

A New Seismic Attribute Aids to Map the Embedded Geological Features from Low Bandwidth Seismic Data*

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Search and Discovery Article #40720 (2011)
Posted March 28, 2011

*Adapted from extended abstract presented at GEO-India, Greater Noida, New Delhi, India, January 12-14, 2011

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Abstract

The seismic resolution (or bandwidth) plays an important role for better visualization or quantification of interesting geological features in interpretation, which helps in reducing the exploration risk. It is difficult to extract the embedded geological information in the seismic data having a low seismic bandwidth. An object oriented seismic attribute generation and analysis provides a better result in such type of seismic data (low bandwidth). In the present paper a new seismic attribute volume has been generated using a mathematical relation, which provides an improved mapping of morphological (e.g. pinch outs, faults, channels etc.) and reflectivity (e.g. lithology, reservoir thickness etc.) components of seismic data with geological objects and also explain the observed results at a set of wells.

Introduction

The aim of seismic amplitude analysis is to make accurate lithology from the wide spread seismic data (or observed data), based on the available well data (or known data), utilising all prior knowledge, throughout a seismic volume. To minimize reservoir lithology and structural uncertainty, we need to have high resolution seismic data. However, due to the inherent limitation of the seismic data (particularly low bandwidth 16-22Hz) having low seismic resolution, it is not possible to map the lithology and other structural features with confidence. A new technique has been developed, using a mathematical relation and calculated a seismic attribute volume, which aids to determine precise mapping of geological features (Faults, Pitchouts, Channel etc), which are otherwise not possible to extract using only input seismic volume.

Brief Description of the Area

The study belongs to North Eastern part of India ([Figure 1](#)) i.e. Galeki-Lakwa Area of North Assam Shelf and belongs to the A &AA Basin,

where the deposition of the shale and sand in sequence has taken place from Kopilli Top to below Girujan Top and from the north west direction of the area .It is well known in the area that discrete channels sands are the main gas producing reservoirs near the Girujan Top. 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 dry channel sands are few, only near the Girujan Top due to insufficient trapping and sealing mechanism. The wells are producing oil from TS1 (Tipam Sand), TS2, BMS, LBS1 (lower Barail sand), LBS2, Kopilli etc. The input seismic data has a dominant frequency of 18 Hz till BCS (Barail Coal Sands) and 16-18 Hz below BCS.

Methodology

The flow diagram of the methodology adopted was as follows:

- Input
- Horizons Correlation
- Spectral Decomposition
- Calculation of Seismic Attribute Volume
- $V_{attr} = V_{avg} * (T/F)$
- Attributes Analysis
- Output
- (Comparison of Results)

Where:

- Input = Seismic 3-D PSTM Stack Volume
- V_{avg} = Avg Velocity volume (available)
- T= Two way time (Seismic 3-D PSTM Stack Volume)
- F = Dominant Frequency = Spectral Decomposition Volume (10-20Hz)
- V_{attr} = Seismic Attribute Volume

The PSTM Stack 3-D Seismic volume, Average Velocity volume along with the correlated well logs of Lakwa-Galeki area and of North Assam Shelf (NAS) were available. The objective of the study was to look for the exploratory locations particularly in Girujan and below Barail Coal Sand (BCS).The correlated well log 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 ([Figure 2](#)). 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

$$V_{attr} = V_{avg} * (T/F) \text{ ----- (1)}$$

New Seismic attribute volume (Vattr) has been generated. Seismic attributes namely - RMS amplitudes and Coherency and P-impedance have been analyzed, for the available Seismic 3-D PSTM Stack and Vattr volumes in the zone of interest. The comparison of the study with normal seismic 3-D volume and newly generated seismic attribute volume (Vattr) have been analyzed and presented.

Discussion

We lose a lot of information during seismic processing sequence e.g. amplitude is lost due to automatic gain control, stacking changes frequencies and amplitudes, traces are reshaped during deconvolution and other filtering process. To extract the seismic attribute is an attempt to recover this information in a meaningful display. The available PSTM Stack seismic data has the dominant frequency about 16-18 Hz in the zone of interest ([Figure 2](#)). The average velocity volume of the area has the smooth variation of velocity with depth. The Spectral Decomposition volume has been generated in the frequency band of 10-20 Hz for the analysis. Using the formula (1) and substituting the relevant available parameters in it, the new seismic attribute volume (Vattr) has been generated. The spectral analysis on Vattr volume ([Figure 2](#)) shows the little sharpening of the wavelet and reduction in the side lobes along with the broadening of the power spectrum in the zone of interest in comparison to the original seismic volume. This depicts that the resolution of Vattr volume must be more than the seismic volume. The seismic sections around a well ([Figure 3](#)) from the seismic (left) and from Vattr volume (Right), depicts the precise mapping of the events like pinchouts, overlap, lenses etc, which are diminished in the original seismic volume. The overlay of the same seismic line ([Figure 4](#)), where traces are from Vattr volume and colour is from the seismic volume, depicts the marginal improvement of the events.

