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Multi geophysical attribute analysis reveals new plays in the Dharvi Dungar Formation of the Barmer Basin, Rajasthan, North West India

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Introduction

Cairn India has made more than 20 exploration discoveries in Barmer Basin of Rajasthan (Figure 1). The study area (Kaameshwari west) is covered by three 2D vibroseis surveys acquired by Shell in 1996, and subsequently by Cairn Energy in 2003 and in 2004. Approximately 650 sq km of 3D seismic was recorded in 2006 and fast track processed in 2006-07. Oil and gas discoveries in wells Kaameshwari-W-2, Kaameshwari-W-3 and Kaameshwari-W-6 close to the basin's western margin opened up potential flexural margin plays that could not have been defined on 2D seismic.

Subsequently, 3D PSTM reprocessing showed significant improvements over the entire stratigraphic section. The improvement in seismic data has aided furthering the understanding of depositional systems along the western flexural margin. Conceptual basin margin fan-delta and related incised valley fill (IVF) systems were imaged within the Dharvi Dungar Formation, which is the regional cap rock. Several amplitude anomalies were also identified in the Dharvi Dungar Formation. Multi-attribute analysis and forward modeling linked to a geological model of the Dharvi Dungar Formation suggest that these anomalies could be due to gas charged sands.

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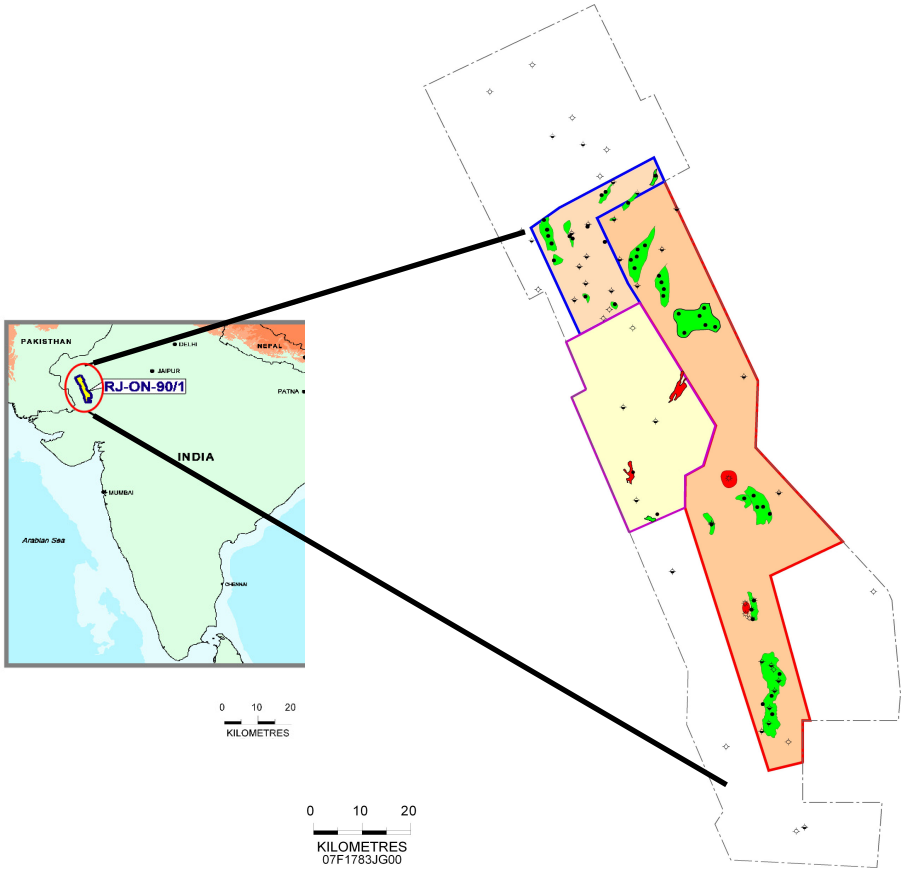

