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Research Article

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Application of Coherence Attribute for Prospect Identification

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Abstract: Structural features, such as faults, acts as traps and a conduit for the migration of hydrocarbon, while stratigraphic features, such as channels and point bars act as reservoirs for the accumulation of hydrocarbon. These geological features have significant importance in the discovery of commercial quantity of hydrocarbon. Geological features not delineated along time slices on conventional seismic data, have been successfully delineated. The identification of subtle structures possesses great challenges when using time slices on a conventional data. Along time slice, these subtle geological features are difficult to view, but by the application of seismic attributes such as coherence attributes, along the time slice, the features are seen clearly. This research focuses on the application of coherence attribute in delineating geological features (such as channels, point bars, sand distribution, faults, and sub-seismic faults) that can lead to the delineation of commercial quantity of hydrocarbon bearing reservoirs in the study areas from two data set in the Niger Delta. The identification of faults and channels and point bars, in the study areas could lead to the drilling of commercial quantity of hydrocarbon.

Keywords: Coherence Attribute, Fault, Channels and Time slice

Introduction

As the search for hydrocarbon moves into more challenging environments, new geophysical techniques are being developed, while techniques that are not capable of providing better ways to map hydrocarbon bearing reservoirs are being dropped or improved (Holdaway & Irving, 2017; Lai et al., 2022). The worldwide high demands for hydrocarbon have moved the search for hydrocarbon into remote areas and more challenging environment, such as deep-waters and deep jungles in order to meet the high demand for hydrocarbon supply.

After the acquisition of geophysical data in these challenging environments by the seismic acquisition team, they are processed by the Processing Geophysicists, after which interpreters are expected to interpret the processed seismic data set. The interpreted seismic data set is then passed on to the drilling team for drilling. If the data set is not properly interpreted failure is bound to occur during drilling.

Before the drilling phase, it is paramount to use a high-end interpretation algorithm such as coherence attribute to interpret these data, so as to visualize geological structures (such as channels, sand bodies, faults, etc.) that are difficult to see on a conventional seismic data set. Geological structures always play a major role in the identification of prospect in the oil and gas section (Yan et al., 2017; Kobr, 2021). The identification of subtle structures possesses a great challenge when using the conventional seismic data. Along the time slice of the data, these subtle geological features are difficult to view, but using seismic attributes such as coherence attributes, along the time slice, these features can be seen clearly. According to Chopra and Marfurt (2007), depositional systems such as river channels, often show up better on time slices, relative to vertical sections. Using coherence attribute along time slices are of great importance for interpreting such geological features that are hidden on a conventional time slice.

According to Chopra, and Marfurt (2007), the detection and mapping of faults, channels and reservoir plays significant role in hydrocarbon exploration and outputs. Better hydrocarbon production can be achieved by accurately delineating and detecting the reservoir lithology and the overall reservoir configuration. The application of Coherence attributes in detecting faults and channels can reduce the challenges in detecting these geological features in a conventional seismic data set. This attribute can be helpful to detect sands associated with fluvia detaic channels (Caldwell et al., 1997).

Channels being stratigraphy traps play significant roles in the oil industry. They are filled up with porous deposits and bounded in a non-porous medium. They contain sandstone that are porous enough to hold hydrocarbon, due to their porosity and the presence of seal makes channels to be an appropriate oil and gas reservoir (Mohebian et al., 2013). These channels are generally difficult to interpret due to their subtle nature using conventional seismic interpretation method. However, using coherence attribute provides an advance technique to effectively image and interpret these stratigraphic features.

The weakness of conventional method of seismic interpretation can be seen during the drilling of production wells (Ambati et al., 2021; Gabdullin, 2023). Sub-seismic faults are difficult to map using conventional methods, when these faults are properly delineated, they can cause the loss of the drilling mud used during drilling, because these sub-seismic faults can cause the absorption of more drilling mud. This act can make the well to be abandoned by the drillers if they do not understand that it was the presence of sub-seismic faults that were absorbing the drilling mud (Ashique and Samiranjan, 2010; Ngeri et al., 2015).

The aim of this research is to use coherence attributes to enhance structural and stratigraphic trap in order to reduce uncertainty during drilling.

Coherence Attribute

Different software vendors have different name for coherence attribute. Terms such as coherence, semblance, similarity, discontinuity, and many others are used to refer to the same attribute. Coherence attribute was developed to image discontinuities on seismic trace by analyzing waveform similarity. This attribute enhances the effective delineation and understanding of stratigraphic features (as well as faults) that are not clearly seen on amplitude seismic section (Caldwell et al., 1997). Coherence is a measure of the similarity and dissimilarity between seismic traces. Most time the terminology used for coherence attributes can be confusing.

