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Research Paper

3D Seismic Attributes Analysis for Reservoir Characterization: Gabo field, Niger Delta, Nigeria.

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ABSTRACT
Seismic attribute is defined as a component extracted from seismic data which can be analyzed in order to enhance the hidden information used to identify a good geological or geophysical prospect in certain geological environment.Seismic attributescorrectly image the subsurface information in time and depth and correctly characterize the amplitudes of the reflections. They also help determine if the structures and their closures are favorable for hydrocarbon accumulation in the "Gabo" field. The methodology employed includes well to seismic tie, seismic attribute analysis and reservoir properties maps generated. Root mean square (RMS) amplitude, envelope, instantaneous frequency, average energy and average magnitude maps were extracted on seismic events with pronounced high amplitude reflection continuity. This study presents the results of the application of seismic volume attributes analysis, which revealed differences in lithologyand better reservoir characterization. It was concluded that attribute analysis could be used to identify hydrocarbon prospect, predict reservoir rock properties and characterize reservoir.
KEYWORDS:*Seismicattributes, amplitudes, reflection, reservoir, structures, hydrocarbon and lithology.*

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I. INTRODUCTION

A seismic attribute is a quantitative measure of a seismic characteristic of interest (Adewoye et al. 2015). Seismic attributes have been increasingly used in both exploration and reservoir characterization studies and routinely been integrated in the seismic interpretation processes (Partyka et al., 1999). There are different classes of seismic attributes based on the nature of estimation and property of the reservoir they reveal. Seismic attributes are derivatives from the original amplitude seismic that can be used to characterize lithological variation, stratigraphy, faults and fractures, hydrocarbon responses, as well as subtle detection of depositional facies architecture from seismic in three dimension (Hart, 2002).

Seismic attributes are classified into two, which include: Geometrical attributes and Physical attributes (Sheriff, 1991). Physical attributes are those attributes which relates to wavepropagation, and lithology. It entails of the physical constraints of the subsurface which comprises: amplitude, phase and frequency. These can also be classified as pre-stack and post-stack attributes, and further classified as: instantaneous and wavelets attributes respectively. Instantaneous attributes are calculated sample, which indicates an incessant change of attributes to the time and space axis while the wavelet attributes signify features of wavelet and their amplitude variety (Schlumberger, 2009).

II. LOCATION OF THE STUDY AREA

The Gabo field is located within the Niger delta, Nigeria (Figure **1)**. The field is situated within latitudes 4° 19′ 00" N and 5° 50′ 00" N and Longitudes 5° 30′ 30" E and 6° 10′ 00" E. The base map of the area showing the seismic lines and well locations is shown in Figure 2. The base map indicates the relative positions of the wells in the field as well as political boundaries, company leases and other pertinent information relating to exploration within the field.

The Niger Delta Basin is situated on the passive margin of West Africa. The sub-aerial part of the delta covers about 75,000km^2 and extends for more than 300 km from the apex to the mouth. The basin started as a proto-Niger Delta following the tectonic evolution of the Benue-Abakaliki Trough (Bustin, 1988). This tectonic episode occurred 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 Daukoru, 1975; Whiteman, 1982). The Niger Delta is characterized by major regressive phase from the Eocene to Holocene; this was initiated by the uplift of the Benin and Calabar flanks during the Paleocene to Early Eocene (Murat,1972).

