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Exploration Strategy for New Plays in Tripura Fold Belt – A Contemporary Approach

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Summary

The exploration inputs in last four decades on Assam-Arakan Fold Belt of Tripura in the form of geological mapping, aerial photography and landsat imageries has resulted in identification of fifteen exposed and four unexposed structures for hydrocarbon exploration. Till date, in Western Tripura nine structures were taken up for drilling out of which seven structures have been proved to be hydrocarbon bearing. With limited demand for saleable gas, exploration remained dull till a gas base mega Power Plant was planned. In near future higher demand of gas is expected on long-term basis to cater this upcoming Power Plant. This has led to put an impetus to enhance exploratory activities to increase the reserve base. Apart from the looking into conventional structural closure, identification of new plays particularly in Western Tripura is the answer to any unexpected shortfall to meet the projected demand of the Power Plant. The area is sparsely covered with seismic survey. Besides, the chaotic reflection pattern along the crest of the anticline is an additional hurdle for extending the correlation as well as realistic sub-surface imaging. With these limitations, attempt has been made to identify various plays particularly in grey areas like stratigraphic prospects in the syncline between established gas fields, strati-structural prospects in the flanks of established gas fields and other structural features by integrating available G & G data. This has resulted identification of seven additional prospects pertaining to different plays in the area. Those are Agartala Syncline, eastern flank of Rokhia and Tichna, northern extension and western bulge of Baramura and new structural stratigraphic features in Pathalia and Khowai-Kalyanpur. The systematic and extensive exploratory efforts of these prospects will certainly help to convert the huge unexplored prognosticated resources into in-place hydrocarbon volumes, which may be proved to be as an integral part for catering to gas to the Power Plant.

Introduction

Structurally, Tripura Fold Belt, a part of Assam Arakan Fold Belt, is characterized by series of parallel, elongated and doubly plunging asymmetric anticlines arranged en-echelon pattern and separated by wide synclines. The general trend of the anticlines is NNW to SSE to N-S with slight convexity towards west. The intensity of folding increases towards east with progressively older rocks being exposed in the cores of the anticlines. Each anticline is generally bounded by longitudinal reverse faults on one or both the flanks/limbs. Huge sediments were deposited in the fold belt area during the Cenozoic period.

Till date fifteen exposed and four unexposed structures are identified, of these eleven prospects have been probed by drilling,; nine in Western and two in Eastern Tripura. Commercial viable gas reserves have been established in seven prospects in Western Tripura within hydrostatic and transition pressure regimes in Bokabil, Upper Bhuban and Upper part of Middle Bhuban formations (Fig.1). Efforts for assessing prospects within Lower Bhuban and Barail remain unsuccessful due to high pressure/over-pressure problems.

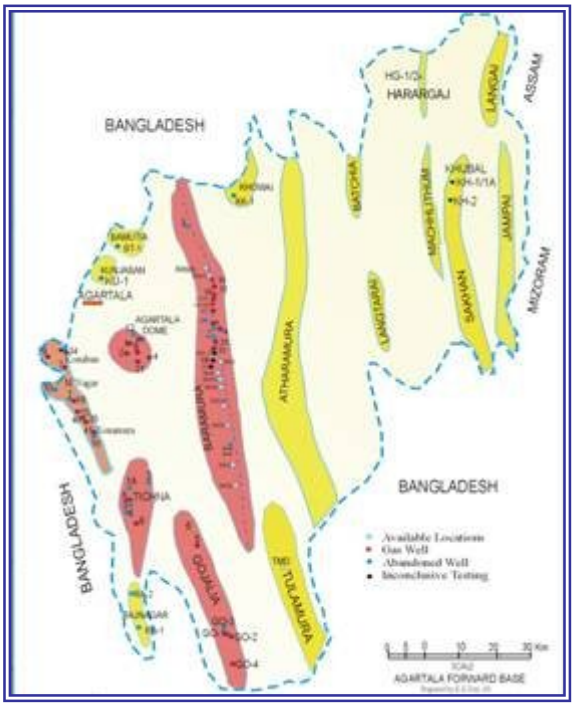

Fig.1: Identified Structures showing Gas Fields, Tripura

Present Study

The field size distribution in the geological plays indicates that the bigger fields and the conventional plays are generally discovered in the earlier stages of exploration and the smaller ones and the unconventional are at a later stage. In view of this, an attempt has been made to visit new plays, even though they are in high risk areas.

