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Best practices application of geophysical techniques: Cairn Examples

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Summary

Technology is an essential part of our business. From the application of leading edge seismic techniques to the development of a unique solution to pipeline heating, the application of fit for purpose technology has been a hallmark of the Cairn India success story.

In this presentation we show a series of examples depicting the application of geoscience technology in various basins in South Asia. The focus is on the incremental, evolutionary nature of the technology with emphasis on selection and adaptation of the appropriate solution for the problem at hand.

In addition to selecting the right technologies, the key to success lies in developing and retaining a well motivated and well trained staff who know how integrate Geology and Geophysics to find hydrocarbons.

Mangala Field

The Mangala Field was discovered in January 2004 by the N-B-1 well, subsequently renamed as Mangala-1. Mangala was continually appraised during 2004-2007 with the drilling of eight more wells, the acquisition and interpretation of a 3D seismic survey, and major data gathering and analysis efforts involving core, fluids, and well testing.

The Mangala structure is a simple tilted fault block dipping at ~9º to the southeast. The current structural interpretation is based on a 3D pre-stack time migrated (PSTM) seismic volume and well data (Figure-1). The depth of the Mangala structural crest at the Fatehgarh level is ~600mSS and the oil-water contact (OWC) is at ~960mSS, resulting in a total oil column of ~360m. Ground level elevations range from 175-200m AMSL.

The old 3D seismic resulted in poor imaging close to western boundary fault leads to uncertainty in structural mapping at the crest of the fault. Furthermore, the limited seismic resolution hampered the detailed reservoir characterization. To overcome these limitations high trace density dataset (HD3D) was acquired in 2006-07. Figure-2 shows improvement in the imaging at main bounding fault and high resolution within the reservoir unit.

Mangala rocks are more sensitive to lithology change compared to fluid change. The densities and velocities of the Fatehgarh sands are lower than overlying/underlying shale units. As a result P-impedance inversion of HD3D dataset was used for lithology discrimination (Figure-3).

Inversion has greatly helped in mapping the thin Upper Fatehgarh channel sands and also accurate placement of the wells during development campaign.

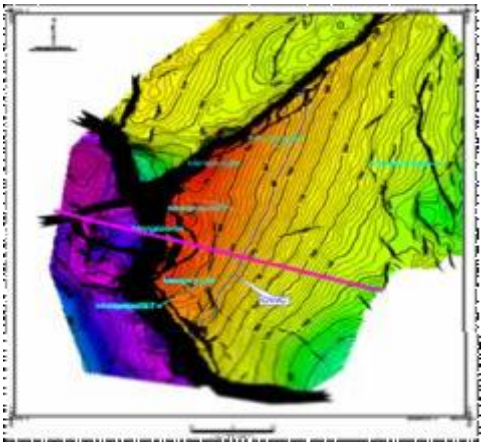

Figure 1: Depth map at top reservoir (Mangala Field).

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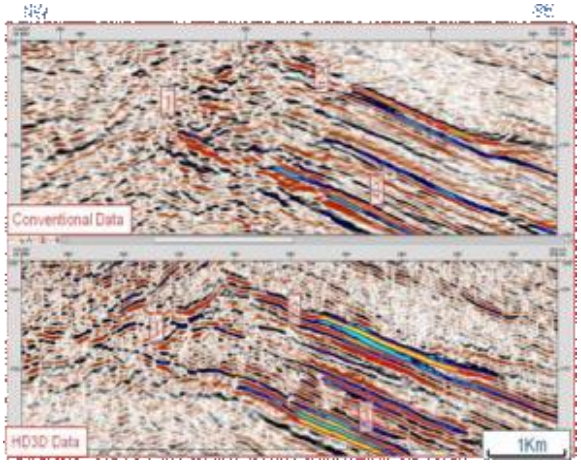

Figure 2: HD (high density) 3D data was acquired in 2006-07 with 10m x 10m station interval (Mangala field). High trace density data has demonstarated the better imaging of faults, events and also higer resolution within reservoir interval.

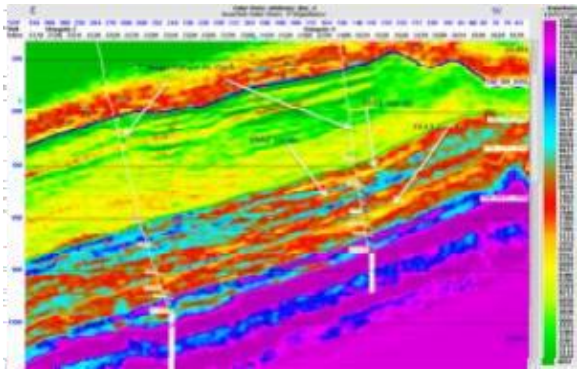

Figure-3: Due to the velocity and density contrast between shale and sand, P-impedance is being used as an effective lithology discriminator in Mangala Field.

Bhagyam Field

The Bhagyam field, situated within the RJ-ON-90/1 Contract Area, is a world class oil discovery. The field was discovered in 2004 by drilling of N-V-1well. The field was appraised from 2004-2006 with the drilling of nine more wells.

