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Tectonic elements and Geodynamic setting of Kutch region : Implications for Hydrocarbon reservoir bellow the Deccan Trap of Kutch Basin

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Extended Abstract

The Kutch basin forms the northern part of the western continental margin of India that is classified as a passive margin. The broad lithology of the Deccan Trap associated system is composed of Tertiary sediments dominated by limestone, sand and shale underlain by thick basalt of Upper-Cretaceous to Palaeozoic, overlying Mesozoic sediments. The thickness of basalt cover varies from 300 m in the northwest to 2000 m in the southwest (Figure 1). Reunion plume was attributed for the Deccan flood basalt that covered most part of western side of Indian subcontinent, including Kutch ~ 65 Ma. Three contiguous NW-SE trending major tectonic elements have been identified in the offshore Kutch basin (Dhananjay Kumar et al, 2004, see Figure 1). These are :

The Kori Comorin depression ;

The Korl Comorin ridge;

The Laxmi-Laccadive depression

Figure 1 also shows four E-W trending onshore ridges in Kutch region. The basin is pericratonic and can be sub-divided into NE-SW to E-W trending and westerly plunging ridges and depressions.

The basalt in the Kutch basin differs from many basalts in other parts of the world, as the thickness of the basalt, composed of extrusive lava flows, varies considerably. In fact, there is a association of different groups of basic and ultracratonic rocks, which suggest different phases of igneous activity, viz., synrift stage, post rift thermotectonic stage and inversion stage (Biswas, 2005). Therefore, pre rift stage or early rift stage must have been involved with lithospheric streching. Hence, the basin is highly heterogeneous. Seismic velocities of Deccan Traps are complex and together with velocity inversions introduce multiples, scattering, attenuation and mode conversion which blocks the seismic images below Deccan Traps. Hence, identification of Hydrocarbon bearing structures becomes difficult.

In this study, we bring out the importance of various trends, as shown earlier, in Kutch basin (offshore, onshore and land) for the tectonic upheavel in this region. These trends are mostly of strike-slip in nature. The northern end of the basin is occupied by Great Rann and to the south lies the Gulf of Kutch (GOK) and to the SE side is little Rann. GOK is 50 km (30 mi) wide and extends for 160 km (99 mi) between the Kutch and Kāthiāwār peninsulas. The head of the gulf adjoins the vast salt marsh known as the Little Rann of Kachchh. This GOK is supposed to have formed by opening of sea process, which could have directed the extensional forces onto the Basin. It is envisaged that Indian plate was trying to be deformed into a macro plate which has formed around Kutch Peninsula. It has been seen that while the two plates move apart, the ground sinks to make room for the Red Sea and the Gulf of Aden. The opening of GOK also seems to be linked with Chaman fault (onland and plate boundary between Indian and Arabian Plate) in continuation with Owen Fracture Zone (OFZ) & Murray Ridge (in the Ocean) and extensional process were responsible since the collision of Indian plate with Eurasian plate.

Therefore, the Hydrocarbon potential of this region has to be dealt and understood from the complex strike-slip behaviour in the backdrop of the tectonic and geodynamic evolution of this region.

Strike-Slip Tectonic engulfs compression, extension and also shearing in the overall kinematics of strike-slip faults. It is envisaged that the combined resultant of these faults was responsible for basin formation (Harland, 1971; Woodcock and Schburt, 1994). Even the basin inversion can be linked in the strike-slip belts. Most of the strike slip faults and fractures are attributed to simple shear with the generation of rotational couple, the latter acting over a border zone and straining it variably, which is probably attributing for the major occurrence of earthquake in Kutch region (Fig.2 of Biswas, 2005).

A Median ridge (Hinze) crosses the existing E-W faults, which further seems to be line of transition zone between stable and unstable block of Kutch. Most of the earthquakes are to the east of Hinze Zone.

These strike-slip faults getting activated basically from the stresses originating from MAKRAN Subduction which are destabilizing the old faults and the ridges (such as Delhi-Ridge etc. in Dhanjay Kumar et al, 2004). Flower structure (positive) are favoured for strike-slip nature which can be seen in the aftershock hypocentres along N-S profiles (Fig.6 of Biswas, 2005).

It will be shown and discussed that tectonics contribution is basically driven by ridge push and Makran subduction zone for the over all stability of Kutch which also disturbs the structure/structures holding hydrocarbon reservoirs in this region, due to Block rotation (Nicholson et al, 1986). Block rotation requires a detachment surface at depth to permit rotational movement and low angle structures indicating flower structures (Nicholson et al, 1986). This detachment can be seen in the crust (Fig. 4 of Biswas, 2005). The Bi-model distribution of the earthquakes (mostly Aftershocks) show that there exists a zone ~20 km, where most earthquakes have occurred during the Earthquake of 2001. This could be the zone of Detachment.

