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More Precise Mapping of Geological Features with The Newly Generated Fresnel Zone Volume Attributes – A Case Study

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Summary

Horizontal resolution refers to how close two reflecting points, situated horizontally, can be recognized as two separate points rather than one, which depends on the dominant frequency and the average velocity at that level. The limit of such type of horizontal resolution is determined by Fresnel zone radius. The paper presents a case study, using the concept of Fresnel zone radius, which brings a better and sharp stratigraphic and fault features mapping in the area, which are validated at the well.

Introduction

A reflection is not energy from just one point beneath the surface. A reflection is energy that bounces back at surface from a region. As waveforms are really non-planar, reflections from a surface are returned from over a region and over an interval of time. The area that produces the reflection is known as the First Fresnel Zone.(Fig.1)

determine the minimum size feature that can be resolved.
(Courtesy :Schlumberger)

The current study has used the concept of Fresnel zone and calculated the Fresnel zone volume. The seismic attribute analysis carried out on the Fresnel Zone volume helps to determine more resolved stratigraphic and fault features, which are otherwise not possible to get using the conventional seismic volume by doing the same analysis.

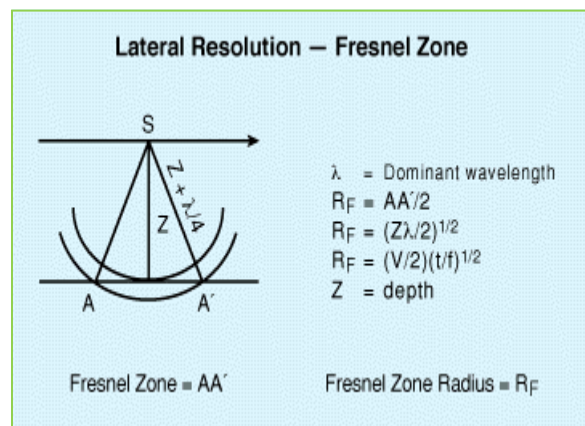


Figure. 1 A Fresnel zone, shown in this 2D sketch as length A-A'. In 3D seismic, the Fresnel zone is a circular and has diameter A-A'. The size of the Fresnel zone can be calculated which helps to

Brief of the Area

The study belongs to North Eastern part of India (Fig.2) i.e. Galeki -Lakwa Area of North Assam Shelf belongs to A &AA Basin, where the deposition of the shale and sand in sequence has taken place from Kopilli to below Girujan Top from the north west direction of the area (Shown by broad arrow in (Fig. 12)). The sands are either dry, water bearing or containing oil in the zone of interest from below Girujan Top to Kopilli Top. The traces of gas sands are a few, only near the Girujan Top. The wells are producing oil from TS1 (Tipam Sand), TS2, BMS, LBS1 (lower barail sand), LBS2, Kopilli etc. The input seismic data is having dominant frequency of 24 Hz till BCS (Barail Coal Sands) and 16-18 Hz below BCS.



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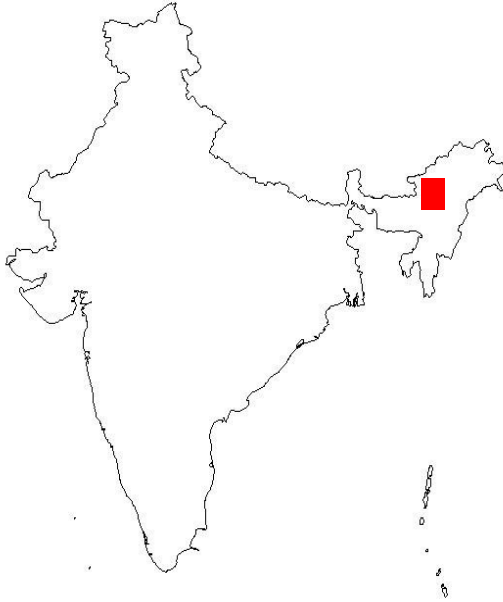
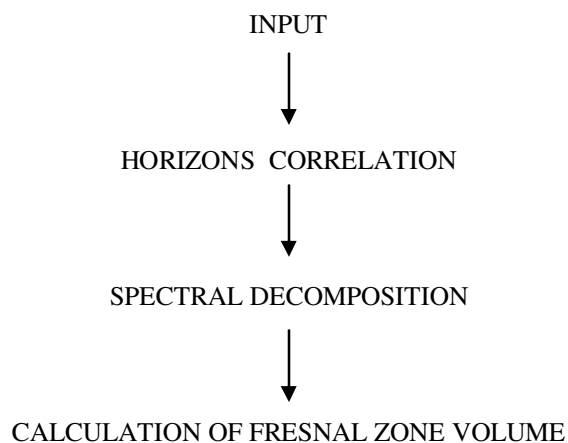


Figure.2 Area of study is from the North Eastern part of India i.e North Assam Shelf (NAS) and marked with the red rectangle .

