



Sand Geometry and Depositional Model of Miocene (TS-4) Sands in North Assam Shelf, A&AA Basin, Assam, India

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Summary

In North Assam shelf, the TS-4 Sands of Miocene age has not been systematically explored perhaps due to non availability of a basinal scale picture of its sand distribution pattern and depositional model. However, TS-4 sands developed within the LCM are one of the producing horizons of Tipam Group of Formation in North Assam Shelf. Log data of about 1000 wells, production-testing data, laboratory data, core data and the seismic data of the area have been studied to understand the sand geometry, depositional environment and hydrocarbon prospectivity of TS-4 sands.

The study has brought out the sand geometry and the depositional model of TS-4 sands for the entire shelf. It is seen that sand deposition, guided by the lineament geometries were deposited as fluvial channel in a flood plain area mostly as anastomosing, at places meandering channels. The TS-4 sand isopach map was also studied with the present day channel pattern and the lineaments. The channel pattern and the flood plain of the North Assam Shelf shows very good similarity with that of TS-4 Sand (channel pattern), the only difference being the change in the slope from south to the north.

Since the role of lineament control on the sand distribution pattern has been proved, the study has increased the predictability of sand locale for the entire North Assam Shelf. Thus this work will be very useful to the geoscientists for the future exploration of TS-4 sands in the North Assam Shelf.

Introduction

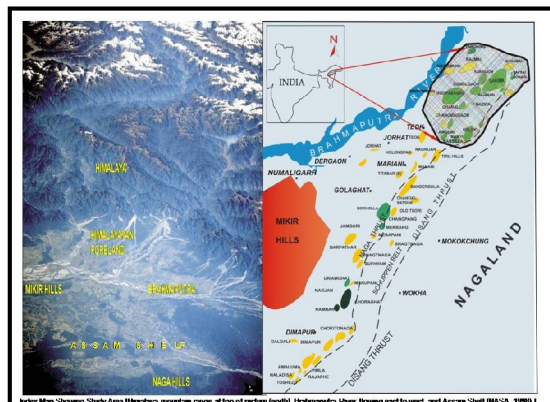


Figure 1: Index map of the study area

The area of study belongs to North Assam Shelf encompassing Panidihing in the north, Geleki in South, Sonari-Banamali East and Disangmukh in the west, (fig.1). Thin discrete sands of Middle Miocene age developed within the LCM(Lower Clay Marker) has been named as TS-4 sands in North Assam Shelf of Assam & Assam-Arakan Basin, North-East India. Stratigraphically, LCM (TS-4) belongs to the Geleki Sandstone Formation and is sandwiched between TS-5A sand below and TS-3 sand of the “Lakwa sandstone Formation” at top. These sands are one of the producing horizons of Tipam Group in North Assam Shelf. Due to its discrete nature and limited aerial extent with poor seismic resolution, systematic exploration, development and reservoir maintenance of TS-4 sands have been major concern till date. Due to poor seismic resolvability of the TS-4 sands, earlier works purely on the basis of seismic data did not help much to understand these sands. As a result, a study primarily based on the well logs of the area was needed to be carried out not only to



understand the sand distribution and prospectivity of these sands but also to understand the controlling factors that influenced the distribution of the sands. This understanding in turn will increase the predictability of these sands in a particular area / set up. Secondly, a comparison with present day situation with similar set-up has helped to better understand the tectonic control on the fluvial channels in the area at present as well as in the past.

Brief Geology of the Area

This Basin represents a classic example of a poly-history basin, which developed as a passive margin and later changed into a foreland in a peripheral position with respect to the major Naga schuppen belt and the contiguous Indo-Burma orogenic front. Assam-Arakan Basin covers more than one lakh square km. of area and falls in the Northeastern part of India. Sedimentary records have been confirmed from Palaeocene to Recent in age with a major break in sedimentation during Oligocene, Late Miocene and Pliocene time (fig.2). Since Middle Miocene, fluvial sedimentation dominates as the collision of the Indo-Burmese plate caused the accretionary prism to rise and the sea was completely withdrawn from this part. The Himalayan Orogeny, which is of larger dimension, influenced the area from north in the Pliocene time and the slope of the Assam Shelf tilted to the north. However, the regional slope of the area as indicated by the present day flowing Brahmaputra (NE to SW) was throughout the same. The "Proto Brahmaputra" from the south shifted gradually to the present day position as the tilting continued.

