Conditioning of 3D seismic data for better delineation of thin Girujan sands from seismic in Lakhmani area

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Keywords

Quadrature- 90°-phase converted seismic 3D data

Summary

Girujan Clay Formation belonging to Tipam group of Mio-Pliocene age has been encountered in the sub-surface in central and western parts of Assam Shelf in Assam & Assam Arakan Basin. It provides an effective "Regional seal" facilitating significant hydrocarbon accumulations in Lakwa sandstones in certain areas of ONGC Blocks. Besides acting as regional seal Girujan Clay Formation being deposited in low energy environment system consists of thick claystone unit with minor sand layers of continental origin and characterised by mottling colours are also proved to be hydrocarbon bearing in multiple pays in some areas. Characterisations of these thin sands using 3D seismic is big challenge. This study aims to delineate these thin sands from seismic by conditioning the 3D seismic data.

Introduction

The Upper Assam shelf is bounded by the eastern Himalayan fold belt in the north, the Mishmi hills in the northeast and the Patkai-Arakan fold belt in the east. It has been one of the major petroleum producing geological province of India with reservoir rocks from Pre-Cambrian to Pliocene age. The study area falls near to established fields Lakwa-Lakhmani (Figure 1).

The deposition of Girujan Clays marked the period of quiet sedimentation in a low energy environment which characterized the closing phase of Miocene. After Girujan there was unconformity along with uplift throughout northeast India and high energy sedimentation prevails. This post Girujan tectonics resulted in reversing the attitude of existing faults, forming of inverted structures along with re-adjustment of blocks as well as redistribution of Hydrocarbons.

0°-Phasing

Girujan sands delineation technique is borrowed from a seismic-sedimentological approach for mapping by

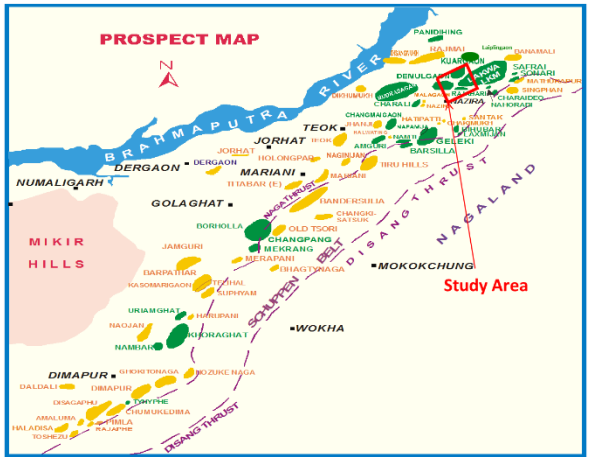

Figure 1 Study area and major oil fields around.

Hongliu Zeng et al. 2003, where one main key technique were followed: conditioning of 0°-phase seismic data to Quadrature volume for better well log integration with seismic and also amplitude is more reliable for lithology prediction at seismically thin beds. In Quadrature domain interface of the beds are coming near to zero crossings of seismic waveform.

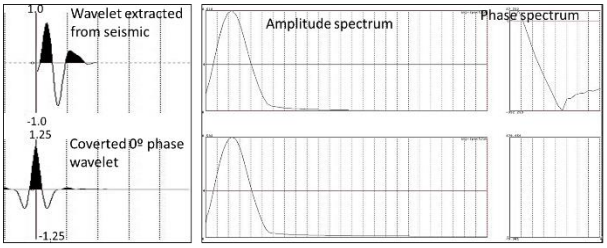

Figure 2 Extracted wavelet from Girujan time zone and equivalent converted zero phase wavelet.

