

GRAVITY AND COMPACTION ANTICLINES

by

CRAIG FERRIS*

Compaction Anticlines are not new to geologists. The hypothesis of the compaction anticline was presented by Nevin and Sherrill in 1929.¹ Figure 1 shows the results of a laboratory experiment conducted by Nevin and Sherrill, wherein buried hills, surrounded by compactible material, produce structures.

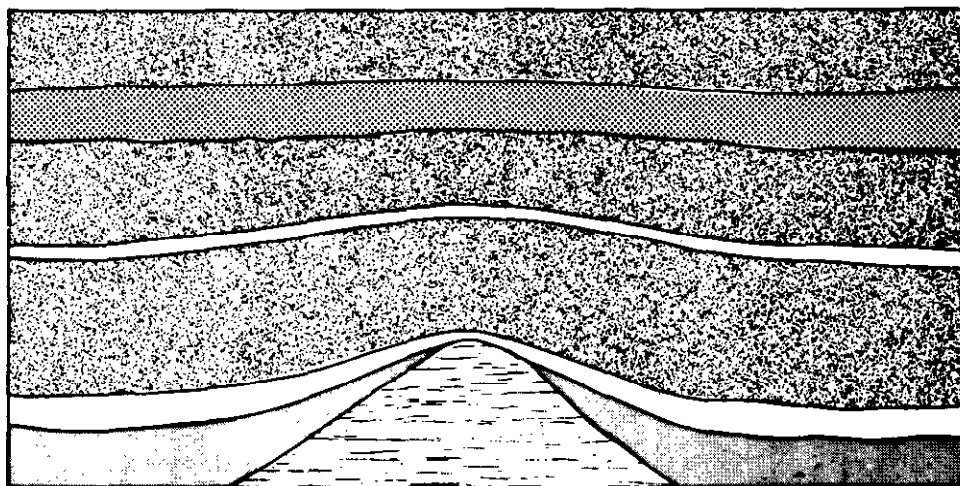


FIG. 1.

The three compaction anticlines which will be discussed are text-book examples of the hypothesis proposed by Nevin and Sherrill. Many geologists have forgotten the compaction anticline hypothesis and are not taking advantage of available grass roots geologic information.

An index map of Michigan showing the location of the Boyd Field in the Thumb Area of Michigan is shown in Figure 2. This figure also shows the location of the gravity profile and the Gamma Ray-Neutron log section. Figure 3 shows the Gamma Ray-Neutron logs across the Boyd Reef pinnacle. The enlarged Gamma Ray-Neutron logs of the pay section, the Niagaran Reef, are shown in Figure 4. Figure 5 gives the formation tops taken from the Gamma Ray-Neutron logs. A compaction anticline may be seen in all formations, including the shallow Berea, the first marker. Well 21744 is 26 feet high with respect to Well 21803, to the West, and it is 39 feet high with respect to Well 21282,

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¹NEVIN, C. M. and SHERRILL, R. E., 1929, Studies in Differential Compaction, Am. Assoc. Petroleum Geologists Bull., v. 13, no. 1, p. 1-22.

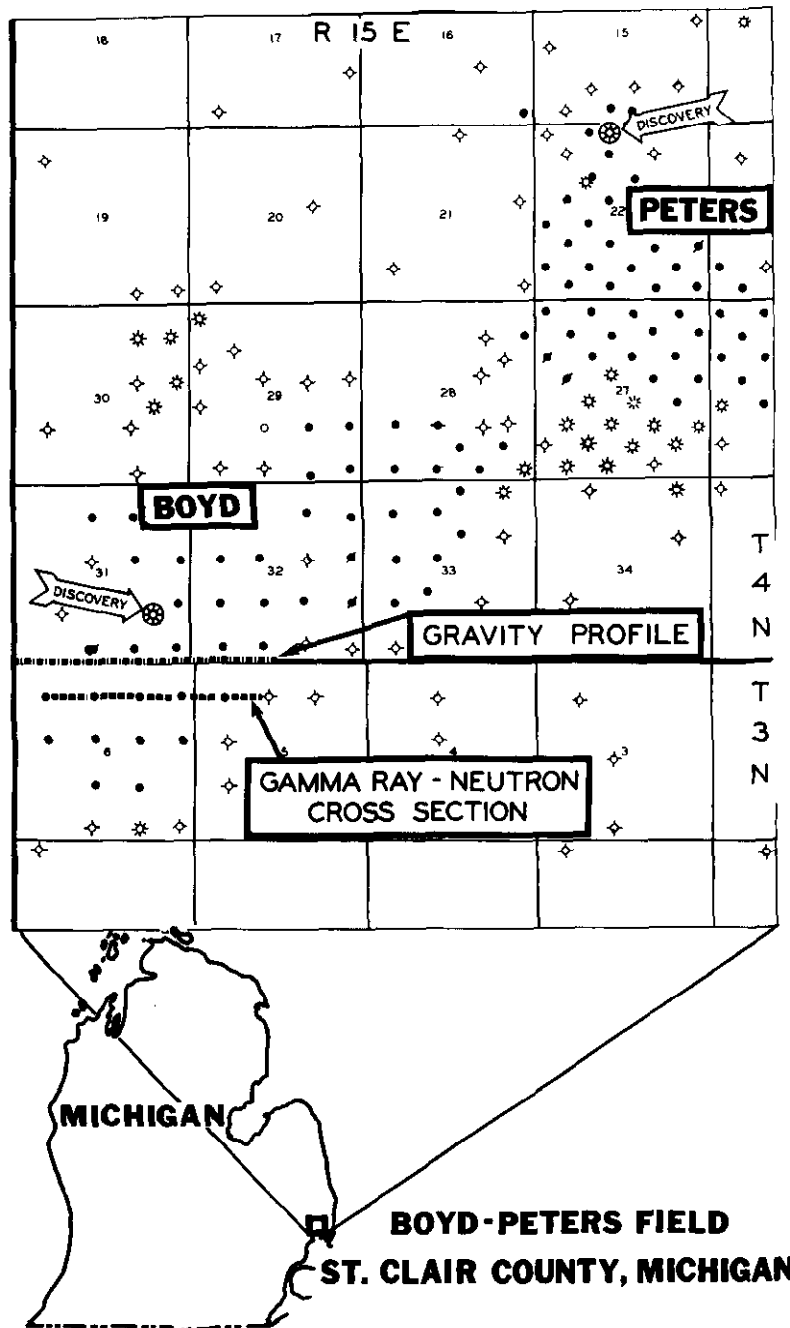
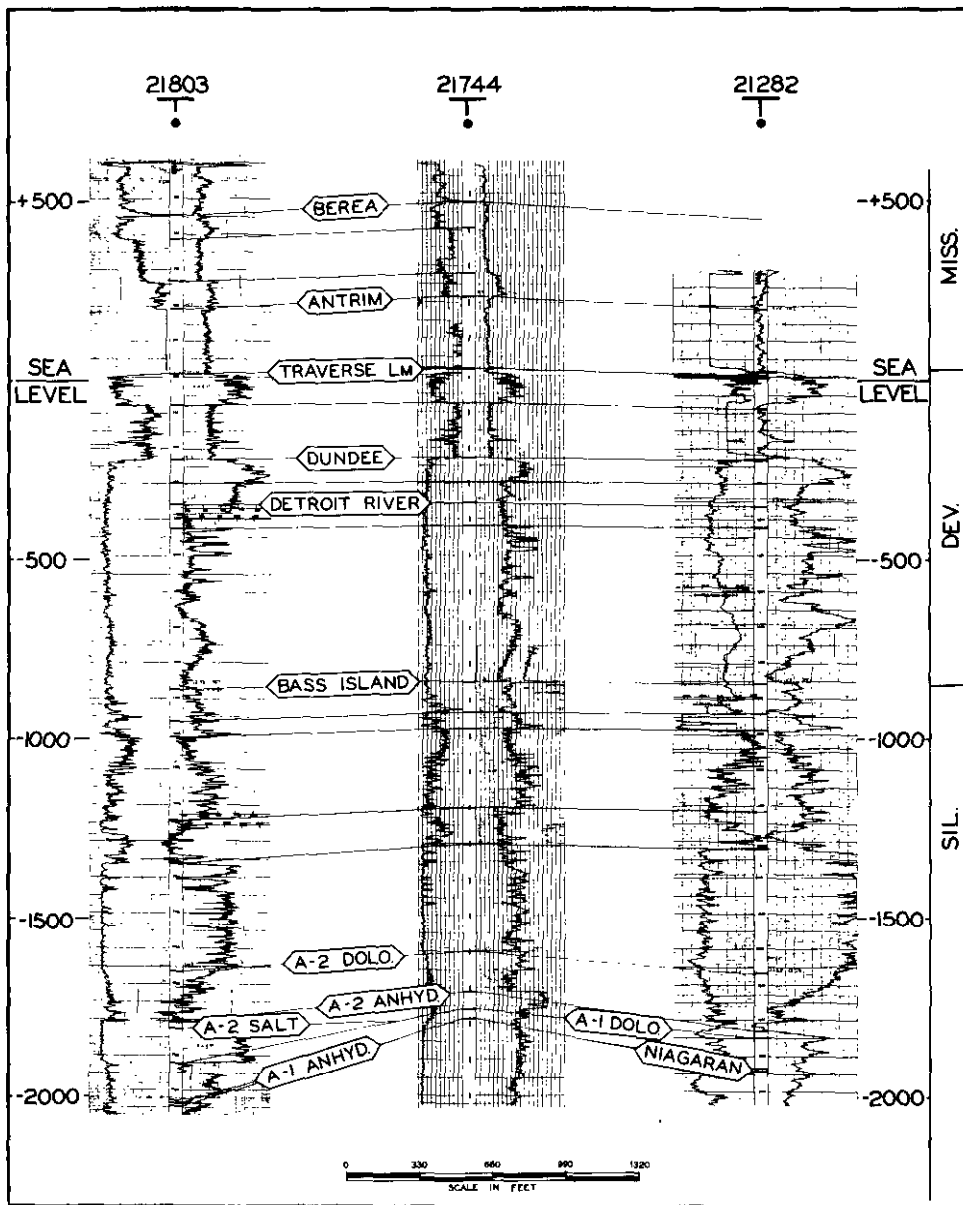


