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Structural Reconnaissance

of the Mississippi Valley Area from Old Monroe, Missouri, to Nauvoo, Illinois

BY
FRANK KREY

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In co-operation with
Illinois Geological Survey

MISSOURI BUREAU OF GEOLOGY AND MINES
H. A. Buehler, Director and State Geologist
ROLLA, MISSOURI

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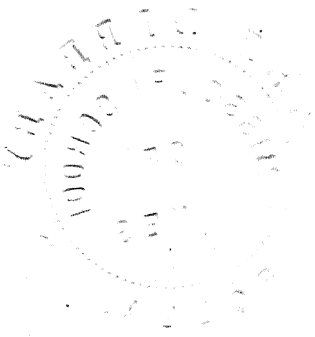

LETTER OF TRANSMITTAL

April 16, 1924.

To the President, Governor Arthur M. Hyde, and the Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen: It is my pleasure to transmit herewith a report by Frank Krey covering a structural reconnaissance of the Mississippi Valley area from Old Monroe, Missouri, to Nauvoo, Illinois. The report has been completed under a co-operative agreement between the Illinois Geological Survey and the Missouri Bureau of Geology and Mines.

The results include the general stratigraphy and structural features covering an area in which there has been manifested much interest in the possible production of oil and gas.

The area lies partially within each state, making a complete study impossible by either Survey alone.

Respectfully submitted,

H. A. BUEHLER,

Director and State Geologist.

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By FRANK KREY

CHAPTER I—INTRODUCTION

PURPOSE

The work upon which this report is based was undertaken primarily to determine the presence of any prominent structural features along the Mississippi Valley which might be of importance in the development of the oil resources of the region. Careful observations were made of the different rock formations at their outcrops, their stratigraphic relations, their variations in lithologic character and thickness, and their distribution.

The field work was done in the summer of 1922 from the early part of June to the early part of October, of which time seven weeks were spent in Missouri and the remainder in Illinois. The writer was assisted in the field by Messrs. George Ekblaw and A. H. Meyer, Mr. Ekblaw working from early June until the middle of September, when Mr. Meyer joined the writer and remained until the completion of the field season.

LOCATION OF AREA

The area covered by this report includes all the counties of Illinois and Missouri immediately adjoining Mississippi River, beginning with St. Charles County, Missouri, and Jersey County, Illinois, on the south, and extending northward to the north boundary of Missouri and to the north boundary of Hancock County, Illinois (Pl. I).

ACKNOWLEDGMENTS

The writer wishes to acknowledge his indebtedness to Mr. F. W. DeWolf, formerly Chief of the Illinois State Geological Survey, and to Mr. H. A. Buehler, State Geologist of Missouri, for many helpful suggestions in planning the work. Thanks are

also due Messrs. Geo. Ekblaw and A. H. Meyer for their faithful and efficient help in the field. Observations along the Mississippi River bluff in Missouri between Winfield and Hannibal were made by Mr. Ebklaw. The publications of both the Illinois and Missouri Surveys have been freely drawn upon and different phases of the work have been discussed with members of the Illinois Geological Survey, particularly Drs. T. E. Savage and Stuart Weller.

General Statement

It is obvious that the structure over much of the region, based as it is on comparatively few rather widely scattered observations can be considered suggestive only so far as small local areas are concerned. The chief value of the work, therefore, is not its application to any one locality, but rather in furnishing a background and an understanding of the broad regional factors without which the detailed work in small areas can not be rightly interpreted.

Methods Employed

Traverses along both the Illinois and Missouri bluffs of Mississippi River, and detailed observations on structure and stratigraphy at least once every mile, and generally oftener, comprised the data upon which this report is based. In addition to the bluff traverses, other east-west traverses were made across the counties at intervals of from two to three miles, but observations were limited to only a few outcrops in a mile, and in some cases no exposures of rock were found for stretches of several miles.

Elevations were obtained with a barometer or with a barometer and topographic maps, and except for a month at the beginning of the work, the barometer was used in conjunction with a barograph.

Degree of Accuracy

The accuracy of the elevations varies somewhat at different localities. Where the barometer was used with topographic maps having contour intervals of twenty feet, the elevations are probably all correct to within twenty feet. On the other hand, where the barometer was used without the barograph and without the numerous checks afforded by a topographic map, the

elevations may not be correct within fifty feet. Fortunately the only area worked under such conditions was the whole of Lincoln County and the southern part of Pike County, Missouri. When used with the barograph, the barometer gave excellent results and numerous checks showed the elevations in all cases to be correct well within twenty-five feet. Topographic maps made by the Mississippi River Commission showing both bluffs, afforded data for the immediate valley of Mississippi River and topographic maps were also available for most of Lewis, Clark and Marion counties, and parts of Pike, Lincoln, and St. Charles counties, Missouri. In Illinois, topographic maps were available for the southern tip of Calhoun county and small areas in Pike, Adams and Hancock counties.

Manner of Presentation

In presenting the results of this reconnaissance, as much information as possible is placed upon the structure map of the region, (Pl. I) the structure being shown by means of contours on the base of the Burlington limestone. Outcrops are shown by appropriate symbols, given in the legend of Pl. I and are accompanied by index numbers in each county. Table 1 lists under counties arranged alphabetically the index numbers designated on Plate I, the formation names, and the elevation of the tops of the formations where contacts are exposed. The major faults are indicated on Plate I. Areas in which detailed structural mapping has been done are outlined on the map. Approximate locations of all wells known to reach the Kimmswick ("Trenton") limestone are also shown. Variations in thickness and character of the formations are indicated by two longitudinal sections, (Pl. II) along Mississippi River, one (A-A) on the Missouri and the other (B-B) on the Illinois side, and by three east-west sections across the area (Pl. III).

The main body of the report is divided into three parts, the first dealing with the stratigraphy, the second with the structure, and a third with the oil possibilities.

TABLE 1. List of index numbers given on Plate I, including names of formations and elevations of the tops of the formations where contacts are exposed.

ILLINOIS

Map number	Formation	Elevation on top of formation	Map number	Formation	Elevation on top of formation
		Ft. above sea level			*Ft. above sea level*
Adams County			Adams County		
1	Keokuk	550	39	Keokuk	660
2	Warsaw-Spergen	580	40	Warsaw-Spergen	590
3	Keokuk	560	41	Warsaw-Spergen	585
4	Keokuk	550	42	St. Louis	615
5	Keokuk	560	43	a	
6	Keokuk	555	44	Keokuk	520
7	Keokuk	615	45	Warsaw-Spergen	600
8	Warsaw-Spergen	615	46	Hannibal	b
9	Warsaw-Spergen	600	47	a	
10	Warsaw-Spergen	600	48	Warsaw-Spergen	595
11	Keokuk	570	49	Warsaw-Spergen	590
12	Keokuk	570	50	a	
13	a		51	a	
14	Warsaw-Spergen	630	52	a	
15	Warsaw-Spergen	640	53	Keokuk	b
16	Keokuk	560	54	Hannibal	525
17	Keokuk	560	55	Hannibal	485
18	Warsaw-Spergen	655	Brown County		
19	Warsaw-Spergen	660	1	a	
20	Warsaw-Spergen	655	Calhoun County		
21	Warsaw-Spergen	640	1	Silurian	450
22	a		2	Hannibal	600
23	Keokuk	690	3	Silurian	505
24	Burlington	b	4	Hannibal	520
25	Burlington	b	5	Silurian	470
26	Keokuk	625	6	Silurian	455
27	Keokuk	660	7	Silurian	600
28	a		8	Hannibal	590
29	Keokuk	600	9	Hannibal	520
30	Keokuk	620	10	a	
31	a		11	Silurian	455
32	Keokuk	625	11A	Silurian	b
33	Keokuk	650	12	Maquoketa	490
34	Keokuk	680	13	Hannibal	600
35	Keokuk	620	14	Maquoketa	b
36	Hannibal	430	15	Silurian	500
37	Keokuk	b			
38	Keokuk	680			

ILLINOIS—Continued

Map number	Formation	Elevation on top of formation	Map number	Formation	Elevation on top of formation
		Ft. above sea level			*Ft. above sea level*
Calhoun County			Hancock County		
16	Maquoketa	560	25	Warsaw-Spergen	580
17	Maquoketa	570	26	Warsaw-Spergen	595
18	Silurian	490	27	Keokuk	530
19	Kimmswick	480	28	Warsaw-Spergen	595
20	Silurian	565	29	Warsaw-Spergen	605
21	Kimmswick	520	30	Keokuk	540
22	St. Peter	540	31	Warsaw-Spergen	600
22A	Maquoketa	b	32	Keokuk	540
23	Silurian	460	33	Keokuk	540
24	Silurian	510	34	Keokuk	530
25	Burlington	b	35	Keokuk	565
26	St. Louis	b	36	Keokuk	565
27	St. Louis	b	37	Keokuk	620
28	St. Louis	b	38	a	
29	St. Louis	b	39	a	
30	St. Louis	b	40	Keokuk	560
31	St. Louis	b	41	Keokuk	550
Hancock County			42	a	
			43	a	
1	Keokuk	565	44	Keokuk	520
2	Keokuk	560	45	Warsaw-Spergen	585
3	Warsaw-Spergen	625	46	a	
4	Warsaw-Spergen	620	47	a	
5	Warsaw-Spergen	610	48	Keokuk	565
6	Keokuk	580	49	Keokuk	560
7	Keokuk	555	50	Warsaw-Spergen	615
8	Keokuk	570	51	Keokuk	585
9	Warsaw-Spergen	625	52	Warsaw-Spergen	545
10	Warsaw-Spergen	615	53	Warsaw-Spergen	580
11	a		54	a	
12	a		54A	Keokuk	500
13	Warsaw-Spergen	605	55	a	
14	Warsaw-Spergen	605	56	Keokuk	540
15	Warsaw-Spergen	645	57	Warsaw-Spergen	570
16	Warsaw-Spergen	640	58	Warsaw-Spergen	580
17	Keokuk	545	59	Keokuk	525
18	Warsaw-Spergen	595	60	Warsaw-Spergen	570
19	Keokuk	565	61	Warsaw-Spergen	585
20	Warsaw-Spergen	580	62	Keokuk	535
21	Keokuk	550	63	Keokuk	545
22	Keokuk	535	64	a	
23	Warsaw-Spergen	615	65	Warsaw-Spergen	600
24	Warsaw-Spergen	590	66	Warsaw-Spergen	590

ILLINOIS—Continued

Map number	Formation	Elevation on top of formation	Map number	Formation	Elevation on top of formation
		Ft. above sea level			*Ft. above sea level*
Hancock County			Pike County		
67	Warsaw-Spergen...	570	16	Hannibal.....	615
68	Warsaw-Spergen...	580	17	a	
69	Warsaw-Spergen...	580	18	a	
70	a		19	Hannibal.....	700
71	a		20	Hannibal.....	620
72	Warsaw-Spergen...	580	21	a	
73	Keokuk.....	540	22	Hannibal.....	575
74	Warsaw-Spergen...	565	23	Hannibal.....	585
75	a		24	Hannibal.....	580
			25	Burlington.....	b
Jersey County			26	Burlington.....	b
			27	Hannibal.....	460
1	Hannibal.....	500	28	Hannibal.....	600
2	a		29	Hannibal.....	575
3	Silurian.....	500	30	a	
4	Maquoketa.....	580	31	a	
5	Silurian.....	520	32	Hannibal.....	600
6	a		33	Hannibal.....	615
7	Hannibal.....	450	34	Silurian.....	495
			35	Silurian.....	500
Pike County			36	Hannibal.....	620
			37	Hannibal.....	580
1	a		38	Hannibal.....	590
2	Hannibal.....	590	39	Hannibal.....	550
3	Hannibal.....	540	40	Hannibal.....	550
4	Hannibal.....	520	41	Hannibal.....	510
5	Hannibal.....	585	42	Hannibal.....	460
6	Hannibal.....	555	43	Hannibal.....	475
7	Hannibal.....	620	44	Hannibal.....	475
8	Hannibal.....	550	45	Hannibal.....	520
9	a		46	Hannibal.....	545
10	Burlington.....	b	47	Hannibal.....	570
11	Hannibal.....	575	48	Hannibal.....	595
12	Hannibal.....	655	49	Maquoketa.....	505
13	a		50	Hannibal.....	600
14	Hannibal.....	765	51	Silurian.....	545
15	Hannibal.....	605	52	Silurian.....	505
			53	Silurian.....	480

MISSOURI

Map number	Formation	Elevation on top of formation
		Ft. above sea level
Clark County		
1	Keokuk	550
2	Warsaw-Spergen	595
3	Warsaw-Spergen	575
4	Warsaw-Spergen	560
5	Warsaw-Spergen	580
6	Keokuk	520
7	Warsaw-Spergen	600
7a	Warsaw-Spergen	b
8	Warsaw-Spergen	605
9	Warsaw-Spergen	580
10	Warsaw-Spergen	600
11	Keokuk	520
12	a	
13	Warsaw-Spergen	590
14	Keokuk	535
15	a	
Lewis County		
1	Keokuk	580
2	Warsaw-Spergen	600
3	St. Louis	b
4	St. Louis	b
5	St. Louis	b
6	St. Louis	b
7	St. Louis	b
8	Warsaw-Spergen	590
9	Warsaw-Spergen	580
10	a	
11	Warsaw-Spergen	590
12	Hannibal	b
13	a	
14	Keokuk	530
15	Keokuk	535
16	Keokuk	555
17	Keokuk	b
18	a	
19	Keokuk	585
20	Keokuk	530
21	Keokuk	b
22	Keokuk	570
23	Keokuk	580

Map number	Formation	Elevation on top of formation
		Ft. above sea level
Lincoln County		
1	Plattin	580
2	Plattin	610
3	Kimmswick	b
4	Plattin	700
5	St. Peter	b
6	Joachim	650
7	St. Peter	b
8	Plattin	720
9	Plattin	780
10	Plattin	720
11	Maquoketa	620
12	Kimmswick	520
13	Kimmswick	480
14	Kimmswick	500
15	Kimmswick	540
16	Kimmswick	540
17	Plattin	515
18	Kimmswick	600
19	Maquoketa	690
20	Hannibal	740
21	Maquoketa	610
22	Maquoketa	530
23	Burlington	b
24	Burlington	b
25	Burlington	b
27	Burlington	b
28	Burlington	b
29	Plattin	b
30	Plattin	600
31	Plattin	690
32	St. Peter	700
33	Plattin	610
34	a	
35	Plattin	630
36	Plattin	730
37	Burlington	b
38	Joachim	580
39	Kimmswick	630
40	Burlington	b
41	Burlington	b
42	Maquoketa	640
43	St. Peter	660

MISSOURI—Continued

Map number	Formation	Elevation on top of formation	Map number	Formation	Elevation on top of formation
		Ft. above sea level			*Ft. above sea level*
Lincoln County			Marion County		
44	Kimmswick	780	12	Hannibal	640
45	Plattin	740	13	Hannibal	560
46	Devonian	780	14	Hannibal	515
47	Kimmswick	620	15	a	
48	Devonian	720	16	a	
49	Plattin	510	17	Hannibal	500
50	Kimmswick	640	18	Hannibal	530
51	Burlington	b	19	Hannibal	b
52	Burlington	b	20	Burlington	b
53	Burlington	b	22	Hannibal	665
54	a		23	Hannibal	680
55	Kimmswick	650	24	Devonian	b
56	Plattin	b	25	Louisiana	640
57	Joachim	b	26	Louisiana	570
58	St. Peter	b	27	Hannibal	670
59	St. Peter	670	28	Louisiana	660
60	Plattin	680	29	a	
60A	St. Peter (Cap-au-Gres fault)	b	30	Louisiana	b
			31	Hannibal	b
61	St. Louis	b	32	Hannibal	b
62	St. Louis	b	33	Hannibal	b
63	Warsaw-Spergen	b	34	Hannibal	b
64	St. Louis	b	35	a	
65	Warsaw-Spergen	b	36	a	
66	Burlington	b	37	Hannibal	590
67	St. Louis	b	38	Louisiana	b
68	Warsaw-Spergen	510	Pike County		
69	St. Louis	b	1	a	
70	a		2	Maquoketa	490
71	St. Louis	b	3	Kimmswick	530
Marion County			4	Devonian	610
1	Keokuk	555	5	Louisiana	550
2	Burlington	b	6	Hannibal	670
3	Burlington	b	7	Maquoketa	680
4	Burlington	b	8	Maquoketa	550
5	a		9	Hannibal	670
6	a		10	Maquoketa	560
7	Burlington	b	11	Maquoketa	590
8	Burlington	b	12	Kimmswick	565
9	Burlington	b	13	Hannibal	630
10	Burlington	b	14	Louisiana	560
11	Hannibal	640	15	Kimmswick	630

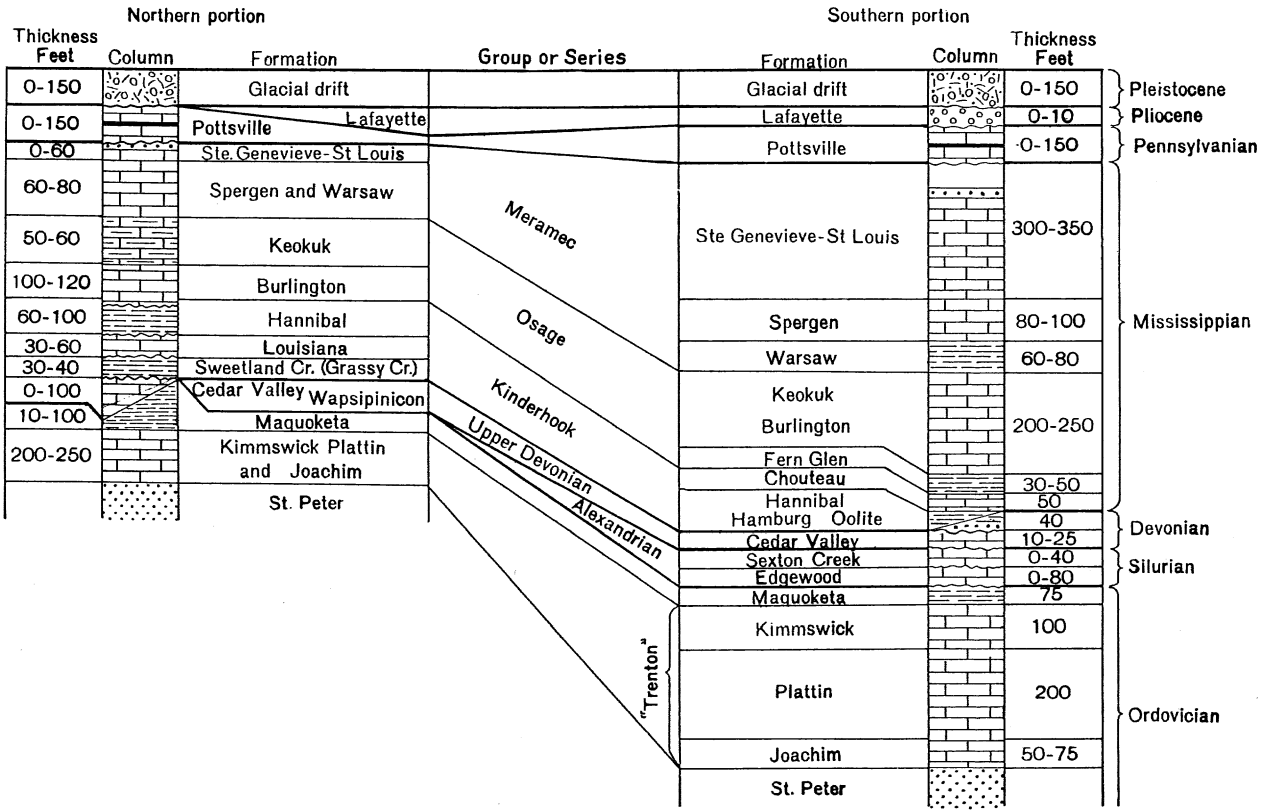
MISSOURI—Continued

Map number	Formation	Elevation on top of formation	Map number	Formation	Elevation on top of formation
		Ft. above sea level			*Ft. above sea level*
Pike County			Ralls County		
16	Maquoketa	720	13	Kimmswick	610
17	Hannibal	720	14	a	
18	a		15	Plattin	580
19	Hannibal	685	16	Hannibal	580
20	Kimmswick	490	17	Kimmswick	580
21	Maquoketa	570	18	Devonian	640
22	Maquoketa	590	19	Hannibal	680
23	Kimmswick	560	20	Hannibal	650
24	Maquoketa	640	21	Hannibal	590
25	Maquoketa	670	22	Hannibal	615
26	a		23	Hannibal	605
27	Maquoketa	550	24	Hannibal	610
28	a		25	Burlington	b
29	Maquoketa	540	26	Hannibal	585
30	Maquoketa	540	27	Hannibal	585
31	Kimmswick	650	28	a	
32	Plattin	690	29	Burlington	b
33	Maquoketa	b	30	Hannibal	620
34	Maquoketa	b	31	Louisiana	620
35	Hannibal	700	32	Kimmswick	635
36	Kimmswick	670	33	Plattin	490
37	Plattin	690	34	Hannibal	670
38	Kimmswick	690	35	Maquoketa	560
39	Maquoketa	770	36	Kimmswick	580
40	Maquoketa	550	37	Plattin	550
41	Maquoketa	540	38	a	
Ralls County			39	Kimmswick	500
			40	Hannibal	610
1	Louisiana	680	41	Hannibal	640
2	Hannibal	710	42	Burlington	b
3	Hannibal	620	43	Burlington	b
4	Hannibal	640	44	Burlington	b
5	Maquoketa	580	45	Hannibal	600
6	Maquoketa	560	46	Hannibal	650
7	Maquoketa	550	47	Burlington	b
8	Hannibal	630	48	Burlington	b
9	Hannibal	680	49	Burlington	b
10	Hannibal	675	50	Burlington	b
11	Kimmswick	570	51	Burlington	b
12	Kimmswick	590	52	a	

MISSOURI—Continued

Map number	Formation	Elevation on top of formation	Map number	Formation	Elevation on top of formation
St. Charles County		*Ft. above sea level*	St. Charles County		*Ft. above sea level*
1	Warsaw-Spergen...	470	11	St. Louis.....	b
2	Warsaw-Spergen...	b	12	St. Louis.....	b
3	Keokuk.....	b	13	a	
4	Keokuk.....	b	14	Warsaw-Spergen...	520
5	Keokuk.....	b	15	Keokuk.....	490
6	Keokuk.....	b	16	Keokuk.....	460
7	a		17	a	
8	Keokuk.....	b	18	Hannibal.....	470
9	Keokuk.....	b	19	Kimmswick.....	460
10	Warsaw-Spergen...	510			

a Well known to reach "Trenton."
b Level data not available.



