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Spectral Decomposition reveals the subsurface channels: A Case Study

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Summary

Spectral decomposition technique was applied to understand the sand depositional model and other subsurface geological features of the area. From the study four distinct and different channels were delineated in the study area. This study provides a case study of spectral decomposition as useful tool for delineation of subsurface geological features like channel systems etc.

Keywords*: Spectral Decomposition, Seismic Attributes*

Introduction

Spectral Decomposition has become preferred tool for seismic interpreter for understanding and identifying the stratigraphic plays, identifying the minor faults, and also helps in direct detection of hydrocarbons. Spectral decomposition illuminates the subsurface structure with different frequency bands if any of them gives better resolution. At specific frequencies certain structures are more visible due to tuning effect. Spectral decomposition is a process by which the seismic data is converted into discrete frequency volumes using mathematical algorithms like Discrete Fourier Transform (DFT), time-frequency continuous wavelet transform (TFCWT), continuous wavelet transform (CWT), and S transform (ST). Using any these algorithms the seismic data is converted in discrete frequency volumes.

It is known that different subsurface geological elements respond to different frequencies. It becomes difficult to identify these elements from seismic data which is made up of complex frequencies. By studying the data using with specific frequencies will reveal the hidden structures like buried channels, low angle faults, etc.

Study Area

The study area, covered by 3D seismic PSTM data, is steeply dipping towards west, and shallows towards east and NE part. The area is covered by several NW-SE and NE-SW running faults intersected by E-W trending faults. The area is a multi-layer reservoir producing HC at least from 4 reservoir layers. The thickness of the reservoir varies from 2 to 20 meters in different parts of the study area. (Fig-1).

It is desired to understand the sand geometry of the study area in order to suitably position the new locations. Attribute, inversion, semblance studies were carried out to derive the different properties.Though these studies did provide certain clues as to the sand geometry, a definite conclusion could not be arrived at. Hence it is decided to attempt the spectral decomposition method to understand the sand geometry.

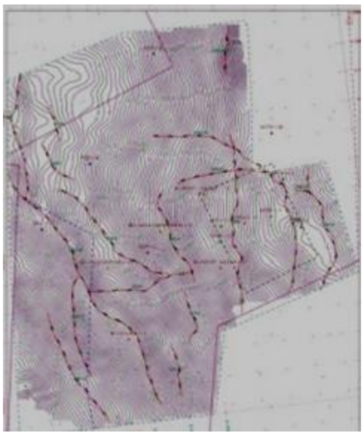

Fig 1 Time Structure map showing the structural elements of the study area

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Methodology

Four seismic horizons namely A, B, C, D corresponding to the zone of interest were identified and mapped /propagated in the study area (Fig 2).

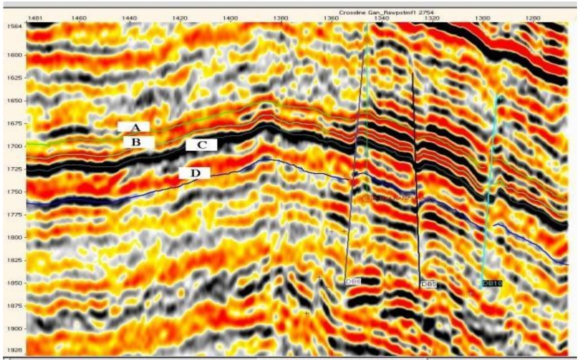

Fig 2 Part of the seismic section showing the correlation

Seismic attributes like absolute amplitude, instantaneous frequency, instantaneous phase and semblance were generated for the window of zone of interest proved to be of little use in understanding the sand distribution in the study area. Attribute properties were extracted over the horizons A, B, C and D.

Amplitude attribute extracted over the horizon C (Fig 3) shows presence of a channel in the North-eastern part of the study area.

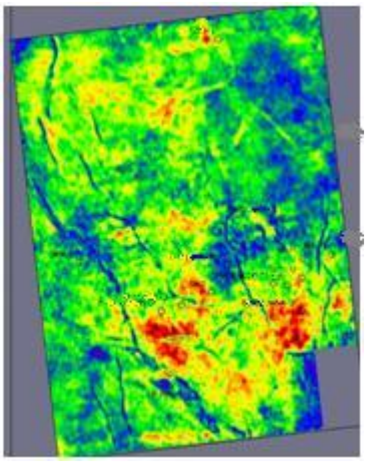

Fig 3. Absolute amplitude attribute map on top of horizon C showing the presence of a channel in the north-eastern part of the study area.