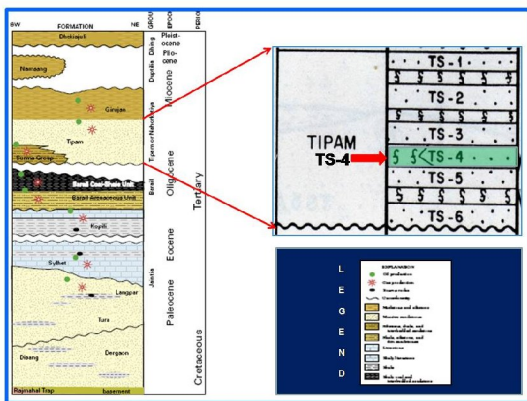


Figure 2: Lithostratigraphy of North Assam Shelf

Present Work

Well Log Study and Log Correlation

Figure 3 shows the typical well log of TS-4 sands within LCM pack. Study of well log correlation brings out the vertical and spatial dispositions of LCM and TS-4 sands (fig. 4a & 4b). Thickness of LCM varies from 12 m to more than 100m and thickness of the sands developed within the LCM also varies from 0 to about 50 m. in the North Assam Shelf. At many places these sands are stacked to one sand while in other places they occur as three to four individual

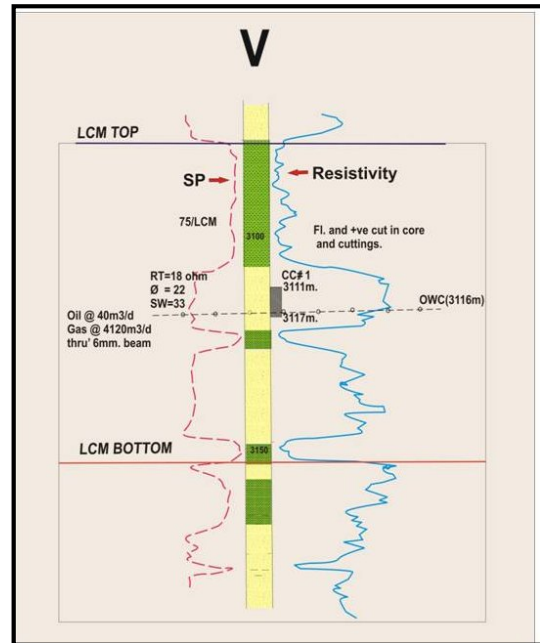


Figure 3: Typical well log of TS-4 sands within LCM pack

sands. However, the middle one, named as TS-4B is better developed than the others and having limited extent in the North Assam Shelf. The thickness of LCM increases from north and northwest to south and southeast. However, in the structurally higher areas the thickness of LCM is reduced due to the scooping off its upper part (Fig.5).

Isopach Map of LCM and TS-4 Sands

No particular depositional pattern of the LCM is visible from the isopach map. This is due to the scooping off of the upper part of LCM. Thus, it represents a surface more on erosional pattern showing more complexity in the high-energy areas (i.e. the structurally higher /growing areas) than in the lows (ref.fig.5).

