STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

# NIAGARAN REEFS AND OIL ACCUMULATION IN THE DE WITT-MCLEAN COUNTY AREA, ILLINOIS

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# NIAGARAN REEFS AND OIL ACCUMULATION IN THE DEWITT-MCLEAN COUNTY AREA, ILLINOIS

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## ABSTRACT

This report discusses Niagaran reefs and their relation to oil accumulation in the DeWitt-McLean County area of Illinois. The Lloyd A. Harris No. 1 T. P. Kiley, NE NW NW, sec. 28, T. 21 N., R. 3 E., DeWitt County, discovered the Wapella East oil pool in Niagaran reef dolomite at a depth of 1,112 feet in November, 1962. This discovery, 25 miles north of the northern boundary of the major oil producing area of Illinois, drew attention to a large section of central Illinois previously overlooked. It is estimated that about 2,000,000 barrels of oil will be recovered by primary methods.

The importance of the development of a compaction anticline over the Wapella East reef is minor compared to tectonic deformation. Some five-sixths of the total deformation on the top of the Silurian (about 110 feet) occurred since Devonian time, four-fifths since Mississippain time, and one-fourth since the deposition of Pennsylvanian Danville (No. 7) Coal. Up to 350 feet of Niagaran reef-rock probably accumulated over much of the area. However, only the structurally highest areas show evidence of oil accumulation.

## INTRODUCTION

The Lloyd A. Harris No. 1 T. P. Kiley, NE NE NW, sec. 28, T. 21 N., R. 3 E., DeWitt County, discovered the Wapella East oil pool in Niagaran reef dolomite at a depth of 1,112 feet in November, 1962 (Howard, 1963). This discovery, 25 miles north of the northern boundary of the major oil producing area of Illinois, drew attention to a large area of central Illinois previously overlooked. Subsequently, 19 additional producers were completed in the Wapella East pool, and over 150 unsuccessful Silurian tests have been drilled in this report area.

This report discusses Niagaran reefs and their relation to oil accumulation in this part of Illinois. The study area (fig. 1) includes all of DeWitt and McLean Counties and parts of Champaign, Ford, Livingston, Logan, Macon, Piatt, Tazewell, and Woodford Counties. It measures 52 miles from north to south, 65 miles from east to west. It includes the area covered by Circular 349 (Howard, 1963) and is the same as that discussed in Circular 369 (Heigold, McGinnis, and Howard, 1964).

Physiographically most of the report area is in the Bloomington Ridged Plain of the Till Plains Section of the Central Lowland Province. The Shelbyville Moraine cuts across the southwest corner of the area; that part of the report area lying southwest of the Shelbyville Moraine is part of the Springfield Plain. The southern two-thirds of the area is drained southwestward by tributaries of the Sangamon River. Most of the northern third is drained westward by the Mackinaw River and its tributaries. Part of the northeast corner is drained northwestward by the Vermilion River, a tributary of the Illinois River. The remaining portion of the northeast corner is drained southeastward by the other Vermilion River, a tributary of the Wabash River.

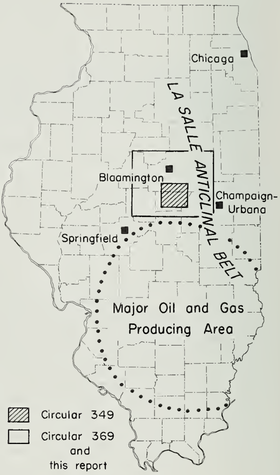



Figure 1 - Location of DeWitt-McLean County area reports and the major oil and gas producing area of Illinois.

Topographic elevations range from 540 feet above sea level in the Salt Creek bottom at the southwestern corner of the area to over 900 feet above sea level along the Bloomington Moraine southeast of Bloomington. The inter-morainal portions of the area are relatively flat with local relief of less than 10 feet. Local relief along the moraines commonly exceeds 100 feet within a section.

