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SEISMIC CHARACTERISATION OF SUBSURFACE STRUCTURAL FEATURES OF PARTS OF "RICHY" FIELD, OFFSHORE NIGER DELTA, NIGERIA.

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ABSTRACT

A total of thirty-four migrated 2D seismic reflection lines and two composite well logs have been interpreted with a view to unravel the subsurface geological structural setting aimed at delineating probable hydrocarbon potentials around "Richy" field, east of Niger delta basin, Nigeria. The interpretation procedure includes horizon identification, fault mapping, timing of horizons at selected shot points, posting of times, time-depth conversion and contouring.

Both the isochron and isodepth (isobath) maps revealed an elongated fault-assisted anticlinal structure trending NE-SW direction with a growth fault in the southwestern part. This suggests that the features can form good hydrocarbon traps. Locations M1 and M2 situated around the crest of the anticlines are recommended drilling points.

The study has demonstrated the relevance of structural control studies in the location of wells for hydrocarbon exploitation.

Key words: structure, horizon, anticline, isobath and isochron)

INTRODUCTION

The commercial accumulation of hydrocarbon in any sedimentary setting is governed largely by the structural disposition of the subsurface rock units within the area. Unfortunately, these structures are in most cases hidden kilometers away from the earth's surface. Sometimes, they can be visualized on seismic sections, even to the uninitiated. However, it is of paramount importance to understand the various types of geological structures in such areas; as such a control greatly aids the identification of prospective well locations. Inaccurate location of wells due to poor understanding of the subsurface structural settings results in huge economic losses during exploitation.

As used in this paper, the term 'structure' refers to the subsurface arrangement of subsurface topography of rock units e.g. faults, anticlines, synclines etc. Thus topographic control is taken to be part of structural control and can be a very good guide to the study of fluid migration in any field. Structural control is as important to hydrocarbon migration as it is to groundwater in the shallow subsurface. It is the complex interaction of these subsurface features that eventually forms hydrocarbon traps, which often check further migration of fluids. The geophysical seismic reflection method is best suited for the definition of these complex subsurface structures, Deng and Ou (1995), Fournier and Derain (1995).

STRATIGRAPHY/STRUCTURAL SETTING

The tertiary Niger delta is one of the major regressive sequences in the world. The delta

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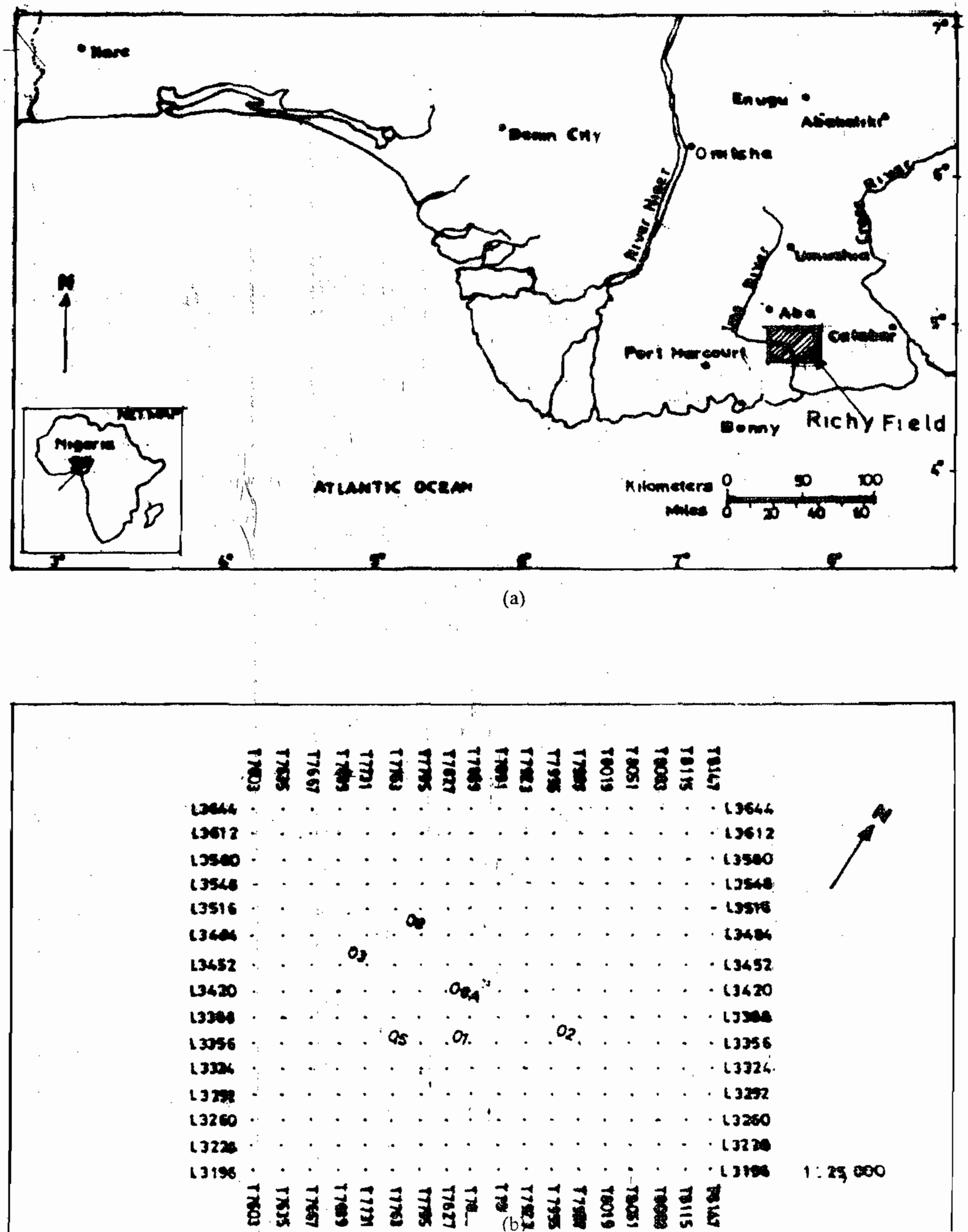


