Multiple High Potential Plays Revealed Through Enhanced Seismic Imaging in Krishna Sub-Basin

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Summary

Krishna sub-basin within Krishna-Godavari (KG) basin is relatively under explored compared to its northern counterpart Godavari sub-basin. The newly acquired long offset 3D seismic data processed by broadband technology in pre-stack time and depth domain, significantly improved imaging for deeper structural and shallower stratigraphic prospects with significant hydrocarbon resource potential

Introduction

Krishna sub-basin is the southernmost part of the KG basin. This basin was part of a large intra-cratonic rift basin, consisting of Permo-Triassic pre-rift Gondwana sediments, overlain by syn-rift sediments. Syn-rift sediments were deposited during Late Jurassic- Early Cretaceous time within half graben structures formed due to India-Antarctica rifting. This syn-rift oil play is the key emerging play in KG basin.

The exploration block KG-OSN-2009/3 (Cairn India operated; PI: 100% interest) embraces the shallow waters of Krishna sub-Basin, southwest to Krishna delta (Figure: 1). The block lies within shallow waters with water depth varying from ~ 5m close to shore, to about 200m beyond the present day shelf break.

So far, no well has been drilled within the block. Outside south-west corner of the block, just 5 km away there is recent oil discovery (MD-1) from syn-rift play. There is upcoming onland field in north-east direction, Nagayalanka, oil discovered from syn-rift play adjacent to the block.

Other than the above deeper play there are numerous shallower stratigraphic plays identified within block, like stacked turbiditie fan complex, alluvial fan deposit, carbonate build-up, channel sands etc.

Initially block was only covered by sparsed vintage 2D seismic data of variable quality. Reprocessing of vintage 2D seismic data was done to improve imaging quality along with acquisition of new 3D seismic data. Advanced long offset 3D seismic data acquisition and processing techniques brought significant contribution in imaging and interpretation for both structural and stratigraphic leads and prospect portfolio (Figure: 3).

Figure 1: KG-OSN-2009/3 block location along with highlighted adjacent syn-rift discoveries and existing fields

Broadband Imaging and Identified Plays

Offshore Krishna sub-basin appears to be southernmost extension of pericratonic KG basin and its main feature is northeast-southwest trending rotated syn-rift grabens. Litho-stratigraphy of Krishna basin consists of an Archean metamorphic basement, overlain by pre-rift sediments consists mostly fluvial-deltaic deposits (sand, shale, coal and red beds) and it appears as semi-parallel sequence to basement in seismic cross section. Overlying syn-rift sequence appears as wedge shaped and deposited in fluvio-lacustrine environment. Immediately overlying Raghavapuram shale represents the first marine transgression of Aptian-Albian time. This shale is thin over structural high and pinch-out westerly. During Upper Cretaceous time, a thick (1 to 1.5 km) prograding package was deposited in passive margin setting consists of lower shale package (named as upper Raghavapuram package) and upper sandy package, named as Tirupati sandstone. KT is marked by presence of Razole volcanic towards onshore (equivalent to Deccan volcanic) and limestone sequence towards offshore. Important stratigraphic units within Tertiary sequence are Palaeocene Vadaparu shale, Eocene Bhimanapalli limestone and Miocene growth fault unit.

Improvement in seismic interpretation is critically linked to better seismic imaging, which can be obtained by advancement in seismic acquisition and processing technology. Broadband processed seismic, is one of the very latest improvement in seismic imaging technology. Seismic data often lose its resolution with depth. The signal, especially the high frequency, is heavily attenuated due to absorption as it travels through thick overburden. Low frequency has better penetration. However, low frequency suffers the ghost effect for conventional flat streamer acquisition. Overall the illumination for the deep target is generally poor. Broadband processing partly remove the ghost effect to recover the lower frequencies that are very critical for interpretation of the deeper targets (Roberto et al., 2015)

Conceptual plays for this block were derived from geological knowledge of Krishna-Godavari basin and based on latest interpretation of new 3D seismic data. Identified plays were subdivided into two categories, deeper strati-structural plays and shallower stratigraphic plays.

