Exploration success adds significant reserves to declining Ravva Field

Uday Mishra, M Suresh Kumar, Kondal Reddy, Subhendu Sarkar, Vivek Shankar, Prakash Bajpai, Varad Sabharwal, Jyotsna Prusty, Cairn India Limited*
uday.mishra@cairnindia.com

Keywords

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Summary

During the planning of the recent Phase-5 development drilling campaign at Ravva, an exploration prospect was identified that could be reached from the existing platform and hence developed immediately after discovery. With this objective, Exploration Well-X was planned to target the untested fault block due north of the producing REFB field (Figure 1). The prospect was identified by leveraging several seismic technologies, with AVO being the most important of them. The key challenges were to ascertain hydrocarbon presence and reservoir thickness ahead of the drill bit.

The results were very encouraging. Well-X encountered a 28m oil column in Middle Miocene M30, M20 and Sub-M20 sands. MDT pressures confirmed that the reservoirs were at initial reservoir pressure. Pressure transient data was collected to delineate the reservoir extent and further subsurface modeling was carried out. Initial testing rates for the M30, M20 and Sub-M20 sands were 4300, 1200 and 7200 bopd, respectively. Post drill analysis, in addition, highlighted additional undrilled exploration & development opportunities within the northern fault blocks.

Introduction

The Ravva field (Figure 1) is located in the shallow offshore area of the Krishna Godavari Basin on the eastern coast of India (PKGM-1 block).

The field is operated by Cairn India (22.5%) on behalf of its JV partners ONGC (40%), Videocon (25%) and Ravva oil Singapore (12.5%). The field was discovered in 1987 and was brought into production in 1993. The producing reservoirs are unconsolidated Miocene sandstones deposited in a mixed wave and tide dominated delta. Oil production from Ravva was increased in two steps to reach a plateau of ~ 50,000 bopd by 1999, with water injection providing pressure maintenance. The oil production plateau rate continued for 9 years until 2007, after which the field started declining. During this period, many producers had to be abandoned due to high water cut.
Main Ravva producing reservoirs comprises of two areas separated by a shale filled erosional unconformity- RAD & REFB and RE-North fault block is located north of REFB block (Figure 1).

Since the field's discovery, eleven additional Middle Miocene exploration wells have been drilled in the area. Several relatively small discoveries were made, but none of them could be successfully developed due to the in-place volumes being too small for a stand-alone development, while also being too far from existing platforms to be developed.

With this view an exploration well was planned to target RE-North block from existing RE platform (Figure 1), targeting Miocene aged sands lying within an untested fault block due north of the main REFB field. The well resulted in a significant discovery. All the studies conducted to identify and de-risk this exploration prospect, along with well results, are presented in this paper.

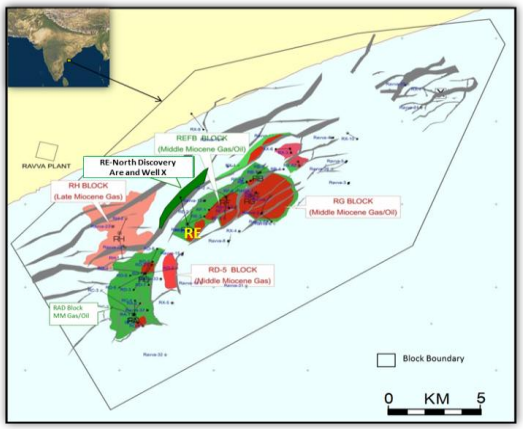

Fig.1: Ravva oil and gas distribution map showing significant discovery area added by Well X.

Exploration Prospect Identification & De-risking

Methodology and Workflow:

The methodology and workflow shown in Figure 2 was followed in order to identify and mature this lead, and other exploration prospects, lying within close proximity to the Ravva field's existing platforms.
The RE-North lead was derisked by extending our understanding of sand distribution and hydrocarbon

presence at the REFB main field to the north across the untested RE-North fault block.

