104.2	1116.0		729.8
Residue	237.	460.	2560.	2266.0	2517.
Silica	9.3	12.4	18.4		14.5
Manganese	0.0	*0.0	0.0		0.0
Alkalies	136.	254.	226.0		280.0

Hypothetical combinations

	Parts per million	Grains per gallon	Parts per million	Grains per gallon	Parts per million	Grains per gallon	Parts per million	Grains per gallon	Parts per million	Grains per gallon
otassium Nitrite										
otassium Nitrate	4.8	.28	2.9	.17	2.3	.13			1.7	.10
otassium Chloride			3.4	.20	200.6	11.71			99.3	5.80
odium Nitrate	6.8	.39								
odium Chloride	6.7	.39	12.2	.71	488.6	28.53			886.7	51.86
odium Sulphate			78.1	4.57	870.9	50.86			944.1	55.21
odium Carbonate										
Ammonium Chloride	0.1	.01								
mmonium Sulphate ~~Carbonate~~			0.2	.01	132.0	7.71			5.6	.33
Magnesium Chloride	2.5	.14								
agnesium Sulphate	33.8	1.97	64.1	3.75	472.8	27.61			108.5	6.35
agnesium Carbonate	26.0	1.52	72.1	4.22					72.5	4.24
alcium Sulphate					74.4	4.34				
Calcium Carbonate	104.4	6.10	186.9	10.93	287.9	16.81			266.3	15.57
ron Carbonate										
ron Oxide	0.3	.02	0.0	0.0	1.1	.06			0.0	.00
Alumina	2.0	.12	1.0	0.06	7.1	.41			3.0	.17
Silica	9.3	.54	12.4	.72	18.4	1.07			14.5	.85
Bases										
Non-volatile	0.7	.04	0.8	.05	2.2	.13			2.0	.11
Total	197.4	11.52	434.1	25.38	2558.3	149.37	2138		2404.2	140.59
% Error										

The city water of Lewistown comes from 3 driven wells and 1 drilled, cement cased well in the Spoon River bottom lands in the SW. ¼ SW. ¼ sec. 32, T. 5 N., R. 3 E. (Lewistown twp) about 2½ miles southwest of the city. The wells are 28 feet deep. The upper part of the wells is through loam and below this is sand with some gravel, appendix C - Part II. Water stands in the wells 15 feet below the surface before pumping. The average consumption of water is 175,000 gallons per day and the wells were said to have a capacity of 344,000 gallons per day. A sample collected ~~on~~ September 22, 1921 had a mineral content of 434 and a total hardness of 325 parts per million and contained no iron.

The ~~###~~ water of Cuba is derived from a well 1768 feet deep in the northern part of the village. The base of the well is 298 feet below the top of the St. Peter sandstone, and probably near its base. The sequence of strata penetrated in this well is shown in figs. 15 + 181. The water stands in the well 103 to 136 feet below the surface. The well is cased to a depth of 317 feet. The temperature of the water is 73° F., which indicates that a large part of the water comes from the lower part of the well. The mineral content is 2558, the total hardness 735 and the iron content .8 parts per million in a sample collected May 28, 1923. As shown in Table 3, the principal dissolved solids are sodium sulphate, sodium ~~carbonate~~ chloride and magnesium sulphate in the order of abundance named. The ~~###~~ water from the St. Peter sandstone is known to become increasingly saline toward the south in Illinois and a little farther south than this it is too salty to be suited for human use. ~~Thus~~ In Rushville, about 45 miles southwest of Cuba ~~###~~ a well in the St. Peter sandstone yielded water containing 4121 parts ~~###~~ of dissolved solids per million, principally sodium chloride. A part of the sulphates and chlorides in the Cuba well may come from porous lay#ers in the Burlington limestone (Mississippian), the Niagaran dolomite (Silurian) and the Galena dolomite (Ordovician) above the St. Peter, as the## water from these horizons is not cased off. In 1923 the amount of water pumped daily was estimated at 15,000 gallons.

The village of Bryant has no public ######### water supply. Water is obtained by residents from dug or bored wells in sand at depths of 18-20 feet. This is about the thickness of the Pleistocene materials at Bryant, so the water probably comes from the top of the bed rock surface.

The village of St. David has no public water supply. Water is obtained from private wells dug into the drift to depths ranging from 20 to 35 feet, ### 15 to 20 feet above the surface of the bed rock.

Flowing wells.

Three deep wells which were drilled in search of petroleum are now flowing wells. The strongest flow comes from the well drilled for Mr. J. B. Depler by W. H. Gray and Brother along the north bank of Big Creek near the center of the NE. ¼ sec. 8, T. 5 N., R. 3 E. (Lewistown twp.) about 3 miles northwest of Lewistown. A flow of water containing considerable sulphur was recorded at 600 feet. Below the Galena (Trenton) limestone and dolomite the well was flowing 1500 gallons a minute. It was drilled to a depth of 2245 feet, probably ending in ####### the upper Cambrian (Croixan) sandstone or dolomite. The well was drilled in 1904 and in 1917 the flow was estimated at 720## gallons a minute. Swimming pools were erected beside the well and a resort established there. The water still has a strong flow. A sample of water from this well collected in 1904 had a mineral content of 2138 and a total hardness of 515 parts per million (Table 3.)

A well drilled for Mr. J. H. White and Sons of Havana for oil in the NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 31, T. 22 N., R. 8 W. to a depth of 1442 feet into the top of the St. Peter sandstone is reported to have had an initial flow of about 5000 barrels per day. A sample of ## water from this well ~~collected~~ had a mineral content of 2400 and a total hardness of 440 parts per million.

A well drilled for oil along the edge of Big Creek valley near the center of sec. 19, T. 5 N., R. 3 E. (Lewistown twp.) is now flowing#. ## No information regarding the# strata from which this water comes was obtained.

Farm wells.

The farm wells are principally in loess, glacial drift, alluvial deposits and the Pennsylvanian strata.

Where the loess is fairly thick and ~~is~~ underlain by Illinoian gumbotil a considerable amount of water is collected in the loess and wells dug to the its base ~~of the loess~~ may obtain an adequate supply. Wells in the loess are somewhat more subject to seasonal variation in yield than deeper wells, as the# loess is ### more immediately dependent upon rainfall than ~~deeper~~ other water bearing ######, horizons. An increased number of wells in the loess or increased pumping, as in stock farms may also lower the level of the water table so that wells must be drilled# to a greater depth after some years. In the northwestern part of the quadrangle the loess is only 6 to 8 feet thick and most of the wells extend ~~through the loess~~ into the underlying till, where the water collects in sand or gravel pockets in the till ~~or its base~~, or at the base of the till i~~tself.~~ The most satisfactory yields come from lenticular masses of sand and gravel which are found in the Illinoian till and from alluvial gravels of Yarmouth age which were buried beneath the Illinoian till.

In the broad sandy terrace east of ~~the~~ Illinois River and in the flood plains of Illinois and Spoon Rivers and some of their larger tributaries a plentiful supply of water is obtainable from alluvial sands and gravels. The depth to water in the flood plains is usually less than 15 feet. In the terrace area ### water can usually be obtained in sufficient quantities in wells 35 to 40 feet ~~in depth~~ deep, but the depth to water is somewhat greater on sand dunes, as the water sinks ~~down~~ readily through the sand.

In a few parts of the quadrangle the Pleistocene and recent deposits have not fur#nished an adequate supply of water for farm use, either because of the larger demands of ~~larger~~ stock farms or because of the absence of ######## sands or gravels in the Pleistocene. In such places wells have been extended into the Pennsylvanian, which has locally yielded an adequate supply of water. The principal aquifers in the Pennsylvanian are the sandstones, although water is occasionally obtained in coal or in the rooms of abandoned mines. Such water #### ## usually contains ~~so~~ # much dissolved# sulphate as to be unsatisfactory. The most important Pennsylvanian sandstone is the Pleasantview, which is locally 50 feet thick and immediately underlies the drift in most of the southern half of the quadrangle. The Cuba sandstone is second in importance. Records ### of Pennsylvanian farm wells are not available, so the ##### aquifers in these wells is not certainly known. It would be expected, however, that an adequate yield might be obtained from the base of the Pleasantview sandstone, especially where this does not immediately overlie the Colchester (No. 2) coal. A few wells (~~See table, Appendix ____.~~) west of Duncan mills were extended into the lower Pottsville or the top of the St. Louis (Mississippian) limestone before an adequate yield of water was obtained, suggesting that some sandstone low in the Pottsville which is not exposed in the Havana quadrangle may be an aquifer of some importance.

The highest aquifer below the Pennsylvanian in the Havana quadrangle is probably the Burlington limestone (Mississippian), which would be reached at a depth of 400 to 500 feet in most parts of the quadrangle.

Water and vegetation.

The rainfall is adequate to support a luxuriant growth of vegetation in most parts of the Havana quadrangle. Years when crops fail because of drought are practically unknown. In the sandy terrace area east of Havana and especially on the dune ridges on this terrace the water sinks to the water table so readily that the subsoil is usually dry and the area is covered by an assemblage of plants with long tap roots or water storing arrangements like the cactus. The plant assemblage here is notably different than that in other parts of the quadrangle, resembling more, the vegetation of the semiarid plains of the west. An experiment has been recently undertaken to determine whether the yield of crops might be materially increased by irrigating this sandy soil with water from wells. No information regarding the results of this experiment ~~are~~ is available.

SOILS 8/

8/ Much of the information in this section is taken from Soil Report No. 28, Mason County Soils, by R. S. Smith, E. E. DeTurk, F. C. Bauer, and L. H. Smith, ####### University of Illinois Agricultural Experiment Station, 1924 and the unpublished map of Fulton County Soils, which was loaned by Dr. R. S. Smith## of the Soils Survey Division.

Although the detailed discrimination of soil types lies outside the scope of this report, geologic processes have played a most important part in the formation of the soils of the Havana quadrangle.

The principal materials from which the soils have been derived are (1) the Peorian loess, (2) the sandy terrace deposits east of ~~the~~ Illinois River and the #### dune# sands on this terrace, (3) Wisconsin loess and slack water deposits on terrace areas west of ~~the~~ Illinois River, (4) postglacial alluvial deposits in ~~the~~ Illinois and Spoon River vall#eys and in many smaller streams and (5) glacial drift and bed rock (Pennsylvanian) on slopes from which the Peorian loess has been removed. The type ~~character~~ of the soil depends upon (1) the character of the materials from which it has been formed, (2) the topographic position in which it is situated, (3) the ease of water circulation through the soil and (4) the length of time that soil forming processes have been at work. Soil types differ, not ## only in the character of the top or surface soil, but also in the subsurface or subsoil. The zones which constitute the ~~soil~~ profile of weathering are described in the interpretation of soils formed during the Sangamon interglacial period (p. 229-231)

The soils of the Havana quadrangle may be classified as upland prairie soils, upland timber soils, terrace soils and swamp and bottomland soils. The characteristics of soil types belonging to each of these classes is here summarized briefly.

Upland prairie ###### soils

Prairie soils are "dark in color, due to the accumulation of organic matter, which is derived very largely from the fibrous roots of prairie grasses. The network of grass roots was protected from rapid and

and complete decay owing to the rather effective exclusion of oxygen by the covering of fine, moist soil, and by the mat of vegetative material formed by old grass stems and leaves." 9/ Upland prairie soils are found

9/ Smith, R. S., DeTurk, E. E., Bauer, F. C., and Smith, L. H. Op. cit. p. 12.

WEST OF ~~the~~ Illinois River on the level plains along drainage divides, like that extending southwest from Cuba. They are less extensive in the Havana quadrangle than the upland timber soils. The following types of upland prairie soils have been mapped in the Havana quadrangle.

(1) Brown silt loam. This ~~soil~~ type is found in many parts of the upland which are slightly rolling, but it does not commonly extend to the immediate banks of the more deeply cut streams. The surface soil, 0 to 6 2/3 inches thick, is brown silt loam, varying on the one hand to black, as it grades into black clay loam and on the other hand to grayish brown or yellowish brown as it grades into the timber types. ###### The natural subsurface stratum varies from 9 to 16 inches and ## is commonly yellowish brown in color. The subsoil begins at a depth of 12 to 22 inches. It is a yellowish clayey silt, but is commonly friable in texture, ########### differing from the next type, in which the subsoil is plastic.

(2) Brown silt loam on clay. This soil is found on the more level and wider interstream divides like that extending west from Cuba which is followed by the T. P. & W. R. R. The surface soil is darker in color than that of the preceding type and thicker, 10 to 12 inches. The subsurface stratum is 12 to 16 inches ~~in~~ thick~~ness~~ and brown do dark brown ~~in color~~. The subsoil is darker ~~in color~~ than that of the preceding type and is commonly plastic. The fracture# surfaces are ~~commonl~~y coated with a film of dark brownish material, which is less common where the soil drainage is better.

(~~4~~ 3) Black clay loam on drab clay. This ~~soil~~ type is found in a small area ~~####~~ south of the T. P. & W. Ry R. in Sec. 25, T. 6 N. R. 2 E. in a level poorly drained area. The surface soil 0 to 6 2/3 inches, varies from dark brown to black plastic granular clay loam. Insert 51a

~~The subsurface, which extends from 6 2/3 to about 20 inches in depth is brownish clay loam. The subsoil is drab or olive-colored silty clay, very~~

Upland timber soils

Upland timber soils differ from upland prairie soils in that they are commonly yellowish gray in color, due to their low organic matter content. ~~These soils~~ They are low in organic matter because the shade from forest trees prevents the growth of prairie grasses, and the trees themselves add very little organic matter to the soil, for the leaves and branches either decay completely or are burned by forest fires. The upland timber soils occur in irregular zones along streams and in the narrow divides between the smaller tributaries. Their topographic position near stream valleys allows the water of rains to ## drain into the ground more rapidly than it can in the more level areas farther from stream courses. This permits a more complete oxidation of the organic material in the soil, which also causes the color to be lighter. The following types of upland timber soils have been mapped in the Havana quadrangle:

(1) Brownish yellow gray silt loam on tight clay. This soil type is found in small patches in flat and rather poorly drained timber soil, generally at some distance from streams. The surface soil 0 to 6 2/3 inches thick, is gray pulverulent silt loam containing small rounded iron concretions. The subsurface stratum varies from 7 to 10 inches in thickness. It consists of whitish gray to yellowish gray silt containing rounded iron concretions. This stratum #### is somewhat impervious to water, but not so much so as the subsoil. The subsoil consists of compact, yellowish tough silty clay or clayey silt that is rather impervious and into which the roots do not penetrate to any extent.

Insert after line 3.

As it passes toward brown silt loam, which nearly always surrounds it, it becomes more silty. ~~##############~~ The subsurface stratum has a thickness of 10 to 16 inches and varies from black to brownish gray clay loam, usually somewhat heavier than the surface soil. The lower part of this stratum frequently is drab or yellowish drab silty clay. The stratum is pervious to water, owing chiefly to the jointing or checking from shrinkage in times of drought. The subsoil to a depth of 40 inches ~~##~~ varies from a drab~~#~~ to a yellowish drab silty clay. As a rule, the iron is not highly oxidized, because of poor drainage and lack of aeration.

(2) Brownish yellow gray silt loam. This ~~soil~~ type is ~~probably~~ the most extensive in the upland area in Fulton County. It occurs in the outer timber belts along streams, and caps many of the narrower divides between streams. The surface soil, 0 to 6 2/3 inches, is a yellow, yellowish gray, gray or brownish gray silt loam, incoherent and pulverulent but not granular. The more nearly level areas are gray in color, while the more rolling phase of the type has a yellow or brownish yellow color. As the type approaches brown silt loam, it becomes decidedly darker. The subsurface stratum varies from 3 to 10 inches in thickness, erosion having reduced its thickness on the more rolling areas. It is usually a gray, grayish yellow, or yellow silt loam, pulverulent, but becoming more coherent and plastic with depth. The subsoil is yellow or mottled grayish yellow clayey silt or silty clay, somewhat plastic when wet but friable when only moist, and pervious to water.

(3) Eroded silt loam. This soil type occurs in the hilly and eroded country along all the stream courses in the upland in Fulton County. In topography it is very rolling, and in most places is so badly broken that it should not be cultivated because of the danger of washing. The surface soil, 0 to 6 2/3 inches, is yellow or grayish yellow, pulverulent silt loam. It varies greatly in color and texture, owing to recent washing. In many places the natural subsoil may be exposed. This exposure gives it a decidedly yellow color. In some places the surface soil is formed from glacial drift and the Pennsylvanian sandstones and shales, but this is only on limited areas and the steeper slopes. The subsurface varies from a yellow silt loam to a yellow clayey silt loam, and on the steepest slopes may consist of weathered glacial drift. The thickness of the stratum varies from 5 to 12 inches, depending upon the amount of recent erosion. The subsoil is normally a yellow clayey silt, but in some areas it is composed entirely of glacial drift.

Terrace soils.

In the broad terrace east of ~~the~~ Illinois River the terrace soils are formed principally from sandy alluvial or wind deposits. In the smaller terrace areas in Fulton County the soils are formed principally on slack water silts or loess deposits. The following types of terrace soil have been differentiated.

(1) Brown sandy loam. This is the most extensive soil type on the terrace ~~####~~ east of ~~the~~ Illinois River. It underlies the more level parts of the terrace. The surface soil, 7 to 3 inches in depth is brown sandy loam low in organic matter. The proportion of sand in the surface soil varies rather widely so that this stratum ~~varies~~ ranges from a sand to a loam. The subsurface is 4 to 16 inches ~~in~~ thick~~ness~~ and varies from yellowish or grayish brown sand to yellowish or grayish brown sandy loam. The subsoil ~~varies from~~ is a yellowish silty sand ~~to~~ or a yellow sand. In some parts of the area recent wind action has covered the surface soil of this type ~~###~~ to a depth of 3 to 6 inches with sand.

(2) Brown gray sandy loam on tight clay. This type occurs in the parts of the terrace southeast of Havana which are naturally poorly drained, where the water table is high and ponds may form after seasons of heavy rain. The large temporary lake in the SW. $\frac{1}{4}$ sec. 8, T. 21 N., R. 8 W. is somewhat typical of areas with this soil. The surface soil, about 8 inches deep is predominantly brown sandy loam. It varies from silt loam to sand. The color of the surface soil is not uniform, varying from grayish brown to gray. The subsurface is 9 to 12 inches ~~in thickness~~ thick. The upper part is brownish gray in color, somewhat similar to the surface, but passes at a varying depth into a gray sandy silt containing little organic matter. The subsurface, at a depth of 17 to 20 inches, passes very abruptly into the subsoil which is a plastic impervious mottled yellow clay, 8 to 20 inches

or more in thickness. Usually a coarse sand is found beneath it. This type of compact subsoil is described on p. 287, Ch. III in connection with the ~~soil~~ profiles of weathering of indian mounds near Havana.

(3) Dune sand. This soil occurs in the part of the quadrangle ~~###~~ which are shown on the geologic map as sand dunes as well as in small patches on the terrace too small ~~###~~ in size and too irregular in shape to be mapped. Many of the dune areas were ~~many of them~~ covered with timber, and some of this still remains, but much of it has been cleared. The surface soil is brownish yellow loamy sand of medium texture. This same material extends to well below 40 inches in depth with no change except that the ~~#########~~ color changes to yellow at a depth of about 8 inches.

(4) Yellow gray sandy loam on sand. This soil ~~type~~ occurs along the ~~#####~~ Illinois river bank margin of the terrace north and south of Havana except where sand dunes occur along the river bluff. This area has been forested and ~~this~~ is, therefore a timber soil. The surface soil is about 7 inches deep and is grayish yellow sandy loam ~~which is~~ very low in organic matter. The subsurface is yellow sandy loam about 13 inches in thickness. It passes into yellow sand subsoil at 18 to 30 inches in depth.

(5) Insert 54a

(6) Brownish yellow gray silt loam over sand and gravel. This is the principal type of terrace soil on the terrace remnants along Illinois River, Spoon River and the smaller streams west of ~~the~~ Illinois River. The surface soil, 0 to 6 2/3 inches, is yellowish brown to grayish yellow silt loam. The subsurface soil is represented by a stratum of yellow to grayish yellow silt 8 to 12 inches ~~in thickness.~~ The subsoil is a yellow, slightly clayey silt. In some places sand or gravel appear at depths of 36 to 40 inches.

Insert at line 18. p. 63.

(5) Black clay loam. This soil underlies part of sec. 21, T. 21 N., R. 8 W. at the southeastern corner of the quadrangle. The area where it occurs lacks natural drainage and ~~drainage~~ ditches have been recently extended into this area. The surface soil, about 8 inches in depth is usually a black clay loam, granular when dry and plastic when wet. Small areas occur in which the surface is sandy clay loam and others in which the surface is a peaty loam. The subsurface soil ~~is~~ about 11 inches in thickness ~~and~~ is a drabbish, black, waxy clay loam. It passes into drab or olive colored, mottled subsoil at about 18 inches. The subsurface and subsoil do not vary as ~~so~~ much as the surface in physical composition, but they ~~###~~ frequently contain an appreciable amount of sand.

(6) Brown silt loam over sand and gravel. This type is found on some of the lower (later) terrace remnants which are only 15 to 20 feet above the flood plain level and on the inner margins of some of the larger terrace remnants west of ~~the~~ Illinois River. # The surface soil, 0 to 6 2/3 inches, is brown to dark brown, granular silt loam #########. It varies from a sandy phase of light brown silt loam to black or very dark brown clayey silt loam. The subsurface stratum varies from 8 to 12 inches in thickness and consists of brown to yellowish brown silt loam containing in many cases a perceptible amount of sand. It is quite pervious and allows ready percolation of water. The subsoil consists of yellow, slightly clayey silt, which is friable and pervious#.## Occasionally sand and gravel are ## found in the lower subsoil

(7) Brown sandy loam over sand and gravel. This soil type is similar in character to the ##### brown sandy loam of the broad terrace area east of ~~the~~ Illinois River. It has a limited distribution along the margins of some of the lower terrace remnants adjacent to the flood plain of ~~the~~ Illinois River in secs. 12 and 34, T. 4 N , R. 3 E., in small alluvial fans along ~~the~~ Illinois River bluff in sec. 29, T. 5 N., R. 4 E. and in a small area of terrace surrounded by flood plain in sec. 10, T. 3 N., R. 3 E. at the southern margin of the quadrangle.

(8) Brown gray silt loam on tight clay over sand an gravel. This soil is found only in a few acres near the southern margin of the lower terrace in sec. 34, T. 4 N., R. 3 E. The surface soil, 0 to 6 2/3 inches, consists of grayish brown to brown silt loam.########## The subsurface is represented by a layer varying from 7 to 12 inches in thickness. The upper few inches are a grayish brown, over a gray, very silty layer, mixed with some sand. The subsoil consists of an upper layer 10 to 16 inches in thickness of tight, slightly sandy clay of a yellowish or mottled yellow and drab color over a more pervious layer of silty or sandy material, drab or

gray in color. The upper part of the subsoil is not readily pervious and is very effective in retarding moisture from going either up or down.

Bottomland soils.

These soils are found principally in the flood plains of ~~###~~ Illinois and Spoon Rivers and also in the ~~#######~~ valley plains of their larger tributaries. The soils are formed from alluvial deposits ~~###~~ which are of recent age. The following soil types are recognized:

(1) Brown Mixed loam. This soil ~~type~~ ~~##~~ is the most extensive of the bottomland types, extending over all parts of the alluvial lands of the quadrangle except in areas within 2 miles of the present channel of ~~the~~ Illinois River and a small area along the lower part of Quiver Creek valley.. The surface soil varies in depth and in texture from a sandy loam to a clay loam, and in color from a light brown to a black. The variation is as great, or greater, below a depth of 8 or 10 inches than is found in the surface. Areas with this type of soil are usually subject to overflow.

(2) Drab clay. This soil occurs in a small area near Liverpool and a large area along the west side of ~~the~~ Illinois River south of Spoon River extending to an average distance of 1½ miles from the river to the southern border of the quadrangle.. The surface soil, 0 to 6 2/3 inches, is a granular plastic clay of a dark drab to almost black color. The subsurface constitutes a layer about 13 inches in thickness. It is a drab, plastic clay. The subsoil does not differ greatly from the surface except that it becomes lighter in color. It still retains, however, the drab or bluish color which results from a lack of the higher oxides of iron. The area with this soil is subject to overflow, except as it is protected by levees.

(3) Deep peat. This soil occurs in the valley of Quiver Creek in sec. 16, T. 22 N., R. 8 W. The soil is a brown to black peat, containing a perceptible amount of sand in places. It varies in depth, but rarely exceeds 10 feet. This soil ~~is~~ high~~est~~ in organic matter ~~of~~ than any of the other soils in the quadrangle.

The kinds of crops which can be grown to best advantage on these soils and the treatment desirable to prevent erosion and to preserve or increase their########## organic content ~~an~~ fertility are ## described in bulletins of the soils survey division of the University of Illinois Agricultural Experiment station, to which the reader is referred for information on these subjects.

Appendix B.

Part I. Mine Data

A. Mines in Colchester (No. 2) coal

Duvall Mine.

Location: NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 22, T. 5 N., R. 3 E. (Lewistown twp.)

Entrance: Shaft 92 feet deep

Altitude of top of coal: 496 feet

Roof: Shale (Francis Creek) 50 feet thick here, limestone above it. Lower 11 inches of this shale is a "draw slate", which causes some trouble with falls. Otherwise the shale forms a good roof.

Coal: 32-36 inches thick, average 32 inches. Discontinuous band of small pyrite concretions 6 inches above base of coal, $1\frac{1}{2}$ inches bony coal near middle of bed. Also a few scattered small pyrite concretions.

Floor: Underclay 2-3 feet, sandstone below this.

Structure of coal: Less than 2 feet difference in elevation of coal in this mine.

Hendree Mine(Abandoned in May, 1928)

Location: NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 6, T. 3 N., R. 3 E. (Kerton twp.).

Entrance: Horizontal drift

Altitude of top of coal: 506 feet

Roof: Sandstone (Pleasantview) roof in most of mine, but 1-2 feet of soft shale between coal and sandstone in some parts of mine. Sandstone has little tendency to cave, but shale falls# away from sandstone where present. Water enters through cracks in sandstone roof.

Coal: 28-34 inches thick, average 30 inches. Pyrite in scattered partings, and concentrated at bottom of coal.

Floor: Underclay

Structure of coal: Coal bed is slightly undulating, with difference in altitude of about 2 feet in different parts of mine

B. Mines in Springfield (No. 5) coal
Under ground mines.

Big Creek Coal Company's Mine No. 2 at St. David (later owned by the Saline County Coal Corporation). Abandoned March, 1928.

Location: Entrance near center of west line SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 16, T. 6 N#., R. 4 E. (Buckheart twp.). Coal mined in secs. 7, 8, 9, 16, 17 and 18 of this township, mostly in the Canton quadrangle.

Entrance: Horizontal drift

Altitude of top of coal: 587 feet at entrance. Fig. 130 shows altitudes in mine.

Roof: Black ~~fissile~~ hard shale 2-4 feet, under limestone cap rock averaging 10 inches. Immediately over coal is 1 to 2 inch layer of fine banded sandy shale and pyrite ("draw slate") which sometimes falls, but usually stays up.

Coal: 4 feet 8 inches# to 5 feet 4 inches, average 5 feet# in thickness. Uniform in character throughout mine, no bedded partings, horsebacks common ~~in some~~ in some parts of mine and uncommon in others ~~parts~~; small discontinuous bands of pyrite and streaks of mother of coal; coal blocky in fracture, finely laminated, facings of calcite and some gypsum. Fig. 141, sections 1-10 shows graphic sections of the coal in this mine.1/

1/ Cady, G. H. Coal Resources of District IV, Illinois State Geol. Survey, Coop. Coal Mining Series, Bull. 26, p. 93, 1921.

Floor: The floor is the usual light blue gray underclay, about 2½ feet thick. It heaves somewhat after about 2 years.

Big Creek Coal Company's Mine No. 4 at Dunfermline (abandoned)

Location: Entrance in NW. ¼ SE. ¼ SE. ¼ sec. 22, T. 6 N., R. 4 E. (Buckheart twp.) Coal mined in secs. 14, 15, 22, 23, 26, and 27, same township.

Entrance: Shaft, 88 feet deep

Altitude of top of coal: Approximately 565 feet at entrance. Fig. 131 shows altitudes in part of mine.

Roof: Black ~~fissile~~ hard shale 12-14 inches under black soft shale, or "clod" 2-3 feet, under limestone cap rock 8 to 10 inches thick. Roof conditions are not especially different from those in other mines south of Canton. The interval between the cap rock and the coal seems to increase to the south and the cap rock becomes a little thicker. It is harder to distinguish the true draw slate from the ~~fissile~~ hard shale (slate) above. The lower 3 inches or so of the slate, which is commonly called draw slate, does not contain the whitish limestone concretions found in mines farther north, nor are large limestone concretions composed largely of pyritized shells present. The parting just below the top of the coal is better here than farther north, so the coal breaks away better from the slate. When the lower inch or so of the slate comes down conditions are almost immediately bad, for the black shale and "clod" have little coherence. Over many of the entries the cap rock is present. In places the cap rock is thin, especially where it has a smooth lower surface. The lower surface is commonly rough, with small knobs that stick down into the clod. See fig. 62

Coal: 66 to 77 inches thick, averaging 68 inches. No well developed benches, but coal shoots in layers because of dirt or charcoal bands. Thin dirt bands are about 8, 14, and 26-30 inches below top of coal and a pyrite band about 2/3 of the way down, which is not continuous. Horsebacks are commonly not over 2 inches thick, composed of gray clay. A thin blackjack or clay band at the bottom of the bed is about $1\frac{1}{2}$ inches thick, and quite continuous. It is commonly dark carbonaceous shale, with a parting just above the ~~fire~~ under clay. Coal is cut just above this band, but it tends to shoot with the coal. Pyrite is present in coal as balls of clean pyrite commonly $2\frac{1}{2}$ to 3 inches thick, and 8 to 14 inches in diameter, weighing 20 to 30 pounds. The largest ones weigh as much as 200 pounds. It is estimated that the pyrite separated is about 1/10 of 1% of the coal mined.

Floor: Underclay, about 2 feet thick. Some rolls in floor, principally at horsebacks, which interfere with mining. The extra pay for rolls in the underclay is $2.80 if they are 2-6 inches high. These occur about 20-30 feet apart in mine.

Cripple Creek Coal Company's mines near Bryant. (Abandoned 1923)

Location: Mine no. 1, Entrance SE. $\frac{1}{4}$ SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 24, T. 6 N., R. 3 E. (Putman twp.) Coal mined in parts of secs. 23, 24, 25 and 26, same township.
Mine no. 2, Entrance SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 24, T. 6 N., R. 3 E. (Putman twp.). Coal mined in part of sec. 24. These two mines and a third one, about one quarter mile north of No. 2 all loaded from the same tipple.

Entrance: Horizontal drift in all mines.

Altitude of top of coal: Approximately 605 feet at entrance of Mine No. 1. 602 feet at entrance of Mine No. 3.

Roof: Black ~~fissile~~ hard shale, 6 inches to 2 feet, under $1\frac{1}{2}$2 feet of soft black shale, which is under limestone cap rock. The limestone reaches a maximum thickness of 12 inches, and is absent in some parts of the mine, where it is replaced by a light gray, non-gritty, plastic shale (base of Canton shale), which is hard to hold. The lower surface of the limestone is studded with small protuberances $\frac{1}{2}$-1 inch which project down into the soft shale below. In one fall the shale over the limestone was found to be 50 feet thick (?). It contains concretions of dolomite or siderite 1 to 2 inches in maximum diameter. The draw slate just above the coal is not present in all parts of the mine, and is reported to reach a maximum thickness of 6 inches.

Coal: 54-66 inches thick, average 57 inches. The coal is separated into benches by three soot or mother-coal bands, 8, 22, and 31 inches from the top of the bed respectively. The upper 12 inches of the coal is bright with dull bands up to 3/8 inch. The next 2 feet 6 inches is bright coal, with very little dull. The bands of coal are practically all under 1/8 inch in thickness. The lower bench, 12 to 18 inches thick, is composed of bright and dull laminae in about equal proportions, in bands 1/16 inch or less in thickness. Pyrite is present in joint facings and lenticular masses in the upper part of the coal 1 inch by 3 inches in dimension. Horsebacks are present in the coal and cut through it at angles varying from vertical to about 45°. The maximum width is about $2\frac{1}{2}$ feet. They are of soft, medium gray clay and often finger out into the coal on both sides. They are usually accompanied by a slight displacement of the coal with resulting slips.

Floor: Medium to dark gray, hard, underclay, 6 to 8 feet thick, the whole thickness not being penetrated in the mine. It contains pyrite balls and plant impressions. The floor heaves only in abandoned rooms.

Structure of the coal: The coal is very hilly in this mine. One "hill" has a grade of 10%, rising 18 feet in 180 feet. It was necessary to use two mules to pull one car up this grade, which is probably the steepest in the mine. It is reported that the thickest coal is found in the "swamps" or low places (maximum 66 inches), while the thinner coal tops the "hills".

East Cuba Coal and Mining Co. Mine (Abandoned).

Location: NE. ¼ sec. 17, T. 6 N., R. 3 E. (Putman twp.)

Entrance: Shaft ~~76~~ 71 feet deep

Roof: Black, ~~fissile~~ hard shale 2½ feet under clod (soft black shale) 6 inches and limestone 2½ feet (?). Large concretions are numerous in the black fissile shale.

Coal: 56½-64 inches thick, averaging 60 inches. Except for lower 1½ to 2 inches of the coal, which is black jack, the coal is bright, black and hard. No mother-coal bands were noticed. Numerous horsebacks are present in the coal.

Section of the coal, room 1, off 2nd east off 1st south off main west

	Thickness Feet	Thickness Inches
Coal	1	11½
Sulphur (Pyrite)		¼
Coal		8¾
Sulphur		1/8
Coal	2	
Sulphur		½
Coal		1½
Underclay	4	10½

Floor: Underclay 2 feet or more

Irregularities: The underground workings penetrated an old stream channel cut through the coal about 150 feet wide, and filled with sand and gravel. This is probably a buried preglacial valley along which the coal was removed.

Applegate and Lewis mine at Cuba (abandoned)

Location: NE. ¼ sec. 19, T. 6 N., R. 3 E. (Putman twp.)

Entrance: Shaft, depth not known

Roof: Black fissile shale about 2 feet, with a kind of soft wet sandstone above. This is probably a locality where Cuba sandstone cuts out cap limestone and Canton shale.

Coal: 52 inches in one section given.
Section of coal, face no. 2 off 7th entry south.

	Thickness Feet	Thickness Inches
Coal	4	3
Black Jack		1

Floor: Underclay

Big Creek Coal Company's Mine No. 3 at Cuba. (Abandoned)

Location: Entrance near center of ~~w~~east line, SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 20, T. 6 N., R. 3 E. (Putman twp.) Coal mined in parts of secs. 16, 17, 20 and 21 same township.

~~E~~ntrance: Shaft about 59 feet deep

Roof: Black fissile shale under soft shale under limestone cap rock.

Coal: 56-62 inches thick. No# notes on this mine. Coal probably similar to other mines at Cuba.

Floor: Underclay

Irregular#ities: Coal is cut out extensively in the south half of sec. 16 by preglacial channels.

Star Coal Company's Mine No. 3 at Cuba. (Abandoned March, 1921)

Location: Entrance in NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 29, T. 6 N., R. 3 E. (Putman twp.). Coal mined in parts of secs. 20, 29 and 30 of this townshi

Entrance: Shaft 26 feet deep

Roof: The roof consists of $2\frac{1}{2}$ feet of black "slate", above which is the limestone cap rock, 12 to 18 inches thick. Draw slate is reported to be absent in this mine, and niggerheads not numerous.

Coal: 56 inches average thickness. Coal is uniform in appearance, hard and rather tough. A narrow vertical sulphur streak lies in the upper part of the bed. Horsebacks are not numerous.

Section of the coal measured in temporary north entry

		Thickness Feet	Thickness Inches
#	Coal	1	9
	Parting		
	Coal		8
	"Soot" seam		
	Coal.	1	8

Floor: Underclay

Strip Mines.

Tiger Coal Mining Company Mine. (Abandoned).

Location: SE. $\frac{1}{4}$ sec. 29, T. 6 N., R. 3 E. (Putman twp.)

Average thickness of overburden: 30 feet

Character of overburden: Loess and drift about 20 feet, gray shale (Canton), limestone cap rock (St. David), soft and hard black shale, 10 feet or less. In part of the area worked in this stripping operation the strata down to the ~~fissile~~ hard shale over the coal have been cut out by preglacial erosion, and loess and drift extend down to within about 3 feet of the coal.

Coal: #56 to 48 inches thick

Drainage: Natural drainage, as the coal is situated above the level of a ravine which flows through the property. The walls of loess and drift became heavily soaked with water during wet seasons and slumping took place extensively, causing serious inconvenience in the mining operations.

United Electric Coal Company's Mine No. 9, near Cuba.

Location: Tipple is situated in NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 28, T. 6 N., R. 3 E. (Putman twp.). Coal mined in parts of secs. 27, 28, 29, 33 and 34 of this township.

Average thickness of overburden: 35-40 feet.

Character of overburden: Loess and drift with some water laid sand and silt (Pleistocene; shale (Canton), limestone cap rock (St. David) soft and hard black shale, with large concretions or "niggerheads". The three following measured sections are typical of the overburden in different parts of the mine:

(1) Section of overburden in abandoned north cut of strip mine in SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 28, T. 6 N., R. 3 E. (Putman twp.)

	Thickness Feet	Inches
Recent system		
15. Soil	1	
Pleistocene system		
Peorian series		
14. Loess, noncalcareous, buff	3	2
13. Loess, calcareous, gray	3	3
Sangamon series		
12. Loess, ### noncalcareous, pink and gray	2	6
Illinoian series		
11. Gumbotil, brownish gray, very plastic when wet	3	
10. Till, noncalcareous, reddish brown, oxidized	2#	
9. Till, calcareous, gray	3	
Pennsylvanian system		
Carbondale series		
St. David formation		
8. Shale, gray, soft, with small limestone concretions (Canton shale)	7	

		Feet	Inches
7.	Clay or shale, dark blue gray, fossiliferous		1½
6.	Limestone concretions, fossiliferous, not persistent		8
5.	Shale, gray, soft, with concretions	7	6
4.	Clay, dark blue gray, principally composed of fossils	1	3
3.	Limestone, gray, in 1 massive band (St. David)		9
2.	Shale, upper part soft and black, lower part, black, finely laminated and hard	2	6
1.	Coal (Springfield or No. 5)		

The total overburden here is 37 feet 7½ inches. It thickens somewhat to the east of this cut, and the coal has not yet been removed there.

(2) Section of overburden in mine face (August, 1927) in SE. ¼ NE. ¼ sec. 29, T. 6 N., R. 3 E. (Putman twp.). (Geol. Sec. 54, Ch. II, p. 223)

	Thickness Feet	Thickness Inches
Recent system		
11. Soil.	1	
Pleistocene system		
Peorian series		
10. Loess, noncalcareous, buff	4	9
9. Loess, calcareous, gray	1	6
Sangamon series		
8. Silt, noncalcareous, brownish gray, with carbonized wood fragments	2	6
Illinoian series		
7. Gumbotil, brownish gray	2	
6. Till, calcareous, yellow brown	3	8
5. Till, calcareous, brownish gray	2	
4. Sand and gravel, calcareous, reddish brown	1	11
Illinoian or pre-Illinoian series		
3. Silt and sand, calcareous, blue gray and buff, finely laminated, base concealed	5	10
Pennsylvanian system		
Carbondale series		
St. David formation		
2. Covered, includes at least 2 feet of black hard shale	3	
1. ~~Coal~~ (~~Springfield~~ or No. 5)		

The total overburden here is 28 feet 2 inches. This cut is about one quarter mile from the outcrop of the coal beneath the Pleistocene deposits, and the limestone cap rock is absent.

(3) Section of overburden in mine face (September 3, 1927), in SW. ¼ NW. ¼ sec. 27, T. 6 N., R. 3 E. (Putman twp.)

	Thickness Feet	Thickness Inches
Recent system		
10 ~~15~~. Soil	1	
Pleistocene system		
Peorian ~~series~~, Sangamon and Illinoian series		
9 ~~14~~. Loess, and drift ~~noncalcareous#, buff~~ (details in Geol. Sec. 58)	14 ~~3~~	1 ~~2~~
~~13. Loess, calcareous, gray~~		
~~Sangamon series~~		
~~12. Silt, noncal~~		

12. Silt, noncalcareous, pinkish gray, with root canals (late Sangamon soil)		10
11. Silt, noncalcareous, brownish gray, gumbo-like, probably derived from loess	1	7
Illinoian series		
10. Gumbotil, brownish gray, with pitted surfaces; weathers to gumbo-like surface; ~~####~~ contains small pebbles of chert and quartz	5	8
9. Till, slightly calcareous, grayish, iron stained	2	10
Pennsylvanian system		
Carbondale series		
St. David formation		
8. Shale, light blue gray, weathered near surface, containing scattered small concretions (Canton shale)	3	5
7. Shale, dark gray, with discontinuous band of concretions 10 inches from top, slightly fossiliferous in lower portion	1	10
6. Shale, light gray, soft, with small calcareous concretions	3	11
5. Clay or shale, dark gray, principally composed of fossil shells	1	
4. Limestone, gray, massive, in one bed (St. David limestone)		10
3. Shale, dark gray, mottled with light gray spots, ~~########~~ finely laminated, fairly soft	1	7
2. Covered, principally black hard finely laminated shale	1	
1. Coal (Springfield or No. 5)	1	

The total overburden here is 30 feet 4 inches. In nearly half the area which was being stripped late in 1927 and early in 1928 the St. David limestone cap rock was absent, being cut out by preglacial erosion.

Equipment: 4 electric stripping shovels, 2 6 yard shovels with 90 foot boom, 1 8 yard shovel with 80 foot boom and .
After the overburden has been stripped the coal surface is swept, the coal is shot, and is loaded by a $1\frac{3}{4}$ yard electric shovel. The coal is hauled to the tipple in 6 ton cars, 12 cars to a trip. At the tipple the coal is cleaned at 4 picking tables, with 4 men at each. The plant is designed for 4000 ton capacity.

Special features of mining: When horsebacks are encountered the coal is loaded to them, then the horseback zone is stripped and piled on the spoil banks. The limestone cap rock occurs in one bed 10 to 18 inches thick, which is stripped in large masses reaching a diameter of 12 to 15 feet, which are dumped on the spoil banks. Most of the coal which has been mined up to the spring of 1929 is in parts of the area where the overburden in less than 30 feet. A large block of coal in the central part of sec. 28 where the overburden is 40 to 50 feet thick has not yet been mined. Fig. 142 shows a typical view in this strip mine.

Part II

Results of Clay Tests

Sample 116.

Kind of material..Clay (Shal

Drying conduct ....Good

Volume drying shrinkage 18.52%
Linear drying shrinkage 6.60%

Water of plasticity 27.00%

Bonding strength - modulus of rupture .. Lbs. per sq. in. 230.0

Bulk specific gravity 1.865

Burning test:

Temp. Fahr.	Cone	Volume shrinkage per cent	Linear shrinkage per cent	Porosity	Color	Fracture
1904°	05	26.61	9.80	10.60	Light red	Vitreous
2057°	02	30.10	11.25	.09	Dark red	Vitreous
2129°	2	29.05	10.80	0	Dark red	Vitreous
2174°	4	Bloated		Overburned		
2246°	6	Badly bloated		Overburned		Vitreous

Fusion test: Clay not refractory

Oxidizing conduct: Good

Summary: Drying shrinkage medium, bonding strength medium, vitrification complete at cone 02, overburned at cone 4, burning shrinkage at vitrification medium. It is a nonrefractory clay.

Suggested uses: Building brick, possibly drain tile, hollow tile, roofing tile, and flower pots

118 a~~nd 119, described above, were~~ collected from beds equivalent to nos. ~~1 and 4 respectively in the above outcrop.~~

Sample 117

Kind of material .... Clay

Drying conduct .... Good

Volume drying shrinkage 21.85%
Linear drying shrinkage 7.80%

Water of plasticity 29.1%

Bonding strength - Modulus of rupture .. Lbs. per sq. in. 233.80

Bulk specific gravity 1.84

Burning test:

Temp. Fahr.	Cone	Volume shrinkage per cent	Linear shrinkage per cent	Porosity	Color	Fracture
1904°	05	13.02	4.54	27.44	Salmon	Granular
2057°	02	14.47	5.08	20.93	Salmon-buff	Granular
2129°	2	15.09	5.31	19.97	Light buff	Granular
2201°	5	19.59	7.01	11.54	Pinkish buff	Granular
2282°	7	23.35	7.84	7.55	Light tan	Granular
2381°	10	21.49	7.74	9.56	Buff with black spots	Granular
2417°	11	Bloated		7.64		

Fusion test: Clay not refractory

Oxidizing conduct: Poor

Summary: Drying shrinkage medium, bonding strength medium, vitrification complete between cone 7 and 10, overburned at cone 10, burning shrinkage at vitrification medium low. It is not refractory.

Suggested uses: Drain tile, hollow ware, etc.

Sample 120.

Kind of material .... Clay

Drying conduct .... Good

Volume drying shrinkage 18.45%
Linear drying shrinkage 6.58%

Sample 118

Kind of material:..Clay

Drying conduct ....Good

Volume drying shrinkage 18.22%
Linear drying shrinkage 6.63%

Water of plasticity 23.22%

Bonding strength - Modulus of rupture .. Lbs. per sq. in. 282.8

Bulk specific gravity.................. .... 1.97

Screen test:

Mesh	Per cent residue retained
28	3.7
48	28.3
65	7.6
100	5.4
200	24.1

Burning test:

Temp. Fahr.	Cone	Volume shrinkage per cent	Linear shrinkage per cent	Porosity	Color	Fracture
1940°	04	6.19	2.14	26.25	Cream	Granular
2057°	02	12.55	4.37	21.57	Cream	Granular
2129°	2	10.42	6.60	21.47		Granular
2138°	3	15.10	5.31	16.99	Light tan	Granular
2246°	6	18.64	6.65	9.80	Tan	Granular
2300°	8	19.20	6.86	10.20	Bluestoned	Granular

Fusion test: Fusion point P.C.E. 27-28

Oxidizing conduct: Poor

Summary: Drying shrinkage medium, bonding strength medium, vitrification incomplete at cone 8, shrinkage at cone 8 medium low. The clay is refractory. It is probably at or near the stratigraphic position of the Cheltenham Clay of the St. Louis district, which is the most important refractory clay of western Illinois.

