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Refinement of Structural Model through 3D seismic – Its Implication in Sediment Dispersal and Hydrocarbon Prospectivity in South Gamij, Cambay Basin, India.

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Summary

Cambay Basin emerged on the oil map of India in early sixties having multiple pays in Paleocene – Late Eocene clastic reservoirs corresponding to different stages of rifting. A number of oil and gas fields including two giants have since been discovered by probing structural traps in Early to Middle Eocene deltaic clastics sediments of Kalol and Kadi formations which are under various stages of exploitation during last five decades. However, still enough hydrocarbon resource can be converted into geological reserves by bringing in the basin margin area under active exploration and also by probing deeper objectives in the basinal area.

South Gamij area located in central part of the eastern basin margin has been reviewed in detail by analyzing 3D seismic data for refining the fault pattern and for better understanding of its role on sediment dispersal to locate potential hydrocarbon traps in the margin area which is yet to be fully explored. The study shows that north-south trending westerly dipping Gamij Fault is a major tectonic element controlling sediment dispersal of Paleogene section. Delineation of basin margin fault complex further east of the Gamij fault has opened a large area for exploration of structural traps in Paleocene and Eocene reservoirs. This demarcated new area for Paleogene prospect has paid its dividend during drilling against the targeted horizons.

Introduction

Cambay Basin located in the northwestern margin of Indian Precambrian Shield, is an integral part of west margin rift basin system. It has all the necessary components of Petroleum habitat, processes and occurrence to be classified as world class petroleum system. Most of the discovered oil fields are on intra-basinal structural highs and are producing from deltaic sediments of Ypresian to Lutetian age. Although the basin has entered into the matured stage (?) of exploration with respect to the structural traps, still a large undiscovered hydrocarbon resource can be realized by refinement of the existing structural model using 3D seismic data particularly along its eastern margin.

This paper gives new insight into structural configuration of South Gamij including the eastern basin margin area and role of the fault system in sediment distribution and hydrocarbon accumulation.

The study covering southern part of Gamij field and adjoining area is located in Ahmedabad Mehsana Tectonic block of North Cambay Basin along its eastern margin (Fig-1). The basin eastern margin complex is characterized by a major west dipping Gamij Fault and series of synthetic faults with diminishing throw (Fig-2 and 3). Gamij field located all along the hanging wall block of Gamij fault (G.F) has hydrocarbon accumulations in multiple reservoirs of Paleocene to Middle Eocene. The field is flanked in the west by Walod Low - one of the principal kitchen area.

Tectono Stratigraphic Setting

The Cambay Basin is an intra cratonic NNW-SSE trending, sigmoidal aborted rift (Fig-1) in the west margin rift basin

system of India (Kundu et at 1993). The Cenozoic rift basin was formed as a result of continental rifting along western margin of India close to Late Cretaceous – Tertiary boundary triggered by profuse magmatic activity. This was followed by subsequent in filling of rift basin with a thick pile of Paleogene clastic sediments concomitant to different rifting phases.

Paleogene sedimentary infill of Cambay rift basin can be sub divided into three mega sequences. First, non marine synrift mega sequence of Paleocene age (Olpad Formation) is deposited as thick volcanic and silici clastic wedges in half grabens including alluvial fans, fan delta and lacustrine facies unconformably overlying Maastrichtian Basalt. Second, Early Eocene Marine mega sequence (Older Cambay Shale) unconformably overlying Paleocene sequence was deposited in late synrift phase and pre-dominantly consists of shales representing principle source rock in basinal scale. The third mega sequence of post riff phase consists of clastic deltaic sediments (Kadi / Kalol formation) deposited during the period of thermal sag.

Data Set

The area is covered by 36 fold 3D seismic data (Fig-4). Wire line logs, cores and well data of about forty wells drilled in the area have been analysed and reviewed in this study. Synthetic Seismograms generated at number of well locations and available VSP data were used for well to seismic calibration.