Fig 1: (a) The Niger Delta region showing the study area (b) Base map of study area.

Fig. 1: (a) The Niger delta region and the study area
(b) Base map of study.

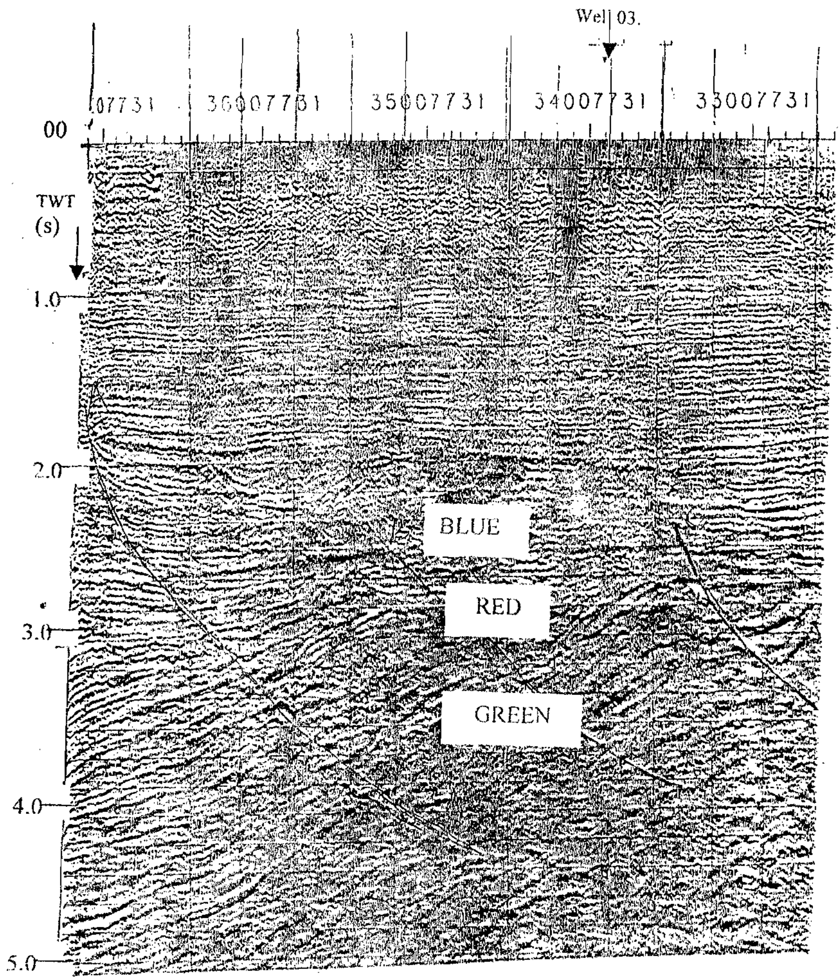
began with the formation of the Benue-Abakaliki trough in the early Cretaceous as a failed arm of a rift triple junction associated with the opening of the south atlantic (Burke, 1972, Weber and Dankoru, 1976 and Whiteman, 1982).

