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1957

Geology and Mineral Resources of the BEARDSTOWN, GLASFORD, HAVANA, and VERMONT QUADRANGLES

Harold R. Wanless

BULLETIN 82

ILLINOIS STATE GEOLOGICAL SURVEY
JOHN C. FRYE, *Chief* URBANA, ILLINOIS

Geology and Mineral Resources of the BEARDSTOWN, GLASFORD, HAVANA, and VERMONT QUADRANGLES

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ILLINOIS STATE GEOLOGICAL SURVEY BULLETIN 82

Urbana, Illinois 1957

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Topographic Mapping in Cooperation with the United States Geological Survey

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GEOLOGY AND MINERAL RESOURCES OF THE BEARDSTOWN, GLASFORD, HAVANA, and VERMONT QUADRANGLES

HAROLD R. WANLESS

CHAPTER I—INTRODUCTION

LOCATION AND EXTENT

The Beardstown, Glasford, Havana, and Vermont quadrangles are located in west-central Illinois, extending generally along Illinois River Valley from near Peoria southwestward about fifty miles (fig. 1). Most of the area is in Fulton County, with small parts in surrounding counties. Each quadrangle is a rectangle bounded by 15-minute parallels of latitude and meridians of longitude, is approximately 17 miles long and 13 miles wide, and has an area of about 225 square miles. The individual maps are on a scale of 1:62,500, or about one inch to one mile. Subsequent to the geologic mapping, the Havana and Vermont quadrangles have been topographically remapped on a larger scale, so that in addition to 15-minute maps, for each quadrangle there are available four maps of 7½-minute quadrangles on a scale of 1:24,000. However, the geologic map illustrations in this report are drawn on the smaller scale.

IMPORTANCE OF AREA

The area includes one of the most important coal strip-mining districts in the State. Strip mining is carried on in each of the four quadrangles but is concentrated in the north half of the Havana quadrangle. Other lesser industries are the quarrying of limestone and of sand and gravel. Clay and shale deposits were formerly worked, but no clay plants are now in operation. The presence of cheap water transportation along the Illinois River offers encouragement to mineral production, particularly coal.

The area has a rich diversity of geologic features. The upland plain northwest of Illinois River is dissected by a multitude of streams along whose valleys exposures of bedrock formations and glacial deposits are abundant. Many years ago it was selected as the typical reference area for the principal numbered coals of the State (Worthen, 1870). In the more recent classification of the Pennsylvanian system according to cyclic sedimentation, the type localities of eight of the cyclothems are in these four quadrangles and several others are in adjoining areas.

Illinois Valley has had a long and complicated history, recorded in its landforms and in deposits in and adjacent to the valley. More recently, aboriginal Indians had important settlements along the valley, and the study of their mounds and village sites has contributed largely to our understanding of the prehistory of the central United States. One large burial mound has been set aside as Dickson Mounds State Park.

The report and the accompanying maps present fundamental geologic information about the area and its mineral resources and interpret this information.

HISTORY OF INVESTIGATION

This report incorporates the results of work by several geologists who are or have been members of the Illinois State Geological Survey.

In 1922 T. E. Savage, assisted by Alfred H. Meyer, mapped the geology of the Vermont Quadrangle. Before Savage's report could be published, it became largely outdated by rapid advances in the knowledge about Pennsylvanian and Pleistocene geology in Illinois, so remapping was required. The Pennsylvanian and older bedrock formations were remapped in 1931-32 by J. M. Weller, assisted by W. C. Krumbein and Rex McGehee. The Pleistocene geology was remapped in 1932 by W. C. Krumbein, assisted by David M. Delo.

The Beardstown quadrangle was mapped geologically by W. V. Searight in 1925-27, assisted by M. E. Leatsler (1925), A. W. Quinn (1926), and H. W. Mumford Jr., (1927). The Pleistocene geology was remapped and the bedrock geologic mapping was reviewed and partly revised in 1932-33 by W. C. Krumbein assisted by David M. Delo (1932) and W. A. Newton (1933). The revised mapping of both quadrangles was under the supervision of George E. Ekblaw, then Head of the Areal Geology Division of the Survey.

The Havana quadrangle was mapped geologically in 1927 and 1928 by H. R. Wanless, assisted by H. B. Willman. The Glasford quadrangle was mapped in 1928-29 by A. C. Bevan, assisted by Sidney E. Ekblaw and D. L. Carroll.

In 1930 Towner B. Root restudied the geology and mineral resources of the Illinois Valley part of the area, and the geology of the rest of the area was reviewed by C. S. Gwynne and H. A. Sellin in connection with a state-wide study of road materials under the direction of George E. Ekblaw.

In 1936 H. R. Wanless was assigned to prepare a report on the four quadrangles. This involved a unified revision of all previously submitted reports, the assimilation of the data previously noted by all the geologists listed above as well as of some others, and field work sufficient to correlate the phenomena observed by the numerous workers, but there was no attempt to remap any areas. The report was prepared largely in 1937 and 1940 to 1944 under the direction of George E. Ekblaw and was modernized in 1955-56 under the direction of H. B. Willman, Head of the Division of Stratigraphy and Areal Geology.

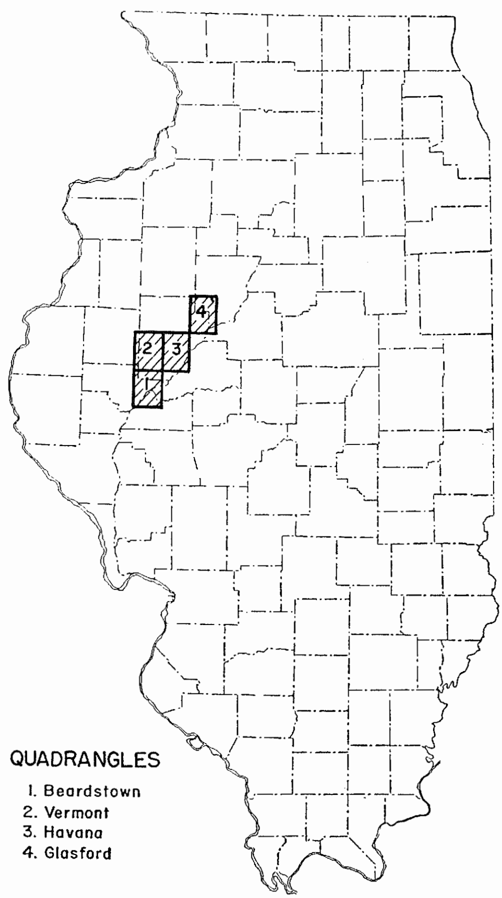


FIG. 1.—Location of the Beardstown, Glasford, Havana, and Vermont quadrangles.

ACKNOWLEDGMENTS

It is impossible to acknowledge properly the part that the several geologists who had worked in the area have had in the preparation of this report, because it is based on their notes, maps, and reports, although the nomenclature and interpretations have of course been brought up to date. The cooperation of George E. Ekblaw, who provided much help in office discussion and in the field while the original report was being prepared under his direction, and of H. B. Willman, who revised the final manuscript for publication and prepared final copy for the geologic maps, is especially acknowledged. Other members of the Survey staff assisted in several ways—M. M. Leighton advised on the interpretation of the Pleistocene succession, J. Marvin Weller aided in the identification of Pennsylvanian faunas and contributed much to the interpretation of the Pennsylvanian sedimentary record, and Gilbert H. Cady, Emeritus Head of the Coal Section, and Jack Simon, present Head of the Section, cooperated in gathering data regarding coal exploration and mining in the area, and parts of the final report were critically read by

Elwood Atherton, A. H. Bell, R. E. Bergstrom, C. W. Collinson, F. L. Doyle, George E. Ekblaw, J. E. Lamar, A. B. Leonard, Jack Simon, and W. A. White. The officers of United Electric Coal Company, Truax-Traer Coal Company, and Morgan Brothers Coal Company have generously made available the records of test-drilling made by their companies in connection with strip-mining operations. The residents of the area have extended full cooperation to the several geologists who have worked in the four quadrangles.

PREVIOUS PUBLICATIONS

The first publications that treat the geology of the Beardstown-Glasford-Havana-Vermont area comprehensively are those of the original Geological Survey of Illinois under the direction of A. H. Worthen, as follows:

Fulton County, by A. H. Worthen, Geological Survey of Illinois, v. IV, p. 75-89, 1870.

Cass and Menard Counties, by H. M. Bannister, Geological Survey of Illinois, v. IV, p. 163-175, 1870.

Tazewell, McLean, Logan and Mason Counties, by H. M. Bannister, Geological Survey of Illinois, v. IV, p. 176-189, 1870.

McDonough County, by A. H. Worthen, Geological Survey of Illinois, v. V, p. 253-265, 1873.

Peoria County, by A. H. Worthen, Geological Survey of Illinois, v. V, p. 235-252, 1873.

Schuyler County, by A. H. Worthen, Geological Survey of Illinois, v. IV, p. 75-89, 1870.

Reports on the geology of adjacent quadrangles have been published as follows:

Geology and Mineral resources of the Avon and Canton quadrangles, by T. E. Savage, *in* Illinois Geol. Survey Bull. 38, p. 1-67, 1922.

Colchester-Macomb Folio, by Henry Hinds, Geological Atlas of the United States, Folio 208, 14 p., U. S. Geological Survey, 1919.

Geology and Mineral Resources of the Peoria Quadrangle, by J. A. Udden, U. S. Geol. Survey Bull. 506, p. 1-100, 1912.

Coal, limestone, shale and clay, and water resources have been discussed in other bulletins of the State Geological Survey, and several shorter articles on various phases of the local geology have been published in scientific journals. (See References, p. 186-188.)

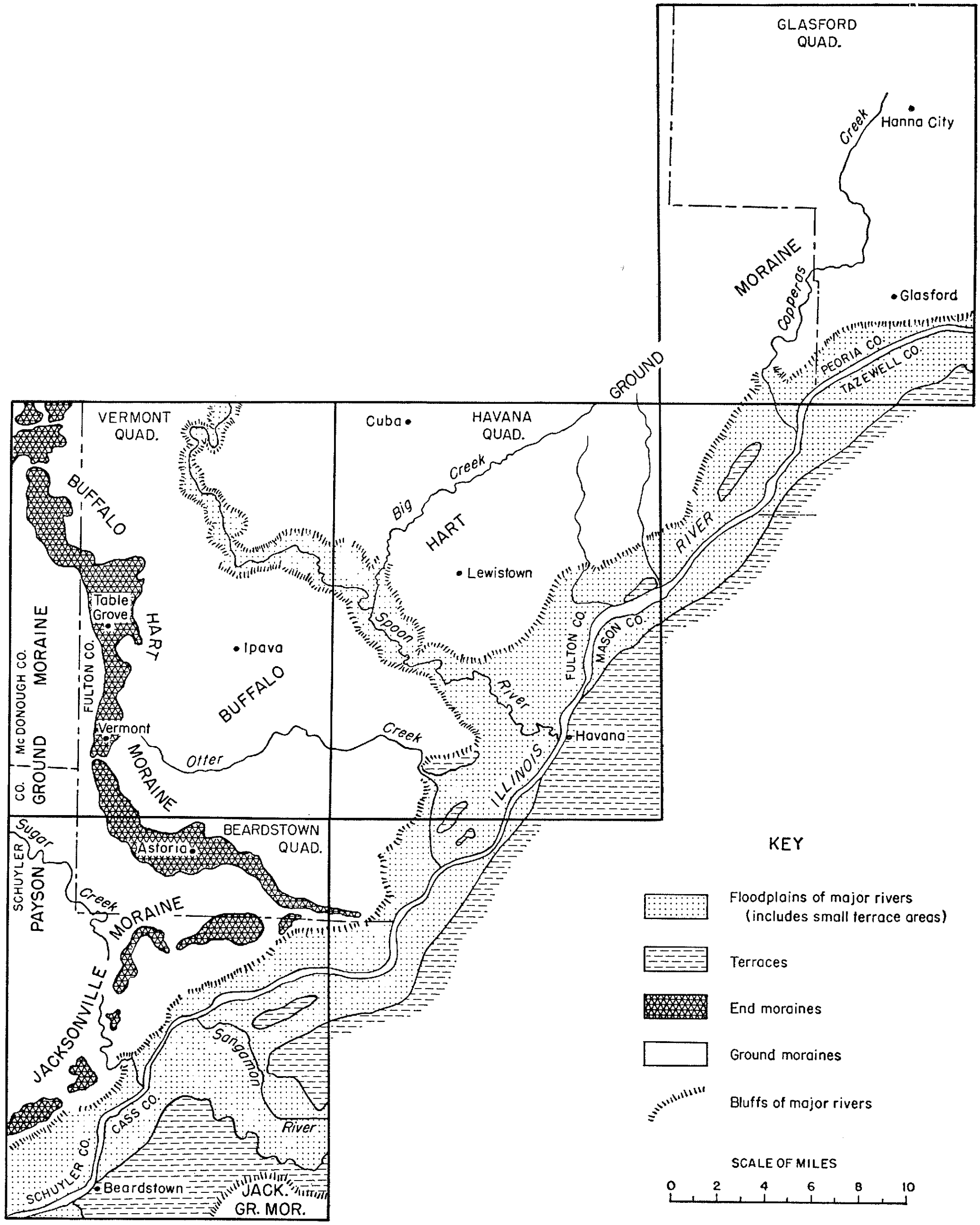


FIG. 2.—Distribution of major physiographic features.

CHAPTER 2—PHYSIOGRAPHY

GENERAL SETTING

The Beardstown-Glasford-Havana-Vermont area is in the midst of a region of rolling plains crossed by the valleys of three major rivers (fig. 2). Hundreds of tributaries of these streams have dissected the original plain surface so that now about half the land is in slopes (pls. 1-4). The slopes are commonly in forest and pasture, in contrast with the extensively cultivated uplands, bottomlands, and terraces.

Physiographically the area is in the Galesburg Plain of the Till Plains Section of the Central Lowland Province (Leighton, Ekblaw, and Horberg, 1948). Most of it is in late youth in the erosion cycle and distinctly different from the plain of Wisconsin drift to the northeast, which is more youthful, and from the dissected plains of Kansan till in Missouri and Iowa, which generally are maturely eroded.

Relief

The highest elevation in the four quadrangles is 790 feet above mean sea level in the northwest-central part of the Glasford quadrangle. The lowest elevations, small depressions in the Illinois River floodplain in the southwest part of the Beardstown quadrangle, are about 426 feet above sea level. The maximum relief of the quadrangles is therefore 364 feet. The greatest local relief is in the vicinity of Frederick and Pleasantview in the southwest part of the Beardstown quadrangle, where the upland is as much as 310 feet above the Illinois Valley floor within 2½ miles of the river. The least eroded upland area is in the central-west part of the Vermont quadrangle. Extensive lowland areas of slight relief occur in the alluvial plains of the Illinois, Sangamon, and Spoon rivers in the southeast parts of the Beardstown and Havana quadrangles.

Climate

The climate of the area is typically temperate. The mean annual temperature ranges from 49.8° at Peoria to 53.0° at Rushville. The mean monthly temperature at Havana ranges from 26.6° in January to 77.5° in July. The growing season averages 177 days between killing frosts. The average annual precipitation is 34 inches, and the average unmelted snowfall is 20.9 inches. As the runoff is about one-fourth of the rainfall, disastrous floods in the major rivers have followed periods of concentrated rainfall, as in 1926-27 and 1943. On the average, 178 days are clear and 177 days are cloudy or partly cloudy.

PHYSIOGRAPHIC PROCESSES

The predominant processes in the development of the topography of the area have been glaciation and the activities of streams, winds, and lakes. The preglacial topography was produced largely by stream erosion, but it was completely concealed by deposits left by the glaciers. Most of the glacial deposits were later mantled by wind-borne loess. During the advance and retreat of the glacier Illinois Valley carried an immense flow of meltwater which at times was heavily laden with sediment and at other times was relatively clear. The valley floor was alternately built up and cut down depending on the load carried by the stream as it reached this area. The glacial topography away from Illinois Valley has been greatly modified by stream erosion.

Man has become an important factor in the topographic development of the area, especially in alteration of the natural drainage. Meandering Sangamon River has been diverted into a straight ditch. Many miles of artificial levees have been constructed along Illinois River and along the ditches which carry drainage from the uplands to the river. Deforestation and cultivation of valley slopes has increased the runoff following heavy rains so that many slopes have been trenched by gullies. Strip mines have left a maze of debris ridges with many small lakes between.

TOPOGRAPHIC FEATURES

The main topographic features of the area are the broad gently rolling uplands dissected by a maze of small valleys, the broad lowlands adjacent to Illinois and Sangamon rivers, and the narrower lowland adjacent to Spoon River (fig. 2). The uplands and small valleys constitute about 77 percent and the three larger valleys 23 percent of the area of the four quadrangles. The upland consists of glacial till plains and moraines of the Illinoian glacial stage and preglacial rock ridges not wholly obliterated by glacial deposits.

The lowlands include the floodplains of the present rivers and terraces representing former levels of the valley floor. A broad terrace, covered in part by sand dunes, lies southeast of the present floodplain of Illinois River in the Glasford, Havana, and Beardstown quadrangles.

Uplands

The uplands are sharply separated from the valley floors of the larger rivers by steep bluffs. They are gently rolling and slope from drainage divides toward the valleys of the larger streams. The uplands range in altitude from 790 feet about two miles southeast of Farmington in the Glasford quadrangle to 550 feet just north of Spoon River near Illinois Valley.

RIDGES

Two of the ridges on the uplands are Illinoian glacial moraines. Others are partially buried preglacial hills. The glacial moraines are old enough so that many of their diagnostic features have been obliterated either by erosion or by later burial with loess which in turn has been modified by erosion.

The Buffalo Hart moraine in the Beardstown and Vermont quadrangles (pls. 1, 4) exhibits in plan a series of bulges with intervening reentrants. A gap of 20 miles in the moraine was cut away by later glacial floods along the Illinois Valley. The moraine is highest near Table Grove in the Vermont quadrangle, where it has an altitude of more than 720 feet, 50 feet above the surrounding plain. The moraine is characterized by a series of rounded knobs rising generally about 20 feet above adjacent lower parts of the moraine. No natural undrained depressions are shown on the topographic maps.

The Jacksonville moraine occurs in the Beardstown quadrangle (pl. 1) where it is overridden by the Buffalo Hart moraine. The moraine ranges in width from one-quarter to three-quarters of a mile and commonly rises 20 to 40 feet above the adjacent plain. It is about 100 feet lower than the Pleasantview rock ridge west across Sugar Creek.

The Pleasantview rock ridge trends northwest from Frederick to the center of the west side of the Beardstown quadrangle (pl. 1) and the village of Pleasantview is on it. Bedrock exposures in sec. 26, T. 2 N., R. 1 W., extend to an elevation of 720 feet, although the till plains both north and south of the ridge have elevations as low as 620 to 650 feet. The slopes of the ridge are so steep that streams have cut a series of parallel ravines on the slopes. Proximity of the ridge to Illinois River produces the greatest local relief in the four quadrangles.

The Farmington ridge is a high drainage divide trending east-west across the northern part of the Glasford quadrangle (pl. 2). The ridge is a broad highland of indefinite limits and slopes from 790 on the west side to 740 feet on the east side of the quadrangle. Bedrock rises to 725 feet at several places and the ridge is probably controlled by the resistant Lonsdale limestone.

Several other drainage divide ridges may be traced for some distance across these quadrangles.

TILL PLAINS

The major part of the uplands consists of relatively level till plains. The till is buried beneath two loess deposits and is extensively dissected by stream erosion. Because loess accumulated to the greatest depth adjacent to Illinois River bluffs there is locally a slight slope from the bluff crests away from the Illinois Valley. In the southeastern part of the Beardstown quadrangle, sand dunes are present on top of the Illinois bluffs. The largest remaining area of undissected till plains is in the central-western part of the Vermont quadrangle, west of the Buffalo

FIG. 3.—Aerial photograph of a portion of the Illinoian till plain showing a multitude of shallow drainage courses that are not shown on the topographic map (pl. 2) fingering into the drainage divide between the headwaters of a tributary to Copperas Creek on the northwest and Little Lamarsh Creek on the southeast. The "L" road corner near the center of the photograph is the southwest corner of sec. 1, T. 7 N., R. 6 E., Glasford quadrangle. Scale about 3 inches equals 1 mile. Photo by U. S. Commodity Stabilization Service.

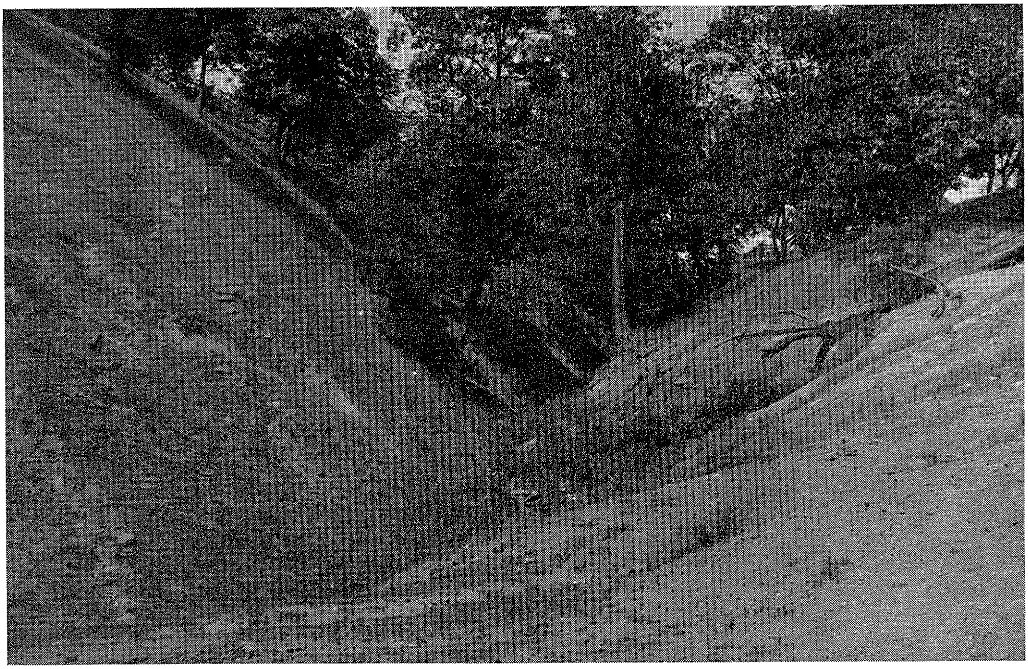


FIG. 4.—Typical valley eroded largely in Pennsylvanian shale in Illinois Valley bluffs, in the SW ¼ SW ¼ sec. 14, T. 5 N., R. 4 E., Havana quadrangle.

Hart moraine. However, the till plains are more extensively eroded than they appear to be on the topographic maps. For example, sec. 1, T. 7 N., R. 6 E., on the topographic map, appears uneroded except for a few small headwater branches of Little Lamarsh Creek in the southern third, whereas the air photograph of the same area (fig. 3) shows an intricately branched system of shallow drainage courses. The headwaters of the drainage courses are clearly shown as dark bands that consist of black topsoil washed from the drainage divides into the drainage courses. Farther downstream the dark topsoil has been cut through and the stream courses show as light bands. The photograph also brings out the soil color gradation from the dark soils of the level drainage divides to the lighter colored, somewhat better drained soils on slopes adjacent to the stream course.

VALLEYS

Most valleys in the area head in unconsolidated glacial deposits and downstream are entrenched in Pennsylvanian bedrock. The valleys in glacial till generally have gentler slopes than those in bedrock.

The variable character of the Pennsylvanian strata, which include relatively resistant beds of sandstone, limestone, and coal and nonresistant beds of shale and underclay, is reflected in the smaller valleys. The limestones and coals, generally thin, commonly form rapids or falls in the streams and ledges along valley slopes (fig. 36). In the thicker sandstones the streams have cut narrow V-shaped gorges at many places and locally flow directly on a floor of sandstone relatively free from debris. The thicker shales and underclays are responsible for broader valleys with gentler slopes, except where overlain by resistant strata.

The lower parts of some valleys in the Beardstown and Vermont quadrangles have been cut into Mississippian strata belonging to the St. Louis, Salem, and Warsaw formations. The St. Louis is a massive limestone, very resistant to erosion. The Salem and Warsaw formations do not differ greatly from the Pennsylvanian in resistance to erosion, the Warsaw resembling the Pennsylvanian shales and the Salem the limestones and sandstones.

ILLINOIS VALLEY

Illinois Valley is the most prominent topographic feature of the area. It is 17 to 20 miles wide where partly in the Glasford and Havana quadrangles and 6 to 12 miles where it crosses the Beardstown quadrangle. The valley floor may be divided into 1) bottomlands and narrow terraces three to four and a half miles wide along the northwest side of the valley and 2) a belt of terraces 10 to 80 feet above the bottomlands and covered at many places with sand ridges, some of which rise as high as 80 feet above the terrace plain.

The bluffs of the Illinois Valley in the area are steep. They average 140 to 160 feet high, ranging from 80 feet just north of the junction with Spoon River Valley to more than 200 feet near Cottonwood School in the Beardstown quadrangle. The bluffs are furrowed by many small stream valleys (fig. 4) that have cut back into the uplands an average distance of about two miles. The river does not abut the valley bluffs at any place in these quadrangles, and it touches the edge of the terraces only at Beardstown, Havana, and Chautauqua Park. The river formerly meandered more than at present, as shown by old meander scars in the bluffs near Tindall School and Banner in the Glasford quadrangle, near the mouth of Big Sister Creek, Sepo, and Enion in the Havana quadrangle, and near Sheldons Grove and Browning in the Beardstown quadrangle. Narrow belts of low terrace preserved in the reentrant angles suggest that the meandering stage occurred during deposition of the low terrace deposits. The terrace is cut away from the areas where the upland projects into the valley. During 1927 Illinois River experienced one of its greatest floods. The flood waters reached the base of the bluff at a few places. The high-water stage was maintained for several months and waves cut low notches at the base of the bluffs and piled driftwood along the shore (fig. 5).

The floodplain of Illinois River averages three to four miles wide. The principal topographic features of the floodplain are natural levees, linear lakes representing abandoned channels of the river, alluvial fans formed by tributary streams entering the valley, and partially buried alluvial bars. Natural levees commonly rise about 4 feet above the average level of the floodplain and border both the present and abandoned channels of the river.

The primitive valley contained numerous large lakes and a maze of meandering channels between them. Many of these lakes have been drained, but a portion of the undrained valley floor remains in the Beardstown quadrangle (fig. 6).

The tributary streams are retarded upon entering the Illinois Valley and some of their sediment is deposited as fans. They vary from steep-sided fans a few hundred feet across at the lower ends of gullies in the Illinois bluff to the fan at the mouth of the Sangamon River, which is a flat plain several miles long and only 4 to 8 feet above the Illinois floodplain. Much of the curving of Illinois River is due to its deflection by fans from tributary valleys. Some well developed fans are also built on the terraces.

Within the floodplain several isolated areas rise 8 to 16 feet above the general floodplain level and are free from flooding by most floods. They seem to be eroded remnants of the lowest terrace but may be unusually high bars of the recent floodplain, now largely buried by younger alluvium.

TERRACES

The terraces in the Illinois Valley southeast of the river are part of a large triangular area that covers about 500 square miles in Mason and Tazewell counties (fig. 59, pls. 1-3), but of which only about 40 square miles are in the Glasford, Havana, and Beardstown quadrangles.

The terrace areas northwest of Illinois River are narrow remnants along the base of the bluffs and many of them are partly buried by slope wash or fans of small streams.

The following terraces have been differentiated along the Illinois Valley: a) Bloomington outwash and slackwater terrace; b) the Manito terrace; c) the Havana terrace; d) the Bath terrace; and e) the Beardstown

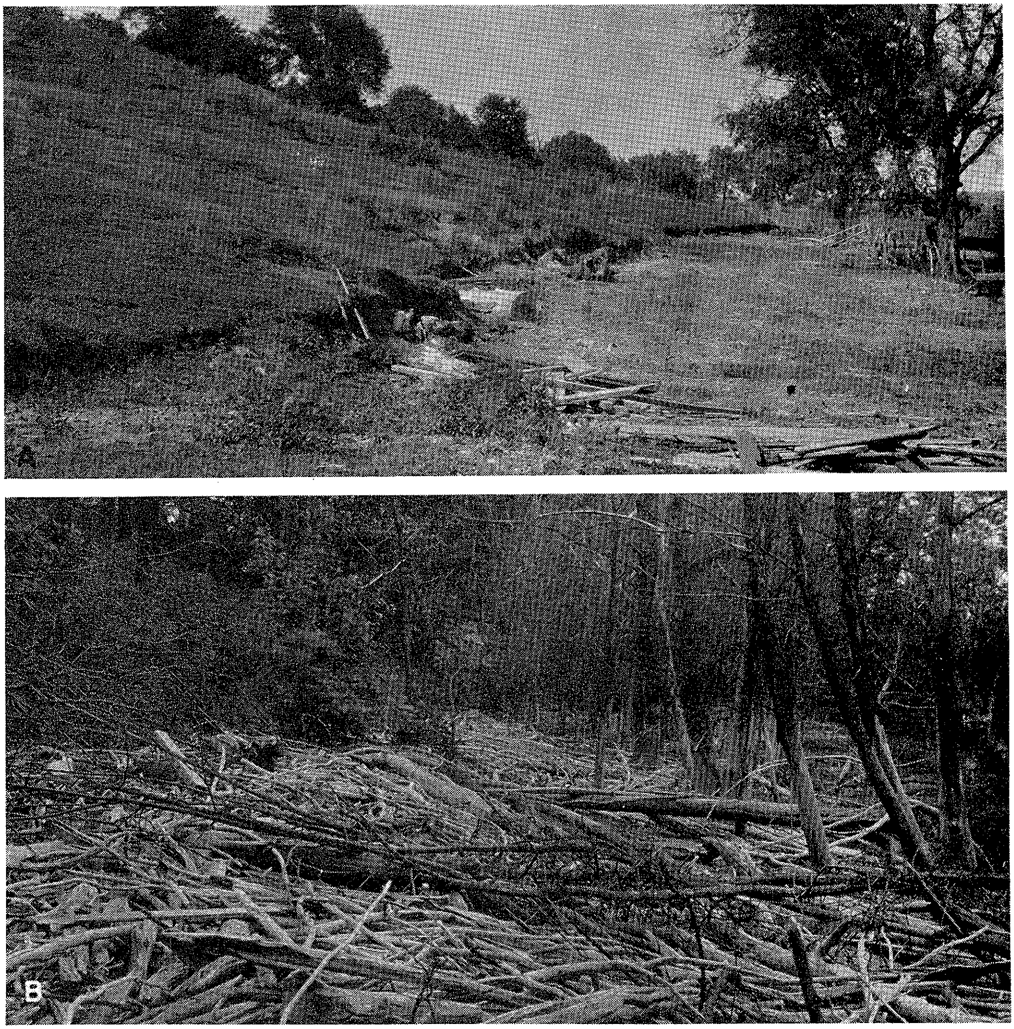


FIG. 5.—Base of Illinois River bluff showing the effect of the 1926–1927 floodwaters.
A.—Scarp one to two feet high cut by waves in the NE ¼ SW ¼ sec. 35, T. 4 N., R. 3 E., Havana quadrangle.
B.—Similar scarp covered by drift wood in sec. 10, T. 22 N., R. 8 W., Manito quadrangle.

terrace. Deposits in these terraces are described in the chapter on Post-Pennsylvanian Stratigraphy and their method and time of development is discussed under Geologic History.

Bloomington outwash terrace.—The original surface of Bloomington outwash is preserved only where protected in the lee of prominent headlands. Bloomington slackwater deposits survive in tributary valleys, such as the lower parts of Copperas, Buckheart, Otter, and Sugar creeks. They extend for many miles up Spoon River. They are commonly loess- or silt-covered benches 480 to 550 feet above sea level and are generally about 40 feet above the streams in their present lower courses.

Manito terrace.—The Manito terrace covers the largest portion of the terrace area southeast of Illinois River. The surface above 500-foot elevation south of Spring Lake in secs. 28 and 29, T. 24 N., R. 6 W., in the Glasford quadrangle, belongs to this terrace. Two sand ridges on the terrace rise to ele-

FIG. 6.—Aerial photograph of a part of the Illinois River floodplain which has not been modified by levee building, including Treadway Lake in the Beardstown quadrangle. Compare with plate 1. Light-colored muddy water of Illinois River mixes with clear lake water near the middle of Treadway Lake. The Beardstown terrace in the lower right corner is also in the upper left corner of figure 8. Scale about 3 inches equals 1 mile. Photo by U. S. Commodity Stabilization Service.

FIG. 7.—Aerial photograph of Havana terrace showing the distinctive mottled soil pattern in an area of low relief. The dark band is the shallow swampy valley of Quiver Creek. The edge of the terrace and Lake Chautauqua show in the upper left corner. The west one-fourth mile is in the Havana quadrangle (pl. 3) and the remainder in the Manito quadrangle. The road crossing Quiver Creek in the central west part is in the NW ¼ NW ¼ sec. 22, T. 22 N., R. 8 W. Scale about 3 inches equals 1 mile. Photo by U. S. Commodity Stabilization Service.

vations of more than 540 feet in sec. 29, and about six miles southwest of that locality two sand ridges rise nearly to 600 feet. In the Havana quadrangle the terrace level is 485 to 490 feet above sea level. Sand ridges rise 30 to 40 feet above the terrace surface and several undrained depressions extend 10 feet or more below the mean terrace level.

Havana terrace.—The Havana terrace slopes from about 485 feet elevation in the southeast corner of the Glasford quadrangle to about 465 feet in the south part of the Havana quadrangle. The valley of Quiver Creek in the Havana and Manito quadrangles was one of the important spillways of the Havana stage (fig. 7). The highest of three terraces south of Sangamon River in the Beardstown quadrangle is referred to the Havana terrace. Small remnants of the terrace are present along the northwest side of the Illinois Valley, especially in protected situations like the reentrant angle in the bluff at the mouth of Otter Creek valley in the Havana quadrangle.

Bath terrace.—The Bath terrace slopes from an elevation of about 465 feet in the Havana quadrangle to about 445 feet in the south part of the Beardstown quadrangle. It has a few low dunes or sand ridges, the highest of which rise to about 500 feet above sea level.

Beardstown terrace.—The Beardstown terrace, ranging in elevation from 436 to 445 feet above sea level, is a low plain without prominent sand ridges and only about 10 feet higher than the Illinois River floodplain. The terrace is marked by abandoned channels that show extraordinary meandering (fig. 8, pl. 1). Some of these channels appear to have belonged to Illinois River and others to Sangamon River and to have been formed at a time when the two streams joined about 4½ miles south of their present junction.

The Beardstown terrace is clearly differentiated from the present Illinois floodplain by the abandoned meanders, which contrast with the straight course of the present river. They are much larger than the Sangamon River meanders.

SANGAMON VALLEY

The Sangamon Valley crosses the Beardstown quadrangle only in its lower 5 to 10 miles where it merges with the Illinois Valley. In this area it is a valley about four miles wide, entrenched in the Illinois Valley terraces. The Sangamon River had a very meandering course before it was diverted to a straight artificial channel (pl. 1). The average radius of curvature of the meanders is one-quarter to one-half mile. Former meanders preserved in the Beardstown terrace have a radius of curvature about twice as large. Sangamon River has changed its channel frequently and there are numerous small crescent-shaped lakes of the oxbow type. The natural channel has a small natural levee.

SPOON VALLEY

The valley of Spoon River is about 25 miles long from the north border of the Vermont quadrangle to its junction with Illinois Valley in the Havana quadrangle. It varies in width from about 2½ miles just above its junction with Illinois Valley to about three-tenths of a mile in the interval between Seville and Bernadotte, but above Seville it widens to about 1½ miles. The wide sections of the valley correspond with pre-Illinoian valleys where the bedrock surface is relatively low, and in the narrow sections the valley is entrenched mainly in bedrock.

A large entrenched meander of the valley occurs at Seville, and the river flows four miles to reach a spot one mile southwest of the bridge at Seville. Below this meander the valley follows a comparatively straight course as far as Bernadotte, but below there it meanders. The radius of curvature of the Spoon River meanders is larger than that of the Sangamon River meanders. Small natural levees border the river in the Havana quadrangle. Numerous terrace remnants are present along both sides of the valley, even in the narrow portions. Remnants of the Bloomington outwash and slackwater terrace are abundant and extend throughout the area. The Havana terrace is recognizable as far upstream as the mouth of Big Creek, and the Beardstown terrace extends about one mile upstream from the Illinois Valley.

FIG. 8.—Aerial photograph of the Beardstown terrace showing abandoned meanders mapped on plate 1. The northwest corner overlaps the area shown in figure 6. The meander at the top is in the central part of sec. 31, T. 19 N., R. 11 W., Beardstown quadrangle. Scale about 3 inches equals 1 mile. Photo by U. S. Commodity Stabilization Service.

DRAINAGE

The rainfall in the area supports a widely branched drainage system of closely spaced streams that flow into the Illinois, Sangamon, and Spoon rivers. The upland areas all have abundant drainage courses, except for a belt near the western margin of the Vermont quadrangle. There are no natural lakes or swamps in the uplands. The drainage pattern of the uplands is generally dendritic and directed toward the major streams, but the dendritic pattern is interrupted by a series of stream courses in a northeast-southwest direction, developed marginal to the Jacksonville moraine.

The lowland area of the Illinois Valley is poorly drained and has extensive lakes and marshes. During the flood of 1927 the entire floodplain was inundated for several months, except for a few of the areas protected by levees. One large lowland lake, Chautauqua Lake, in the eastern part of the Havana quadrangle, is artificial. After the area was flooded in 1927 the levees were not rebuilt except as needed to prevent the drainage of the lake, which is now a migratory waterfowl refuge. The terrace area east of the Illinois River is composed largely of sand and is almost without drainage courses.

Rivers

Illinois River.—Illinois River, which drains about half of Illinois and parts of Wisconsin and Indiana, carries most of the runoff of this region. It crosses the Glasford, Havana, and Beardstown quadrangles, and, through Spoon River, Otter Creek, and Sugar Creek, receives the drainage of nearly all of the Vermont quadrangle.

Illinois River at Beardstown carries the natural drainage from about 22,400 square miles. Since 1900 it has also carried water diverted from Lake Michigan. Illinois River flows 66 miles from the eastern margin of the Glasford quadrangle to the southwest corner of the Beardstown quadrangle, as opposed to an air-line distance of about 57 miles between these points. The mean shore line of Illinois River descends from 436.5 feet to 428.5 feet above sea level in the 66 miles, a drop of 8 feet, or an average gradient of a little less than two inches per mile.

Previous to the diversion of water from Lake Michigan, Illinois River is reported (Leighton, M .O., 1907) to have had an average daily flow near Beardstown of 1,587 second-feet for the three driest months, a daily average of 30,030 second-feet for the three wettest months, and an annual daily average of 5,261 second-feet. The maximum discharge since diversion of Lake Michigan water was 105,000 second-feet on October 9, 1926, and the minimum 9,140 second-feet in July 1936. The average daily discharge since 1920 at Beardstown has been 23,767 second-feet, at Havana 22,265 second-feet, and at Peoria 16,613 second-feet.

The depth of the river channel in the portion of the valley covered by this report in 1933 varied from 6 to 23 feet and averaged 12 to 16 feet. The minimum depth was at the mouth of Spoon River. The channel was only 10 feet deep at the mouth of the Sangamon. The maximum depth occurs about one mile upstream from the mouth of the Sangamon. For navigation purposes a 9-foot channel is maintained. The width of the river ranges from about 500 to 1000 feet, although at the junction with floodplain lakes, as near Havana, it is locally as broad as 2000 feet. At the time of major floods the river occupies nearly all of the floodplain.

The river is probably flowing on alluvial sediments throughout most of the area. In the Glasford quadrangle several coal-test borings near the north bank of the river show the bedrock surface only two or three feet lower than the elevation of the river bed, so there may be small areas where the river flows on bedrock. The river transports principally fine gravel, sand, and silt.

Sangamon River.—Sangamon River crosses the southeast part of the Beardstown quadrangle. The river has been shifted from its natural meandering course into a drainage ditch, except in the lowest 6½ miles. The old channel was 13½ miles long and the present channel is 10½ miles long between the east line of the quadrangle and the junction with Illinois River, a linear distance of seven miles.

Sangamon River drains an area of 2,360 square miles in central Illinois. Its principal stream is about 200 miles long. Sangamon River drops 7.6 feet in 10½ miles, a little less than nine inches per mile. The annual average daily discharge near Oakford, 17½ miles east of the Beardstown quadrangle varied from 807 second-feet in 1931 to 3,778 second-feet in 1933 (Smith, 1937, p. 402-414). Daily discharge varied from 85 second-feet in August, November, and December, 1914, to a maximum 125,000 second-feet in May, 1943.

The ditched portion of the Sangamon has an average width of about 200 feet, but the floodplain is as broad as four miles in the Beardstown quadrangle. At Oakford a high-water stage of 21 feet above low water has been recorded. After Sangamon River was straightened, increased erosion doubled the width of its channel (Pickels and Leonard, 1929). At the mouth of the river the channel is rapidly silting up because it is ponded by backwater from the Illinois River.

Spoon River.—Spoon River follows a winding course through the northeast part of the Vermont quadrangle and the south part of the Havana quadrangle, entering Illinois River opposite Havana. Spoon River flows 39 miles from the northern boundary of the Vermont quadrangle to its mouth, a linear distance of 19¼ miles, and drains an area of 1,790 square miles. Its principal stream is about 115 miles long. It carries drainage from the north half of the Vermont quadrangle and most of the northwest half of the Havana quadrangle.

Spoon River drops 36.7 feet in the 39 miles in the area, an average of about 11 inches per mile. The gradient is uniformly 16 inches per mile as far downstream as Duncan Mills, 13 miles above its mouth, where it changes to 3 inches per mile at the head of the fan built into Illinois Valley. The annual discharge at Seville has varied from 339 second-feet per day in 1934 to 2,598 second-feet in 1927. Daily discharge varied from 3.8 second-feet in August of 1914 to 28,900 second-feet in August of 1924. Floods are frequent but are generally brief. The average width of Spoon River is 100 to 200 feet at low-water stage when the depth is 2 or 3 feet, but at the highest stage the river is 1½ miles wide and more than 20 feet deep.

Spoon River meanders from side to side, widening its valley by lateral erosion at the expense of bedrock, glacial deposits, or terrace materials. It transports sand in the main channel and locally some gravel during flood stages. The deposits formed in its alluvial plain are largely silt and fine sand. At its mouth Spoon River has built a large fan into the Illinois Valley, and in that area is bordered by low natural levees. The fan and levees are outlined by the 440-foot contour between Mound Chapel, Sepo, and Havana in the Havana quadrangle.

Sugar Creek.—Sugar Creek heads in the west-central part of the Vermont quadrangle, follows a winding course for about 38 miles, and joins Illinois River about five miles above Beardstown. The linear distance from the head of Sugar Creek to its mouth is 19 miles. The creek drains an area of 142 square miles. It descends 230 feet in 38 miles, an average of about 6 feet per mile. Because its valley is commonly 150 to 250 feet deep and it is fed by closely spaced tributaries with high gradients, it rises rapidly after heavy rains, but floods do not persist long. Sugar Creek transports gravel, sand, and silt. However, it has not built a prominent fan into Illinois Valley because Illinois River is here crowded toward the northwest side of its valley by the larger Sangamon River fan.

Copperas Creek.—Copperas Creek heads in six main branches in the Glasford quadrangle. The longest stream, East Branch, has a meandering course about 25 miles long in a straight-line distance of 15 miles. The drainage area is about 113 square miles. The gradient is 11½ feet per mile. Copperas Creek has a prominent fan, outlined by the 440-foot contour, where it enters Illinois River.

Lakes and Marshes

Lakes were originally common in the Illinois, Sangamon, and Spoon river valleys. Although many of the lakes have been drained and their basins protected from flooding by artificial levees, many remain in the Beardstown and Havana quadrangles. Most of these lakes are former channels of the river. Spoon and Sangamon rivers commonly form crescent-shaped lakes of the oxbow type. Illinois River is not meandering and the lakes in its valley are generally narrow elongate lakes parallel to the river. Spring Lake in the Glasford quadrangle, Liverpool, Quiver, and Matanzas lakes in the Havana quadrangle, and Stewart, Crane, Long, and Treadway lakes and Muscooten Bay in the Beardstown quadrangle are examples. Several large lakes of this type have been drained, including Thompson Lake north of Havana, which was four miles long. An old channel can apparently be traced through Treadway Lake and Hager Slough into Muscooten Bay in the Beardstown quadrangle. Knapps Island, between Stewart and Crane lakes in the Beardstown quadrangle, is an old river bar now being surrounded and buried by younger alluvial sediment. Large floodplain lakes like Stewart and Crane lakes and Quiver Lake and the former Thompson and Flag lakes in the Havana quadrangle are just upstream from the Sangamon and Spoon river fans.

Springs

Small springs and seeps are common along the slopes of most valleys, especially at the junction of the glacial deposits and Pennsylvanian shales. Much slumping along valley slopes results from the continuous wetting of plastic clays and shales by seep water.

SYSTEM	SERIES	GROUP	FORMATION	GRAPHIC COLUMN	THICKNESS (FEET)	LITHOLOGY
QUATERNARY	PLEISTOCENE				0-200	Loess, till, sand, gravel, silt (details in figure 50)
TERTIARY	PLIOCENE				0-10	Gravel
PENNSYLVANIAN		McLeansboro Carbondale Tradewater			500	Shale, sandstone, clay, coal, limestone (details in figure 22 and table 3)
MISSISSIPPIAN	VALMEYER	Meramec	St. Louis		0-150	Limestone, light, cherty
			Salem		0-46	Dolomite, sandstone, and sandy shale
		Osage	Warsaw		0-75	Shale, dolomitic, with geodes
			Keokuk		0-140	Limestone, cherty
			Burlington		80-100	Limestone, cherty
	KINDERHOOK	Hannibal	Maple Mill		75-150	Shale, greenish and gray
		Champ Clark	Grassy Creek		110-160	Shale, brownish gray to black
DEVONIAN	SENECAN		Cedar Valley		0-100	Limestone, crystalline, dolomitic, sandy
			Wapsipinicon		0-35	Limestone, dolomite
SILURIAN	NIAGARAN				0-210	Dolomite, light gray, cherty
	ALEXANDRIAN		Kankakee		0-45	Dolomite, light gray
			Edgewood		15-20	Dolomite, sandy, shaly
ORDOVICIAN	CINCINNATIAN		Maquoketa		70-90 6-30 50-90	Shale, dolomitic, brown Dolomite, brownish gray Shale, dolomitic, brown to black
	MOHAWKIAN		Galena		175-200	Dolomite, buff, crystalline, porous
			Decorah		5-20	Dolomite, shaly
			Platteville		100	Dolomite, buff, fine-grained
			Glenwood		60-100	Sandstone, shale and dolomite, glauconitic
	CHAZYAN		St. Peter		170-250	Sandstone, light buff, incoherent
	PRAIRIE DU CHIEN		Shakopee		160	Dolomite, reddish, argillaceous
			New Richmond		70	Sandstone, dolomitic
			Oneota		353	Dolomite, with oolitic chert
			Gunter		36	Dolomite, sandy
CAMBRIAN	ST. CROIXAN		Trempealeau		250	Dolomite, light to pinkish
			Franconia		131	Dolomite, sandy, glauconitic
			Galesville		137	Sandstone, light buff, incoherent
			Eau Claire		2' penetrated	Dolomite, sandy

FIG. 9.—Generalized columnar section of exposed strata and strata penetrated in wells.

CHAPTER 3—PRE-PENNSYLVANIAN STRATIGRAPHY

SUMMARY

The bedrock in the Beardstown, Glasford, Havana, and Vermont quadrangles represents all the Paleozoic systems up to and including the Pennsylvanian (fig. 9). The greater part of the area is covered by glacial deposits, loess, and alluvial sediments, but Pennsylvanian and Mississippian strata crop out at many places. The sequence and character of unexposed strata are known from the records of several hundred coal test borings that penetrate Pennsylvanian strata and from more than 200 deep water wells and oil test borings that penetrate deeper strata. Only one well penetrates Cambrian strata (table 1).

All formations exposed or penetrated in borings in or near the Beardstown-Glasford-Havana-Vermont area are sedimentary in origin. Granite or other types of crystalline rocks of pre-Cambrian age probably underlie the area at depths of 4000 to 5000 feet but they have not been reached by boring in this area.

The composite maximum thickness of all the formations exposed and penetrated by wells in the area is about 3500 feet. Strata as young as the Trivoli cyclothem crop out in the Glasford quadrangle and others as old as the Warsaw formation crop out in the Beardstown and Vermont quadrangles. There are also important unconformities, the most notable at the base of the Pennsylvanian system (figs. 23, 24). Pennsylvanian strata in places directly overlie the St. Louis, Salem, Warsaw, Keokuk, and Burlington formations.

The relations of the formations are shown in four cross sections (figs. 10-14), and the description of seven typical deep wells are given in appendix B.

CAMBRIAN SYSTEM

Cambrian strata underlie all parts of the Beardstown, Glasford, Havana, and Vermont quadrangles but are penetrated only in a deep well in the NE¼ NE¼ sec. 8, T. 5 N., R. 3 E., Fulton County, at Depler Springs. No accurate record was kept of the strata penetrated in this boring. The best records of Cambrian strata near the quadrangles are for the deep well of the Midland Electric Coal Company in the NE¼ SE¼ NE¼ sec. 2, T. 8 N., R. 3 E., Fulton County (well 2, app. B) and City Well No. 2 at Canton, both in the Canton quadrangle which is adjacent to the Havana and Glasford quadrangles. The records have been compared with those of wells at Monmouth, Warren County, and Galesburg, Knoxville and Abingdon, Knox County, to determine the nature of variations of the Cambrian in this part of Illinois. Regional correlations have been made by Workman and Bell (1948).

The entire Cambrian section under this area is probably more than 2000 feet thick but only the upper 567 feet is penetrated in the Midland Electric Coal Company well. Cambrian formations encountered in this well are the Eau Claire, Galesville, Franconia, and Trempealeau.

St. Croixan Series

EAU CLAIRE FORMATION

The Eau Claire formation seems to be represented by the sandy dolomite in the basal 2 feet of the Midland Electric Coal Company well. Where fully penetrated in northern Illinois, the Eau Claire is as thick as 500 feet. It is more shaly and dolomitic and more firmly indurated than the overlying Galesville formation. Except in the basal part, the sand in the Eau Claire is much finer grained than that in the Galesville.

GALESVILLE FORMATION

The Galesville sandstone has been penetrated in several deep water wells near the area and is doubtless persistent throughout this part of the State. It is white or buff, fine to coarse sandstone that is incoherent or weakly indurated with dolomitic cement. It is 137 feet thick in the Midland Electric Coal Company well but the thickness ranges from 120 to 140 feet in four wells in nearby areas.

TABLE 1.—THICKNESS AND ALTITUDE DATA FOR MAQUOKETA SHALE AND UNDERLYING FORMATIONS IN DEEP WELLS

Location					Maquoketa thickness	Top Galena	Galena-Platteville thickness	Top Glenwood	Glenwood-St. Peter thickness	Top Shakopee	Shakopee-New Richmond-Oneota thickness	Top Gunter	Cambrian thickness
Twp.	R.	Sec.	Quarter	County									
10N.	1E.	20	SE SW NE	Knox	202	–155	285	–440	145	–585	(33+)	—	—
9N.	1W	11	Cen. NW NW	Warren	195	–125	295	–420	(120+)	—	—	—	—
9N.	5E.	7	NW NE SW	Peoria	95	–475	315	–790	132	–922	(10+)	—	—
8N.	3E.	1	W½ SW	Fulton	162	–350	312	–666	(209+)	—	—	—	—
8N.	3E.	2	SE NE	Fulton	176	–356	301	–659	268	–925	580	–1510	(567+)
8N.	4E.	1	SW SE	Fulton	160	–448	325	–783	(130+)	—	—	—	—
8N.	5E.	27	SE SW	Peoria	178	–546	297	–840	(77+)	—	—	—	—
8N.	6E.	10	NE SE NE	Peoria	201	–536	299	–835	(200+)	—	—	—	—
8N.	7E.	2	NE NE	Peoria	200	–660	—	—	—	—	—	—	—
8N.	7E.	9	SE NE	Peoria	192	–652	313	–965	(100+)	—	—	—	—
8N.	7E.	26	SE SE	Peoria	200	–745	315	–1060	(199+)	—	—	—	—
8N.	8E.	18	NE SE	Peoria	200	–737	(25+)	—	—	—	—	—	—
7N.	6E.	22	NW SW	Peoria	220	–736	280	–1016	(55+)	—	—	—	—
7N.	4E.	27	SE SE	Fulton	?	–510	310	–820	(210+)	—	—	—	—
7N.	4E.	27	SW SE	Fulton	200	–490	300	–790	235	–1025	(6+)	—	—
7N.	4E.	34	NW NW	Fulton	175	–510	290	–800	282	–1082(?)	—	—	—
7N.	4E.	34	NW NW	Fulton	240(?)	–510	290	–800	304?	–1069	(329+)	—	—
7N.	4E.	34	NW NW	Fulton	150(?)	–509	280	–795	273	–1062	(388+)	—	—
7N.	4E.	34	SE NE	Fulton	175	–490	305	–789	(241+)	—	—	—	—
7N.	3E.	33	NW NE NW	Fulton	180	–443	288	–731	(336+)	—	—	—	—
7N.	3E.	33	NE NW NW	Fulton	210	–460	318	–778	122	–900	(110+)	—	—
7N.	1E.	14	NE NW	Fulton	140	–345	(35+)	—	—	—	—	—	—
7N.	1W	1	SE SW NW	McDonough	142	–172	311	–483	(224+)	—	—	—	—
7N.	1W.	33	Center	McDonough	163	–272	303	–559?	(210+)	—	—	—	—
7N.	1W.	33	SE SE NW	McDonough	168	–252	295	–547	270	–817	(40+)	—	—
6N.	2W.	19	SE SE	McDonough	175	–25	(23+)	—	—	—	—	—	—
6N.	2W.	20	NE NW	McDonough	155	–75	(125+)	—	—	—	—	—	—
6N.	2W.	31	NE SW	McDonough	—	—	—	—	225	–660	(270+)	—	—
6N.	1E.	17	SE SE SW	Fulton	199	–253	264	–517	(13+)	—	—	—	—

6N.	1E.	23	SE SW SW	Fulton	177	-338	285	-623	(200+)	—	—	—	—
6N.	1E.	31	SW	Fulton	180	-227	(95+)	—	—	—	—	—	—
6N.	3E.	17	SE SW	Fulton	190	-503	290	-793	298(+?)	-1091(?)	—	—	—
6N.	4E.	29	NE SW	Fulton	172	-557	(213+)	—	—	—	—	—	—
5N.	2E.	24	NE SW	Fulton	208	-465	(20+)	—	—	—	—	—	—
5N.	2E.	29	SW NE	Fulton	195	-412	(158+)	—	—	—	—	—	—
5N.	1W.	13	NE SE	McDonough	185	-280	(31+)	—	—	—	—	—	—
23N.	6W.	31	SE NW SE	Mason	195	-700	320	-1020	(166+)	—	—	—	—
4N.	1E.	6	NE NE	Fulton	181	-302	273	-575	(27+)	—	—	—	—
4N.	1E.	18	NW NW	Fulton	175	-313	(41+)	—	—	—	—	—	—
4N.	1E.	29	NW SW	Fulton	200	-369	279	-645	(5+)	—	—	—	—
4N.	1E.	29	NW SW	Fulton	202	-369	275	-649	(20+)	—	—	—	—
4N.	2E.	6	SE SW	Fulton	200	-385	279	-654	(20+)	—	—	—	—
4N.	2E.	6	SE SW	Fulton	200	-365	270	-640	290	-930	—	—	—
4N.	3W.	30	NW SW NE	McDonough	196	-140	251	-391	(4+)	—	—	—	—
22N.	8W.	31	SE NE	Mason	240	-670	288	-965	(7+)	—	—	—	—
3N.	1W.	20	NW NW	Schuyler	185	-290	(140+)	—	—	—	—	—	—
3N.	2W.	9	NE NW	Schuyler	187	-229	(79+)	—	—	—	—	—	—
3N.	4W.	21	NW SE SE	Schuyler	186	?	245	?	(7+)	—	—	—	—
2N.	2W.	8	NW SE	Schuyler	194	-214	(89+)	—	—	—	—	—	—
2N.	2W.	9	NW SE	Schuyler	188	-305	(70+)	—	—	—	—	—	—
2N.	1W.	30	SE NE	Schuyler	190	-312	295	-607	265(+?)	-872	—	—	—
2N.	1W.	32	NE NE	Schuyler	170	-290	(160+)	—	—	—	—	—	—
18N.	12W.	15	SW NE	Cass	125	?	325	-582	(15+)	—	—	—	—
18N.	12W.	15	(now in river)	Cass	125	-246	375?	-615	(52+)	—	—	—	—
19N.	10W.	15	SE NE NE	Mason	98	-462	354	-816	245	-1061	(168+)	—	—
1N.	1E.	18	SW SE	Schuyler	189	-307	(19+)	—	—	—	—	—	—
1N.	2W.	11	NE SW	Schuyler	188	-227	(55+)	—	—	—	—	—	—
1N.	2W.	25	SW SW	Schuyler	182	-241	(298+)	—	—	—	—	—	—
1N.	2W.	28	SE SE	Schuyler	182	-242	(186+)	—	—	—	—	—	—
1N.	2W.	28	SE NW	Schuyler	189	-264	(2+)	—	—	—	—	—	—
17N.	10W.	29	NW NW	Cass	120	-503	(182+)	—	—	—	—	—	—
1S.	2W.	33	Center NE	Brown	186	-209	(129+)	—	—	—	—	—	—

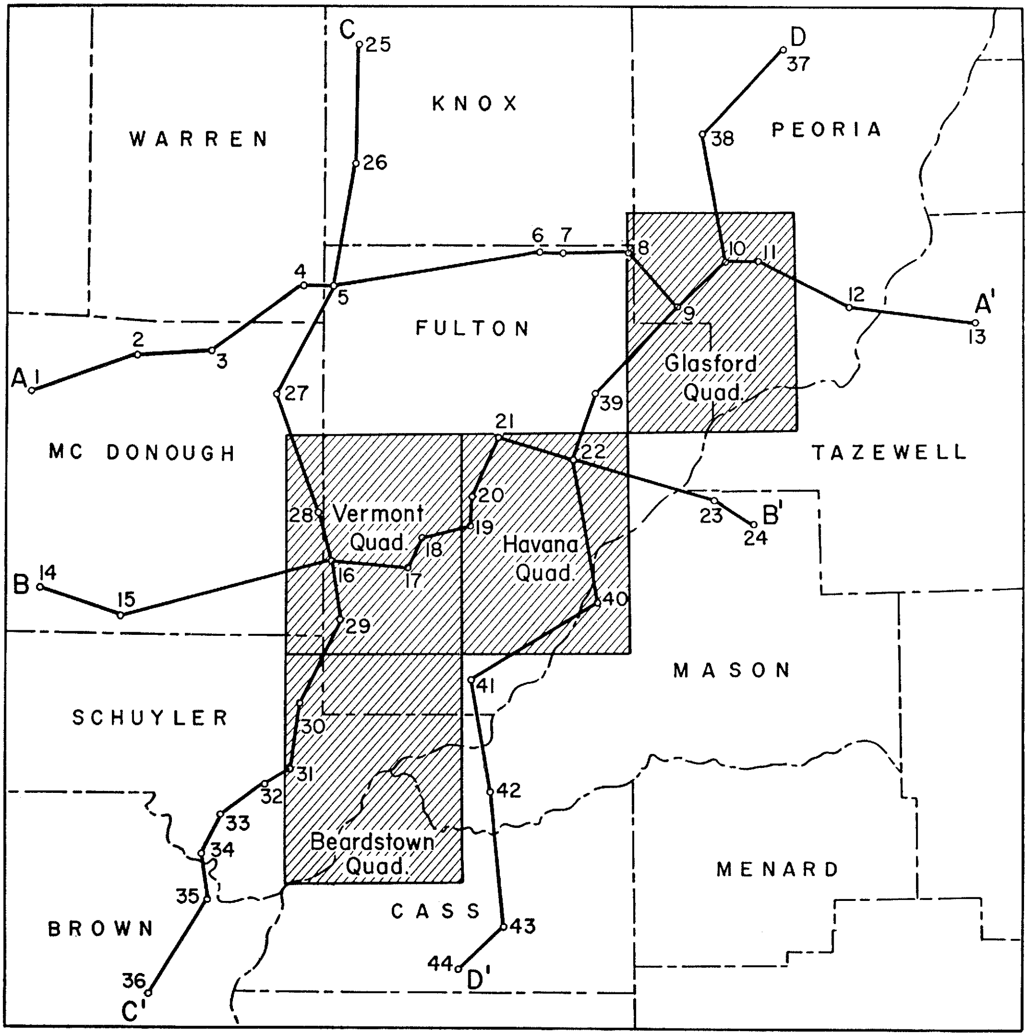


FIG. 10.—Index map showing location of cross sections.

It is less glauconitic and shaly than the overlying Franconia formation.

FRANCONIA FORMATION

The Franconia formation consists of greenish sandy glauconitic dolomite with thin shaly streaks in the Midland Electric Coal Company well, but in wells at Galesburg, Monmouth, Knoxville, and Abingdon it is principally a dolomitic sandstone with shale beds, especially in the lower part. The Franconia is 131 feet thick in the Midland Electric Coal Company well but thickens northwestward and is 195 to 205 feet in five wells in Knox County and 255 feet at Monmouth, Warren County. The thicker sections contain more sandstone and shale and less dolomite. The Franconia is the most glauconitic formation of the entire section in western Illinois.

TREMPEALEAU FORMATION

The Trempealeau formation is white and light gray dolomite with some beds showing pinkish spots. It is very fine-grained, compact or porous, and slightly sandy, especially in the lower portion. It contains drusy, or geodic, quartz in some parts and includes two or more slightly glauconitic zones, one near

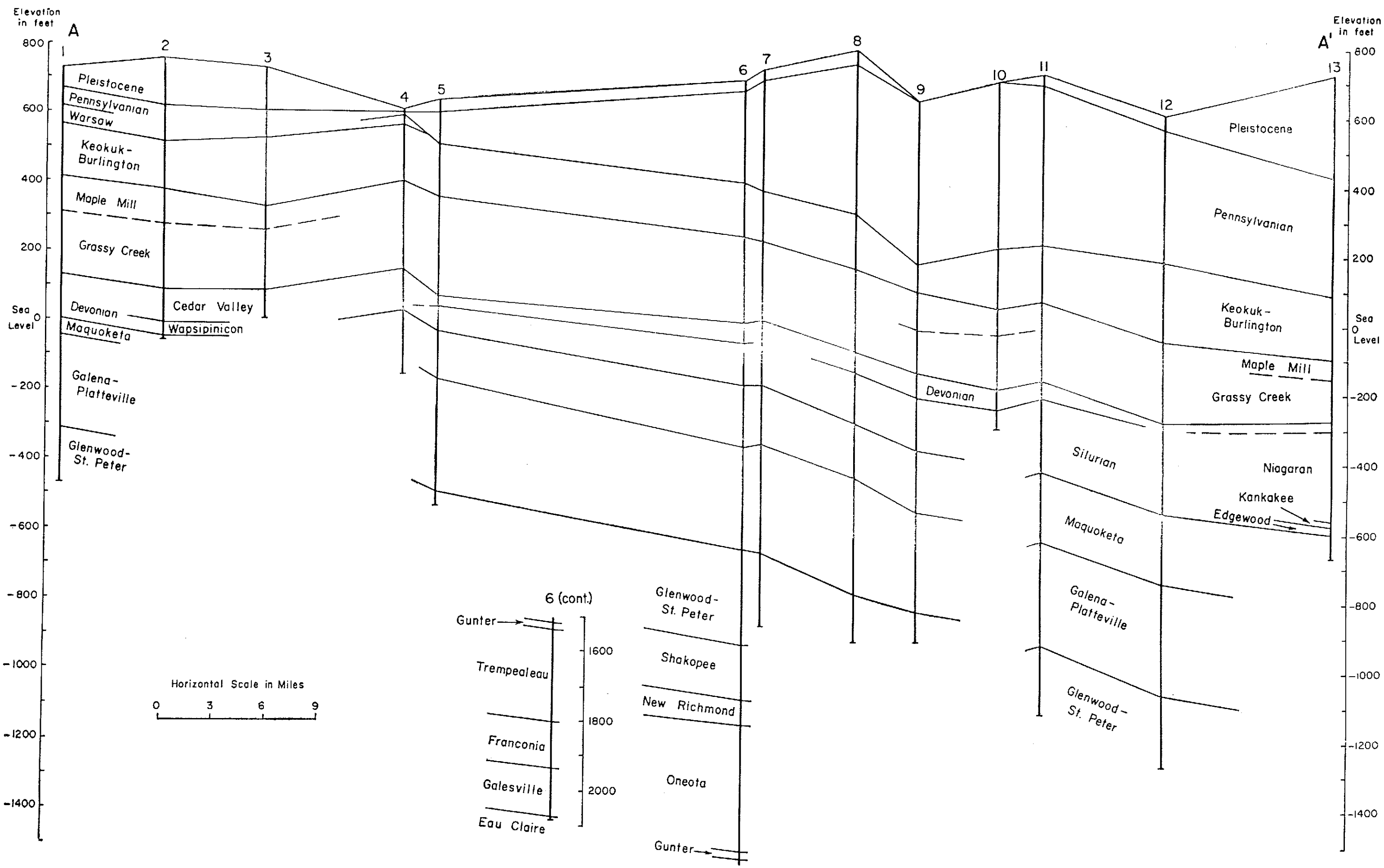


Fig. 11.—Cross section AA'.

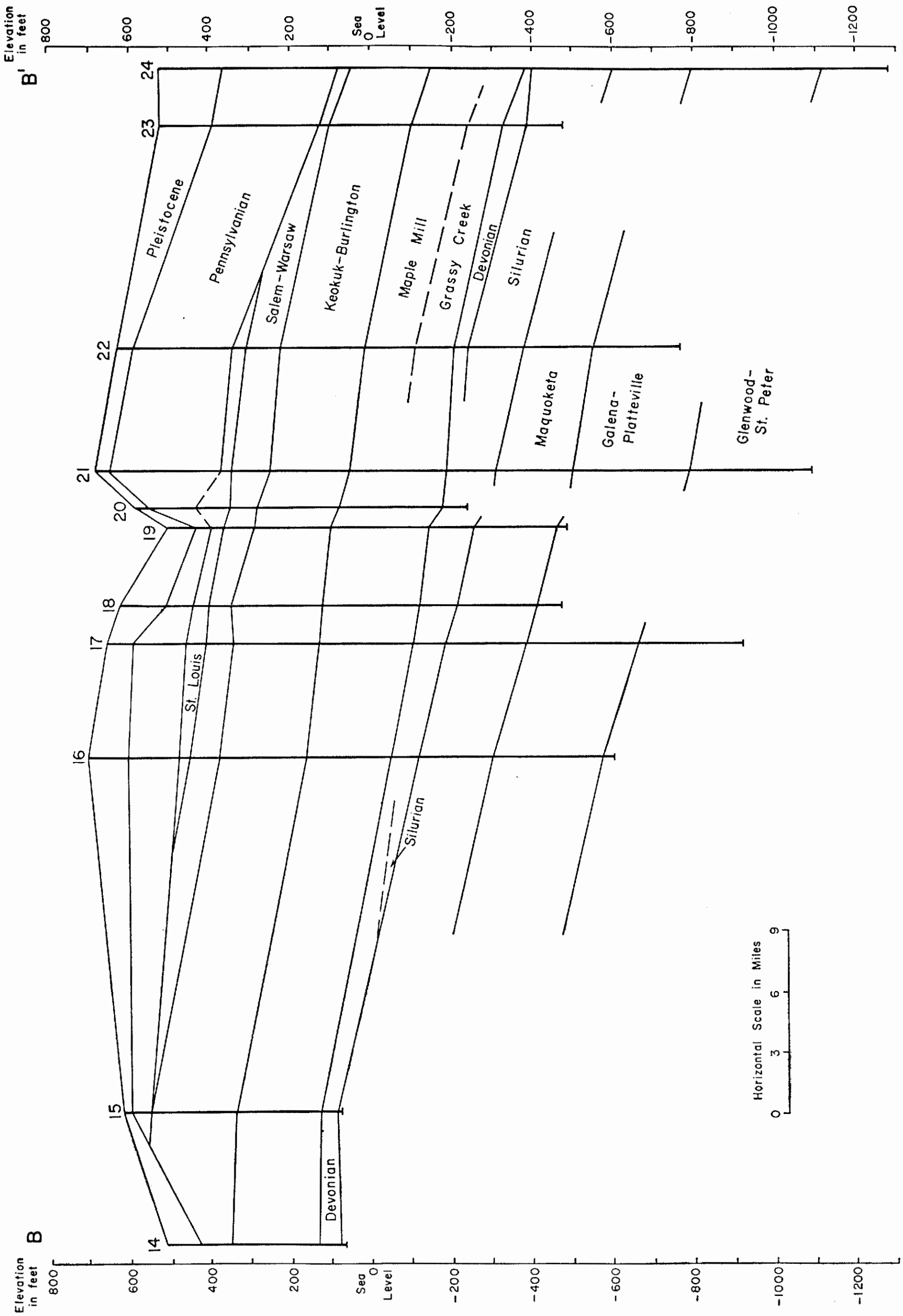


FIG. 12.—Cross section BB'.

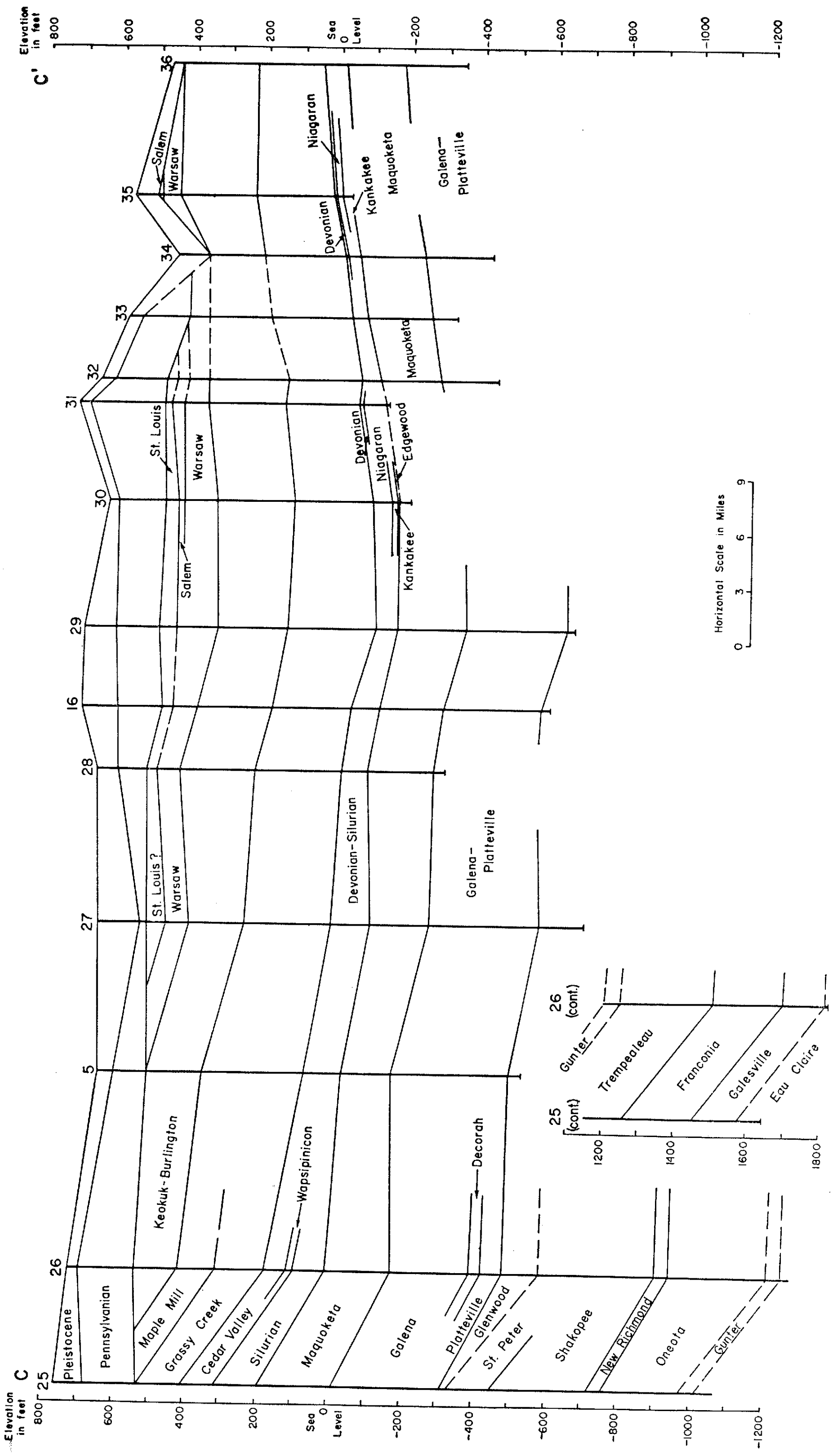


FIG. 13.—Cross section CC′.

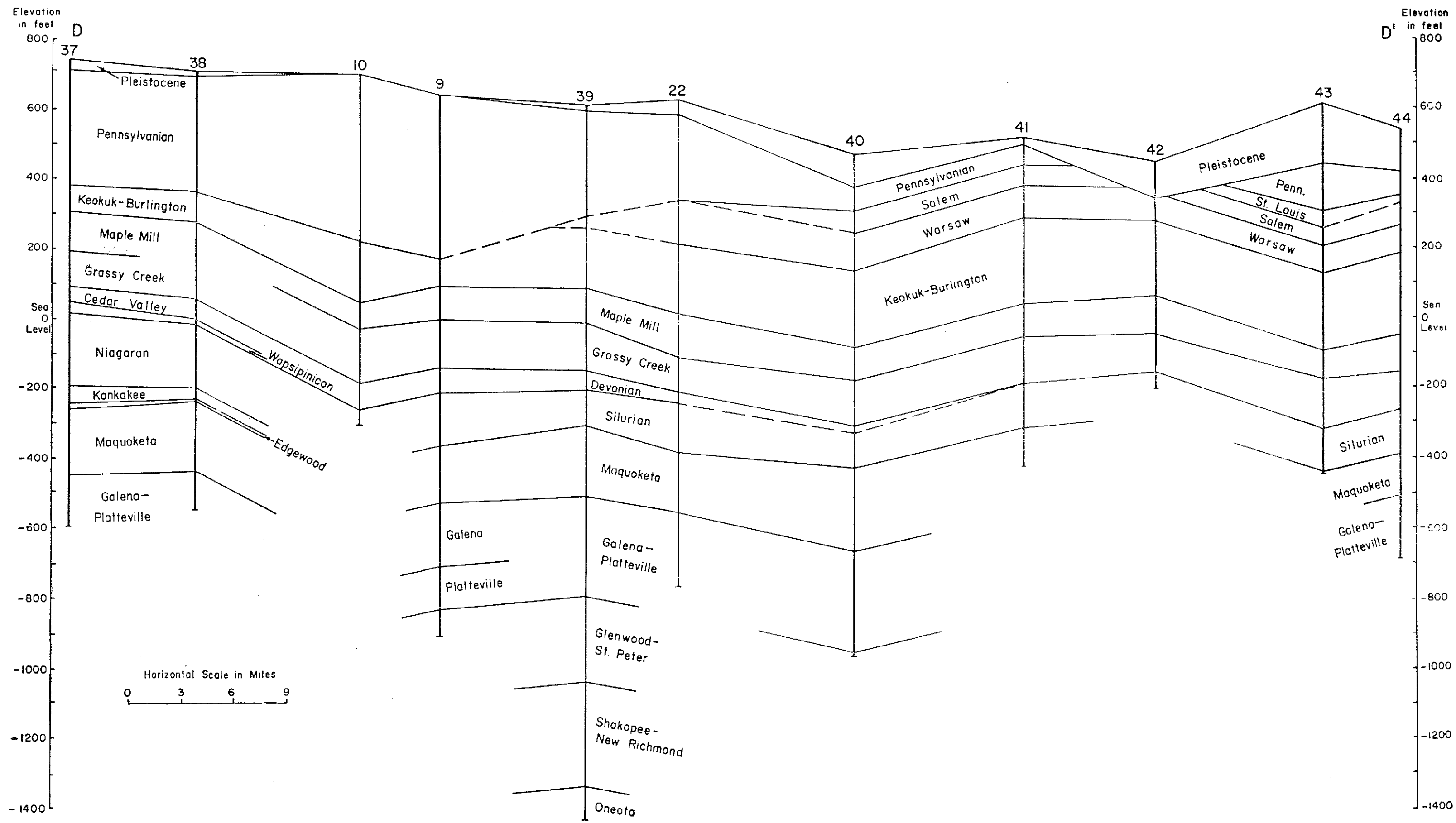


FIG. 14.—Cross section DD'.

its base, and chert at some locations but not at others. It is 251 feet thick in the Midland Electric Coal Company well and ranges from 260 to 290 feet thick in wells at Monmouth, Galesburg, Knoxville, and Abingdon. It is most readily recognized by its drusy quartz.

ORDOVICIAN SYSTEM

Ordovician strata underlie all the Beardstown-Glasford-Havana-Vermont area. They are divided into four series, as follows: 1) Prairie du Chien, represented by the Gunter, Oneota, New Richmond, and Shakopee formations; 2) the Chazyan represented by the St. Peter sandstone; 3) the Mohawkian consisting of the Glenwood, Platteville, Decorah, and Galena formations; and 4) the Cincinnatian consisting of the Maquoketa formation. The Ordovician strata range in thickness from about 1200 to about 1400 feet. The complete sequence is differentiated in the Midland Electric Coal Company well (well 2, app. B).

Prairie du Chien Series

GUNTER FORMATION

The Gunter formation consists of sandy and cherty dolomite together with masses of white dolomitic sandstone and some oolitic chert, drusy quartz, and glauconite. It is differentiated from the overlying Oneota and underlying Trempealeau dolomites by being more sandy and containing definite sandstone beds at some localities. Its thickness is reported as 36 feet in the Midland Electric Coal Company well and 10 to 55 feet in other well records. The variations in recorded thickness are thought in part to indicate difficulties in demarcating the formation from well cuttings rather than regional variations in thickness.

ONEOTA FORMATION

The Oneota formation is light gray dolomite with pinkish spots, sandy in the upper part and cherty in the lower, with white to light gray oolitic chert. It is reported as 353 feet thick in the Midland Electric Coal Company well, 100 to 125 feet thicker than the Oneota in city wells at Galesburg, Monmouth, Knoxville, and Abingdon northwest of this area. The Oneota may be distinguished from the Trempealeau by its light gray oolitic chert.

NEW RICHMOND FORMATION

Although the New Richmond formation is a widespread and relatively thick pure sandstone through much of northern Illinois, it is apparently thinner, more dolomitic, and less easily recognized in this part of the State. In the Midland Electric Coal Company well it is reported as 70 feet of white, medium- to coarse-grained, rather incoherent dolomitic sandstone with two beds of sandy cherty dolomite with tops respectively 20 and 42 feet below the top of the formation. Its thickness is reported as ranging from 5 to 30 feet at Monmouth, Galesburg, Knoxville, and Abingdon.

At those localities the New Richmond seems to be about 100 feet lower in the Prairie du Chien section. This may be interpreted either as a southeastward thinning of the Shakopee and thickening of the Oneota toward the Midland Electric Coal Company well, or as showing that the sandstone reported as New Richmond in the latter well should be correlated with thin sandstone beds in the Shakopee at Galesburg and Knoxville.

SHAKOPEE FORMATION

The Shakopee formation is quite variable and consists of red, pink, and light gray fine-grained dolomite. In the Midland Electric Coal Company well some of it is argillaceous. It contains two beds of light gray incoherent sandstone and a considerable amount of dark red silty shale mottled with green and gray. Some of the dolomite is sandy and some contains masses of white oolitic chert similar to that in the Oneota.

The Shakopee is reported as 160 feet thick in the Midland Electric Coal Company well and from 255 to 275 feet thick in seven wells at Monmouth, Galesburg, Knoxville, and Abingdon. The Shakopee in this area may be distinguished by its reddish and pinkish argillaceous dolomite and red shale and is unlike the Oneota in containing more numerous thin sandstone beds and beds of sandy dolomite. The oolitic chert in some of the light gray dolomite resembles that of the Oneota and the sandstone layers resemble the New Richmond.

Chazyan Series

ST. PETER FORMATION

The St. Peter sandstone has been penetrated by more than 40 borings in and near these quadrangles. It is principally a white to light gray incoherent sandstone with fine to medium quartz grains that are rounded, frosted, and pitted (wells, 1, 2, 4). Some grains show secondary enlargement. The more indurated beds are sporadically distributed and have dolomitic cement. In wells west and northwest of this area in McDonough, Warren, and Knox counties the basal 5 to 15 feet consist of a soft blue-gray shale and pebbles of porous oolitic chert redeposited from the Shakopee formation.

The St. Peter sandstone is 220 to 304 feet thick in wells in and near the area. However, the St. Peter is directly overlain by the Glenwood formation which consists largely of sandstone, and is commonly combined with the St. Peter in drillers logs. As the Glenwood is recognized as being 50 to 150 feet thick in wells in Knox and Warren counties northwest of this area, the St. Peter may be only 170 to 250 feet thick in this area.

In northern Illinois the St. Peter is separated from underlying Prairie du Chien strata by an unconformity marked by sandstone-filled channels 200 to 300 feet deep. In this area the range of St. Peter thickness suggests that these channels are less than 100 feet deep.

Mohawkian Series

GLENWOOD FORMATION

The Glenwood formation may be represented by only a few feet of green sandy shale and sandy dolomite reported in several wells. However, in Knox and Warren counties northwest of this area several wells penetrate 50 to 150 feet of Glenwood sandstone and then 8 to 10 feet of sandy shale and sandy dolomite before entering the St. Peter sandstone. As the thickness reported for the St. Peter in many of the city wells of this area, such as Canton, Cuba, and Ipava, equals or exceeds the combined Glenwood and St. Peter at Galesburg, Monmouth, and Abingdon, 100 feet or more of the St. Peter sandstone may really be Glenwood. Wells at Table Grove, Vermont, Beardstown, and Glasford that penetrate the sandstone only 15 to 55 feet may actually terminate in the Glenwood.

PLATTEVILLE FORMATION

The Platteville formation is a buff to medium brown, very fine to lithographic dolomite or dolomitic limestone that in part contains white to buff chalky chert and thin partings of black carbonaceous shale (wells 1, 2, 4). The lower 16 to 20 feet are described as brown slightly sandy or silty dolomite, which contrasts with the greenish Glenwood sandy dolomite below.

As the Platteville, Decorah, and Galena formations are all predominantly dolomite and limestone, they have not been differentiated in a large proportion of the wells in and near the area. The combined thickness of the three formations ranges from 270 to 320 feet (fig. 15). The Platteville seems to consist of approximately the lower 100 feet.

DECORAH FORMATION

The Decorah formation consists of cherty limestone or dolomite that is generally argillaceous, brown, gray, buff, or purplish gray and contains thin partings of calcareous or carbonaceous shale (wells 1, 4, 5). The driller's log of a well at Vermont, Fulton County, reports 7 feet of brown shale at or near the horizon of the Decorah, and one of the Canton City wells reports 5 feet of sandstone overlying 5 feet of sandstone and limestone near the same horizon. The Decorah is probably 5 to 20 feet thick in this area, judging from its thickness in some wells nearby. The presence of shale distinguishes the Decorah from the overlying and underlying dolomite formations.

GALENA FORMATION

The Galena formation is a dolomite or very dolomitic limestone which is crystalline, medium- to fine-grained, buff, light brown, or greenish gray (wells 1-5, app. B). Much of the formation is vesicular, and the vesicles are commonly coated with dolomite and occasionally with calcite crystals. Chert,

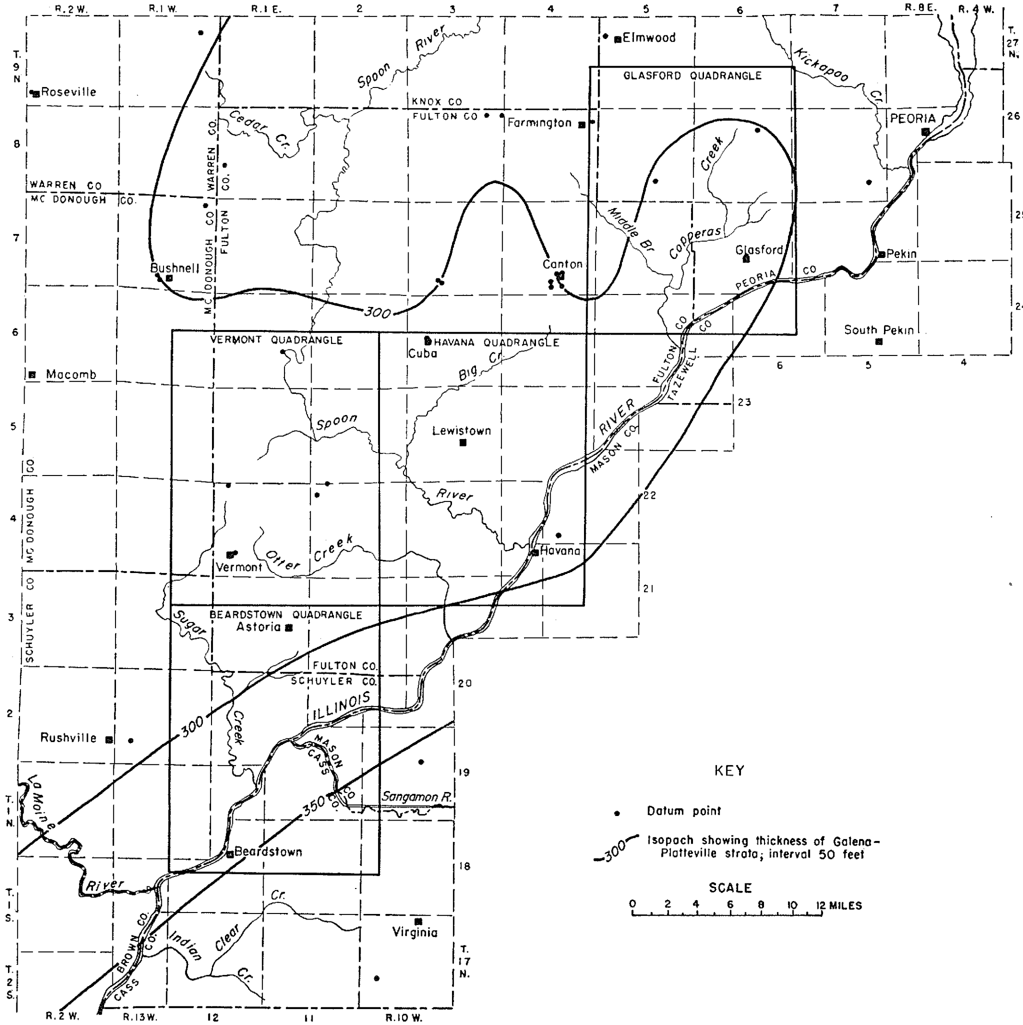


FIG. 15.—Thickness of Galena-Platteville strata.

pyrite crystals, and thin shale partings are found locally. The Galena is 175 to 200 feet thick in those borings in which it can be separated from the Decorah and Platteville formations. It can be distinguished from the Decorah and Platteville by 1) its more definitely crystalline texture, 2) its vesicular structure and greater porosity, 3) its lighter color, and 4) its smaller proportion of chert.

CINCINNATIAN SERIES

MAQUOKETA FORMATION

The Maquoketa formation consists largely of shale with a minor amount of dolomite, siltstone, and sandstone (wells 1-5, 7, app. B). In many wells in this area the Maquoketa can be differentiated into three zones as follows:

	Thickness: feet
Zone 3 (top)	
Shale, partly dolomitic, light greenish to brownish gray, speckled with dark; thinly laminated and soft, with pyritic and phosphatic nodules and thin beds of silty, gray to brown argillaceous dolomite	70–90
Zone 2	
Dolomite, light brownish-gray argillaceous, finely crystalline to coarsely granular	6–30

Zone 1	*Thickness: feet*
Shale, more or less dolomitic, light brownish-gray to black, with some thin bands of weak, dark brownish-gray, argillaceous dolomite with a few feet of sandstone, siltstone or sandy shale at the base	50–90

The more complete sample studies show a larger proportion of dolomite than do the drillers logs, suggesting that most of the dolomite occurs in thin layers interlaminated with shale. The dolomite of zone 2 is commonly reported and is thicker in the northern than in the southern part of the area. In parts of the Beardstown quadrangle and adjoining areas the dolomite apparently wedges out or grades into a dolomitic shale. The lower Maquoketa includes some beds of bituminous shale which burn slightly when ignited. The formation varies in thickness between 160 and 208 feet in 50 borings in and near the area (table 1).

The Maquoketa is unconformably overlain by the lowest Silurian in most of the area, by Devonian Cedar Valley limestone and sandstone in parts of Schuyler and McDonough counties, and by Mississippian Grassy Creek shale in northwestern Schuyler County about 15 miles west of the Beardstown quadrangle. The upper 10 or 15 feet of the Maquoketa may be eroded where it is overlain by the Cedar Valley formation.

SILURIAN SYSTEM

The Silurian system in Illinois has been divided into the Alexandrian series of early Silurian and the Niagaran series of middle Silurian age. Strata of Silurian age probably underlie all parts of the Beardstown-Glasford-Havana-Vermont area, but they thin rather regularly westward from the northeast corner of the Glasford quadrangle, where they are about 250 feet thick, to the western edge of the Vermont quadrangle, where they are less than 25 feet thick. Apparently the wedging out is a result of erosion after Niagaran time but before deposition of Devonian sediments, so that the thinner sections of Silurian contain only the lowest portions of the complete section. As both the Silurian and the overlying Devonian rocks are limestone or dolomite, the two systems are not differentiated in about half of the drillers logs. The combined thickness of the two systems is shown in figure 16. Silurian rocks are described in wells 1-7 (app. B).

Alexandrian Series

The Alexandrian series in this area consists of the Edgewood and Kankakee formations. The Edgewood is commonly sandy, silty, or shaly dolomite. In a few wells the basal 5 to 15 feet is very silty or sandy dolomite, dolomitic siltstone, sandy shale, or very fine-grained sandstone that is light gray or greenish gray, somewhat glauconitic and pyritic. In the Algona Oil Company No. 1 Cramer well in the SE¼ SE¼ SW¼ sec. 27, T. 8 N., R. 5 E., Glasford quadrangle, the basal beds are a conglomerate of shale and phosphatic pebbles. The maximum development of the sandy beds near the four quadrangles is in the Morton Oil and Gas Company Strunk well in sec. 18, T. 25 N., R. 3 W., about 17 miles east of the Glasford quadrangle where the sandstone is 25 feet thick.

The overlying Kankakee formation consists of light gray to buff or pinkish dolomite that is medium to fine-grained and is porous or vesicular. The dolomite contains scattered sand grains and is quite cherty in some wells but not in others. The Alexandrian is about 65 feet thick throughout that part of the area where it is overlain by Niagaran strata. The contact between the Kankakee and Niagaran dolomites is difficult to determine in many wells but light pinkish color in the Kankakee contrasts with white or light gray in the Niagaran and in some places the basal Niagaran is slightly shaly. The Alexandrian is unconformable on the underlying Maquoketa shale. The surface may have considerable relief, accounting for thickness variations in both formations and the variable character of the basal Alexandrian (fig. 11).

Niagaran Series

The Niagaran series is present in the Glasford and Havana quadrangles and perhaps the northeast part of the Vermont quadrangle. It consists of light gray to greenish-gray or buff dolomite that is more or less vesicular, cherty, fossiliferous, and pyritic.

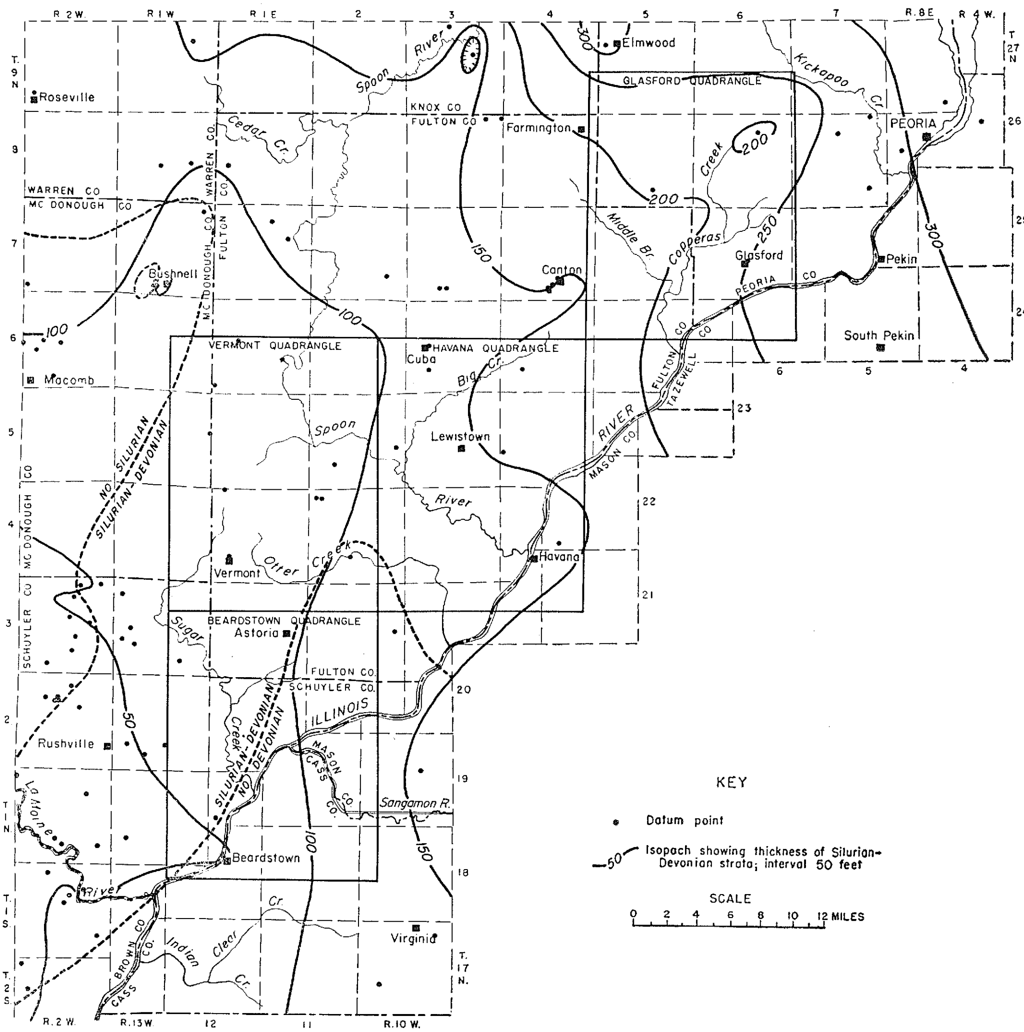


FIG. 16.—Thickness of Silurian-Devonian strata.

Scattered, very fine quartz sand grains occur in some beds. The dolomite contains thin partings of greenish to black shale in the Algona Oil Company Cramer Well. Light greenish or gray clay or shale, reported at its top in several wells, is probably a post-Niagaran deposit in solution cavities formed and filled before the deposition of the Devonian. The Niagaran thins from about 160 feet at the northeast corner of the Glasford quadrangle to nothing in the western part of the area. The Niagaran is less brown and sandy, but is more dolomitic and porous than the overlying Devonian. It is separated from the Devonian limestone by a major unconformity along which late Silurian and early and middle Devonian strata are missing.

DEVONIAN SYSTEM

The Devonian strata of this area belong to two formations, the Wapsipinicon below and the Cedar Valley above. Devonian strata underlie all of the area except the southern part of the Beardstown quadrangle where Silurian strata are thought to be overlain directly by Kinderhook shales (fig. 16). Even in this area, however, 5 to 10 feet of Devonian may be present. In wells in southern Brown County, a short distance southeast of the Beardstown quadrangle, the Devonian is known to be missing. It is also absent in a belt extending northeast of Brown County through eastern Mason and Tazewell counties 15 to 20 miles east of the Havana and Glasford quadrangles, and in an area south of the Colmar oil field (the J. E. Manlove well in sec. 9, T. 3 N., R. 4 W., in northwestern Schuyler County), where the Silurian and Devonian are both absent and Kinderhook shale immediately overlies the Maquoketa shale.

Within the area of the quadrangles the Devonian is 10 to 73 feet thick, by available records. The Devonian is 135 feet thick in the vicinity of Macomb about nine miles west of the Vermont quadrangle. It wedges out completely a short distance southwest of the Beardstown quadrangle and perhaps in the southern part of the Beardstown quadrangle. Devonian rocks are described in wells 1-4 and 6.

The Devonian of this area is separated from the underlying Silurian by a major unconformity. The Devonian overlaps the Niagaran and Alexandrian westward across the area and a short distance west of the area it rests on the Maquoketa shale. There is an unconformity within the Devonian and the Cedar Valley overlaps the Wapsipinicon toward the southwest. The overlying Kinderhook is also separated from the Devonian limestone by a major unconformity and overlaps the Devonian in a belt near Beardstown and northeastward from there, and also in an area south of the Colmar oil field, in northwest Schuyler County.

Senecan Series

WAPSIPINICON FORMATION

The Wapsipinicon has not been separated from the overlying Cedar Valley limestone in most of the wells in this area. In the few wells in which it can be recognized the Wapsipinicon is a gray, brownish-gray, or brown limestone, dolomitic limestone, or dolomite, commonly with very fine-grained to lithographic texture. In a few wells it includes some chert, and is more or less silty and pyritic. It is most readily distinguished by its sublithographic texture and brownish color.

The Wapsipinicon is probably 25 to 35 feet thick in most of the area, except where it is beveled by the Cedar Valley limestone.