Generalized section of strata exposed in the area covered by the report.

CHAPTER II—STRATIGRAPHY

General Statement

The succession of the stratified rocks which occur at the surface in this area includes formations ranging in age from Jefferson City of the Ordovician system to Carbondale of the Pennsylvanian. Rocks older than those that outcrop are known from drill records and may be seen in outcrop on the flanks of the Ozarks to the southwest and in northern and central Wisconsin to the north, but inasmuch as these rocks are not known to contain petroleum and were not studied, they will not be discussed here. Plate IV shows a generalized section of the rocks exposed within the area in the northern and southern portions.

Situated as this region is on the flanks of the old Paleozoic highlands of the Ozark region, the formations deposited during that time reflect to a greater degree the oscillations and shiftings of the sea than do the strata lain down farther east toward the center of the Illinois basin. During periods of emergence, the associated slight warpings gave rise to local high and low areas so that during the periods of erosion, formations have been entirely eroded from the higher areas, but remained undisturbed in the low spots giving rise to unequal and irregular distribution. Furthermore, the extent to which the seas transgressed upon these highlands varied with different periods or even epochs. Some formations are thus seen to rest upon progressively older strata towards the Ozarks. Also, the variation in proximity of the shore line at different places made its influence felt on the character of the sediments-so that the same formation may vary greatly in lithologic character in different localities. Some deposits lain down in bays from the main seas are found at the same elevations with older formations on both sides.

The near-shore characteristics mentioned are especially pronounced for the Silurian, Devonian and early Lower Mississippian, but the area in which these formations come to the surface is limited to southern Calhoun and southwestern Jersey counties in Illinois and the eastern portions of Lincoln, Pike and Ralls counties in Missouri. Much detailed work needs to be done in this area before all the details of the complicated stratigraphic relations are known. Because the data will have to be

obtained from drill records and cuttings over much of this area, samples of cuttings from all deep holes should be carefully collected and logs be preserved.

ORDOVICIAN SYSTEM

Formations of the Ordovician system outcrop along a belt 5 to 15 miles wide, extending from southwestern Jersey County westward across Calhoun County, Illinois, and thence across Mississippi Valley to eastern Lincoln County in Missouri. The southern limit of the belt of outcrop is terminated by a large fault (Cap-au-Gres) which juxtaposes rocks of Mississippian age with those of Ordovician age. In Missouri, the Ordovician rocks outcrop along a northward pitching arch which crosses eastern Lincoln, Pike and Ralls counties, but disappear beneath younger formations before Marion County is reached.

The formations exposed include the Jefferson City group, the St. Peter group, Joachim formation, Plattin formation, Kimmswick limestone, Fernvale limestone, and Maquoketa shale.

JEFFERSON CITY GROUP

The term "Jefferson City Group" is here used in the same sense as employed by Dake[1] and includes both Cotter and Powell formations as well as typical Jefferson City.

Rocks referable to this group outcrop along the bluff and in the ravines cutting the bluff in Lincoln County, Missouri, from the Cap-au-Gres fault northward to within half a mile of Foley, a distance of about 2 miles. Other outcrops of this group were seen near the bottom of a large ravine north of the road near the center of sec. 4, T. 49 N., R. 2 E., and are reported from the south side of Sandy Creek in sec. 35, T. 50 N., R. 2 E.,[2] from the Mississippi River bluff north of the Cap-au-Gres fault in Calhoun County, Illinois.[3]

Since both the "Jefferson City Group" and the overlying St. Peter group are below any known oil-bearing horizon in this region, no time was spent in detailed study of these formations.

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[1]Dake, C. L., The problem of the St. Peter sandstone; Missouri School of Mines and Metallurgy, Bulletin, Vol. VI., no. 1, p. 12, 1921.

[2]Potter, W. B., Geology of Lincoln County in preliminary report on iron ores and coal fields: Geological Survey of Missouri, 1872.

[3]Weller, Stuart, Geology of southern Calhoun County, Ill.; State Geol. Survey Bull. 4, p. 221, 1907.

As observed, the strata consist essentially of gray to buff, earthy, dolomitic limestone with interbedded sandy and cherty layers. The following section measured in the bluff about 1¼ miles south of Foley will serve to show the general character of the formation:

Description of strata	Thickness Feet	Thickness Inches
Limestone, dolomitic, gray, sandy	1	6
Limestone, white, earthy, in uneven beds	1	2
Limestone, gray, earthy, in uneven beds	2	6
Limestone, white, earthy, and knotty chert	1	6
Limestone, gray, sandy	2	—
Limestone, dolomitic, white, earthy and laminated gray, regular beds 2 to 12 inches alternating with sandy layers	16	—
Sandstone, gray, slightly calcareous	5	—
Limestone, dark, porous, sandy, brecciated and cherty, uneven top surface	3	—
Limestone, blue-gray, weathers brown; sandy and oolitic	1	—
Dolomite, porous, brown, cherty at base (contorted and brecciated)	3	—
Dolomite, dark blue gray, porous and finely granular, earthy at base	10	—
Concealed to flat	50	—

The greatest exposed thickness of strata belonging to this group is about 130 feet. This formation, though outcropping only in a limited area, underlies the whole region.

ST. PETER GROUP

Heretofore, the massive sandstone above the "Jefferson City group" has in this area been considered a single stratigraphic unit and has been referred to as the saccharoidal or St. Peter sandstone. Recent work to the south in Ste. Genevieve and Jefferson counties, Missouri, however, shows the St. Peter group to consist of two formations, the massive St. Peter sandstone above, and dolomite and sandstone, together known as the Everton formation, below. In this area dolomitic beds have been observed in the middle portion of the St. Peter group and as the thickness of the St. Peter in this region is equal to the combined thickness of the St. Peter and Everton beds farther south, it is probable that both formations are also present here.

Though outcropping over only a limited extent, the St. Peter group underlies the entire region; is a noted water carrier, and in the northern part of the region provides many artesian

wells of fresh water which farther south becomes increasingly saline. In this area the top of the St. Peter group is considered the base of any probable oil production.

The best exposures of this group are found in Lincoln County, Missouri, and Calhoun County in Illinois, and at least one exposure is known from Ralls County, Missouri.[4]

In Lincoln County, the St. Peter group is prominent in the river bluffs from the Cap-au-Gres fault to about a mile north of Foley. It is also found along the ravines and creeks back from the bluff for a distance of 3 or 4 miles. Other outcrops of St. Peter were observed along Mill Creek and its tributaries in secs. 28 and 33, and near the head of Sandy Creek in secs. 4 and 9, T. 51 N., R. 1 W.

In Calhoun County, Illinois, the St. Peter group outcrops in the Mississippi bluff between West Point and Dogtown landings, where it stands as a sheer bluff and does not lend itself to detailed study.

Wherever observed, the St. Peter is a massive sandstone indistinctly bedded or stratified. The color on the weathered surface is usually brown, but in protected places white or yellow. It is moderately coarse grained; the grains, the surfaces of which are frosted, are loosely cemented, well rounded, and of uniform size. Where the sandstone outcrops in the bed of streams and is subject to the action of running water and other forces of erosion, the bedding is more distinct, surfaces often ripple marked, and cross-bedding shown. At two localities dolomite was found interbedded with the sandstone. At the east point of the bluff about ½ mile south of Foley, a 6-foot bed of dolomite was observed, and in the ravine about a mile south of the last locality, many beds of dolomite 4 to 6 inches thick were found interlayered with sandstone, below which more massive sandstone, showing ripple marks occurred.

The stratigraphic relations of the St. Peter group to the underlying formations were not observed. The contact of the St. Peter with the overlying formation which was noted at several places, appears to be conformable, the St. Peter group apparently grading into the overlying Joachim dolomite. The thickness of the St. Peter group as developed in this area is between 125 and 150 feet.

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[4]Shepard, E. M., Underground waters of Missouri; U. S. Geol. Survey Water Supply Paper 195, p. 54, 1907.

JOACHIM DOLOMITE

The Joachim[5] dolomite, also known as the first Magnesian limestone of the older writers is exposed as a narrow belt bordering the outcrops of St. Peter sandstone and is best exposed in Lincoln County, Missouri, and Calhoun County, Illinois, but local outcrops are also found in Ralls County, Missouri, namely near the south line of sec. 21, T. 55 N., R. 4 W., and near the town of Spaulding, sec. 25, T. 56 N., R. 6 W. Specific locations of observed outcrops in Lincoln County, Missouri, are in the Mississippi River bluff about ½ mile north of Foley; along Sandy Creek in the southwest corner of sec. 30 and S. ½, sec. 32, T. 50 N., R. 2 E.; S. ½, sec. 7, T. 50 N., R. 1 E.; the SE ¼, sec. 10, T. 50 N., R. 1 W., and near the head waters of Sandy Fork in the northwest portion of T. 51 N., R. 1 W. In Calhoun County, Illinois, the best exposure of Joachim is found at the abandoned quarry in the river bluff near West Point landing.

As seen in the quarry in Calhoun County, the Joachim is a massive dolomite occurring in beds up to several feet thick. The color on the fresh surface is gray or yellow, but on the weathered face it is often brown. It is finely granular to crystalline, but some beds may be earthy and in the lower portion sandy. The lithologic characters of the rock are surprisingly uniform throughout its belt of outcrop, and it can easily be recognized by its yellowish color and finely granular to crystalline texture. Fossils are scarce, and wanting in most exposures.

In Calhoun County, Illinois, the formation is approximately 75 feet thick, but in Lincoln County, Missouri, it is not much over 50 feet. The relation of the Joachim with the underlying St. Peter has already been discussed, and its relation to the overlying Plattin appears to be unconformable. In Calhoun County the contact is more or less indistinct, and the formation appears to grade into the overlying Plattin limestone without any distinct break. The upper beds of the Joachim, however, are somewhat more argillaceous than the others. Westward in Lincoln County, Missouri, the Joachim is separated from the Plattin by a distinct shale several feet in thickness. The shale is not well developed in the bluff, but becomes increasingly prominent westward and reaches a thickness of about four feet in western

[5]Winslow, Arthur, Lead and zinc deposits of Missouri: Mo. Geol. Survey, Vol. VI, 1st ser., p. 352, 1894.

Lincoln County. It is green in color and in some places contains nodules of earthy limestone. A similar shale, also present at this horizon in Ralls County, Missouri, may be seen at the localities mentioned as having outcrops of the Joachim. At the outcrop near Spaulding in Ralls County the shale is distinctly sandy.

PLATTIN LIMESTONE

The Plattin[6] limestone overlying the Joachim, outcrops in the same general vicinity as that formation, but because of its greater thickness, it is exposed in a broader belt. In Lincoln County, Missouri, it outcrops for several miles from both sides of a line drawn from the river bluff half way between Apex and Foley northwestward to a point about 4 miles northeast of Louisville. Its outcrop in Pike County, Missouri, is limited to a small area near the south line of the county southwest of Edgewood. In Ralls County, it outcrops at localities mentioned as having outcrops of Joachim. On the Illinois side of Mississippi River, it is exposed only in the river bluffs near West Point Landing in Calhoun County.

Though somewhat variable in lithologic character, it is readily distinguishable from either the overlying or underlying formation. On the weathered surface the color is generally gray, but when freshly broken it is drab or bluish. It is massive with bedding often indistinct. The weathered surface is carious in many places, the pits varying in diameter from a fraction of an inch to more than a foot. The texture varies from granular to lithographic. Coarsely granular, fossiliferous beds are prominent in the lower 50 feet and in the upper portion. Dense, lithographic beds characterized by conchoidal fracture occur at different horizons throughout the formation, but are most abundant near the top and bottom. The larger part of the formation especially the central portion, consists of finely granular, dolomitic limestone, drab in color, but on closer examination an intimate mixture of earthy yellowish dolomite with the drab can be observed. The upper 10-15 feet of the Plattin wherever exposed, consists of layers 6 inches to 2 feet thick of dense, drab to blue, lithographic limestone, separated by partings ¼ to 2 inches thick of drab, calcareous shale which is petroliferous, thin slivers of which burn when lighted with a match. The limestone

[6]Buckley, E. R., and Buehler, H. A., The quarrying industry of Missouri: Missouri Bureau of Geology and Mines, Vol. II, 2nd. ser., p. 111, 1904.

weathers white, and where it occurs in a bluff, it resembles strongly a wall of masonry. Where this horizon makes up the surface rock, it weathers to a light, spongy, porous mass so soft it can be scratched with the finger-nail, and preserves beautifully the enclosed fossil forms. It is for this horizon that Rowley proposed the name Auburn Chert.[7]

The thickness of the Plattin is not much less than 200 feet in Lincoln County, Missouri, for 180 feet may be seen in the bluff about 1½ miles north of Foley. In Calhoun County, Illinois, it does not appear to be greater than 125 feet, and judging from well records, it probably thins out to the north. There is a suggestion also that where the Plattin is thickest the Joachim is thinnest and vice versa.

KIMMSWICK ("TRENTON") LIMESTONE

The Kimmswick[8] limestone which overlies the Plattin is best exposed in northeastern Lincoln County, a strip running northwest-southeast across central Pike County and in the general vicinity of New London in Ralls County, Missouri. In Illinois, the best exposures may be seen in the Mississippi River bluff in the vicinity of Batchtown and along the Illinois River bluff in southwestern Jersey County.

Lithologically, the Kimmswick is essentially a gray, sometimes tinted blue or pink, coarsely granular limestone. Locally, however, especially in the upper portion there is found considerable variation. Where the Cap-au-Gres fault intersects the bluff in Lincoln County, the upper 6 feet of the Kimmswick consists of dense, massive, hard, finely granular limestone, somewhat porous, which on weathering shows a knotty character and is mottled pink and gray. Similar limestone of like thickness is found capping the Kimmswick along Missouri River about 1½ miles west of Hamburg in St. Charles County, Missouri. Over most of Pike and Ralls counties in Missouri, the upper portion of the Kimmswick is light gray, fine-grained limestone which weathers into thin layers. This character also prevails in southwestern Jersey County, Illinois, but in Calhoun and Lincoln counties, the fine-grained, gray beds of the upper Kimmswick are not so much in evidence. This phase seems best

[7]Rowley, R. R., Geology of Pike County: Missouri Bur. of Geology and Mines, Vol. VIII, 2nd. ser., 1907.

[8]Buckley, E. R., and Buehler, H. A., The quarrying industry of Missouri: Missouri Bur. of Geology and Mines, Vol. II, 2nd. ser., p. 111, 1904.

developed in the northern and eastern portion of the area. These fine-grained layers are not a distinct unit, but grade downward into the granular rock and are inter-bedded with it. The typical index fossil *Receptaculites* is most abundant in this upper phase of the Kimmswick.

The Kimmswick is massive, and where it outcrops along the streams, forms cliffs, shows only traces of bedding, and the weathered face is characterized by the peculiar pitting which is so prominent in most of the Plattin. Chert, though not abundant, is scattered throughout the formation.

The greatest observed thickness was about 120 feet, which is present in the river bluff in Lincoln County, Missouri, near Apex. In Calhoun County, Illinois, there does not appear to be much over 60 feet, but the average thickness of the formation is probably not much less than 100 feet.

The break between the Kimmswick and Plattin is in most cases distinct, and the change from the dense lithographic limestones of the Plattin to the granular limestone of the Kimmswick is accomplished within 2 feet or less. On the other hand, the presence throughout the region of outcrop, of the thin, lithographic phase at the top of the Plattin, precludes any erosional surface separating the two in this area and the two formations appear conformable.

MAQUOKETA SHALE

The Maquoketa shale is well exposed in northeastern Lincoln County, eastern Pike County, and central and southeastern Ralls County in Missouri; in both the Illinois River and Mississippi River bluffs in central Calhoun County, and in the Illinois River bluffs in southwestern Jersey County in Illinois.

Unlike the previously described formations, the Maquoketa does not underlie the whole region. It is present throughout the Illinois portion of the area, and outcrops in Lincoln and Pike counties, Missouri, but in north central Ralls County, Devonian limestone is seen resting directly on Kimmswick limestone, and drill records from Scotland, Knox, Monroe, Montgomery, Warren and St. Charles counties, Missouri, show no shale body comparable to the Maquoketa to be present. Field relations in Ralls County probably best observed along the ravines in the east central portion of sec. 29, T. 56 N., R. 4 W., south central portion of sec. 24, T. 56 N., R. 5 W., and in the vicinity of Shiel

in the eastern part of sec. 20, T. 56 N., R. 6 W., show that the Maquoketa was eroded in early Devonian times, and that with the advance of the middle or late Devonian sea from the north, deposits of sandstone and limestone were lain down in this eroded area and are now found at the same elevation as the older rocks which formed the shore line. Data showing the exact location of this bay are not available, but it extended southward at least as far as Ralls County.

The Maquoketa is essentially a calcareous shale of greenish-gray color, which on weathering becomes olive green. The amount of calcareous material varies but increases north and west so that in Pike and Ralls counties, Missouri, the shale is predominantly flaggy consisting of harder, non-laminated, earthy limestone layers one inch to one foot thick separated by less calcareous shale of approximately equal thickness. Farther south in Calhoun and Jersey counties, the upper portion is more argillaceous and siliceous, and the flaggy character is evident only in the lower portion. Locally, in western exposures, as observed near the center of sec. 13, T. 54 N., R. 5 W., the upper 3 feet of Maquoketa consist of coarsely granular, reddish limestone which is abundantly fossiliferous. The apparent increase in lime content to the north and west suggests that the Maquoketa once extended much farther westward than now found.

In Pike County, Missouri, there is seen above the flaggy, green Maquoketa 30 feet or more of thinly laminated, black shale, which weathers blue-gray, but is black in the fresh surface. This shale is characterized by the presence of abundant lingulas, and is separated from the flaggy shale of the Maquoketa by an unconformity marked by a thin, sandy layer containing much pyrite and highly polished, phosphatic nodules. This shale answers the description of the Hamilton shale of Rowley,[9] but since in sec. 19, T. 54 N., R. 2 W., along the south bank of Grassy Creek, it occupies a position below the Noix oolite of the Silurian and above the flaggy Maquoketa, it must be early Silurian or late Maquoketa.

In the bluff farther west where the Silurian limestone is absent, the Sweetland Creek shale rests on the black shale of the Maquoketa. The thickness of the formation varies from about 60 feet in the southernmost exposures of Missouri in Lincoln County to about 100 to 125 feet in Pike and Ralls counties. It

[9]Rowley, R. R., Geology of Pike County: Missouri Bur. of Geology and Mines, Vol. VIII, 2nd ser., p. 24, 1907.

also increases in thickness to the east as drill records in eastern Adams County, Illinois, show thicknesses of 150-200 feet of shale.

Because of the more resistant character of the shale, the contact of the Maquoketa with the underlying formation is not commonly exposed, but in Calhoun County, Illinois, where the contact has been observed, Weller[10] reports 6 inches of red, residuary clay with embedded chert fragments beneath the shale and considers this evidence for a long erosion period separating the two epochs of deposition.

SILURIAN SYSTEM

The Silurian outcrops over only a limited area along the flanks of the uplift which crosses Ralls, Pike, and Lincoln counties, Missouri, and Calhoun and southwestern Jersey counties in Illinois (Pl. V, A).

ALEXANDRIAN SERIES

Only the lower Silurian formations known as the Alexandrian[11] series are present. This series includes the Sexton Creek limestone which is considered of Brassfield age and the Edgewood formation.

Field studies show that the Silurian does not extend as far south as the Cap-au-Gres fault in Lincoln County, and does not continue much farther north than Louisiana in Pike County, Missouri. Westward, Silurian rocks were observed to within 2½ miles southwest of New London in Ralls County. West of here, exposures show that Silurian rocks were eroded probably during early Devonian times and drill records of surrounding regions in Missouri show no Silurian, so that in Missouri the Silurian rocks appear to occupy a tongue-like extension or bay extending westward from the Illinois basin. In Illinois, Silurian rock underlies practically the whole region except an area between Quincy and Warsaw along Mississippi River.