Three distinct facies belts have been identified in the Niger delta (Short and Stauble, 1967):

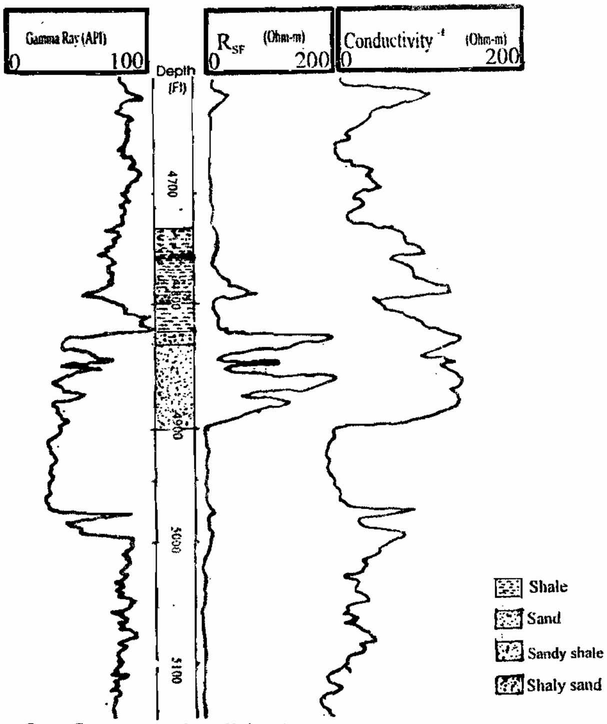
(i) The Benin formation (Miocene to Recent) consists of predominantly massive, highly porous fresh water-bearing sandstone, with local interbed of shale. The sand and sandstone are coarse-grained, very granular and pebbly to fine-grained.

(ii) The Agbada formation, (between Lower-Middle Miocene to Pliocene) consists of alternating sandstones and shales of the delta front, distributary- channel and delta plain origin. The sandstones are medium to fine grained, fairly clean, locally calcareous, glauconitic and shelly with dominantly quartz and potash feldspar with subordinate amounts of plagioclase, kaolinite and ellite. It constitutes the main hydrocarbon habitat in the Niger Delta (Evamy et al, 1978).

(iii) The Akata formation aged Paleocene in the proximal parts of the delta to Recent in the distal offshore, is made up of a sequence of under-compacted marine clays with minor sandy and silty beds. The shales are dark grey, medium hard and may contain lenses of abnormally high-pressured siltstone or fine-grained sandstone. It



2. Typical reflection seismic section (dip line) of the study area.



3. Composite lithology, resistivity and conductivity logs for well 06.

is thought to be the main hydrocarbon kitchen of the Niger Delta (Doust and Omatsola, 1990).

