FAULT SLICING IN THE INTERPRETATION OF FAULTS IN SEISMIC DATA PROCESSING IN ATALA PROSPECT OF RIVER STATE, NIGERIA

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ABSTRACT

Faults are of high interest in petroleum development and production because they segment a reservoir. As a result of the role faults play in the entrapment of hydrocarbons, the techniques for finding and mapping them have considerable practical importance. A fault slice is a section sliced from a 3 – D data volume parallel to the interpreted position of a fault plane and can be used in several ways for the study of faults. The tracking of horizons on fault slices provides a map of fault thrown. Since a fault slice is found within one fault block, it becomes necessary in the study of growth in that block. There exist splinter faults that cause a lot of difficulty in horizon tracking because the data under study experiences small throw faults of limited laterial extent spawned by the major growth faults or parent fault. These splinter faults are secondary faults caused by movement on parent fault. A lot of Splinter faults were identified in the area of study and the azimuths of the Splinter faults relative to the parent fault are fairly constant.

Keywords: Faults, fault slicing, Seismic data, fault plane, growth fault, splinter faults.

INTRODUCTION

Fault is a displacement of rocks along a shear surface. The surface along which the displacement occurs is called the fault plane. The trace of a fault is the line which the fault plane makes with a surface. Faults are classified as normal, reverse, or strike-slip, depending on the relative motion along the fault plane (Sheriff, 1990). These exist a fourth fault associated with plate movement known as transform fault.

When subjected to stresses; rocks may fault, fold or flow depending on the magnitude and duration of the stresses, the strength of the rocks, the nature of adjacent rocks etc. The folding of rocks into anticlines and domes provides many of the traps in which oil and gas are found.

The evidence of faults in Seismic data could be seen by (a) abrupt termination of events, (b) diffractions, (c) changes in dip, (d) distortions of dips seen through the faults, (e) deterioration of data beneath the fault producing a “shadow-zone” (ff changes in the pattern of events across the fault and (g) a reflection from the fault plane.

The detection of faulting on seismic record sections can be quite easy under favourable conditions. The indications, identification and inclination of such features can be quite challenging. As a result of the role faults play in the entrapment of hydrocarbons, the techniques for funding and mapping them have considerable practical importance. If discontinuities are well defined, the position of the fault trace may be highly evident on the record sections. The detection and mapping of thrust faults is based on divergences between reflection s as well as on the repetition of identifiable reflections above and below the thrust plane (Dobrin, 1976). Fault identification and tracing surfaces could be seen in the diffraction patterns resulting from the edges of beds disrupted by faulting. Figure I shows tracing fault surfaces by following vertices of diffraction patterns.