CEDAR VALLEY FORMATION

The Cedar Valley formation is the principal and most widespread Devonian formation of this area. It consists largely of limestone but lenticular beds of sandstone are locally prominent at or near the base of the formation. A basal Cedar Valley sand in the Colmar oil field in McDonough County is called the Hoing sand.

Above the basal sandy zone the Cedar Valley is light gray to brownish-gray, crystalline to subcrystalline limestone, dolomitic limestone, or dolomite. At some localities it includes quite cherty beds with light gray vitreous or dull and chalky chert. Fine- to medium-grained quartz sand in scattered grains is commonly reported. Some beds are argillaceous and have thin partings of calcareous or dolomitic shale. Pyrite is present as scattered grains and irregular masses and gypsum is reported in a few wells in the western part of the area.

The Cedar Valley limestone is very fossiliferous. Some of the limestone beds contain large calcite crystals replacing parts of crinoid stems, corals, and other fossils. Sporangites, a fossil spore, is found in the Cedar Valley limestone as well as in the overlying Grassy Creek shale.

The Cedar Valley limestone is believed to be more than 100 feet thick in an area near Macomb west of the Vermont quadrangle, to average 30 to 40 feet thick in the Glasford and Havana quadrangles, and to wedge out entirely in the southern part of the Beardstown quadrangle.

The Cedar Valley of this area is more coarsely crystalline, more sandy, and more fossiliferous than the Wapsipinicon.

MISSISSIPPIAN SYSTEM

Mississippian rocks underlie all of the Beardstown-Glasford-Havana-Vermont area. They reach a maximum thickness of 600 to

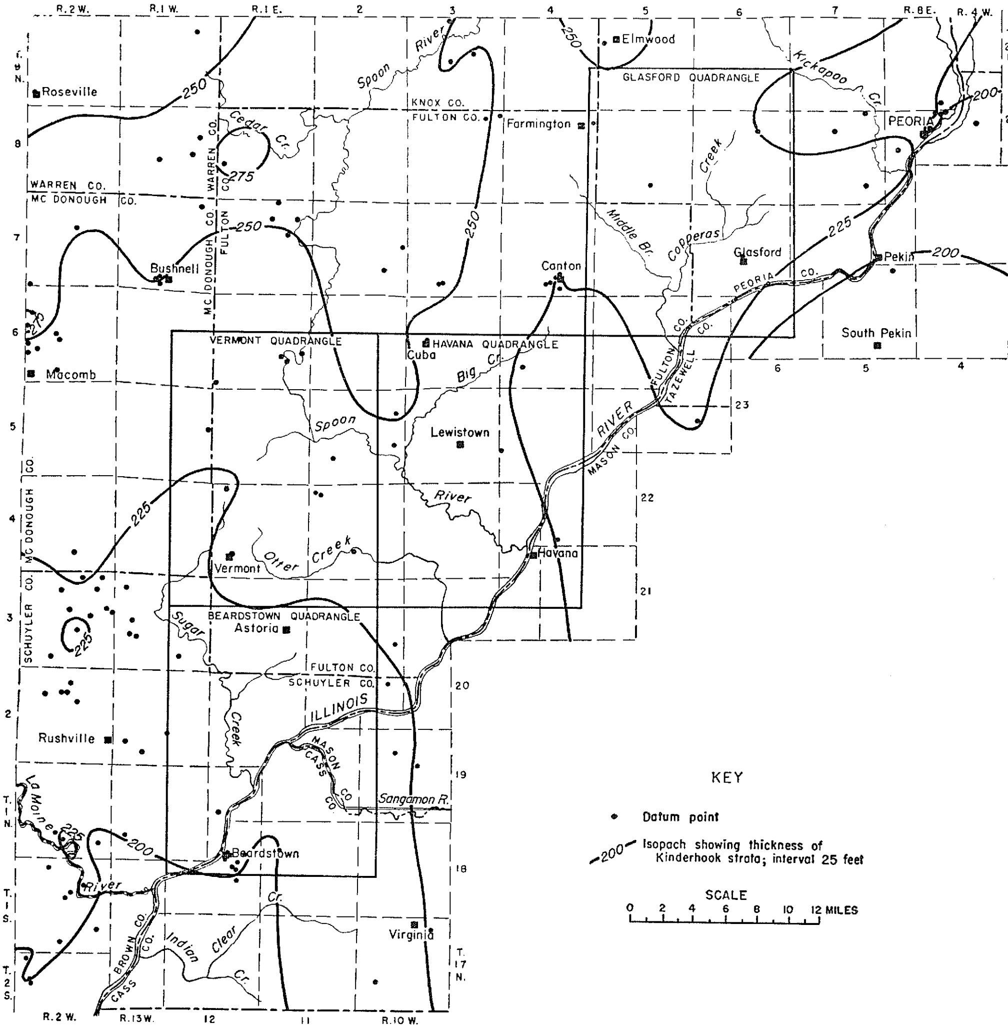


FIG. 17.—Thickness of Kinderhook strata.

800 feet in the southern part of the Beardstown quadrangle but because of northward overlap by the Pennsylvanian are only 350 to 400 feet thick in the northern part of the Glasford quadrangle. The higher Mississippian strata crop out in the Beardstown and Vermont quadrangles (pls. 1, 4) and underlie Pleistocene deposits in the Illinois Valley in the Havana quadrangle. The areal distribution of the formations is shown on plate 5.

The Mississippian rocks of this area belong to the Kinderhook and Valmeyer series. The most complete sequence of the Mississippian rocks is given in the description of the Cass Community Oil Company's Jas. Maslin No. 1 well in Cass County, about five miles southeast of the Beardstown quadrangle (well 7, app. B).

Mississippian strata rest unconformably on Devonian and Silurian formations. They are unconformably overlain by Pennsylvanian beds.

KINDERHOOK SERIES

The Kinderhook series underlies all the area. The great majority of the 100 wells or more that penetrated the Kinderhook encountered only shale (wells 1-7). A few report sandstone or siltstone in the upper or lower parts of the series and a very few wells in southwest Schuyler County and in Peoria and Tazewell counties east of the Glasford quadrangle report 2 to 15 feet of limestone or dolomite in the shale. Kinderhook strata in this area are divided into two formations —the Grassy Creek shale of the Champ Clark group overlain by the Maple Mill shale of the Hannibal group (Workman and Gillette, 1956). Kinderhook strata vary from 195 feet thick in the vicinity of Beardstown and at Peoria east of the Glasford quadrangle to 285 feet thick a few miles northwest of the Vermont quadrangle near Macomb (fig. 17). The thickness appears to increase northwestward across the area at a rate of about one to one and one-half feet per mile.

CHAMP CLARK GROUP

GRASSY CREEK SHALE

The Grassy Creek shale may be divided into two zones in a large number of the well records, namely a lower zone of light greenish or gray shale and an upper zone of dark brown shale.

The lower zone is white, greenish, or gray, somewhat calcareous, slightly micaceous shale commonly ranging from 6 to 35 feet thick. A basal siltstone or very fine-grained white calcareous sandstone (the Sylamore sandstone), locally as thick as 10 feet, is reported in three borings a short distance west and southwest of this area and probably is locally present in the area. Sporangites, a yellowish resinous spore, is present but it is more abundant in the overlying dark shales. This zone was not reported in most of the wells in eastern McDonough County.

The upper zone is dark brown, brownish-gray, dark gray, or black, bituminous pyritic shale with Sporangites abundant in some zones. The shale is reported as firm and "slaty" in some wells but as weak and silty in others. Thin streaks of greenish shale are interlaminated with the dark, and in some wells the upper 20 or 30 feet are mottled or banded greenish and brownish shales. This zone seems to be darker colored and more compact or tough to the south and lighter brownish gray and weaker to the north in Warren, Knox, and Peoria counties. The thicker sections to the north are lighter colored and weaker, whereas the thinner sections to the south are darker brown to black and harder.

Although the Grassy Creek—Hannibal boundary is unrecognizable in many wells, the Grassy Creek seems to range from about 110 to 160 feet thick.

The Champ Clark group, which includes the Grassy Creek shale, is believed to be equivalent to the lower part of the New Albany black shale. Although classified as the basal unit of the Mississippian system, some paleontological evidence favors a late Devonian age. In this area the prominent unconformity at the base associates it more closely with the overlying Mississippian formations.

HANNIBAL GROUP

MAPLE MILL SHALE

The Maple Mill shale is greenish gray, gray, or green, slightly calcareous or dolomitic, pyritic, and flaky or weak. It ranges from about 75 to 150 feet thick, generally thickening from southeast to northwest. It contains siltstone or very fine-grained angular compact sandstone in its upper part in a few wells in Mason, Tazewell, Cass, and Brown counties in the eastern and southern parts of the area. The siltstone or sandstone beds should possibly be referred to the English River sandstone which is more typically developed west of this area.

Valmeyer Series

The Valmeyer series differs from the underlying Kinderhook series in being largely limestone. It is subdivided into two groups, the Osage (below) consisting of the Burlington, Keokuk, and Warsaw formations, and the Meramec (above) consisting of the Salem and St. Louis formations.

OSAGE GROUP

BURLINGTON-KEOKUK FORMATIONS

As the Burlington and Keokuk formations, both of which are limestones, cannot be differentiated in a large proportion of the well records, they are described together.

They do not crop out in the area, although they immediately underlie alluvial deposits of the Illinois River in the Beardstown quadrangle (pl. 5). The Keokuk limestone, which is the upper formation, is absent from the northeastern part of the Glasford quadrangle where basal Pennsylvanian strata rest directly on the Burlington.

The Burlington and Keokuk formations consist predominantly of light gray, white, or buff cherty dolomitic limestones (wells 1-7). Their separation in outcrops in their type area has been based principally on differences in fossils. Near the middle of the combined Burlington-Keokuk a color change from buff or light brown above to white or light gray below, is reported in several of the records and is provisionally used as a dividing horizon between the formations. Some other records, however, show no consistency and the color change is not entirely reliable. On the pre-Pennsylvanian areal geology map (fig. 24), the Pennsylvanian is assumed to overlie Burlington where 100 feet or less of limestone is present, but to overlie Keokuk where there is more than 100 feet of limestone.

The upper part of the Burlington-Keokuk consists of light gray, buff, brownish-gray, or dark gray, dolomitic limestone and dolomite with white, gray, or buff, dense or porous chert occurring in the form of nodules, lenses, or beds. Some beds are very fine-grained to sublithographic, others are fairly coarsely crystalline. A thin zone of oolitic limestone 25 to 50 feet below the top is reported in two records. In a few records the upper part is reported to be wholly dolomite, in others wholly dolomitic limestone, and in others alternations of limestone and dolomite. Glauconite and pyrite are more or less sporadically distributed.

The lower portion of the Burlington-Keokuk is predominantly white or light gray, more or less dolomitic limestone or calcareous dolomite with much white, light gray, or bluish dense chalcedonic or geodiferous chert in lenses, nodules, or bands. It is finely to coarsely crystalline, but some fine-grained beds contain inclusions of coarse-grained dolomite. Stylolites and thin partings of light greenish or bluish shale are reported at several horizons. The Burlington limestone is very rich in crinoid remains, having been first called the "Encrinital limestone." Glauconite is abundant in some layers, pyrite is found as scattered grains, and lemon-yellow sphalerite is reported in a 3-foot sample 57 feet above the base of the Burlington in the Blue Bell Oil Co. Kyle well in sec. 17, T. 8 N., R. 6 E. In those wells where the Pennsylvanian immediately overlies either the Burlington or Keokuk limestone, a surficial concentration of chert is commonly reported, probably a result of leaching of the cherty limestone before the beginning of Pennsylvanian sedimentation.

Where overlain by younger Mississippian beds, the thickness of the Burlington and Keokuk limestones ranges from about 160 to 240 feet, thickening slightly to the south (fig. 18). Where they are truncated by the Pennsylvanian, their thickness is reduced to 80 feet in the northern part of the Glasford quadrangle. At Galesburg, northwest of this area, they are absent, and Pennsylvanian strata rest directly on Kinderhook strata.

The Burlington limestone is believed to be unconformable on the Maple Mill shale because uppermost Kinderhook strata, the Chouteau limestone, and the North Hill group, present south and west of the area, are missing here. The Keokuk is reported to be conformable both with the Burlington below and the Warsaw above. In the Glasford quadrangle Pennsylvanian rocks unconformably overlie both the Burlington and Keokuk formations.

WARSAW FORMATION

The Warsaw is the oldest outcropping formation in the area covered by this report. Its outcrops are restricted to the valleys of Spoon River and tributaries in the northern part of the Vermont quadrangle (pl. 4), and to the west bluffs of the Illinois Valley in part of the Beardstown quadrangle (pl. 1). The Warsaw underlies most of the Vermont, Havana, and Beardstown quadrangles. It is absent from much of the alluvial valley of Illinois River in the Beardstown quadrangle. It probably underlies some of the southwest part of the Glasford quadrangle, but no borings in that quadrangle have penetrated it.

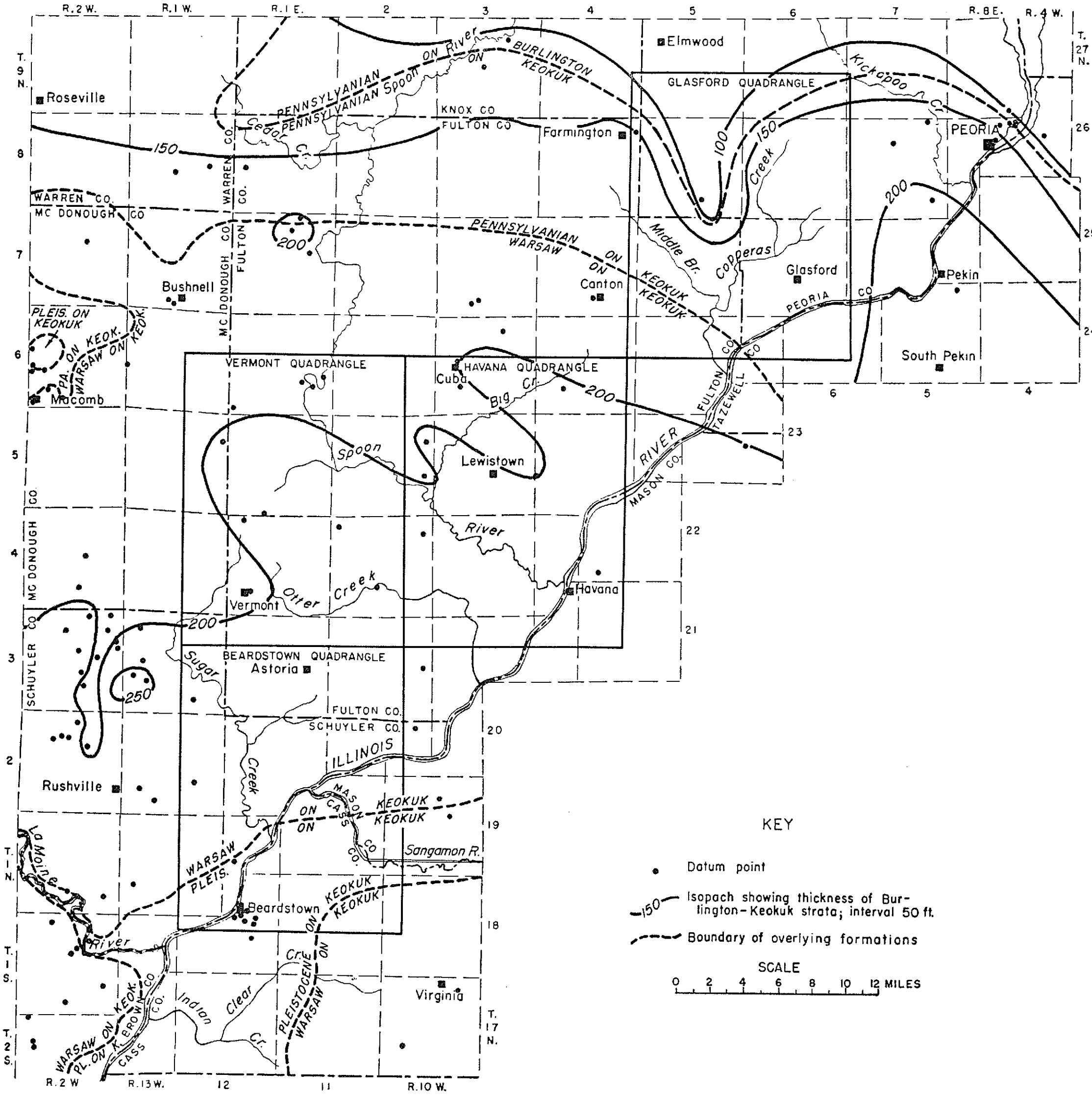


FIG. 18.—Thickness of Burlington-Keokuk strata.

The Warsaw formation consists principally of light gray or greenish-gray calcareous or dolomitic sandy micaceous weak flaky shale (fig. 19; wells 3-7). It contains geodes with quartz and other minerals. Thin beds of dolomite, siltstone, and sandstone occur interbedded in the shale. The most complete record of Warsaw lithology in the area is that for the Arnold-Quinn No. 1 well in the NE¼ NW¼ sec. 27, T. 2 N., R. 1 W., Beardstown quadrangle (well 6, app. B). Some wells show only shale whereas in others limestone, dolomite, or siltstone are reported to predominate. Lateral variation in lithology may be observed in some of the Warsaw outcrops.

The contact with the overlying Salem limestone is gradational and is difficult to determine, either in wells or outcrops. The contact of the Pennsylvanian with lower Salem or Warsaw beds is difficult to recognize in wells, especially in drillers logs.

The Pennsylvanian shales are commonly darker colored and associated with thin coal beds whereas the Warsaw shales are calcareous or dolomitic, greenish, and contain geodes. The basal Pennsylvanian sandstones are commonly nonmicaceous whereas those of the Salem and Warsaw contain visible amounts of mica.

The Warsaw shale commonly ranges from 50 to 75 feet thick in those parts of the area where it is overlain by the Salem limestone. In the preparation of the map of pre-Pennsylvanian areal geology (fig. 24), a thickness of 65 feet was assumed for the Warsaw in those wells in which the Salem and Warsaw could not be satisfactorily separated.

The Warsaw shale is overlain by the Salem limestone with apparent conformity, although marked variation in the thickness of shale beds above the Keokuk may result in part from erosion of Warsaw shales previous to the deposition of the Salem. The Pennsylvanian unconformably overlies the Warsaw where the Salem and St. Louis formations are absent (fig. 19).

MERAMEC GROUP

SALEM FORMATION

The Salem formation underlies a slightly smaller area than the Warsaw and is absent from most of the Glasford quadrangle, the Illinois alluvial valley in the Beardstown and perhaps part of the Havana quadrangle, and part of the northern part of the Vermont quadrangle. It crops out in the Vermont quadrangle along Spoon River, Badger Creek, and other streams (pl. 4) and in the Beardstown quadrangle along the west bluff of the Illinois River and the lower portions of numerous streams northwest of the Illinois (pl. 1). Most of the outcrops show less than 20 feet of section because the base of the Pennsylvanian is commonly within 20 feet of the level of the major streams (fig. 20). As the uppermost Mississippian beds were deeply weathered before their burial by Pennsylvanian sediments, the Salem beds in many small outcrops are wholly or largely altered by weathering.

The Salem is more heterogeneous in lithologic composition than either the Warsaw or St. Louis and shows marked changes in lithology both vertically and laterally (wells 3-7, app. B). The principal types of sediment composing the Salem are:

1) Brown or light brownish-gray argillaceous silty or sandy fetid dolomite commonly occurring in thin plates one to six inches thick.
2) Light gray or greenish-gray glauconitic micaceous dolomitic siltstone or sandstone.
3) Light greenish-gray calcareous or dolomitic sandy shale resembling the Warsaw.

Some of the dolomite beds are dense, but others are crystalline or granular and strongly cross-bedded. Geodes occur in both the dolomite and siltstone or sandstone.

Fossil remains are common in some exposures, and include *Spirifer,* productids, *Orthoceras,* crinoid stems, and fenestellid bryozoa, the fronds of which stand upright in siltstone in one exposure.

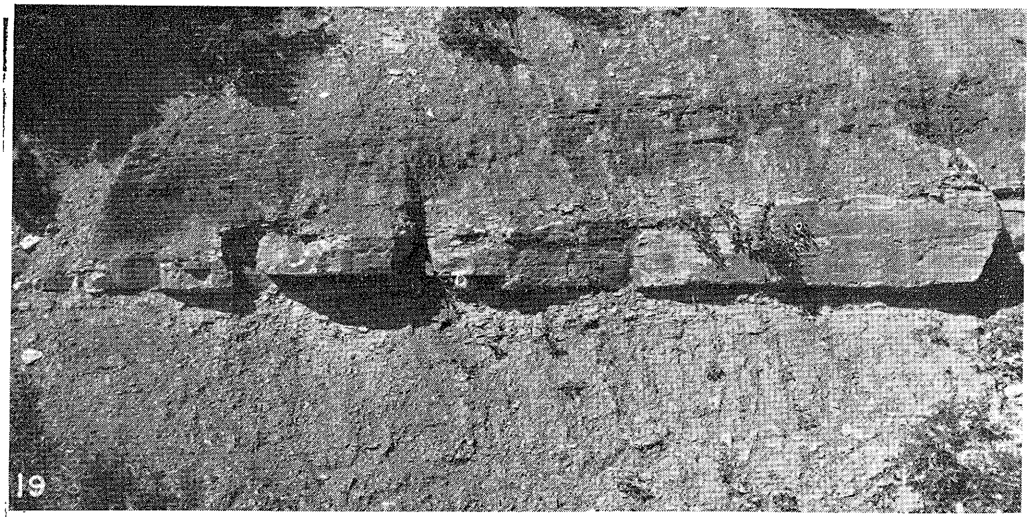
The sandstone may be distinguished from those of Pennsylvanian age because the Salem beds are micaceous, glauconitic, dolomitic, and fossiliferous whereas the lower Pennsylvanian sandstones have none of these characteristics. Good exposures of the Salem in the Beardstown quadrangle occur in the NW¼ NE¼ sec. 24, and the SW¼ SE¼ sec. 13, T. 2 N., R. 1 E., and at Frederick (geol. sec. 7, app. A).

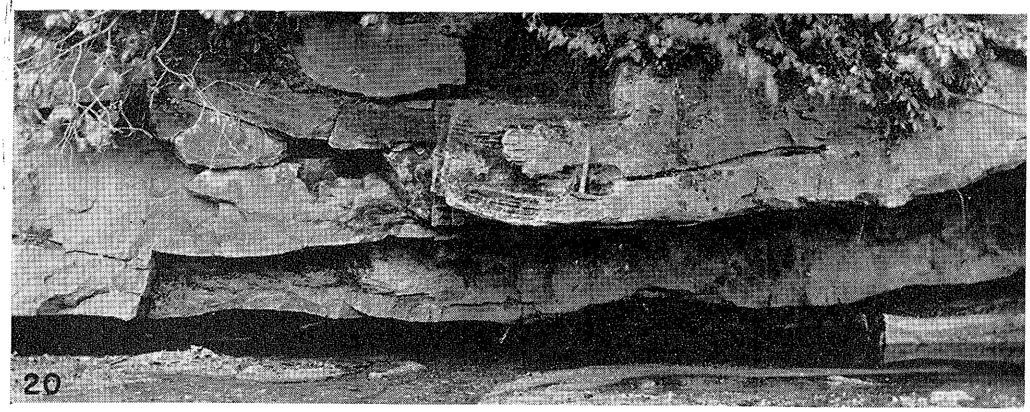
The Salem is distinguished from the Warsaw in that it contains more sandstone, siltstone, and dolomite but less shale. However, thin shale beds in the Salem resemble those in the Warsaw, and geodes filled with quartz or vugs filled with calcite are not uncommon in Salem dolomite and siltstone. It is more brown and sandy than the overlying St. Louis limestone which is light gray, mostly finer grained, and commonly brecciated. The Salem is 30 to 46 feet thick.

Although in some areas the Salem is believed to be overlain unconformably by the St. Louis limestone, this relation is not apparent in the outcrops in this area. In part of the area the Salem is unconformably overlain by Pennsylvanian strata (fig. 24).

ST. LOUIS FORMATION

The St. Louis formation is the youngest Mississippian formation in the Beardstown-Glasford-Havana-Vermont area. It underlies most of the Havana quadrangle, the southern part of the Vermont quadrangle,





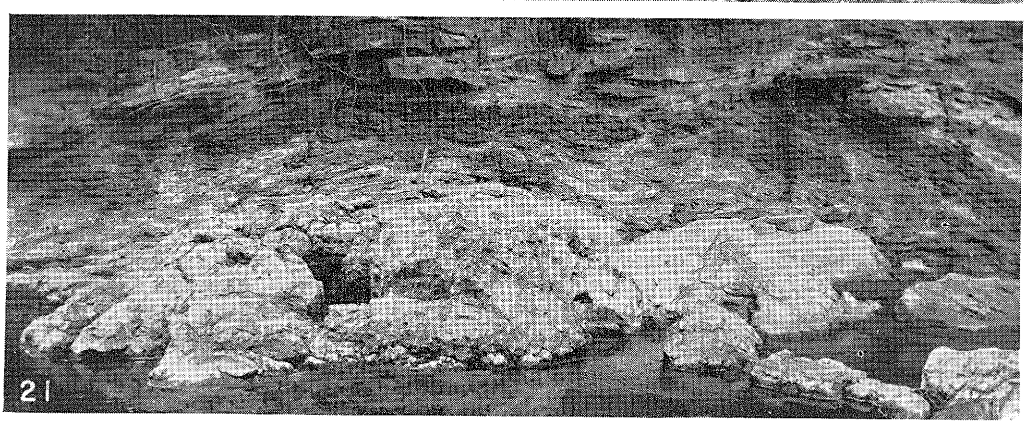


FIG. 19.—Unconformity between Pennsylvanian shale and coal (dark band) at top and Warsaw siltstone (the prominent ledge) and shale, in stream bank about two miles west of Seville, in the NW ¼ NE ¼ sec. 27, T. 6 N., R. 1 E., Vermont quadrangle.

FIG. 20.—Cross-bedded Salem limestone in stream bank about two miles northeast of Browning, in the NW ¼ NE ¼ sec. 24, T. 2 N., R. 1 E., Beardstown quadrangle.

FIG. 21.—Unconformity between Pennsylvanian shale and sandstone (above) and St. Louis limestone ½ mile north of Sheldon's Grove, in the SW ¼ SW ¼ sec. 4, T. 2 N., R. 2 E., Beardstown quadrangle.

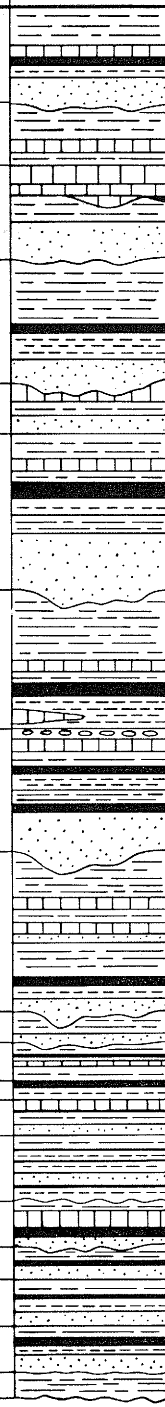
and the northern part of the Beardstown quadrangle and crops out at several places in the Beardstown and Vermont quadrangles (pls. 1, 4, 5). It is well exposed along Mill Creek (geol. sec. 5, app. A) and at Seville (geol. sec. 33). Other exposures are described in geologic sections 34 and 35.

The St. Louis formation is a light gray, white, or light pinkish-gray, dense to lithographic limestone containing variable amounts of white or light gray chert (well 7). Thin beds of light greenish-gray shale are interlaminated with the limestone at some outcrops. A zone at or near the base of the formation is highly brecciated and consists of angular fragments of light gray dense limestone in a matrix that is darker gray and weathers rusty brown. A purplish-brown slightly sandy cherty dolomite overlies light gray dense cherty limestone in some outcrops.

The St. Louis limestone is very fossiliferous in some localities and nonfossiliferous at others. It contains *Syringopora, Lithostrotion canadense,* and other corals, brachiopods, crinoid stems, and fish teeth.

Because of pre-Pennsylvanian erosion the thickness of the St. Louis limestone is extremely irregular. A maximum of about 30 feet has been observed in outcrops and 55 to 67 feet in borings. The driller's log of a well at Astoria in the Beardstown quadrangle reports 195 feet of limestone above the Warsaw shale and below the Pennsylvanian. If the record is correct, 140 to 150 feet of the St. Louis and 45 to 55 feet of Salem strata may be present.

The St. Louis limestone is separated from overlying Pennsylvanian strata by a major erosional unconformity (fig. 21). The St. Louis was more resistant to erosion than underlying Salem and Warsaw strata and formed low hills or mounds that were buried by Pennsylvanian sediments. St. Louis "hills" with the lowermost Pennsylvanian beds wedging out against their flanks are exposed at several places in ravines in the Vermont and Beardstown quadrangles. At an exposure along State Route 100 in the NW¼ SW¼ sec. 34, T. 2 N., R. 1 E., all Pennsylvanian strata older than the DeLong cyclothem wedge out against the St. Louis limestone. The local relief in the unconformity was at least as much as 25 to 30 feet. The uppermost strata of the St. Louis in the hills are deeply iron-stained and solution-pitted, and at some places they are exceptionally cherty.



GROUP	CYCLOTHEM	THICKNESS (FEET)	MEMBER NUMBERS	LITHOLOGY	NAMED MEMBERS
McLEANSBORO	Trivoli	37	145-154		Trivoli limestone Trivoli (No. 8) coal Trivoli sandstone
	Exline	0-40	141-144		Exline limestone
	Gimlet	15-69	131-140		Lonsdale limestone Gimlet coal Gimlet sandstone
	Sparland	8-80	121-130		Farmington shale Sparland (No. 7) coal Copperas Creek sandstone
CARBONDALE	Pokeberry	11-17	118-120		Pokeberry limestone
	Brereton	15-102	107-117		Sheffield shale Brereton limestone Herrin (No. 6) coal Big Creek shale Cuba sandstone
	St. David	18-55	94-106		Canton shale St. David limestone Springfield (No. 5) coal
	Summum	11-85	83-93		Covel Conglomerate Hanover limestone Summum (No. 4) coal Kerton Creek coal Pleasantview sandstone
	Liverpool	5-100	60-82		Purington shale Oak Grove beds Jake Creek sandstone Francis Creek shale Colchester (No. 2) coal Browning sandstone
	Abingdon	1-15	53-59		Isabel sandstone
TRADEWATER	Greenbush	1-14	47-52		Greenbush coal
	Wiley	1-5	42-46		Wiley coal
	Seahorne	3-12	35-41		Seahorne limestone, coal, sandstone
	De Long Upper Middle Lower	9-40	21-34		Upper, Middle, Lower DeLong coals
	Seville	3-38	15-20		Seville limestone Rock Island (No. 1) coal Bernadotte sandstone
	Pope Creek	1-30	11-14		Pope Creek coal, sandstone
	Tarter	3-22	7-10		Tarter coal Tarter sandstone
	Babylon	3-40	2-6		Babylon coal Babylon sandstone
	Pre-Babylon	0-4	1		

FIG. 22.—Generalized columnar section of Pennsylvanian strata.

CHAPTER 4—PENNSYLVANIAN STRATIGRAPHY

Rocks of Pennsylvanian age underlie about three-fourths of Illinois. Together with Pennsylvanian strata in adjacent parts of western Kentucky, southwestern Indiana, and a small area in Missouri, they constitute the Eastern Interior coal basin. The four quadrangles covered in this report are some disstance northwest of the central part of this basin. Pennsylvanian rocks underlie all of the Glasford quadrangle and most of the other three quadrangles; the exceptions are areas where the Illinois and Spoon Rivers and some tributaries cut through them and expose rocks of the Mississippian system (pl. 5). The Pennsylvanian system consists of shale, sandstone, underclay, coal, limestone, ironstone, and conglomerate in the order of abundance named. A total of 154 lithologic units or members have been differentiated, and most of them can be traced readily through much of the area (fig. 22).

THICKNESS

The maximum thickness of Pennsylvanian strata in this area is about 500 feet in the north part of the Glasford quadrangle where the youngest Pennsylvanian strata are found. The section thins about 40 percent from the east part of the Glasford quadrangle southwest to the west part of the Beardstown quadrangle. The thickness of the Pennsylvanian rocks at any place in the area can be estimated by comparing the bedrock topography map (pl. 6) with the contour map showing the elevation of the base of the Pennsylvanian (fig. 23).

STRATIGRAPHIC RELATIONS

Pennsylvanian rocks rest unconformably on strata belonging to the Burlington, Keokuk, Warsaw, Salem, and St. Louis formations of the Mississippian system (fig. 24). The pre-Pennsylvanian surface had a relief of 80 to 100 feet (fig. 23). The resistant St. Louis limestone seems to have formed much of the uplands and the soft Warsaw shale the lowlands. Locally sharp "hills" of Mississippian formations now appear as inliers, surrounded on all sides by outcrops of Pennsylvanian strata. The oldest Pennsylvanian strata were deposited in greater thicknesses in the lowlands or valleys of this old surface than on the hills.

Several unconformities occur within the system. In at least four of them 40 feet or more of strata were locally removed before the overlying stratum was deposited.

CLASSIFICATIONS

Worthen (1870, p. 93) investigated the Coal Measures of Illinois Valley from 1866 to 1870, and reported that he found in Fulton County the most complete exposure of the productive coal beds in the State. He numbered the coals in the area consecutively from No. 1 (the oldest) to No. 7 (the youngest) and later used this as the type section of the Coal Measures of Illinois.

Later David White (1907, p. 201-203) studied the fossil floras of the Illinois Coal Measures and reported that the floras associated with strata below coal No. 2 correspond with Pottsville floras of the Appalachian coal field, the floras between coals 2 and 6, or possibly 7, correspond with the Allegheny, and floras above coal 6 or coal 7 correspond with the Conemaugh.

Following White's studies the Illinois State Geological Survey adopted the names Pottsville, Carbondale, and McLeansboro for divisions of the Coal Measures, corresponding approximately with the Pottsville, Allegheny, and Conemaugh. These divisions were called formations for many years, but later (Wanless, quoted by Weller, 1940, p. 36) the Pottsville was subdivided into two units, Caseyville and Tradewater, and their status, with that of the Carbondale and McLeansboro, was changed to group, as currently accepted (Wanless, 1956a).

Udden (1912, p. 47-50) noted the more or less regular repetition of a sequence of strata in the Peoria region and Weller (1930) later suggested that the cycles of sediments constitute natural formational subdivisions.

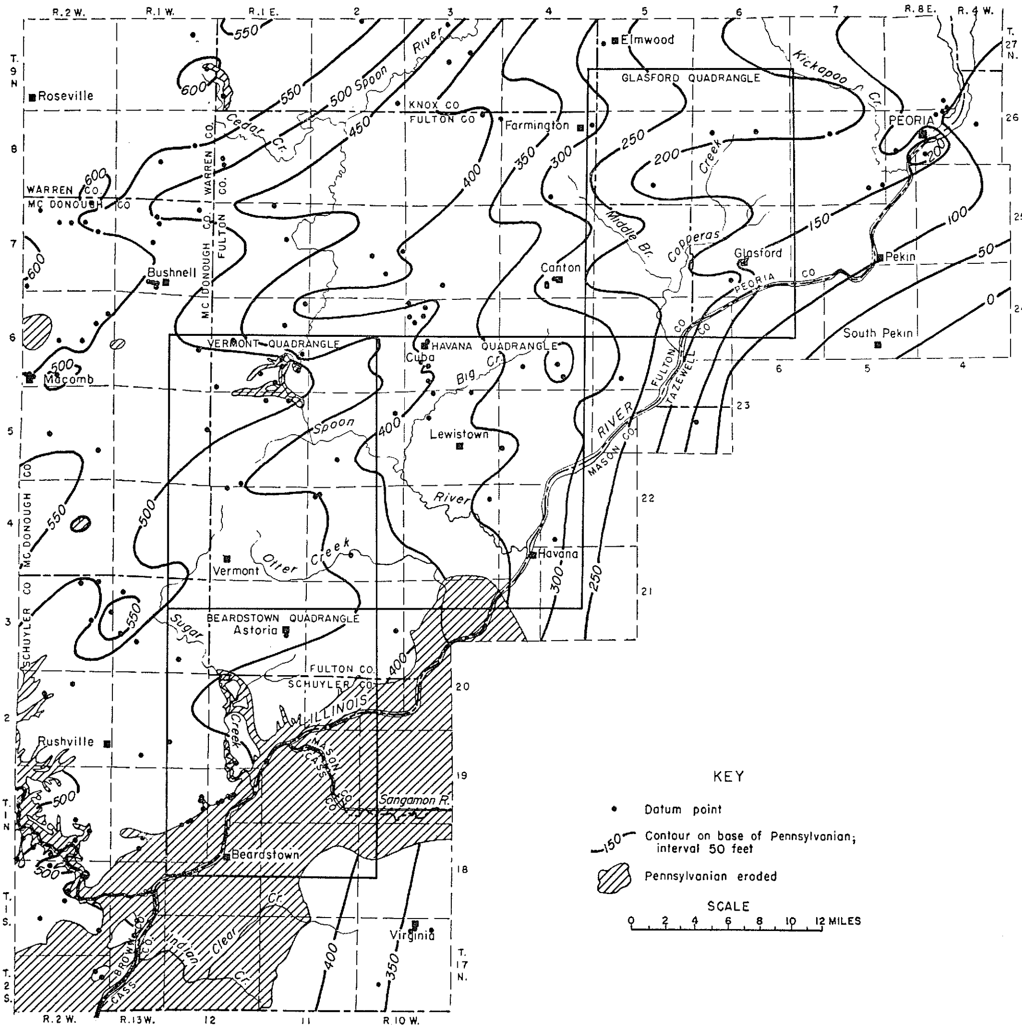


FIG. 23.—Contour map showing elevation of the pre-Pennsylvanian surface.

Wanless and Weller (1932) proposed the term "cyclothem" to describe the units because they are a group of strata with a more definite arrangement than is implied by the name "formation." The major lithologic subdivisions of the cyclothem are classified as members. Some members have well-established names which are continued. A few distinctive members are given names in this report.

To avoid the introduction of scores of new names, many members are given the same name as the cyclothem and are identified by lithology, as Seahorne sandstone, Seahorne coal, Seahorne limestone. In such cyclothems, the type section of the members is the same as the type section of the cyclothem, unless otherwise noted. A few members have informal names, such as "*Cardiomorpha* limestone." Many members are not named.

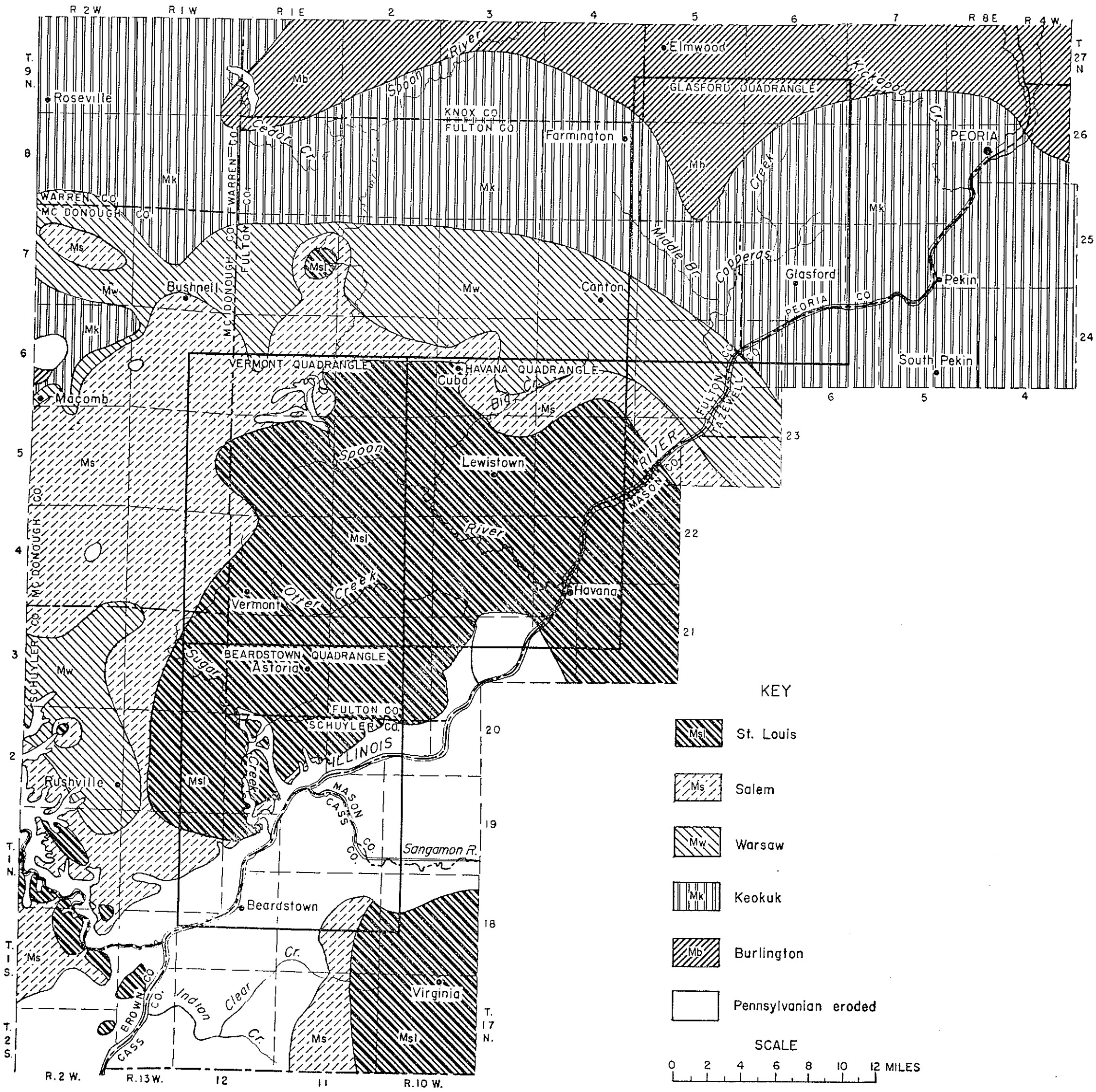


FIG. 24.—Pre-Pennsylvanian areal geology.

CHARACTER OF CYCLOTHEMS

The full sequence of beds composing a typical or ideal cyclothem in this area is given in figure 25. The actual sequence of strata at any particular locality may be less complex (table 2). The members numbered 1, 4, 5 9, and 10 are most commonly found in Illinois, though locally some of them are absent. Some cyclothems contain additional strata, such as a coal above member 1, or a thin marine limestone or coal in member 10. The major rock types are briefly described below.

SANDSTONES

The Pennsylvanian sandstones of western Illinois commonly occur in two phases: 1) a channel phase and, 2) a nonchannel phase.

The channel sandstones (figs. 29, 33, 37, 44) are 15 to 80 feet thick and their uneven base may truncate 10 to 60 feet of the underlying strata. The basal 1 or 2 feet of a chan-

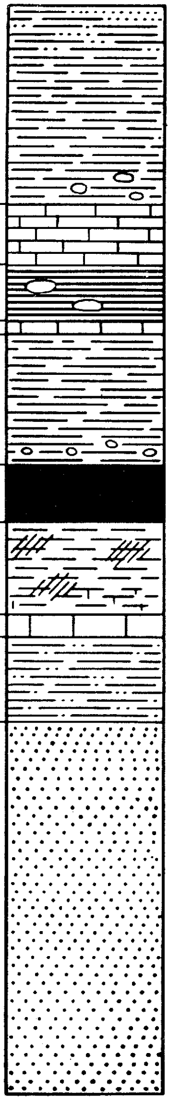


FIG. 25.—Sequence of lithologic units in a complete or ideal cyclothem.

nel sandstone may include a conglomerate with pebbles of shale, limestone, ironstone concretions, and casts of logs, in part coalified. The bedding is generally irregular and includes massive structureless units and thin-bedded or shaly, strongly cross-laminated units, none of which can be traced for any considerable distance. Carbonaceous matter and large mica flakes are common on the bedding planes.

The nonchannel sandstones are thinly and evenly bedded, light yellow gray, have little carbonaceous matter, and rest with apparent conformity on the shales or sandy shales of the underlying cyclothem (fig. 32). Basal conglomerates are not present, and the grains are commonly finer in size than those in the more massive beds of the channel sandstones.

Studies of the grain size and mineralogy of the sandstones of the area have been made

TABLE 2.—RELATIVE COMPLETENESS OF PENNSYLVANIAN CYCLES
x=present at least locally in Beardstown-Glasford-Havana-Vermont area.
y=present elsewhere in Eastern Interior basin.

Cyclothem	1 Sand-stone	2 Sandy shale	3 Under-clay lime stone	4 Under-clay	5 Coal	6 Gray shale	7 Ma-rine lime-stone	8 Black shale	9 Ma-rine lime-stone	10 Shale
Trivoli	x	y	x	x	x	y	x	x	x	x
Exline				x	x			x	x	x
Gimlet	x			x	x	x	x	x	x	x
Sparland	x	x	x	x	x		x	x	y	x
Pokeberry	x			y	y	x			x	y
Brereton	x	x	x	x	x	y	y	x	x	x
St. David	y	y	x	x	x	y	y	x	x	x
Summum	x	x	x	x	x	y		x	x	y
Liverpool	x	y	x	x	x	x	x	x	x	x
Abingdon	x	x	x	x	x			x		x
Greenbush	x	y	x	x	x			y	x	x
Wiley Upper	?			x	x			x	y	y
Wiley Lower	y			x	x			y		y
Seahorne Upper	y			x?	x			y	x	y
Seahorne Lower	x	y	x	x	x	y?		y	y	y
DeLong Upper	y			x	x			x		x
DeLong Middle	x	y		x	x	x				y
DeLong Lower	x			x	x	x?		y	y	x?
Seville	x	y		x	x	y		x	x	x
Pope Creek	x	y		x	x	x?		y	?	x
Tarter	x	y		x	x	x?				x?
Babylon	x	y		x	x	x?		x?	y?	x
Sub-Babylon	x	y		x	x	x				

by Willman (1928) and MacVeigh (1932). The sandstones are all fine- to very fine-grained and in many places they have a larger percentage of silt and clay than sand. The principal mineral in all the sandstones is quartz, but a minor quantity of heavy minerals, including leucoxene, zircon, tourmaline, and rutile, is present. The sandstones from the Seahorne sandstone to the base of the Pennsylvanian system contain little feldspar and mica, and garnet is very rare, but the Isabel and higher sandstones contain abundant grains of mica, feldspar, and garnet. The higher sandstones also contain a larger proportion of argillaceous matter and are more poorly sorted than the lower. Sandstones are widespread in 12 of the 19 cyclothems and are present in several others at a few localities.

UNDERCLAY LIMESTONES

The limestones associated with the underclays consist of irregular masses of light-gray to yellowish-gray argillaceous limestone (figs. 32, 40). They are commonly 1 to 2 feet thick, but range from a row of small nodules to about 5 feet thick. They are surrounded by calcareous underclay or poorly bedded calcareous shale. At the base vertical joints filled with similar limestone locally extend down several feet into the underlying shale or sandstone. Because of their hardness these irregular limestone masses are commonly concentrated as boulders in the stream float. They are generally nonfossiliferous, but *Spirorbis* and certain supposedly nonmarine ostracodes and gastropods are found in several of the limestones and rare marine fossils in a few. These limestones have been called "fresh-water" or "underclay" limestones, and the latter is used in this report. Underclay limestones are fairly widespread in eight of the 19 cyclothems and traces of them have been found in several others.

Underclays

The thickness of the underclays ranges from a few inches to about 15 feet. The uppermost 1 or 2 inches is commonly dark colored, locally hard and slaty, and is commonly known by miners as the "false bottom" of the coal. The remainder is commonly a uniform medium gray, but some clays are medium to light gray. The clay is massive and generally without traces of bedding or lamination (figs. 27, 32, 33, 40, 43, 45). It breaks in irregularly shaped chips. Many fracture surfaces show slickensides. In places the upper several inches has thin coaly streaks that extend obliquely down from the base of the coal and represent coalified roots.

The upper part of most underclays, and all of some, is noncalcareous and contains in many places pyrite and selenite, both in minute grains and large crystalline aggregates. In weathered outcrops (but not in fresh exposures or mines) a prominent rusty-brown streak or band is present at the base of the noncalcareous zone. In places the calcareous portion of the underclay contains minute pellets of limestone near the top and these increase in size and abundance downward, grading into the large masses of the underclay limestone.

Most of the underclays consist principally of illite with minor amounts of kaolinite. The basal Pennsylvanian underclays, which are entirely noncalcareous, consist predominantly of kaolinite. The underclays contain a variable amount of finely divided quartz and a little feldspar. Pyrite in small crystals and large nodules is locally common. In thin section a pellet-like structure of lighter and darker masses of clay is commonly evident. The median grain size of the underclays decreases upward from the top of the underlying sandstone (Krumbein, W. C., personal communication).

Underclays are present in 18 of the 19 cyclothems in the area.

Coals

The coals in this region range from less than ¼ inch to about 6 feet thick. Most of the coals, especially in the lower cyclothems, vary markedly in thickness, thinning from 2 feet or more to less than 6 inches in nearby localities. Where coals have wedged out completely their stratigraphic position commonly is marked by a very thin bed or film of sooty carbonaceous clay at the top of an underclay.

Virtually all the coals belong to the type of banded bituminous coals that contain various proportions of vitrain and clarain, interrupted by thin partings of fusain (figs. 27, 28, 33, 41-43, 47). Pyrite, calcite, and clay are present locally in thin joint facings. In places pyrite forms discontinuous bands in the coal, especially where thick fusain partings are present. Thin beds of clay are persistent in some coals but are present only locally in others. At least two of the coals locally have abundant irregular partings of impure carbonaceous shale. They commonly lack a typical underclay, and seem to record different conditions of deposition than do the normal banded coals.

Coals are present in 17 of the 19 cyclothems in this area, and are known to be present in the other two in other parts of Illinois. Two cyclothems locally have an extra coal.

Black Sheety Shales

The black hard sheety shales, called "slate" in mining terminology, average from about 6 inches to 3 feet thick (figs. 28, 35, 42, 47). They generally split readily into thin plates or sheets, ⅛ inch or less thick, that are slightly flexible. The shale is black to dark gray with small patches of lighter gray on the lamination surfaces.

The shale is pyritic, locally calcareous, and when exposed to weathering numerous needle-like crystals of selenite are formed along the bedding surfaces. The black shales characteristically contain large black concretions of limestone or pyrite. The black hard shale commonly grades upward into black or dark gray soft calcareous shale.

Fossils, usually greatly flattened, occur on the bedding planes. Conodonts, *Orbiculoidea, Lingula,* fish scales and spines, and *Dun-*

barella are the types most commonly observed. Gray streaks and wavy bands on the bedding surfaces may be filled worm borings.

Black hard sheety shales are widely present in six of the 19 cyclothems, and black soft shales occupy the same position in several others.

Marine Limestones

The marine limestones range in thickness from 2 or 3 inches to a maximum of about 20 feet, averaging from 1 to 3 feet (figs. 28, 31, 36, 42, 48, 49). They differ somewhat more markedly from each other than do the coals, underclays, or sandstones, and are especially useful in distinguishing one cyclothem from another. The limestones are mostly light to medium gray, massive without laminations, and weather buff or light brown. A few limestones are characterized by very uneven or knobby upper and lower surfaces, and a brecciated or nodular structure. Some of them resemble the underclay limestones.

The limestones are commonly very fossiliferous. Marine limestones occur both above and below the black sheety shales. Those above the black shale are more common and generally thicker than those below. The latter are sometimes referred to as "middle" limestones because of their position in the cyclothem between the major marine limestone above and the underclay limestone below.

Marine limestones are present in 11 of the 19 cyclothems, and marine fossils have been found in calcareous shales at the positions of the limestones in at least two other cyclothems.

Gray Shales

The gray shales range in thickness from a foot or less to about 50 feet (figs. 32, 47, 65). Gray shales occur at three positions in the ideal cyclothem and are so similar that they cannot ordinarily be distinguished. The gray shale above the sandstones is commonly more sandy and does not usually have concretions, which are generally common in the lower parts of the other shales. The shales above the limestones are commonly calcareous and contain fossils in the lower few feet. The lower part of the gray shales is commonly very fine-grained and clayey, but the upper portion of the thicker shales is silty to sandy. The finer clay-shales commonly exhibit a polygonal or rectangular jointing and the more silty shales may exhibit spheroidal weathering.

Gray shales are found in 9 of the 19 cyclothems. In addition the lowermost four or five cyclothems may contain soft dark blue-gray to black shales in a similar position.

Concretions

Large calcareous concretions, locally called "millstones," are found in the upper portions of some of the thicker sandstones. Some as large as 6 by 18 feet were found. The laminations of the sandstones pass directly through these concretions, showing that they were formed after the sands were deposited.

Large black pyritic or calcareous concretions are common in the black sheety shales (figs. 35, 40). They are generally flattened spheroids as large as 1 foot thick by 2 feet in diameter. At some places they form long, curved, or sinuous masses as much as 10 feet long. The laminae of the shale bend around the concretions, suggesting syngenetic origin. Many are abundantly fossiliferous, and the fossils are not flattened as they are in the black shales that enclose the concretions. They include several species that have not been found in the shale. Pelecypods such as *Solemya and Clinopistha* and goniatites *Anthracoceras* and *Eoasianites* are especially characteristic of these concretions.

Flattened oval clay-ironstone concretions are common in the gray shales. They vary somewhat in abundance and size in the several shales, and range in dimension from about ½ by 2 by 3 inches to 2 by 4 by 12 inches. Most of them occur at definite stratigraphic horizons and locally join to form solid ironstone layers. Small masses of galena, sphalerite, and barite occur locally in the concretions. Some are fossiliferous with *Crurithyris* and various gastropods most characteristic. Plant leaves are found at a few places.

A few of the limestones have a concretionary structure with numerous veinlets of calcite, giving a septarian structure. The sep-

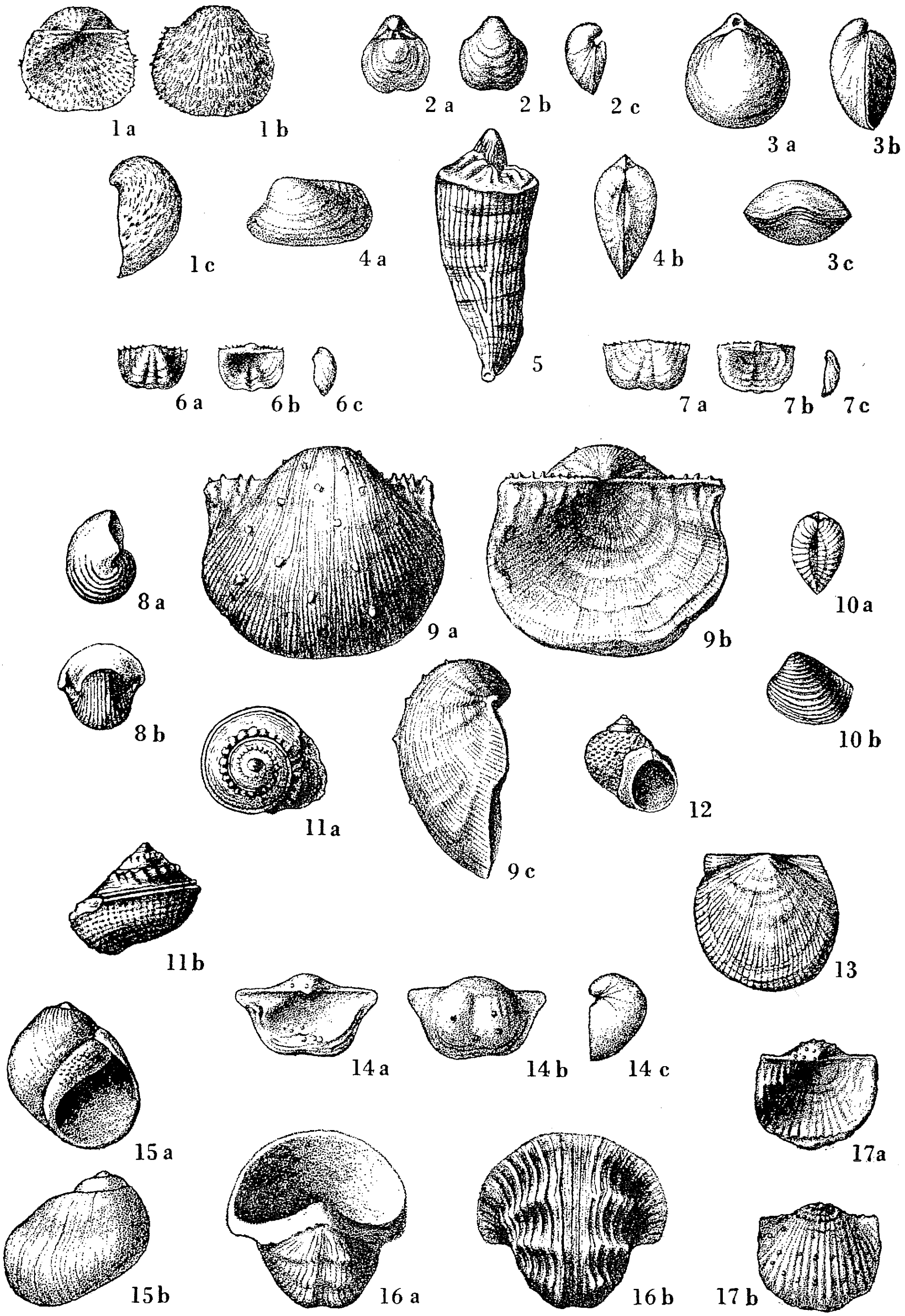


FIG. 26.—Common Pennsylvanian fossils. (Illustration by C. W. Collinson and M. E. Litterer.)

EXPLANATION OF FIGURE 26

All magnifications × 1 except where otherwise noted

1a–1c	*Juresania nebrascensis* (Owen) × 2/3	10a–10b	*Astartella concentrica* (Conrad)
2a–2c	*Crurithyris planoconvexa* (Shumard)	11a–11b	*Glabrocingulum grayvillense* (Norwood & Pratten) × 2
3a–3c	*Composita argentea* (Shepard)	12	*Trachydomia wheeleri* (Swallow)
4a–4b	*Cardiomorpha missouriensis* Shumard	13	*Dunbarella knighti* Newell
5	*Lophophyllidium profundum* (Edwards and Haime)	14a–14c	*Marginifera splendens* Norwood & Pratten
6a–6c	*Mesolobus mesolobus* var. *euampygus* (Girty)	15a–15b	*Natiocopsis altonensis* McChesney
7a–7c	*Mesolobus mesolobus* var. *decipiens* (Girty)	16a–16b	*Cymatospira montfortianus* (Norwood & Pratten) × 2
8a–8b	*Euphemites carbonarius* (Cox)	17a–17b	*Marginifera muricatina* Dunbar & Condra
9a–9c	*Linoproductus "cora"*		

tarian masses locally are overlain by 1 to 4 inches of limestone with cone-in-cone structure. A few concretionary masses have a pisolitic structure.

PALEONTOLOGY

Pennsylvanian strata yield marine invertebrate fossils in 48 of the 154 beds of the general columnar section and fresh-water invertebrates are known from two beds. The dark shales and some limestones contain fish remains. Fossil leaves are found in at least eight beds, petrified wood is common in one bed, and root impressions or *Stigmaria* are found in most of the underclays. Several sandstones contain casts of plant stems, and plant microfossils such as spores are found in all coals and several carbonaceous shales. There are thus few beds that lack fossil traces.

The invertebrate fauna of the Pennsylvanian strata of western Illinois has been the subject of special study and it is listed and discussed more fully in a separate report (Wanless, 1957). More than 500 species were identified. Practically all groups of late Paleozoic invertebrates are represented in the collections. A few of the most common invertebrates are shown in figure 26.

GENERAL SECTION

The general sequence of Pennsylvanian strata in the Glasford, Havana, Vermont, and Beardstown quadrangles is given in figure 22 and the members are listed in table 3. Not all the strata are found in any one part of the area. Members numbered 82 to 154 crop out in the Glasford quadrangle, members 5 to 115 in the Havana quadrangle, members 1 to 106 in the Vermont quadrangle, and members 1 to 130 in the Beardstown quadrangle. The total section is thinner in the south part of the area than in the north, and several beds of the general section are not represented in the Beardstown quadrangle.

The outcrop belts of the cyclothems are shown on the areal geology map (pl. 5), and actual outcrops of individual cyclothems may be determined by comparison with the surficial maps (pls. 1-4).

TABLE 3.—COMPOSITE SECTION OF PENNSYLVANIAN STRATA

Member No.		*Average Thickness Ft.*	*In.*
	McLeansboro group (top of section)		
	Trivoli cyclothem		
154.	Shale, gray, soft	6	6
153.	Shale, calcareous, gray; contains abundant fossils, principally brachiopods	4	6
152.	Limestone, gray, weathering buff, in one bed, fossiliferous (Trivoli limestone)	1	
151.	Shale, calcareous, greenish-gray; contains small limestone concretions, fossiliferous		8
150.	Shale, carbonaceous, black, hard, fossiliferous	1	2
149.	Limestone, shaly, dark blue-gray, thin-bedded, fossiliferous, discontinuous	1	6
148.	Coal, locally has ½-inch clay parting 4 inches from base (Trivoli No. 8 coal)	1	7
147.	Underclay, upper 1 foot 3 inches noncalcareous; lower part has small limestone nodules	3	
146.	Limestone, gray, weathers brown; occurs as large concretions in lower part of calcareous underclay	1	
145.	Sandstone, light blue-gray, massive and thin-bedded, micaceous; contains calcareous concretions (Trivoli sandstone)	15	

Member No.		Average Thickness Ft.	In.
	Exline cyclothem		
144.	Shale, light to dark blue-gray, partly calcareous, slightly fossiliferous, discontinuous; contains thin bands of gray fossiliferous limestone and ironstone concretions	25	
143.	Shale, calcareous, blue-gray, fossiliferous; numerous fossils weather out	15	
142.	Limestone, dark gray to black, platy; contains leaf impressions, *Spirorbis*, and a few marine fossils (Exline limestone)	1	6
141.	Shale, olive-gray, discontinuous; contains small limestone nodules	2	
	Gimlet cyclothem		
140.	Limestone, light gray; varies from a solid bed of fossiliferous limestone to conglomeratic fossiliferous limestone, limestone nodules in greenish-gray clay or shale, and fossiliferous calcareous sandstone; locally includes a marly bed of fusulinids; contains silicified wood in upper portion; ranges from a few inches to 21 feet thick; unconformable on beds as low as No. 7 coal (Lonsdale limestone)	6	
139.	Shale, light gray at top to medium gray at base, discontinuous; contains small limestone nodules	1	
138.	Shale, dark gray to black, locally sheety and hard, elsewhere soft, discontinuous	5	
137.	Shale, calcareous, blue-gray to light gray, hard, discontinuous		6
136.	Limestone, brownish-gray, dense, in one bed, slightly fossiliferous, discontinuous . .		6
135.	Shale, light to medium gray, soft, thin-bedded, discontinuous; contains spheroidal concretions of light blue-gray limestone	5	
134.	Coal, dull and impure, very local (Gimlet coal)		3
133.	Shale, dark gray to black; contains thin streaks of bright coal and plant stem impressions on bedding surfaces . .		7
132.	Underclay, light gray, mottled with buff, brick-red, and lavender, shaly, discontinuous. .	3	
131.	Sandstone, light gray, massive to thin-bedded, discontinuous; strongly cross-bedded and ripple-marked in places; contains casts of logs and thin coaly streaks; unconformable on Farmington shale; maximum thickness 50 feet (Gimlet sandstone)	20	
	Sparland cyclothem		
130.	Shale, light blue-gray; contains numerous large oval to discoidal ironstone concretions; 5 to 43 feet thick (Farmington shale)	30	
129.	Shale, red, or red mottled with gray	4	
128.	Shale, black, hard, sheety; contains small oval concretions .		10
127.	Shale, dark gray, soft	2	
126.	Limestone, very argillaceous, dark gray, fossiliferous; locally is calcareous shale		5
125.	Coal, maximum thickness 2 feet 6 inches (Sparland No. 7 coal)	1	8
124.	Underclay; upper 2 feet 6 inches noncalcareous, lower part calcareous; locally mottled light gray and reddish	8	
123.	Limestone, silty, blue-gray, concretionary, very irregular in thickness, local	1	
122.	Shale, dark brownish-red, mottled with greenish-gray, local	12	
121.	Sandstone, brownish-gray with rusty spots from oxidized pyrite grains, micaceous, thin-bedded, locally massive; unconformity at base truncates Sheffield shale and Brereton limestone; maximum thickness 31 feet (Copperas Creek sandstone)	12	
	Carbondale group		
	Pokeberry cyclothem		
120.	Limestone, medium gray, massive, very uneven upper surface, very fossiliferous; contains large productids (Pokeberry limestone)	2	
119.	Shale or clay, calcareous, greenish-gray; contains nodules and thin bands of fossiliferous limestone	3	
118.	Sandstone, calcareous . . .	6	
	Brereton cyclothem		
117.	Shale, olive-gray, upper beds somewhat sandy; locally contains ironstone concretions (Sheffield shale)	8	
116.	Shale, calcareous, yellow-gray, fossils weather out	1	6
115.	Limestone, light blue-gray, dense to subcrystalline; contains a few pebbles of black phosphatic limestone; commonly has 1½-inch clay parting 6 inches from base; fossiliferous, especially with fusulinids; locally absent (Brereton limestone)	2	6
114.	Shale, dark gray or greenish-gray to black, commonly soft but locally hard and sheety; contains few small or medium-sized calcareous and pyritic concretions	2	

Member No.		Average Thickness Ft.	In.
113.	Clay, sandy, white to light gray, very discontinuous; locally is sandstone; locally replaces the dark gray or black shale above and the upper part of the Herrin (No. 6) coal below; known as "white-top" by the coal miners	1	
112.	Coal; contains three persistent clay partings as follows: 1/4-inch parting 1 foot 8 inches below top, 2 1/2-inch parting (the "blue-band") 2 feet 6 inches below top, 1/2-inch parting 3 feet 4 inches below top; contains other clay partings, pyrite and fusain bands; coal balls local in upper part; locally absent (Herrin No. 6 coal)	4	8
111.	Underclay, light gray; upper 1 1/2 to 2 feet noncalcareous, lower part calcareous and contains small limestone nodules	5	
110.	Limestone, light to brownish-gray, dense to sublithographic, concretionary, nonfossiliferous, discontinuous; occurs in lower part of calcareous underclay	1	
109.	Shale, gray, soft (Big Creek shale)	7	
108.	Limestone, medium gray, weathers brown, fossiliferous, with abundant *Linoproductus* and other brachiopods, very local	6	
107.	Sandstone, light gray with brownish specks, medium- to fine-grained, massive and cross-bedded to thin-bedded; includes some masses of sandy shale; upper part contains large calcareous "millstone" concretions; unconformity at base locally truncates Canton shale and St. David limestone and very locally the Springfield (No. 5) coal; locally absent; maximum thickness more than 80 feet (Cuba sandstone)	40	
	St. David cyclothem		
106.	Shale, sandy, buff, micaceous, discontinuous	5	
105.	Shale, light gray; contains numerous small ironstone concretions (upper part of Canton shale)	30	
104.	Limestone, argillaceous, blue-gray, concretionary, fossiliferous; locally forms a continuous band		6
103.	Shale, light gray; contains small oval ironstone concretions (lower part of Canton shale)	7	
102.	Shale, dark gray, calcareous; locally soft argillaceous limestone; contains abundant fossils that weather out		8
101.	Limestone, light gray, weathers buff, commonly in one massive bed with uneven lower surface, fossiliferous, discontinuous, locally 7 feet thick (St. David limestone)	1	6
100.	Shale, black, mottled with dark gray	1	
99.	Coal, very local	5	
98.	Shale, black, hard, sheety, fossiliferous; contains large calcareous and pyritic fossiliferous concretions	1	10
97.	Coal; without bedded shale partings, but in many places cut by clay "horsebacks" (Springfield No. 5 coal)	5	
96.	Underclay, light to medium gray; upper 3 or 4 inches noncalcareous, calcareous below	2	
95.	Limestone, argillaceous; medium gray; commonly occurs as two or three discontinuous beds separated by dark gray calcareous shale or as light gray hard septarian limestone nodules	2	
94.	Clay, calcareous, gray; contains small pellet-like limestone nodules	2	
	Summum cyclothem		
93.	Limestone, conglomeratic, medium gray; composed of angular-to-rounded small fragments of dark gray limestone; very local (Covel conglomerate)		6
92.	Limestone, blue-gray to brownish, with very uneven upper surface, fossiliferous, discontinous (Hanover limestone)	2	
91.	Shale, light to medium gray, soft, poorly bedded	2	
90.	Shale, dark gray with bands of black, soft; contains large smooth spheroidal black fossiliferous limestone concretions	3	
89.	Coal, shaly; contains clay partings; commonly about 4 inches, but locally 5 feet thick (Summum No. 4 coal)	2	
88.	Sandstone, light gray, fine-grained, massive; contains *Stigmaria*; very local		6
87.	Underclay, light gray to buff; noncalcareous in upper 2 feet, calcareous part below contains small limestone nodules	5	
86.	Limestone, silty to sandy, blue-gray, weathers yellow-brown, very uneven, concretionary, locally septarian	3	
85.	Shale, gray, sandy to silty; commonly penetrated with brownish-gray limestone along ver-		

Member No.		Average Thickness Ft.	In.
	tical joints; locally contains leaf and stem impressions . .	5	
84.	Coal, locally canneloid, very discontinuous; occurs in a few scattered elongate basins in the top of the Pleasantview sandstone; where thick commonly has one or several clay partings; maximum thickness about 4 feet (Kerton Creek coal)	2	
83.	Sandstone, light brownish-gray, fine- to very fine-grained, thin-bedded, micaceous; contains carbonaceous matter along lamination planes and in upper part thin discontinuous beds of coal with large calcareous concretions; occurs in broad channels that truncate the Purington, Oak Grove, and all or part of the Francis Creek member; lenticular masses of shale and a basal conglomerate occur in the channels 5 to 80 feet thick (Pleasantview sandstone)	40	
	Liverpool cyclothem		
82.	Shale, gray, soft, slightly fossiliferous; upper 4 or 5 feet sandy; contains numerous ironstone concretions and bands; upper part has spheroidal or polygonal weathering (Purington shale)	50	
81.	Ironstone, calcareous, gray; contains fossils outlined in whitish casts (top of Oak Grove beds)		4
80.	Shale, dark gray, soft; contains three persistent layers of ironstone concretions that are slightly fossiliferous . . .	2	7
79.	Limestone, dark blue-gray, weathers brown; *Crurithyris* and *Linoproductus* abundant; locally has cone-in-cone on under surface		4
78.	Shale, black, soft, thinly laminated, fossiliferous; *Dunbarella* abundant	1	
77.	Limestone, black, carbonaceous, pyritic, concretionary, discontinuous; pelecypods, especially *Cardiomorpha*, abundant		3
76.	Shale, calcareous, dark gray; *Mesolobus* abundant . . .		1
75.	Shale, dark gray to black, slightly gritty; contains *Marginifera*	1	3
74.	Limestone, argillaceous, dark gray; grades to calcareous shale; composed mostly of loosely cemented and partially crushed shells, especially gastropods		4
73.	Cone-in-cone, discontinuous . .		4

Member No.		Average Thickness Ft.	In.
72.	Limestone, light gray, weathers buff, septarian; in places is a band of septarian concretions, elsewhere is a solid bed of limestone; *Marginifera* common	1	
71.	Shale, gray, slightly fossiliferous		5
70.	Conglomerate of small dark gray limestone pebbles, discontinuous		2
69.	Shale, gray, with one or two discontinuous beds of fossiliferous limestone	1	6
68.	Limestone, siliceous, dark gray to blue-gray, massive, argillaceous, locally sandy or cherty, fossiliferous, discontinuous, maximum thickness 10 feet (base of Oak Grove beds) . .	2	
67.	Shale, black, hard, sheety; contains small gray limestone concretions around which laminae of shale bend giving some beds a "pimply" appearance; also contains large black smooth rounded slightly fossiliferous concretions; contains large concretionary masses of black and dark gray limestone as large as 10 to 12 feet thick; absent in large areas . . .	2	6
66.	Limestone, black, somewhat concretionary, very local; resembles large concretions in black shale; fossiliferous, contains ammonoids		8
65.	Sandstone, medium gray, micaceous, thin-bedded to massive, wave marks on some bedding surfaces; absent or very thin in areas where black sheety shale is present; maximum thickness 18 feet (Jake Creek sandstone)	3	
64.	Shale, silty, gray, evenly bedded, spheroidal weathering; contains a few marine fossils in upper part and fossil leaves in lower 1 to 2 feet; locally absent; maximum thickness 50 feet (Francis Creek shale)	30	
63.	Coal, without clay partings, widely persistent (Colchester No. 2 coal)	2	6
62.	Underclay, light gray, upper part or all noncalcareous . .	2	6
61.	Limestone, light gray, nodular, septarian, discontinuous . .	1	
60.	Sandstone, brownish-gray, micaceous; medium- to fine-grained, generally thin-bedded to massive, and 1 to 3 feet thick; locally truncates 50 feet or more of underlying beds, is massive, cross-bedded, conglomeratic at base; contains lenticular masses of shale, and		

Member No.		Average Thickness Ft.	In.
	is as much as 80 feet thick (Browning sandstone)	3	
	Abingdon cyclothem		
59.	Shale, greenish-gray, finely sandy in upper part, small ironstone concretions in lower part	7	
58.	Shale, dark gray to black		6
57.	Coal, very discontinuous; commonly a coaly streak in clay, locally one foot thick (Abingdon coal)		4
56.	Underclay, dark to medium gray	1	6
55.	Limestone, gray, nodular, discontinuous		6
54.	Shale, silty to sandy, gray	1	6
53.	Sandstone, gray to buff, micaceous, medium-grained, massive to thin-bedded, somewhat cross-bedded, maximum thickness 10 feet (Isabel sandstone)	4	
	Tradewater group		
	Greenbush cyclothem		
52.	Shale, silty, greenish-gray, evenly bedded, soft, with some ironstone concretions	5	
51.	Limestone, purplish-gray, weathers brownish, slightly fossiliferous, very local		5
50.	Coaly streak in clay (Greenbush coal)		½
49.	Underclay, light gray		6
48.	Limestone, gray, dense, nodular, in places forming a solid ledge, slightly fossiliferous, contains *Spirorbis*		5
47.	Underclay, light to medium gray	5	
	Wiley cyclothem		
46.	Shale, dark gray to black, soft, not persistent		3
45.	Coal (Wiley coal)		10
44.	Underclay, medium to light gray	2	
43.	Clay, black, coaly, very local		½
42.	Underclay, medium gray		6
	Seahorne cyclothem		
41.	Limestone, blue-gray, massive, brecciated, very uneven "knobby" upper and lower surfaces; grades laterally into limestone nodules in clay; abundant gastropods; locally absent (Seahorne limestone)	4	
40.	Clay, coaly; locally follows irregular base of Seahorne limestone (Upper Seahorne coal)		½
39.	Shale, pale, greenish-gray, poorly laminated	1	
38.	Coal, commonly a coaly clay (Lower Seahorne coal)		2
37.	Underclay, light gray	2	
36.	Limestone, medium gray, nonfossiliferous; occurs locally as large pisolitic septarian concretions scattered in clay	1	
35.	Sandstone, light gray, fine-grained, thin-bedded; contains very little mica; locally absent (Seahorne sandstone)	3	
	Upper DeLong cyclothem		
34.	Shale, light gray, soft, very poorly laminated	3	
33.	Shale, black, soft, local		4
32.	Coal, shaly (Upper DeLong coal)		1
31.	Underclay, medium dark gray	1	
30.	Coaly clay		1
29.	Underclay, medium gray, mottled with lavender and rusty brown	2	
	Middle DeLong cyclothem		
28.	Shale, gray to drab, soft, poorly bedded		4
27.	Coal, shaly (Middle DeLong coal)		2
26.	Underclay, light gray mottled bluish-gray; contains large selenite crystals locally	3	
25.	Sandstone, shaly, light gray, thin-bedded, micaceous, local	2	
	Lower DeLong cyclothem		
24.	Shale, dark to medium blue-gray, well laminated, soft, discontinous	2	
23.	Coal, discontinuous, or a coaly clay; commonly 3 or 4 inches, but reported as more than 2 feet in some borings (Lower DeLong coal)		4
22.	Underclay, light gray, somewhat sandy	1	
21.	Sandstone, medium to dark gray, fine-grained, very local		6
	Seville cyclothem		
20.	Shale, medium to dark gray; contains heavy ironstone concretions and discontinuous ironstone bands	6	
19.	Limestone, argillaceous, dark blue-gray, dense; contains numerous brachiopods and bryozoa; occurs in areas with thick Rock Island (No. 1) coal (Seville limestone)	2	
18.	Shale, black, locally hard	1	
17.	Coal; commonly only a few inches of coal under soft gray shale, but locally several feet thick under hard shale and Seville limestone (Rock Island No. 1 coal)	2	
16.	Underclay, medium gray, generally very sandy; locally appears to be weathered sandstone; contains *Stigmaria*		6
15.	Sandstone, light gray, fine-grained, hard, locally almost quartzitic, thickness variable; locally truncates all of underlying Pope Creek (Bernadotte sandstone)	6	
	Pope Creek cyclothem		
14.	Shale, dark blue-gray, soft; contains ironstone concretions	6	
13.	Coal, extremely variable in thickness; locally has one or more clay partings (Pope Creek coal)	1	6

Member No.		Average Thickness Ft.	In.
12.	Underclay, dark gray at top, very light gray below	2	
11.	Sandstone, light gray, soft, poorly bedded, very discontinuous (Pope Creek sandstone)	1	6
	Tarter cyclothem		
10.	Shale, dark blue-gray, slightly sandy, discontinuous; contains stem or leaf impressions at some localities	3	
9.	Coal, thickness variable (Tarter coal)	1	6
8.	Underclay, sandy to silty, gray, medium to dark gray	3	
7.	Sandstone, very shaly, brownish-gray, discontinuous (Tarter sandstone)	1	
	Babylon cyclothem		
6.	Shale, dark gray; contains stem and leaf impressions and *Lingula*	6	
5.	Shale, black, flaky, locally hard and sheety, slightly fossiliferous		5
4.	Coal, thickness variable; upper part locally cannel coal (Babylon coal)	1	6
3.	Underclay, sandy, medium to light gray	4	
2.	Sandstone, light yellow-gray, medium-grained, massive; consists of clean quartz sand grains, sparkling from secondary enlargement; locally absent; maximum thickness more than 20 feet (Babylon sandstone)	10	
	Unnamed cyclothem		
1.	Clay, rusty, brownish, or dark gray; locally has shaly structure, locally present between Babylon sandstone and uppermost Mississippian strata	3	

TRADEWATER GROUP

The rocks here referred to the Tradewater group are correlated with typical Tradewater strata of western Kentucky and southern Illinois by microspore floras (Kosanke, 1950, p. 64), by leaf floras (David White, unpublished manuscript) and by marine faunas. The spore floras indicate that the oldest coals (pre-Babylon) of western Illinois are just a little younger than the top of the Caseyville of southeastern Illinois and western Kentucky (Wanless, 1955, fig. 3).

South of the Beardstown quadrangle most of the coals, shales, and sandstones of the Tradewater group wedge out, and several superposed underclays, locally divided by coaly films representing coal beds and other strata such as the Seahorne limestone, form the Cheltenham fireclay of Green, Calhoun, and Madison counties, Illinois, and occupy an extensive area in northeastern Missouri.

The Tradewater group, originally described as a formation (Glenn, 1912, p. 27) consists of Pennsylvanian strata up to the base of the Isabel sandstone. It is divided in this area into pre-Babylon strata (at the base) and the Babylon, Tarter, Pope Creek, Seville, Lower DeLong, Middle DeLong, Upper DeLong, Seahorne, Wiley, and Greenbush cyclothems.

PRE-BABYLON STRATA

(MEMBER 1)

At a few localities in the Vermont and Beardstown quadrangles, a small thickness of clay or shale underlies the Babylon sandstone and overlies Mississippian strata. The maximum observed thickness is 4 feet, but as most of the observed outcrops overlie buried hills of Mississippian strata, a greater thickness of such deposits may be present elsewhere.

No regular sequence of beds was observed in this stratigraphic position, but greenish sandy clay, without marked lamination, and with selenite crystals and fragments of ironstone, limestone, or geodes, is most prevalent. Coaly streaks were found in the clay at three localities. These beds may represent several cyclothems.

The pre-Babylon strata conform in position to knobs or other projections of the Mississippian surface, and locally may fill solution cavities. Geodes in the clay are derived from Mississippian strata, and the clay itself locally may be a residuum on the Mississippian surface.

Geologic sections 5, 6, 34, 35. The geologic sections are given in appendix A at the end of the report.

BABYLON CYCLOTHEM

The Babylon cyclothem resembles the overlying Tarter and Pope Creek cyclothems in so many respects that an isolated outcrop cannot be readily identified. The Babylon sandstone, the most widespread and thickest of the sandstones below the Bernadotte (member 15), is its most characteristic member. In common with the Tarter, Pope Creek, and Seville cyclothems, the thickness and characteristics of the Babylon seem related to the uneven surface of the underlying Mississippian rocks. The Babylon may wedge out against some of the buried hills.

The Babylon cyclothem (Wanless, 1931a, p. 189, 192) was named from exposures along Spoon River half a mile north of Babylon, in the NE¼ NE¼ sec. 14, T. 7 N., R. 1 E., Fulton County, about seven miles north of the Vermont quadrangle (geol. sec. 41).

The Babylon cyclothem underlies nearly all of the area of this report, except the Illinois Valley in part of the Beardstown quadrangle, and a smaller territory in Spoon Valley in the Vermont quadrangle (pl. 5).

The Babylon cyclothem is 3 to 40 feet thick and in general thins toward the southwest. Near Frederick in the Beardstown quadrangle and south of Seville in the Vermont quadrangle, it averages 10 to 12 feet thick, and in several borings near Cuba in the Havana quadrangle it averages 25 feet thick.

The Babylon cyclothem is correlated with the type exposure by its similar relations to the Rock Island (No. 1) coal and Bernadotte sandstone above, and by the distinctive texture of the Babylon sandstone.

Geologic sections 5-7, 26, 27, 33-35, 37, 41.

Babylon Sandstone (Member 2)

The Babylon sandstone, present in practically all parts of the area where the cyclothem occurs, has a maximum exposed thickness of 25 feet. It is especially prominent along the Spoon River and the lower part of Badger Creek between Seville and Bernadotte, where it forms low cliffs at many points.

The sandstone is composed principally of subangular medium to coarse quartz grains. Most of the grains have been secondarily enlarged and have many crystal faces that sparkle in the sunlight. Mica is very uncommon and feldspar has not been found. The upper part of the sandstone in places is firmly indurated, resembling a quartzite, but the lower part in the thicker sandstone exposures is friable. Small pebbles of greenish-gray shale, ironstone, and quartz are present locally near the base. The sandstone is commonly massive, but locally has bedding planes 4 to 6 inches apart. It is cross-bedded at some localities, and the upper portion is locally thin-bedded or shaly. The sandstone is light gray to yellowish-gray, and in many outcrops the surface is stained reddish brown. Carbonaceous streaks are fairly common, and *Stigmaria* is found at the top. Impressions of *Lepidodendron* and *Cordaites* were also observed.

At several places between Seville and Bernadotte in the Vermont quadrangles, as in sec. 26, T. 6 N., R. 1 E., the sandstone may be observed to fill buried valleys in the top of the St. Louis limestone to a depth of 20 feet. The upper surface of the sandstone is also uneven, a local irregularity of 12 feet being observed in the NW¼ sec. 20, T. 5 N., R. 2 E.

The Babylon sandstone is readily recognized throughout western Illinois by its clean sparkling grains and by its basal position in the Pennsylvanian system. It is discontinuous south of the Beardstown quadrangle to a little south of St. Louis, although in places it underlies the Cheltenham fireclay.

It is provisionally correlated with the Grindstaff sandstone member of southern Illinois and the upper part of the Mansfield sandstone of Indiana. These sandstones contain well sorted quartz grains with prominent secondary enlargement.

Geologic sections 5-7, 33-35, 37, 41.

Underclay (Member 3)

The typical light gray underclay of the Babylon coal is a few inches to 6 feet thick and averages about 3 feet. It is generally noncalcareous. At some localities, a few inches of flaky carbonaceous shale with stem impressions occurs at the top. The lower part of the underclay is sandy, and it locally grades down into a medium gray sandy shale at the base. Root traces, including *Stigmaria,* are common.

Geologic sections 5-7, 33-35, 37, 41.

Babylon Coal (Member 4)

The Babylon coal is missing at many exposures of its horizon. It is more commonly present in the Vermont quadrangle than the Beardstown. In 32 outcrops in the Vermont quadrangle it is ½ inch to 4 feet 2 inches thick, averaging 8 inches, and at five outcrops in the Beardstown quadrangle is ½ inch to 1 foot thick, averaging about 2 inches. Coal thicker than 1 foot seems to be quite local, but along a ravine just south of Bernadotte, near the center of sec. 19, T. 5 N., R. 2 E., the coal is locally 4 feet 2 inches thick and is overlain by black shale with thin streaks of bright coal. At the Hamm mine, probably in the Babylon coal, in the SW¼ sec. 27, T. 6 N., R. 1 E., cannel coal 2 feet 6 inches to 3 feet thick has been mined. At the type exposure of the Babylon coal, a few miles north of the Vermont quadrangle (geol. sec. 41), 5½ inches of cannel coal overlies 1¾ inches of banded coal.

Geologic sections 7, 34, 35, 37, 41.

Gray and Black Shales (Members 5 and 6)

The shale overlying the Babylon coal crops out in the same localities as the underlying members of the Babylon cyclothem, and also along the bank of Spoon River at Duncan Mills, sec. 8, T. 4 N., R. 3 E., where the oldest strata exposed in the Havana quadrangle are found (geol. sec. 27). The thickness ranges from a few inches to more than 20 feet. The shale is thicker at Duncan Mills than in the Vermont or Beardstown quadrangles, which suggests thickening to the east.

The upper part of the shale (member 6) is commonly gray to blue gray and is locally sandy. Traces of plant stems are fairly common, and along Mill Creek, near the center of sec. 31, T. 2 N., R. 1 E., the shale contains abundant and well preserved leaves of *Sphenophyllum, Annularia, Cordaites, Sphenopteris, Palmatopteris, Neuropteris* and other genera. *Lingula* is found in the upper part of the shale at the type exposure of the Babylon cyclothem but has not been found in the area of this report.

In the middle or lower part of the shale (member 5), thin bands of vitrain representing coalified stems, masses of fusain, some pyritized wood, and a fish scale have been found. At some localities the bedding surfaces are crowded with flattened stem impressions. The lower part of the shale is very dark gray to black and in places locally is hard and sheety. Ironstone concretions or bands occur at one or several horizons in the shale, and septarian limestone concretions are present at the Duncan Mills outcrop.

Geologic sections 5-7, 26, 27, 33-35, 37, 41.

TARTER CYCLOTHEM

The Tarter cyclothem resembles the adjacent Babylon and Pope Creek cyclothems in most respects and is recognized primarily by its position in the section. In several parts of the area the Tarter coal is the lower of two closely spaced coals of similar thickness.

The Tarter cyclothem is named herein for the Tarter bridge over Spoon River, and the type section is a large ravine a quarter of a mile southwest of the bridge in the SE¼ sec. 2, T. 5 N., R. 1 E., Fulton County, Vermont quadrangle (geol. sec. 34). The name has been used in other reports without being defined.

The Tarter cyclothem underlies about the same area as the Babylon cyclothem. It crops out in the Beardstown, Vermont, and Havana quadrangles at about 70 places. In outcrops the cyclothem is from 3 to 10 feet thick, averaging about 4 feet, and in borings is 7 to 22 feet, averaging about 15 feet. As the borings are northeast of the outcrops, they suggest northeastward thickening.

Minor unconformities separate the Tarter from the overlying and underlying cyclothems. The base of the Tarter sandstone varies from 2 to 15 feet above the Babylon coal. Upper Tarter strata in many places are truncated by the Pope Creek sandstone, and in one place the sandstone also cuts out the Tarter coal. At some localities the Bernadotte sandstone cuts out the entire Pope Creek cyclothem and rests on Tarter strata.

Strata corresponding in position to the Tarter cyclothem are exposed at numerous places in western Illinois from Rock Island County to Brown County. They are absent along the western margin of the coal field for nearly 200 miles south of northern Brown County. In southern Illinois, strata that are believed to correspond to the Tarter cyclothem are found in the upper part of the complex Grindstaff cyclothem.

Geologic sections 5-7, 26, 32-35, 37, 41.

Tarter Sandstone (Member 7)

The Tarter sandstone is present in less than one-third of the outcrops where the Tarter coal and underclay are present. It is a few inches to 3 feet thick. One outcrop, doubtfully referred to the Tarter, includes 9 feet of sandstone.

The sandstone is commonly argillaceous. At several localities it consists of irregular nodular masses at the base of the underclay. The sand grains are principally quartz, with very little mica, and are fine- to very fine-grained. At places the grains are secondarily enlarged. Where more than a foot thick the sandstone appears rather massive. It is commonly light gray or bluish gray, but is locally discolored by carbonaceous matter; the outcrops are commonly iron-stained. Root traces, including *Stigmaria,* are found at several places.

Geologic sections 5, 7, 26, 33-35, 41.

Underclay (Member 8)

The underclay of the Tarter coal is 1 foot 6 inches to 8 feet thick, averaging 2½ feet. The greater thicknesses were found where the Tarter sandstone is absent, and may include part of the underlying shale of the Babylon cyclothem. The underclay is much more persistent than the sandstone.

The underclay is commonly medium gray, noncalcareous, and the lower part is sandy. One or two inches of black bony shale occurs immediately beneath the Tarter coal at a few localities. Root traces are common in the clay. At one locality near Frederick in the Beardstown quadrangle, irregularly shaped calcareous concretions that resemble an underclay limestone are found about 2 feet below the top of the underclay.

Geologic sections 5-7, 26, 33-35, 37, 41.

Tarter Coal (Member 9)

The Tarter coal is especially prominent along Mill Creek and near Sheldons Grove in the Beardstown quadrangle, near Duncan Mills in the Havana quadrangle (fig. 27), and at many places in the north part of the Vermont quadrangle.

The coal is 1 inch to 3 feet thick and averages 1 foot 4 inches in 64 outcrops. The lower 2 or 3 inches of the coal is shaly in a few outcrops. Discontinuous partings of clay, sandstone, and pyrite are present locally. Leaf and stem impressions are conspicuous on bedding surfaces of the shaly coal and in shaly partings.

The Tarter coal is thin and discontinuous over most of western Illinois, although present in many scattered outcrops. It is probably equivalent to the Willis coal of southeastern Illinois, the Bell coal of Union County, Kentucky, and the Lower Block coal of the Brazil field, Clay County, Indiana.

Geologic sections 5-7, 26, 32-35, 37, 41.

Shale (Member 10)

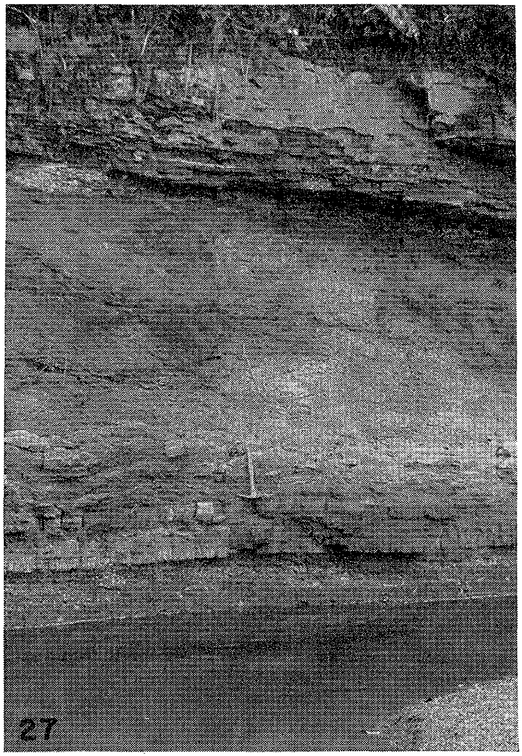
The shale overlying the Tarter coal is a few inches to 6 feet thick in numerous exposures in the Vermont quadrangle but is absent or only a few inches thick at most exposures in the Beardstown and Havana quadrangles where the Pope Creek sandstone or underclay commonly rests on the Tarter coal.

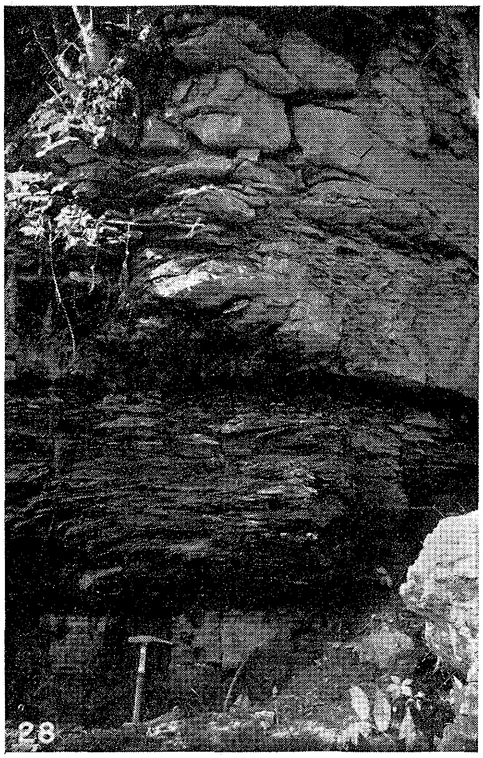
The shale is dark gray to black, thin-bedded, and soft in most exposures. It locally is slightly sandy. One or more bands of ironstone concretions are found in several outcrops. No fossils except poorly preserved plant stem impressions were found in this area, but *Lingula* was found in exposures about seven miles north of the Vermont quadrangle.

Geologic sections 7, 26, 32-35, 37, 41.

POPE CREEK CYCLOTHEM

The Pope Creek cyclothem is similar to the Tarter cyclothem but includes the upper of two closely spaced coals below the Bernadotte sandstone, and its underclay is generally lighter colored than the other underclays older than the Bernadotte sandstone (fig. 27).





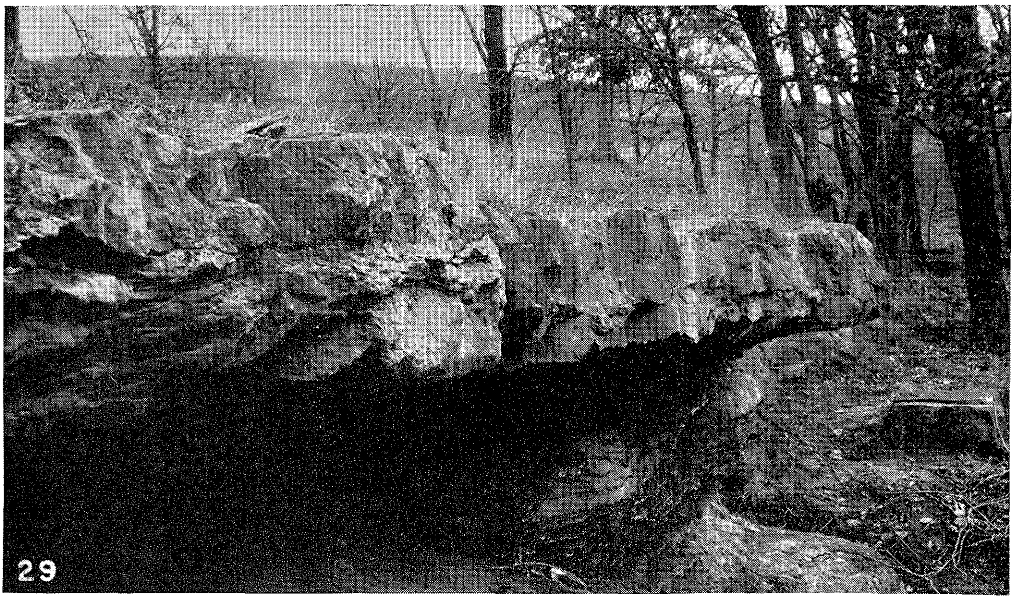


FIG. 27.—The Bernadotte sandstone overlies the Pope Creek coal in the prominent ledge at the top. The thick underclay beneath the Pope Creek coal overlies thin Pope Creek sandstone (at the hammer) which rests on the Tarter coal and its underclay. Exposure on south side of Tater Creek in the NW ¼ sec. 7, T. 4 N., R. 3 E., Havana quadrangle. Geologic section 26.

FIG. 28.—Type locality of the Seville cyclothem showing the Seville limestone at the top overlying black shale and the Rock Island (No. 1) coal, in bluff of Spoon River, in the SW ¼ SW ¼ sec. 23, T. 6 N., R. 1 E., Vermont quadrangle. Geologic section 33.

FIG. 29.—Stream bank showing massive overhanging ledge of Bernadotte sandstone on north side of Otter Creek, in the SE ¼ SE ¼ sec. 29, T. 4 N., R. 3 E., Havana quadrangle.

The Pope Creek cyclothem is named (Wanless, 1931a, p. 189, 192) from exposures on the south side of Pope Creek near the center of sec. 33, T. 14 N., R. 2 W., Mercer County, Alexis quadrangle. The type exposure was previously described (Wanless, 1929, p. 52, geol. sec. 4, beds 3-10).

About 120 outcrops of the Pope Creek cyclothem are found in the Beardstown, Vermont, and Havana quadrangles. The cyclothem is 1 foot to 17 feet thick in measured outcrops and 5 to 30 feet thick in coal test borings, suggesting a northeastward thickening of the section comparable to that noted in the Tarter cyclothem. The Bernadotte sandstone, the basal member of the Seville cyclothem, truncates the Pope Creek shale at several localities and locally cuts out the entire cyclothem.

The strata referred to the Pope Creek cyclothem in this area are correlated with the type exposures in Mercer County because of similar relation to the Rock Island (No. 1) coal and the Bernadotte sandstone.

Geologic sections 5-7, 26, 27, 30-34, 40, 41.

