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STRUCTURAL ANOMALIES IN THE ESPAN OLA BASIN

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INTRODUCTION

Over the past decade, the tectonic basins of the Rio Grande rift have been the focus of an expanding interest in oil and gas exploration. This is primarily due to the recognition of the potential for Cretaceous oil and gas production in these areas. The Cretaceous section has good source rocks and reservoir-quality sands in certain parts of these basins, and this section has probably been buried to levels of organic metamorphism which are high enough for the generation of commercial quantities of oil and gas.

The tectonics of formation of the rift basins have provided abundant potential for structural traps. This structural activity, in conjunction with the stratigraphic variation in the Cretaceous package, makes a double-trap potential in those areas where the rifting has not been severe enough to have destroyed the reservoirs. In some areas, the tectonics have worked against economic oil and gas production by dropping the rocks so deeply that any organic matter has been "overcooked." The last decade of exploration (Black, 1984) has added greatly to the understanding of the rift itself, as well as its tectonic style and the stratigraphy of the contained rocks. Primarily as a result of the recent detailed mapping by a host of excellent workers too numerous to list, as well as the recent oil and gas exploration efforts along the rift, some interesting and previously unsuspected structural styles are now being documented.

DISCUSSION

Of particular interest has been the recognition of probable significant Laramide thrust faulting preserved within the Espanola Basin (Fig. 1) portion of the rift. In 1976 through 1979, TransOcean Oil Company acquired over a hundred miles of seismic reflection data on certain areas of this basin. Although of relatively good to excellent quality, much of the data originally presented more questions than answers. As a result of early misconceptions and preconceived ideas, much of the data was ignored or misinterpreted. For example, large areas of the basin were assumed to be filled primarily with Tertiary basin fill. Because of such assumptions, these areas of the rift were also assumed to be less (or non-) prospective for oil and gas exploration. In retrospect, some of these areas may have good potential.

The exploration drilling in the southern portions of the Espanola Basin (Santa Fe embayment) has confirmed the presence of significant thrust faulting in the Cretaceous. In this area, seismic data originally

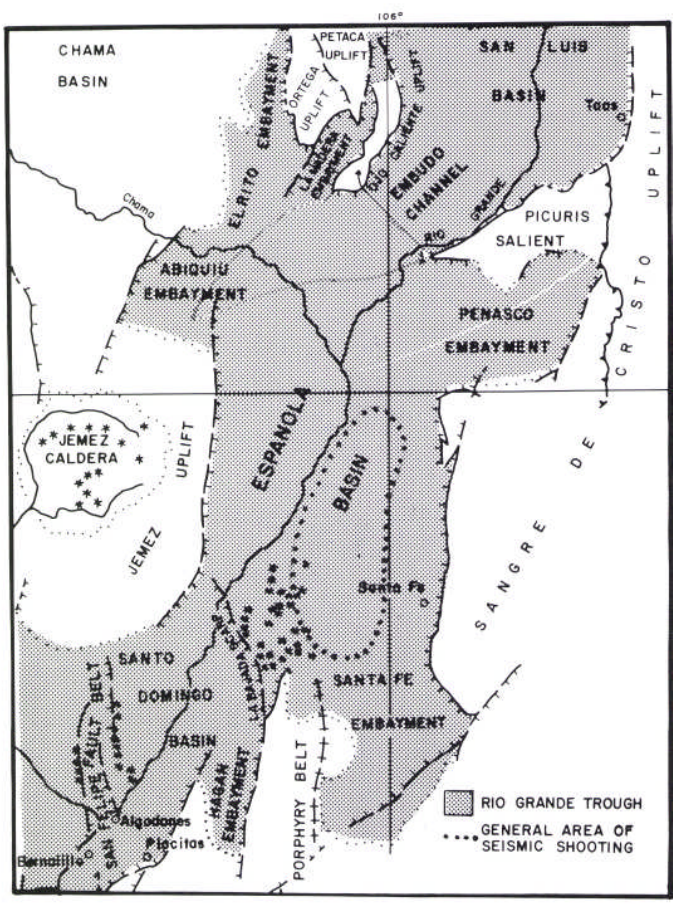

FIGURE 1. Tectonic diagram of a part of the upper Rio Grande area. Adapte from Kelley (1954) and Dane and Bachman (1965).

