See also these maps:

Birds quadrangle:

4107 d5.1-49 — McLeansboro outcrops and surficial deposits.

4107 d5.1-50 — Outcrops and water wells.

4107 i8-7, 8 — Oil wells and oil data.

Hardinville quadrangle:

4107 d5.1-47 — McLeansboro outcrops and surficial deposits.

4107 d5.6-44 — Surficial geology.

4107 i8-2, 3, 5 — Oil wells and oil data.

Sumner quadrangle:

4107 i8-1 — Oil well locations and structure in Main and Allendale pools. By R.S. Blatchley 1911-12

4107 i8-6 — Oil well locations and producing formations.

Vincennes quadrangle:

4107 d5.1-48 — Outcrops and water wells.

4107 i8-4 — Oil well locations and structure maps. 3 sheets

All quadrangles:

4107 u-5 — Generalized columnar section. 2 sheets

See also Savage # Sand 10.

GEOLOGY OF THE
HARDINVILLE, SUMNER, BIRDS,
AND VINCENNES QUADRANGLES

BY

T. E. SAVAGE, J. L. RICH,

AND R. S. BLATCHLEY,

1916 ?

Complete list of illustrations sent to U.S.G.S. for folio

List of Illustrations for Sumner-Vincennes Folio

Fig. 1, p.1: Index map of southern Illinois and portions of adjacent states.

Fig.2, p.1: Geologic sketch map of Illinois and surrounding region.

Fig.3, p.21: ~~Journal~~ Generalized columnar section of rocks encountered in deep wells in the Sumner and Vincennes quadrangles.

Fig.4, p.58: Shale and limestone lentil below the Parker coal exposed in east bank of river 1 mile east of Lawrenceville. One side of a low anticline is shown.

Fig. 5, p.58: Close up view of shale and overlying thin sandstone beds below the Parker coal in bank of Embarrass river 1 mile east of Lawrenceville.

Fig. 6, p.48: Diagramatic illustrations of the probable inconformable relation between the Mississippian rocks at the Sumner and Vincennes quadrangles.

Fig. 7, p.115: Index map showing location of quadrangles with reference to the southeastern oil fields in Illinois.

Fig. 8, p.126: A section in Vincennes quadrangle showing oil sands across the productive part of the LaSalle anticline along the first tier of wells south of center of sections 27,26,and 25. T. 3 N., R. 12 W.

Plate I., Columnar sections in Lawrence County (recommend this Plate be placed on a separate page together with the columnar section, Fig.3, as given after the geologic map in the Patoka folio No.105).

Geologic map of Vincennes quadrangle.
Geologic map of Sumner quadrangle } Not sent 4/16/62

Map of Vincennes quadrangle showing oil fields and contours on the Kirkwood sand (as Plate 8 of Bulletin 33).

Map of Sumner quadrangle showing oil fields and contours on Kirkwood sand.

Areal Geology sheet of Sumner Quadrangle

Areal Geology sheet of Vincennes Quadrangle

Structure of Kirkwood sand, Sumner, Quadrangle

Productive areas for each sand, — Vincennes Quadrangle

Productive areas for each sand, — Sumner Quadrangle

Illustration No. 3, called for in table of contents. 4107 W-5

Structure on Kirkwood sand — Vincennes quadrangle.

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1916?

I. INTRODUCTION

Location and Area.- The Hardinsville, Birds, Sumner and Vincennes quadrangles are located in the lower Wabash Valley between parallels 38°30' and 39° and meridians 87° 30' and 88°. They include an area of square miles most of which lies in Illinois while a smaller part extends east of the Wabash river into Indiana. These quadrangles cover the whole of Lawrence County, Illinois and portions of Crawford, Jasper, Richland, Edwards and Wabash Counties, Illinois and Sullivan, Knox and Gibson Counties, Indiana.

Importance.- The southern and more profusely productive half of the main Illinois oil fields as well as some of the smaller associated fields of Indiana is located within the Hardinsville, Birds, Sumner and Vincennes quadrangles. The oil and gas which have been produced here for many years have been very important factors in the economic development of Illinois.

General Geologic Relations.- The Hardinsville, Birds, Sumner and Vincennes quadrangles are located within the glaciated plains and the bed rock throughout much of this region is buried beneath considerable thicknesses of drift. This area is also situated within the eastern interior coal fields and the uppermost consolidated rocks all belong to the Pennsylvanian System. The southern extremity of the La Salle anticline extends obliquely across these quadrangles and has played an important part in the accumulation of oil in this district.

Ms. #11

II GEOGRAPHY

Topography

General Features.- The Hardinsville, Birds, Sumner and Vincennes quadrangles, are an area of small relief with relatively gentle slopes bordering the hills and valleys and the altitude is low considering the distance from the sea.

The highest point, about 645 feet above sea level, is in the NE. 1/4 sec. 35, T. 6 N., R. 12 W. in the Birds quadrangle and the lowest point, slightly less than 386 feet, is along the south border, where Bonpas Creek leaves the Sumner quadrangle. While the maximum relief in this area is about 259 feet the slopes are usually rather gentle. Probably the steepest gradient in this region is on the slopes of Dicksburg Hills near the south border of the Vincennes quadrangle, where there is a difference in altitude of more than 100 feet in a distance of about one-eighth of a mile.

The principal features of the surface are due largely to erosion and deposition by streams and glaciers. The original surface of this area was formed by the deposition of glacial drift and stood at an elevation of 430 to 530 feet. Into this rather gently rolling plain the larger streams have carved their valleys to depths of from 80 to 100 feet and widened them in places from one to eight or nine miles.

The region in general presents five distinct types of topographic forms: Maturely dissected uplands; undulating upland prairies; valleys; sand dunes; and island hills.

Maturely dissected Uplands.- Areas of comparatively rough topography for this part of Illinois occupy a large area between the Wabash and Embarrass Rivers as far west as Honey Creek and south from the Embarrass River between Sumner and Bridgeport to the south boundary of the Sumner quadrangle. A smaller area of similar topography prevails in the immediate vicinity of Mt. North school in the southwestern part of the Hardinsville quadrangle. The topography of these area has been strongly influenced by the character of the underlying rock which is largely of a more resistant nature than that which occurs in the more rolling areas. The blanket of glacial drift here is also thinner and while it has smothered out the topography to some extent it has not entirely obliterated the features of the bed rock surface.

Upland Prairies.- Nearly level or gently undulating uplands upon the north side of the Embarrass river were of Honey Creek while upon the south they occur both to the east and west of the belt of maturely dissected uplands which extend southward from between Sumner & Bridgeport. These areas are remnants of the surface of the drift sheet which with the exception of some slight trenching by the streams have been little altered. The drift filled up many of the inequalities of the surface of the bed rock but this process was not carried to perfection and the surface of the drift was never really smooth but had many minor irregularities such as low ridges and hills and broad shallow valleys.

Valleys.- The streams which drain these quadrangles occupy preglacial valleys, the larger of which are filled to a

depth of 100 feet or more with drift and are bordered in most places by low slopes of till. Exposures of the bed rock along their courses are rare except where meanders of the larger streams infringe against the sides of their valleys or along the upper portion of the smaller streams where a steep gradient has aided them in rapid down cutting. The gradients of the larger streams are very gentle probably averaging less than five feet of fall per mile but some of the smaller tributaries and ravines in the maturely dissected areas are much steeper.

Among the conspicuous topographic features of the quadrangles are the broad flood plains that border the larger streams and the relatively wide flats along even the smaller creeks of the region. The flood plain of the Wabash river which varies from 4 to 6 miles in width is broken here and there by hills or dunes of sand more than 20 feet high. Small lakes or swamps which represent abandoned portions of old channels in various stages of filling are also present, as Brodies Lake, Grays Pond, Millers Pond, Long Pond, and Buzzard Pond.

Embarrass river is bordered by a flood plain 2 to 5 miles wide, which stands 10 to 15 feet above the level of low water. A considerable portion of this flat at a distance from the river channel, is poorly drained owing to the obstruction of the natural levees[1/] two to five feet high, that have been formed by deposits adjacent to the channel during time of overflow. There are also occasional depressions representing abandoned channels of the river, some of which, as Horseshoe Pond, and Circle Pond are permanently occupied with water, whereas others have become nearly filled and form marshes or sloughs that contain water during only

1/ See maps of Embarrass River drainage project, sheets No.3 and No. 4.

only a part of the year.

In the southern part of the Birds and the northern portion of the Vincennes quadrangles the flood plains of the Wabash and Embarrass rivers are separated by no intervening upland and attain a combined width of 13 1/2 miles but near their junction the flats narrow to 7 or 8 miles which width is maintained to the south border of the Vincennes quadrangle.

Important flood-plain areas also occur along the larger tributaries in this region. Of these, North Fork of Embarrass has a flood plain 1 to 2 miles wide, and along the lower courses of Big, Honey, and Brushy Creeks on the north side of the main stream and along Muddy Creek, and the Slough, on the south the width of the flood plains is in places one-half mile to one mile or more. The channel of Bonpas Creek in the south half of the Sumner quadrangle is bordered by a flood plain 1 to 2 miles wide, the almost level surface of which is less than a dozen feet above the level of low water and throughout the greater part of its length Little Bonpas Creek flows in a flood plain 1/2 to 1 mile wide. The lower courses of the tributaries to these creeks, as Crooked Creek on the West and Jordan Creek on the east, are about 6 miles in length and have flood plains nearly one mile wide. The channel of Raccoon creek throughout the greater portion of its length is bordered by a low flat one to two miles in width, which on eadh side merges so gradually into the low bordering plain of till that in many places it is difficult to determine where the flood plain ends and the till plain begins.

In pre-Wisconsin time this creek turned eastward in the south half of section 8, T. 2 N., R. 12 W., and followed for

a distance of 4 or 5 miles a valley 1 to 2 miles north of its present channel. The valley of Crawfish Creek, in the southeast part of the Sumner quadrangle, also has a width of flood plain out of all proportion to the size of the present stream, the borders of which merge gradually into the adjacent upland. In the north part of Sumner quadrangle, Shirly and Muddy creeks flow in wide drift bordered valleys which could not have been excavated by these streams in post Illinoian time.

Sand Dunes.- An important area of sand dune topography in this region is that bordering the east side of the Wabash River Valley from Vincennes south to Decker. Over this area the hills are irregular in arrangement and altitude; the higher ones rising more than 100 feet above the flood-plain of the Wabash from which the larger part of this wind blown material was clearly derived. Loose sand so completely covers the slopes and crests of the hills over this belt that there are no outcrops of hard rocks, and exposures of glacial till are exceedingly rare.

In some places dunes of wind-blown sand also covers considerable areas over the flood plains of the Embarrass and Wabash rivers. Deposits of loose sand cover a few square miles east of Lawrenceville, between the Embarrass river and the Beaver Pond drainage ditch. Low hills of sand occur over a discontinuous belt, 1 to 3 miles wide which extends north of Dicksburg Hills to Chimney Hills, and thence northeast to Purcell and northward near the east margin of the flood plain to Vincennes. Others occur along the Wabash in the Birds quadrangle and along the North Fork of the Embarrass river in the Hardinsville quadrangle. Over the upland west of the valley of the Embarrass and Wabash rivers loose

sand covers a considerable area in the vicinity of Sand Barrens, as well as West and north of St. Francisville.

Island Hills.- Isolated hills of indurated rock rising above the flood plains of the Wabash and Embarrass rivers are conspicuous at a number of places in the valleys of these streams. On the east side of the Wabash river, Dicksburg Hills, standing about 100 feet above the flood plain, and Chimney Hills, nearly as high, represent such islands that were developed by the removal of the strata from around them. Farther north, near Vincennes, several such hills occur west of Wabash river rising 100 feet above the flood plain. Others occur one mile east of Lawrenceville northeast of Billett.

Drainage

Streams.- The Wabash river is the master stream of the Hardinsville/Birds/Sumner & Vincennes quadrangles. It rises in western Ohio, and flows westward across central Indiana and thence southwest forming the boundary between Illinois and Indiana for nearly 200 miles of its course above its junction with the Ohio. It enters the Birds quadrangle at an elevation of about 421 feet and leaves the Vincennes quadrangle at an elevation of about 387 feet. Its length in these quadrangles is about 53 1/2 miles and its average gradient in this part of its course is about 7 1/2 inches per mile. The average discharge of Wabash river at Vincennes, Indiana, is estimated at 9374 cubic feet per second. Its drainage basin above Vincennes embraces 12,720 square miles, and the average run-off per square mile is about 0.737 cubic feet per second.

Measurements indicate that Wabash River annually carries past Vincennes 4,884,480 tons of mineral matter, thus reducing the level of its basin above Vincennes at an average rate of 1 inch in about 500 years.1/

1/ Dole, R. B. and Stabler, Herman, Water Supply Paper No. 234, U. S. Geol. Survey, 1909, p. 88.

The most important tributary to the Wabash in this area is the Embarrass River which rises about 75 miles to the north in Champaign County. It follows an irregular southeast course across these quadrangles and joins the Wabash about five miles southwest of Vincennes. It receives the runn-off from about one-half of this area which includes the whole of the Hardinville, the southwestern half of the Birds and the northern quarter of each of the Sumner and Vincennes quadrangles. The average gradiant of the Embarrass in this part of its valley is a little less than 1 foot per mile.

The average discharge of ~~the~~ Embarrass River at Lawrenceville is 1816 cubic feet per second, from its drainage basin of about 2390 square miles, the run-off for each square mile averaging about .76 second foot. The river annually carries past Lawrenceville 623,790 tons of mineral matter of which a remarkably large proportion is in solution, the ratio of the dissolved minerals to those carried in suspension is as 283 to 66.2/ It is estimated that Embarrass River

2/ Dole, R. B., and Stabler, H., Water Supply Paper, No.234, U.S. Geological Survey, 1909, P.88.

above Lawrenceville removes each year about 260 tons from every square mile of its basin, thus lowering the surface of its entire drainage area at an average rate of 1 inch in about 735 years.

Swamps and Ponds.- Important areas of swamp land occur upon the flood plains of the Wabash and Embarrass Rivers and rather extensive drainage projects have been undertaken to render the larger ones suitable for cultivation. A number of lakes and ponds also occur upon these same flood plains which have no drainage outlets during the ordinary stages of the rivers.

Culture

The largest city within these quadrangles is Vincennes, Indiana with a population of --------- . Lawrenceville, with a population of ---------- is the most important city in the Illinois portion while Robinson, of nearly equal size, is partly included within the Birds quadrangle. A number of other less important towns are situated along the railroads in various parts of the quadrangles.

The Birds and Vincennes quadrangles are traversed from north to south by the Big Four Railroad and the B & O passes east and west across the Sumner and Vincennes quadrangles. A portion of an east west line of the Illinois Central is included along the northern edge of the Hardinville quadrangle. Vincennes may be reached not only by the Big Four and B & O already mentioned but also by the C & E I and Vandalia railroads.

The Illinois State highway No. 1 extending from Chicago to Metropolis more or less parallels the Big Four across the Birds and Vincennes quadrangles. This road is intersected at Lawrenceville by highway No. 12 which connects Vincennes with St. Louis. No. 1 highway is joined at Robinson by No.33, which extends to Effingham.

Long stretches of gravel roads are present upon the flood plains of the Wabash and Embarrass Rivers but the country roads of the uplands are almost entirely of graded dirt.

III STRATIGRAPHY: ROCKS NOT EXPOSED

General Statement.- All of the rocks exposed in the Hardinville, Birds, Sumner and Vincennes quadrangles belong to the McLeansboro formation of the Pennsylvanian System. Beneath these beds occurs a great thickness of strata none of which outcrop within a distance of many miles and which are therefore known only from the logs of deep wells.

Well Records.- Between 9,000 and 10,000 wells have been drilled for oil within these quadrangles but only skeleton logs recording simply the positions of the oil sands are available for the great majority of them. Detailed logs are available for some while in a few cases samples were saved at intervals of from 5 to 10 feet and sent to Illinois Geological Survey for study.

The productive oil sands in these quadrangles lie at depths of from 450 to 1750 feet and occur either in the Pennsylvanian or the upper part of the Mississippian systems, and very few wells have been drilled below these horizons. The deepest well in the State, however, was sunk a short distance southwest of Robinson in the N 1/2 Sec. 12, T. 6 N., R. 13 W. and was continued well into the Trenton limestone. The following log has been compiled both from the driller's record and the samples sent to the Survey for study. The description of strata marked by an asterisk are from the driller's log, no samples having been saved. All others are from the study of samples taken at intervals of from 5 to 8 feet.

H. B. Zahnesir et al. well on the
Jones farm N. 1/2 Sec. 12, T. 6 N., R. 13 W.
Surface elevation 525 feet.

Pennsylvanian

	Thickness	Depth
* Drift and shale - streak of coal at 155 and thin lime at 115	195	195
* Limestone	5	200
* Shale - very sandy	20	220
* Shale with coal at 265 and thin limes at 245 and 285	80	300
* Sand	20	320
* Shale with thin lime at 330	20	340
* Limestone	15	355
* Streak of coal	5	360
* Shale with streak of coal at 390 and thin lime at 380	40	400
* Sand - slightly shaley	30	430
* Shale with streak of coal at 435 over thin lime and another coal streak at 470	70	500
* Limestone	15	515
* Coal	5	520
* Shale with streaks of coal at 550,630,670 and 700 and thin limes at 540 and 620	230	750
* Shale-sandy with streak of coal at 760	10	760
* Sand	25	785
* Sand - medium shaly with streak of coal at 790	15	800
* Sand	30	830
* Shale-streak of coal at 840	30	860
* Sand	15	875
* Shale	15	890
* Shale	15	905

	Thickness	Depth
* Shale	30	935
* Sand	15	950
* Shale	15	965
* Sand	25	990

1550
990
560

Chester

Limestone - sandy white and black shale	5	995
Sandstone - micaceous white with black shale fragments	5	1000
Limestone - gray black argillaceous	12	1012
Shale - dense black	7	1019
Sandstone - fine grained argillaceous with fragments of coal	15	1034
* Sandstone and shale	46	1080
Sandstone, fine grained argillaceous with fragments of coal	11	1091
Sandstone,fine grained argillaceous with fragments of coal	3	1094
* Gray and white sandstone, gray and black shale	285	1377
Sandstone,fine grained gray badly discolofed by iron and mixed with shale	at	1377
Shale,gray	5	1382
Sandstone,fine grained white gray shale and black shale	12	1394
Like preceding - very little shale	10	1404
Shale,gray	5	1409
Sandstone,fine grained white gray shale and black shale	22	1431
Like preceding, largely gray shale	10	1441
Shale,gray clay	4	1445

	Thickness	Depth
Limestone,medium grained crystalline gray white	17	1462
Shale,gray sandy and fine grained gray sandstone	3	1465
Limestone,oolitic white and dense gray shale	10	1475
Like preceeding - largely shale	5	1480
Shale,dense gray with gragments of white sandy oolitic limestone. 75 % insoluble in HCL	15	1495
Like preceeding 46 % insoluble in HCL	15	1510
Shale,gray with fine grained dense gray buff limestone	5	1515
Like preceeding 28 % insoluble in HCL	25	1540
Lower Mississippian		
Limestone,white crystalline oolitic sample very fine	25	1565
*Limestone,gray white dense crystalline and oolitic	45	1610
Limestone,gray white crystalline,oolitic	20	1630
*Limestone,gray white	15	1645
Limestone,fine grained dense,crystalline, gray white	90	1735
Like preceding with fragments of gray limestone	30	1765
Limestone,fine grained,dense buff	5	1770
Like preceding with gray brown and gray limestone	5	1775
Limestone,fine grained dense buff gray	5	1780
Limestone,fine grained dense gray brown with few sand grains and angular quartz fragments	90	1870
Like preceding with few grains of buff limestone	20	1890

	Thickness	Depth
Limestone,fine grained,dense gray brown buff with some lighter buff	50	1940
Like preceding slightly iron stained	20	1960
Like preceding with large fragments of dark gray shale	5	1965
Like preceding, few shale fragments	30	1995
Limestone,fine grained dense gray brown buff with some lighter buff	10	2005
Limestone,gray, gray brown and buff, fine grained	20	2025
Limestone,gray and white gine grained	50	2075
Rust brown, porous masses of $CaCO_3$ powder cemented together	5	2080
Limestone,fine grained,gray and white	175	2255
Limestone,fine grained buff white dense	35	2290
Like preceding with numerous fragments of fine grained buff or gray micaceous sandstone and black shale	5	2300
Limestone,white with small angular quartz fragments	5	2305
Like preceding 8 per cent insoluble in HCL	5	2310
Limestone,white and buff iron, rust common	25	2335
Limestone,fine grained dense white and gray with few quartz grains slightly iron stained and contains rust fragments	30	2365
Limestone,dense,fine grained,white gray	30	2395
Like preceding,with fragments of gray shale	25	2420
Like preceding,with small fragments of blue gray shale	15	2435
Limestone,fine grained dense crystalline white and gray	35	2470

	Thickness	Depth
*Limestone,white and gray,fine grained dense with few quartz grains and little shale	195	2665
Limestone,dense hard fine grained gray black and gray white argillaceous with white chert and some angular quartz 49 per cent insoluble in HCL	30	2695
Like preceding stained brown with iron	35	2730
Sweetland Creek Shale		
Shale,hard,black with much pyrite	5	2735
Like preceding with about 30 per cent buff limestone	5	2740
Like preceding with about 60 per cent buff limestone	5	2745
Shale,dense with few fragments of pyrite	5	2750
Like preceding with few Sporengites	12	2762
Shale,hard brittle black containing Sporengites and a little pyrite	129	2891
Like preceding with about 40 per cent buff porous limestone	6	2897
Devonian Silurian Limestone		
Limestone,granular porous crystalline buff with white chert about 45 % insoluble in HCL somewhat iron stained	30	2927
Like preceding with about 40 per cent gray granular crystalline limestone and a few small black shale fragments 16 % insoluble in HCL	48	2975
Limestone,granular porous crystalline buff with white chert	6	2981
Like preceding with about 40 % gray granular crystalline limestone	21	3002
Limestone,granular porous crystalline buff and gray with white chert, composit samples buff	20	3022

	Thickness	Depth
Like preceding but composit samples gray	15	3037
Like preceding but composit samples buff brown from iron staining	34	3071
Like preceding - composit samples gray	24	3095
Limestone,coarse crystalline granular dense white	6	3101
Like preceding completely soluble in HCL except few small chert fragments	54	3155
Limestone,buff and gray crystalline with much white chert iron stained about 32% insoluble in HCL	89	3244
Limestone,fine grained dense and porous gray and white and solomitic limestone with few rounded quartz grains	114	3358
Limestone,fine grained dense and porous gray and white and dolomitic limestone,gray and white chert in small amount about 34% insoluble in HCL	203	3561
Limestone,fine grained dense gray dolomitic with a few fragments of white pink and purple limestone	35	3596
Like preceding numerous fragments of white pink and purple limestone	7	3603
Like preceding very little pink or purple limestone	7	3610
Like preceding numerous fragments of white pink and purple limestone	21	3631
Limestone,dense,fine grained white and gray	14	3645
Limestone,purple pink and green with minor amounts of white and gray	7	3652
Limestone,dense fine grained gray with fragments of white and purple limestone	13	3665
Limestone,dense fine grained white and gray	28	3693

	Thickness	Depth
Limestone,fine grained,dense hard, brittle with few white limestone fragments about 24 per cent argillaceous residue with HCL	12	3714
Limestone,dense,white about 60 per cent, like preceding	14	3728
Limestone,fine grained,dense.hard brittle with few white limestone fragments	27	3755
Limestone,dense,white and gray in about equal amounts 39 per cent insoluble in HCL residue largely chert	14	3769
*Limestone,fine grained,dense hard brittle gray and white and chert	27	3796
Limestone,dense white and gray in about equal amounts	14	3810
Limestone,fine grained,dense gray	7	3817
Limestone,fine grained dense buff white	7	3824
Like preceding but badly iron stained	21	3845
Limestone,purplish pink greenish gray and white	7	3852
Limestone,mostly purple,some gray and white	14	3866
Limestone,pink white greenish,purplish and gray	12	3878
Like preceding,more largely white	12	3890
Limestone,dense brittle fine grained gray and white	30	3920
Limestone,pink white greenish purplish and gray	18	3938
Limestone,dense hard fine grained,white with few grey fragments	12	3950
Like preceding about 50 per cent gray and white chert	18	3968

Maquoketa Shale	Thickness	Depth
Shale, dense friable gray black containing some very fine sand	192	4160
Shale, dense, moderately hard, brittle, gray black	32	4192
Like preceding contains considerable calcareous material	28	4220
Like preceding sample, coated with calcareous powder	8	4228
Shale, dense, black contains pyrite few fragments of fine grained dense white limestone	8	4236
Equal amounts of dense black shale and fine and medium crystalline gray and gray white limestone	4	4240
Trenton Limestone		
Limestone, fine and medium grained crystalline dense gray and gray white with few black shale fragments	150	4390
Limestone, dense, fine grained hard brittle gray black and gray fractures similarly to chert	44	4434
Like preceding with considerable amount of granular crystalline gray and gray white limestone	138	4572

The drilling that penetrated the oldest rocks in this region of which detailed information was obtained, was put down 18 miles north of the Hardinville area, in the NW. 1/2, SE. 1/4, Sec. 1, T. 10 N., R. 14 W., Clark County, to a depth of 3017 feet, reaching nearly to the base of the Ordovician.

Below a depth of 350 feet a sample of the rock was taken from every bailer, and from the study of these samples the following log of the boring was compiled:

Log compiled from a study of rock samples from a boring on the Shover Farm, in the NW. 1/4,SE. 1/4, Sec. 1, T. 10 N., R. 14 W., Clark County. (The saving of samples was begun at a depth of 350 feet. Elevation about 600 feet.

	Thickness Feet	Depth Feet
Pennsylvanian:		
Pottsville formation:		350
Shale,gray,fine	190	540
Sandstone,gray,coarse and fine	20	560
Shale,gray and dark gray	37	597
Mississippian:		
Ste.Genevieve and St.Louis limestones:		
Limestone,grayish to white,fine	100	697
Limestone,gray,fine	53	750
Limestone,gray with green streaks; some chert	30	780
Limestone,gray,oolitic	40	820
Limestone,gray with grains of dark mineral	20	840
Limestone,gray,with small bi-valves and crinoid fragments	10	850
Salem limestone:		
Limestone,gray with fragments of crinoids, bryozoa, and shells of Endothyra	15	865
Limestone,gray,oolitic	55	920
Osage and Kinderhook groups:		
Limestone,brownish gray	50	970
Limestone,fragmental; with many dark and green specks	50	1020
Limestone,white and gray; some white chert and dark gray shale	40	1060
Limestone,gray	30	1090
Limestone,dark gray,shaley	35	1155
Shale,gray,calcareous,stony, or shaly limestone	185	1340
Limestone,gray,crinoidal	20	1360
Shale,dark,dalcareous,stony	40	1400
Shale,dark gray,calcareous,stony,micaceous; some fine sand	80	1480
Sandstone,greenish gray,fine,slightly calcareous	70	1550
Shale,dark gray,stony,calcareous; or shaly limestone	15	1565
Shale,green,fine	15	1580
Limestone,yellowish-gray,compact	20	1600
Devonian system:		
Upper Devonian shale:		
Shale,black,highly bituminous,fine-grained; with spores of Sporangites huronense	90	1690

	Thickness Feet	Depth Feet
Hamilton and Onondaga limestone:		
Limestone,gray and white,with fragments of fossils	95	1785
Limestone,ywllowish gray,dolomitic,some chert	35	1820
Sand,white,moderately fine	10	1830
Silurian system:		
Niagaran and Alexandrian limestones:		
Limestone,yellow and brown,dolomitic	70	1900
Limestone,white and grayish white, dolomitic; some grains of glauconite and bits of chert	120	2020
Limestone,gray,dolomitic	130	2150
Limestone,gray,dolomitic,some gray chert	50	2200
Ordovocian system:		
Trenton limestone:		
Limestone,waxy luster,fine,nondolomitized	20	2220
Limestone,gray	65	2285
Limestone,dark gray,dolomitic,laminated	10	2295
Limestone,gray and white,fine grained	30	2325
Limestone,gray;some green grains of glauconite	5	2330
Limestone,light gray,waxy luster	50	2380
Limestone,white,compact,with much chert	20	2400
Limestone,white and gray,fine grained	55	2455
Limestone,pinkish brown; some fragments of crinoid stems	45	2500
Limestone,pink,gray and white,waxy luster	10	2510
Limestone,gray and white	35	2545
Limestone,pinkish white	25	2570
St.Peter sandstone:		
Sandstone,white,calcareous	30	2600
Limestone,gray,dolomitic,sandy	10	2610
Sand,bluish gray to dark gray,fine,in a dolomitic shaly matrix	20	2630
Sandstone,dark gray,fine,dolomitic	10	2640
Prairie du Chien limestone:		
Limestone,gray and white; with fragments of bryozoa and brachiopods	15	2655
Limestone,white,with crystals of calcite,quartz and pyrite	5	2700
Limestone,gray,fragmental	5	2705
Limestone,light,dark,and yellowish-gray with some chert	15	2720
Limestone,dark gray,fine-grained; some chert	15	2735
Limestone,dark gray and black	15	2750
Limestone,black,shaly,with black bituminous shreds and bits of gray limestone	107	2857

	Thickness Feet	Depth Feet
Limestone, gray, fragmental, with a few black bituminous films	5	2862
Limestone, gray, fragmental	28	2890
Limestone, gray and cream, sub-crystalline, granular	46	2936
Limestone, light gray, granular, with fragments of fossils	30	2966
Limestone, gray, granular, with fragments of fossils	17	2983
Limestone, gray and yellowish gray, fragmental	34	3017

A deep boring put down in White County, near the northeast corner of the SW. 1/4, NW. 1/4, Sec. 18, T. 7 S., R. 10 E., about 40 miles south of the Sumner quadrangle furnished unusually accurate information concerning the Pennsylvanian and upper Mississippian strata in that region to a depth of 2232 feet. This boring was made with a diamond drill, and all but the upper 300 feet of the core was sent to the Illinois Geological Survey. From the study of this core the following record and interpretation of the strata were made. The upper 300 feet of the record was taken from the driller's log, and the remainder was made from the study of the core.

Log of deep drilling near the northeast corner of SW. 1/4, NW. 1/4, Sec. 18, T. 7 S., R. 10 E., in White County.