Faults are (often) easily visible on individual vertical sections, but many of these faults need to be examined to determine the lateral extent of the faulting. Stratigraphic changes are difficult to detect on vertical seismic lines because of their limited profile in this view, but these stratigraphic changes can be seen clearly on coherence attributes (Bahorich and Farmer, 1995).

Chopra in (2002) used coherence attribute in detecting trace discontinuities of seismic data to detect faults and stratigraphic features of interest to the seismic interpreter. According to Chopra (2002), the presence of fault will change the trace characteristic in a way that the seismic traces lose coherency. Seismic traces that are similar to each other are mapped with high-coherence values while traces that are dissimilar to each other are mapped with low-coherence values. In a high-coherence events seismic traces are similar from trace to trace, while in a low-coherence event seismic traces are dissimilar from trace to trace (Caldwell et al., 1997). Figure 1 show two seismic traces showing high and low coherence events.

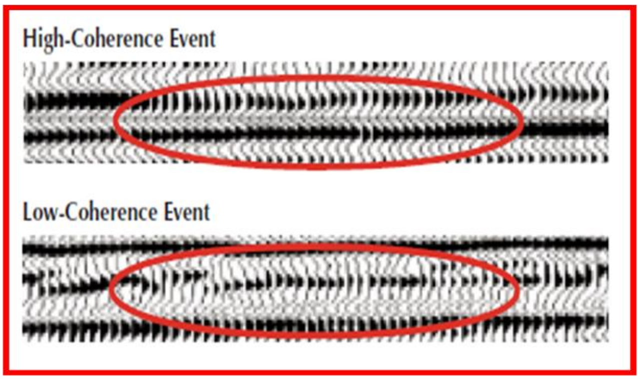

Figure 1: Image showing High and Low Coherence Events.
Source: Caldwell et al. (1997)

From geological point of view, highly coherent events on seismic trace indicates laterally continuous lithologies, on the other hand abrupt changes of events on seismic traces indicates faults and fractures in the sediment (Chopra and Marfurt, 2007). The regions of seismic trace cut by the fault plane typically have different seismic characteristics than the corresponding regions of adjacent traces, resulting in a significant discontinuity in local trace-to-trace coherence (Bahorich & Farmer, 1995). The uniqueness of the coherence attributes is its sensitivity to changes of seismic events, this quality has made the coherence attribute an effective tool in delineating subtle information from seismic data (Chopra and Marfurt, 2007).

Since the inception of coherence attribute in 1995, it has increased the probability of finding hydrocarbon in matured and new fields by delineating stratigraphic (and structural) traps that

were not visible with traditional procedures (Caldwell et al., 1997). Map views of coherence attribute enable the geophysicists the opportunity to identify stratigraphic changes more clearly that were difficult to see on conventional 3D seismic volume (Bahorich & Farmer, 1995).

Figure 2 shows one of the earliest published work on coherence attributes by Bahorich & Farmer, (1995). Figure 2(A) show a time slice through a seismic data, while Figure 2(B) show coherence display of the seismic volume. Channels and faults not seen clearly on the time slice are seen visualize easily on the coherence slice.

