THE LOWER DOLOMITE MEMBER OF THE ORDOVICIAN CHAZY LIMESTONE AND THE ST. PETER SANDSTONE OF NORTH-CENTRAL KENTUCKY AND SOUTHWESTERN OHIO[1]

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ABSTRACT

Until recently little was known of the exact disposition of the Lower Dolomite Member of the Chazy Limestone and the St. Peter Sandstone in the area of study. This study has been done to illustrate their relationship to the underlying erosional topography on the Knox Dolomite Group.

The Lower Dolomite Member of the Chazy Limestone varies in thickness from a maximum of 100 feet to zero. The greater thicknesses are deposited in erosional valleys developed in the Knox Dolomite and the thinner sections are found deposited over the higher remnants, or hills, of Knox Dolomite. The use of geophysical well logs for placing the upper contact of this unit is very helpful.

The sandstone pinches out in the area of study in an easterly direction. A local depression or basin was formed in northern Kentucky where in excess of 60 feet of sand accumulated. The sands were probably from two sources: 1) sand from the St. Peter source area as erosion progressed landward, and 2) local erosion of Knox Dolomite "hills".

[1]Manuscript received August 3, 1963.

THE OHIO JOURNAL OF SCIENCE 65(2): 85, March, 1965.

In north-central Kentucky and southwestern Ohio, rocks lying between the Knox unconformity and the lithographic limestones of the Black River Group have been called the Chazy-Black River Group. Exceptions have been the separation of the St. Peter Sandstone, when present, and occasionally a unit termed "Glenwood Shale."

Recent work by Calvert (1962) and data furnished by many new exploration wells within the past two years have made possible a detailed description of the lower dolomite member of the Chazy Limestone (Calvert, 1962) and the St. Peter Sandstone in north-central Kentucky and southwestern Ohio.

I have attempted in this paper to describe and delimit the areal and vertical distribution, lithologic nature, and general implications of rocks in this lower portion of the Chazy Limestone and the sandstones when present. To achieve these ends, a detailed study was made of cores, well cuttings, radioactivity, and electric logs and reliable descriptive drillers' logs available. Data presented here are all subsurface and represent all that are available for publication. Location of all datum points used is shown in figure 1.

REVIEW OF STRATIGRAPHIC TERMS

Ohio

Before the work of Calvert (1962), no generally accepted Chazyan terminology was in use in Ohio. The rocks of the Chazy Limestone interval were grouped with the overlying lithographic limestones of the Black River Group and termed the Chazy-Black River Group. Occasionally a unit was separated and termed the "Glenwood." This term has been used for shale, limestone and dolomite or combinations of these rocks.

Chazy Limestone.—Calvert (1962) introduces this term for use in Ohio to describe the rocks between the lithographic limestone of the Black River Group and the dolomites below the Knox unconformity. This limestone was described by Emmons (1842) for the town of Chazy in Clinton County, New York. Calvert (1962) has shown that this unit is the same as the Murfreesboro Limestone of Miller and Fuller (1954) in their report of the Rose Hill, Virginia, area. Calvert states that this unit has been easily recognized from gamma ray logs and well cuttings in Ohio, Pennsylvania, New York, Kentucky, and Ontario and corresponds to the Chazy Limestone of Emmons (1842).

Because of this correlation, Calvert (1962) introduces the name Chazy Limestone into Ohio as the first formational name used for these rocks. The Chazy Limestone may be divided into three distinct members; the lower dolomite member, the middle limestone member, and the upper argillaceous (cherty) member.

Lower dolomite member.—The lower dolomite member is characterized by Calvert (1962) as having a basal conglomeratic zone "composed of subangular pebbles and cobbles in a gray, argillaceous dolomite matrix." Numerous rounded, frosted, quartz grains, and thin lenses of sandstone (up to 5 ft in thickness) are found in this lower zone. Calvert (1962) states that "above this basal conglomerate is a finer grained, conglomeratic zone composed of greenish-gray dolomite which commonly contains white, angular chert pebbles and is marked by thin interbeds of green and gray shale. The main portion of the lower dolomite member lies above the conglomeratic zones; it is characterized by beds of gray or light brown, dense to finely crystalline, argillaceous dolomite, interbedded with thin beds of green shale and a few argillaceous limestones. The limestones increase in number toward the top of the member."