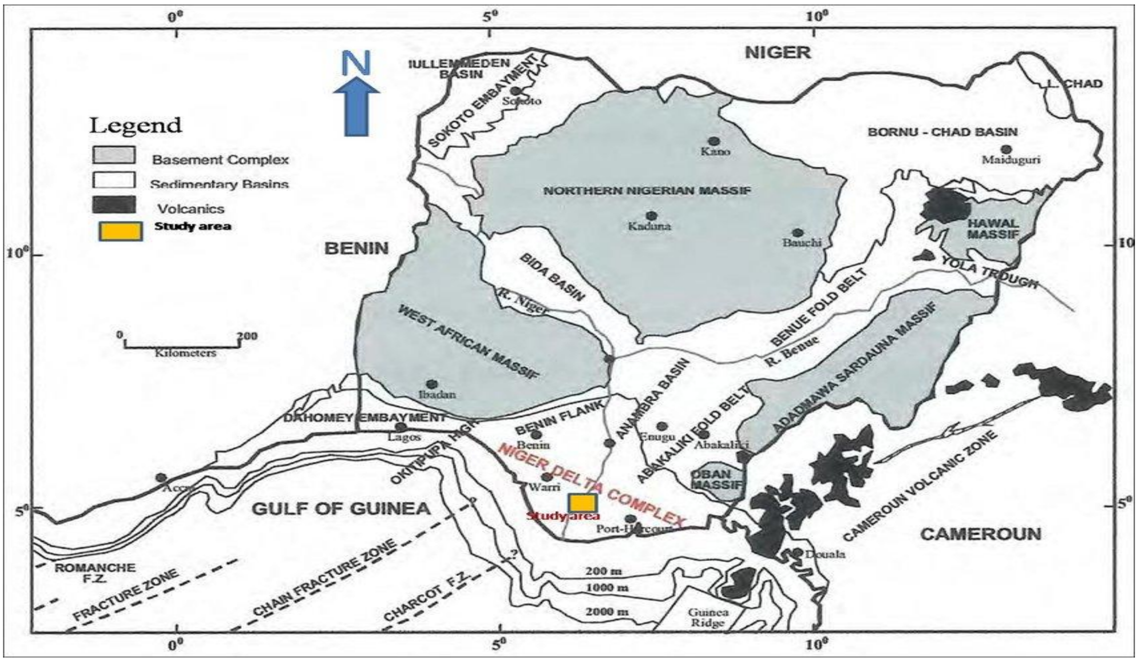

Figure 1: Map of Nigeria, showing Niger delta basin and the location of the studied area (modified after Whiteman,1982)

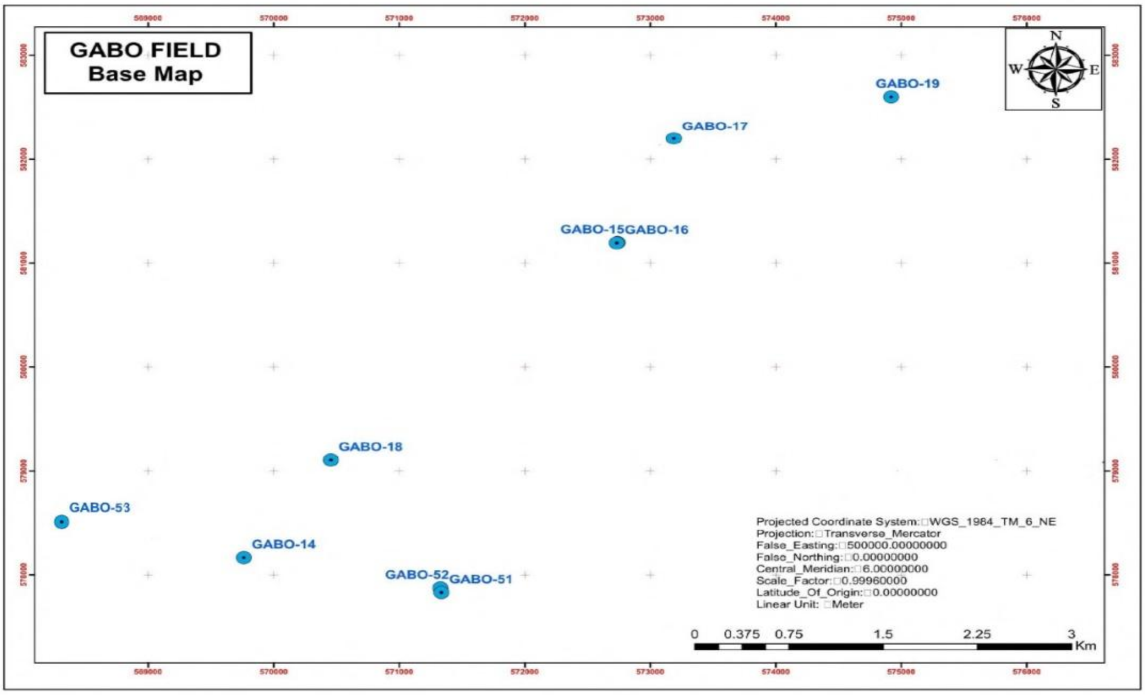

Figure 2: Base map of Gabo field, Niger Delta showing well locations

III. METHOD AND/ OR THEORY

3.1 Data sets used: The data set used for this study comprised of 3D seismic reflection data (961 inline and 444 crossline) covering an estimated area of 76km^2, check shot survey data and base map of the study area. All files are in standard digital format. Petrel software was employed for data analysis. These data belong to Total

Exploration and Production, Nigeria, and was released under the approval of the Department of Petroleum Resources (DPR), Nigeria.

The Check shotdata are derived from seismic shooting along the surface whereby geophones are placed at intervals within the borehole in order to provide relation between time and depth. The check shot data provided for this study enables the seismic interpretation to be tied to the well logs for analysis.

3.2 Methodology: The main steps involved in the analysis and interpretation of data for this study are shown in Figure 3. These steps include data importation and conditioning, well to seismic ties and seismic attributes analysis.

