STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

GEOLOGY FOR PLANNING IN ST. CLAIR COUNTY, ILLINOIS

Alan M. Jacobs, compiler

ILLINOIS STATE GEOLOGICAL SURVEY
John C. Frye, Chief
Urbana, IL 61801

CIRCULAR 465
1971

GEOLOGY FOR PLANNING IN ST. CLAIR COUNTY, ILLINOIS

Alan M. Jacobs, compiler

ABSTRACT

St. Clair County lies in southwestern Illinois across the Mississippi River from St. Louis, Missouri. One-fifth of the total land surface of 673 square miles is on floodplains of the Mississippi and Kaskaskia Rivers and Silver Creek. The floodplains are underlain by as much as 120 feet of gravel, sand, silt, and clay. The remaining four-fifths of the land surface is on uplands that contain flat or dissected plains, low ridges and mound-shaped hills, about 20 square miles of strip mines, and an area of karst topography. The uplands are underlain by as much as 75 feet of till and sand and gravel, and generally 12 to 30 feet of loess and related silt; however, near the Mississippi River bluffs there are more than 100 feet of loess and related silt. These deposits have been redistributed into spoil piles in the strip mines. Beneath these deposits or cropping out in places are gently sloping beds of limestone, shale, sandstone, siltstone, claystone, and coal. Thinly layered, fractured limestone underlies the area of karst topography.

Mineral and water resources are abundant in the county. Limestone of the St. Louis, Ste. Genevieve, and Fraileys Formations is quarried in the uplands in the western part of the county. Sand and gravel resources are found in the broad floodplains and in those ridges and hills adjacent to the Kaskaskia River. Clay and shale of commercial value are found in the Modesto Formation in the northern part of the county and in beds associated with the Herrin (No. 6) and Colchester (No. 2) Coals. The No. 6 Coal is the main coal resource and is mined at the surface and underground. Petroleum has been produced from the Cypress, Yankeetown, and Aux Vases Sandstones, from the Galena Group, and from limestone reefs of the Silurian System; and

some of these units are suitable for gas-storage projects. Water resources include ground water from near-surface unconsolidated deposits and from bedrock and surface water from the Mississippi River.

In some areas geologic conditions impose limitations on the use of land for construction and the disposal of waste, whereas in other areas no particular problems preclude use for those purposes. Rarely are the limitations severe enough that they cannot be overcome by available engineering and construction techniques.

This geologic information was prepared for land-use and resource planning on a county-wide scale. Individual site or local-area plans will require additional on-site evaluations.

INTRODUCTION

Land and People

St. Clair County lies in southwestern Illinois across the Mississippi River from St. Louis, Missouri (fig. 1). One-tenth of the county's total area of 673 square miles lies on the Mississippi River floodplain in the northwestern corner. The remaining area consists of flat uplands dissected by minor stream valleys and floodplains of tributaries of the Mississippi River. Beneath the land surface, a few to a little more than 100 feet of unconsolidated sediments rest on bedrock.

Of the county's 279,601 people (1970), half live in the four largest cities: East St. Louis (68,026); Belleville (41,123); Cahokia (20,135); and Centreville (11,060). Population density and industrialization are greatest on the Mississippi River floodplain and along a line from East St. Louis to Belleville. Outside these areas farming, grazing, and mining are the main land uses. Although about 70 percent of the land area is farm land, 70 percent of the working force is employed not in farming but in manufacturing or in white collar occupations.

Geology for Planning

Rural areas adjacent to metropolitan centers have been quickly transformed into suburban and urban areas by construction of industrial, residential, and service facilities. These transformations are occurring in St. Clair County because of its proximity to the greater St. Louis metropolitan area.

Land use in rural areas has been guided by soil conditions for agriculture and by geologic conditions for mineral development. The significance of both types of conditions to land use has become more appreciated in urban and suburban planning; for example, geologic conditions control the presence of construction materials needed for urban development and the physical suitability of sites for industrial, residential, and service facilities.

Rationale

In recognition of these controls the East-West Gateway Coordinating Council, an intergovernmental planning commission for the St. Louis area, re-

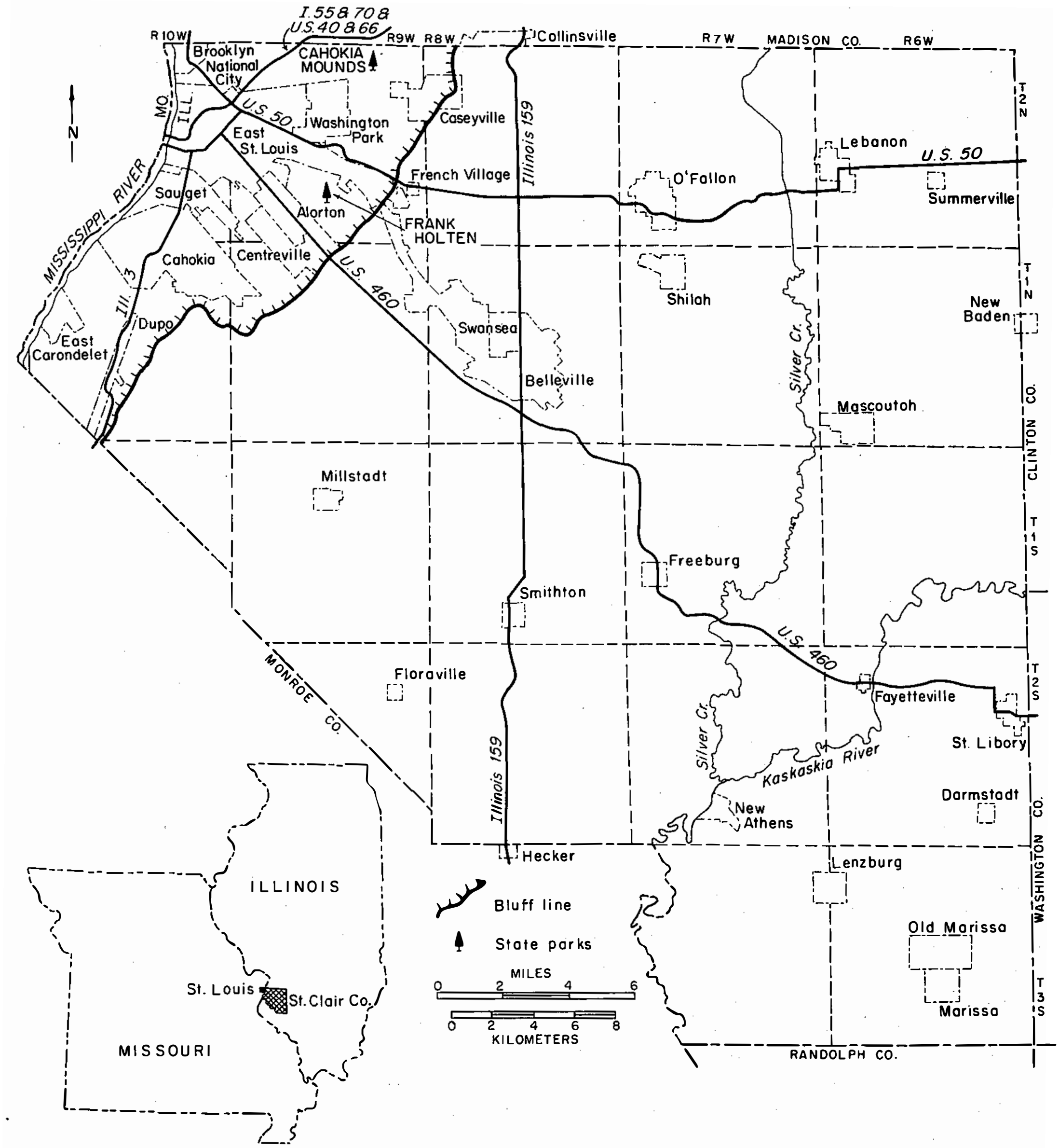

Fig. 1 - Communities, main highways, and state parks in St. Clair County, Illinois.

quested from the Illinois State Geological Survey geologic information on areas of Illinois in the St. Louis region. This report was prepared in response to that request.

Acknowledgments

The report was organized and compiled by Alan M. Jacobs with the help of the following contributors. All are members of the Illinois State Geological Survey staff except as otherwise noted.

	Contribution:
William H. Baker (Illinois State Water Survey)	Ground-water quality and potential yields of water wells
James W. Baxter	Limestone resources
Donald C. Bond	Crude oil; natural gas; and gas-storage projects
Paul B. DuMontelle	Geologic considerations for construction
Norman C. Hester	Sand and gravel resources
M. E. Hopkins	Coal resources
Alan M. Jacobs	Surficial deposits and geologic processes
I. Edgar Odom (Northern Illinois University)	Clay and shale resources
Kemal Piskin	Thickness of surficial deposits and topography of bedrock surface
Hubert E. Risser	Economic role of mineral resources
Frank B. Sherman	Water resources and geologic conditions for waste disposal

The geologic information was compiled from drilling records and field notes on file at the Survey, from field studies, and from mineral-resource records.

Basic Concepts

Different sciences use the same technical terms or conventions differently. The following paragraphs, therefore, clarify certain concepts for this report. (Definitions of specialized terminology are included where the terms are used.)

The terms *sand, silt,* and *clay* can be used to represent particle-size classes or types of sediments. Where particle-size classes are represented, the terms *sand-size particles, silt-size particles,* or *clay-size particles* are used and the size limits follow a simplified Wentworth scale (table 1). Where types of sediments are represented, the terms *sand, silt,* and *clay* are used and the sediment has the name of the dominant size-class constituent according to the triangular diagram in figure 2.