Pope Creek Sandstone (Member 11)

The Pope Creek sandstone is more generally present in outcrops in T. 6 N., R. 1 E., in the north part of the Vermont quadrangle than elsewhere in the area. It has been noted at only one outcrop in the Beardstown quadrangle, three in the Havana, and 16 in the Vermont. At about 80 percent of the outcrops of the Pope Creek cyclothem no sandy beds are present between the Pope Creek and Tarter coals.

The sandstone is a few inches to 5 feet thick, averaging about 1 foot. It is commonly light gray, fine-grained, very slightly micaceous, not very massive, and not very well laminated. In common with other lower Pennsylvanian sandstones it locally sparkles because of the secondary enlargement of quartz grains. Root traces, including *Stigmaria,* are found at several places, and the sandstone may appear to grade up into a very sandy underclay. This gradational relationship is well shown in an exposure along Tater Creek in the Havana quadrangle (geol. sec. 26).

The Pope Creek sandstone has been found at several other places in western Illinois, and it appears to be at the same stratigraphic position as the thick cliff-forming Delwood sandstone of southern Illinois.

Geologic sections 26, 32, 34, 41.

Underclay (Member 12)

The underclay of the Pope Creek coal is much more widespread than the sandstone. It averages about 4 feet thick in the Vermont quadrangle, 2 feet 6 inches in the Havana, and 1 foot 6 inches in the Beardstown. In the Beardstown quadrangle and at some outcrops in the Havana, it constitutes the whole interval between the Pope Creek and Tarter coals.

The underclay is light gray and at some places nearly white. It is commonly slightly sandy, especially in the lower part.

The clay is equivalent to the "stoneware" clay of the Colchester region, a little west of the Vermont quadrangle. The clay, which is 8 feet thick, is used in the manufacture of refractories. It is equivalent to the lower part of the Cheltenham fireclay of the St. Louis area.

Geologic sections 5-7, 26, 27, 32, 34, 35, 37, 41.

Pope Creek Coal (Member 13)

The Pope Creek coal is widely distributed in the area, having been noted at more than 120 outcrops. It ranges in thickness from a coaly streak a fraction of an inch thick to about 3 feet, averaging 1 foot 3 inches. At several places, where it is more than a foot thick, it has been dug for local use. Coal up to 4 feet thick was reported to have been struck in water wells or test pits at this horizon in a few places, but coal of such thickness was not observed in outcrops. The coal generally has no partings, but partings of clay or hard shale up to 3 inches thick were observed at four outcrops. At many places the coal immediately underlies the Bernadotte sandstone (fig. 27), and the upper laminae of the coal are truncated by the sandstone.

The Pope Creek coal is widespread but generally thin through western Illinois. It is correlated with the Upper Block coal of the Brazil field, western Indiana, a splint coal of great economic importance. It is probably equivalent to the Ice House, Aberdeen, and Elm Lick coals of western Kentucky.

Geologic sections 5-7, 26, 27, 32, 35, 37, 41.

Shale (Member 14)

The shale overlying the Pope Creek coal is as much as 12 feet thick, but at about half of the exposures the shale is entirely cut out by the Bernadotte sandstone. The shale is commonly dark blue-gray and soft in the upper portion, grading downward to black and fairly hard in the basal 6 inches. Ironstone concretions as much as 2 inches by 4 inches, or thin ironstone bands, are fairly common in the shale, though not present in all outcrops. At some exposures the shale is silty or finely sandy and micaceous. Imperfectly preserved plant fossils were found at a few outcrops, but marine fossils were not seen. However, *Lingula* is rather common in the black shale at the base of this member near Carbon Cliff, Rock Island County, about 70 miles north of the area.

Geologic sections 7, 32, 34, 37, 41.

SEVILLE CYCLOTHEM

The Seville cyclothem is probably marked by more striking local variability than any other cyclothem in the area, except perhaps the Gimlet. The Seville limestone is an excellent key bed because of its distinctive lithology and fauna and its occurrence overlying the thick No. 1 coal. However, the limestone is present at less than 20 percent of the places where its horizon is exposed, and the coal is absent or very inconspicuous at many places where the limestone is absent. The Bernadotte sandstone is probably the most easily recognized member of the cyclothem in the area as a whole because it is the hardest and one of the most massive of the sandstones.

The Seville cyclothem is named (Wanless, 1931a, p. 189, 192) for the town of Seville, which is about one mile northeast of the type exposures in the southwest bank of Spoon River in the SW¼ SW¼ sec. 23, T. 6 N., R. 1 E., Fulton County, Vermont quadrangle (geol. sec. 33, figs. 28, 30).

The Seville cyclothem was noted in more than 200 outcrops in the Vermont, Havana, and Beardstown quadrangles, and its character in other parts of the area is known from 57 coal test borings in the Havana and Glasford quadrangles and in the adjacent portion of the Canton quadrangle. The most numerous outcrops are along Spoon River and its tributaries between Seville and Bernadotte in the Vermont quadrangle (pl. 4).

The thickness of the Seville cyclothem ranges in outcrops from 3 to 26 feet, and in borings from 2 to more than 38 feet. Variations nearly as marked as these may be observed within a square mile, but there seems to be a regional thinning from north to south.

The Seville cyclothem commonly rests unconformably on the Pope Creek shale or coal, and there is some evidence of an unconformity at the top of the Bernadotte sandstone. Depressions in the sandstone surface are the sites of the thicker No. 1 coal and Seville limestone. The distribution of these thick coal and limestone areas is not well known, but the belts seem to have a linear distribution that somewhat resembles stream valleys. The coal of the overlying Lower DeLong cyclothem is thicker in such areas than elsewhere in the region.

Strata that correspond to the Seville cyclothem may be traced over most of the northwest part of the Illinois coal field. Along the west side of the coal field south of the Beardstown area there is little or no representation of the cyclothem for 150 miles, but corresponding strata in southern Illinois are included in the Macedonia cyclothem. The cyclothem is present in western Kentucky and in the Mercer group in the upper part of the Upper Pottsville strata of Ohio, Pennsylvania, and West Virginia. It may be recognized over wide areas in the eastern United States because of the distinctive lithology and fauna of its marine limestone member.

Geologic sections 5, 6, 26, 27, 30-35, 37, 40, 41.

Bernadotte Sandstone (Member 15)

The Bernadotte sandstone is named (Savage, 1927, p. 309, fig. 2) from exposures along the stream just south of the now abandoned town of Bernadotte, in the SW¼ sec.

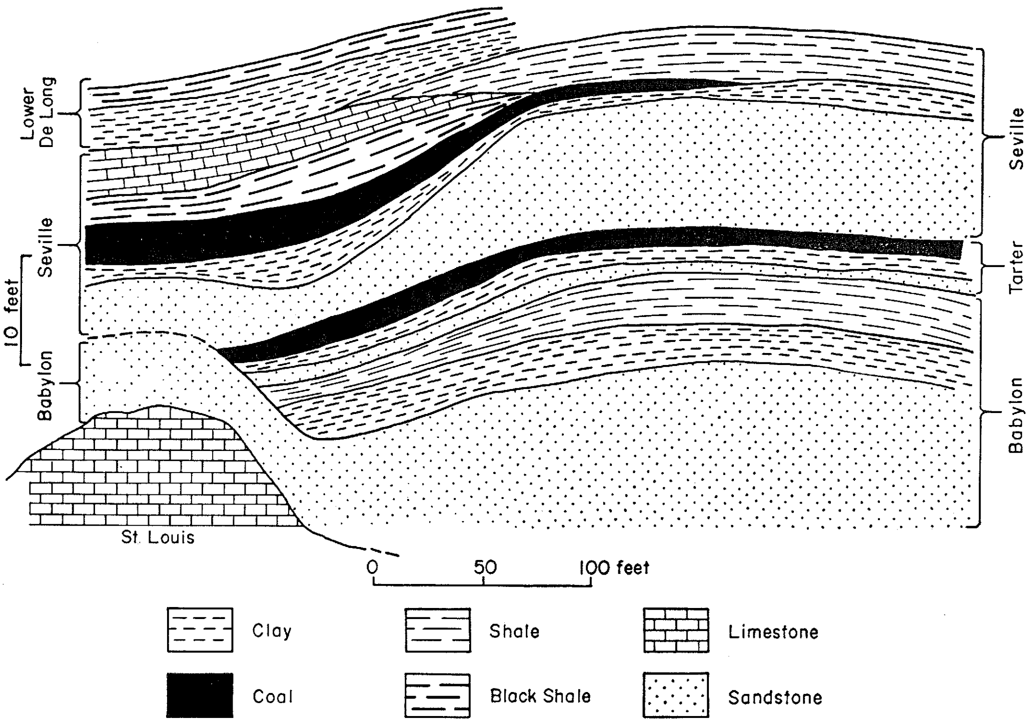


FIG. 30.—Cross-section showing stratigraphic relations at the type locality of the Seville cyclothem, in the bluff of the Spoon River, in the SW ¼ SW ¼ sec. 23, T. 6 N., R. 1 E., Vermont quadrangle.

19, T. 5 N., R. 2 E., Fulton County, Vermont quadrangle (geol. sec. 37). In the original description, Savage correlated this bed with the massive sandstone that terminates the outcrop of the No. 1 coal and Seville limestone at the type outcrop of the Seville cyclothem along Spoon River (geol. sec. 33). At the south end of this outcrop (fig. 30) the sandstone thickens to about 16 feet and rests directly on a coal. Savage thought that the coal was the No. 1 coal and believed that the Seville limestone was cut out by the sandstone. Outcrops now available show that the No. 1 coal and Seville limestone thin out as they rise above the sandstone, and that the coal that underlies the sandstone is the Pope Creek or Tarter coal. The Bernadotte sandstone, therefore, is older than the No. 1 coal, rather than younger, as Savage supposed.

The Bernadotte sandstone crops out more extensively than the other members of the Seville cyclothem, and because it is firmly indurated it makes conspicuous ledges (figs. 27, 29). It is as much as 18 feet thick at a few exposures, but averages 3 to 6 feet thick.

The sandstone is gray to brownish gray, very fine-grained, and contains 25 to 50 percent silt. A fresh surface of the sandstone appears glassy. The sandstone contains a small amount of mica. The uppermost 2 feet is firmly cemented with silica and is quartzitic. The underlying part of the sandstone is rather slabby with regular horizontal bedding at some places and cross-bedding at others. *Stigmaria* casts are common in the upper part, and carbonaceous matter is found along bedding planes in the lower part of the sandstone.

Although the base of the massive sandstone is commonly rather flat, the underlying shales are truncated at several places, as at the type exposure at Bernadotte. The top of the sandstone, where thick, is also uneven, and the overlying coal, limestone, and shale wedge out against "hills" of thicker sandstone. The nearly flat base and sloping upper surface of the sandstone is shown in figure 29.

The Bernadotte sandstone is equivalent to the "Stigmarian" sandstone under the Rock Island (No. 1) coal in the Alexis quadrangle (Wanless, 1929, p. 56-57), northwest of this area. It is equivalent to the much thicker and more massive Murray Bluff sandstone of southern Illinois. The Aberdeen sandstone of Butler County, western Kentucky, a typical channel limestone, also occupies the same stratigraphic position.

Geologic sections 5, 26, 27, 30-35, 37, 41.

Underclay (Member 16)

The underclay of the Rock Island (No. 1) coal is somewhat less extensive than the Bernadotte sandstone. In several outcrops and coal test borings, coal No. 1 rests directly on the sandstone. The underclay has a maximum thickness of about 5 feet and averages less than 1 foot thick. It is medium to light gray, and the top 2 or 3 inches is purplish or dark gray at several places. It is commonly sandy or very sandy. Where root impressions are present in the upper portion of the underlying sandstone, the clay grades down into the sandstone with no clearly marked boundary. The clay appears to be generally thinner where the overlying coal is thicker.

Geologic sections 5, 6, 26, 30, 33, 34, 37, 40.

Rock Island (No. 1) Coal (Member 17)

Worthen (1870, p. 94) designated the exposure in the bank of Spoon River one mile southwest of Seville (geol. sec. 33), as the type exposure of coal No. 1 for western Illinois, and subsequently (Worthen and Shaw, 1873, p. 221, 229-232) correlated the Rock Island coal with it. Later Savage and Udden (1922, p. 3, 37, 38, 44, and 49) suggested that the Rock Island coal was the No. 6 coal, but still later studies (Wanless, 1931b) showed that the correlation of the Rock Island coal with the No. 1 bed was correct.

The Rock Island coal has discontinuous distribution in this area. In the vicinity of Seville the coal is locally 3 to 4 feet thick and has been mined for more than 60 years (fig. 28). The thick coal seems to lie in a belt that trends eastward, and is a little more than half a mile wide. It adjoins areas where the coal is less than 6 inches thick or is absent, as shown in the old quarry south of Marietta (geol. sec. 31). The outcrops of coal more than 2 feet thick are all in T. 6 N., R. 1 E., but local areas of thicker coal have been penetrated in wells. Coal from 3 inches to 1 foot thick is present in many other parts of the area, but as it lacks the characteristic black shale and Seville limestone, it is distinguished from the Lower DeLong, Pope Creek, or Tarter coals only by its position above the massive hard Bernadotte sandstone. The coal is commonly without bedded partings, but where it is thin it may be very shaly.

The Rock Island (No. 1) coal is discontinuous throughout much of northwestern Illinois. Local areas of thick coal occur in Rock Island, Henry, Mercer, Warren, Knox, and Peoria counties. The coal is correlated with the Minshall coal of western Indiana, which has similar relations to the overlying limestone. The Murphysboro coal of southwestern Illinois, which has been called the No. 2 bed, is probably of the same age.

Geologic sections 6, 26, 32-34, 37, 40.

Black Shale (Member 18)

The black shale overlying the Rock Island (No. 1) coal is generally limited to areas where the No. 1 coal is thicker than 2 feet and the Seville limestone is present (fig. 28). Maximum thickness of the shales in outcrops is about 4 feet, but coal test borings near Cuba report black shale with a maximum thickness of 9 feet 6 inches. Where the shale is less than a foot thick, it is generally soft, but in some outcrops where it is more than 2 feet thick it is hard and sheety. In other localities in western Illinois, large fossiliferous concretions occur in the black shale, but they were seen at only one outcrop in the Vermont quadrangle. The black shale seems to be confined to depressions formed by differential compaction of the underlying coal.

Geologic sections 6, 26, 32, 33, 40.

Seville Limestone (Member 19)

The Seville limestone has been very well known for many years because of its well preserved and diverse fauna. It originally was designated the Parks Creek limestone by Savage (1927, p. 309), apparently a typographical error for Barker Creek near Seville.

The limestone is erratic in occurrence and variable in thickness. It is exposed only in T. 6 N., R. 1 E., Vermont quadrangle, and T. 2 N., R. 2 E., Beardstown quadrangle. A thin sandy fossiliferous limestone unlike the typical Seville was also found in sec. 13, T. 5 N., R. 1 E., Vermont quadrangle. The limestone is also reported in coal test borings at three separate localities in the Havana quadrangle, and in borings north of Cuba it is reported to range up to 31 feet 2 inches thick. In outcrops the maximum thickness is a little more than 4 feet.

The limestone is commonly dark blue gray to nearly black, fine-grained, somewhat argillaceous, and has uneven, wavy laminations which give it a nodular appearance (fig. 28). 28).

The limestone is fossiliferous at all exposures and a large fauna, mainly brachiopods and bryozoa, has been described from it (Wanless, 1957).

Although discontinuous, the Seville limestone has been recognized at many places in western Illinois and elsewhere in the eastern United States. Limestones correlated with the Seville include the Curlew limestone of southern Illinois and western Kentucky, the Minshall limestone of Indiana, the Magoffin marine zone of eastern Kentucky, the Lower Mercer limestone of Ohio and Pennsylvania, and the Verne limestone of Michigan. The name Seville has recently been applied to a limestone in Missouri and Oklahoma at the top of the Krebs group. Most of these beds also consist of gray earthy argillaceous limestone and have similar local variations in thickness.

Geologic sections 6, 32, 33, 40.

Gray Shale (Member 20)

The gray shale at the top of the Seville cyclothem is present almost exclusively where the Seville limestone is absent, although locally 1 or 2 feet may be present above the limestone. It has a maximum thickness of about 8 feet. The gray shale rests on the Seville black shale, No. 1 coal, or Bernadotte sandstone. The shale is commonly dark gray to blue gray and contains large irregularly shaped ironstone concretions, locally in definite bands and locally septarian. Pyrite occurs in the ironstone concretions and disseminated through the dark shale. No fossils were found in the shale or concretions. The gray shale may be in part contemporaneous with the Seville limestone.

Geologic sections 6, 31, 32, 34, 37.

DELONG CYCLOTHEMS

The interval between the Seville and Seahorne cyclothems is occupied by a group of strata consisting principally of underclay, with soft shale and from one to four coaly streaks or thin coal beds. Locally one or two thin sandstones are present, but no limestones have been found in this area. The sequence of beds includes three rudimentary cyclothems. As studies in other areas have supported this view, they are recognized as the Lower, Middle, and Upper DeLong cyclothems.

The DeLong cyclothems are named (Wanless, 1931a, p. 188, 192) for the town of DeLong which is about 1½ miles northeast of the type exposures along Brush Creek, in secs. 5 and 8, T. 9 N., R. 2 E., Knox County, Galesburg quadrangle.

The DeLong cyclothems crop out widely in the Havana, Vermont, and Beardstown quadrangles. As most of the interval is soft beds, the outcrops are commonly covered by soil or talus, but they may be seen in numerous roadcuts and freshly eroded stream banks.

The zone of predominant clays with three or four thin coaly streaks is widespread in the northwest part of the Illinois coal field, indicating much more uniform sedimentation than occurred during the Seville and earlier stages. The DeLong strata are not very prominent in western Indiana, but they appear to be represented in the Stonefort cyclothem of southern Illinois, and the upper part of the Mercer group, uppermost Pottsville, of Pennsylvania and Ohio.

LOWER DELONG CYCLOTHEM

The Lower DeLong cyclothem is 10 or 11 feet thick in coal test borings near Cuba but only 1 foot or less in some outcrops in the Beardstown quadrangle. The cyclothem has only four members in this area—a sandstone, an underclay, a coal, and a shale.

In a few outcrops and coal test borings the Lower DeLong cyclothem truncates 2 or 3 feet of the upper Seville shale or limestone. The evidence for truncation is more striking in other parts of western Illinois.

Geologic sections 6, 25, 30-34, 37, 40.

Sandstone (Member 21)

The sandstone is discontinuous at the base of the Lower DeLong cyclothem but is more commonly present farther north in western Illinois. It is recorded in only 20 outcrops and coal test borings scattered throughout the area. It has a maximum thickness of 1 foot 6 inches in outcrops and 7 feet in two coal test borings. It is fine-grained and slightly micaceous. In bright light it sparkles because of secondary enlargement of quartz grains. It contains some carbonized plant material in a few outcrops.

Geologic sections 31, 34.

Underclay (Member 22)

The underclay of the Lower DeLong coal is fairly widespread, but at places in the Beardstown quadrangle the overlying coal and shale are absent and it cannot be readily separated from the Middle DeLong underclay. It is light to medium gray and has a maximum thickness of about 4 feet. The lower part is locally sandy and at one locality contains small irregularly shaped limestone concretions.

Geologic sections 6, 31, 32, 37.

Lower DeLong Coal (Member 23)

The Lower DeLong coal is only locally present and at most outcrops it is represented by 2 inches or less of sooty, carbonaceous shale or bony coal. Where the coal is absent, its position can be recognized by the abrupt change from the dark blue-gray laminated shale above to the light gray nonlaminated underclay below. The maximum thickness observed in outcrop is 9 inches, but some coal test borings near Cuba report coal up to 4 feet 2 inches thick. The outcrops more than 2 feet thick are all in T. 6 N., R. 3 E., Havana and Canton quadrangles. The thick Lower DeLong coal is in a region of thick No. 1 coal and Seville limestone, and where the beds thin out abruptly within a short distance the Lower DeLong coal also thins or disappears.

The Lower DeLong coal is fairly widespread, though discontinuous, in western Illinois. It is equivalent to the No. II coal of western Indiana. It is also equivalent to the Mining City coal of Butler County in western Kentucky and a coal about 50 feet above the Murphysboro coal near Murphysboro in Jackson County, Illinois. This coal has a marine limestone roof at many places in southern Indiana and western Kentucky, and a few marine fossils were found in an impure limestone above it in Warren County, western Illinois.

Geologic sections 6, 31, 32, 37.

Shale (Member 24)

The roof of the Lower DeLong coal is reported as 5 inches of limestone in one coal test boring in sec. 6, T. 6 N., R. 3 E., but elsewhere in the area the coal or coal horizon is commonly overlain by a medium or dark blue-gray shale. The shale is commonly 2 to 5 feet thick but as much as 9 or 10 feet thick in borings near Cuba. The shale in places contains one or more bands of ironstone concretions resembling those in the Seville shale. Where the shale is more than 3 feet thick, the lower 6 inches or 1 foot is commonly very dark gray or black. This is the highest horizon of the soft dark blue-gray shales like those in the Seville, Pope Creek, Tarter, and Babylon cyclothems. Higher Pennsylvanian shales in this region are light gray or light olive gray and can be readily distinguished from the dark lower shales.

Geologic sections 30-34, 37, 40.

MIDDLE DELONG CYCLOTHEM

The Middle DeLong cyclothem is 3 to 8 feet thick, averaging about 5 feet. The Middle DeLong cyclothem is similar to the Lower DeLong in containing only four members—sandstone, underclay, coal, and shale.

Geologic sections 5, 6, 30-32, 34, 37, 40.

Sandstone (Member 25)

The sandstone at the base of the Middle DeLong cyclothem is discontinuous, but outcrops and borings show that it is locally present in all parts of the area. In outcrops it commonly is not more than 2 feet 6 inches thick, but at two localities, in secs. 10 and 24, T. 3 N., R. 1 W., local channel deposits tentatively referred to this sandstone thicken to 10 feet or more.

The sandstone is fine-grained, soft, shaly, and somewhat micaceous. At some outcrops it includes thin platy beds of more firmly indurated sandstone that form ledges or waterfalls in ravines. The channel deposits are cross-bedded, have lenticular shaly beds, and contain carbonaceous matter on some bedding surfaces.

The sandstone is correlated with the Curlew sandstone of western Kentucky and southern Illinois and tentatively correlated with the Vergennes sandstone of southwestern Illinois. Both of these sandstones are massive, medium- to coarse-grained, very micaceous, and may be 20 to 50 feet thick.

Geologic sections 5, 31, 32, 37.

Underclay (Member 26)

The underclay of the Middle DeLong coal is the most widely distributed member of the Middle DeLong cyclothem. It is commonly 3 to 5 feet thick. The clay is generally medium or dark gray with a purplish cast in the uppermost 1 or 2 feet, and lighter gray below with a pale greenish or yellowish cast. Where the basal sandstone is absent the clay grades down into laminated shale of the Lower DeLong cyclothem. The uppermost part of the shale is light gray, like the clay, grading down into mottled light and dark shale and on down into solid dark gray shale. The lower part of the clay may be sandy where the sandstone is absent.

In places the underclay is separated from the Upper DeLong underclay by only an inch or so of coaly clay. These two clays constitute the thickest underclay interval below the Colchester (No. 2) coal, and together with the Seahorne and Pope Creek clays, constitute the Cheltenham fireclay of Green, Calhoun, and Madison counties in Illinois and St. Louis County in Missouri. The underclay in this area is only moderately refractory.

Geologic sections 5, 6, 30-32, 34, 37.

Middle DeLong Coal (Member 27)

The Middle DeLong coal commonly consists of black coaly clay or shale or bony coal with a maximum thickness of 4 inches. The coal is reported to be as thick as 9 inches in two or three borings near Cuba. The coal is persistent as a thin coaly bed over most of western Illinois and has been recognized at several places in eastern Iowa. It is not known to be minable at any place in the Eastern Interior coal basin.

Geologic sections 5, 6, 31, 32, 34, 37.

Shale (Member 28)

In most outcrops, the Middle DeLong coal is overlain by the Upper DeLong underclay, but in a few places they are separated by soft light gray shale. The Middle DeLong shale averages less than 6 inches thick and has a maximum thickness of 2 feet 6 inches.

Geologic sections 30, 32.

UPPER DELONG CYCLOTHEM

In outcrops the Upper DeLong cyclothem is 3 to 8 feet thick and averages about 5 feet. In a few coal test borings near Cuba it has a maximum thickness of 20 feet, apparently due to thickening of the upper shale (member 34). The cyclothem includes two very thin coaly beds or coaly streaks which might belong to separate cyclothems. However, the interval between them is clay that is considered to be a parting in the coal. There is no evidence of truncation of Upper DeLong strata by the overlying Seahorne sandstone, but an abrupt change in lithology at the top may indicate a diastem.

Geologic sections 5, 6, 28, 30-32, 34, 37, 39, 41.

Underclay (Member 29)

The basal bed of the Upper DeLong cyclothem is underclay. It is medium gray and a little darker and a little harder than the Middle DeLong underclay. It is 1 foot to 3 feet 6 inches thick, averaging about 2 feet. It is a little thinner in the Beardstown quadrangle than elsewhere.

Geologic sections 5, 6, 31, 32, 34, 37, 40

Upper DeLong Coal and Clay (Members 30 to 32)

This zone consists of two very thin beds of coal or coaly clay (members 30 and 32), neither of which is more than 3 inches thick, separated by a parting of 6 inches to about 2 feet of brownish-gray hard clay (member 31). The two coal streaks can be found at most outcrops of the cyclothem in the Vermont quadrangle. In the Havana and Beardstown areas, only one of them is seen in many exposures, and where the lower coal is absent it is difficult to separate the parting from the underclay.

Farther north, in Knox and Warren counties, the clay parting is persistently about 1½ to 2 inches thick and is hard yellowish-gray clay, recognized at many widely separated places. The parting also occurs in southeastern Iowa. In southern Illinois the Bald Hill coal, which has a 2-inch parting of hard yellow-gray clay, seems to be of the same age. The Fire Clay coal of eastern Kentucky, which is at least close to the same age as the Upper DeLong coal, has a persistent parting of from 4 to 6 inches of dark brownish-gray nonplastic flint clay. The parting appears to be a widespread stratigraphic unit that is useful for correlation.

Geologic sections 30, 31, 34, 37 (member 30); 6, 31, 34, 37 (member 31); 5, 6, 30-32, 34, 37, 40 (member 32).

Shale (Members 33 and 34)

The shale above the Upper DeLong coal averages 1 foot 6 inches thick in the Beardstown quadrangle, 3 feet 6 inches in the Vermont quadrangle, 5 feet in outcrops in the southern part of the Havana quadrangle, and 10 to 15 feet in coal test borings near Cuba in the northern part of the Havana quadrangle. The lower 4 or 5 inches (member 33) is dark gray to black at several outcrops. The upper part of the shale (member 34), immediately below the Seahorne sandstone, is poorly laminated and resembles an underclay.

Geologic sections 32, 34 (member 33); 5, 6, 28, 30, 34, 37, 39, 40 (member 34).

SEAHORNE CYCLOTHEM

The Seahorne cyclothem includes the Seahorne limestone which is one of the most diagnostic key beds of the area. The cyclothem also includes the lowest widespread underclay limestone of the area and the highest of the light-colored sandstones that sparkle because of secondary enlargement of quartz grains. The cyclothem has no black shale, no upper gray shale, and its two coals are little more than carbonaceous streaks.

The Seahorne cyclothem is named (Wanless, 1931a, p. 188, 192) from exposures along Seahorne Branch in the S½ SE¼ sec. 5, T. 3 N., R. 3 E., Havana quadrangle, Fulton County (geol. sec. 30).

The Seahorne cyclothem crops out rather extensively in the Vermont and Beardstown quadrangles and the south half of the Havana quadrangle. It is cut out in the area of the Browning channel in the north part of the Beardstown quadrangle. It is also present in about 50 coal test borings, mostly in the north part of the Havana quadrangle. The Seahorne limestone forms prominent ledges along streams and waterfalls in ravines. Where not a continuous ledge, it occurs as boulder-like masses in the clay. The Seahorne sandstone is less resistant but forms some ledges and small waterfalls.

The Seahorne cyclothem is 3 to 12 feet thick and has abrupt local variations. The sharp lithologic break at the base of the Seahorne cyclothem suggests a minor disconformity, but the underlying shale is not appreciably truncated by the sandstone.

The Seahorne cyclothem is widely distributed in western Illinois, and it has also been recognized in southern Iowa where it contains two marine limestones, the upper of which resembles the Seahorne limestone. Corresponding beds are found in western Missouri, about 200 feet below the top of the Cherokee shale. The cyclothem also has been found in southern Illinois and western Kentucky where it has two marine limestones, the lower of which is the Stonefort limestone. This cyclothem may include the uppermost strata of the Pottsville of the Appalachian coal basin and the lowest Allegheny strata. Its two limestones are tentatively correlated with the Vanport and Putnam Hill of the Lower Allegheny of Ohio.

Geologic sections 5-7, 23, 28-32, 34, 36, 37, 39, 40, 42.

Seahorne Sandstone (Member 35)

The Seahorne sandstone ranges from about 6 inches to 6 feet thick and is less than 2 feet thick in outcrops in the Beardstown quadrangle. Where the sandstone is more than 3 feet thick, it generally consists of two units separated by about 1 foot of light gray sandy shale. This threefold division of the sandstone is found at numerous localities in western Illinois.

The sandstone is fine-grained and in the Beardstown area it is a siltstone. A sample from the Havana quadrangle (Willman, 1928) contains 18 percent clay and cement, 52 percent silt, 25 percent very fine sand, and 5 percent fine sand. It consists principally of grains of quartz, many of which show secondary enlargement. Numerous brown specks are caused by weathering of pyrite. Some small flakes of mica are present, but there is little feldspar. The heavy minerals constitute less than 1 percent and consist principally of zircon and tourmaline with a ratio of about 3:1. About 80 percent of the zircon grains are angular, but 75 percent of the tourmaline grains are rounded. The sandstone is noncalcareous.

The sandstone is commonly white or light gray. It sparkles slightly in the sunlight because of secondary enlargement of the quartz grains, but this is less prominent than in the Bernadotte and Babylon sandstones. The bedding is commonly even, and the beds are generally less than 3 inches thick.

The Seahorne sandstone has been recognized at many places in western Illinois and southern Ohio, and it may correspond with the Homewood sandstone, the top of the Pottsville of the Appalachian coal field. Generally there is no sandstone in this cyclothem in southern Illinois.

Geologic sections 6, 23, 28, 30, 34, 36, 37, 39, 40.

Underclay Limestone (Member 36)

The underclay limestone member occurs as irregularly shaped masses of light gray limestone in the lower part of the underclay. It is very discontinuous but is most common in the south part of the Havana and north part of the Beardstown quadrangles. At an outcrop in sec. 26, T. 3 N., R. 2 E., Beardstown quadrangle, the limestone masses are as large as 2 by 3 by 4 feet, are very irregular in shape, have many rounded knobs that are checked and cracked, and are incrusted with cone-in-cone up to ¾-inch thick. At some places the limestone has a pisolitic structure.

Geologic sections 28, 37.

Underclay (Member 37)

The underclay member is widespread and is 1 to 6 feet thick, averaging about 3 feet 6 inches. Where the underclay is more than 4½ feet thick the underclay limestone and sandstone are generally absent. The underclay is commonly light gray to nearly white, but is stained with limonite in many outcrops. The upper 2 feet 6 inches to 3 feet is noncalcareous. Where thicker the lower part is calcareous and contains small limestone nodules. The underclay is persistent south from this area and is the upper very light-colored part of the refractory Cheltenham fireclay.

Geologic sections 5-7, 23, 28, 30-32, 34, 36, 37, 40, 42.

Lower Seahorne Coal (Member 38)

The Lower Seahorne coal is merely a coaly streak or a black bony shale about 1 inch thick in most outcrops. At some places it is as much as 3 inches thick. It is commonly 6 inches to 2 feet below the Seahorne limestone and appears as a wavy band, bending down under the projecting knobs of the limestone.

The coal is thin throughout northwestern Illinois but is absent for about 150 miles south of the Beardstown quadrangle. At Campbell Hill in Jackson County, it is more than 4 feet thick and has been mined. It is correlated tentatively with the upper Stonefort coal of southern Illinois, the Holland coal of southern Indiana, the Lewisport coal of Hancock County, western Kentucky, and the Brookville coal of Ohio and Pennsylvania. If these correlations are correct, this is the base of the Allegheny formation.

Geologic sections 5, 28, 30, 31, 37, 40, 42.

Shale (Member 39)

The Lower Seahorne coal is commonly overlain by 6 inches to 2 feet of clay or shale. The upper part resembles an underclay and is commonly gray. The lower part in places in slightly laminated and is pale green.

The pale green shale has been found at many locations in Illinois and elsewhere. It occurs immediately above the Cheltenham fireclay in the St. Louis region, and similar pale green shale is found in the Utica and Goose Lake clays of northern Illinois.

Geologic sections 5, 28, 30, 31, 37, 40, 42.

Upper Seahorne Coal (Member 40)

At a very few localities a coal or coaly streak less than one inch thick occurs at the base of the Seahorne limestone. It forms a wavy band that follows the irregularities of the lower surface of the limestone. If the Seahorne limestone is correctly correlated with the Vanport limestone, this bed is equivalent to the Clarion coal of the Appalachian field.

Geologic section 31.

Seahorne Limestone (Member 41)

The Seahorne limestone grades from scattered limonite-stained nodules in clay about 4 inches thick to a solid ledge more than 6 feet thick. The limestone is persistent in the south part of the area. In the north part of the Havana quadrangle it is generally absent in the few outcrops of the Seahorne cyclothem, and it is recorded in only 6 of 43 coal test borings. It is below drainage in the Glasford quadrangle, but it has not been recognized in any of the coal test borings.

The limestone is nodular in structure, even in those outcrops where it forms solid ledges (fig. 31). Larger boulder-like masses of the limestone are to be seen in float along most of the streams where it crops out. Many of these masses have a septarian structure—the numerous joints filled with calcite and siderite crystals. The joints are most numerous and widest at the surface of the limestone masses but thin out toward the centers of the masses. The limestone has a conglomeratic or brecciated structure, especially in its upper part. It consists of masses of dense medium to dark blue-gray limestone of irregular shape as much as 1 foot thick in a matrix of light gray limestone that is slightly coarser grained. One sample tested consisted of 88 percent material soluble in hydrochloric acid, 10 percent yellow clay, and 2 percent grains larger than silt size, mostly hardened aggregates of clay with a few pyrite crystals.

The limestone has a large fauna totaling more than 75 species (Wanless, 1957), although in places it is nonfossiliferous. At one outcrop in sec. 30, T. 4 N., R. 3 E., Havana quadrangle, three separate faunal facies were recognized. The dark blue-gray dense limestone fragments in the conglomerate or breccia contain numerous large shells of brachiopods, especially productids and *Composita.* The lighter gray matrix limestone contains abundant gastropods, almost to the exclusion of other forms. More than 50 species have been found at this one outcrop. The third phase is also light-colored limestone, but contains only *Spirorbis* and ostracodes, an assemblage typical of many underclay or "freshwater" limestones, rather than marine limestones.

The gastropod fauna is most characteristic. *Trachydomia* sp. and *Naticopsis* sp. are common and characteristic large gastropods, but nearly all of the other gastropods are minute—less than 2 mm. long. *Naticella, Yvania,* and *Pseudozygopleura* are among the widespread forms. This fauna belongs to a different facies than any other limestone of the area except the Lonsdale, which resembles it in some respects.

At one place a large root *Stigmaria* 20 inches long was found in the top of the limestone.

Nodular septarian limestone of this type is characteristic of very shallow marine waters and it has been considered algal by some workers. The brecciated upper surface of the limestone and the lateral gradation to boulders in clay suggests a period of emergence during which the limestone was partially removed by solution.

The Seahorne limestone has been recognized over much of the northwest part of the Illinois coal field, although absent in Knox and Warren counties. It occurs also in southern Iowa. A fauna closely resembling the gastropod fauna of this bed has been described from the limestone caprock of the Tebo coal in Henry County, Missouri. The Seahorne limestone is present but discontinuous in southern Illinois and western Kentucky and has been found at only a few localities in western Indiana. It is tentatively correlated with the Vanport limestone of Pennsylvania and Ohio, in the lower part of the Allegheny formation.

Geologic sections 5-7, 23, 28-32, 34, 36, 37, 39, 40, 42.

WILEY CYCLOTHEM

The Wiley cyclothem is normally the thinnest cyclothem of the area and consists almost entirely of coal and underclay. A second coal and underclay occur at the base of the cyclothem very locally. They are not widespread enough to be differentiated as a separate cyclothem. A sandstone is locally present at the base of the cyclothem and in a few places shale overlies the coal. The Wiley coal is persistent in most of the area and is a good key bed.

The Wiley cyclothem is named (Wanless, 1931a, p. 188, 192) from an exposure on the south bluff of a ravine about three-fourths of a mile northwest of the Wiley school, in the SW¼ NW¼ sec. 16, T. 7 N., R. 2. E, Avon quadrangle, Fulton County (geol. sec. 42).

The Wiley cyclothem crops out in about the same area as the Seahorne, except in part of the Beardstown quadrangle where it is too thin to be recognized. The coal is recognized in coal test borings in the Glasford and the north part of the Havana quadrangles. The cyclothem is absent in the area of the Browning channel sandstone.

The Wiley cyclothem is 4 inches to about 4 feet 6 inches thick. A few inches to 1 foot of local variation may be found in almost all parts of the area because the clay thickens and thins over knobs of the Seahorne limestone. In addition to these local variations the coal and clay both thin from north to south across the area.

The Wiley cyclothem is recognized generally through the northwest part of the Illinois coal field. South of the Beardstown quadrangle it is absent along the western border of the coal field for about 150 miles but it is present in southern Illinois and also western Kentucky near the top of the Tradewater group. In Vermillion, Parke, and Clay counties, western Indiana, two coals, each with a black hard sheety roof shale, occur between Seahorne and Greenbush beds and seem to correspond with the two Wiley coals of western Illinois.

Geologic sections 5, 6, 23, 28-32, 34, 36, 37, 40, 42.

Underclay and Lower Coal (Members 42 and 43)

The lower coal and underclay were seen at only two outcrops, in secs. 19 and 30, T. 5 N., R. 2 E., Vermont quadrangle, and consist of ½ to 1½ inches of coaly clay or poor coal (member 43) above 6 inches to 2 feet of medium gray underclay (member 42).

Sandstone

From 1 foot to 1 foot 3 inches of soft gray micaceous sandstone occurs between the Wiley underclay and the Seahorne limestone at two exposures in secs. 5 and 9, T. 3 N., R. 3 E., Havana quadrangle. This sandstone has not been seen at the same places as the lower coal and underclay, so its relation to them has not been determined.

Geologic section 37.

Underclay (Member 44)

The underclay of the Wiley coal ranges from about 2 inches in some exposures in the Beardstown quadrangle to 4 feet thick in the Vermont and Havana quadrangles, averaging about 2 feet 6 inches. It is light to medium gray and resembles most of the underclays of the area. Where it is more than 2 feet thick, the lower part commonly contains irregular concretions of gray limestone that may mark a discontinuous underclay limestone.

Geologic sections 5, 6, 23, 28-32, 34, 36, 37, 40, 42.

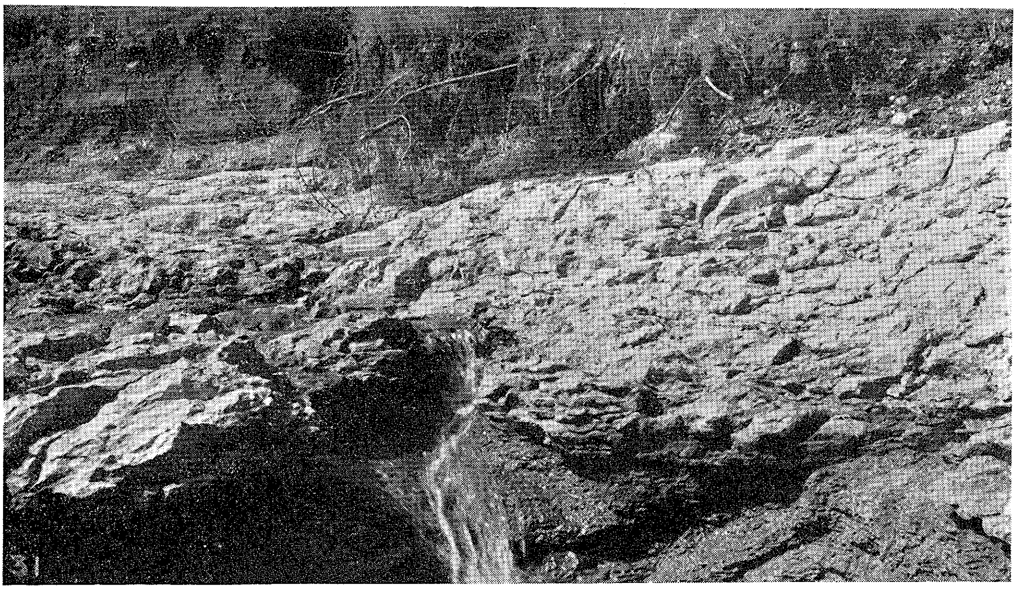


FIG. 31.—Nodular facies of Seahorne limestone along ravine east of Beardstown, in the SW ¼ sec. 11, T. 18 N., R. 11 W., Beardstown quadrangle.

FIG. 32.—Strata from the underclay of the Colchester (No. 2) coal at the top to the thin Wiley coal at the base, on east side of Turkey Branch, in the NE ¼ SE ¼ sec. 31, T. 4 N., R. 3 E., Havana quadrangle. Geologic section 29.

FIG. 33.—Pleasantview sandstone directly overlying the Colchester (No. 2) coal, the underclay, and at the base a man standing on top of the Isabel sandstone, in the south bank of Tater Creek, in the SE ¼ sec. 35, T. 5 N., R. 2 E., Havana quadrangle.

Wiley Coal (Member 45)

The Wiley coal is widespread and was recorded in 202 outcrops and 46 coal test borings. It is only a coaly streak a fraction of an inch thick in the south part of the Beardstown quadrangle but thickens to 1 foot 4 inches of good coal in the north part of the Havana quadrangle. It averages 3 inches in the Beardstown quadrangle, 8 inches in the Vermont, and 10 inches in the Havana. Generally it is without bedded partings.

Worthen mentioned this coal in his report on Fulton County but did not designate it by number because it is too thin to be minable. It is present in southern Illinois and western Kentucky where it has been called the Davis coal or No. 6 coal in Kentucky. It is also present in western Indiana, but has not been named there. It seems to be equivalent to the Mineral coal of Missouri and Kansas.

Geologic sections 5, 6, 23, 28-32, 34, 36, 37, 40, 42.

Shale (Member 46)

The Wiley coal is commonly overlain by the Greenbush underclay, but in some outcrops, mostly in the Vermont quadrangle, it is overlain by 2 inches to 1 foot of dark blue-gray to black laminated shale. This shale is commonly soft, but is fairly hard in a few outcrops.

Geologic sections 23, 29, 34, 40.

GREENBUSH CYCLOTHEM

The Greenbush cyclothem is widespread, but like the Wiley cyclothem it is very thin in the south part of the Beardstown quadrangle. It does not contain a persistent coal in western Illinois but in places has a limestone bed just above the position of the coal and another limestone in the underclay. Marine fossils are present in the higher limestone in a few outcrops. The gray shale (member 52) is the lowest of a series of fairly well bedded gray shales with flattened oval ironstone concretions.

The Greenbush cyclothem is named (Wanless, 1931, p. 188, 192) from outcrops in a ravine in sec. 24, T. 8 N., R. 1 W., Greenbush Township, Warren County, in the Avon quadrangle (geol. sec. 40).

The Greenbush cyclothem crops out in about the same area as the Wiley. As both cyclothems are generally less than 10 feet thick, they are usually found together in roadcuts and stream banks (fig. 32). The cyclothem thickens from about 1 foot in places in the Beardstown quadrangle to 14 feet in the north part of the Vermont quadrangle. It averages 6 to 10 feet in most of the area.

The Greenbush cyclothem rests with apparent conformity on the Wiley cyclothem. The overlying Isabel sandstone rests on the Greenbush shale with an abrupt contact and truncates the shale at some places. In the area of the Browning sandstone channel in the Beardstown quadrangle the cyclothem is absent.

The cyclothem is widespread in northwestern Illinois. It resembles the overlying Abingdon cyclothem in possessing a gray shale with ironstone concretions and a thin coal, but it differs in having a more persistent underclay limestone, a marine limestone that is found only locally, and no basal sandstone. The Greenbush cyclothem is present in southern Illinois and western Kentucky where it includes the highest beds referred to the Tradewater group.

Geologic sections 5, 6, 23, 25, 28-32, 34, 36, 37, 40, 42.

Underclay and Underclay Limestone (Members 47 to 49)

At two or three outcrops in the Vermont quadrangle, 1 foot or less of very sandy clay or shale with thin lenses of very fine-grained sandstone occurs at the base of the Greenbush. It may be equivalent to a sandstone elsewhere but is too local to be differentiated as a member in this region. The sandy beds are generally absent and the Greenbush underclay rests directly on the Wiley clay or shale.

The limestone (member 48) is medium or dark blue gray, weathers dark reddish brown, and occurs either as one or two more or less continuous bands or as concretions that may show septarian structure with calcite and siderite veinlets. The limestone is usually within 3 to 6 inches of the top of the underclay, whereas most other underclay limestones are near the base of the underclay. It is commonly 3 to 10 inches thick and averages 6 inches. Most of the outcrops showing the limestone as continuous bands are in the Vermont quadrangle, and only concretions are present in the Havana quadrangle (fig. 32). *Spirorbis* is abundant in the limestone at several outcrops in the Vermont quadrangle, and indistinct traces of other fossils were seen.

The light gray underclay (member 47 below the limestone and 48 above) ranges from less than 10 inches to 3 feet thick. It is absent in some outcrops in the southern part of the Beardstown quadrangle.

Geologic sections 5, 6, 23, 28, 29, 32, 34, 36, 37, 40, 42 (member 47); 6, 23, 34, 40, 42 (member 48); 23, 28-31, 34, 36, 40, 46 (member 49).

Greenbush Coal (Member 50)

The Greenbush coal in places is a thin coaly streak or coal bed up to 1 inch thick. In other places an inch or so of dark gray to black carbonaceous shale is locally present, but in many others no carbonaceous material occurs at this horizon.

Not more than one or two inches of Greenbush coal has been found in western Illinois. The Greenbush coal is probably equivalent to the DeKoven coal of southern Illinois and western Kentucky and one of the benches of the Rock Creek coal in western Indiana.

Geologic sections 6, 23, 28, 31, 32, 36, 40.

Greenbush Limestone (Member 51)

The Greenbush coal or its horizon is directly overlain by limestone, except locally where separated from it by an inch or so of dark gray shale. The limestone is discontinuous but is most commonly found in the Havana quadrangle where it is as much as 1 foot thick. It is tentatively recognized in some coal test borings near Cuba where it has a thickness up to 1 foot 6 inches. More commonly it is 3 to 6 inches thick and consists of fine-grained nearly lithographic light gray limestone that weathers deep reddish brown. A sample dissolved in hydrochloric acid was 91 percent soluble, 5 percent buff clay, 3½ percent silt, and ½ percent fine sand. The silt and fine sand consist principally of brown or gray micaceous silt and hardened aggregates of the same material, and a few flakes of mica as large as 0.2 mm. diameter. Marine fossils are uncommon in the limestone, but crinoid stems and *Chonetes* were found in a ravine in the NW¼ NE¼ sec. 23, T. 5 N., R. 1 E., Vermont quadrangle, and *Crurithyris planoconvexa* was found in the SW¼ NW¼ sec. 28, T. 5 N., R. 3 E., Havana quadrangle.

Geologic sections 6, 23, 28, 29, 37, 42.

Shale (Member 52)

The shale overlying the Greenbush limestone is commonly the thickest and most widely exposed member of the cyclothem (figs. 32, 33). It is generally 1 to 3 feet thick in the Beardstown quadrangle and 3 to 6 feet in the Vermont and Havana quadrangles. It has a maximum thickness of 10 feet in the central part of the Vermont quadrangle.

The shale is greenish gray, but grades to darker shale in the lowermost 6 inches. It is silty to slightly sandy in the upper part, and grades into clay shale below. It contains flattened oval ironstone concretions arranged more or less regularly in bands. The shale is generally nonfossiliferous, but traces of fossil stems and leaves were found in a few outcrops.

The shale is 20 to 30 feet thick in the Wabash Valley in Vermillion and Parke Counties, Indiana.

Geologic sections 5, 6, 23, 25, 28-32, 34, 36, 37, 40, 42.

Carbondale Group

The Carbondale group, originally described as the Carbondale formation (Shaw and Savage, 1912, p. 6), consists of strata from the base of the Isabel sandstone to the base of the Copperas Creek sandstone. It is divided in this area into the Abingdon (at the base), Liverpool, Summum, St. David, Brereton, and Pokeberry cyclothems.

ABINGDON CYCLOTHEM

The Abingdon cyclothem (Weller, Wanless, Cline and Stookey, 1942) consists of strata originally included in the Liverpool cyclothem (Wanless, 1931a). The Liverpool cyclothem was defined from outcrops in the Havana quadrangle, where its basal sandstone appears to rest on the Greenbush cyclothem. However, studies in the Vermont quadrangle showed the presence of a persistent shale, thin coal, underclay, and sandstone below the basal Liverpool sandstone and above the Greenbush shale. It now appears that the basal sandstone of the Liverpool cyclothem at most outcrops in the Havana quadrangle is really the basal sandstone of the lower cyclothem, and that the coal and underclay of the lower cyclothem have lensed out eastward. Restudy of a few areas in the Havana quadrangle demonstrated the presence in other places of this lower coal and underclay. The new cyclothem was called Lower Liverpool (Weller, 1942) but was renamed Abingdon for outcrops about four miles east of Abingdon near the center of sec. 6, T. 9 N., R. 2 E., Knox County.

In the Chandlerville quadrangle and the north part of the Beardstown quadrangle, in a belt several miles wide, a sandstone not far below the Colchester (No. 2) coal occupies a channel which cuts through all lower Pennsylvanian beds and locally rests on Mississippian strata. It has been called the Browning channel sandstone (Searight, 1929) because it occupies a considerable part of Browning Township. Because the Abingdon beds have not been recognized between the Browning sandstone and the Colchester coal, it is inferred that the Browning sandstone is a channel facies of the basal Liverpool sandstone. The evidence is not wholly conclusive, because the basal Liverpool sandstone and the Abingdon shale, coal, and underclay, may have pinched out north of the Browning channel. In that case the Browning sandstone would be a channel facies of the Isabel sandstone and would underlie directly the underclay of the Colchester (No. 2) coal. However, in this report the Browning sandstone is considered to be the basal sandstone of the Liverpool cyclothem.

The Abingdon cyclothem is 1 to 15 feet thick, averaging 3 to 4 feet in the Beardstown quadrangle, 5 to 8 feet in the Havana, and 7 to 12 feet in the Vermont. The cyclothem cannot be recognized in many of the coal test borings in the north part of the Havana quadrangle where the interval is described as light sandy shale. The greatest thickness known for this cyclothem in western Illinois is 25 to 30 feet in Rock Island County, which indicates a regional thinning from north to south.

The basal sandstone of the cyclothem truncates several feet of the Greenbush shales at several places and commonly has a sharp, slightly irregular basal surface.

The Abingdon cyclothem is found rather generally in western Illinois, especially north of the area of this report. It is also present in southern Illinois, western Indiana, and western Kentucky, where it probably includes the lowest beds of the Carbondale formation, as used in Kentucky.

Geologic sections 6, 23, 25, 28-32, 34, 36, 37, 40, 42.

Isabel Sandstone (Member 53)

The Isabel sandstone is named (Wanless, 1931a, p. 192) for Isabel Township, where it is well exposed in the NW¼ NE¼ sec. 16, T. 4 N., R. 3 E., Havana quadrangle, Fulton County (geol. sec. 28). The sandstone is widely distributed but is absent at several localities in the Beardstown quadrangle. It is 6 inches to about 10 feet thick, reaching its maximum thickness near its type outcrop.

The sandstone is fairly well indurated, locally forming ledges or small waterfalls (fig.

33). The upper part is commonly thin-bedded and the lower part more massive with wavy bedding surfaces. Crossbedding is seen in some of the thicker exposures. The sandstone, where fresh, is greenish or yellowish gray. It weathers light brown speckled with large dark brown limonitic spots, probably formed by the oxidation of pyrite crystals. In texture it is poorly sorted, the average of six specimens consisting of 22 percent fine sand, 32 percent very fine sand, 16 percent silt and 30 percent clay and cement. It has more fine sand and more clay than other sandstones of the area and is classed as a very fine sandstone.

The cement is calcium carbonate, which varies in amount, the harder ledges having a larger percentage of the cement. Where the sandstone is thin, the upper part locally contains small calcareous concretions. The quartz grains are angular and show some secondary enlargement, although less prominently than in lower sandstones. Feldspar and mica are common, in contrast with earlier Pennsylvanian sandstones, in which mica is rare and feldspar absent. The most characteristic heavy minerals, zircon and tourmaline, occur in the ratio 42:58. This is the only sandstone member in which tourmaline is more abundant than zircon. Some 93 percent of the zircon grains are rounded, but only 30 percent of the tourmaline grains show much rounding. Garnet, which is absent or very rare in earlier Pennsylvanian sandstones, makes up about 8 percent of the heavy minerals and was found in all samples studied (Willman, 1928).

In its poorly sorted texture, its speckled brown color, and its relatively large content of calcium carbonate, feldspar, mica, and garnet, the Isabel sandstone resembles the higher Pennsylvanian sandstones and is unlike the older, light gray, nonfeldspathic, well sorted, sparkling sandstones. Carbonaceous matter is much less common than in the higher Pleasantview and Cuba sandstones, but plant stem impressions are found in the finer sandstones in a few places and the casts of large roots (*Stigmaria*) were found at one exposure.

The Isabel sandstone is present in southern Illinois, where it is called the Palzo sandstone, and it probably is equivalent to the Sebree sandstone of Kentucky.

Geologic sections 6, 23, 25, 28-30, 32, 34, 36, 37, 40, 42.

Underclay and Underclay Limestone (Members 54-56)

The underclay and underclay limestone members have a maximum thickness of about 5 feet. They are most commonly present in the north and central parts of the Vermont quadrangle and have been seen in only a few outcrops in the Havana and Beardstown areas. Member 55 is the limestone which is underlain (member 54) and overlain (member 56) by underclay. The underclay ranges from light to dark gray, is generally less than 3 feet thick, and in places has a shaly structure within a few feet of the top. The lower part is calcareous and contains the discontinuous limestone (member 55). The limestone is in the form of small nodules of light gray limestone, slightly septarian concretions of fine-grained hard light bluish-gray limestone up to 8 to 10 inches in diameter, and joints filled with limestone. Where weathered the concretions are surrounded by limonitic shells up to half an inch thick. The concretions occur either in the lower part of the underclay or in calcareous sandy shale that grades down into the Isabel sandstone.

Geologic sections 29 (member 54); 32 (member 55); 31, 32, 34, 36 (member 56).

Abingdon Coal (Member 57)

In most parts of the area the Abingdon coal is represented by only an inch or two of coaly clay, and in many outcrops in the Havana and Beardstown quadrangles not even a carbonaceous zone is found. In a few places in the north and central parts of the Vermont quadrangle, especially in secs. 14, 15, and 24, T. 5 N., R. 1 E., and sec. 19, T. 5 N., R 2 E., impure coal to a maximum thickness of 1 foot 4 inches has been observed. About 1 foot of coal also has been observed several places north of Vermont quadrangle.

The coal is correlated with the No. III coal of Parke and Clay counties, western Indiana. Near Staunton, Indiana, it reaches a thickness of 6 to 8 feet and has been mined extensively.

Geologic sections 31, 32, 34, 36.

Shale (Members 58 and 59)

The shale overlying the Abingdon coal is most prominent in the north half of the Vermont quadrangle, where it reaches a maximum thickness of 8 to 10 feet. It is present in several outcrops in the Havana quadrangle, between two beds of sandstone, averaging 2 to 3 feet thick. It is quite discontinuous in the Beardstown quadrangle, reaching a maximum thickness of 3 feet.

In the Vermont quadrangle the lower 6 to 10 inches of the shale locally is dark gray to black (member 58), and a few marine fossils were reported in black pyritic concretions in this bed a few miles north of the Vermont quadrangle in sec. 15, T. 7 N., R. 1 E. The upper part of the shale, and commonly all of it, is faintly greenish (member 59). It contains ironstone concretions or ferruginous limestone concretions of irregular shape at several places. Where the higher Browning sandstone member is absent, limestone joint-fillings locally extend down from the Liverpool underclay into the shale. The shale is slightly sandy and micaceous at many places, and its upper part contains thin discontinuous laminae of sandstone. *Neuropteris, Mariopteris, Pecopteris, Sphenophyllum, Annularia, Calamostachys,* and *Lepidophyllum* were found in this shale in the SE¼ NW¼ sec. 5, T. 2 N., R. 2 E., Beardstown quadrangle.

This shale is more than 20 feet thick in Mercer and Rock Island counties, and it has been used for brick manufacture at Clay City, Gilchrist, and Griffin, in Mercer County, where it is called the Gilchrist shale.

Geologic sections 31, 32, 36 (member 58); 6, 23, 25, 30-32, 34, 36, 37, 40 (member 59).

LIVERPOOL CYCLOTHEM

The Liverpool cyclothem is one of the most widely exposed cyclothems of the area and includes several prominent key beds. It is distinguished by the presence of the Colchester (No. 2) coal, which is the most widespread Pennsylvanian stratum of the area and the most persistent coal of the Eastern Interior coal basin. The marine limestone is not a single limestone or shale, but rather a series of thin but widely persistent bands of limestone and shale, each with distinctive lithology and fauna. The cyclothem has several abnormalities, such as the thick Francis Creek shale member between the coal and the black sheety shale. The Jake Creek sandstone member and a coal locally present above it are probably representatives of the Lowell cyclothem of northern Illinois.

The Liverpool cyclothem is named (Wanless, 1931a, p. 188, 192), from outcrops in secs. 17 and 20, T. 5 N., R. 4 E. (Liverpool township), Fulton County, Havana quadrangle (geol. secs. 24, 25).

The Liverpool cyclothem has a maximum thickness of nearly 100 feet and a minimum of about 5 feet. The wide range in thickness is due mostly to truncation by the Pleasantview sandstone, locally as much as 70 feet. Also the thicknesses of some members vary greatly, the Francis Creek shale ranges from zero to 45 feet and the Browning sandstone from zero to 60 feet. The cyclothem is thickest in the Glasford quadrangle, the north part of the Havana quadrangle, and the north-central part of the Vermont quadrangle.

The Liverpool cyclothem is separated from adjacent cyclothems by major erosional unconformities, the most prominent in the Pennsylvanian strata of western Illinois. In a large part of the area the upper part of the Liverpool cyclothem down to the lower part of the Francis Creek shale is cut out by the channel facies of the overlying Pleasantville sandstone. In the area of the channel facies of the Browning sandstone, beds of the Liverpool cyclothem cut through all older Pennsylvanian beds and rest on Mississippian strata (pl. 5). In each case local channels or valleys filled with sandstone extend down 60 to 80 feet into the underlying strata. These valleys are steep walled and the margins locally have slopes as steep as 55°. The boundaries of the channels are moderately straight. Within the cyclothem there is some evidence of minor unconformities below the Jake Creek sandstone, below the black sheety shale member, and below a thin band of limestone conglomerate in the Oak Grove marine member.

Geologic sections 2, 5-7, 22-25, 28-32, 34, 36-40.

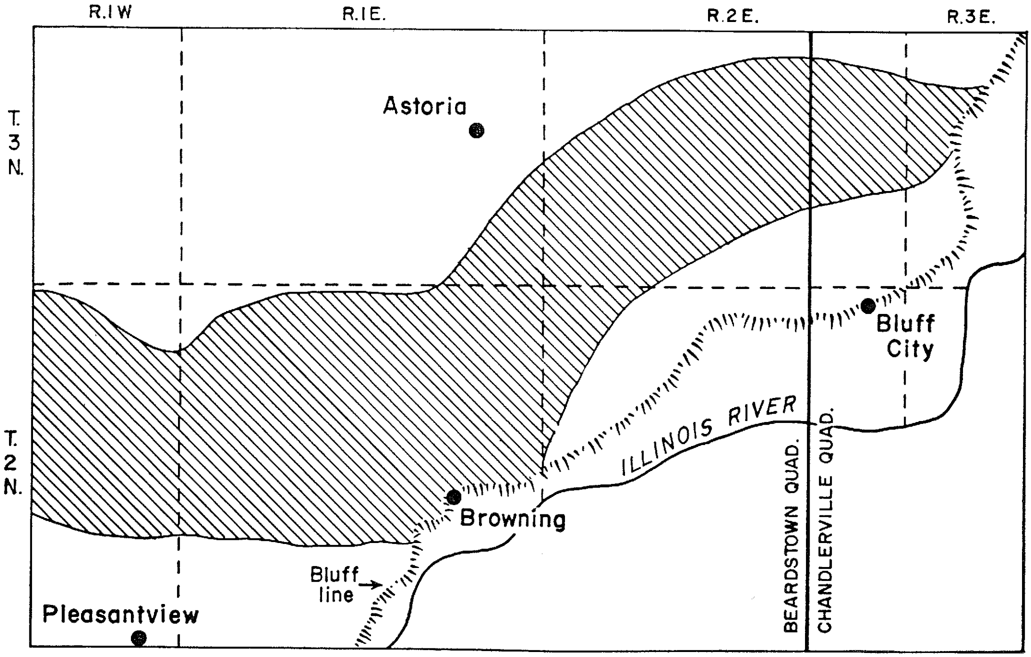


FIG. 34.—Distribution of Browning sandstone channel shown by line pattern.

BROWNING SANDSTONE (MEMBER 60)

The Browning sandstone is named (Searight, 1929) for exposures in sec. 18, T. 2 N., R. 1 E., Schuyler County, Beardstown quadrangle. If the sandstone in the Browning channel is a channel facies of the Isabel sandstone, as discussed under the Abingdon cyclothem, a new name will be needed for the basal sandstone of the Liverpool cyclothem.

The Browning sandstone has well developed channel and nonchannel facies. The channel facies is limited almost wholly to the Browning channel in the north half of the Beardstown quadrangle and the northwest part of the Chandlerville quadrangle (fig. 34). The channel deposits are well exposed in Scab Hollow and other tributaries of Sugar Creek, along the upper parts of Elm and Wilson Creeks in the Beardstown quadrangle, and along Kerton Creek in the Chandlerville quadrangle. The channel deposits have a maximum thickness of about 80 feet along Scab Hollow. The sandstone is locally 20 feet thick in parts of secs. 27, 32, and 35, T. 4 N., R. 2 E., and secs. 3 and 7, T. 3 N., R. 2 E., Vermont quadrangle. These areas may be along branches of the Browning channel.

The channel deposits consist of massive to shaly sandstone, siltstones, and shales. Argillaceous beds, if present, are found in the upper part. The member locally grades from very fine sandstone at the base, through siltstone, to shale at the top. At places the member consists almost wholly of sandstone, as along Kerton Creek, east of the Beardstown quadrangle, and at others it is mostly silty shale or siltstone. The sandstone consists of lenticular massive and shaly beds that exhibit crossbedding. It is blue gray, weathers buff with brown spots, is micaceous and argillaceous, and resembles the Isabel sandstone and the channel deposits of the Pleasantview sandstone. The shales are blue gray, silty, micaceous, and contain laminae of very fine sandstone. The basal beds of the sandstone locally contain pebbles of shale, siltstone, or ironstone, and carbonized casts of logs.

Fossil plant leaves and stems are found in the shaly beds of the Browning channel, and are abundant and well preserved at some places, especially in the upper part, a few feet below the Colchester (No. 2) coal. The best collecting locality is a roadcut just northwest of the Union ("Onion" on topographic map) school, 2 to 4 feet below the coal in the NE¼ NE¼ sec. 24, T. 2 N., R. 1 W., Beardstown quadrangle, where *Neuropteris, Odontopteris, Pecopteris, Annularia, Cordaites,* and other forms are found. Another good collecting locality is a stream bluff of Kerton Creek in the NW¼ NW¼ sec. 24, T. 3 N., R. 2 E., just east of the Beardstown quadrangle, where the plant horizon is about 18 feet below the coal.

The nonchannel sandstone is commonly 3 feet or less thick and is shaly to platy. In the Havana quadrangle it resembles the Isabel sandstone in color, lithology, and appearance, and it may rest directly on the Isabel sandstone in places.

Channel deposits of the Browning sandstone also are found in the Galesburg and Monmouth quadrangles, in T. 9 N., R. 1 W., Warren County. Another prominent channel sandstone of this age east of Muscatine, Iowa, at Wild Cat Den State Park, has a maximum thickness of 80 or 100 feet. This channel trends northeastward, roughly parallel to the Browning channel. Outliers of micaceous Pennsylvanian sandstone in channels cutting Silurian and Ordovician rocks near Morrison and Sterling in Whiteside County, Illinois, may be related to it.

Geologic sections 2, 23, 25, 37.

Limestone (Member 61)

The underclay limestone of the Liverpool cyclothem consists of concretions in the lower part of the underclay. The limestone is not found in all outcrops of the underclay, but is widely present. It seems to be absent in the Browning channel area. The concretions vary greatly in size and shape, reaching a maximum diameter of 3 to 5 feet. Those of the Havana quadrangle commonly exhibit a septarian structure. They contain some pyrite and when weathered are coated with a brown limonitic shell. The concretions weather out and form large boulders in many of the smaller streams. They are similar to concretions in the underclay below the Springfield (No. 5) coal. No fossils were found in them.

Geologic section 34.

Underclay (Member 62)

The underclay of the Colchester (No. 2) coal is widespread, ranges from about 1 to 7 feet thick, averaging 3 feet. It seems to be a little thinner in the Havana quadrangle than in the Vermont. The upper 1 or 2 inches is commonly dark gray to black and is locally hard. It is called a "false bottom" by the miners. The lower part is light gray and is locally stained rusty. Thin coal streaks extend diagonally from the base of the coal down into the underclay in some exposures, and root impressions and slickensides are common. The clay below the upper 2 feet 6 inches is calcareous in many outcrops. Over the Browning channel the clay is more laminated and shaly than elsewhere.

Geologic sections 2, 5-7, 23, 25, 29-32, 34, 36.

Colchester (No. 2) Coal (Member 63)

The number 2 was assigned to this coal from outcrops in Fulton County (Worthen, 1870). The coal was later correlated with the Colchester coal, of McDonough County (Hinds, 1919), and the name Colchester (No. 2) is in general use throughout western Illinois. Worthen recognized coals that he numbered 2 and 3 in Fulton County. Coal 2 was said to be typically developed near Lewistown in the Havana quadrangle, with a roof of gray shale, whereas coal 3, near Frederick in the Beardstown quadrangle, had a roof of black hard sheety shale with large black concretions. More recent studies showed that the gray shale (Francis Creek shale, member 64) wedges out near Frederick, so the coal under the black shale is the same as the coal under the gray shale. The number 2 has been retained but the number 3 abandoned.

The coal has been observed at about 600 outcrops and was noted in about 40 coal test borings (pl. 7). It is remarkably persistent throughout Illinois and its thickness is so uniform it has been called the 30-inch coal. Except for the Frederick area, the coal is 1 foot 9 inches to 3 feet 3 inches thick, averaging 2 feet 6 inches. The coal is locally absent near Frederick, in sec. 7, T. 1 N., R. 1 E. (geol. sec. 7), where it is represented by only a few inches of black bony shale. In other outcrops nearby the coal is only 6 or 7 inches thick. Although upper Liverpool beds are cut out over a large part of the area by channel deposits of the Pleasantview sandstone, the coal is not known to be cut out at any place, though the uppermost few inches are truncated at some outcrops (fig. 33).

The roof of the coal is most commonly the Francis Creek shale, but in secs. 1, 12, 13, and 24, T. 1 N., R. 1 W., Beardstown quadrangle, the coal immediately underlies the black sheety shale. Coal test borings show that the black shale is also immediately over the coal in secs. 9, 20, and 28, T. 6 N., R. 4 E., Havana quadrangle. There seems to be no general relationship between the thickness of the coal and whether its roof is the Francis Creek shale, black sheety shale, or Pleasantview sandstone.

The No. 2 coal is commonly without partings, but in two outcrops partings of ½ inch to 1 inch of black bony shale have been observed. Pyrite occurs as thin bands, in some places at or very near the top of the coal and near the middle at other places. The coal appears to be somewhat more bony and shaly over the Browning channel than elsewhere. The cleavage faces of the coal are coated with thin plates of calcite or calcite and pyrite mixed.

Except for its local absence near Frederick, No. 2 coal is apparently continuous throughout the Illinois coal field. In northern Illinois it is correlated with the Third vein of the LaSalle region and with the Morris or Wilmington bed of Will and Grundy counties. It was formerly correlated with the Murphysboro coal in southwestern Illinois, but is now known to occur 150 to 200 feet higher.

The Colchester bed is 18 inches thick or less in southern Illinois. It is correlated with the IIIa or Velpen coal of western Indiana, and the Schultztown coal of Ohio County, western Kentucky. On the basis of floral evidence it was tentatively correlated with the Lower Kittanning coal of the Appalachian field (White, 1907). It is also very widespread in southern Iowa and is known as the Whitebreast coal in Lucas County. It is equivalent to the Croweburg coal of Missouri and eastern Oklahoma. It is thus one of the most widespread coal beds, if not the most widespread, of the United States.

Geologic sections 2, 5-7, 23-25, 28-32, 34, 36.

Francis Creek Shale (Member 64)

The Francis Creek shale is named (Savage, 1927, p. 309) from exposures along Francis Creek in sec. 22, T. 5 N., R. 1 E., Fulton County, Vermont quadrangle (geol. sec. 7).

This shale occurs in a lenticular body that trends eastward and wedges out southward a little south of the Beardstown area and northward about 30 miles north of the Havana and Vermont quadrangles. The line of greatest thickness passes through Lewistown and Bernadotte and then west to Colchester, McDonough County, about 15 miles west of the Vermont quadrangle. Maximum thickness is 40 to 45 feet near Lewistown in the Havana quadrangle and near the type locality in the Vermont quadrangle, and 55 feet near Colchester. The shale is partially or wholly truncated in the areas of Pleasantview sandstone channels. It is replaced by the Jake Creek sandstone member in the south part of the Vermont quadrangle, and it is locally absent near Frederick in Schuyler County and near St. David in Fulton County.

The shale is commonly medium gray with an olive, greenish, or bluish cast. The lower 3 inches to 1 foot is locally dark gray to black and in places contains thin lenses of bright coal as much as half an inch thick. In outcrops near Frederick the uppermost 2 or 3 feet below the black sheety shale is black or dark gray soft shale. The shale is silty in most exposures, and the upper 2 or 3 feet is notably sandy and locally contains thin beds of very fine-grained sandstone in the north parts of the Havana and Vermont quadrangles. These sandstone beds are probably equivalent to the Jake Creek sandstone. They commonly have markings on the bedding surfaces resembling wave marks and locally contain fossils including *Marginifera muricatina*. The shale is unevenly bedded and exhibits well developed spheroidal weathering in many localities. Ironstone concretions are found locally, but they are much less common than in the Purington shale.

Fossil plants, mainly leaf and stem impressions, are found in the lower 2 or 3 feet of the shale at a few places, especially in secs. 4 and 17, T. 5 N., R. 3 E., Havana quadrangle, and large collections were made in the Colchester area, west of the Vermont quadrangle. Along Mazon Creek and near Braidwood and Coal City in Grundy and Will counties, this shale contains abundant ironstone concretions that have yielded what is probably the best known Pennsylvanian flora in the United States (Noe, 1925).

Geologic sections 5-7, 22-25, 28, 30-32, 34, 36, 38.

Jake Creek Sandstone (Member 65)

The Jake Creek sandstone is herein named for exposures along the upper part of Jake Creek, in the NE¼ sec. 13, T. 4 N., R. 1 E., Vermont quadrangle (geol. sec. 38). It is only locally present but has a maximum thickness of about 18 feet. The outcrops more than 3 feet thick are all in a north-south linear belt in the south-central part of the Vermont quadrangle, secs. 24 and 36, T. 5 N., R. 1 E., and secs. 13, 24, 25, and 36, T. 4 N., R. 1 E. Outcrops are lacking in the three sections between those named, and the sandstone may be nearly continuous in a belt eight miles long and a mile or less wide.

The sandstone is thin-bedded in most exposures, but where the bedding is relatively thick some beds in the upper part are as much as 2 feet thick. It is fine-grained and micaceous, resembling the Pleasantview sandstone in most respects. Carbonaceous matter is found on many bedding surfaces, and well preserved plant impressions were found in the NW¼ SE¼ sec. 13, T. 4 N., R. 1 E.

Although the Jake Creek sandstone may be older than the Liverpool black sheety shale, the two beds are not found at the same localities. The sandstone may be equivalent to the basal sandstone of the Lowell cyclothem of northern Illinois that overlies the black sheety shale. Sandstone at least approximately equivalent to the Jake Creek has been seen in Brown, Adams, and Calhoun counties, south and southwest of the area of this report. Most of the prominent Pennsylvanian sandstones, such as the Bernadotte, Isabel, Pleasantview, and Cuba, are generally absent in that region, and in some places the Jake Creek sandstone is the only sandy bed in the Pennsylvanian section.

Geologic section 38.

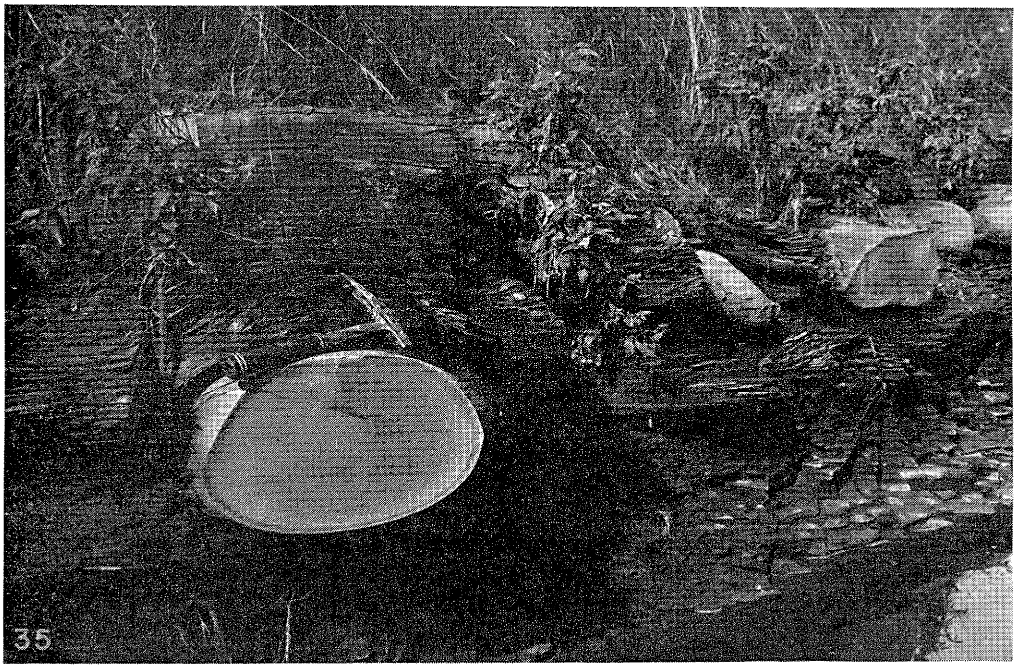
Black Shale and Limestone (Members 66 and 67)

The black sheety shale (member 67) with its characteristic large concretions is one of the most widespread beds associated with the Colchester (No. 2) coal in the central United States. It has been seen in Iowa, Missouri, Illinois, Indiana, and western Kentucky. In this area, however, the black shale has a sporadic distribution and is absent from many parts of the area. It is cut out by the Pleasantview sandstone in the north part of the Beardstown quadrangle. It is absent where the Francis Creek shale is more than 30 feet thick and where the Jake Creek sandstone is present. Coal test borings show the shale to be present near Cuba and St. David in the Havana quadrangle and in the Glasford quadrangle.

The shale ranges from 1 foot 6 inches to 6 feet thick. It is black, hard, and sheety, has well developed rectangular jointing, and cleaves easily into flexible laminae. The shale contains, in about the middle third, numerous small flattened oval gray limestone concretions, up to 1 inch in diameter and ⅓-inch thick, around which the laminae of the shale bend. The concretions give the bedding surfaces a pimply appearance.

The shale also contains large smooth-surfaced concretions of black limestone as much as 2 feet thick and 8 or more feet long. They are flattened spheroids (fig. 35), or long and sinuous. The laminae of the shale bend around these concretions. Some of the concretions are slickensided. They are well exposed along Mill Creek, in the Beardstown quadrangle (geol. sec. 5) and in the Havana quadrangle (geol. sec. 24).

In exposures near Marietta, in secs. 14, 16, 22, and 23, T. 6 N., R. 1 E., Vermont quadrangle, large lenticular masses of black limestone (member 66) appear to underlie directly the black shale, the shale laminae bending up and over the concretions. These may represent a lower concretion development than those in the black shale, or the lower part



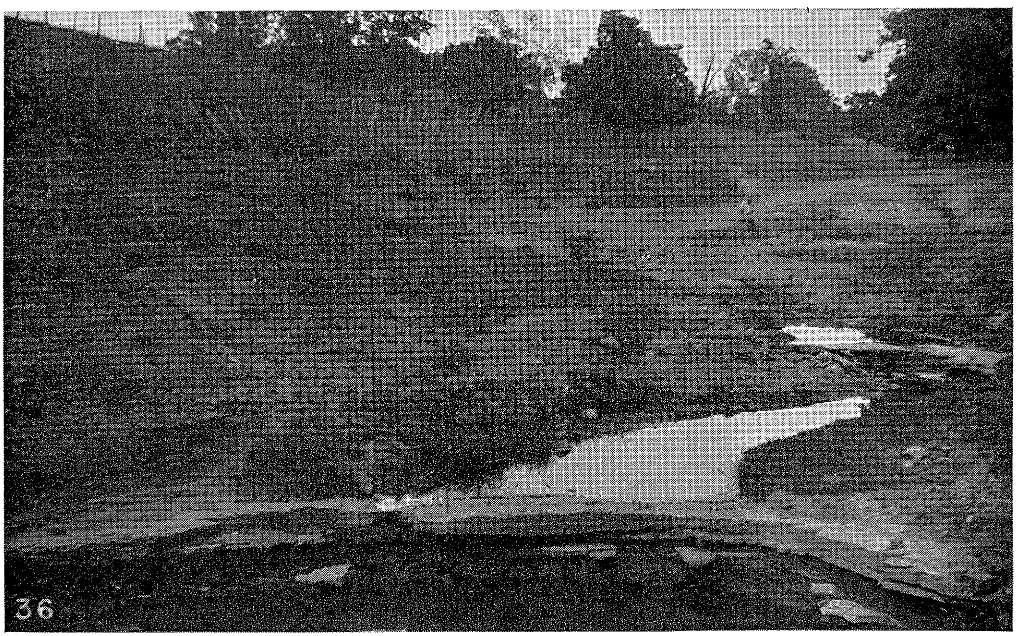


Fig. 35.—Black sheety shale of the Liverpool cyclothem containing large black limestone concretions with shale laminae arching over the concretions along Big Sister Creek, in the NE ¼ NW ¼ sec. 17, T. 5 N., R. 4 E., Havana quadrangle. Geologic section 24.

Fig. 36.—Type section of the Oak Grove beds of the Liverpool cyclothem showing thin beds of limestone in shale, with small waterfalls over the basal gray limestone in the foreground and the dark brown weathering limestone in middle distance, south of Cuba, in the SW ¼ SE ¼ sec. 6, T. 5 N., R. 3 E., Havana quadrangle. Geologic section 22.

of the black shale may be absent and the concretions thus situated at its base. Similar masses of limestone are found in an exposure along Big Creek in the center of the NE¼ sec. 35, T. 6 N., R. 3 E., Havana quadrangle. In exposures in the northwest part of sec. 20, T. 5 N., R. 4 E., Havana quadrangle, a black platy concretionary limestone occurs at this stratigraphic position without the black sheety shale. A similar limestone is found along Stuart Creek in secs. 35 and 36, T. 6 N., R. 2 E., Havana quadrangle, also without associated black shale.

In addition to the concretions thus far mentioned, large masses of brecciated limestone, hard black shale, calcareous concretions, and septarian limestone, firmly cemented together, are found at some places at the top of the black shale. The fragments of black shale are tilted at various angles. The maximum width of these brecciated masses is 12 feet, and the maximum thickness 4 feet 6 inches. Similar masses have been found at this horizon at various places in western and northern Illinois.

The black shale is slightly fossiliferous, containing *Orbiculoidea* and conodonts. The large limestone masses contain some goniatites, fish spines, and pelecypods. Fossils are much less common than in the similar black shale and concretions of the St. David cyclothem.

Geologic sections 24, 25 (member 66); 5, 7, 24, 31, 40 (member 67).

Oak Grove Beds (Members 68 to 81)

The Oak Grove beds are named (Wanless, 1931a, p. 192) from exposures in the ravine just north of the Oak Grove school in the SW¼ SE¼ sec. 6, T. 5 N., R. 3 E., Havana quadrangle (geol. sec. 22, fig. 36).

They consist of a series of thin marine limestone and shale beds, each characterized by a more or less distinctive lithology and fauna and traced over a wide area in the north half of Illinois. The sequence has been seen also in southern Iowa, western Missouri, and western Indiana. It is probably the most useful key for correlation in the western Illinois section. Fourteen members have been differentiated and are described separately. For convenience some of them have been given informal names such as Septarian limestone, *Cardiomorpha* limestone, and so forth.

Limestone (Member 68)

The basal limestone bed of the Oak Grove sequence is discontinuous but is present in the south half of the Beardstown quadrangle, locally in the east half of the Havana quadrangle and in the north part of the Vermont quadrangle.

In the Beardstown quadrangle the member is 1 foot to 10 feet thick, and attains the latter thickness in Mill Creek (geol. sec. 5). It is dark blue gray, dense, and hard, ringing when struck with a hammer. It is siliceous, and where it is more than 6 feet thick, 2 feet of chert is locally found at the top. It contains a variety of brachiopods, crinoid stems, and fusulinids, which stand out as white impressions against a dark gray background.

In the Havana quadrangle the limestone ranges from 1 foot 3 inches to 2 feet 6 inches thick. It is commonly slightly sandy, dark gray to brownish gray, and contains brachiopods, bryozoa, and fusulinids.

Near Marietta in the Vermont quadrangle, the limestone ranges from 2 to 6 inches thick, is dark gray to black, is fossiliferous, and resembles the concretions in the underlying black sheety shale.

Geologic sections 5, 7, 24.

Shale and Limestone (Members 69-71)

In places the basal Oak Grove limestone is overlain by 1 to 5 feet of medium to dark gray slightly fossiliferous shale that locally contains one or more thin bands of fossiliferous limestone or limestone concretions. The interval is thicker in the north and east part of the Havana quadrangle than elsewhere. The shale and thin bands of limestone do not seem to be as persistent or as distinctive in lithology as those higher in the Oak Grove sequence.

The most distinctive band is a 2- to 4-inch bed of limestone conglomerate (member 70), that was seen only in secs. 4 and 8, T. 5 N., R. 3 E., Havana quadrangle. It consists of small rounded pebbles of black or dark gray phosphatic limestone, worn bryozoa, crinoid stem fragments, and other fossil fragments in a matrix of lighter gray limestone. Samples are 87 to 88 percent calcium carbonate. Where this conglomerate is present, the basal Oak Grove limestone and the black sheety shale are absent and the conglomerate rests directly on the Francis Creek shale, suggesting that it is a marine basal conglomerate deposited after a brief interval of erosion. Where the black sheety shale is absent, any bed in this interval may rest on the Francis Creek shale or the Jake Creek sandstone. In the central parts of the Havana and Vermont quadrangles, where the Francis Creek shale is thickest, the Septarian limestone (member 72) commonly rests on it, and members 69, 70, and 71 are absent.

Geologic sections 7, 25, 31, 40 (member 69); 22, 24, 36, 40 (member 71).

Septarian Limestone and Cone-in-Cone (Members 72 and 73)

The Septarian limestone (member 72) is probably the most widespread of the Oak Grove beds in western Illinois. It is not characteristically developed in the south part of the Beardstown quadrangle but has been observed in more than 200 outcrops in the Havana and Vermont quadrangles. It commonly forms a ledge along a stream bank or a small waterfall in a ravine. It breaks in large blocks that may be found on grassy slopes or as float in stream beds where its outcrop is concealed. The limestone is medium to dark gray and ranges from a few inches to 1 foot 6 inches thick.

At intervals along the outcrop, large flattened oval masses of light gray buff-weathering limestone with septarian structure occur. In some outcrops these concretions seem to be at the horizon of the limestone bed but in others they appear to come just above the bed. The limestone is everywhere fossiliferous and is characterized by *Marginifera muricatina.* Some of the shells are marked by minute calcareous worm tubes. At most places other species are uncommon but a much larger variety of forms was found in this bed in a small ravine in the Illinois Valley bluff, in the NW¼ NE¼ sec. 29, T. 5 N., R. 4 E., Havana quadrangle.

Cone-in-cone (member 73) has been found on the upper surface of the thicker masses of this limestone at about 30 outcrops. It is 1 to 10 inches thick and is apparently thicker over the thicker portions of the septarian concretions than elsewhere. At one outcrop 6 inches of cone-in-cone was found on the under side of the limestone, rather than on the upper surface.

This limestone band, with characteristic septarian and cone-in-cone structures, has been found at various localities in northern and western Illinois, in southern Iowa, and in Clay and Parke counties, Indiana.

Geologic sections 22, 24, 25, 31, 36, 38, 40 (member 72); 24, 36, 38, 40 (member 73).

Calcareous Shale (Members 74-76)

The calcareous shale overlying the Septarian limestone contains three members but is usually only 1 to 2 feet thick and is only 6 inches thick in the Vermont quadrangle. It is thicker in the north and east part of the area but may thin out entirely in the west part of the Vermont quadrangle.

The basal bed (member 74) consists of 2 to 4 inches of soft crumbly very calcareous shale or slightly indurated ferruginous argillaceous limestone. It is made up principally of shells that weather out readily and may be gathered in large numbers. The most common and most characteristic forms are small gastropods, such as *Euphemites, Pharkidonotus, Cymatospira, Bucanopsis, Glabrocingulum, Euomphalus* and *Meekospira,* together with brachiopods, corals, small cephalopods (*Pseudorthoceras*), pelecypods (*Nucula*) and other forms.

Above this bed is 3 inches to 1 foot 6 inches of dark gray silty to slightly sandy shale (member 75) in which marine fossils are uncommon but which contains *Marginifera muricatina* as casts or molds.

At several localities in this and adjacent areas the overlying bed is 1 inch of calcareous shale or marl (member 76) which consists mostly of uncemented white-coated shells of *Mesolobus.* A few other species are found in this member but about 90 percent of the shells are *Mesolobus.*

Geologic sections 22, 24 (member 74); 22, 24, 31, 38 (member 75); 24 (member 76).

Cardiomorpha Limestone (Member 77)

The *Cardiomorpha* limestone is a discontinuous bed of fairly large pancake-shaped concretions. It ranges from half an inch to 6 inches thick and is absent in more places than it is present. In some places it is found only as boulder-like masses in the float.

The limestone is dark gray to nearly black, hard, and very fine-grained. A sample dissolved in hydrochloric acid was found to be 84 percent calcium carbonate, 11 percent clay, and 5 percent siliceous residue coarser than clay. Some of the residue is pyrite in the form of internal casts of pelecypod shells.

The limestone contains abundant fossils that are mostly uncrushed pelecypods, especially *Cardiomorpha missouriensis* and *Chaenomya* sp. A species of *Bellerophon* is the only common gastropod. None of the species in this limestone have been found in the immediately underlying shale and few in the overlying shale. The same fauna is found in 1 or 2 inches of shale at this horizon in localities in the Vermont quadrangle where the limestone band is absent.

Geologic section 22.

Dunbarella Shale (Member 78)

The *Dunbarella* shale is widespread in the Havana and Vermont quadrangles and elsewhere in western and northern Illinois, and it has been found in southern Iowa and western Indiana. It thickens from 5 inches in the west part of the Vermont quadrangle to 2 feet in the east part of the Havana. It has not been recognized in the Beardstown area.

The shale is dark gray to black, soft, and flaky. Its bedding surfaces are crowded with flattened impressions of *Dunbarella rectilaterarea*. A few other species of black-mud habitat have been found, such as *Lingula carbonaria, Orbiculoidea missouriensis,* and *Nuculana bellistriata,* but in many exposures only *Dunbarella* was found after careful search.

Geologic sections 7, 22, 24, 31, 36.

Linoproductus Limestone (Member 79)

The *Linoproductus* limestone is a very widespread member that has been recognized through most of western Illinois and in some other areas. It ranges from 2 to 6 inches thick, averaging 3½ inches in more than 100 outcrops. It is dark blue gray and weathers a distinctive bright rusty brown. A sample of the limestone is 86 percent soluble in hydrochloric acid and contains 7 percent clay, 4 percent silt, and 2 percent coarser particles. The coarser residue consists principally of aggregates of very fine dark gray micaceous silt, small nodules of pyrite, a few grains of quartz, fragments of silicified hollow spines, probably productid spines, and silicified and pyritized shells, principally minute gastropods. The limestone is very fossiliferous. It weathers to a soft porous ironstone in which the fossils are preserved as molds and casts. The most abundant species are large shells of *Linoproductus "cora"* and small pale blue shells of *Crurithyris planoconvexa.* In addition there are many gastropods, such as several species of *Sphaerodoma, Glabrocingulum grayvillense,* numerous pelecypods, and others. At some localities the limestone contains very few fossils other than *Linoproductus* and *Crurithyris* but at others a much larger variety occurs. Seventy-five species were found in this limestone near Viola, Mercer County (Wanless, 1931b) but only about 40 species were found in this area.

Geologic sections 7, 22, 24, 31, 36, 38.

Shale (Member 80)

The shale overlying the *Linoproductus* limestone is dark blue gray to nearly black and contains from two to four discontinuous bands of small flattened oval ironstone concretions. It ranges from 10 inches to 2 feet 7 inches thick and thickens toward the eastern side of the Havana quadrangle. A few fossils are present in the concretions, and at some localities the uppermost 2 or 3 inches of the shale is very fossiliferous. The fossils are preserved as very thin and fragile shells, somewhat flattened, or as casts and molds that show delicate shell sculpture. *Crurithyris, Crenipecten,* and minute circular plates of holothurians are the most common and distinctive fossils. Several kinds of foraminifera also were found. The shale has some spots of deep bluish green, probably from the alteration of pyrite grains.

Geologic sections 22, 24.

Fossil-Cast Limestone (Member 81)

The Fossil-cast limestone, the highest bed of the Oak Grove sequence, is quite widespread but has not been found as continuously as the Septarian and *Linoproductus* limestones. It is 1 to 4 inches thick, averaging 2½ inches. It is dark gray and weathers somewhat lighter brown than the *Linoproductus* limestone. A sample dissolved in hydrochloric acid was 81 percent soluble, 13 percent clay, 2 percent silt, and 4 percent coarser residue that consists in large part of silicified small gastropods. The bed is very fossiliferous. The fossils are uncrushed, but the actual shells are largely or wholly leached, and only some chalky white calcite (?) remains. External and internal casts preserve the minute details of shell sculpture more distinctly than any other fossiliferous bed in the area. *Crurithyris, Crenipecten,* and various gastropods, especially *Cymatospira, Glabrocingulum, Meekospira,* and *Euomphalus* are most characteristic.

Geologic sections 22, 24.

Purington Shale (Member 82)

The Purington shale is named (Poor, 1935) from exposures at the pits of the Purington Paving Brick Company at East Galesburg, Knox County. It is widely distributed in the north parts of the Vermont and Havana quadrangles, and is locally present south of the Pleasantview channel in the south part of the Beardstown quadrangle. It is the lowest exposed member in the Glasford quadrangle, and it is also widespread in other parts of northern and western Illinois. In about half of the area the shale is cut out by channel deposits of the Pleasantview sandstone. In those areas where there is little or no truncation by the sandstone, it attains a maximum thickness of about 50 feet.

The shale is light to medium gray and contains flattened oval ironstone concretions, which are most common in the middle and lower parts. At two or three horizons in the lower part the concretions locally form persistent bands that somewhat resemble the uppermost of the Oak Grove beds. The shale has well developed rectangular jointing in the lower 5 to 10 feet, and polygonal jointing above. Where the upper part is more silty it has spheroidal weathering. Marine fossils are found in the lower part of the shale and its concretions, but they are less common than in the Oak Grove. *Crurithyris* and gastropods such as *Cymatospira* seem to be most common. Fossil leaves were found in the concretions at one locality. In those areas where the member attains its maximum thickness, the upper 5 or 6 feet is silty to very finely sandy and appears to grade upward into the more sandy beds of the Pleasantview sandstone. The contact is abrupt where the sandstone is in channels.

Geologic sections 7, 22, 24, 31.

SUMMUM CYCLOTHEM

The Summum cyclothem crops out widely over the area (pl. 5), and its basal sandstone (Pleasantview) crops out more extensively than any other Pennsylvanian member. The cyclothem contains two coals whose distribution is related to the uneven upper surfaces of the Pleasantview sandstone. The cyclothem has typical underclay limestone, dark shale that contains large concretions, and a marine limestone (Hanover). There is no upper shale corresponding to the Purington and Canton shales.

The Summum cyclothem is named (Wanless, 1931a, p. 182, 192) from exposures just northeast of Summum in the large ravine in the N½ sec. 3, T. 3 N., R. 2 E., and sec. 34, T. 4 N., R. 2 E., Fulton County, Vermont quadrangle (geol. sec. 39).

The Summum cyclothem is 11 feet or less to about 85 feet thick. The maximum thickness is in channel areas of the basal Pleasantview sandstone. Members above the sandstone seem to be thicker in the Glasford than in the Havana and Beardstown quadrangles.

The Summum cyclothem is separated from the Liverpool below by one of the most prominent erosional unconformities in the Illinois Pennsylvanian, but there is little or no evidence of unconformity between the Summum and the overlying St. David cyclothem. An unconformity seems to occur locally just above the Pleasantview sandstone.

Geologic sections 1-3, 5-7, 17, 20-23, 28-30, 37, 39.

Pleasantview Sandstone (Member 83)

The Pleasantview sandstone is named (Searight, 1929) from outcrops in Mill Creek, near Pleasantview, in sec. 36, T. 2 N., R. 1 W., and sec. 31, T. 2 N., R. 1 E., Schuyler County, Beardstown quadrangle (geol. sec. 5, fig. 37).

The Pleasantview sandstone has been noted in more than 725 outcrops. In the south parts of the Havana and Beardstown quadrangles, it is the highest Pennsylvanian stratum over a large area.

The sandstone consists of two types, the channel sandstone and the non-channel or sheet sandstone. The non-channel sandstone is extensively exposed in the north-central part of the Havana quadrangle, the southwest part of the Glasford quadrangle, the southwest part of the Beardstown quadrangle, and a small area west of Bernadotte in the central part of the Vermont quadrangle. It ranges from 2 or 3 feet to 15 or 20 feet thick. It is commonly very fine-grained and blue gray or yellow gray. It is evenly bedded in many places and the bedding surfaces have well preserved ripple marks (fig. 38). Cross-bedding is present at several places. The sandstone is commonly calcareous and locally is quite firmly indurated. At several places, the sandstone contains large flattened spheroidal concretions of hard blue-gray calcareous sandstone. The sandstone locally is very shaly or merely a sandy shale as in an outcrop of 15 feet of sandy shale containing abundant fossil plants in the bank of Cripple Creek in the SW¼ NE¼ sec. 25, T. 6 N., R. 3 E., Havana quadrangle.

The channel deposits (fig. 39) seem to belong to two systems (S. E. Ekblaw, 1931). A smaller channel about 1½ miles wide, with a trend of about N. 10° W., crosses the north-central part of the Havana quadrangle, is especially well exposed in the basin of Slug Run, in T. 6 N., R. 3 E., and has been traced northward in the Canton quadrangle across the westward draining valleys of Put Creek, Lost Grove Creek, and Coal Creek.

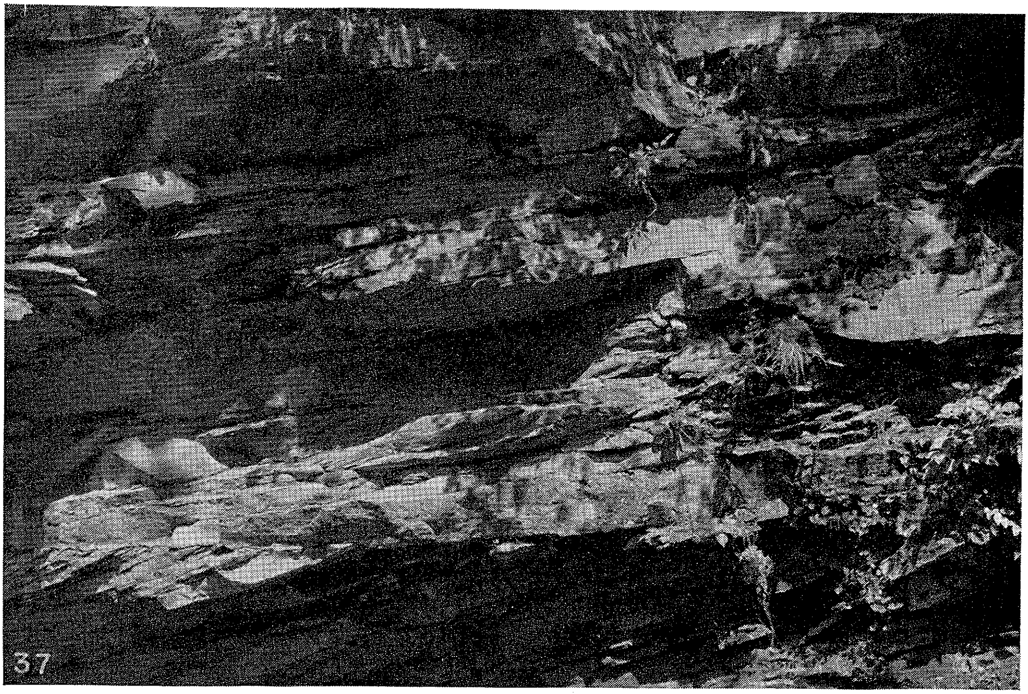
The northern border of a larger channel trends generally southwestward from the Illinois River bluff in sec. 29, T. 5 N., R. 4 E., Havana quadrangle, to a point near Bernadotte in the Vermont quadrangle, then almost straight south for about nine miles, and then nearly west to about the southwest corner of the Vermont quadrangle. The southern border of this larger area extends from the Illinois River bluff in sec. 13, T. 1 N., R. 1 W., Beardstown quadrangle, northwest to the quadrangle line about two miles west of Pleasantview. Because the Pennsylvanian strata have been stripped from a broad belt east of Illinois River, this channel cannot be traced farther in that direction. However, channel deposits in Cass County in the southeast part of the Beardstown quadrangle apparently belong to this channel.