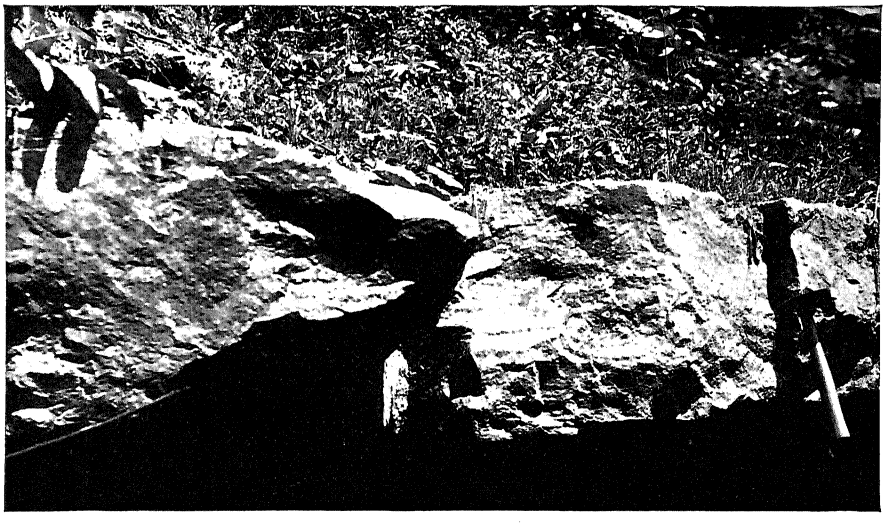
EDGEWOOD FORMATION

The Edgewood formation is divided into two members: the Bowling Green dolomite above, and the Cyrene dolomite

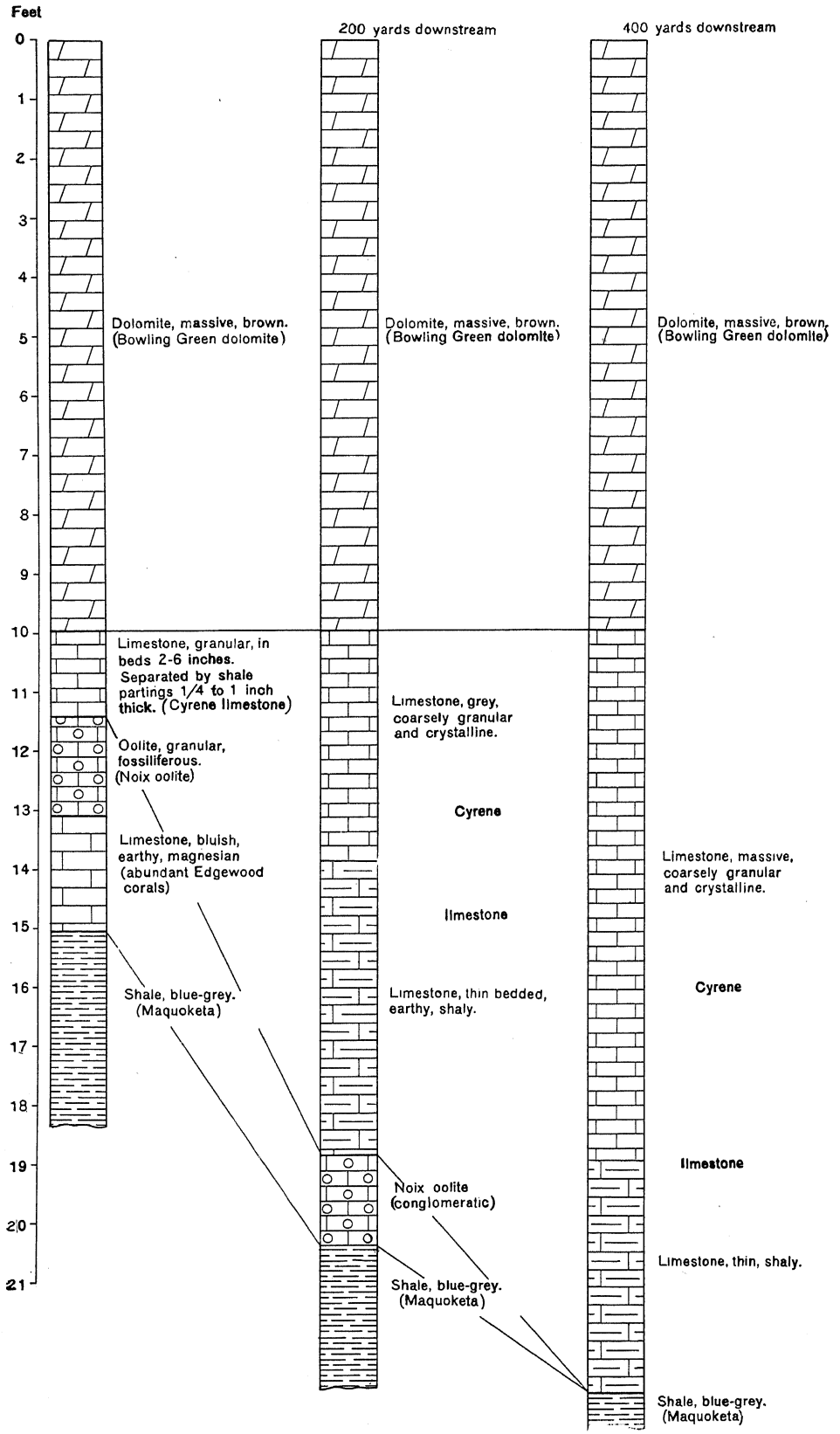
[10]Weller, Stuart, Geology of southern Calhoun County: Ill. State Geol. Survey Bull. 4, p. 223, 1907.

[11]Savage, T. E., Stratigraphy and paleontology of the Alexandrian series in Illinois and Missouri: Ill. State Geol. Survey Bull. 23, p. 68, 1917.

A. Steeply dipping Silurian limestone along the Cap-au-gres fault, 6 miles west of Grafton, Jersey County, Illinois.



B. Ledge of Noix oolite above Maquoketa shale in bed of creek on east side of road about 5 miles south of Hamburg, Calhoun County, Illinois.



Sections taken at intervals along Grassy Creek, Sec. 24, T. 54 N., R. 3 W., Pike County, Missouri.

and limestone below. A portion of the Cyrene member which is oolitic is called the Noix oolite. Savage[12] considers the oolite equivalent to the upper portion of the Cyrene.

The upper portion of the Edgewood (Bowling Green member) is a lithologic unit throughout the area, but the lower portion shows considerable variation. At most exposures, the Noix oolite constitutes the basal Silurian formation, and rests directly on Maquoketa shale (Pl. V, B), although in Grassy Creek in sec. 24, T. 54 N., R. 3 W., the Noix oolite is separated from the Maquoketa by from 1 to 3 feet of earthy, magnesian limestone which is abundantly fossiliferous. In general, it may be said that the Noix oolite forms the basal formation of the Silurian in the vicinity of the river bluffs on both Illinois and Missouri sides. Locally, however, as in southern Calhoun County and along Grassy Creek in sec. 24, T. 54 N., R. 3 W., of Pike County, Missouri, the basal Silurian formation is a coarsely crystalline, gray fossiliferous limestone. Eastward in Jersey County, Illinois, no Noix oolite was seen, and westward in Missouri near Bowling Green and Cyrene in Pike County and northwestern Lincoln County, the basal Silurian is a fossiliferous, earthy, magnesian limestone up to 20 feet thick and no Noix oolite appears to be present. In the southeast corner sec. 13, T. 53 N., R. 3 W., near Bowling Green, about 3 feet of earthy, magnesian limestone with abundant oolites typical of the Noix occur below the fossiliferous Cyrene. Unfortunately no fossils are associated with this oolite, but the relations shown suggest that the Noix is stratigraphically below beds referred to Cyrene. It is not improbable that detailed stratigraphic work in this region will show that both the Noix oolite and the coarsely crystalline limestone of Grassy Creek, Pike County, Missouri, and Calhoun County, Illinois, are distinct formations or that the oolite and limestone are one formation, while the Bowling Green and the fossiliferous, earthy, magnesian limestone together constitute another. The sections taken at intervals of 200 yards along Grassy Creek in the western part of sec. 24, T. 54 N., R. 3 W., (Plate VI), show very well the variable character of the lower Silurian.

Lithologically the Noix oolite presents several phases. In the bluff south of Louisiana, along Grassy and Noix creeks, and along a branch of Turkey Creek about 1 mile southwest of New

[12]Savage, T. E., Stratigraphy and paleontology of the Alexandrian series in Illinois and Missouri: Ill. State Geol. Survey Bull. 23, p. 77, 1917.

London in Ralls County, it appears as a gray, partly granular limestone with scattered white oolites which make up varying proportions of the mass. Elsewhere along the bluff region of Mississippi Valley, it appears as a dense, chocolate colored, almost lithographic rock, massive in character and showing a conchoidal fracture. In this rock, the oolites are best seen on the weathered surface as they become lighter in weathering, but even on the fresh surface, the lighter color of the oolites makes them stand out from the darker, almost lithographic ground mass so that in a fresh surface the oolites appear not unlike reflections in a mirror.

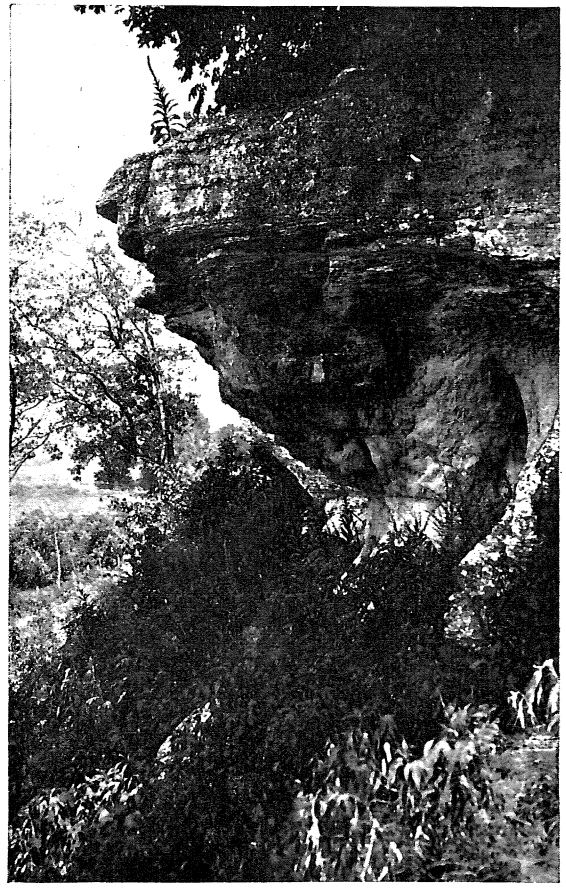
The gray-colored oolites of the Noix are distinctive and once seen can never be confused with any other oolite of the Mississippi Valley. They are almost perfectly rounded, and surprisingly uniform in size, between 1/16 and 1/32 of an inch in diameter.

The thickness of the oolitic beds varies, but in general, the granular, oolitic phase may reach a thickness of 10 feet or more, but the dense phase is commonly in one layer not more than 4 feet thick in most places.

The coarsely granular and crystalline phase of the Cyrene is massive in character, light gray or tinted bluish or pink, resembling greatly the Burlington limestone in lithologic character. This phase is apparently local in distribution, and may represent erosion remnants of a once more widespread formation, or it may be the undolomitized phase of the Cyrene. The greatest thickness observed is about 10 feet.

The typical Cyrene as developed in the vicinity of Bowling Green, Edgewood and Cyrene in Pike County and in northwestern Lincoln County, Missouri, is brown to blue-gray, earthy, magnesian limestone which weathers into thin beds, but is massive when fresh. It is distinguished from the overlying Bowling Green mainly by its abundant fossils and somewhat more earthy character. The greatest thickness of this horizon is about 20 feet, which was observed in northwestern Lincoln County in the east bluff of Cuivre River south of the road in the NW. ¼, sec. 22, T. 51 N., R. 2 W.

The Bowling Green dolomite representing the bulk of the Silurian in this region, is well exposed throughout the area of outcrop. It overlies the Cyrene and is a massive, porous dolomite, buff to gray when fresh, but weathering to a uniform, yellowish-brown color. The pores are often stained red with



A. Limestone bluff on the east side of Mississippi River valley, 4 miles south of Hamburg, showing unconformity between the Sexton Creek and underlying Bowling Green limestones.

B. Brecciated St. Louis limestone northwest of St. Patrick, Missouri. (See page 43.)

iron and small, dendritic, black markings are common. Fossils are scarce, though imperfect casts formed by the leaching out of fossils are more common. The thickness of the Bowling Green varies greatly from place to place. In the river bluff near Dameron in northeastern Lincoln County, the thickness of Bowling Green is not less than 70 feet; northward from here, the formation though varying greatly in thickness, gradually becomes less and finally pinches out so that it is missing near Louisiana; westward in Pike County, Missouri, the formation also thins, but more gradually, as the westernmost exposures still show from 10 to 20 feet of dolomite. The average thickness for Pike and northern Lincoln counties, Missouri, is between 20 and 30 feet. In Calhoun County, Illinois, the thickness is somewhat more uniform and averages almost 30 to 35 feet in the southern portion but becomes gradually thinner northward. In Jersey County, Illinois, the thickness is about 40 to 50 feet, but also shows a gradual thinning to the north and a thickening eastward along the southern edge of the county.

SEXTON CREEK LIMESTONE

The Sexton Creek limestone which is not so widespread as the underlying Bowling Green formation is best developed in the vicinity of the Mississippi River bluffs (Pl. VII, A). In Missouri, it is found along the bluff from south of Dameron in Lincoln County northward to the vicinity of Clarksville, but no exposures of Sexton Creek are found at any distance west of the river in Lincoln, Pike, or Ralls counties. In Illinois good exposures are found in both Illinois and Mississippi River bluffs. On the Illinois side of Mississippi River, the Sexton Creek is exposed almost continuously from 2 miles south of Gilead in Calhoun County northward to Rockport in Pike County. Along Illinois River in Calhoun County, the Sexton Creek outcrops as far north as Hardin, and in Jersey County it is exposed in the vicinity of Rosedale. Eastward, however, in the vicinity of Grafton, no exposures of the typical Sexton Creek occur.

As commonly developed, the Sexton Creek is a hard, dense, light gray limestone, massive, and found in beds up to 2 feet or more thick. Locally it is almost lithographic or has layers of more coarsely granular rock. In the vicinity of Pleasant Hill, the limestone is interlayered with one or more layers of buff-colored dolomite. Locally, as at Pleasant Hill, the color is mottled red and green, the green color being due to thin irregular

partings of shaly material which ramify the rock in all directions and cause the beds to weather with irregular and uneven surfaces.

The thickness of the Sexton Creek is extremely variable, ranging from a fraction of a foot to 50 feet, with variations of from 5 to 20 feet found within distances of 100 yards. Such extreme variations in thickness result from erosion channels made previous to the deposition of Sexton Creek which were later filled by the sediments in the advancing Sexton Creek sea. The greatest thickness of rock is found south of Hamburg in Calhoun County, Illinois, where about 50 feet of Sexton Creek may be seen, but north and south of here the thickness becomes less, so that the average thickness in Illinois is probably less than 15 feet. In Missouri, the greatest thickness is found in the bluffs near the south line of Pike County, and while old erosion channels may show 25 feet or more, the average thickness is not over 10 feet.

Devonian System

General statement

The rocks of the Devonian system in this region consist mainly of limestones with minor amounts of sandstone. The Illinois Geological Survey has been regarding the black Sweetland Creek shale, which overlies the Devonian limestones as uppermost Devonian, but the Missouri Geological Survey assigns the Grassy Creek shale, which corresponds to the Sweetland Creek shale, to the basal Mississippian for stratigraphic reasons.[13] Although the Sweetland Creek shale may be late Devonian in age, it is much more closely related to the overlying Mississippian than the underlying Devonian in this region, and will therefore be treated with the Lower Mississippian in this report.

In Illinois, the Devonian limestones of this area are correlated with the Wapsipinicon-Cedar Valley limestones of Iowa.[14,15] In northeastern Missouri, the Devonian limestones are separated into four formations as follows:[13]

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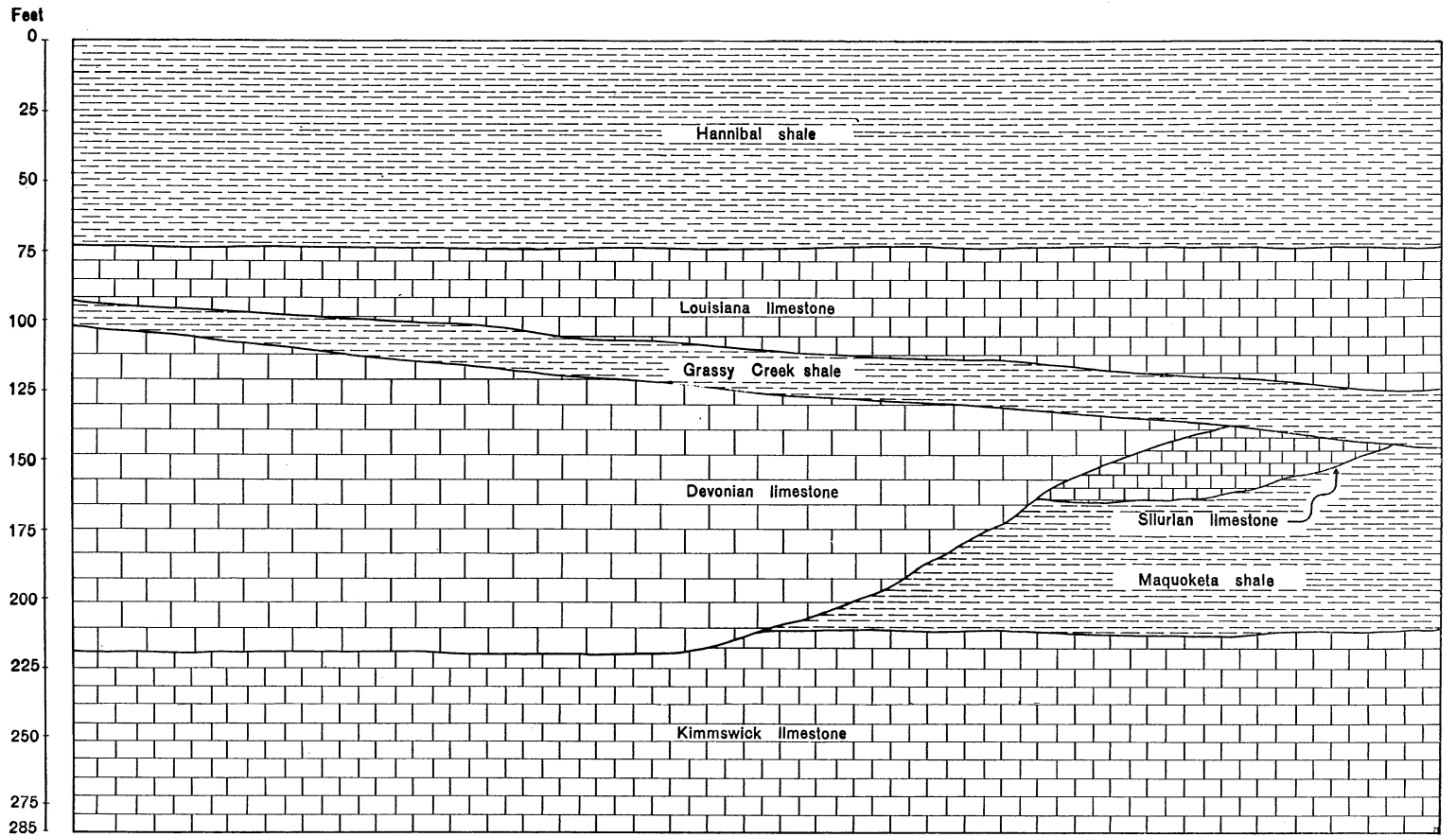
[13]Branson, E. B., The Devonian of Missouri: Missouri Bur. of Geology and Mines, Vol. XVII, 2nd ser., p. 5, 1923.

[14]Weller, Stuart, Geology of southern Calhoun County: Ill. State Geol. Survey Bull. 4, 1907.

[15]Savage, T. E., The Devonian formation of Illinois: Amer. Jour. of Science, 4th Ser., Vol. 49, p. 179, 1920.



East-west section across northern Ralls County, Missouri.

Snyder Creek shale
Callaway limestone
Mineola limestone
Cooper limestone

Of these formations, all except the Snyder Creek shale are present in this area. Because of the difference in nomenclature and in the absence of correlations showing the equivalency of the Devonian in Illinois and Missouri, the limestones of this age will be treated as a unit and discussed as the Devonian limestone.

DISTRIBUTION

Like the exposures of the older rocks, the Devonian outcrops are confined to the flanks of the Cap-au-Gres uplift and were observed only in southern Marion, Pike, Ralls, and Lincoln counties, in Missouri, and Calhoun and southwestern Jersey counties in Illinois. Throughout Pike and Lincoln counties, Missouri, and Calhoun and Jersey counties, Illinois, the Devonian reaches a thickness of 20 feet in a few places, and probably averages less than 10 feet. It is patchy in its distribution and is missing entirely over wide areas. Thus in the immediate vicinity of Mississippi River valley between Quincy, Illinois, and Clarksville, Missouri, no Devonian is present although the proper horizon is exposed for several miles in both bluffs of the river.

In northern Ralls and western Marion counties, Missouri, however, the Devonian thickens rapidly and reaches a maximum thickness of not less than 100 feet in northwestern Ralls County. This increase in thickness of the Devonian in Ralls County is the result of pre-Devonian erosion of lower formations and the subsequent deposition of Devonian limestones on this slope which marked an early shoreline of the invading Devonian sea. The relation of the Devonian to earlier and later formations is shown in the accompanying generalized sketch (Pl. VIII).

Similar relations hold from north to south as from west to east. The distribution and stratigraphic relations of the Devonian point to a northern, or possibly western, Devonian basin from which the seas transgressed upon the Ozark highland.

CHARACTER OF THE ROCK AND STRATIGRAPHIC RELATIONS

The best exposures of the Devonian limestones are in Ralls County, Missouri, in the vicinity of Flint Hill church in sec. 28,

T. 56 N., R. 4 W. about three miles northeast of New London, and westward along all the larger tributaries north of Salt River as far west as Shiel in sec. 20, T. 56 N., R. 6 W. In Marion County, Devonian rocks were observed only in secs. 8, 9 and 22, T. 57 N., R. 7 W., near the junction of Sees Creek and the south fork of North River.

The character of these Devonian limestones varies somewhat from place to place. In the vicinity of Flint Hill church it rests on either Maquoketa shale or Noix oolite. Here the basal layer of the Devonian is compact, gray, granular limestone containing pebbles and boulders of Noix oolite and fragments of chert, and is overlain by about 50 feet of dense, gray to blue, finely crystalline to granular limestone, many layers of which show a brecciated or conglomeratic character on the weathered surface. In the lane back of the house in the east central portion of sec. 29, T. 56 N., R. 4 W., sandstone fragments and slabs were observed which apparently came from the lower portion of the formation. Some of the higher limestone layers exhibited intricate cross bedding and a tendency to split into thin layers one inch or less thick.

At the east side of the road near the ravine in the south central part of sec. 24, T. 56 N., R. 5 W., the Devonian is separated from the Kimmswick by strata less than 20 feet in thickness. This is overlain by several feet of only partially exposed, gray, dense, conglomeratic limestone, upon which lies 8-12 feet of gray sandstone, generally soft and friable but locally cemented into hard, massive sandstone. The grains of the sandstone are well rounded and frosted, not unlike grains of the St. Peter sandstone, but are somewhat smaller. The color of the sandstone is generally gray or yellowish, but locally the weathered surface may be brown. The sandstone is in turn overlain by about 40 feet of dense, fine-grained limestone with few or no fossils. About a mile north of the ravine in sec. 24, T. 56 N., R. 5 W., there is exposed in a road cut above the Devonian limestone about 6 feet of black fissile shale. The limestone beneath the shale is a finely granular, brown dolomite, but farther down the ravine to the east, the dolomite gives way to the dense, gray, brecciated phase. Good exposures of the dense, gray, brecciated limestone with sandstone near the base may also be seen in the ravines in secs. 22 and 23 of T. 56 N., R. 5 W. Along the creek in sec. 28, T. 56 N., R. 6 W., there are also good exposures of the Devonian limestone, but no sandstone member is present in the lower

portion of the section and about 50 feet of dense, massive, somewhat brecciated limestone rests on the Kimmswick limestone. Above the dense, brecciated rock, there is a 20-foot layer of massive, somewhat earthy and finely granular, dolomitic rock which is overlain by about 30 feet of more variable limestone in which non-brecciated, dense limestone is interbedded with earthy to granular layers. These upper beds are abundantly fossiliferous in which respect they differ widely from the very slightly fossiliferous lower portion. Also, the upper 30 feet appears to be separated from the underlying massive layer by an unconformity and the basal layer is locally conglomeratic. The contact of the underlying massive layer and the dense, brecciated limestone is also irregular and it is possible that detailed stratigraphic work will show the Devonian limestone in northern Ralls County to consist of several distinct members or even formations.