	Thickness Feet In.	Depth Feet
Pleistocene and Recent series:		
Clay and sand	11	11
Pennsylvanian series		
McLeansboro formation		
Shale, calcareous	11	22
Sandstone, shaly	10	32
Shale, dark	12.10	44.10
Coal	.10	45.08
Shale, gray	4. 4	50
Sandstone, shaly	7	57
Shale, dark	19. 2	76. 2
Coal	. 9	76.11
Shale, gray	7. 1	84

Pennsylvanian series (Continued)	Thickness Feet	In	Depth Feet	In
Shale,green and dark	6		90	
Limestone	1		91	
Shale,dark,with hard bands	13		104	
Shale,dark blue	4		108	
Limestone	6	10	114	10
Shale,black	1	6	116	4
Sandstone,shaly	26	8	143	
Sandstone	2		145	
Shale,dark	19	2	164	2
Shale,black		6	164	8
Shale,green	7	4	172	
Shale,dandy	6		178	
Lime and shale mixed	1		179	
Shale,dark	2		181	
Shale,dark blue	49	6	230	6
Shale and lime mixed	1	6	232	
Shale,black	2	5	234	5
Shale,gray	10	7	245	
Shale,dandy	11		256	
Shale,dark	3		259	
Shale,dark blue	21	6	280	6
Shale,dark	4	6	285	
Shale,light blue	15		300	
Shale,dark gray,slightly gritty	30		330	
Shale,gray	4	2	334	2
Coal,bony and shale		8		10
Shale,dark gray	1	10	336	8
Shale,light gray	6	6	343	2
Limestone,gray,shaly		6	343	8
Shale,gray and greenish	5	10	349	6
Sandstone,gray,fine grained	6	6	356	
Limestone,gray	4		360	
Limestone,gray	9		369	
Shale,black		2	369	2
Limestone,gray,with 1 ft. of conglomeratic limestone,2 ft. above base	9		378	2
Sandstone,gray and pink	4	6	382	8
Shale,brown,dark and green	4	2	386	10
Sandstone,green,fine	3	2	390	
Sandstone,gray,fine,micaceous	30		420	
Shale,gray,slightly sandy	120		540	
Shale,dark gray	34	8	574	8
Coal	2	4	577	
Shale,black to dark	9	8	586	8
Sandstone,gray,shaly		9	587	5
Limestone,gray	5	3	592	8
Shale,gray,sandy below	7	4	600	
Sandstone,gray,micaceous	2	6	602	6
Shale,dark gray,gritty	8	10	611	4
Limestone,shaly or shale,calcareous, dark,with chonetes mesolobus and Girtyina ventricosa	5		616	4
Shale,black		4	616	8

	Thickness Feet - In	Depth Feet In
Carbondale formation		
Coal, Harrin (No.6)	5	621. 8
Shale, gray, clay	3. 9	625. 6
Sandstone, gray, shaly, fine grained	3	628. 6
Sandstone, gray, micaceous, in fine to medium grains	39	667. 6
Shale, dark to gray	1. 8	669. 2
Coal	. 2	669. 4
Sandstone, fine, micaceous, gray to drab, banded in dark and light laminae	15. 6	684.10
Sandstone, gray to dark, fine grained	18	702.10
Shale, dark gray, gritty	15	717.10
Shale, black	. 2	718
Coal, Springfield (No.5)	4	722
Shale, gray and dark	3	725
Sandstone, shaly, conglomeratic at base	10	735
Sandstone, fine, gray, with dark bands	12. 6	747. 6
Sandstone, gray, fine, micaceous	30	777. 6
Shale, dark gray, sandy	29. 6	807
Shale, dark gray	. 8	807. 8
Limestone, dark, shaly	6	808. 2
Shale, black, with pyrite	3.10	812
Coal	1.10	813.10
Sandstone, gray, shaly in the lower half	18.10	832. 8
Coal	. 8	833. 4
Sandstone, dark to gray	4. 8	838
Sandstone, dark gray, fine-grained	6	844
Shale, dark, sandy	4. 4	848. 4
Coal	. 4	848. 8
Sandstone, gray, micaceous	5. 8	854. 4
Shale, black	. 6	854.10
Sandstone, dark, fine	1	855.10
Shale, darkgray, sandy with Lingula sp.	11. 2	867
Shale, dark gray	1. 3	868. 3
Sandstone, dark gray, fine-grained	16.9	885
Shale, dark gray	6. 3	891. 3
Coal	3	891. 6
Shale, gray	1	892. 6
Sandstone, fine, gray, conglomeratic near the middle	4. 6	897
Sandstone, gray, micaceous	6	903
Sandstone, gray, banded, fine-grained	18	921
Shale, dark gray, gritty	8	929
Shale, dark gray	7. 2	936. 2
Coal	3. 4	939. 6
Sandstone, shaly, dark, fine-grained	6	945. 6
Sandstone, shaly, or sandy shale	13.6	959
Shale, dark, gritty	1. 6	960. 6
Coal	1	961. 6
Shale, gray	6	967. 6
Coal	3	970. 6

Pennsylvanian series(Cont'd) Pottsville formation	Thickness Feet In	Depth Feet In
Sandstone,gray,micaceous	8. 4	978.10
Shale,black and gray	6. 9	985. 7
Coal	. 3	985.10
Sandstone,dark fine-grained	. 5	986. 3
Shale,black	2. 3	988. 6
Coal	1	989. 6
Shale,black	2	991. 6
Sandstone,gray and dark	8	999. 6
Shale,sandy,black	2. 2	1001. 8
Coal	. 4	1002
Sandstone,gray,fine and coarse-grained	15	1017
Sandstone,gray,fine,shaly	16. 6	1033. 6
Shale,gray,gritty	13. 6	1047
Shale,gray to dark	12	1059
Shale,black	3	1062
Coal	1	1063
Sandstone,gray	1. 8	1064. 8
Shale,dark	. 4	1065
Sandstone,gray,micaceous	11	1076
Sandstone,gray,coarse	25	1101
Sandstone,with bands of sandy clay shale	8	1101. 8
Sandstone,coarase,gray	30.10	1132. 6
Sandstone,coarse,gray,with dark shale partings	3. 3	1135. 9
Sandstone,gray,coarse,conglomeratic	. 3	1136
Shale,dark,dandy	4	1136. 4
Sandstone,gray,coarse,micaceous	1. 3	1137. 7
Shale,black gritty	2	1139. 7
Sandstone,gray,coarse	3. 5	1143
Shale,gray and sandy	1	1144
Sandstone,gray,coarse	6	1150
Sandstone,gray,fine	1	1151
Shale,dark	8	1151. 8
Sandstone,gray to dark,fine	4.10	1156. 6
Shale,dark gray	9. 6	1166
Shale,gray,sandy,thin coal band near bottom	10. 6	1176. 6
Shale,gray	2	1178. 6
Coal	2	1178. 8
Shale,gray,sandy	15. 6	1194. 2
Coal	. 6	1194. 8
Shale,gray,sandy	6	1200. 8
Sandstone,dark,fine	25. 4	1226
Sandstone,banded,light and dark gray,fine	12. 6	1238. 6
Shale,dark gray,fine,sandy	10	1248. 6
Sandstone,conglomerate,dark gray	6	1249
Sandstone,gray,coarse,with shale partings	7	1256
Sandstone,gray with shale partings	5	1261
Sandstone,gray,coarse,micaceous	63. 4	1324. 4
Sandstone,shaly,dark-gray,fine	20. 8	1345
Sandstone,gray	3	1348
Shale,dark,dandy	2. 4	1350. 4

	Thickness Feet. In	Depth Feet. In
Pennsylvanian series(Cont'd)		
Sandstone,gray	10. 4	1360. 8
Shale,dark,sandy	1. 4	1362
Sandstone,coarse,gray	5	1367
Sandstone,gray,with narrow dark bands	4	1371
Sandstone,gray,coarse	2	1373
Shale,dark gray	1	1374
Sandstone,gray,coarse	1	1375
Sandstone,dark,fine,micaceous	6	1381
Sandstone,gray,fine,with Lingula mytiloides	18	1399
Shale,dark,sandy	4	1399. 4
Coal	2	1399. 6
Shale,black	3	1399. 9
Sandstone,gray,fine	8 3	1408
Shale,sandy,gray and black	2	1410
Sandstone,gray,fine	10 .9	1420. 9
Shale,black,sandy	3. 3	1424
Sandstone,gray,medium	20. 6	1444. 6
Shale,dark,gritty	. 8	1445. 2
Sandstone,gray,medium	7. 6	1452. 8
Sandstone,dark,fine	6	1458. 8
Shale,gray,sandy	3	1461. 8
Sandstone,gray,fine	3. 4	1465
Shale,gray	1. 6	1466. 6
Sandstone,gray,fine	14	1480. 6
Shale,black,sandy	8. 6	1489
Sandstone,gray and dark,fine	4	1493
Shale,dark,sandy	9. 6	1504
Shale,dark,sandy	2. 6	1506. 6
Sandstone,gray,medium	20. 6	1527
Sandstone,gray	3. 4	1530. 4
Sandstone,dark,fine,shaly	1. 4	1531. 8
Shale,dark,micaceous	12	1543. 8
Sandstone,gray,fine	1. 4	1545
Shale,dark gray	11	1556
Sandstone,fine,dark,with light bands, shaly near the bottom	29	1585
Sandstone,dark,fine,shaly	44 3	1629. 3
Sandstone,gray	1	1630. 3
Shale,dark,sandy	14. 9	1645
Shale,dark gray,sandy	21. 9	1666. 9
Coal,shaly	3	1669. 9
Shale,black,with coal partings	4. 3	1674
Sandstone,fine,in light and dark bands	21	1695
Shale,dark,gritty	9	1704
Shale,dark,gritty	2. 4	1708. 4
Sandstone,gray,fine	9	1715. 4
Shale,dark	10. 3	1725. 7
Sandstone,dark,fine	8. 5	1734
Sandstone,bluish-gray,fine	8. 6	1742. 6
Sandstone,gray	1	1743. 6
Shale,dark,sandy	1.10	1745. 4
Sandstone,gray to dark,fine	2. 6	1747.10

	Thickness Feet, In	Depth Feet, In
Pennsylvanian series(Cont'd)		
Shale,dark,sandy	4. 2	1752
Sandstone,gray,somewhat conglomeratic	1. 4	1753. 4
Shale,dark,sandy	3. 2	1756. 6
Sandstone,conglomeratic	1. 1	1757. 7
Sandstone,gray,fine	1. 5	1759
Mississippian series:		
Chester Group:		
Limestone,gray,crystalline	3. 3	1762. 3
Limestone,gray,with Productus punctatus, P.cestrensis and Derbya kaskaskiensis	16	1778. 3
Shale,gray	1. 4	1778. 7
Limestone,gray	10	1779. 5
Shale,green and gray	1	1780. 5
Limestone,greenish gray	8	1781. 1
Shale,gray and green	8. 6	1789. 7
Limestone,greenish-gray	1. 6	1791. 1
Limestone,shaly,purple and green	8	1799. 1
Limestone	8	1799. 9
Shale,bluish-gray,with Productus cestrensis	2. 9	1802. 6
Limestone,gray to dark	2	1804. 6
Shale,dark gray	4. 8	1809. 2
Limestone,dark,shaly	5	1814. 2
Shale,dark gray	14.6	1828. 8 — 10 ft. error
Limestone,light gray	6. 4	1835
Shale,dark gray	4	1835. 4
Limestone gray,with Derbya kaskaskiensis; productus cestrensis, and Composita subquatrata	3. 4	1838. 8
Shale,dark gray	16. 6	1855. 2
Limestone,dark gray,shaly	1. 6	1856. 8
Sandstone,gray,shaly,calcareous	5. 4	1862.
Sandstone,dark,fine,irregularly laminated	11. 4	1873. 4
Shale,dark,gritty	4. 2	1877. 6
Limestone,with Derba kaskaskiensis, and Spriferina spinosa	1	1878. 6
Shale,black,with Derbya kaskaskiensis, and productus pileiformis	6	1879
Limestone,dark	1	1880
Shale,dark,calcareous	2	1882
Limestone,gray,crystalline,with Derba kaskaskiensis,Spirifer leidyi, and Composita subquadrata	9	1891
Limestone,gray,with Productus pileiformis, and Reticularia sp.	14 4	1905. 4
Limestone,bluish,shaly below,with Derbya kaskaskiensis, and Spirifer leidyi	2	1907. 4

Mississippian series (Cont'd)	Thickness Feet In.	Depth Feet In.
Shale, green, red and purple	2	1909. 4
Shale, dark gray, gritty	1. 8	1911
Shale, dark to bluish-gray	2	1913
Sandstone, gray	10. 8	1923. 8
Shale, dark	14. 6	1938. 2
Limestone, dark, shaly	3. 6	1941. 8
Sandstone, gray	8. 4	1950
Shale, dark, gritty	2. 6	1952. 6
Limestone, dark, shaly	2. 3	1954. 9
Shale, dark	2. 6	1957. 3
Limestone, dark, shaly	1. 4	1958. 7
Shale, dark, calcareous	9.10	1968. 5
Sandstone, gray to dark, shaly	7. 9	1976. 2
Sandstone, gray	12.10	1989
Shale, dark, fine	18	2007
Limestone, dark, shaly	4	2011
Shale, dark	4	2011. 4
Limestone, gray	2. 6	2013.10
Shale, dark	2	2014
Limestone, grey to dark	3. 9	2019. 9
Shale, greenish-gray to dark	3. 3	2021
Sandstone, gray, medium	4. 4	2025. 4
Shale, dark, sandy	2. 6	2027.10
Limestone, dark, shaly	3.10	2031.8
Shale, dark	9. 4	2041
Shale, like the last	3. 2	2044; 2
Sandstone, gray	3. 8	2047.10
Shale, dark	2. 6	2050. 4
Sandstone, dark to gray, shaly	3	2053. 4
Sandstone, gray, medium	10	2063. 4
Sandstone, gray, with dark shale laminae	13. 8	2077
Sandstone, gray, coarse	27	2104
Sandstone, gray, and dark shale	1. 2	2105. 2
Sandstone, gray	5	2110. 2
Sandstone, dark	1	2111. 2
Sandstone, gray	13	2124. 2
Sandstone, gray, with dark spots	6.10	2131
Sandstone, gray, coarse	18	2149
Shale, dark gray, calcareous	2. 8	2151. 8
Limestone, dark gray	2. 4	2154
Shale, dark, calcareous	4. 6	2158. 6
Limestone, gray	3. 6	2162
Limestone, gray to dark, shaly	3. 6	2165. 6
Shale, dark, fine	5	2170. 6
Limestone, gray to dark, with shale partings	21 6	2192
Limestone, gray, shaly, with Spirifer increbescens	1. 4	2193. 4
Limestone, gray	11. 8	2205
Shale, dark, fine	9. 9	2214. 9
Limestone, gray	2	2216. 9
Shale, dark, calcareous	1	2218. 9
Limestone, dark, shaly	2	2219. 9
Shale, gray	2	2221. 9
Shale, dark to black	10. 1	2231. 10
Limestone, yellowish-gray, leached	2	2232

Ordovician system

In the record of the deep drilling in Clark County the lower 817 feet of strata are thought to belong to the Ordovician system, the lowermost 377 feet representing the Prairie du Chêen limestone, the succeeding 70 feet corresponding to the St. Peter sandstone, and the next higher 370 feet thought to be the equivalent of the Trenton limestone of Indiana. No rocks resembling the Richmond strata in Indiana or the Maquoketa of Illinois appear at the proper horizon in this record, and it is thought that no strata corresponding in age to the Richmond or Maquoketa were deposited over the La Salle anticline in this region. The deep Jones well near Robinson however shows the presence of 272 feet of shaly beds in the proper position of the Maquoketa which undoubtedly underlies the whole area of these quadrangles. The absence of this shale to the north may indicate the position of a portion of the barrier which separated the Illinois from the Indiana basin during Richmond time.

Silurian System

The Silurian beds which underlie the Hardinville, Birds, Sumner and Vincennes quadrangles consist of limestones and dolomites and probably represent both the Alexandrian and Niagaran series which are extensively exposed in Indiana and northern Illinois.

Devonian System

The grey limestone overlying Silurian dolomites is thought to represent the middle Devonian (Onondaga and Hamilton) limestone of the New York section. These, in western Indiana, comprise the Sellersburg and Jeffersonville limestones having a thickness of about 145 feet, whereas in southwestern Illinois they have a combined thickness of

250 feet.

Above this limestone occurs 90 feet of black shale of Upper Devonian age containing numerous spores of Sporangites huronense. This shale is widely distributed in northern and central Illinois and corresponds to the Sweetland Creek shale of eastern Iowa.

Mississippian System

In the deep boring in Clark County the Mississippian strata are 1000 feet thick but in the deep drilling near Robinson these rocks are 1740 feet in thickness. The increase in thickness towards the south is due largely to the absence in Clark County of the Chester strata, which near Robinson are 550 feet thick. Most of the deeper drillings in the Hardinville and Birds quadrangle penetrate the Mississippian rocks for about 475 feet, and stop in the Ste. Genevieve limestone; a few go deeper into the Meramec and Osage groups.

Kinderhook formation

The upper Devonian shale is succeeded by a considerable thickness of gray shale and shaly limestone with some sandstone which comprise the Kinderhook formation, the lowest member of the Mississippian series.

Osage group

The rocks of the Osage group overlie the Kinderhook, and are dominantly limestones which in the western and southern parts of the State can be readily separated by their fossils into the coarsely crinoidal, cherty, Burlington limestone below, and the impure, shaly Keokuk limestone above; but in the logs of drillings in this region, or from the study of samples of borings, it is not possible to determine the line of division between these formations. The combined thickness of the Osage group and the Kinderhook formation in this region is about 680 feet.

Meramec group.

The Osage limestone is succeeded by the Meramec group of which the Salem, St. Louis and Ste. Genevieve limestones are represented. The former is distinguished in the rock samples by being partially oolitic, and in places very fossiliferous, shells of Endothyra baileyi being common. The St. Louis is a hard, gray or blue, often fine-grained and cherty limestone, having a thickness of about 200 feet. In the well records the top of the St. Louis can not be definitely separated from the overlying Ste. Genevieve limestones, although a sedimentary break occurred between them.

The Ste. Genevieve limestone, overlying the St. Louis, is conspicuously a soft white oolite with the grains large and well defined, and with occasional layers of calcareous shale and small amounts of flint or chert. In this oolite is a recurrence of types of fossils which were abundant in the Salem limestone but absent in the St. Louis.

The contact of the Ste. Genevieve limestone with the overlying Chester rocks is well defined by an erosional unconformity and a marked difference in the lithology, but the lower portion of the Ste. Genevieve limestone merges so gradually into the St. Louis limestone that in most cases the latter can be distinguished only by the absence of oolite, difference in hardness and of color. The Ste. Genevieve is conspicuously cross-bedded along its area of outcrop in Western Illinois, where its maximum thickness is 100 feet, but with an average of about 80 feet. Its average thickness in the Hardinville and Birds quadrangles is about 85 feet, and its depth varies from 1550 to 1700 feet.

McClosky sand. - The McClosky sand or oil-producing portion of

the Ste. Genevieve limestone is confined to the upper 20 to 50 feet of the formation. It is so named because oil was first tapped from that horizon on the McClosky farm five miles south of Lawrenceville SW¼ sec. 25, T. 3N., R. 12W. . In some cases the term "sand" is a misnomer, as the producing zone is in some places an oolitic limestone, the oolite grains having been mistaken for grains of coarse quartz sand.

The McClosky sand is the most prolific oil horizon in the Sumner and Vincennes quadrangles, and elsewhere in Illinois, because of its exceptionally large initial flow and its steady yield. The oil is concentrated in a very thin zone. In its type area in the Vincennes quadrangle the average thickness of the zone is 9 feet with a range of 1 to 35 feet. A few wells in the northern part of the Sumner area show the producing zone to average twelve feet with a range of three to twenty-five feet. The many gushers from this sand have largely upheld the Illinois production when the yield from other sands was declining.

Chester Series

The Chester series is composed of a sequence of sandstones, shales and limestones. Studies in those parts of Illinois when these beds outcrop have shown that the sandstones are very persistent and by means of them the series is readily divided into a number of alternately sandstone and shaly limestone formations. The complete section of the Chester as developed in southern Illinois is about 1000 feet thick and is divided into the following formations:

Kinkaid limestone	Glen Dean limestone
Degonia sandstone	Hardinburg sandstone
Clore limestone	Golconda limestone
Palestine sandstone	Cypress sandstone
Menard limestone	Paint Creek limestone
Waltersburg sandstone	Bethel sandstone
Vienna limestone	Renault limestone
Tar Springs sandstone	Aux Vases sandstone

The thickness of the Chester strata beneath these quadrangles varies considerable. In the Hardinville and Birds quadrangles the minimum and maximum limits are about 300 and 465 feet respectively being thinnest along the north boundary of the deep oil field and thickest along the west flank of the La Salle anticline, while the average thickness in the oil wells which completely penetrate these beds is about 365 feet.

The gradual thicknening of Chester strata continues in a southward direction in the northern part of Sumner and Vincennes quadrangles but in the southern part of Lawrence County, thickening of these beds becomes very rapid and in the Allendale region of

(Log p 12 shows 560' Chester 6112)

northeastern Wabash County the complete Chester section is probably present.

The variation in the thickness of the Chester from place to place in this part of Illinois is the direct result of folding and erosion which occurred during the interval of time which elapsed between the deposition of the last of the Mississippian and the first of the Pennsylvanian sediments. At this time folding occurred along the axis of the La Salle anticline which raised most of Lawrence County and the area to the north in a broad gentle arch above the surrounding territory. This uplifted area was apparently bounded in southern Lawrence County by a comparatively steep southward dipping monocline. Erosion was active upon this uplifted area and the uppermost beds were worn away until the whole region was probably reduced to a nearly level plain upon which Pennsylvanian sediments were later deposited. Thus in Wabash County which was not uplifted no erosion occurred and the whole Chester section is still preserved while in Lawrence County the upper half to two-thirds of this series was removed. Farther north all of the Chester beds were eroded away together with considerable thicknesses of underlying strata.

Although the Chester series is composed of a number of distinct formations of varying lithologic character no attempt will be made here to discuss them under the headings of the various formations which occur beneath these quadrangles because adequate information is not available. The lithological phases of this series which have been commonly reported in the drilling records of the region will however be described in as much detail as seems advisable and tentative correlations with the general Chester section will be noted.

Tracy Sand.- The Tracy sand is the lowest oil producing member of the Chester series and is correlated with the Aux Vases sandstone of the general Chester section. It is generally a soft highly calcareous sandstone and in many cases is separated from the Ste. Genevieve limestone by a bed of shale. Two limestones and two shale beds which are referred to the Renault formation commonly separate this sand from the next overlying sand. This second sand is water bearing and is probably the equivalent of the Bethal sandstone of the Chester section. Above this in turn occur shales and limestones of the Paint Creek formation.

Kirkwood Sand.- The Kirkwood sand occurs near the middle of the Chester strata as present in Lawrence County and is the most wide spread oil producing horizon of the region. It is correlated with the Cypress sandstone. In some portions of the quadrangles the Kirkwood sand is divided into two and sometimes three lenses of which the upper one is composed largely of white to gray sand, in medium sized grains, and is the thickest and most regular. The lower lenses are separated from the upper one by a bed of shale.

This sandstone is overlain by thin limestones and much shale which are referred to the Golconda formation. A red shale commonly occurs immediately above the Kirkwood sand and serves as an excellent horizon marker.

"Gas" Sand.- The "Gas" sand is usually the first regular sand encountered in the Chester beds of Lawrence County. It occurs on an average of about 75 feet above the Kirkwood sand, is composed of white sand grains of medium size loosely cemented together and probably represents the Hardinsburg sandstone of the

general Chester section. It is overlain in the Lawrence County oil fields by from 75 to 225 feet of strata referred to higher formations in the Chester.

Red Shales.- The red shales of the Chester group are conspicuous horizon markers over all southern Illinois; The drillers use them in their interpretation because they tend to discolor the bailing water and thus indicate their presence. Most of the detailed records in Lawrence County show at least three red shale horizons in the Chester. The upper one lies about 50 feet below the uppermost limestone of the Chester, the second occurs immediately above the Kirkwood sand and is the key to that important member, and the third lies between the Kirkwood and the Tracey sands.

Biehl and Jordan Sands.- The Biehl and Jordan sands of the Allendale pool in northeastern Wabash County occur much higher in the Chester section than any of the producing horizons in Lawrence County when they are absent having been removed by pre-Pennsylvanian erásion. These two sands are lenticular phases of the same sandstone formation near the top of the Chester and are tentatively correlated with the Degonia sandstone. The succession of Chester beds beneath this sandstone is not well known in Wabash County but careful records of deeper drilling will probably show the presence of equivalents of the various producing sands of Lawrence County at some greater depth.

Pennsylvanian System

The Pennsylvanian rocks are completely penetrated by many of the deep oil borings in the quadrangles. This system includes all of the beds which occur in this region between the unconsolidated glacial till and the top of the Chester series of the Mississippian system. These beds vary in thickness between about 800 and 1600

feet being thinnest along the axis of the La Salle anticline in the northern part of the area. To the south and west the Pennsylvanian beds become much thicker, 1747 feet being represented in the Diamond drill core in White County.

Pennsylvanian Series

Pottsville formation

General Characteristics.- The Pottsville formation includes the lower strata of the Pennsylvanian rocks, and is composed chiefly of massive sandstones merging into sandy shales in the upper part and often containing beds of shale and occasional thin seams of coal. The formation rests unconformably upon the Mississippian rocks and embraces all the strata from the base of the Pennsylvanian up to the bottom of the Murphysboro (No.2) coal seam. There is much irregularity in the thickness of this formation, due largely to the uneven surface upon which it was laid down.

Most of the oil wells in the northern portion of the Hardinville and Birds quadrangles penetrate the Pottsville only 50 to 150 feet. The formation in this part of the area is from 290 to about 600 feet thick, the average being 395 feet. It appears to be thinnest in the eastern part on the crest of the La Salle fold, and thickest along the west border of the Hardinville quadrangle.

The average thickness of the Pottsville in the Sumner quadrangle is 488 feet, with a range of 290 to 708 feet, the greatest thickness being towards the southwest part of the area. The average thickness in the Vincennes quadrangle is 552 feet, with a range of 308 to 685 feet. These strata are thickest in the south part of the quadrangles, where more than 700 feet of Pottsville strata have been

found. Farther south the core of the deep diamond drilling in White County shows a thickness of 787 feet of Pottsville rocks.

Owing to the inability to distinguish the Murphysboro coal in some of the churn drillings, the top of the Pottsville formation is assumed to begin with the first massive sandstone member beneath the important coals, although some of the overlying shales may belong to this formation. The formation is assumed to extend downward to the first prominent limestone, although some sandstone or shale, older than the Pottsville, may in places overlie the uppermost Mississippian limestone. It is recognized that the limits of the Pottsville are thus somewhat arbitrarily assigned, but these assumed limiting horizons are recognizable in the drillings, and they are certainly not far from correct.

In the development of the oil fields, the Pottsville formation in this region was brought into prominence by the finding of oil in the upper portion where the sand beds are lenticular, and in the basal part where the sandstone is more massive and persistent.

Buchanan Oil Sand.- The basal oil-bearing member of the Pottsville formation was named the Buchanan sand in 1906, from the R. O. Buchanan farm in the SE 1/4, Sec. 16, T. 3 N., R. 12 W., on which oil was first tapped from that horizon. The type area for the sand is in sections 15,16,17,20,21,and 22, T. 3 N., R. 12 W. Data of its distribution are very scattered over the rest of the field. The upper portion of the sand is coarse-grained to conglomeratic, and the basal part is, as a rule, fine and soft, with a considerable amount of siderite.

In this region the Buchanan sand varies from 1236 to 1640

feet in depth, and has an average thickness of 35 feet, with a maximum of 125 feet in the type area. The average thickness in the Vincennes quadrangle is 62 feet, with a range of 10 to 292 feet. In the producing area of the latter quadrangle, the thickness narrows to 31 feet with a maximum of 120 feet. The average interval between the top of the Buchanan sand and the top of the Kirkwood sand, in the Sumner quadrangle, is 238 feet, with a range of 157 to 313 feet, while in the Vincennes quadrangle the average interval in 302 wells is 254 feet, with a range of 102 to 369 feet.

Robinson-Bridgeport Sands.- The upper sandstone lenses of the Pottsville rocks are called the Robinson sands in the Crawford County portion and the Bridgeport sands in the Lawrence County division of the quadrangles; both are named from towns adjacent to the productive areas. In most places the oil-bearing zone which includes the Robinson-Bridgeport sands consist of three widely distributed lenses with other occasional divisions. The more persistent lenses of the Robinson sand are separated by an average distance of about 50 feet and have a combined thickness from 2 to 50 feet. However, the lenses often merge into each other vertically and in some wells are united into a single bed having a maximum thickness of 122 feet. In other places the lenses pinch out laterally, and in several wells are entirely absent, their horizons being occupied by shale. In the upper and middle parts, the Robinson-Bridgeport sand is a coarse-grained, brown, micaceous sandstone, containing at many places thin lentils of bituminous shale; but the basal lenses are white and somewhat conglomeratic.

The position of the upper lens of the Bridgeport sand varies in depth between 600 and 1,000 feet, the difference being due in

part to the dip of the strata. It is difficult to average the thickness of the lenses of the Bridgeport sand or of the distances between them, because of their great variability. Along the south line of the Hardinville quadrangle the average thickness is 35 feet. Many of the records indicate that the lower lenses of the Robinson-Bridgeport sand merge into the massive sandstones that comprise the basal part of the Pottsville formation.

The upper lens of the Robinson sand is generally irregular over most of the Crawford County portion of the quadrangle. Marked irregularity of deposition took place near the northern part of the area, as indicated by the absence of the upper lens as well as of those at greater depths.

Carbondale Formation

General Characteristics.- The Carbondale formation includes all the rocks between the top of the Herrin (No.6) coal and the base of the Murphysboro (No.2) seam. The name is taken from the town of Carbondale in Jackson County where there are good exposures of these rocks. In these quadrangles the rocks of this formation average 250 feet thick with a range from 200 to 500 feet. The dominant material of the formation is shale with much micaceous sandstone in the basal portion. The most important beds of this division are the Murphysboro coal at the base, the Herrin coal at the top, and the Harrisburg (No.5) coal generally lying 40 to 60 or more feet below the Herrin coal. These coals are widely distributed over the State, but they cannot everywhere be distinguished with certainty in the numerous records of churn drillings in the quadrangles.

Between the different coal beds of this formation the well

records show a surprisingly similar succession of strata, consisting of a thin limestone above the coal followed by a rather thick bed of dark and gray shale, which passes upward into a thinner bed of gray micaceous sandstone underlying the underclay of the next higher coal bed. Most of the borings were made by churn drills and, since the logs are taken from the drillers records or compiled from the study of rock samples, the thickness of the different coals could not be definitely determined.

Murphysboro coal and associated beds.- The Murphysboro coal in this region as in the southwest part of the State, appears in most places to be divided into two benches which are separated by 12 to 35 feet of gray and black shale. The coal thought to represent this bed is usually noted in the detailed logs of borings but being churn drillings they do not accurately record the thickness of the benches.

Strata between the Murphysboro and Harrisburg Coals.- Above the upper bench of the Murphysboro coal there usually occur 50 to 70 feet of gray, micaceous sandstone, which corresponds in position to the Vergennes sandstone member in the southwestern part of the State. A few feet of shale intervene between this sandstone and a thin coal that is often found about 150 feet below the Herrin bed. The latter coal is succeeded by another bed of dark and gray shale 25 to 40 feet thick, which is sandy and micaceous in the upper part, where it grades into a gray, micaceous sandstone lying below a few feet of underclay of the coal thought to represent the Harrisburg bed.

Harrisburg (No.5) coal.- The coal correlated with the Springfield or Harrisburg seam in this region lies about 40 to

80 feet below the Herrin bed, the distance between these coals being somewhat less than in the vicinity of Harrisburg, Saline County, where the interval is about 100 feet. This coal is correlated with the Springfield (No.5) coal of western and southwestern Illinois, which in those areas lies 40 to 65 feet below the Herrin bed. Over an extensive area in southern and southwestern Illinois the thickness of this coal is remarkably uniform, rarely varying more than a few inches from 4 1/2 feet. In the core of the diamond drilling in White County this coal measured 4 feet thick. In the Sumner and Vincennes quadrangles the thickness is probably about the same as farther south, but it cannot be accurately determined in the churn drill records.

Strata Between Harrisburg and Herrin Coals.- The Harrisburg coal is overlain by a few feet of black laminated shale which is succeeded by a thin limestone that in the rock samples showed numerous fragments of fossils. Above the limestone occur 30 feet or more of mostly dark shale, followed by a few feet of sandstone, above which, in a number of records, a thin coal is reported lying 15 to 35 feet below the Herrin coal. Above the horizon of the thin coal is usually a thin limestone overlain by several feet of gray and dark shale which is separated from the thin underclay of the Herrin coal by a few feet of gray micaceous sandstone.

Shallow Oil Sand.- The Shallow oil sand is so named because of its shallow depth. Its exploitation is chiefly confined to a small area near the extreme south end of the mail oil field. It usually occurs at a depth of 450 to 550 feet in this region, where it has an average thickness of about 21 feet, with a range of 7 to 48 feet. This sand is thought to correspond strati-graphically

to the sandstone frequently found below the underclay of the Herrin coal.

Herrin (No.6) Coal.- The position of the Herrin coal in the logs of drillings in this region was determined by the shells of Girtyina ventricosa in the samples of the limestone above this bed. Over the area of outcrop of this coal and associated beds in western and southern Illinois this species of Girtyina is always present in the limestone above the Herrin coal and has not been found in such abundance at any other horizon in the State. Consequently, this fossil is considered a good guide to the limestone above the Herrin coal and furnishes a reliable means of correlating this coal bed in different parts of the State. These wells could not be determined from the churn-drill samples, or from the records kept by the drillers.

McLeansboro Formation

The McLeansboro formation includes the strata in this region from the top of bed rock underlying the glacial drift downward to the top of the Herrin coal. The name is from the town of McLeansboro, Hamilton County, where these rocks are known to have a thickness of more than 1,000 feet. The average thickness in the wells in the Hardinville and Birds quadrangles in which the position of the Herrin coal could be certainly determined is about 513 feet while in the Summer Vincennes quadrangles it ranges from 325 to 590 feet. It is not possible to certainly distinguish the top of the Herrin coal or the base of the McLeansboro formation in many of the drillers logs in this region, but this horizon was determined in the wells from which samples of drillings contained shells of Girtyina ventricosa in limestone fragments immediately above the coal bed.

The rocks of the McLeansboro formation consist chiefly of shales and sandstones, or more commonly sandy shales and shaly sandstones, a few widely separated beds of limestone, and thin coal seams. The most conspicuous and easily distinguished member of the formation is the limestone at the base of this formation, immediately above the Herrin coal or more often separated from it by a few inches of dark shale. This is a hard, commonly dark limestone containing numerous shells of Girtyina ventricosa. This easily recognized fossil is not known to occur in such abundance at any other horizon in the State and hence is a reliable marker of this limestone and makes it the key stratum to the underlying Herrin coal.

A number of thin coals occur at different levels in the McLeansboro formation, but none is sufficiently thick to be of commercial importance, and the most of them are probably not continuous over extensive areas. The lowest coal occurs 45 to 60 feet above the Herrin seam, and others are found 50 to 60 feet or 100 to 120 feet, 155 to 185 feet, 240 to 260 feet, and 312 to 335 feet above the Herrin bed; in a few of the records another coal is reported 375 to 395 feet above the Herrin coal. Besides the coals mentioned above, one or more others are frequently noted at different levels in the records of drillings and are probably of local development/

The succession of strata between any two adjacent coal seams is generally quite similar, consisting at the base of a thin, impure, shaly limestone followed by shale which commonly occupies a little more than half the interval and which graded upward into sandstone followed by the underclay of the next coal. The shales

are often sandy and may pass laterally into sandstones, and the sandstones into shales, within short distances.

In a number of the records, a red shale is reported 150 to 200 feet above the base of the McLeansboro, and a bed of sandstone 40 to 60 feet thick often occurs 20 to 30 feet higher in the section. Two or three thinner sandstones separated from one another by thicker beds of shale are usually found in the upper 200 feet of the formation and a limestone 6 to 12 or more feet thick is rather persistent about 365 feet above the base of the McLeansboro formation.

