STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

DEEP STRATIGRAPHIC TEST WELL NEAR ROCK ISLAND, ILLINOIS

T. C. Buschbach

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

CIRCULAR 394 1965

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ABSTRACT

Exploration for underground gas storage reservoirs resulted in the drilling of a deep stratigraphic test well about 10 miles south of Rock Island, Illinois. Radioactivity, electrical, and sonic logs, with a description of cores and samples from the well, provide information not available previously about the sequence of deeper strata in the region. Precambrian rocks were encountered at a depth of 3,855 feet. Possible reservoirs for gas storage were found in the St. Peter, Ironton-Galesville, and Mt. Simon Sandstones.

INTRODUCTION

The search for reservoirs suitable for underground storage of natural gas in northwestern Illinois resulted in the drilling during 1961 of a deep stratigraphic test well, the Ralph E. Davis Associates' No. 1 E. A. South in Henry County, about 10 miles south of Rock Island. As this is the first well drilled to the Precambrian basement in this part of the state, the study of the well provides information about the sequence of deeper strata in the region. This report describes the strata encountered in the well and presents the geologic setting revealed by it and by other drilling in the vicinity.

The Rock Island area (fig. 1) is geographically suitable for underground storage of natural gas because it is near a population center and located only 150 miles west of Chicago. Two interstate pipelines traverse the area.

Natural gas has been stored underground in Illinois since 1953 (Bell, 1961), and the use of underground storage has increased steadily from that time. Residential space heating in populous northern Illinois causes great fluctuations in the use of gas, with extremely high demand during the colder periods. Long distance pipelines carrying gas to this area from the Mid-Continent and Gulf Coast regions are expensive, and the most economical gas rates to the consumers are obtained by using the pipelines at or near capacity throughout the year. Underground storage of natural gas has served an important function by providing reservoirs near

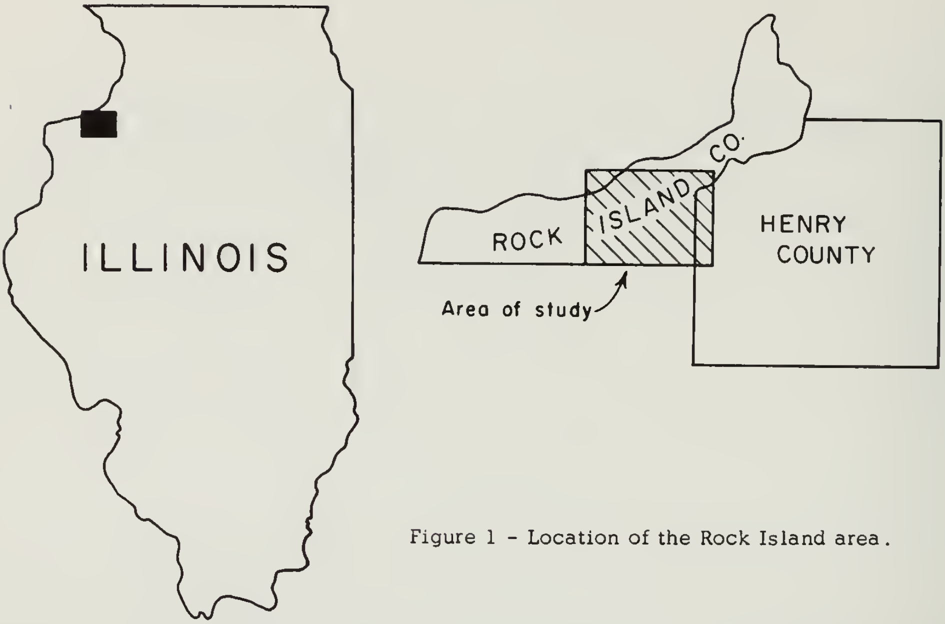


Figure 1 - Location of the Rock Island area.

population centers where gas may be stored during the summer months and withdrawn during the winter. During the coldest days of the 1963-1964 heating season, about one-half of the gas used in the suburban Chicago area came from underground storage.

Basic requirements for underground storage of gas include (1) a domed structure with adequate closure, (2) rock layers with sufficient porosity and permeability to serve as a reservoir for the gas, (3) an impermeable cap rock overlying the reservoir, and (4) the absence of open faults or joints in the cap rock that would allow escape of the gas.

Acknowledgements

Mr. Ralph E. Davis, of Ralph E. Davis Associates, Houston, Texas, kindly made available sample studies, geophysical logs and drill-stem tests of the deep well, logs of structure tests, and progress reports. He granted permission to publish the information. Dr. G. L. Knight and Mr. S. Richard Harris were consulting geologists on the project. N. K. Church, Kirby Oil Industries, studied samples of the No. 1 South well at the drilling site. Descriptions and interpretations by these men have been incorporated in the report. M. Schulenberg and S. M. Butler, of Ralph E. Davis Associates, were very helpful during my visits to the area for core studies and conferences. The hospitality of Mr. and Mrs. E. A. South is gratefully acknowledged.

GEOLOGIC SETTING

The Rock Island area is situated structurally on the extreme northwest flank of the Illinois Basin. The bedrock consists of Paleozoic strata that dip gently southeast toward the center of the basin. There is no evidence of Paleozoic or later igneous activity or major faulting in the area.

All Paleozoic systems except Permian are represented in the sequence (fig. 2), but Pennsylvanian, Mississippian, and Devonian strata are locally eroded. Cambrian strata are a little over 2,000 feet thick and consist chiefly of sandstone with some dolomite, siltstone, and shale in the upper half. The Ordovician strata are a little more than 1,000 feet thick and consist of cherty dolomite with some sandstone, shale, and limestone. The Silurian System is represented by about 260 feet of vuggy dolomite at the Davis No. 1 South well, but its thickness is variable due to a major unconformity at its top.

The Devonian strata are more than 100 feet thick in the No. 1 South well, but they thin and are absent north of this area. They consist of limestone with some dolomite in the upper part. The Devonian-Mississippian New Albany Shale is locally present in the area but not in any of the wells studied. Pennsylvanian strata consisting of sandstone, siltstone, shale, and coal form the bedrock of much of the area, but they have been eroded from the Rock and Mississippi Valleys where Devonian rocks are exposed. Most of the area is mantled with varying thicknesses of Pleistocene glacial deposits.

STRUCTURE

The geologic structure of the area drawn on the top of the Galena Dolomite of Champlainian (Middle Ordovician) age is shown on figure 3. The top of the Galena Dolomite is the shallowest datum plane suitable for predicting structure of the Glenwood-St. Peter Sandstone and the deeper potential storage zones. Drillers readily recognize the Galena top, and geophysical logs reflect the marked change in lithology between the pure dolomite of the Galena and the overlying Maquoketa Shale. The tops of shallower units—the Maquoketa Shale, Silurian dolomite, and Devonian limestone—are unconformities with significant relief and are less reliable datum planes for drawing structure.

The thickness of the Maquoketa varies about 30 feet in the area, partly because of the unconformity at the base of the Silurian. Therefore, its top is not a reliable mapping surface.

In western Illinois, a major unconformity at the top of the Silurian makes maps of this surface of little use in delineating structures. Most water wells in the area described obtain their water from the Silurian. Radioactivity surveys of about 70 water wells revealed the Devonian-Silurian contact clearly, but they did not show any useful internal marker within the Silurian.

An equally great unconformity at the base of the Pennsylvanian makes the Devonian top also unreliable for structure mapping.

A broad anticlinal feature with almost 100 feet of relief is present northwest of the deep well (fig. 3). The anticline strikes northwest-southeast and and plunges gently to the southeast. The highest well drilled in the area is the Davis No. 1 Schmiers, sec. 31, T. 17 N., R. 1 W., Rock Island County, where the top of the Galena is 5 feet below sea level.