On some of the maps of mineral resources and land uses accompanying this report, a color-coding system suggests geologic suitability of the land for particular purposes: green means few geologic limitations; yellow means intermediate conditions; and red indicates significant geologic limitations for a par-

TABLE 1 - SIMPLIFIED WENTWORTH SCALE OF PARTICLE SIZES

Size class	Diameter of particles (mm)
Clay	Less than 1/256
Silt	1/256 to 1/16
Sand	1/16 to 2
Granule	2 to 4
Pebble	4 to 64
Cobble	64 to 256
Boulder	Greater than 256

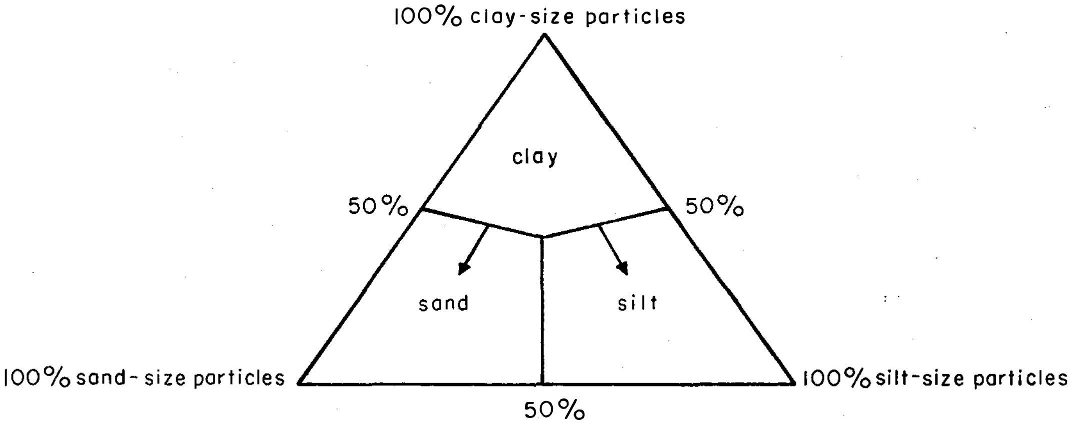

Fig. 2 - Simplified triangular diagram of sediment types. *Clay* includes sandy and silty clay. *Sand* includes silty and clayey sand. *Silt* includes sandy and clayey silt. (The arrows indicate an expansion of the clay region, as a small amount of clay may give clay-like properties.)

ticular land use. Each color has been divided into as many as three numbers, number 1 indicating the least and number 3 indicating the greatest number of limitations.

This report has been prepared for land-use and resource planning on a county-wide scale. It does not replace on-site evaluations for specific projects. Boundary lines on each map are approximate and are intended for use only at the published scale.

GENERAL GEOLOGY

Beneath the uplands and floodplains of St. Clair County, as much as 150 feet of surficial deposits (unconsolidated sediments) overlie the bedrock. Most of the surficial deposits were laid down during the last 200 thousand years by rivers, glaciers, and winds. The underlying bedrock contains sediments that were deposited more than 200 million years ago by oceans and rivers and were later hardened to form rock. Those geologic processes that are still altering the land include weathering, erosion, movement of underground water, accumulation of sediments at the base of slopes, modifications of stream channels, and flooding. The land is also being modified by the activities of man — construction, mining, farming, and waste disposal.

Geologic Regions

The physical properties and thickness of surficial deposits and the topography determine, in part, the suitability of different areas for different land uses. For convenience, the county has been subdivided into regions on the basis of topography and surficial deposits (pl. 1): upland till plain, ridges (sand), ridges (till), karst, narrow valleys and valley walls, strip mines, Mississippi River floodplain, and Kaskaskia River and Silver Creek floodplains.

Upland Till Plain

The upland till plain is relatively flat (fig. 3) and is underlain by 10 to a little more than 100 feet of surficial deposits that lie on bedrock. The surficial deposits are unconsolidated sediments that can be differentiated into various layers. The lowest layers include glacial tills (Banner Formation, Smithboro Till, and Vandalia Till; fig. 4), which are mixtures of sand, silt, clay, and gravel that were deposited by glacial ice. The tills differ slightly in their sandiness and in the properties of their clays. Beds of silt and sand and gravel are interbedded with tills. The tills are overlain by a widespread mantle of silt (Roxana Silt and Peoria Loess; fig. 4). The thickness of the silt is varied (pl. 1): along stream divides the thickness is greater than 100 feet in places near the Mississippi River floodplain, but eastward it thins considerably to about 10 feet at the eastern border of the county. Most of the silt was deposited by wind and is called loess.

In the upper few feet of some of the surficial deposits, but especially in deposits beneath the loess, there are zones which show the effects of weathering. The weathered zones are significant because they affect some uses of the land. They have resulted from: (1) breakdown of particles into smaller sizes; (2) forma-

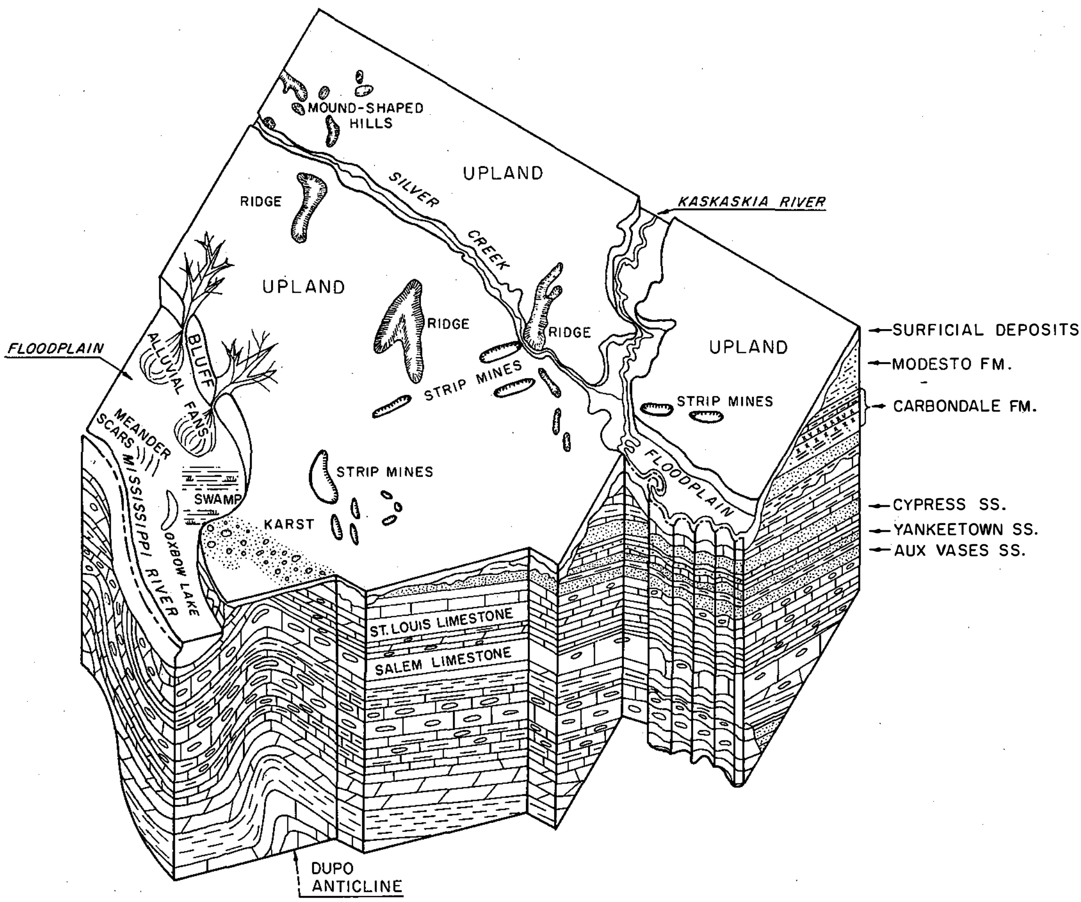

Fig. 3 - Three-dimensional geologic view of St. Clair County, Illinois.

mation of clays that shrink and swell with changes in water content; (3) leaching of calcium carbonate; and (4) formation of oxides of iron and manganese. The effect of the weathering has been to transform the original material into a less porous material having greater shrink and swell potential.

Ridges (Sand and Till)

The uplands of St. Clair County for the most part resemble a flat plane into which stream valleys are carved (fig. 3). The flatness of the upland surface, however, is interrupted by a belt of low ridges and mound-shaped hills. These ridges are about 3 to 5 miles long and about ½ to 1 mile wide. The hills are lined up along the trend of the ridges. The tops of both the ridges and the hills are about 50 feet above the surrounding upland.

There are two types of ridges and hills — those composed mostly of sand but containing some gravel and isolated pockets of till and those composed mostly of till but also containing pockets of sand and gravel and isolated blocks of bedrock (pl. 1). Those ridges and hills that contain a relatively high proportion of sand are located near the confluence of the Kaskaskia River and Silver Creek. All the ridges are covered with loess.

Karst

Even though there is a cover of surficial deposits, solution of underlying limestone in the western part of the uplands has produced a special topography known as "karst." Karst regions are characterized by rolling hills, circular depressions (sinkholes), caves, and a scarcity of streams that maintain a continuous surface route. The name "karst" comes from an area in Yugoslavia and Italy where these landforms are well displayed. Conditions for the formation of karst topography include the presence of thinly layered, fractured limestone, a temperate climate, and a steep gradient of underground drainage; all three of these conditions exist in western St. Clair County.

Solution is the main process in a karst area. Rain water or melted snow percolates into the ground and works its way through the cracks and planes between layers of limestone. Limestone contains calcium carbonate, which is somewhat soluble in water, especially if the water contains dissolved carbon dioxide. Surface waters usually contain carbon dioxide from the atmosphere or from decaying organic matter in the soil. Calcium carbonate is removed from the rock by ground water, leaving voids in the rock. Solution is accompanied by the collapse of unsupported rock above the voids. Collapse near the surface can form steep-sided sinkholes. Connected voids result in cave systems and underground routes of streams.

Karst topography is present in this region of St. Clair County (fig. 3 and pl. 1) because: (1) the thinly layered, fractured St. Louis Limestone is at the surface; (2) the climate is temperate; and (3) ground water of this region flows along a steep gradient toward the base of the Mississippi River bluffs. Sinkholes in St. Clair County are from tens to hundreds of feet in diameter and are tens of feet deep; some contain water (sinkhole ponds) because clay has sealed their underground outlets. No streams maintain a continuous surface route. Bretz and Harris (1961) reported on two caves: Oerter, or Stemler, Cave (NW 1/4 sec. 12, T. 1 S., R. 10 W.) and Falling Spring Cave (northeast of Dupo).

