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Geological Modelling of Tipam Sand –IV, Upper Assam Shelf, India.

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Summary

Brahmaputra valley is a tectonic valley formed between two convergent orogenic belts –Himalayan and Assam Arakan fold belts. Rudrasagar Field, situated here in Upper Assam shelf is a prolific producer of hydrocarbons mainly from passive margin sediments of Oligocene age which are unconformably overlain by thick sands (TS-I to TS-VI) of Tipam Group of Mio-Pliocene age deposited in a fluvial system where accommodation has a tectonic control forming composite system of Low Accommodation System tract (LAST) and High Accommodation System tract (HAST) which define a single sequence. Amalgamated multistoried channel sands deposited by laterally coalesced channels of mega braided channel system during low accomodation system tract (LAST) can be seen in TS-I to TS-III and TS-V to TS-VI while TS-IV sands are embedded within LCM which is clay dominated, deposited during HAST by constrained channels in wide flood plain. These sands are thin and not identifiable on seismic. The distribution of these constrained channels has been mapped, which are hydrocarbon producer in some of the wells. Possible lower order units have been identified and detailed sand geometry has been brought out as Unit-I, II and III because sand to sand correlation was not possible. Based on the studies thirty wells have been identified for zone transfer and prospective corridors for exploration of TS-IV have also been identified.

Sands of Unit –II, which is the middle unit are most extensively developed over the area. Unit –I (Lowermost Unit) and Unit-III (Uppermost Unit) sands are sparsely distributed having lesser thicknesses of sand.

Keywords: *Flood plain, constrained channel, point bar, sand isolith, meandering channel, high accommodation system tract.*

Introduction

Rudra Sagar field is situated in Upper Assam Basin, which is a polycyclic foreland basin located at the base of Himalayan and the Assam -Arakan fold belts (Figure 1). It is situated 3.2 kilometers North West of Charali field. The study area with 3D seismic coverage and drilled well locations is shown in Figure-2. The field is under commercial production since 1966. So far 80 exploratory and 113 development wells (as on 1.4.2013) have been drilled to explore and exploit Barail Main Sand which is the principal pay here. The presence of hydrocarbon is also known in TS-IV sand which has given commercial production of oil from three wells. An attempt has been made to map the TS-IV sands and establish their prospectivity.

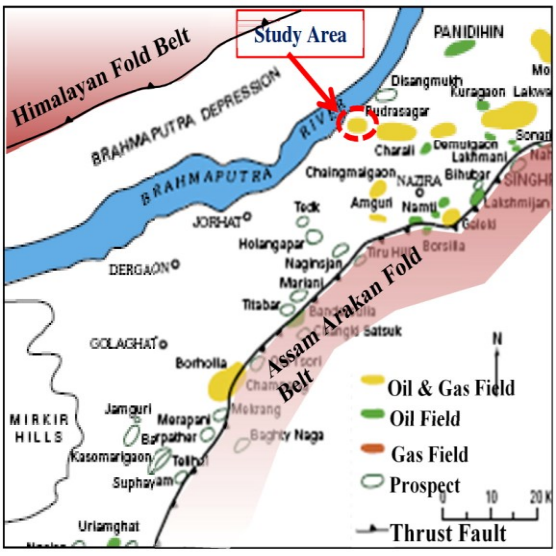

Figure 1: Location Map of Study Area.

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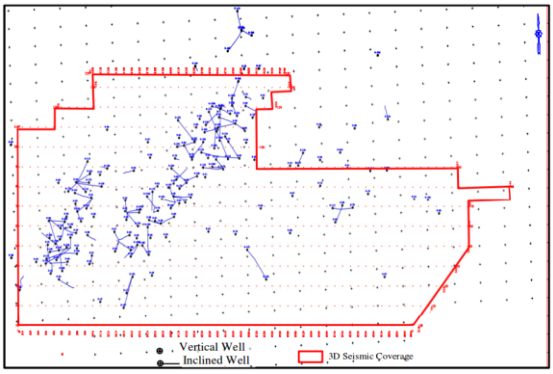

Figure 2: Study Area with 3D Seismic Coverage and Drilled Wells.

Methodology

Sequence stratigraphic approach has been adopted. First of all Sequence Boundaries (SB) were defined on seismic and logs, which were further sub divided into lower order units and so on as shown in figure 3.