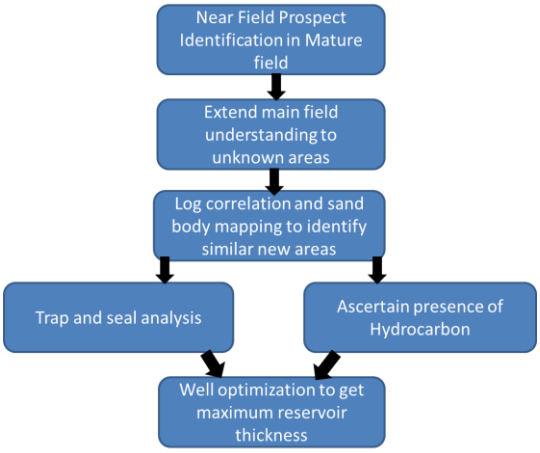

Fig.2: Methodology and workflow

Reservoir and Hydrocarbon Presence:

The high quality Middle Miocene sands across the REFB main field, which are believed to be extensive in nature, were deposited in a mixed wave and tide dominated deltaic depositional environment. Correlation of wells along with detailed horizon mapping, seismic attribute analysis and geobody extraction, supported the belief that high quality reservoir sands could extend landwards (northwards) towards the RE-North fault block (Figure 3). In addition to the reservoir studies, AVO analysis was conducted in order to try and derisk the presence of hydrocarbons across the area.

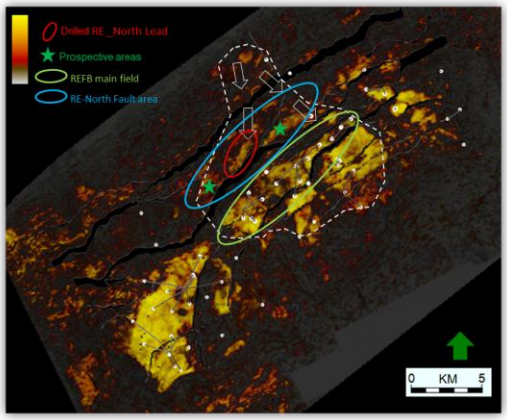

Fig.3: Geobody at Middle Miocene level showing depositional trend.

Ravva seismic data is AVO friendly and the Type II/III AVO signature (Figure 4) of the producing Middle Miocene sands was crucial in the development of the main field area. AVO modeling at Ravva suggested the following:

- Top of Oil/Gas sand generates a negative response with amplitude increasing with offset
- Top of Brine sand generates a positive response with amplitude decreasing with offset.

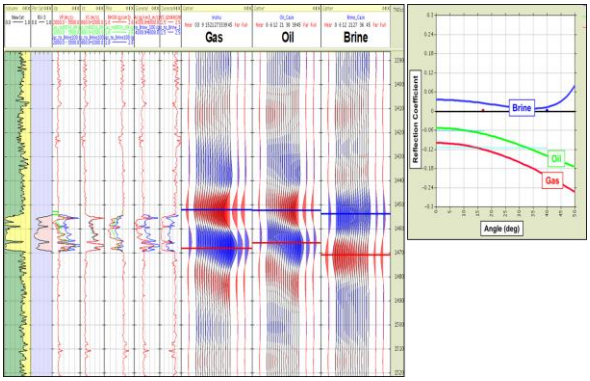

Fig.4: AVO modeling of type well showing AVO response of Middle Miocene sands in Ravva

Given the main field experience, an attempt was made to identify AVO signatures across the RE-North fault area. Classic AVO effects were identified, as shown in Figure 5, where the negative impedance (red color) far offset seismic data clearly increased in amplitude relative to the near offset data.

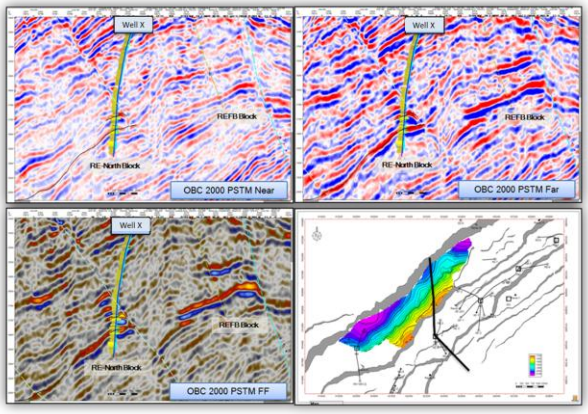

Fig.5: Section along RE-North Prospect and the main REFB Field showing AVO effects by comparing Near and Far seismic stacks. A Fluid Factor section is also shown along the same line showing brightening across hydrocarbon bearing areas.