Saddles along the crest of the structure isolate several irregular domes that protrude above the -30 foot elevation on the Galena. One such dome, with its center near the Oscar Stapp well (sec. 25, T. 17 N., R. 2 W.), appears to have about 13 feet of closure within an area of 800 acres. A second dome, with its center near the Ed Schmiers well, has approximately 25 feet of closure within an area of 3,500 acres. A possible third dome, with its center near the Oak Glen Home well (sec. 3, T. 16 N., R. 1 W.), has a closure of about 9 feet within an

SYSTEM	SERIES	GROUP	FORMATION	MEMBER
QUATERNARY	PLEISTOCENE			
PENNSYLVANIAN				
DEVONIAN	UPPER	New Albany		
	MIDDLE		Cedar Valley	
			Wapsipinicon	
SILURIAN	NIAGARAN			
	ALEXANDRIAN		Kankakee	
			Edgewood	
ORDOVICIAN	CINCINNATIAN	Maquoketa	Brainard	
			Ft. Atkinson	
			Scales	Clermont
				Elgin
	CHAMPLAINIAN	Galena	Wise Lake	
			Dunleith	
			Guttenberg	
		Platteville		
		Ancell	Glenwood	
			St. Peter	Starved Rock
				Kingdom
				Tonti
				Kress
	CANADIAN	Prairie du Chien	Shakopee	
			New Richmond	
			Oneota	
CAMBRIAN	CROIXAN		Eminence	Momence
			Potosi	
			Franconia	
			Ironton-Galesville	
			Eau Claire	
			Mt. Simon	
PRECAMBRIAN				

Figure 2 - Stratigraphic classification used in this report.

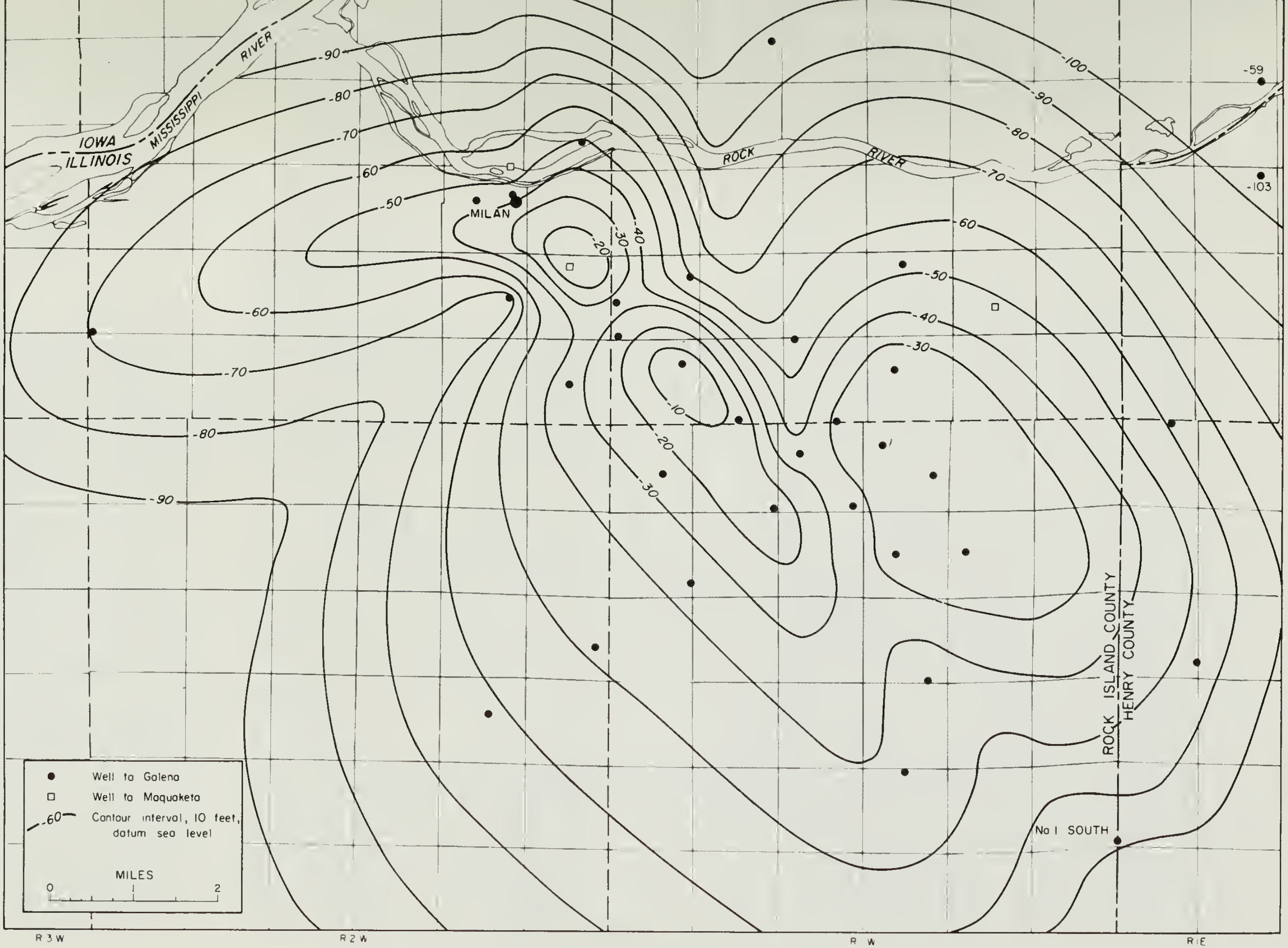


Figure 3 - Structure on top of the Galena Dolomite.

area of 3,800 acres. These minor closures lie within a broad dome covering about 15,000 acres within the -40 foot contour on top of the Galena.

Although the structure of the area appears to be one of gentle arching, the datum points are widely spaced, and further drilling may show additional relief on the top of the Galena Dolomite. North and northwest closure is well established and indicates the presence of a syncline bordering the area on the north. Drillers' logs and sample studies from water wells north of the Rock River show anomolously high and low elevations for the Galena top, and structural mapping at the north edge of the area is probably less accurate than farther south.

Structure of pre-Galena strata.—Galena and Platteville strata are remarkably uniform in thickness in the Rock Island area. The structure of the top of the Glenwood should be nearly the same as that on the top of the Galena. There is no evidence of reef formation or of differential compaction in Cambrian and Ordovician strata of this area. Structures represented on top of the Galena or Glenwood probably are also present at greater depths. However, there is pre-St. Peter deformation elsewhere in northern Illinois (Willman and Payne, 1942; Willman and Templeton, 1951); therefore, the closure mapped on the Galena may be greater or less on Prairie du Chien (Canadian-Lower Ordovician) and Cambrian formations.

Regionally the Cambrian and Prairie du Chien strata thin gradually northward, and it can be anticipated that the northward closure on the lower formations will diminish slightly.

No major faulting has been recognized in the area.

STRATIGRAPHY

The succession of strata in the Rock Island area is illustrated by the well log of the Ralph E. Davis, No. 1 E. A. South well in sec. 30, T. 16 N., R. 1 E., Henry County (fig. 4). A sample study of this well is presented in table 1. Supplementary data from nearby shallow wells and outcrops are incorporated in the following brief description of the stratigraphy.

Quaternary System—Pleistocene Series

Much of the bedrock in the area is mantled with glacial drift and loess of Pleistocene age. Pleistocene deposits vary within short distances from a few feet to over 200 feet thick. The drift is locally eroded along rivers and streams where the bedrock is exposed, but it is generally about 100 feet thick in the upland areas. A buried early Pleistocene valley of an eastward flowing stream crosses the area and cuts deeply into the Pennsylvanian rocks (Horberg, 1950), but it probably does not reach older rocks as shown on the state geologic map of 1945.

