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GEOLOGY OF THE PADUCAH AND SMITHLAND QUADRANGLES IN ILLINOIS

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ILLINOIS STATE GEOLOGICAL SURVEY

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ABSTRACT

The Illinois parts of the Paducah and Smithland Quadrangles lie at the northern end of the Mississippi Embayment and include outcrops of Mississippian, Cretaceous, Tertiary, and Pleistocene sediments. Mississippian rocks are exposed in northeast trending fault blocks that bring Valmeyeran limestone and Chesterian shale, sandstone, and limestone units to the surface. Cretaceous formations overlap onto these fault blocks. Pliocene gravels cap the higher erosion surfaces overlapping the Cretaceous rocks. Similar gravels appear locally at lower elevations near Metropolis. The surface of the higher Pleistocene terrace deposits slopes from 360 feet to over 400 feet elevation. A lower terrace level is prominent at 335 feet elevation. Minor movements along the post-Mississippian fault system have taken place since deposition of the Cretaceous sediments and are apparently continuing at the present time.

Mineral resources in the area include limestone, sandstone, sand and gravel, clay and shale, and ground water. The limestones, although limited in extent, may have possibilities as sources for Portland cement-making, concrete aggregate, road stone, agricultural limestone, and building stone. The sandstones may be usable as building stone and possibly has other purposes. Sand and gravel for use as road stone and concrete aggregate are distributed widely in the area. Some of the clays and shales have good refractory properties. Ground water is available from several gravel- and sand-bearing strata and is potentially available from jointed limestones. Vein minerals and petroleum have not been discovered, to date, in commercial quantities.

INTRODUCTION

The parts of the Paducah and Smithland Quadrangles in Illinois (pl. 1) include approximately 165 square miles, more than one-half of which is covered by Pleistocene terrace and Ohio River alluvial deposits. Cretaceous sand and clay underlie most of the area, but these are well exposed only in the higher steep-sided hills above the highest terrace level. Pliocene gravels cap most of the ridges and hills at elevations above 500 feet. Mississippian sandstone, shale, and limestone crop out along the deeper valleys in the northeastern part of the area.

Previous Investigations

Weller and Sutton (1940) discussed the regional geology of the Mississippian rocks and included a small-scale map of these strata in the Paducah and Smithland Quadrangles, and Weller (1940) showed the fault pattern of the Mississippian strata in the area. Studies relating to Cretaceous sedimentary structures and mineralogy by Pryor (1960), Pryor and Glass (1961), and Potter and Pryor (1961) included descriptions of samples from the map area. Lamar and Reynolds (1951) and Potter (1955) studied the petrology of the Pliocene gravels, and Leighton and Willman (1949) discussed the Pleistocene history of the region. Other investigations in the area (fig. 1) are listed in the references.

The Brownfield 15-minute Quadrangle to the north of the Paducah Quadrangle (fig. 1) was mapped by Weller and Krey (1939). Pryor and Ross (1962) mapped the three quadrangles—LaCenter, Cairo, and Thebes—to the west, and the cross sections of that study connect with those of this study (fig. 2). The field work for the Illinois parts of the Paducah and Smithland Quadrangles was done during 1961 and 1962.

Acknowledgements

T. W. Lambert, U. S. Geological Survey, kindly directed attention to exposures just north of the Paducah Quadrangle that showed evidence of post-Cretaceous faulting. W. A. Pryor, Gulf Research Corporation, spent several days in the field discussing interpretations of many of the key sections of the Cretaceous-Early Tertiary sequence, and B. C. Moneymaker, Tennessee Valley Authority, kindly supplied base data from damsite borings along the Ohio River, which have been used in preparing parts of the cross sections. Helpful discussions on various problems with J. C. Frye, H. B. Willman, D. H. Swann, Elwood Atherton, J. E. Lamar, J. W. Baxter, and other members of the Illinois State Geological Survey staff is gratefully acknowledged.

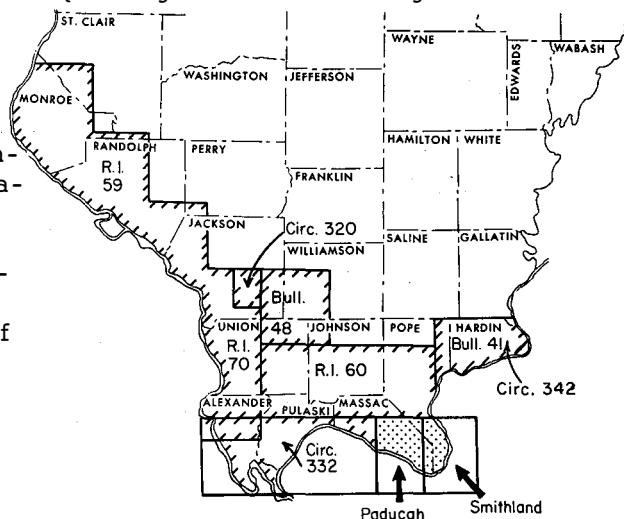


Fig. 1 - Index map showing the location of the Illinois parts of the Paducah and Smithland Quadrangles and other nearby quadrangles mapped by the Illinois State Geological Survey.

PHYSIOGRAPHY

The Illinois parts of the Paducah and Smithland Quadrangles lie in the northernmost part of the Mississippi Embayment (a part of the Gulf Coastal Plain) and in a southern extension of the Shawnee Hills. The major topographic features are the Ohio River floodplain and gorge, gently rounded hills composed of Cretaceous, Pliocene, and Pleistocene sediments, and steep-sided ridges of Paleozoic strata. In Kentucky, adjoining the map area, both the northward-flowing Cumberland and Tennessee Rivers join the Ohio River.

The highest elevation is 585 feet in the northern part of the Smithland Quadrangle, and the lowest is 290 feet on the Ohio River west of Metropolis, a relief of nearly 300 feet in ten miles.

STRATIGRAPHY

The general stratigraphic succession underlying the Paducah-Smithland map area is shown in figures 3 and 4. Nearly 600 feet of strata are exposed in the map area including Pleistocene terrace deposits, Pliocene "Lafayette" Gravel, Cretaceous McNairy and Tuscaloosa Formations, and Mississippian Chesterian and Valmeyeran strata.

A deep well, Rigney and Dodson, No. 1 Lewis, drilled in Pope County in sec. 18., T. 16 S., R. 6 E. (Paducah Quadrangle) reached a total depth of 4,100 feet. It penetrated the St. Louis Formation at the top and extended into 580 feet of Ordovician at the bottom. A summary log of this well (appendix A) gives the general lithology and thickness of the Ordovician, Silurian, Devonian, and lower and middle Mississippian strata.

Another well, just north of the Paducah Quadrangle, penetrated 861 feet of Chesterian strata (fig. 5) reaching the Cypress Sandstone. The stratigraphic units between the Cypress Sandstone and the St. Louis Formation, the interval not covered in these two well sections, are estimated to be 700 feet thick.

Cambrian and early Ordovician (Canadian) rocks are penetrated by only a few wells in southern Illinois, and their distribution and stratigraphy are not thoroughly known. They are about 6,000 feet in combined thickness and are overlain by about 7,000 feet of younger Ordovician, Silurian, Devonian, and Mississippian strata. The overlying Cretaceous strata are locally about 200 feet thick, and the early Tertiary strata are absent in the map area. The late Tertiary (Pliocene) gravels may reach 50 feet in thickness, and the Quaternary Pleistocene valley-fill deposits are locally 100 feet thick.

Paleozoic Strata

Ordovician System

Champlainian Series.—The oldest strata encountered in the Rigney and Dodson, No. 1 Lewis well are 268 feet of dark gray, fine-grained, dolomitic limestone belonging to the Platteville Group. These strata are overlain by 66 feet of the Galena Limestone Group. The contact is placed at a thin bed showing markedly lower electrical resistivity than beds above or below. The Galena is generally

