STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

AREAL GEOLOGY OF THE ILLINOIS FLUORSPAR DISTRICT

Part 1 — Saline Mines, Cave in Rock, Dekoven, and Repton Quadrangles

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ABSTRACT

This is the first of a series of three reports and maps on the geology of the Illinois fluorspar district, which is in Hardin, eastern Pope, and southern Saline and Gallatin Counties.

The Illinois portions of four $7\frac{1}{2}$-minute quadrangles—Saline Mines, Cave in Rock, Dekoven, and Repton—are delineated on the map that accompanies this report. Nineteen units of Mississippian rocks from the Salem Limestone (middle Valmeyeran) to the Clore Formation (late Chesterian), four Pennsylvanian units, and three Pleistocene units are mapped and differentiated by color. In addition, the lowermost Pennsylvanian unit, the Caseyville Formation, is further differentiated by lines marking the top and bottom of prominent sandstone members.

A gentle, regional structural slope northward into the Illinois Basin is broken by the Rock Creek Graben which is about 2 miles wide, crosses the area diagonally from northeast to southwest, and has 1000 to 1500 feet of structural relief. The area east of the graben is virtually unfaulted, but there are several minor faults within the graben and west of it.

Fluorspar and less important zinc and lead ores occur in bedding replacement deposits and as vein deposits in favorable strata of Mississippian age. Limestone is quarried commercially from Mississippian strata, and coal has been mined from Pennsylvanian beds.

INTRODUCTION

Remapping of the Illinois fluorspar district was begun in the fall of 1957 in response to the need for a more detailed topographic and geologic map to aid in the development of the fluorspar, zinc, and lead resources of Hardin and Pope Counties. The geologic map will be published in three parts. Part I of the series, which covers approximately the eastern one-third of Hardin County and the southeastern tip of Gallatin County, includes the Illinois portions of the Saline Mines, Cave in Rock, Dekoven, and Repton $7\frac{1}{2}$-minute quadrangles (fig. 1; and pl. 1, in pocket).

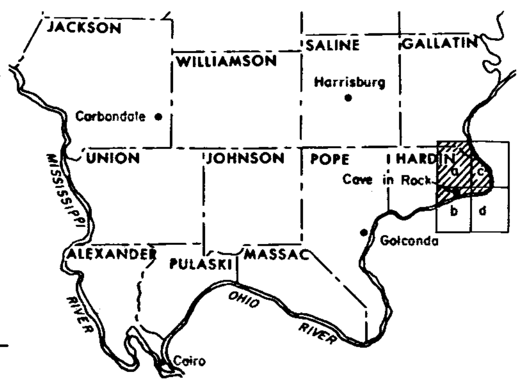

Fig. 1 - Part of southern Illinois showing the location of (a) Saline Mines, (b) Cave in Rock, (c) Dekoven, and (d) Repton $7\frac{1}{2}$-minute quadrangles.

Generalized maps of part of Hardin County were prepared by Engleman (in Worthen, 1866, Vol. I, facing p. 350) and Bain (1905), but Stuart Weller made the first detailed map of the district (Stuart Weller et al., 1920), published in color on a topographic base, scaled 1 inch to the mile. Later J. M. Weller modified the map, and his work was published in black and white although not on a topographic base (Weller et al., 1952).

The present map is on the scale of approximately $2\frac{1}{2}$ inches to the mile and therefore permits showing more stratigraphic and structural detail. The report does not deal extensively with paleontology nor does it give detailed geology of the mineral deposits, subjects that are covered more thoroughly in earlier reports (Weller et al., 1920; Weller et al., 1952).

The geologic mapping has been conducted jointly by the Industrial Minerals, Stratigraphy and Areal Geology, and Coal Sections of the Illinois State Geological Survey. The Mississippian rocks and the Mississippian-Pennsylvanian contact were mapped primarily by James W. Baxter assisted by David A. Schaefer and Albert Pernichele. The Pennsylvanian area was mapped by Paul Edwin Potter, F. L. Doyle, and George E. Desborough. Potter supervised all Pennsylvanian field work and determined the top and bottom of the Battery Rock Sandstone, the base of the Pounds Sandstone, and all higher contacts other than the top of the Pounds. Desborough mapped the top of the Pounds Sandstone in segment 1 of the Rock Creek Graben (pl. 2). Doyle, who was primarily responsible for mapping the top of the Pounds Sandstone outside of the graben, mapped the base of the Pounds in some areas and also mapped Pleistocene sediments.

The over-all direction of the mapping program was shared by the heads of the Survey sections involved — J. E. Lamar, Industrial Minerals; Jack A. Simon, Coal; and H. B. Willman, Stratigraphy and Areal Geology. Other members of the Survey staff, including James C. Bradbury, David H. Swann, and William H. Smith, were consulted on specific problems. The mineral industries of Hardin County cooperated in many ways, especially in allowing access to records of diamond drill and cable tool drillings.

TOPOGRAPHY

The area covered by this report is a part of the Shawnee Hills section of the Interior Low Plateaus Physiographic Province (Horberg, 1950, p. 15-93). Most of the area consists of ridges marking the outcrop or presence of some of the harder layers of rock, notably the sandstones, and of depressions underlain by softer shales and limestones. However, an area at an elevation of about 400 to 460 feet that lies north and northwest of Cave in Rock is characterized by abundant depressions, known as limestone sinks, some of which are periodically or permanently water-filled. They have been formed mainly in the area underlain by the St. Louis Limestone. A region containing abundant sinks is referred to as having karst topography.

Salisbury (in Weller et al., 1920, p. 47-52) recognized five erosional topographic levels that he believed to be remnants of more extensive flat areas. These plains and their elevations above sea level are as follows:

Buzzard's Point plain	860-900 feet
Karbers Ridge plain	600-640 feet
McFarlane plain	500-540 feet
Elizabethtown plain	400-420 feet
Present floodplain	320-340 feet

Horberg (1950) tentatively considered the Buzzard's Point plain as part of the Dodgeville peneplain and the McFarlane plain as part of the Central Illinois peneplain. These erosional surfaces were not evaluated on the basis of the 1:24,000 topographic and geologic maps.

Three constructional terraces recognized along the Ohio River and its tributary valleys were built by glacial meltwater that flooded down the Ohio and backed up into its tributaries during late Wisconsinan time. The lowest terrace, at an elevation of 350 to 355 feet, is present only locally. The intermediate terrace has an elevation of about 360 feet, and the highest terrace occurs at 380 to 390 feet. The terraces are shown on the geologic map (pl. 1).

STRATIGRAPHY

The bedrock formations exposed in the mapped area belong to the Mississippian and Pennsylvanian Systems. The oldest exposed beds are assigned to the Salem (Mississippian) Limestone and the youngest are sandstones and shales of the Carbondale or possibly the Modesto Formation (Pennsylvanian).

The geologic formations shown on the accompanying map (pl. 1, in pocket) are in general those recognized by the mineral industries of Hardin County. Most of the names assigned to them are in current use by those engaged in mineral exploration in the district and are in general accordance with stratigraphic nomenclature used on previous maps. However, the map with this report and the following discussion of stratigraphy reflect recent refinement of the classification of Chesterian and Genevievian rocks (Swann, ms. in preparation) and of the Pennsylvanian strata (Kosanke et al., 1960). Figure 2 shows the rock stratigraphic classification used in this report and its relation to previous classifications.

The following geologic column shows the succession and relationships of the various stratigraphic units subsequently discussed and indicates those units that are differentiated on the geologic map. General lithologic character and approximate thicknesses also are given.

TABLE 1 - STRATIGRAPHIC COLUMN

		Approx. thickness (feet)
Quaternary System		
Pleistocene Series		
Recent (stream alluvium)		
Wisconsinan (terrace deposits, silt and sand)		
Pennsylvanian System		
McLeansboro Group		500?
Kewanee Group		
Carbondale Formation		
(shale, sandstone, thin limestone, minable coal)		350
Spoon Formation		
(shale, sandstone, thin limestone, coal)		425
McCormick Group		
Abbott Formation		
Section below Grindstaff Sandstone		
(shale and sandstone)	100	
Grindstaff Sandstone Member		
(cross-bedded, small amounts of matrix, mica, feldspar)	30	
Section between Grindstaff and Finnie Sandstones		
(shale and sandstone)	60	
Finnie Sandstone Member		* 300
(reddish brown, cross-bedded, intermediate amounts of matrix, mica, feldspar)	35	
Section between Finnie and Murray Bluff Sandstones		
(shale, silty shale, sandstone)	45	
Murray Bluff Sandstone Member		
(larger amounts of matrix, mica, feldspar)	30	
Caseyville Formation		
Pounds Sandstone Member		
(medium to coarse, conglomeratic sandstone)	80	
Section between Pounds and Battery Rock Sandstones		
(shale, sandstone, Gentry Coal, Sellers Limestone)	90	
Battery Rock Sandstone Member		* 330
(medium to coarse, conglomeratic sandstone)	60	
Lusk Shale Member		
(shale, shaly sandstone)	100	
Mississippian System		
Top of Chesterian Series		
Pope Megagroup		
Clore Formation		
Ford Station Member (shale, limestone)	40	
Tygett Sandstone (sandstone, shale)	30	* 110
Cora Member (shale, limestone)	40	
Palestine Sandstone (fine-grained sandstone)		60
Menard Limestone		
Unnamed shale member	12	
Allard Member (fine-grained limestone)	35	
Unnamed shale member	15	* 115
Scottsburg Member (sublithographic limestone)	40	
Unnamed shale member	7	
Walche Member (argillaceous, fossiliferous limestone)	6	

TABLE 1 - continued

		(feet)
Waltersburg Formation (shaly sandstone, shale)		30
Vienna Limestone (fine-grained limestone, shale)		15
Tar Springs Sandstone (fine-grained sandstone, shaly sandstone)		65
Glen Dean Limestone (fossiliferous limestone)		60
Hardinsburg Sandstone (fine-grained sandstone, shaly sandstone, shale)		90
Golconda Group		
Haney Limestone (fossiliferous limestone)	35	
Fraileys Shale (shale, siltstone, limestone)	90	* 130
Beech Creek Limestone (fossiliferous limestone)	5	
West Baden Group		
Cypress Sandstone (fine-grained sandstone)		90
Ridenhower Formation (sandstone, shale, shaly sandstone)		45
Bethel Sandstone (fine- to medium-grained sandstone, basal conglomerate)		60
Mammoth Cave Megagroup		
Cedar Bluff Group		
Downeys Bluff Limestone (fossiliferous limestone, shale)		30
Yankeetown Shale (shale, siltstone, limestone)	20	
Renault Limestone		* 45
Shetlerville Member (fine-grained limestone, oolitic limestone)	25	
Top of Valmeyeran Series		
Levias Member (oolitic limestone)		15
Pre-Cedar Bluff formations		
Aux Vases Sandstone		
Rosiclare Member (calcareous sandstone; sandy, oolitic limestone)		20
Ste. Genevieve Limestone		
Joppa Member (oolitic limestone, fine-grained limestone)	30	
Karnak Member (oolitic limestone)	30	
Spar Mountain Sandstone (calcareous sandstone or sandy limestone)	5	* 145
Fredonia Member (oolitic limestone, fine-grained limestone)	80	
St. Louis Limestone (cherty, fine-grained limestone)		350
Salem Limestone (argillaceous limestone, calcarenite) Base not exposed.		100+

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

THIS REPORT based on KOSANKE ET AL., 1960 (PENNSYLVANIAN) SWANN (ms in preparation) MISSISSIPPIAN					I.S.G.S. BULLETIN 76 WELLER, J.M., ET AL., 1952		I.S.G.S. BULLETIN 47 BUTTS, 1925 (PENNSYLVANIAN) I.S.G.S. BULLETIN 41 WELLER, S., 1920 (MISSISSIPPIAN)	
SYSTEM	MEGA-GROUP	GROUP	FORMATIONS	MEMBERS (bounding members only in Kewanee Group)	FORMATIONS	MEMBERS	FORMATIONS	MEMBERS (or bounding units in Pennsylvanian)
PENNSYLVANIAN		McLEANSBORO	MODESTO		(NO FORMATIONS YOUNGER THAN STONEFORT RECOGNIZED)		MC LEANSBORO	
		KEWANEE	CARBONDALE	Danville (No.7) Coal			CARBONDALE	Herrin (No.6) Coal
				Colchester (No.2) Coal				
			SPOON	Palzo				Davis Coal
				Reynoldsburg Coal	STONEFORT		TRADEWATER	
		MC CORMICK	ABBOTT	Murray Bluff	MACEDONIA			
				Finnie	DELWOOD			
				Grindstaff	GRINDSTAFF			
			CASEYVILLE	Pounds	POUNDS		CASEYVILLE	Pounds
				Battery Rock	BATTERY ROCK			
				Lusk	LUSK			
MISSISSIPPIAN	POPE		KINKAID *	Goreville	KINKAID		KINKAID	
				Cave Hill				
				Negli Creek				
			DEGONIA *		DEGONIA			
			CLORE	Ford Station	CLORE		DEGONIA	
				Tygett			CLORE	
				Cora				
			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				
				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					

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

Fig. 2—Rock-stratigraphic classification of Mississippian and Pennsylvanian strata.

MISSISSIPPIAN SYSTEM

Mississippian rocks exposed in the mapped area belong to the Mammoth Cave and Pope Megagroups as recognized by the Illinois State Geological Survey (Swann and Willman, 1961, p. 473). The Mammoth Cave Megagroup consists predominantly of carbonate strata and the Pope Megagroup of alternating sandstone, shale, and limestone formations.

MAMMOTH CAVE LIMESTONE MEGAGROUP

The Mammoth Cave Megagroup (Swann and Willman, 1961, p. 481) consists chiefly of carbonate strata Valmeyeran and Chesterian in age but contains some sandstone, siltstone, and shale. In the mapped area it is predominantly limestone and includes all exposed formations below the base of the Bethel Sandstone.

VALMEYERAN SERIES

Salem Limestone

The Salem Limestone heretofore has not been mapped as a distinct formational unit in Hardin County and earlier workers recognized no rocks older than the St. Louis Limestone in the area mapped for this report. However, a lower portion of the interval, previously mapped as the St. Louis, contains beds that are lithologically similar to the Salem at other localities and that agree in position with the Salem as traced by Pinsak (1957) from its type region in central Indiana to within 15 to 20 miles of the mapped area.

The Salem Limestone crops out in the Ohio River bluff from a point one mile west of Cave in Rock to a point just west of the west line of sec. 20, T. 12 S., R. 9 E., a distance of 3 miles. The total thickness of the Salem cannot be measured in eastern Hardin County because its lower contact is not exposed, but its maximum exposed thickness of more than 100 feet may be seen near Tower Rock in the NW$\frac{1}{4}$ NW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 20 on the north flank of the Tolu Dome. In the vicinity of Tower Rock the part of the formation exposed consists largely of dark brownish gray to black, argillaceous limestone which is mostly fine-grained and has a strong, petroliferous odor. An upper portion has beds and lenses of medium- to coarse-grained calcarenite that contain endothyroid foraminifera including Endothryra baileyi, a fossil that is diagnostic of beds at the top of the Salem Limestone at other localities in Illinois (Baxter, 1959, p. 30). Some Endothryra are pyritized, and most of the specimens are darker colored than the enclosing matrix. The calcarenite is generally lighter colored than the fine-grained portions of the formation. The colonial coral Lithostrotion proliferum occurs abundantly in some beds of the Salem, particularly in the dark, argillaceous, fine-grained limestone near the top.

The Salem is conformably overlain by St. Louis Limestone, and there is a gradual lithologic transition between the calcarenitic upper part of the Salem and the cherty, fine-grained beds of the St. Louis Limestone.