In present study, on-land data acquired with Dynamite source with minimum phase was converted

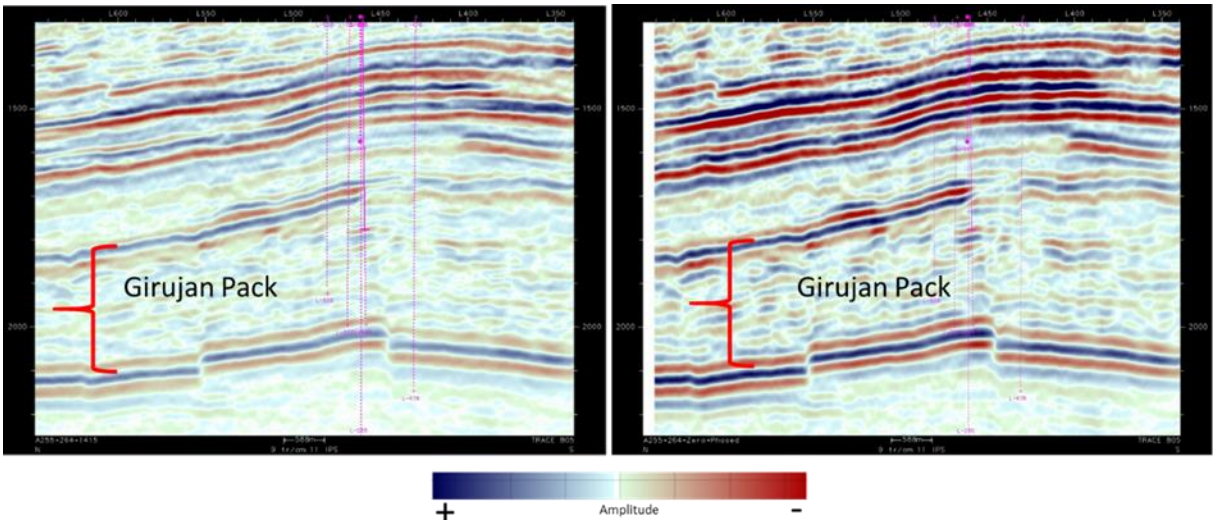

Figure 3 Seismic section shows the comparison between mixed phase seismic section and zero phase section.

to zero phase using the seismic source wavelet extraction technique ‘‘fourth order cumulant matching” approach (Lazear, Geophysics, July 1993, p.1042-1051). Extracted wavelet and converted corresponding zero phase wavelet is presented in Figure 2. Result observed is overall improvement in continuity with better resolution (Figure 3). This 0º-phase data is converted to quadrature trace for facies correlation of Girujan sands.

Girujan sands characteristics from logs

Girujan sands of the thickness range 5-8m are observed in our study area. Highly gas saturated sands have the characteristic of formation resistivity more than 20 ohm-m and sonic more than 110 µs/ft log readings. These sands have been found to be relatively lower in acoustic P- impedance w.r.t background Clay (Figure 4).

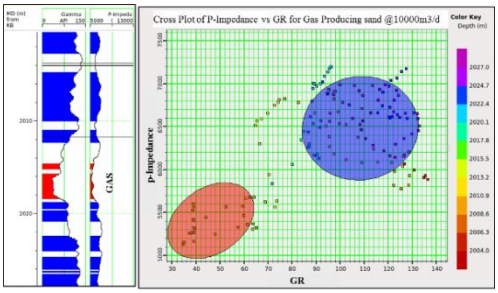

Figure 4 Cross plot of a gas bearing sand unit producing at the rate 10000m^3/d.

Wedge Modelling for seismic tuning analysis of Girujan sands

To examine the impact of thin beds of Girujan sands on seismic amplitudes a wedge model were setup for the gas and water bearing cases (Figure 5). Synthetic seismic responses are constructed using a 30 Hz reverse Ricker wavelet (as per ONGC Polarity convention) and is being presented in Figure 6 & Figure 7. Amplitude response from top boundary of sand is coming very prominent in water bearing case as compared to gas bearing case where response observed is almost negligible. For water saturated case up to thickness of 26m constant amplitude response has been observe and tuning occurs around 12m thickness. The main idea of this model is to understand implications of tuning on seismic amplitude and it is observed that distortion created in seismic amplitude by tuning phenomena is very weak for these unconsolidated channel sands.