Pennsylvanian System

Strata of Pennsylvanian age, consisting of sandstone, shale, and siltstone, with thin beds of coal and limestones form the bedrock in much of the area (Savage and Udden, 1921). The sequence of Pennsylvanian strata is similar to that described in the Alexis quadrangle to the south (Wanless, 1929). The Pennsylvanian rocks are a little over 100 feet thick in the E. A. South well. They thicken southward and thin northward to a feather edge at Rock Island. Pennsylvanian strata unconformably overlie rocks of Devonian or Silurian age.

Some of the coal beds have been mined in the area, and the clays and shales have been used in the manufacture of ceramic products (Parham, 1961).

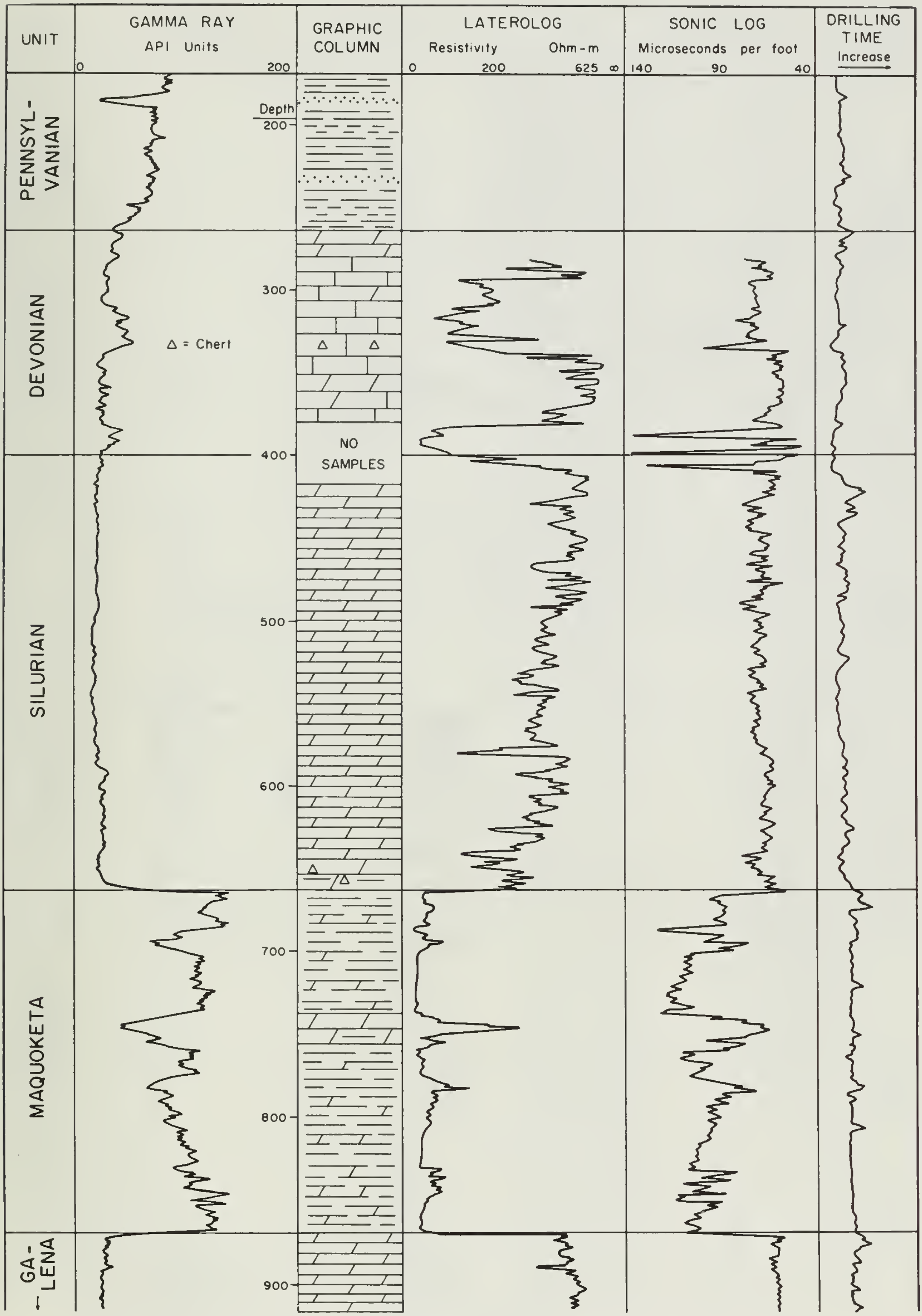
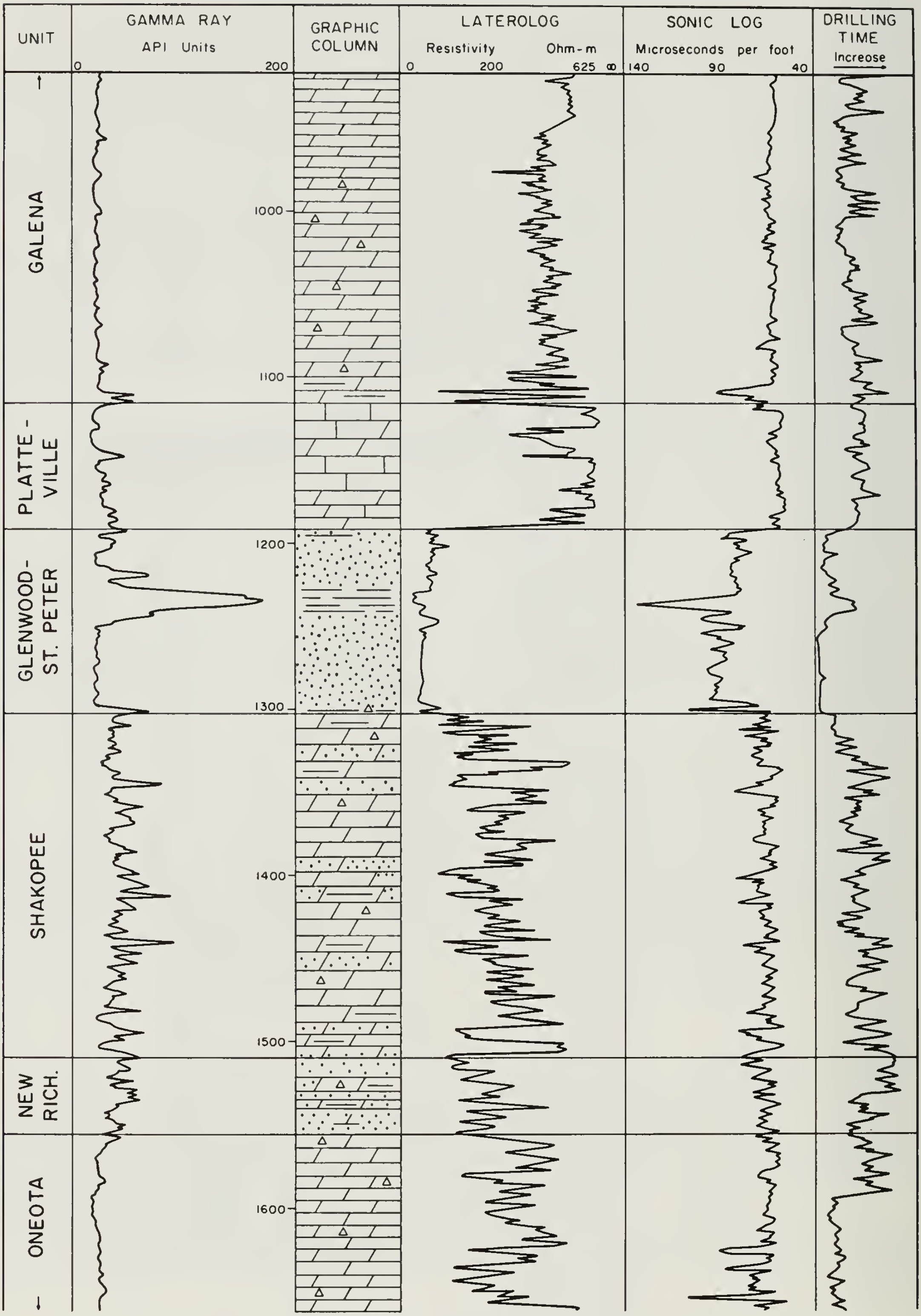


Figure 4 - Graphic column and geophysical logs, Davis No. 1, E. A. South well.