The seismic section of the coherency Volumes ([Figure 5](#)), original Seismic and Vattr volume, shows that the fault features are sharper and smoother in Vattr volume than in original seismic. The RMS amplitude of the coherency volumes from Seismic and Vattr volume, between the horizon LBS1 and LBS2 ([Figure 6](#)), shows the fault patterns, which are found to be more sharper and more resolved in the Vattr coherency map view than in the seismic.

The RMS amplitude from the seismic and Vattr volumes between the horizons TS1 and TS2 shows ([Figures 7 and 8](#)) the distribution of the sand body in the north western part of the area, where more wells are drilled. 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) ([Figure 7](#)). 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 falls in the same lithology (colour) ([Figure 8](#)) derived from Vattr volume. This calibrates and validates the results at the well locations.

Discrete channel sands are the main gas reservoir below the Girujan Top (i.e. 60 ms below Girujan Top). Due to the limitation of the bandwidth of seismic data, it is not possible to map the channel sands more precisely, however, Vttr volume provides the better distribution of the channel sand geometry ([Figure 9](#)). Moreover, the P- impedance volumes further provides a better distribution of the channel sands, where all producing wells (black dot) ,as required, are placed over the channel sands, which is not the case with P-impedance derived for the seismic ([Figure 10](#)). It explains the observed results at the wells. The dry well analysis of the area shows that the wells are dry due to the insufficient trap and sealing mechanism.

Conclusion

Different information has value on its own, but independent information adds non-linearly. Therefore it is very important to analyse geological objects from every meaningful way possible. A discussion on new seismic attribute generation and analysis has been presented, which also explains the results. There are pros and cons to all of the methods and in practise they all have a place initially in qualitative and later in quantitative interpretation. The discussed innovative technique for seismic attribute generation is quick to apply and simple to implement. The same concept can also be used for more precise mapping of the rock property and other reservoir parameters using well log data.

Acknowledgement

The authors are thankful to Oil & Natural Gas Corporation Ltd. for providing the opportunity

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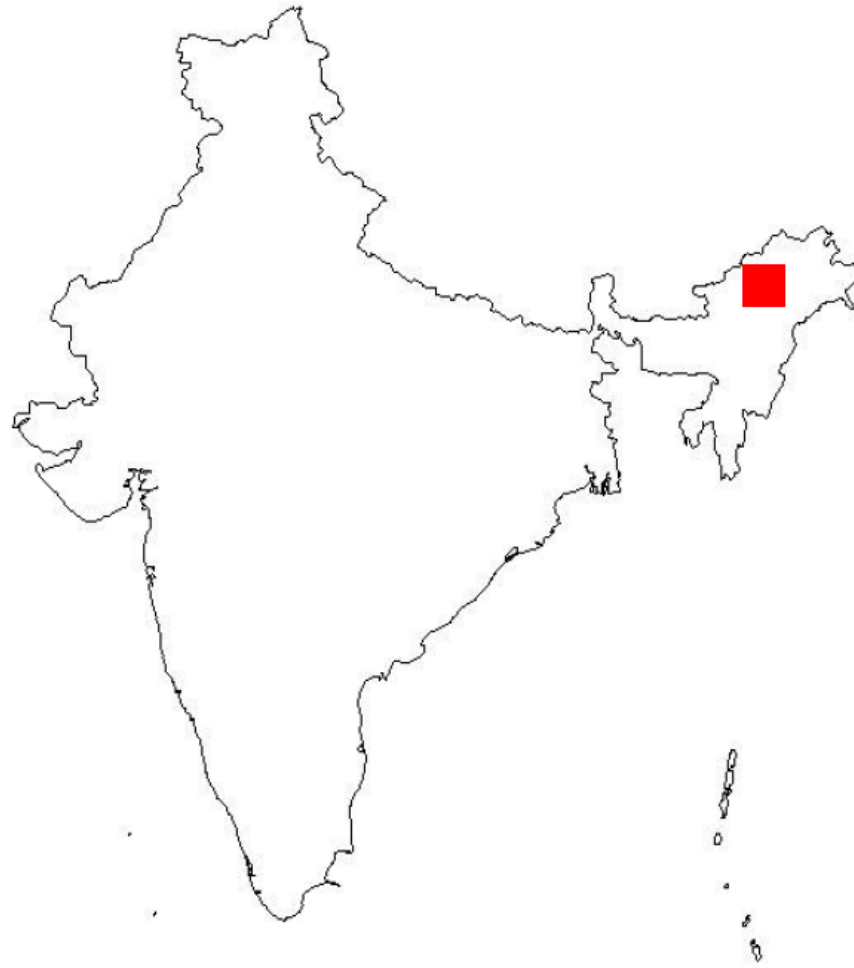


Figure 1. Area of study is from the North Eastern part of India i.e. North Assam Shelf (NAS) and marked with the red rectangle

