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Prospectivity of Hydrocarbon of Zakiganj Area, Sylhet, Bangladesh

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Abstract: ***The southern part of Zakiganj prospect is one of the remaining undrilled potential structure and suitable for hydrocarbon entrapment in Surma Basin. The fold belt is characterized by series of meridional to submeridional folds and extends into the Indian territory of Assam, Tripura, and Mizoram to the east. Considering Tripura and Assam states of India, now exploration targets would be along nose and flanks of major plunging anticlines where prospects are segmented by transverse fault. The surface geology of Zakiganj is covered by young gravelly sand, alluvial silt and clay. Geology of Fenchuganj gas field is similar to that of other fields situated in Surma Basin and reservoirs are covered with Miocene sediments. In Zakiganj prospect the source rock is probably Jenum Formation (Barail Group) of Oligocene age. The reservoirs rock is Mio-Pliocene age Sandstones of Bhuban and BokaBil Formation. Upper Marine Shale is clearly recognized from contour map and supposed to be a regional vertical seal in this area. The traps of fold belts are formed by the anticlinal folds along transverse fault. Intra-formational seals are also recognized from Fenchuganj well data. From Google earth image and subsurface contour map, the best possible prospect might be against transverse fault.***

Keywords: Zakiganj Prospect, Hydrocarbon Trap, Surma Basin, Transverse Fault

1. Introduction

Zakiganj is situated in the eastern fold belt of Surma Basin which is the most prolific natural gas province and has been the center of exploration activities in Bangladesh (Alam et al., 2014). Zakiganj prospect in Surma Basin is located on the north-eastern part of Bangladesh in Block 13 and 14. It is located between 24°51' and 25°4' north latitudes and between 92°18' and 92°30' east longitudes. The prospect area is bounded on the north by Kanaighat Upazila of Bangladesh and Meghalaya of India, on the south-east by Tripura of India, on the west by Kanaighat Upazila and on the south-west by Beanibazar Upazila. Kushiara & Surma river passes along the border of the Zakiganj which is divided into India & Bangladesh. This area is topographically plain land with swampy area. Zakiganj and its adjacent areas lie in between two contrasting structural set-ups, the uplifting Shillong Plateau in the north and subsiding Sylhet Trough (Surma Basin) in the south (Khan et al., 2006). It is surrounded by different gas fields with Miocene reservoirs such as Sylhet, Kailastila, Beanibazar and Fenchuganj in the south-west of Zakiganj area (Figure 7). Previously many works have been done in Surma Basin by use of seismic and well data. The northern portion of Zakiganj area failed to discover any commercial hydrocarbon but hydrocarbon potentiality of southern portion of Zakiganj area is not identified yet. The subsurface two way time contour map shows structural trend with faults of Zakiganj prospect (Figure 6). The present study mainly focused on structural analysis, correlation of seismic lines with Fenchuganj gas sand distribution and petroleum potential analysis over Surma Basin. The objectives of this study are to reveal sub-surface geology of this region and delineation of possible hydrocarbon traps or prospects. 2D seismic lines are covered by Zakiganj prospect in Surma Basin (Figure 1).

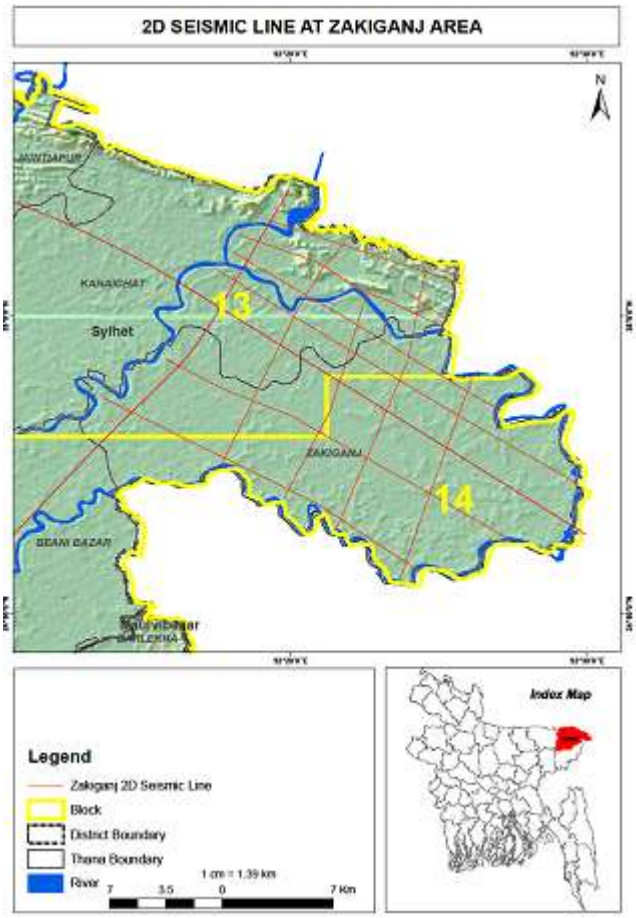

Figure 1: 2D seismic line coverage map of Zakiganj prospect (Baqi et al. 1985)