Methodology

The flow diagram of the methodology adopted was as follows.



$$R_{fres} = V_{avg} * (T/F)^{1/2}$$

↓
ATTRIBUTES ANALYSIS

↓
OUTPUT

(Comparison of Results)

Where

V_{avg} =Avg Velocity volume (available)

T = Two way time (Seismic 3D Volume)

F =Dominant Frequency=Spectral Decomposition Volume(10-20Hz)

R_{fres} =Fresnal Zone Radius

The PSTM Stack 3D Seismic volume, Average Velocity volume along with the correlated Well logs of Lakwa - Galeki area, of North Assam Shelf(NAS) were available. The objective of study was to look out for the exploratory locations particularly for the below Barail Coal Sand(BCS).The correlated well logs picks along with the synthetic seismogram are used for the tracking of the horizons in the area(Total 08) The spectral analysis has been carried out on the seismic volume in the zone of interest(Fig.3).It is found that the dominant frequency in the zone of interest was around 16-18Hz.A Spectral Decomposition volume in the band of 10 -20 Hz has been generated from Seismic volume. Using the following formula, by substituting the relevant available parameters

$$R_{fres} = V_{avg} * (T/F)^{1/2} \text{ ----- (1)}$$



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Fresnal zone volume has been generated. Seismic attributes namely- RMS amplitudes and Coherency have been analyzed, in the available Seismic and Fresnal zone volumes in the zone of interest.

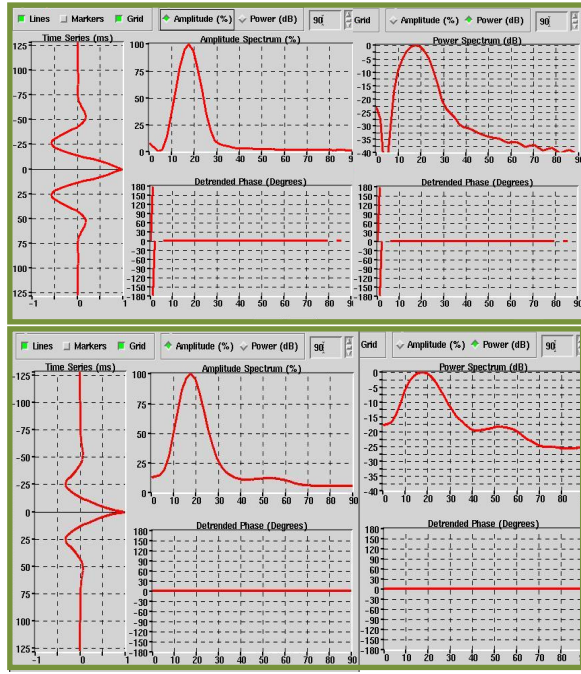


Figure.3. (Above) Spectrum from input Seismic volume. (Below) Spectrum from Fresnal zone radius volume. The latter shows the sharpness of wavelet with reduction of side lobes along with the broadness in power spectrum.

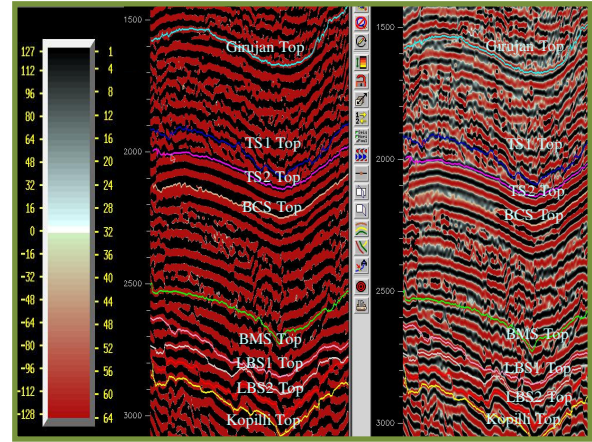


Figure 4. Inline 1500 (Left) from Input Seismic volume.(Right) from Fresnal zone radius volume. The latter shows the marginal improvement in the connectivity of the events

