GEOLOGY AND OIL PRODUCTION IN THE TUSCOLA AREA, ILLINOIS

H. M. Bristol and Ronald Prescott

ABSTRACT

The Tuscola Anticline, in east-central Illinois, lies astride the complex LaSalle Anticlinal Belt and dips steeply westward into the Fairfield Basin and gradually eastward into the Murdock Syncline. The anticline is broken into two structural highs, the Hayes Dome and the Shaw Dome.

Pleistocene sediments, 50 to 250 feet thick, cover the area. Pennsylvanian sediments cover much of the area, thinning to expose an inlier of Mississippian, Devonian, and Silurian rock north of Tuscola. The basal Cambrian formation, the Mt. Simon Sandstone, is penetrated by only two wells.

Oil production from the Kimmswick (Trenton) commenced in 1962 from the R. D. Ernest No. 1 Schweighart well, near Hayes, and as of January 1, 1968, approximately 30 wells were producing oil. Cumulative oil production as of January 1, 1968, is approximately 94,000 barrels. The potential pay zone is confined to the upper 50 to 100 feet of structure and to the upper 125 feet of the Kimmswick, whose permeability ranges from 0.1 to 2.0 millidarcys, averaging 0.6, and whose porosity ranges from 2 to 12 percent. The low gravity of the Kimmswick oil presents production problems. Oil and gas production from the Fairfield Basin portion of the area is from the Spar Mountain Sandstone. Oil shows, to date unproductive, are present in Pennsylvanian, Devonian, and Silurian rocks.

INTRODUCTION

The Tuscola area, in northern Douglas and southern Champaign Counties, is an area of about 672 square miles. The town of Tuscola lies near the geographical center of the report area. The region is relatively flat with local relief of less than 50 feet. Topographic elevations range from 600 feet above sea level in the south, on the Embarras River, to over 760 feet at the north, on Yankee Ridge.

Structurally, the Tuscola area (fig. 1) lies at the extreme northeastern edge of the Fairfield Basin and about at the midpoint of the LaSalle Anticlinal Belt. It includes such prominent features as the Tuscola Anticline, the Murdock Syncline, the northern end of the Cooks Mills Anticline, and the northwestern corner of the Brocton Dome.

Wells were drilled for oil in this area as early as the last half of the 19th century. It was from these wells that information about the southward extension of the LaSalle Anticline was obtained.

Information about the Fairfield Basin portion of the area was obtained through drilling during 1956 through 1958, when oil was found in the Spar Mountain Member of the Ste. Genevieve Formation on the Cooks Mills Anticline at Bourbon, Bourbon North, and Chesterville.

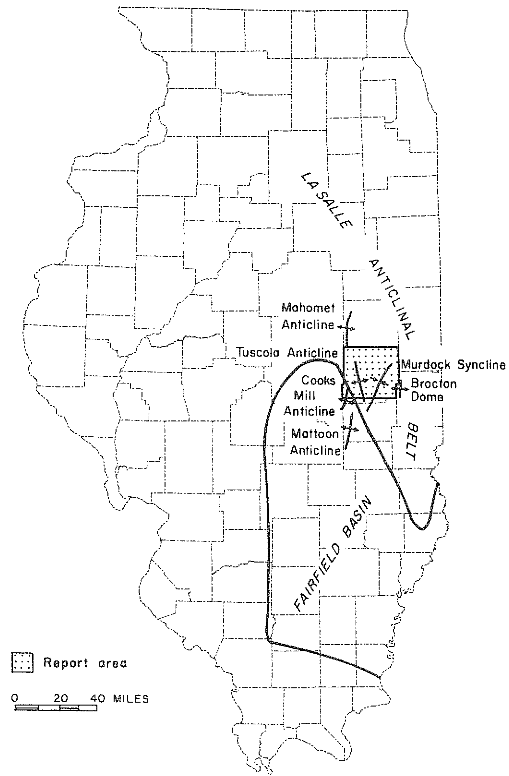


Figure 1 - Location of Tuscola Anticline and report area in relation to the Fairfield Basin and the LaSalle Anticlinal Belt.

Oil was discovered on the Tuscola Anticline by R. D. Ernest in 1962 near Hayes, north of Tuscola, in the No. 1 Schweighart well, sec. 4, T. 16 N., R. 8 E., Douglas County. The initial production of this well was 15 barrels of oil per day from the Kimmswick (Trenton) Limestone. This well aroused temporary interest in the Tuscola Anticline, but it was not until late 1965 that intensive development of the Hayes field was begun by M. H. Richardson. Approximately 50 oil wells have been drilled in the field; about 38 were producing at their peak January 1, 1967.

Oil production in the area, however, is not confined to the Hayes pool. Production is also found in the Chesterville, Chesterville East, Bourbon, and Bourbon South pools, in T. 15 N., R. 7 and 8 E., Douglas County (Whiting, 1959). The pay zone in these pools is the Spar Mountain (Rosiclare) Sandstone of middle Mississippian (Valmeyeran) age. No attempt is made here to rework this area; however, the Spar Mountain production now has been extended north into T. 16 N., R. 8 E., where gas has been found in the Ficklin pool.

The general geologic setting, the stratigraphic sequence of beds, the structural evolution (which has resulted in the accumulation of oil), and a review of the economic results are described below.

Acknowledgments

The authors are especially indebted to C. V. Crow, of Illinois Power Company, and M. H. Richardson. The data used are in the records of the Illinois State Geological Survey. Electric logs and sample studies were the primary source of information; other sources, such as conferences with operators and staff members and scout information, were also used.

STRATIGRAPHY

The deepest stratigraphic test within the Tuscola area is the Ohio No. 1 Shaw well in the SW$\frac{1}{4}$ sec. 36, T. 16 N., R. 8 E., Douglas County, which began in the Devonian and penetrated 100 feet into the Mt. Simon Sandstone. This hole is on the Shaw Dome portion of the Tuscola Anticline. From slightly west of this drill hole, the strata dip sharply to the west and gently to the south and east. Data for the geologic column were taken from a compilation of several holes drilled in the mapped area (table 1 and Appendix).

Pleistocene Series

Pleistocene sediments in the Tuscola area range from about 40 to nearly 290 feet in thickness. They consist of unconsolidated soils, sands, gravels, and boulder clays that were deposited during glacial times. Glacial deposits of Wisconsinan, Illinoian, and Kansan age are present. An isopach map of the Pleistocene sediments (fig. 2) and a bedrock topographic map (fig. 3) are presented for a portion of the area around the Hayes pool.

The pre-Pleistocene topography in this area was marked by two major streams that drained to the northwest, flanking the Tuscola Anticline. These streams were tributaries of the Pesotum River that, in turn, flowed into the Mahomet (Teays) River (Horberg, 1950; Stephenson, 1967). Between the tributaries in the area, 100 feet and less of Pleistocene sediments over the Tuscola Anticline lie directly on Silurian and Devonian age limestones and dolomites of the Hunton Megagroup. Near the town of Murdock, the Pleistocene is thin, resting on Pennsylvanian sediments. On the outward flanks of the streams, which parallel the Tuscola Anticline, the bedrock is again close to the surface but is made up of beds of Pennsylvanian age.

Pennsylvanian System

In the southwestern corner of the area, the Pennsylvanian System is represented by about 1200 feet of sediments. The Pennsylvanian is present throughout, except over a portion of the top of the Tuscola Anticline (fig. 4).

Rocks of the Pennsylvanian System are predominantly silty or sandy shales, with local developments of sandstones and limestones. Two readily identifiable limestones, the Millersville and the Shoal Creek, are present. The number and position of the coals can be found on the composite log (Appendix). Several coals of economic value are mined. Clegg (1959, 1965a) gives a more detailed discussion of the Pennsylvanian strata on the LaSalle Anticlinal Belt.

TABLE 1 - GEOLOGIC SECTION FROM THE SOUTHWESTERN CORNER OF THE REPORT AREA

SYSTEM		SERIES	GROUP	FORMATION	THICKNESS (MIN. TO MAX.)
QUATERNARY		PLEISTOCENE			40 - 290
PENNSYLVANIAN			McLeansboro	Mattoon	0 - 300
				Bond	0 - 200
				Modesto	0 - 200
			Kewanee	Carbondale Spoon	0 - 200
			McCormick	Abbott	0 - 300
MISSISSIPPIAN		CHESTERIAN	Golconda	Beech Creek	0 - 50
				Undifferentiated Chesterian	0 - 150
		VALMEYERAN		Ste. Genevieve *Spar Mtn. Mem.*	0 - 100
				St. Louis	0 - 170
				Salem	0 - 100
				Borden *Carper pay zone*	0 - 700
		KINDERHOOKIAN		Chouteau	0 - 20
			New Albany	Hannibal	0 - 130
DEVONIAN		UPPER		Saverton Grassy Creek Sweetland Creek	
	HUNTON MEGAGROUP	MIDDLE		Lingle	0 - 65
				Grand Tower *Dutch Creek Mem.* *Tioga Bentonite Bed*	0 - 200
SILURIAN		NIAGARAN		Moccasin Springs	440
				St. Clair	140
		ALEXANDRIAN		Sexton Creek	10 - 25
ORDOVICIAN		CINCINNATIAN	Maquoketa	Brainard	70 - 90
				Ft. Atkinson	30 - 50
				Scales	80 - 90
		CHAMPLAINIAN	Galena	Kimmswick	140 - 165
				Decorah	10 - 20
			Platteville		250 - 300
			Ancell	Joachim	90 - 135
				St. Peter	150 - 175
	KNOX MEGAGROUP	CANADIAN	Prairie du Chien	Shakopee	450 - 565
				New Richmond	10 - 15
				Oneota	290 - 350
				Gunter	15 - 35
CAMBRIAN		CROIXAN		Eminence	80 - 120
				Potosi	280 - 310
				Franconia	250 - 425
	POTSDAM MEGAGROUP			Ironton- Galesville	90 - 100
				Eau Claire	490 - 720
				Mt. Simon	300+
PRECAMBRIAN					

Mississippian System

Chesterian

Chesterian beds range in thickness from 0 to 200 feet. The variation in thickness is due to an erosional unconformity with the overlying Pennsylvanian strata and to a feathering out of the Chesterian formations at the northern edge of the Fairfield Basin.

The youngest Chesterian beds represented in the area are those of the Golconda Group. The basal limestone formation, the Beech Creek (Barlow), is identifiable in the subsurface in the southwestern part of the area. Northward it becomes less easily identified on the electric logs, until it disappears at about the northern edge of T. 16 N., R. 8 E.

No attempt has been made here to identify the separate formations of the lower Chesterian in this area because they all thin and become increasingly shaly in this extreme northern end of the Fairfield Basin.

Valmeyeran

Three members of the Ste. Genevieve Limestone are recognizable in sample study. They are from top to bottom the Karnak, Spar Mountain, and Fredonia. The Ste. Genevieve Formation is less than 100 feet thick; its pre-Pennsylvanian subcrop extends as a narrow belt from northwest to southeast in the southwestern corner of the area (fig. 4).

The Karnak is a dense, rather pure limestone. When it is under the Chesterian, its top is easily recognized as the first massive limestone kick on the eletric log. The Spar Mountain is extremely variable in its lithology, which ranges from dolomite through limestone, sandy limestone, and shale. This oil-productive zone is found 20 to 50 feet beneath the top of the Karnak. The Fredonia is a dense limestone, containing layers of gray to brownish gray dolomites. In this area, there appears to be little oolitic limestone; therefore, no McClosky production has been found. The contact with the underlying St. Louis Formation is difficult to identify.

The St. Louis Formation is light brownish gray dense limestone; it may contain blue-gray chert interbedded with light brownish, finely crystalline dolomite or dolomitic lime and anhydrite. Anhydrite is considered a good criterion for identification of the St. Louis, but chert is more commonly used. The thickness of the St. Louis, as determined from sample studies, ranges from 0 to 170 feet in the area.

The Salem Limestone is a gray-tan to brown crystalline pelletized limestone composed primarily of a fossil hash. It is generally identified by the presence of the foraminifera *Endothyra* in large numbers. The thickness of the Salem here ranges from 0 to 100 feet.

The Borden "Osage" Siltstone is a sequence of dolomitic gray siltstone, cherty dolomite, and shale about 650 to 700 feet thick. Fine-grained sandstone, known as the Carper, up to 50 feet thick, is locally present in the lower third of the formation. This sandstone has been productive in some of the surrounding areas.