Figure 1: Location map of Barmer Basin

PSTM reprocessing

PSTM reprocessing (2007-08) improved imaging significantly compared to the existing 2D and fast track 3D data (Figure 2). Noise was reduced significantly after the application of Random Noise Attenuation (RNA) and dip filters in various domains. Anomalous Amplitude Attenuation (AAA), Surface Consistent Amplitude Compensation (SCAC) and Spatially Continuous Velocity Analysis (SCVA) helped to increased S/N ration and coherency in the data. Low frequency data was not filtered off and it helped significantly to improve deeper data. Migration parameters were selected to image higher dips. For better amplitude fidelity, AGC was not applied to Pre-Stack Gathers as it had been in the fast track processing.

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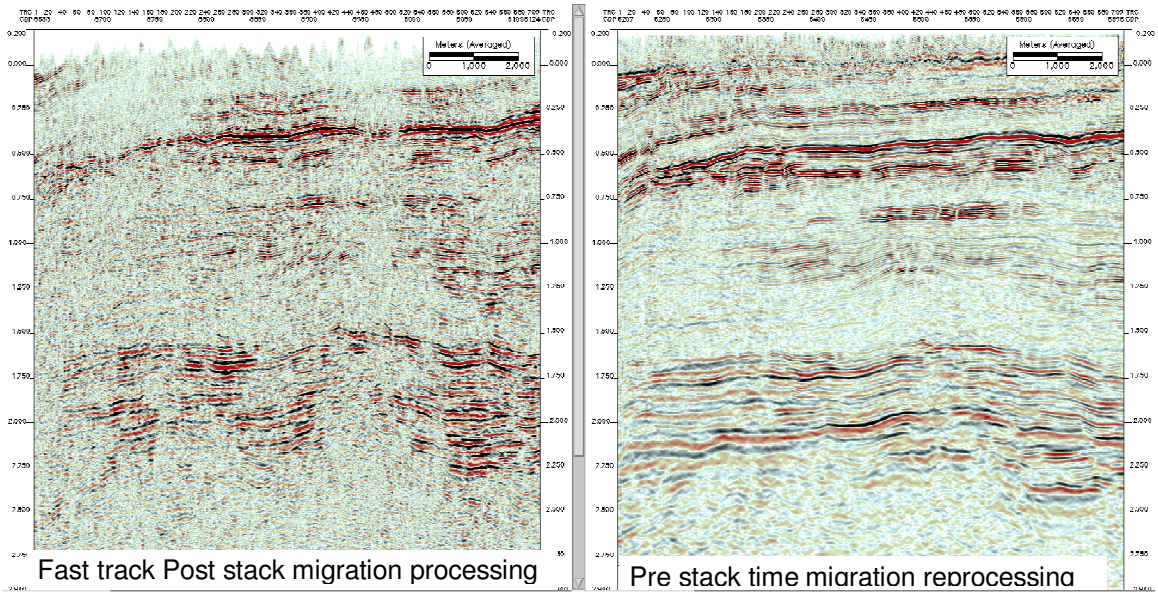

Figure 2: Improvements after Pre Stack Time Migration Reprocessing

Multi-attribute analysis and integration with the geological model

The Dharvi Dungar Formation, overlying the lacustrine Barmer Hill Formation, is a predominantly shaly package with three regressive cycles containing siltstones, occasional lignites and minor sandstones beds recording the filling of the Barmer Hill lake and development of swamps. Transgressive shales in the lower part of the sequence form the regional seal in the basin. Seismic data shows DharvI Dungar Formation as a low amplitude section just below the lignitic Thumbli section. The basal part of Thumbli Formaton is also an argillaceous, low amplitude sequence. The Barmer Hill and Fatehgarh formations below Dharvi Dungar are of higher amplitude.

A number of progradational sequences were identified in 2D and 3D seismic data forming flexural marginal deltas in different stratigraphic units. The top of the progradational sequences coincide with an erosional unconformity in which incised valleys are developed.