## STRUCTURAL AND STRATIGRAPHIC SETTING

The report area is at the northern end of the Illinois Basin. Four-fifths of the area lies west of the steepest dips along the western flank of the LaSalle Anticlinal Belt. In the basin rock strata dip regionally southeastward to southward at an average rate of approximately 25 feet per mile. The glacial drift thickness varies from 0 to 400 feet but is 200 feet or more in most of the area. Records of oil tests, natural gas storage structure tests, and water wells provide geologic data on the deeper strata.

| SYSTEM | SERIES | FORMATION OR GROUP | THICKNESS (FEET) |
|---|---|---|---|
| QUATERNARY | PLEISTOCENE | | 0 - 400 |
| PENNSYLVANIAN | | | 350 - 800 |
| MISSISSIPPIAN | CHESTERIAN | | 0 - 100 |
| | VALMEYERAN | Ste Genevieve | 60 - 100 |
| | | St Louis — Salem | 180 - 200 |
| | | Sonora | 40 - 60 |
| | | Warsaw | 90 - 180 |
| | | Keokuk — Burlington | 120 - 220 |
| | | Fern Glen | 40 - 70 |
| | KINDERHOOKIAN | Chouteau | 15 - 40 |
| DEVONIAN | UPPER | New Albany | 80 - 220 |
| | MIDDLE | Cedar Valley | 0 - 50 |
| | | Wapsipinicon | 0 - 40 |
| SILURIAN | NIAGARAN | Hunton Megagroup | 275 - 700 |
| | ALEXANDRIAN | | 25 |
| ORDOVICIAN | CINCINNATIAN | Maquoketa | 200 |
| | CHAMPLAINIAN | Galena | 150 - 180 |
| | | Platteville | 200 - 250 |
| | | Joachim | 40 |
| | | St. Peter | 230 ± |
| | CANADIAN | Shakopee | 300 ± |
| | | Oneota | 425 ± |
| CAMBRIAN | CROIXAN | Eminence | 75 ± |
| | | Potosi | 250 ± |
| | | Franconia | 275 ± |
| | | Ironton — Galesville | 150 ± |
| | | Eau Claire | 575 ± |
| | | Mt. Simon | 2000 est. |
| PRECAMBRIAN | | | |

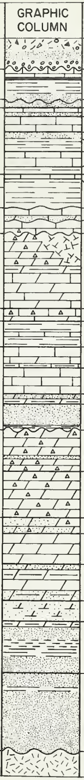




Figure 2 - Generalized columnar section.

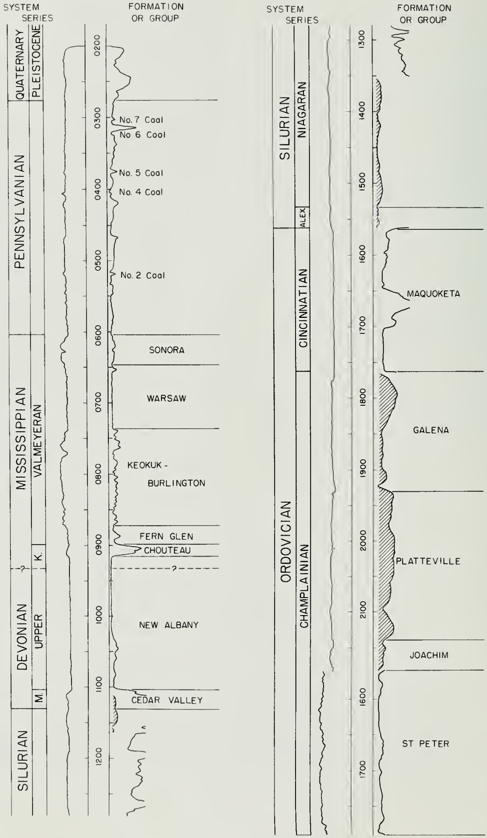
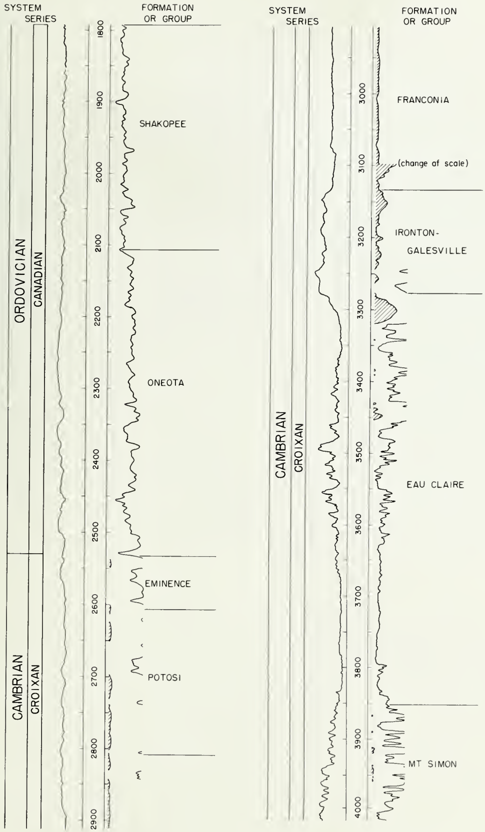