2. Geologic Overview

Zakiganj structure is located in the Surma Basin is a sub-basin of the Bengal Basin situated in the north-eastern part of Bangladesh. The basin is bounded on the north by the Shillong Massif, east and south-east by the Chittagong-

Tripura fold belt of the Indo-Burman ranges and west by the Indian Shield Platform (Figure 2). The fold belt is characterized by series of meridional to sub-meridional folds and extends into the Indian territory of Tripura and Mizoram to the east. Also known as frontal fold belt, this province represents the western and outermost part of the Indo-Burman origin. The fold belt shows sign of diminishing intensity of structures towards the west in which direction it gradually fade away and merge with the central foredeep province (Figure 3) (Alam et al, 2014).

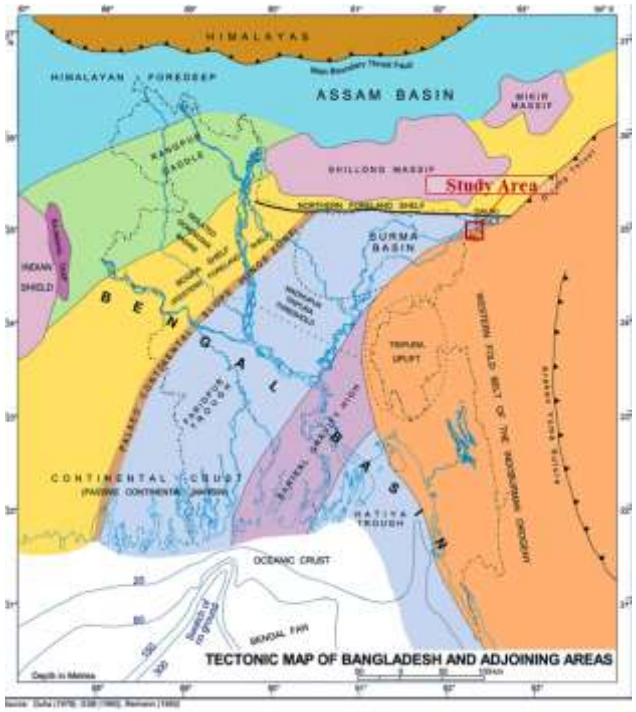

Figure 2: Tectonic Map of Bangladesh (Source: Google Map).

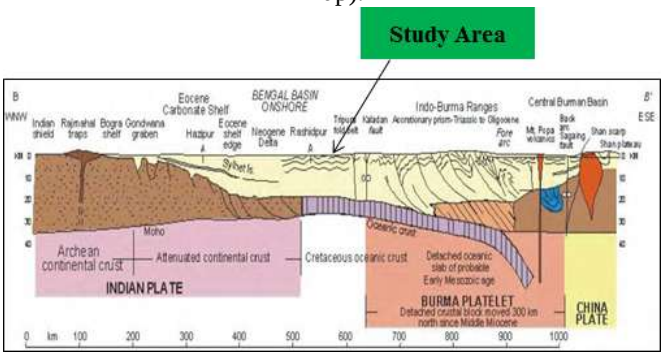

Figure 3: Scematic west-east cross section showing major tectonic province and sedimentary units in Bangladesh. The Bengal Basin evolved into a major depocentre after the late Eocene-Oligocene when the Northward-drifting Indian plate collided with the Eurasian plate resulting in the initial uplift of the Himalayas (Petrobangla, 2000).

Zakiganj subsurface geology shows high relief, tighter folds with faults structure. Thrusting and faulting represents intense tectonic deformation in the area. Structure appears suitable for hydrocarbon entrapment. In Tripura and Assam states of India, different play types already explored along the crest, nose, syncline, flank, transverse faults etc., and they have already drilled many wells in this area. Considering hydrocarbon exploration in the region, including Tripura and Assam area of India, our exploration targets would be along the noses of major plunging anticlines where the reservoirs are segmented by transverse fault (Figure 4). From the Google map, it may be noticed that normally the structural trend of this area is along NE direction but in Zakiganj it is slightly shifted to NW and Kushiara River is flowing in this direction. Possibly a transverse fault is passed along the border of India and the reservoirs are segmented by transverse and reverse faults. In such a case, there are good chances for trapping of hydrocarbon (Figure 4).