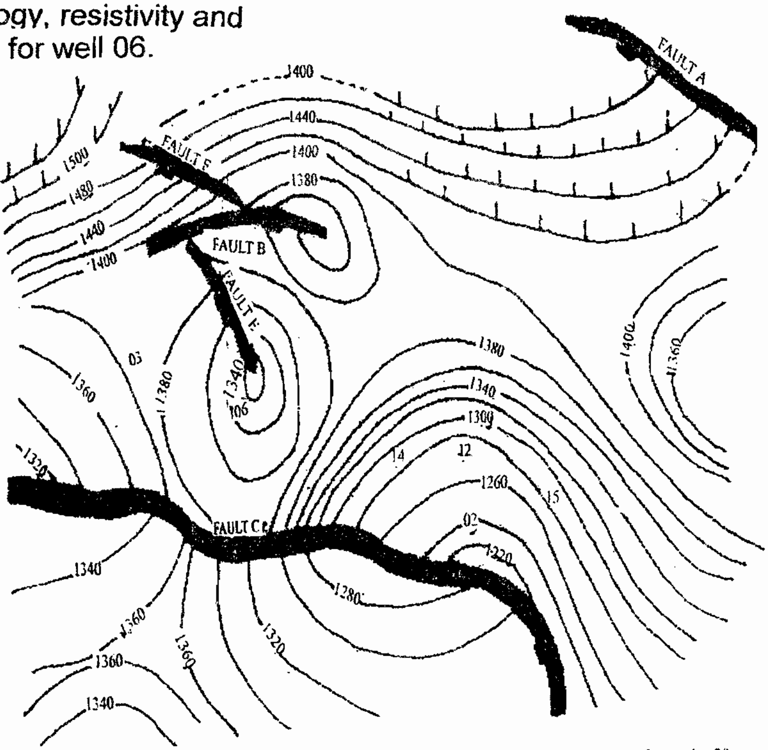
The basin has suffered extensive deformation resulting in faults, anticlines, fractures and the formation of traps in which huge reserve of hydrocarbon accumulated. The large synsedimentary faulting (growth faults) is most conspicuous. They are believed to result from rapid sedimentation load and gravitational instability of the sediment pile accumulating on the mobile under-compacted Akata shales (whiteman, 1982).

MATERIALS AND METHODS

The materials employed in the actualisation of this work include:

*the base map, Figure 1(a and b), which shows the geographic location and the distribution of the seismic lines and shot points, as well as the well locations;

*the Seismic section (figure 2) which is composed



4. Time structure (Isochron) map of the Blue horizon

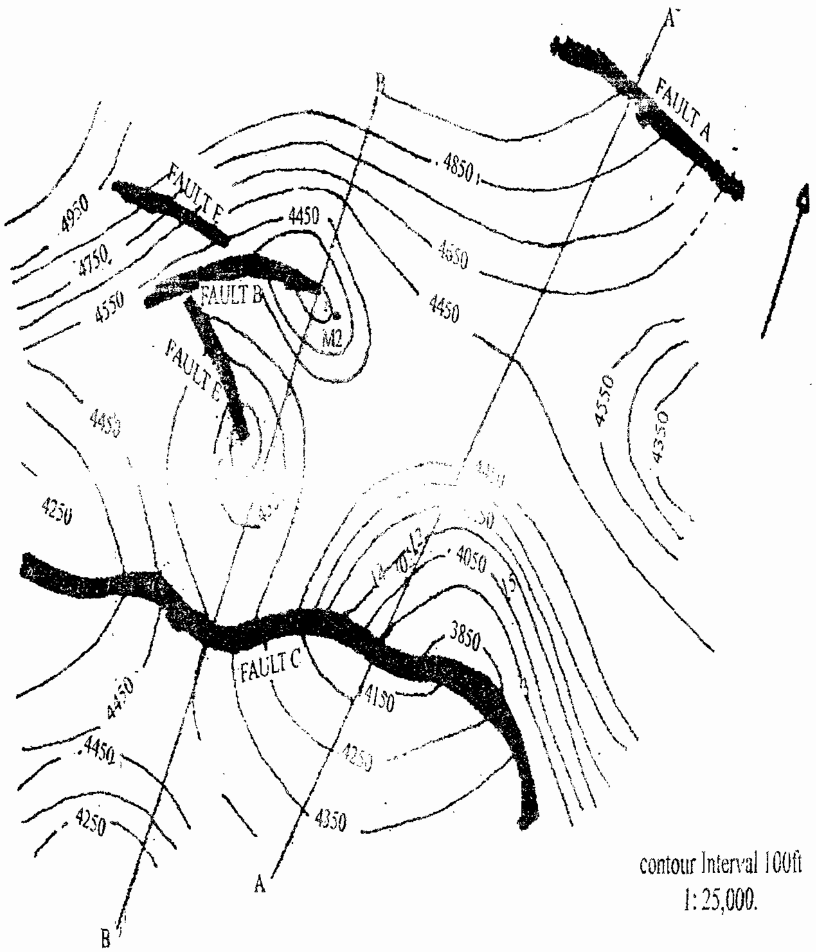
of a series of closely-spaced vertical wiggle lines with either variable area or density. It shows a vertical cross section of the earth as obtained at individual seismic shot point locations. The shot points could be reasonably spaced apart (two dimensional) or spaced in some specific geometric format (e.g. three dimensional) seismic sections;