Figure 3 - Electric log of the Lloyd A. Harris No. 4 Ryan, sec. 21, T. 21 N., R. 3 E., DeWitt County (above the St. Peter Sandstone) and the Peoples Gas Light and Coke




Company No. 1 Fee, sec. 9, T. 21 N., R. 7 E., Champaign County (top of St. Peter to total depth).

Figure 2 shows the stratigraphic position, gross lithology, and approximate thickness of sedimentary strata in the area. Figure 3 shows the electrical characteristics of the sedimentary section. The electrical characteristics of strata above the top of the St. Peter Sandstone are shown by the electric log of the Lloyd A. Harris No. 4 Ryan, sec. 21, T. 21 N., R. 3 E., DeWitt County, which bottomed 38 feet in the St. Peter. The electric log of the Peoples Gas Light and Coke Company No. 1 Fee, sec. 9, T. 21 N., R. 7 E., Champaign County, is used from the top of the St. Peter to total depth, 166 feet in the Mt. Simon Sandstone.

Figure 4 shows stratigraphic relations across the area from the Pennsylvanian down to the Silurian. Since the plane of reference is Pennsylvanian Colchester (No. 2) Coal, this cross section shows structural deformation that had taken place before No. 2 Coal was deposited. The major deformation began near or shortly after the close of Mississippian time. Erosion cut down as far as the Silurian at the north and east sides of the report area before local deposition of Pennsylvanian strata. Figure 4 shows Pennsylvanian strata resting on Kinderhookian (Lower Mississippian) Chouteau Limestone. Conditions were relatively stable during Pennsylvanian time after deposition of No. 2 Coal. Considerable post-Pennsylvanian structural deformation has taken place.

The geologic structure map (fig. 5) is drawn on the top of the Devonian-Silurian Hunton Limestone Megagroup, except in the northeastern corner where the unconformity beneath the glacial deposits cuts into the Hunton, and the structure is drawn on the base of the Hunton. The structural grain of the area is dominated by the Gibson City and Mahomet Domes on the LaSalle Anticlinal Belt in ranges 7 and 8 E. and by the Downs Anticline, Parnell and Deland Domes in the middle of the area. Structural control in most of the western half of the area is sparse. The steeply dipping western flanks of the Downs Anticline and the LaSalle Anticlinal Belt are evidence of their genetic similarity.