St. Louis Limestone

The St. Louis Limestone underlies a large part of the Cave in Rock quadrangle where it forms a semicircular belt, 2 to 2$\frac{1}{2}$ miles wide, that curves around the Salem. The older Salem appears at the center of a domal structure that has its apex near Tolu, Kentucky, across the Ohio River from Tower Rock. The belt of St. Louis bedrock extends from a position in or adjacent to the Ohio River bluff almost to the foot of the northwest-trending escarpment that is capped by the Bethel Sandstone, the lowermost resistant formation of the Pope Megagroup.

The St. Louis is predominantly cherty, brownish gray, sublithographic to fine-grained limestone, but it contains some interbedded, fossiliferous limestone, some fine-grained, dolomitic limestone, and in its upper part oolitic limestone. In general the limestone is lighter colored than that of the underlying Salem, darker than that of the overlying Fredonia, and characteristically finer grained than that in either of the adjacent formations. Abundant, heavy chert bands and chert nodules are also characteristic of the St. Louis.

The upper and lower limits of the St. Louis are transitional, a fact that accounts for wide variation in estimates of its thickness. Previous estimates of its thickness in eastern Hardin County have been as great as 500 feet, but drill records suggest that a lower portion of that sequence should be correlated with the Salem and that younger beds, formerly mapped as part of the Fredonia, should be added to the St. Louis, making a total thickness of 350 to 400 feet. The lower beds of the St. Louis crop out in the Ohio River bluff west of the ferry landing at Cave in Rock and the Salem rises to the base of the bluff within a mile of the landing. St. Louis Limestone has been quarried in the river bluff 0.7 mile west of Cave in Rock. Younger St. Louis beds, including the transition to Ste. Genevieve Limestone, crop out east of the landing in the vicinity of Cave in Rock State Park.

Ste. Genevieve Limestone

The correlation of the Rosiclare Sandstone Member of the fluorspar district with the Aux Vases Sandstone (Dana and Scobey, 1941; Swann and Atherton, 1948; Swann, ms. in preparation) results in restricting the Ste. Genevieve in Hardin County to the unit beneath the Aux Vases (formerly called the Fredonia Member). The Ste. Genevieve Limestone overlies the St. Louis but the contact is not known to be exposed in eastern Hardin County. Ste. Genevieve Limestone crops out in the lower portions of the Bethel Sandstone escarpment southeast of the Rock Creek Graben. The best exposures are artificial in the quarries north of Cave in Rock (fig. 3) and in the mine openings in the Spar Mountain fluorspar mining area. The Ste. Genevieve also occurs at or near the surface in an intensely faulted area just north of the Rock Creek Graben on the west edge of the Saline Mines quadrangle.

The Ste. Genevieve Limestone, 140 to 160 feet thick, consists of limestone of variable lithologic character, including diagnostic, medium to light gray, oolitic limestone. Interbedded with oolitic limestone are some beds that are crystalline and fossiliferous and others that are dense and almost as fine-grained as lithographic limestone. Several erratic, sandy lenses, "sub-Rosiclare sandstones", occur at various intervals within the formation, but the complete sequence is relatively free of silica in the form of chert.

Swann (ms. in preparation) recognizes four subdivisions of the Ste. Genevieve Limestone, based primarily on exposures outside of Hardin County. In ascending order these are the Fredonia Limestone (redefined and restricted), Spar Mountain Sandstone, Karnak Limestone, and Joppa Limestone Members. This differentiation at some places can be made in cores and individual outcrops in Hardin County, but the contacts involved are not readily traceable in the field. Therefore the Ste. Genevieve is undifferentiated on the map (pl. 1).

Fig. 3—Quarry face and hillside showing units from the Ste. Genevieve Formation to the Bethel Sandstone. Rigsby and Barnard quarry in the SW¼ SW¼ SE¼ sec. 1, T. 12 S., R. 9 E.

The contact of the Ste. Genevieve with the underlying St. Louis is rarely exposed but is presumed to be conformable. The Ste. Genevieve is overlain by the Rosiclare Member of the Aux Vases Formation. The relationship is one of conformity or of only slight unconformity.

Fredonia Member — The Fredonia Member, the lowermost member of the Ste. Genevieve Formation, is best exposed in the SW ¼ NE¼ NW¼ sec. 3, T. 12 S., R. 9 E. in the Benzon (Austin) mine area. It also occurs in the floor of the limestone quarry in the SE¼ SW¼ SW¼ sec. 1, T. 12 S., R. 9 E.

The Fredonia Member consists of gray to light gray, oolitic limestone and medium gray, fine-grained, dolomitic limestone. The light gray, oolitic limestone is better developed in areas in which the overlying Spar Mountain Sandstone is not recognized. Oolites of the "McClosky" type, larger than most oolites, are diagnostic although not restricted to the Fredonia. At the Benzon (Austin) area, the oolitic limestone is markedly cross-bedded. Core drilling indicates that the thickness is about 60 to 80 feet.

Spar Mountain Sandstone Member — The Spar Mountain Sandstone Member is the most persistent of several sub-Rosiclare sandstone lenses although it has proved to be erratic in distribution. It is best developed in secs. 3 and 4, T. 12 S., R. 9 E. where it consists of greenish gray, calcareous sandstone or sandy limestone and lies about 60 feet below the Rosiclare Member of the Aux Vases Sandstone. The upper and lower limits of the Spar Mountain are not sharply defined because it grades into the Fredonia below and the Karnak above. The maximum thickness recognized is somewhat less than 10 feet.

Karnak Member — The Karnak Member overlies the Spar Mountain Sandstone, but where the Spar Mountain is thin or absent it is difficult to recognize the Karnak. In the Benzon mine area in sec. 3, T. 12 S., R. 9 E., the Karnak consists of approximately 30 feet of mainly oolitic limestone which is not as light colored or as pure as the oolitic limestone of the Fredonia Member. Generally it occurs in beds which are thicker and more homogeneously oolitic than those of the Joppa Member at the top of the Ste. Genevieve. The Karnak is the lowermost member of the Ste. Genevieve that has been replaced extensively by bedded fluorspar deposits.

Joppa Member — The Joppa Member, at the top of the Ste. Genevieve Formation in Hardin County, is the chief fluorspar horizon. It consists of oolitic limestone and fine-grained limestone characterized by numerous shale partings or thin shale beds. The Joppa-Karnak relationships are seen most clearly in the lower portions of the Spar Mountain escarpment about 3½ miles northwest of Cave in Rock where they are exposed at old mine adits. There the Joppa is about 30 feet thick. The Joppa Member, largely limestone in Hardin County, is dominantly clastic some 20 or 30 miles to the north and west and is nearly all sandstone and shale still further to the north and west where it may be considered a member of the Aux Vases Sandstone.

Aux Vases Sandstone

The Aux Vases Sandstone has its type locality in Randolph County in southwestern Illinois. Recent subsurface and outcrop correlation (Swann, ms. in preparation) has shown that the Rosiclare Sandstone of Hardin County is equivalent to a part of the Aux Vases, and it is now considred a member of the Aux Vases.

The Rosiclare Sandstone was formerly considered a member of the Ste. Genevieve Formation (Ulrich and Smith, 1905, p. 111), but since the Joppa (which further west is the lower member of the Aux Vases) is placed in the Ste. Genevieve in Hardin County, the only member of the Aux Vases present here is the Rosiclare.

Rosiclare Member — The Rosiclare Member overlies the Ste. Genevieve in the face of the Spar Mountain escarpment and in the continuation of that Bethel-capped ridge to the Ohio River. It consists of compact, gray or greenish gray, calcareous sandstone and siltstone or silty limestone of which the more calcareous parts may be finely oolitic. The sandstone beds are generally about 2 inches thick, but in some places the beds are thicker and in many respects resemble Chesterian sandstones. This is especially true of weathered outcrops from which carbonate has been leached so as to form a porous weathered surface.

Sandy, micaceous, greenish gray shale occurs locally at the base of the Aux Vases Sandstone. The sandstone-shale contact is sharp, but there is little evidence of unconformity although limestone pebbles have been recorded in drill records. The shale, where present, is a few inches to 3 feet thick in most exposures, although a maximum thickness of 8 feet has been reported.

Within the mapped area, the total thickness of the Aux Vases ranges from 15 to about 40 feet, but it is consistently present.

Cedar Bluff Group

The Cedar Bluff Group is predominantly limestone and consists of three formations. In ascending order they are the Renault Limestone, Yankeetown Shale, and Downeys Bluff Limestone.

Renault Limestone

The Renault Limestone, as now recognized in Hardin County (fig. 2), consists of two limestone members separated by a possible unconformity. Except for their stratigraphic position above the Aux Vases, they are difficult to distinguish from Ste. Genevieve. The Levias Member at the base was formerly placed in the Ste. Genevieve, first as part of that formation but later as a unit in the upper Ste. Genevieve; still later it was considered as a unit in the Ohara Member and, most recently, as a bonafide member of the Ste. Genevieve Formation. The Shetlerville Member lies above the unconformity and was considered first as the lower of the two units in the Shetlerville Formation, then as the Shetlerville Member of the Renault Formation, and now (because the shaly equivalent of the Yankeetown is omitted) as the upper of the two units in the Renault. The new classification has resulted from the correlation of the Rosiclare Sandstone with the Aux Vases and the recognition of a southeastern Illinois correlative of the Yankeetown Sandstone of southwestern Illinois (Swann, ms. in preparation).

The Renault overlies the Aux Vases Sandstone, locally with evidence of unconformity. It is conformably overlain by the Yankeetown Shale. The thickness of the Renault varies, possibly ranging from 35 to as much as 60 feet with most of the variation in the thickness of the Levias Member. The Levias appears as a separate unit on the geologic map (pl. 1) whereas the Shetlerville Member of the Renault and the overlying Yankeetown Shale are mapped together.

Levias Member — The Levias Member of the Renault consists of light gray, medium-grained, oolitic limestone but it also has darker beds of sublithographic limestone. Generally, the Levias can be differentiated from the Ste. Genevieve and the Shetlerville by the presence of pink crinoid grains which may serve as nuclei for oolite growth in oolitic limestone or may float in a microcrystalline matrix in sublithographic phases of the limestone.

Good exposures of Levias Limestone can be seen on Lead Hill and at various places along the Spar Mountain Escarpment about 3½ miles northwest of Cave in Rock. At these places it occurs in relatively thick beds which total approximately 20 feet. The thickness of the Levias, however, varies in Hardin County. In the mapped area the observed thicknesses in core drillings ranged from 5 to 35 feet, and it is possible that the Levias may be absent locally because of pre-Shetlerville erosion.

The contact of the Levias with underlying Aux Vases Sandstone is rarely exposed in natural outcrops. Some drill records report an unconformable relationship and the presence of a basal conglomerate, but this contact is more commonly transitional.

CHESTERIAN SERIES

Shetlerville Member — The Shetlerville Member of the Renault is the lowermost representative of the Chesterian Series in Hardin County. The name Shetlerville is restricted to the predominantly limestone strata in the lower part of the shale and limestone sequence which separates the Levias and Downeys Bluff Limestones. The Shetlerville crops out at various places on the foreslopes of the Bethel-capped escarpments in the mapped area, but in general it is not as well exposed as the Levias.

The Shetlerville, about 25 feet thick, consists largely of relatively pure, brownish gray, more or less oolitic limestone, but it grades to dense, sublithographic limestone. A lower part is more argillaceous and very finely sandy limestone. The Shetlerville generally is more argillaceous than the limestone of either the Levias or the Downeys Bluff. The relatively pure upper part of the Shetlerville Member is 10 to 20 feet thick and the basal, argillaceous zone is from 2 to more than 10 feet thick.

The contact of the Shetlerville with the underlying Levias as shown in diamond drill cores is at many places a well-marked unconformity, and in at least one place there is a basal conglomerate. The contact with the overlying Yankeetown Shale was not observed in field exposures, but cores reveal that the limestone grades upward into the shale.

Yankeetown Shale

The Yankeetown Shale overlies the Shetlerville Limestone and the shale in Hardin County was formerly considered to be a part of the Shetlerville (fig. 2). It is not known to crop out in the mapped area, but, because it is soft, it produces covered intervals along the foreslopes of the Bethel-capped escarpment.

The thickness of the Yankeetown ranges from 15 to 30 feet, probably averaging about 20 to 25 feet in the mapped area. Subsurface drill records reveal that the Yankeetown, although mostly shale, includes various lithologies. It consists of calcareous, green to greenish gray or red, fossiliferous shale; dark gray, fossiliferous shale; greenish gray and red mottled, argillaceous dolomite or dolomitic siltstone; and buff or greenish gray, medium to coarse-grained, fossiliferous limestone.

The contact of the Yankeetown Shale with the underlying Shetlerville Limestone is transitional with limestone abundant in the lower part of the Yankeetown. The Yankeetown is overlain in turn by the Downeys Bluff Limestone. This contact has been described as unconformable at the type locality of the Downeys Bluff, but similar relations were not observed in eastern Hardin County.

Paucity of outcrops and the transitional base make it difficult to draw a line separating the Yankeetown Shale from the Shetlerville Member of the Renault Limestone. Therefore, Shetlerville-Yankeetown appears as a single unit on the map (pl. 1).

Downeys Bluff Limestone

The Downeys Bluff Limestone is the uppermost representative of the Mammoth Cave Megagroup; its deposition ended a long period of almost uninterrupted carbonate deposition. Its distribution in eastern Hardin County is similar to that of the underlying Yankeetown and Renault Formations, but at many places it is covered with talus from the overlying sandstone. The upper beds of the Downeys Bluff may be seen on the hillside north of the Rigsby and Barnard quarry $1\frac{1}{2}$ miles north of Cave in Rock (fig. 3).

The Downeys Bluff Limestone, from 25 to 40 feet thick, consists of relatively massive beds of gray to brownish gray, medium-grained, crinoidal limestone. Oolites, smaller than those in the Ste. Genevieve, are common and locally abundant. Some beds within the formation are dolomitic and fine-grained. Chert commonly gray but at some places pink, is common, especially in the upper part.

A few feet of shale above the massive limestone is silty or sandy, greenish or reddish gray, and at many places is calcareous with marine fossils. Its distribution and thickness is probably erratic throughout Hardin County, but in general the top shale thickens toward the west. About a foot of shale is present in the subsurface in the Goose Creek mining area.

The contact of the Downeys Bluff Limestone with the underlying Yankeetown Shale has been discussed. The Downeys Bluff is unconformably overlain by the Bethel Sandstone. Relief developed on the pre-Bethel erosional surface locally removed the upper shale of the Downeys Bluff.

POPE MEGAGROUP

The Pope Megagroup (Swann and Willman, 1961, p. 481) consists of alternating limestone, sandstone, and shale formations. In eastern Hardin County it includes all Mississippian formations above the Downeys Bluff Limestone and has a maximum thickness of about 950 feet, but it is less than 800 feet thick where pre-Pennsylvanian stream channels cut deeply into Mississippian strata.

West Baden Group

The West Baden Group occupies the interval between the Downeys Bluff Limestone and the Beech Creek Limestone. It is approximately 200 feet thick and consists, in ascending order, of the Bethel Sandstone, the Ridenhower Formation, and the Cypress Sandstone. The West Baden Group is differentiated on the map of eastern Hardin County (pl. 1), but the contacts enclosing the Ridenhower are largely interpretive being based on limited outcrops, thicknesses observed in drilling, and topography.

Bethel Sandstone

The Bethel Sandstone almost invariably forms a prominent ridge where it is exposed in Hardin County in normal sequence with the underlying limestone formations. It caps the prominent ridge extending northwestward from a point on the Ohio River just east of Cave in Rock to sec. 33, T. 11 S., R. 9 E., and is there terminated by the Peters Creek Fault Zone. It also appears in a fault slice within the Peters Creek Fault Zone southwest of this point, and it underlies an area north of Hogthief Creek, chiefly in secs. 19 and 20, T. 11 S., R. 9 E.