Time units				"Rock" units		Sediment type	Topographic setting
System	Series	Stage	Substage	Formation	Member		
Quaternary	Pleistocene	Holocene		Man-made deposits		Disturbed till, sand and gravel, and pieces of bedrock; silt containing Indian artifacts	Ridged spoil piles; Indian mounds
				Cahokia Alluvium / Peyton Colluvium		Silt, clay, clayey sand / Pebbly silt	Floodplains / Alluvial fans
		Wisconsinan	Woodfordian	Peoria Loess / Henry		Silt (loess) / Sand and gravel	Flat and dissected uplands, bluffs
			Farmdalian	Robein Silt / Henry		Silts, sandy silts, silts with organic matter / Sand and gravel	
			Altonian	Roxana Silt / Henry	Meadow Loess	Silt (loess) / Sand and gravel	
					McDonough Loess	Silt (loess)	
					Markham Silt	Silt with some sand with small pebbles	
		Sangamonian		Glasford	Berry Clay	Clay, silt, small pebbles	Buried undrained depressions
		Illinoian	Jubileean		Hagarstown	Gravel, sand, till	Elongate ridges and mound-shaped hills
			Monican		Vandalia Till	Till (sandy)	Flat and dissected uplands
					Mulberry Grove Silt	Silt with some organic matter	
			Liman		Smithboro Till	Till (silty)	
		Yarmouthian		Banner		Till, clay, sand and gravel, silt	
		Kansan					

Time units		Rock units			Thickness of formation (ft)	Description
System	Series	Group	Formation	Selected members		
Pennsylvanian	Desmoinesian	McLeansboro	Bond	Shoal Creek Limestone	30	Shales; siltstones; sandstones with thin limestones; claystones; and coals
			Modesto	Chapel (No. 8) Coal	250	
				Scottville Limestone		
		Kewanee	Carbondale	Danville (No. 7) Coal	180	
				Brereton Limestone		
				Herrin (No. 6) Coal		
				Harrisburg (No. 5) Coal		
				Colchester (No. 2) Coal		
			Spoon		150	
	Atokan	McCormick	Abbott		30	
Mississippian	Chesterian	Okaw	Glen Dean Limestone		0-20	Shales, sandstones, limestones
			Hardinsburg Sandstone		0-30	
			Haney Limestone		0-30	
			Fraileys		0-75	
			Beech Creek Limestone		0-10	
			Cypress Sandstone		0-60	
		Paint Creek	Ridenhower		0-40	
			Bethel Sandstone		0-20	
			Downeys Bluff Limestone		0-10	
			Yankeetown Sandstone		0-20	
			Renault		0-30	

Fig. 4 - Geologic column of St. Clair County, Illinois (page 8 — surficial deposits; pages 9-11 — bedrock).

Time units		Rock units		Thickness (ft)	Description
System	Series	Group	Formation		
Mississippian	Valmeyeran		Aux Vases Sandstone	60-80	Sandstone
Mississippian	Valmeyeran		Ste. Genevieve Limestone	0-80	Limestone
Mississippian	Valmeyeran		St. Louis Limestone	200-250	Limestone, some dolomite
Mississippian	Valmeyeran		Salem Limestone	70	Limestone
Mississippian	Valmeyeran		Ullin Limestone	70	Limestone
Mississippian	Valmeyeran		Warsaw-Borden	100-400	Siltstone (east) to siltstone and shale with dolomite
Mississippian	Valmeyeran		Keokuk-Burlington	0-160	Limestone
Mississippian	Valmeyeran		Fern Glen	0-60	Limestone and shale
Mississippian	Kinderhookian		Chouteau Limestone	10-25	Limestone
Mississippian	Kinderhookian	New Albany	Hannibal Shale	0-10	Shale
Devonian	Upper	New Albany	Sweetland Creek Shale	0-15	Shale
Devonian	Upper	New Albany	Sylamore Sandstone	0-15	Sandstone
Devonian	Lower		Bailey Limestone	0-150	Limestone
Silurian	Cayugan-Niagaran		Moccasin Springs Limestone	0-300	Limestone with some shale
Silurian	Cayugan-Niagaran		St. Clair Limestone	0-60	Limestone
Silurian	Alexandrian		Sexton Creek Limestone	10-45	Limestone
Silurian	Alexandrian		Edgewood	0-30	Limestone

Time units		Rock units				Thickness (ft)	Description
System	Series	Group	Subgroup	Formation	Member		
Ordovician	Cincinnatian	Maquoketa		Brainard Shale		65	Shale
				Ft. Atkinson		25	Dolomite
				Scales Shale		60	Shale with dolomite
	Champlainian	Galena	Kimmswick			95	Limestone
			Decorah			25	Limestone with shale
		Platteville				200	Limestone
		Ancell		Joachim Dolomite		160	Dolomite and shale
				St. Peter Sandstone		50-75	Sandstone
		Everton				125-150	Sandstone and dolomite
	Canadian	Prairie du Chien		Shakopee Dolomite		300-350	Dolomite with sandstone
				New Richmond Sandstone		0-80	Sandstone
				Oneota Dolomite		350	Dolomite
				Gunter Sandstone		0-10	Sandstone
Cambrian	Croixan			Eminence Dolomite		125	Dolomite
				Potosi Dolomite		340	Dolomite
				Franconia	Derby-Doerun	160	Dolomite
					Davis	110	Sandstone, dolomite, and shale
				Eau Claire		380	Limestone, dolomite, and shale
				Mt. Simon Sandstone		0-400	Sandstone
Precambrian	(3000 - 5000 ft deep)						Granite

Wayne Finch of East St. Louis informed the Survey of the existence of ten additional caves whose entrances are lined up from Stemler Cave to a point 1 mile northeast.

Continued formation of these features and enlargement of this region is possible because the potential for karst formation still exists. Karst topography is not now developed east of this area because the St. Louis Limestone is covered by other formations. If, however, the other formations were eroded and the St. Louis Limestone were exposed at the surface, karst development could progress eastward. The rate of formation, however, is very slow and the formation of new karst features has not been reported. The rate of solution could be increased by the increase in carbon dioxide content of precipitation resulting from combustion in industrial processes. In any one area an on-site investigation could determine whether karst processes are active.

Narrow Valleys and Valley Walls

Parts of the uplands have been deeply dissected by streams (fig. 3); the resulting incised valleys are set apart as a separate geologic region (pl. 1). These areas are characterized by steep slopes, widespread bedrock outcrops, and accumulations of eroded materials. The parts of this region that are adjacent to the Mississippi River bluffs have thick accumulations of loess and related silts.

Strip Mines

Topography and surface materials of the strip-mine areas (pl. 1) are man-made or man-altered. Overburden from mining is generally redistributed into elongate ridges, called spoil piles, which are tens of feet high and consist of a poorly compacted mixture of pieces of bedrock, including fragments of coal, and surficial deposits. Drainage is poor and lakes form in the deeper portions of the excavations. Acidic soil conditions and erosion have inhibited rapid re-establishment of vegetation, but reclamation activities have resulted in partial revegetation.

Broad Floodplains

As the name implies, a floodplain is a low, flat area that can be inundated with river water and its sediment load during times of flooding. The floodplains of the Mississippi River, the Kaskaskia River, and Silver Creek are more than 1 mile wide in St. Clair County; in this report the Mississippi River floodplain is treated as one region and the Kaskaskia and Silver Creek floodplains as another (pl. 1 and fig. 3). European settlers of St. Clair County built towns on the Mississippi River floodplain to be near supplies of water and a main travel route. These towns have grown and have dealt with natural flooding by building levees. Such corrective measures have not been completely successful for all kinds of development because in spite of the levees the ground can become saturated with water near the surface during wet weather.

The floodplain of the Mississippi River comprises about 10 percent of the county's surface area and is called the American Bottoms; it has an elevation of about 400 feet and a gradient of about 6 inches per mile. The northern part is about 6 to 8 miles wide. South of Cahokia the floodplain is about 2 to 3 miles wide.

Topographic features, such as meander scars, oxbow lakes, and swamps (fig. 3), were formed by channel migration and flooding. Meander scars are remnants of former meanders that have been abandoned by the main river (fig. 3). They retain their crescent shape, and some, like the one in Frank Holten State Park, contain water (oxbow lakes). Swamps are still found in meander scars and in other poorly drained sites on the floodplain.

Where small tributary streams flow from the adjacent uplands east of the bluff onto the floodplain, alluvial fans, small fan-shaped landforms consisting of sand, silt, clay, and gravel (Peyton Colluvium, fig. 4), are developed at the foot of the bluff (fig. 3).

The northern part of the floodplain, between East St. Louis and the eastern bluff, contains the Cahokia Indian Mounds, parts of which are now in the Cahokia Mounds State Park (fig. 1).

According to Bergstrom and Walker (1956), deposits in this floodplain attain a thickness in excess of 120 feet and consist of gravel, sand, silt, and clay (Cahokia Alluvium, fig. 4). The upper 15 to 30 feet is commonly silt and clay with fine sand. Below a depth of 30 feet are variously sorted sands and gravels.

The floodplains of the Kaskaskia River and of Silver Creek are combined into one region because they are connected and display similar features. The Kaskaskia River floodplain is about 2 miles wide, although near Fayetteville it narrows to less than ½ mile wide and the channel loses its meanders. Upstream and downstream from this valley constriction, floodplain landforms include swamps, oxbow lakes, and terraces. The Kaskaskia River has well developed meanders. The thickness of its valley fill is less than that of the Mississippi but may be greater than 100 feet in places.

The Silver Creek floodplain is about 1 mile wide and its characteristics are similar to but are smaller in scale than those of the Kaskaskia River. The floodplain sides are indistinct where there are terraces, intersections of elongate ridges, and strip-mining operations. In T. 2 N., R. 7 W., the natural channel of Silver Creek has been modified by the construction of drainage ditches.

Bedrock Geology

The bedrock in St. Clair County consists of strata of limestone, dolomite, sandstone, shale, claystone, and coal, most of which are either horizontal or gently sloping (fig. 4). Beneath the town of Dupo, however, the rocks are bowed up into a truncated anticline (Dupo Anticline, fig. 3). The strata on the eastern flank of the anticline slope downward toward the east; therefore, the rock units that are exposed at and near the bluffs are present far beneath the surface in the eastern part of the county. The rocks continue to slope toward the east into the center of a structural basin in southern Illinois (Illinois Basin).

The structural attitude of the rocks in the Dupo Anticline and the Illinois Basin affects the areal distribution of bedrock units. Coal, which is in the youngest bedrock units, is not present in the extreme western part of the county (pl. 5). Where present, coal increases in depth toward the east. Limestones of commerical quality are found in strata that lie beneath the coal-bearing rocks and thus surface quarrying of high-quality stone is restricted to an area west of the coal-bearing rocks. Crude oil and natural gas are found in yet deeper strata that do not lie near the surface in this county.

