# Discovery of Paleocene Sandstone facies below Deccan-trap: A very significant lead for future exploration in Cambay Basin.

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**Summary**

Cambay Basin is one of the earliest Hydrocarbon producing provinces of India. Exploratory efforts till now were focused for exploring tertiary sediments. In general wells are terminated on reaching the technical basement i.e. Deccan Trap. An exploratory well recently drilled in the eastern margin of the Basin in Charada-Mansa area has encountered about 200 meters arenaceous facies below/within(?) Deccan Trap. This sedimentary sequence was encountered after penetrating Deccan-trap thickness of more than 800 meters and the bottom of the sequence could not be established as drilling was terminated after achieving the pre-decided Target Depth. Initial dating carried out gives its age as Paleocene based on Palyno-fossil assemblage and fungal spores. Presence of such huge thickness of reservoir below/within(?) Deccan Trap is a very significant lead for future exploration of hydrocarbon in Basin margin areas and beyond.

**Introduction**

Cambay Basin is a narrow elongated (NNW - SSE) extensional basin located on the western margin of Indian plate (Fig. 1). Precambrian rocks of Aravalli System are exposed in the northeast. Deccan Trap of late Cretaceous to early Tertiary age with underlying Mesozoic strata is exposed on the eastern and western flanks of the basin. This Cenozoic extensional basin is a typical "intra cratonic aborted rift" which evolved due to rifting along Dharwarian orogenic trend during the northward migration of the Indian plate after its break up from Gondwanaland in Late Mesozoic and the Basin came into existence during Early Cretaceous. The rift-drift transition phase of Indian plate witnessed volcanic events in the western India during which huge thickness of Deccan trap was deposited in Cambay Basin.

The extensional architecture of the basin is defined by two types of faults viz., 'listric normal faults', striking N-S to NNW-SSE and 'transfer faults', trending ENE-WSW to NE-SW. The listric faults mostly run sub parallel to the rift - border faults transfer faults frequently offset the listric faults.

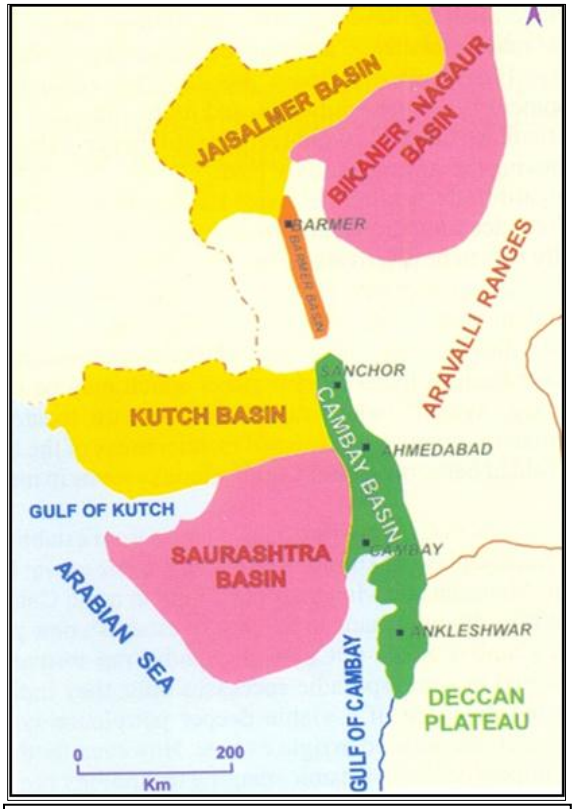


Fig.1 Geological map of Cambay Basin.

During Late Miocene, few areas in the basin experienced inversion tectonics related to Himalayan Orogeny. Thus basin architecture is defined by an en-echelon arrangement of asymmetric half grabens bordered by listric normal faults oblique to the rift axis and are separated by transfer fault zones/accommodation zones and basement highs. A thick sequence of sedimentary rocks ranging in age from Paleocene to Recent overlies the Deccan Trap, which is considered as technical basement in Cambay Basin. A total of about 6 km thick tertiary sedimentary sequence is expected in the deepest part of the Cambay Basin. A complex network of these faults compartmentalizes the basin into distinct tectono-sedimentary blocks bordered by major transfer faults (Fig 2). Based on major basement faults the Cambay Basin is subdivided into five major

tectonic blocks, which have been named from south to north Viz. (I) Narmada-Tapti Block, (II) Jambusar-