Kinderhookian Series

The Kinderhookian Series is represented at the top by 5 to 20 feet of light gray, finely crystalline dolomitic limestone of the Chouteau Formation. Underlying the Chouteau is about 130 feet of black or brownish, pyritic, spore-bearing shale

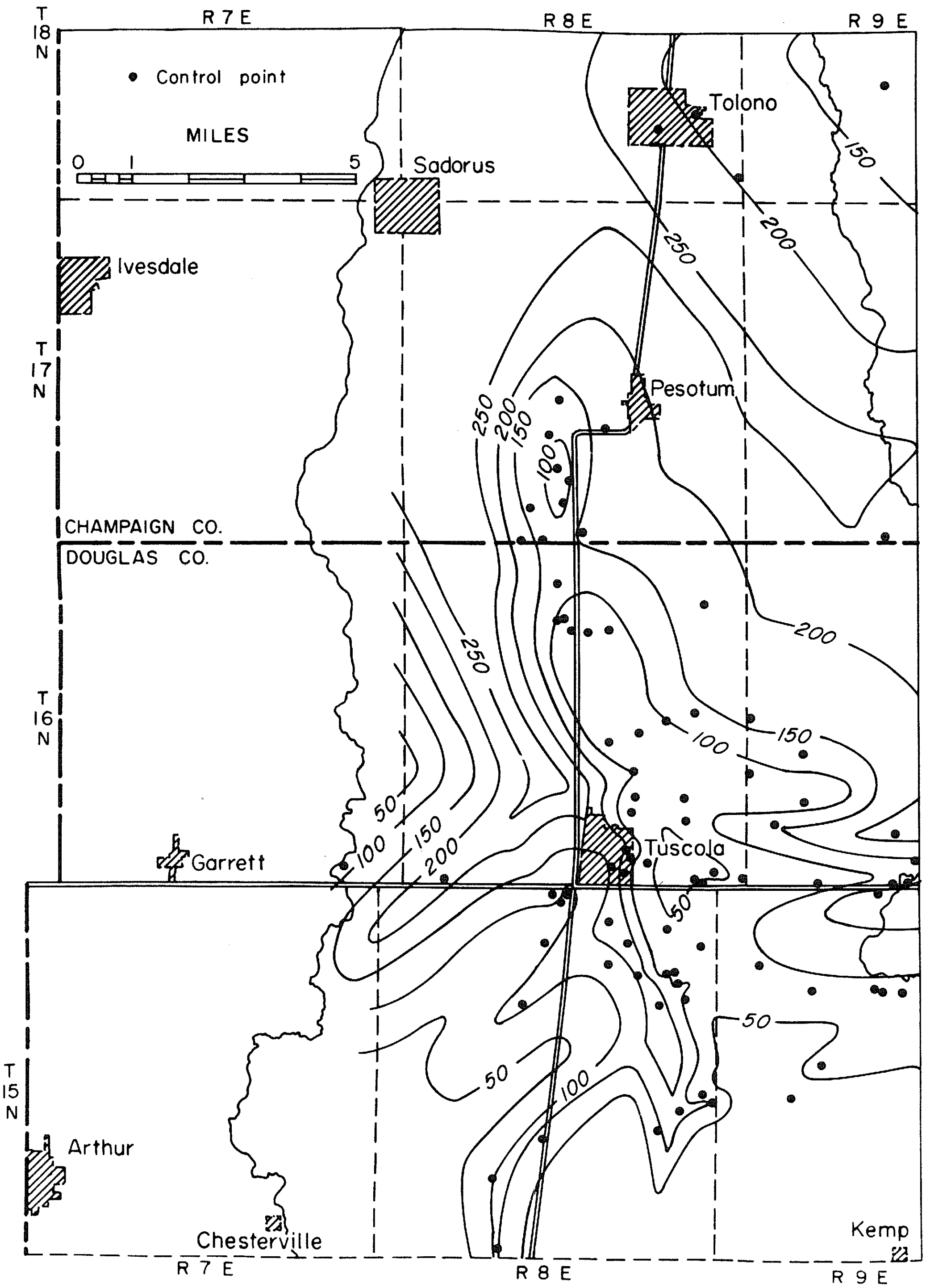
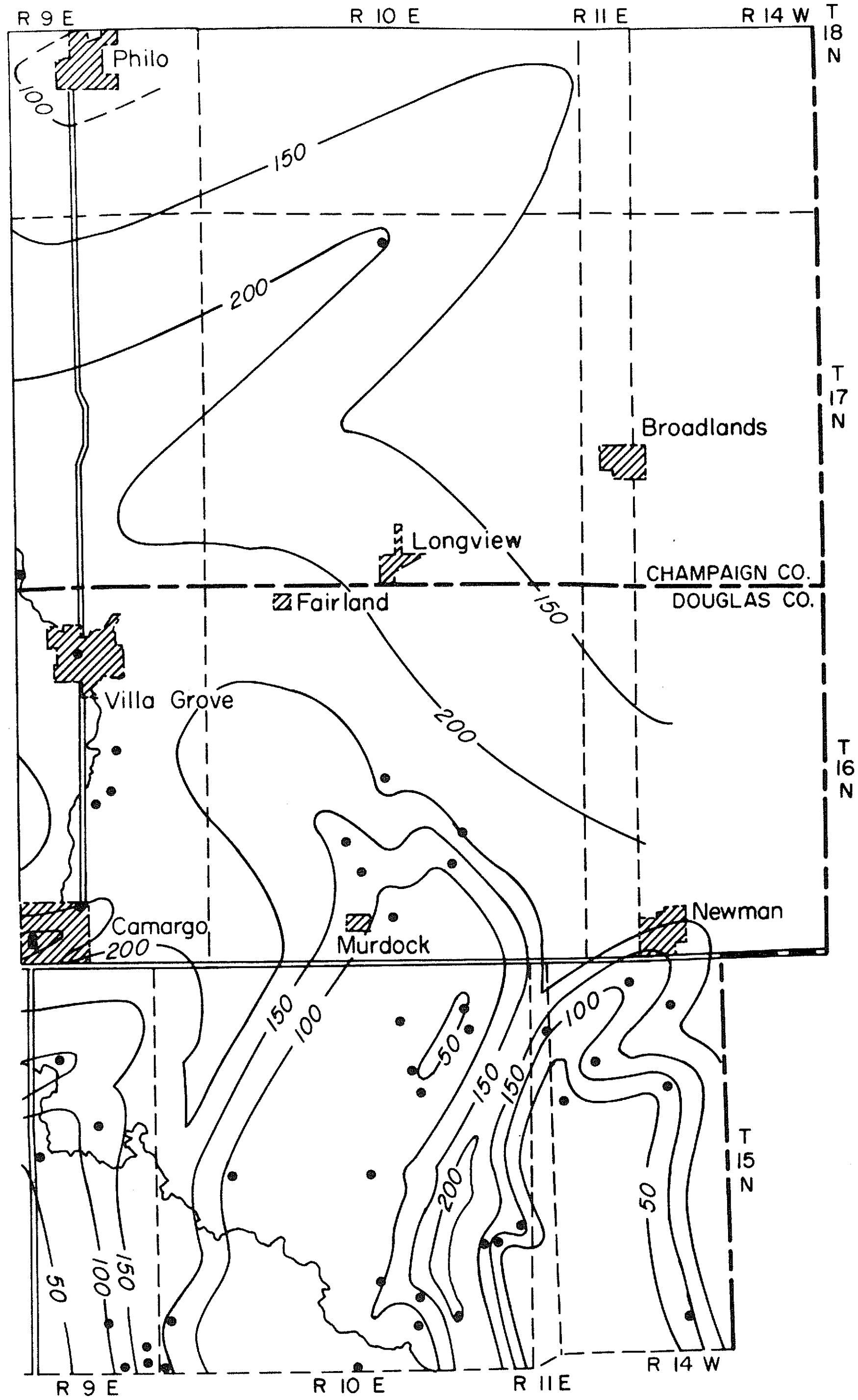


Figure 2 - Pleistocene isopach;



thickness above bedrock.

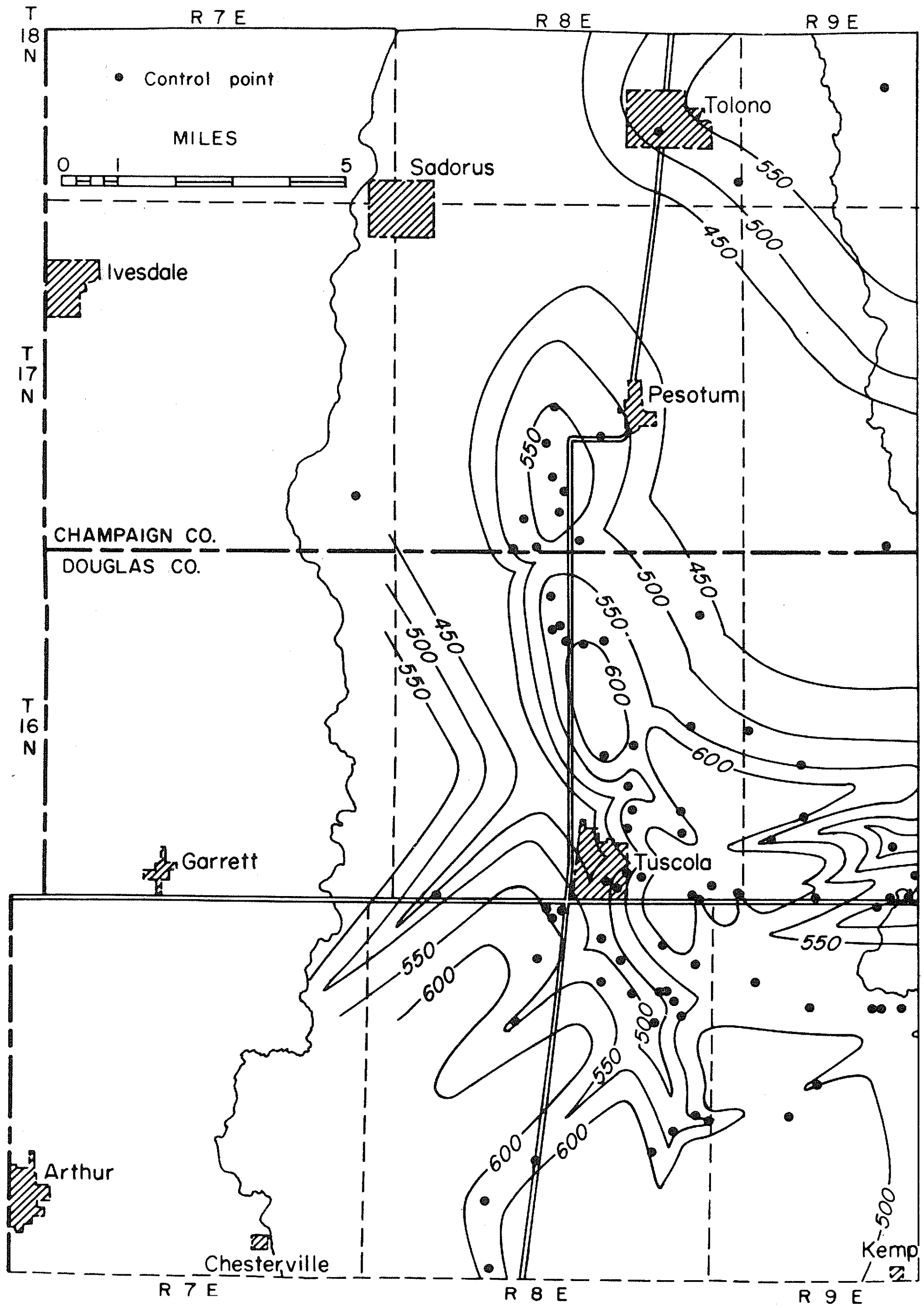
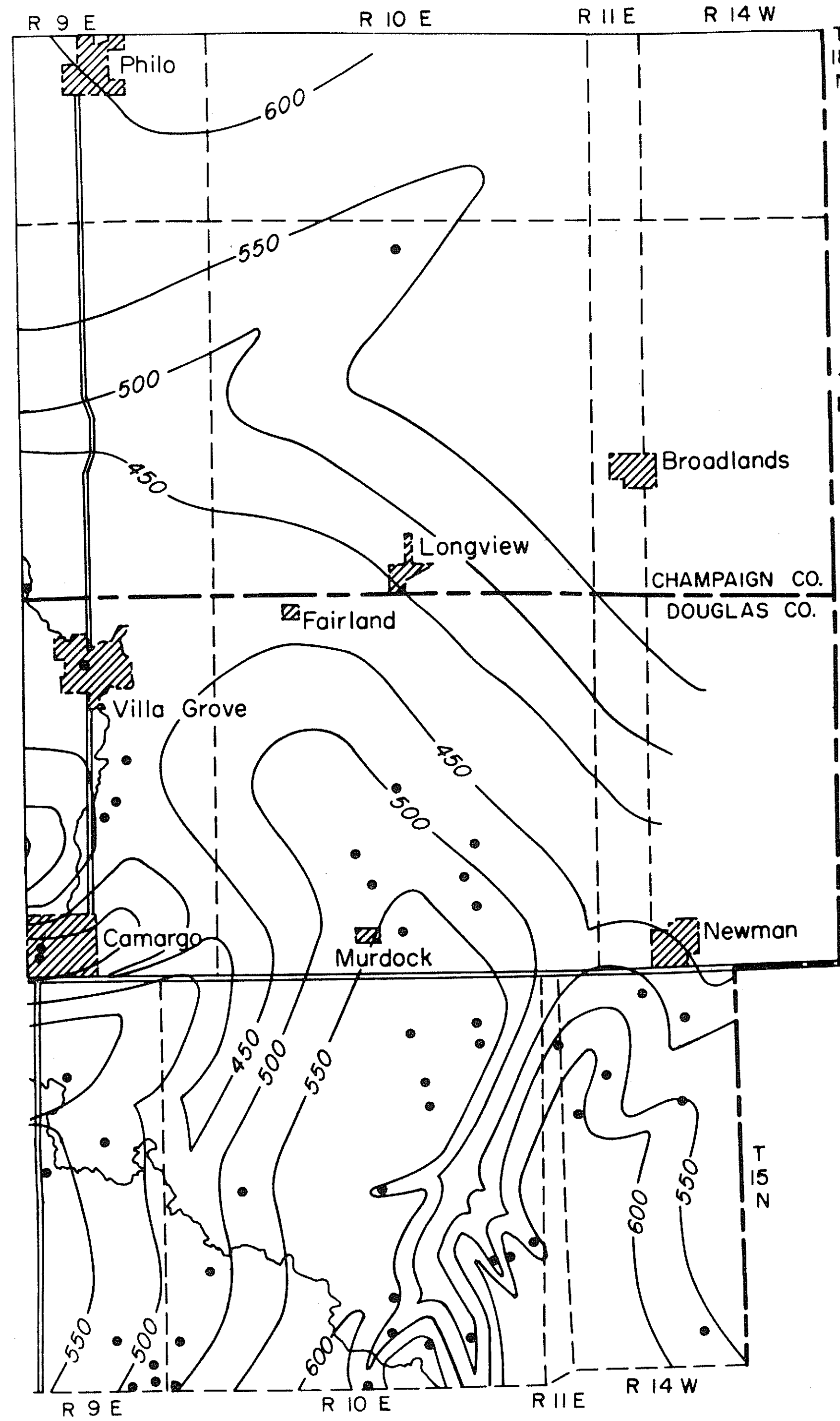


Figure 3 - Bedrock topography. Note the influence of the Tuscola Anticline



on the Pleistocene isopach and bedrock topography in figure 2.