St. Peter Sandstone.—This unit was formally described by Owen (1852) at the type locality near Minneapolis, Minnesota. Since that time this unit has presented vexing problems to stratigraphers concerning its origin, areal extent and the interpretation of its geologic history.

Dapples (1955) has shown the St. Peter Sandstone limits reaching into the

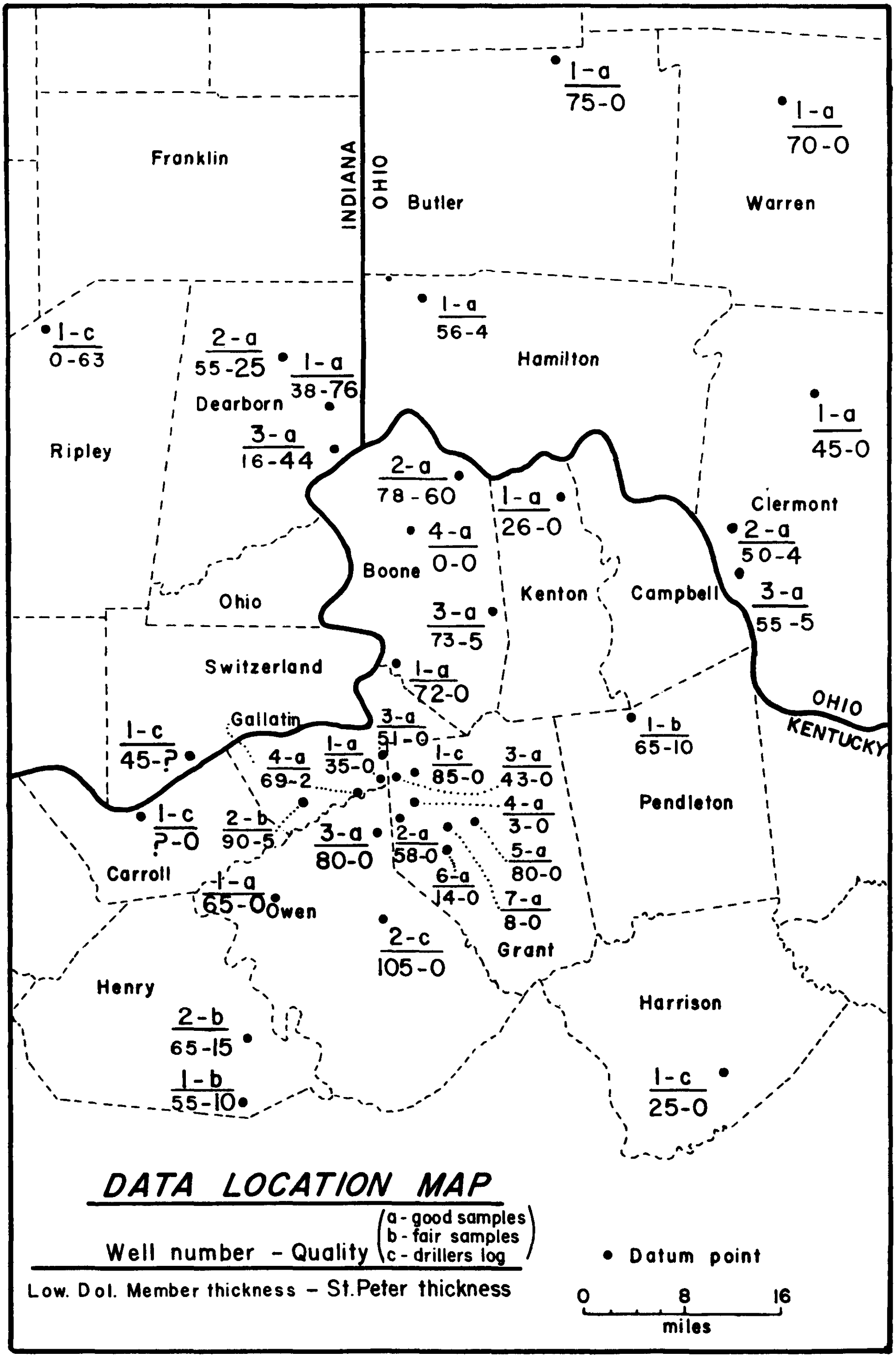

FIGURE 1. General data location map.