Several amplitude anomalies have been identified in the Dharvi Dungar Formation. The polarity of the data suggest that top of the feature is a soft event (acoustic impedance decreasing) and the base is a hard event (acoustic impedance increasing). In the dip direction, these features are conformable with the structure, downlapping on an intra Dharvi Dungar Formation maximum flooding surface (MFS) and thinning down-dip (Figure 3). In strike direction, these are fan shaped lenticular bodies that show channelised features at the top (Figure 4).

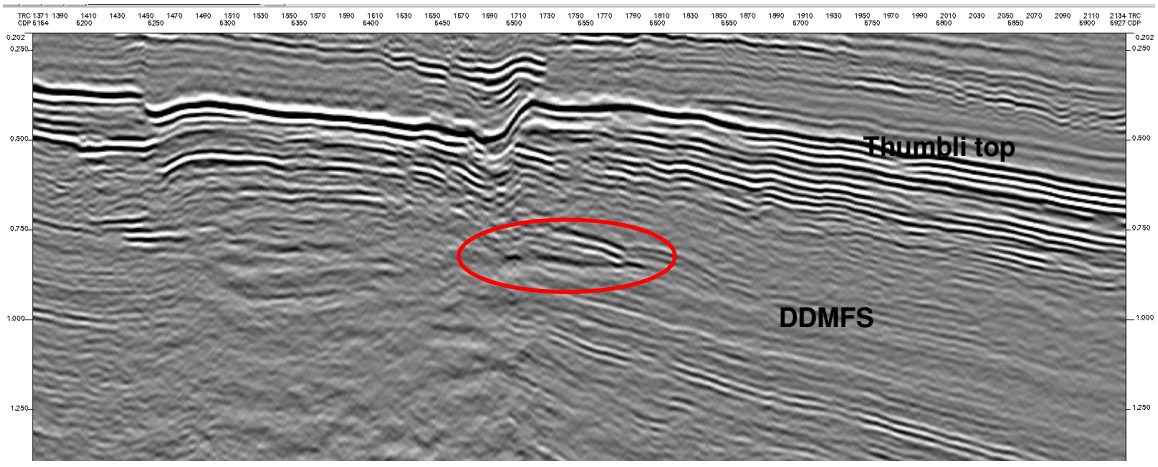

Figure 3: Dip line through one of the prospects in Dharvi Dungar. Prospect is highlighted.

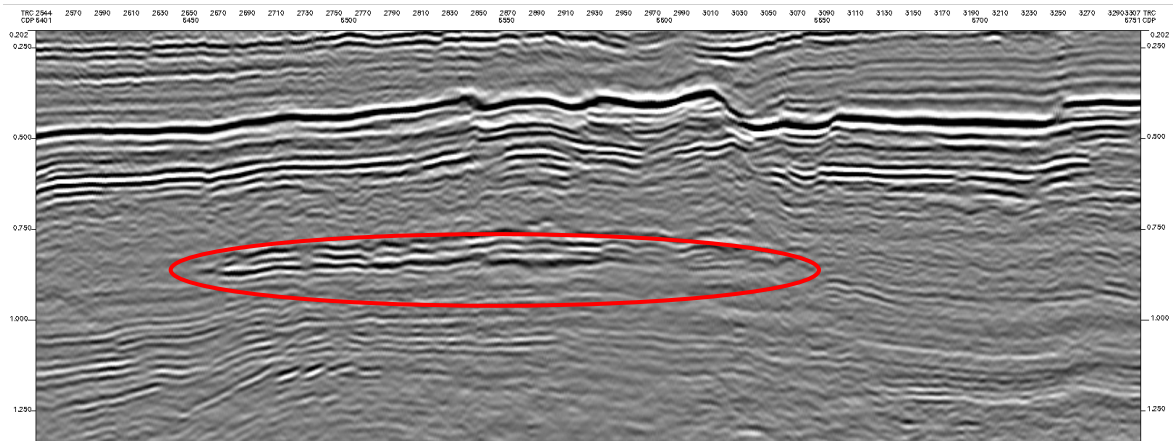

Figure 4: Strike line through the prospect mentioned in Figure 3. Prospect is highlighted.