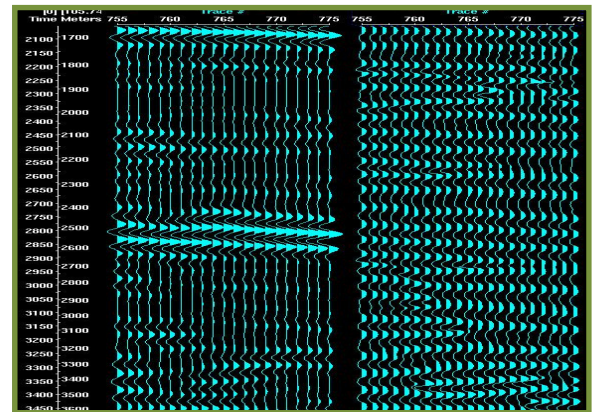


Figure 5.Traces around a well (Left) from input seismic volume and (Right) from calculated fresnel zone volume. It is to be noted that the diminished seismic amplitudes events(From input seismic volume) has been developed(although flow in frequency) in the Fresnel zone volume.



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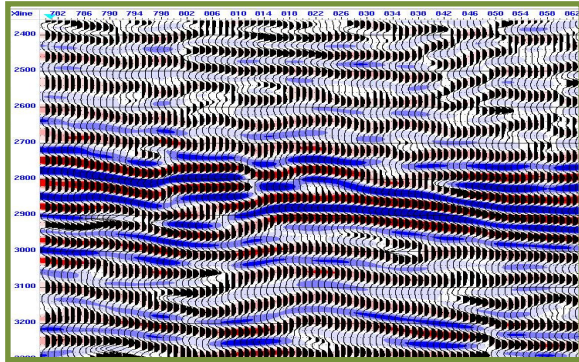


Figure 6 Overlay of Inline 1500, Trace shows data from the fresnel zone volume and colour from input seismic volume.

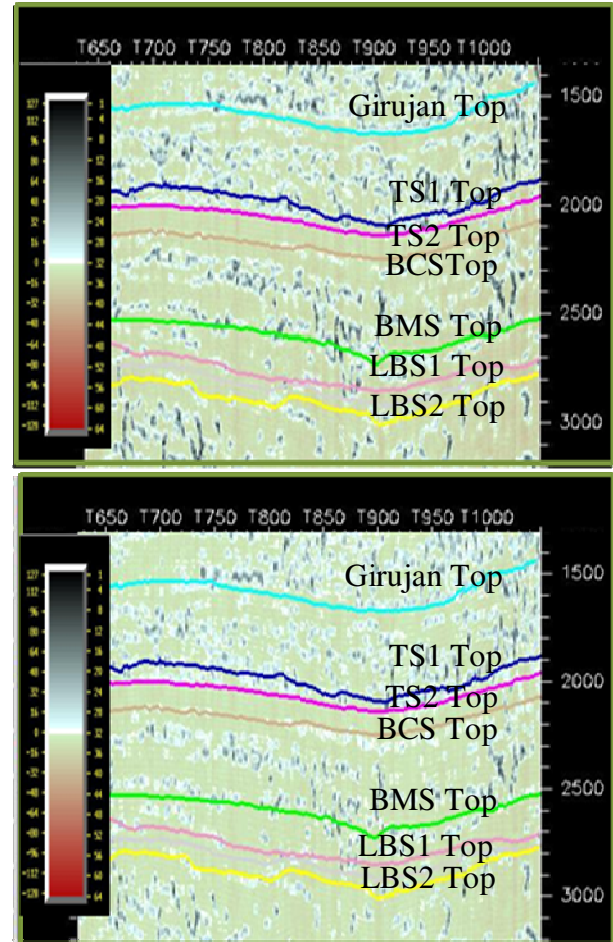


Figure 7 Inline 1500 (Above) From coherence output of input seismic volume.(Below) From coherence output of Fresnel zone radius volume. The latter shows the smoothening and sharpening of the fault features.