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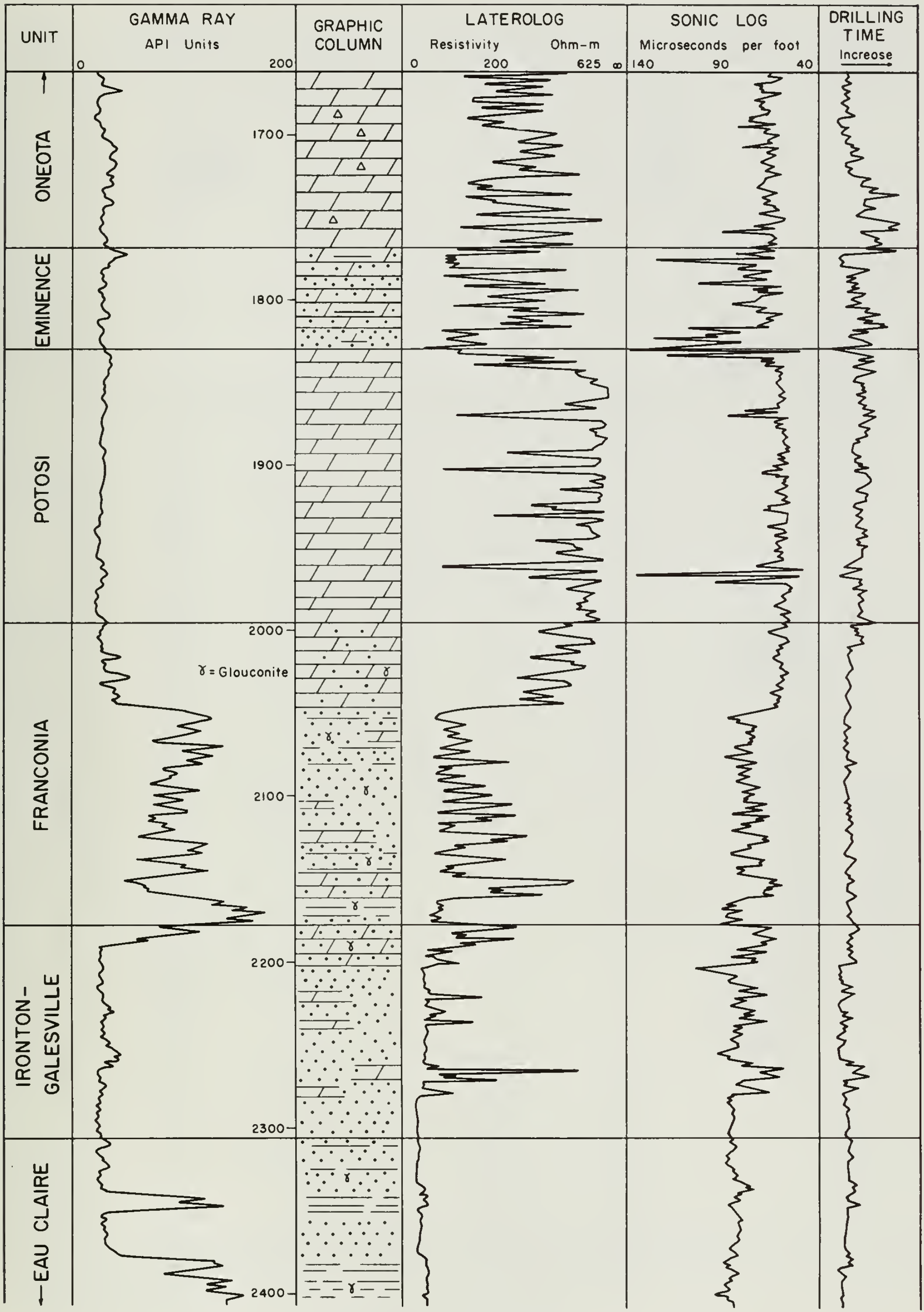

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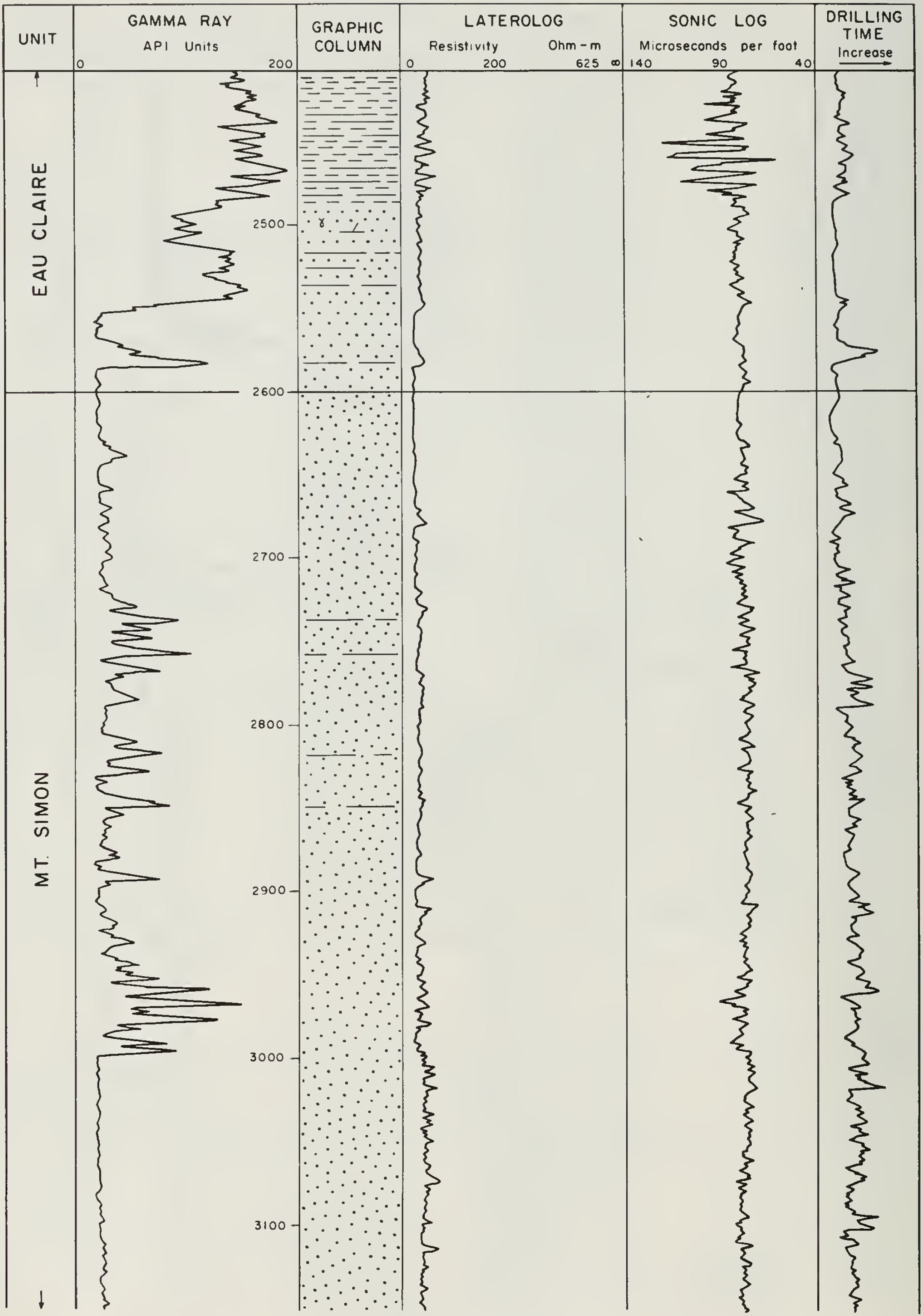