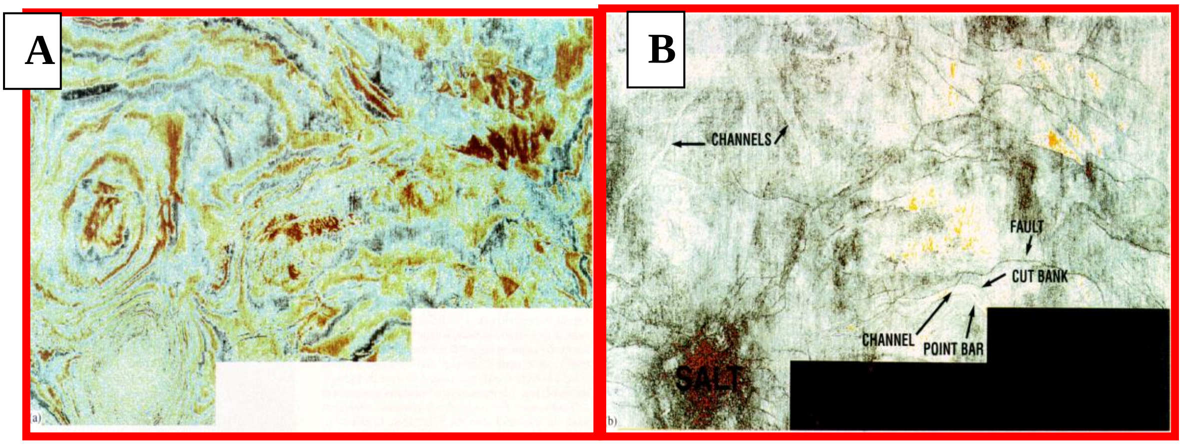

Figure 2: One of the Earliest Published Works on Coherence Attributes (a) Time Slice(b) Coherence Attribute. Source: Bahorich & Farmer (1995).

Materials and Methods

Petrel software package and Opendtech 4.6.0 software were used in carrying out this work, the data used was a secondary data set from Shell Petroleum Development Company (SPDC). In order to achieve the expected result, the research was done in three stages; in the first state the conventional method of interpreting seismic data was applied. The seismic data was analyzed to see the area of interest; after which it was applied with a filter to remove some random noise from the data. Horizons of interest were picked to produce surfaces. For the picking of faults, the conventional method of picking faults from amplitude section on a 3D seismic volume was used.

In the second stage of this research, coherence attribute was applied on the seismic data so as to map structural and stratigraphic traps clearly that were not seen when the conventional method of interpretation was applied on the data. The results obtain in this second stage shows that the coherence attribute was more superior to the conventional method in displaying faults and channels.

Finally, in stage 3, a detailed interpretation of the results was carried out. A workflow of the methodology is displayed in Figure 3.

Results And Discussion

The data used for this research are two sets of 3D seismic data set acquired from a land and marine environment. Both the conventional methods of interpretation and coherence attribute where applied on both data sets. Time slice was interpreted from the land data to highlight major and subtle faults not seen on the seismic data when conventional method of interpretation was used. Figure 4a shows the time slice of the seismic data at 2.5 s, on the time slice, the faults on the red circular loops cannot be easily seen by an interpreter of few years of experience, to see this faults on the time slice, it would take an experience interpreter to know that the red circular loops are region of faults. Figure 4b shows the application of coherence attribute on the time slice at 2.5 s, when compared to the time slice in Figure 4a, it shows a good result. The faults in the black and red circular loops in Figure 4b were not seen on the time slice data in Figure 3a.

Figure 5a shows time slice at 2.8 s, the sub-seismic faults in the red circular loop and red arrows cannot be delineated, even an experience interpreter cannot delineate such sub-seismic faults. Applying coherence attribute to the time slice at 2.8 s shows a better image of the faults and sub-seismic faults in the red circular loops and red arrows in Figure 5b, the output of the coherence attribute in delineating sub-seismic fault is better when compared to the time slice in Figure 5a

Figure 6a shows Horizon H2 from the marine data, looking at the red circular loop and the red rectangular loop, one can see features that looked like channels, these channels are not clearly seen, such channels are difficult to interpreter. In Figure 6b, coherence attribute was applied to Horizon H2, the result from the coherence attribute imaged the channel better when compared with Figure 6a.

Figure 7a shows time slice at 3 s from the marine data, the presence of a meandering channel body cannot be accurately delineated. Interpreting such result would be difficult since the channel is difficult to delineate. Applying coherence attribute to the time slice at 3 s, shows a significant improvement in delineating the meandering channel, this is shown in Figure 7b.

