STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

AREAL GEOLOGY OF THE ILLINOIS FLUORSPAR DISTRICT

Part 3 – Herod and Shetlerville Quadrangles

James W. Baxter
George A. Desborough
Chester W. Shaw

ILLINOIS STATE GEOLOGICAL SURVEY
John C. Frye, *Chief* URBANA

CIRCULAR 413 1967

AREAL GEOLOGY OF THE ILLINOIS FLUORSPAR DISTRICT
Part 3—Herod and Shetlerville Quadrangles

James W. Baxter, George A. Desborough, and Chester W. Shaw

ABSTRACT

This report and map of the Herod and the Illinois part of the Shetlerville 7½-minute Quadrangles complete the geologic remapping of the Illinois fluorspar district. These quadrangles include portions of eastern Pope, western Hardin, and southern Saline Counties and comprise the western part of the mineralized district.

Twenty-nine sedimentary rock units ranging from Lower Devonian to middle Pennsylvanian in age, and two units of Pleistocene age, are differentiated on the geologic map. In addition, the top and bottom of major sandstone members within formations of Pennsylvanian age are delineated wherever possible.

The Herod and Shetlerville Quadrangles occupy a position on the north and west flanks of a large domal anticline that extends southeastward from the Shawneetown-Rough Creek Fault Zone in northern Pope, southern Saline, and southern Gallatin Counties into Kentucky. Hicks Dome, subsidiary to the domal anticline, but located on its axis, forms a structural apex on the eastern margin of the Herod Quadrangle. North and west of Hicks Dome, the strata dip into the Moorman-Eagle Valley Syncline.

Hicks Dome lies between two major northeast-trending grabens that transect the domal anticline—the Rock Creek Graben on the east and the Dixon Springs Graben on the west. Strata between and within the grabens are marked by numerous faults and fractures. Most major faults in these areas trend northeast-southwest but some cross faults are northwest-trending. The north and west flanks of Hicks Dome are marked by numerous radial and arcuate faults; the latter have a concentric relation to the dome.

Intrusive igneous rocks—mica peridotite dikes, lamprophyric dikes, and intrusive breccias with igneous affinities—occur, particularly in the vicinity of Hicks Dome.

Some of the faults and breccias are mineralized and principally carry fluorspar. Fluorspar production has been significant, although small compared to the Rosiclare and Cave in Rock areas. Two limestone quarries are now operating in the vicinity of Shetlerville, both producing from the Ste. Genevieve (Mississippian) Limestone. Coal seams in the Caseyville and Abbott (Pennsylvanian) Formations have been prospected locally but are generally thin and probably not laterally persistent as minable coals.

INTRODUCTION

The Herod $7\frac{1}{2}$-minute Quadrangle and the Illinois part of the Shetlerville $7\frac{1}{2}$-minute Quadrangle constitute the western part of the Illinois fluorspar district and include portions of Pope, Hardin, and Saline Counties (fig. 1). This report is the last of a series of three in which Part 1 (Baxter, Potter, and Doyle, 1963) covered quadrangles in the eastern portion and Part 2 (Baxter and Desborough, 1965) quadrangles in the central portion of the district.

Geologic mapping in the Herod and Shetlerville Quadrangles was carried on jointly by the Industrial Minerals Section and the Coal Section of the Illinois State Geological Survey. The senior author coordinated the mapping program, compiled the geologic map in its final form, and prepared the report. George A. Desborough mapped Pennsylvanian strata and was primarily responsible for the field determination of the Mississippian-Pennsylvanian contact. Chester W. Shaw mapped Mississippian strata of Chesterian age, and James W. Baxter mapped those of Valmeyeran age (fig. 2).

We wish to acknowledge the cooperation received from the mineral industries operating in the district as well as the consultations with numerous colleagues at the Illinois State Geological Survey and with representatives of the U. S. and Kentucky Geological Surveys.

TOPOGRAPHY

The area of this report is part of the Shawnee Hills section of the Interior Low Plateaus Physiographic Province (Horberg, 1950, p. 19, 25). It is an area of rough topography in which ridges mark the outcrop or presence of the resistant sandstone units and depressions mark areas underlain by less resistant shales and limestones. Areas underlain by limestone locally exhibit sinkhole topography.

The topographic surface is one of considerable relief. The highest point,

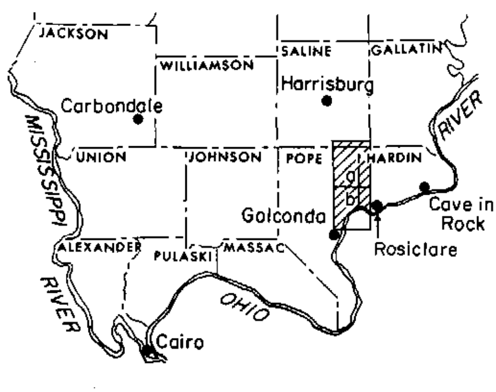


Figure 1 - Part of southern Illinois showing the location of (a) Herod and (b) Shetlerville $7\frac{1}{2}$-minute Quadrangles.

Williams Hill, in sec. 7, T. 11 S., R. 7 E., reaches an elevation of 1064 feet above sea level. Normal pool level of the Ohio River, held by the dam located downstream at Golconda, is 310 feet, giving a total relief of 754 feet.

In the Herod Quadrangle, limestone of Devonian age and an intrusive breccia of uncertain age form a topographic high in the central part of a structural dome that has its apex near the southeastern edge of the quadrangle. The limestone and breccia are surrounded by a belt of less resistant New Albany and Springville Shales that underlie a broad topographic depression, which is bordered by a prominent ridge capped by siltstone and chert of the Fort Payne Formation.

In the quadrangles east of the Herod and Shetlerville Quadrangles, three terrace levels of late Wisconsinan age were recognized at elevations of 350, 360, and 380 to 390 feet. However, the lowest terrace generally cannot be differentiated from the present floodplain of the Ohio River. The intermediate terrace is the best developed and most widespread of the three terraces, and remnants of it are well preserved. The high terrace was not recognized.

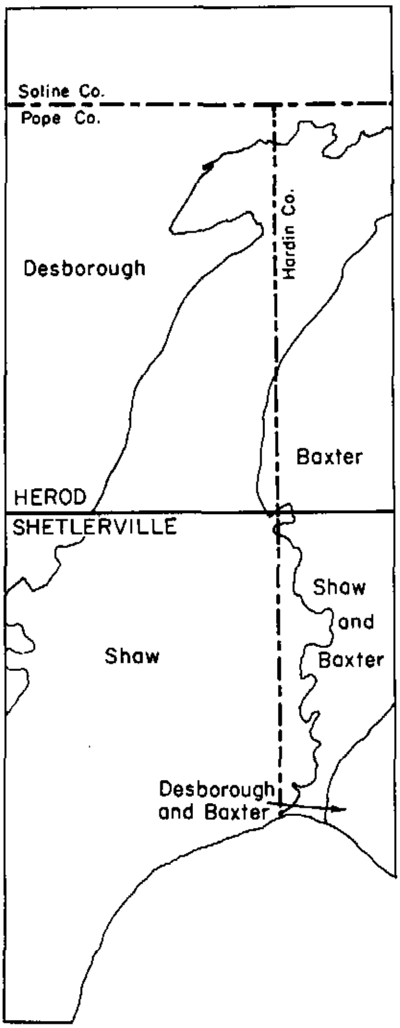


Figure 2 - Areas mapped by Baxter, Desborough, and Shaw.

STRATIGRAPHY

Sedimentary strata that crop out in the Herod and Shetlerville Quadrangles have a thickness in excess of 4000 feet. The stratigraphic column and the manner in which the units are differentiated on the geologic map are shown in table 1. The rock stratigraphic classification shown in figure 3 incorporates recent reclassification of Genevievian and Chesterian rocks (Swann, 1963) and the earlier classification of rocks of Pennsylvanian age (Kosanke et al., 1960).

DEVONIAN SYSTEM

HUNTON LIMESTONE MEGAGROUP

Devonian limestone and chert of the Hunton Megagroup (Swann and Willman, 1961, p. 478) are believed to lie near the surface in a small area at the apex of Hicks Dome in sec. 30, T. 11 S., R. 8 E. and sec. 25, T. 11 S., R. 7 E. Exposures are poor and consist mainly of residual chert. Layers of grayish brown chert in red clay at one time were exposed by the roadside in the SW$\frac{1}{4}$ sec. 30 (Weller, Grogan, and Tippie, 1952, p. 58). The probable thickness exceeds 250 feet, and on the basis of thicknesses in near-

TABLE 1 - STRATIGRAPHIC COLUMN

		Approx. thickness (feet)
Quaternary System		
Pleistocene Series		
Recent (stream alluvium)		
Wisconsinan Stage (terrace deposits, silt and sand)		
Pennsylvanian System		
Kewanee Group		
Spoon Formation (shale)		?
McCormick Group		
Abbott Formation		
Murray Bluff Sandstone (medium to coarse, micaceous sandstone)	50–80	
Undifferentiated (shale, thin-bedded argillaceous sandstone, Delwood Coal Member)	20–80	
Finnie Sandstone (micaceous, argillaceous sandstone)	30–120	* 300–400
Undifferentiated (shale, thin-bedded sandstone, Willis Coal Member)	40–80	
Grindstaff Sandstone (fine- to medium-grained sandstone)	20–120	
Undifferentiated (shale, thin-bedded sandstone)	40–80	
Caseyville Formation		
Pounds Sandstone (medium- to coarse-grained conglomeratic sandstone)	0–100	
Undifferentiated (shale, thin-bedded sandstone, Gentry Coal Member, Sellers Limestone Member)	40–120	* 300–500
Battery Rock Sandstone (medium- to coarse-grained conglomeratic sandstone)	40–120	
Lusk Shale (shale, thin-bedded sandstone)	40–200	
Mississippian System		
Top of Chesterian Series		
Pope Megagroup		
Kinkaid Formation (gray, cherty limestone)		0–80
Degonia Sandstone (shale, thin-bedded siltstone and sandstone, chert)		0–30
Clore Formation (shale, limestone, siltstone, thin-bedded sandstone)		100–120
Palestine Sandstone (sandstone, silty shale, siltstone)		50–60
Menard Limestone (limestone and shale)		100–130
Waltersburg Formation (shale, thin-bedded sandstone or siltstone)		15–50
Vienna Limestone (limestone, shaly limestone)		10–20
Tar Springs Sandstone (sandstone, shale, thin coals)		90–110
Glen Dean Limestone (limestone, shale)		40–70
Hardinsburg Sandstone (sandstone, shaly sandstone, shale)		90–115
Golconda Group		
Haney Limestone (medium- to thick-bedded limestone)	15–50	
Fraileys Shale (shale, siltstone, thin limestone beds)	80–90	* 105–140
Beech Creek Limestone (commonly silty limestone)	5–15	
West Baden Group		
Cypress Sandstone (sandstone, shale, siltstone)		80–100
Ridenhower Formation (shale, shaly sandstone, siltstone, thin limestone lenses)		25–65
Bethel Sandstone (sandstone, basal conglomerate)		80–110

TABLE 1 - Continued

		(feet)
Mammouth Cave Megagroup		
Cedar Bluff Group		
Downeys Bluff Limestone (fossiliferous limestone, shale)		25–40
Yankeetown Shale (shale, siltstone, limestone)	15–30	* 30–45
Renault Limestone		
Shetlerville Member (medium gray, partly oolitic, dense limestone)	15–25	
Top of Valmeyeran Series		
Levias Member (light gray, oolitic limestone, fossiliferous limestone)		15–35
Pre-Cedar Bluff Formations		
Aux Vases Sandstone		
Rosiclare Member (calcareous sandstone, sandy limestone)		15–35
Ste. Genevieve Limestone		
Joppa Member (oolitic limestone, fine-grained limestone)	30±	
Karnak Member (oolitic limestone)	30±	* 120–160
Spar Mountain Sandstone (calcareous sandstone, sandy limestone)	0–7	
Fredonia Member (oolitic limestone, fine-grained limestone)	80–100	
St. Louis Limestone (cherty, fine-grained limestone)		350–400
Salem Limestone (dark-colored, fine-grained limestone, dolomitic limestone, foraminiferal limestone, some chert)		500±
Ullin Limestone (medium- to coarse-grained, crinoidal, bryozoan limestone)		125–360
Knobs Megagroup		
Fort Payne Formation (calcareous siltstone, silty limestone, chert)	200–615	* 225–640
Springville Shale (gray and greenish gray shale, lower 2-3 feet buff to gray shale with calcareous siltstone or limestone lenses possibly equal to Chouteau (Kinderhookian) Limestone)	10–25	
Mississippian and Devonian Systems		
New Albany Group (carbonaceous shale, upper part of Kinderhookian age)		395±
Devonian System		
Hunton Megagroup		
Lingle Limestone (cherty, partly argillaceous limestone)	106**	
Grand Tower Limestone (light-colored, cherty limestone, sandy at base)	144**	250+
Clear Creek Formation (calcareous dolomite and chert, base not exposed)	?	

*Strata enclosed in brackets are mapped together as a unit (pl. 1, in pocket).

**Thicknesses from Maretta Oil Company and Northern Ordnance Company-Fricker No. 1 oil test in SE¼ SE¼ sec. 30, T. 11 S., R. 8 E., on south side of Hicks Dome.

THIS REPORT						J.M. WELLER ET AL., 1952		S. WELLER ET AL., 1920 BUTTS, 1925	
SYSTEM	SERIES	MEGA-GROUP	GROUP	FORMATION	MEMBER (Key members only, in Pennsylvanian)	FORMATION	MEMBER	FORMATION	MEMBER
PENNSYLVANIAN			Kewanee	Spoon		Macedonia		Tradewater	
			McCormick	Abbott	Murray Bluff				
					Finnie	Delwood			
					Grindstaff	Grindstaff			
				Caseyville	Pounds	Pounds		Caseyville	
					Battery Rock	Battery Rock			
					Lusk	Lusk			
MISSISSIPPIAN	CHESTERIAN	Pope		Kinkaid	Goreville *	Kinkaid		Kinkaid	
					Cove Hill				
					Negli Creek				
				Degonia		Degonia			
				Clore	Ford Station	Clore			
					Tygett			Degonia	
					Cora			Clore	
				Palestine		Palestine		Palestine	
				Menard	Allard	Menard		Menard	
					Scottsburg				
					Walche				
				Waltersburg		Waltersburg		Waltersburg	
				Vienna		Vienna		Vienna	
				Tar Springs		Tar Springs		Tar Springs	
				Glen Dean		Glen Dean		Glen Dean	
				Hardinsburg		Hardinsburg		Hardinsburg	
			Golconda	Haney		Golconda		Golconda	
				Fraileys					
				Beech Creek					
			West Baden	Cypress		Cypress		Cypress	
				Ridenhower		Paint Creek		Paint Creek	
				Bethel		Bethel		Bethel	
		Mammoth Cave	Cedar Bluff	Downeys Bluff		Renault	Downeys Bluff	Renault	
				Yankeetown			Shetlerville	Shetlerville	
				Renault	Shetlerville				
	VALMEYERAN				Levias	Ste. Genevieve	Levias	Ste. Genevieve	Lower Ohara
				Aux Vases	Rosiclare		Rosiclare		Rosiclare
				Ste. Genevieve	Joppa		Upper Fredonia		Fredonia
					Karnak				
					Spar Mountain		Spar Mountain		
					Fredonia		Lower Fredonia		
				St. Louis		St. Louis		St. Louis	
				Salem					
				Ullin	Harrodsburg	Warsaw-Salem		Warsaw	
					Ramp Creek				
		Knobs		Fort Payne		Osage Group		Osage	
				Springville		Kinderhook Gp.		Chattanooga	
	KIND.		New Albany			New Albany			
DEVONIAN	UPPER					Alto			
	MIDDLE	Hunton		Lingle		Lingle		"Limestone of Devonian Age"	
				Grand Tower		Grand Tower			
						Dutch Creek			
	LOWER			Clear Creek		Clear Creek			

* Removed by pre-Pennsylvanian erosion in area of this report

Figure 3 - Development of stratigraphic classification.

by wells, the oldest strata reaching the surface are believed to be the upper part of the Clear Creek Formation.