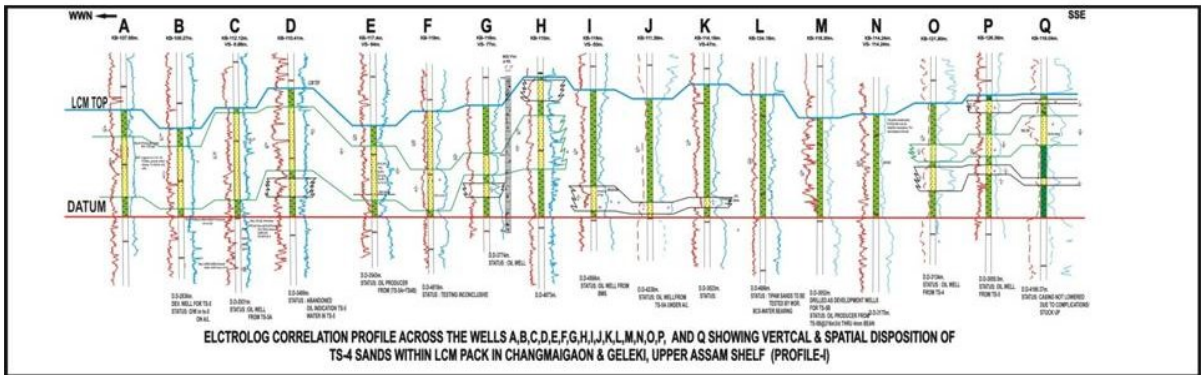


Figure 4a: Electrolog Correlations Showing the vertical and spatial disposition of TS-4 sands of North Assam Shelf (Profile-I)

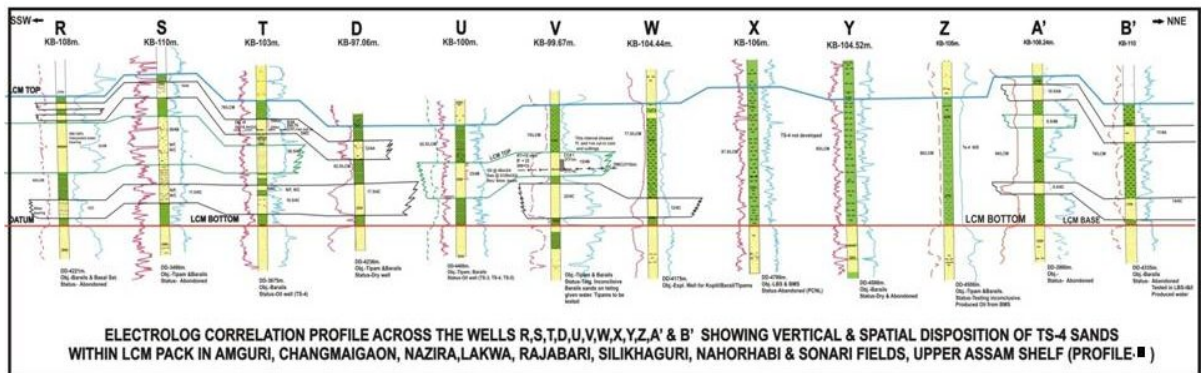


Figure 4b: Electrolog Correlations Showing the vertical and spatial disposition of TS-4 sands of North Assam Shelf (Profile-II)

The thickness of the LCM is also not linearly higher in the structurally lower areas, which is mainly due to more compaction in such areas. The high compaction in such areas is for two reasons: - due to greater depth and due to absence of sand and silts.

Apart from TS-4B there are few other sands developed within the LCM but much localized in nature. Hence regional map has been prepared for TS-4B sand (fig.6). TS-4B sand occurs in a channel network with regional slope from NE to SW. It was deposited as channel

sands, anastomosing channels and at some places as meandering channels. The sand isopach as well as the LCM isopach map have been superposed on the time structure map close to top of TS-5A sand (fig.7). The integration has led to the various observations. TS-4b sand net works were probably controlled by the fault-lineaments and the paleo-highs. The channels of the TS-4 sands mostly followed the lineaments and tried to avoid the highs in the areas like Rudrasagar, Lakwa, and Charali etc. In Changmaigaon and Geleki these sands are found throughout the field. This might be due to the fact that these two fields were not highs during the deposition of TS-4 sands and came up afterwards due to inversion.