From a previous inversion study, a Fluid Factor attribute volume was generated, which based on validation at several well locations, has proven to be an excellent hydrocarbon indicator across the producing field. As can be seen in Figure 3, a hydrocarbon bearing signature is also evident across the RE-North prospect.

Pre-drill, the expectation was for Well-X to encounter high quality hydrocarbon bearing Middle Miocene sands, with the AVO and Fluid Factor attribute analyses playing a large role in derisking the exploration prospect.

Trap and Seal:

The RE-North Prospect (Fig.6) is located north of the REFB block and is separated from it by a major NE-SW trending fault, having approximately 80 meters of throw.

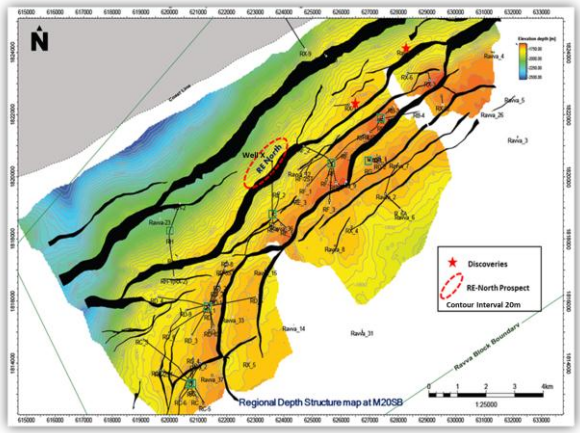

Fig.6: Depth Structure map at M20SB level showing structural setup of RE-North prospect.

Fault seal analysis indicated that Middle Miocene sands on the high side of the RE-North fault are juxtaposed against thick Lower Late Miocene shales (LLM) on the low side, providing the fault seal. The LLM shales, which lie unconformably above and are separated from the Middle Miocene sands by an erosional sequence boundary (LLMSB), in addition, provide the top seal (Figure 7).

As depicted in Figure 3, sand body mapping suggests limited extension of Middle Miocene sands northeast and southwest of the RE-North prospect, most likely due to lateral facies changes. The M20SB Structure map (Figure 6), in addition, indicates that the RE-North prospect is on the structural high.

The RE-North prospect, therefore, is actually a combination structural-stratigraphic trap, which relies on the LLM shales for fault and top seal, while relying on a Middle Miocene facies change (sand to shale) to provide the lateral seal.

While the work leading up to the RE-North discovery was a fully integrated study, with team Geologist and Geophysicists working in concert, there is no doubt that identification and derisking of the lead, and well optimization, was driven in large part by successful implementation of proven Geophysical techniques, such as AVO analysis, as well as attribute analysis of various seismically derived volumes, such as Fluid Factor shown in Figure 3.

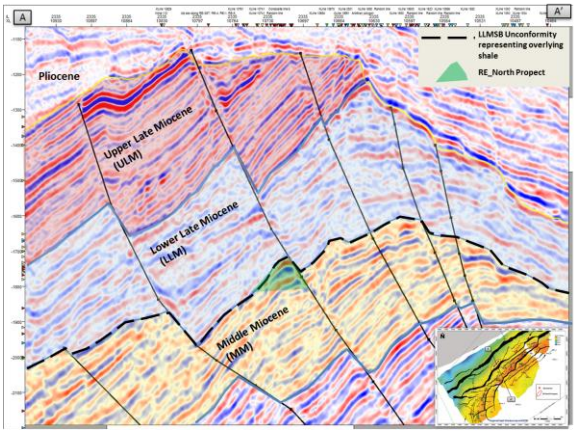

Fig.7: Seismic section in dip direction along RE-North prospect area showing stratigraphic setup.

Well Results

Well-X was successfully drilled from the RE platform. The top of the Middle Miocene reservoir was encountered at 1700 mSS. In total, 3 oil columns of 12m, 8m and 8m from the M30, M20 & Sub-M20-1 intervals, respectively, were encountered.

The M30 and M20 intervals encountered at Well-X, as shown in the well cross section (Figure 8), correlate nicely to the equivalent producing Middle Miocene sands across the main REFB field. This correlation was supported by seismic well ties and horizon interpretation across the region, as shown in Figure 9.

The lower most oil bearing interval at Well-X, the Sub-M20-1, however, is not present across the main field, as this sand has been truncated by the Base M20 erosional unconformity (Figure 8).

