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Economic Impact of Limited Three Dimensional (LTD) Seismic Acquisition in a Complex and Expensive Exploration Setting

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Summary

In geologically complex fold and thrust terrains, recording conventional 2-D seismic is often so expensive that exploration companies acquire the minimum amount possible, any more being economically difficult to justify. Under these circumstances 3-D seismic data is often perceived as financially unreasonable, especially in the exploration phase of an evaluation. Such was the case for Mobil and partners in the Amazon rain forest in 1996 in an area known to be structurally complex. Under these conditions Mobil executed a 'Limited [low fold] Three Dimensional' (LTD) seismic survey. The incremental cost of acquiring the 128 km^2 LTD volume was approximately 5% of the cost of the conventional 2D data that was acquired to delineate the structure. Later interpretation of the volume resulted in decreased drilling costs, additional 'proved reserves', and better understanding of the complex internal structure drilled.

Introduction

Earliest documented 3-D surveys were described in the 1972 in a paper entitled 'Three Dimensional Seismic Method', G. G. Walton, Esso Production Research Company. This early 3D survey consisted of one shot line and an orthogonal receiver line as shown in Figure 1.

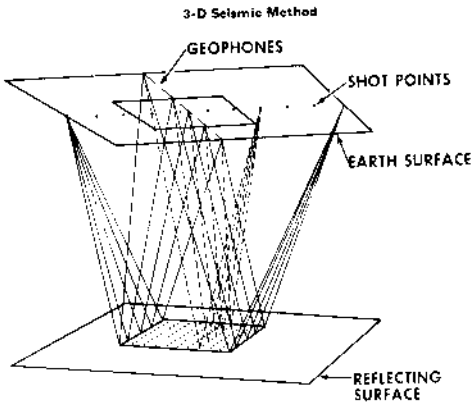

Figure 1. Raypaths into an early 'X-spread' 3D recording geometry. G.G. Walton, 1972

Mobil's LTD survey recorded in 1997 consisted of five consecutive single fold patches acquired at the intersections of a strike line with each of five dip lines along the strike of a major structure. The individual patches were processed and later merged to form a single 128 km^2 volume of single fold 3D data. Figure 2 illustrates recording geometry of the modern LTD compared to the earliest documented 3D.

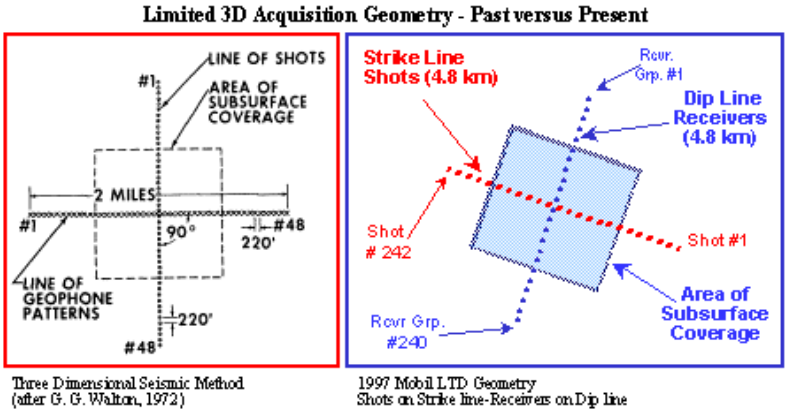

Figure 2. Recording geometry of the modern LTD compared to the earliest documented 3D.

Results

Modern processing techniques applied to the single-fold data resulted in a 3D volume that demonstrated the three dimensional nature of the structure more accurately than extrapolation between two-dimensional lines. At first glance the LTD cross-line appears much noisier and lacks continuity, but closer examination reveals the internal geologic complexity to be consistent with compressional structures of this type. Figure 3 is a comparison of the 2D data and the corresponding 3D cross-line.