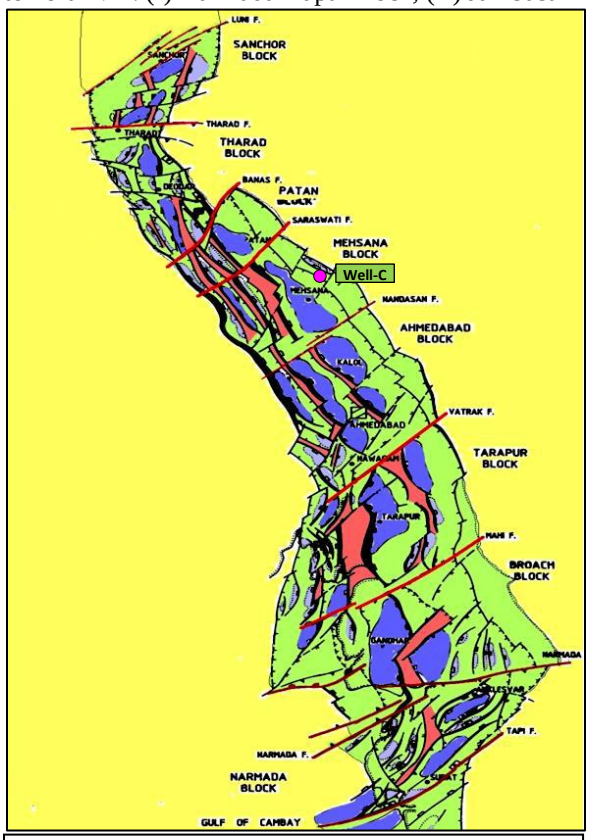


Fig.2 Tectonic map of Cambay Basin (after J.Kundu et.al, 1996).

Broach Block (III) Tarapur-Cambay Block (IV) Mehsana-Ahmedabad Block and (V), Sanchor-Patan Block. The first two blocks informally comprise South Cambay Basin and last three blocks are North Cambay Basin separated by Mahi River. The present study is from northern part of Mehsana – Ahmedabad Block. Exploration in North Cambay Basin hitherto was mostly confined to lower Eocene synrift to post rift plays pertaining to Older Cambay shale, Younger Cambay shale (Kadi & Kalol formations). The exploratory efforts so far were based on structural elements and have met with considerable success in finding hydrocarbons from multiple stratigrahic levels (Fig.3).

**Discussion**

Hydrocarbon discovered so far in Cambay basin is in tertiary sequences. Exploration has reached a mature stage and at present it is focused on subtle traps and small amplitude entrapment situations in the areas bordering established fields. As all major structural

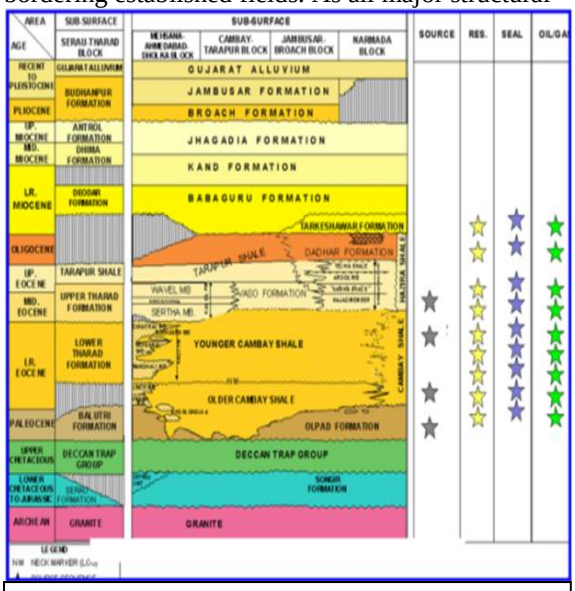


Fig.3.Hydrocarbon finds in various stratigraphic levels in Cambay Basin

features are already explored and are being exploited. Expectation of another big find in tertiary sequence is considered to be very bleak. World over most of the oil production is from geologically older formations of Mesozoic age (>50%), where as in India most of the oil was discovered in Tertiary sediments, hence