western portion of Ohio and Kentucky. Presently there is no method by which the sandstone of the St. Peter may be differentiated from the local accumulations of sand on the Knox unconformity.

Kentucky

In Kentucky, the most recent and comprehensive work on these rocks was by Freeman (1949; 1953). She grouped the Chazyan rocks with the lithographic limestone of the Black River Group and termed the entire unit the Chazy-Black River Group. The name "Glenwood" is not commonly used for north-central Kentucky by Freeman, although she used it in other areas of Kentucky to describe some dolomite occurrences.

Freeman has mapped the St. Peter Sandstone on the southeast side of the Cincinnati Arch Trend but did nothing with the St. Peter in north-central Kentucky. She states, and I agree, that this sandstone on the southeast side of the arch is not continuous with that found in north-central Kentucky and Ohio.

The nomenclature of Calvert (1962) previously discussed has been shown by him to be valid for Kentucky as well as Ohio and so will be used to describe the rocks of north-central Kentucky.

LOWER DOLOMITE MEMBER AND ST. PETER SANDSTONE NORTH-CENTRAL KENTUCKY AND SOUTHWESTERN OHIO

Contacts

The contact of the Chazyan rocks with the underlying Knox Dolomite is a sharp, erosional unconformity. The lithologic difference is equally as sharp in most sections, the underlying Knox Dolomite being a cream-gray to tan, medium to coarsely crystalline, very vuggy dolomite as contrasted to the darker green-gray to gray, saccharoidal, massive dolomite of the lower Chazy Limestone.

The contact of the lower dolomite member of the Chazy Limestone with the overlying middle limestone member is sometimes hard to place in well cuttings, however, with the use of gamma-ray neutron well logs, there is little trouble discerning the boundary.

Gamma-ray Neutron Log Characteristics

The best tool for definition of the rocks which compose the Chazyan interval is the Gamma-ray neutron well log. The gamma-ray curve is characterized by the natural radioactivity increasing in the Chazy Limestone (fig. 2). The radiation level shown by the gamma-ray curve at a depth of 680 ft in figure 2 is characteristic of the Black River Group. The upper argillaceous member and the middle limestone member of the Chazy Limestone yields an intermediate radiation level on the gamma-ray curve as shown from 704 ft to 740 ft. The lower dolomite member, however, yields the highest radiation level, as can be seen in the gamma-ray curve from 740 ft to 817 ft (fig. 2). This high radiation is the result of much shaly material and a great amount of bentonitic material. Radiation then drops off in the Knox to a level nearly equal to that of the Black River Group.

The induced radiation (neutron curve) is high in the Black River Group and upper argillaceous and middle limestone members due to the general lack of water or shale in the section (fig. 2). This is contrasted with the lower dolomite member of the Chazy Limestone which has some porosity, shale and much bentonitic material which gives a low response on the neutron curve. When sandstone is present, the gamma-ray response is similar to that of the Black River Group; however, the neutron curve exhibits a low response due to the water present in the sand. The lower contact as defined on the neutron curve is marked by a higher general level of response in the Knox Dolomite but averaging somewhat less than that of the Black River Group. This intermediate level is the result of the presence of water and lack of shale in the upper portion of the Knox Dolomite.