Along the road north of New London in sec. 13, T. 56 N., R. 5 W., the Devonian limestones are overlain by about 10 feet of black shale which is in turn overlain by the Louisiana limestone.

The Devonian limestone on the Illinois side of the Mississippi and in Pike and Lincoln counties, Missouri, rests in most places on the Silurian. In the vicinity of the Cap-au-Gres fault in Lincoln County, Missouri, it overlaps the Silurian and rests upon the Maquoketa shales. Northward in the vicinity of Bowling Green and Louisiana in Pike County, the black shale rests on the Silurian and no Devonian limestones are present, so that these Devonian limestones in the Missouri portion of the area examined are limited to a rather small area, including only Lincoln County and southeastern Pike County.

Eastward across the Mississippi, the same Devonian limestone appears in the bluff of Calhoun County and extends from Hamburg southward to within six miles of the fault. North of Hamburg, the Devonian is missing and the Kinderhook shales rest on the Silurian. On the east side of Calhoun County, the Devonian again appears in Illinois River bluff from Hardin where it dips beneath younger formations southward to the village of Meppen, but south of there the Kinderhook shale rests on Silurian limestones. Eastward across Illinois River the Devonian again appears in the bluff and is present wherever strata of the proper stratigraphic horizon are exposed, which is from the vicinity of Nutwood to Grafton.

The Devonian of Illinois and south of Ralls County, Missouri, is predominantly a very fossiliferous, earthy, dolomitic limestone, but locally as in the vicinity of Nutwood in Jersey County, and in the bluff in the vicinity of Hardin in Calhoun County, and in Lincoln County, Missouri, it grades upward into a coarsely granular, gray limestone. The dolomitic beds are gray and earthy on the fresh surface, but the weathered face is brown and in the absence of fossils, is distinguished with difficulty from the underlying dolomite of the Silurian, where the light gray limestone of the Sexton Creek formation is absent. The basal layers of the Devonian are locally sandy and in some places, as in Calhoun and Jersey counties, thin layers of pure quartzose sandstone carrying the same fossils as the underlying limestone may be found. The thickness of the formation varies from place to place, but the maximum observed in outcrop is less than 20 feet, and near Grafton it is less than 5 feet.

Mississippian System

Lower Mississippian Sub-System

With the exception of small areas of Pennsylvanian rocks and a few scattered remnants of Tertiary gravels, the consolidated rocks exposed in the remaining area are lower Mississippian in age. These Lower Mississippian rocks are separated into several series which are further subdivided into formations as shown in the following table:

Subdivisions of the Lower Mississippian strata

Sub-system	Group or Series	Formation
Lower Mississippian	Meramec	Ste. Genevieve St. Louis Spergen Warsaw
	Osage	Keokuk Burlington Fern Glen
	Kinderhook	Chouteau Hannibal Louisiana Sweetland Creek (Grassy Creek)

KINDERHOOK SERIES

Sweetland Creek (Grassy Creek) shale.—In Missouri north of a line extending east and west through a point several miles south of Louisiana, Pike County, a black, fissile shale containing abundant sporangites occurs at the base of the Kinderhook. As observed at most outcrops, the basal portion of the shale is sandy and locally becomes a thin layer of sandstone containing coprolites and fish teeth. The main bulk of the shale is a massive, thinly laminated shale which is black when fresh, but weathers to a gray or blue gray color. Locally, however, the black fissile character is not developed and the mass of shale is blue-gray. The upper portion is often greenish in color and lacks the finely laminated structure of the black. This shale is well exposed in the river bluff in the vicinity of Louisiana where it rests on the Noix oolite and farther north on the Maquoketa. It is also exposed along Grassy Creek west of Louisiana.

In Ralls County, Missouri, exposures are found: (1) in the river bluffs in the vicinity of Saverton; (2) at the road cut in the southern part of sec. 13, T. 56 N., R. 5 W.; (3) where the road crosses a branch of Turkey Creek in sec. 2 about 1½ miles southwest of New London; (4) along Cedar Creek in the southern portion of sec. 28, T. 56 N., R. 6 W.; and (5) near the mouth of Brush Creek in sec. 30, T. 55 N., R. 4 W. At the last named locality the black shale is more sandy and contains several well defined layers of sandstone which contain abundant fish remains.

Section near mouth of Brush Creek in sec. 30, T. 55 N., R. 4 W.

	Thickness	
	Ft.	*In.*
Limestone, Louisiana	10	—
Shale, calcareous	—	4
Shale, black laminated	4-5	—
Sandstone, fine, gray, soft and friable	3	—
Shale, dark, weathers gray	1½-2	—
Sandstone, conglomeratic (mottled green from included shale)	1	—
Shale, gray, calcareous, massive layer (Maquoketa?)	4	—

In Marion County good exposures of the black shale were seen at the ravine in the SW. ¼ sec. 18, T. 57 N., R. 7 W., also along Sees Creek in sec. 15, T. 57 N., R. 7 W., and in sec. 29, T. 57 N., R. 6 W. The character of the shale in Marion County is similar to that previously described, but the variation in the amount of the black laminated layers is greater.

Across the Mississippi in Illinois, the black shale is well exposed in the river bluffs in the vicinity of Rockport and Atlas in Calhoun County, but becomes thin southward and is not present at and south of Hamburg. Along the Illinois River bluff, the black shale is well exposed just south of Bedford in Pike County, but farther south as near Hardin in Calhoun County where the horizon of the black shale appears, no shale is present and the Louisiana limestone rests directly on Devonian limestone.

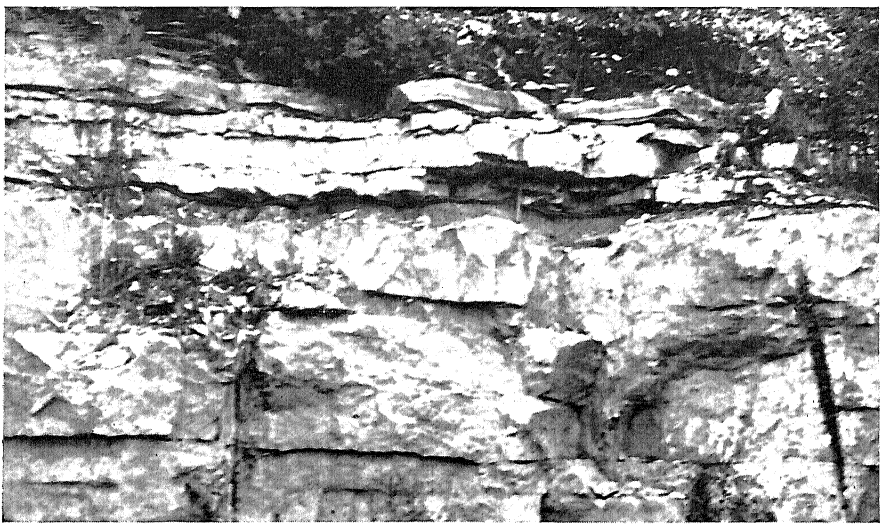
The black shale is not well developed in Jersey County, but has been observed locally as near the mouth of the ravine where the powder plant is located east of Grafton.

The thickness of the black shale is variable. On the Missouri side in the vicinity of Louisiana, it is from 4 to 6 feet, along Grassy Creek about 5 to 10 feet, farther north in Ralls County 10 to 20 feet, and in Marion County as much as 40 feet of black shale is revealed. In Illinois similar variations are found. Near Rockport and Atlas, 50 feet or more can be referred to the black shale, though neither the overlying Louisiana limestone or underlying formations are present. It may be said that the black shale shows increased thickness to the north and east, the greatest increase being toward the center of the Illinois basin. Westward the formation changes in character and becomes more sandy and grades into sandstone.

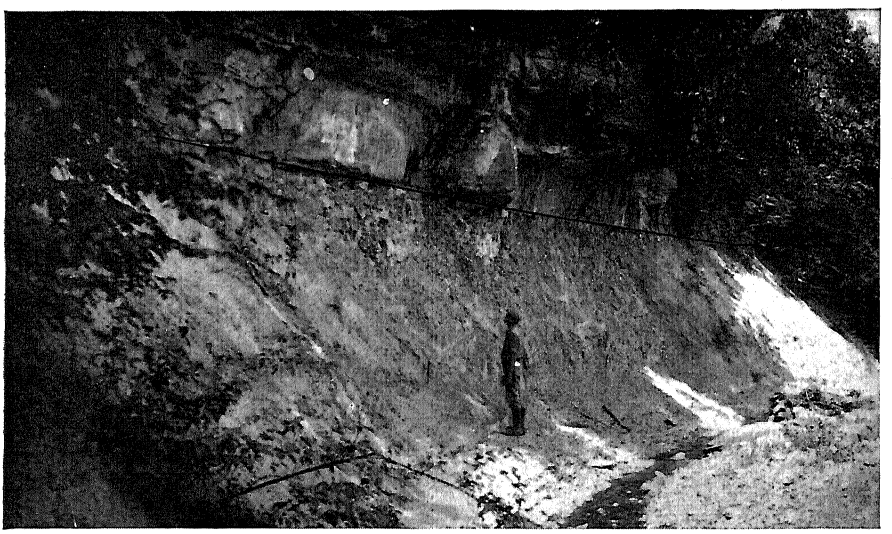
The relation of the black shale to the underlying formations is distinctly unconformable, for the black shale rests locally on the Maquoketa shale, Silurian or Devonian limestone. The break between the overlying Louisiana limestone and black shale is not so pronounced and no distinct evidence of unconformity is observable where both are present. Southward, however, as in southern Calhoun and Jersey counties, Illinois, and in southern Pike County, the Louisiana overlaps the black shale and rests directly on the Devonian (Pl. IX, A).

Louisiana limestone.—The Louisiana limestone is much more local in its distribution than any of the previously described formations. It is best exposed in the Mississippi River bluff between Louisiana and Hannibal, Missouri, where it reaches a thickness of about 60 feet. It continues northwest with only a slight diminution in thickness, but becomes thinner rapidly to the southwest and east.

The limestone is well exposed in Marion County in the river bluff at Hannibal and along Sees Creek, Lick Creek and South River in T. 57 N., Rs. 6 and 7 W. It outcrops also in Ralls



A. Unconformable contact between the Devonian and the overlying Louisiana limestone in quarry about 3 miles south of Hardin. Note shaly layer at contact indicated by hammer.



B. Contact of Hannibal shale and Chouteau-Burlington limestone near Hardin in Calhoun County, Illinois.

County, but westward from the bluffs it is much thinner, being less than 15 feet thick at its most western outcrops. In Pike County it is prominent in the river bluffs, but becomes thinner rapidly to the west and south, finally disappearing apparently as no exposures have been observed in Lincoln County.

Eastward in Illinois the Louisiana is much thinner. In the vicinity of Hamburg in Calhoun County, it is about 5 feet thick and gradually disappears southward. Northward it is present as far as the Pike County line, but no good exposures of Louisiana have been observed any farther north. On the east side of Calhoun County, an 8-foot outcrop of Louisiana appears in the bluff just north of Hardin, and continues southward with a gradual decrease in thickness until it pinches out entirely about 4 miles south. The Louisiana limestone does not appear again north of Hardin though its horizon is exposed near the north line of the county and south of Bedford in Pike County. Across Illinois River in Jersey County, several feet of Louisiana limestone are exposed in the vicinity of Nutwood, but it does not appear in the bluffs near Grafton.

Where best developed, the Louisiana is a dense, practically lithographic limestone occurring in 2 to 6-inch layers separated by thin partings of shale. The rock weathers light gray and the average bluff exposure resembles greatly a wall of masonry. The fracture is conchoidal and the rock gives forth a ringing sound when struck with the hammer. Locally, however, the upper beds may be dolomitic and the rock then takes on a buff or brown, sandy appearance. Elsewhere, thin layers of brown dolomite alternate with gray limestone layers causing the bluff exposures to appear banded. Where the upper portion is predominantly dolomitic it often contains numerous calcite geodes varying in size from less than an inch to several inches in diameter. In general, the variations in the character of the rock are confined to the upper half of the formation and the lower portion is very similar throughout the region of outcrop. At most exposures there is found below the limestone non-laminated, massive, blue-gray shale which reaches a thickness of several feet near Louisiana, but at most exposures may be less than a foot.

Hannibal shale.—In the vicinity of Hannibal, Missouri, the Louisiana limestone is overlain by about 60 feet of greenish, sandy and generally non-laminated shale. Near Hannibal and to the north and west in Marion and Ralls counties, the shale is predominantly sandy in the upper portion, and was termed "Ver-

micular Sandstone" by the older geologists because of its sandy character and the presence of small, ramifying, tubular holes filled with softer, earthy material than the surrounding mass. Such holes are considered to be worm borings. Southward as in southern Pike and Lincoln counties, Missouri, the shale becomes less sandy and thinner, so that in Lincoln County, the shale is only about 40 feet thick and locally less. Still farther south in Missouri along Missouri River, just west of Hamburg in St. Charles County, the horizon of the Hannibal shale shows the overlying Chouteau resting on 6 feet of pure, medium-grained, massive sandstone, which is, in turn, underlain by about 4½ feet of gray, sandy, fossiliferous oolite. At Grafton in Jersey County, Illinois, about 1 foot of fossiliferous, sandy oolite occurs at the base of the Hannibal, and farther north at Hamburg in Calhoun County, the base of the Hannibal shale consists of dense, siliceous limestone interbedded with sandy shale. At this horizon, fossiliferous oolite called "Hamburg oolite," the fauna of which is described by Weller[15], is intercalated locally with the siliceous limestones and shales. Fossiliferous, oolitic limestone has been noted at this horizon on the east side of Calhoun County in the road cut along the bluff just south of Cliffdale. Farther north in Pike County, Illinois, there is exposed in the creek bed in the NW. ¼, sec. 25, T. 6 S., R. 5 W., about 1 mile southwest of Rockport, 6 feet of massive, oolitic conglomerate consisting of pebbles of lithographic Louisiana limestones in a matrix of oolites.

The main body of the Hannibal shales in Illinois, as in Missouri, is thinnest to the south and becomes gradually thicker northward. Thus near Grafton in Jersey County and in southern Calhoun County it is between 30 and 40 feet, but near the north line of Calhoun, is between 80 and 100 feet, this interval continuing into Pike County where the Hannibal shale rests on the Sweetland Creek so that the contact is not everywhere observable. The character of the shale likewise changes from south to north. In the southern portion, the shale is mostly nonlaminar with a structure like earthy cement rock. Farther north it becomes increasingly siliceous; in northern Pike County, Illinois, the upper portion is a massive calcareous fine-grained sandstone, in places abundantly fossiliferous capped by from 1 to 15 feet of dense, siliceous limestone in the vicinity of Kinder-

[15]Weller, Stuart, Trans. St. Louis Acad. Sci., vol. 16, No. 7, p. 465.

hook and northward. The limestone shows a gradual thickening north from Kinderhook and at Fall Creek about 10 feet of sandy dolomite, lithologically similar to that below the limestone occurs above the limestone.

At these northernmost exposures, the Hannibal shale is immediately overlain by Burlington limestone (Pl. IX, B) which is locally conglomeratic at the base with pebbles of the siliceous limestone in a matrix of the coarsely granular limestone.

Chouteau limestone.—In the southern portion of the area in southern Pike, Lincoln and St. Charles counties, Missouri, and in Calhoun and Jersey counties, Illinois, the Hannibal shales are overlain by a limestone which is referred to as the Chouteau.

The limestone is somewhat variable in character, but in most exposures appears as a dense, tough and somewhat earthy limestone with a few scattered chert nodules. The weathered surface becomes gray in color and is often characterized by a knotty appearance brought about by softer, shaly portions weathering away from more resistant cores. The more shaly layers have a speckled appearance, caused by scattered faces of crystalline calcite in a dense drab background. Small calcite geodes, seldom more than an inch in diameter, are prominent in the soft, earthy and dolomitic phase. Locally, as in southern Calhoun County, the basal layer may be granular and in Jersey County, the topmost beds are, in places, lithographic in texture.

The Chouteau is well exposed in Missouri River bluffs east of Hamburg in St. Charles County, and in Lincoln County, Missouri; in Illinois in the river bluffs of Calhoun County in the vicinity of Hardin, and in bluffs of southwestern Jersey County. The limestone in Lincoln County, Missouri, southern Calhoun and Jersey counties, Illinois, is from 40 to 60 feet thick, but thins northward gradually to Calhoun County, Illinois, and Pike County, Missouri, north of which it disappears.

The Chouteau appears to be conformable with the underlying shale and the interval occupied by both remains practically constant, because as the limestone thins northward the shale increases in thickness. In Calhoun and Pike counties, Illinois, the approximate contact of the overlying Osage group and the Chouteau is marked by a soft, dolomitic layer which in the bluff face is usually weathered back several feet.

OSAGE SERIES

The Osage series, consisting mainly of crinoidal limestones with only minor amounts of shale, is best exposed in the bluffs along Mississippi and Illinois rivers, and in western Ralls, Pike and Lincoln counties and central St. Charles county, Missouri. The divisions are given in the table, page 32.

Fern Glen formation.—The Fern Glen formation has been recognized only in the vicinity of Chautauqua and Grafton in Jersey County, Illinois, but the red and green shales and shaly limestones which form so conspicuous a feature of the formation at its type locality are almost wholly lacking. At Chautauqua a 25 to 30-foot massive layer of granular limestone free from chert is found above the dense limestone of the Chouteau and is overlain by about 25 feet of shaly limestone, predominantly greenish in color but locally pink or red, containing thin layers or nodules of blue or green chert. Above this shaly limestone lies the white, coarsely granular, crinoidal limestone of the typical Burlington. A somewhat similar section occurs at Grafton, but the shaly phase is even less pronounced, the shale being limited to thin partings between layers of granular limestone. This formation is undoubtedly present in St. Charles and Lincoln counties, Missouri, but the horizon was not examined in those counties. Undoubtedly the Fern Glen continues northward from Grafton, but assumes more and more the character of the Burlington, and can be distinguished only by its fossils. Like the Chouteau, it thins to the northward and is certainly not present far north of Kinderhook.

Burlington-Keokuk limestone.—Above the Fern Glen, coarsely granular, crinoidal limestone of the Burlington-Keokuk occurs in great thickness. In the northern part of the area this mass of limestone is readily divisible into two formations on the basis of the fossils and lithology, but in the southern part there is no apparent break, and while both formations are present, it is practically impossible to find a line of separation.

The Burlington-Keokuk limestone is well exposed along the bluffs on the Illinois side from east of Grafton northward to Dallas in Hancock county and also outcrops along most of the creeks in southern Pike and Calhoun counties. In Missouri, it shows in the bluff from Kissinger, Pike County, northward to the north line of the State and is exposed along most of the creeks

in central St. Charles and in western Lincoln (Pl. X, A), Pike, Ralls, and Marion counties.

The Burlington limestone is typically a massive, coarsely granular, light gray, crinoidal limestone. Bedding planes are usually indistinct in fresh exposures, but where weathered, the rock shows beds of 6 inches to 8 feet thick. The details of the section vary from place to place, and locally there are intercalated with the gray limestone varying amounts of brown, dolomitic rock. Chert, abundant especially in the upper portion, occurs as irregular layers and nodules which may be thin plates or masses a foot or more thick.

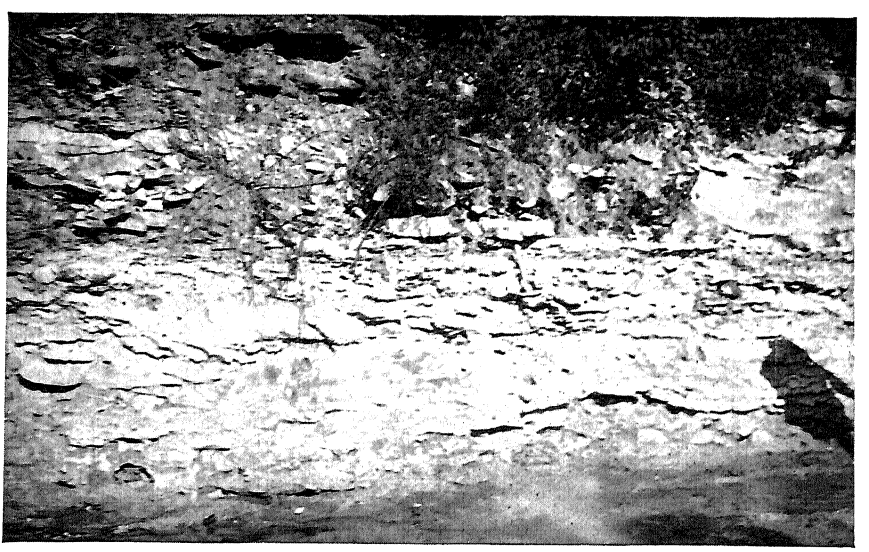
The thickness of the Burlington, including the cherty transition beds, is about 100 feet. The total thickness of the Osage, therefore, is about 160 feet in the northern portion and between 250 and 300 feet in Jersey County, but the increase to the south is due mainly to the presence of the Fern Glen formation, the Burlington-Keokuk itself remaining fairly constant.

In the northern part of the region where the Keokuk is recognized as a distinct formation, it consists of layers of rather coarsely granular limestone 6 inches to 6 feet thick, separated by shaly layers up to two feet thick. The texture, while granular, is finer than the Burlington, and less crinoidal, and the color is usually a bluish-gray as compared with the light gray or white color of the Burlington. Chert, as thin platy layers and nodules, is abundant near the top of the formation, and again at the base where an interval of about 30 feet of very cherty limestone marks the transition of the Keokuk into the Burlington. The large, middle portion of the formation, however, is relatively free from chert. Southward, the shale intervals become progressively smaller and the limestones more crinoidal and more coarsely grained until it becomes difficult to distinguish the two. The thickness of the Keokuk exclusive of the lower 30 feet of cherty limestone is between 60 and 80 feet, an interval surprisingly constant for Clark and Lewis counties, Missouri, and Hancock County, Illinois.