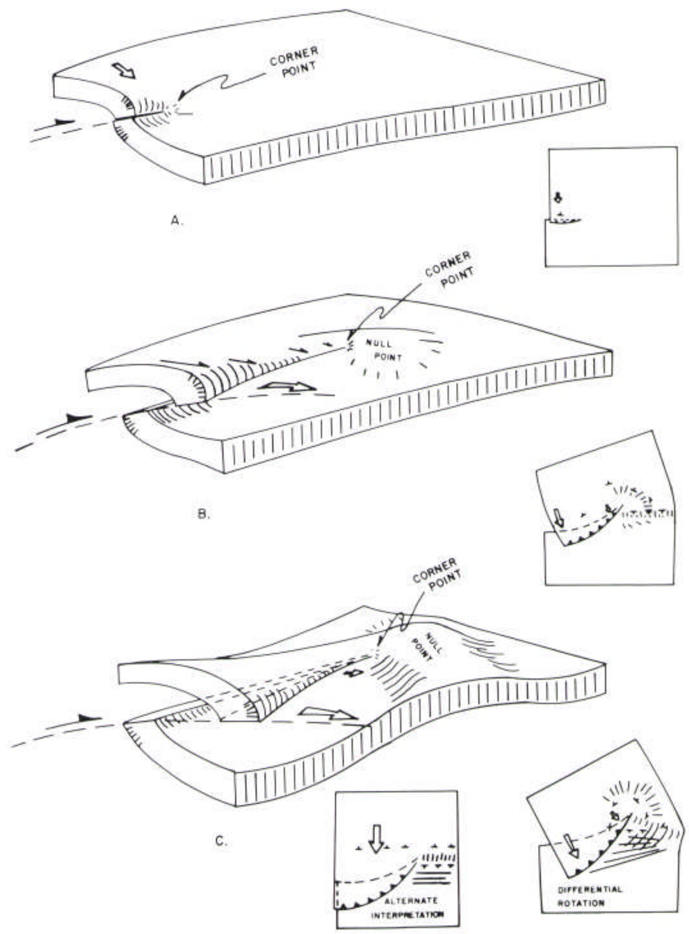

FIGURE 2. Simplified block diagrams showing progressive detachment and rotation of thrust sheet around corner or "null" point and area of uplift.