The channel sandstone has a maximum thickness of nearly 80 feet. It rests unconformably on all beds down to the Colchester (No. 2) coal (fig. 34) but is not known to cut out the coal.

The channel sandstone is buff and yellowish brown to gray. Carbonaceous matter is more abundantly distributed through the thinner layers of Pleasantview sandstone than in the other sandstones, and some bedding surfaces are nearly black. The lower 2 or 3 feet has a concentration of stem impressions of *Cordaites, Lepidodendron, Sigillaria, Calamites,* and other plants. Thin streaks of coaly material result from the carbonization of driftwood logs.

The basal part of the sandstone is conglomeratic at many places. The pebbles consist of ironstone concretions like those in the Purington shale, shale and siltstone fragments, and locally fragments of fossiliferous Oak Grove limestone. The pebbles are limited to the basal 3 feet of the channel deposits, are angular to subrounded, and as large as 6 inches in diameter. The long dimensions of the ironstone concretions generally parallel the beddings, but the shale fragments are usually oriented at various angles.

The major part of the channel sandstones consists of lenticular, massive beds, alternating with thin shaly beds. This zone is markedly cross-bedded, but the foreset beds do not slope uniformly in one direction. It is not uncommon for a mass that shows foreset beds sloping in one direction to be cut by a mass in which the foreset beds slope in a direction nearly at right angles to the first. The upper



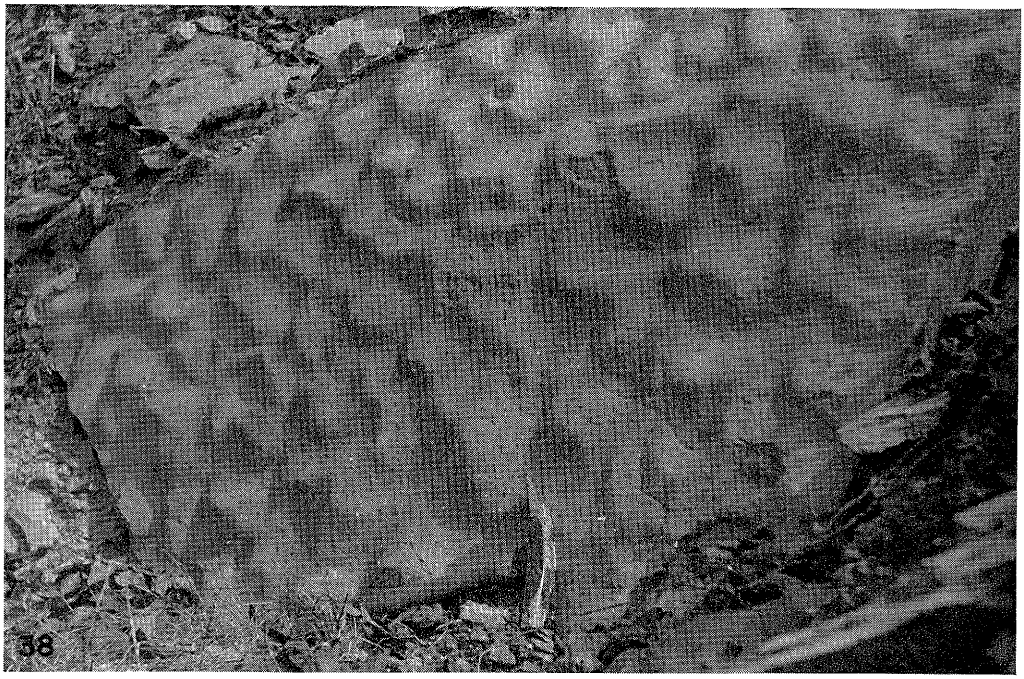


Fig. 37.—Cross-bedded Pleasantview sandstone along Mill Creek, in the NE ¼ SW ¼ sec. 31, T. 2 N., R. 1 E., Beardstown quadrangle. Geologic section 5.

Fig. 38.—Ripple-marked surface of Pleasantview sandstone along Big Creek, in the SE ¼ SW ¼ sec. 19, T. 6 N., R. 4 E., Havana quadrangle.

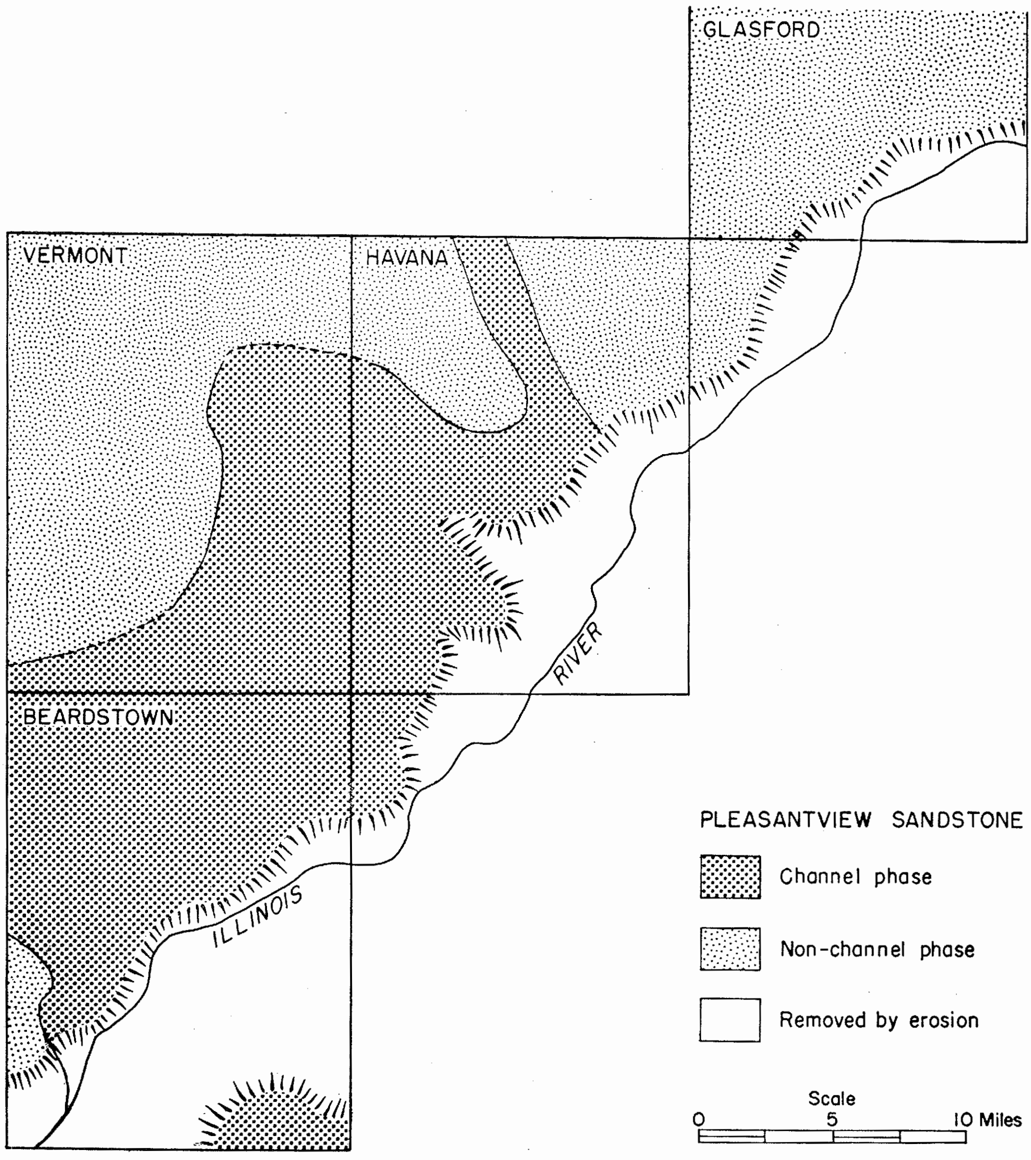


FIG. 39.—Distribution of Pleasantview sandstone channels.

6 to 10 feet of the channel deposits has somewhat more uniform bedding and contains calcareous concretions as large as 6 by 8 by 12 feet. The concretions are hard, blue gray, fine-grained, and specked with small black or brown spots. They appear to be made of many small slabs cemented firmly together. Thin shaly calcareous beds grade laterally into the concretions without disturbance of the bedding.

The sandstone consists mostly of fine angular quartz grains set in a matrix of finer material, which gives the appearance of poor sorting. A few grains show crystal faces. Muscovite is abundant and is concentrated with finely divided carbonaceous matter along bedding planes. Feldspar grains are common, mostly clouded by weathering. At some localities limonite specks are abundantly distributed through the sandstone. The average of 10 samples contains 3 percent fine sand, 46 percent very fine sand, 27 percent silt, and 24 percent clay and cement. The individual samples show little constancy in texture. Of the heavy minerals, zircon slightly exceeds tourmaline in abundance. About half of the zircon grains are rounded, and nearly all of the tourmaline is angular. Garnet makes up 6 percent of the heavy mineral fraction.

The margins of the channel deposits truncate horizontal underlying strata with slopes from 15 to 56 degrees. Within the sandstone, here and there massive lenses cut sharply across shaly beds, giving the appearance of an unconformity. In areas where the sandstone rests on the Colchester (No. 2) coal, its base is relatively flat, but in places it rises 1 or 2 feet above the coal exposing remnants of the Francis Creek shale.

The upper part of the sandstone is unusually shaly and contains well preserved plant leaves in sec. 20, T. 5 N., R. 4 E., Havana quadrangle. Casts of stems are common in the basal part of the channel deposits.

Thick and prominent deposits of sandstone are found at this horizon at many places in western Illinois, southern Iowa, and western Indiana. In Indiana, the sandstone is well exposed at Hanging Rock, Vermillion County.

Geologic sections 1, 2, 5-7, 17, 20, 21, 23, 28-30, 37, 39.

Kerton Creek Coal (Member 84)

The Kerton Creek coal is named (Searight, 1929) from outcrops on the north side of Kerton Creek in the NE¼ NE¼ sec. 15, T. 3 N., R. 2 E., Fulton County, Beardstown quadrangle (geol. sec. 1). It has a very discontinuous distribution, and not even a coaly streak is found to mark its position outside the limited areas where it is present, all of which are in areas of channel deposits of the Pleasantview sandstone.

The coal has a maximum thickness of about 5 feet in the SW¼ SE¼ sec. 25, T. 6 N., R. 3 E., Havana quadrangle. The coal is commonly impure or bony. It is reported to consist of 3 feet of cannel coal in a shaft at Ipava.

At most places the coal slopes into basins 10 to 20 feet deep in the top of the Pleasantview sandstone. In an exposure in the SW¼ NW¼ sec. 20, T. 5 N., R. 4 E., Havana quadrangle, the coal is only 17 feet above the Oak Grove Septarian limestone, and in sec. 29, T. 5 N., R. 4 E., the coal locally is only 4½ feet above the Septarian limestone, though the Pleasantview sandstone is more than 40 feet thick within a quarter of a mile of this outcrop. The Summum (No. 4) coal, which normally is very thin, also thickens as it dips down into the depression. It is commonly 3 to 5 feet above the Kerton Creek coal. In places the Kerton Creek coal truncates bedding planes of the Pleasantview sandstone or is separated from the sandstone by 1 or 2 feet of sandy shale that conforms with the coal in dip. The coal has no underclay.

The Kerton Creek coal is equivalent to a cannel coal locally 5 feet thick east of Roodhouse, Greene County. In each of these areas the coal occupies a narrow trough, and the Summum (No. 4) coal above it also dips and thickens into the trough.

Geologic sections 1, 39.

Shale (Member 85)

The shale overlying the Pleasantview sandstone is commonly 1 to 5 feet thick, is slightly sandy, and grades down into the sandstone. It locally is cut by vertical joints filled with masses of impure limestone extending down from the Summum underclay limestone above. In some areas where the Kerton Creek coal is present and thick, 8 to 15 feet of gray shale containing plant leaves overlies the coal and underlies the Summum underclay. Locally the beds immediately over the coal are black sheety shale with a limited marine fauna.

Geologic sections 1, 3, 5, 21, 39.

Underclay Limestone (Member 86)

The underclay limestone of the Summum cyclothem is widely distributed in the area and elsewhere in western Illinois, but it is locally absent where the Summum (No. 4) and Kerton Creek coals are thick. The underclay limestone is a few inches to 5 feet thick. In places it consists merely of irregularly shaped limestone concretions in the calcareous part of the underclay (fig. 40). The larger concretions have a septarian structure. At many places the concretions grade down into a very uneven bed of gray silty to sandy limestone. A sample of the limestone was 73 percent soluble in hydrochloric acid, contained 10 percent clay, 14 percent silt, and 3 percent sand. The coarser residue is composed of 75 to 80 percent very fine angular quartz grains, 20 percent minute pyrite crystals and rosettes, and a few flakes of muscovite. The limestone may be distinguished from other underclay limestones of the area by its sandy texture, brown weathering, and very uneven structure.

Geologic sections 1, 3, 5, 17, 20, 21, 39.

Underclay (Member 87)

The underclay of the Summum (No. 4) coal is widespread and averages 3 to 5 feet thick. It resembles other underclays of the area in most ways. The upper 1 foot 6 inches to 2 feet is noncalcareous. The lower calcareous part contains small limestone nodules that grade down into the underclay limestone. Selenite crystals are fairly common in the noncalcareous part of the clay, and the lower part is stained rusty.

Geologic sections 1, 3, 5, 17, 20, 21, 39, 43, 44.

Sandstone (Member 88)

A bed of sandstone about 5 or 6 inches thick was found in this area only in the SW¼ sec. 22, T. 6 N., R. 3 E., Havana quadrangle (geol. sec. 20), but it has been found in a few outcrops farther north in the Canton quadrangle. It is white to light gray, very fine-grained, firmly indurated, and is composed of quartz grains, mostly silt and very fine sand. It contains some muscovite flakes as large as 0.5 mm. diameter. The quartz grains show some secondary enlargement. The sandstone contains *Stigmaria* in the Canton quadrangle outcrops.

Geologic section 20.

Summum (No. 4) Coal (Member 89)

Worthen (1870) considered the Springfield (No. 5) coal in the region north and northeast of Canton, where it is 50 to 60 feet below the Herrin (No. 6) coal, to be a different coal than that 16 to 20 feet below the No. 6 coal near Cuba. He applied the number 5 to the coal near Cuba and the number 4 to the coal elsewhere. Recent studies have shown that the two coals are the same. The number 5 has been retained for the first coal below No. 6, and the number 4 reapplied to the Summum coal, which is a short distance below the Springfield (No. 5) bed, and was not numbered in Worthen's section of Fulton County.

The No. 4 coal is widespread, commonly is a fraction of an inch to 4 inches thick, and occurs about 8 to 10 feet below the Springfield (No. 5) coal. In several scattered areas the coal is 3 to 5 feet thick. The areas of thick coal are all in areas of the channel phase of the Pleasantview sandstone. Most of these localities are places where the Kerton Creek coal is also present and one or both of the coals have been mined.

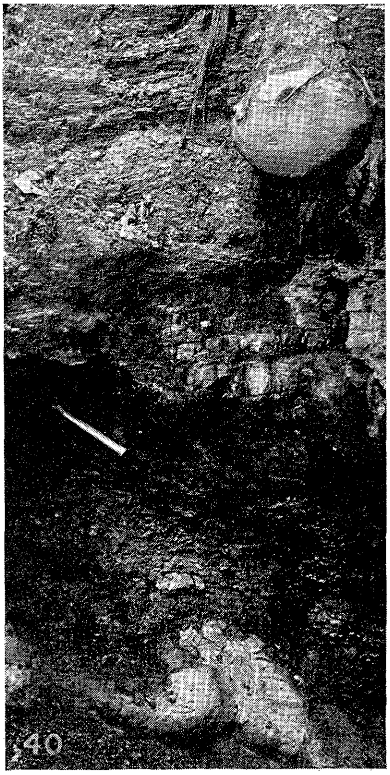
The upper 1 foot of the coal is cannel coal containing well preserved pyritized fossils at a shaft in the SW¼ SW¼ sec. 8, T. 4 N., R. 2 E., Vermont quadrangle. Two or three thin bands of pyrite also occur in this coal where it is thick. The very large concretions in the roof shale at places extend down into the upper part of the coal.

The Summum (No. 4) coal is found widely in western and northern Illinois and is recognized most easily by the large concretions in the roof shale. It is equivalent to the No. 4 coal of southern Illinois, the No. IVa or Houchin Creek coal of western Indiana, the Upper Well (8B) of Union County, Kentucky, the Goshen coal of Ohio County, Kentucky, and the Mulky coal of Missouri.

Geologic sections 1, 3, 5, 17, 20, 21, 39, 44.

Shale (Members 90 and 91)

The shale overlying the Summum (No. 4) coal consists of a lower dark shale (member 90) and a local upper light shale (member 91). It is widespread and has been recognized in all four of the quadrangles. It ranges from 2 to about 12 feet thick and is thicker in the Glasford quadrangle than elsewhere. The dark shale is unlike the other black shales in that it is generally soft rather than hard and sheety. The shale is principally dark gray to



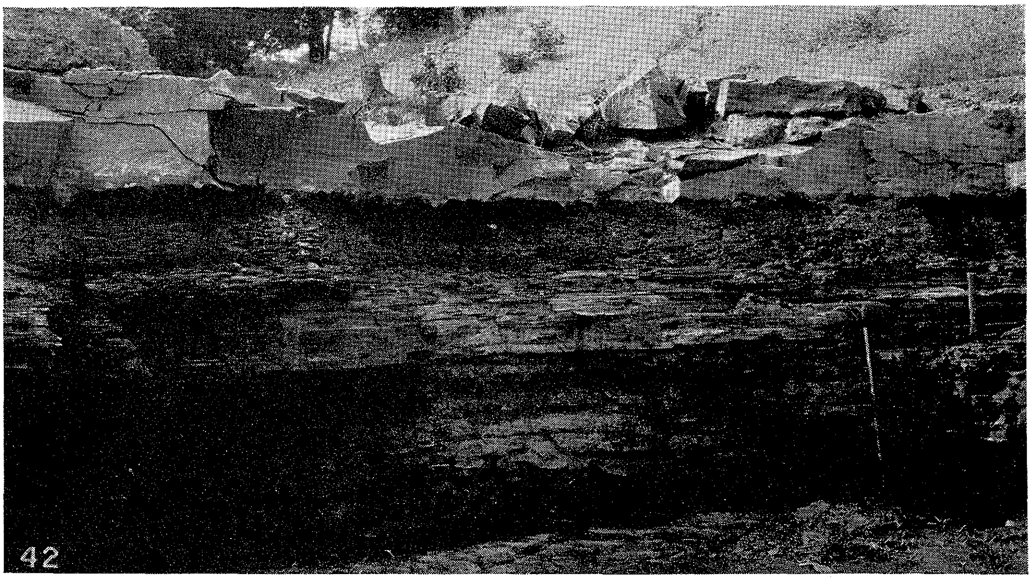


FIG. 40.—The Summum (No. 4) coal overlain by dark shale with distinctive round black limestone concretions and underlain by underclay with septarian concretions along Big Creek, in the NW ¼ SW ¼ sec. 35, T. 6 N., R. 3 E., Havana quadrangle.

FIG. 41.—Horseback in Springfield (No. 5) coal, along tributary of Evelen Branch, in the SW ¼ SE ¼ sec. 13, T. 6 N., R. 3 E., Havana quadrangle.

FIG. 42.—The Springfield (No. 5) coal overlain by black sheety shale, soft black shale, and the St. David limestone in strip mine west of St. David, in the SW ¼ NW ¼ sec. 24, T. 6 N., R. 3 E., Havana quadrangle.

black but contains several laminae of lighter gray shale. Shale tentatively correlated with this member is hard and sheety in exposures in secs. 33 and 34, T. 4 N., R. 2 E., Vermont quadrangle, and secs. 22 and 23, T. 3 N., R. 1 E., Beardstown quadrangle.

Characteristic large black limestone concretions occur in the lower part of the shale (fig. 40). They are smooth-surfaced and tend to have the shape of flattened spheroids rather than the irregular or sinuous shape of the concretions in the Liverpool cyclothem black shale. The surfaces commonly show regularly spaced shallow pits as much as ½ inch deep. The limestone is denser and less pyritic than that in the St. David cyclothem black shale concretions. Concretions as large as 5 by 6 by 8 feet occur at the type outcrop of the Summum cyclothem (geol. sec. 39). The concretions contain fish spines, *Orbiculoidea,* and a small ammonoid, *Anthracoceras wanlessi,* which is especially diagnostic of this horizon.

Small limestone concretions about the size of a walnut are found in the upper part of the shale at some localities. The shale is black and sheety in northern Illinois and throughout western Indiana and contains hard dark gray to black limestone similar to that in the concretions. The black shale and concretions are also present in southern Illinois, western Kentucky, and Missouri. The dark shale grades up into soft light to medium gray shale (member 91) about 2 feet thick in places in the Beardstown quadrangle.

Geologic sections 1, 3, 5, 17, 20, 21, 39.

Hanover Limestone (Member 92)

The Hanover limestone is named (Van Pelt, J. R., Illinois Geological Survey field notes, 1928) from exposures in a ravine near the Hanover school, in the NE¼ SW¼ sec. 27, T. 10 N., R. 11 W., Greene County, Roodhouse quadrangle.

It is very discontinuous in this area, but is most persistent near Pleasantview, in the southwest part of the Beardstown quadrangle. The limestone ranges from 1 to 4 feet thick near Pleasantview but is 6 inches or less elsewhere.

In the Pleasantview area, the limestone is conglomeratic with dark blue-gray limestone masses in a matrix of light gray limestone. It is generally massive, but in the thickest exposures shows rude bedding. Both the upper and lower surfaces are uneven and hummocky. Near Summum the limestone has the same lithology, but is only 6 inches thick. Southwest of Bernadotte in the Vermont quadrangle it is sandy and micaceous and only 1½ inches thick. Near Cuba in the Havana quadrangle it consists of pellet-like nodules of light gray limestone in calcareous clay.

This limestone contains marine fossils, mostly the more common brachiopods, and no one species is especially diagnostic. Fusulinids have been found in the outcrops near Pleasantview.

In most exposures the Hanover limestone is overlain unconformably by the St. David underclay and underclay limestone. Its lithology and relations are quite similar to those of the Seahorne limestone and Wiley underclay. The knobby character of the upper surface of these limestones may be due in part to weathering previous to the deposition of the underclay.

The Hanover limestone is one of the widespread Pennsylvanian limestones of the central United States. It is represented by sandy glauconitic limestone in Knox County, Illinois, by light gray limestone near LaSalle in northern Illinois, and by light gray limestone with uneven upper surface in the area south of the Beardstown quadrangle in Adams, Brown, Scott, Greene, Calhoun, Jersey, and Madison counties. It has been recognized in southern Iowa and is correlated further with the caprock of the Mulky coal of Missouri, and the Blackjack Creek limestone of Kansas and Oklahoma. It is generally absent in western Indiana and southern Illinois.

Geologic sections 3, 5, 17, 20, 39.

Covel Conglomerate (Member 93)

The Covel conglomerate is named (Willman, 1939) from exposures along Covel Creek, south of Ottawa, in the SE¼ SW¼ sec. 26, T. 33 N., R. 3 E., LaSalle County, Ottawa quadrangle.

This member is widely distributed across northern Illinois, and has been recognized in southern Iowa and western Indiana, but it apparently dies out southward and has been found in only two places in the area of this report, in neither of which are its relations to associated beds well displayed. It is present in the SW¼ NE¼ sec. 32, T. 7 N., R. 5 E., Glasford quadrangle, and the SE¼ SE¼ sec. 24, T. 6 N., R. 3 E., Havana quadrangle. It also occurs just east of the Glasford quadrangle (geol. sec. 43).

The conglomerate occurs as discontinuous lenses in gray calcareous shale or clay. It is commonly only 1 to 3 inches thick but some blocks at the locality in the Havana quadrangle are 10 inches thick. It consists largely of well rounded small pebbles of dark gray to black phosphatic limestone in a matrix of lighter gray limestone. A few water-worn fossil fragments show that the conglomerate is part of the underlying Summum marine beds rather than a basal conglomerate of the St. David cyclothem. Because of its distinctive lithology, it is a very useful bed for correlation.

Geologic section 43.

ST. DAVID CYCLOTHEM

The St. David cyclothem includes the Springfield (No. 5) coal, the most important coal of the area, which has been mined by shaft and stripping in many places. The cyclothem possesses no basal sandstone member in this area, but is otherwise complete and typical. There are two abnormalities in its sequence, 1) a local coal above the St. David black shale, and 2) a marine limestone or band of concretions below the middle of the Canton shale at the horizon of a coal in other parts of Illinois.

The upper part of the St. David cyclothem is truncated by channels of the basal Brereton (Cuba) sandstone, in much the same manner as the Liverpool cyclothem is truncated by the Pleasantview sandstone. In the Glasford quadrangle the cyclothem is locally cut out by the Cuba sandstone.

The St. David cyclothem is named (Wanless, 1931a, p. 182, 192) for exposures in a ravine on the north side of Big Creek, about one mile west of St. David (secs. 17, 20, and 21, T. 6 N., R. 4 E., Fulton County, Havana quadrangle, geol. sec. 21). The name St. David was originally applied to the marine limestone member (Savage, 1927, p. 309) and subsequently was extended to the entire cyclothem.

The St. David cyclothem underlies nearly all of the Glasford quadrangle and much of the northern half of the Havana quadrangle (pl. 5). It has been eroded in all except two small areas in the Vermont quadrangle, one about two miles west of Bernadotte and the other north of Summum. In the Beardstown quadrangle it is present only in the highland near Pleasantview.

The cyclothem is 18 to 55 feet thick in localities where the upper part is not truncated by the Cuba sandstone. It is thicker in the north part of the area, averaging 45 to 50 feet near St. David and east of Cuba but only 20 feet thick near Pleasantview.

The St. David cyclothem appears to be conformable on the Summum cyclothem, but its contact with the Brereton cyclothem above is an important erosional unconformity along which more than 50 feet of St. David strata are locally eroded.

Geologic sections 3-5, 11, 17-21, 39, 43, 44.

Clay (Member 94)

The basal member of the St. David cyclothem is clay. It is 5 or 6 feet thick at places in the Glasford quadrangle but is unimportant in the Havana quadrangle, except near the eastern margin. It is calcareous, light to medium gray, has a light yellowish cast, and contains scattered small pellets of darker gray clay. It is not laminated and more closely resembles the underclays than the shale or sandstone that more commonly occur at this position.

Geologic sections 17, 39, 43.

Underclay Limestone (Member 95)

The underclay limestone has its maximum development in T. 7 N., R. 5 E., in the southwest part of the Glasford quadrangle, where two to four beds of medium gray argillaceous concretionary limestone, 3 to 14 inches thick, are separated by hard calcareous clay and shale in an interval 4 to 7 feet thick. Similar beds are found farther west in the south half of the Canton quadrangle. In the Havana quadrangle one or two continuous limestone beds occur at a few places, but more commonly large irregularly shaped septarian concretions of light gray limestone are found in underclay 1 to 3 feet below the Springfield (No. 5) coal. Similar septarian concretions occur in the Vermont and Beardstown quadrangles but are less persistent. In the Pleasantview area they locally rest on the Hanover limestone.

A sample of the limestone from the Havana quadrangle is 84 percent soluble in hydrochloric acid and the insoluble material is 12 percent yellow-brown clay, 2 percent silt, and 2 percent coarser material. The coarser part consists of small aggregates of brownish-gray micaceous silt, nodular masses with pyritic centers surrounded by concentric bands of limonite; and fairly well rounded grains of quartz sand as large as 0.3 mm. diameter. No fossils were found in this limestone or its associated shale and it appears to be nonmarine.

Geologic sections 17, 19-21, 39, 43, 44.

Underclay (Member 96)

The St. David underclay is widespread and essentially coextensive with the overlying coal. It is 1 foot 6 inches to 5 feet thick and is thicker in the Glasford quadrangle than elsewhere. The upper 6 inches to 1 foot is noncalcareous at most places, but at a few outcrops the clay is calcareous within 1 or 2 inches or immediately below the coal. The lower half is slightly laminated. Minute calcareous concretions in the calcareous underclay locally grade down into larger concretions and into the underclay limestone.

Geologic sections 3-5, 17, 19-21, 39, 43, 44.

Springfield (No. 5) Coal (Member 97)

The number 5 was originally applied to this coal in Fulton County (Worthen, 1870, p. 93) and subsequently the coal was correlated with that mined near Springfield in Sangamon County (Savage and Shaw, 1913). The coal is widely distributed in the area (pl. 7). Information regarding the coal is derived from about 350 outcrops and mine workings and about 650 coal test borings.

The coal is 3 feet 6 inches to about 6 feet thick. It is thinnest in the northwest part of the Glasford quadrangle, where it averages less than 4 feet. It averages about 4½ feet thick in the east and south parts of the Glasford area, about 5 feet in the north part of the Havana quadrangle, and more than 5 feet in smaller areas in the Vermont and Beardstown quadrangles. Scattered coal test borings show less than 3 feet of coal, but these apparently encountered horsebacks—nearly vertical clay seams. A few records report 9 to 11 feet of coal but they probably combined the Springfield (No. 5) coal with a coal that locally overlies the St. David black shale.

The Springfield (No. 5) coal contains no persistent clay or shale partings (fig. 42). Pyrite may be present as thin films along vertical joints in the coal or as discontinuous bands of small concretions 1 to 2 inches in diameter. Three such bands, at 6, 16, and 27 inches below the top of the coal, were measured in a strip mine near Cuba. Pyrite concretions 1 to 3 inches thick make pits or depressions in the upper surface of the coal. Calcite is found as facings along joints in the coal.

Coal No. 5 is characterized by the abundance of irregularly shaped clay seams called "horsebacks" (fig. 41). Horsebacks may be seen at many strip-mine exposures and also in a small ravine in the SW¼ SE¼ sec. 13, T. 6 N., R. 3 E., Havana quadrangle, where the coal dips downstream at about the same slope as the gradient of the stream, and has a continuous exposure nearly a quarter of a mile long. In this exposure the horsebacks are 6 inches to 3 feet wide and extend in many directions. The clay in the horsebacks is lighter gray and more sandy than the underclay. Some horsebacks cut through the black roof shale but others die out in the coal above the underclay. At some horsebacks the coal seems to bend up toward the edges of the clay seams, as if the clay had been injected from below. The clay is more sandy than any bed above the coal and below the Cuba sandstone. A large "coal-ball" composed of brown limestone with fossilized plant material was found along the margin of a horseback in a strip mine near Cuba.

In a strip mine near Cuba, the uppermost 1 inch of the coal locally consisted of alternate laminae of bright or banded coal and dull bony beds containing *Orbiculoidea, Composita, Marginifera,* and various other forms. Marine fossils were found on about six laminae.

The Springfield (No. 5) coal lies in an eastward-trending basin, has its greatest thickness near the south end of the basin, and thins regularly northward until it finally wedges out about 35 or 40 miles north of the Glasford quadrangle (Wanless, 1932). The southern margin of the basin is a little south of Springfield, and the coal reaches its greatest thickness, more than 6 feet, near Springfield and Decatur. It is absent at Cambridge, Henry County, and along the upper Illinois valley near LaSalle, Marseilles, and Morris.

The Springfield (No. 5) coal is the most extensively mined coal of the Eastern Interior coal basin. It is also found in western Indiana where it wedges out northward about half way between Danville, Illinois, and Clinton, Indiana. It extends southward through the rest of the western Indiana coal field as the No. V, Alum Cave, and Petersburg coals. It extends throughout southern Illinois, where it is known as the Harrisburg (No. 5) coal, and into western Kentucky, where it is called No. 9 coal. It is correlated with the Summit coal of Missouri.

Geologic sections 3-5, 17, 19-21, 39, 43, 44.

Black Shale (Member 98)

The Springfield (No. 5) coal is overlain by black shale 8 inches to 2 feet 6 inches thick. The lower part is mostly hard and sheety and breaks into thin plates which are slightly flexible (fig. 42). The upper part is somewhat softer and is flaky rather than sheety. At many places a dark gray to black soft shale ½ inch to 2 inches thick occurs at the base of the sheety shale and immediately above the coal. It is known by the miners as "draw slate" because it commonly comes down with the coal. The shale has a well developed system of rectangular or rhomboidal joints. The shale contains black limestone concretions as large as 9 by 18 by 24 inches. At places the concretions are very pyritic.

The black shale is fossiliferous, more so at some places than at others. The most characteristic forms are *Lingula carbonaria, Orbiculoidea missouriensis, Dunbarella recti-laterarea,* conodonts, and fish spines, scales, and tubercles. Irregular patches of structureless organic matter that may be of algal origin also are found. Branching light gray masses on bedding surfaces may be seaweed impressions or filled worm-tubes.

The large limestone concretions are more fossiliferous than those of the Summum and Liverpool cyclothems. The more pyritic concretions contain most abundantly a large pelecypod, *Solemya* trapezoides. The calcareous concretions contain a larger diversity of forms. More than 60 different species have been found at an outcrop on the east side of a ravine north of Big Creek in the SE¼ SW¼ sec. 26, T. 6 N., R. 3 E., Havana quadrangle (Wanless, 1957). The most characteristic forms in the calcareous concretions are *Composita argentea, Solemya parallella,* and *Clinopistha radiata* var. *laevis*.

In an exposure about 1½ miles east of the Havana quadrangle, in the NE¼ sec. 30, T. 6 N., R. 5 E., Manito quadrangle, two stumps spread out on top of the coal, and extend up 7 inches to 1 foot 3 inches through the black sheety shale. They consist of pyritiferous limestone and one shows woody external structure.

Geologic sections 3, 5, 17, 19-21, 39, 43, 44.

Coal (Member 99)

A coal very locally overlies the black shale. It is best exposed in a small gully on the east side of a large ravine in the SW¼ NE¼ sec. 16, T. 7 N., R. 5 E., Glasford quadrangle (geol. sec. 17). There the coal is directly under the Cuba sandstone, is 6 feet 6 inches thick, and is separated from the Springfield (No. 5) coal by 3 to 10 inches of black sheety shale. The Springfield coal is 5 feet 6 inches thick, giving a combined thickness of nearly 12 feet of coal. Because marine fossils such as *Lingula* and *Orbiculoidea* are found in the black sheety shale, which resembles the usual roof shale, it is believed that this coal is above, rather than a part of, the Springfield coal. In the NE¼ SE¼ of sec. 18, in the same township, 9 feet of coal was formerly mined and this probably also combines the two coals.

A similar occurrence of this coal may be seen about one mile north of Cuba in a ravine and local strip mine in the SW¼ SE¼ sec. 8, T. 6 N., R. 3 E., Havana quadrangle, and 10 feet of coal is reported in a coal test boring in the SE¼ NE¼ sec. 10, of the same township. Savage (1922, p. 242) considered that this great thickness of coal resulted from the convergence of coals Nos. 6 and 5. More recent information has shown that the Cuba sandstone, Canton shale, and St. David limestone are above the thick coal and that No. 6 coal occurs above them. Similar relations are known near Clinton, Vermillion County, Indiana, where a canneloid coal 1 foot 3 inches thick immediately overlies the black sheety shale roof of the No. V coal and is 19 feet below the St. David limestone.

Geologic section 17.

Shale (Member 100)

Shale that commonly rests on and apparently grades into the St. David black sheety shale is widely distributed, but has not been seen in the few places where the local coal (member 99) is present. The shale is 6 inches to 3 feet thick, averages about 1 foot, and is thickest in the Glasford quadrangle.

The lower part of the shale is black and fairly well bedded, but softer than the black sheety shale below (fig. 42). The upper part may include some medium blue-gray shale, mottled with black. The pattern suggests some organic structure, such as seaweeds or worm borings. Fossil remains, except microfossils, are rare and generally absent. The shale is abruptly terminated at the top of the uneven basal surface of the St. David limestone.

Geologic sections 3, 4, 19-21, 39, 43.

St. David Limestone (Member 101)

The St. David limestone was named by Savage (1927, p. 309) for exposures near St. David in the Havana quadrangle.

The limestone is widespread through the area, and has been found in about 175 outcrops. It is locally absent at several outcrops in the Glasford quadrangle and at a few in the Havana quadrangle. Because of its hardness and massive character, it commonly forms ledges and waterfalls. Huge blocks of the limestone may be seen on the spoil banks of strip mines near Cuba. The limestone thickens southward and ranges from 4 inches or less at some outcrops in the Glasford quadrangle to a maximum of 7 feet in the Beardstown quadrangle. It averages 6 to 8 inches thick in the Glasford, 1 foot in the Havana and Vermont, and 2 feet in the Beardstown quadrangle.

The limestone is most typically developed in the north half of the Havana quadrangle, where it is a single bed 10 inches to 2 feet thick, light blue gray, and dense. It weathers buff or light yellow brown. After long exposure, blocks break into angular fragments 2 or 3 inches in diameter. The lower surface of the limestone is very uneven, with knobs projecting downward into the underlying shale (fig. 42). The upper surface is slightly uneven, owing in part to large nautiloid shells that extend upward an inch or more into the overlying calcareous shale. As it thins northeastward the limestone grades to small discontinuous concretions of gray fossiliferous limestone 4 to 6 inches thick. Where thickest in the west part of the Beardstown quadrangle the limestone consists of several beds in calcareous shale.

A sample of this limestone is 88 percent soluble in hydrochloric acid and contains 10 percent clay, 1 percent silt, and 1 percent coarser fragments. The coarser residue consists of small irregularly shaped nodules of pyrite, pyritized bryozoa (*Rhombopora* sp.), pyritized and silicified hollow spines, probably from productid shells, aggregates of light gray micaceous silt, and a few well rounded quartz grains.

The limestone is everywhere fossiliferous, and its fauna is characteristic. The most diagnostic fossils are *Marginifera splendens, Mesolobus mesolobus* var. *euampygus, Chonetina verneuiliana* (?), and *Dictyoclostus americanus*. The first three named species are not common in older Pennsylvanian strata. Fusulinids are present but much less common than in the Brereton limestone. The upper surface of the limestone locally contains many large shells of *Liroceras* sp. up to 6 inches across.

The St. David limestone is widely distributed in western Illinois but thins out and is absent north of the Peoria and Glasford areas. It is equivalent to the Houx limestone, the caprock of the Summit coal of Missouri. In Indiana it is the Alum Cave limestone of Sullivan County.

Geologic sections 3-5, 18-21, 39, 43.

Shale (Member 102)

The shale is fairly widespread, but is not present in some localities. Its thickness averages about 1 foot, ranging from 6 inches to 1 foot 6 inches. It consists in large part of loose shells, which are somewhat broken and crushed, in dark gray very calcareous shale.

The best fossil collecting locality is the calcareous shale adhering to the upper surface of large blocks of the St. David limestone on the waste piles of strip mines in the Havana quadrangle. The most characteristic fossils are *Mesolobus mesolobus* var. *euampygus, Chonetina verneuiliana* (?), *Chonetes granulifer, Marginifera splendens, Marginifera muricatina, Punctospirifer kentuckyensis, Hustedia mormoni, Composita argentea,* and crinoid plates (*Eupachycrinus tuberculatus* and others). The St. David cyclothem includes the only faunal zone where *Marginifera splendens* and *Marginifera muricatina* are commonly found together. *M. muricatina* is the common form below the St. David and *M. splendens* is the common form above.

Geologic sections 18-20, 39.

Canton Shale (Lower Part—Member 103)

The Canton shale is named (Savage, 1922, p. 240-241) from exposures near Canton in secs. 28 and 33, T. 7 N., R. 4 E., Fulton County, Canton quadrangle, where the shale is used in the manufacture of brick.

The lower part of the Canton shale cannot readily be distinguished from the upper part (members 105-106) in those areas where the marine limestone or concretion band separating them is absent. The shale is 2 to 10 feet thick and averages 7 feet. It is light to medium gray, but the upper 1 or 2 feet is locally darker. The shale is soft, generally has polygonal jointing, and contains small flattened oval ironstone concretions similar to but smaller than those in the Purington shale. This member is normally not more than one-fifth of the total Canton shale.

Geologic sections 3, 4, 18-21, 34, 43.

Limestone in Canton Shale (Member 104)

The limestone is a discontinuous band of blue-gray limestone concretions that forms a solid bed of limestone at a few places. It ranges from 4 inches to 1 foot thick but is not present at all outcrops.

The concretions are associated at places with a few inches of calcareous dark gray fossiliferous shale that resembles member 102 and is unlike the usual Canton shale. A sample of one of the concretions is 72 percent soluble in hydrochloric acid and contains 17 percent clay, 11 percent silt, and less than half a percent of coarser material. The latter consists of fine angular quartz grains, pyrite crystals, a few muscovite flakes, and siliceous hollow spines, probably from productid shells. The concretions and associated calcareous shale are slightly fossiliferous and *Linoproductus* sp. is the most common form.

This limestone is fairly widespread in west-central Illinois. Near West Jersey, Stark County, and at various places in LaSalle County, a bed of cannel coal or canneloid slate locally occurs at this horizon. These beds are equivalent to a widespread coal and limestone farther east and south—coal Va of Indiana, coal No. 10 of western Kentucky, and coal No. 5a of southern Illinois.

Geologic sections 19-21.

Canton Shale (Upper Part—Members 105 and 106)

The upper part of the Canton shale consists of two members—a lower gray clay-shale (member 105) and an upper silty or sandy shale (member 106) (fig. 43). Together they have a maximum thickness of more than 40 feet.

The gray clay-shale is similar to the lower part of the Canton shale (member 103) and is about 25 feet thick. It contains numerous small ironstone concretions, mostly not in definite bands. The overlying silty to slightly sandy shale is commonly 10 to 15 feet thick. It grades up into fine sandstone of the nonchannel phase of the Cuba sandstone

The relations are like those where the Purington shale is overlain by nonchannel deposits of the Pleasantview sandstone.

The Canton shale, as a whole, is absent or greatly thinned along channels of the Cuba sandstone. It is also absent or very thin in secs. 19 and 20, T. 6 N., R. 3 E., Havana quadrangle, just south of Cuba, where coals Nos. 6 and 5 are only 16 to 20 feet apart. The shale may have been eroded before deposition of the Cuba sandstone, or it may have originally wedged out in this area. The shale is thin and the Cuba sandstone absent near Pleasantview in the Beardstown quadrangle.

The Canton shale is widespread in western and northern Illinois. It is absent south of the Beardstown area for about 100 miles along the western border of the coal basin, where the underclay of the Herrin (No. 6) coal immediately overlies the St. David limestone or calcareous shale.

Geologic sections 16, 19-21 (member 105); 16, 19, 20, 39 (member 106).

BRERETON CYCLOTHEM

The Brereton cyclothem is a typical cycle of sedimentation with a marked erosional unconformity at the base, a prominent basal sandstone, underclay limestone, underclay, coal, black shale, marine limestone, calcareous shale, and gray shale. In one outcrop an additional marine limestone occurs below the underclay limestone and above the basal sandstone (geol. sec. 19). It is not known elsewhere, but seems to correspond in position with the "lower" marine limestone of the Kansas megacyclothem (Moore, 1936), a member not commonly found in Illinois. The cyclothem has a development that is quite abnormal and very thin in the outlier near Pleasantview in the Beardstown quadrangle. The basal sandstone, underclay limestone, coal, black shale, and gray shale, are all absent, and the cyclothem consists of only the marine limestone, coal trace, and underclay. As previously described, several Tradewater cyclothems change character in much this manner as they are traced from the Illinois basin toward the Ozark flank.

The Brereton cyclothem is named (Wanless, 1931a, p. 182, 192) for outcrops about two miles northeast of Brereton on the east bank of Middle Copperas Creek in the SE¼ NE¼ sec. 1, T. 7 N., R. 4 E., Fulton County, Glasford quadrangle (geol. sec. 16, fig. 43). The name was originally given to the limestone member (Savage, 1927, p. 309) and was subsequently applied to the entire cyclothem.

The Brereton cyclothem crops out extensively in the Glasford quadrangle and in scattered places in the north part of the Havana quadrangle where it is the highest Pennsylvanian cyclothem. Its basal sandstone is exposed near Summum and is the highest Pennsylvanian unit in the Vermont quadrangle. The outlier near Pleasantview is the only occurrence in the Beardstown quadrangle (pl. 5).

The cyclothem is 15 feet or less thick in the Beardstown quadrangle, 20 to 40 feet in the Havana quadrangle, and 30 to 102 feet in the Glasford quadrangle. Variations in thickness are due to the wedging out of several members and to the unconformities at its base and top.

Geologic sections 3, 4, 12, 16-20, 39, 43, 44.

Cuba Sandstone (Member 107)

The Cuba sandstone is named (Savage, 1927, p. 309) from exposures north of Cuba in sec. 8, T. 6 N., R. 3 E., Fulton County, Havana quadrangle. The sandstone crops out extensively in the Glasford quadrangle and the north part of the Havana quadrangle. It is generally resistant to erosion and forms rock ledges or bluffs at many places (fig. 44).

The sandstone is 3 to more than 80 feet thick. A thickness of 92 feet is tentatively identified as belonging to this member in a coal test boring in the SE¼ NE¼ sec. 6, T. 7 N., R. 7 E., (about half a mile east of the Glasford quadrangle) where its base is lower than the Springfield (No. 5) coal, and it probably cuts out the entire St. David cyclothem. Through most of the Glasford quadrangle and east of Cuba in the Havana and Canton quadrangles, the sandstone ranges from about 30 to 80 feet thick and varies inversely with the underlying St. David beds. In the vicinity of Cuba, especially in secs. 8, 19 to 21, and 30, T. 6 N., R. 3 E., Havana quadrangle, the sandstone is less than 5 feet thick (fig. 43) and is locally absent, even where its base is only 3 to 6 feet above No. 5 coal.

The sandstone is commonly light brownish gray and spotted with bright brown specks. It is commonly thin-bedded and shaly in the upper part, the beds thickening downward. At many places in the north part of the Havana quadrangle the sandstone is very evenly bedded in beds 1 to 3 inches thick, the whole structure suggesting a pile of boards.

In channel facies the bedding is less uniform, and massive zones, strongly cross-bedded zones, or shaly zones are found. This variability is comparable with that observed in the channel deposits of the Pleasantview sandstone. In some channels more than half of the material is shaly, as reported in numerous coal test borings and observed in outcrops in the west half of the Glasford quadrangle. Some beds are ripple-marked.

The texture of the sandstone is fine-grained to very fine-grained, the channel deposits on the average are coarser and more poorly sorted than the nonchannel deposits, as shown in the following analyses (Willman, 1928):

	Channel sandstone, 1 sample *Percent*	Nonchannel sandstone, average of 4 samples *Percent*
Fine sand	36	0
Very fine sand	35	35
Silt	14	46
Clay and cement	15	19

The sandstone consists principally of angular quartz grains, some of which show secondary enlargement. Mica is abundant and feldspar common. The sandstone contains a relatively small amount of carbonaceous matter as compared to the Pleasantview sandstone. Zircon exceeds tourmaline by approximately 2:1, and garnet totals 4 percent of the heavy mineral grains. The sandstone is weakly cemented with calcium carbonate, and near the top contains calcareous concretions as large as 2 by 6 by 10 feet, similar to those in the upper part of the Pleasantview sandstone. At several places thin seams of bright coal up to 4 inches thick are found in the basal 1 foot of the channel sandstone.

The unconformity at the base of the sandstone is very marked.

Fossil casts of *Calamites* and *Sigillaria* are found in the basal parts of the channel sandstone at some places and leaf impressions are found in sandy shale that probably belongs to this member in the NE¼ NE¼ sec. 21, T. 7 N., R. 5 E., Glasford quadrangle.

The Cuba sandstone is well exposed in western Illinois, is especially prominent in the Peoria region, and is equivalent to the Vermilionville sandstone in northern Illinois. It is absent along the west side of the coal basin from this area south about 150 miles to southern Illinois, where it is again present. It is also present in western Indiana, but seems to be more prominent in northern Illinois than elsewhere in the Eastern Interior coal basin.

Geologic sections 16, 17, 19, 20, 39, 42, 44.

Limestone (Member 108)

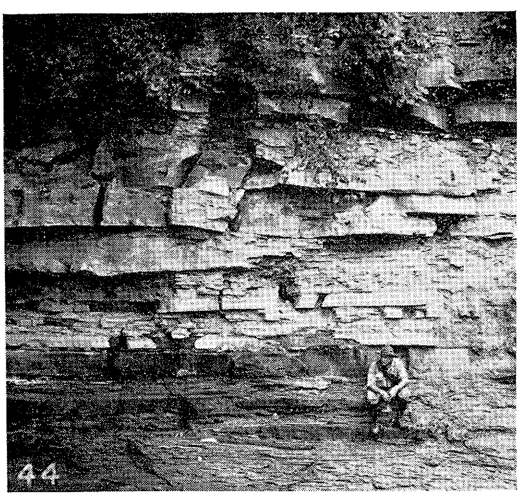
A marine limestone overlies the Cuba sandstone at only one place, a ravine just east of Cuba in the N½ NW¼ sec. 21, T. 6 N., R. 3 E., Havana quadrangle (geol. sec. 19). The limestone is medium to dark gray, weathers brown, and is dense. It is 4 to 6 inches thick, and occurs as a single massive bed. A sample is 86 percent soluble in hydrochloric acid, and the insoluble residue consists of 9 percent clay, 3 percent silt, and 2 percent coarser residue that is mainly small quartz grains, crystals of selenite, flakes of muscovite, and small pyrite crystals. The limestone contains abundant *Linoproductus* and several other species, mostly brachiopods. It is separated from the Cuba sandstone by 4 inches of soft gray shale. This limestone occupies the position of the Higginsville limestone of Iowa and Missouri.

Geologic section 19.

Big Creek Shale (Member 109)

The Big Creek shale is named (Savage, 1927, p. 309) from outcrops along Big Creek in T. 7 N., R. 4 E., Fulton County, Canton quadrangle.

The shale is 10 to 30 feet thick in outcrops and coal test borings in the Glasford quadrangle, but was found in only one out-



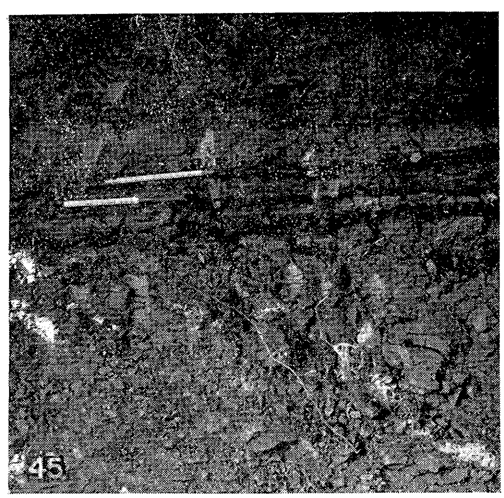


FIG. 43.—Type section of Brereton cyclothem showing Herrin (No. 6) coal overlain by thin Brereton limestone and Sheffield shale, and underlain by underclay, a thin shaly facies of the Cuba sandstone and Canton shale at the base, along Middle Branch of Copperas Creek, in the NE ¼ SE ¼ NE ¼ sec. 1, T. 7 N., R. 4 E., Glasford quadrangle. Geologic section 16.

FIG. 44.—About 30 feet of Cuba sandstone along the Middle Branch of Copperas Creek, just south of center of the NE ¼ sec. 17, T. 7 N., R. 5 E., Glasford quadrangle.

FIG. 45.—Herrin (No. 6) coal thinned to three streaks of black clay separated by the blue-band clay parting (marked by the pencils) and the lower clay parting, near Pleasantview, in the NE ¼ NW ¼ sec. 26, T. 2 N., R. 1 W., Beardstown quadrangle. Geologic section 3.

crop in the Havana quadrangle, where it is 11 feet thick. As the upper part of the underlying Cuba sandstone is commonly shaly, the boundary between it and the Big Creek shale is indefinite at many places. The shale is gray, soft, and locally slightly sandy. No fossils were observed in it.

Geologic sections 18, 19, 44.

Underclay Limestone (Member 110)

The underclay limestone consists of scattered concretions of light gray dense locally septarian limestone in the lower part of the underclay. No concretions were found at numerous outcrops. Concretions up to 4 feet thick and 25 feet long are reported in secs. 25, 26, and 36, T. 9 N., R. 6 E., in the northeast part of the Glasford quadrangle. No fossils were found in this member.

Geologic sections 3, 4, 19, 44.

Underclay (Member 111)

The underclay of coal No. 6 is a continuous bed 2 feet 6 inches to 7 feet thick (fig. 43). In most respects it resembles the underclays of the area. The upper 1 foot 6 inches to 2 feet is commonly noncalcareous, but the lower part is calcareous and contains small nodules of limestone. At an outcrop just north of the Havana quadrangle (geol. sec. 44), the underclay is divided 13 inches below the coal by 3 feet 10 inches of dark gray finely laminated shale with leaf and stem impressions.

Geologic sections 3, 4, 16, 18, 19, 44.

Herrin (No. 6) Coal (Member 112)

The number 6 was applied to this coal by Worthen (1870, p. 93) from outcrops in Fulton County, and it was later given the name Herrin (Shaw and Savage, 1912) for the bed that has been extensively mined near Herrin, Williamson County, in southern Illinois.

This coal is mined more extensively than any other coal in Illinois. It is characterized throughout Illinois by partings of blue-gray clay ¼ inch to 3 inches thick. The thickest of these bands is known as the "blue band," and the coal is sometimes called the "blue-band coal."

Information about this coal is derived from 125 outcrops or mine workings in the Glasford quadrangle, 105 coal test borings in or closely adjacent to the Glasford quadrangle, and six outcrops and four coal test borings near Cuba in the Havana quadrangle. The horizon of the coal is also exposed near Pleasantview in the Beardstown quadrangle, but the coal is absent in that vicinity. The coal ranges from less than 2 feet to 5 feet 10 inches thick and averages 4 feet to 4 feet 6 inches.

The coal is characterized by three partings of gray clay. The upper averages ¼ inch thick and is 1 foot 7 inches below the top of the coal, the middle or blue band is 2 to 3 inches thick and 2 feet 6 inches below the top, and the lower is ½ to 1 inch thick and 3 feet 5 inches below the top. (fig. 43). The clay shows a pellet-like structure, with darker pellets surrounded by lighter gray clay (Allen, 1932).

A detailed section in the Pleasantview outlier (geol. sec. 4) shows that the blue band and lower clay parting persist outside the actual area of coal deposition (fig. 45). The same relation has been observed near Mt. Sterling, Brown County, in St. Louis and Montgomery counties, Missouri, in Warrick County, Indiana, and in the Labette shale in Kansas. These partings are probably the thinnest persistent strata in the Pennsylvanian section of Illinois. It has been suggested that they might be bentonite, resulting from falls of volcanic ash during coal deposition, but relict structures of volcanic glass have not been discovered by microscopic examination, so this suggestion has not been confirmed.

Small pyrite concretions are present in the coal, a few of the outcrops showing a discontinuous pyrite band about half way between the blue-band and the lower clay parting. Outcrops near Cuba show black siliceous concretions, as large as 3 feet 6 inches wide, on the top of the coal, some of which extend down 8 inches into the coal.

The No. 6 coal is most readily correlated by its persistent partings of clay, which make it one of the most useful key beds in the central United States. It is correlated with the Streator coal of northern Illinois, the Second Vein coal of the LaSalle region, the Belleville coal of St. Clair County, Illinois, the Herrin coal of southern Illinois, the Mystic coal of southern Iowa, the Lexington coal of Missouri, coal No. 11 of western Kentucky, and probably with the No. VI coal of Indiana, all of which have the characteristic partings. The Middle Kittanning coal of Ohio has a persistent series of three clay partings, and may be equivalent to the Herrin (No. 6) coal.

Geologic sections 3, 4, 16, 18, 19, 44.

SANDY CLAY—WHITE-TOP (MEMBER 113)

In west-central Illinois, a discontinuous deposit of light gray sandy micaceous clay, sandy shale, or calcareous sandstone, called "white-top," locally replaces the upper part of the coal and very locally the entire coal. The white-top also projects into the coal along vertical joints and bedding planes. It has sharp contacts with the coal, both at its base and in joints in the coal, and the adjacent coal does not have a higher ash content than other parts of the coal.

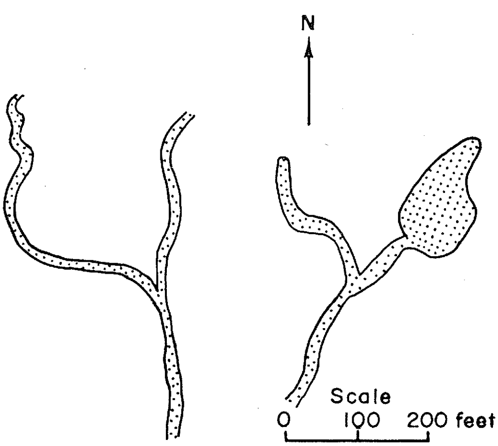


FIG. 46.—Distribution of "white top" on the Herrin (No. 6) coal in a part of the strip mine of the Midland Electric Coal Company, in the NE ¼ sec. 7, T. 8 N., R. 3 E., Canton quadrangle. Adapted from a company map.

The white-top underlies the Brereton limestone but is not seen in the same outcrop as the Brereton black shale (member 114). It is believed to be older, as the black shale is a marine sediment, and the white-top, like the coal beneath, is probably nonmarine. The white-top in places resembles the clay horsebacks found in the Springfield (No. 5) coal, but it occurs in broader belts and is more sandy than the horsebacks.

The white-top is well exposed in the large strip mine of the Midland Electric coal company in sec. 1, T. 8 N., R. 3 E., about five miles west of the Glasford quadrangle (fig. 46). It commonly occurs in winding linear belts that on the average are about 25 feet wide and cut about 2 feet into the coal. One of the larger areas is oval and 150 by 75 feet in dimension. The linear areas bear some resemblance in pattern to winding stream channels.

Geologic section 16.

DARK SHALE (MEMBER 114)

The dark shale overlying coal No. 6 ranges from 3 or 4 inches to 2 feet 6 inches thick. Thinning is related to the Brereton limestone, which seems to replace the upper part of the shale, and the white-top, which replaces the lower part. The shale is commonly dark gray or greenish gray and soft, but at some exposures its lower part is black, hard, and sheety, like the roof shale of the Springfield (No. 5) coal. Where soft and greenish gray, it is commonly nonfossiliferous, but where it is hard and black it may contain the typical black shale fauna, such as *Lingula, Orbiculoidea, Dunbarella* and conodonts.

In some outcrops the shale contains ironstone or dark gray limestone concretions resembling those over the Summum (No. 4) and Springfield (No. 5) coals. The concretions contain a few fossils. Near Pleasantview a calcareous greenish-gray shale with a marine brachiopod assemblage is present at this horizon.

Geologic sections 3, 4, 16, 18, 44.

BRERETON LIMESTONE (MEMBER 115)

The Brereton limestone was observed in 90 outcrops in various parts of the Glasford quadrangle (fig. 43). It is discontinuous at many places but is not uniformly absent in any area where its horizon is exposed. It is commonly resistant to erosion and forms ledges or small waterfalls at many places. It is the highest Pennsylvanian unit in the Havana quadrangle, showing in three outcrops in secs. 19 and 20, T. 6 N., R. 3 E.

It also was found in three outcrops near Pleasantview in the Beardstown quadrangle.

The limestone averages 1 foot thick in the Beardstown quadrangle, 2 feet in the Havana, and about 3 feet in the Glasford where it has a maximum thickness of 4 feet 3 inches. At many exposures it may be observed to thin from 3 or 4 feet to less than 1 foot within a few hundred feet.

The limestone commonly forms two benches separated by 1 or 2 inches of calcareous shale. The upper bench is more massive and forms about three-fourths of the member. The limestone is light to medium gray, weathers buff, and is dense to slightly crystalline. It contains small calcitic veinlets and at places rounded nodules or pebbles of black phosphatic limestone. Its upper and lower surfaces are both somewhat uneven, and at one exposure the upper surface shows crude ripples 6 inches high and 1 foot between crests.

A sample is 92 percent soluble in hydrochloric acid and contains 3 percent clay, 5 percent silt, and half a percent coarser material that is largely small pyrite crystals, rounded to subangular grains of quartz, and hardened aggregates of ferruginous clay. The variation in composition and structure of the insoluble residue of the Brereton limestone was studied by Cohee (1932).

The Brereton limestone has long been known in Illinois as the *Fusulina* limestone, and it probably contains fusulinids, especially *Fusulina girtyi,* more generally than any other Pennsylvanian limestone. In addition, other minute fossils, including two or three kinds of foraminifera, and the brachiopod *Phricodothyris perplexa* are the most characteristic.

The Brereton limestone is recognized in all parts of the Eastern Interior coal basin. It is called the Herrin limestone in southern Illinois and the Providence limestone in western Kentucky. It has not been named in Indiana, though it is present at many places. It is the caprock of the Mystic coal of Iowa and the Lexington coal of Missouri, where it is named the Myrick Station limestone.

Geologic sections 3, 12, 16, 18, 44.

Calcareous Shale (Member 116)

Calcareous shale overlies the Brereton limestone at only a few outcrops in the Glasford quadrangle. It is yellowish gray or olive green, calcareous, and 6 to 18 inches thick. Numerous fossil shells weather out, including common brachiopods, horn corals, and crinoid stems. It resembles the calcareous shale above the St. David limestone.

Geologic section 16.

Sheffield Shale (Member 117)

The Sheffield shale is named herein for exposures near Sheffield, near the center of sec. 24, T. 16 N., R. 6 E., Bureau County, where it is used in the manufacture of brick. The name Copperas Creek was used by Savage for this member and the overlying sandstone, but the name has been restricted to the sandstone.

The Sheffield shale is widespread in the Glasford quadrangle, though it is cut out at some localities by channel deposits of the Copperas Creek sandstone. It also was found at two outcrops near Pleasantview in the Beardstown quadrangle.

The shale has a maximum thickness of 22 feet and averages 8 or 10 feet thick. It is only 4 feet thick in the Beardstown quadrangle. It varies in thickness because it was truncated by the overlying Copperas Creek sandstone.

The shale is light gray, with brownish, olive, or bluish cast. It is commonly more sandy than the Canton or Purington shales, which it otherwise resembles. It contains small ironstone concretions at some localities. No fossils were found in it.

Geologic sections 3, 16.

POKEBERRY CYCLOTHEM

The Pokeberry cyclothem is restricted to a small area in the Beardstown quadrangle where it consists of a discontinuous basal sandstone and more widespread limestone and calcareous shale. It is named herein from outcrops about a mile east of Pokeberry school in sec. 26, T. 2 N., R. 1 W., Beardstown quadrangle (geol. sec. 3). The name has been used in other reports without being defined. The Pokeberry is believed to be equivalent to the Jamestown cyclothem of southwestern Illinois, which has similar relations to the Brereton cyclothem below. The Pokeberry and Jamestown limestones are similar in appearance and in fauna. The Pokeberry cyclothem ranges from 11 to 17 feet thick.

Geologic sections 3, 4.

Sandstone (Member 118)

The sandstone is 5 to 6 feet thick at the type exposure, but is absent in another branch of the same ravine. It is quite strongly calcareous and forms a waterfall at the type locality.

Geologic sections 3, 4.

Calcareous Shale and Pokeberry Limestone (Members 119 and 120)

The Pokeberry limestone (member 120) and underlying calcareous shale (member 119) are limited to secs. 22, 23, 25, 26, and 35, T. 2 N., R. 1 W., Beardstown quadrangle. The Pokeberry limestone is hard and forms ledges along the streams. It is commonly a solid bed 1 foot 6 inches to 2 feet thick. The limestone overlies green calcareous shale or clay that contains nodules or bands of limestone. The shale interval is 2 feet 6 inches to 3 feet thick.

The limestone is blue gray to greenish gray and iron-stained along joints. It is hard and dense and in some exposures has a conglomeratic or brecciated structure. It is not well bedded and has a very knobby upper surface. Current-ripple marks, 2½ to 3 inches from crest to crest and ¼ inch high, were found at one outcrop. This limestone resembles the Seahorne rather strikingly in lithology, structure, and weathering appearance.

The limestone contains abundant large and well preserved fossils, mostly brachiopods. *Dictyoclostus portlockianus* is especially abundant and characteristic. A large and robust fusulinid also is present. The limestone is tentatively correlated with the Jamestown limestone, which, like it, contains abundant large productid shells.

Geologic sections 3 (member 119); 3, 4 (member 120).

McLeansboro Group

The McLeansboro group in this area consists of the Sparland, Gimlet, Exline, and Trivoli cyclothems. It was named (DeWolf, 1910, p. 181) from McLeansboro, Hamilton County, Illinois, near which a deep core drilling revealed a good section of the Upper Pennsylvanian beds. The McLeansboro was originally defined as a formation consisting of all Pennsylvanian beds above the top of the Herrin (No. 6) coal in Illinois. After the Pennsylvanian sequence was reclassified on the basis of cyclothems, the McLeansboro was made a group and the boundary was changed to the base of the Sparland cyclothem. This group is approximately equivalent to the Conemaugh formation of the Appalachian coal field, but may also include some of the Upper Allegheny. It includes the upper part of the Des Moines series and the Missouri series of the Midcontinent region. The boundary between these series is probably at the base of the Trivoli cyclothem.

SPARLAND CYCLOTHEM

The Sparland cyclothem has a prominent basal sandstone, the Copperas Creek sandstone, and a widespread coal, No. 7. It is without limestone in most outcrops, but locally has an underclay limestone and a very thin impure marine limestone below the black shale.

The Sparland cyclothem is named (Wanless, 1931a, p. 182, 192), for exposures on Thenius Creek, about one and a half miles north of Sparland, in sec. 2, T. 12 N., R. 9 E., Marshall County.

The Sparland cyclothem is widespread in the Glasford quadrangle, especially the north half of the quadrangle (pl. 5). It includes the youngest Pennsylvanian strata in the Beardstown quadrangle, near Pleasantview. It and higher Pennsylvanian beds have been completely eroded from the Havana and Vermont quadrangles.

The Sparland cyclothem ranges from about 8 to about 80 feet thick. In the outlier near Pleasantview, the maximum thickness is 31 feet. The variation in thickness is due to unconformities at both top and bottom.

Geologic sections 3-5, 8, 10, 12, 14, 16.

Copperas Creek Sandstone (Member 121)

The Copperas Creek sandstone is named (Savage, 1927, p. 309) for exposures along Copperas Creek, probably in the Glasford quadrangle. A specific type locality was not designated.

The sandstone crops out in the north and east parts of the Glasford quadrangle. It is commonly massive, well indurated, and forms waterfalls or ledges at many places. It is 3 to 27 feet thick and is thickest where it cuts out the Sheffield shale, Brereton limestone, and dark shale and rests directly on the Herrin (No. 6) coal. It averages about 10 feet thick.

The sandstone is light olive green to brownish gray, commonly has brown limonitic specks, is massive to shaly, and is less commonly cross-bedded than the Cuba sandstone. It is quite strongly calcareous and in places is almost a sandy limestone. It is strongly micaceous, and the quartz grains are largely angular. A sample contains 22 percent silt and clay, 78 percent sand, and 0.1 percent heavy minerals. About 10 percent of the sand grains are feldspar. The heavy minerals are tourmaline, zircon, and garnet in about the ratio of 2:1:1. Most of the heavy mineral grains are angular and subrounded.

The Copperas Creek sandstone has channel and nonchannel phases similar to those of the Pleasantview and Cuba sandstones. The channels seem to be cut less deeply and are not known to cut through the Herrin (No. 6) coal. The Copperas Creek sandstone is correlated with the Anvil Rock sandstone in southern Illinois, Indiana, and western Kentucky.

Geologic sections 12, 16.

Shale (Member 122)

The shale overlying the Copperas Creek sandstone is known principally in the north and east parts of the Glasford quadrangle, where it consists of 8 to 30 feet of shale that is red, or mottled gray, blue green, and red. It underlies the Sparland underclay without marked break in most outcrops, and cannot be sharply separated from that member. Its characteristics and relations to associated beds are well shown along a ravine tributary to Warsaw Run in the SW¼ sec. 28, T. 9 N., R. 6 E., Peoria County, Glasford quadrangle. Savage referred to this member as the Ralls Ford shale but recent field studies seem to show that the fossiliferous shale at that locality is above, not below, the No. 7 coal.

Underclay Limestone (Member 123)

The underclay limestone member consists of comparatively small concretions of brownish-gray silty limestone in the lower part of the Sparland underclay. The zone of concretions is commonly a few inches thick but locally is about 1 foot thick. The concretions were not found at about two-thirds of the outcrops of the underclay.

Geologic sections 3, 16.

Underclay (Member 124)

The underclay of the Sparland (No. 7) coal is 4 to 12 feet thick and averages 10 feet. The upper 1 foot 6 inches to 2 feet 6 inches is noncalcareous, and the lower part is calcareous. In the east part of the Glasford quadrangle and the adjacent part of the Peoria quadrangle, the clay rests on and apparently grades into red shale and the two units together are 15 to 30 feet thick. At some outcrops the uppermost 1 foot of the underclay is laminated, shaly, and contains bands or thin streaks of bright coal, probably derived from carbonized roots.

Geologic sections 3, 4, 14, 16.

Sparland (No. 7) Coal (Member 125)

Number 7 was applied to this coal (Worthen, 1870, p. 93) from outcrops in Fulton County, probably in the Glasford or Canton quadrangles. It is named for the town of Sparland in Marshall County where it has been mined.

This coal is widespread in the north half of the Glasford quadrangle (fig. 47) except locally where black carbonaceous shale occurs at its horizon. The coal is represented by a coaly streak or a coal 1 to 4 inches thick in the outlier near Pleasantview. The coal is about 1 foot to 2 feet 6 inches thick in the Glasford quadrangle and averages 1 foot 6 inches in 70 outcrops and 60 coal test borings. It is generally without partings, but contains a parting of clay ½ inch to 1½ inches thick at a few outcrops. At an exposure in the NW¼ sec. 20, T. 8 N., R. 6 E., Glasford quadrangle, a thin fossiliferous limestone bed occurs in the top of the coal and the coal extends into lamination planes in the limestone. A few horsebacks have been found in this bed, but they are uncommon. At an exposure in the SW¼ NW¼ sec. 34, T. 8 N., R. 6 E., Glasford quadrangle, the coal is cut out by the Gimlet sandstone.

The Sparland (No. 7) coal is correlated with the Danville (No. 7) coal of eastern Illinois, the No. VII coal of Vermillion, Vigo, Sullivan, Greene and Knox counties, Indiana, and probably with coal No. 14 of western Kentucky. It is generally absent or unimportant in Missouri, Kansas, and Iowa. It may be equivalent to the Upper Freeport coal in Ohio, Pennsylvania, and West Virginia.

Geologic sections 3, 4, 14.

Limestone (Member 126)

A limestone overlies the Sparland (No. 7) coal at only about eight places in the Glasford quadrangle. It is discontinuous at all these places and has a maximum thickness of about 8 inches. It varies from a bed or lens of fairly hard limestone to a very calcareous, slightly indurated shale. It is dark gray to nearly black, argillaceous, carbonaceous, and pyritiferous. It contains abundant fossils, poorly preserved plant traces, and bits of coal. *Chonetes granulifer* is the most common fossil.

Geologic section 14.

Dark Gray and Black Shale (Members 127 and 128)

Dark to black shale is present above the No. 7 coal at all places where the coal is exposed, but in some coal test borings the overlying gray Farmington shale is reported to be directly on the coal. The dark shale is commonly 1 foot 6 inches to 2 feet thick and consists of a lower portion that is very dark gray and soft (member 127) and an upper part that is hard, black, and sheety (member 128) (fig. 47).

The lower part of the shale is generally fossiliferous and commonly contains light to medium gray limestone concretions about the size and shape of hazel nuts. Such concretions are found in both the Glasford and Beardstown quadrangles. The upper part of the shale is commonly black and sheety with *Orbiculoidea,* conodonts, and other black shale fossils. In one exposure brachiopod shells retain their original color markings. Small pyritic or calcareous concretions are found in the black sheety shale at a few places, but typical large concretions, like those over coals Nos. 2, 4, and 5, were not found. In a few outcrops dark calcareous fossiliferous shale a few inches thick overlies the hard sheety shale.

Geologic sections 3, 14, 16.

Red Shale (Member 129)

Red shale 3 to 5 feet thick is present in all outcrops of the Sparland cyclothem in the outlier near Pleasantview, in secs. 22, 26, 35, and 36, T. 2 N., R. 1 W., Beardstown quadrangle. It is not present in the Glasford quadrangle. The shale is soft, clayey, and red, and its base is 1½ to 3 feet above the horizon of coal No. 7. No fossils were observed in it. It may be a local phase of the lower Farmington shale.

Geologic sections 3, 4, 5.

Farmington Shale (Member 130)

The Farmington shale is named (Savage, 1927, p. 309) for exposures in Farmington township, T. 9 N., R. 4 E., in the Canton and Glasford quadrangles.

This shale is widely present in the Glasford quadrangle (figs. 47, 65) although it is entirely cut out by the Gimlet sandstone at a few localities. It has a maximum thickness of 50 feet. It is the highest Pennsylvanian member in the Beardstown quadrangle, where a maximum of 15 to 25 feet is found.

The shale is gray to olive green and commonly contains gray ironstone concretions up to 2 inches thick by 1 foot in maximum diameter. They are commonly flattened ovoids but locally have irregular or crenulated edges. Some of the larger concretions have hemispherical pits as large as 3 inches deep and 6 inches in diameter. In the Beardstown quadrangle the concretions are irregularly shaped and consist of limestone instead of ironstone. This shale resembles the Purington and Canton shales, but the concretions are larger. A few marine fossils are found in the lower part of the shale.

Geologic sections 3-5, 8, 10, 14, 16.

GIMLET CYCLOTHEM

The Gimlet cyclothem includes a sandstone, underclay, coal, "middle" limestone, black shale, "upper" limestone (Lonsdale), and upper shale, with an additional limestone and black shale above the "upper" limestone. All the members of this cyclothem are discontinuous, but the most widespread and most variable member is the Lonsdale limestone, which locally cuts through part or all of the lower members of the cyclothem and the upper part of the Sparland cyclothem.

The Gimlet cyclothem is named (Wanless, 1931a, p. 182, 192) for an exposure on Gimlet Creek in the SE¼ sec. 16, T. 12 N., R. 9 E., Marshall County. The Gimlet cyclothem crops out in this area only in the north part of the Glasford quadrangle (pls. 2, 5). The Lonsdale limestone member is very resistant to erosion, and forms waterfalls, ledges, or bluffs along streams.

The composite thickness of the members is 85 feet, but because of the variability and discontinuity of all the members the maximum thickness of the cyclothem is only 69 feet. The minimum thickness is probably 15 to 20 feet.

The Gimlet cyclothem is separated from the Sparland and Trivoli cyclothems by erosional unconformities, and other erosional breaks seem to occur above and below the Lonsdale limestone, which in many places is a conglomerate.

The Gimlet cyclothem is correlated throughout northern and western Illinois by the peculiar and distinctive lithology and fauna of the Lonsdale limestone.

Geologic sections 8-13, 15.

Gimlet Sandstone (Member 131)

The Gimlet sandstone has a maximum thickness of 50 to 60 feet in the NW¼ sec. 12, T. 8 N., R. 6 E., Glasford quadrangle, but is locally absent in some localities where higher Gimlet beds rest on the Farmington shale. The sandstone fills channels that cut from 50 feet above coal No. 7 to about 5 feet above the Brereton limestone.

The sandstone is commonly light to brownish gray, or gray with rusty spots, fine- to medium-grained, micaceous, and cross-bedded or evenly bedded. It contains coal lenses or masses at places, and coalified impressions of logs are found in the more massive beds. In one outcrop prominent and symmetrical ripple marks, 4 inches from crest to crest, trend N. 10° E. Discoidal or log-like calcareous concretions also are present. Where more than 10 feet thick it resembles the Copperas Creek and Cuba sandstones.

Geologic sections 8-13, 15.

Underclay and Lower Shale (Members 132 and 133)

The underclay and lower shale members were found at only nine outcrops, being cut out elsewhere by unconformities. They are 4 inches to 16 feet thick. A typical underclay (member 132) is found at only three places. Elsewhere the underclay is replaced by a poorly bedded shale (member 133) that is lavender, blue gray, or brick red. At some places this shale rests directly on the Farmington shale, and is not easily separated from it. A few inches of finely laminated carbonaceous shale with plant stem impressions and thin streaks of bright coal occurs at the top of the underclay.

Geologic sections 10 (member 132); 13 (member 133).

Gimlet Coal (Member 134)

The Gimlet coal is very discontinuous and was found in only three outcrops and one coal test boring. It is 2 to 7 inches thick in the outcrops and 1 foot thick in the boring.

Geologic section 13.

Limestone and Shale (Members 135 and 136)

The shale (member 136) overlying the Gimlet coal is light to medium gray, soft, and contains spheroidal concretions of light blue-gray limestone. It is commonly about 5 feet thick.

The shale is overlain by limestone (member 135) that ranges from a bed 1 foot thick to a discontinuous band of concretions in shale and has been found at only ten exposures. The limestone is dark gray to nearly black and dense to subcrystalline. It is slightly fossiliferous and contains brachiopods and crinoid stems. The concretions are discoidal to flattened, the largest 3 by 4 by 42 inches. At one exposure in sec. 26, T. 8 N., R. 6 E., Glasford quadrangle, the concretions underlie the limestone band and are separated from it by 6 inches of dark shale.

Geologic sections 8, 10, 11, 13, 15 (member 135); 10, 13 (member 136).

Dark Shales (Members 137 and 138)

The dark shales of the Gimlet cyclothem consist of 3 to 14 feet of carbonaceous shale, averaging about 6 feet thick. The lower few inches is commonly dark blue-gray calcareous fossiliferous shale (member 137). The upper and larger part is commonly black, varying from soft to hard and sheety (member 138). Indistinct plant traces were seen at some places and *Dunbarella* and a few other pelecypods were seen at one place. This shale in places abruptly underlies the Lonsdale limestone and in others grades up into lighter gray shale with light gray limestone concretions.

Geologic sections 10, 13.

Lonsdale Limestone and Shale (Members 139 and 140)

The Lonsdale limestone is named (Udden, 1912, p. 38-40) for exposures in the old Lonsdale quarries, in the N½ sec. 6, T. 8 N., R. 7 E., Peoria County, Glasford and Peoria quadrangles (geol. sec. 15). The limestone is distributed principally along the ridge in the north part of the Glasford quadrangle (fig. 66). It is found in about 90 different places in the quadrangle and the exposures extend eastward into the Peoria quadrangle. At many places the small streams draining north or south from the ridge flow in the limestone for a little distance then drop over it in a waterfall.

The Lonsdale is unusual in that it has locally at its base prominent channels similar to those at the base of the sandstones. The Lonsdale limestone normally is about 60 to 70 feet above the No. 7 coal, but locally this

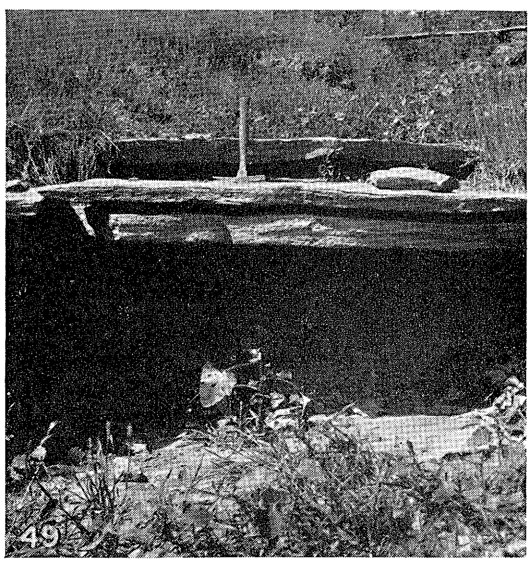


FIG. 47.—Sparland (No. 7) coal overlain by dark shale and gray Farmington shale and underlain by underclay along Tiber Creek, near the southeast corner of the NW ¼ SE ¼ SW ¼ sec. 2, T. 7 N., R. 5 E., Glasford quadrangle.

FIG. 48.—Nodular Lonsdale limestone along ravine southwest of Trivoli, in the SW ¼ NE ¼ SW ¼ sec. 15, T. 8 N., R. 5 E., Glasford quadrangle.

FIG. 49.—Black plant-bearing Exline limestone southwest of Smithville, in small gully in the SW ¼ SW ¼ sec. 22, T. 8 N., R. 6 E., Glasford quadrangle.

interval is decreased to 5 feet or less, and at one place the base of the limestone is only about 20 feet above the Herrin (No. 6) coal and is probably below the level of No. 7 coal.

In places the Lonsdale limestone (member 140) is separated from the black shale below by as much as 1 foot of gray shale (member 139) that contains limestone nodules. The limestone averages 6 to 8 feet thick but has a maximum thickness of about 25 feet, and is only 2 or 3 feet thick at some places.

Where the Lonsdale limestone is several feet thick, it commonly consists of two parts. The lower part is dense to slightly crystalline, massive to thick-bedded, well jointed, fossiliferous, and 3 to 7 feet thick.

The upper part of the limestone generally is composed of nodules of light gray or mottled light and medium gray fairly pure limestone cemented with medium gray limestone (fig. 48). The rock appears conglomeratic or brecciated. Elsewhere the nodules are embedded in greenish- or yellowish-gray calcareous clay. Fossils are more common in this member than in the lower and occur in both nodules and clay. A marl-like facies at one locality is composed mostly of fusulinids and crinoid stem segments loosely cemented together.

Where the limestone cuts through underlying members of the Gimlet and Sparland cyclothems, it varies more in lithology and includes beds of limestone conglomerate. The conglomerate consists of somewhat rounded limestone pebbles or concretions interbedded with calcareous sandstone that resembles the Gimlet sandstone. Fossils also are present in the conglomerate.

The Lonsdale limestone has a large and diversified fauna that includes 143 listed species (Waldo, 1928). The more massive limestone contains only a few species, but the nodules at a few localities contain an unusually large variety of forms, many of which are not known in any other member in this area.

The nodules have been considered algal deposits by some, but definite proof has not been found. The limestone is probably a clearer water facies than such beds as the Brereton or St. David limestone. The fauna bears some resemblance to that of the Seahorne limestone, in that each contains a variety of gastropods. The fauna includes 3 foraminifera, 4 corals, 14 crinoids (mostly different kinds of stems), 4 echinoids, 1 worm, 9 bryozoa, 35 brachiopods, 19 pelecypods, 38 gastropods, 7 cephalopods, 4 trilobites, 1 ostracode, and 4 kinds of fish remains. Silicified wood in large masses also is found at several outcrops.

Schizophoria resupinoides, Mesolobus (new species), *Rhynchopora illinoisensis, Baylea adamsi* and *Gosseletina spironema* have not been found in higher Pennsylvanian strata and *Conocardium missouriensis, Lophophyllidium distortum, Goniasma lasallensis, Euconospira turbiniformis* and *Rhipidomella carbonaria* are not known in beds older than the Lonsdale limestone. The gastropods *Porcellia gillanus* and *Strophostylus peoriensis* are known only from this bed. Masses of marly limestone in calcareous shale below the main limestone at two outcrops consist almost wholly of loosely cemented fusulinids of the following species: *Fusulina acme* (most common), *F. lonsdalensis, F. megista, F. mysticensis* and *F. eximia*.

The Lonsdale limestone is correlated with the Madisonville limestone (in part) of western Kentucky, the West Franklin limestone of southern Indiana, and the Cooper Creek limestone of Appanoose County, Iowa. It is thus one of the extensive Pennsylvanian limestones of the eastern United States.

Geologic sections 10, 13 (member 139); 8-13, 15 (member 140).

EXLINE CYCLOTHEM

The Exline cyclothem has no basal sandstone although the basal strata rest unconformably on the Lonsdale limestone of the Gimlet cyclothem. The cyclothem consists of a poorly developed underclay, a thin coal streak, a black shale, an unusual type of black limestone in which plant remains are more common than animal fossils, and a thick upper marine shale.

The Exline cyclothem is named for Exline, Appanoose County, Iowa, near which it is well exposed (Cline, 1941, p. 65-66). The strata here referred to the Exline cyclothem were formerly included in the upper part of the Gimlet cyclothem.

The Exline cyclothem occurs only in the north part of the Glasford quadrangle (pl. 5). The cyclothem is about 40 feet thick but its thickness varies because of unconformities that separate it from the Gimlet cyclothem below and the Trivoli cyclothem above.

The Exline cyclothem includes strata equivalent to the youngest strata of the Des Moines series in the Midcontinent region. An important faunal and floral break separates it from the overlying Trivoli cyclothem, which is equivalent to the basal beds of the Missouri series. The Exline limestone corresponds in part with the Lenapah limestone of Kansas. It is also correlated with the Brouillett cyclothem of the Wabash Valley in eastern Illinois and western Indiana, and probably with the upper portion of the West Franklin limestone of southern Indiana and the Madisonville limestone of western Kentucky.

Geologic sections 8, 9, 12, 15.

Shale and Underclay (Member 141)

Shale and underclay 1 to 30 feet thick in places separate the Lonsdale limestone from the Exline limestone. The shale is thickest near the center of the SW¼ sec. 27, T. 8 N., R. 6 E. It is commonly gray to dark gray and in places the upper part is nearly black. The darker shale is commonly finely laminated and locally contains plant stems, some of which form thin bands of bright coal. The lower part of the shale is lighter gray and in places is sandy. In some exposures it is poorly bedded and resembles underclay. A thin streak of coal separates the lower light shale or underclay from the upper dark shale at some outcrops. Marine fossils were found in nodules in the lower part, but these may belong to the Lonsdale limestone. The shale appears to be unconformable on the Lonsdale limestone.

Geologic sections 12, 15.

Exline Limestone and Shale (Member 142)

The Exline limestone and shale, fairly persistent along the drainage divide in the north part of the Glasford quadrangle, were seen at 35 outcrops. The member consists of black limestone locally overlain by black shale. The limestone is 3 inches to 2 feet 7 inches thick and is more persistent than the shale, which is 3 to 5 inches thick.

The limestone varies from dark gray to black, is evenly bedded or platy, and is very carbonaceous. In places it is divided into two or three benches separated by thin partings of shale (fig. 49). Nearly all of the insoluble residue is organic and floats in water. It is very black and contains some plant spores.

The limestone contains well preserved plant stems and leaves, associated with numerous impressions of *Spirorbis*. One or two marine pelecypods of the genus *Schizodus* were seen. The black shale is fairly hard and sheety, and contains *Cordaites* leaves and plant stems, but no marine fossils.

The limestone in places is several feet above the Lonsdale limestone, in others rests directly on it, and in an outcrop in the SW¼ NE¼ sec. 34, T. 9 N., R. 5 E., it rests on the Farmington shale, and all members of the Gimlet cyclothem are absent.

Similar limestone has not been found elsewhere in Illinois, but in Edgar County in eastern Illinois and in western Indiana the Brouillett coal occurs a few feet above the Lonsdale limestone, and its roof shale contains a thin marine limestone corresponding in age to this black limestone and associated beds. The Exline limestone in Iowa has a normal marine fauna, although it resembles the Exline in Illinois. The Exline limestone may be equivalent to the upper part of the West Franklin of Indiana and the Madisonville of Kentucky.

Geologic section 9.

Calcareous Shale (Member 143)

The calcareous shale above the Exline limestone was found in twelve exposures and is 3 to 25 feet thick. It is not sharply separated from the overlying noncalcareous shale and the same contact may not have been used in all places. The shale is calcareous, bluish to brownish gray, and soft. In places it contains scattered light gray limestone nodules like those in the Lonsdale limestone. In some exposures the middle or lower part contains medium to dark gray septarian limestone concretions 6 to 12 inches in diameter. They do not contain fossils.

In the shale, fossils are abundant and well preserved. The fauna is dominantly molluskan with such genera as *Astartella, Nuculopsis, Nucula, Euphemites, Glabrocingulum* and *Sphaerodoma* most abundant. Microfossils including ostracodes and foraminifera also are abundant (Bean, 1938). Fossils are especially common at an exposure in the SW¼ SE¼ sec. 34, T. 9 N., R. 5 E.

Geologic sections 8, 9, 12.

Gray Shale (Member 144)

The gray shale resembles the underlying shale but is not calcareous and does not contain abundant fossils. It has a maximum thickness of about 25 feet, is blue gray and well bedded, and contains some flattened oval clay ironstone concretions, and one or two bands of blue-gray fossiliferous limestone about 2 inches thick. It also contains some large limestone concretions without fossils, similar to those in the underlying calcareous shale. A few fossils are found in the shale, and the thin limestone bands contain abundant *Derbya*. The shale generally resembles the Farmington, Canton, and Purington shales.

Geologic sections 8, 9.

TRIVOLI CYCLOTHEM

The Trivoli cyclothem includes the highest Pennsylvanian and the highest bedrock strata in the four quadrangles. It is a typical cyclothem with a basal sandstone, underclay, limestone, underclay, coal, "middle" limestone, black shale, "upper" limestone, calcareous shale, and gray clay-shale.

The Trivoli cyclothem is named (Wanless, 1931a, p. 182, 192) for an exposure in a ravine near Trivoli northeast of the Pea Ridge School in the SW¼ sec. 3, T. 8 N., R. 5 E., Peoria County, Glasford quadrangle (geol. sec. 8).

The Trivoli cyclothem has a limited distribution along the drainage divide ridge in the north part of the Glasford quadrangle and is found only near Trivoli and Hanna City (pl. 5). It has a maximum thickness of about 37 feet at the type exposure, where the top is eroded.

The Trivoli cyclothem is the highest Pennsylvanian unit in western Illinois, but it is widespread in central, southern, and eastern Illinois.

Geologic sections 8, 9.

Trivoli Sandstone (Member 145)

The Trivoli sandstone is more widely distributed than other members of the cyclothem and was seen in 15 outcrops. It is 3 to 18 feet thick but is usually more than 10 feet thick.

The sandstone is commonly light gray or blue gray, has rusty spots and is medium- to fine-grained, thin- to medium-bedded, and micaceous. Calcareous sandstone concretions occur in the upper part in one exposure, and carbonaceous matter is present on the bedding planes in some exposures. Generally the lower part of the sandstone grades without very marked break into the underlying Gimlet gray shale, but locally it cuts down through this shale to rest on the black limestone. In such places the sandstone is somewhat more massive and resembles other channel sandstones of the area.

The Trivoli sandstone may be of the same age as the Moberly and Warrensburg channel sandstones of Missouri, the basal members of the Missouri series, and the Inglefield sandstone of southern Indiana.

Geologic sections 8, 9.

Underclay Limestone (Member 146)

The underclay limestone member has been seen in only three outcrops. It consists of brownish-gray impure nonfossiliferous limestone concretions as much as 10 inches thick in the lower part of the calcareous underclay.

Geologic sections 8, 9.

Underclay (Member 147)

The underclay of the Trivoli (No. 8) coal is commonly about 4 feet thick. The upper 1 foot 3 inches is noncalcareous and the lower calcareous part contains small limestone nodules. It generally resembles other underclays of the area.

Geologic sections 8, 9.

Trivoli (No. 8) Coal (Member 148)

The number 8 was first applied to this coal in Sangamon County, near Springfield (Worthen, 1870). The name Trivoli was later introduced from the town of Trivoli in the Glasford quadrangle. The coal was seen in only eight outcrops, three in the vicinity of Trivoli, and five near Hanna City. It is 1 foot 3 inches to 2 feet thick. In one exposure there is a clay parting ½ inch thick, 4 inches from the base. Horsebacks are locally present.

Although widespread in Illinois, the Trivoli coal is too thin to be mined in most places. It is equivalent to the Parker coal of southern Indiana. It is probably equivalent to the Ovid coal of Iowa and Missouri.

Geologic sections 8, 9.

Limestone (Member 149)

The limestone overlying the Trivoli (No. 8) coal consists of 6 inches to 2 feet 4 inches of dark blue-gray very argillaceous limestone in discontinuous lenses in dark shale. It is present in three outcrops. In one exposure 2 inches of rusty clay and 4 inches of soft black shale occur between the limestone and the underlying coal. The limestone is very fossiliferous, but the fossils are somewhat crushed and not well preserved. *Crurithyris planoconvexa* is the most common form.

Geologic section 8.

Black Shale (Member 150)

The black shale ranges from 4 to 14 inches thick. It is finely laminated and fairly hard, but breaks into thin flakes instead of large flat sheets like the St. David and Liverpool cyclothem black shales. No concretions were found in this black shale. Fossils include *Orbiculoidea, Leiorhynchus,* and *Dunbarella.*

Geologic section 8.

Calcareous Shale (Member 151)

The calcareous shale consists of greenish to gray calcareous fossiliferous shale that grades into the black shale below and the Trivoli limestone above. It is 8 inches to 4 feet thick and contains crinoid stems and other fossils.

Geologic sections 8, 9.

Trivoli Limestone (Member 152)

The Trivoli limestone was seen at six outcrops and is 10 inches to 1 foot 4 inches thick. It is light gray, weathers buff, and occurs in one massive bed that resembles the St. David limestone in lithology and appearance. The limestone contains *Marginifera splendens* and *Chonetina verneuiliana* and other fossils. It is correlated with the Spring Valley limestone of Bureau County, Illinois, the Parker limestone of Posey County, Illinois, the Sniabar limestone of southern Iowa, Missouri, and eastern Kansas.

Geologic sections 8, 9.

Calcareous Shale (Member 153)

The calcareous shale and the overlying member have escaped erosion in only one locality, the type exposure of the Trivoli cyclothem (geol. sec. 8). The shale is 4 feet 6 inches thick and very fossiliferous. *Chonetina verneuiliana* is common and various brachiopods, crinoid stems, bryozoa, pelecypods, gastropods, and cephalopods, are present. The fauna is similar to that in the calcareous shale over the St. David limestone (member 102), except that in the St. David bed *Mesolobus mesolobus* var. *euampygus* is most common, whereas that species is absent in the Trivoli calcareous shale.

Geologic section 8.

Gray Shale (Member 154)

The gray shale is soft and is 6 feet 6 inches thick. It is similar to the Canton shale. This shale was probably originally much thicker, as it is 20 to 40 feet thick near Springfield and Edwardsville, Illinois, where it is used in the manufacture of brick.

Geologic section 8.

CHAPTER 5—POST-PENNSYLVANIAN STRATIGRAPHY

Tertiary (?) System

In various places in Illinois and other midwestern states, thin deposits of gravel composed of rounded quartz pebbles, brown-stained and polished chert, ironstone concretions, and other locally derived materials containing more or less sand, are found resting on the bedrock and underlying the earliest Pleistocene sediments (Horberg, 1950, 1956). In some places they are a firm conglomerate cemented with dark brown to nearly black iron oxide. Although generally nonfossiliferous these sediments have been referred to the late Tertiary (Pliocene) Lafayette formation.

Brown gravel, locally cemented to conglomerate, is found at several places in the Beardstown-Glasford-Havana-Vermont area resting on bedrock but underlying Pleistocene deposits. Although the gravel consists principally of polished brown chert, quartz, and ironstones like the Tertiary gravel, a small number of pebbles of igneous or metamorphic rocks can be found in it at nearly every outcrop. Because these types of rocks are foreign to Illinois and are believed to have been brought into Illinois by glaciers, the brown gravel of this region probably represents a reworking of late Tertiary gravel during early Pleistocene time. The gravels are well displayed in the northern part of the Havana quadrangle (geol. sec. 51) and the southern part of the Glasford quadrangle (geol. sec. 50).

Brownish chert and quartz comprise 10 to more than 40 percent of the pebbles in till in various parts of the area (table 4). These pebbles resemble those characteristically found in late Tertiary gravels and probably were derived from deposits of such gravel overridden by the glaciers in or near the area. Although no deposits of Tertiary gravel in place were found, the evidence suggests that such gravel was relatively widespread in the area before glaciation. At one outcrop in the north part of the Havana quadrangle (geol. sec. 51) the gravel underlies early Kansan loess or silt, so it cannot be younger than early Aftonian or Nebraskan in age.

Quaternary System

Pleistocene Series

The Pleistocene deposits of the Beardstown-Glasford-Havana-Vermont area include materials referred to all of the glacial and interglacial ages (fig. 50). The area was glaciated during the Nebraskan, Kansan, and Illinoian stages. A Wisconsin (Tazewell) glacier advanced to within two miles of the northeast corner of the Glasford quadrangle, and outwash or eolian deposits of each Wisconsin substage have been identified. Deposits referred to the Yarmouth and Aftonian interglacial stages and Kansan and Nebraskan glacial stages are found at scattered places beneath the Illinoian till. Loess deposits of Farmdale and Peorian age almost everywhere mantle the Illinoian till, and the Peorian loess is the most widespread surficial material in the area.

The average thickness of the Pleistocene deposits in the area is probably less than 50 feet. In the southeast part of the Beardstown quadrangle no bedrock is exposed in some valleys that have a relief of 160 feet and therefore the Pleistocene deposits there may be 200 feet or more thick. In other places more than 120 feet of Pleistocene deposits are exposed along ravines that do not reach bedrock. On rock ridges, like the Pleasantview and Farmington ridges, the Pleistocene deposits are locally less than 15 feet thick.

The approximate thickness of the Pleistocene deposits at any place in the area may be determined by subtracting the elevation of the bedrock surface at that place (pl. 6) from the elevation of the present surface at the same place (pls. 1-4).