MERAMEC SERIES

The Meramec series, which is divided into several formations as shown in the table (page 32), outcrops in the vicinity of the Mississippi River bluffs, in Lewis, Clark, southern Lincoln and

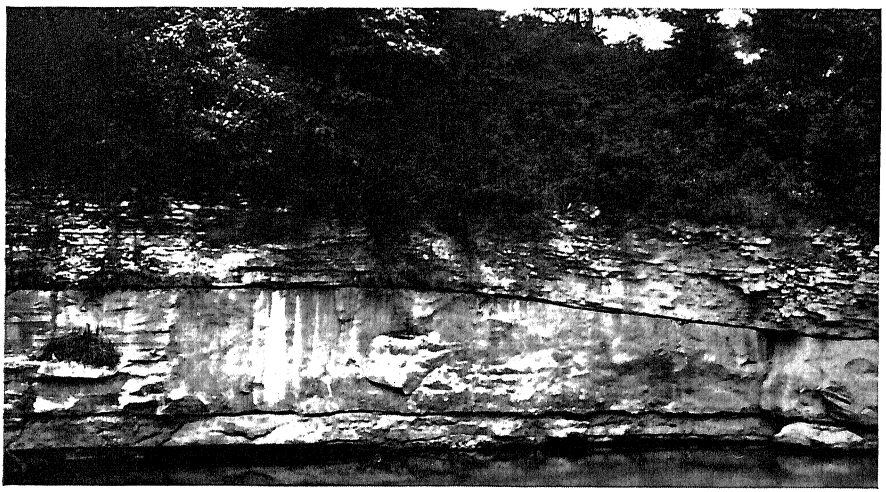
A. Structural slope of steeply dipping Burlington-Chouteau limestone on the west limb of the Lincoln fold about 3 miles northeast of Silex. The strike of the rocks is N. 15°W. and the dip 65°W., Lincoln County, Missouri.



B. Lower Warsaw geode bed near Warsaw, Hancock County, Illinois.

A. Structural slope of steeply dipping Burlington-Chouteau limestone on the west limb of the Lincoln fold about 3 miles northeast of Silex. The strike of the rocks is N. 15°W. and the dip 65°W., Lincoln County, Missouri.

B. Lower Warsaw geode bed near Warsaw, Hancock County, Illinois.



A. Possible contact between Ste. Genevieve and underlying St. Louis limestone in an old quarry northeast of Spanish Lake, Missouri.

B. Tilted St. Louis limestone on the south limb of Lincoln fold, 6 miles west of Grafton, Jersey County, Illinois.

Section immediately below the St. Louis limestone at Warsaw, Illinois

	Thickness *Feet*
Dolomite, dense, earthy with scattered quartz grains	1-2
Limestone, gray, granular, distinctly cross-bedded	2-3
Shale and limestone, earthy, magnesian	2-3
Shale with lenses of blue-gray more coarsely granular fossiliferous limestone	—
Shale, calcareous with numerous geodes in lower portion	35

Below the St. Louis, in the ravine east of the north-south road in the southeast corner of the SW. ¼, sec. 34, T. 4 N., R. 9 W., 48 feet of lenticular, earthy, magnesian limestone grading to shale may be found. None of the granular limestone lenses found farther north are present in the 60 feet exposed here. Such partial sections of this horizon as are exposed along the creeks of Adams and northern Pike counties show rocks similar to those already described, with the exception that the earthy, magnesian limestones and shales predominate. Farther south in Jersey County, the upper portion contains larger amounts of granular limestone and only the lower 30 to 40 feet are shale. Locally, oolitic layers are interbedded with the granular limestone.

In Missouri, where this horizon is well exposed in the vicinity of the bluffs in Clark and Lewis counties, it shows characteristics similar to those on the Illinois side. A good exposure of the horizon is to be seen along the ravine just north of St. Francisville in sec. 32, T. 65 N., R. 6 W. Other good exposures are to be seen along the bluff northward to Canton in Lewis County. In St. Charles County, the Warsaw-Spergen is well exposed in the bluff of Missouri River north of Greens Bottom, sec. 28, T. 46 N., R. 4 E., but here the upper beds are more calcareous and shale predominates only in the lower 40 feet.

The thickness of this group increases from north to south. In the northern portion as in Hancock County, Illinois, and Clark County, Missouri, the thickness is between 60 and 80 feet, while in St. Charles County, Missouri, it is between 125 and 150 feet, and attains a similar thickness where exposed in Jersey County.

St. Louis and Ste. Genevieve formations.—Unlike the preceding group the St. Louis and Ste. Genevieve are mainly limestones (Pl. XI, A) and contain practically no shale, except thin partings.

The distribution of these formations is practically the same as that of the Warsaw-Spergen, and at most exposures St. Louis limestone is found capping the lower formation.

In the more northern localities as in Adams and Hancock counties, Illinois, and Lewis and Clark counties, Missouri, the basal portion of the St. Louis is a brecciated or conglomeratic limestone from 10 to 30 feet in thickness. Throughout this region the base of the formation consists of a more or less nodular layer 2 to 3 feet thick, of dense, hard, very finely crystalline limestone, characterized by small crenulations which are made prominent by thin lines of a darker substance at intervals of about ¼ of an inch. Immediately above this basal layer, the formation consists of boulders of limestone in a matrix of shale which is locally sandy and farther south becomes limestone. The limestone boulders are usually light gray, dense, similar in character to the overlying layers but different from the underlying formations. The boulders vary in size from less than 3 inches to several feet in diameter. This horizon becomes less conspicuous to the south and at the southernmost exposures of the St. Louis in St. Charles and Lincoln counties, Missouri, and Jersey and Madison counties, Illinois, it is not evident near the base of the formation. Above the brecciated or conglomeratic beds, the limestone is commonly a light gray, hard, dense limestone, almost lithographic in texture, and characterized by conchoidal fracture. Generally it occurs in layers of from a few inches to two feet thick, which are separated in places by partings of light green, calcareous shale. Locally, layers of brown dolomite and even sand lenses are found not far above the brecciated portion. Chert layers and nodules are common. In Lewis and Clark counties, Missouri, where this formation may be from 40 to 60 feet thick, the upper portion contains oolitic layers interbedded with the dense, and at several localities a sandstone layer up to 6 feet thick is present.

At the more southern localities, as in the vicinity of Alton and the southern tip of Calhoun County in Illinois, and eastern St. Charles and southern Lincoln counties, Missouri, the St. Louis limestone is much thicker, but the light gray color and the dense texture are also characteristic here. Oolitic beds are rare, although not unknown in this formation, and do not become prominent below the Ste. Genevieve. The lower portion of the St. Louis contains more or less magnesian limestone.

The crenulated layer so characteristic of the base of the St. Louis in the northern part, is not evident in the southern part, nor is the brecciated horizon developed near the base. However, near Alton and in the bluffs of southern Calhoun County, Illinois, and in southern Lincoln County, Missouri, a well defined brecciated zone made up of limestone boulders of different kinds of St. Louis limestone cemented together by limestone occurs about 120 feet above the base of the St. Louis, and curiously enough the layer of limestone below it shows the crenulated character so typical of the basal St. Louis farther north. The topmost beds exposed in the bluff near the town of Alton are referred to the Ste. Genevieve limestone. These upper beds include at their base a massive layer 15 to 20 feet thick of oolitic limestone, overlain by about 18 feet of massive sandstone, above which is more oolitic and lithographic limestone. The oolitic limestone of Lewis, Clark and St. Louis counties, Missouri, should also be referred to the Ste. Genevieve, but until more detailed work is done in this area the exact relations of the St. Louis and Ste. Genevieve in this area will remain in doubt.

The thickness of the St. Louis and Ste. Genevieve is very variable. In the more northern localities this horizon is overlain by the Pennsylvanian and was deeply eroded before the deposition of that period. As a result, there are great differences in thickness within short distances; locally all the St. Louis has been removed and the Pennsylvanian rests on older formations. In general, however, the thickness in Clark and Lewis counties, Missouri, and Hancock and Adams counties, Illinois, ranges between almost nothing and 60 feet. To the south there is a gradual thickening of this formation and in the vicinity of Alton, it reaches a thickness between 250 and 270 feet, of which 200 to 225 feet are St. Louis.

Pennsylvanian System

Rocks of the Pennsylvanian system are present locally within the area, but are not distributed widely enough to be of service in determining the structure.

As observed, they consist mainly of shales and sandstone with minor amounts of limestone. They occur as scattered outliers in eastern St. Charles, southern Lincoln, northern and western Marion counties, and probably are present beneath the drift over most of Lewis and Clark counties. In Illinois they

were observed only in the eastern part of Hancock County, central and eastern Adams County, northern Pike County and the southern end of Calhoun County.

Tertiary System

In southern Calhoun County, one or two of the ravines revealed bronzed and polished chert pebbles, typical of gravels in southern Illinois and Missouri, considered as Tertiary in age, and it is probable that small patches of such deposits exist beneath the overlying soil and drift at other localities within this area.

Quaternary System

Deposits of gravel, till and loess cover most of the upland back from the bluffs in much of the northern area, so that rock outcrops are limited to the vicinity of the bluffs and the larger streams. In the more southern area of Calhoun County, Illinois, and St. Charles, Lincoln, Pike, Ralls and Marion counties, Missouri, however, the drift is thin or wanting, and outcrops are abundant.

CHAPTER III—STRUCTURE

General Statement

The structure shown on the structure map (Pl. I) is based on the elevation of the base of the Burlington limestone. This contact was chosen because it was observed at the greatest number of places; is easily recognized in well logs; is essentially parallel to the underlying formations in small areas; and the intervals separating it from other formations in the geologic column above the St. Peter sandstone are fairly well known.

A fifty-foot contour interval is used in representing the structure, as it is felt that this is the smallest interval that could be chosen and still be consistent with the methods used and amount of data available.

Most of the elevations upon which the structure is based are given in Table 1, page 8. Since the scarcity or abundance of outcrops has a direct bearing on the accuracy of the detailed structural work, the plotted outcrops suggest the areas in which such work is feasible and also shows regions in which structural details will have to be obtained from subsurface data.

It should be remembered in using the map, that the correctness of any contour is dependent upon the number of observations upon which it is based. Therefore, in areas where outcrops shown are few or entirely lacking, the structure represents the writer's opinion only. The structural mapping of such areas is subject to change as more data become available. It is advisable in all cases that detailed structural work be done before any drilling is undertaken.

Structural Features

The most pronounced structural feature of the region is a large anticlinal fold which extends from Grafton in Jersey County, Illinois, westward across southern Calhoun County, thence across the Mississippi Valley, and continues westward and southwestward across Lincoln, Pike, Ralls, and southern Marion counties, Missouri.

For convenient reference, this fold will be known as the Lincoln anticline, because it reaches its greatest development in Lincoln County, Missouri.

Associated with this fold is a large fault designated by older writers of geology as the Cap-au-Gres fault. This fault parallels the Lincoln fold and breaks it just south of the crest. In southwestern Jersey and southern Calhoun counties, Illinois, and in Lincoln County, Missouri, the fold is most pronounced and apparently dies out both to the east and west.

The next fold of regional importance is the anticline referred to as the Pittsfield-Hadley anticline in the Illinois State Survey reports[16]. This fold attains its greatest prominence near Pittsfield in Pike County, Illinois, but can be traced from Bedford, Illinois, to LaGrange, Missouri. In the vicinity of Quincy, it flattens out into a broad, flat, terrace-like structure, which is probably caused by the convergence of three distinct anticlinal areas. The general trend of this terrace, which is a prominent structural feature throughout western Adams County, Illinois, is about north and south.

The remaining area, which is practically flat, shows some structural features, but these are more or less local. South of the Cap-au-Gres fault a pronounced syncline, the axis of which has an east-west direction, extends from the vicinity of Troy, Missouri, to Brussels, Illinois.

LINCOLN FOLD

The Lincoln fold is not a simple symmetrical fold, but is rather an area of uplift on which are many minor structural features such as anticlines, domes, synclines and faults.

Direct evidence of the Lincoln fold and associated fault is first seen in Illinois about one mile east of Grafton in the ravine in the NW. ¼ of sec. 14, T. 6 N., R. 12 W., where the powder plant is located. The bluff east of the ravine is capped by Burlington limestone, while west of the ravine Silurian limestone makes up the bluff. In the ravine itself the rocks are tilted and strongly suggest faulting, though the displacement here is not very great, certainly less than fifty feet.

In the town of Grafton west of the road leading north in the NW. ¼ of sec. 15, T. 6 N., R. 12 W., the Silurian limestone along the bluff dips locally 3 to 4 degrees south, showing the presence of an anticline parallel to the bluff. The westward rise of the rocks indicate it to be an eastward pitching structure.

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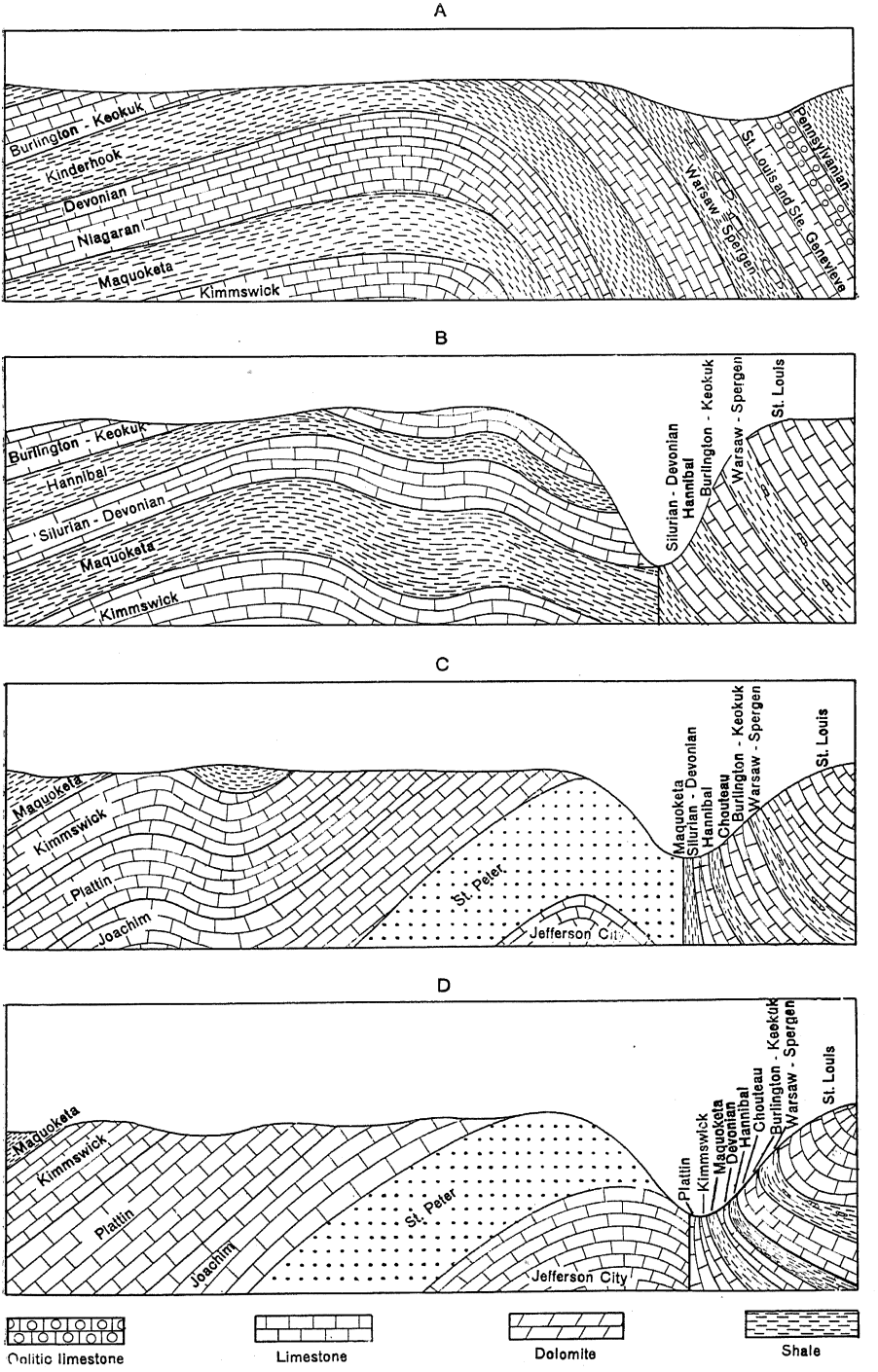
[16]Coryell, H. N., Parts of Pike and Adams counties: Ill. State Geol. Survey Bull. 40, p. 75, 1919.



Cross sections to show the relation of the Cap-au-gres fault to the Lincoln fold.

A. Along Illinois River bluff, Jersey County, Illinois.
B. Along Illinois River bluff, Calhoun County, Illinois.
C. Along Mississippi River bluff, Calhoun County, Illinois.
D. Along Mississippi River bluff, Lincoln County, Missouri.

Farther west along the bluff road, in secs. 13 and 14, exposures of St. Louis limestone and Pennsylvanian shale are seen dipping steeply to the south (Pl. XI, B), and still farther west the cross section of the fold as seen along the north-south road in sec. 9, T. 6 N., R. 13 W., shows an unbroken arch having a gentle slope of about twenty-five feet per mile to the north and a steep dip of almost forty-five degrees to the south. The lowest formation exposed is the Kimmswick limestone.

Across Illinois River, the fold again appears in the bluffs in sec. 35, T. 12 S., R. 2 W. Although the south limb still retains its steep dip, the north limb is undulating with a dip of about 25 feet per mile, and the crest of the fold, located about three miles north of where the sharp change in direction of dip occurs (Pl. XII, A), is approximately sixty feet higher than near the bend, but is about fifty feet lower than in Jersey County. As no continuous section showing the change from the steeply dipping south limb to the gently undulating north limb can be seen here, it is possible that there is a break or slight fault in the fold.

The crest of the fold rises sharply to the west and in the Mississippi bluffs in sec. 29, T. 12 S., R. 2 W., if the original structure were restored would be about 350 feet higher than on the Illinois side of Calhoun County (Pl. XII, B). The formations of the south limb are almost vertical, and even the north limb has a pronounced dip. Furthermore, the abrupt change in dip on the south limb is marked by actual displacement which causes Maquoketa shale to abut against St. Peter sandstone, making a throw of about 300 feet (Pl. XII, C).

In Missouri, exposures in the river bluff about a mile north of Winfield show the crest of the fold to have been about 100 feet higher than in Calhoun County. The south limb is faulted and the formations immediately adjoining the fault are practically vertical. The displacement of the fault is still about 300 feet, but the formations brought into contact are the Jefferson City dolomite and the Plattin limestone (Pl. XII, D). The north limb of the fold retains its more gentle dip.

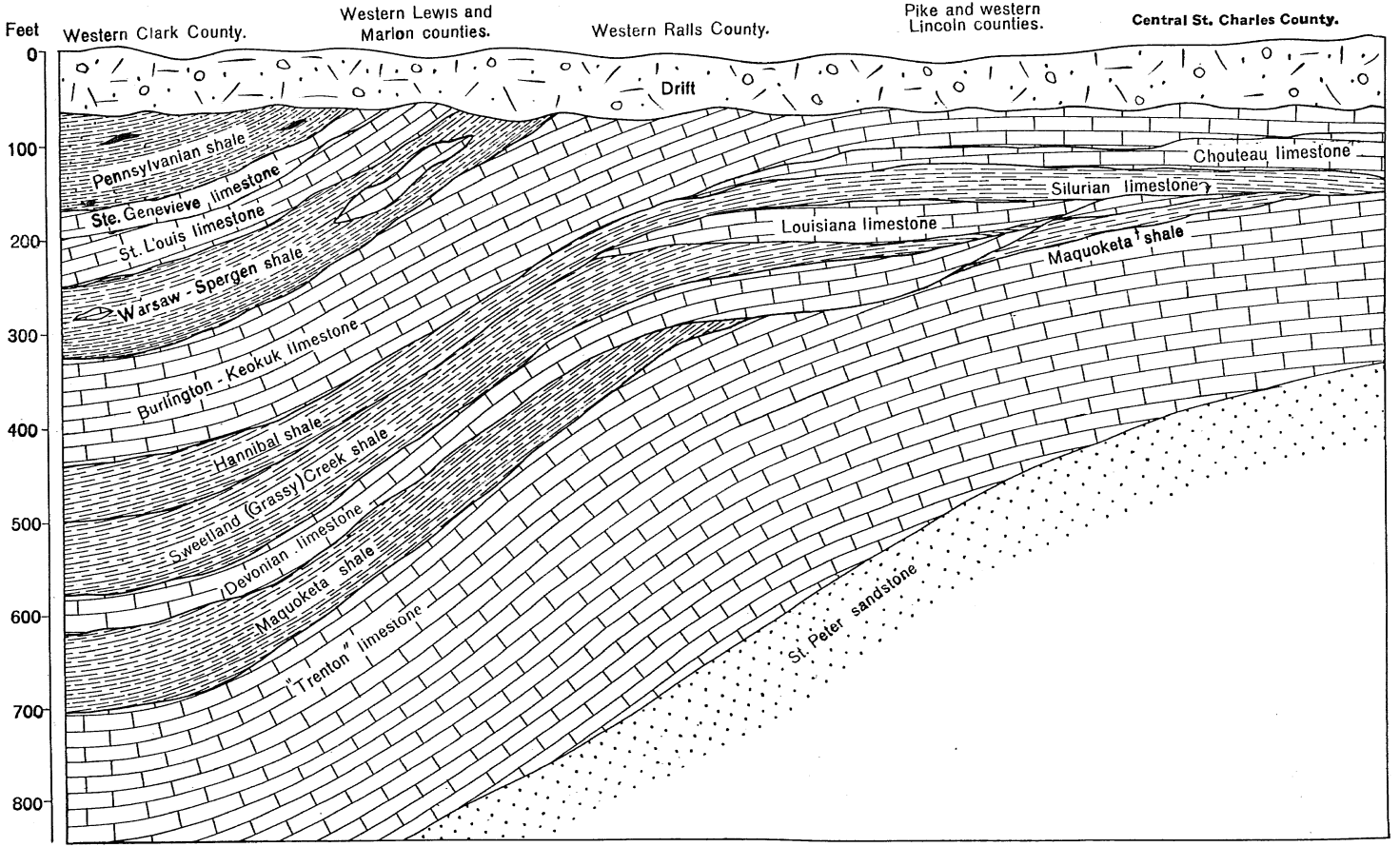
The bluff section north of Winfield apparently marks the approximate top of a dome, for westward the crest of the anticline becomes lower and in the southeast corner of T. 50 N., R. 1 E. is about 200 feet lower than in the bluff. West from here it rises again, and in the northwest corner of T. 50 N., R. 1 E., reaches about the same elevation as near the bluff. The trend

of the fold which up to this point has been about N. 70° W changes somewhat abruptly and becomes almost due north, veering only slightly to the west. This sharp northward bend of the fold is apparently accompanied by faulting, for highly disturbed beds were observed in sec. 3, T. 50 N., R. 1 W., and also along the road just north of sec. 3 in the adjoining township. The strike of the rock in the former case is N. 20° W. and the dip 55 degrees west, while in the latter case the strike is about north and south and strata almost vertical.