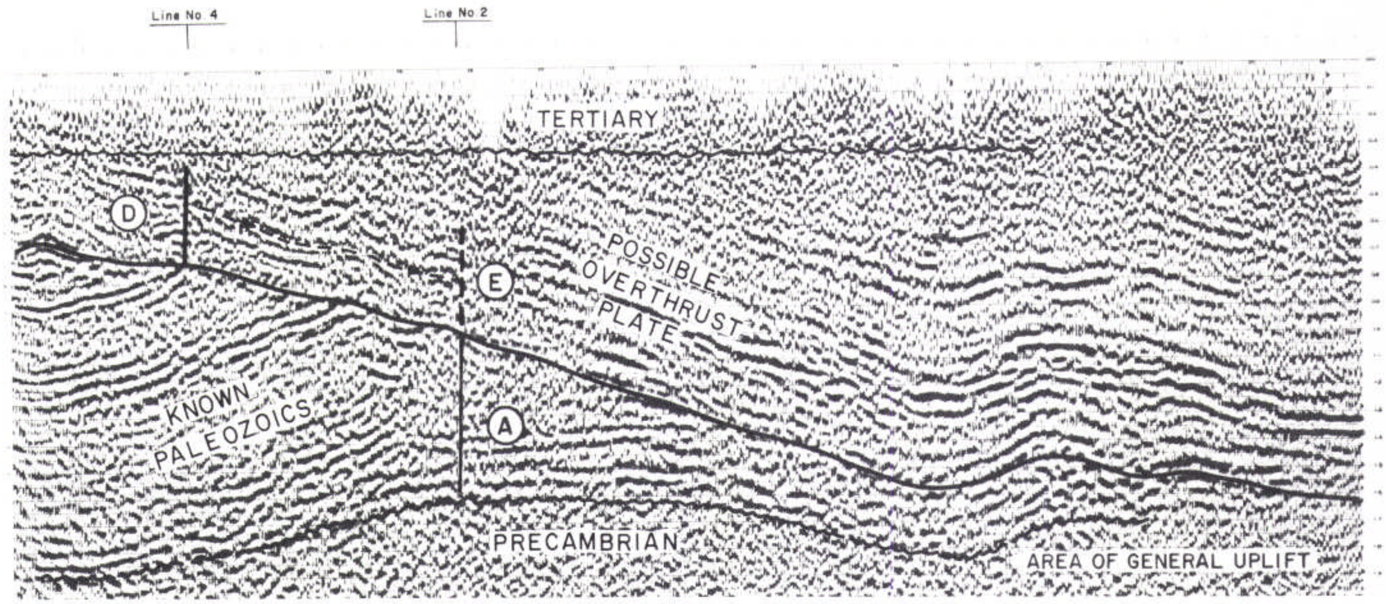

FIGURE 3. Seismic line no. 1.

thought to be "noise" are now recognized as real data. The integration of information on water-wells and core-holes which bottomed in Paleozoic rocks, along with the growing wildcat-well control and a logical reconstruction of the pre-rift geologic history of the basin, strongly suggests that the Laramide thrust faulting (so well demonstrated in the Paleozoic and Precambrian rocks of the Sangre de Cristo Range east of Santa Fe) should also be present and preserved in areas of the rift.

If Laramide thrusting has taken place here, evidence of it should be preserved in the downthrown Paleozoic and Mesozoic sections beneath the Tertiary sands and gravels of the rift grabens. Although thrusting is now confirmed in the Cretaceous section by both seismic and well data, definite evidence of it in the Paleozoic section awaits confirmation by drilling. Seismic data strongly suggest, however, that Paleozoic rocks are involved.

TENTATIVE SEISMIC INTERPRETATIONS

Figure 2 shows progressive detachment and rotation of a thrust sheet around the corner point of a thrust fault.

In the Espanola Basin, unique documentation of this structural style is suggested in the Paleozoic rocks at the termination of what appear to be thrust faults. In the basin east of Los Alamos, it is possible to run seismic lines across an area where an apparently in-place and unthrusted Paleozoic section becomes detached and is thrust over itself to varying degrees along the fault.

On subsequent crossing and subparallel seismic lines (which form a seismic loop), it is possible to correlate from the lower Paleozoic plate laterally out of the first seismic section onto a perpendicular line which passes into the "corner point" area. We can then correlate parallel to the first seismic line on a third seismic section passing out of the "corner point" onto a fourth section. Correlations on this line can be made back to the original line where one apparently emerges in an upper Paleozoic plate above the original starting place—an obvious mistie. Although the correlations do not tie, they are nonetheless apparently correct, and in this sense the lines in fact do "tie."

Such a geologic puzzle reminds one of the MObius strip where observers can start on one side of a MObius loop at any point, and by going once around the loop find themselves on the other side of the loop.

Figures 3 through 6 are portions of seismic lines in the Espanola Basin. Because of ongoing exploration, the precise location and orientation of these lines cannot be shown. The correlations on the lines are tentative and the conclusions are those of the author only; however, the ramifications of these correlations, if correct, are considerable.

