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GEOPHYSICAL CASE HISTORY OF THE ANDERSON RANCH FIELD, LEA COUNTY, NEW MEXICO*

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ABSTRACT

The Northwest Shelf area of Southwest New Mexico has had an exceptionally rapid growth as an oil producing province. The Anderson Ranch field, discovered by the Continental Oil Company in 1953, is one of the typically prolific oil fields in this Northwest Shelf area. This field (Figure 1) is the most southwesterly of a series of Devonian oil fields in the Northwest Shelf area of New Mexico. It is located 22 miles west of Lovington, New Mexico in sections 2 and 11, T. 16 S.-R. 32 E., Lea County, New Mexico.

The Anderson Ranch area was first found to be anomalous by a shallow oil well drilled in 1927 which found the Rustler Anhydrite unusually high. Core drilling carried out in 1940 developed an Anhydrite nose over the area. A reflection seismograph survey was carried out in the period from 1950 to 1951 which succeeded in mapping a closed anticline in the face of many difficulties in obtaining usable seismograms. It is believed that the seismic map prepared for the deepest horizon was caused by multiple reflections. The anticline so revealed was drilled in a unitized drilling program and a well was completed in the Devonian for an initial potential of 1,968 barrels of oil per day. This was the discovery well.

EARLY EXPLORATION

The first indication of structure in the Anderson Ranch area was obtained by shallow subsurface geology. In 1927 the Caprock Oil and Gas Corporation drilled a well in section 11, T. 16 S.-R. 32 E. This well found the top of the Rustler Anhydrite (upper Permian) unusually high. No original maps exist but a search of old well data indicates that by 1938 the subsurface map drawn on the Rustler Anhydrite must have appeared somewhat as shown in Figure 2. For several years the nosing contours produced by the Anhydrite remained as a remainder of possible anomalous structure in the area. In 1940, Continental Oil Company began a core drill program to check Anhydrite structure in more detail over this nose. Rustler Anhydrite structure mapped by this core drilling is shown in Figure 3.

THE SEISMIC SURVEY

After accumulating some scattered leases over the general area of interest, the Continental Oil Company in December, 1950 began a reflection seismogram survey in an attempt to evaluate deep structure under the core drill anomaly. The party chief of the seismic crew at this time was Dale Fickinger who was later replaced by Ben W. Smith.

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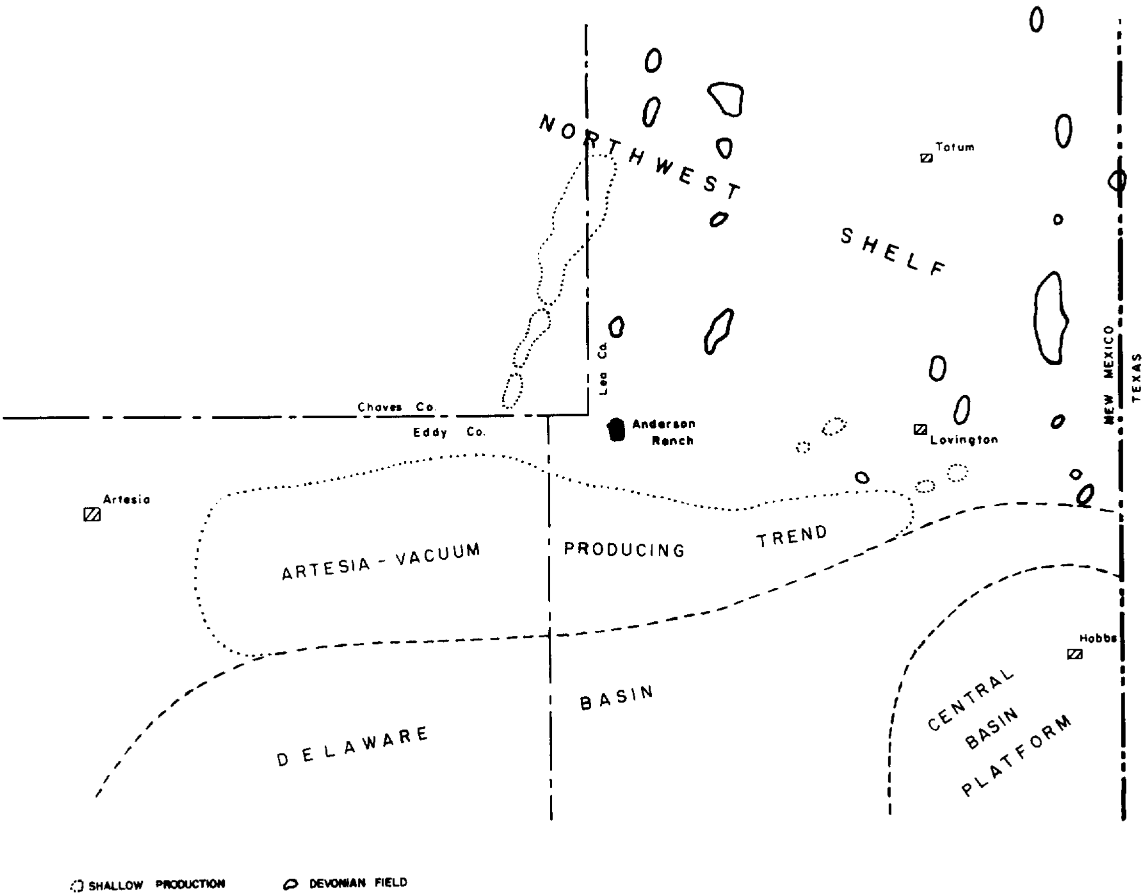

FIG. 1. Location plat of Anderson Ranch field, Lea County, New Mexico.

Many problems were encountered in the field operations. Seismograms were very poor. Deep shot holes were necessary and the holes could not be reloaded after the first shot because of a bed of unconsolidated sand which was betwen 200 and 300 feet thick. After numerous trials, a standard procedure was adopted using continuous profiles, six receptors per trace, split spreads, and a normal spread length of 1,320 feet. Twenty traces were recorded on each seismogram. Shotholes were bottomed in the Triassic redbed below the Ogallala sand at a depth of 330 feet.

Figure 4 shows typical seismograms obtained during the survey. Figure 5 shows some fair seismograms obtained during the survey. The quality of the seismograms was poor with practically no reflections recorded earlier than 1.0 second. Phasing, erratic and conflicting dips, and poor continuity were charac-