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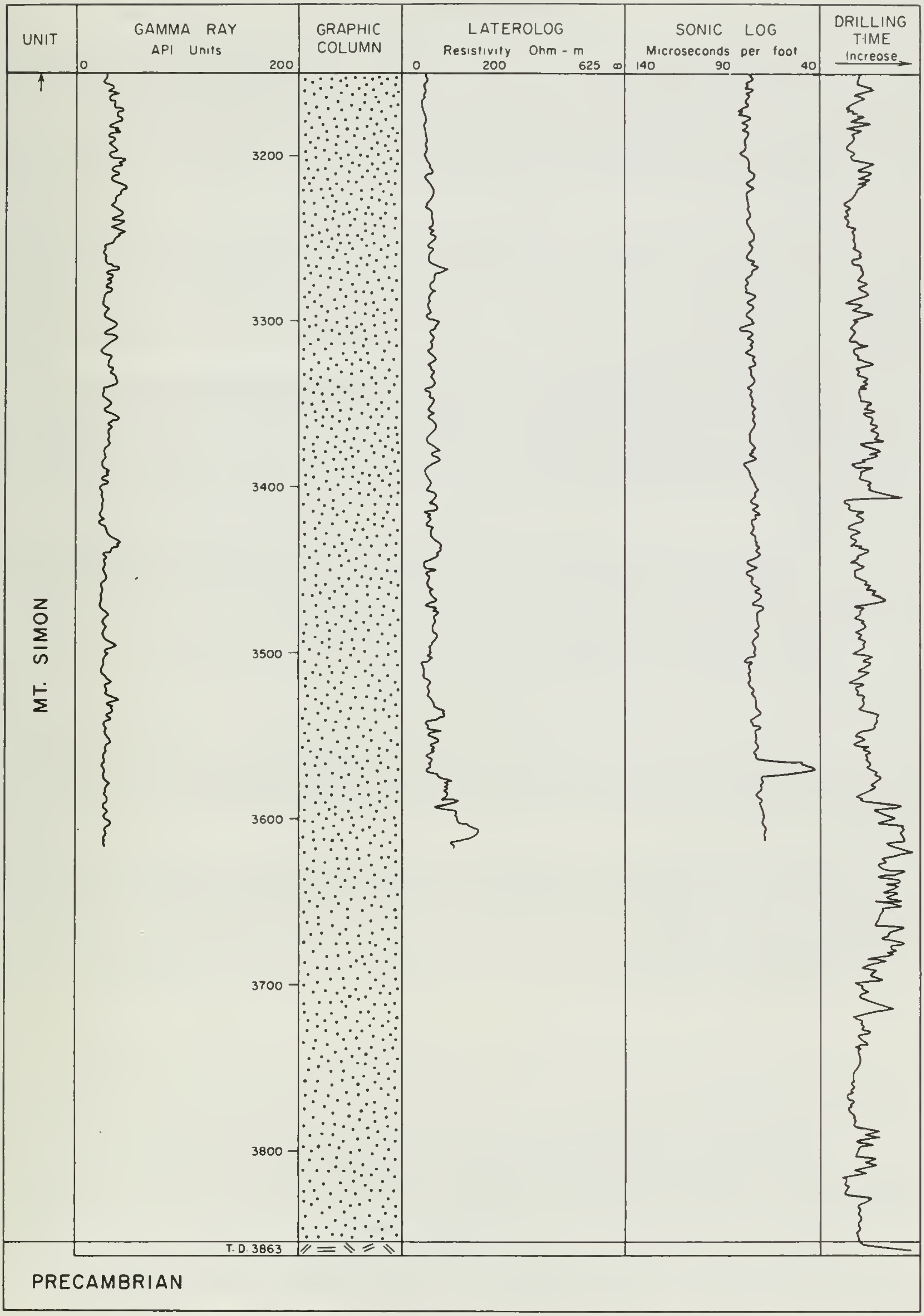

Figure 4 - continued

Mississippian System

Although lower Mississippian (Kinderhookian) shales have been reported south of this area (Workman and Gillette, 1956), no Mississippian strata were recognized in the structure tests that were studied. Mississippian fossils are present in basal Pennsylvanian conglomerate (Savage and Udden, 1921), but Mississippian strata were largely removed from the immediate area by erosion prior to deposition of Pennsylvanian sediments.

Devonian System

The Devonian System is represented in the Rock Island area by the Cedar Valley and Wapsipinicon Limestones of Middle Devonian age (Savage and Udden, 1921). West and south of the area, green and dark brown to black, spore-bearing New Albany Shale of Devonian age overlies the limestone, and a few feet of the shale is locally present in the Rock Island area.

The Cedar Valley consists of light gray to brown limestone and dolomite that are characteristically very fine grained and fossiliferous. The underlying Wapsipinicon consists chiefly of gray, lithographic limestone. South of the area anhydrite and gypsum are present, and the brecciation of the lower beds of the Wapsipinicon in the Rock Island area may have been caused by solution of the evaporites.

Devonian strata are over 100 feet thick in the E. A. South well. They crop out along the Rock and Mississippi Rivers at Milan and Rock Island but are generally absent a few miles farther north. Their occurrence in the subsurface to the south was described by Whiting and Stevenson (1965).

The Devonian limestones are quarried in the area for road stone, concrete aggregate, and agricultural limestone.

Silurian System

Silurian strata in the area consist primarily of dolomite and are assigned to the Niagaran and Alexandrian Series. Niagaran rocks are light gray, vuggy dolomite. Reef development is common in the Niagaran (Willman, 1943; Lowenstam, 1949).

Alexandrian rocks are composed of light yellowish gray, partly cherty dolomite and are assigned to the Kankakee Formation. Locally a few feet of gray siltstone that is argillaceous and dolomitic at the base of the Silurian is assigned to the Edgewood Formation.

Silurian strata are 263 feet thick in the E. A. South well. They crop out north of the Rock Island area.

Ordovician System

Maquoketa Shale Group

In the Rock Island area, the Maquoketa Shale Group consists chiefly of dolomitic and silty shale, but dolomite is dominant in the middle part. The Maquoketa is about 210 feet thick but varies locally from 190 to over 220 feet. The group consists of the Brainard Shale (at the top), the Fort Atkinson Dolomite, and the Scales Shale (Templeton and Willman, 1963).

The Brainard Shale consists of silty, dolomitic, greenish gray shale that contains a few streaks of silty dolomite. The formation is 75 to 90 feet thick.

It is overlain unconformably by Silurian dolomite.

The Fort Atkinson consists of fine-grained, silty, gray dolomite with interbedded greenish gray shale. It is recognizable on geophysical logs throughout the area. The Fort Atkinson is 15 to 20 feet thick.

The Scales Shale is divided into the Clermont and Elgin Members. The Clermont is similar to the Brainard, but the shale has a slight brownish color and includes more interbedded dolomite. The Clermont is about 80 feet thick in the area. The Elgin Member consists of dark brown to brown, silty, dolomitic shale. It includes thin beds of dolomite and, at the base and top, thin beds with small phosphatized and pyritized gastropod, pelecypod, and brachiopod fossils that are called "depauperate zones." The Elgin is 30 to 45 feet thick in the Rock Island area.