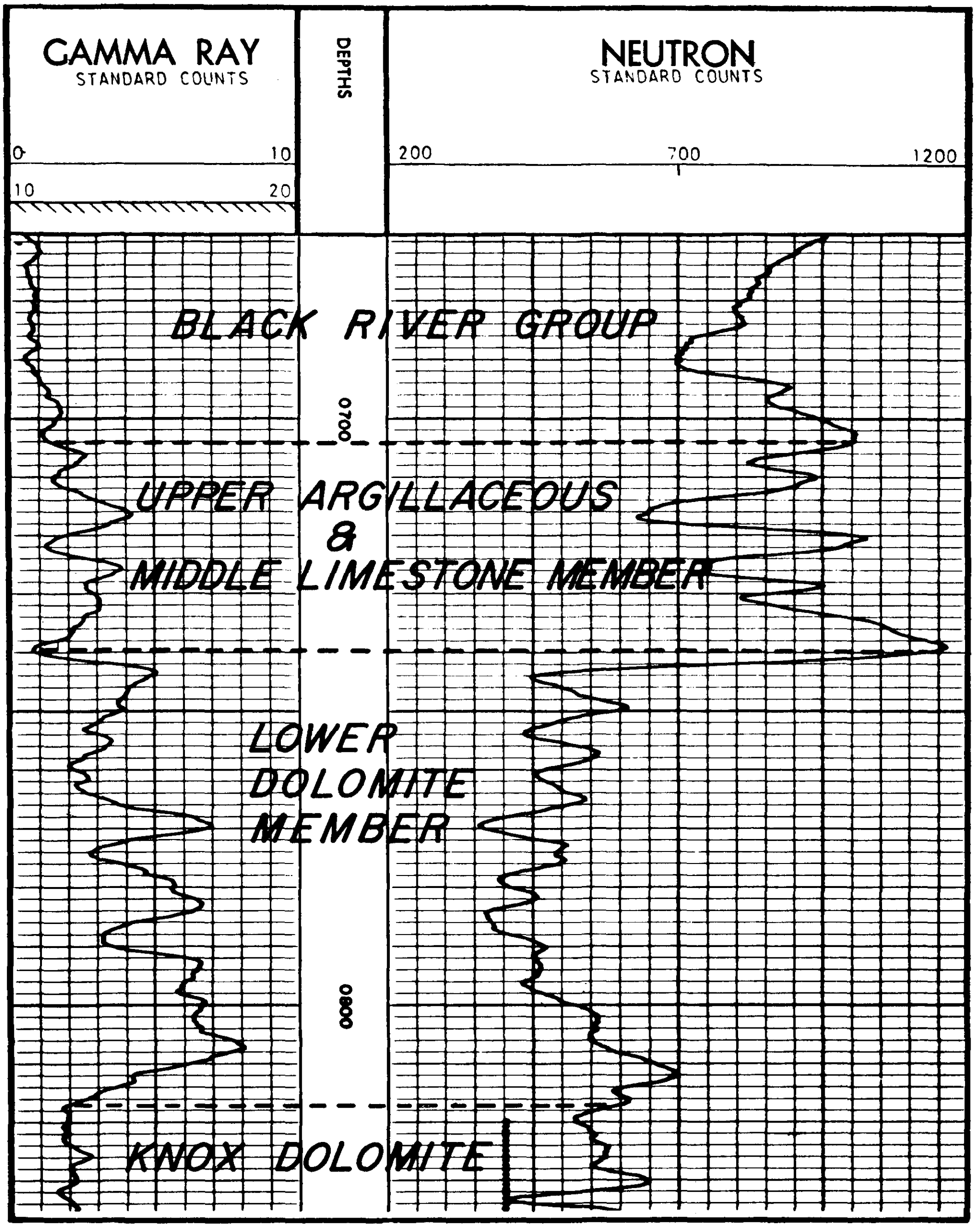

FIGURE 2. Portion of a Gamma Ray—Neutron well log illustrating typical responses.