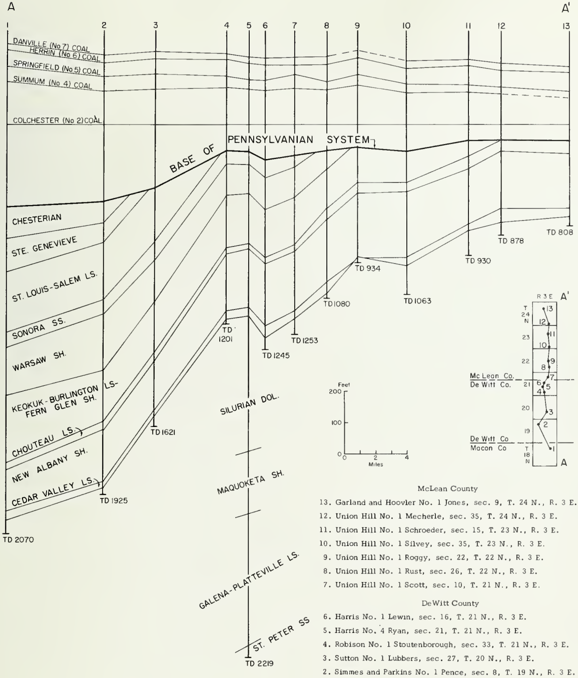
There has been considerable post-Pennsylvanian structural deformation of the area. Sub-parallelism of coals shown in figure 4 indicates relatively stable conditions in late Pennsylvanian time. Figure 6, however, shows folding of the Danville (No. 7) Coal to be similar to, but less than, that of the Devonian Cedar Valley Limestone (fig. 7). This suggests that structure testing to the Danville (No. 7) Coal, about 300 feet deep at Wapella East, or possibly shallower Pennsylvanian markers might serve as a reliable and relatively inexpensive method of finding favorable structures in the area. The distinctiveness of Pennsylvanian electric logging markers eliminates the need for extensive coring.

Heigold, McGinnis, and Howard (1964) suggest that there is a relation between structure and gravity anomalies.

## NIAGARAN REEF-ROCK DISTRIBUTION

According to Lowenstam (1949, p. 9), the progressive decrease of terrigenous clasitc content from southern to northwestern Illinois is the most conspicuous regional variation in Niagaran lithology. He describes three Niagaran sedimentation belts: a southern reef-free high-clastic belt; a reef-bearing low-clastic belt to the northwest; and further to the northwest a reef-bearing clastic-free belt. The area discussed in this report lies across the center of Lowenstam's central reef-bearing low-clastic belt (fig. 8).

Lowenstam (1950) defines a reef as a rigid, wave-resistant topographic structure erected by actively building and sediment-binding biotic constituents.




McLean County

13. Garland and Hoovler No. 1 Jones, sec. 9, T. 24 N., R. 3 E.
12. Union Hill No. 1 Mecherle, sec. 35, T. 24 N., R. 3 E.
11. Union Hill No. 1 Schroeder, sec. 15, T. 23 N., R. 3 E.
10. Union Hill No. 1 Silvey, sec. 35, T. 23 N., R. 3 E.
9. Union Hill No. 1 Roggy, sec. 22, T. 22 N., R. 3 E.
8. Union Hill No. 1 Rust, sec. 26, T. 22 N., R. 3 E.
7. Union Hill No. 1 Scott, sec. 10, T. 21 N., R. 3 E.