These high amplitude features also show frequency absorption, change in phase with surrounding reflectors and increase of amplitudes in far offsets (see Figures 5 and 6).

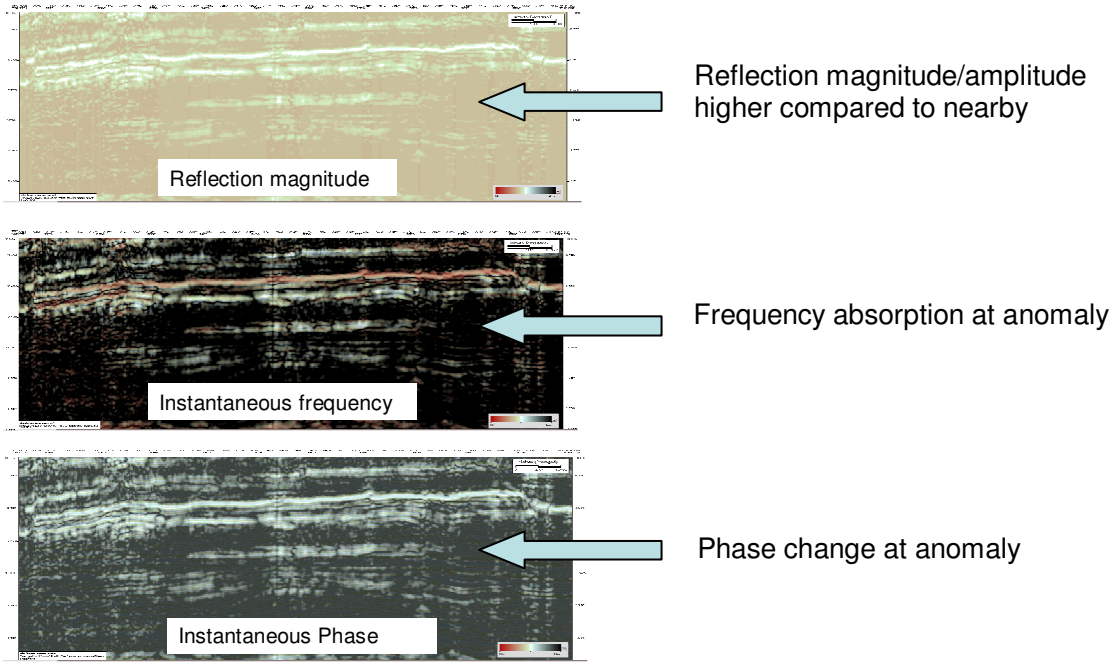

Figure 5: Example seismic attribute characteristics on representative line

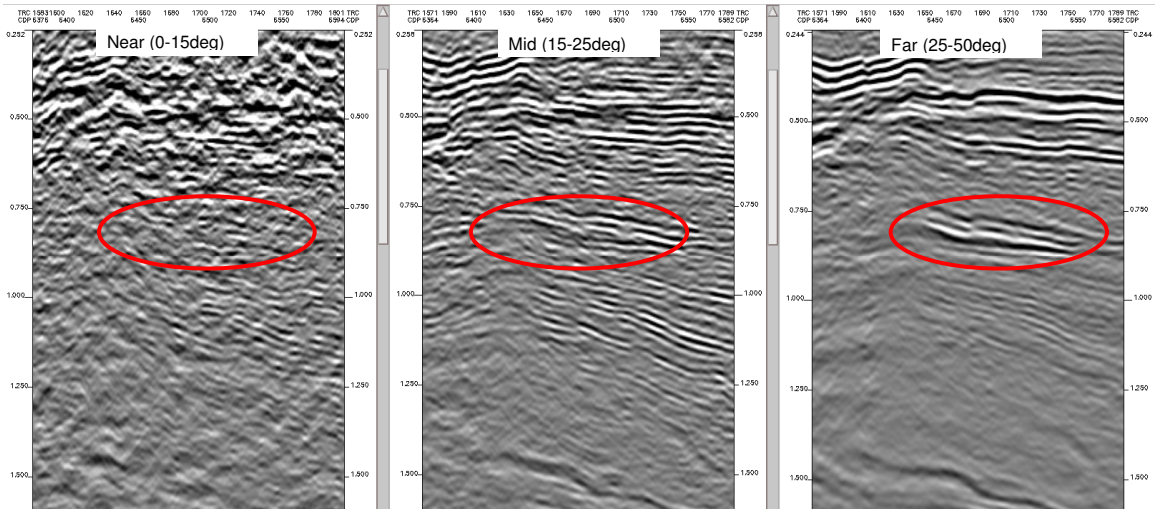

Figure 6: Amplitude increasing in far stacks for the prospect. Prospect is highlighted.

Forward modeling and fluid replacement studies with nearby wells (Kaameshwari-West-3 and Kaameshwari-West-6) suggest that gas sands exhibit an AVO Class III response and that the full stack amplitude of a gas saturated sand is approximately twice that of a brine saturated sand; coals exhibit full stack amplitudes more than 5 times those of brine sands. After forward modeling, seismic amplitudes of anomalies were compared, which suggested that these could be gas saturated sands.

Development of the Geological Interpretation