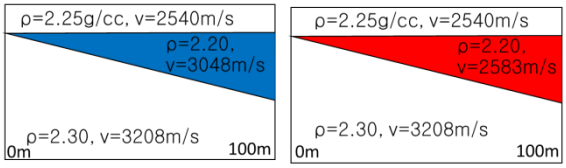

Figure 5 Wedge model for Girujan sands encased in a clay dominated unit. On the left is for water bearing sand unit and on right is the case of gas bearing.

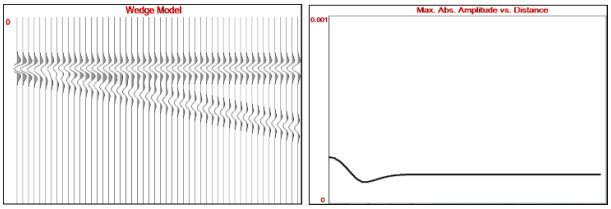

Figure 6 Synthetic response and amplitude response curve for water bearing case.

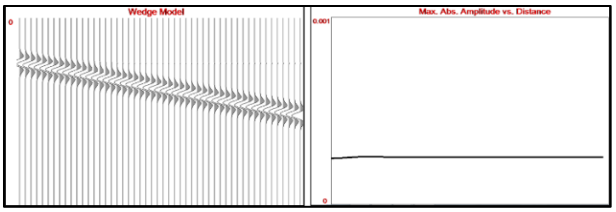

Figure 7 Synthetic response and amplitude response curve for gas bearing case.

Correlation of Girujan facies on Quadrature volume

With this understanding Girujan sand units were tied to seismic main events using T/D generated from synthetic seismograms in zero phase data. Two main events indicated by red arrow (gas pay) and green arrow (prominent event) were chosen for amplitude analysis(Figure 8). Correlation of these events at zero crossings is performed in Quadrature volume for both events and their amplitude patterns were analysed for meaningful delineation of Girujan sands or to bring out depositional environment pattern in our study area.

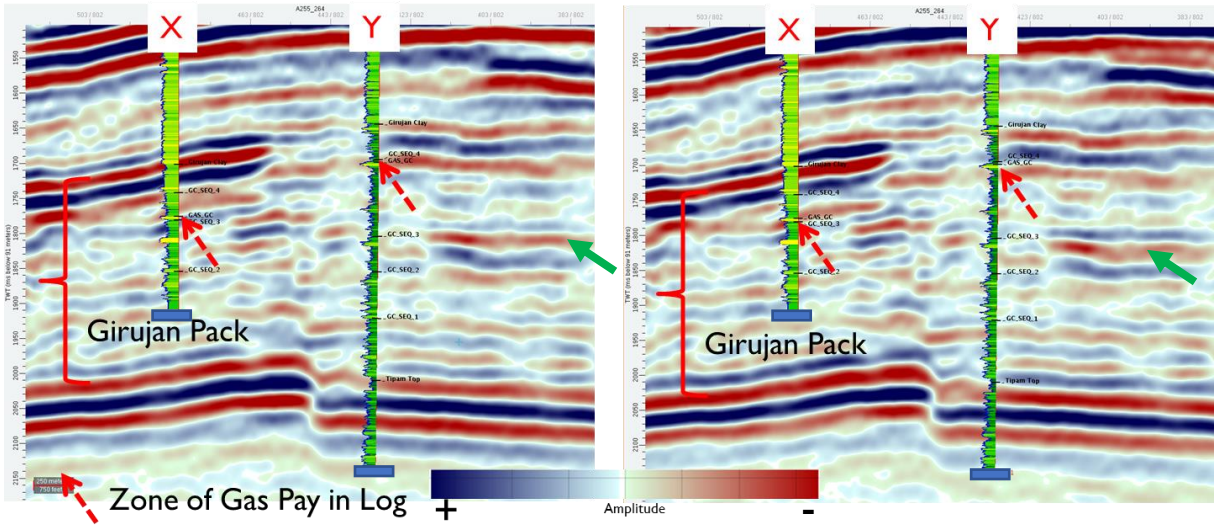

Figure 8 Tying of lithology log (GR) on seismic section both on zero phase data (left) and quadrature data (right) for event analysis.