Galena Group

The Galena Group consists primarily of buff dolomite with some red shale partings at its base. The Galena is 247 feet thick in the southern part of the area and 260 feet thick in the north. This group includes the Wise Lake (at the top), the Dunleith, and the Guttenberg Formations (Templeton and Willman, 1963). The Dubuque Formation, at the top, and the Spechts Ferry Formation, at the base, were not recognized in the borings.

The Wise Lake Formation consists of fine- to medium-grained, buff dolomite that contains a moderate number of small vugs. A few thin reddish brown shale partings are also present. The Wise Lake is about 110 feet thick in the area.

The Dunleith Formation is similar to the Wise Lake, but it contains chert in bands and nodules 1 to 2 inches thick. The Dunleith is 125 to 130 feet thick.

The Guttenberg Formation consists of reddish buff to brown, medium- to coarse-grained dolomite and interbedded reddish brown shale in beds up to one-quarter inch thick. Laterologs and gamma ray logs show the shaliness of the Guttenberg (fig. 4). The formation is 15 to 20 feet thick in the area.

Regional evidence indicates there is a slight unconformity at the top of the Galena, but no relief on the surface was noted in this area.

Platteville Group

The Platteville Group consists of very fine-grained, grayish brown limestone and dolomite. The limestone is fossiliferous, and chert nodules are present in the middle of the group. The formations were not differentiated in this study. The Platteville is a little over 70 feet thick in the eastern part of the Rock Island area and about 60 feet in the western part.

Ancell Group

Glenwood Formation.—The Glenwood Formation consists of fine-grained, dolomitic and argillaceous sandstone. It is only a few to 5 feet thick in the area.

St. Peter Sandstone.—In western Illinois and southeastern Iowa, the St. Peter characteristically consists of a sandstone-shale-sandstone sequence. Following the correlations suggested by Templeton and Willman (1963, p. 47), the upper sandstone is assigned to the Starved Rock Member, the middle shale to the Kingdom Member, and the lower sandstone to the Tonti Member. A thin basal conglomerate is assigned to the Kress Member.

The Starved Rock Member is fine- to medium-grained, porous sandstone that includes some thin, dark, argillaceous laminae and a few green shale partings.

This sandstone is nearly 40 feet thick in the southern part of the area but thins to about 15 feet or less in the northern part.

The Starved Rock has been called the "Repeater sandstone" and is the "unnamed sandstone" of Agnew (1955).

The Kingdom Member consists of green shale that is plastic when wet. The shale is 10 to 20 feet thick and appears to be present throughout the area.

The Tonti Member consists of white, fine- to medium-grained, porous sandstone that is 50 to 100 feet thick in the area. At the base of the Tonti, there are a few feet of bright green shale and chert rubble assigned to the Kress Member.

The St. Peter unconformably overlies the Shakopee Dolomite, and the thicker sections of Tonti Sandstone occur where the sandstone fills erosional and solutional depressions on the Shakopee surface (Buschbach, 1961).

Prairie du Chien Group

The regional relations of the Prairie du Chien Group and Cambrian strata are described by Workman and Bell (1948) and Bell et al. (1964). The stratigraphy and nomenclature of these rocks in northern Illinois is discussed by Willman and Templeton (1951) and Buschbach (1964).

Shakopee Dolomite.—The Shakopee Dolomite is a variable unit of very fine-grained dolomite, thin beds of sandstone, green shale partings, and chert nodules. A few thin beds of coarse-grained, porous dolomite are also present. The Shakopee is 207 feet thick in the E. A. South well, and it is thinner locally where the St. Peter Sandstone reaches its maximum thickness. The Shakopee thickens markedly southeastward and exceeds 800 feet in the Illinois Basin.

New Richmond Sandstone.—The New Richmond Sandstone consists of sandstone and dolomite. The sandstone is dolomitic, medium to fine grained, subrounded, and slightly friable. The dolomite is sandy, light pinkish gray, very fine grained, and includes sandy and oolitic chert. The New Richmond is 47 feet thick in the E. A. South well and thickens eastward, reaching a maximum of about 175 feet in north-central Illinois.

Oneota Dolomite.—The Oneota Dolomite consists of light gray to light brown, medium-grained, cherty dolomite. Some zones have $\frac{1}{4}$- to $\frac{1}{2}$-inch vugs that contain calcite, quartz crystals, drusy dolomite, or soft white silica. Green shale partings are common. The Oneota is a little over 200 feet thick in the Rock Island area and thickens regularly southeastward. The Gunter Sandstone, commonly found beneath the Oneota in this region, was not present in the No. 1 South well.

Cambrian System

Eminence Formation.—The Eminence Formation consists of light gray to light brown, fine- to medium-grained, sandy dolomite that contains oolitic chert. Dolomitic sandstone is present in beds 10 to 14 feet thick and in thin stringers. A well developed sandstone in the basal 14 feet of the Eminence is the Momence Sandstone Member.

The Eminence is about 60 feet thick in this area. To the north, it thins slightly and becomes increasingly sandy, grading into the Jordan Sandstone in extreme northwestern Illinois and southern Wisconsin. The Eminence thickens southward and is more than 300 feet thick in southeastern Missouri. The sandstone to dolomite ratio decreases regularly southward.

Potosi Dolomite.—The Potosi Dolomite is a light grayish brown, fine-grained, slightly glauconitic dolomite. The formation is characterized by drusy quartz.

Numerous zones of lost circulation were encountered while drilling the Potosi in the E. A. South well. The Potosi is 166 feet thick.

Franconia Formation.—The Franconia Formation consists of fine-grained glauconitic sandstone, fine-grained sandy dolomite, and silty green shale. The formation is characterized by abundant glauconite.

The Franconia is about 180 feet thick near Rock Island. It thickens southward and becomes less sandy. The upper part of the Franconia grades into the Derby-Doerun Dolomite of Missouri. The lower shaly unit is correlated with the Davis Formation of Missouri.

Ironton-Galesville Sandstone.—The Ironton-Galesville Sandstone consists chiefly of medium-grained, friable, slightly dolomitic sandstone. At the top, there is 20 feet of sandy glauconitic dolomite. Both the sand and glauconite are much coarser grained than in the overlying Franconia Formation.

The Ironton-Galesville Sandstone is about 130 feet thick in this area. It is 100 to a little over 200 feet thick throughout most of northern Illinois, but it thins in the central part of the state and is absent in the southern third.

Eau Claire Formation.—The Eau Claire Formation is a variable unit of sandstone, siltstone, and shale. The sandstone is silty, dolomitic, glauconitic, micaceous, and fossiliferous. The siltstone is grayish orange, micaceous, and compact. The shale is silty, green to red, micaceous, and brittle. Shale is most abundant near the middle of the formation.

The Eau Claire is about 300 feet thick in the Rock Island area where it is in a predominantly sandstone facies. It thickens markedly southeastward, possibly reaching 1,000 feet in the southeastern corner of the state. Shale appears to increase in that direction. Directly southward from Rock Island, the Eau Claire changes little in thickness, but it grades to a dolomite facies that is called Bonneterre in Missouri.

Mt. Simon Sandstone.—The Mt. Simon Sandstone consists of fine- to coarse-grained, poorly sorted, friable sandstone. Some zones are compact and well cemented by silica or hematite. It is essentially nondolomitic and nonglauconitic. The upper half of the Mt. Simon contains some interbedded red and green shale. The lower part of the formation is pink and arkosic. The amount of feldspar increases downward.