*the composite well log (Figure 3) is a record, in graphic form, of the variation in physical and geological properties of the earth as a function of depth, as measured in a borehole. It provides a continuous geologic record of the subsurface through the various reflecting horizons at a particular location;

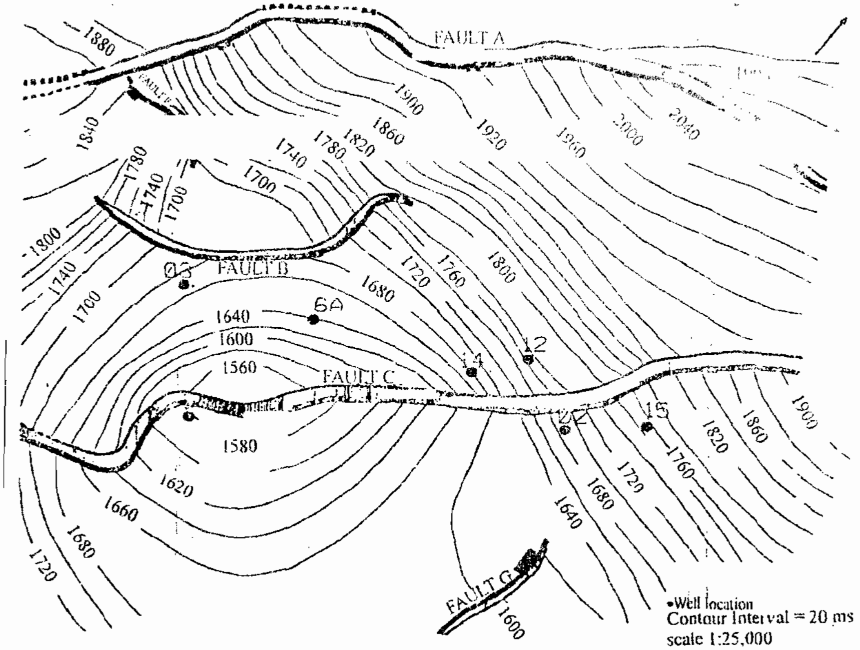
*the check shot survey data which correlate the seismic wave traveltime with depth in the earth medium. It is employed, in this work, in the conversion of time to depth in the preparation of iso-depth map.

Faults are recognized on seismic sections by the following indicative features:
(i) termination of events and offset of reflections;
(ii) abrupt change in the geologically significant dip configuration;
(iii) abrupt lateral velocity change;
(iv) mistie around loop e.t.c.

It is wise to start fault mapping on the dip lines due to better imaging, before transfer to the strike lines. The transfer is carried out by folding and



5. Depth structure (Isodepth or isabath) map of the Blue Horizon.



6. Time structure map of the Red horizon.

placing the line on the strike line to establish correlation between the two lines at the point of intersection.

Seismic interpretation assumes that the coherent events observed on seismic records are reflections due to acoustic-impedance contrasts in the earth. These contrasts, Sheriff (1983), are associated with bedding which represents the geologic structure. Thus, mapping the arrival times of coherent events is related to the geologic structure. Fitch (1976), Anstey (1977) and McQuillin (1979) treat the routine procedure of seismic interpretation in reasonable detail.