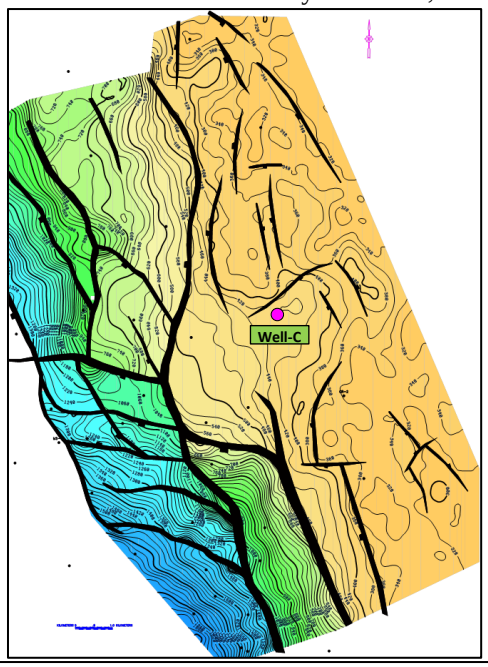


Fig.4.Time structure map of Charada-Mansa area at Olpad Top

there are lots of discussions going on in oil industry forums regarding need for exploring Mesozoic sediments especially in the margin part of Cambay Basin. However the huge thickness of Deccan Trap was the major impediment in this effort. Now with advancement of drilling technology drilling through the Deccan trap is considered achievable, hence the location-C was identified in the eastern margin Charada-Mansa area (Fig.2&4.) to explore this objective. From the earlier drilling data & seismic mapping it was established that Deccan Trap top was

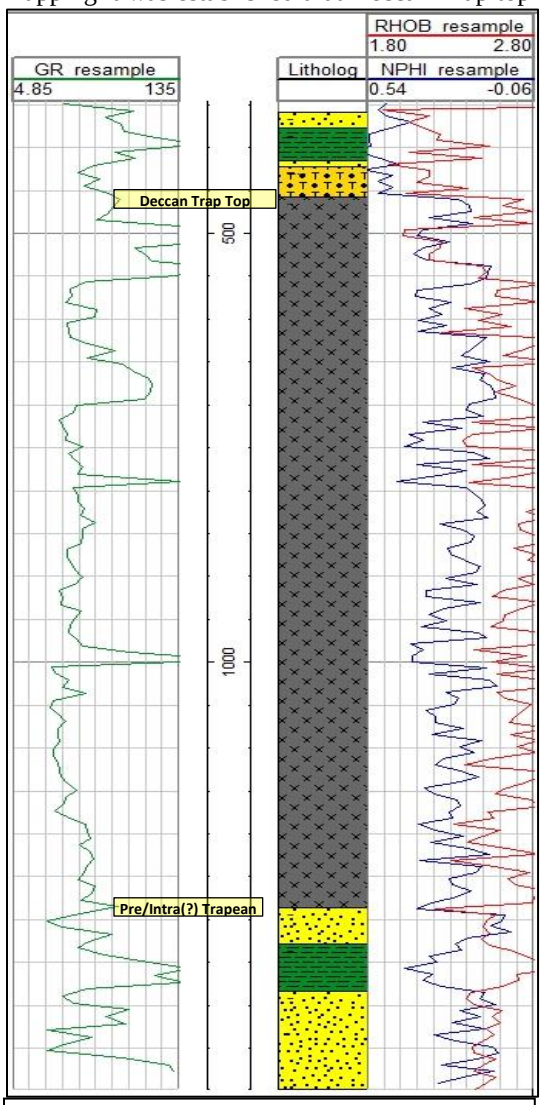


Fig.5 Composite Log of the well C

expected in the well at a depth of around 400-480m, however the location was released with a Target Depth of 1500 meters to investigate Mesozoic sediments below Deccan Trap in addition to Tertiary sediments. In this well Deccan Trap top was encountered at a depth of 460m and after drilling nearly 820m of trap thickness, arenaceous and argillaceous facies were encountered at 1280m onwards and continued till the target depth of 1500m, the well could not be drilled further to establish the bottom of the sequence due to operational constraints. This was the first time such huge Paleocene sedimentary sequence was encountered in Cambay Basin below/within(?) Deccan trap.