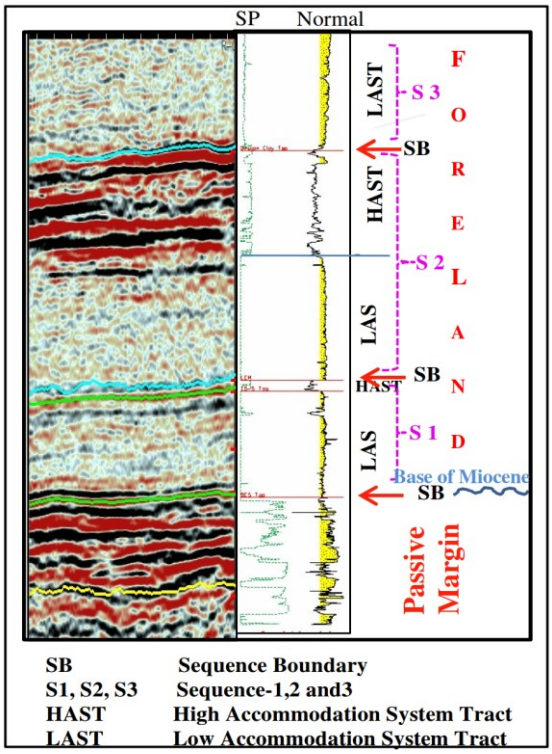

Figure 3: Figure showing Sequence stratigraphic Approach adopted during the course of study.

All the work has been done on Landmark workstation. Out of 193 wells as on 1.4.2013, 170 wells were covered by making 29 profiles (Figure-4) in dip and strike direction and correlated at formation tops viz. Girujan top, LCM top, TS-V top, TS-VI top, BCS top, BMS top, Kopili top, Sylhet top, Tura top and Basement top using stratworks.

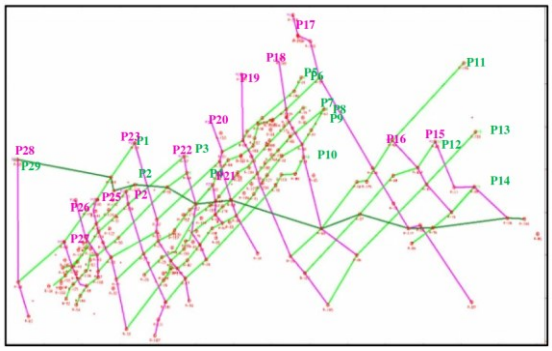

Figure 4: Plan of Log Correlation profiles.

The same profiles were used for detailed correlation of TSIV sands. The well data was tied with seismic 3D volume covering an area of 72.7 SKM. Horizons were correlated in seismic and time structure maps were prepared in Z map. Then structure contour maps were prepared through map migration depth conversion through Depth Team Explorer. Structure contour maps were corrected near well points wherever required and were extended in the northern part in the area which is not covered by 3D seismic but few wells are present in that area. Thickness maps for different units were generated. Litho pie diagrams, Sand Isolith map and sand percentage maps were prepared for TS-IV (LCM Top to TS-V Top).

G & G interpretation

3D seismic volume encompassing 72.7 SKM and log data of 170 wells have been studied and considered for the interpretation. Mainly SP , NOR, 8m, 4m, 2m, GR, LLD/ ILD, DT and CAL logs have been used. Density and Neutron porosity logs were not recorded in the Tipam Section as the main interest was always in Barails being the proved play and a prolific producer in this area. Out of 193 wells drilled so far as on 1.4.2013, TS-IV has been tested in six wells. Out of six, three wells produced oil and three produced water. TS-IV sands are part of Tipam Group deposited in fluvial environment by tectonically controlled accommodation in foreland basin formed at the base of Himalayan and Assam Arakan Fold belts which resulted by collision of Indian plate with Eurasian and Burmese plates during Miocene. Here in Foreland system a single sequence has been defined by Low Accommodation System tract (LAST) and High

Accommodation System tract (HAST) . Amalgamated multistoried channel sands deposited by laterally coalesced channels of mega braided channel system during low accomodation system tract (LAST) can be seen in TS-I to TS-III and TS-V to TS-VI while TS-IV sands are embedded within LCM which is clay dominated, deposited during HAST by constrained channels in wide flood plain.

