



Hydrocarbon Prospectivity of Khubal Structure and its Adjoining Area of Tripura Fold Belt - Some Key Issues

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Abstract

Gas discovery in Khubal structure in 2009 from a Lower Bhuban Sand of Lower Miocene age was a great news in the exploration history of eastern part of Tripura Fold Belt. The paysand produced gas at @ 1,54,474 m³/d through 8mm bean. After this discovery hopes are rekindled for the Geoscientists to step up exploration activities in eastern Tripura. This discovery is of great significance in eastern Tripura after a number of failures in structures like Hararganj, Langai, Lagntarai etc. There is an urgency in exploration/exploitation strategy due to ONGC's commitment for a steady supply of Gas to the downstream petroleum sector. From this study it could be inferred that this success is another story of synclinal exploration like eastern Sundalbari Syncline in western part of Tripura fold Belt. The entrapment of Gas in the Lower Bhuban Sand is a case of up-dip pinchout in western limb of Khubal Anticline and the sand continuing further down dip towards Champabari Syncline. The concealed northern plunge part along the axial region of Khubal structure is prospective from hydrocarbon point of view in comparison to the tectonically disturbed axial part towards south. Now it is more important to understand the entrapment model than just puncturing the anticlinal highs. The southern and eastern rising trend of the structure is prospective from hydrocarbon point of view but the entrapment model for the sand units should be understood properly. The sand units are found to be discrete in nature and look to be deposited as a complex system of stacked tidal bars/Channels with Mud flats. In well Khubal#D, the 52m producing Lower Bhuban sand pinches out towards KH#E and in KH#F, it becomes shaly. In KH#F it is structurally lower by 73m w.r.to KH#D. So a careful exploration strategy should be adopted to identify the vertico-lateral dispersal of discrete sands and their entrapment model. Petrophysical evaluation of sands is also a challenge due to bad holeconditions and paucity of good quality logs. So developing a proper petrophysical model will also guide in future for formation evaluation.

Introduction

Khubal structure lies in the eastern part of Tripura Fold Belt (Figs. 1, 2&3). Khubal anticline lies between Jampai and Machhlithum Anticline. Deo syncline separates it from Jampai structure to the east. The structure is a doubly plunging, Anticline trending in NNE-SSW direction with abrupt separation from Sankhan anticline to south by a strike slip fault. The northern plunge of the structure is relatively wide and well marked, but the southern plunge is short and abruptly truncated. The structure is about 30km long and 15km wide. Two structure building longitudinal reverse faults are well marked. The Champabari Syncline separates it from Hararganj Anticline towards west. The Champabari syncline is narrow towards south where as it takes a turn and almost aligns with the plunge axis of Khubal Anticline towards North and becomes wider. Khubal structure got prominence in 2009 when a Lower Bhuban Sand of Lower Miocene age produced gas at @ 1,54,474 m³/d through 8mm bean. This discovery is of great significance in eastern Tripura after a number of failures in structures like Hararganj, Langai, Lagntarai etc. In Khubal structure also there is no significant success after KH#D. In southern part of the structure, KH#A KH#B and KH#C in structurally higher position close to anticlinal axis were found dry. In recent past also KH#E & KH#F have gone dry except minor non commercial gas production from KH#E. By the time of writing this paper two wells KH#H & KH#I were under drilling and KH#G was kept aside for testing after drilling completion. So the question arises what happened to the 52m

thick paysand of KH#D ? It can be noted that the sand pinches out in SE direction in KH#F within 1000m. In this study an attempt has been made to find some plausible answers to the failures in exploration pursuits and the way forward. The objective of the study was to establish correlative signature of