DEVONIAN AND MISSISSIPPIAN SYSTEMS

New Albany Shale Group

The New Albany Shale Group crops out in a relatively broad circular belt on Hicks Dome. The best exposures are in the bed and banks of Hicks Branch, particularly in the NW¼ NW¼ SE¼ sec. 25, T. 11 S., R. 7 E., where the contact with the Springville is exposed. The New Albany Shale is dark gray to black, carbonaceous, and silty. It contains pyrite and flakes of mica and weathers to a dirty brown color. Parts of the shale are somewhat fissile, but some beds up to one foot thick are compact and devoid of internal bedding structure. Recent drilling, less than 6 miles northwest of the outcrop area, penetrated 369 feet of New Albany.

The New Albany Shale overlies the Lingle Limestone of late Middle Devonian age. A lower calcareous portion, probably equivalent to the Alto Formation, overlies the Lingle (Weller, Grogan, and Tippie, 1952, p. 58). Based on regional relationships, a few feet at the top of the New Albany is of Mississippian (Kinderhookian) age (D. H. Swann, personal communication, 1966).

MISSISSIPPIAN SYSTEM

VALMEYERAN SERIES

Springville Shale

The Springville Shale of Valmeyeran age is represented by 10 to 25 feet of gray to greenish gray shale. The shale is exposed in the bed and bank of Hicks Branch in the NW¼ SE¼ sec. 25, T. 11 S., R. 7 E. The basal 2 to 3 feet, consisting of gray to buff shale with lenses of very silty, fossiliferous limestone, may be Kinderhookian in age and equivalent to the Chouteau Limestone. This basal unit conformably overlies the New Albany Shale and grades upward into typical Springville Shale.

The Springville is conformably overlain by the Fort Payne Formation and is mapped with the Fort Payne because it is thin and poorly exposed in the map area.

Fort Payne Formation

The Fort Payne Formation, 200 to 615 feet thick, constitutes a zone of transition between the shales of the Knobs Megagroup and the carbonate rocks of the Mammoth Cave Megagroup. It reaches the surface on the flanks of Hicks Dome, where it forms a prominent encircling ridge. Outcrops occur at various places near the crest of the ridge and along Hicks Branch in the SW¼ sec. 25, T. 11 S., R. 7 E., where that stream cuts through the ridge. Along Hicks Branch, the outcrops consist mainly of an even-bedded, noncalcareous, siliceous residuum with interbeds of clay.

The Fort Payne Formation appears to vary considerably in lithologic aspect, but details of this variation are not well known because of limited exposures and scarcity of drilling data. The Fort Payne consists largely of dark gray to black siliceous limestone and/or calcareous siltstone, parts of which have undergone secondary silicification. In general, a lower part, 50 to 100 feet thick, is somewhat less calcareous and is less affected by silicification. A middle part, 220 to 450 feet thick, is strongly silicified and contains interbedded dark brownish gray, brittle to tough shale. The upper part, as mapped, on the basis of exposures along Hicks Branch, consists of dark gray to black, very silty, cherty, fine-grained limestone in which recognizable fossils or fossil fragments are scarce. The thickness of the upper unit varies, probably being about 125 feet at Hicks Dome.

The contact of the Fort Payne with the underlying Springville Shale is marked by a fairly sharp lithologic change. It is conformably overlain by the Ullin Limestone.

Ullin Limestone

The Ullin Limestone (Lineback, 1966) has been established with formational rank, and the name has been applied to crinoidal-bryozoan beds that, in the map area, overlie the Fort Payne Formation and underlie the Salem Limestone. The Ullin Limestone occupies a position on the flanks of Hicks Dome where poor exposure, known faults, and suspected faults obscure stratigraphic detail.

The Ullin is equivalent to the Harrodsburg Limestone as previously recognized in the subsurface of the Illinois Basin and as used in our earlier report covering the Karbers Ridge Quadrangle (Baxter and Desborough, 1965, p. 7). The name Harrodsburg is now restricted to an upper part of the Ullin Limestone, the Harrodsburg Member, and the name Ramp Creek Member is applied to the impure lower part. This differentiation can be made in the subsurface near Hicks Dome (Lineback, 1966, p. 35), but the members are not readily recognizable in the outcrop area at Hicks Dome.

The Ramp Creek Member consists of cherty, brownish gray, fine- to medium-grained limestone composed of crinoidal-bryozoan detritus that is generally finer grained and darker colored than that of the Harrodsburg. Lineback assigns 200 feet to the Ramp Creek in an oil test located in sec. 32, T. 10 S., R. 7 E., Saline County, about 6 miles northwest of Hicks Dome.

The Harrodsburg Member consists of light gray limestone composed of crinoid ossicles, light gray to almost white chalky matrix, and a variable proportion of sparry calcite cement. The chalky matrix is largely fine-grained fossil detritus, mainly bryozoan material. The thickness of the Harrodsburg Member in subsurface varies greatly. In a well near Cave in Rock, in eastern Hardin County, the Harrodsburg is approximately 270 feet thick and accounts for nine-tenths of the total thickness of Ullin Limestone. The well in sec. 32, T. 10 S., R. 7 E., in Saline County, about 6 miles northwest of Hicks, shows only 160 feet of Harrodsburg, but part of this shortening may be caused by faulting. The Harrodsburg Member has not been definitely identified in the outcrop along Hicks Branch in the eastern part of sec. 26, T. 11 S., R. 7 E., but beds lithologically similar to the Harrodsburg occur on the west side of the small stream in the NW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 6, T. 12 S., R. 8 E., in the adjoining Karbers Ridge Quadrangle.

The total thickness of the Ullin Limestone cannot be accurately estimated for the outcrop area surrounding Hicks Dome because of inadequate exposures and lack of drilling information. Weller et al. (1920) mapped an estimated 250 feet as Warsaw, and Weller, Grogan, and Tippie (1952) called this interval "Warsaw-Salem." It appears now that the lower part (approximately 125 feet) better fits the description of the Fort Payne (Lineback, 1966, p. 22) and that the upper part can be referred to the Ullin Limestone. Therefore, the thickness of the Ullin probably varies from 125 feet or less in the vicinity of Hicks Dome to 360 feet or more in the subsurface to the north and west.

The Ullin Limestone is conformably overlain by the Salem Limestone. Although the Salem contains beds that are lithologically similar to parts of the Ullin, the basal Salem is marked by interstratified, impure dolomitic limestone and increased amounts of chert.

Salem Limestone

The Salem Limestone occupies a belt approximately half a mile wide that encircles Hicks Dome. The best exposures are along Hicks Branch, Buck Creek, and Hobbs Creek on the west and southwest sides of the dome. The upper and lower limits of the Salem are transitional and, therefore, estimates of its thickness vary. Based on cores of wells drilled near Cave in Rock and at Rosiclare, it is about 500 feet thick. This is considered a reasonable estimate for Hardin County.

The Salem Limestone is composed of three distinct units recognized from gross lithologic features in core drillings. The lower unit, approximately 260 feet thick, consists of fossil-fragmental limestone, similar to the Harrodsburg Member, with intercalated dark, fine-grained limestone. Portions of the lower part of the Salem are argillaceous, silty, and dolomitic, with some prominent cherty beds. The middle unit, 100 to 120 feet thick, is largely medium- to thick-bedded, brownish gray, calcarenitic limestone that is oolitic in part and contains abundant endothyroid foraminifers, including Endothyra baileyi. The upper unit, 120 to 150 feet thick, consists predominantly of thin- to medium-bedded, gray to almost black, fine-grained limestone that is somewhat argillaceous and dolomitic. Thin beds and lenses of medium to dark gray calcarenite contain endothyroid foraminifers, including Endothyra baileyi. The colonial coral Lithostrotion proliferum also occurs in the upper unit. Chert is less abundant in the upper unit than in the lower part.

The contact with the underlying Ullin Limestone in subsurface is commonly marked by 15 to 20 feet of fine-grained, silty limestone that is assigned to the Salem. The Salem, in turn, is conformably overlain by the St. Louis Limestone.

St. Louis Limestone

The St. Louis Limestone typically consists of thin- to medium-bedded, brownish gray, sublithographic to fine-grained limestone with characteristic heavy bands and nodules of chert. However, the St. Louis is lithologically variable, having interbedded fossiliferous limestone, fine-grained dolomites, dolomitic limestone, and oolitic limestone. The upper and lower limits of the formation are transitional and, therefore, estimates of its thickness vary. As used here, the St. Louis Limestone includes those strata that occur from the black limestone of the upper Salem upward to within 120 to 160 feet of the base of the Aux Vases Sandstone. As thus defined, the St. Louis is 350 to 400 feet thick and includes beds previously mapped as Ste. Genevieve (Weller et al., 1920); dark, fine-grained limestone previously mapped as St. Louis is assigned to the Salem. The St. Louis crops out along streams west of Hicks Dome, particularly Hicks Branch, Hobbs Creek, and Buck Creek.

The contact of the St. Louis with the underlying Salem Limestone is probably transitional but is generally marked by darker gray and black colors in the Salem, the presence of Endothyra baileyi in the Salem, and an increased proportion of chert in the St. Louis. The St. Louis is overlain conformably by the Ste. Genevieve Limestone.

Ste. Genevieve Limestone

The Ste. Genevieve Limestone crops out in a narrow strip surrounding Hicks Dome but is best exposed in quarry operations in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 23, T. 12 S., R. 7 E., and in the vicinity of Rich Hill, where it is quarried just north of the center of the N$\frac{1}{2}$ SE$\frac{1}{4}$ sec. 35, T. 12 S., R. 7 E. The Ste. Genevieve is 120 to 160 feet thick. It consists of limestone of varying lithologic character and several sandy lenses that appear to be erratically distributed.

The Fredonia Member occurs at the base of the Ste. Genevieve Limestone and consists of gray to light gray, oolitic limestone and medium gray, fine-grained dolomitic limestone. Oolitic limestones of the McClosky type, found in the Illinois Basin area, are well developed locally and occur in thick cross-bedded units. The Fredonia is about 60 to 100 feet thick. Most of this thickness is free of chert.

The Spar Mountain Sandstone Member, the most persistent sandy zone, has been recognized in some drill records overlying the Fredonia Member. It occurs about 60 feet below the Aux Vases Sandstone in the Rosiclare area and where present ranges up to about 7 feet thick.

The upper 50 to 60 feet of the Ste. Genevieve represent two members that cannot be accurately delimited. These are the Karnak and Joppa Members. The interval consists of medium- to thick-bedded limestone layers that are partly fossiliferous and oolitic and generally medium gray in color. They are somewhat darker than the oolitic limestone of the Fredonia Member.

The Ste. Genevieve Limestone is generally lighter colored, purer, and more oolitic than the underlying St. Louis and contains much less chert. The contact is transitional. The Ste. Genevieve is generally conformably overlain by the Aux Vases Sandstone.

Aux Vases Sandstone

The Aux Vases Sandstone is represented in the fluorspar district by the Rosiclare Member, which is equivalent to a part of the Aux Vases of southwestern Illinois (Swann, 1963, p. 30).

Rosiclare Member—The Rosiclare Member of the Aux Vases Sandstone crops out in a narrow arcuate belt that extends from the Hamp mine vicinity in sec. 18, T. 11 S., R. 8 E., in the Herod Quadrangle, to the Stewart Fault near the Baker mine in sec. 14, T. 12 S., R. 7 E. From that point, it extends southward to the Ohio River near Shetlerville.

The Rosiclare Member is 15 to 35 feet thick and consists of very fine-grained, gray or greenish gray, calcareous sandstone or calcareous siltstone with interbedded oolitic limestone. The sandstone is commonly cross-bedded and in some cases ripple marked. The oolitic limestone is commonly silty or sandy. A foot or more of sandy greenish gray shale commonly occurs at the base of the member. Good outcrops of Rosiclare in the Herod Quadrangle occur in the Hamp mines area in the NW$\frac{1}{4}$ sec. 13, T. 11 S., R. 7 E., and in the north-central part of sec. 23, T. 11 S., R. 7 E. In the Shetlerville Quadrangle, the Rosiclare is well exposed in the Rich Hill area east of Shetlerville in the SE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 35, T. 12 S., R. 7 E., and in the upper levels of the quarry in the north-central part of the SE$\frac{1}{4}$ of that section.

The Rosiclare, in general, conformably overlies the Ste. Genevieve Limestone, although at a few places in Hardin County, pebbles of limestone in calcareous sandstone above the basal shale suggest some degree of unconformity at that horizon (Weller, Grogan, and Tippie, 1952, p. 61). The Rosiclare is conformably overlain by the Levias Member of the Renault Limestone.

Cedar Bluff Limestone Group

The Cedar Bluff Limestone Group is predominantly limestone and includes strata from the top of the Aux Vases Sandstone to the base of the Bethel Sandstone. In ascending order, it includes the Renault Limestone, the Yankeetown Shale, and the Downeys Bluff Limestone.

Renault Limestone

The Renault Limestone consists of two members. The lower member, the Levias, is of Valmeyeran age; the upper member, the Shetlerville, is Chesterian (Swann, 1963, p. 31). The Levias is mapped as a separate unit (pl. 1, in pocket); the Shetlerville and the overlying Yankeetown Shale are mapped together.

Levias Member—The Levias Member of the Renault Limestone has an outcrop pattern similar in distribution to the underlying Aux Vases Sandstone. The Levias is 15 to 35 feet thick, averaging about 25 feet. It consists of relatively thick-bedded limestone with only minor amounts of greenish gray shale. The limestone is commonly light brownish gray, medium grained, and partly oolitic. Some beds are medium gray, fine grained to sublithographic. The beds are usually somewhat fossiliferous, and pink crinoid fragments or, in some cases, pink oolites are diagnostic. Levias outcrops in the area are scarce, but the member is well exposed in an abandoned quarry about a quarter of a mile south of Shetlerville in the SE$\frac{1}{4}$ NE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 35, T. 12 S., R. 7 E., and it caps a small hill in the NE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 26, T. 12 S., R. 7 E.

The contact between the Levias and the underlying Aux Vases Sandstone is generally conformable, although a few drill holes in the fluorspar district have a conglomerate zone at the base of the Levias. The Levias is unconformably overlain by the Shetlerville Member.