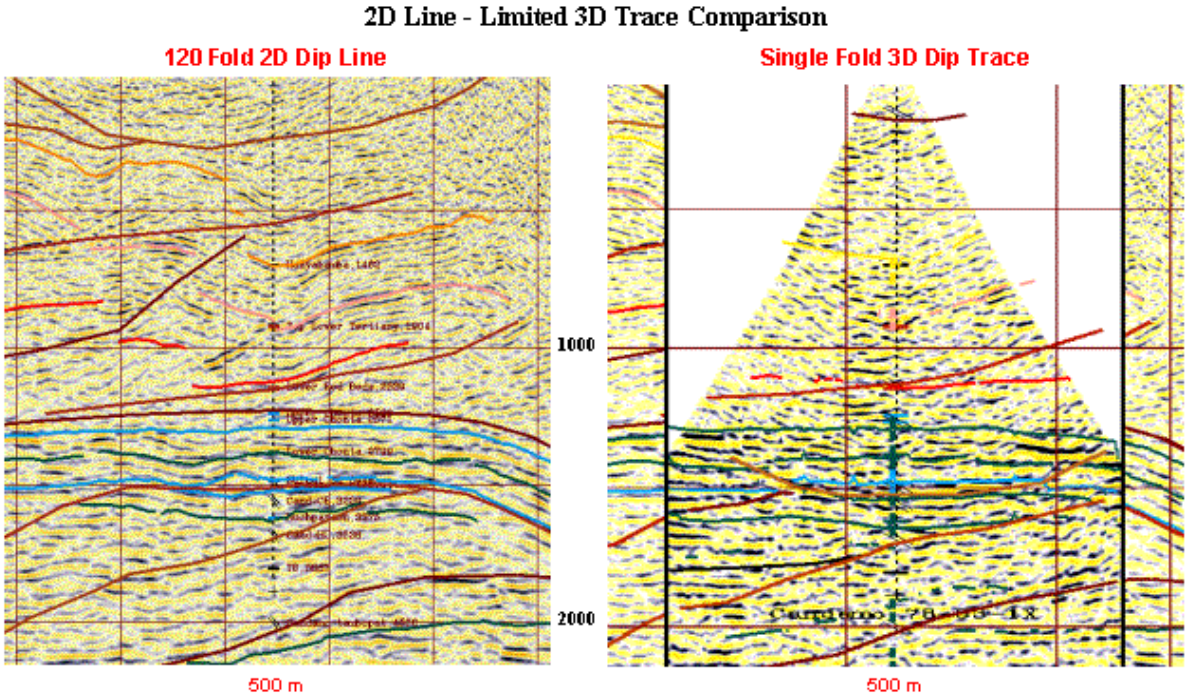

Figure 3. 2D Line compared to equivalent Limited 3D cross-line.

Internal to the structure, the LTD volume exhibited numerous structural complexities not apparent on the 120-fold high quality 2D data. Another cross-line, extracted from the survey over 500m off of the recording line, clearly illustrates internal structures below a roof fault, which would not be imaged by the existing 2D lines (Figure 4). Acquiring the survey at a later time with an increased acquisition effort may have yielded better overall data quality and improved reservoir description capability, but at a significantly higher cost.

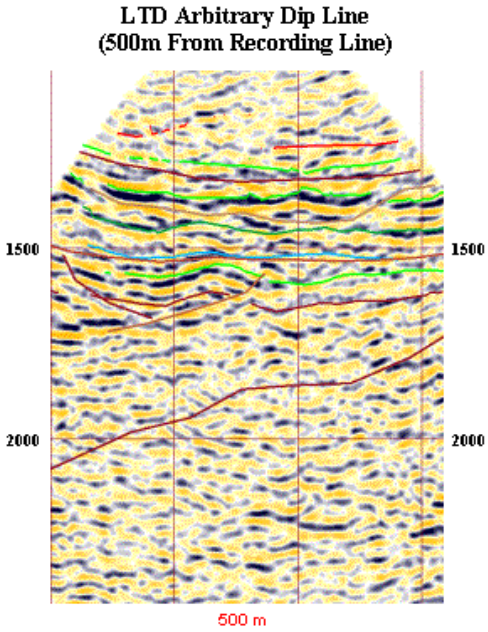

Figure 4. LTD cross-line 500m from 'dip' recording line illustrating internal structures not imaged on 2D lines

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Conclusions

While the image quality was below what is generally expected from 3D data, there were positive technical and economic benefits, including:

- Improved ability to predict small faults and internal complexities in the reservoir prior to drilling, which improved planning and drilling of well.
- Improved imaging below proposed TD, which reduced drilling time. (The LTD data imaged a target fault below contract drill depth that was not resolved on 2D data.)
- Improved imaging of internal complexities at reservoir level, which in turn, resulted in greater accuracy of 'proved' reserve calculations (post drill).

Acquiring the survey at a later time may have yielded better data quality, but the economic benefits in this case justified acquiring the survey at the time the 2D recording was being carried out. Assuming a cost of US $100,000 per patch inclusive of processing, the LTD savings based on saving 5 days of drilling at $80,000 per day was $400,000. Assuming a 12% 'Minimum Return on Investment Required', the Net Present Value (NPV) on the incremental investment of $100,000, for a single LTD seismic volume, while drilling the well 2 years later, would be $220,000. With modern surveying, acquisition and processing techniques the resulting data could easily be merged with any subsequent 3D seismic data acquired to evaluate a discovery on the structure and build an integrated reservoir model.

References

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