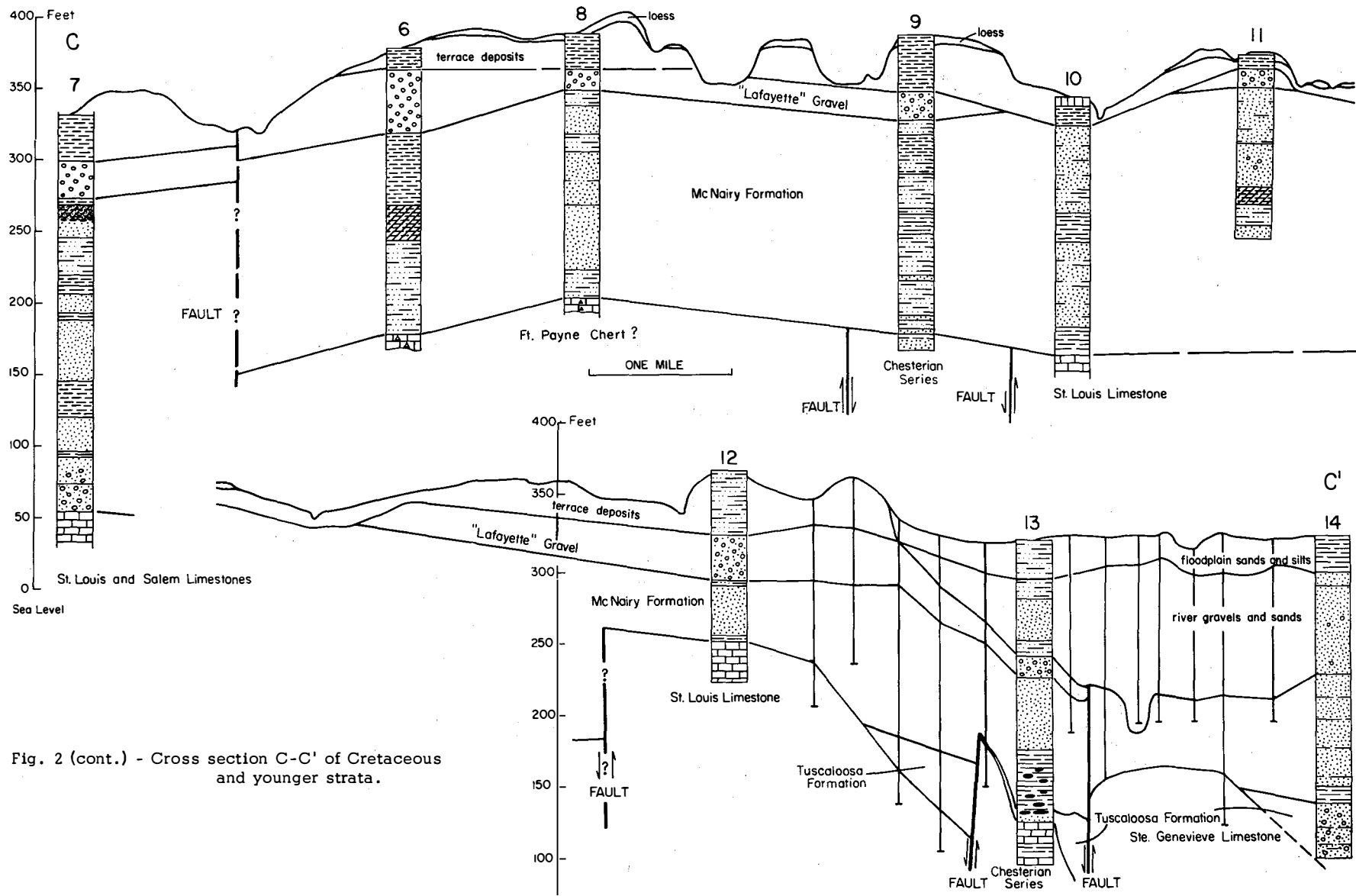
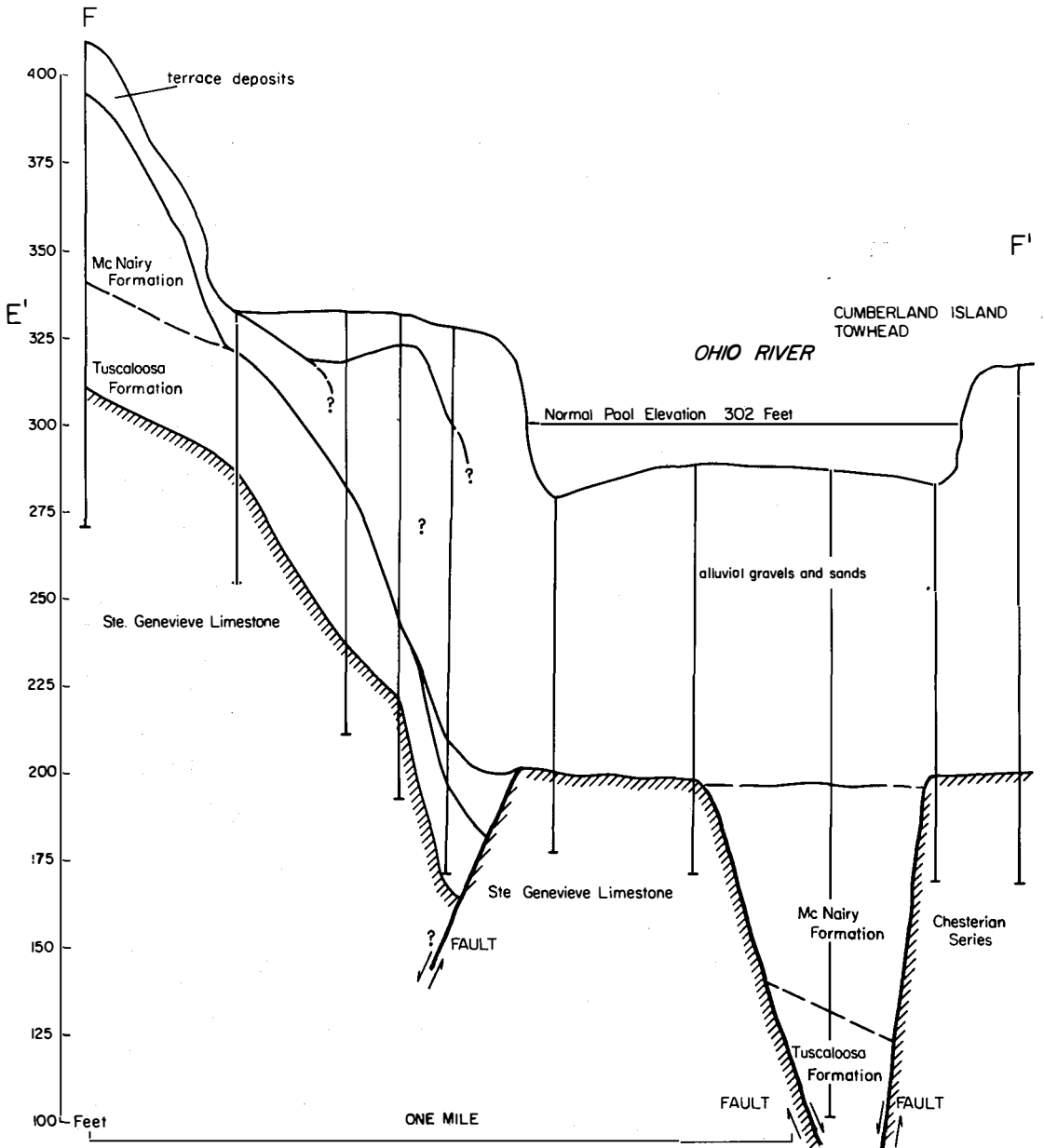


Fig. 2 (cont.) - Cross section C-C' of Cretaceous and younger strata.



KEY













	Silt		Cherty limestone
	Sandstone		Hematite zone
	Shale and clay		Weathered zone
	Sandy shale		Lignitic shale
	Gravel		Lignitic sand
	Limestone		No sample

Fig. 2 (cont.) - Cross section F-F' of Cretaceous and younger strata and stratigraphic symbol key.

SYSTEM	SERIES	GROUP	FORMATION	LITHOLOGY	THICKNESS		
QUATERNARY	PLEISTOCENE				0-100		
TERTIARY	PLIOCENE		"LAFAYETTE"		0-50		
CRETACEOUS	GULFIAN		McNAIRY <small>Levings Mbr.</small>		120-230		
			TUSCALOOSA <small>Little Bear Soil</small>		0-20		
MISSISSIPPIAN	CHESTERIAN		SEE FIGURE 4		1000		
		VALMEYERAN		STE. GENEVIEVE		200	
				ST. LOUIS		350-400	
				SALEM		500-600	
				HARRODSBURG		95	
				FT. PAYNE		650-700	
				SPRINGVILLE CHOUTEAU		40 5	
		DEVONIAN	UPPER	NEW ALBANY		285	
			MIDDLE		LINGLE GRAND TOWER		15 50
					CLEAR CREEK		655
LOWER			BACKBONE		25		
			BAILEY <small>Grassy Knob Mbr.</small>		550		
SILURIAN	NIAGARAN			MOCCASIN SPRINGS		100	
			ST. CLAIR		60		
	ALEXANDRIAN	SEXTON CREEK		80			
ORDOVICIAN	CINCINNATIAN	MAQUOKETA		300-320			
	CHAMPLAINIAN		GALENA		60-130		
			PLATTEVILLE		600-850		
			JOACHIM		240-360		
			DUTCHTOWN		130-160		
			ST. PETER		0-150		
			EVERTON		90-150		

Fig. 3 - Generalized columnar section of the strata underlying the Smithland and Paducah Quadrangles in Illinois (see also figure 4).

lighter gray, coarser grained, and less dolomitic than the underlying Platteville Group, but the change in lithology at the contact is not great.

Cincinnatian Series.—The Maquoketa Group is the highest Ordovician unit reported in the Rigney et al. well. It is 316 feet thick and is dominantly dark gray to black siltstone and shale in its upper part and interbedded dark gray shale, siltstone, and silty limestone in its lower part.

Silurian System

Alexandrian Series.—The lowest Silurian unit recognized in the Rigney et al. well is the Sexton Creek Limestone. The Girardeau and Edgewood Limestones exposed below the Sexton Creek Limestone in the Thebes Quadrangle (Pryor and Ross, 1962) are apparently absent. The Sexton Creek is a cherty, glauconitic, very fine grained limestone, about 80 feet thick.

Niagaran Series.—The St. Clair Limestone is 60 feet thick and is dominantly a sublithographic limestone with red calcite grains and crinoidal fragments scattered throughout. Two or three feet of red shale form the base of the unit. The upper 190 feet of Silurian strata are mainly dark gray, calcareous shale and siltstone with about 30 feet of red siltstone and silty limestone at the base and are probably equivalent to the Moccasin Springs Formation which is exposed to the west in the Thebes Quadrangle (Pryor and Ross, 1962).

Devonian System

The Lower Devonian Bailey Formation is 550 feet thick and is divided into two members. The lower unnamed member consists of 265 feet of brownish gray, cherty dolomite and silty limestone. The upper member, the Grassy Knob Chert Member, consists of 285 feet of medium to dark gray, massive chert with subordinate amounts of dark brownish gray dolomite and limestone. The Backbone Limestone, which separates the massive chert beds of the upper part of the Bailey from those of the overlying Clear Creek Chert, is 20 feet thick in the Rigney et al. well.

The Middle Devonian Clear Creek Chert reaches 660 feet in thickness and is composed of light to medium gray chert, cherty dolomite, and in its lower part, some limestone. It is unconformably overlain by the Grand Tower Limestone, a light gray limestone 50 feet thick with a thin sandy basal portion. Above the Grand Tower, 14 feet of dark gray, cherty limestone is assigned to the Lingle Limestone.

The New Albany Group, above the Lingle, is largely black shale. The lowest part is of Middle Devonian age and consists of 44 feet of black shale with high electrical resistivity and a few thin limestone beds. The middle part is of late Devonian age and consists of 100 feet of gray as well as black shale and has a lower electrical resistivity than the lowest and highest parts. The highest unit consists of 140 feet of black shale with high electrical resistivity.

Mississippian System

The early Mississippian Kinderhookian Series is about 4 feet thick and includes the thin, brown argillaceous Chouteau Limestone (Buschbach, 1952). Shales and siltstones of Kinderhookian age were not recognized in the well study and, if present, are apparently thin. The lower part of the middle Mississippian Valmeyeran Series consists of 38 feet of Springville Shale. This is overlain by the Ft. Payne Chert, consisting of 220 feet of shaly, calcareous, siliceous siltstone at the base and 440 feet of silty, calcareous chert above. Overlying this is 92 feet of Harrodsburg Limestone, which is generally a light gray crinoidal limestone, but the Rigney et al. well also includes considerable dark limestone. The upper part of the

Valmeyeran Series consists of the Salem Limestone, a fine-grained, dark, dolomitic limestone in its lower 300 feet and a brown, fossiliferous limestone with scattered oolites and the foraminifer *Endothyra* in its upper 200 feet; the St. Louis Limestone, a dark gray, medium-grained limestone, about 350 to 400 feet thick, with bands of fossil fragments; and the Ste. Genevieve Limestone, about 200 feet thick, generally a light gray, coarse-grained limestone with sandstone lenses, particularly in its upper part.

Ste. Genevieve Limestone.—Outcrops of pre-Chesterian strata are rare; however, the northeast-trending fault that crosses sec. 33, T. 15 S., R. 7 E., has 20 to 25 feet of Ste. Genevieve Limestone exposed along its southeast side. This is a medium to dark gray, coarse, fossiliferous limestone with echinodermatal fragments, ostracodes, other fossil debris, and deformed oolites. This is probably the Fredonia Limestone Member, which attains a thickness of 175 to 200 feet to the north in Hardin County in the area near Hicks Dome.

The late Mississippian Chesterian Series is about 1,000 feet thick and consists of 12 or more alternations of sandstone, shale, and limestone in nearly cyclic repetition (Weller, 1920; Lamar, 1925, p. 26-77; Swann, 1963, fig. 1). Chesterian sedimentation was transitional with the underlying Ste. Genevieve Limestone, and the series is unconformably overlain by Pennsylvanian sediments. The Aux Vases, Renault, Yankeetown, and Downeys Bluff Formations are present but not exposed in the area mapped.

Bethel Sandstone.—The Bethel Sandstone is a fine-grained, yellow-brown weathering, massive sandstone that reaches nearly 80 feet in thickness and is exposed in a narrow northeast-trending fault block about two miles northwest of Hamletsburg. It lies in fault contact with the Ste. Genevieve Limestone near the northeast corner of this belt of outcrops and in fault contact with the Fraileys Formation along the northwest side.