IV Stratigraphy: Rocks Exposed

Outcrops of strata all belonging to the middle part of the McLeansboro formation of the Pennsylvanian system are rather restricted due to the heavy blanket of overlying glacial till. The exposures throughout this area probably represent a thickness of about 390 feet of beds. A generalized section of the rocks exposed in the Hardinville and Birds, Sumner and Vincennes quadrangles is given below:

Generalized section of Pennsylvanian rocks exposed in the Hardinville and Birds, Sumner and Vincennes quadrangles	Feet	Inches
Sandstone, gray to yellowish brown	15	
Shale, gray sandy	26	
Sandstone, coarse, brown micaceous	13	
Shale, olive brown to chocola te	10	
Shale, gray to black	9	
Limestone, gray hard with rough surfaces	2	6
Shale, bluish gray plastic	6	
Sandstone, laminated	11	
Shale, sandy	12	
Limestone, fossiliferous	2	
Coal (Aldrich seam)	1	4 2
Shale, gray, sandy	13	
Sandstone, gray to brown, hard	12	
Shale, bluish sandy	12- 30	
Sandstone, massive coarse grained	10- 28	
Shale, gray with many iron concretions	0 -10	
Sandstone, thin bedded shaly	7	
Shale, dark to gray	6 -10	
Coal (Friendsville seam)	0- 3	6
Shale, clayey	2- 4	
Shale, bluish gray with iron concretions	0 - 9	
Sandstone, thinbedded	0 - 3	
Sandstone, massive coarse grained micaceous in places conglomeratic at base	18- 35	
Shale, dark or bluish gray sandy	0- 18	
Limestone, coarse grained shaly fossiliferous	4	3
Shale, calcareous		4
Shale, Barken stage	1	
Shale, bluish gray sandy with many small iron concretions	2	
Sandstone, gray thin bedded micaceous	17	
Shale, black to gray	18-24	
Shale, black to dark bluish gray, somewhat laminated containing numerous shells of Ambocoelia planeconvexa and many gastropods	4	

	Feet	Inches
Lenticular limestone, dark shaly fossiliferous	0-2	
Coal local		4
Shale, gray clayey		6
Sandstone, local thin bedded	0-4	
Shale, gray locally sandy	7	
Shale, dark to bluish gray laminated in lower part with few iron concretions	20	
Coal	1	10
Shale, dark to bluish gray, laminated	3	6

Strata below the Parker coal.- The oldest strata outcropping in the area belong to an horizon about 375 feet above the Herrin coal or the base of the McLeansboro formation. They are exposed in the south bank of No Business Creek near the southwest corner of sec. 20, T. 6 N., R. 10 W., and for several rods farther up the stream from this place. These rocks consist mostly of shale containing a coal seam on the lower part, as shown in the following section:

Section of strata exposed in the south bank of No Business Creek, in Section 20

	Feet	Inches	
1. Shale, dark to blue	3	6	Section copied upside down? 4 should be at top
2. Coal	1	10	
3. Shale, dark to blue, laminated in the lower part, with occasional iron concretions	20	4	
4. Shale, sandy, bluish gray, with hard bands cemented with iron oxide	1	6	

The altitude of the coal at this place is about 445 feet. The rocks show small irregularities in dip, but the general slope is toward the south. During low water strata corresponding to those in the above section are exposed in the west bank of Wabash River, in Sec. 7, T. 6 N., R. 10 W. The coal in this vicinity has been worked by shafts for local use in a few places near the south side of Sec. 1, T. 6 N., R. 11 W., at a depth of 30 to 35 feet. Shale corresponding to some part of member No.3 of the above section is exposed near the Cannon School in the east half of Sec. 6, T. 5 N., R. 10 W., to a thickness of 9 feet. Strata belonging above

those described in the last section outcrop in the bed and banks of a ravine two and one-half miles southeast of Palestine, in the NW. 1/4 sec. 7, T. 6 N., R. 10 W., where the following section was made.

Section of rocks exposed in the NW. 1/4 Sec. 7, T. 6 N., R. 10 W.

		Feet	Inches
12	Sandstone, yellowish gray in thin layers	5	
11	Shale, gray, sandy, thin bedded	12	
10	Shale, dark	8	
9	Shale, blue, with many nodules of iorn	6	
8	Shale, calcareous, bluish gray, with many gastropod shells	2	
7.	Shale, calcareous, blue, with many shells of Ambocoelia planiconvexa, and other fossils	1	6
6	Shale, black, laminated, hard	1	
5	Limestone, lentil, in a single layer		6
4	Coal		4
3	Shale, gray, clayey	5	6
2	Sandstone, thin bedded	4	
1	Shale, gray, sandy	7	

The altitude of the limestone layer, No.5 of the above section, is about 449 feet above sea level. The calcareous shale members 7 and 8 of the section contain numerous fossils which are listed in the table on a later page.

Strata corresponding to the calcareous and fossiliferous shale members of the last section, together with strata belonging to higher horizons, are exposed along the east bank of Lamotte Creek in the Sw. 1/4 sec. 2, T. 6 N., R. 11 W. The section given below was made along this creek one-half mile to one mile south of Palestine.

Section of Strata exposed 1/2 mile to 1 mile south of Palestine

		Feet	Inches
9	Limestone, gray, shaly, coarse grained, fossiliferous	4	
8	Coal (Parker bed)	1	
7	Shale, clayey, gray	6	
6	Shale, clayey, with many ironstone nodules	3	
5	Sandstone, gray to yellow, thin bedded	14	
4	Shale, gray to blue	17	
3	Shale, bluish gray, calcareous, with many gastropod shells	2	

	Feet	Inches
2 Shale, blue, calcareous, with many shells of Amboccelia planoconvexa, and other fossils	1	6
1 Shale, black, laminated	1	

Some part of the shale and sandstone members, No. 4 and No. 5 of the above section, are exposed almost continuously in the east bank of this creek for a distance of nearly one mile. Strata equivalent to some part of those described in the last section are exposed in the bluff of Wabash River a short distance west of the middle of the south side of Sec. 8, T. 5 N., R. 10 W., but the limestone lentil and underlying coal are absent. The succession of strata at this place is as follows:

Section of Strata exposed near the Middle of the south side of Sec. 8.

	Feet
Shale, dark to blue	15
Shale, dark, with impure calcareous bands containing numerous shells of Amboccelia planiconvexa, and other fossils	5
Sandstone	12
Shale, sandy, bluish	10

Th

Section of strata exposed near the middle of the south side of sec. 8

	Feet
Shale, dark to blue	15
Shale, dark, with impure calcareous bands containingnumerous shells of Amboccelia planiconvexa, and other fossils	5
Sandstone	12
Shale, sandy, bluish	10

The altitude of the calcareous shale zone at this place is about 447 feet.

Rocks corresponding to those outcropping one-half mile south of Palestine are well exposed in the east bank of Brushy Creek, 2 1/2 miles south of Flat Rock. The succession of strata at this place is as follows:

Section of strata exposed 2 1/2 miles south of Flat Rock

		Feet
6	Sandstone, thin bedded, gray to yellow, micaceous	8
5	Shale, gray to blue	18
4	Shale, calcareous, bluish gray, with many gastropod shells	4
3	Shale, blue, calcareous, with many shells of Amboccelia planiconvexa and other fossils	2
2	Limestone, lenticular, in a single layer	1 - 1 1/4
1	Shale, bluish, sandy	5

The altitude of the limestone layer, No. 2 of the above section, is about 445 feet. Three and one-half miles west of the last exposure the limestone horizon and overlying shale outcrop in thebanks of a stream in the NW 1/4 of sec. 22, T. 5 N., R.12 W. The strata here dip towards the northwest and the elevation of the base of the limestone is about 486 feet, or about 40 feet higher than the level of the corresponding horizon 2 1/2 miles south of Flat Rock. The succession of strata at this place is shown below.

Section of Strata exposed in NW. 1/4 Sec. 22, T. 5 N., R. 12 W.

	Feet	
Sandstone, gray to yellow, micaceous	3	
Shale, dark, with numerous small iron concretions, and containing Ambocoelia planiconvexa and other fossils in lower part	24	
Limestone, lentil in a single layer	3	6

Strata corresponding to those outcropping 2 1/2 miles south of Flat Rock are again well exposed in the east bank of Embarrass River one mile east of Lawrenceville.

Section of rocks exposed in the east bank of Embarrass River one mile east of Lawrenceville.

5.	Sandstone, yellowish-brown, micaceous, in thick and thin layers	9
4.	Shale, black and gray	24
3.	Shale, black somewhat laminated, containing shells of Ambocoelia planiconvexa in abundance, and other fossils	4
2.	Limestone, lentil, in a single layer, fossiliferous	1-2
1.	Shale, bluish-gray to black	18

At this place the strata dip towards the north at the rate of about 18 feet in a distance of 20 rods, in which direction the lower strata soon disappear beneath the bed of the river. The altitude of the fossiliferous bed at this place is about 425 feet. Strata corresponding to those in the lower part of the foregoing section are well exposed at a number of places along tht east side of the island-like area of Pennsylvanian strata 1 to 2 miles northwest of Vincennes, near the east side of sec. 9, T. 3 N., R. 10 W., where the limestone lentil outcrops at an elevation of about 426 feet. Corresponding strata also outcrop in the north side of the hill one mile south of Vincennes, in the SE. 1/4, sec. 29, T. 4 N., R. 10 W., at about the same altitude. Rocks equivalent to the middle and upper parts

of the above section are exposed during low water in the south bank of Embarrass River west of the wagon bridge in the north part of Lawrenceville where the fossiliferous horizon lies at an altitude of about 423 feet.

Strata thought to represent the fossiliferous portion of the sections above mentioned outcrop 22 miles west of Lawrenceville, in the west bank of a stream 2 1/2 miles south of Olney at an elevation of about 450 feet.

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Fossils from the limestone and fossiliferous shale below the Parker coal:

	East bank of Embarrass River 1 mi. E. of Lawrenceville	E Mound 1 mi. NW of Vincennes	SE¼ sec. 29, T. 3 N. R 10 N.	River bank in N part of Lawrenceville	2½ mi. S. of Olney
Ammodiscus sp.	X			X	
Lophophyllum profundum	X	X	X	X	X
Zeacrinus cf. acanthoporus	X			X	
Fistulipora nodulifera	?			X	
Polypora distincta	?			X	
Cf. Acanthocladia fruticosa	?			X	
Orbiculoidea missouriensis			X		
Lingula sp.	X		X		
Derbya crassa	X			X	X
Chonetes glaber	?	X			X
Chonetes vernequilianus	X	X		X	X
Chonetes variolatus	X				
Productus cora	X	X			X
Productus costatus					X
Marginifera splendens?	X	X		X	X
Pugnax rocky montana	X		X		
Pugnax utah		X			X
Cryptacanthia compacta	X				
Spirifer cameratus	X	X	X	X	X
Spiriferina kentucky ensis	X			X	
Amboccelia planiconvexa	X	X	X	X	X
Hustedia mormoni	X				X
Composita argentea	X	X	X	X	X
Clinopistha radiata var. laevis	X				
Edmondia aspenwallensis	X				
Nucula parva	X				X
Nuculo ventricosa					X
Macrodon tenuistraiata	X				
Pseudomonotis radiatus?	X				
Aviculopecten occidentalis	X				
Aviculopecten cf. fasciculatus	X				
Aviculopecten neglectus	X				
Entolium aviculatum	X				
Lima retifera	X				
Astartella vera	X	X	X	X	X
Astartella varica	X				
Pleurophorus occidentalis	X				
Pleurotomaria brazoensis					X
Phanerotrema grayvillensis	X	X	X	X	X
Trepospira Sphaerulata	X	X	X	X	X
Bellerophon percarinatus				X	X
Euphemus carbonarius	X	X	X	X	X
Petallostium montfortianum	X	X	X	X	X
Worthenia tabulata	X			X	X
Schizostoma catilloides	X		X	X	
Platyceras parvus	X		X		
Orthonema conica	X		X		
Meekospira peracuta	X		X	X	
Bulimorpha nitidula			X	X	
Soleniscus brevis	X		X	X	
Sphaerodoma primogenia			X	X	
Orthoceras rushense	X	X X	X	X	
Meloceras sp.				X	

Strata Between the Parker and Friendsville Coals

The thin bedded sandstone overlying the shale in the exposures previously described outcrops in the east side of the hill in the NE. 1/4 sec. 32, T. 3 N., R. 10 W., and also on the north end of the hill one and one-fourth miles farther southwest.

Sandstone belonging to the same horizon, and strata belonging to higher levels are exposed about 5 miles farther west, in the north end of the hill northeast of Billett where the following section was made.

Section of rocks exposed in the hill one mile northeast of Billett:

4	Till, borwn, pebbly	4
3	Limestone, hard, fossiliferous	1
2	Sandstone, yellowish-gray, shaly micaceous	2
1	Sandstone, laminated micaceous, in fine and coarse grains	19

In the place where the last section was made the Parker coal is absent; the horizon of this coal is immediately below the limestone, No.3 of the last section, the altitude of which is about 443 feet. Where the Parker coal is present it is usually about 1 foot thick. It is more frequently absent in the Vincennes area than in the Birds Quadrangle farther north and is generally separated from the overlying limestone by a few inches of calcareous shale.

Strata equivalent to a part of those above described outcrop in the south bank of Raccoon creek and along a tributary to this stream in the SE. 1/4, sec. 26, T. 2 N., R. 12 W., where the following succession is exposed:

Section of Strata Exposed in Bank of Raccoon Creek in Section 26

6	Sandstone, gray, micaceous	7
5	Shale, sandy, or shaly sandstone, in thin layers	11
4	Limestone, shaly, fossiliferous	1-3
3	Shale, black, laminated	4
2	Sandstone, micaceous, in thin layers	5
1	Sandstone, micaceous, in thin layers	9

The thin-bedded sandstone corresponding to the upper member of the section 2 1/2 miles southeast of Palestine is well exposed in many of the ravines between this place and the town. It is the lowest member exposed near the northwest corner of sec. 7, T. 6 N., R. 10 W., where the following section was made.

Section of strata exposed near the Northwest corner of Sec.7, T. 6 N., R. 10 W.

10	Loess, brown	8
9	Loess, yellowish gray with fossils	13
8	Till, brown, pebbly	12
7	Shale, sandy, bluish	10
6	Limestone, coarse grained, in 3 or 4 layers	4
5	Shale, gray, calcareous	3
4	Coal (Parker bed), (Elevation 489 ft.)	1
3	Shale, blue, clayey	5
2	Shale, bluish gray, sandy, with many small iron concretions	2
1	Sandstone, in thin layers, micaceous yellowish-gray	17

The sandstone horizon forming the basal member of the above section is well exposed in the wagon road up the hill near the middle of the east half of the same section to an altitude of 490 feet.

Parker coal + overlying strata :—

Rocks equivalent to the upper members of the last section and overlying strata are well exposed in the beds of several ravines near the north side of section 12, T. 6 N., R. 11 W. The section given below was made in the northwest 1/4 of this section.

Section of Strata exposed in the NW 1/4, Sec. 12, T. 6 N., R 11 W.

9	Till, yellow, sandy	22
8	Sandstone, massive, rather coarse, yellow to gray, micaceous in places conglomeratic at the base	32
7	Shale, blue to dark	16
6	Limestone, coarse grained, in 3 or 4 layers	4
5	Coal (Parker bed), elevation 466 ft.	1
4	Shale, blue, clayey	5
3	Sandstone, thin bedded	10
2	Shale, sandy, or shaly sandstone	8
1	Shale, dark to black	12

The limestone above the Parker Coal, member No. 6 of the above section, is exposed in the river bluff one and one-half miles farther east at an altitude of about 499 feet, showing an eastward rise of the strata between these points of about 30 feet. This limestone horizon and overlying shale outcrop in several places in the hillsides in the south half of sec. 2, T. 6 N., R. 11 W., at an altitude of about 464 feet above sea level, and they are well exposed in the banks of a stream in east half of sec. 35, T. 6 N., R. 11 W., as shown below:

Section of strata exposed in the East 1/2 of sec. 35

		Feet.	Inches
7	Shale, blue to dark	18	
6	Limestone, coarse grained, in 3 to 5 layers	4	6
5	Shale, calcareous, dark	3	
4	Limestone	1	
3	Shale, dark	1 - 2	
2	Coal (Parker bed), elevation 465 ft.	1	
1	Shale, blue, clayey	2	6

The strata at this place are conspicuously undulating, in places the limestone horizon dips below the bed of the stream, and a few rods farther up or down the creek it rises in the bank 6 or 8 feet above the level of the water. The upper shale member at this place is cut by numerous joints, 2 to 6 inches apart, which

trend in a nearly NW-SE direction. Some horizon of the massive sandstone that lies above the upper shale member of the last section is exposed in many of the ravines farther north between this place and Palestine, as in sections 14, 23, 24, 26, and 27, and a thickness of 25 feet of this sandstone outcrops along a stream in the NW 1/2 sec. 4, T. 6 N., R. 11 W. In the NW. 1/4 sec. 30 of the same township, a 6-inch coal band lies between this sandstone and the underlying shale bed, and farther down this ravine the Parker coal and overlying limestone are exposed at an elevation of about 480 feet. Farther south this massive sandstone horizon above the Parker coal lies immediately beneath the till over the uplands between Flat Rock and Heathville and southward and is exposed near the heads of the ravines north and northwest of Flat Rock.

This sandstone is exposed in the upper part of Dicksburg Hills near the south border of the quadrangle. It outcrops in Chimney Hills, a few miles farther north; and in Gordon Hills and Claypole Hills a few miles south of the quadrangles. This sandstone is exposed in the west bank of Wabash River at St.Francisville, and underlies the hill on which the town is built. It also outcrops in the hills north and west of St.Francisville, in sects. 5,7,16 and 18, T. 2 N., R. 11 W.

Still farther south a bed of massive sandstone, corresponding to that exposed at St.Francisville, outcrops in a continuous ledge for a distance of nearly one-fourth of a mile in the west bank of Wabash River in the NW. 1/4 sec. 19, T. 1 N., R. 11 W., where it has a thickness of more than 40 feet. The lower part of this ledge is rather coarse grained, gray and micaceous, in layers 1 to 6 feet thick, some of which are conspicuously crossbedded.

In the upper part the sandstone is less massive, and in places it becomes distinctly laminated. Strata equivalent to some horizon of this sandstone are exposed in several other places along the east and north sides of this hill east of Allendale, and they outcrop in a few places in the hills west of Allendale, in the southwest part of the Vincennes quadrangle.

A distinct unconformity is present at the base of this sandstone. In some places the sandstone rests directly on the limestone overlying the Parker coal and in other places a thickness of a few to 25 or more feet of shale intervenes between this limestone and the base of the sandstone. In some places in the Birds quadrangle farther north the basal part of the sandstone bed consists of a conglomerate in which pebbles of shale, limestone and sandstone occur in a matrix of calcareous sandstone, and in other places a seam of coal, 4 to 6 inches thick, occurs immediately beneath the sandstone and above the shale.

At the locality one-half mile west of Flat Rock the Parker coal and overlying limestone are well exposed in the west bank of a creek south of the wagon road where the following section was made:

Section of strata exposed one-half mile west of Flat Rock

7	Shale, sandy	2	
6	Conglomerate, composed of pebbles of limestone and shale and iron concretions in a matrix of sandstone	1	6
5	Shale, gray, calcareous	3	
4	Limestone, coarse grained, fossiliferous, in 3 or 4 layers	3	
3	Shale, black	1	6
2	Coal (Parker bed)	1	6
1	Shale, gray to dark	3	6

The altitude of the coal in this exposure is about 486 feet. The strata dip southward at an angle of 6 or 8 degrees so that 30

rods farther down stream the limestone lies at the level of the water. This limestone horizon above the Parker coal is exposed in the bed of a stream in the SE. 1/4 sec.29, T. 6 N., R. 11 W., at an elevation of about 508 feet above sea level, where it dips gently toward the south. The Parker coal was said to have been stripped for local use in this vicinity some years ago.

Corresponding strata also outcrop along a stream in the NW. 1/4 sec. 26, T. 5 N., R. 11 W., where limestone is at an altitude of about 515 feet. The succession of these strata is given below.

Section of strata exposed along a Stream in sec. 26, T. 5 N. R. 11 W.

	Feet
5 Limestone, coarse grained, fossiliferous	1
Coal (Parker bed)	1
Shale, gray, clayey	4
Sandstone, thin bedded	13
Shale, bluish	15

Sandstone belonging below the level of the Friendsville coal and thought to correspond to the horizon of that exposed at St. Francisville, outcrops in a number of places along the ravines in the west 1/2 of sec. 32, T. 4 N., R 12 W., to a height of 18 feet, and to a maximum altitude of 521 feet. This sandstone also outcrops to a height of 12 feet above the water of a stream in the NW 1/4 of sec. 31, of the same township, and in a few places in the NE. 1/4 of sec. 6, T. 3 N., R. 12 W.

The most westerly known exposure of the Parker coal in the Hardinville and Birds quadrangles is near the SW. cor. sec. 14, T. 5 N., R. 12 W., where it outcrops in the roadside at the foot of the hill at an altitude of about 533 feet above the sea. The section of strata outcropping at this place is as follows:

Section of strata exposed near the SW. cor. sec. 14., T. 5 N., R. 12 W.

Loess, yellowish brown	5	
Till, brown, pebbly	4	
Sandstone, brown, massive	10	
Shale, gray, weathered	4	
Limestone, sandy	3	6
Coal (Parker bed) altitude 533 feet		6
Shale, clayey	3	

The outcrop described in the foregoing section is 6 miles west and one mile north of the exposure described in the preceding section and the altitude of the limestone indicates a westward rise of the strata between these places of about 18 feet. The last exposure is 2 1/2 miles south and 2 miles west of the outcrop of Parker coal near Flat Rock, but the level of the coal is 47 feet higher than it is in the vicinity of Flat Rock.

The limestone above the Parker coal is generally fossiliferous, yeilding the species listed in the table below at the localities indicated at the top of the several columns:

Fossils from the limestone above the Parker Coal

	W 1/2 sec.35 T.6 N.R.11 W.	1/2 mi. west of Flat Rock	1/2 mi. S. of Palestine
Lophophyllum profundum	X	X	X
Derbya crassa	X	X	X
Chonetes vernuiliannus	X	X	X
Productus cora	X		X
Productus costatus	X		X
Productus semireticulatus	X		X
Pustula semipunctata			X
Marginifera splendens	X		
Rhipidomella pecosi	X	X	X
Spirifer cameratus	X	X	X
Spiriferina kentuckyensis	X		X

Fossils from the Limestone above the Parker Coal
(Continued)

	E 1/2 sec.35 T 6 N.R.11 W.	1/2 mi. west of Flat Rock	1/2 mi. S. of Palestine
Hustedia mormoni	X		
Composita subtilita	x	x	x
Euphemus carbonarius	X		

The limestone member in the exposure ~~and in the section near Billett, furnished the following fossil~~ along the south bank of Racoon Creek and a tributary to this stream in the SE 1/4 sec. 26 T. 2 N., R. 12 W. and in the section near Billett, furnished the following fossils:

Derbya crassa
Chonetes verneuilianus
Productus cf. cora
Marginifera splendens
Spirifer cameratus
Reticularia perplexa
Ambocoelia planconvexa
Composita argentea
Nucula parva
Pseudomonotis radiatis
Allerisma costata
Astartella vera
Phanerotrema gray villensis
Loxonema sp.
Meekospira peracuta.

Overlying the/ The locally conglomeratic sandstone and separated from it by a few inches to 1 or 2 feet of under clay, occurs a coal that has been called the Friendsville bed. This coal is best developed in the SE. quarter of the Sumner Quadrangle, and farther south where in places it reaches a thickness of 3 or 4 feet. In the northeast quarter of this quadrangle the horizon of the Friendsville coal appears to be represented by two thin coals separated by 1 to 3 feet of shale. Strata between the Friendsville and Aldrich coals.- A coal shaft put down to the Friendsville coal one mile east of the Viallage of Friendsville penetrated the following strata:

Log of coal shaft one mile east of Friendsville

	Feet	
Clay and till	10	
Sandstone, and sandy shale	26	
Coal (Friendsville bed)	3	6

The altitude of the coal here is about 435 feet. The dip is towards the west, about one foot in ten, so that the coal cannot be worked in the west part of the mine on account of the water following down in that direction. One-fourth mile south of this mine the coal outcrops in a hill at an altitude of about 432 feet and is overlain by 28 feet of sandstone and sandy shale.

The sandstone forming the prominent hills in the central part of the south half of the quadrangle belongs to a horizon above the Friendsville coal and below the 18-inch (Aldrich) bed that outcrops in the west-central part of the area. The resistant nature of this sandstone is responsible for the preservation of the hills.

In the SW. 1/4, sec. 33, T. 2 N., R. 12 W., a coal probably representing the Friendsville bed is exposed in a ravine at an altitude of about 472 feet. The succession of strata at this place is as follows:

Section of strata in sec. 33, T. 2 N., R. 12 W.

	Feet
Sandstone, gray to brown	7
Shale, black	1 1/2
Coal	1 1/2

For several miles north from this locality no outcrops of Pennsylvanian strata occur along Raccoon creek or its branches, but rocks probably equivalent to those in the southeast part of the quadrangle, are exposed in the vicinity of Bridgeport.

A thin coal belonging 40 feet or more above the horizon of the Parker bed is exposed in 2 or 3 places along the banks of a stream near the middle of the east 1/2 of sec. 9, T. 5 N.R. 12 W. and also in the NW 1/4 sec. 15, of the same township. The succession of strata at the former locality is as follows:

Section of ~~shale~~ strata exposed near the middle E 1/2 of sec.9.

Sandstone, thin bedded, shaly	8
Shale, dark	5
Coal, altitude about 495 feet	1 1/2

One mile southeast of the exposure last described corresponding strata outcrop in the bed and banks of a stream near the NW. corner of sec. 15, T. 5 N.R. 12 W. as shown below.

Section of strata exposed near the NW corner sec. 15.

5	Shale, gray, with many ironstone concretions	10 ft.
4	Sandstone, thin-bedded, shaly	7
3	Shale, dark	6
2	Coal-(altitude about 508)	1 1/3
1	Shale, clayey	4

The thin coal described above lies near the horizon of the Friendsville coal farther south, in the Sumner quadrangle, and probably corresponds to that bed. Along the wagon road one-fourth mile east of the exposure decribed in the last section a thickness of 9 feet of rather massive, coarsegrained, yellowish-hrown, sandstone lies above the level of the uppermost shale member of the section. Following west, one half mile down the stream, from the place where the last section was made the following strata are successively passed over.

section has been worked [illegible]

The lowest strata exposed consist of a few feet of gray, sandy shale outcropping along a stream in the northwest quarter of Sec. 8, T. 6N., R. 12 W., to an altitude of 512 feet. They belong to a level a little higher than the top of the hard rock in the last detailed record given above, of a drilling in section 5 of Honey Creek township. One and one-half miles south of this outcrop a bed of sandstone 19 feet thick, belonging to a horizon above the sandy shale, is exposed in the south bank of the same creek to an altitude of 497 feet. The sandstone is yellowish gray, coarse and very micaceous, in layers 1-1/2 to 4 feet thick, which dip south at a low angle. A higher level of this sandstone ledge was struck in several water wells in section 29 of the same township at an altitude of about 504 feet. A somewhat higher horizon is thought to be represented by a few feet of sandy shale exposed near the northest corner of the Southeast quarter of section 32 of the same township, to an altitude of 500 feet.

Strata exposed along a stream in the NE 1/4 sec. 16.

	Feet
Shale, gray	4
Shale, gray, clayey, with many ironstone concretions	3
Shale, gray to blue	2 1/2
Sandstone, thin bedded	3 1/2

A thin coal corresponding to member no. 2 of the next to the last section has been worked in a small way to supply local trade near the village of Villas, in the NE 1/4 sec. 5, T. 5 N.R. 12 W, and outcrops in a few places along the streams in that vicinity.

This thin coal and overlying shale and sandstone is exposed along a stream near the middle of the north side of sec. 4, T. 5 N.R. 12 W. at an altitude of about 500 feet. A shale bed corresponding to the shale overlying the coal in the last section is exposed along a stream in the NW 1/4 sec. 8, T, 6 N.R. 12 W. to an altitude of 512 feet. One and one-half miles south of this outcrop a bed of sandstone 19 feet thick, corresponding to the sandstone below the thin coal ~~best~~ last mentioned is exposed in the south bank of the creek in the NE 1/4 sec. 18 of the same township to an altitude of 497 feet. The sandstone is yellowish gray, coarse, and very micaceous, in layers 1 1/2 to 4 feet thick, which dip southward at a low angle. Still farther south, in sec. 29 of this township the top of this sandstone ledge was encountered in several water wells at an elevation of about 504 feet. A corresponding ledge of massive sandstone lies near the surface in the east half of sec. 28 where it is exposed in the banks of several ravines, to a maximum height of 14 feet, and a maximum elevation of about 480 feet.

In a well about 5 miles north of Friendsville, in the NE. 1/4 sec. 26, T. 2 N., R. 13 W., a coal, thought to correspond to the Friendsville bed, was encountered below a bed of sandstone at an elevation of 439 feet. In a well at the Frogeye school near the middle of the east side of sec. 24 of the same township, a 3-foot coal probably the Friendsville bed, was found at an altitude of 430 feet. This coal was formerly mined one half mile south of the village of Linn, in the NE. 1/4 sec. 6, T. 1 N., R. 12 W., the log of this shaft is given below:

	Feet
Soil and till.....	12
Sandstone.....	8
Shale.....	4
Coal, Friendsville bed.....	1 1/2-3

In this region the coal dips towards the west and a little towards the north, and lies at an altitude of about 425 feet. The sandstone above the coal has been quarried at this place for local use.

Thin coals and associated shale beds b elonging above the St. Francisville sandstone, were noted in the upper part of the detailed logs from secs. 7 and 30, Bridgeport township, and outcrop in the north bank of a branch of Indian Creek, near the middle of sec. 12, T. 3 N., R. 13 W., at an altitude of about 500 feet. The succession of strata at this place is as follows:

Section of strata near the middle of sec. 12, T. 3 N., R. 13 W.

	Feet
Shale, gray.....	1
Coal.....	1
Shale, dark.....	2 1/2
Coal.....	1

One-fourth mile farther west this coal was formerly mined on a small scale where it occurs at an altitude of 495 feet. It has been encountered in a number of water wells in this vicinity reaching a maximum elevation of 527 feet near the middle of the south side of sec. 6, T. 3 N., R. 12 W.

The highest strata of the McLeansboro formation in this part of the area is a bed of sandstone 37 feet thick encountered in a water well near the SE. cor. sec. 4 T.5 N., R. 12 W., at an elevation of 584 feet. Sandstone corresponding to this bed is exposed in several places in secs. 3, 4, 9, 10, 15 and 16, T. 5 N., R. 12 W.

The oldest rock that outcrops near the west side of the Hardinville quadrangle is a bed of sandy shale, 9 to 10 feet thick, exposed in the banks of North Fork of Embarrass River in the NW. 1/4 sec. 10, T. 7 N., R. 14 W., to an altitude of 460 feet. About one mile west of this place, in the northwest quarter of section 9, a higher sandstone 17 feet thick is exposed in the bank of a stream to an altitude of 478 feet. A few feet of this sandstone bed again outcrops in the east bank of the river near the middle of the west side of sec. 16, T. 7 N., R. 14 W., to an altitude of 468 feet.

South of the river the Pennsylvanian rocks form the core of a prominent ridge in the southwest quarter of the quadrangle. An exposure in the wagon road along the north side of sec. 34, T. 5 N., R. 14 W., showed the following succession of strata:

Section of rocks along the wagon road on the north side of sec. 34, T. 5 N., R. 14 W.

	Feet	Inches
Clay, yellow, loess like	11	
Till, pebbly	5	
Sandstone, gray to brown	12	
Shale, gray	23	
Coal (blossom)	1	6
Clay, shale	3	
Sandstone, and sandy shale	12	

The altitude of the coal in the section is about 475 feet. Near the top of the ridge in the northwest quarter of section 34, a

a quarry was formerly worked in a sandstone bed corresponding to the upper sandstone member of the foregoing section. Outcrops of rocks representing some part of the section occur in a number of places in the flanks of this ridge in sections 3, 4, 8, and 9 of the same township.

A bed of shaly sandstone, 27 to 33 feet thick, is exposed for several rods both north and south of the wagon bridge over Murphy creek on the north side of sec. 16, T. 4 N., R. 14 W., to an altitude of 548 feet, and a thickness of 15 feet of a similar sandy shale is exposed a short distance north of the middle of sec. 28 of this township to an altitude of 530 feet.

All the strata outcropping near the west side of the Hardinville quadrangle are thought to correspond to the strata lying above the horizon of the Parker coal in the eastern part of the Hardinville area and in the Birds quadrangle. The thin coal described in the last detailed section probably represents the thin bed exposed in secs. 9 and 15, T. 5 N., R. 12 W. The sandstone ledge above this coal in the last section would correspond to the highest sandstone horizon exposed farther east in secs. 3, 4, 9, 10, 15, and 16 of the same township, and to the sandstone occurring below the Aldrich coal farther south in the Sumner quadrangle.

A ledge of rather massive laminated sandstone belonging a short distance above the Friendsville coal is exposed along the streams in the NW. 1/4 of sec. 36, T. 4 N., r. 13 W., to a maximum thickness of 20 feet. On the hill in the SW. 1/4 of the same section a bed of sandstone outcrops to an elevation of 535 feet, and was reached in a well at an altitude of 564 feet. A somewhat

higher level of this bed occurs in King Hill, one mile west of the latter locality.