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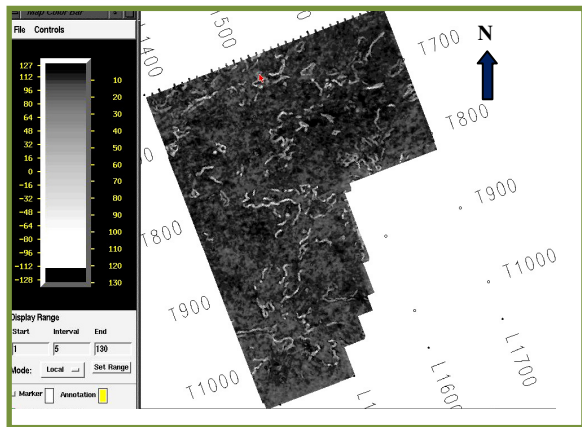
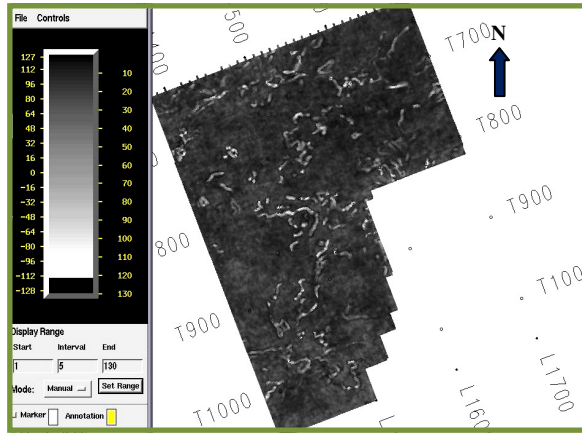


Figure 8. Fault patterns observed between two horizons LBS1 and LBS2 (Above) from input seismic coherence volume. (Below) from Fresnal zone radius volume. The latter shows the sharpness and increase in the resolution of the fault pattern in the map view.

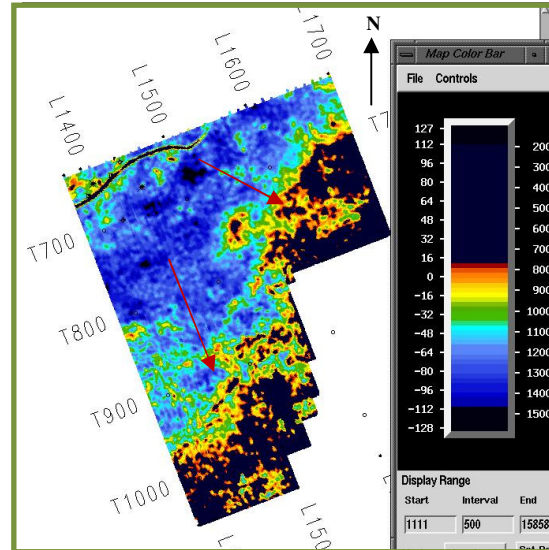


Figure 9. RMS amplitude observed between two horizons TS1 and TS2 from input seismic volume. The arrow shows the sand depositions patterns.

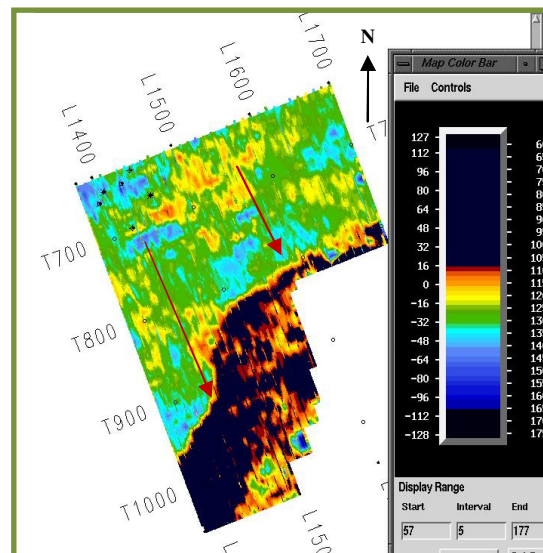


Figure 10. Isochrone between the same horizons TS1, TS2. The arrows show the more thickness for the deposition of the sand.