Beginning in known Paleozoic strata on line I (Fig. 3) at section A and correlating from this point on a perpendicular seismic line 2 to section B (Fig. 4), we can turn parallel to line 1 on seismic line 3 (Fig. 5) and correlate to section C where line 3 (Fig. 6) crosses line 4. We can then correlate back from section C to the original line 1 along line 4 to section D. If we now correlate back toward point A on line 1, we find ourselves at point E in an "upper" plate—and yet our correlations have seemed reasonable and continuous.

What we may have done, in effect, is to accurately tie our seismic net across low-angle thrust faults and through what at first appeared to be a mistie. In reality, our seismic lines may have been shot across both the thrusts and the "corner" point, and our correlations are actually correct. If so, we are not mistied at all—we are in a sense simply halfway through a seismic Möbius strip—back on the line where we began but on the "other side" (in this case, the top side) of the loop.

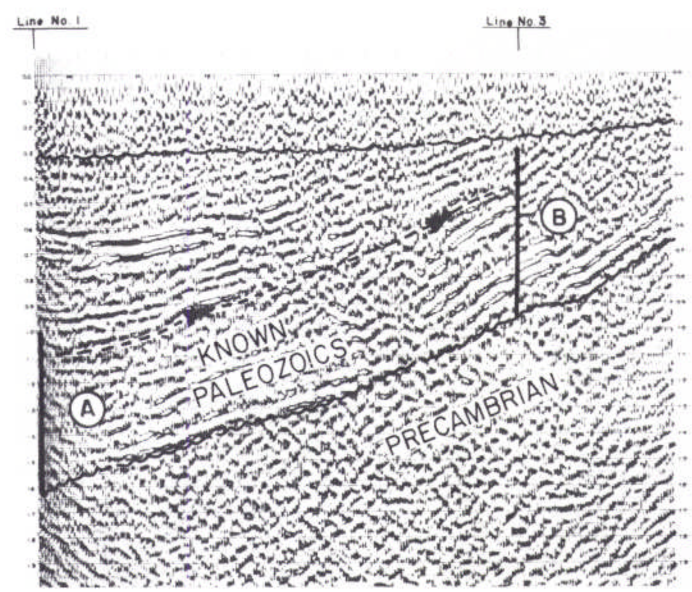

FIGURE 4. Seismic line no. 2.

