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Analyses of Structural Trends in Bornu Basin Using Some Selected Seismic Attributes

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Abstract- Analyses of structural trends in Bornu basin was carried out using Coherence, Variance, and Curvature Seismic attributes with the aim of understanding the structural features in the basin which are suitable for hydrocarbon accumulation. The Coherence, Variance and Curvature attributes analysis also aim in identifying, analyzing and interpreting Structural Trends in the Basin optimally. Firstly 3-D seismic data of the basin was integrated with well data. Hence lithostratigraphic interpretation, seismic structural analyses, seismic attributes analyses and prospects identification at the Basin were carried out using Schlumberger`s petrel 2017 interpretation software. The lithostratigraphic interpretation showed that the study area is characterized by sand- shale interbedding. Lithologic correlation carried out showed the presence of a basin and intra-reservoir seals. The Structural analysis revealed various types of faults such as normal faults, Listric, also fold such as the anticline where older rocks are formed, which also help in hydrocarbon trapping. The use of Coherence and Curvature attributes shows that Coherence and Variance Attribute are the most effect and efficient attributes in revealing the hydrocarbon potential in the Basin.

I. INTRODUCTION

Chad Basin is a sedimentary basin which extends into parts of Niger, Chad, Central African Republic, Cameroon and Nigeria known as Bornu basin. (Avbovbo, Ayoola, and Osahon, 1986). For more than three decades, researchers and scholars on petroleum potentials in Nigeria have concentrated in Southern part, such as in the Niger Delta, Anambra Basins, and recently in Benue Trough, while little geophysical and geological works have been carried out in the Nigerian portion of the Chad Basin. Nigerian Government has demonstrated renewed efforts in its search for hydrocarbon accumulation at Chad basin in order to increase its oil and gas reserve. (Mohammed, and Tela, 2012). This is because several wells drilled in the Nigerian sector of the Chad basin over the years have not encountered commercial quantity of hydrocarbon, whereas commercial hydrocarbon deposits have been discovered at some other parts of West Africa contiguous to the Bornu Basin and bearing similar geology with it (Obaje, Wehner, and Scheeder, 2004). This is the Nigerian sector of the Chad basin also known as "Bornu Basin". which Shows that major source and reservoir rocks in Termit Basin has occurred from continental Aptian to Cenomanian deposits of Abu Gabra and Bentiu formations respectively and these could be correlated with the Bima Sandstone in the Bornu basins (Hamza and Hamidu, 2012).

Researchers are increasingly employing more geophysical techniques on three dimensions (3-D) data to review, and gain further understanding of both geophysical and geological characteristics of the Bornu Basin in recent times. Seismic attributes have been used by researchers to interpret reflection geometry, amplitudes, and continuity of seismic trace to analyzed subsurface geologic features.

II. MATERIALS AND METHODS

The data utilized for this work are 3D-seismic volume in SEG-Y format, four well logs suits in LAS file format, check shot data, formation tops and the field map showing the location of each well. The seismic volume in 3D window is shown in Figure 2.1. The well log suite includes Gamma ray (GR) log ranging from 0 -160 API (American Petroleum Institute), Resistivity Log (LLD) ranging from 0.2 – 2000 Ωm, Neutron Porosity (ΦN) in the range of 1.83 – 2.67, Sonic log (DT) ranging from 40 – 240 µs/ft and density (RHOB) in the range of 1.9 – 2.9 g/cm3, Table 2.1 showed the well log suites, their scales and properties. The data were obtained from Nigerian National Petroleum Corporation (NNPC) in line with

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the Department of Petroleum Resources (DPR) and the Federal government's policy on education. Petrel ® E&P software platform 2017, was used for the 3D seismic interpretation, attribute analyses, and well logs data display. Four wellheads (Kasade, Kinasar, Bulte and Kanadi) were utilized for this study, Figure 3.2, is the geologic map showing the locations of the wells, the coordinate of the wells are; Kasade (14250000N, 3280000E), Kinasar (14500000N, 3640000N), Bulte (14450000N, 3280000N), Kanadi (14400000N, 3600000E).