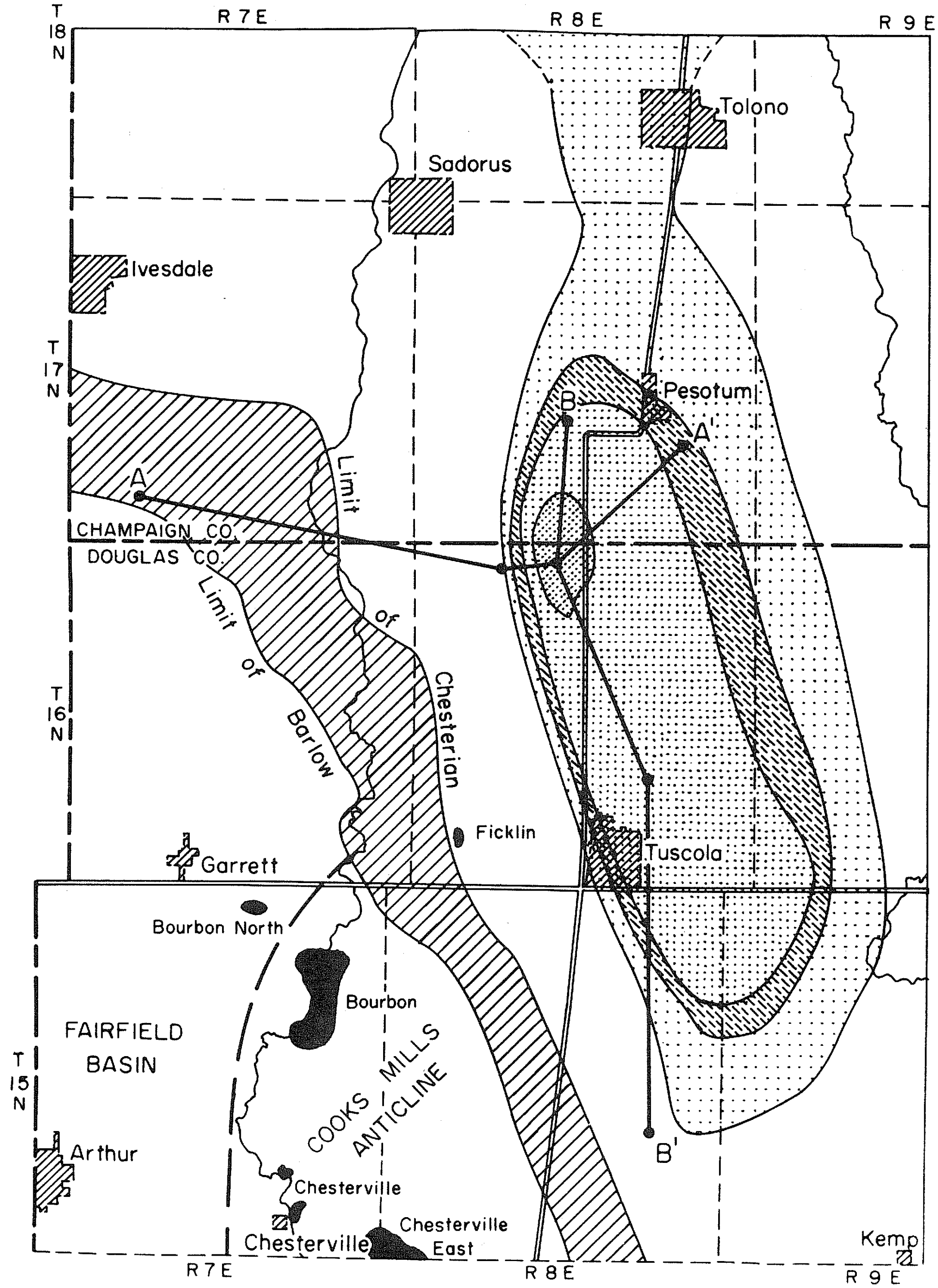
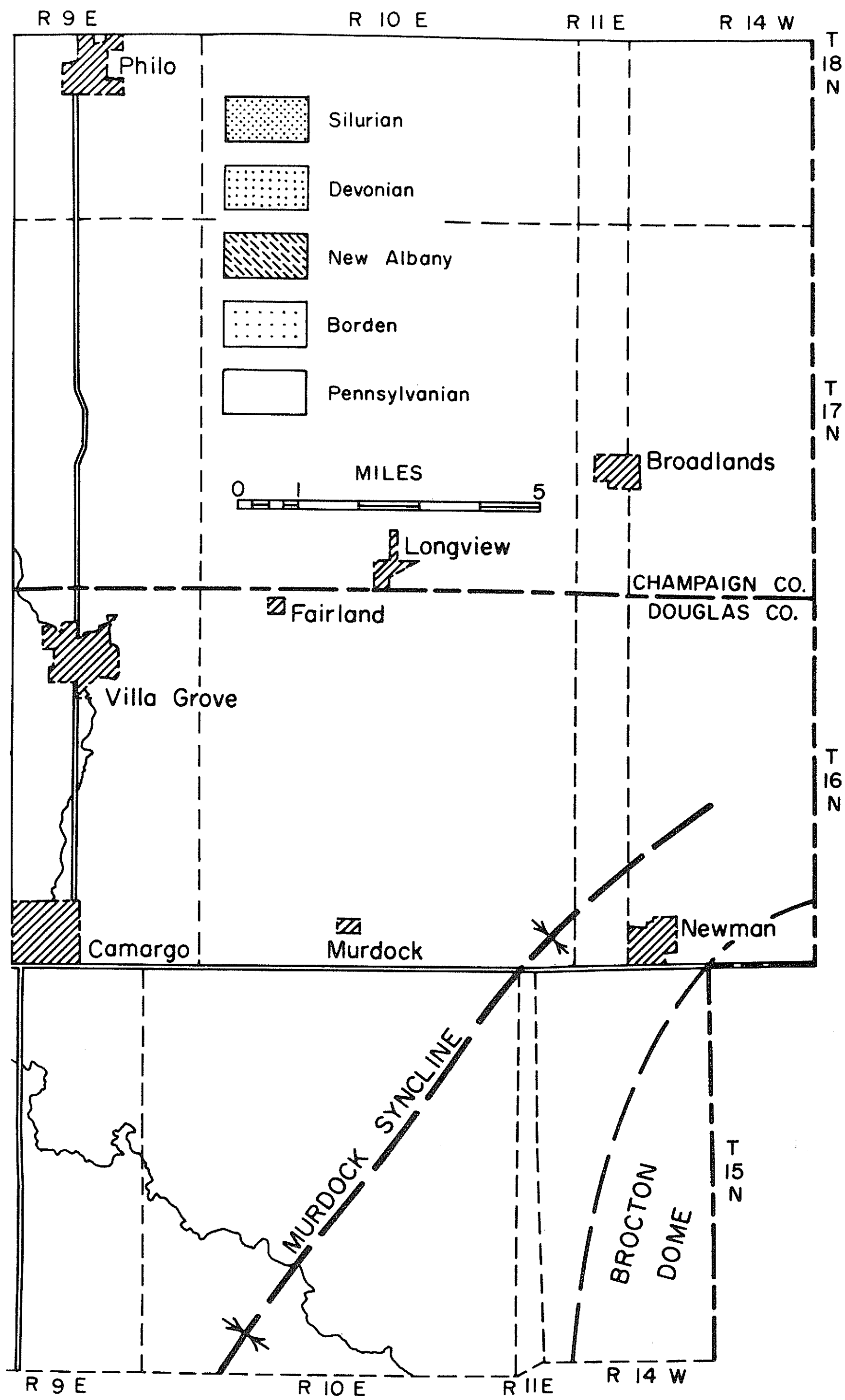


Figure 4 - Pre-Pleistocene geologic map. Northeastward extension of Chesterian and



Barlow rocks also illustrated. For lines A-A' and B-B' see figures 8 and 9.

assigned to the New Albany Group. The upper few feet of the New Albany is the Mississippian Hannibal Shale, and the rest is Devonian in age.

Devonian System

The Devonian System is represented by three units. The uppermost is the Devonian portion of the black New Albany Shale discussed above, underlain by the Lingle and Grand Tower Limestones. These last two formations, along with the underlying Silurian, make up the Hunton Limestone Megagroup, a rather easily recognizable, mappable unit.

In the Ohio No. 1 Williams well, sec. 13, T. 16 N., R. 8 E., Douglas County, the samples show approximately 60 feet of Lingle Formation. The top 20 feet is a gray-brown slightly sandy and cherty dolomite. This is underlain by 40 feet of dolomitic limestone, buff-gray to gray, cherty, and finely crystalline. In the Ohio No. 1 Shaw well, sec. 36, T. 16 N., R. 8 E., Douglas County, the Lingle is represented by only 10 feet of limestone, which is buff, crystalline, and fossiliferous. At Tuscola, in sec. 34, T. 16 N., R. 8 E., the Lingle is represented by 63 feet of limestone, similar to that in the Williams well. On the very top of the Hayes pool, the Lingle Formation has been completely eroded away.

The Grand Tower Formation, underlying the Lingle, is a dolomite, often sandy and slightly cherty, fine to very finely crystalline, and generally porous. In the Tuscola area, it is approximately 110 feet thick. In the Bourbon area to the west, in T. 15 N., R. 7 E., the Grand Tower is about 50 feet thick. In the Murdock Syncline, it is at least 125 feet thick.

The Dutch Creek Member of the Grand Tower Formation is a zone of sandy layers whose grains are white to clear, medium, subrounded, and incoherent. The zone, where present, varies from 5 to 20 feet in thickness. Below this sand is a dolomite zone 20 to 30 feet thick that is light gray-buff to brown and cherty, with interbedded sand grains. On the basis of information available at present, we cannot determine if it is Silurian, Lower Devonian (Bailey or Clear Creek), or Grand Tower; we have placed it in the Grand Tower.

The resistivity curve often exhibits a great reduction in going from the Devonian to the Silurian. However, the actual contact between the Devonian and the Silurian is not always at the point where the resistivity begins to decrease, but may be slightly above this point. In the Hayes pool proper, the Silurian-Devonian contact cannot be picked from the Laterolog, which is the log that was most commonly run there, since this log shows no break at this contact.

The Tioga Bentonite, a bed of volcanic ash near the top of the Grand Tower, is recognized in only two wells (fig. 5). In the E. V. Richardson No. 1 Cole, sec. 23, T. 15 N., R. 8 E., the Tioga "blip" is found on the electric log at a depth of 340 to 342 feet; the Devonian section is 186 feet thick with the bentonite 76 feet from the top. The other well in which the Tioga Bentonite is present is the Illinois Power No. 1 Koss, sec. 21, T. 17 N., R. 8 E. For discussion of the Tioga Bentonite see Meents and Swann, 1965.

Silurian System

The Silurian rocks of the area belong to two series: the upper is the Niagaran and the lower is the Alexandrian. The Niagaran includes all but about 20 feet of the Silurian.