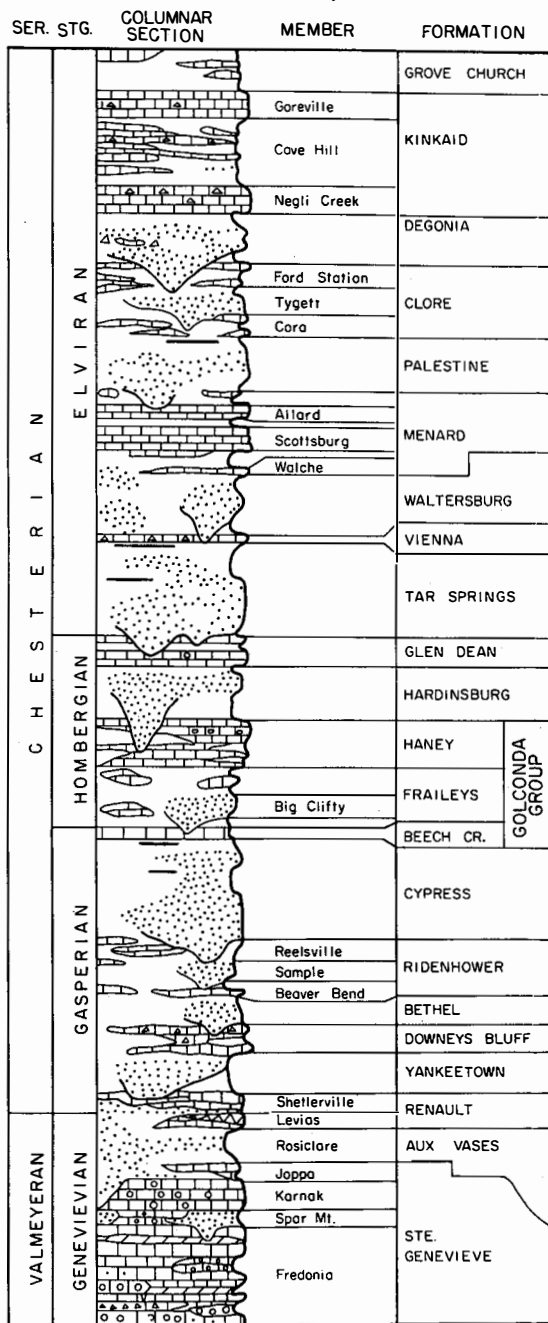


Fig. 4 - Generalized columnar section of late Mississippian rocks of Illinois (after Swann, 1963, fig. 1)

Ridenhower Formation.—The Ridenhower Formation is principally dark gray to black shale with a thin-bedded, very fine-grained sandstone near the middle (Sample Sandstone Member) and a fine- to coarse-grained limestone (Reelsville Limestone Member) near the top that is commonly preserved beneath the unconformity at the base of the overlying Cypress Sandstone (fig. 6). The Ridenhower Formation apparently reaches 60 feet in thickness in this area, but the base is not exposed and only the upper 40 feet are seen.

Cypress Sandstone.—The Cypress Sandstone has a massive sandstone unit, 55 feet thick, as its lowermost part. This is succeeded by a shale and sandstone, 30 feet thick, and above that a massive sandstone, 25 feet thick with a few feet of shaly sandstone at the top (fig. 7). The basal part of this sequence is well exposed in the gullies in the southern half of sec. 7 and the south half of sec. 18, T. 15 S., R. 7 E. (Smithland Quadrangle). The middle and upper part is exposed along the Bay City-New Liberty Road in the north half of sec. 1, T. 15 S., R. 6 E. (Smithland Quadrangle).

Golconda Group.—The Golconda Group consists of the Beech Creek Limestone, Fraileys Formation, and Haney Limestone. The Beech Creek Limestone, only 2 to 10 feet thick, is not exposed in the area, and apparently it is either concealed by alluvium or faulting. The Fraileys Formation is composed of nearly 110 feet of dark gray to black shale and interbedded thin, black limestone. The limestone beds are commonly fine grained and have abundant fenestrate bryozoan fragments. In general, the formation is poorly exposed in discontinuous exposures in NE $\frac{1}{4}$ sec. 32, T. 15 S., R. 7 E. (Smithland Quadrangle). The Haney Limestone, 45 to 65 feet thick, is composed in its lower part of about 35 feet of limestone, locally containing oolids, and shale. The upper 10 to 30 feet of the formation is shale with numerous coarse-grained fossiliferous limestone beds. Outcrops of the upper part of the formation may be seen in the bluff just west of road corner (elevation 457) in sec. 2, T. 15 S., R. 6 E. (Paducah Quadrangle).

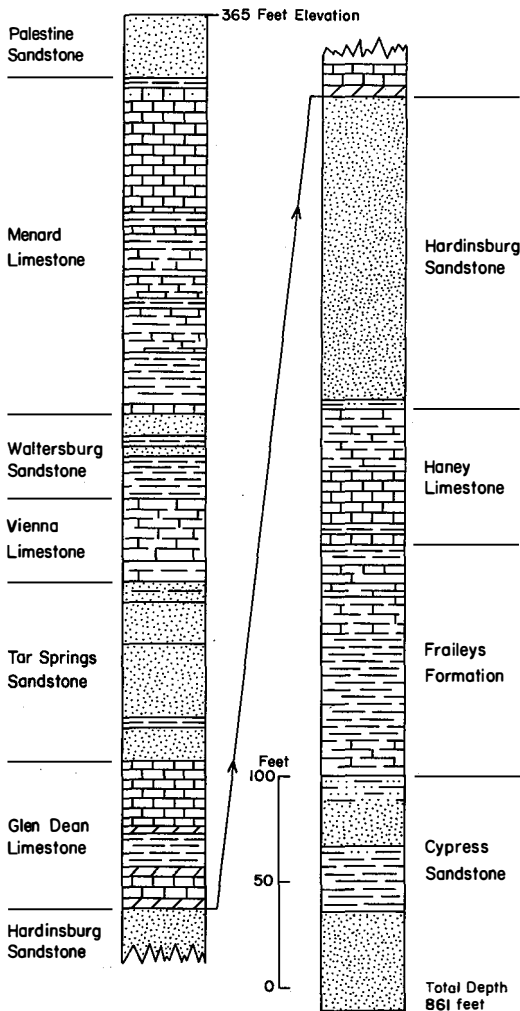


Fig. 5 - Graphical section of the Fitch Brothers, No. 1 Pullen and Farmer well, NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 20, T. 14 S., R. 5 E., from a sample study by D. L. Stevenson.

Hardinsburg Sandstone.—The Hardinsburg Sandstone is the thickest of the Chesterian sandstones in the map area and reaches 245 feet thick in the Fitch Bros., No.1 Pullen & Farmer well (fig. 5). The lower part of the formation is well exposed in the bluffs along Barren Creek

in secs. 2 and 3 and higher parts are seen in sec. 1, T. 15 S., R. 6 E. (Paducah Quadrangle). A down-dropped fault block in the SW $\frac{1}{4}$ of sec. 3 displays the Hardinsburg beneath the overlying Glen Dean Limestone (fig. 8).

Glen Dean Limestone.—The Glen Dean Limestone is about 70 feet thick. It is composed of a lower massive limestone, 15 feet thick, that may be slightly dolomitic; a middle black shale unit, 7 to 15 feet thick, in which fenestrate bryozoan fronds are abundant on the bedding surfaces; and an upper massive limestone and interbedded shale unit, 35 feet thick, in which large fossil fragments and oolids are conspicuous. The Glen Dean is well exposed in the Ohio River bank in the SE $\frac{1}{4}$ sec. 36, T. 14 S., R. 6 E. (Smithland Quadrangle), where both the base and top of the formation are visible (fig. 8). The lower part of the formation also is exposed in the SW $\frac{1}{4}$ sec. 3 and in the SW $\frac{1}{4}$ sec. 4, T. 15 S., R. 6 E. (Paducah Quadrangle).

Tar Springs Sandstone.—The Tar Springs Sandstone is the youngest Chesterian formation recognized in outcrops in the map area and is 85 feet thick in the Fitch Bros., No. 1 Pullen & Farmer well. It is composed of massive sandstone with a few 2- to 5-foot beds of shale and shaly sandstone. The lowest massive sandstone contains beds of medium to coarse sandstone, which seem to characterize this unit in secs. 3, 4, 9, and 10, T. 15 S., R. 6 E. (Paducah Quadrangle). The Tar Springs is overlain in these sections by Pliocene "Lafayette" Gravel.

Younger Chesterian Formations.—The Fitch Bros., No. 1 Pullen & Farmer well (fig. 5) penetrated several Chesterian formations younger than those exposed in the map area. The Vienna Limestone is nearly 40 feet thick and is overlain by shaly sandstone and very fine-grained sandstone of the Waltersburg Sandstone, also about 40 feet thick. The Menard Limestone is formed of three limestone and two shale units, which total nearly 150 feet in thickness. Thirty-five feet of Palestine Sandstone occur at the top of this well. The Clore, Degonia, Kinkaid, and Grove Church Formations are not present in the map area, although they are present north of the Cache Valley.

Pennsylvanian System

Although not found south of the Cache Valley in southern Illinois, Pennsylvanian sediments unconformably overlie Chesterian strata (Siever, 1951) immediately north of the valley and to the east across the Ohio River in Kentucky. In the Sherterville Quadrangle in Kentucky, the Rock Creek Graben exposes shale, siltstone, and sandstone units of the Caseyville Formation.

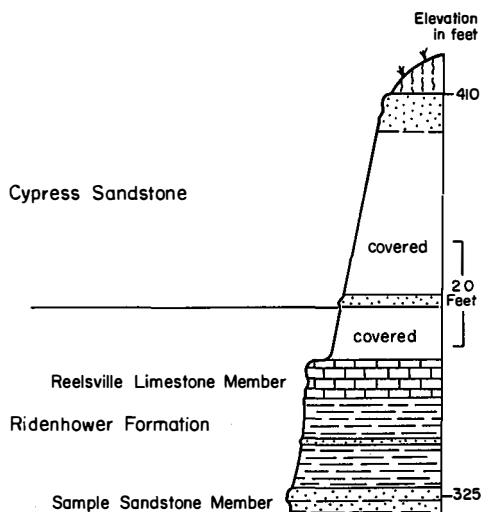


Fig. 6 - Outcrop section of the upper part of the Ridenhower Formation and the lower part of the Cypress Sandstone, NW $\frac{1}{4}$ sec. 20, T. 15 S., R. 7 E., Smithland Quadrangle.

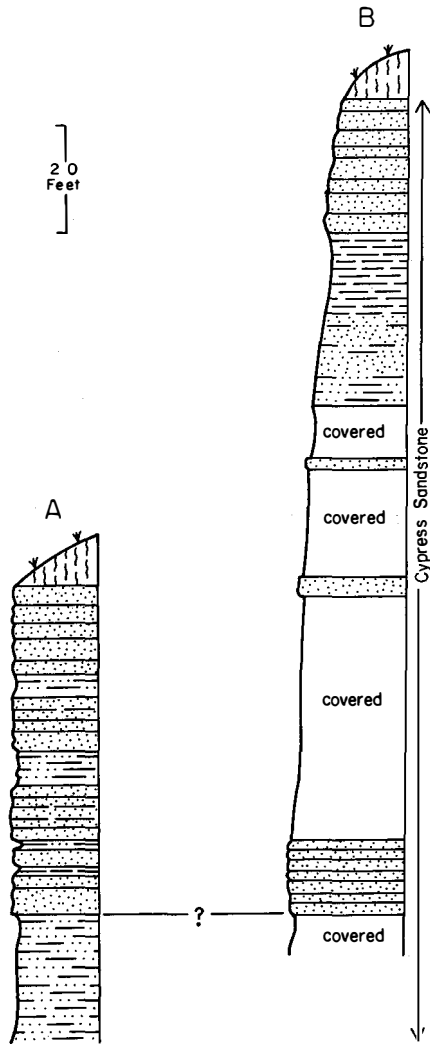


Fig. 7 - Outcrop sections of the Cypress Sandstone: (A) NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 7, T. 15 S., R. 7 E., Smithland Quadrangle; (B) NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, T. 15 S., R. 6 E., Smithland Quadrangle.