Ohio

The lower dolomite member of the Chazy Limestone thins eastward from the Ohio-Indiana state line, where 80 ft is found, to a thickness of about 20 ft at Cincinnati, then increases in thickness to about 60 ft in the Clermont County area (fig. 3). Associated with this thinning is a rapid thinning of the St. Peter Sandstone from about 60 ft at the Ohio-Indiana state line to a complete pinch out

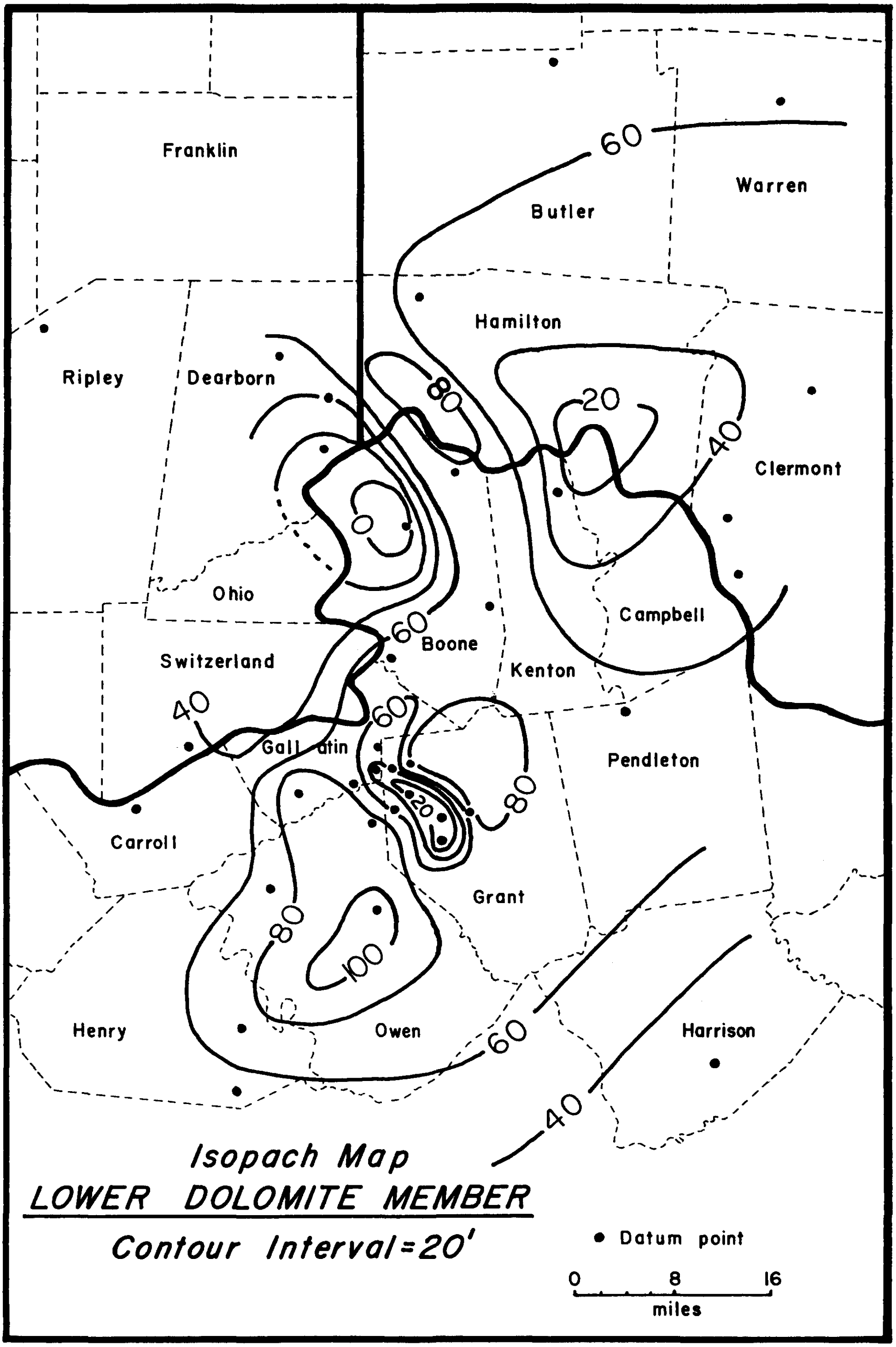

FIGURE 3. Isopach map of the Lower Dolomite Member of the Chazy Limestone.