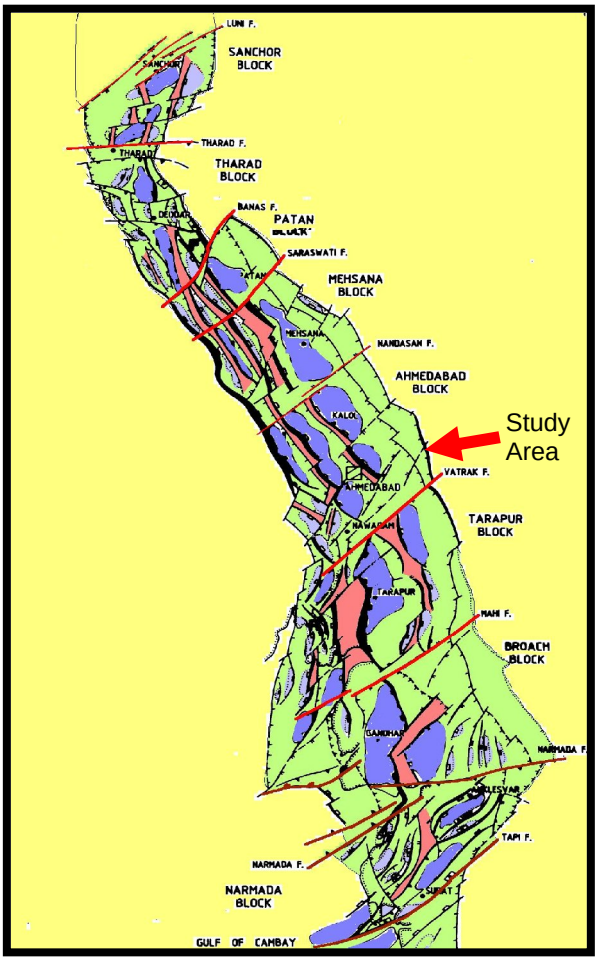

Fig. 1: Location map of South Gamij field with major

Interpretation

Interpretation of 3D seismic data involving mapping of different stratigraphic levels has brought out detail structural architecture of the area. Depth map at Kalol Top (Fig-5) and Time structure map at Olpad Top (Fig-6) depicts north-south trending Gamij fault delineating the margin area from its basinal part. The footwall eastern margin complex, which was not decipherable in vintage 2D seismic data, has further been dissected into three structural segments by synthetic faulting along the main fault. Delineation of this margin fault system has brought in new area for further exploration. Cross faults have subdivided these longitudinal segments into different fault blocks providing entrapment opportunities. The initial field growth was along the accommodation fold formed in the hanging wall block of Gamij Fault which is further segmented by step faults into four longitudinal fault blocks, with sequential diminishing

throw towards west. Subtle cross faults have also been identified which further dissects these longitudinal segments into smaller blocks. A prominent cross trend towards southern part of the area has been brought out. Structural configuration is mostly conformable at the mapped levels (Fig 5 & 6) except for basin ward shift of structural elements at Olpad level.

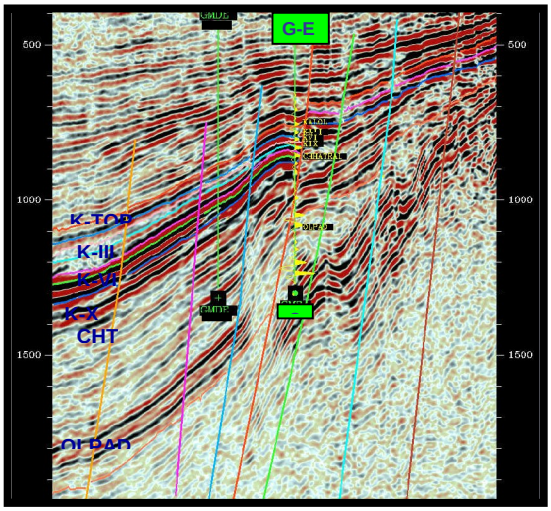

Fig. 2: Dip oriented seismic Inline - X showing structural elements.