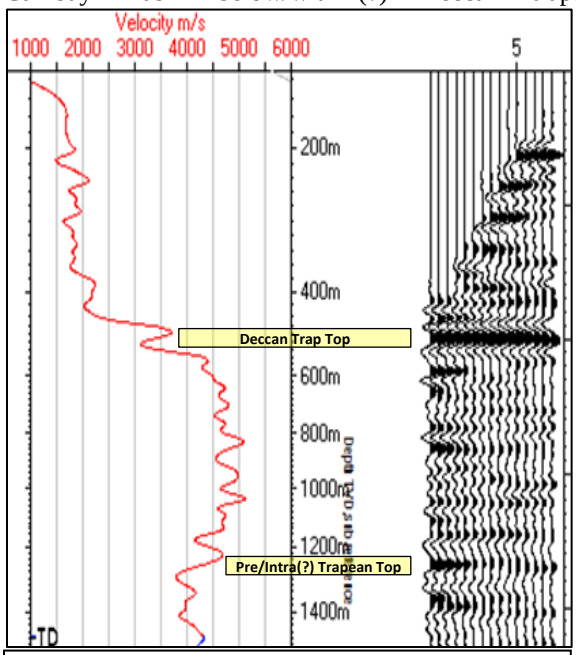


Fig.6. Interval velocity plot from VSP along with corridor stack

Composite Log of the well C is shown in Fig.5. Data from VSP also shows interval velocity inversion corresponding to this formation (Fig.6). Although initial interpretation put the arenaceous and argillaceous section encountered below 1280 m as Mesozoic sediments, lab studies of the side wall cores conducted at RGL Baroda gives its age as Paleocene in age based on the occurrence of Spinizonocolpites adamanteus, Tricolporopollenites sp, Grevilloideaepites sp, Yeguapollis pro latus, Proxapertites assamicus, P. emendatus, Milfordia homeopunctata, Senegalinium pallidum and Fungal spores. Object-I in the interval 1475-1480m, 1444-1450m, 1430-1436m, 1422-1427m in arenaceous Intra/Pre trappeans gave influx of ~36m$^3$ of Water of 7-7.7gpl salinity. Object-III in the interval 1290-1315m in arenaceous Intra/Pre trapeans gave influx of ~34m$^3$ of water of 10.5-14.91gpl salinity; this