The Bethel is a light gray, fine-grained sandstone which contains some medium-grained sandstone that is coarser than any other Mississippian sandstone in Hardin County. In its lower parts there are local streaks of clear quartz granules, and generally there is a basal conglomerate containing quartz granules, limestone pebbles, shale pebbles, and fossil fragments. Commonly the sandstone is massive and more or less irregularly cross-bedded.

Unconformable stratigraphic relations of the Bethel with the underlying Downeys Bluff Limestone are exposed in the Ohio River bluff east of Cave in Rock, near the line between secs. 16 and 17, T. 12 S., R. 10 E., where the Bethel has a basal conglomerate as much as 18 inches thick. The contact of the Bethel with the overlying Ridenhower Formation is poorly exposed in the mapped area, but drill records indicate a gradual transition from sandstone into overlying shaly sandstone and shale. It is difficult, on the basis of drill records, to place a contact between the two formations, probably because of the presence of other discontinuous shale zones within the West Baden sequence in an area where that sequence is mostly sandstone. In eastern Hardin County 50 to 70 feet is a reasonable estimate of the thickness that should be assigned to the Bethel.

Ridenhower Formation

The Ridenhower Formation includes the shale, shaly sandstone, and limestone strata separating the Bethel and Cypress Sandstones. The formation is recognized with difficulty in drilling records and outcrop. It appears as a separate unit (Paint Creek Formation) on previously prepared maps of Hardin County, and its position was arbitrarily based mainly on topographic expression of its shaly beds.

In Indiana the interval between the Bethel and Cypress has been described as composed of three formations: the Beaver Bend Limestone, the Sample Sandstone, and the Reelsville Limestone (Malott 1919, p. 9-11). Swann and Atherton (1948, p. 279) show a belt 10 to 20 miles wide extending north-northeast from the vicinity of Marion, Kentucky, toward Washington, Indiana, in which the entire West Baden Group is sandstone. This belt passes through eastern Hardin County east of Cave in Rock.

The Ridenhower normally is recognized in drilling in the fluorspar district as interlaminated, wavy-bedded shale and sandstone. Sandstone beds may contain fragments of shale. Discontinuous beds of greenish gray, dark gray, black or red shale are 10 to 20 feet thick. Thin limestone beds are seen at a few places in the upper part, although 4 feet of limestone was reported in drilling in the vicinity of the Hillside Mine near Rosiclare, Illinois, on an adjoining quadrangle. A 3-inch brown, oolitic limestone in the upper part of the formation was drilled in sec. 34, T. 11 S., R. 9 E., in the mapped area. Limestone pebbles are commonly found in shaly sandstones of the Ridenhower.

A shale or shaly sandstone zone 10 to 20 feet thick can be followed fairly well in outcrop from sec. 34, T. 11 S., R. 9 E., to the southeast as far as sec. 5, T. 12 S., R. 10 E. From that point to the Ohio River, however, the West Baden Group is represented entirely by sandstone. The basal 50 to 60 feet displays the massive, compact character of the Bethel. It is overlain by 40 to 50 feet of white to light gray, extremely fine-grained, flaggy sandstone succeeded by about 80 feet of fairly massive sandstone which is shaly in the upper 30 feet. This tri-partite sandstone represents a Bethel, Sample, and Cypress succession. Flaggy sandstone possibly representing the Sample, is also present below the shaly Ridenhower beds where such are recognized — for example at the branch of the creek in the SE$\frac{1}{4}$ NW$\frac{1}{4}$ NE$\frac{1}{4}$, sec. 34, T. 11 S., R. 9 E.

The contact of the Ridenhower with the underlying Bethel Sandstone (discussed above) is apparently conformable. Stratigraphic relations with the overlying Cypress Sandstone are poorly defined in surface exposures, but the local presence of shale pebbles in massive sandstone beds (presumably Cypress) and of at least two subsurface horizons containing limestone pebbles suggest some degree of unconformity between the two formations and local unconformity within the Ridenhower. East of Cave in Rock, however, the Ridenhower interval is fully occupied by flaggy sandstone that possibly reflects continuous sandstone deposition.

Cypress Sandstone

The Cypress Sandstone is the youngest rock unit of the West Baden Group. It is at the surface along the north side of the Goose Creek Fault Zone, primarily in sec. 17, T. 11 S., R. 9 E., and in the relatively unfaulted area southeast of the Peters Creek Fault Zone. In the latter area it occupies a position in the southeast-trending escarpment capped by sandstone of the West Baden Group or forms a secondary prominence down the dip slope formed on older West Baden strata. In secs. 8 and 9, T. 12 S., R. 10 E., this dip slope has been eroded so that the Cypress is largely confined to the relatively steep ridge just northeast of Anthony Creek in sec. 9.

The Cypress Sandstone is 80 to 100 feet thick. The lower half is predominently massive, buff or light gray, fine-grained sandstone; the massive layers in the Cypress are generally finer grained than similarly bedded sandstone in the Bethel. The upper half of the Cypress has considerable amounts of interbedded shale, and subsurface records report green shale and siltstone at the top of the formation.

The Cypress overlies the Ridenhower Formation in a manner discussed above. It is conformably overlain by the Beech Creek Limestone with some degree of transition between the two formations. However, the Beech Creek is not everywhere present in its normal form, so in some core and cable tool holes it is impossible to place the contact except within a 10 to 20 foot transition zone.

Golconda Group

The Golconda Group occurs at the surface in the slope immediately north of Goose Creek in the east-central portion of the mapped area and is terminated to the northeast by a fault. It also occupies a belt extending across the unfaulted area from the SE$\frac{1}{4}$ sec. 27, T. 11 S., R. 9 E., to the Ohio River.

The Golconda Group has an aggregate thickness of 120 to 160 feet. It consists of alternating limestone and shale formations, predominently shale. McFarlan et al. (1955, p. 18) recognized the following three-fold subdivision of the Golconda: the Beech Creek Limestone (lowest), Fraileys Shale (middle), and Haney Limestone (top). The type section of this three-fold subdivision is a hillside exposure in the NE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 9, T. 12 S., R. 10 E. However, because exposures showing the relationships of these formations are rare, the Golconda Group is mapped as a single unit (pl. 1).

Beech Creek Limestone

The Beech Creek Limestone is thin and discontinuous in eastern Hardin County but it is recognizable in about half of the diamond drill and cable tool holes logged during exploration for fluorspar. It has been observed in only one or two outcrops but is presumed to be present throughout a large portion of the mapped area.

The Beech Creek is generally 1 to 5 feet thick and consists of slightly argillaceous, dark to medium gray, fine- to medium-grained limestone. Locally it may be silty or sandy. It overlies the Cypress Sandstone conformably and is conformably overlain by interbedded shales and limestone of the Fraileys Formation.

Fraileys Shale

The Fraileys Shale is about 90 feet thick in the mapped area and is 94 feet thick at the type section. The shales and limestone of the Fraileys are not well exposed and details of stratigraphy have been observed at only the type section and in diamond drill cores. It consists largely of shale but has intercalated beds of buff, fossiliferous limestone and calcareous siltstone. Interbedded limestone is especially characteristic of the lower half of the formation whereas red or green siltstone is largely restricted to the upper half and locally grades into fine-grained sandstone. Shale in the lower part of the Fraileys is generally dark gray to black and commonly contains ironstone concretions.

The Fraileys Shale conformably overlies the Beech Creek Limestone where that formation is recognized. Otherwise, there is a gradual transition from the sandstone and shale of the Cypress into the interbedded shale and limestone of the Fraileys. It is conformably overlain by the Haney Limestone.

Haney Limestone

The Haney Limestone is exposed with some regularity along the belts of Golconda outcrop. It consists of massive limestone, 30 to 50 feet thick, and usually has minor shale partings. The limestone is brownish gray, fine- to coarse-grained, fossiliferous or locally oolitic. The Haney is generally difficult to distinguish from younger limestones of the Pope Megagroup, particularly the Glen Dean.

The Haney, which conformably overlies the Fraileys Shale, is overlain by the Hardinsburg Sandstone, and this contact generally is considered unconformable. The massive limestone commonly is separated from the massive sandstone of the Hardinsburg by 5 to 50 feet of shale. It is difficult to pick a base of the Hardinsburg in such cases, because the shale grades upward from soft gray, green, or red, fossiliferous shales into more compact, silty or sandy shale. However, at some places where the shale was removed by channel erosion, massive Hardinsburg Sandstone rests unconformably upon the Haney Limestone.

(End of Golconda Group)

Hardinsburg Sandstone

The Hardinsburg Sandstone has its maximum development in the general southeast Illinois-Kentucky area. It caps a major escarpment in the relatively unfaulted southeastern part of the mapped area, occupying a belt extending from the Ohio River bluff in sec. 10, T. 12 S., R. 10 E. to the Peters Creek Fault Zone. The sandstone is especially massive in the southeastern part of this belt and forms prominent bluffs on both sides of a north-trending creek gully in the western part of sec. 10.

The thickness of the Hardinsburg ranges from about 90 to 120 feet. Characteristically, the formation is an interlamination of light gray, fine-grained sandstone and light, greenish gray shale. Massive, ridge-forming sandstone bodies are common, especially in the lower part. The upper portion is more shaly and normally less well exposed. Thin seams of coal or highly carbonaceous shale have been reported from this formation.

The Hardinsburg, which overlies the Haney Limestone in a manner already described, is overlain conformably by the Glen Dean Limestone. This contact is not known to crop out in the mapped area, but in diamond drill cores the base of the Glen Dean is usually sharply defined, although at some places the lower portion of the limestone is shaly and there appears to be a gradual transition from one formation to the other.

Glen Dean Limestone

The Glen Dean Limestone occupies a northwest-trending belt from the Ohio River bluff near the center of sec. 10, T. 12 S., R. 10 E., to its termination by the Peters Creek Fault Zone in secs. 23, 26, and 27, T. 11 S., R. 9 E. A very good section is exposed in the river bluff. It also shows in blocks within the faulted area, and, north of the intensely faulted area, it occupies a belt chiefly in secs. 16 and 17, T. 11 S., R. 9 E. The limestone has been quarried in a small way in the NW$\frac{1}{4}$ NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 15, T. 11 S., R. 9 E.

The Glen Dean is 50 to 60 feet thick in the mapped area. It consists of limestone and shale with a massive limestone in both the upper and lower parts. The limestone is brownish gray, fine- to coarse-grained, fossiliferous, and contains conspicuous crinoid segments and bryozoan fragments. Some beds within the formation appear to be quite siliceous and a little chert is present. The upper massive limestone unit is fairly light colored and locally oolitic. The lower bench is generally less pure, more fossiliferous, and at some places grades into silty or sandy dolomite at or near the base. The two benches locally are separated by a shale bed, but in eastern Hardin County this division is less evident.

The Glen Dean conformably overlies the Hardinsburg Sandstone and is overlain unconformably by the Tar Springs Sandstone. The upper contact has not been observed in outcrop but drilling records show many places in which a good part of the upper shale portion of the Glen Dean was eroded before the Tar Springs sands were deposited.

Tar Springs Sandstone

The Tar Springs Sandstone occurs as remnants capping several knobs southwest of Haney Creek from the Ohio River bluff in sec. 10, T. 12 S., R. 10 E., for a distance of about 3 miles. From that point it holds up a dissected escarpment, terminated to the northwest by the Peters Creek Fault Zone. It also occurs in fault slices north of the Rock Creek Graben and occupies a belt in the northwestern corner of the area that is underlain by Mississippian strata, thus forming a discontinuous ridge dissected at several points by Harris Creek.

The Tar Springs Sandstone, from about 50 to 80 feet thick in eastern Hardin County, consists of light gray to buff, fine-grained, cross-bedded sandstone alternating with shaly, even-bedded sandstone. It is commonly more massive in the lower part but has more shale and even-bedded sandstone in the middle and upper portions. There is generally a thin, impure coal seam within 2 or 3 feet of the top of the formation and, locally, at least one other coal seam near the middle of the formation. A full sequence of the Tar Springs, revealing its stratigraphic relationships, is not well exposed in the area mapped, but an excellent exposure occurs along Harris Creek in the NW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 18, T. 11 S., R. 9 E. in the Karbers Ridge 7$\frac{1}{2}$-minute quadrangle.

The Tar Springs overlies the Glen Dean Limestone with an abrupt boundary that probably involves some degree of unconformity. The Tar Springs appears to grade conformably into the overlying Vienna Limestone. This contact is well shown in the west bank of Harris Creek near the SW corner SE$\frac{1}{4}$ SE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 18, T. 11 S., R. 9 E., Karbers Ridge quadrangle mentioned above.

Vienna Limestone

The Vienna Limestone is poorly exposed in eastern Hardin County but is assumed to be uniformly present. It is exposed in a small gully just north of the road in the NE$\frac{1}{4}$ NW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 30, T. 11 S., R. 10 E. and in the lower portions of several other gullies along that same escarpment. It also crops out at various places north of Harris Creek in the northern portion of the Mississippian outcrop area in the Saline Mines quadrangle and in fault blocks within the faulted area.

The Vienna Limestone, which is from about 10 to 20 feet thick, consists of a lower, massive limestone 6 to 15 feet thick overlain by a few feet of shale. The limestone is somewhat impure, commonly siliceous, dark brownish gray, and relatively fine-grained. However, at many places the lower portion is light colored, medium- to coarse-grained, fossiliferous, and locally oolitic, similar to beds in the Glen Dean. The upper shale rarely, if ever, is exposed but in diamond drill cores it is dark greenish gray, calcareous, and has ironstone concretions as much as 3 or 4 inches in diameter.

The Vienna conformably overlies the Tar Springs Sandstone and is conformably overlain by the Waltersburg. The upper contact of the Vienna is not exposed at the surface, but a diamond drill core of this interval shows a gradual transition from greenish, calcareous shales through silty shale to shaly sandstone.

Waltersburg Formation

The Waltersburg Formation, also poorly exposed within the mapped area, was observed in a few gullies in the lower slopes north of the road in the vicinity of Lamb and Minerva No. 1 mine in the Saline Mines quadrangle and in similar situations elsewhere. Thin-bedded, shaly sandstone of the Waltersburg can be seen in a small creek gully in the SE$\frac{1}{4}$ SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 19, T. 11 S., R. 10 E., and the upper beds of the formation are exposed in the gullies on either side of the road ascending Tucker Hill in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 24, T. 11 S., R. 9 E.

The thickness of the Waltersburg Formation ranges from 15 to more than 50 feet. As judged by drill records and limited outcrops, it appears to be thin to the northwest but thicker to the southeast. The formation consists of very shaly, thin-bedded sandstone or of thinly interlaminated shale and sandstone similar to the Hardinsburg. The lower 10 to 20 feet, not seen in outcrop, is mainly shale with ironstone concretions and is transitional into calcareous shales of the Vienna.

The Waltersburg overlies the Vienna Limestone, and the relationship is probably everywhere one of conformity. It is overlain by the Menard Limestone. The upper contact interval is exposed in the gully just east of the road ascending Tucker Hill in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 24, T. 11 S., R. 9 E. where the sandstone of the Waltersburg and the lower member of the Menard are separated by 16 feet of shale. The shale is uniformly laminated and silty but becomes less silty toward the top. The upper 4 feet is essentially non-silty and possibly should be referred to the Menard Limestone.