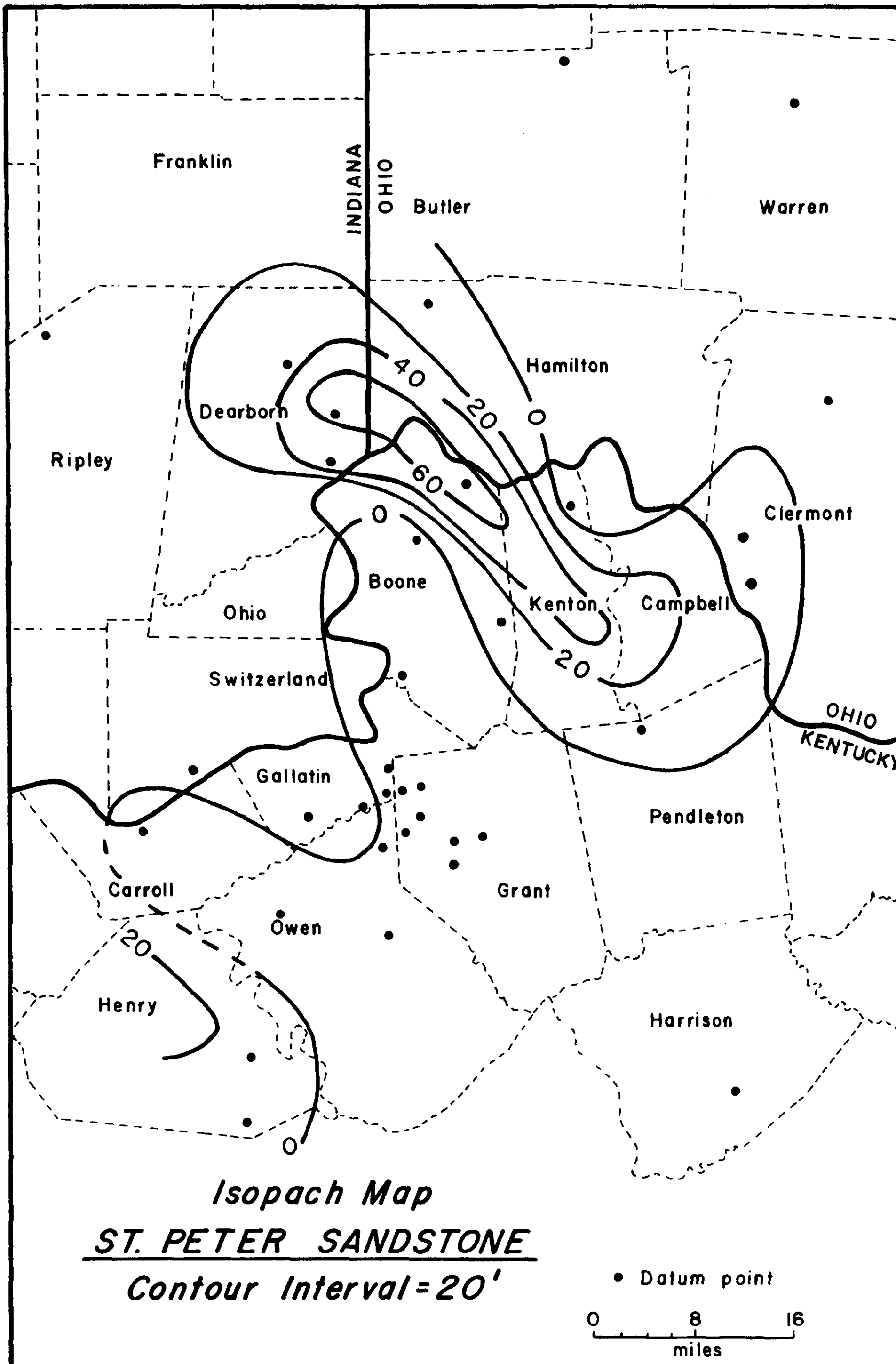

FIGURE 4. Isopach map of the St. Peter Sandstone.

(fig. 4) in the eastern half of Hamilton County. This sandstone will be discussed in detail in a later section.