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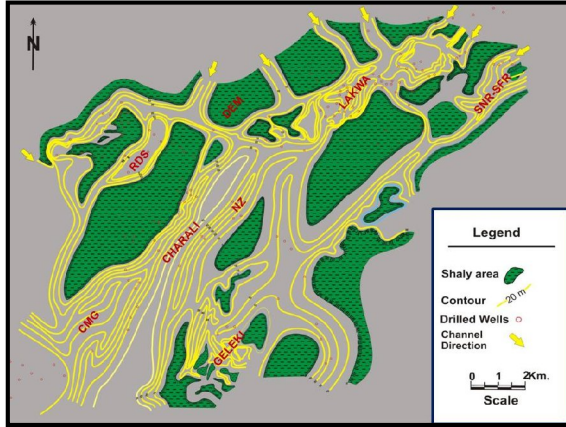
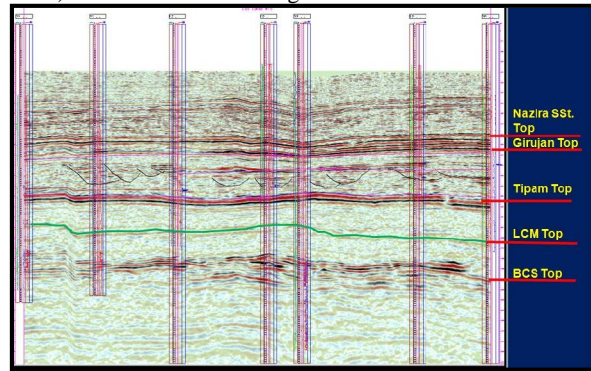


Figure 5: LCM Isopach Map of North Assam Shelf

which are dominantly sandy units, generates interesting situation. On integration with the seismic attribute map (fig.9 A, B & C) it is observed that areas where the thickness of LCM is considerable and no sand has been deposited, the top and bottom boundaries are defined by strong reflection co-efficient and clear strong wavelet with natural peak frequency at that depth. This situation gives rise to strong amplitude or sweeter areas in sweetness map. Areas where the sands within the LCM have been deposited have several reflections co-efficient in quick succession causing lowering of amplitude and also frequencies. The picture largely satisfies the observation in the wells. However, a reprocessing effort particularly in thereby, making mapping and analysis of this kind of units easier and more confident.

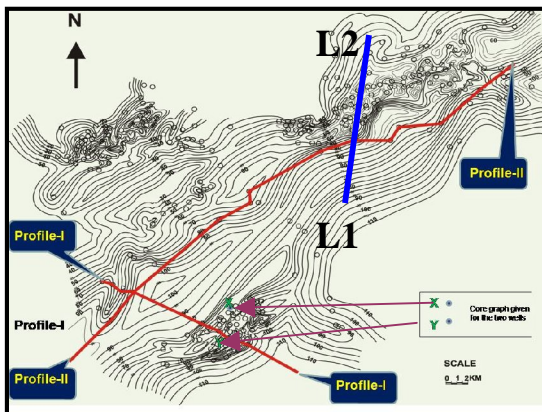
field) controlled the drainage in the TS-4 time also. As



indicated by the present day drainage that the main river (the Brahmaputra) a braided system flowing in the north and its tributaries are flowing to the NW to meet it, similarly during the TS-4 time such a braided river system could exist to further south to which the channels of the TS-4 flowed to SW to meet. This braided system probably migrated to the north in course of time to deposit the TS-3 sand over the LCM.

Seismic Study

Seismically, LCM pack as a whole is represented by one cycle of wavelet trace and sands developed within it is beyond seismic resolution (fig.8). The geological setting of "Lower Clay Marker" in between TS-3 and TS-5 both of