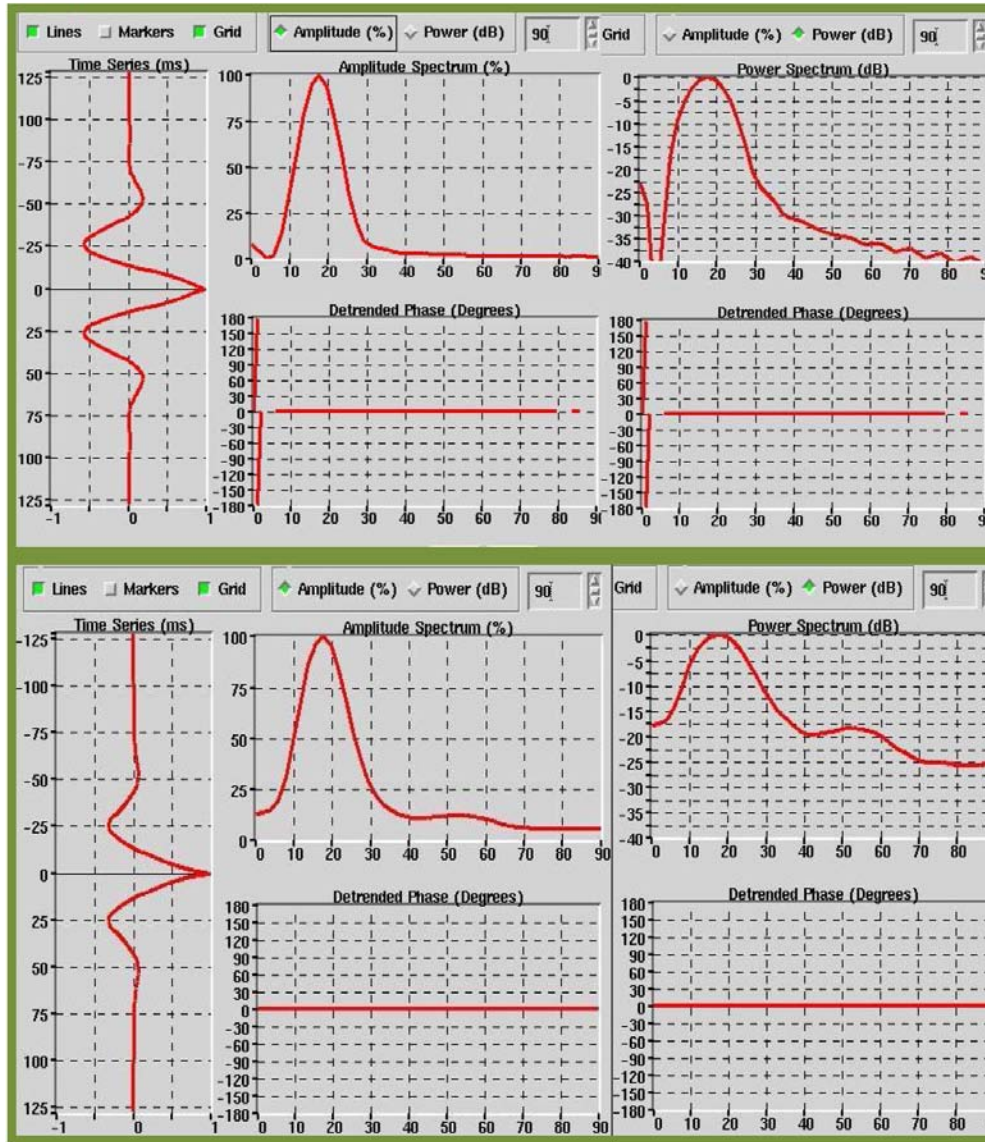


Figure 2. (Above) Spectrum from input Seismic volume. (Below) Spectrum from new seismic attribute volume (Vattr). The latter shows the sharpness of wavelet with reduction of side lobes along with the broadness in power spectrum.