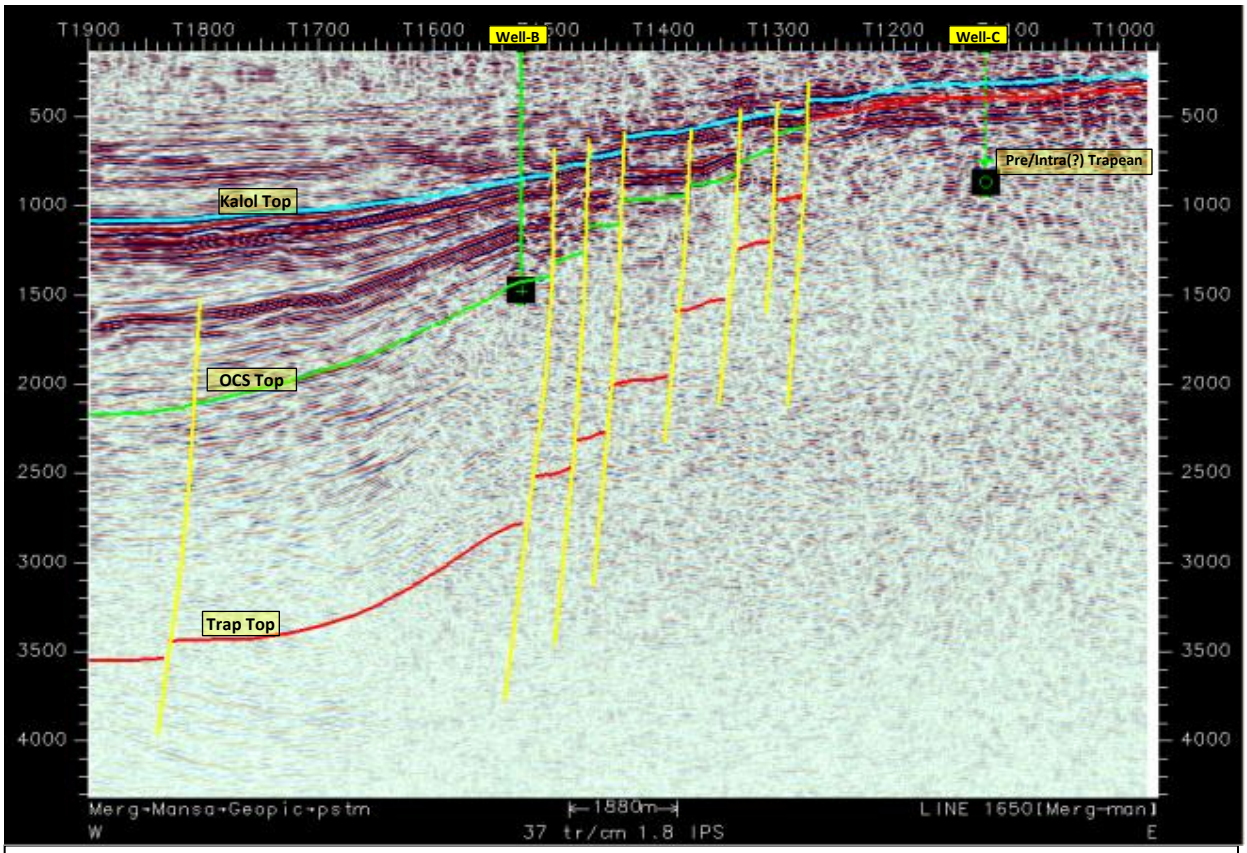


Fig.7. Seismic section through well-C

proves that this formation is a good reservoir rock. Geologically the arenaceous sequences encountered in this well could be of interest from the hydrocarbon point of view. A thick trap could provide a very good seal for the underlying reservoir rock. Presence of argillaceous facies could itself act as source rock. Since the sequence is lying just below the trap so the prevalent temperature gradient can also act as a catalyst in generation of lighter hydrocarbon. Along with this the basin configuration of eastern margin of Cambay Basin, which is defined as an en-echelon arrangement of asymmetric half grabens, creates the opportunity of juxtaposing of these older reservoir facies to Cambay shale sequence. Cambay shale is considered to be a very good source rock and it is established to have generated huge volume of hydrocarbon in the Cambay basin. So, the hydrocarbon generated from Cambay Shale can and would have migrated into the arenaceous rock sequence encountered in 'well C' at places where they juxtapose with each other due to faulting.

Seismic section through well-C (Fig. 7) shows that the possibility of Cambay shale juxtaposing against this sedimentary sequence is quite good.

Though the sequence has produced water on conventional testing in the 'well C' it does not dither future prospectivity of the formation. Very limited seismic data is available in the area beyond ONGC's acreage and also the imaging of seismic data below Deccan Trap is very poor. So the present seismic data does not help in mapping of the sequence. It is therefore needed to develop/use better/advance technology to acquire seismic data below trap. This will help in mapping the sequence and to find out the actual entrapment positions. This makes the marginal area as well as area east of Cambay Basin boundary interesting for future hydrocarbon exploration. Further drilling of deeper wells in the marginal area will establish the extent of the sedimentary sequence.

## Challenges

Better suited technology should be employed to image the sedimentary sequence encountered in well C and find out its continuity geographically like deep sounding, TEM or Seismic imaging using large source and long offset.

## Conclusion

Sedimentary sequence encountered 800m below Deccan trap top in the well C in Charada-Mansa area in the eastern margin of Mehsana block has opened up the exploration potential of Cambay Basin near the eastern margin as well as beyond the existing margin. Advanced imaging technology can be utilized to map the sedimentary sequence below Deccan Trap. Any hydrocarbon found within this sequence can lead to discovery of new field with huge potential.

## Acknowledgements

The authors are thankful to the ONGC management for granting permission to publish the paper and use the data and the findings of various projects. We are also grateful to Mr. A. V. Sathe, ED-Basin Manager, Western Onshore Basin, ONGC, Vadodara for the guidance and encouragement. The authors are thankful to VSP party and RCC, Vadodara for VSP data acquisition and processing and also to RGL, ONGC, Vadodara for Laboratory support. Authors would also like to acknowledge the support of Geoscientists of Forward Base, Mehsana and Mehsana Block, WON Basin, ONGC Vadodara for their support and constructive discussions. The views expressed in the paper are solely of the authors and not necessarily of the organization in which they are working.

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