SAND AT THE TOP OF THE NIAGARA GROUP AS A SOURCE OF WATER IN WEST-CENTRAL OHIO[1]

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At Harrisburg, Ohio, three wells drilled about 1896 in search of oil or gas struck a prominent water-bearing zone in the limestone bedrock at the depth of about 400 ft. Artesian pressure was sufficient to cause the water level to rise above the land surface and the wells flowed. As reported in 1899 by Edward Orton, Jr., former State Geologist, their total rate of flow was about 850,000 gallons a day. This flow was sufficient, according to Orton, "to run steadily a 9½ ft. water wheel, which is applied to grinding grain, sawing lumber, and the like."

At Plain City the story was largely repeated. Two wells, drilled in 1889 in search of oil or gas, also struck a water-bearing zone in the limestone, in this case at a depth of 397 ft. The water rose 18 ft. above the land surface and the combined flow from both wells was estimated at 2,000,000 gal. day, or nearly 1,400 gal. min. The wells were allowed to flow to waste for a few years, until a waterworks plant was built, after which they became a source of supply for the village.

The most significant fact about the wells at Harrisburg and Plain City, from the point of view of those engaged in developing water resources, was not that the wells flowed, for this is not unusual, but that the yields were so large. When the flowing wells at Harrisburg were drilled they attracted a great deal of attention locally, and the abundant water supply they provided was a prime factor in the establishment nearby of a large State school. The wells have supplied this school for more than 40 yr. The present pumpage, about 500,000 gal. day, is from one of the three wells; the other two are capped. The supply well was test pumped for approximately 8 hr. on October 8, 1946, at rates averaging about 470 gal. min. and drawdown measurements were made. The well was flowing at the start of the test and no determination was made of the water level before pumping started. During the test the water level declined to 26 ft. below the land surface. If the piezometric surface is assumed to have been 10 ft. above the land surface at the start of the test, the total drawdown was 36 ft. and the specific capacity of the well was 13 gal. min./ft. of drawdown.

The original wells at Plain City have been replaced by two other wells of approximately the same depth. The flow from the newer wells is less than the flow reported in 1899 from the original wells, indicating that some diminution of head in the aquifer has occurred over the past 50 yr. The present wells are pumped together most of the time at a combined rate of about 300 gal. min. At this rate of withdrawal water levels in the wells commonly are 3 ft. below the land surface, or less. In the summer, when the demand increases to about 500 gal. min, all the pumping, because of the characteristics of the supply system, is from a single well. This well is equipped with a turbine pump, with the impellers set 45 ft. below the surface. Pumping at Plain City is continuous, for the town has no storage reservoir. Water is pumped directly into the distribution system. In 1953 the average pumpage was 500,000 gal. day.

The large yields from the wells at Harrisburg and Plain City are in sharp contrast to the yields ordinarily obtained from the limestone deposits in central and western Ohio. Most wells drilled into these deposits in search of large water supplies for industrial or municipal use do not yield more than about 100 gal. min. In these days of mounting demand for water it is important to explore all possi-

[1]Publication authorized by the Director, U. S. Geological Survey.

bilities for developing additional groundwater supplies. We should, therefore, examine the facts to ascertain whether the wells at Harrisburg and Plain City represent special cases, involving certain areas where the limestone deposits merely happen to be unusually productive, or whether these wells may have tapped a deep artesian aquifer that may be an important source of water in west-central Ohio. At least superficially, the latter view seems to receive support from the fact that the wells at Harrisburg and Plain City were drilled to elevations sub-substantially lower than those commonly reached by wells in the area. An examination of the problem must begin with the geology.