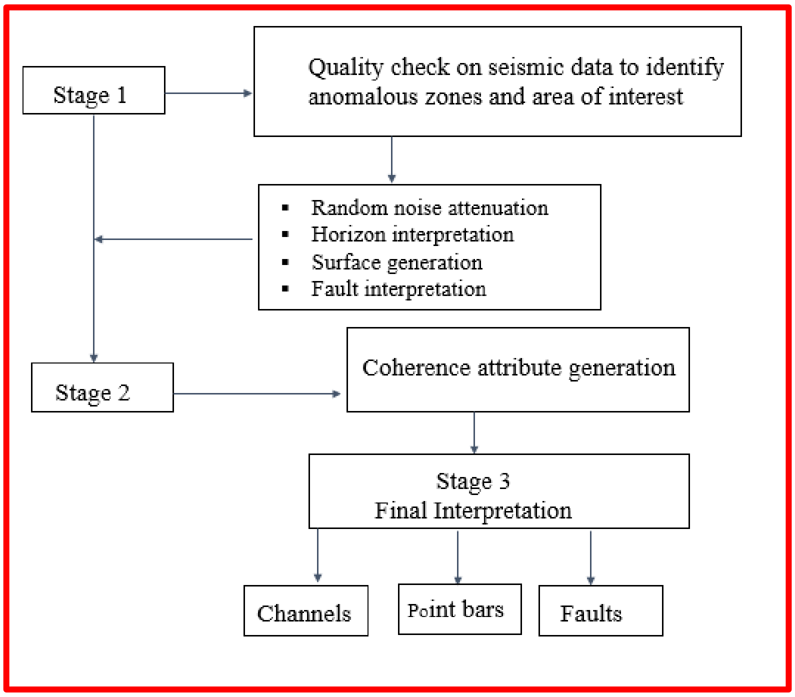

Figure 3: Research Workflow

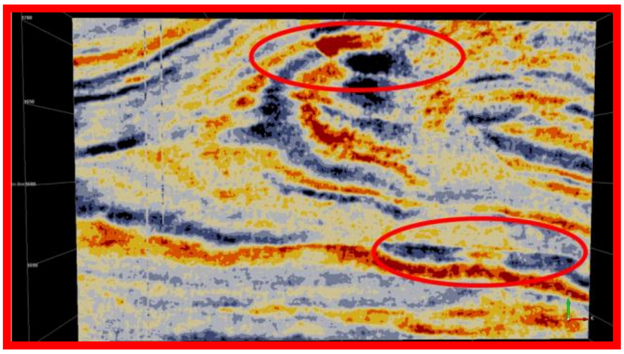

Figure 4a: Time Slice of the Seismic Data at 2.5 s. Red Circular Loop shows Fault Regions.

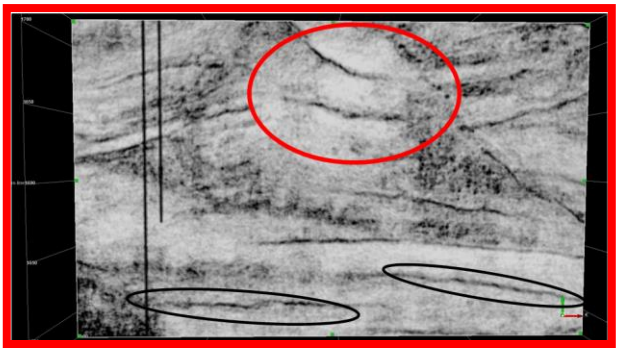

Figure 4b: Coherence Attribute of the Seismic Data at 2.5 s. Red Circular and Black Loops shows faults regions

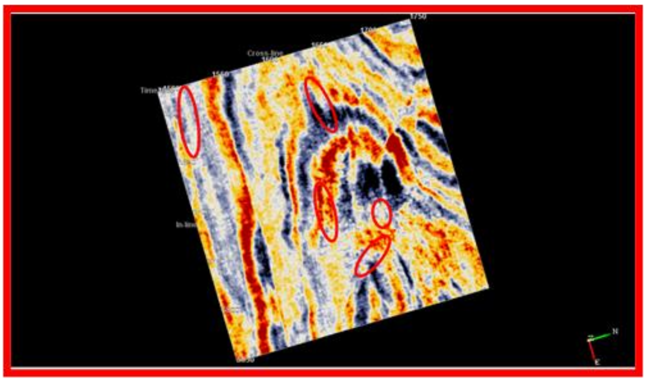

Figure 5a: Time Slice at 2.8 s, Sub-seismic Fault in the Red Circular Loop and red arrows cannot be Delineated

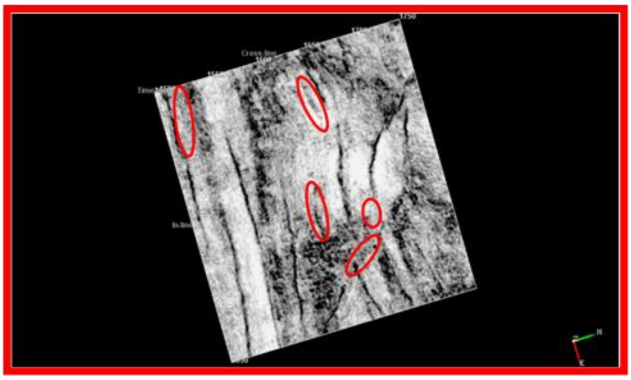

Figure 5b: Coherence Attribute at 2.8 s, Sub-seismic Fault in the Red Circular Loop and red arrows are seen.