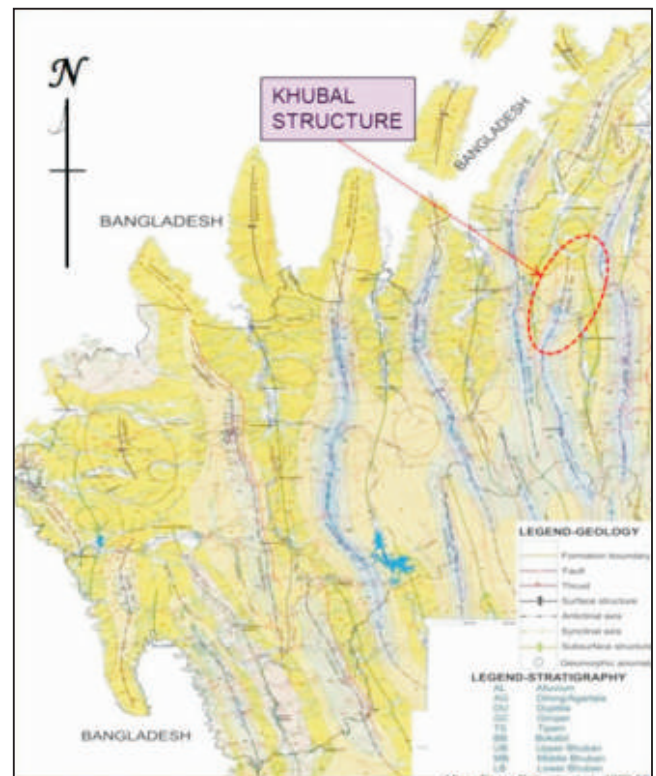


Fig. 1: Geological Map of Tripura

the sand units of Bokabil, Upper Bhuban and Lower Bhuban formations in Khubal and adjoining area. Understanding depositional regime of Bokabil, Upper Bhuban and Lower Bhuban formations in Khubal and adjoining area.



Fig. 2: Satellite image showing Khubal Structure and adjoining Area

Understanding depositional regime of Bokabil, Upper Bhuban and Lower Bhuban Formations, Petrophysical evaluation of the hydrocarbon bearing sand units and identification of prospective areas from Hydrocarbon point of view.

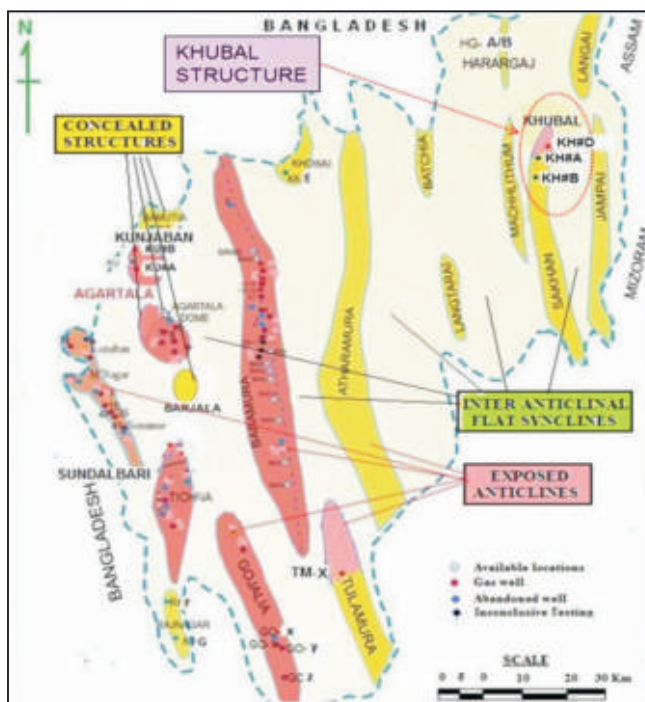


Fig. 3: Map showing structures of Tripura

Geological Setting & Stratigraphy

Khubal structure lies in the eastern part of Tripura Fold Belt (Fig. 1,2&3). Khubal anticline is towards east of Hararganj and Machhlithum Anticline. Jampai and Langai Anticlines are situated towards east of Khubal Anticline Deo

syncline separates it from Jampai Anticline towards east. The structure is a doubly plunging, Anticline trending in NNE-SSW direction with abrupt separation from Sankhan anticline to south by a strike slip fault. The northern plunge of the anticline is broad and well marked, but the southern plunge is short and abruptly truncated. The structure is about 30km long and 15km wide. Two structure building longitudinal reverse faults are well marked. The Campabari Syncline separates it from Hararganj Anticline towards west. The Champabari syncline is narrow towards south where as it takes a turn and almost aligns with the plunge axis of Khubal Anticline towards North and becomes wider. Khubal Anticline exposes about 1900m of Neogene clastics. The oldest formation exposed in the core of the Anticline is Upper Bhuban formation flanked by Bokabil and Tipam Formations. The Upper Bhubans are exposed towards Southern eroded part of the Anticline whereas Bokabil, Tipams towards southern plunge part.

The cross faults have shifted the anticlinal axis as evident from photogeological maps. The generalized stratigraphy of Khubal structure and adjoining areas is given in earlier part of this paper.