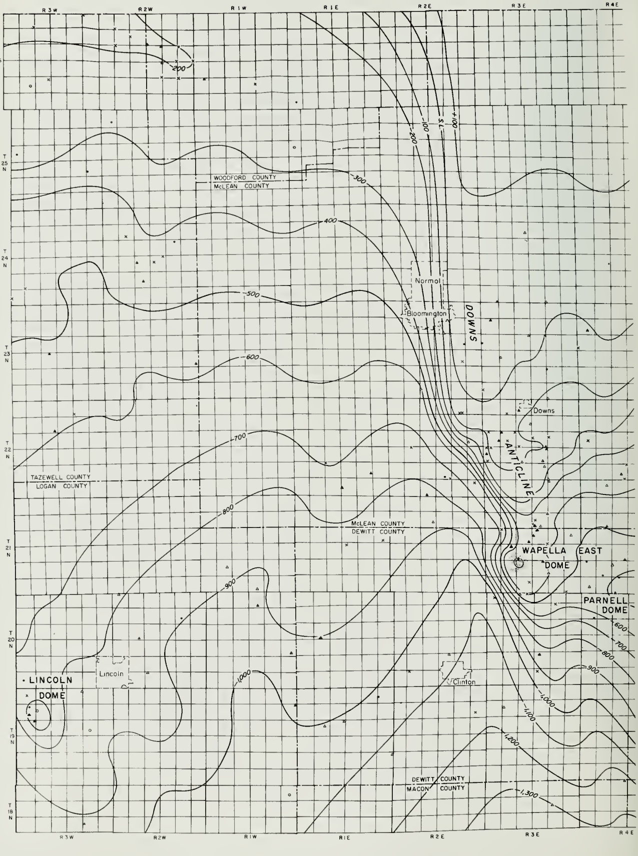
DeWitt County

6. Harris No. 1 Lewin, sec. 16, T. 21 N., R. 3 E.
5. Harris No. 4 Ryan, sec. 21, T. 21 N., R. 3 E.
4. Robison No. 1 Stoutenborough, sec. 33, T. 21 N., R. 3 E.
3. Sutton No. 1 Lubbers, sec. 27, T. 20 N., R. 3 E.
2. Simmes and Parkins No. 1 Pence, sec. 8, T. 19 N., R. 3 E.

Macon County

1. Richardson No. 1 Wilson, sec. 11, T. 18 N., R. 3 E.

Figure 4 - (A-A') south-north cross section. Datum: Colchester (No. 2) Coal.


R3W
R2W
R1W
R1E
R2E
R3E
R4E
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
T 19 N
T 18 N
WOODFORD COUNTY
McLEAN COUNTY
TAZEWELL COUNTY
LOGAN COUNTY
McLEAN COUNTY
DEWITT COUNTY
DEWITT COUNTY
MACON COUNTY
Normal
Bloomington
Downs
Lincoln
Clinton
DOWNS
ANTICLINE
WAPELLA
DOME
EAST
PARNELL
DOME
LINCOLN
DOME
200
-300
-400
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-200
-100
-75
+100

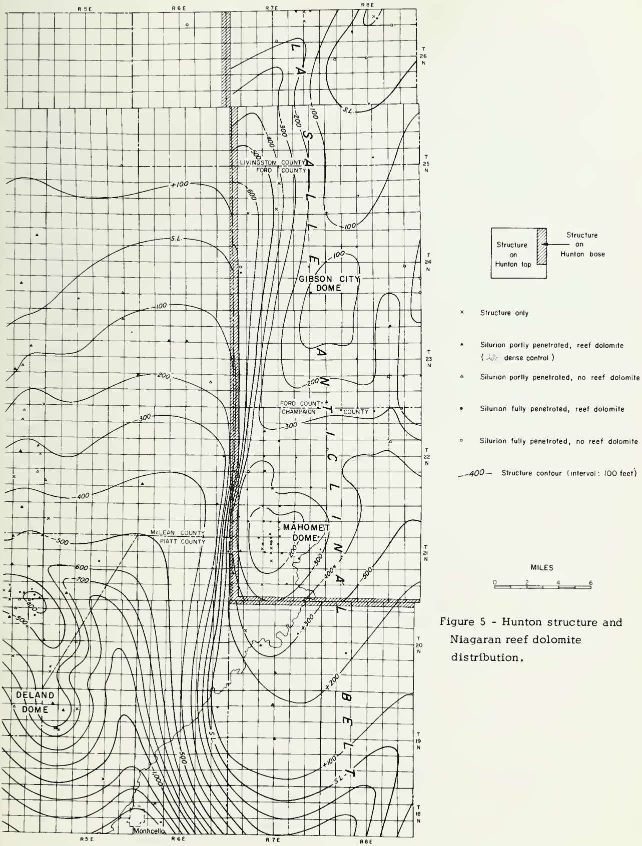


Figure 5 - Hunton structure and Niagaran reef dolomite distribution.

The core of the reef was erected as a loosely meshed frame by the skeletons of the reef-building organisms. Remains of the faunal associates of the reef-builders largely fill the interstices of this frame and commonly flank the reef core. Dolomitization has destroyed partially the fossils in large portions of the reefs. The principal forms of fossil preservation in the dolomitized reefs are casts and molds. Colonial corals and stromatoporoids, the main reef-builders, are most abundant in the reef cores but are greatly outnumbered by crinoidal remains in the reef-flank beds. Bedding in the core is obscure but tends to be horizontal. Bedding in the flank beds is obvious and inclined.