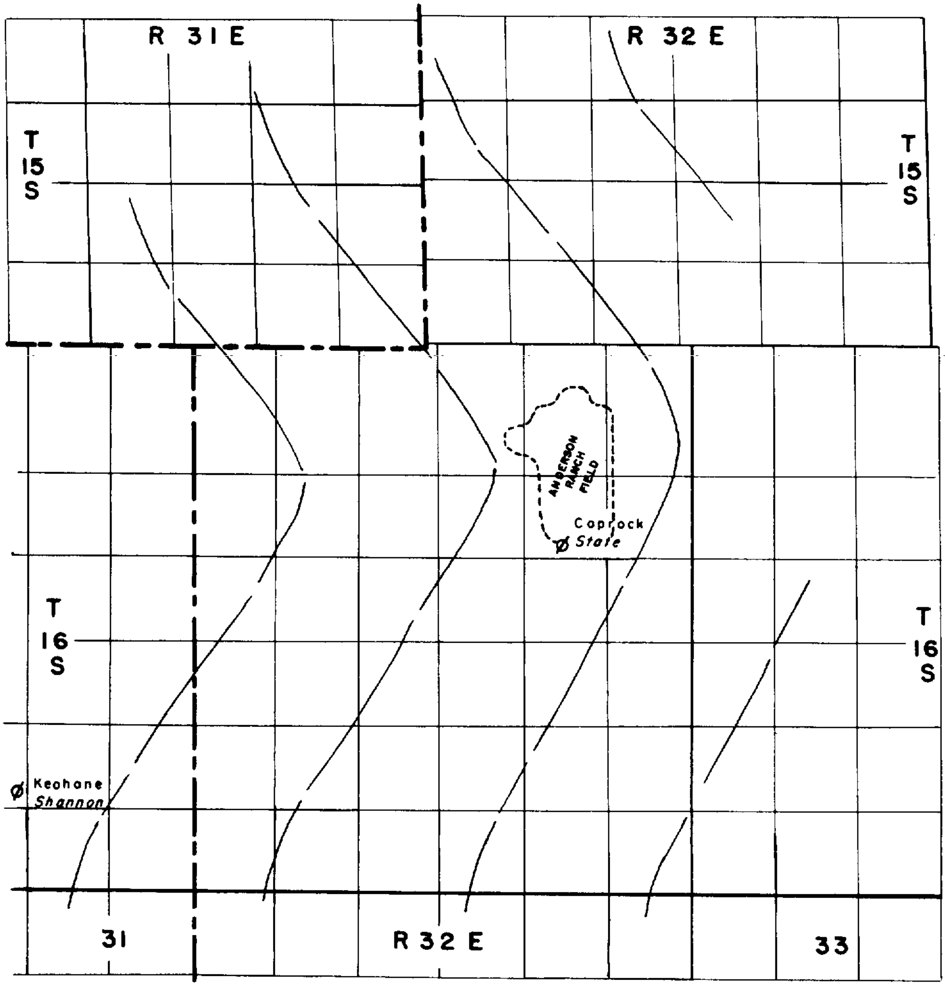

FIG. 2. 1938 regional subsurface map on top of Rustler Anhydrite. Contour interval is 100 feet.

teristic of the seismic records. The most consistent reflections were generally obtained between 1.5 and 2.0 seconds through the pre-Pennsylvanian section.

Figure 6 shows a West-East seismic time section across the Anderson Ranch structure. This line is about $2\frac{1}{4}$ miles long. It will be seen that the best seismic data lie in the range 1.5 to 2.0 seconds. The phasing and the numerous erratic dips shown on the section are typical of the area. Data are recorded on this section as late as 3.0 seconds. This can also be observed on the sample records shown in Figures 4 and 5.

Figure 7 shows a South-North time section across the structure. Part of this line (shotpoints 248–251) is covered by the sample records shown in Figure 4.

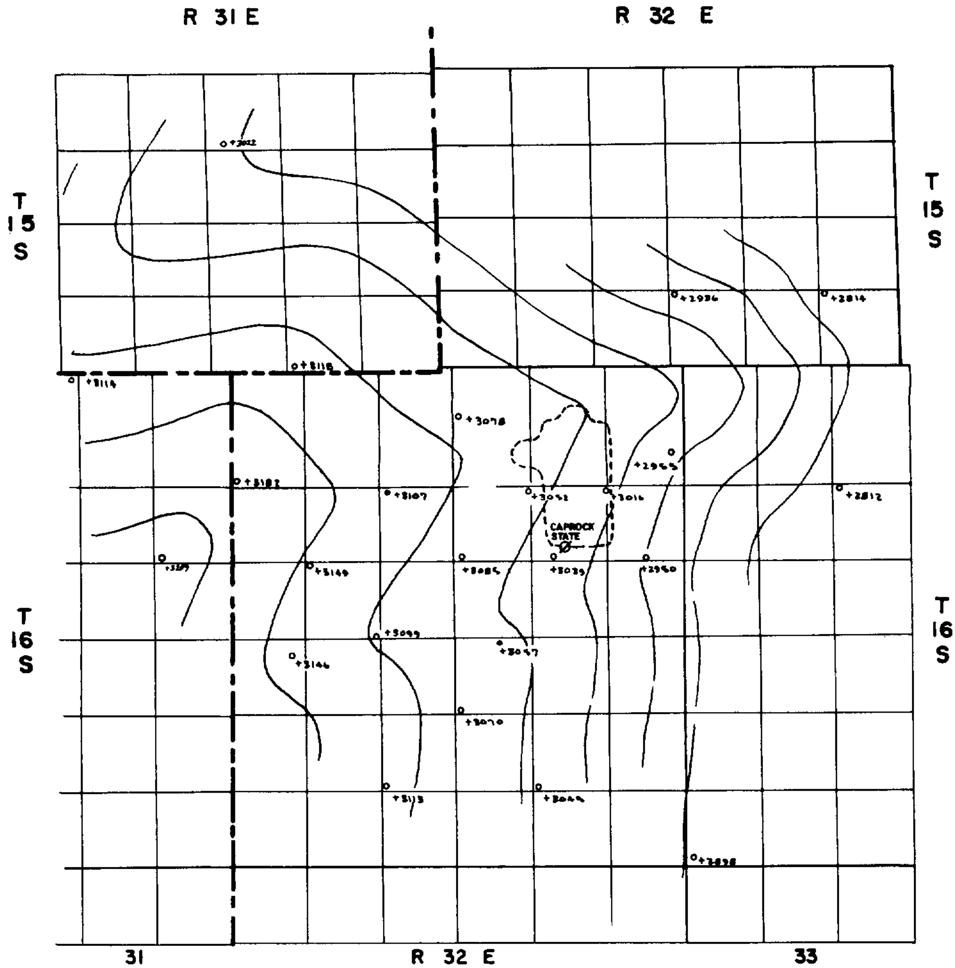

FIG. 3. Core drill map on top of Rustler Anhydrite. Contour interval is 50 feet.

The earliest reliable data again is for times greater than 1.5 seconds. Here again the unusually late events should be noted.

Events appearing as reflections were consistently recorded as late as 3.0 seconds. These events influenced the interpretation in the Anderson Ranch area. Because they did influence interpretation, some discussion of these late arrivals is given in the present paper.