GENERAL GEOLOGY AND HYDROLOGY

The bedrock beneath the glacial and alluvial deposits in most of central and western Ohio is formed by limestones and dolomites of Silurian and Devonian ages. These carbonate rocks underlie the area in the form of a relatively smooth plane, which is interrupted by buried valleys where the rocks were cut through or trenched deeply by streams of former drainage systems. Along an east-west line passing through Columbus and Springfield, the general level of the bedrock surface declines in elevation from about 1,000 ft. above sea level in western Clark County to about 850 ft. above sea level in western Franklin County. The strata dip gently to the east, away from the crest of the Cincinnati anticline. The angle of dip, as well as the thickness of the beds, become greater in an eastward direction as the rocks descend into the Appalachian basin. In the aggregate, the carbonate rocks range in thickness from 200 ft. or less between Dayton and Piqua, in western Ohio, to more than 800 ft. in the central part of the State in the area between Columbus and Delaware. The major units of the carbonate rocks, beginning near the base of the Silurian system, are: the Brassfield limestone; the Niagara group which, in west-central Ohio, includes the Osgood shale, the Euphemia dolomite of Foerste (1935) the Springfield limestone, and the Cedarville [2] dolomite; the Bass Island dolomite of the Cayuga group, called in older reports the "waterlime" or lower Monroe; and the Columbus and Delaware limestones of Middle Devonian age.

All the rock units named above, except the Osgood shale, are excellent sources of ground water for farm and domestic use. In many places they are also good sources of water for industrial or municipal use. In general, the carbonate rocks above the Osgood shale constitute a single aquifer within the depths commonly reached in drilling. Some beds locally are more permeable than others, either because of their structure or because they are more fractured or jointed, and yields of wells range over wide limits. Relatively permeable zones may occur along bedding planes or at disconformities between the major rock units. Changes in permeability also may result from facies changes. Many of the permeable zones are persistent over wide areas and may, in effect, constitute semi-independent aquifer systems, even though locally they may be hydraulically interconnected with the entire rock sequence in which they occur. The present evidence, illustrated by the results of drilling at Harrisburg and Plain City, shows that there is a highly permeable zone in the carbonate rocks in western Franklin County and surrounding area below the depths commonly reached in drilling. Wells drilled to this zone encounter it at progressively lower elevations from west to east, and the rate of decline in elevation of this permeable zone is approximately equal to the regional dip of the strata. Generally this permeable zone has been overlooked by drillers because of its relatively great depth. It appears to be of potential importance in some areas as a source of water for large-scale industrial or municipal use.

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[2]Formerly called Guelph dolomite.

NEWBURG SAND (?) ZONE OF DRILLERS

The permeable zone in the carbonate rocks that supplies the flowing wells at Harrisburg and Plain City is at or near the top of the Niagara group. Orton (1899, p. 660) refers to these wells as:

> "examples of excellent supplies of water derived from the porous or Guelph division of the Niagara limestones."

Stratigraphically, the zone appears to lie at the horizon of the Newburg sand zone of drillers. The Newburg is named from the Newburg, or Newburg Heights, district in the southeast part of Cleveland, where the stratum formerly yielded gas at depths ranging from 2,300 to 2,600 ft. According to Stout (1935, p. 307):

> " the so-called sand is generally impure, porous dolomite, varying from light gray to pink in color. Locally the horizon contains thin lenses of sandstone, evidently deposits left along a line of disconformity. The position of the Newburg sandstone is variable, but commonly it is found 150–200 feet above the base of the "Big lime". Stratigraphically, the deposits are interpreted to lie near the contact between the Salina formation[3] and the underlying Guelph dolomite. The thickness of the Newburg sand ranges from 1 to 30 feet. . . This also is one of the chief water-bearing horizons in the deep seated rocks. The flow is so great that it is known to the driller as the "Big water" in the "Big lime." It is sometimes referred to as the "Second water."

It is significant that the Newburg, which lies under deep cover in the eastern part of the State, is generally noted for its water-bearing properties. Judging by its widespread occurrence, the high permeability of this "sand" seems to be of inherent nature and evidently is characteristic of the stratum, generally. For this reason the Newburg sand (?) zone of drillers should be traceable as a water-bearing stratum over much wider areas than those in which it is now recognized, perhaps to its outcrop area in western Ohio. Data are few, unfortunately, in the area intervening between the oil and gas fields of eastern Ohio and the outcrop area of the Niagara group, and the general continuity of the Newburg as a zone of high permeability cannot be established with certainty on the basis of the present evidence. However, the evidence points to the probability that it is continuous.