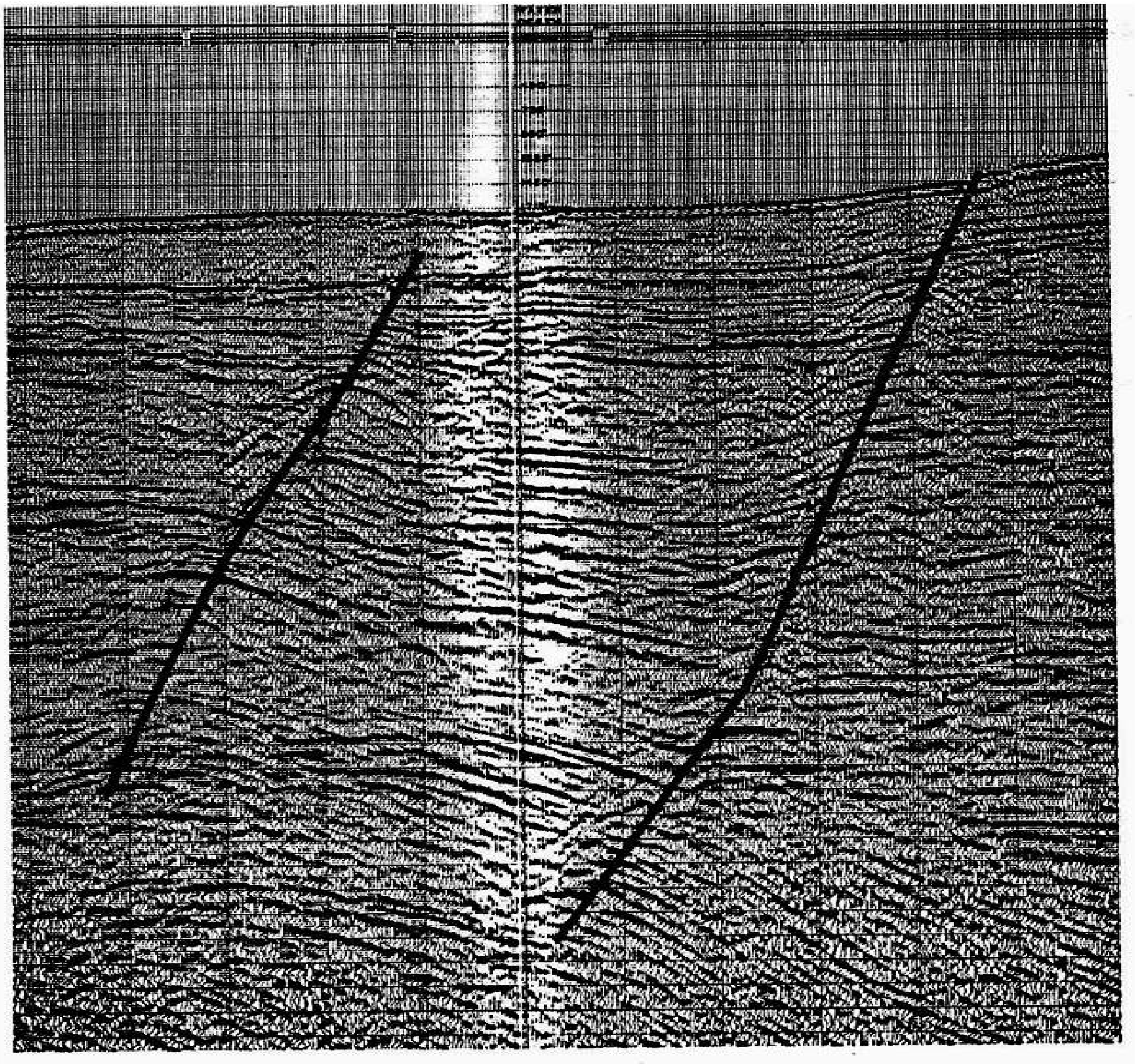

Fig. 1: Tracing fault surfaces by following vertices of diffraction patterns.

Fault slice is the act of slicing through a three dimensional data volume along a curved surface parallel to a fault plane. Faults are of high interest in petroleum development and production because they segment a reservoir. It is of high importance to know the exact number and locations of faults or whether they provide a seal for the reservoir fluids. The application of fault slicing as a method of seismic interpretation is highly examined in this paper.

Three-dimensional (3 – D) seismic surveys have become common place in active petroleum provinces such as the Gulf of Mexico, and the normal structural interpretation of these surveys is well established (Horvath, 1985). Slicing of a 3 – D data volume along an interpreted horizon was introduced by Brown et al. (1981) who addressed stratigraphic issues. The horizon slice for stratigraphic purposes is now very much in use for interpretation processes. This work is aimed at carrying out slicing ideas to faults in the interpretation process of 3 – D seismic data.

Location

The Trans-Ramos 3 – D prospect spans a large area of OMLS (omission lines) 46 to 60. The total area of the prospect is approximately 320 square kilometers. The area is swampy and low lying with surface elevation gradually rising from 2.28m in the south to 1.98m up north (Egbai, J.C. and Ekpekpo, 2003).

Vegetation varies from mangrove to rainforest interspersed with raffia palms. The area is drained by numerous rivers and creeks which makes access to some locations difficult.

The area is situated approximately between Latitudes $4^0 20'$N and $4^0 45'$N and between Longitudes $6^0 40'$E and $7^0 40'$E. The prospect covers Opukushi and Benisede fields. The adjoining villages are Opomoyo, Akarino, Dodo, Tumogbena, Osuopele, Bulou-Ojobo, Opomoko, etc. These are all located Western Ijaw Local Government Area of Rivers State, Nigeria.