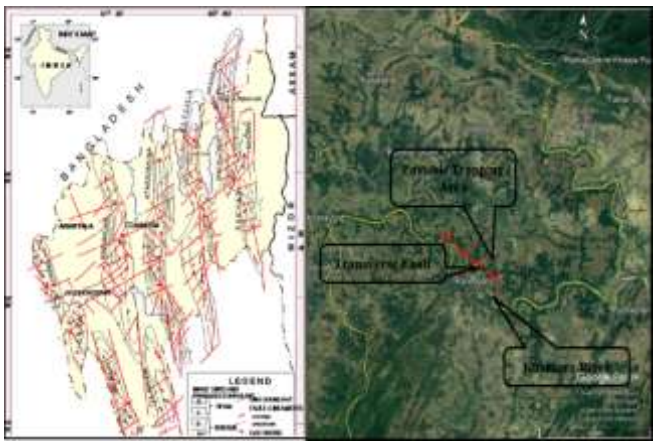

Figure 4: Structural orientation of Tripura in India and Zakiganj (Source: Google Earth).

The prospect area belongs to the sub-basin of the Bengal Basin in north-eastern Bangladesh, contains a thick fill (12 to 16 km) of Late Mesozoic and Cenozoic strata that record its tectonic evolution. This area occupied a slope/basinal setting on a passive continental margin from Late Mesozoic through Eocene time. Oligocene delta plains to delta front lithofacies (Barail Formation) were derived from incipient uplifts in the eastern Himalayas. Subsidence increased markedly in the Miocene time. Early Miocene to Early Pliocene sediments of the Surma Group was deposited in a large, mud-rich delta system that may have drained a significant proportion of the eastern Himalayas (Alam et al, 2014).

Subsidence rates in the area increased dramatically (3-8 times) from Miocene to Plio-Pleistocene time when the fluvial Tipam Sandstone and DupiTila Formation were deposited. Later Tipam SST was eroded at the top of structure and generated local unconformity surface due to the upliftment of this structure. The surface geology of Zakiganj is covered by young gravelly sand, alluvial silt and clay (Figure 5).

The stratigraphy of this area is related to the stratigraphy of the Surma Basin and is based on lithological correlation with rocks in the Assam oil fields. The stratigraphic succession of Fenchuganj gas field is based on geological, seismic and well data. Stratigraphic succession with a brief lithological descriptions of Fenchuganj gas field is given in Table 1. It should be noted that the best reservoirs have been found in the Miocene sediments, mainly composed of alternating grey to dark grey clay, very fine to medium grained sandstones (Islam et al, 2014).

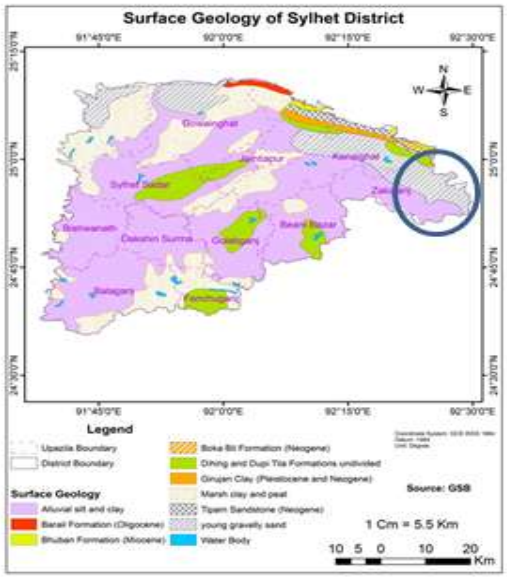

Figure 5: Surface Geology Map of Zakiganj (Source: Geological Survey of Bangladesh)

Table 1: Lithostratigraphic succession of Fenchuganj Gas Field (Islam et al, 2014)