With limited demand for saleable gas, exploration remained dull, till ONGC planned to set up a Power Plant in Tripura. The additional demand for the Power Plant has been profiled with indicative components with the view of high exploratory success ratio along as well as huge unexplored areas. This warranted an effort to bring out the prospective locales for different types of plays favorable for hydrocarbon entrapment. Considering the western part of Tripura a relatively safe and logistically approachable, the north-south corridor between well-established gas fields in Western Tripura was taken up for the study. The area includes Agartala Syncline, the area between Konaban and Agartala Dome in the north to the area between Tichna-Gojalia in the south, Additionally, other areas like Baramura, Khowai-Kalyanpur and Rokhia structure has also been re-looked from where accretion of substantial hydrocarbon entrapment is possible.

i) Agartata Syncline

In North Western Tripura, Konaban and Agartala Dome are the established gas fields comprising more than half of proved GIIP of Tripura. The area between these two fields was mapped as a low and named as Bishalgarh Low. Till date explicit thought for exploration has not been taken up in the synclines of Tripura. The axial trend of this low is NNW-SSE. Further north, Titas gas field of Bangladesh lies along the same alignment. The western rising flank of this low is steeper towards Rokhia than that of the eastern limb towards Agartala Dome.

Critical observations of the available data, seismic in particular, have been done for identification of unconventional reservoirs within the low. In the dip lines, a number of build-ups/reversals and channel-fills within Middle and Upper Bhuban sequences have been observed. The vertical, as well as lateral variations in RMS velocity are also seen. The build-ups, pinch-outs and low amplitude reversals in the area are shown in Fig.2.

Fig.2 Time structure map on top of Mid. Bhuban, Agartala Syncline

Few of those features along the dip sections are shown in Fig.3 and 4. The build-up and channel-fills are clearly seen in the seismic line passing across the syncline (Fig.3). The distinctive build-up features are shown in a magnified section (Fig.4) parallel to the line of Fig.3.

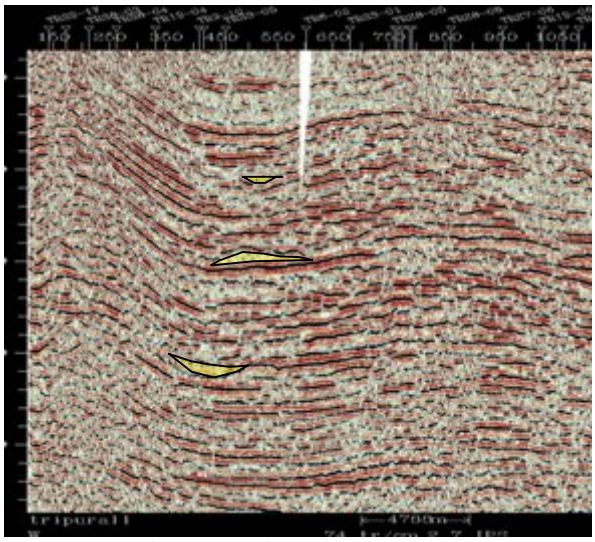

Fig.3 Channel fills build-up futures in seismic section, Agartala Syncline

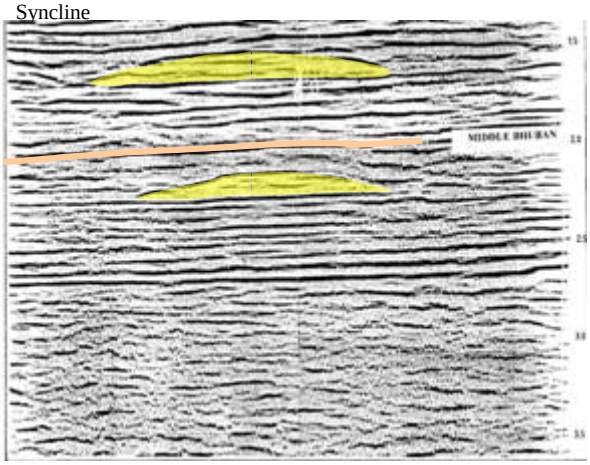

Fig.4 Reversal and build-up futures in seismic section, Agartala Syncline

The identified prospective locales for future explorations are:

- Pinch-out prospects along the limbs of the syncline/low; as the sediment influx was mainly from north-eastern direction where the eastern margin fault of Rokhia structure might have played a major role for entrapment conditions.
- The reversals as seen in different dip lines within the low are to be delineated to bring out the exact closure along with detection of reservoir facies within the closure.
- The build-ups seen in the area appear to be of discrete in nature. However, proper imaging of these features pertaining to their extension may open up new thrust area for future exploration.

ii) Tichna-Gojalia

Tichna is an established gas field in southwestern Tripura. In addition to the pays in Middle and Upper Bhubans, the field is also well known for shallow reservoirs within Bokabil Formation. In the east, Gojalia structure is en-echelon to Tichna with Belonia syncline in between. In Gojalia, the wells in the northern part are comparatively better producers. In the present study, attempt has been made to find out some prospective locales within the synclinal and flank areas between these two established gas fields. The established play for hydrocarbon entrapment in the area is mainly structural, *i.e.*, along the axis and is controlled by cross faults. Critical observation of the available seismic lines indicates that the flank of northern part Tichna anticline has development of geo-body (Fig.5).

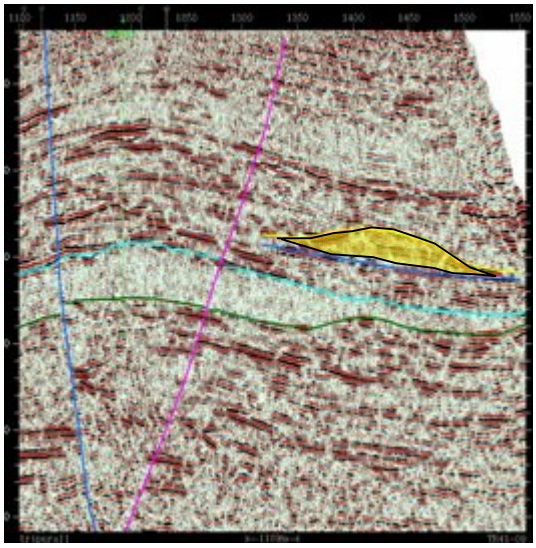

Fig.5 Geo-body as seen in the eastern flank of Tichna

The northern culmination of Tichna anticline also shows another interesting feature, reflection free zone in Mid. Bhuban (Fig.6), appeared to be relicts. The interval velocity analysis of the line also shows lower interval velocity zones against the identified relict features (Fig.7). Considering this fact the zone can be inferred as arenaceous unit and are worth probing, especially in those locales having structural support like faults.

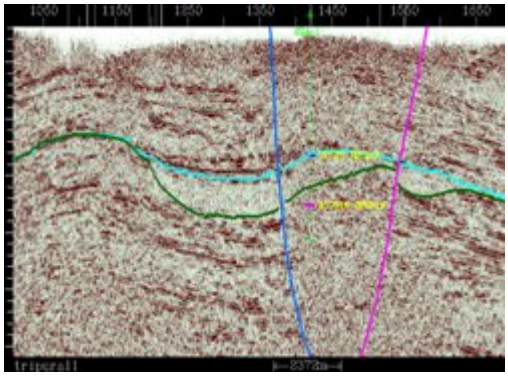

Fig.6 Relict feature in one of the seismic line in the Northern culmination of Tichna anticline