METHODS AND ANALYSIS

The 3 – D data utilized for this work were recorded in the swampy area of Atala Prospect of Rivers State measuring about 4km x 4km. The surface data points are 33m apart in both directions, and the zones of interest are around 4s.

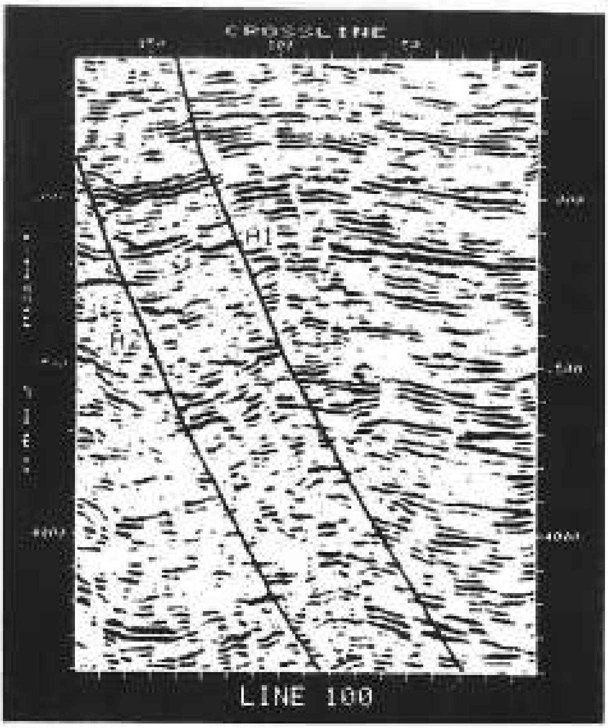

Fig 2. *Vertical section showing fault F_1 (major fault) and F_2 (upthrown fault)*

Figure 2 shows a line from the middle of the prospect F_1 is a major fault. F_2 is upthrown fault block of interest. As a result of the angles of both faults, the vertical section of Figure 2 and any other vertical section generated, regardless of azimuth, will intersect not only the fault block of interest but also the blocks on either side of it (Brown *et al.,* 1987). Slices through the data volume parallel to fault F_1 and on the upthrown side of it remain within the fault block.

Method of Fault Slicing

A "fault slice" is a section sliced from a 3-D data volume parallel to the interpreted position of fault plane. The aim of this is to track the fault first from normal vertical sections as Fig.2, and from these tracks constructs a fault plane map as shown in Figure 3.

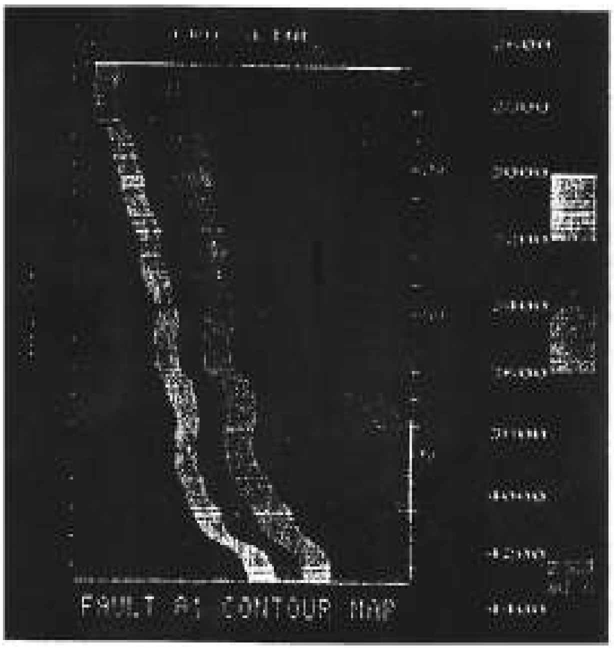

Fig 3; *Structural contour map of fault, F_1*

In Figure 4, fault slicing is shown. Here the slice are taken through the data, volume parallel to the interpreted position of a fault plane and displayed in vertical time. These fault slices were parallel and spaced two basic data point intervals (66m) apart. The fault slice is displayed in vertical travel time, so that the normal character related to frequency content is retained. The horizontal broken-line arrows in Figure 4 show that the fault slices have the coordinates of a crossline section, namely, line number and vertical time.