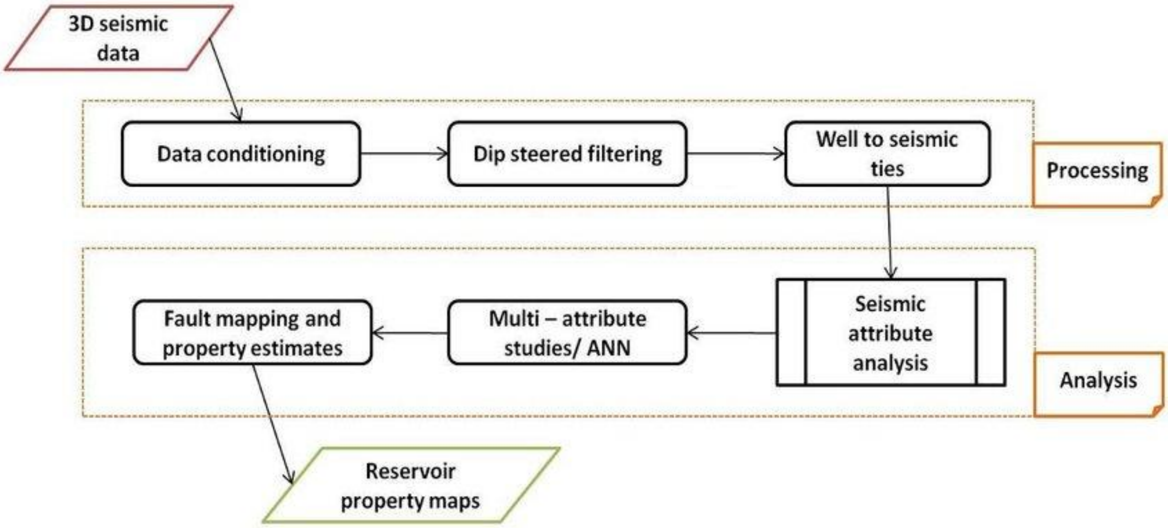

Figure 3: Workflow for 3D seismic attribute studies and interpretation

IV. RESULTS AND DISCUSSION

4.1 Synthetic Seismogram: The synthetic seismogram generated for two wells in the Gabo field are shown in Figures 4 and 5.Thewell to seismic tie was done by linking checkshot data to wells and displaying on seismic section. A checkshot and calibrated sonic from all the wells were used for the well-to-seismic tie. There is a sufficient match between the reservoir B and reservoir C tops with its corresponding seismic reflection. The well-to-seismic tie enabled the top of the reservoirs B, and C to be correlated with confidence across the seismic sections, however other reservoirs were not considered because they tend to be a thin reservoir while some were tested water-bearing.