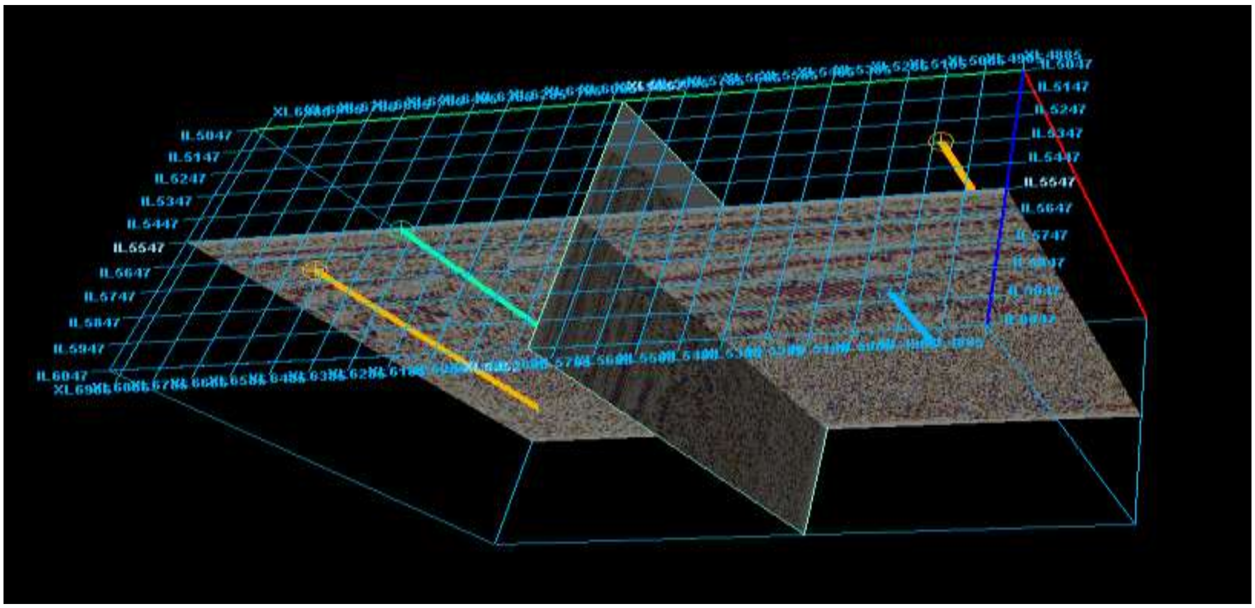

Figure 2.1

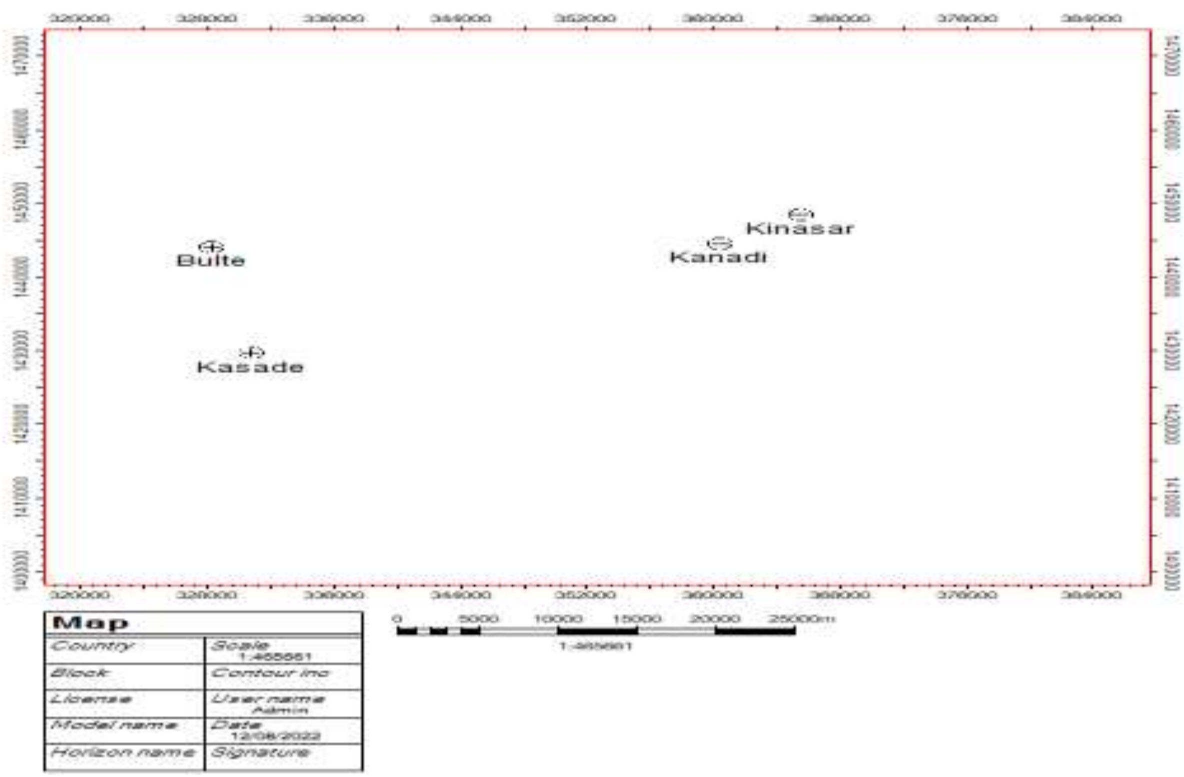

Figure 2.1.2: Base Map of the Study Area Showing the location of wells

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III. METHOD

The 3D seismic data and the well logs were imported into the petrel environment and displayed in various windows such as interpretation window, well section window and 3D window for data quality check (Data QC). The data with their respective coordination reference system was loaded into the Petrel Software. The well data was used for lithological interpretation and stratigraphic correlation. The log data was integrated with the seismic data using time-depth data which is the check shot data to generate a synthetic seismogram and as well initiate a relationship between the well log data and the seismic data, (seismic to well tie). The seismic data was used for subsurface fault interpretation and horizon mapping. Gamma ray log which has a scale of 0 to 160 API (America Petroleum Institute) was used for lithology determination and lithostratigraphic correlation. Shale baseline of 60 API was adopted, thus zones with gamma ray reading less than 60 API were marked as sand zones and vice versa. The resistivity log is of the scale of 0.2 to 2000Ohms meter and was used to identify potential hydrocarbon zone. The sonic log was also used for the seismic to well tie process.

IV. RESULTS AND DISCUSSION

4.1 Well Logs Results

The formation tops were mapped using the gamma ray log, by observing remarkable changes in gamma ray signatures across the wells, the formation of tops (Chad, Kierri-kierri, Fika and Gongila) were identified, marked and correlated across wells, The well section was flattened on top of the Chad formation which is encountered at approximate depth of 0 – 300m across the wells. The well top formations correlating in the study area in (Figure 4.1), while their depths, Table 4.1 shows to the marked formation tops in the study area. Bulte, Kasade and Kanadi, names of wells.