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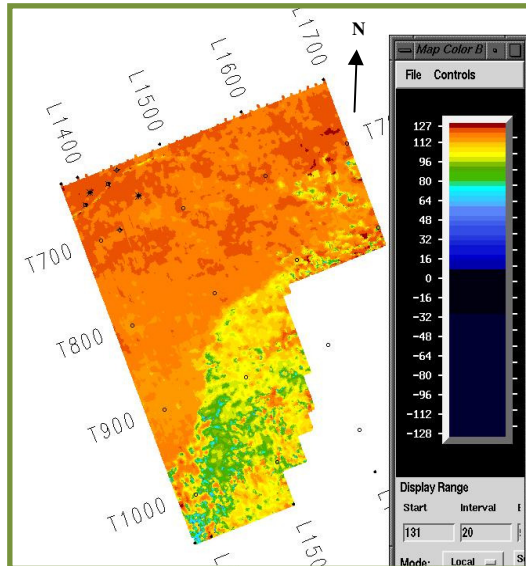


Figure 11. RMS amplitude observed between two horizons TS1 and TS2 from Fresnal zone radius volume. It shows the sand deposition pattern is different from the Figure 9, which is also validated at the well location.

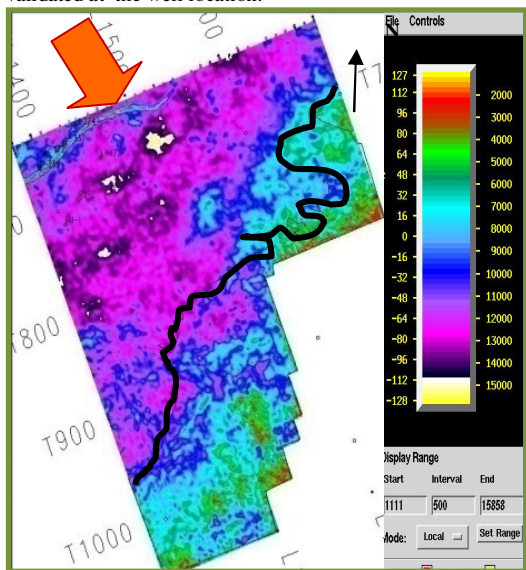


Figure 12. The RMS Amplitude derived between TS1 and TS2 with poly from the Figure.11 for the sand body geometry.

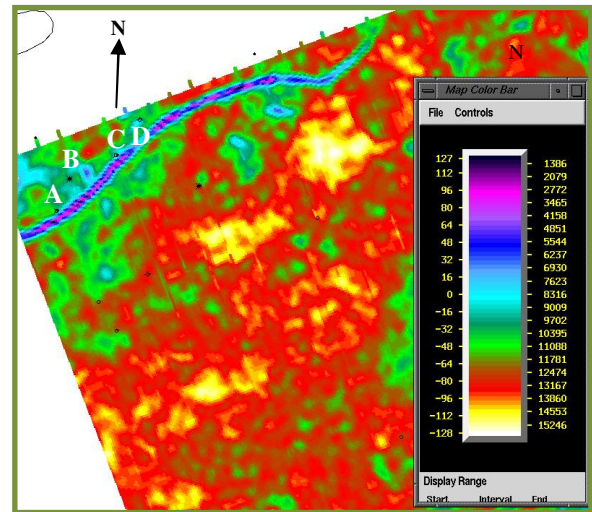


Figure 13. RMS amplitude from the input seismic volume observed between the producing horizons TS1, TS2 and the set of wells A, B, C and D, as shown in dots. The C and D wells falls in different lithology (Sky colour) than the other producing wells A and B (Green colour). Although, it is known that A, B, C and D are producing from the same lithology.

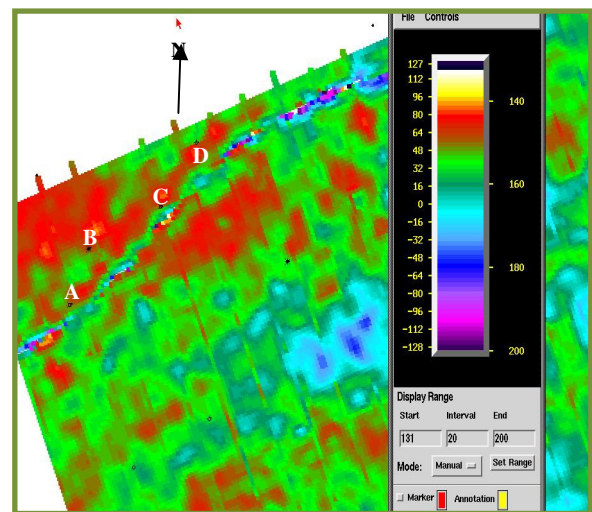


Figure 14. RMS amplitude from the Fresnal zone volume, shows that all the wells A, B, C and D falls in the same lithology (Red Colour), which validates the result, as required.