BEDROCK TOPOGRAPHY

The surface of the bedrock (pl. 6), if stripped of its cover of Pleistocene sediments, would be an undulatory plain sharply cut by those present day valleys that extend through the drift and by numerous other valleys that are now filled with Pleistocene deposits. The highest elevation of this surface is 750 feet

TABLE 4.—LITHOLOGY OF PEBBLES AND BOULDERS FROM THE ILLINOIAN, KANSAN, AND NEBRASKAN (?) TILLS
Percentage

Kind of rock	Illinoian				Kansan			Nebraskan
	1	2	3	4	5	6	7	8
Limestone	29.8	32.7	19.1	36.9	31.9	15.6	16.9	0.0
Dolomite	25.4	26.2	21.9	20.0	10.6	3.9	6.6	0.0
Sandstone	5.0	7.6	5.6	16.9	12.8	19.5	28.8	3.3
Shale	1.6	2.3	4.2	0.0	0.0	14.0	9.9	0.0
Shale, "slate"	2.7	0.0	2.8	0.0	4.2	0.0	0.0	0.0
Coal	0.6	0.4	0.0	0.0	2.1	3.9	2.8	8.2
Chert, gray	10.5	5.7	16.8	0.0	12.8	9.4	1.9	14.7
Chert, brown	2.2	0.4	2.8	0.0	6.4	11.7	2.8	13.1
Ironstone concretion	4.4	7.2	8.5	0.0	4.2	2.3	11.3	1.6
Quartz	4.4	4.2	7.0	0.0	2.1	3.9	5.2	14.7
Granite	2.2	1.6	1.4	7.7	6.4	2.3	3.4	11.5
Syenite	0.0	0.0	0.0	3.0	0.0	0.8	0.5	0.0
Diorite	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Gabbro	0.0	1.6	0.5	4.6	2.1	0.8	0.0	0.0
Porphyry	0.0	0.0	0.0	0.0	0.0	0.8	0.5	0.0
Basalt	9.4	7.2	7.5	6.1	2.1	7.0	3.4	22.9
Rhyolite	0.0	0.0	0.5	0.0	0.0	0.0	1.4	1.6
Gneiss	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Quartzite	1.6	1.6	0.5	3.0	2.1	0.8	2.4	1.6
Graywacke	0.0	0.0	0.0	1.5	0.0	2.3	0.0	1.6
Argillite	0.0	0.0	0.9	0.0	0.0	0.0	0.5	0.0
Jasper	0.0	0.0	0.0	0.0	0.0	0.8	0.9	4.9
Hematite	0.0	0.8	0.0	0.0	0.0	0.0	0.5	0.0
Total	99.8	100.3	100.0	99.7	99.8	99.5	99.7	99.7

LOCATIONS OF SAMPLES
(All from Havana quadrangle)

Illinoian till

(1) Pebble count from calcareous till in ravine in SW¼ SE¼ sec. 32, T. 4 N., R. 3 E.
(2) Pebble count from calcareous till in ravine in NE¼ NE¼ sec. 5, T. 3 N., R. 3 E.
(3) Pebble count from calcareous till in ravine in NW¼ SE¼ sec. 16, T. 4 N., R. 3 E.
(4) Boulder count from calcareous till, same locality as sample 2.

Kansan till

(5) Pebble count from calcareous till, same locality as sample 2.
(6) Pebble count from calcareous till, same locality as sample 1.
(7) Pebble count from calcareous till, same locality as sample 3.

Nebraskan ? till

(8) Pebble count from noncalcareous till, same locality as sample 1.

About 200 pebbles ¼ inch to 2 inches in diameter were classified for pebble counts and 100 chips from boulders for the boulder count.

about two miles east of Farmington in the north part of the Glasford quadrangle. The lowest reported elevation is 338 feet in a well about two miles east of Beardstown. The total relief of 412 feet exceeds the present topographic relief of the area by about 50 feet.

BEDROCK VALLEYS

The largest valley in the bedrock surface is that of the Illinois River. Its breadth approximately corresponds with the present valley, although in places it was considerably widened during the Pleistocene. Its floor ranges from less than 20 to more than 100 feet below the present valley floor. The old valley was occupied by the Mississippi River from preglacial to early Wisconsin time (Horberg, 1950, p. 58, 72). Below Peoria the present Illinois River occupies a relatively narrower and shallower valley for a few miles and then broadens out into the bedrock valley that traverses this area. The rock floor of this valley seems to be deepest under the

STAGE	SUBSTAGE	UNIT	COLUMN	MAXIMUM THICKNESS (feet)	LITHOLOGY	
RECENT				45	Stream alluvium, fans, colluvium, dune sand	Sand dunes
WISCONSIN	MANKATO	Beardstown Ter. Lake Chicago Bath Terrace		40	Sand, pebbly sand	
	CARY	Havana Terrace Valparaiso ? Manito Ter.		40	Sand, pebbly sand	
	TAZEWELL	Tazewell		10	Loess, gray, buff	
		Bloomington (Peorian Loess - 50')		20	Silt, laminated; sand	
				9	Clay, red	
				100	Sand, gravel	
		Shelbyville-Champaign		20	Sand, gravel	
	IOWAN			15	Loess, gray, buff	
	FARMDALE			18	Loess, brown	
SANGAMON					Weathered zone on Illinoian drift	
ILLINOIAN	BUFFALO HART			30	Till	
		Intra-Illinoian, undifferentiated		10	Silt, varved	
	JACKSONVILLE			45	Sand, gravel	
				45	Till, gravel	
	PAYSON			50	Till	
	LOVELAND			15	Loess	
YARMOUTH					Weathered zone on Kansan drift	
				10	Gravel and silt	
KANSAN				15	Sand, gravel	
				8	Silt, fossiliferous	
				32	Till	
				5	Loess	
				2	Silt, laminated	
AFTONIAN					Weathered zone on Nebraskan drift	
				5	Silt, leached	
				12	Gravel	
NEBRASKAN				6	Till, sand	
PRE-ILLINOIAN–PRE-PLEISTOCENE				10	Silt, sandy, locally cobbly at base	

FIG. 50.—Generalized columnar section of Pleistocene deposits.

terrace east of the present floodplain, but west and north of the river in the Glasford and part of the Havana quadrangles the bedrock surface under the floodplain is shallow. There were many tributary valleys northwest of the Illinois Valley, of which the following were apparently the largest: 1) the Elmwood-Kickapoo Valley, 2) the Copperas Creek—Glasford Valley, 3) the Smithfield—Spoon River Valley, 4) the Vermont—Otter Creek Valley, 5) the upper Wilson Creek—Skiles Branch Valley, and 6) the Sugar Creek—Browning Valley.

The Elmwood-Kickapoo Valley drained eastward from Elmwood and crossed the northeast corner of the Glasford quadrangle in the vicinity of Edwards, where its floor is below 450 feet above sea level, about 50 feet below the present Kickapoo Creek Valley.

The Copperas Creek—Glasford Valley drained most of the central and southern two-thirds of the Glasford quadrangle through a series of branches which entered the Illinois Valley a little southwest of Glasford and about five miles northeast of Banner where the present-day stream enters the valley.

The Smithfield—Spoon River Valley follows the present Spoon Valley through the Avon quadrangle to a point 1½ miles north of the Vermont quadrangle where it leaves the present valley, extends up Laswell Branch of Put Creek, crosses the till plain a little east of Smithfield, and then follows the valley of Muddy Branch to rejoin the present Spoon Valley about 1½ miles northeast of Bernadotte. The present Spoon Valley above Laswell Branch and below Muddy Branch is broader and bounded by rather gentle slopes, whereas between these points it is narrow, shallow, winding, and bounded by rock bluffs. The floor of the rock valley two miles north of the Vermont quadrangle is at least 457 feet above sea level and east of Bernadotte about 427 feet, both elevations 40 to 50 feet below the present valley floor.

The Vermont—Otter Creek Valley averages a little less than a mile in width. It is somewhat straighter than the present winding valley of Otter Creek and lies a little north of the present valley through most of the Vermont quadrangle, apparently heading a little north of Vermont.

The upper Wilson Creek—Skiles Branch Valley follows the upper two miles of Wilson Creek Valley in the east part of the Beardstown quadrangle, then leaves that valley and crosses under the till plain and the Buffalo Hart moraine to the present small valley of Skiles Branch near the mouth of which it joins the Illinois Valley. The present valleys of lower Wilson Creek to the northeast and Elm Creek to the west are largely trenched in rock.

The Sugar Creek—Browning Valley enters the Beardstown area from the northwest and is about four times as broad as the present valley of Sugar Creek. Near the Fulton-Schuyler county line the old valley curves southeast across lower Harris Branch, the Frederick moraine, upper Dutchmans Creek, and the till plain to join Illinois Valley about one mile southwest of Browning and two miles northeast of the present outlet of Sugar Creek.

Ridges and Uplands

The principal ridges or uplands of the bedrock surface are: 1) the Farmington—Hanna City ridge, 2) the Pleasantview ridge, 3) the Astoria upland, 4) the Table Grove—Bernadotte upland, 5) the Marietta—New Philadelphia upland, 6) the Cuba—St. David upland, and 7) the Summum upland.

The Farmington—Hanna City ridge trends eastward across the north part of the Glasford quadrangle and corresponds generally with the Farmington ridge of the present topography. It includes the highest elevations (750 feet) of the bedrock surface. Its north flank slopes toward the Elmwood—Kickapoo Valley and its south slope was drained by the many branches of the Copperas Creek—Glasford Valley.

The Pleasantview ridge trends about N. 30° W. in the west-central part of the Beardstown quadrangle, generally corresponding with the modern Pleasantview ridge. Its northeast flank slopes toward the Sugar Creek—Browning Valley and includes isolated uplands east of the modern Sugar Creek Valley. Its southwest flank slopes toward the preglacial Crane Creek Valley a little west of the Beardstown quadrangle. Its altitude is more than 700 feet above sea level over several square miles.

The Astoria upland is a flattish plain trending eastward in the north part of the Beardstown quadrangle. Its elevation is more than 600 feet, and it slopes northward toward the Otter Creek Valley, southwest toward the Sugar Creek—Browning Valley, and east toward the Wilson Creek—Skiles Branch Valley, which separates this upland from that near Summum.

The Table Grove—Bernadotte upland is an elliptical plain with a general eastward trend, now bisected by Francis Creek Valley, which is trenched in rock through most of its course. Isolated portions of this upland also lie across Spoon River north of Bernadotte. The upland attains an elevation of 660 feet in four small areas.

The Marietta—New Philadelphia upland trends northeastward in the north part of the Vermont quadrangle, with its highest elevation a little more than 640 feet. It is separated from the Table Grove—Bernadotte upland by a buried valley tributary to the Smithfield—Spoon River. The buried valley crosses lower Badger Creek and is followed by some upper tributaries of Barker Creek. Detached remnants of this upland also lie across Spoon River. The upland is extensively dissected by lower Barker Creek and its tributaries.

The Cuba—St. David upland trends eastward in the north part of the Havana quadrangle, with a maximum elevation of more than 600 feet. It includes the larger part of the till plain where the Springfield (No. 5) coal has been strip mined. It is dissected to a large extent by Big Creek and its tributaries.

The Summum upland in the southeast part of the Vermont and northeast part of the Beardstown quadrangles lies between the Otter Creek—Vermont Valley to the north and the upper Wilson Creek—Skiles Branch Valley to the southwest. Its maximum elevation is a little more than 600 feet.

In addition to the major valleys of the bedrock surface there is an intricate system of tributaries whose pattern is largely unknown. Throughout the area small ravines with outcrops of bedrock extending well toward their headwaters adjoin ravines that are eroded entirely in drift. This was clearly demonstrated in the north part of the Havana quadrangle where holes to test for strip coal were drilled at one-fourth mile intervals. The first drilling seemed to indicate an almost uninterrupted block of coal through a considerable area. Later drilling with different spacing of holes showed that the coal had been eroded from more than half the area. The small buried valleys chanced to lie between the original drill holes and also between the present ravines along which coal outcrop is nearly continuous.

A small buried valley is well exposed in the lower part of the large ravine in the S½ sec. 11, T. 18 N., R. 11 W., Beardstown quadrangle. The present stream is deeply trenched in Pennsylvanian strata of the Summum and Liverpool cyclothems. About one-third mile above its junction with the Illinois Valley a vertical contact at least 30 feet high separates limestone, black sheety shale, and gray shale of the Liverpool cyclothem on the south from fresh gray till on the north. About 250 yards downstream a somewhat similar but less well exposed contact between till and bedrock marks the north border of the buried valley. The present stream crosses the pre-Illinoian valley almost at right angles. The valley is somewhat broader where trenched in the till than it is in bedrock. At the contact of the till and the Francis Creek gray shale in the valley wall, the shale has been eroded more than the till and the till stands out in relief.

Age of Bedrock Surface

The major uplands and valleys of the bedrock surface probably date back to the pre-Pleistocene time, although most of them may have been deepened and others developed during the Aftonian, Yarmouth, and Sangamon interglacial ages as well as in post-Illinoian time. The isolated patches of pre-Illinoian deposits referred to the Yarmouth, Kansan, Aftonian, and Nebraskan are found largely in small buried valleys or at moderately low elevations, showing that the erosion of those particular valleys took place at least as far back as the Yarmouth. An outcrop of Kansan till in sec. 3, T. 5 N., R. 2 E., Vermont quadrangle, is directly along the Smithfield—Spoon River Valley in Muddy Branch, and other patches of Kansan till have been recognized in the Copperas Creek—Glasford, the lower part of the Vermont—Otter Creek, the upper Wilson Creek—Skiles Branch, and the Sugar Creek—Browning valleys, seemingly proving that these valleys were already in existence by the close of the Aftonian interglacial age.

The buried highlands of the bedrock surface seem to have had fairly uniform slopes that are well displayed on the southwest slope of Pleasantview ridge. There the slope averages about 60 feet per mile. These slopes do not seem to have been trenched by deep bedrock valleys before Illinoian glaciation. The Illinoian glacier, however, obliterated several of the old valleys like the Sugar Creek—Browning Valley south of the Fulton–Schuyler county line and deposited a morainic ridge, the Jacksonville, on the western slope of this old valley. As a result the drainage of Sugar Creek was shifted about two miles west of its old course to the northeast flank of Pleasantview ridge and the present valleys of lower Sugar Creek and its western tributaries were cut deeply into the ridge during Sangamon time. The slopes of these newer valleys were mantled with Peorian loess during the early part of the Wisconsin glacial age but this loess mantle was eroded from many of the valley slopes during later Wisconsin and Recent time. Ravines deeply trenched in bedrock in other parts of the area also result from glacial derangement of the drainage lines.

The bedrock surface is a composite result of preglacial, glacial, interglacial, and postglacial erosion and shows systems of valleys that probably were occupied by streams at quite different times.

NEBRASKAN STAGE

Till certainly of Nebraskan age in place has been reported at only one locality in the area, where it has been exposed in a roadside gully near the center of the S½ sec. 26, T. 6 N., R. 3 E. (George E. Ekblaw, personal communication).

Additional evidence of Nebraskan glaciation occurs in the southeast part of the Havana quadrangle (Wanless, 1928). Along a ravine in the NE¼ sec. 5, T. 3 N., R. 3 E., a rounded mass of oxidized calcareous Nebraskan till is covered by dark blue-gray unoxidized Kansan till, but it may be a transported mass. In a ravine in the NW¼ SE¼ sec. 32, T. 4 N., R. 3 E. (geol. sec. 62, fig. 51), two beds of noncalcareous pebbly clay separated by seven feet of noncalcareous sand and gravel, all underlying calcareous Kansan till, are believed to be Nebraskan till truncated and contorted by overriding Kansan ice. Currently there is some question whether or not all of this material is in place or partly transported and whether the pebbly clay is actually till or weathered pre-Kansan alluvium. In either case, the deposits indicate Nebraskan glaciation nearby. A similar noncalcareous pebbly clay of uncertain origin but pre-Kansan in age is exposed in the head of a ravine in the NW¼ SE¼ sec. 16, T. 4 N., R. 3 E. (geol. sec. 58).

Possible Nebraskan outwash is described in succeeding paragraphs.

AFTONIAN STAGE

The Aftonian stage is represented in this area by 1) brown leached gravel of early Aftonian or possibly Nebraskan age and 2) noncalcareous silt with wood, probably of early or middle Aftonian age.

Early Aftonian (?) Gravel

Deposits of early Aftonian or late Nebraskan gravel occur in the north-central part of the Havana quadrangle, especially in and near the valley of Slug Run, a northern tributary of Big Creek. The best outcrops are in secs. 22, 23, 26, and 33, T. 6 N., R. 3 E., where the gravel seems to form a nearly continuous deposit along a bedrock valley. The gravel is best exposed in a small pit in the bottom of the ravine in the SE¼ SW¼ sec. 26, T. 6 N., R. 3 E. The pre-Kansan age of the gravel is clearly demonstrated at one place (geol. sec. 51). Similar gravel, probably of Aftonian age, has been observed in a few outcrops along Copperas Creek north of Banner in the Glasford quadrangle (geol. sec. 50), and in sec. 30, T. 6 N., R. 4 E., Havana quadrangle.

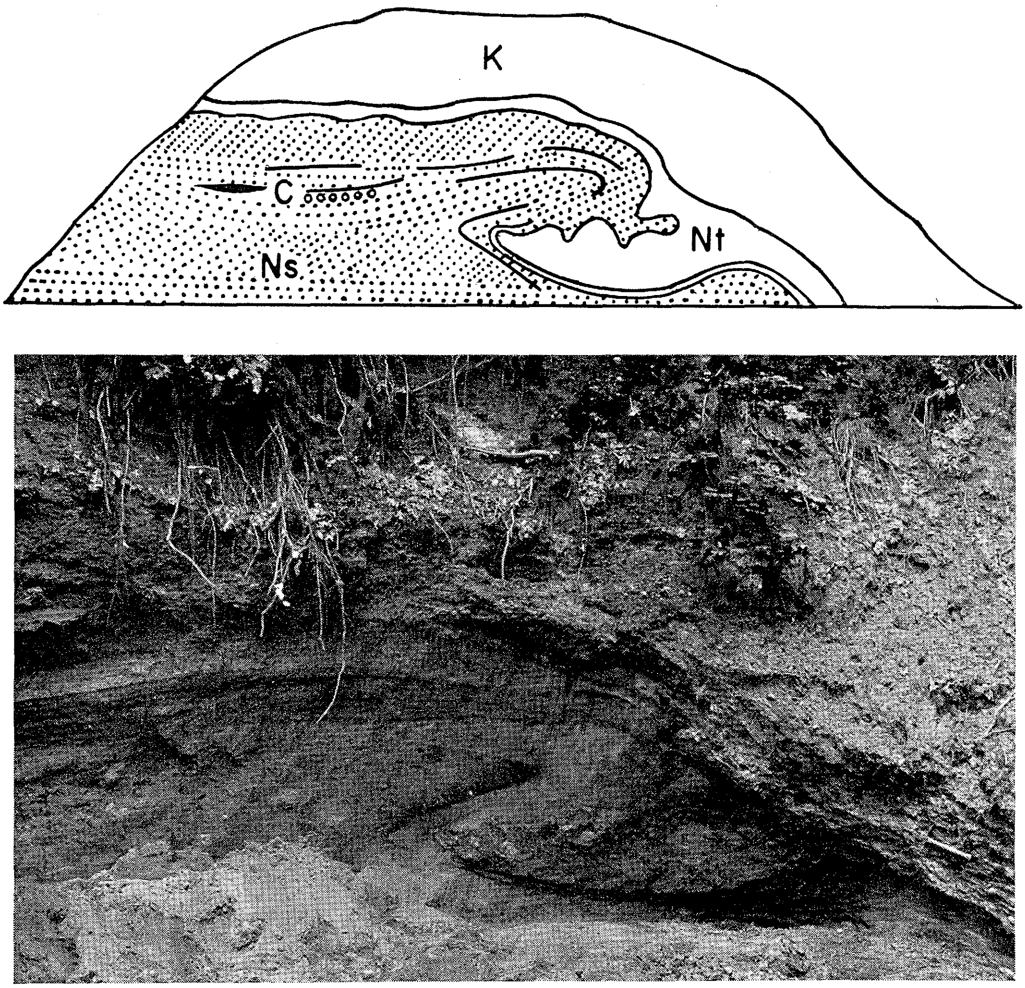


FIG. 51.—Exposure of Kansan till overlying Nebraskan (?) till and sand in ravine near Enion, in the SW ¼ SE ¼ sec. 32, T. 4 N., R. 3 E., Havana quadrangle. K, calcareous Kansan till; Nt, noncalcareous Nebraskan till; Ns, Nebraskan cross-bedded sand, noncalcareous, iron-stained; C, weathered coal.

The gravel has a maximum observed thickness of 12 feet and consists principally of rounded and somewhat polished chert pebbles, rounded quartz pebbles, ironstone concretions, and a few larger somewhat weathered fragments of granite and other igneous and metamorphic rocks. The pebbles are commonly deeply iron stained and at some outcrops are firmly cemented with brown iron oxide to form a moderately hard conglomerate. At a few outcrops the pebbles are firmly embedded in tough greenish-blue sandy silt like that observed beneath Illinoian and Kansan till at several places.

Although the gravel closely resembles the late Tertiary brown chert gravel of other localities, the presence of pebbles of granite and other igneous rocks identifies it as Pleistocene. Also these deposits are found in bedrock valleys whereas the Tertiary gravels occur in the bedrock upland areas. Because this gravel is deeply leached and iron stained below strongly calcareous Kansan silts and till, it must, therefore, be at least as old as Aftonian and may be either early Aftonian alluvial gravel or Nebraskan outwash.

Aftonian Silt

About 5 feet of compact noncalcareous brown silt underlies calcareous Kansan till near the main forks of a ravine in the NW¼ SE¼ sec. 16, T. 4 N., R. 3 E., Havana quadrangle (geol. sec. 58). The silt contains abundant fragments of carbonized wood up to the size of small logs. It rests on a tough, greenish-blue sandy silt that grades down into the Pleasantview sandstone. Locally a few inches of clay with igneous and metamorphic pebbles, probably of Nebraskan age, occur between the silt and the sandstone. The silt appears to represent an alluvial or lake deposit. Because it is leached of carbonates it is probably Aftonian in age, but the presence of abundant wood fragments suggests that it may be an early Kansan alluvial deposit composed of material derived from weathered deposits on the Aftonian uplands. The wood was identified as spruce.

KANSAN STAGE

Kansan drift is found in each of the four quadrangles covered by this report, in exposures generally limited to bedrock valleys or places of moderately low altitude. In numerous exposures silt or loess of early Kansan, Yarmouth, or Aftonian age is directly overlain by Illinoian till. As Kansan till is missing in these exposures, it seems likely that the Kansan glacier did not entirely cover this area. The Kansan glacier invaded this area from the northwest, but the east part of the Glasford quadrangle and portions of the Beardstown quadrangle near the Illinois Valley may have escaped glaciation. Although sands and gravels that are probably outwash deposits from the Kansan glacier are present at a few places, no extensive outwash plain, valley train, or terminal moraine has been discovered.

The Kansan deposits include: 1) early Kansan calcareous laminated silt, 2) pro-Kansan loess and peaty soil, 3) till, and 4) sand and gravel.

Geologic sections 48, 51, 54, 58, 59, 62, 69.

Early Kansan Silt

In the Glasford and Havana quadrangles the early Aftonian (?) brown chert gravels are immediately overlain by 2 feet of highly calcareous brownish gray somewhat laminated silt with small irregularly shaped calcareous concretions (geol. sec. 51). This silt is immediately overlain by Kansan till and appears to have been deposited either in a pond or sluggish stream during early Kansan time. It may have been derived largely from pro-Kansan loess.

Pro-Kansan Loess

In the ravine in which Nebraskan (?) till was found in the southern part of the Havana quadrangle (geol. sec. 62), the overlying Kansan till contains boulder-like masses of blue-gray calcareous fossiliferous loess and blocks of hard compact soil with wood fragments. Isolated logs from forests that were overridden by the Kansan ice also are included in the till (fig. 52). Fossils from the loess are listed in appendix C. In a ravine about three miles farther north (geol. sec. 58) pro-Kansan loess 5 feet thick underlies weathered Kansan till and is also leached of carbonates. About 10 feet of gray silt underlying Kansan till along a tributary of Copperas Creek just west of the Glasford quadrangle may also be pro-Kansan loess.

Kansan Till

The Kansan till is recognized by its position as the first till below the Illinoian, from which it is separated by fossiliferous loess or silt, by weathered sand or gravel, or by a weathered zone on the Kansan till. The Kansan till is much more compact than the Illinoian. It is generally darker blue gray than the Illinoian till where unweathered and its oxidized surface is commonly darker brown than the oxidized Illinoian till. Sand and gravel laminations are commonly contorted (fig. 53), probably as a result of shove by the Illinoian glacier. In a few places large boulders are more common in the Kansan than in the Illinoian till. The Kansan till contains more brown chert, shale, and sandstone and much less dolomite than the Illinoian till (table 4). The maximum thickness of Kansan till is 32 feet along Hinkle Creek near the center W½ SW¼ sec. 20, T. 7 N., R. 6 E., Glasford quadrangle.

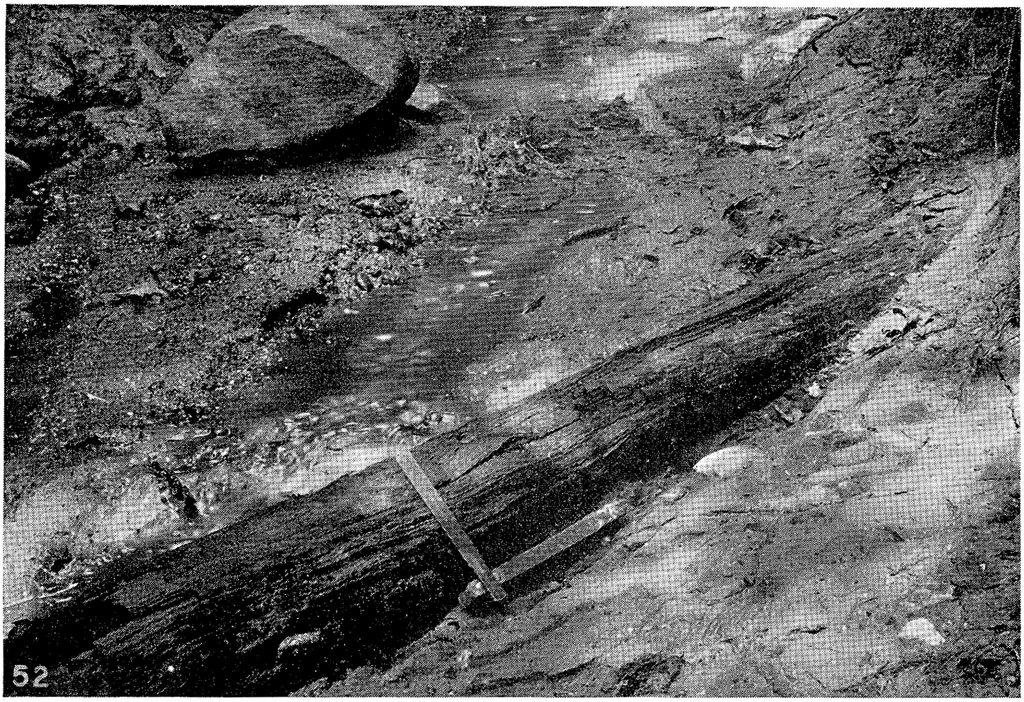


FIG. 52.—Log in Kansan till in ravine near Enion, in the SW ¼ SE ¼ sec. 32, T. 4 N., R. 3 E., Havana quadrangle.

FIG. 53.—Kansan till contorted into sharp folds by overriding Illinoian ice in ravine near Enion, in the SW ¼ SE ¼ sec. 32, T. 4 N., R. 3 E., Havana quadrangle.

Late Kansan Sand and Gravel

At a few localities unweathered Kansan till is immediately overlain by gravel or sand. In a ravine along Otter Creek in the south part of the Havana quadrangle (geol. sec. 62) Kansan till is overlain by 15½ feet of brown noncalcareous gravel with sand streaks and 1½ feet of yellow sand. These deposits are overlain by Illinoian till and pro-Illinoian Loveland loess in different parts of the ravine. Calcareous Kansan till is overlain by about 5 feet of calcareous sand with streaks of gravel along Big Sister Creek in the Havana quadrangle (geol. sec. 54).

Numerous outcrops of deep greenish-blue noncalcareous sand and gravelly sand below Illinoian till, but not associated with Kansan till, may also be of Kansan age. A typical exposure along Wilson Creek in the SW¼ SW¼ NE¼ sec. 27, T. 3 N., R. 2 E., Beardstown quadrangle, shows 6 feet of brown sandy gravel, feebly calcareous along joints, between noncalcareous silt and sand above and noncalcareous silt, which contains wood, below. This sand and gravel is irregular in distribution and variable in lithology and stratigraphic relations.

Late Kansan Silt

A bed of compact blue-gray calcareous fossiliferous silt 3 to 8 feet thick occurs 10 feet above the base of an exposure along Big Sister Creek in the Havana quadrangle (geol. sec. 54). The lower part of the silt is massive, but the top foot is very finely and regularly laminated, is very calcareous, and has an abundance of fragile somewhat crushed shells and indistinct plant traces that probably represent some sort of pond vegetation. The fauna in both parts of the silt is of fresh-water type, including both gastropods and pelecypods (app. C). The regularity of lamination suggests that the bands may record successive years of accumulation in a pond or lake, each band requiring a year for its accumulation. This fossiliferous silt appears to be a unit within the late Kansan sand and gravel. It is separated from the Kansan till below by several feet of calcareous gravelly sand and is overlain by several feet of sand and gravel, of which the upper part is noncalcareous. The sand and gravel is overlain by fossiliferous Loveland loess and Illinoian till. The leached zone appears to represent Yarmouth weathering and suggests that the fossiliferous silt is late Kansan.

YARMOUTH STAGE

The Yarmouth stage is represented in this area principally by the weathered zone developed on the Kansan till, but some sands and silts of undetermined pre-Illinoian age are probably Yarmouth. Yarmouth deposits occur principally in valley areas of the bedrock surface.

In Iowa, gumbotil was developed on the Kansan till to a maximum depth of 15 feet during Yarmouth time (Kay, 1931). As the Kansan till in these quadrangles is generally less than 15 feet thick, the complete profile of weathering is rarely displayed. At some localities all of the Kansan till is altered to gumbotil. Elsewhere the upper portion of the profile of weathering was scraped off by the Illinoian glacier, and Illinoian till rests on the oxidized leached zone or on the oxidized calcareous zone of Kansan till.

Where Illinoian till rests on unoxidized calcareous Kansan till, the contact between the two generally cannot be recognized. Kansan gumbotil in this area has been overridden and compressed by the weight of the Illinoian glacier, so that it is very compact and tough. It contains a few pebbles, mainly quartz and chert. It is commonly light gray or greenish gray and plastic. The maximum thickness of gumbotil found was nearly 10 feet near the center of the SW¼ sec. 4, T. 2 N., R. 1 E., Beardstown quadrangle.

An excellent exposure in a railroad cut along the West Branch of Copperas Creek (geol. sec. 48) shows two weathered zones, both of which may be Yarmouth. In this outcrop, weathered Kansan till is locally overlain by leached, oxidized, and cemented gravel, which is in turn overlain by 8 to 10 feet of compact blue-gray noncalcareous silt with a well developed profile of weathering. The weathered zone on the Kansan till seems to be truncated by the gravel. The gravel and the overlying weathered silt appear to be Yarmouth deposits.

OTHER PRE-ILLINOIAN DEPOSITS

In about 40 percent of the outcrops of pre-Illinoian deposits, there is neither Kansan till below nor Loveland loess above. The precise age of these deposits therefore cannot be determined. They may be Kansan or older with the Yarmouth soil eroded, or they may be Yarmouth or early Illinoian.

One of the common deposits is a compact sandy greenish–blue silt that is generally not bedded (geol. secs. 49, 50, 58, 59, 69). The silt is tough and was evidently compressed by the Illinoian or an earlier glacier. It generally rests directly on Pennsylvanian bedrock, and its basal few inches include fragments of sandstone or shale grading down into the unweathered bedrock. Where weathered, the outer surface is stained reddish or dark brown. In places the silt contains logs of partially carbonized wood and smaller more comminuted fragments of plant debris. Plant material may be so abundant as to produce locally a peaty silt.

At one locality in the NW¼ SW¼ NE¼ sec. 27, T. 5 N., R. 2 E., Vermont quadrangle, the silt contains small nodules of vivianite (iron phosphate) that are brilliant blue on fresh exposure. The vivianite is believed to result from decomposition of wood fragments in the silt. Some of the nodules are in the wood. Finely disseminated vivianite may be responsible for the characteristic greenish–blue color of the silt at many localities.

At a locality in the eastern part of the Glasford quadrangle (geol. sec. 49) a few vertical cylinders with concentric iron banding, interpreted as fossil crayfish borings, are found in this type of silt.

Similar silt is found under Kansan till where it is certainly of Aftonian or early Kansan age, and also interbedded with gravel, possibly Nebraskan in age. Some of the silt deposits may be as young as Yarmouth or early Illinoian age. The gradational relations between this silt and the bedrock at many places suggests a mixture of alluvial or lake silt and sand and residual soil, which indicates that the area had not yet been glaciated when the silt was deposited and favors a pre-Kansan or early Kansan age for the deposits.

The deep bedrock valley beneath the floodplain and terraces in Illinois Valley in the southeast parts of the Glasford and Beardstown quadrangles probably contains remnants of the early Pleistocene Sankoty sand (Horberg, 1950, p. 34). The sand is probably pre-Kansan in age. It was deeply eroded during both Kansan and Illinoian glaciations and in this area it is everywhere buried by Wisconsin outwash.

ILLINOIAN STAGE

Deposits of the Illinoian glacial stage are distributed throughout the area except in the Illinois Valley and those tributary valleys from which they have been removed by post-Illinoian erosion. Evidences of Illinoian glaciation include 1) glacial striae on the surface beneath Illinoian drift, 2) till deposited directly by the glacier, 3) gravel and sand deposited on or under the glacier and as outwash, 4) silt, sand, gravel, and varved sediments deposited in temporary lakes formed along valleys blocked by ice, and 5) deposits of loessial silt blown onto the uplands from the valley trains.

The Illinoian drift forms principally till plains or ground moraines but includes two Illinoian moraines—the Buffalo Hart moraine, which crosses the Beardstown and Vermont quadrangles, and the Jacksonville moraine, which crosses the Beardstown quadrangle and is overridden by the Buffalo Hart moraine in the northeast part of the quadrangle (fig. 54; Ekblaw and Wanless, 1952). The buried Jacksonville moraine can be approximately traced across the Havana and Glasford quadrangles.

Studies principally outside this area suggest that withdrawal of the Illinoian ice was interrupted by readvances, of which the Buffalo Hart and Jacksonville moraines mark the terminal or outermost deposits. The Illinoian drift outside these moraines is ground moraine behind the outermost Illinoian Payson moraine. On the basis of these moraines and extensive pro-Illinoian loess deposits, the Illinoian is subdivided into four substages—Loveland, Payson, Jacksonville, and Buffalo Hart (Leighton and Willman, 1950, p. 602).

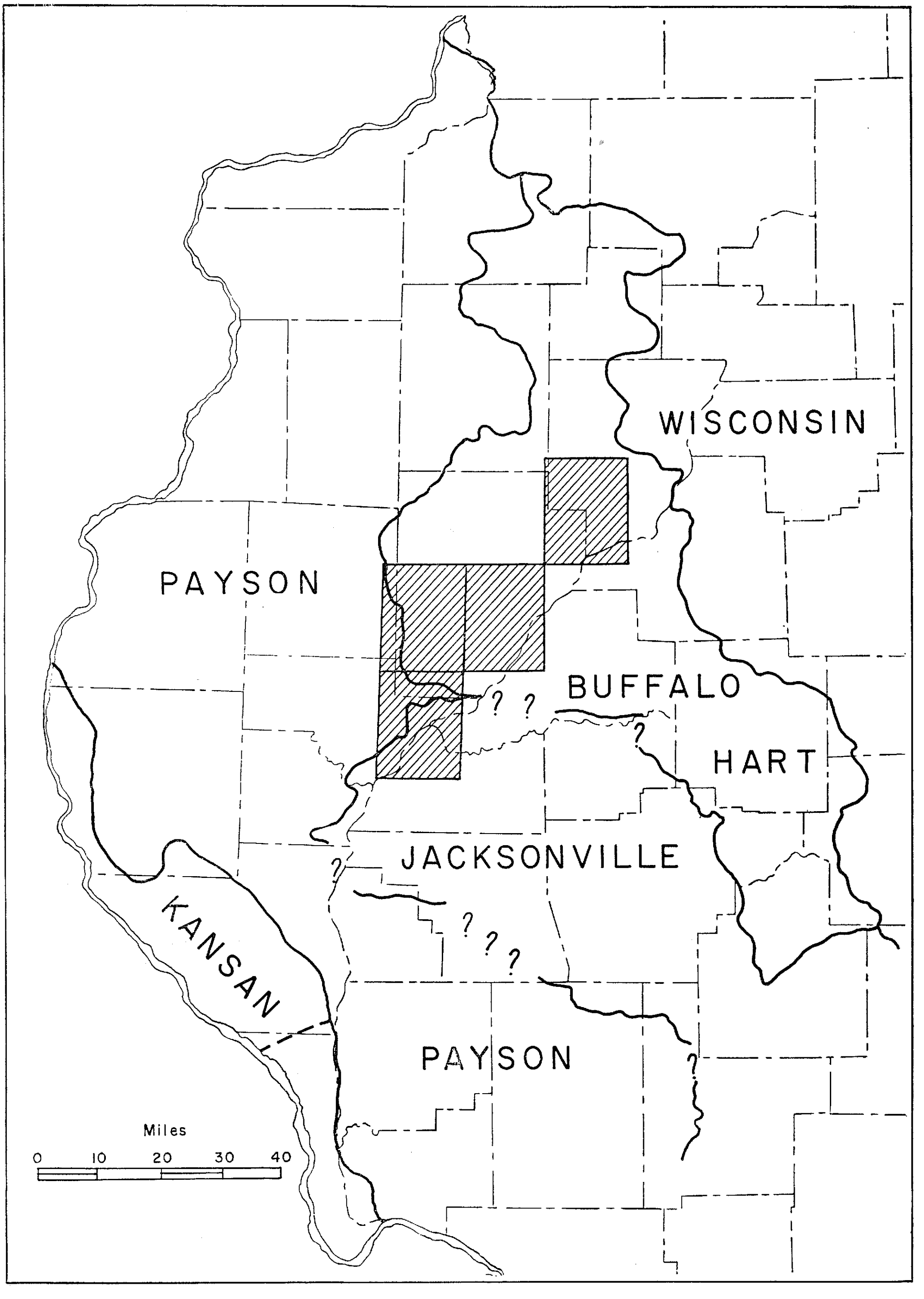


FIG. 54.—Glacial drift of western Illinois, by George E. Ekblaw.

STRIAE

Glacially polished and striated surfaces have been found on Loveland loess and silt and on Lonsdale limestone, Cuba sandstone, St. David limestone, and Seahorne limestone at twelve localities in the Beardstown, Glasford, and Havana quadrangles. The striae indicate an ice movement toward the southwest ranging from S. 25° W. to S. 73° W. At a locality in the SW¼ NW¼ sec. 4, T. 2 N., R. 2 E., Beardstown quadrangle, striae on the Seahorne limestone are oriented N. 50° W., nearly at right angles to the other striae. They probably indicate a local northwestward advance of the Jacksonville ice from a lobe in the Illinois Valley. In a small ravine in the SW¼ NW¼ sec. 31, T. 9 N., R. 5 E., Glasford quadrangle, the stream flows for about 50 feet over the surface of a mass of Lonsdale limestone that apparently was moved several miles to this locality before it became the pavement over which the glacier scraped.

Although the striae on Loveland loess or silt are certainly of Illinoian age, some of those on bedrock might have been made by the Kansan or possibly even the Nebraskan glacier. However, these glaciers advanced from the west and northwest, nearly at right angles to the direction of most of the striae.

LOVELAND (PRO-ILLINOIAN) SUBSTAGE

The Loveland loess is a brownish–gray or reddish–brown compact nonlaminated calcareous silt which is fossiliferous at several exposures. The fossils (app. C) are generally gastropods, which are mostly land types typical of loess deposits, except *Pomatiopsis scalaris* and *Fossaria parva tazewelliana,* which are amphibious, inhabiting shallow stagnant pools or moist meadows, and *Stagnicola caperata,* which is of true aquatic habitat. A few pelecypods in some deposits suggest either that ponds were scattered over the surface where the loess accumulated or that the shells were introduced by some external agent such as birds. The pelecypod shells are all small. The loess is generally very compact and tough because it was overridden by ice. It exhibits an oblique jointing so that it scales off in sheets parallel to the surface of the outcrop in some places. Small calcareous concretions or kindchen are found at places, especially along the North Fork of Otter Creek, where they are flattened and of doorknob shape, and in some other outcrops, where they are slender and cylindrical, of pipestem shape. The latter may have formed around roots. Wood is found in some deposits that probably accumulated in poorly drained lowland areas. In one exposure (geol. sec. 69) the lower part is nearly a peat.

The Loveland loess ranges from less than a foot thick to a maximum of 12 to 15 feet in a few outcrops near the Illinois Valley in the south part of the Havana and the northeast part of the Beardstown quadrangles. It is commonly 3 to 7 feet thick.

The loess rests on early Illinoian silts, Yarmouth and late Kansan silt, sand, and gravel, Kansan gumbotil, and on bedrock. The loess is overlain by Illinoian till with an abrupt contact at all places. The surface of the loess exhibits glacial polish and striae at several localities. As it is calcareous to the top at nearly all localities, it appears that the loess was deposited shortly before the overlying drift. It therefore is considered to be pro-Illinoian in age and derived from the valley trains of the advancing Illinoian ice.

Geologic sections 54, 59, 62, 66, 69.

ILLINOIAN TILL

Because all Illinoian till in this area is essentially similar, it can generally be differentiated only on the basis of its geographic location with reference to the moraines. At numerous outcrops north and east of the Buffalo Hart moraine a zone of sand, gravel, or laminated silt occurs within the Illinoian drift. The till below this parting is older than the surface till and is referred to the Jacksonville substage drift. Elsewhere no basis was found for differentiating the three Illinoian tills.

Illinoian till differs from Kansan till in that it is generally lighter gray where unweathered, lighter yellowish brown where oxidized, and less compact and tough because it is not an overridden till. However, some older Illinoian till in the Glasford quadrangle, probably Payson till, is nearly as compact as the Kansan till. East of Peoria, where the Illinoian till is overlain by Wisconsin till, the Illinoian till is tough and compact like the Kansan of this area.

Although at most places the Illinoian till is somewhat less bouldery than the Kansan, it locally contains boulders of granite and other igneous rocks as large as 6 by 8 by 10 feet and still larger blocks of sedimentary rocks. The largest block of rock discovered in the drift is exposed in the bed of Baughman Branch in the NW¼ sec. 32, T. 6 N., R. 2 E., Vermont quadrangle. The block consists of limestone and is 16 feet thick. The stream is entrenched in a small gorge through the limestone for a distance of 50 to 100 feet.

In a ravine in the N½ NW¼ sec. 23, T. 6 N., R. 2 E., Havana quadrangle, a mass of the Springfield (No. 5) coal about 4 feet thick and 15 feet long with its hard black roof shale attached is embedded in till. This is about two miles from the present outcrop of the coal.

A limestone boulder of undetermined age, 6 by 10 by 14 feet, its upper surface polished and striated, is embedded in the till in the SE¼ SW¼ sec. 23, T. 7 N., R. 6 E., Glasford quadrangle.

The abundance of dolomite pebbles in the unweathered Illinoian till (table 4) reflects the prevalence of dolomite formations in the Lake Michigan region, across which the Illinoian glaciers advanced. The percentage of dolomite is twice or more that in the Kansan drift which came from the area where limestone is equivalent to or exceeds dolomite. This criteria for differentiating the Kansan and Illinoian tills of this region was used by Horberg (1956, p. 10, 20) in studies along the Mississippi Valley.

Among the rock types of known source area in the Illinoian till are Niagaran dolomite, probably from northeastern Illinois, and jasper conglomerate from the pre-Cambrian Lorrain quartzite northeast of Lake Huron. The latter type of rock is not known to occur in the Kansan till and its presence in till in this area is considered proof of Illinoian age. It is not sufficiently abundant to be very useful in differentiating the drifts.

Gravel and sand occur in the Illinoian drift in deposits sufficiently thick that gravel pits have been locally opened in them. The gravel deposits range from thin lenses a foot or less thick and only a few feet long to deposits that are nearly 50 feet thick and extend over a considerable area in the vicinity of Frederick in the Beardstown quadrangle. The thickest gravels are outwash deposits overlying the youngest Illinoian till. At many other places gravel occurs between tills and in some places the greater part or even all of the drift is sand and gravel. At a few places fragments of Kansan gumbotil, dark blue-gray compact Kansan (?) till, pre-Illinoian logs and gastropods are incorporated in the till. The inclusion of older Pleistocene deposits is somewhat less common in the Illinoian than in the Kansan till.

The Illinoian drift is rarely more than 60 feet thick in outcrops, but some stream valleys that have more than 120 feet of local relief have not reached bedrock and the Illinoian till is considerably thicker than 60 feet in such places. At many places in the upland areas the Illinoian till is less than 10 or even less than 5 feet thick. On some slopes the Peorian loess truncates the till and rests on bedrock. The average thickness of the till is probably 25 to 35 feet.

Payson Substage

The Payson substage is named for Payson, Pike County, which is on the outermost Illinoian moraine (Leighton and Willman, 1950, p. 602). In this area the till plain outside the Jacksonville and Buffalo Hart moraines is referred to the Payson drift. It is the surface drift of the northwestern and west-central parts of the Beardstown quadrangle and approximately the western one-fourth of the Vermont quadrangle west of Vermont, Table Grove, and New Philadelphia (pls. 1, 4).

Although the Payson drift is generally less than 20 feet thick over the higher part of the Pleasantview ridge, it is at least 140 feet thick in the vicinity of Bader in the Beardstown quadrangle, where it obliterates the pre-Illinoian Valley of Sugar Creek. It is 110 feet thick in sec. 34, T. 6 N., R. 1 W., Vermont quadrangle, where it obliterates a pre-Illinoian Valley that seems to have drained southwest into the Macomb quadrangle.

The Payson drift generally contains less gravel or sand than Jacksonville or Buffalo Hart drift, but at several places close to the

Jacksonville and Buffalo Hart moraines it is overlain by sand or gravel outwash.

Geologic sections 46, 55, 58, 59, 64, 66, 68.

Jacksonville Substage

The Jacksonville substage is named for Jacksonville in Scott County, which is on the Jacksonville moraine (Ball, 1937, p. 219). At its maximum advance the Jacksonville glacier formed a large lobe that extended down the broad lower Illinois Valley. On the northwest side of the Illinois Valley the moraine is close to the bluffs in areas with a high bedrock surface, such as the Pleasantview ridge, but it bends several miles inland into areas of low bedrock surface, such as the buried pre-Illinoian valleys of lower Sugar Creek in the Beardstown quadrangle and Spoon River in the Havana quadrangle. The west side of the lobe of this moraine on the east side of Sugar Creek Valley is on the lower eastern slope of the Pleasantview bedrock ridge. The building of this moraine soon after the obliteration of the pre-Illinoian valley of lower Sugar Creek by the older Illinoian crowded Sugar Creek higher on the flanks of the ridge and led to its present deep entrenchment.

The area in which Jacksonville drift forms the surface deposits is confined to the Beardstown quadrangle, but the position of the moraine across the Havana and Glasford quadrangles, where it is buried by Buffalo Hart drift, is clearly indicated by marginal valleys and outwash gravels and is faintly indicated by buried morainic topography.

The Jacksonville drift contains much outwash sand and gravel. About two miles west of the Beardstown quadrangle thick gravel deposits occur on the outer slope of the moraine, but where the moraine is on the flank of the Pleasantview ridge the outwash is principally in the Coal Creek gap through the moraine and on its inner southeastern slope. The greatest thickness of outwash gravel is 46 feet, about one-third mile northwest of Frederick, in the NE¼ SE¼ sec. 7, T. 1 N., R. 1 E. In this vicinity the gravel is coarse and poorly sorted with numerous boulders more than 2 feet in diameter; one boulder 3½ feet in diameter was noted. Some of the gravel is cemented with calcium carbonate to a firm conglomerate. The gravel overlies till and is in turn overlain by Farmdale or Peorian loess. The gravel commonly is cross-bedded in various directions. Some beds dip southeast toward the Illinois Valley. This gravel may have been deposited on the glacial surface or in a depression between the glacier and the valley slope.

Geologic sections 46, 48, 55, 58, 59, 64, 66.

Jacksonville–Buffalo Hart Deposits

Inside the Buffalo Hart moraine in the Vermont, Havana, and Glasford quadrangles, deposits of gravel, sand, and silt occur within the Illinoian drift and are overlain by Buffalo Hart till. These include Jacksonville outwash deposits, alluvial or lacustrine deposits formed during the Jacksonville recession, outwash from the advancing Buffalo Hart glacier, and Buffalo Hart ice-contact deposits.

The intra-Illinoian gravel and sand deposits (geol. secs. 58, 65, 66) have a maximum thickness of about 30 feet. At one exposure in the Havana quadrangle, gravel and sand is interlaminated with several bands of till.

Along a tributary of Big Sister Creek in the Havana quadrangle (geol. sec. 54, fig. 55) a series of 234 regular alternations of sand and silt varves seem to be annual deposits that accumulated in a lake fed by glacial meltwater. The varved deposits overlie sand and gravel containing large blocks of coal. In places the varved deposits are faulted, which suggests that they formed in part over stagnant glacial ice and were let down when the ice melted. An exposure along Copperas Creek in the Glasford quadrangle (geol. sec. 48) shows as much as 55 feet of stratified silt, sand, and gravel overlain by 3 to 8 feet of till between the Farmdale loess above and weathered Kansan silt below. The sediment varies in texture from laminated coarse silt, with a suggestion of annual varves, to fine gravel. Both of these deposits probably accumulated in lakes which were formed in valleys blocked by the Jacksonville glacier.

Deposits of blue-gray calcareous compact laminated silt, overlain and underlain by Illinoian till, are especially well exposed near

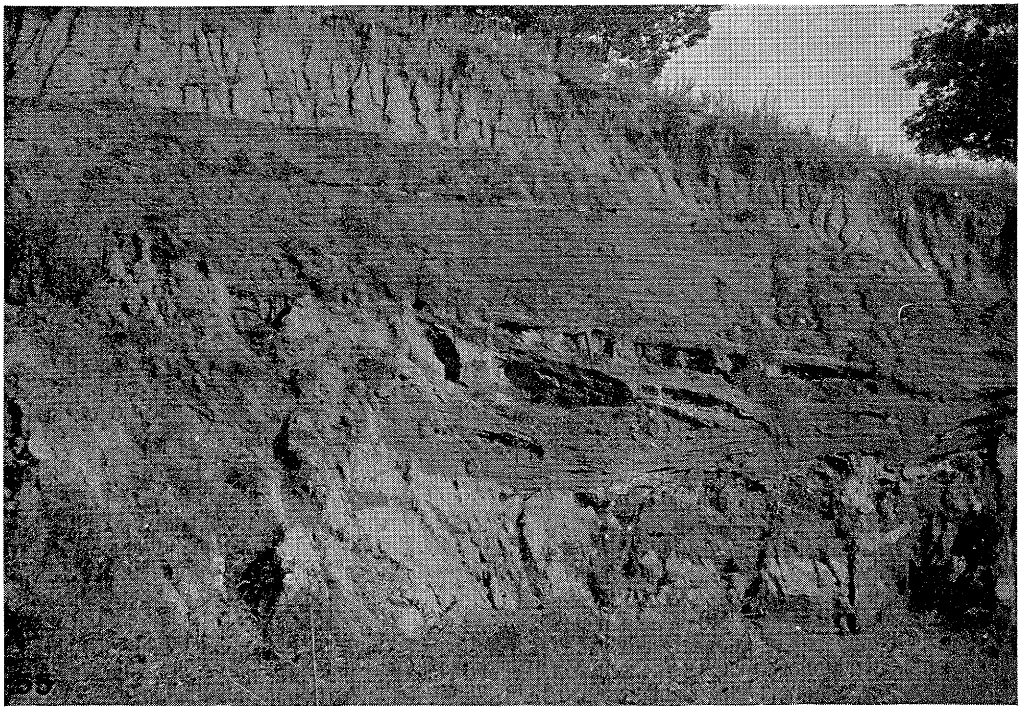


Fig. 55.—Illinoian varved silt and sand in tributary of Big Sister Creek, in the NW ¼ SE ¼ sec. 8, T. 5 N., R. 4 E., Havana quadrangle.

Fig. 56.—Roadcut in Peorian loess showing the typical vertical face of the calcareous loess (below) which is moss covered and dark, and the slightly retreating face of the lighter colored upper zone from which carbonates have been leached, on upland south of Otter Creek, in the SE ¼ SW ¼ sec. 30, T. 4 N., R. 3 E., Havana quadrangle.

the south border of the Havana quadrangle (geol. sec. 65). In a few exposures it is separated from the underlying till by one foot or less of sand and gravel. The underlying till is calcareous but the uppermost 6 inches is strongly oxidized. This silt occurs in the interlobate trough between the Sugar Creek and Spoon River lobes of the Jacksonville moraine. The underlying till is of Payson age.

Buffalo Hart Substage

The Buffalo Hart substage is named for Buffalo Hart in northern Sangamon County (Leverett, 1899, p. 74-76). The Buffalo Hart moraine extends through the northeast part of the Beardstown quadrangle and then northward through the west part of the Vermont quadrangle. Buffalo Hart deposits also form the surface drift through all of the upland areas of the Havana and Glasford quadrangles.

Outwash deposits are scarce along the moraine but some gravel and sand occurs over the older Illinoian till and under the Farmdale or Peorian loess along small ravines that drain westward from the moraine toward Sugar Creek, both north and south of Vermont. Buffalo Hart till cannot be differentiated from the older Illinoian tills, except locally where intra-Illinoian gravel, sand, and silt deposits are present.

Geologic sections 50-52, 58, 61, 64, 66, 69.

SANGAMON STAGE

The Sangamon interglacial stage is represented by the weathered zone on Illinoian till and outwash. The profile of weathering that developed during Sangamon time is exposed in many roadcuts in all four quadrangles. Moderately well drained profiles of the silttil or mesotil type are common along the margins of valleys, as in a cut along U. S. Highway 24 south of Otter Creek in the Havana quadrangle (geol. sec. 61).

The poorly drained or gumbotil profile is displayed in the steep banks at the edges of strip-mining operations in the northern part of the Havana quadrangle (geol. secs. 51, 52) and along the deep cuts of the Chicago, Burlington and Quincy railroad east of Sugar Creek in the Beardstown quadrangle. In this area the gumbotil, mesotil, or silttil ranges from 2 to 6 feet thick.

The humus zone overlying the gumbotil is not commonly well displayed, but in an exposure about 1½ miles south of Astoria in the SE¼ SW¼ sec. 26, T. 3 N., R. 1 E., Beardstown quadrangle, 1½ to 2 feet of black soil occurs beneath Farmdale loess and over Illinoian gumbotil. Beneath the gumbotil the Illinoian drift is commonly oxidized and leached to a depth of 3 to 6 feet, and it is oxidized but not leached for an additional 4 to 12 feet. In some exposures the Illinoian till is so thin that it has been entirely leached.

In the southwest part of the Vermont quadrangle Buffalo Hart outwash has been weathered to a gumbosand at a few localities. The laminated silt and sand overlying Illinoian till in the Glasford quadrangle (geol. sec. 48) is noncalcareous to a depth of 20 feet.

WISCONSIN STAGE

Glaciers of Wisconsin age covered much of northeastern Illinois and extended to within two miles of the northeast corner of the Glasford quadrangle but did not cover any part of this area (fig. 57). However, loess deposits of at least three substages are widespread. Also Illinois and Spoon valleys contain extensive gravel and sand deposits of Wisconsin outwash. Many of the tributary valleys were ponded by the floods of glacial waters carried through the Illinois Valley during the Wisconsin glacial stage, and slackwater deposits of sand and silt accumulated in the temporary lakes. On the outwash terraces wind blew the sand into dunes.

The Wisconsin stage is subdivided into five substages: Farmdale, Iowan, Tazewell, Cary, and Mankato. It is probable that all of these substages are represented in this area, but the Mankato substage is less definitely identified than the others.

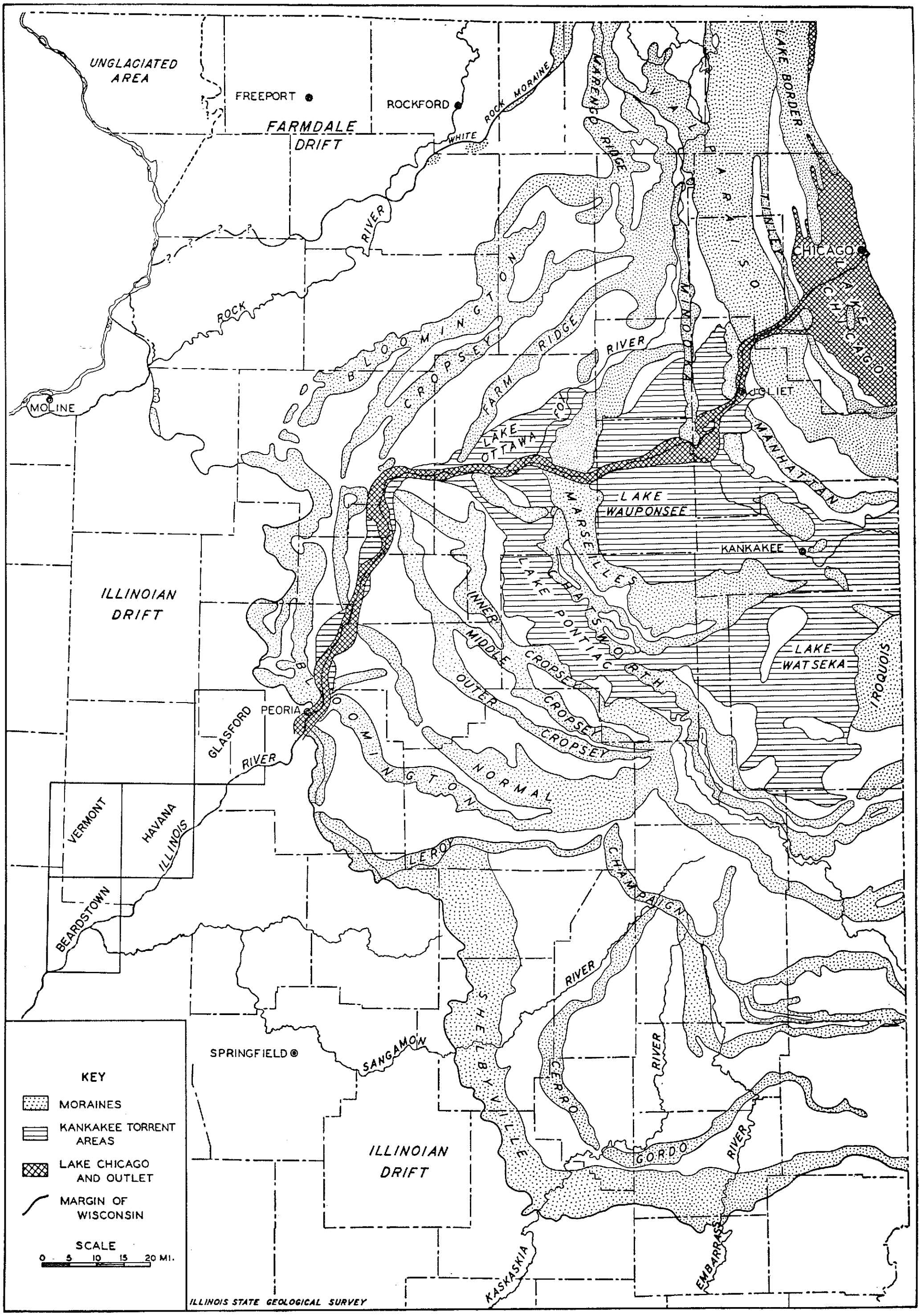


FIG. 57.—Wisconsin moraines in Illinois, by George E. Ekblaw.

Farmdale Substage

The Farmdale substage is named for Farmdale, in Tazewell County (Leighton, *in* Wascher, Humbert, and Cady, 1948, p. 390), west of which the Farmdale loess is well exposed along Farm Creek. In this area the substage is represented largely by the Farmdale loess but includes local deposits of peat and water-laid wood-bearing silts. The loess is believed to be derived from Farmdale valley-train deposits along the Illinois Valley. The presence of the Farmdale glacier in northern Illinois recently has been reported (Shaffer, 1954b).

FARMDALE LOESS

The Farmdale loess is almost continuously present in the uplands of the area overlying weathered Illinoian till and underlying Peorian loess. In a few places in the plain along the west border of the Vermont quadrangle the Farmdale loess is absent and the Peorian loess rests on Illinoian till. At places along the margins of valleys the Peorian loess extends down the valley slopes and truncates the Farmdale loess to rest on Illinoian till or even on bedrock. The Farmdale loess averages 2 to 3 feet thick in the Vermont quadrangle and in those parts of the other quadrangles farther than six or eight miles from the Illinois Valley bluff. Near the bluff the loess is commonly 4 to 9 feet thick and it is 10 to 18 feet at five localities in the Beardstown quadrangle.

The Farmdale loess is commonly pinkish or reddish gray to chocolate brown where drainage conditions are fairly good, but it may exhibit an upper ashy gray to dark gray or black zone in poorly drained flattish areas. The loess is noncalcareous at nearly all localities, except for secondary carbonates. At one exposure in the Havana quadrangle (geol. sec. 60) the loess is 9 feet thick and the lower 3 feet 3 inches is calcareous. The loess appears to have been leached as deep as 5 feet 9 inches before the deposition of the overlying Peorian loess. Unlike the other loesses in this area molluskan shells are rare and have been found in the Farmdale loess at only one locality (app. C). Shells may have been present before leaching, as the Peorian loess is quite fossiliferous at some places and nonfossiliferous at others. Fragments of wood or even logs occasionally are found in the humus on the Farmdale loess, and a peat has been exposed during strip mining operations in the north part of the Havana quadrangle (John Voss, personal communication). Logs have been reported in well borings in a 3-foot zone, probably Farmdale peat, at a depth of 16 feet near Glasford. The partially indurated femur of a mammal was found associated with wood in peaty soil at an outcrop in sec. 1, T. 5 N., R. 4 E., Havana quadrangle.

Geologic sections 48, 51-53, 59-62, 66, 68, 69.

Iowan Substage

The Iowan substage is named for the drift of the Iowan lobe of glaciation in eastern Iowa (Chamberlin, 1895, p. 270-277). The Iowan was formerly considered a glacial stage, but it was later designated a substage of the Wisconsin stage (Leighton, 1933, p. 168).

An extensive valley train along Mississippi River, which still followed Illinois Valley during Iowan time, was the source of a thick mantle of loess blown onto the uplands of the area. The surface of the valley train was at a level lower than later Wisconsin valley trains, and the Iowan outwash deposits are not differentiated from the later deposits. The Iowan loess, likewise, generally cannot be differentiated from the later Wisconsin loess but its presence is demonstrated by exposures a few miles east of Peoria along Farm Creek (Leighton, 1926, 1931), where the brown Farmdale loess is overlain by 6 feet of buff Iowan loess, which in turn is overlain by Tazewell till, and 7½ feet of buff Tazewell loess. In this area, which is outside the region covered by Tazewell till, the two buff loesses merge into a single deposit to which the name Peorian is applied. The Tazewell loess possibly includes some Cary and Mankato deposits but these are believed to be relatively minor. The Peorian thus includes all the undifferentiated Wisconsin loess younger than Farmdale loess. Although the Peorian loess generally cannot be subdivided into Iowan and Tazewell components on the till plains, they can be differentiated in some of the terraces in the valleys. The loess which underlies outwash and slackwater deposits of Tazewell age is Iowan loess (geol. sec. 53) and that above is Tazewell loess. From the thicknesses in the area covered by Tazewell till it appears that the Iowan comprises somewhat less than half of the Peorian loess.

Peorian Loess

The Peorian loess covers all the upland plains of the area and mantles the upper slopes of most of the stream valleys. It is absent along the smaller tributaries that were cut after the deposition of the loess, and along the Illinois Valley, which was occupied by valley trains when the loess was being deposited. The loess has been eroded from areas where outcrops and pre-Illinoian Pleistocene deposits are mapped (pls. 1-4). It generally is missing from valley bottoms where recent alluvium is mapped, except along small valleys where the loess is locally overlain by alluvium.

The loess ranges generally from 6 feet to more than 50 feet and is as much as 90 feet thick along the bluff southeast of the Illinois Valley in Cass County. Thicknesses measured just east of the Beardstown quadrangle show the following relations between thickness and distance from the valley margin (Smith, 1942, p. 157):

Distance from bluff (miles)	*Thickness (feet)*
0.2	92
0.5	68
1.75	32
2.0	26
4.0	18
5.5	17½
10.0	14

The loess is thinner northwest of the Illinois Valley, and a maximum of 35 to 40 feet was observed at a few places along the bluff near Frederick and near the mouth of Spoon River. The greater height of the bluff southeast of the Illinois Valley appears to be due largely to the greater thickness of loess. On both sides of the valley the surface of the land has a slight slope away from the bluffs because of the rapid thinning of the loess. The loess locally thickens slightly along the bluffs of Spoon River but its thickness is not related to any of the other valleys.

The loess is a very uniform gray to buff unstratified silt. It is somewhat coarser in texture near the Illinois River bluffs than elsewhere and is coarser southeast of the valley than northwest. Tests of two samples showed that 95.5 to 99.8 percent of the grains pass the 200-mesh sieve (openings 1/16 mm.). The coarser material consists principally of 1) hollow tubes, probably root canals lined with calcite to which the silt particles adhere, 2) a few grains of quartz sand, and pyrite, and 3) a few flakes of muscovite and biotite mica. Although the loess is scarcely cemented, it stands easily in steep faces and possesses a distinctly vertical jointing (fig. 56).

The loess is calcareous where unweathered. Much of the calcium carbonate is in very fine particles, but large calcareous concretions, very irregular in shape and several inches long, are abundant at some localities. Small concretions of limonite are present, principally in the weathered loess. Fresh loess is yellowish gray or mottled gray and buff. Where weathered it changes to a light yellowish brown in most exposures, although it may be reddish brown on the slopes of large valleys where it was weathered under good drainage. This loess is the parent material of nearly all present-day soils of the region.

Calcareous Peorian loess is abundantly fossiliferous at many places (appendix C). The species are all terrestrial gastropods except three—*Stagnicola caperata, Pomatiopsis scalaris,* and *Fossaria parva tazewelliana*—which inhabit moist meadows that are covered by water during some seasons but where loess may accumulate at other seasons. The first two species are restricted to loess on the lower slopes of valleys, but the last is found in all topographic situations. Three of the species —*Columella alticola, Vallonia gracilicosta* and *Succinea grosvenorii*—are now found only in the drier western states.

Geologic sections 46, 48, 51, 52, 58-62, 66, 68, 69.

Tazewell Substage

The Tazewell substage is named for Tazewell County, Illinois, in which moraines of this substage are well developed (Leighton, 1933, p. 168). Drift of Tazewell age covers most of northeastern Illinois, and its outer margin is commonly marked by a prominent moraine, the Shelbyville. During the retreat of this glacier several minor readvances resulted in the following succession of moraines: Cerro Gordo—Leroy, Champaign, Bloomington, Metamora, Normal, Cropsey, Farm Ridge, Chatsworth, and Marseilles (fig. 57). Some of these are complex morainic systems. The Illinois Valley served as an outlet for meltwaters of all these glaciers. The Sangamon River carried meltwaters from the Shelbyville, Cerro Gordo, Leroy, Champaign, Bloomington, Normal, and Cropsey glaciers, and Spoon River and Kickapoo Creek carried discharge from the Shelbyville and Bloomington glaciers.

The largest volume of outwash material is of Bloomington age. This largely buried the earlier deposits of Shelbyville to Champaign age. Outwash later than the Bloomington was smaller in volume, was transported from greater distances, and was later modified by torrential waters during the Cary substage.

PRE-BLOOMINGTON DEPOSITS

A part of the valley fill of the Illinois and Sangamon valleys is probably Wisconsin outwash older than Bloomington, but it has not been differentiated from younger outwash.

Terraces along Kickapoo Creek in the northeast part of the Glasford quadrangle consist of gravel and sand mostly of Shelbyville age (geol. sec. 47). The water-bearing sands in Spoon River Valley in the Havana and Vermont quadrangles probably are also Shelbyville outwash.

BLOOMINGTON DEPOSITS

The Bloomington moraine (fig. 57) crosses the Illinois Valley just north of Peoria. An immense fan-shaped deposit of outwash in the Illinois Valley extends from the moraine down the valley farther than Beardstown (fig. 58). The major part of the sand and gravel fill that buries the bedrock surface to an average depth of about 100 feet is believed to have been formed at this time. Lakes were formed in the lateral tributaries on the northwest side of the Illinois Valley when they were dammed by the outwash and flood waters. Silts were washed into these lakes from the Illinois Valley, and deltas of gravel, sand, and silt were built at the upstream ends of the lakes.

Outwash in the Illinois Valley.—Outwash deposits in the Illinois Valley near Beardstown and Havana average nearly 100 feet thick in the terrace area southeast of the river, but these include some deposits older than Bloomington. The surface of the valley train in the Beardstown, Glasford, and Havana quadrangles was eroded by flood waters during the Cary and Mankato substages, and the upper sediments may have been largely redeposited at those times. Smooth plains, which are probably the original surfaces of the valley train, are found farther east in the Delavan and Manito quadrangles. The valley fill is well washed gravel near the head of the fan, but it grades downstream to fine gravel, gravelly sand, and sand with occasional small pebbles. Some wells penetrate interbedded gravel and sand, indicating a fluctuation in volume of the discharge.

The gravel is well exposed in the pit of the Kingston Lake Gravel Company, in the north bank of the Illinois River, in the SE¼ SW¼ sec. 30, T. 7 N., R. 7 E., Glasford quadrangle, and in a gravel pit at Liverpool in the Havana quadrangle. The 20-foot face shows 2½ feet of Recent silt and sand over 5 to 6 feet of flat-bedded sandy gravel, which in turn overlies 10 to 11 feet of strongly cross-bedded gravel with foreset beds dipping west-southwest at angles of 20°-25°. The elevation of the surface is here 450 feet above sea level compared with an estimated elevation of 550 feet for the original surface of the valley train at this locality. The flat-bedded gravel appears to be a Chicago Outlet River deposit and the cross-bedded gravel is Bloomington outwash.

Fine sandy gravel is well exposed in the roadcut east of Spring Lake in the SW¼ SW¼ sec. 20, T. 24 N., R. 6 W., Glasford quadrangle, and in a nearby gravel pit, where the surface elevation is about 500 feet, probably 30 feet below the original surface of the

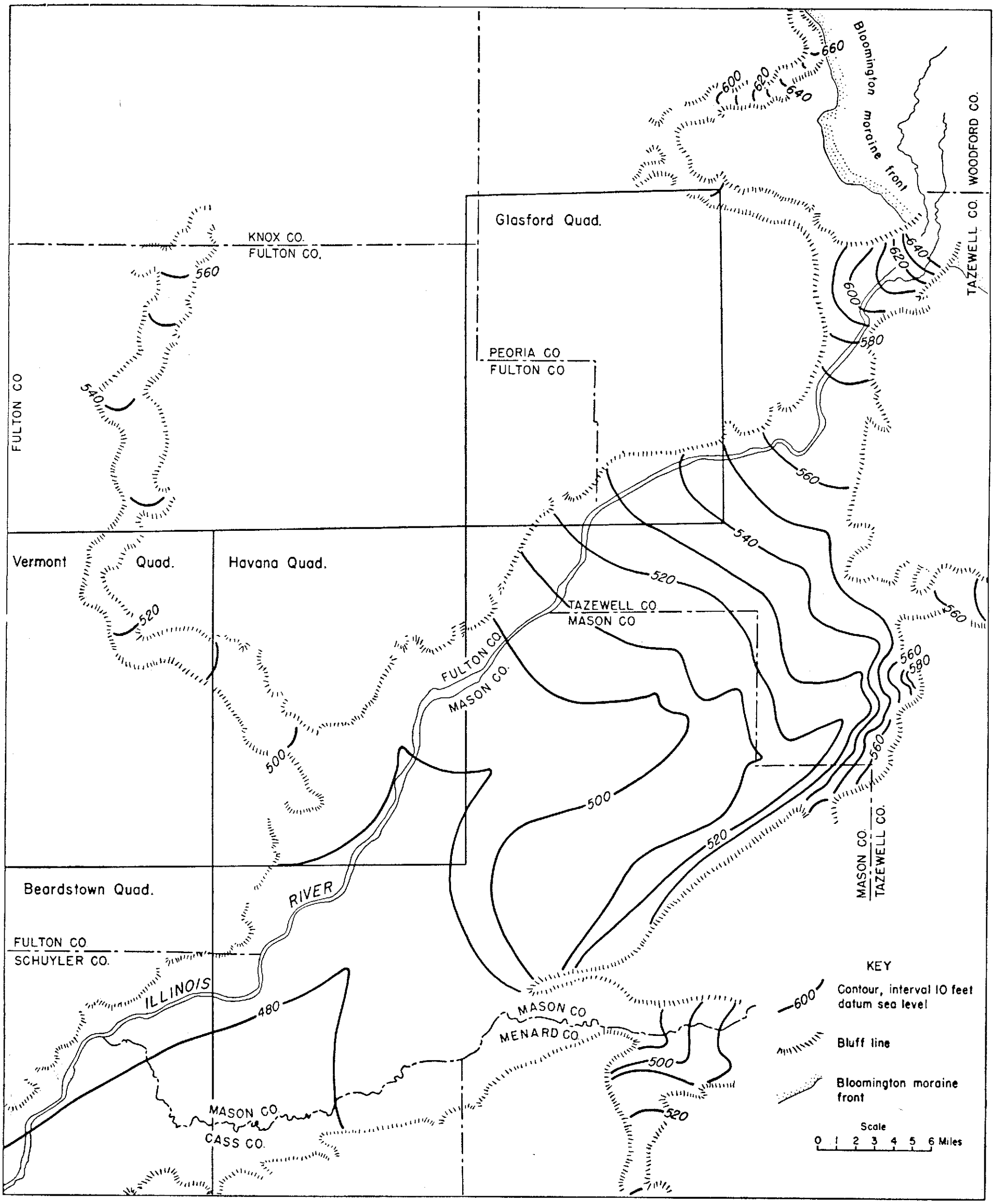


FIG. 58.—Contour map showing the original form of the Bloomington valley train.

fan. The pebbles average 1 or 2 inches in diameter, and a few are as large as 4 inches. Cross-beds dip southwest down the Illinois Valley.

In the Havana quadrangle an exposure in the Illinois River bluff at Riverside Park (geol. sec. 67) shows about 6 feet of horizontally bedded sand over gravelly sand with foreset beds dipping down the valley. The gravel pit of Ted Heffernan in the NW¼ SW¼ sec. 10, T. 3 N., R. 3 E., Havana quadrangle, shows 13 feet of cross-bedded gravel at an elevation of 440 feet in an area now subject to overflow by the Illinois River.

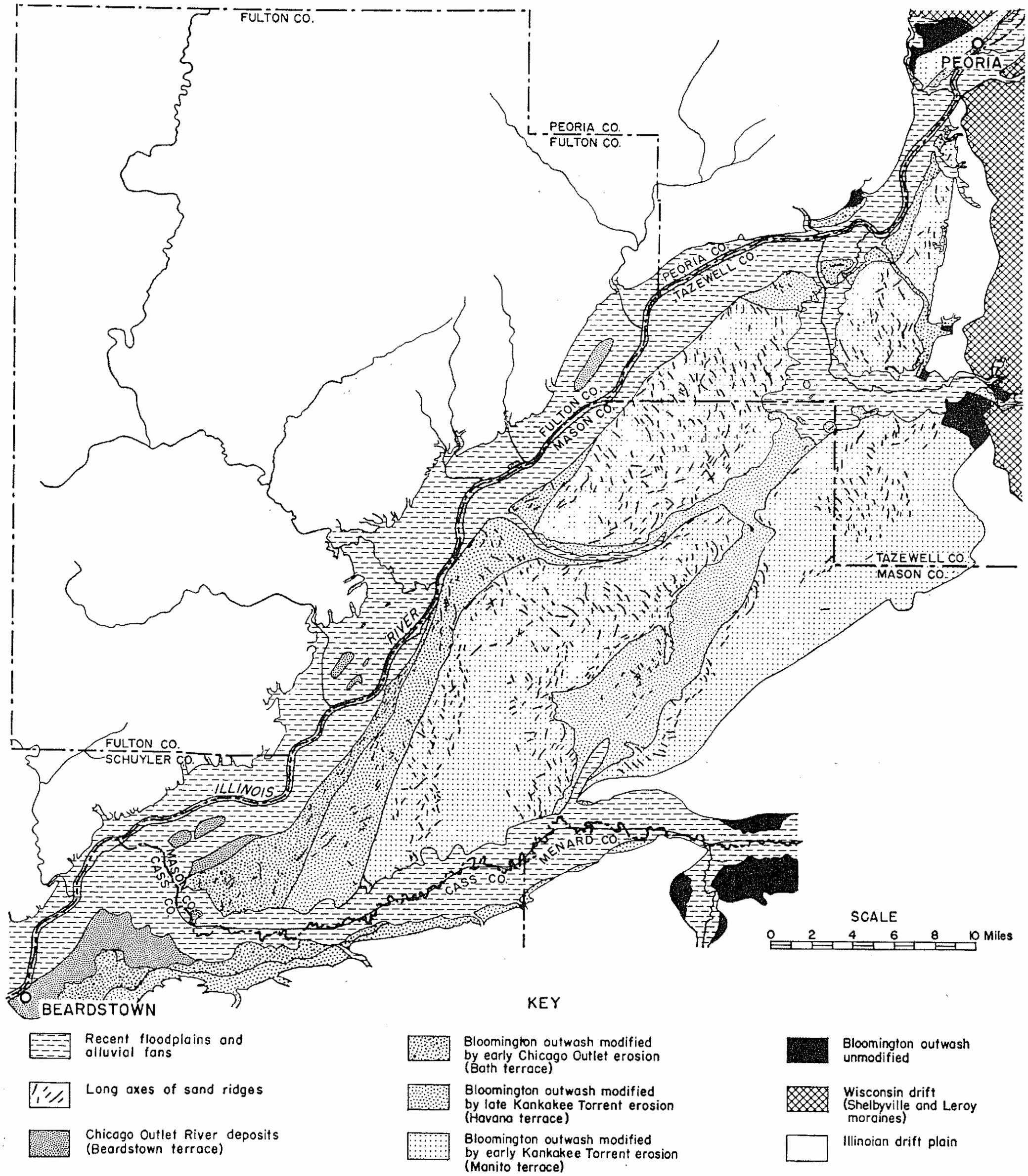


Fig. 59.—Distribution of terraces and pattern of sand ridges in Illinois Valley from Peoria to Beardstown.

In the Beardstown quadrangle an exposure on the north bank of Wilcox Lake, in the NW¼ SW¼ sec. 29, T. 19 N., R. 10 W., shows 32 feet of sand, apparently containing only a few very small pebbles. It is reported that wells near Beardstown penetrate 20 to 25 feet of sand over 2 feet of red clay with elevation 431 feet that overlies 10 feet of coarse sand and about 60 feet of gravel. These scattered outcrops, pits, and borings suggest uniform outwash grading downstream from gravel to sand.

Outwash in other valleys.—Kickapoo Creek, Spoon River, and Sangamon River carried Bloomington outwash directly from the ice front. Kickapoo Creek, in the northeast corner of the Glasford quadrangle, is bordered by a terrace at an elevation of 530 feet, underlain by silt, sand, and gravel (geol. sec. 47). The lower part of these deposits is probably Shelbyville outwash and the silty upper part is a Bloomington lake deposit, indicating that by Bloomington time Kickapoo Creek Valley was ponded by the immense volume of outwash in Illinois Valley.

Spoon River in the Vermont and Havana quadrangles was approximately 50 miles from the Bloomington ice front. Outwash terraces in the valley slope from about 530 feet above sea level in the north part of the Vermont quadrangle to about 495 feet at the junction with the Illinois Valley. The rock floor of the Spoon River Valley is buried beneath 40 to 60 feet of gravel and sand that is mainly Shelbyville outwash. The exposed sections of the terrace show much silt and fine sand that is partly Bloomington outwash (geol. sec. 53). Exposures in the lower four or five miles of Spoon Valley (geol. sec. 56) exhibit the same succession as those in the small valleys northwest of the Illinois Valley that were ponded by the Bloomington valley train. This indicates that Bloomington outwash in the Spoon Valley was not sufficient to build a fan into the Illinois Valley, but that Illinois Valley material was washed into a temporary lake in lower Spoon Valley and there buried an earlier Shelbyville valley train.

Sangamon Valley in the Beardstown quadrangle is entrenched in the south flank of the large Bloomington valley train in the Illinois Valley. Outwash from the Sangamon Valley cannot readily be differentiated from that in the Illinois Valley, and the Sangamon River, like Spoon River, was probably ponded in its lower course by Illinois Valley outwash.

Geologic sections 47, 53, 63, 67.

Bloomington slackwater deposits.—Many of the smaller tributaries to Illinois Valley were dammed by the Bloomington valley train, and the resulting temporary lakes were filled with sediment that was washed in, partly from Illinois Valley and partly from the headwaters of the drainage basins in which the lakes were formed (fig. 60). Terraces of these slackwater deposits are especially prominent in the lowermost mile of the tributaries, so that the valleys of the present streams are appreciably narrowed above their junctions with the Illinois Valley, as is well shown in Otter Creek Valley in the Havana quadrangle. Although the slackwater terraces at the mouths of the tributary valleys have about the same elevation as the valley train in the Illinois Valley, they rise gradually upstream, and the upstream portions are composed of material washed in from the surrounding areas.

The slackwater deposits have a characteristic succession. The lowest exposed unit is commonly a red clay or very fine silt that is massive or poorly laminated, calcareous, and slightly fossiliferous. This is overlain by a pink and gray zone 10 to 20 feet thick, generally consisting of alternate bands of red or pink silt or clay, and gray silt or sand, suggestive of seasonal deposition. The lower part of this zone contains more pink and the upper part more gray material. Exposures closer to the Illinois Valley also are generally pinker than those farther up the tributary valleys where there is generally a larger amount of sand and gravel interbedded with the silt. The silt and very fine sand are generally fossiliferous and contain an aquatic fauna composed of gastropods and pelecypods, together with a few land shells that may have been washed in from nearby Peorian loess deposits. Root (1936) suggests that if the banding of this zone is annual, the pink layers were probably deposited in the summer, when the Illinois Valley was filled with mud-laden waters from the melting glacier, and the gray, more sandy layers were deposited in the winter, when the water level was lower in the Illinois Valley and sediment was washed out from the drainage basin upstream. The Bloomington till is commonly pink or red in northern Illinois and red outwash from the Bloomington ice is believed to be the source of the color in the lower clay and the middle laminated silts.

At one locality in the Havana quadrangle (geol. sec. 56) the laminated silt is mostly gray and is more fossiliferous than elsewhere. It contains an abundance of gastropods and small pelecypods of the genus *Pisidium* (app. C). Fossil wood is common in Bloomington slackwater silts, and logs more than 6 feet long and 7 inches in diameter have been found.

Geologic sections 45, 53, 56, 57, 63, 64.

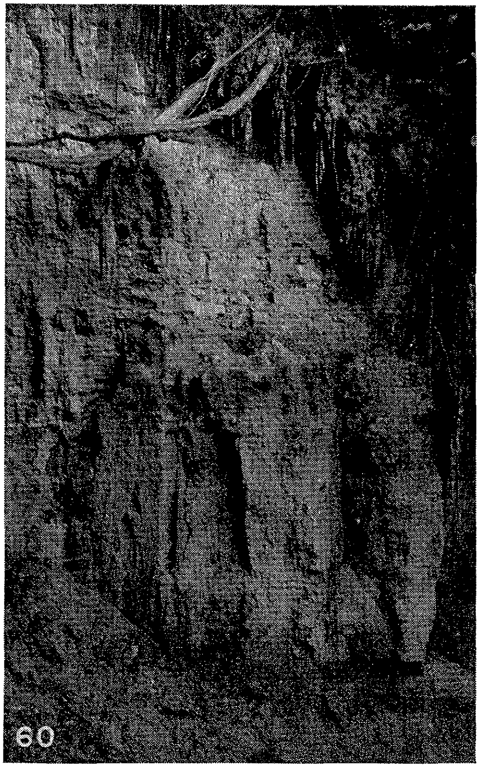


FIG. 60—Bloomington slackwater silt and clay, southeast side of East Creek, in the NW ¼ NE ¼ sec. 11, T. 4 N., R. 3 E., Havana quadrangle.

FIG. 61.—Mudcracks on the Spoon River floodplain at Duncan Mills. The larger mudcracks formed after a long period of inundation in the spring of 1927, and the smaller ones after one or two days of flooding in the fall of the same year.

Tazewell Loess

The Bloomington slackwater deposits generally are overlain by 5 to 15 feet of gray to buff Tazewell loess or loess-like silt. Although the lower part of the silt exhibits feeble lamination at some places and may be waterlaid, the major part of it resembles a typical loess and has characteristic vertical jointing. It is calcareous except where weathered and contains a fauna of terrestrial gastropods typical of the loess (app. C). The Tazewell loess extends from the terraces up the adjoining valley walls and onto the uplands where it forms the upper part of the Peorian loess. The absence of loess on the Kankakee Torrent terraces of Illinois Valley indicates that the deposition of the loess had almost entirely ended by early Cary time.

Geologic sections 45, 56, 57.

Cary Substage

The Cary substage is named for the village of Cary in McHenry County, Illinois, which is located on a prominent part of the Valparaiso morainic system (Leighton, 1933, p. 168). The Cary glacier invaded extreme northeastern Illinois and deposited the Minooka, Manhattan, Valparaiso, Tinley, and Lake Border moraines (fig. 57). Illinois Valley carried meltwater from the glacier during the building of these moraines, and early in Valparaiso time unusually large drainage from an extensive ice front produced a glacial flood, the Kankakee Torrent. The erosion by this torrent, the deposits of the declining waters, and sand dunes formed on the terraces following the flood, constitute the record of the Cary substage in this area.

KANKAKEE TORRENT

During Valparaiso time meltwater from the south portion of the Cary glacier occupying Lake Michigan basin, as well as from the Saginaw and Erie ice lobes in Michigan and Indiana, poured into the Kankakee River and thence into the Illinois River and created the Kankakee Torrent (Ekblaw and Athy, 1925). The effects of this torrent in the mid-Illinois Valley below the head of the Bloomington valley train near Peoria were both erosional and depositional.

The Kankakee Torrent was constricted through the narrow valley at Peoria but south of there it spread over the Bloomington valley train and eroded three principal channels: 1) the present Illinois Valley along the northwest margin of the valley train, 2) a valley starting at the sharp north bend of lower Mackinaw River about three miles southeast of the Glasford quadrangle, extending southwest into the valley of Quiver Creek, and joining the present Illinois Valley in the east part of the Havana quadrangle, and 3) a valley branching southeast from the preceding in sec. 17, T. 22 N., R. 6 W., and extending south and southwest into the valley of Crane Creek to join Sangamon Valley in sec. 36, T. 20 N., R. 8 W.

In the constricted valley between Peoria and Pekin the entire surface of the valley train was destroyed. In the broad valley below Pekin the valley train was modified but not wholly destroyed. Four large segments of the modified valley train are 1) between the present Illinois and Quiver Creek valleys, including the sandy terrace area in the southeast part of the Glasford quadrangle and a very small area north of Quiver Creek in the Havana quadrangle; 2) south of the Quiver Creek valley, northwest of Crane Creek, southeast of Illinois Valley and north of Sangamon Valley, including the remainder of the sandy terrace in the Havana quadrangle and an area in Lynchburg township in the Beardstown quadrangle; 3) between Crane Creek valley and the southeast margin of the valley train; and 4) between Mackinaw Valley, Illinois Valley, and the east margin of the valley train near Pekin. The third area was modified least.

Because the flood waters came from large lake-like expansions between the moraines in the upper Illinois Valley, it is improbable that they introduced much new sediment into this area. The deposits are therefore probably mainly reworked Bloomington outwash.

A system of elongate bars was developed on the surface swept by the floods, and their long axes aid in reconstructing the major currents (fig. 59). The bars closest to the Illinois River trend south or southeast, nearly at right angles to the direction of the valley, then curve gradually southwestward as they approach the Quiver Creek or Crane Creek outlets. Similar bars curve away from the Quiver Creek and Crane Creek outlets. The bars are now elongate sand ridges modified by wind action. Several occur in Havana; on one of them the old high school and water tower are situated. Many others are present east of Havana and in the extreme southeast part of the Glasford quadrangle.

Some of the largest bars occur just east of the Havana quadrangle in secs. 21 and 27, T. 23 N., R. 7 W., Manito quadrangle, where two segments of one ridge rise approximately 80 feet above the adjacent plain to an altitude of about 590 feet. This is probably 60 to 70 feet above the original level of the Bloomington valley train at this point and about 150 feet above the present level of Illinois River. The size and height of these bars indicate the immense volume of water that passed through the valley during the Kankakee Torrent stage. Cuts in the sand ridges generally reveal sand or pebbly sand similar to the deposits of the valley train. In several exposures flat-bedded sand or gravel truncating the inclined foreset beds of the Bloomington valley train are believed to be Kankakee Torrent deposits.

Two ill-defined levels covered by Kankakee Torrent waters are named the Manito and Havana terraces, the Havana being the lower. The lower terrace borders the Illinois River, Quiver Creek, and Crane Creek valleys and suggests that during its later stages the torrent was restricted to these valleys. In a few places two systems of sand ridges cross one another nearly at right angles, the earlier ridges trending away from the Illinois

Valley and the later ridges paralleling the Quiver Creek valley.

On the northwest side of the Illinois Valley and the lower portions of the tributary valleys, there are commonly terrace remnants 20 to 25 feet lower than the level of the Bloomington valley train and slackwater deposits. These terraces correspond in level to the Havana terrace and are presumably of the same age. Cuts in these terraces commonly show a few feet of sand and gravel unconformably overlying the laminated pink and gray silt or the red clay of the Bloomington slackwater deposits or resting directly on bedrock. In the terrace at Duncan Mills on Spoon River less than one foot of sand overlies Pennsylvanian bedrock, and in sec. 13, T. 5 N., R. 4 E., Havana quadrangle, a rubble of pebbles rests on pink calcareous silt. These terraces are principally erosional and appear to be contemporaneous with the degradation of the Bloomington valley train by Kankakee Torrent waters.

SAND DUNES

The wind has reworked the sands of the Kankakee Torrent bars and produced numerous dunes and blowouts. Dunes are distributed over the broad sandy terrace east of the Illinois Valley and lesser areas of dunes occur on terraces along Spoon River and on the upland of the southeast part of the Beardstown quadrangle. One of the principal dune areas extends from near the southeast corner of the Havana quadrangle southeastward about 7 miles to the junction of the Crane Creek and Sangamon valleys in the Petersburg quadrangle.

On the south side of Sangamon Valley sand blown from the valley mantles the slopes and forms small dune patches on the bluffs. The cross-bedded sand rests unconformably on Peorian loess. The relation of the sand to Peorian loess on the valley slope is well shown in the road ascending the bluff in the SE¼ NW¼ sec. 17, T. 18 N., R. 10 W., Beardstown quadrangle.

The dune sand is fine to medium and small pebbles may be found on the floors of blowouts that penetrate the underlying water-laid deposits. The sand contains 15 to 20 percent feldspar (Willman and Payne, 1942).

Most of the dunes are stabilized by forest growth or grass, but in several areas the soil has been too intensively farmed and shifting of the sand has been resumed. The major time of dune formation probably was immediately after decline of the Kankakee Torrent, before vegetation was well established, but some of the dunes have occasionally migrated onto the terraces and even onto the uplands since the torrent.

MANKATO SUBSTAGE

The Mankato substage is named for Mankato, Minnesota, which is on the drift of the latest major advance of the Wisconsin glaciers (Leighton, 1933, p. 168).

The Mankato glaciers did not reach Illinois, but during Mankato and the latter part of Cary time, Lake Chicago formed behind the Cary moraines in the Lake Michigan basin and drained into the Illinois Valley.

The Lake Chicago waters, although of large volume, appear to have been restricted to the present Illinois River Valley. The Quiver Creek Valley may have carried early Lake Chicago waters for a short time. Two terraces below the lowest Kankakee Torrent terrace seem to record two stages of Lake Chicago drainage.

The Bath terrace is the higher of the Lake Chicago terraces and covers a large area in the east-central part of the Beardstown quadrangle and a narrow strip near Matanzas Lake near the south border of the Havana quadrangle. It is named for the town of Bath which is located in the latter area. The surface of the Bath terrace is about 20 feet below the Havana terrace. In this area the terrace appears to be an erosional surface on the older sands and gravels. The few sand ridges in this area nearly parallel the trend of Illinois Valley and probably were built in Lake Chicago time. The sand in the ridges is similar to that underlying except that it is flat-bedded instead of cross-bedded.

The Beardstown terrace is only 10 to 20 feet lower than the Bath terrace and only 5 to 15 feet above the present floodplain. It covers a large area at and northeast of Beardstown. A meander system unlike that of the present river is well preserved on the terrace (fig. 8). The meander channels, and in fact most parts of the Beardstown terrace, are so low that they are inundated during major floods of Illinois River. Knapps Island between Stewart and Crane Lakes, the low ridges in the Illinois floodplain in the south part of the Havana quadrangle in which the Heffernan gravel pit is located, Liverpool Island, and the low terrace in which the Kingston Lake Sand and Gravel Company pit is located on the north bank of the Illinois River at the east margin of the Glasford quadrangle are all remnants of the Beardstown terrace. The exposures in pits on this terrace show 2 to 6 feet of flat-bedded sand or gravel over leached inclined foreset beds of the Bloomington valley train.

RECENT STAGE

Since the last Lake Chicago waters passed through the Illinois Valley, several different kinds of deposits have been formed under conditions unrelated to glaciation. Most of the types of these postglacial deposits are still in process of formation.

River and Stream Alluvium

FLOODPLAINS

Floodplains extend along all the major and most of the smaller streams, as shown on the geologic maps (pls. 1-4), but they extend up the smaller valleys much farther than they can be mapped. Many of the smaller streams are entrenched in smooth grass-covered floodplains 5 to 15 feet above the streams and too high to be inundated except briefly after exceptionally heavy rains. These flats are considered by some to have been abandoned as floodplains since settlement of the area about one hundred years ago. Cutting the forests increased the amount of runoff and thus deepened the stream channels. The floodplains in these smaller valleys consist of highly variable material, depending upon the composition of the valley walls. Most of the alluvium has a matrix of silt which is reworked loess from the uplands.

The larger floodplains are generally floored with clay, silt, and sand (fig. 61). The upper deposits are displayed in stream cuts commonly 5 to 10 feet high but the base of the recent alluvium and the substratum on which it rests are generally concealed. Before drainage, flood control, and navigation developments, the Illinois floodplain included a large series of floodplain lakes and numerous such lakes are present today in the Beardstown quadrangle (fig. 6). The sediment in these lakes includes silt and mud carried in during floods, together with vegetable debris and some shells. Peat deposits are found in some parts of the floodplains. The thickness of the Recent floodplain deposits in the Illinois Valley is not easy to determine, as they rest on somewhat similar Lake Chicago deposits. The latter in places have a very thin cover of Recent alluvium but in other places the alluvium is probably as much as 40 to 50 feet thick. Borings for coal in this floodplain north of Illinois River in the Glasford quadrangle show 15 to 20 feet of Recent alluvium resting on bedrock.

CHANNEL DEPOSITS

Channel deposits coarser than those in the floodplains are found in all the streams of the area. The floors of the smaller intermittent streams on bedrock are covered with large angular fragments of sandstone, limestone, black sheety shale or ironstone concretions derived from the Pennsylvanian or Mississippian formations, together with other more rounded boulders of granite, gneiss, and other rock types derived from the drift. Although the Sangamon, Spoon, and Illinois rivers have low gradients and are sluggish streams under normal conditions, they flow rapidly during floods and deposit large sand bars that are exposed at low-water stages.

Alluvial Fans

The smaller streams have built fans of alluvium where they emerge from narrow valleys to the broad flats of larger valleys. The largest fans are in the Illinois Valley and many are shown by an outward bend of the 440- and 460-foot contours at the mouths of tributary valleys. The major alluvial fans and associated areas of slopewash are shown in the geologic maps (pls. 1-3).

A deeply trenched ravine across a large fan in secs. 34 and 35, T. 4 N., R. 3 E., Havana quadrangle (geol. sec. 64) exposes a loess-like silt that is leached to a depth of 5½ feet. Beneath the leached zone the silt contains numerous gastropod shells redeposited from the Peorian loess (app. C). The silt rests on the partially weathered surface of Tazewell slackwater silts. The steeper fans formed by smaller streams usually contain silty sand and gravel as well as silt.

Slopewash

Nearly all of the steeper slopes and many gentle ones are mantled with silt washed down from the Peorian loess on the adjacent uplands, as may be seen in nearly every roadcut along a slope in the area. Such deposits are generally only a few feet thick.

Landslides and Slumps

The steeper slopes throughout the area are affected by slumping, especially during or just after seasons of exceptionally heavy rainfall. Areas especially subject to slumping are those underlain by gumbotils or other plastic Pleistocene materials and by the underclays of coal beds.

Very large landslides have occurred along the deep cuts of the Chicago, Burlington and Quincy Railroad east of Sugar Creek in the Beardstown quadrangle. The most destructive landslides were in the cut in the SE¼ NE¼ sec. 32, T. 2 N., R. 1 E. (Searight, 1929). Exceptionally heavy rains during the fall and winter of 1926 and the spring of 1927 saturated the soils, and late in March or early in April a landslide 950 feet long covered the track. Materials to a depth of 70 feet back from the face of the cut were involved in the slide. The materials in the cut are approximately 24 feet of Peorian and Farmdale loess, more than 15 feet of Illinoian till, and a lower 30 feet obscured by the slump was probably also Illinoian till. Springs and seeps emerge through slumped material 35 feet below the top of the cut, probably from sand and gravel underlying the till of the Jacksonville moraine.