Menard Limestone

The Menard Limestone occupies belts north of Harris Creek in the northwestern part of the Saline Mines quadrangle and northeast of Haney Creek and the road near Lamb in the southeastern part of the mapped area. Good outcrops showing the internal stratigraphy occur in the latter belt, particularly in the vicinity of Tucker Hill in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 24, T. 11 S., R. 9 E. and near Minerva No. 1 mine in the NW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 19, T. 11 S., R. 10 E. The Menard also occurs in blocks within the faulted area.

This formation in eastern Hardin County is normally 100 to 130 feet thick, 70 to 80 feet of which is limestone that lies mainly in three stratigraphic units with intervening shale. These units are, in ascending order, the Walche, Scottsburg, and Allard Members (Swann, ms. in preparation). Pre-Pennsylvanian stream erosion has produced channels which in subsurface may locally reduce the thickness of the Menard to as little as 60 feet.

Walche Member — The Walche Member occurs at the base of the Menard Limestone. Its relationship to the underlying Waltersburg Formation has been mentioned. The Walche is generally 3 to 8 feet thick and consists of dark gray, argillaceous, fossiliferous limestone that, though rarely exposed, is assumed to have continuity throughout a large portion of the mapped area. It can be seen in a small gully just east of the road ascending Tucker Hill in the SE¼ SE¼ NW¼ sec. 24, T. 11 S., R. 9 E.

The lower limestone is separated from the Scottsburg Member by 5 to 7 feet of shale with only minor amounts of interbedded limestone.

Scottsburg Member — The Scottsburg Member is generally 30 to 40 feet thick and consists of massive, dark grayish brown, sublithographic limestone with only minor shale partings. Beds in its lower part contain abundant specimens of the brachiopods Composita subquadrata and Spirifer increbescens. A good exposure of beds with this fauna occurs along the lower portion of the road ascending the hill in the NW¼ SE¼ SW¼ sec. 28, T. 11 S., R. 10 E. The Scottsburg is comparatively free of chert although locally some chert occurs in thin, platey, discontinuous layers. Certain beds oxidize to an orangish brown, brighter than other ferruginous beds in the Menard.

The Scottsburg Member is separated from the overlying Allard Member by 10 to 20 feet of gray shale. Red and greenish gray shale have been reported in a few drill holes that have penetrated this interval.

Allard Member — The Allard Member is generally 30 to 35 feet thick and consists predominantly of dark gray, fine-grained limestone. In contrast to the Scottsburg, it has more chert, more interbedded shale and is less uniformly fine-grained, especially in the upper half. Dolomitic beds occur near the center of the member.

The Allard Member is generally separated from the Palestine Sandstone by 10 to 15 feet of shale that is dark gray and commonly fairly fissile. The limestone appears to grade into shale or, at some places, into silty shale below its abrupt contact with clean sandstone. Nevertheless, there is not conclusive evidence of pre-Palestine erosion, particularly where the lower part of the Palestine is in a thin-bedded or sheet phase, but where it is in a massive, channel phase the evidence suggests slight unconformity.

Palestine Sandstone

The Palestine Sandstone crops out north of the Rock Creek Graben where it occupies its normal position between the Menard Limestone and Clore Formation. It caps the prominent ridge a quarter of a mile south of Cadiz and occupies a belt terminated by the northernmost, major down-dropped Pennsylvanian block in sec. 10, T. 11 S., R. 9 E. The Palestine also occurs at the surface on the downthrown side of the Goose Creek Fault Zone, primarily in secs. 19 and 20 of that township, and in a tilted fault block in sec. 21. Southeast of the graben the Palestine lies either beneath the Clore Formation or at the Pennsylvanian unconformity, except in the area of deepest erosion in the Evansville pre-Pennsylvanian channel, such as that in the SE¼ sec. 19 and the NW¼ sec. 29, T. 11 S., R. 10 E. There the Menard is generally the highest Chesterian formation. Southeast of the area of deepest erosion the Palestine reappears as a prominent, ridge-forming sandstone. A good exposure is in the small gully in the SW¼ SW¼ SW¼ sec. 35, T. 11 S., R. 10 E.

The total thickness of the Palestine has not been measured in any single section nor has an unfaulted section been penetrated in recent drilling within the mapped area. However, it is estimated that the Palestine is about 60 feet thick. It consists of light gray to yellowish brown, fine-grained sandstone. Generally it is evenly thin-bedded, ripple-marked, and has a considerable amount of interbedded shale, especially in its upper part. The shale is dark gray, arenaceous, and commonly carbonaceous. Some massive, cross-bedded sandstone occurs, particularly in the lower part of the formation.

The Palestine overlies the Menard Limestone; the details of this contact are considered in a previous section. The Palestine, in turn, is overlain by the Clore Formation, but the contact has not been seen in outcrop nor has the interval commonly been penetrated in core drilling. It is probable that the shaly sandstone of the upper part of the Palestine generally is overlain conformably by calcareous shale and limestone of the Clore Formation.

Clore Formation

The Clore Formation is the uppermost Mississippian formation recognized with certainty in the mapped area. It generally occurs at the pre-Pennsylvanian unconformity, occupying the lower foreslopes of the escarpment that is capped by the resistant Caseyville Sandstone. Locally, however, older Mississippian formations occur at the unconformity, specifically in the area of pre-Pennsylvanian stream channel erosion mentioned previously and considered in more detail in a subsequent section of this report. The Clore also appears at the unconformity where that feature is exposed in fault blocks and slices within the mapped area.

Clore outcrops are too few in number to delimit the formation accurately or to determine its internal stratigraphy in eastern Hardin County, and there is a paucity of subsurface data on the youngest Mississippian formations in the mapped area. The better outcrops occur along the foreslopes of the Caseyville-capped ridge in the N½ sec. 34, T. 11 S., R. 10 E. Exposures outside the mapped area and subsurface information for adjoining parts of southeast Illinois and northwest Kentucky reveal that the Clore has a total thickness of more than 100 feet, but within the mapped area the thickness ranges from 0 to about 90 feet, depending on the amount of pre-Pennsylvanian erosion. The formation consists of interbedded shale, limestone, and siltstone but locally has thin sandstone units. Swann (ms. in preparation) subdivides the Clore into three members on the basis of stratigraphic details observed outside of Hardin County. These are, in ascending order, the Cora (shale and limestone), the Tygett (shale and/or sandstone), and the Ford Station (shale, limestone, and siltstone) Members. Limited outcrop and subsurface data indicate that this stratigraphic sequence is probably valid for the fluorspar district.

The Clore Formation overlies the Palestine Sandstone, and the relationship is probably one of conformity as is generally true for transition from Chesterian sandstone formations to an overlying limestone and shale formation. Contact with the overlying Degonia sandstone, where it has not been removed by pre-Pennsylvanian erosion, is probably one of slight unconformity. However, within the mapped area no Mississippian formations younger than the Clore were observed, and the Clore is separated from the shales and sandstones of the Pennsylvanian System by a major unconformity.

Degonia Sandstone and Kinkaid Formation

The Degonia Sandstone and Kinkaid Formation are not known to crop out in the mapped area and are presumed to have been eroded by pre-Pennsylvanian erosion. However, they are known to occur both east and west of the mapped area, within very short distances, and they may be present locally.

MISSISSIPPIAN-PENNSYLVANIAN UNCONFORMITY

The Mississippian and Pennsylvanian sediments are separated by a major regional unconformity. In the mapped area approximately 200 feet of relief was developed by erosion on the surface of Chesterian sediments. The unconformity has been mapped in subsurface across the basin by Siever (1951) and Wanless (1955, fig. 2). In field mapping, it is important to recognize the unconformity in outcrop, especially the marked erosional channels that occur locally, in order to distinguish the effects of pre-Pennsylvanian erosion from the effects of post-Pennsylvanian faulting. Where faulting was superimposed on the complicated rock distribution patterns produced by channel erosion, as occurs at some places, difficult problems in field mapping can arise. Mapping is further complicated by the similarity of some of the mapped units, especially the sandstones, that occur above and below the unconformity.

Geologic mapping in the field can generally determine the position of the Mississippian-Pennsylvanian unconformity to within 15 to 20 feet, but talus from overlying Pennsylvanian sandstones commonly obscures the actual contact in all but a few exposures. The contact can be seen in the northwest-trending ravine in the NE$\frac{1}{4}$ NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 19, T. 11 S., R. 10 E., and at Battery Rock in the southeast corner of the NE$\frac{1}{4}$ NE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 34, T. 11 S., R. 10 E.

Another excellent exposure showing 8 to 10 feet of Pennsylvanian, silty, carbonaceous shale and thin-bedded sandstone directly overlying the upper bench of the Menard Limestone occurs at a meander scar in the north-trending ravine in the SE$\frac{1}{4}$ NE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 19, T. 11 S., R. 10 E. (fig. 4). This exposure occupies the approximate position of maximum erosion of Chesterian sediments within one of the major southwestwardly oriented pre-Pennsylvanian channels of the Illinois Basin, the Evansville Channel (Wanless, 1955, p. 1763). In outcrop this channel extends from sec. 7, T. 11 S., R. 8 E., Hardin County, to a point just across the Ohio River near Cedar Point in 3-L-18 (Carter Grid), Crittenden County, Kentucky. Erosion at the base of the Evansville Valley is the principle feature of the Mississippian-Pennsylvanian unconformity in the mapped area.

The Clore Formation appears to lie immediately below Pennsylvanian sediments in most of the Rock Creek Graben and west of the graben. Although some of the Degonia Formation may be present in outcrop, it was not definitely identified. East of the graben, limestones of the Clore Formation are exposed in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 13, T. 11 S., R. 10 E., Palestine Sandstone also occurs at the unconformity in sec. 24, T. 11 S., R. 9 E., and in portions of sec. 19, T. 11 S., R. 10 E. The area of deepest channel erosion lies in the SE$\frac{1}{4}$ sec. 19 and the NW$\frac{1}{4}$ sec. 29, T. 11 S., R. 10 E. Here the upper limestone bench of the Menard Limestone is generally the highest Chesterian unit. Eastward along the outcrop toward the Ohio River, the Pennsylvanian lies on progressively younger

Fig. 4—Allard Member of the Menard Limestone in creek bed overlain by shaly sandstone of the Lusk Member of the Caseyville Formation in the SE¼ NE¼ SE¼ sec. 19, T. 11 S., R. 10 E. This exposure shows the unconformity between the Mississippian and Pennsylvanian sediments in the area of greatest erosion associated with the pre-Pennsylvanian Evansville Channel.

Chesterian units—Palestine and then Clore at Battery Rock. Across the Ohio River in 3-L-18, Crittenden County, Kentucky, the lower bench of the Kinkaid Limestone lies at the unconformity.

The Evansville Valley that was cut into Chesterian sediments had an important effect on the thickness and distribution of the basal Pennsylvanian units in the mapped area.

PENNSYLVANIAN SYSTEM

The main belt of Pennsylvanian sediments crossing the northern part of the mapped area is expressed topographically as a series of dissected cuestas that dip gently to the north-northeast. Pennsylvanian sediments occur also in the main graben where they support an irregular topography and underlie the highest elevations in the area. Thickness of the Pennsylvanian section (from the highest exposed unit down to the basal unconformity) is approximately 1250 feet. An appreciably greater Pennsylvanian section is present in subsurface north of the Saline River. Only about 600 feet of the section is well exposed, of which nearly half is sandstone. At one place or another, each principle sandstone forms prominent bluffs and ledges. The sandstones provide the principle mappable units of the lower Pennsylvanian clastic sequence.

The Caseyville Formation (from the base of the Pennsylvanian to the top of the Pounds Sandstone Member) and the Abbott Formation (from the top of the Pounds Sandstone to the top of the Murray Bluff Sandstone Member) were delineated. The top and bottom of the Battery Rock Sandstone Member and the base of the Pounds Sandstone were also mapped, except in the graben. Although the Lusk Shale, Battery Rock Sandstone, and Pounds Sandstone Members were all recognized at specific localities in the graben, they could not be consistently mapped.

McCormick Group

The McCormick Group, which includes almost all of the well exposed Pennsylvanian sediments in the mapped area, is approximately 600 feet thick. It consists of the Caseyville and Abbott Formations and contains four major named sandstones and at least three thin coals. The McCormick Group is well exposed, from the base of the Battery Rock Sandstone to the top of the Grindstaff Sandstone, near Illinois Route 1 in the SE$\frac{1}{4}$ sec. 3 and NE$\frac{1}{4}$ sec. 10, T. 10 S., R. 9 E.

Caseyville Formation

The Caseyville Formation extends from the base of the Pennsylvanian to the top of the Pounds Sandstone Member. Thicknesses range between 250 to 350 feet, and sandstones form approximately 70 percent of the formation. Unlike other Pennsylvanian or Chesterian sandstones, outcrops of Caseyville sandstones commonly contain rounded to subrounded quartz granules and pebbles which may be as large as half an inch in diameter but generally are smaller. They occur within beds and as lag concentrates along bedding planes. The sandstones principally consist of clean quartz sand; mica is sparingly present, and detrital matrix is largely lacking. Cross-bedding is well developed (fig. 5). The shales of the Caseyville Formation are light to medium gray, commonly silty, and, at many places, carbonaceous. Marine fossils in either the sandstones or the shales were not observed in the area and are very rare elsewhere.

Lusk Shale Member — The Lusk Shale Member is the most variable in both thickness and lithology of any of the formally recognized members of the McCormick Group. Its thickness in the mapped area is directly related to the extent of erosion of Chesterian sediments by the Evansville Valley. Near the center of the channel in secs. 19 and 20, T. 11 S., R. 10 E., the Lusk Shale is approximately 100 feet thick, but where Pennsylvanian sediments rest on the upper part of the Clare or possibly on the Degonia Formation, the Lusk is only a few feet thick or may be absent. About 50 percent of the Lusk Shale Member consists of massive and thin-bedded sandbodies as much as 30 feet thick, some of which

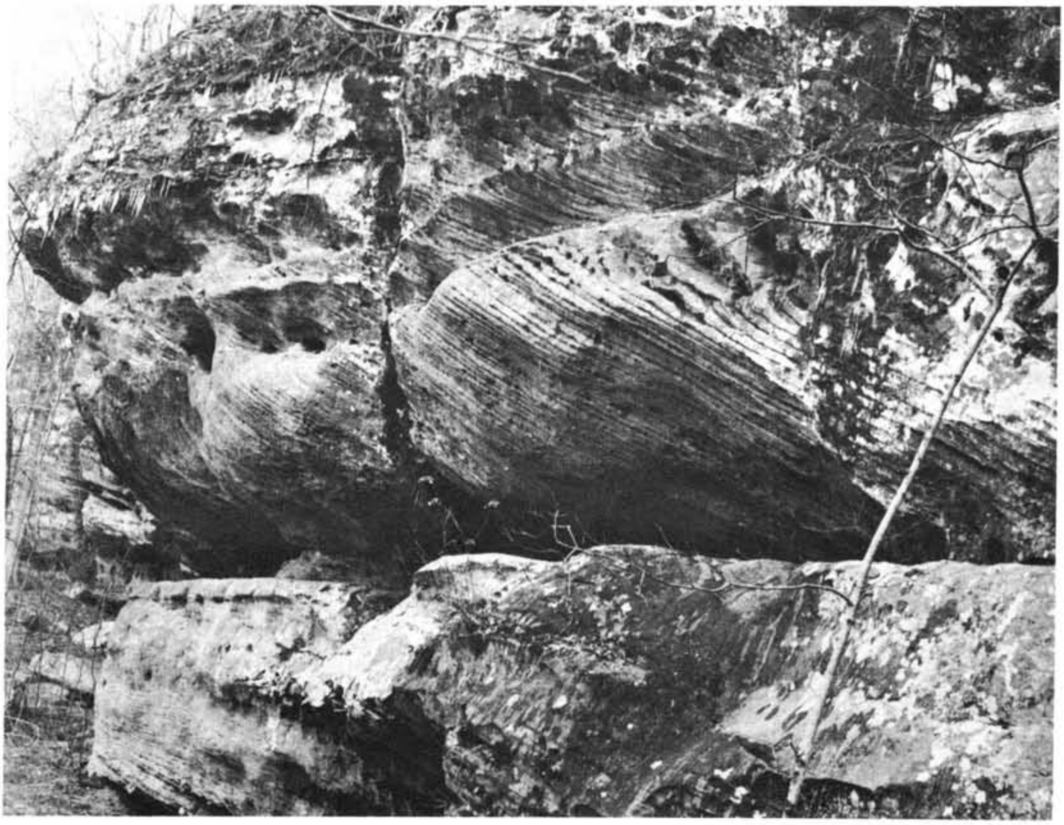

Fig. 5—Cross-bedded sandstone of the Caseyville Formation in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 17, T. 11 S., R. 10 E.

are useful for local mapping. The sandbodies commonly have ripple marks and cross-bedding that is typically oriented to the southwest. Plant casts are abundant at many places in both the shales and the thin-bedded sandstones. Quartz granules and pebbles are sparingly present. The Lusk Shale is well exposed in the upper reaches of Cane Creek in secs. 19 and 20, T. 11 S., R. 10 E.