Kentucky

In north-central Kentucky, the thickness of the lower dolomite member varies from 80 ft in Grant County to zero ft in the center of Boone County at datum point number 4 (fig. 1). In Boone County, the St. Peter Sandstone is also found and reaches a thickness of 60 ft at datum point 2 (fig. 1). The relationship of the sandstone and the lower dolomite member to the Knox Dolomite is shown in figure 5a. This section shows the accumulation of the sandstone in the "Knox valleys" and the pinch out of the sandstone against the "Knox hills" in the Chazy Sea.

South of Boone County, in the Grant-Gallatin County area, there is a greater concentration of drilling (fig. 3) which illustrates better the variable thickness of the lower dolomite member. The St. Peter Sandstone is absent in most of the area except in the southwest portion (Gallatin Datum point 4) where 2 ft of sand is found. Further south in the same county, at datum point 2, 5 ft of sandstone is found. Figure 5b illustrates the relationship of the lower dolomite member and the thin sandstone in Gallatin County. As in Boone County, the sands are found in the "Knox valleys". The following section is typical of the lower dolomite member in most of north-central Kentucky.

Gallatin County Datum Point 4

Thickness in feet	*Description*
---	Lower Dolomite Member.
24.0	Dolomite, gray, finely crystalline, small mottled areas due to the presence of a near black dolomite, occasional rounded, frosted quartz sand grains found. At a point seven feet from the top of this unit, there are doubly-terminated quartz crystals about ⅜ inch long.
4.0	Dolomite, green, sub-lithographic.
23.0	Dolomite, gray, similar that above but with some shale.
18.0	Dolomite, green-gray, finely crystalline, much rounded, frosted sand present.
69.0	Total Thickness.
---	St. Peter Sandstone.
2.0	Sandstone, quartz, rounded, frosted, dolomitic cement, average grain size ½–1 mm.
---	Knox Dolomite.

Throughout the southernmost portion of the area of investigation, the lower dolomite member of the Chazy limestone exhibits the same variability as was illustrated in the previous discussion. The data throughout this portion is more scattered and somewhat less reliable so nothing more than reference to the data, as mapped in figures 3 & 4, will be made.

ST. PETER SANDSTONE

In the area of investigation, the problem of identifying the sandstone found as true St. Peter Sandstone has been quite vexing. The sandstone may not be continuous with the type St. Peter but instead a product of the local accumulation of sediment derived from the sandy phases of the underlying Knox Dolomite or perhaps may be a sandstone unit within the top of the Knox Dolomite. It is known that there is no connection of the sandstone found in north-central Kentucky with the sandstone Freeman (1953) mapped on the southeast side of the Cincinnati Arch. The pinch out line shown in figure 4 is well documented from core and cutting information. This then brings up the obvious question as to whether this sandstone at one time was connected with the sandstone described by Freeman (1953) in a continuous sheet across the Cincinnati Arch. The presence of a gradational contact of the sandstone with the over-lying dolomite suggests there was no disturbance, such as erosion, after the deposition of the sands.