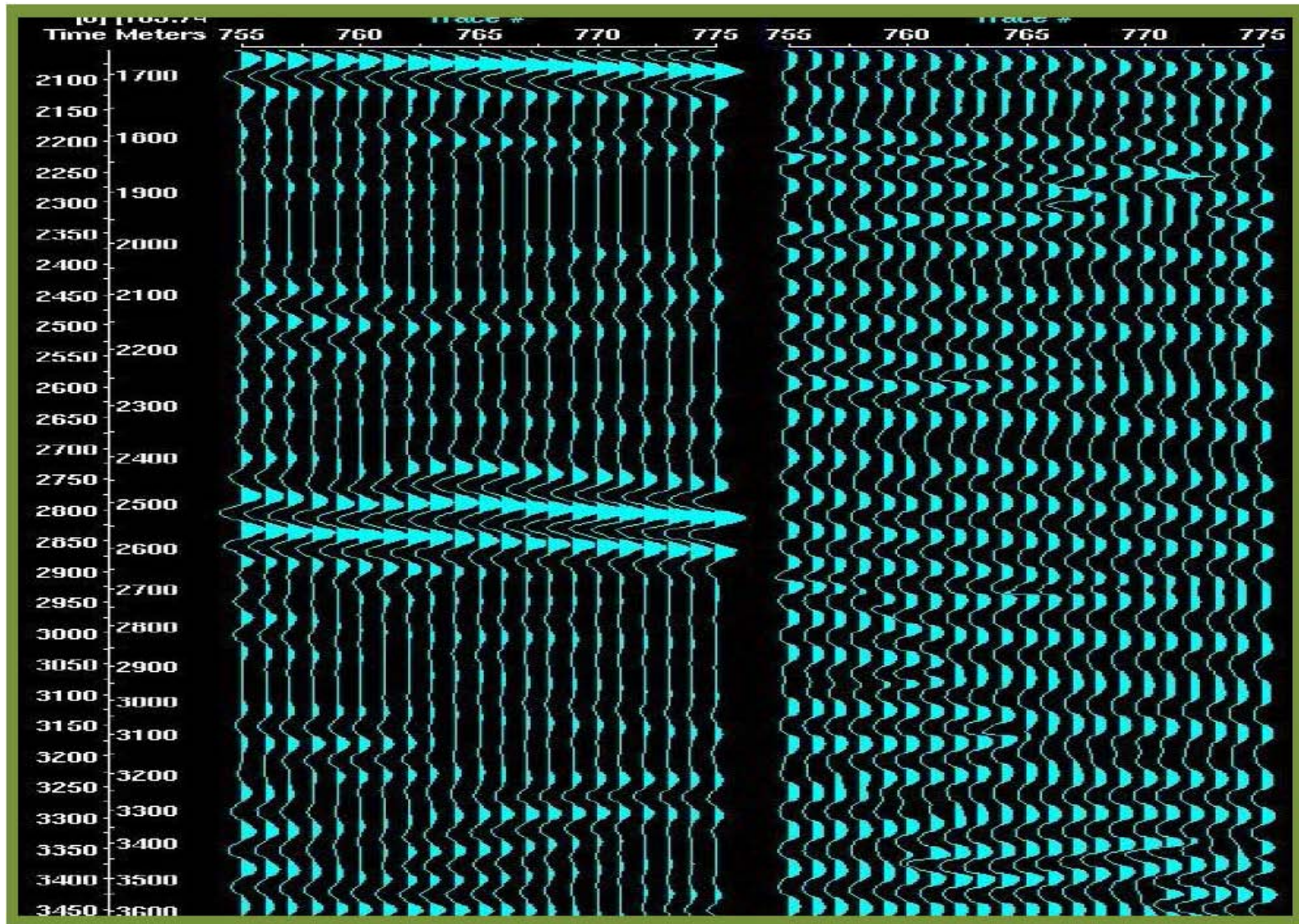


Figure 3. Traces around a well (Left) from input seismic volume and (Right) from new seismic attribute volume. It is to be noted that the geological features like pinch outs, lenses etc, are clearly shown in the new seismic attribute volume(right).



Figure 4. Overlay of Inline 1500. Trace shows data from the new seismic attribute volume and colour from input seismic volume.

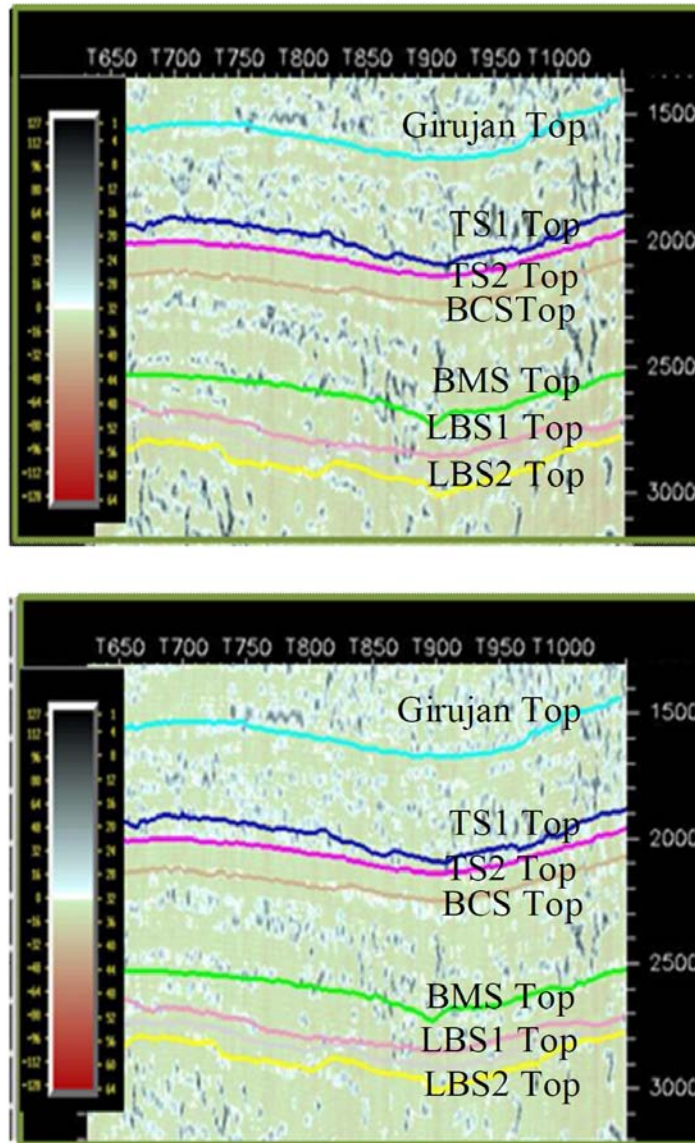


Figure 5. Inline 1500 (Above) From coherence output of input seismic volume. (Below) From coherence output of new seismic attribute volume. The latter shows the smoothing and sharpening of the fault features in time section.