The structure contour map at LCM top (Figure-5) indicates north east to south west trending three longitudinal structural highs separated by intervening lows. These structures were formed along NE-SW trending faults which accommodated passive margin and foreland sediments. Subsequent activation during Pliocene resulted in structural inversion giving rise to present configuration. The maximum density of wells can be seen on the highs present in the western half of the study area which formed high at Barail top also and all the wells here have been drilled to explore and exploit Barail Main Sand which is a prolific producer in this area. The easternmost high is the biggest in size dissected by a longitudinal fault and a small low, forming a fault closure in the up thrown side and four way closure in the downthrown side. This is a late formed structure which has resulted due to structural inversion in this area during Pliocene time, shown by palaeo -tectonic analysis along line aa'in Figure-6.

Palaeo –Tectonic analysis shows the slopes from west to east till the end of Girujan time and post Girujan the slopes are reverse i.e. from East to West. All the three producing wells from TS-IV sand are falling outside the area covered by 3D seismic and here structure contour map has been shown by dotted lines (Fig-5) and has been drawn only on the basis of well data. Wells A, B and C are having oil column of 8 meters to 10 meters as shown in their log motifs in Figure 7.

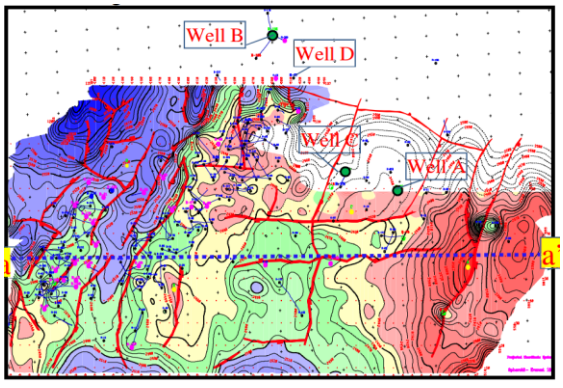

Figure 5: Structure Contour Map on Top of LCM.

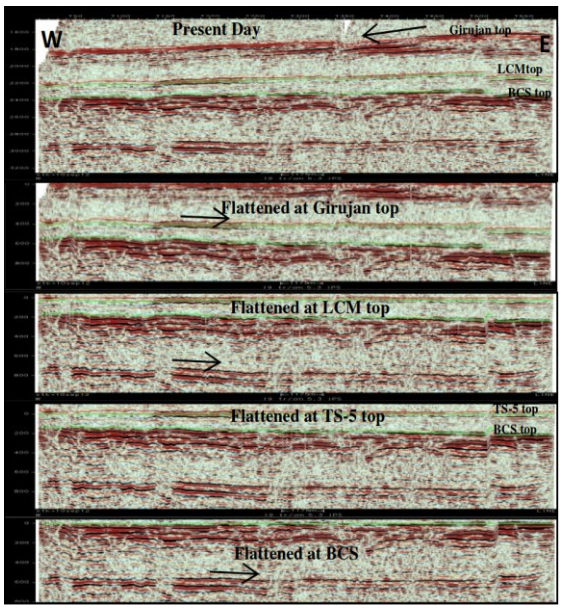

Figure 6: Palaeo –Tectonic Analysis along a Seismic Line aa' as shown in above figure.

The cumulative oil production from these three wells as on 1.1.13 is 1, 23,032 tons. Out of three wells, well 'C' is flowing since 1995 till date. The other two wells started cutting water at an early date after giving little production. The salinity data was collected for TS-IV which is given in table – 1.

The salinity data shows that the sands are fresh water deposits and in well no. 'A' the water produced is not the formation water of TS-IV sand and probably coming from

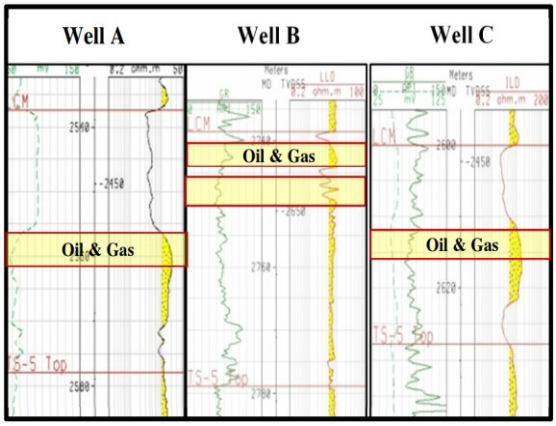

Figure 7: Log Motifs of Wells B & C showing perforated intervals by yellow color and testing results.