Sand Geometry & Depositional Setup

In Khubal area the penetrated sediments consists of Lower, Middle, Upper Bhuban, Bokabil and Tipam and post Tipam sediments. Upper Bhuban and Bokabils are exposed in southern part of Khubal Structure where as Tipams are exposed in the northern plunge part. But in most of the wells only part of Lower Bhuban has been penetrated. It can be observed in correlation profiles(Fig.:4) in the study area that lithologically Upper Bhuban and partially penetrated Lower Bhubans are more argillaceous, where as Middle Bhuban is more arenaceous. Bokabil is represented by massive sand units with intervening shale/claystone bands. Tipams consist of massive fresh water sand units with thin intervening claystone/shale units. Partially penetrated Lower Bhubans are characterised by alternating Sandstone/siltstone and silty shales with major shale sections with more regressive phases. The gas producing blocky massive sand unit of 52m thickness of Lower Bhuban formation has been named as KH-LB-1 as per this study. The log motif of this sand shows a parallel combination of Resistivity, Gamma Ray and Neutron- Density curves (Fig.:7c).The massive sand unit almost pinches out in KH#F towards SE direction. Similarly it pinches out in KH#F, KH#E & KH#A towards west and south west direction. About 45m of the equivalent sand is observed in well KH#G towards west of well KH#D (Fig.:6b) However it becomes more shaly in this well. From the Master Log of KH#D (Fig.:5) it can be observed that it has angular to sub angular, poorly to moderately sorted quartz grains suggestive of a closer provenance. The dispersal pattern of the sand unit is depicted in Figure No:6a which suggests the sand unit to be a combination of stacked tidal channels and bars elongated in NNE-SSW direction in a shallow marine

CHRONOSTRATIGRAPHY		LITHOSTRATIGRAPHY		GENERALISED LITHOLOGY	THICKNESS (m)*	DEPOSITIONAL ENVIRONMENT	REMARKS	
AGE	GROUP	FORMATION/MEMBER						
QUATERNARY	RECENT TO PLEISTOCENE		ALLUVIUM	Loose sands, silts and clays		Fluvial	Present in Northern part. Eroded in central part	
			DHING	Pebble beds, conglomerates and sandstones with thin beds of clay				
***** U N C O N F O R M I T Y *****								
NEOGENE	PLIOCENE	DUPITALA	UPPER	Coarse, pebbly sandstone & mottled clays		Fluvial	Present in Northern part. Eroded in central part	
			LOWER					
	***** U N C O N F O R M I T Y *****							
	MIO-PLIOCENE	TIPAM	GOBINDPUR	Varigated soft & sticky clays often silty with Sandstone		Fluvial	Exposed Present in Northern part. Eroded in central part	
			JAIPUR	Mainly sandstone with clays and claystone.				
	MIOCENE	SURMA	BOKABEL	Alternate layers of sandstone / siltstone and shale with subordinate claystone	600-700	Brackish/Shallow Marine	Exposed in central part	
UPPER BHUBAN			Shale with alternate sandstone/siltstone beds.	500-550		Exposed in south central part		
MIDDLE BHUBAN			Thick beds of shale with siltstone and sandstone alternations.	1000-1200	Outer shelf/Shallow Marine	Fully penetrated		
LOWER BHUBAN			Alterations of sandstone and shale		Brackish/Marginal Marine	Partially penetrated		
***** U N C O N F O R M I T Y *****								
PALAEOGENE	OLIGOCENE TO LATE EOCENE	BARAIL	RENJI	Dominantly sandstone with thin shale layers		Brackish/Marginal Marine	Not penetrated	
			JENAM	Shale and occasional sandstone				
			LAISONG	Alterations of thin sandstone and shale beds				
	EOCENE	DISHANG	DISHANG	Dark grey shale with thin beds of sandstone				

