Paper No. 2012757

Disposition of Tectonically Controlled Hydrocarbon Reservoirs and Integrated Approach for Simulation in Cambay Basin

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Abstract

We report that the hydrocarbon reservoirs in Cambay Basin are largely controlled by tectonics. The extensional tectonics is responsible for formation of basin, subsidence along the faults parallel to graben have been responsible for deposition of sedimentary successions during Mesozoic and Tertiary times. The basinal faults reached to critical depth and caused decompressional melting and eruption of Cretaceous volcanics. Several units of these volcanics are logged within the uninterrupted sedimentary succession for nearly 90 million years, from the beginning to the end of Cretaceous. The upwelling heat before the volcanic phase has facilitated distillation of Mesozoic sediments to generate hydrocarbons and required seals. Prolonged extensional tectonics resulted in subsidence of central portion of the large graben to form Tertiary basin. This basin has interrupted Tertiary succession, which hosts nearly 50 oil & gas Fields. We demonstrate that there is potential of Mesozoic hydrocarbons in shoulder areas of the Tertiary basin. We also believe that the prolific gas produced from the volcanic units in Ingoli and Padra fields is contributed by the underlying Mesozoic sequence. The hydrocarbons produced from the overlying Olpad formation, which is mainly trap wash, also indicates older source rock. These findings have led us to have a relook of reservoirs and characterize them by integrated geological, geophysical methods and simulate with available drill hole logs.

Introduction

The Cambay structure is located on the western side of peninsular India and has NNW-SSE trend in the northern part and attains N-S trend in the southern continuation along the West Coast. This structure forms very important petroliferous basin of India. Earlier only the axial part with the Tertiary sequence was studied and described as Cambay Graben. Misra 2007, 2008 and Misra and Misra 2010 suggested that, it is much wider structure with Mesozoic Dharangandhra and Wadhwan on the western side and Himatnagar sequences in the east. These sequences seem to be deposited within progressively widening and subsiding structure. The lineament zones are observed further in the west passing through Cambay, Nal Sarovar and eastern margin of Little Rann of Kutch in NW direction Fig. 1. Similarly the margin of Mesozoic basin in Saurashtra towards the west and central Gujarat in the east are marked by the prominent lineament zones. Apart from these lineament zones many other geomorphological features and hot springs are found associated with sub surface boundaries. Geological evidences also suggest that thicker Mesozoic succession is much thicker, due to compounding effects of subsidence along Kutch rift

in the north and Narmada-Tapti Tectonic Zone in the south. This sedimentation was followed by the Cretaceous volcanic activity where this structure also acted as effusive zone. The axial part of Cambay structure has faulted down to accommodate Tertiary succession.
The northern extension of Cambay Structure forms Barmer Basin. This basin is located between the NE-SW trending Jaisalmer Basin in the north and Kutch rift in the south. Felsic and mafic volcanic rocks occur in the shoulder area of this basin. They are also logged in drill holes forming the technical basement. It is filled by both Mesozoic and Tertiary sediments. Hydrocarbons are produced from Tertiary as well as fractured basement. Profound effect of tectonics and preferential accumulation of hydrocarbons is displayed. The oil and gas fields, such as Saraswati, Raageshwari, Kameshwari, Mangla, Aishvariya, Shakti, Bhagyam, Vijaya, Vandana and many other, are parallel to basin and associated faults. Of these Raageshwari field is producing hydrocarbons from volcanic units.