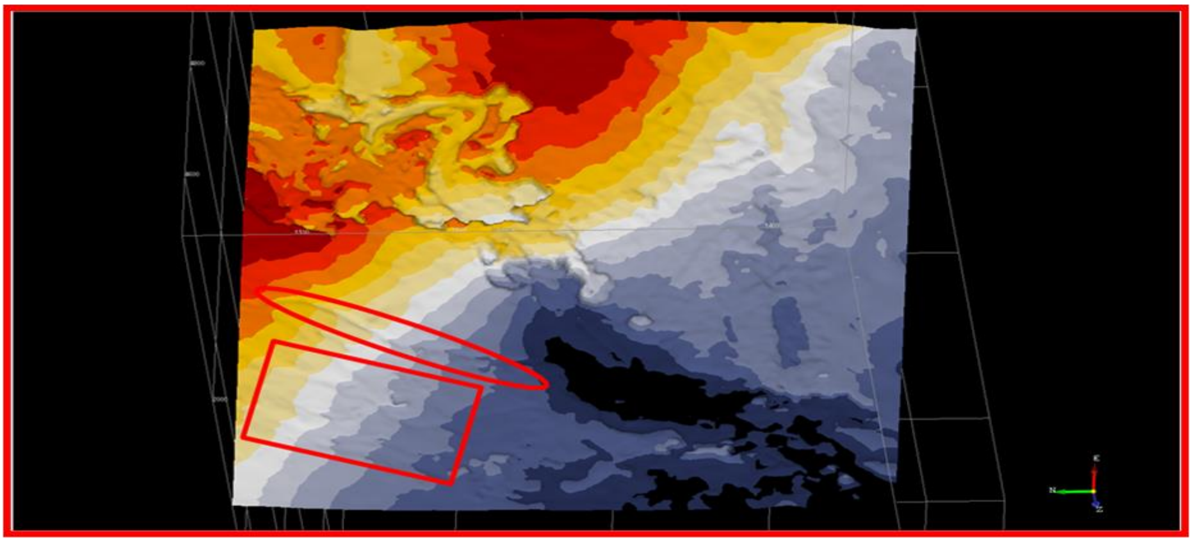

Figure 6a: Image showing Horizon H2 From the Marine Data.