The total thickness of section in the Anderson Ranch area is 17,000 feet as a best estimate. A velocity survey made in the Continental #2D Anderson Ranch well yielded an average velocity to the Devonian of 16,200 feet per second. It is believed that the reflection from the basement rock occurs at a reflection time of around 2.1 seconds. Some of the reflections occurring at times greater than 2.1

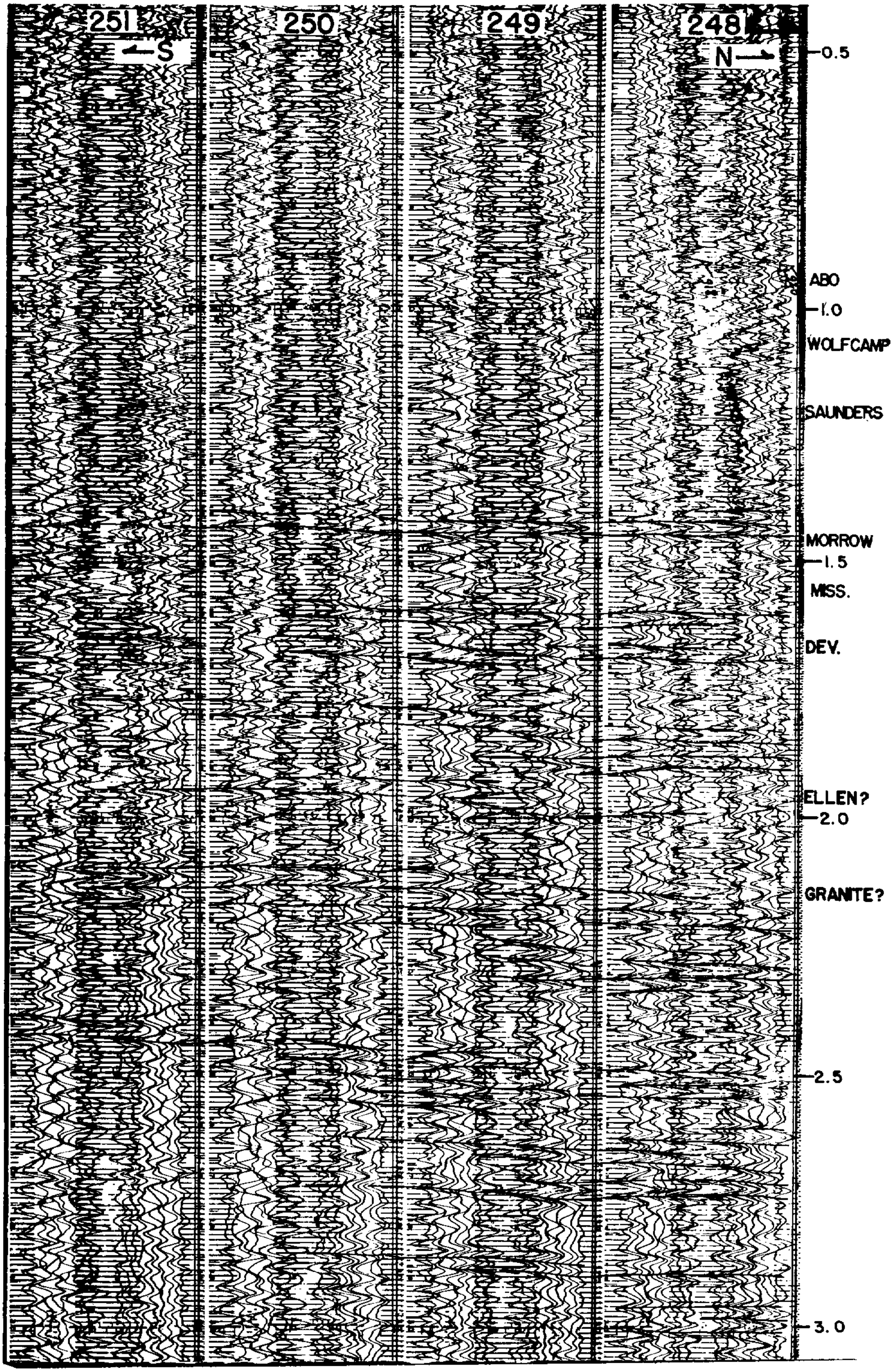

FIG. 4. Representative seismic records, Anderson Ranch area.

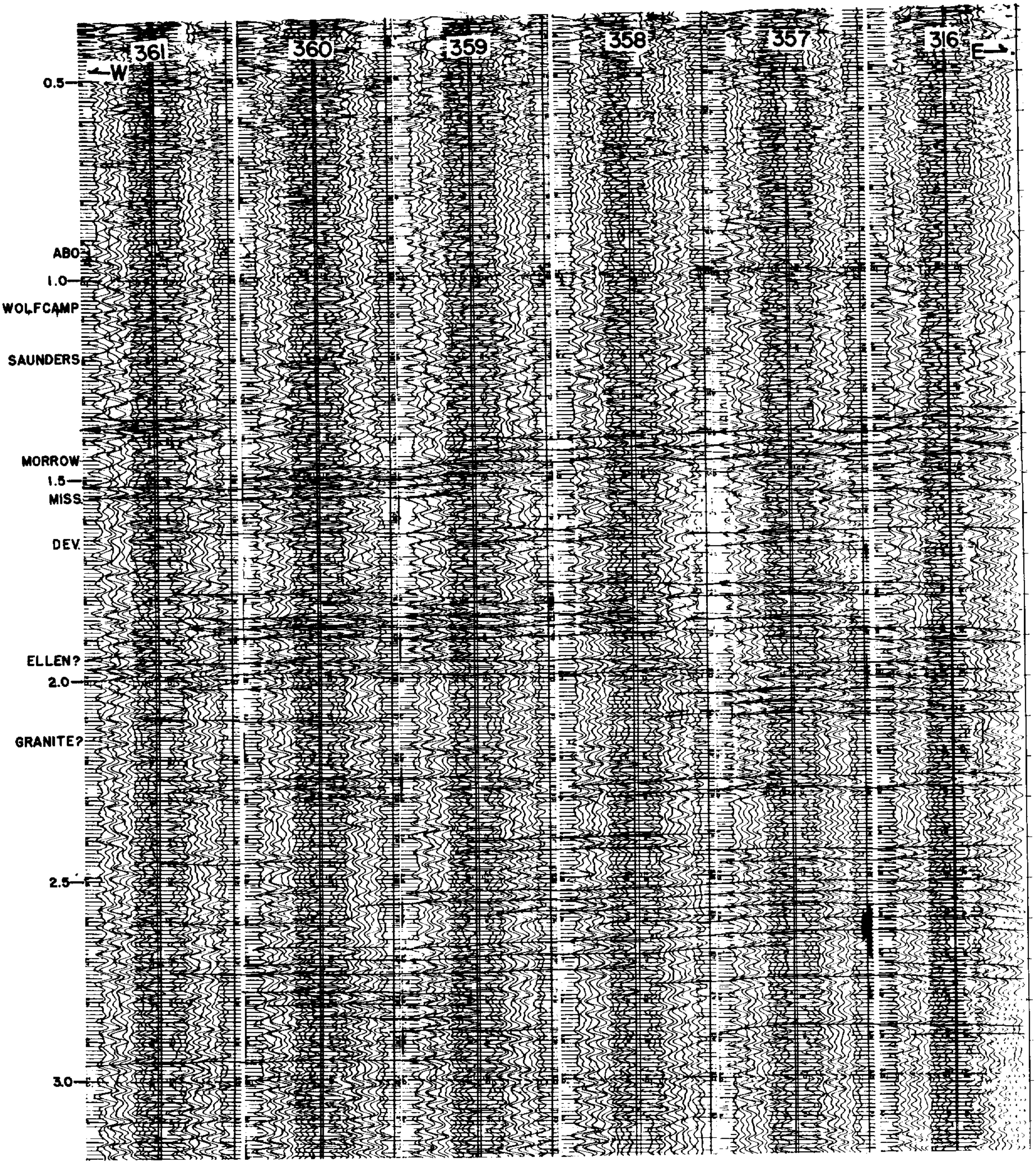

FIG. 5. Above-average seismic records, Anderson Ranch area.