Cambay Basin

The central part of the Cambay structure is described as Cambay basin. Due to faulting and subsidence, enormous thickness of hydrocarbon bearing Tertiary rocks is deposited. Several coal and lignite seams are interbedded with this succession. At many places 400m thick alluvium is logged. This suggests that subsidence is prevailing even during the Quaternary times. From geothermal point of view the rift and grabens are invariably associated with the high heat flow. This is evidenced by the alignment of thermal springs along them and cluster of thermal springs in the intersectional areas. In Cambay basin there are over 65 hydrocarbon pools. A majority of them (nearly 80%) are having structural trapping mechanism, while 15% have stratigraphic and rest have a combination of both. During present study, it has been observed that almost all the pools are controlled by continuing basin forming tectonics, from the deposition of source rocks, reservoir rocks as well as trapping mechanism. The oldest hydrocarbon pools within the Cambay basin are Ingoli and Padra fields which are prolific producers of natural gas from the Cretaceous volcano-sedimentary sequence. The Olpad formation classed as trap wash, is relatively thick in the central part of the Cambay Graben and hosts significant Eocene fields such as Kadi, Kalol, Mehsana, Cambay,Gandhar and Shobhasan. Miocene pools like Ambe, Lakshmi,Parvati,Gauri and Hazira are located along the Narmada-Tapti Tectonic Zone.

Conclusions

Study has incorporated tectonics as well as interlayered volcanic units in totality. Data sets acquired during hydrocarbon exploration at exponential cost is amalgamated. The Cretaceous volcano-sedimentary sequence forms fractured basement for Tertiary succession and is itself prolific producer of hydrocarbons in Cambay basin The volcanic units have primary, secondary and tertiary porosity and permeability. Primary one is mainly because of vesicular nature of the volcanic , secondary is largely due to development of the cooling cracks and tertiary has been due to development of fracture , joints and faults associated with later deformation. Ingoli and Padhra fields in Cambay basin are prolific producers of hydrocarbons from the Volcano-sedimentary sequence.

The volcanic units have also posed insurmountable problems in gathering information about underlying Mesozoic and older rocks; because seismic waves normally do not penetrate through the thick basaltic units. Drilling through the basalt is also difficult and costly.

The study recommends intersectional regions of Cambay with Barmer in north and with Narmada-Tapti Tectonic Zone in south as highly potential regions for detailed exploration. Similarly shoulder areas, volcanic and sub volcanic regions in and along Cambay Graben need special attention for exploration of Mesozoic hydrocarbons. Re-entry and further drilling in wells abandoned on reaching volcanic units is recommended to recover hydrocarbons from volcano-sedimentary sequence.