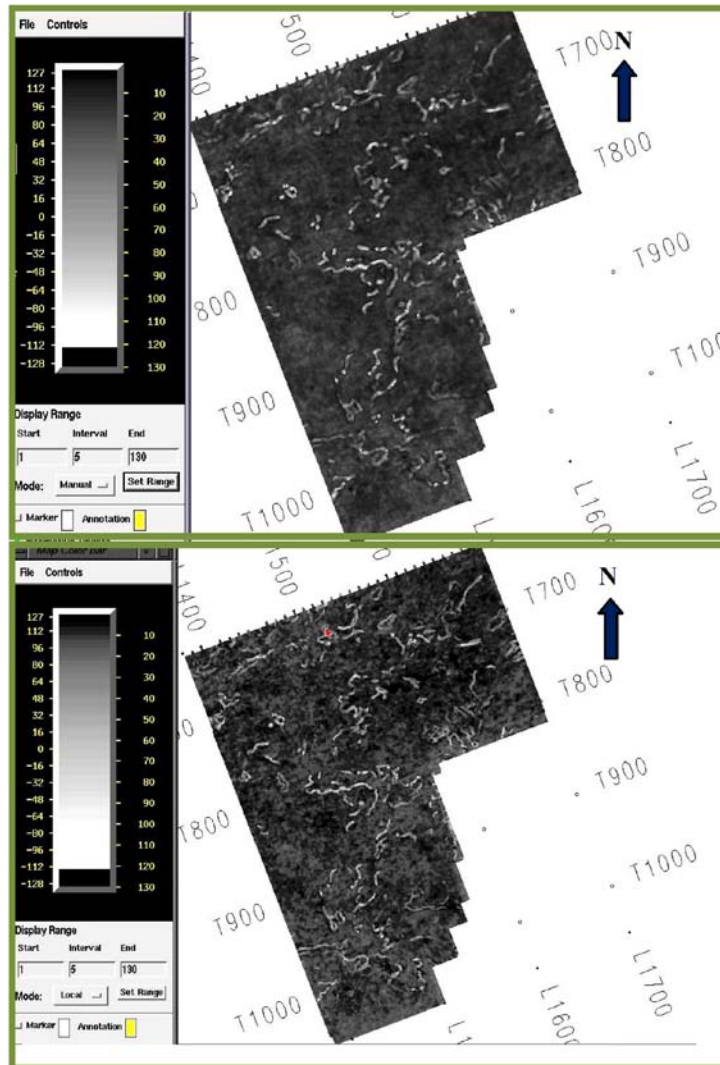


Figure 6. Fault patterns observed between two horizons LBS1 and LBS2 in coherency volumes of (Above) from input seismic (Below) from new seismic attribute volume. The latter shows the sharpness and increase in the resolution of the fault pattern in map view.