TABLE-1

S.NO.	WELL	SALINITY (gpl)
1.	A	6.65
2.	D	1.29
3.	B	0.325
4.	C	0.78

Barail sands due to channeling. As the main objective was always in Barails or below, the cementation problem may be there in Tipam section in other wells also.

The Isochronopach map (Figure 8) depicts the depositional axis trending NE to SW and then taking a meander having thickness varying from <10m to 40m. The cumulative sand Isolith and sand percentage maps (Figure 9 & 10) also follow the same axial trends where sand thicknesses vary from maximum 28 meters to 0 meters. The maximum thickness is of 28 m is seen in the northern side, 22 meters in the western side. The eastern central part is having the maximum sand thickness of 16 meters. These maps indicate the provenance mainly to the North east/ north and to North West. The maximum sand percentage is seen along the channel axis. Litho pie diagram (Figure-11) shows the percentage of sand and shale/ clay stone in all the wells. The sand percentages are more on the western side as compared to wells on the eastern side. The size of the circle is relative to the total thickness of TS-IV (LCM top to TS-V top).

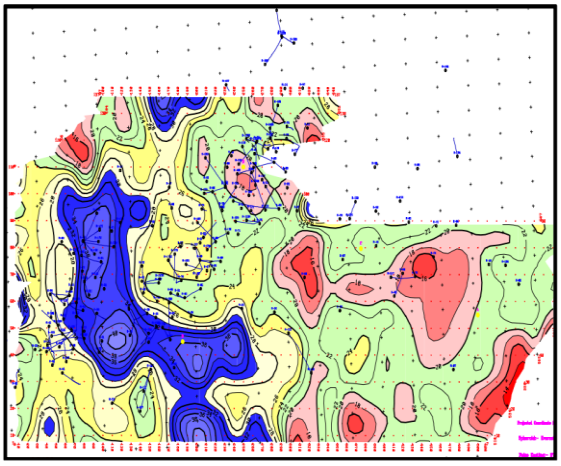

Figure 8: Isochronopach Map of TS-IV (between TS-V top and LCM top).

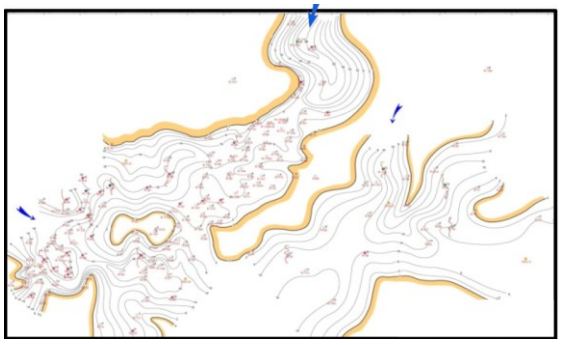

Figure 9: Sand Isolith Map between TS-V top and LCM top.

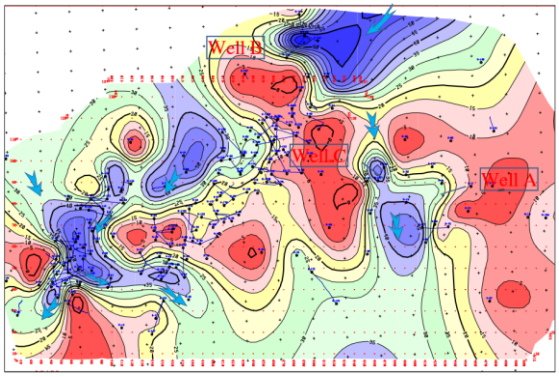

Figure 10: Sand Percentage Map between TS-5 top and LCM top.

Within LCM three distinct correlatable units viz Unit lowermost unit, Unit-II, middle unit and Unit-III topmost unit were identified on logs based on claystone breaks (Figure 12) and were correlated across all well log profiles. These claystone breaks are clear in few wells while in other wells either continuous clay is there or thicker sands are there due to overriding or overlapping channels (Figure 13 and 14), where units were divided on the basis of thickness from nearby well.

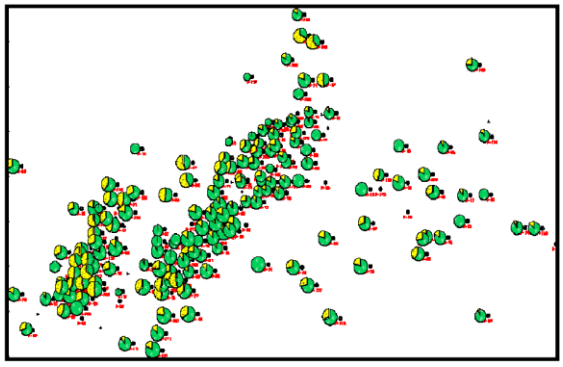

Figure 11: Pie Diagram showing shale/ clay stone and sand percentages of TS-IV.