CHESTERIAN SERIES

Shetlerville Member—The Shetlerville Member of the Renault Limestone occupies a narrow belt adjacent to the underlying Levias Member and crops out occassionally in the lower foreslopes of a ridge capped by sandstones of the West Baden Group located just east of Big Grand Pierre Creek. The Shetlerville, 15 to 25 feet thick, is the basal unit of the Chesterian Series. A lower part, 1 to 4 feet thick, is argillaceous, silty, medium- to coarse-grained limestone that is oolitic at some places. The impure beds locally grade to siltstone at the base. An upper part, 10 to 20 feet thick, commonly consists of relatively pure, partly oolitic, medium-grained to sublithographic limestone with small amounts of interbedded gray shale. The Shetlerville does not crop out extensively, as it tends to be masked by overlying shale and by rubble from the Bethel Sandstone. However, it is exposed at several widely separated points and, on the basis of numerous core drillings, can be assumed to be uniformly present. It can be seen in an abandoned quarry about a quarter of a mile south of Shetlerville in the SE$\frac{1}{4}$ NE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 35, T. 12 S., R. 7 E., where it is about 15 feet thick.

The contact of the Shetlerville with the subjacent Levias Member is unconformable and, in some exposures, marked by a basal limestone conglomerate. The Shetlerville is conformably overlain by the Yankeetown Shale.

Yankeetown Shale

The Yankeetown Shale is not well exposed but is present in drill records and underlies covered intervals in the middle foreslopes of ridges capped by Bethel Sandstone. The Yankeetown is 15 to 30 feet thick. Although largely composed of calcareous, greenish gray or dark gray, fossiliferous shale, it contains beds of interbedded argillaceous dolomite or dolomitic siltstone and buff or greenish gray, medium- to coarse-grained, fossiliferous limestone. Red mottling in the shale, dolomite, and siltstone is diagnostic. Outcrops on the southern slope of a small hill in the SE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 11, T. 12 S., R. 7 E., and in the vicinity of Shetlerville, contain a prolific marine fauna.

The contact between the Yankeetown and the underlying Shetlerville is gradational. The Yankeetown is conformably overlain by the Downeys Bluff Limestone.

Downeys Bluff Limestone

The Downeys Bluff Limestone crops out in the upper foreslopes of the ridges capped by the Bethel Sandstone, which it directly underlies. The Downeys Bluff, 25 to 40 feet thick, consists of gray and brownish gray, fine- to coarse-grained, fossiliferous limestone that is locally oolitic and occurs in thin to medium beds, some of which are notably cross-bedded. Interbeds of light gray shale and some beds of fine-grained, dolomitic limestone are also present. Gray or pink chert is commonly present, especially in the upper part of the formation.

A few feet of greenish or reddish gray shale occurs locally above the top of the limestone. The shale is silty or, in some cases, sandy, is greenish or reddish gray, and, at many places, is calcareous and fossiliferous. Its distribution is probably erratic, but where present, it separates limestone of the Downeys Bluff from sandstone of the Bethel and underlies a conglomeratic zone in the Bethel where the latter is present. Swann (1963, pl. 1) assigns the shale to the Bethel, but in this series it was mapped as a part of the Downeys Bluff Limestone.

Natural outcrops of the Downeys Bluff Limestone are generally few and incomplete in the Herod Quadrangle, but it is seen on many mine dumps and test pits in the Empire mining area. A part of the formation is exposed in the SW$\frac{1}{4}$ NW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 23, T. 11 S., R. 7 E. Outcrops are frequent, but likewise incomplete, throughout the general areas of Eichorn and Shetlerville. The best exposures are on a north-sloping hillside above a house and barn near Shetlerville in the NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 26, T. 12 S., R. 7 E., and in the south-central part of sec. 11, T. 12 S., R. 7 E., half a mile south of Eichorn, where it is exposed in a hill with a small sandstone cap.

The contact between the Downeys Bluff Limestone and the Yankeetown Shale is one of transition marked by a gradual increase in the amount of shale. The Downeys Bluff is unconformably overlain by the Bethel Sandstone.

West Baden Group

The West Baden Group is a thick, predominantly clastic unit composed largely of sandstone. It is more than 200 feet thick and includes three formations: the Bethel Sandstone at the base, the Ridenhower Formation, and the Cypress Sandstone at the top.

Bethel Sandstone

The Bethel Sandstone caps a prominent ridge just south of Pinhook Creek, on the north side of Hicks Dome, and east of Big Grand Pierre Creek, on the west side of the dome. The Bethel continues, with occasional offset due to faulting, to the Ohio River, near Shetlerville.

The Bethel, 80 to 110 feet thick, consists predominantly of light gray, fine- to medium-grained sandstone. Beds in the lower 55 to 70 feet are mostly 1 to 5 feet thick and commonly form bluffs. However, the lower 20 to 30 feet locally has intercalated thin-bedded sandstone, and the basal 15 to 20 feet, at some places, consists of thin-bedded, shaly sandstone. The upper third of the formation consists of light gray, fine-grained sandstone in beds from less than 1 inch to 2 feet thick.

Good outcrops of Bethel Sandstone in the Herod Quadrangle occur along Hicks Branch in the SE¼ sec. 22 and in the SE¼ SW¼ sec. 34, both in T. 11 S., R. 7 E. In the Shetlerville Quadrangle, the sandstone is well exposed in the railroad cut southwest of Shetlerville near the SW cor. sec. 35, T. 12 S., R. 7 E., and caps hills in the general vicinities of Shetlerville and Eichorn.

The unconformable contact between the Bethel Sandstone and the underlying Downeys Bluff Limestone is commonly marked by a basal conglomerate in outcrop and exploratory drilling in the eastern and central parts of Hardin County. However, the conglomerate is rare, or perhaps absent, in western Hardin and eastern Pope Counties. The Bethel is conformably overlain by the Ridenhower Formation.

Ridenhower Formation

The Ridenhower Formation, commonly characterized by shale, shaly sandstone, and one or more thin limestone beds, was difficult to map throughout the fluorspar district. In eastern Hardin County, east of Cave in Rock, the Ridenhower interval is occupied by flaggy sandstone not significantly different from parts of the Bethel or Cypress, whereas in western Hardin and Pope Counties, where the shaly character is better developed, exposures are inadequate for precise delineation of the formation. Mapping of the Ridenhower in the Herod and Shetlerville Quadrangles is largely based on limited outcrops, topographic expression of the shaly beds, and thicknesses as known from drill records.

The Ridenhower Formation is not exposed extensively, because of the prominence of shaly beds. In the Shetlerville Quadrangle, an area of relatively gently dipping beds, the Ridenhower occupies a position well down the dip slope of the Bethel-capped ridge that extends north-south along the Hardin-Pope County line. On the west and north flanks of Hicks Dome, in the Herod Quadrangle, the complete West Baden Group is essentially confined to a single Cypress-capped ridge and the Ridenhower forms a prominent break in slope near the top.

The Ridenhower Formation, 25 to 65 feet thick, consists of light gray, very fine-grained, thin- to medium-bedded sandstone interbedded with and locally grading to shale and/or siltstone. The siltstone is light gray to brown and is more prominent in the lower 10 to 30 feet of the formation. The shale is dark gray to greenish gray and is commonly silty . A few feet of limestone probably occurs locally at the top of the formation, being present in drill holes east of Big Grand Pierre Creek, south of Illinois Highway 146.

The Ridenhower is well exposed in the SW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 34, T. 11 S., R. 7 E., along Buck Creek, where it occurs as a thick sandy shale. In the Shetlerville Quadrangle, greenish gray sandy shale of the Ridenhower crops out along the road near the center of sec. 15, T. 12 S., R. 7 E.

The contact with the underlying Bethel Sandstone is rarely exposed, but as judged on evidence in core drillings, a gradual transition appears from one formation to the other. The Ridenhower is overlain by the Cypress Sandstone, and this contact is at least locally marked by an unconformity.

Cypress Sandstone

The Cypress Sandstone crops out in a belt that swings around Hicks Dome on the north and west, extending along the south side of Pinhook Creek and along the east side of Big Grand Pierre Creek, to the Ohio River west of Shetlerville. The Cypress is generally 80 to 100 feet thick. The lower half to two-thirds is predominantly massive, light gray or buff-colored, fine-grained sandstone, but locally much of the lower unit may be thin-bedded sandstone and silty shale. The upper third to one-half has interbedded shale; subsurface records in the district report green shale and siltstone at the top of the formation.

Numerous outcrops of Cypress Sandstone occur on dip slopes east of Big Grand Pierre Creek, in lower Buck Creek in the SW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 34, and along Hicks Branch in the SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 22, both in T. 11 S., R. 7 E. The Cypress is well exposed along the highway south of Pinhook Creek in the SW$\frac{1}{4}$ sec. 14, T. 11 S., R. 7 E. In the Shetlerville Quadrangle, it is well exposed in a railroad cut on the Ohio River in the NE$\frac{1}{4}$ sec. 4, T. 13 S., R. 7 E.

The contact with the underlying Ridenhower Formation at some places is marked by a conglomeratic zone that encloses shale pebbles and more rarely limestone pebbles. The Cypress is conformably overlain by the Beech Creek Limestone of the Golconda Group or, where the Beech Creek is missing, by the Fraileys Shale.

Golconda Group

The Golconda Group includes those strata, predominantly limestone and shale, formerly referred to the Golconda Formation and comprises, in ascending order, the Beech Creek Limestone, Fraileys Shale, and Haney Limestone. The formational status now assigned to these units raises the Golconda to group rank. The formations are generally recognizable in core drillings and cable tool borings throughout the fluorspar district, but exposures are rarely complete enough to reveal the internal stratigraphy of the group. Therefore, the Beech Creek Limestone, Fraileys Shale, and Haney Limestone are mapped as a single unit—the Golconda Group.

The Golconda Group, 105 to 140 feet thick, crops out in an almost continuous belt adjacent to the alluvial flat of Pinhook Creek, north of Hicks Dome, and Big Grand Pierre Creek, west of Hicks Dome. The Golconda reaches the Ohio River bluffs 1 mile west of the mouth of Big Grand Pierre Creek.

The Beech Creek Limestone is generally less than 10 feet thick and may not be laterally persistent. It consists of slightly argillaceous, fine- to medium-grained limestone that is dark to medium gray and commonly silty or sandy.

The Fraileys Shale, 80 to 90 feet thick, is largely light to dark gray, partly calcareous and fossiliferous shale but has interbedded limestone and siltstone. Limestone interbeds are especially characteristic of the lower 30 to 40 feet, and siltstone occurs near the middle and at the top of the formation. Red and green siltstone are fairly common in the top 10 or 15 feet.

The Haney Limestone is 15 to 50 feet thick and consists of limestone with some interbedded shale. The limestone is brownish gray, fine- to coarse-grained, usually fossiliferous, and partly oolitic. Locally, as much as 10 feet of greenish gray, soft, silty, calcareous shale is present at the top of the Haney. Swann (1963, pl. 1) assigns the top shale to the overlying Hardinsburg; however, it is here considered a part of the Haney in order to be consistent with earlier reports in this series (Baxter, Potter, and Doyle, 1963; Baxter and Desborough, 1965).

In the Herod Quadrangle, the Golconda Group is frequently exposed on the slopes west of Big Grand Pierre Creek and Grand Pierre Lake. It is well exposed in the central part of sec. 14, T. 11 S., R. 7 E., in the north bank of Pinhook Creek. In the Shetlerville Quadrangle, outcrops of limestone occur west of Big Grand Pierre Creek and along the Ohio River from a point near the mouth of Big Grand Pierre Creek to Golconda. Specific localities in the Shetlerville Quadrangle are along Illinois Highway 146 in the SE$\frac{1}{4}$ sec. 21 and in the SW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 9, both in T. 12 S., R. 7 E.

The contact between the Golconda and underlying Cypress Sandstone can be accurately placed at the base of the Beech Creek Limestone, in areas where the Beech Creek is present in its normal form. However, in some core holes the Beech Creek cannot be recognized and the contact lies within a 10- or 20-foot interval. The Golconda is overlain by the Hardinsburg Sandstone; the contact has been generally regarded as unconformable. However, the unconformity occurs at the base of massive sandstone of the Hardinsburg, in many instances located 10 to 30 feet above massive limestone of the Haney. In such cases, the contact appears to be conformable and, as defined for the purpose of this report, transitional. The contact, as defined by Swann (1963, pl. 1), is marked by a sharp change from limestone to shale.

(End of Golconda Group)

Hardinsburg Sandstone

The Hardinsburg Sandstone occupies a position above the Golconda in relatively steep bluffs north of Pinhook Creek and west of Big Grand Pierre Creek. It caps the bluff of the Ohio River from a point 1 mile west of the mouth of Big Grand Pierre Creek to a point just north of Golconda.

The Hardinsburg Sandstone has its maximum development in the Illinois fluorspar district, attaining a thickness of 90 to 115 feet in the map area. Because of the soft nature of shaly beds in the middle and upper parts, the Hardinsburg is not well exposed. Only the lower third is a prominent ridge-forming sandstone.

The stratigraphic sequence of beds in the Hardinsburg is best studied in drill cores, particularly in those from three holes in the eastern half of sec. 9, T. 12 S., R. 7 E., near the center of the map area. A lower part, 40 to 45 feet thick, consists of light gray to white, very fine-grained sandstone in beds up to 2 feet thick. In this fairly massive phase, it is generally indistinguishable from any of several other sandstones of the Pope Megagroup. Cross-bedding is fairly common, but planar beds that break into rectangular blocks are probably more characteristic. Some drill holes show several feet of shaly sandstone at the base of the formation.

A middle thin-bedded unit, 50 to 55 feet thick, consists of interbedded sandstone or siltstone and silty shale in varying proportions, usually in shades of light to dark gray and light to dark greenish gray. Greenish gray to light gray interlaminated sandstone and shale or siltstone and shale are diagnostic.

The upper part, 10 to 25 feet thick, is mostly light gray, very fine-grained sandstone that is commonly ripple marked. Dark gray, silty shale is common in the upper few feet.

The Hardinsburg Sandstone is frequently exposed in road cuts and ditches along the Karbers Ridge Road and is well exposed in a fault exposure in the SW$\frac{1}{4}$ sec. 12, T. 11 S., R. 7 E., in the Herod Quadrangle. In the Shetlerville Quadrangle, it caps hills west of Big Grand Pierre Creek in the north and central parts of sec. 16, T. 12 S., R. 7 E. It crops out in a highway cut in the SW$\frac{1}{4}$ SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 21, T. 12 S., R. 7 E., and is well exposed at the south end of the bluff in the north part of sec. 33, T. 12 S., R. 7 E.

The contact of the Hardinsburg with the underlying Golconda generally has been considered to be unconformable. However, at some places, the massive sandstone of the Hardinsburg is separated from limestone of the Haney by a variable thickness of shale and shaly sandstone. In such cases, there is a gradual transition upward from soft greenish or reddish gray fossiliferous shale to more compact silty or sandy shale and finally to shaly sandstone. At other places, massive sandstone rests directly on limestone of the Haney. The Hardinsburg is conformably overlain by the Glen Dean Limestone.