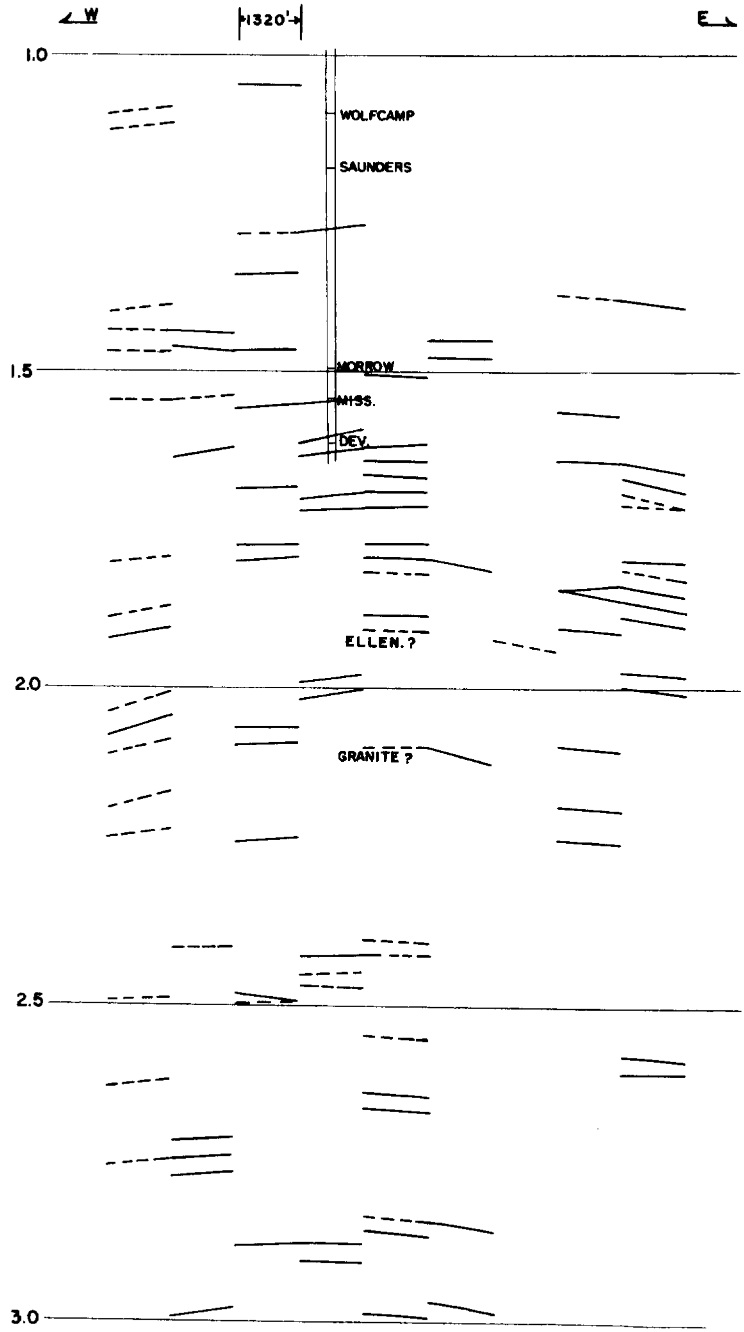

FIG. 6. West-East time section across Anderson Ranch structure.

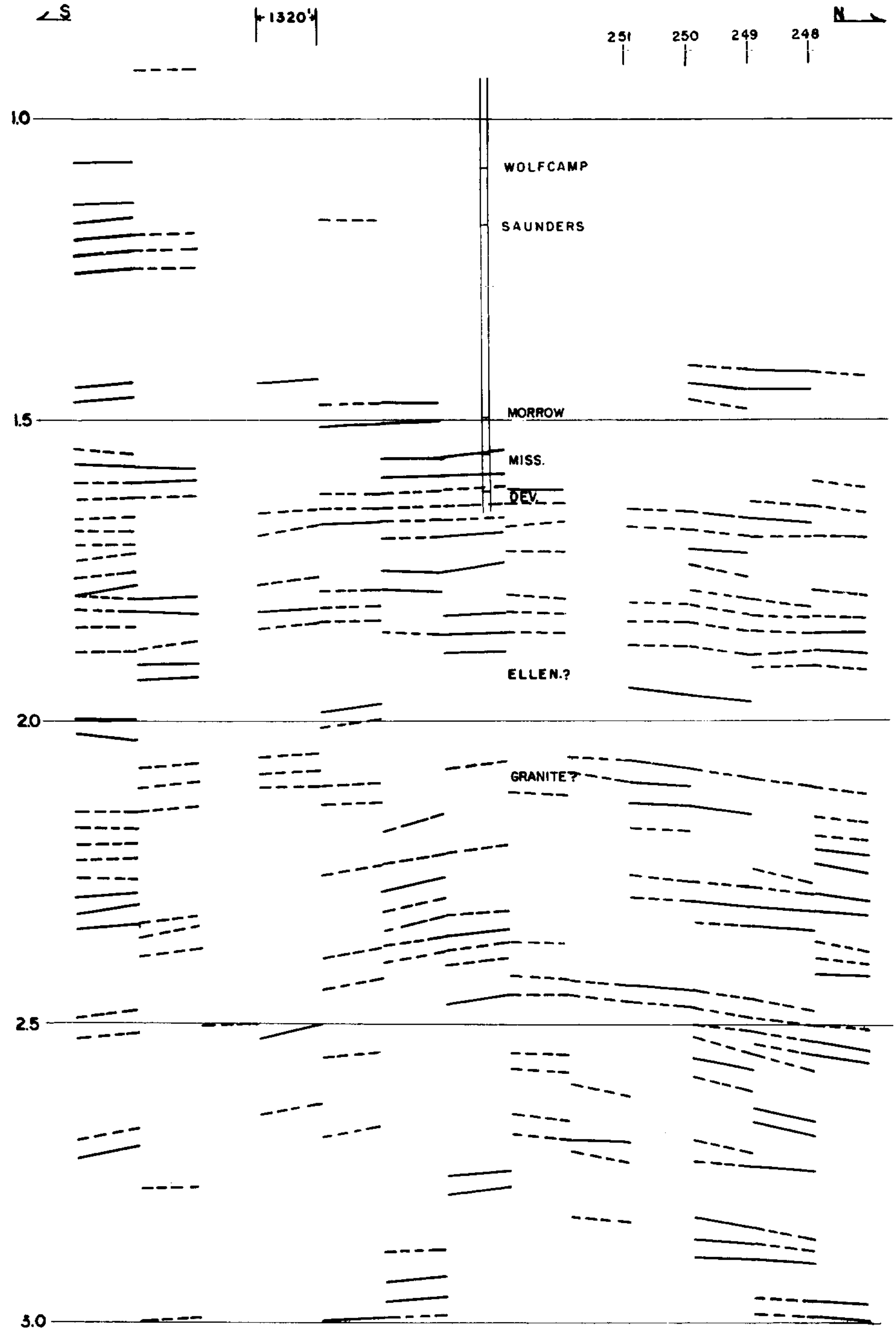

FIG. 7. South-North time section across Anderson Ranch structure.