GEOLOGIC RESOURCES

Limestone

Most of St. Clair County is underlain by bedrock of the Pennsylvanian System (fig. 4). Unfortunately, the limestone units of this system are thin and uneconomical to quarry. However, along the Mississippi River bluffs, there are areas underlain by bedrock of the Mississippian System (fig. 4). In this system some limestone units are thick enough in places for large-scale quarry operations (table 2). Future operations are possible in these areas of the county.

TABLE 2 - LIMESTONE QUARRIES IN ST. CLAIR COUNTY, ILLINOIS

Name	Location Sec.-T.-R.	Bedrock Formation(s) (see fig. 4)
Columbia Quarry Co., Dupo No. 9	27-1N-10W	St. Louis
Columbia Quarry Co., Krause No. 1	10-1S-10W	St. Louis
East St. Louis Stone Co.	14-1N-10W	Ste. Genevieve St. Louis
Quality Stone Co.	29-2S-8W	Fraileys
Casper Stolle Quarry	14-1N-10W	Ste. Genevieve St. Louis

The following bedrock units contain limestones, but the rock either is too thin, is poor in quality, or is exposed in areas in the county that are too small to be of economic value as a resource at present: Modesto Formation, Carbondale Formation, Haney Limestone, Beech Creek Limestone, Ridenhower Formation, and Downeys Bluff Limestone.

Limestone of the Fraileys Formation, in those places where it is about 20 feet thick, is quarried in sec. 29, T. 2 S., R. 8 W. Thick limestones of the Valmeyeran Series (fig. 4) crop out in and adjacent to the Mississippi River bluffs from Cahokia south to the county line. Here the bluffs are composed almost entirely of limestone and the summits are as low as about 60 feet above the floodplain at Cahokia and as high as 250 feet near the county line on the southwest. The limestone beds slope to the southeast at a gentle (4-degree) angle. The Ste. Genevieve, St. Louis, Salem, and Ullin Limestones (fig. 4) make up a total of about 380 feet of limestone exposed in the bluff. These limestones are also the upper bedrock units in a 20 square mile area extending from the bluffs eastward $2\frac{1}{2}$ to 4 miles. The limestone is covered with unconsolidated materials of various thicknesses (pl. 2). This area of limestone now accommodates four relatively large quarry operations and provides the most favorable locations for new quarry sites.

Chemical analyses of limestone samples from St. Clair County localities are published in other Illinois Geological Survey publications (Bradbury, 1963; Lamar, 1957).

Sand and Gravel

The sand or sand and gravel deposits of St. Clair County are for the most part in the valleys of the Mississippi and Kaskaskia Rivers, in the lower part of the Silver Creek valley, and in hills and ridges bordering the northwest side of the Kaskaskia River floodplain (pl. 4).

Of the sand and gravel reported, sand is by far predominant. Gravel is found in the Mississippi and Kaskaskia River floodplains, but at depths generally exceeding 60 feet. Some gravel deposits are in the hills and ridges but the deposits appear to be localized.

In the Mississippi River floodplain, sand underlies 10 to 40 feet of silt and clay overburden; the average thickness of overburden is approximately 25 feet. The only sand operations in the county are located in the Mississippi River floodplain.

In St. Clair County the Kaskaskia River floodplain and the lower part of the Silver Creek floodplain are underlain by sand (particles .062 to 2 mm) or sand and fine gravel (particles 2 to 25 mm). As in the Mississippi River deposits, sand dominates. The clean, fine- to medium-grained sand (particles 1/8 to 1/4 mm) underlies approximately 20 feet of overburden.

Hills and ridges that roughly parallel the Kaskaskia River on the northwest side are underlain by sand in a number of localities. However, it remains to be proved that all of these hills and ridges contain sand or sand and gravel. Where found, the sand is overlain by approximately 20 feet of overburden.

The hills and ridges in the central, north central, and northeastern portions of St. Clair County contain sand or sand and gravel in some localities. The subsurface data available, however, suggest that these deposits are isolated and that lateral continuity is very limited.

Clay and Shale

Clay and shale resources of economic value are found in the Modesto Formation and in beds associated with coals of the underlying Carbondale Formation (fig. 4). The potential of these resources was evaluated from outcrop samples on the basis of six criteria: (1) thickness of deposits; (2) mineralogy and particle-size distribution; (3) ceramic tests; (4) thickness of overburden; (5) degree of urban development; and (6) connection with other mining operations. According to these criteria and available information, four main areas of clay and shale are of present and future economic value.

Clay and shale above and below the Scottville Limestone Member of the Modesto Formation in the area southeast of French Village, secs. 31 and 32, T. 2 N., R. 8 W. (pl. 4), are of present and future economic value. Twenty feet of silty and mica-bearing shale is present above the limestone. Ceramic tests indicate that this shale is suitable for red-fired clay products such as brick and tile. Clay and shale for brick and other structural clay products have been mined sporadically from sec. 32 in the past 10 years. The shale interval below the limestone unit is at least 30 feet thick. Tests indicate that this shale is usable for red-fired clay products and light-weight aggregate. It is presently being mined in sec. 31 for light-weight aggregate. Overburden is 20 ±10 feet thick in this area (pl. 2). Urbanization is moderate near the area.

The second area also contains clay and shale from beds above and below the Scottville Limestone Member of the Modesto Formation. This area is situated east of Caseyville (pl. 4), but there is no known record of clay or shale mining here. Overburden is also 20 ±10 feet thick. Urbanization is also moderate.

In a third area, the vicinity of Freeburg and Millstadt, claystone up to about 4 feet thick is consistently present below the No. 6 Coal, which is now being mined (pl. 5). The clay is potentially usable for bonding of molding sand. Because of its thinness, this clay could be economically exploited only in association with coal mining.

A fourth area, located south of Millstadt (pl. 4), contains about a 7-foot thickness of clay below the Colchester (No. 2) Coal. The clay is suitable for buff-fired clay products and medium-duty refractories.

Coal

Several of the principal coals of Illinois have been given numbers; the highest coals carry the highest numbers. Coals of commercial value in St. Clair County include the Herrin (No. 6) and, to a lesser extent, the Harrisburg (No. 5) and possibly the Danville (No. 7) Coal Members of the Carbondale Formation (fig. 4). Figure 4 shows the positions of the No. 5, No. 6, and No. 7 Coals in the geologic column. The coals are separated by other rocks, such as sandstones, claystones, shales, and limestones. The total thickness of all units from the bottom of the No. 5 Coal to the top of the No. 7 Coal is about 100 feet.

Because of the structural attitude of the rocks in the Dupo Anticline and on the flank of the Illinois Basin (p. 13), the coals vary in depth and are absent in some parts of the county. The trace of the No. 6 Coal (pl. 5) where it is at the surface of the bedrock (subcrop line) is a significant line. West of this line the No. 6 Coal is absent, and eastward from this line it is present at progressively greater depths. The No. 6 Coal is more than 250 feet beneath the surface in the northeastern part of the county.

The subcrop lines of the No. 5 and No. 7 Coals roughly parallel the subcrop line of the No. 6 Coal because the strata are nearly parallel and the surface relief is not extreme. Because the No. 5 Coal is commonly thin or absent and where present is highly varied in thickness in this part of the state, it is likely to be mined only in places and in connection with existing stripping operations of the No. 6 Coal. In the future the No. 7 Coal, which is also thin and varied, might also be mined in connection with strip mining in the No. 6.

Some of the land disturbed by strip mining has been reclaimed for useful purposes. Recreation, agriculture, and waste disposal (see page 32) are the major potentials for land use. At the present time, recreation is the principal activity in these stripped areas.

The Herrin (No. 6) Coal

The No. 6 Coal (pl. 5), where present, generally maintains a relatively constant thickness of 6 feet or slightly more and therefore is a minable resource. In the northern half of T. 2 N., R. 6 W., in the northeast part of the county, however, the coal is split into two or more seams or is thin or absent and therefore is not considered to be a minable resource.

This coal is generally a high-volatile C bituminous coal in rank, and at present most of it is being used primarily in the generation of electric power. The coal is relatively uniform in quality, and variations that appear in analyses are slight (table 3).

The most marked variation in the coal is in the sulfur content. Low-sulfur coal is present in those parts of T. 1 and 2 N., R. 6 and 7W., that border the

TABLE 3 - TYPICAL RANGES IN CHEMICAL ANALYSES OF THE NO. 6 COAL, ST. CLAIR COUNTY, ILLINOIS (as received basis)

Moisture	10%-13%
Volatile matter - those products in coal (other than moisture) released as a gas or vapor rather readily during heating	35%-40%
Fixed carbon - that part of the carbon content of coal which is not readily liberated on heating but which supplies the coal with longer lasting burning characteristics	37%-42%
Ash - inorganic residue from coal combustion	9%-12%
Calorific value (Btu/lb) - relating to fuels, a measurement of the heat produced by combustion in a calorimeter under specified conditions	10,700-11,100

region where the coal is split, thin, or absent. In this low-sulfur area, Gluskoter and Simon (1968) estimated that there are 380.94 million tons of No. 6 Coal in the ground and that it is for the most part 5 to 6 feet thick and has only 1 to $2\frac{1}{2}$ (average $1\frac{1}{2}$) percent sulfur content (dry basis). Throughout the remainder of the county, the sulfur content ranges from about 3 to 5 percent. Lately power companies have been increasingly interested in finding areas of low-sulfur coal because its use would aid in reduction of sulfur dioxide emissions into the atmosphere.

The subcrop line of the No. 6 Coal traverses the county from north to south (pl. 5). In the southern two-thirds of the area where this coal is present, this line is fairly irregular. There are considerable areas where the coal is overlain by less than 100 feet of total overburden and is strip mined extensively. To the north, the subcrop line is intersected by the east valley wall of the Mississippi River and the coal crops out near the base of the bluff. Because the coal in the north-central part becomes relatively deeply buried a short distance back from the outcrop along the bluff, essentially no strip-mining operations are found there. Instead, underground mining has, in the past, been extensive in this district (pl. 5). At the present time, three individual mines are operating in the county, two underground mines and one large strip mine.

Considerable acreages have been mined out by both underground and surface operations in this county (pl. 5). Production data for the years 1950-1969 are shown in table 4. Data on reserves were compiled by Cady et al. (1952) for all coals 28 inches or more in thickness, and by Smith (1958) for strippable coals, that is, those coals 18 inches or more in thickness and lying under less than 150 feet of overburden. The remaining reserves in St. Clair County, indicated in table 5, represent the total amount of minable coal (as defined in the Cady and Smith studies) still in the ground. No exclusions are made for mining conditions, populated areas, highways, lakes, or man-made structures. The figures for total coal in the ground do not indicate the amount of coal that may be recovered. This is dependent on many factors, such as thickness, minability, availability for mining, and a wide range of economic factors. Where underground mining takes place, normally about 50 percent of the coal is recovered.