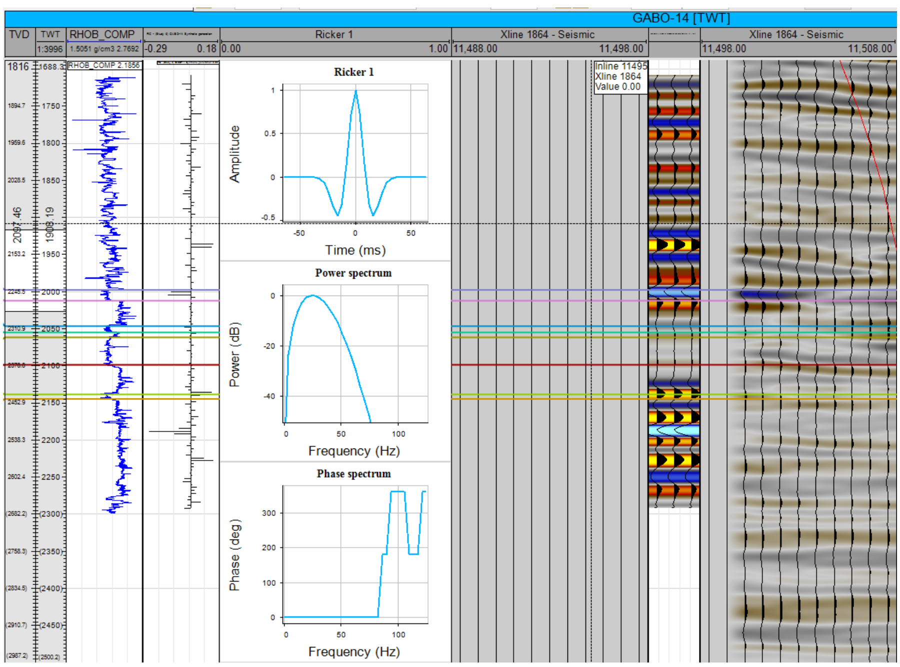

Figure 4: Synthetic seismogram generated for Gabo field from Gabo-14

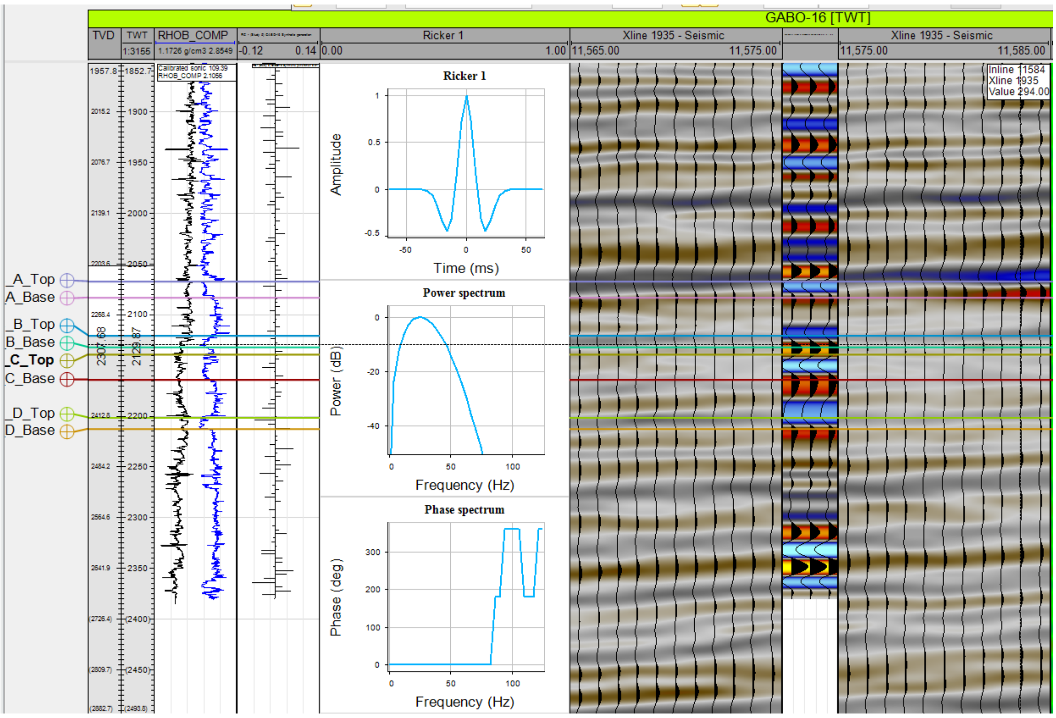

Figure 5: Synthetic seismogram generated for Gabo field from GABO-16

4.2 Seismic Attribute Analysis:

4.2.1 Variance Edge Attribute: The variance edge attribute computed for the field is shown in Figure 6.Variance attribute was used in order to enhance the fault interpretation where it was becoming difficult to trace. The dark lines within the map can be interpreted aa identified and subtle faults within the area.

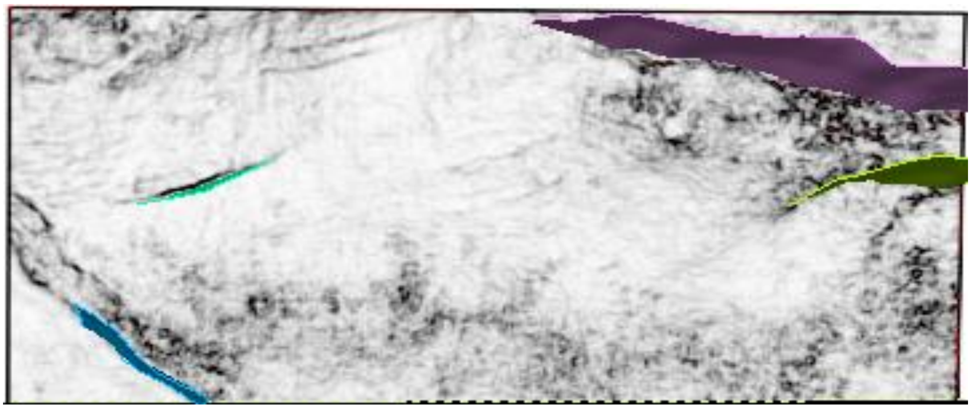

Figure 6: Interpreted Faults on Variance Attribute on z-slice

4.2.2 Mean Square (RMS) Amplitude Attribute: The RMS amplitudes generated for reservoirs B and C are shown in Figures 7 and 8 respectively. The RMS amplitudes are direct indication of lithology since they emphasize the variation in acousticimpedance over a selected sample interval. Higher RMS amplitudes values represented by red/green/yellow colour bands denote stacks of sand accumulation, which also conform to places of high hydrocarbon attenuation but do not necessarily reflect reservoir quality while lower RMS amplitudes values represented by light blue/purple colour bands are direct indication of shale.

