

Paradigm Shifts And Redefine Success In Oil Exploration: A Case Study From Barmer Basin, Rajasthan, India

Sabyasachi Dash¹, Arpita Mandal¹, Premanand Mishra¹, and Pinakadhar Mohapatra¹

¹Cairn Oil & Gas (Vedanta Limited)

ABSTRACT

Barmer Basin in NW India is an important petroliferous lacustrine rift systems caused by the failed extensional continental rifting. There have been 38 discoveries in the basin across various stratigraphies till date. In this time frame of exploration there has been a lot of paradigm shifts in ideas & theories. Through this paper the authors wish to highlight some of these theory busters and its subsequent impact on exploration strategies.

The first three discoveries in the basin were restricted to the southern part of the basin. The idea prevailing at that moment was that the source rocks in the north are at a very shallow depth making it highly improbable to be in the maturity window. This myth got busted with the Mangala & Aishwariya oil discoveries in 2004 at depths of ~1000m TVDSS. The basin had undergone structural inversion post Miocene due to Himalayan compressional orogeny whereas the expulsion of hydrocarbon occurred during late Eocene times (Dolson et al., 2015). The post Miocene erosion has removed upto 1km of sediments in the northern part of the basin. This opened up numerous plays in this area for exploration.

The most prolific of the reservoirs in the basin is the Paleocene Fatehgarh Formations which are dominantly fluvial systems. It was considered to be the onset of the rifting phase as a result of separation of India-Seychelles (70-65 Ma). Age dating of these rocks revealed that the upper Fatehgarh is Paleocene with dominant fluvial input from NNW. The lower Fatehgarh (now called Ghaggar Hakra) is Cretaceous with fluvial input from NNE and is part of an earlier rifting phase as a result of separation of India-Madagascar (92-84 Ma). This changed the exploration strategy vis-à-vis the play being chased with better understanding of provenance & prediction of facies.

Initial exploration campaign targeted the multi Darcy fluvio lacustrine Fatehgarh Formations whereas the overlying Barmer Hill Formation was interpreted as the primary source rock, a possible top seal for the Fatehgarh Formation but never as a reservoir. With the data gathered from the campaign, the Barmer Hill Formation was identified as a potential secondary reservoir. Re-entry and retesting of wells in the Barmer Hill Formation has proved to be commercial & hence has led to significant addition of reserves in the company portfolio.

In the early days of exploration, the basin was thought to be in Normal stress regimen since it is an extensional rift basin. Detailed study of image logs from a number of wells suggested that it is in Strike-slip stress regime (Dash et al., 2017). Seismic data interpretation has also established a late strike slip movement in the region. This has helped in choice of perforation strategy to design hydraulic fractures, phasing and orientation of perforating guns to minimize fracture initiation pressure, predicting the type of fracture to be created from stimulation depending upon failure mode, etc. The understanding of in-situ stresses has helped increase productivity of wells by five to ten fold.

Paucity of newer basins and ever increasing demand of fossil fuels ensures that newer approach by restructuring of the available data is required for successful exploration campaigns. This is particularly true for mature basins where prevailing structural and depositional concepts comes into the way of lateral thinking. It is not the data, but the alternating way of interpretation that has ensured this industry to reach the epitome and quench the need of the civilization.