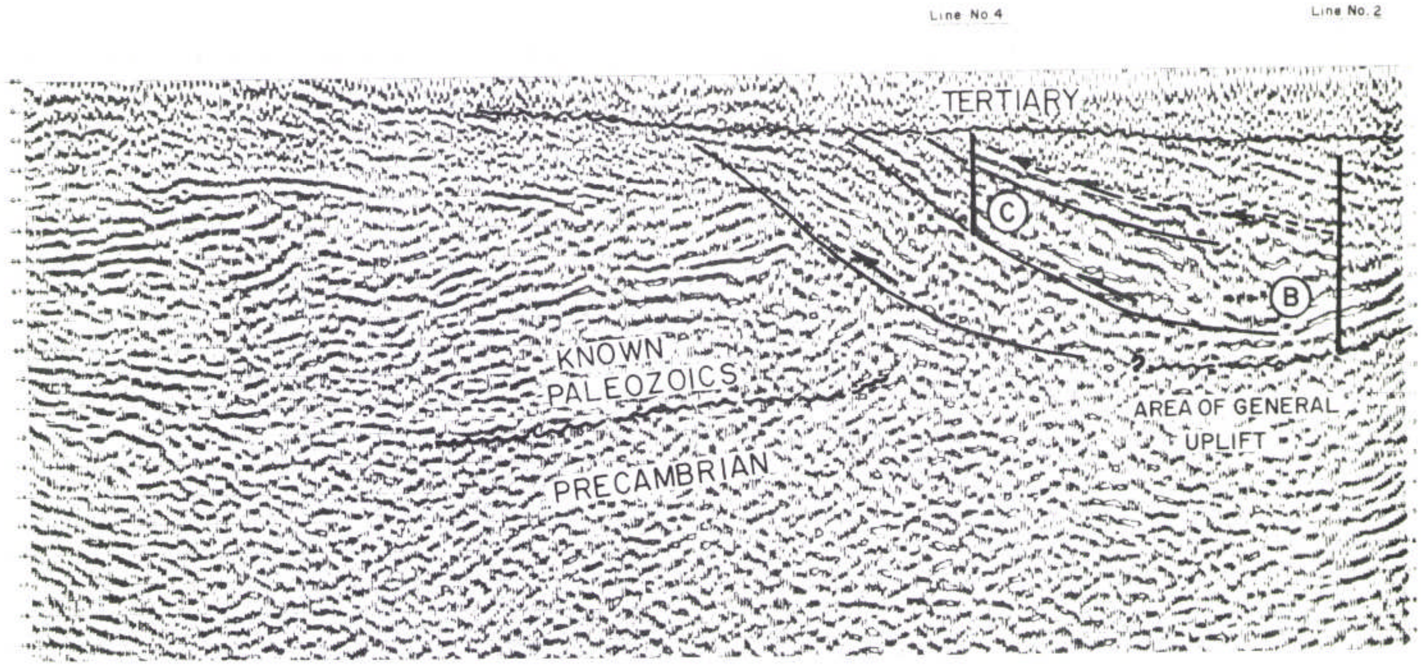

FIGURE 5. Seismic line no. 3.

Figure 7 shows the relative location of the four seismic lines in relation to the thrusting and the "corner point."

Figures 3 through 6 are the actual lines which forced our reconsideration of the sediment package and thus the possible structural configuration in the Paleozoic rocks of the Espafiola Basin. A fifth line (Fig. 8) dramatically shows the nature of the suspected imbricate thrusting as well as part of the corner point, and can also be tied into the seismic net with the same accurate "misties" as demonstrated above. Seismic line 1 in Figure 3 shows the sole thrust well, and Figure 8 shows a splay of imbricate thrusts as the corner point is approached. Note also how the basement and overlying rocks are generally uplifted as one approaches the corner point.

Nowhere within the basins is thrusting observable in outcrop within the Paleozoic section. However, the shallower effects of Laramide thrusting can possibly be seen in outcrop where both Cretaceous and basal Tertiary Galisteo sediments have been folded sharply and thrust-faulted in the area from the town of Galisteo southwestward to at least as far as the old Cash Ranch. Some early workers (Stearns, 1953; Lisenbee, 1976) have reasonably assumed deformation in the Cretaceous in this area had been caused by shale diapirism. Others (Black, 1979; Lisenbee and others, 1979) inferred the tectonic style as being more indicative of compressional tectonics and representing local thrust faulting.

Both seismic and well control now strongly suggest that a major component of early movement was probably due to Laramide compression, although local deformation of the sediments due to compression associated with lateral movements along the San Lazarus, Los Angeles, and Lamy faults may very well be important. This zone which underwent deformation in Precambrian and Paleozoic times (Lisenbee and others, 1979) may have served to focus the effects of Laramide thrusting on the Cretaceous rocks.