Mine subsidence.—In several areas where the Springfield (No. 5) or the Colchester (No. 2) coals have been mined, subsidence of the overlying strata has produced irregular depressions or sinks in the surface of the till plain. Locally the cave-ins occur under small streams which then drain into the mine workings. Areas pitted by mine subsidence occur near Cuba, St. David, Astoria, and Pleasantview.

Swamp and Lake Deposits

Peat deposits are found at a few places in swamps in abandoned river channels, especially in the lower part of Quiver Creek Valley and in a meandering channel just east and south of Beardstown.

Postglacial lake deposits in the floodplain lakes are principally clays and silts, with varying amounts of plant debris and numerous shells. Most of these lakes have been drained but many still exist in the Beardstown quadrangle.

Soil

The soils of the area are developed principally on the Peorian loess and to a lesser degree on the alluvial sediments of the Bloomington valley train, the Kankakee Torrent, the Lake Chicago Outlet River, and on sand dunes, floodplains, alluvial fans, slope wash, and organic accumulations in lakes or swamps. Development of most of the soils of the area started in Wisconsin time and has continued to the present.

The soils of the area average 3 to 4 feet thick but are thicker on more permeable materials and on the floodplains where sediment is frequently added to the soil. Most of the soils are developed from sediments that were originally calcareous. The Peorian loess has been entirely leached of its original carbonates at a few places northwest of the Illinois Valley where it is relatively thin. Where the Peorian loess includes a calcareous lower portion, as it does at most places, the leached zone ranges from 2 feet 8 inches to 9 feet, averaging 4 or 5 feet. The leached zone on Tazewell loess on terraces of Bloomington slackwater deposits ranges from 3 feet to 6 feet 6 inches, averaging about the same thickness as that on the upland Peorian loess. On Kankakee Torrent sandy deposits southeast of the Illinois River the leached zone ranges from 3 feet 6 inches to 32 feet, the latter being recorded in the bluff north of Wilcox Lake in sec. 29, T. 19 N., R. 10 W., Beardstown quadrangle.

The soils of western Illinois belong to the prairie soils and gray-brown podzolic soils groups, the latter being a hardwood forest soil group. The prairie soil group is a very dark brown soil that grades through brown to a lighter colored parent material at a depth ranging from 3 to 5 feet. The gray-brown podzolic soils have a thin organic layer over grayish-brown leached soil that overlies a brown horizon. Both of these major groups are represented in the Beardstown-Havana-Glasford-Vermont area, the former on the more level till plains and the latter in the more dissected and sloping areas which originally had a forest cover.

The soils of the eight counties in the Beardstown, Glasford, Havana, and Vermont quadrangles are mapped and described in the Soil Reports of the University of Illinois Agricultural Experiment Station (Hopkins et al., 1913a, 1913b, 1916; Mosier et al., 1921; Norton et al., 1934; Smith et al., 1924, 1932, 1947).

Sediments of Human Origin

In his manifold activities man has greatly modified the area. Among the more important deposits resulting directly from his activities are the artificial levees along the Illinois River and the waste piles from strip mining. By deforesting and cultivating the sloping lands man has accelerated erosion and the formation of floodplain and channel deposits and alluvial fans. Through the building of artificial levees the height of great floods has been increased. This has resulted in greater flood velocities and, therefore, coarser textured sediments on the natural levees and floodplains. Slumping and landslides are more numerous on cleared slopes than on those still in forest.

CHAPTER 6—STRUCTURAL GEOLOGY

The most noteworthy structural feature of Illinois is the Illinois basin, the deepest part of which, in southeastern Illinois, is depressed more than 5,000 feet below its borders. The area described in this report is in the northwest part of the basin, where the rock strata dip gently eastward toward the deepest part.

Because of the eastward dip the base of the Pennsylvanian system declines from 600 feet above sea level near Macomb in McDonough County, to 87 feet above sea level near Morton in Tazewell County, a drop of 513 feet in 62 miles, an average of 8 to 9 feet per mile. This regional dip is modified by relatively small anticlines and synclines whose axes vary in trend from northeastward to eastward (fig. 62). Most of them have a structural relief of less than 100 feet. All pitch eastward toward the basin. Many minor structures are revealed in large strip mines, underground mines, and outcrops.

The structure of pre-Pennsylvanian rocks differs from that of the Pennsylvanian rocks because of late Mississippian and early Pennsylvanian movements. The basal Pennsylvanian beds rest on the St. Louis limestone at Bushnell, on Keokuk at Avon and Abingdon, and on Hannibal or Grassy Creek shale at Galesburg. Although the base of the Pennsylvanian rises 15 feet in about 30 miles from Bushnell to Galesburg, the base of the Kinderhook rises 404 feet, an average of 13 to 14 feet per mile.

Because of the pre-Pennsylvanian unconformity, the structure map of the top of the Kinderhook (fig. 63) is based entirely on records of wells that penetrate the Kinderhook. The Pennsylvanian structure maps on coals Nos. 2 and 5 (pl. 7) are based on abundant coal-test drill records and show a much more complex structural pattern than the Kinderhook map. As the Pennsylvanian structures are also present in the Kinderhook, the Kinderhook structure actually is more complex than the Pennsylvanian. The structure map of the base of the Pennsylvanian (fig. 23) likewise shows many structures that must be present in the pre-Pennsylvanian strata, and it is further complicated by showing the erosional topography of the unconformity.

Structural data on the Maquoketa and older formations are compiled in table 1.

STRUCTURES OUTLINED PRINCIPALLY ON PENNSYLVANIAN COALS

For the eastern part of the area, where many coal tests have been drilled, structure contour maps of coals Nos. 5 and 2 (pl. 7) and the base of the Pennsylvanian (fig. 23) show several anticlines and synclines as follows.

Elmwood Syncline

Along the northern border and just north of the Glasford quadrangle is a syncline with a trend of N. 75° to 80° E., which is here named for the town of Elmwood, Peoria County, situated nearly along its axis. Its south limb is shown by the northward dip of outcropping Pennsylvanian strata north of State Highway 116 in T. 9 N., R. 6 E. The north flank is based on Princeville wells in T. 11 N., R. 6 E., which show notably higher elevations for the base of the Pennsylvanian than in the Elmwood syncline. This syncline is tentatively extended southwestward to connect with a shallow syncline near the Warren-McDonough county line in R. 2 W. and R. 1 W. The Elmwood syncline is fairly symmetrical on the base of the Pennsylvanian, with an average differential depression of 40 to 50 feet, but it is strongly asymmetrical on the pre-Pennsylvanian horizons, with a steeper and longer north limb. It pitches eastward at 10 or 15 feet per mile.

Farmington Anticline

The axis of the Farmington anticline is five to seven miles south of and parallel to the Elmwood syncline. The anticline is here named from the town of Farmington at the northeast corner of Fulton County in the Glasford quadrangle. From north to south near Farmington the No. 5 coal is estimated at 530 feet altitude in the Elmwood syncline, 600 feet on the Farmington anticline, and about 530 feet in the Fairview syncline to the south. Its trend is shown on the contour map of the base of the Pennsylvanian

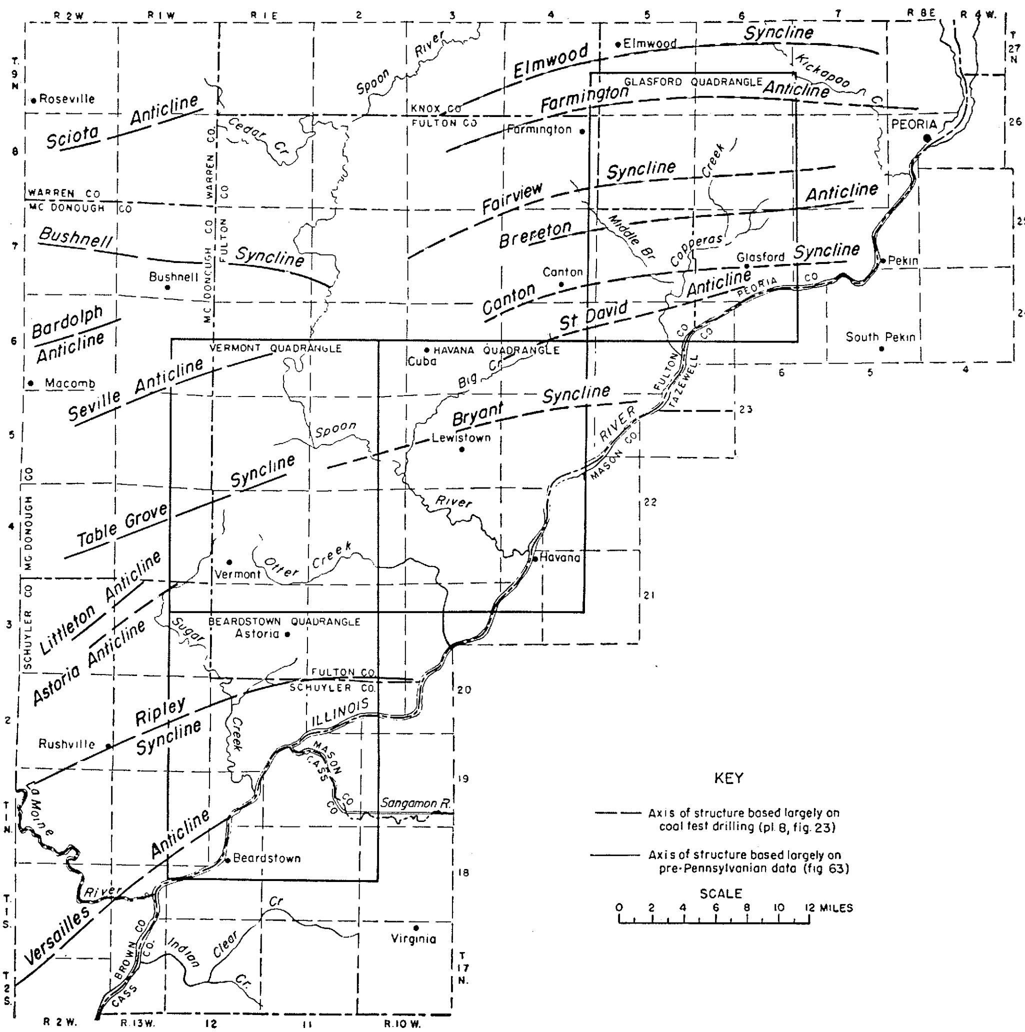


FIG. 62.—Axes of named structures.

(fig. 23) as curving southwestward paralleling the Elmwood syncline to connect with the Sciota anticline in McDonough County. The anticline is also shown by contours on the top of the Lonsdale limestone (fig. 66). The Farmington anticline is quite asymmetrical in the pre-Pennsylvanian, with a relief of about 50 feet on the north limb and 150 to 200 feet on the south. It pitches eastward 6 to 10 feet per mile.

Fairview Syncline

The Fairview syncline parallels the Farmington anticline, and its axis is about four miles south of that structure. It is named here for Fairview in Fulton County. It includes most of the large area in the north part of the Glasford quadrangle in which the Lonsdale limestone and younger strata have escaped erosion, and is also responsible for a westward projection of Springfield (No. 5) coal in T. 8 N., and T. 7 N., R. 2 E. It is slightly asymmetrical in the Pennsylvanian with a relief of about 70 feet on its north limb and 50 feet on the south. The north limb is steeper in the pre-Pennsylvanian rocks. It has been tentatively connected with the Bushnell syncline in McDonough County.

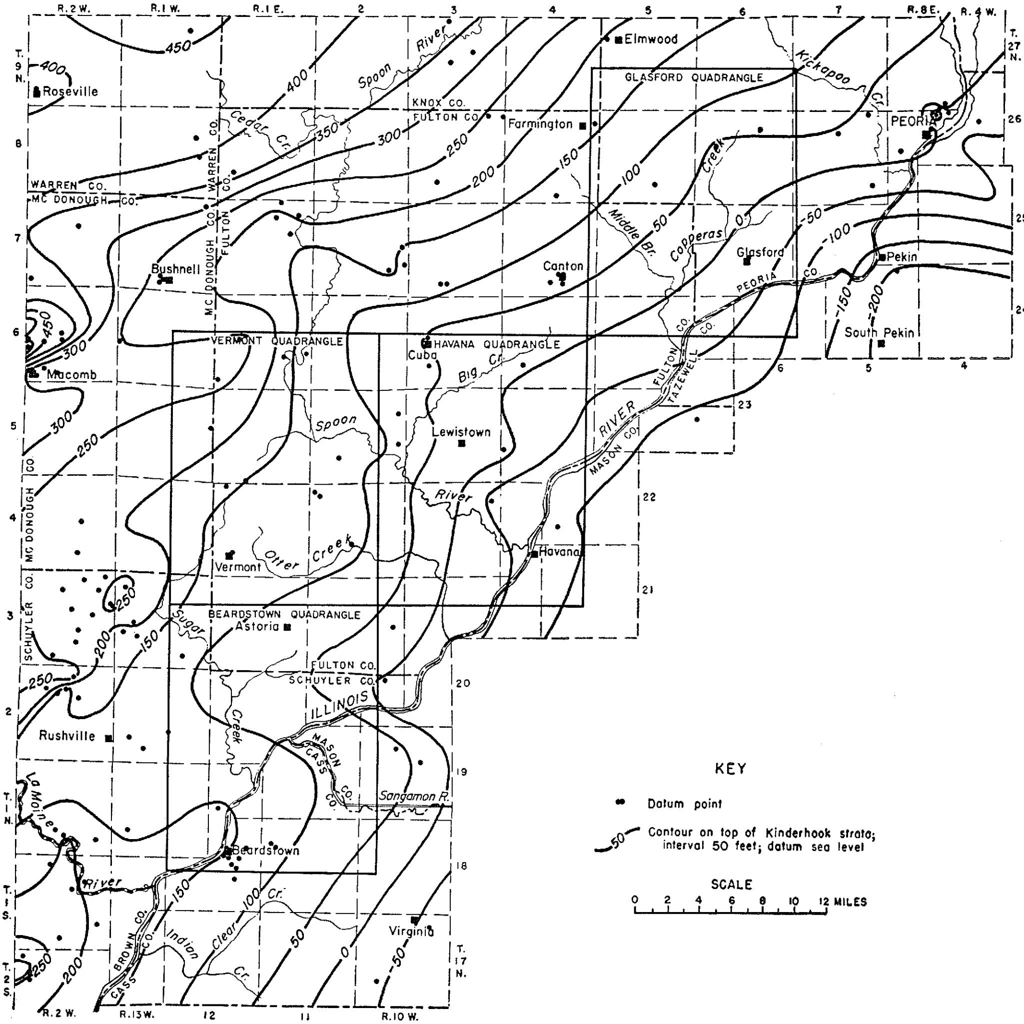


FIG. 63.—Structure map of the Kinderhook shale.

BRERETON ANTICLINE

The Brereton anticline south of the Fairview syncline passes through the village of Brereton for which it is here named. This anticline crosses the south-central part of the Glasford quadrangle and has been tentatively extended southwestward to connect with the Seville anticline. The Brereton anticline has about 50 feet of differential elevation in the No. 5 coal in the Glasford quadrangle, and the south flank is a little steeper.

CANTON SYNCLINE

The Canton syncline, here named from the city of Canton, Fulton County, lies south of the Brereton anticline. It is best displayed on contour maps of coals Nos. 2 and 5 (pl. 7). It has average differential depression of about 50 to 75 feet, and pitches eastward at about the same rate as the Fairview syncline and Brereton anticline.

ST. DAVID ANTICLINE

The St. David anticline, which is nearly parallel to the Canton syncline and lies about four miles south of it, is here named from the mining town of St. David in the Havana quadrangle. This structure is outlined in detail on the map showing the structure of the Springfield (No. 5) coal (pl. 7), as sev-

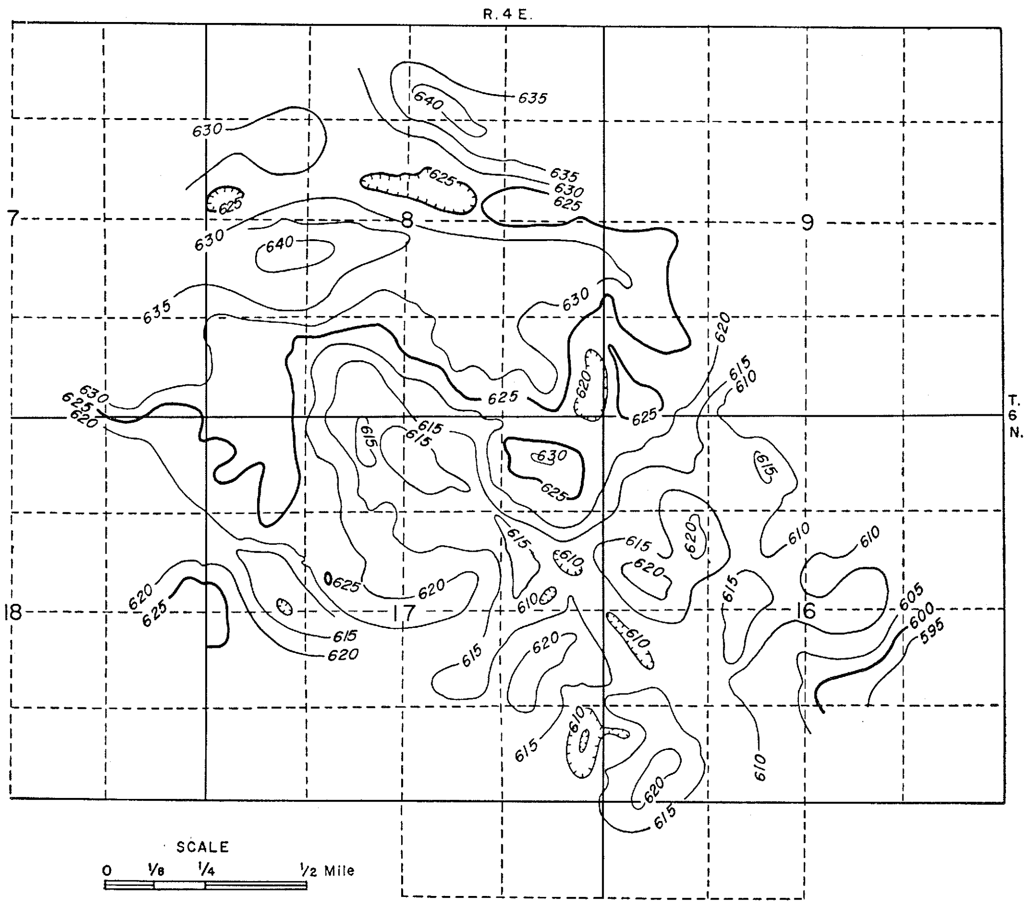


FIG. 64.—Structure map of Springfield (No. 5) coal in mine No. 2 of the Big Creek Coal Company near St. David, in the Havana and Canton quadrangles. From a company map.

eral hundred coal test borings are along this fold. The St. David anticline seems to be more irregular than the Brereton, but this may result from the larger amount of available information.

Bryant Syncline

The St. David anticline is bordered on the south by a shallow syncline here named from the village of Bryant in the Havana quadrangle. This structure, or a north-south cross fold, seems to be responsible for the steep eastward dip in the southeastern part of T. 6 N., R. 4 E. and in T. 5 N., R. 4 E.

Astoria Anticline

In the Vermont and Beardstown quadrangles several small anticlines shown on the map of the Colchester (No. 2) coal have nearly east-west trends (pl. 7). One of the most marked is in the south half of T. 3 N., Rs. 1 and 2 E., a little south of Astoria, and is here named the Astoria anticline. From the crest of this fold in sec. 23, T. 3 N., R. 2 E., the coal drops from 580 to 540 feet within a mile both north and south.

STRUCTURES OUTLINED PRINCIPALLY ON PRE-PENNSYLVANIAN STRATA

In the west part of the area where the data on the coals are not complete enough to outline the structure clearly, a better picture is afforded by the data on the top of the Kinderhook and older horizons (fig. 63). The following structures appear in that area.

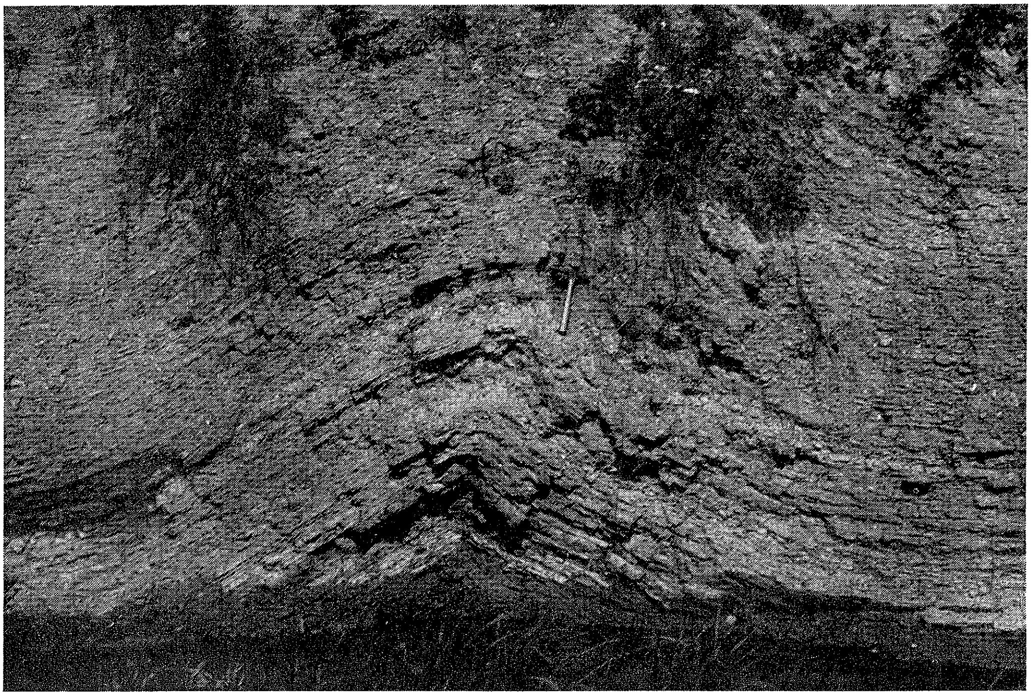


FIG. 65.—Fold in Farmington shale probably due to ice shove, northwest of Trivoli, in the NE ¼ SW ¼ SW ¼ sec. 34, T. 9 N., R. 5 E., Glasford quadrangle.

Sciota Anticline

A small sharply pitching anticline is here named from Sciota, McDonough County, a little west of the map area. The map of the top of the Kinderhook shows an elevation of 544 feet on the crest of this fold in sec. 31, T. 7 N., R. 3 W., dipping to the east to 450, north to 490, and southeast to 310 feet. It may be a dome-like uplift.

Bardolph Anticline

A somewhat similar anticline or dome about seven miles southeast of Sciota, a little north of Macomb, has its highest elevation in sec. 18, T. 6 N., R. 2 W., and is here named the Bardolph anticline after the town of Bardolph in McDonough County. The top of the Kinderhook declines southward from 520 feet on the crest of the structure to 292 feet at Macomb, about three miles to the south. Truncation of both the Sciota and Bardolph structures has produced inliers of Mississippian rocks, now covered by drift.

Bushnell Syncline

The depression between the Sciota and Bardolph anticlines is here named the Bushnell syncline from Bushnell in McDonough County.

Seville Anticline

A rather broad anticline with southwestward trend is here named the Seville anticline for the village of Seville in the Vermont quadrangle. A large inlier of the St. Louis, Salem, and Warsaw formations, surrounded by Pennsylvanian strata, occurs along the anticline near Seville (pl. 5). This inlier may be partially a topographic high on the pre-Pennsylvanian erosion surface, but it also appears to be structurally high in the pre-Pennsylvanian strata.

Table Grove Syncline

South of the Seville anticline a rather broad and flattish syncline extends northeastward from T. 4 N., R. 2 W. to T. 5 N., R.

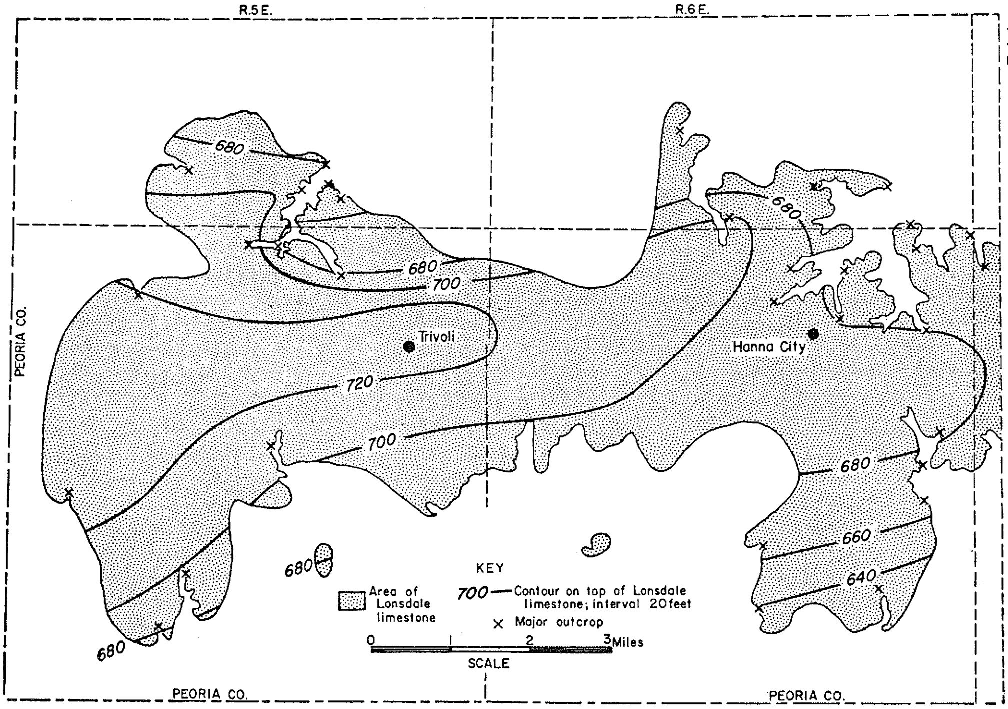


FIG. 66.—Structure map of Lonsdale limestone in north part of the Glasford quadrangle.

2 E. The syncline is here named Table Grove for the town of Table Grove in western Fulton County.

Littleton Anticline

A comparatively short anticline in T. 3 N., R. 2 W. and R. 3 W., is named the Littleton anticline from the town of Littleton in Schuyler County. Its crest is 150 to 200 feet above the lowest part of the Ripley syncline, 8 to 9 miles southeast, but perhaps 100 feet can be attributed to regional dip.

Ripley Syncline

The Kinderhook structure map shows a rather broad syncline with northeastward trend extending from T. 1 N., R. 2 W. to T. 3 N., R. 3 E., here named the Ripley syncline for the village of Ripley in Brown County.

Versailles Anticline

In the southwest part of the area an anticline with southwest-northeast trend is here named the Versailles anticline for the town of Versailles in Brown County.

Structures East of Illinois River

Similar structures probably occur east of the Illinois River but so few wells extend to the base of the Pennsylvanian strata that their presence is not revealed. Wells near Beardstown faintly suggest the extension of the Versailles anticline into that vicinity, and the well near Morton in Tazewell County seems to be situated on an eastward extension of the Farmington anticline.

MINOR STRUCTURES

In areas where the Springfield (No. 5) coal has been mined, the coal exhibits a series of minor rolls or hills and basins, which do not seem to follow any organized structural pattern (fig. 64). The pattern does not suggest folds due to lateral compression, and many of the minor structures may be caused by differential compaction.

TABLE 5.—TREND OF JOINT SYSTEMS

No.	¼	¼	¼	Sec.	Twp.	Range	Quadrangle	Formation	NE trend	NW trend
1	NW	SE	NW	19	7N	7E	Glasford	St. David "slate"	N.65°E*	N.25°W.
2	NW	SW	NW	19	7N	7E	Glasford	St. David "slate"	N.60°E*	N.30°W.
3	NW	SE	NE	2	6N	5E	Glasford	Canton shale	N.90°E	N. 0°E.
4	SW	SW	SW	1	3N	1E	Beardstown	St. David "slate"	N.55°E	
5	NW	SW	SW	26	2N	1W	Beardstown	Springfield (No. 5) coal		N.45°W.
6	SW	NE	NE	26	2N	1W	Beardstown	Canton shale		N.35°W.
7	SW	SE	SW	5	1N	1E	Beardstown	Liverpool "slate"		N.58°W.
8	SW	NE	SW	7	1N	1E	Beardstown	Liverpool "slate"	N.55°E	N.60°W.
9	NE	SW	NE	7	1N	1E	Beardstown	Liverpool limestone	N.50°E	N.55°W.
10	SW	NE	SW	13	1N	1W	Beardstown	Liverpool "slate"	(N.15°W)	N.70°W.
11	NE	NE	NW	13	1N	1W	Beardstown	Liverpool "slate"	N.40°E	N.55°W.
12	SE	SW	NW	1	8N	6E	Glasford	Exline limestone	N.20°E	N.70°W*.
13	SW	SE	NW	33	8N	6E	Glasford	Sparland black shale	N.20°E*	N.70°W.
14	NE	NE	NW	13	5N	2E	Havana	Pleasantview sandstone	N.60°E	N.20°W.

*Most prominent.

Compaction structures are prominently developed over erosional channels in Pennsylvanian strata, especially where the channels were not entirely filled with sandstone.

ICE-SHOVE STRUCTURES

In many places where soft shales directly underlie drift, they are intensely folded with sharp closed folds, some of which are overturned (fig. 65). These structures result from overriding by Pleistocene glaciers.

JOINTS

Many of the Pennsylvanian strata exhibit prominent vertical joints. Joints are best developed in the black sheety shales of the Liverpool and St. David cyclothems. Joint directions were not measured extensively, but two systems of joints which vary in angle between 65° and 115° are generally present (table 5). The joint systems commonly trend northeast-southwest and northwest-southeast, but at one locality they are north-south and east-west.

CHAPTER 7—GEOLOGIC HISTORY

The Beardstown-Glasford-Havana-Vermont area is now a fertile plain trenched by numerous streams, but in earlier times it has been 1) the floor of inland seas varying in depth, temperature, salinity, turbidity, and distance from shore; 2) the site of successive widespread marshes; and 3) a land deeply buried beneath three successive ice sheets. Deeply buried pre-Cambrian rocks have not yet been penetrated by borings in the area, and the geologic history begins with events of the Cambrian period.

Paleozoic Era

CAMBRIAN PERIOD

Early and Middle Cambrian sediments are not known to exist in or near Illinois, but during the Late Cambrian or St. Croixan epoch the region was submerged, and a thick sequence of dolomites and sandstones was deposited. The St. Croixan series thickens southward in Illinois, and the sandstones become coarser grained to the north, suggesting a northward sea invasion on the flanks of the Wisconsin highland.

The earliest St. Croixan sediment, the Mt. Simon sandstone, was principally sand derived from the mantle rock of the old land surface. The overlying Eau Claire formation consists more largely of siltstone, shale, and dolomite, which suggests that by this time the strand line was more distant. The clean, well sorted Galesville sand overlying the Eau Claire might have been developed either in desert dunes or along sandy beaches, but it was deposited in the sea as shown by its marine fossils. Although sandy, the overlying Franconia formation is more dolomitic, glauconitic, and shaly, and the glauconite is believed to indicate a shallow sea floor on which sediments accumulated slowly. The relatively pure carbonate sediments of the Trempealeau formation indicate clearing seas during late Cambrian time. The absence of the Jordan sandstone in this region suggests brief emergence at the close of the Cambrian period but no major erosional break is indicated.

ORDOVICIAN PERIOD

Prairie du Chien Epoch

The Ordovician period began with the return of the sea to most of Illinois. The Prairie du Chien sediments thicken southwestward in the direction of the Ozark highlands, indicating maximum subsidence in that direction. Following the initial deposition of sandy silty dolomite of the Gunter formation, the seas became clear and the relatively pure Oneota dolomite was deposited. Sand was again carried into the area during New Richmond time but its mixture with dolomite and chert suggests that this area was on the margin of the major area of sand deposition. Shakopee time was an interval of changing marine conditions that were reflected in the alternation of pure and impure dolomite and the many beds of chert and sandstone.

At the close of the Prairie du Chien epoch a major uplift resulted in truncation of the Prairie du Chien and some of the Cambrian strata in northeastern Illinois, but the Fulton County area was evidently less elevated and suffered less erosion.

Chazyan Epoch

St. Peter stage.—Early in middle Ordovician time the sea readvanced from the south, and the St. Peter sandstone was deposited in it. This sand appears to have been worked over by the wind and later redeposited in the shallow sea. As the Glenwood sand is unconformable on the St. Peter sand farther north, St. Peter time may have been closed by emergence in the Fulton County area.

Mohawkian Epoch

Glenwood stage.—The Glenwood deposits consist of reworked rounded and frosted St. Peter grains in a matrix of finer and more angular sand with some associated silt, clay, dolomite, and glauconite, and appear to represent rapidly changing conditions. In some parts of Illinois the Glenwood stage was terminated by brief emergence and erosion.

Platteville, Decorah, and Galena stages.—The Platteville, Decorah, and Galena sediments were deposited during the greatest marine invasion of the interior of North America, when more than half of the present continent was submerged. The seas were populated by a large and diverse fauna. In the Fulton County area the sediments were predominantly carbonates but included a very little shale during the Decorah stage. The Galena stage may have been terminated by slight emergence in this area.

Cincinnatian Epoch

Maquoketa stage.—During the Maquoketa stage calcareous muds rather than carbonate sediments were principally deposited. From time to time the proportion of carbonate sediment increased so that thin beds of argillaceous or shaly dolomite were deposited. These beds were particularly common about the middle of Maquoketa time. Maquoketa seas supported a varied fauna, among which brachiopods and bryozoa are most conspicuous. Maquoketa time was closed by uplift and erosion.

SILURIAN PERIOD

Alexandrian Epoch

During the Early Silurian or Alexandrian epoch Illinois was largely submerged by seas that advanced from the Gulf of Mexico. The first sediments included fine angular sand and some silt and glauconite, but the sea soon cleared so that calcareous or dolomitic sediments, with associated chert, were formed during later Alexandrian time.

Niagaran Epoch

Although the close of the Alexandrian epoch was marked by a shoaling of the sea, the earlier Niagaran sediments of this region are similar to the Alexandrian. The seas were populated with a rich fauna, including large individuals of brachiopods, corals, cephalopods, and trilobites. Coral reefs developed on the sea floor during this time but none have been reported in west-central Illinois. The Niagaran marine invasion was terminated by emergence so that Illinois was land during later Silurian time.

DEVONIAN PERIOD

Arching of bedrock strata in western Illinois permitted erosion of Niagaran and Alexandrian strata, and locally even the Maquoketa, before the beginning of Devonian sedimentation. This domal uplift affects an area about 120 miles from east to west and 90 to 100 miles from north to south, with its highest elevation near Warsaw, Hancock County, Illinois. In the Beardstown-Glasford-Havana-Vermont area only the lowest Alexandrian strata escaped erosion along the western edge of the Vermont and Beardstown areas but eastward successively higher formations remain so that at Morton, several miles east of the Glasford quadrangle, about 260 feet of Niagaran strata are present. The surface of the dome appears to have remained relatively high, inasmuch as the first Devonian formation, the Wapsipinicon, was deposited only on the flanks of the dome and is overlapped by the younger Cedar Valley limestone.

Wapsipinicon stage.—Some shale, reported near the top of the Silurian, probably is a Devonian deposit in solution cavities. The Wapsipinicon sediment is lithographic dolomitic limestone. The fine texture and scarcity of fossil remains suggests chemical deposition in shallow sea waters that were weakly agitated. The Wapsipinicon stage was terminated by brief emergence.

Cedar Valley stage.—The first sediment of the Cedar Valley is a thin deposit of well rounded sand, irregularly distributed in shallow channels cut into the pre-Cedar Valley surface. The pre-Devonian high in western Illinois must have subsided, as shown by the fact that the richly fossiliferous sandy dolomitic Cedar Valley limestone attains a greater thickness there than farther east. During late Devonian time the region again emerged and was exposed to erosion. Uplift a little southwest of the Beardstown-Glasford-Havana-Vermont area locally permitted erosion of the Devonian limestones, so that the Kinderhook shale rests on the Maquoketa shale.

MISSISSIPPIAN PERIOD

Kinderhook Epoch

The area was again inundated during early Kinderhook or Grassy Creek time. The sediment was mud, now a black to dark brown shale, which was spread over a region from Iowa and Illinois on the north to Oklahoma and Georgia on the south, and from Kansas on the west to Virginia on the east. The shale contains an abundance of small waxy sporangites, probably belonging to a lycopod plant, which must have been transported by the wind into the sea. The close of Grassy Creek time was marked by alternate deposition of brownish-gray and greenish-gray shales that were transitional to the light greenish-gray Hannibal shale. Kinderhook sedimentation was terminated by emergence and erosion.

Valmeyer Epoch

OSAGE AGE

Burlington and Keokuk stages.—The Burlington and Keokuk limestones were deposited in seas crowded with large brachiopods and crinoids. Temporary interruptions in deposition are indicated by slightly uneven bedding planes on which glauconite grains and phosphatic nodules are concentrated.

Warsaw stage.—The Warsaw is a shale or siltstone interbedded with thin bands of fossiliferous limestone, resembling those in the Maquoketa. The Warsaw and upper Keokuk are characterized by geodes, which have been interpreted as fillings in cavities formerly occupied by fossils, or as resulting from the solution of limestone concretions. The gradational contact suggests there was no significant emergence and erosion at the end of the Warsaw stage.

MERAMEC AGE

Salem stage.—The initial Meramec sediments consist of sandy or shaly dolomite, glauconitic siltstone, sandstone, and sandy or calcareous shale, which suggest accumulation in shallow seas. The fauna is less abundant, has less diversity, and is made up of smaller individuals than the Osage fauna. The Salem stage was closed by emergence and some erosion.

St. Louis stage.—The area was again covered by the sea during the St. Louis stage when the principal deposit was very fine-grained lithographic limestone. Conditions of life were evidently less favorable than during Salem or Warsaw times, but small colonies of the coral *Lithostrotionella* were common. Colonial corals are limited to shallow seas, and agitation of the water is suggested by the light color of the sediment, occasional cross-bedding, ripple marks, and widespread brecciation.

Although the St. Louis limestone is the youngest Mississippian formation preserved in the Fulton County area, it is likely that the Ste. Genevieve limestone and perhaps even the late Mississippian Chester formations may have been deposited and eroded before the overlying Pennsylvanian sediments were deposited.

Post-St. Louis, Pre-Pennyslvanian Time

After the close of Mississippian time the Eastern Interior basin was subjected to its greatest deformation since the pre-Cambrian. The deformation and erosion stripped all post-St. Louis sediments from the region, eroded the St. Louis, Salem, Warsaw, and Keokuk strata from the north part of the area, and imparted a notable southward tilt to the pre-Pennsylvanian strata.

PENNSYLVANIAN PERIOD

Pennsylvanian sediments are unlike older formations in this region in consisting of many different rock types. Many of the shales, limestones, and ironstones contain fossil evidence of their marine origin, but the coals are believed to have formed in broad fresh-water marshes, and most of the sandstones, conglomerates, underclays, underclay limestones, and some shales probably accumulated in fresh-water environments such as river valleys, lagoons, lakes, or lowland plains. The sediments are arranged in rhythmic sequences called cyclothems, each recording a cycle of sedimentation during part of which the area was above sea level and during the remainder beneath sea level.

The thickness of strata composing several of the individual cyclothems is so small that one might be inclined to assign purely local importance to frequent changes in lithology and to the small erosional breaks between or within cyclothems. Regional studies, however, have shown that the lower part of the Pennsylvanian sequence has a thin development in western Illinois, and that slight thicknesses there represent greater thicknesses elsewhere. Thus the average interval from the Colchester (No. 2) coal to the base of the Pennsylvanian in western Illinois is about 125 feet, but in southeastern Illinois this part of the Pennsylvanian column is represented by about 1,300 feet of strata. Deposition started relatively early in Pennsylvanian time, but either proceeded very slowly in western Illinois or was interrupted frequently by intervals of nondeposition.

History of an Average Cycle

Erosion interval.—The cycle began with the area emergent. Streams had cut valleys into the underlying strata to a maximum depth of 150 feet. The upper shales (bed 10) were easily cut through, but in some cases valley cutting was retarded on the marine limestone (bed 9), the black sheety shale (bed 8), and especially on the coal (bed 5). Although many erosional valleys have cut out the limestone, and a few the black shale, the coal has been removed only locally. At the time of valley cutting the coal was still a hard tough compact peat that would offer great resistance to erosion. (See fig. 25, p. 54).

Sandstone.—After erosion had ceased, or while it was still in progress, the eroded valleys began to fill with sediment, largely fine-grained micaceous sand, associated with a minor quantity of coarser fragments of shale, ironstone, siltstone, or limestone derived from the valley walls. It has not been determined whether the sandy sediment was transported downstream along the course of the valleys from a source near the heads of the streams, or whether it might have been backed up into the valley from its lower portion as an estuary might eventually fill with sediment carried in from the sea. The sand was not derived from the debris eroded to produce the valleys, as that was principally shale. When the valley was filled, the sand spread as a thin sheet over adjacent areas. The sands grade upward to siltstone and in many cases to sandy shale, which suggests a reduction in the strength of currents. In a few instances, especially the Seville and Summum cycles, the valleys were not entirely filled when sand deposition ceased, resulting in absence of sand deposition between the valleys and abnormal structural relations in subsequent deposits.

Underclay limestone.—The irregularity of the limestone masses and the lack of diagnostic fossils leaves considerable doubt as to the origin of the underclay limestones. They have yielded a few ostracodes and gastropods regarded as "fresh-water" types. The nodular masses have been interpreted at some places as algal growths. Their high clay content and their local occurrence as joint fillings suggest that some of the limestones at this horizon may be secondary carbonates leached from higher horizons.

Underclay.—The underclays have been variously interpreted 1) as marine or fresh-water sediment leached by humic acids from the overlying coal swamp; 2) as old soils produced before the coal swamps developed; 3) as loess deposits; and 4) as detritus derived from a low lying or peneplained landmass that was slowly accumulating in a sedimentary basin and undergoing weathering at its source, during transportation, and during occasional periods of emergence after deposition. The underclays have a larger portion of fine and superfine clay sizes (less than 0.1 micron) than present-day marine clays (Dietz, 1941). They have a fine pellet structure suggestive of alluvial sedimentation (Allen, 1932; Grim and Allen, 1938). Occasional unweathered particles of feldspar which are surrounded by more altered particles may have been introduced by the wind. The absence of carbonates in the upper part of the underclays may result either from leaching before the beginning of coal accumulation or by cessation of lime deposition during the latest stage of underclay deposition.

Coal.—Coal is believed to have been deposited in vast freshwater swamps which were probably only a few feet above sea level, somewhat like the Dismal Swamp of Virginia. The swamps were populated by a diversity of large trees overgrown by lianas, but probably without herbaceous undergrowth. The forests notably lacked flowering plants, so that tree ferns, horsetails, and club mosses composed most of the flora. Whether the climate was tropical or cool, there were no winters sufficiently cold to interrupt the growth of vegetation and form annual growth rings. The coal swamps appear to have developed simultaneously over large portions of the interior of the United States between Pennsylvania and Oklahoma (Wanless, 1956b).

The remarkable persistence of uniformly thin clay partings, such as those in Herrin (No. 6) coal, is difficult to account for. It is hard to see how these clay beds could be formed either by 1) flocculation from suspended clay in the swamp water; 2) washing in from the border of the swamp; or by 3) wind deposition of dust or volcanic ash, without being frequently interrupted by coal breaks. The flat surface on which the clay partings rest may have been developed by the temporary destruction of the forest.

Gray shales.—The accumulation of peat in the swamps was commonly terminated by submergence beneath shallow marine waters. In a few instances the initial sediment following the coal was shale deposited in a freshwater lake. Some of the gray shales overlying the coals yield well preserved delicate leaves of plants, but no marine fossils. The Francis Creek gray shale in the Liverpool cyclothem commonly contains fossil plants in its lower part, is barren of fossils in the middle, and yields marine fossils in its upper portion. This sequence suggests change from fresh to marine waters but without notable change in the character of the shale.

Marine limestone.—The first marine stratum in many cycles is the limestone bed beneath the black sheety shale. Such beds are present only in the younger cycles of the region. They contain a typical varied fauna of marine invertebrates.

Black sheety shales.—The black sheety shales are probably the early deposits in a sea too shallow to permit current action. Such areas are soon deprived of oxygen by the decay of dead organisms. As there are no scavenging organisms, the mud is stained black by organic matter and iron sulphides. Such environments are still occupied by planktonic (floating) or nektonic (swimming) forms and a limited variety of mud-loving bottom dwellers. The black shales yield the remains of phosphatic brachiopods, some mollusks, some cephalopods, the spines, scales, and tubercles of fish, and conodonts. That there were local centers of abundant life is shown by large calcareous or pyritic concretions that contain abundant fossils not found in the surrounding black shale. The fauna of the pyritic concretions differs from that of calcareous concretions. The black shales result from the compaction of mud many times thicker than the present shale. The fossil shells of some species are completely flattened in the shale, although similar shells are strongly convex in associated concretions.

Marine limestone.—The transition from the poorly aerated mud-filled basins to clearer seas is marked first by a color change from dark to light in the shale and then by an increase in the content of calcareous matter, first to calcareous shale, then argillaceous limestone, and finally fairly pure limestone. The maximum depth attained during marine inundations varied; shallow depths were marked by inarticulate brachiopods and some mollusks, intermediate depths by articulate brachiopods, corals, and cephalopods, and slightly greater depths by fusulinids.

Another type of limestone is the very nodular nonbedded type represented by the Seahorne, Hanover, and part of the Lonsdale. Such limestones have a pseudo-conglomeratic structure, for which an algal origin has been suggested, and are characterized by the predominance of gastropods such as *Naticopsis, Trachydomia, Pseudozygopleura,* and *Baylea,* which are absent in the more argillaceous molluscan faunas. It is not known whether these species would require greater or lesser depths of water, but the greater purity of the limestone suggests a clear sea.

Upper gray shale.—The regressive phases of the marine invasion are commonly better recorded than the progressive stages. The sequence grades upward from limestone through argillaceous limestone and calcareous shale into noncalcareous and nonfossiliferous shale. The salinity of the water may have declined during deposition of the shale. The lower few feet of the shale commonly contains casts and moulds of mollusks, and such forms are also found in ironstone bands and nodules in the lower part of the shale. The upper part of the shale and its ironstones are generally entirely without fossils. Ironstones are less common toward the top and the shales may become more silty and even sandy. The sea gradually withdrew, and the cycle closed with complete emergence.

Beginning of Pennsylvanian Sedimentation

The post-Mississippian surface had not been reduced to a level plain when Pennsylvanian sedimentation began, and the earlier sediments were restricted to valleys or lowlands of the erosion surface. Strata as high as the Lower DeLong wedge out against pre-Pennsylvanian hills. In early Pennsylvanian time a broad, low arch extended northeastward from the Ozark highlands, occupied much of east-central Missouri, and extended into western Illinois as far north as Schuyler County. Earlier Pennsylvanian beds wedge out against this arch, but thin deposits, mostly refractory underclay, accumulated discontinuously over the eastern and northern flanks of the uplift. About 20 miles southwest of the Beardstown area, the underclay of the Colchester (No. 2) coal overlies the Mississippian Warsaw shale, and fourteen earlier Pennsylvanian cycles are absent. As this arch is approached various strata wedge out and the intervals between persistent beds like the Colchester coal and Seahorne limestone diminish greatly. The southern portion of the Vermont and nearly all of the Beardstown quadrangle was influenced by proximity to this uplift. This elevation was independent of the post-Mississippian movements, as the latter result in a northward overlap of basal Pennsylvanian on successively older pre-Pennsylvanian formations, whereas the early Pennsylvanian arching results in southward overlap of younger on older Pennsylvanian beds without appreciable truncation of the underlying Mississippian. The effects of this uplift were most marked previous to the accumulation of No. 2 coal, but No. 6 and No. 7 coals wedge out north of the outlier near Pleasantview in the Beardstown quadrangle and No. 5 coal wedges out near Mt. Sterling, about 15 miles southwest of the Beardstown area.

Pre-Babylon Cycle

A rudimentary cyclothem older than the Babylon was deposited in valleys or lowlands in the pre-Pennsylvanian surface. As no marine fossils have been found, the earliest Pennsylvanian sedimentation in the region appears to have been entirely fresh-water.

Babylon Cycle

The Babylon sands are the coarsest Pennsylvanian sands in this region. They include very coarse sand grains or fine grit. This was generally the initial Pennsylvanian sediment over much of the area and it commonly contains chert concretions, which littered the erosion surface. The accumulation of underclay and coal followed the general order of cyclic deposition. The coal is locally canneloid, which suggests a mixture of transported organic and mineral matter in small ponds. The marine incursion did not reach this area but a short distance to the north conditions were favorable for *Lingula.*

Tarter Cycle

The sequence of events outlined for the Babylon would fit the Tarter, except that the sand is finer-grained and has no basal gravel. The coal is not canneloid. The sequence appears to be entirely fresh-water.

Pope Creek Cycle

The Pope Creek cycle was marked by less extensive sand accumulation, followed by deposition of a thicker and whiter underclay than in either of the two preceding cycles. The underclay is refractory, and it probably marks a long period of slow deposition when iron, alkalies, and alkaline earths were leached during transportation and after deposition. Coal-forming conditions resembled those of Tarter time, and the shale over the coal contains abundant fresh-water plants rather than marine fossils.

Seville Cycle

After the Pope Creek cycle, valleys were carved into the Pope Creek, and locally even through the Tarter sediments. These valleys were partially filled with the Bernadotte sandstone. Coal swamps formed in the unfilled valleys, and the valleys were nearly filled with plant debris. When the area was invaded by marine waters, long arms of the sea, like modern estuaries, occupied the valleys. The combined weight of the water and marine sediment compacted the plant debris to form the Rock Island (No. 1) coal.

The sea passed from the shallow *Lingula* stage, in which black mud accumulated, to successively deeper conditions, with mollusks, brachiopods, bryozoa, and a few fusulinids. Compaction of the plant debris permitted the accumulation of limy muds as much as 30 feet thick locally. The limestone, the underlying black shales, and the coal, all thin and wedge out at the margin of the old unfilled valleys. The later Seville is recorded by dark blue shales that extend beyond the coal and limestone areas. The old valleys continued to influence sedimentation into early DeLong time.

DeLong Cycles

The DeLong interval records three partial cycles of sedimentation, but only a little coal and sandstone and no marine sediments were deposited. The coal of the early DeLong cycle thickens over areas that have thick Rock Island (No. 1) coal and Seville limestone, which records continued compaction of the Rock Island coal. The wide extent of the thin coaly streaks of the Middle and Upper DeLong is in contrast to the discontinuity of earlier strata that were deposited principally in depressions between hills on the post-Mississippian surface.

Seahorne Cycles

The DeLong cycles may have been terminated by slight elevation, although the Seahorne sand was distributed as a thin sheet over most of the plain and is not found in valley-like depressions. The sand wedges out on the flanks of the uplift to the southwest. It may have come from a westerly or northwesterly source, as it is more prominent in southeastern Iowa where it has a channel phase.

In places the Seahorne consists of two partial cycles. A thin coal is overlain by a limestone that contains a brackish-water fauna, another thin coal, and the major Seahorne limestone. Marine invasions probably came from the west, as in south-central Iowa two marine limestones of this age, the Munterville and Seahorne, are widespread. The lack of bedding, the nodular and highly brecciated condition, and the abnormal fauna of the Seahorne limestone suggest 1) that it is of algal origin, or 2) that the lime muds were exposed and fractured by desiccation or by wave or current action before they were consolidated. The discontinuity of the limestone may have been caused by leaching when the overlying Wiley underclay was deposited.

Wiley Cycles

Two cycles are partially recorded in the Wiley cyclothem, shown by a thin coal that locally occurs in the underclay beneath the principal Wiley coal. In western Indiana two coals, each with underclay, black sheety shale, and upper shale, and one with a marine limestone, occur in the position of the Wiley cyclothem. No marine beds and no sandstone accumulated in this part of Illinois during Wiley time.

Greenbush Cycle

Greenbush sedimentation began with deposition of the underclay. Late in underclay deposition limy mud containing *Spirorbis* was deposited in ponds of fresh or slightly brackish water. A slight marine invasion followed the local accumulation of coal, but the sea must have withdrawn quickly, as fossils were found at only two places. The final deposits were typical upper gray shale.

Abingdon Cycle

A minor irregularity at the base of the Isabel sandstone suggests a brief emergent interval after the Greenbush cycle. The sand differs from earlier Pennsylvanian sandstones in its abundant mica and garnet. The sand may have been derived from a different land mass or sediments that yielded sand, or the older sandstones may have been stripped away so that crystalline rocks were exposed. The land area may have been north in the Canadian shield or northwest in the Transcontinental arch. No marine invasion seems to have reached this area during Abingdon time. Both Greenbush and Abingdon strata wedge out southwestward.

Liverpool Cycle

The close of the Abingdon cycle was marked by the deepest erosion that had occurred since the beginning of Pennsylvanian time. Some valleys cut through all earlier Pennsylvanian sediments. One such valley, the Browning channel, is several miles wide and traverses the north part of the Beardstown quadrangle. The valley was largely filled with sand but contains some well laminated silt and clay with plant leaves, which suggests accumulation in lakes or lagoons within the valley. The channel seems to have been wholly filled with sediment, so that the overlying Colchester (No. 2) coal is a little thinner, rather than thicker, over it. Following deposition of the underclay limestone and underclay, the region was converted into a vast swamp in which the Colchester (No. 2) coal accumulated.

Over the coal the gray Francis Creek shale accumulated in a fresh-water basin. The ten or more shales and limestones that form the Oak Grove beds indicate the arrival of marine waters. In part of the area several feet of Jake Creek sand accumulated during Oak Grove time. The greater prominence of the sandstone to the southwest suggests that the sand came from the Ozark dome. In the later part of the Liverpool cycle the Purington shale records gradual transition from marine to brackish and perhaps fresh-water conditions. At the close of the Liverpool cycle most of the area was emergent.

Summum Cycle

At the beginning of the Summum cycle, another major interval of valley cutting preceded deposition of the Pleasantview sandstone. The Pleasantview sandstone only partly filled the valleys when sand deposition ceased. In the resulting depressions the discontinuous Kerton Creek coal was deposited. The subsequent compaction of the Kerton Creek coal and the still partially unfilled valleys permitted the Summum (No. 4) coal to thicken from a few inches to 4 or 5 feet over areas that contain the Kerton Creek bed. Coal deposition was followed by marine inundation, in the earlier stages of which dark gray muds associated with large calcareous concretions were deposited. The main seaway approached from the southwest, for the Hanover limestone is purer, thicker, and more extensive in that direction.

St. David Cycle

There is no evidence of erosion at the beginning of the St. David cycle, and no basal sand deposits were laid down in this area. The swamp in which the Springfield coal accumulated must have simultaneously covered vast areas in Illinois and surrounding states. The clay seams or horsebacks that cut across the coal might have been 1) squeezed up from the underlying underclay, 2) accumulated in cracks or channels in the coal during an emergence just after coal deposition, or 3) washed down into open cracks in the coal and its roof shale and limestone.

Marine invasion began, soon after coal deposition, in a poorly aerated sea in which black muds and calcareous and pyritic concretions accumulated. As the sea cleared and deepened, light-colored limy muds that made the St. David limestone were deposited. The St. David sea reached a depth equivalent to the brachiopod phase in the Havana and Glasford quadrangles and fusulinid phase in the Beardstown quadrangle. The change from marine to fresh-water was marked by a progressive increase in clay and decrease in lime and abundance of life until the barren Canton shales were formed. A brief return of marine conditions is recorded in a thin fossiliferous limestone with fossiliferous shales below the middle of the Canton shale. The St. David cycle was terminated by another emergence.

Brereton Cycle

An extensive system of erosional valleys developed at the beginning of the Brereton cycle. These valleys cut through the Canton shale and St. David limestone, and the valley floors were commonly the black sheety shale or Springfield coal but locally were some distance below the coal. The Cuba sandstone filled these valleys and overspread the uneroded plains. Revival of uplift of the Ozark flank some time after the accumulation of the Springfield (No. 5) coal is suggested by the wedging out of the Canton shale, Cuba sandstone, and Herrin (No. 6) coal in the Beardstown quadrangle. The convergence of coals 5 and 6 near Cuba may result from this cause. Near Cuba, a brief marine incursion followed the deposition of the Cuba sandstone, but normally the sand grades upward into typical underclay limestone and underclay. Widespread marshes persisted long enough for the thickest Illinois coal, the Herrin (No. 6) to accumulate. The widespread clay layers in the coal seem more likely to have been distributed by wind than by water, but their lack of interruption by coal stringers poses a problem as to what levelled the swamp just prior to their deposition. The white-top or sandy clay in the upper part of the coal bed may be a deposit in winding tidal channels in the surface of the coal swamp, just after coal deposition had ceased. The initial sea was somewhat better aerated than the initial St. David submergence, as the shale is commonly dark gray and soft instead of black, hard, and sheety. The Brereton sea may have been deeper and clearer than others, as a fusulinid phase is widespread.

Pokeberry Cycle

The record of the Pokeberry cycle is restricted to a small area in the west part of the Beardstown quadrangle. Sandstone accumulated very locally and was followed almost immediately by marine invasion and deposition of limy muds in which an abundance of large brachiopods of the genera *Dictyoclostus* and *Echinoconchus* are found.

Sparland Cycle

Emergence and erosion of a system of valley channels preceded deposition of the Copperas Creek sandstone at the beginning of the Sparland cycle. The sandstone is somewhat thinner and less extensive than the Cuba and Pleasantview and is followed by siltstone and underclay limestone in normal sequence. The underclay of the No. 7 coal is one of the thickest underclays in the region, although associated with a thin coal. Coal swamps were widespread again at the Sparland stage, but the swamp seems to have ended southwestward against the Ozark flank, so that only very thin coal is present in the Beardstown quadrangle.

The coal swamp was terminated by brief marine invasion, during which a thin impure limestone accumulated before the black roof shale was deposited. This is the earliest widespread marine limestone between the coal and the black shale. The fine slimy muds of the black shale environment permit little circulation of water, and brachiopod shells containing their original color markings are found in the shale. No marine limestone formed above the black shale in this region, but a few feet of laminated red shale was deposited in the Beardstown quadrangle. The red shale gave way to typical Farmington gray shale, whose deposition probably began in marine water but may have ended in brackish or fresh water.

Gimlet Cycle

The emergence at the close of Sparland time was accompanied by erosion during which the entire Sparland was locally removed. The succeeding sand deposit resembles the older sandstones, and it was followed by the normal cyclic pattern, with deposition of an underclay, thin coal, gray shale, marine Lonsdale limestone, and black hard shale. Generally the sequence below the Lonsdale is lacking because of pre-Lonsdale erosion.

The Lonsdale limestone was deposited on an erosional surface with as much relief as that developed by pre-Gimlet erosion. In places the Lonsdale cuts through earlier Gimlet and Sparland strata and rests on Brereton strata. The Lonsdale limestone is unlike all other marine limestones of the region. The limestone pellets or nodules that characterize the conglomeratic phases may be of algal origin or a chemical precipitate. A diversified fauna including fusulinids suggests that the Lonsdale sea may have attained greater depth than most marine invasions of this region. Some coquina-like beds suggest adequate current action to sort shell fragments.

Exline Cycle

After the deposition of the Lonsdale limestone the area emerged, as shown by petrified trees that have been found rooted in the top of the limestone. The foliage of land vegetation mingled with shallow water forms and crustaceans in a black limy mud environment. The water gradually deepened and circulation improved so that a normal marine molluscan and ostracode fauna occupied the region while the upper calcareous shales were accumulating. The Exline cycle closed with emergence.

Trivoli Cycle

The Trivoli cycle began with the area emergent and subject to valley cutting. The sequence of events in this cycle conforms very closely to the ideal pattern of the cycle, with deposition of a basal sandstone, underclay limestone, underclay, coal, marine limestone, black shale, and a second marine limestone that grades through calcareous shale to an upper gray shale. The upper limestone records a more extensive marine invasion than the one before black shale accumulation, but failed to attain the fusulinid phase.

Later Pennsylvanian

Although strata younger than the Trivoli are lacking in the Beardstown-Glasford-Havana-Vermont area, several cycles of sedimentation of post-Trivoli age are found in the deeper part of the Illinois basin. Most of them include brief marine inundations, but at a few stages marine limestones equalling or exceeding in thickness any in western Illinois were formed. As a similar succession of cycles has been found in Iowa and Missouri, they probably formerly covered western Illinois.

PERMIAN PERIOD

Sedimentation continued from the Pennsylvanian period into the Permian without notable interruption, both in Kansas and Nebraska to the west and in Ohio, Pennsylvania, and West Virginia to the east. The sediments in Kansas are largely marine, those in the eastern area are largely or wholly nonmarine. If the two areas were connected during Permian time the strand line probably shifted back and forth across Illinois. Western Illinois probably became a land area at some time during the Permian and may never again have been inundated by marine waters. The interior plateaus were elevated at this time. The deformation further deepened the basin in southeastern Illinois and produced the gentle eastward dip of the rocks in the Fulton County region.

Mesozoic Era

The Mesozoic era as well as most of the succeeding Cenozoic era was here a time of erosion. There is no measure of the thickness of strata which may have been stripped, but since even the youngest coals of the region are of bituminous grade, they at some time were probably buried beneath at least 1000 feet of strata.

Cenozoic Era

TERTIARY PERIOD

The upper Mississippi Valley continued to be a land area that drained southward toward the Mississippi embayment. Late in Tertiary time long-continued erosion interrupted by uplifts produced three successive peneplains that are widespread in the middle west and eastern states (Horberg, 1946, fig. 1). Their remnants are still conspicuous features of the landscape in areas that escaped Pleistocene glaciation. Their surfaces in places are floored with polished brown chert and quartz gravels. Remnants of the highest and oldest erosion surface, named the Dodgeville peneplain, are present in the driftless area of northwestern Illinois, but no remnants survive in central-western Illinois.

A later erosion surface, called the Lancaster peneplain, is recognized in northern Illinois and in the unglaciated highlands between the Illinois and Mississippi valleys in Calhoun County. Although slightly modified by late erosion, the two highest bedrock uplands of this area, the Farmington and Pleasantview ridges at elevations of 650 to 750 feet, are referred to the Lancaster plain.

The remainder of the bedrock upland surface west of Illinois River was degraded from this peneplain and formed an interplain slope to the lower Central Illinois peneplain. The bedrock surface east of the Beardstown quadrangle, where elevations are 600 to 650 feet, now deeply mantled with glacial drift, is referred to this surface. Still later, and near the end of Tertiary time, a system of broad valleys had developed a lower plain with elevations ranging from 450 to 550 feet. This surface has been called the Havana strath because it is extensively developed near Havana. Just before the beginning of Pleistocene time the major valleys were trenched about 100 feet in the Havana strath. The preglacial Mississippi and Mahomet-Teays valleys joined in Mason County about 15 miles east of Havana and flowed through Illinois Valley in the Beardstown quadrangle at a level probably 50 to 200 feet below the present river.

PLEISTOCENE EPOCH

The Pleistocene epoch was marked by world-wide change in climate which resulted in great continental glaciers and extensive valley glaciers in the higher mountain ranges. Four times during Pleistocene time the glaciers spread widely and then wasted away. The glacial stages were separated by longer interglacial stages of comparatively mild climate. Three of the glaciations reached the Beardstown-Glasford-Havana-Vermont area, and the fourth came close and greatly affected the area (Horberg, 1950, fig. 21, p. 100-101). Ice from the Keewatin center of radiation west of Hudson Bay reached this area during the Nebraskan and Kansan glaciations. The ice passed west of the driftless area of the upper Mississippi Valley and entered this region from the northwest. The Illinoian ice came from the Labradorean center east of Hudson Bay and entered this area from the northeast. Wisconsin ice, likewise, came from the northeast but reached its maximum extent a few miles east of the area.

The Pleistocene fauna of the Beardstown-Glasford - Havana - Vermont area consists largely of molluscs but the remains of mastodons have been found in bog deposits. The molluscan faunas of dry-land, moist-meadow, and fresh-water environments are abundantly represented (app. C). Many species and varieties are forms living today either in this region or in other climatic environments. The existence of molluscan life near the ice margin is shown by the fossils in slackwater silts and clays that were deposited in temporary lakes ponded by the meltwater from the Bloomington ice front. Loess faunas suggest that the loess climate was both cooler and drier than that of the area today. The plant remains are principally wood fragments. Leaves are uncommon.

Nebraskan Age

Nebraskan ice advancing from the northwest is believed to have reached this region. However, the exposures of Nebraskan till in this area are so limited that the till may possibly have been transported by Kansan ice from areas of more definite Nebraskan drift along Mississippi Valley northwest of the area. The greater abundance of chert and quartz in the Nebraskan than in later drifts suggests that an important local source of debris was the chert gravel on the Tertiary peneplain.

Gravels in the vicinity of Slug Run southeast of Cuba and north of Banner appear to be valley trains of Nebraskan outwash but might be Aftonian alluvial deposits reworked from Nebraskan drift or outwash. The gravels appear to have been deposited in a south-trending valley about one-third mile wide which slopes 40 feet in three miles. The valley was on the south slope of a bedrock ridge extending from near Canton southwest to Cuba. Therefore, if the gravel is not Nebraskan outwash, the Nebraskan drift must have been present within a few miles.

Aftonian Age

Although no gumbotil or gumbo gravel was found on the Nebraskan deposits, they were deeply weathered during Aftonian time.

The widespread compact greenish-gray silt, sand, or gravel is probably Aftonian alluvium but may include some pre-Nebraskan deposits. The presence of spruce wood in these deposits shows the cool climate of the northern coniferous forest. The silts occur principally in valleys in the bedrock surface, which indicate extensive dissection of the Tertiary erosion surface before their deposition.

Kansan Age

Early in Kansan time loess and calcareous silt were formed in a cooler and drier climate. The species of shells found in the loess (app. C) are also common in other loess deposits.

Kansan glaciers are believed to have invaded the Middle West from both the Keewatin and Labradorean centers. The drift from the Keewatin center extends into western Illinois as far as the Beardstown and Havana quadrangles. Kansan drift from the Labradorean center has been found beneath younger Illinoian drift at many places in southern Illinois and Indiana. Parts of the Beardstown and Glasford quadrangles seem to have been unglaciated areas between drift from the two centers.

Illinois River may have established its course through the Glasford and Havana quadrangles at this time as a result of blocking of the preglacial Mississippi and Mahomet-Teays valleys by the Kansan lobe from the northeast. The amount of Kansan drift was probably inadequate to obliterate the valleys in the pre–Kansan surface. Exposures of Kansan drift are generally less than 20 feet thick, deposited mostly in valleys in the bedrock surface. The thin drift on the upland was largely eroded during the Yarmouth interglacial age or scraped off by the Illinoian glacier.

Yarmouth Age

The Yarmouth age, which was the longest interglacial age, is recorded principally in the deep profile of weathering that formed on the Kansan drift. In many places erosion by streams during Yarmouth time or by the advancing Illinoian glacier removed much or all of the weathered zone.

At one place near Breeds in the Glasford quadrangle Yarmouth weathering was interrupted by deposition of silt, as indicated by a weathered zone on Kansan till overlain by silt on which another profile of weathering developed. Some of the undifferentiated blue-green silt, sand, and gravel deposits overlain by Illinoian drift may have accumulated during Yarmouth time.

Yarmouth erosion appears to have been very extensive and the present Illinois Valley may have been excavated to approximately its present dimensions. The major tributary streams, now buried, were probably widened and lengthened, but they may not have been deepened inasmuch as Kansan drift is found at a low elevation in most of the valleys.

Illinoian Age

When outwash from the advancing Illinoian ice built a valley train in Illinois Valley, silt from the floodplains was blown onto the bluffs and uplands forming an extensive cover of loess. Outcrops of the Loveland loess are more numerous and the loess is thicker within four miles of the valley margin than at greater distance. The loess is fossiliferous and contains 17 species of terrestrial gastropods, two species which inhabit meadows subject to seasonal overflow, and two species of pelecypods probably introduced by birds. About 60 percent of the species are extinct, but the others are more characteristic of the drier and cooler parts of the United States than of Illinois (Baker, 1929). The loess is absent at many places and it was probably eroded from most of the upland area when overridden by the advancing Illinoian glacier.

The Illinoian glacier invaded this region from the northeast, as shown by numerous boulders or pebbles of Jasper conglomerate derived from the Lorrain quartzite and of Huronian tillite from north and northeast of Lake Huron. The Illinoian ice did not produce a large volume of outwash, although sand and gravel deposits are somewhat more common than in the Kansan drift.

Although the predominant direction of movement of the Illinoian glacier was southwestward, the shape of the ice front was influenced by irregularities in the pre-Illinoian topography—lobes projected forward in the lowlands and interlobate angles were formed by drag against the highlands.

The pre-Illinoian surface was probably drained by a system of fairly deep and broad tributaries that drained southeastward into

Illinois Valley. The Illinoian glacier moved predominantly parallel to Illinois Valley but nearly at right angles to the tributaries. The glacier tended to push a lobe down Illinois Valley a little in advance of the main ice front, whereas the tributary valleys tended to fill with stagnant ice and debris, leading to their ultimate obliteration. Thus the lower Copperas Creek—Glasford Valley, the Smithfield—Muddy Branch portion of Spoon River Valley, parts of Otter Creek Valley in the southeast part of the Vermont quadrangle, the upper Wilson Creek—Skiles Branch Valley and the lower part of the Sugar Creek—Browning Valley were filled and abandoned. Small valleys whose trend nearly coincided with that of the glacial advance were enlarged and thus gave rise to many prominent valleys that trend northeastward.

The fluctuations of the Illinoian glacier in western Illinois are shown by the Payson, Jacksonville, and Buffalo Hart moraines (fig. 54). The moraines were weathered, eroded, and buried by loess, and have more gentle slopes and less relief than Wisconsin moraines. Each moraine represents a readvance of the ice so that areas farther back from the drift border are buried under more layers of drift and a greater thickness of Illinoian drift. Near the drift border the topography is rolling and the drift surface has preserved pre-Illinoian irregularities. Farther north and east where the drift is thicker it more completely obliterates the pre-Illinoian relief features so that only such large relief features as the Farmington bedrock ridge are reflected in the Illinoian till plain.

PAYSON GLACIATION

The earliest advance of the Illinoian glacier covered the entire area of this report and at its maximum extent deposited the Payson moraine. When it melted this ice deposited the Payson ground moraine which occurs in the Beardstown and Vermont quadrangles. The Payson till plain has little outwash but in western Illinois it has a remarkable series of parallel valleys, two to four miles apart, whose courses almost exactly coincide with the direction of ice movement. They are best developed west of this area but the South Fork of Sugar Creek in the northwest part of the Beardstown quadrangle is one of these valleys. The Pleasantview rock ridge exerts more control on stream trends than does the dominant drainage pattern of the Payson till plain. This glacier may have wasted by stagnation and the stream courses originated on or under the ice field, draining the meltwaters toward the glacial border.

JACKSONVILLE GLACIATION

After withdrawing east of the area, the glacier readvanced and deposited the Jacksonville drift. The Jacksonville glacier was unable to advance far out of the Illinois Valley. Lobes extended a few miles into the old valley of Crooked Creek just southwest of the Beardstown quadrangle and the positions of the old lower Sugar Creek—Browning and Wilson Creek—Skiles Branch valleys. A reentrant angle was formed near Frederick where the Pleasantview bedrock ridge extends to the bluff of Illinois Valley. Northeast of the Beardstown quadrangle where the Jacksonville deposits are overridden by those of the Buffalo Hart glacier, a reentrant angle formed where the Summum—Kerton Creek bedrock upland extends to the bluff of Illinois River. Two large lobes, the southern in Spoon River lowland and the northern in the Copperas Creek lowland, were separated by a slight reentrant which is probably responsible for morainic hills about 1½ miles northeast of Dunfermline.

A considerable amount of outwash was deposited along the outer border of the Jacksonville glacier except against the Pleasantview bedrock ridge. There most of the outwash is on the inside of the moraine. This outwash may have formed during the wastage of the ice in a trench between the glacier in Illinois Valley and the upland. Gravels within the Illinoian drift may be Jacksonville outwash buried by Buffalo Hart drift.

Northwest of Illinois Valley, lakes were formed in the lower parts of valleys that were blocked by the Jacksonville glacier. Varved silts and sands accumulated in some of these valleys, as along Big Sister Creek Valley and the West Fork of Copperas Creek. The system of valleys in the Glasford quadrangle from sec. 32, T. 7 N., R. 5 E., eastward along the West Branch of Copperas Creek past Breeds and Sandler Spur, and the East Branch of Copperas Creek as far northwest as sec. 10, T. 7 N., R. 6 E., probably developed as a marginal stream just outside the Jacksonville glacier. This system of valleys cuts off the drainage of a system of branching ravines which, if projected, would enter Illinois Valley about two miles southwest of Glasford. The valley of Big Creek seems to follow the same directional trend and to cut off southward-flowing streams which once drained southward into Illinois Valley through Little Sister, Big Sister, and other valleys.

Because Illinois Valley was occupied by ice, the lakes in the ponded valleys could drain only by spilling over from one lake to the next. Ten or more escape channels drained across narrow upland divides from the east part of the Glasford quadrangle to and beyond the west part of the Beardstown quadrangle (pls. 1-4). The lake waters in the East and West Branches of Copperas Creek overflowed first to upper Duck Creek in the Glasford quadrangle then to upper Buckheart Creek, and then to upper Big Creek in the Canton quadrangle. The waters then escaped from Big Creek to the East Fork of Stuart Creek, flowed along Stuart Creek to Spoon River, up a tributary valley south of Spoon River near the Vermont-Havana quadrangle line to Tater Creek, across a divide into North Fork of Otter Creek, along Otter Creek to the northeast part of the Beardstown quadrangle, through an escape channel about two miles west-northwest of Astoria into Gaines Branch of Sugar Creek, then probably up South Fork of Sugar Creek through a channel across the Pleasantview rock ridge about two miles north of Rushville into Horney Branch of Crooked Creek. Ponded waters southwest of the Pleasantview rock ridge occupied an escape channel from Coal Creek west into an eastern branch of Crane Creek about 2½ miles west of Frederick. These escape valleys were occupied for such a brief time that they were not deeply eroded.

The Jacksonville moraine blocked certain pre-Illinoian valleys, which then required new drainage outlets. Thus the lobe of the glacier along the east side of lower Sugar Creek and near Bader blocked the old Sugar Creek—Browning Valley and shifted the stream up the northeastern slope of the Pleasantview rock ridge. The present lower Sugar Creek Valley is now deeply trenched in rock. In the eastern part of the Beardstown quadrangle the lower part of the old Wilson Creek—Skiles Branch Valley was obliterated and the present lower Wilson Creek Valley, deeply trenched in rock, developed just outside the Jacksonville end moraine.

BUFFALO HART GLACIATION

The Jacksonville glacier retreated a considerable distance and during this brief mid-Illinoian period of weathering there was slight oxidation but no leaching before the Buffalo Hart glacier advanced. At its maximum extent along Illinois Valley the Buffalo Hart ice stopped about 25 miles short of reaching the Jacksonville moraine, but west of the valley it overrode the Jacksonville moraine and extended 15 or 20 miles farther.

The Buffalo Hart ice front was sensitive to irregularities in the surface, and small lobes of the glacier pushed farther west or southwest: 1) in the old Wilson Creek—Skiles Branch Valley, with the apex near the Lookout school, sec. 33, T. 3 N., R. 2 E.; 2) in Otter Creek Valley with the apex near the Beardstown-Vermont quadrangle line in sec. 8, T. 3 N., R. 1 W.; and 3) in the upper Barker Creek Valley with the apex near the Pilot Grove school in sec. 11, T. 5 N., R. 11 W. Minor interlobate angles developed where the moraine crossed rock ridges, as at Astoria, Table Grove, and New Philadelphia.

The Buffalo Hart glacier seems to have produced less outwash than the Jacksonville, although a small valley train of Buffalo Hart age was formed in upper Sugar Creek Valley in the Vermont quadrangle. Marginal stream valleys parallel to and just outside the Buffalo Hart moraine are Elm Creek in the Beardstown quadrangle and upper Sugar Creek between Table Grove and Vermont.

Illinois Valley was not completely filled by Illinoian drift and when the ice melted away, Mississippi River returned to its previous channel.

Sangamon Age

During the Sangamon interglacial age weathering produced gumbotil in the flatter parts of the till plain and mesotil or silttil profiles along the slopes of valleys. There seems to be little difference in the thickness of the weathered zones on the Payson and Buffalo Hart drifts.

As the area was not again buried beneath glacial ice, the present drainage system began to develop during the Sangamon age. Illinoian drift was largely eroded from Illinois Valley, as shown by post-Sangamon sand and gravel deposits that commonly overlie bedrock in the valley. Some streams were trenching courses determined by temporary marginal stands of the Illinoian glacier at the Jacksonville and Buffalo Hart positions. Other streams reexcavated valleys they had occupied during pre-Illinoian time. Stream courses were largely determined by the slope of the till plain toward Illinois Valley or its tributaries or away from Illinoian moraines and bedrock ridges.

Wisconsin Age

Wisconsin glaciation consisted of five successive glacial advances, the Farmdale (oldest), Iowan, Tazewell, Cary, and Mankato. None of the glaciers reached the area of this report although the third (Tazewell) glacier came within less than two miles of the Glasford quadrangle. However, the first and second glaciations are recorded by widespread loesses and the next three by glacio-fluvial, alluvial, or lacustrine deposits in Illinois Valley and its tributaries.

FARMDALE SUB-AGE

During Farmdale glaciation loess was blown onto the uplands bordering Illinois Valley. The loess attains its maximum thickness close to the valley, and thins rapidly northwestward away from the valley. The usual loess fauna of gastropods is rarely found in the Farmdale loess in this area. The pinkish color of the Farmdale loess, which aids in separating it from the gray or buff overlying loess, suggests that the loess was derived from pinkish alluvial sediments in Illinois Valley.

The Farmdale loess was leached to a depth of seven feet before deposition of the overlying Peorian loess in those few places where its thickness was that great. Elsewhere it was completely leached. Along some valley slopes the Farmdale loess and Illinoian drift were eroded before Peorian time.

IOWAN SUB-AGE

Mississippi River still occupied Illinois Valley through this area when the Iowan glacier advanced. The Iowan valley train in Illinois Valley was the source of an extensive deposit of loess that mantled the upland and is sharply differentiated from the weathered Farmdale loess below. The presence of the Iowan loess is most clearly shown in the type Farmdale exposures, along Farm Creek east of Peoria, where the Iowan loess is overlain by the oldest Tazewell (Shelbyville) till. In this area, which was not covered by Tazewell ice, loess continued to accumulate through Tazewell time, and to a lesser extent Cary time. These loesses cannot generally be differentiated, and together they comprise the Peorian loess.

TAZEWELL SUB-AGE

Although the Tazewell ice did not reach this area, its meltwater carried vast quantities of outwash which are now found in terraces in Illinois Valley, in backwater deposits in the tributary valleys, in dune sands, and in loess. The Tazewell glacier advanced from the northeast and its drift covers most of the northeastern quarter of Illinois.

Shelbyville glaciation.—The Shelbyville glacier, the oldest and most extensive of the Tazewell glaciers, crossed Illinois Valley at Peoria and reached to within two miles of the Glasford quadrangle northeast of Edwards. The Shelbyville moraine rises 60 to 150 feet above the adjacent Illinoian drift plain. Outwash from the Shelbyville ice front was brought into the area through Spoon River, Kickapoo Creek, Illinois River, and Sangamon River. The water-bearing gravels of Spoon River Valley are probably of this age, as are exposed gravels in terraces along Kickapoo Creek and some of the buried gravels in Sangamon Valley east of Beardstown. Where the terminal moraine crossed Illinois Valley near Peoria, the moraine and outwash dammed the river at about the 600-foot stage. As the ice front retreated a lake known as Lake Kickapoo (Willman and Payne, 1942) formed behind the dam. While it existed very little sediment was brought into Illinois Valley below Peoria.

Leroy, Cerro Gordo, and Champaign glaciations.—Following retreat of the Shelbyville glacier the Leroy, Cerro Gordo, and Champaign moraines were built and the meltwaters flowed into Illinois and Sangamon valleys. No outwash deposits of these glaciers are recognized in this area.

Bloomington glaciation.—The Bloomington glacier overrode the Champaign and Cerro Gordo end moraines, and north of Peoria its end moraine is only two to four miles inside the Shelbyville. The ice front crossed Illinois Valley about four miles northeast of the business center of Peoria. The Bloomington glacier evidently melted more rapidly than its predecessors, and it built an enormous valley train or outwash fan in Illinois Valley. Nearly all outcrops show long foreset beds of sand and gravel dipping uniformly down the valley. The surface of the valley train also declined (fig. 58) from about 640 feet at the edge of the glacier to about 485 feet near Beardstown. This valley train probably buried earlier similar but smaller deposits that had formed from the Shelbyville and Leroy glaciers. The current of the meltwaters declined in strength as it spread from the narrowly constricted valley between Peoria and Pekin to the broad valley of western Tazewell and Mason counties so that the materials grade downstream from gravel to gravelly sand and sand.

Sangamon, Spoon, and Kickapoo valleys all carried Bloomington meltwaters but the outwash is smaller in quantity and finer in texture than the Shelbyville outwash. The flow was not large enough to prevent outwash in Illinois Valley from being swept into the lower ends of these valleys. The smaller valleys northwest of Illinois Valley which did not receive Bloomington meltwaters were also ponded by growth of the fan across the mouths of their valleys. These lakes persisted until they were filled with silt and clay outwash swept into their lower portions from Illinois Valley and with silt and sand mostly eroded from loess and Illinoian drift. The outwash from Illinois Valley is red or pink in contrast with the buff and gray sediments derived from the valleys themselves. Most of the slackwater deposits show a gradation from redder and finer to grayer and coarser sediment both upstream and from the base up. Apparently more fine sediment came from Illinois Valley outwash earlier in the period of lake filling than later, when tributary streams built deltas over the earlier lake silts. The silts formed in these temporary lakes are very fossiliferous. They contain fresh-water molluscs as well as wood (app. C). The species of molluscs which survive today are more common in the northern states and Canada than in the central states (Baker, 1930). A sample of wood from this terrace was analyzed for carbon-14 content, and found to be 15,600±600 years old.*

Lake Illinois.—The great fan of Bloomington outwash in Illinois Valley below Peoria ponded the river and as the ice withdrew northeastward Lake Illinois was formed at an elevation of about 600 feet. This lake extended up the valley to beyond Marseilles and persisted through the later Tazewell glaciations. The overflow of relatively clear water from Lake Illinois would not have been adequate to fill the entire valley but followed the lowest available course across the fan, very likely against the western valley wall, a course which Illinois River has followed through most of its later history.

Later Tazewell glaciation.—After the Tazewell glacier withdrew from the Bloomington terminal moraine at Peoria, it continued to fluctuate and built the Normal, Cropsey, Farm Ridge, and Marseilles moraines farther to the northeast (fig. 57). Loess continued to be deposited, and when the streams were entrenched on the Bloomington fan and on the slackwater deposits in the tributary valleys, loess also covered these deposits.

Along lower East Creek in the Havana quadrangle, the loess overlying a slackwater terrace is about 40 percent as thick as the Peorian loess in a nearby outcrop. The fauna of the Tazewell loess is typical of loess fau-

*Sample W-381, Washington laboratory, U. S. Geol. Survey; personal communication from Meyer Rubin, Nov. 7, 1955. Sample collected by M. M. Leighton and H. R. Wanless.

nas, consisting of land gastropods with a few amphibious species that are especially common in the loess definitely referred to the Tazewell in valleys occasionally subject to overflow.

CARY SUB-AGE

Early in Cary time when the ice front stood at the position of the Valparaiso moraine in northeastern Illinois, meltwaters from the Lake Michigan, Saginaw, and Lake Erie lobes were concentrated into the Kankakee Valley, through which they discharged into the upper Illinois Valley. At this stage the glacier melted rapidly and gave rise to the Kankakee Torrent. The erosional and depositional features of this torrent are the only records of the Cary sub-age in this area.

Kankakee Torrent.—The volume of water that poured into the upper Illinois Valley was so great that it overtopped by 30 to 40 feet the 600-foot level of Lake Illinois. In the upper Illinois and Kankakee valleys bars of coarse rubble and erosion scars in the upland plain testify both to the depth and velocity of the torrent waters. The apex of the Bloomington valley train at Peoria was destroyed but a substantial portion of it in the angle at the junction of Kickapoo and Illinois valleys escaped erosion and now forms most of the higher level residential district of Peoria.

Below Peoria the initial flow of the torrent followed the channel along the west side of the valley train but soon overflowed and deposited torrential bars on the surface of the valley train to a maximum height of nearly 80 feet. The trend of the currents away from the present valley is clearly shown by the directions of the bars (fig. 59). The torrent waters followed pre-existing channels across the valley train and cut new channels. Some of the waters moved up the lower Mackinaw Valley and then southwest along the valley of Quiver Creek to Illinois Valley above Havana and along Crane Creek Valley to the Sangamon. From each of these valleys the torrent waters spread farther southeast. The overflow waters were finally concentrated along the southeast margin of the valley where a complex of sand ridges and later dunes record the flow.

As the volume of torrent waters subsided they were contained more completely within Illinois, Mackinaw—Quiver Creek, and Crane Creek valleys. Bars paralleling these valleys transect earlier bars formed by overflow currents diverging from the valleys. Crane Creek Valley seems to have been first abandoned, since it is higher and its junction with Quiver Creek Valley is partly blocked by a transverse bar. The broad smoothly curving Quiver Creek Valley, whose lower stretches are now stagnant and marshy, shows that a large flow of water formerly passed through it. Two successive erosion surfaces, the Manito and Havana terraces, were developed during the earlier and later parts of Kankakee Torrent time.

The torrent waters removed a considerable thickness of the Bloomington valley train except in protected situations so that remnants of the original surface remain only in the valley wall, as at Big Sister and Otter creeks in the Havana quadrangle. The torrent in places eroded bedrock, leaving a thin veneer of sand or gravel on a terrace about 25 feet lower than the Bloomington level. Tributary streams also degraded their valleys in adjustment to the Kankakee Torrent level of Illinois Valley and so produced such benches as the Duncan Mills terrace on Spoon River.

During temporary low-water stages of the Kankakee Torrent the sand and silt of the bars began to be reworked by wind, the sand being shifted southeastward. In several portions of the sandy terrace wind action has almost obliterated the shapes of the torrential bars and developed a dune complex, as for example just east and southeast of the Havana quadrangle.

CARY AND MANKATO SUB-AGES

When the ice front retreated from the Valparaiso moraine Lake Chicago formed behind the moraine. The outlet of the lake was at Chicago along Des Plaines Valley to Illinois Valley. The lake existed through late Cary time and early Mankato time until the ice melted from the straits of Mackinac at which time the eastward outlet was established and the Chicago outlet was abandoned.

The Lake Chicago outlet waters were probably confined to the present Illinois alluvial plain, although at their highest stage they may also have reoccupied the Mackinaw—Quiver Creek outlet. Two terraces are attributed to the effects of the outlet waters. The Bath terrace, 15 or 20 feet lower than the Havana terrace, is believed to be an erosional bench cut into the valley-train deposits. The Beardstown terrace, about 20 feet lower and only 5 to 10 feet above the present floodplain, probably represents a depositional surface after a stage of deeper erosion.

Recent Age

In the uplands of the Beardstown-Glasford-Havana-Vermont area weathering and erosion has continued since the deposition of the Peorian loess.

No evidence of Pleistocene man has been found in or near Illinois. Although animal remains are common in the Indian mounds and village sites of the region, no evidence has been found to suggest that the mound builders were contemporary with great Pleistocene mammals such as the mammoth and mastodon. The remains of a muskox were found in one of the mound excavations in this area, but it was lower than the lowest human remains, so there is no evidence that man and the muskox were contemporary in Illinois Valley.

The earliest men frequently inhabited the bluffs overlooking Illinois Valley; they especially favored projecting promontories between valleys. They also inhabited fans or terrace remnants at the base of the bluffs, as near Sepo, or small tracts of higher ground within the alluvial plains, as at Liverpool. The earliest men used somewhat crude implements of chipped stone, and they baked clay into rough generally unornamented pottery. They buried their dead with religious ritual, for the body was flexed and various ornaments or utensils were buried with them.

When the mound builders inhabited the region they developed numerous new skills including improvement in techniques of chipping stone, designing stone tools and weapons, and polishing stone implements. They used metallic copper, bone, and shell, and improved the design and variety of patterns for ornamentation of pottery. They used fire, caught fish and shell fish in the rivers, hunted upland game on the prairies, smoked pipes, domesticated the dog, developed a stabilized village life, and carried on trade. Communication with other contemporary men is shown by the presence of shell ornaments or vessels of marine Gulf Coast species and the extensive use of copper, probably obtained from the Keewenaw peninsula of northern Michigan (Cole and Deuel, 1937).

Among the animals found in camp refuse and apparently used for food are several species of clams and snails, fish, turtles, snakes, turkeys, the bald eagle, ducks, hawks, and many other birds, the black bear, raccoon, weasel, mink, skunk, badger, fox, wolf, woodchuck, squirrel, beaver, muskrat, rabbit, wapiti (elk), deer, and bison (Baker, 1930, 1931). No trace of articles of European manufacture has been discovered during extensive excavations of the mounds of this area. During the eighteenth and early nineteenth centuries the Sauk and Fox, Potawatomi, Kickapoo, and Miami tribes from the east and northeast invaded Illinois, driving out the native Illini, or Illiniwek, Indians who may have been descended from the mound builders.

White men settled the region early in the nineteenth century and found favorable homesites in the fertile soils of the upland prairies and of the Illinois and Sangamon bottomlands. Settlements were established at Beardstown, Havana, and Liverpool, and primitive roads across the prairie led to the early founding of Lewistown and Astoria. During a little more than a century man has cleared the forest, plowed the virgin prairie and forest soils, drained the more level or swampy lands, built levees and dams, straightened meandering streams, dug sand and gravel, mined coal, quarried limestone, and made excavations for buildings, highways, and railroads.

CHAPTER 8—ECONOMIC GEOLOGY

The mineral resources of the area include coal, sand and gravel, clay and shale, limestone, water, and soil. All of these resources are used. Coal mining is a major industry of great importance to the region. Adequate supplies of groundwater are available at most places. Much of the area has productive soils on which a diversified agriculture is based. Most parts of the area are amply supplied with local sources of construction materials —sand, gravel, limestone, and clay and shale for brick and tile. Although there has been no commercial production of oil and gas, numerous test wells have been drilled.

COAL

Twenty-three coal beds occur in the Pennsylvanian section in this area. Eleven of the coals are not known to reach a thickness of 28 inches, the minimum thickness for commercially minable coal under present conditions (Cady, 1952). These are the middle and upper DeLong, lower and upper Seahorne, lower and upper Wiley, Greenbush, Abingdon, Gimlet, Exline, and Trivoli (No. 8) coals. Of these the upper Wiley and Trivoli (No. 8) coals are generally a foot or more thick and have in aggregate a large tonnage. The others are rarely more than a few inches thick and may be disregarded. The lower DeLong has not been observed to be as thick as 28 inches in outcrop, but in a few coal test borings is reported to be as thick as 4 feet 2 inches. Although the average thickness of eight coals is less than 28 inches, they have a maximum thickness as follows:

	Thickness	
	Ft.	*In.*
Babylon coal	4	2
Tarter coal	3	
Pope Creek coal	3	
Rock Island (No. 1) coal	5	7
Kerton Creek coal	5	
Summum (No. 4) coal	5	9
Local coal in St. David cyclothem	2	6
Danville (No. 7) coal	2	6

Each of these coals is thus locally minable and several have been mined, particularly the Rock Island (No. 1) and Summum (No. 4) beds.

The principal coal production has come from three beds, the Colchester (No. 2) coal, which averages 30 inches thick, Springfield (No. 5) coal, averaging 54 to 60 inches, and Herrin (No. 6) coal, averaging 48 to 54 inches.

Coal has been mined in this region at least since the time of the Civil War. Mining was by underground methods until 1923, when strip mining was started on a large scale. The underground mines have almost all been shut down, except in the Glasford quadrangle. For many years now Fulton County has been one of the most active areas of coal stripping in the State. The Springfield (No. 5) coal is the principal coal stripped, though a large mine has operated for many years in the Herrin (No. 6) coal at Middle Grove, about four miles west of the Glasford quadrangle. Although the Colchester (No. 2) coal is the most widespread of the coals and evidently has a vast potential tonnage, its smaller thickness has discouraged large-scale mining operations up to the present.

The strip mining of coal has generally left a series of unsightly ridges of debris. For many years no effort was made either to level the waste piles or to place the fertile top soil or loess back at the surface. However, the mixed soils have supported plant growth readily and many debris piles of the 1920s are now covered with fair-sized trees. About 1945, attempts were made to convert stripped land into a range for fattening cattle. The tops of debris piles were leveled by bull dozing to give access to animals and trucks. Starting about 1950, stripping machines have been put into use which place the top soil back on the surface and leave a surface which may be reclaimed for crop plantings. The most successful machine of this sort is the stripping wheel which removes the Pleistocene loess and drift by a rotating wheel with a series of small buckets. The debris is carried as far as 350 feet on a conveyor belt which moves horizontally. The debris is dropped on waste piles of Pennsylvanian shale, limestone, and sandstone built up in the traditional manner. The spreading of top soil in this manner can leave the land so that it can be planted in grasses the next year and in crops within a few years. It seems likely that in the future most stripped lands will be restored to recreational or productive agricultural use.

All coals of western Illinois belong to the high-volatile bituminous "C" rank. Analyses of coal samples from this area are given by Cady (1935, 1948).

The coal beds that at least locally have commercial possibilities are briefly described below. Further details concerning the character, distribution, and thickness are given in the chapter on Pennsylvanian Stratigraphy. The outcrop lines and areas underlain by coals Nos. 2 and 5 are shown on plate 7. The approximate depths to the coals at any place can be estimated by comparison of the elevation of the coals, shown by structure contours, with the elevation of the land surface, shown on the topographic maps (pls. 1-4).

Babylon, Tarter, and Pope Creek Coals

The Babylon, Tarter, and Pope Creek coals are widespread but generally not thick enough to have economic value. They are characterized by marked variability. None of these coals is likely to support commercial mines in the near future, but in limited areas, especially in the Vermont quadrangle, they may serve as local sources of fuel from creek bank outcrops.

A local deposit of boghead (algal) coal occurs in the top 2 or 3 inches of the Tarter coal in SW¼ sec. 34, T. 6 N., R. 1 E. (Kosanke, 1951). This type of coal was formerly in demand as a source of kerosene or "coal oil." It is the only boghead coal thus far reported in Illinois.

Rock Island (No. 1) Coal

Through western Illinois the Rock Island (No. 1) coal occupies local linear troughs in which it is commonly of minable thickness, and outside of which there may be only a few inches or no coal at all. Three such troughs are known in this area. One, about half a mile wide, trends east-west and crops out in the Spoon River bluffs near Seville, in the Vermont quadrangle. This belt of relatively thick coal passes through secs. 22, 23, 24, 27, and 28, T. 6 N., R. 1 E. Another similar belt is near and north of Cuba, has apparent north-south trend, and is known from borings and one mine. It probably extends through parts of secs. 5, 6, 7, and 8, T. 6 N., R. 3 E. Most of this area is just north of the Havana quadrangle in the Canton quadrangle. The coal is currently mined by a shaft in sec. 8. Another area known only from borings is in the vicinity of Sepo in the Havana quadrangle, in sec. 4, T. 4 N., R. 4 E., and sec. 12, T. 4 N., R. 3 E. The Rock Island (No. 1) coal has a solid limestone roof except locally where it is a black slaty shale. Roof conditions are usually good, but because the coal commonly overlies the hard Bernadotte sandstone it is difficult to excavate a haulage way for mechanized mining.

Lower DeLong Coal

The lower DeLong coal is too thin to be minable except very locally where it thickens to 3 or 4 feet in the same restricted basins in which the Rock Island (No. 1) coal is thick and minable. Such an area is the district near Cuba mentioned above. The lower DeLong coal has a soft dark shale roof which would be well adapted to strip mining, but would form a poor roof for underground mining.

Colchester (No. 2) Coal

The Colchester (No. 2) coal is the most widespread of any coal in the region and is present in all four quadrangles (pl. 7). It is also the most uniform in thickness. It is less than 28 inches thick only in a small area near Frederick in the Beardstown quadrangle, where it is as thin as 7 inches. The coal has been mined in literally thousands of small drifts, nearly all in the period before extensive strip mining. A few shafts were operated, as near Lewistown. Because the coal is only 30 to 36 inches thick it was necessary to remove either roof or floor material for haulage-ways or to mine with little more than crawl space. The latter was generally practiced, and the mines were abandoned as soon as the face was 50 to 100 feet back from the outcrop. Many valleys which cut this coal have abandoned drift entries at intervals of about 200 feet along the valley sides.

A very insignificant part of this coal has been mined. It is almost everywhere free from partings and commonly does not contain pyritic nodules. Its roof varies, but most commonly is the gray Francis Creek shale. In some areas, as in the south part of the Havana quadrangle, the Pleasantview sandstone may completely replace the Francis Creek shale and form the coal roof. At a few places in the south part of the Beardstown quadrangle the Liverpool black slaty shale forms the roof. The Francis Creek shale slakes upon contact with the atmosphere, and in general may not provide a good mine roof. Roof falls account for abandonment of most of the small drift mines. The Pleasantview sandstone forms a better roof where massive than where it contains shaly layers. The black slaty shale usually forms a good roof.

It seems unlikely that underground mining of this coal will be undertaken on a large scale in the near future, but strip mining would be feasible in scattered areas throughout the Havana, Beardstown, and Vermont quadrangles. The coal has been tested for possible strip mining in a belt in the southern part of the Glasford quadrangle between the Illinois River and the bluff line. The coal is about 30 inches thick and its average cover does not exceed 30 feet.