In the southwest part of the Sumner quadrangle, strata belonging below the Alrich coal are exposed in a number of places west of Bonpas Creek where they consist of 10 to 12 feet of gray, somewhat sandy laminated shale, underlain by a bed of gray sandstone. A ledge of this sandstone 6 to 8 feet thick has been quarried at a few places along a stream in the southwest quarter of section 16, T. 2 N., R. 14 W., where it is quite hard, and occurs in layers 4 to 10 inches thick. Below this sandstone there is a bed of bluish more or less sandy, shale which outcrops in the vicinity of West Salem where it is used in the manufacture of brick and tile. A well put down at the brick plant penetrated 30 feet of this shale.

Sandstone belonging below the shale near West Salem is exposed in a number of places east of Little Bonpas Creek, in the southeast quarter of sec. 32, T. 2 N., R. 13 W., and in the east half of sec. 12, and the northwest part of sec. 13, T. 1 N., R. 13 W., and also outcrops farther east in the prominent hills in the southcentral part of the Sumner quadrangle.

In the SW. 1/4 of sec. 22, T. 2 N., R. 13 W., a thin coal was formerly worked by a drift near the top of the hill at an altitude of about 534 feet. The succession of strata exposed along a stream at this place is as follows:

Section of strata exposed in the SW. 1/4, sec. 22

Sandstone and sandy shale	14
Shale	1/4
Coal	1

This coal belongs above the Friendsville and may correspond to the Aldrich bed, but the limestone which usually occurs above the Aldrich coal is absent. At a number of levels on the west side of the hill, a few feet of sandstone is exposed below the coal above an altitude of 482 feet.

The Aldrich Coal and Overlying Strata: A thin coal corresponding to that referred to as the Aldrich bed in the Patoka folio, is present over several square miles in the central and western parts of the Sumner quadrangle. This bed is usually quite uniform in thickness, varying little from 1 1/2 feet. It is underlain by a few feet of underclay or shale and is generally overlain by a few feet of underclay or shale and is generally overlain by a ~~few feet of unisce~~ simple layer of hard, shaly, fossiliferous limestone, 2 to 2 1/2 feet thick. This coal and associated strata are well exposed in the banks of a stream near the northwest corner of sec. 32, T. 3 N., R. 13 W. The section of these rocks is given below:

Section of strata near the northwest corner of section 32.

	Feet	
Sandstone, gray, micaceous	5	
Shale, sandy, laminated	13	
Limestone, fossiliferous in a single layer	2	1/6
Shale, gray to dark		1/4
Coal (Aldrich bed)	1	1/2
Shale	3	11

The coal at this place lies at an altitude of 502 feet, and has been stripped for local use over a considerable area. The coal and the associated strata outcrop in many places in this vicinity. It was formerly worked on a small scale along the streams

1 1/4 miles south and 1/2 mile west of the place where the last section was made, where a similar succession of strata are exposed, the altitude of the coal being 498 feet. Two miles farther west and 1/2 to 1 mile south, this coal is stripped for local use along the branches of a tributary to Bonpas creek in sections 2 and 11, T.2 N., R. 14 W. at an elevation of 469 feet. It was encountered in a well near the middle of the

east side of section 10 at an altitude of 455 feet. Farther northwest, in the NE 1/4 of sec. 3, of the same township, it was formerly stripped at an elevation of 455 feet, and in the SW 1/4 of section 33, T. 3 N., R. 14 W. it also occurs at about the same altitude.

In the west bank of a creek near the middle of sec. 34, T. 3 N., R. 14 W. the following strata are exposed:

Section of strata exposed in the west bank of creek near middle of sec. 34.

	Feet
Shale, gray	4
Shale, black, laminated	1
Shale, gray	4
Limestone, hard, partially decayed	2 1/2
Sandstone, or sandy shale, laminated	14
Shale, sandy, and hard sandstone in alternating layers	9
Limestone, fossiliferous	2
Coal (Aldrich bed)	1 1/2

The coal in the foregoing section has an elevation of 458 feet and is the equivalent of the coal in the section previously described. In a water well in the south half of section 16, T. 2 N. R. 14 W. it was encountered at 449 feet altitude. West of Bonpas creek along the west border of the Sumner quadrangle, this coal rises to 472 feet near the west side of sections 8, 17, and 20, T. 2 N., R. 14 W. The general dip of the coal in this region is toward the west at the average rate of about 12 feet to the mile. It also dips southward somewhat less rapidly. At almost all of the localities in this region a fossiliferous limestone 2 to 2 1/2 feet thick occurs a few inches above the coal. The more common fossils found in this limestone at different localities are the following.

Aldrich

Fossils from the limestone above the coal.

	NW 1/4 Sec.32 T.3 N R.13W	SE 1/4 Sec.11 T.2 N. R.14W.	NW 1/4 Sec.31 T.3 N. R.13 W	NE 1/4 Sec.20 T. 2 N R.14 W
Lophophyllum profundum	X	X	X	X
Zeacrinus sp	X	X	X	
Rhombopora lepidodendroides	X	X	X	X
Derbya crassa	X	X	X	X
Chonetes granulifer	X	X	X	X
Chonetes verneuilianus	X			X
Productus cora		X	X	
Productus costatus	X	X		X
Productus nebraskensis		X		
Productus semireticulatus				X
Pustula punctatus	X	X		X
Marginifera muricatus	X	X	X	X
Rhipidomella pecosi	X	X	X	X
Pugnax uta	X			
Spirifer cameratus	X	X	X	X
Spiriferina kentuckyensis	X	X	X	X
Reticularia perplexa	X		X	
Ambocelia planiconvexa	X	X	X	X
Hustedia mormoni	X		X	X
Composita argentea	X	X	X	X
~~Aviculo~~pecten occidentale		X		
Allorisma subcuneata		X		X
Euphemus carbonarious	X	X		
Petallostium montfortianum		X	X	
Straparollus catilloides		X	X	X
Orthoceras rushense	X	X		
Sphaerodoma primogenia		X		

Along the wagon road near the middle of the east side of sec. 20, T. 3 N. R., 14 W. are exposed the following strata belonging above the horizon of the Alrich Coal.

Section of strata, near middle of east side of sec. 20.

	Feet
Sandstone, micaceous, coarse - - - - - - -	6
Shale, olive brown to chocolate color -	9
Limestone, white, hard, with rough surfaces, in layers 3 to 6 inches thick- (altitude 276 feet)	2 1/2
Shale, blue, plastic - - - - - - - - - - -	5
Sandstone, gray - - - - - - - - - - - - -	1

In the banks of Bonpas creek between the southeast corner of section 8, and the south side of section 28, T. 3 N., R.14 W., there is exposed the following succession of strata the middle part of the section corresponding to those of the section last described, the youngest outcropping farthest north and successively older rocks are encountered towards the south.

Section of strata exposed along Bonpas creek between sections 8 and 28, T. 3 N., R. 14 W.

Shale, gray, sandy - - - - - - - - - - - - -	25
Sandstone, gray, coarse, micaceous - - - - -	13
Shale, olive brown to chocolate colored- - -	10
Shale, gray and black - - - - - - - - - - - -	9
Limestone, gray, hard, with rough surfaces-	2 1/2
Shale, blue - - - - - - - - - - - - - - - - -	5 1/2
Sandstone, gray, micaceous - - - - - - - - -	11

Strata equivalent to some part of the section last described are exposed in many places in the banks and branches of a tributary of

bonpascreek, 2 1/2 miles farther east. In the east bank of a creek near the middle of the north side of section 26, T. 3 N., R. 14 W. there are exposed the rocks described below:

Section of strata near the middle of north side of sec. 26.

Sandstone, gray to yellowish-brown, micaceous - - - - - - 13 ft.

Shale, olive brown to chocolate colored - - - - - - - - - 10

Shale, dark, calcareous, with several fossils - - - - - - 1

Shale, gray to black, laminated - - - - - - - - - - - - - 4 1/2

The calcareous shale member in the above section furnished the fossils:

Lophophyllum profundum,
Derbya crassa
Chonetes glaber
Chonetes variolata
Productus cora
Productus costatus
Marginifera muricata
Marginifera splendens?
Rhipidomella pecosi
Pugnax uta,
Spirifer cameratus
Reticularia perplexa
Amboccelia planoconvexa
Hustedia mormoni,
Composita argentea
Clinopistha radiata
Leda bellastriata?
Aviculopecten occidentalis,
Aviculopecten sp.,
Astartelle vera
Phanerotrema grayvillensis,
Euphemus carbonarius
Orthoceras rushense

One-fourth mile farther down the creek from the locality last described, there is an outcrop of 2 to 3 feet of gray limestone with rough surfaces, in layers 4 to 7 inches thick, which corresponds to the limestone (3rd member) of the section described above in section 20. Considerable quantities of this limestone are said to have been burned for lime by the early settlers in this region. Rocks rep-

resenting the lower strata described in the foregoing section, together with sandstone and shale, belonging a little lower in the McLeansboro formation outcrop in many places farther down Bonpas creek and its tributaries in sections 33, 34, and 35, T? 3 N., R? 14 W. Strata of corresponding age are also exposed along the branches of Little Bonpas creek in sections 30, 31 and 32 of T. 3 N., R.13 W. The greater elevation of the surface of the region makes possible the exposure of strata belonging above the horizon of the limestone above described in a number of places in the north half of the northwest quarter of the Sumner quadrangle. These consist of sandy shale overlain by a coarse grained sandstone. This bed of rather coarse, yellowish-gray sandstone outcrops in the branch of Bugaboo creek, near the middle of the south side of sec. 34, T. 4 N., R.14 W., and along the road one and one-half miles farther east, near Prairieton Chapel where a ledge 8 feet thick is exposed to an elevation of 505 feet. The log of a water well at the house near this exposure shows the following succession of strata:

Log of water well lies a short distance east of Prairieton Chapel.

Till, sandy and pebbly	10
Sandstone, coarse, micaceous	40
Shale, bluish, sandy	30
Limestone, hard	3-5
Sandstone, gray	15

A thickness of 15 feet of sandstone corresponding to the upper sandstone in the foregoing section was encountered above a blue shale in a water well in the NW 1/4, sec. 32, T. 4 N., R.14 W. at an altitude of 528 feet. Rocks belonging below the horizon of this sandstone outcrop along the headwaters of Bonpas Creek south

of Claremont, where a bed of gray micaceous sandstone and sandy shale, dipping towards the south, is exposed to an altitude of about 500 feet. Strata representing the same general portion of the section outcrop farther east in the vicinity of Hadley. Near the middle of the east side of section 6, T. 3 N., R.13 W., 12 feet of sandstone is exposed to an altitude of 473 feet; and near the SE corner of Sec. 1, T. 3 N., R.14 W, a thickness of 4 to 8 feet of shale outcrops both north and south of the railroad to an elevation of 491 feet. In a cut along the railroad a short distance north of the middle of the south side of the same section the following strata are exposed above an elevation of 522 feet.

Section of strata in cut along railroad in Sec. 1, T. 3 N., R. 14 W.

Clay, loess-like	5
Till, brown, pebbly and sandy	1 1/2
Sandstone, brown, micaceous	15

About 1/8 mile southwest of the exposure in the railroad cut, a thickness of 17 feet of coarse, micaceous sandstone outcrops along the wagon road. A small quarry has been opened in the sandstone in the NW 1/4, sec. 12 of the same township where a ledge 8 feet thick is at present exposed. In water wells in this vicinity this sandstone is encountered at an elevation of 519 feet.

Farther south the gradient of Bonpas Creek is steeper than the southward dip of the strata so that successively lower strata appear in the banks of the creek in a southward direction. Where the wagon road crosses Bonpas creek near the SW corner of sec. 9, T. 3 N., R.14 W., a bed of sandy shale 25 feet thick is exposed in the east bank to an altitude of 491 feet, and a thickness of 16 feet appears

in the west bank to an elevation of 487 feet. Beds of shale and sandstone equivalent to the above outcrop in numerous places along Bonpas creek and its tributaries for a distance of 3 miles below the last exposure.

Near the southeast corner of sec. 17, T. 3 N., R.14 W. 18 feet of sandstone is exposed above 9 feet of shale, to an elevation of 499 feet, and in the opposite (west) bank of the creek, a ledge of micaceous sandstone appears for a distance of 8 rods to a maximum height of 13 feet.

V Stratigraphy: Surficial Deposits

A mantle of unconsolidated material belonging to the Quarternary system covers the Pennsylvanian rocks over almost all of this region to a thickness varying from a few feet over the higher hills to more than 100 feet over parts of the larger valleys. The average thickness of these deposits in 205 water wells that penetrated to hard rock in this area, is about 18 feet. They consist of glacial drift or till, interglacial soils, glacio-fluvial beds of sand and gravel, and loess belonging to the Pleistocene series; and of recent alluvium, sand dunes, soils and swamp deposits.

Pleistocene series

Differentiation of the deposits

During the long interval between the deposition of the youngest of the Pennsylvanian rocks in this region and the laying down of the overlying glacial tills, the area was a land surface subjected to the action of weathering and erosion. During this time a mantle of residual material and soil accumulated over the greater portion of the uplands and beds of alluvium were deposited along the larger streams.

In some places remnants of the old soil and residual clay and sand and alluvium of pre-Pleistocene or pre-quarternary age are doubtless present beneath the glacial till, for such deposits have been found in a few of the water wells in the Hardinville quadrangle. A 71-foot well near the middle of the W. 1/4 sec. 20, T. 4 N., R. 12 W., obtains water from a gravel bed immediately above hard rock which may represent a pre Pleistocene stream deposit. The log of another well put down near the NW. cor sec. 30, T. 4 N., R. 12 W., obtains

water from a gravel bed immediately above hard rock which may represent a pre-Pleistocene stream deposit. The log of another well put down near the NW. cor. sec. 30, T. 5 N., R. 14, W., indicates the presence of a soil horizon beneath Illinoian till, as shown below.

Log of well near the NW. cor. sec. 30, T. 5 N., R. 14 W.

4. Clay pebbly	18
3. Muck, black	1
2. Clay, pebbly	1
1. Sandstone	1

In the above log it seems certain that member No.3 represents a pre-Illinoian soil zone. The pebbly clay of member No.2 may indicate a remnant of a till sheet earlier than the Illinoian or it may be residual material, or an alluvial deposit laid down by a pre- Illinoian stream.

The log of another well near the northeast corner of section 21 of the same township shows a similar soil horizon below the Illinoian till.

Log of well near the NE. cor. sec. 21, T. 5 N., R. 14 W.

Clay, sandy	4
Clay, pebbly, (hard pan)	15
Muck, black	6

Besides the pre-Illinoian soil zone, the Pleistocene deposits recognized in the quadrangles are the Illinoian glacial drift, which is present over almost the entire area; the Sangamon soil, which has been penetrated in a number of water wells in the quadrangles; loess which forms a thin blanket over the drift in the more hilly parts of the region and is thought to be mostly of Iowan age; and remnants of terrace deposits of sand and gravel over the flood plains

of the Embarrass and Wabash Rivers which represent glacio fluvial deposits of Wisconsin age.

Illinoian Drift

Distribution.- Much the greater portion of the Pleistocene deposits in this region consists of glacial drift of Illinoian age, and, except where removed by more recent erosion, this drift is present over the entire surface of the quadrangles. The upper surface of this drift is more or less irregular, but nowhere in this region are morainal features developed. The pre-Illinoian surface upon which the drift was spread was also quite uneven and hence the thickness of the Illinoian drift as far from uniform. It is thickest over the main lines of pre-Illinoian drainage which correspond in general to the present valleys of the Wabash and Embarrass Rivers and their larger tributaries.

A 100-foot well put down not far from the present channel of Big Creek, near the middle of sec. 16, T. 6 N., R. 13 W., penetrated recent alluvium for 42 feet and reached hard rock at a depth of 122 feet. In putting down a well in the SW. 1/4 sec. 19, T. 4 N., R. 12 W., a thickness of more than 100 feet of Pleistocene deposits, mostly Illinoian drift, was penetrated, and a drilling for oil near the SE. cor, Sec. 7, T. 4 N., R. 12 W., reached hard rock at 111 feet. In all these wells the Illinoian drift makes up the larger portion of the Pleistocene materials.

A well put down on the flood plain of Muddy Creek, at Sumner, penetrated 50 feet of Pleistocene material (mostly Illinoian till) before reaching bed rock. Another well near the middle of the south side of sec. 26, T. 3 N., R. 13 W., near the valley of Raccoon Creek, reached hard rock at a depth of 54 feet. A well in the valley

of Crawfish Creek in the NE 1/4 of sec. 7, T. 1 N., R. 13 W., passed through 40 feet of Illinoian till. A well 1/2 mile south of Bridgeport in the valley of Indian Creek, penetrated 90 feet of Pleistocene deposits, mostly Illinoian till before reaching Pennsylvanian rocks; and wells in the lower course of the valley of Bonpas Creek in the Patoka quadrangle, are said to penetrate a thickness of 150 feet of Pleistocene deposits, the greater portion of which is probably Illinoian till.

Over the higher uplands of the Birds quadrangle, and on the hills near the east side of the northeast quarter of the Hardinville area, and over the rougher parts of the southwest quarter, the Illinoian drift is comparatively thin. An exposure near the middle of sec. 17, T. 6 N., R. 12 W., shows only three feet of drift above a ledge of sandstone, and in the SE. 1/4, sec. 27, T. 5 N., R. 14 W., are only five feet of Illinoian till above an outcropping ledge of hard rock. Exposures showing the entire thickness of the Illinoian drift in the Hardinville quadrangle are not common as the streams have in only a few places cut entirely through the Pleistocene beds, but in the Birds area such exposures are much more frequent.

On the hills in the central portion of the Sumner quadrangle, the Illinoian till is less than 10 feet thick.

The Illinoian till in this region consists of an intimate mixture of clay, sand, pebbles, and a few small bounders of many kinds of rock. Where partially weathered its color varies from yellowish-gray to light brown, but in the deeper, unweathered portions it is bluish gray. The clay and sand comprising the main body of the till were probably derived for the most part from local beds of McLeansboro shale and sandstone which hae been deeply disintegrated before the

Illinoian ice sheet moved over the region.

The coarser constituents of the till, the pebbles and boulders, consist in part of crystalline rock transported by the ice sheet from areas far to the north and northeast of the quadrangles; and, in part, of pebbles of chert, sandy shale, iron concretions, and occasional fragments of limestone of sedimentary origin that were carried a much shorter distance. The boulders of igneous rock are few, mostly pink granites and green stones, less than two feet in diameter. Many pebbles less than 1 inch in diameter were picked out of the drift at a number of localities for the purpose of finding what ratio those of sedimentary, and so probably of local origin, bore to those of igneous origin. The results are shown in the following table.

Table showing the relative number of pebbles of different kinds of rock from the Illinoian till

Kind of rock	Near middle of sec.9,T. 3 N., R. 14 W.	Near middle of S. side of sec. 4, T. 2 N.,R.14 W.	NW 1/4 sec.30 T.2 N., R. 13 W.	NW 1/4 sec.23, T.3N., R.14 W
	No. of pebbles	No. of pebbles	No. of pebbles	No. of pebbles
Granite	5	10	9	23
Schist	3		1	8
Quartz (crystalline)	28	8	15	35
Quartzite	51	29	26	45
Chert	178	87	97	116
Sandy shale	17	46	15	37
Iron concretions	212	8	4	174
	494	188	167	438

The predominance of the sedimentary material in the pebbles of the drift in this region will be seen from the above table in which 82 per cent of the pebbles taken from the first locality; 75 per cent

of those from the second; 70 per cent of those from the third, and 74 per cent of those from the fourth were of chert, sandy shale, or iron concretions that might have been derived from local Pennsylvanian beds.

Within the Illinoian till there occur zones of glaciofluvial sand and gravel that were sorted out from the till and deposited as frontal aprong or along the channels of streams that flowed out from the front of the ice sheet during a temporary retreat. At different levels sandy zones in the drift have been firmly cemented with calcium carbonate deposited from percolating water. These are known by drillers of water wells as "cement" or "cement rock" and are said to require blasting in digging through them. An exposure showing such cemented bands may be seen in the west bank of Honey Creek in the SE. 1/4 sec. 30, T. 6 N., R. 12 W.

Section exposed in the west bank of Honey Creek, sec. 30, T. 6 N., R. 12 W.

3. Till, sandy with pebbles, red	12
2. Till, sandy, with pebbles, yellowish to brown, somewhat cemented with calcium carbonate	1 1/2 - 2 1/2
1. Till, sandy and pebbly, dark gray to blue, with several bands firmly cemented with calcium carbonate (cemtnt rock)	9

A representative section of the Pleistocene deposits is exposed in the west bank of Bonpas Creek, in the SE. 1/4, sec. 17, T. 3 N., R. 14 W. as shown below:

Section of strata in west bank of Bonpas Creek, sec. 17.

Clay, loess-like	4 1/2
Till, yellowish-brown, with pebbles (Illinoian)	16
Sandstone, micaceous	13

Another good section of till is exposed for several rods above and below Yeager ford in the east bank of North Fork of Embarrass River, in the SW. 1/4 sec. 33, T. 6 N., R. 14 W., as shown below:

Section in east bank of North Fork at Yeager ford

3. Clay, Loess-like, yellowish brown, somewhat sandy	6	6
2. Till, pebbles numerous, yellowish brown, cemented bands in the lower part	14	
1. Till, pebbles numerous, bluish, hard, much cemented	12	

The total thickness and the relations of the Illinoian till at different places in the area are shown in the logs of the following wells:

Log of well near middle of sec. 28, T. 6 N., R. 13 W.

	Thickness		Depth	
	Feet		Feet	
Clay, loess-like, with occasional small pebbles	9	6	9	6
Till, sandy, with numerous pebbles, and showing cemented bands in lower part.	20		29	6
Clay, bluish gray, pebbly	2	6	32	
Shale, bluish	8		40	

Log of well near SE. cor. sec. 35, T. 6 N., R. 14 W.

	Thickness	Depth
	Feet	Feet
Clay and till	12	12
Till, bluish gray, pebbly, (hardpan or cement rock)	29	41
Sandstone, gray	8	49

Log of well near center of sec. 31, T. 6 N., R. 13 W.

	Thickness	Depth
	Feet	Feet
Clay and till	13	13
Till, pebbly (hardpan)	17	30
Quicksand	5	35

Log of well near SE cor. sec. 18, T. 4 N., R. 13 W.

	Thickness Feet	Depth Feet
Till, pebbly, yellowish gray above, becoming bluish below	24	24
Sand	5	29
Sandstone	1	30

Log of well near northeast cor. sec. 11, T. 6 N., R. 13 W.

	Thickness Feet	Depth Feet
Till, pebbly, yellow	15	15
Gravel and sand	5	20
Till, sandy and pebbly	5	25
Sand and gravel	5	30
Till, sandy and pebbly	5	35
Till, with streaks of gravel and sand	70	105
Shale, gray, micaceous	15	120

Log of water well in sec. 6, T. 2 N., R. 13 W.

	Thickness Feet	Depth Feet
Clay, loess-like, few or no pebbles	4	4
Till, pebbly (Illinoian)	11	15
Shale	5	20

Log of well in SE. 1/4 sec. 28

	Thickness Feet	Depth Feet
Clay, loess-like	4	4
Till, blue, pebbly, (Illinoian)	35	39
Sandstone	1	40

Log of water well in sec. 17

	Feet		Feet	
Clay, loess-like	2	6	2	6
Till, pebbly (Illinoian)	14		16	6
Sand		6	17	

Many of the shallow water wells penetrate a bed of sand or gravel in the till, 1 to 10 or more feet thick, from which they obtain the water. Many of these sand beds are small pockets, but some of them appear to extend for considerable distances. Older Valley filling: One of the conspicuous topographic features of this region is the broad nearly flat bottoms of the smaller as well as of the larger stream valleys. The material of this filling in the smaller valleys is chiefly glacial till, but occasional sandy layers, and more rarely bands of gravel are present. In the filling of the larger valleys, glacial till occurs in the lower part, and sand and gravel make up a much larger proportion of the fluvial deposit. The main time of this great and extensive valley filling in this region was during the Illinoian glacial stage, as is indicated by the fact that in some places these deposits are covered with a thickness of several feet of loess, and in some places a part of the till of the valley filling had been removed by the streams prior to the deposition of the loess, and a deposit of typical yellow fossiliferous Iowan loess, overlain by the younger more widespread brown loess, has been deposited over the top and upper part of the terrace slope. An exposure showing such a relation of loess to the terrace slope occurs in the SE 1/4, sec. 24, T. 4 N., R. 12 W. and in other places in the Birds quadrangle.

Although the main part of the filling of the valleys took place during Illinoian time, the larger valleys received

glacio fluvial deposits of sand and gravel during the Wisconsin glacial state and additions of loess, and deposits of fluvial silts adjacent to the stream channels have been made in later Pleistocene and Recent time.

Sangamon Soil

No exposures of Sangamon soil are known in the quadrangles but this zone has been encountered in a number of water wells in the area. This old soil consists of dark carbonaceous clay which often contains numerous fragments of wood. It is usually encountered at depths from 10 to 18 feet and is often directly overlain by sand, but in some places by clay. It was developed during the Sangamon interglacial time over poorly drained areas in places where conditions were favorable for the preservation of the organic matter.

The following logs of wells in this region will show the relation of the Sangamon soil to the associated Pleistocene beds:

Log of well near the middle of south side of sec.28, T. 6 N., R. 14 W.

	Thickness Feet	Depth Feet
Sand	6	6
Muck, black, with brush and wood fragments	4	10
Muck, black, sticky	5	15
Clay, dark, pebbly	10	25

Log of well near middle of south half sec.13 T. 5 N. R. 14 W.

	Thickness Feet	Depth Feet
Sand	18	18
Muck, black	1	19

The following logs of water wells in this region will show the relation of the Sangamon soil to the associated Pleistocene beds:

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see p. 8a Savage MS-11

Log of well near middle of S 1/2 Sec. 14, T.3 N., R.13 W.

	Feet
Clay - - - - - - - - - - - - - - - - -	29
Muck, black - - - - - - - - - - - - - -	6

Log of well in SW 1/4, sec. 25, T.3 N., R.14W.

	Feet
Clay, yellowish-gray - - - - - - - - - - - - - - - -	10
Muck, black, with wood fragments - - - - - - - - -	1
Till, bluish gray with pebbles - - - - - - - - - -	12
Sandstone, gray - - - - - - - - - - - - - - - - - -	1

Another well in the southwest 1/4 of section 4, T.2 N., R.13 W. passed through the following beds.

Log of well in section 4, T.2 N., R.13 W.

Clay -	20
Muck, black with wood fragments - - - - - - - - - -	3
Till, bluish, pebbly - - - - - - - - - - - - - - -	3

In the southwest quarter of the quadrangle, a well put down in the valley of Crawfish Creek in the NE 1/4, sec. 7, T.1 N., R. 12 W. penetrated the following strata:

Log of well in sec. 7, T.1 N., R.12 W.

Clay -	18
Quicksand -	3
Clay -	8
Sandy clay, dark, with many wood fragments (Owner said it resembled a decayed brush heap)	3
Till, bluish, pebbly - - - - - - - - - - - - - - -	7
Sandstone -	1

In another well in the valley of Jordan Creek, in the NE 1/4, sec. 23, T.1 N., R.14 W, the following strata were penetrated:

Log of well in section 23, T. 1 N., R.14 W.

Clay, white -	13
Sand, with clam shells - - - - - - - - - - - - - -	1/2
Soil, black -	5

Log of well near middle of south half sec.21, T. 6 N., R. 14 W.

	Thickness Feet	Depth Feet
Clay,sandy	10	10
Muck,black,with wood fragments	2	12
Sand and clay	12	24

Log of well near middle of east side sec. 25, T. 4 N. R. 13 W.

	Thickness Feet	Depth Feet
Clay	18	18
Muck and rotten leaves	6	18 6
Clay	1 6	20
Gravel	1	21

Another well three miles north of the last in the valley of a tributary of Raccoon Creek encountered about 14 feet of black muck with wood fragments, overlying pebbly till, at a depth of 18 feet.

In a well near the middle of the east side of sec. 8, T.1 N., R. 13 W. a zone of black muck containing wood fragments lying above a bed of sand and gravel 10 feet thick was reported at a depth of 12 feet.

In a number of pla ces there is exposed along the slopes a band of gravel or concentrated pebbles in an iron-stained zone at the top of the Illinois drift and beneath a few feet of loess-like clay. The pebbles in this zone were concentrated at the surface of the drift by the removal of the finer constituents of the till through sheet wash and erosion during the Sangamon interglacial stage previous to the deposition of the overlying loess.

The following sections of exposures will show the relation of this zone of concentrated pebbles and oxidized material to the underlying Illinoian till and the overlying surficial material.

Section of Pleistocene beds exposed near the middle of the south side of sec. 14, T.5 N., R. 12 W.

	Thickness Feet	Depth Feet
Clay, resembling loess but with occasional small pebbles	5 6	5 6
Gravel, sandy, reddish-brown, grading downward into pebbly till	6	6
Till, sandy, with numerous pebbles, reddish-brown above, yellowish gray below (Illinoian drift)	11	17

Section exposed along the roadside near the NE. cor sec. 19, T. 6 N., R. 12 W.

	Thickness Feet	Depth Feet
Clay, yellowish gray, with a few pebbles	4	4
Gravel, sandy, reddish brown, grading downward into pebbly till	6	4 6
Till, sandy, with many pebbles, reddish above changing to grayish brown below (Illinoian drift)	5	9 6

Section exposed at the north end of Spencer bridge, near the NW. cor. sec. 9, T. 5 N., R. 13 W.

	Thickness Feet	Depth Feet
Clay, yellowish-gray, fine, with a few pebbles	5	5
Gravel, sandy, yellowish-brown	6	5 6
Till, pebbly, yellowish brown above and bluish gray below, cemented bands at different levels in the lower half	26	31 6

In the north part of the Sumner quadrangle, such a zone of concentrated gravel is exposed below 4 feet of loess and above Illinoian till along the wagon road one half mile west of

the town of Hadley. One and one-half miles northeast of Summer near the middle of the south half of sec. 34, T. 4 N., R. 13 W. and near the SW. corner of sec. 5, T. 4 N., R. 12 W., such a gravel zone is overlain by 4 to 5 feet of loess-like clay. In the south half of the area a zone of concentrated gravel overlying Illinoian till is exposed, beneath 6 feet of loess-like clay in the wagon road near the middle of section 22, T. 1 N., R. 14 W., and farther east near the middle of south side of sec. 4, in the SW. 1/4 of sec. 9, and near the middle of the west side of sec. 13, T. 1 N., R. 13 W., 4 to 7 feet of loess overlies such a zone of gravel.

Loess

Distribution and Thickness - The loess has a much greater development in the northwest and west-central portions of Illinois than in the eastern and southern parts of the State. It has a much greater thickness over the older Kansas drift sheet in Iowa and the Illinoian drift sheet in Illinois, than over the younger till sheets of the Iowan and Wisconsin glacial stages. The surface of the Illinoian drift in the Hardinville and Birds, Sumner and Vincennes quadrangles is generally covered by a blanket of loess of variable thickness. The thickness is greatest, 4 to 20 feet, over the more hilly portions of the area particularly north of Embarrass River between Honey Creek on the west and Wabash River on the east. Over considerable areas of the more level uplands in the quadrangles the thickness does not exceed 1 to 3 feet, and in places, as south of Oblong between North Fork and Big Creek, loess is entirely absent.

Physical Character - The loess consists of fine-grained, unstratified material which in this region is generally brown in color. In places where the loess is unusually thick the lower part of the deposit is yellowish-gray, and the upper part is a brown material such as is generally present over the till. The lower, yellow loess contains typical loess fossils, and appears to be a remnant of an older deposit, while the upper brown loess seldom contains any fossils, and when these are present, the shells are much smaller than those of the same species in the lower yellow loess. The loess is composed of minute angular particles of quartz, feldspar, hornblende, calcite, and other minerals, the undecomposed and igneous nature of many of which indicates that they were derived from the rock flour of glacial till.

The texture is usually quite uniform throughout, except for occasional pebbles which range in size from a small fraction of an inch to one inch in diameter, and which occur only in the lower 3 or 4 feet of the deposit.

Some of the pebbles occurring in the lower part of the loess are of chert or limestone or sandstone of local origin, and others are of crystalline rock. Any kind of pebbles present in the underlying till may occasionally occur in the lower part of the overlying loess, not only on the gentle slopes but also over the more level parts of the region, and not alone in the Sumner and Vincennes quadrangles but they are occasionally present in the lower 2 to 5 feet of the loess over the greater portion of the Mississippi Valley.

The following mechanical analyses of loess made by Milton Whitney of the U. S. Department of Agriculture, give some information with regard to the size of the grains of the surface loess in eastern Illinois, and probably indicate fairly well the texture of the surface loess of the Sumner and Vincennes quadrangles.

Mechanical analyses of the loess in eastern Illinois

Diameter in millimeters	Conventional name	Galatia, 1 to 18 in. from surface	near Greenup, 2 to 15 in. from surface	Moweaqua, 2 to 18 in. from surface
		Per cent	Per cent	Per cent
2 to 1	Fine gravel	0.00	0.30	0.00
1 to .5	Coarse sand	0.00	1.05	0.08
.5 to .25	Medium sand	0.02	3.42	0.77
.25 to .1	Fine sand	0.30	3.30	0.11
.1 to .05	Very fine sand	5.21	6.47	4.88
.05 to .01	Silt	57.75	55.48	52.50
.01 to .005	Fine silt	12.78	11.70	12.15
.005 to .0001	Clay	20.36	14.90	22.10
	Total mineral matter	96.42	96.62	92.59
	Organic matter water loss	3.58	3.38	6.61
	Loss by direct ignition	6.01	3.11	5.73

Subdivisions and fossils- Two kinds of loess can be distinguished in this region. Both of these kinds are thought to have had a similar origin, but to be largely offdifferent age. Over the greater portion of the surface of the uplands the loess overlying the Illinoian till is generally brown, and claylike and rarely contains fossils. In places on the hills bordering the larger streams where the loess is unusually thick, a clearly marked plane of unconformity is present in the midst of this deposit. The upper part of the loess is brown, contains no fossils, and resembles the loess that is generally present over the uplands. The lower part of such

deposits is yellow to yellowish gray, more porous than the upper loess, and often contains numerous loess fossils.