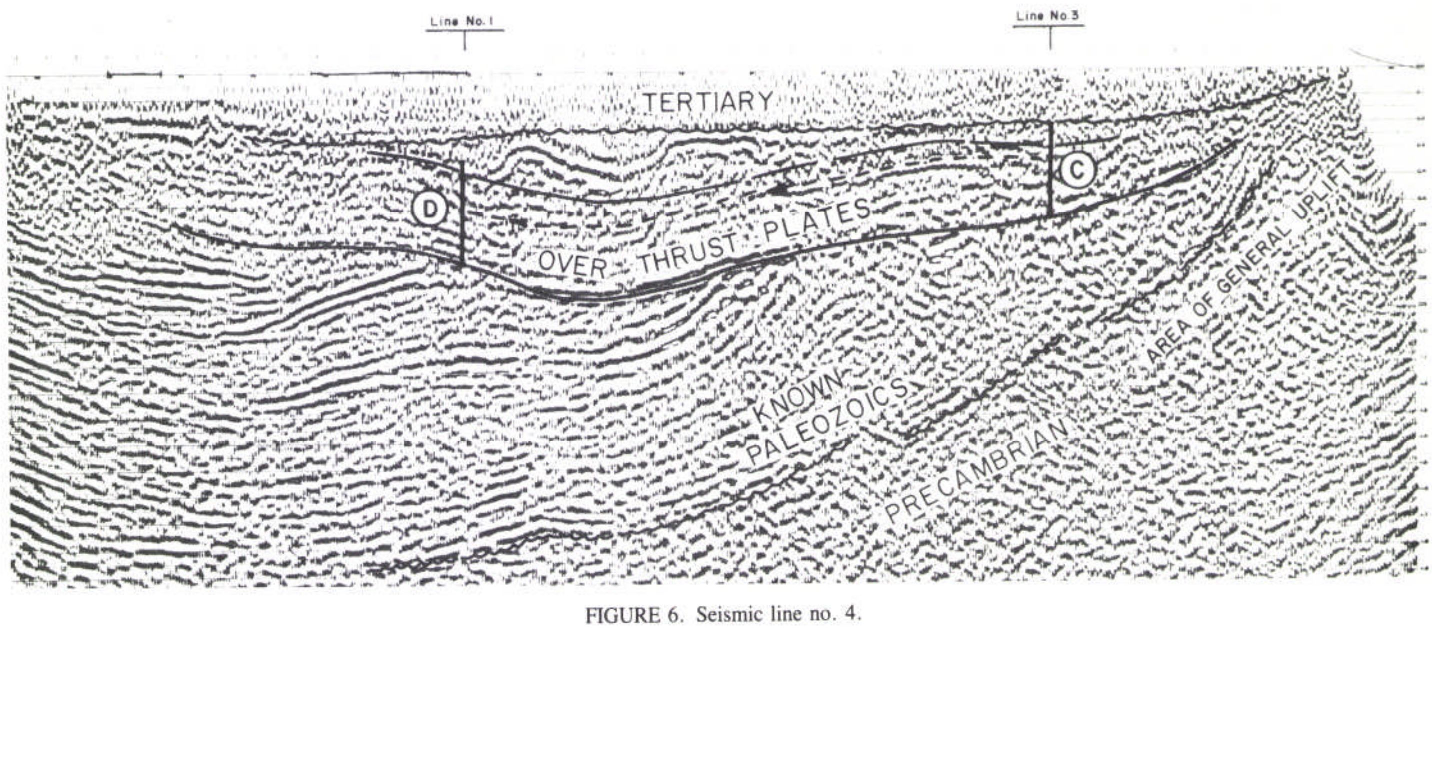

FIGURE 6. Seismic line no. 4.

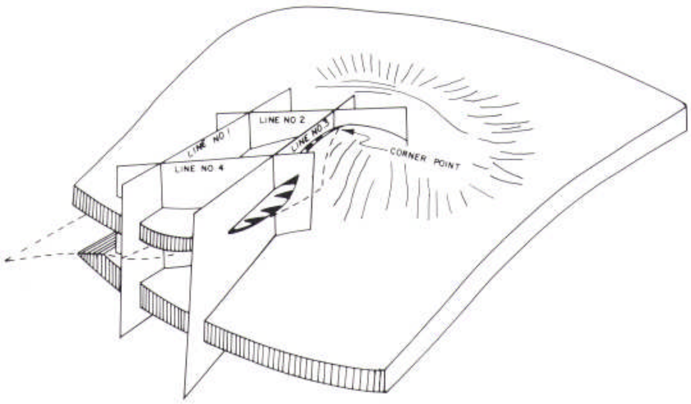

FIGURE 7. Block diagram showing relative location of seismic lines to thrust sheet and corner point.