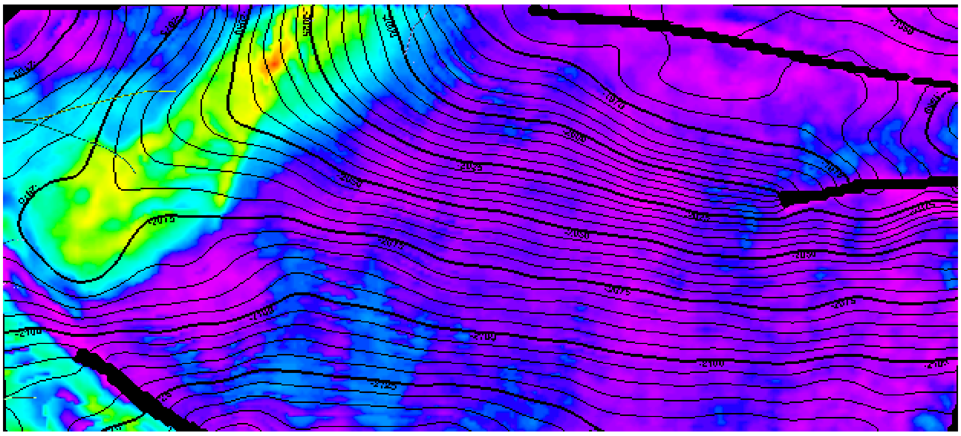

Figure7: Root Mean Square Amplitude map of Reservoir B

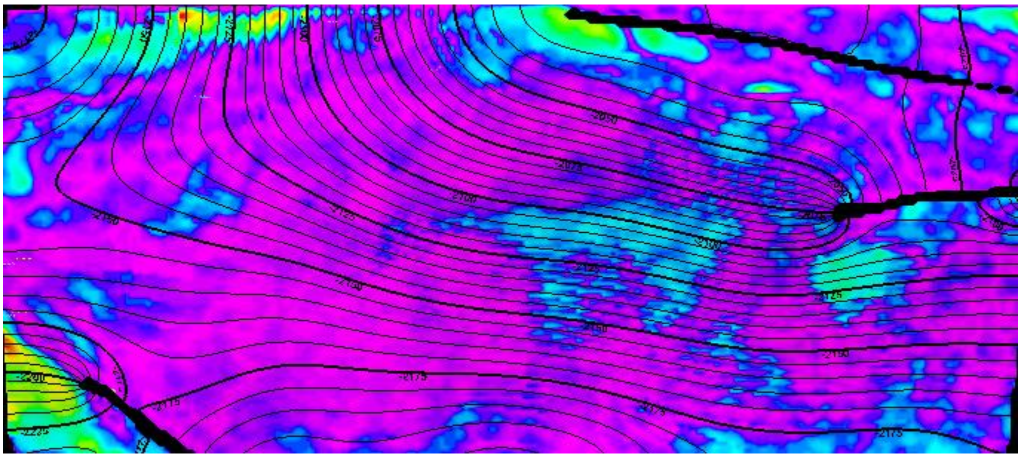

Figure8: Root Mean Square Amplitude map of Reservoir C

4.2.3 Instantaneous Frequency Attribute: The computed instantaneous frequency attribute for reservoirs B and C are shown in figures 9 and 10 respectively. The instantaneous frequency is characterized by sharp reduction in reservoirs containing hydrocarbon. The reservoir zones are indicated with the green colour in the maps. The instantaneous frequency is characterized by sharp reduction in hydrocarbon reservoirs. It is usually unstable in the presence of noise.