The main reservoir unit in Bhagyam is the Fatehgarh Group, consisting of inter-bedded sands and shales. The group has been sub-divided into the Lower Fatehgarh Formation dominated by well-connected sheetflood and braided channel sands, and the Upper Fatehgarh Formation dominated by a combination of braided channel sands and sinuous, meandering, fluvial channel sands.

127 sq km of 3D seismic data was acquired in 2005 which was subsequently processed in 2006 and interpreted for mapping the structure. The accurate placement of the wells was impaired by poor imaging on the crestal part of the structure.

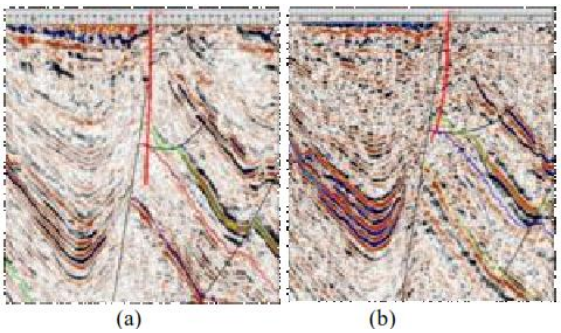

Figure-4: Objective oriented PSTM reprocessing has helped in better imaging of the crestal part in the Bhagyam field. This has resulted in change of the initial positioning of B1-PS8G location to up-dip side.

The same data were re-processed in 2011 with the objectives to improve the imaging at up-dip side. The re-processed PSTM data was used for final placement of the wells during development campaign to target the up-dip oil (figure-4).

Mannar Basin (Sri Lanka)

Cairn Sri Lanka (a 100% owned subsidiary of Cairn India) is the operator and owns the 100% participating interest in the SL-2007-01-001 exploration block located in the Gulf of Mannar. About 1752 sq km of 3D seismic data was acquired in 2010 which was processed and interpreted for the structure mapping of several prospects.

Figure-5: Optical stacking helps in inferring the seismic morphologies and depositional system within Oligocene level in Mannar basin.

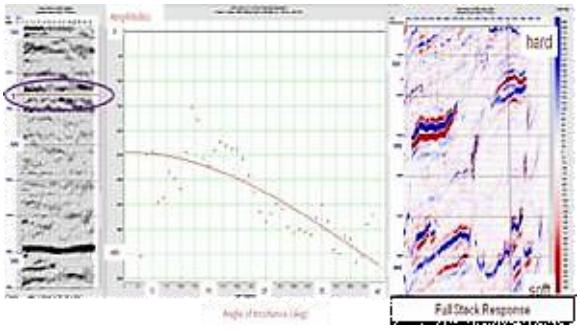

Figure-6: AvO analysis on seismic gathers is used to reduce the subsurface uncertainties during exploration campaign in Mannar basin. Observe the Class-III AvO response on the top of the gas reservoir.

Cairn Sri Lanka has successfully drilled three exploration wells to date; out of which two have encountered hydrocarbons. The hydrocarbon bearing rocks are sensitive to fluid change. Figure-6 illustrates the Class-III type of AvO response from the top of a gas reservoir. DHI techniques have greatly helped to reduce the sub-surface uncertainties during exploration campaign.

Ravva Field

Ravva field has been under production since 1993. The main producing reservoirs occur in Mid Miocene (oil) and Late Miocene (gas) sandstones at depths varying between 800 to 1800 m. The field has undergone multiple phases of development campaigns and is on decline phase with increasing water cut.

The reservoir management strategy of down dip water injection and upward (re)completion has been instrumental in achieving good levels of sweep and displacement. With substantial reserves remaining for the main development blocks, and significant exploration potential identified, particularly within the Early Miocene and Oligocene sections, incentives exist to investigate opportunities to leverage emerging E&P technologies to add incremental reserves and arrest production decline.

To tap the un-swept oil potential, 4D seismic acquisition campaign was carried out in 2010. Base and repeat surveys, 2000 & 2010 respectively, were processed with the same parameters to preserve the 4D signal. Noticeable 4D signal was observed within the Middle Miocene reservoirs (figure-7). The altered seismic amplitudes are attributed as production related changes within the reservoir.

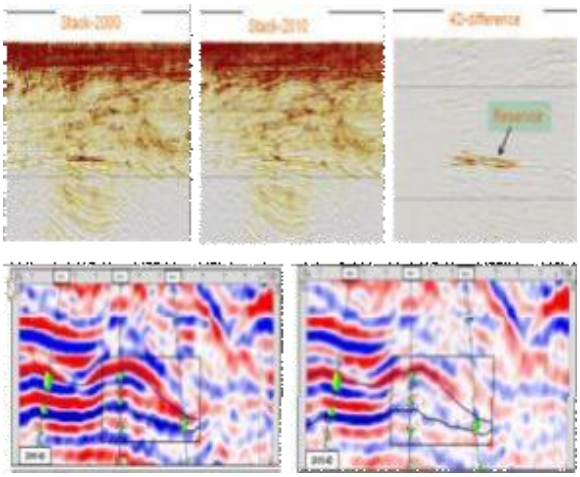

Figure-7: The base OBC survey was acquired in 2000 and repeat in 2010. 4D effect visible on the difference volume (top right corner). Observe the decrease in amplitudes inside the rectangle at the middle Miocene reservoir which are attributed to production related changes.

Acknowledgements

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