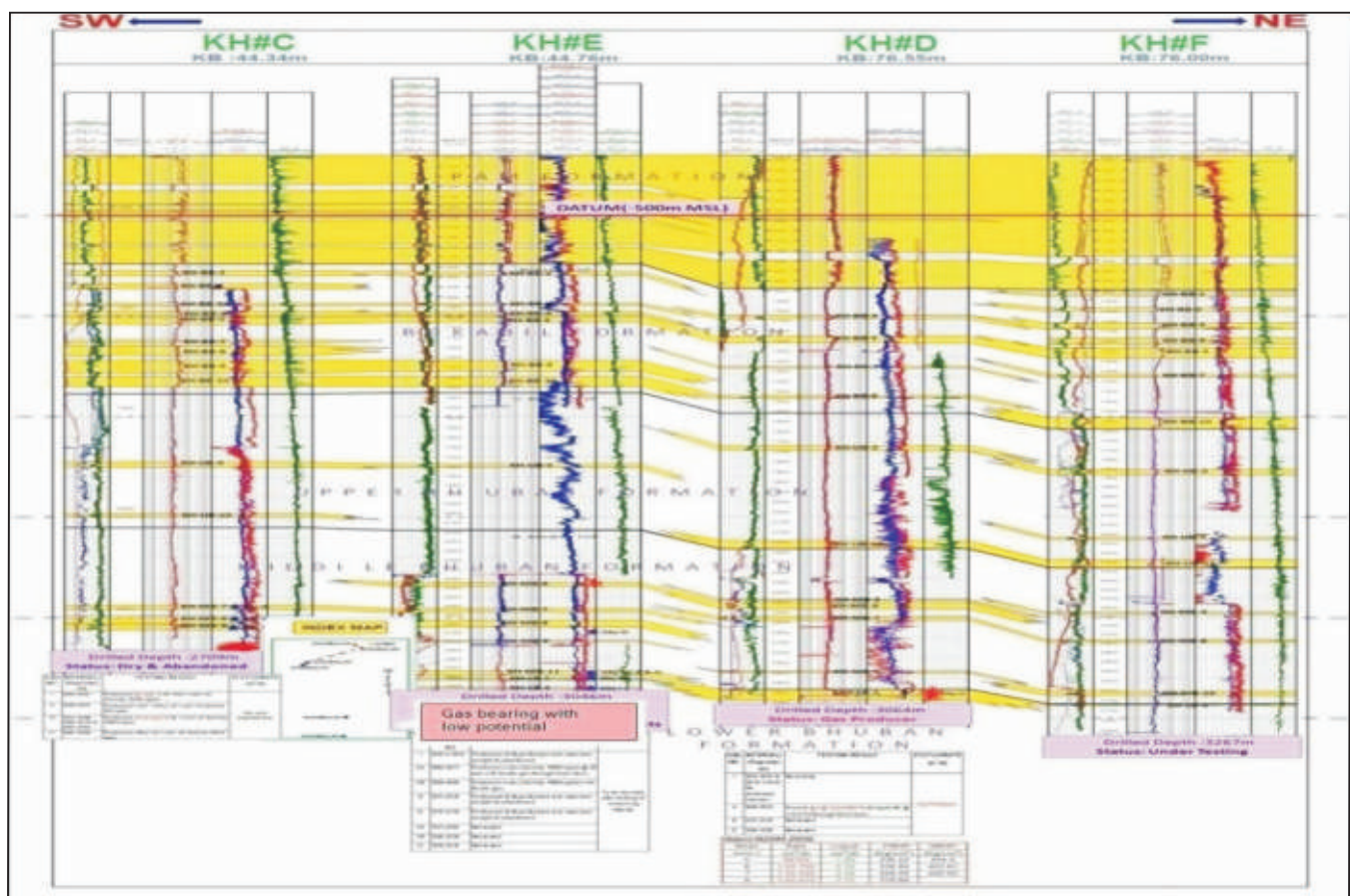


Fig. 4: Structural Correlation along wells KH#C, KH#C, KH#E, KH#D & KH#F

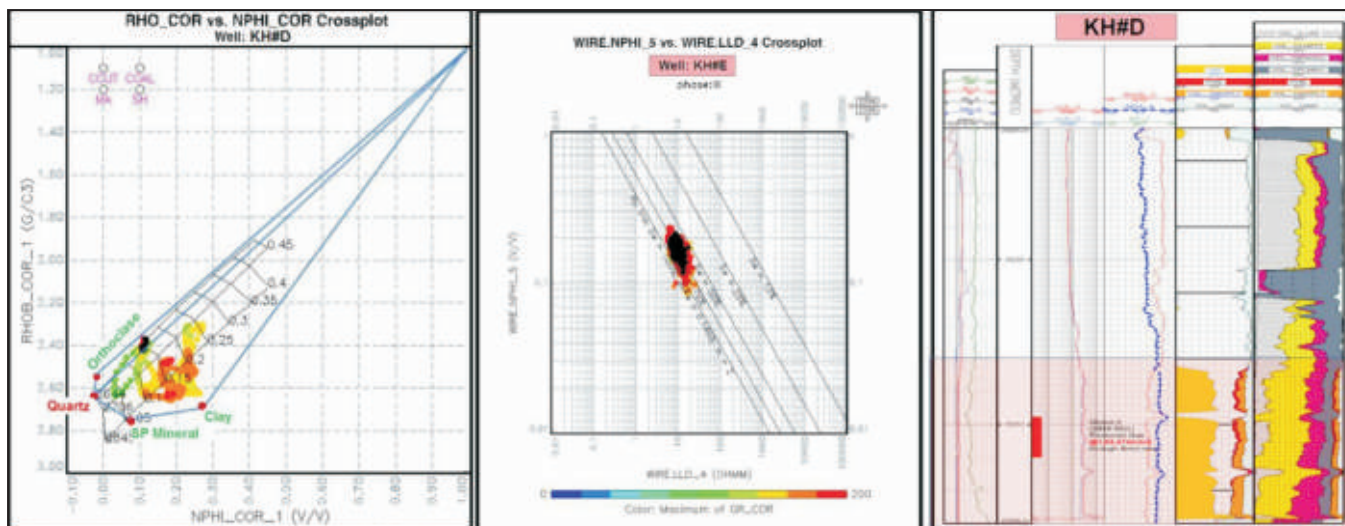


Fig. 7(a): RHO-NPHI cross plot of KH#D (a): NPHI-LLD Crossplot of KH#E (c): Processed output of KH-LB-1 paysand in KH#D

KH#E. At Lower Bhuban top level KH#G is down by 33m w.r.to KH#D. So the producing sand which is 52m thick in KH#D and 45m thick in KH#G is a clear case of Synclinal stratigraphic trap because it is hydrocarbon bearing in KH#G also. There is a narrow low towards east of released location KHYY and further east a rising trend continues which may be prospective from HC point of view. So far no success has been tasted in western rising flank towards Hararganj Anticline from commercial hydrocarbon discovery point of view. But the rising trend towards east w.r.to KH#E looks to be prospective if KH-LB-1 and KH-MB-10 sands are encountered.

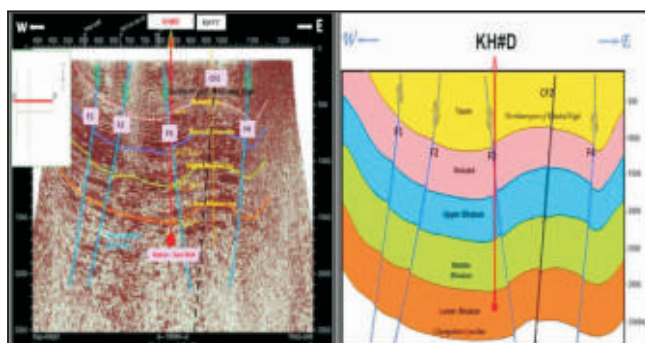


Fig. 9: (a) Interpreted Seismic Section X-X' (b) Seismo-Geological Section along X-X'

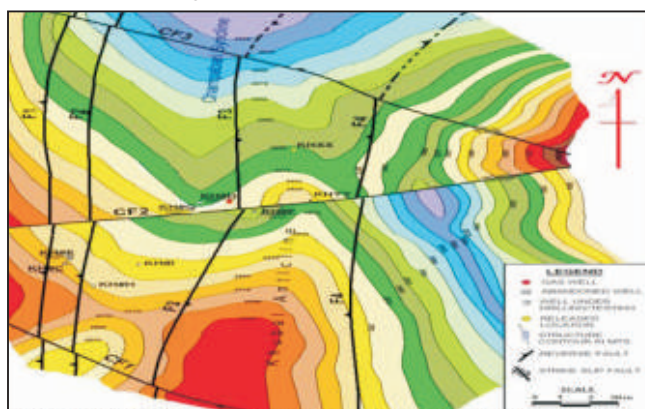


Fig. 10: Structure contour Map at top of Lower Bhuban Formation

Conclusions

- From Geological and petrophysical observations the Lower Bhuban & Middle Bhuban sand units look to be deposited as combination of stacked tidal channels and bars where as Upper Bhuban sand units are deposited in more regressive phase with marine incursions. Sand units of Bokabil formation look to be deposited as stacked distributary mouth bars and distributary channels where as Tipams consist of massive fresh water sand units of stacked braided bars and channels of river systems.
- In Khubal Structure, wells have gone dry with structural advantage and show complex sand dispersal pattern. So a careful exploration strategy should be adopted to identify the vertico- lateral dispersal of discrete sands and their entrapment model rather than puncturing anticlinal highs.
- The concealed northern plunge part along the axial region of Khubal structure is prospective from hydrocarbon point of view with likely undisturbed closure in plunge region for Bhubans, particularly Lower and Middle Bhuban formations.
- The southern and eastern rising trend of Khubal anticline is prospective from hydrocarbon point of view. Identification of entrapment in arenaceous units has to be further narrowed down.
- The Champabari Syncline and the Geomorphic anomaly in Northern part Khubal Structure should be taken for Synclinal exploration for stratigraphic traps after success in KH#D with suitable entrapment condition.

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