Mesozoic Strata

Pre-Cretaceous Unconformity

The rocks immediately underlying Cretaceous strata commonly have a well-defined weathered zone, called the Little Bear Soil, with bands and nodules of hydrous iron-oxide (Pryor and Ross, 1962). Because it is widespread (Ross, 1963, p. 9), this soil profile forms an extremely valuable marker bed. It is developed on strata from Mississippian to Ordovician in age. Well records locally report several feet of clay, sand, and gravel that commonly fill caverns and sinkholes in the underlying Mississippian limestones. The Little Bear Soil is well exposed a short distance west of the Paducah Quadrangle in sec. 2, T. 15 S., R. 2 E. (LaCenter Quadrangle) along Post Creek (Pryor and Ross, 1962, p. 16).

Cretaceous System

Tuscaloosa Formation.—The Tuscaloosa Formation was named by Smith and Johnson (1887, p. 18) for about 1,000 feet of quartzitic and micaceous sands and clays with lenses of pebbles, exposed along the Tuscaloosa (Black Warrior) River near Tuscaloosa, Alabama. In Tennessee, Marcher (1961) and Marcher and Stearns (1962) show the Tuscaloosa thickening eastward from the eroded and beveled Pascola Arch and passing into near-shore marine deposits near the eastern edge of its present outcrop area. Pryor (1960, p. 1475) and Pryor and Glass (1961, p. 39) recognized the Tuscaloosa Formation in Illinois as thin, 0 to 15 feet, and discontinuous lenses of clayey sand and chert gravels.

In the map area, the Tuscaloosa Formation overlies the Little Bear Soil or, in its absence, unweathered Paleozoic strata. The Tuscaloosa is thin and is composed of coarse sands and black, gray, or white chert pebble gravels, which locally thicken to about 20 feet in some wells. This relation and the wide distribution of the Little Bear Soil suggest that the Tuscaloosa filled shallow depressions in an otherwise fairly smooth erosion surface. Where thickest the Tuscaloosa is predominantly gravel, and where thin it is coarse sand with scattered chert pebbles. In outcrops the Tuscaloosa Formation is thin (up to 5 feet) and is poorly exposed

in the Paducah and Smithland Quadrangles, except for the north-south roadcut in the SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 2, T. 16 S., R. 6 E. (Paducah Quadrangle) (fig. 9). Pebbles in the Tuscaloosa are dominantly chert, are commonly black, or may be bleached to a light cream color. They occur as thin lenses in the clay and the coarse micaceous sand. East of Metropolis, the Tuscaloosa locally grades vertically into the McNairy Formation through several feet of coarse and fine sand beds.

The contact of the Tuscaloosa with the McNairy is marked by a change from medium and coarse sand to fine, silty, micaceous sand. This is usually a bedding plane contact, but locally it is transitional so that the lower beds of the McNairy may have appreciable amounts of coarse quartz sand mixed with the fine sand and silt. These relations suggest that the Tuscaloosa in southern Illinois is a conglomeratic sequence at the base of the McNairy transgressive sands. It may be lithologically continuous with the type section of the formation near Tuscaloosa, Alabama, but most likely it is younger in age.

McNairy Formation.—The McNairy was named originally as a member of the Ripley Formation (Stephenson, 1914, p. 17-18) for shallow water, nonglauconitic sands with subordinate clay in the upper part of the Cretaceous of the Mississippi Embayment (Lamar and Sutton, 1930). The McNairy is recognized in Illinois as a formation (Pryor, 1960, p. 1476) that has three well defined members (1) a lower member of very fine, white to light gray micaceous sand that contains minor amounts of "ironstone" and white, gray, and blue clay, 0-120 feet thick; (2) a middle member, the Levings Member, composed of black clays and thin lignite beds with abundant plant fossils, 0-30 feet thick; and (3) an upper member with several 2- to 5-foot white silt lenses, 0-500 feet thick.

In the Illinois portion of the Paducah and Smithland Quadrangles, only sand referable to the lower micaceous member crops out. The lignite bearing Levings Member is absent in the outcrop area because of nondeposition or erosion, but it is reported in wells near Metropolis (fig. 2, Cross section C-C'). The upper member is missing in the map area. Moneymaker and Grant (1954) also described lignitic beds within the McNairy, two miles west of Metropolis.

The McNairy Formation lies as a wedge above block-faulted Chesterian strata and local lenses of Tuscaloosa (Lamar and Sutton, 1930). It lies beneath an irregularly truncated surface at the base of the "Lafayette" Gravel. This wedge thickens from an erosional edge in the northeast part of the map area to about 200 feet in the Metropolis city well (fig. 2, Cross section C-C'), in the NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 11, T. 16 S., R. 4 E. (Paducah Quadrangle), where it is underlain by 21 feet of

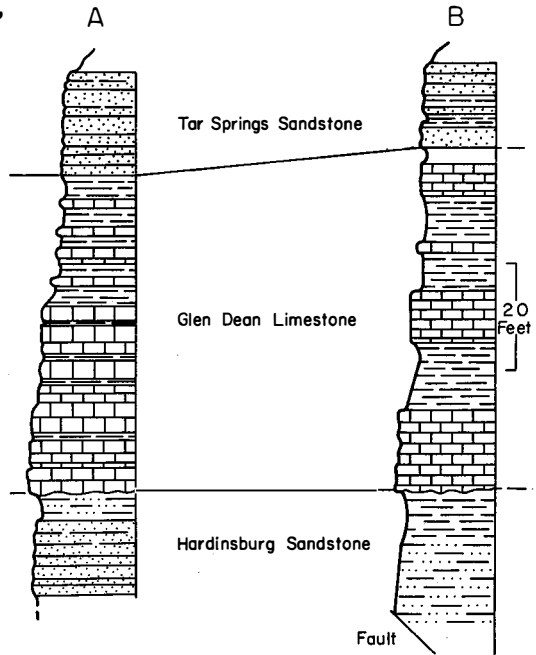


Fig. 8 - Outcrop sections of the Glen Dean Limestone: (A) SW $\frac{1}{4}$ sec. 3, T. 15 S., R. 6 E., Paducah Quadrangle; (B) SE $\frac{1}{4}$ sec. 36, T. 14 S., R. 6 E., Smithland Quadrangle.

white sand and gravel of the Tuscaloosa Formation and 13 feet of chert gravels that are apparently a Little Bear Soil residuum developed on the Mississippian St. Louis Limestone. This pre-Cretaceous surface slopes to the southwest on the average of 30 feet per mile.

A composite section of the lower part of the McNairy includes nearly 200 feet of thinly laminated, blue and gray silts and clays and cross-laminated sand with few resistant layers (fig. 9). The basal contact of the McNairy with the Tuscaloosa Formation is exposed in a roadcut in the SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 3, T. 16 S., R. 6 E. (Paducah Quadrangle), where 65 feet of very fine, white, micaceous sand are exposed in massive beds. This sand unit is also exposed one mile west of Hamletsburg in the SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 9, T. 16 S., R. 7 E. (Smithland Quadrangle).

The upper contact of the McNairy with the "Lafayette" Gravel is well exposed in many roadcuts at about 485 to 510 feet elevation, particularly along the township-line road between Tps. 14 and 15 S. in Rs. 4 and 5 E. near the northern boundary of the Paducah Quadrangle, and also in the Illinois Central Railroad cuts west and south of the village of Round Knob. The McNairy commonly has a 5- to 10-foot brick-red weathered zone, where the "Lafayette" type gravels are thin (2 to 6 inches) or missing.

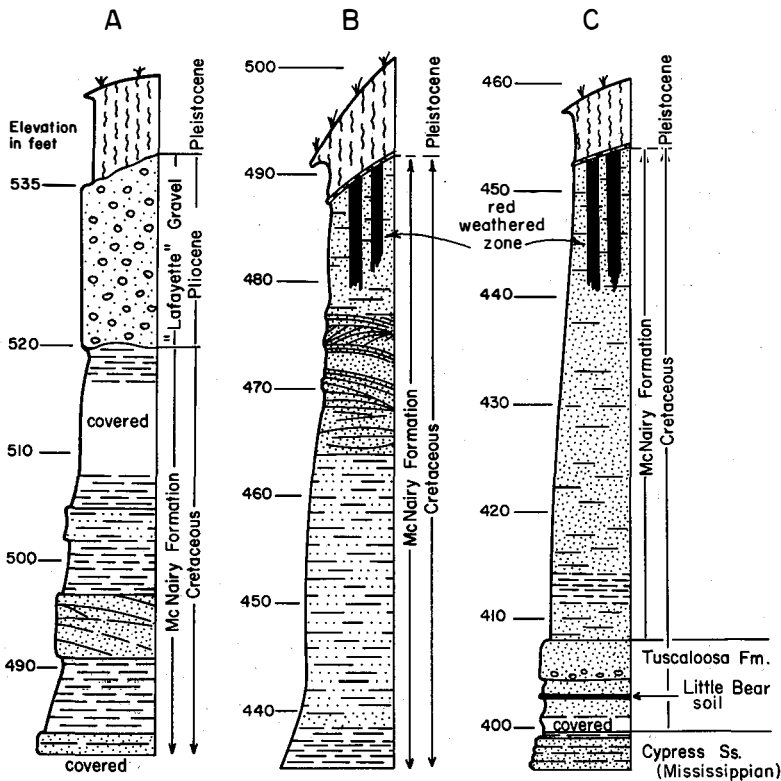


Fig. 9 - Outcrop sections of the Tuscaloosa and McNairy Formations: (A) NE $\frac{1}{4}$ sec. 29, T. 15 S., R. 6 E.; (B) SW $\frac{1}{4}$ sec. 23, T. 15 S., R. 6 E.; (C) NE $\frac{1}{4}$ sec. 3, T. 16 S., R. 6 E., Paducah Quadrangle.

Cenozoic Strata

Tertiary System-Pliocene Series

"Lafayette" Gravel.—Chert pebbles cap many of the higher hills and prominences in the northern part of the two quadrangles. Similar chert pebble gravels also crop out at several localities at considerably lower elevation so that several levels of these gravels seem to be present. The relation between these different levels is not thoroughly understood yet, and even within individual levels abrupt changes in thickness and grain size present complicating problems. Their widespread and relatively thin sheet-like distribution suggests that these gravels were deposited in broad braiding channels. Although commonly widespread in parts of southernmost Illinois, small patches of similar gravels occur locally beneath glacial deposits farther north (Horberg, 1946, 1950; Lamar and Reynolds, 1951; Leighton and Willman, 1948, 1949). Potter (1955) studied the petrology of these gravels in southernmost Illinois, Kentucky, Tennessee, and Missouri in the areas where they have nearly continuous distribution. Stratigraphically these gravels lie on a major unconformity in southernmost Illinois that cuts across strata from Ordovician to Eocene in age, and topographically they cap the higher hills.