Suggested uses: Building brick, possibly quarry tile, roofing tile, flue lining, sanitary ware, stove linings.

Sample ~~no.~~ 119.

Kind of material.. Clay

Drying conduct ....Good

Volume drying shrinkage 30.90%
Linear drying shrinkage 11.55%

Water of plasticity 24.10%

Bonding strength - Modulus of rupture -- Lbs. per sq. in. 248.5

Bulk specific gravity 1.91

Burni g test:

Temp. Fahr.	Cone	Volume shrinkage per cent	Linear shrinkage per cent	Porosity	Color	Fracture
1904°	05	10.97	3.80	20.11	Tan	Granular
2057°	02	18.05	6.42	11.86	Dark tan	Granular
2129°	2	17.83	6.34	14.68	Dark tan	Granular
2174°	4	Bloated		5.71		
2282°	7	Bloated		15.37		

Fusion test: Clay not refractory

Oxidizing conduct: Poor.

Summary: Drying shrinkage medium high, bonding strength medium, vitrificatio - overburns suddenly between cones 2 and 4. Shrinkage at cone 2 medium low. It is nonrefractory.

Suggested uses: Building brick, possibly hollow tile.

Sample 120

Kind of material ....Cla

Drying conduct: . ...Goc

Volume drying shrinkage 18.45
Linear drying shrinkage 6.58

Water of plasticity 24.3%

Bonding strength - modulus of rupture .. Lbs. per sq. in. 363.34

Bulk specific gravity 1.90

Buringg test:

Temp. Fahr.	Cone	Volume shrinkage per cent	Linear shrinkage per cent	Porosity	Color	Fracture
1904°	05	16.27	5.75	15.92	Light buff	Smooth
2057°	02	20.12	7.215	9.49	Light buff	Smooth
2129°	2	21.76	7.854	1.28	Light tan	Smooth
2201°	5	Bloated		3.40	Overburned	Smooth
2246°	6	Bloated		16.05		

Fusion test: Clay not fefractory.

Oxidizing conduct: Good.

Summary: Drying shrinkage medium, bonding strength medium, vitrification complete at cone 2, overburned at cone 2, burning shrinkage at vitrification medium low. It is a nonrefractory clay.

Suggested uses: Building brick, possibly drain tile, hollow tile, etc.

APPENDIX C

Part I.

Logs of deep wells in and near the Havana quadrangle[1/] (Fig. 147)

1. Glasford village well. NW. ¼ SW. ¼ sec. 22, T. 7 N., R. 6 E.

Elevation approximately 614 feet

1/ Log derived from record furnished by D. A. Howard, City Clerk

---

	Thickness Feet	Depth Feet
Recent, Pleistocene and Pennsylvanian (?) systems		
Subsoil and sandstone	160	160
Pennsylvanian system		
Carbondale and Pottsville ~~formations~~ series		
Sandstone (some water)	15	175
Shale, black	50	225
Limestone	10	235
Shale	65	300
Sandstone (little water)	20	320
Shale	50	370
Pennsylvanian system (?) or Mississippian		
Limestone, white	10	380
Shale	90	470
Mississippian system		
Keokuk and Burlington formations		
Limestone, white and gray	180	650
Kinderhook and Sweetland Creek formations[2/]		
Shale, light and dark	230	880
Devonian and Silurian systems		
Wapsipinicon and "Niagaran" formations	###	
Limestone, white and gray (little water)	250	1130
Ordovician system		
Maquoketa formation		
Shale and "slate"	220	1350
Galena and Platteville formations		
Limestone	280	1630
St. Peter formation		
Sandstone	#55	1685

2/ Sweetland Creek shale. Although the Sweetland Creek formation is assigned to the Mississippian System, it may belong in the Devonian System.

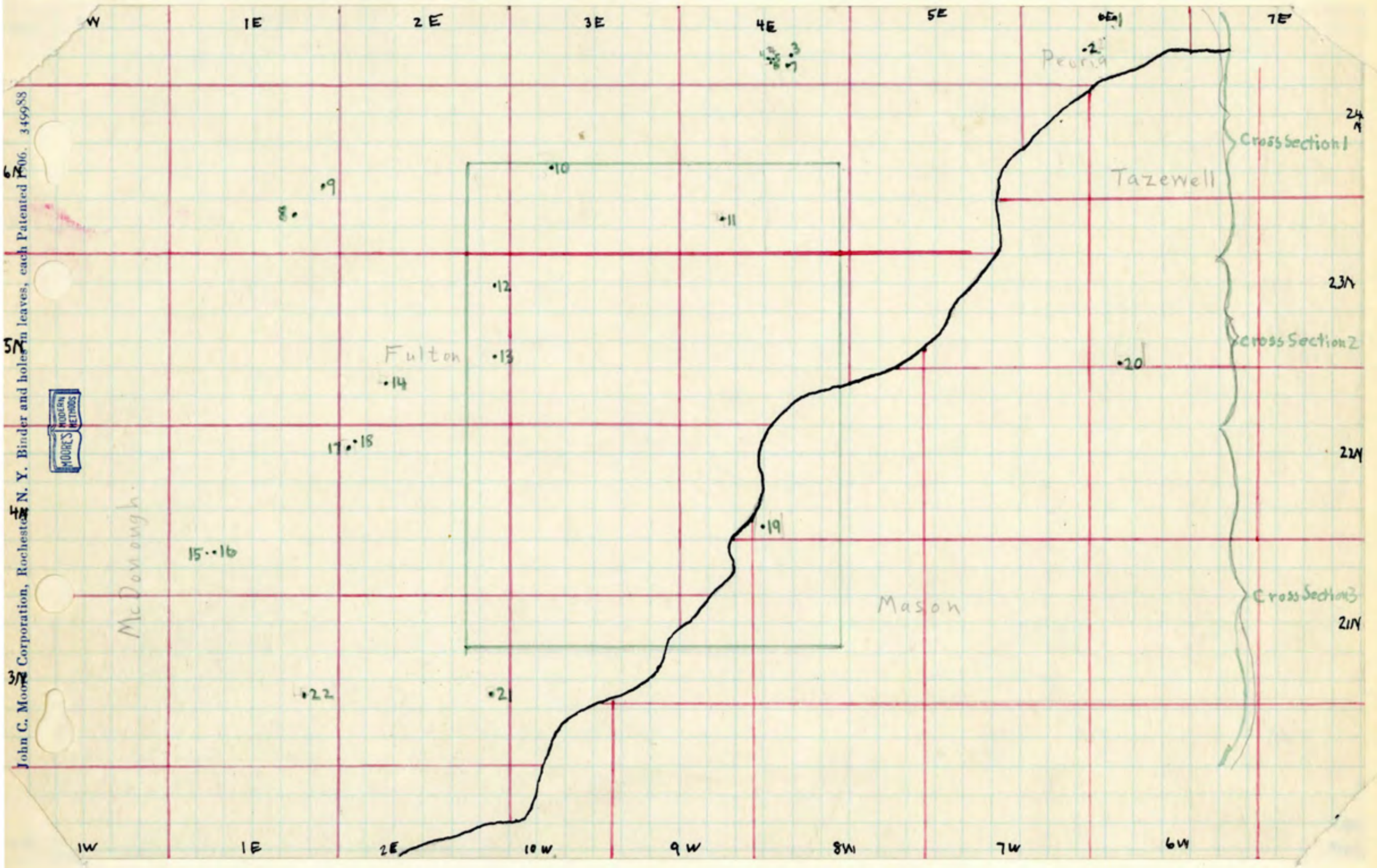


Fig. 14B. Sketch map of the Havana quadrangle and vicinity showing the locations of the drill holes of which records are given in Appendix A, part I and which are graphically represented in cross-sections 1, 2 and 3.

SW.1/4 SW.1/4

2. Hanna City Oil and Gas Company Somemaker no. 1 well. 2/ Sec. 28, T. 7 N., R. 6 E.

Elevation ~~##~~ approximately 495 feet

2/ Log derived from description of samples studied by L. E. Workman

---

~~##~~
~~##########~~

	Thickness Feet	Depth Feet
Recent and Pleistocene systems (and Pennsylvanian?)		
No samples	114	114
Pennsylvanian system		
Carbondale ~~formation~~ Series		
Shale, calcareous, silty, black, weak, containing casts of crinoid stems, pebbles of chert, siderite and grains of sand	12	126
Limestone, argillaceous, dark brown, full of fossil fragments; a few masses of clay, sandy, dark green	3	129
Coal, bony	2	131
Pottsville ~~formation~~ Series?		
Fire clay, medium gray, soft	7	138
Sandstone, calcareous, light gray, fine, fairly firm, porous, micaceous	5	143
No samples	31	174
Sandstone, calcareous, light gray, very fine, compact, micaceous, containing much pyrite and siderite in masses; a few chips limestone, gray, dense and shale, black, brittle	6	180
Shale, gray, weak#	44	224
Shale, light and dark gray, slightly sandy, weak	10	234
Shale, partly sandy, gray, weak to firm	18	252
Shale, gray, weak, and some shale, carbonaceous, black, brittle and sandstone, slightly calcareous, gray, very fine, compact, containing pyrite	2	254
Sandstone, slightly calcareous, gray, very fine, compact, containing some pyrite, micaceous	12	266
No samples	9	275
Conglomerate, composed of subround pebbles quartz to 5 mm. diameter and pebbles chert, containing much brown dense siderite	3	278
Conglomer#ate, composed of pebbles of quartz, chert, siderite, and iron stained weathered limestone and some fine sand, limonite cemented	7	285
No sample	3	288
Mississippian system		
Burlington formation		
Chert, bluish gray and silty, containing much crystalline pyrite	5	293
Chert, bluish gray, much crystalline pyrite, a slight# calcite reaction	5	298
Chert, bluish gray and white, much crystalline pyrite, calcite reaction fair, shows fossil texture, a few pieces shale, brown, weak, containing much scattered crystalline pyrite	8	306

3. Parlin & Orendorff well.13/ SE. corner of sec. 27, T. 7 N., R. 4 E.

Elevation approximately 670 feet

13/ Log derived from record furnished by the company.

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Clay	42	42
Pennsylvanian system		
Carbondale ~~formation~~ series		
Shale	45	87
Coal (No. 5)	5	92
Shale	18	110
Limestone	5	115
Flint (cherty limestone)	#15	130
Shale	48	178
Shale, black	18	196
Shale	29	225
Coal (No. 2) and shale	10	235
Pottsville ~~formation~~ series		
Shale	132	367
Mississippian system		
Warsaw formation		
Limestone	11	378
Shale	5	383
Keokuk and Burlington formations		
Limestone	39	422
Shale and limestone	6	428
Limestone	34	462
Limestone and shale	120	582
Kinderhook and Sweetland Creek formations		
Shale	226	808
Devonian system		
Wapsipinicon formation		
Limestone	63	871
Silurian system		
"Niagaran" formation		
Limestone (reported in combination with the Maquoketa shale below)	124?	995?
Ordovician system		
Maquoketa formation		
Shale (reported in combination with "Niagaran" limestone above)	185?	1180?
Galena and Platteville formations	###	####
Limestone	310	1490
St. Peter formation		
Sandstone	210	1700

4. Canton city well No. 3. 1/ NW. ¼ NE. ¼ NW. ¼ NW. ¼ sec. 34, T. 7 N., R. 4 E. (145 feet northwest of Canton city well No. 1)

Elevation approximately 600 feet

1/ Log derived from description of samples studied by George E. Ekblaw.

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Missing	18	18
Till, calcareous, light bluish gray	22	40
Missing	5	45
Till, calcareous, gray to greenish gray	5	50
Pennsylvanian system		
Carbondale and Pottsville ~~formations~~ Series		
Shale, very calcareous, dark gray	10	60
Shale, non-calcareous, light gray	60	120
Sandstone, micaceous, gray, very fine-grained and limestone, dense or very finely crystalline, dark gray	10	130
Coal, shaly	1	131
Shale, calcareous, micaceous, coaly, blackish and greenish gray	5	136
Shale, calcareous, greenish; siltstone, arenaceous, greenish brown; and coal (No. 2)	39	175
Pottsville ~~formation~~ Series		
Shale, carbonaceous, micaceous, noncalcareous, black or gray	10	185
Shale, micaceous, pyritiferous, slightly calcareous, nearly black	15	200
Shale, micaceous, non-calcareous, black; interlaminated with siltstone, micaceous, arenaceous, dense, light gray	65	265
Sandstone, micaceous, fine-grained; a few chert grains	30	295
Sandstone and chert, chalky, granular, white or clear	5	300
Mississippian system		
Warsaw formation		
Shale, sandy, calcareous, light gray	35	335
Keokuk and Burlington formations		
Limestone, cherty	155	490
Sandstone, calcareous, cherty; quartz grains, calcareous matrix	22	512
Kinderhook and Sweetland Creek formations		
Shale, faintly calcareous, greenish-gray	208	720
Shale, micaceous, non-calcareous, grayish-tan	20	740
Shale, micaceous, slightly calcareous, greenish-gray	18	758
Devonian and Silurian systems		
Wapsipinicon (Devonian)and "Niagaran" (Silurian) formations		
Limestone, white, mottled with bluish	142	900
Ordovician system		
Maquoketa formation		
Shale, slightly calcareous, pyritiferous, dark greenish gray	200	1100
Galena formation		
Limestone, dolomitic, argillaceous, drab or bluish gray	20	1120
Dolomite, cherty, bluish gray, finely granular	165	1285

Platteville formation		
Dolomite, dark drab, with much chert	10	1295
Limestone, dolomitic, some chert, dark drab	105	1400
St. Peter formation		
Sandstone, white; rounded quartz grains	235	1635
Prairie du Chien series		
Shakopee formation		
Shale, greenish; siltstone, gray, pyritiferous; and dolomite	4	1639
Dolomite, greenish-gray, finely crystalline	2	1641

5. Canton city well No. 2.[1] NW. 1/4 NE. 1/4 NW. 1/4 NW. 1/4 sec. 34, T. 7 N., R. 4 E. (30 feet north and 10 feet east of Canton city well No. 1)

Elevation approximately 610 feet

---

[1] Log derived from driller's record.

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Clay	18	18
Pennsylvanian system		
Carbondale ~~formation~~ series		
Shale	14	32
Shale, gray	45	77
Shale	45	122
Shale, gray	8	130
Coal, and slate (shale)	1	131
Shale	5	136
Shale, blue	41	177
Shale, gray	13	190
Coal (No. 2) and slate (shale)	2	192
Pottsville ~~formation~~ series		
Slate (shale)	28	220
Shale, black	45	265
Limestone, sand and shale	55	320
Mississippian system		
Warsaw formation		
Shale	30	350
Keokuk and Burlington formations		
Limestone, flint (chert), sand and shale	100	450
Shale and marl	75	525
Kinderhook formation		
Shale	100	625
Sweetland Creek formation		
Shale, brown	40	665
Limestone and shale	40	705
Shale, brown	55	760
Devonian and Silurian systems		
Wapsipinicon (Devonian) and "Niagaran" (Silurian) formations		
Limestone	160	920
Ordovician system		
Maquoketa formation		
Limestone and shale	200	1120
Galena and Platteville formations		
Limestone	200	1320
Limestone and sand (Dolomite?)	90	1410
St. Peter formation		
Sandstone	240	1650

Prairie du Chien series		
Shakopee formation		
Shale	4	1654
Rock (dolomite) and shale	60	1714
Rock, brown (dolomite) and shale	50	1764
Shale and sand (dolomite)	46	1810
Shale, limestone, and sand (dolomite)	134	1944
New Richmond or Oneota formation, or both		
Sandstone (partly dolomite?)	99	2043

6. Canton city well no. 1.[1] NW. ¼ NE. ¼ NW. ¼ NW. ¼ sec. 34, T. 7 N., R. 4 E.

Elevation approximately 610 feet

---

[1] Log derived from driller's record.

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Clay	14	14
Pennsylvanian system		
Carbondale ~~formation~~ Series		
Shale, blue	29	43
Shale, gray	45	88
Shale, blue	40	128
Coal	1	129
Fire clay	6	135
Shale, blue	35	170
Shale, gray	22	192
Coal (No. 2)	2	194
Pottsville ~~formation~~ Series		
Slate (shale)	12	206
Shale	55	261
Limestone, sandstone and shale	65	326
Mississippian system		
Warsaw formation		
Shale	15	341
Limestone, black	7	348
Keokuk and Burlington formations		
Limestone, flint (chert), sandstone, slate (shaly limestone) and #marl	192	540
Kinderhook and Sweetland Creek formations		
Shale	225	765
Devonian system		
Wapsipinicon formation		
Limestone	63	828
Silurian system		
"Niagaran" formation		
Limestone (reported in combination with Maquoketa shale below)	72?	900?
Ordovician system		
Maquoketa formation		
Shale (reported in combination with "Niagaran" limestone #### above)	200?	1100?
Galena and Platteville formations		
Limestone	205	1305
Limestone, sandstone, and shale	100	1405
St. Peter formation		
Sandstone	241	1646

7. Old Canton city well (Jones Park).[1] NW. corner, SE. ¼ NE. ¼ sec. 34, T. 7 N., R. 4 E.

Elevation approximately 660 feet

---

[1] Log derived from driller's record.

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Surface (clay)	22	22
Sand	2	24
Clay, blue	16	40
Pennsylvanian system		
Carbondale ~~formation~~ Series		
Shale	40	80
Coal (No. 5)	4 ½	84 ½
Shale	15	99 ½
Limestone	20	119 ½
Shale	61	180 ½
Slate (shale)	15	195 ½
Shale	30	225 ½
Coal (No. 2)	1 ½	227
Pottsville ~~formation~~ Series		
Fire clay	6	233
Shale	15	248
Flint (hard limestone?)	5	253
Shale	35	288
Slate (shale)	7	295
Coal	1	296
Slate (shale)	12	308
Shale	50	358
Mississippian system		
Warsaw formation		
Limestone	17	375
Shale	23	398
Keokuk and Burlington formations		
Limestone, blue	18	416
Shale, sandy	12	428
Sand and gravel (cherty limestone)	30	458
Sandstone	7	465
Limestone, white	100	565
Kinderhook and Sweetland Creek formations		
Shale	226	791
← Devonian system		
Wapsipinicon formation		
Limestone (creviced)	62	853
Silurian system		
"Niagaran" formation		
Sandstone (Dolomite)?	7	860
Limestone	120	980

Ordovician system		
Maquoketa formation		
Shale and limestone	175	1155
Galena formation		
Limestone	186	1341
Platteville formation		
Sandstone	5	1346
Limestone	10	1356
Sandstone and limestone	20	1376
Limestone	69	1445
St. Peter formation		
Sandstone, white	282	1727

10-69

~~12~~ 8. John C. Schafer well No. 2.[1] Sec. 26, T. 6 N., R. 1 E.

Elevation 511 feet

1/ Log derived in part from driller's record and partly from description of samples studied by H. M. Dubois.

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Soil	4	4
Gravel and clay	6	10
Mississippian system		
St. Louis formation		
Clay, white, and limestone	10	20
Limestone	10	30
Slate (probably shaly limestone)	10	40
Sandstone, gray, soft, micaceous; fine, angular, calcareous grains; some brown chert	10	50
Spergen and Warsaw formations		
Slate, black (shale or shaly limestone)	60	110
Keokuk and Burlington formations		
Limestone, gray, fine-grained	15	125
Limestone, cherty, gray, fine-grained, more cherty below	20	145
Chert, gray to white, with gray, crystalline limestone	10	155
Chert, light gray, with gray, coarsely crystalline, siliceous limestone and coarse-grained, quartzose sandstone	5	160
Chert, white, with gray, coarsely crystalline siliceous limestone	30	190
Limestone, white, coarsely crystalline, with much white chert	62	252
Chert, white, with white, crystalline, siliceous limestone and gray shale	8	260
Limestone, siliceous, some oolitic, white, coarsely crystalline, with white chert	45	305
Kinderhook formation		
Shale, blue green, fine-textured	105	410
Sweetland Creek formation		
Shale, brownish-black, bituminous	20	430
Slate, blue (shale)	5	435
Slate, white (shale)	35	470
Shale, bituminous, carbonaceous, gray-green	69	539
Devonian system		
Wapsipinicon formation		
Limestone, gray, fossiliferous	29	568
Limestone, gray, with gray chert	12	580
Silurian system		
"Niagaran" formation		
Dolomite, gray, with some shale and a few quartz grains	8	588

9#. J. C. Morgan well.[1/] Sec. 24, T. 6 N., R. 1 E.

Surface elevation, 486 feet

1/ Log derived in part from driller's record but largely from description of samples studied by T. E. Savage.

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Soil	5	5
Sand, yellow	3	8
Pennsylvanian system		
Pottsville ~~formation~~ series		
Slate, blue (shale)	6	14
Coal (No. 1?)	2	16
Slate, blue (shale)	9	25
Shale, black	23	48
Mississippian system		
St. Louis formation		
Limestone, gray, finely crystalline	50	98
Spergen and Warsaw formations		
Slate, blue (shale)	84	182
Keokuk and Burlington formations		
Limestone, gray, coarse and fine grained, cherty	193	375
Kinderhook formation		
Slate, blue (shale)	115	490
Sweetland Creek formation#		
Shale, brown	20	510
Slate, blue (shale)	103	613
Devonian system		
Wapsipinicon formation		
Limestone, gray, crystalline, pyritic	26	639
Limestone, cherty	21	660
Silurian system		
"Niagaran" formation		
Dolomite, gray, crystalline	9	669

10. Cuba city well.[1/] SE. 1/4 SW. 1/4 sec. 17, T. 6 N., R. 3 E.

Elevation 677 feet

1/ Log derived from driller's record

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Subsoil and clay	34	34
Pennsylvanian system		
Carbondale and Pottsville ~~formations~~ Series		
Shale, sandy	~~68~~ 68	102
Sandstone	4	106
Coal (No. 5?)	5	111
Shale	144	255
Rock (limestone), black, hard	5	260
Shale, gray and dark	50	310
Mississippian system		
St. Louis formation		
Limestone, white	25	335
Spergen and Warsaw formations		
Shale	95	430
Keokuk and Burlington formations		
Limestone, white to gray, cherty	197	627
Kinderhook and Sweetland Creek formations		
Shale, gray or dark	243	870
Devonian and Silurian systems		
Wapsipinicon (Devonian) and "Niagaran" (Silurian)formations		
Limestone and dolomite, gray and brown	120	990
Ordovician system		
Maquoketa formation		
Shale, dark gray to brown	78	1068
Shale, light gray, dolomitic	102	1170
Galena and Platteville formations		
Dolomite, dark gray	40	1210
Dolomite, gray to tan	160	1370
Shale and sand (shaly dolomite)	100	1470
St. Peter formation		
Sandstone, white, clear rounded quartz grains	298	1768

11. F. W. Harrison well.[1/] SE. ¼ NE. ¼ SW. ¼ sec. 29, T. 6 N., R. 4 E.

Elevation approximately 625 feet

1/ Log derived from driller's record

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Soil	4	4
Mud, yellow (till clay)	28	32
Mud, blue (till clay)	10	42
Pennsylvanian system		
Carbondale ~~formation~~ series		
Coal (No. 5?)	5	47
Shale, blue	28	75
Shale, light	55	130
Shale, dark	8	138
Limestone	3	141
Coal (No. 2)	5	146
Pottsville ~~formation~~ series		
Shale, dark (~~fire~~ under clay)	4	150
Shale, light	25	175
Shale, sandy	25	200
Shale, dark	15	215
Shale, sandy	20	235
Sandstone	35	270
Shale, dark	17	287
Mississippian system		
St. Louis formation		
Limestone	33	320
Spergen and Warsaw formations		
Shale	15	335
Limestone	5	340
Sandstone	5	345
Shale, light	4	349
Limestone	54	403
Shale, light	12	415
Keokuk and Burlington formations		
Limestone	200	615
Kinderhook formation		
Shale, blue	125	740
Sweetland Creek formation		
Shale, brown	10	750
Shale, blue	30	780
Shale, brown	35	815
Shale, blue	23	838
Devonian system		
Wapsipinicon formation		
Limestone	18	856
Sand (dolomite)	16	872

Silurian system		
"Niagaran" formation		
Limestone	138	1010
Ordovician system		
Maquoketa formation		
Shale, blue	172	1182
Galena and Platteville limestone		
Limestone	213	1395

172
385
557

12. Robert Zemple well.[1] NE. corner, NW. 1/4 sec. 12, T. 5 N., R. 2 E.

Elevation approximately 605 feet

---

[1] Log derived from driller's record

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Soil	16	16
Sand	9	25
Pennsylvanian system		
Carbondale ~~formation~~ Series		
Soapstone (shale)	30	55
Muck, blue (shale)	20	75
Coal (No. 2?)	2	77
Pottsville ~~formation~~ Series		
Shale, gray	23	100
Shale, blue	25	125
Shale, dark	25	150
Mississippian system		
St. Louis formation		
Limestone	85	235
Spergen and Warsaw formations		
Shale	40	275
Sand rock (sandy shale or shaly limestone)	30	305
Keokuk and Burlington formations		
Rock, gray (limestone)	60	365
Limestone, white, coarse-grained	140	505
Kinderhook formation		
Shale, blue	95	600
Sweetland Creek formation		
Shale, brown	100	700
Shale, blue	60	760
Devonian and Silurian systems		
Wapsipinicon, (Devonian) and "Niagaran" (Silurian) formations		
Limestone	60	820

13. Brock well.[1/] NE. 1/4 SW. 1/4 sec. 24, T. 5 N., R. 2 E.

Elevation approximately 500 feet

1/ Log derived from driller's record

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Soil	40	40
Sand and gravel	30	70
Pennsylvanian system		
Pottsville ~~formation~~ Series		
Soapstone (shale)	5	75
Fireclay (shale)	4	79
Coal	1 1/2	80 1/2
Fire clay	4 1/2	85
Shale, black	18	103
Soapstone, shale	10	113
Mississippian system		
St. Louis formation		
"Brake", white (shale)	12	125
Limestone, shaly	12 1/2	137 1/2
Spergen and Warsaw formations		
Shale	46 1/2	184
Limestone, shaly	2	186
Shale	10	196
Limestone, shaly	2	198
Slate, blue (shale)	12	210
Limestone, shaly	8	218
Keokuk and Burlington formations		
Limestone	186	404
Kinderhook and Sweetland Creek formations		
Shale	244	648
Devonian and Silurian systems		
Wapsipinicon (Devonian) and "Niagaran" (Silurian) formations		
Limestone	109	757
Ordovician system		
Maquoketa formation		
Shale, blue	150	907
Limestone, shaly, dark	10	917
Shale, blue	12	929
Galena formation		
Limestone and shale, blue	36	965
Dolomite and shale, blue	20	985

14. Carl Marshall well.[1] SE. corner, SW. 1/4 NE. 1/4 sec. 29, T. 5 N., R. 2 E.

Elevation 618 feet

---

[1] Log derived from driller's record

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Soil and clay, yellow	28	28
Clay, blue	8	36
Sand, fine	13	49
Clay, blue, and gravel	18	67
Sand	3	70
Clay, blue	39	109
Sand	3	112
Clay, fine	5	117
Pennsylvanian system		
Pottsville ~~formation~~ series		
Soapstone (shale)	31	148
Sandstone	33	181
Mississippian system		
St. Louis formation		
Limestone and flintrock (chert)	40	221
Spergen and Warsaw formations		
Shale, blue	60	281
Keokuk and Burlington formations		
Limestone and flint rock (chert)	220	501
Kinderhook and Sweetland Creek formations		
Shale, blue, brown and white	240	741
Devonian and Silurian systems		
Wapsipinicon (Devonian) and "Niagaran" (Silurian) formations		
Conglomerate rock (limestone rubble?)	10	751
Limestone	84	835
Ordovician system		
Maquoketa formation		
Slate (shale)	100	935
Limestone	20	955
Shale	75	1030
Galena formation		
Sandstone (dolomite)	58	1088

15. Johnson well. 1/ Sec. 29, T. 4 N., R. 1 E.

Elevation approximately 695 feet

1/ Log derived from driller's record

	Thickness Feet	Depth Feet
Missing record	1023	1023
Ordovician system		
Maquoketa formation		
Shale, sandy	42	1065
Galena and Platteville formations		
"Caprock", brown (limestone)	5	1070
Limestone and sand (dolomite)	6	1076
Limestone	7	1083
Limestone and sand (dolomite)	185	1268
Shale, brown	7	1275
Limestone, buff	13	1288
"Sandstone", (dolomite)	11	1299
Limestone, buff and white	41	1340
St. Peter formation		
Sandstone, white	5	1345

16. Vermont Mills well.[1/] Sec. 29, T. 4 N., R. 1 E.

Elevation 695 feet

1/ Log derived from driller's record

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Soil and clay	88	88
Pennsylvanian system		
Carbondale ~~formation~~ Series		
Soapstone (shale)	51	139
Coal (No. 2)	1 1/2	140 1/2
Pottsville ~~formation~~ Series		
Fire clay	14 1/2	155
Rock (limestone)	1	156
Shale	44	200
Sandstone	7	207
Mississippian system		
St. Louis formation		
Shale	4	211
Limestone, white	29	240
Limestone, brown	18	258
Spergen and Warsaw formations		
Shale	27	285
Missing	19	304
Sandstone	6	310
Shale	50	360
Limestone	8	368
Shale	5	373
Keokuk and Burlington formations		
Limestone and chert	130	503
Limestone, white	64	567
Kinderhook and Sweetland Creek formations		
Shale, blue, gray, and brown	240	807
Devonian and Silurian systems		
Wapsipinicon (Devonian) and "Niagaran" (Silurian) formations		
Rock (limestone) with pyrite	5	812
Limestone	61	873
Ordovician system		
Maquoketa formation		
Shale, green, gray, and brown	91	964
Shale and fine sand	101	1065
Galena and Platteville formations		
Limestone, brown	5	1070
Limestone and sand-rock (dolomite)	274	1344
St. Peter formation		
Sandstone	20	1364

17. City well at Ipava.[1] NW. ¼ SE. ¼ SW. ¼ sec. 6, T. 4 N., R. 2 E.

Elevation 650 feet

---

[1] Log derived from driller's record

	Thickness Feet	Depth Feet
Pleistocene and Recent systems		
Soil and loess	23	23
"Soapstone" (probably hard, blue till)	27	50
Sand and gravel	15	65
Pennsylvanian system		
Carbondale ~~formation~~ series		
Limestone shell (shaly)	2	67
Slate, white (shale)	44	111
Coal (No. 2)	2-3	113
Pottsville ~~formation~~ series		
Limestone shell (shaly)	3	116
Slate (shale)	24	140
Limestone	3	143
Shale, white	17	160
Shale, brown	10	170
Shale, light	10	180
Sandstone	15	195
Mississippian system		
St. Louis formation		
Limestone, shell (shaly)	5	200
Limestone	45	245
Spergen and Warsaw formations		
Slate, green (shale)	65	310
Slate (shale)	10	320
Keokuk and Burlington formations		
Limestone, hard and sharp	114	434
Limestone, white	67	501
Limestone, brown	24	525
Kinderhook formation		
Slate, dark (shale)	105	630
Sweetland Creek formation		
Shale, brown	30	660
Slate, white (shale)	40	700
Shale, brown	20	720
Slate, white (shale)	35	755
Devonian and Silurian systems		
Wapsipinicon (Devonian) and "Niagaran" (Silurian) formations		
Limestone, brown	80	835
Ordovician system		
Maquoketa formation		
Slate, light (shale)	55	890
Shale, brown	21	911
Limestone, blue and brown, with slate (shale)	114	1025
Galena and Platteville formations		
Limestone	279	1304
St. Peter formation		
Sandstone	20	1324

18. Ipava Woolen Mill well.[1] Sec. 6, T. 4 N., R. 2 E.

Elevation approximately 640 feet

[1] Log derived from driller's record

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Soil	23	23
Pennsylvanian system		
Carbondale ~~formation~~ series		
Soapstone (shale)	47	70
Slate, black (shale)	30	100
Pottsville ~~formation~~ series		
Shale, white	50	150
Slate, black (shale)	50	200
Mississippian system		
St. Louis formation		
Limestone	50	250
Spergen and Warsaw formations		
Shale, black	80	330
Keokuk and Burlington formations		
Limestone	100	430
Sandstone (cherty limestone?)	35	465
Limestone, white	43	508
Kinderhook and Sweetland Creek formations		
Slate, blue and brown (shale)	232	740
Devonian and Silurian systems		
Wapsipinicon (Devonian) and "Niagaran" (Silurian) formations		
Limestone	85	825
Ordovician system		
Maquoketa formation		
Slate, green (shale)	93	918
Limestone	18	936
Shale	74	1010
Galena and Platteville formations		
Limestone	270	1280
St. Peter formation		
Sandstone	290	1570

19. Hahn well[1]. Center of S. side, NW. ¼ sec. 31, T. 22 N., R. 8 W. of 3d P. M. (near Havana)

Elevation approximately 470 feet

---

[1] Log derived from driller's record; detailed descriptions derived from samples studied by A. W. Thurston.

	Thickness Feet	Depth Feet
Recent and Pleistocene (and Pennsylvanian?) systems		
Missing record	94	94
Pennsylvanian system		
Pottsville ~~formation~~ series (?)		
Limestone	11	105
Slate, white (shale)	60	165
Mississippian system		
St. Louis formation		
Limestone	65	230
Spergen and Warsaw formations		
Slate, white (shale)	10	240
Limestone	80	320
Slate, white (shale)	15	335
Keokuk and Burlington formations		
Limestone	220	555
Kinderhook formation		
Slate, white (shale)	95	650
Sweetland Creek formation		
Slate, brown	130	780
Devonian and Silurian systems		
Wapsipinicon (Devonian) and "Niagaran" (Silurian) formations		
Limestone, white	10	790
Limestone, brown	5	795
Limestone, white to light gray	95	890
Limestone, light tan, very cherty	60	950
Ordovician system		
Maquoketa formation		
Shale, calcareous, sandy, medium to dark greenish-gray	30	980
Sandstone, shaly, calcareous, fine-grained, medium greenish-gray	20	1000
Shale, calcareous, sandy, greenish-gray, with limestone, light brown	140	1140
Galena and Platteville formations		
Limestone, dolomitic, brown, with gray shale	60	1200
Limestone, dark tan to light brown, with light chert	180	1380
Limestone, dark tan or dark gray	55	1435
St. Peter formation		
Sandstone,; clear quartz grains, rounded, medium size	7	1442

20. American Milk Products Co. well,1/ Union, ### SW. ¼ SW. ¼ sec. 32, T. 23 N., R. 6 W. of 3d P.M.
Elevation approximately 520 feet.

1/ Log derived from driller's record

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Surface soil and drift	121	121
Pennsylvanian or Mississippian system		
Pottsville (group) or St. Louis formation (?)		
Limestone and shale	134	255
Mississippian system		
St. Louis (?), Spergen, Warsaw, Keokuk and Burlington formations		
Limestone	370	625
Kinderhook and Sweetland Creek (?) formations		
Sandstone	140	765
Red marl and limestone	10	775
Devonian and Silurian systems		
Wapsipinicon (Devonian) and "Niagaran" (Silurian) formations		
Limestone	115	890
Limestone and marl	71	961
Ordovician system		
Maquoketa formation#		
Sandstone	139	1100
Red marl and shale	32	1132

21. John Salisbury well.[1/] SE. ¼ NW. ¼ sec. 24, T. 3 N., R. 2 E.

Elevation approximately 500 feet

1/ Log derived from driller's record; detailed descriptions derived from samples studied by A. W. Thurston.

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Soil	2	2
Sand	16	18
Gravel	8	26
Pennsylvanian system		
Pottsville ~~formation~~ series		
Sandstone	30	56
Slate (shale), sandy, micaceous, light greenish-gray	24	80
Mississippian system		
St.Louis formation		
Limestone, light gray, hard	37	117
Limestone, light buff to dark tan or gray, hard, cherty	23	140
Limestone, sandy, brown	5	145
Limestone, cherty, light gray	10	155
Limestone, sandy, light gray	#5	160
Limestone, very cherty, light gray	4	164
Spergen and Warsaw formations		
Shale, bluish-gray with limestone, sandy	4	168
Limestone, sandy	21	189
Limestone, sandy, with slate (shale), white	35	224
Limestone, dark gray	6	230
Shale, dalcareous, light gray	5	235
Limestone, shaly	5	240
Keokuk and Burlington formations		
Limestone, shaly, cherty, gray, crinoidal	81	321
Limestone, light brownish-gray, dense, with sandstone, calcareous, fine-grained and shale	9	330
Limestone and chert	15	345
Limestone, sandy, cherty, light gray	16	361
Limestone, very cherty, light cream-gray	119	480
Kinderhook formation		
Shale, light	95	575
Sweetland Creek formation		
Slate(shale), brown	25	600
Shale, dark brownish-gray	20	620
Shale, cinnamon-colored, petroliferous	60	680
Slate (shale), gray	30	710

21. (cont.)

Devonian and Silurian systems		
Wapsipinicon (Devonian) and "Niagaran" (Silurian) formations		
Limestone, light gray	20	730
Limestone, dolomitic, light gray	45	775
Limestone, dolomitic, cherty, light cream-gray	59	834
Limestone	3	837
Ordovician system		
Maquoketa formation		
Shale, light greenish-gray	38	875
Shale, dark gray, with gray limestone	33	908
Limestone, light gray, and shale, calcareous, dark gray	36	944

22. Astoria Creamery well [1]. Center of S. side, SE. 1/4 NE. 1/4, sec. 23, T. 3 N., R. 1 E.

Elevation approximately 690 feet

---

[1] Log derived from driller's record

	Thickness Feet	Depth Feet
Recent and Pleistocene systems		
Clay, blue and yellow	52	52
Pennsylvanian system		
Carbondale ~~formation~~ series		
Limestone	1	53
Coal (No. 5)	6	59
Fire clay (and shale)	25	84
Shale	80	164
Coal (No. 2)	3	167
Pottsville ~~formation~~ series		
Shale	60	227
Limestone	2	229
Coal	2	231
Mississippian system		
St. Louis formation		
Limestone	65	296
Spergen and Warsaw formations		
Shale	50	346
Keokuk and Burlington formations		
Limestone	195	541

Appendix C. Part II.

Well records (cont.)

Key No. on map	Location by township and quarter section	Altitude	Description and correlation	Thickness Feet	Depth Feet
			Key: 1, Recent and Pleistocene systems#--A, Wisconsin and Recent series (terrace and flood plain)##--B, Peorian, Sangamon, and Illinoian series; 2, Pennsylvanian system--A, Carbondale series--B, Pottsville series; 3, Mississippian system--A, St. Louis formation		
	Fulton County T. 6 N., R. 4 E. (Buckheart Twp.)				
23	21 NE NE	635	1B. Loess and drift (water from drift)	30	30
24	30 SE SW	620	1B. Loess, drift and sand (water from sand)	20	20
25	34 NE SE	605±	1B, 2A. No record. Ends on top of Springffeld (No. 5) coal#	40	40
#6	T. 6 N., R. 3 E. (Putman Twp.)				
26	19 SW NW	665±	1B. Loess and drift	78	78
			2A. Sandstone (Pleasantview sandstone?)	4½	82½
	T. 6 N., R. 2 E. (Cass Twp.)				
27	24 NE SE	680	1B. Loess and drift (water from sand)	22	22
28	24 NE SE	680	1B. Loess and drift	23	23
			2A. Sandstone		23
29	25 SE NE	660±	1B. Loess and drift (water from gravel	25	25
30	25 SE NE	660±	1B, 2A#####No record. Ends in "blue stone.	35	35
#1	T. 5 N., R. 3 E. (Lewistown Twp.)				
31	3 NW SW	600±	1Ba. Yellow clay (loess and drift)	25	25
			b. Blue clay (drift)	50	75
			c. Sand and gravel		75
32	8 NE NE	490±	1A, 1B. Sand and gravel and drift	38 5/6	38 5/6
			2Ba. Shale and coal measures	60	98 5/6
			b. No record	31 1/6	130
			3A, ###. Limestone		130
			No record, ends in Cambrian system	2115	2245

33	32 SW SE	457	1Aa.	Top soil	7	7
			b.	Sand, fine	8	15
			c.	Sand, coarse	3	18
			d.	Sand, coarse and gravel	3	21
			e.	Gravel	6	27
			f.	Mud	1/6	27 1/6
			g.	Fine sand		27 1/6
	T. 5 N., R. 4 E. (Liverpool Twp.)					
34	6 SE NW	605±	1B.	Loess and drift	61	61
			2Aa.	Rock	$1\frac{1}{4}$	$62\frac{1}{4}$
			b.	Coal (Springfield or No. 5)	5	$67\frac{1}{4}$
	T. 4 N., R. 3 E. (Isabel Twp.)					
35	7 NW SE	540±	1B, 2A, 2Ba.	No record. Sandstone at base	170	170
			2Bb.	Coal (Rock Island or No. 1)	4	174
	T. 4 N., R. 2 E. (Pleasant Twp.)					
36	1 NW NE	580+	1B, 2A, 2B.	No Record. No. 1 coal absent	179	179
			3A.	Limestone		179
37	1 SE NE	580+	1B, 2A, 2B.	No record	121	121
			3A.	Limestone. Open crevice at 144 foot depth	30+	151+
	Mason County T. 21 N., R. 9 W. (Havana Twp.)					
38	1 SE NE	500±	1A.	Sand and gravel	75	75

Appendix C. Part III.

Deeper coal test borings in and near the Havana quadrangle.