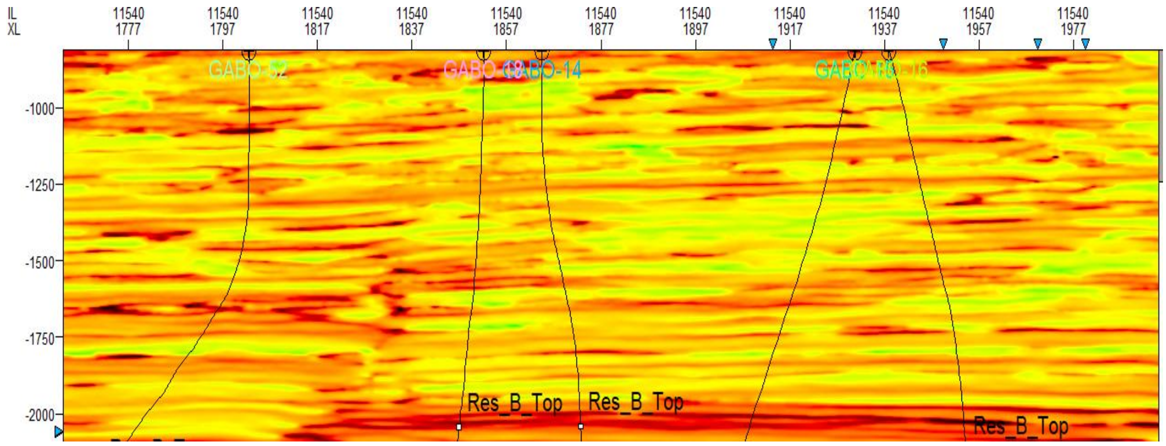

Figure9: Instantaneous Frequency Attribute of Reservoir B

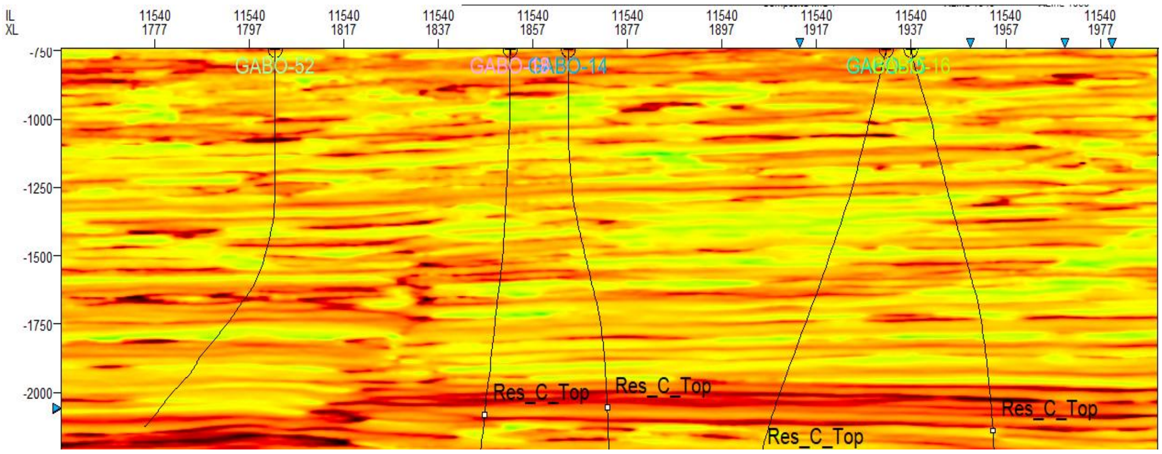

Figure 10: Instantaneous Frequency Attribute of Reservoir C

4.2.4Envelope Attribute: The envelope attribute computed for the two reservoirs B and C are shown in Figures 11 and 12 respectively. The envelope attribute is also known as Reflection Strength. The envelope attribute is used to detect bright spots, sequence boundaries and subtle changes in lithology. The circled zones in blue colour in the maps are indication of hydrocarbon.