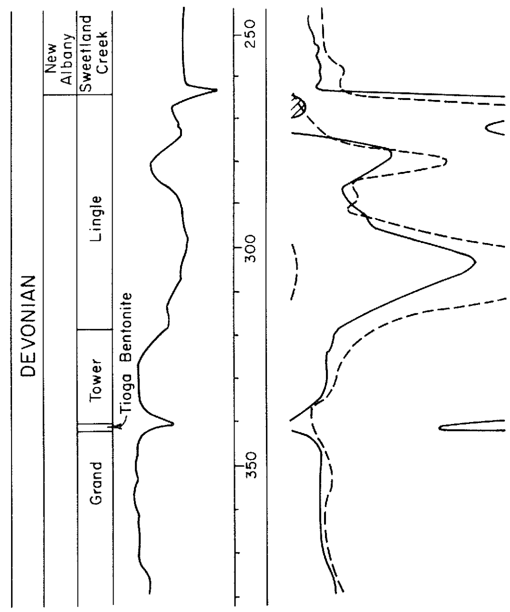


Figure 5 - Section of log showing Tioga Bentonite.

The Niagaran rocks are divided into two formations. The Moccasin Springs is the formation in which reefs may be expected in this area. Its thickness is about 440 feet. It is dolomite, light gray to nearly white, or slightly buff and granular to finely crystalline. Chert is not common but may be found in layers throughout; it is usually milky to clear white. Floating sand grains may also be found throughout. Increased resistivity reading on the electric log may be observed; this could be due to an increase in the lime or sand content.

The lower Niagaran formation, the St. Clair, is about 140 feet thick. It is a dolomitic limestone, slightly argillaceous, fine to crystalline in texture, and green-gray in color with pink to red and green spots. The spots are its distinguishing characteristic. The St. Clair can also be detected on the electric log by the increase in resistivity in going from the Moccasin Springs to the St. Clair. The exact contact is best obtained by sample examination above and below the electric log contact, as it is not easily discernible on the Laterolog.

The Alexandrian Series is represented by the Sexton Creek Formation. The Sexton Creek is a slightly argillaceous, glauconitic limestone, brown-gray in color, dense to crystalline in texture. No red or pink was noted in the samples that were studied. On the electric log it can be picked by a decrease in porosity and an increase in resistivity in approximately the bottom 20 feet of the Hunton.

Ordovician System

Maquoketa Group

The Maquoketa Group is rather easily divided into three formations: the uppermost, the Brainard Shale, the middle, the Ft. Atkinson Limestone, and the base, the Scales Shale. The total thickness of the three units is approximately 180 to 230 feet.

The Brainard Shale is dark gray and slightly carbonaceous to carbonaceous. It is generally 70 to 90 feet thick. It is easily distinguished from the overlying Silurian and the underlying Ft. Atkinson Limestone on the electric log.

The Ft. Atkinson Limestone is gray, sublithographic to crystalline, slightly dolomitic in part, and generally fossiliferous in its crystalline portions. It is 30 to 50 feet thick in the area.

The Scales Shale is much like the Brainard Shale. It is dark gray to slightly brown, calcareous in part, with an occasional argillaceous dark brown dolomitic streak; it is about 80 to 95 feet thick. The contact with the Kimmswick below is easily distinguished on electric logs; the contact with the Ft. Atkinson Limestone above may be slightly more difficult to pick, as the contact is more gradational.

Galena Group

The Kimmswick (Trenton) Limestone is tan to light gray-brown to nearly white; it is calcarenitic to cryptocrystalline, with numerous brown to white calcite crystals throughout. It has a few calcite-filled hairline fractures occurring at irregular angles and is slightly fossiliferous and stylolitic, with the shale content being confined to thin, black partings. Many of the stylolitic partings are filled with kerogenlike material. Locally, dolomite rhombs can be found in small voids or spots. Core analysis shows porosity ranging from 2 to 12 percent and permeabilities ranging from 0.1 to 0.5 millidarcys in the top 100 feet. This is the oil bearing zone of the Hayes pool on the Tuscola Anticline. The thickness of the Kimmswick in this area is 140 to 165 feet. The Kimmswick is not subdivided here.

A thin unit, the Decorah Limestone, occurs at the base of the Galena Group. This limestone appears more argillaceous, is darker, and fossils may be more common than in the lower Kimmswick beds or the upper Platteville beds. Thickness is generally 10 to 20 feet. The self-potential curve lies farther right than that of the Kimmswick and the Platteville.

Platteville Group

Lying conformably beneath the Decorah is the Platteville Limestone Group with a total thickness of 250 to 300 feet. Three units are recognized in sample studies and electric logs. The upper unit, of about 100 feet thickness, is a gray to light brown limestone, often sublithographic to micritic in texture. The limestone contains stylolites and some dolomitic replacement areas. White nonvitreous chert nodules are scattered sparsely throughout.

Below this unit is a second unit, a dolomitic limestone, darker gray to brown, finely crystalline to micritic. This unit is also about 100 feet thick.

The lowest unit of the three is a dolomitic limestone bed, dense, gray to brown, with stylolites and a few nonvitreous chert nodules. Silty dolomitic layers may occur. As a unit, this is slightly more dolomitic than the other two. Perhaps this corresponds to the Pecatonica of northern Illinois.

Ancell Group

The Joachim Dolomite of the Ancell Group is slightly silty to argillaceous. It is buff to gray-brown, finely crystalline to micritic, and may contain scattered fine sandy streaks. It is 125 to 155 feet thick in the area (table 2). The top may be identified by a constriction in the self-potential and resistivity curves. The contact between the Joachim and the St. Peter Sandstone is not easy to pick on the electric logs, but in samples or cores it can be easily identified by the change from dolomite to sand. The change between the Joachim and the St. Peter is more noticeable on the conductivity curve than on the resistivity curve.

St. Peter Sandstone.—Beneath the thick series of "Trenton" carbonates—Kimmswick, Decorah, and Platteville—lies the first good porous sandstone, the St. Peter, which is 150 to 175 feet thick. It is a dolomitic sandstone in roughly its upper third and a rather clean sandstone in its remaining two-thirds. The sand

TABLE 2 – THICKNESS OF KIMMSWICK AND OLDER FORMATIONS (IN FEET)

Formation	Well, location: Sanders No. 1 Harrison 22-15N-5E	Total	Ill. Power No. 1 DeBolt 4-16N-8E	Total	Ohio No. 1 Shaw 36-16N-8E	Total	Cabot Corp. No. 1 Cabot 31-16N-8E	Total
Kimmswick	142		151		153		157	
Decorah	15		14		18		10	
Platteville	251	717	293	741	297	748	277	755
Joachim	133		133		128		151	
St. Peter	176		150		152		160	
Shakopee	458				565			
New Richmond	10				11			
Oneota	292				349			
Gunter	28				15			
Eminence	118	2098			60	2350		
Potosi	282				305			
Franconia	313				255			
Ironton–Galesville	100				95			
Eau Claire	497				695			
Mt. Simon	230+				100+			

is fine- to medium-grained, slightly frosted to clear, and white to slightly buff in color. Pyrite may be dispersed throughout, as well as thin light-colored shale partings. Horizontal permeabilities range from 0.1 to 900 millidarcys, with an average, from one core of 150 feet, of 163 millidarcys. In the same core, the average porosity was 17.3 percent, ranging from 4 to 25 percent. The contact with the Shakopee Formation below is usually quite pronounced and clear-cut. The Shakopee causes a sharp increase in resistivity readings.

Prairie du Chien

Shakopee Dolomite.—The lithology of the Knox Megagroup and the Potsdam Megagroup, or from the top of the Shakopee to the Precambrian, is not well known in this area, as only five wells penetrated this section.

The Shakopee is light gray to tan-gray, finely crystalline dolomite, 450 to 565 feet thick. Small amounts of white to nearly clear chert, occasionally oolitic, are found throughout. Sandy dolomites with fine- to medium fine-grained sand occur near the base of the formation. Near the base, the dolomite gradually darkens. A constriction of the resistivity and self-potential curves, probably caused by a shaly zone, marks the contact with the New Richmond-Oneota.

New Richmond Formation.—In the wells that penetrate it, the New Richmond is represented by a more sandy dolomite than the formations above or below; a small shaly zone is present at the base. The formation is from 10 to 15 feet thick.

Oneota Dolomite.—Beneath the New Richmond Formation lies the Oneota Dolomite, light gray to tan-gray to slightly pinkish gray in color, finely crystalline to crystalline in structure, and often quite cherty. The chert is often oolitic. The Oneota is difficult to distinguish from the Shakopee. Electrically, it has slightly higher resistivity, and slightly higher (more negative) self-potential than the Shakopee. The formation is about 290 to 350 feet thick.

Gunter Sandstone.—In this area, the Gunter is a light gray dolomitic sandstone, slightly glauconitic, with some oolitic chert. On the electric log it is difficult to distinguish from the Oneota above, but it has slightly higher (more negative) self-potential and lower resistivity than the underlying Eminence. It is from 15 to 35 feet thick in the area.

Cambrian System

Croixan Series

Eminence Dolomite.—The Eminence, at the top of the Croixan Series (Cambrian System), is white to light gray dolomite, fine to medium crystalline in texture, and 80 to 120 feet thick. It may contain layers of sandy dolomite and small oolitic vuggy chert bands. Electrically, it can be separated from the overlying Ordovician by a still greater increase in resistivity and a slight decrease in self-potential. On the Laterolog, it cannot be distinguished from the Potosi below.

Potosi Dolomite.—The Potosi is a gray to brown dolomite, with zones of drusy quartz common throughout. Near the base, traces of glauconite may occur. Vugs are found in the cores. The formation is 280 to 310 feet thick. The electric log indicates a rather uniform, resistant bed with an occasional small "soft" notch.

Franconia Dolomite.—Fine-grained brown to tan dolomites, with traces of glauconite, make up the 320 to 425 feet of the Franconia Formation. This formation is quite uniform in its upper two-thirds, but in the bottom third it becomes a silty oolitic dolomite with glauconite pebbles and is slightly pinkish to light brown. This portion, possibly equivalent to the Davis of Missouri, shows a gradual reduction of resistivity and self-potential on the electric log.

Ironton-Galesville Sandstone.—Beneath the Franconia Dolomite lies a dolomitic sandstone approximately 100 feet thick, herein called Ironton-Galesville. It may be either the Ironton or the Galesville or both. In the Ohio No. 1 Shaw well, two sands are separated by a dolomite. In the electric log of the Sanders No. 1 Harrison well, sec. 23, T. 15 N., R. 5 E. (Appendix), the lower half of this 100-foot interval is characterized by a break inward of the self-potential curve.

Eau Claire Formation.—The Eau Claire Formation is from 490 to 720 feet thick. In this area, it can be broken into three units. The upper 150 feet is a brown to white, very oolitic, dolomitic limestone, which leaves a silty residue after being dissolved in acid. This unit is more resistant, electrically, than the Franconia. The middle and lower units are siltstones that are glauconitic, slightly micaceous, slightly oolitic, and red to pink and green in color. The middle unit, about 150 feet thick, is broken lithologically and electrically.

At the base of the Eau Claire is a rather uniform unit about 160 feet thick, extending from 6130 to 6290 feet in the Sanders well. This unit is a shaly siltstone. The siltstone is glauconitic, red and green in color, and micaceous, possibly with thin dolomite layers.

Mt. Simon Sandstone.—The lowest Cambrian sandstone, the Mt. Simon, has been penetrated by two wells, neither of which went completely through it. The Sanders No. 1 Harrison well went 235 feet into it and the Ohio No. 1 Shaw went 100 feet. The thickness has been estimated to be about 1600 feet. The Mt. Simon is a quartzitic sandstone, fine- to coarse-grained in texture, porous, and coherent to noncoherent. The sand grains are generally angular and clear, often with a red-brown staining.

Precambrian System

The Precambrian System has not been reached by any well in this area. For classification and discussion of the Cambrian and Ordovician Systems in Illinois see Buschbach, 1964.

STRUCTURE

The structural framework of the Tuscola area is closely related to that of the LaSalle Anticlinal Belt and the Fairfield Basin.

In the map area, the Pennsylvanian and older strata dip steeply to the west from the crest of the Tuscola Anticline into the Fairfield Basin; on the eastern flank of the anticline, the strata dip gently to the east into the Murdock Syncline (fig. 6). Two other structures may be noted: the northern end of the Cooks Mills Anticline in the southwestern corner of the map, and the northwestern flank of the Brocton Dome in the southeastern corner.

The dominant feature, the Tuscola Anticline, has an inlier of Mississippian, Devonian, and Silurian strata (fig. 4). The anticline is broken into two structural highs, the Hayes Dome and the Shaw Dome, with a saddle between the two (fig. 7). The separation or saddle between the Hayes Dome portion and the Shaw Dome portion is in the common corner of secs. 22, 23, 26, and 27, T. 16 N., R. 8 E.

The Murdock Syncline in the area of this report is confined to the eastern flank of the Tuscola Anticline on the west and the western flank of the Brocton Dome on the east. The syncline is open and extends southward between the Brocton Dome and the Tuscola Anticline to the neighborhood of Charleston.

The Cooks Mills Anticline is terminated to the northeast by the western flank of the LaSalle Anticlinal Belt.