No.	Location by township and quarter-quarter section	Alt.	Description and Correlation	Thickness Feet	In.	Depth Feet	In.
			Correlation Key: 1, Recent and Pleistocene systems; 2, Pennsylvanian system -- A, Brereton formation; B, St. David formation; C, Summum formation; D, Liverpool formation; E, Greenbush formation; F, Wiley formation; G, Seahorne formation; H, "Brush Creek" formation; I, Bernadotte formation; J, Seville formation; K, Pope Creek formation; L, Babylon formation; 3, Mississippian system--A, St. Louis formation; B, Warsaw and Spergen formations				
	Fulton County T. 6 N., R. 4 E. (Buckheart Twp.)						
1	9 NE. SW. SE.	648	1. Clay (loess and drift)	30		30	
			2Ba. Shale (Canton)	17	6	47	6
			b. Limestone (St. David)	1	4	48	10
			c. Shale, dark		9	49	7
			d. "Slate" (shale)	2	2	51	9
			e. Coal (Springfield No. 5)	4	8	56	5
			f. "Fire-clay" (underclay)	2		58	5
			g. Shale (partly 2C)	13	7	72	
			2Ca. "Slate" (shale) and coal (Kerton Creek)		3	72	3
			b. Shale	3	9	76	
			c. "Hard brown rock" (limestone?)	2		78	
			d. Sandstone (Pleasantview)	10		88	
			e. Shale	2		90	
			f. Shale, sandy, light (Pleasantview)	18		108	
			2Da. Shale, gray (Purington)	19		127	
			b. Shale, dark, streaky	9	8	136	8
			c. "Slate", (shale), dark	2	6	139	2
			d. Shale, light	2		141	2
			e. Shale, dark	4	4	145	6
			f. "Cap rock" (limestone)	2	2	147	8
			g. "Slate" (shale)	2		149	8
			h. Coal (Colchester No. 2)	3	3	152	11
			i. "Fire-clay" (underclay)	1		153	11
2	15 NE. NE. SW.	620	1a. Clay (loess and drift)	18		18	
			b. Sand	10		28	
			2Ba. Shale (Canton)	5	4	33	4
			b. Limestone (St. David)		5	33	9
			c. Shale		7	34	4
			d. "Slate" (shale)	1	1	35	5

				e. Coal (Springfield No. 5)	4	9	40	2
				f. "Fire-clay" (underclay)	1	10	42	
				g. Shale (partly 2C)	16		58	
				2Ca. Sandstone (Pleasantview)	8		66	
				b. Shale, sandy, light (Pleasantview)	14		80	
				c. Shale, sandy, dark (Pleasantview)	26		106	
				d. Sandstone (Pleasantview)	27		133	
				2Da. Shale, dark	1	8	134	8
				b. Limestone		7	135	3
				c. Shale, gray, soft	2	7	137	10
				d. Shale, dark	3	6	141	4
				e. "Cap-rock" (limestone), hard	1	6	142	10
				f. ~~Shale streaked~~ "Slate" (shale), streaked	3	2	146	
				g. Shale	7	2	153	2
				h. Coal (Colchester No. 2)	2	8	155	10
				i. "Fire-clay" (underclay)	1	4	157	2
				j. Sandstone (Isabel)		10	158	
3	16	SE. SE. SW.	573	2Ba. "Fire-clay" (underclay of Springfield No. 5 coal)	16		16	
				2Ca. Shale	10		26	
				b. "Slate" (shale)	1		27	
				c. Sandstone (Pleasantview)	9		36	
				2Da. Shale (Purington)	48		84	
				b. "Slate" (shale)		6	84	6
				c. Shale	6		90	6
				d. Limestone, hard	3		93	6
				e. Coal (Colchester No. 2)	6(?)		99	6
				f. "Fire-clay" (underclay		6	100	
				g, and 2E, 2F, and 2G. Sandstone	34		134	
				2H. (?) Gravel wash	5		139	
				2Ia. "Slate" (shale)and "fire-clay" (underclay	5		144	
				b. Sandstone (Bernadotte)	12	6	156	6
				2Ja. Coal (Rock Island No. 1)	4		160	6
				b. Sandstone	25		185	6
				2Ka. Coal	1	6	187	
				b. Sandstone	10		197	
4	16	NE. SW. SE.	556	1a. Subsoil (alluvium)	12		12	
				b. Gravel	2		14	
				2Ca. "Fire-clay" (underclay)	8		22	
				b. Shale, sandy (Pleasantview)	48		70	
				2Da. Shale (Purington)	16	6	86	6
				b. Limestone, lower part hard	3		89	6
				c. "Clod" (calcareous clay), with small particles of coal and some gas and oil	1	3	90	9
				d. "Slate" (shale)	1		91	9
				e. Coal (Colchester No. 2)	4		95	9

5	20	NW. NW. SE.	551	1 and 2C or 2D. Clay	22		22	
				2Da. Shale with hard streaks (Purington)	12	8	34	8
				b. Shale, hard	6	9	41	5
				c. Shale, sandy, hard	2	6	43	11
				d. Limestone	1	4	45	3
				e. "Slate" (shale), very black	3	9	49	
				f. "Rock band" (limestone?)		2	49	2
				g. Coal (Colchester No. 2)	2		51	2
				h. "Fire-clay" (underclay	#1	2	52	4
				i. Sandstone (Isabel)	2	8	55	
6	21	NE. NE. SE.	613	1a. Clay (loess and drift)	15		15	
				b. Sand and gravel	6		21	
				c. Clay (drift)	9		30	
				2Ca. Shale	1	6	31	6
				b. Limestone, soft and sandy	8		39	6
				c. "Fire-clay" (underclay)	2		41	6
				d. Sandstone (Pleasantview)	16	6	58	
				e. Shale	6		64	
				f. Shale, sandy, dark	20		84	
				g. Sandstone (Pleasantview)	5		89	
				2Da. Shale, light (Purington)	13	6	102	
				b. Shale, dark	7	9	110	
				c. "Cap-rock" (limestone), hard	1	6	111	
				d. "Slate" (shale)	2	11	114	
				e. Shale (Francis Creek)	4	6	119	
				f. Coal (Colchester No. 2)	2	4	121	
				g. "Fire-clay" (underclay)	2	1	123	
				h. Shale, sandy, dark (Isabel)	1	7	125	
7	21	NW. NE. NW.	586	1. Clay ~~##########~~ (loess and drift)	10		10	
				2Ca. Shale	#2		12	
				b. Sandstone (Pleasantview)	12		24	
				#2Da. Shale (Purington)	29		53	
				b. Shale, dark	5		58	
				c. Shale, gray	5	2	63	
				d. Limestone, hard	1	6	64	
				e. "Slate" (shale)	3	2	67	1
				f. Shale (Francis Creek)	2	10	70	
				g. Coal (Colchester No. 2)	2	9	73	
				h. "Fire-clay" (underclay)	2		75	
				i. Shale, sandy	14	4	89	
				j. Sandstone, hard	1		90	
				2E or 2F. Shale, sandy	2	4	93	
				2Fa. Coal	1	5	94	
				b. "Fire-clay" (underclay)	1	6	96	
				2Ga. Shale, dark, sandy	1		97	
				b. Sandstone	7		104	
				2Ha. Shale	7		111	
				b. "Slate" (shale)		7	111	
				c. Sandstone		7	112	
				2Ia. "Fire-clay" (underclay)	1	4	113	
				b. Sandstone (Bernadotte)	7	6	121	
				2Ja. Shale	1	6	122	
				b. Shale, dark	1	4	123	

				c. "Slate" (shale)	1		124	1
				d. Coal (Rock Island No. 1)	1		125	1
				e. "Fire-clay" (underclay)	1	7	127	
				f. Coal	2	1	129	
				g. "Fire-clay" (clay)		2½	129	
				h. Coal		3	129	1
				i. "Fire-clay" (clay)		2½	130	
				j. Coal		10	131	
				k. Shale	3		134	
				l. "Fire-clay" (underclay)	5		139	
				m. Sandstone	4		143	
				2Ka. Shale, sandy, gray	2		146	
8	28	SW. NW. NE.	615	1. Clay (loess and drift)	21		21	
				2Ba. "Slate" (shale)	1	8	22	8
				b. Coal (Springfield No. 5)	4	10	27	6
				c. "Fire-clay" (underclay)	7	6	35	
				2Ca. "Slate" (shale, soft	1	6	36	6
				b. Shale, gray	9	6	46	
				c. Shale, sandy	19		65	
				d. Shale, gray	24		89	
				e. Sandstone	14		103	
				2Da. Limestone, sandy	1		104	
				b. Shale, light and dark (Purington?)	16		120	
				c. Shale, sandy, dark, hard	2	4	122	4
				d. Limestone	1	7	123	11
				e. "Slate" (shale)	3	11	127	10
				f. Coal (Colchester No. 2)	2	4	130	2
				g. "Fire-clay" (underclay)	1	8	131	10
				h. Shale, sandy	6	2	138	
				i. Sandstone	9	9	147	9
				2E or 2F. Shale, sandy	2	6	150	3
				2Fa. Coal	1	2	151	5
				~~b. "Fire-clay" (underclay)~~	6			
				b, and 2Ga. "Fire-clay" (underclay)	6	6	157	11
				2Gb. Shale, sandy	7	1	165	
	T. 6 N., R. 3 E. (Putman Twp.)							
9	3	SE. SW. SW.	640±	1. Clay, sand, gravel and boulders (loess and drift)	55		55	
				2Ca. Shale, light	5		60	
				b. Sandstone, shaly (Pleasantview)	20		80	
				c. Shale, sandy, blue (Pleasantview or Purington)	54		134	
				2Da. Shale, dark	7		141	
				b. "Slate" (shale, hard) and shale, blue	11	8	157	8
				c. Coal (Colchester No. 2)	2	4	160	
				d. Shale, blue (underclay and sandy shale)	8		168	
				e. Shale, sandy	5		173	
				2E or 2F. Shale, dark, sandy	5		178	
				2Fa. Coal	1		179	
				b and 2B and 2H. Shale	21		200	
				2H. Sandstone	2		202	
				2Ia. Shale, light and dark	8		210	

				~~b. Shale, dark, and sandstone bands~~	~~15~~		~~239~~
				b. Sandstone and shale, sandy	4		214
				2Ja. "Slate" (shale)	4		218
				b. Coal (Rock Island No. 1?)	1	9	219
				c. Shale, light	2	3	222
				d. Shale, sandy	2		224
				2Ka[x](?) Shale, dark and sandstone bands	15		239
				b. Sandstone	4		244
				2La.(?) Coal	2		246
				b. Shale, dark and light	42		288
				c. Sandstone	24		312
				d. Shale, sandy, dark	24		336
				e. Shale, blue (may be 3B)	20		356
				~~3A.~~			
				3Ba. Limestone	2		358
				b. Shale, limey	20		378
				c. Limestone	4		382

[x] Correlation of beds below Rock Island coal in this log is very uncertain.

10.	5	NW. NE. SW.	550± 5'	1a. Clay, sandy (alluvium)	20		20
				b. Drift, sandy	9		29
				2Da. Shale, mixed	11		40
				b. Shale, dark	2		42
				c. Shale, light (Francis Creek)	14		56
				d. Coal (Colchester No. 2)	3		59
				e, and 2E. Shale, sandy, light	11		70
				F 2Fa. Coal	2	4	72
				b. "Fire-clay" (underclay)	3	8	76
				2G and 2 H. Shale, sandy, light	19		95
				2Ia. Shale, mixed	10		105
				b. Shale, gray	6	4	111
				c. Coal		4	111
				d. Sandstone		6	112
				e. Coal	1	2	113
				f. Shale, light (underclay?)		8	114
				2Ja. Limestone (Parks Creek?)	5		119
				b. Coal (Rock Island No. 1)	2	1	121
				c. "False bottom" (carbonaceous shale)		6	121
				d. Shale, sandy, light	4	11	126
				e. Sandstone, light		6	127
				2Ka. Shale, dark	4		131
				b. Shale, light	4		135
				2K, 2L or 3B. Shale. light and light gray	45		180
11.	5	NE. SW. SW.	550± 5'	1a. Drift, sandy	10		10
				b. Sand and gravel	8		18
				2Da. Shale, sandy, light	4		22
				b. Sandstone, light (Isabel?)	9		31
				2Ea. Shale, mixed	23	6	54
				b. Coal		6	55
				c. Shale, sandy, light	5	8	60
				2Fa. Coal	1		61
				b. Sandstone, light	3		64

				c. Shale, sandy, light	3		67	
				2Ga. Coal		10	68	
				b. Shale, sandy, light	1	6	70	
				c. Sandstone, light	5		75	
				2Ha. Coal		8	75	
				b. Shale, sandy, light	4	4	80	
				2Ia. Shale, gray	2		82	
				b. Coal		4	82	
				c. Shale, gray	1	2	83	
				d. Coal		6	84	
				e. Shale, sandy, light (Bernadotte?)	2	8	86	
				2Ja. Coal (Rǒck Island No. 1?)	1	8	88	
				b. Shale, light	9	8	98	
				2Ka (?) Shale, gray	9	6	107	
				b. Shale, sandy, light	2	6	110	
				c. Shale, gray	3		113	
				d. Sandstone, light	1	6	114	
12#	5	SE. NE. NW.	550± [5]	1a. Clay, sandy (alluvium)	6		6	
				b. Sand and gravel	27	6	33	
				2E and 2F. Shale, mixed	13	6	47	
				2Fa. Coal	1	2	48	
				b, and 2G. Shale, light	12	10	61	
				2Ga. Sandstone, light	7		68	
				2H and 2I. Shale, mixed	16	3	84	
				2Ia. Coal		9	85	
				b. Shale, sandy, light	1	6	86	
				2Ja. Limestone		6	87	
				b. Limestone, dark (Parks Creek)	16		103	
				c. "Clod" (calcareous clay)		1	103	
				d. Coal (Rock Island ## No. 1)	2	5	105	
				e. "False bottom" (carbonaceous shale)		6	106	
				f. Sandstone	4		110	
13	6	NW. NW. SE.	640± [5]	1a. Clay (loess and drift)	25		25	
				b. Drift, sandy	55		80	
				2Da. Shale, mixed	10		90	
				b. Sandstone, light (may be Pleasantview, 2C)	3		93.	
				c. Shale, sandy, light	2	6	95	
				d. "Slate" (shale), black	1	7	97	
				e. "Rock" (limestone), brown	1	4	98	
				f. Shale, light (Francis Črеek)	10	4	108	
				g. Coal (Colchester No. 2)	2	1	110	1
				h. Shale, sandy, light	8	6	119	
				i. Sandstone, gray	4	10	124	
				2E. Shale, sandy, gray	12	8	136	1
				2Fa. Coal		10	137	
				b. Shale, ######light	1	6	139	
				c. Sandstone, light	3	8	142	1
				2G and 2H. Shale, sandy, light	32	5	175	
				2Ia. Shale, dark	3		178	
				b. Limestone, dark		5	178	
				c. Coal	1	8	180	
				d. Shale, sandy, gray		8	181	
				2Ja. Limestone, dark (Paxxks Creek)	17	6	198	

No.	Sec.	Location	Elev.	Unit	Description	Ft.	In.	Depth	
				b.	"Slate" (shale), sandy	1	6	200	
				c.	Coal (Rock Island No. 1)	4	5	204	
				d.	"False bottom" (carbonaceous shale)		8	205	
				e.	Shale, sandy, light	4		209	
14	6	NW. NW. SE.	640± 10	1a.	Clay, sandy (loess and drift)	22		22	
				b.	Drift, gray	17		39	
				c.	Sand, gray	12	6	51	
				2D.	Shale, light and gray (apparently includes Colchester coal)	37	6	89	
				2E.	Shale, sandy, light	14	8	103	
				2Fa.	Coal	1	4	105	
				~~2Fb, and~~ 2G and 2H.	Shale, sandy, light	24	6	129	
				2Ha.	Sandstone, light	3		132	
				b.	Shale, sandy, light	15	8	148	
				c.	Sandstone, light		8	148	1
				d.	Shale, sandy, light	9	3	158	
				2Ia.	Shale, dark	3	1	161	
				b.	Coal	1	7	162	
				c.	Shale, sandy, light	4	7	167	
				d.	Sandstone, light		10	168	
				2Ja.	Limestone, dark (Parks Creek)	11	6	179	
				b.	"Clod" (calcareous clay)		4	180	
				c.	Coal (Rock Island No. 1)	3	8	183	
				d.	Sandstone	1	4	185	
15	6	SW. NW. SE.	625± 5	1a.	Clay (loess and drift)	19		19	
				b.	Sand	6		25	
				c.	Drift, gray	76	6	101	
				2D.	Shale, sandy, light (Isabel)	12	6	114	
				2Ea.	Shale, sandy, gray	4	9	118	
				b.	Rock (limestone), brown		8	119	
				c.	Shale, gray	4	6	123	1
				2Fa.	Coal	1	2	125	
				b, and 2G.	Shale, light	11	1	136	
				2Ha.	Shale, dark	1	6	137	
				b.	Shale, mixed	15	4	153	
				c.	Coal		7	153	
				d.	Shale, light	5		158	
				e.	Coal		9	159	
				f.	Shale, light	2	4	161	
				2Ia.	Shale, gray		8	162	
				b.	Clay, boulder (concretion?)		10	163	
				c.	Coal		8	163	1
				d.	Shale, mixed	1		164	1
				2Ja.	Limestone, dark (Parks Creek)	26	4	191	
				b.	Coal (Rock Island No. 1)	4	4	195	
				c.	Shale, sandy, gray	1	2	196	
				d.	Shale, sandy, light	4	8	201	

16	6	SE. SW. SE.	565± 10'	1a.	Clay (loess and drift)	22		22
				b.	Sand	36		58
				2E.	Shale, mixed	5	10	63
				2Fa.	Coal		8	64
				b, and 2G.	Shale, light	17	2	81
				2Ha.	Shale, mixed	8	10	90
				b.	Rock (limestone?) brown		8	91
				c.	Shale, mixed		10	92
				d.	Sandstone, light		6	92
				2Ia.	Shale, light	8	8	101
				b.	Shale, dark		6	101
				c.	Coal	1	5	103
				d.				
				2Ja.	Shale, dark	1	6	104
				b.	Shale, mixed	5	5	110
				c.	Limestone, dark (Parks Creek)	18	1	128
				d.	Shale, dark	6	3	134
				e.	Coal	4	6	138
				f.	Shale, gray	1	2	140
				g.	Shale, light	3		143
17	6	SW. SW. SE.	555± 10'	1a.	Clay (loess and drift)	21		21
				b.	Drift, gray	36	6	57
				c.	Sand	25	3	82
				2G and 2H.	Shale, mixed	25	8	108
				2Ha.	Sandstone, gray		10	109
				2Ia.	Shale, mixed	10	3	119
				b.	Coal		10	120
				c, and 2J.	Shale, mixed	10	5	130
				2Ja.	Limestone, dark (Parks Creek)	8	10	139
				b.	Shale, dark	7	7	147
				c.	Coal (Rock Island No. 1)	3	11	151
				d.	Shale, dark	1		152
				e.	Shale, sandy, light	1	5	153
18	6	NE. SW. SE.	560± 10'	1a.	Clay, sandy (loess and drift)	17		17
				b.	Drift, gray	25		42
				c.	Sand and gravel	3		45
				2D and 2 E.	Shale, mixed	16	6	61
				2E.	Sandstone, light	1	4	62
				2Fa.	Shale, mixed	1	2	64
				b.	Coal		8	64
				c.	Shale, mixed	4	6	69
				2G and 2H.	Shale, light gray	26	2	95
				2Ia.	Shale, dark	1	9	97
				b.	Coal	2	5	99
				c.	Shale, mixed	1	2	100
				2Ja.	Limestone, dark (Parks Creek)	14	2	114
				b.	Shale, dark		3	115
				c.	Coal (Rock Island No. 1)	2	4	117
				d.	"Fire-clay" (underclay)	3	6	120
				2Ka.	Shale, gray	12		132
				b.	Coal		5	133
				c.	Shale, light gray	2	10	136

(38)

No.	Sec.	Location	Elev.	Strata	Ft.	In.	Depth
19	6	NE. SE. SE.	560± 5'	1a. Clay, sandy (alluvium)	34		34
				b. Sand and gravel	4		38
				2D and 2E. Shale, mixed	16	8	54
				2Fa. Coal	1		55
				b. Shale, light	1	4	57
				2Ga. Rock, boulder (Seahorne limestone?)	2		59
				b, and 2H. Shale, sandy, light	31		90
				2Ia. Shale, dark	3	1	93
				b. Coal		3	93
				c. Rock, sulphur (pyrite)	#	6	93
				d. Coal	1	10	95
				e. "False bottom" (carbonaceous shale)		4	96
				f. Sandstone	1		97
20	7	NW. NE. NE.	545± 5'	1a. Drift, sandy	10		10
				b. Sand and gravel	19		29
				2E. Shale, light	3	6	32
				2Fa.		8	33
				b, and 2G, 2H, and 2I. Shale, mixed	36	10	70
				2Ja. Limestone, dark (Parks Creek)	20	9	90
				b. "Clod" (calcareous clay)		1	90
				c. Coal (Rock Island No. 1)	3	11	94
				d. Sandstone	1		95
21	7	SW. NE. NE.	551± 5'	1a. Soil and clay (alluvium)	20		20
				b. Sand and gravel	6		26
				2D. Shale, mixed	9		35
				2D or 2E. Shale, sandy, mixed	7		42
				2E. Shale, light gray	1	8	43
				2Fa. Coal	1	2	44
				b, and 2G and 2H. Shale, mixed	23	6	68
				2Ia. Shale, dark	3	8	72
				b. Sandstone, light	12	6	84
				2Ja. Limestone, dark (Parks Creek)	31	2	115
				b. "Clod" (calcareous clay)		2	115
				c. Coal (Rock Island No. 1)	4	5	120
				d. "Hard bottom" (underclay on sandstone)		3	120
22	7	SW. NW. NE.	550± 5'	1a. Clay, sandy	9		9
				b. Sand	10		19
				2D. Shale, light	7	4	26
				2E. Shale, gray	11	10	38
				2Fa. coal	1	6	39
				b and 2G. Shale, light	7	4	47
				2Ga. Sandstone, light	1	2	48
				2H. Shale, mixed	17	2	65
				2Ia. Rock (limestone?), black		8	66
				b. Shale, dark	2	6	68
				c. Shale, mixed	8	6	77
				d. Coal	1	1	78
				e. Shale, dark		8	78
				f. Sandstone, light (Bernadotte)	4		82
				2Ja. Limestone, dark (Parks Creek)	13	2	95

				b. Shale, dark	7	6	103
				c. Coal (Rock Island No. 1)	4	2	107
				d. Shale, light	1		108
23	7	NE. SE. NE.	640± 10'	1. Soil and clay (loess and drift)	10		10
				2Ca. Shale, mixed	11		21
				b. Sandstone, light (Pleasantview)	8		29
				c. Shale, sandy, light	10		39
				2Da. Shale, sandy, gray (Purington)	11		50
				b. Shale, gray (Purington)	42		92
				c. "Slate" (shale), dark	1		93
				d. "Boulder" (limestone)	1		94
				e. Shale, light (Francis Creek)	14		108
				f. Coal (Colchester No. 2)	2	4	110
				g. Shale, ###### light	4	8	115
				h. Shale, sandy, light	5		120
				2E. Shale, sandy, gray	9	6	129
				2Fa. Coal		10	130
				b and 2G and 2H. Shale, light	17	8	148
				2Ha. Sandstone, light	2		150
				b. Shale, sandy, light	14		164
				2Ia. Coal		4	164
				b. "Rock" (limestone?) and shale	2	8	167
				2Ja. Limestone, dark (Parks Creek)	21		188
				b. Shale, hard	7	8	195
				c. "Clod" (clay, calcareous)		4	196
				d. Coal (Rock Island No. 1)	4	5	200
				e. Sandstone		7	201
24	7	SW. SE. NE.	625± 10'	1. Clay, sandy (loess and drift)	20		20
				2C. Shale, mixed (Pleasantview and Purington)	26		46
				2Da. Shale, gray (Purington)	27		73
				b. "Slate" (shale), dark	2		75
				c. Shale, light (Francis Creek)	14		89
				d. Coal (Colchester No. 2)	2	7	91
				e. Shale, light	2		93
				f. Sandstone, light (Isabel)	4	5	98
				2E. Shale, sandy, light	13		111
				2Fa. Coal	1		112
				b and 2G and 2H. Shale, mixed	28	8	140
				2Ha. Coal		4	141
				b and 2I. Shale, mixed	11	4	152
				2Ia. Coal		4	152
				b. Shale, sandy, light	1	8	154
				2Ja. Limestone, dark (Parks Creek)	12	2	166
				b. Shale, dark, hard	9	6	176
				c. Coal (Rock Island No. 1)	4	6	180
				d. Shale, bituminous		2	180
				e. Shale, sandy, light	4	4	185
25	7	NE. NE. NW.	545± 5'	1a. Clay (alluvium)	19		19
				b. Sand	11		30
				c. Drift, light	7	6	37
				2G. Sandstone, gray	1		38
				2Ha. Shale, light	11		49
				b, and 2I. Shale, mixed	20	10	70
				2Ia. Coal		7	70 1

				b. Shale, light	4	6	75
				2Ja. Limestone, dark (Parks Creek)	11	6	86
				b. Shale, dark	8		94
				c. Coal, dirty		11	95
				d. Coal (Rock Island No. 1)	3		98
				e. Shale, sandy, light	1	6	100
				f. Sandstone, light	1	4	101
				g. Shale, sandy, light	3	6	105
				h. Sandstone, light		10	106
				i. Shale, sandy, light	6		112
				2Ka. Shale, dark	1	2	113
				b. Coal and "slate" (shale)		6	113
				c. Shale, sandy, light	1		114
26	7	SE. NE. NW.	540-	1a. Clay and sand (alluvium)	10		10
				b. Sand	14		24
				2Ha. Shale	7	6	31
				b. Shale, dark	1		32
				c. Sandstone, light	1	6	34
				2Ia. Shale, light	9	6	43
				b. Shale, gray	7	2	50
				c. Coal		10	51
				d. Shale, dark		5	51
				e. Coal	2	5	54
				f and 2J. Shale, mixed	1	7	55
				2Ja. Coal (Rock Island No. 1?)		9	56
				b. Shale, mixed	6	10	63
				2Ka. Shale, dark	1	6	65
				b. Coal	1		66
				c. Shale, dark	2	6	68
				d. Shale, sandy, brown	10	8	80
				e. Sandstone, light	9	11	90
				f. Shale, sandy, light	3	4	93
				2La. Shale, dark	3	10	97
				b. Rock (limestone?) dark		4	97
				c. Shale, dark	6	9	104
				d. Coal		4	104
				e. "Fire-clay" (underclay)	1	6	106
				f. Sandstone, light	6	4	112
				g. Shale, sandy, light	2	6	115
				3A. Limestone	1	5	116
~~27~~	~~7~~	~~SE. NE. NW.~~	~~540-~~				
27	7	SE. NE. NW.	540-	1a. Clay, sandy (alluvium)	8		8
				b. Sand	4		12
				2E. Shale, mixed	8	4	20
				2Fa. Coal		11	21
				b. Shale, mixed	4	3	25
				2Ga. Rock (limestone), brown	1	2	26
				b and 2H and 2I. Shale, mixed	28		54
				2Ia. Coal	1	10	56
				b. Shale, dark	2	4	58
				2Ja. Limestone, dark (Parks Creek)	3	11	62
				b. Shale, dark	1	4	64
				c. Coal (Rock Island No. 1)	2	5	66
				d. Shale, gray	2		68
				e. Shale, mixed	3	8	72
				f. Sandstone, light	6	6	78

28	7	SE. NW. NW.	560± 20'	1. Clay, sandy (alluvium)	9		9	
				2Da. Shale, mixed (Francis Creek)	19	2	28	
				b. Coal (Colchester No. 2)	2	6	30	
				c, and 2E. Shale, light	12	8	43	
				2Ea. Shale, dark	2		45	
				b. "Boulder" (limestone), brown		6	45	1
				c. Shale, gray	3	8	49	
				2Fa. Coal	1	2	50	
				b. Shale, light	1	2	51	1
				2Ga. "Boulder" (limestone)	1	2	53	
				b and 2H. Shale, light	18		71	
				2Ha. Sandstone	4		75	
				b and 2I. Shale, light	9		84	
				2Ia. "Slate" (shale), dark	6	6	90	
				b. Coal	2		92	
				c. Coal, dirty		5	92	1
				d. Coal	1	6	94	
				e. Sandstone		4	94	
				2Ja. Limestone	3		97	
				b. Limestone, dark (Parks Creek)	3	9	101	
				c. Coal (Rock Island No. 1)	2	11	104	
				d. Shale, bituminous		1	104	1
				e. Shale, light, sandy	4	2	109	
				2Ka. Shale, gray	3		112	
29	7	NE. NE. SE.	655± 10'	1. Loess and drift	18		18	
				2A. Sandstone, yellow (Cuba)	10	4	28	
				2Ba. "Slate" (shale), dark	1	10	30	
				b. Coal (Springfield No. 5)	4	6	34	
				c. Shale, light	2	4	37	
				d. Sandstone, light	2		39	
				2Ca. Shale, mixed	19		58	
				b. Sandstone, light (Pleasantview)	12		70	
				c. Shale, sandy, gray (Pleasantview and Purington)	37		107	
				2Da. Shale, gray (Purington)	20		127	
				b. "Slate" (shale), dark	1		128	
				c. "Rock" (limestone), dark	1		129	
				d. Shale, light (Francis Creek)	14		143	
				e. Coal (Colchester No. 2)	2	4	145	
				f, and 2E. Shale, sandy, light	18	8	164	
				2Fa. Coal	1		165	
				b and 2G. Shale, sandy, light	12		177	
				2Ha. Shale, dark	1		178	
				b. Coal		4	178	
				c. Shale, sandy, light	18		196	
				2Ia. Shale, dark	7		203	
				b. Coal		4	203	
				c. "Sulphur" (pyrite)		2	203	1
				d. Coal	3	2	207	
				e. Sandstone		4	207	
				2Ja. "Boulder" (limestone)		8	208	
				b. Limestone, dark (Parks Creek)	11		219	
				c. Shale, dark, hard	6	7	225	
				d. Coal (Rock Island No. 1)	4	4	229	
				e. Shale, sandy, light	6	1	236	

~~(13)~~(42)

0	7	NE. SW. NE.	665± 10'	1. Clay, sandy (loess and drift)	25		25#
				2Ca. Shale, mixed	15		40
				b. Sandstone, light (Pleasantview)	23		63
				2Da. Shale, gray (Purington)	39		102
				b. "Slate" (shale), dark	2		104
				c. "Slate" (shale), light (Francis Creek)	14		118
				d. Coal (Colchester No. 2)	2	6	120
				e and 2E. Shale, sandy, light	18	6	139
				2Fa. Coal		8	139
				b. Sandstone, light	2	4	142
				2G ~~and~~ 2H, and 2I. Shale, mixed	37		179
				2Ja. Limestone, dark (Parks Creek)	8	9	187
				b. "Clod" (calcareous clay)		3	188
				c. Coal (Rock Island No. 1)	2		190
				d. Shale, light, sandy	7	6	197
				2Ka. Shale, dark	2	10	200
				b. Coal	2	4	202
				c. Shale, bituminous		10	203
				d. "Fire-clay" (underclay)	1		204
31	7	NE. NW. SE.	660± 10	1. Clay, sandy (loess and drift)	19		19
				2Ba. Coal (Springfield No. 5)	4		23
				b. Shale, light	2	6	25
				c. Sandstone, light	1	6	27
				2Ca. Shale, mixed	22		49
				b. Sandstone, light (Pleasantview)	6		55
				c. Shale, sandy, light	10		65
				2Da. Shale, sandy, gray	20		85
				b. Shale, gray (Purington)	30		115
				c. Shale, light (Francis Creek)	13	4	128
				d. Coal (Colchester No. 2)	2	2	130
				e. Shale, light	1	6	132
				##f. Sandstone, light	2		134
				2Ea. Shale, sandy, light	10		144
				b. "Boulder" (limestone)	1	6	145
				c. Shale, gray	3	6	149
				2Fa. Coal		8	149
				#G#/###/##.			
				b and 2G. Shale, light	4	4	154
				2G and 2H. Shale, mixed	24		178
				2Ha. Coal		4	178
				b. Shale, sandy, light	13	8	192
				2Ia. Shale, gray	1		193
				b. Coal		4	193
				c. Shale, sandy, light	2	8	196
				d. Sandstone, light (Bernadotte)	8		204
				e. Shale, sandy, light	6		210
				2Ja. Coal (Rock Island No. 1)	3	1	213
				b. "False bottom" (carbonaceous shale)		3	213
				c. Shale, sandy, light	2	8	216
				d. Shale, sandy, gray	3		219
				e. Shale, sandy, light	2	6	221
				2Ka. Shale, gray	#21	6	243
				b. Shale, sandy, light	6		249
				2La or 3B. Shale, calcareous	1		250

					~~19~~		~~19~~	
32	7	NE. NW. SE.	660±5'	1. Clay (loess and drift)	19		19	
				2Ca. Shale, mixed	17		36	
				b. Sandstone, light (Pleasantview)	6		42	
				c. Shale, sandy, light	21		63	
				2Da. Shale, gray (Purington)	35		98	
				b. "Slate" (shale), dark, hard	9		107	
				c. Shale, light (Francis Creek)	12		119	
				d. Coal (Colchester No. 2)	2	4	121	4
				e. Shale, sandy, light	6	8	128	
				f. Sandstone, light (Isabel)	3		131	
				2E. Shale, sandy, light	9		140	
				2Fa. Coal		10	140	10
				b, and 2G and 2H. Shale, light	13	2	154	
				2H and 2I. Shale, mixed	15		169	
				2Ia. Coal		4	169	4
				b. Shale, sandy, light	5	5	174	9
				2Ja. Limestone, dark (Parks Creek)	4	10	186	7
				b. Coal (Rock Island No. 1)	2	5	189	
				c. "False bottom" (carbonaceous shale)		2	189	2
				d. Shale, sandy, light	11	5	200	7
				2Ka. Coal		4	200	11
				b. "Fire-clay" (underclay)	2		202	11
				2La. Shale, gray	8	9	211	8
				b. Shale, sandy, light	9	4	221	
33	8	SE. NW. NW.	560±10'	1a. Soil and clay (alluvium)	17		17	
				b. Sand and boulder (drift)	3		20	
				2Da. Shale, light (Francis Creek)	1		21	
				b. Coal (Colchester No. 2)	3		24	
				c and 2E. Shale, mixed	19		43	
				2Fa. Coal	1		44	
				b and 2G and 2H Shale, mixed	21		65	
				2Ha. Sandstone, light	5		70	
				b and 2I. Shale, light, sandy	9	5	79	5
				2Ia. Coal	2	5	81	10
				b. Sandstone (Bernadotte)		8	82	6
				2Ja. Limestone, dark (Parks Creek)	11	6	94	
				b. "Clod" (calcareous clay)		2	94	2
				c. Coal (Rock Island No. 1)	3	2	97	4
				d. Sandstone	1	8	99	
34	8	NE. NW. NW.	560±10'	1. Sand and clay (alluvium and drift)	32		32	
				2D and 2E. Shale, mixed	11	6	43	6
				2Fa. Coal		6	44	
				b and 2G. Shale, light	9		53	
				2Ga. Shale, sandy, light	11		64	
				b. Sandstone, light	1	6	65	6
				c. Shale, sandy, light	3	6	69	
				d. Sandstone, light	3		72	
				2Ha. Shale, light	2		74	
				b. Coal		2	74	2
				c and 2I. Shale, light	3	7	77	9
				2Ia. Shale, gray		6	78	3
				b. Coal	2		80	3
				c. Shale, light	1		81	3
				d. Coal	1	9	83	
				e. Shale, sandy, gray	2		85	

				f. Shale, sandy, light	6		91
				2Ja. Shale, gray		6	91
				b. Coal (Rock Island No. 1?)		6	92
				c and 2K. Shale, mixed	34		126
				2La. Shale, gray	15		141
				b. Sandstone, light	6		147
				3B? Shale, calcareous	4		151
35	8	SW. NW. NW.	550±	1a. Clay, sandy (alluvium)	13		13
				b. Sand and boulders (drift)	2		15
				2Da. Shale, mixed (Francis Creek)	20		35
				b. Coal (Colchester No. 2)	2	2	37
				c. Shale, light	7	10	45
				d, and 2E. Shale, sandy, light	10		55
				2Ea. Shale, ~~####~~ gray, sandy	2		57
				2Fa. Coal		10	57
				b. Shale, light	1	2	59
				2Ga. "Boulders" (limestone), light	1		60
				b and 2H. Shale, light	27		87
				2Ha. Sandstone, light	3		90
				2Ia. Shale, light	4		94
				b. Shale, dark	4		98
				c. Coal, dirty	1		99
				d. Coal	2	8	101
				e. Sandstone		4	102
				2Ja. "Boulder" (limestone), light	1		103
36	8	NW. NW. NW.	550±	1a. Clay, sandy (alluvium)	10		10
				b. Sand and boulders (drift)	8		18
				2E. Shale, mixed	8		26
				2Fa. Coal		10	26
				b and 2G and 2H. Shale, mixed	30	2	57
				2Ia. Coal	1	8	58
				b. Shale, light	1	4	60
				2Ja. Limestone, dark (Parks Creek)	4	2	64
				b. "Clod" (calcareous clay)		3	64
				c. Coal (Rock Island No. 1)	1	5	65
				d. "False Bottom" (carbonaceous shale)		2	66
				e. Sandstone	3		69
				f. Shale, light, sandy	6		75
				g. Sandstone, dark	4	6	79
				2Ka. Coal		6	80
				b. Shale, sandy, light	7	6	87
				c. Sandstone, light	5	6	93
				2La. Shale, dark	1		94
				b. Coal	1		95
				c. Shale, mixed	28		123
37	8	NE. SW. NW.	560±	1#. Drift, sandy	12		12
				2Da. Shale, mixed	18		30
				b. "Slate" (shale), hard, dark	2		32
				c. Shale, light (Francis Creek)	9	9	41
				d. Coal (Colchester No. 2)	2		43
				e. Shale, light	6	3	50
				f. Sandstone, light (Isabel)	3		53
				2E. Shale, mixed	10		63

				2Fa. Coal	1		64
				b and 2G. Shale, light	23		87
				2Ga. Shale, mixed	8	6	95
				b. Sandstone, light	3		98
				2Ha. Shale, light	2	10	101
				b. Coal, soft		6	101
				c. Shale, sandy, gray	1	8	103
				2Ia. "Slate" (shale), dark	3	4	106
				b. Coal	4	2	111
				c. Sandstone		4	111
				2Ja. Limestone		8	112
				b. Limestone, dark (Parks Creek)	10	1	122
				c. Shale, dark	4	1	126
				d. Coal (Rock Island No. 1)	4	5	130
				e. Shale, bituminous		2	130
				f. Shale, sandy, light	4	3	135
38	8	SW. NE. NW.	620± 20'	1. Clay (loess and drift)	20		20
				2A. Sandstone, yellow (Cuba)	24		44
				2Ba. Coal, old wash (Springfield No. 5)	7		51
				b. "Fire-clay"(underclay)	2		53
				c. Sandstone	2		55
				2Ca. Shale, mixed	16		71
				b. Coal (Kerton Creek)	2		73
				c. Shale, sandy, light (Pleasantview)	17		90
				d. Shale, sandy, gray (Pleasantview and Purington)	18		108
				2Da. Shale, gray (Purington)	16		124
				b. "Slate" (shale), dark	2		126
				c. Shale, light (Francis Creek)	14		140
				d. Coal (Colchester No. 2)	2	4	142
				e, and 2E. Shale, sandy, light	17	8	160
				2Ea. Shale, gray	1	6	161
				2Fa. Coal	1		162
				b and 2G. Shale, mixed	22	6	185
				2Ga. Shale, sandy, light	6		191
				2Ha. Shale, mixed	7		198
				b. Coal	1		199
				c and 2I. Shale, light	6		205
				2Ia. Coal	4	2	209
				b. Shale, sandy, light	3	10	213
				2Ja. "Slate" (shale), dark	7		220
				b. Coal (Rock Island No. 1)	3	9	223
				3. Sandstone		3	224
39	8	SE. SE. NW.	570± 20'	1a. Clay, sandy (alluvium)	7		7
				b. Sand and drift	7		14
				2Da. Shale, mixed	34	4	48
				b. Coal (Colchester No. 2)	2	6	50
				c, and 2E. Shale, sandy, light	19	2	70
				2Fa. Coal	1	3	71
				b. Shale, light	2	9	74
				2Ga. "Boulder" (limestone)	1		75
				b, Shale, mixed	25		100
				2Hc. Sandstone, light	4		104
				2Ia. Shale, light	2		106
				b. "Slate" (shale), dark	1		107
				c. Coal, dirty	1	5	108

				d ~~and 2I~~. Shale, light	3	3	111	8
				~~2I~~e. Coal		9	112	5
				f. Coal rock (probably pyritic concretion)		10	113	3
				g. Coal		6	113	9
				h. "Fire-clay" (underclay)		9	114	6
				2Ja. Limestone	1		115	6
				b. Limestone, dark (Parks Creek)	2	6	118	
				c. "Slate" (shale), sandy	3	3	121	3
				d. Coal and "sulphur" (pyrite)		6	121	9
				e. Coal (Rock Island No. 1)	3	3	125	
				f. Sandstone	1	6	126	6
40	8	NE. NW. SW.	570± 20'	1a. Drift, sandy	7		7	
				b. Sand and gravel	2		9	
				2Da. Shale, mixed (Purington)	22		31	
				b. Rock (limestone)	2	2	33	2
				c. Shale, gray (Francis Creek)	13	7	46	9
				d. Coal (Colchester No. 2)	2	6	49	3
				e. Shale, gray	1	1	50	4
				f. "Boulder" (limestone concretion)		11	51	3
				2E. Shale, light	16	4	67	7
				2Fa. Coal	1	4	68	11
				b, 2G and 2H. Shale, light	26	1	95	
				2Ha. Sandstone, light	2		97	
				2Ia. Shale, light	6		103	
				b. Shale, dark	2	6	105	6
				c. Coal	4	4	109	10
				d. Shale, sandy, light	5	2	115	
				e. Sandstone, light (Bernadotte?)	8		123	
				f. Shale, sandy, gray	3		126	
				2Ja. Coal (Rock Island No. 1?)		3	126	3
				b. Shale, sandy		9	127	
				2Ka. "Boulder" (limestone)		6	127	6
				b. Shale, gray	8	6	136	
				c. Coal	3	10	139	10
				d. Shale, sandy, light	6	2	146	
				e. Shale, gray	3		149	
				f. Sandstone, light	1		150	
41	8	SE. NW. SW.	580± 20'	1. Clay, sandy (loess and drift)	12		12	
				2Ca. Coal (Kerton Creek)	1	4	13	4
				b. Shale, sandy, light	19	8	33	
				c. Shale, sandy, gray	19	4	52	4
				2Da. "Slate" (shale), dark	3		55	4
				b. "Rock" (limestone), brown		8	56	
				c. Shale, dark	3		59	
				d. "Slate" (shale), dark	2		61	
				e. Shale, light (Francis Creek)	15		76	
				f. Coal (Colchester No. 2)	2	5	78	5
				g. Shale, light	1	7	79	5
				h. "Boulder" (limestone concretion)		7	80	
				2E. Shale, sandy, light	15		95	
				2Fa. Coal		4	95	
				b and 2G, 2H, 2I and 2J. Shale, mixed	49	8	145	
				2Ja. Shale, gray	12		157	
				b. Shale, sandy, light	9		166	
				2Ka. Shale, gray	20		186	

				b. Coal		4	186	4
				c. "Fire-clay" (underclay)	3	8	190	
				d. Sandstone, light	5		195	
42	8	SW. NE. SW.	860± 10'	1. Surface (loess and drift)	24	3	24	3
				2Aa. Shale, sandy, light	11	3	35	6
				b. Sandstone, yellow (Cuba)	9		44	6
				c. Sandstone, gray	18	5	62	11
				2Ba. Shale, gray	1	2	64	1
				b. "Slate" (shale), black	2	10	66	11
				c. Coal (Springfield No. 5)	4	7	71	6
				d. Shale, light	1	6	73	
				e. Sandstone, light	3	6	76	6
				2Ca. Shale, gray	2		93	
				b. "Cap rock" (limestone)	1		94	
				c. Coal (Kerton Creek)		8	94	8
				d. Shale, gray	11	5	106	1
				e. Coal (in Pleasantview sandstone?)	2	10	108	11
				# f. Sandstone, gray (Pleasantview)	14	3	123	2
				2Da. Shale, gray (Purington)	16	2	139	4
				b. Shale, light gray (Francis Creek)	26	3	165	7
				c. Coal (Colchester No. 2)	2	6	168	1
				d. Shale, light	2		170	1
				e. Sandstone, light (Isabel)	12		182	1
				2E. Shale, sandy, gray	4	5	186	6
				2F. Coal		11	187	5
				2Ga. Rock, hard (limestone)	3		190	5
				# b, 2H and 2I. Shale, sandy, light	24	10	215	3
				2Ia. Shale, sandy, gray	13		228	3
				b. Sandstone, gray (Bernadotte? or may be several beds)	51	5	279	8
				2K or 2L? Coal		3	279	11
				b. "False bottom" (carbonaceous shale)		5	280	4
				c. Sandstone, white (probably 2L)	1	4	281	8
43	19	? ? SE	668± 10'	1. Drift (and loess)	20		20	
				2Ba. "Rock" (limestone), gray (St. David)	1		21	
				b. "Slate" (shale)	6		27	
				c. Coal (Springfield No. 5)	4	11	31	11
				d. Shale, dark	1		32	11
				e. ~~Shale~~ Sandstone, ~~sandy~~, light	1	2	34	1
				2Ca. Shale, light gray	15	1	49	2
				b. Sandstone, gray (Pleasantview)	1		50	2
				c. Shale, sandy, ~~gray~~ light	7	4	57	6
				2Da. Shale, gray (Purington)	47	10	105	4
				b. Shale, dark	4	6	109	10
				c. "Rock" (limestone), dark	1		110	10
				d. Shale, dark		10	111	8
				e. Shale, black	1		112	8
				f. "Rock" (limestone), dark		8	113	[illegible]
				g. Shale, gray (Francis Creek)	24	10	138	[illegible]
				h. Coal (Colchester No. 2)	2	5	140	[illegible]
				i. Shale, dark		8	141	[illegible]
				j. Shale, light	2	2	143	[illegible]
				k. Sandstone, light	3	10	147	[illegible]

			2Ea.	Shale, light	10	3	157
			b.	Sandstone, light	1		158
			2Fa.	Shale, gray		10	159
			b.	Coal		9	160
			c.	Shale, dark		6	160
			d.	Shale, light		8	161
			2Ga.	Shale, dark		5	161
			b.	"Fire-clay" (underclay)	2	6	164
			c.	Sandstone, light	3		167
			2Ha.	Shale, light	1	4	168
			b.	Shale, dark	1	3	169
			c.	Shale, gray	2	6	172
			d.	Shale, sandy, light	10	5	182
			e.	Shale, gray	4	6	187
			f.	Shale, dark	1		188
			g.	Shale, light	3	2	191
			h.	Shale, dark		6	191
			i.	Coal		10	192
			j.	Shale, gray		8	193
			k.	Shale, sandy, light		9	194
			l.	Sandstone, light	1	8	195
			2Ia.	Shale, gray	1		196
			b.	"Slate" (shale), black		6	197
			c.	Coal		10	198
			2Ja.	Shale, dark		10	198
			b.	Shale, gray	4	11	203
			c.	Coal		5	204
			d.	Shale, dark	1	3	205
			e.	Shale, gray	1	7	207
			f.	Coal	2	8	209
			g.	Shale, dark	1	2	210
			h.	Shale, gray		8	211
			i.	Shale, light	6	9	218
			2K or 2La.	Shale, gray	1	6	219
			b.	Shale, black	11	1	230
			c.	Shale, sandy, light gray	3	8	234
			d.	Shale, sandy, light	8	9	243
			3A.	Limestone, white	2		245
44	21	SW/ SW/ NW.	682	1.	Subsoil (loess and drift)	27		27
			2Ba.	Shale (Canton)	24	6	51
			b.	"Slate" (shale)	1	9	53
			c.	Coal (Springfield No. 5)	5	2	58
			d.	"Fire-clay" (underclay)	1	7	60
			e.	"Hard band" (limestone concretion)	1	6	61
			2Ca.	Shale	20	6	82
			b.	Shale, sandy (Pleasantview)	33		115
			2Da.	Shale, gray (Purington)	27		142
			b.	"Hard band" (limestone)		6	142
			c.	"Slate" (shale), black		8	143
			d.	Shale, gray (Francis Creek)	28	10	172
			e.	Coal (Colchester No. 2)	2	3	174
			f.	"Fire-clay" (underclay)		6	174
			g.	"Sulphur rock" (concretion)		6	175
			h and 2E.	Shale, sandy, gray	16	2	191
			2Fa.	Coal	1	4	192
			b and 2G.	"Fire-clay" (underclay)	3	3	196