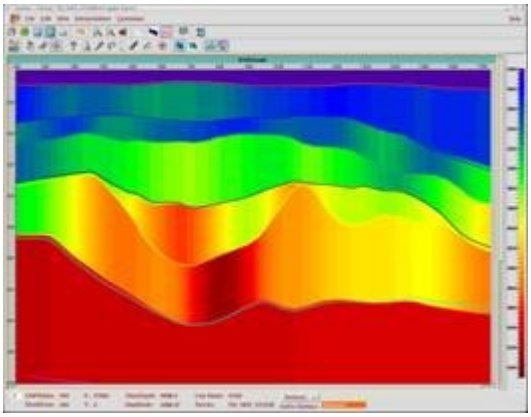

Fig.7: Interval velocity analysis of the line (shown in Fig.6) showing relatively lower int. vel. against the relict feature

Extension of these relicts has also been mapped (Fig.8). This is the first time such features are identified in Tripura.

Fig.8 Iso-chronopach of fill in the relict, North Tichna

In view of above, the northern culmination and the flank of Tichna structure appear to be prospective for hydrocarbon entrapment in the following plays:

- The area east of northern culmination, where the geo-body with low amplitude seismic signature as well as the fault closures are seen, is worth probing.
- The relicts within Middle Bhuban bounded by cross faults are plausible locales for entrapment as there is no dearth source rock in the area.
- The low between Tichna and Gojalia is interesting for stratigraphic, structural and strati-structural plays

iii) Rokhia Anticline

Rokhia anticline is the western-most exposed anticline in Assam-Arakan Fold Belt. This anticline is bounded by Agartala-Bishalgarh Syncline in the east and Plains of Bangladesh in the west. It is a doubly plunging and NNW–SSE trending almost symmetrical anticline. Like other structures, Rokhia structure is also bounded by two reverse faults and comprises a number of culminations and also cut by a number of cross faults. The northern plunge of northern culmination is Konaban field well-known for multilayered pays and the apex falls in Bangladesh. The central culmination, Manikyanagar field comprises is the largest producer and the southern culmination is known as Sonamura field.

- Exploration opportunities still exist in the northern plunge beyond the proven gas limits of Konaban.
- Presence of gas in the eastern flank of Manikyanagar has already been proved, however the commercial viability yet to be established. In view of that the closure against the structure building fault in the eastern flank holds high prospectivity.

iv) Pathalia

The Agartala Dome loses its domal feature and narrows down southward giving rise a separate structure Pathalia. This is an anticlinal feature plunging southward and is the southern extension of Agartala Dome and separated by a prominent E-W trending cross fault (Dotiwala et.al 2000). This is evidenced from LANDSAT imagery shift in the axes of anticlines and synclines (Fig.9). The fault has also been mapped by earlier workers with sparsely available seismic data. The general trend of the structure is NNE-SSW and is bounded by a pair of reverse faults.

Fig.9: LANDSAT imagery showing Baramura Structure

The convergence of plunges of Pathalia structure from the north and Sundulbari from the south has resulted in a low. However, the similar structural set

up to that of Agartala Dome cannot be overlooked. There is only one well drilled in the northern part of the area. The well is located on the southeastern part of Agartala Dome in the westerly dipping fault zone separated by a cross fault from the main Pathalia structure. But, the equivalent deeper pays of Agartala Dome could not been penetrated in this well. Agartala Dome, in the north, one of the largest gas fields in Tripura is juxtaposed with the Pathalia structure and hence, the area appears to be prospective as far as deeper pays are concerned. Further, the inferred depositional models also suggest presence of sufficient reservoir facies within Middle and Upper Bhubans. Additionally, the up-plunge of Pathalia is also cut up by a cross fault which are supposed to be entrapment locales in Tripura. Hence, the area appears to be prospective for structural plays and is worth probing for deeper prospect