TABLE 4 - COAL PRODUCTION, ST. CLAIR COUNTY, ILLINOIS, 1950-1969*

Year	Tons mined underground	Tons strip-mined	Total tons mined	Strip-mined (%)
1950	2,183,334	1,556,902	3,740,236	42
1951	2,219,513	1,560,182	3,779,695	41
1952	1,912,015	1,563,533	3,475,548	45
1953	1,979,191	1,528,345	3,507,536	44
1954	1,552,257	1,291,807	2,844,064	45
1955	1,884,198	1,363,905	3,248,103	42
1956	2,355,957	1,616,061	3,972,018	41
1957	2,038,439	1,971,320	4,009,759	49
1958	2,186,673	3,151,653	5,338,326	59
1959	2,141,573	3,136,626	5,278,199	59
1960	1,523,607	3,321,250	4,844,857	69
1961	893,276	3,525,599	4,418,875	80
1962	1,142,302	3,691,779	4,834,081	76
1963	1,264,794	4,446,984	5,711,778	78
1964	1,499,333	4,304,263	5,803,596	74
1965	1,293,401	4,412,101	5,705,502	77
1966	387,532	5,726,502	6,114,034	94
1967	390,122	6,441,122	6,831,244	94
1968	638,653	6,458,462	7,097,115	91
1969	516,495	5,275,331	5,791,826	91
	30,002,665	66,343,727	96,346,392	69

*Data are from the annual coal reports for the years 1950-1969 in Coal, Oil and Gas Reports (State of Illinois Dept. of Mines and Minerals, 1951-1970).

TABLE 5 - ESTIMATED REMAINING COAL RESERVES (IN THE GROUND), JANUARY 1, 1970, ST. CLAIR COUNTY, ILLINOIS (IN THOUSANDS OF TONS)
(Modified from Cady et al., 1952, and Smith, 1958)

Strippable coal (18 inches or more in thickness and 150 feet or less in depth)	1,141,339*
Deep coal (28 inches or more in thickness and 150 feet or more in depth)	1,857,348
Total remaining reserves	2,998,687**

* All Herrin (No. 6) Coal.
** Of this total, 621,565 thousands of tons are in the Harrisburg (No. 5) Coal, mostly as weakly indicated reserves. The remainder is in the Herrin (No. 6) Coal.

Petroleum

Crude Oil

Crude oil has been found in several fields throughout the county (pl. 5) in the Galena Group, Cypress Sandstone, and limestone reefs of the Silurian System (fig. 4 and table 6). Wells are customarily situated in areas where the land has other uses, especially on croplands where small tracts of a farm field are set aside for pumps and collecting tanks.

When crude oil is produced, brine (water containing a considerable proportion of dissolved salts) is generally also produced (Meents et al., 1952). If the volume of brine is appreciable, it is usually pumped back into a disposal well (see pages 30-31) that returns the brine to the oil-producing strata or other porous rock. When brine disposal is carried out according to accepted practices, no damage is done to the land surface or to ground-water supplies.

Future production may be found in limestone reefs beneath the eastern part of the county. Each such area of production is not likely to be large but could contain from one million to several million barrels of recoverable crude oil.

Natural Gas and Gas Storage

Natural gas has been produced from the Cypress, Yankeetown, and Aux Vases Sandstones and from limestone reefs in the Silurian System (fig. 4 and table 7) from reservoirs distributed throughout the county (pl. 5). Gas wells require about the same amount of land as oil wells and can also be situated on land shared for certain other uses.

The porous rock from which natural gas is produced can be used to store both natural and synthetic gas fuels. Gas is stored by pumping it back down to suitable strata. Precautions are taken to store the gas at about the same pressure as that which originally existed in the reservoir. Observation wells, located above each storage project, detect leakage before damage to the surface environment can result. Proper engineering practices have prevented gas leakage from underground gas-storage sites from being a problem in St. Clair County.

Significant data on reserves of natural gas and available gas-storage projects are found in table 7. Future discoveries of natural gas are not likely to lead to big commerical reserves, but the porous rocks from which the gas comes could serve well as gas-storage projects because of their nearness to the metropolitan St. Louis area. Storing gas underground rather than on the surface in huge tanks makes the land surface available for other uses.

Water

Water is a relatively scarce commodity throughout most of St. Clair County. Only in the Mississippi River floodplain are large quantities of both surface and ground water readily available. Throughout much of the county maximum use must be made of both surface and ground water. Ground-water development in the area is often restricted by the presence of highly mineralized water at relatively shallow depths. Saline water is frequently encountered at depths of 500 feet or less in much of the county.

TABLE 6 - OIL FIELDS IN ST. CLAIR COUNTY, ILLINOIS

Name	Location	Bedrock source (see fig. 4)	Depth (ft)	No. of wells	Discovery date	Production
Dupo	T. 1 N., R. 10 W.	Galena Group	700	321	1928	Several hundred bbls/month
Freeburg	T. 1,2 S., R. 7 W.	Cypress Ss.	380	2 (non-producing)	1955	0
Marissa West	T. 3 S., R. 7 W.	Cypress Ss.	215	3	1962	Negligible
Tilden North	T. 3 S., R. 5,6 W.	Silurian System; reef	2014	14	1968	437 bbls/day

TABLE 7 - NATURAL GAS RESERVOIRS IN ST. CLAIR COUNTY, ILLINOIS

Name	Location	Bedrock source (see fig. 4)	Depth (ft)	Discovery date	Remarks
Freeburg*	T. 1,2 S., R. 7 W.	Cypress Ss.	350	1956	71 wells are operated; 1969 max. storage 6632 million cubic feet
New Athens†	T. 2 S., R. 7 W.	Cypress Ss.	250	1961	4 non-producing wells at present
St. Libory†	T. 1 S., R. 6 W.	Cypress Ss. Yankeetown Ss. Aux Vases Ss. Silurian System; reef	622 754 825 1800	1964	About 12 non-producing wells from all units
Marissa West†	T. 3 S., R. 7 W.	Cypress Ss.	241	1960	6 wells drilled, of which 4 are abandoned and 2 are non-producing at present
Tilden North*	T. 3 S., R. 5,6 W.	Cypress Ss.	780	1961	45 wells are operated; 1969 max. storage 3095 million cubic feet

*Natural-gas storage project.
†Non-producing natural-gas reservoir.

Surface Water

Most communities in the western part of the county use water from the Mississippi River for municipal supplies (supplied by the East St. Louis and Interurban Water Company). Communities in the eastern part of the county use both ground water and surface water (East-West Gateway Coordinating Council, 1968).

The Illinois State Water Survey has investigated potential reservoir sites in south-central Illinois (Dawes and Terstriep, 1966). Sites selected in St. Clair County as a result of this study are shown on plate 6. Surface-water reservoirs in areas of relatively gentle topography may be subject to rapid siltation and extensive mud-flat development. Despite these problems, surface reservoirs will undoubtedly play a role in the future water resource development of eastern St. Clair County.

Ground Water

Excellent water-yielding sand and gravel deposits are present in the Mississippi River floodplain. These aquifer materials are generally present below a depth of approximately 50 feet. Considerable interest in the water resources and the related geology of the county has developed over the years because of the large quantities of ground water pumped for industrial use. Relatively recent publications by the Illinois State Water Survey and the Illinois State Geological Survey (Schicht, 1965; Bergstrom and Walker, 1956) treat the ground-water resources and related geology of the area in considerable detail. Both reports suggest that continued development is possible for a number of years. Pumpage values for locations in the Mississippi River floodplain and elsewhere in the county are shown on plate 6.

That part of the Mississippi River floodplain relatively near the river (coded G-1, pl. 6) is particularly suitable for the development of high-capacity wells. Unconsolidated deposits range in thickness from 60 to a little more than 120 feet (Bergstrom and Walker, 1956; see pl. 2). Conditions are favorable in most areas along the river for ground-water recharge from the river. The probability of developing a sand and gravel well capable of producing 500 gallons per minute or more in this area is considered to be high.

That part of the floodplain near the base of the bluff (coded G-2) is less favorable for the development of high-capacity wells than is that part near the river. The sand and gravel deposits near the bluff are thinner than those near the river and are somewhat discontinuous. The probability is high that a well will produce slightly more than 20 gallons per minute, but much larger yields are less likely.

Aquifers in the area coded G-3 consist primarily of sand and gravel deposits in the Kaskaskia River floodplain. Little information is available about the thickness, texture, and continuity of these aquifer units. The unconsolidated materials found in the valley attain maximum thicknesses of just over 100 feet (pl. 2). It appears that low yields are obtainable throughout much of the area, but the probability of developing a well yielding 100 gallons per minute or more is only fair. Sites where high-capacity wells could be developed could probably be found, but only through an extensive exploration program.

Wells in the area coded Y-2 are varied in their productivity. Yields of more than 20 gallons per minute for unconsolidated materials in this area are relatively rare. There is only a fair probability of developing a well with a larger capacity. The best yields are obtained from the valley-fill deposits associated with Silver Creek. Wells in Silver Creek valley fill capable of producing 100 gallons per minute have been developed at Lebanon and Mascoutah.

The part of St. Clair County where limestone bedrock is present near or at the land surface has been coded R-1. Much of this region is characterized by sinkholes resulting from solution of limestone (karst topography). Wells tapping surficial deposits in this area are relatively unproductive because unconsolidated materials are thin and sand or gravel deposits are generally absent. Wells tapping bedrock units are extremely varied in productivity because water is localized in fissures in the limestone. The number of water-bearing fissures encountered by the drill hole largely determines the amount of water that can be pumped. Surface topography is also important in this area because water-bearing fissures are drained by nearby low areas.

The remainder of the county has been coded R-2. Even moderate-capacity wells are rare in this region except in the area around Belleville, where yields of 50 gallons per minute are sometimes obtained from wells tapping bedrock units approximately 500 feet deep. Throughout the rest of the area wells in bedrock are usually shallower (ranging from 80 to 200 feet) and produce less than 20 gallons per minute. The upland surficial deposits are generally unproductive, seldom yielding more than 5 gallons per minute.

Quality of Ground Water.— All ground water contains some dissolved minerals, often in greater quantity than in surface water. The kinds of dissolved minerals present and their concentration depend on the geologic environment, ground-water movement, and the source of the ground water (such as precipitation or river water). Man has impaired the quality of the ground water in some areas.