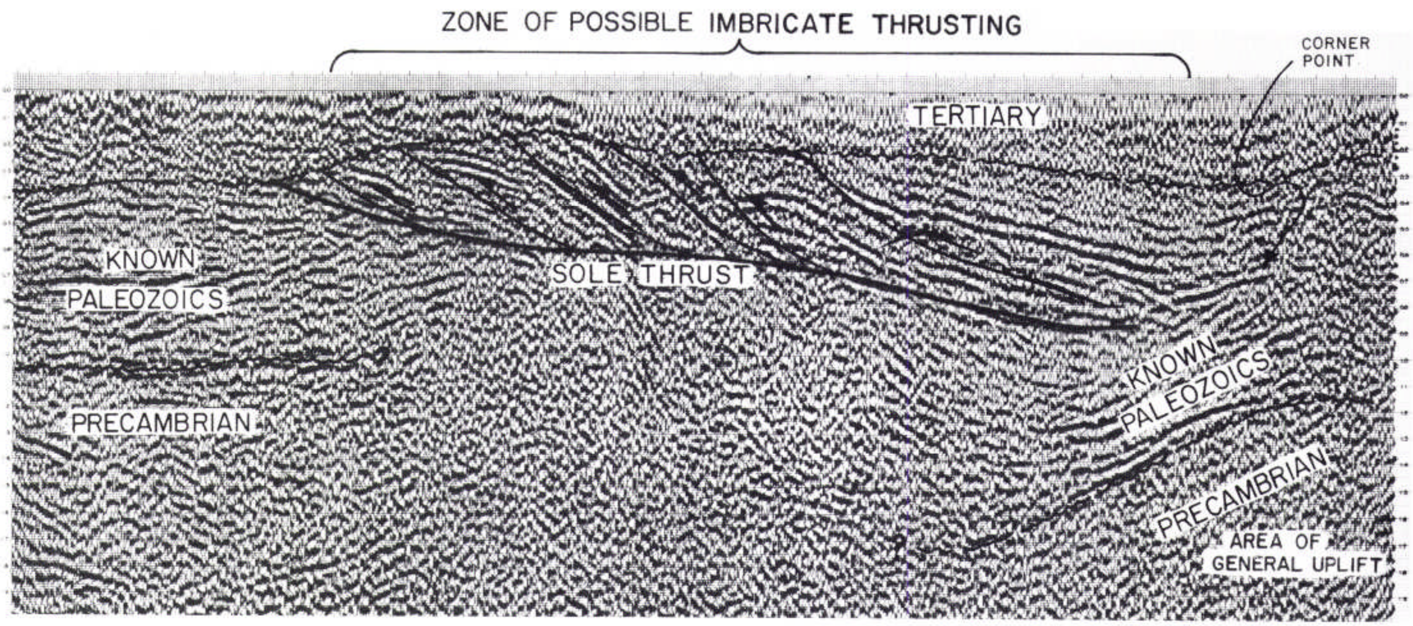

FIGURE 8. Seismic line no. 5. Note that area of general uplift coincides with termination of sole thrusts and imbricate thrusting at the apparent corner point.

CONCLUSIONS

Strata that were originally assumed to be Tertiary basin fill lying on Precambrian rocks may actually consist of imbricately thrust Mesozoic and Paleozoic rocks overlying an undeformed Paleozoic section. The whole Mesozoic and Paleozoic section may have been thrust over itself during Laramide deformation and then covered by a mantle of Tertiary sands and gravels in most of the Espanola Basin.

ACKNOWLEDGMENT

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