FIG. 2.



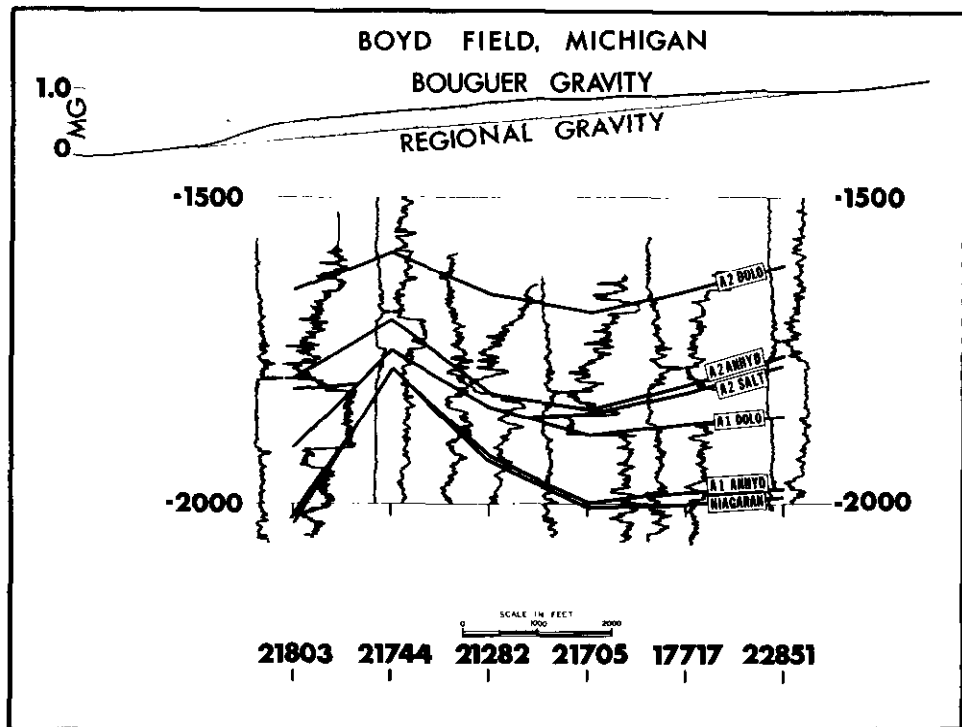


FIG. 4.

to the East. A condensed vertical section taken from Gamma Ray-Neutron logs is shown in Figure 6. The vertical exaggeration is 66 to 1. A compaction effect may be seen on every formation above the reef and/or carbonate buildup, making a compaction anticline in each horizon.

The location of the Redwater Reef in Alberta, Canada is shown on the index map in Figure 7. The location of the gravity profile and the electrical logs which are parallel and adjacent to the gravity profile logs are shown. The maximum residual gravity anomaly associated with the Redwater Reef is in excess of 0.5 milligal. A gravity profile, 19 miles in length, is shown in Figure 8. The 0.5 milligal maximum gravity anomaly may be seen to be centered directly over the Redwater Reef. Sixteen electrical logs of wells which are parallel and adjacent to the gravity profile are shown in Figure 9. A compaction anticline may be seen in the Ireton, Nisku, and Calmar, which are directly over the Leduc formation. The Bouguer gravity profile and Residual gravity profile show maximum gravity anomalies of approximately 0.5 milligal. Formation tops taken from the electrical log "picks" are shown in Figure 10. A compaction anticline may be seen in all formations above the Reef, including the Upper and Lower Cretaceous.