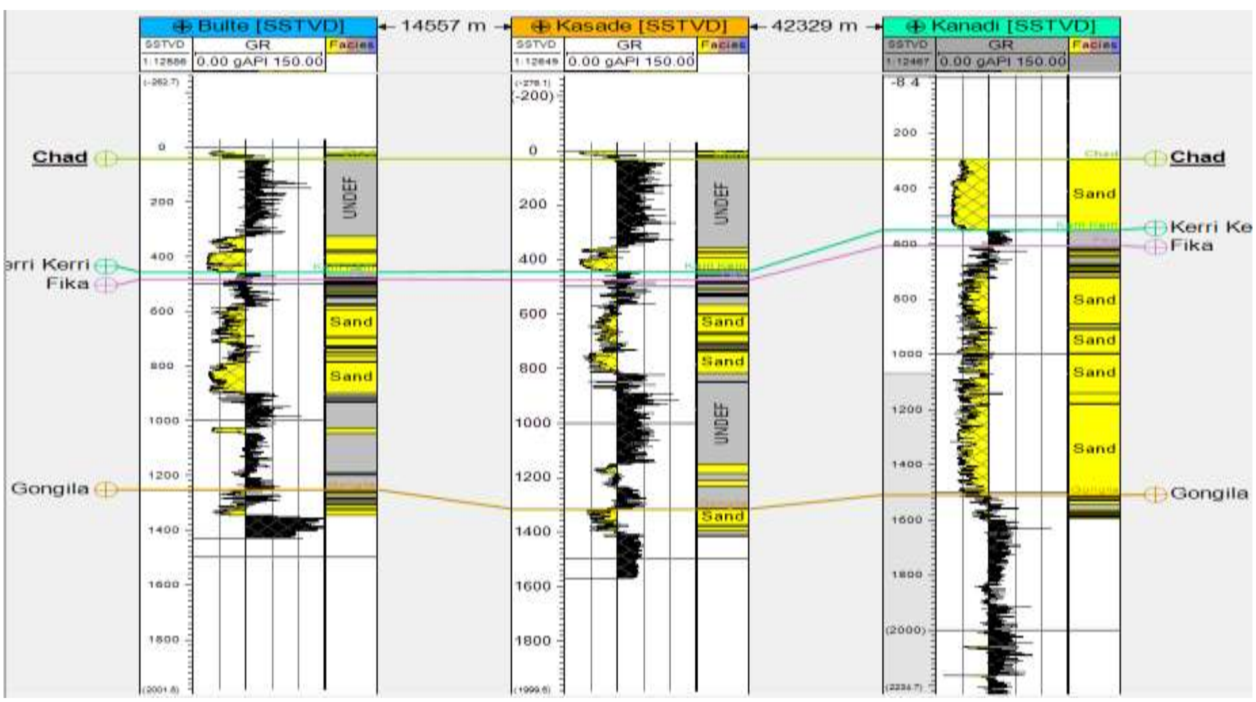

Figure 4.1the well top formation

4.2. Lithological Description

The lithological description of the study area was done using the Gamma ray log motifs. Two distinct lithology were identified they are; Sand lithology and Shale lithology. The sand lithology is associated with the lower Gamma ray readings, while the shale

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lithology are associated with the higher Gamma ray reading in (Figure 4.2). The lithology description shows an intercalation of sand and shale in sequence suitable for hydrocarbon production and storage, whereby the underlying shale serve as source rock, the embedded sand serve as reservoir rock overlain by another shale bed which serves as seal. This system of sand shale intercalation is observed across the four marked formations and extends up to the depth of 3500m. The sand and shale facie were further marked using discrete log class tool available in the Petrel interpretation software.