Glen Dean Limestone

The Glen Dean Limestone is not well exposed but crops out in gullies north of the Karbers Ridge Road on the north flank of Hicks Dome and occupies a position high in the foreslopes of the ridge just west of Big Grand Pierre Creek as far south as Hobbs Creek. From this point, the Glen Dean outcrop belt swings southwest and, though interrupted by minor faults, extends to the southwest corner of the Shetlerville Quadrangle.

The Glen Dean Limestone consists of interbedded limestone and shale; as a consequence, it is not well exposed and is difficult to map. Drill core information is mostly limited to two areas—the Shelby and McGuire properties in the SE$\frac{1}{4}$ sec. 9, T. 12 S., R. 7 E., near the center of the map, and the Rose Creek mine in the S$\frac{1}{2}$ sec. 11, T. 11 S., R. 7 E., in the northern part of the map. The records show a range in thickness from about 40 to nearly 70 feet, with the formation roughly divisible into three units.

The lower unit, 15 to 18 feet thick, consists of brown, fine- to coarse-grained, fossiliferous limestone that has abundant bryozoan and crinoid fragments. Single-crystal crinoid ossicles with characteristic overgrowths in optical continuity give the crinoidal beds a marked crystalline appearance. The middle unit, 11 to 15 feet thick, consists of smooth, calcareous, dark gray shale. The upper unit, 15 to 38 feet thick, has interbedded brownish gray or brown, fine- to coarse-grained, fossiliferous limestone and gray shale. Differences in observed thickness of the upper unit are due at least in part to pre-Tar Springs erosion. A fairly massive limestone layer 6 to 9 feet thick generally occurs at the base of the upper unit, and the upper 10 to 12 feet, where not eroded, is predominantly shale.

The Glen Dean is very poorly exposed in the Herod Quadrangle but can be seen in a test pit dug on a fault north of Honeycomb Church in the NE$\frac{1}{4}$ NE$\frac{1}{4}$ SE$\frac{1}{4}$

sec. 11, T. 11 S., R. 7 E., and in large float blocks in another faulted area in the NW$\frac{1}{4}$ NW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 22 of that township. In the Shetlerville Quadrangle, good continuous exposures of limestone occur along a gully and in a small quarry in the NW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 29, T. 12 S., R. 7 E., east of Gowins. Good outcrops also occur in a steep northeast-trending gully in the SE$\frac{1}{4}$ SW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 5, T. 13 S., R. 7 E., also in the Shetlerville Quadrangle.

The basal contact of the Glen Dean is usually marked by an abrupt change from dark gray or dark greenish gray shale of the Hardinsburg to limestone. The Glen Dean is unconformably overlain by the Tar Springs Sandstone.

Tar Springs Sandstone

The Tar Springs Sandstone crops out in a narrow, practically continuous, belt that extends from the NW$\frac{1}{4}$ sec. 7, T. 11 S., R. 8 E., to the Shelby Fault of the Hobbs Creek Fault System at the center of sec. 17, T. 12 S., R. 7 E. South of the Hobbs Creek faults, the Tar Springs occupies an outcrop belt approximately 1 mile wide that extends southwest to the edge of the Shetlerville Quadrangle.

The Tar Springs Sandstone is a thick important clastic unit in the southern Illinois outcrop area. In the Herod and Shetlerville Quadrangles, it is 90 to 110 feet thick and consists of sandstone and shale. The full formation was cut in core drilling in the Rose Creek mine area in the NE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 11, T. 11 S., R. 7 E., and 70 to 80 feet of Tar Springs, including the lower contact, was cut in drilling in the Shelby-McGuire area in the SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 9, T. 12 S., R. 7 E., where the Tar Springs occurs at the surface.

Thick alternating layers of light gray or buff-colored, fine-grained, cross-bedded sandstone and relatively thin- and even-bedded shaly sandstone make up the Tar Springs, although considerable lateral variation is seen in the amount and relative position of the shaly beds. Whereas in eastern Hardin County the lower part of the formation is usually pure, light gray to white sandstone with very little shale, in the quadrangles studied there is a tendency for the complete Tar Springs to have interbedded gray and dark gray, often silty, shale. However, shale is most characteristic of the upper part, and some beds become carbonaceous and in some cases include a thin, impure coal bed. At least two and possibly three of these coals are present—one near the top of the Tar Springs, another about 20 feet below the top, and possibly a third near the middle of the formation.

Outcrops of Tar Springs in the Herod Quadrangle are common, and the characteristic thin coal at the top is frequently exposed. Good exposures occur in the S$\frac{1}{2}$ SE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 15, in the NE$\frac{1}{4}$ sec. 28 along the road east of Hogg Cemetery, and in the S$\frac{1}{2}$ NE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 11—all in T. 11 S., R. 7 E. At the latter locality, shaly sandstone and a thin coal have been exposed in a test pit at a depth of about 10 feet. Good exposures of unusually massive sandstone make cliffs 30 to 40 feet high along Simmons Creek in sec. 31, T. 12 S., R. 7 E., and thin- to thick-bedded sandstone ledges are well exposed in the Hurricane Hollow area in sec. 6, T. 13 S., R. 7 E.

The basal Tar Springs unconformity is more pronounced and more frequently encountered than that at the base of the Hardinsburg; in some cases, a good part of the shale at the top of the Glen Dean has been eroded before the deposition of the Tar Springs. The Tar Springs is conformably overlain by the Vienna Limestone.

Vienna Limestone

The Vienna Limestone is 10 to 20 feet thick and poorly exposed but is assumed to be persistent throughout the map area. Widely separated outcrops have been observed in gullies far down dip slopes formed on Tar Springs Sandstone.

The Vienna Limestone consists of impure, commonly siliceous, dark brownish gray, fine-grained limestone and shale. Its presence in outcrop is commonly marked by a zone of residual chert and silicified fossils. The limestone occurs either as a massive bed or as several beds with interbedded medium to dark gray shale.

Fairly good exposures of Vienna Limestone occur on the west flanks of Hicks Dome in Pope County and in the Shetlerville Quadrangle. The better outcrops in the Herod Quadrangle are just east of the road in the NW¼ NW¼ NE¼ sec. 22 and west of the road near Hogg Cemetery in the SE¼ SW¼ NE¼ sec. 28, both in T. 11 S., R. 7 E. Good outcrops in the Shetlerville Quadrangle are found in a stream bank near the center of the NW¼ SE¼ NE¼ sec. 8, on a hillslope in the NE¼ NW¼ sec. 20, north of Gowins north section line in the NW¼ NW¼ NW¼ sec. 29, and in the NW¼ NW¼ NE¼ sec. 31, all in T. 12 S., R. 7 E. The Vienna also crops out in a stream bank in the NW¼ NW¼ NE¼ sec. 12, T. 13 S., R. 6 E., and in a gully bottom and test pit in the SE¼ NW¼ NW¼ sec. 6, T. 13 S., R. 7 E.

The basal contact of the Vienna Limestone is relatively sharp; the change to limestone usually comes a few feet above the uppermost thin coal bed in the Tar Springs Sandstone. The contact with the overlying Waltersburg Formation is commonly transitional from greenish gray calcareous shale through silty shale to shaly sandstone. It has been common practice in the fluorspar district to include the lower 5- to 10-foot calcareous part of this transition in the Vienna (Weller, Grogan, and Tippie, 1952, p. 67, 74; Baxter, Potter, and Doyle, 1963, p. 18), but Swann (1963, p. 38) assigns all this shale to the Waltersburg. The Vienna Limestone as defined is generally 6 to 15 feet thick.

Waltersburg Formation

The Waltersburg Formation is moderately resistant, at some places capping a low dissected ridge line. At other localities it occupies a position on the lower foreslopes of ridges capped by Palestine Sandstone. The Waltersburg is about 40 feet thick in much of the map area and consists of shale with thinly interbedded sandstone and siltstone. The shale is dark gray, commonly silty, and in the lower 10 to 20 feet may be calcareous and contain ironstone concretions. The sandstone is greenish gray, very fine grained, thin bedded, and grades to coarse siltstone; the latter is predominant in many outcrops and drillings.

The Waltersburg is not well exposed in the Herod Quadrangle, but in the Shetlerville Quadrangle, it crops out along a stream and on a hillside east of the road in the NE¼ NE¼ sec. 8, T. 12 S., R. 7 E. A good outcrop of sandstone and shale lying between exposures of Menard and Vienna Limestones is in the NW¼ NW¼ NW¼ sec. 29, T. 12 S., R. 7 E.

The basal contact of the Waltersburg was described in the discussion of the Vienna Limestone. The Waltersburg is conformably overlain by the Menard Limestone.

Menard Limestone

The Menard Limestone occurs in several fault-bounded slices east and south of Herod and in the foreslopes of a narrow ridge extending from Big Grand Pierre

Creek, in the NW$\frac{1}{4}$ SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 15, T. 11 S., R. 7 E., to the Hobbs Creek Fault System in the SW$\frac{1}{4}$ sec. 17, T. 12 S., R. 7 E. South of the Hobbs Creek Fault System, the Menard underlies Palestine-capped hills to the west edge of the Shetlerville Quadrangle, a distance of about 3 miles.

The Menard Limestone is 100 to about 130 feet thick and consists of three named members, predominantly limestone, with intervening unnamed shale intervals. In ascending order the limestone members are the Walche, Scottsburg, and Allard Members.

The limestone is predominantly dark brownish gray, dense, and in beds 1 to 3 feet thick. Limestone units 10 to 15 feet thick, with only minor shale partings, are commonly present and are representative of the named members. The Walche Member, at the base of the Menard, is generally 3 to 8 feet thick and somewhat argillaceous and fossiliferous. The Scottsburg Member, 30 to 40 feet thick, consists of thick-bedded, grayish brown, sublithographic limestone with interbedded shale. The limestone in the lower part of the member has abundant specimens of the brachiopods Composita subquadrata and Spirifer increbescens. Although these fossils are not restricted to the Menard, beds from which the whole fossils can be broken out of the enclosing limestone with relative ease are considered diagnostic. The Scottsburg is commonly dolomitic, and portions weather to a bright brownish orange color. The Allard Member, 30 to 35 feet thick, consists of dark gray, fine-grained limestone, contains small nodules of chert, and commonly has beds of dolomitic limestone that weather yellowish brown in outcrop.

The Menard Limestone is well exposed in a stream bank west of the road in the Herod Quadrangle in the SE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 15, T. 11 S., R. 7 E., and good outcrops of fossiliferous Menard occur east of Illinois Highway 34 and east of the Partain Cemetery in sec. 10, T. 11 S., R. 7 E. In the Shetlerville Quadrangle, the Menard is well exposed in a gully and along adjacent slopes in the SE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 1, T. 13 S., R. 6 E., and good outcrops are found in a stream bank and up adjacent southerly slopes just south of the road in the north-central part of sec. 8, T. 12 S., R. 7 E. The Menard also crops out in the SW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 31, T. 12 S., R. 7 E., just east of a small cemetery.

The basal contact of the Menard is not well exposed but is probably somewhat gradational. It can be picked with reasonable accuracy in drill holes having a well developed Walche Member. The Menard is overlain unconformably by the Palestine Sandstone.

Palestine Sandstone

The Palestine Sandstone outcrop belts are distributed similar to those of the Menard Limestone. The Palestine generally forms small bluffs or ledges; small cuestas are prominent in areas where the strata dip 5 to 15 degrees.

The Palestine, 50 to 60 feet thick, consists of light gray to yellowish gray, very fine- to medium-grained sandstone with considerable interbedded, carbonaceous, dark gray, silty shale and siltstone. Shale and siltstone are especially common in the upper part. Generally, the sandstone is thin bedded, even bedded, and ripple marked, although thick- and medium-bedded sandstones with prominent cross-bedding features occur, particularly in the lower part.

Exposures of Palestine in the Herod Quadrangle occur in secs. 10, 11, and 15, T. 11 S., R. 7 E. The Palestine overlies the Menard Limestone over most of the N$\frac{1}{2}$ sec. 10 with frequent exposures along the road running past Partain Cemetery. Thick-bedded ledges in the lower part of the formation are exposed in the NW$\frac{1}{4}$ sec. 11, and a faulted section of Menard, Palestine, and younger strata is well exposed along a creek-cut bank in SE¼ SW¼ sec. 15. In the Shetlerville Quadrangle, good outcrops of Palestine are in secs. 8 and 30, T. 12 S., R. 7 E. The sandstone is well exposed in the north-central part of sec. 8, where it occurs in relatively thick beds that form ledges and talus blocks north of the road, and in the SW¼ SW¼ sec. 30, where it crops out on both sides of Simmons Creek.

The contact of the Palestine with the underlying Menard is generally sharp not only where the basal sandstone represents a channel phase but also where it represents a thin-bedded sheet phase. The Palestine is conformably overlain by the Clore Formation.

Clore Formation

The Clore Formation occurs at the surface along the southern slopes of ridges capped by Pennsylvanian sandstones in the vicinity of Herod. It crops out in a faulted belt that extends from a point in the SW¼ sec. 11, T. 11 S., R. 7 E., just west of the Rose Creek mine area, to Julien Hill and War Bluff in the northwest corner of the Shetlerville Quadrangle. It also reaches the surface in the Wamble Mountain area, in narrow fault-slices along the Shawneetown Fault Zone, and in the Rock Creek Graben.

The Clore Formation ranges in thickness from 100 to perhaps 120 feet and is rarely well exposed. The lithologic character is quite variable vertically and laterally. Limestone, calcareous shale, silty shale, siltstone, and fine- to very fine-grained sandstone are present.

Swann (1963, p. 40) points out the complex cyclic alternation of shale, limestone, and sandstone within the Clore in a manner similar to that of the entire Pope Megagroup, only in miniature. He recognizes upper and lower limestone dominated units and a middle unit in which sandstone is dominant. In ascending order, these are the Cora Limestone, Tygett Sandstone, and Ford Station Limestone Members. However, in the map area, shale is dominant. Limestone beds are rarely observed in place because of the incompetent nature of the shales with which they are interbedded. Although the Tygett is probably the most laterally persistent sandstone horizon in the Clore, at least two other sandstones may be better developed locally. One of these is in the Cora Member and usually lies 5 to 10 feet above the base of the formation; the other is in the Ford Station and lies about 80 feet above the base of the formation. The local development of sandstone adds to the complexity of the Clore and presents problems in correlation, even over short distances, that lead to miscorrelation of the individual sandstones and miscorrelation with the Palestine and overlying Degonia.

Limestones of the Clore are commonly dense, dark gray, relatively impure, and in beds 5 to 20 inches thick. Some beds are dolomitic, weathering to yield yellowish boulders that occur as float in streams. Fossils generally are not abundant, except in some beds in the Cora Member. The shales may be olive green, gray, brown, or dark gray.

Outcrops of Clore are generally small and incomplete. The clore is most often seen in float and is mapped on this basis. However, limestones of the Clore and overlying sandstone, probably the Tygett, are exposed in a small quarry in the SW¼ SW¼ SW¼ sec. 11, T. 11 S., R. 7 E., in the Herod Quadrangle. In the Shetlerville Quadrangle, the Clore is exposed in secs. 7 and 19, T. 12 S., R. 7 E. It can be seen in a gully along the side of a secondary road about a quarter of a mile north of Lusk in sec. 7, and it crops out in an old road, streams, adjacent banks, and hillslopes below War Bluff in the SW¼ NW¼ sec. 19.