v) Baramura

Baramura was the first structure where first well drilled in Tripura and produced gas in 1975.A total of ten pay sands have been identified within Upper and Middle Bhuban formations. It is an elongated and doubly plunging asymmetric anticline trending NNW-SSE with a minor convexity to the west. The eastern limb is steep and it is affected by a reverse fault, while the western limb is comparatively gentler and wider in the central culmination. Bokabil Formation forms the core while Tipam Formation is exposed on the limbs and on the northern and southern plunge areas (Mitra et.al 1967). Till date very limited seismic data available over the structure; in the northern plunge and in the west of central Baramura virtually there is no seismic coverage. Broadening of the structure in the central part of the anticline and bulging feature towards west has been indicated by various workers. The Barail and Lower Bhuban formations are believed to have provided the source while the reservoir within the Middle, Upper Bhuban and Bokabil formations are proved to be good producers. The shale within the Bhubans and Bokabil act as regional seals and enhances the prospectivity of for most of the structural closures supported by cross faults. It is apparent from the LANDSAT imagery that the major gas producing Habiganj Structure (with 3.7 TCF GIIP) of Bangladesh is the continuation Baramura Structure. Hence, the northern plunge of holds high prospectivity and worth resuming the exploratory activity.

Exploration activities even in the flanks of Baramura anticline remained dormant. Residual gravity map of Tripura indicates the continuation of a high trend from Agartala Dome through the bulge of central Baramura, which is also seen on seismic lines. The high trend lies in close proximity to Agartala Dome, Tichna and Gojalia anticlines. This prominent broadening of the western flanks with gentle dips within Tipam Formation is quite apparent in the field geology map and satellite imageries (Fig.10). This feature provides a conspicuous area for exploration with cross and strike faults that might have facilitated the entrapment of hydrocarbons in both structural and stratigraphic conditions.

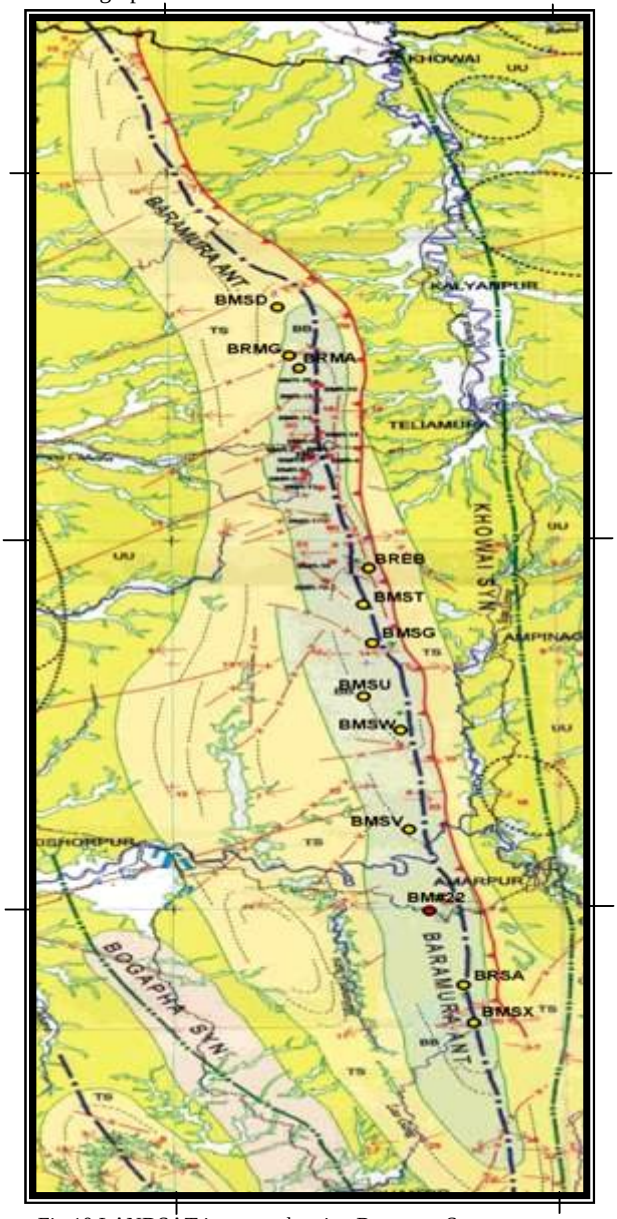

Fig.10 LANDSAT imagery showing Baramura Structure

The western limb of the Baramura Anticline, which is broad and gently dipping in the central part, was also studied with the objective to find suitable geological setting for accumulation of hydrocarbons. Seismic coverage in the area is very scanty.