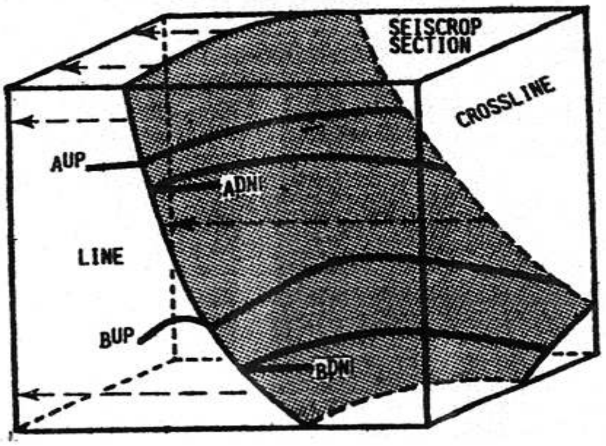

Fig. 4: *Fault slicing*

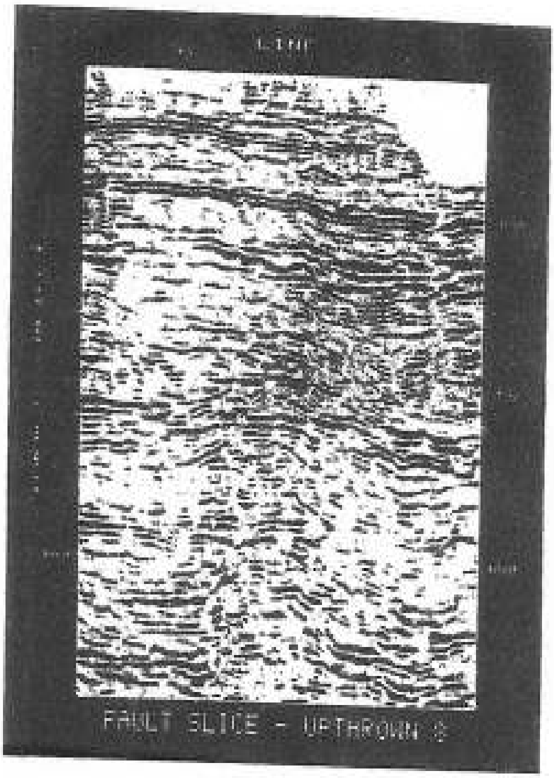

Fig 5 *Fault slice parallel to fault F_1*

Figure 5 shows fault slice parallel to fault F_1, eight data points from the fault on the upthrown side. Three – dimensional surveys are commonly designed to have the line direction perpendicular to the strike of major faults. A fault oriented in the line direction could be taken as a reference fault, hence the approach is taken to project onto a vertical plane in the line direction. As a result that a fault slice is found within one fault block, it becomes necessary in the study of growth in that block.