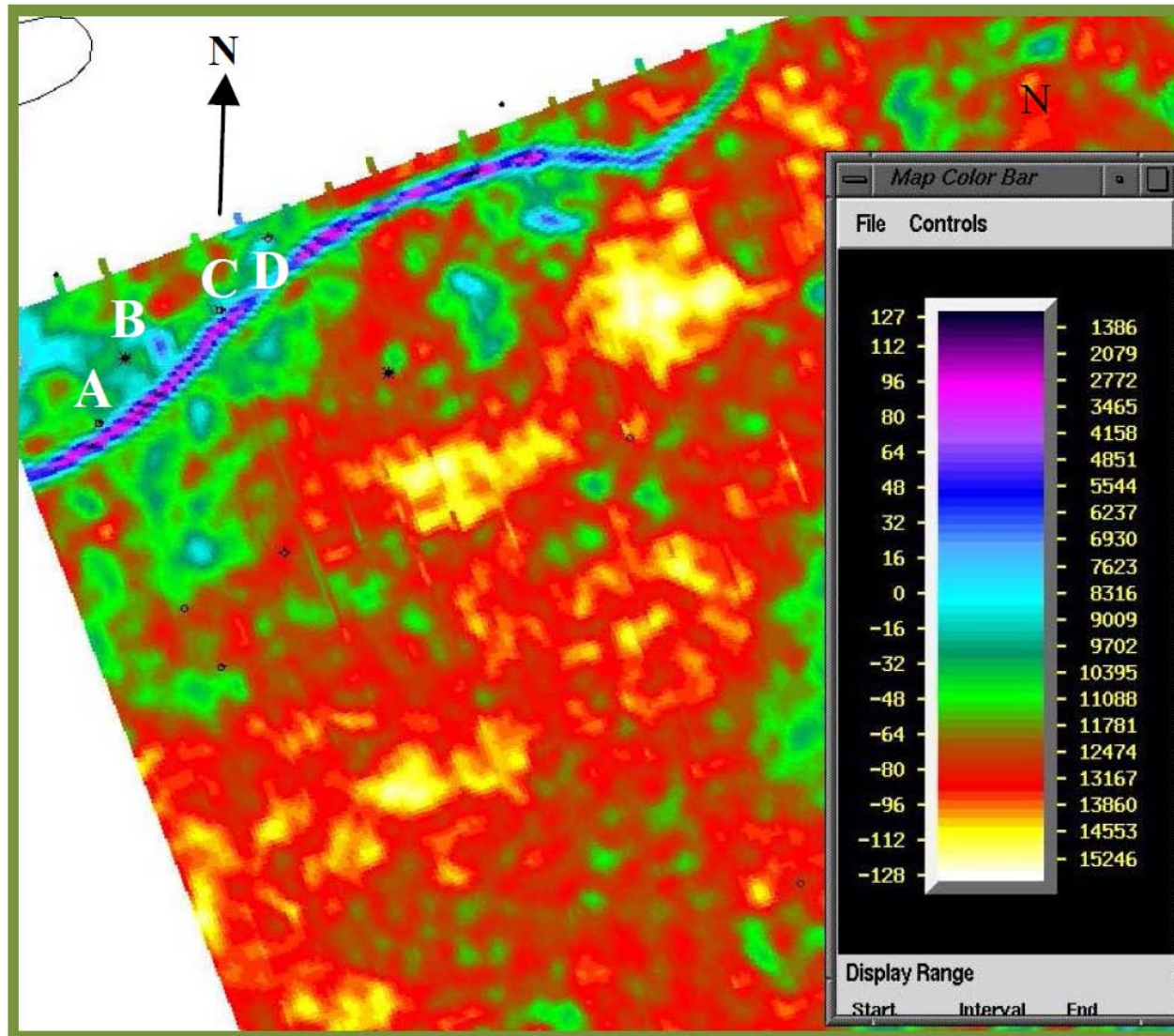


Figure 7. RMS amplitude from the input seismic volume observed between the producing horizons TS1,TS2 and the set of wells A,B,C and D, as shown in dots. The C and D wells falls in different lithology (Sky colour) than the other producing wells A and B(Green colour). Although, it is known that A, B, C and D are producing from the same lithology.