Lithologic characteristics of reef-rocks as a whole are high carbonate purity, prevalent bluish gray color, conspicuous vesicular texture of the dolomite, and the absence of chert. The lithologic characters of reef-rock compared to deposits of the normal Niagaran facies are distinguished in electric logs by usually higher resistivity and by consistently higher negative self-potentials.

## Reef Dolomite Distribution in the Report Area

The Niagaran section was studied in virtually all available sample sets, and diamond cores taken within the report area. These totaled over 260 of which approximately one-fourth were diamond cores collected by the author.

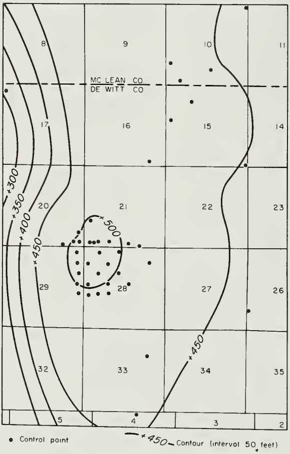


Figure 6 - Structure on Pennsylvanian Danville (No. 7) Coal.

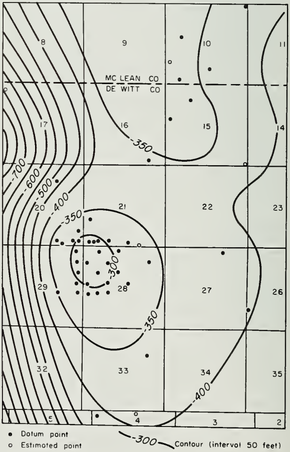


Figure 7 - Structure on top of Devonian Cedar Valley Limestone.

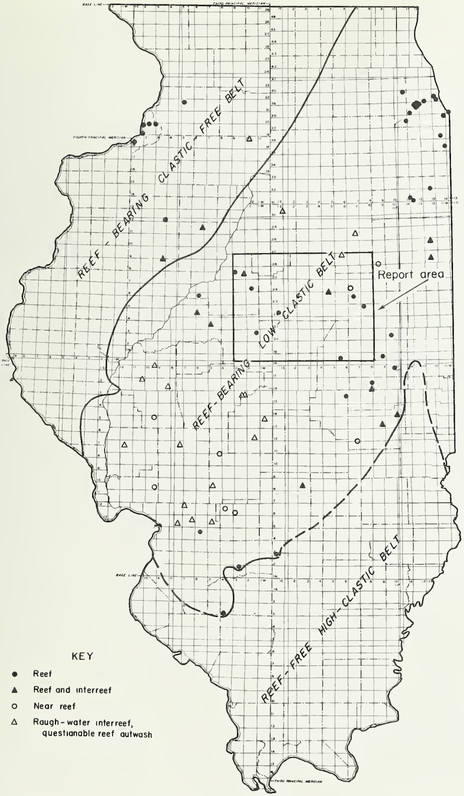


Figure 8 - Location of report area on map of "Niagaran reef occurrences and sedimentation belts in Illinois" (Lowenstam, 1949, fig. 6).

All of the criteria stated above were used in the identification of reef dolomite in the samples and cores except acid-insoluble residues. However, major emphasis was placed on bluish gray color, vesicular texture of the dolomite, and its apparent purity. In a few cases where samples were not available, the presence or absence of reef dolomite was determined solely from the electric log. The top of the Niagaran cannot be picked from the electric log in areas where highly resistive, dense Devonian limestone rests on highly resistive Niagaran reef dolomite. The erosional surface on top of the Niagaran is generally rubbly, fissured (containing Devonian clay, sand, and gravel), and sometimes apparently cavernous to depths of 50 feet or more. This adds to the difficulty of sample and electric log interpretation.

Figure 5 essentially shows the distribution of bluish gray, vesicular reef dolomite and holes that did not encounter it. This illustration does not show thicknesses of reef dolomite encountered, nor the distinction between reef-flank and reef-core deposits.