Results and Discussions

As described above two events were chosen for analysis and the extracted amplitudes are exhibited in Figure 9 and Figure 10. In Figure 9 a system of meandering channel system is seen towards SE. One such major channel system is highlighted in dotted line. Drilled Well-A and Well-B falls in point bar of this channel. Well-A is a gas bearing at this level. However Well-C which falls in the channel axis is

devoid of sand at this level (as seen in log). Presently this area has around seven gas bearing wells falling around this channel system. From the analysis of another event which was a prominent event in Girujan has brought out a clear system of amalgamated channel complex and its inter channel flood plains (Figure 10). Both these events analysis has helped in bringing out depositional setup which can help in exploration for these thin sands.

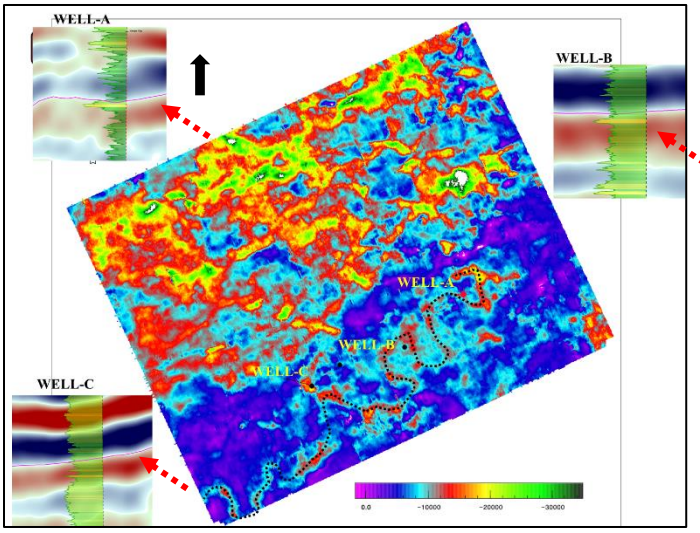

Figure 9 Average amplitude analysis of a seismic trough event that corresponds to a gas bearing sand unit.

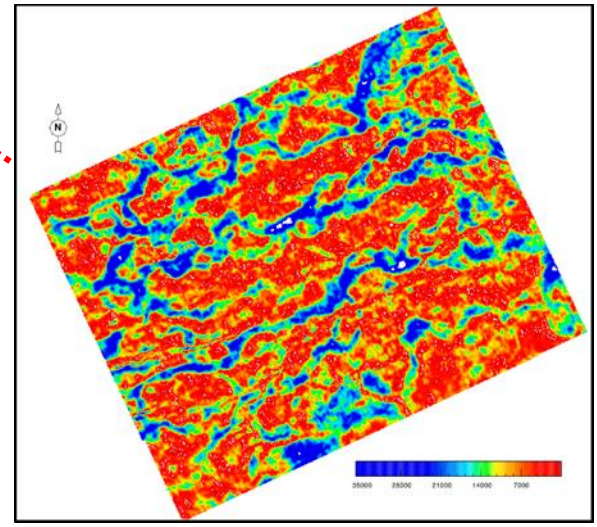

Figure 10 Mean absolute amplitude analysis of a prominent seismic trough event within the Girujan pack.

Conclusions

0°-phase processing has enabled the reflectors within the Girujan to become more pronounce and continuous. Seismic amplitude analysis on Quadrature volume has clearly brought out morphology of channel system (amalgamated system) and inter channel flood plains morphology envisaged at the time of deposition of Girujan formation.

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