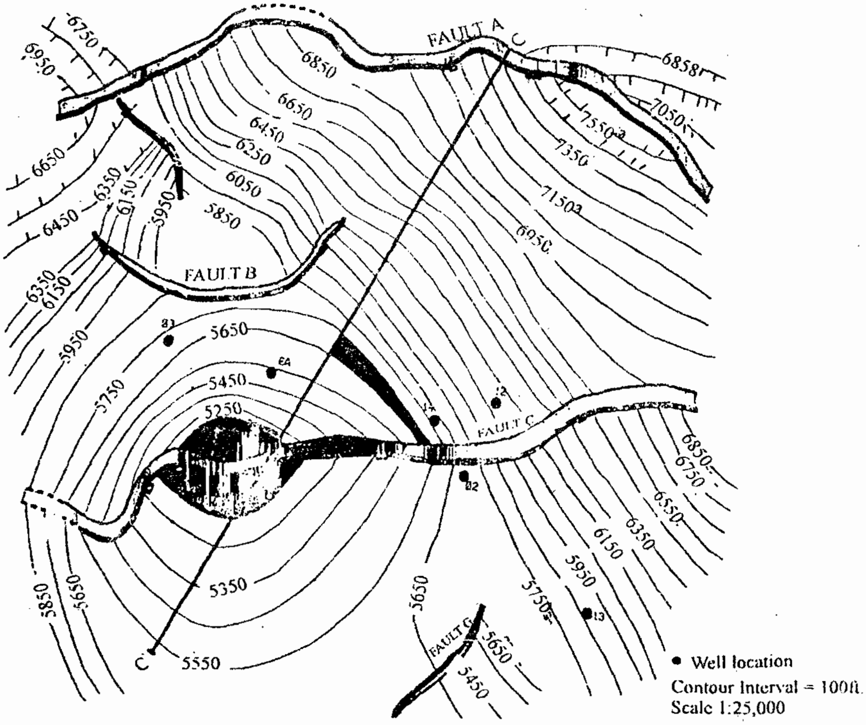
The process of generating structure maps involves essentially, the task of fault mapping, picking and mapping of horizons, loop tying, posting of times, time-depth conversion and contouring of times and depths

PRESENTATION AND DISCUSSION OF RESULTS

Figures 4 and 5 are typical time structure (isochron) and depth structure (isodepth or isobath) maps of the 'Blue' horizon. This horizon is the unconformity surface, that is, the base of Qua Iboe (BQI). In all, five major faults could be clearly identified. They are: Faults A, C and F trending West-East with a throw to the south. Fault B trends South West-North East with an approximate South throw while Fault E trends North West-South East and throwing approximately West.

The structural highs (anticlines) are observed to be fault-dependent (Faults B & C) and fault-assisted closures, Fault E. These structures, especially Fault C and the associated anticlinal structures have greatly supported the hydrocarbon trapping mechanism in the field. The geological cross sections taken along AA' and BB' (Figure 5) also confirm a faulted anticlinal structure in the area.

Figures 6 and 7 are respectively the isochron and isodepth maps of the 'Red' horizon located below the Blue horizon around two-way traveltime (TWT) of about 2.8 seconds corresponding to a depth of about 5202 feet (1586 metres). It could be observed that, apart from the major faults on the Blue horizon, virtually



7. Depth structure map of the Red horizon

all the salient anticlinal rollover structures (closures), except for the southwestern flank, have disappeared. This shows that the probability of finding hydrocarbon traps around this area is reduced.

From Figure 3, comprising gamma ray, resistivity and conductivity logs, a hydrocarbon reservoir is readily delineated around the depth window 4750 - 4900 feet (1448-1494 metres). Thus, from the time-depth (TD) curve , this reservoir lies within the two-way travel time (TWT) of 1.4 and 1.52 seconds, which falls within the 'blue' and 'red' horizons. The presence of the reservoir further justifies the structural control earlier discussed.

CONCLUSION

From this study, a comprehensive two-dimensional seismic reflection structural interpretation of "Richy" field has been carried out. Both isochron and isodepth maps of both the 'Blue' and 'Red' horizons have been produced. In all, five major faults have been identified in the study area: faults A, C and F trending east-west, fault B trending south-west North-east and fault E trending North-west South-east.

The structural highs (anticlinal structures) are largely fault-dependent. Both structures therefore dictate the hydrocarbon trapping mechanism in the area. The trapping structures tend to vanish with depth as depicted by the comparison of the structural maps on both the Blue and Red horizons.

From the wireline log analysis, a hydrocarbon reservoir was delineated and lies between the 'Blue' and 'Red' horizons around the depth of 1244 and 2134 metres (4080 and 7000 feet) corresponding to a TWT of 2.5 and 3.92 seconds. The presence of this reservoir clearly supports the subsurface geological structural pattern in the area.

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