APPLICATIONS OF THE SEISMIC ATTRIBUTES CUBE IN THE CUU LONG BASIN, OFFSHORE VIETNAM

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Abstract

Seismic attributes are a powerful aid to seismic interpretation. They allow us to interprete faults and channels, recognise the depositional environment and unravel the structural deformation history more rapidly. This paper discusses several examples of seismic attributes as CTC and ESP from the Cuu Long basin offshore Vietnam.

Seismic coherency (CTC) is a measure of the similarity between seismic traces. Coherency data play an important role in the delineation of structural and stratigraphic features by enhancing the images seen on the conventional 3D seismic data. A coherency cube was utilised to enable a quick interpretation of the structural framework of an area of a block in the Cuu Long basin. In particular CTC attribute slices near the surface of basement, together with fault interpretation of seismic data, could indicate the presence of possible smaller localised faults the basement surface of C and VT structures.

Event Similarity Prediction (ESP) is a seismic discontinuity volume attribute. Seismic discontinuity attributes quantify the degree to which neighboring seismic traces vary from each other. They detect abrupt lateral changes in seismic data character caused by faults, diapirs and stratigraphy. ESP data were used to assist prediction of the distribution of faults/fractures zone inside the CNV basement area. These examples illustrate how CTC and ESP data can be used in exploration to improve the imaging of geological features.

1. Introduction

A seismic attribute is any measure of seismic data that helps us visually enhance or quantify features of interpretation interest. A good seismic attribute is either directly sensitive to the desired geologic feature or reservoir property of interest, or allows us to define the structural or depositional environment and thereby enables us to infer some features or properties of interest. First introduced in the early 1970s, seismic attributes are now used widely for lithological and petrophysical prediction of reservoir properties [1 - 3].

The Cuu Long basin is one of the potential basins of Vietnam where petroleum activity is active. From the end of the1990s, seismic attribute analysis started to be applied to the exploration technology in this basin, primarily because the industry had embraced 3D technology - which was by far the most successful new exploration technology [4, 5]. The single most important contribution in making drilling decisions at that time was the concept of 3D attribute extractions. Finally it was possible to compute attributes for full 3D volumes and examine features of interest in their three dimensional perspective. By animating through those volumes, geosientists could quickly interpret variations in structural and stratigraphic style from seismic line to seismic line, and could quickly link subtle variations in seismic lines to their corresponding attributes.

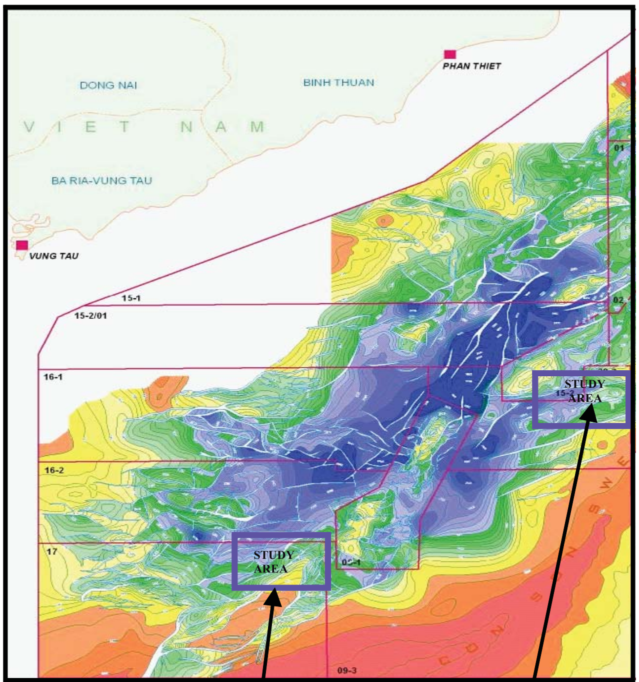
With the Cuu Long basin where 3D seismic surveys had been done and were being conducted annually, good 3D interpretation workflows on interative workstations were being perfected. Complex trace analysis was performed on full 3D seismic volumes and used in the interpretations. However, most 3D seismic interpretation was performed on vertical inlines and crosslines and then projected onto time slice. Although that worked well, it led to ambiguities in the lateral resolution of faults, especially where faults joined together, crossed, or simply ended as a result of changes in geologic stress [1 - 3].

In order to resolve these events, the method of revealing fault surfaces within 3D volume for area where no fault reflections have been apply, these are CTC and ESP method. By using CTC and ESP, we could indicate the presence of possible smaller localised faults near basement surface of structures in the Cuu Long basin (structure C and VT) as well as predict the distribution of faults/fractures zones inside the CNV basement area.