On figure 4, the truncated edge of the Chesterian, beneath the Pennsylvanian, is shown by a dashed line. The truncation on top of the Tuscola Anticline is illustrated by two cross sections from west to east and from south to north (figs. 8, 9).

Weller (1906) extended the LaSalle Anticline south to Tuscola on the basis of information from wells drilled nearby. In 1906, Blatchley published Weller's map

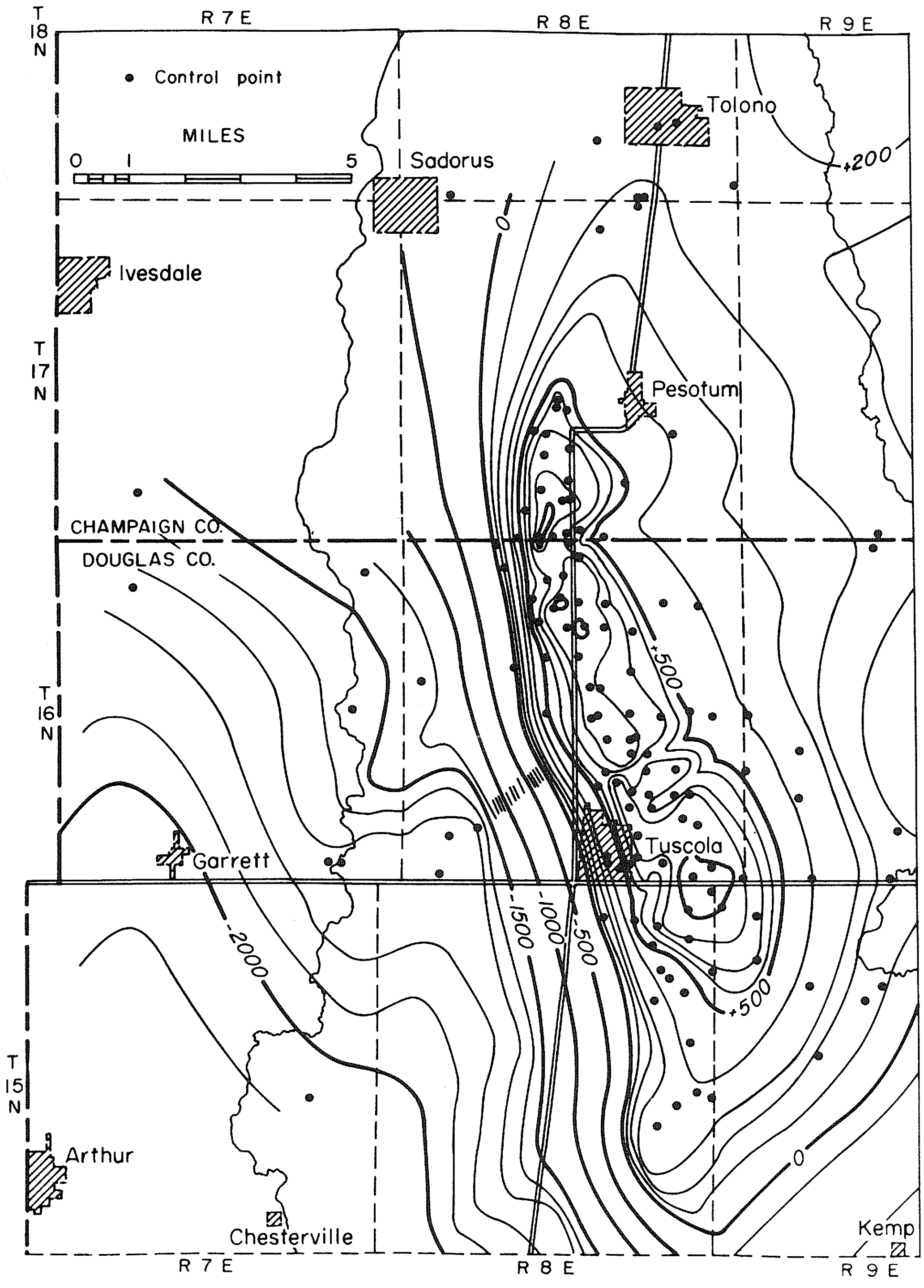
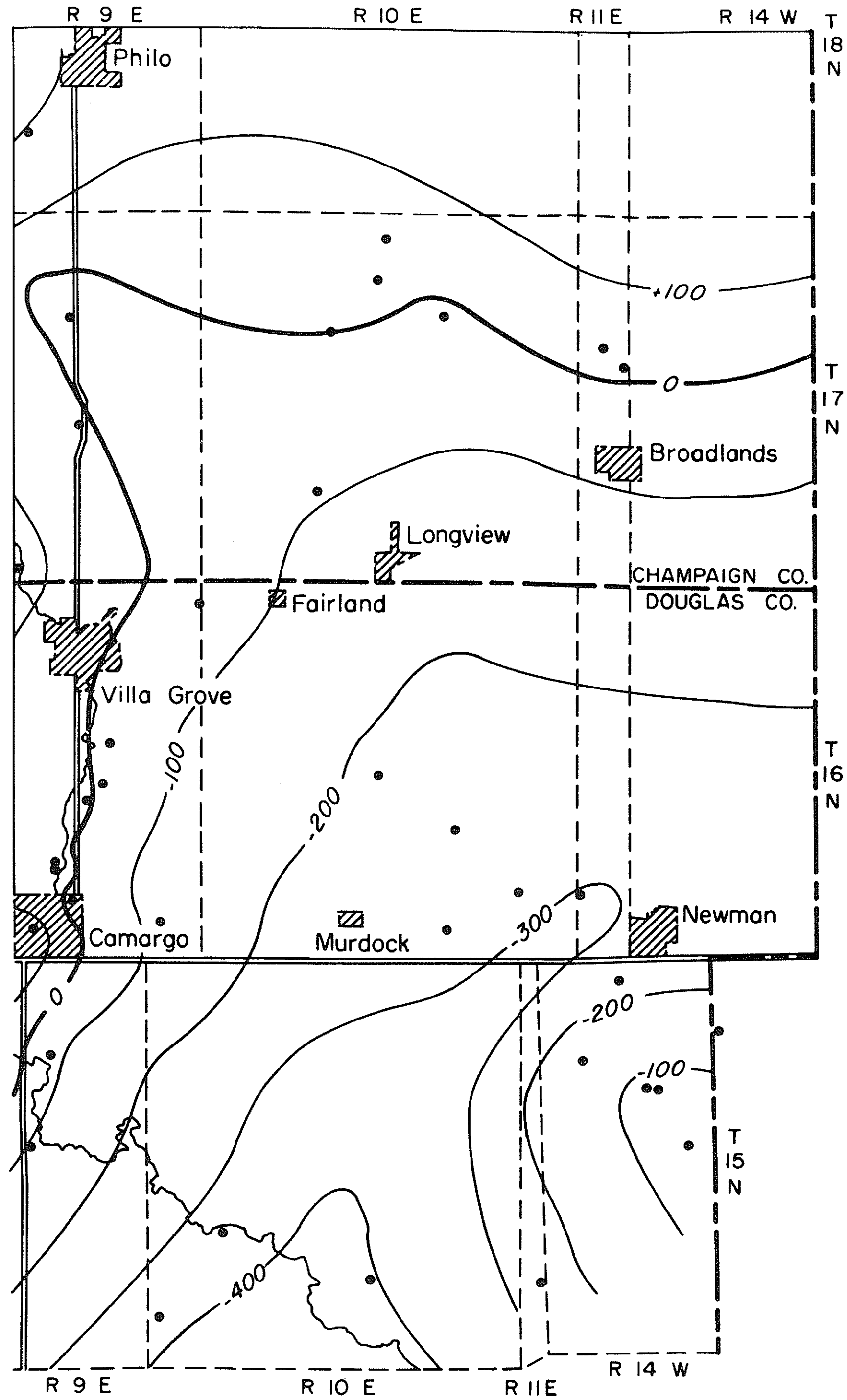


Figure 6 - Geologic structure of the Hunton Limestone Megagroup. 100-foot interval is used above 500



contour interval used below 500 feet above sea level; a 25-foot contour feet above sea level.

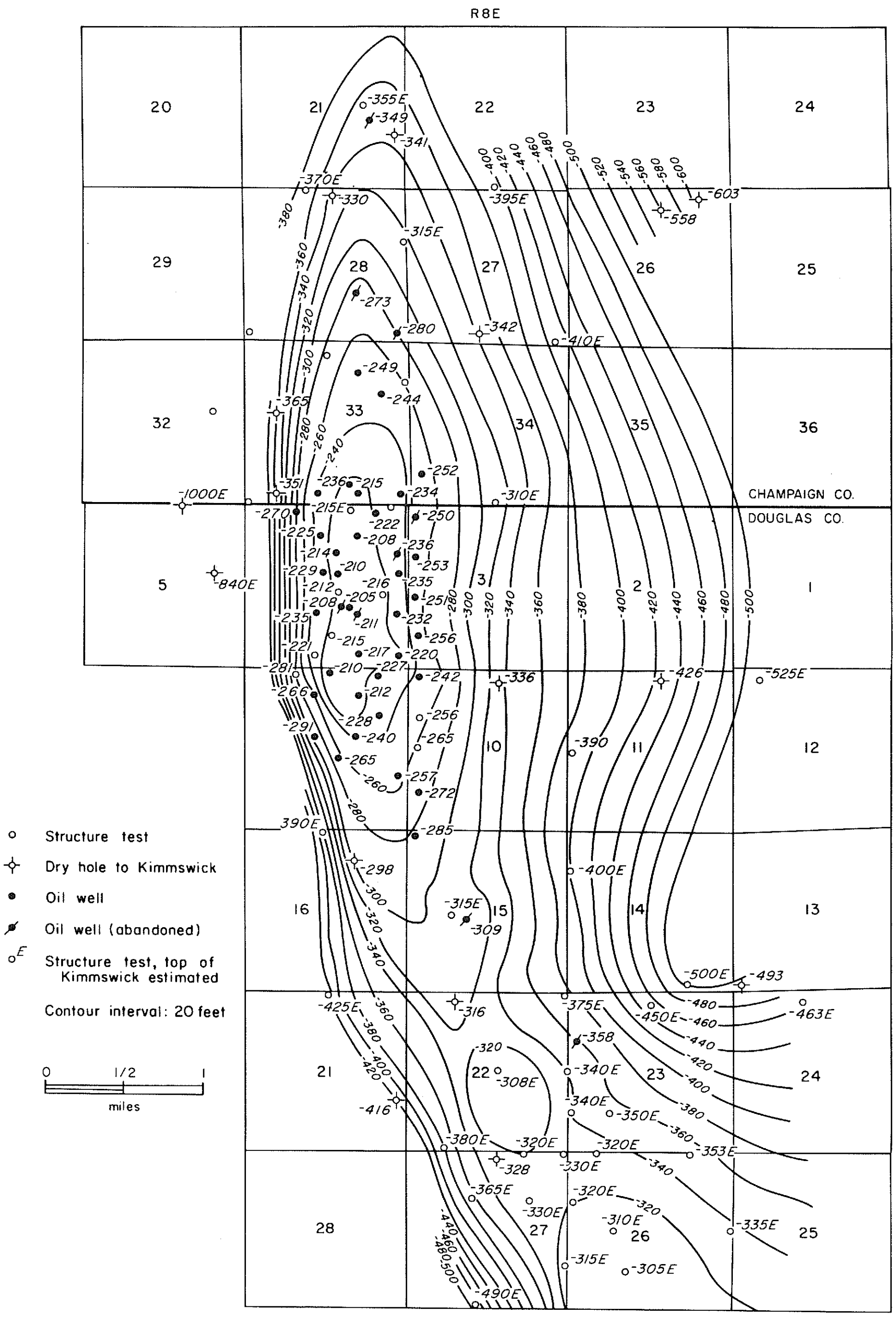


Figure 7 - Northern part of Tuscola Anticline (Hayes pool); structure on top of Kimmswick.

extending the LaSalle Anticline south into the Crawford County area. Cady (1920) summarized all the previous work, and firmly established the complex nature of this structure. It has since become known as the LaSalle Anticlinal Belt.

Clegg (1965b) applied the name Tuscola Anticline to that structural part of the LaSalle Anticlinal Belt extending from slightly north of the Champaign-Douglas County line southeastward to near Charleston. Previously, this was often referred to as the Tuscola Dome.

Another structural feature, the Murdock Syncline, lying between the Tuscola Anticline to the west and the Brocton Dome to the east, was first mentioned by Cady (1952). In 1965, Clegg (1965b) briefly described the Murdock Syncline.

HISTORY OF STRUCTURE AND SEDIMENTATION

During Cambrian, Ordovician, Silurian, and Devonian times, the Tuscola area was a part of a great shallow basin. Cambrian sandstones and dolomites were deposited throughout the area in rather uniform, probably cyclic, layers. Little shale occurs, although the Eau Claire Formation does have some thin shale layers. The Lower and Middle Ordovician sediments were similar to the Cambrian, with the exception that there were fewer sandstones. The axis of the basin in pre-St. Peter time must have lain to the east, as the sediments thicken slightly in that direction. On top of the carbonate and sand section, 4000 to 5000 feet thick, the Maquoketa Shale was deposited during the Upper Ordovician time. After the Ordovician, the seas again began to deposit calcareous beds of Silurian and Devonian age. As much as 500 feet of Silurian limestone and dolomite was deposited. The Silurian was overlain unconformably by dolomite and limestone of the Middle Devonian, which are sandy in part and nowhere exceed 200 feet. On top of this carbonate sequence was deposited the organic-rich New Albany Shale.