BOYD FIELD, MICHIGAN

FORMATION TOPS FROM GAMMA RAY-NEUTRON LOG "PICKS"

FORMATION	WELL	WELL	WELL
	21803	21744	21282
M Berea	+ 465	+ 491	+ 452
M Antrim	+ 205	+ 230	+ 202
D Traverse Lm	+ 20	+ 33	+ 17
D Dundee	- 220	- 215	- 223
D Det River	- 345	- 340	- 350
S Bass Island	- 861	- 837	- 845
S A2 Dolo	- 1652	- 1588	- 1656
S A2 Anhyd	- 1796	- 1699	- 1818
S A1 Dolo	- 1908	- 1747	- 1838
S Niagaran	- 2034	- 1774	- 1928

FIG. 5.

The structural contours on the Porosity Zone of the Leduc formation of the Redwater Reef is shown in Figure 11 as published by the Alberta Society of Petroleum Geologists. Figure 12 shows a condensed vertical section made from the electrical log "picks." The compaction anticline over the Redwater Reef may be seen in all formations. The vertical exaggeration is 132 to 1. The Bouguer Gravity profile and Residual Gravity profile are shown in their correct horizontal location as regards to the condensed vertical section.

Figure 13 shows the location of the Denmark Field in Canaan Township, Morrow County, Ohio. The location of a gravity profile and the location of a parallel and adjacent Gamma Ray-Neutron log section are also shown on this figure. Four Gamma Ray-Neutron logs in the Denmark Field are shown in Figure 14. The enlarged Gamma Ray-Neutron logs of the pay section at the Denmark Field is shown in Figure 15. The Upper Copper Ridge (Trempealeau) erosional remnant may be seen displacing the lower Chazy (Glenwood). The Myers No. 1 well is reported to have produced over one-half million barrels of oil.

Formation tops taken from the Gamma Ray-Neutron log "picks" are shown in Figure 16. A small, but appreciable, compaction anticline is present only 180 feet under the surface. Figure 17 is a condensed verti-

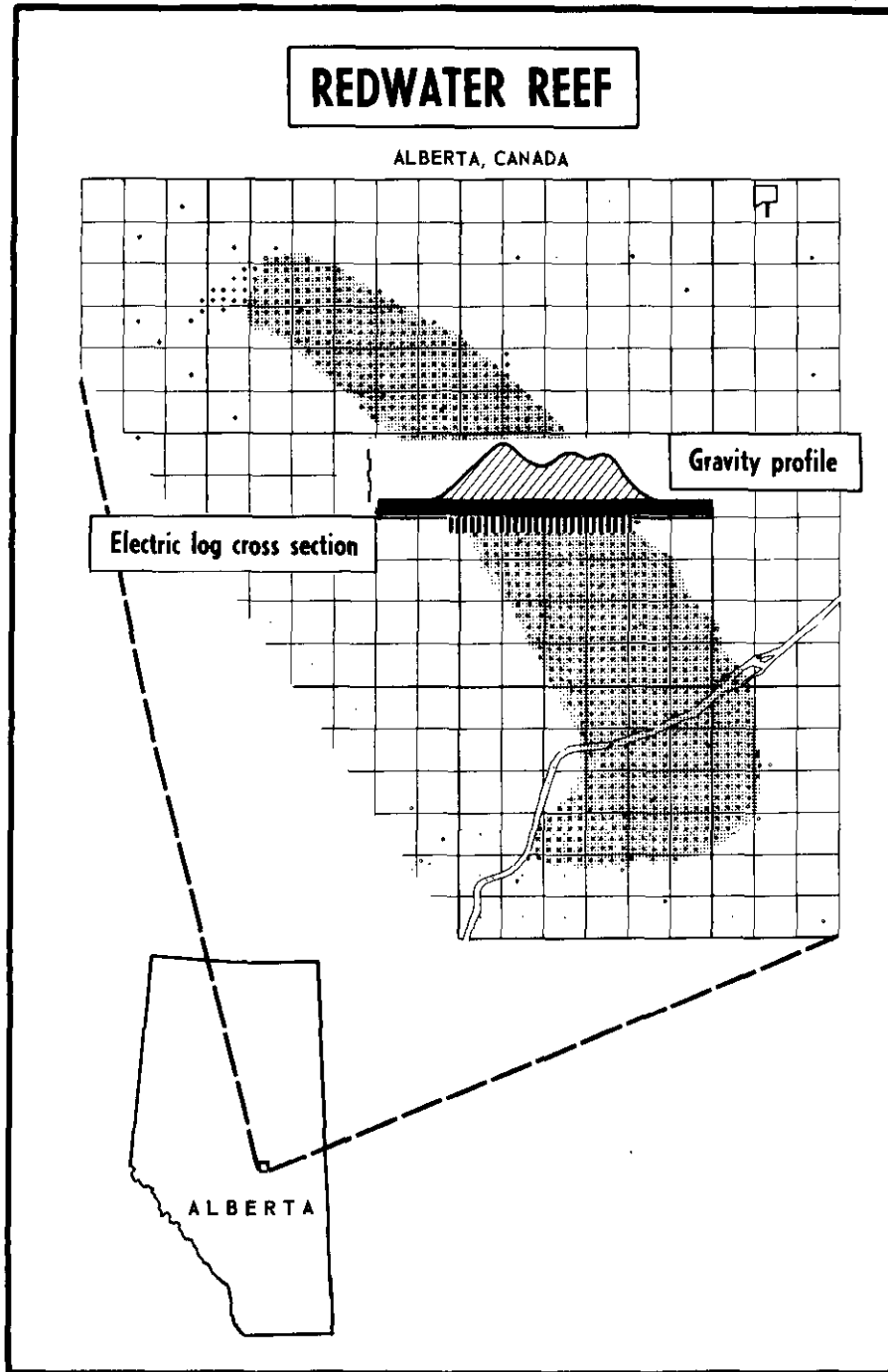


FIG. 7.