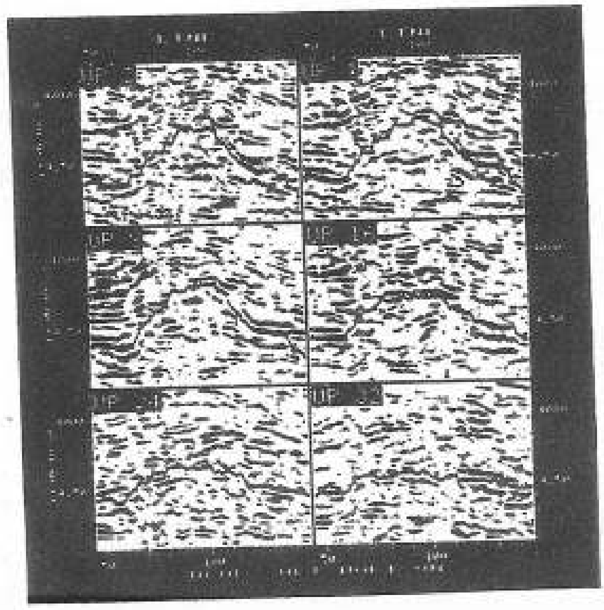

Fig 6: *Portions of six fault slices in the upthrown block*

Figure 6 shows details of six fault slices from the upthrown block of fault F_1. It shows interpreted tracks for near-salt horizon. The tracks show a prominent structure close to the fault. The tracks of Figure 6 and those close to other fault slices were mapped to generate the structural contour map of Figure 7, which shows a clear structural high adjacent to the lower edger of the map. The lower edge is straight as a result that the map is from fault slices relative to the reference fault, F_1. If we view Figure 6 from the orthogonal coordinates of the survey, a coordinate transformation must be carried out from line and fault line to line crossline. The transformation of Figure 7 is shown in Figure 8 and the lower edge of the map shows the intersection of the near-salt horizon and fault F_1.

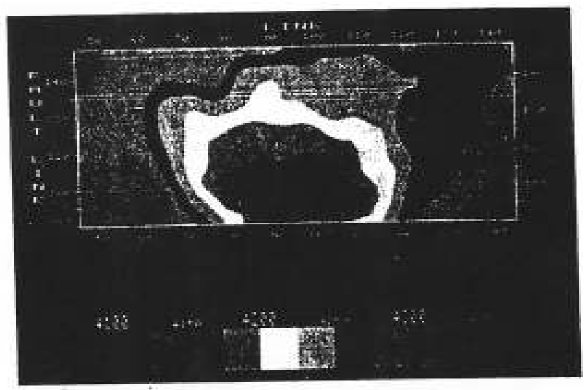

Fig 7: Near-salt horizon mapped from fault slices. Contour interval is 25ms

Fig 8: Near-salt horizon map of Figure 7 transformed to normal survey coordinates

Throw Mapping Across a Growth Fault

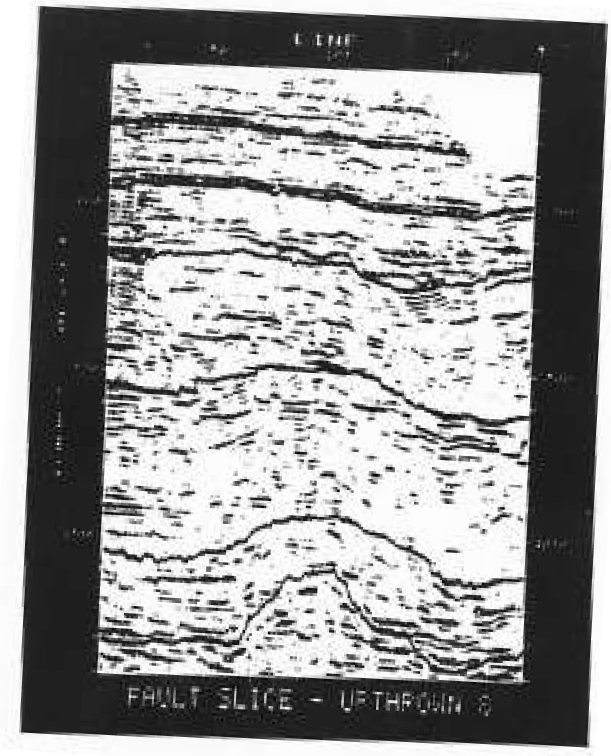

Fig 9: *Fault slice, eight data points from fault F_1 on the upthrown side.*

Figure 9 shows fault slice, eight data points from fault F_1 on the upthrown side as shown in Figure 5. It shows interpreted tracks for six horizons which are tacked on Figure 9, the deepest of which is the horizon mapped in Figure 7. When the correlation of these horizons across the fault were fully established, the six horizons were tacked on a fault slice eight data points from the fault in the down thrown block.