Ground-water quality varies widely in St. Clair County, as shown by the partial analyses displayed on plate 6. Probably the most significant factor influencing ground-water quality in this county is depth. Saline water is usually encountered at a depth of 500 feet or less on the upland and at slightly shallower depths on the Mississippi River floodplain (Bowman, 1907). Deeper drilling will encounter water containing extremely high dissolved-mineral concentrations. Regional data suggest that total dissolved-mineral concentrations range from 50,000 to 80,000 parts per million in the bedrock units in St. Clair County belonging to the Devonian and Silurian Systems (fig. 4) (Meents et al., 1952). These rocks generally lie about 2,000 feet below land surface in the county but may lie only 1,000 feet or so beneath the southern part of the Mississippi River floodplain.

Within the relatively shallow zone of potable water, considerable variation in water quality may occur both laterally and vertically. Water obtained from surficial deposits is usually of slightly better quality than water from bedrock. Water from bedrock is usually "older" in the sense that it has been underground for a longer time than water in the surficial deposits. Water from bedrock has therefore had time to more nearly reach chemical equilibrium with its geologic environment. An exception to this general rule occurs in the karst region of western St. Clair County, where water moves through fissures too rapidly to achieve chemical equilibrium.

Greater variations in water quality can be expected within short lateral distances in the unconsolidated deposits than would normally be found within similar distances in a bedrock aquifer. Within the unconsolidated aquifers, introduction of man-made pollution, the presence of organic deposits, and encroachment of saline ground water from the bedrock tend to influence and generally impair the quality of the water.

ECONOMIC ROLE OF MINERAL RESOURCES

The production of minerals has played an important economic role in St. Clair County since the early 1830's, when coal was produced near Belleville.

The first railroad in Illinois was built to haul coal from the bluffs in St. Clair County to the shore of the Mississippi River opposite St. Louis (Risser and Major, 1968).

In 1969, the mineral output of St. Clair County consisted of coal, stone, sand, crude oil, and clay products having an estimated value of $30.8 million (Busch, 1971a). Of this, about $25 million was in coal (Busch, 1971b), $4.9 million in stone (unpublished records, Ill. State Geol. Survey), and the remainder in other mineral products (Busch, 1971b).

Total employment in all mining in the county in 1969 was reported at 723 persons, with a payroll estimated at $7.0 million (U. S. Bureau of the Census, 1970).

Coal

St. Clair County ranked fourth among the counties of Illinois as a producer of coal in 1969. Since 1882, when continuous records of production were begun, the county has produced a cumulative total of 302 million tons of coal. Of the 1969 coal production of 5.8 million tons, 5.3 million tons, or 91 percent, came from strip-mining operations (Busch, 1971b). In the surface mining of coal, more than 12,000 acres of land have been affected (Filer, 1971).

Despite the relatively steady level of coal production (5.3 million tons in 1959 compared to 5.8 million tons in 1969; see table 4), improvements in technology and equipment have resulted in a reduction of the number of mine employees from 922 in 1959 (State of Ill. Dept. of Mines and Minerals, 1960) to 492 in 1969 (State of Ill. Dept. of Mines and Minerals, 1970). The coal mining payroll in 1969 was estimated at about $5.24 million (based on figures from State of Ill. Dept. of Mines and Minerals, 1970, and from correspondence from Ill. Bureau of Employment Security, Springfield, Ill., April 14, 1970).

Stone

During the past decade, St. Clair County has annually produced an average of 2.3 million tons of stone, worth some $3.7 million (unpublished records, Ill. State Geol. Survey). Employment in 1969 was reported at 147 men and the estimated payroll at $936,000 (U. S. Bureau of the Census, 1970).

Other Mineral Resources

In addition to the production of coal and stone, the production of sand and gravel and of clay products also contributes directly to employment and income in the area.

Projections

Projections by the U. S. Bureau of Mines indicate a growth of 51 percent to 85 percent in the United States consumption of coal between 1968 and 1985 (U. S. Bureau of Mines, 1969). For the longer range between 1968 and the year 2000, the Bureau has predicted that the demand for coal will increase between 87 and

497 percent (U. S. Bureau of Mines, 1970). The variations in the demand projections are contingent upon the long-term competitive position of coal, which, in turn, will be influenced by the status of the technology of coal gasification and liquefaction and the growth of nuclear power. The share of total coal demanded by the utilities for the generation of electricity in the year 2000 has been predicted to range from a low of 57 percent to a high of 93 percent. The low figure assumes that by the year 2000 a sizable amount of coal will be going to coal gasification and liquefaction plants.

St. Clair County should be in a good position to benefit from this predicted large increase in demand because of its significant reserves, its location near a major metropolitan area, and its access to cheap water transportation on the Mississippi River, which will be improved by the completion of canalization of the Kaskaskia River. However, if an economic method of flue gas desulfurization cannot be developed, air pollution regulations controlling sulfur oxide emissions may eliminate most of the market for St. Clair County coals by the utilities. Over the longer term, it seems likely that the market for this coal with the greatest potential growth is in gasification and/or liquefaction.

United States consumption of stone is projected to increase by 56 percent from 1968 to 1985. Should St. Clair County production share fully in this projected growth, an increase from the present 3 million tons to 4.8 million tons would occur. A large temporary increase may occur in the next 2 to 3 years if a site in the St. Clair County area is selected for the Greater St. Louis Airport now under study.

OTHER RESOURCES

In addition to supplying information about resources that are commonly in the domain of geological expertise, geologists can help other specialists solve problems concerning the use of land resources for farming, grazing, recreation, nature preserves, and the study of historic and prehistoric sites. St. Clair County has many of these resources, which deserve consideration in the planning process. Among others, the following agencies and institutions can provide useful information on these resources.

Agency or Institution	Resource
U. S. Department of Agriculture Soil Conservation Service Edwardsville Office	Soils
University of Illinois Urbana Campus	Archeological sites; farming and grazing land
Southern Illinois University Edwardsville Campus	General
Illinois State Natural History Survey Urbana	Nature preserves
Illinois Department of Conservation Springfield	Archeological and historic sites; nature preserves; recreation

Illinois Department of Public Works and Buildings, Division of Waterways Springfield	Recreation
Illinois State Museum Springfield	Archeological and historic sites

GEOLOGIC CONDITIONS AFFECTING CONSTRUCTION

In most of St. Clair County geologic conditions are suitable for normal types of construction. In a few areas there are limitations that have posed problems, but they are rarely severe enough to preclude development of a construction project. The engineering characteristics of each region shown on plate 7 are outlined in the explanation accompanying the map and are discussed below under region headings.

Only the broad aspects of the geologic factors that influence engineering projects in each region in St. Clair County are discussed in the following paragraphs. It is expected that this discussion will serve as a guide to the kinds of geologic-engineering problems that may arise from disturbance of nature's equilibrium by construction. In a given project detailed information must be developed for the site. The engineering characteristics of the geologic materials of St. Clair County will be more fully known and understood as more detailed information becomes available.

Upland Till Plain

Streams in upland loess deposits develop steep-sided valleys (coded G-2B on pl. 7). In some areas the bottoms of these valleys lie in the underlying till. Loess bluffs, 20 or more feet high, stand as nearly vertical walls. The most important factors determining the strength and stability of the loess deposits are (1) cementation of the grains with small amounts of clay and lime, (2) water content, and (3) rate of movement of the water through the deposits. The silt deposits have a uniform particle size with more than 80 percent silt-size particles (table 8). The small amounts of cementing material help develop high strengths in dry loess and, in contrast, provide little or no strength as the material becomes saturated with water. The fine and uniform particle size of the loess makes it porous with very small pore openings. Sediments with more than 30 percent clay-size particles tend to be nearly impermeable. The strong capillary action in the loess deposits affects the rate of water infiltration as well as the rate of water drainage. Water contents of the loess deposits vary with the amount of rainfall and the presence of nearby surface waters.

Loess is easily excavated, but cuts and excavations may require a long time to drain in order to develop and maintain stable slopes. Protective measures to prevent slumping may be required in some excavations. Surface runoff water tends to gully unprotected slopes. Wet weather may weaken the loess and cause construction delays until working areas dry out.

Accumulation of frost is dependent upon water movement as well as upon below-freezing temperatures. Silts tend to conduct water to the freezing zones. Therefore, fine-grained, water-logged silts are more susceptible to frost action than are clayey or very coarse deposits. Damage to slab homes and roads from

TABLE 8 - ENGINEERING PROPERTIES OF SELECTED SURFICIAL DEPOSITS FROM ST. CLAIR COUNTY, ILLINOIS*
(Numbers in parentheses indicate number of samples run)

Description	Particle-size analysis			Natural moisture content (%)	Proctor density		Potential volume change†
	sand (%)	silt (%)	clay (%)		maximum dry density (lb/ft^3)	optimum water content (%)	
Silts	2	81	17 (50)	27.2 (45)	108.5	17.2 (5)	2.4 -marginal (4)
Clayey silts	8	63	29 (7)	—	114.4	14.9 (7)	—
Sandy till	39	40	21 (6)	—	125.0	12.5 (4)	0.3 -noncritical (4)
Silty till	27	42	32 (14)	—	120.2	11.1 (6)	0.4 -noncritical (4)

*Tested by Paul B. DuMontelle and Peter Tarkoy.
†Maximum possible volume change from changing moisture conditions.

frost heaving in silts can be minimized by proper design. Compared to silts, most coarse materials are well drained because they have larger spaces between particles and do not develop high capillary forces.

Clays are not uniformly distributed in the silts but rather are in zones. Some of the clayey silts have as much as 29 percent clay-size particles (table 8). Although most of these clayey zones are associated with depressions, the clay may also be found at depth associated with an older, buried surface. Some of the clay minerals in these clayey zones shrink when they are dried and swell when they are wetted. In some areas shrinking and swelling may cause damage to poorly designed structures. The swelling potential of the silt samples tested showed a marginal volume change (table 8). As with problems associated with frost heaving, proper design can minimize the possibility of damages caused by the shrinking and swelling of clays.

In areas of thick loess some public buildings and private homes have experienced severe cracking of foundations and walls. In some instances this damage has been attributed to failure caused by a significant increase in moisture content within the loess deposits. In other instances the damage has been attributed to subsidence over areas of mined-out coal.

Till or bedrock underlying the thick deposits of silt has high bearing strengths suitable for the construction of most projects. In some areas the deposits beneath the silt are too deep to be of use in supporting foundations.