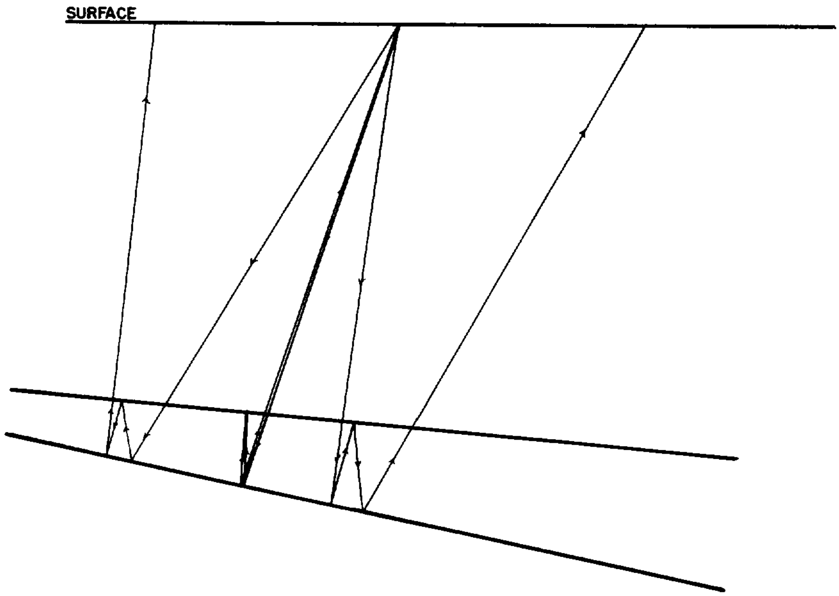

FIG. 8. Paths of multiple reflections between diverging beds. Sketch depicts a split spread setup.

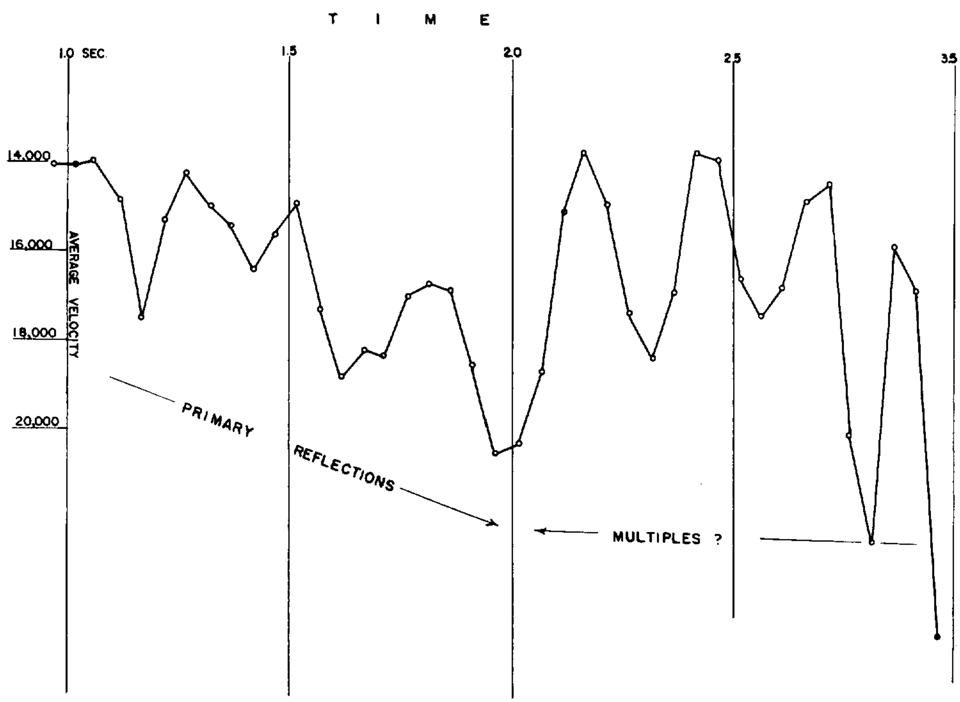

FIG. 9. Delta-T velocity determination, Anderson Ranch area.

seconds could have been caused by reflection interfaces within the basement rock, but it is believed that most of the events recorded in the range 2.1 to 3.0 seconds are multiple reflections.

If these events are truly multiple reflections, they were most likely caused by the strongly reflecting horizons in the 1.5 to 2.0 second region. It is possible that these apparent reflections could have been produced by multiples between the shallow horizons and the base of the low velocity layer. This is a favorite place for the occurrence of multiples. This, however, is believed not likely, since prominent primary reflections were not observed at shallow depths. This would indicate that low coefficients of reflection existed for the shallow horizons.

It will be observed that late events show dips which are generally in the same direction as, but somewhat greater than, dips from within the sedimentary section. The magnified dip shown by these alleged multiples suggests that these multiple reflections occur between diverging beds as has been sketched in Figure 8. In this case, both normal stepout and dip become exaggerated. That multiple reflections often show exaggerated dip has been observed by earlier authors of papers in GEOPHYSICS.[1]

Abnormally large stepout is considered an important criterion for recognizing an event as a multiple reflection. Near the close of the Anderson Ranch seismic survey, a statistical analysis of seismic velocities was prepared involving stepout readings from 397 spreads. The curve shown in Figure 9 is quite ragged, but it will be observed that this analysis showed the normal increase in velocity with depth down to an arrival time of about 2.0 seconds. Between 2.0 and 2.8 seconds, the computed velocities decreased, indicating that abnormaly large stepout did predominate late on the records. To recapitulate, multiple reflections appear to explain the persistent late events.

The maps shown in Figures 10, 11, and 12 are drawn from the original data as they appeared before drilling. The most reliable and consistent zones on the seismic records were chosen for the preparation of these seismic structure maps. Two continuous correlation maps were prepared. The shallowest map designated by "upper zone" and shown in Figure 10 was drawn for a reflection time of 1.8 seconds. This later proved actually to represent the lower Devonian. The map designated by "pre-Pennsylvanian" and shown in Figure 11 with a reflection time of 2.07 seconds probably represents basal Ellenburger limestone.

Figure 12 shows a dip map prepared from dips in the zone between 2.4 and 3.0 seconds. By converting this time zone to feet, it would appear that this zone spans a depth range of 19,600 to 24,600 feet and so lies from 2,600 to 7,600 feet below the estimated top of the granite. This map designated by "lower dip" is probably drawn from multiple reflection data. At the time the shooting was being carried out, this map was, in fact, annotated "possible multiple reflections." It must be kept in mind that this shooting was done in 1950 and that no pre-Permian holes had been drilled within the survey area, so the survey was not tied to any

[1] See articles by T. P. Ellsworth, C. H. Johnson, and J. C. Waterman, v. 13, 1948.