				2Ga.	Sandstone	9		205
				2Ha.	Shale, gray	5		210
				b.	Sandstone	5		215
				2Ia.	Shale, gray	9		224
				b.	Coal		9	224
				c.	Shale, dark	1		225
				2Ja.	Shale, light gray	5	3	231
				b.	"Slate" (shale)		2	231
				c.	Coal (Rock Island No. 1?)	4		235
				d.	"Slate" (shale)		3	235
				e.	"Fire-clay" (underclay)	1	9	237
				f.	Shale, soft		4	237
				g.	Shale, sandy	2	6	240
				h.	Limestone (possibly concretion)		4	240
				i.	Sandstone	3	3	243
				2Ka.	Shale, gritty	1		244
				b.	"Slate" (shale)	2		246
				c.	Limestone		2	246
				d.	"Slate" (shale)		3	247
				e.	"Fire-clay" (underclay?)	2		249
				f.	Shale, dark gray	3	6	252
				g.	Limestone		2	252
				h.	"Slate" (shale), dark gray	9	4	262
				i.	"Fire-clay" (underclay)	3		265
				j,	and 2L. Sandstone and shale	3		268
				2La.	"Slate" (shale), black	7		275
				b.	Coal	2	2	277
				c.	"Slate" (shale)	1		278
				d.	Sandstone, with chips of "slate" (shale)	2	10	281
45	22	NE. NE. SW.	655	1a.	Clay, yellow (loess and drift)	10		10
				b.	Sand	15		25
				c.	Clay, blue (drift)	7	3	32
				2Ba.	"Slate" (shale)	3	2	35
				b.	Coal (Springfield No. 5)	5		40
				c.	"Fire-clay" (underclay)	10	7	51
				2Ca.	Shale, gray	5		56
				b.	Limestone	5		61
				c.	#Shale, sandy	8		69
				d.	Sandstone (Pleasantview)	62	6	131
				2Da.	"Slate" (shale)	6	6	132
				b.	Shale, sandy, dark	1	3	133
				c.	Shale, sandy, light (Francis Creek)	26	3	159
				d.	Coal (Colchester No. 2)	2	6	162
				e.	Shale, gray	1	8	163
				f.	"Fire-clay" (underclay)	2		165
				g.	Sandstone (Isabel)	6		171
				2Ea.	Shale, light	2	4	174
				b.	Shale, gray	6		180
				2Fa.	Coal	1	3	181
				b,	and 2G. "Fire-clay" (underclay)	5	5	186
				2Ga.	Sandstone	2		188
				# b.	Shale, sandy	3	4	192
				c.	"Slate" (shale)		8	192

		d.	Shale, sandy, streaks of "Slate" (shale)	3	4	196
		e.	Sandstone	5		201
		2Ha.	Shale, gray	4	2	205
		b.	"Slate" (shale)		8	205
			~~Sandstone, hard~~	~~16~~		
		c.	Shale, gray	2	2	208
		d.	Sandstone, hard	16		224
		2Ia.	Shale, gray	1	6	225
		b.	Coal		7	226
		c.	Shale, gray		4	226
		d.	Sandstone, hard	6	7	233
		2Ja.	Shale, dark	2	5	235
		b.	Limestone		7	236
		c.	Sandstone, dark	1		237
		d.	Shale, dark	1	3	238
		e.	Coal (Rock Island No. 1?)	1	4	239
		f.	Shale, dark gray		8	240
		g.	"Fire-clay" (underclay)	1		241
		h.	Sandstone, hard	8	1	249
		2Ka.	Coal		3	249
		b.	Sandstone, hard	1	6	251
		c.	"Fire-clay" (underclay)	2	6	253
		2La.	Shale, dark	6	6	260
		b.	Coal		8	260
		c.	"Fire-clay" (underclay)	4		264
		d.	Shale, dark	2	5	267
		e.	"Fire-clay" (underclay)	1	8	268
		f.	Shale, dark	2	9	271
		g.	Sandstone, hard		10	272
		h.	Shale, dark	6	4	278
		i.	Shale, gray	4		282
		j.	"Fire-clay" (underclay)	3		285
		k.	Shale, light	1	8	287
		l.	Shale, sandy, light	2	7	290
		m.	Shale, dark gray	10		300
46.	24 NW. NW. NW. 672	1.	Subsoil and clay (loess and drift)	48		48
		2Ba.	Shale		10	48
		b.	"Cap rock" (limestone)		10	49
		c.	Shale	8	10	58
		d.	"Slate" (shale)	1	4	59
		e.	Coal (Springfield No. 5)	5	3	65
		f.	"Fire-clay" (underclay)	2	6	67
		g.	"Hard rock" (limestone concretion)	1	3	68
		2Ca.	Shale	12	2	81
		b.	Shale, sandy (Pleasantview)	25		106
		2Da.	Shale, gray (Purington)	47		153
		b.	Limestone		7	153
		c.	Shale, dark	6		159
		d.	"Slate" (shale)	2		161
		e.	Shale, gray (Francis Creek)	11	7	173
		f.	Coal (Colchester No. 2)	2	6	175
		g.	"Fire-clay" (underclay)	1	6	177
		h.	Shale, gray	3	4	180

		i.	Sandstone (Isabel)	5		185
		2Ea.	Shale, sandy	6	6	192
		##b.	Coal		3	192
		# c.	"Fire-clay" (underclay)		5	192
		d.	Limestone		8	193
		e.	Shale, sandy	1	2	194
		f.	Limestone	1		195
		g.	Sandstone		6	196
		2Fa.	Shale, sandy	2	4	198
		b.	Coal	1	8	200
		c.	"Slate" (shale)		2	200
		d. and 2G	"Fire-clay" (underclay)	3	10	204
		2Ga.	Sandstone	9		213
		2H and 2I.	Shale, gray, with streaks of sandstone	19	4	232
		2Ia.	Coal		8	233
		b.	Sandstone (Bernadotte?)	7		240
		2Ja.	Shale, gray	6	6	246
		b.	Limestone		3	246
		c.	Coal (Rock Island No. 1?)	1	8	248
		d.	Sandstone	6	1	254
		2Ka.	Shale, dark gray, streaky	18	6	273
		b.	Shale, gray	9	11	282
		c.	"Fire-clay" (clay)		2	283
		d.	Coal	1		284
		e.	"Fire-clay" (underclay)		8	284
47	25 SE. NE. NW. 540	1.	Clay and sand (alluvium)	10		10
		2C#a.	Sandstone (Pleasantview)	38	6	48
		2Da.	Shale, dark	3	6	52
		b.	Shale, sandy, hard	3		55
		c.	Shale, gray	3	2	58
		#d.	Shale, dark	1	7	59
		e.	"Slate" (shale)	2	10	62
		f.	Shale, dark, hard		9	63
		g.	Coal (Colchester No. 2)	2	9	66
		h.	"Fire-clay" (underclay)	3	1	69
		i.	Sandstone	12	4	81
		2Ea.	"Fire-clay" (clay)		6	82
		b.	Limestone		6	82
		c.	Sandstone	1	$7\frac{1}{2}$	84
		2Fa.	Shale	2	$2\frac{1}{2}$	86
		# b.	Coal		7	86
		c.	"Fire-clay" (underclay)	6	3	93
		2Ga.	Limestone		10	94
		b.	"Fire-clay" (underclay)	3	6	97
		c.	Shale, light	5	6	103
		2Ha.	"Slate" (shale), dark	2	8	105
		b.	Shale, sandy	2	10	108
		c.	Sandstone	1	6	110
		2Ia.	Shale, gray, soft	2		112
		b.	Sandstone, hard	2	6	114
		c.	Sandstone, gray, soft	7	6	122
		d.	Sandstone, hard (Bernadotte?)	4		126
		2Ja.	Shale, gray	24	$8\frac{1}{2}$	151
		b.	Coal (Rock Island No. 1)	4	5	156
		c.	"Slate" (shale), rotten	2	$6\frac{1}{2}$	158
		d.	Sandstone, gray	1		159
		2Ka.	Shale, with streaks of hard shale	4	4	164

48	27	NW. NE. SE.	608	1a. Clay (alluvium)	13		13
				b. Gravel	4		17
				2Ca. "Rock" (limestone?), dark	10		27
				b. Shale, gray	9		36
				c. Sandstone	10		46
				d. Shale, sandy	8		54
				e. Sandstone, gray (Pleasantview)	42		96
				f. Sandstone, hard	9		105
				g. Sandstone, white	4		109
				h. Sandstone, gray	4		113
				2Da. Shale, sandy, dark	1	1	114
				b. Coal (Colchester No. 2)	1	11	116
				c. "Slate" (shale)		1	116
				d. "Fire-clay" (underclay)	2	3	118
				e. Sandstone (Isabel)	9	4	127
				2E. Shale, gray	6	8	134
				2Fa. Coal		8	135
				b. and 2G. "Fire-clay" (underclay)	1	8	136
				2Ga. Sandstone	7		143
				2Ha. Shale, gray	4	5	148
				b. "Slate" (shale)		6	148
				c, and 2I. Shale, light	8	5	157
				2Ia. Sandstone (Bernadotte?)	14		171
				b. Shale, sandy	4		175
				c. Sandstone, gray	8		183
				d and 2J. Shale, sandy	16	9	199
				2Ja. Coal (Rock Island No. 1?)		3	200
				b. Shale, sandy, light	4	7	204
				2Ka. Shale, dark	6	11	211
				b. Coal		9	212
				c. "Fire-clay" (underclay)	3	10	216
				d. Shale, sandy, white	1	5	217
				2La. "Slate" (shale)		7	218
				b. Shale, sandy, dark	1	11	220
				c. Limestone		6	220
				d. Shale, gray	3		223
				e. "Fire-clay" (clay)	1		224
				f. Shale, sandy, gray	2	6	227
				g. "Fire-clay" (clay)	2		229
				h. Shale, dark	13		242
				i. Shale, light	4	9	246
				j. Limestone (may be 3A)		9	247
49	32	NE. NE. SE.	620±	1. Clay, sandy (loess and drift)	35		35
				2Da. Shale, mixed (Purington?)	37	2	72
				b. "Boulder" (limestone), gray		6	72
				c. Sandstone (probably sandy shale), gray (Francis Creek)	40	8	113
				d. Shale, light gray	2		115
				e. Coal (Colchester No. 2)	2	5	117
				f. "Fire-clay" (underclay), sandy	6	3	124
				g. Sandstone, light, hard (Isabel)	4	5	128
				2Ea. Shale, sandy, gray	1	11	130
				b. "Boulder" (limestone), gray	1	6	131
				c. Shale, light gray	2	7	134
				d. "False top" (clay?)	4	4	134
				2Fa. Coal		6	135
				b and 2G. "Fire-clay" (underclay), sandy	7	9	143

				2Ga. Sandstone, light, hard	4	2	147
				2Ha. Shale, light		10	148
				b. Shale, dark	1	6	149
				c. Shale, sandy, light	4	6	154
				2Ia. Shale, gray	6	4	160
				b. Shale, sandy, light	1	2	161
				c. Sandstone, "crystallized"(Bernadotte)	1		162
				2Ja. Shale, mixed	12		174
				b. Limestone, dark(Parks Creek)	11	2	185
				c. Coal (Rock Island No. 1)	2	2	187
				d. "False bottom" (carbonaceous shale)	1	6	189
				e. Shale, light gray	1	2	190
				f. Sandstone, white		8	191
50	32	?	NE. SW.	660±20'	1. Clay, sandy (loess and drift)	20	6	20
				2Da. Shale, light gray (Francis Creek)	10	8	31
				b. Coal (Colchester No. 2)	2		33
				c. Shale, light	4	10	38
				d. Sandstone, light (Isabel)	9		47
				2E. Shale, light gray	5	3	52
				2Fa. Coal	1	1	53
				b and 2G. "Fire-clay" (underclay)	5	4	58
				2Ga. Sandstone, light, hard	1	8	60
				2Ha. Shale, mixed	14	4	74
				b. Shale, sandy, light	8		82
				2Ia. Shale, mixed	12	4	95
				b. "Slate", gray	1	5	96
				c. Sandstone, light, hard (Bernadotte?)	6	3	102
				2Ja. Shale, sandy, gray (may include 2K)	18	2	120
				2La. "Slate" (shale), gray	12	9	133
				b. "Slate" (shale), black	7	6	141
				c. "Sulphur rock" (pyrite)		2	141
				d. Coal		5	141
				e. "Fire-clay" (underclay)	6		147
				f. Sandstone, white	1	2	148
				3A. Limestone, white	16	7	165
51	33	NW. NW. SE.	614.	1. "Dug well" (in loess and drift)	32		32
				2C and 2D. Sandstone, soft (Pleasantview) and shale)	85		117
				2Da. Coal (Colchester No. 2)	3		120
				b. and 2E. Shale	18		138
				2Fa. "Slate" (shale)		6	138
				b. Coal	1	6	140
				c and 2G. Shale	3		143
				2Ga and 2H and 2I. Sandstone (?)	30		173
				2Ja. Limestone (Parks Creek?)	3		176
				b. Limestone, white, hard	3		179
				c. "Slate" (shale), hard		2	179
				d. Shale	9		188
				e. Coal (Rock Island No. 1?)	5	2	193
				f. "Fire-clay" (underclay)		6	193
				g. Sandstone	16		209
				2Ka. Coal	2	6	212
				b. Sandstone	6		218

52	35	NW. NW. NW.	512	1a.	Sand and gravel (alluvium)	15		15	
				b.	Sand and gravel and coal wash	11		26	
				2Ea.	Shale	3		29	
				b, and 2F.	Sandstone, with streaks of "slate" (shale)	20		49	
				2Ga.	"Fire-clay" (underclay)		6	49	6
				b.	Sandstone, hard	1	6	51	
				2Ha.	Limestone		6	51	6
				b.	"Slate" (shale)	1		52	6
				c.	Shale, with dark streaks	1#3		65	6
				d.	"Slate" (shale)		6	66	
				e.	"Fire-clay" (clay)	1#	11	67	11
				f.	"Slate" (shale), dark		10	68	9
				g.	"Fire-clay" (underclay)	4	2	72	11
				h.	Sandstone	1	8	74	7
				2Ia.	Shale, dark	5	4	79	11
				b.	Coal		10	80	9
				c.	"Fire-clay" (underclay)	1	2	81	11
				d.	Sandstone (Bernadotte?)	10	1	92	
				2Ja.	Shale, gray	11	1	103	1
				b.	Coal (Rock Island No. 1?)		5	103	6
				c.	"Fire-clay" (underclay)	5		108	6
				2Ka.	Shale, dark	7	11	116	5
				b.	Coal	1	9	118	2
				c.	"Fire-clay" (underclay)	4	10	123	
				2La.	Shale, gray	10	6	133	6
				b.	"Slate" (shale)		9	134	3
				c.	"Fire-clay" (clay)		3	134	6
				d.	"Slate" (shale)		3	134	9
				e.	Shale, sandy, light	5	3	140	
				f.	Sandstone, hard	3	3	143	3
				g.	Water crevice		6	143	9
				h.	Sandstone, hard	2	2	145	11
				i.	Sandstone, soft		7	146	6
				3A.	Limestone, hard	20	6	167	
~~53~~	T. 5N., R. 3 E. (Lewistown Twp.)								
53	2	NW. NW. NW.	618±	1a.	Soil and clay (loess)	13	6	13	6
				b.	Drift, sandy, gray	16		29	6
				c.	Sand	3	6	33	
				d.	Drift, yellow, sandy, with boulder	8		41	
				e.	Sand and gravel	1	8	42	8
				2Ca.	Shale, gray ~~(Francis Creek)~~	4	1	46	9
				b.	Coal ~~(Colchester No. 2)~~ (Kerton Creek)	~~2~~ 2	~~7~~ 7	~~49~~ 49	4
				c.	Shale, mixed	10	8	60	
				d.	Sandstone, gray (Pleasantview)	13	10	73	10
				2Da.	Shale, light gray (Purington)	15	9	89	
				b.	Shale, dark	1	11	91	
				c.	Limestone, blue, hard	2	6	94	
				d.	Shale, sandy, light (Francis Creek)	26	11	120	1
				e.	Coal (Colchester No. 2)	2	5	123	
				f.	"Fire-clay" (underclay)	2		125	
				g.	Shale, sandy, light	3		128	
				h.	Sandstone, light (Isabel)	7	8	136	

	2Ea.	Shale, light	2		138	
	b.	Limestone	2	6	140	
	c.	Shale, light gray	2		142	
	2Fa.	Shale, dark		9	143	
	b.	Coal, dirty		3	143	
	c and 2G.	"Fire-clay" (underclay), sandy	3	7	147	
	2Ga.	Sandstone, light	9	3	156	
	2Ha.	Shale, gray	1	2	157	
	b.	"Slate" (shale), black		10	158	
	c ~~and 2I.~~	Shale, sandy, light	21	8	180	
	2Ia.	Limestone		6	180	
	b.	"Slate" (shale), gray	5	4	185	1
	c.	Sandstone, gray, hard	1	4	187	#
	2Ja.	"False top" (shale)		2	187	
	b.	Coal		8	188	
	c.	"Fire-clay", ~~sandy~~ (underclay), sandy	4	2	192	
	d.	Shale, sandy, gray	11	8	203	1
	2Ka.	Limestone, hard		5	204	
	b.	Shale, sandy, gray	7	5	211	
	c.	Coal		10	212	
	d.	Shale, gray		2	212	
	e.	"Fire-clay" (underclay), sandy	1	10	214	
		~~Shale, sandy, gray~~				
	2La.	"Slate" (shale), dark, soft	7	2	221	
	b.	Coal		7	222	
	c.	Shale, light gray	6	9	229	
	d.	Shale, sandy, light	3	5	232	
	e.	Sandstone, light		9	233	
	f.	Limestone, blue, very hard	1		234	
	g.	Sandstone, gray, soft	2		236	
	h, or 3B.	"Slate" (shale), gray	5	11	242	
	i.	Limestone, blue, hard		9	242	1
	j.	"Slate" (shale), gray	11	2	254	
	k.	Shale, light gray	1	3	255#	
	l.	"Fire-clay" (clay), sandy		4	255	
54 #2 ? ? ? ?	1a.	Soil and clay (loess)	13		13	
	b.	Drift, sandy, gray	25		38	
	c.	Sand and gravel	2		40	
	d.	Drift, sandy, gray		8	40	
	2Ca.	Shale, light	4	4	45	
	b.	Shale, dark		5	45	
	c.	Coal blossom (Kerton Creek?)	5	2	50	
	d.	Sandstone, gray (Pleasantview)	45	2	95	
	e.	Shale, sandy, gray	2	2	97	
	2Da.	"Slate" (shale), black	1	6	99	
	b.	Shale, sandy, gray	6	6	105	
	c.	Shale, light (Francis Creek)	15	1	120	1
	d.	Shale, light gray	1	6	122	
	e.	Coal (Colchester No. 2)	2	2	124	
	f.	Coal, dirty		2	124	
	g.	Coal		3	124	1
	h.	"Fire-clay" (underclay)	4	8	129	
	i.	Sandstone, light (Isabel)	7	5	137	
	2Ea.	Shale, light gray	2		139	
	b.	Sandstone, light	1	11	140	1
	c.	"Boulder" (limestone)	2	1	143	
	d.	Shale, light gray	2	10	145	10

		2Fa.	Coal		6	146	4
		b.	Shale, light	1	6	147	10
		2Ga.	Shale, sandy, light	6	8	154	6
		b.	Sandstone, light	2	2	156	8
		2Ha.	Shale, sandy, light	2	6	159	2
		b.	"Slate" (shale), black	1	5	160	7
		c.	"Fire-clay" (underclay), sandy	6		166	7
		2Ia.	Shale, light	2	6	169	1
		b.	Shale, dark		4	169	5
		c.	Shale, sandy, light	1	8	171	1
		d.	Sandstone, light	4	5	174	6
		e.	Shale, dark		6	175	
		f.	Sandstone, light	6	5	181	5
		2Ja.	"Slate" (shale), dark	6	11	188	4
		b.	Limestone		8	189	
		c.	Coal (Rock Island No. 1)		8	189	8
		d.	Shale, sandy, gray	1	2	190	10
		e.	Sandstone, light hard	2	1	192	11
		f.	Sandstone, gray very hard	6	8	199	7
		g and 2K(?)	Sandstone, light	19	4	208	11
		2K or 2La.	"Slate" (shale), gray		9	209	8
		b.	Sandstone, light	1	8	211	4
		c.	"Slate" (shale), gray	3	9	215	1
		d.	Limestone		#6	215	7
		e.	"Slate" (shale), gray	9	8	225	3
		f.	Shale, sandy, light	1	9	227	
		g.	"Slate" (shale), gray	12	9	239	9
		h.	Sandstone, gray		5	240	2
		i.	"Slate" (shale), black	3		243	2
		j.	"Fire-clay" (clay), sandy	1	1	244	3
		k.	Sandstone, light		2	244	5
55	8 SW. SE. SW.	485	1. Clay, yellow (alluvium)	12	9	12	9
		2G and 2H.	Shale, mixed	18	3	31	
		2Ia.	Shale, gray	5		36	
		b.	Sandstone, gray (Bernadotte)	14	4	50	4
		2Ja.	Coal (Rock Island No. 1?)	1	1	51	5
		b.	Shale, dark		8	52	1
		c.	"Fire-clay" (underclay)	1	2	53	3
		d.	Sandstone, light, hard	21	6	74	9
		2Ka.	Sandstone, with streaks of coal	2	6	77	3
		b.	"Fire-clay" (underclay)	2	8	79	11
		2La.	Mixed shale	2	7	82	6
		b.	Shale, gray	11	9	94	3
		c.	Shale, light	#1	2	95	5
		d.	Sandstone, light	7	6	102	11
		3Aa.	Limestone, very hard	5	1	108	
		b.	##Shale, limy		5	108	5
		c.	Limestone, very hard	61	7	170	
56	18 NW. SE. NE.	480	1. Clay, yellow (alluvium)	12		12	
		2E.	Shale, gray	1	2	13	2
		2Fa.	Coal		6	13	8
		b and 2G, 2H and 2I.	Mixed shale	32	4	46	
		2Ia.	Sandstone, gray (Bernadotte?)	27	5	73	5
		2Ja.	"Slate" (shale), black	2	6	75	11
		b.	Sandstone, light, hard	#7	1	83	

(~~28~~) 571

2Ka.	"Slate" (shale), black	2		85	
b.	Sandstone, light	6	2	91	2
2La.	Coal		1	91	3
b.	Shale, light gray	1	9	93	
c.	Coal	3	5	96	5
d.	"False bottom" (carbonaceous ahale)		5	96	10
e.	Shale, gray	2	8	99	6
f.	Coal		$\frac{1}{2}$	99	$6\frac{1}{2}$
g.	Shale, mixed		$10\frac{1}{2}$	100	5
h.	Sandstone, light	5		105	5

Havana Quadrangle Levels

Location	Outcrop and Remarks	Elevation
✓1114.51	Top of Coal	587.6 ✓
✓1124.47	Base of Coal	574.0 ✓
✓1113.23	Base of Coal	556.1 ✓
✓1125.49	Base of Coal	554.2 ✓
✓1125.27	Base of Coal	543.3 ✓
✓1124.11	Top of Coal	560.1 ✓
✓1126.32	Top of Coal	569.0 ✓
✓1722.89	Top of Shaft. 96' to top of coal.	585.8 ✓
✓1129.48	Base of Coal	599.3 ✓
✓1120.56	Top of Coal	606.3 ✓
✓1116.31	Base of Coal in mine. (This point has an elevation of 149 on mine map.)	582.5 ✓
✓1121.78	Top of Coal. Outcrop poorly defined.	609.5 ✓
✓1128.52	Lower concretion zone	582.2 ✓
	Upper concretion zone	585.8 ✓
✓1135.64	Base of coal blossom	567.4 ✓
✓1135.88	Top of Coal	540.3 ✓
✓1136.36	Base Coal in mine north of road. Changed loc.	502.7 ✓
✓1136.58	Top of lime cap rock in cut bank.	500.5 ✓
✓1801.44	Base of coal	532.3 ✓
✓1801.11	Gray lime south end of exposure	473.65 ✓
	" " north end of exposure	470.25 ✓
✓1811.39	Top of gray lime	469.15 ✓
✓1801.29	Top Coal	504.2 ✓
✓1812.58	Top coal	494.65 ✓
✓1812.23	Base of Coal	481.6 ✓
✓1812.81	Base of coal	485.65 ✓
✓1814.88	Top of cap rock at road.	509.7 ✓
✓1822.98	Top of gray lime.	484.0 ✓

Location	Outcrop and Remarks	Elevation
1820.27	Top of gray lime	512.3
1817.84	Top No. 2 Coal	475.45
1817.84	Top of gray lime	495.25
1817.81	Top of gray lime	510.2
1820.88	Top of coal	495.35
1821.75	Top 1' layer white sugary ss. (Potteville)	454.6
1822.56	Top gray lime	499.1
1815.56	Top gray lime	503.0
1816.74	Base #2. coal	467.7
1817.49	Measured down shaft to top of coal	477.6
1713.89	Top of coal	546.75
1818.15	Base of old drift. Base of coal uncertain.	579.4
1807.83	Top of gray lime	500.5
1829.68	Top of gray lime	513.4
1829.55	Top #2 coal	471.2
1832.17	Base of coal	497.2
1831.49	Coal creek. Base coal.	488.
1808.23	Top gray lime	514.5
1808.73	Top gray lime	497.4
1132.11	Base of coal in mine	552.8
1131.82	Base of old drift on south side of ravine	571.7
1225.82	Base of coal. (This mine has rather steep east dip. Cars gravity out to mouth mine.)	565.0
1121.14	Base of coal	584.3
1117.23	Top of coal	593.0
1119.75	Top of coal	601.1
1119.21	Base of coal	600.4
1118.43	Top of Coal	589.4
1234.80	Top of gray lime	549.7

Location	Outcrop and Remarks	Elevation
1703.58	Top of gray lime	528.6
1119.18	Base of coal	569.6
1213.72	Top of coal	578.5
1215.93	Base of coal	592.0
1223.17	Top of Coal	607.0
1224.17	Base of Coal	597.7
1223.62	Top of slate	587.8
1225.19	Top of coal	600.9
1225.67	Base of coal	568.0
1224.72	Top of coal	579.5
1226.43	Base of coal	588.5
1226.48	Top of coal	604.8
1222.35	Base of coal	614.8
1221.35	Top of slate	628.4
1221.78	Base of coal	613.8
1230.58	Top of coal	620.5
1230.59	Base of #6	643.7
1230.33	Base of coal	623.7
1229.38	In ravine south of mine dump: south side of ravine 285' E of RR track; rod on base of old entry. Definite outcrop not found	621.0
1227.19	Base of coal	613.6
1233.33	Top of gray lime	559.4
1232.95	Top gray lime	563.1
1233.19	Top gray lime	567.3
1705.99	Top #2 coal	516.7
1704.07	Top Coal	495.3
1705.84	Top gray lime	545.3
1705.58	Top gray lime	551.7
1705.25	Top gray lime in abandoned road; changed loc.	553.0

Page 4--Havana Quad. levels.

Location	Outcrop and remarks	Elevation
1732.07	Top gray lime	556.2
1731.92	Top gray lime	552.9
1705.09	Top #2 coal	521.0
1602.66	Top gray lime	566.7
1601.06	Top coal	545.8
1601.05	Base coal high on cut bank. Poor contact.	543.9
1703.19	Top of gray lime	524.9
1233.83	Top of 5" ls. layer below which is 10" of blk. sl.; then ss.	538.6
1235.25	Top gray lime	522.0
1235.75	Base of coal	562.9
1234.33	Top of coal	506.1
1234.88	Top of 6" blk crinoidal lime layer	535.9
1335.81	Top of black lime layer	567.9
1706.62	Top gray lime	562.3
1709.19	Top Coal	506.8
1708.87	Base of Coal	511.2
1708.59	Top of lime	547.7
1719.05	Base of Coal	505.5
1613.29	Base of Coal	522.0
1718.09	Base of Coal	521.4
1612.77	Top of Coal	530.5
1612.54	Base of coal	521.0
1612.59	Base of gray lime	560.4
T612.99	Top gray lime	561.7
1707.39	Top gray lime	567.9
1708.15	Base of coal	524.2
B707.54	Base of coal	491.8
1707.91	Base of coal	507.0

Location	Outcrop and remarks	Elevation
1718.94	Base of Coal	517.1
1718.36	Base of coal	495.1
1718.21	Base of coal	500.8
1719.98	Top of coal	518.0
1719.64	Base of coal	480.0
1732.37	Base of coal in abandoned drift	493.4
1733.29	Top of coal in outcrop in road. Changed loc.	532.7
1728.26	Base of coal	524.2
1736.04	Top of coal	501.9
2002.74	Base of coal in abandoned drift	478.3
2003.14	Base of coal	485.1
1733.02	Base of coal	513.3 (512.3)
2017.68	Top of coal	519.1
2016.39	Base of coal	496.1
2016.85	Top of coal	477.4
2022.90	Top of coal	480.4
2026.44	Base of coal	513.4
20~~20~~35.28	Top of coal (changed location)	484.2
2031.92	Base of coal	509.0
2006.48	Base of coal (Dips south in this mine)	503.6
2505.51	Base of knobby lime	472.2
2505.90	(Base #2 coal (Top of knobby ls is 19.8' below base coal.	493.1
2505.94	~~Base~~ Top knobby lime	477.9
2408.84	Top knobby lime	488.5
2033.39	Top knobby lime	485.9
2032.27	Top of coal	498.3
2025.91	Top of coal	533.5
2029.56	About base of coal	505.7

Page 6--Havana Quad. levels.

Location	Outcrop and remarks	Elevation
2030.55	Base of coal	515.4
2136.17	Base of coal in road; changed location	531.0
2135.66	Base of coal	528.4 7
2126.43	Top of coal	512.4
2019.62 2.67	Base of coal	492.1
2113.91	Base of coal	499.7
1626.32	Base of coal	536.2
1635.60	Base of coal	508.8
1636.14	Top of knobby lime	499.0
2101.18	Top of coal	517.6
2007.58	Base of coal	509.3
2101.23	Base of coal	570.1
2112.79	Top of coal	497.4
1722.94	Top of shaft. (64' to top of coal)	558.7
1729.07	Base of coal Top Septarian ls. 500' upstream	509.5 516.8
1708.40	Base of coal	505.9
1704.44	Top of gray ls.	547.8
1704.86	Top gray lime	537.0
1225.25	Base of coal	581.5

Havana Quadrangle Levels

Location	Outcrop and Remarks	Elevation
1114.51	Top of Coal	587.6
1124.47	Base of Coal	574.0
1113.23	Base of Coal	556.1
1125.49	Base of Coal	554.2
1125.27	Base of Coal	543.3
1124.11	Top of Coal	560.1
1126.32	Top of Coal	569.
1722.89	Top of Shaft. 96' to top of coal.	585.8
1128.48	Base of Coal	599.3
1120.56	Top of Coal	606.3
1116.31	Base of Coal in mine. (This point has an elevation of 149 on mine map.)	582.5
1121.78	Top of Coal. Outcrop poorly defined.	609.5
1128.52	Lower concretion zone	582.2
	Upper concretion zone	585.8
1135.64	Base of coal blossom	567.4
1135.88	Top of Coal	540.3
1136.36	Base Coal in mine north of road. Changed loc.	502.7
1136.58	Top of lime cap rock in cut bank.	500.5
1801.44	Base of coal	532.3
1801.11	Gray lime South end of exposure	473.65
	" " North end of exposure	470.25
1811.89	Top of gray lime	469.15
1801.29	Top Coal	504.2
1812.58	Top coal	494.65
1812.23	Base of Coal	481.6
1812.81	Base of coal	485.65
1814.88	Top of cap rock at road.	509.7
1822.98	Top of gray lime.	484.0

Location	Outcrop and Remarks	Elevation
1820.27	Top of gray lime	512.3
1817.84	Top No. 2 Coal	475.45
1817.84	Top of gray lime	495.25
1817.81	Top of gray lime	510.2
1820.88	Top of coal	495.35
1821.75	Top 1' layer white sugary ss. (Potteville)	454.6
1822.56	Top gray lime	499.1
1815.56	Top gray lime	503.0
1816.74	Base #2. coal	467.7
1817.49	Measured down shaft to top of coal	477.6
1713.89	Top of coal	546.75
1818.15	Base of old drift. Base of coal uncertain.	579.4
1807.83	Top of gray lime	500.5
1829.68	Top of gray lime	513.4
1829.55	Top #2 coal	471.2
1833.17	Base of coal	497.2
1831.49	Coal creek. Base coal.	488.
1808.23	Top gray lime	514.5
1808.73	Top gray lime	497.4
1132.11	Base of coal in mine	552.8
1131.82	Base of old drift on south side of ravine	571.7
1225.82	Base of coal. (This mine has rather steep east dip. Cars gravity out to mouth mine.)	565.0
1121.14	Base of coal	584.3
1117.23	Top of coal	593.0
1119.75	Top of coal	601.1
1119.21	Base of coal	600.4
1118.43	Top of Coal	589.4
1234.80	Top of gray lime	549.7

Location	Outcrop and Remarks	Elevation
1703.58	Top of gray lime	528.6
1119.18	Base of coal	569.6
1213.72	Top of coal	578.5
1215.93	Base of coal	592.0
1223.17	Top of Coal	607.0
1224.17	Base of Coal	597.7
1223.62	Top of slate	587.8
1225.19	Top of coal	600.9
1225.67	Base of coal	568.0
1224.72	Top of coal	579.5
1226.43	Base of coal	588.5
1226.48	Top of coal	604.8
1222.35	Base of coal	614.8
1221.35	Top of slate	628.4
1221.78	Base of coal	613.8
1230.58	Top of coal	620.5
1230.59	Base of #6	643.7
1230.33	Base of coal	623.7
1229.38	In ravine south of mine dump: south side of ravine 285' E of RR track; rod on base of old entry. Definite outcrop not found	621.0
1227.19	Base of coal	613.6
1233.33	Top of gray lime	559.4
1232.95	Top gray lime	563.1
1233.19	Top gray lime	567.3
1705.99	Top #2 coal	516.7
1704.07	Top Coal	495.3
1705.84	Top gray lime	545.3
1705.58	Top gray lime	551.7
1705.25	Top gray lime in abandoned road; changed loc.	553.0

28

Location	Outcrop and remarks	Elevation
1232.07	Top gray lime	556.2
1231.92	Top gray lime	552.9
1705.09	Top #2 coal	521.0
1602.66	Top gray lime	566.7
1601.06	Top coal	545.8
1601.05	Base coal high on cut bank. Poor contact.	543.9
1703.19	Top of gray lime	524.9
1233.83	Top of 5" ls. layer below which is 10" of blk. sl.; then ss.	538.6
1235.25	Top gray lime	522.0
1235.75	Base of coal	562.9
1234.33	Top of coal	506.1
1234.88	Top of 6" blk crinoidal lime layer	535.9
1335.81	Top of black lime layer	567.9
1706.62	Top gray lime	562.3
1709.19	Top Coal	506.8
1708.87	Base of Coal	511.2
1708.59	Top of lime	547.7
1719.05	Base of Coal	505.5
1613.29	Base of Coal	522.0
1718.09	Base of Coal	521.4
1612.77	Top of Coal	530.5
1612.54	Base of coal	521.0
1612.59	Base of gray lime	560.4
T612.99	Top gray lime	561.7
1707.39	Top gray lime	567.9
1708.15	Base of coal	524.2
B707.54	Base of coal	491.8
1707.91	Base of coal	507.0

Location	Outcrop and remarks	Elevation
1718.94	Base of Coal	517.1
1718.36	Base of coal	495.1
1718.21	Base of coal	500.8
1719.98	Top of coal	518.0
1719.64	Base of coal	480.0
1732.37	Base of coal in abandoned drift	493.4
1733.29	Top of coal in outcrop in road. Changed loc.	532.7
1728.26	Base of coal	524.2
1736.04	Top of coal	501.9
2002.74	Base of coal in abandoned drift	478.3
2003.14	Base of coal	485.1
1733.02	Base of coal	512.3 (512.3)
2017.68	Top of coal	519.1
2016.39	Base of coal	496.1
2016.85	Top of coal	477.4
2022.90	Top of coal	480.4
2026.44	Base of coal	513.4
2020.28	Top of coal (changed location)	484.2
2031.92	Base of coal	509.0
2~~0~~506.48	Base of coal (Dips south in this mine)	503.6
2505.51	Base of knobby lime	472.2
2505.90	(Base #2 coal (Top of knobby ls is 19.8' below base coal.	493.1
2505.94	Base knobby lime	477.9
2~~4~~508.84	Top knobby lime	488.5
2033.39	Top knobby lime	485.9
2032.27	Top of coal	498.3
2~~0~~125.91	Top of coal	533.5
2029.56	About base of coal	505.7

Page 6--Havana Quad. levels.

Location	Outcrop and remarks	Elevation
2030.55	Base of coal	515.4
2136.17	Base of coal in road; changed location	531.0
2135.66	Base of coal	527.4
2126.43	Top of coal	512.4
2019.62	Base of coal	492.1
2113.91	Base of coal	499.7
1626.32	Base of coal	536.2
1635.60	Base of coal	508.8
1636.14	Top of knobby lime	499.0
2101.18	Top of coal	517.6
2007.58	Base of coal	509.3
2101.23	Base of coal	570.1
2112.79	Top of coal	497.4
1722.94	Top of shaft. (64' to top of coal)	558.7
1729.07	Base of coal	509.5
	Top Septarian ls. 500' upstream	516.8
1708.40	Base of coal	505.9
1704.44	Top of gray ls.	547.8
1704.86	Top gray lime	537.0
1225.25	Base of coal	581.5

Total outcrops levelled -- 156

Clay tests taken by

JEL - 3-25-32

Returned 3/25/32

Test No. 1 Clay No. 116

(Fulton 1223.44 along gulley at hea
leading to Slug Run) Canton shale -
Test for fuller's earth properties
and brick.

Kind of material.. Clay

Drying conduct .... Good

Volume drying shrinkage 18.52%

Linear drying shrinkage 6.60%

Water of plasticity 27.00%

Bonding strength - modulus of rupture .. Lbs. per sq. in. 230.0

Bulk specific gravity 1.865

~~Screen test~~:

Mesh	~~Per cent residue~~	~~Character of residue~~
20		
40		
60		
120		
200		

Not made

Burning test:

Cone	Volume shrinkage per cent	Linear shrinkage per cent	Porosity	Color	Fracture
05	26.61	9.80	10.60	Light red	Vitreous
02	30.10	11.25	.09	Dark red	"
2	29.05	10.80	0	Dark red	"
4	Bloated		Overburned		
6	Badly bloated		"		"

Fusion test: Clay not refractory

Oxidizing conduct: Good

Summary: Drying shrinkage medium, bonding strength medium, ~~screen residues~~ ———, vitrification complete at cone 02, overburned at cone 4, burning shrinkage at vitrification medium. It is a nonrefractory clay.

Suggested uses: Building brick, possibly drain tile, hollow tile, roofing tile, and flower pots.

Test No. 2 Clay No. 120

(Fulton ~~1801~~ 2 1.04 - Stream cut on S. wall opposite R. R. 9-10-27. Fire clay below No. 2 coal)

Kind of material	Clay
Drying conduct	Good
Volume drying shrinkage	18.45%
Linear drying shrinkage	6.58%
Water of plasticity	24.3%
Bonding strength - modulus of rupture ... Lbs. per sq. in.	363.54
Bulk specific gravity	1.90

~~Screen test:~~

Mesh	Per cent residue	Character of residue
20	not made	
40		
60		
120		
200		

Burning test:

	Cone	Volume shrinkage per cent	Linear shrinkage per cent	Porosity	Color	Fracture
1904°F	05	16.27	5.75	15.92	Light buff	Smooth
2057°	02	20.12	7.215	9.49	Light buff	"
2129°	2	21.76	7.854	1.28	Light tan	"
2201°	5	Bloated		3.40	Overburned	"
2246°	6	Bloated		16.05		

Fusion test: Clay not refractory

Oxidizing conduct: Good

Summary: Drying shrinkage medium, bonding strength medium, ~~screen residue~~ , vitrification complete at cone 2, overburned at cone 2, burning shrinkage at vitrification medium low. It is a nonrefractory clay.

Suggested uses: Building brick, possibly drain tile, hollow tile, etc.

Test No. 3 <u>Clay No. 117</u>

(Fulton ~~1~~2 801.14 - Stream cut bank on spur below R.R. -9-10-27 - fire clay below 10" coal below No. 2)

Kind of material	Clay
Drying conduct	Good
Volume drying shrinkage	21.85%
Linear drying shrinkage	7.80%
Water of plasticity	29.1%
Bonding strength - Modulus of rupture .. Lbs. per sq. in.	233.80
Bulk specific gravity	1.84

Screen test:

Mesh	Per cent residue retained	~~Character of residue~~
~~20~~ 28	23.9	
~~40~~ 48	10.4	
~~60~~ 65	2.5	
~~120~~ 100	4.9	
~~200~~ 200	16.4	

Burning test:

	Cone	Volume shrinkage per cent	Linear shrinkage per cent	Porosity	Color	Fracture
	05	13.02	4.54	27.44	Salmon	Granular
	02	14.47	5.08	20.93	Salmon-buff	"
	2	15.09	5.31	19.97	Light buff	"
	5	19.59	7.01	11.54	Pinkish buff	"
	7	23.35	7.84	7.55	Light tan	"
2381°	10	21.49	7.74	9.56	Buff with black spots	"
2417°	11	Bloated		7.64		

Fusion test: Clay not refractory

Oxidizing conduct: Poor

Summary: Drying shrinkage medium, bonding strength medium, ~~screen-residue~~ , vitrification complete between cone 7 and 10, overburned at cone 10, burning shrinkage at vitrification medium low. It is not refractory.

Suggested uses: Drain tile, hollow ware, etc.

Test No. 16 Clay No. 118

(Fulton 2030.63 - Fire clay below thin coal at base of section, Otter Creek road cut)

Kind of material .... Clay

Drying conduct .... Good

Volume drying shrinkage 18.22%

Linear drying shrinkage 6.63%

Water of plasticity 23.22%

Bonding strength - Modulus of rupture .. Lbs. per sq. in. 282.8

Bulk specific gravity 1.97

Screen test:

Mesh	Per cent residue retained	Character of residue
~~20~~ 28	3.7	
~~40~~ 48	28.3	
~~60~~ 65	7.6	
~~120~~ 100	5.4	
~~200~~ 200	24.1	

Burning test:

	Cone	Volume shrinkage per cent	Linear shrinkage per cent	Porosity	Color	Fracture
1940°	04	6.19	2.14	26.25	Cream	Granular
	02	12.55	4.37	21.57	Cream	"
	2	10.42	6.60	21.47	Cream (omit)	"
2138°	3	15.10	5.31	16.99	Light tan	"
	6	18.64	6.65	9.80	Tan	"
2300°	8	19.20	6.86	10.20	Bluestoned	"

Fusion test: Fusion point P.C.E. 27-28

Oxidizing conduct: Poor

Summary: Drying shrinkage medium, bonding strength medium, ~~screen residues~~ ________, vitrification incomplete at cone 8, shrinkage at cone 8 medium low. The clay is refractory.

Suggested uses: Building brick, possibly quarry tile, roofing tile, flue lining, sanitary ware, stove linings.

Test No. 8 Clay No. 119

(Fulton 2030.63 - Fire clay or shale below sugary ss. Otter Creek road cut)

Kind of material .... Clay

Drying conduct .... Good

Volume drying shrinkage 30.90%

Linear drying shrinkage 11.55%

Water of plasticity 24.10%

Bonding strength - Modulus of rupture .. Lbs. per sq. in. 248.5

Bulk specific gravity 1.91

~~Screen test:~~

Mesh	Per cent residue	Character of residue
20		
40		
60		
120		
200		

Not made

Burning test:

Cone	Volume shrinkage per cent	Linear shrinkage per cent	Porosity	Color	Fracture
05	10.97	3.80	20.11	Tan	Granular
02	18.05	6.42	11.86	Dark tan	"
2	17.83	6.34	14,68	Dark tan	"
2174° 4	Bloated		5.71		
2282° 7	Bloated		15.37		

Fusion test: Clay not refractory

Oxidizing conduct: Poor

Summary: Drying shrinkage medium high, bonding strength medium, ~~screen residues~~ , vitrification--overburns suddenly between cones 2 and 4. Shrinkage at cone 2 is medium low. It is nonrefractory

Suggested uses: Building brick, possibly hollow tile.

OUTLINE OF THE GEOLOGY OF THE HAVANA QUADRANGLE

Location

The Havana quadrangle is situated in Fulton and Mason Counties, Illinois. It is bounded by the parallels 40°15' and 40°30' north latitude, and the meridians 90°00' and 90° 15' west longitude. The area is approximately 225 square miles.

Physiography

Drainage

The Havana quadrangle is a part of the interior glaciated plain. The southeastern portion of the quadrangle is crossed by the Illinois River valley, three to four miles in average width. The River flows along or near the eastern margin of its valley across the quadrangle. The Spoon River, a large tributary enters the Illinois near Havana. It has a valley plain one to two miles in width in this quadrangle. Big Creek, a large tributary of Spoon River, and Otter Creek, a large tributary of the Illinois, south of Spoon River, are the other principal streams.

Relief

The western margin of the Illinois River valley is bordered by bluffs 80-140' in height separating the river valley from the relatively level uplands forming the northern and western portions of the quadrangle. The uplands are sharply trenched by many streams, so that level upland areas exceeding two miles in width which are not interrupted by gullies or ravines are uncommon. The upland surface rises gradually from the bluffs near Sepo, where its elevation is about 550' toward the north and northwest to the vicinity of Cuba where the elevation is 670 to 680 feet. The Illinois valley is 430-440' in altitude.

The southeast side of the Illinois River valley is part of a very broad terrace, or former lake-like expansion of the Illinois River which is covered with wind blown sand in many places piled into dunes. A rather prominent belt of dunes, in general parallelling the southeastern margin of the Illinois River flood plain, and averaging 2½ miles distant from it in this quadrangle are interpreted by the writer as representing a former shore line and beach dunes of the lake-like expansion of the Illinois River. The plain between this belt of dunes and the margin of the Illinois flood plain is 465-475' in altitude, although there are isolated sand dunes on this plain which exceed 500' in altitude. This plain conforms in altitude with the lower of two terrace levels on the west side of the Illinois River valley, which is correlated with the time when the Illinois River served as the drainage outlet for Lake Chicago, the predecessor of Lake Michigan. The shore and shore dunes may then have been formed during the Lake Chicago stage.