2. Example of Applying Seismic Coherency into Block 17

The area of CTC application is located in the Western part of the Cuu Long basin (Fig.1). We used two 3D seismic surveys: 460km^2 of 3D survey acquired by PGS and processed by Golden Pacific Group and 152km^2 3D survey carried out by Enterprise Oil Exploration Limited in 1996. In the area, the sea-floor varies from 40 - 55m water depth, except above some recent coral reefs (one of them rises up near sea level, which deranged the acquisition in the Northern part of the study area). The area is close to the Dragon oil field group, where oil is produced from Early Miocene Sandstone and Pre-Tertiary fractured basement. Our objective was to interpret two 3D seismic data cubes including attribute processing and analysis in combination with well data to describe the geometry of potential reservoirs and to evaluate their prospectivity.

CTC computes local trace to trace dissimilarity. These dissimilarity measurements yield the visual identification



Area applying CTC
Area applying ESP

Fig.1. *Location map of the applications seismic attributes areas*

of such features as faults, facies changes, and other geologic patterns. Faults and stratigraphic changes will often standout as prominent anomalies in otherwise homogenous data. CTC processing converts normal seismic data into CTC attributes by measuring lateral data similarity through correlation and semblance techniques.

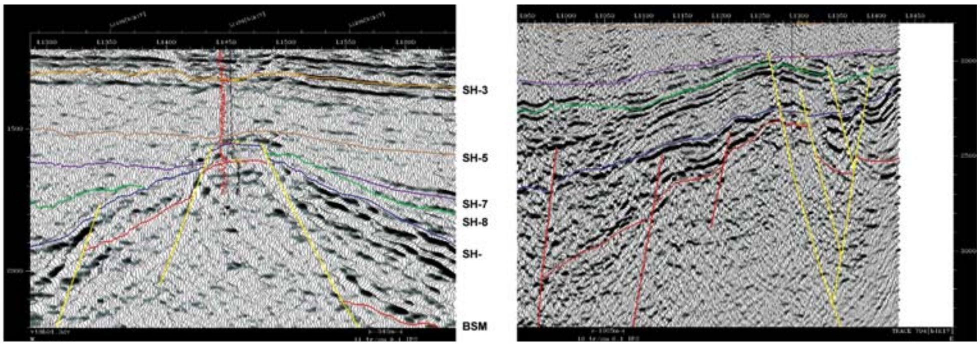
We could view and interpret CTC attributes just as normal seismic amplitudes. The advantage of the CTC data is that contrasts between similar and dissimilar data are much more apparent. Conceptually, we would expect high similarity values from trace to trace when the geology is flat and continuous, lower values when it is dipping and continuous, and anomalous values when it is discontinuous. This is very useful if we try to pick faults or delineate stratigraphic changes [1 - 3]. We are using available Landmark software Postack-ESP3D to produce CTC attributes, and use SeisWorks 3D for analysis of CTC attributes with the purpose to predict the development of the fracture system of near surface of basement in the area around the "Cam" and "Vai Thieu" structures.

Not all the 3D seismic data cube is selected but, a subset volume has been chosen around the "Cam" and "Vai Thieu" structures in order to reduce the processing time. Fig.2 shows the interpreted seismic section through these structures.

CTC attribute cubes of selected areas were generated and used for analysis. Fig.3 and 4 show CTC attribute slices at 2400ms and 1860ms near surface of basement for Cam and Vai Thieu structures respectively. In these slices, the dark bands show areas of low similarity or dissimilarity and we would expect to see in these areas the possible presence of faulting. The white zones show the trace to trace similarity. Analyzing several CTC attribute slices near the surface of basement, together with fault interpretation of seismic data, we would expect the presence of possible smaller localised faults near the basement surface of Cam and Vai Thieu structures. This indicates the possible presence of fractures in the near surface of basement in the Cam and Vai Thieu structures (Fig.5).

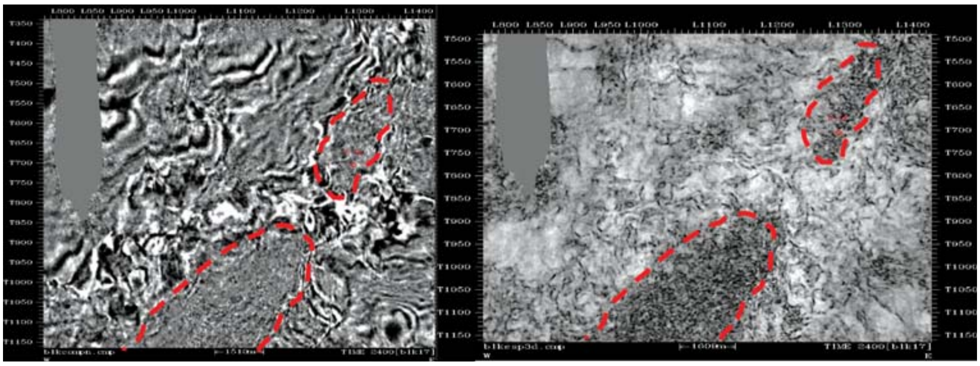
3. Example of Applying ESP into Block 09