Fisk (1944) and Leighton and Willman (1949) recognized three erosional surfaces on which typical "Lafayette" Gravel is preserved. Leighton and Willman referred the highest surface, typically developed between 580 and 600 feet elevation in southern Illinois, to the Lancaster surface (Horberg, 1950). The second, called the Smithland surface, is between 450 and 500 feet elevation in southern Illinois. Leighton and Willman referred the third surface at about 400 feet elevation to the Havana Strath. Lower deposits of gravel of the same general type locally contain large concentrations of reworked "Lafayette" Gravel, and where they contain hydrous iron-oxide cement, they are difficult to distinguish from the higher gravel deposits.

These upland gravel deposits are termed "Lafayette" in southern Illinois. The history of the various names applied to the chert gravels and a discussion of the stratigraphic problems associated with them were summarized by Potter (1955, p. 1-3). The "Lafayette" is composed dominantly of dark, olive-brown chert pebbles that may reach $2\frac{1}{2}$ to 3 inches in their longest dimension but are usually smaller, $\frac{3}{4}$ to 1 inch. Most deposits are lenticular. They commonly attain a maximum thickness of 25 to 30 feet but are rarely thicker. The thicker lenses of these gravels are commonly one-half mile wide and several miles long. The coarser gravels have prominent cross-bedding, but many of the finer gravels show little evidence of bedding. The lenticular nature of the gravels is perhaps partly the result of their original deposition. However, dissection of the hills, down slope movement of the gravels, and subsequent deposition of as much as 12 feet of loess may give these deposits a more lenticular character than they had originally. Several of the pebble beds are cemented by hydrous iron-oxides, such as limonite, but these cemented beds are commonly less than 5 percent of the total volume. The basal several feet of the "Lafayette" Gravel may have considerable amounts of admixed red clay and silt, probably derived from the underlying McNairy Formation. In the Smithland and eastern part of the Paducah Quadrangles, the gravel lenses are discontinuous, and large areas of weathered McNairy strata are overlain by a thin layer of gravel, only one or two pebbles thick.

Gravels of the "Lafayette" type occur in several creek beds at about 420 feet elevation, in Barnes Creek in the $NE\frac{1}{4}$ $NE\frac{1}{4}$ sec. 9, T. 15 S., R. 5 E. (Paducah

Quadrangle), and at about 290 feet elevation, in the bank of the Ohio River at Fort Massac State Park in the NE $\frac{1}{4}$ sec. 12, T. 16 S., R. 5 E. (Paducah Quadrangle). Lamar (1929, p. 71) discussed the Western Indiana Gravel Company pit, which operated along Massac Creek about 2 miles north of Metropolis (NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 36, T. 15 S., R. 4 E.). This pit worked a 25- to 40-foot bed of chert gravel that was firmly cemented with hydrous iron-oxides. Six to eight feet of silty stream sediments overlie this chert gravel. Elsewhere in the southern part of the map area, well records show similar gravels overlying the McNairy Formation (fig. 2).

The base of the highest of the gravel levels in the map area decreases in elevation from nearly 540 feet in the northeastern part of the Paducah Quadrangle to about 440 feet at the western edge of the quadrangle. This decrease in elevation is apparently accomplished by several subsidiary terrace levels or "steps" (fig. 2), which may be related to the fault pattern of the underlying Mississippian strata (see p. 20), and possibly the result of recurrent fault movement in post-"Lafayette" time (Ross, 1963). Just north of the map area in the SE $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 28, T. 14 S., R. 5 E. (Brownfield Quadrangle), the bed of a small creek exposed the Cretaceous McNairy Formation and "Lafayette" Gravel with steep dips apparently related to a fault in the underlying Chesterian sandstone. The vertical displacement is more than 20 feet. Whether this faulting also is younger than the Pleistocene terraces is difficult to ascertain; however, it may be responsible for the locally irregular surface on some terraces north of Metropolis.

The area near the village of Round Knob, about 6 miles north of Metropolis, has marked changes within short distances in the elevation of the "Lafayette" Gravel that are suggestive of faulting near the edge of the Dixon Springs Graben. As indicated by the Cretaceous sediments and their distribution (Ross, 1963) and the recorded earthquake activity (Moneymaker, 1960; McGinnis, 1963), the fault

STAGE	SUBSTAGE	LOESS UNIT
RECENT		
WISCONSINAN (Glacial)	Valderan	Peoria
	Twocreekan	
	Woodfordian	
	Farmdalian	
	Altonian	Roxana
SANGAMONIAN		
ILLINOIAN (Glacial)		Loveland
YARMOUTHIAN		
KANSAN (Glacial)		?
AFTONIAN		
NEBRASKAN (Glacial)		

Fig. 10 - Pleistocene nomenclature.

blocks beneath this part of the Mississippi Embayment have had renewed displacements and are currently active. There seems no reason to assume that these blocks ever have been completely inactive since their initial faulting. Thus, some of the anomalous elevations of the "Lafayette" Gravel surfaces may be the result of faulting, and some of the broader flexures may be the result of warping.

Quaternary System-Pleistocene Series

Pleistocene deposits of the map area (fig. 10) consist of (1) the Loveland, Roxana, and Peoria Loesses, up to 15 feet in total thickness, found on the higher hills and only part of the Peoria Loess on the lower Pleistocene terrace (Leighton and Willman, 1950; Leonard and Frye, 1960; Frye and Willman, 1960); (2) water-deposited silts, sands, and pebbly sands, 20 to 40 feet thick, that form terraces; and (3) sand and gravels of the Ohio River alluvial valley, derived from glacial outwash. These deposits directly overlie

Mississippian, Cretaceous, or Tertiary strata in most of the area. The distribution of these deposits is complicated by a relatively recent shift in the Ohio River from its former course in the deep alluvial Cache Valley southward through the narrow bedrock channel from Bay City to the mouth of the Cumberland River and then westward into the Tennessee River along a bedrock channel.

Pleistocene Terraces.—Along the Illinois side of the Ohio River in the map area, two terrace levels (at about 335 feet and 400 feet elevation) are formed in light green to medium gray silts with thin lenses of gravel and sand. The streams flowing south in this area commonly lie in these silts, but the succession is not exposed extensively. The two terrace levels are traceable from near Hamlettsburg westward to Joppa, about 23 miles. The Ohio River cuts against banks of older strata upstream from Hamlettsburg and downstream from Joppa. North of Hamlettsburg to Bay City, small remnants of only the lower terrace are preserved. Much of the bottomland of Cache Valley is formed by a terrace having this lower elevation.

Part of the silt sequence may be seen near Choat, 2½ miles west of the Paducah Quadrangle, where the upper 30 feet of terrace deposits are well exposed (fig. 11). Well records also indicate that 35 to 40 feet of these silts lie above gravels of the "Lafayette" type near Metropolis. Silts of this general type are known from elevations as high as 420 feet, and in much of the map area they have been dissected to form extensive low hills for 4 or 5 miles back from the Ohio River. Because of this dissection, it has been possible to recognize only two terrace levels, although higher and intermediate terrace levels probably were present at one time.

The silts, sands, and gravel lenses are well bedded and laminated. These quiet water deposits probably were derived from the Tennessee River system before the Ohio River abandoned the Cache Valley and broke through the low divide at New Liberty to join the Tennessee River during the later part of the Pleistocene. However, many questions as to the origin of these silts and their place in the stratigraphic history of the map area are not entirely answered.

Loesses.—The uplands and terraces of the map area are mantled by loess, which is well exposed in many roadcuts. In the uplands, the loess typically overlies red-brown weathered McNairy or orange-brown "Lafayette" Gravel. The upper surface of the McNairy is commonly covered by a thin, 1- to 6-inch sheet of reworked "Lafayette" Gravel pebbles and locally may have iron-oxide cemented lenses. The loess is thickest near the village of Round Knob, where because of proximity to the Cache Valley, it may reach up to 15 feet in thickness. It thins gradually to the southeast to 7 or 8 feet in thickness. On the lower terrace, the loess is generally less than 3 feet thick.

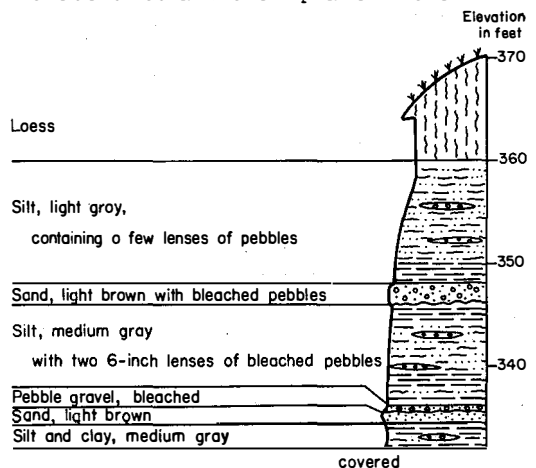


Fig. 11 - Pleistocene terrace section near Choat, Illinois, center of north line, sec. 28, T. 15 S., R. 4 E., LaCenter Quadrangle.

The lower part of the loess sequence is very clayey and red-brown to brown in color. Higher, the loess becomes less clayey and lighter in color.

The following typical loess sequence is exposed at about 420 feet elevation along an east-west road at the southwest corner of sec. 15, T. 15 S., R. 5 E. (Paducah Quadrangle):

		Thickness (inches)
Present soil	Zones A and B	6 to 12
Peoria Loess	Light brown to gray-brown silt	30
	Medium brown to red-brown clayey silt	8
	Light brown silt	12
Roxana Loess	Medium brown clayey silt	8
Loveland Loess	Red-brown, very clayey silt, mottled; contains manganese and iron-oxide nodules	18
"Lafayette" Gravel	Gravel, $\frac{1}{2}$ - to 1-inch pebbles; iron-oxide cemented sand at base	0 to 6
McNairy Formation	Red to red-brown weathered sand	more than 36

Shift of Ohio River.—During late Pleistocene time, the Ohio River shifted from the broad alluvial bottomland of Cache Valley into a narrow channel through the low divide between the Cumberland and Tennessee Rivers near New Liberty. As the Cumberland River is entrenched in a meander valley that closely parallels the Cretaceous-Paleozoic contact and the Tennessee River is similarly entrenched in a valley that closely parallels the Cretaceous-Tertiary boundary in this area, the Tennessee River apparently flowed westward before the diversion, and the Cumberland River flowed northward to the Cache Valley at Bay City. The transfer of the Ohio River from Cache Valley, thus, was up the Cumberland River, across the divide near Hamlettsburg, and down the lower reaches of the Tennessee River. The diversion of the river across the divide may have resulted from an unusually high river level such as the Kankakee Flood (Leighton and Willman, 1949). However, the divide is abreast of the Paducah Graben and in line with faults farther to the southwest that are known to have been active in relatively recent time (Ross, 1963), which suggests that renewed movement on this structure could be responsible for the drainage transfer.

Recent.—The Recent alluvial deposits that underlie the floodplains of the smaller streams are generally 4 to 8 feet thick and are composed of reworked material from the terrace deposits and older formations. Pebbles of "Lafayette" Gravel are common. The streams apparently were gradually building up the surfaces of their floodplains in areas back from the Ohio River until the uplands came under fairly extensive cultivation in the late 1800's. Cultivation and the resultant increase in surface runoff have shifted the regime of these streams so that at present they are scouring deep gullied channels. The Recent alluvial deposits of the Ohio River floodplain are silts and sands, which are 30 to 40 feet thick. These overlie coarse river gravels and sands, which reach 100 feet in thickness in the Black Bottom area.

STRUCTURE

The structural framework of the Paducah and Smithland Quadrangles is related closely to the structure of the Illinois-Kentucky fluorspar district and to the structure of the Mississippi Embayment (Ross, 1963).