After Middle Devonian time, the strata were deposited on a relatively flat surface lying very close to sea level. During St. Louis time, this shallow basin became somewhat restricted and evaporites were deposited. It was not until the end of St. Louis or mid-Ste. Genevievian time that a change in sedimentation became apparent in the area, for during Ste. Genevievian and Chesterian times, the area shows the deposition of more clastic type sediments such as shales and thin sandstone and limestone stringers. The area at this time must have been shallow, low lying, and near the mouths of the major streams that were pouring their fine-grained clastic sediments into the Fairfield Basin. Few well developed sands are found in the Chesterian sediments, and no differentiating traces are left of beds younger than Golconda time. Certainly by the end of Chesterian time this area was subjected to a long period of erosion. It was during the period of uplift, throughout Pennsylvanian time and later, that the LaSalle Anticlinal Belt was formed.

The Tuscola area, lying on this major warping, was greatly affected by the event. Although the strata originally dipped gently southward, they now dip steeply west on the western flank of the Tuscola Anticline and gently southwestward on the eastern flank. The over-all movement during this uplift was at least 2500 feet. The removal of 1100 feet of Pennsylvanian sediments and 1200 feet of Mississippian sediments, plus 200 feet of Devonian sediments, accounts for this 2500 feet.

Probably at no time during this uplift were the highlands exposed to erosion at any elevation such as 2500 feet; they were more likely from 100 to 500 feet high.

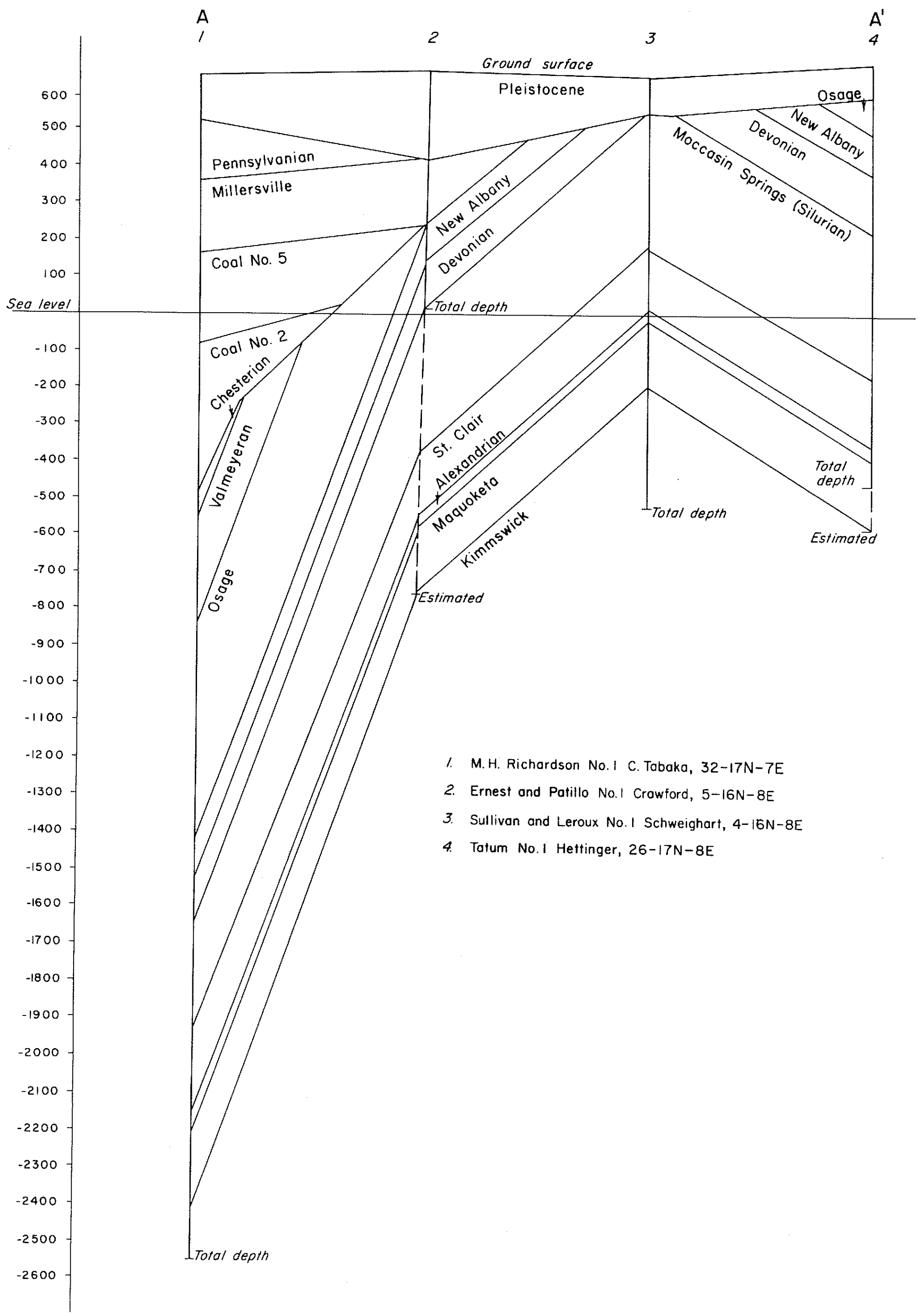


Figure 8 - West to east cross section of Tuscola Anticline (see fig. 4 A-A').

This thought is suggested by the very regular (even) western flank of the Hayes pool and the fact that no deep or steep valleys, which would tend to indicate high headlands, are to be found on the structure.

While the corresponding Fairfield Basin was being downwarped with the rising of the LaSalle Anticlinal Belt, Pennsylvanian sediments were being poured in to fill up the basins. Thus, by the end of Pennsylvanian time, both the Fairfield Basin and the Murdock Syncline were filled with Pennsylvanian sediments.

It is quite probable that the uplift continued after Pennsylvanian time because Pennsylvanian sediments of the Kewanee and McLeansboro Groups are found on both flanks of the Tuscola Anticline, tilted upward with the Tuscola Anticline. Nowhere in the area are rocks of early Abbott or Caseyville (early Pennsylvanian) to be found, indicating the absence of a sedimentary basin during the early part of the Pennsylvanian.

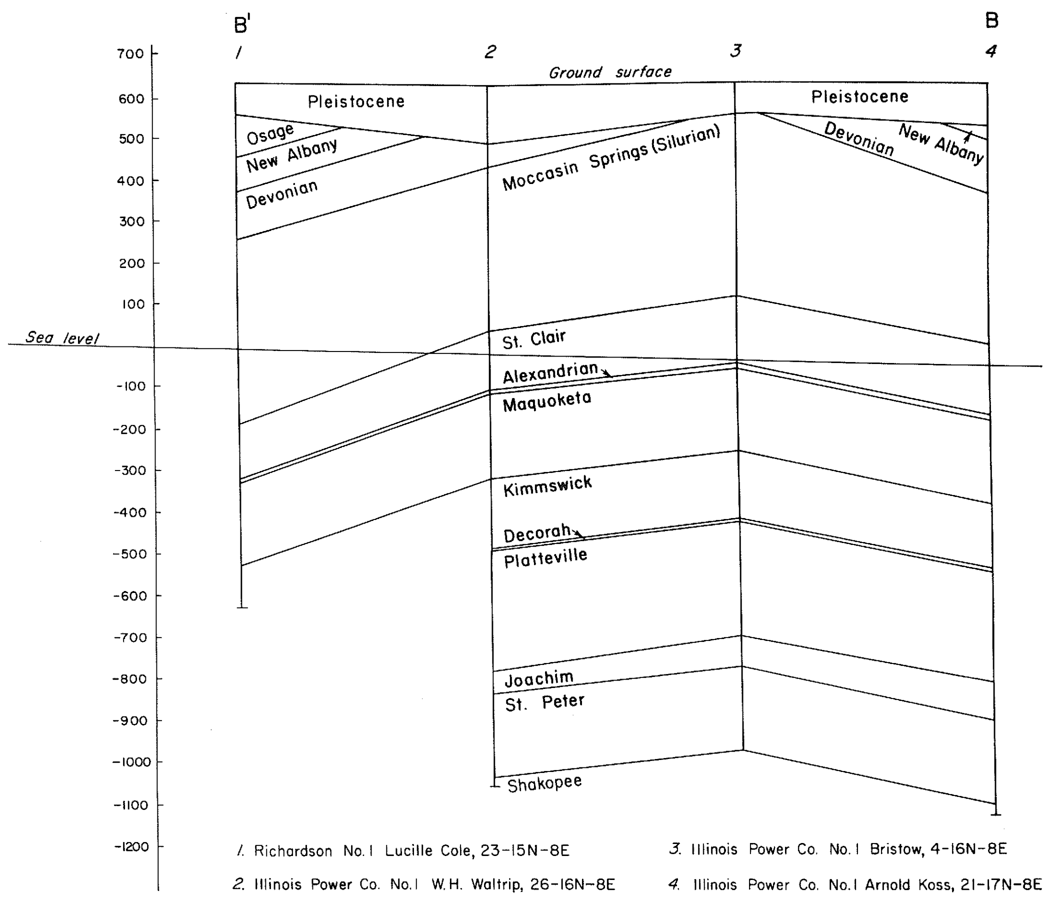


Figure 9 - South-north cross section of Tuscola Anticline (see fig. 4 B'-B).

OIL PRODUCTION

Hayes Pool

The discovery well of the Hayes pool was R. D. Ernest No. 1 Schweighart, drilled and completed in June 1962, in sec. 4, T. 16 N., R. 8 E., Douglas County. The well was completed in the Kimmswick (Trenton) Limestone after a "river frac" for 15 barrels of oil pumping in 24 hours. No electric log was run on the discovery well, but for all practical purposes, the tests from a previously drilled well nearby, the Sullivan and Leroux No. 1 Schweighart, could be used.

Four drill stem tests (D.S.T.) were run in the Trenton lime on the Leroux well:

Drill Stem Test No. 1—902-952 feet, open 2 hours, recovered gas in 70 minutes, 10 feet of mud, slight show of oil, bottom hole pressure 235 pounds.

Drill Stem Test No. 2—950-1002 feet, open 2 hours, recovered 350 feet of gas, 15 feet of mud, slight show of oil, bottom hole pressure 65 pounds.

Drill Stem Test No. 3—1001-1028 feet, open 2 hours, recovered 80 feet of gas, 3 feet of oil, 5 feet of oil-cut mud, bottom hole pressure 0 pounds.

Drill Stem Test No. 4—1028-1054 feet, open $1\frac{1}{2}$ hours, recovered 6 feet of mud, very slight show of oil, bottom hole pressure 0 pounds.

Three cores were taken from the Leroux well:

Core No. 1—952-1002 feet, all cores showed lime with streaked saturation and a few fractures.

Core No. 2—1003-1028 feet.

Core No. 3—1029-1054 feet.

Total depth was 1040 feet on R. D. Ernest No. 1 Schweighart well and $4\frac{1}{2}$-inch casing was set at 930 feet, approximately 37 feet into the Kimmswick (Trenton) Limestone.

The well was cleaned out to total depth and acidized with 500 gallons of Mud Cut Acid to clean up the lime faces. The well tested some heavy oil and gas with a 150-foot fill-up of oil in open hole. The well was then shot with 150 quarts from 940 to 1040 feet, after which it was put on pump, making from 2 to 4 barrels of oil a day. After a few days, the rods were pulled and a river frac of 59,000 gallons of water and 59,000 pounds of sand was injected. After cleaning out the frac load, the well initially produced 15 barrels of oil in 24 hours. In general, the same procedure was followed on the remaining three wells on the Schweighart lease.

Illinois Power Co. completed their No. 2 DeBolt well, also in sec. 4, in the following manner. They encountered the Kimmswick (Trenton) Limestone at 882 feet and drilled to a total depth of 1083 feet. They set $4\frac{1}{2}$-inch casing to 1077 feet and plugged back to 1040 feet, perforating at 943 to 948, 953 to 968, 983 to 993, and 1003 to 1013 feet. Each zone was fractured separately and "perf. balls" were used to block off the previously fractured zones. In each zone, the material used was 25,000 gallons of water, 1000 pounds of walnut hulls, 11,500 pounds of 10-20 sand, 150 gallons of Mud Cut Acid, 25 gallons of Morflo, 435 gallons WG-5, and 25 gallons of nonemulsifying agent.

After a 20-day clean-out and testing program, the well was completed for 14.5 barrels of oil per day, with some water and gas.

The API gravity of the oil from the DeBolt No. 1 well was 30.6°; interfacial tension against water was 35.0 (dynes/cm) and the viscosity was 17.1 centipoises at 100° F, 27.8 at 77° F, and 184.9 at 50° F.