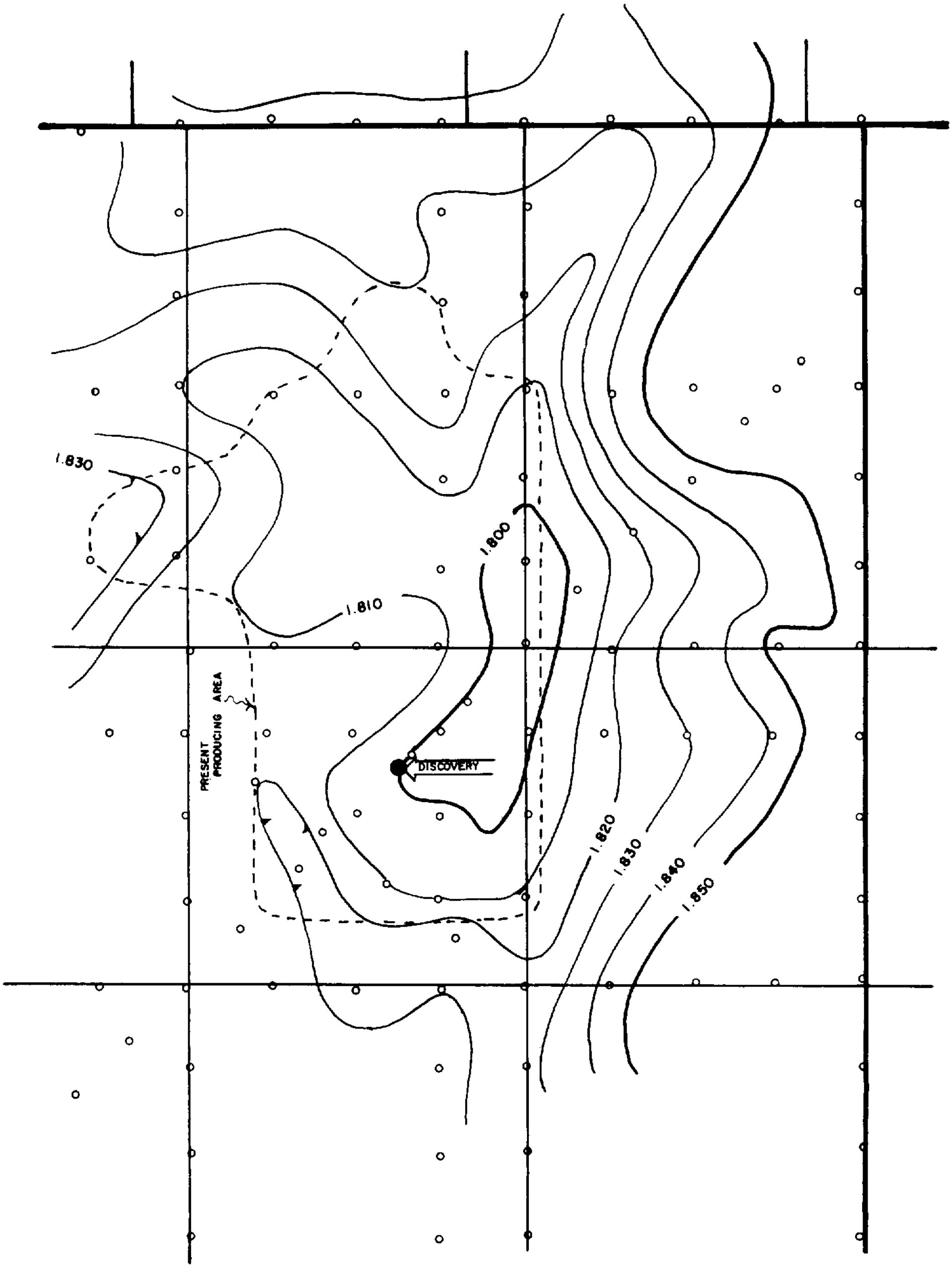

FIG. 10. Reflection seismic map of "upper zone." Subsequent drilling showed this map to represent a "lower-Devonian" horizon. Contour interval is .010 second.

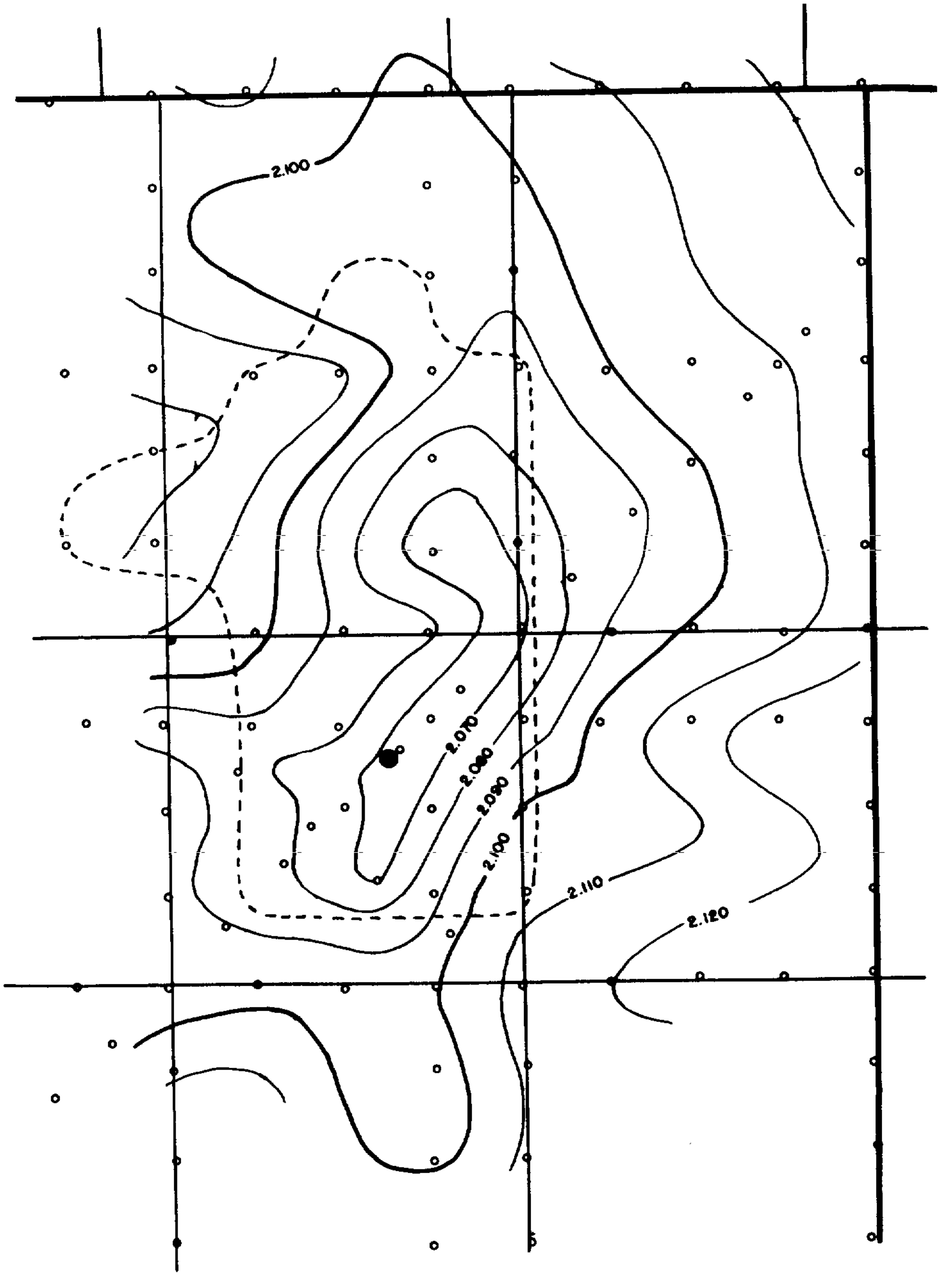

FIG. 11. Reflection seismic map of "pre-Pennsylvanian." This map probably represents a horizon near the base of the Ellenburger. Contour interval is .010 second.