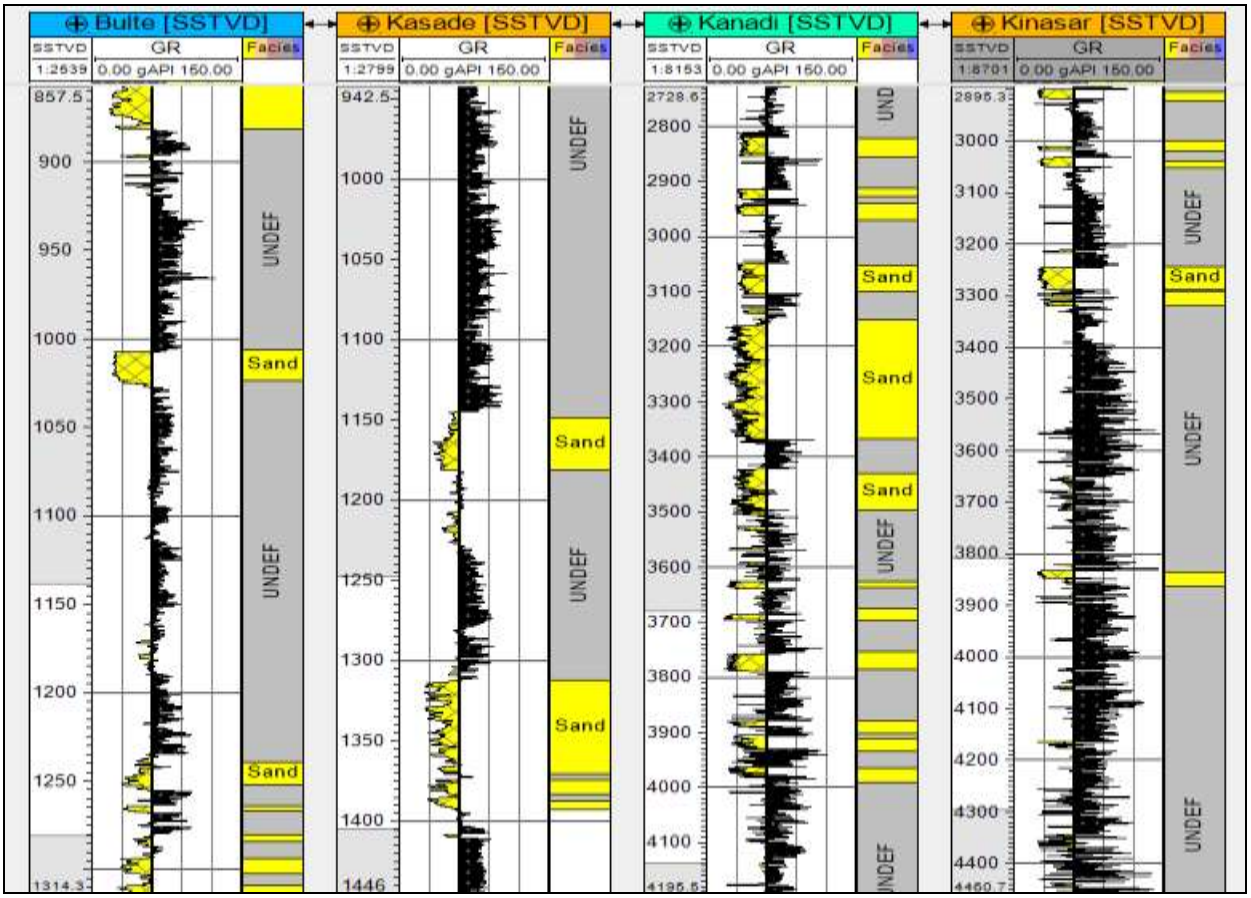

Figure 4.2 Lithological description

4.3. Seismic Interpretation

Fault Mapping

Faults were interpreted on the seismic volume based on the discontinuity of reflectors, displacement of reflectors, abrupt termination of reflectors, and rollover reflectors. These faults were mapped along the inline and cross line with the help of a