On the basis of the meager data available, a map (figure 1) has been drawn showing contours on the Newburg sand (?) zone of drillers in the western half of Franklin County and the surrounding area. The map shows the Newburg to range in elevation from more than 500 ft. above sea level in the western part of Franklin County to 100 ft. above sea level in the central part of the county. The elevation of the Newburg is 528 ft. above sea level at Plain City, and 392 ft. above sea level at Harrisburg. The dip of the zone is about 25 ft./mile, or about the same as the regional dip. The zone is reached at depths ranging from about 350 ft. in lowland areas along the principal streams in the western part of Franklin County to about 500 ft. in similar areas in the central part of the county. Data on which the accompanying map is based include, besides the records of the wells at Harrisburg and Plain City, the records of six other wells. A show of water, a facies change, or a change in drilling characteristics was reported in each well at or near the depth of the Newburg. Pertinent information from the records of these wells, which are identified by name on the map, figure 1, is summarized as follows:

Riebel well—drilled for oil or gas in 1922 on the Charles Riebel farm near Georgesville. The driller reported a soft zone in the limestone between depths of 355 and 360 ft., the estimated elevation (510 ft. above sea level) of the Newburg.

Grove City well—drilled at the village waterworks in 1954 to a depth of 472 ft. The well probably bottomed within about 50 ft. of the Newburg, which is estimated to lie at an elevation of about 330 ft. above sea level. The drillers re-

[3]Basal formation of the Cayuga group.

ported striking a large cavity or fissure in the rocks at the bottom of the well. When the cavity was struck, the water in the well abruptly rose about 20 ft. above its former level. The well was test pumped at the rate of about 450 gal./min. The specific capacity after 12 hr. was 17 gal./min./ft. of drawdown, appreciably greater than the specific capacity of any of the other wells in the village well field.