A) Deeper Strati-Structural Plays:

There are mainly two types of play falls under this category. 1)Fluvio-deltaic, Permo-Triassic, Pre-rift play and, 2)Fluvio-lacustrine, Late Jurassic-Early Cretaceous, Syn-rift play. These consist of rotated tilted fault blocks that upon mapping yield three-way dip and fault closures in similar fashion to KG offshore Deen-Dayal field of GSPC and to Cairn's onshore Mangla field. Postulated reservoir and source rock unit for the Pre-rift play are Gondwana sediments, a good analogy being the KG onshore Mandapeta field, whereas intra syn-rift lacustrine shale layers and post-rift regional marine Raghavapuram shale may cap these structures as top seal. For the Syn-rift play, fluvial- lacustrine sands (lake environment) is the expected reservoir, lacustrine shale the expected source rock and post-rift Raghavapuram marine shale the regional top seal.

B) Shallower Stratigraphic Plays:

Stratigraphic plays identified within post rift sequences are as follows: 3) Aptian-Albian, Stacked turbidite, Channel play, 4) Upper Cretaceous, Deltaic sand, low stand fan plays, 5) Palaeocene, Slope-channel complex play, 6) Eocene, Carbonate play and 7) Miocene, Growth fault paly.
Please refer Figure: 2 for detailed description of reservoir-source-seal pairs for these identified plays.

Conclusions

Most of the identified play types within the shallow offshore KG-OSN-2009/3 block are exploratory type and properly defined by newly acquired broadband 3D seismic with better deeper imaging output.

In regards to the risks, geological chance of success is relatively higher for the syn-rift play due to recent oil discoveries made in close proximity to the block. One discovery from adjacent northern onshore KG-ONN-2003/1 block (Nagayalanka), and another offshore, near the SW corner of the block, upon drilling of the Dhirubhai-36 well (MD-1). Moreover the same play is strongly supported by the recent MA and MJ discoveries by RIL-BP in KG offshore.