A locality in which both beds of loess are well exposed is in the wagon road up the hill south of the Bright Light ferry over Wabash River, in the NW. 1/4 sec. 7, T. 6 N., R. 10 W., where the following section was made:

Section of loess exposed in sec. 7 T. 6 N., R. 10 W.

		Feet
3	Loess, brown, without fossils	8
2	Loess, yellowish gray, fossiliferous	13
1	Till, brown, pebbly (Illinoian)	12

The altitude of the top of the yellow loess at this place is about 526 feet. The following fossils were collected from the lower loess, No.2 of the section whereas no fossils were found in the upper brown loess deposit. The fossils in this list, as all of the other fossils from the loess listed in this report, were identified by Dr. Wm. H. Dall of the U. S. Geological Survey.

Fossils from the lower loess in the above section

Succinea avara Say

Polygyra multilineata Say

Polygyra hirsuta Say

Strobilops labyrinthica Say

Helicodiscus parallelus Say

Circinaria concava Say

Vitrea radiatula Alder

Lymnaea desidiosa Say

A similar succession of Pleistocene deposits is exposed in the wagon road up the hill 2 miles north of Russellville, near the middle of the E. 1/2 sec. 29, T. 5 N., R. 10 W. The following section was made at this place.

Section of Pleistocene beds exposed in sec. 29.

	Feet
Loess, brown, without fossils	7
Loess, yellow to gray, fossiliferous	11
Till, brown with small pebbles (Illinoian)	14

The yellow loess at this place was about 478 feet above sea level and furnished the fossils listed below:

Fossils from the lower loess, of the last section

Succinea avara Say

Polygyra profunda Say

Polygyra hirsuta Say

Polygyra fraterna Say

Pyramidula alternata Say

Helicina occulta Say

About one and one-half miles north of Green Hill chruch, in the SW. 1/4 sec. 20, T. 6 N., R. 10 W., is exposed a thickness of 7 feet of yellow, fossiliferous loess, overlain by 6 feet of brown, nonfossiliferous clay. The lower yellow loess at this place contained very numerous loess concretions and furnished the following fossils:

Fossils from the lower loess in the SW. 1/4, sec. 20, T. 6 N. R. 10 W.

Succinea avara Say	Vitrea radiatula Alder
Polygyra fraterna Say	Pomatiopsis lapidaria Say
Vallonia pulchella Muller	Pupilla sp. fragne
Pyramidula shimeki Pilsbry	Lymnaea desidiosa Say

Along the wagon road near the middle of the W. 1/2 sec. 31, T. 5 N., R. 10 W., the following section of Pleistocene beds are exposed:

Section of loess exposed in the W. 1/2 sec.31, T. 5 N., R. 10 W.

	Feet
Loess, brown, without fossils	8
Loess, yellowish gray, fossiliferous	6

The top of the yellow loess at this locality was 482 feet above the sea, and the species of fossils it contained are listed below:

Fossils from the lower yellow loess in the W. 1/2 sec.31, T. 5 N., R. 10 W.

Succinea avara Say

Helicodiscus parallelus Say

Strobilops labyrinthicus Say

Helicina occulta Say

In the east side of a small hill of loess surrounded by sand covered terrace deposits the following section was exposed in the SE. 1/4, sec. 24, T. 4 N., R. 12 W.

Section of Pleistocene beds exposed in SE. 1/4 sec. 24, T. 4 N., R. 12 W.

	Feet
Loess, brown without fossils	4
Loess, yellow, fossiliferous	3
Clay, fine, with concretions	2

The fossils listed below were collected from the yellow loess at this place, the top of which was about 440 feet above sea level.

Fossils from yellow loess in SE. 1/4 sec. 24, T. 4 N., R. 12 W.

Succinea avara Say

Pyramidula shimeki Pilsbry

Bifidaria armifera Say

Pomatiopsis lapidaria Say

Lymnaea desidiosa Say

The following species of fossils were found in the yellowish gray loess beneath 9 feet of brown loess, in the south bank of Embarrass River at Lawrenceville:

Fossils from lower loess in south bank of Embarrass River at Lawrenceville.

Succinea avara Say

Polygyra multilineata Say

Polygyra hirsuta Say

Polygyra fraterna Say

Pyramidula shimeki Pilsbry

Circinaria concava Say

Helicina occulta Say

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On the east side of Chimney Hills, along the wagon road between sections 31 and 32, a few feet of yellowish-gray loess containing fossils similar to those listed above is exposed near the top of the hill and continues down the slope nearly to the floodplain. This yellowish-gray loess is overlain by a thickness of 5 to 8 feet of yellowish-brown pebbleless clay such as covers the surface of the uplands over the greater part of the quadrangles.

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A similar exposure of loess occurs along the wagon road in the NW. 1/4 sec. 18, T. 1 N., R. 11 W., where a bed of gray to yellow, fossiliferous loess, 5 feet thick, is overlain by a thickness of 6 feet of brown clay, containing no pebbles or fossils, such as generally covers the surface of the uplands. A bed of yellow fossiliferous loess underlying a few feet of brown loess is also exposed near the middle of W. 1/2 sec.10, T. 4 N., R. 12 W., and again near the middle of the E. 1/2, sec. 2, and near the middle of the E. 1/2 sec.24 of the same township.

The yellow, fossiliferous loess that in places in this region immediately overlies the Illinoian drift resembles the typical loess of northern and western Illinois, where it is in many places separated from the underlying Illinoian till by a peat bed or old soil horizon, and is thought to be chiefly of Iowan age. The overlying brown non-fossiliferous loess which generally covers the Illinoian till over the uplands of this region is thought to be in part of Iowan, and in part of later age. The brown color and lack of fossils is thought to be due to the slow rate of accumulation of this deposit, thus permitting more complete oxidation and leaching of this material than occurred in the underlying yellow loess which is present only in places exceptionally favorable for such accumulation as shown by the greater thickness of the deposit where it is found.

Mode of Accumulation - The homogeneous, well-sorted character of the loess indicates that it has been transported and deposited by either wind or water, for no other geological agent is capable of so thoroughly sorting the material it deposits. The general distribution of the loess, that being thicker on the hills bordering the larger streams than over the lowlands, and especially thick on the tops of the hills bordering the windward side of valleys; the usual lack of stratification or lamination of the loess deposits; the vertical distribution or range in elevation of the loess that is present on the tops of the highest hills as well as in places over the lower slopes and lowlands; and where it is well developed, the presence in the loess of entire shells of species of air-breathing gastropods that now live

on relatively dry woodland hills, - all these are strong evidences that most of the loess in the Mississippi Valley was carried and deposited by the wind rather than by water.

Source.- The local peculiarities of loess distribution, being thickest on the bluffs bordering the larger streams and especially upon the hills on the east side opposite the direction from which the prevailing winds blow, is such as to indicate that a large part of this material has been immediately derived from the river flood plain which during times of drought are at present productive sources of dust. A large part of the loess material carried for a distance by the wind and dropped in places not well covered with vegetation was doubtless picked up and carried forward some distance an dropped again, and again, until much of it is now a long distance from its original source.

Another possible source of a small part of the lower portion of the loess is the boring of earthworms by which fine material from the underlying till was brought up to the surface, the aggregate results of their work during the time the loess was accumulating to the limits of depth of such borings, may have been of appreciable amount. Animals in making their burrows would also bring up from lower levels some of the material now found in the lower part of the loess. However, it is thought that no very important part of the loess was derived from the underlying drift by the activity of such animals.

Wisconsin Terrace Remnants

Discontinuous areas of sand and gravel occur over the broad river flats in this region, and represent a filling of the

valleys of the Embarrass and Wabash rivers to a height of 10 to 15 or more feet above the present level of the floodplains. The materials range in size from coarse sand to pebbles mostly less than two inches in diameter. These coarse deposits are worked as gravel pits in several places in the area.

This material is thought to have been deposited along the valleys of the loaded streams that drained away from the front of the Wisconsin ice sheet during the time the margin of this glacier extended southward within the drainage basins of these streams. Since the Wisconsin ice sheet melted from the region the rivers have carried less sediment, and hence have developed their floodplains at a level several feet lower than the top of the Wisconsin valley filling, a few remnants of which are all that are left.

Dune Sand

The most conspicuous dunes of sand in the Hardinville and Birds quadrangles cap the bluffs bordering each side of Wabash River. In this region, as also farther south, the valley of the Wabash is generally bordered on the east to a width of one to four miles by sand dunes. Most of these, however, lie east of the border of the area. On the west side of the Wabash sand deposition has been much less extensive. An important sand dune area occurs in secs. 3, 4, and 5, T. 6 N., R. 11 W. Loose sand also covers the tops of the hills in sec. 11 of the same township, in sec. 32, T. 6 N., R. 10 W., in secs. 17, 18, 29, and 31, T. 5 N., R. 10 W., and also in secs. 8, 9, 11, and 12, T. 4 N., R. 11 W. The summits of these dunes are usually higher than the upland surface 2 or 3 miles back from the river.

Besides the sand dunes that occur on the bluffs smaller areas of low dune-like hills are in places present on the flood plain of the river. Most of these dunes are elongated in a north-south or northwest-southwest direction and are irregularly arranged. The most conspicuous dunes east of the river are in sec. 5, 6, 8, 9, 10, and 15, T. 6 N., R. 10 W., and in secs. 6, 21, 22,27, and 34, T. 5 N., R. 10 W. West of Wabash River the largest dunes are in secs. 13, 16, 17, 18, and 19, T. 4,N., R. 11 W. A thin veneer of sand is usually present above the patches of gravel that form terrace remnants in several places near the south border of the Birds quadrangle.

The most important areas of wind-blown sand in the Hardinville quadrangle border the east and west sides of North Fork of Embarrass River in Willow Hill and Sainte Marie townships.

The sand is composed chiefly of quartz grains, which are commonly yellow to brown, and of medium size though not at all uniform. The sand rarely shows any signs of stratification. It is more recent than the Illinoian till, but is not all of the same age. A part of the sand was more recently deposited than the main bed of loess for in places on the hills sand overlies the lower yellow loess. A part of it is younger than the Wisconsin terrace deposits for in many places small sand dunes stand on the gravel terraces over the flood plains of the Wabash and Embarrass rivers.

The position of sand dunes on the flood plains and on the bordering hills; their relation to broad areas of flood plain; their grains composing them, which resemble the particles of intermediate size among the constituents of the alluvium; and

the fact that they are much the best developed on the east side of the valleys or flood plains, indicates that the sand was gathered chiefly from exposed portions of the flood plains and terraces in times of drought and was transported and deposited by the prevailing westerly winds on the obstructing hills, where the velocity of the wind was checked, and where a covering of vegetation may have furnished permanent lodgment for the load that was dropped.

Alluvium.

Alluvium forms the flood plains of all the larger streams of the area, the most extensive being the valleys of Wabash and Embarrass rivers. Smaller areas occur along the larger tributaries and bordering the lower courses of almost all the smaller creeks of the area. The alluvium consists of stratified beds of silt, sand, and gravel, clay and occasional areas of muck. The larger streams of this region are at present adding to the alluvium during every season of high water, but their gradients are so gentle that only fine silt is generally being laid down, and a very large percentage of the mineral carried by the streams is in solution.

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Wabash River at Vincennes carries an average of 336 parts per million of mineral matter in solution compared with 193 parts per million carried in suspension, or nearly twice as much mineral matter is carried by the Wabash in solution as in suspension. Embarrass River at Lawrenceville carries on an average 283 parts of mineral matter per million in solution compared with only 66 parts per million in suspension, or more than four times as much mineral matter is carried in solution as in suspension by this stream.

A zone of muck or black clay is often found above Illinoian till at a depth of 10 to 30 feet below the present surface. This muck is thought to have been formed in shallow depressions in what was the surface of the region during the Sangamon interglacial stage, and the alluvium 10 to 30 feet thick which overlies these muck deposits has probably been laid down during post Sangamon time, probably in large part during the time of great aggradation of the larger stream valleys, when the margin of the Wisconsin ice sheet stood not many miles to the north and northeast of this area.

During the time of greatest aggradation of the streams on late Wisconsin time the river flat of the Wabash and Embarrass, in this region was several feet higher than the level of the floodplain of the present streams as shown by the hieht of the gravel terrace remnants in their valleys. The filling up of the valleys to such a height caused the silting up of the lower courses of the streams tributary to the Wabash and Embarrass to a corresponding height. Since the Wisconsin ice sheet withdrew from the drainage basins of these rivers, their waters have been burdened with a much lighter load of sediments and have been able to gradually lower their channels to their present level. At the same time the tributary streams began to lower the portion of their channels adjacent to the rivers to a corresponding level, and since then have continued the headward development of this lower channel within the wider, higher level flood plain of the valley. Raccoon Creek has developed a channel several feet wide about 10 feet below the level of the main flood plain, as far

north as the middle of section 8, T. 2 N., R. 12 W. In a similar manner Crawfish Creek has cut a narrow channel 6 or 7 feet below the main flood plain as far north as the middle of the north half of sec. 20, T. 1 N., R. 12 W.

Towards the mouths of the tributaries where the lower channel has been developed to a considerable width, the latest deposits on the surface of the lower flood plain are of practically the same age as the uppermost deposits of alluvium on the higher flood plain bordering the lower channel and headward in the valley above the place where the lower channel has been developed. The lower channels are not sufficiently wide to hold the water of the streams during time of flood, consequently the surface of both the high-and the low-level flood plains receive a deposit of silt during every time of high water. Hence, the alluvial deposits of the low-level flood plains are all of post Wisconsin age, while all but the upper part of the alluvium of the higher level flood plains are probably of Wisconsin age, an undetermined thickness in the upper part being post Wisconsin.

The natural levees consist of slight embankments of mud, sand and fine gravel formed in some places along the banks near the channel of Embarrass River during times of overflow and to a less extent along the channel of the Wabash. The deposit is made where the current of the overflowing river is first checked by the shallowness of the water on passing outward from the channel of the stream. Such a bank is present to a height of 2 to 5 feet south of the Embarrass river in the east half of the Hardinville quadrangle, and north of the river in the west part. These

probably represent the most recent deposits in the area except the upper veneer of alluvium and some of the swamp deposits.

Swamp Deposits

In the areas of swamp land and ox-bow lakes, and ponds that are found on flood plains of the Wabash, Embarrass, and North Fork. There are accumulating deposits of vegetable matter miggled with river silt that is spread over the bottom land during periods of overflow. These deposits are in places several feet deep, dark colored from the organic content, and when properly drained make the most fertile soil in the quadrangle.

Structural Geology

General Relations

In southeastern Illinois the layers of rock ~~generally~~ have a general westward slope of 20 to 60 feet per mile into the Illinois basin. The deepest part of this basin extends about on a line through the towns of Cerro Gordo, Lovington, Olney, and southward, the deepest part being in Wayne, Hamilton, and Edwards counties. The Hardinville quadrangle is situated on the east side of the basin not far from its center in a north-south direction in a region where the strata have been uplifted along a more or less definite anticline supposed to be continuous with the La Salle anticline in the northern part of the State at La Salle. The crustal movement has been sufficient in places to distort the strata from an approximately horizontal plane in which they were deposited into an anticline of considerable magnitude having a northwest-southeast trend of about N. 31°W. and pitching gently toward the south. This zone of disturbance extends parallel with

and east of the deepest part of the Illinois basin and crosses near the middle of the Hardinville quadrangle in a nearly north-south direction. The Birds quadrangle, with the exception of its southwest corner, is east of the disturbed area.

A detailed study of the structure of the oil sands of the quadrangle has shown that the older and deeply buried beds are distincly more folded than the younger rocks nearer the surface, including those as low as the Herrin (No.6) coal. The non-parallelism of the beds is due probably largely to the effect of folding during or at the close of Mississippian time, followed by partial erosion of the folded strata, and later by the deposition of the Pennsylvanian beds, and further slight deformation at the end of the Pennsylvanian period, and possibly, by a minor amount of folding during that period.

Birds quadrangle

As far as can be determined from outcrops of Pennsylvanian rocks in this area, the strata are more or less undulating, but the structure is not dominated by any distinct fold or definite uplift. In the southern part of the Birds quadrangle these upper rocks have a slight southward dip, as shown in the fact that where the calcareous, fossiliferous zone below the Parker coal outcrops one-half mile south of Palestine, the altitude is about 440 feet, and strata corresponding to this horizon are exposed 9 miles farther southwest, 2 1/2 miles south of Flat Rock, at an elevation of about 444 feet, being nearly level between these points, whereas a similar horizon outcrops 10 miles still farther south in the east bank of Embarrass River one mile east of Lawrenceville, at an altitude of about 422 feet.

The limestone above the Parker coal also shows irregularities of dip and in places a northward slope, as is indicated by the elevations at the following places:

	Feet
1/2 mile south of Palestine.....	464
sec.35, T. 6 N., R. 11 W.....	481
NW. corner, sec.26, T. 5 N., R. 11 W.....	516
Center east side sec.7, T. 6 N., R. 10 W.....	499
2 1/2 miles farther west.....	464
sec.35, T. 6 N., R. 11 W.....	481
Near Flat Rock.....	483
2 Miles north of Flat Rock.....	508

A slight arching of the strata in a northeast-southwest direction appears to be present about 2 miles north of Flat Rock. A low dome is also indicated in sec. 22 and 23, T. 5 N., R. 12 W.

Computations on the elevation of the Herrin coal in this region also show general irregularities of dip rather than a strongly dominant anticlinal structure. The dip of the coal in this region thus appears to be in general toward the north and east at a gradual but probably not uniform rate, as shown by the following drilling data:

Location	Elevation of coal Feet
Center sec.21, T. 5 N., R. 11 W....	-26
Siler well, 7 miles west and 3 miles north	+ 9
11 miles south of Siler well.....	+15
10 miles west of Siler well.....	-50
14 miles northwest of Siler well.....	-35

Comparatively few wells deeper than the Robinson sand horizon have been drilled in the Birds quadrangle, consequently, the discussion of the structure of the deeper rocks is based on only a few scattered records. The available data indicate that

a comparatdvely sharp monocline extending southeastward from the western edge of the map at about latitude 38°50' to near the center of the south line of the quadrangle separates a low basin on the southwest, occupying all the southwest corner of the quadrangle from a relatively high, nearly flat area which occupies all of the quadrangle north and northeast of the monocline. This monocline, is withoug doubt, a continuation of the one recognized in the Hardinville quadrangle as bounding the Robinson oil pool on the west.

The facts on which the preceding summary statement of the structure is based are as follows: In the southwestern corner of the quadrangle at least 6 deep wells have been drilled. In one of these near the south center of sec. 22, T. 4 N., R. 12 W., a sand, probably the Kirkwood, lying beneath two beds of red shale, was encountered at a depth of 240 feet above datum, or 1,260 feet below the sea. Another well, near the center of sec. 25, T. 4 N., R. 12 W., penetrated to a depth of 1, 892 feet, or 30 feet above datum, and ended in a sand, probably Kirkwood. The top of the Ste. Genevieve formation or "big lime" was not reached in either well. To the north of the assumed line of monoclinal folding every well of which a record is avilable penetrated the "big lime" at elevations between 400 and 490 feet above datum. The locations of these wells with the elevations, above datum, of the top of the "big lime" (Ste. Genevieve) are tabulated below. The first in the list is only 3 3/4 miles north of the well in sec. 25 already mentioned, which at 30 feet above datum was still above the Ste. Genevieve.

	Feet above sea level
NW. 1/4 sec. 8, T. 4 N., R. 11 W.	400
NW. cor. sec. 11, T. 4 N., R. 11 W.	430
NE. 1/4 NE. 1/4 sec. 31, T. 5 N., R. 10 W.	435
SW. cor.NE.1/4 sec.3, T.5 N., R. 12 W.	460
NW. 1/4 sec.14, T. 6 N., R. 12 W.	490

These figures indicate that north of the monocline, the Mississippian rocks lie approximately flat, but have a slight dip toward the east or southeast.

The data yielded by the wells which penetrate the Robinson sand in the Birds quadrangle prove that sand to lie essentially flat over the entire northern two-thirds of the area. Inasmuch as the exposed Pennsylvanian rocks reveal only slight irregularities in structure, whereas the Mississippian rocks show differences in elevation of over 400 feet in the southern part of the quadrangle, the existence of a great unconformity between these series is very clearly indicated.

The absence in the wells which reveal the "big lime" at elevations of 400 feet or more above datum, of recognizable representatives of any but the basal rocks of the Chester group, indicates that the major unconformity is between the top of the Mississippian series and the base of the Pennsylvanian series. This interpretation harmonizes with the evidence of unconformity at this horizon yeilded by the fact that south of this area, in the southern part of the Vincennes quadrangle the thickness of the Chester beds occupyáng the interval between the "big lime" and the base of the Pottsville increases, wedge-like, toward the south.

Hardinville quadrangle

General features - The structure of the Hardinville quadrangle is known only where it is revealed by well drillings. These are confined almost exclusively to the eastern half of the quadrangle. The dominant structures thus revealed are a broad, flat area in the northeast corner of the quadrangle nearly co-extensive with the Robinson oil pool, along the western margin of which is a more or less uniform dip to the southwest at the rate of about 80 to 100 feet per mile; a broad flat depression along Embarrass River; and a well-defined, elongated dome or anticline in the southeastern corner of the quadrangle. The area of greatest uplift is in the NE. 1/4 sec.30, T. 4 N., R. 12 W., near the southeast corner of the quadrangle. The maximum known dip on the flanks of the anticline is 260 feet per mile. The known width of the anticline is about 3 miles, and the length of the distinctly arched structure within the quadrangle is about 6 miles, but it extends south into the Sumner and Vincennes quadrangles.

The "lay", or structure, of the deeply buried strata of the deep oil pool at the southern end of the Hardinville quadrangle is shown on the structure map by contour lines of 20-feet interval drawn through points of equal elevation on the upper surface of the Kirkwood oil sand or, where this sand is lenticular, on the top of the sand zone as nearly as this could be determined from the records of oil drillings. These contours are based on an assumed datum plane 1,500 feet below sea level, in order to avoid the confusion likely to arise from the use of minus signs before the numbers on the contours. The contour numbers were secured by adding the datum interval 1,500 feet, to the elevation of the

mouth of each well and subtracting from this the depth to the top of the producing sand. The mental picture of the surface of the sand is made clearer by realizing that each contour interval measures a vertical distance of 20 feet. Changes in the dip of the beds are shown by variations in the horizontal distances between the lines on the map. The dip is steepest where the contour lines are closest together.

Crawford County Portion.- It has not been found practicable to represent by contours the structure of the top of the Robinson sand on account of the extremely lenticular nature of the sand. The western margin of the Robinson oil pool along the line from Oblong southeast to Bottoms School in the NE. corner sec. 11, T. 5 N., R. 13 W., is clearly determined by a monoclinal dip of the strata to the southwest along this line. The dip where measured ranges between 50 and 125 feet per mile. Only the outer wells in the field reveal the dipping strata. How far to the southwest the dip continues is not known. The top of this monocline appears to be almost perfectly flat. Scattered data on the fossiliferous limestone overlyingcoal No.6 indicate differences in elevation of not over 50 feet in eight or ten miles. These slight differences have not been discovered to belong to any definite system. The data on the Robinson oil sands yield little of value in determining the structure where the dip is so low, because the irregularities in the thickness of the sand and the irregularities due to the impossibility of definite correlation of the various lenses within the Robinson horizon are greater than any possible variation due to undulating structure or to slight arching or folding. The distinct

western slope of the monocline has not been definitely located southeast of Bottoms School. The southern limit of the productive oil pool in secs. 7 and 8, T. 5 N., R. 12 W., appears to be due to the character of the sand rather than to structure.

Lawrence County Portion.- The structure of the Lawrence County portion of the quadrangle is shown by the contours drawn on the top of the Kirkwood oil sand. The north end of the deep oil pool near the county line and in secs. 25, 26, 35, and part of 36, T. 5 N., R. 13 W., and sec. 30, T. 5 N., R. 12 W., is marked by nearly flat-lying strata. They seem to represent a very low fold which, in a cross-section of the explored portions extending along the south line of secs. 25 and 26, shows a relief of less than 40 feet. The axis of this portion of the fold plunges toward the north at a rate not exceeding 30 feet per mile. From the north end, the axis of the dome rises almost uniformly at an average rate of about 30 feet per mile to its highest point in sec. 30, T. 4 N., R. 12 W. As the axis rises toward the south the flanks become more clearly defined and steeper. In the extreme southeastern corner of the quadrangle the anticline is very distinctly developed. Its crest rises at least 300 feet above the lowest explored points on its sides. The dip averages about 205 feet per mile, the quadrangle on the south end being somewhat steeper on the east side. At the north end of the dip averages 150 to 175 feet per mile. The crest of the arch for a width of about one mile is relatively flat. To this fact is ascribed the apparent flatness of the strata at the extrememnorthern end of the oil pool. It is probable that this northern end is merely a continuation of the flat crest of the arch which, on account of its northward plunge, does not expose

its flanks at this point. It is possible, however, that the apparent flattening represents an actual dying out of the fold. The relation of the fold to the monocline north of Embarrass River is not definitely known.

Vincennes Quadrangle

In the Vincennes quadrangle the structure of that portion of the Pennsylvanian rocks that lie near the surface has been determined by observations on the calcareous and fossiliferous zone below the Parker coal. Across the north end of this quadrangle the strata lie nearly horizontal, as indicated by exposures south and northwest of Vincennes, one mile east of Lawrenceville, and at Lawrenceville. Farther west, near Olney, across the north end of the Sumner quadrangle, this horizon outcrops at an elevation about 25 feet higher than at the exposure at Lawrenceville. At the south end of the Vincennes quadrangle, between Dicksburg Hills and the west bank of Wabash River 5 miles farther west, the strata dip westward about 40 feet, or about 8 feet to the mile. In a north-south direction, between Vincennes and Dicksburg Hills the strata dip southward about 50 feet, or about 5 feet to the mile.

The structure of the Vincennes quadrangle represents a broad flat crest of the LaSalle anticline, which has the appearance of an extensive terrace. It is 8 miles long and about 3 3/4 miles wide. The dome-like structure in the adjoining quadrangles merges into a mild trough in section 3, 9, 10, 15, 21, and 22, T. 3 N., R. 12 W. Except for a mild dome about 60 feet high through sections 23, 26, 27, 34, and 35 of the same locality(fig.8) the sand lies at a rather uniform level about the 400 foot contour.

To the west and south the rocks dip down steeply in a monoclinal fold extending southeastward from the western border of the quadrangle in sec. 21, T. 3 N., R. 12 W., and passing through sec. 20, T. 2 N., R. 11 W., under St. Francisville. Except near the western border of the quadrangle, where the lower limits of the fold are not known, the monocline flattens out within a distance of one or two miles and merges into a flat-lying terrace or basin which underlies the southern and southwestern parts of the quadrangle, and in which the rocks are about 400 feet lower than on the anticline at the south end of the main oil field. A minor arch in this low-lying area has permitted the accumulation of oil in the Allendale field, and a flat terrace at the base of the monocline seems to be the controlling factor in the St. Francisville field.

The eastern flank of the principal anticline dips much less steeply than the western. From the crest there is an eastward dip of about 40 feet in a distance of two miles, beyond which the rocks flatten out and the average dip, as indicated by well records, does not exceed 10 feet per mile. On this flat eastern limb of the anticline, or, more strictly, monocline, small local domes 20 to 60 feet in height have been discovered to be responsible for outlying oil pools such as that 1 1/2 miles northwest of Billett and the Murphy pool.

It is probable that a second monocline crosses the northeastern corner of the quadrangle in a northwest-southeast direction, entering from the Birds quadrangle, but there are not sufficient data to prove conclusively its existence.

Sumner Quadrangle

In the northeast part of the Sumner quadrangle the lay of the lower Pennsylvanian rocks has been determined from the depth to the oil sands in the numerous oil wells. In the west-central part of the area, where the Aldrich coal can be observed in frequent outcrops and is reached in several water wells, the dip of the strata can be rather accurately made out. In the southeast quarter of the quadrangle where the Friendsville coal lies near the surface the structure can be ascertained by using this as the key stratum. In the northwest portion of the quadrangle frequent outcrops of any easily recognized stratum are wanting and the structure is not so definitely known. By combining the observations based on these separate beds in different areas the structure can be worked out for the greater part of the quadrangle.

In the central one-third of the west half of the area the Aldrich coal dips towards the west from an altitude of 502 feet, one-half mile west of center school in the NW 1/4, sec. 32, T. 3 N., R. 13 W., to 455 feet in the vicinity of Bonpas Creek 4 1/2 miles farther west, reaching as low as 449 feet near the middle of the south side of sec. 16, T. 2 N., R. 14 W. The westward dip in this region being about 11 feet to the mile. West of Bonpas Creek the coal rises to 472 feet near the west border of the quadrangle in sec. 8, 17, and 35, T. 2 N., R. 14 W., at the rate of about 12 feet to the mile.

A southward dip of 2 feet to the mile is also indicated in this region between the southwest corner of sec. 33, T. 3 N., R. 14 W. where the elevation of the coal is 455 feet and the middle of the south side of sec. 16 T. 2 N., R. 14 W., 3 miles farther south, where the altitude is 449 feet. The sandstone exposed in the west bank of Bonpas Creek, in the SE 1/4 of sec. 9, T. 3 N., R. 14 W. also dips

southward at a low angle.

In a mine operated by A. B. Kern one mile east of Friendsville the altitude of the Friendsville coal is 432 feet. The level of the coal in the mine rises and falls considerably but the main dip and drainage is towards the west at the rate of about 1 foot in a distance of 20 feet. In a mine on the Price farm one mile north of the Kern mine the elevation of the coal is 400 feet, showing a northward dip of 32 feet to the mile between these places. A slight northward dip is also shown by a drilling in the NW 1/4, sec. 33, T. 2 N., R. 12 W., which found the Friendsville coal at an altitude of 466 feet, while three-fourths of a mile south of this place the coal outcrops at an altitude of 470 feet. In a well near the middle of the west side of sec. 25, T. 2 N., R. 13 W., three miles west of the drilling in sec. 33, the coal was found at an altitude of 420 feet, indicating a dip towards the west of about 15 feet to the mile. In a well one mile north of the latter locality the coal was also found at an elevation of 420 feet, and one mile farther east it was reached at an altitude of 428 feet, showing a westward dip of 8 feet between these points. In an old quarry 1/2 mile south of Linn, the strata dip mainly towards the west but also incline a little northward.

An exposure of coal and sandstone, dipping slightly south and east, occurs near the middle of the S 1/3 of sec. 22, T. 2 N., R. 13 W. A slight anticlinal structure appears to be present in the prominent hills in the south central part of the quadrangle, but in places farther north in sec. 13, T. 3 N., R. 13 W., the dip of the strata is mainly westward.

From rock exposures and from data on the coal encountered in water wells it is known that their are many irregularities in

direction and amount of dip in this region, but these irregularities do not extend for any considerable distances and do not greatly affect the main southward or south dip of the strata in the quadrangle.

None of the coal beds, or other easily recognized stratum, is found in outcrops and in shallow wells, over such a large part of the area that it can be used as a datum or key horizon for the construction of a general map showing the structure of the rocks in the Sumner and Vincennes quadrangles. For the northeast part of the Sumner area, where numerous oil drillings have been put down, such a map has been made, based on the elevation of the Kirkwood sand in the different oil wells.

The structure of the Kirkwood sand in the Sumner quadrangle represente the southeastern extension of an elongated dome, the northern part of which extends about 8 miles in a northwest direction into the Hardinville quadrangle. The dome in the Sumner area is about three miles long and 2 1/2 miles wide. South of the dome the dip of the formations is arrested by a broad, irregular flat which covers most of the oil fields of the Vincennes quadrangle and its northern and northwest edges overlap the east side of the Sumner quadrangle. The strata dip to the west along the north boundary at the rate of about 225 feet per mile and to the east, about 150 feet per mile. The dip from the crest of the dome southward to the flat is about 65 feet per mile.

VI. GEOLOGIC HISTORY

Paleozoic era

Only the later events of the geologic history of the Hardinville, Birds, Sumner and Vincennes quadrangles can be deciphered

from the rocks exposed at the surface. The record of the early Paleozoic periods is obtained through a study of the logs of deep borings in this area, and are inferred from studies in other areas in this general region. The processes that operated in the quadrangle affected also an extensive area surrounding it, and hence much of the history of the quadrangle is contained in the more complete record of the larger province of which it is a part.

During the Paleozoic era the area comprising the State of Illinois was alternately submerged in an epicontinental sea, and elevated so as to form a part of the land mass of the Continent. During the periods of submergence the shores of the interior sea varied widely at different times and shifted greatly during a single period. In these seas there accumulated beds of more or less comminuted marine shells and layers of mud and sand which, by pressure of overlying strata and through cementation by calcium carbonate and iron oxide deposited from percolating water, became consolidated into beds of limestone, shale, and sandstone. During the successive periods of emergence the surface was subjected to erosion, and consequently the Paleozoic succession of this region shows numerous breaks in sedimentation which are recorded in erosional unconformities. Since the end of the Paleozoic era, the surface of this region has been continuously above the sea.