The plain behind the general belt of dunes mentioned above, averages 485-500' in altitude but scattered dunes and some extensive groups of dunes are situated on this plain. This higher plain with sand dunes extends east along the state highway east of Havana approximately 14 miles east from the eastern margin of the Havana quadrangle, where a line of bluffs appear to mark the eastern margin of the Illinois valley former lake-like expansion here 22-25 miles in width. The higher plain here mentioned is slightly lower than the higher of two terraces on the west side of the valley, which is correlated with the stage when the Illinois River received glacial outwash from the Bloomington stage of the early Wisconsin glacier where this glacier crossed the Illinois River near Peoria 35-50 miles upstream from this area.

Terraces

Remnants of two terraces, the upper averaging 490-510' in altitude, and the lower 465-480' in altitude are present along the western margin of the Illinois river and along Spoon River, Big Creek, Otter Creek and several other smaller stream valleys. The terrace remnants along Spoon

River and the smaller streams are, as a rule more extensive than those along the Illinois River bluffs, except those parts of the Illinois River bluffs which were protected from the sweep of waters from the northeast. This distribution of terraces suggests that the flood of waters from the glacial Lake Chicago combined with the torrential flow from the glacial Kankakee River basin were effective agents of scour in the exposed parts of the Illinois River Valley.

Floods

The alluvial plains of the Illinois and Spoon Rivers are subject to frequent and disastrous floods. Both valleys are protected by systems of artificial levees. The tributary streams entering the Illinois River cross alluvial plains in straight artificial ditches protected by levees. During the floods of 1926-27 some levees broke and the bottom lands in the southern part of the quadrangle were flooded during most of the fall, winter, and spring. The road from Havana west across the bottom lands was closed to traffic in October, 1926, and except for a few days was not open to traffic until July, 1927. The flood waters retained their high level during 1926-27 along the Illinois valley long enough to cut a low wave cut scarp along their outer margin and to line this shore with great masses of drift wood. These can be seen well along the bluff road 3 miles east of Enion, and at Baldwin Beach along the east side of Quiver Lake. The largest masses of driftwood seen were along the southeast margin of the valley on the Manito quadrangle, a few miles wast of the east line of the quadrangle. (Photo)

Drainage

The west side of the Illinois river valley is generally well drained but the terrace and sand dune area east of the Illinois River is almost without surface drainage. Heavy rains during 1926 in the sand dune area formed a pond $\frac{1}{2}$ mile long by $\frac{1}{4}$ mile wide which had not yet been drained during the summer of 1927. Water is ponded in many undrained derpressions and in several cases roads have been flodded as a result of a period of heavy rains and thus closed off. The very level lands near the southeast corner of the quadrangle are now being drained by a system of drainage ditches entering White Oak Creek, Quiver Creek, northeast of Havana also receives a considerable part of its water from drainage ditches. It appears that more ditches may be profitably installed in this part of the area.

Slumping

As a result of heavy rains during the season 1926-27, many of the stream walls have slumped extensively, blocking the drainage of some of the smaller streams, and causing new exposures on slopes which had been covered entirely with soil and vegetation. The drainage of the slopes has thus been obstructed and many portions have developed small marshy or poorly drained sections.

Effects of strip mining.

The strip mined area southeast of Cuba has produced over one square mile of territory composed of the spoil banks of material removed from above the coal. So far this is a totally abandoned region, but the year after stripping has taken place a rather luxuriant growth of weeds begins to mantle the slopes, so it is possible that the fertility of the soil may not be entirely ruined by stripping. It seems to the writer desirable to experiment with the growth of orchards or vineyards on these spoil banks, as the area of land yielding no return from this cause is rapidly increasing.

Effects of underground mining

In several places in the vicinity of Cuba and elsewhere in the northern part of the quadrangle cave-ins are present in the beds of ravines. One such cave-in, in the S.W.$\frac{1}{4}$ sec. 23, T.6 N. R.3 E. (Putman) was photographed In part of sec. 29, T 6 N, R 3 E, (Putman) numerous small pits are seen in the upland surface resulting from underground mining.

PART II

Stratigraphy

The exposed strata of the Havana quadrangle belong to the Pennsylvanian and Pleistocene systems.

Deep drillings have penetrated strata of the Mississippian, Devonian, Silurian, and Ordovician systems. An artesian well which was drilled to a depth of 2245' as an oil test well, probably penetrates strata of Cambrian age to a depth of 500-600', but no accurate log of this well was obtained.

The thicknesses of the formations which are not exposed are indicated in the following logs of wells.

(1) City well of Cuba, sec. 17, T.6 N, R.3 E.(Putman)

			Thickness	Depth
17	Subsoil and clay (Pleistocene)		34	34
16	Shale, sandy, (Cuba sandstone and Canton shale?)		68	102
15	Sandstone		4	106
14	Coal (No.5?) (Seems 50' too deep)		5	111
13	Shale, (Carbondale & Pottsville)		144	255
12	Hard black rock (Cap of #1 coal?)		5	260
11	Shale (Pennsylvanian-Warsaw?)		50	310
10	Limestone white (bed rock)(Warsaw?)		25	335
9	Shale (?)		5	340
8	Limestone (Keokuk-Burlington)		287	627
7	Shale (Kinderhook-Sweetland Creek)		243	870
6	Limestone (Devonian-Niagaran)		120	990
5	Shale, brown	Maquoketa	78	1068
4	Shale, light		102	1170
3	Limestone, Trenton(Galena-Platteville)		207	1377
2	Sand and gravel ?		93	1470
1	Sandstones, St. Peter, to base of formation		298	1768

(2) Oil test drilling on the farm of F. W. Harrison, east of Bryant

		Thickness	Depth
Pleistocene		42	42
Coal (No. 5)		5	47
Shale, blue		30	77
Shale, light (Purington?)		55	132
Shale, dark		8	140
Lime		3	143
Coal (No. 2?)		5	148
Shale, dark		4	152
Shale, light		25	177
Shale, sandy		25	202
Shale, dark	Pottsville	15	217
Shale, sandy		20	237
Sand		35	272
Shale, dark		17	289

		Thickness	Depth
Lime - St. Louis or Salem		33	320
Shale		15	335
Limestone		5	340
Sand	Warsaw?	5	345
Shale, light		4	349
Limestone		54	403
Shale, light		12	415
Limestone, Keokuk (Burlington)		200	615
Shale, blue (Kinderhook)		125	740
Shale, brown		10	750
Shale, blue	Sweetland Creek	30	780
Shale, brown		35	815
Shale, blue		23	838
Limestone		18	856
Sand	Devonian?	16	872
Limestone - Niagaran and Devonian?		138	1010
Shale, blue (Maquoketa)		172	1182
Limestone (Galena-Platteville)		213 to base of well	1395

(III) Oil test drilling on farm of Robert Zempel, sec. 12, T. 5 N, R. 2 E.

		Thickness	Depth
Pleistocene		25	25
Soapstone		30	55
Muck, blue	Carbondale	20	75
Coal (#2)		2	77
Shale, gray		23	100
Shale, blue	Pottsville	25	125
Shale, dark		25	150
Limestone, Salem		85	235
Shale		40	275
Sandstone	Warsaw	30	305
Rock, gray (limestone?)(Keokuk)		60	365
Limestone, white, coarse (Burlington)		140	505
Shale, blue (Kinderhook)		95	600
Shale, brown		100	700
Shale, blue	Sweetland Creek	60	760
Limestone to base of well (Devonian)		60	820

(IV) Oil test drilling on farm of Brock, sec. 24, T.5 N, R.2 E, situated on high (Wisconsin) terrace on north side of Spoon River.

		Thickness	Depth
Pleistocene		70	70
Soapstone		5	75
Fire clay		4	79
Coal	Pottsville	1'6"	80' 6"
Fire clay		4'6"	85
Slate, black		18	103
Soapstone		10	113
White brake Salem?		12	125
Shale, Calcareous		22'6"	137'6"
Fire clay		46'6"	184
Shale, calcareous		2	186
Fire clay	Warsaw?	10	196
Shale, calcareous		2	198
Slate, blue		12	210
Shale, calcareous		8	218
Brake and Big limestone (Keokuk?)		19	237

	Thickness	Depth
"Big line" water nearly fresh (Keokuk-Burlington)	167	404
Shale, (Kinderhook-Sweetland Creek)	244	648
Second line water - strong flow - salty and sulphurous (Devonian-Silurian)	109	757
Blue shale and mud (Maquoketa)	150	907
Dark lime shell } ?	10	917
Blue mud } ?	12	929
Blue mud and shells strong flow of water at 965', fresh, flat taste } Trenton Galena Platteville	36	965
Dolomite and blue mud } Trenton Galena Platteville	20	985

(V) Log of oil test drilling in sec. 32, T.21N, R.8 W, (Mason county) about two miles south of the quadrangle.

	Thickness	Depth
Not reported (Pleistocene-Pennsylvanian?)	94	94
Limestone with water (Salem?)	11	105
"Slate" white } Salem-Warsaw	60	165
Limestone, with water } Salem-Warsaw	65	230
"Slate", white } Salem-Warsaw	10	240
Limestone, with water } Salem-Warsaw	80	320
"Slate" white	15	335
Limestone, dry (Keokuk)	100	435
Limestone, with water (Burlington)	120	555
"Slate", white (Kinderhook)	95	650
"Slate" brown (Sweetland Creek)	130	780
Limestone, white } Niagaran	10	790
Limestone, brown, with water, mineralized } Niagaran	5	795
Limestone, white, with water } Niagaran	155	950
"Slate", white } Maquoketa	90	1040
"Slate", brown } Maquoketa	100	1140
Limestone, brown, with water (Galena-Platteville)	240	1380
Sandstone (St. Peter?)		

Summarized from the above logs, the generalized section of pre-Pennsylvanian strata in the Havana quadrangle is as follows:

Limestone (Salem-St. Louis)	80'-0	
Shale, with beds of sandstone and limestone (Warsaw)	80-200'	av. 95'
Limestone, upper beds fine grained, dry, lower beds coarse grained, cherty (Keokuk-Burlington)	180-287'	av. 200'
Shale, light gray in upper 90-100' (Kinderhook) Brownish below (Sweetland Creek)	225-255'	av. 245'
Limestone, light gray with strong flow of mineralized water, at or near top (Devonian?-Niagaran) (one well reports 16' sand 18' below top.)	109-170'	
Shale, blue gray to brownish, calcareous, some thin limestone beds (Maquoketa)	172-250'	(4 wells)
Dolomite, brownish gray (Galena-Platteville)	207-240'	(3 wells)
Sand and gravel?	93'	(1 well)
Sandstone, St. Peter (water mineralized)	298'	(1 well)

Pennsylvanian system

The consolidated rocks exposed in the Havana quadrangle belong to the Pottsville, Carbondale, and Mc Leansboro formations of the Pennsylvanian system.

Pottsville formation
Unexposed strata

The Pottsville formation includes strata from the base of the Colchester (#2) coal, to the base of the Pennsylvanian. In this region the Pottsville strata include four rather widely distributed coal beds, the lowest of which is apparently not exposed anywhere in the quadrangle, but is recorded from drillings at several places.

This coal is the thickest of the Pottsville coals, being reported as 3 to 7 feet in thickness, and is correlated with the coal exposed along Spoon River in the vicinity of Seville, the #1 coal of Worthen. The #1 coal may commonly be recognized in drillings by the presence of a thick limestone cap rock, ranging from 5 or 6 to nearly 30' in thickness, resting directly on the coal, or separated from it by 2-6' of black carbonaceous shale.

A drilling in the Illinois River bottom in sec. 9, T. 4 N., R. 4 E., which penetrated the #1 coal is as follows:

	Thickness	Depth
Dirt and sand	29	29
Limestone, black, hard	11'6"	40' 6"
Coal #1	5	45'6"
Fire clay	1'6"	47
Shale, and sandstone	19	66
Shale, black, gummy	5	71

In the vicinity of Cuba the #1 coal lies about 80' below the top of the Pottsville formation, and the records available indicate that this is approximately the average interval between the two coals elsewhere.

The #1 coal appears to have been deposited in narrow basins several miles in length and it pinches out and disappears along with its limestone cap rock, within a few hundred feet of locations where it is 4-6' thick under several feet of cap rock.

In part the irregularity of #1 coal may be due to unconformities, as a coal near the position of #1 coal is reported under a hard sandstone cap rock in drillings south of Spoon River 1-2 miles west of Duncan Mills. The sandstone which Savage reports as cutting out the #1 coal in the Vermont quadrangle (Bernadotte sandstone) has not been recognized in outcrop on the Havana quadrangle.

Exposed Strata

The lowest Pennsylvanian strata exposed in the Havana quadrangle are seen on the south side of Spoon River at Duncan Mills and west of here along Tater Creek 1-2 miles, and on the south side of Otter Creek in sec. 25, T.4 N. R.2 E. (Pleasant).

A generalized section of the Pottsville strata near Duncan Mills is as follows:

17.	Fire clay	1'6"
16.	Coal	1'
15.	Fire clay	2'6"
14.	Sandstone, massive, hard (quartzitic) apparently even contact on	3'[illegible]
13.	Coal	1'6"
12.	Fire clay	3'
11.	(Sandstone, locally present)	3'4"
10.	Coal (2" clay seam 8" below top) (reported 2'6"-3')	1-2' exp.
9.	Shale, gray	3'
8.	Ironstone concretions	2"
7.	Shale, gray	1'6"
6.	Ironstone concretions	2"
5.	Shale, gray, sandy	10"
4.	Concretion (Locally large septarian concretions 2' thick)	2"
3.	Shale, gray, slightly sandy	2'6"
2.	Shale, black, fissile, hard	5"
1.	Shale, blue gray, papery, soft, micaceous, slightly sandy to lowest exposure 300 yds. e. of hard road ridge at Duncan Mills at water level of Spoon River.	10-12'

Strata 1-8 are not known to be exposed elsewhere in the quadrangle. The coal beds nos. 10 and 13 are widespread in this area and are commonly reported in drillings. Both of these beds thin westward from Duncan Mills and in a creek bank on the south side of Tater Creek both beds appear to underlie directly sandstone which rest unconformably on the coal (see photo).

The sandstone roof of the upper coal is a very hard and massive fine grained sandstone with quartzitic texture, which is recognized at several other localities in the quadrangle. This coal succession has been described as a split coal by Culver and it is tentatively correlated with a Pottsville coal succession exposed in the Mill Creek section in the Beardstown quadrangle, near Pleasantview. Neither of the two coal beds were exposed in greater thickness than 2', but either may attain workable thickness. A sandstone, which is very massive and hard, and is correlated with the roof of the upper coal (#14 of above section) attains a thickness of 6' along the north bank of Otter Creek in the S.E.¼, sec. 29, T.4 N, R.3 E. (Isabel.)

Strata between the "Quartzitic" sandstone and the "Knobby" limestone

Above the hard sandstone mentioned above there occurs a succession of shale, fire clay, sandstones and thin coal beds, which are quite variable in character. The most characteristic member is a sandstone 8-20' above the quartzitic sandstone which is fine grained, white or light gray and "sugary" in texture.

A cut bank on the south side of Otter Creek in the N.E.¼, N.E.¼, sec. 35, T.4 N, R.2 E, (Pleasant) shows the following succession:

20.	~~Shale~~ Sandstone	3'
19.	Shale, gray, with ferruginous septarian concretions (lower part may be fire clay)	3'
18.	Coal	6"
17.	Fire clay	2'
16.	Limestone, gray, knobby, fossiliferous	2'
15.	Fire clay	2'
14.	Coal, parting	2"
13.	Fire clay	3' 4"
12.	Sandstone, light gray "sugary"	2'
11.	Fire clay	4' 6"
10.	Shale, black, carbonaceous, slightly coaly	5"
9.	Shale, dark gray	8"
8.	Fire clay, light	4-7"
7.	Shale, dark, carbonaceous	2"
6.	Fire clay, gray	8"
5.	Sandstone, brown weathering coarse	10"
4.	Fire clay, light	11"
3.	Shale, light gray above, dark gray below with ferruginous concretions	5' 6"

2.	Shale, black, carbonaceous (coal horizon)	2"
1.	Fire clay, dark gray	6"

#1 is probably within 2' of the upper coal bed of the split coal.

A cut bank on the south side of Tater Creek near the N.W. cor. N.W.¼ N.W.¼ sec. 7, T.4 N, R.2 E.(Pleasant) shows strata nearly equivalent in age to those above (See photo)

10.	Shale, gray, or fire clay, weathered	3'
9.	Coal blossom	5"
8.	Fire clay, gray	10"
7.	Limestone concretions, septarian not continuous (Pottsville knobby limestone?)	8"
6.	Clay, buff weathering not bedded	4'
5.	Sandstone, gray, massive ledge, iron stained, especially on joint surfaces ("Sugary")	1'5"
4.	Shale, gray, bedded	4'6"
3.	Coal, bony, mixed with shale	3"
2.	Coal	2"
1.	Fire clay	8"

Nos. 5,7, and 9 of this section may be correlated respectively with nos. 12,16 and 18 of the section above.

An artificial stream cut made by the C.B. & Q. Ry, near the center of th the east line of sec. 32, T.5 N, R.3 E, (Lewistown) shows the following Pottsville succession (Photo).

Carbondale

31.	Scattered outcrops of Vergennes sandstone at top of cut	5' +
30.	Blossom of #2 coal not shown in outcrop, drifted on at several places near here.	

Pottsville

29.	Fire clay	2'
	Top of cut	
28.	Shale, greenish gray, micaceous, finely laminated, sandy, with irregular iron coated, laminated masses of sandstone	4' 6"
27.	Sandstone, hard, brownish, ledge forming	2'
26.	Shale, gray, sandy	6"
25.	Sandstone, light brown, fine grained, ledge forming, iron coated, not persistent	1'
24.	Shale, sandy or sandstone, shaly, micaceous, laminated greenish gray, and light yellow with numerous iron coated limestone nodules around which laminae of shale bend. Upper part very sandy with some concretions of sandstone	3'10"
23.	Limestone, dark brown, iron saturated	5"
22.	Clay, (fire clay) not bedded, dark gray, carbonaceous	6"
21.	Limestone, light brown, dense, nodular, with iron coated knobby surface	1'6"
20.	Limestone concretions, light brown, not continuous 2'x6" thick.	

Pottsville

19	19.	Fire clay, gray, lower 6" very dark	2'9"
	18.	Shale, black, fissile, not persistent	2"
	17.	Coal	10"
	16.	Fire clay with gypsum crystals, containing a few scattered limestone concretions, gray, iron coated, massive (Pottsville knobby limestone horizon?) about 1'3" below coal)	3'
	15.	Sandstone, white to light gray, soft to ledge forming ("Sugary")	1'6"
	14.	Shale, gray, sandy	11"
	13.	Sandstone, gray, sugary	9"
	12.	Shale, gray, soft	1'
	11.	Sandstone, gray, soft, iron stained	6"
	10.	Shale, gray, soft	3"
	9.	Sandstone, ledge forming	3'4"
	8.	Shale, light gray, sandy	1'10"
	7.	Sandstone	2"
	6.	Shale, gray, sandy	$9\frac{1}{2}$"
	5.	Sandstone	1"
	4.	Shale, light gray, slightly sandy	2'10"
	3.	Shale, blue gray, dark (coal horizon)	1'6"
	2.	Fire clay, light gray	3'2"
	1.	Sandstone, hard, quartzitic, somewhat crossbedded exposed to water level.	3'

In the above section the coal bed #17 is correlated with #9 of the preceding section. The horizon of the Pottsville knobby limestone appears to be represented by scattered calcareous concretions and the sandstone with a "sugary" texture, (#13 and #15) ~~are~~ is correlated with #5 in the preceding section and #12 of the section in sec. 35, T. 4 N, R. 2 E. The sandstone #1 is texturally similar to, and apparently equivalent to the sandstone roof of the upper bed of the "split" coal, previously described.

Pottsville knobby limestone.

A thin limestone bed which is widespread in this and adjacent quadrangles usually occurs 16-25' below the top of the Pottsville formation. It is gray in color, with an irregular upper and lower surface, and is frequently somewhat brecciated or conglomeratic. It is usually fossiliferous, but in some exposures fossils are very uncommon. In a few exposures this limestone appears to be represented by scattered concretions which are usually not fossiliferous. In continuous outcrop it may be observed to thin within short distances from 3 or 4 feet to 6 inches or to completely disappear. In the northern part of the quadrangle it is usually absent being typically developed in only 2 exposures in the part of the quadrangle north of Spoon River. The maximum exposed thickness is 6' on the south side of Seahorne Branch in the S.E.¼ S.E.¼ sec. 5, T.3 N, R.3 E. (Kerton) where it is continuously exposed and is unusually fossiliferous.

The most characteristic feature of the fauna is the abundance of gastropods of species which are rare or absent in other limestones in this quadrangle. Trachydomia wheeleri, Naticopsis altonensis, Naticella sp.? Zygopleura (2 or 3 species) Pleurotomaria (several species) Euconospira? are characteristic of this limestone especially the first two species. Spirifer cameratus, Marginifera muricata, Squamularia perplexa, Composita argentea, Productus cora, Productus nebraskensis, Productus costatus, Chonetes mesolobus, Chonetes sp.?, Pustula sp.? (small variety), Fusulina sp.? Rhombopora lepidodendroidea, Griffithides sp.?, Allorisma costatus, are among the other forms collected from the Pottsville knobby limestone.

Strata between the Colchester #2 coal and the Pottsville knobby limestone.

About 1'6" above the knobby limestone there is usually a coal bed 6" -1'6" in thickness separated from the limestone by fire clay. Above the coal bed the normal succession is fire clay, gray shale, sandstone, and fire clay with calcareous septarian concretions below the Colchester #2 coal. This interval is typically exposed in a high cut bank on the east side of a ravine in the N.W.¼ N.E.¼, sec. 16, T. 4 N, R. 3 E, (Isabel) where the following section was measured: (Photo)

Carbondale	12.	Sandstone, thin to medium bedded (Vergennes)	12'
	11.	Shale, gray	203'
	10.	Coal, Colchester #2 blossom, formerly drifted on here, now mostly covered with slump.	2' plus
Pottsville	9.	Fire clay and covered	8-10'
	8.	Sandstone, massive, forming hard, projecting ledge, cross bedded	8-10'
	7.	Underclay, light gray, with 2 discontinuous levels of calcareous septarian concretions	9'
	6.	Coal	1'
	5.	Fire clay, dark	2"
	4.	Fire clay, light	2'4"
	3.	Limestone, Pottsville knobby, fossiliferous with very irregular lower surface (Photo)	3'6"-4'
	2.	Fire clay, with one or two levels of calcareous septarian concretions	2-3'
	1.	Sandstone, white or light gray, buff weathering, upper beds hard and "sugary".	3' exp.

This interval is also well exposed in a cut bank on the east side of Turkey Branch about 200 yards north of the wagon road bridge in the N.E.¼, S.E.¼, sec. 31, T.4 N, R.3 E, (Isabel) (Photo)

	11.	Sandstone, Vergennes	Carbondale	3'
	10.	Coal, Colchester #2 (a few inches of gray shale may overlie this as sandstone is slumped over coal.)		2'6" ap.
Pottsville	9.	Underclay, light gray, with calcareous septarian concr.		3'6"-4'
	8.	Shale, gray, sandy		3'
	7.	Sandstone, micaceous, forming ledge, moderately hard		5'
	6.	Shale, gray		4'6"
	5.	Shale, gray, with 2 levels of ironstone conrections		1'
	4.	Fire clay, gray,with one level of large septarian limestone concretions, nonfossiliferous concretions not continuous)		3'
	3.	Shale, black, carbonaceous		1½"
	2.	Coal		8"
	1.	Fire clay, light		2' to creek bed.

South of bridge knobby limestone outcrops in bed of stream 1'3" below coal #2 of above section.

A brownish gray sublithographic unfossiliferous limestone which is not entirely continuous and in some outcrops appears to be concretionary in character occurs above or in the shale, corresponding to #6 of the above section. This is well exposed in the ravine along the hard road south of Otter Creek in Sec. 30, T.4 N, R.3 E. (Isabel).

Carbondale Formation.

The Carbondale formation is represented in the Havana quadrangle by strata from the Colchester #2 coal at the base to the Herrin #6 coal at the top.

Colchester (#2) coal.

This coal is remarkably persistent and is found at all places where its horizon is exposed in outcrop or penetrated in drillings, thus differing from the #1 coal which is usually confined to small areas. Its thickness is also remarkably constant averaging 2'6" over the entire area in which it is exposed in this quadrangle. The range of thickness is from 2'-2'10". The coal is not characterized by any shale partings but lenticular flattened concretions of pyrite are commonly observed in it. It is a harder coal than the Springfield (#5) coal and has been very extensively mined by local drifts. The floor is always a fire clay which contains normally septarian limestone concretions nonfossiliferous. The roof of the coal is normally a gray shale or "soapstone", but in the southern part of the quadrangle ~~where~~ the Vergennes sandstone in many places rests directly on the coal or is separated from it by 10& to a few inches of gray shale. The coal has been mined under both shale and sandstone roofs.

Strata between the Colchester (#2) coal and the limestone bands (Marietta limestone, etc.)

The roof of the Colchester (#2) coal is a gray soapy shale or soapstone, which often contains remains of plants in the beds 1-2' above the coal. This shale varies in thickness from 18-20' to 45'. In adjacent quadrangles this shale is entirely absent and the black fissile shale or "slate" above rests directly on the coal in some exposures, but this relation is not present in the Havana quadrangle. The shale has no horizons of lenticular calcareous concretions differing from the Purington shale in this respect. It is also distinguished from other thick shales in this area by a characteristic spheroidal weathering.

A typical exposure of this shale is in a high cut bank on the south side of a creek north of the middle of the west line of sec. 4, T.5 N. R.3 E, (Lewistown) (Photo)

4.	Limestone, gray, fossiliferous	8"-1'
3.	Shale, gray, with spheroidal weathering and fossil plants (cordaites, ferns, etc.) in lower 2'	42-45'
2.	Coal, Colchester (#2)	28 + appr.
1.	Fire clay, dark to light gray (Pottsville)	2'

The shale #3 of the above section has a maximum thickness here. The interval between the coal and the calcareous beds above is somewhat less in the eastern part of the quadrangle. The following exposure on the gullied north slope of a west fork of Big Sister Creek in the S.W.¼, N.W.¼, sec. 21, T.5 N, R.4 E, (Liverpool) is typical of the succession in the eastern part of the quadrangle.

10.	Shale, gray		3-4'
9.	Limestone, gray, fossiliferous, with Marginifera muricata, etc.		1'
8.	Shale, dark gray, fossiliferous		2'
7.	Limestone, black, platy, concretionary in dark sandy shale, (fossiliferous)		8"-1'
6.	Sandstone, light gray, calcareous cement with marine fossils, Marginifera muricata, etc.		2'
5.	Shale, gray, with spheroidal weathering		24'
4.	Coal, Colchester #2 blossom	Pottsville	2'6" appr.
3.	Underclay, light gray	Pottsville	2'6"
2.	Sandstone, massive, light ledge forming	Pottsville	1'6"
1.	Sandstone, soft, thin bedded, grading down into shale, gray		8'

The calcareous zone 20-45' above the Colchester (#2) coal.

Above the roof shale of #2 coal in all exposures except those where the Vergennes sandstone unconformity cuts out these beds, there is a succession of carbonaceous and calcareous shales, concretion layers, and thin limestones, including several strata characterized by special faunas which form excellent horizon markers over wide areas. ~~which~~ Some of the elements of this sequence of shale and limestone may be traced into the Manito, Canton, Avon, Vermont, Galesburg, Monmouth, and Alexis quadrangles as well as through much of the northern part of the Havana quadrangle.

Above the spheroidal weathering roof shale there is normally (1) a sandy shale or sandstone with wave or wash marks (2) a black, fissile "pimply" carbonaceous shale, with large niggerheads which are non-fossiliferous or sparingly fossiliferous, (3) a dark shale with lenticular calcareous concretions, sparingly fossiliferous, (4) a gray limestone, sometimes septarian, 6"-2'6" thick with abundant Marginifera mucicata and other fossils, and usually a layer of cone-in-cone on the upper surface, (5) a dark gray to black layer with lenses of fossiliferous limestone in the lower part a ½ inch zone of white weathering Chonetes mesolobus shells, and abundant impressions of Lingula and Aviculopecten in the upper part, (6) a thin dark gray brown weathering ferruginous limestone with many fossils, especially Ambocoelia planoconvexa and Productus cora, (7) a gray shale, slightly fossiliferous, with 2 or 3 levels of discontinuous flattened oval calcareous concretions, which are slightly fossiliferous, and, (8) a two inch band of concretionary limestone, containing numerous fossils, especially gastropods. Above the last bed occurs the shale which is called the Purington shale. There are other elements which appear in the section in some areas, and certain of the elements, notably (2) are not persistent in all parts of the quadrangle.

This sequence of beds is well exposed in the ravine south of the north section line road in the N.W.¼, sec. 17, T.4 N, R.4 E, (Liverpool)

+

20.	Shale, gray, with polygonal fracture (Photo) in upper portion and rectangular fracture in lower 5-10' containing several bands of flattened oval ironstained calcareous concretions, especially in the lower 10' (Purington)	50' ext.
19.	Shale, dark gray, no fossils seen	1½"
18.	Clod, gray, somewhat fossiliferous	1½"
17.	Calcareous and ferruginous concretion band, persistent with scattered pyritic fossils	4"
16.	Shale, bluish gray, with four or five persistent layers of calcareous and ferruginous concretions, sparingly fossiliferous	2'7"

15.	Limestone, dark gray, brown weathering, very fossiliferous Amboecelia, etc.	3"
14.	Shale, black, very thin bedded, soft, weathering reddish brown on exposed surfaces with Aviculopecten rectilaterarius, Lingula umbonata, etc.	1'3"
13.	Shale, dark gray, slightly more sandy and thicker bedded than shale above. Fossils weathering white. A nearly solid band of Chonetes mesolobus, some Derbya crassa and other species 6" from top.	1'9"
12.	Shale, black, or clod, with Marginifera muricata, etc.	3"
11.	Limestone, light gray, yellowish or buff weathering, cone-in-cone on upper surface, sparingly fossiliferous (gray limestone)	8"
10.	Limestone, gray, brownish, weathering, Marginifera muricata etc.	4"
9.	Shale, dark gray	10"
8.	Limestone, shaly, dark gray, slightly fossiliferous	2"
7.	Shale, dark	2"
6.	Limestone, shaly, dark fossiliferous	2"
5.	Shale, dark	7"
4.	Shale, light bluish gray	1'4"
3.	Limestone, dark gray, fossiliferous with Spirifer cameratus and bryozoa locally developed directly above black slate in upper portion of cut	4"
2.	Shale, black, fissile, papery, very pimply on upper surface containing large niggerheads 2-3' in diameter. Niggerheads being about 1'6" from top.	3'
1.	Shale, blue gray, roof shale of #2 coal.	2'

Large masses of apparently brecciated limestone containing niggerheads septarian fragments, and masses of "pimply" slate, extend from black slate up through shale zones to gray limestone, Maximum diameter 10-12', maximum thickness 4-5'.

One or two miles south of this locality the black fissile shale and niggerheads (#2 of the above section) disappear and there is found a massive hard limestone with a different fauna than any of the above members. This is apparently a development of one of the thin limestone bands in the above section (#3,6, or 8) as in one exposure it occurs above the black slate with niggerheads and below the gray limestone.

Two cut bank exposures in the N.E.¼ N.E.¼ sec. 17, T. 5 N. R 4 E. (Liverpool) show the following succession:

10.	Shale, gray with calcareous concretions (Purington)	50'
9.	Limestone, dark gray, brown weathering, fossiliferous	3"
8.	Shale, black, with Aviculopecten, etc. c~~oncretions~~.	2'3"
7.	Limestone concretions, gray, septarian, with Marginifera muricata etc. in fossiliferous clod	4"
6.	Limestone, gray, fossiliferous	6"
5.	Shale, black, fossiliferous, with 2 fossiliferous concretion layers near middle and others which are not in continuous layers Lower 1'6" thicker bedded and sandy	5'3"
4.	Limestone, gray dense, forming one massive ledge, fossiliferous	2'6"
3.	Shale, black fissile, hard, with large niggerheads lower beds "pimply"	2'6"
2.	Shale, black, soft	3"
1.	Shale, gray (Roof shale of #2 coal)	2'

The succession of the calcareous bands in the western part of the quadrangle is typically exposed in the ravine north of the Oak Grove School in the [redacted]. S.W.¼ S.E.¼, sec. 6, T.5 N, R.3 E, (Lewistown) where the following section was measured.

11.	Shale, gray, soft, with scattered flattened calcareous concretions weathering brown (Purington)	20'
10.	Limestone, gray, fossiliferous, concretionary (gastropod fauna)	2"
9.	Shale, dark gray, fossiliferous near top fauna similar to concretion bed above, with two discontinuous levels of calcareous concretions slightly fossiliferous	2'
8.	Limestone, dark gray, very fossiliferous, brown weathering	5"
7.	Shale, black, fossiliferous, with Aviculopecten in upper portion and Marginifera in lower portion. Chonetes band 6-8" from base.	1'6"
6.	Limestone, gray, fossiliferous, seems to be divided into two layers the lower of which is softer, and very dark gray to black.	8"
5.	Shale, gray, soft	8"
4.	Limestone, gray, crinoidal	1"
3.	Shale, gray, soft	3"
2.	Limestone concretions, slightly fossiliferous	1"
1.	Shale, dark gray, rather sandy in upper portion with wash or wave marks	8' exp.

It will be observed that the beds above the gray limestone (#6) in this section are very closely similar to those in the previous section, situated 8 and 11 miles east of this locality, but the lower part of the section beds 1-5 show more variation. The black pimply slate, with

Niggerheads and the massive limestone above it are not represented in this section. The crinoidal band (4) is a characteristic member of the section in the exposures along Big Creek and its tributaries and some exposures along Stuart Creek. It attains a thickness of 10"-1'. In some creeks in this vicinity this bed appears as a conglomerate composed of crinoid stems somewhat water worn, limestone fragments, and black nodules of phosphate. It may be that the crinoidal band is conglomeratic in all cases, although this is not always evident. Another variation in the succession of the calcareous bands is the development of a massive hard black limestone, containing numerous pelecypods and gastropods and some species of goniatites (Gen. and sp. undet.). The relations of this limestone to the gray limestone are exposed in one outcrop, where it is 1' below the gray limestone. The thickness of this black limestone ranges from 3" to 1' in its exposures, all of which are in sections 35 and 36, T. 6 N. R. 2 E. (Cass). This black limestone resembles lithologically and faunally the limestone exposed between Marietta and Marietta station 8-10 miles west of here, to which Savage has applied the name Marietta limestone, and the limestone above the black slate and niggerheads over #2 coal exposed in Mill Creek, Schuyler Co., in the Beardstown quadrangle, to which the name "flinty" limestone has been applied by Dr. Culver and Mr. Searight. The black limestone here attains a thickness of 8-10'. It is probably that the exposures along Stuart Creek mentioned above are situated near the eastern border of the main basin in which this limestone was deposited. Bpth faunally and lithologically it bears little or no resemblance to the "gray" limestone above.

Paleontology of the limestone bands.

Fossils were collected from the following members of the succession described above:

Sandy shale at top of roof shale (Marginifera muricata)
Black fissile shale (Slate) (Lingula)
Niggerheads (Very sparingly fossiliferous)
Massive limestone between gray limestone and black slate
(near Buckheart Creek) and along Illinois River bluffs (Bryozoa-
Spiriferina kentyckyensis, Spiriferina cameratus, Composita
Argentea etc.
Black limestone near Stuart Creek
Cardiomorpha missouriensis
Goniatite, etc., etc.,
Gray limestone (Septarian)
Derbya crassa
Marginifera muricata
Squamularia perplexa
Spirifer cameratus
Composita argentea
Chonetes mesolobus
Acanthopecten carboniferous
Leda meekana
Yoldia knoxensis? or Oweni?
Schizodus rossicus?
Sphaerodoma brevis
" primigenia
" fusiformis
Aclisina robusta
Phanerotrema grayvillensis
Bucanopsis meekana
Euphemus carbonarius
Patellostium montfortianum
Meekospira nitidula
" peracuta
Pharkidonotus percarinatus
Pseudorthoceras knoxense
Chonetes verneuiliana
Aviculopecten sp.?
Entolium aviculatum
Lima retifera
Astartella vera
Nuculopsis ventricosa
Cardiomorpha missouriensis
Lophophyllum profundum
Rhombopora lepidodendroidea
Other bryozoa
Foraminifera 2-3 species
Metacoceras sp.?
Crinoid stems
Trepospira sphaerulata?
etc. etc.

Clod (weathered limestone concretions over gray limestone, with fossils weathered out. Fauna similar to above list also:

Marginifera splendens
Pugnax osagensis
Pustula nebraskensis
Schizostoma catilloides
Trepospira depressa
Pleurotomaria sp.?
Edmondia gibbosa?
Fish spine
Nucula anodontoides?
Eupachycrinus tuberculatus
etc.

Crinoidal band below gray limestone

crinoid stems

Bryozoa, etc.

Black shale above gray limestone
Marginifera muricata etc.

Chonetes mesolobus band (White fossils)

Chonetes mesolobus   Leda meekana, etc.

Black soft shale below brown limestone

Aviculopecten rectilaterarius   Lingula umbonata
Spirorbis anthracosia, etc.

Pelecypod limestone below brown limestone

Large varied pelecypod fauna and scaphopod?

Brown limestone

Lingula umbonata
Productus cora
Spirifer cameratus
Amboecoelia planoconvexa
Cardiomorpha missouriensis
Leda meekana
Nucula parva
Astartella vera
Schizodus sp.?
Pleurophorus sp.?
Patellostium montfortianum
Sphaerodoma primigenia
Large nautilid Gen. and sp.?
Marginifera muricata

Gray shale 2' above brown limestone

Pelecypod and gastropod fauna

2" concretionary limestone at base of Purington shale

Chiefly gastropod fauna.

The above lists are only based on incomplete records of field determinations of the commoner forms, based on check lists made at time of collections. The total fauna collected in the 15 members of the section from which collections were made is probably over 100 species.

Purington Shale.

Above the 2" limestone concretion band 3' ± above the brown limestone there is a gray soft soapy shale, containing many discontinuous levels of flattened oval ironstained calcareous concretions 10"x5"x4" in average size. Marine fossils are sparingly found in the lower concretion layers of this shale. The fracture of the shale in the lower 10' is usually rectangular and in the upper portion it is usually

~~poloony~~

polygonal. The thickness of the shale ranges from 35-50' where it is not cut out by the Vergennes sandstone. It is correlated with the thick shale which is quarried in the pits of the Purington Paving Brick Company, East Galesburg, named by Mr. Poor, the Purington shale. In a cut bank on the east side of the east branch of Cripple Creek near the center of the south line of the S.E.$\frac{1}{4}$, sec. 24, T. 6 N, R. 3 E, (Putman) in a slightly sandy shale which was correlated with the upper rather sandy phase of the Purington shale, a large collection of well preserved fossil plants was obtained. Elsewhere no fossil plants were found in this shale.

Pleasantview or Vergennes sandstone.

The upper part of the Purington shale is normally sandy and in some exposures grades up into a sandstone without apparent unconformity. This is especially true south and southeast of Cuba. Elsewhere in the quadrangle, a sandstone which appears to be similar in lithologic character to that following the Purington shale in normal sequence truncates the middle or lower beds of the Purington shale, rests on or cuts out the calcareous bands below the Purington shale, and may truncate or cut out entirely the roof shales of the #2 coal. Over rather wide areas south of Spoon River this sandstone rests directly on the Colchester (#2) coal or is separated from it by 15' or less of the roof shale. The Colchester (#2) coal is in some places slightly truncated by this sandstone but is not known to be cut out by it at any place in the Havana Quadrangle. The sandstone, or succession of sandstone and sandy shales, is correlated with the massive crossbedded sandstone which is excellently exposed in Mill Creek, Schuyler county, in the Beardstown quadrangle, to which Mr. Searight has applied the name Pleasantview sandstone, from the nearby village of Pleasantview. Sandstone of similar stratigraphic positions in neighboring quadrangles has been correlated with the Vergennes sandstone of southern Illinois. The relations between this sandstone and the underlying beds strongly suggests an erosional unconformity in which 60-80' of sediment were eroded where the sandstone rests directly on the Colchester (#2) coal. It appears likely that channels cut during pre-Vergennes time crossing the northern part of the quadrangle were entirely or partially filled with sediment at this time. It is impossible to state whether the Purington shale was ever deposited in the southern half of the quadrangle, but if it was deposited there it was entirely eroded before the Vergennes sandstone was deposited. The limestone bands also, are exposed only in the northern half of the quadrangle. In certain locations the Purington shale, limestone bands are cut out within short distances, 1/8 to ¼ mile.

The basal beds of the Vergennes are frequently conglomeratic in character. The pebbles consist of round or subround dark gray limestone concretions, containing a few marine fossils. These may have been derived from some strata of the limestone bands where the Vergennes rests on older strata. A few fragments of the brown fossiliferous limestone, apparently from the Vergennes sandstone were observed at one locality. The lower 3 or 4 feet also usually contain numerous impressions of Stigmaria, Lepidodendra, Cordaites, and Calamites, some of which represent large logs of probable drift material. Above the basal 3 or 4 feet pebbles and large wood fragments are usually absent, but carbonaceous streaks or traces are seen in all parts of the Vergennes.

The Vergennes sandstone is normally a thin bedded soft micaceous shaly sandstone or sandy shale, cut sharply by lenticular masses of harder sandstone. It is usually rather strongly crossbedded and foreset beds often dip 8-12°. No persistent direction of dip of the foreset beds was observed except within ¼ mile or a smaller area. The upper beds frequently contain large limestone concretions 6-12' in diameter and 2-6' in thickness. These are flattened oval in shape and appear to consist of sandstone locally well cemented by calcite. Ripple marks are common in the more massive beds of the Vergennes. The sandstone is usually rather strongly ferruginous and fresh fragments may contain undecomposed grains of iron silicate minerals such as amphibole and pyroxene. In several places the finer micaceous beds of the Vergennes appear to be truncated sharply by more massive and more sandy beds, suggesting the possibility of some cessation of deposition and ~~possible~~ erosion within Vergennes time. In one outcrop the basal beds of the more massive sandstone are somewhat conglomeratic while the beds below are finer textured, more shaly, and do not appear to contain any pebbles. Thin lenticular masses of coal are occasionally observed in the Vergennes and along the Illinois River bluffs in the NW.¼ NE.¼ sec. 29, T 5 N, R 4 E, (Liverpool) a 6 foot coal bed locally present 6' above the gray limestone above #2 coal appears to be a lenticular coal bed in the Vergennes as it appears to thin within 50' to 3-4" and to lie between sandstone beds. There is no fire clay apparent below this bed and it may be an accumulation of transported vegetable material, rather than an in situ accumulation. At one locality in sec. 20, T 5 N, R 4E, (Liverpool) the upper surface of the Vergennes sandstone is a layer of light gray sandstone with numerous well preserved plant impressions from which a collection was made.

Field evidence suggests that locally the Vergennes sandstone did not fill the valleys of pre-Vergennes erosion and that the #5 coal and associated strata are not in all places parallel with the #2 coal.

In exposures along Cripple Creek in the SE.¼, sec. 24, there appears to be no sandstone between the #5 coal and the Purington shale, suggesting that in certain places no sandstone may have been deposited at this time.

Strata between the Vergennes sandstone and the Springfield (#5) coal.

The strata above the Vergennes sandstone include a shale, a coal bed, locally present, a nodular limestone, a dark shale with niggerheads, and fire clay with septarian concretions and a thick coal bed (#5). Along the ravine in the S.E.¼, S.E.¼, sec. 17, T.6 N., R.4 E., (Bushheart) and extending south into section 21 the section from 24 feet above the #5 coal to the Vergennes sandstone is well exposed. The section is as follows:

22.	Shale, gray, many small ironstone concretions	Canton Shale	10'
21.	Shale, black, usually soft, in a few places nearly fissile.	Canton Shale	1'
20.	Concretions, blue gray limestone, fossils rare more nearly a solid band here than usual	Canton Shale	6-10"
19.	Shale, soft, black	Canton Shale	1'
18.	Clod, hard, sparingly fossiliferous	Canton Shale	1"
17.	Shale, soft, black	Canton Shale	1'
16.	Shale, soft, gray	Canton Shale	6'
15.	Limestone, gray, fossiliferous (cap rock)		1'4"
14.	Shale, soft gray, grades down into		8"
13.	Shale, soft black		1'
12.	Shale, fissile, black, occasional pyritic niggerheads		1'
11.	Earthy layer		1"
10.	Coal, Springfield #5		5'4"
9.	Fire clay, containing septarian concretions 1' in diameter, not very abundant		4'
8.	Shale, gray		5'
7.	Clay, light gray, containing large smooth black niggerheads, non-fossiliferous		6"
6.	Shale, black		6"
5.	Soft coally layer (Horizon of lower coal)		3"
4.	Fire clay		3'
3.	Limestone, very irregular bedded, somewhat nodular, blue gray, brown weathering		2-3'
2.	Fire clay and shale, gray		4' plus
1.	Sandstone, thin bedded, brownish gray (Vergennes)		6'

A variation in this section is the development of a coal bed 3-4' thick 10-20' below the #5 coal at the horizon of #5 in the above section. This coal bed and associated strata are best exposed in a ravine in the N.W.¼, S.E.¼, sec. 35, T.6 N., R.3 E., (Putman) about ½ mile west of the Morningstar School.