The Mt. Simon unconformably overlies an eroded Precambrian basement, and, consequently, local variations in thickness of several hundred feet can be expected in this area. The formation is 1,250 feet thick in the E. A. South well. It thickens regularly eastward and exceeds 2,000 feet in parts of northeastern Illinois. The Mt. Simon thins southward and southwestward. Locally in western Illinois and eastern Missouri, it is absent where hills of Precambrian rocks protrude up to the Eau Claire Formation.

Precambrian

The eight feet of Precambrian rocks cored in the E. A. South well consist of coarse-grained, dark-colored igneous rock that contains a considerable amount of biotite. It is called a granodiorite (Bradbury and Atherton, 1965).

PROSPECTIVE GAS STORAGE ZONES

Potential reservoirs in the Rock Island area include the Starved Rock and Tonti Members of the St. Peter Sandstone, the Ironton-Galesville Sandstone, and a unit that includes sandstones of the lower Eau Claire and upper Mt. Simon.

The Starved Rock Sandstone Member averages 20 feet in thickness and has about 20 percent porosity. At the top of the member, there is about 6 inches of weak, green shale, which is overlain by very fine-grained limestone of the Platteville Group. The entire area is underlain by 200 feet of Maquoketa Shale, which is 320 feet above the top of the Glenwood.

The Starved Rock thins from over 35 feet thick in the southeast part of the area to about 15 feet in the central part. A driller's log of a well in Milan (sec. 23, T. 17 N., R. 2 W.) at the north edge of the area shows no sandstone at this position, but a well on Vandruff Island (sec. 13, T. 17 N., R 2 W.) in the Rock River showed a sandstone thickness of about 15 feet. Wells just north of the area indicate thinning and, locally, pinching out of the Starved Rock. The northwest thinning of this sandstone across an anticlinal axis is a possible stratigraphic trap.

The Tonti Sandstone Member is 50 to 100 feet thick in the area. It is friable and porous, with 20 percent porosity throughout much of the unit. There are some interbeds of less permeable sandstone, but it is doubtful that the less permeable beds are continuous units in the area. Immediately overlying the Tonti is the Kingdom Member, a soft, green shale that is 10 to 20 feet thick.

The Ironton-Galesville Sandstone is over 100 feet thick and has variable porosity due to dolomite cementation. The lower 25 feet of the formation appears to have at least 15 percent porosity. Immediately overlying the Ironton-Galesville is the Franconia Formation that has a 20-foot shaly section at its base (Davis Member).

In the lower Eau Claire and upper Mt. Simon, there is a unit of sandstone about 80 feet thick that has an estimated 15 percent porosity. The shaly middle Eau Claire overlies this unit.

TABLE 1 — SAMPLE STUDY, RALPH E. DAVIS, NO. 1 E. A. SOUTH, HENRY COUNTY, SW¼SW¼SW¼ SEC. 30, T. 16 N., R. 1 E., SAMPLE SET 41,427, DESCRIBED BY T. C. BUSCHBACH

	Thickness (feet)	Depth (feet)
QUATERNARY SYSTEM		
PLEISTOCENE SERIES		
Till, silty, yellowish gray, leached	50	50
Till, calcareous, yellowish orange to olive, oxidized, sandy at base	113	163
PENNSYLVANIAN SYSTEM		
Shale, calcitic, dark gray, carbonaceous, pyritic, hard; coal; abundant sand, medium, uncemented, angular, pyritic	27	190
Shale, silty, gray, brittle, micaceous; siltstone, argillaceous, gray; some coal and weak, dark gray shale; a little sandstone, light yellowish gray, fine, firm	75	265
DEVONIAN SYSTEM		
CEDAR VALLEY FORMATION		
Dolomite, very silty, light brownish gray to light greenish gray, very fine	15	280
Limestone, dolomitic, light grayish brown, gray, white, very fine to lithographic, partly fossiliferous; chert at 330–340'	100	380
WAPSIPINICON FORMATION		
Lost circulation, no samples	20	400
SILURIAN SYSTEM		
NIAGARAN SERIES		
No samples	18	418
Dolomite, light gray, fine to medium, crystalline, porous, vuggy (reef rock)	72	490
Dolomite, as above, pale yellowish gray	10	500
Dolomite, light gray to pale yellowish gray, fine to medium, crystalline, porous, vuggy in part	100	600
ALEXANDRIAN SERIES		
Dolomite, light gray to light yellowish gray, fine to medium, partly porous; trace of glauconite	40	640
Dolomite, cherty, light yellowish gray to light gray, fine; trace of glauconite; a few weak, light green argillaceous streaks	23	663
ORDOVICIAN SYSTEM		
CINCINNATIAN SERIES		
MAQUOKETA SHALE GROUP		
BRAINARD SHALE		
Shale, silty, dolomitic, greenish gray; few dolomite streaks 690–700'	75	738
FORT ATKINSON DOLOMITE		
Dolomite, silty, argillaceous, gray, fine; interbedded shale, silty, greenish gray — shale increases towards base	17	755
SCALES SHALE		
CLERMONT MEMBER		
Shale, silty, dolomitic, greenish gray to grayish brown; interbedded dolomite in 1"–2" beds and irregular nodules	75	830
ELGIN MEMBER		
Shale, silty, dolomitic, dark brown to grayish brown; dolomite streaks, brown, fine; depauperate zone at base and top	40	870
CHAMPLAINIAN SERIES		
GALENA GROUP		
WISE LAKE FORMATION		
Dolomite, grayish buff, gray mottled, fine, pyritic; 1" calcite crystals	1	871
Dolomite, buff, medium to fine, porous, partly vuggy; thin reddish brown shale partings; numerous gastropods 945' to base	107	978
DUNLEITH FORMATION		
Dolomite, cherty, buff, fine to medium; rare thin shale partings	126	1104
GUTTENBERG FORMATION		
Dolomite, reddish buff, coarse; dark reddish brown shale partings 1/16"–1/4" thick at 3"–6" intervals; 3" green shale at base	7	1111
Wavy interbeds of dolomite, brown, coarse; dolomite, gray, fine; shale, reddish brown	7	1118
PLATTEVILLE GROUP		
Limestone, brown, lithographic, dense; dolomite, brown, fine; shale partings, reddish brown; beds of *Strophomena* and 1/2" dark brown shale at base	14	1132
Dolomite, calcitic, grayish brown, very fine	5	1137
Dolomite, calcitic, cherty, grayish brown, very fine (chert in 1"–4" nodules)	11	1148
Limestone, brownish gray, very fine, some gray "birds eye" mottling; chert nodules	4	1152
Limestone, grayish brown, very fine to coarse, fossiliferous, cherty in upper 10'; thin dark brown to dark gray shale partings	18	1170
Dolomite, calcitic, grayish brown to brown, partly gray mottled, fine; limestone, dolomitic, brownish gray, very fine	21	1191
ANCELL GROUP		
GLENWOOD FORMATION		
Sandstone, dolomitic, fine, fucoidal; many irregular dark gray argillaceous laminae; 6" green shale at base	4	1195
ST. PETER SANDSTONE		
STARVED ROCK MEMBER		
Sandstone, white, fine to medium, porous, friable, some cross bedding; faint green, argillaceous coloring; 2' sandy green shale at 1218–1220'	34	1229
KINGDOM MEMBER		
Shale, dark green, hard	10	1239
TONTI MEMBER		
Sandstone, white to light greenish gray, fine to medium, friable, porous, some cross bedding; few 6"–8"		