Battery Rock Sandstone Member — The first persistent Pennsylvanian sandstone above the unconformity is the Battery Rock Sandstone. It provides the lowest, good, mappable Pennsylvanian unit anywhere in the main outcrop belt where it commonly forms a prominent bluff 20 to 50 feet high. Red cedar trees generally rim the larger bluffs. It has a maximum thickness of about 70 feet, but at the type section at Battery Rock in the E$\frac{1}{2}$, sec. 27 and sec. 26, T. 11 S., R. 10 E. it is 50 to 60 feet thick. Ripple marks and cross-bedding are common, the latter generally dipping west and northwest. Quartz granules and pebbles commonly are present. The Battery Rock Sandstone has an unconformity at its base. The sandstone is well exposed at many places and is prominently exposed at the type section at Battery Rock and in the bluff in the N$\frac{1}{2}$ sec. 10, T. 11 S., R. 9 E.

Section between Battery Rock and Pounds Sandstone Members — The interval between the Battery Rock and Pounds Sandstone Members ranges from 80 to 100 feet.

Sandstone may locally form as much as 70 percent of the total section, but 30 to 50 percent is probably more typical. Much of the sandstone is thin-bedded, fine- to medium-grained, and interbedded with various amounts of silty shale. The road cut along Illinois Route 1 in the NE¼ NE¼ NE¼ sec. 10, T. 11 S., R. 9 E., reveals basal thin-bedded sandstones that lie conformably on the massive Battery Rock. Massive, cross-bedded sandstones in the interval are especially prominent along Cane Creek in secs. 17 and 20, T. 11 S., R. 10 E. A persistent, mappable sandstone, well exposed in the NE¼ NE¼ NE¼ sec. 10, T. 11 S., R. 9 E., and along the road in the SE¼ SW¼ SE¼ sec. 3 of the same township, can be confused easily with the overlying Pounds Sandstone. East of the graben, the lower sandstone is well exposed in the SE¼ SW¼ SE¼ sec. 18, T. 9 S., R. 10 E., where it forms a small bluff north of the road. Ripple marks, cross-bedding, some plant impressions, and quartz granules and pebbles occur in the sandstones of the interval. In southeastern Illinois two named members—the Sellers Limestone and the Gentry Coal—have been recognized in this interval.

The Sellers Limestone Member is known from only one outcrop where it forms a small ledge in a bluff facing east along the Ohio River in the NW¼ NE¼ SE¼ sec. 21, T. 11 S., R. 10 E. No other outcrop of this limestone is known. It is a ferruginous, arenaceous, poorly-bedded but abundantly fossiliferous limestone, 2 feet thick. Although the stratigraphic relations of the Sellers Limestone are not definitely known, it is believed to underly the Gentry Coal Member (Ill. correlation chart by Siever in Wanless, 1956).

The Gentry Coal Member, formerly called the Battery Rock Coal by Worthen and Engelmann (in Worthen, 1866, p. 360-361), probably is best exposed in the vicinity of Battery Rock in the SW¼ NE¼ sec. 27, T. 11 S., R. 10 E. Worthen and Engelmann (in Worthen, 1866, p. 361) also reported that the coal has an average thickness of about 26 inches and lies about 60 feet above the Battery Rock Sandstone in the vicinity of Battery Rock. Its thickness is probably less than 26 inches throughout most of the mapped area.

The section between the top of the Battery Rock Sandstone and the base of the Pounds Sandstone has been named Drury Shale in southwestern Illinois by Lamar (1925, p. 91-95). The name Drury Shale, however, cannot be used in southeastern Illinois because the Gentry Coal and the Sellers Limestone previously have been recognized in the interval.

<u>Pounds Sandstone Member</u>—The Pounds Sandstone is the most prominent, persistent, and readily mapped sandstone of the McCormick Group in the mapped area. It forms impressive bluffs that commonly are rimmed by red cedar trees (fig. 6). It is more than 80 feet thick and is well exposed at many places, particularly along the Ohio River in secs. 17 and 21, T. 11 S., R. 10 E. Its unconformable contact with the underlying shale is also well displayed along the Ohio River in the SW¼ SE¼ NE¼ sec. 21 of the same township. Here the Pounds contains a conspicuous shale pebble conglomerate that also is found in its base across the Ohio River at Caseyville, Union County, Kentucky. Quartz granules and pebbles are generally prominent, and cross-bedding, predominently oriented to the south and southwest, is usually conspicuous. Thick cross-beds, such as those shown in figure 6, are an identifying characteristic of the Pounds Sandstone in this area. Typically, the Pounds is the thickest, most conglomeratic, and most conspicuously cross-bedded sandstone of the Caseyville Formation.

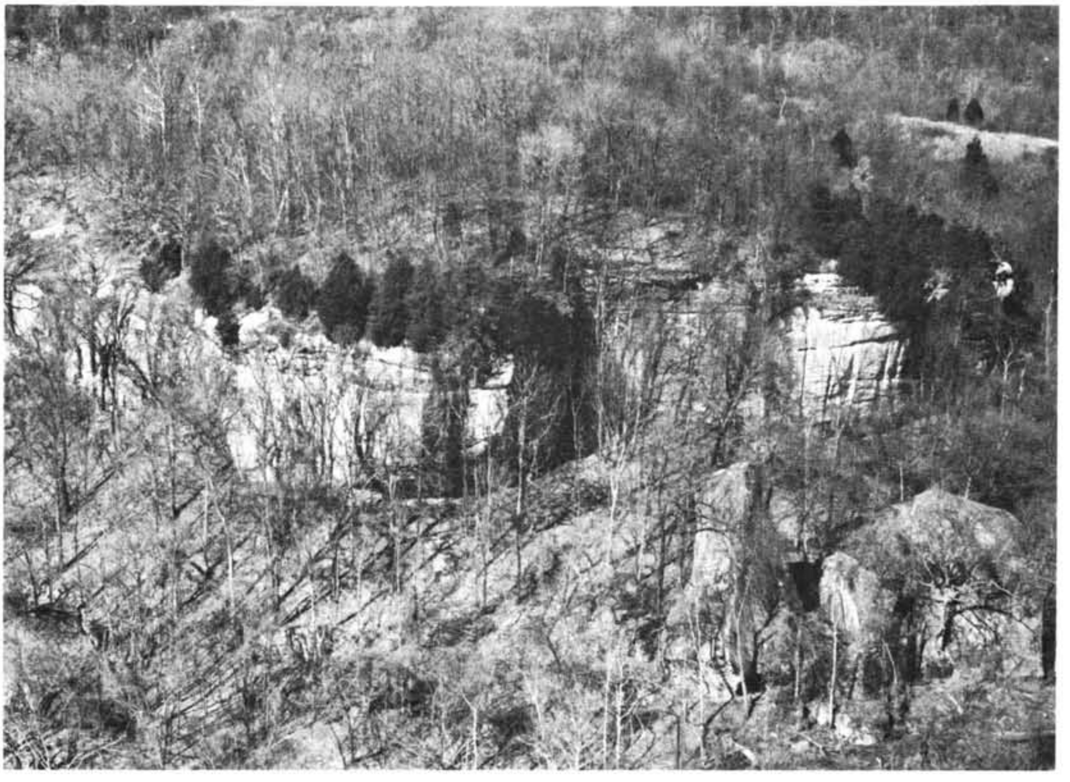

Fig. 6—Bluff of Pounds Sandstone covered by cedar trees. Loose blocks have slid on underlying shale toward Ohio River. NW$\frac{1}{4}$ SE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 21, T. 11 S., R. 10 E.

Abbott Formation

The Abbott Formation, which extends from the top of the Pounds Sandstone to the top of the Murray Bluff Sandstone Member, appears to be approximately 300 feet thick. In contrast to the Caseyville Formation, sandstones of the Abbott have virtually no quartz granules and pebbles in the mapped area, but they have more abundant matrix, more feldspar, and more mica. In hand specimens the sandstones typically appear to be intermediate between the clean quartz sandstones of the Caseyville and the argillaceous and micaceous subgraywacke sandstones of the overlying Kewanee Group. Moreover, the three named sandstone members of the formation, the Grindstaff, the Finnie and the Murray Bluff, commonly can be distinguished from one another in hand specimens. The Grindstaff Sandstone has the least amount of mica, matrix, and feldspar; the Finnie Sandstone has intermediate amounts; and the Murray Bluff Sandstone has the most. The shales of the formation, which cannot be lithologically distinguished from those of either the Caseyville or Spoon Formations, are typically medium to dark gray and are commonly silty and carbonaceous. Marine fossils are relatively rare in either the shales or sandstones of the Abbott.

Section below the Grindstaff Sandstone Member—The shales and sandstones below the Grindstaff Sandstone Member may have a maximum thickness of 100 feet. Shale, silty shale, and some thin-bedded, ripple-marked, fine- to medium-grained sandstone form most of the section. Although the interval is not generally well exposed, it is visible in two ravines draining southward in the SW¼ SE¼ NE¼ and the SE¼ SW¼ NE¼ sec. 3, T. 11 S., R. 9 E. In the graben in T. 11 S., R. 9 E., it forms most of the slope facing northeast in the SE¼ SE¼ sec. 15 and can be seen along Rock Creek in the NW¼ sec. 22. The Reynoldsburg Coal (Weller, 1940, p. 39) appears to lie in the upper portion of the interval. This coal seems to be rather persistent, but probably is no more than a few inches thick in most places. It can be seen in the creek bed in the NE¼ SE¼ NE¼ sec. 4, T. 11 S., R. 10 E. At the latter exposure, Worthen and Engelmann (in Worthen, 1866, p. 362) reported 22 inches of coal.

Grindstaff Sandstone Member—The Grindstaff Sandstone is 25 to 35 feet thick, cross-bedded, and contains somewhat more matrix and mica than the Pounds Sandstone. Quartz granules and pebbles were not observed, although Butts (1925, p. 44) reported them to the west in Eagle Valley. The Grindstaff forms fairly persistent small bluffs and ledges across the area. It can be seen in the graben in a road cut along Illinois Route 1 in the NW¼ NE¼ NW¼ sec. 14 and is well exposed along the crest of the hill overlooking the Ohio River in the NW¼ sec. 17, T. 11 S., R. 10 E.

Section between Grindstaff and Finnie Sandstone Members—As much as 60 feet of medium- to dark-gray shale and thin-bedded sandstone conformably overlie the Grindstaff Sandstone. The Willis Coal Member, which occurs in the upper part of this interval, has been mined locally along a tributary of Beaver Creek in secs. 28, 29, 30, 31, 32, and 33, T. 10 S., R. 9 E. Thicknesses of coal up to 42 inches have been reported (Smith and Lennon, pl. 3A, in Smith, 1957) in sec. 30, T. 10 S., R. 9 E. The Willis Coal also crops out in the northward-trending ravines in sec. 34, T. 10 S., R. 9 E., and in ravines in the northern half of secs. 2 and 3, T. 11 S., R. 9 E. In much of this area the coal appears to have been eroded by the overlying Finnie Sandstone.

Finnie Sandstone Member—The Finnie Sandstone is the first of the Pennsylvanian sandstones that can be distinguished easily from the underlying ones by its greater content of mica, feldspar, and matrix. Also it commonly is more reddish brown and ferruginous than most other Pennsylvanian sandstones. The Finnie is not prominently developed in the area, and generally its thickness is not more than 35 feet. Cross-bedding and ripple marks are present. It can be seen along the north side of the creek in the NW¼ NE¼ SE¼ sec. 30, T. 9 S., R. 9 E. In the graben it caps the hill in the NE¼ sec. 14, T. 11 S., R. 9 E., and it is well exposed in a meander scar of Harris Creek in the SW¼ NE¼ SE¼ sec. 11 of the same township.

Section between the Finnie and Murray Bluff Sandstones—Approximately 40 to 50 feet of poorly exposed shale, silty shale, and some thin-bedded sandstone conformably overlie the Finnie Sandstone Member.

Murray Bluff Sandstone Member—The Murray Bluff Sandstone is poorly exposed in secs. 28, 29, and 30, T. 10 S., R. 9 E. It contains more matrix, mica, and feldspar than the Finnie Sandstone. Its thickness is estimated at 30 feet. It could not be definitely identified in outcrop in the mapped area.

Kewanee and McLeansboro Groups

The Kewanee Group consists of two formations, the Spoon and the Carbondale. This group is poorly exposed in the Saline Mines quadrangle although it is well represented in subsurface north of the Saline River, under the alluvium of the floodplain of the Ohio and Saline Rivers, and in subsurface in the graben in portions of secs. 2, 10, and 11, T. 11 S., R. 9 E. It also may have a restricted occurrence in subsurface in the graben south of the Saline River in the NW$\frac{1}{4}$ sec. 12, T. 11 S., R. 9 E.

Limited exposures of the Kewanee Group occur along the Saline River. South of the Saline River old diggings in what are believed to be the Davis Coal and DeKoven Coal Members occur in secs. 21 and 28, T. 10 S., R. 10 E. North of the Saline River in the vicinity of the Saline Mines Church are old diggings of the Davis Coal and Harrisburg (No. 5) Coal Members. The Palzo Sandstone Member can be seen in the open shaft of an abandoned mine in the SW$\frac{1}{4}$ NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 35, T. 10 S., R. 9 E.

McLeansboro sediments may be present in the subsurface in the graben south of the Saline River in the SW$\frac{1}{4}$ sec. 1, SE$\frac{1}{4}$ sec. 2, NE$\frac{1}{4}$ sec. 11, and NW$\frac{1}{4}$ sec. 12, T. 11 S., R. 9 E. McLeansboro sediments, however, are definitely under the floodplain between the Ohio and Saline Rivers. Thicknesses of several hundred feet or more are believed to occur.

QUATERNARY SYSTEM

PLEISTOCENE SERIES

Paleozoic strata in eastern Hardin County are overlain by a mantle of unconsolidated deposits, mostly of Pleistocene age. These deposits include residuum, accumulated in situ from weathering of bedrock; alluvium, deposited by rivers and streams; loess, deposited by wind; and colluvium, deposited through the combined actions of gravity and rain wash on steep slopes. Only the alluvial deposits—the Recent alluvium and the Wisconsinan terraces—are shown on the geologic map.