The basal contact of the Clore appears to be transitional, grading into the underlying Palestine. The Clore is overlain by the Degonia Sandstone, probably with unconformity.

Degonia Sandstone

The Degonia Sandstone is a thin unit but is mappable in the field where it is overlain by the Kinkaid Formation. The Degonia overlies the Clore in most areas cited above but is locally absent because of pre-Pennsylvanian erosion. The maximum thickness of the Degonia is about 30 feet.

The Degonia is locally represented by a 20- to 30-foot sandstone but is frequently a very fine-grained sandstone, siltstone, or shale. Where not predominantly sandstone, it is common to find the lower part composed of interbedded siltstone and greenish gray, thin- to medium-bedded, fine-grained, micaceous sandstone and the upper part largely composed of shale. Olive green and red shales may be present in the upper part and are locally diagnostic. Ripple-marked chert, up to 7 feet thick, is present at the top of the Degonia, and as much as 2 feet may occur at the base. The chert appears to have been derived from the alteration of extremely fine-grained, calcareous siltstone. At some places in the Shetlerville Quadrangle, the Degonia is less than 15 feet thick and is either a shale, a siltstone, or a very fine-grained sandstone.

The Degonia is not well exposed in the Herod Quadrangle, but small shaly sandstone outcrops occur in the lower foreslopes of hills capped by Pennsylvanian strata in secs. 21 and 28, T. 11 S., R. 7 E., and in the banks of Big Grand Pierre Creek in the E$\frac{1}{2}$ SW$\frac{1}{4}$ sec. 15, T. 11 S., R. 7 E. In the Shetlerville Quadrangle, exposures are equally sparse, but outcrops of ripple-marked chert and sandstone occur on the southeast slopes of Julien Hill in sec. 18, T. 12 S., R. 7 E. Thin Degonia—shale and siltstone and/or shale and very fine-grained sandstone—is seen in the SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 24, T. 12 S., R. 6 E., in the vicinity of War Bluff.

The basal contact of the Degonia with the underlying Clore Formation is at least locally unconformable. The Degonia is conformably overlain by the Kinkaid Formation.

Kinkaid Formation

The entire Kinkaid Limestone is probably not present anywhere east of R. 6 E. and south of T. 11 S. in southeastern Illinois, as it was partially or completely removed by pre-Pennsylvanian erosion. The Kinkaid overlies the Degonia in areas mentioned above, except where removed by pre-Pennsylvanian erosion. Where fully preserved, the Kinkaid consists of three members, in ascending order, the Negli Creek Limestone, the Cave Hill Shale, and the Goreville Limestone Members. The Kinkaid is 0 to 80 feet thick in the map area. The Goreville Limestone Member is probably not present.

The lowest member of the Kinkaid, the Negli Creek Limestone, is present in most of the Shetlerville and Herod Quadrangles, where not removed by post-Pennsylvanian erosion. The Negli Creek is generally represented by 30 to 35 feet of gray and dark gray, dense to medium-grained crystalline limestone that commonly weathers light gray. It is recognized by its massive, thick-bedded character, by the common occurrence of algal limestone (Girvanella) in the lower part, and by large gastropods and small foraminifers near the middle. Interbeds of light gray shale occur near the top.

The Cave Hill Member of the Kinkaid is largely shale with some interbedded limestone and/or dolomite. When present, this member is generally poorly exposed because of its soft nature and steep talus slopes that form at the base of hills capped by basal Pennsylvanian sandstones.

The Cave Hill Member has a thickness of 80 to 100 feet where unaffected by late Mississippian or early Pennsylvanian erosion. However, in the quadrangles mapped for this report, it has a maximum known thickness of approximately 40 feet.

The upper member of the Kinkaid Formation, the Goreville Limestone, is not known to outcrop in the Herod or Shetlerville Quadrangles but may be present locally. North and west of the map area, the Goreville is lithologically similar to the Negli Creek Member, although generally finer grained and less fossiliferous.

The Negli Creek Member of the Kinkaid crops out in the NE$\frac{1}{4}$ sec. 21, T. 11 S., R. 7 E., where it occurs in small isolated outcrops in contact with the Degonia. In the Shetlerville Quadrangle, good outcrops are found in the NE$\frac{1}{4}$ sec. 7, T. 12 S., R. 7 E., but elsewhere outcrops are small and largely masked by Pennsylvanian float.

The Kinkaid Formation conformably overlies the Degonia Sandstone and is unconformably overlain by the Lusk Shale Member of Pennsylvanian age.

THE MISSISSIPPIAN-PENNSYLVANIAN UNCONFORMITY

The Mississippian-Pennsylvanian unconformity is an irregular surface in the Illinois-Kentucky fluorspar district with relief of at least 60 feet in the Herod Quadrangle, where late Mississippian or early Pennsylvanian erosion locally removed formations of late Chesterian age above the Clore. Post-Chesterian erosion cut down as low as the Menard Limestone in eastern Hardin County, Illinois (Baxter, Potter, and Doyle, 1963, p. 21).

At some places, iron oxide-rich layers up to 18 inches thick occur at the unconformity. This has been found in several places in the district. Chert breccia and/or chert conglomerate are commonly present at the unconformity. The matrix may be iron oxides or sandstone that is either ferruginous or clean.

The unconformity generally is not exposed but usually can be established in field mapping with an accuracy of plus or minus 15 feet. The recognition of the highest calcareous shale, chert, or limestone float in streams establishes the top of the Chesterian strata, unless the basal Pennsylvanian rests on sandstones of Chesterian age. In the latter case, identification of the unconformity is often more difficult. However, in the Herod and Shetlerville Quadrangles, the sandstones in the basal Pennsylvanian Lusk Shale are commonly more argillaceous and frequently more ferruginous than those of Chesterian age.

PENNSYLVANIAN SYSTEM

Pennsylvanian sediments constitute about half of the bedrock surface in the Herod Quadrangle and are exposed along the northern and western sides of the study area. These sediments cover a much smaller portion of the Shetlerville Quadrangle north of the Ohio River. They give rise to the most prominent topographic features and form the highest hills and bluffs of the area. Based on extrapolation, the maximum thickness of the Pennsylvanian sediments at any particular locality probably does not exceed 850 feet. Pennsylvanian rocks, constituting most of the McCormick Group, have a thickness of 550 feet near Williams Hill in the Herod Quadrangle. Sandstone and shale are the dominant lithologies of these rocks. In most of the area, massive sandstone units and intervening units, which are dominantly shale, are differentiated in field mapping. However, in some areas, massive sandstone units, which are present elsewhere, are absent.

The Caseyville and Abbott Formations, and certain members of these formations, were differentiated. A small portion of the lower Spoon Formation is probably present and is undifferentiated. Three members of the Caseyville Formation and three members of the Abbott Formation are recognizable in nearly all of the Pennsylvanian outcrop area, except in the vicinity of Williams Hill. Member contacts are projected in only a few areas where there is poor development of individual mappable members.

Certain coal and limestone members of the Caseyville and Abbott, developed in adjacent areas, were not observed in this study area. Thin coals are present in the area but are laterally discontinuous for the most part. No coals exceeding 19 inches in thickness were observed. The lateral lithologic variability of lower Pennsylvanian rocks is well exposed in the area.

McCormick Group

Virtually all of the Pennsylvanian rocks of the area belong to the McCormick Group (Caseyville and Abbott Formations), the thickness of which locally ranges from about 500 to 800 feet. This includes rocks above the Mississippian-Pennsylvanian unconformity and below the top of the Murray Bluff Sandstone Member of the Abbott Formation.

Caseyville Formation

The Caseyville Formation is composed of those strata from the base of the Pennsylvanian to the top of the Pounds Sandstone Member. However, the Pounds Sandstone is not developed in the vicinity of Williams Hill in the area around sec. 7, T. 11 S., R. 7 E.; in this area, the top of the Caseyville has been projected. The formation is between 300 and 500 feet thick in the area and is composed of massive sandstones and shale or thin-bedded argillaceous sandstones. The Battery Rock and Pounds Sandstone Members, both thick, massive sandstones, were mapped, but the Pounds is apparently absent in the northwest part of the quadrangle.

The massive Caseyville sandstones are usually clean and contain quartz pebbles and granules that are locally abundant. Intervening shaly intervals are characterized by thin-bedded sandstones and shales that may be carbonaceous and/or arenaceous. Laterally discontinuous massive sandstone lenses up to 20 feet thick may occur in the dominantly shale intervals between the named massive sandstone members. Massive sandstone members invariably have good topographic expression and are generally conspicuous on aerial photos.

It has been revealed in this study as well as in the investigations of Baxter, Potter, and Doyle (1963) and Baxter and Desborough (1965) that all of the members of the Caseyville Formation in southeastern Illinois are discontinuous at one place or another. In general, the Lusk, Battery Rock, and Pounds Members are mappable units in the area, but locally one or the other may be absent or not well developed.

<u>Lusk Shale Member</u>—The Lusk Shale Member lies above the Mississippian rocks and below the Battery Rock Sandstone. It is a variable unit and generally consists of shale and/or thin-bedded sandstones. However, lenses of massive sandstone from 20 to 70 feet thick may occur in this member.

In the northeastern part of the Herod Quadrangle, the Lusk Member is more than 200 feet thick and contains a massive sandstone that is 70 feet thick in the NW$\frac{1}{4}$ sec. 1, T. 11 S., R. 7 E. Except for this massive sandstone lens, thin-bedded argillaceous sandstone is the dominant lithology. In contrast, the Lusk is a gray to green shale about 40 feet thick in the west-central part of the Herod Quadrangle.

Evidently the Lusk is present in all of the Pennsylvanian outcrop area of these two quadrangles, but its thickness and lithologic character are quite variable. At present, there is no evidence of marked concomitant variation in the thickness of the Lusk and the uppermost Mississippian formations, as indicated by relatively thick Lusk occurring on highest Chesterian strata.

Battery Rock Sandstone Member—Because of the local absence of the Battery Rock Sandstone in the adjacent area to the east (Baxter and Desborough, 1965) and the local presence of a thick, massive sandstone in the Lusk Shale Member of the Herod area, designation of the Battery Rock as the first persistent bluff-forming Pennsylvanian sandstone above the unconformity is generally, but not necessarily, applicable in certain areas.

The Battery Rock Sandstone is present in all of the Caseyville outcrop area of the quadrangles; its thickness ranges from about 40 to 120 feet. Quartz pebbles are common and cross-bedding is conspicuous.

Measurement of cross-bedding dip directions indicates that the transport direction of the Battery Rock Sandstone was largely from east to west or northwest.

Interval between Battery Rock and Pounds Sandstone Members—This interval is characterized by shale and thin-bedded sandstone or interbedded shale and sandstone, and is nonresistant to erosion. Its thickness ranges from 40 to 120 feet where the Battery Rock and Pounds are present. Where the Pounds is absent, in the vicinity of Williams Hill (sec. 7, T. 11 S., R. 7 E.), definition of the interval is lacking, and more than 200 feet of shale, thin-bedded sandstone, and argillaceous sandstones are present below the first massive sandstone in the lower Abbott Formation.

The Sellers Limestone Member was not recognized in the area. The Gentry Coal Member is present in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 25, T. 12 S., R. 7 E., as evidenced by prospect pits; it was not found elsewhere in the area.

Locally, a massive sandstone up to 20 feet thick may occur in this interval.

Pounds Sandstone Member—The Pounds Sandstone is well developed in the northeastern and eastern parts of the Dixon Springs Graben in the Herod Quadrangle, where it forms bluffs up to 100 feet high. This unit is the most laterally persistent massive sandstone in the Caseyville outcrop area east of the Herod area and west of the Ohio River. The bluff-forming character of this sandstone east of the Herod area enables it to be traced for several miles on aerial photographs, except where faulting occurred. Also, the abundance of quartz pebbles and clean character permit easy differentiation of the Pounds Sandstone and sandstones in the overlying Abbott Formation.

North and east of Illinois Highway 34 the Pounds is mapped, but the excellent exposures of about 500 feet of section above the unconformity in the vicinity of Williams Hill reveal that the Pounds Sandstone is absent. East of Williams Hill, in the E$\frac{1}{2}$ sec. 8, T. 11 S., R. 7 E., the presence of several feet of sandstone containing abundant large quartz pebbles indicates that the base of the Pounds is about 100 feet above the Battery Rock Sandstone. The top of the Caseyville Formation in the Williams Hill area has been estimated on the basis of its usual position relative to the Battery Rock Sandstone and the lowest massive sandstone in the Abbott Formation.

The Pounds Sandstone is well developed on the east side of the Dixon Springs Graben, forming bluffs from 40 to 80 feet high. In the graben, the Pounds Sandstone forms impressive bluffs of massive sandstone that are best exposed at One Horse Gap in sec. 31, T. 11 S., R. 7 E.

Abbott Formation

The interval between the top of the Pounds Sandstone and the top of the Murray Bluff Sandstone constitutes the Abbott Formation, which is between about 300 and 400 feet thick in this area. Three sandstone members, the Grindstaff, Finnie, and Murray Bluff, are mapped, and these are separated by shaly intervals of variable thickness.

In the northeastern part of the Herod Quadrangle, the three sandstone members are well developed and are thus readily mapped. In the vicinity of Williams Hill (sec. 7, T. 11 S., R. 7 E.), however, these sandstone members are very poorly developed, as indicated by the presence of about 200 feet of shale, thin-bedded sandstone, and shaly sandstone between an elevation of about 800 and 1000 feet in the NW$\frac{1}{4}$ sec. 7, T. 11 S., R. 7 E. Furthermore, this area presents correlation problems in the Abbott because of the absence of the Pounds Sandstone, which is a useful stratigraphic marker elsewhere.

Locally, the lithologic character of the individual sandstone members in the Abbott Formation is such that hand specimen identification of members is possible. However, at many localities this is not possible. The sandstones in the Abbott Formation generally contain more mica and clay matrix than sandstones in the Caseyville.

Quartz pebbles are locally present in the Grindstaff and Finnie Sandstone Members seen in the Herod Quadrangle. For the most part, however, quartz pebbles are not as common in these members as they are in the Pounds and lower sandstones. The presence or absence of quartz pebbles is not a reliable basis for differentiating sandstones of the Caseyville and Abbott Formations in this area. The contrast in mica content and matrix of Caseyville and Abbott sandstones locally provides a basis for distinguishing between these two formations where faulting obscures the stratigraphic position of a particular unit. The petrographic difference between the Murray Bluff and Battery Rock is evident in hand specimens where these two members lie adjacent to each other along the large fault in sec. 34, T. 10 S., R. 7 E.

Thin coals of the Abbott Formation were observed at a few localities in the area. Sandstone members of the Abbott Formation were not differentiated in the complex fault zone along the west side of the quadrangle.

Interval Below the Grindstaff Sandstone Member—The interval below the Grindstaff Sandstone Member is characteristically composed of thin-bedded sandstone and shale with an occasional lens of massive sandstone less than 15 feet thick. The thickness of this interval is generally between 40 and 80 feet but the thickness is uncertain where the Pounds Sandstone is absent. Because of the nonresistant nature of this interval, it is generally poorly exposed.