In the map area, the Cretaceous and early Tertiary strata of the Mississippi Embayment Syncline dip gently south and southwest and overlap on to the Paleozoic rocks, which dip north and northeast and which form the southern flank of the Illinois Basin. The axis of the Embayment Syncline cuts across the southern flank of the Illinois Basin and is nearly parallel to the set of northeast trending faults that form major grabens from the Illinois-Kentucky fluorspar district southwestward beneath the sediments of the Mississippi Embayment.

The distribution of Paleozoic rocks beneath the overlapping Cretaceous sediments is shown by Ross (1963, fig. 6). The Paleozoic strata are broken by numerous faults that are, for the most part, the southwestward extension of the structural pattern of the Illinois-Kentucky fluorspar district (Weller, 1920; Weller, 1940; Stonehouse and Wilson, 1955; Weller, Grogan, and Tippie, 1952; Weller and Sutton, 1951; Heyl and Brock, 1962). The major faults generally strike northeast and are aligned to form a series of subparallel grabens in which the beds generally dip irregularly northward. Marked changes in stratigraphic displacement occur along these faults. The faults extend farther than the main displacement of the downwarped grabens. Where the displacement of the main graben diminishes, narrow extremely complex fault zones take up the main displacement. This is well shown by the southwestern extension of the western fault zone on the Rock Creek Graben. In addition to the northeast trending fault system, there are a few northwest trending faults.

Three major graben belts (fig. 12) cross the map area: the Dixon Springs Graben, extending across the northwest corner of the area; the Rock Creek Graben, entering the northeast corner of the Paducah Quadrangle and extending to the southwest passing beneath Cretaceous sediments; and the Paducah Graben, a poorly exposed graben, which extends from Hamlettsburg south-westward toward Paducah, Kentucky, and which is a narrow complex fault zone in its Illinois' length. In addition to these major grabens, the intervening areas are commonly broken by northeast trending faults, which generally parallel the bounding faults of the grabens. The displacements are seldom as great on these faults as on those bounding the major grabens.

The northeast trending system of faulting that dominates the structural framework had its major development in the interval between Pennsylvanian and Cretaceous time, but it has been recurrently active to the present time. Renewed displacements occurred in latest Cretaceous time after the deposition of the McNairy Formation and before the deposition of the Owl Creek Formation. Movement after Eocene deposition but before deposition of "Lafayette" Gravel aided in preserving a portion of the Wilcox Formation to the west near Mound City and perhaps aided in its removal elsewhere. Evidence previously noted suggests that locally some faulting has displaced beds as young as the "Lafayette" Gravel, and earthquake activity in the upper part of the Mississippi Embayment suggests that this system of faults is still active. The continuation of the major northeast-trending fault system southwestward in part forms the zone of flexure and faulting along the axis of the Embayment Syncline. The Reelfoot Lake Fault Escarpment is along this trend and is still traceable after its movement of 1811 and 1812

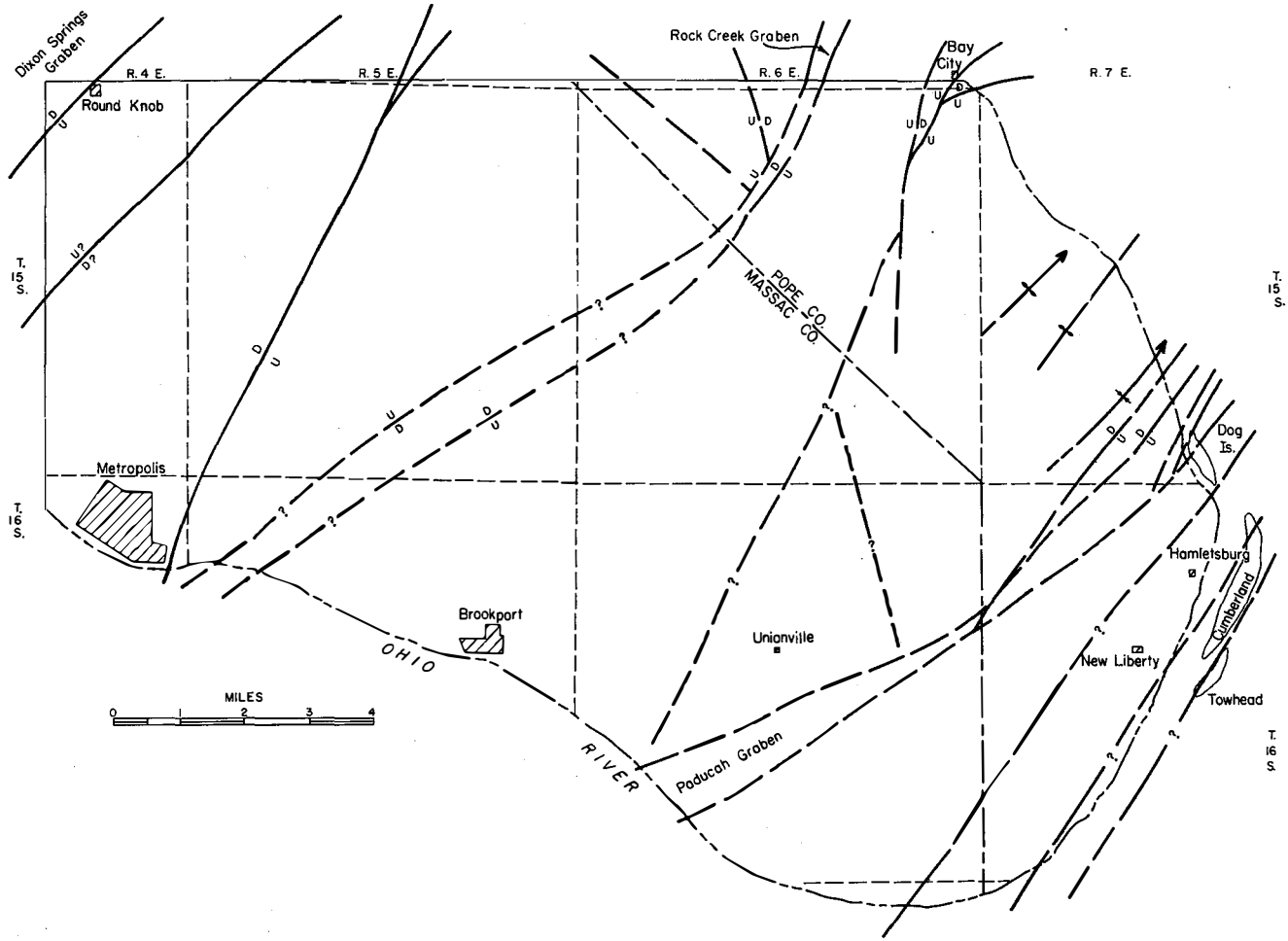


Fig. 12 - Generalized map of probable faults in underlying Mississippian strata, Smithland and Paducah Quadrangles.

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(Fuller, 1919). Moneymaker (1960) and McGinnis (1963) illustrated the pattern of recorded earthquakes that is closely related to this zone.

Intrusive igneous rocks, although not found within the map area, are locally associated with the major zones of faulting a few miles to the northeast and east (Diller, 1892; Rust, 1937; Currier, 1944; Weller and Grogan, 1945; English and Grogan, 1948; Clegg, 1955; Clegg and Bradbury, 1956; Bradbury, 1962).

MINERAL RESOURCES

Limestone

The limestone resources of the map area are discussed by Lamar (1959, p. 50-52), who suggested that the Ste. Genevieve Limestone and various Chesterian limestones may be possible sources of stone for Portland cement-making, concrete aggregate, road stone, agricultural limestone, and other such uses. In the map area, the Ste. Genevieve Limestone lies at shallow depths beneath the hills near Hamlettsburg in sec. 9 and 10, T. 16 S., R. 7 E. (Smithland Quadrangle) and in sec. 33, T. 15 S., R. 7 E. (Smithland Quadrangle), and the Glen Dean Limestone crops out in sec. 3 and 4, T. 15 S., R. 6 E. (Paducah Quadrangle).

Sandstone

The Mississippian Chesterian sandstones, the Bethel, Cypress, and Tar Springs Sandstones, if crushed and properly processed may be sources of silica sand, molding sand, furnace sand, and sand for other industrial uses (Briggs and Lamar, 1955). Some of these, where fresh, are probably suitable building stone. These sandstones underlie much of the Pope County part of the map area beneath a thin loess or thin Cretaceous cover.

Sand and Gravel

The alluvial deposits of the Ohio River floodplain and of the low terrace are sources of sand and gravel that have been used locally for road surfacing, base course, and concrete aggregate. Numerous gravel pits are located in the "Lafayette" Gravel, many on or near the ridge tops, but one pit removed gravel of the "Lafayette" type from a submerged pit along Massac Creek in NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 36, T. 15 S., R. 5 E. (Paducah Quadrangle), north of Metropolis (Lamar, 1929). Thick lenses of gravel are easily accessible on hill and ridge tops above 500 to 520 feet elevation throughout most of the Paducah and Smithland Quadrangles in Illinois. The "Lafayette" Gravel is an important source of road metal in the map area. Local thick lenses of gravel in the Ohio River alluvium are also used for road metal, but the gravel is somewhat finer in size (up to 1 $\frac{1}{2}$ inches in diameter) than the "Lafayette" Gravel. The very fine to fine sands of the McNairy Formation are very silty and have not been exploited to any extent for economic purposes. The sand resources of the general area have been described by Shrode and Lamar (1953).

Clay and Shale

The clay and shale resources of Massac and Pope Counties are discussed by Lamar (1948, p. 74-103). Some of the Chesterian shales would be suitable probably for making common brick and tile and, within the map area, the Fraileys Formation in sec. 32, T. 15 S., R. 7 E. (Smithland Quadrangle) offers easy access

and minimum overburden. The Cretaceous clays are generally thin and lenticular within the map area but locally may be economically feasible as sources of clay for refractories, structural clay products, flue liners, paving brick, roofing tile, flower pots, stoneware, pottery, sewer pipe, terra cotta, and fillers.

Vein Deposits

Although the structure of the Mississippian strata is similar to, and probably a continuation of, that of the fluorspar district (Weller, Grogan, and Tippie, 1951; Baxter, and others, 1963) 15 miles to the northeast, no extensive mineralization has been commercially developed in this map area. Several prospect pits have been opened, particularly in the NW $\frac{1}{4}$ sec. 9, T. 15 S., R. 6 E. (Paducah Quadrangle) and in the center of the N $\frac{1}{2}$ sec. 33, T. 15 S., R. 7 E. (Smithland Quadrangle). Calcite mineralization fills joints in the Glen Dean Limestone exposed in the bank of the Ohio River in SE $\frac{1}{4}$ sec. 36, T. 14 S., R. 6 E. (Smithland Quadrangle), but barite and fluorspar were not observed.

Petroleum

Only two wells have been drilled to depths greater than 4,000 feet in this map area in the exploration for oil—the Marshall, No. 1 H. McGhee, NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 3, T. 16 S., R. 5 E. (Paducah Quadrangle); and the Rigney & Dodson, No. 1 J. H. Lewis, SW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 18, T. 16 S., R. 7 E. (Smithland Quadrangle), which reported a slight show of oil near the top of the Devonian carbonate sequence. A regional study of petroleum possibilities, which included the Paducah and Smithland Quadrangles, was published by Weller (1940).