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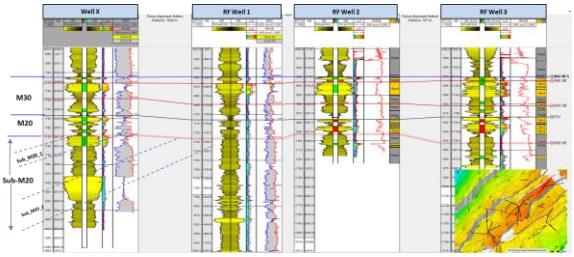

Fig.8: Well X log section showing various sands encountered and it's correlation with main RF area wells.

The Well-X discovery was of critical importance to the asset team, as it confirmed that seismic can accurately predict the presence of high quality oil bearing sands deposited in a semi-stratigraphic setting. Without the predictive power of the seismic tool, there would have been no reason or justification to drill this lead. Moving forward towards development, these learnings will serve the Ravva team well.

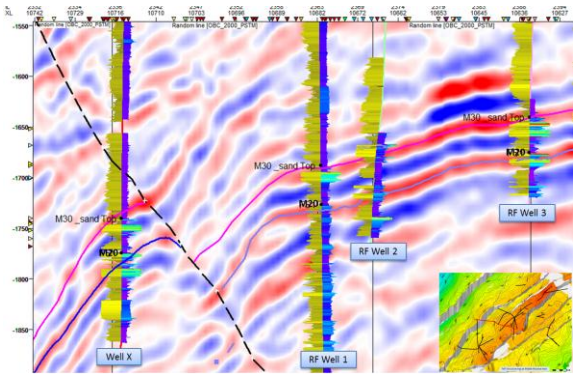

Fig.9: Seismic section along Well X and main field RF area wells.

RFT Pressures were recorded from the M30, M20 and Sub M20_1 (oil bearing) and Sub M20_2 (water bearing) intervals. The recorded pressures suggested that the reservoirs were at initial conditions, with no evidence of depletion. The MDT data also confirmed the isolation of the northern block from the producing REFB field, where all the Middle Miocene reservoirs are in pressure decline due to ongoing production. The M30, M20 and Sub M20_1 reservoir pressure gradient data had an oil gradient, while the Sub-M20_2 sand clearly showed a water gradient (Fig.10).

The MDT also suggested that the two sand units within the Sub-M20 interval might not be in pressure communication and could be hydrodynamically independent based on different reservoir pressures.

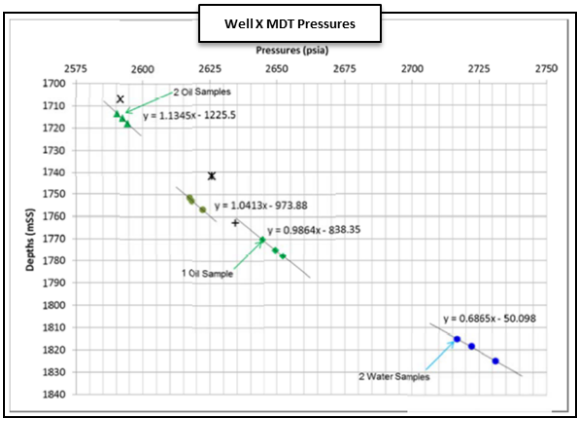

Fig10: MDT pressures with sample points.

Well-X was critical to the asset, as it successfully added significant reserves to the declining Ravva field which is currently monetized by putting this well on production.

Key Learning's

- ✓Well and seismic correlation to extend the main producing REFB sands across the RE-North prospect
- ✓AVO studies as well as structural & stratigraphic analysis was key to identifying and developing Ravva near field potential
- ✓Drilling an extended reach well and putting it on production was successful which serves as a guide for other near field exploration and development opportunities.
- ✓Proper well path optimization and the ability to target high quality sands with a high degree of accuracy serves as a guide for future wells.
- ✓The success of this well has opened up additional opportunities for full scale exploration and development of the northern block.

Conclusions

The RE-North prospect was drilled from the existing RE platform. Oil bearing Middle Miocene Sands were encountered, which added additional reserves to a field in decline.
The Well-X discovery confirmed the presence of Middle Miocene sands in the RE-North fault block area which has opened up additional opportunities for future exploration across the area.

References

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