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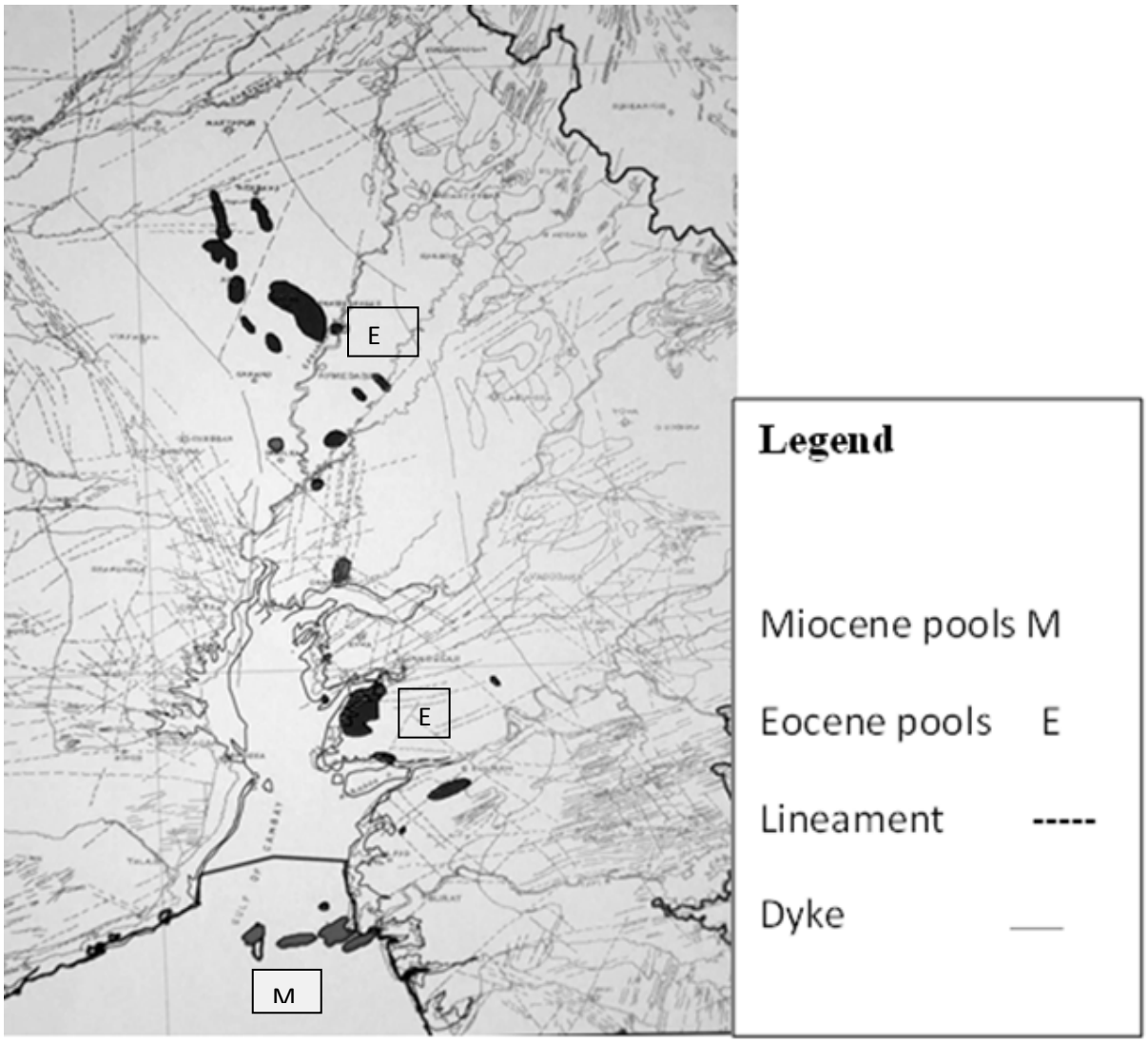

Fig. 1 Map of Cambay Basin and adjoining region. Lineaments parallel to Cambay structure can well be seen along with dyke swarm corresponding with the Narmada-Tapti Tectonic Zone

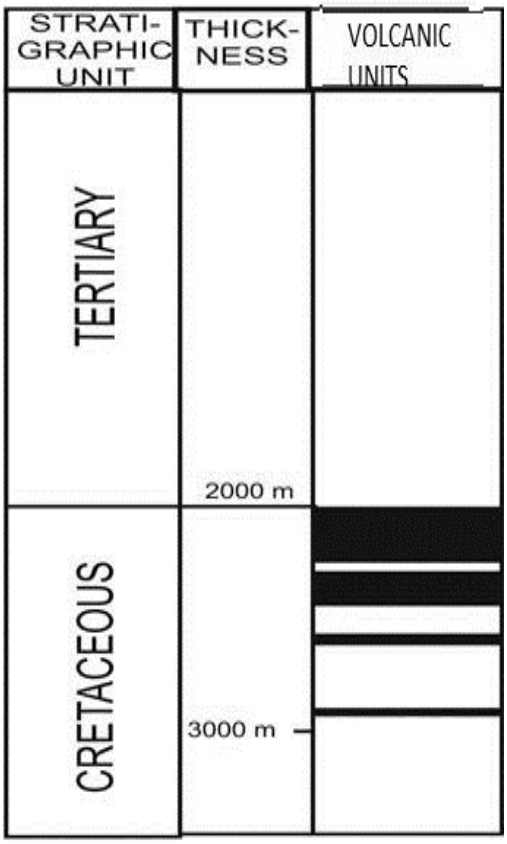

Fig.2 Generalized log prepared from drill holes of Cambay basin. Several volcanic units of basalt are seen interlayered with the sediments of Cretaceous period. The successive increase in thickness of volcanic units can also be seen.