The tectonics associated with strike-slip allowed the making of areas of Extension, subsidence and basin formation alternate with areas of extension, folding, thrusting and uplift, some times involving basement rocks of the surface. Therefore, the basin formation is associated and complexed with the tectonics and structures pertaining to them have deformed in such a way that their detection by seismic method is quite difficult, together with the Deccan Trap problems (a heterogeneous formation with many different flows with different chemical nature).

We also envisage that tensile fractures developed in small scale shear zones in low grade rocks and often show high pore fluid pressures. We have elsewhere shown that the development of pore pressure is generated by serpentinites in the hypocentral zone of Kutch/Bhuj earthquake of 2001. The fluids in the central region of Kutch provides more dynamics for the basin.

It is therefore suggested that the exploration of the hydrocarbon bearing structure must be read and concentrated in the fault capped regions, instead of looking for structures in the hydrocarbon bearing Mesozoic formation.

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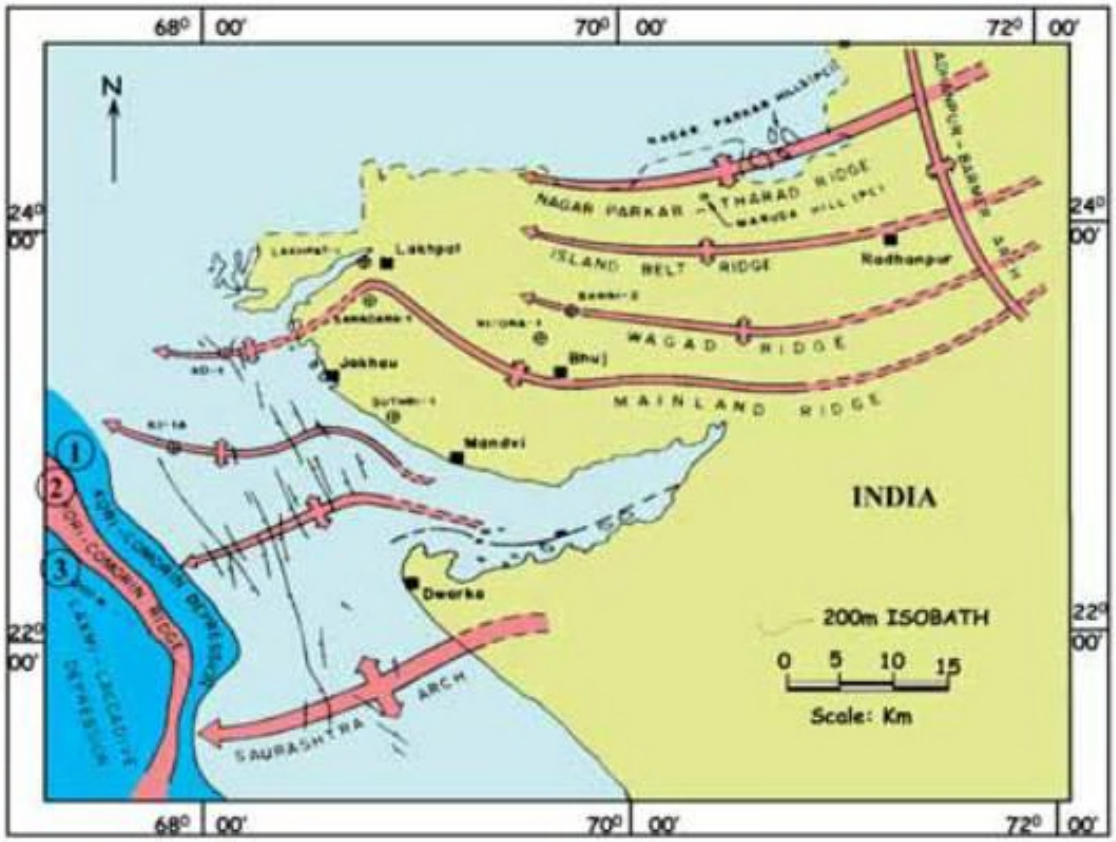

Figure 1 *Tectonic trends in the Kutch basin. Three continuous NW-SE trending tectonic elements in the offshore Kutch basin and four E-W trending onshore ridges are shown (after Dhananjay Kumar et al, 2004).*