Ground water

Most of the water wells extend into the gravels at the base of the Tuscaloosa to reach adequate supplies of ground water, although several small quantity wells have sources in the sands of the McNairy Formation and in gravels in the "Lafayette" (Pryor, 1956). Much of the southwestern part of the map area is underlain by fractured, jointed, and cavernous Mississippian limestones that are potentially good sources of ground water. Shallow wells in the alluvial deposits of the Ohio River supply water for many farms in the Black Bottom area.

APPENDIX A

Summary of Rigney and Dodson Oil Company, No. 1 J. H. Lewis well SW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 18, T. 16 S., R. 7 E., Pope County. Samples and electric log studied by E. Atherton, August, 1963. Cable tool samples studied to depth 1842 feet. Depths below 1450 feet adjusted to electric log.

	Thick- ness	Bottom		Thick- ness	Bottom
QUATERNARY SYSTEM			No sample	5	360
No samples	60	60	Limestone, cherty, slightly silty		
Silt, orange brown, sandy, clayey	5	65	dark grayish brown, little light		
Chert gravel	20	85	gray, very fine to coarse,		
Sand, gray, subangular, medium	3	88	fossiliferous, <i>Endothyra</i> ; lime-		
Chert gravel	27	115	stone, argillaceous, brownish		
Chert gravel; sand, gray, fine to			black, dense, shaly	12	372
medium, subangular	25	140	Limestone, cherty, dark grayish		
Chert gravel	12	152	brown, dense to sublithographic;		
MISSISSIPPIAN SYSTEM			limestone, as above	7	379
Valmeyeran Series			Limestone, cherty, grayish brown,		
St. Louis Limestone			little light gray, dense.	16	394
Limestone, cherty, dark grayish			Limestone, cherty, brownish gray,		
brown, dense to sublithographic	8	160	light gray, fine to coarse,		
Limestone, cherty, brownish gray,			fossiliferous	10	404
dense	5	165	Limestone, argillaceous, brownish		
Limestone, cherty, medium dark			black, dense, shaly; little		
brownish gray, very fine to fine,			limestone, light gray, coarse	5	409
dense	5	170	Limestone, dark grayish brown,		
Poor sample (chert gravel, caved)	10	180	dense, with brownish black shaly		
Limestone, cherty, medium dark brownish			streaks		420
gray, dense to sublithographic,			Limestone, slightly cherty, brownish		
fossiliferous	20	200	gray, light gray, fine to coarse;		
Limestone, cherty, brownish gray,			little limestone, argillaceous,		
dense, fossiliferous	17	217	dark brownish gray, slightly shaly,		
Salem Limestone			brownish black	15	435
Limestone, dark grayish brown,			Jame, in part with <i>Endothyra</i>	18	453
dense to sublithographic, in part			Limestone, slightly oolitic, brownish		
very finely sandy	13	230	gray, very little light gray, fine		
Limestone, silty, medium dark			to coarse grained, fossiliferous,		
grayish brown, very fine to fine,			in part with <i>Endothyra</i> , lower part		
dense	14	244	slightly cherty	48	501
Limestone, medium dark grayish			Limestone, oolitic, dark grayish		
brown, sublithographic, trace			brown, medium to coarse	6	507
oolitic	8	252	Limestone, very silty, dark grayish		
Limestone, cherty, dark grayish			brown, extra fine; little limestone,		
brown, in part dense, in part fine			brownish gray, light gray, fine		
to coarse grained	6	258	to coarse, fossiliferous	13	520
Limestone, cherty, silty, dark			Limestone, very silty, cherty, dark		
brownish gray, very fine, dense;			brownish gray, extra fine	11	531
little limestone, dark brownish			Limestone, very cherty at top,		
gray, very fine to coarse, dense,			brownish gray, little light gray,		
fossiliferous	20	278	fine to coarse, fossiliferous	33	564
Limestone, silty, dark brownish			Limestone, very silty, dark brownish		
gray, extra fine, dense	10	288	gray, extra fine; little limestone,		
Limestone, as above; little chert,			as above, slightly cherty	23	587
brownish black	7	295	Limestone, very silty, dark		
Limestone, cherty, dark brownish			brownish gray; limestone, cherty,		
gray, dense; limestone, brownish			brownish gray, light gray, very		
gray, fine to coarse grained,			fossiliferous	16	603
<i>Endothyra</i>	8	303	Limestone, slightly cherty, light		
Limestone, slightly cherty,			gray, brownish gray, fine to coarse,		
argillaceous, shaly, brownish			fossiliferous	9	612
black	7	310	Limestone, brownish gray, dense to		
Limestone, as above; limestone,			sublithographic; little limestone,		
dark brownish gray, fine to			as above	13	625
coarse, dense	12	322	Limestone, slightly cherty, brownish		
No samples	8	330	gray, little light gray, dense	21	646
Limestone, dark grayish brown,			Limestone, brownish gray to light		
little light gray, fine to coarse,			gray, fine to coarse, fossilifer-		
fossiliferous	6	336	ous	7	653
Limestone, slightly cherty, dark			Limestone, very fossiliferous,		
brownish gray, fine to coarse,			light gray, drab gray	17	670
dense, fossiliferous, with brownish			Same, but cherty	30	700
black shaly streaks	14	350	Limestone, cherty to very cherty,		
Limestone, grayish brown, little			light gray, brownish gray, fine		
light and dark gray, fine to			to coarse, fossiliferous; little		
coarse grained, <i>Endothyra</i> ; lime-			limestone, very silty, dark		
stone, as above	5	355	brownish gray	22	722

	Thick- ness	Bottom		Thick- ness	Bottom
Limestone, silty to very silty, cherty, dark brownish gray, little shaly, brownish black; limestone, cherty, brownish gray to light gray, fossiliferous	18	740	Kinderhookian Series Chouteau Limestone Limestone, argillaceous, brownish gray, sublithographic (No Hannibal or Saverton Shale recognized.)	4	1540
Harrodsburg Limestone			DEVONIAN SYSTEM		
Limestone, slightly cherty, medium light brownish gray, little light gray, in part speckled dark gray, mostly coarse, fossiliferous	16	756	New Albany Shale Group		
Limestone, brownish gray, little light gray, some dark grains, mostly coarse, fossiliferous	13	769	Shale, black, dark brownish gray streak, trace pyritic	140	1680
Limestone, very cherty, brownish gray light gray, fine to coarse, fossiliferous; little shale, calcareous, brownish black	6	775	Shale, black; shale, medium, dark gray, non-calcareous	15	1695
Limestone, medium light brownish gray, little pale gray, fine to coarse, very fossiliferous	8	783	Shale, as above; trace of siltstone, gray, pyritic, with black shale partings	9	1704
Limestone, cherty to very cherty, brownish gray, light gray, some dark grains, fine to coarse, fossiliferous; in lower part, little shale, very dark gray	31	814	No samples	25	1729
Same, but extra cherty	18	832	Shale, black; trace pyrite; trace of fine laminae of siltstone, gray	37	1766
Fort Payne Chert			Shale, black, slightly pyritic; little shale, dark gray	16	1782
Limestone, silicified, dark grayish brown, dense, grading to chert; trace of shale, black	49	881	Shale, black, pyritic, dark brownish gray streak	25	1807
Limestone, very silty, siliceous, dark brownish gray to black, grading to chert	7	888	Shale, black; little pyrite; trace of sandstone laminae, calcareous, gray, very fine, compact, very pyritic	16	1823
Limestone, very silty, very cherty, dark brownish gray, little light gray, extra fine; trace of shale, black	8	896	Shale, black; limestone, very dolomitic, argillaceous, black, fine, slightly fossiliferous (Base of New Albany Shale Group)	3	1826
Limestone, very siliceous, dark brownish gray, grading to chert; trace of shale, black	10	906	Lingle Limestone		
Limestone, very silty, cherty, dark grayish brown, dense, little brownish gray to light gray, extra fine	43	949	Limestone, extra cherty, medium to dark brownish gray, very fine, dense to sublithographic; little dolomite, very cherty, brownish gray, very fine to fine, dense	9	1835
Limestone, very silty, dark grayish brown, grading to chert; in part with little limestone, very silty, brownish gray to light gray, extra fine (Base of S.S. #27130)	22	971	Limestone, very cherty, medium to dark brownish gray, dense to sublithographic	5	1840
Limestone, very silty, silicified dark brownish gray, little light gray, grading to chert, very dark gray	255	1226	Grand Tower Limestone		
No sample	6	1232	Limestone, light gray, fine to very coarse, fossiliferous, crinoidal (Base of cable tool drilling; rotary drilling samples begin)	9	1849
Limestone, very silty, silicified slightly cherty, dark brownish gray, little black, extra fine, dense	47	1279	Limestone, light gray, fine to very coarse, fossiliferous; limestone, light brownish gray, very fine to fine	6	1855
Un-named non-cherty member			Limestone, cherty, light gray, few dark grains, fine to coarse, fossiliferous	10	1865
Limestone, very silty, dark brownish gray to black, extra fine, dense, silicified	103	1382	Limestone, cherty, light gray, light brownish gray, fine to coarse, fossiliferous	10	1875
No sample	12	1394	Limestone, light brownish gray, fine to coarse	10	1885
Siltstone, extra calcareous, black, extra fine, dense, silicified	91	1485	Limestone, cherty, light gray, white, fine to coarse, fossiliferous; trace of limestone, sandy, dolomitic, light gray, very fine to fine	5	1890
Siltstone, as above, very glauconitic, to extra glauconitic in part; trace sandstone, extra glauconitic, very dark gray, very pyritic, very fine, compact	13	1498	Clear Creek Dolomite		
Springville Shale			Dolomite, very cherty, gray, brownish gray, very fine; chert, dark gray	10	1900
Shale, medium dark gray, non-calcareous, tough	22	1520	Chert, gray, light gray; dolomite, light gray, gray, very fine	30	1930
Shale, calcareous, medium dark gray	16	1536	Dolomite, very cherty, light gray, gray, very fine	45	1975
			Dolomite, as above; chert, white, slightly dolomitic	50	2025
			Dolomite, as above	5	2030
			Dolomite, cherty, gray, very fine	5	2035
			Dolomite, very cherty, light gray, gray, very fine, calcareous	30	2065