software known as petrel, some of the faults are shown in (Figure 4.3), and as well mapped in time slices with the help of coherence attribute in comparison with curvature attributes in 3D windows. Normal faults were interpreted, which is an evidence of extensional tectonic regimes

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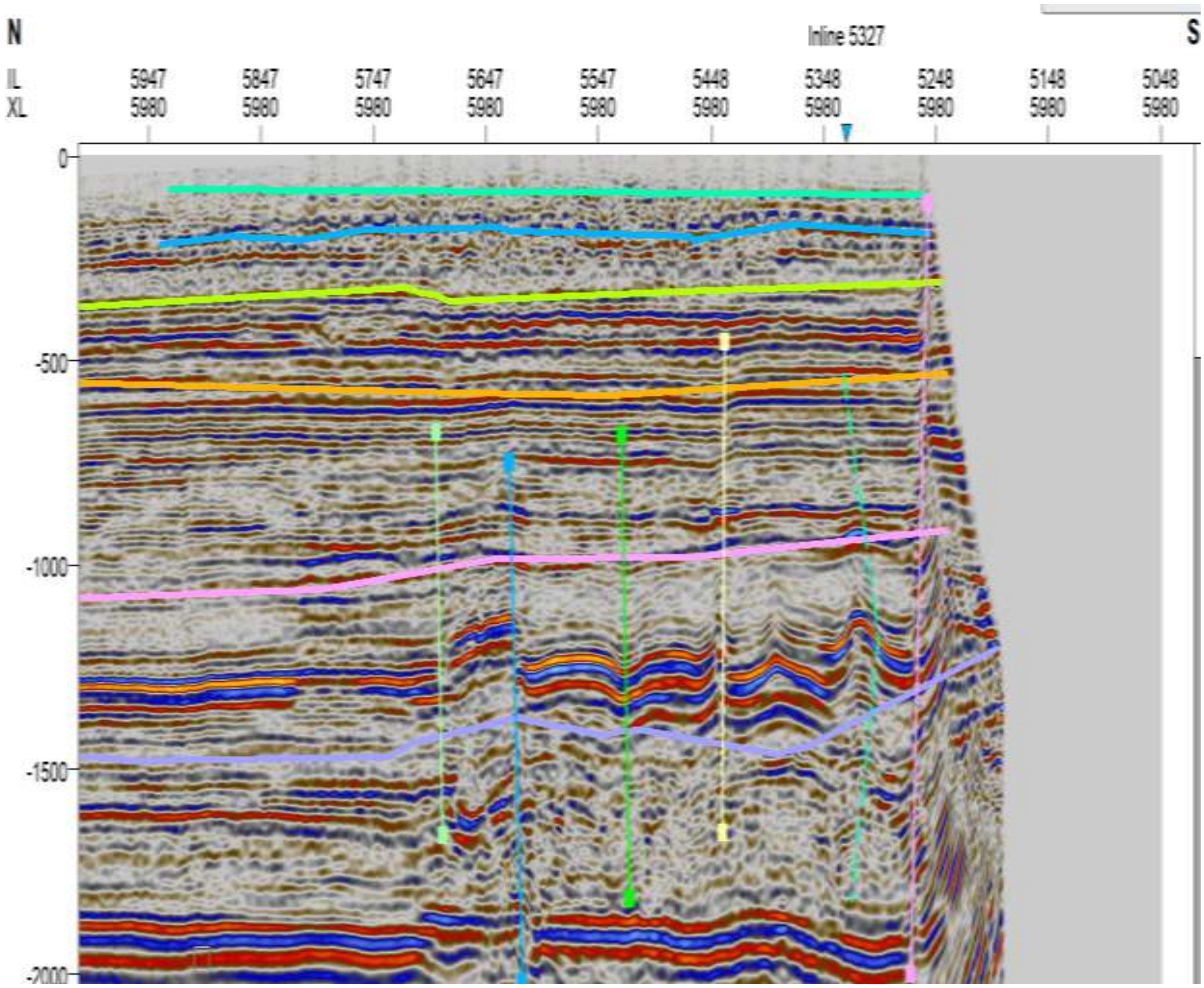