Particle-size analyses of samples from St. Clair County (table 7) indicate that the till units, which have an equal distribution of sand-, silt-, and clay-size particles, can be compacted better than loesses and clayey silts, which consist primarily of silt- and clay-size particles. The natural moisture contents of the till units were not determined.

Ridges (Sand and Till)

The upland deposits in the ridges of sand and till (coded G-1 and G-2A) are easily excavated and are generally well drained, resulting in dry conditions in the excavations. In places, slumping and creep may occur on steep slopes. Till, sand and gravel, or bedrock having high bearing strengths are generally present below the surface covering of loess. Erosion may occur unless slopes are protected by proper design and treatment. Open or closed depressions on the upper parts of the ridges may be poorly drained and susceptible to the previously discussed problems associated with clayey sediments.

Karst

Parts of the upland areas (coded Y-2B) are stable and are already occupied by farms or communities. The uplands are well drained, and bedrock beneath surficial deposits provides adequate foundation support for most construction projects. An investigation program for heavy construction might reveal cavernous limestone that would require treatment to insure stability.

The lowland areas (coded Y-2A) are less stable and are used principally for agriculture. Depressions in the landscape resulting from solution cavities and fissures partially filled with clayey materials may present the most serious problems to construction. Periodic fluctuation of the rainfall and ground-water levels may lead to ponding of surface water and movement of debris downward into bedrock fissures and caverns. The water-logged, fine-grained materials may locally be subject to frost heaving during the winter. In places the unconsolidated sediments developed from the weathering of the limestone beds consist in part of clays that shrink and swell as the ground-water conditions vary. Damage can be prevented by proper design.

Excavations for basements, sewerage lines, pipelines, highway cuts, or other installations constructed below surface grade may encounter shallow bedrock. Bedrock aquifers exposed during these kinds of construction projects may become contaminated with pollutants entering through open cracks and crevices. If the aquifers are encountered in construction, the bedrock should be sealed to prevent pollution.

Narrow Valleys and Valley Walls

Periodic flooding may occur in some parts of the valleys (coded G-3, Y-1A, and Y-2A). In places, shrinking and swelling due to changes of the water content of clayey deposits may cause damage to unprotected structures.

The thin cover of surficial deposits in some areas may limit the quantities of suitable borrow material available to construct large embankments. The shallow bedrock in parts of these areas provides high bearing strength for support of almost any type of structure. As in the area of karst topography, excavation may unexpectedly encounter bedrock. If aquifers are exposed during construction, it may be necessary to seal the beds to prevent contaminating materials from entering the aquifers and polluting local water supplies.

Strip Mines

Spoil piles in the strip mines (coded Y-1B) consist primarily of a variety of mixed materials dumped in regular ridges. In many cases, coarse bedrock materials were deposited at the bottom of the ridges and the finer surficial materials were deposited on the top of these ridges. An increase in depths reached in mining generally has resulted in increased heights of the spoil piles.

Various methods to improve the stability of the slopes are being tried. These methods include changing procedures of dumping, bulldozing the tops from the piles and filling the "v's" between ridges, planting of the slopes, and bulldozing and grading the surface to restore it to a gentle topography. The amount of redistribution of the materials depends on plans for subsequent use of the land.

Large pieces of bedrock are encountered in the piles. A knowledge of the geology of the overburden above the mined-out coal and the methods by which the overburden has been removed may help in anticipating the presence of large pieces of bedrock.

The materials in these piles have been subjected only to compaction loads of their own weight and therefore they may be expected to adjust to any additional loading. Because of the manner in which the materials in the piles were deposited, some materials may become compacted, causing the surface of the piles to settle. Some stabilization of the deposits probably occurs during a period of years after deposition, and this process may prove to be an important consideration in selecting building sites.

In general, the surfaces of the spoil piles are well drained. Because the spoil materials are porous, they allow water to rise quickly within the piles. The increase in water content lowers the shear strength of the materials and settlement of materials may take place.

Broad Floodplains

The floodplain regions as shown on plate 1 are limited to the valley bottoms having widths of a mile or more. Parts of the lowland areas along all main streams less than 1 mile wide may also have some of the engineering characteristics described for broader floodplains.

The floodplain areas (coded Y-3 on pl. 7) have a very gentle slope with little or no relief. The materials are easily excavated, and suitable borrow material is available nearby for most construction projects.

The valley deposits are loosely consolidated. The shear strength of the sediments is generally low because their water content is high. Excavations for basements, sewerage lines, and other underground installations may require protective structures to prevent caving. During periods of heavy rainfall, parts of the floodplain areas may be flooded. Levees have been constructed to control surface water, but during times of high water levels ground-water pressures may increase within the protected areas. Excavations in these areas could result in sand boils or quicksand.

Parts of the floodplains consist of compressible organic deposits that may allow settlement of material under loading. Clayey deposits made up in part of clays that shrink and swell with changes in water content may be present in places. Sediments near the surface that contain water are common in parts of the floodplains and are subject to troublesome frost heaving.

Underground Mined-Out Areas

Underground mined-out areas are widely distributed throughout most of St. Clair County (pls. 5 and 7).

Theoretically, any void space beneath the surface of the ground is a potential area of subsidence of the surface. Historically, few immediate subsidence problems directly attributed to mining have occurred in St. Clair County. Some evidence, however, does indicate that long-term subsidence may have occurred in some areas. All areas shown as underground mined-out areas should be considered and investigated on an individual basis.

GEOLOGIC CONDITIONS AFFECTING WASTE DISPOSAL

Waste-disposal sites should be situated where they will do the least harm to the environment. Broad evaluations have been made of the geologic factors in Illinois that relate to waste disposal, both for injection of liquid wastes into deep wells (Bergstrom, 1968a, b) and for landfilling of putrescible solid wastes (Cartwright and Sherman, 1969).

Disposal of Liquid Wastes into Deep Wells

Municipal governments and planning agencies are rarely involved in deep-well disposal projects; regulatory powers and most industry-government interactions are at the state level. Deep-well disposal is sometimes undertaken when hydrogeologic conditions are suitable and when it is inconvenient to use present technology to treat waste waters. Waste must be stored in a place from which there is little likelihood that it will return to man's environment. Disposal horizons must be located where wastes cannot contaminate potable water, economic minerals, crude-oil and natural-gas reservoirs, or gas-storage project areas (see p. 19).

Bergstrom (1968b) divided the state into five regions on the basis of their feasibility as areas where waste could be disposed of in deep wells. Most of St. Clair County was considered to be somewhat favorable for having sites for deep-well disposal. Disposal might be possible at various depths in rocks of the Devonian or Silurian Systems (fig. 4), approximately 2,000 feet below land surface in much of the county but considerably shallower in the southern part of the Mississippi River floodplain. Disposal is also possible in several permeable layers deeper than the Silurian strata.

Disposal of large quantities of industrial wastes from the East St. Louis-Dupo area is currently a major problem. The high concentration of industry, the shallow depth of the Devonian and Silurian Systems, and the relatively low permeabilities of the deeper horizons rule out the likelihood that a substantial part of the industrial wastes generated in this area can be disposed of by deep-well injection.

Sanitary-Landfill Sites

A sanitary landfill is operated by placing refuse in layers on the land or in trenches having well drained conditions, compacting the refuse, and covering it with a layer of earth after each day's operation. A sanitary landfill, properly operated, prevents odor, insects, rodents, fires, and blowing papers from becoming a nuisance. The physical conditions at a proposed landfill site, however, must be evaluated to determine whether the soil-rock-water relationship is such that pollution of ground water or surface water is likely or whether man-made safeguards against pollution are necessary and feasible.

Regional geologic information is used as a guide in delineating natural limitations and safeguards relative to solid-waste disposal. Landfills may be located at sites where there are natural safeguards that minimize the potential for pollution, or they may be located at sites that have less than optimal natural conditions, provided that suitable engineering or operating procedures are employed. Areas where natural conditions have limitations for waste disposal should be considered likely to require engineering modifications.

The regions delineated on plate 8 are based on the physical conditions that affect the movement of leachate from a landfill into surface water or into a ground-water reservoir. The area coded R-3 generally lacks natural safeguards against pollution. Part of this area is characterized by the presence of sinkholes at the land surface. Limestone bedrock is present at relatively shallow depths (generally less than 50 feet). The presence of sinkholes and fissures in the limestone permits rapid movement of polluted water with very little filtration or dilution. Sites where more than 50 feet of relatively impermeable unconsolidated material overlies the bedrock and protects it from the infiltration of leachate are relatively rare. Man-made pollution controls may not be feasible in this area and if feasible will probably be expensive.

Area R-2 consists of the Mississippi River floodplain. This area has few natural safeguards to prevent ground-water pollution. Unconsolidated sand and gravel aquifers underlie the area. Very few of them are more than 50 feet below the land surface. The upper limit of rock or sediment saturated with water is shallow throughout most of the area and, despite an extensive levee system, periodic flooding occurs over parts of the area.

The area coded R-1 may contain some sites where natural safeguards exist, but they are sufficiently scarce that the area must be considered generally unfavorable for the location of sanitary landfills without engineered controls. The area comprises valley fill along Silver Creek and the Kaskaskia River. The fill in general has a relatively low permeability because its silt content is high, but discontinuous deposits of sand and gravel are present (especially along the Kaskaskia). These deposits are important as possible sources of water because eastern St. Clair County has few favorable ground-water areas.

Much of the area coded Y-2 probably has suitable physical conditions for sanitary-landfill operations. Well records on file at the Illinois State Geological Survey indicate that some scattered shallow aquifers are present. Test drilling at proposed sites and well inventories around them will establish the presence or absence of such aquifers, and the possibility of polluting them can be evaluated.

Much of St. Clair County is coded G-2. There are no known shallow aquifers present in this area. The unconsolidated material overlying the bedrock is generally thick and relatively impermeable. The bedrock in this area generally has few aquifers because it consists largely of shale. The many strip-mined areas in the county are, in general, regarded as possibly favorable localities for sanitary landfills. The feasiblity of using such areas is closely related to the size of the proposed operations. The presence of large blocks of rock in the spoil piles might cause problems in earth moving and in obtaining the 6-inch daily cover required by state law. Small operations can usually work around troublesome areas, and large-scale operations would probably have equipment available to handle most rock sizes likely to be encountered. Intermediate-size operations (e. g., for a single community) might or might not be able to support the large crawler tractors and excavating equipment that landfilling operations in a strip mine would require.