GRAVITY AND COMPACTION ANTICLINES

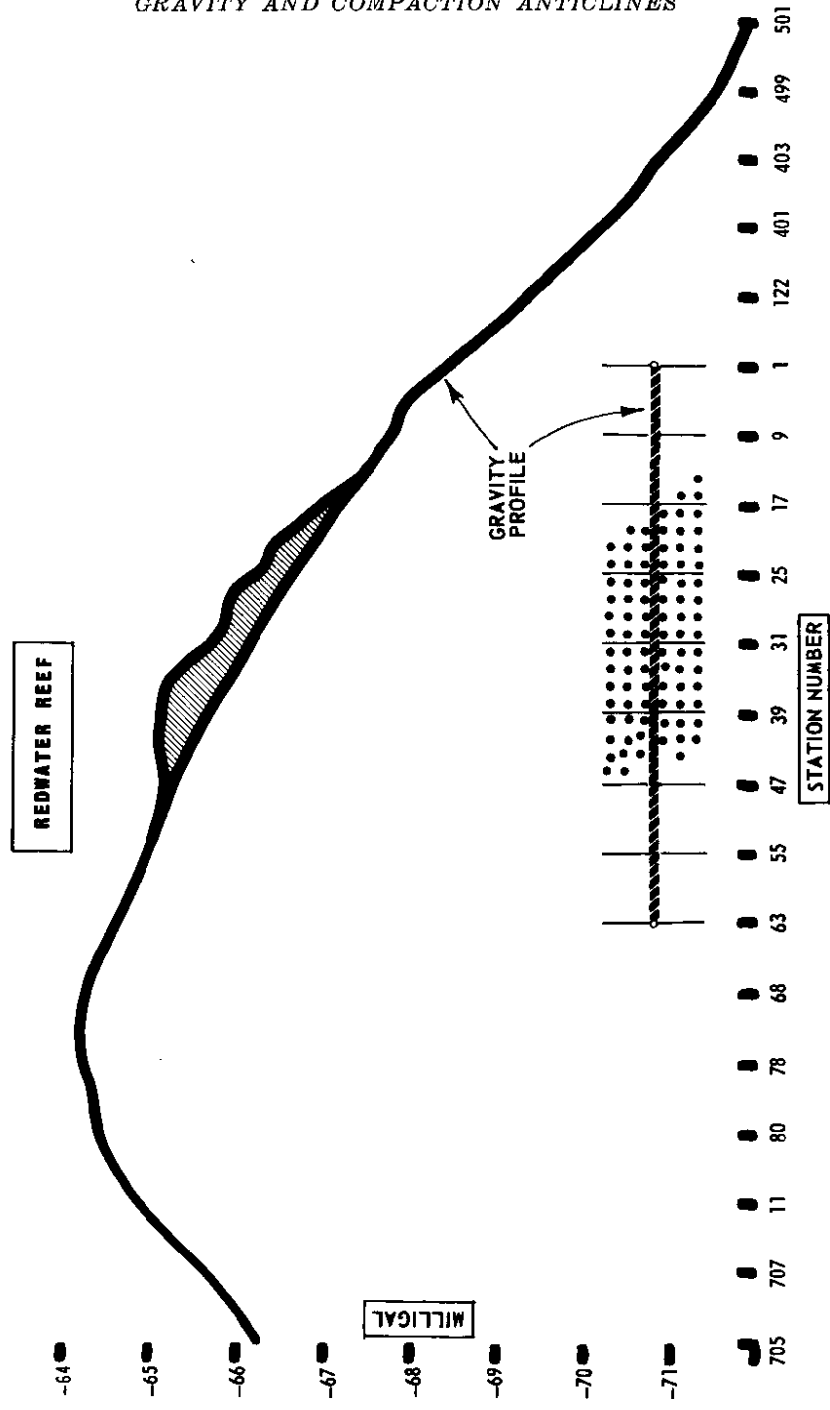


FIG. 8.

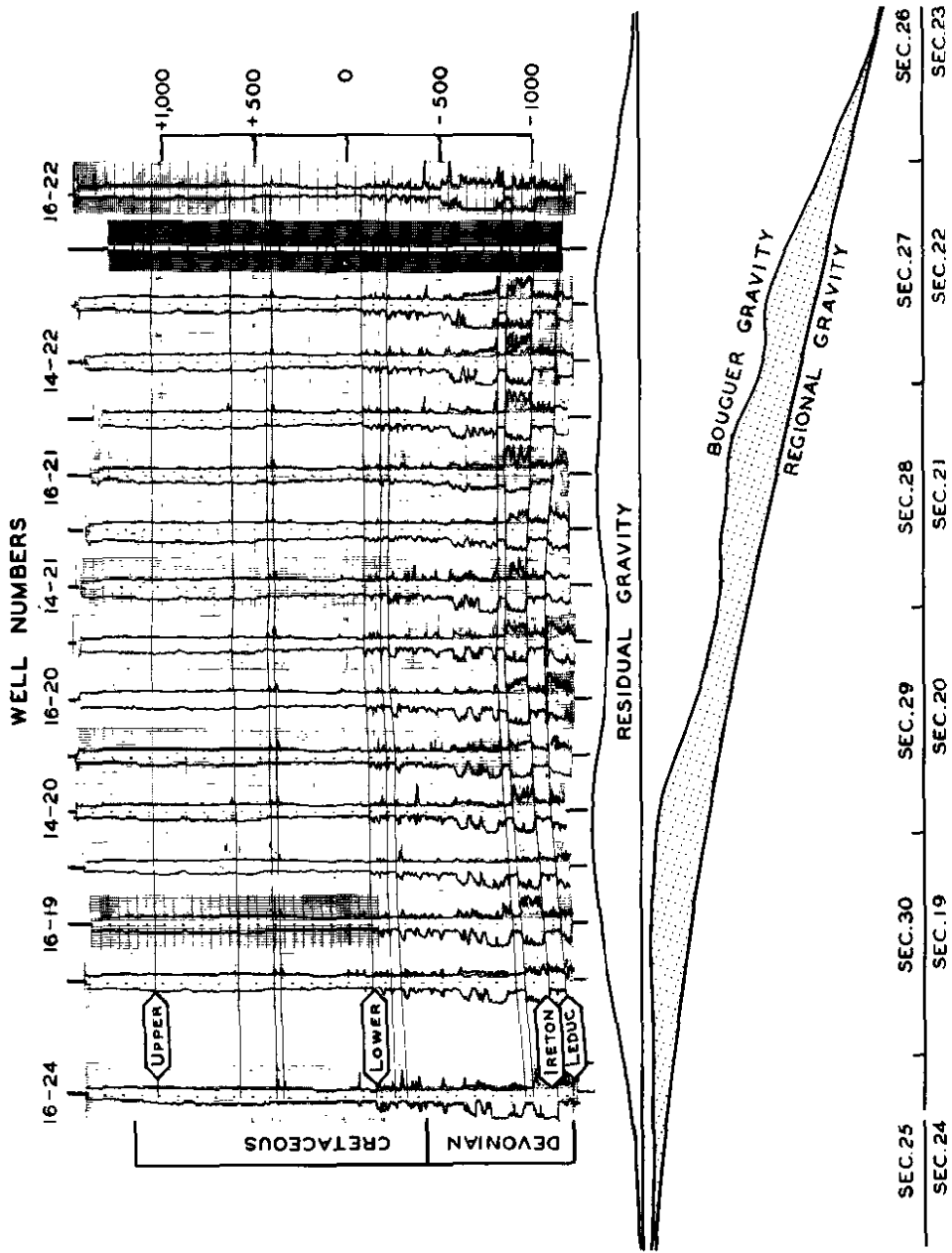


FIG. 9.