Figure 7 is a contoured structural map of the top of the Kimmswick (Trenton) Limestone in the Hayes pool. The spacing pattern followed is based on 20-acre locations.

The potential pay section is confined to the upper 50 to 100 feet of structure and to approximately the upper 125 feet of the Kimmswick (Trenton). Wells completed lower structurally or below this section contour produce water with little oil.

Permeability varies from 0.1 to 2.0 millidarcys, the average being about 0.6 millidarcys. Permeability decreases in the area north of the Schweighart lease, although the Trenton in those wells south for about 3 miles seems to be slightly more permeable and fractured.

A graph of the oil production of the field, along with the number of wells completed and the cumulative production, is shown in figure 10.

An interesting feature of the Tuscola Anticline is the presence of oil shows in the Devonian and upper part of the Silurian rocks. Very good shows of oil were found in the holes drilled all around the anticline, but none of them has been produced thus far. Where the Devonian and Silurian have been tested, water has taken over the well. The lack of a good caprock on top of the structure has undoubtedly allowed the oil to escape and the voids have been filled with either fresh water from above or a combination of fresh water and salt water from below. At the present time, only traces of oil remain. Perhaps somewhere nearby a slight flexure might trap some of this oil.

The difficulties encountered in producing the Trenton oil have been manifold. Foremost is the paraffining up of the wells, especially in cold weather. Second, in many cases, the wells produce salt water, which should be disposed of below ground. Third, although gas is available for producing operations in the early life of a well, it soon must be augmented by electricity or bottled gas.

The oil produced is trucked out of the area, as no pipeline gathering systems are available. Secondary or tertiary recovery methods are being studied for increased recovery.

SUMMARY

In Champaign and Douglas Counties, the LaSalle Anticlinal Belt had begun to develop by the middle of Mississippian time; the belt was almost fully developed late in Pennsylvanian time. Much potential Mississippian and Pennsylvanian reservoir rock was uplifted and eroded along the crest of the LaSalle Anticlinal Belt; Devonian and Silurian strata generally have been brought too close to the surface to produce oil.

Trenton production from the Hayes field on the Tuscola Anticline has not been great, and there is little likelihood that commercial Trenton oil will be produced from structures smaller than the Tuscola Anticline.

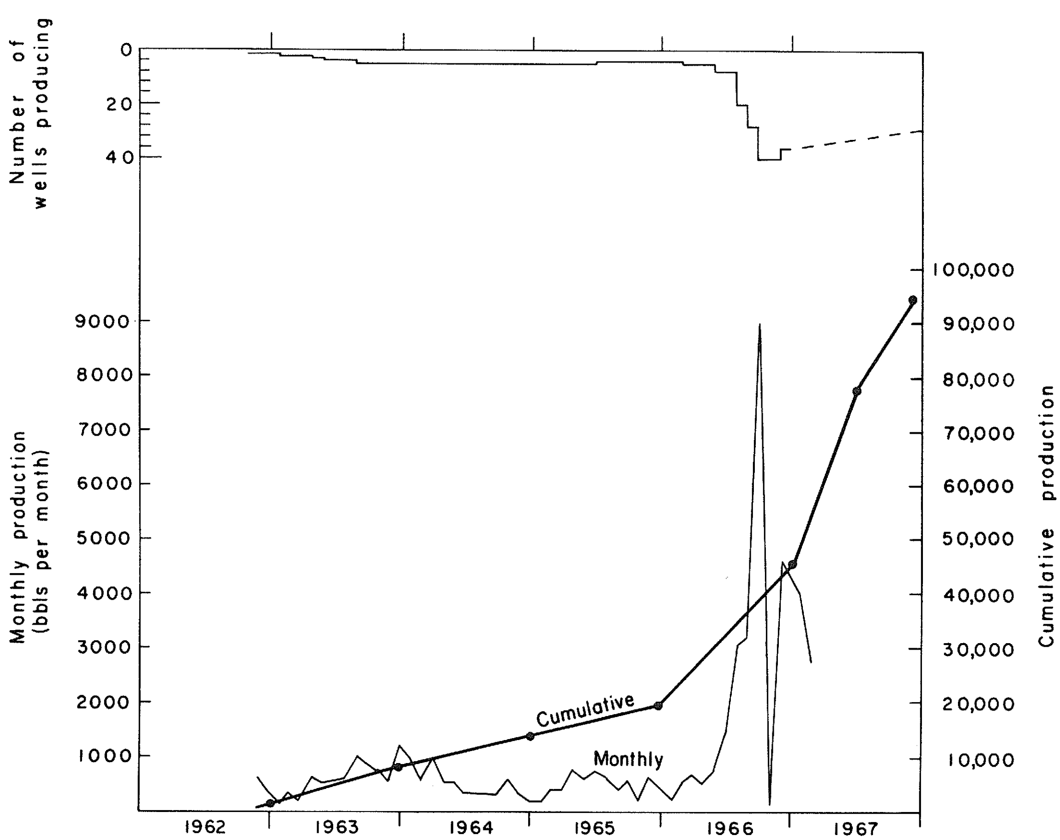


Figure 10 - Hayes pool oil production.

REFERENCES

Blatchley, W. S., 1906, The petroleum industry of southeastern Illinois: Illinois Geol. Survey Bull. 2, 109 p.

Buschbach, T. C., 1964, Cambrian and Ordovician strata of northeastern Illinois: Illinois Geol. Survey Rept. Inv. 218, 90 p.

Cady, G. H., 1920, Structure of the LaSalle Anticline, in DeWolf, F. W., and others, 1920, Yearbook: Illinois Geol. Survey Bull. 36, p. 85-179.

Cady, G. H., 1952, Minable coal reserves of Illinois: Illinois Geol. Survey Bull. 78, 138 p.

Clegg, K. E., 1959, Subsurface geology and coal resources of the Pennsylvanian System in Douglas, Coles, and Cumberland Counties, Illinois: Illinois Geol. Survey Circ. 271, 16 p.

Clegg, K. E., 1965a, Subsurface geology and coal resources of the Pennsylvanian System in Clark and Edgar Counties, Illinois: Illinois Geol. Survey Circ. 380, 28 p.

Clegg, K. E., 1965b, The LaSalle Anticlinal Belt and adjacent structures in east-central Illinois: Illinois Acad. Sci. Trans., v. 58, no. 2, p. 82-94; Illinois Geol. Survey Reprint Ser. 1965-H.

Horberg, Leland, 1950, Bedrock topography of Illinois: Illinois Geol. Survey Bull. 73, 111 p.

Meents, W. F., and D. H. Swann, 1965, Grand Tower Limestone (Devonian) of southern Illinois: Illinois Geol. Survey Circ. 389, 34 p.

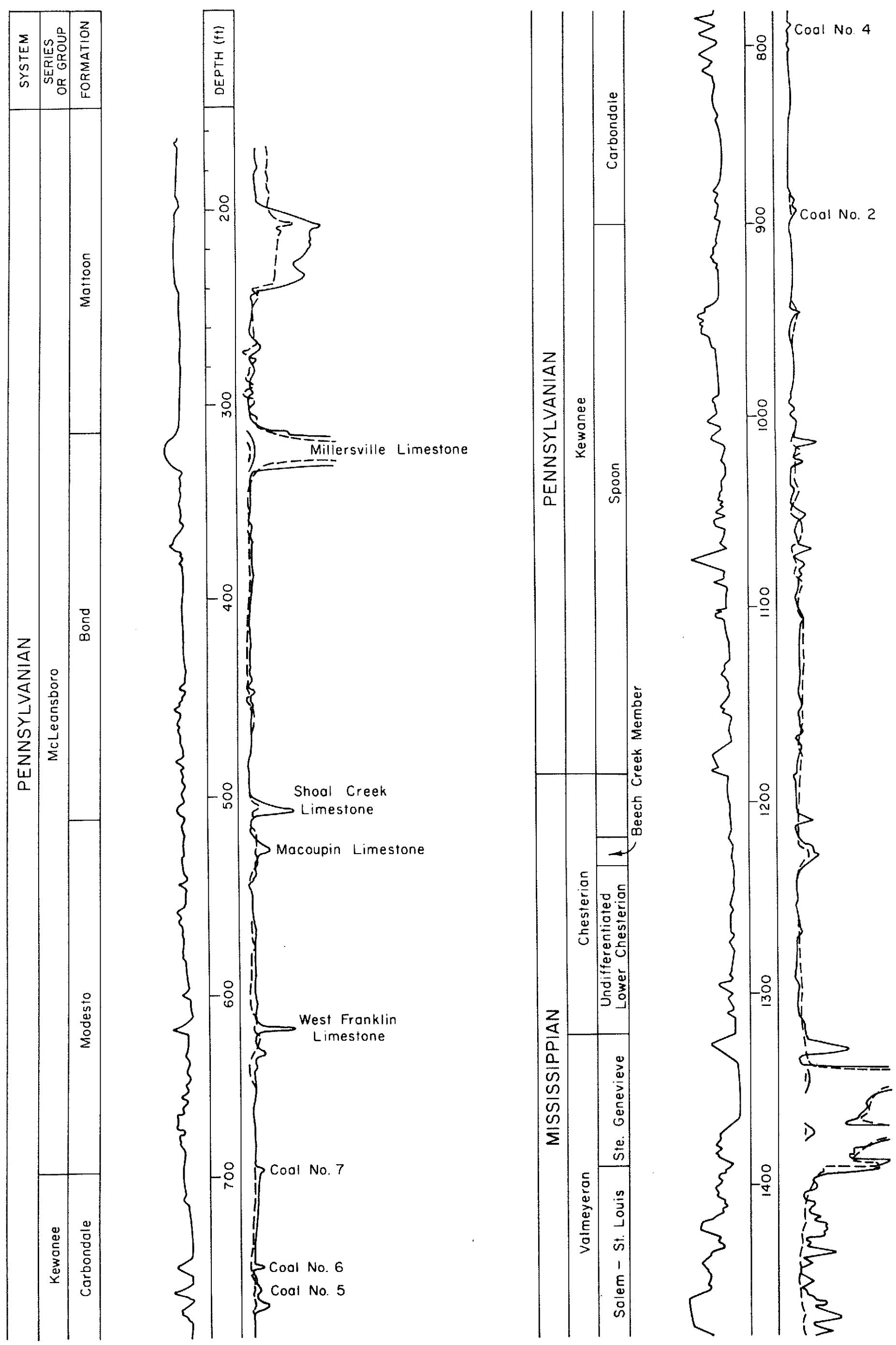
Stephenson, D. A., 1967, Hydrogeology of glacial deposits of the Mahomet Bedrock Valley in east-central Illinois: Illinois Geol. Survey Circ. 409, 51 p.

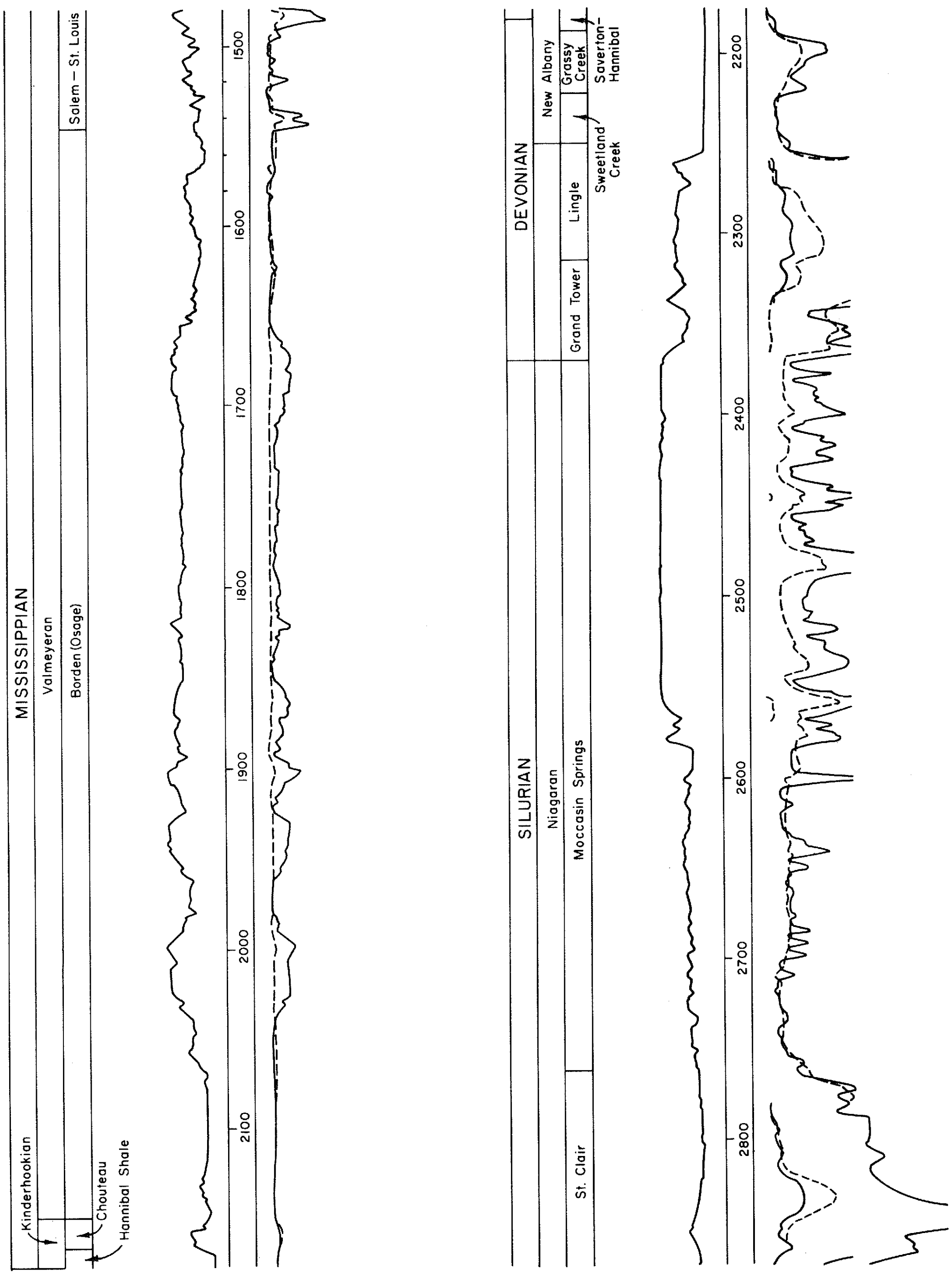
Weller, Stuart, 1906, The geological map of Illinois: Illinois Geol. Survey Bull. 1.