The northward trend of the axis is of short extent, for in the northwest portion of T. 51 N., R. 1 W., the axis turns westward again and crosses the northern part of T. 51 N., R. 2 W., in a general east-west direction, and shows a gentle plunge to the west. Near the west line of the township it changes direction again to northward, crossing Pike County in a N. 20° W. direction, and continuing into Ralls County almost to New London where it again turns to the west and passes into and crosses Marion County in a N. 50° W. direction.

The faulting which is so intimately associated with the folding throughout most of Lincoln County, Missouri, and Calhoun County, Illinois, is not prominent west of the northward bend of the fold, the only evidence of faulting west of here being the faulted zone along the creek in sec. 4, T. 51 N., R. 3 W. For a distance of several hundred yards to the east of the road, the rocks are greatly fractured and minor faults extend in every direction. It is possible, however, that this faulted zone represents a continuation of the main fault, though the total displacement along the faulted zone does not appear to be more than fifty feet.

Just south of New London, the trend of the fold becomes more westerly again—N. 70° W., and retains this direction as far west as Spaulding near the southeast corner of T. 56 N., R. 6 W. Throughout this extent the south limb is steeply folded, but the north limb dips gradually. In the vicinity of Spaulding, beds have been observed dipping so steeply as to suggest local faulting. Beyond Spaulding, the rocks take on a more northerly trend once more, and the fold crosses Marion County in an approximate N. 45° W. direction with the folding less and less pronounced.



Generalized north-south section of strata penetrated on the Missouri side of the Mississippi Valley area.

THE PITTSFIELD-HADLEY ANTICLINE

The Pittsfield-Hadley anticline, which is roughly parallel to the Lincoln fold, lies well down the north slope of that structure. Its easternmost expression in the area under discussion is found in the Illinois River bluff near Bedford in T. 6 S., R. 2 W., where the base of the Burlington limestone at the crest of the fold is about 150 feet higher than the same horizon at the foot of the south limb. From this point, the fold has a general northwest trend, crossing Pike and southeastern Adams counties, Illinois, entering Missouri near the town of LaGrange in T. 61 N., R. 6 W., and continuing across Lewis County. The crest of the fold rises gradually west of Bedford to the top of the elongated dome located near the center of T. 5 S., R. 4 W., Pike County, where it begins to descend, continuing with possible minor interruptions throughout its extent. The amount of closure represented in the dome is about 175 feet.

WESTERN ADAMS COUNTY TERRACE

Near the center of T. 3 S., R. 7 W., Adams County, the Pittsfield-Hadley anticline, which crosses Pike County as a simple fold, broadens out and diverges into three distinct axes. One axis retains the original trend and crosses over into Missouri near LaGrange, as mentioned before. A second one trends a little west of north to near the center of T. 2 N., R. 9 W., where it changes to a northwesterly direction, entering Missouri about half way between Gregory and Canton and continuing across northeastern Lewis County and southwestern Clark County. The third axis strikes northward through the tier of townships included in R. 7 W. as far as T. 2 N., where it takes on a more easterly direction and apparently dies out. East of this axis, the rocks dip gradually to the east, and west of the LaGrange axis the rocks dip to the west, but in the intervening area the strata are practically flat although they dip gradually to the north.

THE SOUTHERN LINCOLN COUNTY SYNCLINE

South of the Cap-au-Gres fault the rocks are folded in a large eastward plunging syncline, the axis of which extends from immediately north of Brussels in southern Calhoun County west across southern Lincoln County, Missouri, beyond the

town of Troy in T. 49 N., R. 1 W. The south limb of the syncline strikes almost due west in western Lincoln County, but in St. Charles County it is northwest-southeast.

MINOR STRUCTURES

Within the area included by Hancock County, Illinois, and Lewis County, Missouri, the rocks are comparatively flat lying and do not present variations of over 100 feet. Such irregularities as do occur are more or less local, but a few structurally high areas appear to have regional significance.

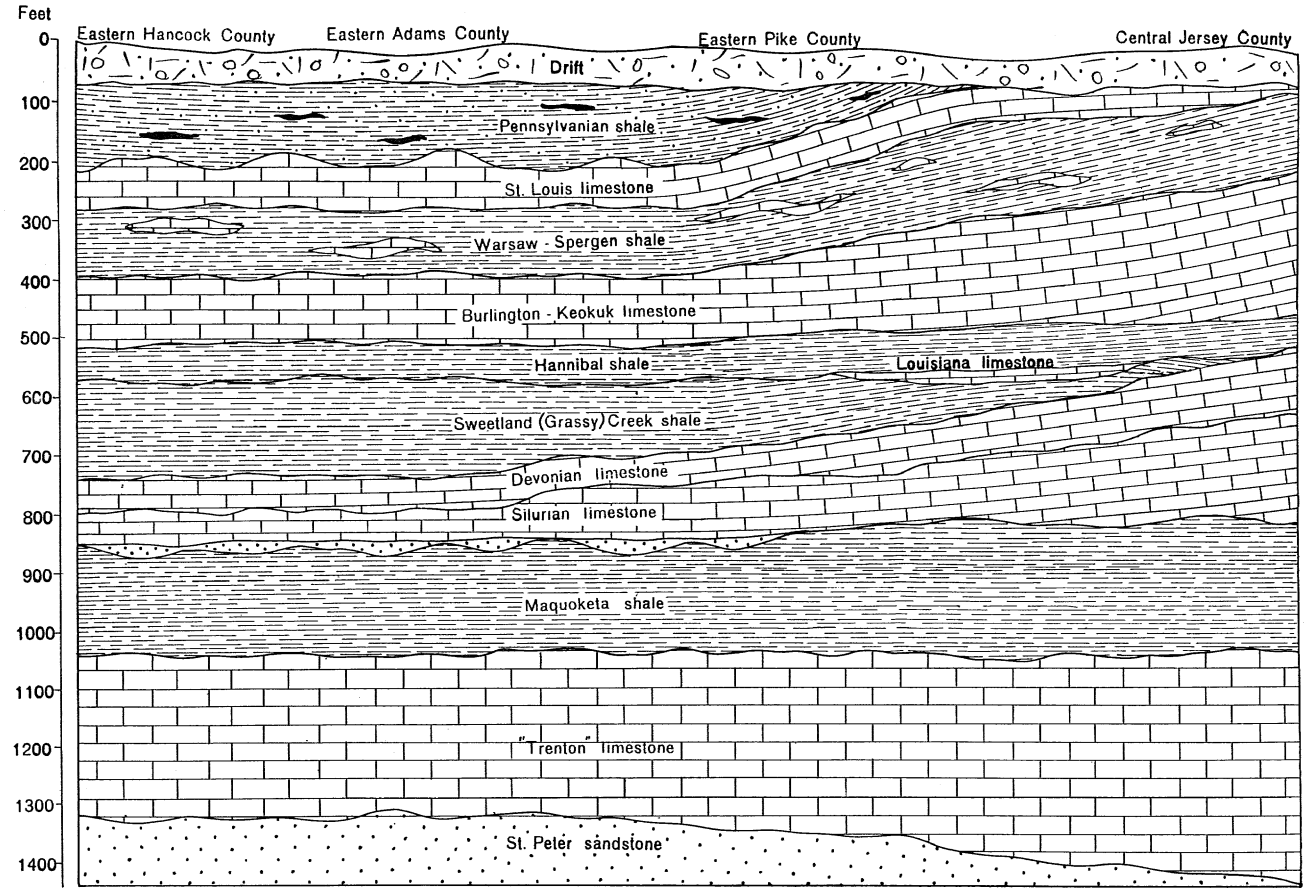
In Lewis County, Missouri, the rocks are arranged in a series of low, broad folds having a distinct northwest-southeast trend and as seen in the river bluffs, the northern third represents the south limb of an anticline whose crest is north of the State line. The middle third shows a low arch and the southern third represents the south limb of an anticline whose axis lies south of the County line.

A reflection of the broad central fold is seen in Hancock County, Illinois, in the structurally high area which extends from north of Warsaw eastward across the county past Carthage and leaves the county near the junction of Tps. 5 and 6 N. Other structurally high areas are found near Nauvoo in the northwest corner of T. 6 N., R. 8 W., the center of T. 7 N., R. 8 W., and the north half of T. 7 N., Rs. 5, 6 and 7 W. A high area is also indicated in the western part of T. 4 N., R. 5 W. In addition to minor folds mentioned, many smaller folds are indicated in the structure sections of the bluffs and a small fold is also shown in the Missouri River bluff west of the center of T. 46 N., R. 4 E.

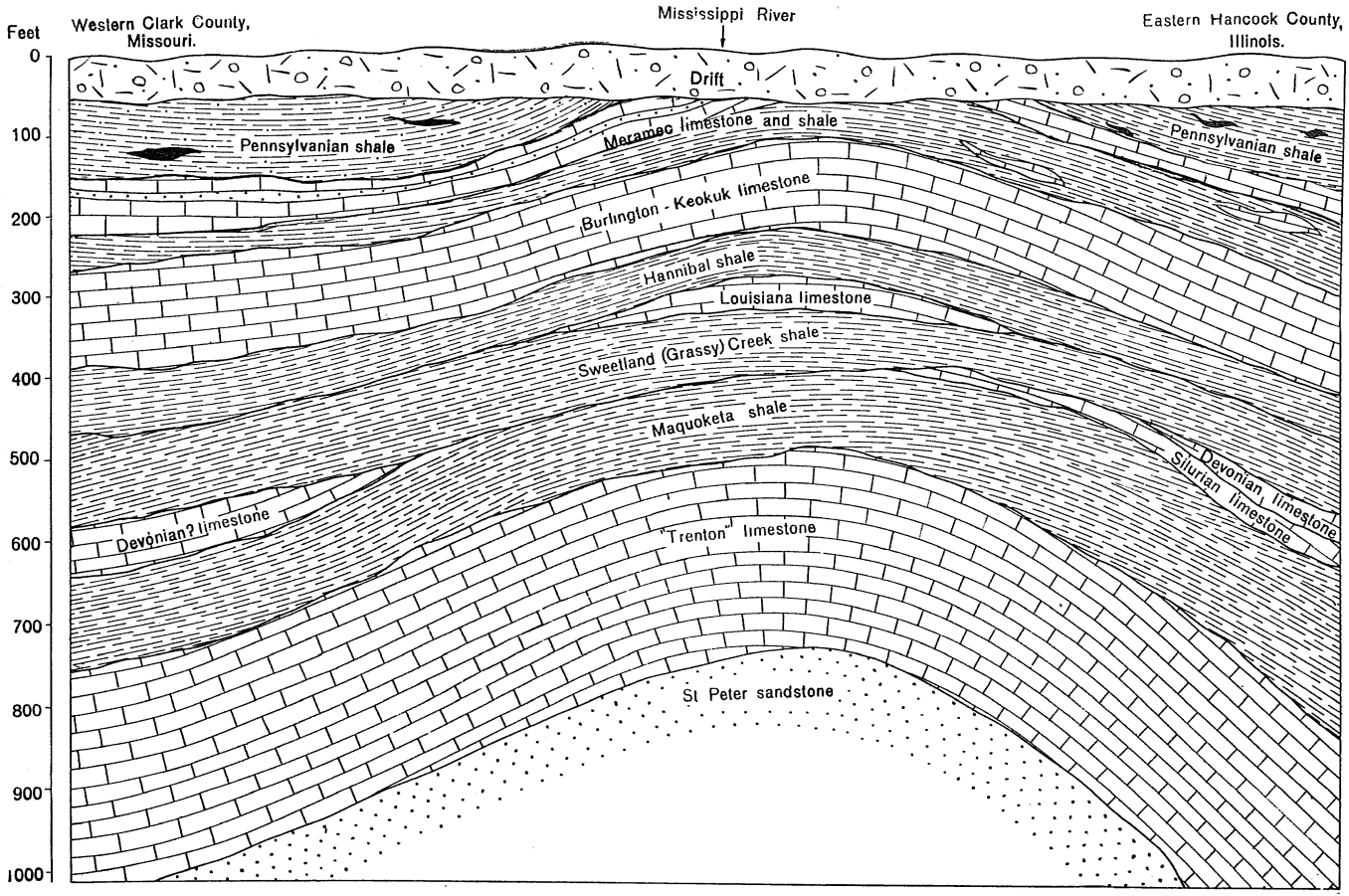
PERIODS OF DEFORMATION

The structure as represented on the structure map is for the most part the result of post-Pennsylvanian deformation, but inasmuch as it is based entirely on data obtained from Mississippian rocks it is not improbable that it diverges somewhat from a representation of only Pennsylvania deformation, and combines elements of both post-Pennsylvanian and pre-Pennsylvanian deformation.

A study of the stratigraphy shows that the rocks were elevated and submerged several times within the geologic history of the region, and that the changes in level were sometimes ac-



Generalized north-south section of strata penetrated on the Illinois side of the Mississippi Valley area.



Section across Clark County, Missouri, and Hancock County, Illinois.

companied by warping. Since no oil has ever been found in rocks older than the Kimmswick ("Trenton"), a consideration of deformation previous to that time is not pertinent to a discussion which deals with a structural reconnaissance made for the purpose of considering the relation of structure to the possibility of finding oil, and will therefore not be included.

Times of submergence were usually inaugurated by a warping and sinking of the areas adjoining the Ozark region, while the Ozarks themselves apparently remained stationary or sank more slowly. Upon emergence the Ozark region was generally the first to become land, and since the Ozark region was land during most of Paleozoic times the formations laid down during that time thin out towards the Ozarks and often change in character as the old land masses are approached.

The retreat of the sea after the Kimmswick limestone had been lain down was accompanied by a slight tilting of the strata to the southeast, and possibly a slight downwarp of the beds just north of the area included in this report. Subsequent erosion, therefore, left deposits which thicken to the south and east, the rate of increase averaging not much over two feet per mile, although there is local variation.

During the next submergence or possibly during the emergence after the Maquoketa shale had been deposited, the surface was again tilted, but this time to the north, for that formation thickens to the north and east. The amount of tilting was again small in the northern portion of the area, but becomes increasingly greater to the east where the dip may reach as much as 20 feet or more per mile.

During the ensuing Silurian period, and possibly immediately after, there may have been a slight sagging in the southern portion of the area, as evidenced by the presence of Silurian strata in Jersey and Calhoun counties, Illinois, and in northern Lincoln, Pike, and southern Ralls counties, Missouri, and the absence of these formations in the north central part of the area. They are also known to be present in the eastern portion of the area, although in diminished thickness, but their very presence there suggests continued slight tilting to the east.

The presence of the Silurian in the southern portion of the area may also be accounted for by considering that the area was lowered more than the rest by erosion and by subsidence subsequently became occupied by an arm of the Silurian sea.

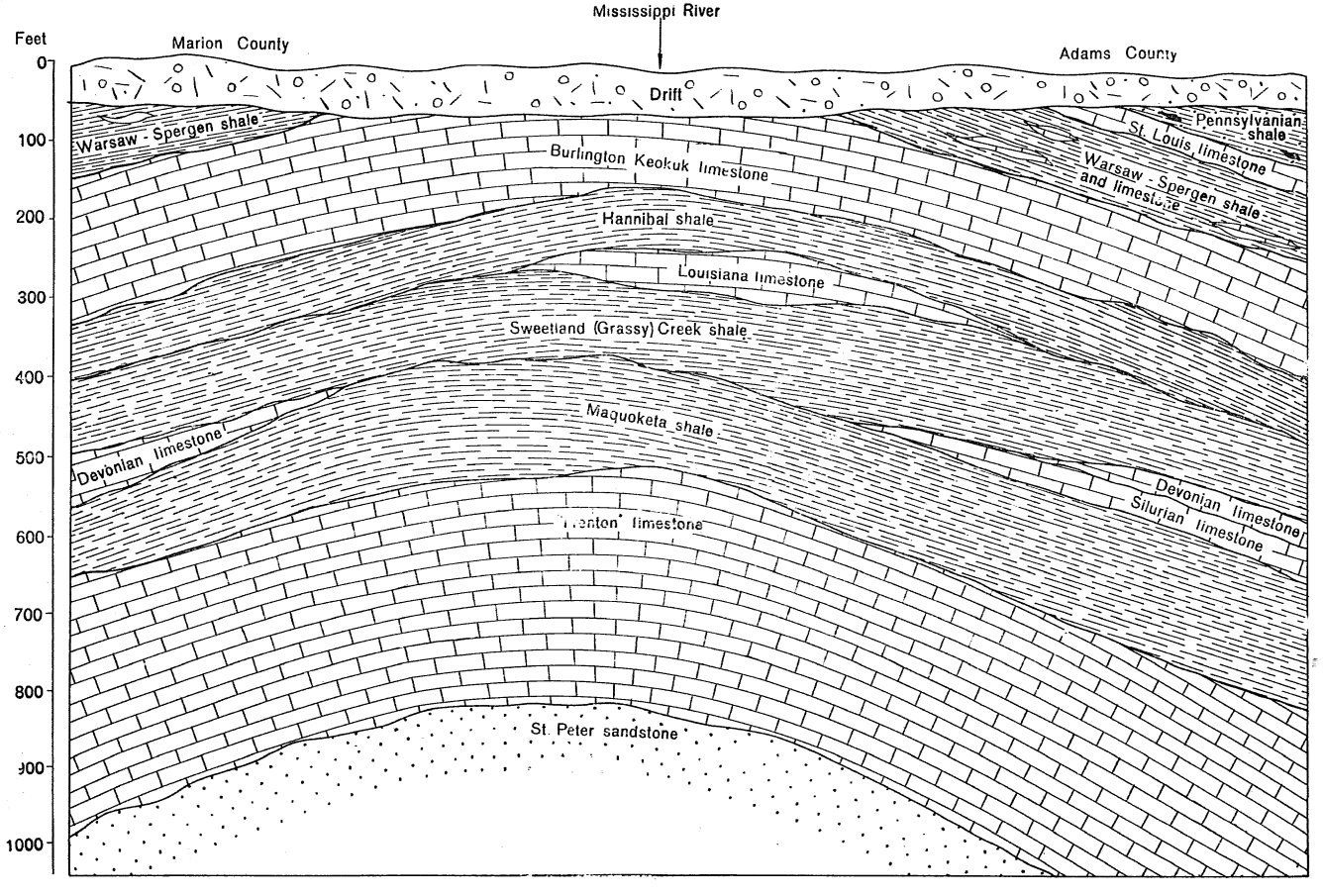
North of the area under consideration there is known to have been pronounced sagging during Silurian times.

Though the Devonian in Illinois and eastern Missouri was marked first by depression to the southeast, south of the region studied, and later by depression to the north of the area studied, the amount of folding or warping which actually took place within this area is apparently negligible, and although a thickness of 125 feet and more of northern Devonian rocks does occur in Ralls County, their relations are such as to suggest that they are deposits formed in bays occupying pre-Devonian erosional lowlands.

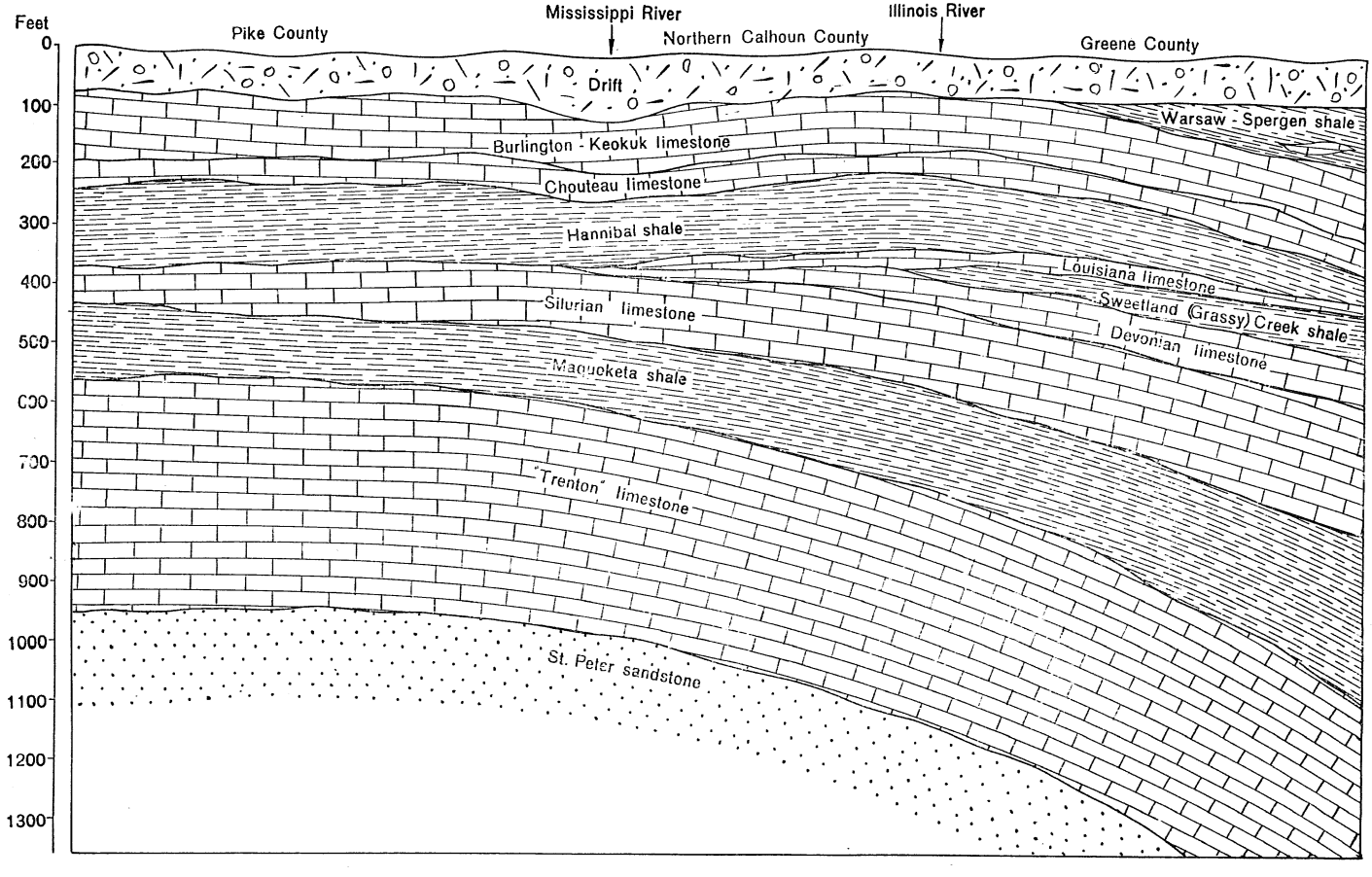
If the black shale above the Devonian limestones is considered Mississippian in age, then the Mississippian was inaugurated in this area by a tilting to the northeast. As in earlier periods the amount of tilting is appreciable only if widely separated areas be considered, as its average is less than 5 feet per mile, though it varies locally.