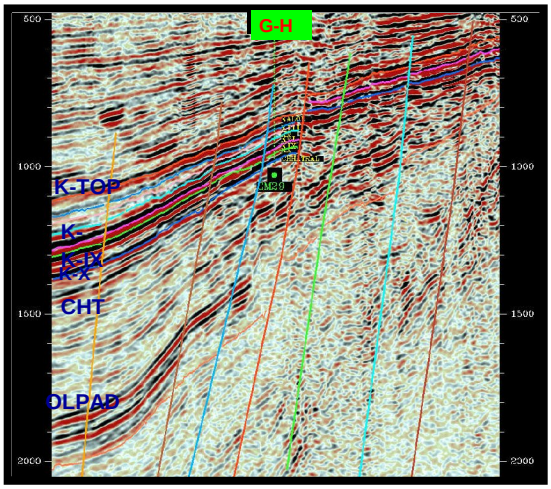

Fig. 3: Dip oriented seismic Inline - Y showing structural elements.

Depositional Model

Reservoirs in Olpad, Chhatral (aranaceous unit in Younger Cambay Shale), K-X, K-IX, and K-VI + VII, K-V and K-III

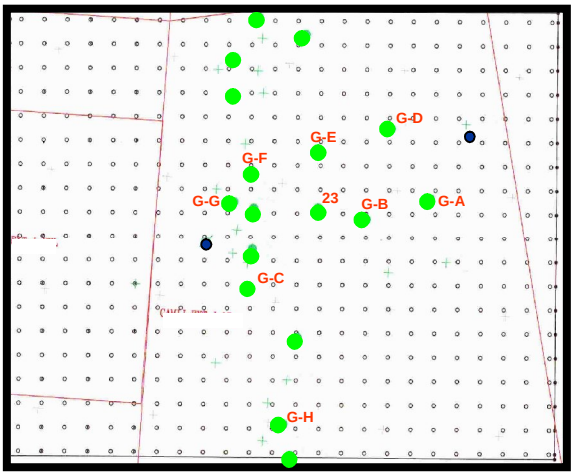

Fig. 4: 3D coverage in Study Area.

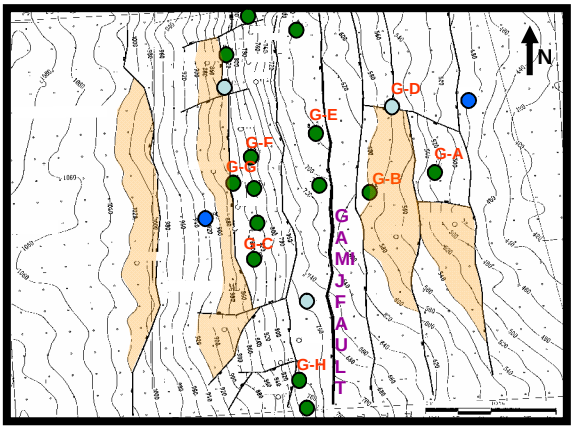

Fig. 5: Depth Map at Kalol (Middle Eocene)Top.