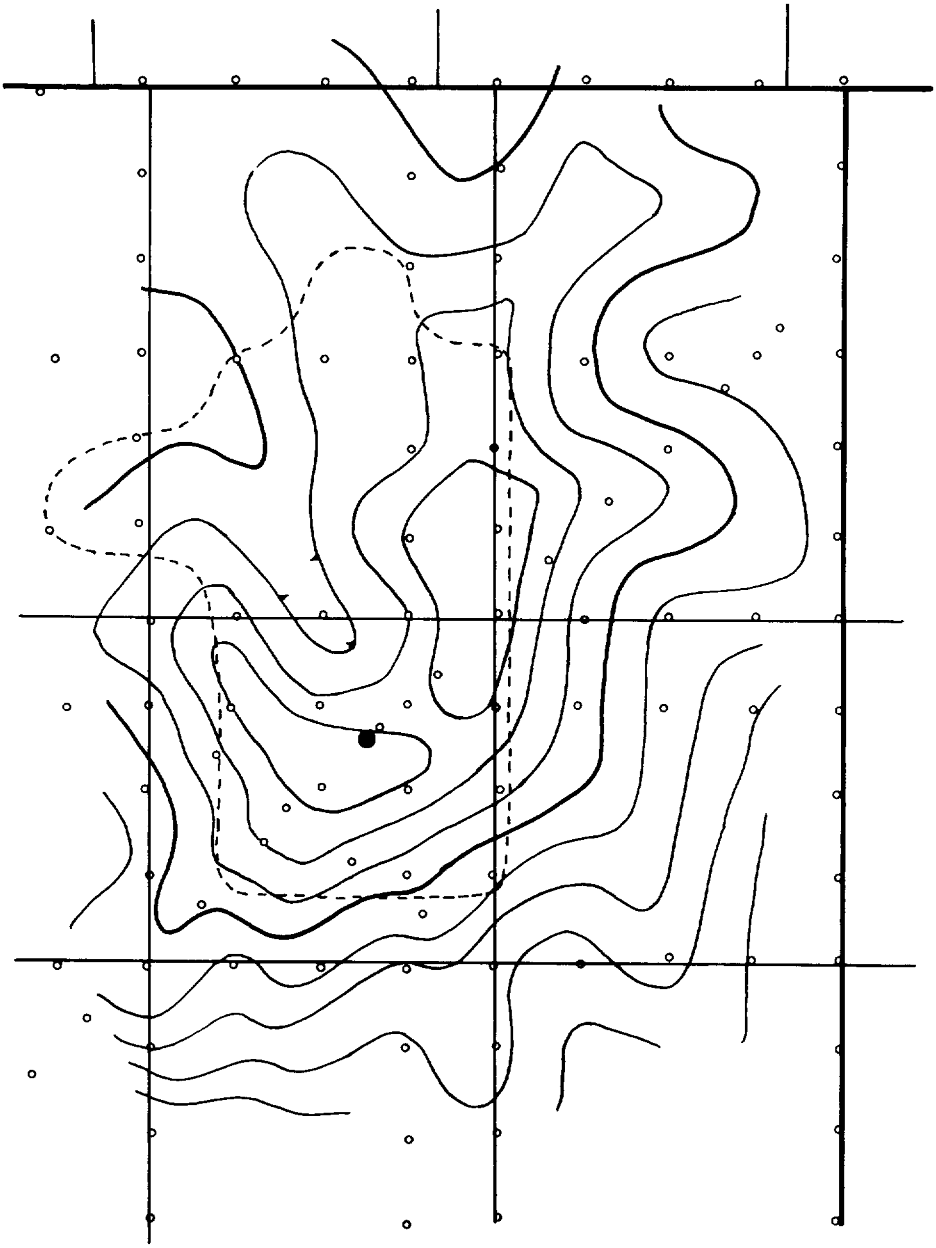

FIG. 12. Seismic dip map from the "lower dip" zone (2.4 to 3.0 seconds interval). This map is probably based on multiple reflection "dips." Contour interval is .010 second.

deep hole stratigraphic marker. It should also be noticed that this map is in close agreement with the continuous correlation maps and, in fact, is in agreement with present producing limits of the field. It will be observed that the structural relief on this map is somewhat greater than on the preceding maps. Referring again to the north-south time section across the structure as shown in Figure 7, the magnified relief in the zone represented by this map is apparent on the time section.

DISCOVERY AND DEVELOPMENT

Although many technical problems had to be met during the seismic survey, the closed anticline as mapped from the seismic data was considered worthy of a test. A "State of New Mexico" unit was formed from the acreage over the structure and a location was staked. The discovery well was spudded on June 9, 1952. The first commercial oil shows were encountered at 9,750 feet. A drill stem test carried out at this depth flowed 28 barrels of oil per hour from the Saunders formation.

The next commercial oil shows appeared in a spectacular manner on September 20, 1952 when this well blew out while preparations were being made for a drill stem test from the Bend Sand (Pennsylvanian) at 12,142 feet. After blowing for three days, the well caught fire and burned until September 27. Following extensive hole cleaning operations, drilling was resumed on this well in December. On March 11, 1953, a drill stem test from the Devonian flowed 409 barrels of 54 gravity oil through a one inch choke in 11 hours. The well was completed in Devonian dolomite in the interval 13,374 to 13,474 feet for an initial potential production of 1,968 barrels of oil per day.

Development drilling has resulted in eight Devonian producers and 14 Saunders "lower Wolfcamp" producers on the Anderson ranch structure. The greater part of the field was developed on 80 acre spacing with Devonian and Saunders wells alternating. Figure 13 shows the present Wolfcamp subsurface structure. The present Devonian subsurface structure is shown in Figure 14. The contour interval is 20 feet. It should be noticed that the verified Devonian subsurface structure is of only 100 feet relief.

This field is at present producing 3,600 barrels of oil per day. Two-thirds of the production is Devonian and one-third is Saunders production. Cumulative production to December 1, 1956, less than four years after completion of the discovery well, has been 3,327,000 barrels. It is quite evident that an important oil discovery has resulted from the exploratory efforts at Anderson Ranch despite very poor data and despite technical puzzles which have never been entirely resolved.

I wish to thank the Continental Oil Company for permission to publish this paper and I wish also to thank my many associates in the Continental Oil Company for advice and for historical information.