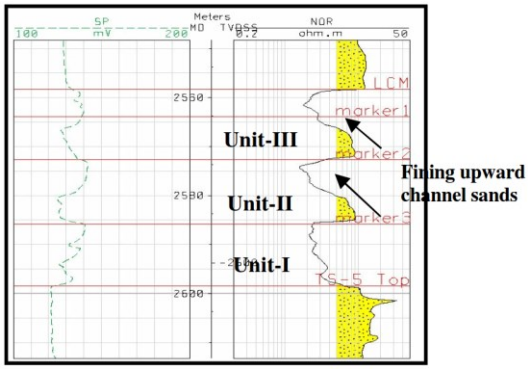

Figure 12: Log of a Well showing three units within TS- IV.

Two detailed electro log correlation profiles have been shown in Figure-13 & 14. Shale breaks are not continuous at many places where multi-storeyed sands are present, stacked one over the other (Figure 14).

Sand isolith maps have been prepared for each unit (Figure15, 16 &17). Sand Isolith maps depicts low energy constrained meandering channels mainly depositing sands in the form of point bars, levee, Crevasse splay and Ox Bow Lake. Unit- II i.e. middle unit (Figure 15) is the most extensive unit spread over the entire area having maximum thickness along the channel axis (10-14m) and less towards flanks. Well 'A' and 'C' have produced oil and gas from this unit. Unit is lowermost unit and unit-III is uppermost unit. Both these units are having main depositional centers to the northeastern and in south western part while in rest of the area sands are sparsely distributed having lesser thicknesses and bigger areas of non-deposition of sands. Well 'B' located on the northern side has produced hydrocarbons from unit (Fig-17).

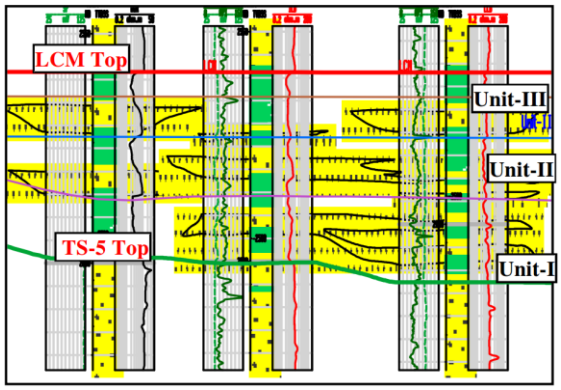

Figure 13: Profiles showing detailed ElectroLog Corrrelation within TS-4.

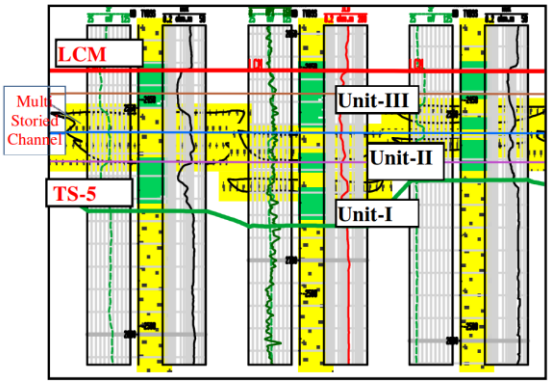

Figure 14: Profiles showing detailed ElectroLog Corrrelation within TS-IV.

The log motifs are showing cylindrical pattern in the channel axis, and are fining upwards towards the flanks of channel depositing point bars and levee (Figure-18). Prospective corridors for exploring TS-IV have been identified based on sand depositional model and structure forming traps (Figure-19). The most prospective areas are where structure is having good thicknesses of sands whereas the areas where sand thickness is zero to two meters are least prospective.

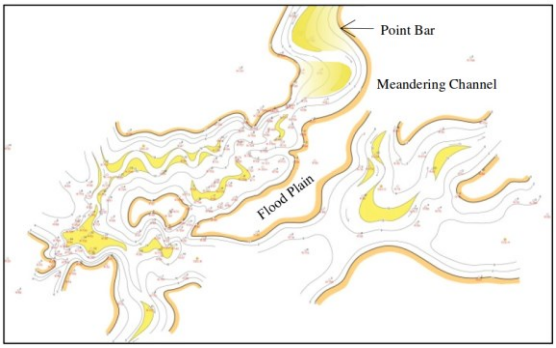

Figure 15: Sand Isolith Map of Unit-II, TS-IV showing channel features and channel directions.