In the transition from Mississippian to Pennsylvanian times there was warping as is shown by the fact that apparently flat lying Pennsylvanian rocks rest at the same elevation on rocks as low as the Burlington, or as high as the St. Louis stratigraphically. The amount of warping or tilting is slight and appears to correspond roughly with existing structures.

Besides the main epochs of warping mentioned there have been many others whose records are not readily discernible, and it is impossible with the data at hand to attempt to outline even the larger features. The resulting effect of these different periods of warping has been to destroy the parallelism of the formations of different periods, or even formations of the same period. Apparently, however, the last period of warping was the greatest, and since all deformation of surface rocks is reflected to some depth in the underlying strata, structures corresponding to the surface rock structure are also found in the underlying beds. It is possible, however, that the outlines of low, broad folds found at the surface may be completely neutralized in the lower strata by underlying structures formed at some earlier period, and it is just as possible that folds which are present in lower rocks do not have any surface expression and can be discovered only from study of subsurface data. Difference in trend of early folds crossed by later folds tends to alter outlines of the structure, but in this area later folds appear to parallel and accentuate earlier ones.



Section across Marion County, Missouri, and Adams County, Illinois.



Section across Pike County, Missouri, Calhoun and western Greene counties, Illinois.

In this region, the major effect has been to cause a gradual divergence of the strata toward the center of the Illinois basin to the east. Plates XIII and XIV illustrate the changes from north to south on the Missouri and Illinois sides of the Mississippi Valley area. Plate XV represents a generalized section from Clark County, Missouri, to Hancock County, Illinois; Plate XVI represents one farther south across Marion County, Missouri, and Adams County, Illinois, and Plate XVII one across Pike County, Missouri, Calhoun and Western Greene counties, Illinois. Many other local and minor variations also occur, but these can be determined only from a detailed study of the area.

CHAPTER IV—OIL POSSIBILITIES

Introduction

Except for the small amounts of gas obtained from the Pittsfield-Hadley dome in Pike County, Illinois, there is no production of oil or gas within the area described in this report. The nearest producing field is the Colmar field, located near the eastern edge of Hancock County, Illinois, in T. 4 N., R. 4 W., in which the oil is obtained from discontinuous sand lenses at the top of the Maquoketa shale. South of the area there is oil production from the Kimmswick ("Trenton") in the vicinity of Waterloo, Monroe County, Illinois, and to the east some oil is obtained from the top of the Mississippian rocks near Jacksonville, and from Pennsylvanian rocks near Carlinville and Staunton, Macoupin County, Illinois. The adjoining area in Missouri has not produced oil.

Previous Exploration

Most of the deep wells in the Missouri portion of the area, of which there is any record, have been drilled for water, and are, therefore, not oil tests. It is improbable, however, that any good show of oil would be overlooked even in wells drilled for water, and they may, in a measure, be considered oil tests.

It should be remembered, however, that water wells are located without regard to structure, so that absence of oil in no way condemns any of the surrounding territory which is structurally more favorably located. A detailed discussion of the relations of wells drilled to future prospecting is out of place in a general discussion such as this, and should be considered in more detailed work.

In Illinois, the discovery of oil in the Colmar field just east of Hancock County, and the presence of gas in the Pittsfield-Hadley dome have stimulated the search for oil in areas within this State, and a correspondingly greater number of oil tests have been drilled. The approximate location of these wells is shown on the accompanying map (Pl. I), and the available logs are given in the succeeding pages.

All areas, within which detailed structural work has been done, are indicated on Plate I.

Review of the Principles of Oil Accumulation

In considering the oil possibilities of any area, many factors must be taken into account besides the structure, and it is only after all known factors have been considered that intelligent prospecting can be done. Therefore, before continuing a detailed discussion of the oil possibilities and the factors operating to bring them about, a brief review of generally accepted principles is presented.

In order that commercial deposits of oil may be formed the source must be adequate and in the productive regions of this continent there are usually heavy beds of carbonaceous shale or thick horizons of limestone that are highly fossiliferous. The matter of adequate source is the prime factor as without it accumulation cannot take place even though structural conditions may be perfect.

ORIGIN OF OIL

Oil and gas are apparently derived from vegetable and animal matter which is buried with the lime, mud, or sands that comprise the rocks. After the carbonaceous matter is once entombed in the rocks and oil is formed, various forces tend to move it about, and under certain conditions concentrate it in local areas, thus giving rise to so-called oil pools.

MIGRATION OF OIL

The forces or factors most active in the migration of oil are: (1) gravity; (2) gas pressure; (3) capillarity; (4) difference in specific gravity of oil and water; (5) flow of underground waters, and (6) pressure from sedimentation and deformation.

(1) Gravity is effective only in dry rocks, in which the pore space is large enough to be overcome by the influence of capillarity. (2) Pressure developed in gas by any means such as heat, chemical action, etc., would tend to cause the gas to expand, and if the pressure became great enough, would force any oil in the surrounding pores to move out ahead of it. (3) Capillary attraction in dry rocks would tend to draw the oil into the finer pores, but if water is present, the greater attraction of the water would cause the water to be drawn into the finer pores, and tend to concentrate the oil in the larger pores. (4) The difference in specific gravity of oil and water in rocks which are

saturated, or partly saturated, with a mixture of both, causes a separation of the two and a movement of the oil to the top of the water. In tilted rocks, the amount of movement due to this cause may be considerable. (5) In water-bearing rocks, the water does not commonly remain stationary, and under favorable circumstances as when rocks are tilted or folded and exposed at two different levels, there may be a definite artesian circulation, causing the oil to be carried along on top of the water considerable distances to be trapped by higher folds, or flushed out of the rocks entirely. (6) Probably the greatest force in concentrating the oil eventually in the more porous layers of rock is the increase in pressure on the original oil-bearing strata by deposition of overlying layers of rock or the diastrophic force which induces folding. The weight of the superincumbent layers, or the pressure causing folding compacts the lower layers, and the oil originally present in the more shaly beds is forced out into the porous sand layers in which the individual grains do not compact so readily.

ACCUMULATION OF OIL

Conditions essential to the accumulation of oil into pools are: (1), a porous stratum which can be made to serve as a reservoir; (2), an impervious covering of rock to retain the oil in the reservoir, and (3), tilting, folding, terracing or other structural modification that will cause large quantities of oil to collect and be retained within a comparatively small area.

The reservoir is commonly supplied by sandstone, but any rock which offers sufficient voids is a prospective reservoir. Thus limestones, which have become dolomitized, or fractured, or have been exposed to weathering, or contain porous, granular and oolitic layers have all been known to act as reservoirs. Even shales which are usually too compact to act as reservoirs, may provide a suitable reservoir in exceptional cases, as when fractured along a fault. The cap rock or impervious cover of the reservoirs is generally a shale, but a dense limestone or cemented sandstone may serve equally as well.

The outlines of the reservoirs are in most cases the result of folding of the rocks. The "lie" of the rocks is known as the structure, the determination of which is exceedingly important in the discovery and development of an oil field. The most favored location for a reservoir depends upon the amount of water contained in oil-bearing rocks.

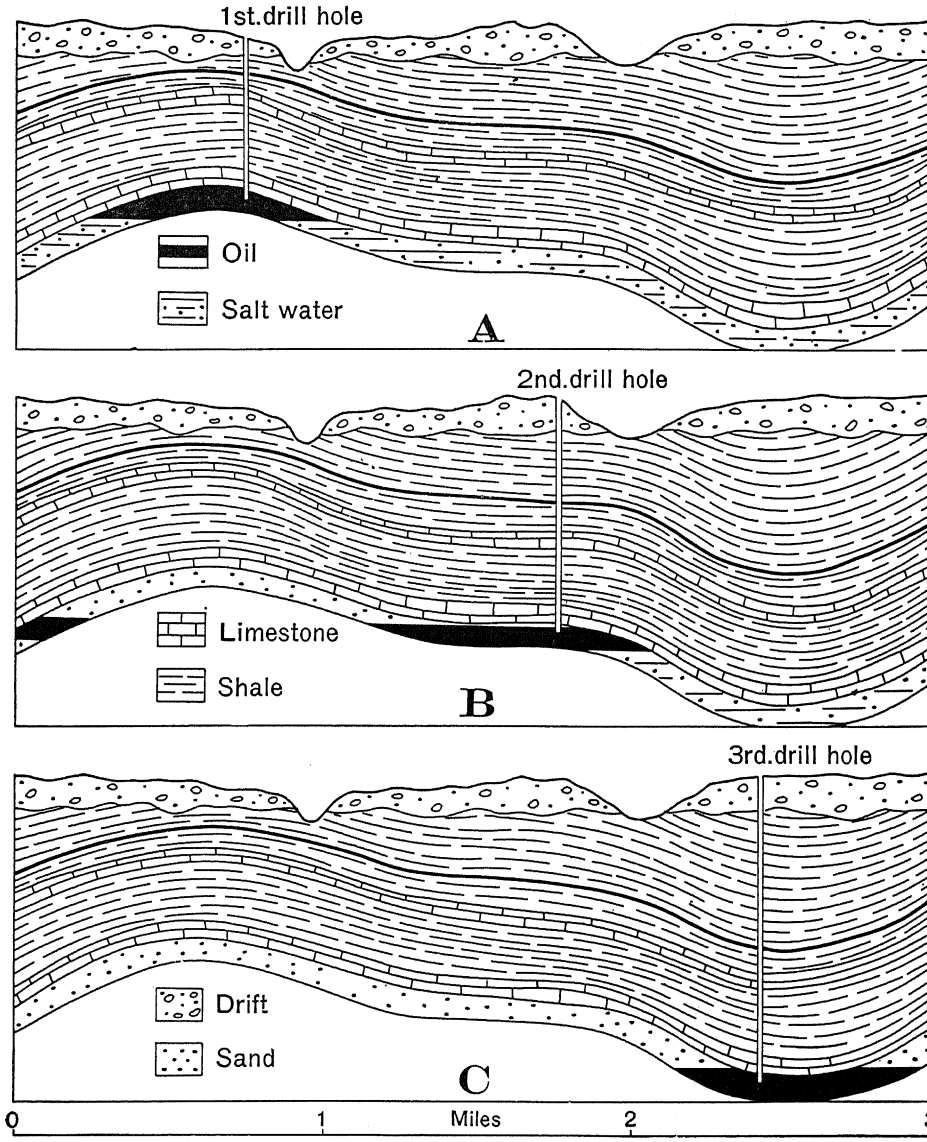


Diagram showing conditions governing oil accumulation.

A. In oil sands saturated with water.
B. In oil sands partly saturated.
C. In sands containing no water and only partly filled with oil.

In water-bearing rocks, structures of the dome type, long arches designated as anticlines, terraces made by flattening of the dip, or monoclines are all known to be sites of possible reservoirs (Pl. XVIII). The reason for this is, of course, that after folding, the oil and gas which was once spread out thinly over a wide area, in rising to the top of the water, becomes trapped in these structures and therefore concentrated within a small area. Other factors beside folding, however, may bring about similar conditions. Thus, sand lenses completely surrounded by shale may, even where the strata are flat lying, have enough slope to the upper surface to permit the oil to gather at one end. In tilted rocks where oil-bearing strata are exposed at the surface, the escaping oil may leave deposits of asphalt which effectively seal the outcrop and permit the accumulation of oil immediately behind the outcrop. Rocks once exposed to surface weathering and erosion, become more porous and later when buried, may become reservoirs. In faulted regions, the formation of gouge may seal the fault and permit accumulation of oil along the fault zone. In short, any set of circumstances which will cause a concentration of oil or gas from a larger area to a smaller one may produce oil or gas pools.

As gravity is the effective migratory force in rocks barren of water, oil will work down the dip of the rocks and collect at the lowest possible place, such as bottom of synclines or sags on the slopes, in positions the reverse of those when the sands are filled with water (Pl. XVIII, C). Dry sands, however, are not common in the area here considered.

COMBINED EFFECT OF FOLDING AND EROSION

After oil has become concentrated in folds there is the possibility that subsequent erosion will expose the oil-bearing strata at the surface and incoming fresh waters may flush out the oil from reservoirs near the outcrop.

Evidences of Oil and Gas Within the Region

Aside from the fact that oil is produced in adjoining regions, there is direct evidence that oil has been, and may be, present within this region. The best evidence of this is, of course, the actual production of gas from the Pittsfield-Hadley dome. Other evidence, however, is furnished by the presence of the oil-bearing shales of the Sweetland Creek formation; by the thin

shaly partings at the top of the Plattin limestone, which burn readily when ignited; and by the presence, locally in both the Kimmswick limestone and Edgewood dolomite of small pockets containing black asphaltic residuum. Near Niota, Hancock County, Illinois, a thin, geodiferous layer near the top of the Keokuk limestone contains numerous geodes filled with heavy, black oil, but the surrounding rock is not bituminous. At several localities within the area, drillers of deep wells have reported shows of oil and gas in the Kimmswick ("Trenton") limestone, in the "Niagaran dolomite," from sandy phases of the Kinderhook and Sweetland Creek shales, and also from the Burlington limestone.

Probable Oil Horizons

The greatest production of oil in Illinois comes from the Pennsylvanian and upper Mississippian formations, but some oil has also been produced from the formations of the lower Mississippian system, the Devonian, the Silurian, and the upper formations of the Ordovician system. In fact, the producing horizons of oil are so widely distributed that no test can be considered complete unless it penetrates the Kimmswick ("Trenton"). Nowhere, however, within the State has oil been found below the Kimmswick.

Within the area considered, the number of probable oil horizons is less than in the interior of the State, for no upper Mississippian rocks are present; the Pennsylvanian rocks are thin or lacking, and where present they represent the surface rock so that any oil they may have contained once has long since escaped. The Osage and Meramec rocks also outcrop at the surface over most of the area, but these horizons are negative so far as oil production is concerned. Therefore, of the oil producing horizons, only the Kinderhook, the Devonian, Silurian, and upper Ordovician offer possibilities.

Factors Affecting Oil Accumulation Within the Area

STRUCTURE

As shown in the chapter describing the structure, there are a number of distinct folds which might have caused a gathering and localization of any oil present in the rocks. These, in the order of their size, are the Lincoln fold, the Pittsfield-Hadley

anticline, the Adams County terrace, and the minor structurally high areas in Hancock County, Illinois, and Clark County, Missouri.

THE LINCOLN FOLD

Though possessing many excellent minor structural irregularities which might have caused localization of oil, the Lincoln fold can not be considered as a possible oil structure because its crest and slopes expose rocks lower than the Kimmswick. Any oil that may have been present in this structure has long since escaped. For this reason, northeastern Lincoln County, central and eastern Pike County, and all except the extreme western part of Ralls County do not warrant prospecting for oil. In Marion County, where the crest of the anticline plunges to the northwest, and possible oil-bearing strata have an impervious cover, the discovery of doming anywhere along the crest of the axis might be considered favorably. Similarly, any minor folding in western Ralls and Pike counties which interrupt the regional southwest dip might also bear investigation. These possibilities are the only favorable structural features associated with the Lincoln fold, and although reconnaissance work did not offer much promise, a suggestion of a flattening and minor folding was observed in the vicinity of Center, in western Ralls County.

PITTSFIELD-HADLEY ANTICLINE

The Pittsfield-Hadley anticline shows a distinct doming in Pike County, Illinois, and since some of the probable oil-bearing horizons are present here, under sufficient cover this dome might be considered favorable. Southeast and northwest of Pike County, the axis of the fold plunges gently away from the dome, and other localities which might be considered structurally favorable can be proved only by the discovery of other doming along the crest. No evidence pointing to such doming was observed in this reconnaissance, and can be determined only by detailed work.

ADAMS COUNTY TERRACE OR MONOCLINE

The broad northward dipping monocline that underlies western Adams County can be considered favorable structure only if detailed work shows it to possess minor folding which might serve to trap any oil migrating up the slope. However, no prominent folding of this kind was observed.

MINOR STRUCTURES

The higher portions of the minor structures of Hancock County, Illinois, and Clark County, Missouri, should be considered possible oil structures only after drilling has shown production on the more favorable ones farther south.

EFFECT OF EARLIER PERIODS OF FOLDING

In discussing periods of earlier folding, it was shown that throughout this area there has been continuous tilting to the east, and much to the north. The effect of such tilting, of course, would be to permit the oil to migrate up the dip to the west and south. If then these earlier formations were exposed at the surface after being tilted, any oil they may have contained, except for small quantities as were caught within minor irregular warps and folds, would have escaped. That the lower rocks, especially the Kimmswick ("Trenton") limestone were exposed at the surface as late as Devonian time is shown in Ralls County, where the Devonian rests on Kimmswick, and in St. Charles County, where the Kimmswick limestone was the surface rock as late as Kinderhook time. These facts are unfavorable to the occurrence of oil in the Kimmswick in this region except in places where the oil might have been retained due to local folding, which trapped the oil and retained it during future folding.

CONCLUSION CONCERNING STRUCTURAL FACTORS

That the predominating anticlinal fold of the region should expose all the known oil-bearing rocks at the surface is considered unfavorable to large accumulations of oil within the region. The oil-bearing horizons are of necessity barren in the vicinity of their outcrop, but may contain oil in some of the minor folds where they are under sufficient cover to prevent the escape of the oil.

Structures most favorable to the retention of oil are, therefore, minor folds on the slopes of the Lincoln fold, and any doming along the crest of the fold where it plunges in Marion County and farther northwest. The order of importance of these minor structures is: (1) small domes or buckling of the crest of the Lincoln fold from Marion County, Missouri, northwestward; (2) minor anticlines or closures on the slope of the fold in western Ralls and Pike counties, Missouri; (3) Pittsfield-Hadley dome and other closures found along the crest; (4)

closures on the Adams County monocline; and (5) closures in the gently folded areas in Hancock County, Illinois, and Clark and Lewis counties, Missouri.

The earlier folding in the area, accompanied by exposure of the rocks, is considered unfavorable to the retention of oil except locally, in rocks below the Devonian in the western part of the area, but it is not so important in the eastern portion, which is nearer to the center of the Illinois basin, because folding here was not always accompanied by exposure of the strata.

STRATIGRAPHY

The presence of bituminous material in all the shale formations and the fact that some of the shales as the Sweetland Creek, will give off oil on distillation, suggest that the shales are probably the original source for most of the oil present within the area. Accumulations of oil should therefore occur in the associated porous rocks.

Rocks that might act as reservoirs which are associated with shale formations are: (1) Kimmswick ("Trenton") limestone; (2) local sand lenses at the base of the Silurian (Hoing sand); (3) Silurian limestone and dolomite; (4) Devonian limestones; (5) Louisiana limestone; (6) local sand layers within the Sweetland Creek shale; and (7) dolomitic layers of the Chouteau and Burlington formations.

KIMMSWICK ("TRENTON") LIMESTONE

Although the name "Trenton" is in common usage in the oil industry for formations of this horizon, the proper name of this formation in this region is Kimmswick. The limestone is directly below the locally bituminous Maquoketa shale, and the "Trenton" itself shows oil shale partings at the top of the Plattin. Another factor favoring accumulation of oil in the Kimmswick is its porosity, though it diminishes to the north and east where the granular layers become subordinate and are interbedded with dense fine grained layers.

Several other unfavorable circumstances beside those due to structure and distribution already mentioned may be noted. Locally, as in northern Ralls County, Missouri, the Maquoketa shale is absent above the Kimmswick. It outcrops at higher levels both to the north and south of the area under discussion, so that there may exist an artesian circulation which would tend

to flush out any oil from its path. A suggestion of such circulation is found in the apparent decrease in the salinity of water in this horizon from its outcrop northward. Fresh water was found at a depth of 500 feet below the valley flat in the Kimmswick in a well drilled at Warsaw, Hancock County, Illinois, and farther north near Stronghurst, in Henderson County, Illinois, both fresh and salt water are reported from the Kimmswick. Also, where tested under the most favorable structural conditions on the Pittsfield-Hadley anticline the Kimmswick did not yield oil.

HOING SAND

The Hoing sand is not known from outcrop, and is apparently limited in its distribution within this area to the eastern portion, in Hancock and Adams counties, Illinois. So far as known, the sand occurs as discontinuous lenses, and though ideally situated as regards its relations to a shale body, it is an important probable oil horizon over only a small area.

SILURIAN LIMESTONE AND DOLOMITE

Where the Hoing sand is absent, the porous Silurian dolomite of the Alexandrian series is the rock immediately above the Maquoketa, and might serve as an oil reservoir. The unfavorable feature of the Silurian is its limited distribution, for it is present under sufficient cover only in the eastern portion of the area, in Hancock, Adams, and Pike counties, Illinois.