REFERENCES CITED

Bergstrom, R. E., 1968a, Feasibility criteria for subsurface waste disposal in Illinois: Ground Water, v. 6, no. 5, p. 5-9.

Bergstrom, R. E., 1968b, Feasibility of subsurface disposal of industrial wastes in Illinois: Illinois Geol. Survey Circ. 426, 18 p.

Bergstrom, R. E., and T. R. Walker, 1956, Ground-water geology of the East St. Louis area, Illinois: Illinois Geol. Survey Rept. Inv. 191, 44 p.

Bowman, Isaiah, assisted by C. A. Reeds, 1907, Water resources of the East St. Louis District: Illinois Geol. Survey Bull. 5, 128 p.

Bradbury, J. C., 1963, Limestone resources of the lower Kaskaskia Valley: Illinois Geol. Survey Circ. 346, 22 p.

Bretz, J H., and S. E. Harris, Jr., 1961, Caves of Illinois: Illinois Geol. Survey Rept. Inv. 215, 87 p.

Busch, W. L., 1960, Mineral production in Illinois in 1959: Illinois Geol. Survey Circ. 300, 36 p.

Busch, W. L., 1971a, Illinois mineral production by counties, 1969: Illinois Geol. Survey MEB 28, 13 p.

Busch, W. L., 1971b, Mineral production in Illinois in 1969: Illinois Geol. Survey Circ. 455, 22 p.

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

Cartwright, Keros, and F. B. Sherman, 1969, Evaluating sanitary landfill sites in Illinois: Illinois Geol. Survey EGN 27, 15 p.

Dawes, J. H., and M. L. Terstriep, 1966, Potential surface water reservoirs of south-central Illinois: Illinois State Water Survey Rept. Inv. 54, 119 p.

East-West Gateway Coordinating Council, 1968, Water and sewerage facilities report, phase I: East St. Louis, East-West Gateway Coordinating Council pub. 23 08.0, 76 p.

Filer, E. E., 1971, 1970 Annual Report, Surface-Mined Land Reclamation: Illinois Dept. of Conservation, 13 p.

Gluskoter, H. J., and J. A. Simon, 1968, Sulfur in Illinois coal: Illinois Geol. Survey Circ. 432, 28 p.

Lamar, J. E., 1957, Chemical analyses of Illinois limestones and dolomites: Illinois Geol. Survey Rept. Inv. 200, 33 p.

Meents, W. F., A. H. Bell, O. W. Rees, and W. G. Tilbury, 1952, Illinois oil-field brines — their geologic occurrence and chemical composition: Illinois Geol. Survey Ill. Pet. 66, 38 p.

Risser, H. E., and R. L. Major, 1968, History of Illinois mineral industries: Illinois Geol. Survey Ed. Ser. 10, 30 p.

Schicht, R. J., 1965, Ground-water development in East St. Louis area, Illinois: Illinois State Water Survey Rept. Inv. 51, 70 p.

Smith, W. H., 1958, Strippable coal reserves of Illinois. Pt. 2. Jackson, Monroe, Perry, Randolph, and St. Clair Counties: Illinois Geol. Survey Circ. 260, 35 p.

State of Illinois Dept. of Mines and Minerals, 1951-1970, Coal report[s] of Illinois, 1950-1969, in Coal, Oil and Gas Report[s] (separate publications for each year): State of Illinois.

U. S. Bureau of the Census, 1970, County business patterns, 1969 — Illinois CBP — 69 — 15: U. S. Govt. Printing Office, Washington, D. C., 158 p.

U. S. Bureau of Mines, 1969, Minerals yearbook — 1968: U. S. Bureau of Mines, Dept. of the Interior, Washington, D. C., p. 21 of Vol. I-II, 1208 p.

U. S. Bureau of Mines, 1970, Mineral facts and problems, 1970: U. S. Dept. of the Interior, Bureau of Mines Bull. 650, p. 49-52.

ADDITIONAL REFERENCES

Baxter, J. W., 1960, Salem Limestone in southwestern Illinois: Illinois Geol. Survey Circ. 284, 32 p.

Baxter, J. W., 1965, Limestone resources of Madison County, Illinois: Illinois Geol. Survey Circ. 390, 39 p.

Bell, A. H., 1929, The Darmstadt Anticline and related structures, St. Clair County: Illinois Geol. Survey Ill. Pet. 18, p. 2-13.

Bell, A. H., 1929, The Dupo oil field: Illinois Geol. Survey Ill. Pet. 17, p. 1-14.

Bruin, Jack, and H. F. Smith, 1953, Preliminary investigation of ground-water resources in the American Bottom in Madison and St. Clair Counties, Illinois: Illinois State Water Survey Rept. Inv. 17, 28 p.

Busch, W. L., 1969, Illinois mineral production by counties, 1967: Illinois Geol. Survey MEB 24, 10 p.

Busch, W. L., 1969, Mineral production in Illinois in 1968: Illinois Geol. Survey Circ. 447, 24 p.

Buschbach, T. C., and D. C. Bond, 1967, Underground storage of natural gas in Illinois — 1967: Illinois Geol. Survey Ill. Pet. 86, 54 p.

Cady, G. H., E. F. Taylor, A. E. Spotti; contrib. by A. H. Bell, 1940, Structure of Herrin (No. 6) Coal bed in Randolph, western Perry, southwestern Washington, and southeastern St. Clair Counties, Illinois: Illinois Geol. Survey Circ. 58, 19 p.

DuMontelle, P. B., compiler, 1970, Terranes and mineral resources of Madison, St. Clair and Monroe Counties, Illinois: Illinois Geol. Survey unpubl. ms. DuMontelle No. 1, 9 p.

Ehrlinger, H. P., and H. W. Jackman, 1970, Lower Mississippi River terrace sands as a commerical source of feldspar: Illinois Geol. Survey IMN 43, 18 p.

Fenneman, N. M., 1910, Physiography of the St. Louis area: Illinois Geol. Survey Bull. 12, 83 p.

Fenneman, N. M., 1911, Geology and mineral resources of the St. Louis Quadrangle, Missouri-Illinois: USGS Bull. 438, 73 p.

Hanson, Ross, 1950, Public ground-water supplies in Illinois: Illinois State Water Survey Bull. 40, 1036 p.

Hanson, Ross, 1958, New public ground-water supplies in Illinois, 1950-1957: Illinois State Water Survey Bull. 40, Supplement I, 260 p.

Hanson, Ross, 1961, Additions to public ground-water supplies in Illinois: Illinois State Water Survey Bull. 40, Supplement II, 656 p.

Heigold, P. C., 1968, Notes on the earthquake of November 9, 1968, in southern Illinois: Illinois Geol. Survey EGN 24, 16 p.

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

Hunter, R. E., 1965, Feldspar in Illinois sands — a further study: Illinois Geol. Survey Circ. 391, 19 p.

Illinois State Geological Survey, 1959, Maps of areas of mined-out coals: Illinois Geol. Survey Maps 27, 29.

Illinois State Geological Survey Educational Extension, 1963, Geological Science Field Trip Guide Leaflet 1963-F Dupo (Leaders: Ed Odom, George Wilson, Gary Dow): 20 p.

Illinois State Geological Survey Educational Extension, 1970, Geological Science Field Trip Guide Leaflet 1970-A Millstadt-Dupo (Leaders: W. E. Cote, D. L. Reinertsen, G. M. Wilson, and M. M. Killey): 40 p.

Illinois State Geological Survey Educational Extension, 1970, Geological Science Field Trip Guide Leaflet 1970-F Millstadt-Dupo (Leaders: W. E. Cote, D. L. Reinertsen, G. M. Wilson, and M. M. Killey): 40 p.

Illinois, University of, 1938, St. Clair County: County Soil Report, no. 63, Agricultural Experiment Station, Univ. of Ill., 36 p.

Lamar, J. E., 1967, Handbook on limestone and dolomite for Illinois quarry operators: Illinois Geol. Survey Bull. 91, 119 p.

Major, R. L., 1966, Mineral resources and mineral industries of the East St. Louis Region, Illinois: Illinois Geol. Survey MEB 12, 32 p.

Mast, R. F., 1970, Size, development, and properties of Illinois oil fields: Illinois Geol. Survey Ill. Pet. 93, 42 p.

Meents, W. F., 1959, Freeburg gas pool, St. Clair County, Illinois: Illinois Geol. Survey Circ. 272, 19 p.

Odom, I. E., 1971, Clay and shale resources of Madison, Monroe, and St. Clair Counties: Illinois Geol. Survey IMN 45, 18 p.

Searcy, J. K., R. C. Baker, and W. H. Durum, 1952, Water resources of the St. Louis area, Missouri and Illinois: USGS Circ. 216, 55 p.

Selkregg, L. F., W. A. Pryor, and J. P. Kempton, 1957, Groundwater geology in south-central Illinois: Illinois Geol. Survey Circ. 225, 30 p.

Shaw, E. W., 1915, Belleville-Breese, Illinois, folio: Geologic Atlas of the U. S.

Shaw, E. W., 1922, New Athens-Okawville, Illinois, folio: Geologic Atlas of the U. S.

Simon, J. A., and W. H. Smith, 1969, An evaluation of Illinois coal reserve estimates: Illinois Mining Inst. Proc., v. 76, p. 57-68.

Wanless, H. R., 1934, Pennsylvanian rocks of Madison and St. Clair Counties: Ill. Acad. Sci. Trans., v. 26, no. 3, p. 105.

Weller, Stuart, and J. M. Weller, 1939, Preliminary geological maps of the pre-Pennsylvanian formations in part of southwestern Illinois — Waterloo, Kimmswick, New Athens, Crystal City, Renault, Baldwin, Chester, and Campbell Hill Quadrangles: Illinois Geol. Survey Rept. Inv. 59, 15 p.

Willman, H. B., and J. C. Frye, 1970, Pleistocene stratigraphy of Illinois: Illinois Geol. Survey Bull. 94, 204 p.

Willman, H. B., J. A. Simon, B. M. Lynch, and V. A. Langenheim, 1968, Bibliography and index of Illinois geology through 1965: Illinois Geol. Survey Bull. 92, 373 p.

Willman, H. B., and others, 1967, Geologic map of Illinois: Illinois Geological Survey.

Illinois State Geological Survey Circular 465
35 p., 8 plates, 4 figs., 8 tables, 5500 cop., 1971
Urbana, Illinois 61801

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

CIRCULAR 465

ILLINOIS STATE GEOLOGICAL SURVEY

URBANA 61801