Figure 4.3 showing faults

4.4. Comparing Coherence and Curvature Attribute
Coherence volume attribute anomaly depends on change in frequency while curvature attribute anomaly depends on dip gradient. Both attributes are good in mapping out subsurface structures like faults but coherence attribute is better than curvature attribute because coherence attribute has more defined resolution and clarity in detecting fractures, it also outline all the minor and major faults. Figure 4.4a shows coherence volume attribute at time slice 1700ms, indicating interpreted faults across the seismic volume, while (Figure 4.4b) is curvature attribute along with the interpreted faults in the 3D window. The use of these attributes which are the Coherence and Variance, shows that Coherence and Variance attribute have better resolution and hence significance in optimization of structures.

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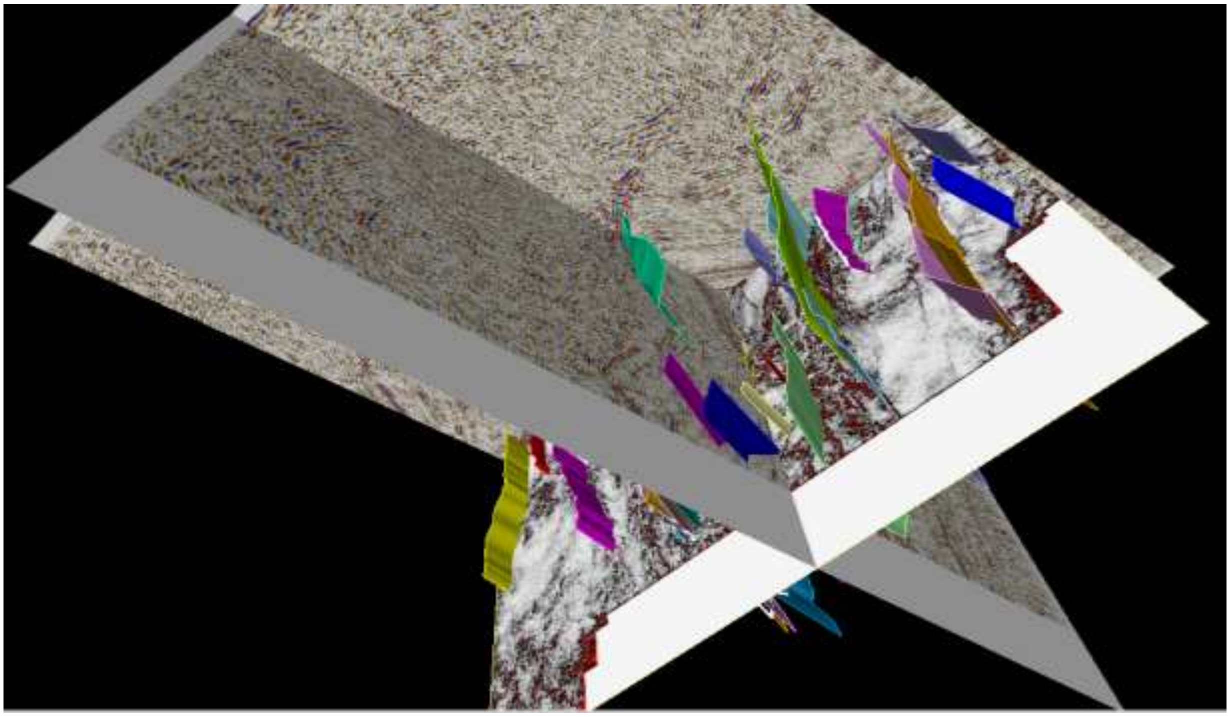
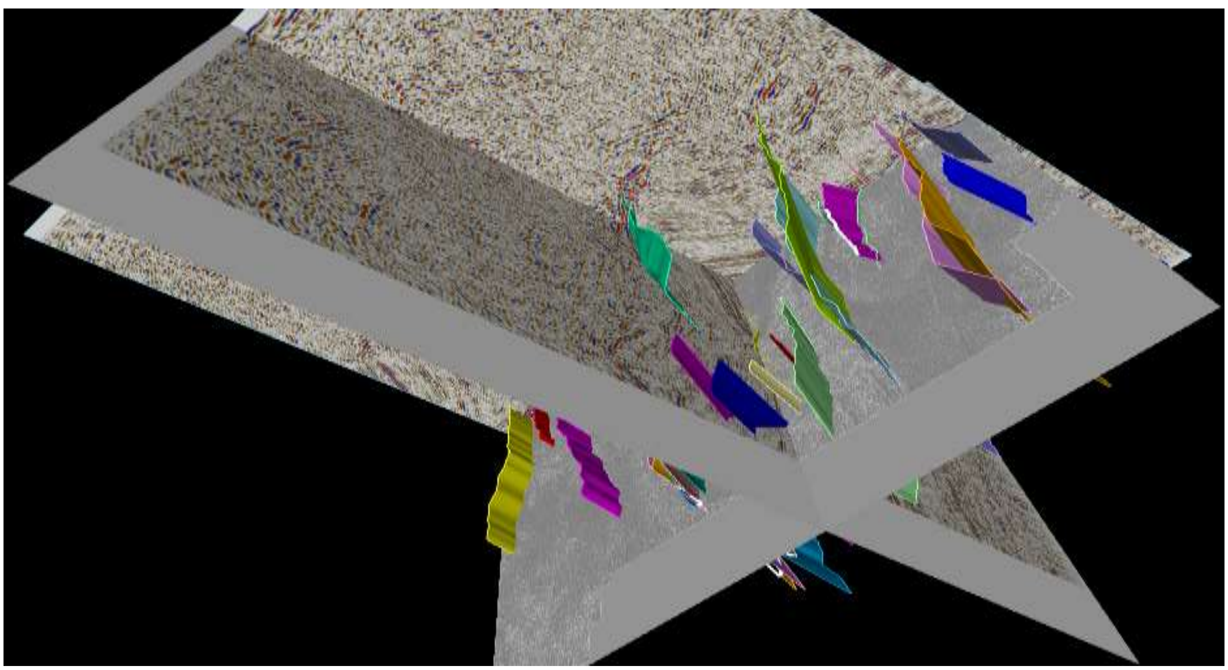


4.4a. Coherence Attribute at Time Slice 1700ms Showing Interpreted Faults in the Seismic Volume



4.4b. Curvature Attribute at Time Slice 1700ms with Interpreted Faults in the Seismic Volume

4.5. Time Structural Map

After mapping the horizons, time maps were generated for the picked formation tops (Fika, and Gongila). From the legend labelled elevation time (ms), the area of the map colored yellow is zone of higher seismic velocity in the map while the zone of green coloration shows low velocity zones and blue and pink coloration indicates lower velocity with respect to the contour values across the map, while close or dense contouring (red color) indicates zones of structural highs. The result shows some structural high (anticline) for Fika formation, there is also some structural highs evident for the Gongila formation together with a diapiric structures (figure4.5b). These structures supports the accumulation of hydrocarbon. (Figure 4.5a)