Residuum

At many places in eastern Hardin County the limestone bedrock is overlain by an accumulation of clay which is a residuum from the solution of limestone by ground water. The clay probably began to accumulate long before Pleistocene time. Some of the relatively flat upland surfaces that are underlain by the clay are erosion surfaces formed during Pliocene time, and the highest may be still older. The older surfaces are not distinguished by a consistently greater thickness of residuum, and the Pleistocene residuum cannot be differentiated from the earlier.

The residuum is usually yellow, brown, or red clay and in places contains an abundance of angular chert fragments. It generally is only a few feet thick and is thickest in areas underlain by impure or cherty limestone. Some concentrations appear to be produced by wash and slumping from the upper slopes of nearby hills. As much as 50 feet of residuum is present locally along fractures or faults. The residuum is especially prevalent in the area of the Elizabethtown plain west of Cave in Rock. At one time a deposit of residual clay containing fluorspar was worked by open-cut methods in the Morrison-Oxford workings near Spar Mountain.

Alluvial Deposits

The alluvial deposits of the Ohio River and its tributaries consists largely of silt interbedded with sand. Beds of gravel derived from the local bedrock occur in the Recent alluvium along some of the tributary valleys.

Above the present floodplain underlain by the Recent alluvium, alluvial deposits are found in three terraces, the surfaces of which are remnants of older levels of valley fill. The deposits in these terraces are not deeply weathered and all are believed to have been formed during the Wisconsinan Stage, the last interval of glacial invasion of the headwater of the Ohio Valley.

A low terrace, separable from the Recent alluvium at only a few places, exists near the mouth of the Saline River and is best displayed at Saline Landing. It is mapped with the alluvium, but its outer margin, a low scarp, is indicated by a line where recognizable. The elevation of the terrace is about 350 to 355 feet above sea level with the base of the scarp at about 340 feet.

The most widespread terrace surface is an intermediate one (pl. 1, Qwi) which, near the Ohio River, has an elevation of about 360 feet, locally 370 feet or above. The usual scarp height is about 15 to 20 feet but decreases to as low as 5 feet in the upper reaches of small valleys. The terrace is prominent along Harris and Rock Creeks in secs. 12 and 13, T. 11 S., R. 9 E., and along the Ohio River in secs. 20 and 22, T. 12 S., R. 9 E.

Deposits underlying the terrace are well exposed in a cut bank of Rock Creek in the NE$\frac{1}{4}$ NW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 13, T. 11 S., R. 9 E., and consist of well-bedded, calcareous, clayey silts with thin lenses of sand. A lens of sand 8 feet below the top of the deposit contains abundant snails identified by A. B. Leonard (personal communication) as branchiate forms, probably of Woodfordian age. Farther upstream in a cut bank of Goose Creek in the NW$\frac{1}{4}$ NW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 16, T. 11 S., R. 9 E., the deposits consist of non-bedded, non-calcareous, clayey silt . The deposits appear to be lake deposits in slack water caused by rapid build-up of the Ohio River floodplain by glacial outwash. The type of gastropods found in the deposits tends to live in ponded water. Farther up the tributary valleys the floodplains probably developed normally.

In southeastern Hardin County, mainly in the Cave in Rock quadrangle, auger borings in the SE$\frac{1}{4}$ NW$\frac{1}{4}$ of sec. 21, T. 12 S., R. 9 E., show that the intermediate terrace consists of silts, sandy silts, and sands, all noncalcareous to a depth of 10 to 12 feet.

The highest terrace (pl. 1, Qwh) has an elevation of 380 to 390 feet, 15 to 20 feet above the intermediate terrace. It is commonly found within a mile of the Ohio River and is best displayed in the W$\frac{1}{2}$ sec. 21, T. 12 S., R. 9 E. It is more limited in distribution than the intermediate terrace. No exposures of the materials underlying the high terrace were found, but auger borings show them to be composed chiefly of sand with occasional silt beds.

Colluvium

The lower part of most of the steep hills throughout the area is covered by an accumulation of material called "colluvium" that is derived from the upper slopes by creep, slump, and slope wash. The dominant material is silt which is mostly reworked loess, but angular fragments of the bedrock are common. The material is crudely sorted and contains lenses of stream gravel in numerous steep-sloped alluvial fans at the mouths of small ravines. The colluvium is as much as 20 to 30 feet thick.

Loess

The uplands of the mapped area are everywhere covered by deposits of non-bedded, buff to light brown clayey silt, called loess. The loess was deposited by winds which blew it up onto the uplands from the Ohio River bottomlands which were repeatedly flooded and covered with silt during the glacial times. The loess is commonly 10 to 15 feet thick but is as much as 30 feet thick in the Ohio River bluffs.

The loess is principally the Peoria Loess of Woodfordian (middle Wisconsinan) age, but in places the lower part contains a few feet of dark brown Roxana Silt (early Wisconsinan), and even more locally a thin deposit of reddish brown, very clayey silt correlated with the Loveland Loess of Illinoian age.

STRUCTURE

The geologic structure of Hardin and Pope Counties is more complex than that of any other area in Illinois. The area falls within a region marked by a great number of faults, the regional aspect of which were discussed by Stuart Weller et al. (1920, p. 55-75) and J. M. Weller et al. (1952, p. 78-83).

The quadrangles surveyed for this report occupy a position between the Tolu Dome to the south and the Mooreman-Eagle Valley Syncline to the north. In general, the sedimentary strata dip gently to the northeast, descending from the dome into the syncline. Drilling records indicate that this dip continues into the structurally deepest portion of the Illinois Basin a few miles northeast of the mapped area, and that the deepest portion of the basin in Illinois lies in the northeast corner of the mapped area.

The continuity of Mississippian and Pennsylvanian strata is interrupted by the Rock Creek Graben, an elongate down-dropped segment which trends northeast-southwest, passing diagonally across the mapped area.

CHARACTERISTICS OF MAJOR FAULTS

The names and general distribution of the faults and systems of faults are shown on a scale of 1 inch to the mile (pl. 2). Each fault is classified as to the amount of throw, and the down-dropped side is indicated. The classes are as follows: Class I, faults of large displacement (more than 500 feet); Class II, faults of moderate displacement (50-500 feet); and Class III, faults of small displacement (less than 50 feet.)

Except for the possibility of thrust faulting associated with the Rock Creek Graben (Weller et al., 1952) and the evidence of local horizontal movement in workings of bedded fluorspar deposits (Currier, 1944, p. 27), faults are of the normal type.

Major faults for the most part trend northeast-southwest and generally are subparallel. Where dips of faults could be measured or inferred from drilling, they were steep angles of about 70°. In general the faults are fairly straight, but there are several which curve rather sharply near their intersection with straight portions of subparallel faults.

FIELD EVIDENCE OF MAJOR FAULTS

MECHANICAL DEFORMATION

Intense jointing, relatively steep dip of dragged beds, silification, brecciation and fault gouge are evidence of mechanical deformation related to faulting.

Competent beds near faults generally have at least two sets of joints, the most persistent set trending northeast-southwest, parallel to faulting, with the second set normal to the direction of faulting. Jointing is generally more intense near faults.

The relatively steep dip of the beds, caused by drag, is good evidence of the proximity of faults. Steep dips generally occur only near the fault, the beds a short distance away rapidly assuming normal attitude. Beds dragged into a vertical or nearly vertical position are relatively rare, the average dip in these situations being no greater than 25°.

Fault breccia, often associated with slickensides, occurs especially near faulted sandstone formations. At many places the presence of breccia and slickensides is the only indication of proximity to a fault. The observed fault or fault zone is apt to be occupied by a greenish gray clayey material, fault gouge.

TOPOGRAPHIC EVIDENCE

Topographic evidence of faulting includes such features as lineation of stream courses, sharp angle turns in a stream course, lineation of resistant ridges at an angle to the regional strike of the beds, offset in ridges capped by resistant beds, and, to a lesser extent, the presence of springs, especially where they coincide with other linear features.

MINOR FAULTS AND FRACTURE ZONES

Bedded fluorspar deposits in the Cave in Rock district occur along groups of joint-like fractures and minor faults which trend from N 45° to 60° E and N 30° to 85° W. Vertical displacement of the faults ranges from a few inches to a maximum of 20 feet (Weller et al., 1952, p. 110) and there is evidence of local horizontal movement. It is uncertain whether or not these ore-related structures have surface expression, and it may be that they die out vertically (Weller et al., 1952, p. 112).

In the area southeast of the graben from Peters Creek Fault to the Ohio River, some of the outcrop features suggest the presence of minor faults and fracture zones similar to those associated with bedded deposits. In general, these features (relatively steeply dipping beds, intensification of the jointing pattern, lineation of gullies, and the presence of springs) trend northeast-southwest and coincide with re-entrants along ridges capped by resistant beds. Associated with these linear features, and perhaps delimited by them, are structural segments which show locally persistent differences in strike and may represent slightly tilted blocks bounded by the minor faults and fracture zones.

A good example occurs in the SE$\frac{1}{4}$ sec. 27, T. 11 S., R. 10 E., in the vicinity of Battery Rock where the beds of a segment strike northeast-southwest with a persistent northwest dip of about 5°, in discordance with a regional northwest-southeast strike and northeast dip (pl. 1). A similar situation exists north of the Rock Creek Graben in the NW$\frac{1}{4}$ sec. 2, T. 11 S., R. 9 E. Closely spaced measurement of dip and strike as well as other observations can be useful in determining the boundaries of such segments or slightly tilted blocks even in the absence of surface expression of their bounding elements.

JOINTS

Joints were measured at 57 Pennsylvanian and 30 Mississippian outcrops, chiefly sandstones. Altogether data were collected from 168 locations.

The sediments of the mapped area have a systematic joint pattern. Figure 7 shows an example of a regular and well-developed joint system that is typical of much of the area. Plate 2 shows a wind rose of joint directions and the principal trend of faulting. The primary joints parallel the faulting and the secondary joints are perpendicular to it; the two classes combined make up approximately two-thirds of all the measurements. The remaining third is uniformly distributed and is considered as a background pattern of randomly oriented joints on which are superimposed the systematic joint patterns. The systematic joint patterns were developed by the same stresses that produced the principal fault trends, and their common origin is reflected in the parallelism of prominent joints to fault trends in outcrops near known faults.

Although exceptions, of course, do exist, joints also tend to be spaced more closely and better developed near faults. Thus jointing is more intense in and near the graben than far outside of it. Good joint sets occur throughout the area, however, and irrespective of location and lithology, their most common orientation is northeast-southwest. Where two well developed joint sets are present, their acute angle of intersection is commonly 75° to 85°. Except near some faults, the joint sets are essentially vertical.

ROCK CREEK GRABEN

The Rock Creek Graben occupies a diagonal, central belt 1$\frac{1}{2}$ to 2$\frac{1}{2}$ miles wide (pl. 2). The southeast limit of this belt is marked by the Peters Creek Fault System. The northeast edge is marked by intersecting and cross-cutting faults in a rather complex zone 1 to 1$\frac{1}{2}$ miles wide.

The youngest strata exposed in the graben are limited exposures of Carbondale or possibly McLeansboro age that crop out near the Saline River in secs. 1 and 2, T. 11 S., R. 9 E. This approximate age is inferred from subsurface oil test data in section 11 of that township.

Three major systems of faults are related to the graben structure. They are, from southeast to northwest, the Peters Creek, Hogthief Creek, and Goose Creek Fault Systems.

PETERS CREEK FAULT SYSTEM

The Peters Creek Fault System (pl. 2) is essentially a single fault or fault zone in its northeastern portion, but to the southwest it splits into a number of separate faults which share the displacement in an essentially step-like manner. The faults with greater throw are downthrown to the northwest, and the total displacement is more than 1000 feet.

Fig. 7—Well-developed joint sets trending northeast and southeast in thin bed of Vienna Limestone, SE¼ NW¼ NE¼ sec. 30, T. 11 S., R. 10 E.

HOGTHIEF CREEK FAULT SYSTEM

The Hogthief Creek Fault System marks the northwest boundary of the Rock Creek Graben southwest of the Saline Mines quadrangle (pl. 2). It is a complex system ranging in width from a few hundred feet to about half a mile. Along the southeastern part of its course in the Saline Mines quadrangle, the northwesternmost fault of the system is downthrown about 1200 feet on the southeast side, with Caseyville faulted against St. Louis Limestone. South-west of the mapped area the throw is greater, probably as much as 1600 feet. This fault merges into a fault complex north of Rock Creek School where cross-cutting and intersecting faults cause a reversal of throw so that throughout the greater part of its length in the Saline Mines quadrangle the northeastern side is downthrown. It divides the graben into two segments with the more deeply downthrown segment (pl. 2) lying to the northwest.

Southeast of this fault of major displacement are lesser normal and possibly thrust faults that separate thin slices of lower Pennsylvanian and upper Chesterian formations. The southeasternmost faults of this system that are known to enter the Saline Mines quadrangle from the west enter near the north line of sec. 31, T. 11 S., R. 9 E. They are three in number and converge along the valley of Rock Creek in section 29. The over-all effect is downthrow to the southeast, but the total throw is probably less than 50 feet.

GOOSE CREEK FAULT SYSTEM

The Goose Creek Fault System is essentially parallel to the Hogthief Creek System throughout the greater part of the latter's extent in the Saline Mines quadrangle (pl. 2). It bounds the graben on the northwest and is confined largely to a single fault or fault zone along the northeastern portion of its course. However, near the center of sec. 16, T. 11 S., R. 9 E., it splits to the southwest into numerous lesser faults, most of them downthrown on the southeast side. The greatest displacement beyond the point of divergence is along the fault which carries the Goose Creek-Hoeb-Greene fluorspar vein. The diverging faults terminate against a fault that trends N. 75° E. and that bounds an upthrown wedge of lower Chesterian and Valmeyeran formations.

The total displacement along the Goose Creek Fault, shared in a step-like manner by the divergent faults of the system, is more than 500 feet, with the downthrown side to the southeast. The displacement along Goose Creek vein ranges from about 500 feet at the Goose Creek shaft to about 250 feet at the Greene shaft.

A fault of large displacement enters the mapped area in the SE$\frac{1}{4}$ sec. 19, T. 11 S., R. 9 E., and trends approximately N. 75° E., meeting the north fault of the Hogthief Creek System just east of the west line of sec. 21, T. 11 S., R. 9 E. Along most of its course it is downthrown to the northwest with a throw of about 700 feet, bringing Palestine against Bethel.

AREA NORTHWEST OF THE ROCK CREEK GRABEN

The area northwest of the Rock Creek Graben is underlain by Mississippian and Pennsylvanian formations that dip gently in a northeasterly to northwesterly direction. Two faults are known to enter the Saline Mines quadrangle in the area of Pennsylvanian outcrop in sec. 6, T. 11 S., R. 9 E., the Wolrab Mill Fault on the south and what is possibly a branch of the Lee Fault on the north. Their displacement is small and the faults appear to die out to the northeast. On the west margin of the quadrangle the Wolrab Mill Fault is downthrown about 30 or 40 feet on the southeast side and the Lee branch is downthrown somewhat less, possibly about 20 feet, on the northwest.

Another fault, confined to Mississippian formations, enters the Saline Mines quadrangle in the SE$\frac{1}{4}$ sec. 18, T. 11 S., R. 9 E. The north side is downthrown and the throw is probably about 50 feet.

A fault of large displacement is known from subsurface data to underlie the floodplains of the Saline and Ohio Rivers. Its approximate position in secs. 26 and 35, T. 10 S., R. 9 E., is shown on the geologic and structure maps (pls. 1 and 2). Locally it may have as much as 800 feet vertical throw with downdropping to the east. However, at the southwest end of its mapped extent, the displacement is certainly considerably less; for in sec. 2, T. 11 S., R. 9 E., near its junction with the Goose Creek Fault System, beds of the Abbott Formation lie on both sides of the fault as extended.