Figure 16: Sand Isolith Map of Unit-I, TS-IV showing channel features and channel direction

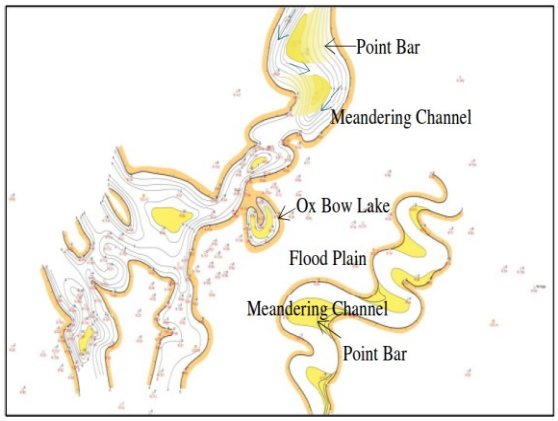

Figure 17: Sand Isolith Map of Unit-III, TS-IV showing channel features and channel directions.

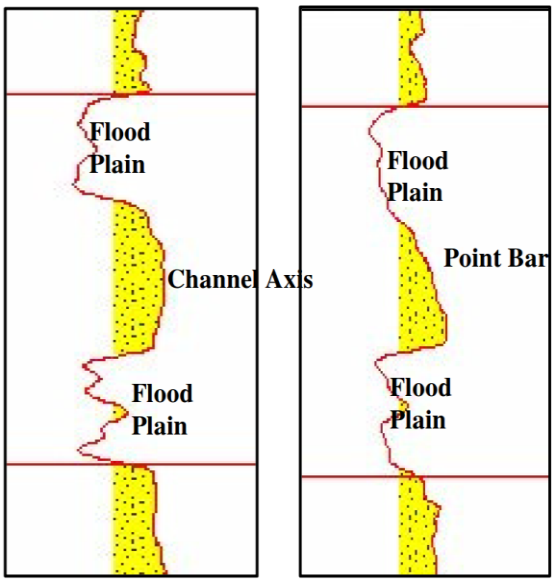

Figure 18: Log signature for Point Bar, Channel axis and Flood Plain deposit.

Prospective corridors for exploring TS-IV have been identified based on sand depositional model and structure forming traps (Figure-19). The most prospective areas are where structure is having good thicknesses of sands whereas the areas where sand thickness is zero to two meters are least prospective.

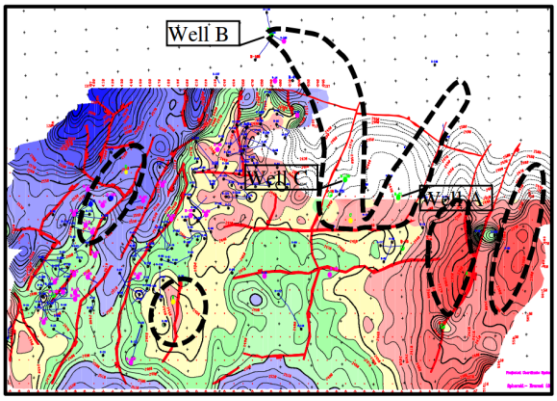

Figure 19: Structure contour map of TS-4 top showing prospective corridors marked with dotted line.

Conclusions

Sand depositional model suggests that TS-IV is a part of HAST dominated by clays representing flood plain where sands were deposited by low energy , constrained, meandering channels in the form of point bars , levees, ox bow lake and crevasse splay deposits. These sands form a good reservoir and are embeded within thick clays of LCM. Three sub units were mapped within LCM seperated by clays. The provenance appears to be from north east/ north and also from north west. The middle unit ie Unit-II is highly prospective in the late formed high present in the eastern side and in the eastern central part where already two producing wells are present while other two units are having more sand thickness in the northern part of channel and also in the south western part, where wells have been identified for zone transfer. In Rudrasagar three wells have produced oil and gas from TS-IV and hydrocarbon shows have been noticed in few wells. TS-IV sands are producing hydrocarbons in nearby field Charali which is only 3.2 kilometers southeast of this area which further adds to the prospectivity of this area.

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