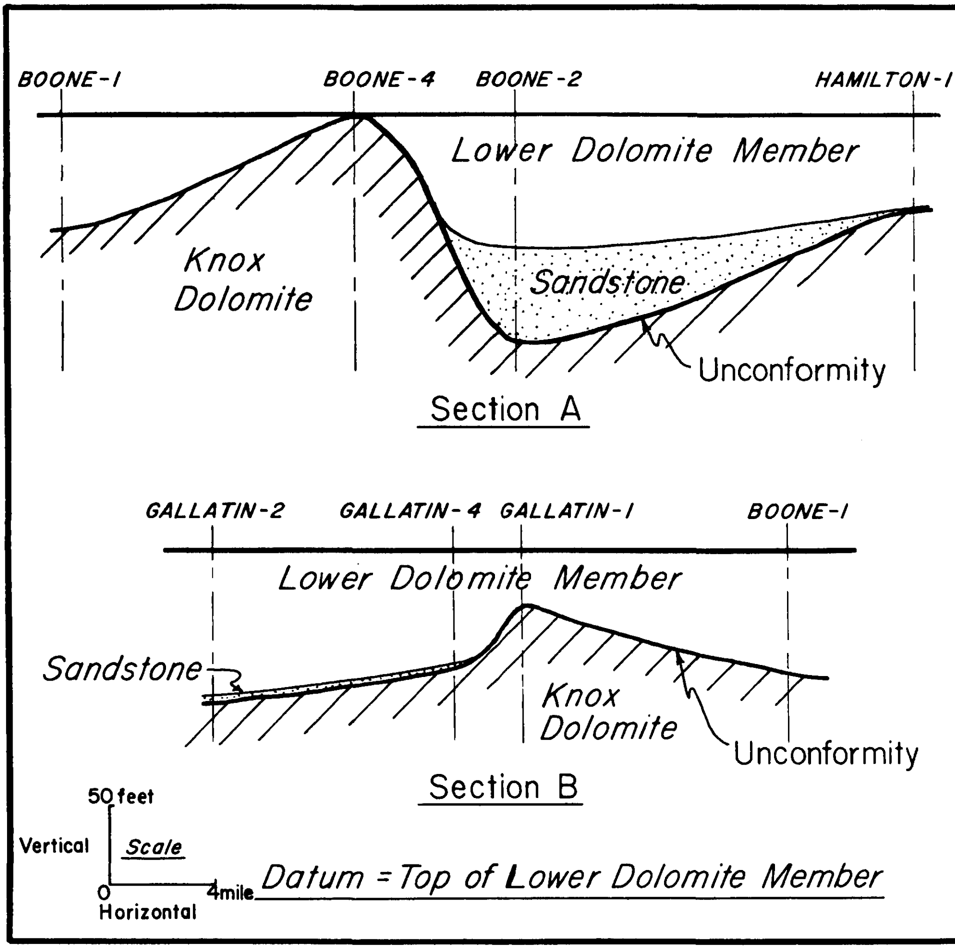

FIGURE 5. Typical cross sections illustrating relationships of the Lower Dolomite Member, sands and the underlying Knox Dolomites.

The similarity of the quartz grains in the Knox Dolomite with those of the St. Peter has been used as a basis for stating that Knox erosion was the source of the St. Peter found in north-central Kentucky and southwest Ohio. It is more probable that the quartz sand in the Knox Dolomite was derived from the same or similar source as the St. Peter Sandstone. No doubt some of this sandstone was contributed by erosion of the Knox Dolomite. The thickening and thinning of the lower dolomite member in response to the Knox topography indicates that there were many hills available for erosion to furnish sand in the surrounding valleys.

A possibility exists that at one time the St. Peter Sandstone may have been much greater in thickness, undergoing later erosion which accounted for its spotty distribution and variable thickness in the area of investigation. All cores examined by this author yielded a gradational contact of the sandstone with the overlying lower dolomite member. The spotty distribution of the sandstone is probably the result of depositional control being exercised by Knox topography with the sands being deposited in the Knox valleys and being swept off the Knox hills.

GEOLOGIC HISTORY

Preceding Chazyan time, the Knox was exposed at the surface regionally by a general regression of the epicontinental seas. Enough time elapsed to allow a fairly rugged topography to form on this surface with relief as much as 300 ft in some places. When the seas again transgressed upon the lands, erosion of the rocks inland progressed both westward and northward, thus furnishing sands to the transgressing seas forming sandy beaches and sea bottoms. During this general encroachment, a small basin in the Boone County area began subsiding, allowing thick sediment accumulation. A positive Knox area in the north and small Knox islands furnished minor amounts of sand to this transgressing sea for a time. This northerly, and major St. Peter source finally became completely inundated near the end of the time of deposition of the lower dolomite member with the deepening seas being reflected by the middle limestone and upper argillaceous members of the Chazy and the lateral and vertical change from sands to shales and dolomites or limestones.

ACKNOWLEDGEMENTS

I would like to thank the Cincinnati Gas and Electric Company for making available some test hole data in the Kentucky area and Warren Calvert, Ohio Geological Survey, for his enlightening discussion on the Chazy Limestone.

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