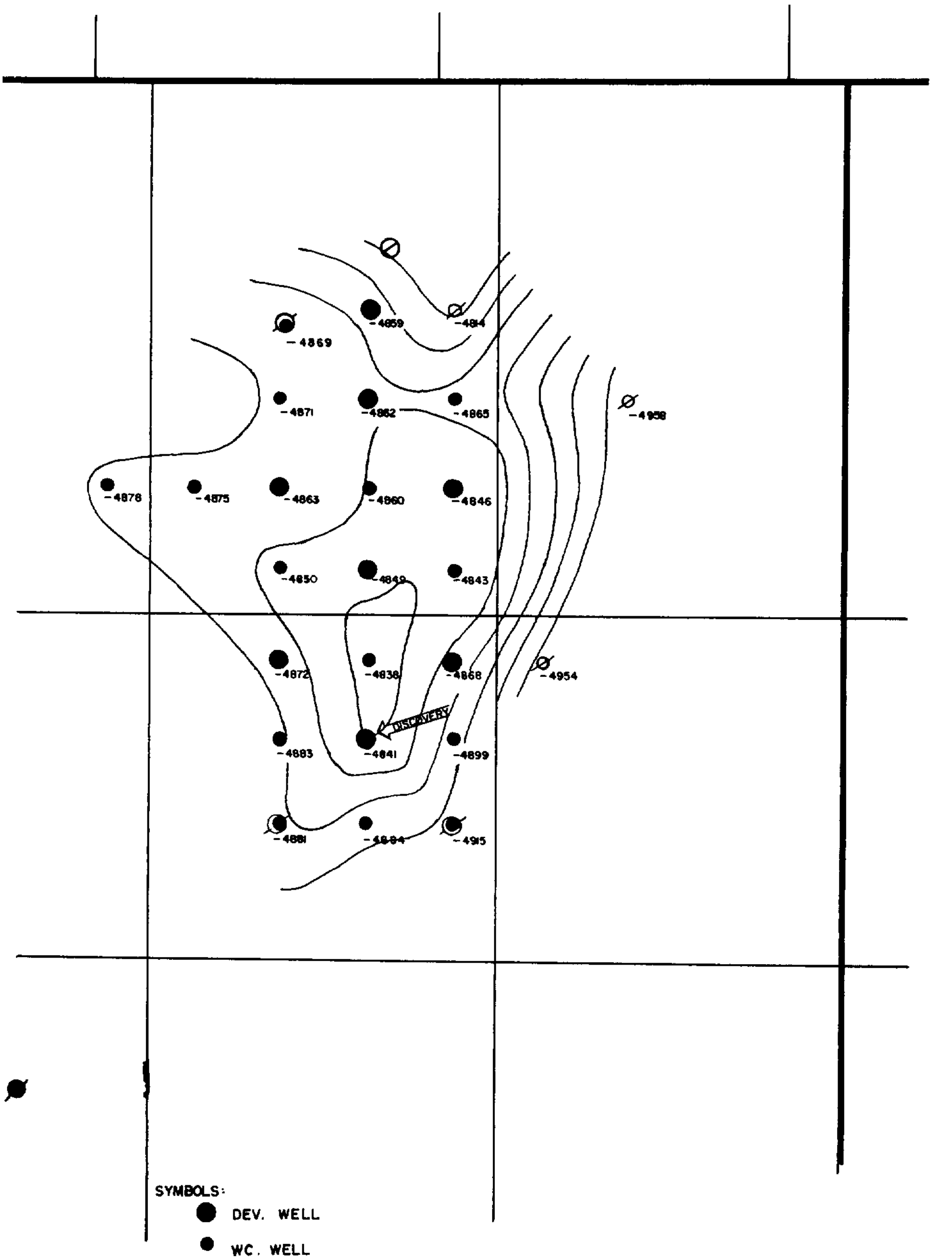

FIG. 13. Subsurface structure map on the Wolfcamp (electric log marker). Contour interval is 20 feet.

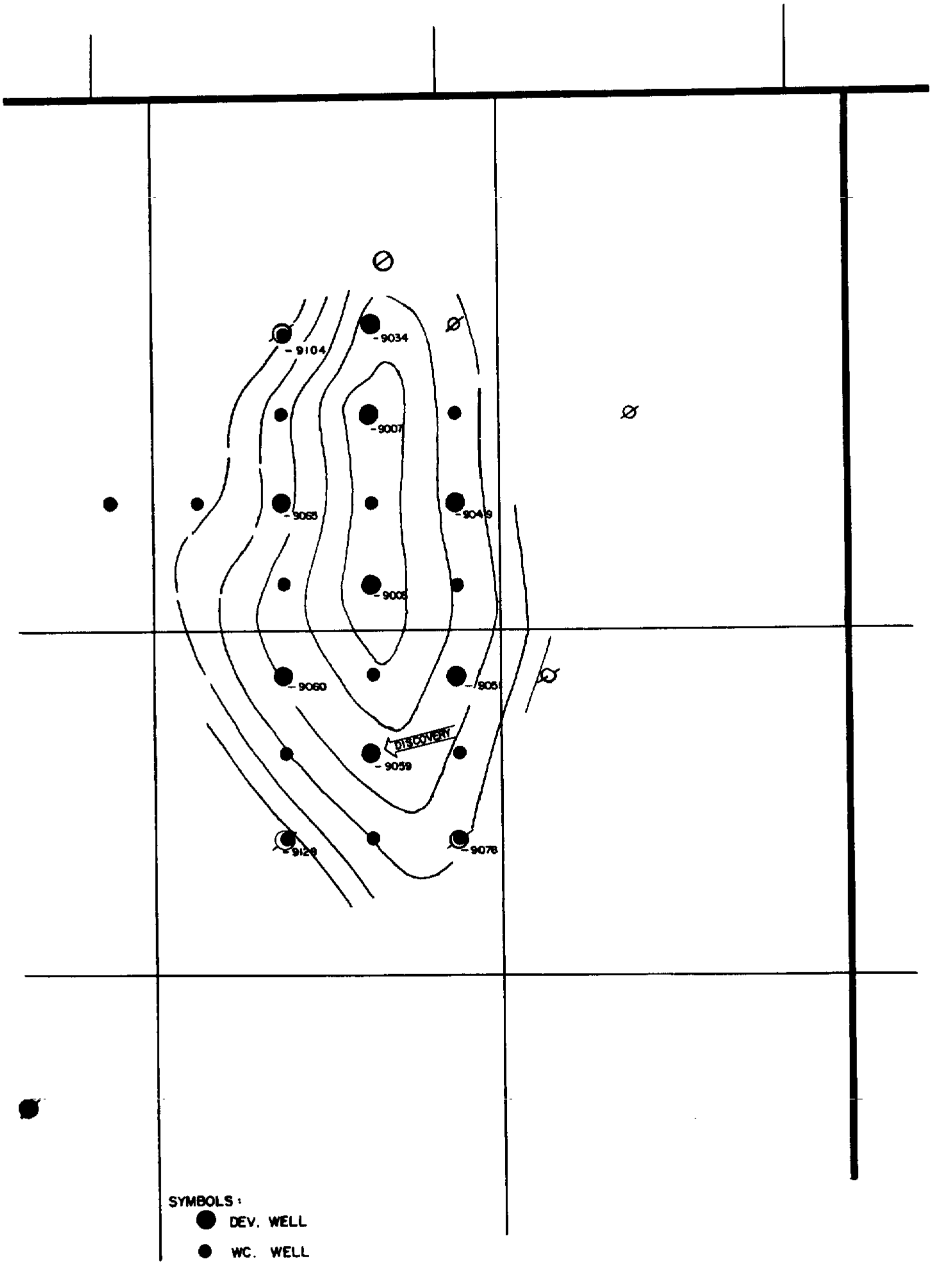

FIG. 14. Subsurface map on the top of the Devonian. Contour interval is 20 feet.

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