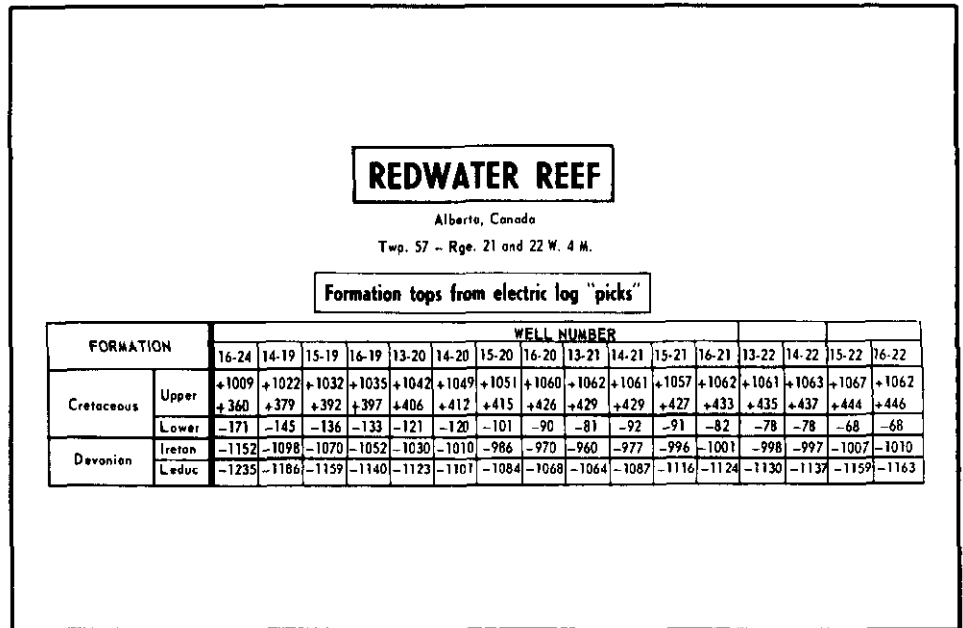


FIG. 10.

cal section taken from the Gamma Ray-Neutron logs (vertical exaggeration is 66 to 1). This figure also shows the Bouguer gravity profile in the correct horizontal position as regards to the condensed vertical section. A compaction anticline may be seen in all formations above the Upper Copper Ridge (Trempealeau) erosional remnant.

The gravity anomaly at Denmark is small, however, the gravity data has been "stacked" and "filtered." A small micro subsurface structure is present in the Olentangy (Devonian) at the Denmark Field. A large gravity anomaly cannot be expected to be associated with a small micro subsurface structure.

The gravity anomalies at Boyd, Redwater, and Denmark are 0.32 milligal, 0.56 milligal and 0.07 milligal, respectively. These are small gravity anomalies, however, in each instance the probable error of the gravity profile has been studied. The probable error,²

$$\epsilon = \frac{0.3452 \sum | -g_1 + 2g_2 - g_3 |}{n}$$

where g_1 = Bouguer Gravity value of Station No. 1
 g_2 = Bouguer Gravity value of Station No. 2
 g_3 = Bouguer Gravity value of Station No. 3
 n = number of triplets computed

²McCOLLUM, E. V., 1952, Quality of Geophysical Measurements: Geophysics, v. 17, no. 1, p. 56-69.

is Boyd $\epsilon = \pm 0.0047$ mg.
 Redwater $\epsilon = \pm 0.0077$ mg.
 Denmark $\epsilon = \pm 0.0037$ mg.

The Bouguer Gravity anomaly is 68, 73, and 19 times the probable error at Boyd, Redwater, and Denmark, respectively. The gravity anomalies are therefore believed to be real and significant.