Kerton Creek and Summum (No. 4) Coals

The Kerton Creek and Summum (No. 4) coals in commercial thickness are limited to trough-like areas which result from incomplete filling of erosional channels by the Pleasantview sandstone. In these areas the Kerton Creek coal lies on the uneven upper surface of the sandstone and the No. 4 coal is 10 to 15 feet above it. Where thick the Kerton Creek coal characteristically displays numerous partings of clay, shale, and "bone," detracting from its value as a fuel. The No. 4 coal is commonly freer from such partings. The coals have been found principally near Bryant in the north part of the Havana quadrangle, near Summum in the southeast part of the Vermont quadrangle, and near Astoria in the Beardstown quadrangle. Roof materials are probably not favorable for underground mining and extreme local variability in thickness would be a deterrent to strip mining on a large scale. Small-scale stripping has been used.

Springfield (No. 5) Coal

The Springfield (No. 5) coal is the thickest and most valuable coal of the region. It is present in all four quadrangles, but its major area is in the north part of the Havana quadrangle and nearly all of the Glasford quadrangle (pl. 7). It has been extensively mined underground near St. David in the Havana quadrangle, and in various parts of the Glasford quadrangle, but strip mining has largely replaced underground mining since about 1925. The coal thickens gradually southward so that it ranges from about 4 feet in the north part of the Glasford quadrangle to 6 feet in parts of the Beardstown quadrangle. The coal is free from bedded partings and has a uniform black hard slaty shale roof. In places the coal is cut by numerous clay veins or horsebacks which require cleaning of the coal before it can be marketed.

In strip mining this coal, overburden as thick as 80 feet is locally removed. Some of the significant improvements in strip mining technique have been applied to this coal. Nearly all parts of its outcrop in the Havana and Beardstown quadrangles have been mined or are under lease. Because of the eastward dip, the cover on the coal becomes too thick for strip mining in parts of the Glasford quadrangle, and large areas of the coal are unmined.

Local Coal Above No. 5 Coal

In a small gully in the SW¼ SE¼ sec. 16, T. 7 N., R. 5 E., in the Glasford quadrangle, 6 feet 6 inches of coal immediately underlies the Cuba sandstone and is underlain by 3 to 10 inches of black shale and 5 feet 6 inches of No. 5 coal. This gives a local thickness of 12 feet of coal with a small parting. The upper coal does not appear in nearby gullies, so it is evidently quite local. Just east of the Glasford quadrangle in sec. 6, T. 7 N., R. 7 E., the local coal is reported in three borings as 3 feet 9 inches to

5 feet 3 inches thick and is separated from the No. 5 coal by 4 to 20 inches of "slate" or "fireclay."

Herrin (No. 6) Coal

The Herrin (No. 6) coal is second in production in this area. It underlies most of the Glasford quadrangle and will be important in the future. In the Havana quadrangle it is restricted to a small area near Cuba, most of which is mined out. It is only a thin coal streak in a small area of the Beardstown quadrangle, and it is not present in the Vermont quadrangle. The coal contains two kinds of impurities, three persistent bedded partings, of which the middle "blue band" is 2 to 3 inches thick, and irregular bodies of light gray sandy clay known as "white-top." White-top is absent in some areas but in others composes 20 to 50 percent of the coal. The large amount of impurities in this coal gave it a poor reputation in western Illinois for many years. In 1933 the Midland Electric Coal Company opened its large Middle Grove strip mine in this coal about six miles west of the Glasford quadrangle. A large washing plant was installed and the washed coal has developed a good reputation as a clean coal.

Sparland (No. 7) Coal

The Sparland (No. 7) coal is possibly minable only in the Glasford quadrangle where it is 1 to 2½ feet thick, averaging 1½ feet. It is widespread but barely reaches the minimum thickness for classification as a minable coal. It is overlain by dark gray to black calcareous shale. In the future this thin widespread coal may be of commercial value for strip mining. No. 7 coal is locally present in the Beardstown quadrangle but averages only 2 to 4 inches thick.

SAND AND GRAVEL

Sand and gravel deposits are plentiful along the Illinois Valley, but infrequent in the upland areas northwest of the valley. They are of four types: 1) brown chert gravels eroded from late Tertiary erosion surfaces and redeposited in valley alluvial deposits of the early Pleistocene; 2) Illinoian outwash sands and gravels, especially near the Jacksonville moraine; 3) Wisconsin outwash and dune deposits of gravel and sand largely in Illinois Valley and associated terraces; and 4) recent alluvial deposits along smaller stream valleys.

Brown chert gravels are found principally along the valley of Slug Run in the north part of the Havana quadrangle and in the lower valley of Copperas Creek north of Banner in the Glasford quadrangle. A small operation was started using this gravel in sec. 26, T. 6 N., R. 3 E., a few years ago, but it was soon abandoned because the gravel was locally cemented into a firm conglomerate. The gravel in exposures north of Banner appears less indurated and sufficiently well sorted for use as road gravel.

Gravel and sand of Illinoian age associated with the Jacksonville moraine has been worked locally in Coal Creek Valley west of Frederick in the Beardstown quadrangle; along North Fork of Otter Creek, sec. 24, T. 4 N., R. 2 E., along Stuart Creek, sec. 13, T. 5 N., R. 2 E., and along a tributary of Big Sister Creek in sec. 8, T. 5 N., R. 4 E., in the Havana quadrangle; and along West Branch of Copperas Creek in sec. 33, T. 7 N., R. 5 E., in the Glasford quadrangle.

Illinoian deposits are quite variable in proportions of sand and gravel and are locally interrupted by tongues of glacial till or fine sand that must be rejected. In the Coal Creek locality about 33 feet of gravel is exposed and includes some boulders more than 7 feet in diameter. A similar thickness is found at the other places but large boulders are generally absent. Most of the deposits are outwash deltas formed in small valleys and are quite lenticular. The availability of gravel in Illinois Valley will probably be a deterrent to their extensive development.

The great fan of outwash in the Illinois Valley extends from Peoria to Beardstown (fig. 59). This deposit is clean, well sorted gravel near Peoria and Pekin where it has been developed extensively. The deposit becomes finer down stream, and below Havana it is largely fine sandy gravel and gravelly sand. In much of the large terrace area east of the bottomlands the gravel is largely obscured by bars and dunes of sand.

The gravel is best exposed in the bottomland area, especially in low terraces rising as islands a few feet above the present floodplain. Gravel pits have been operated at Kingston Lake at the east margin of the Glasford quadrangle north of Illinois River, at Spring Lake just south of the Glasford quadrangle southeast of the river, at Duck Island about two miles east of the Havana quadrangle, and at Liverpool "Island" north of the river, and near Otter Creek at the south margin of the Havana quadrangle. These deposits have yielded most of the gravel for surfacing rural roads throughout the area. Washing and screening plants are located at Liverpool and Duck Island. At these places there is generally 8 to 10 feet of flat-bedded gravel overlying gravel with foreset beds sloping down the valley. Small elevations above Illinois bottomlands in the Havana quadrangle in secs. 35 and 36, T. 4 N., R. 3 E., and sec. 11, T. 3 N., R. 3 E., are probably composed of similar though somewhat finer gravel. Knapps Island, between Stewart and Crane lakes in the Beardstown quadrangle, may yield commercial gravel, but it is not known to have been tested.

Nearly all streams in the area are floored with some sand, gravel, or boulders. In some valleys such deposits are adequate for local supplies. Outwash deposits along Spoon River and Kickapoo Creek would be most promising. Small streams paralleling the Jacksonville moraine have accumulated redeposited concentrations of sand and gravel derived from outwash along their valleys. A good example is West Fork of Copperas Creek in secs. 33 and 34, T. 7 N., R. 5 E., in the Glasford quadrangle.

CLAY AND SHALE

Clay and shale beds make up an aggregate thickness of 382 feet or 59 percent of the Pennsylvanian strata of the area. Twenty-one underclays range from a few inches to 10 feet thick. The thickest clay underlies the Sparland (No. 7) coal. Among the shales those in the Trivoli, Exline, Sparland, Brereton, St. David, Liverpool (both Purington and Francis Creek shales) cyclothems at least locally are more than 10 feet thick. All of these shales might be used for manufacture of building brick and tile, especially the Exline shale (40 feet thick), Farmington shale (37 feet), Canton shale (43 feet), Purington shale (52 feet), and Francis Creek shale (30 feet to a maximum of about 50 feet).

Underclays in the section below the Colchester (No. 2) coal usually contain kaolinite as the dominant clay mineral and are commonly noncalcareous throughout. The higher underclays are largely illite and only the upper 2 to 4 feet is noncalcareous. Some of the kaolinitic underclays are refractory.

The clay and shale resources of western Illinois have been intensively studied in recent years and will be described in a forthcoming publication.

LIMESTONE

The Mississippian Salem and St. Louis limestones are locally exposed in the Beardstown and Vermont quadrangles, (pls. 1, 4) and have been quarried on a small scale in a few places. The limestone in these formations is generally suitable for crushing for road stone, agricultural limestone, and probably for concrete aggregate. However, the outcrops are nearly all in the bottom of steep valleys or at the base of the Illinois River bluffs, and the areas under thin overburden appear to be generally too small for commercial development at present. About 30 feet of St. Louis limestone is exposed in the lower part of Mill Creek in the NE¼ NE¼ sec. 31, T. 2 N., R. 1 E., and 30 feet of Salem limestone is exposed about two miles northeast of Browning in the SE¼ NW¼ sec. 24, T. 2 N., R. 1 E., Beardstown quadrangle. Exposures of the St. Louis limestone may be underlain by 50 to 75 feet of limestone.

The Pennsylvanian section contains 28 beds of limestone but only the Lonsdale limestone is quarried at present. All are described in the chapter on Pennsylvanian Stratigraphy. Some of the limestones are nodular masses in underclays and are so irregular as to be useless as sources of limestone. The others are mostly above the coals and range from a few inches to 3 feet in average thickness. A few locally attain greater thickness—the Seville, Seahorne, a limestone at the base of the Oak Grove marine member, St. David, Brereton, and Lonsdale limestones. Only the Lonsdale limestone seems capable of commercial limestone production.

The Seville limestone is medium to dark gray limestone and is limited in outcrop to the vicinity of Seville, secs. 21, 22, 23, 24, and 27, T. 6 N., R. 1 E., in the Vermont quadrangle. It has a maximum thickness of 4 feet. The limestone is reported to be 31 feet thick in a boring north of Cuba, but no such thickness is known in outcrop.

The Seahorne limestone is extremely variable, ranging from 4 inches to about 6 feet thick. It is light gray and fairly pure. It may be suited for small-scale quarrying at various places in the Havana, Vermont, and Beardstown quadrangles.

Dark blue-gray limestone occurs immediately above the Liverpool black shale in the south half of the Beardstown quadrangle and has a maximum thickness of 10 feet along Mill Creek (geol. sec. 5). It is siliceous and cherty. Although relatively hard it is too impure to be used for agricultural limestone.

The St. David limestone attains a maximum thickness of 7 feet near Pleasantview in the Beardstown quadrangle where it is interbedded with calcareous shale. Elsewhere it is a single bed only 1 to 2 feet thick.

The Brereton limestone thickens northeastward from 1 foot in the Beardstown quadrangle to a maximum of 4 feet 3 inches in the Glasford quadrangle.

The Lonsdale limestone is limited to the Glasford quadrangle, where it ranges from about 2 to 25 feet thick and averages 6 to 8 feet thick. The limestone varies from a solid bed to a mass of loose nodules in clay. It is present under shallow cover under much of the bedrock ridge east of Farmington (fig. 66). A number of small quarries have been opened in this area and are operated intermittently as a source of road stone and agricultural limestone.

BUILDING STONE

The Bernadotte sandstone was formerly quarried for rough building stone at Marietta Station in the north part of the Vermont quadrangle where it is locally 16 to 18 feet thick. It is a buff hard well cemented fine-grained noncalcareous sandstone that would yield suitable blocks for bridge abutments and other rough construction purposes. Massive sandstone in channel phases of the Browning, Pleasantview, and Cuba sandstones may also be suited for some building purposes.

WATER RESOURCES

The Beardstown, Glasford, Havana, and Vermont quadrangles have abundant surface water and groundwater resources. Large supplies are available from the Illinois River and its major tributaries. The thorough dissection of the area by streams has provided many favorable sites for impounding reservoirs for small farm and municipal supplies.

Canton (west of the Glasford quadrangle), Astoria (Beardstown quadrangle), and Vermont obtain water from reservoirs formed by damming small streams. The Canton reservoir is in the West Branch of Copperas Creek (secs. 19 and 30, T. 7 N., R. 5 E., Glasford quadrangle), about three miles east of Canton. The Astoria reservoir is in a tributary of Otter Creek (sec. 15, T. 3 N., R. 1 E.,) north of Astoria. The Vermont reservoir is in a branch of Sugar Creek (secs. 24 and 25, T. 4 N., R. 1 W.). Both the Astoria and Canton surface reservoirs replace earlier deep wells, the water from which was strongly mineralized.

Groundwater is obtained from both unconsolidated surficial deposits and bedrock formations. The former include 1) recent alluvial deposits of streams, 2) sands and gravels deposited by glacial meltwaters in the Illinois and smaller valleys, and 3) gravel zones or lentils in the glacial drift.

The water-yielding zones in the bedrock include 1) Pennsylvanian sandstones, 2) Mississippian (St. Louis, Keokuk, and Burlington) limestones, 3) Devonian and Silurian limestones and dolomites, 4) Galena-Platteville dolomite, 5) St. Peter sandstone, and 6) Galesville sandstone.

Information on groundwater conditions in the Glasford quadrangle is given in Illinois State Geological Survey Bulletin 75 (State Water Survey Bulletin 39), "Groundwater in the Peoria Region" (Horberg, 1950). A summary of the groundwater geology in Peoria and Fulton counties is given in Illinois

State Geological Survey Circular 222, "Groundwater Geology in Western Illinois, North Part" (Bergstrom, 1956).

Municipal Groundwater Supplies

Groundwater has been developed for municipal supplies at Beardstown, Cuba, Glasford, Hanna City, Havana, Ipava, and Lewistown (Hanson, 1950). Beardstown, Cuba, Havana, and Lewistown obtain supplies from Pleistocene and Recent sands and gravels, whereas Glasford, Hanna City, and Ipava use water from the St. Peter sandstone. Other nearby towns that obtain water from the St. Peter, or have formerly, are Astoria, Avon, Bushnell, Canton, Cuba, Farmington, and Rushville.

Water in many of the bedrock formations is under artesian pressure which causes it to rise in the well above the top of the aquifer. In wells in the deep St. Peter and Galesville sandstones the water rises several hundreds of feet. For example, in the Ipava village well where the top of the St. Peter sandstone was encountered at a depth of 1304 feet, the water level in 1948 was 120 feet below ground surface (Hanson, 1950).

The amount of dissolved solids in water from the St. Peter sandstone increases southward from the outcrop in northern Illinois. The quadrangles in this study are near the southern limit of the area in which water from the St. Peter is usable for domestic consumption. According to analyses reported by the Illinois State Water Survey (Habermeyer, 1925; Hanson, 1950), water from the St. Peter sandstone municipal wells had the following amounts of total dissolved solids in parts per million (ppm): Farmington, 2161; Glasford, 1866; Bushnell, 1874; Cuba, 2380; Ipava, 2953; Astoria, 3628; and Rushville, 4285. Thus, although the St. Peter sandstone is sufficiently permeable to supply groundwater in quantities suitable for municipal requirements, the water is nearly unsuitable for domestic use.

The finest aquifer in the region is the great fan of outwash sand and gravel that underlies the terrace areas and parts of the floodplain in the Illinois Valley. These deposits are the source of water supply at Havana and Beardstown in wells that range in depth from 60 to 100 feet. Peoria and Pekin obtain water from similar deposits at depths ranging from 85 to 140 feet.

According to production data reported by the State Water Survey (Hanson, 1950) well yields of several hundred to several thousand gallons per minute have been obtained from sand and gravel in the Illinois Valley. The water from such wells is not salty as is water from the St. Peter sandstone but contains dissolved solids in the order of 344 ppm at Peoria, 345 ppm at Pekin, 186 ppm at Havana, and 321 ppm at Beardstown (Hanson, 1950).

Lewistown, although located on the upland, obtains its water from wells in the Spoon River floodplain about 2½ miles southwest of the town. Wells are from 25 to 42 feet deep. Simultaneous pumping from three wells at 400 gallons per minute produces a drawdown of 4 feet (Hanson, 1950).

Cuba, after considerable search for water less mineralized than that from the St. Peter, drilled two wells to 22 and 35 feet depth, probably in a gravel lens near the base of the glacial drift. Neither well produced more than 60 gallons per minute and the supply did not prove very reliable. Attempts to develop suitable surface water supply south of the town in Big Creek or north in Put Creek, were prevented because sulphurous coal mine drainage goes into each creek.

The towns of Trivoli, St. David, Bryant, Table Grove, Browning, Frederick and smaller communities do not have municipal water supplies, but depend on shallower privately owned wells.

Farm Supplies

Farm supplies are obtained from wells in 1) gravelly lenses in or near the base of the Illinoian drift, 2) sandy and gravelly deposits in preglacial valleys, 3) sandy and gravelly alluvium along such streams as Spoon River, and 4) bedrock formations.

Large diameter dug wells are commonly constructed to obtain water from the Illinoian drift where only thin, discontinuous streaks of sand are present. In dug wells water is supplied to the pump from storage and can seep into the well between periods of pumping. Drilled or driven wells, which

TABLE 6.—OIL AND GAS TESTS

Operator	Farm	Location	Sec.	Twp.	Range	Depth	Deepest formation
		Beardstown quadrangle					
J. Mackler, Jr.	S. Simpson	NW NW NW	35	3N.	1W.	830	Maquoketa
Astoria Oil & Gas Co.	J. Salisbury	SE NE NW	24	3N.	2E.	1167	Galena
O. D. Arnold, et al.*	Quinn	SE NE NW	27	2N.	1W.	851	Niagaran
Ohio Oil Co.	G. L. Orwig, et al.	Cen. NW SW	33	2N.	1E.	662	Maquoketa
Ohio Oil Co.	G. B. Christie	SE SE SE	26	1N.	1W.	465	Devonian-Silurian
Ohio Oil Co.	Jesse Lowe	NW SW SE	18	1N.	1E.	922	Galena
D. P. Fleeger	Meyer	?	7	18N.	11W.	567	Niagaran
Ehrhardt	Meyer	SE SE SE	7	18N.	11W.	546	Niagaran
		Glasford quadrangle					
Algona Oil Co.	Chas. Cramer	SE SE SW	27	8N.	5E.	1560	Glenwood-St. Peter
Blue Bell Oil Co.	Kyle #1	NW SW NW	17	8N.	6E.	1010	Silurian
Hanna City Oil & Gas Co.	Sonnemaker	SW SE SW	28	7N.	6E.	315	Burlington
		Havana quadrangle					
Charles Measley	R. Zemple	NE NE SW	12	5N.	2E.	820	Devonian-Silurian
Spoon River Oil & Gas Co.	Brock	SW NE SW	24	5N.	2E.	985	Galena
Spoon River Oil & Gas Co.	Miller	?	4	5N.	3E.	1045	Platteville
Lewistown Oil & Gas Co.	J. B. Depler	SW NE NE	8	5N.	3E.	2243	Franconia
Darrell Borton, et al.	P. J. McNally	SW SW SW	19	5N.	4E.	1105	Galena
J. H. White & Sons	Hahn	SE SE NE	31	22N.	8W.	1442	St. Peter
		Vermont quadrangle					
John L. Smith	J. R. Bradley	SE SE SW	17	6N.	1E.	1130	St. Peter
B. J. Grigsby*	Elsbert	SE SW SW	23	6N.	1E.	1400	St. Peter
T. N. Schnell & H. I. Botkins	J. C. Morgan	NE SE SW	24	6N.	1E.	669	Niagaran
Clark Hanks	J. C. Schafer? #2		26	6N.	1E.	588	Devonian
?	J. E. Harris	NW NW SW	31	6N.	1E.	920	Galena
Sewell Well Co.	A. Bartholomew	NE NE NE	6	4N.	1E.	1167	Galena
E. Graves	George Cox	NW NW	18	4N.	1E.	996	Galena
W. B. Lagers & F. E. Webb*	C. E. Cleer	SW NE NE	28	4N.	2E.	1026	Decorah

*Log of well given in Appendix B.

have little storage capacity, are used where water-yielding formations have sufficient capacity to supply water directly to the demand of the pump. Drilled wells are common in areas along the Jacksonville moraine where there are outwash sands and gravels, in areas where there are substantial thicknesses of sand and gravel in preglacial valleys (such as near Slug Run in the north part of the Havana quadrangle), in stream valleys such as that of Spoon River, and in extensive upland areas where the drift is thin and it is necessary to go into the bedrock for groundwater sources.

The groundwater conditions in bedrock and unconsolidated deposits in Fulton and Peoria counties have been mapped by Bergstrom (1956).

FLOWING WELLS

In 1904 a well that flowed was drilled for J. B. Depler along the north bank of Big Creek near the center of the NE¼ sec. 8, T. 5 N., R. 3 E., about three miles northwest of Lewistown in the Havana quadrangle.

This well was drilled to a depth of 2245 feet, ending in Cambrian sandstone. In 1917 the well flowed 770 gallons per minute. The water is warm, contains 2138 parts per million of mineral matter, and has been used for a swimming pool (Habermeyer, 1925, p. 354). In search of oil a well was drilled for J. H. White and Sons in the NW¼ SW¼ sec. 31, T. 22 N., R. 8 W., to a depth of 1442 feet into the top of the St. Peter sandstone. It is reported to have flowed originally 5,000 barrels per day. The water has a total dissolved content of 2400 parts per million.

OIL AND GAS POSSIBILITIES

Twenty-five test wells have been drilled in search for oil and gas in the four quadrangles, eight in the Beardstown, three in the Glasford, six in the Havana, and eight in the Vermont (table 6). The tests have ranged in depth from 315 feet to 2243 feet and the deepest ended in the Franconia (Cambrian) formation. None of the tests discovered oil or gas, although "shows" were reported in two or three. Interest in this area followed the discovery of the Colmar-Plymouth oil field in McDonough County, about 20 miles west of the Vermont quadrangle in 1914.

Many of the Mississippian formations which have yielded the largest amount of oil in the Illinois basin are absent in the Fulton County area. The Pennsylvanian sandstones are mostly too shallow to serve as suitable reservoirs. Greatest interest, therefore, has centered on the Devonian and Ordovician strata.

Production in the Colmar-Plymouth field was from a sandstone called the Hoing sand at the base of the Devonian Cedar Valley limestone. In that area the Cedar Valley formation overlaps the older Devonian limestone and the entire Silurian system to rest on the Ordovician Maquoketa shale. The Hoing sand appears to have its best development, a maximum thickness of 30 feet and average thickness of 14 feet, in the area near Colmar. Although sandstone or sandy limestone is reported at the position of the Hoing sandstone in some wells in this area, it is generally thinner and less permeable than in the Plymouth-Colmar area and no oil has been found in it.

The predominant structure of the area is a regional dip of 6 to 20 feet per mile east or southeast toward the Illinois basin. Along this slope a series of small anticlines and synclines have axes generally parallel to the slope toward the basin and a relief of 40 to 75 feet (fig. 62).

The failure of the oil and gas tests and other wells drilled for water to find commercial concentrations of oil or gas in the Cedar Valley or Galena formations, the very low angles of dip, and the general lack of westward dip or terrace structure, offer a discouraging outlook for oil and gas exploration in this region. However, many of the oil tests were not located in the most favorable structural positions. The Grassy Creek shale is a likely source rock, but between the Pennsylvanian and St. Peter sandstone there seems to be a lack of good reservoir rocks. Unless strata older than the Galena are to be tested it is unnecessary to drill deeper than 1000 to 1400 feet in this area.

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APPENDIX A

GEOLOGIC SECTIONS OF OUTCROPPING ROCKS

PART 1. PENNSYLVANIAN SECTIONS

Sections are arranged north to south within each quadrangle as follows:

- Beardstown—1–7
- Glasford—8–17
- Havana—18–30
- Vermont—31–39
- Others—40–44

Geologic section 1.—Roadcuts, stream banks, and mine openings near road intersection, center NE ¼ sec. 15, T. 3 N., R. 2 E., Beardstown quadrangle, Fulton County. Type outcrop of Kerton Creek coal.

Unit No.		*Thickness: Ft.*	*In.*
Summum cyclothem			
90–91	Shale, medium gray, mottled purplish, buff, and yellow, hard; large black limestone concretions	5	
89	Summum (No. 4) coal; slopes toward basin, deepest part of which is southwest of road intersection	5	4
87	Underclay, light to medium gray, upper 6 inches dark	3	9
86	Limestone concretions in clay	1	6
85	Shale, dark gray to black, thin coaly seams	1	8
84	Kerton Creek coal; dips into basin southwest of road corner	1½–6	
83	Pleasantview sandstone		
	Shale, sandy, black to green, hard, finely laminated plant impressions	0–1	6
	Sandstone, brownish-gray, massive to thin-bedded and shaly, micaceous; base concealed	20	

Geologic section 2.—Roadcut just northwest of Union ("Onion" on topographic map) School, E ½ NE ¼ sec. 24, T. 2 N., R. 1 W., Beardstown quadrangle, Schuyler County.

Unit No.		*Thickness: Ft.*	*In.*
Summum cyclothem			
83	Pleasantview sandstone, brownish-gray, carbonaceous, thin-bedded	10	
Liverpool cyclothem			
63	Colchester (No. 2) coal; upper part probably truncated by sandstone	1	6
62	Underclay, shaly, light gray	1	6
60	Browning sandstone		
	Shale, silty, brownish-gray, micaceous; more sandy in lower part; abundant and well preserved fossil plants; base concealed	18	

Geologic section 3.—Two forks of ravine, NW ¼ sec. 26, T. 2 N., R. 1 W., Beardstown quadrangle, Schuyler County (fig. 45).

Unit No.		*Thickness: Ft.*	*In.*
Sparland cyclothem			
130	Farmington shale, calcareous, gray, slightly fossiliferous; irregular concretions of light gray limestone in upper 3 feet	13	
129	Shale, red, soft	3	
	Shale, light gray	1	
127–128	Shale, dark gray to black; soft above and hard and sheety below; small oval concretions	1	7
125	Sparland (No. 7) coal		1
124	Underclay, light gray, noncalcareous		10
124	Underclay, calcareous, light gray; large selenite crystals	3	
123–124	Clay, calcareous, blue-gray to rusty; small irregular limestone concretions in lower part	5	6
Pokeberry cyclothem			
120	Pokeberry limestone		
	Clay, calcareous, hard; many fragments of fossiliferous limestone		3
	Limestone, blue-gray, fine-grained, very fossiliferous; contains well preserved large brachiopods, especially *Dictyoclostus portlockianus*, and *Fusulina;* uneven upper surface grades into overlying clay	1	6
119	Clay, rusty gray		6
"	Limestone, greenish-gray, nonfossiliferous, somewhat concretionary	1	
"	Clay, calcareous, greenish-gray; crinoid stem fragments		8
"	Limestone, light gray, very fine-grained, slightly fossiliferous		7½
"	Concealed		
118	Sandstone, calcareous, light gray, speckled with small brown spots	0–6	
Brereton cyclothem			
117	Sheffield shale		
	Limestone, light gray, weathers buff, slightly fossiliferous	1	2
	Shale, calcareous, greenish-gray; small concretions		4
	Shale, sandy, light greenish-gray, poorly bedded	1	1
	Shale, dark gray		1
	Shale, light gray; small irregular limestone concretions	4	6
	Clay, rusty, numerous limestone concretions	1	5
115	Brereton limestone, blue-gray, weathers buff, slightly fossiliferous		4
114	Shale, blue-gray		4
112	Herrin (No. 6) coal position; clay, black to dark gray, coaly		½
111	Underclay, light bluish-gray	2	
"	Underclay, rusty		10

Unit No.	*Thickness:*	*Ft.*	*In.*
110	Underclay, calcareous, blue-gray; few limestone concretions in lower part	1	10
St. David cyclothem			
103	Canton shale, blue-gray; numerous flattened oval ironstone concretions	6	
	Concealed	1	
101	St. David limestone		
	Limestone, light gray, massive, fossiliferous; *Marginifera splendens*	2	3
	Limestone, blue-gray, nodular, fossiliferous; in calcareous shale	1	3
	Limestone, gray, persistent		3
	Shale, calcareous, gray		$1\frac{1}{4}$
	Limestone, gray		3
	Shale, calcareous, gray		9
	Limestone, gray		$2\frac{1}{2}$
	Shale, calcareous; few limestone nodules	1	6
100	Shale, dark gray, soft	1	4
98	Shale, black, hard, sheety; numerous large black limestone concretions	1	6
97	Springfield (No. 5) coal	4	6
96	Underclay, gray; poorly exposed	3	
Summum cyclothem			
92	Hanover limestone, blue-gray, fine-grained, fossiliferous; upper surface knobby	2	6
91–90	Shale, calcareous, dark gray; small black pyritic concretions in lower part	1	1
89	Summum (No. 4) coal		2
87	Underclay, gray; lower part calcareous	2	8
86	Limestone, sandy, light blue-gray, concretionary, somewhat bedded, nonfossiliferous	1	4
85	Shale, very sandy, blue-gray, well bedded; large calcareous sandstone concretions	20	
83	Pleasantview sandstone, olive-gray, massive to thin-bedded; base concealed	40	

Geologic section 4.—Ravine draining southwest, SW ¼ sec. 26, T. 2 N., R. 1 W., Beardstown quadrangle, Schuyler County.

Unit No.	*Thickness:*	*Ft.*	*In.*
Sparland cyclothem			
130	Farmington shale, gray	18	
129	Shale, red	5	
125	Sparland (No. 7) coal		2
124	Underclay	2	
	Concealed	10	
Pokeberry cyclothem			
120	Pokeberry limestone		
	Clay, gray; fragments of fossiliferous limestone	2	
	Limestone, gray, massive, fossiliferous; *Dictyoclostus portlockianus*		8
	Concealed	1	
118	Sandstone, gray, rusty spotted	5	
Brereton cyclothem			
114	Shale, sandy, greenish-gray, micaceous	1	
112	Herrin (No. 6) coal (total coal and partings 2¾-5¼ inches)		
	Coaly streak		$\frac{1}{16}$-1
	Clay, medium gray (blue-band)		2
	Coaly streak		$\frac{1}{8}$–$\frac{1}{2}$
	Clay, medium gray		$\frac{1}{4}$–1
	Coaly streak		$\frac{1}{4}$–$\frac{3}{4}$
111	Underclay, medium gray	2	
110	Clay, calcareous; limestone nodules	1	
St. David cyclothem			
103	Canton shale, gray	9	
101	St. David limestone, gray, fossiliferous	2	
100?	Shale, calcareous, gray; thin beds of fossiliferous limestone	3	
	Concealed	3	
97	Springfield (No. 5) coal; top concealed	2	
96	Underclay, dark gray; base concealed	1	

Geologic section 5.—Mill Creek, sec. 36, T. 2 N., R. 1 W., and sec. 31, T. 2 N., R. 1 E., Beardstown quadrangle, Schuyler County. Type exposure of Pleasantview sandstone.

Unit No.	*Thickness:*	*Ft.*	*In.*
Sparland cyclothem			
130	Farmington shale, sandy, olive-gray, finely laminated; olive-gray ferruginous limestone concretions	15	
129	Shale, red, soft	1	
	Concealed (includes Pokeberry and Brereton cyclothems)	25–30	
St. David cyclothem			
101	St. David limestone, gray, massive, fossiliferous, calcareous shale partings	5	10
98	Shale, black, hard, sheety; large black limestone concretions	2	2
97	Springfield (No. 5) coal	3	10
96	Underclay, light gray, upper 3 inches dark		10
"	Underclay, gray		8
"	Concealed	1	
"	Underclay, calcareous, gray, hard; contains calcareous nodules	1	4
Summum cyclothem			
92	Hanover limestone, bluish- to brownish-gray, fine-grained, massive, fossiliferous; uneven and brecciated upper surface	2	4
91	Shale, slightly sandy, gray to dark gray, well bedded; calcareous near base	2	2
90	Clay, carbonaceous; small black pyrite nodules		2
89	Summum (No. 4) coal position; shale, black, coaly		2
87	Underclay, gray, upper 3 inches dark		8
"	Underclay, calcareous, light blue-gray, hard	2	
"	Concealed	2	

Unit No.	*Thickness:*	*Ft.*	*In.*
86	Clay, sandy, calcareous, blue-gray; contains irregularly shaped sandy limestone concretions		8
85	Shale, sandy, light blue-gray; blue-gray sandy limestone concretions	2	2
83	Pleasantview sandstone, yellow-gray, fine-grained, cross-bedded; the foreset beds dip west; large brownish calcareous sandstone concretions in upper part; thin-bedded in upper 8 feet, more massive below with beds to 2 feet thick; unconformity at base	65	
Liverpool cyclothem			
68	Oak Grove beds; limestone, dark blue-gray, hard, fine-grained, slightly cherty, fossiliferous, massive to slabby bedded	10	
67	Shale, black, fairly soft		8
"	Shale, black, hard, sheety; large black limestone concretions	3	2
64	Francis Creek shale, gray; thickens eastward	12–25	
63	Colchester (No. 2) coal	2½–3	
62	Underclay, gray; grades laterally to blue-gray shale to black shale	1	10
Greenbush cyclothem			
52	Shale, light blue-gray, well bedded	1	6
47	Underclay, light gray		10
Wiley cyclothem			
45	Wiley coal; 2 inches black shale in middle		4
44	Underclay		2½
Seahorne cyclothem			
41	Seahorne limestone, blue-gray, dense, massive, fossiliferous; uneven upper and lower surfaces	2	
39	Shale, pale greenish, poorly bedded		4
38	Clay, coaly		½
37	Underclay, light gray; yellowish near top	2	7
"	Clay, dark blue-gray; selenite crystals	1	3
Upper DeLong cyclothem			
34	Shale, yellow-green to buff	1	6
32	Clay, coaly		¼
29	Underclay, sandy, light gray, hard		2
Middle DeLong cyclothem			
27	Clay, coaly		⅛
26	Clay, silty, dark gray, hard		6
"	Clay, silty, light gray		8
25?	Clay, sandy, light blue-gray	1	6
Seville cyclothem			
16	Clay, very sandy, light gray	1	6
15	Bernadotte sandstone, shaly, light gray, thinly bedded	3	
Pope Creek cyclothem			
13	Pope Creek coal		16–30
12	Underclay, dark blue-gray		6
"	Clay, coaly		½
"	Clay, gray	1	5
Tarter cyclothem			
9	Tarter coal	2	2
8	Shale, blue-gray, thinly bedded	1	2
8	Underclay, blue-gray	7	
7	Shale, sandy, dark blue-gray	2	
"	Clay, light gray	1	
"	Shale, sandy, blue-gray	1	
"	Sandstone, thin-bedded		8
Babylon cyclothem			
6	Shale, sandy, light gray; abundant leaf and stem impressions and thin streaks of bright coal	6	
3	Clay, shaly	2	
2	Babylon sandstone, white, sparkling; contains *Stigmaria*	2	
Unnamed cyclothem (pre-Babylon)			
1	Coal streak		2
"	Clay, variegated, gray and reddish-brown; vesicular siliceous masses to 8 inches thick, probably derived from St. Louis limestone; one silicified specimen of *Lithostrotionella canadense*	2	
Mississippian system			
Meramec series			
	St. Louis limestone, light gray; uneven upper surface; base concealed	30	

Geologic section 6.—Two ravines on west side of Elm Creek, SE¼ NE¼ and NE¼ SE¼ sec. 5, T. 2 N., R. 2 E., Beardstown quadrangle, Schuyler County. Strata above the Seahorne limestone from the northern ravine; lower strata from the southern.

Unit No.	*Thickness:*	*Ft.*	*In.*
Summum cyclothem			
83	Pleasantview sandstone, yellow-gray, carbonaceous, massive	8	
Liverpool cyclothem			
64	Francis Creek shale, gray	0–6	
63	Colchester (No. 2) coal	2	7
62	Shale, black, hard (false bottom)		3
"	Underclay, gray; calcareous concretions in lowermost one foot	5	
Abingdon cyclothem			
59	Shale, sandy, gray, thin-bedded	1	6
53	Isabel sandstone, yellow-gray, thin-bedded	2	
Greenbush cyclothem			
52	Shale, blue-gray, thin-bedded	2	
51	Limestone, brownish-gray, dense, concretionary		0–2
50	Greenbush coal		0–½
47–48	Underclay, gray; large limestone concretions in upper part	1	6
Wiley cyclothem			
45	Clay, black, coaly		3
44	Underclay, gray		3
Seahorne cyclothem			
41	Seahorne limestone, light gray, massive, nodular, fossiliferous; uneven upper surface	4	
	Concealed	1	
37	Underclay, light gray, soft, plastic when wet	2	6

Unit No.		*Thickness:* *Ft.*	*In.*
35	Seahorne sandstone, light gray, fine-grained, thin- to medium-bedded	1	
	Upper DeLong cyclothem		
34	Clay, rusty gray		5
34	Clay, light blue-gray	1	9
"	Clay, dark blue-gray		8½
32	Upper DeLong coal, bony		1½
29–31	Underclay, medium purplish-gray	2	7
"	Underclay, light gray	1	8
	Middle DeLong cyclothem		
27	Clay, coaly		2
26	Underclay, light gray	2	
	Lower DeLong cyclothem		
23	Coaly streak		2
22	Underclay, light gray	1	6
	Seville cyclothem		
20	Shale, slightly sandy, light greenish-gray	3	
"	Shale, dark gray, soft, well bedded		7
19	Seville limestone, ferruginous, nodular, nonfossiliferous		8
	Limestone, argillaceous, blue-gray, mottled light gray		3
	Shale, calcareous, dark gray, hard, fossiliferous		5
	Limestone, brownish-gray, fossiliferous		7
18	Shale, black, hard, poorly bedded	2	
17	Rock Island (No. 1) coal		4½
16	Underclay, dark gray, somewhat laminated		4
"	Underclay, medium gray	1	5
	Pope Creek cyclothem		
13	Pope Creek coal		1½–3
12	Underclay, light to medium gray		10
	Tarter cyclothem		
9	Tarter coal		3½
"	Pyrite band, discontinuous		0–½
"	Tarter coal	1	6
8	Underclay, dark gray		4
"	Underclay, medium to light gray	2	3
	Babylon cyclothem		
6	Shale, dark gray, thin-bedded; discontinuous streaks of coal, numerous plant stem impressions, and dark blue-gray ironstone concretions	4	
2	Babylon sandstone, light blue-gray, wavy bedded	5	
	Unnamed cyclothem (pre-Babylon)		
1	Clay, bluish-gray	0–1	
"	Sandstone, yellow-gray, hard	0–2	
"	Clay, very sandy, light gray	1	
"	Clay, brownish-gray; limestone nodules from underlying St. Louis limestone	?	
	Mississippian system		
	Meramec series		
	St. Louis limestone, light gray, brecciated; knobs extend into overlying clay; base concealed	2	

Geologic section 7.—Shale pit and ravine, E½ sec. 7 and SW¼ sec. 8, T. 1 N., R. 1 E., Beardstown quadrangle, Schuyler County.

Unit No.		*Thickness:* *Ft.*	*In.*
	Summum cyclothem		
83	Pleasantview sandstone, light yellow-gray, fine-grained, micaceous, massive	15	
	Liverpool cyclothem		
82	Purington shale, silty, brown	16	
	Oak Grove beds		
79?	Limestone, brownish, fossiliferous		9
69?–78	Siltstone, calcareous, gray	6	
68	Limestone, dark blue-gray, massive, dense, fossiliferous, weathers brown	3	
67	Shale, black, hard, sheety; contains large black concretions	3	
64	Francis Creek shale, medium gray; small septarian concretions at two horizons in lower part	30	6
63	Colchester (No. 2) coal position; shale, black, hard, bony		6
62	Underclay, light gray, poorly bedded; lower part laminated	9	
	Seahorne cyclothem		
41	Seahorne limestone, brecciated; fragments of medium dark gray dense limestone in matrix of brownish-gray fossiliferous limestone	4	3
37	Clay and shale, poorly exposed, possibly includes DeLong and Seville (?) cyclothems	10	6
	Pope Creek (?) cyclothem		
14	Shale, gray	4	
13	Coal blossom	1	
12	Underclay, light blue-gray	2	8
"	Underclay, sandy, darker gray	2	2
	Tarter (?) cyclothem		
10	Shale, carbonaceous, flaky		1
9	Tarter coal		15–25
8	Underclay, sandy, greenish-gray, hard, somewhat laminated		5
7?	Underclay, sandy, gray, with blocky fracture; carbonaceous root impressions	5	6
	Babylon cyclothem		
6	Shale, slightly sandy, light to medium gray; carbonized stems form thin lenticular coal streaks	3	5
5	Shale, dark gray, micaceous		3
4	Coal, pyritic		2
3	Shale, dark		2
"	Underclay, light gray; root traces	5	4
"	Concealed	5	
2	Babylon sandstone, yellow-gray, medium-grained, sparkling	1	
	Concealed	5	
	Mississippian system		
	Meramec series		
	Salem-Warsaw formation		
	Dolomite, brown; weathers brick red and porous; base concealed	10	

Geologic section 8.—Ravine draining northeast and north, SW¼ sec. 3, T. 8 N., R. 5 E., Glasford quadrangle, Peoria County. Type exposure of Trivoli cyclothem.

Unit No.	*Thickness:*	*Ft.*	*In.*
Trivoli cyclothem			
154	Shale, gray, soft	6	6
153	Shale, calcareous, gray, very fossiliferous; *Chonetina, Composita argentea, Neospirifer cameratus*	4	6
152	Trivoli limestone, gray, weathers buff, fossiliferous		8–11
151	Shale, calcareous, light gray, fossiliferous	4	
150	Shale, black, soft, slightly fossiliferous		8
149	Limestone, dark blue-gray, slabby, shaly; abundant fossils, especially *Crurithyris*		7
"	Limestone, very shaly, dark gray, fossiliferous		7
148	Trivoli (No. 8) coal; cut by horseback	1	9
147	Underclay, dark gray; thin coaly streaks		3
"	Underclay, noncalcareous, medium to light gray	1	1
146	Underclay, calcareous; scattered nonfossiliferous limestone concretions	1	6
145	Trivoli sandstone, yellow-gray, massive to thin-bedded, micaceous	15	
Exline cyclothem			
144	Shale, slightly sandy, light gray	3	
"	Shale, blue-gray, soft		8
143	Limestone, gray, weathers light brown; contains fossil casts		3
"	Shale, gray, soft	5	
Gimlet cyclothem			
140	Lonsdale limestone, light gray, nodular, fossiliferous	10	
	Limestone, shaly, gray, fossiliferous; contains abundant *Marginifera splendens* and large crinoid stem segments	4	
135	Shale, gray	0–4½	
131	Gimlet sandstone, yellow-gray, massive, cross-bedded; foreset beds dip northwest; locally unconformable below Lonsdale limestone	5–20	
Sparland cyclothem			
130	Farmington shale, gray; base concealed	6	

Geologic section 9.—North-sloping ravine near center NE¼ sec. 3, T. 8 N., R. 5 E., Glasford quadrangle, Peoria County.

Unit No.	*Thickness:*	*Ft.*	*In.*
Trivoli cyclothem			
153	Trivoli limestone, gray, weathers buff, massive, fossiliferous; *Chonetina, Marginifera splendens*	1	4
151	Shale, calcareous, greenish-gray, fossiliferous; limestone concretions		8
150	Shale, black, hard, sheety, fossiliferous; flattened *Orbiculoidea* and *Dunbarella*	1	2
148	Trivoli (No. 8) coal, upper 4 inches very bony	2	
147	Underclay, light gray, poorly exposed	3	7
146	Limestone, gray, weathers brown, nonfossiliferous, concretionary		10
"	Clay, calcareous, yellow-gray; small limestone concretions		9
145	Trivoli sandstone, blue-gray, slightly micaceous; well indurated at top, shaly below; large flattened oval concretions, to 8 inches thick, 4 feet below top	14	6
Exline cyclothem			
144	Shale, gray, soft	1	
"	Limestone, blue-gray, weathers reddish-brown, fossiliferous; *Derbya*		2
"	Shale, gray, soft	6	
"	Shale, calcareous, gray, fossiliferous		3
"	Shale, dark gray; large calcareous and pyritic concretions	2	
144	Shale, gray, soft	13	
143	Shale, slightly calcareous, blue-gray, scattered limestone and pyritic concretions; *Euphemites, Astartella,* and *Nuculopsis*	2	
"	Shale, light gray	5	
"	Concealed	3	
"	Shale, gray, soft, carbonaceous	1	6
142	Shale, black, hard, sheety; poorly preserved plant impressions		4
"	Exline limestone, black, carbonaceous, platy; fern leaves, *Cordaites, Spirorbis, Schizodus,* fish teeth	1	2
Gimlet cyclothem			
140	Lonsdale limestone, light gray, nodular, fossiliferous, somewhat conglomeratic; grades into limestone nodules in shale	3–10	
131	Sandstone, yellow-gray; base concealed	2	

Geologic section 10.—Ravine near center S½ sec. 5, T. 8 N., R. 5 E., Glasford quadrangle, Peoria County.

Unit No.	*Thickness:*	*Ft.*	*In.*
Gimlet cyclothem			
140	Lonsdale limestone, light gray, nodular, unevenly bedded, fossiliferous; knobby upper surface	4	
	Limestone, fossiliferous; nodules like above in matrix of light gray calcareous shale	6	
	Limestone, light gray, dense, hard, massive, well jointed, fossiliferous	3	6

Unit No.	*Thickness:*	*Ft.*	*In.*
139	Shale, calcareous, light gray; limestone nodules		3
"	Shale, slightly calcareous, medium to dark blue-gray, hard		10
138	Shale, slightly calcareous, dark gray to black, thin-bedded, soft	6	
137	Shale, calcareous, blue-gray, hard		6
136	Limestone, light to medium gray, dense to subcrystalline, hard, slightly fossiliferous		4
132–135	Shale, noncalcareous, light gray, soft	1	2
"	Shale, noncalcareous, light gray, mottled with buff and brick-red, soft, well bedded		10
	Concealed	3	
132	Shale, noncalcareous, light gray, soft; lower part hard	4	6
131	Shale, silty to sandy, brownish-gray	1	
Sparland cyclothem			
130	Farmington shale, light gray; flattened oval ironstone concretions; base concealed	15	

Geologic section 11.—Waterfall in small ravine north of road, SW¼ NW¼ sec. 28, T. 8 N., R. 5 E., Glasford quadrangle, Peoria County.

Gimlet cyclothem			
140	Lonsdale limestone, light gray, unevenly bedded; upper surface nodular; fossiliferous	4	
	Shale, calcareous, yellowish-green		1
	Shale, gray		2
	Shale, dark gray to greenish		$\frac{1}{4}$
	Shale, olive		$4\frac{3}{4}$
	Limestone, bluish-gray, nodular coarse-grained, massive		11
	Marl, light gray, soft; abundant *Fusulina*		2
135?	Shale, light blue-gray; lower part sandy		$7\frac{1}{2}$
131	Sandstone, light blue-gray, medium-grained, micaceous; base concealed	4	

Geologic section 12.—West branch of Copperas Creek, W½ NW¼ sec. 34, and E½ SE¼ sec. 33, T. 8 N., R. 6 E., Glasford quadrangle, Peoria County.

Exline cyclothem			
141–143	Shale, sandy, fossiliferous; limestone nodules	5	
Gimlet cyclothem			
140	Lonsdale limestone, conglomeratic, gray; a mass of ½-2 inch limestone pebbles in limestone matrix; uneven basal surface		$3–8\frac{1}{2}$
131	Sandstone, olive-gray, micaceous, thin-bedded; coal lentils 2-8 inches thick	2	
	Concealed	3	
Sparland cyclothem			
121	Copperas Creek sandstone, light gray, rusty spotted, loosely cemented	10	
	Concealed	2	

Unit No.	*Thickness:*	*Ft.*	*In.*
Brereton cyclothem			
115	Brereton limestone, blue-gray, crystalline, irregularly bedded, fossiliferous; few black limestone nodules	2	6

Geologic section 13.—Northwest tributary to Largent Creek, SE¼ SW¼ sec. 13, T. 8 N., R. 6 E., Glasford quadrangle, Peoria County.

Gimlet cyclothem			
140	Lonsdale limestone, light gray, nodular	3	
	Limestone, thin irregular beds	1	6
	Limestone, light gray, massive, one bed	5	6
139	Shale, gray, well bedded	1	
138	Shale, black, carbonaceous, soft	1	
137	Shale, gray; weathers into small chips; sandy at base, clayey at top	6	
136	Shale, black, hard, sheety	1	
135	Shale, olive- to slate-gray; flat limestone concretions	6	
134	Gimlet coal		2
132	Underclay		4
131	Sandstone, buff; base concealed		6

Geologic section 14.—Cut-bank on east side of Copperas Creek, SW¼ NW¼ sec. 20, T. 8 N., R. 6 E., Glasford quadrangle, Peoria County.

Sparland cyclothem			
130	Farmington shale, blue-gray, some dark gray bands; many zones of dense dark gray ironstone concretions, some subspherical, some log-like, but most discoid; some have crenulate edges	10	
128	Shale, black, hard, sheety	1	
"	Shale, black, soft, clayey; light gray nutshaped limestone concretions; few fossils in lower part	1	8
127	Shale, dark blue-gray, clayey	1	
126	Limestone, gray, flaky, slightly fossiliferous, inter-bedded with coal; discontinuous		0–4
125	Sparland (No. 7) coal, cut by horsebacks	1	10
124	Underclay, light blue-gray; base concealed	8	

Geologic section 15.—Ravine in NW¼ NW¼ sec. 6, T. 8 N., R. 7 E., Glasford quadrangle, Peoria County. At or near type locality of Lonsdale limestone.

Exline cyclothem			
141	Shale, gray	3	
Gimlet cyclothem			
140	Lonsdale limestone, light gray, nodular, hard	12–14	
	Sandstone, calcareous, blue-gray	1–2	
	Limestone, light gray	3	
135?	Shale, sandy, gray	5	
131	Sandstone, blue-gray, soft, massive	3	
"	Sandstone, and sandy shale; base concealed	3	

Geologic section 16.—High east bank of Middle Copperas Creek and roadcut a little to the north, SE¼ NE¼ sec. 1, T. 7 N., R. 4 E., Glasford quadrangle, Fulton County (fig. 43). Type outcrop of Brereton cyclothem.

Unit No.		*Thickness: Ft.*	*In.*
Sparland cyclothem			
130	Farmington shale, gray, soft, weathers buff	4	6
128	Shale, black, soft to hard		3
127	Sparland (No. 7) coal	1	7
124	Underclay, light to dark gray, plastic	1	
"	Underclay, light gray	8	
123	Underclay, slightly sandy, calcareous; limestone concretions	1	
121	Copperas Creek sandstone		
	Sandstone, argillaceous, gray, weathers reddish-brown, massive	1	
	Sandstone, buff to gray, fine-grained; shaly in upper part and massive below	12	
Brereton cyclothem			
117	Sheffield shale, gray, soft; small ironstone concretions	7	4
116	Shale, calcareous, yellow-gray, fossiliferous; crinoid stems and brachiopods	1	4
115	Brereton limestone, gray; in two benches, the upper bench 2 feet 2 inches thick and more massive than the lower	3	6
114	Shale, light gray, weathers buff, soft; small black calcareous and pyritic concretions		4
"	Shale, black to dark gray		1
112–113	Herrin (No. 6) coal		
	Coal, irregular masses of micaceous siltstone at top (white top)		8
	Coal		11$\frac{1}{2}$
	Shale, medium gray, laminated		$\frac{1}{8}$–$\frac{3}{8}$
	Coal		11$\frac{1}{4}$
	Clay, medium blue-gray (blue-band)		2$\frac{3}{4}$
	Coal		3$\frac{1}{2}$
	Pyrite		0–$\frac{3}{4}$
	Coal		5$\frac{3}{4}$
	Clay, dark gray		$\frac{3}{4}$
	Coal	1	$\frac{1}{2}$
111	Underclay, noncalcareous, dark blue-gray	1	
"	Underclay, light gray		6
"	Underclay, calcareous, light gray; contains selenite crystals	2	6
107	Cuba sandstone, greenish-gray, mottled brownish, hard; lower part calcareous	3	
St. David cyclothem			
	Canton shale		
106	Shale, slightly sandy, medium gray	4	
105	Shale, light greenish-gray; contains small ironstone concretions and limestone joint-fillings; base concealed	8	

Geologic section 17.—Small gully on east side of large creek ¼ mile south of road, SW¼ NE¼ sec. 16, T. 7 N., R. 5 E., Glasford quadrangle, Fulton County.

Unit No.		*Thickness: Ft.*	*In.*
Brereton cyclothem			
107	Cuba sandstone, yellow-gray, thin-bedded, shaly, micaceous	7	
St. David cyclothem			
99	Coal	6	6
98	Clay, blue-gray; grades laterally into black sheety shale which contains *Lingula* and wood impressions		3–10
97	Springfield (No. 5) coal	5	6
96	Underclay, noncalcareous, dark gray		2
"	Underclay, light to medium gray	1	
"	Underclay, calcareous, medium gray, hard; contains small calcareous concretions	4	6
95	Limestone, gray; concretionary	1	5
"	Shale, calcareous, medium to dark gray, poorly bedded		10
"	Shale, dark blue-gray, well bedded		4
"	Clay, dark gray, not bedded	1	
"	Limestone, gray, concretionary; discontinuous		0–16
"	Clay, dark gray, hard		10
"	Limestone, blue-gray, concretionary	0–2	
94	Clay, calcareous, light yellow-gray; small dark gray spots	1	
"	Clay, medium blue-gray, hard, not laminated; with darker spots	5	6
Summum cyclothem			
92	Hanover limestone position; shale, calcareous, light gray, poorly bedded, slightly fossiliferous		6
91	Shale, blue-gray, well bedded; lower part darker	1	
90	Shale, black, hard, sheety		8
89	Summum (No. 4) coal		3$\frac{1}{2}$
87	Underclay, light gray; poorly exposed	4	
86	Underclay, calcareous, gray; contains irregularly shaped limestone concretions	1	8
83	Pleasantview sandstone, yellow-gray, soft, thin-bedded; base concealed	3	

Geologic section 18.—Abandoned coal strip mine and cave-in above mine in Springfield (No. 5) coal, NW¼ SW¼ sec. 20, T. 6 N., R. 3 E., Havana quadrangle, Fulton County.

Brereton cyclothem			
115	Brereton limestone, gray, fossiliferous; *Fusulina*		8
114	Shale, brownish		7
"	Shale, black, soft, weathered	1	4
112	Herrin (No. 6) coal (total coal and partings 5 feet 6 inches)		
	Coal, soft, weathered		1
	Concretions, pyritic, black, hard; calcite bands; (as much as 4 inches thick)		

Unit No.		*Thickness: Ft.*	*In.*
	Coal (including concretions above)	1	2
	Clay, gray		¼
	Coal		10¾
	Clay, blue-gray (blue-band)		2½
	Coal		6
	Pyrite concretions		¼–¾
	Coal		6
	Clay, gray		1
	Coal		2½
	Pyrite concretions		1
	Coal		8½
	Clay, gray		1
	Coal		11
	Concealed	1	
109–111	Shale, gray, soft	1	4
"	Shale, black, laminated; coal fragments		4
"	Shale, light gray		5
"	Underclay, calcareous, dark to medium gray; large gray sublithographic limestone concretions as much as 3 feet in diameter	8	
"	Clay, light gray, soft	4	1
St. David cyclothem			
103	Canton shale, dark gray, soft	2	
102	Shale, calcareous, blue-gray, fossiliferous		11
101	St. David limestone, gray, top exposed		

Geologic section 19.—Ravine east of Cuba, N¼ NW¼ sec. 21, T. 6 N., R. 3 E., Havana quadrangle, Fulton County.

Unit No.		*Thickness: Ft.*	*In.*
Brereton cyclothem			
112	Herrin (No. 6) coal		6
111	Underclay, gray	1	3
110	Limestone, blue-gray, weathers brown, nonfossiliferous	1	
109	Big Creek shale, gray, soft, middle part covered	11	
108	Limestone, dark gray, weathers brown; abundant *Linoproductus* and other brachiopods		4
"	Shale, gray, soft		4
107	Cuba sandstone, light gray, soft, thin-bedded; upper 3 inches calcareous, hard	6	3
St. David cyclothem			
105–106	Canton shale, gray; slightly sandy in upper part; ironstone concretions in lower part	28	
104	Shale, dark gray to black		3
"	Limestone, ferruginous, fossiliferous		4
102	Shale, calcareous, dark gray, fossiliferous		7
101	St. David limestone, gray, massive, fossiliferous		11
100	Shale, black, soft, thin-bedded	1	
98	Shale, black, hard, sheety	1	7
97	Springfield (No. 5) coal	4	8
96	Underclay, gray	2	3
95	Limestone, gray, concretionary, septarian		6

Geologic section 20.—Ravine and several side branches NE¼ SE¼ sec. 21, T. 6 N., R. 3 E., Havana quadrangle, Fulton County.

Unit No.		*Thickness: Ft.*	*In.*
Brereton cyclothem			
107	Cuba sandstone, buff, fine-grained, thin-bedded	8	
St. David cyclothem			
106	Canton shale, sandy, buff, thin-bedded, micaceous	5	
105	Shale, gray; layers of flattened oval ironstone concretions	18	
104	Limestone, blue-gray, concretionary, slightly fossiliferous, discontinuous		10
103	Shale, gray, soft	9	
102	Shale, calcareous, gray; consists principally of flattened and somewhat weathered crinoid stems, corals, brachiopods		8
101	St. David limestone, light blue-gray, weathers buff, massive, absent in one side gully	1	6
100	Shale, black to dark gray, soft	1	
98	Shale, black, carbonaceous, hard, sheety, finely laminated; large calcareous pyritic concretions	1	6
97	Springfield (No. 5) coal	5	
96	Underclay, light gray, noncalcareous		11
96–95	Underclay, gray, calcareous; large irregular septarian limestone concretions	3	
Summum cyclothem			
92	Hanover limestone position; clay, calcareous; contains small pellet-like nodules of light gray limestone, some of which contain marine fossils	1	
90	Limestone, brownish-gray; fragments of petrified wood, fish spines and teeth and *Orbiculoidea missouriensis*		1½
"	Clay, dark gray		½
"	Clay, light gray		¼
89	Summum (No. 4) coal position; clay, dark gray, carbonaceous		¼
88	Sandstone, calcareous, white, hard, very fine-grained, massive; discontinuous		0–5
87	Underclay, gray	3	
"	Limestone, dark gray, concretionary, somewhat septarian; discontinuous	0–1	
"	Clay and shale; poorly exposed	6	
86	Limestone, argillaceous, blue-gray, weathers light rusty brown; very irregularly bedded; uneven upper and lower surfaces project into adjacent clay		1–2
	Concealed	2	
83	Pleasantview sandstone, gray to buff; thin-bedded and silty in upper 10 feet ,mas-		

Unit No.		*Thickness: Ft.*	*In.*
	sive below; locally strongly cross-bedded with foreset beds dipping southwest; base concealed	16	

Geologic section 21.—Ravine sloping southeast to Big Creek, SE¼ SE¼ sec. 17, NE¼ NE¼ sec. 20, and NW¼ NW¼ sec. 21, T. 6 N., R. 4 E., Havana quadrangle, Fulton County. Type outcrop of St. David cyclothem.

Unit No.		*Thickness: Ft.*	*In.*
St. David cyclothem			
105	Canton shale, gray; many small ironstone concretions	10	
104	Limestone, blue-gray, concretionary, slightly fossiliferous		10
"	Shale, black, soft	1	
"	Shale, calcareous, gray, hard, fossiliferous		1
103	Shale, gray, soft	6	
101	St. David limestone, gray, massive, fossiliferous	1	4
100	Shale, medium gray, soft		8
"	Shale, black, soft	1	
98	Shale, black, hard, sheety; large black limestone concretions	1	
"	Shale, dark gray, soft, earthy		1
97	Springfield (No. 5) coal	5	4
96	Underclay, light gray	3	
95	Limestone, gray, in septarian concretions; discontinuous	1	
Summum cyclothem			
91	Shale, gray	5	
90	Shale, light gray; large smooth black limestone concretions		6
"	Shale, black		6
89	Summum (No. 4) coal, soft		3
87	Underclay, light gray	3	
86	Limestone, silty, blue-gray, weathers brownish, irregularly bedded	2–3	
85	Underclay, gray, shaly	4	
83	Pleasantview sandstone, brownish-gray; base concealed	6	

Geologic section 22.—Small ravine north of Oak Grove School, SW¼ SE¼ sec. 6, T. 5 N., R. 3 E., Havana quadrangle, Fulton County (fig. 36). Type exposure of Oak Grove beds.

Unit No.		*Thickness: Ft.*	*In.*
Liverpool cyclothem			
82	Purington shale, gray, soft; ironstone concretions	20	
	Oak Grove beds		
81	Shale, dark gray, fossiliferous; *Crurithyris*, *Crenipecten*, various gastropods, pelecypods, and holothurian plates		2
"	Ironstone, calcareous, fossiliferous; fossils preserved as casts and moulds coated white; some casts filled with crystalline calcite and siderite		3
80	Shale, dark gray; slightly fossiliferous; three bands of flattened oval ironstone concretions	2	
79	Limestone, dark gray, weathers rusty brown, fossiliferous; abundant *Crurithyris* and *Linoproductus;* forms small waterfall		5
78	Shale, black, soft, thin-bedded; abundant *Dunbarella rectilaterarea*	1	
77	Limestone, dark gray to nearly black, dense, concretionary, pyritic, fossiliferous; *Cardiomorpha*, *Chaenomya*, and other pelecypods; very discontinuous		0–1
75	Shale, silty, dark gray, slightly fossiliferous		6
74	Shale, calcareous, contains abundant fossils which weather out		2
72	Limestone, medium gray, fossiliferous; *Marginifera muricatina;* forms waterfall		5
"	Limestone, dark gray to black; softer than preceding		3
71	Shale, dark gray; concretionary masses of fossiliferous limestone	1	
64	Francis Creek shale, gray; base concealed	10	

Geologic section 23.—East bank of C. B. & Q. R.R. diversion channel, NE¼ SE¼ sec. 32, T. 5 N., R. 3 E., Havana quadrangle, Fulton County.

Unit No.		*Thickness: Ft.*	*In.*
Summum cyclothem			
83	Pleasantview sandstone, buff to gray, micaceous; in scattered outcrops at top of bank	5	
Liverpool cyclothem			
64	Francis Creek shale, gray	1	6
63	Colchester (No. 2) coal	2	6
62	Underclay, light gray	2	
Abingdon cyclothem			
59–60?	Shale, sandy, greenish-gray, micaceous, thinly laminated; irregular limonite-coated laminated masses of sandstone	4	6
53	Isabel sandstone, brown, massive, hard; forms ledge	2	
	Shale, sandy, gray		6
	Sandstone, light brown, fine-grained, hard	1	
Greenbush cyclothem			
52	Shale, sandy, greenish-gray and light yellow, micaceous; numerous ironstone nodules	3	10
51	Limestone, dark brown, limonite saturated		5
50	Greenbush coal		¼
49	Underclay, carbonaceous, dark gray		6
48	Limestone, light brown, dense, nodular; limonite-coated knobby surface	1	6
"	Limestone concretions, light brown; discontinuous; maximum thickness	2	6
47	Underclay, gray, lower 6 inches dark gray	2	9

Unit No.		Thickness: Ft.	In.
Wiley cyclothem			
46	Shale, black, hard, finely laminated; discontinuous		2
45	Wiley coal		10
44	Underclay, gray; selenite crystals	1	3
Seahorne cyclothem			
41	Seahorne limestone concretions, gray, massive, limonite-stained; discontinuous		10
37	Underclay, gray; limestone concretions	1	9
35	Seahorne sandstone, white to light gray, soft to hard, fine-grained	1	6

Geologic section 24.—Ravine, N½ NW¼ NW¼ sec. 17, T. 5 N., R. 4 E., Havana quadrangle, Fulton County (fig. 35). Type exposure of upper part of Liverpool cyclothem.

Unit No.		Thickness: Ft.	In.
Liverpool cyclothem			
82	Purington shale, gray, soft; several bands of flattened oval ironstone concretions, especially in lower 10 feet; jointing polygonal in upper part and rectangular in lower 5–10 feet	50	
	Oak Grove beds		
81	Shale, dark gray		1½
"	Shale, calcareous, gray, fossiliferous, fossil casts		1½
"	Ironstone, calcareous, dark gray, pyritic, somewhat concretionary; fossils preserved as casts and moulds lined with white		4
80	Shale, gray, slightly fossiliferous; 4 or 5 persistent layers of ironstone concretions	2	7
79	Limestone, dark gray, weathers rusty brown, very fossiliferous; abundant *Crurithyris* and *Linoproductus*		3
78	Shale, black, soft, weathers reddish-brown, finely laminated; abundant flattened impressions of *Dunbarella rectilaterarea*	1	3
"	Shale, dark gray, slightly sandy		6
76	Shale, calcareous; mostly white shells of *Mesolobus*		1
75	Shale, slightly sandy, dark gray, slightly fossiliferous	1	3
74	Shale, very calcareous, dark gray; abundant *Marginifera* and various gastropods		4
73	Cone-in-cone		0–2
72	Limestone, light gray, fossiliferous; forms a solid band, but locally consists of large septarian concretions		8–12
"	Limestone, argillaceous, gray, fossiliferous		4
71	Shale, gray to dark gray		10
68–69	Limestone, shaly, dark gray, slightly fossiliferous		2
"	Shale, dark gray		2
"	Limestone, shaly, dark gray, fossiliferous		2
"	Shale, dark gray		7
"	Shale, light blue-gray	1	4
66–67	Discontinuous large masses of brecciated septarian limestone concretions, and hard sheety shale, maximum diameter 10–12 feet and maximum thickness 4–5 feet	0–5	
"	Limestone, dark gray, fossiliferous; discontinuous		0–6
"	Shale, black, sheety, hard; contains small limestone concretions, giving a "pimply" appearance, and also large smooth-surfaced concretions, some spheroidal and others long and serpentine	3	
64	Francis Creek shale, gray; soft; upper 2 feet sandy, gray to dark gray; lower part in mine shaft	27	
63	Colchester (No. 2) coal (in small mine)	2	6

Geologic section 25.—Roadcut and ravine near center NE¼ sec. 20, T. 5 N., R. 4 E., Havana quadrangle, Fulton County. Type exposure of lower part of Liverpool cyclothem.

Unit No.		Thickness: Ft.	In.
Liverpool cyclothem			
	Oak Grove beds		
72	Limestone, gray, locally septarian, fossiliferous	1	
69	Shale, dark gray	3	
66	Limestone, dark gray, platy, hard, conchoidal fracture; resembles concretions from black shale which is absent	1	6
64	Francis Creek shale, gray, soft; upper 2 feet sandy	24	
63	Colchester (No. 2) coal	2	6
62	Underclay	2	6
60	Browning sandstone, light gray	1	
Abingdon cyclothem			
59?	Shale, sandy, gray	1	6
53	Isabel sandstone, yellow-gray; massive	2	
Greenbush cyclothem			
52	Shale, gray, soft; ironstone concretions; base concealed	4	

Geologic section 26.—Two cut banks on south side of Tater Creek, NW¼ NE¼ sec. 7 and SW¼ NW¼ sec. 8, T. 4 N., R. 3 E., Havana quadrangle, Fulton County (fig. 27).

Unit No.		Thickness: Ft.	In.
Lower DeLong cyclothem			
22	Underclay, light gray	1	6
Seville cyclothem			
18	Shale, dark gray		6
17	Rock Island (No. 1) coal		10
16	Underclay, shaly	2	6

Unit No.	*Thickness:*	*Ft.*	*In.*
15	Bernadotte sandstone, light gray, fine-grained, massive	2	
Pope Creek cyclothem			
13	Pope Creek coal	1	6
12	Underclay, dark		8
"	Underclay, light	2	10
"	Clay, black		2
"	Underclay, light	2	3
11	Sandstone, light gray, irregularly bedded; upper surface uneven	1	2
Tarter cyclothem			
10	Clay, carbonaceous, shaly		3
9	Tarter coal		5
"	Clay, gray		1
"	Tarter coal		8
8	Underclay, gray	1	6
7	Sandstone, yellow-gray; root traces		6
Babylon cyclothem			
6	Clay, sandy, light gray; base concealed		8

Geologic section 27.—South bank of Spoon River at Duncan Mills, center sec. 8, T. 4 N., R. 3 E., Havana quadrangle, Fulton County.

Seville cyclothem			
15	Bernadotte sandstone, buff to gray, hard, massive	3	
Pope Creek cyclothem			
13	Pope Creek coal	1	4
12	Underclay, light gray	2	
	Concealed (includes Tarter cyclothem)	3	
Babylon cyclothem			
6	Shale, gray, soft	3	
"	Ironstone concretions		2
"	Shale, gray, soft	1	6
"	Ironstone concretions		2
"	Shale, slightly sandy, gray		10
"	Limestone concretions, gray, large, septarian; irregularly distributed in shale	2	
"	Shale, slightly sandy, gray, micaceous, thin-bedded	2	6
5	Shale, black, hard, finely laminated		5
"	Shale, blue-gray, soft, papery; base concealed	12	

Geologic section 28.—High bank on southeast side of ravine, NW¼ NE¼ sec. 16, T. 4 N., R. 3 E., Havana quadrangle, Fulton County. Type outcrop of Isabel sandstone.

Unit No.	*Thickness:*	*Ft.*	*In.*
Summum cyclothem			
83	Pleasantview sandstone, buff, thin-bedded to massive; locally conglomeratic in lower part	12	
Liverpool cyclothem			
64	Francis Creek shale, gray	3	
63	Colchester (No. 2) coal	2	6
	Concealed	8	
Abingdon cyclothem			
56	Underclay, shaly, gray	1	
53	Isabel sandstone, buff, brown limonite spots, hard, massive, cross-bedded; forms prominent projecting ledge	10	
Greenbush cyclothem			
52	Shale, gray, soft, well bedded	4	
51	Limestone, gray, weathers buff, nonfossiliferous	1	
"	Shale, gray		3
50	Coaly streak		$\frac{1}{8}$
47–49	Underclay, light gray; large irregular limestone concretions	3	
Wiley cyclothem			
45	Wiley coal	1	
44	Underclay, dark gray		2
"	Underclay, light gray	2	4
Seahorne cyclothem			
41	Seahorne limestone, blue-gray, fine-grained, fossiliferous; knobby upper surface; lower surface projects irregularly into underlying clay	3	
39	Shale, brownish- to greenish-gray, poorly bedded	1	
38	Clay, coaly		$\frac{1}{2}$
36–37	Underclay, light gray; contains numerous large limestone concretions	3	
35	Seahorne sandstone, white or light gray; upper beds hard, weathers buff; base concealed	3	
Upper DeLong cyclothem			
34	Shale, light gray, poorly bedded; base concealed	1	

Geologic section 29.—East bank of Turkey Branch north of road, NE¼ SE¼ sec. 31, T. 4 N., R. 3 E., Havana quadrangle, Fulton County (fig. 32).

Summum cyclothem			
83	Pleasantview sandstone, yellow-gray, largely massive	10	
Liverpool cyclothem			
63	Colchester (No. 2) coal	2	6
62	Underclay, light gray; contains limestone concretions in lower part	3	6
Abingdon cyclothem			
54	Shale, sandy, gray	3	
53	Isabel sandstone, yellow-gray, massive, hard, micaceous	5	
Greenbush cyclothem			
52	Shale, gray, soft, evenly bedded	4	6
"	Shale, gray; calcareous ironstone concretions in 2 layers	1	
51	Limestone, gray, weathers brown, fine-grained		3
47–49	Underclay, light gray; contains numerous large irregular limestone concretions	4	3
Wiley cyclothem			
46	Shale, black, carbonaceous, hard		$1\frac{1}{2}$
45	Wiley coal		8
44	Underclay, light gray, soft	1	3
Seahorne cyclothem			
41	Seahorne limestone, gray; knobby upper surface; exposed in bed of Turkey Branch south of bridge; base concealed	2	

Geologic section 30.—Seahorne Branch, S½ SE¼ sec. 5, T. 3 N., R. 3 E., Havana quadrangle, Fulton County. Type outcrop of Seahorne cyclothem.

Unit No.		Thickness: Ft.	In.
	Summum cyclothem		
83	Pleasantview sandstone, brownish-gray, massive	20	
	Liverpool cyclothem		
64	Francis Creek shale, gray		6
63	Colchester (No. 2) coal	2	
59-62	Underclay, gray, and shale of Abingdon cyclothem undifferentiated	6	
	Abingdon cyclothem		
53	Isabel sandstone, gray, micaceous	2	2
	Greenbush cyclothem		
52	Shale, greenish-gray; contains ironstone concretions	15	6
49	Underclay, gray	3	
	Wiley cyclothem		
45	Wiley coal		11
44	Underclay, light gray	3	
	Seahorne cyclothem		
41	Seahorne limestone, light blue-gray, compact, massive, fossiliferous; upper part brecciated; uneven upper and lower surfaces	3	6
39	Shale, pale greenish-gray, poorly bedded	2	2
38	Seahorne coal, bony		1½
37	Underclay, gray	4	
35	Seahorne sandstone, light gray, fine-grained, thin-bedded	2	
	Upper DeLong cyclothem		
34	Shale, light gray, poorly bedded	1	5
30–32	Clay	1	
29	Underclay, light gray	2	6
"	Underclay, dark gray		6
	Middle DeLong cyclothem		
28	Shale, sandy	1	
26	Underclay, light gray	6	
	Lower DeLong cyclothem		
24	Shale, dark blue-gray, thin-bedded	3	
22	Underclay, blue-gray	2	6
"	Underclay, light gray	1	6
	Seville cyclothem		
17	Rock Island (No. 1) coal, bony		6
16?	Shale, carbonaceous, hard		3
15	Bernadotte sandstone, light gray, very hard; uneven upper surface; *Stigmaria;* base concealed	3	

Geologic section 31.—Roadcut and an old quarry near Marietta Station, NW¼ NE¼ sec. 21, T. 6 N., R. 1 E., Vermont quadrangle, Fulton County.

Unit No.		Thickness: Ft.	In.
	Liverpool cyclothem		
82	Purington shale, gray; ironstone concretions	4	
	Oak Grove beds		
79	Limestone, dark gray; contains *Crurithyris*		2
75–78	Shale, dark gray, soft, fossiliferous	1	4
72	Limestone, blue-gray, fossiliferous; *Marginifera muricatina*		8
69	Shale, light gray	2	
67	Shale, black, hard, sheety; large black limestone concretions	1	9
64	Francis Creek shale, light gray	10	
63	Colchester (No. 2) coal	2	4
62	Underclay, rusty	1	
	Abingdon cyclothem		
59	Shale, silty, gray; irregular limestone concretions; clay shale in lower part	6	
58	Shale, dark gray to black		4
57	Coaly streak		½
56	Underclay, medium gray	1	6
	Greenbush cyclothem		
52	Shale, gray; ferruginous limestone nodules in upper part	4	6
50	Coaly streak		¼
49	Underclay, medium gray, locally sandy	1	10
49?	Sandstone, thin-bedded, micaceous; discontinuous	1	6
	Wiley cyclothem		
45	Wiley coal		11½
44	Underclay, light gray; discontinuous carbonaceous streaks	1	4
44?	Sandstone; discontinuous		0–4
	Seahorne cyclothem		
41	Limestone, light gray; occurs as boulders in clay		0–8
40	Coaly streak		⅛
39	Clay, light gray	1	8
38	Coaly streak		½
37	Underclay, dark gray to black		3
"	Underclay, light gray	4	8
	Upper DeLong cyclothem		
32	Coaly streak		½
31	Underclay, dark gray		4
"	Underclay, medium gray to greenish		11
30	Coaly streak		½
29	Underclay, sandy, medium gray	1	2
	Middle DeLong cyclothem		
27	Coal; three or four streaks in clay		3
26	Underclay, light gray	3	6
"	Shale, rusty	2	2
25	Sandstone, shaly, micaceous, very fine-grained	2	4
	Lower DeLong cyclothem		
24	Shale, dark gray, soft, flaky		10
23	Coaly streak		½
22	Underclay, medium gray		6
21?	Shale, finely sandy, massive	1	
	Seville cyclothem		
20	Shale, silty, dark gray, slickensided	1	6
"	Shale, dark gray, soft, thin-bedded; ironstone concretions	3	6
15	Bernadotte sandstone, light gray, rusty, fine-grained, hard, sparkling; base concealed	18	

Geologic section 32.—Roadcut, railroad-cut of T. P. and W. R.R., and ravine, SE¼ sec. 22, T. 6 N., R. 1 E., Vermont quadrangle, Fulton County.

Unit No.		*Thickness: Ft.*	*In.*
Liverpool cyclothem			
64	Francis Creek shale, gray to olive-gray	18	
63	Colchester (No. 2) coal	1	11
62	Underclay, noncalcareous, light gray	2	2
"	Underclay, calcareous, rusty; selenite crystals	2	
60?	Sandstone position; shale, silty and sandy, gray; upper 8 inches gray to red	8	8
Abingdon cyclothem			
59	Shale, dark gray, thin-bedded	2	
"	Shale, rusty		8
58	Shale, black, carbonaceous		3
57	Coaly streak		1
56	Underclay, dark brown		4
"	Underclay, sandy, light gray	3	
55	Limestone concretions, large, brown, rusty; discontinuous		6
53	Isabel sandstone, gray	2	
Greenbush cyclothem			
52	Shale, medium gray	3	
50	Shale, dark gray, locally coaly		3
47	Underclay, gray, mottled yellow and rusty	3	
Wiley cyclothem			
45	Wiley coal, soft		10
44	Underclay, dark gray		4
"	Underclay, light gray	2	
Seahorne cyclothem			
41	Seahorne limestone, light gray, in discontinuous band of large concretions		8
	Concealed	2	
37	Underclay, light gray	1	
Upper DeLong cyclothem			
33	Shale, carbonaceous		$2\frac{1}{2}$
32	Shale; contains canneloid coal		$\frac{1}{2}$
29	Underclay, light brownish-gray	1	6
Middle DeLong cyclothem			
28	Shale, dark blue-gray		6
27	Clay, coaly		1
26	Underclay, light gray	5	
25	Shale, light gray	4	
25	Sandstone, reddish		1
Lower DeLong cyclothem			
24	Shale, dark gray, thin-bedded; selenite crystals	3	
23	Coaly streak		$\frac{1}{2}$
22	Underclay, medium to dark gray	1	6
Seville cyclothem			
20	Shale, dark gray; ironstone concretions	1	6
19	Seville limestone, argillaceous, light blue-gray, unevenly bedded, weathers platy, fossiliferous; pinches out to south	3	4
18	Shale, carbonaceous, black, soft		3
17	Rock Island (No. 1) coal	$2\frac{1}{2}$–3	
	Concealed	8	
Pope Creek cyclothem			
14	Shale, dark gray to chocolate	2	
13	Pope Creek coal	2	6
12	Underclay		1
11	Pope Creek sandstone, shaly	5	
Tarter cyclothem			
10	Shale, carbonaceous, black, thin-bedded	4	
9	Tarter coal		3–6
8	Underclay; base concealed		8

Geologic section 33.—Southwest bank of Spoon River, SW¼ SW¼ sec. 23, T. 6 N., R. 1 E., Vermont quadrangle, Fulton County (fig. 28). Type exposure of the Seville cyclothem and Worthen's No. 1 coal.

Unit No.		*Thickness: Ft.*	*In.*
Lower DeLong cyclothem			
24	Shale, slightly sandy, dark blue-gray, thin-bedded	1	9
22	Underclay, medium dark gray		10
"	Underclay, light gray	2	
Seville cyclothem			
19	Seville limestone, argillaceous, blue-gray, unevenly bedded, fossiliferous; brachiopods, bryozoa, crinoid stems; upper part slabby; pinches out to south	0–4	
18	Shale, dark blue-gray to black, carbonaceous, soft; discontinuous band of flat fossiliferous limestone concretions; pinches out to south	0–3	
"	Clay, yellow-brown, crumbly		3
17	Rock Island (No. 1) coal; rises 10 to 15 feet and thins to south	1–3	
16	Underclay, sandy, dark gray		6
"	Underclay, sandy, light gray, rusty	1	6
15	Bernadotte sandstone, light to olive-gray, fine-grained; thickens to south as Seville limestone and black shale disappear and No. 1 coal thins; rests on hill of St. Louis limestone	2–16	
Tarter (or Pope Creek?) cyclothem			
10?	Shale, blue-gray; stem impressions		5
9?	Coal; partly truncated by Bernadotte sandstone at south end of exposure	1	7
8?	Underclay, slightly sandy, dark blue-gray	1	2
7?	Sandstone, dark blue-gray, soft		9
Babylon cyclothem			
6	Shale, slightly sandy, dark blue, well bedded	1	4
3	Underclay, slightly sandy, light gray	3	6
2	Babylon sandstone, yellow-gray, medium-grained, massive, cross-bedded; thins out to north against hill of St. Louis limestone	0–12	
Mississippian system			
Meramec series			
	St. Louis limestone, light gray, brecciated, fossiliferous; exposed in north part of outcrop; base concealed	10	

Unit No.		Thickness: Ft.	In.
Geologic section 34.—Ravine southwest of Tarter Bridge, SE¼ sec. 2, T. 5 N., R. 1 E., Vermont quadrangle, Fulton County. Type exposure of Tarter cyclothem.			
Liverpool cyclothem			
64	Francis Creek shale, medium bluish-gray, thick-bedded, soft; ironstone concretions	20	
63	Colchester (No. 2) coal	2	8
62	Underclay, gray	3	
61	Shale or clay, gray; contains medium gray, dense to earthy irregular limestone concretions	3	
Abingdon cyclothem			
59	Shale, gray	3	
57	Clay, laminated; carbonaceous plant impressions; locally coaly		2
56	Underclay, gray	1	6
53	Isabel sandstone, medium light gray, micaceous, massive	0–2	
Greenbush cyclothem			
52	Shale, silty, medium blue-gray, earthy gray limestone concretions abundant in upper part	6	
50	Clay, coaly		2
49	Underclay, light gray, soft		6
48	Limestone, medium to dark gray, dense and hard; irregularly bedded; rough, rusty surfaces; *Spirorbis* as white casts		6–18
47	Underclay, finely sandy, medium gray	1	6
Wiley cyclothem			
46	Shale, black, soft		2
45	Wiley coal; one-inch clay parting near middle		6
44	Underclay, medium gray	2–2½	
Seahorne cyclothem			
41	Seahorne limestone, medium dark gray, fossiliferous, brecciated, septarian; contains sphalerite veinlets	½-1½	
37	Underclay, light gray, soft	2	
35	Seahorne sandstone, light gray, fine-grained, medium- to thin-bedded	2–3	
Upper DeLong cyclothem			
34	Shale, finely sandy, light gray, soft	2	6
33	Shale, dark gray; macerated plant impressions		4
32	Upper DeLong coal		1½
31	Underclay, silty, medium gray	1	6
30	Clay, coaly		1
29	Underclay	1	6
Middle DeLong cyclothem			
27	Middle DeLong coal		1
26	Underclay, silty, light bluish-gray	2	8
"	Underclay, shaly, gray	2	6
Lower DeLong cyclothem			
24	Shale, sandy, medium gray, thick-bedded, hard	4	6
21	Sandstone, gray, brown speckled, micaceous		6

Unit No.		Thickness: Ft.	In.
Seville cyclothem			
20	Shale, medium dark blue-gray, well bedded	5	
"	Shale, medium dark blue-gray; ironstone bands and concretions	2	6
17	Rock Island (No. 1) coal		6
16	Underclay, medium gray; abundant root impressions; discontinuous	0–1	
15	Bernadotte sandstone, light buff; massive and hard to thin-bedded and soft; upper part Stigmarian	5	6
Pope Creek cyclothem			
14	Shale, light to medium gray, soft	3	
13	Pope Creek coal		3–6
12	Underclay, light gray	3	
11	Pope Creek sandstone, buff, thin-bedded	0–3½	
Tarter cyclothem			
10	Shale, dark gray, flaky; fossil leaves and small ironstones	0–2½	
9	Tarter coal; strongly sulphur-stained	1	1
8	Underclay, sandy, gray	2	
7	Tarter sandstone, gray		0–6
Babylon cyclothem			
6	Shale, dark gray, flaky, ferruginous	5	
4	Babylon coal	1	6
3	Underclay, medium gray		8
"	Sandstone, light gray; root traces	1	11
"	Clay, silty, light to medium gray	3	
"	Underclay, light gray; joints filled with light brownish-gray silty clay	2	6
2	Babylon sandstone, yellowish-gray, medium-grained, sparkling	4	
Unnamed cyclothem (pre-Babylon)			
1	Shale, dark gray to black, soft, flaky, ferruginous	1	2
"	Sandstone, gray		7
"	Shale, dark gray to black; flaky above, slaty in lower part; contains ironstone lenses	1	3
"	Coal; locally extends down in cracks in underlying sandstone		4
"	Sandstone, soft, massive; contains *Stigmaria;* thins against buried hills of St. Louis limestone	3–6	
Mississippian system			
Meramec series			
	St. Louis limestone, buff to gray, cherty, almost lithographic; exposed in isolated knobs showing spheroidal spalling; base concealed	0–4	

Geologic section 35.—Cut bank on west side of Badger Creek, SW¼ NW¼ sec. 3, T. 5 N., R. 1 E., Vermont quadrangle, Fulton County.			
Seville cyclothem			
15	Bernadotte sandstone, light gray, very fine-grained, micaceous	2	

Unit No.		*Thickness: Ft.*	*In.*
Pope Creek cyclothem			
13	Pope Creek coal		4
12	Underclay, brownish-gray	2	6
Tarter cyclothem			
10	Shale, drab to brownish-gray	3	
"	Shale, dark gray, flaky; ironstone concretions 1 foot above base	4	6
9	Tarter coal		9
8	Underclay, light gray; coaly streaks	2	
"	Underclay	2	
Babylon cyclothem			
5–6	Shale, medium to dark gray	2	6
4	Babylon coal		8
3	Underclay, sandy, gray	2	
2	Babylon sandstone		
	Shale, sandy, dark gray	4	
	Sandstone, light gray		6
Unnamed cyclothem (pre-Babylon)			
1	Coal		2
"	Underclay, light gray	2	6
Mississippian system			
Meramec series			
	St. Louis limestone; occurs in knob surrounded by Pennsylvanian beds; base concealed	2	

Geologic section 36.—Roadcut on west side of Francis Creek, NE¼ SW¼ sec. 22, T. 5 N., R. 1 E., Vermont quadrangle, Fulton County. Type exposure of Francis Creek shale.

Unit No.		*Thickness: Ft.*	*In.*
Liverpool cyclothem			
	Oak Grove beds		
79	Limestone, dark gray, weathers brown, fossiliferous		3
78	Shale, black, soft, laminated, fossiliferous; *Dunbarella*		4
73	Cone-in-cone, discontinuous		0–3
72	Limestone, blue-gray, concretionary, septarian, fossiliferous; *Marginifera muricatina*		6
71	Shale, calcareous, gray; contains crinoid stems		2
64	Francis Creek shale, greenish-gray, spheroidal weathering; lower 5 feet slightly sandy, gray	39	6
63	Colchester (No. 2) coal	2	6
62	Underclay, light gray	3	
Abingdon cyclothem			
59	Shale, gray	3	
58	Shale, dark gray		2
57	Clay, coaly		¼
56	Underclay, light gray	1	
53	Isabel sandstone, shaly, calcareous, greenish-gray, fine-grained	2	6
Greenbush cyclothem			
52	Shale, gray; ironstone concretions	4	
50	Clay, coaly		⅛
47–49	Underclay, medium gray	1	2
Wiley cyclothem			
45	Wiley coal; shaly at top		4
44	Underclay, medium gray	1	2
Seahorne cyclothem			
41	Seahorne limestone, light gray, in discontinuous boulders	0–1	
37	Underclay, light gray	3–4	
35	Seahorne sandstone, light gray, fine-grained; base concealed	3	

Geologic section 37.—Road and ravine just southwest of Bernadotte, SW¼ sec. 19, T. 5 N., R. 2 E., Vermont quadrangle, Fulton County. Type outcrop of Bernadotte sandstone.

Unit No.		*Thickness: Ft.*	*In.*
Summum cyclothem			
83	Pleasantview sandstone, shaly, yellow-gray, micaceous, soft	37	
Liverpool cyclothem			
63	Colchester (No. 2) coal	2	½
62	Underclay, light gray, coaly streaks	1	6
"	Underclay, rusty		10
60	Sandstone position; clay sandy, light greenish-gray; contains small ironstone concretions	1	2
	Concealed	1	
Abingdon cyclothem			
59	Shale, slightly sandy, greenish-gray, micaceous	4	6
53	Isabel sandstone, yellow-brown, micaceous; massive in upper part, shaly below	2	
Greenbush cyclothem			
52	Shale, slightly sandy, olive-gray	2	6
51	Limestone, light gray, concretionary		4
47	Underclay, light gray	1	6
Wiley cyclothem			
45	Wiley coal		6
44	Underclay, light gray	1	6
"	Underclay, rusty, hard; limestone concretions	1	4
43	Clay, black, coaly		½
42	Underclay, dark gray		6
Seahorne cyclothem			
41	Seahorne limestone, light gray, concretionary, septarian, fossiliferous	1	9
39	Clay, light gray		3
38	Clay, coaly		1½
37	Underclay, light gray	1	9
36	Underclay, rusty, hard; large brown limestone concretions	2	
"	Underclay, light gray		8
35	Seahorne sandstone, light gray, fine-grained, hard, sparkling; minute mica flakes	2	
Upper DeLong cyclothem			
34	Shale, light gray, soft, thin-bedded	2	6
"	Shale, blue-gray		5
32	Upper DeLong coal		½
31	Underclay, brownish-gray		10
"	Underclay, light gray		5
30	Clay, carbonaceous, coaly		2
29	Underclay, dark to medium gray	2	
Middle DeLong cyclothem			
27	Middle DeLong coal, bony		2½
26	Clay, light gray	3	
25	Sandstone, shaly, light gray, fine-grained, micaceous; discontinuous	1	

Unit No.		*Thickness: Ft.*	*In.*
Lower DeLong cyclothem			
24	Shale, light gray	2	
"	Shale, dark gray		5
23	Clay, black, coaly		$\frac{1}{4}$
22	Underclay, sandy, purplish gray	1	9
Seville cyclothem			
20	Shale, finely sandy; medium gray and black interlaminated	2	4
"	Shale, sandy, medium gray, soft		10
17	Rock Island (No. 1) coal, slaty	1	
16	Underclay, sandy		3
15	Bernadotte sandstone		
	Sandstone, purplish to light yellow-gray, weakly laminated; abundant *Stigmaria*	1	2
	Sandstone, light gray, fine-grained, hard, massive, quartzitic; well bedded in lower part; locally cuts into Pope Creek coal	4–6	
Pope Creek cyclothem			
14	Shale, light gray, laminated	1	6
"	Shale, silty, black		9
13	Pope Creek coal, slaty		2–10
12	Underclay, medium to light gray	$1\frac{1}{2}$–3	
Tarter cyclothem			
10	Shale, dark gray to black, fossiliferous; leaves and stems; discontinuous	0–2	
9	Tarter coal, slaty		2–12
8	Underclay, dark gray to black, hard, ferruginous	1	8
Babylon cyclothem			
6	Clay or shale, black; thin coaly streaks local		10
4	Babylon coal	1–4	
3	Underclay, medium gray		0–9
2	Babylon sandstone, light gray, fine-grained, sparkling, thin-bedded; base concealed	3	

Geologic section 38.—Jake Creek, NE¼ sec. 13' T. 4 N., R. 1 E., Vermont quadrangle, Fulton County' Type exposure of Jake Creek sandstone.

Liverpool cyclothem			
	Oak Grove beds		
79	Limestone, dark gray, fossiliferous		1
75–78	Shale, medium gray	1	
73	Cone-in-cone		1
72	Limestone, gray, fossiliferous; *Marginifera*, *Mesolobus*, *Crurithyris*		6
65	Jake Creek sandstone		
	Shale, sandy; with ironstone nodules	1	6
	Sandstone, brownish-gray, carbonaceous, micaceous; upper 8 feet massive, lower part thin-bedded; poorly preserved plant impressions; grades into underlying shale	18	
64	Francis Creek shale, gray; sandy in upper part; base concealed	25	

Geologic section 39.—Ravine northeast of Summum, NE¼ sec. 3, T. 3 N., R. 2 E., and E½ sec. 34, T. 4 N., R. 2 E., Vermont quadrangle, Fulton County. Type exposure of Summum cyclothem.

Unit No.		*Thickness: Ft.*	*In.*
Brereton cyclothem			
107	Cuba sandstone, massive to thin-bedded	5	
St. David cyclothem			
103–106	Canton shale, silty, gray; small ironstone concretions; sandy in upper portion	30	
102	Shale, calcareous, blue-gray, fossiliferous		6
101	St. David limestone, argillaceous, blue-gray, very fossiliferous		8
100	Shale, black, soft; small pyritic concretions		6
98	Shale, black, sheety, hard; numerous large fossiliferous concretions; pyritized fossils at base	3	
"	Shale, calcareous, black to dark gray, soft, fossiliferous		4
97	Springfield (No. 5) coal	5	6
96	Underclay, dark gray		4
"	Underclay, gray, noncalcareous		10
"	Underclay, gray		5
"	Underclay, calcareous, dark gray, weathers brownish	1	8
95	Clay, light gray, hard, calcareous; irregular limestone concretions	1	6
"	Limestone, argillaceous, light blue-gray, nonfossiliferous, concretionary	3	
94	Clay, gray, calcareous	2	
Summum cyclothem			
92?	Shale, gray, thin-bedded; blue-gray limestone fill in joints		8
92	Hanover limestone, blue-gray, brecciated; very rough surface		4–8
90–91	Shale, light gray to nearly black, soft, well-bedded; limestone concretions ranging from 6 x 6 x 6 inches to 5 x 6 x 8 feet; concretions are nearly black, dense, spheroidal, smooth surfaced, slightly fossiliferous; shale laminae bend around concretions	4	6
"	Limestone, blue-gray		1
89	Summum (No. 4) coal; has ½-inch clay parting at some outcrops; 4 inches to	5	9
87	Underclay, dark gray		2
"	Underclay, light gray	3	
86	Shale, olive-gray, well-bedded	3	
86	Shale, slightly sandy, blue-gray	1	8
"	Shale, light gray, poorly bedded; large septarian limestone concretions	2	
85	Shale, dark blue-gray		6
84	Kerton Creek coal; discontinuous	0–1	
83	Pleasantview sandstone, fine-grained, micaceous; blue-gray at top to brownish		

Unit No.		Thickness: Ft.	In.
	gray below; thin-bedded above, beds to 4 feet thick below; cross-bedded, foreset beds mostly dip north or northwest; carbonaceous material and well preserved stem impressions on some bedding surfaces and thin streaks of bright coal	80	
Liverpool cyclothem			
63	Colchester (No. 2) coal	2	6
62	Underclay, poorly exposed	5	
60	Browning sandstone, light gray, massive, cross-bedded	20	
Seahorne cyclothem			
41	Seahorne limestone, blue-gray, hard, fine-grained, knobby upper surface	1	9
37	Clay, sandy, yellowish-gray	3	6
35	Seahorne sandstone, very light gray, fine-grained, hard	1	4
Upper DeLong cyclothem			
34	Shale, light gray, well bedded; base concealed	3	

Geologic section 40.—Ravine tributary to Swan Creek, E. ½ sec. 24, T. 8 N., R. 1 W., Avon quadrangle, Warren County. Type exposure of Greenbush cyclothem.

Unit No.		Thickness: Ft.	In.
Liverpool cyclothem			
	Oak Grove beds		
73	Cone-in-cone, discontinuous		4
72	Limestone, gray, very fossiliferous; *Marginifera*		9
71	Shale, dark gray, weathers rusty	1	4
69	Shale, calcareous, dark gray; contains abundant crinoid segments		7
67	Shale, black, hard, sheety; pimply appearance in middle part	1	5
64	Francis Creek shale, light gray, soft, spheroidal fracture	7	
63	Colchester (No. 2) coal	2	
62	Underclay, light gray, weathers yellowish-brown; lower part calcareous	3	
Abingdon cyclothem			
59	Shale, light grayish olive, evenly bedded, weathers yellowish; very sandy near base	3	6
53	Isabel sandstone, olive-gray, slightly micaceous		4
Greenbush cyclothem			
52	Shale, light olive-gray, evenly bedded; sandy at top, blue-gray and less sandy toward base	15	
50	Greenbush coal		½–1
49	Underclay, dark gray		2
48–49	Clay, light gray, slightly greenish; sandy in lower part, irregular limestone concretions	4	
47?	Sandstone, olive-gray, micaceous; slabby in upper part, shaly below	4	6

Unit No.		Thickness: Ft.	In.
Wiley cyclothem			
46?	Shale, gray, finely bedded	2	7
46	Shale, dark gray, rusty on fracture surfaces		6
"	Shale, dark gray to black, gray laminae		5
45	Wiley coal	1	3
44	Underclay, gray; ½-inch coaly streaks inclined at various directions	2	
Seahorne cyclothem			
41	Seahorne limestone, concretions in clay		6
39	Clay, sandy, alternating greenish-blue and brownish-gray, bands		7
38	Lower Seahorne coal		2
37	Underclay, dull bluish-gray to greenish-gray and deep blue; darker in lower part	2	
35	Seahorne sandstone, light bluish-gray, micaceous, slabby, regular bedding	1–3	
Upper and Middle DeLong cyclothems			
34	Shale, sandy, poorly bedded and gray in upper portion, well bedded and darker gray below	3	6
30–32	Shale, coaly; ½-inch coal beds at top and base		6
29	Underclay, dark gray	1	1
"	Clay, dark gray to bluish-gray; calcareous nodules		9
Lower DeLong cyclothem			
24	Shale, slightly sandy, dark blue-gray, thin-bedded	1	8
22	Underclay, sandy, gray		2
Seville cyclothem?			
19?	Sandstone, dark gray, calcareous, carbonaceous, micaceous, hard; slabby		6
18?	Shale, black; carbonaceous; wood impressions		3
17	Rock Island (No. 1) coal; 1-inch pyrite parting 1 inch below top	2	6
16	Underclay, sandy, dark gray; base concealed	1	4

Geologic section 41.—West bank of Spoon River ½ mile north of Babylon, NE¼ NE¼ sec. 14, T. 7 N., R. 1 E., Avon quadrangle, Fulton County. Type exposure of Babylon cyclothem.