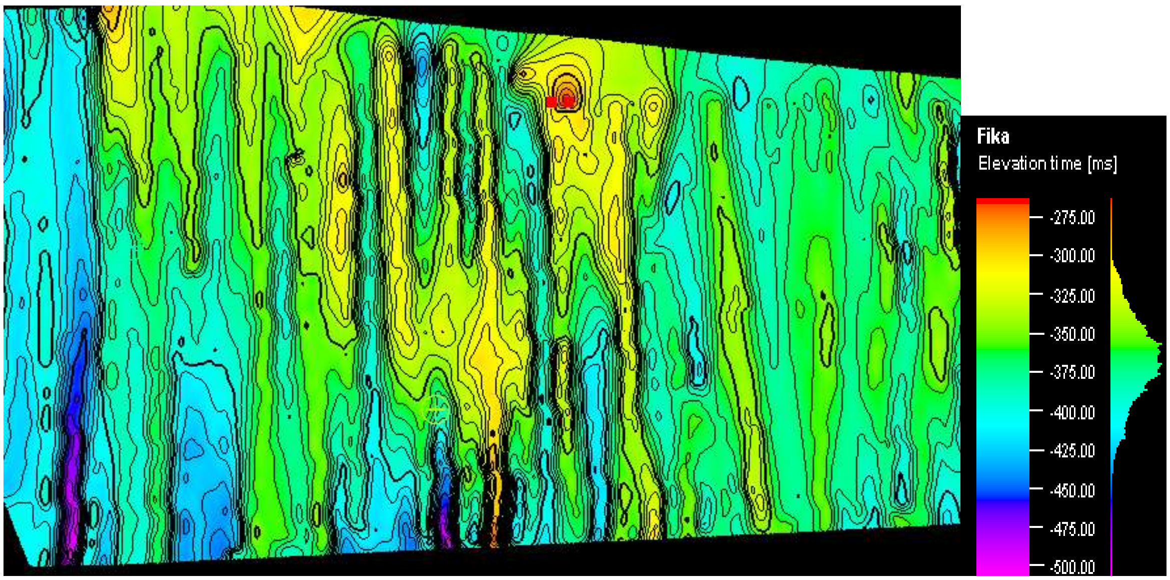


Figure 4.5a. Time Structural Map for Fika Formation

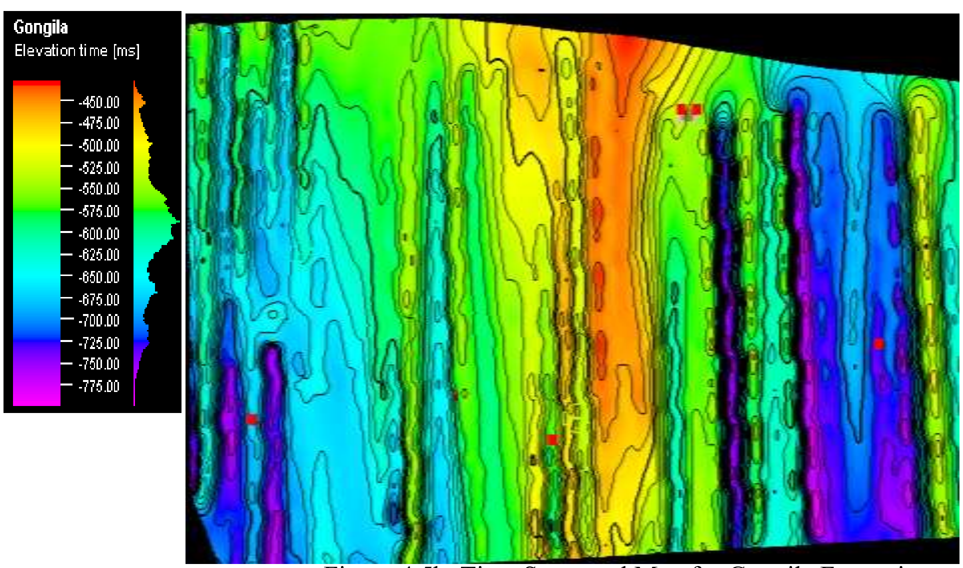


Figure 4.5b. Time Structural Map for Gongila Formation

V. CONCLUSIONS

Based on the interpreted results obtained, it can be concluded that coherence, variance and curvature attributes are more efficient in the analyses of structural and fractural trends in sedimentary basins. Coherence and variance attribute when compared with curvature attribute simultaneously gave the same results based on frequency and gradient reading respectively. However, the coherence and variance attributes are preferred to curvature attribute because they show higher resolution of structures. Micro and macro geological structures can be mapped by coherence attribute. The lithological analysis revealed that Bornu basin contains the two major rock types that could generate and store hydrocarbon which are shale and sand formation respectively.

5.1 Contribution to Knowledge

This work has led to structural analyses in Bornu basin using coherence, variance and curvature attributes. It has contributed immensely to proper location of future wells in the basin for efficient hydrocarbon production. It has also given information on the size of hydrocarbon reserve, and has determined the trap integrity (e.g., Fault). Which gives information where wells should be drilled, in those area of identified anticline for more exploration activities.

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