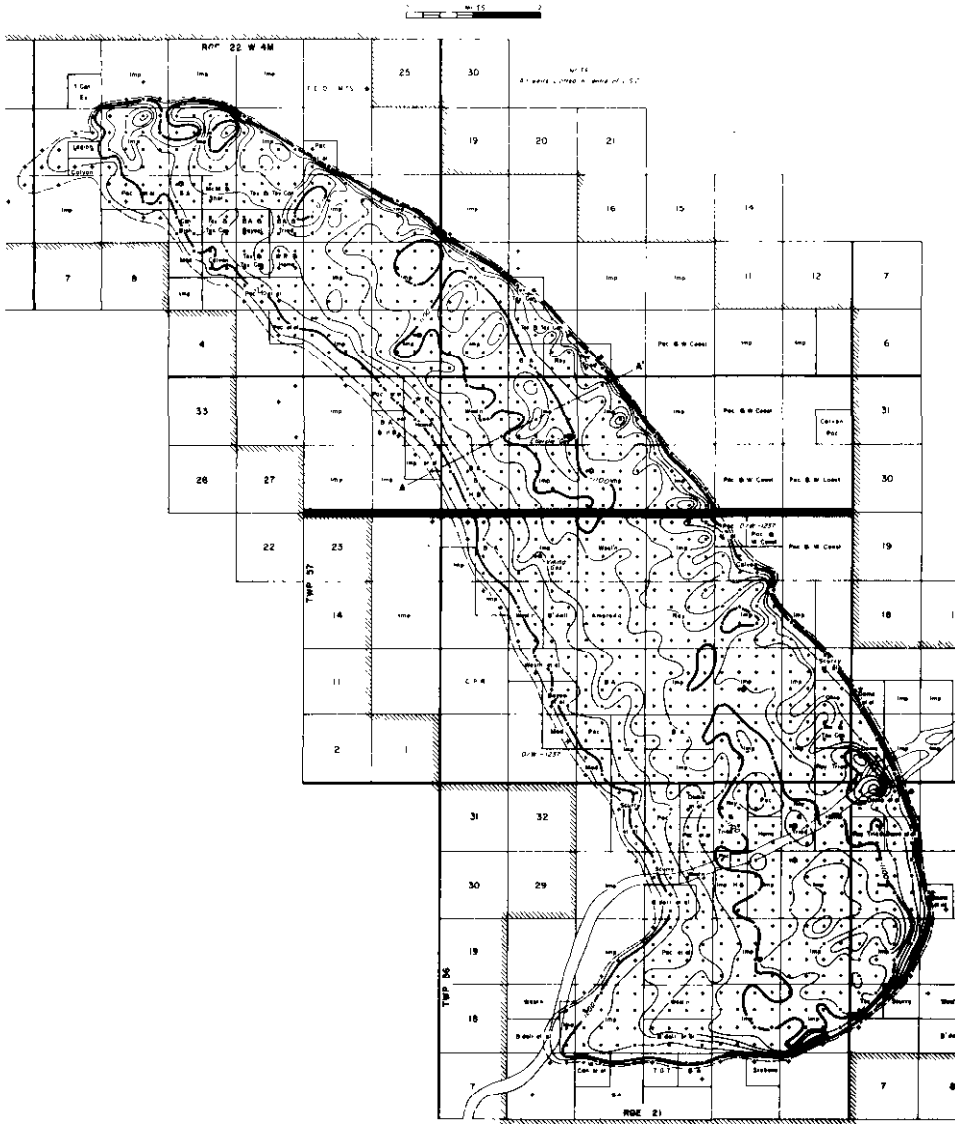


FIG. 11.

Condensed vertical section based on electric log "picks"

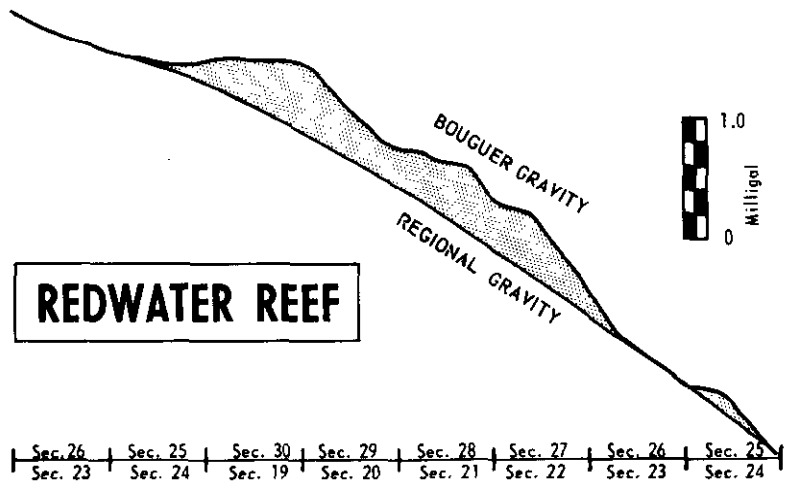
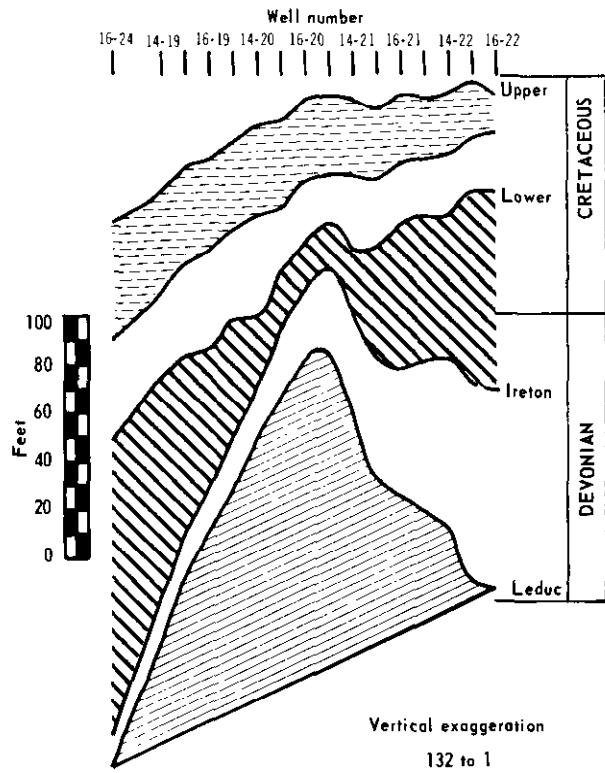


FIG. 12.

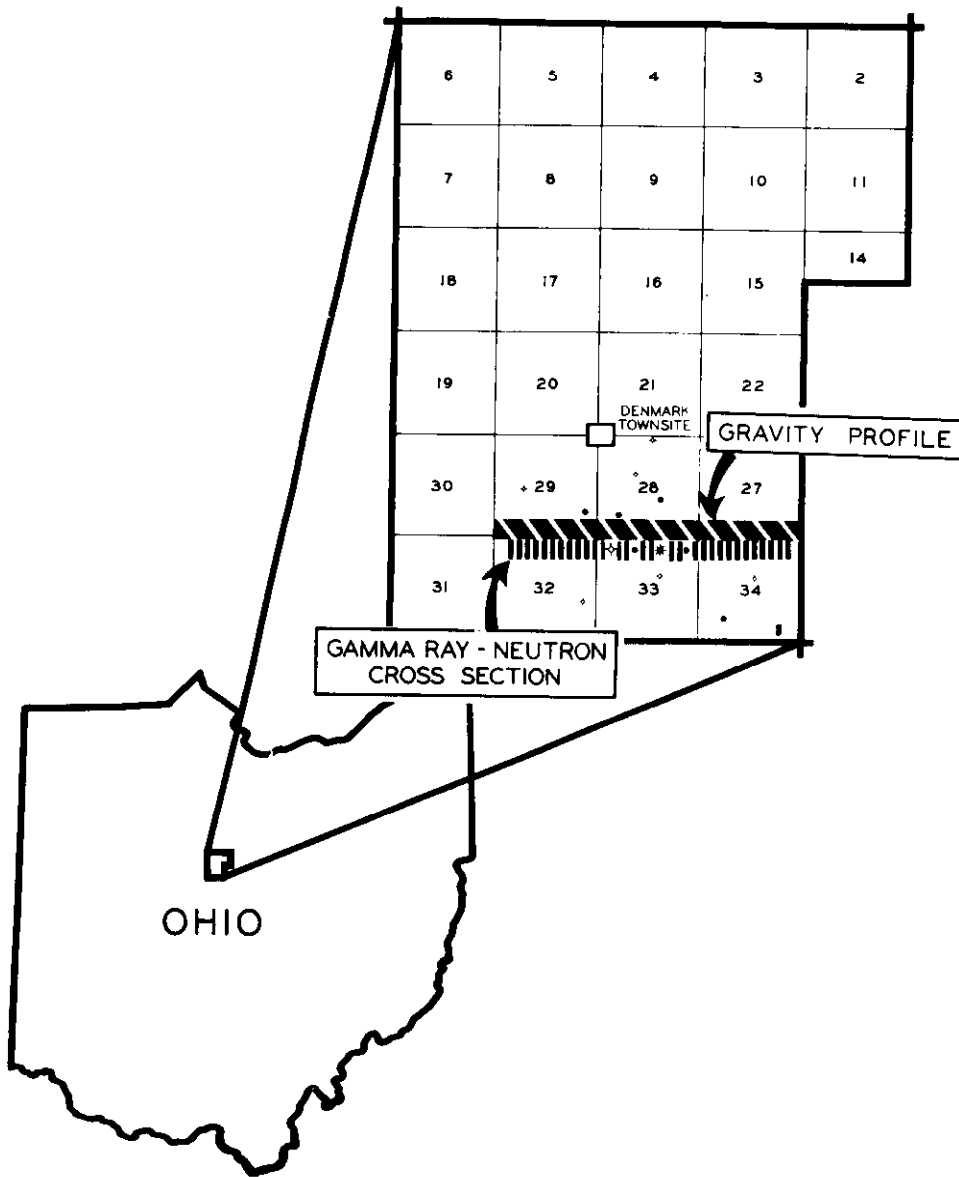


FIG. 13.