Unit No.		Thickness: Ft.	In.
Seville cyclothem			
15	Bernadotte sandstone, white, fine-grained, massive- to medium-bedded	6	
Pope Creek cyclothem			
14	Shale, black, carbonaceous, hard	1	6
13	Pope Creek coal	2	
12	Underclay, light gray	3	
11	Shale, sandy, blue-gray, micaceous	2	6
"	Shale, sandy, blue-gray; ferruginous limestone concretions	1	
"	Shale, sandy, blue-gray, carbonaceous	4	
"	Sandstone, reddish brown; conglomeratic beds toward base,		

Unit No.	*Thickness:*	*Ft.*	*In.*
	contain angular fragments of black shale and coal	1–2	
Tarter cyclothem			
10	Shale, black		2
"	Limestone, ferruginous, gray, nodular		0–4
"	Shale, black, carbonaceous, soft, finely laminated	1	11
9	Tarter coal		$1\frac{3}{4}$
"	Bone		$1\frac{1}{4}$
"	Tarter coal, shaly		4
8	Underclay, light gray	3	4
"	Clay, rusty	1	3
Babylon cyclothem			
6	Shale, dark blue-gray, soft; *Lingula*	1	9
"	Limestone, gray, ferruginous, concretionary		5
"	Shale, gray, micaceous		5
6	Limestone, pyritic		2
5	Shale, black, carbonaceous, soft		8
"	Shale, black, carbonaceous, hard, sheety	3	3
4	Babylon coal, canneloid		$5\frac{1}{2}$
"	Babylon coal		$1\frac{3}{4}$
3	Shale, black, hard, laminated		2
"	Underclay, sandy, light gray	4	
2	Babylon sandstone, white to light gray, medium-grained, sparkling; contains carbonized wood impressions	2	
	Shale, sandy, dark gray	1	
	Concealed	4	
	Sandstone, light yellow, hard; *Stigmaria*	1	
Mississippian system			
Meramec series			
St. Louis (?) formation			
	Limestone, light gray, hard, in bed of Spoon River	1	

Geologic section 42.—South bank of ravine, near west line of SW¼ NW¼ sec. 16, T. 7 N., R. 2 E., Avon quadrangle, Fulton County. Type exposure of Wiley cyclothem.

Unit No.	*Thickness:*	*Ft.*	*In.*
Abingdon cyclothem			
53	Isabel sandstone, light blue-gray, weathers olive- brown; unevenly bedded; calcareous concretions	6	
	Sandstone, blue-gray, massive, micaceous	1	10
	Sandstone, shaly, blue-gray, alternate dark and light bands, micaceous, thin-bedded	3	
Greenbush cyclothem			
52	Shale, sandy		6
51–52	Shale, dark gray; discontinuous band of large discoidal limestone concretions	4	6
51	Shale, black, soft, fossiliferous; plant stems, *Spirorbis*, pelecypods, and small limestone concretions		1
49	Underclay, medium gray; traces of coal		7
"	Clay, light gray, soft		10
"	Clay, rusty		8
47	Clay, calcareous; large irregular limestone concretions	1	4
Wiley cyclothem			
45	Coal, bony		3
"	Wiley coal	1	1
44	Underclay, blue-gray, soft		5
"	Underclay, light gray		8
"	Underclay, calcareous; irregular limestone concretions	1	7
Seahorne cyclothem			
41	Seahorne limestone, blue-gray, septarian; uneven upper surface; discontinuous	3	
39	Shale, pale, greenish		8–24
38	Lower Seahorne coal		4
37	Underclay, light gray; base concealed	2	

Geologic section 43.—High bluff on south side of La Marsh Creek, NE¼ NE¼ sec. 17, T. 7 N., R. 7 E., Peoria quadrangle, Peoria County (two miles east of Glasford quadrangle).

Unit No.	*Thickness:*	*Ft.*	*In.*
Brereton cyclothem			
107	Cuba sandstone, brown, soft, thin-bedded	25	
	Sandstone, brown, massive, uneven lower surface	35	
St. David cyclothem			
103	Canton shale, gray, soft		6
101	St. David limestone, dark gray; a discontinuous layer of limestone nodules		0–4
100	Shale, dark gray to black, soft, fossiliferous	1	6
98	Shale, black, hard, sheety	1	
97	Springfield (No. 5) coal	4	7
96	Underclay, dark gray, noncalcareous		5
"	Underclay; medium gray at top, dark gray at base; few limestone nodules; slightly bedded at base	1	4
95	Shale, black, and limestone, gray, laminated; beds up to ¼ inch, black shale predominating		5
"	Limestone, very argillaceous, mottled black and greenish-gray		3–6
"	Limestone, argillaceous, greenish-gray, nonfossiliferous; uneven lower surface		8–12
"	Shale, very dark gray, soft, thin-bedded		1–6
95	Limestone, argillaceous, greenish gray; slightly laminated in lower portion		1–3
94	Shale, dark gray, soft, thin-bedded, slightly fossiliferous; small limestone nodules		0–4
Summum cyclothem			
93	Covel conglomerate, dark gray, small dark gray limestone pebbles in light gray matrix		0–2
87	Underclay, gray, calcareous; base concealed	6	

Geologic section 44.—Small ravine, E½ SE¼ sec. 8, T. 6 N., R. 3 E., Canton quadrangle, Fulton County. At or near the type outcrop of the Cuba sandstone. The Cuba sandstone is only 3 feet thick here but thickens to 20 feet about 1 mile west, where the top is eroded.

Unit No.		*Thickness: Ft.*	*In.*
Brereton cyclothem			
115	Brereton limestone, gray, weathers buff, fossiliferous; *Fusulina*	4	
114	Shale, black, soft	2	
112	Herrin (No. 6) coal (total 3 feet 11½ inches)		
	Coal	2	
	Clay, blue-gray		2
	Coal		8
	Clay, gray		½
	Coal	1	1
111	Shale, black, hard, bony		3
"	Underclay, dark blue-gray		10
"	Shale, dark gray, sheety, finely laminated; stem and leaf impressions	3	10
"	Underclay, dark gray, no lamination	1	10
"	Underclay, medium gray, calcareous	2	3
110	Limestone, medium gray, dense, nodular; root impressions	1	8
	Concealed	1	
109	Big Creek shale, gray, soft, well bedded	2	4
	Concealed	3	
107	Cuba sandstone, buff, thin-bedded to massive; lower part more massive; west of here, the thick sandstone is massive, and log impressions and streaks of bright coal are present in lower 1 foot	3	
St. David cyclothem			
98	Shale, black, hard, sheety		9
"	Shale, black, carbonaceous, fairly soft, fossiliferous; *Dunbarella rectilaterarea*		6
97	Springfield (No. 5) coal	4	8
96	Underclay, yellow-gray, mostly calcareous	2	3
95	Limestone, gray, concretionary, in calcareous clay	1	
Summum cyclothem			
89	Summum (No. 4) coal position; clay, black		2
87	Underclay, blue-gray, weathers buff, noncalcareous	1	6
"	Underclay, calcareous, gray; contains small limestone concretions; base concealed	2	

PART 2. PLEISTOCENE SECTIONS

Sections are arranged north to south within each quadrangle as follows:

Beardstown—45, 46	Vermont—68
Glasford—47-50	Canton—69
Havana—51-67	

Geologic section 45.—Stream-cut in terrace, elevation 490 feet, SW¼ NW¼ NW¼ sec. 24, T. 2 N., R. 1 E., Beardstown quadrangle, Schuyler County.

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Tazewell loess, pale yellow-brown, calcareous, massive	5	
Bloomington slackwater deposits		
Silt, grayish-white to dark yellow-brown with pinkish-gray zones, the latter more common below, strongly calcareous, well bedded	9–15	
Silt, whitish-gray and pinkish-gray in alternating zones, calcareous, well bedded; abundant gastropods and a few pelecypods; locally sandy, especially at base; sharp break at base	0–6	
Silt, clayey, red, strongly calcareous, massive, fossiliferous; cracked in upper part	2	
Silt, similar to overlying, more largely gray than pink, poorly exposed	6	
Silt, bluish-gray, strongly calcareous, massive; base concealed	1	

Geologic section 46.—West wall of ravine about one-third mile northwest of Frederick, NE¼ SE¼ SE¼ sec. 7, T. 1 N., R. 1 E., Beardstown quadrangle, Schuyler County.

Wisconsin stage		
Peorian loess, yellow, calcareous, lower part fossiliferous	30±	
Illinoian stage		
Jacksonville gravel, very coarse, poorly sorted, calcareous; locally cemented to conglomerate; cross-bedded, foreset beds dip 17° southeast; numerous boulders more than 2 feet in diameter	46	
Payson till, gray, calcareous, upper 1 foot oxidized	25	
Covered to outcrop of Salem (Mississippian) dolomite	4	

Geologic section 47.—Roadcut in terrace, elevation 530 feet, on west side of Kickapoo Creek, NE¼ NE¼ SW¼ sec. 24, T. 9 N., R. 6 E., Glasford quadrangle, Peoria County.

Wisconsin stage		
Shelbyville or Bloomington outwash		
Soil, blackish-brown, and clay, yellowish-brown	4	
Sand, light gray, very fine-grained, minute cut-and-fill cross-bedding; the lower 1 foot contains many coarse sand and gravel lenses; partly cuts out underlying sand	5–8	
Sand, light gray, fine-grained, minutely cross-laminated		6

Unit No.	*Thickness: Ft.*	*In.*
Sand, medium gray, evenly bedded, occupies channel cut in underlying silt	0–3	
Silt, gray and brownish-gray, fills erosional depressions; sandy near base	3–7	
Sand and gravel, yellow and brown, firmly cemented, poorly sorted; few bands of silt; base concealed	8	

Geologic section 48.—High cut on north side of T. P. & W. R.R. along west Branch of Copperas Creek, SE¼ NW¼ sec. 33, T. 7 N., R. 5 E., Glasford quadrangle, Fulton County.

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Peorian loess		
Soil, light gray, silty	1	11
Silt, brownish-gray, noncalcareous		6
Farmdale loess, chocolate brown, noncalcareous	2	
Illinoian stage		
Jacksonville drift		
Silt, finely sandy, chocolate brown above, reddish-brown below, noncalcareous; few pebbles of chert and quartz; more sandy and pebbly in lower part	8	
Sand, silty, pebbly, reddish-brown, noncalcareous; lower part very gravelly, with lens of gray sand at base	6	
Silt and fine sand in alternate beds, yellowish-brown, noncalcareous	8	
Silt, coarse, yellowish-gray, calcareous, well bedded; lower 2 feet in regular laminae about one inch thick, probably varves, faint laminations in each varve	14	
Silt, similar to above, but not so well bedded; thin lenticular layers of gray clay	3	
Sand and gravel, mostly pebbly sand, cross-bedded; beds of fine gravel and scattered cobbles	15	
Till, yellowish-gray, calcareous, thickens toward east	3–8	
Silt and sand, pebbly, calcareous, laminated, marked by water seepage	2–3	
Yarmouth stage		
Soil, black to dark gray, noncalcareous		0–6
Silt, brownish-black, grading down to blue, with brown on fracture surfaces, noncalcareous	2	
Silt, blue, weathering brown, noncalcareous	6–8	
Gravel, cemented, brown, noncalcareous, discontinuous	0–6	
Kansan stage		
Till, dark blue-gray, weathers brown, noncalcareous	2	
Till, dark gray, calcareous, blocky, exposed toward west end of cut; base concealed	0–2 exposed	

Geologic section 49.—South bank of ravine west of Canton Road mine, NE¼ NE¼ sec. 25, T. 7 N., R. 6 E., Glasford quadrangle, Peoria County.

Unit No.	*Thickness: Ft.*	*In.*
Illinoian stage		
Till, light gray, largely unweathered	15	
Pre-Illinoian stage or stages		
Silt, sandy, deep greenish-blue, noncalcareous, very compact; lenses of gravel; prominent vertical columns showing concentric bands of iron-stain appear to be crayfish borings; darker slightly calcareous silts contain numerous partially carbonized logs and a few imperfect leaf impressions; downstream overlies Pennsylvanian strata	20	

Geologic section 50.—Small wooded ravine about 200 yards west of Copperas Creek, NE¼ SE¼ SE¼ sec. 3, T. 6 N., R. 5 E., Glasford quadrangle, Fulton County. The lower strata are better displayed in cut of secondary road in west bank of Copperas Creek about 200 yards south of this ravine.

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Peorian loess, noncalcareous	1	
Illinois stage		
Buffalo Hart drift		
Till, oxidized and leached	2	
Till, calcareous, lower part faintly bedded, suggesting deposition in water	2	
Marl, whitish, very calcareous, crowded with small limestone concretions		2
Silt, brownish, calcareous, very finely laminated, slightly interbedded with thin marl lenses like above		3
Aftonian (?) stage		
Silt, clayey, brown, noncalcareous, dense, grading down through sand to gravel		8
Gravel, brown, noncalcareous, strongly oxidized, firmly cemented, interbedded with sand, mostly brown chert and quartz pebbles	4	
Silt, blue-green, weathers dark brown, noncalcareous, very compact and tough, few pebbles	1	6
Gravel, brown, well cemented with limonite to a firm conglomerate, mostly brown chert and quartz pebbles; unconformable on Purington (Pennsylvanian) shale	3	

Geologic section 51.—Exposures in strip mine, in roadcut north of Big Creek valley, and in small gravel pit in ravine floor, SE¼ SW¼ sec. 26, T. 6 N., R. 3 E., Havana quadrangle, Fulton County.

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Peorian loess		
Soil, light gray to light buff	1	
Silt, yellow-brown, noncalcareous, compact	2	8
Silt, light brownish-gray with yellow streaks, noncalcareous, oxidized	6	6
Farmdale loess, chocolate brown, noncalcareous; lighter and more friable		

Unit No.	*Thickness: Ft.*	*In.*
at top, darker and more compact below, grades into underlying clay	3	
Illinoian stage		
Buffalo Hart drift (?)		
Clay, silty; occasional quartz pebbles	1	
Gumbotil, brown, darker at top; few quartz pebbles	2	
Till, yellow-brown, oxidized, noncalcareous	3	
Till, yellow-brown, oxidized, calcareous, probably waterlaid till	5	
Till, gray, unweathered; 1 foot thick in strip mine where it rests on St. David limestone with polished surface and striae trending S. 60° W. and fainter striae trending S. 15° E. or S. 45° E.; 19 feet in roadcut to south	1–19	
Kansan stage		
Till, leached and oxidized in upper portion, nearly a gumbotil, with secondary calcium carbonate along joints	6	
Till, medium to dark blue-gray, calcareous; sand lenses	8	
Silt, gray, somewhat laminated, with small strongly calcareous nodules	2	
Aftonian or Nebraskan stage		
Gravel, locally cemented to conglomerate, deep brown, ferruginous, composed of pebbles of chert, quartz, ironstone, and a few igneous and metamorphic rocks; in roadcut and small abandoned gravel pit in ravine west of road; rests on Pleasantview (Pennsylvanian) sandstone	7	

Geologic section 52.—Strip mine near SW cor. NW ¼ sec. 27, T. 6 N., R. 3 E., Havana quadrangle, Fulton County. Exposure later destroyed by mining.

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Peorian loess		
Silt, dark gray, some humus	1	
Silt, buff, noncalcareous	3	2
Silt, mottled buff and gray, calcareous	2	8
Farmdale loess		
Silt, pinkish-gray, noncalcareous, loosely aggregated, with root canals		10
Silt, brownish-gray, noncalcareous, plastic, gumbolike	1	7
Illinoian stage		
Buffalo Hart drift		
Gumbotil, brownish-gray, noncalcareous, plastic; showing minutely pitted surface where fractured; pebbles of chert and quartz	5	8
Till, reddish-brown, noncalcareous; few deeply weathered limestone pebbles and abundant pebbles of silicate rocks; on Canton (Pennsylvanian) shale	2	10

Geologic section 53.—East cut-bank of ravine in terrace, elevation 510 feet, NE¼ SW¼ sec. 14, T. 5 N., R. 2 E., Havana quadrangle, Fulton County.

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Bloomington and post-Bloomington outwash and slack-water deposits		
Silt, sandy, brownish, noncalcareous	8	
Sand, yellowish-brown, noncalcareous, fine	5	
Sand, bluish-gray to brown, calcareous, finely laminated, suggesting seasonal deposition	3	8
Silt, sandy, brownish, calcareous		2
Silt, slightly sandy, brownish to blue-gray, calcareous; scattered pebbles of quartz and chert to one half inch diameter; poorly preserved gastropods and some small calcareous concretions in lower part	4	
Silt, brown, highly calcareous; abundant calcareous concretions		1
Iowan loess, light gray, slightly calcareous, plastic	3	6
Farmdale substage		
Loess, slightly sandy, chocolate brown with reddish cast, noncalcareous, plastic; fragments of carbonized wood; scattered pebbles to three fourths inch diameter in basal portion, thickens to south	2–3	
Silt, sandy, dark bluish-gray, noncalcareous; numerous pebbles; base concealed	2	

Geologic section 54.—High cut-bank on east side of Big Sister Creek, SW¼ NW¼ NW¼ sec. 8, T. 5 N., R. 4 E., Havana quadrangle, Fulton County.

Unit No.	*Thickness: Ft.*	*In.*
Illinoian stage		
Soil, grayish-brown to dark gray, noncalcareous, loose	1	
Mesotil, brownish-gray, with dark brownish stains on fracture surfaces, noncalcareous; scattered pebbles of quartz, chert, and a few igneous rocks	8	
Till, rusty brown along fracture surfaces, bluish-gray in centers of large masses, noncalcareous above to lightly calcareous	1	8
Till, gray, calcareous	7	
Sand, reddish or yellowish, calcareous	1	6
Silt or sand, blue-gray, calcareous	1	4
Clay, slightly silty, dark bluish-gray, carbonaceous, calcareous, bituminous or earthy odor; numerous fragments of carbonized wood; striae on upper surface trend S. 60° W.; ½ inch clay layer at base	1	6
Loveland loess, dark, gray above, brownish-gray below, calcareous, slightly fossiliferous, some wood fragments and carbonized specks	1	8
Kansan stage		
Sand, yellowish to reddish-brown, slightly calcareous, fine-grained in upper part, coarser below	6	
Gravel, reddish-brown, noncalcareous to slightly calcareous, thickens toward south end of cut	2–4	
Silt, blue-gray, very calcareous, marly, abundant aquatic fauna, finely and regularly laminated suggesting varves	3	9

Unit No.	*Thickness: Ft.*	*In.*
Silt, blue-gray, calcareous, massive; gastropod and pelecypod fresh-water fauna	2½–4	
Sand, reddish, calcareous, grading down into gravel, partly cemented, with uneven lower surface	5	
Till, dark blue-gray, calcareous, bouldery; base concealed	5	

Geologic section 55.—Cut-bank on east side of ravine, NW¼ SE¼ sec. 8, T. 5 N., R. 4 E., Havana quadrangle, Fulton County. Many variations of the succession described here may be observed in small gravel pits extending for about one-fourth mile south (downstream).

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Peorian loess, buff, noncalcareous	6	
Illinoian stage		
Jacksonville drift		
Silt, gray to brownish-gray and sand, yellowish, fine, finely laminated, in regular alternations, pairs of laminae total 234; average thickness of pairs $\frac{1}{4}$–$\frac{3}{4}$ inch; lowest 54 laminae dip into depression in underlying gravel; above these there is 2 feet 6 inches of sand in one lamina in north part of cut thinning to less than 1 inch near south end of cut; above this sand 10 laminae dip slightly toward center of cut; overlain by a sand lamina with maximum thickness near middle of 15 inches, thinning toward both ends of cut; above this the laminae are nearly horizontal, giving a board-like structure; 123 laminae above the last mentioned sand is another sand lamina 2–3 inches thick	13	6
Sand and gravel, strongly cross-bedded, most foreset beds dip southeast; uneven upper surface; numerous large blocks of coal	6–12	
Payson till, gray	3	
Pre-Illinoian silt, compact, blue-green, noncalcareous, on Purington (Pennsylvanian) shale	2	

Geologic section 56.—Roadcut in terrace, elevation 485 feet, on secondary east-west road half a mile east of U. S. Route 24, center of east line SW¼ sec. 4, T. 4 N., R. 3 E., Havana quadrangle, Fulton County.

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Tazewell loess, brownish, noncalcareous	2	11
Bloomington slackwater deposits		
Silt, gray, calcareous, poorly stratified, few kindchen; abundant fresh-water gastropods and pelecypods	12	3
Silt, brownish-red to pinkish-gray, calcareous, massive and unstratified, fresh-water gastropods, crumbly, base concealed	9–10	

Geologic section 57.—Cut-bank in narrow terrace on southeast side of East Creek, NW¼ NW¼ NE¼ sec. 11, T. 4 N., R. 3 E., Havana quadrangle, Fulton County.

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Tazewell loess, blue-gray, traces of lamination; upper 2½ feet noncalcareous; lower part calcareous, fossiliferous	8	
Bloomington slackwater deposits		
Gravel, calcareous	0–1	
Sand and silt, consisting of laminae of bluish-gray sand and brick red silt; some bands of gravel; some laminae show cross-bedding; fauna of fresh-water gastropods and pelecypods	9	6
Clay or silt, brick red to maroon, calcareous, faintly bedded, few poorly preserved fossils	4	
Clay or silt, alternating bands of dark gray and maroon; base concealed	5	6

Geologic section 58.—Exposures near three forks of ravine NW¼ SE¼ sec. 16, T. 4 N., R. 3 E., Havana quadrangle, Fulton County.

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Peorian loess		
Silt, gray and grayish-white, yellow bands, very fine-grained, calcareous; many zones of calcareous concretions; traces of irregular bedding in lower 6 inches	7	
Silt, finer grained than above, calcareous; distinct laminae shown by rusty and dark carbonaceous stains		6
Silt, coarser than above, gray and yellow-brown; distinct beds one quarter inch thick, calcareous		6
Illinoian stage		
Buffalo Hart till, clayey, gray and grayish-brown, some portions silty, gritty but not pebbly, noncalcareous except for secondary concretions	2	
Jacksonville drift		
Silt, clayey, yellow-brown and gray; sand and pebbly concentrate at base; secondary concretions of calcium carbonate	1	6
Sand, very fine-grained, yellow and gray; many gray silt bands; few pebbles; coarser and more gravelly toward base	4	6
Gravel, yellow; many sand and silt bands and till balls; till yellow, oxidized, and calcareous; silt calcareous, compact, and laminated coal and charcoal fragments	1	6
Payson till, bluish- and blackish-gray, calcareous; upper part soft, lower part compact and breaks with hackly fracture	4	
Kansan stage		
Till, clayey, brownish-gray, noncalcareous, polygonal fracture; few pebbles of chert and dense igneous rocks; nearly a gumbotil in texture	1	6
Till, bluish-gray, reddish-brown along fracture surfaces, calcareous, compact	2	6
Silt, brownish-gray, noncalcareous, compact; abundant wood litter (probably pro-Kansan loess)	5	

Unit No.	*Thickness: Ft.*	*In.*
Nebraskan stage		
Silt, brownish-gray, noncalcareous; granite and greenstone pebbles (weathered till or weathered alluvium from nearby till)	1	
Nebraskan or pre-Nebraskan stage		
Silt, sandy, greenish, with small angular fragments of sandstone, resting on and grading down into Pleasantview (Pennsylvanian) sandstone		6

Geologic section 59.—Cut-bank on east side of ravine, SW¼ NW¼ sec. 26, T. 4 N., R. 3 E., Havana quadrangle, Fulton County. Less than ¼ mile north of geologic section 60.

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Peorian loess		
Soil, dark gray	1	
Silt, light brown, noncalcareous . .	1	8
Silt, gray, calcareous, fossiliferous; calcareous concretions	5	
Farmdale loess, pinkish in upper part, gray in lower 6 inches, noncalcareous	2	8
Illinoian stage		
Jacksonville gravel concentrate . .	½–1	
Payson till, gray, calcareous	5	8
Loveland loess, carbonaceous, dark gray to black, noncalcareous, full of fragments of carbonized wood, cut out in north part of cut by overlying till		0–6
Kansan stage		
Sand and gravel, brown, noncalcareous, lenticular		0–8
Silt, bluish, noncalcareous, micaceous; rises toward northern end of cut where it underlies Illinoian till; uneven upper surface; base concealed	2	

Geologic section 60.—Small gully draining eastward, southeast of farm house near west line SW¼ NW¼ sec. 26, T. 4 N., R. 3 E., Havana quadrangle, Fulton County. Top of exposure 18 feet below level upland. Less than ¼ mile south of geologic section 59.

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Peorian loess		
Soil, dark, moist		6
Silt, buff, noncalcareous	2	3
Silt, mottled grayish-yellow, calcareous	1	6
Silt, gray, calcareous, very fossiliferous; limestone concretions . . .	8	9
Farmdale loess		
Silt, sandy, grayish-brown, noncalcareous, fine, loose		2
Silt, sandy, pinkish, noncalcareous; band of carbonized fragments one inch from top		10
Silt, finely sandy, drab colored, noncalcareous; secondary calcium carbonate along root canals . .		8
Silt, sandy, gray, streaks of pale pink, noncalcareous; calcium carbonate concretions and segregations along canals	4	
Silt, sandy, light gray, calcareous, nonfossiliferous	1	9
Silt, rusty brown, noncalcareous except for secondary carbonates along tubules; fragments of carbonized wood.		6
Silt, finely sandy, pinkish, calcareous	1	
Illinoian stage		
Silt, pinkish in upper 4 feet, changing to grayish in lower part, noncalcareous except for concretions of calcium carbonate locally; few scattered small pebbles of chert, quartz, rhyolite, and feldspar up to ½ inch; plant tubules, canals and some carbonized wood; base concealed	6	

Geologic section 61.—Roadcut on east side of U. S. Highway 24 on south side of Otter Creek, near center SE¼ sec. 30, T. 4 N., R. 3 E., Havana quadrangle, Fulton County.

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Peorian loess		
Silt, brown	1	
Silt, brown, noncalcareous, compact, gumbo-like, sticky	1	7
Silt, reddish-brown, noncalcareous .	2	6
Silt, gray to yellow-gray, calcareous, weathering with a smooth surface, only slightly gullied, somewhat fossiliferous	9	9
Farmdale silt, mottled gray and buff, noncalcareous, distinctly laminated; numerous calcareous and iron-stained root canals	1	
Loess, brown, noncalcareous, more compact than above; whitish markings on fracture surfaces; small subspherical calcareous concretions generally less than ⅜ inch, some attached to rootlet canals lined with calcium carbonate; also some irregular concretions ranging from elongate to complexly ramified; minute iron oxide pellets near base.	3	
Silt, brown, noncalcareous, more loosely aggregated than above. .	1	6
Illinoian stage		
Buffalo Hart drift		
Silt, slightly clayey, brownish-red in upper part, brighter red in lower, noncalcareous; few small siliceous pebbles; one large disintegrated granite boulder; large, irregular and etched pinkish-red calcareous concretions expecially in lower part	5	
Till, buff to yellow, noncalcareous; large and small pebbles much more numerous than above; much more plastic and tenacious than above	2	
Sand and gravel, leached, rusty . .	3	
Till, partially oxidized and calcareous; cut by vertical and horizontal seams of calcium carbonate; on Pleasantview (Pennsylvanian) sandstone	10	

Geologic section 62.—Steep ravine west of Otter Creek, SW¼ SE¼ sec. 32, T. 4 N., R. 3 E., Havana quadrangle, Fulton County.

Unit No. Thickness:	*Ft.*	*In.*
Wisconsin stage		
Peorian loess		
Silt, gray below, buff above, noncalcareous	3	4
Silt, gray, calcareous; calcareous and ferruginous concretions	7	6
Farmdale substage		
Loess, reddish, noncalcareous; carbonized wood fragments	3	3
Silt, pink and gray, laminated, slightly calcareous; pebble concentrate at top	1	
Illinoian stage		
Till, brownish-gray, noncalcareous	2	9
Sand and gravel, noncalcareous	2	6
Till, reddish-brown, slightly calcareous above, more calcareous below	1	6
Till, light gray, calcareous	15	
Loveland loess, gray, calcareous, nonfossiliferous, discontinuous	1–0	
Kansan stage		
Sand, yellow, noncalcareous, very fine, with gravel concentrate at top		6
Gravel, brown, noncalcareous; beds of coarse reddish sand	15	6
Till, dark gray, calcareous, bouldery, deformed into sharp folds by ice shove; numerous large masses of wood and logs; large blocks of thoroughly leached and oxidized Nebraskan till; blocks of blue-gray calcareous fossiliferous pro-Kansan loess; large blocks of dark forest soil (Aftonian?) containing small fragments of carbonized wood; basal surface uneven	12	
Nebraskan stage (?)		
Till, brownish-gray, noncalcareous; large mass 2 feet 6 inches thick projects toward east into underlying sand; sharply separated from overlying till	1–1½	
Sand, light buff, noncalcareous, somewhat cross-bedded, foreset beds dip east; lenses of weathered coal	2	
Gravel, noncalcareous, lenticular	1	
Sand, noncalcareous; base concealed	4	
Till, brownish, noncalcareous, exposed by digging in creek bed, may be lenticular; base concealed		6

Geologic section 63.—Cut-bank in terrace, elevation 490–500 feet, on southeast side of east fork of largest ravine in NE¼ sec. 33, T. 4 N., R. 3 E., Havana quadrangle, Fulton County.

Unit No. Thickness:	*Ft.*	*In.*
Wisconsin stage		
Bloomington outwash and slackwater deposits		
Soil, black to brownish-gray, noncalcareous		7
Gravel and sand, slightly calcareous in upper part, strongly calcareous below	8	
Silt, carbonaceous, gray, calcareous; many small fragments of carbonized wood and some gravel	2	6
Gravel, lenticular; fragments of wood	0–2	
Silt, gray, calcareous; includes logs over 6 feet in length and 9 inches in diameter; contains terrestrial gastropods	1	6
Silt, gray, calcareous, interbedded with gravel, bituminous odor; fragments of wood and blocks of calcareous till; base concealed	1	

Geologic section 64.—Deeply trenched ravine across an alluvial fan and terrace, elevation 460–480 feet, at east edge of SE¼ NE¼ sec. 34, T. 4 N., R. 3 E., Havana quadrangle, Fulton County.

Unit No. Thickness:	*Ft.*	*In.*
Recent stage		
Alluvial fan on surface of terrace		
Silt, yellow-gray, noncalcareous; bleached surface soil	1	
Silt, dark gray with humus, noncalcareous; few pebbles	1	2
Silt, buff, noncalcareous, weakly bedded; scattered pebbles	3	4
Silt, yellow-gray, calcareous, slightly fossiliferous; probably redeposited Peorian loess from bluffs to north	2	7
Wisconsin stage		
Bloomington slackwater deposits		
Silt, brownish-gray, dark, noncalcareous; some humus; fine laminations		9
Silt, yellowish-gray, slightly calcareous above, strongly calcareous below, yellowish-gray; mixture of terrestrial and fresh-water mollusks	3	
Sand, calcareous, fossiliferous; beds of gravel; base concealed	5	6

Geologic section 65.—Cut-bank on south side of Seahorne Branch just southwest of sharp bend in SW¼ NW¼ sec. 5, T. 3 N., R. 3 E., Havana quadrangle, Fulton County.

Unit No. Thickness:	*Ft.*	*In.*
Illinoian stage		
Buffalo Hart till, gray, calcareous	5	
Buffalo Hart—Jacksonville drift		
Silt, blue-gray, weathers yellow-brown, calcareous, laminated	6–10	
Sand and gravel, calcareous, lenticular, in small depression in underlying till	0–1	
Payson drift		
Till, reddish-brown, calcareous, oxidized		6
Till, gray, calcareous; about 300 yards east rests on a glaciated surface of compact brownish-gray Loveland loess; base concealed	3–4	

Geologic section 66.—Small ravine in Illinois River bluff NE¼ SE¼ sec. 8, T. 3 N., R. 2 E., Havana quadrangle, Fulton County.

Unit No. Thickness:	*Ft.*	*In.*
Wisconsin stage		
Peorian and Farmdale loesses	11	
Illinoian stage		
Buffalo Hart drift		
Gumbotil, brownish-gray	1	9
Till, reddish-brown and gray	10	
Buffalo Hart—Jacksonville drift		
Sand, yellow, calcareous	1	6

Unit No.	*Thickness: Ft.*	*In.*
Silt, blue-gray, calcareous, nonfossiliferous	8	
Concealed	6	
Silt, blue-gray, calcareous, laminated	4	
Payson till, gray, calcareous	15	
Loveland substage		
Loess, gray, calcareous, nonlaminated, fossiliferous; pipe-stem concretions	5	8
Silt, dark gray, generally noncalcareous, somewhat laminated, bituminous odor; many fragments of carbonized wood and gastropods		9
Loess or silt, gray, calcareous, slightly fossiliferous; interbedded with some sand and gravel; on Seahorne (Pennsylvanian) limestone	3	6

Geologic section 67.—Bank of Illinois River at Riverside Park, Havana, NW¼ NE¼ SE¼ sec. 11, T. 21 N., R. 9 W., Havana quadrangle, Mason County.

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Cary or Mankato substage		
Soil, sandy, scattered pebbles	3	6
Silt, drab yellow-gray, calcareous, massive, bedded only in lower 1½ inches	1	2
Sand and silt, horizontally bedded in alternating bands, wind-type cross bedding		7
Sand, silty, calcareous, very fine-grained; minute wind-type cross bedding		11
Bloomington outwash (?)		
Sand, gravelly, calcareous, oxidized rusty at top; torrential or delta bedding dipping downstream to south; erosional upper surface; base concealed	5	6

Geologic section 68.—Auger boring in field west of road, SE cor. NE¼ sec. 34, T. 5 N., R. 1 W., Vermont quadrangle, McDonough County.

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Peorian loess		
Soil, black, sticky, rich in humus	2	6
Silt, gray, upper part mottled yellow, noncalcareous	6	6
Farmdale loess, dark brown to black, loess-like, noncalcareous	3	
Illinoian stage		
Payson drift		
Silt, sandy, dark brown to black, noncalcareous; scattered pebbles	1	
Gumbotil, dark gray, mottled yellow, pebbly, noncalcareous; base of boring		6

Geologic section 69.—Roadcut along Illinois Highway 78 on west slope of West Fork of Middle Copperas Creek 1¼ miles northeast of Norris, near center E½ sec. 35, T. 8 N., R. 4 E., Canton quadrangle, Fulton County. (Measured by A. C. Bevan 1928 and H. A. Sellin 1930.)

Unit No.	*Thickness: Ft.*	*In.*
Wisconsin stage		
Peorian loess; lower 5 feet very calcareous, numerous carbonate concretions	8	6
Farmdale loess, noncalcareous; flaky lamination near top; lens of carbonaceous matter 4 inches thick	1½–2	
Illinoian stage		
Buffalo Hart drift		
Gumbotil; large rotten granite boulders at base	3	
Till, rusty, noncalcareous	2	
Till, oxidized in upper part, calcareous, pebbly	11	
Loveland substage		
Silt, sandy, light to dark gray or blue-gray, calcareous, plastic; abundant gastropods and pelecypods in lower part	1½–2½	
Carbonaceous zone, grading from peat to old forest soil to peaty marl, discontinuous		8
Kansan stage		
Gravel and sand concentrate		3
Till, brown, compact	1	
Till, bright blue, firm	9	
Concealed	15–20	
Till, sandy, calcareous, friable, hackly fracture; many gravel pockets water-laid	15	
Silt, light gray; rust stains along fractures; iron oxide concretions; base concealed	10	

APPENDIX B

RECORDS OF DEEP WELLS AND COAL TEST BORINGS

PART I. DEEP WELLS

The following records of seven deep wells provide typical information about the subsurface formations in the area. Records of many other wells are available for reference at the State Geological Survey, Urbana, Illinois. Descriptions in quotations are from driller's logs.

1. *Layne Western Co.—Hanna City No. 1 well*, NE¼ SE¼ NE¼ sec. 10, T. 8 N., R. 6 E., Glasford quadrangle, Peoria County, elevation 720 feet.

Sample study by Philip M. Busch.

	Thickness feet	*Depth feet*
Pleistocene system		
Silt, dolomitic, dark yellow, micaceous	30	30
Pennsylvanian system		
McLeansboro group		
Limestone, light yellow-gray to light grayish-brown, fine (Lonsdale)	5	35
Shale, silty, gray, pale grayish-green, brown, partly micaceous, weak (Farmington)	80	115
Shale, dark gray, weak, ironstones	5	120
Coal (No. 7) and shale, black, carbonaceous, firm	5	125
Underclay, light gray, weak, calcareous in lower part	5	130
Shale, calcareous, silty, sandy, light gray to light greenish-gray, micaceous, weak; a little limestone, gray, fine	10	140
Sandstone, dolomitic, light gray, fine to coarse, micaceous, compact (Copperas Creek)	10	150
Carbondale group		
Shale, silty, light gray, micaceous, weak (Sheffield)	10	160
Coal (No. 6) and shale, black, carbonaceous, firm; shale, silty, grayish-green, weak	5	165
Underclay, calcareous, light gray, weak	5	170
Dolomite, very argillaceous, grayish-green, very fine; shale, dolomitic, grayish-green, weak	5	175
Shale, dolomitic, light gray to grayish-green, weak	20	195
Sandstone, dolomitic, silty, light greenish-gray, fine to medium, micaceous, compact (Cuba); shale, silty, gray, weak (Canton); limestone, light yellow-brown	15	210
Shale, calcareous, silty, light yellowish-gray, weak	5	215
Shale, calcareous, dark gray, weak; at base shale, calcareous, black, carbonaceous, weak to firm	20	235
Coal (No. 5)	5	240
Shale, calcareous, silty, very dark gray to light gray; a little limestone, gray to yellowish-gray, fine	25	265
Coal (No. 4); siltstone, dolomitic, light gray, micaceous, friable; a little limestone, light green to yellowish-gray, fine	5	270
Shale, calcareous to dolomitic, light yellow and dark gray, weak; a little coal, underclay, and siltstone	55	325
Shale, calcareous, gray, weak	5	330
Limestone, argillaceous, dark gray to yellowish-brown, fine to coarse, fossiliferous; at base shale, black, carbonaceous, firm (Oak Grove)	10	340
Shale, dolomitic, light gray to yellowish-gray, weak, partly silty, (Francis Creek)	30	370
Sandstone, dolomitic, gray, fine to medium, micaceous, compact; shale, light gray, weak; limestone, gray to yellowish-brown, fine; coal (No. 2) and shale, black, carbonaceous	10	380
Shale, silty to sandy, yellowish-gray to light yellow-gray, weak	35	415
Sandstone, gray, medium, incoherent to compact; sandstone argillaceous, silty, yellow-brown, micaceous, (Isabel?)	20	435
Tradewater group		
Shale, gray, carbonaceous specks, weak, partly micaceous and silty	5	440
Coal (Wiley) and shale, black, carbonaceous; shale, gray to yellowish-gray, weak	15	455
Shale, grayish-brown, weak; coal; shale, dark gray, weak	10	465
Shale, silty to sandy, dark to yellowish-gray, weak	25	490
Mississippian system		
Keokuk and Burlington formations		
Dolomite, yellowish-gray, fine to coarse, sugary, slightly glauconitic, partly argillaceous	35	525
Chert, white to gray, dense, fossiliferous; dolomite, light yellowish-gray to light brown, fine, slightly glauconitic, partly calcareous	35	560
Dolomite, light yellowish-gray, fine, very cherty, sugary, partly glauconitic	5	565
Limestone, light yellowish-gray, fine to coarse, fossiliferous	5	570
Dolomite, yellowish-gray, fine, very cherty, sugary, fossiliferous	10	580
Limestone, light yellow-gray, fine to coarse, cherty, fossiliferous	5	585
Dolomite, light yellow-gray, fine, very cherty, sugary	10	595
Limestone, light yellow-gray, fine to coarse, cherty, fossiliferous;		

	Thickness feet	Depth feet
partly dolomitic; dolomite streaks, light yellow-gray, fine, cherty, sugary	60	655
Kinderhook series		
Shale, green, some light grayish-brown and black, weak to firm	130	785
Shale, dark brown, weak to firm, a few spores	5	790
Shale, green to dark brown, weak to firm	10	800
Shale, dark brown, weak to firm, a few spores	35	835
Shale, brown to green, weak to firm, spores	10	845
Shale, dark brown, almost black, weak to firm, spores	5	850
Shale, light grayish-brown, some green and gray, weak to firm	25	875
Shale, dolomitic, dark grayish-brown, spores	5	880
Devonian system		
Cedar Valley formation		
Dolomite, argillaceous, yellow-gray, fine to medium, sugary	10	890
Limestone, dolomitic, grayish-brown, fine to coarse, fossiliferous, dark specks and streaks, argillaceous toward base	30	920
Wapsipinicon formation		
Dolomite, calcareous, argillaceous, yellowish-gray, fine to medium, fossiliferous, sugary	10	930
Limestone, dolomitic, argillaceous, sandy, yellow-brown to gray	5	935
Silurian system		
Niagaran series		
Dolomite, light gray to gray, fine to coarse, a little quartz	145	1080
Dolomite, light gray to yellowish-gray, fine to medium	20	1100
Alexandrian series		
Dolomite, light gray, some green and light brown, fine to medium	5	1105
Dolomite, very light yellowish-brown, fine to medium, slightly cherty	28	1133
Siltstone, dolomitic, sandy, argillaceous, green to grayish-brown	12	1145
Ordovician system		
Maquoketa formation		
Shale, dark yellowish-brown, weak; some dolomite, argillaceous, dark brown to black, fine to medium	85	1230
"Lime, gray"	10	1240
"Shale, blue"	50	1290
"Lime shell, gray"	1	1291
"Shale, gray-blue"	41	1332
"Lime and shale, gray, broken"	14	1346
Galena formation		
Dolomite, grayish-brown, fine to coarse, scattered red specks	154	1500
Dolomite, sandy, yellowish-gray, fine to coarse	20	1520
Dolomite, sandy, light gray to light brownish-gray, fine to coarse, cherty	8	1528
Decorah formation		
Dolomite, light gray to brownish-gray, dark reddish-brown specks, fine to coarse, cherty; few brown shale partings	12	1540
Platteville formation		
Dolomite, grayish-brown to yellowish-brown, fine to coarse, slightly cherty to cherty, a few brown shaly streaks	105	1645
Glenwood and St. Peter formations		
Sandstone, light gray, fine to coarse, incoherent	20	1665
Sandstone, silty, very argillaceous, light yellowish-gray, fine to coarse, incoherent	35	1700
Sandstone, light yellowish-gray, medium, incoherent	10	1710
Sandstone, silty to slightly silty, light yellowish-gray, fine to coarse, incoherent	15	1725
Sandstone, light yellowish-gray to white, medium to coarse, angular, incoherent	25	1750
Sandstone, light yellowish-gray, fine to coarse, incoherent, partly angular, slightly ferruginous bands	70	1820
Sandstone, silty, argillaceous, yellowish-gray, fine to coarse, incoherent	20	1840
Sandstone, yellowish-gray, medium to coarse, cherty, ferruginous	5	1845

2. *J. S. Young—Midland Electric Coal Co. well*, NE¼ SE¼ NE¼ sec. 2, T. 8 N., R. 3 E., Canton quadrangle, Fulton County, elevation 700 feet.

Samples below 295 feet studied by Margaret A. Blair.

	Thickness feet	Depth feet
Pleistocene system		
Soil and clay (Peorian loess)	15	15
Glacial drift; sand, gravel and clay (Illinoian)	20	35
Pennsylvanian system		
Carbondale group		
Shale, sandy, gray, hard (Canton)	35	70
Limestone, sandy, soft (St. David)	2	72
"Slate, black"	3	75
Coal (No. 5), hard	3	78
Underclay; shale, gray	7	85
Limestone, soft	6	91
Shale, gray, sandy, soft	149	240
Coal (No. 2), hard	2	242
"Shale, black; slate"	20	262
Tradewater group		
"Shale, dark gray, sandy"	14	276
Limestone, gray (Seahorne?)	5	281
"Shale, black"	14	295
Mississippian system		
Keokuk and Burlington formations		
Dolomite, gray, very fine; chert, light gray	36	331
Limestone, dolomitic, light buff and light gray, fine to medium, cherty	41	372
Dolomite, white, very fine; chert, white, fossiliferous	40	412

	Thickness feet	Depth feet
Limestone, dolomitic, white, very fine to medium; chert, white, fossiliferous	23	435
Dolomite, calcareous, white, very fine, a few light greenish-gray spots	13	448
Kinderhook series		
Shale, dolomitic, greenish-gray, flaky (Hannibal)	12	460
Shale, dark brown, carbonaceous, laminated, firm (Grassy Creek)	170	630
Shale, dark brownish-gray, firm, sporangites; some gray shale	72	702
Devonian system		
Cedar Valley and Wapsipinicon formations		
Dolomite, light brown and gray, fine, porous	18	720
Limestone, dolomitic, argillaceous, gray, very fine	22	742
Dolomite, brownish-gray, fine, porous	20	762
Silurian system		
Niagaran and Alexandrian series		
Dolomite, white, very fine to fine, slightly vesicular	67	829
Dolomite, white and light gray, very fine to medium	46	875
Shale, dolomitic, very finely sandy, light greenish-gray, weak	5	880
Ordovician system		
Maquoketa formation		
Shale, gray, mottled green and brown, flaky to firm	27	907
Dolomite, brownish-gray, fine to medium; and shale; dolomitic, brownish-gray	44	951
Dolomite, brownish-gray, mottled, fine-grained	20	971
Shale, dolomitic, gray, partly greenish, flaky	69	1040
Dolomite, shaly, dark brownish-gray; shale, dolomitic	12	1052
Shale, dolomitic, brownish-gray	12	1064
Galena formation		
Dolomite, light brownish-gray, fine, slightly porous	201	1265
Decorah and Platteville formations		
Dolomite, brownish-gray, speckled dark brown, very fine; a little chert, gray, speckled with brown	10	1275
Dolomite, brownish gray, very fine- to fine-grained	82	1357
Glenwood and St. Peter formations		
Sandstone, white, medium, incoherent, a little brown sandy dolomite at top	29	1386
Sandstone, white, fine to coarse, incoherent	47	1433
Sandstone, white, very fine to medium, incoherent	192	1625
Shakopee formation		
Shale, light and soft	5	1630
Dolomite, red and light gray, fine-grained; a little oolitic chert	5	1635
"Shale, red, cherty"	7	1642
"Limestone with red shale layers"	18	1660
Shale, slightly silty and sandy, red, firm	3	1663
Chert, white, oolitic	2	1665
"Limestone with red shale layers'	5	1670
Shale, dark red, firm	9	1679
"Limestone with red shale layers"	8	1687
Shale, silty, dark red, mottled with green and gray, laminated, firm	11	1698
"Limestone with red shale layers"	5	1703
Sandstone, gray and yellow, fine to coarse, incoherent; a little dolomite, light gray, very fine	15	1718
"Limestone with red shale layers"	21	1739
Dolomite, argillaceous, gray and red, fine to very fine	16	1755
Dolomite, light gray and pink, fine to very fine; a little sandstone	20	1775
"Limestone, gray"	10	1785
New Richmond formation		
Sandstone, white, medium to coarse, incoherent	20	1805
Dolomite, sandy, light buff-gray, medium to coarse; cherty; sandstone similar to overlying	7	1812
Sandstone, dolomitic, very light gray, medium and coarse	13	1825
Dolomite, finely sandy, light buff, pink, and gray, very fine; chert, sandy, white to buff	5	1830
"Sandstone, white"	20	1850
Sandstone, slightly dolomitic, medium and coarse, glassy, incoherent	7	1857
Oneota formation		
Dolomite, slightly sandy, very light gray, fine; a little greenish shale	40	1897
"Limestone, white, sandy"	118	2015
"Limestone, brown, frequent crevices"	15	2030
Dolomite, very light gray, pink spots	22	2052
Dolomite, light gray, pink spots, fine to medium, scattered specks of glauconite	25	2077
"Limestone, brown, with frequent crevices"	13	2090
Dolomite, light brown to light gray, fine; chert, white, oolitic	20	2110
"Limestone, brown, with frequent crevices"	30	2140
Dolomite, light gray, pink spots, fine to medium, oolitic chert	13	2153
"Limestone, brown, with frequent crevices"	57	2210
Gunter formation		
Dolomite, very sandy, white, cherty, slightly glauconitic, grades to sandstone	10	2220
No samples	21	2241
Dolomite, sandy; sand, white, fine	5	2246
Cambrian system		
Trempealeau formation		
No samples	64	2310
Dolomite, white, slightly pinkish, very fine	8	2318
No samples	19	2337

	Thickness feet	*Depth feet*
Dolomite, pink and white, very fine to fine	70	2407
Dolomite, sandy, light gray, a few pink spots, very fine to fine, slightly glauconitic	3	2410
Dolomite, white with pink spots, very fine	11	2421
Dolomite, sandy, light gray, very fine, slightly glauconitic	10	2431
Dolomite, sandy, argillaceous, brownish-gray, fine, pyritic, micaceous, slightly glauconitic	53	2484
No samples	18	2502
Dolomite, very sandy, brownish-gray, very fine to fine, slightly glauconitic	5	2507
Franconia formation		
Dolomite, slightly sandy to very sandy, brown and gray mottled, fine, slightly glauconitic and pyritic	69	2576
Dolomite, white to light gray, pink spots, fine, slightly porous	7	2583
Dolomite, very sandy, brownish-gray, mottled light, fine, slightly glauconitic	19	2602
Dolomite, sandy, slightly argillaceous, gray, mottled light and dark, fine, slightly glauconitic; a little shale, greenish gray, firm	23	2625
No samples	13	2638
Galesville formation		
Sandstone, dolomitic, light gray and brown, fine to coarse, incoherent	14	2652
Sandstone, white, coarse and fine, incoherent	23	2675
Sandstone, dolomitic, light gray, a few brown spots, fine to coarse, incoherent	15	2690
Sandstone, white, fine to coarse, incoherent	30	2720
Sandstone, dolomitic, light gray, fine to medium, incoherent	5	2725
No samples	21	2746
Sandstone, white, coarse to medium, incoherent	29	2775
Eau Claire formation		
Dolomite, sandy, brown, mottled light, fine	2	2777

3. *Cliff Neely—Village of Cuba No. 4 well*, sec. 29, T. 6 N., R. 3 E., Havana quadrangle, Fulton County, elevation 680 feet.

Sample study by Philip M. Busch.

	Thickness feet	*Depth feet*
Pleistocene system		
No samples (loess and Illinoian drift)	30	30
Pennsylvanian system		
Carbondale group		
Coal (No. 5); a little underclay, gray, weak; limestone, gray to brown, sublithographic to very fine, partly sugary	10	40
No sample	18	58
Sandstone, gray, fine to medium, micaceous, compact	14	72
Coal trace (No. 4); underclay, calcareous, yellowish-gray to gray, weak; limestone, grayish-brown, very fine; dolomite, argillaceous, gray, very fine	10	82
Shale, calcareous, silty, light gray to light grayish-green, finely micaceous, weak	28	110
Shale, dolomitic, silty, yellowish-gray to dark gray, weak (Purington)	40	150
Shale, silty, dark gray to black, finely micaceous, weak to firm; limestone, argillaceous, dark gray, fine, partly fossiliferous; ironstone (Oak Grove)	5	155
Coal trace (No. 2); underclay, calcareous, gray, weak; limestone, argillaceous, gray, fine	5	160
Shale, calcareous, silty, yellowish-gray, weak	5	165
Tradewater group		
Shale, gray, weak	10	175
No sample	5	180
Shale, dolomitic, silty, yellowish-gray, weak	10	190
Shale, very sandy, silty, yellowish-gray, micaceous, weak	10	200
Shale, yellowish-gray, weak, lower part silty and micaceous	45	245
No sample	9	254
Shale, dolomitic, silty, sandy, light to yellowish-gray, weak	46	300
Mississippian system		
Salem formation		
Limestone, light grayish-brown, fine to medium, *Endothyra baileyi*	22	322
No sample	3	325
Shale, silty, yellowish-gray, weak (probably out of place)	5	330
Limestone, light grayish-brown, fine to medium-grained, *Endothyra baileyi*	5	335
Shale, silty, yellowish-gray, weak (probably out of place)	5	340
Warsaw formation		
Shale, silty, gray, weak	70	410
Keokuk and Burlington formations		
Limestone, argillaceous, pale yellowish-gray, dark speckled, fine to coarse, cherty, slightly glauconitic, fossiliferous, partly dolomitic	15	425
Limestone, pale grayish-brown, dark speckled, fine to coarse, cherty, fossiliferous, lower part argillaceous	25	450
No sample	4	454
Limestone, pale yellowish-gray, dark specks, fine- to coarse-grained, very cherty, fossiliferous, partly dolomitic	31	485
Chert, white to light yellowish-gray, partly dark speckled, dense	5	490
Limestone, dolomitic, light yellowish-gray, fine to coarse, cherty, slightly glauconitic; dolomite at base	105	595
Kinderhook series		
Shale, pale green to green, weak (Hannibal)	90	685

	Thickness feet	Depth feet
Shale, yellowish-green to brown, weak, very few spores	40	725
Shale, grayish-brown to dark brown, mostly weak, few spores	10	735
Shale, silty, light grayish-green, weak	10	745
Shale, grayish-brown to dark brown, mostly weak, few spores	5	750
Shale, silty, light grayish-green to light yellowish-green, weak	25	775
Shale, grayish-brown to dark brown, weak to firm, few spores	10	785
Shale, green to grayish-brown to yellowish-gray to dark brown, weak, few spores	30	815
Shale, light grayish-brown to light greenish-gray	10	825
Shale, grayish-brown, some dark brown, mostly weak, few spores	30	855
Devonian system		
Cedar Valley and Wapsipinicon formations		
Limestone, dolomitic, grayish-brown, some yellowish-gray, fine to coarse, slightly glauconitic and sandy	20	875
Dolomite, calcareous, sandy, grayish-brown, some gray, fine to coarse, cherty; sandstone at base, partly calcareous, light gray, medium to coarse, angular	15	890
Silurian system		
Niagaran and Alexandrian series		
Dolomite, light gray, fine- to medium-grained, sugary	44	934
Dolomite, light yellowish-gray to pale gray, fine to coarse	26	960
Ordovician system		
Maquoketa formation		
Shale, silty, light green, weak; a little dolomite at top	25	985
Shale, silty, yellowish-gray, weak	15	1000
Shale, grayish-brown, some green and dark brown	15	1015
Shale, silty, pale grayish brown to yellowish-green, weak	10	1025
Shale, grayish-brown, some dark brown, weak	25	1050
Shale, silty, light green, weak, lower part silty	35	1085
Shale, silty, grayish-brown, some dark brown and green, weak	5	1090
Shale, dolomitic, silty, yellowish-gray, weak	10	1100
Dolomite, argillaceous, yellowish-gray to gray, fine- to medium-grained	10	1110
Shale, dolomitic, silty, brownish-gray, weak	35	1145
Shale, dolomitic, silty, brownish-gray, weak, phosphatic nodules and depauperate fossils; dolomite, grayish-brown, fine to coarse, pyritic	5	1150
Shale, dolomitic, silty, pale yellowish-gray, weak	5	1155
Galena formation		
Dolomite, yellowish-brown to yellowish-gray, fine to coarse	130	1285
Dolomite, grayish-brown, fine to coarse, slightly cherty at base	50	1335
No sample	35	1370
Dolomite, cherty, grayish to yellowish-brown, fine to coarse	10	1380

4. *B. J. Grigsby—Elsbert No. 1 well,* SE¼ SW¼ SW¼ sec. 23, T. 6 N., R. 1 E., Vermont quadrangle, Fulton County, elevation 577 feet.

Sample study by T. C. Buschbach.

	Thickness feet	Depth feet
Pleistocene system		
"Dirt" (loess)	25	25
"Blue clay" (Illinoian till)	30	55
Pennsylvanian system		
Tradewater group		
Sandstone, slightly dolomitic, white to light gray, very fine to fine, sideritic, micaceous, friable (Bernadotte)	9	64
Coal (Pope Creek)	1	65
Shale, silty, weak	10	75
Shale, sandy, silty, gray to black; grades to sandstone, argillaceous, light gray to gray, fine to medium, incoherent (Babylon)	15	90
Mississippian system		
Salem formation		
Limestone, sandy, silty, light grayish-buff, sublithographic to fine; sandstone, calcareous, white, fine, incoherent	13	103
Dolomite, silty, calcareous, buff, sublithographic to very fine	7	110
Limestone, dolomitic, sandy, buff, very fine, grades to sandstone, calcareous, light buff, fine	7	117
Dolomite, calcareous, silty, buff to brown, sublithographic; a little sandstone, calcareous, white, fine-grained	8	125
Limestone, dolomitic, very sandy and silty, light buff to light greenish-gray, sublithographic to very fine, glauconitic	5	130
Dolomite, silty, sandy, buff, very fine to fine, glauconitic	18	148
Warsaw formation		
Shale, silty, slightly dolomitic, light greenish-gray, weak, glauconitic	27	175
Shale, as above, except dolomitic	50	225
Dolomite, silty, argillaceous, gray, very fine-grained, cherty, glauconitic	10	235
Keokuk and Burlington formations		
Limestone, dolomitic, slightly argillaceous, gray speckled, coarse, cherty, glauconitic, fossiliferous; dolomite, silty, argillaceous, gray to buff, very fine, glauconitic	24	259
Limestone, dolomitic, white, coarse, cherty, fossiliferous	46	305
Limestone, dolomitic, white, coarse, glauconitic; dolomite, white, very fine, sugary	100	405
Limestone, dolomitic, white, fine to coarse, slightly cherty	12	417

	Thickness feet	Depth feet
Hannibal shale		
Shale, slightly calcareous, silty, green to greenish-gray, weak to brittle, a few spores	93	510
Grassy Creek formation		
Shale, silty, slightly dolomitic, brown to black, brittle, spores	65	575
Shale, slightly dolomitic, light green, weak	25	600
Shale, silty, slightly dolomitic, brown to dark brown, tough, spores	55	655
Devonian system		
Cedar Valley formation		
Dolomite, silty, light gray, very fine, sugary; grades to siltstone and sandstone	5	660
Limestone, dolomitic, very sandy, and silty at top, very fine to coarse	25	685
Limestone, very dolomitic, buff, very fine to coarse, cherty	17	702
Silurian system		
Alexandrian series		
Dolomite, calcareous, cherty, light gray, fine to coarse	8	710
Dolomite, sandy, white, fine	5	715
Dolomite, buff and gray, very fine, partly vesicular	23	738
Ordovician system		
Maquoketa formation		
Shale, dolomitic, light greenish-gray, weak	47	785
Shale, silty, dolomitic, light green to brown, weak; grades to dolomite, argillaceous, silty, light gray to light brown, very fine	130	915
Galena formation		
Dolomite, buff, fine to medium	195	1110
Decorah formation		
Dolomite, buff, brownish speckled, fine, crystalline	15	1125
Platteville formation		
Dolomite, light buff to buff, very fine to fine, very sandy at base	75	1200
St. Peter formation		
Sandstone, white, fine to coarse, incoherent	30	1230
Sandstone, slightly silty, white, very fine to coarse, incoherent	80	1310
Sandstone, white, fine to coarse, incoherent	30	1340
Sandstone, slightly silty, white, very fine to coarse, incoherent	60	1400

5. *W. B. Lagers and E. F. Webb—Claude E. Cleer No. 1 well*, SW¼ NE¼ NE¼ sec. 28, T. 4 N., R. 2 E., Vermont quadrangle, Fulton County, elevation 550 feet.

Sample study by Marvin P. Meyer.

	Thickness feet	Depth feet
Pleistocene system		
"Soil"	3	3
"Red clay" (Illinoian drift)	15	18
Pennsylvanian system		
Carbondale and Tradewater groups		
"Shale, light blue and white"	12	30
Sandstone, silty, micaceous, white to brown, very fine, compact; a little shale, light buff to brown	25	55
Sandstone, silty, light gray, very fine; micaceous, carbonaceous; shale, black, micaceous, carbonaceous	32	87
Chert, sandy, brown to red	5	92
Sandstone, very fine to medium, slightly glauconitic, micaceous; shale, black, carbonaceous; shale, light gray; a little coal	8	100
Sandstone, white, medium to coarse; chert, sandy, brown to red; shale, sandy, white	16	116
Mississippian system		
St. Louis and Salem formations		
Limestone, brown, lithographic	2	118
Dolomite, brown, very fine	8	126
Limestone, buff, lithographic; sandstone, calcareous, fine to coarse, white at top	14	140
Limestone, very sandy, white to light green, very fine to coarse, glauconitic; limestone, sandy, buff, glauconitic, fossiliferous	15	155
Dolomite, sandy, silty, light gray, buff to brown, very fine; glauconitic; limestone, buff, lithographic; chert; conglomerate	8	163
Warsaw formation		
Shale, dolomitic, light gray to green, micaceous	9	172
Dolomite, light gray to buff, glauconitic, lower part argillaceous to sandy	33	205
Dolomite, silty, sandy, light gray to buff, very fine, slightly glauconitic, fossiliferous; chert; shale, dolomitic, gray	20	225
Shale, dolomitic, silty, gray, micaceous; limestone, argillaceous, buff to gray, lithographic, fossiliferous, grades to argillaceous dolomite at base	14	239
Keokuk and Burlington formations		
Limestone, light gray to light buff, cherty, very fossiliferous	6	245
Dolomite, silty, light gray, very fine, cherty	5	250
Limestone, silty, light gray to light buff, very cherty, glauconitic, very fossiliferous	40	290
Chert, calcareous, light gray, slightly glauconitic; dolomite, silty, buff to brown, slightly glauconitic	13	303
Limestone, buff, glauconitic, very cherty, very fossiliferous, shale partings at top, lower part sandy	87	390
Limestone, sandy, light buff, cherty, fossiliferous, slightly glauconitic at base	62	452
Kinderhook series		
Shale, dolomitic, greenish-gray; dolomite, silty to sandy, gray, very fine	38	490
Shale, dolomitic, gray to brown, spores	165	655
Shale, slightly dolomitic, light gray, spores	10	665

	Thickness feet	Depth feet
Shale, brown, spores; a little dolomite, argillaceous, sandy, brown, light gray, very fine	20	685
Silurian system		
Niagaran series		
Dolomite, light buff to white, very fine, slightly glauconitic, sugary, a few foraminifera at base	63	748
Dolomite, pink, finely crystalline; glauconitic; dolomite, sandy, white to light green, very fine to fine	17	765
Alexandrian series		
Dolomite, buff, finely crystalline, cherty, slightly glauconitic	28	793
Ordovician system		
Maquoketa formation		
Shale, dolomitic, brownish-gray	2	795
Dolomite, sandy, gray, very fine	10	805
Shale, dolomitic, light gray, weak, sandy in part, grayish-green, phosphatic nodules in lower part	77	882
Dolomite, very sandy, argillaceous, light gray	53	935
Shale, dolomitic, sandy, light gray, brown flakes	41	976
Galena formation		
Dolomite, buff, brown speckled at top, finely crystalline	34	1010
Dolomite, buff to brown, mottled, red speckled, fine to medium	140	1150
Decorah formation		
Dolomite, cherty, buff, brown speckled, fine to medium, crystalline; shale, dolomitic, reddish brown, speckled	20	1170

6. *O. D. Arnold et al.—Quinn No. 1 well*, NE¼ NW¼ sec. 27, T. 2 N., R. 1 W., Beardstown quadrangle, Schuyler County, elevation, 720 feet.

Sample study by Gordon W. Prescott.

	Thickness feet	Depth feet
Pleistocene system		
Silt or loess	20	20
Till, gravelly	8	28
Pennsylvanian system		
Carbondale group		
Limestone, silty, argillaceous, greenish-gray, very finely crystalline; shale, green; sandstone, silty, light gray, very fine, compact	16	44
Shale, calcareous, slightly silty, light to medium gray, weak	16	60
Limestone, silty, gray, very fine, pyritic (St. David)	5	65
Shale, gray, carbonaceous, micaceous; shale, black, carbonaceous; coal (No. 5)	5	70
Limestone, slightly argillaceous, gray, very fine to fine, pyritic, fossiliferous; some shale, light gray, weak	11	81
Shale, black, carbonaceous; coal (No. 4?)	5	86
Shale, slightly silty, brownish-gray, micaceous	4	90
Limestone, argillaceous, gray, fine- to coarse-grained, fossiliferous; shale, light gray, weak	10	100
Shale, silty, light gray, very micaceous, pyritic; shale, black, carbonaceous	3	103
Shale, silty, light gray, micaceous, carbonaceous	45	148
Limestone, gray, lithographic to very fine-grained	4	152
Shale, silty, medium dark gray, carbonaceous, micaceous	4	156
Sandstone, silty, light gray, very fine, carbonaceous, micaceous, compact	14	170
Coal (No. 2?); shale, light gray, weak	2	172
Shale, slightly silty, light gray, pyritic, micaceous, weak to firm	13	185
Sandstone, argillaceous, light gray, very fine, compact; shale, silty, gray, sideritic	25	210
Tradewater group		
Shale, silty, gray, micaceous, firm	4	214
No sample	4	218
Sandstone, slightly silty, light gray, very fine to coarse grained, micaceous, sideritic, compact	21	239
Mississippian system		
Salem formation		
Limestone, light gray, very fine; shale, greenish-gray, firm	8	247
Dolomite, light brownish-gray, compact; dolomite, silty, greenish-gray	9	256
Sandstone, dolomitic, silty, light greenish-gray, very fine, compact	9	265
Dolomite, sandy, silty, light brownish-gray, slightly glauconitic, sugary	5	270
Dolomite, argillaceous, brownish-gray, crystalline to granular, slightly porous	24	294
Warsaw formation		
Shale, dolomitic, gray, weak, micaceous, flaky, geodal quartz	7	301
Shale, dolomitic, gray, weak, micaceous, flaky; some limestone	11	312
Dolomite, gray, very fine	3	315
Shale, dolomitic, gray to greenish, weak to firm; limestone, lithographic	6	321
Shale, dolomitic, gray, weak, micaceous, flaky; some dolomite, gray, very fine, compact	21	342
Dolomite, silty to argillaceous, gray, sugary, geodal quartz	19	361
Keokuk and Burlington formations		
Dolomite, slightly argillaceous, light gray, very fine, very cherty, compact to sugary	24	385
Limestone, dolomitic, slightly argillaceous, brownish-gray, very fine to medium crystalline, cherty, oolitic, fossiliferous, glauconitic in lower part	15	400
Limestone, dolomitic, light to brownish-gray, very fine to coarse, very cherty, slightly glauconitic, fossiliferous	15	415
Dolomite, light gray, very finely crystalline, very cherty	10	425

	Thickness feet	*Depth feet*
Chert; a little dolomite, light brown, sugary	8	433
Limestone, dolomitic, light gray, very fine to medium, very cherty, slightly fossiliferous	24	457
Chert; a little dolomite, light brownish-gray, crystalline	3	460
Limestone, dolomitic, light gray, very fine to medium, very cherty	29	489
Dolomite, slightly calcareous, light gray, very fine, very cherty	39	528
Limestone, dolomitic, light gray, very fine to fine, very cherty	4	532
Limestone, light gray, very fine to fine, very cherty	8	540
Limestone, dolomitic, very light gray, very fine to fine, cherty	35	575
Kinderhook series		
Shale, silty, greenish-gray, slightly pyritic, firm; a little dolomite, slightly calcareous, light gray	34	609
No samples	81	690
Siltstone, slightly dolomitic, argillaceous, dark brownish-gray; shale, silty, brown, a few sporangites	72	762
Sandstone, dolomitic, light gray, very fine, compact; shale, light green	11	773
Shale, dolomitic, slightly silty, gray to brownish-gray	13	786
No sample	4	790
Devonian system		
Limestone, slightly dolomitic, sandy, brownish-gray, very fine to fine	10	800
Silurian system		
Niagaran series		
Limestone, dolomitic, light gray, very fine to fine	20	820
Dolomite, slightly calcareous, light gray, very fine to fine	16	836
Limestone, slightly dolomitic, light gray, very fine to fine, cherty	15	851

7. *Cass Community Oil Co.—James Maslin No. 1 well*, NW¼ SE¼ SE¼ sec. 2, T. 17 N., R. 10 W., Virginia quadrangle, Cass County, elevation 627 feet. Sample study by Frank E. Tippie.

	Thickness feet	*Depth feet*
Pleistocene system		
"Loam, black"	3	3
"Clay, yellow"	7	10
"Clay, light gray to blue"	25	35
"Gravel and sand, water"	10	45
"Gray and blue clay"	10	55
Sand, calcareous, light brown, very fine to coarse	10	65
Silt, very finely sandy, light brown	25	90
Sand, calcareous, argillaceous, gray, very fine to coarse	5	95
Clay, slightly calcareous, silty to sandy, light brown	5	100
Silt, calcareous, sandy, gray to greenish, very finely sandy	75	175
Pennsylvanian system		
Carbondale group		
Shale, calcareous, silty, gray, weak; shale, calcareous, silty, black, carbonaceous	10	185
Shale, black; limestone, argillaceous, gray, brown, very fine (Oak Grove); coal (No. 2)	15	200
Shale, light gray, micaceous, very weak	5	205
Sandstone, calcareous, light gray, very fine	5	210
Tradewater group		
Limestone, white, brown, gray, very fine to lithographic, pyritic (Seahorne)	10	220
Sandstone, white, medium-grained, sideritic, incoherent	5	225
Shale, sandy, white, very weak	5	230
Shale, silty, dark gray to black, carbonaceous	10	240
Coal (No. 1?); shale, light gray, sideritic, very weak; siltstone, light brown	10	250
Sandstone, silty, light brown, very fine, carbonaceous, friable to incoherent (Bernadotte)	40	290
Shale, sandy, silty, light gray, very weak	5	295
Sandstone, white, fine to medium, friable to incoherent (Babylon?)	17	312
Mississippian system		
St. Louis limestone		
Limestone, light brown, very fine to lithographic	13	325
Limestone, slightly silty, light brown, very fine, slightly cherty	10	335
Limestone, slightly silty, light gray, lithographic	5	340
Limestone, slightly silty, light brown, lithographic, slightly cherty	10	350
Dolomite, slightly silty, light brown to white, very fine	8	358
Salem formation		
Shale, calcareous, silty, green, gray; dolomite, argillaceous, light brown, very fine	9	367
Sandstone, very calcareous, argillaceous, green, fine, glauconitic	18	385
Limestone, light brown, coarse, partly sandy, partly oolitic	15	400
Sandstone, calcareous, argillaceous, gray, fine	5	405
Limestone, light brown, fine to coarse, very fossiliferous; partly oolitic; dolomite, white to light brown, very fine	8	413
Warsaw formation		
Shale, silty, calcareous, gray, very weak	6	419
Shale, dolomitic, dark gray, partly cherty	11	430
Limestone, dolomitic, argillaceous, gray, very fine	10	440
Shale, calcareous, gray	20	460
Limestone, sandy, white to gray, coarse; sandstone, calcareous, argillaceous, gray, fine	10	470
Limestone, argillaceous, silty, gray, very fine to medium, slightly cherty	5	475
Sandstone, calcareous, argillaceous, gray, fine	15	490

	Thickness feet	Depth feet
Keokuk and Burlington formations		
Limestone, silty, white, fine- to coarse-grained, very cherty	25	515
Dolomite, silty, light gray, very fine, very cherty; limestone, dolomitic, light gray, white and brown, fine to coarse, very cherty	25	540
Limestone, light gray, fine to coarse, very cherty	35	575
Dolomite, white to buff, very fine, very cherty	20	595
Limestone, dolomitic, fine to coarse, very cherty	10	605
Dolomite, white, very fine, cherty	5	610
Limestone, dolomitic, white, fine to coarse, very cherty	10	620
Dolomite, white, very fine, cherty	5	625
Limestone, dolomitic, white, fine to coarse, very cherty	25	650
Dolomite, white, very fine, cherty	5	655
Limestone, dolomitic, white, very fine to coarse, cherty	55	710
Kinderhook series		
Shale, slightly dolomitic, green, pyritic, very weak; a little siltstone, slightly dolomitic, light gray, compact	90	800
Shale, silty, brownish-gray, sporangites	75	875
Shale, slightly dolomitic, silty, dark brown, pyritic, sporangites	40	915
Shale, green, very weak	10	925
Shale, slightly calcareous, silty, light brownish-gray to dark brown	10	935
Silurian system		
Niagaran and Alexandrian series		
Dolomite, slightly silty, white, brownish-gray, very fine-grained, partly cherty	75	1010
Limestone, argillaceous, greenish, very fine, pyritic	5	1015
Limestone, dolomitic, white, pinkish, very fine to fine	5	1020
Limestone, white, greenish tinge, sublithographic	5	1025
Dolomite, white, very fine-grained	5	1030
Limestone, dolomitic, white, very fine-grained	15	1045
Dolomite, white, light brown, very fine, cherty; siltstone, dolomitic, green at base	15	1060
Ordovician system		
Maquoketa formation		
Shale, dolomitic, silty, green, very weak	10	1070

PART 2. COAL TEST BORINGS

The following records of three coal test borings in and near the Glasford and Havana quadrangles provide virtually complete descriptions of the Pennsylvanian succession. Several hundred additional coal test borings, mostly shallow tests for coal No. 5 in the north half of the Havana quadrangle, are in open file at the Illinois State Geological Survey, Urbana. No deep coal tests are available in the Beardstown and Vermont quadrangles and the south half of the Havana quadrangle.

8. *Clark Coal and Coke Company, Hole 3*, SE¼ NE¼ sec. 16, T. 8 N., R. 7 E., Peoria quadrangle, about 2½ miles east of the Glasford quadrangle, Peoria County. Elevation 610 feet.

	Thickness Ft. In.	Depth Ft. In
Pleistocene system		
Surface clay	6	6
Pennsylvanian system		
Sparland cyclothem		
Shale, dark	3	9
Shale, black	1	10
Coal (No. 7)	1 – 5	11 – 5
Clay shale (underclay)	13 – 7	25
Sandstone (Copperas Creek)	9	34
Brereton cyclothem		
Shale, gray	7	41
Shale, black	1	42
Sandstone and coal (white-top)	5	42 – 5
Coal (No. 6)	2 – 7	45
Shale parting (blue-band)	3	45 – 3
Coal (No. 6)	1 – 9	47
Slate, dark	3	50
Shale, sandy	19 – 7	69 – 7
Sandstone (Cuba)	40 – 5	110
St. David cyclothem		
Shale, gray	5	115
Coal (No. 5)	4 – 2	119 – 2
Shale, dark, soft	1 – 10	121
Shale, black	2	123
Clay, shale	5	128
Summum cyclothem		
Shale, black	2	130
Shale, dark, soft	8	130 – 8
Shale, sandy, light	25 – 9	156 – 5
Sandstone, dark (Pleasantview)	10	166 – 5
Liverpool cyclothem		
Shale, dark, hard (Purington)	48 – 7	215
Slate	2	217
Shale, sandy	4	221
Shale, dark	5 – 6	226 – 6
Coal (No. 2)	2 – 6	229
Clay shale (underclay)	6	235
Greenbush cyclothem		
Shale, dark	15	250
Shale, black	3	253
Sandstone	1	254
Wiley cyclothem		
Shale, light	2 – 7	256 – 7
Coal (Wiley)	1 – 11	258 – 6
Fireclay	1 – 6	260
Seahorne cyclothem		
Shale, sandy	6	266
DeLong cyclothems		
Shale, blue, soft	8	274
Shale, dark	4	278
Shale, black	1	279
Clay shale	2	281
Shale, black	2 – 3	283 – 3
Coal (Lower DeLong)	11	284 – 2
Clay shale	2	286 – 2
Seville cyclothem		
Clay shale	7 – 10	294
Shale, dark	5 – 3	299 – 3
Sulphur (horizon of No. 1 coal)	5	299 – 8
Shale, sandy, dark	4 – 4	304
Sandstone, shale bands	5	309

	Thickness Ft. In.	Depth Ft. In.
Shale, sandy, dark	1	310
Sandstone (Bernadotte)	26 – 9	336 – 9
Pope Creek cyclothem		
Coal (Pope Creek)	1 – 5	338 – 2
Fireclay	1 – 10	340
Tarter cyclothem		
Shale, dark	3	343
Shale, black	6	349
Sandstone	1	350

9.—*Composite of two coal test borings of Big Creek Coal Company near St. David, Havana quadrangle, Fulton County.* (A) From surface to No. 2 coal, Hole 308, NE¼ NE¼ SW¼ sec. 15, T. 6 N., R. 4 E., elevation 620 feet. (B) Below No. 2 coal, Hole 310, NW¼ NE¼ NW¼ sec. 21, T. 6 N., R. 4 E., elevation 586 feet.

	Thickness Ft. In.	Depth Ft. In.
Pleistocene system		
Clay (loess and drift)	18	18
Sand	10	28
Pennsylvanian system		
St. David cyclothem		
Shale (Canton)	5 – 4	33 – 4
Limestone (St. David)	5	33 – 9
Shale	7	34 – 4
Slate	1 – 1	35 – 5
Coal (No. 5)	4 – 9	40 – 2
Fireclay	1 – 10	42
Summum cyclothem		
Shale	16	58
Sandstone	8	66
Shale, sandy, light to dark	40	106
Sandstone (Pleasantview)	27	133
Liverpool cyclothem		
Shale, dark	1 – 8	134 – 8
Limestone	7	135 – 3
Shale, gray to dark, soft	6 – 1	141 – 4
Caprock, hard (Oak Grove limestone)	1 – 6	142 – 10
Slate, streaked (black shale)	3 – 2	146
Shale (Francis Creek)	7 – 2	153 – 2
Coal (No. 2)	2 – 8	155 – 10
Fireclay	2	157 – 10
Shale, sandy	14 – 4	172 – 2
Sandstone, hard (Isabel)	1	173 – 2
Greenbush and Wiley cyclothems		
Shale, sandy	2 – 4	175 – 6
Coal (Wiley)	1 – 5	176 – 11
Fireclay	1 – 6	178 – 5
Seahorne cyclothem		
Shale, sandy, dark	1	179 – 5
Sandstone	7	186 – 5
DeLong cyclothems		
Shale	7	193 – 5
Slate	7	194
Sandstone	7	194 – 7
Seville cyclothem		
Fireclay	1 – 4	195 – 11
Sandstone (Bernadotte)	7 – 6	203 – 5
Pope Creek cyclothem		
Shale, dark in lower part	2 – 10	206 – 3
Slate	1	207 – 3
Coal (Pope Creek)	1	208 – 3
Fireclay	1 – 7	209 – 10
Tarter cyclothem		
Coal	2 – 1	211 – 11
Fireclay	2½	212 – 1½
Coal	3	212 – 4½
Fireclay	2½	212 – 7
Coal	10	213 – 5
Shale	3	216 – 5
Fireclay	5	221 – 5
Sandstone	4	225 – 5
Babylon cyclothem		
Shale, sandy, gray	2	227 – 5

10.—*Big Creek Coal Company Hole 305*, SW¼ NW¼ sec. 21, T. 6 N., R. 3 E., Havana quadrangle, Fulton County. Elevation 682 feet.

	Thickness Ft. In.	Depth Ft. In.
Pleistocene system		
Subsoil (loess and Illinoian drift)	27	27
Pennsylvanian system		
St. David cyclothem		
Shale (Canton)	24 – 6	51 – 6
Slate (black shale)	1 – 9	53 – 3
Coal (No. 5)	5 – 2	58 – 5
Fireclay	1 – 7	60
Hard band (limestone concretions)	1 – 6	61 – 6
Summum cyclothem		
Shale	20 – 6	82
Shale, sandy (Pleasantview)	33	115
Liverpool cyclothem		
Shale, gray (Purington)	27	142
Hard band (Oak Grove limestone)	6	142 – 6
Slate, black	8	143 – 2
Shale, gray (Francis Creek)	28 – 10	172
Coal (No. 2)	2 – 3	174 – 3
Fireclay	6	174 – 9
Sulphur rock (concretion)	6	175 – 3
Shale, sandy, gray (includes Greenbush cyclothem?)	16 – 2	191 – 5
Wiley cyclothem		
Coal (Wiley)	1 – 4	192 – 9
Underclay	3 – 3	196
Seahorne cyclothem		
Sandstone	9	205
Upper and Middle DeLong cyclothems		
Shale, gray	5	210
Sandstone	5	215
Lower DeLong cyclothem		
Shale, gray	9	224
Coal	9	224 – 9
Shale, dark	1	225 – 9
Seville cyclothem		
Shale, light gray	5 – 3	231
Slate (black shale)	2	231 – 2
Coal (No. 1)	4	235 – 2
Slate	3	235 – 5
Fireclay	1 – 9	237 – 2
Shale, soft, lower part sandy	2 – 10	240
Limestone (possibly concretion)	4	240 – 4
Sandstone (Bernadotte)	3 – 3	243 – 7
Pope Creek cyclothem		
Shale, gritty	1	244 – 7
Slate	2	246 – 7
Limestone	2	246 – 9
Slate	3	247
Fireclay	2	249
Tarter cyclothem		
Shale, dark gray	3 – 6	252 – 6
Limestone	2	252 – 8
Slate, dark gray	9 – 4	262
Fireclay	3	265
Sandstone and shale	3	268
Babylon cyclothem		
Slate, black	7	275
Coal (Babylon)	2 – 2	277 – 2
Slate	1	278 – 2
Sandstone, chips of shale	2 – 10	281

APPENDIX C

PART 1.—MISSISSIPPIAN FOSSILS

1. St. Louis limestone at several outcrops along a ravine tributary to Spoon River in the E½ sec. 26, T. 6 N., R. 1 E., Fulton County (Vermont quadrangle). List prepared by T. E. Savage. Names brought up to date by C. W. Collinson.
   Lithostrotionella castelnaui Hayasaka
   Lithostrotion proliferum Hall
   Syringopora monroense Beede
   Echinocrinus cf. *wortheni* (Hall)
   Sulcoretepora cf. *lineata*
   Fenestella sp.
   Polypora biseriata Ulrich
   Streptorhynchus ruginosum (Hall and Clarke)
   Linoproductus ovatus (Hall)
   Dictyoclostus scitulus (Meek and Worthen)
   Echinoconchus alternatus (Norwood and Pratten)
   Spirifer littoni Swallow
   Cf. *Composita trinuclea* (Hall)
   Anematina ? *proutana* (Hall)
   Straparollus cf. *planispira* (Hall)
   Straparollus similis Meek and Worthen
   Rhineoderma ? *piasaensis* (Hall)
   Aviculopecten sp.
   Cf. *Leiopteria subplana* (Hall)
   Myalina St. Ludovici Worthen
   Cf. *Pteronites spergenensis* Whitfield

2. St. Louis limestone along Mill Creek in the NE¼ sec. 31, T. 2 N., R. 1 E., Schuyler County (Beardstown quadrangle).
   Lithostrotionella castelnaui Hayasaka
   Syringopora sp.
   Linoproductus ovatus (Hall)
   Aviculopecten sp.

PART 2.—PENNSYLVANIAN FOSSILS

More than 500 species of Pennsylvanian fossils have been collected from the Beardstown, Glasford, Havana, and Vermont quadrangles. They are listed in a separate report (Wanless, 1957) which discusses the ecology and ranges of the faunas and includes a list of collecting localities.

PART 3.—PLEISTOCENE FOSSILS

Collections by H. R. Wanless, except where noted

List of Localities

Kansan Deposits

1. Pro-Kansan loess, ravine in NW¼ SE¼ sec. 32, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
2. Late Kansan lacustrine silt, cut-bank on east side of Big Sister Creek, SE¼ NW¼ NW¼ sec. 8, T. 5 N., R. 4 E., Fulton County, Havana quadrangle.
3. Late Kansan silt below dark soil zone, ravine in Illinois River bluff, NE¼ SE¼ sec. 8, T. 3 N., R. 3 E., Fulton County, Havana quadrangle.

Illinoian—Loveland Loess

4. Same as locality 2.
5. Same as locality 3.
6. Ravine in SW¼ NW¼ sec. 26, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
7. Ravine in NE¼ sec. 5, T. 3 N., R. 3 E., Fulton County, Havana quadrangle.
8. Ravine north of Spoon River, in SE¼ SW¼ sec. 30, T. 5 N., R. 4 E., Fulton County, Havana quadrangle.
9. Ravine east of Coal Creek, in SE¼ SW¼ sec. 30, T. 5 N., R. 4 E., Fulton County, Havana quadrangle.
10. Forked ravine east of Badger Creek, center SE¼ sec. 3, T. 5 N., R. 1 E., Fulton County, Vermont quadrangle. Collected by George E. Ekblaw.
11. C. B. & Q. railroad cut, NE¼ SE¼ sec. 32, T. 2 N., R. 1 E., Schuyler County, Beardstown quadrangle. Collected by Walter Searight.
12. Ravine in SE¼ SW¼ sec. 4, T. 2 N., R. 2 E., Schuyler County, Beardstown quadrangle. Collected by Walter Searight.
13. Ravine in NE¼ NW¼ sec. 18, T. 2 N., R. 2 E., Schuyler County, Beardstown quadrangle. Collected by Walter Searight.
14. Ravine in NW¼ NW¼ sec. 34, T. 3 N., R. 2 E., Fulton County, Beardstown quadrangle. Collected by Walter Searight.
15. Ravine in NW¼ NW¼ sec. 1, T. 2 N., R. 1 E., Schuyler County, Beardstown quadrangle. Collected by Walter Searight.
16. Cut-bank on west side of Wilson Creek, NW¼ SE¼ sec. 27, T. 3 N., R. 2 E., Fulton County, Beardstown quadrangle. Collected by M. M. Leighton, George E. Ekblaw, W. C. Krumbein.

Farmdale Loess

17. Road-cut of U. S. Highway 24 north of Spoon River, in NE¼ NE¼ sec. 8, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.

Peorian Loess

18. Same as locality 17.
19. Road-cut west of Otter Creek, in SW¼ SE¼ sec. 32, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
20. Road-cut of U.S. Highway 24, south of Otter Creek, near center SE¼ sec. 30, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
21. Road-cut of private road on south side of ravine, in SE¼ NE¼ sec. 27, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
22. Road-cut of north-south road south of ravine and north of Fulton school, in NE¼ sec. 27, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
23. Exposure at head of gully west of road, in SE¼ SW¼ sec. 3, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
24. Road-cut of private road in bluff of Illinois River, in SE¼ SE¼ sec. 31, T. 5 N., R. 4 E., Fulton County, Havana quadrangle.
25. Road-cut of private road in bluff of Illinois River, in SW¼ SW¼ sec. 14, T. 5 N., R. 4 E., Fulton County, Havana quadrangle.

26. Road-cut in low spur of east-west road, in SW¼ SE¼ sec. 22, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
27. Road-cut across head branches of Seahorne Branch, west of NE cor. sec. 7, T. 3 N., R. 3 E., Fulton County, Havana quadrangle.
28. Road-cut in north-south road, just north of middle of south line of sec. 21, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
29. C. B. & Q. railroad cut in SE¼ NW¼ sec. 4, T. 1 N., R. 1 E., Schuyler County, Beardstown quadrangle. Collected by Walter Searight.

Bloomington Slackwater Deposits

30. Cut-bank of East Creek, in NE¼ NW¼ sec. 11, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
31. Cut-bank of Otter Creek, in NW¼ SW¼ sec. 33, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
32. Road-cut near center of east line of SW¼ sec. 4, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
33. Same as locality 32; lower reddish silt.
34. Cut-bank of south side of south branch of ravine tributary to Spoon River, near middle o west line of sec. 29, T. 5 N., R. 3 E., Fulton County, Havana quadrangle.
35. Cut-bank along west side of north branch of Otter Creek, near center SW¼ sec. 19, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
36. Ravine along east edge of SE¼ NE¼ sec. 34, T. 4 N., R. 3 E., Fulton County, Havana quadrangle; later Wisconsin silt on Bloomington slackwater silt, partly redeposited from Peorian loess.
37. Same as locality 36.
38. Stream cut in terrace northeast of Browning, about ⅛ mile north of Illinois Valley bluff, in NW¼ NW¼ NW¼ sec. 24, T. 2 N., R. 1 E., Schuyler County, Beardstown quadrangle; alternating gray and pink silt. Collected by T. B. Root.
39. Same as locality 38; 2 feet of red clayey silt below alternating gray and pink silt. Collected by T. B. Root.

Tazewell Loess

40. Road-cut in NE¼ NE¼ sec. 23, T. 2 N., R. 1 E., Schuyler County, Beardstown quadrangle. Collected by T. B. Root.
41. Same as locality 30.
42. Cut-bank on south side of East Creek, in NW¼ SE¼ sec. 3, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
43. Same as locality 35.
44. East fork of ravine, in NE¼ sec. 33, T. 4 N., R. 3 E., Fulton County, Havana quadrangle.
45. Along Dickson Creek, in SE¼ SE¼ sec. 1, T. 4 N., R. 3 E., Fulton County, Havana quadrangle; may include some Bloomington slackwater silt.

APPENDIX C.—
PLEISTOCENE

Fossil	Kansan			Loveland													F
Locality	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
LAND SPECIES																	
1. *Anguispira alternata* (Say)																	
2. *Anguispira solitaria* (Say)																	
3. *Carychium exiguum* (Say)																	
4. *Carychium exile canadense* Clapp									x		x						
5. *Cionella lubrica* (Müller)																x	
6. *Columella alticola* (Ingersoll)										x							
7. *Columella hasta* (Hanna)																	
8. *Discus cronkhitei* (Newcomb)																	
9. *Discus cronkhitei anthonyi* (Pilsbry)										x							
10. *Discus macclintocki* (Baker)																x	
11. *Discus macclintocki angulata* (Baker)	1	1	4			5	S						x	x			
12. *Euconulus fulvus* (Müller)										x			x			x	
13. *Gastrocopta armifera* (Say)																	
14. *Gastrocopta contracta* (Say)																	
15. *Gastrocopta pentodon* (Say)							1										
16. *Gastrocopta tappaniana* (C. B. Adams)																	
17. *Haplotrema concavum* (Say)							1										
18. *Helicodiscus parallelus* (Say)											x					x	
19. *Hendersonia occulta* (Say)	1	2	6		1	4	M		x	x			x	x	x	x	
20. *Hendersonia occultarubella* (Green)																	
21. *Hawaiia minuscula* (Binney)																	
22. *Mesodon clausa* (Say)																	
23. *Mesodon thyroides* (Say)																	
24. *Oxyloma decampi fultonensis* (Baker)							1										
25. *Pupila* cf. *hebes* (Ancey)														11			
26. *Retinella electrina* (Gould)										x						x	
27. *Retinella hammonis* (Ström)											x		x				
28. *Retinella indentata* (Say)					1		1										
29. *Stenotrema hirsuta* (Say)																	
30. *Stenotrema hirsuta yarmouthensis* (Baker)						2	2				x		x				
31. *Stenotrema leai* (Binney)																x	
32. *Stenotrema leai peoriensis* (Baker)							1					x		x			
33. *Striatura milium* (Morse)																	
34. *Strobilops labyrinthica* (Say)																	
35. *Strobilops virgo* Pilsbry					1	1	7	1				x		x		x	
36. *Succinea grosvenorii gelida* Baker							3		x	x	x	x	x			x	
37. *Succinea ovalis* (Say)																	
38. *Succinea ovalis pleistocenica* Baker			4		2	M	M	2	x		x		x	x	x	x	
39. *Triodopsis multilineata wanlessi* (Baker)										x	x		x	x	x		
40. *Vallonia gracilicosta* Reinhardt																	
41. *Vertigo elatior loessensis* (Baker)	1					1	4			x		x	x			x	
42. *Vertigo modesta* (Say)							1										
43. *Vertigo ovata* (Say)																	
44. *Zonitoides arboreus* (Say)							1										
AMPHIBIOUS SPECIES																	
45. *Fossaria dalli grandis* Baker										x							
46. *Fossaria modicella* (Say)																	
47. *Fossaria parva* (Lea)																	
48. *Fossaria parva tazewelliana* (Wolf)				1			3		x	x	x		x	x	x	x	x
49. *Fossaria* sp.										x							

F–Farmdale 7–number of specimens M–many S–several x–present

PART 3.
FOSSILS

Peorian												Bloomington										Tazewell						
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	
			2					7											3					1				1
											x							4	M									2
																		2	1									3
3			3			3														x					1	2		4
																												5
3			3			M	1			1								2								2		6
						1																						7
1				1	1	S	M		3	5		1						1								2		8
																				x								9
2			1			S		2		2	x																	10
																												11
						2				1												x			1		1	12
																		1	2									13
																		S	4									14
																			2									15
																				x								16
	6		M	2	1	6		1		1		1							4	x		x				1		17
1	2							1										8	S					1				18
	1	3	M	6		M	M		M	M					1	1				x				6		3		19
																			2									20
	5																											21
																		1	5									22
																		2	2									23
1												1				M				x			1		2			24
																												25
																						x						26
S	7		M	1		5	1			1		2						2					4					27
																		3	6							1		28
																			7			x		1			2	29
	8		M			10		1				1						2					1			3		30
				2	4	M	M			M		2				1		1				x		1	1	5		31
											x																	32
																			1									33
																								1	1			34
																			1									35
S	M		M		M	M	M	6	M	M		3			4			3		x		x	4	5	M	10	1	36
																			2						S			37
		M	M	M		M	M		M	M	x							S		x						7		38
x		2	M		S	8	S	6	S	S	x							1	1			x	2			1		39
						1	3																					40
S	3		5			M	6		2	2										x		x			M		8	41
1	1		M				7											6		x					3			42
																				x								43
	1							1										1										44
																												45
																1					x							46
															8		M				x	x		6				47
M	M		M		M	M	M	4	M	M		M				M		M	M	x			M			M	7	48
																												49

APPENDIX C.—
PLEISTOCENE

Fossil — Age	Kansan			Loveland													F
Locality	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
50. *Pomatiopsis lapidaria* (Say)																	
51. *Pomatiopsis scalaris* Baker							3				M			x		x	
52. *Stagnicola caperata* (Say)								M									x
AQUATIC SPECIES																	
53. *Amnicola winkleyi leightoni* Baker																	
54. *Fossaria odrussa decampi* (Streng)																	
55. *Gyraulus altissimus* (Baker)				M							1						
56. *Gyraulus crista* (Linne')																	
57. *Gyraulus urbanensis* (Baker)																	
58. *Helisoma antrosa striata* (Baker)																	
59. *Helisoma companulatum* (Say)																	
60. *Musculum* sp.																	
61. *Physella integra* (Haldeman)																	
62. *Pisidium abditum* (Haldeman)							4										
63. *Pisidium compressum* (Prime)				5													
64. *Pisidium concinnulum* Sterki							2										
65. *Pisidium medianum* Sterki																	
66. *Pisidium noveboracense* (Prime)																	
67. *Pisidium puuperculum crystalense* Sterki																	
68. *Pisidium rotundatum* (Prime)																	
69. *Pisidium scutellatum* Sterki																	
70. *Pisidium tenuissimum* Sterki																	
71. *Pisidium variabile brevius* Sterki																	
72. *Pisidium vesiculare* Sterki																	
73. *Pisidium walkeri* Sterki																	
74. *Pisidium* sp.																	
75. *Planorbula indianensis* Baker																	x
76. *Sphaerium striatinum* (Lam.)																	x
77. *Sphaerium sulcatum* (Lam.)																	
78. *Sphaerium tenue* (Prime)																	
79. *Stagnicola palustris elodes* (Say)																	
80. *Stagnicola* sp.										x							
81. *Valvata lewisii precursor* Baker				2													
82. *Valvata tricarinata* (Say)				M													
83. *Valvata tricarinata perconfusa* Walker																	
84. *Valvata tricarinata simplex* Gould																	

F–Farmdale 7–number of specimens M–many S–several x–present

PART 3.
FOSSILS—(Continued)

Peorian												Bloomington										Tazewell						
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	
...	...	...	...	...	...	...	...	...	...	...	...	...	7	...	...	...	...	2	...	...	...	...	...	...	...	...	6	50
M	1	...	...	...	...	...	...	...	...	...	...	M	...	...	2	...	6	...	...	x	...	x	M	4	...	...	...	51
2	...	...	...	...	...	...	...	...	...	...	...	...	8	...	12	...	M	...	...	x	x	...	M	6	...	...	...	52
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	x	...	...	...	...	...	...	...	53
...	...	...	...	...	...	...	...	...	...	...	...	...	...	M	...	M	...	...	...	...	...	...	1	...	...	...	...	54
...	...	...	...	...	...	...	...	...	...	...	...	...	...	M	1	M	M	...	...	x	x	...	7	2	...	...	...	55
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	56
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	57
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	x	x	...	...	...	...	...	...	58
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	x	x	...	...	...	...	...	...	59
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	x	...	...	...	...	...	...	60
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	...	...	...	3	61
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	62
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	7	...	...	...	4	63
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	S	S	...	...	...	...	...	...	3	6	64
...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	65
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	66
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9	...	...	...	...	...	...	...	...	...	...	67
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...	...	...	...	...	...	...	...	...	...	68
...	...	...	...	...	...	...	...	...	...	...	...	...	...	M	...	1	2	...	...	...	...	...	...	...	...	...	...	69
...	...	...	...	...	...	...	...	...	...	...	...	...	...	10	...	1	...	...	...	...	...	...	...	...	...	...	...	70
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	71
...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	72
...	...	...	...	...	...	...	...	...	...	...	...	...	...	S	...	...	...	...	...	...	...	...	...	...	...	...	...	73
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	x	x	...	...	...	...	...	...	74
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	75
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	76
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	x	...	...	...	...	...	...	...	77
...	...	...	...	...	...	...	...	...	...	...	...	...	...	M	...	...	...	...	...	...	...	...	...	...	...	...	...	78
...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	M	...	...	...	...	...	...	...	...	...	...	...	79
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	80
...	...	...	...	...	...	...	...	...	...	...	...	...	...	M	2	M	2	...	...	...	...	...	...	...	...	...	...	81
...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	x	x	...	M	...	...	...	...	82
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	M	1	...	...	...	83
...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	84

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