DEVONIAN LIMESTONE

The Devonian limestone is thin and has about the same distribution as the Niagaran. In the southern portion of the area, it contains sandy beds, both near the top and at the base, but these beds also are under sufficient cover only in the eastern portion of the region here considered.

SWEETLAND CREEK SHALE

The Sweetland Creek shale is locally sandy near its base, and such sandy phases are excellent prospective oil reservoirs. As much as 8 feet of sandstone have been observed in the Sweetland Creek shale along Brush Creek in the region where it joins Spencer Creek in southern Ralls County, and the basal portion of shale is also sandy in Pike County, Illinois, where it is exposed in the bluff north of Pleasant Hill. These sandy phases, however, appear to be only local developments.

LOUISIANA LIMESTONE

The Louisiana limestone is typically a dense, almost lithographic rock, entirely unsuitable as a retainer of oil, and although it is possible that it may be locally fractured or contain porous dolomitic beds, it is probably not important as a possible oil-producing horizon.

KINDERHOOK SHALE

The Kinderhook shale is locally sandy with medium-sized grains and might, under proper conditions, become a reservoir for oil. It is exposed at the surface over most of the southern portion of the area, and exists under cover only in the northern part.

HIGHER FORMATIONS

None of the higher formations is present here under sufficient cover to warrant considering their oil possibilities.

SUMMARY OF CONCLUSIONS

The conclusions drawn from a study of the data afforded by this reconnaissance are:

(1) That the region does not offer much promise of more than small local production.

(2) That the Kimmswick ("Trenton") limestone, which is in general the most promising oil horizon in western and southwestern Illinois, is distinctly less favorable to possible production in this region than it is farther south and east.

(3) That the most likely oil horizons, aside from the Kimmswick lenses where they are affected by pre-Mississippian folds, are local sands or sandy phases associated with the Maquoketa, Sweetland Creek, or bituminous phases of Kinderhook shales.

(4) That the portion of the region including southwestern Jersey County and southern Calhoun County, Illinois, northeastern Lincoln County, eastern and central Pike County, and eastern Ralls County, Missouri, is barren territory.

(5) That the areas most favorable structurally are: (a) closures on the Lincoln fold where its axis plunges north in Marion and Knox counties, Missouri; (b) a minor fold on the flanks of the Lincoln Fold in extreme western Pike, Ralls, and adjoining counties in Missouri; (c) the Pittsfield-Hadley dome in

Pike County, Illinois; (d) closures associated with the crest of the Pittsfield-Hadley anticline or Adams County monocline, or the structurally high areas of the northern portion of the area.

(6) That local sand lenses at the top of the Maquoketa are present only in the eastern portions of Pike, Adams and Hancock counties, Illinois, and that the sandy phase of Sweetland Creek shales is best developed in western Ralls and probably adjoining regions.

(7) That prospecting should be preceded by detailed field and sub-surface work.

CHAPTER V—RECORDS OF WELLS DRILLED IN THE MISSISSIPPI VALLEY AREA

The following drill records are considered typical for the counties from which they come and will serve to show the character of the rocks encountered in drilling. Correlations of the strata penetrated are those of the writer unless otherwise stated.

Because of the difficulty of distinguishing between the different Ordovician limestones above the St. Peter sandstone and below the Maquoketa shale in drill records, the term "Trenton" is used to include the several limestones.

Records of Wells Located in Missouri

CLARK COUNTY

Record of Missouri Condensed Milk Factory well at Kahoka[1]

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Soil and yellow clay	15	15
Clay, yellow, drab, and blue	135	150
Sand and gravel	11	161
Mississippian system		
St. Louis and Ste. Genevieve limestones		
Limestone, gray	9	170
Sandstone, soft (water)	9	179
Limestone, very fine, gray	51	230
Warsaw-Spergen formation		
"Soapstone"	60	290
Burlington-Keokuk formation		
Limestone	110	400
"Fire clay"	6	406
Limestone with chert	66	472
Kinderhook series		
Hannibal and Grassy Creek (Sweetland Creek) shales		
"Soapstone," blue	30	502
Sandstone, bluish	9	511
Shale, blue gray	126	637
"Soapstone," ash color	20	657
Shale, brown	25	682

[1] Wilson, M. E., The occurrence of oil and gas in Missouri: Missouri Bur. of Geol. and Mines, Vol. XVI, 2nd ser., p. 97, 1922.

Record of Missouri Condensed Milk Factory Well at Kahoka—Continued

Description of strata	Thickness *Feet*	Depth *Feet*
Silurian-Devonian systems not present		
Ordovician system		
Maquoketa shale		
Shale	85	767
"Trenton" limestone		
Limestone	293	1060
St. Peter sandstone		
Sandstone	131	1191

Although no Louisiana limestone is shown in this log it is probable that this limestone is present, at least in the eastern portion of the county. The Silurian-Devonian rocks are absent over most of the county, but may be encountered in the extreme western part.

LEWIS COUNTY

Record of the Canton Oil and Gas Company well No. 2 in the SW. ¼ NW. ¼ sec. 14, T. 62 N., R. 6 W.[2]

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Loess, clay, and shale	40	40
Mississippian system		
Burlington-Keokuk (includes some Warsaw) formations		
Limestone, blue to gray, crystalline, white and blue chert	100	140
Limestone, fine grained, gray-blue	80	220
Limestone, medium grained, gray, blue, white chert	60	280
Kinderhook series		
Hannibal shale		
Shale, gray, uniform	50	330
Shale, sand, greenish	40	370
Louisiana limestone		
Limestone, gray, brown, fine grained	50	420
Grassy Creek (Sweetland Creek) shale		
Shale, bluish gray	40	460
Silurian-Devonian systems not present		
Ordovician system		
Maquoketa shale		
Shale, clayey, dark gray	20	480
No record	65	545

[2]Idem, p. 96.

Record of the Canton Oil and Gas Company well No. 2 in the SW. ¼ NW. ¼ sec. 14, T. 62 N., R. 6 W.—Continued

Description of strata	Thickness *Feet*	Depth *Feet*
Ordovician system—*Continued*		
"Trenton" limestone		
Limestone, light to dark gray, fine grained, more crystalline towards base	175	720
Limestone, light gray, very hard, fine grained	30	750
Limestone, magnesian, fine grained, brown and hard.	60	810
No record	70	880
Limestone, almost non-magnesian	15	895
St. Peter sandstone		
Sandstone, white, coarse grained	33	928

The above log is typical for most of the county, but to the west and especially the southwest, limestones of Devonian age may be expected between the Maquoketa and Grassy Creek (Sweetland Creek) shales. The limestone at 370 feet is somewhat thicker and lower in the section than would be expected from a study of the outcrops farther south, but this may be due to an error in logging the well.

LINCOLN COUNTY

Record of Prairie Oil and Gas Company well at Moscow Mills[3]

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Soil and clay	8	8
Hardpan, yellow	4	12
Pennsylvanian system (?)		
Soapstone, blue	40	52
Mixed gravel (water)	3	55
Mississippian (?) system		
Sandstone, white, hard	25	80
Keokuk-Burlington and Chouteau formations		
Limestone, brown, cherty	260	340
Hannibal and Maquoketa shale with possibly some Devonian		
Soapstone, blue, soft	10	350
Limestone, brown	72	422
Shale, brown	3	425
Kimmswick ("Trenton") limestone		
Limestone, brown and white	95	520
Sandstone, yellow, hard	15	525
Limestone, brown, hard	126	661
St. Peter sandstone		
Sandstone	79	740

[3] Idem, p. 100.

Record of William Overall well in SE. ¼, sec. 1, T. 49 N., R. 1 E.

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Soil, light, ashy	2	2
Hardpan	3	5
Clay, light brown	10	15
Soapstone, gray streaks of sand	27	42
Pennsylvanian system		
Soapstone, dark blue	94	136
Mississippian system		
Burlington-Chouteau formation		
Limestone, brown	54	190
Limestone, blue	30	220
Hannibal shale		
Shale, dark	35	255
Ordovician system		
Maquoketa shale		
Shale, dark blue	40	295
"Trenton" formation		
Limestone, gray	155	450
Limestone with shale	115	565
Sandstone, hard	12	577
Limestone, gray	18	595
St. Peter sandstone		
Sandstone	61	656

In correlating the above log the writer took the liberty of separating the 75-foot dark shale formation into two portions, the upper 35 feet of which is referred to the Hannibal, while the lower portion is referred to the Maquoketa. The separation is based on observations of outcrops about a mile northwest of the well which show Hannibal shale resting on Maquoketa. Locally in this same vicinity Devonian limestone as much as 12 feet thick comes in between the Hannibal and Maquoketa shales.

MARION COUNTY

Record of well at Palmyra

Description of strata	Thickness *Feet*	Depth *Feet*
Mississippian system		
Burlington limestone		
Limestone, brownish	20	20
Limestone, finer	11	31
Kinderhook series		
Hannibal (?) formation		
Sand, gray	34	65

Record of well at Palmyra—Continued

Description of strata	Thickness *Feet*	Depth *Feet*
Mississippian system—*Continued*		
Louisiana limestone		
Limestone	25	90
Grassy Creek (Sweetland Creek) shale		
Clay, light blue	70	160
Silurian-Devonian systems missing		
Ordovician system		
Maquoketa shale		
Clay, dark olive, little limestone	125	285
("Trenton") limestone		
Limestone, dove color	15	300
Limestone, light gray, compact	55	355
Limestone, compact, dove color	15	370
Limestone and quartz (?) crystals	190	560
Limestone, impure light and dark gray	40	600
St. Peter sandstone		
Sand, fine	100	700

It is probable that some of the shale included in the Maquoketa belongs with the Kinderhook. While the above log will serve to give an idea of the character and thickness of the formations in the eastern portion of the county, it is known from outcrops and well records that in the western portion of the county the Devonian system is present and is represented by limestone which may reach a thickness of 80 feet or possibly a little more.

The following logs from the vicinity of Nelsonville in northwestern Marion County and from the Jacksonville well at Monroe City in eastern Monroe County afford a general idea of the strata penetrated in drilling to the St. Peter sandstone in western Marion County.

Record of C. H. Mohr well near Nelsonville in sec. 21, T. 59 N., R. 8 W.[4]

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Clay	45	45
Mississippian system		
Kinderhook series		
Hannibal shale		
Shale, blue	150	195
Louisiana limestone		
Limestone	60	255
Grassy Creek (Sweetland Creek) shale		
Shale, gray	35	290

[4]Idem, p. 101. Wilson, M. E., The occurrence of oil and gas in Missouri; Missouri Bur. of Geol. and Mines, Vol. XVI, 2nd ser., p. 101, 1922.

Record of C. H. Mohr well near Nelsonville in sec. 21, T. 59, 59 N., R. 8 W.—Continued

Description of strata	Thickness *Feet*	Depth *Feet*
Devonian system (including some "Trenton" limestone)		
Limestone	220	510
Ordovician system		
"Trenton" limestone		
Sandstone, red	15	525
Limestone	125	650
St. Peter sandstone		
Sandstone, white, mineral water	10	660
Rock, hard	2	662
Sand and limestone	213	875

Lack of detail in the above log makes correlation difficult, but suggested correlations indicate the writer's interpretation of the log.

MONROE COUNTY

Record of Jackson well at Monroe City

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Gravel	17	17
Fire clay	19	36
Mississippian system		
Burlington and Chouteau formations		
Lime, white	36	72
Sand, white	78	150
Lime, brown	25	175
Hannibal shale (?)		
Shale, blue	110	285
Louisiana limestone (?)		
Lime, brown	24	309
Lime, light brown	6	315
Grassy Creek (?) shale (Sweetland Creek)		
Mud, blue	16	331
Devonian (?) system		
Lime, gray	39	370
Lime, white	6	376
Lime, blue	47	423
Ordovician system		
Trenton limestone (?)		
Lime, white	29	452
Oil sand	6	458
Lime, white	59	517
Shale, light brown	34	554
Lime, gray	2	556

Record of Jackson well at Monroe City—Continued

Description of strata	Thickness *Feet*	Depth *Feet*
Ordovician system—*Continued*		
Water sand	5	561
Blue shale	4	565
Lime, gray	25	590
St. Peter sandstone (?)		
Sand, white	85	675
Sand, blue	95	760

PIKE COUNTY

Record of Roberts well, Clarksville[5]

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Clay	75	75
Mississippian system		
Burlington-Chouteau formations		
Limestone, crystalline, gray, cherty	25	100
Kinderhook series		
Hannibal shale		
Shale, bluish-gray	100	200
Louisiana limestone		
Limestone, fine grained, light to dark gray	40	240
Grassy Creek shale (Sweetland Creek)		
Shale, dark blue	10	250
Silurian system		
Limestone, brown to white, fine grained	20	270
Ordovician system		
Maquoketa shale		
Shale, gray to bluish-gray, calcareous	75	345
Limestone, argillaceous, sandy and dove-colored	95	440
Kimmswick-Plattin ("Trenton") limestone		
Limestone	310	750
St. Peter sandstone		
Sandstone, well rounded grains	83	833+

The Kimmswick ("Trenton") makes up the surface rock over most of eastern Pike County, but in the central and western portions Mississippian rocks are found at the surface. From this region the following well records from Bowling Green may be considered typical.

[5]Idem, p. 100.

Record of well at Bowling Green

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Soil and drift	70	70
Clay, dark red	6	76
Missing	14	90
Mississippian system		
Burlington limestone		
Limestone, cherty	10	100
Limestone, yellow, some chert	15	115
Kinderhook series		
Chouteau limestone		
Limestone, cream colored, fine grained	25	140
Limestone, dark gray	15	155
Hannibal shale		
Shale, dark gray, calcareous	10	165
Shale, blue gray	85	250
Missing	5	255
Shale, gray	2	257
Silurian system		
Alexandrian series		
Limestone, argillaceous, light gray	1	258
Limestone, argillaceous, dark gray	7	265
Limestone, argillaceous, light gray	10	275
Sandstone, impure	1	276
Limestone, sandy, dark	4	280
Ordovician system		
Maquoketa shale		
Limestone, argillaceous, light gray-green	10	290
Limestone, argillaceous, dark gray-green	50	340
Limestone, sandy, brown	5	345
Limestone, sandy, brown, fine-grained	5	350
"Trenton" limestone		
Limestone, dark gray	30	380
Limestone, light gray	70	450
Limestone, cream	70	520

RALLS COUNTY

The "Trenton" makes up the surface rock over most of the central portion of the county and it is only in the western and northern portions that these formations are buried to an appreciable depth. To the north and west the formations between the surface and the St. Peter will be similar to those of Marion county, and to the south they will be like those of Pike county. The following logs are available for northern and western Ralls county, but they show no detail and the writer is of the opinion that they are inaccurate.

Record of T. E. Allison well at Perry[7]

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Dirt	2	2
Flint rock and boulders	20	22
Limestone	12	34
"Soapstone" shale	126	160
Limestone, white	10	170
Shale, red, "soapy"	50	220
"Soapstone" shale	210	430
Limestone, gray to brown	48	478
Sandstone, white, coarse	12	490

ST. CHARLES COUNTY

Record of R. D. Silver well, near St. Peters[8]

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Alluvium	25	25
Mississippian system		
Meramec series with possibly some Keokuk		
Limestone, fine-grained, gray chert	115	140
Osage series and Chouteau		
Limestone, gray to white, coarsely crystalline	140	280
Limestone, gray, finely crystalline	119	399
Kinderhook series		
Hannibal shale		
Shale, gray to brown, sandy	38	437
Ordovician system		
"Trenton" limestone		
Limestone, gray to white, coarsely crystalline	105	542
Limestone, dark gray, fossiliferous	49	591
Limestone, gray to drab	151	742
Dolomite, brown to gray	56	798
St. Peter sandstone		
Sandstone, white, rounded grains	202	1000

Record of McMenarny Bros. well, sec. 36, T. 48 N., R. 2 E.

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Soil, ashy color	3	3
Clay, brown, yellowish	41	44
Soapstone, blue	12	56

[7]Wilson, M. E., Oil and gas possibilities in Missouri.: Mo. Bur. of Geol. and Mines, Vol. XVI, p. 101, 1922.

[8]Wilson, M. E., Oil and gas possibilities in Missouri. Mo. Bur. of Geol. and Mines, Vol. XVI, p. 98, 1922.

Record of McMenarny Bros. well, sec. 36, T. 48 N., R. 2 E.—Continued

Description of strata	Thickness *Feet*	Depth *Feet*
Mississippian system		
Osage series		
Limestone, soft gray, chert	49	105
Limestone, white, chert	200	305
Kinderhook series		
Chouteau formation		
Missing	25	330
Limestone, dark gray to blue	40	370
Hannibal shale		
Shale, calcareous, greenish-blue	15	385
Shale, blue gray	15	400
Missing	15	415
Ordovician system		
"Trenton" limestone		
Limestone, white to brown	125	540
Limestone, blue, shaly	30	570
Limestone, gray, fine-grained	110	680
Limestone, gray drab	70	750
St. Peter sandstone		
Sandstone	60	810

Records of Wells Located in Illinois

ADAMS COUNTY

Record of S. A. Hubbard well near Quincy, sec. 16, T. 1 S., R. 9 W.

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Alluvium, sand and clay	124	124
Mississippian system		
Louisiana limestone		
Limestone, lithographic	30	154
Sweetland Creek (Grassy Creek) shale		
Shale, blue gray, sandy	60	204
Ordovician system		
Maquoketa shale		
Shale, blue	96	310
"Trenton" limestone		
Limestone, dense to granular, white-brown	307	617
St. Peter sandstone		
Sandstone, gray	138	755

Record of Johnson well near Brown County line in sec. 24, T. 2 S., R. 5 W.

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Clay and gravel	14	14
Mississippian system		
Meramec series		
Limestone, gray	24	38
Shale, blue, thin streaks of shells	90	128
Burlington-Keokuk formation		
Limestone, white	220	348
Kinderhook series		
Hannibal and Sweetland Creek (Grassy Creek) shale		
Shale, green	25	373
Shale, blue	40	413
Shale, black	120	533
Silurian-Devonian systems		
Lime, gray	30	563
Ordovician system		
Maquoketa shale		
Shale, blue	27	590
Shale, gray, with sand streaks	40	630

CALHOUN COUNTY

Record of Kinscheff well near Kampsville, sec. 10, T. 9 S., R. 2 W.

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Soil, clay, and gravel	42	42
Mississippian system		
Kinderhook series		
Sweetland Creek (Grassy Creek) shale and Louisiana limestone?		
Limestone, hard and broken	5	47
Shale, gray to blue	36	83
Silurian-Devonian systems		
Limestone	8	91
Limestone, with shale bands	7	98
Limestone	103	201
Ordovician system		
Maquoketa shale		
Shale, blue	84	285
Shale, hard, gray, lime bands	20	305
Shale, blue, with lime bands	63	368
"Trenton" limestone		
Limestone	340	708
St. Peter sandstone		
Sandstone	145	853

HANCOCK COUNTY

Record of Popel-Giller Brewing Company well at Warsaw

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Soil and clay drift	40	40
Mississippian system		
Warsaw formation		
Limestone, blue, and shale	15	55
Burlington-Keokuk formation		
Lime rock, blue	50	105
Lime and grit	25	130
Grit and fire clay	10	140
Limestone, gray	45	185
Hannibal shale		
"Soapstone," blue	30	215
Sandstone	19	234
Louisiana limestone		
Rock, lithograph, light	46	280
Rock, lithograph, dark	10	290
Limestone, bastard	6	296
Sweetland Creek (Grassy Creek) shale		
"Soapstone"	69	365
Shale, brown	40	405
Maquoketa (Cincinnati) shale		
Shale, brown	99	504
"Trenton" limestone		
Limestone, brown	126	630
St. Peter sandstone[a]		
Sandstone, brown	182	812

[a]It is probable that some of the rock included with St. Peter sandstone is a dolomitic limestone and should be included with the "Trenton."

Record of McCune well near West Point in SE. ¼, SE. ¼, sec. 16, T. 3 N., R. 7 W.

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Drift	147	147
Mississippian system		
Burlington-Keokuk formation		
Limestone, coarse, blue, fossiliferous, changes to buff limestone, then to blue shaly limestone	219	366
Kinderhook series		
Hannibal and Sweetland Creek (Grassy Creek) shale		
Shale, gray, thin bedded	235	601

Record of McCune well near West Point in SE. ¼, SE. ¼, sec. 16, T. 3 N., R. 7 W.—Continued

Description of strata	Thickness *Feet*	Depth *Feet*
Silurian-Devonian systems		
Limestone, gray to buff, with some shale near the bottom; in the bottom a few sand grains (clear colorless angular, slightly rounded grains)	89	690
Ordovician system		
Maquoketa shale		
Shale, gray	42	732
"Trenton" dolomite		
Dolomite, buff, fine grained	220	952

JERSEY COUNTY

Record of City Waterworks well at Jerseyville

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Clay	26	26
Pennsylvanian system		
Slate, black	74	100
Mississippian system		
Meramec series		
Lime, flinty	16	116
Slate	24	140
Lime	5	145
Slate	23	168
Lime	12	180
Slate	27	207
Lime	10	217
Slate	4	221
Osage series and Chouteau limestone		
Lime	229	450
Flint	30	480
Lime	50	530
Kinderhook series		
Hannibal shale		
Slate	25	555
Lime	10	565
Slate	10	575
Silurian-Devonian systems		
Lime, hard	65	640
Slate	10	650
Lime and flint	160	810
Ordovician system		
Maquoketa shale		
Slate	80	890
Lime	50	940
Slate	35	975

Record of City Waterworks well at Jerseyville—Continued

Description of strata	Thickness *Feet*	Depth *Feet*
Ordovician system—*Continued*		
"Trenton" limestone		
Lime	387	1362
St. Peter sandstone		
Sandstone	180	1542

PIKE COUNTY

Record of Ducey well near Pittsfield in sec. 29, T. 5 S., R. 4 W.

Description of strata	Thickness *Feet*	Depth *Feet*
Pleistocene system		
Soil and drift	36	36
Mississippian system		
Burlington limestone		
Limestone	65	101
Kinderhook series		
Hannibal and Sweetland Creek (Grassy Creek) shales		
Shale	140	241
Silurian-Devonian systems		
Limestone	64	305
Ordovician system		
Maquoketa shale		
Shale	138	443
"Trenton" limestone		
Limestone	298	741
St. Peter sandstone		
Sandstone	8	749

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