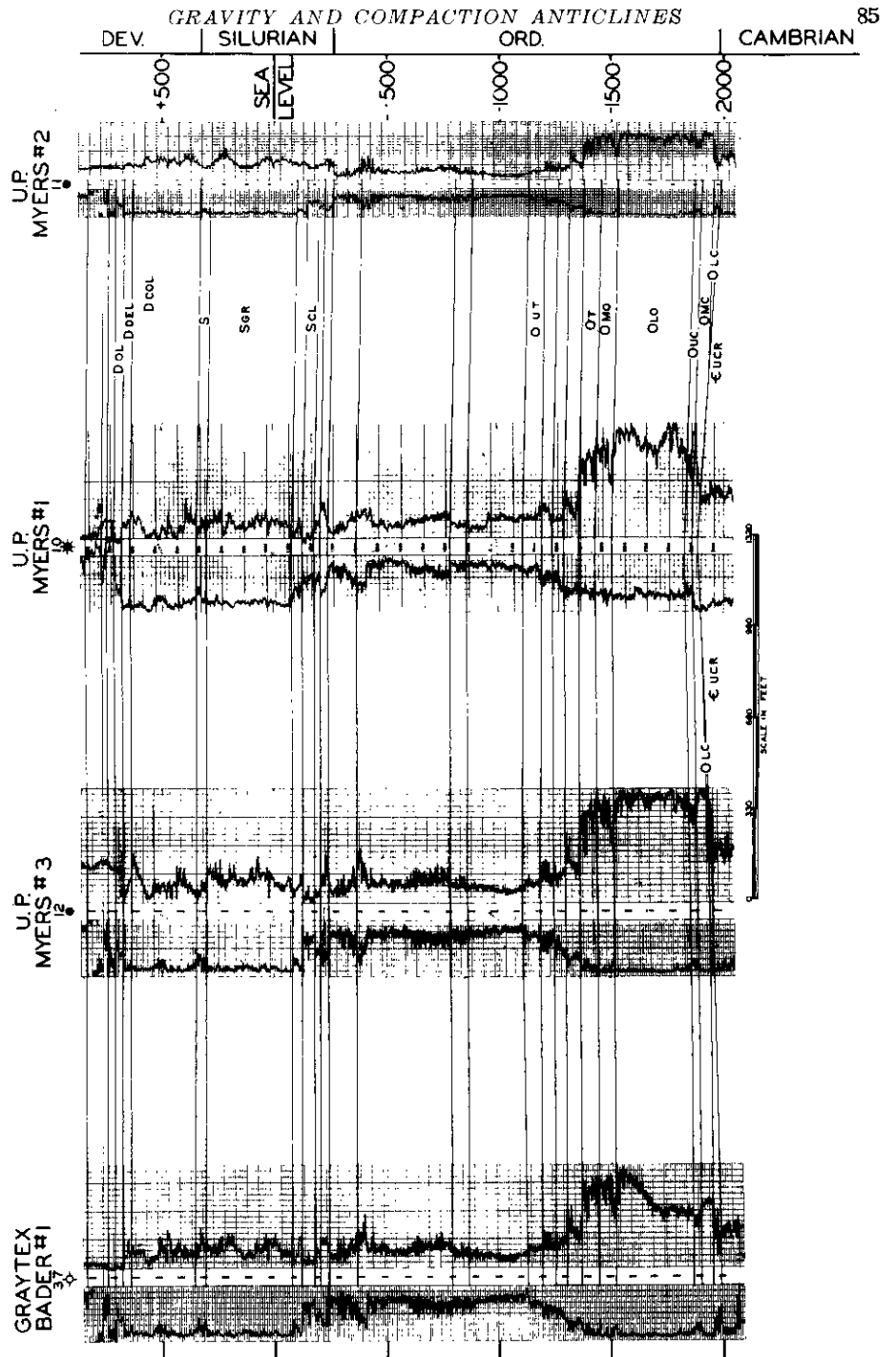


FIG. 14.

CRAIG FERRIS

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U.P.
MYERS #2

U.P.
MYERS #1

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GRAYTEX
BADER #1

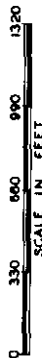
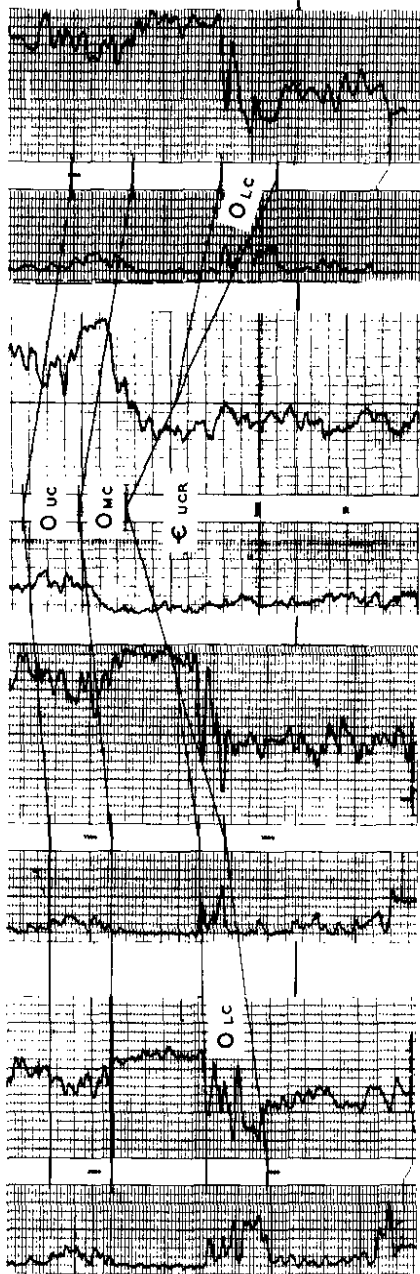


FIG. 15.