Same attribute extracted over horizon D also indicates a channel feature (Fig 4) but the extent of this channel is limited in comparison to that of horizon C. Also the contribution of this channel to the sands present in the south eastern part of the study area is not clearly established from this attribute.

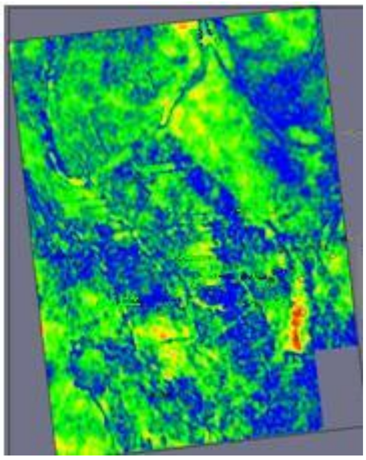

Fig 4. Absolute amplitude attribute map on top of horizon D showing the possible presence of a channel in the north-eastern part of the study area.

Spectral decomposition technique of the seismic data was carried out in the zone of interest in the frequency range from 10 to 50 Hz. Different frequency slices along the 4 horizons were generated. Upon the examination of these slices it is found that at 42.5 Hz frequency the subsurface geological features were well tuned.

Observations

Upon the examination of the frequency slices generated over horizon D, it is seen that two distinct channels were revealed in the study area. Theses channels appear to be from the north. (Fig-5) and labeled CH1 and CH2.

CH1 appears to be passing into the south-eastern part of the study area where the amplitudes are high (indicated in red and yellow color showing that the sands available in this area are deposited by this channel.

CH2 is crossing the CH1 in the northern part and has more meandering than CH1 and probably has deposited to the further southern part of the study area.

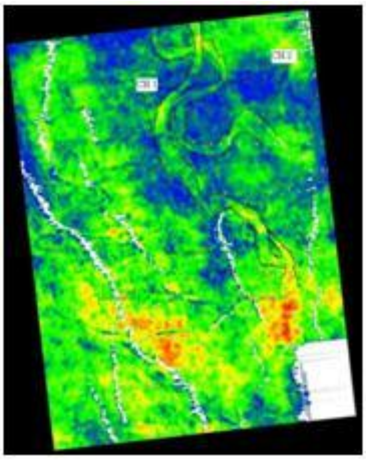

Fig 5 Frequency slice at 42.5 Hz generated along the horizon D shows 2 distinct channels in North-Eastern part of the study area, labeled as CH1 and CH2.

Another possible channel system is envisaged from the north-western part of the study area (Fig 6) marked as CH3 and CH4.

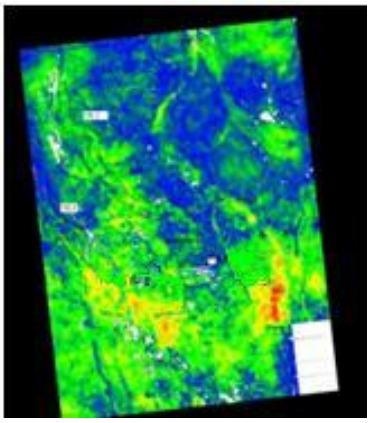

Fig 6 Frequency slice along horizon C at 42.5 Hz showing channel system in North western and western parts of the study area labeled as CH3 and CH4. CH-1 and CH2 in the North eastern part also can be seen at this level.

From the above discussion it is clear that that the deposition in the southern part of the area is due to two distinct channel systems. CH1 is contributing to the sands available in the south-eastern part of the area. CH2 appears to be trending further eastern part of the study area. CH3 and CH4 are contributing to the sands available in the south-western part of the area. Most probably the two deposits are separated by North-South running faults.

Conclusions

Spectral decomposition is a technique for bringing out the hidden geological or geomorphological features like channels. Above study demonstrates that this technique can be used effectively to understand the sand distribution in the area.

The study brought out four channels in the study area of which two from north-east direction and two are from the north-west direction. These two channel systems are contributing to two sand depositions in the southern part of the area. Also it is seen that theses sand depositions are independent of each other and may have different reservoir properties.

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