Unfolding New Prospectivity in a Mature Rift Basin through Paradigm Shift in Basin Evolution Concepts: Barmer Basin Story

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ABSTRACT

The Barmer Basin is a N-S oriented failed continental rift located in western India, extending from the Cambay rift in south till Devikot High in the north and with 6 km (20,000 ft.) of sedimentary fill. The exploration efforts in last two decades has focused on releasing the potential of Tertiary syn-rift and post rift sequences. 38 discoveries have been made by Cairn India Limited in the basin, with 7.3 billion barrels of stock tank oil in place (STOIP), dominantly from the prolific Paleocene Fatehgarh Formation.

Jurassic sedimentary rocks are present just west and northwest in Bikaner-Nagaur basin and Jaisalmer basin. The exploration campaign undertaken in Barmer Basin prior to 2014 did not penetrate these sediments and occurrences of older Jurassic rift and associated sequences were ruled out in earlier understandings. Further studies following the first exploration campaign helped in defining the tectono-stratigraphic evolution of the basin, which was, previously, poorly understood (Gombos et al., 1995; Compton, 2009).

Based on the revised understanding, Barmer basin is now considered to be a multi-cyclic rift basin, related to NW-SE India-Africa separation (185-165 Ma) followed by NE-SW India-Madagascar rifting (92-84 Ma) and subsequent separation of India-Seychelles (70-65 Ma). Present structural configuration of the basin is defined by two non-coaxial extensional events, with NW-SE extensional related structures incorporated in the NE-SW extensional event (Bladon, 2014), followed by structural inversion along the northern end related to India-Asia collision. Presence of an older rift system can also be inferred from gravity data. Gravity modeling concluded a deeper sedimentary unit underlying the earlier inferred crystalline basement, interpreted from seismic data, along specific profiles on the basis of variation between observed and modeled gravity. Though seismic acquisition was not designed for deeper targets, presence of Mesozoic basins can also be inferred in seismic lines in the profiles with gravity variations. An exhaustive geochemical analysis program established a distinct oil group atypical of the typed source rocks in the discovered fields and was subsequently attributed to deeper Mesozoic source rocks (Farrimond et al., 2015).

In 2014, an exploratory well was drilled in the deeper Mesozoic targets. The well encountered 18m potential source rock and 170m reservoir within the target interval, with significant gas shows. Detailed study of samples from this interval suggests presence of highly degraded woody debris, bisaccate pollen (undifferentiated) and simple fern spores (probably Deltoidaspora/Cyathidites spp.) of possible lacustrine origin, with a Thermal Alteration Index value of 3+/4. Presently the well is suspended for testing.

This well successfully established a working Mesozoic Petroleum system and has opened up vistas for maturing older rift prospects. Gravity along with reprocessed seismic data is being used to demarcate other probable Jurassic proto-rift basins. Based on palinspastic reconstructions,

it appears that the vast expanse of Neoproterozoic-Cambrian Jodhpur and Nagaur formation sandstones and Delhi-Aravalli Fold Belt were a significant source provenance for reservoir, quality of which is observed to be greatly altered by cementation, and thus requires stimulation. Recent discovery from a similar older rift in Alaman Basin, Egypt reaffirms our understanding of a huge potential in the untested Jurassic rifts within Barmer basin.