14.	Limestone, gray, massive, fossiliferous	1'5"
13.	Shale, gray, soft	1'5"
12.	Shale, black, soft	9"
11.	Shale, black, fissile, hard	8"
10.	Coal (Springfield #5)	5' appr.
9.	Fire clay, light, with calcareous septarian concretions	2'
8.	Covered	3-5'
7.	Shale, gray, sandy	3'
6.	Shale, soft black	6-8"
5.	Lenticular hard black limestone with traces of fossilized wood	1'
4.	Shale, fire clay like, not bedded, gray , containing many large round and oval concretions, gray limestone, which cut through many colored bands of shale and in places are deep down in the coal.	1'
3.	Coal, faulted frequently, rises and falls sharply over short distances, horsebacks. Fault surfaces slickensided.	2'
2.	Shale, blue gray, very sandy, containing large septarian concretions, grades down into	5'x6'
1.	Sandstone, thin bedded, dark colored from abundant carbonaceous partings (Vergennes)	15'

The coal bed (#3 in this section) is locally developed in a number of ravines on the southeast side of Big Creek east and west of this section and a coal bed about 37' below #5 coal which may be equivalent to this is exposed along Slug Run in sec. 27, T. 6 N., R. 3 E., (Putman). Because this coal underlies a dark shale containing large nonfossiliferous niggerheads it is believed to be equivalent to a coaly horizon represented by #5 in the section preceding the one above. In exposures where a thick coal is developed a typical fire clay has not been found below this coal bed, but where the coal horizon is represented by a few inches of coal or carbonaceous shale 2-3' of fire clay with septarian concretions have been observed at this position. This coal also appears to exhibit ~~no one~~ more pronounced benching than does the #5 coal above. This suggests the possibility of a drifted origin fot the thicker accumulations of coal at this horizon and perhaps an in situ origin for the thinner

accumulations, i.e. providing the correlation is correct. Drillers report a thin coal or coaly shale at this position in nearly all drillings. The Illinois coals were numbered in Fulton County by Worthen, and these numbers have been subsequently applied to coal beds in other parts of the state which could be correlated with those in Fulton County. It appears that the nos. 4 and 5 were applied to the same coal bed in different localities in Fulton County and the coal bed was subsequently called #5. The #3 was applied to a coal bed directly underlying black fissile shale 30' plus above #2 and thus it corresponds to a position in the section in the Havana quadrangle, although no coal is known to be present at this hosizon. As the coal discussed above, although thin, appears to represent
(in this area between #2 and #5, and not at the horizon ~~of~~
a fairly widespread coal horizon, and as it is the only coal horizon of Worthen's #3 coal, the writer proposes to call this bed coal #4 or the Bryant coal, as the best exposures are 3 to 4 miles west of Bryant. The type exposure may be considered that in the last described section.

An interesting variation in the succession of beds between the #5 coal and the limestone bands above the #2 coal is seen in exposures along the ravine in the S.W.$\frac{1}{4}$, N.W.$\frac{1}{4}$, sec. 20, T.5 N, R.4 E. (Liverpool)

A generalized section along this ravine is as follows:

Height above base of section			
43'8"	19.	Limestone cap rock, gray, fossiliferous, not exposed but a few fragments visible around a mine dump.	1-2'
41'8"	18.	Shale, black, fissile, with pyritic fossiliferous niggerheads	2'
39'8"	17.	Coal, probably Springfield #5 marked here by numerous benches or clay bands, which is not normal in this coal.	5'-5'6"
34'2"	16.	Fire clay, light	2'5"
31'2"	15.	Coal, harder than coal above	3'2"
28'	14.	Limonitic concretion layer	3"
27'9"	13.	Gray, sandy shale, containing well preserved ferns and other fossil plants	2-3"
27'6"	12.	Shale, black, to blue gray, fissile	8"-1'
26'10"	11.	Sandstone, hard, massive, fresh surface, blue gray mottled with ironstained micaceous, cross bedded, apparently unconformable on beds below (Vergennes?)	3'
23'10"	10.	Shale, dark blue gray, oxidizing to dark brown, contains Cordaites, etc., fissile, probably a shaly basal phase of Vergennes sandstone.	10'

13'10"	9.	Limestone, brown, fossiliferous, seen in float on cut bank on south side of stream, but not in place.	3-5"
13'5"	8.	Shale, dark, including fossiliferous clod	1'10"
11'7"	7.	Limestone, gray, buff weathering, fossiliferous	5"
11'2"	6.	Shale, gray, weathering brownish	2'
9'2"	5.	Conglomerate, hard, carbonaceous, weathering brownish	5"
8'9"	4.	Limestone, blue gray, massive, ledges forming, laminated, fossiliferous, sandy, micaceous, with fauna of small individuals, surface covered with irregular branching tubules resembling worm tubes, weathering brown, Marginifera, Chonetes, Bryozoa, etc.	1'3"
7'6"	3.	Shale, or shaly sandstone, micaceous blue gray	2'6"
5'	2.	Concretions or niggerheads, large flattened oval	1'6"
3'6"	1.	Shale, blue gray (Roof shale of #2 coal)	3'6" exp.

The base of this section is probably 16-20' above #2 coal. It is thus apparent that the interval between the #2 and #5 coals if #17 is correctly interpreted as the #5 coal ~~#2 and #5 coals~~ is here about 60' instead of 100-125' the normal interval. This apparently indicates that the Purington shale had been eroded from this area, forming a basin which was only partially filled by Vergennes deposition, as the Vergennes sandstone is here much thinner than it normally is where the Purington shale is thin or absent. Thus the two coals, nos. 15 and 17, here may have been formed in a depression in the post-Vergennes surface. Altho this is the most striking instance there are several other sections which indicate considerable variation in the interval, and thus lack of parallelism between nos. 2 and 5 coals.

Springfield #5 coal.

This coal is widespread in the northern third of the quadrangle, except the southwest portion of the northern third. It is absent from all other parts of the quadrangle in outcrop although it may underlie a small portion of the highlands of the extreme southwest quarter of the quadrangle, as it is known at Summum about one mile west of the quadrangle. This coal bed, like #2 appears to have been deposited over the entire area of this quadrangle, as it is present wherever its horizon is exposed. It ranges in thickness from 4'6" to 5'6" and averages 4'10"-5' It is characterized by the absence of bedded impurities such as clay bands and in this respect differs notably from the #6 coal. The chief impurities are pyrite in scattered concretions or in discontinuous lenses and clay in the form of horse backs. In some mines these are a cause of much difficulty in mining the coal (See photo.) Coal balls, or limestone and pyritic concretions containing well preserved organic remains, ~~are~~ were observed at one locality. The floor of the coal is a white fire clay 2-4' thick containing large septarian calcareous concretions usually 1' below the coal. The roof consists of black fissile shale (miners' slate.) with scattered calcareous and pyritic concretions or niggerheads. This coal bed is mined throughout the area of its exposures by strip mines and drift and shaft mines, and forms the chief source of mineral wealth of the area.

Strata between the Springfield (#5) coal and the Cuba sandstone.

The normal succession of beds above the #5 coal are well exposed in the cuts in the strip mine operated by the United Electric Coal Company in secs. 27.28,29,33,34, T. 6 N., R. 3 E., (Putman). The following exposure was measured in an abandoned north cut of the mine in the S.W.¼, N.W.¼, sec. 28 T. 6 N., R. 3 E. (Putman).

13.	Shale, gray, soft, soapy, with small iron stained calcareous concretions, (Canton shale)		7'
12.	Clod, (calcareous clay, not distinctly bedded)		1½"
11.	Limestone, blue gray, concretions, containing Productus cora, etc. (not cintinuous)		7"
10.	Shale, gray, soft, with concretions (Canton)		7'6"
9.	"Clod", dark blue gray, very fossiliferous (see below)		1'3"
8.	Limestone, gray, one massive band (cap rock)		9"
7.	Covered by slump, including gray shale, black soft shale and black fissile shale with niggerheads		2'6"
6.	Coal	Springfield #5 coal	9"
5.	Pyrite band, not continuous		1"
4.	Coal		1'5"
3.	Pyrite band, not continuous		1"
2.	Coal		2'2"
1.	Fire clay, gray		6" ex.

The variations in the section are chiefly noticeable in the limestone cap rock, #8 of the above section and the clod above this. In some exposures the cap rock is absent and soft gray shale (Canton) rests directly on the black fissile shale over the coal. Within short distances the cap rock appears and may thicken to 12-15". The maximum thickness for this bed observed is 24". Where the cap rock is absent the gray limestone concretion band (#11 above) may be only 2-3' above the black fissile shale. In some places the clod (#9 above) seems to form a compact bed of crinoidal limestone. The Canton shale averages 20-27' thick and grades up into a sandy micaceous shale, 5' thick, approximately, and a sandstone, the Cuba sandstone.

In the vicinity of Cuba the interval between the Herrin (#6) coal and the Springfield (#5) coal is unusually small and a part of the strata normally lying between these coals is absent. The strata between the coals in this vicinity are well exposed in a ravine just south of the road near the center of the north line of sec. 30, T. 6 N, R. 3 E, (Putman). The top of this section is 6' below the base of the #6 coal.

5.	Limestone, brownish, nodular, sublithographic, with a few poorly preserved fossils. Appears to be embedded in a blue clay.	11"
4.	Sandstone, gray, micaceous, thin bedded	7'
3.	Shale, sandy, blue	3'6"
2.	Limestone, gray, fossil, weathers buff except near top where it is gray, and resembles a clod (cap rock)	2'
1.	Shale, gray, sandy	6"

The base of this exposure is about 2' above the top of the #5 coal. It is apparent that the Canton shale normally 20-30' thick is here absent, altho the sandy beds above (#3 and 4) do not appear to be unconformable on the beds below. This sandstone is probably the Cuba sandstone.

Paleontology

The beds above the #5 coal include several fossiliferous horizons. Collections were made from the black fissile shale forming the roof of the coal, the niggerheads, in this shale, the limestone cap rock, the "clod" above the limestone, the limestone concretions about 7' above the cap rock and the "clod" or clay in which the concretions are embedded.

Black fissile shale.

The most characteristic forms in this shale are Orbiculoidea, Missouriensis, Lingula umbonata, Aviculopecten rectilaterarius, Petrodus occidentalis, Marginifer muricata, and spines of fish.

Other species which have been found in the balck shale include:

Lima retifera
Pygnax rockymontana
Solenomya trapezoides
Clinopistha radiata laevis
etc. etc.

Niggerheads

The most characteristic niggerhead species are Orbiculoidea, Missouriensis, Composita argentea, Solenomya trapezoides, Clinopistha radiata laevis, Productus cora, and Marginifera muricata. Other niggerhead species include:

Edmondia aspenwallensis
Chonetes mesolobus
Schizodus rossicus
Squamularia perplexa
Solenomya radiata
Entolium aviculatum
Productus nebraskensis
Placunopsis recticardinalis
Coloceras globulare?
Meekospira nitidula
Pleurophorus occidentalis
" oblongus
" tropidophorus
Chonetes verneuiliana
Nucula parva
Petrodus occidentalis
Fish spine
Phaneratrema grayvillense
Trepospira depressa
Lima retifera
Pseudorthoceras knoxense
Schizodus alpinus
Cardiomorpha missouriensis
Astartella vera
Derbya crassa

Limestone cap rock

The most characteristic forms in this bed are Chonetes mesolobus euampygus, Marginifera splendens, and Productus cora. In the strip mines on the upper surface of the cap rock there are numerous very large nautilids 4-8" in diameter representing several species and perhaps genera. Other species include:

Marginifera muricata	Rhynchopora illinoisensis
Derbya crassa	Productus nebraskensis
Chonetes verneuiliana	" semireticulatus
" granulifer	Spirifer cameratus
Meekella striatacostata	Crinoid stems.

Clod over #5 coal

This bed usually consists mainly of fossils, among which the following are characteristic: Hustedia mormoni, Composita argentea, Chonetes granulifer, Chonetes verneuiliana, Spiriferina kentuckyensis, Eupachycrinus tuberculatus, and crinoid stems. Other species include :

Chonetes mesolobus	Phanerotrema grayvillense
" euampygus	Ambocoelia planoconvexa
Crinoid plates (Zeacrinus?)	Marginifera muricata
Lophophyllum profundum	" splendens
Pugnax osagensis	Rhombopora lepidodendroidea
Spirifer cameratus	Bryozoa, other forms
Patellostium montfortiannum	Allorisma terminale

Productus cora

Limestone concretions.

Productus cora is by far the most abundant form in this bed. Other species include Productus semireticulatus and Pustula punctata.

Cuba sandstone.

Above the Canton shale, as mentioned above there is normally exposed a sandy shale the upper portion of which has a distinctly board-like lamination. This grades up into a sandstone with no apparent break. In a few exposures this sandstone measures 20-30'. This sandstone includes some millstone concretions similar to those in the Vergennes sandstone. Certain beds are distinctly ripple marked but cross bedding is rather uncommon.

As mentioned. above, in some areas, especially in the vicinity of Cuba this sandstone appears to cut out some of the Canton shale and other beds above the #5 coal, and generally does not exhibit unconformable relations with the beds below. In this respect the relations of the Cuba sandstone to the Canton shale and the #5 succession very closely resemble the relations of the Vergennes sandstone to the Purington shale. It appears that in each case the deposition of the shale was followed by an erosional break, in which valleys or lowland of some size were produced, ~~upon which~~ the sands next deposited rests unconformably on the underlying beds. On the uneroded uplands, the transition from the shaly to the sandy beds appears gradational, rather than unconformable.

The Herrin (#6) coal and associated strata.

The #6 coal is normally 6-8' above the top of the Cuba sandstone, although in the vicinity of Cuba where the interval between the Herrin (#6) and the Springfield (#5) coal is small, the Cuba sandstone may be absent. The #6 coal is exposed only in the vicinity of Cuba in sections 19 and 20, T. 6 N, R. 3 E, (Putman) and in two or three small outcrops west of Buckheart Creek in sec. 25, T. 6 N, R. 4 E. (Buckheart). The Herrin (#6) coal differs from the Springfield (#5) coal in the presence of several clay bands giving a decidedly benched character to the coal. The "blue band," a band of dark clay and pyrite, normally near the base of the #6 coal, was not observed. The coal is overlain by dark soft shale, which does not resemble the fissile shale over the #5 coal and by a massive limestone in which the fusulinid Girtyina (Fusulinella) ventricosa is most characteristic. The beds above #6 coal belong to the McLeansboro formation No younger Pennsylvanian strata than the cap rock of the #6 coal are exposed in the Havana quadrangle.

The following section measured in an abandoned stripping near the south end of Cuba and a caved in entrance over workings in the #5 coal 200 feet west may be considered typical of this interval

N.W. 1/4, S.W. 1/4, sec. 20, T.6 N, R.3 E (Putman)

29.	Limestone, gray, with Girtyina ventricosa (cap rock)		8" (full thickness 1'9½")
28.	Shale, brownish		7"
27.	Shale, black, soft, weathered		1'4"
26.	Coal, weathered	Herrin (#6) Coal	1"
25.	Concretions, hard, black, pyritic, with some calcite bands, absent in places		4"
24.	Coal, including concretions above		1'2"
23.	Clay, gray		¼"
22.	Coal		10¾"
21.	Clay, blue gray		2½"
20.	Coal		1¾"
19.	Charcoal parting variable, not continuous		1/8"
18.	Coal		1"
17.	Charcoal parting variable not continuous		½"
16.	Coal		2¼"
15.	Concretions, pyrite, blackish		¾-¼"
14.	Coal		6".
13.	Clay, gray		1"
12.	Coal		2½"
11.	Concretions, pyrite		1"-0
10.	Coal		8½"
9.	Clay, gray		1"
8.	Coal		11"
	Total bed		5' 5 7/8"
	Total impurities	11 1/8" in 9 bands	
7.	Shale, soft, gray, bedded		1'4"
6.	Shale, black, laminated, carbonaceous with coal fragments		4"
5.	Shale, light gray, bedded		5"
4.	Clay, soft gray, not bedded, upper foot dark gray containing regular level of large gray, sublithographic limestone concretions with a few fossils vary from 1-3' in thickness, about 5' from top of clay.		8'
3.	Clay, dark gray to light gray, soft		4'1"
2.	Shale, dark gray, soft		2"
1.	Shale, blue gray, with marine fossils, apparently "clod" above cap rock of #5 coal.		11"

Base of cave-in.

In this exposure ~~of~~ the base of the section is approximately on the cap rock of the #5 coal the interval between the cap rock and the base of the #6 coal is 16'3" including no sandstone. About 1½ miles north of Cuba in the Canton quadrangle, the interval between the #5 and #6 coals is about the same, but most of the interval between consists of the Cuba sandstone. The interval between coals 5 and 6 at the Buckheart Creek exposure is ~~situated~~ estimated at 50-60'.

Paleontology

The limestone cap rock of the #6 coal contains most abundantly Girtyina ventricosa ~~dns~~ and Squamuleria perplexa. Several other species were collected from this horizon. No higher Pennsylvanian strata than the cap rock of the #6 coal are exposed in the Havana quadrangle. Higher strata were probably deposited here and eroded before the Pleistocene as they are exposed only a few miles north of the quadrangle in the Canton quadrangle.

Pleistocene System.

The Pleistocene system is represented in the Havana quadrangle by glacial deposits of three glacial periods and glacial outwash of a fourth period, and soils, silts, loess, sands and gravels, of four interglacial periods. The Iowan glacial stage is the only Pleistocene stage which cannot be definitely associated with deposits in this area. The most complete Pleistocene succession in the quadrangle is along a ravine in the N.W.$\frac{1}{4}$, S.E.$\frac{1}{4}$, sec. 32, T.4 N, R.3 E.(Isabel) as follows: The beds from the Peorian to the leached Yarmouth gravels were measured in a sharp cut south side gully. The Yarmouth gravels and Kansan till along the main ravine, and the Nebraskan till and sand in a cut bank on the south side of the ravine. The lower part of the ravine is cut through a terrace of Wisconsin age, of which a section is given following the main ravine section:

Top of section 22' below upland plain.

11.	Loess, buff to gray, with reddish brown spots along joints and root canals, non-calcareous (Peorian)	3'4"
10.	Loess, gray, with some ferruginous concretions and a few calcareous kindchen, calcareous (Peorian)	7'6"
9.	Loess, reddish, noncalcareous, (Sangamon) Lower surface dips north, and contains carbonized wood in basal portion	3'3"
8.	Silts, pink and gray laminated, with pebble concentrate at top, slightly calcareous, probably only along local centers, thin and disappears to north, cut out by Sangamon loess	1'
7.	Till, brownish gray, leached (Illinoian)	2'9"
6.	Sand and gravel, leached	2'6"
5.	Till, reddish brown, slightly calcareous at top, more calcareous below (Illinoian)	~~2'9"~~ 1'6"

4. Till, gray, calcareous, Illinoian 15'
3. Sand, yellowish, non-calcareous, very fine, gravel concentrate at top (Yarmouth) 6-8"
2. Gravel, brownish, including some beds of course reddish sand, non-calcareous at mouth of tributary along main ravine about 100' west and upstream from mouth of tributary above sand and fine gravel is seen 1' gray silt or loess, calcareous. No fossils seen (Yarmouth) with carbonized wood fragments. Corresponds in altitude to fine yellow sand above. 15'6"
1. Till, gray, calcareous (Kansan) containing many large fragments of wood fairly well preserved, very much deformed by ice shove, showing sharp folds, more boulders than Illinoian till above, (pebble and boulder count made) contains numerous blocks of thoroughly oxidized and leached till (Nebraskan) and also many large blocks of blue gray calcareous silt with some poorly preserved (gastropods [Aftonian] Collections made of wood and gastropods. Many fragments of forest soil with ~~many~~ small fragments of carbonized wood bituminous odor. (photos of deformed till and wood in till.) 12'

High cut bank south side of ravine (2 photographs and sketch)

7. Soil and slump 2'
6. Till with slight concentrate of sand and gravel above till gray, calcareous (Kansan) rests on very irregular surface which dips to west 10' in 25'. 5'
5. Till, brownish gray, sharp break with till above, non-calcareous, large mass 2'6" thick projecting into sand below (Nebraskan) 1'6"
4. Sand, light buff, noncalcareous somewhat crossbedded, foreset beds dipping east, includes several lens-like masses of weathered coal. (Nebraskan) 5' appr.
3. Gravel, lenticular non calcareous (Nebraskan) 1'
2. Sand to base of cut (Nebraskan) 4'
1. Slight showing of till exposed by digging may be lenticular or may represent base of sand non-calcareous.

The terrace at the lower end of this ravine just west of Otter Creek shows the following section:

5. Soil 6"
4. Silt or loess, reddish brown, non-calcareous 6-10'
3. Silt, brownish gray, strongly calcareous, with numerous kindchen, and a few small pebbles, numerous pipe stem concretions of limonite, showing signs of lamination where freshly exposed, sparingly fossiliferous. Kindchen concentrated in definite bands emphasizing stratification. Shows slight alternation of fine grained buff sands and brownish gray clays, suggesting varve deposition. Line is concentrated at tops of the clay layers, 1" band of weathered coal in brownish clay near base of laminated material. 12'
2. Gravel, calcareous 1'
1. Sand, red, calcareous. 1'

The Nebraskan glacial stage is represented only in one other section in a ravine in the N.E.$\frac{1}{4}$, N.E.$\frac{1}{4}$, sec. 5, T.3 N. R.3 E. (Kerton) about $\frac{1}{2}$ mile south east of the ravine described above. The Aftonian deposits are only known in the included blocks of soil and silt in the Kansan drift in the ravine described above.

The section exposed in a cut bank on the north side of the ravine is as follows:

Two photographs and one sketch made here.

8.	Slump	3-4'
7.	Till, calcareous, Illinoian	12'6"
6.	Calcareous concentration in clay, whitish	1"
5.	Silt, Yarmouth, calcareous, bluish, dark blue gray, dark chocolate brown on weathered surface, smoothed upper surface, containing numerous ironstained concretions of irregular shape reaching diameter of 1'6". At east end of cut lenticular mass of gray brown non-calcareous till has been thrust into this silt dividing it into two arms (Photo). East of this the Yarmouth silt disappears in lower arm. Upper surface inclined steeply apparently west. Fossiliferous, containing gastropods and a few small pelecypods. Collection made.	6'
4.	Till, gray, noncalcareous, Kansan 1'6" below lower arm of Yarmouth, total including lenticular masses	6'6"
3.	Till, rusty, calcareous (Kansan)	6"
2.	Till, Kansan, gray, clacareous to stream level. In eastern part of cut just above stream level is seen a rolled ball with knob extending above main mass of brown oxidized but calcareous till, Nebraskan (Photo). At east end of cut lower surface of Kansan till rises and exposes	3'3"
1.	Sand, yellow brown, calcareous (Nebraskan?)	2'

Downstream about 200 yds. sands similar to these and in similar position overlie brownish calcareous till, probably Nebraskan. These two exposures represent, so far as the writer is aware, the first occurrences of Aftonian and Nebraskan deposits in Illinois, and they were examined carefully, to see if any other interpretation might be given for the succession, but the field evidence in each case supported the theory of an older drift sheet considerably contorted as a result of being overridden by two later ice sheets.

Kansan Glacial Deposits

The Kansan glacial deposits consist of till which is usually a dark blue gray in color, more strongly carbonaceous and calcareous than the Illinoian till above. In some exposures it appears contorted due to being overridden by the Illinoian ice. It is usually more compact than the Illinoian till, and contains more and larger boulders than the Illinoian till usually does. It is recognized by its position beneath Yarmouth interglacial deposits or by a weathered zone below the Illinoian till. Where the Kansan directly underlies Yarmouth silts it may or may not show a weathered zone.

A good exposure of Kansan till directly underlying Illinoian till is near the junction of three head forks of about 300 yards south of the center of sec. 16, T. 4 N, R. 3 E, (Isabel). Cut walls of the ravine here show:

3.	Till, dark blue gray, calcareous (Illinoian)	8-10'
2.	Till, brownish gray, polygonal fracture, clayey, leached, with few igneous and chert pebbles, nearly a gumbotil in texture (Kansan)	1'6"
1.	Till, reddish brown, along fractures, blue gray in centers of fragments bounded by fracture planes, non-calcareous, hard	2'6"

The above section was measured in the east fork about 110' above mouth. The other two forks show hard, reddish brown, non-calcareous Kansan till directly below dark gray calcareous Illinoian till, the "gumbotil" being absent.

Yarmouth Interglacial deposits

The Yarmouth interglacial deposits include silt, loess?, soil, sands and gravels. The Yarmouth deposits are nearly always present between the Illinoian and Kansan and in two or three widely separated localities the succession brownish silt, black soil or bituminous silt and greenish silt was observed. In several places these Yarmouth deposits rest directly on the Pennsylvanian strata. The upper surface of fossiliferous Yarmouth silts is usually calcareous, indicating a later Yarmouth age. Wood is rather common in the soils or bituminous silts and shells of gastropods and occasional pelecypods are found in the ~~xxxxxxx~~ bluish silt or loess.

The Yarmouth silts are much more compact than the Peorian or Sangamon due to contortion by the overriding Illinoian ice and in a few places are notably contorted. In the vicinity of Big Creek west of Bryant in many exposures a brown noncalcareous gravel or partly cemented conglomerate below Illinoian till appears to be a gravel concentrate of Yarmouth time, perhaps a stream gravel.

The most complete exposure of Yarmouth deposits is in a high cut bank on the east side of Big Sister Creek in the N.W.¼, N.W.¼, sec. 8, T.5 N, R.4 E.(Liverpool). The section measured here is as follows:

13.	Soil, black humus (A zone) recent	1'
12.	Gumbotil, (Illinoian) brownish gray, with non-calcareous dark brownish stains on fracture surfaces containing scattered quartz and chert pebbles, mostly small. Contains occasional igneous pebbles (B zone.)	8'
11.	Till, rusty brown, (Illinoian) along all fracture surfaces bluish in centers of larger masses, slightly calcareous, rusty or ferretto zone. (C zone)	1'8"
10.	Till, gray, calcareous (Illinoian)(D zone)	7'
9.	Sand, reddish or yellowish, calcareous (Illinoian outwash)	1'6"
8.	Silt, blue or fine sand, calcareous (Illinoian or Yarmouth)	1'4"
7.	Silt, dark bluish gray, carbonaceous, calcareous with numerous carbonized wood fragments (Late Yarmouth soil)	1'8"
6.	Silt, dark gray, brownish gray below, micaceous, calcareous contains concretions of limonite, sparingly fossiliferous	1'5"
5.	Sand, yellowish or reddish, fine grained in upper foot, coarser below, very slightly calcareous	6'
4.	Gravel, reddish brown, 2' in central part of cut thickening toward north end to 4' calcareous	4'
3.	Silt, blue gray to mouse gray, finely laminated with white rod-like markings as partings. In a few places not bedded. Few sandy layers, particularly near base. Shells of small gastropods abundant. Stands out like a layer of hard rock. Separated by a hard limonitic layer along the irregular, wavy contact with bed below. 5' at north end and 2'-2'6" at central portion of cut.	2-5'
2.	Sand reddish, calcareous, cross bedded, grading into gravel, partly cemented, irregular lower surface 5'.	
1.	Till, dark blue gray, Kansan, calcareous, bouldery, very irregular upper surface. Maximum exposure 5'.	

Beds 2-7 of the above section are all of Yarmouth age. This is the only exposure in which calcareous sands and gravels were found between two fossiliferous silts of Yarmouth age.

Another good exposure of the Yarmouth deposits is in a ravine along the bluffs of the Illinois River in the N.W.¼, S.E.¼, sec. 8, T. 3 N, R. 3 E, (Kerton) just north of the south line of the Havana quadrangle, a section measured here is as follows:

Top of section 33' below upland, interval being Peorian loess.

12.	Loess, Peorian - Sangamon	11'
11.	Gumbotil, Illinoian	1'9"
10.	Till, Illinoian calcareous	10'
9.	Sand, yellow, calcareous	1'6"
8.	Silt, blue gray, calcareous non-fossiliferous (Intra-Illinoian silt)	8'
7.	Covered	6'
6.	Loess, or silt, like #8	4'
5.	Till, calcareous, Illinoian	est.15'
4.	Silt, gray, calcareous. Not bedded, with pipe stem fossiliferous (Yarmouth)	5'8"
3.	Silt, dark gray, containing many fragments of carbonized wood, and some small gastropods. Shows some lamination like that in A zone of soil profile, carbonaceous, not generally calcareous, bituminous, odor (Yarmouth)	9"
2.	Silt, gray, interbedded with sand and gravel, calcareous fossiliferous (Yarmouth)	3'6"
1.	Bed rock (Pottsville)	

Beds 2-4 represent the Yarmouth here, and it will be noticed that no Kansan till is here present.

The Yarmouth deposits in the vicinity of Big Creek are typically exposed in a road cut near the middle of the west line of sec. 26, T. 6 N, R. 3 E, (Putman), where the following section was measured:

5.	Loess (Peorian)	12'
4.	Till, gray, Illinoian	37'
3.	Silt, gray, buff weathering, non-calcareous (Yarmouth)	1'6"-2'
2.	Gravel, brown cemented to conglomerate, deeply weathered at surface, consisting of concretions from Pennsylvanian, chert fragments, and occasional pre-Cambrian pebbles (Yarmouth)	7-8'
1.	Sandstone, Vergennes	16'6"

Although the brown conglomerate is present in numerous exposures in this vicinity it always rests directly upon the Pennsylvanian strata, no till being present below it. This may represent early Yarmouth stream gravels completely weathered before Illinoian glaciation.

Paleontology

Gastropod and pelecypod shells were collected from the Yarmouth deposits at several localities. These are being identified by Mr. F.C. Baker. Wood was also collected from the Yarmouth deposits at several places.

Illinoian Glacial Deposits.

The Illinoian glacial stage is represented by till, sand, gravel, and silt. The Illinoian till is the most widespread and youngest till in the Havana quadrangle. It is usually lighter gray in color than the Kansan till, and contains less numerous large boulders. In several parts of the quadrangle, rather extensive lenticular masses of sand and gravel are interbedded with the till. In the western part of the qudrangle, especially in the lower part of the drainage of Stuart Creek the gravels and sands may compose as large a part or even a larger part of the Illinoian section than the till. At several localities, especially in the southern portion of the quadrangle, a rather thick gray silt or loess-like silt lies between two beds of till both of which are calcareous in all sections which were observed. As no fossil gastropods or traces of plants were found in any exposures of these silts, there is no evidence that they are interglacial. Slight irregularity in the lower surface of the silt and a slight amount of oxidation of the till below these silts suggests that they were exposed to weathering and erosion for a brief time, completely freed from ice and later recovered. This points to a recession of the Illinoian glacier followed by a readvance over most of the area of the quadrangle. As no morainic hills are recognized in this region, the relations of these two stages of the Illinoian cannot be correlated as yet with surface moraines, although this relation seems general enough to justify an attempt at such correlation. In a few localities there are exposed finely laminated sands and silts which appear to represent outwash material from the Illinoian glacier. A high cut bank on the southside of a ravine near the center of the north line of the N.W.¼, sec. 13, T.5 N, R.3 E.(Bernadotte) shows well the occurrence of gravel and sand lenses in the Illinoian till (photo):

Top of cut 6' below level upland.

16.	Loess, buff, non-calcareous (Peorian)	6'
15.	Loess-like silt, reddish brown, with numerous carbonized plant traces (Sangamon?)	2'6"
14.	Gumbotil, (Illinoian) grayish brown, with pitted surfaces and blackish coatings of joint surfaces. Pebbles not numerous and principally chert and quartz	3'6"
13.	Till, yellowish brown, non-calcareous	4'6"
12.	Silt, buff, very slightly calcareous	1'6"
11.	Till, gray, sandy at top, Illinoian, strongly calcareous	5'
10.	Sand, yellowish, with 1' gravel band near base including fragments of calcareous till, strongly calcareous at top, slightly calcareous below	2'6"
9.	Sand, yellowish, almost entirely free from gravel Distinctly bedded coal concentrate at base of sand 1-2"	3'8"
8.	Gravel, slightly cemented, well assorted (calcareous)	6'
7.	Till, calcareous	48
6.	Gravel, calcareous, with some lenses of sand	10'6"
5.	Sand, white, well assorted, calcareous	2'
4.	Bleached zone, limonitic	6"
3.	Sand, reddish brown	3'
2.	Till, gray, calcareous with limestone pebbles, calcareous, lenticular, not persistent	3'
1.	Gravel, coarse, calcareous, to base of section	8'

In the above section beds 1-14 are all Illinoian in age, and the base of the Illinoian section is not exposed. Sand and gravel are exposed in many sections in this vicinity.

A cut bank on the south side of Seahorne branch in the S.W.¼, N.W.¼, sec. 5, T.3 N, R.3 E.(Kerton) show well the intraglacial Illinoian silt mentioned above. (Sketch and photograph).

The following section shows a representative development of this silt:

Till, reddish, non-calcareous, Illinoian	5'
Silt, pinkish gray, gumbo~~xxx~~-like, nonOcalcareous	2'9"
Silt, gray, somewhat laminated, calcareous. Irregular lower surface. Maximum thickness observed	9'
Till, gray, calcareous, Illinoian (In some exposures the upper 6"-2' of till below this silt are oxidized and leached)	11'
Silt, brownish gray, compact, calcareous, with upper surface smoothed by Illinoian glacier (Sparingly fossiliferous-Yarmouth)	2' exp.

In one exposure (See sketch) a slight concentrate of sand and gravel was observed at the base of the silt on reddish brown till. In another exposure on a ravine tributary to Otter Creek about ½ mile n.e. of the above section 6"-1' of well assorted gravels overlie the silt directly. Where the overlying till is calcareous the top of the silt is calcareous, showing that no leaching of the silt preceded the readvance of the Illinoian glacier. This silt is also well exposed on a cut bank on the south side of the North Branch of Otter Creek 3 miles northwest of the above sections.

The best exposure of the laminated sands and silts or varves is in a cut bank on the east side of a ravine tributary to Big Sister Creek in the S.W.¼, N.E.¼, sec. 8, T.5 N, R.4 E.(Liverpool) (photo):

5.	Loess, non-calcareous, buff (Peorian)	6'
4.	Sand, yellowish, and gray or brownish gray silt strongly calcareous laminated, with regular alternation of sand and silt, indicative of annual deposition, probably outwash deposits into a ponded body of water, or a record of varve deposition. The average thickness of the laminae or "varves" is ¼-¾". The beds separate easily along the sand zones of the laminae. A rough count was made of the laminae and 180 were counted in this upper portion of the cut. Nos. 147 and 157 from the top are unusually thick, each having 1-2" of yellow sand. The lower of these bands thickens to 1' of sand within the cut.	
3.	Sand, apparently a local thickening of the summer outwash of one year, at center of cut thinning to 1-2" toward south end of cut.	2'6"
2.	Sands and silts, laminated, like those described above, 54 counted.	2'6"
1.	Sand and gravel, cross bedded to base of cut	6-8'

About 200' south of here a cut bank on the opposite side shows in the sand (#1 of above section) one or two very large blocks (1' thick by 2' in diameter) of coal are embedded in the sand and fine gravel which may be ice drifted blocks of coal. These are not uncommon in stratified sands in the Illinoian or other drifts.

The cut described above appears to represent a small basin shaped depression in which sediment was deposited for a number of years and then during one or two years of excessive melting the basin was filled level full so that the later varves are almost level across the site of this old basin.

A somewhat similar deposit of intra or early Illinoian age was exposed in a strip mine cut near the middle of the east line of sec. 29, T. 5 N, R. 3 E. (Putman) where the following section was exposed:

9.	Soil	1'
8.	Loess, buff, non-calcareous (Peorian)	4'9"
7.	Loess, gray, calcareous (Peorian)	1'6"
6.	Silt, brownsih gray, or loess (Late Sangamon soil) with carbonized wood fragments, non-calcareous	2'6"
5.	Gumbotil, brownish gray, Illinoian	2'
4.	Till, yellow brown, calcareous (ferretto)	3'8"
3.	Till, brownish gray, calcareous (Illinoian)	2'
2.	Sand and gravel, reddish brown, calcareous	1'11"
1.	Silt and sand, finely laminated, suggesting seasonal deposition, blue gray and buff, calcareous (Varves?) Intra- or pre- Illinoian	5'10"

Pennsylvanian

Sangamon Deposits

The Sangamon interglacial stage is represented by loess and loess-like silts, and by soils developed on Sangamon deposits in late Sangamon time and on Illinoian deposits in early Sangamon time. The loess of Sangamon age is usually thin and leached in its entire thickness, but it is somewhat thicker near the bluffs of the Illinois River, where a calcareous zone may be present. The surfaces of the Illinoian deposits and of the late Sangamon deposits furnish an excellent opportunity for the study of the development of ancient soil profiles under conditions of good and poor drainage. The Sangamon #### loess or silt is prevailingly pink, in contrast with the gray Peorian loess above, and although it commonly contains carbonized flakes of wood, no large logs or well preserved branches or twigs were observed in the Sangamon deposits like those which were found in the Yarmouth soils or carbonaceous silts or in the Kansan till. Fossils were collected from the Sangamon deposits at only one locality, and these were limited in number and the correlation of the beds as Sangamon may be open to question.

An excellent exposure on the walls of a gully which has been subject to extensive slumping (photo) shows well the development of soil profiles on the pre-Peorian surfaces. This is in a gully near the west line of the SW. ¼ NW. ¼ sec. 26, T. 4 N., R. 3 E. (Isabel). The section here was described by Dr. M. M. Leighton at the time of a field conference as follows:

Top of cut 18 feet below level upland.

Peorian	Soil, loessial, dark, moist	6"
	Loess, leached, buff	2'3"
	Loess, calcareous, mottled grayish ~~###~~ yellow in upper 18", becoming distinctly grayish below, very fossiliferous, with limestone kindchen	8'9"

Sangamon zone Soil Profile:-

Horizon A

Silt, grayish brown, fine, sandy; leached, loose — 2"

Horizon B

(1) Silt, pinkish, fine, sandy, compact; with root canals having limonite discoloration; having band of carbonized fragments 1" from top; massive structure. — 10"

(2) Silt, drab colored, fine, sandy; root canals with limonite coloration, leached except for secondary concentration of lime carbonate along canals. — 8"

Horizon C

Silt, gray, fine, sandy, with streaks of pale pink; canals with limonite coloration, non-calcareous; few concretions and segregations of lime carbonate along canals. — 4'

Horizon D

Silt, light gray, calcareous, fine, sandy, some secondary concentration of lime carbonate along root canals with limonite coloration, non fossiliferous. — 1' 9"

Below the foregoing lies a 6" rusty zone, leached, with the exception of $CaCO_3$ along tubules; fragments of carbonized wood in this zone.

Silt, pinkish, calcareous, fine sandy, loessial with tubules and canals with rusty coloration — 1'

Silt, with a few scattered pebbles, quartz, rhyolite and feldspar, up to about ½", noncalcareous, in matrix. Upper 4' pinkish, changing to grayish in lower part and becoming gray, plant tubules throughout with some carbonized plant traces and wood. — 6'

(About 100 feet southeast lower part of spur shows $CaCO_3$ concretions in lower part.

Lower silt may represent a wash from the Illinoian till on the lower slopes. ~~####~~ Above this to the base of the fossiliferous loess seems to be mainly leached Sangamon loess, there having been a short interruption soon after the loess deposition started.

It is evident that much erosion of the surface of the Illinoian till took place during Sangamon time in certain places, as may be indicated by the following remarkably condensed Pleistocene section on the east bank of the above ravine about ¼ mile north of the above described section. (Diagram and photograph).

9.	Soil.	1'	
8.	Loess, brownish, noncalcareous (Peorian)	1'	8"
7.	Loess, gray, calcareous, fossiliferous, very fossiliferous near lower surface (Peorian)	5'	
6.	Loess (Silt), pinkish generally, gray in lower 6", noncalcareous. Sharp break at base.(Sangamon)	2'	8"
5.	Gravel concentrate		6"-1'
4.	Till, gray, calcareous, Illinoian. Unconformible on	5'	8"
3.	Silt, dark gray to black, carbonaceous, non-calcareous bituminous odor, full of fragments of carbonized wood, including recognizable stem fragments; cut out at north end of cut (Yarmouth)		6"
2.	Gravel and sand, brownish, lenticular mass, near center of cut, noncalcareous, out at north end of cut (Yarmouth)		8"
1.	Silt, bright bluish, micaceous, noncalcareous. Rises toward north end of cut where it directly underlies Illinoian till, with wavy irregular surface. (Yarmouth)	2' plus	

In this cut the Illinoian till cuts across three elements of the Yarmouth section and itself has been extensively eroded, so that no non-calcareous zone is preserved on its surface, as in other cuts in the vicinity. The late Sangamon silt above the residual gravel on the Illinoian till is thin, but its upper surface shows little or no evidence of erosion, although if originally calcareous, it was completely leached before the deposition of the overlying calcareous Peorian loess.

In the northern part of the quadrangle, more distant from the larger rivers which supplied the wind with its fine loessial sediment, a dark gray or black soil of Sangamon age is more common than it is near the bluffs where the Sangamon zone is usually pinkish.

An exposure just northwest of the town of Bryant in the SW. ¼ SW. ¼ sec. 30, T. 6 N., R. 4 E. (Buckheart) shows this development typically:

6.	Soil	1'
5.	Loess, dark brown, noncalcareous,(Peorian)	2' 6"
4.	Silt, loessial, gray, calcareous; iron stained, pipestems no fossils seen. (Peorian)	5'
3.	Silt, dark brown to black, banded, with carbonized wood fragments and light gray loessial silt. Looks like soil interbedded with loess. All noncalcareous. (Sangamon)	3' 3"
2.	Till, gray, very fine, with few pebbles; polygonal fracture and gumbo-like properties; noncalcareous. Illinoian gumbotil	4' 6"
1.	Till, reddish brown, calcareous. Illinoian ferretto zone.	2'
	Base concealed.	

In exposures near the slopes of large streams, instead of the formation of gumbotil on the surface of the Illinoian till, a reddish thoroughly oxidized till is formed. This may be almost completely leached of its pebbles and boulders for several feet from the surface and may then be difficult to distinguish from the noncalcareous Sangamon loess-like silt, which is usually pinkish. An excellent development of such a well-drained profile is exhibited in the cut wall along the hard road (State Highway 31) on the south side of Otter Creek in sec. 30, T. 4 N., R. 3 E. (Isabel). The following section was measured:- (Photos)

Peorian loess.	
Soil Profile.	
A zone	
Silt, brownish, not compact.	1'
B zone	
Silt, brownish, compact, gumbo-like, sticky. Breaks into irregular polygonal blocks	1' 7"
C zone	
Silt, less fractured than that of B zone, less sticky, reddish brown, non-calcareous	2' 6"
D zone	
Loess, gray, calcareous, weathers with smooth surface; very slightly gullied. Fossiliferous	9' 9"
Sangamon-Illinoian zone	
Soil profile.	
A zone	
Silt, mottled, gray and buff, noncalcareous; distinctly laminated, containing numerous root canals which are calcareous and iron stained	1' 6"
B zone	
Silt, brownish, more compact than A zone, with whitish markings on fracture surfaces, noncalcareous	2' 3"

Sangamon-Illinoian zone
Soil profile (cont.)
C zone

Above, brownish silt, more loosely aggregated than that in B zone, showing less numerous fractures, leached, grading down into silt, reddish, with occasional pebbles, slightly calcareous, probably around root canals, grades down into reddish till, noncalcareous	12'
Sand, reddish	3' 3"
Till, brownish gray, noncalcareous	7"

D zone

Till, gray, calcareous, Illinoian	10' to base of cut

In the above section the Illinoian deposits are leached to a depth of 19' 6" and in the upper 11-12' nearly all or all of the pebbles or boulders which were present in the till have been leached away. It is possible that a few feet of the uppermost portion of this represents a silt deposited by wind during late Sangamon time and subsequently leached before the deposition of the Peorian loess.

The road cut of the State Highway 31 north of Spoon River is situated along the margin between the high terrace (500') of Wisconsin age and an outlying hill. The terrace shows fossiliferous silts of Wisconsin age in a cut about ½ mile away, over reddish silts slightly fossiliferous. The road cut shows gray fossiliferous silts over reddish silts which are slightly fossiliferous, but the fauna of the gray silts is largely different, and the situation is such as to suggest that the hard road cut shows a loess which was deposited on the slope of the outlying hill. In this case it is probably Peorian and the reddish silts below may be of Sangamon or early Peorian age. A section measured here is as follows:

5.	Soil	1'
4.	Silt, light brown or buff, loessial, noncalcareous, becoming mottled with gray silt toward base. (Peorian?)	4' 8"
3.	Silt, loessial, with laminated fracture, gray, calcareous, abundantly fossiliferous. (Peorian?)	14' 6"
2.	Silt, more clayey than abve, light pinkish, fossiliferous, less abundantly than silt above, different fauna, suggesting fresh water, rather than eoliah deposition.	10' 8" to base of cut

1. Illinoian till seen in gutter on opposite side of road 4-5' lower. If the physiographic interpretation of this section given above is correct, nos. 3 and 4 of the above section are Peorian loess and no. 2 is Sangamon loess or silt. This may be checked by the faunal assemblages collected in beds 2 and 3 of the above section. The Sangamon loess was not found to be fossiliferous except at the above questionable exposure.

PEORIAN INTERGLACIAL DEPOSITS.