Ordovician period.

The oldest strata encountered in borings in the Mississippi Valley accumulated in the sea during a period of widespread submergence. During this time the bordering lands were low and waters clear, and the thick "Lower Magnesian" or Prairie du Chien limestone was laid down over the entire state. Deep borings in this region

have penetrated the Prairie du Chien limestone to a depth of 377 feet without reaching the base of the formation. This deposition was closed by an extensive emergence during which erosion channels were in places cut to a depth of 100 or more feet into this limestone before the succeeding strata were deposited.

During the next submergence the streams that drained the bordering lands brought into this basin large quantities of sand which the waves sorted very perfectly and spread widely over the sea bottom. In this manner was laid down the St.Peter sandstone, having a thickness in this region of 70 feet. Following the deposition of the St.Peter sandstone the epicontinental sea became clear and conditions for a long time were favorable for the growth of marine organisms secreting calcareous shells. From the shells of successive generations of these animals a bed of limestone, 370 or more feet thick, belonging to the Mohawkian epoch and corresponding to the so called "Trenton limestone" of Indiana, was accumulated. This limestone deposition was brought to a close by an emergence whith persisted until lake Cincinnatian (Richmond) time when the shallow sea again advanced and submerged this area. These waters unlike those which preceded them were turbid and in them the Maquoketa shale with a total thickness of some ------ feet was deposited. It is possible that slight upbowing of the La Salle anticline took place at this time and that this newly raised axis farther to the north may have remained above the sea thus forming a portion of the barrier between the Richmond sea of Indiana and the Maquoketa sea of Illinois.

Silurian period

The LaSalle fold in this region is thought to have been present as a barrier between the Illinois and the Indiana basins of deposition during early Silurian time, until the close of the Brassfield epoch. During the middle Silurian submergence which was widespread, and long continued, there were deposited the Niagaran limestones of the Mississippi valley, which were subsequently changed to dolomite, and which in this region have a thickness of 370 feet, and rest unconformably upon the Trenton limestone.

Devonian period

Deposition of the Niagaran limestone was closed by the withdrawal of the sea, and land conditions prevailed over this region during the remaining portion of the Silurian period, and the early part of the Devonian. During middle Devonian time a relatively clear sea advanced from the northeast over this area in which was deposited 140 feet of limestone probably representing the Jeffersonville and Sellersburg limestones of Indiana, and the Onondaga and Hamilton limestones of the New York section. This limestone accumulation was followed by sea withdrawal and a considerable interval of land conditions. Succeeding this emergence, a muddy sea advanced over the larger portion of the state, and spread over the region a bed of dark, fine grained shale to a thickness of 100 feet or more, which contained great numbers of spores of some lycopodiaceous plants, indicating that land areas were present at no great distance away.

Mississippian period

Following the submergence in late Devonian time, land conditions prevailed over this region until the beginning of the submergence of the Mississippian epoch. In Kinderhook time the streams that drained the bordering lands carried to the sea considerable quantities of fine sand and clay. By the end of the Kinderhook, and during Osage time which followed, the sea was receding and becoming clearer so that the deposits of the Osage were largely limestones, the accumulation of which was closed by the withdrawal of the sea to the south of the region. When the next advanced during the Salem epoch it was very shallow and bordered by lands so low that they contributed but little sediment to the basin. In this shallow sea the Salem limestone, which in places consists mainly of oolite, was accumulated unconformably above the Osage. During the succeeding St.Louis epoch, limestone deposition persisted, and the sea in this region continued to deepen, and to extend farther northward, reaching as far as central Iowa.

At the close of the St.Louis epoch the Mississippian sea withdrew from the upper Mississippi Valley to some extent and shoaler condition prevailed throughout the Ste. Genevieve epoch. In these shallow waters conspicuously oolitic limestone accumulated, similar in many ways to that of the Salem. The Ste. Genevieve Epoch was terminated by a complete withdrawal of the sea and the recently submerged area of Illinois and adjacent states again became land and was subjected to mild erosion.

This period of emergence however was succeeded by another of deposition. The Chester ~~area~~ seas which advanced at this time

were rather unstable and constantly shifting their borders. A systematic series of advances and retreats occurred so that at times clear seas deposited limestone while again temporary withdrawal caused this area to become part of the land and be subject to slight erosion. Between these extreme stages clastic deposits were formed and the whole succession of sedimentation during Chester time produced a series of alternating sandstone and shaly clacareous formations.

Pennsylvanian period

The withdrawal of the sea in which the Chester beds had been deposited closed the sedimentation of the Mississippian period in this region was attended by important uplift along the La Salle axis, following which land conditions prevailed over the state for a long time, during which the surface became so trenched with stream channels as to develop considerable relief.

During Pennsylvanian time, the region was in general gradually subsiding, for, while the deposits were laid down in shallow water, at times a little above and at other times a little below sea level, the aggregate thickness of these strata is many hundreds of feet, and when the youngest were laid down the oldest must have been far below the level of the sea.

Pottsville epoch.

The invasion of the Pennsylvanian sea which, advancing from the south, transgressed older formations over extensive areas in the northern part of the Mississippi valley, was initiated by slight warping movements. The early deposits of this time consisted of sand and mud which were spread over the uneven surface of older rocks and now form the sandstone and shale of the Pottsville formation. Early Pottsville sedimentation in Illinois was for a long

time confined to a rather narrow area west of the La Salle anticline and in the southern part of the state. As erosion of the lands progressed, probably accompanied by warping movements, the sea gradually advanced northward and spread further eastward and westward. The probable source of the great volume of coarse sediments of the Pottsville formation in this region, was in part the sandstones of the Chester group which formed the lands on the west of the basin, and which bordered the sea on the north until it had advanced northward beyond the limits of the quadrangles, and in part the exposed areas of sandstone and crystalline rock farther north in Minnesota and Wisconsin. Layers of carbonaceous material interbedded with the Pottsville sandstones indicate the existence of shallow fresh water marshes in which vegetable matter accumulated to such depth as to form beds of coal fromaa fraction of an inch up to two feet in thickness.

Carbondale epoch

During the Carbondale epoch, which succeeded the Pottsville the region was at times beneath the sea and receiving deposits of shale, sandstone and limestone, and at other times slightly above sea level. The surface remained so low and flat that at different times shallow swamps covered extensive areas, and received accumulations of vegetable matter which were subsequently transformed into coal.

At the beginning of the Carbondale epoch this area was a part of a shallow marsh which covered most of southern Illinois and in which the vegetable matter of the Murphysboro coal accumulated to a thickness of several feet. This accumulation was stopped by movements that permitted beds of sand and mud to be

spread over the former marshes. Sedimentation continued with occasional development of peat marsh conditions until late in the epoch when shallow swamp conditions were developed over thousands of swuare miles in western and southern Illinois, wouthwestern Indiana, and western Kentucky, in which the material that formed the Springfield coal was accumulated. This long period of vegetable accumulation was closed by a subsidence of the Illinois basin permitting a shallow sea to again invade the region from the south. As the sea advanced over the swamp deposit the waves worked over the upper surface of the vegetable accumulation, comminuting the material and mixing it thoroughly with the fine sediment derived from the bordering lands, and finally depositing it in thin laminated bands of black carbonaceous clay. As the thickness of this black clay deposit increased the waves were not able to reach such large amounts of vegetable material and conditions became more favorable for the growth of marine organisms and for the preservation of calcareous shells that were buried in the sediment, and at length a thin bed of argillaceous limestone was laid down above the black shale. This was followed by the deposition of sand and mud until near the close of the epoch when extensive shallow peat swamp conditions again prevailed for a log time over the Eastern Interior provicne, and the vegetable material which formed the Herrin coal was accumulated.

It is thought that at the beginning of accumulation of the vegetable matter of the coal beds the swamps were very shallow, and that they deepened so slowly either by subsidence of the area or from the gradual building up of the border or outlet of the basin by sedimentation, or both, that the plants could usually

adjust themselves to the changes and the accumulation of the vegetable matter in a general way kept pace with the increasing depth. Throughout the entire period of accumulation of the coal beds the water of the swamps was so shallow that during the recurring cycles of drought successive levels of the vegetable mass were temporarily exposed, and the surface so modified by partial atmospheric decay as to result in the formation of dull laminae containing mineral charcoal, which so generally alternate with the bright laminae in the coal beds of Illinois.

McLeansboro epoch

At the beginning of the McLeansboro epoch the widespread vegetable deposits that had accumulated in this region in late Carbondale time were buried beneath a few inches of mud laid down in the sea that again advanced over the region from the south. Above this there accumulated a bed of limestone formed from the shells of marine animals. Following this limestone deposition there were laid down a few hundred feet of strata consisting of sandy mud interbedded with sand, with the accasional recurrence of limestone conditions. Fresh water marsh conditions were very much less extensive and of much shorter duration than during Carbondale time. The kind of sediments deposited at any place changed from time to time, and in different places in the Illinois basin emergence and erosion occurred at different times for a longer or shorter period during this epoch. The LaSalle anticline, especially in the south half of the quadrangle, was temporarily dry land at different times during the McLeansbororas well as at various times in the previous Carbondale epoch as shown by the fact that the coal beds do not appear to be continuous across the arch in that region, and the strata

thicken on the west side of the anticline towards the deepest part of the basin. Closing McLeansboro deposition the sea withdrew from the region the greater portion of which has not since been submerged.

Permian period

The record in this region of events during late Pennsylvanian and Permian time is not well preserved, but terrestrial conditions prevailed as is shown in the remnants of river-floodplain deposits occurring in Illinois and Indiana. About 75 miles north of the Sumner-Vincennes area there have been found bones of reptiles that were buried in the alluvial deposits of a stream that drained that region in late Pennsylvanian or early Permian time. This area has stood so low during the long interval between the Permian and the present that the surface has not been denuded to the depth of the old Permian river channels, and in such relations to surrounding lands that no sediments except glacial deposits were laid down over the surface.

Post-Paleozoic deformation

The Paleozoic era was closed by widespread movements which resulted in the uplift of the Appalachian mountains on the east, and the Ouachita mountains and Ozark dome on the west, and the further uplift of the La Salle anticline in eastern Illinois, which permanently banished the sea from the region. At this time also occurred the elevation of the Shawnee Hills across the south end of the state, west of Shawneetown, and the basin structure in southeast Illinois was developed. The general altitude of the surface which, previous, to these movements had stood not far from sea level, was increased to such an amount that the vertical movements subsequently occurring

in this region have to some extent affected stream erosion, but have not permitted invasion by the sea, and hence have left an obscure record.

Mesozoic era

After the elevation and deformation at the close of the Paleozoic era new processes were operative over the region, and the areas which previously had received rock material more or less interruptedly have since suffered almost continuous erosion to the present time, the rate of erosion in different places varying with the elevation which from time to time was increased by further uplifts. No record of general downward movements during this period has been preserved.

In the Appalachian mountains, and the Ozarks, important uplifts took place during this era some of which may have affected Illinois, though to a much less extent. Between the times of elevation the surface was more or less nearly base-leveled by long-continued erosion, the record of one cycle being partially or entirely destroyed by erosion during the next. All possible stages occurred in the process of base leveling, and the less complete the cycle of erosion the more easily was its record obliterated during the next period of peneplanation. In central Illinois the uplifts were slight and but little denudation took place, but in the northern and southern parts of the State, where the uplifts were more considerable, the tops of some of the hills of resistant rock appear to constitute remnants of two periods of peneplanation that occurred during this era.

Cenozoic era

Tertiary period

A new cycle of erosion in this region was probably initiated by an uplift early in Tertiary time, and before the close of this period the surface of this part of Illinois had become reduced to a nearly level plain. Near the end of the Tertiary period there was a general elevation of the land in the Missippi Valley which quickened erosion and permitted the streams to trench deeper their valleys. Well borings show that the larger tributaries to the Wabash in the Sumner and Vincennes quadrangles are flowing over pre-glacial valleys, now largely filled with drift and alluvium, that were eroded in late Tertiary time to a depth of 100 feet or more below the beds of the present streams, and in some places to a width of 2 to 8 miles.

The Wabash river in this region is flowing in a preglacial valley which was eroded more than 100 feet below the present flood plain and to a width of 5 to 10 miles. The course of the present Embarrass river between Newton and Lawrenceville is determined largely by a preglacial valley which in the east half of the quadrangle was cut to a depth of nearly 125 feet below the bed of the present stream and to a width of 2 to 4 miles, as shown by the logs of numerous oil wells in this part of the area. Honey creek follows a pre-glacial valley which is filled with drift to a depth of 75 feet. Brushy creek and Lamotte Creek also follow valleys which in pre-Illinoian time were much wider and deeper than the valleys of their successors. Farther west Big Creek follows a preglacial channel, the bottom of which in a

boring one mile southwest of Stoy was found to be one hundred feet below the bed of the present stream. On the divide that separates these old channels the rock surface is 160 feet higher than the bottoms of the preglacial valleys. The North Fork of the Embarrass is also following an ancient channel which was very much lower than that of the present stream.

The course of the present Embarrass river between Newton and Lawrenceville is determined by a preglacial valley which was carved in the Pennsylvanian rocks to a depth of about 100 feet below the level of the present flood plain. Indian Creek is following a valley in which the depth to bed rock in the vicinity of Bridgeport is about 90 feet. The rock valley at present occupied by Muddy Creek, north of Sumner, is at least 40 feet lower than the water of that stream, as is also the valley occupied by Crawfish Creek. Raccoon Creek is also following a valley eroded in pre-Illinoian time to a depth of at least 54 feet below the level of its present floodplain. In the lower course of the valley of Bonpas Creek bed rock lies more than 100 feet below the level of the water.

South of the Embarrass there were two prominent tributaries to the ancient river having the same general courses as (the present channels of) Muddy creek and the Slough. A well in the southwest corner of the S. W. 1/4 of the N W. 1/4 of sec. 6, near the present channel of the Slough, penetrated 100 feet of Pleistocene material before reaching bed rock.

The maximum known relief of the pre-glacial surface in this area was about 320 feet. The general topography of the region at that time was much as it is today, the valleys and divides having

a somewhat similar arrangement to those of the present but the relief was considerably greater, for the valleys were deeper and the divides were doubtless somewhat higher before the glaciers rubbed down the sharper prominences.

Pleistocene period

During the early part of the Pleistocene epoch erosion was active in this region as shown by the depth of the pre-Illinoian stream channels and the small amount of alluvial material that had accumulated in their valleys before the Illinoian drift was deposited. While the general features of this portion of Illinois were much as at present, they differed in certain important details. The surface forms of that time had been very largely produced by weathering and stream erosion, while the present features of the land were formed not only by the erosion of streams and glaciers but also by the deposition of a thick mantle of transported surficial material, a large part of which was brought to its present position by glacial ice and a smaller part by winds and by streams. The general effect of the action of continental glaciers was to rub down the sharper and more prominent elevations and to fill up the depressions, thus tending to smooth off the irregularities of the surface, while the immediate effect of valley erosion is to increase the relief.

Illinoian time

With the exception of the pre-Illinoian soil and gravel beds in this region a part of which was probably of late Tertiary age, the first known recorded event of the Pleistocene epoch was the advance of the Illinoian ice sheet. Earlier ice sheets, the Kansan and the Nebraskan (pre-Kansan) covered extensive areas in

the northern Mississippi valley, but no deposits representing either of these have been found in these quadrangles. It is possible that a part of the Illinoian till in this region was derived from an older till which was so completely worked over and incorporated in the later as to be no longer recognizable as a distinct deposit. The continental glaciers seem generally to have removed the upper few feet of loose material from the areas over which they passed, in many places taking all of it and even abrading the upper part of the underlying rock ledges. In other places, however, the ice sheet overrode the surface without greatly disturbing the surficial materials, and in some places even left the old soil undisturbed. In both the Hardinville and Vincennes quadrangles such a black muck or old soil layer was reported in a number of well records below a thickness of 15 to 18 feet of Illinoian till.

The Illinoian ice sheet moved outward from the Labrador center of accumulation, far to the northeast of Illinois. As it advanced it gathered up much of the loose material from the surface over which it moved, and mixed it thoroughly with other debris brought from a much greater distance. In this manner the till in Illinois came to consist of an intimate mixture of material derived from local sedimentary rocks and of debris derived from crystalline rocks brought from much farther northward. When the Illinoian glacier melted it left a mantle of till which buried the valleys and lower hills that had been developed in pre-Illinoian time, leaving the surface much more level than before.

When the preglacial channel of Embarrass River west of Lawrenceville became filled with Illinoian drift, the river was able to find a shorter outlet to the Wabash south of Lawrenceville

through the preglacial valley of Indiana creek, which it was unable to follow when it flowed at a lower level. Owing to the fact that the water of the Embarrass is in this region so near the level of that of its master stream, Wabash River, the Embarrass has not been able to lower this portion of its channel and develop terraces to any considerable extent since the withdrawal of the Wisconsin ice sheet. Consequently neither this river nor its tributaries have been able to trench very deeply or excavate very widely this valley filling, and thus develop very prominent terraces along their valley sides.

Sangamon time

The melting of the Illinoian glacier was the result of a climatic change and was followed by a long interval during which the climate did not differ greatly from that prevailing in the region today. During this interglacial time, known as the Sangamon stage, the surface of the drift was covered with vegetation and the streams developed valleys of considerable depth. The deeper pre-Illinoian valleys were probably not quite filled with drift or, if they were, the much greater thickness of the till over the former valleys caused it to settle there more than over the areas where it was thinner, leaving depressions marking the courses of the larger pre-Illinoian streams. These depressions subsequently became occupied by the streams that drained the Illinoian drift surface. Over the more level portions of the surface organic matter derived from the imperfect decay of successive generations of plants, accumulated in places to such an extent as to form a black soil (Sangamon soil). On the slopes where erosion was active and organic matter was not permitted to accumulate, the surface became more or less oxidized and the finer part of the till were in places removed

leaving the coarser constituents concentrated at the surface as a zone of pebbles.

Iowan time

After the Sangamon conditions had continued undisturbed for a long time and the development of valleys was well advanced, conditions became favorable for the accumulation of extensive deposits of dust by the winds, a large part of which probably occurred during the time of maximum advance of the Iowan ice sheet in northeastern Iowa. This dust or loess was spread over the Sangamon soil, and over the surface of the concentrated gravels and of the leached and eroded surface of the Illinoian till where the Sangamon soil was absent.

Peorian time

After a time dust transportation diminished and deposition was generally overbalanced by erosive processes. The craving of valleys continued until Wisconsin time when the larger valleys had been eroded in the Illinoian drift to levels probably below those of the present.

Wisconsin time

The influence of still another ice sheet was felt in this region. After a long period of the Peorian interglacial conditions, the Wisconsin gladier invaded northern and central Indiana and northern and eastern Illinois, and moved southward to a position below Paris and Mattoon. The upper part of the basin of the Embarras was covered by this ice sheet for a distance of nearly 60 miles and the Wabash valley was occupied by ice nearly as far south as Terre Haute. These rivers were the lines of discharge of great quantities of water from the margin of the glacier and became overloaded with

debris liberated by the melting ice. As a result broad alluvial plains of silt, sand and gravel were deposited along these valleys filling the channels formerly eroded in the Illinoian till, and compelling their tributaries to build up the lower portions of their channels to a corresponding level. The basins of some of the streams that did not head in the area of the Wisconsin ice sheet, and so carried insufficient sediment to promptly fill their valleys to such a height, may have been transformed into temporary lakes miles from their junction with the Wabash.

Recent epoch

In recent time there has been no change in the altitude of this region, nor any important change in the land relief except valley cutting along the Embarrass and Wabash and their tributaries.

After the Wisconsin ice sheet melted from the region the amount of debris carried by the Embarrass and Wabash was greatly decreased and the rivers were enabled to develop their present channels at a much lower level in adjustment to the reduced load and volume, removing in this process a large portion of the filling made during Wisconsin time. As the Wabash lowered its channel, the tributaries of the river began to sink their beds to lower levels in order to preserve their topographic adjustment with their master stream. Since that time they have continued this process headward, Raccoon Creek having developed a channel a few rods wide and 6 to 8 feet below its main flood plain for a distance of ten miles from its mouth, and Crawfish Creek has cut a narrow channel a few feet deep into its former flood plain to a point about four miles from its mouth nearly a mile above the south border of the area. Along the streams at a distance from the river the valley

filling of Wisconsin time has not been trenched,and aggraded stream channels are at present one of the most conspicuous features of the region. The smaller streams have carved gulleys in the slopes in many places exposing bed rock for short distances, but these outcrops are more often over the higher areas and steeper slopes where the ~~slop~~ drift mantle is thin, than along the larger streams where in only a few places had side cutting removed the till and exposed the rock banks of the ancient channels.

Mineral resources.

The mineral resources of the Sumner and Vincennes quadrangles include oil, gas, coal, stone, soil ,and water.

Petroleum and natural gas

The Sumner and Vincennes quadrangles embrace about one-sixth of the great oil fields of southeastern Illinois, as indicated by the position of the known fields on the sketch map (fig. 1) Of the 460 square miles embraced by the quadrangles, about 12 in the Sumner area, and ~~26~~ 28 in the Vincennes quadrangle, a total of (38) 40 square miles, have produced enormous quantities of oil and some gas. ~~It is estimated that one-fourth of the production of Illinois oil, approximately 51,000,000 barrels, have been taken to date from these two areas.~~

Oil was first discovered in this area in July 1906. The development from this time was rapid but the actual productive limits of the oil pools of the two areas were not defined until the beginning of 1912. Since that time the development has been confined chiefly to inside drilling and to the development of the Billett, Murphy, St. Francisville, and several minor pools. There have been more large producing oil wells inthis region than in all the rest of the Illinois fields combined. These wells have maintained a remarkable yield and the new drilling has made an exceptional showing in comparison with the earlier wells. For these reasons this part of the Lawrence County field is the richest in Illinois.

Oil and gas in greater or less quantities are found in seven producing sands which lie between depths of 450 and 1985 feet, ranging from the "shallow sand" high in the Pennsylvanian rocks to the "McClosky sand"

in the Ste. Genevieve formation of the Mississippian series. Most of the oil comes from the McClosky sand or Ste. Genevieve limestone, and the Kirkwood sand of the Chester formations. In the order of their productivity there oil bearing horizons are the McClosky, Kirkwood, Buchanan, Bridgeport, Tracey, "Gas", and "Shallow" sands. These sands are almost exclusively oil sands, except the Tracey and "Gas" sands, which produce fair amounts of gas near the north end of the Sumner quadrangle. All of the typical sands are as a rule medium grained and fairly porous. The "pay" or part of the sands in which the oil is found, is generally (very much softer) and more porous than the surrounding sandstone. The "pay" is from 1 or 2 to 30 feet or more thick and covers a range of areal extent from ~~an~~ acre to many square miles.

The oil pools in the two quadrangles are the southeastern extension of the Lawrence County oil fields. They cross the northeast corner of the Sumner quadrangle and spread over the northwest quarter of the Vincennes area in a direction north by about 18° west. The field is about 10 miles long and from 2 to 5 miles wide. The west side of the field is rather regular in direction, ~~except for a small westward extension on the terrace in sections 7, 17, and 18, T.3 N., R.12 W.~~ The east side is very irregular.

Pools in the McClosky sand

The McClosky sand is the most prolific source of oil and gas in this region. It furnishes the most of the "green" oil of Lawrence County, and many of the wells to this sand having produced initially from 300 to 2450 barrels of oil per day. ~~Instead of being a sand,~~ this horizon is, in places at least, a soft oolitic limestone belonging to the Ste. Genevieve formation. The top of the McClosky oil sand under-

226 feet, and the Tracy sand about

lies the Kirkwood sand about 111 feet. These intervals widen perceptibly as the formations dip into the Illinois basin. The Ste. Genevieve limestone has a total thickness of about 85 feet. It is oil bearing from 20 to ~~40~~ 80 feet beneath the top, and the productive portion ~~having~~ has an average thickness of about 10 feet.

The McClosky sand is productive along a very narrow strip about 1/4 mile wide and two miles long, in sec 30 and 31, T 4N, R 12 W; a narrow strip in sec 5 and 8, T 3N, R 12 W, and on the terrace in secs 20, 29, and 30, T 3 N, the Summer quadrangle. The depth of ~~sand is between~~ the sand ranges from 1550 ~~and~~ to 1690 feet, except on the last-named terrace where it is ~~about~~ < 1955. The type locality for this sand is in sections 23, 25, 35, and 36, T.3 N., R.12 W., in the Vincennes quadrangle, where the sand derived its name from the M. McClosky farm in section 35. Here The average depth ~~in this locality~~ is about 1775 feet.

Oil pools in the Tracey sand.

The top of the Tracey sand lies about 108 feet beneath the top of the Kirkwood sand or near the base of the Tribune formation in the Chester group. It is a highly calcareous sandstone and commonly yields a "sour" or sulphur ~~smelling~~ oil of high gravity. In the northern part of the Lawrence County field this sand ~~is~~ produces chiefly gas ~~producing horizon~~, but only small amounts of gas have been recorded in the Sumner and Vincennes quadrangles. ~~It is not widely productive of oil,~~ but the producing areas, for the most part, ~~being~~ are small isolated pools. The type locality for the sand is in sections 11, 14, ~~and~~ 24, 25, 35, and 36, T.3 N. R.12 W. in the Vincennes quadrangle.

Oil pools in the Kirkwood sand.

With a single exception the Kirkwood sand is the most prolific source of oil in this region and it is the most widely drilled sand in Illinois. It has been found productive over most of the Lawrence County field and in fact, its productive portion represents the shape of this field. It is correlated with the producing sands of Marion, Clinton, Bond and Randolph counties in Illinois, and Pike County, Indiana. The Kirkwood sand was first tapped in 1907 on the Kirkwood farm in the NE 1/4 sec. 14, T.3 N., R.12 W., in the Vincennes quadrangle.

The range of depth of the Kirkwood sand in this region is 1320 to ~~1985~~ 1850 feet, and the differences ~~being~~ are due chiefly to ~~the influence of~~ structure details. The highest portion is over the structural dome on the crest of the anticline, a part of which is shown along the north boundary of the Sumner quadrangle; and the lowest position is ~~far down the west limb of the anticline~~ on the terrace at the St. Francisville pool. ~~previously described~~. The Kirkwood sand lies near the middle of the Chester rocks, in general about 186 feet beneath the top. It is about 108 feet above the Tracey sand, and 226 feet above the oil ~~producing~~ zone of the Ste. Genevieve limestone.

The Kirkwood sand is a medium, fine-grained sand, often called the "sugar" sand because it resembles brown sugar in the churn drill samples. In several localities in Lawrence County, it is lenticular, and consists of two or in some places three lenses. ~~having, in many cases, two lenses and sometimes three~~. The top lens is very uniform and regular over the entire county and for this reason, is chosen as the key horizon for the structure maps of this folio. The average thickness of the sand in the quadrangles is 33 feet.

The Kirkwood sand shows an excellent initial production, ~~often reaching~~ in many cases as high as 1000 barrels, with an average close to 150 barrels. It is the most reliable of all the sands in its initial yield and steady production, and its decline has been very slow in comparison with the shallower sands. The Kirkwood sand oil is generally considered sweet oil, which is more nearly free from sulphur than is the oil from the lower sands, although in some localities the sulphur content is variable. The average specific gravity of the oil is about 36° Beaume.

Oil pools in the "Gas" sand.

The "Gas" sand is locally the first sand encountered in the Chester rocks, and is the first underlying the Buchanan sand. It is called the "Gas" sand because of the small amounts of gas which it produces over the northern part of the Lawrence County pool. Some production of oil is reported over very scattered areas. The "Gas" sand is not distinguished in the Vincennes quadrangle and is only found productive along the north boundary of the Sumner quadrangle. The average thickness of the sand is 16 feet. It is about 123 feet beneath the top of the Chester rocks and 87 feet above the Kirkwood sand.

Oil pools in the Buchanan sand

The Buchanan sand is the next producing sand above the "Gas" sand. It was first discovered in September, 1906 on the R. O. Buchanan farm in the SE 1/4 sec. 16, T.3 N., R.12 W., near the boundary of the two quadrangles. This sand is found at an average depth of 1320 feet in its type area in sections 15, 16, and 17, T.3 N., R.12 W. Outside of this area the data concerning this sand are very scattered, and where found in such as does exist, this sand is not generally distinguishable from the overlying Potts-

ville sandstones. Most of the well data in the type area indicates a shallow penetration into this sand, just enough to insure a sufficient and safe shot. This oil zone is in most places underlain by salt water for which reason in some localities in the State the Buchanan sand is called the "salt sand". This sand has been one of the most prolific oil sands in the Illinois fields. A large initial production has been credited to its wells but their yield has declined somewhat faster than that of some of the other sands of the area. Little or no gas is noted in the type area. The average thickness of the pay in the producing zone is about 35 feet. The top of the sand lies about 350 feet, lower than the Bridgeport Sands + 246 feet above the Kirkwood. There are several small isolated oil pools in the Vincennes quadrangle, the most notable of which is the one northwest of Lawrenceville, and another at the south end of the field, and the Allendale pool. The northern pool wells in the main field have been very prolific while the wells at the south end are very light.

Oil pools in the Bridgeport sand.

The first oil well in the region of the Sumner and Vincennes quadrangles was drilled to the Bridgeport sand in the town of Bridgeport in July 1906. The name of the town was given to the sand and because of its shallow depth and good initial production this horizon attracted much interest and subsequently was widely developed both north and south of the town. The producing strip as since defined, is 5 miles long and about 1 1/4 miles wide, of which 3 1/4 miles of length are in the north part of the Sumner quadrangle. In most all cases this sand is found to be barren in the rest of the wells in the two quadrangles, except at the south end of the field in

the Vincennes area, where the sand is productive over an area of about 3 square miles.

The Bridgeport sand is lenticular comprising three generally distributed lenses over the oil fields, which, in some cases, ~~become~~ are consolidated and, in others, are supplanted with shale. The general thicknesses of the lenses and the intervals between them are very difficult to estimate because of their variableness and overlapping character. The top lense is about 35 and 44 feet thick respectively in the producing areas of the Sumner and Vincennes quadrangles. The Bridgeport sand is almost exclusively oil bearing in the Sumner area but yields abundant gas in the Vincennes quadrangle.

Oil pools in the shallow sand

The oil pools in the shallow sand are limited to the extreme south end of the Vincennes quadrangle. There are but eight producing wells in this sand and these yield a very small amount of oil. ~~The average depth of~~ the sand is about 450 feet, deep, and ~~being~~ about 500 feet above the Bridgeport sands.

Distribution of oil and gas

Oil

The oil sands of this region have proven very rich and ~~They~~ have shown remarkable ~~durability in their~~ sustained yields but the inventable through moderate decline has set in and the total annual production of the ~~and have promise of long life. The exceptional daily yield of the lower sands has~~ State shows a steady decrease ~~upheld the Illinois production when the other sands were declining but these have~~ now not begun to show signs of a gradual decline, thus allowing the annual total production to decrease.

Sumner quadrangle

The following table shows the results of drilling in the Sumner quadrangle:

Table of well data for the Sumner quadrangle

Township	Productive wells	Gas wells	Dry holes	Total
Bridgeport	1056	10	96	1162
Christy	1	..	5	6
Dennison	25	..	3	28
Lawrence	93	..	10	103
Lukin	..	..	8	8
Petty	114	7	12	133
Wabash	4	..	11	15
Total	1293	17	145	1455

There are 1,455 wells mapped in this area, of which 145 or 10 per cent, were barren.

The following table shows 935 wells that furnish data on initial production for each sand in this area. They are listed by townships, sands, and extent of yield:

Table showing initial production of the sands in the Sumner quadrangle

		Barrels					
Township	Sand	0-10	11-49	50-99	100-199	200-499	Over 500
Petty	Bridgeport	2	8	9	7	3	..
	Kirkwood	4	7	10	11	4	1
	McClosky	1	3	..	2	1	..
Bridgeport	Bridgeport	4	47	116	103	12	4
	"Gas"	1	2	3	1	1	..
	Buchanan	2	6	10	22	61	8
	Kirkwood	5	76	98	88	30	3
	Tracey	2	6	4	1	..	..
	McClosky	5	8	15	9	5	3
Lawrence	Bridgeport	..	1	4	8	1	..
	Buchanan	..	2	9	13	11	..
	Kirkwood	1	7	13	15	3	..
	McClosky	..	1	..	..	..	..
Wabash	Buchanan	3	2	2	3	2	..
Total		30	176	293	283	134	19

The oil accumulation of the Bridgeport, "Gas", Kirkwood, Tracey, and McClosky sands in the Sumner quadrangle ~~is~~ has been controlled by an extensive

291
226
417

elongated dome lying along the crest of the LaSalle anticline. Only the south half of the dome is represented on the map of this area. The best productions are not found on the crest of the dome but around the flanks. Very little production comes from these sands around the base of the dome, but the ~~Kirkwood~~ McCloskey sand shows a fair production of oil on the structural terrace south of the dome. The Buchanan sand is especially noted for its production in the type area. Previous studies[1] of the strudture of this sand show that the oil is concentrated in two small symmetrical domes, each about 100 feet high. The wells of the Bridgeport sand show an average initial yield of about 150 barrels of oil within the pool ~~and then suddenly show~~ but such oil yields are in sharp contrast to the great quantities of salt water encountered just beyond the ~~its~~ boundaries of the pool.

Vincennes quadrangle

The following tables show the extent of drilling in the Vincennes quadrangle:

Table of well data for Vincennes quadrangle.