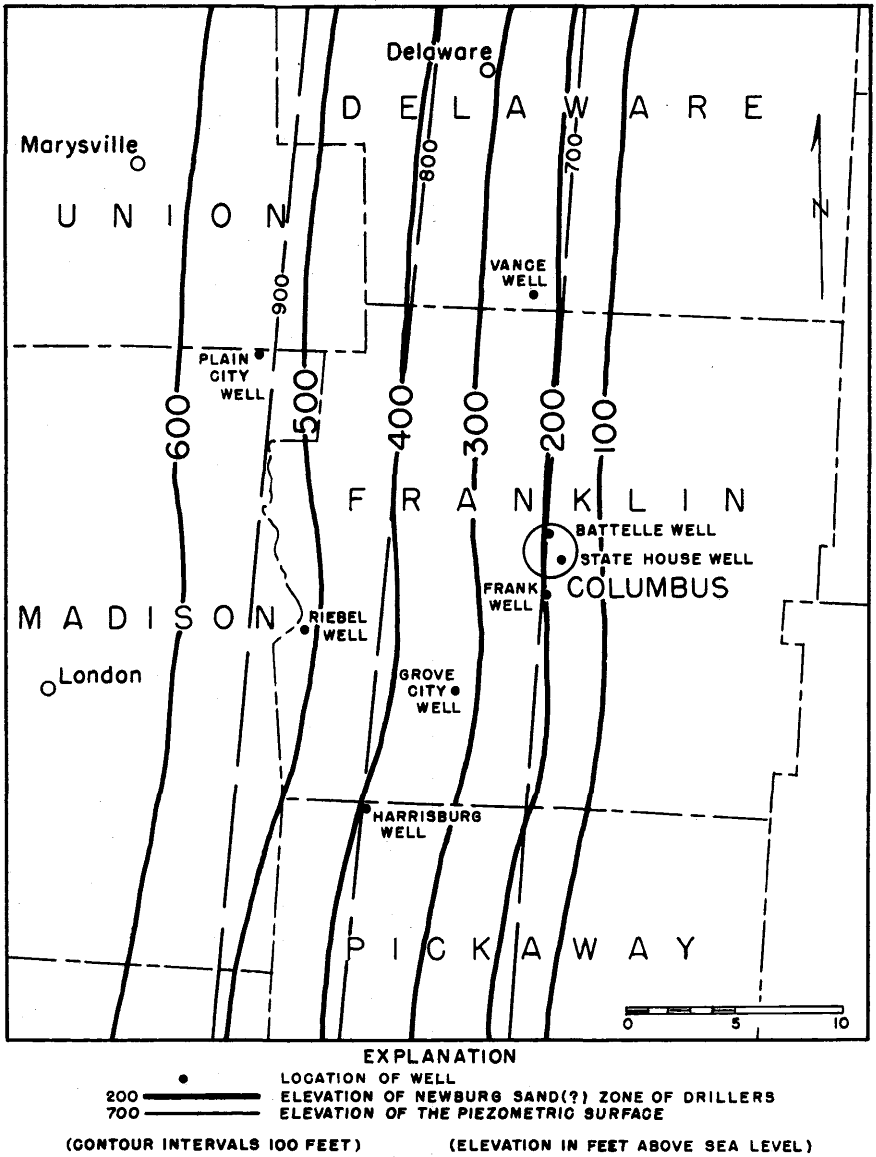

FIGURE 1. Map of a portion of west-central Ohio showing contours on the Newburg sand(?) zone of drillers and the piezometric suface in wells drilled to this zone.

Because of the poor quality of the water the 472-foot well was subsequently plugged at the depth of 348 ft., after which it was again test pumped. The specific capacity after 12 hr. was 6.5 gal./min./ft. of drawdown, indicating the major part of the yield during the previous test to have been from the deeper strata.

Vance well—drilled for oil or gas on the Herman E. Vance farm, Orange Township, Delaware County, 1937. The Newburg sand (?) zone of drillers is reported by Stout and Lamey (1940, p. 675) to lie at the depth of 690 ft, or at the elevation of 230 ft. above sea level.

Frank well—drilled for oil or gas in 1890 on the George C. Frank farm, about 2 miles south of Columbus. According to reports, drillers hit water at "about 500 feet" and the well flowed open for many years. At this location the depth of 500 ft. would be about 200 ft. above sea level, the estimated position of the Newburg.

State House well—according to Orton (1888, p. 107) a well drilled for water in Columbus at the State House during the period 1857–60 was reported to have struck "salt water" at the depth of 675 ft. This depth is at the elevation of 190 ft. above sea level, the approximate position of the Newburg.

Battelle well—test well drilled by the Battelle Memorial Institute, Columbus, Ohio, in 1954 for the purpose of testing drilling methods and equipment. At this site the elevation of the Newburg sand (?) zone of drillers is estimated to be about 200 ft. above sea level, or somewhere near the depth of 520 ft. The drillers did not report a show of water at this depth and there is no mention in the drilling log of substantial mud loss in this part of the hole, which, had it occurred, would have been an indication of greater than average permeability. However, the rocks between the depths of 500 and 560 ft. contained an abundance of gypsum and anhydrite. Drill cuttings revealed especially prominent anhydrite zones between the depths of 500 and 510 ft., and between the depths of 530 and 560 ft. Within these zones the rocks consisted of 30 percent to 50 percent anhydrite, reflecting abrupt lithologic changes in the normal dolomite sequence. It is probable that these lithologic changes are illustrative of stratigraphic conditions which locally may produce radical differences in the character of the Newburg.

Where the Newburg sand (?) zone of drillers is associated with an abundance of secondary minerals, as it is in the area of the Battelle well, it may be of lower than average permeability. The mineral constituents, in this case anhydrite, may occupy most of the voids within or adjacent to this zone and cause the water which ordinarily is present to follow other paths. These alternate paths may occur as discrete zones either above or below the Newburg, but they are hydraulically connected with, and in a sense are "fed" by water from the Newburg. Evidence of such conditions is provided by the record of a well, not shown on figure 1, that was drilled for oil or gas in 1886 at the Wassall Sewer Pipe Works, located about a mile south of the Battelle well and at about the same elevation. The well at the pipe works was reported by Orton (1888, p. 282) to have yielded sulfur water from the depth of 573 ft. Orton thought this marked the top of the Niagara group, but this interpretation is inconsistent with the sections observed in the other wells whose records are reported herein. The writer believes, therefore, that Orton's interpretation is incorrect and that the water reported at the depth of 573 ft. in the Wassall Sewer Pipe Works well came from rocks at least 50 ft. below the top of the Niagara group. The drillers reported "gypsum in quantity" at the depth of 550 ft., which is substantially the same elevation as the lower of the two prominent anhydrite zones discovered in the Battelle well. With final reference to this point, it seems probable to the writer that at Grove City the Newburg sand (?) zone of drillers was the source of water found in the lower part of the 472-foot well, even though this well was several tens of feet short of actually reaching the stratum.