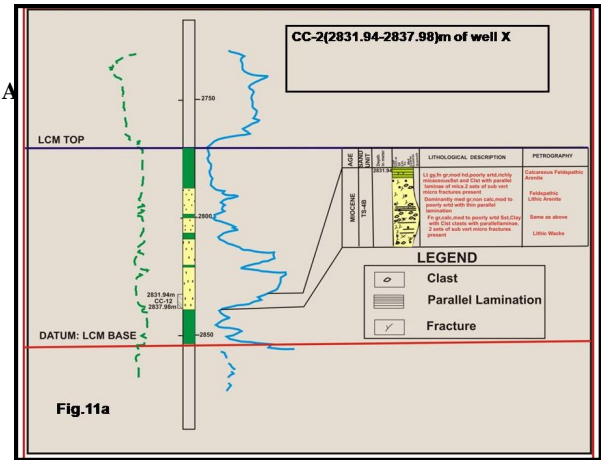
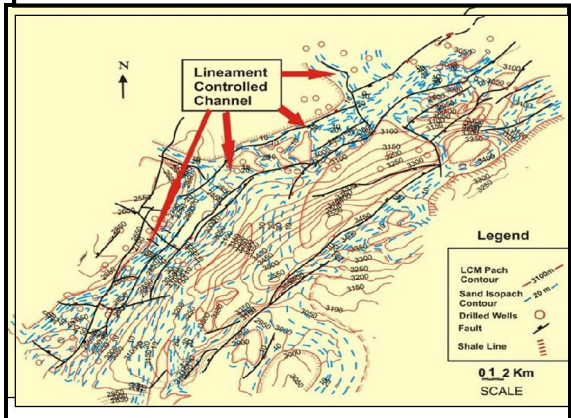
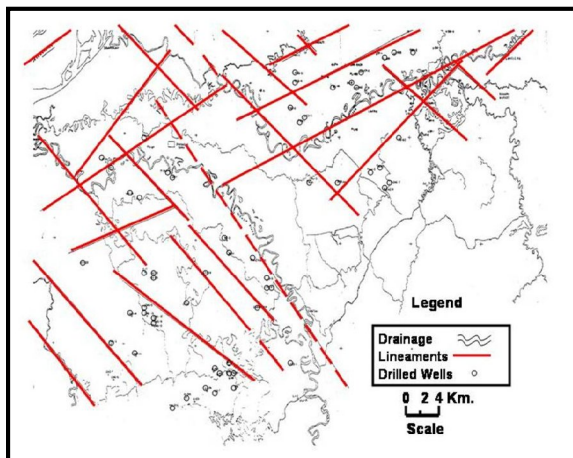
Core study

Based on core data five different litho-facies have been identified within TS-4 sands (Goswami et.al. 2002). The

Figure 6: Isopach Map of TS-4B sands of North Assam Shelf



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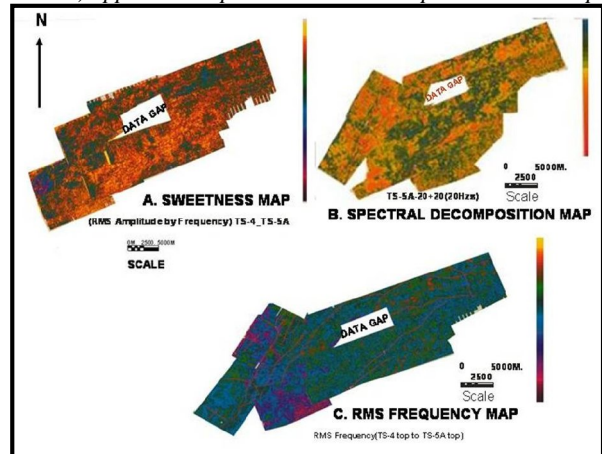


area (also the main structure building fault of Rudrasagar

Figure 8: Seismic line (L1-L2) Showing Top of Various Stratigraphic Horizons (Line positions shown in fig.5)

Figure 9: (A) Sweetness Map, (B) Spectral Decomposition Map & (C) RMS Frequency Map of North Assam Shelf

variation in lithological association indicates the change in micro-environmental conditions. Integration of core data with well logs is shown in the figure 11(a&b). Pebbly sandstone with intraclasts (bottom part of CC-2 in #X; fig. 11 a & top part of CC-2 in #Y; fig. 11 b) have been *inferred to be derived from the eroded banks within the fluvial system*. Cross-bedded sandstone (core of #Y; fig. 11 b) appears to represent sediments deposited on the slip





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faces of migrating channel sands or part of point bar units. Horizontally bedded laminated sandstone (core of #X; fig. 11 a) might have been deposited under high velocity

Figure 10: Map Showing Present Day Lineament Pattern Along with Drainage System of North Assam Shelf

condition. Massive sandstone (core of #Y; fig. 11 b) got deposited under high-energy condition. Position of the two wells X&Y are shown in the fig.5.