Township	Productive wells	Gas wells	Dry holes	Total
Lawrence	536	..	120	656
Dennison	1104	12	185	1301
Wabash	49	..	22	71
Allison	7	..	6	13
Total	1696	12	333	2041

The oil sands of this area have proven the richest of the Illinois fields. The range of initial production has been from 5 to ~~2500~~ 3500 barrels and in a ~~large number~~ many of the wells, ~~as many as~~ up to four of the seven producing sands of the region yield immense amounts of oil. The best producing sands of this area have a thickness of from 10 to 35 feet of sand which is generally free from large amounts of salt water. Of the ~~1361~~ 2041 wells mapped in the area only

[1] Blatchley, R.S. Oil fields of Crawford and Lawrence Counties, Ill. State Geol. Survey, Bull. No. 22, p. 107. 1913

333 16.3 1696
~~179~~ or ~~14.1~~ per cent were dry. Of the ~~1071~~ producing wells,
1265 ~~864~~ give the following data of initial production:

Table showing initial production of the sands in the Vincennes quadrangle.

Township	Sands	Barrels 0-10	11-49	50-99	100-199	200-499	Over 500
Lawrence	Buchanan	3	5	9	29	42	2
	Kirkwood	9	69	58	46	2	1
	Tracey	1	3	3	1	..	..
	Kirkwood-Tracey	1	1	5	3	..	..
	McClosky	..	14	7	..	3	3
	Tracey-McClosky	..	3	..	3	1	..
	Kirkwood-Tracey-McClosky	..	3	4	2	..	..
	Kirkwood-McClosky	..	4	1	4	6	1
Dennison	Shallow	..	5	1	..	..	..
	Bridgeport	17	81	70	55	26	..
	Buchanan	4	16	11	23	13	..
	Kirkwood	12	87	80	70	23	1
	Tracey	1	4	2	1	1	..
	Kirkwood-Tracey	1	6	8	16	3	..
	McClosky	4	13	12	8	8	20
	Tracey-McClosky	..	3	1	3	1	..
	Kirkwood-Tracey-McClosky	..	2	7	30	25	17
	Kirkwood-McClosky	1	8	14	18	10	10
Allison	McClosky	1	5	..	1	..	..
Wabash	Biehl and Jordan	3	8	13	10	8	2

The Kirkwood sand pool is the most extensive in the Vincennes quadrangle, followed in order by the McClosky, Bridgeport, Tracey, Buchanan, and Shallow sand pools. There are two areas where several sands are highly productive in the same wells. The Bridgeport, Kirkwood, Tracey, and McClosky sands show a combined production in the main area in sections 23, 25, 26, 35 and 36, T.3 N., R.12 W. and Sec. 2, T2N, R12W. In section 14 of the same locality many wells produce from the Kirkwood, Tracey, and McClosky sands.

The Bridgeport sand shows a good yield of oil in an isolated

area covering about three square miles at the south end of the field. This sand seems to lie high structurally, and in accordance with the established theory of the presence of gas in raised portions of the sand, produced abundant gas in almost all of the wells, some of which are wholly gas producing.

The Buchanan sand extends into the Vincennes quadrangle from the Sumner area, and is also productive in the Allendale pool. There are many large wells in the Vincennes area but generally they are not so large as those in the Sumner. One or two rich spots occur in this sand both at the north and south ends of the field.

The Kirkwood sand yields considerable oil over the entire area and is especially productive in sections 14, 25, and 35. This sand has attracted recent interest in that several wells are producing commercial amounts of oil in outlying pools to the east of the general pool, notably in a locality 1½ miles northeast of Billett; at the eastern end of the Murphy pool; sec 4 and 5, T 2N, R 11W; and in the first discovered in 1914 a short distance south of T. Travis wells.

The Tracey sand is spotted over most of the area, except in sections 25, 26, 35, and 36 where there is a pool about ~~2 1/2~~ 3 square miles in extent ~~in which~~ where this sand ~~shows~~ yields its best oil production ~~of oil~~.

The McClosky sand has produced more gushers in the Vincennes quadrangle than all of the rest of the sands in the two areas combined. Its largest and producing area as well ~~as the~~ type locality lies in sections 23, 24, 35, and 36. There are many large wells in this area that produce oil from the McClosky sand in combination with either the Kirkwood or Tracey sand or both. The McClosky sand also shows abundant gas in ~~the~~ some parts of this pool. The next best producing area of this sand ~~lie~~ is in section 14. A small, but very rich pool in the McCloskey, known as the Murphy pool was opened in 1914 in the southern half of sec 5 and the northern half of sec 8, T 2N, R 11W. The pool declined rapidly after the first [illegible] Further westward in the McCloskey has been found in

The oil in the Vincennes quadrangle is, for the most part, concentrated over a broad flat, plateau-like crest of the major fold. The general structure conforms to the 400-foot contour on the structure map and in only one instance it shows a tendency toward a raised structure. An elongated dome of about 60 feet in height shows its crest lying along the west lines of sections 23, 25, and 35. (see profile, fig — (here put in C of Vincennes folio report, pl III.)

Gas

Gas is not so abundant in the Sumner and Vincennes quadrangles, as it is in other great American oil fields. The majority of wells in the Lawrence County field produce small amounts of casing-head gas which is mostly consumed in drilling and pumping wells. The one locality where gas is produced commercially is in the Bridgeport sand in sections 22, 23, 25, 26, 35, and 36, in Bridgeport town ~~which has been used commercially~~. The greater part of this gas is "combination" gas or that which has been used in making the oil flow and is caught from the wells with the oil.

Relations of structure to the accumulation of oil and gas.

There is probably no better example of the conformability of oil pools to geologic structure than that presented by the Illinois oil fields. The greater part of Illinois lies within the Eastern Interior coal basin, which broadly speaking is an extensive spoon-shaped basin, the bottom of which extends along a line through Cerro Gordo, Lovington, and Olney, and thence southward into its deepest part in Wayne, Hamilton, and Edwards counties. The east

side of the basin rises into the strong, longitudinal LaSalle fold. The ascent is at the average rate of about 50 feet per mile but it is more rapid in Lawrence County as shown by the contours over the very sharp apex of the anticlinal dome. The basin and the lower flanks of the fold are known to yield abundant water in all the sands which are productive in the main fields. The uppermost part of the flanks of the major fold contain an abundance of oil. The western limits of the fields are abrupt and beyond this line the sands are water bearing. Enough data are at hand to justify the conclusion that this is a line of water saturation and that above this line and over the fold most of the porous portions of the sands are oil bearing. The accumulation of oil and gas in their present position may be looked upon as ~~in ideal,~~ in accordance with the generally accepted anticlinal theory. The following factors of accumulation due to structure are apparent:

1. There is an extensive anticline with a marked basin on at least one side.

~~2. The depressions on both sides of the fold showing abundant water, comprise extensive "feeding" areas for the arch.~~

2 6. The sands are commonly porous and hence form suitable reservoirs.

3 4. There are abundant shales and some limestones overlying the sandstones, which probably serve as impervious covers to the reservoirs.

4 5. The sands in both limbs of the anticline are abundantly saturated with salt water, which is probably instrumental in holding the oil and gas captive in its present position.

5 8. Although the general structure of the oil fields is dominated by a major fold its crest is very irregular and is interrupted by numerous minor domes and transverse depressions which together

with irregularities in porosity, have been instrumental in segregating the pools.

67. With the exception of the extensive flat area in the Vincennes quadrangle the best collection of oil was found on the large dome and near its base in the Sumner quadrangle. The minor domes over the entire region are logical reservoirs for gas but contrary to expectation the largest amounts of gas do not usually lie at the apexes of the domes but down their flanks. The best amount of oil lies on the extensive flat crest of the major anticline.

Note

This comment should be at bottom of page 125 and numbered 2.

For section on coal, see Savage MS # 11.

Coal.

No coal is at present mined in the Hardinville quadrangle, but thin beds outcrop in a number of places, and have been reported from 15 water wells in the area. In the north east quarter of the quadrangle a thin coal is exposed along the streams in a number of places in Honey creek and Robinson townships; as, near the middle of the east side of section 17 and also in the northwest 1/4, section 4 both in T. 5 N.R. 12 W. In the S.E. 1/4, N.W. 1/4 of section 5, T. 5N., R 12 W. an 18-inch coal was found in a water well beneath 22 feet of drift at an altitude of 479 feet. Another well in the east half of the N.W. 1/4 of section 23, T. 6 N., R. 13 W penetrated a 7-inch coal 29 feet below the surface, at an altitude of about 472 feet. In the log of another well near the middle of the west side of Sec. 11 of the same township a thin coal was reported at an elevation of 465 feet; and in a well in the S.E. 1/4 of section 8, T. 5 N.R. 12 W. coal was found at an altitude of about 429 feet.

In the west part of the quadrangle the log of a water well near the northwest corner of section 1 T. 5 N.,R. 14 W., reported a thin seam of coal 25 feet below the surface at an altitude of 428 feet. An outcrop of a coal one to one and one-half feet thick occurs on the west side of the ridge near the middle of the south side of section 27 T. 5 N., R. 14 W.

Farther south in the S.W. 1/4 of the quadrangle well borings have revealed the presence of two rather thin coal beds about 100 feet apart. In a well boring th the N.W. 1/4 of section 16, T. 4 N., R. 13 W., coal was found at an altitude of about 530 feet. In another well near the middle of the west side of Section 22 T. 4 N., R. 14 W., a thin coal was passed through at an elevation of about 428 feet, and in another near the middle of the north side of section 21 of the same township a higher coal was encountered at an elevation of 531 feet. In an oil well a short distance west of the middle of section 20 of the same

township the lower coal was reached at an elevation of 417 feet. Another well 235 feet deep near the middle of section 18 of the same township passed through both of these beds.

A coal bed of considerably greater thickness is reported in the logs of several oil wells of the area at depths varying from 450 to 650 feet. A portion of the log of an oil boring on the Childress farm, in section 24 T. 4, N., R. 13 W., showing the depth and succession of strata overlying the thicker coal and the character of the entire section of Pennsylvanian rocks in the region, is given below:

Log of well number 3 on the Childress farm.

	Thickness feet	Depth. feet
Quaternary.		
Recent and Pleistocene.		
Quicksand, white, soft	50	50
Carboniferous.		
Pennsylvanian		
McLeansboro and Carbondale formations:-		
Sandstone, limestone and shale, light and dark	220	270
Limestone, white hard	15	285
Shale and limestone, white, soft	135	420
Coal and shale, black, soft	13	433
Shale and limestone, white, soft	52	485
Shale, brown, soft	10	495
Sandstone, white, soft	35	530
Shale, black, soft	10	540
Shale, white, soft	95	635
Coal	7	642
Shale, brown	133	775
Limestone, white, hard	25	800
Red rock, soft	10	810
Shale, white, hard and soft	30	840
Limestone, white, hard	10	850
Shale, black	130	980

The Hardinville Birds, Sumner and Vincennes quadrangles are situated in th e east-central part of the eastern interior coal basin where no coal mining on a commercial scale has been done. However, at a number of places within this area a thin bed has been worked by strippings, or drifts, or shallow shafts to supply local demands.

Coals above Herrin (No.6) Coal.- Four seams of coal, 1 foot or more in thickness, outcrop in parts of the area. The lowest coal that has been worked in the area is exposed in the south bank of No Business creek, near the southeast corner of sec.20, T. 6 N., R. 10 W. The bed is 1 foot 10 inches thick at this place and lies at an elevation of about 445 feet above sea level. It has been mined by drifts in two or three places at this locality, and was formerly worked by shafts in a few places near the south side of sec. 1, T. 6 N., R. 11 W., at a depth of 30 to 35 feet.

About 35 feet above the horizon of the seam above described a coal 4 or 5 inches thick is exposed in a few places immediately below the limestone lentil underlying a calcareous, fossiliferous shale. In most of the outcrops of this horizon no coal was present,

and at no place is it known to be developed in workable thickness. A coal which occupies an horizon corresponding to the Parker coal farther south and lying about 42 feet above the thin 4-inch coal mentioned above, is exposed in several places in the Birds quadrangle. It outcrops in the SW. 1/4 sec. 2, T. 6 N., R. 11 W., where the thickness is 1 foot and the altitude about 460 feet. Near the northwest corner of sec. 7, T. 6 N., R. 10 W., this coal is exposed in a thickness of 1 foot and an altitude of about 489 feet. It outcrops again in about the same thickness in the NW. 1/4 sec. 12, T. 6 N., R. 11 W., at an altitude of about 466 feet; and at several places in the east half of sec. 35, of the same township where the elevation is about 475, and in the NW. 1/4 sec. 30 of this township at an altitude of 480 feet. One-half mile west of Flat Rock this coal is well exposed in the bank of a creek where the thickness is 1 1/2 feet and the altitude is about 483 feet. It is reported to have been stripped several years ago at a place in the SW. 1/4 sec. 29, T. 6 N., R. 11 W., in the NW. 1/4 sec. 26, T. 5 N., R. 11 W., in the NW. 1/4 sec. 30, T. 6 N., R. 10 W., and in a few other places in the quadrangle.

The Parker coal is quite persistent both in occurrence and thickness. The bed is too thin to be of commercial importance, but it may sometime become of some value as a local supply. At a few places in the west part of the Birds and in the northeast quarter of the Hardinville area quadrangle a coal 1 1/2 feet thick is exposed at a level about 70 feet above that of the Parker bed. This coal lies at about the horizon of the Friendsville coal farther south in the Sumner quadrangle and probably corresponds to that bed.

The Friendsville is the only coal of importance at present

worked in the Sumner and Vincennes quadrangles. It belongs to the McLeansboro formation and occurs under a few square miles in the southeast part of the Sumner area, and farther south between Bonpas Creek and the Wabash River. It is not known west of Bonpas Creek, nor does it persist in thickness south as far as Grayville, or east of the Wabash River. In a northward direction it is not certainly known farther than 6 miles north of Friendsville.

This coal outcrops in a few places near the town of Friendsville and is worked for local supply in a few mines in that vicinity. In this region the bed is generally about 5 feet thick, and lies 30 to 50 feet below the surface. At the Keen mine, one mile east of Friendsville the shaft is 36 feet deep and the coal is 3 1/2 feet thick. The shaft on the Price farm, one mile farther north, is 47 feet deep, and the coal is there 3 feet thick. A shaft one and one-half miles south of the Keen mine is 32 feet deep. This bed was formerly worked by a shaft 1/2 mile south of Linn, in the NE. 1/4, sec. 6, T. 1 N., R. 12 W. at a depth of 27 feet, and was reached in a well at the Frogeye school in sec. 24, T. 2 N., R. 13 E., at a depth of 18 feet, and in a drilling in the NW. 1/4, sec. 33, T. 2 N., R. 12 W. at a depth of 37 feet. The coal in this region is usually overlain by a bed of sandstone which, in a few places, is separated from the coal by a few inches to 4 feet of shale.

The bed is somewhat irregular in its dip, the general inclination being towards the west, but a slight eastward dip is shown east of Friendsville, and a slope towards the north is also locally indicated in that region.

Aldrich coal

A thin coal lying 60 to 80 feet above the Friendsville and thought to correspond with the Aldrich bed of the Patoka quadrangle,

is present over several square miles in the west central part of the Sumner quadrangle. It varies between 10 and 24 inches thick, and is too thin to be of importance except as it may be stripped at the crop to supply local needs. It has been worked in this manner on a small scale over a few square rods in the NW 1/4, sec. 22, T. 3 N., R. 13 W., where the thickness is about 24 inches; and in the NE. 1/4 of sec. 31 of the same township, where it is 16 inches thick. In the NE. 1/4, sec. 6, T. 2 N., R. 13 W. where this coal was formerly worked, the thickness is also about 16 inches. It persists at about this thickness a few miles farther west where it is locally worked along the branches of Bonpas Creek, in the SE. 1/4 of sec. 2, and the NE. 1/4 of sec. 11, T. 2 N., R. 14 W.

Exposures farther west where the coal was formerly stripped near the middle of sec. 3, T. 2 N., R. 3 W. the thickness is about 20 inches. West of Bonpas Creek in sections 5, 8, 17, and 20, T. 2 N., R. 14 W. the thickness is 16 to 20 inches. East of Little Bonpas Creek a thin coal exposed about one mile southwest of Lancaster, and encountered in a water well 2 miles south and 1/2 mile west of the latter locality, is thought to represent the Aldrich bed. From near the center of the Sumner quadrangle this coal dips rather uniformly westward to the valley of Bonpas Creek at an average rate of about 11 feet to the mile. West of Bonpas Creek it rises at a slightly more rapid rate to the west border of the quadrangle. In a southward direction the average dip of the coal in this region is about 5 feet to the mile. A thin coal outcrops in a few places, and has been found in several wells in sec. 12, T. 3 N., R. 13 W., sec. 6, T. 3 N., R. 12 W., and sec. 31, T. 4 N., R. 12 W.

The coal corresponding to the Parker bed farther south in the Patoka quadrangle, and occurring farther north in the Birds

quadrangle, is not generally present in the Sumner and Vincennes areas. The thin coal that lies near the level of the flood plain on the south side of Dicksburg Hills is thought to represent this bed.

The thicker Herrin, Springfield, and Murphysboro coals of the Carbondale formation are present in White County, about 40 miles south of the Sumner quadrangle, where the core of a diamond drilling showed the Herrin coal to be 5 feet thick at a depth of 616 feet; the Springfield coal 4 feet thick at 722 feet; and the Murphysboro coal 3 feet thick at 970 feet. In a number of the oil drillings in the Sumner quadrangle a coal thought to be the Herrin was encountered at depths between 500 and 585 feet, but its thickness could not be determined in the churn drill samples. In the deep drillings in the Hardinville quadrangle, immediately north of the Sumner, both the Herrin and the Springfield beds have been recognized. It is probable that one or more of these coals are present in workable thickness over the Sumner area and possibly over the greater portion of both the Sumner and Vincennes quadrangle.

In the southwest quarter of the Hardinville quadrangle well borings have revealed the presence of two rather thin coals about 100 feet apart above the horizon of the Herrin bed. In a well boring in the NW. 1/4 of section 16, T. 4 N., R. 13 W., coal was found at an altitude of about 530 feet. In another well near the middle of the west side of sec. 22, T. 4 N., R. 14 W., a thin coal was penetrated at an elevation of about 428 feet, and in another near the middle of the north side of section 21 of the same township a higher coal was encountered at anaelevation of 531 feet. In an oil well a short distance west of the middle of section 20 of the same township the lower coal was reached at an elevation of 417 feet. Another well

235 feet deep near the middle of section 18 of the same township passed through both of these beds.

Herrin (No.6) coal.- In the records of several deep borings in the Hardinville and Birds quadrangles, from which samples of drillings were studied, the position of the Herrin (No.6) coal has been definitely recognized at depths ranging from 500 to 565 feet, by the presence of shells of Girtyina ventricosa in the limestone above the coal. In a boring near the center of sec. 21, T. 5 N., R. 11 W., the Herrin bed was encountered at a depth of 562 feet, or an elevation of 26 feet below sea level. In another well in the NW. 1/4 sec. 5, T. 5 N., R. 12 W., this coal was found at a depth of 486 feet and an altitude of about 9 feet above sea level. Another boring three miles farther west and one mile north of the last, in the SE. 1/4 sec. 27, T. 6 N., R. 13 W., reached the Herrin coal at a depth of 500 feet, or about 2 feet above sea level. From the samples or the records of borings made by churn drills it is not possible to determine accurately the thickness of this coal at the different places. However since the overlying limestone has a similar development here to what it has where this coal is of good thickness in other parts of the State, there is little doubt but that this coal is here of fair thickness. From the distribution of the wells in which this coal has been definitely recognized it seems fairly certain that it is present under the greater portion of the Hardinville and Birds quadrangles within easy working depths.

In five of the wells in this region from which samples were studied a coal was present at depths ranging from 55 to 70 feet below the Herrin bed. This is doubtless the horizon of the Harrisburg (Springfield or No.5) coal which also may be present in workable

thickness beneath a considerable part of the quadrangles.

In the logs of several of the oil wells in this area coals ranging from 3 to 8 feet thick were reported at other horizons. However, owing to the difficulty of accurately determining the thickness of the coals penetrated in churn drilling, and since no thick coals are persistent at any of these horizons, in other parts of the State, it is thought that little importance should be attached to reports of thick coals below the Harrisburg or Springfield bed in in this region.

During the last few years leases have been secured for the coal rights under practically all the land within 2 to 5 miles of the Big Four Railroad in the Birds quadrangle in the vicinity of Flat Rock, Birds, and Pinkstaff. However, nothing has been done towards the development of the coal resources of the area in a commercial way, and it will doubtless be several years before coal from this region will be put in the market. However, after the more easily available coal deposits of the eastern interior basin have been exhausted, the coal in this area may become an important source of wealth.

Clays

Raw material suitable for the manufacture of common brick and tile are present in several places in these quadrangles. They consist of shales of Pennsylvanian age, and of loess, allutium, and glacial till deposited during Pleistocene and Recent time. With the exception of glacial drift the loess is the most widely distributed and most generally accessible and is the only clay that is utilized in the area. Outcrops of shale occur at various places but shale has been used in the manufacture of clay goods only at

Vincennes and West Salem. At the latter locality the West Salem Hollow Brick and Tile Company operate an up to date plant for the manufacture of common builders, face brick, and drain tile from a mixture of the McLeansboro shale and aluvial clay in a ratio of about 65 per cent of the former and 35 per cent of the latter. The clay in the pit is dug to a depth of 21 feet, showing the following section:

Section of clay pit of West Salem Hollow Brick and Tile Co.

	Feet
Clay, loess-like, yellowish, gray without pebbles	2 1/2
Clay, yellow, with a few pebbles	4
Clay, brown, iron-streaked with many pebbles	5
Shale, bluish-gray, sandy, laminated, micaceous	10

The shale belongs to a horizon several feet lower than the Aldrich coal. It is a bluish-gray, laminated and somewhat sandy, and has been dug to a maximum depth of 10 feet, and used without weathering. A well near the pit showed a thickness of 30 feet for this shale bed.

Scharneakan Brothers also operate a clay working plant at West Salem, manufacturing common building brick and drain tile to supply local trade. No shale is used in the mix. Loess clay is stripped from the surface for making brick and screened glacial till chiefly used in the making of tile.

In the NE. 1/4 sec. 27, T. 3 N., R. 10 W., at Vincennes, Indiana, Kexmiller and Teshner manufacture soft mud building brick to supply the home market. Brown, sandy, loess clay is used as raw material, being stripped from the surface of the less sandy areas, a thickness of about 6 feet being dug below which

the clay contains too much sand for successful use.

A plant for the manufacture of brick and tile is in operation at the town of Oblong, at the north end of the Hardinville quadrangle, where the Oblong Brick Manufacturing Company have made soft mud building brick for a number of years to supply a local demand. The plant is equipped with a Quaker brick machine and plug and a square updraft kiln of a capacity of 160,000 brick. The brick are dried in an open yard, and little loss is sustained from their cracking or checking on drying or burning. The raw material is loess clay which is stripped from the surface to a depth of two or three feet. Below this depth is pebbly glacial till which cracks badly with open-air drying, unless the clay is thoroughly slacked before it is used. It is estimated that about 1,500 pounds of coal are required by this company to 1,000 brick.

For several years Mr. D. F. Johnson has manufactured the common grades of brick and tile at Pinkstaff in the south part of the Birds quadrangle. Surface soil and clay are used for the raw material which is worked by the soft-mud process. The market is limited to a radius of a few miles, the annual output depending largely on the local demand.

Building Stone

Stone suitable for building purposes is not common in the quadrangles and there are no quarries in active operation except temporarily when rough stone is required for a foundation. In the Summer quadrangle a sandstone ledge has been quarried in a small way in the NW. 1/4, sec. 12, T. 3 N., R. 14 W., the stone for a stone house and the basement of a large barn having been taken or some years ago. The stone is coarse grained, micaceous, in un

layers and in places cross bedded, a thickness of 9 feet being at present exposed.

A dark gray limestone belonging above the Aldrich coal bed, showing very irregular surfaces and breaking with very rough fracture, outcrops in a few places along a branch of Bonpas Creek in the NW. 1/4, sec. 26, T. 3 N., R. 14 W. The bed is 2 1/2 feet thick and consists of 4 or 5 imperfect layers, of rather pure calcium carbonate. It is said locally to have been burned for lime in considerable quantities by the early settlers.

Some years ago a few small quarries were opened in a sandstone bed outcropping along a stream in the SW. 1/4, sec. 14, T. 2 N., R. 14 W. The layers are 4 to 10 inches thick and quite hard, forming a ledge 6 to 9 feet thick. A quarry has also been worked in a bed of sandstone 8 feet thick lying above the Friendsville coal and exposed in a branch of Crawfish Creek 1/2 mile south of Linn, in the NE. 1/4 of sec. 6, T. 1 N., R. 12 W. The rather massive sandstone present in the prominent hills in the central part of the Sumner quadrangle would in many places furnish a good grade of rough stone for common foundation work and rough masonry. In the Vincennes quadrangle rough quarry stone could be obtained from the sandstone horizon exposed at St. Francisville and farther south in the Dicksburg Hills and in the hills east and west of Allendale.

A few years ago Mr. H. C. Bond worked a small quarry in the sandstone ledge near the top of the ridge in the NW. 1/4 of sec. 34, T. 5 N., R. 14 W. to supply the local demand for rough foundation stone, But this quarry has recently been abandoned. Some parts of the massive sandstone bed outcropping in the vicinity

of Westport in sec. 28 and 33, T. 5 N., R. 12 W., would furnish stone usable for common masonry. This sandstone horizon is reported to have been quarried in a small way some years ago in the SW. 1/4 sec. 21 and also in the NW. 1/4 sec. 28, T. 6 N., R. 11 W.

Sand and Gravel

In the Hardinville quadrangle sand suitable for plaster and cement is abundant in the sand hills bordering the west side of North Fork in sec. 19, 20 and 30, and farther west in T. 6 N., R. 14 W., and also on the east side of the river in sec. 21 and 28 of the same township. A considerable amount of the sand used in the areas is taken from the beds of the larger streams. The supply of gravel in this quadrangle is obtained largely from gravel beds along the channels of the Embarrass and North Fork and their larger tributaries.

In the Birds quadrangle abundance of sand occurs north Lamotte Creek in the vicinity of Palestine and over areas of flood plain and on the hills bordering the valley, south and east of Pinkstaff, and in many places over the flood plain of the Wabash and Embarrass rivers in this region. Gravel also is widely distributed in this quadrangle over the flood plains and along the channels of these rivers.

A considerable amount of sand and gravel for local use has been taken from the channels of Bonpas Creek and its tributaries in the vicinity of Claremont and West Salem. A part of the sand and gravel used in the town of Sumner is obtained from the channel of Muddy Creek and its branches; and large quantities used in Bridgeport are taken each year from the bed of Indian Creek. In the Vincennes area large quantities of gravel are also annually

taken from the gravel pit in the S. 1/2, sec. 31, T. 4 N., R. 10 W., from a large pit in the northeast part of vincennes, and from numerous local pits opened in the valleys of the Embarrass and Wabash rivers.

Soils

The region embracing the Hardinville, Birds, Sumner and Vincennes quadrangles is primarily an agricultural one and contains considerable areas of fairly fertile land. The staple products are corn wheat ahd hay while some ~~prin~~ fruit is also grown for market. In this region four types of soils are recognized which however in places grade imperceptibly into one another. The soil types are: (1) alluvium (2) sand (3) glacial till and (4) loess. These soils like all others, have been formed by geologic processes to which they owe to a large extent their texture, their physical and chemical composition, and their fertility. The character of the soil at any place depends upon the character of the rocks from which it was derived, and on the conditions and forces by which it has since been affected.

Alluvial soils.-The alluvial soils are found over the flood plains of the rivers and larger creeks in this region and aggregate many square miles in area. A large portion of the flood plains of the Embarrass is subject to overflow nearly every year, and during times of unusually high water the larger part of the river flat bordering the Wabash becomes submerged. Along the Embarrass and the most of the crreks, these soils are generally light colored and consist of clay, and silt and very fine sand, but the alluvium along the Wabash contains a large percentage of gravel. Owing to the frequent overflow of these areas during high

water, most of the bottom lands along the Embarrass have not been brought under cultivation, but along the Wabash alluvial areas are better drained, and most of them have been put under the plow. In recent years a few large drainage ditches have been made to carry off the water, but no system of levees has been undertaken to prevent the occurrence of overflows. These alluvial soils when protected from inundation and properly drained are the most productive of any in the quadrangles.

Sandy soils.- Sandy soils occur especially over the sand dunes and sandy areas indicated on the map accompanying this report. The principal areas in the Hardinville quadrangle are east and west of the North Fork and south of the Embarrass in the west half of the quadrangle. In the Birds quadrangle they occur chiefly over the flood plain and on the hills bordering the valley of Wabash River. This soil is light, granular and very porous. It does not contain much plant food and hence the soil is infertile, and since it lacks the power to retain moisture, the crops over these areas suffer seriously during periods of drought.

Glacial till.--

Areas of soil developed directly upon glacial till are confined mostly to slopes that are so steep that the mantle of loess has been removed by erosion. However, there are also limited areas of upland over which a loess covering is absent, or is so thin that the plow brings pebbly till to the surface. These soils consist mainly of clay, which is generally somewhat sandy, and usually more or less gravelly. The glacial soils are generally so compact that, unless tiled, they permit very imperfect underdrainage, on which account, the crops on this type of soil usually suffer in wet seasons.

Loess soils. - -

A mantle of loess generally covers the till and forms the immediate surface over the greater portion of the uplands to a depth of 2 to 5 feet and over the more hilly areas and thickness reaches 7 to 10 feet. It is brown or yellowish-brown to gray, and always porous for several inches below the surface. In places below a depth of 12 or 15 inches it becomes more dense, and clayey, and the color changes from gray to brown. The constituent particles of the loess were originally derived largely from the till, and thus they consist of diverse materials brought from widely separated areas. The loess thus contains all the essential ingredients of an unusually fertile soil. Its physical characters are also conducive to a good soil, its particles being so fine as to give it a good power of resisting drought and prevent the rapid leaching of its plant food, while at the same time it is sufficiently porous to permit good underdrainage. The loess areas were originally forest covered, and where the slopes are not so steep as to permit rapid erosion, this soil is at present the most generally productive of any in the area, producing good yields of corn, wheat and grains and is favorable for the growth of apples, berries and other fruits.

Water Resources

The water present in the soil and rocks below the surface is known as ground water, the source of which is rainfall. The average rainfall in this region is approximately 40 inches. When rain water sinks into the ground it eventually reaches a depth below which the pores of the soil and rocks are filled with water. The upper surface of this zone is known as the ground water level, or water-table. The water-table is not a perfectly level plane,

as the surface of the water of a pond, but it is lower in the vicinity of streams and in areas where the surface materials are porous, and is higher over uplands and where the surface materials are more impervious.

The depth of the water-table in any region is not constant but depends primarily upon the variation in the amount of precipitation and upon the nature of the rock or soil.

The upper portion of the ground water is continually moving laterally and downward towards the permanent streams, at a rate varying largely with the nature of the soil or rocks. During periods of drought the water moving towards the streams is not replaced by rain water and hence, as the supply of ground water is diminished, the water-table is lowered. This general action is aided by evaporation at the surface, and many continued until temporary streams and wells become dry. In order to furnish a permanent water supply a well must be dug below the level to which the water-table falls in dry seasons.

The depth of the water-table is also affected by the nature of the rock or soil. Fine-grained, closely, compacted material affords little pore space for the water, and hence furnishes less favorable conditions for the downward percolation of the water than do the coarser grained soils and rocks. In the more impervious material, as clay, the water-table is usually nearer the surface than in more porous beds, as sand. Among other factors affecting the height of the water-table are evaporation, temperature, and atmospheric pressure.

In addition to the periodic variation in the level of the water table, there has been in recent years a permanent lowering

of this level in Illinois, largely as a result of increased run-off due to deforestation and drainage, and to increased consumption of water with the increase of population and industries.

If the depth to the water table may be assumed to be the depth to which the water stands in the shallow wells, then on the comparatively level prairie uplands in this region the average depth of the water table below the surface is about 8 feet. In the more dissected parts of the quadrangles the average depth is about 15 feet, and over the dryer portions of the larger flood plains in the area the depth is about 8 feet.

In some of the wells the depth to water varied widely from the average figures given above. The greater number of the wells in which the water level was excessively lower were dug through the surficial materials into bed rock. In such cases it is probable that the till above the rock was saturated but the deeper strata were not, hence the water that seeped into the well from the surficial material was not sufficient to fill up the well to that level, or the water may have drained away through the rock. An example of such a difference in the level of the water in wells dug in the till and in the underlying rock is shown in two wells near a house on a hill in the SE. 1/4, sec. 15, T. 2 N., R. 13 W. Where one well 61 feet deep passed into Pennsylvanian rock at a depth of 12 feet and the depth to water was 49 feet while another well 18 feet, ~~deep passed into Pennsylvanian rock at a d~~200 feet west of the first and on a little higher ground, did not reach hard rock, and the depth to water in the well was only 8 feet.

Shallow wells

An abundant supply of excellent water for farm and domestic use is often obtained from dug wells at shallow depths. Most of the

wells upon which information was secured, obtained water from thin beds of sand or gravel within, immediately above, or immediately below the Illinoian till at an average depth of 18 feet. Where the layer of sand or gravel is a few inches or more in thickness, it usually furnishes an abundance of water for farm uses. Except over the flood plains, these beds of sand and gravel do not appear to be continuous over very extensive areas for the width of some of them is known to be narrow; nor are they confined to a single level within the till, for in some wells a sand bed was encountered at more than one level. The water in these sand and gravel beds is frequently under considerable pressure, so that when the overlying till is dug through it rises rapidly in the well to a height of several feet above the water bearing stratum. A few scattered wells depend for a source of supply upon the water in the unassorted glacial till, but such are always weak, usually failing during seasons of drouth.