The majority of diamond cores collected in the area are from the densely drilled Tps. 21, 22, and 23 N., Rs. 3 and 4 E. Reef-core can be identified by the abundance of stromatoporoids and colonial corals and the relative absence of bedding. Reef-core rocks seem to be randomly distributed across the area. Reef-flank beds are identified in diamond cores by apparent bedding and abundance of fragmental crinoid remains. They are less dense than reef-core and more uniformly permeable. A rough differentiation between reef-core and reef-flank can be made from examination of cuttings. Reef-core cuttings are generally darker bluish gray, finer grained, and less vuggy than reef-flank.

The geographic distribution of Lowenstam's several types of interreef sediments—rough-water, still-water, and intermediate deposits is not shown in figure 5. The bulk of interreef sediments encountered in the area is of the intermediate type—greenish gray to tan-gray, very fine-grained, chalky dolomite. Chert and silicified fossils (frequently tabulate corals) are common. Silty and shaly lenses and laminae commonly are irregular and wavy, thereby producing a nodular appearance. Rough-water deposits of light gray to tan-gray, slightly crystalline, sucrosic dolomite are prevalent. Still-water deposits of brownish to greenish gray, shaly siltstone are encountered less frequently.

Figure 9 shows the electrical characteristics and vertical distribution of reef dolomite and interreef deposits throughout the Niagaran. In all but the northeast portion of the report area, the great majority of Silurian tests that did not encounter reef dolomite bottomed only a few feet in the Niagaran. Figure 9 suggests that many undoubtedly would have encountered reef dolomite had they gone deeper. In the northeastern part of the area, most holes reaching the Silurian penetrated the entire Silurian. Up to 350 feet of Niagaran reef-rock probably accumulated over much of the area.

The Niagaran thins over 400 feet westward due in large part to pre-Cedar Valley (Devonian) erosion. Evidence of local Silurian thickening due to Niagaran reef development has been obscured by this erosion. It appears that reef development began some 150 feet lower in the Niagaran in the western than in the eastern part of the area.

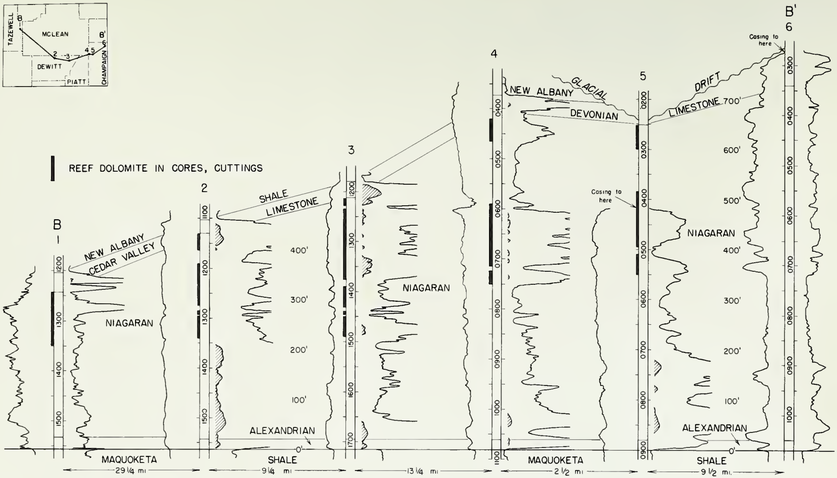


Figure 9 - Electric log stratigraphic cross section. Datum: Silurian Base. (1) Ross Production No. 1 Howe Heirs, sec. 14, T. 24 N., R. 2 W., Tazewell County. (2) Harris No. 4 Ryan, sec. 21, T. 21 N., R. 3 E., DeWitt County. (3) Kaufman No. 1 York-Moody, sec. 36, T. 21 N., R. 4 E., DeWitt County. (4) Union Hill No. 15-M, sec. 7, T. 21 N., R. 7 E., Champaign County. (5) Peoples Gas Light and Coke No. 1 Fee, sec. 9, T. 21 N., R. 7 E., Champaign County. (6) Northern Illinois Gas No. PX-23, sec. 14, T. 22 N., R. 8 E., Champaign County.