As the area of the Havana quadrangle was not covered by an ice sheet during the Iowan glacial stage, the deposits of Peorian age rest unconformibly on the Sangamon or older deposits. The Peorian is represented by a very wide-spread deposit of wind blown eolian silt, the loess, which mantled the uplands, slopes, and valley floors of Peorian time. It is the superficial material of all parts of the Havana quadrangle except those parts from which it has been removed by post-Peorian erosion. It underlies all the uplands of the area and frequently forms the surface of the gentler slopes of the larger stream~~s~~ valleys, showing that these valleys had attained approximately their present depth and form by the early Peorian. There has in most cases been sufficient downward cutting since Peorian time to remove the loess from the valley floors and the meandering of the streams has caused much which mantled the slopes to be removed. As the loess was deposited by wind and largely supplied by silts deposited on the flood plains of the larger streams, the loess is somewhat thicker near the valleys of the Spoon and Illinois River~~s~~ bluff than in the northwestern portion of the quadrangle, which is several miles removed from a direct source of supply. Thus in sec. 21, T. 6 N., R. 3 E. (Putman) near Cuba, the Peorian loess is only 5-7' in thickness in several exposures, while in sec. 3, T. 4 N., R. 3 E. (Waterford) a thickness of 26' is present. This is near the bluff of the Spoon River, and at various other points near the Spoon River and Illinois River bluffs thicknesses of 20-35' are known. The loess normally consists of an upper portion which is buff and noncalcareous, and a lower portion which is gray or mottled gray and buff and calcareous. In this lower portion there are commonly seen irregular calcareous concretions or kindchen and cylindrical concretions of limonite# or pipe stems. It also contains in some exposures abundant shells of land-living gastropods. A large collection was made of these fossils from 12 localities in the quadrangle, and these have been turned over to Mr. F. C.Baker for determination. In places where the loess is thin the calcareous zone may be absent, showing that the two loesses are not two different deposits, but rather that the buff ~~###~~ loess~~#########~~ was formed by the leaching of the gray. The development of the soil profile is well shown on the Peorian loess in road cuts. The Peorian soil profile has been described above in connection with the underlying Sangamon soil profile in two or three sections. The calcareous loess is more resistant to weathering than the noncalcareous loess above and therefore in road cuts has a tendency to form vertical or nearly vertical walls which are very slightly affected by gullying as compared with other Pleistocene beds. (See photo). Thus the calcareous Peorian loess may usually be recognized by its weathering form. Although no tests have been made as yet it appears that the thicker Peorian loess near the Illinois and Spoon River bluffs is slightly more sandy than the thinner Peorian loess in the northwestern part oftheHavana quadrangle. As the Peorian loess has been described above in connection with other Pleistocene sections it is not necessary to give any detailed sections here. No other Peorian deposits than the loess are known inthis quadrangle.

WISCONSIN GLACIAL STAGE

Early Wisconsin Deposits.

The Havana quadrangle was not covered by an ice sheet during the Wisconsin glacial stage. The early Wisconsin glacier at the stages when the

Shelbyville moraine and Bloomington moraines were formed stood about 30-40 miles northeast of the northeast corner of this quadrangle. During all parts of the Wisconsin glacial stage the Illinois River received outwash deposits from the ice sheet. At the time when the Bloomington moraine was built the western part of the ice sheet extended into the Spoon River drainage basin in Stark County, and thus the Spoon River independently received outwash deposits. This outwash silted up the Illinois River valley to an altitude of approximately 500-510' in this quadrangle. The larger tributaries which had been cut below the 500' level for some distances upstream were ponded by this silting up of the major streams, and fine silts or slack water deposits, partly supplied by the streams themselves, and partly washed in by the major stream. Subsequent dissection has caused the abandonment of this level by all of the larger and many of the smaller streams, but along many streams portions of this plain remain as a terrace, whose average level is 510-495'. Certain of the smaller streams retain terrace remnants which slope upstream, but appear downstream to connect with this 500' level. These terraces probably represent aggradation by these streams when the creeks or rivers to which they were tributary were ponded, and their gradient correspondingly diminished. Along the west side of the Illinois River valley the remnants of this terrace level are few and narrow, but along some of its tributaries, especially Spoon River, Otter Creek, and Big Creek, terrace remnants are quite numerous and extensive. The terrace cuts of roads and streams usually show laminated silts or in many cases the succession gray silt or loess, pink and gray laminated silt, and red silt or clay. As this succession was observed in cuts of streams belonging to different drainage systems, (i.e., Spoon River and Otter Creek) the succession appears to be a general one, rather than a local one.

An excellent cut bank on the south east bank of East Creek near the NW. cor. of the NE. $\frac{1}{4}$ sec. 2, T. 4 N., R. 3 W. (Waterford) where the following section was measured: (Photo)

3. Silt, massive, blue gray, loess-like, showing some traces of lamination, at least in lower portion, fossiliferous; irregular lower surface. 8'
2. Sand and silt, strongly laminated, brick red and bluish gray, interbedded with some bands of gravel. Some laminae show cross-bedding in coarser materials. The sharp alternation of different colors suggests seasonal deposition. Probably outwash from the Bloomington moraine. Calcareous, fossiliferous. 9' 6"
1. Clay or silt, not bedded, dark red, calcareous, fossils very uncommon. 7' 6"

The following section of a cut bank on the south side of Otter Creek near the center of the west line of sec. 33, T. 4 N., R. 3 E. (Isabel) about 7 miles southwest of the above section clearly shows the same elements.

4. Silt, brownish gray, or loess, non-calcareous, grades up# into present soil. 5'
3. Silt, gray, or loess, calcareous. No fossils seen. 10'
2. Sand and silt, pink and gray, well laminated. Alternating pink and gray bands, thicknesses ranging from $\frac{1}{4}$" to several inches, some bands of the sand are coarse, with numerous pebbles. Gray bands usually very fine silt and reddish bands clay, may be seasonal banding, slightly fossiliferous 10'
1. Silt, very fine, or clay, red, not bedded, calcareous, fossiliferous. 6'

   Slump, to creek level 4'

A section of the 500' terrace, which cannot be definitely correlated with the above is in a cut bank of a ravine in the NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 14, T. 5 N., R. 2 E. (Bernadotte):-

8. Silt, brownish, sandy, noncalcareous 8'
7. Sand, yellowish brown, fine, noncalcareous 5'
6. Sand, bluish gray, brown in irregular bands and around root canals, calcareous 3' 8"
5. Silt, brownish, sandy 2"
4. Silt, blue gray, slightly sandy, light brownish along joint fractures and root canals, occasional small pebbles of chert and quartz up to $\frac{1}{2}$" diameter, some poorly preserved fossil gastropods. Some small calcareous concretions in the basal portion. 6'
3. Silt, clayey, plastic, slightly sandy, light gray, brownish in small spots along root canals, very slightly calcareous, effervesces only after prolonged treatment with dilute HCl. 3' 7"

3. Silt, pink, slightly sandy, containing fragments of carbonized wood, and in the basal portion, scattered pebbles up to $\frac{3}{4}$" diameter. Non-calcareous. 2-3'

2. Silt, dark bluish gray, sandy, with numerous pebbles, non-calcareous. 2' to base of section.

It is probable that much of the pink or red material in these deposits is outwash material equivalent in age to the Bloomington moraine, as this moraine is characterized by notably reddish drift at many places. The silting up of the larger streams apparently converted many of the smaller streams into ponds or marshes, especially in their lower stretches. Evidence of this lies in the presence of considerable concentrations of coniferous wood which may have been the wood of a swamp forest in a few places. The following section is from an exposure in a cut bank on the south side of the east fork of a ravine in the NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 33, T. 4 N., R. 3 E. (Isabel):- (Photo)

6. Soil, black to brownish gray, noncalcareous 7'.
5. Gravel and sand, slightly calcareous at top, strongly below, reddish. 8'
4. Silt, gray, carbonaceous, with many small fragments of carbonized wood, some gravel, fossiliferous, calcareous. 2' 6"
3. Gravel, lenticular masses, containing wood 2'-0.
2. Concentration of large wood fragments, including logs over 6' in length by 9" in diameter. Coniferous wood. Silts washed in around logs contain gastropod shells. 1' 6"
1. Silt, gray, interbedded with gravel, bituminous odor, fragments of wood and some blocks of calcareous till. 2-3' to base

In the middle fork of this same creek there are found concentrations of limonite which are probably of bog origin. A section of the terrace deposits here also shows the development of a soil profile of probable swamp origin.

Soil Profile.

~~10~~ 9. A-1 zone.
Soil, dark gray, with laminations. 11"

8. A-2 zone.
Soil, dark gray, granular. 5"

7. B-1 zone.
Silt, dark gray, compact. 1' 3"

6#. B-2 zone.
Silt, dark gray, compact, iron coatings on many faces, grading down into 1'
5#. Silt, saturated with limonite, probably bog limonite, brownish to dark blue gray. Becomes more deeply stained at base. 1' 6"
4#. Gravel, iron stained. 3"
3#. Gravel, gray, calcareous. 4"
2#. Silt, gray, calcareous, fossiliferous, carbonized wood fragments, blackish at base, mixed with gravel, sharp contact on 3' 5"
1. Till, gray, calcareous, Illinoian. 3'.

In this instance a small valley which was actively enough eroded to have removed all Peorian and Sangamon deposits and weathered Illinoian till was ponded by the silting up of the Illinois valley, to which this is directly tributary, and the lower end became swampy, depositing the beds described above. The silting of the stream valleys as a result of Wisconsin outwash affected the valley of Big Creek throughout the quadrangle, although the terrace remnants here are mainly small and scattered. Otter Creek valley was also silted up throughout the part of its valley in this quadrangle. Small remnants of the 500' terrace are also seen along the North Branch of Otter Creek, Seahorne Branch, Stuart Creek, Tater Creek, East Creek, Dickson Creek, Sepo Creek, Little Sister Creek, and Buckheart Creek, as well as several smaller unnamed creeks.

An interesting terrace remnant which probably belongs with the 500' terrace is the floor of a rather broad valley in which no stream now flows, in the southern part of sections 7 and 8, T. 4 N., R. 3 E. (Isabel). This appears to have been the pre-Wisconsin valley of Tater Creek, which was separated from Spoon River valley by a narrow divide near the northern border of section 7. The silting up of the Spoon River valley apparently raised its level above this divide and the lower valley was abandoned.

Paleontology.

The various silts of the 500' terrace section were found to be fossiliferous in many exposures, and gastropods and pelecypods were collected from the terrace deposits at 9 localities. In a few exposures these were more abundantly fossiliferous than the most fossiliferous parts of the Peorian loess. The collections are now being studied by Mr. F. C. Baker, and it is expected that they will throw light upon some of the local physiographic environments of the faunae, as well as the climatic succession. Well preserved logs or branches are also not uncommon in these deposits, and several fragments of wood were collected.

Later Wisconsin Deposits.

After the recession of the Wisconsin glacier from the position of the Bloomington moraine the waters which filled the valley of the Illinois River were apparently freer from sediment and removed much material which had been deposited earlier. The complete absence of the 500 foot terrace from the walls of the Illinois valley along most of the quadrangle indicate that these waters may have completely destroyed the terrace and perhaps widened the valley appreciably at some points. Most remnants of the 500' terrace along theIllinois River are at the mouths of large tributaries in rather protected situations. In Spoon River, on the other hand, remnants of the 500' terrace are much more extensive, reaching a maximum width of about 1 1/3 miles near the western part of the quadrangle. The lowering of the level of theIllinois valley due to post-Bloomington-pre-Lake Chicago erosion appears to have amounted to 25 to 35 feet, as indicated by a lower terrace, whose altitude averages 465-475'. In many cases this lower terrace appears to be purely an erosional surface, developed on materials of the higher terrace. In some instances only a slight thickness of silt or soil separates this surface from bed rock, so that this lower terrace may be called a rock terrace in some cases. Duncan Mills is situated on such a rock terrace on the south side of Spoon River. The larger tributary streams appear to have had time to adjust themselves to the lowered level of the Illinois River valley plain and thus some of them, especially Spoon River and Otter Creek preserve extensive remnants of this terrace.

It is probable that the lowering of the valley of the Illinois River to its present level took place chiefly when it was scoured by the glacial torrent of Lake Chicago and the Kankakee River, as the river at present is an aggrading, rather than degrading stream, and could not have cut below the terrace level over a width of 3½ to 4 miles. While the effect of this flood was principally degradational, silts may have been deposited in sheltered portions of the valley on the surface of the low terrace during times of high water. A ravine cut across the low terrace along the east line of section 34, T. 4 N., R. 3 E. (Isabel) shows the following section:-

7.	Silt, yellowish, fine, bleached soil.	1'
6.	Silt, dark gray, humus, with few pebbles.	1' 2"
5.	Silt, buff, noncalcareous, with scattered pebbles, not distinctly bedded.	3' 4"
4.	Silt, yellowish gray, calcareous.	2' 7"
3.	Silt, brownish gray, dark, noncalcareous, showing some lamination as in A zone of soil.	9"
2.	Silt, yellowish gray, slightly calcareous above, strongly below, fossiliferous.	3'
1.	Sand, and some beds of gravel, calcareous.	5' 6"

In the above section the surface of bed 3 is interpreted as an erosional surface on the high terrace upon which leaching acted for some time and a soil profile was started. Later flooding, probably at the time of theKankakee-Chicago torrent flooded this surface again, depositing about 7' of silt, which has been subsequently weathered much more deeply than the older surface. Fossils are numerous in bed 2 of the above section, and some fossil gastropods, including large forms preserving the original color markings, were found in the upper series, in bed 4.

In a few places sand was found as the surface material of the low terrace, as in a cut about 1 mile west and 1/3 mile south of the above section.

On the east side of the Illinois River valley the plain east of Havana corresponds in altitude with the low terrace on the west side of the river, but it is covered entirely with sand, which in many places is piled up in the form of small dunes. As mentioned in discussing the Physiography of the region the rather general belt of dunes 2-3 miles east of the Illinois River are interpreted as the shore dunes of the stage when the Illinois River filled its valley to the 470-475' level. The age and origin of the extensive dunes beyond this shore dune belt, which extend away from the river 15-18 miles is not clear to the writer, but it may be that a part of this sand may have been derived from the Bloomington outwash, and perhaps a part may be equivalent in age to the Peorian loess.

The Illinois valley must have formed a lake like expanse at least 20 miles wide in this area, but the age of this valley widening is not clearly indicated. It may be pre-glacial.

Recent deposits.

These include flood plain deposits, alluvial fans, slump, and talus material, sand dunes of recent movement and recent wind-blown dust or loess, in addition to the spoil piles of some of the large underground coal mines and the strip banks of the surface coal mines. None of these deposits possess characters worthy of special mention.

Historical Geology

This will not be presented in this advanced outline, as the historical material necessary for understanding the Pleistocene succession has been presented along with the Pleistocene stratigraphy.

Structural Geology

The structure contour map will be drawn on the levels of the Colchester (#2) coal and the Springfield (#5) coal. Exact levels on 156 stations (100 already completed by Mr. Spoor) distributed quite evenly over the area combined with field notes regarding directions of inclination in the various stream valleys. The guide strata used for the structure determination include in addition to the #2 and #5 coals are the gray limestone band 30-45' above the #2 coal and the Pottsville knobby limestone 18-25' below the #2 coal. These beds will be used with the known interval above and below the #2 coal for data on the coal. It is probable that the #2 coal will afford a much clearer picture of the structure of the pre-Pennsylvanian rocks than the #5 coal, because the #5 coal appears at least to some degree to parallel the undulating upper surface of the Vergennes sandstone and to range in interval from 45-50 to 130' above the #2 coal.

The prevailing structural feature is a regional dip to the southeast. On this there is much local rolling of the strata. The greatest relief within short distances appears to be along Buckheart Creek where the inclinations of the #5 coal and associated beds are locally quite apparent in outcrops. A synclinal depression appears to be located in the SW ¼ of sec. 24, T.6N., R.4.E. (Buckheart) and an anticlinal or slight dome appears to be indicated in the NW¼ of sec. 11, T.5.N., R.4E. (Liverpool)

There is not enough data available to draw a map of the structure of any pre-Pennsylvanian horizon in this quadrangle.

Minor structural features

In many places thin bedded shales, limestones, sandstones, or calcareous concretion bands are sharply flexed locally. (See 3 pictures). This has been ascribed to ice shove, but as in many cases the strata affected are 20-40' below the base of the glacial drift, this flexure may be due to some other cause such as uneven settling of the strata accompanying consolidation.

Faults and cracks of considerable size in the coal beds expecially the #5 coal, are usually filled with ~~xxxx~~ clay washed into the bed from below. These clay seams in the coal are called horsebacks (See photographs)

Ripple marks, septarian concretions, and cone-in-cone are other structures which might be mentioned here (See ~~xxxxxxx~~ pictures of these structures.)

Economic Geology

The mineral resources of the area in addition to the soil consist of coal, shale, fire clay, sand and gravel, and water. Although there have been several deep wells drilled in this area in search of petroleum none has been discovered as yet. Natural gas has been found in quantities sufficient for use on farms, principally at shallow depths and probably largely from the Pleistocene.

Coal.

The Havana quadrangle is underlain in various parts by 4 coal beds which normally attain a thickness of 2'6" or more and may thus be considered available for use under existing conditions. These are the Herrin #6, Springfield #5, Colchester #2, and Rock Island #1 coals. Of these all have been mined except the #1 coal and it is known to underly the quadrangle in workable thickness in a few places. In addition there is one thinner coal horizon between the #5 and #2 coals, here called the Bryant #4 coal, which locally attains a workable thickness and has been mined in a few places There are also several coaly or carbonaceous horizons between the #2 and #1 coals, of which 2 are especially persistent. The upper of these is usually 2-3' above the Pottsville knobby limestone and ranges in thickness from 5 or 6 to 18 inches. It is present so far as known wherever its horizon is exposed. It is not known to have been worked at any place in the Havana quadrangle. Two coal beds separated by 3-5' of fire clay or fire clay and sandstone occur about 25' lower in the Pottsville section, the upper bed directly below the "quartzitic" sandstone. These two beds vary greatly in thickness and are not persistent in all exposures, but locally each may attain a thickness greater than 2'. One or two drifts are known to have been driven on one or both of these two beds, altho they are at present available for use only in very restricted areas.

Herrin (#6) Coal

This bed is known to underly only parts of sections 19,20,and 21, T.6N., R.3E. (Putman) and a very small area in sec. 25, T.6N., R.4E., (Buckheart). The latter area so far as known has no value as the coal is weathered and directly underlies the glacial drift. At present no mines are operating in this coal. It has 3 to 9 bedded impurities in its exposures near Cuba and the separation of these would add greatly to the cost of producing the coal. If the impurities are not separated this coal would be greatly inferior to the #5 coal which underlies all of the area in which the #6 coal is present, but at a slightly greater depth. The roof of the #6 coal is 2-3' of rather soft black shale under a massive limestone cap rock. The shale would doubtless fall some in mining but the cap rock would make a good roof. All of the #6 coal is near enough the surface to be mined by surface or strip mining methods if there should be a demand for this.

Springfield (#5) Coal

This coal underlies large parts of T.6N., R.3E.(Putman) and T.6N., R.4E., (Buckheart) and sections 1,12,14 and 20, T.5 N., R.4 E., (Liverpool). It is remarkably persistent and regular in thickness, ranging from 4'6" to 5'6" in the outcrops and records observed. It is not usually marked by any bedded impurities (clay bands, etc.), but lenticular bands of pyrite usually thin, are not uncommon. The Springfield coal is near the surface along its line of outcrop and for a distance of 2-3 miles from its outcrop is near enough to the surface to be mined by stripping. Local stripping has been carried on for many years near the outcrops of the coal in ravines, but in most cases the coal mined in this manner was so near the surface that it was weathered or "crop" coal in part. The presence of a limestone cap rock roof made hand stripping difficult or impossible. Since 1923 the United Electric Coal Company has been operating a strip mine southeast of Cuba in which 4 electric shovels are now engaged in stripping off the overburden above the coal. These shovels are capable of stripping 50 feet or more of rock and unconsolidated deposits above a five foot bed of coal. This mine at present produces on the average of 75 car loads of coal a day or an annual production of about 800,000 tons. Land which is underlain by this coal bed near enough the surface for stripping is much greater than that already developed. A map will be prepared to show the approximate distribution of such land. The #5 coal is in some places cut by clay seams or horsebacks which make mining difficult and have caused some weathering of the coal on either side of the horsebacks. Much good coal is lost which adheres firmly to the clay. The roof of the #5 coal is a hard fissile shale or "slate" containing in some places large pyritic band calcareous concretions or niggerheads. Where these are numerous they may weaken the roof and cause bad roof falls. Above 2'6"-3'6" shale is one band of massive limestone cap rock 6"-2' in thickness. This is not persistent in all parts of the area. It forms a good roof if the shale below is removed. The floor of this coal is fire clay. This coal is the most valuable mineral resource of the area, although it has been mined out under large parts of the quadrangle, by former underground mining. The coal which has been stripped in recent years is largely coal which lay too near the surface to be mined underground.

Coal #4 (Bryant coal) New name.

A coal bed 15-20' below the Springfield #5 coal is usually only a few inches thick but in a few places in the quadrangle increases to a workable thickness 2'6"-4'. It is best developed in secs. 27 and 35, T.6N., R.3E. (Putman) and in the SW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 20, T.5N.,T.4 E.(Liverpool), where it is only 2-5' below the #5 coal. It is more irregular in thickness than the #5 coal has a black shale roof with niggerheads and not cap limestone. It is faulted more than the #5 coal apparently. The floor is shale or sandy shale (not fire clay). It has been mined in a few ravines by local drifts where the #5 coal above has also been mined. It will never constitute an important resource because of its irregularity in thickness. At the locality in sec. 20, Liverpool twp. it is reported to be a better burning coal than the #5 coal above.

Colchester (#2) Coal.

This coal is widely distributed in the quadrangle and is exposed at many places south and west of the line of outcrop of the #5 coal. It, like the #5 coal forms a continuous bed of remarkably uniform thickness. It is absent only where erosion has cut into the underlying Pottsville strata. It averages 2'6" in thickness and has been called by the miners the 30 inch coal throughout this region. The coal has no regularly bedded impurities although it commonly contains lenticualr masses of pyrite which parallel the bedding. It is rather a brighter coal than the #5 coal, and because of its reputation as a better burning coal has been widely exploited in spite of the presence of a thicker coal only a few miles away. The roof of the coal is a soft gray shale or soapstone normally, but in some places, notably south of Spoon River, the Vergennes sandstone has cut out the roof shale and over large areas rests directly on the coal or is separated from it by only a few feet of shale. The slabby character of the Vergennes is said to cause this to form a poor roof even poorer than the "soapstone". The common method of mining this coal is by drifts along the sides of the ravines which extend back under the hill only about 200-400'. These drifts may be spaced as closely as every 100' along the walls of ravines. (See photo). In the vicinity of Lewistown it has been quite extensively mined by shafts 30-60' in depth, two or three of which are still in operation. This coal has also been stripped from the valleys of ravines in which it is near the surface at many places. It is not known to lie near enough the upland at any point to be available for stripping on a larger scale. This coal is next to the #5 coal most important and by the development of improved mining methods for use on thinner coal beds large quantities may yet be mined, as the mines under the present system are not carried back any considerable distance before being abandoned.

The coal beds between the Colchester (#2) and the Rock Island (#1) coals were mentioned at the beginning of the discussion of coal (see above) No beds in this interval are likely to be of any general importance, altho they may be locally mined.

Rock Island (#1) Coal.

This coal bed does not outcrop anuwhere in the area, but is reported, in drillings at several places, in the vicinity of Cuba, under the Illinois River flood plain east and northeast of Sepo, and under the Spoon River flood plain near the Mound Chapel, west of Duncan Mills, and under the valley of Otter Creek near the west line of the quadrangle. It is reported in drillings to reach a thickness of 4-7' and to underlie a massive limestone cap rock or a sandstone, either of which would probably form a good roof. This coal in contrast with the #2 and #5 coals appears to be present only in narrow basins of restricted area which can be outlined only ~~be~~ by extensive drilling. It is likely also that near the margins of these basins the cap rock is thin or absent, and thus the coal is not likely to have the value which the more regular beds above have. It has been tested by drilling rather extensively in the past 10 years or so and is probable that some attempt will be made to develop it within a few years.

No coals are known to occur below the #1 coal in this area.

Shale.

Shale is abundantly distributed in the Havana quadrangle and at many sites it is favorably situated for working, although none has been used as yet.

Three shale beds appear to offer the greatest possibilities for future development. These are the Canton Shale above the #5 coal, the Purington Shale below the Vergennes sandstone, and the roof shale of the #2 coal. The Canton shale has been used for the manufacture of brick near Canton, and the Purington shale at East Galesburg at the Purington Paving Brick plant, and as the shale in this area resembles closely that which has been used it should be available. The roof shale of the #2 coal is not known to have been used anywhere and it may be too sandy or too carbonaceous. A sample of the Canton shale from sec. 23, T. 6 N., R. 3 E. (Putman) was collected for testing by the Ceramics Department. A diagram will be prepared showing the location of sites which might be tested for shale.

Fire Clays

All of the coal beds except the Bryant #4 are underlain by fire clays. These fire clays usually contain septarian calcareous concretions which may diminish their possible value. Samples were collected of the fire clay below the Colchester (#2) coal in sec. 2, T.4N., R.2W. (Pleasant) and from 3 Pottsville fire clays for testing by the Ceramics Department.

Sands

Very large deposits of sand are available in the Havana quadrangle, as no other deposits than sand are known on the east side of the Illinois River valley. This sand is acumulated in dunes at many places and the railroad lines on the east side of the river cut through many of these dunes. It has not been studied as yet to see what it would be most useful for. It is probably too well assorted and rounded for a molding sand, and it is doubtful whether it would be pure enough for glass sand.

Gravels

The deposits of gravel available are lenticular masses of gravels usually interbedded with sands or included in the glacial drift. These are most abundant in the west central part of the quadrangle, especially in the lower part of Stuart Creek valley. None are near railroad lines, and thus their use would have to be largely local.

Limestone and Building Stone.

The limestone beds are too thin and too impure to be considered possible sources oflimestone and there are no layers of rock massive enough and sufficiently resistent to weathering to have much value as building stone. The "quartzitic" sandstone of Pottsville age is the hardest and most resistant to weathering of the rocks of the area.

Water.

The source of farm wells is normally the base of the Pleistocene deposits or lenticular masses of sand or gravel in the Pleistocene deposits or lenticular masses of sand or gravel in the Pleistocene deposits. In only a few areas is it necessary to drill into pre-Pleistocene deposits. The city water of Cuba is derived from the St. Peter sandstone at 1700 feet. It is rather hhighly mineralized. The water supply of Lewistown comes from ~~several~~ shallow wells in the flood plain of Spoon River several miles southwest of the town. An artesian flow may be obtained from the Niagarian limestone, but the water is highly mineralized.

Oil and Gas

The logs of the oil test drillings in the area are given above under subsurface geology. Structures suitable for further testing if any will be described after the structure contour map is completed.

No logs are at present available of wells which have obtained appreciable quantities of natural gas.

Havana Quadrangle

SYSTEMATIC LIST OF FULTON COUNTY PLEISTOCENE MOLLUSCA

Stagnicola palustris elodes(Say) Stagnicola sp.
x Stagnicola caperata(Say) Fossaria dalli grandis F.C. Baker
Fossaria parva(Lea)
– x Fossaria parva tazewelliana(Wolf)
Fossaria modicella(Say) Fossaria sp.
Fossaria obrussa decampi(Streng) Helisoma antrosum striatum (F.C. Baker)
Planorbula crassilabris(Walker) Helisoma campanulatum (Say)
Gyraulus altissimus(F.C.Baker)
Gyraulus urbanensis(F.C.Baker)
Gyraulus crista(Linn.)
Physella integra(Haldeman) Aplexa hypnorum (Linn.) Found
x Pomatiopsis lapidaria(Say)
– x Pomatiopsis scalaris F.C.Baker
Valvata tricarinata(Say)
Valvata tricarinata perconfusa Walker
Valvata tricarinata simplex Gould
Valvata lewisii precursor F.C.Baker
Sphaerium striatinum(Lam.) Sphaerium simile Sphaerium sulcatum (Lam.)
Sphaerium tenue (Prime) Amnicola leightoni F.C. Baker
Pisidium compressumPrime) Musculium sp.
Pisidium noveboracense(Prime)
Pisidium abditum Hald.
Pisidium concinnulum Sterki
Pisidium walkeri Sterki
Pisidium scutellatum Sterki
Pisidium tenuissimum Sterki
Pisidium medianum Sterki
Pisidium rotundatum ~~Sterki~~ (Prime)
Pisidium vesiculare ~~(Sterki)~~ Sterki
Pisidium variabilis brevius Sterki

Pisidium sp.

All fresh water species

44

Check against chart
4107
y-1

Havana Quadrangle

SYSTEMATIC LIST OF FULTON COUNTY PLEISTOCENE MOLLUSCA

- Polygyra monodon(Rackett) — Polygyra fraterna (Say)
- Polygyra monodon peoriensis F.C.Baker
- Polygyra hirsuta(Say)
- Polygyra hirsuta yarmouthensis F.C.Baker — Polygyra multilineata (Say)
- Polygyra multilineata wanlessi F.C.Baker — Polygyra profunda (Say)
  — Polygyra profunda pleistocenica F.C.Baker
- Polygyra clausa(Say)
- Polygyra thyroides(Say)
- Columella hasta(Hanna)
- Columella alticola(Ingersoll)
- Gastrocopta armifera(Say)
- Gastrocopta contracta(Say) ← Gastrocopta tappaniana (C.B.Adams)
- Gastrocopta pentodon(Say)
- Vertigo modesta(Say)
- Vertigo loessensis F.C.Baker ← Vertigo ovata (Say)
- Strobilops labyrinthica(Say)
- Strobilops virgo Pilsbry
- Vallonia gracilicosta Reinh.
- ~~Circinaria~~ Haplotrema concava(Say)
- Zonitoides arborea(Say)
- Striatura milium(Morse)
- ~~Pseudohyalina~~ Retinella minuscula(Binney)
- ~~Polita~~ hammonis ~~electrina(Gould)~~ (Ström)
- Glyphyalinia indentata(Say)
- Euconulus fulvus(Drap.)
- Anguispira alternata(Say)
- Anguispira solitaria(Say)
- ~~Gonyodiscus shimekii(Pilsbry)~~
- Gonyodiscus macclintocki(F.C.Baker)
- Gonyodiscus macclintocki angulata F.C.Baker
- Gonyodiscus ~~cronkhitei~~ anthonyi(Pilsbry)
- Helicodiscus paralellus(Say)
- Succinea ovalis(Say)
- Succinea ovalis pleistocenica F.C.Baker
- Succinea grosvenori gelida F.C.Baker
- Succinea retusa fultonensis F.C.Baker
- Hendersonia occulta(Say)
- Hendersonia occulta rubella(Green)
- Carychium exiguum(Say)
- Carychium exile canadense Clapp.

Pupilla cf. hebes (Ancey)

Land Shells

43

Retinella

~~Pupilla cf. hebes (Ancey)~~

~~Haplotrema concavum~~

38
30
68

IDENTIFICATION OF PLEISTOCENE FOSSILS. HAVANA QUADRANGLE
Dr.H.R.Wanless

Aftonian: 2032.62. All land shells and characteristic of loess deposits Hendersonia occulta(1);Gonyodiscus ~~shimekii~~ maccIintocki angulata F.C.Baker; (1); Vertigo ~~gouldii~~ loessensis (1)

Yarmouth:

2505.77 All land shells but the last two, which are amphibious and breath air(fresh water Pulmonates)

- Succinea refusa + fultonensis, (1)
- Succinea ovalis pleistocenica Many
- Succinea grosvenori gelida (3)
- Polygyra monodon peoriensis (1)
- Polygyra multilineata wanlessi (2)
- Gonyodiscus ~~shimekii~~ macclintocki angulata Several
- Zonitoides arborea (1)
- Glyphyalinia indentata (1)
- Circinaria concava (1)
- Strobilops virgo (7)
- Hendersonia occulta Many
- Vertigo ~~gouldii~~ loessensis (4)
- Vertigo modesta (1)
- Pomatiopsis scalaris (3)
- Fossaria parva tazewelliana 3
- Gastrocopta pentodon (1)

The following two species of typical fresh water shells must have been carried to the location by foreign agencies.
Pisidium abditum(4)Pisidium concinnulum (2)

2508.60 Both typical loess land mollusks

Below soil	Above soil
Succinea ovalis pleistocenica (4)	Succinea ovalis pleistocenica (3)
Hendersonia occulta(6)	Hendersonia occulta(1)
Gonyodiscus ~~shimekii~~ macclintocki angulata(4)	--------------
------------	Strobilops ~~labyrinthica~~ (1) virgo
------------	Glyphyalinia indentata(1)

2026.06.Typical loess fossils,all land shells.

Succinea ovalis pleistocenica Many	Strobilops virgo (1)
Gonyodiscus ~~shimekii~~ macclintocki angulata (5)	Vertigo ~~gouldii~~ loessensis (1)
Hendersonia occulta (4)	Polygyra hirsuta yarmouthensis(2)

2003.31 Land shells are typical loess fossils. Fresh water form found in wet places where loess might later accumulate.

Land	Fresh water
Succinea ovalis pleistocenica (2)	Stagnicola caperata (Many)
Strobilops virgo (1)	woodland form

1808.18 ~~2005.10~~ Upper fossiliferous gray silt. Loess fossils.
Hendersonia occulta(2) Gonyodiscus ~~shimekii~~ macclintocki angulata (1)

1808.18 ~~2005.10~~ Lower silt,water laid,containing typical fresh water species
Valvata tricarinata (Many) Gyraulus altissimus (Many)
Valvata lewisii presursor(2) Pisidium compressum(3)
Fossaria parva ~~tazewelliana~~ (woll) river form

Interpretation probably that fresh water shells were deposited on flood plain which later became covered with loess. Representing, possibly, and early and a later period in Yarmouth time.

1725. Loess fauna
Hendersonia occulta
Succinea grosvenori gelida
Succinea ovalis pleistocenica
Fossaria parva tazewelliana
Carychium exile canadense

Sangamon:

2008.89 All fresh water species. The deposit above contains typical Peorian fossils, several of which are not known from Early Wisconsin. Hence the lower deposit must be Sangamon.

Planorbula crassilabris
Fossaria parva tazewelliana
Stagnicola caperata
Sphaerium striatinum

Peorian:

2008.89 All but last two species typical land fossils of Peorian. Last two species amphibious and ~~xxxxxxxxxxxxxxxxxxx~~ frequently associated with typical loess. It could not be Early Wisconsin.

Succinea retusa fultonensis (1)
~~Succinea retusa (1)~~
Succinea grosvenori gelida Several
Polygyra multilineata ~~wanlessi~~ fragments
Gonyodiscus shimekii ~~angulata~~ (1) ~~(5)~~ anthonyi
Helicodiscus paralellus (1)
~~Glyphyalinia indentata~~
Columella alticola (3)
Polita hammonis electrina (Several)
Gonyodiscus macclintocki (2)

Vertigo ~~gouldii~~ loessensis Several
Vertigo modesta (1)
Carychium exile canadensis (3)
Pomatiopsis scalaris Many
Fossaria parva tazewelliana Many
Stagnicola caperata (2)

~~2032.60 Typical loess fauna. Gonyodiscus shimekii is of the Peorian type, not the Yarmouth type(angulata).~~

2032.60

Succinea grosvenori gelida Many
~~Gonyodiscus shimekii (5)~~
Polygyra hirsuta yarmouthensis (8)
Circinaria concava (6)
Helicodiscus paralellus (2)
Pseudohyalina minuscula (Binney) (5)

Polita hammonis electrina loessensis (7)
Zonitoides arborea (1)
Vertigo ~~gouldii paradoxa~~ (3)
Pomatiopsis scalaris (1)
Fossaria parva tazewelliana Many
Vertigo modesta (1)
Hendersonia occulta (1)

As far as fauna goes it might be either Yarmouth or Peorian. The key fossil, Gonyodiscus shimekii, is not present. All are found in Peorian loess.

2030.53 Typical Peorian loess fossils.

Succinea ovalis pleistocenica (Many)
~~Gonyodiscus shimekii (1)~~
Hendersonia occulta (5)
Polygyra multilineata wanlessi (2)

2037.86. Typical Peorian loess fossils.

Succinea ovalis pleistocenica Many
Succinea grosvenori gelida Many
Polygyra multilineata wanlessi "
Polygyra hirsuta yarmouthensis "
Circinaria concava "
Polita hammonis electrina "
Gonyodiscus ~~shimekii~~ macclintocki (1)

Anguispira alternata (2)
Fossaria parva tazewelliana Many
Carychium exilis canadense (30)
Vertigo ~~gouldii (5)~~ loessensis
Vertigo modesta Many
Columella alticola (3)
Hendersonia occulta Many

2037.66 Typical loess fossils

Succinea ovalis pleistocenica - Many
Gonyodiscus shimekii (1) anthonyi
Circinaria concava (2)
Hendersonia occulta (6)
Polita hammonis electrina (1)
Polygyra monodon (2)

Peorian continued.

2003.31 Typical loess fossils

Succinea grosvenori gelida Many
Fossaria parva tazewelliana Many
Gonyodiscus ~~shimekii~~ (1) anthonyi
Circinaria concava (1)
Polygyra monodon (4)
Polygyra multilineata wanlessi Several

1831.82. A typical Peorian loess section, with the key fossil, Gonyodiscus shimekii, commonly represented.

Succinea ovalis pleistocenica Many
Succinea grosvenori gelida "
Gonyodiscus ~~shimekii~~ anthonyi several ~~4~~
Circinaria concava (6)
Polygyra multilineata wanlessi (8)
Polygyra hirsuta yarmouthensis (10)
Polygyra monodon Many
Hendersonia occulta Many
Gonyodiscus macclintocki, several
Polita hammonis electrina (5)
Vallonia gracilicosta (1)
Euconulus fulvus (2)
Columella hasta (1)
Columella alticola Many
Vertigo ~~gouldii~~ loessensis Many
Carychium exile canadensis (3)
Fossaria parva tazewelliana Many

1814.21 All typical loess fossils.

Upper strata

Succinea ovalis pleistocenica (4)
Succinea grosvenori gelida Many
Gonyodiscus ~~shimekii~~ anthonyi Many
Vallonia gracilicosta (3)
Polygyra monodon Many
Vertigo modesta (5)
Polygyra multilineata wanlessi several
Fossaria parva tazewelliana (6)

Lower strata

S.o.pleistocenica Many
S.g.gelida Many
G.shimekii (4) anthonyi

P.monodon (2)
V.modesta (3)
P.m.wanlessi (5)

F.p.tazewelliana Many
Polita hammonis electrina (1)
Hendersonia occulta Many
Columella alticola (1)
Vertigo ~~gouldii~~ loessensis (6)

There appears to be no difference in the character of the fossils. Those lacking in the upper strata are for the most part small species which might not have been in the samples taken. The absence of Hendersonia occulta is noteworthy.
Upper loess is grayer than lower loess.

2022.52 Typical loess fossils

Succinea grosvenori gelida (6)
Polygyra multilineata wanlessi (6)
Polygyra hirsuta yarmouthensis (1)
Fossaria parva tazewelliana (4)
Helicodiscus parallelus (1)
Circinaria concava (1)
Anguispira alternata (7)
Zonitoides arborea (1)
Gonyodiscus ~~shimekii (2)~~ macclintocki

2507.79. Typical loess fossils.

Succinea ovalis pleistocenica Many
Succinea grosvenori gelida Many
Gonyodiscus ~~shimekii~~ (3) anthonyi
Polygyra multilineata wanlessi Several
Hendersonia occulta Many
Vertigo ~~gouldii~~ (2) loessensis
Fossaria parva tazewelliana Many

Peorian continued

2021.41. Typical loess fauna

Succinea ovalis pleistocenica Many	Vertigo ~~gouldii~~ loessensis (2)
Succinea grosvenori gelida Many	Columella alticola(1)
Polygyra multilineata wanlessi Several	Euconulus fulvus (1)
Gonyodiscus ~~shimekii~~ (~~2~~) 5 anthonyi	Hendersonia occulta Many
Polygyra monodon ~~Many~~	Circinaria concava (1)
Polita hammonis electrina (1)	
Fossaria parva tazewelliana Many	
Gonyodiscus macclintocki (2)	

Early Wisconsin.

2011.49 The middle laminated layer probably represents an earlier period when the region was a flood plain. Later, the loess accumulated above the plain and only land or fresh water pulmonates(amphibious) are found. Probably these two strata represent Early and late Early Wisconsin.

Laminated layer	Upper gray loess
Valvata tricarinata Many	---------------
V.tricarinata perconfusa Many	--------------
Pisidium ~~xxxxxxxxxx~~ compressum(7)	-------------
Pisidium variabile (1) brevius	-----------
Fossaria obrussa decampi(1)	-----------
Stagnicola caperata Many	---------
Polygyra multilineata wanlessi (2)	-------------
Fossaria parva tazewelliana Many	F.p.tazewelliana Many
Pomatiopsis scalaria Many	P. scalaris Many
Gyraulus altissimus (7)	----------------
Polygyra hirsuta yarmouthensis(1)	P.h.yarmouthensis (1)
Polita hammonis electrina(4)	P.h.electrina (2)
Succinea retusa (1) fultonensis	S.retusa (1) fultonensis
Succinea grosvenori gelida(4)	S.g.gelida (3)
----------------	Circinaria concava (1)
----------------	Polygyra monodon (2)
----------------	Gonyodiscus cronkhitei anthonyi (1)

1729.04 Both strata contain principally water shells, the few land shells probably having been washed into deposit or dropped from higher level of bank. Brown silt contains larger fauna.

Brown silt	Lower gray silt
Stagnicola elodes Many	Stagnicola elodes Many
Fossaria parva tazewelliana (10)	F.p.tazewelliana Many
Fossaria obrussa decampi Many	-------------
Gyraulus altissimus Many	G.altissimus Many
Gyraulus crista (2)	------------
Valvata lewisii precursor Many	------------
~~Succinea retusa (4)~~	
~~Pisidium pauperculum crystalense (1)~~	----------
~~Pisidium compressum (1)~~	~~-------------~~
Pisidium ~~[illegible] (1)~~ rotundatum (3)	----------
Succinea ~~retusa (4) [illegible] tenuissimum (1)~~ retusa fultonensis (4) *	Succinea retusa fultonensis ~~[illegible]~~ Many *
Polygyra monodon (1) *	-----------
Hendersonia occulta (1) *	-----------
Pisidium ~~[illegible]~~ scutellatum	-----------
" " tenuissimum	
~~Gyraulus arcticus~~	----------
Fossaria modicella (1)	

Early Wisconsin-continued.

2019.33 The fauna represents two stages, the upper apparently a loess fauna of land shells, the lower a fresh water fauna. This was undoubtedly a flood plain deposit(from the presence of Pomatiopsis lapidaria and Stagnicola caperata) upon which the loess was later deposited. This is entirely a land fauna

Water fauna

Valvata lewisii precursor(2)
Pomatiopsis ~~lapidaria~~ (6) scalaris
Gyraulus altissimus Many
Stagnicola caperata Many
Fossaria parva Many

Pisidium pauperculum crystalense 9
Pisidium compressum 1
Pisidium scutellatum 2

Loess fauna

Succinea ovalis Few
Succinea grosvenori gelida Many
Succinea retusa ~~decampi~~ (2) fultonensis
Polygyra monodon (1)
Euconulus fulvus (1)
Strobilops ~~virgo~~ (1) labyrinthica
Vertigo ~~gouldii~~ Many loessensis
Vertigo modesta (3)
Carychium exile canadensis (1)

~~2003.64. Water laid silt - too many fresh water shells (including Valvatas) for loess.~~

2003.64. Too many fresh water shells for loess(including Valvatas?)

Fresh water ~~species~~

Valvata tricarinata perconfusa(1)
Gyraulus altissimus(3)
Stagnicola caperata (3)
Fossaria parva (6)
Pomatiopsis scalaris(4)

Land species

Succinea grosvenori gelida (5)
Polygyra monodon (1)
Polygyra hirsuta (1)
Anguispira alternata(1)
Hendersonia occulta(60)
Helicodiscus parallelus(1)
Strobilops labyrinthica (1)

2004.42 Probably represents flood plain deposit with land shells washed down from upper strata. B.is more typically a fresh water deposit because of the number of specimens present.

A.Lower red silts

Sphaerium tenue Many
Pisidium scutellatum Many
Pisidium walkeri Several
Pisidium tenuissimum (10)
Pisidium medianum (1)
Pisidium vesiculare (1)
Valvata lewisii precursor(2)
Gyraulus altissimus(1)
Fossaria parva (8)
Stagnicola caperata (12)
Pomatiopsis scalaris(2)
Succinea grosvenori gelida (4) *
Hendersonia occulta (1) *

B.Upper gray silts

Valvata lewisii precursor Many
Gyraulus altissimus Many
Fossaria obrussa decampi Many
Stagnicola palustris elodes(2)

transfer to this column

2033.04 The species represented are are all living today and also occur in Late Wisconsin deposits.

Valvata tricarinata(1)
Valvata tricarinata simplex(1)

Pomatiopsis lapidaria(7)
Stagnicola caperata(8)

6

Early Wisconsin-continued.

2033.87 All land mollusks. Is not a swamp deposit, though one species of Pisidium is present. Probably flood plain deposit beside stream. The fauna appears to resemble the early part of Early Wisconsin.