A number of the shallow wells in different parts of the quadrangle obtain water from a bed of sand overlying a zone of black mud, often containing numerous wood fragments. In a few wells a bed of sand was reported both above and below the zone of organiz matter. Water is sometimes found in the lower part of the upper sand and, in the wells that do not reach the black mud, is of good quality, but in the wells that penetrate the soil or muck horizon the water usually has a bad odor, and is unfit for use.

Over the flood plain areas water is obtained by driving a point down to beds of sand or gravel in the alluvial deposits to a depth of 10 to 30 feet. Abundance of water is usually encountered over these flood plains within 6 or 8 feet of the surface, but the

points are driven to greater depths to secure a better quality of water. The water is generally good, except where it comes from very near the surface, but in some of these wells the water contains a considerable amount of iron sulphate. The town of Sumner obtains its water supply from scattered wells in the alluvial sand and gravel of the old valley occupied by Muddy Creek, and the water supply of Claremont and Allendale is obtained mostly from dug wells at shallow depths.

The city of Robinson obtain its water supply from wells put down to porous beds on the flood plain of the Wabash River in the vicinity of Palestine, about 6 miles east of Robinson. The water comes from beds of gravel and sand at a depth of 50 to 70 feet.

The water supply of Palestine is also obtained from wells that penetrate porous beds of sand and gravel in the alluvium bordering Wabash River not far from the town. The quality of the water from this source and at this depth appears to be good, and the supply is abundant. The other towns in the Illinois portion of these quadrangles have no municipal water supply but depend on private wells.

Deep Wells.)-Over the hilly area east of Honey Creek to the Wabash River the till is usually thin and the water in many of the wells comes from beds of sandstone at depths varying from 15 to 80 feet. South of Embarrass some of the wells near the west and the south borders of the Hardinville and the hilly portion of the Sumner and Vincennes quadrangles also obtain water from the rock beneath the till. Many of these wells are entirely drilled . When hard rock is reached a casing is put down to the rock and drilling in the solid rock is resumed with a smaller bit. Other wells are dug to bed rock and then drilled from 25 to 200 feet deeper.

The water supply in these wells comes from sandstone beds lying at different horizons. The water in the sandstone is not under much pressure as shown in the fact that it does not stand in the wells at a level much, if any, above the top of the sandstone from which it is derived. The water from the hard rocks is variable in quality, that from sandstones not associated with coal is usually excellent, but sometimes it is hard and the water from strata associated with coal is usually charged with iron sulphate resulting from the decomposition of pyrite.

Surface water supplies.- Surface water is used by many of the power houses and pumping staions in the oil fields, the water being obtained from small reservoirs made by building dams across ravines. A supply of surface water abundant in amount for all ordinary purposes is furnished by the Embarrass and the North Fork and the other larger creeks but the quality of this water over the area of active oil operations is not of the best. The city of Newton about 8 miles west of the quadrangle, obtains its water supply from the Embarrass river without filtering or otherwise purifying the water. It is probable that the quality of the water in the river continues fairly good into the west part of the Hardinville quadrangle. The Embarrass River furnishes the water supply at Lawrenceville but here the water of the river contains a large amount of sodium and chlorine, and its percentage composition varies very much throughout the year.[1]

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[1] Collins, W. D: Quality of the Surface Waters of Illinois, Water Supply Paper 239, U. S. Geol. Survey

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This may be due in large measure to the effect of salt water draining from oil wells in this region. If the streams of the region continue

to receive waste waters from the oil wells, they will be of little value as a source of supply either for municipal use or for manufacturing purposes.

Water power.- The streams of this region have so little fall that they cannot be important sources of power, and no water power is now utilized in the area.

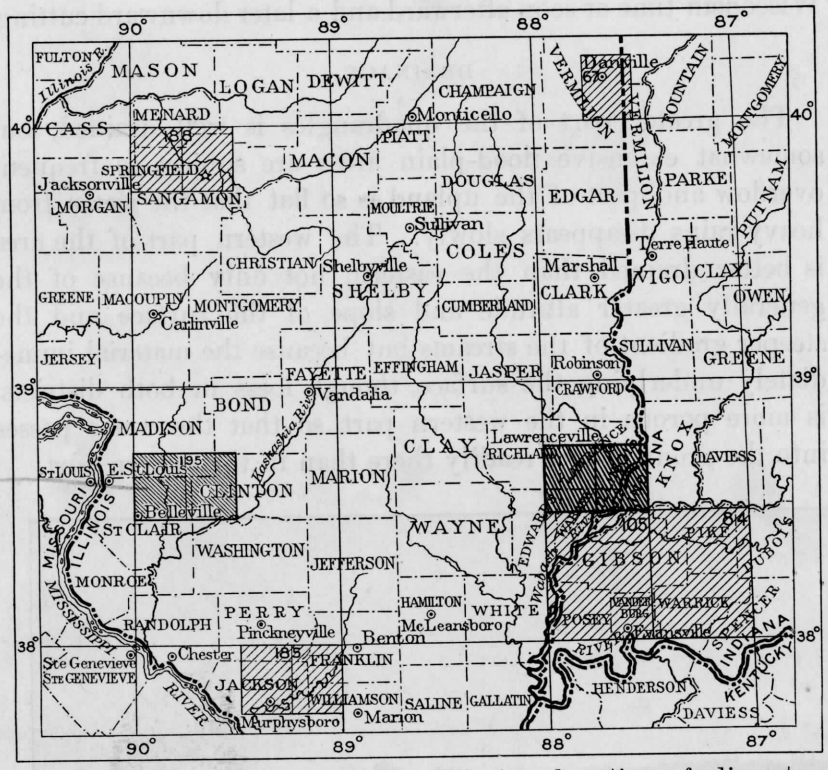


FIGURE 1.—Index map of southern Illinois and portions of adjacent States.

The location of the ~~Belleville~~ and ~~Breese~~ quadrangles (No. ~~182~~) is shown by the darker ruling. Published folios describing other quadrangles, indicated by lighter ruling, are the following: Nos. 67, Danville; 84, Ditney; 105, Patoka; 185, Murphysboro-Herrin; 188, Tallula-Springfield.

Sumner Vincennes

Spread Section lines + d

Add Hardinsville + Birds

Fig 1

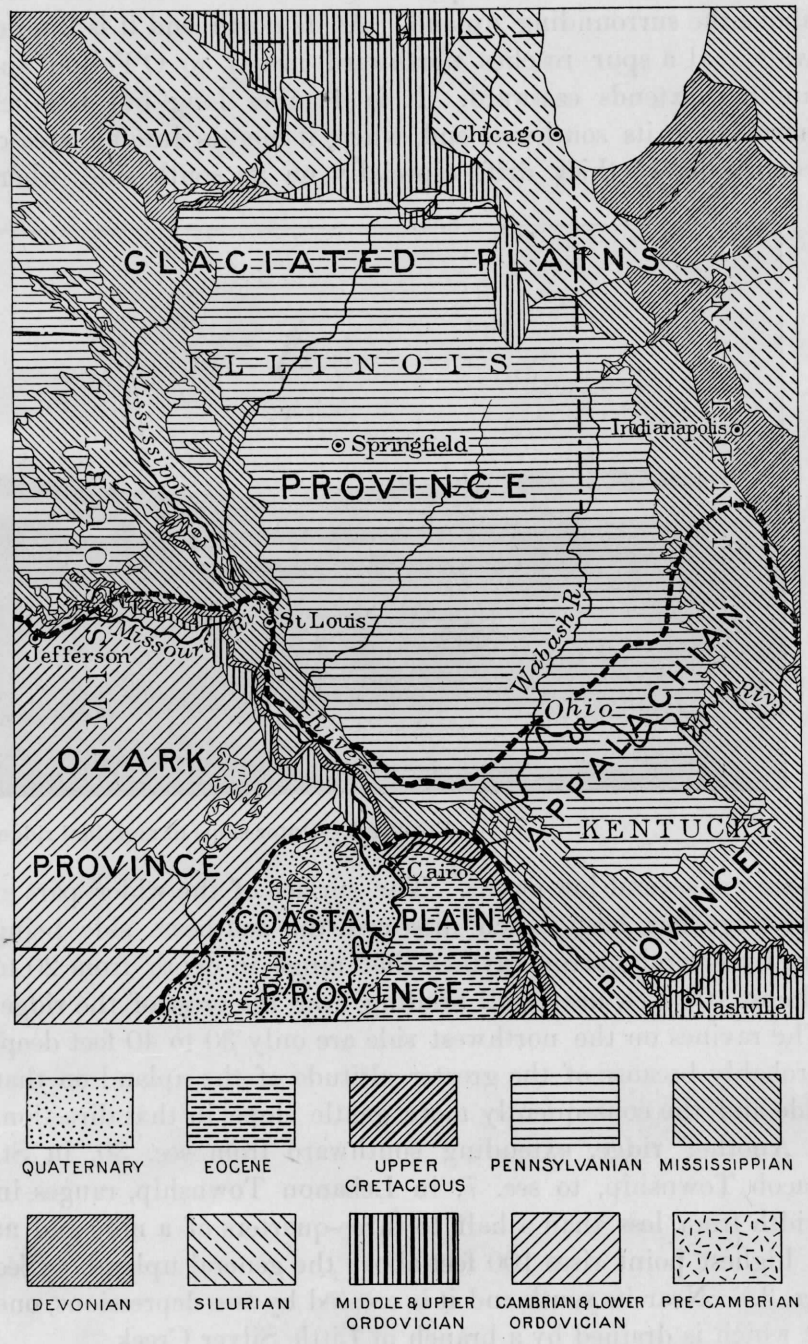


FIGURE 2.—Geologic sketch map of Illinois and surrounding region.

Shows also physiographic provinces of the region. The indefinite boundary between the Ozark and Appalachian provinces coincides approximately with the southeast boundary of Illinois. Map copied from geologic map of North America, U. S. Geol. Survey, 1911.

This figure is too complicated. The physiographic Provinces should be shown on a smaller figure. MRC

The physiographic provinces should be changed to agree with the provinces outlined by the Comm. & the A.A.G. MRC

Fig. 2.

Fig. Physiographic divisions in and about Illinois.

Fig 4. Shale above calcareous, fossiliferous shale and limestone lentil, below Parker coal, in east bank of creek 2 1/2 mile south of Flat Rock.

Fig. 4. Shale + limestone lentil below the Parker coal, exposed in east bank of river 1 mile east of Lawrenceville. One side of a low anticline is shown.

Fig. 5 Parker coal and overlying strata in west banks of creek 1/2 mile west of Flat Rock

Fig. 5. Shale & overlying thin sandstone beds below the Parker coal in bank of Embarrass river near Lawrenceville.

Fig 6. a low arch in the limestone above the Parker coal along a stream in east part of sec. 35, T 6N, R 11W.

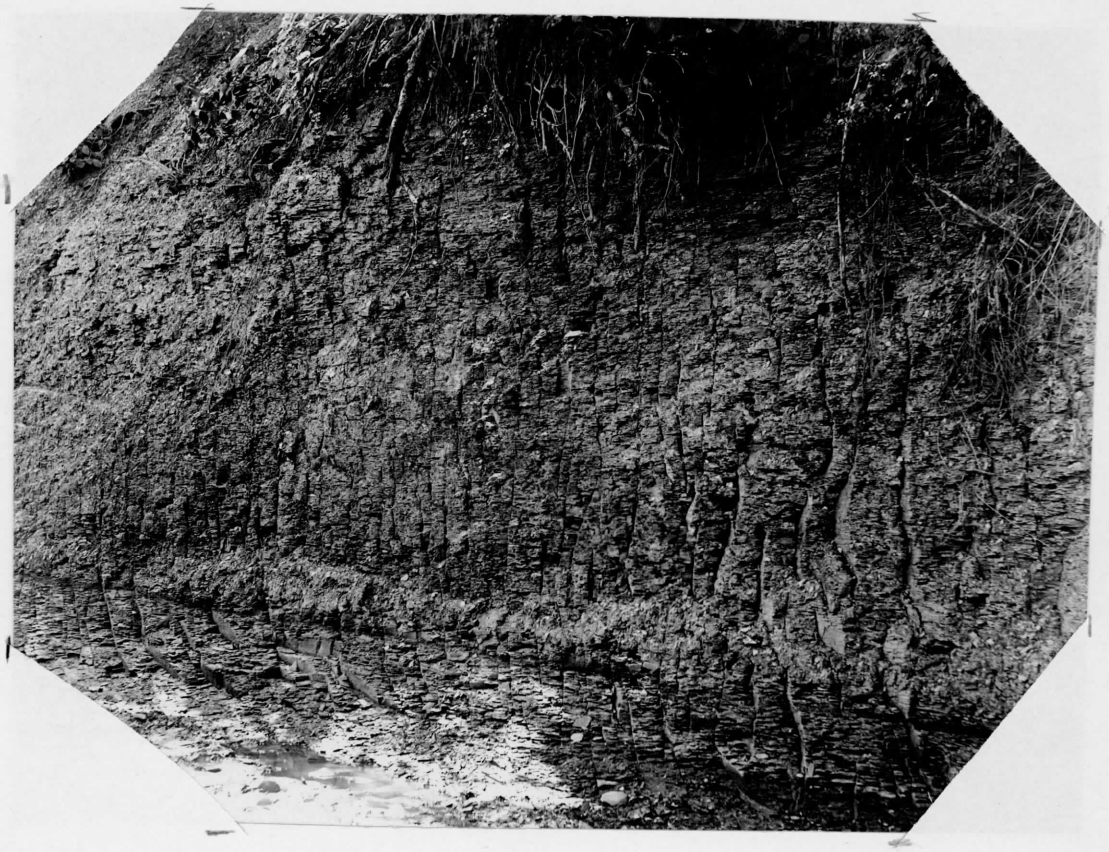


Fig 7. Strongly jointed shale above limestone overlying Parker coal, along a stream in east half of sec 35, T 6N, R 11W.

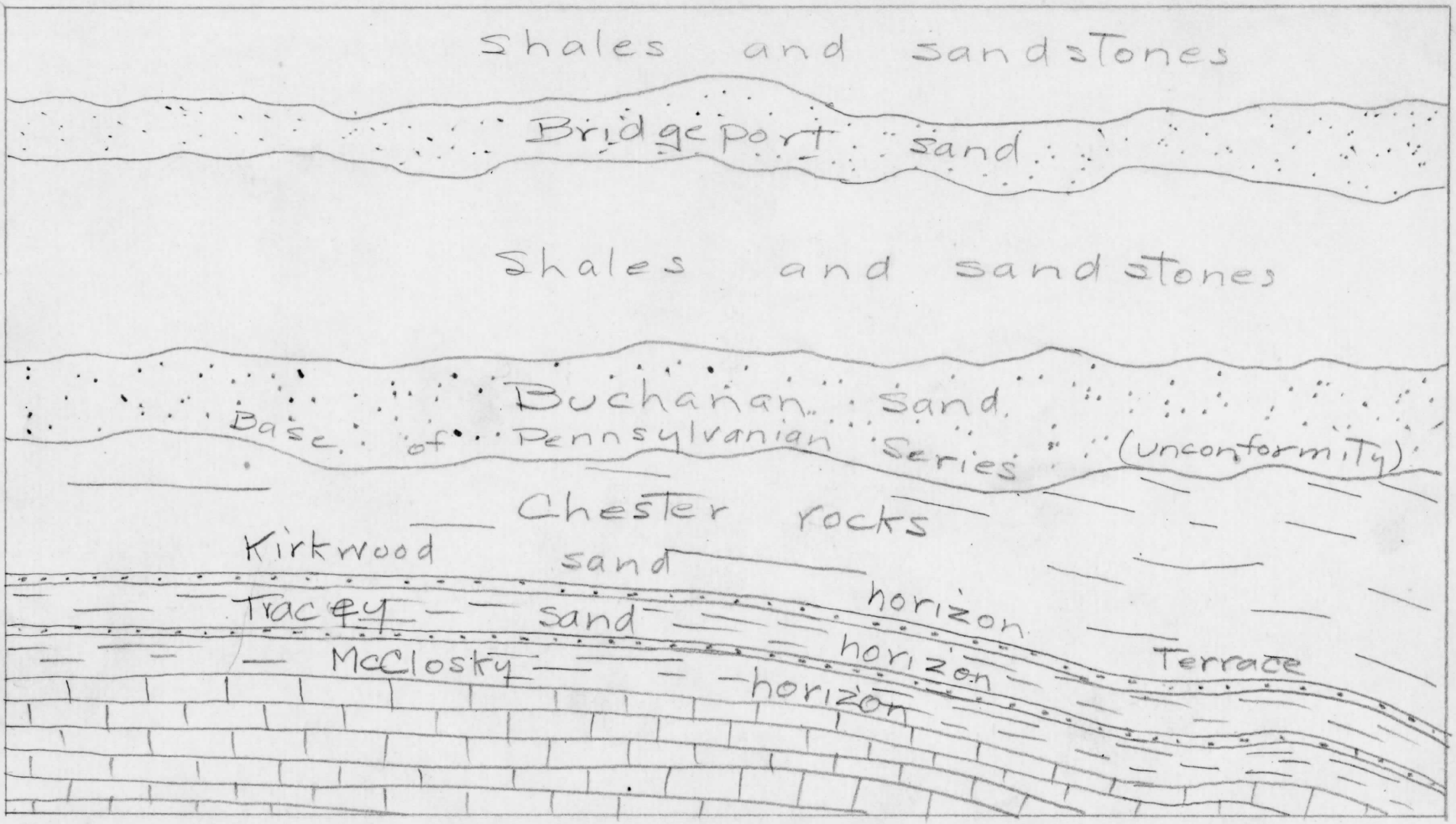
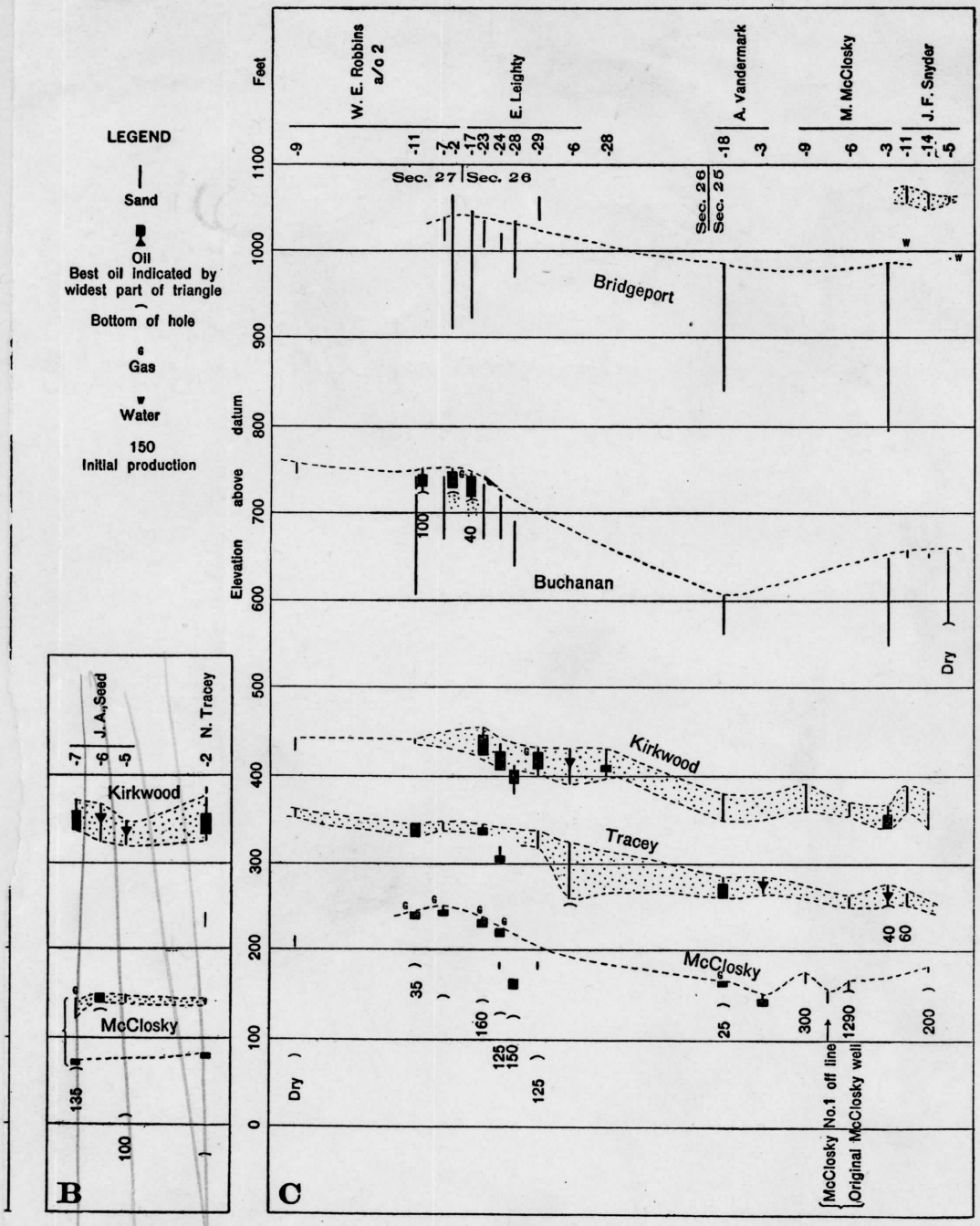


Fig. 6, from Fig. ~~10~~ 14, year book for 1915.

Figure 8



howing oil sands:

g even bedding of the McCloskey as compared with the more irregular Tracey, Kirk-port sands.

Lawrence Township, showing more than one McCloskey oil sand.

e part of La Salle anticline along first tier of wells south of center of secs. 27, 26, and luding original McCloskey well).

Title given in list of illustrations

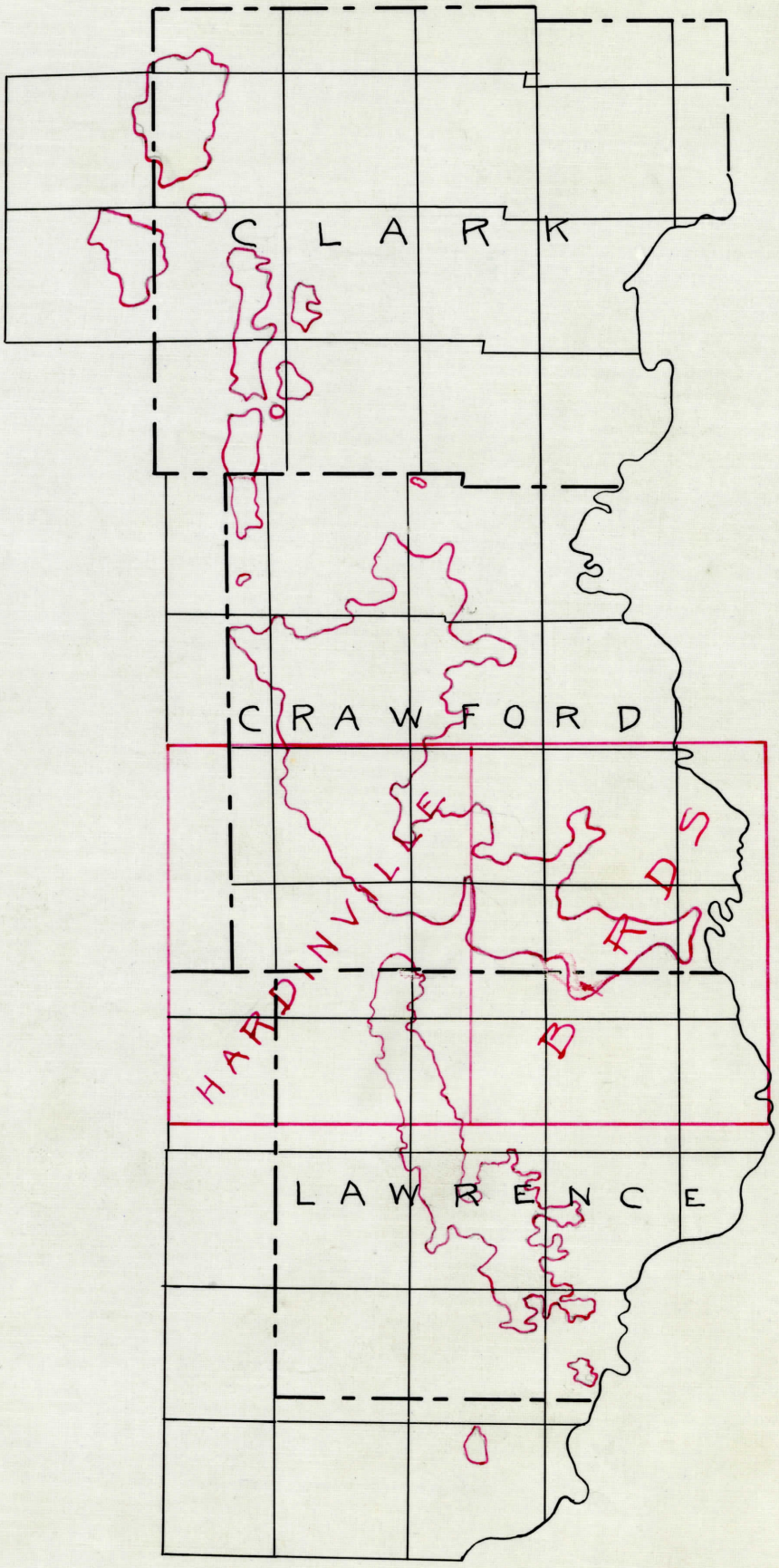


Fig 9

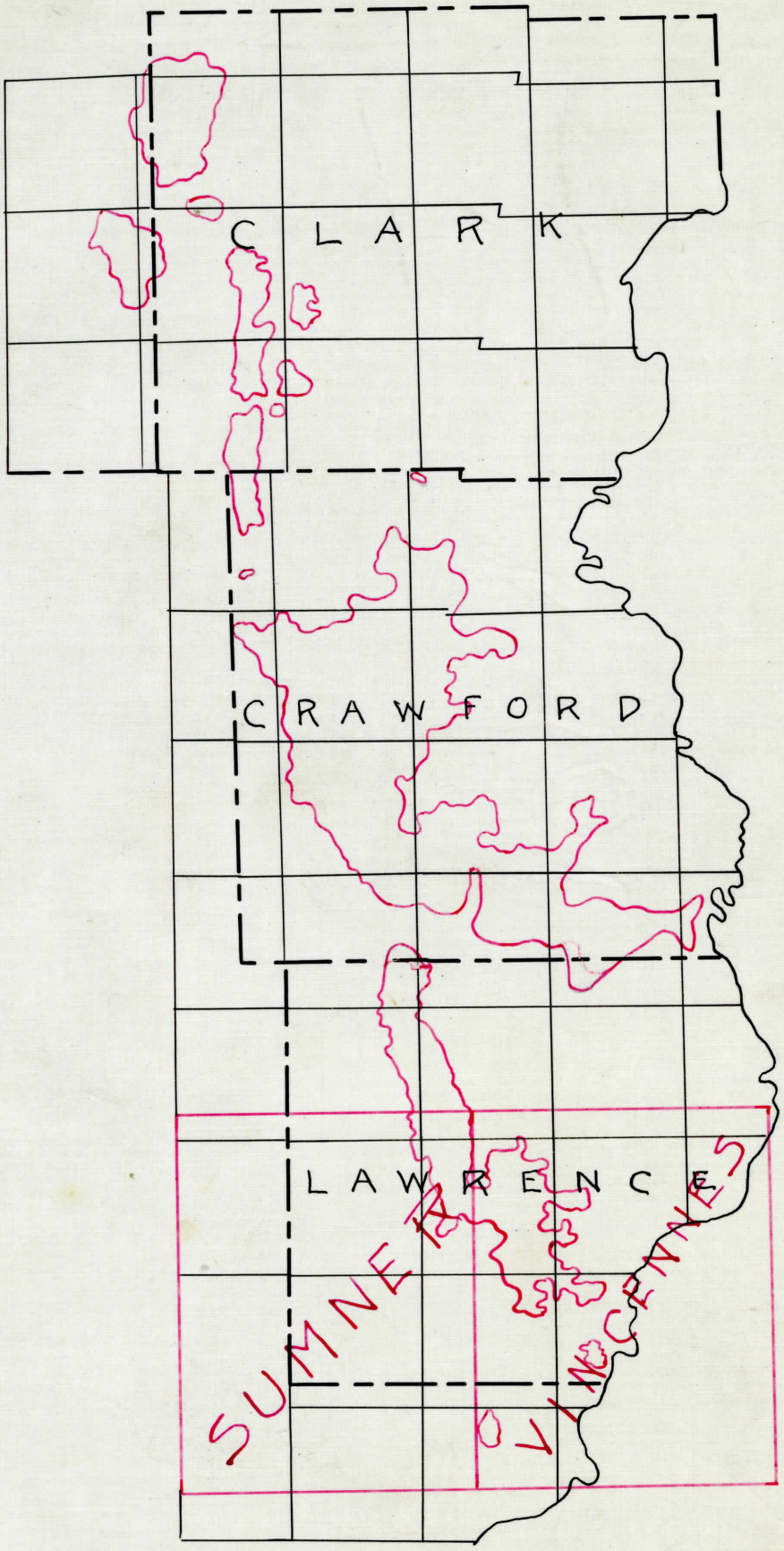


Fig 9

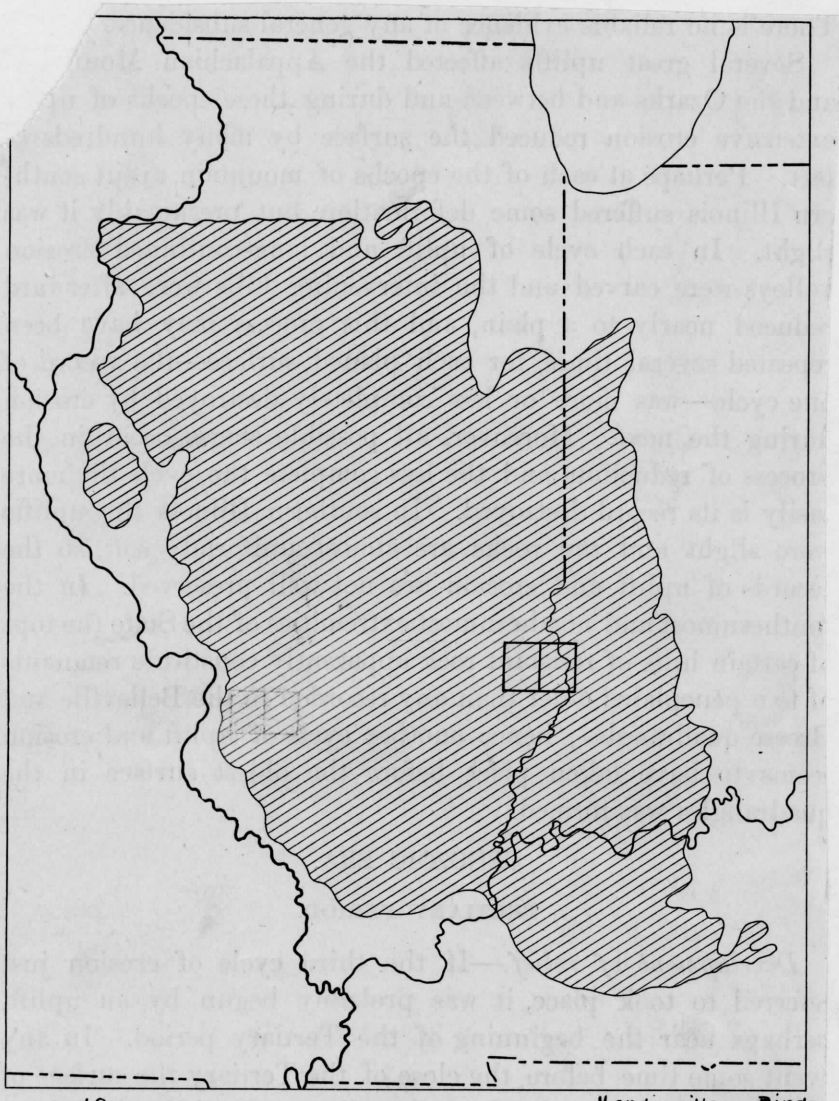


FIGURE ~~11.~~—Outline map showing the location of the ~~Belleville~~ and ~~Breese~~ quadrangles (the small rectangles) in the eastern interior coal basin of Illinois, Indiana, and Kentucky, represented by the ruled area.

Fig. 10.

Memo on the material for the Sumner- Vincennes Folio.

In addition to the figures called for in the list of illustrations, I have included the structural map on the Kirkwood sand for the Sumner quadrangle; the structural map on the Kirkwood sand for the Vincennes quadrangle (this has been taken from Rich's article in Bulletin 33.); map showing the areal extent of the different oil sands in the Sumner quadrangle; a map showing the areal extent of oil sands in the Vincennes quadrangle. These with the other illustrations called for in the list are now ready to go forward. This includes section C from Rich's article on the Vincennes quadrangle in our Bulletin 33. There are also two plates, one the areal geology of the Sumner quadrangle, and the other, the areal geology of the Vincennes quadrangle. 1916

In that portion of the text devoted to the oil and gas sands in this area, I find no mention of the illustrations made by Blatchley showing the areal extent of different sands. These maps have been carefully prepared and I believe constitute a real addition to the text material. I believe this includes all of the points brought up in our conversation this morning.

J.A.H.