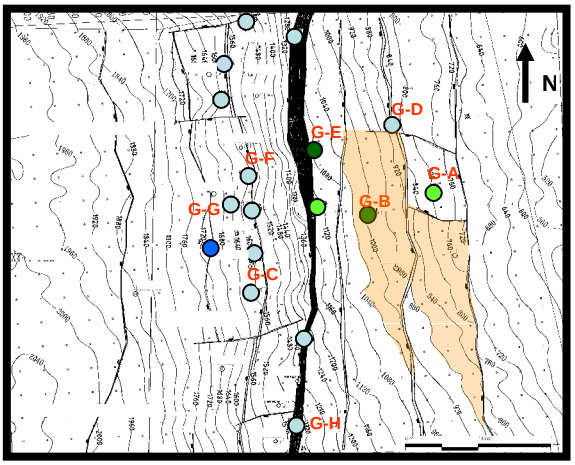

Fig. 6: Time Structure Map near Olpad (Paleocene) Top

+ IV units of Kalol Formation are hydrocarbon bearing in the study area. Stratigraphic electro log correlation profiles connecting wells in basinal and marginal area (Figs 7,8,9 and 10) show lithofacies variation of Chhatral and Kalol units. Paleocene Olpad is represented by admixture of epiclastic ranging from volcaniclastic siltstone to conglomerate along the alluvial fan complex and siliciclastic sediments of lacustrine origin. The volcaniclstic sandstone representing midfan facies are best reservoirs. Litho association of Chhatral unit depicts thin layers of siltstone within intercalating shale having thickness variation from 35 to 70m from east to west. Siltstone, sandstone and carbonaceous shale characterize lithofacies of K VI+ VII and K III+ IV units. Sand / Silt geometry maps of Chhatral (Fig 11) and K-III+IV (Fig 12) depicts distribution pattern of reservoir facies in the area. Sedimentary structures and the distribution pattern suggest deposition of Chhatral in prodelta / distal delta front environment, whereas K-III+IV unit is inferred to have been deposited as distal delta front facies.

Drastic thickness reduction of Paleogene sediments are observed across the major tectonic element i.e. Gamij Fault signifying control of the sedimentation dispersal with manifestation of north-south to north northeast – south southwest trending predominant depositional lobes of Chhatral (Fig-11) as well as of K-III+IV units (Fig-12).

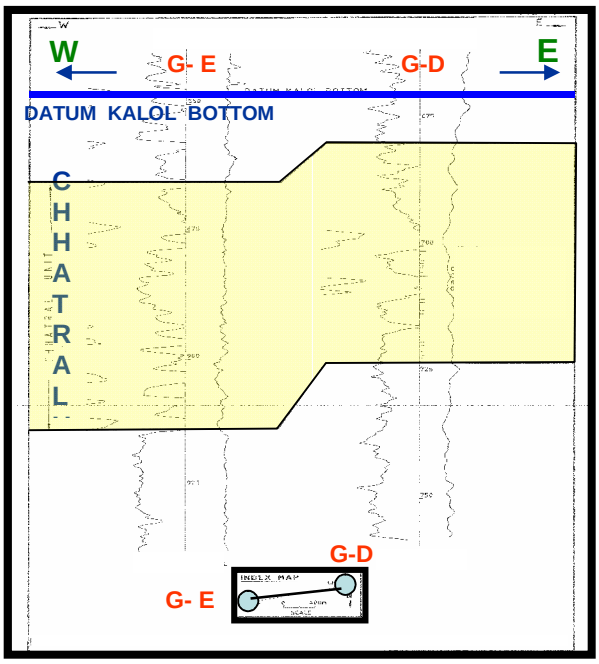

Fig. 7: Stratigraphic correlation along dip profiles of Chhatral Unit through wells G-D and G-E.

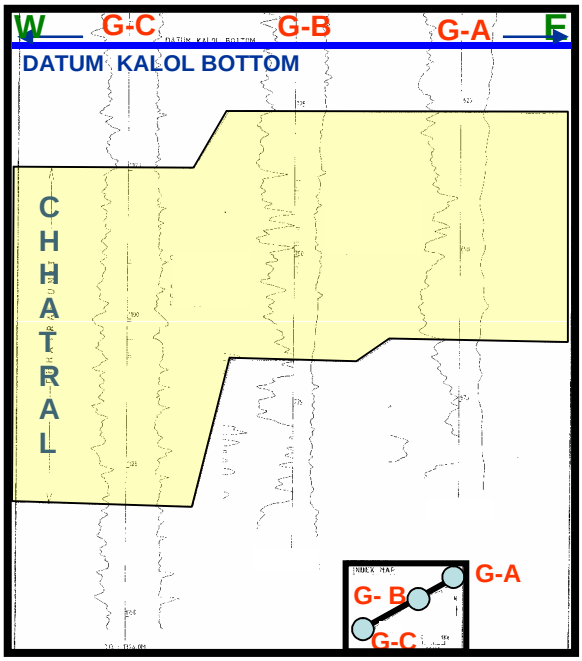

Fig. 8: Stratigraphic correlation along dip profiles of Chhatral Unit through wells G-A, G- B and G-C.

