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 finding 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 1 shows 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).

**Fig. 1:** Tracing fault surfaces by following vertices of diffraction patterns.
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°20′N and 4°45′N and between Longitudes 6°40′E and 7°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 F₁ (major fault) and F₂ (upthrown fault)**

Figure 2 shows a line from the middle of the prospect F₁ is a major fault. F₂ 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 F₁ 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, F₁**

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.
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.

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 edge 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 $F_1$. 

Figure 7: Near-salt horizon mapped from fault slices. Contour interval is 25ms.
Throw Mapping Across a Growth Fault

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.

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

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

Fig 10: Contour map of interpreted throw over the plane of fault $F_1$
Figure 11 shows Splinter faults tracked on one fault slice. These Splinter faults are assumed to be secondary faults caused by movement on parent fault, $F_1$.

Figure 12 shows one Splinter fault tracked on a set of fault slices. Figure 13 shows contour maps of four Splinter faults. As a result, 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