The Reynoldsburg Coal Member is apparently present in the graben in the southwestern part of the Herod Quadrangle, where it occurs about 20 feet above the top of the Pounds Sandstone. Although the coal is not exposed, prospect pits and coal float indicate its presence. An 8-inch coal occurring at the position of the Reynoldsburg is present at Williams Hill in the NE$\frac{1}{4}$ sec. 7, T. 11 S., R. 7 E.

Grindstaff Sandstone Member—The Grindstaff Sandstone Member is present as a mappable lithologic unit in all the area east of Illinois Highway 34 and in the Dixon Springs Graben. It is either very thin or not developed in the Williams Hill area. Where the Grindstaff is recognizable, its thickness varies from 20 to 120 feet. Its lithologic character is variable, inasmuch as it shows affinity with sandstone members of both the Caseyville and the Abbott Formations. Commonly, the Grindstaff may be a clean sandstone or contain some mica and clay matrix; most frequently it contains less mica and matrix than the Finnie. Quartz pebbles are locally present (SE$\frac{1}{4}$ sec. 25, T. 10 S., R. 7 E.) but are not as abundant as those in the Pounds Sandstone.

Cross-bedding and ripple marks are common. Disturbed bedding due to penecontemporaneous sliding is not uncommon. The Grindstaff forms much of the dip slope in the southern part of the Dixon Springs Graben and is well developed in the NE$\frac{1}{4}$ sec. 36, T. 11 S., R. 6 E.

Interval between Grindstaff and Finnie Sandstone Members—The interval between the Grindstaff and Finnie Sandstones is largely shale and arenaceous shale and is generally carbonaceous. Locally, lenses of massive sandstone up to 10 feet thick occur in this interval. The thickness of this interval generally ranges from about 40 to 80 feet but locally may be as little as 15 feet. In the NE$\frac{1}{4}$ sec. 1, T. 11 S., R. 6 E., this interval is well exposed and is about 120 feet thick.

The Willis Coal Member is definitely recognized in this interval at two localities, one in the NE$\frac{1}{4}$ sec. 30, T. 10 S., R. 7 E., where it is about 18 inches thick and is in contact with the Finnie Sandstone; the other in the graben in the SW$\frac{1}{4}$ sec. 31, T. 11 S., R. 7 E., where it is 19 inches thick at one exposure. The coal is about 20 feet below the base of the Finnie Sandstone at the locality in sec. 31. A poorly exposed coal in the extreme northwestern corner of sec. 21, T. 11 S., R. 7 E., is believed to be the Willis Coal.

Finnie Sandstone Member—The Finnie Sandstone Member is quite variable in thickness and lithologic character in the Herod Quadrangle and ranges in thickness from 30 to 120 feet. Generally, the Finnie is micaceous, contains a conspicuous clay matrix, and is commonly ferruginous. In the northeastern portion of the quadrangle, the Finnie is medium to fine grained, dirty, micaceous, and less than about 50 feet thick. It is evenly to irregularly bedded, and cross-bedding and ripple marks are common. It rarely forms small bluffs or prominent ledges. The most accessible exposures of the Finnie in this area are in the valley of Eagle Creek in sec. 34, T. 10 S., R. 7 E.

In the northwestern part of the quadrangle, the Finnie is very thick and forms bluffs up to 100 feet high. Bedding thicknesses range from 6 inches to 3 feet in this area, and the sandstone is coarse grained. Quartz granules and small quartz pebbles are common. Ferruginous material is conspicuous on weathered bluffs and ledges.

In the Dixon Springs Graben, the Finnie caps some of the elongate hills on the dip slope. Its thickness exceeds 70 feet in the southern part of the graben.

Interval between Finnie Sandstone and Murray Bluff Sandstone Members—The interval between the Finnie Sandstone and the Murray Bluff Sandstone Members is dominantly shale and thin-bedded argillaceous sandstone. The thickness is variable and ranges from about 20 to 80 feet. The interval is present principally in the northern part of the quadrangle. It is poorly exposed in most of the quadrangle but is excellently exposed in the roadcut in the NE¼ sec. 4, T. 11 S., R. 7 E. The Delwood Coal, which occurs in this interval in the Karbers Ridge Quadrangle (Baxter and Desborough, 1965), has not been recognized in the Herod Quadrangle but may be present.

Murray Bluff Sandstone Member—The Murray Bluff Sandstone Member is present along the large fault in the north-central and extreme northwestern parts of the Herod Quadrangle. Its thickness ranges from about 50 to 80 feet, and locally it forms small bluffs. Characteristically, the Murray Bluff is a medium- to coarse-grained massive sandstone that contains abundant mica flakes. The lithologic character of the Murray Bluff is locally less variable than that of the two lower sandstone members of the Abbott Formation. The clay matrix of the Murray Bluff is not conspicuous in hand specimens because of the coarseness of the quartz grains.

The Murray Bluff is well exposed in the NE¼ sec. 25, T. 10 S., R. 6 E., and the NE¼ sec. 34 and the SE¼ sec. 27, both in T. 10 S., R. 7 E.

Spoon Formation

Strata of the Spoon Formation are thought to be present in the northeastern part of the Herod Quadrangle, although no exposures of the interval were recognized. It is possible, however, that strata as high as the Bidwell Coal Member may be present.

QUATERNARY SYSTEM

PLEISTOCENE SERIES

Pleistocene deposits include residuum that accumulated in situ from weathering of bedrock, alluvial deposits of rivers and streams, loess deposited by wind, and colluvium deposited on and at the foot of steep slopes by rainwash and gravity. Only the alluvial deposits—alluvium and terraces of Wisconsinan age—are shown on the geologic map.

Residuum

Limestone bedrock, especially of Valmeyeran age, is commonly overlain by clay that is a residuum from the solution of the limestone by ground water. Solution probably began long before Pleistocene time, but the older residuum cannot be differentiated from the younger. The clay is generally red, brown, or yellow, and often contains an abundance of angular chert fragments. The residuum is usually only a few feet thick, but concentration is produced by local slumpage and wash from nearby hills. Greater thickness also occurs along faults and fractures that have allowed deeper penetration of ground water.

Alluvial Deposits

Recent alluvium and terrace deposits constitute the alluvial deposits. The terraces are remnants of old levels of valley fill that date back to the Wisconsinan Age of the Pleistocene Epoch. Recent alluvium consists mainly of interbedded sand and silt, but beds of coarse gravel (mostly chert derived from local bedrock) occur along many tributary valleys.

A well developed terrace level that reaches an elevation of about 360 feet is recognized along the Ohio River and in the valley of Big Grand Pierre Creek. This terrace corresponds to the intermediate terrace (Qwi) of our earlier reports (Baxter, Potter, and Doyle, 1963; Baxter and Desborough, 1965). A lower terrace may be present locally but is not differentiated from alluvium. The high terrace mapped in reports cited was not recognized in the present quadrangles.

Colluvium

The lower foreslopes of steep ridges are covered by colluvium that was derived from the upper slopes and deposited in its present position by creep, slump, and slope wash. Silt, mostly reworked loess, is predominant, but angular rock fragments are common. The colluvium, as much as 30 feet thick, forms steep-sloped alluvial fans at the mouth of small ravines where it is crudely sorted and contains lenses of stream gravel.

Loess

Loess–nonbedded, buff to light brown clayey silt–covers upland areas onto which it was blown from the valleys of the Ohio River and other major streams. The stream valleys were repeatedly flooded and covered with silt during glacial times. The loess is largely the Peoria Loess of Woodfordian age, but in places, the lower part contains a few feet of dark brown Roxana Silt of early Wisconsinan age. Even more locally, a thin basal deposit of reddish brown, very clayey silt is present and is correlated with the Loveland Silt of Illinoian age.

The loess is commonly 5 to 15 feet thick, but it is as much as 30 feet thick in the Ohio River bluffs.

IGNEOUS ROCKS

Intrusive basic igneous rocks and intrusive breccias that have igneous affinities occur in the Illinois fluorspar district. Their distribution is shown in figure 4. Many of these occurrences have been investigated petrographically, most recently by Clegg and Bradbury (1956), and chemically, by Bradbury (1962). The location of the various outcrops in the Herod and Shetlerville Quadrangles are cited below and are shown by appropriate symbols on the geologic map (pl. 1).

Igneous Dikes

Intrusive mica peridotite and lamprophyric igneous rocks in the Herod and Shetlerville Quadrangles occur as dikes, which are tabular bodies that have a discordant relation to bedding planes in the intruded sedimentary strata. No record of igneous material in the form of concordant sills is found, although such sills occur at Downeys Bluff of the Ohio River south of Rosiclare, 1½ miles east of the map area (Baxter and Desborough, 1965, p. 27). The dikes range from a few inches to over 100 feet wide (Weller, Grogan, and Tippie, 1952, p. 72) and trend northwest-southeast. Commonly, the outcrops have been deeply weathered, and even the freshest material has been altered either by serpentinization, by the addition of carbonates (chiefly calcite), or, less commonly, by silicification (Clegg and

Bradbury, 1956, p. 13). The name, location, and petrographic character of known basic dikes are as follows:

Joiner Dike - NW$\frac{1}{4}$ NE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 36, T. 11 S., R. 7 E., Herod Quadrangle, near Hicks; weathered mica peridotite (now largely concealed).

Mix Dike - NE$\frac{1}{4}$ NE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 18, T. 13 S., R. 7 E., Shetlerville Quadrangle, near Golconda; mica peridotite (now concealed).

Unnamed dike - NW$\frac{1}{4}$ SE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 23, T. 11 S., R. 7 E., Herod Quadrangle, near Herod (now concealed).

Unnamed dike - near middle of west line of SW$\frac{1}{4}$ SE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 26, T. 11 S., R. 7 E., Herod Quadrangle; no further information.

Breccias

Intrusive breccias, associated with structures that have been interpreted as diatremes, are considered "explosion breccias" (Brown, Emery, and Meyer, 1954; Clegg and Bradbury, 1956). The inferred circular or eliptic shape of the areas of breccia outcrop and the size of these areas, up to 200 feet in diameter in some cases, have resulted in the use of such terms as plugs and pipes. However, the true geometric configuration of the breccia bodies is not accurately known. They commonly have igneous affinities consisting of angular to subrounded fragments of sedimentary, metamorphosed sedimentary, and igneous rocks in a matrix of finely ground rock and mineral fragments. The mineral fragments include quartz, pyroxene, augite, hornblende, apatite, mica, and feldspar. The feldspar is partly plagioclase of oligoclase-andesine composition (Clegg and Bradbury, 1956, p. 15).

The name and location of known occurrences of intrusive breccias of this type in the Herod Quadrangle are as follows:

Stacey Breccia - NW$\frac{1}{4}$ NW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 36, T. 11 S., R. 8 E., Herod Quadrangle, near Hicks; large boulder on hillside.

Herod-1 Breccia - SE$\frac{1}{4}$ SW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 1, T. 11 S., R. 7 E., Herod Quadrangle, near Herod.

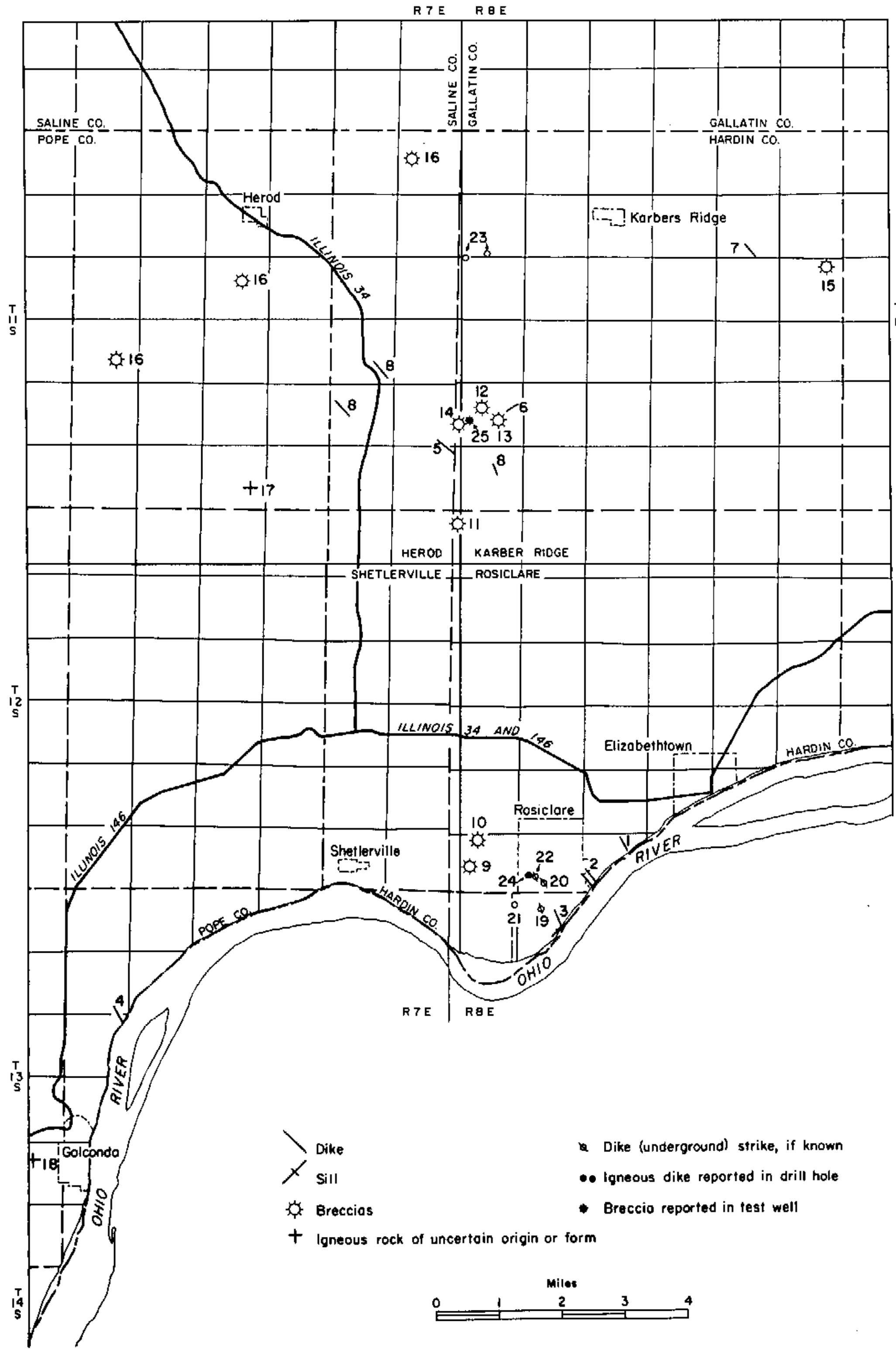
Herod-16 Breccia - NW$\frac{1}{4}$ SW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 16, T. 11 S., R. 7 E., Herod Quadrangle, near Herod.

Herod-19 Breccia - SW$\frac{1}{4}$ NW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 19, T. 11 S., R. 7 E., Herod Quadrangle, near Herod.