All the attribute maps were analyzed to visualise the depositional system represented by these amplitude anomalies. Data was spectrally decomposed to see in different frequency bands. Horizon slice at 30 Hz shows a channel system emerging from the western margin fan delta. These channels formed a small fan complex as they moves towards the central axis of the basin (Figure 7).

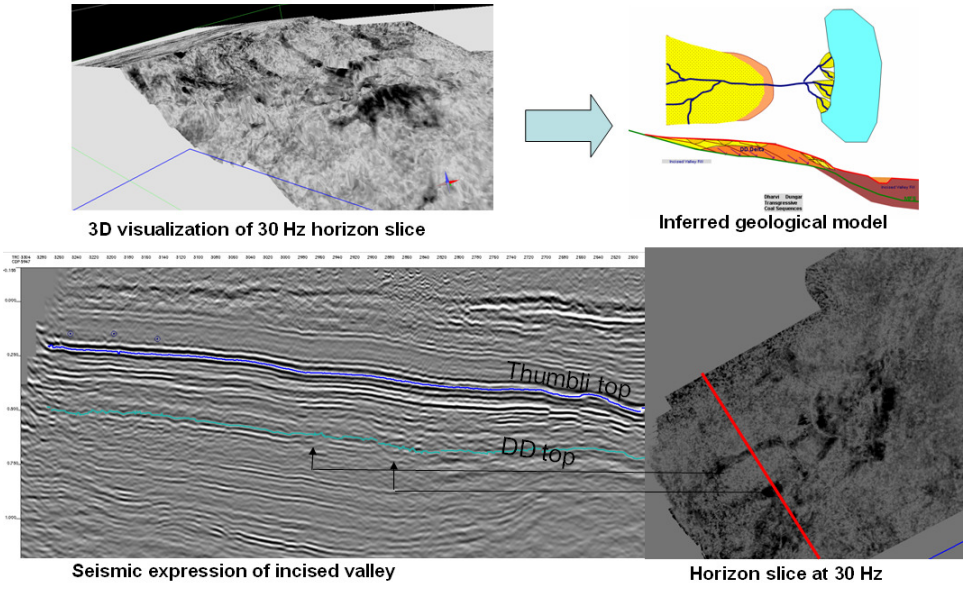

Figure 7: Summary of the geological model and the inferred seismic expression

Conclusion

Several amplitude anomalies have been identified in the Dharvi Dungar Formation, a new play in the Barmer Basin, that was previously considered only as a regional seal. Forward modeling and attribute analysis suggests that these are probably due to gas-charged sands. Integration of the seismic geometries with a geological understanding of the basin suggests the presence of a fan-delta and associated incised valley system developed along the western margin of the Barmer Basin, opening up a new exploration play in the basin.

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