AREA SOUTHEAST OF ROCK CREEK GRABEN

The area southeast of the Rock Creek Graben is relatively unfaulted and, so far as determined, there are no faults of major displacement. The pattern of rock formations is roughly semicircular, reflecting the Tolu Dome structure the apex of which is near Tolu, Kentucky.

The Tolu Dome, as reflected in Illinois, is a relatively gentle unwarping of bedrock formations which results in the exposure of Salem Limestone in the Ohio River bluff west of Cave in Rock. This structure is possibly similar to Hicks Dome to the northwest. The Tolu Dome is truncated on the northwest by the Peters Creek Fault and separated from Hicks Dome by the Rock Creek Graben that trends northeast-southwest.

Minor faults and fracture zones occur in mine workings in the Cave in Rock district and similar structures, possibly with some related horizontal movement, may be inferred by structural discordances elsewhere. It has not proved feasible to show the minor discordances on the geologic map, so the area southeast of the Peters Creek Fault System is shown as essentially unfaulted, that is, only two faults are shown.

The Tower Rock Fault, which is associated with a minor ore occurrence in the SE$\frac{1}{4}$ sec. 17, T. 12 S., R. 9 E., is known to extend for several hundred feet in a N 30° to 20° E direction. Evidence of the fault in the form of breccia, intense silicification, and mineralization is seen in a series of pits and shafts. A fault with a maximum displacement of 20 feet has been followed for several hundred feet in the W. L. Davis mine in the NE$\frac{1}{4}$ sec. 34, T. 11 S., R. 9 E.

Two northeast-southwest trending faults probably underlie the floodplain of the Ohio River in the extreme southeast part of Hardin County. The position of these faults as shown on the geologic map is inferred largely from geologic maps of adjacent portions of Kentucky.

ECONOMIC GEOLOGY

Hardin County and the adjacent parts of Pope, Saline, and Gallatin Counties contain a diversity of mineral resources that include fluorspar, lead, zinc, limestone, coal, clay, shale, and sandstone. These resources have been discussed in other publications, and, as this report is concerned primarily with the areal and stratigraphic geology of the eastern part of Hardin County, resources are discussed only briefly here. Reference is made, however, to other publications where further information may be found.

FLUORSPAR, LEAD, AND ZINC

Mining and milling of fluorspar, lead, and zinc ore have long been a major factor in the economy of Hardin County. J. M. Weller et al. (1952) give a comprehensive discussion of the geology of ore occurrence. Earlier data are given in reports by Stuart Weller et al. (1920), Bastin (1931), and Hatmaker and Davis (1938). A popular account of fluorspar occurrence, mining, and uses is given by Finger et al. (1960).

Fluorspar deposits of three types occur in the Illinois part of the mining district. These are (1) bedded or " blanket" deposits formed primarily by selective replacement of limestone beds, (2) fissure-filling or vein deposits along faults of moderate displacement (mostly 100 to 500), and (3) residual or "gravel spar" deposits derived by weathering from either the bedded or vein primary deposits.

BEDDED DEPOSITS

Bedded deposits at Lead Hill and Spar Mountain, about 4 miles northwest of Cave in Rock, were sites of early lead and fluorspar mining. The deposits were essentially flat-lying, cropping out in the hillside so that miners could drift in with the ore. These deposits have been mined extensively, but only two mines, Crystal and Victory, have operated recently. Cable tool and diamond core drilling, particularly since 1940, have delineated the northeastward extension of the ore trends to deeper levels because the favorable ore horizons dip gently. Deeper mines being operated or maintained in a standby condition are located in T. 11 S., R. 9 E. They are the Minerva Company's No. 1 mine in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 24; Ozark-Mahoning's Deardorff, Davis, and Green mines in the N$\frac{1}{2}$ secs. 34 and 35; Ozark-Mahoning's Oxford mine in the NW$\frac{1}{4}$ sec. 25; and Ozark-Mahoning's Hill-Ledford mine near the midpoint of the east line of sec. 23. The ore is reached by vertical shafts that range in depth from about 150 to 800 feet.

VEIN DEPOSITS

Commercial vein deposits that are chiefly fluorspar, a relatively recent discovery in the mapped area, occur along a fault near Goose Creek. Major production has come from the Goose Creek and Hobe mines in the SE$\frac{1}{4}$ sec. 17, T. 11 S., R. 9 E., and minor production in sandstone has come from the Greene mine to the northeast in sec. 16. These ore bodies are reached by vertical shafts about 300 feet deep, but at the Greene mine the main body of ore lies at a depth of about 500 feet, approximately 200 feet below the lowest level of the shaft.

RESIDUAL DEPOSITS

Residual deposits, some of which are related to small vein and replacement ore bodies have been prospected in the vicinity of Cave in Rock but only minor production was reported. These prospects, as well as minor bedded and vein prospects, are included in the list of mines and prospects.

MINES AND OPERATING MINING COMPANIES

The following is a list of mining companies operating in the area mapped for this report:

Goose Creek Mining Company, Cave in Rock, Illinois

Hoeb Mining Company, Cave in Rock, Illinois

The Minerva Company, Eldorado, Illinois

Ozark-Mahoning Company, Mahoning Mining Division, Rosiclare, Illinois

The more important mines are identified by name on the geologic map (pl. 1). The following list includes these and other mines, mine shafts, adits, and prospects, each identified by a reference number which appears at the appropriate location on the geologic map (pl. 1).

Vein Deposits in the Rock Creek Area

1. Goose Creek mine
2. Hoeb mine
3. Greene mine
4. Dutton prospect

Bedded Deposits in Cave in Rock District and Other Prospects

5. Fluorspar Products mines, Lead Hill group
6. Grischy mines, Lead Hill mine
7. Grischy mines, Cave in Rock group
8. Austin mines, Blue Valley shaft
9. Tems prospect
10. Oxford-Morrison open pit
11. Austin mines, lead mine
12. Austin mines, Cleveland mine
13. Austin mines, Green-Defender mine
14. Austin mines, East Green mine
15. Frayser, Wall property
16. Frayser, Wall property
17. Minerva mines, Victory mine, Addison shaft
18. Minerva mines, Victory mine, Carlos shaft
19. Minerva mines, North Victory adit
20. Minerva mines, Crystal mine adits
21. Minerva mines, Crystal mine adit
22. Minerva mines, Crystal mine shafts
23. Patton shaft
24. Ozark-Mahoning mines, Deardorff mine
25. Ozark-Mahoning mines, W. L. Davis mine
26. Ozark-Mahoning mines, W. L. Davis No. 2 shaft
27. Ozark-Mahoning mines, No. 16 shaft
28. Ozark-Mahoning mines, A. L. Davis mine
29. Ozark-Mahoning mines, East Green mine
30. Ozark-Mahoning mines, West Green mine

31. Ozark-Mahoning mines, North Green mine
32. Ozark-Mahoning mines, E. Davis mine
33. Ozark-Mahoning mines, Oxford mine
34. Ozark-Mahoning mines, Hill-Ledford mine
35. Minerva Mines, Minerva No. 1 mine
36. Martin prospect
37. Eureka prospect
38. Hill Property workings
39. Winn Property workings
40. Underwood Property, Rodgers'mine
41. Underwood Property workings
42. Frayser workings
43. Frailey workings
44. Patrick mine
45. Palmer mine
46. Tower Rock workings

COAL

The coal resources of Gallatin and Hardin Counties have been evaluated by Cady (1952) and Smith (1957). In the Carbondale Formation, near Saline Mines and to the north, the thickness of the Danville (No. 7) Coal appears to range from 14 to 30 inches, of the Herrin (No. 6) Coal 30 to 48 inches, of the Briar Hill (No. 5A) Coal 18 to 36 inches, and of the Harrisburg (No. 5) Coal 48 to 60 inches.

In the Spoon Formation the DeKoven Coal is reported to be as much as 36 inches thick, and the Davis Coal as much as 48 inches thick. Little is known of possible lower coals, although in SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 30, T. 10 S., R. 9 E., the Willis Coal in the Abbott Formation is reported to have a thickness that ranges up to 42 inches.

The Gentry Coal (formerly called the Battery Rock Coal), in the Caseyville Formation, has been reported to occur with a thickness of as much as 26 inches or more in the vicinity of Battery Rock (Worthen, 1866, p. 361), but the coal is not known to be more than a few inches thick elsewhere. Coals of uncertain stratigraphic position have been mined in small hillside mines in the mapped area, although it is probable that such coals are included among those listed.

No large mines have been developed in the area. The principal operations have occurred in the vicinity of Saline Mines where the No. 5 Coal was mined prior to the Civil War. Small mines in the immediate vicinity have worked sporadically until recent years. The DeKoven and Davis Coals were mined from a shaft immediately south of Saline Mines in the SW$\frac{1}{4}$ NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 35, T. 10 S., R. 9 E., although mining was probably confined principally to the thicker Davis Coal. Willis Coal at the location described above has been worked in a few small hillside mines.

Small mines operated before and during the Civil War in the Gentry Coal in secs. 26 and 27, T. 11 S., R. 10 E., Hardin County.

Coal prospecting has occurred principally in Gallatin County. Data from oil tests and other sources, however, in the Rock Creek Graben, suggest that strata as young as the Modesto Formation may be present in the vicinity of the Saline River and that the No. 5 Coal and other persistent coal beds of the Carbondale Formation may be present within the graben. Nevertheless, east of Saline Mines and in the graben, coal testing has not been adequate to evaluate fully the possible presence of No. 5 or higher coals.

Although a relatively small area in the northern part of the Saline Mines quadrangle is underlain by the more persistent coal beds, the principal reserves are in the Davis and DeKoven Coals and possibly in the No. 5 Coal. Additional coal test drilling will be required to determine the full extent of these reserves. Reserves of other coals in the area of this study are considered to be relatively minor.

LIMESTONE

Two limestone quarries, operated by Rigsby and Barnard Quarry Company, adjoin each other in the S½ SW¼ sec. 1, T. 12 S., R. 9 E., about 2 miles north of Cave in Rock. The rock quarried is the Ste. Genevieve Limestone, and products include roadstone and agricultural limestone. An abandoned quarry, in which 75 feet of St. Louis limestone is exposed, is about a mile west of Cave in Rock in the NW¼ NW¼ NE¼ sec. 23, T. 12 S., R. 9 E.

The Missouri Portland Cement Company has acquired property near the Ohio River 2 miles east of Cave in Rock and has begun development of a deposit of the Ste. Genevieve Limestone. When in operation, this quarry will supply limestone to a cement plant being constructed near Joppa, Illinois.

The Salem, St. Louis, and Ste. Genevieve Formations are the thickest and generally the most quarriable limestones in the area mapped. They offer possibilities as sources of building stone and crushed stone for various purposes. The Ste. Genevieve, and probably the St. Louis Limestone, are, at least in part, of suitable composition for use in making cement. Some of the limestones and shales of the Pope Megagroup may offer combinations of raw materials for the same purpose. The limestone resources of Hardin and Pope County and their possible uses are discussed in more detail in a recent report (Lamar, 1959). Other data regarding cement making materials are to be found in a somewhat earlier report (Lamar et al., 1956). Building stone possibilities are described in a report on "Illinois Building Stone" (Lamar and Willman, 1955).

CLAY AND SHALE

The clays and shales of the mapped area include loess, residual clay, and clay and shale associated with the upper Mississippian and Pennsylvanian rocks. The clays and shales of the Pope Megagroup are likely to be calcareous, and many of them have limestone interbedded with them. Although some of them may be of suitable chemical composition for use with limestone in cement making, their usefulness for making ceramic products appears limited. Possibly some of them could be used for making common brick or drain tile.

The Pennsylvanian clays and shales are associated with thick sandstone formations and are likely to be silty or sandy. Probably some of them could be used for the manufacture of structural clay products.

The residual clays of the mapped area include both cherty and non-cherty clay. Many of the clays rest on an uneven limestone bedrock surface and are therefore variable in thickness. A sample taken from a 6-foot outcrop about $2\frac{1}{2}$ miles northeast of Eichorn, west of the area mapped, was tested and found to be suitable for making common and face brick (Lamar, 1948).

Loess was at one time used considerably in Illinois for manufacturing brick and drain tile, but shale has largely replaced it for these purposes. Nevertheless, it is probable that some of the loess in the area mapped, particularly that from the upper leached parts of the deposits, could be used to make structural clay products.

CHERT GRAVEL

In some places chert resulting from the weathering of limestones has been concentrated by streams into comparatively small deposits of gravel that have been used as a minor source of material for patching roads. Also it is understood that sand and gravel consisting principally of brown chert pebbles, were dredged some years ago from bars in the Ohio River. More of these materials may be available from this source.

SANDSTONE

The Upper Mississippian and Pennsylvanian rocks of the area mapped include a number of thick sandstone formations. Some of these have been used to a small extent for foundations and similar structures, and at one time sandstone was quarried commercially for building stone near Shetlerville, to the west of the area mapped. Probably a number of the sandstone formations could supply building stone, chiefly in shades of brown, cream, or almost white. It is also possible that, if suitably processed, some of the sandstones would yield sand acceptable for glass making, molding sand, and other purposes (Biggs and Lamar, 1955). The economic feasibility of such a procedure is uncertain.

BARITE

Barite occurs in association with fluorspar in some of the vein and bedded replacement fluorspar deposits of the mapped area. Its distribution is spotty, however, and deposits of proved commercial grade and size are apparently rare (Bradbury, 1959). There is no present production of barite.

IRON ORE

In the early history of Hardin County, iron was produced by smelting locally mined, limonitic iron ore. Operations were centered about 4 miles north of Elizabethtown where two iron smelting furnaces were in operation. There has been no commercial production of iron or iron ore for many years.

The ore is said to have occurred in pockets of comparatively small size resting on or near the top of the bedrock. In the area mapped, numerous small pits that were dug in prospecting for iron ore were noted on both sides of the lower

Cave in Rock road in the vicinity of the old Tower Rock school house about 3¼ miles west of Cave in Rock. Also as a result of mining operations, several tons of limonitic ore were piled years ago beside a pit on a densely wooded hillside, locally referred to as Iron Hill, in the NW¼ SE¼ SE¼ sec. 17, T. 12 S., R. 9 E., a mile north of the Ohio River. The ore is in masses that range from egg-size to a foot in length. It has a columnar, botryoidal, or honeycombed texture, and the color ranges from light ocher to dark red and black. The limonite occurs in an area of deeply weathered limestone, probably the St. Louis Formation There is no record of commercial production from this area.

OIL AND GAS

In the area mapped,small shows of heavy, black oil have been noted in oolitic portions of the Ste. Genevieve in cores of drillings made to find fluorspar and at a few places in fluorspar mines. A well in the NW¼ NW¼ NW¼ sec. 20, T. 11 S., R. 10 E., was acidized and pumped during a period of about 30 days. It yielded about 100 barrels of oil from the Shetlerville Member of the Renault. No commercial accumulations are known to have been encountered.

Because the area of the quadrangles has been but little prospected, its oil and gas possibilities are uncertain. The area is faulted, and in some parts of Illinois faults are known to produce conditions favorable to the accumulation of oil. However, in view of the intensity of the Hardin County faulting, the presence of mineralization along some of the faults, and the absence of oil or gas shows along them, the significance of these faults in connection with oil accumulation is problematical. Some of the oil sands that produce oil elsewhere in Illinois crop out in the area, and oil production, therefore, is not generally to be expected near the outcrops. A structure map covering the area and a further discussion of the oil possibilities of southern Illinois is given by Weller (1940, pl. 1).