Recharge to the Newburg in the eastern part of the State, where it is deeply buried, probably comes principally from the surrounding rocks. Some of the water in this zone may be connate water, trapped in the rocks at the time of their deposition. In west-central Ohio, near the outcrop area of the Niagara group, recharge to the Newburg probably is derived mostly from seepage through the glacial deposits in areas where they directly overlie this permeable stratum. The

Newburg crops out beneath the glacial drift in wide areas in Madison County and eastern Clark County where the consolidated rocks are deeply trenched by the buried Teays Valley. It is probable that in this buried valley area the Newburg receives the major portion of the recharge which sustains the wells at Harrisburg and Plain City. Evidence for this lies in the fact that the piezometric surface in wells drilled to the Newburg occurs at progressively higher elevations from east to west and merges with the regional water table a few miles west of Plain City. The piezometric surface in wells drilled to the Newburg slopes eastward from the recharge area at a rate averaging somewhere between 15 ft. and 20 ft./mile, the slope reflecting the loss in head as the water moves down the dip of the stratum. The general elevation of the piezometric surface ranges from about 900 ft. above sea level along the Madison County-Franklin County line to about 700 ft. above sea level at the Frank well in the central part of Franklin County. Flowing wells from the Newburg sand (?) zone of drillers in Franklin County thus are restricted to lowland areas.

TABLE 1

Analyses of water from the Newburg sand(?) zone of drillers at Harrisburg, Plain City, and Grove City

Chemical constituents (parts per million)	*Harrisburg* (2–16–55)[1]	*Plain City* (2–15–55)	*Grove City* (10–23–54)
Silica (SiO_2)	15	11	10
Iron (Fe)	.37	.75	.36
Manganese (Mn)	.00	.00	.00
Calcium (Ca)	134	143	424
Magnesium (Mg)	48	52	124
Sodium (Na)	35	19	51
Potassium (K)	3.4	3.5	5.8
Bicarbonate (HCO_3)	389	420	316
Carbonate (CO_3)	0	0	0
Sulfate (SO_4)	239	235	1,220
Chloride (Cl)	23	12	84
Fluoride (F)	2.1	1.7	2.3
Nitrate (NO_3)	.2	.2	.4
Dissolved solids (residue on evaporation at 180 C.)	720	724	2,230
Hardness as $CaCO_3$:			
Calcium, magnesium	532	573	1,570
Noncarbonate	213	226	1,310
Specific conductance (micromhos at 25° C.)	1,050	1,040	2,460
pH	7.4	7.2	7.0
Color, units	5	5	3
Hydrogen sulfide (H_2S)	.1	.5	3.6

[1]Date of collection

QUALITY OF THE WATER

The most serious limiting factor imposed on the use of water from the Newburg sand (?) zone of drillers in most areas is its poor chemical quality. More than a few miles east of the recharge area the water is mineralized to the extent that it is generally unfit for most purposes. Present evidence shows that the dividing line between areas where the water from the Newburg is of generally satisfactory quality and areas where the quality is decidedly inferior may lie somewhere in west-central Franklin County. At best this is a generalization, for in all probability this hypothetical line is subject to much variation in position.

The quality of the water from the wells at Harrisburg and Plain City is essentially similar, and is within the common range of waters from a limestone region. At Grove City the quality is quite different, for there the water from the Newburg is so highly mineralized and hard that it is unfit for most purposes. A comparison between these waters is shown in the following table, based on recent analyses made by the U. S. Geological Survey, Columbus, Ohio.

The chief chemical constituents in the water from the Grove City well are calcium (Ca) and sulfate (SO_4), probably derived from anhydrite deposits, particles of which were detected in the drill cuttings from the well.

Anhydrite, or calcium sulfate ($CaSO_4$), occurs at various places in Ohio. It is commonly interbedded in the lower part of the dolomitic limestones of the Cayuga group, and it occurs to some extent in all the carbonate rocks. Deposits of anhydrite generally are in close association with deposits of gypsum which has the same chemical composition but contains water of crystallization ($CaSO_4 \cdot 2H_2O$). Generally these calcium sulfate deposits are of small extent. Deposits of proved economic value are found at only two localities in the State, on the north and south shores, respectively, of Sandusky Bay.