DENMARK FIELD, OHIO

FORMATION TOPS FROM GAMMA RAY-NEUTRON LOG "PICKS"

FORMATION	GRAYTEX BADER 1	UNITED MYERS 3	UNITED MYERS 1	UNITED MYERS 2
D O1	+ 706	+ 707	+ 711	+ 707
D Col	+ 635	+ 635	+ 639	+ 631
S C1	- 122	- 129	- 135	- 143
O Ut	- 1120	- 1119	- 1116	- 1126
O Tr	- 1365	- 1370	- 1366	- 1379
O Uc	- 1863	- 1861	- 1844	- 1872
O Mc	- 1898	- 1896	- 1876	- 1906
O Lc	- 1951	- 1946	ABSENT	- 1956
€ Ucr	- 1985	- 1960	- 1903	- 1987

FIG. 16.

In each instance we are unable to explain the gravity anomaly as being due solely to the reefs and/or carbonate buildups at Boyd and Redwater, or the erosional remnant at Denmark.

Our inability, as geophysicists, to explain the gravity anomalies in precise detail, is due to insufficient density information. Our inability, as geophysicists, to explain many seismic anomalies is due to insufficient velocity information. As management gives us sufficient density and velocity logs, we-geophysicists, will be able to explain every gravity and seismic anomaly. Management can assist the geophysicists by providing density and velocity logs from the surface to the total depth of every well. Too many wells are logged only in the pay section. Near surface density and velocity data are vital to every geophysical interpreter. Mechanical well logs, geophysical logs, showing near surface formations give valuable information on Compaction Anticlines. Compaction Anticlines in many cases are the key to deep structures.

Three structures, namely, Boyd, Redwater and Denmark which have associated compaction anticlines, have been illustrated. These structures show that when all the parameters are known, geology and geophysics are compatible. "Grass roots" structures such as Boyd, Redwater and Denmark can be found by a refined orthodox exploration tool, the gravity meter. These near surface compaction anticlines are a clue to deeper Silurian, Ordovician and Cambrian structures. Ira Cram in his SEG

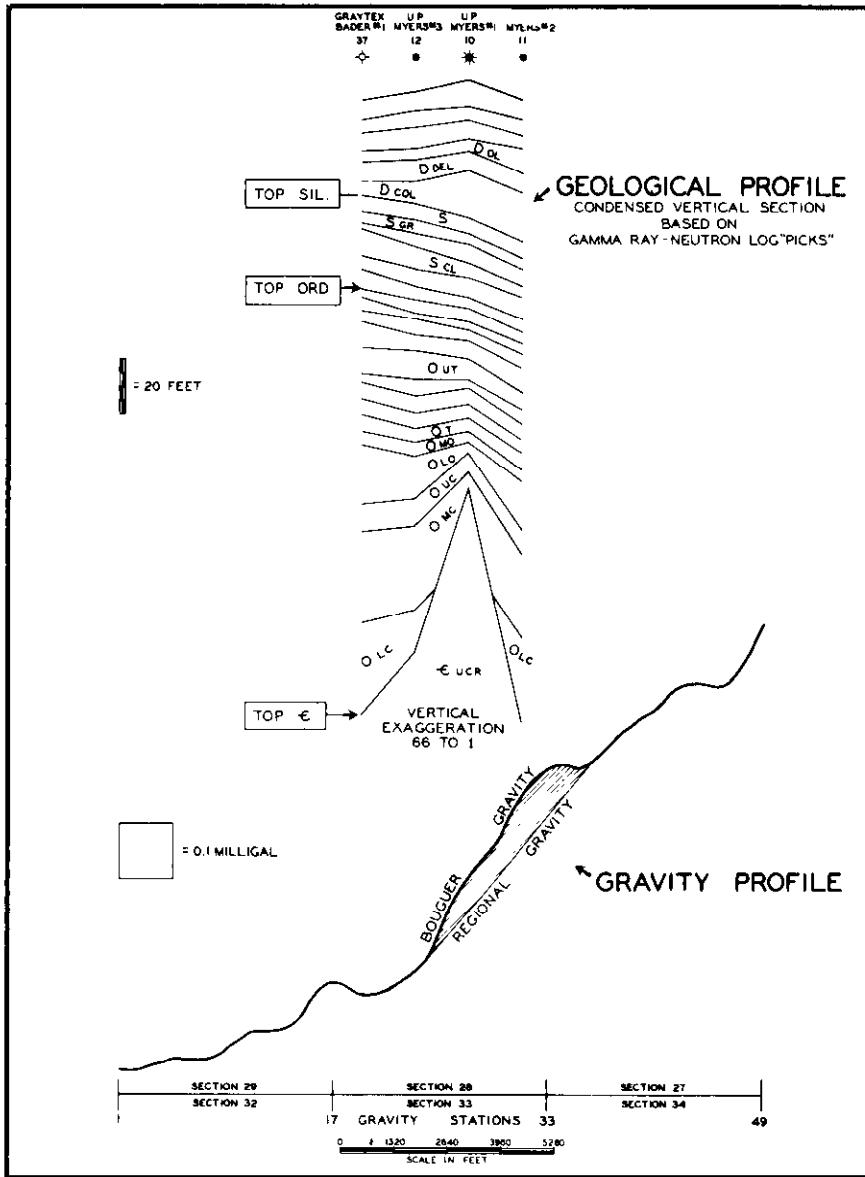


FIG. 17.

keynote address in New Orleans suggested, "we have been too orthodox in our drilling." Alberta offers many areas for unorthodox drilling.

The gravity method has been grossly misused in Alberta. In the past, many companies have used the gravity meter because it was the cheapest exploration tool. It was possible to hold a concession by a gravity survey. The resultant gravity surveys, because of inadequate station spacing, were reconnaissance in nature, hence, found no reefs. Once such reconnaissance gravity surveys have been conducted it is most difficult to convince management that additional gravity control is needed. Explorationists have finally learned how to use the gravity meter as a detail exploration tool. Reefs and other micro subsurface structures are being found with the gravity meter which were heretofore thought to be undetectable by the gravity meter. It is possible that many reefs have been overlooked in Alberta.

Today some people are saying we need a new exploration tool. We do not need a new exploration tool. I am proud to be a geophysicist and say, "We have been too successful. We have found too much oil."

Today, we have many new-fangled exploration gadgets, however, there is no substitute for brains. These refinements of our geophysical tools are opening a new era for the explorationist.

Wallace Pratt once said "Oil is found in the minds of men." *Oil is found in the minds of men.* I repeat, we do *not* need a new exploration tool. Our profession, yours and mine, has the brains. — Let's use them.

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