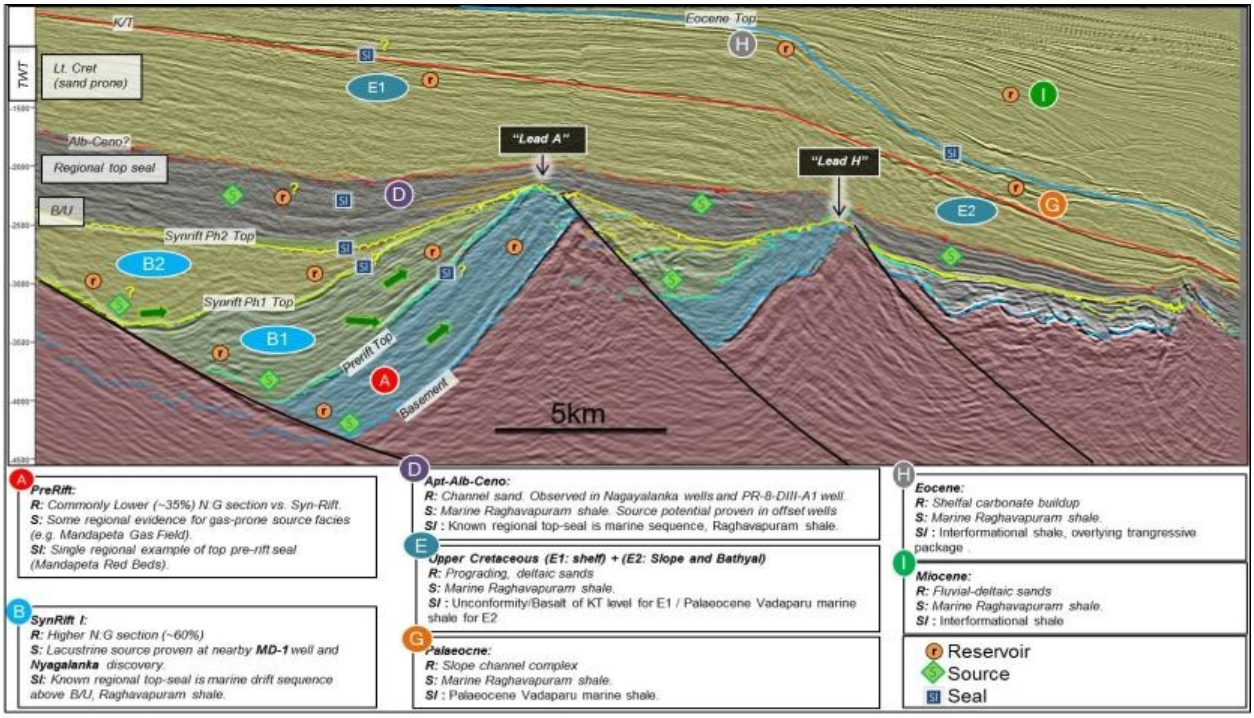

Figure 2: Dip seismic section demarketing identified plays

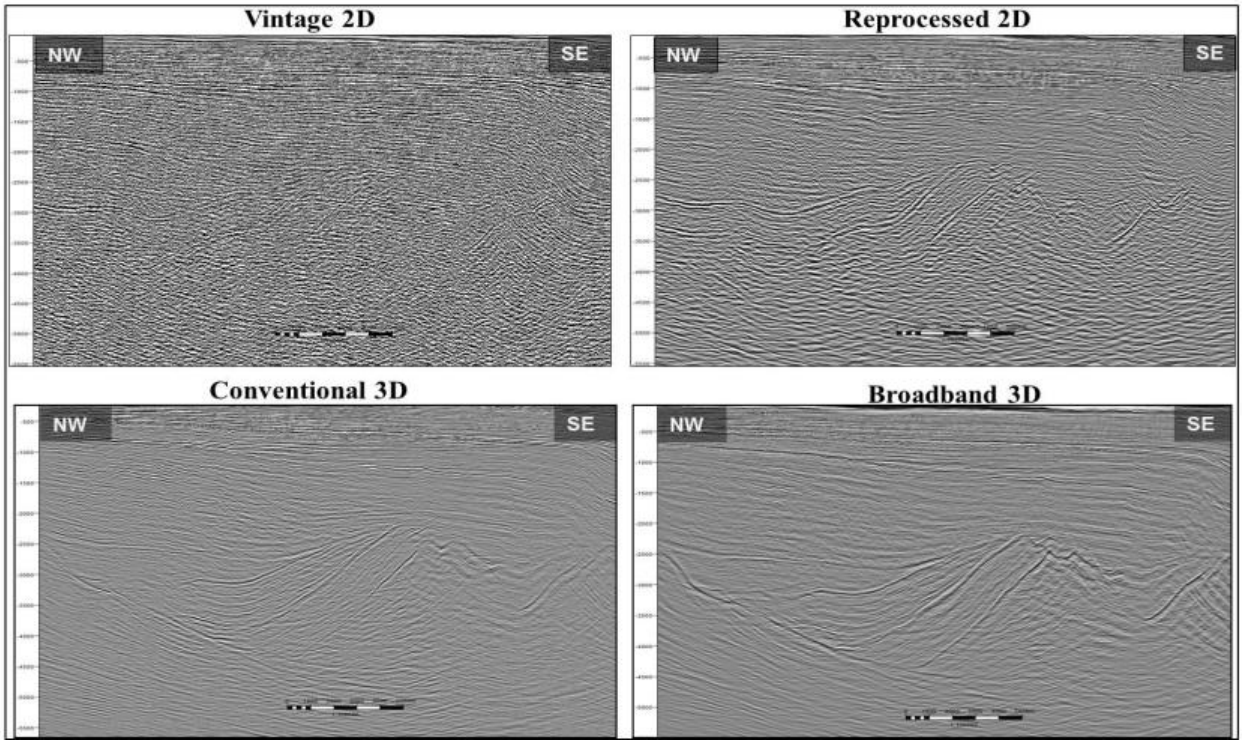

Figure 3: Improvement of seismic imaging with technology

References:

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