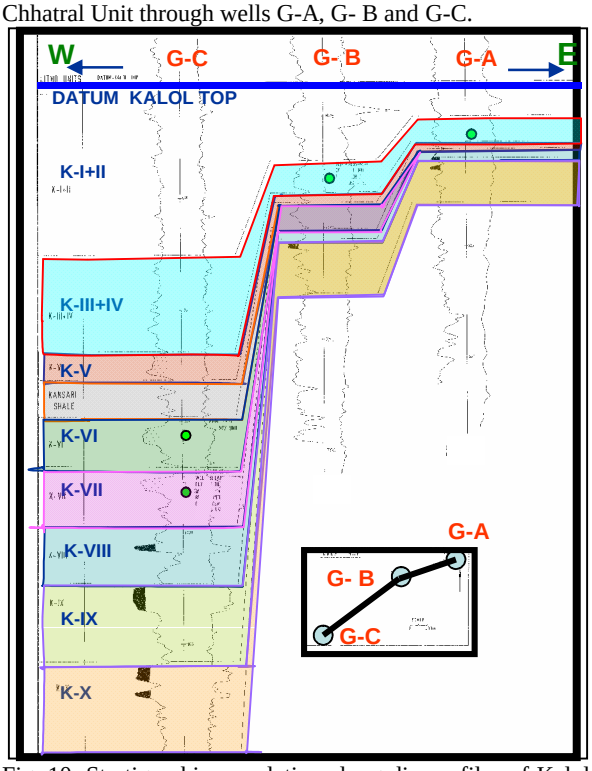

Fig. 10: Stratigraphic correlation along dip profiles of Kalol Units through wells G-A, G- B and G-C.

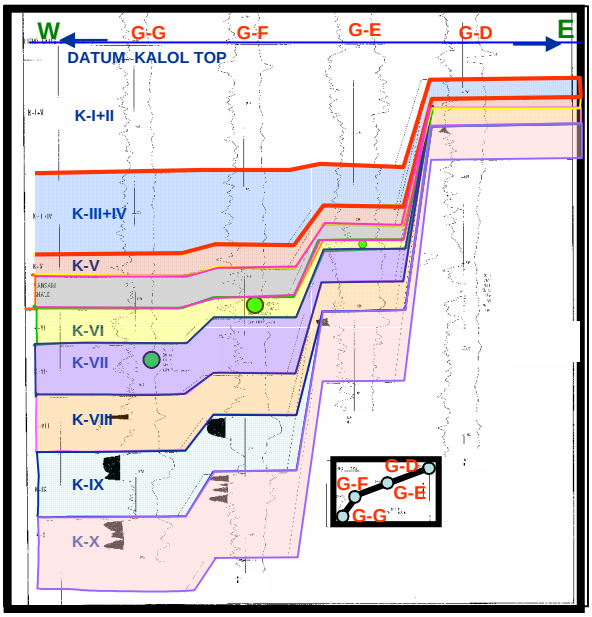

Fig. 9: Stratigraphic correlation along dip profiles of Kalol Units through wells G-D, G- E, G-F and G-G.