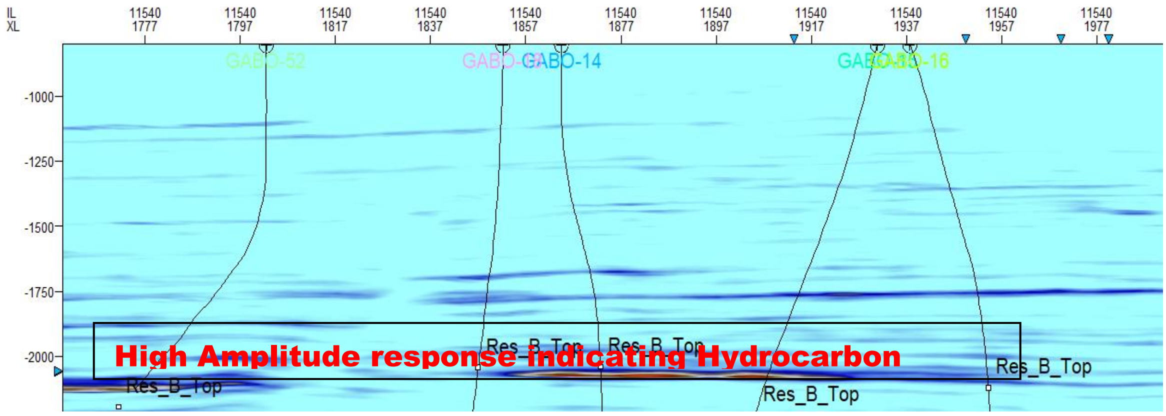

Figure 11: Envelope Attribute of Reservoir B

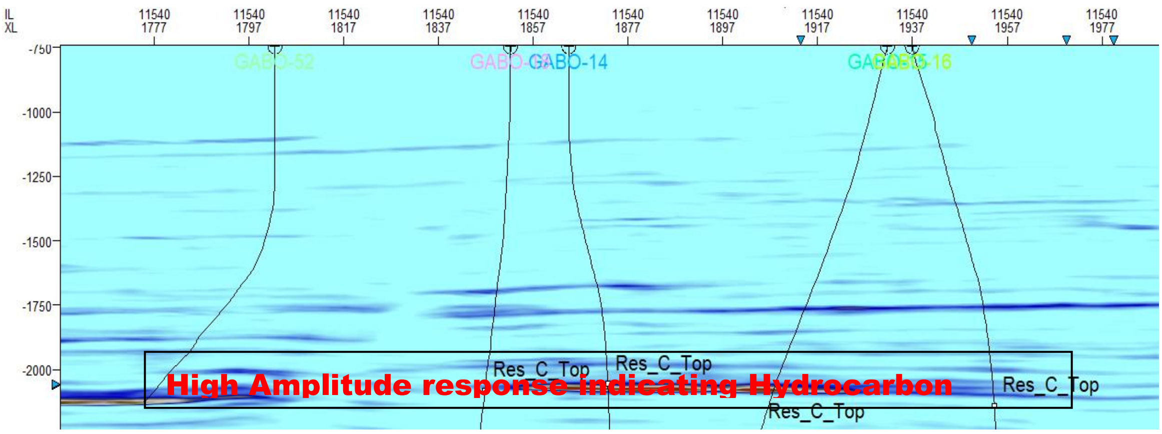

Figure 12: Envelope Attribute of Reservoir C

4.2.5 Average Magnitude Amplitude: Figures 13 and 14 show the generated average magnitude amplitude for reservoirs B and C respectively. It is used as a direct hydrocarbon indicator. The zones with yellow and blue colours in the map are direct hydrocarbon zones. The Average magnitude amplitude has the same characteristics as the average energy amplitude map.

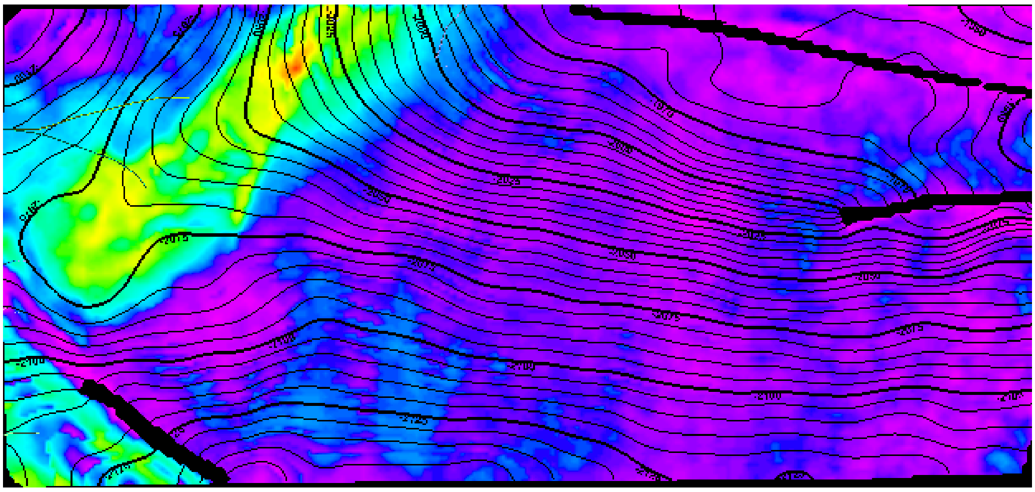

Figure 13: Average Magnitude Amplitude map of Reservoir B

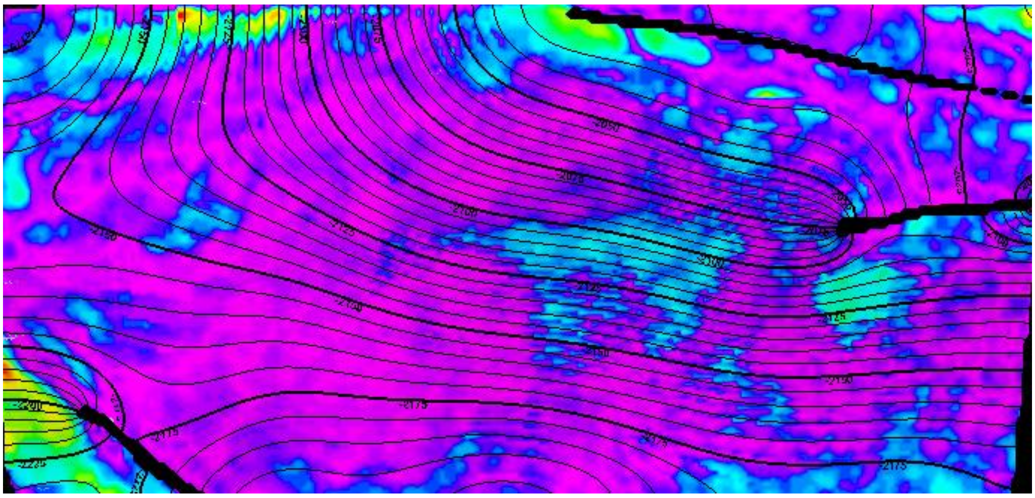

Figure 14: Average Magnitude Amplitude map of Reservoir C

4.2.6Depth Structure map for Reservoir B Top: Figure 15 depicts the depth structure map of reservoir B; the map has a minimum depth of 1960m and maximum depth of 2140m. It is compartmentalized by series of normal fault. The map was computed from the time structural map of the reservoir with the aid of the checkshot data.