Anhydrite and gypsum deposits are so highly variable in their distribution and continuity that it is virtually impossible to predict their occurrence locally in advance of drilling. In describing the gypsum deposits at a quarry near Sandusky Bay, Bownocker (1920, p. 220) reports as follows:

> ". . . in some localities the beds can not be correlated with those shown in sections a short distance away. Within a few rods gypsum may be reduced one-half in thickness and in places it is cut out entirely."

Anhydrite occurs at or near the Newburg sand (?) zone of drillers in north Columbus and traces of this mineral were found at Grove City in the rocks above the Newburg. The anhydrite deposits associated with the Newburg may be of general occurrence in the central part of Franklin County.

Hydrogen sulfide (H_2S) may also relate to the calcium sulfate deposits and if so this may account for the high concentration of this constituent in the water from the Grove City well. It is thought that hydrogen sulfide may be produced by reduction of sulfate.

SUMMARY AND CONCLUSIONS

The main points of interest revealed by the present investigation are:

1. An apparently widespread zone of relatively high permeability occurs in the carbonate rocks in Ohio at or near the top of the Niagara group, at the horizon of the Newburg sand (?) of drillers. In western Franklin County and surrounding areas the Newburg is below the depths commonly reached in drilling and for this reason it has been generally overlooked as a source of water.

2. Yields from the Newburg far exceed yields commonly obtained from wells drilled generally into the limestone deposits. Supplies at least in the magnitude of 0.5 mgd to 1 mgd probably are available from the Newburg at many places in west-central Ohio.

3. Recharge to the Newburg in west-central Ohio occurs principally in areas where the stratum crops out beneath permeable glacial deposits. Recharge conditions probably are most favorable in buried-valley areas where the stratum crops out in the valley walls adjacent to saturated permeable valley fill of glacial origin.

4. The quality of water from the Newburg in areas relatively close to its outcrop is fairly typical of limestone waters generally, except where the rocks are interbedded with calcium sulfate deposits. The presence of calcium sulfate results in water of inferior quality, which may be unsatisfactory for most purposes. Calcium sulfate in the water may not be detrimental for some uses where large quantities of water are needed, such as for supplemental irrigation.

The meagreness of the data on which this report is based, and the potential importance of the Newburg sand (?) zone of drillers as a source of water for large-scale use, make it essential that more be learned about the water-bearing properties of this stratum. Test holes are needed to determine accurately the thickness and physical properties of the Newburg. Its position in the stratigraphic column must be better defined for purposes of correlation. The outcrop areas of the Newburg should be mapped and related to the shape of the regional water table. This relationship may reveal the areas that furnish the most recharge to the stratum, and if so, would be of aid in locating supply wells to best advantage.

Information on the quality of water available from the Newburg obviously is needed, both to delineate the areas locally where the water may be of poor quality and to define in regional terms the general limits of the area in which the aquifer may be expected to yield potable water.

Controlled pumping tests are needed to determine in quantitative terms the water-bearing properties of the Newburg. It may be possible to map areas of differing permeabilities and to define these areas in terms of probable long-term yields of wells. It would also be important to determine whether intensive development close to areas of recharge may result in up-dip migration of mineralized water which may now be kept down dip by recharge.

A preliminary program of test drilling and testing need not be unduly expensive. It could be supplemented by a more comprehensive program if the initial results were favorable. Such a program might prove of great economic value in the years ahead.

REFERENCES

Bownocker, J. A., and **R. W. Stone.** 1920. Chapter on Ohio in Gypsum deposits of the United States. U. S. Geol. Survey Bull. 697, p. 218–224.

Foerste, A. F. 1935. Correlation of Silurian formations in southwestern Ohio, southeastern Indiana, Kentucky, and western Tennessee: Denison Univ. Bull., Jour. Sci. Lab. 30: 119–205.

Orton, E. 1888. The Trenton limestone as a source of oil and gas in Ohio: Ohio Geol. Survey 6: 101–310.

———. 1899. The rock waters of Ohio: U. S. Geol. Survey 19th Ann. Rep. pt. IV, Hydrography, p. 637–717.

Stout, W. 1935. Natural gas in central and eastern Ohio: Geology of natural gas, Am. Assoc. Petrol. Geologists, p. 897–914.

———, and **Lamey, C. A.** 1940. Paleozoic and pre-Cambrian rocks of Vance well, Delaware County, Ohio: Am. Assoc. Petrol. Geologists, Bull. 24: 672–692.