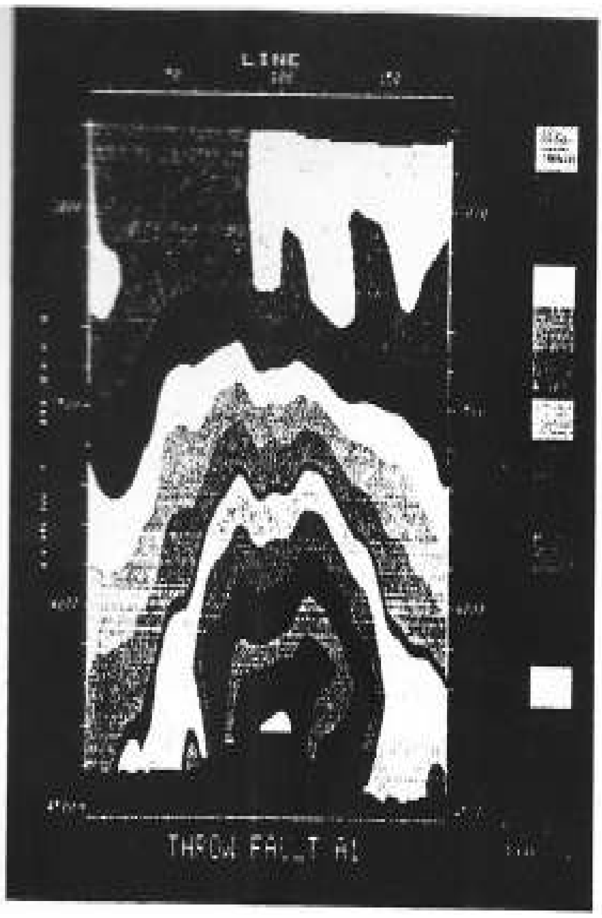

Fig 10: *Contour map of interpreted throw over the plane of fault F_1*

Figure 10 shows contour map of interpreted throw over the plane of fault F_1. The contour interval is 33ms of throw. The major black contour lines indicate increments of 100ms of fault throw. The shape of the contour indicates that the throw increases as depth increases.

Splinter Faults Mapping

Splinter faults cause a lot of difficulty in horizon tracking. This is because the data under study experiences small throw faults of limited lateral extent spawned by the major growth faults like fault F_1.

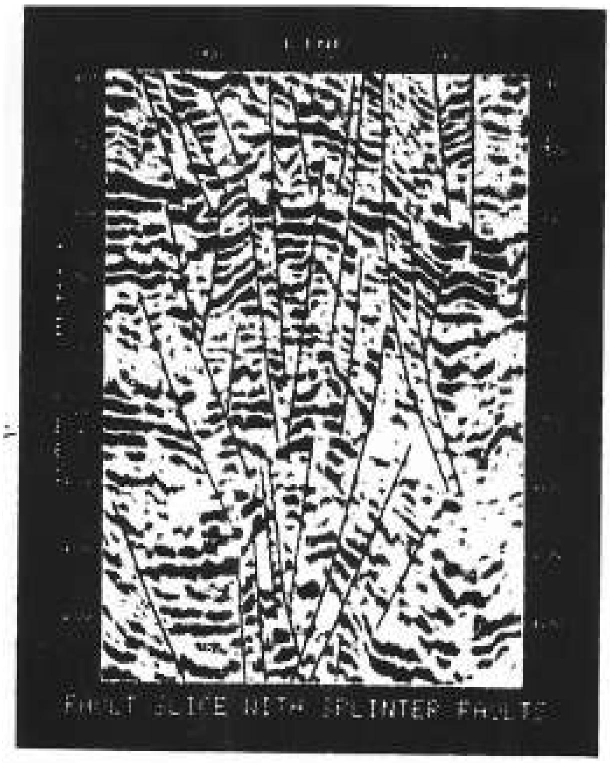

Fig 11: *Splinter faults tracked on one fault slice.*

Figure 11 shows Splinter faults tracked on one fault slice. These Splinter fault are assumed to be secondary faults caused by movement on parent fault, F_1.