This example was done by using ESP (Even Similarity Prediction) processing and analysis of approximately 260km^2 data selected from 3D PSDM 2004 full stack volume acquired for Hoan Vu Joint Operating Company to study the distribution and intensity of faults and fractures within the basement rocks of Ca Ngu Vang (CNV)



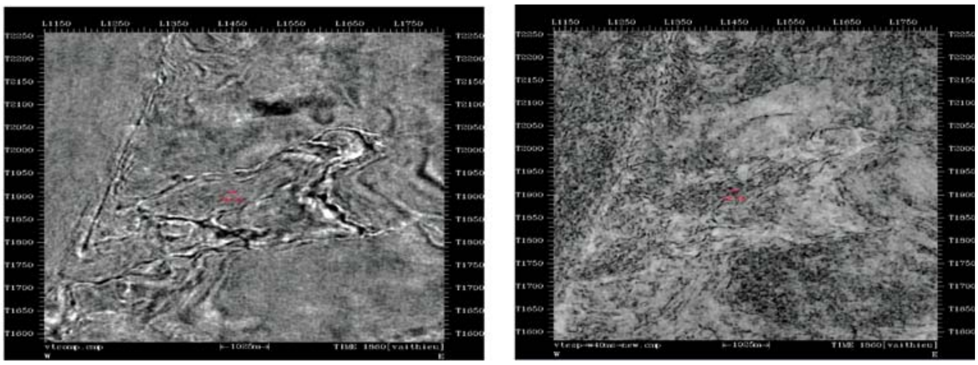
(a) (b)

Fig.2. *Interpreted seismic section through VT (a) and Cam (b) structure*



(a) (b)

Fig.3. *Cam area. Time slice (a) and CTC slice (b) at 2400ms*



(a) (b)

Fig.4. *VT area. Time slice (a) and CTC slice (b) at 1860ms*

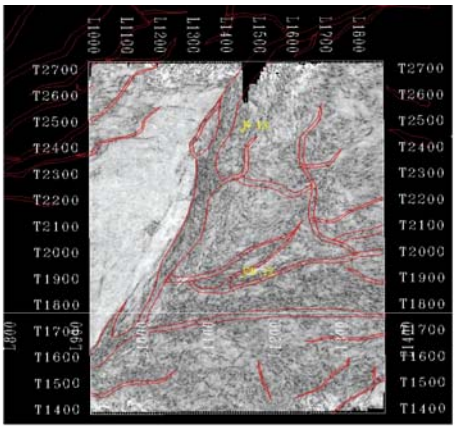
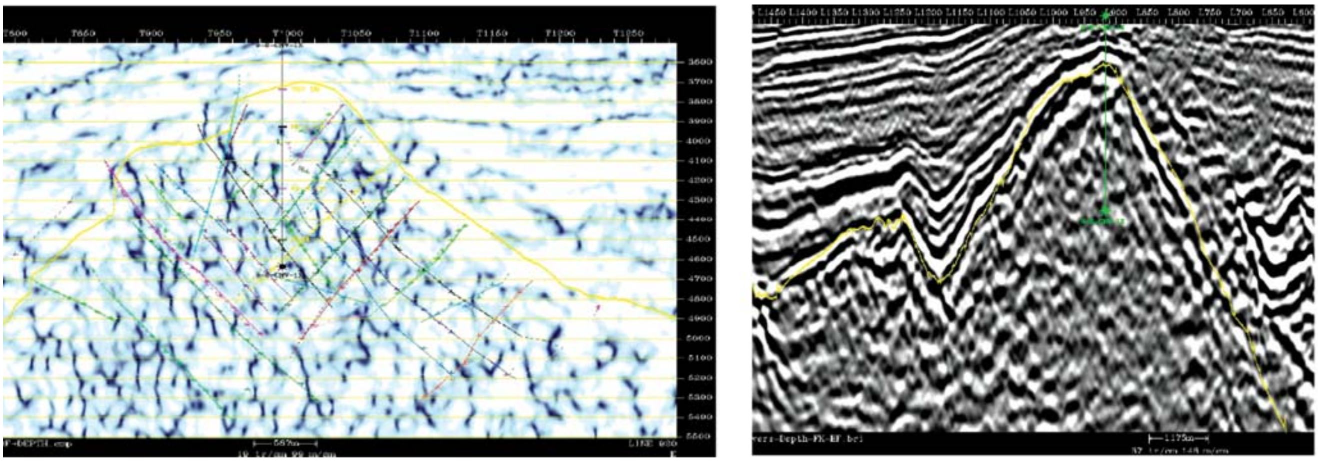


Fig.5. *Coherency map along basement horizon overlaid fault systems*

field in the block 9-2 (Fig.1) as well as the possible reservoir quality distribution regarding the faults and fractures distribution.