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Discussion

Subsurface area over which energy is collected to cause a seismic reflection event is called the Fresnel zone (Fig.1). The concept of Fresnel zone mainly deals in the spatial (horizontal) resolution of the events, which helps in the more precise mapping of lateral extension of lithology and other geological features. The available PSTM Stack seismic data has the dominant frequency about 16-18hz in the zone of interest (Fig.3). The average velocity volume of the area has the smooth variation of velocity with depth. The Spectral Decomposition volume has been created in the frequency band of 10 -20Hz for the analysis. Using the formula (1) and substituting the relevant available parameters in it, the Fresnel zone radius volume or simply Fresnel zone volume has been generated. The spectral analysis on the Fresnel zone volume (Fig4), shows the little sharpening of the wavelet and reduction in the sidelobes along with the broadening of the power spectrum in the zone of interest in comparison to the original seismic volume. Which depicts that the horizontal resolution of the Fresnel zone volume must be more than the seismic volume. The comparison of the same seismic Inline 1500 (Fig.4) from seismic and Fresnel volume shows, a marginal improvement in the lateral continuity of the events. The seismic sections around a well (Fig.5) from the seismic (left) and from Fresnel zone volume (Right), shows the development of the events, which are diminished in the original seismic volume. The overlay of the same seismic line (Fig.6), where traces are from Fresnel volume and colour is from the seismic volume, depicts the marginal improvement of the events.

The seismic section of the coherency Volumes (Fig.7), original Seismic and fresnel zone, shows that the fault features are more sharp and smoothen in Fresnel zone than in original seismic. The RMS amplitude of the coherency volumes from Seismic and Fresnel zone, between the horizon LBS1 and LBS2 (Fig.8), shows the fault patterns, which are found to be more sharper and more resolved in the Fresnel zone coherency map view than in the seismic.

The RMS amplitude derived between the horizons TS1 and TS2 from the seismic and Fresnel zone volumes (Fig.9), shows the depositional pattern of the sand, particularly in the south eastern part. The arrows on the isochronopach shows that the thickness of the sand must more in the North eastern part (Fig.10) and its pattern is also

different from RMS Amplitude derived from original seismic volume (Fig.9). The RMS amplitude between the same horizons i.e TS1 and TS2, from the Fresnel zone volume (Fig.11), shows the depositional pattern of the sand body which is found to be matching at the well locations. The poly of the sand body distribution from the Fresnel Zone overlay on the distribution pattern from the seismic volume (Fig.12), shows that the spatial distribution of the sand body is more sharp and clear derived from the Fresnel zone volume than the original seismic volume between the said horizons. The same RMS amplitude from the seismic and Fresnel zone volumes between the horizons TS1 and TS2, shows (Fig.13 & 14) the distribution of the sand body in the north western part of the area, where the more concentration of the wells are available. The wells namely- A,B,C and D are producing oil between the horizons TS1 and TS2. The well C and D do not fall in the same lithology (colour) (Fig.13). While the wells A,B,C and D are producing from the same formation as per the log data, however, all the wells A,B,C and D do fall in the same lithology (colour) (Fig.14) derived from the Fresnel zone volume. Which calibrates and validates the results at the well locations.

Conclusion

The ability to observe improved spatial resolution such as fault pattern in sands, lateral facies changes etc. is a function of the Fresnel zone size. The horizontal resolving power of the two events are certainly more in Fresnel zone volume than in 3D seismic volume. The same concept can also be used for precise mapping of the tidal channel cuts, pinchouts etc and other resolvable lateral features.

Acknowledgement

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References

Lindsey ,J.P, The Fresnel zone and its interpretive significance,TLE 1989,SEG Publication.

Brown Alister,3D seismic data Interpretation,Vth Edition.

Nathalie Favretto-Cristini¹ and Paul Cristini¹ and Eric de Bazelaire², Usefulness of the Interface Fresnel zone for simulating the seismic reflected amplitudes, unpublished,2006.