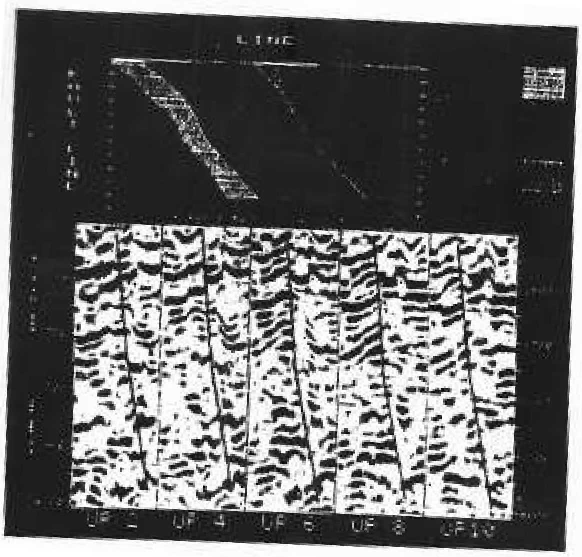

Fig 12: *One splinter faults tracked on a set of fault slices.*

Figure 12 shows, one Splinter fault tracked on a set of fault slices and the resulting contour map.

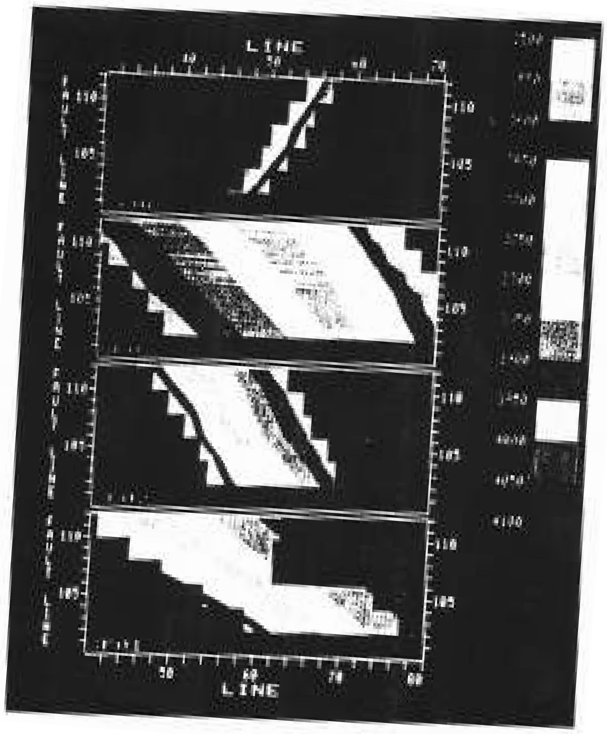

Fig 13: *Contour maps of four splinter faults.*

Figure 13 shows contour maps of four Splinter faults. As a result that maps are all in fault-line coordinates relative to the parent fault, F_1, the apparent strike of the contours directly gives the azimuth between each Splinter fault and the parent. The magnitude and direction of the dip both change, the azimuths of the Splinter faults relative to the parent fault are fairly constant, varying only between 30 degrees and 50 degrees.

CONCLUSION

A 3-D Seismic data acquisition was carried out in Atala prospect resulting in seismic processing, thereby leading to fault foundings. Several fault related problems could be studied by applying slices through a 3-D seismic data volume parallel to the interpreted position of a fault plane. The entire data got from the fault slices are at constant distance from the fault, and because the fault slice can be generated close to a fault, fault slices are valuable for mapping fault throw, fault-related growth structure, and splinter faults. A lot of splinter faults were identified in the area of studied.

REFERENCES

Brown, A.R., Edwards, G.S. and Howard, R.E. (1987) Fault slicing – A new approach to the interpretation of fault detail. *Geophysics* **52 (10):** 1319-1327.

Brown, A.R., Dahm, C.O. and Graebner, R.J. (1981). Stratigraphic case history using three-dimensional seismic data in the Gulf of the Thailand. *Geophysical Prospecting* **29:** 327 – 349.

Dobrin, M.B. (1976) *Introduction to Geophysical prospecting* (third edition), McGrall Hill, New York.

Egbai, J.C. and Ekpekpo, A. (2003). Migration velocity analysis by Fourier transform in seismic data processing. *Journal of Nigerian Association of Mathematical Physics* **7:** 147-154.

Horvath, P.S. (1985) The effectiveness of offshore three-dimensional seismic surveys – case histories. *Geophysics* **50:** 2411-2430.

Sheriff, R.E. (1990). *Encyclopedic dictionary of exploration Geophysics,* third edition. Pub. By Society of Exploration Geophysicists (SEG), Tulsa, Oklahoma.