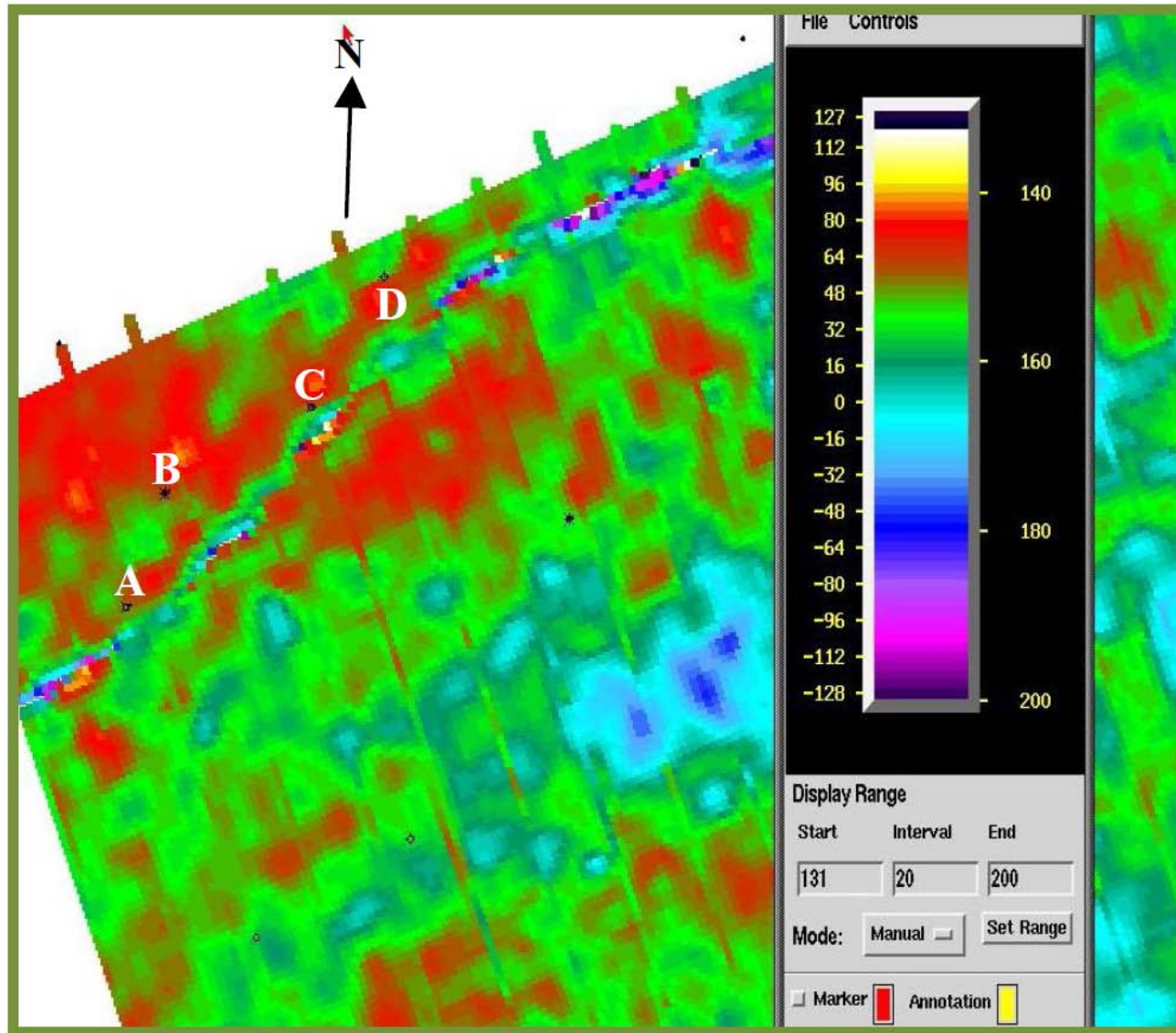


Figure 8. RMS amplitude from the new seismic attribute volume, shows that all the wells A,B,C and D falls in the same lithology (Red Colour), which validates the result, as required