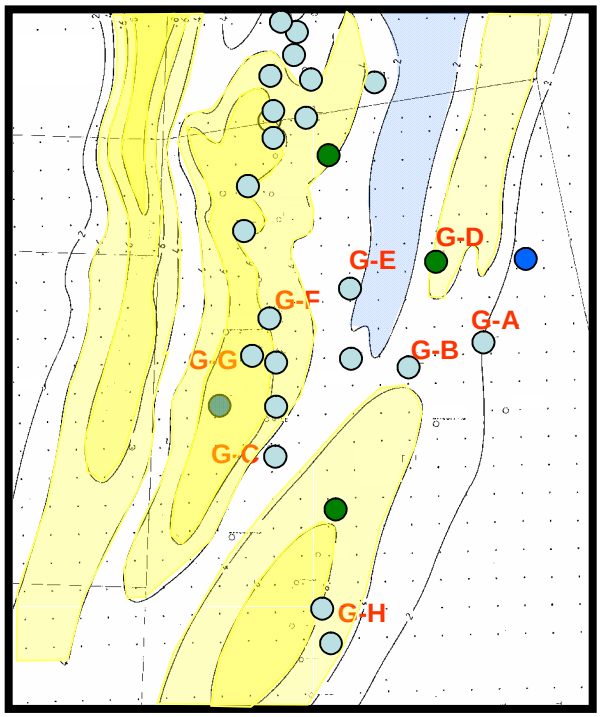

Fig. 11: Sand / Silt geometry map of Chhatral Unit

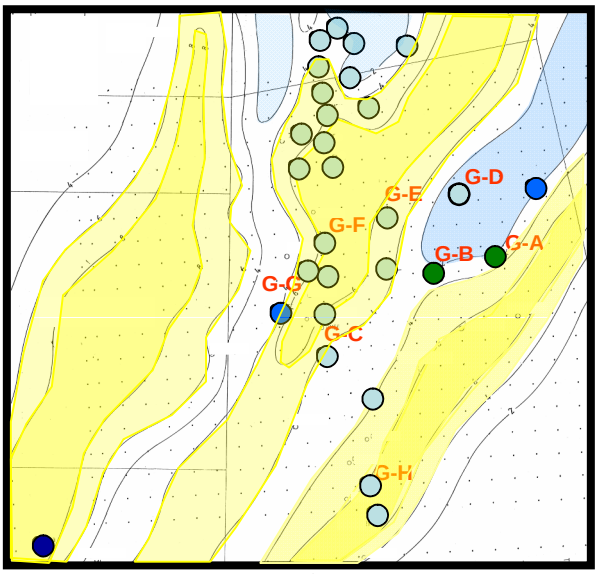

Fig. 12: Sand / Silt geometry map of Kalol- III + IV Unit

Conclusion

3D data has helped in precise mapping of faults in the area. Gamij fault remained a major deformational element controlling sedimentation of Paleogene sequence. Kalol reservoirs were deposited by distributaries in distal delta front regime. K III+IV unit of Kalol Formation has widespread distribution and is promising in the margin area, whereas development of K-VI+VII unit is restricted in the hanging wall side of Gamij fault. North-south to northwest trending dispersal is observed for both units. E-W to ENE-WSW trending cross faults segmenting longitudinal fault blocks has influenced fluid distribution in Kalol pays. Chhatral reservoirs show good development towards southern and western part of the study area and have stratigraphic entrapment. The study has brought out Paleogene prospectivity in the footwall side of Gamij fault by bringing out suitable fault closure entrapment model. Exploratory drilling inputs have already converted its prospectivity into tangible gains.

Selected Reference

Hazarika, P., et al, (2002): Mineralogy, Microfacies and reservoir petrography of Kalol Pay V, VI and VII of Gamij field, IRS, Ahmedabad, Unpublished ONGC Report.

Kundu, J., Wani, M.R. and Thakur, R. K. (1993) Structural styles in South Cambay Rift Basin and its control on post rift deltaic sedimentation: Proc. of the 2nd Seminar on Petroliferous Basins of India, eds. S. K. Biswas et al., Indian Petroleum Pub., Dehradun, Vol. 2, P. 79-96.

Thakur, R.K., Singh, D. N., Singh, N. P., Chatterjee, C. L., (2005) Integrated analysis of 3D Seismic Data of South Gamij, Unpublished ONGC Report.

Thakur, R.K., et al (2003): Integrated interpretation of 3D Data, North Gamij Area, Cambay Basin, Unpublished ONGC .Report.

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