NIAGARAN OIL ACCUMULATION

Howard's (1963) report on the Wapella East reef included photographs of of reef-core and reef-flank rock and mentioned that the Devonian Cedar Valley Limestone thinned 16 feet over the reef. Apparently this was the order of topographic relief existing in the area prior to the onlap of the Cedar Valley.

The importance of the development of a compaction anticline over the Wapella East reef is minor compared to tectonic deformation. Figure 10 indicates that the interval between the top of the Mississippian Burlington-Keokuk and the top of the Niagaran thins only about 20 or 25 feet over the pool area. As mentioned above, at least 16 feet of thinning occurred during Devonian time.

Figure 7 shows about 90 feet of structural closure on the top of the Devonian Cedar Valley. Figure 6 shows about 25 feet of structural closure on the Pennsylvanian No. 7 Coal. Some five-sixths of the total deformation on the top of the Silurian (about 110 feet) occurred since Devonian time, four-fifths since Mississippian time, and one-fourth since the deposition of Danville (No. 7) Coal.

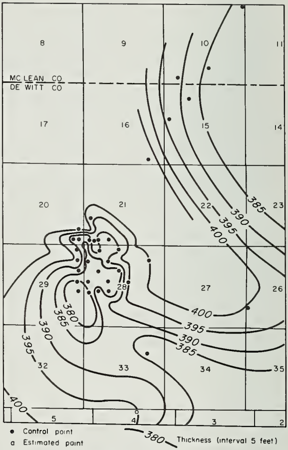


Figure 10 - Thickness of strata between the top of Mississippian Burlington-Keokuk Limestone and the top of Silurian.

The No. 4 Ryan well (fig. 9, hole 2), through the Niagaran showed that the oil-producing reef dolomite interval is above an interreef interval topped at a depth of 1,165 feet. The oil-water contact (approximately 350 feet below sea level) is at a depth of about 1,160 feet. Reef dolomite, however, extends down to a depth of 1,340 feet. It is also apparent from figure 9 that the uppermost reef section of holes 4 and 5 may be missing at hole 2 (at Wapella East) and that the oil-producing reef section at hole 2 is missing farther west at hole 1. This is probably due to pre-Cedar Valley erosion.

Niagaran reef dolomite and effectively porous, sucrosic interreef dolomite are widely distributed over the report area. However, only the structurally highest areas show evidence of oil accumulation. In addition to Wapella East, examples shown on figure 5 are (1) Lincoln Dome in the NW$\frac{1}{4}$ of T. 19 N., R. 3 W., Logan County; (2) Parnell Dome in the SE corner of T. 21 N., R. 4 E., DeWitt County; (3) Deland Dome in the NW$\frac{1}{4}$ of T. 19 N., R. 5 E., Piatt County; and (4) Mahomet Dome, T. 21 N., R. 7 E., Champaign County.

Asphaltic oil and water were encountered at the Lincoln Dome. Oil-saturated reef dolomite was cored at the Parnell and Deland Domes, but the closeness of the oil-water contact to the top of the structures appears to be a problem. There is abundant oil-stained reef dolomite at the Mahomet Dome.

## OIL PRODUCTION

Wapella East pool was discovered in November, 1962. A total of 20 producing wells have been completed, essentially defining the limits of the pool. As of June 1, 1964, 375,000 barrels of oil had been produced, an average of some 18,000 barrels per well. The discovery well had produced 40,000 barrels of oil by this date. Present daily production is limited by the operator to 700 barrels of oil, which is the rate he feels will ultimately recover the most oil.

Although 550,000 barrels of fluid had been produced by April 28, 1964, fluid levels were essentially the same as six months before, according to tests on the 20 wells by accoustical well sounder. This indicates that bottom-hole pressures remained the same and that there is a natural water-drive. It is estimated that about 2,000,000 barrels of oil will be recovered by primary methods.

Since the discovery of Wapella East over 150 unsuccessful Niagaran tests have been drilled in the report area. In May, 1963, E. H. Kaufman discovered oil in the Mississippian Sonora Sandstone at Parnell (sec. 36, T. 21 N., R. 4 E., DeWitt County). According to the Illinois Pipeline Production Report some 1,800 barrels of oil had been taken from two wells by the end of May, 1964.

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