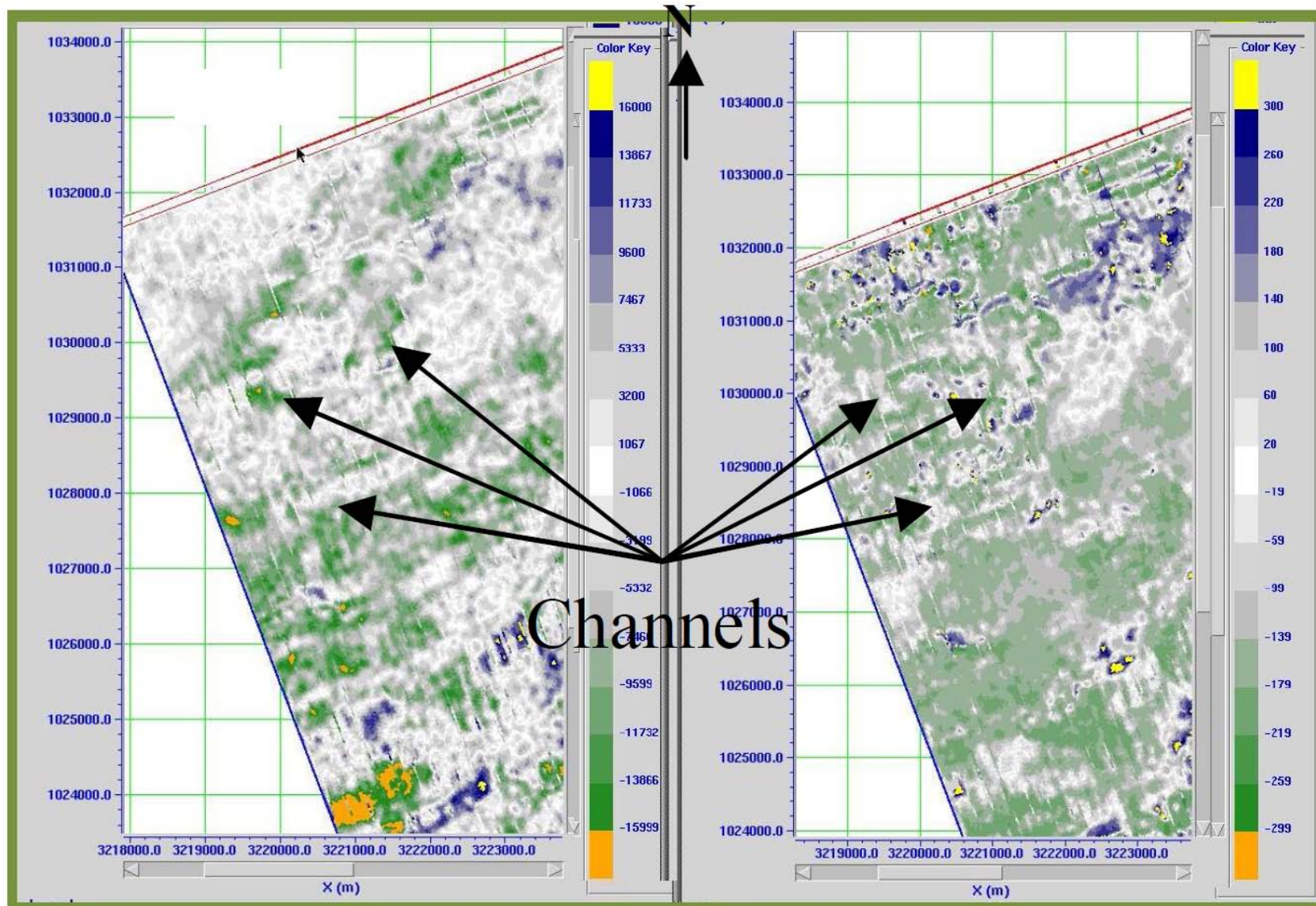


Figure 9. RMS amplitude in windows of 10 ms from the input seismic volume (left) and new seismic attribute volume (right) in the zone of known discrete channel sands. The new seismic attribute (right) provides more precise geometry of different channel sands.

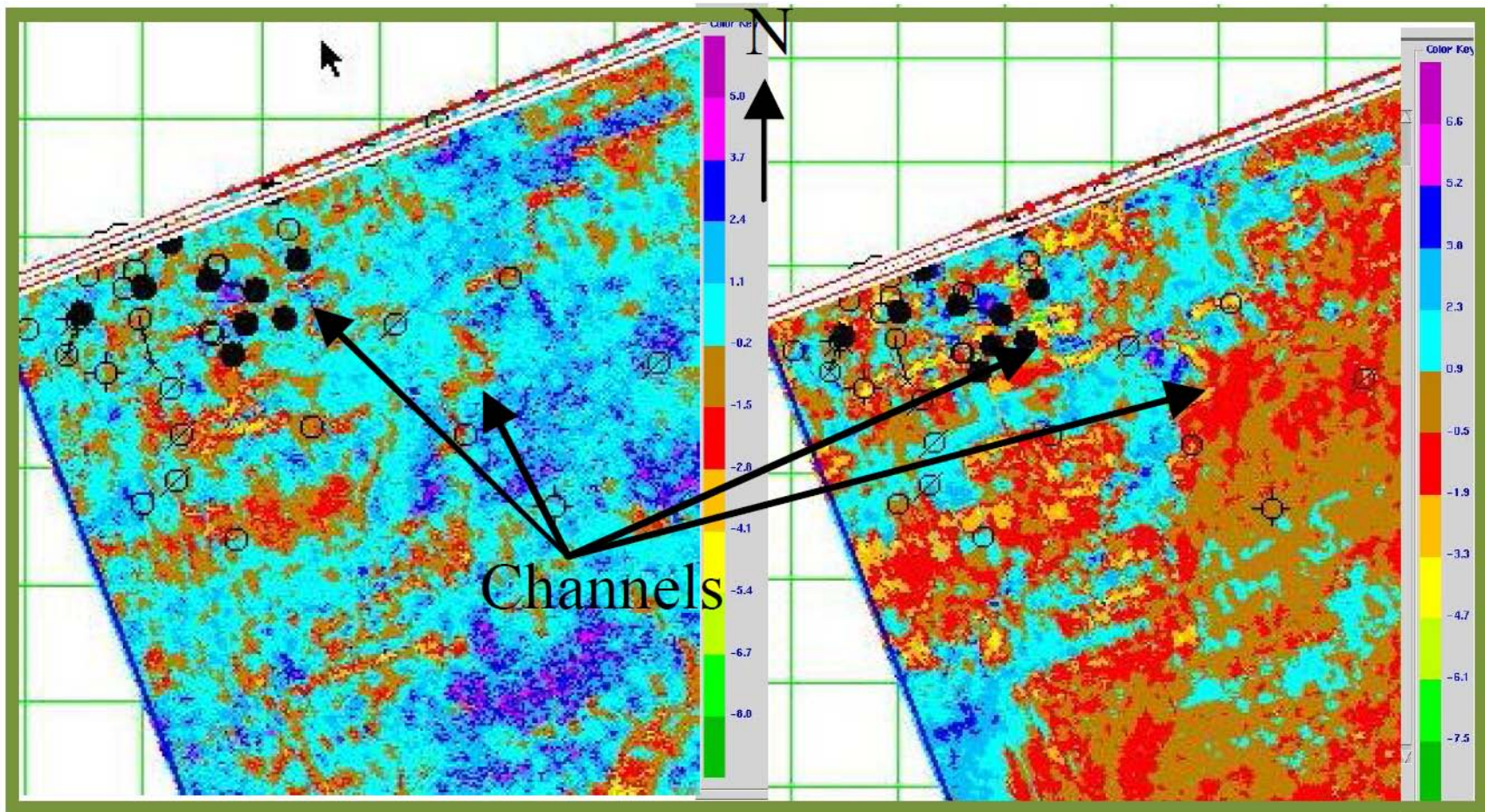


Figure 10. RMS amplitude in windows of 10 ms from the P- impedance volume of input seismic (left) and Vatttr volume (right). All the producing wells, black dots, are placed over the channel sandbody (right) which is not the case with input seismic (left). It confirms the observed results at the set of wells.