	Thickness (feet)	Depth (feet)
streaks of sandstone, white, fine, well cemented	62	1301
KRESS MEMBER		
Shale, bright green; chert pebbles; dolomite fragments	2	1303
CANADIAN SERIES		
PRAIRIE DU CHIEN GROUP		
SHAKOPEE DOLOMITE		
Variable unit of dolomite, partly sandy, partly cherty, light gray to light brownish gray, very fine to fine, slightly glauconitic, partly vuggy; some relict oolitic structure; some thin green shale partings; some thin beds of sandstone, dolomitic, buff, medium; few beds of dolomite, coarse to medium, porous; chert, chalky to tripolitic, occurs as nodules and as replacement networks; includes thin stringers of sandstone in places; some nearly vertical fracturing 1430' to base	193	1496
Dolomite, silty, light grayish brown, very fine; interlaminated with green shale	1	1497
Dolomite, light grayish brown, very fine	7	1504
Dolomite, sandy in lower part, light brown and light grayish brown, mottled, fine, crystalline, vuggy; calcite crystals in some vugs	6	1510
NEW RICHMOND SANDSTONE		
Sandstone, dolomitic, medium to fine, moderate sorting, subrounded to subangular, slightly friable; dolomite, sandy, light gray to light pinkish gray, very fine; shale partings, green; chert, sandy, white, chalky, oolitic; slight oil stain in vug at 1532	47	1557
ONEOTA DOLOMITE		
Dolomite, light grayish brown to light gray, very fine; thin glauconitic films	3	1560
Dolomite, slightly sandy, brownish gray, medium to fine, crystalline, partly vuggy; some calcite and drusy dolomite in vugs; little chert	20	1580
Dolomite, cherty, light brownish gray, fine to medium, crystalline, partly vuggy	8	1588
Dolomite, white to pale yellowish brown, medium, porous; some soft white silica in vugs; a trace of shale, light green, brittle	22	1610
Dolomite, cherty, light gray to light brownish gray, medium to fine, porous, slightly pyritic; some green shale partings; pale orange chert 1670-1680'; dolomite, very coarse at 1690-1700'	90	1700
Dolomite, light brownish gray, medium to fine, porous, slightly glauconitic; dolomite, pink, coarse, hematitic; trace of sand	20	1720
Dolomite, cherty, light gray to light yellowish brown, fine; some thin contorted beds of green shale ..	20	1740
Dolomite, partly cherty, light yellowish brown to brown, fine to coarse, porous, vuggy; calcite, quartz crystals, drusy dolomite, and white siliceous powder in vugs; few green shale partings; some partial chert replacement	29	1769
CAMBRIAN SYSTEM		
CROIXAN SERIES		
EMINENCE FORMATION		
Dolomite, sandy, grayish brown to light brownish gray, fine to medium; chert, oolitic, sandy, white; thin stringers of sandstone, light green, medium, cemented with white, chalky silica; thin stringers and blebs of green clay	11	1780
Sandstone, dolomitic, white, medium, moderately sorted, subrounded, coherent	10	1790
Dolomite, sandy, light brownish gray, fine to medium; chert, sandy, oolitic, white; some calcite, pyrite, and green shale	26	1816
MOMENCE SANDSTONE MEMBER		
Sandstone, siliceous, dolomitic, white to tan, medium, poorly sorted .	14	1830
POTOSI DOLOMITE		
Poor samples - lost circulation ..	10	1840
Dolomite, slightly sandy, light grayish brown, fine, very slightly glauconitic at top; a little drusy quartz and dolomite. Lost circulation at 1865'	60	1900
Dolomite, light grayish brown, a little light pink mottling, fine, slightly glauconitic; drusy quartz; some pyrite and calcite associated with lost circulation zone at 1960' .	96	1996
FRANCONIA FORMATION		
Dolomite, slightly sandy, light gray to pink, fine, glauconitic	49	2045
Sandstone, dolomitic, slightly argillaceous, greenish gray, fine, very glauconitic, friable, porous; shale partings, gray, brittle; a few streaks of dolomite, silty, sandy, brownish gray, very fine, slightly glauconitic	102	2147
Dolomite, light buff, fine, crystalline; dolomite, silty, sandy, gray, very fine, slightly glauconitic	13	2160
Shale, silty, green, brittle to weak, micaceous, slightly glauconitic; sandstone, silty, grayish orange, very fine, glauconitic	17	2177
IRONTON - GALESVILLE SANDSTONE		
Dolomite, sandy (some coarse), light grayish brown, medium, very glauconitic (some coarse), vague spherules; few beds of sandstone, dolomitic, medium, light grayish brown, well cemented, poorly sorted, glauconitic	23	2200
Sandstone, slightly dolomitic, white, medium, poorly sorted, friable; few streaks of sandstone, dolomitic, light brown, white, pale pink, medium to fine, well cemented .	106	2306
EAU CLAIRE FORMATION		
Sandstone, slightly dolomitic,		

	Thickness (feet)	Depth (feet)
light gray, fine, friable, glauconitic; some dark gray shale partings; little dolomite, silty, light gray to light pinkish gray, very fine	34	2340
Sandstone, silty, light gray to pink, very fine to fine, friable, glauconitic, fossiliferous; shale, silty, green, gray, weak to brittle .	38	2378
Siltstone, grayish orange to light gray, coarse, compact, glauconitic, micaceous; shale, greenish gray, brittle, micaceous	72	2450
Interbedded siltstone, as above, and shale, greenish gray, red, brittle, micaceous	38	2488
Sandstone, silty, dolomitic, light gray to grayish orange, very fine, compact, glauconitic, micaceous, fossiliferous; a little conglomerate of dolomite, yellow, pink, white, coarse, glauconitic; fossil fragments; some sand	27	2515
Sandstone, as above; grades to coarse siltstone; shale, silty, greenish gray, brittle, micaceous; conglomerate, as above	35	2550
Sandstone, dolomitic, light gray to light brown, fine, friable to compact, fossiliferous, pyritic, partly sooty; some shale, silty, greenish gray, brittle, micaceous ...	50	2600
MT. SIMON SANDSTONE		
Sandstone, white to light gray, medium to fine, poorly sorted, friable, rounded, slightly sooty	44	2644
Sandstone, white, medium, poorly sorted, rounded, friable; some very coarse grains	76	2720
Sandstone, pink, medium, poorly sorted, friable, hematitic; some pale yellow grains; shale, red, green	90	2810
Sandstone, silty, argillaceous, pink, pale yellow, medium to fine, very poorly sorted, friable; little shale, silty, red, very micaceous, brittle	40	2850
Sandstone, pink to red, medium to coarse, friable, poorly sorted, partly hematitic; some pale yellow grains	100	2950
Sandstone, white, pale yellowish gray, medium, poorly sorted, rounded to subangular, friable, clean, porous; some broken grains	50	3000
Sandstone, white, fine, moderate sorting, subrounded, friable to well cemented by silica	190	3190
Sandstone, white, pink, fine (some medium), subrounded, friable to slightly friable; some red ferruginous bands	220	3410
Sandstone, red, pink, little white, medium, subangular, friable to slightly friable, poorly sorted, hematitic	190	3600
Sandstone, white, pink, fine to medium, subangular, moderately sorted, slightly friable; some beds hard, well cemented by silica, low porosity	75	3675
Sandstone, pink, fine to medium, moderately sorted, slightly friable, low porosity	45	3720
Sandstone, pink, medium, subrounded, moderately sorted, friable, porous	30	3750
Sandstone, white, pink, red, medium to fine, rounded, friable; soft white to pinkish clay — possibly drilling mud	75	3825
Sandstone, arkosic, coarse, red, pink, rounded and angular quartz fragments; very little feldspar	15	3840
Sandstone, arkosic, red, hematitic; quartz fragments, as above, but increased feldspar	15	3855
PRECAMBRIAN		
Granodiorite, coarse, dark; pink and red feldspar, clear quartz, considerable biotite	8	3863
		T.D.

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Illinois State Geological Survey Circular 394
20 p., 4 figs., 1 table, 1965

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

CIRCULAR 394

ILLINOIS STATE GEOLOGICAL SURVEY

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