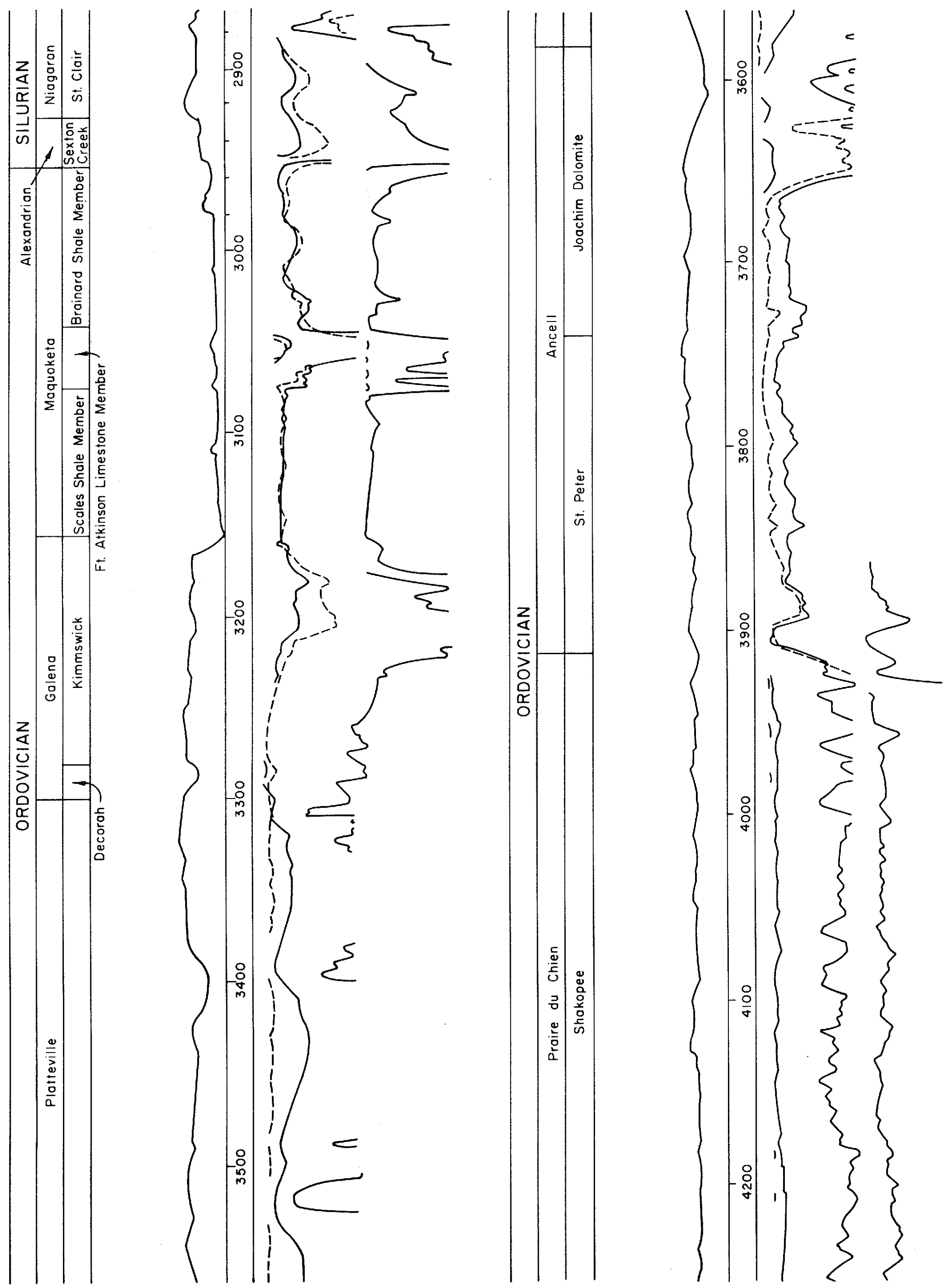
Whiting, L. L., 1959, Spar Mountain Sandstone in Cooks Mills Area, Coles and Douglas Counties, Illinois: Illinois Geol. Survey Circ. 267, 24 p.

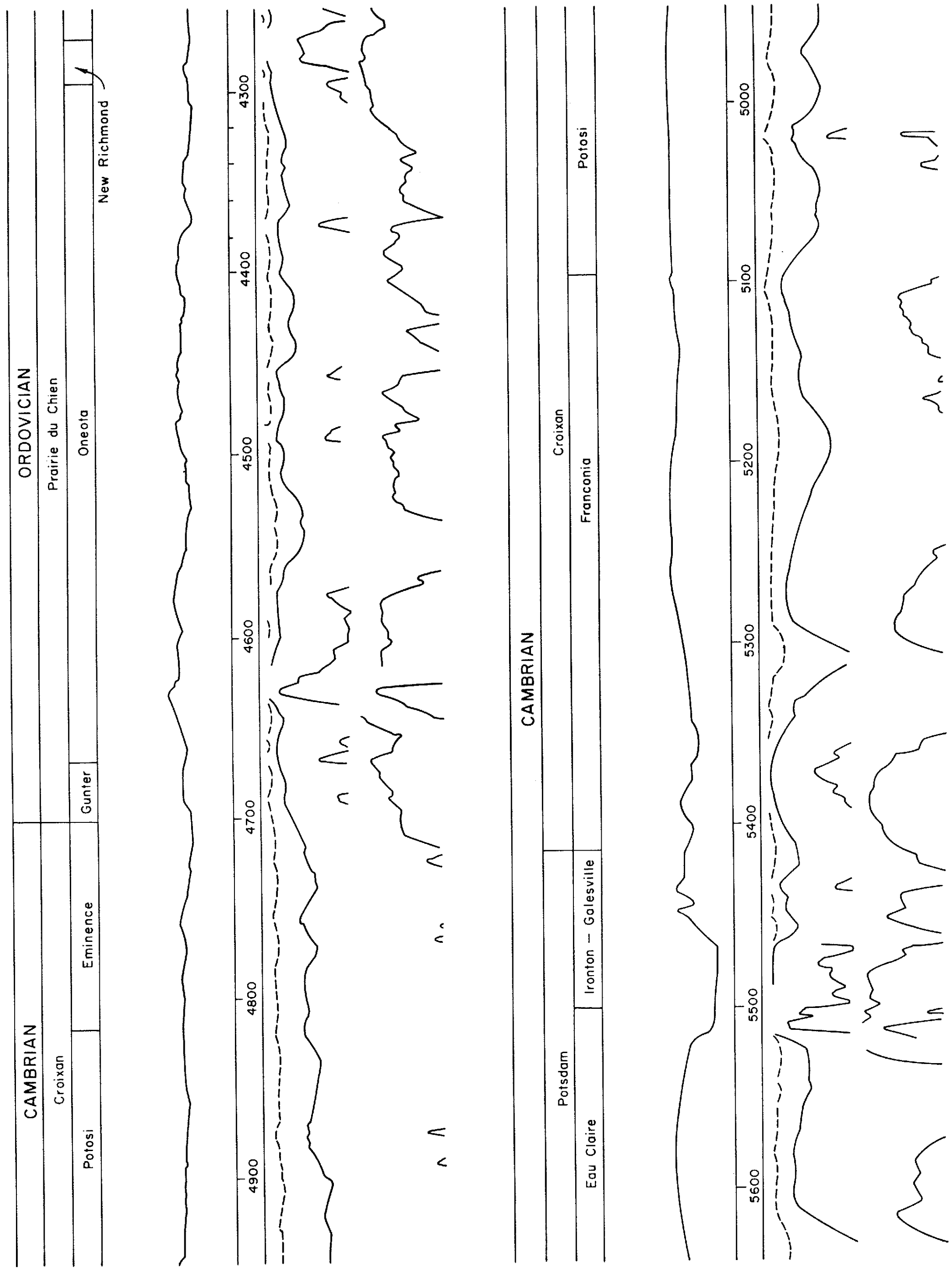
APPENDIX

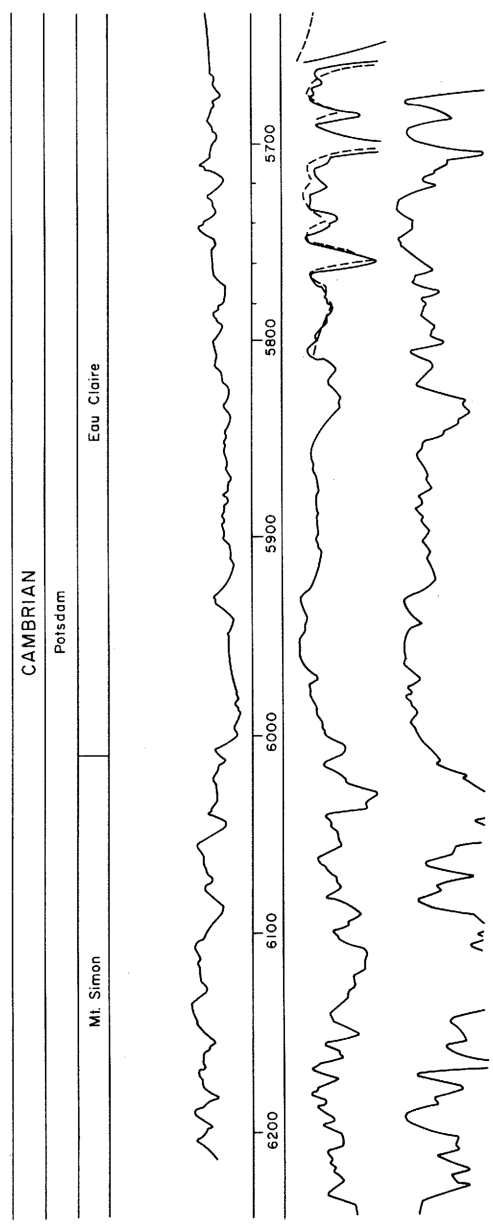
COMPOSITE ELECTRIC LOG OF SOUTHWESTERN CORNER OF REPORT AREA




MISSISSIPPIAN
Valmeyeran
Borden (Osage)
Salem – St. Louis
Kinderhookian
Chouteau
Hannibal Shale
1500
1600
1700
1800
1900
2000
2100
DEVONIAN
New Albany
Grassy Creek
Lingle
Grand Tower
Sweetland Creek
Saverton–Hannibal
SILURIAN
Niagaran
Moccasin Springs
St. Clair
2200
2300
2400
2500
2600
2700
2800


SILURIAN
ORDOVICIAN
Niagaran
St. Clair
Sexton Creek
Alexandrian
Brainard Shale Member
Maquoketa
Scales Shale Member
Ft. Atkinson Limestone Member
Galena
Kimmswick
Decorah
Platteville
2900
3000
3100
3200
3300
3400
3500
ORDOVICIAN
Ancell
Joachim Dolomite
St. Peter
Praire du Chien
Shakopee
3600
3700
3800
3900
4000
4100
4200


ORDOVICIAN
Prairie du Chien
Oneota
New Richmond
Gunter
CAMBRIAN
Croixan
Eminence
Potosi
4300
4400
4500
4600
4700
4800
4900
CAMBRIAN
Croixan
Potosi
Franconia
Ironton -- Galesville
Potsdam
Eau Claire
5000
5100
5200
5300
5400
5500
5600


CAMBRIAN
Potsdam
Eau Claire
Mt. Simon
5700
5800
5900
6000
6100
6200

Illinois State Geological Survey Circular 424
34 p., 10 figs., 2 tables, app., 1968

Printed by Authority of State of Illinois, Ch. 127, IRS, Par. 58.25.