Pisidium concinnulum (3)
Succinea ovalis pleistocenica (7) Variation toward ovalis
Succinea grosvenori gelida (10)
Polygyra multilineata wanlessi (1)
Circinaria concava(1)
Hendersonia occulta (3)
Helicodiscus paralellus (1)
Gonyodiscus cronkhitei anthonyi(2)
Glyphyalinia indentata(1)
Columella alticola (2)
Carychium exile canadensis (2)
Polygyra monodon (5)
Polygyra hirsuta(3) yarmouthensis
Fossaria parva tazewelliana Many

2001.83 Terrace silts. Lower tarrace. Mixture of land and fresh water species. Not listed on original sheets.

Fresh water	Land
Pisidium compressum (4)	Succinea grosvenori gelida (1)
Pisidium novaboracense(1)	Polygyra hirsuta(2)
Pisidium concinnulum (6)	Helicodiscus paralellus (1)
Fossaria parva (7) tazewelliana	Euconulus fulvus (1)
Pomatiopsis lapidaria (6)	Vertigo ~~gouldii~~(2) loessensis
Physella integra (3)	

Early Wisconsin-continued

2034.93 Early and Late Wisconsin. The two horizons are arranged in parallel columns for comparison.

Early	Late
Succinea ovalis pleistocenica (Several)	S.ovalis (2)
Succinea grosvenori gelida (3)	------------
Polygyra monodon(1)	----------
Polygyra hirsuta (2) yarmouthensis	P.hirsuta (7)
Polygyra multilineata wanlessi(1)	P.m.wanlessi(1)
Polygyra clausa(1)	P.clausa(5)
Polygyra thyroides (2)	P.thyroides (2)
Anguispira solitaria (4)	A,solitaria Many
Glyphyalinia indentata (3)	G.indentata (6)
Zonitoides arborea (1)	-----------
Helicodiscus paralellus (8)	H.paralellus Several
Polita hammonis electrina (2)	~~P.h.electrina (2)~~
Gonyodiscus cronkhitei anthonyi(1)	------------
Gastrocopta armifera(1)	G.armifera (2)
Gastrocopta contracta Several	G.contracta (4)
Columella alticola (3)	--------------
Vertigo modesta (6)	--------------
Vertigo gouldii(4)	----------
Carychium exiguum (3)	C.exiguum (1)
Gyraulus parvus urbanensis(1)	-------------
W. Fossaria parva tazewelliana Many	F.p.tazewelliana Many
Pomatiopsis lapidaria(2)	----------
Physella integra (2)	P.integra (3)
Pisidium concinnulum Several	P.concinnulum Several
--------------	Circinaria concava (4)
--------------	Hendersonia occulta(2) rubella
-------------	Anguispira alternata(3)
---------------	Gastrocopta pentodon(2)
-------------	Strobilops virgo(1)
-------------	~~Pseudohyalina minusculus (1)~~ Striatura milium (1)

The strata in the upper part of the ravine must be very early Late Wisconsin, because of the presence of Polygyra multilineata wanlessi and Fossaria parva tazewelliana, which are thus far absent from other deposits of Late Wisconsin. Otherwise the fauna is typical of Late Wisconsin time.

Havana Report
Chapter VI. Mineral Resources. May date from 1929.

CONTENTS

Page

CHAPTER V. MINERAL RESOURCES.

The mineral resources of the Havana quadrangle, which have been developed, or may be of value at some future time, are coal, sand and gravel, clay and shale, limestone, and natural gas. Several wells have been drilled in search of petroleum, but none has yet been discovered. The water resources and the soil are of primary importance, for it is upon these resources that the prosperity of the district principally depends.

Coal.

The generalized section of the Pennsylvanian strata (fig. 16) shows coal beds at 12 horizons in the Havana quadrangle. Several of these are no value as they are too thin to be worked. Other beds may be thick enough to be worked profitably in some parts of the area, but are to variable in thickness or too discontinuous to be of any present value. The coal beds of greatest present or future value are the RockIsland (No. 1), the Colchester (No. 2), the Springfield (No. 5) and the Herrin (No. 6).

Coal beds below the Rock Island (No. 1) coal.

Several coal test borings in the northern half of the quadrangle penetrate strata 30 to 50 feet below the Rock Island coal. In some of these one or two coal beds are reported. The greatest thickness reported for any coal below the Rock Island is 2 feet 2 inches, a short distance east of Cuba. The coal bed which possesses this thickness is probably about 20 or 25 feet below the horizon of the Rock Island coal, but in this area it does not appear to sufficiently widespread to merit testing.

Rock Island (No. 1) coal.

This coal bed has been penetrated in drillings in several parts of the quadrangle, and its thickness is reported as ranging from 2 1/2 to 7 feet. It ~~###~~ is not exposed at any place in the quadrangle unless a coal bed exposed on the west side of a ravine south of Otter Creek in the SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 25, T. 4 N., R. 2 E. (Pleasant) should be the Rock Island coal. The section exposed at this locality is described on p. ___. Here the total coal exposed is 5 feet $3\frac{1}{2}$ inches, but this is in six benches, with a total of 4 feet 9 inches of shale, clay and ironstone concretions between these benches. The lowest bench is at least $2\frac{1}{2}$ feet thick, and is being stripped for local consumption. According to the information available the Rock Island coal has been found in 9 out of 26 test borings or wells drilled to its horizon. It may be present but thin in several other coal test borings, but cannot be recognized, because of the absence of its characteristic limestone cap rock. It seems to be present more continuously about $1\frac{1}{2}$ miles north of Cuba in the southern part of the Canton quadrangle than in any area which has been drilled systematically in the Havana quadrangle. but it seems to be absent northeast of Cuba. The records available show that it is fairly widespread in the southwest part of the quadrangle south of Spoon River, but in that area it may have more clay partings than it has farther north. This coal has been reported in sec. 4, T. 5 N., R. 4 E. and sec. 12, T. 4 N., R. 3 E. in the Illinois River flood plain near enough to the surface to be stripped profitably if it is sufficiently extensive and thick and free from clay partings. It probably also underlies some parts of the flood plain of Otter Creek in secs. 25, 26, 35, and 36, T. 4 N., R. 2 E. (Pleasant) and sec. 30, T. 4 N., R. 3 E. (Isabel) at such a depth that it might be stripped if it is otherwise suitable.

The coal has a hard fissile shale roof in some places and a limestone roof in others in the northern half of the quadrangle, but it may have a shale or sandstone roof in its exposures south of Spoon River. As it has not been mined at any place in this area it is impossible to state whether the roof would be suitable for underground room and pillar mining.

The principal obstacle in the development of th####### Rock Island coal in the Havana quadrangle at present is the ########### extreme irregularity of this coal, both in thickness and distribution. It will probably not be mined extensively until other more continuous coal beds in the region become exhausted.

Coal beds between the Rock Island (No. 1) and the Colchester (No. 2) coals.

There are at least 5 coal horizons between the Rock Island and Colchester coals. One of these is in each of the sequences from the 2nd to the 6th, as described in Chapter II. The only coal beds of any economic importance are those in the second and third sequences, which have been described as the Duncan Mills coals. Locally each of these coals reaches a thickness of 2 to 2½ feet, and they are commonly separated by less than 5 feet of clay and sandstone. A local drift was opened in the upper coal bed along the bank of Tater Creek about 1 mile northwest of Duncan Mills.
several
One or two coals in this position are reported in coal test borings in the vicinity of Cuba. The roof of the upper coal bed is commonly the Bernadotte sandstone, one of the hardest members of the entire Pennsylvanian section, which should form a satisfactory roof if the coal should be found to be sufficiently thick to be profitably mined. It is not likely that either of these coals will be mined extensively as long as thicker coal beds are available.

Colchester (No. 2) coal.

This coal bed underlies all of the Havana quadrangle except those parts from which it has been removed by post-Pennsylvanian erosion. Its thickness is quite uniformly 2½ feet, and it ranges from 2 feet to nearly 3 feet. It is commonly free from ###### clay partings, although pyrite occurs in it in small concretions which ### in some places form a nearly continuous bed. Fig. 141 shows the areas underlain by this coal bed. ######## The roof this coal ################ is either a soft gray shale, the Francis Creek shale or a thin bedded fine grained sandstone, the Pleasantview sandstone. The shale roof is found in most of the north half of the quadrangle, and the sandstone roof in most of the area south of an#### east-west line drawn through the southern part of Lewistown.

This coal has been mined by shafts, ##### drifts along the outcrop, and by local stripping of the beds of ravines in which it outcrops. The shaft mining is principally in the vicinity of Lewistown, where this coal lies at a depth of 50 to 80 feet below the surface. Most of this coal is sold locally. Drift mines are situated in nearly all of the ravines where the coal outcrops, but most of them were abandoned when the field work in this quadrangle was done. Commonly the coal is mined out to a distance of about 100 feet from the outcrop at the drift entrance, and the drift is abandoned and a new one opened a short distance up or down the ravine. Fig. 142 shows a slope of a ravine along the outcrop of the Colchester coal #### in which six abandoned drift# entrances are visible. Although hundreds of drifts of this kind have been operated, comparatively little of the coal has been mined. The following are notes on two of the mines in the Colchester coal, with representing both of the types of roof.

(~~Mine notes on mine at Lewistown~~).

Duvall Mine, NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 22, T.5 N., R. 3 E. (Lewistown)
Coal: 32-36 inches in mine, average 32 inches. Discontinuous band of small pyrite concretions 6 inches above base of coal, $1\frac{1}{2}$ inches bony coal near middle of bed. Also a few scattered small pyrite concretions.
Floor: Fire clay 2-3 feet, sandstone below this.
Roof: Shale (Francis Creek) 50 feet thick here, limestone above it. Lower 11 inches of this shale is a "draw slate", which causes some trouble with falls. Otherwise the shale forms a good roof.
Structure: Less than 2 feet difference in elevation of coal in this mine.

Hendree Mine, NW.$\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 6, T. 3 N., R. 3 E. (Kerton). Abandoned in May, 1928.

Coal: 28-34 inches in mine, average 30 inches. Pyrite in scattered partings, and concentrated at bottom of coal.

Floor: Fire clay.

Roof: Sandstone (Pleasantview) roof in most of mine, but 1-2 feet of soft shale between coal and sandstone in some parts of mine. Sandstone has little tendency to cave, but shale falls away from sandstone where present. Water enters through cracks in sandstone roof.

Structure: Coal bed is slightly undulating, with difference of altitude of about 2 feet in different parts of mine.

One analysis of the Colchester coal in the Havana quadrangle has been made.

See p. 19a

The Colchester coal does not appear to be near enough the surface over any large area to permit strip mining on a large scale, and its thickness is too small to permit underground mining by modern methods, unless a part of the underclay is removed along with the coal, but it is as thick as the important coal beds of some adjacent states and may be mined on a larger scale when the Springfield (No. 5) coal is more nearly exhausted in this part of Illinois.

Kerton Coal.

The only coal bed between the Colchester (No. 2) and Springfield (No. 5) coals in the Havana quadrangle is the coal bed of the eighth sequence, which is here called the Kerton coal from exposures on

Kerton Creek in the northeastern part of the Beardstown quadrangle. This coal is much more limited in distribution in the Havana quadrangle than the Colchester coal. The distribution of this coal seems to be closely connected with the "channel" in the northern part of the quadrangle which was cut before the Pleasantview sandstone was deposited. To the east and west of this channel the horizon of the Kerton coal is present, but the coal is not over 4 to 6 inches in thickness. In the channel area its thickness becomes much greater, and a number of local drifts and strip mines have been opened in this coal. This coal is known to be of minable thickness only in parts of secs. 27 and 35, T. 6 N., R. 3 E. (Putman) and secs. 19 and 20, T. 5 N., R. 4 E. (Liverpool) In the NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 27, T. 6 N., R. 3 E. (Putman) this coal is 4 feet thick with a 3 inch clay parting $2\frac{1}{2}$ feet below the top, and 37 feet below the Springfield coal. About $1\frac{1}{4}$ miles southeast in sec. 35 of the same township it is 2 feet thick and 12 feet below the Springfield coal. In the southwest quarter of sec. 35 the following section was measured in a small gully south of Big Creek where the Kerton coal had been mined locally.

		Thickness Feet	In.
	Carbondale		
14	Shale, gray, soft		8
13	Coal, hard		4
12	Shale, black, coaly, with some thin beds having coaly fracture		10
11	Coal, tough, without fracture		3
10	Shale, gray and black		2
9	Coal		5
8	Mixture of noncontinuous bands of coal, black shale and gray clay	3	2
7	Pyrite, not continuous		1
6	Coal, hard		6
5	Charcoal parting		$\frac{1}{4}$
4	Coal, hard		$5\frac{1}{2}$
3	Charcoal parting		$\frac{3}{4}$
2	Coal, hard	1	$4\frac{1}{2}$
1	Fire clay		6

The total thickness of coal in the above section is about $3\frac{1}{2}$ feet, but it is so separated by clay partings as to have little value. In a small area near the middle of the east line of the NE. $\frac{1}{4}$ sec. 19, T. 5 N., R. 4 E. (Liverpool) and in the adjacent part of sec. 20 of the same township, ### a coal which is believed to be equivalent to the Kerton coal is $3\frac{1}{2}$ feet in thickness and only about 3 feet below the Springfield (No. 5) coal. This coal is so variable in thickness and so restricted in distribution that it is unlikely that it will ever be mined except in local drift# or strip mines near its outcrop, as it has been mined up to the present time.

Springfield (No. 5) coal.

This coal bed is found only in the northern half of the quadrangle, but it has been much more extensively mined than any of the other coal beds. In the past it was mined in a number of large underground mines, as well as small drift and shaft mines and local stripping operations, but ########## since 1923 strip mining of this coal has been carried on more and more extensively, and at the present time it has nearly supplanted other methods of mining this coal.

Fig. 136 shows the approximate area########## underlain by this coal bed together with the areas from which it has been mined by large mining operations of which mine maps are available. The ######## locations of the entrances to local mines which have removed smaller quantities of coal are also indicated.

In 61 outcrops where this coal was measured and ## 377 ##### records of coal test borings which penetrated this coal it ranges in thickness from 3 feet 6 inches to 6 feet. 52 of these thickness records are below 4 feet 6 inches, 367 records show between 4 feet 6 inches and 5 feet 4 inches of coal and 19 records show between 5 feet 5 inches and 6 feet. A number of other drill records report coal less than 3 feet ######## 6 inches thick, but most of these records show that the drilling penetrated a clay seam or horseback, or that it was situated so near the outcrop of the coal that it had been thinned by preglacial weathering or erosion, so these lesser thicknesses do not represent the true thickness of the coal. The same may be true of a number of the records of coal less than 4 feet ## 6 inches thick which were tabulated above. The average thickness of the coal as determined from the 438 records is about 4 feet 9½ inches.

The coal is fairly free from bedded impurities, as it in# other parts of western Illinois. In the vicinity of Cuba the lower 1½ inches of this coal is mixed with much pyrite, and this layer which is called "false bottom" usually adheres to the underlying clay, and is left in the mine. Pyrite occurs in small concretions scattered through the coal, especially in its# upper part. The most important impurities in the coal are the "horsebacks" or clay seams which are widely distributed through the coal. These are composed of clay similar to the underlying "fire clay" which has been forced up into cracks in the coal. These "horsebacks" commonly occur in faults in the coal, whose displacements ~~is~~ vary from a few inches to 1½ feet. They are commonly branching and much coal adheres to them both between and outside of the branches, so they are a cause of much loss of coal and trouble in mining. These are not uniformly distributed in the coal, and where they are present they seem to run in all directions. In some places there is much pyrite as well as clay along these horsebacks, and in others there ## are to be found ## brownish masses of silicified or calcified wood. Such material also occurs as floor "boulders" in some mines, and causes some trouble. Sections of the coal are shown in figure 143

The floor is clay which shows little tendency to heave. Large calcareous septarian concretions are common in this clay about 1 foot below the coal, but these have little effect upon mining.

The roof is a hard fissile black shale averaging 1 to 1½ feet in thickness overlain by a softer black or black and gray shale, about 1 foot thick, locally called "clod" by the miners. Both of these beds of shale are variable in thickness. Large pyritic and calcareous concretions are found in the black fissile shale immediately above the coal. These concretions are not uniformly distributed in the slate, but are present in nearly all parts of the quadrangle underlain by the Springfield (No. 5) coal. The lower part of the shale sometimes falls when the coal is removed, and the large concretions or "niggerheads" in the shale also cause some roof falls. When the lower part of the shale has fallen and the upper softer shale exposed to the air the whole shale may fall away from the limestone caprock, which is 2½ to 4 feet above the coal. In general, however, the hard fissile shale forms a satisfactory roof for underground mining.

Notes on Mines.

The large underground mines in the Springfield (No. 5) coal were all closed at the time field work was done in the Havana quadrangle, so notes on these mines are taken from the survey files and a published report./

/ Cady, G. H. Coal Resources of District IV, Ill. State Geol. Survey, Coop. Mining Series, Bull. 26, pp. 87-104, 1921.

Big Creek Coal Company's Mine No. 2 at St. David (later owned by the Saline County Coal Corporation). Abandoned March, 1928.

~~Location and~~ Entrance: Horizontal drift near center of west line, SW. ~~¼ SE. ¼ sec.~~ 16, T. 6 N., R. 4 W. Coal mined in secs. 7, 8, 9, 16, 17, and 18, of this township, mostly in Canton quadrangle.

Thickness of coal: 4 feet 8 inches to 5 feet 4 inches, average 5 feet.

Character of coal: Uniform throughout mine, no bedded partings, horsebacks common in some parts of mine and uncommon in other parts; small discontinuous bands of pyrite and streaks of mother of coal; coal blocky in fracture, finely laminated, facings of calcite and some gypsum.

Fig. 105 shows graphic sections of the coal in this mine.__/

__/ Cady, G. H. Op. cit. P.93.

Floor: The floor is the usual light blue gray underclay, about 2½ feet thick. It heaves somewhat after about 2 years.
###

Roof: Black fissile shale 2-4 feet, under limestone cap rock average 10 inches. Immediately over coal is 1 to 2 inch layer of fine banded sandy shale and pyrite ("draw slate") which sometimes falls, but usually stays up.

Big Creek Coal Company's Mine No. 4 at Dunfermline (abandoned)

Location: Entrance: Shaft, 88 feet to coal, in NW.¼SE. ¼SE. ¼ sec. 22, T. 6 N., R. 4 E. Coal mined in secs. 14, 15, 22, 23, 26, and 27, same township.

Thickness of coal: Ranges from 5 feet 6 inches to 6 feet 4 inches, average 5 feet 8 inches.

Character of coal: No well developed benches ######, but coal shoots in layers because of dirt or charcoal bands. Thin dirt bands are about 8, 14, and 26-30 inches below top of coal and a pyrite band about 2/3 of the way down, which is not continuous. Horsebacks are commonly not over 2 inches thick, composed of gray# clay. ## ######### A thin blackjack or clay band at the bottom of the bed is about 1½ ################################ inches thick, and quite continuous. #### It is commonly dark carbonaceous shale, with a# parting just above the fire clay. Coal is cut just above this band, but it## tends to shoot with coal. Pyrite is present in coal as balls of clean pyrite commonly 2½ to 3 inches thick and 3 to 14 inches in diameter, weighing 20 to 30 pounds. The largest ones weigh as much as 200 pounds. It is estimated that the## pyrite separated is about 1/10 of 1% of the coal mined.

Floor: Fire clay, about 2 feet thick. Some rolls in floor, principally at horsebacks, which interfere# with mining. The extra pay for rolls in the fire clay is $2.80 if they are 2-6 inches high. These occur about 20-30 feet apart in mine.

Roof: Black fissile shale 12½-14 inches under black soft shale, or # "clod" 2-3 feet, under limestone cap rock 8 to 10 inches thick. Roof conditions are not especially different from those in other mines south of Canton. The interval between the cap rock and the coal seems to increase to the south and the caprock becomes a little thicker. It is harder to distinguish the true draw slate from the fissile shale ("slate") above. The lower 3 inches or so of the slate, which is commonly called draw slate does not contain the whitish limestone concretions found in mines farther north, nor are large limestone concretions composed largely of pyritized shells present. The parting just below the top of the coal is better here than farther north, so the coal breaks away better from the slate. When the lower inch or so of the slate comes down conditions are almost immediately bad for the black shale and clod have very little coherence. Over many of the entries the cap rock is present. In places the cap rock is thin, especially where it has a smooth lower surface. The lower surface is commonly rough, with small knobs that stick down into the clod (see fig. _)

Cripple Creek Coal Company's mines near Bryant. (Abandoned? 1923)

Location: Mine no. 1, Entrance SE. $\frac{1}{4}$ SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 24, T. 6 N., R. 3 E. (Putman). Horizontal drift on coal. Coal mined in parts of secs. 23, 24, 25 and 26, same township.
Mine no. 2, Entrance SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 24, T. 6 N., R. 3 E. Horizontal drift on coal. Coal mined in part of sec. 24.
The two mines and a third one, about one quarter mile north of No. 2 all loaded from same tipple.

Thickness of coal: 4 feet 6 inches to 5 feet 6 inches, average 4 feet 9 inches.

Character of coal: The coal is separated into benches by three soot or mother-coal bands, 8, 22, and 31 inches from the top of the bed respectively. The upper 12 inches of the coal is bright with dull bands up to 3/8 inch. The next 2 feet 6 inches is bright coal, with very little dull. The bands of coal are practically all under 1/8 inch in thickness. The lower bench, 12 to 18 inches thick, is composed of bright and dull laminae in about equal proportions, in bands 1/16 inch or less in thickness. Pyrite is present in joint facings and lenticular masses in the ~~#####~~ upper part of the coal 1 inch by 3 inches in dimension. Horsebacks are present in the coal and cut through it at angles varying from vertical to about 45°. The maximum ~~########~~ width is about $2\frac{1}{2}$ feet. They are of soft, medium gray clay and often finger out into the coal on both sides. They are usually accompanied by a slight displacement of the coal with resulting slips.

Structure of the coal: The coal is very hilly in this mine. One "hill" has a grade of 10%, rising 18 feet in 180 feet. It was necessary to use two miles to pull one car up this grade, which is probably the steepest in the mine. It is reported that the thickest coal is found in the "swamps" or low places (maximum 5 feet 6 inches), while the thinner coal tops the "hills".

Floor: Medium to dark gray, hard, underclay, 6 to 8 feet thick, the whole thickness not being penetrated in the mine. It contains pyrite balls and plant impressions. The floor heaves only in abandoned rooms.

Roof: Black fissile shale, 6 inches to 2 feet, under ~~under~~ 1-2 feet of soft black shale, which is under ~~#########~~ limestone cap rock. The limestone ~~#######~~ ~~#############~~ reaches a maximum thickness of 12 inches, and is absent in some parts of the mine, where it is replaced by a light gray, non-gritty, plastic shale (base of Canton shale), which is hard to hold. The lower surface of the limestone is studded with small protuberances $\frac{1}{2}$-1 inche which project down into the soft shale below. In one fall the shale over the limestone was found to be 50 feet thick (?). It contains concretions of dolomite or siderite 1 to 2 inches in maximum diameter. The draw slate just above the coal is not present in all parts of the mine, and is reported to reach a maximum thickness of 6 inches.

East Cuba Coal and Mining Co. mine (Abandoned).

Location. NE. ¼ sec. 17, T. 6 N., R. 3 E. (Putman). . Entrance shaft ##### 76 feet to coal.

Thickness of coal: Ranges from 4 feet 8 inches to 5 feet 4 inches, average 5 feet.

#C################

Section of the coal, room 1, off 2nd east off 1st south off main west

	Thickness Ft.	In.
Coal	1	11¼
Sulphur (Purite)		¼
Coal		8¾
Sulphur		1/8
Coal	2	
Sulphur		½
Coal		1½
Fire clay	4	10½

Character of the coal: Except for the lower 1½ to 2 inches of the coal, which is black jack, the coal is bright, black, and hard. No mother-coal bands were noticed. Numerous horsebacks are present in the coal.

Floor: Fire clay about 2 feet.

Roof: Black, fissile shale 2½ feet under clod (soft black shale) 6 inches and limestone 2½ feet (?). Large concretions are numerous in the black fissile shale.

Irregularities: The underground workings penetrated an old stream channel cut through the coal about 150 feet wide, and filled with sand and gravel. This is probably a buried preglacial valley along which the coal was removed.

Applegate and Lewis mine at Cuba (abandoned)

Location: NE. ¼ sec. 19, T. 6 N., R. 3 E. (Putman).

Thickness of coal: 4 feet 4 inches in 1 section given.

Section of coal, face no. 2 off 7th entry south.

	Thickness Ft.	Inches
Coal	4	3
Black Jack		1

Floor: Fire clay

Roof: Black fissile shale about 2 feet, with a kind of soft wet sandstone above. This is probably a locality where Cuba sandstone cuts out cap limestone and Canton shale.

Big Creek Coal Company's Mine No. 3 at Cuba. (Abandoned)

Location: Entrance near center of east line, SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 20, T. 6 N., R. 3 E. (Putman). Shaft about 59 feet to ###### top of coal. Coal mined in parts of secs. ## 16, 17, 20 and 21, same township.

Thickness of coal. 4 feet 8 inches to 5 feet 2 inches

Character of coal: No notes on this mine. Probably similar to other mines at Cuba.

Floor: Fire clay.

Roof: Black fissile shale under soft shale under limestone cap rock.

Irregularities: Coal is cut out extensively in the south half of sec. 16 by preglacial channels. ~~Fig. ___ shows the distribution of these channels in this mine, as indicated on mine maps.~~ ?

Star Coal Company's Mine no. 3 at Cuba. (Abandoned ## March, 1921.

Entrance in NW. 1/4 NE. 1/4 NW. 1/4 sec. 29, T. 6 N., R. 3 E. (Putman). Coal mined in parts of secs. 20, 29 and 30 of this township

Location: ~~Mine map indicates location in ############ NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ and NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 30, T. 6 N., R. 3 E. Survey notes show location in NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 20, same township (probably this is Mine No. 3 of the Big Creek Coal Co.) and in sec. 29, same township. The first location is probably correct, as an abandoned mine is situated there.~~ Entrance shaft ## 36 feet to coal.

Thickness of coal. Averages 4 feet 8 inches.

Section of the coal# measured in temporary north entry

	Thickness Ft.	In.
Coal	1	9
Parting		
Coal		8
"Soot" seam		
Coal	1	8

Character of the coal: At the section given the coal was uniform in appearance, hard and rather tough. A narrow vertical sulphur streak lay in the upper part of the bed. Horsebacks are not numerous.

Floor: Fire clay.

Roof: The roof consists of $2\frac{1}{2}$ feet of black "slate", above which is the limestone cap rock, 12 to 18 inches thick. Draw slate is reported to be absent in this mine, and niggerheads not numerous.

Strip Mines.

Tiger Coal Mining Company Mine. (Abandoned).

Location: SE. ¼ sec. 29, T. 6 N., R. 3 E. (Putman).

Thickness of coal: 4 feet 8 inches to 4 feet 10 inches.

Average thickness of overburden: 30 feet.

Character of overburden: Loess and drift about 20 feet, gray shale, (Canton) limestone cap rock, soft and hard black shale, 10 feet or less. In part of the area worked in this stripping operation. The strata down to the fissile shale over the coal have been cut out by preglacial erosion, and loess and drift extend down to within about 3 feet of the coal.

Drainage: Natural drainage, as the coal is situated above the level of a ravine which flows through the property. The walls of loess and drift became heavily soaked with water during wet seasons and slumping took place extensively, causing serious inconvenience in the mining operations. ~~##~~

United Electric Coal Company's Mine No. 9, near Cuba.

Location: Tipple is situated in NE. ¼ SW. ¼ SW. ¼ sec. 28, T. 6 N., R. 3 E. (Putman). Coal mined in parts of secs. 27, 28, 29, 33 and 34 of this township.

Thickness of coal: Average 4 feet 10 inches.

Sections of coal: See fig. 143.

Thickness of overburden: Average 35-40 feet.

Character of overburden: Loess and drift with some water laid sand and silt (Pleistocene); Shale (Canton), limestone cap rock (St. David) soft and hard black shale, with large concretions or niggerheads. The following measured sections are typical of the overburden in different parts of the mine.

Section of overburden in abandoned north cut of strip mine in the SW. ¼ NW. ¼ sec. 28, T. 6 N., R. 3 E.

	Thickness Feet	In.
Recent system		
13 Soil	1	
Pleistocene system		
Peorian		
14 Loess, buff, noncalcareous	3	2
15 Loess, gray, calcareous	3	3
Sangamon		
12 Loess, pink and gray, ~~####~~	2	6
Illinoian		
11 Gumbotil, brownish gray, very plastic when wet	3	
10 Till, reddish brown, oxidized	2	
9 Till, gray, calcareous	3	
Pennsylvanian system		
Carbondale series		
8 Shale, gray, soft, with small limestone concretions (Canton shale)	7	
7 Clay or shale, dark blue gray, fossiliferous		1½
6 Limestone concretions, not continuous, fossiliferous		7

	Thickness F##t.	In.
Pennsylvanian system (cont.)		
Carbondale series (cont.)		
5 Shale, gray, soft, with concretions	7	6
4 Clay, dark blue gray, principally composed of fossils	1	3
3 Limestone, gray, in 1 massive band (St. David		9
2 Shale, upper part soft and black, lower part black,### fissile and hard	2	6
1 Coal (Springfield)		

The total overburden# here# is 37 feet 7 $1\frac{1}{2}$ inches. It thickens somewhat to the east of this cut, and the coal has not yet been removed there.

Section of overburden in mine face (August, 1927) in SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 29, T. 6 N., R. 3 E. (Putman).

	Thickness Fte	In.
Recent system		
11 Soil	1	
Pleistocene system		
Peorian		
10 Loess, buff, noncalcareous	4	9
9 Loess, gray, calcareous	1	6
Sangamon#		
8 ############Silt, brownish gray, with carbonized wood fragments	2	6
Illinoian		
7 Gumbotil, brownish gray	2	
6 Till, yellow brown, calcareous	3	8
5 Till, brownish gray, calcareous	2	
4 Sand and gravel, reddish brown, calcareous	1	11
Illinoian or pre-Illinoian		
3 Silt and sand finely laminated, blue gray and buff, calcareous, base covered	5	10
Pennsylvanian system		
Carbondale formation		
2 Covered, includes at least 2 feet of black fissile # shale	3	
1 Coal, Springfield		

The total overburden here is 28 feet 2 inches. This cut is about one quarter mile from the outcrop of the coal beneath the Pleistocene deposits, and the limestone cap rock is absent. ####

Section of overburden in mine face (September 3, 1927), SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 27, T. 6 N., R. 3 E. (Putman).

	Thickness Feet	In.
Recent system		
Soil	1	
Pleistocene system		
Peorian		
14 Loess, buff, noncalcareous	3	2
13 Loess, gray, calcareous	2	8

	Thickness Ft.	In.
Pleistocene system (cont.)		
Sangamon		
11 Silt, ###### pinkish gray, with root canals (late Sangamon soil)		10
11 Silt, brownish gray, gumbo like, probably developed from loess	1	7
Illinoian		
10 Gumbotil, Illinoian, brownish gray, pitted surface, weathers to gumbo like surface, small pebbles of chert and quartz	5	8
9 Till, grayish, iron stained, slightly calcareous	2	10
Pennsylvanian system		
Carbondale series		
8 Shale, light #### blue gray, weathered near surface, containing scattered small concretions (Canton shale)	3	5
7 Shale, dark gray, with discontinuous band of concretions 10 inches from top, slightly fossiliferous in lower portion	1	10
6 Shale, light gray, soft, with small calcareous concretions	3	11
5 Clay or shale, dark gray, principally composed of fossil shells	1	
4 Limestone, gray, massive, in one bed (St. David)		10
3 Shale, dark gray, mottled with light gray spots, fissile, fairly soft	1	7
2 Covered, principally black fissile hard shale	1	
1 Coal, Springfield		

The total overburden here is 30 feet 4 inches. In nearly half the area which was being stripped late in 1927 and early in 1928 the St. David limestone cap rock was absent, being cut out by preglacial erosion.

Equipment: 4 electric stripping shovels, 2 6 yard shovels, with 90 foot boom, 1 8 yard shovel with 80 foot boom and
After the overburden has been stripped the coal# surface is swept, the coal is shot, and is loaded by a $1\frac{3}{4}$ yard electric shovel. The coal is hauled to the tipple in 6 ton cars, 12 cars to a trip. At the tipple the coal is cleaned at 4 picking tables, with 4 men each. The plant is designed for 4000 ton capacity.

Special features of mining: When horsebacks are encountered the coal is loaded to them, then the horseback zone is stripped and piled on the spoil banks. The limestone cap rock occurs in one bed 10 ###### to 18 inches thick, which is stripped in large masses reaching a diameter of 12 to 15 feet, which are dumped on the spoil banks. Most of the coal which has been mined up# to the spring of 1929 is in parts of the area where the overburden is less than 30 feet. A large block of coal in the central part of sec. 28 ################ where the overburden is 40 to 50 feet thick has not yet been mined. (Fig. 144 shows a typical view in this strip mine.

LIMESTONE

There are 12 limestone members in the Pennsylvanian succession exposed in the Havana quadrangle. The highest of these, the Brereton limestone, is the basal layer of the McLeansboro, 9 are in the Carbondale and 2 in the Pottsville. The greatest thickness attained by any of these limestones is 6 feet, the thickness of the Ray limestone (Pottsville) along the south bank of Seahorne Branch in part of the SE. ¼ sec. 5, T. 3 N., R. 3 E. (Kerton). The average thicknesses of most of the limestones is less than one foot, so it is unlikely that any of them will be of economic importance except for local use in competition with the thicker and purer Mississippian limestones of other parts of western Illinois.

The percentage ~~of $CaCO_3$~~ soluble in dilute hydrochloric acid ($CaCO_3$, etc.) in typical specimens of each of the 12 limestones is given here: (The member numbers are from the general Pennsylvanian section, p. ___)

Member No.	Local name	% $CaCO_3$, etc. ~~% of $CaCO_3$~~.
100	Brereton (Cap of No. 6 coal)	91.44
95		86.00
91		72.02
88	St. David	87.13
77		72.74
72		81.35
70		86.58
66		73.63
64		81.28
62		88.08
54		90.62
49	Ray	88.18

The impurities in the limestones are principally clay, minute grains of quartz, or clay particles cemented into small concretions by silica or iron oxides, and in some of the limestones pyrite, usually as the casts of fossil shells. Most of the limestones contain enough iron to weather to a brown color.

In the strip mining of the Springfield (No. 5) coal near Cuba the St. David limestone (No. 88), the cap rock of the coal is commonly removed in large blocks and piled on the spoil banks (fig. ___). Although this limestone averages only about 1 foot in thickness it could probably be separated at the stripping of the coal if there were any local demand for limestone, as for agricultural limestone. Its recovery from the spoil banks themselves would be difficult, because of the uneven topography of the stripped areas.

SAND AND GRAVEL

The supply of these materials in the Havana quadrangle comes entirely from the Pleistocene deposits. Gravel is not plentiful, and no large production may be expected from this quadrangle, but sand is very abundant in the broad terrace east of the Illinois River near Havana.

Some gravel has been dredged from the channel of the Illinois River near Havana for use in constructing a concrete wall around Beardstown, protecting it from floods. Gravel also occurs in the Illinoian and Yarmouth deposits in parts of the quadrangle.

The Yarmouth gravels are principally exposed along Big Creek and Slug Run in secs. 22, 25, 26 and 36, T. 6 N., R. 3 E. (Putman) and sec. 30, T. 6 N., R. 4 E. (Buckheart) and along Big Sister Creek in sec. 8, T. 5 N., R. 4 E. (Liverpool). (See fig. 80). This gravel ranges from 4 to 15 feet in thickness. It was exposed to weathering for a long time after its deposition before it was buried by Illinoian glacial drift and it is therefore oxidized to a brown color, some of the pebbles are largely decomposed, and it has been locally cemented into a conglomerate. All of these qualities would detract from its value as a gravel resource, and in addition it is not favorably exposed for development, as it is commonly overlain by an overburden of 20-35 feet of loess and drift.

The Illinoian gravels were deposited either in front of the advancing ice sheet, which later buried them, under the ice in subglacial channels, during a temporary recession of the ice from the area, or as outwash deposits in front of the receding ice sheet. The conditions of their deposition were, in general, not suited for a good assortment of the ffagments according to size, and changes in the rate of melting of the ice and the consequent change in the velocity of flow of the glacial waters, caused frequent variations in the size of the materials deposited, from coarse gravels or boulder deposits to sands. Sands and gravels deposited under these conditions are especially abundant in the west central part of the quadrangle along Stuart Creek and its tributaries in secs. 13 and 14, T. 5 N., R. 2 E. (Bernadotte), along a tributary of Big Creek in sec. 7, T. 5 N., R. 3 E. (Lewistown), and along the north branch of Otter Creek in sec. 24, T. 4 N., R. 2 E. (Pleasant). The greatest thickness of gravel of Illinoian age is exposed in the high cut bank on the sough side of a tributary of Stuart Creek in the NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 13, T. 6 N., R. 2 E. (Bernadotte) shown in fig. 85. The total amount of gravel in this cut is $24\frac{1}{2}$ feet.
See described section p. (212-214, Ch. II)
The overburden consists of 8-10 feet of loess, $14\frac{1}{2}$ feet of till and $6\frac{1}{2}$ feet of sand. ~~The gravel itself occurs in 3 layers, separated by about 7 feet of till and 5 feet of sand.~~ The layers of gravel and sand in this cut seem to be somewhat lenticular and the proportions given here might change a short distance back from the outcrop. The gravel and the sand are here fairly well assorted, and have not been much weathered. This locality is, however, ###### about 4 miles from the nearest railroad, so it# could ## be probably developed only for local use.
Insert 30a.

The soil and surficial deposits in the terrace east of the Illinois River near Havana are nearly all sandy, but the level terrace areas ~~con~~ ####### are underlain by a more impure sandy loam than the hills, which are principally well assorted dune sand. The principal dune areas are

Secondary concentrations of gravel are found in ~~the form of~~ bars in streams flowing ####### past exposures of Pleistocene gravels, and gravels may also be concentrated by streams out of the glacial drift (see fig, (Ch. I, p. 10)). Small supplies of ###### rather well washed gravel for local use in road construction or repair might be obtained from such concentrations in the smaller streams in many parts of the quadrangle.

shown on the geologic map (Plate I). The thickness of sand here is not known, but the Havana city wells penetrate about 75 feet of sand and gravel. Several of the dune areas are situated near railroad lines and sand pits could be easily opened in these. In the NW. $\frac{1}{4}$ sec. 7, T. 21 N., R. 8 W. (Havana) there is a dune area near the Illinois Central and Chicago and Illinois Midland (shown on map as Chicago, Peoria and St. Louis) railroads. A dune ridge continues south through sections 7, 18, and 19 of the same township just west of the Chicago and Illinois Midland R. R.

This railroad also crosses a small sand dune area in the NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 33, T. 22 N., R. 8 W. This area adjoins the most extensive dune tract in the quadrangle. State Highway 43, east of Havana crosses a sand dune belt nearly 2 miles in width in secs. 4 and 5, T. 21 N., R. 8 W. Some of the sand dune areas might also be accessible to the proposed Illinois River deep waterway

(~~Probable uses to which the sand may be put~~)

asphalt
asbestos shingle

Sieve analysis
Common molding sd. 125 Dune sand
Asphalt
Stock 105
Engine 113
Traction 115
Filter 112
Cutting 111
Core 111
~~Glass~~ 165
Shingles 101
Friction 117
Polishing 123
Plaster 131
R.R. 124
Brewing 139
Sweeping 141
Tumbling 141
(Sandbags
Levees 136

CLAY AND SHALE

Clay and shale are abundant in the Pennsylvanian strata exposed in the Havana quadrangle. Excluding the carbonaceous, ~~###~~ calcareous and sandy shales there are 10 shale members and 12 under ~~fire~~clay horizons in the general succession of Pennsylvanian strata. (P. ___). Six shales and 3 under- ~~fire~~ clays are in the Carbondale series and 4 shales and 8 under- ~~fire~~ clays in the Pottsville.

The under ~~fire~~ clays are much thinner than the shales and unless they are sufficiently refractory for ~~######~~ the manufacture of fire brick and other refractory materials their use would be less satisfactory than that of the shale. The under ~~fire~~ clays also contain large calcareous septarian concretions scattered through them and some pyrite and gypsum, which would be undesirable impurities.

The shales which are thickest and could be most easily ~~#####~~ dug are the Canton shale (members 90-92) about 28-30 feet thick, with a thin limestone concretion band about 8 feet from its base, the Purington shale (member 74) about 30-50 feet thick and the Francis Creek shale (member 59), which varies from 18-20 feet in the east central part of the quadrangle to 45-50 feet in the west central part.

Four samples of clay and 1 of shale were collected and burning tests were made upon them by the Department of Ceramics of the University of Illinois. The results of these tests, together with field notes describing the exposures from which the samples were taken are given here:

Sec. 30, T. 4 N., R. 3 E. (Isabel)

Two samples, nos. 118 and 119, were collected in the ravine exposure just west of State Highway 31 south of the bridge over Otter Creek. The section exposed here is as follows: (fig. 146)

10

		Thickness Feet	In.
15	Clay, gray, with large septarian calcareous concretions	1	6
14.	Coal		8-10
13.	Clay, gray	3	
12.	Limestone concretions, fossiliferous, not continuous here, but forming a limestone ledge 3 feet thick about 300 feet further up ravine	1	
11.	Clay, gray, with large calcareous concretions	2	
10.	Coal parting		1
9.	Clay, gray, with large unfossiliferous calcareous concretions and gypsum crystals	2	6
8.	Coal parting		1
7.	Clay, gray, with gypsum crystals	3	
6.	Sandstone, fine grained, hard		4
5.	Sandstone, thin bedded	5	
4.	Shale, gray, or clay	4	6
3.	Shale, dark gray		2
2.	Coal		$1\frac{1}{2}$
1.	Clay, gray, poorly bedded	3	

Sample no. 118 is from no. 1 and sample no. 119 is from no. 4 of the above section.

Sample no. 118.

Kind of material.. .Clay

Drying conduct.. Good

Volume drying shrinkage 18.22%

Linear drying shrinkage 6.63%

Water of plasticity.. 23.22%

Bonding strength - Modulus of rupture -- Lbs. per sq. in. 282.8

Burning test:

Temp. Fahr.	Cone	Volume shrinkage per cent	Linear shrinkage per cent	Porosity	Color	Fracture
1904°	05	10.97	3.80	20.11	Tan	Granular
2057°	02	18.05	6.42	11.86	Dark tan	Granular
2129°	2	17.83	6.34	14.68	Dark tan	Granular
2174°	4	Bloated		#5.71		
2282°	7	Bloated		15.37		

Fusion test: Clay not refractory

Oxidizing conduct: Poor.

Summary: Drying shrinkage medium high, bonding strength medium, vitrification-overburns suddenly between cones 2 and 4. Shrinkage at cone 2 is medium low. It is nonrefractory.

Suggested uses: Building brick, possibly hollow tile.

Sec. 1, T. 4 N., R. 2 E. (Pleasant).

Two samples, nos. 117 and 120, were collected along the ravine south of the C. B. & Q. R.R. near the middle of the west line of this section, where the following section is exposed:

	Thickness Feet	In.
15. Sandstone, thin to massive bedded, uneven lower surface (Pleasantview)	60	
14. Shale, gray (Francis Creek)	8-11	
13. Coal (Colchester or no. 2)	2	6
12. Underclay	4	
11. Sandstone	4	
10. Shale and nonbedded clay	5	
9. Coal		6-10
8. Underclay	1	6
7. Limestone, blue, fossiliferous	1	
6. Clay, not bedded	5	
5. Sandstone, white, coarse, granular	1	3
4. Shale, gray	6	
3. Shale, black		4
2. Coal		1
1. Underclay	5	

Sample no. 117 was collected from bed no. 8 and sample no. 120 was collected from bed no. 12, the underclay of the Colchester (No. 2) coal. Samples

Water of plasticity 24.3%

Bonding strength ½ modulus of rupture ... Lbs. per sq. in. 363.34

Bulk specific gravity 1.90

Burning test:

Temp. Fahr.	Cone	Volume shrinkage per cent	Linear shrinkage per cent	Porosity	Color	Fracture
1904°	05	16.27	5.75	15.92	Light buff	Smooth
2057°	02	20.12	7.215	9.49	Light buff	Smooth
2129°	2	21.76	7.854	1.28	Light tan	Smooth
2201°	5	Bloated		3.40	Overburdened	Smooth
2246	6	Bloated		16.05		

Fusion test: Clay not refractory.

Oxidizing conduct: Good.

Summary: Drying shrinkage medium, bonding strength medium, vitrification complete at cone 2, overburned at cone 2, burning shrinkage at vitrification medium low. It is a nonrefractory clay.

Suggested uses: Building brick, possibly drain tile, hollow tile, etc.

Sec. 23, T. 6 N., R. 3 E. (Putnam).

no. 116,

A sample of the Canton shale, was collected along a gully in the NE. ¼ SW. ¼ of this section. The section exposed here is as follows:

	Thickness Feet	In.
Sandstone, thin and thick bedded, very fine grained (Cuba sandstone)	20	
Shale, slightly sandy, evenly bedded	5-6	
Shale, gray (Canton shale) (see fig. ___)	25 +	

Sample 116.

Kind of material ....Clay (Shale)

Drying conduct ....Good

Volume drying shrinkage 18.52%
Linear drying shrinkage 6.60%

Water of plasticity 27.00%

Bonding strength - modulus of rupture .. Lbs. per sq. in. 230.0

Bulk specific gravity 1.865

Burning tests:

Temp. Fahr.	Cone	Volume shrinkage per cent	Linear shrinkage per cent	Porosity	Color	Fracture
1904°	05	26.61	9.80	10.60	Light red	Vitreous
2057°	02	30.10	11.25	.09	Dark red	Vitreous
2129°	2	29.05	10.30	0	Dark red	Vitreous
2174°	4	Bloated		Overburned		
2246°	6	Badly bloated		"		Vitreous

Fusion test: Clay not refractory

Oxidizing conduct: Good

Summary: Drying shrinkage medium, bonding strength medium, vitrification complete at cone 02, overburned at cone 4, burning shrinkage at vitrification medium. It is a nonrefractory clay.

Suggested uses: Building brick, possibly drain tile, hollow tile, roofing tile, and flower pots.

The Canton shale has been used in the vicinity of Canton for the manufacture of paving, ~~and~~ building and sidewalk brick, hollow block and drain tile [1]

[1] Savage, T. E. Geology and Mineral Resources of the Avon and Cant[on] quadrangles, Illinois State Geol. Survey, Bull. 38, p. 262, 1921.

and it could probably make equally satisfactory products in the Havana quadrangle.

Purington shale.

No samples of this were collected for tests, as similar shale in the stratigraphic position has been used for many years at East Galesburg, Knox County in the manufacture of paving brick. [1]

[1] The results of tests of a sample of this shale collected at East Galesburg is published in "Clay Materials in Illinois Coal mines", by R. T. Stull and R. K. Hursh, Illinois State Geol. Survey, Coop. Coal Mining series, Bull. 18, p. 37, 1917. It is stated that it is suitable for common, front and paving brick and hollow tile.