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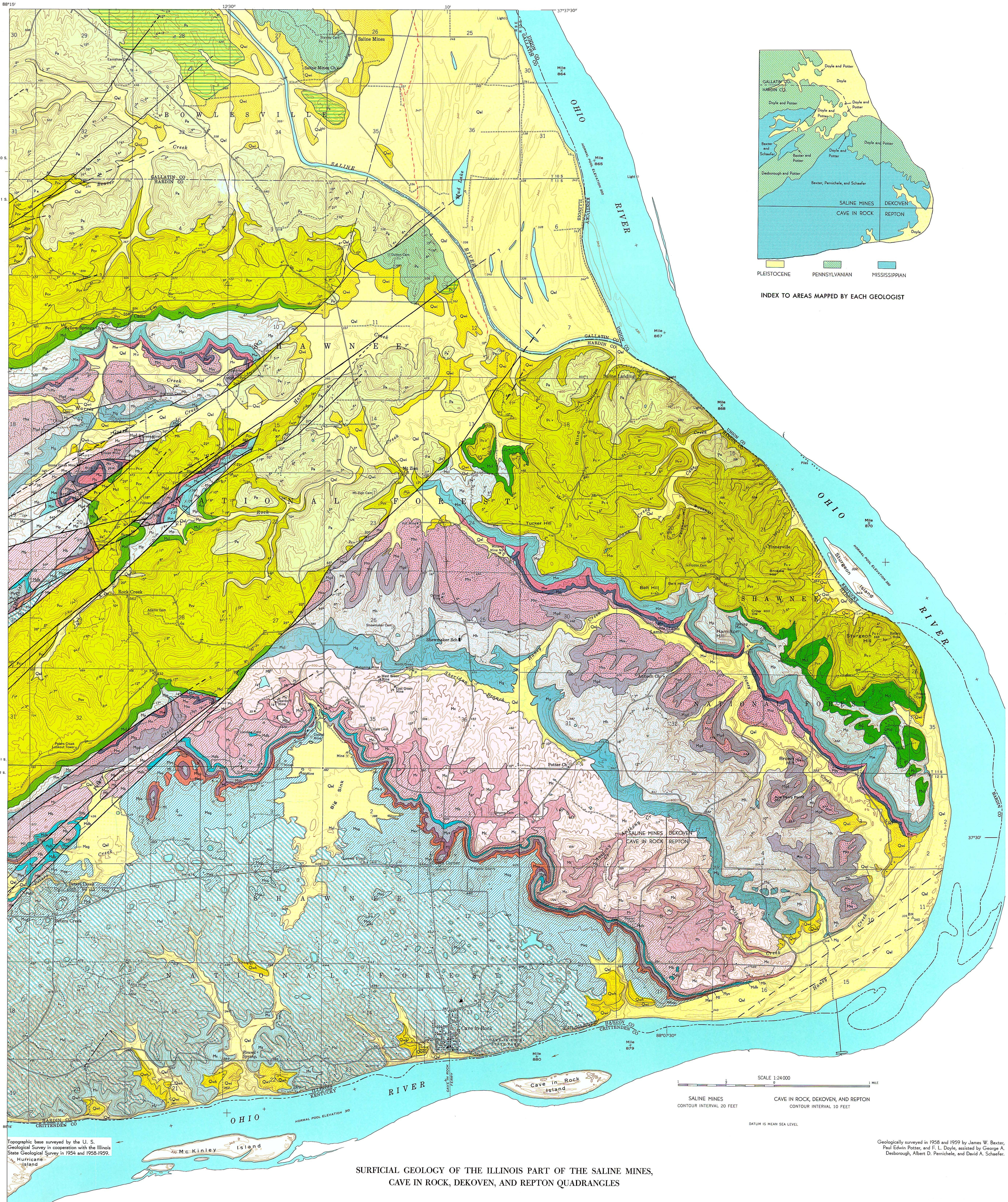


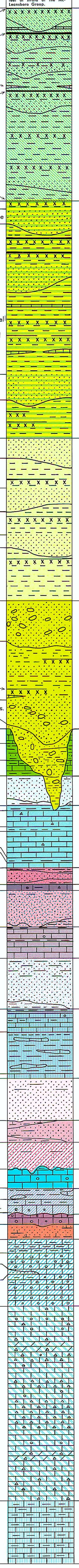
Topographic base surveyed by the U. S. Geological Survey in cooperation with the Illinois State Geological Survey in 1954 and 1958-1959.

Geologically surveyed in 1958 and 1959 by James W. Baxter, Paul Edwin Potter, and F. L. Doyle, assisted by George A. Desborough, Albert D. Pernichele, and David A. Schaefer.

SURFICIAL GEOLOGY OF THE ILLINOIS PART OF THE SALINE MINES, CAVE IN ROCK, DEKOVEN, AND REPTON QUADRANGLES

INDEX TO AREAS MAPPED BY EACH GEOLOGIST

GENERALIZED COLUMNAR SECTION OF EXPOSED ROCKS



System	Series	Megagroup	Group	Formation	Member	Lithology	Symbol	Thickness in feet
PENNSYLVANIAN			McLeansboro			Records of drilling in the continuation of the Rock Creek Graben beneath the floodplain in the N.E. corner of the map indicate the presence of at least 1000 feet of strata of the McLeansboro Group.		
PENNSYLVANIAN			Kewanee	Carbondale	Danville (No. 7) Coal; Brereton Ls.; Herrin (No. 6) Coal; Briar Hill (No. 5A) Coal; St. David Ls.; Harrisburg (No. 5) Coal; Summum (No. 4) Coal; Shawneetown Coal; Colchester (No. 2) Coal		Pc	350
PENNSYLVANIAN			Kewanee	Spoon	Palzo Sandstone; DeKoven Coal; Davis Coal; Stonefort Ls.; Wise Ridge Coal; Mt. Rorah Coal; Creal Springs Ls.; Granger Ss.; New Burnside Coal		Ps	400-450
PENNSYLVANIAN			McCormick	Abbott	Murray Bluff Sandstone; Delwood Coal; Finnie Ss.; Willis Coal; Grindstaff Ss.; Reynoldsburg Coal		Pa	300–350
PENNSYLVANIAN			McCormick	Caseyville	Pounds Ss.; Gentry Coal; Sellers Ls.; Battery Rock Ss.; Lusk Shale		Pcv	250–350
MISSISSIPPIAN	CHESTERIAN	POPE		Clore	Ford Station; Tygett; Cora		Mcl	90–100
MISSISSIPPIAN	CHESTERIAN	POPE		Palestine Sandstone			Mp	60±
MISSISSIPPIAN	CHESTERIAN	POPE		Menard Limestone	Allard; Scottsburg; Walche		Mm	100–130
MISSISSIPPIAN	CHESTERIAN	POPE		Waltersburg			Mw	15–50
MISSISSIPPIAN	CHESTERIAN	POPE		Vienna Limestone			Mv	10–20
MISSISSIPPIAN	CHESTERIAN	POPE		Tar Springs Sandstone			Mts	50–80
MISSISSIPPIAN	CHESTERIAN	POPE		Glen Dean Limestone			Mgd	60±
MISSISSIPPIAN	CHESTERIAN	POPE		Hardinsburg Sandstone			Mh	90–120
MISSISSIPPIAN	CHESTERIAN	POPE	Golconda	Haney Limestone; Fraileys Shale; Beech Cr Limestone			Mg	120–160
MISSISSIPPIAN	CHESTERIAN	POPE	West Baden	Cypress Sandstone			Mc	80–100
MISSISSIPPIAN	CHESTERIAN	POPE	West Baden	Ridenhower			Mr	30–50
MISSISSIPPIAN	CHESTERIAN	POPE	West Baden	Bethel Sandstone			Mb	50–70
MISSISSIPPIAN	CHESTERIAN	MAMMOTH CAVE	Cedar Bluff	Downeys Bluff Ls.			Mdb	25–40
MISSISSIPPIAN	CHESTERIAN	MAMMOTH CAVE	Cedar Bluff	Yankeetown Shale; Renault Limestone	Shetlerville Ls.		Mys	40–55
MISSISSIPPIAN	VALMEYERAN	MAMMOTH CAVE	Cedar Bluff	Renault Limestone	Levias Ls.		Ml	5–35
MISSISSIPPIAN	VALMEYERAN	MAMMOTH CAVE		Aux Vases Sandstone	Rosiclare Ss.		Mav	20–40
MISSISSIPPIAN	VALMEYERAN	MAMMOTH CAVE		Ste. Genevieve Limestone	Joppa Ls.; Karnak Ls.; Spar Mountain Sandstone; Fredonia Ls.		Msg	140–160
MISSISSIPPIAN	VALMEYERAN	MAMMOTH CAVE		St. Louis Limestone			Msl	350–400
MISSISSIPPIAN	VALMEYERAN	MAMMOTH CAVE		Salem Limestone			Ms	100+

KEY

PLEISTOCENE

Recent

Qal — Stream alluvium; includes some areas of low terrace; boundary of low terrace shown by dashed line where prominent (silt, clay, sand, and gravel)

Wisconsinan

Qwi — Intermediate terrace (well bedded, calcareous, clayey silts; a few sandy lenses)

Qwh — High terrace (sand with occasional silt beds)

PENNSYLVANIAN

Pc — Carbondale Formation (shale, sandstone, thin limestone, minable coal)

Ps — Spoon Formation (shale, sandstone, thin limestone, coal)

Pa — Abbott Formation (shale, sandstone, thin coal)

Pcv (bp, tbr, bbr) — Caseyville Formation (sandstone, shale, and conglomerate; top (tbr) and base (bbr) of Battery Rock Sandstone and base (bp) of the Pounds Sandstone shown in some areas)

MISSISSIPPIAN

Mcl — Clore Formation (gray shale, thin limestone and sandstone beds)

Mp — Palestine Sandstone (fine-grained sandstone, mostly thin bedded; some shale)

Mm — Menard Limestone (dark, fine-grained, partly fossiliferous limestone; shale)

Mw — Waltersburg Formation (shale; shaly sandstone)

Mv — Vienna Limestone (dark, fine-grained, partly cherty limestone, locally calcarenitic)

Mts — Tar Springs Sandstone (fine-grained, partly cross-bedded sandstone; shale)

Mgd — Glen Dean Limestone (fine- to coarse-grained, fossiliferous, partly oolitic limestone; shale)

Mh — Hardinsburg Sandstone (sandstone; upper part has interlaminated greenish gray shale)

Mg — Golconda Group (Haney Limestone, fine- to coarse-grained, fossiliferous limestone; Fraileys Shale, shale, siltstone, some limestone; Beech Creek Limestone, argillaceous, dark, fine- to medium-grained limestone)

Mc — Cypress Sandstone (fine-grained sandstone; interbedded shale in upper half)

Mr — Ridenhower Formation (interlaminated, wavy-bedded shale and sandstone; soft, dark shale; light colored thin- to medium-bedded sandstone)

Mb — Bethel Sandstone (light gray, fine- to medium-grained sandstone; basal conglomerate)

Mdb — Downeys Bluff Limestone (medium-grained crinoidal limestone, locally oolitic; some chert)

Mys — Yankeetown Shale and the Shetlerville Member of the Renault Limestone (Yankeetown shale, calcareous, gray, with thin siltstone and limestone beds; Shetlerville Member, gray, more or less oolitic limestone; grades to dark, fine-grained limestone at top)

Ml — Levias Member of the Renault Limestone (light colored, oolitic limestone, locally fine-grained)

Mav — Aux Vases Sandstone (Rosiclare Member, very fine-grained, very calcareous; some sandy limestone; shale at base)

Msg — Ste. Genevieve Limestone (gray to almost white, variable texture but largely oolitic; thin, calcareous sandstone lenses)

Msl — St. Louis Limestone (fine grained, cherty)

Ms — Salem Limestone (gray to almost black, argillaceous; foraminiferal calcarenite)

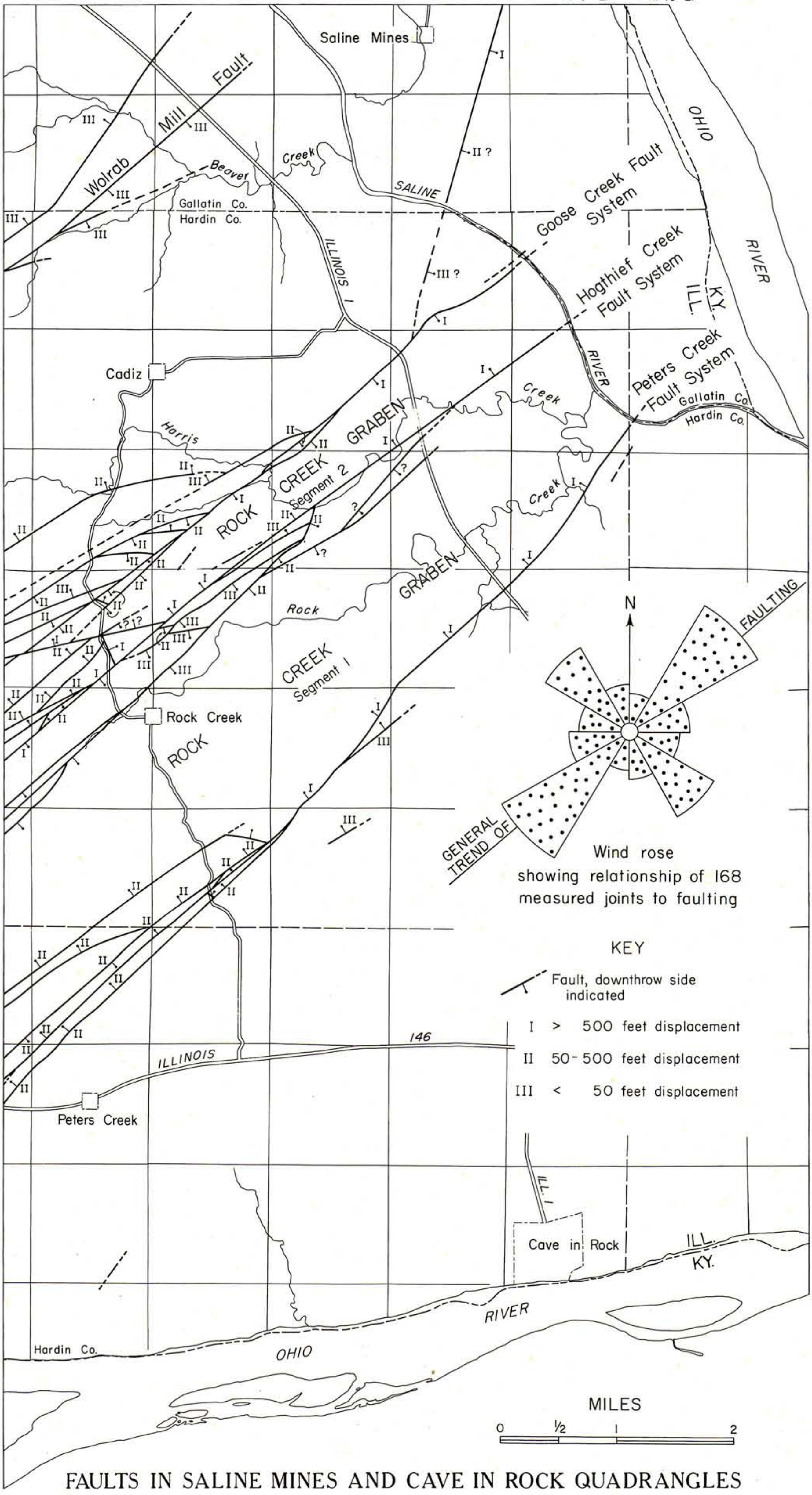
Fault

Strike and dip of bedding

Mine

Mine shaft

Adit



FAULTS IN SALINE MINES AND CAVE IN ROCK QUADRANGLES

CIRCULAR 342

ILLINOIS STATE GEOLOGICAL SURVEY

URBANA