4.2.7 Depth Structure map for Reservoir C Top: Figure 16 depicts the depth structure map of horizon C. the map has a minimum depth of 1960m and maximum depth of 2140m. It is compartmentalized by series of normal fault. The faults form a closure for the reservoir.

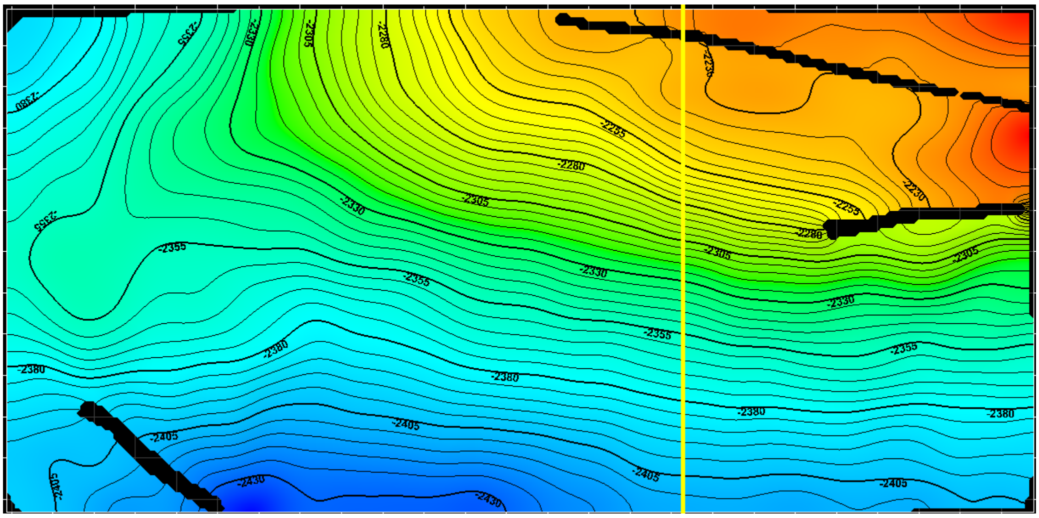

Figure 15: Depth Structure map for Reservoir B Top

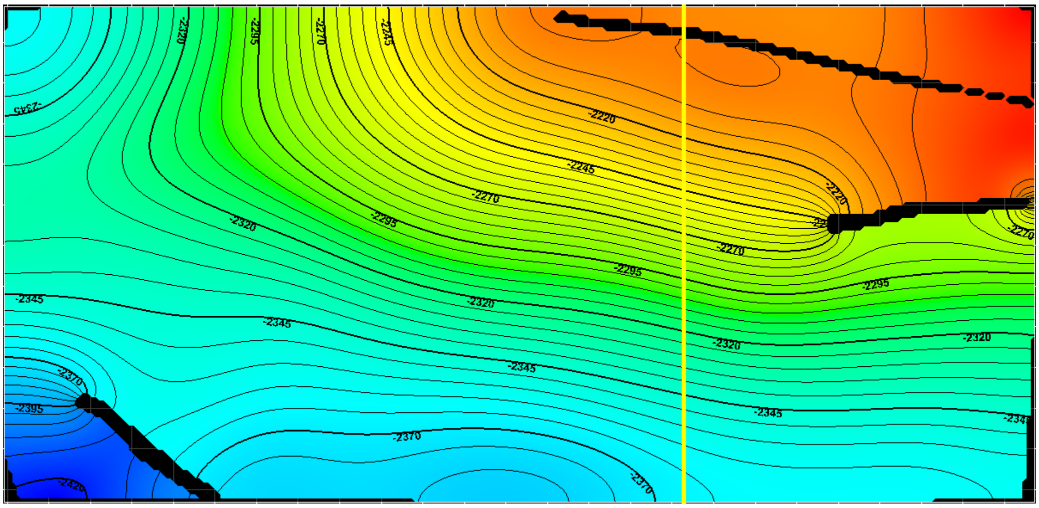

Figure 16: Depth Structure map for Reservoir C Top

V. CONCLUSION

Seismic attribute analysis revealed more information about the study area. Instantaneous amplitude and RMS seismic attributes generated conform to high amplitudes indicating either favourable lithology or porosity. The approach showed that computing seismic attributes analysis rather than relying on traditional visualization of faults and hydrocarbon zones from horizon picks, gives better results. The Attributes gave improved geologic maps including information on potential prospective zones and facies corresponding to reflector boundary. It was concluded that attribute analysis could be used to identify hydrocarbon prospect, predict reservoir rock properties and characterize reservoir.

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