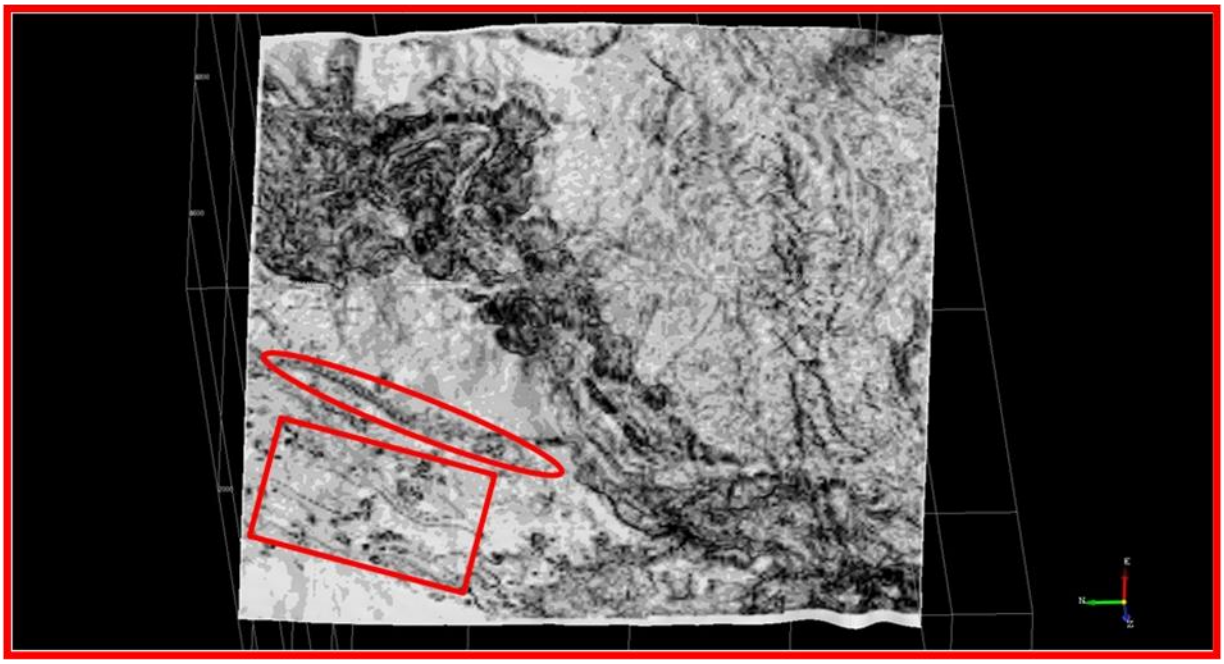

Figure 6b: Coherence Attribute of Horizon H2 from the Marine Data

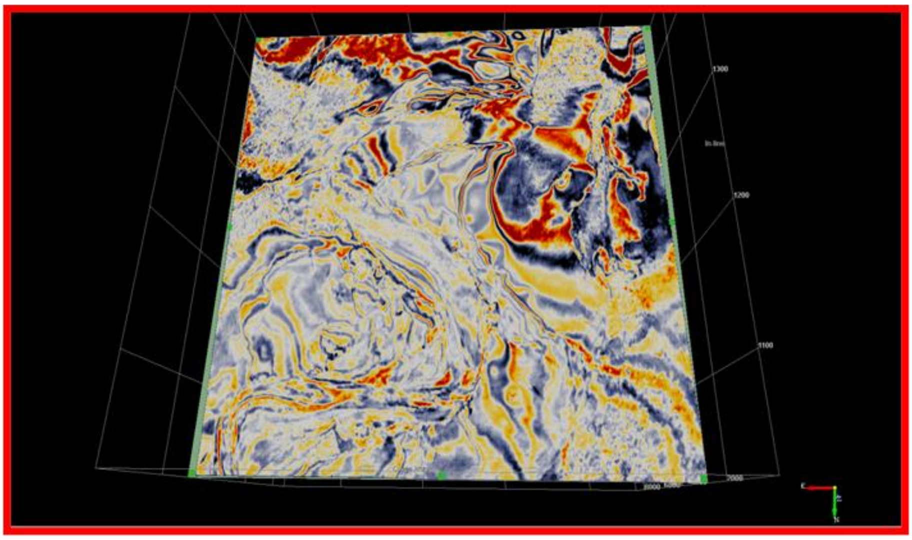

Figure 7a: Time slice at 3 s. The Presence of Channel is Difficult to Delineate.

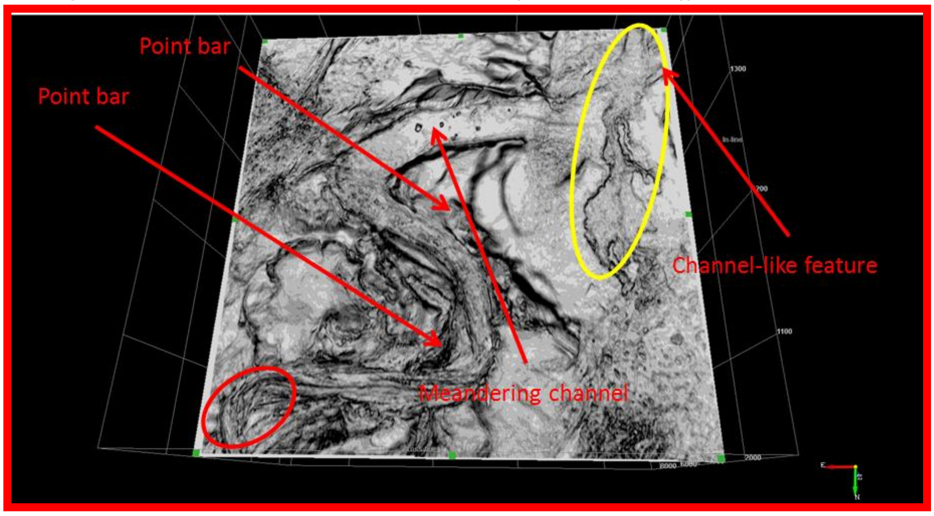

Figure 7b: Coherence attribute at 3 s. The Presence of Channel, point bars are Delineated

Conclusion

From this research it is understood that the role of Coherence attribute in the enhancement of structures and stratigraphic features cannot be underestimated. The identification of geological features such as faults, channels and point bars have been delineated coherence attribute. Sub-seismic faults not delineated by conventional methods were delineated using coherence attribute. Using such attribute can help geologist and geophysicists to position wells at the right targets

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