Grants Intrusive - SW$\frac{1}{4}$ NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 6, T. 12 S., R. 8 E., Herod Quadrangle, near Eichorn.

Breccia "Dikes"

Recent detailed mapping of the Hicks Dome area has revealed a profusion of vertical or nearly vertical dikelike breccia bodies that, in general, radiate from Hicks Dome. Breccia "dikes" have been seen that are enclosed by New Albany Shale and Fort Payne Chert; others occur in areas underlain by limestone and chert of Devonian age. In general, preliminary examination of hand specimens indicates that the breccia at any locality is composed of silicified fragments derived from strata lithologically similar to the enclosing formations. A study of the relation


R7E
R8E
SALINE CO.
POPE CO.
SALINE CO.
GALLATIN CO.
GALLATIN CO.
HARDIN CO.
Herod
Karbers Ridge
ILLINOIS 34
T 11 S
T 12 S
T 13 S
T 14 S
HEROD
KARBER RIDGE
SHETLERVILLE
ROSICLARE
ILLINOIS 34 AND 146
ILLINOIS 146
Elizabethtown
HARDIN CO.
Rosiclare
Shetlerville
POPE CO.
HARDIN CO.
OHIO
RIVER
Golconda
Dike
Sill
Breccias
Igneous rock of uncertain origin or form
Dike (underground) strike, if known
Igneous dike reported in drill hole
Breccia reported in test well
Miles
0
1
2
3
4

of these features to the origin and history of Hicks Dome, to the intrusive rocks, and to faulting is in progress.

STRUCTURE

Geologic structure in the Herod and Shetlerville Quadrangles encompasses the full spectrum of complexity exhibited in the Illinois fluorspar mining district (pl. 2, in pocket). These quadrangles are located on the north and west flanks of a large, collapsed domal anticline, the axis of which plunges to the southeast (Heyl and Brock, 1961, p. D4; Heyl et al., 1965, p. 9-12). The anticline terminates to the northwest against the Shawneetown Fault Zone and extends to the southeast into Kentucky, where it is displaced southwestward by faulting. It extends south through western Kentucky as the Kuttawa Arch, dying out south of Princeton, Kentucky (Heyl and Brock, 1961, p. D6 and fig. 294.2). Hicks Dome is a structurally complex geologic feature situated near the northernmost extent of the domal anticline and on its axis.

Strata north and northwest of Hicks Dome dip into the Moorman-Eagle Valley Syncline, the axis of which parallels the Shawneetown-Rough Creek Fault Zone and enters the Herod Quadrangle near the west line of sec. 26, T. 10 S., R. 7 E. The syncline is recognized to a point near Herod where it merges with complex faulting of the Herod Fault Zone. Approximately $1\frac{1}{2}$ miles northeast of the synclinal axis another reversal of dip occurs, forming the Horton Hill Anticline. The full significance of this structure, like that of the Eagle Valley Syncline, is obscured by faulting.

Hicks Dome

Hicks Dome is an asymmetrical feature involving approximately 4000 feet of vertical uplift with steeper dips on the north and northwest flanks and lesser dips

---

Figure 4 - Distribution of igneous rocks.

Dikes and Sills (exposed or reported at surface)

1. Orr's Landing Dike
2. Rosiclare dikes
3. Sills and Dike at Downeys Bluff
4. Mix Dike
5. Joiner Dike
6. Robinson Dike
7. Philadelphia School Dike
8. Unnamed dikes (3)

Igneous rocks of uncertain form

17. Pope County granite fragments
18. Golconda "Dike"

Dikes underground in mines

19. Good Hope Dike
20. Blue Diggings 600 and 700 Level Dike
21. Blue Diggings 300 Level Dike
22. Argo dikes
23. Hamp mine dikes

Breccias (exposed or reported at surface)

9. Soward "Plug"
10. North Soward "Plug"
11. Grants "Intrusive"
12. Hicks Dome "Plug"
13. Rose mine "Plug"
14. Large breccia boulder (?)
15. Sparks Hill "Plug"
16. Unnamed breccia occurrences (3)

Igneous rocks reported in drill holes

24. Dike
25. Breccia (Hamp test well)

in other directions. The axis trends approximately N. 35° W., and when extended to the southeast, intersects the Tabb Fault System, lying between Mexico and Princeton, Kentucky. Hicks Dome is complexly faulted; the pattern of faulting, brecciation, and intrusion by igneous rocks is consistent with the view that the dome was formed by gaseous explosions (Brown, Emery, and Meyer, 1954; Heyl and Brock, 1961, p. D6).

Characteristics of Faults

Faults and fault systems in the map area are shown on a scale of 1 inch to a mile on plate 2. Most are classified as to the amount of throw and the downdropped side indicated. The classes are as follows: Class I, faults of large displacement (more than 500 feet); Class II, faults of moderate displacement (50 to 500 feet); and Class III, faults of small displacement (less than 50 feet).

Most faults in the area trend northeast-southwest. Two major grabens dominate the fault patterns in the area. Each is bounded on the northwest by a major fault or fault zone. The southeast boundaries are not as well defined, being characterized by a series of steplike faults accumulating downthrow to the northwest.

The Dixon Springs Graben extends from the northeast corner of Pope County southwestward to Bay Bottoms, where it becomes concealed by Cretaceous and younger sediments of the Mississippi Embayment area. In the map area, it is bounded on the northwest by the Herod Fault Zone and on the southeast by the Hobbs Creek Fault System. The Herod Fault intersects the Shawneetown Fault Zone in sec. 25, T. 11 S., R. 6 E. Southwest of that point, the name Lusk Creek Fault Zone is used for the north-bounding fault (Weller, Grogan, and Tippie, 1952).

The Rock Creek Graben crosses the Ohio River between Shetlerville and Rosiclare. It trends approximately N. 20° E. on the Kentucky side of the river, but north of the river it swings abruptly to trend N. 55° E. north and northeast of Rosiclare. The Wallace Branch Fault Zone, an offset continuation of the Illinois Furnace-Interstate Fault trends of the Rosiclare Quadrangle, bounds the graben on the west; on the east, it is bounded by the Big Creek Fault and related faults in the vicinity of Rosiclare (Baxter and Desborough, 1965).

Most faults in the district, particularly those best known from drilling and mining, are high-angle normal faults with fault planes that dip 70 to 80 degrees. However, the district apparently has had a long and complicated structural history involving normal, strike-slip, and high-angle reverse faulting with each successive event leaving its record.

<u>Northwest-trending faults and fractures</u>—Northwest-trending faults and fractures, such as the Shetlerville Fault and fractures along which igneous dikes are emplaced, parallel the axis of the large domal anticline to which they are genetically related. They formed early in relation to other faults, possibly from tensional stresses set up by intrusion of a large body of magma deep within the basement complex (Heyl and Brock, 1961, p. D6; Weller et al., 1920, p. 56).

<u>Radial faults and fractures</u>—Tension faults and fractures radiate from the central area of Hicks Dome. The faults are most numerous at those places where there was spatial coincidence between the local forces that formed Hicks Dome and the earlier forces that formed the northwest-trending domal anticline.

<u>Arcuate faults</u>—Arcuate faults, crossing radial faults, occur around the flanks of Hicks Dome. Most of them curve or lie roughly concentrically around the dome.

They probably are related to tensional forces, but later collapse movements increased their displacement and perhaps concomitantly offset them. Hence, they may not cross radial faults directly, as mapped.

Northeast-trending faults—The northeast-trending faults shown in plate 2 apparently were formed by partial collapse of the domal anticline, possibly combined with compressive forces acting along the Shawneetown-Rough Creek Fault Zone, as suggested by Heyl and Brock (1961, p. D6). Evidence of high-angle reverse faults along the Shawneetown-Lusk Creek Fault Zones and horizontal slickensides associated with major northeast-trending faults in the fluorspar district indicate that the relative importance of the strike-slip and high-angle reverse faulting as compared to normal faulting has been underestimated. Evidence of strike-slip faulting supports the hypothesis that the northeast-trending faults are related to the New Madrid Fault Zone, which acted as shear relief fractures for the Shawneetown-Rough Creek Zone.

Description of Important Faults

Names have been given to a number of faults that are important for geologic or economic reasons. The location, extent, and other information on these are pertinent.

Empire Fault—The Empire Fault is a northeast-trending fault that crosses the SE¼ sec. 27, T. 11 S., R. 7 E. It cannot be accurately traced very far into the area of thick limestone surrounding Hicks Dome and may possibly continue farther than mapped. The fault plane dips steeply to the southeast and is downthrown in that direction, probably about 15 feet. The Empire Fault carries the Empire Vein (Weller, Grogan, and Tippie, 1952, p. 81).

Hamp Fault—The Hamp Fault is an arcuate fault that occurs on the north flank of Hicks Dome in the NE¼ sec. 13, T. 11 S., R. 7 E. Over much of its extent in the Karbers Ridge Quadrangle, the fault plane dips steeply and is downthrown to the south. Near its western end, however, crosscutting faults or other causes appear to result in downthrow to the north. The Hamp Fault is mineralized, principally with fluorspar.

Herod Fault Zone—The Herod Fault Zone extends across the Herod Quadrangle from sec. 25, T. 11 S., R. 6 E., where it emerges from the Lusk Creek Fault Zone, to a point near Herod, where it splits into two faults. Along this course, downthrow is to the southeast. From the split near Herod, one branch, downthrown on the northwest, continues east of north, closely paralleling the axis of the Eagle Valley Syncline. The southernmost branch is offset but continues north of east, bounding an area of complex faulting in the vicinity of the Rose Creek mine. The Herod Fault Zone has minor occurrences of barite and fluorspar mineralization, which have been prospected.

Hobbs Creek Fault System—The Hobbs Creek Fault System bounds the Dixon Springs Graben on the southeast. It is a system of interconnected faults a quarter to half a mile wide that accumulates downthrow to the northwest. Near the Pope-Hardin County line, along Hobbs Creek, it merges into radial and arcuate faulting, probably offsetting the latter. In this connection, arcuate faulting possibly continues across the area between Hobbs Creek and Buck Creek; however, conclusive evidence of this was not obtained. The open pit diggings east and northeast of

Sturgill Cemetery in sec. 3, T. 12 S., R. 7 E., may indicate mineralization related to arcuate faulting with minor displacement.

Pell Fault—The Pell Fault extends north from the Wallace Branch Fault Zone in secs. 25 and 24, T. 12 S., R. 7 E. Displacement along the southern part of the fault is approximately 400 feet, downthrown to the east. Displacement decreases northward so that the fault cannot be traced into the limestone area north of Pell mine. Several mines have been located on the Pell Fault.

Pierce Fault—The Pierce Fault extends across the northern half of sec. 34, T. 11 S., R. 7 E. Displacement is very minor, possibly downthrown slightly on the southeast side (Weller, Grogan, and Tippie, 1952, p. 82). The Pierce Fault carries a narrow fluorspar vein.

Raum Fault—The Raum Fault enters the Shetlerville Quadrangle near the center of the south line of sec. 12, T. 12 S., R. 6 E. It continues northeastward along the foot of Benham Hill to a point near One Horse Gap, where it swings northward, following the foot of an escarpment capped by sandstone of Pennsylvanian age. It intersects the south branch of the Herod Fault Zone, 1 mile southeast of Herod. The Raum Fault is downthrown on the northwest side with displacement generally in excess of 100 feet. It is not known to be mineralized.

Shelby Fault—The Shelby Fault is a part of the Hobbs Creek Fault System. It crops out and has been prospected near the center of the S½ sec. 9, T. 12 S., R. 7 E., where it is downthrown on the southeast side and its fault plane dips southeast at an angle of about 60 degrees (Weller, Grogan, and Tippie, 1952, p. 82). Displacement is about 200 feet locally. The Shelby Fault appears to continue across the limestone area, curving gently northward, passing near Rose mine near the center of Hicks Dome (Baxter and Desborough, 1965, pl. 1 and 2).

Shawneetown Fault Zone—The Shawneetown Fault Zone swings across the northwest corner of the Herod Quadrangle and then southward along the western edge of the quadrangle to the point in sec. 25, T. 11 S., R. 6 E., where it joins the Herod Fault to form the Lusk Creek Fault Zone. The Shawneetown Fault Zone is complex and is dominated by high-angle reverse faulting. Displacement north of the immediate area is locally as great as 3400 feet (Weller, Grogan, and Tippie, 1952, p. 82), but in the Herod Quadrangle, it is not much in excess of 500 feet. Downthrow is to the northwest and west. Some faults of moderate displacement associated with the Lusk Creek Zone have been prospected for minerals. The Rock Candy Mountain workings in sec. 25, T. 11 S., R. 6 E., are examples.

Shetlerville Fault—The Shetlerville Fault trends just west of north for a distance of about 2½ miles from Shetlerville, intersecting the Stewart Fault Zone just north of Illinois Highway 146. Downthrow is to the west with displacement about 50 feet.

Stewart Fault—The Stewart Fault trends about 25 degrees east of north, crossing Illinois Highway 146 near the center of the west line of sec. 23, T. 12 S., R. 7 E., and crossing Illinois Highway 34 near the center of sec. 14, T. 12 S., R. 7 E. Downthrow is to the west, with local displacement as much as 100 feet. Numerous mines and prospect shafts have been opened along about 1½ miles of its mapped extent.

Sycamore Fault—The Sycamore Fault carries the narrow Sycamore Vein and extends north of east through the center of sec. 34, T. 11 S., R. 7 E. Displacement is apparently minor.

Twitchell Fault—The Twitchell Fault extends for at least a mile northeast from the Pell Fault, from a point about 600 feet south of Illinois Highway 146. It is downthrown to the southeast, with displacement from less than 50 to perhaps 100 feet. The Twitchell Fault has been prospected by shafts and diamond drilling.

Wallace Branch Fault Zone—The Wallace Branch Fault Zone forms the western boundary of the Rock Creek Graben and is an offset continuation of the Illinois Furnace-Interstate Fault trend. It is a narrow fault zone in which high-angle reverse faulting was probably important. Local displacement may reach 1000 feet.

Wolrab Mill Fault—The Wolrab Mill Fault enters the Shetlerville Quadrangle from the east, near the northeastern corner of the quadrangle. It does not cross the Stewart Fault in the vicinity of Stewart mine and apparently does not continue into the Parkinson mine area, as previously mapped (Weller et al., 1920; Weller, Grogan, and Tippie, 1952). Throughout its limited extent, the Wolrab Mill Fault is downthrown to the southeast with only minor displacement. It is not known to be extensively mineralized.

ECONOMIC GEOLOGY

The Herod and Shetlerville Quadrangles are situated along the western margin of the southern Illinois mining district. The mining of fluorspar and ores of lead and zinc began in 1839 and has centered chiefly in the Rosiclare and Cave in Rock areas. Outlying deposits, including those covered in this report, were worked intermittently. The geology, mining methods, and metallurgical details involved have been discussed in earlier publications (Weller et al., 1920; Bastin, 1931; Hatmaker and Davis, 1938; Weller, Grogan, and Tippie, 1952). The occurrence, use, and possible value of other mineral resources, particularly quarryable limestone, have been discussed in various publications that are cited in the sections that follow.