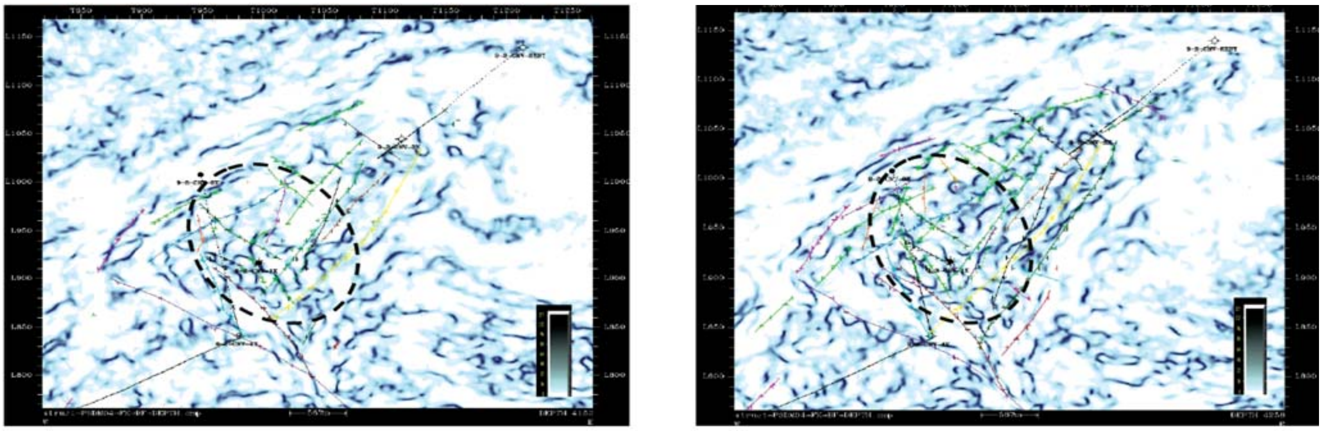
We used available Landmark software "Post-stack-Structure Cube" to produce and analyse ESP attributes with the purpose of studying the distribution of fault/fractures systems [1 - 3].

Structure cube is a seismic discontinuity volume attribute. Its primary application is to serve the purpose: facilitate 3D seismic interpretation by highlighting faults, channels, and other geologic features, especially in a time-slice view. Seismic discontinuity attributes quantify the degree to which neighboring seismic traces vary from each other. They detect abrupt lateral changes in seismic data character caused by faults, diapirs and stratigraphy. Structure Cube compares all the traces in an analysis window with the average trace of the window to compute seismic discontinuity. The comparison is accomplished through weighted correlations, which are sensitive to the relative magnitude of the trace amplitude values, unlike standard correlation. It scales the output data to be in the range of 0 - 100, with 0 being perfectly continuous, and 100 being perfectly discontinuous. For interpretation, one can view and interpret ESP attributes just as one would normal seismic amplitudes. Figures 6 and 7 show the ESP results processed from PSDM 2004 full stack data. In order to interpret the results, in these pictures, the light bands indicating the lowest values (near 0) refer to "being perfectly continuous" and the dark-bands indicating higher values (near 100) refer to "being perfectly discontinuous". To recognise features such as faults we can use the dark-bands for interpretation.



(a) (b)

Fig.6. *Inline 920. ESP section (a) and seismic section (b)*



(a) (b)

Fig.7. *ESP depth slice at 4152m (a) and at 4256m (b) with faulst/fractures interpretation*

4. Conclusions

The association of attributes with 3D seismic data introduced new life into attribute analysis, moving it away from seismic stratigraphy and toward exploitation and reservoir characterisation. Seismic attribute as CTC and ESP has a important role in improving the confidence of interpretation by improving the imaging of structural fabric and stratigraphic features. They are of relatively new application and are to be integrated with other technologies to provide additional insights. Two examples have been discussed showing the integration of seismic attribute cubes in an exploration setting to improve the imaging of geological features ranging in scale from reservoir barriers to faults/fractures. Applications of the attribute cube in the Cuu Long basin enables geocientists to continue to extract more and more information from seismic data.

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