vi) Khowai-Kalyanpur

The Khowai-Kalyanpur is a concealed structure and is located between Baramura anticline on the west and Atharamura on the east. The available seismic data is very scanty. Based on the LANDSAT imagery, it is seen that the continuation of the southern plunge of Rashidpur structure of Bangladesh (GIIP of 2.2 TCF). The structure trends NNW-SSE. Only one well has been drilled in the structure and penetrated Middle Bhuban Formation within the hydrostatic pressure regime and indication of gas has been reported. The aerial extend is limited in the south by NELP block of GAIL Consortium which comprise of Atharamura Structure.

Two seismic lines have been studied and two elongated geo-bodies have been identified as stacked one above the other within the Middle Bhuban. The data quality is very poor, even though the change of facies along the dip direction could be seen. Strong reflection events within the geo-bodies may be due to sand-shale alternations which are followed by poor reflection zones due to shale to the east and west of the bodies. The area may yield good result after proper sub-surface imaging.

Conclusions

In Tripura, till date only 10% of prognosticated resources have been converted into geological reserves, which is insufficient to cater the upcoming gas base Power Plant in the state. The overall prospective areas for future exploration in Western Tripura is shown in Fig.12, however detailed subsurface imaging is warranted.

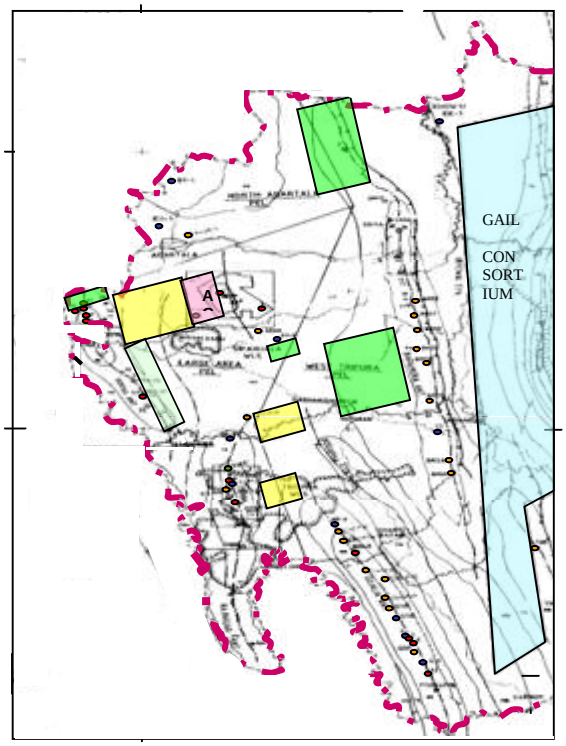

Fig.12 Area showing for the new play for future exploration in Western Tripura

In the present study an attempt has been made to bring out the prospective locales for different types of plays favorable for hydrocarbon entrapment within the area mentioned above. Each play was studied in detail and their potentials are indicated, however exact position of locations would require detailed interpretation of new as well as available G & G data for the various plays identified. The study reveals following conclusions to make a thrust for future exploration in Tripura:

- The synclines of established gas fields, like Agartala Syncline and Bogapa Syncline are new the thrust areas, where stratigraphic as well as stati-structral plays could generate a considerable leads for the future exploration.
- The flanks of established gas fields, mainly eastern, are the other interesting areas, where geo-bodies in Tichna and the closure against the structure building faults in Rokhia may result a significant contribution for converting prognosticated resources into in-place gas volumes.
- The relict feature, identified for the first time, in the northern culmination of Tichna is another interesting play to be probed.
- Northern plunge of Baramura and Rokhia and the central bulge of Baramura are also expected to be big contributor.
- Considering close proximity of large gas fields, Pathalia and Khowai-Kalyanpur are also required to be properly explored with detailed sub-surface imaging.

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