FLUORSPAR, LEAD, AND ZINC

Ore bodies in the Illinois-Kentucky mining district are of three general types: (1) bedded deposits, formed by selective replacement of limestone strata; (2) fissure-filling or vein deposits, along faults and fractures; and (3) residual deposits, derived from one of the other types. Known deposits within the area of this report are mainly of the vein type. In some workings, however, replacement ore has been found, usually because of replacement of limestone strata in the foot wall adjacent to the vein.

Commercial production, principally of fluorspar, has come from several deposits; intermittent commercial or marginal production has come from a number of widely scattered properties in the Herod and Shetlerville Quadrangles.

The most important production has come from the Empire, Red, Pierce, Douglas, Slapout, and Hicks Creek mines in the Empire district in secs. 27 and 34, T. 11 S., R. 7 E; the Stewart, Baker, Jefferson, Fairbairn and Humm mines, located along the Stewart Fault in secs. 14 and 23, T. 12 S., R. 7 E.; the Hamp mines in secs. 12 and 13, T. 11 S., R. 7 E.; the Parkinson mine in the SW$\frac{1}{4}$ sec. 22, T. 12 S., R. 7 E.; and the Rock Candy Mountain property in sec. 25, T. 11 S., R. 6 E.

A major portion of the ore has come from vein deposits or from residual deposits derived from veins. A few mines, particularly some in the Empire district and the Hamp mine, have produced replacement ore, as previously stated.

List of Mines and Prospects

Some of the more important mines are identified by name on the geologic map (pl. 1). These, and other properties listed below, are each identified by a reference number that appears at the proper location on the geologic map.

1. Hamp mines
2. Rose Creek mine, Knox shaft
3. Rose Creek mine, Yingling shaft
4. J. R. Hamp mine
5. Rainey (Hutchinson) mine
6. Beecher Williams mine
7. New Baldwin mine
8. Baldwin mine
9. O. Crabb mine
10. Empire mine
11. Empire mine, Egyptian shaft
12. Red mine, old shaft
13. Red mine, new shaft
14. Pierce mine
15. Pierce mine, PMT shaft
16. Pierce mine, PMT shaft
17. Douglas mine shaft
18. Douglas mine shaft
19. Slapout mine
20. Slapout mine, Hicks Creek shaft
21. Churchill shaft
22. Rock Candy Mountain mine
23. Shelby mine
24. Sheldon mine
25. Baker mine, old shaft
26. Baker mine, No. 1 shaft
27. Stewart mine, No. 5 shaft
28. Stewart mine, No. 4 shaft
29. Stewart mine, No. 3 shaft
30. Stewart mine, Stewart shaft
31. Stewart mine, No. 2 shaft
32. Stewart mine, No. 1 shaft
33. Mackey group, No. 1 shaft
34. Mackey group, No. 2 shaft
35. Mackey group, No. 3 shaft
36. Mackey group, No. 4 shaft
37. Williams group, No. 1 shaft
38. Williams group, No. 2 shaft
39. Williams group, No. 3 shaft
40. Humm mine and mill
41. Jefferson mine, No. 1 shaft
42. Jefferson mine, No. 2 shaft
43. Cobb mine
44. Pell mine
45. Twitchell mine
46. Parkinson mine
47. Barnett shaft
48. Fairbairn shaft
49. Reed shaft
50. Tri-State (Miller) mine
51. Cox mine shafts
52. Prospect pit, mineralization
53. Prospect pit, mineralization
54. Prospect pit, mineralization
55. Prospect pit, mineralization
56. Prospect pit, mineralization
57. Prospect pit, mineralization
58. Williams property
59. Tanner prospect
60. Jacob Hamp prospect
61. Fowler property
62. Prospect pit
63. Connard No. 4 prospect
64. Connard No. 2 prospect
65. Cornett prospect
66. Farrell prospect
67. Hicks prospect
68. Connard No. 3 prospect
69. Connard No. 1 prospect
70. Big Joe prospect
71. Charles Crabb No. 1 prospect
72. Charles Crabb No. 2 prospect
73. Oscar Crabb prospect
74. Davenport prospect
75. Gullett prospect
76. Prospect pits
77. McGuire prospect
78. Seinor prospect

79. Cowsert prospect
80. Hobbs prospect
81. Balfour prospect
82. Holliman prospect
83. Baker prospect
84. Rahn Crystal prospect
85. Rahn prospect
86. Dubois property, No. 4 shaft
87. Dubois property, No. 3 shaft
88. Dubois property, Fisher shaft
89. Mackey prospect
90. Sam Parkinson prospect
91. Black Jack prospect
92. Rotes prospect
93. Cox property, prospect shafts

Coal

The resources of areas including the Herod and Shetlerville Quadrangles have been evaluated by Cady et al. (1952) and Smith (1957). Coals belonging to the Caseyville and Abbott Formations occur mainly in the northern part of the map area but are generally thin and probably not laterally persistent. In some instances, coals may be cut out by overlying sandstones.

The Willis Coal Member of the Abbott Formation is definitely recognized at two localities—one in the NE¼ sec. 30, T. 10 S., R. 7 E., where it is about 18 inches thick and is in contact with the Finnie Sandstone; the other in the Dixon Springs Graben, where it is 19 inches thick at one exposure in the SW¼ sec. 31, T. 11 S., R. 7 E. In the second locality, the coal is about 20 feet below the base of the Finnie. A poorly exposed coal in the NW¼ NW¼ NW¼ sec. 21, T. 11 S., R. 7 E., is believed to be the Willis Coal. The Reynoldsburg Coal of the Abbott Formation is apparently present in the Dixon Springs Graben in the southwestern part of the Herod Quadrangle. Prospect pits and coal float indicate its presence about 20 feet above the top of the Pounds Sandstone. An 8-inch coal at the position of the Reynoldsburg is present at Williams Hill in the NE¼ sec. 7, T. 11 S., R. 7 E. The Delwood Coal of the Abbott Formation was not recognized.

The Gentry Coal of the Caseyville Formation is indicated by prospect pits in the SE¼ SE¼ sec. 25, T. 12 S., R. 7 E., in the Rock Creek Graben; no evidence of its presence was found elsewhere in the area.

Limestone

Limestone resources of Pope and Hardin County have been discussed by Lamar (1959). Their possibilities as a source of cement-making materials are considered in an earlier report by Lamar et al. (1956) and recently by Lamar and Harvey (1966, p. 45-71).

Quarrying of limestone has been carried on in the vicinity of Shetlerville for over 50 years. The Parkinson Quarry, now abandoned, located in the NE¼ SW¼ sec. 35, T. 12 S., R. 7 E., was worked in the Renault Formation. Presently producing are the Williams Quarry in the SE¼ SE¼ SE¼ sec. 23, T. 12 S., R. 7 E., in the Ste. Genevieve Formation, and the Quincy Quarry Company's new development, in the vicinity of Rich Hill, in the east-central part sec. 35, T. 12 S., R. 7 E. Operations in the Ste. Genevieve, including underground workings, have occurred in the latter area, off and on, for years.

Limestone formations of the Mammoth Cave Megagroup are the thickest and generally most quarryable in the map area. Parts of the Ste. Genevieve, St. Louis, and possibly the lower formations are of suitable composition for the manufacture of cement. The Salem Limestone has beds of dark gray to black, fine-grained limestone that show promise for use as chips in the construction of terrazzo floors. All formations of the Mammoth Cave Megagroup probably are, in part, suitable for roadstone, riprap, and agricultural limestone. Portions of the Ste. Genevieve, St. Louis, and possibly the Salem have suitable characteristics for use as concrete aggregate.

Limestone formations of the Pope Megagroup usually contain interbedded shale and may offer combinations of material for cement making. This may be true for the Golconda Group that occupies a position in the Ohio River bluff in the southwestern portion of the Shetlerville Quadrangle, although the proportion of shale may be too high.

Shale and Clay

Shales of Pennsylvanian and Mississippian age have not been examined in detail to determine their suitability for various uses. Pennsylvanian shales are generally silty or sandy but perhaps could be used for the manufacture of structural clay products. Shales of the Pope Megagroup are likely to be calcareous, and although some may be suitable for use in the manufacture of cement, their usefulness for ceramic products is limited. Some possibly could be used for making common brick or drain tile.

The New Albany Shale is about 370 feet thick in the vicinity of Hicks Dome. The shale is dark gray to black, carbonaceous, and generally carries small quantities of pyrite. It is believed to be more siliceous than shale of similar age at other places in southern Illinois. However, it has been observed only in outcrop, and fresh material may be of suitable composition for the manufacture of cement if mixed with a properly selected limestone.

Residual clays that in some cases contain chert fragments overlie limestone bedrock surfaces but are variable in thickness. Large areas underlain by limestone indicate the possibility of considerable quantities of this type of clay. A sample near Eichorn, derived from the Ste. Genevieve Limestone, was tested and found suitable for making common and face brick (Lamar, 1948).

The use of loess for brick and drain tile manufacture has declined in recent years; shale now is used almost exclusively. Loess deposits in the map area are generally thin but in some areas may have suitable thicknesses of material that would make structural clay products.

Chert and Gravel

Chert deposits of two types afford a large reserve of material that has been used locally as road metal. Creek gravel, composed largely of chert fragments from the Mammoth Cave Limestone Megagroup and from the Fort Payne Formation, underlies a portion of the floodplain areas along such streams as Hicks Branch and a north fork of Hicks Branch near Hicks Dome. Hills underlain by the Fort Payne commonly are covered by a residuum of variable thickness that consists of broken chert. The chert of the Fort Payne is commonly minutely jointed and when quarried breaks into sizes suitable for some types of road construction and maintenance; it has been extracted from a pit located near the center of the N$\frac{1}{2}$ sec. 25, T. 11 S., R. 7 E.

Sandstone

Flaggy sandstones of the West Baden Group have been quarried periodically in the NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 34, T. 12 S., R. 7 E., for use as building stone. The sandstones are shades of brown, brownish yellow, cream, and almost white. Sandstones from other deposits also have had a similar use on a small scale. Except for its use as building stone, the sandstone of the area appears to have limited commercial possibilities. Sieve tests and other data on five samples of sandstone from the area are given by Biggs and Lamar (1955, p. 8, 13, 14-17).

Oil and Gas Possibilities

Oil and gas possibilities of extreme southern Illinois have been investigated by Weller (1940). Oil tests have been drilled in the immediate vicinity of Hicks Dome and on the Horton Hill Anticline without encountering commercial accumulations. Stratigraphic traps related to faults have yielded oil in fields 30 miles to the northeast, but the significance of faulting and related structures to the accumulation of oil in an area as broken up as the fluorspar district is questionable.

REFERENCES

Bastin, E. S., 1931, The fluorspar deposits of Hardin and Pope Counties, Illinois: Illinois Geol. Survey Bull. 58, 116 p.

Baxter, J. W., and Desborough, G. A., 1965, Areal geology of the Illinois fluorspar district. Part II - Karbers Ridge and Rosiclare Quadrangles: Illinois Geol. Survey Circ. 385, 40 p.

Baxter, J. W., Potter, P. E., and Doyle, F. L., 1963, Areal geology of the Illinois fluorspar district. Part I - Saline Mines, Cave in Rock, Dekoven, and Repton Quadrangles: Illinois Geol. Survey Circ. 342, 44 p.

Biggs, D. L., and Lamar, J. E., 1955, Sandstone resources of extreme southern Illinois: Illinois Geol. Survey Rept. Inv. 188, 21 p.

Bradbury, J. C., 1962, Trace elements, rare earths, and chemical composition of southern Illinois igneous rocks: Illinois Geol. Survey Circ. 330, 12 p.

Brown, J. S., Emery, J. A., and Meyer, P. A., Jr., 1954, Explosion pipe in test well on Hicks Dome, Hardin County, Illinois: Econ. Geology, v. 49, no. 8, p. 891-902.

Butts, Charles, 1925, Geology and mineral resources of the Equality-Shawneetown area: Illinois Geol. Survey Bull. 47, 76 p.

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

Clegg, K. E., and Bradbury, J. C., 1956, Igneous intrusive rocks in Illinois and their economic significance: Illinois Geol. Survey Rept. Inv. 197, 19 p.

Hatmaker, Paul, and Davis, H. W., 1938, The fluorspar industry of the United States with special reference to the Illinois-Kentucky district: Illinois Geol. Survey Bull. 59, 128 p.

Heyl, A. V., Jr., and Brock, M. R., 1961, Structural framework of the Illinois-Kentucky mining district and its relation to mineral deposits: U. S. Geol. Survey Prof. Paper 424D, art. 294, p. D3-D6.

Heyl, A. V., Jr., Brock, M. R., Jolly, J. L., and Wells, C. E., 1965, Regional structure of the southeast Missouri and Illinois-Kentucky mineral districts: U. S. Geol. Survey Bull. 1202B, 20 p.

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

Kosanke, R. M., Simon, J. A., Wanless, H. R., and Willman, H. B., 1960, Classification of the Pennsylvanian strata of Illinois: Illinois Geol. Survey Rept. Inv. 214, 84 p.

Lamar, J. E., 1948, Clay and shale resources of extreme southern Illinois: Illinois Geol. Survey Rept. Inv. 128, 107 p.

Lamar, J. E., 1959, Limestone resources of extreme southern Illinois: Illinois Geol. Survey Rept. Inv. 211, 81 p.

Lamar, J. E., and Harvey, R. D., 1966, Geology of cement raw materials in Illinois, in A symposium on geology of cement raw materials: Proceedings of the 2nd Forum on Geology of Industrial Minerals, Indiana Geol. Survey and Indiana Univ., Bloomington, 197 p.

Lamar, J. E., Machin, J. S., Voskuil, W. H., and Willman, H. B., 1956, Preliminary report on Portland cement materials in Illinois: Illinois Geol. Survey Rept. Inv. 195, 34 p.

Lineback, J. A., 1966, Deep-water sediments adjacent to the Borden Siltstone (Mississippian) Delta in southern Illinois: Illinois Geol. Survey Circ. 401, 48 p.

Smith, W. H., 1957, Strippable coal reserves of Illinois. Part I - Gallatin, Hardin, Johnson, Pope, Saline, and Williamson Counties: Illinois Geol. Survey Circ. 228, 39 p.

Swann, D. H., 1963, Classification of Genevievian and Chesterian (Late Mississippian) rocks of Illinois: Illinois Geol. Survey Rept. Inv. 216, 91 p.

Swann, D. H., and Willman, H. B., 1961, Megagroups in Illinois: Am. Assoc. Petroleum Geologists Bull., v. 45, no. 4, p. 471-483.

Weller, J. M., 1940, Geology and oil possibilities of extreme southern Illinois—Union, Johnson, Pope, Hardin, Alexander, Pulaski, and Massac Counties: Illinois Geol. Survey Rept. Inv. 71, 71 p.

Weller, J. M., Grogan, R. M., and Tippie, F. E., 1952, Geology of the fluorspar deposits of Illinois: Illinois Geol. Survey Bull. 76, 147 p.

Weller, Stuart, Butts, Charles, Currier, L. W., and Salisbury, R. D., 1920, The geology of Hardin County and the adjoining part of Pope County: Illinois Geol. Survey Bull. 41, 416 p.

Illinois State Geological Survey Circular 413
41 p., 4 figs., 1 table, 1967

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