	Thick- ness	Bottom		Thick- ness	Bottom
Same, but cherty, in part with fine light and dark laminae	5	2070	Chert; dolomite, gray, very fine; clear quartz in upper part	30	2705
Dolomite, very cherty, calcareous, light gray, medium dark gray, very fine	5	2075	Chert and dolomite, as above; little limestone, extra cherty, extra silty, dolomitic, medium to dark brownish gray, dark gray, extra fine, dense, silicified	20	2725
Chert, very light gray, little dolomite, medium dark gray, very fine	10	2085	Chert; limestone, extra silty, dolomitic, medium to dark brownish gray, dark gray, extra fine, silicified	40	2765
Dolomite, very cherty, calcareous, light gray to medium dark gray, very fine	20	2105	Limestone, extra cherty, extra silty, dolomitic, medium to dark brownish gray, dark gray, extra fine grading to dolomite; trace of shale, black	30	2795
Same, extra cherty	30	2135	Chert; limestone, extra silty, dolomitic, medium to dark brownish gray, little light and dark gray, extra fine, grading to dolomite (Base of Grassy Knob Chert Member)	60	2855
Same, mostly chert	10	2145	Limestone, very cherty, extra silty, dolomitic, dark brownish gray, extra fine	10	2865
Same, very cherty to cherty	45	2190	Limestone, extra silty, very dark brownish gray, extra fine	10	2875
Dolomite, very cherty to cherty, calcareous, light gray, gray, very fine	25	2215	Limestone, cherty, silty, dolomitic, dark to light gray, extra fine, glauconitic, slightly pyritic, in part dense	10	2885
Same, but cherty, very calcareous, grading to limestone	40	2255	Limestone, slightly cherty, silty, dolomitic, brownish gray, light gray, little dark gray, mostly extra fine, glauconitic, slightly pyritic	10	2895
Limestone, cherty, gray fine to coarse, fossiliferous, fine black grains, green grain	10	2265	Limestone, cherty to very cherty, dolomitic in part, gray to light gray, dense to sublithographic; near base little dolomite, gray, dark gray, extra fine	30	2925
Dolomite, very cherty, very calcareous, light gray, little gray, very fine	30	2295	Limestone, very cherty, dolomitic, brownish gray, little light gray, extra fine, in part dense; dolomite, gray to dark gray, extra fine	50	2975
Limestone, very cherty, dolomitic, drab gray, light gray, very fine, rather dense	20	2315	Limestone, as above; little limestone, dolomitic, dark gray, extra fine, dense	10	2985
Same, but cherty	30	2345	Limestone, very cherty, dolomitic in part, brownish gray to gray, little light gray, little dark gray, extra fine, mostly dense to sublithographic	70	3055
Limestone, very cherty to extra cherty, light gray, drab gray, very fine mostly dense to sublithographic	60	2405	Same, but cherty, mostly sublithographic	40	3095
Limestone, cherty, dolomitic, light gray, little drab gray, very fine, dense in part, glauconitic in part	30	2435	Same, slightly cherty, mostly brownish gray, sublithographic	25	3120
Limestone, cherty to extra cherty dolomitic, light gray, very fine, in part dense	30	2465	SILURIAN SYSTEM		
Limestone, cherty, light gray, very fine to coarse	20	2485	Niagaran Series		
Limestone, very cherty, dolomitic in part, light gray, drab gray, very fine, in part dense	15	2500	Moccasin Springs Limestone		
Limestone, cherty, brownish gray, dense to sublithographic, few dark grains, trace very fine euhedral quartz, trace glauconite	15	2515	Siltstone, extra calcareous, dark gray; limestone, brownish gray, sublithographic	22	3142
Limestone, cherty to very cherty, dolomitic, brownish gray, light gray, very fine, trace glauconite	35	2550	Siltstone, as above, trace with pyrite spicules	32	3174
Backbone Limestone			Limestone, extra silty, gray, sublithographic; siltstone, extra calcareous, dark gray	22	3196
Limestone, cherty, slightly dolomitic, light gray, little brownish gray, few dark grains, very fine to coarse, some dense, slightly glauconitic, fossiliferous	20	2570	No sample	10	3206
Bailey Limestone			Shale, dark gray; little siltstone and limestone, as above	31	3237
Grassy Knob Chert Member			Limestone, extra silty, olive gray to gray, sublithographic; little limestone, very silty, light gray, extra fine; trace of shale, green	10	3247
Limestone, cherty, brownish gray to dark gray, dense to sublithographic	5	2575	Limestone, very silty, olive gray to gray, little light gray, extra fine, dense to sublithographic, lower part very cherty	13	3260
Limestone, extra cherty, dolomitic, brownish gray to dark gray, dense to sublithographic	10	2585			
Chert, bluish gray; limestone, very dolomitic and silty, brownish gray to dark gray, very fine	20	2605			
No sample	10	2615			
Limestone, very cherty, very silty, dark grayish brown, dark gray, extra fine, dense	30	2645			
Same, dolomitic, in part	20	2665			
Limestone, very cherty, very silty, medium to dark grayish brown, dark gray, little light gray, extra fine, dense	10	2675			

PADUCAH AND SMITHLAND QUADRANGLES

	Thick- ness	Bottom		Thick- ness	Bottom
Siltstone, calcareous, dark gray; limestone, as above	16	3276	Limestone, very silty, dark olive gray, little light gray, extra fine to very fine; shale and siltstone, calcareous, very dark gray	45	3745
Siltstone, calcareous, dark red, shaly	6	3282	Shale, calcareous, silty, very dark gray; siltstone, very calcareous, very dark gray; little shale, calcareous, dark gray, smooth	11	3756
Limestone, silty, red, sublithographic; siltstone, as above	26	3308	Shale, calcareous, dark gray, smooth	10	3766
St. Clair Limestone			Champlainian Series		
No sample	17	3325	Galena Limestone Group		
Limestone, light to medium brownish gray, light gray, sublithographic, trace hematitic streaks and grains	10	3335	Limestone, slightly cherty, light to medium brownish gray, light gray, very fine to medium	4	3770
Limestone, red, little gray, light gray, sublithographic, some dark red hematitic grains	20	3355	Limestone, cherty in part, light medium brownish gray, very fine to coarse, slightly fossiliferous, little black (tarry?) material	15	3785
Limestone, light brownish gray, light gray, sublithographic	11	3366	Same, slightly cherty, <u>Receptaculites</u>	10	3795
Shale, red, calcareous (Osgood Shale Member)	2	3368	Limestone, light brownish gray, very fine to coarse	5	3800
Alexandrian Series			Limestone, light gray, light to medium brownish gray, very fine to coarse, fossiliferous	5	3805
Sexton Creek Limestone			Limestone, as above; limestone, brownish gray, sublithographic, slightly cherty	25	3830
Limestone, very cherty, gray, light gray, sublithographic, trace of glauconite	7	3375	Electric Log shows a low-resistive bed suggesting shale or bentonite, not recognized in samples	2	3832
Limestone, very cherty, drab gray, little light gray, sublithographic (No sample 3310-20')	50	3425	Platteville Limestone Group		
Same, but cherty	10	3435	Limestone, brownish gray sublithographic	3	3840
Limestone, cherty, drab gray, brownish gray, little light gray, sublithographic, trace glauconite	15	3450	Limestone, brownish gray, lithographic; little dolomite, brownish gray, very fine	15	3855
ORDOVICIAN SYSTEM			Limestone, as above; limestone, light gray, brownish gray, very fine to coarse, in part chalky	10	3865
Cincinnatian Series			Limestone, dolomitic, light gray, brownish gray, very fine to coarse granular, fossiliferous; little chalk, white	5	3870
Maquoketa Shale Group			Limestone, as above, in part with trace chert	20	3890
Siltstone, very shaly, very dark gray, non-calcareous; little siltstone, gray to dark gray, tough, quartzitic, non-calcareous; trace of pyrite	75	3525	Limestone, brownish gray, sublithographic; little chert, black	15	3905
Limestone, cherty, gray to white, very fine to coarse, glauconitic, fossiliferous; siltstone, as above	10	3535	Limestone, light gray, light brownish gray, very fine to coarse; little chalk, white	10	3915
No samples	20	3555	Limestone, brownish gray, light gray, very fine to coarse granular in part with streaks of brownish black shaly dolomite	15	3930
Limestone, argillaceous, very shaly, in part very silty, dark gray to gray, very fine to coarse, very fossiliferous, few small black Gastropods and coarse, light fossil fragments, trace chert; shale, very calcareous, dark gray	20	3575	Same; with limestone, brownish gray sublithographic	15	3945
No sample	10	3585	Limestone, brownish gray, light gray, very fine to coarse granular: little dolomite, calcareous, brownish black to brownish gray, very fine	5	3950
Limestone, argillaceous, silty, shaly, dark gray, very fine; shale very calcareous, dark gray	20	3605	Same; with limestone, light gray, lithographic	20	3970
Limestone, argillaceous, silty, dark olive gray, little light gray, in part speckled, very fine to fine; shale, very calcareous, dark gray	10	3615	Limestone, brownish gray, light gray, mostly very fine to fine; little limestone, brownish gray, dense to sublithographic; very little dolomite, calcareous, brownish black, very fine	30	4000
Limestone, very silty, dark olive gray, extra fine, rather dense; shale, calcareous, very dark gray	25	3640	Limestone, brownish gray to medium dark brownish gray, lithographic; little dolomite, medium dark brownish gray to brownish black, very fine	25	4025
Same, mostly shale	10	3650			
No samples	10	3660			
Shale, calcareous, very dark gray, silty	10	3670			
Limestone, silty, very finely sandy, dark olive gray, light gray, very fine, in part speckled; limestone, extra silty, dark olive gray to very dark gray, extra fine, grading to siltstone; shale, calcareous, very dark gray	30	3700			

	Thick- ness	Bottom
Limestone, medium dark gray, lithographic; little dolomite, as above	5	4030
Limestone, oolite or calcarenite, brownish gray, medium to coarse; limestone and dolomite, as above	10	4040
Limestone, medium dark brownish gray, dense to sublithographic, trace chert; little dolomite, black, very fine	15	4055
Limestone, gray, lithographic; limestone, medium dark brownish gray, dense to sublithographic	5	4060
Limestone, brownish gray, lithographic	5	4065
Limestone, medium dark brownish gray, lithographic, trace chert, black shale partings	5	4070
Limestone, cherty, medium dark brownish gray, lithographic, few black shale partings	10	4080
Same, slightly cherty; little dolomite, dark brownish gray to brownish black, very fine	20	4100
		TD

APPENDIX B

Wells used in compilation of cross sections (see index map, fig. 2):

1. Smith & Cunningham, Wenike, SE $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 4, T. 15 S., R. 4 E.;
Total Depth 213 feet, studied by E. C. Cockrum.
 2. Smith & Cunningham, Hansman, NE $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 5, T. 15 S., R. 5 E.;
T. D. 100 feet, studied by E. C. Cockrum.
 3. Wittig, Davidson, SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 35, T. 14 S., R. 5 E.;
T. D. 182 feet, studied by W. Lambert.
 4. Smith & Cunningham, Johnson, NE $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 20, T. 15 S., R. 5 E.;
T. D. 185 feet, studied by E. C. Cockrum.
 5. Wittig, Country Club, NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 30, T. 15 S., R. 5 E.;
T. D. 353 feet, studied by W. Lambert.
 6. Smith & Cunningham, Gurley, SE $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 31, T. 15 S., R. 5 E.;
T. D. 206 feet, studied by E. C. Cockrum.
 7. Luth, Metropolis City Well, NW $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 11, T. 16 S., R. 4 E.;
T. D. 420 feet, studied by M. P. Meyer.
 8. Smith & Cunningham, Powers School, NE $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 29, T. 15 S., R. 5 E.;
T. D. 183, studied by E. C. Cockrum.
 9. Metropolis Nat. Well Co., St. John's Church, NE $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 34, T. 15 S., R. 5 E.;
T. D. 223 feet, driller's log.
 10. Marshall, H. McGhee, NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 3, T. 16 S., R. 5 E.;
T. D. 4100 feet, studied by J. N. Payne.
 11. Wittig, School Dist. #36-A, NE $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 1, T. 16 S., R. 5 E.;
T. D. 130 feet, studied by W. Lambert.
 12. Tennessee Valley Authority, Paducah Dam Site borings, well number L - A,
studied by H. S. Rankin.
 13. Tennessee Valley Authority, Paducah Dam Site borings, well number L - 6,
studied by H. S. Rankin.
 14. Tennessee Valley Authority, Paducah Dam Site borings, well number L - 15,
studied by H. S. Rankin.
- Profile D - D'. Tennessee Valley Authority, Dog Island Dam Site borings (part),
studied by H. S. Rankin.
- Profile E - E'. Tennessee Valley Authority, Upper Smithland Dam Site borings (part),
studied by H. S. Rankin.
- Profile F - F'. Tennessee Valley Authority, Lower Smithland Dam Site borings (part),
studied by H. S. Rankin.

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