Depositional Model

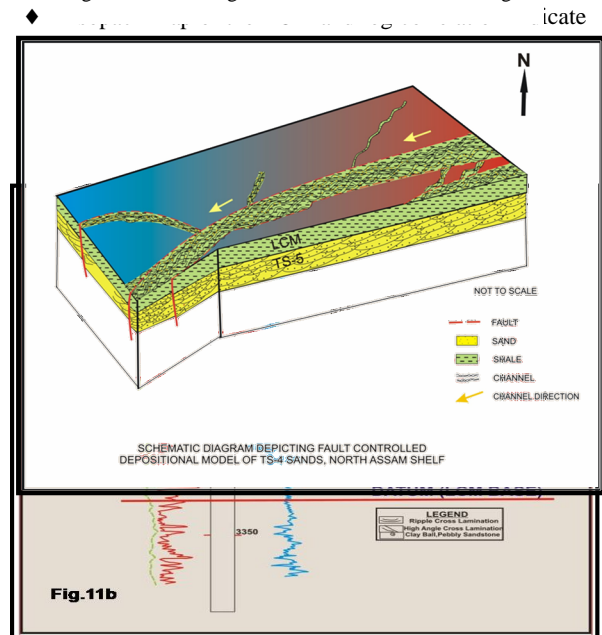
Lower Clay Marker" (LCM) is one of the major, distinctive clay markers throughout the upper Assam Shelf. Sedimentation in the Miocene period in Upper Assam basin had been influenced by the tectonic activities related to the collision of the Burmese plate and the Indian plate. After the TS-5A, the Upper Assam Shelf became a flood plain area as it is today. The gradient became gradually lesser and the channel network was dominantly controlled by the lineaments/faults. Therefore, some of the isolated channels filled by sands now occur within the LCM and the main channels controlled by the lineaments occur as the major sand named as TS-4B within LCM. After the deposition of LCM, another pulse of tectonic activity increased the gradient again and thus caused the erosion/scoop up in the structurally higher (high energy) areas. Scooping off sediments from the structurally higher areas caused the problem in the correlation of the sands when it is hanged

Fig.12: Schematic Diagram Showing Lineament Controlled Depositional Model of TS-4 Sands of North Assam Shelf from the top. The LCM thus represents a flood plain deposit sandwiched between two cycles of braided river systems representing by the TS-5 and TS-3 sands. The sand distribution within the LCM has been controlled mainly by the faults/lineaments, which were active during its deposition, and by the paleo-relief. Late stage compression/inversion as well as the tilting of the basin has caused the change in the hade of many faults at least in the younger horizon. Though, the post depositional tectonic activities made it difficult to properly understand the distribution of the TS-4 sands, the present day Brahmaputra valley filled with thick clays and its southern tributaries controlled mostly by lineaments replicates the depositional model of the LCM and TS-4 sands. A schematic diagram (fig. 12) has been presented to shows the conceptualized depositional model of TS-4 sands of Upper Assam Shelf.

Conclusions

- ◆ TS-4 sands were deposited as fluvial channel in a flood plain area mostly as lineament controlled, anastomosing, at places meandering channels.
- ◆ The regional slope was from NE to SW.
- ◆ Sand thickness increases from NE to SW.
- ◆ Present day channel pattern and the flood plain of the North Assam Shelf shows very good similarity with that of TS-4 Sand (channel pattern), the only difference being the change in the slope from south

Figure 11a&b: Integration of core data with well logs



that the upper boundary of LCM is erosional.

- ◆ In structurally higher areas the upper part of LCM had been scooped out by the channels of the TS-3 Sands. Therefore, the LCM isopach map does not reflect the true depositional pattern rather the erosional pattern imprinted on it.
- ◆ The erosion of the upper part of the LCM also reduced the clayey part and thus made it difficult to identify on seismics as well as on the attributes.
- ◆ The present day Brahmaputra valley filled with thick clays and its southern tributaries controlled mostly by lineaments replicates the depositional model of the LCM and TS-4 sands
- ◆ The methodology adopted in the study has helped to understand the depositional environment, sand geometry and the control of lineaments/structures etc on deposition
- ◆ Lineament controlled depositional model of TS-4 sands increases the predictability of the sand locale for the entire North Assam Shelf.



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