Age	*Formation*	*Depth (m)*	*Thickness (m)*	*Lithology*
Recent	Alluvium	0-30	30	Unconsolidated sand, silt and clay
Late Pliocene	DupiTila	30-298	268	Mostly sandstone and minor clay
Middle Pliocene	Tipam	298-1150	85	Sandstones are light to off white, medium, ferruginous, poorly consolidated and composed of mainly quartz with few mica & dark colour minerals
Miocene	Upper Bokabil	1150-1466	316	Grey to bluish grey shale, soft to moderately hard and compact and also laminated
	Middle Bokabil	1466-1766	300	Sandstone and shale alteration
	Lower Bokabil	1766-2236	470	Mostly shale with minor sandstone
Early Miocene	Upper Bhuban	2236-down to 4977	914-2741 (Vary)	Alteration of sandstone and shale with minor calcareous siltstone

3. Material and Method

The geological, geophysical and well data used in this paper were collected from some local and International publications. The main target of this study was to decipher the surface geology, subsurface structural configuration and tectonics of the Zakiganj structure using this data. In order to construct subsurface structural map and to interpret subsurface geologic features, Petrobangla carried out 12 fold seismic reflection survey over the Sylhet Basin in 1978-1979. During this survey period, some regional lines were also acquired in this target area. Fenchuganj well data analysis and ties with seismic lines give us useful information about selection of seismic horizons. The structural interpretation of study area has been made by well defined seismic reflectors two way reflection times were used to construct time maps. (Banu et al., 2000).

The conversion from velocity to density has been done using the relationship

$\rho=0.31v^{0.25}$
Where, ρ is density in g/cm3.
v is velocity in m/sec (Hossain, 2000).

4. Prospect Analysis

Hydrocarbon generation and accumulations depend on four elements; a source rock, migration path, a reservoir rock and a trapping mechanism/seal. In Zakiganj and Fenchuganj structure, the source of natural gas found in the province is believed to be the shale beds of Jenum Formation (Barail Group) of the Oligocene age. The shale have total organic carbon (TOC) of 0.6% to 2.4% and have attained thermal maturity with vitrinite reflectance of 0.65% at total depth indicating marginal maturity but would be fully mature in adjacent generative depression. It has been suggested that gas has been generated at depths between 6000 to 8000 meters below the surface and migrated up through multi kilometer sand-shale sequence for a long vertical distance before being accumulated in the Mio-Pliocene sand reservoir. Some geologists believe that lower Miocene shale in the lower part of Surma Group may also have generated some gas. Generally Miocene shale have low (<0.5%) TOC content and are thermally immature to generate gas in the drilled structures. But some shale in the lower Miocene Bhuban Formation may have the required TOC and thermal maturity (when within generative depression) to generate some gas.

The reservoirs of the gas in the fold belt province are all of Mio-Pliocene age sandstones generally occurring in the depth between 1000 to 3400 meters. These sand layers belong to Bokabil and Bhuban Formations. The sandstone reservoirs are generally excellent in quality with respect to porosity-permeability values. The sands are generally medium to fine grained, sub litharenite in composition and texturally mature with little clay content. The sand reservoirs originated in the shallow marine to deltaic depositional conditions.

The traps of fold belts are formed by the anticlinal folds with shale seal. The anticlinal structures provide excellent traps for gas accumulation rendering the fold belt a rich natural gas province. The anticline in the fold belt range from simple gentle and concealed undulation in the subsurface in the western part of the fold belt to high amplitude strongly faulted ones with highly rugged surface topography towards east (Alam et al., 2014).

From the Google image (Figure 4)) and subsurface contour map (Figure 6, 7), it may be noticed that the structural trend of this area is along NE direction and prospects are segmented by transverse faults. In such a case, there are good chances for trapping of hydrocarbon. The possible trapping area along transeverse fault is observed in Figure 6. In Zakiganj area, it is observed that all traps are mostly

structural and anticlinal to fault bounded in Surma Basin. The Upper Marine Shale is clearly recognized from contour map and supposed to be a regional vertical seal in the Zakiganj and Sylhet area. Intra-formational seals are also recognized from Fenchuganj well data.

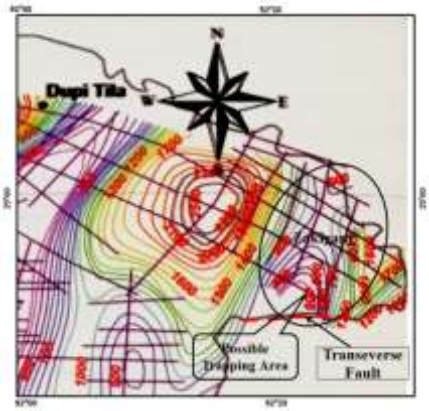

Figure 6: Sub Surface two way time Contour Map of Upper Marine shale in Zakiganj Prospect (Source: Assmann et al. 1983, Baqi et al. 1985 and Biswas et al., 2005).

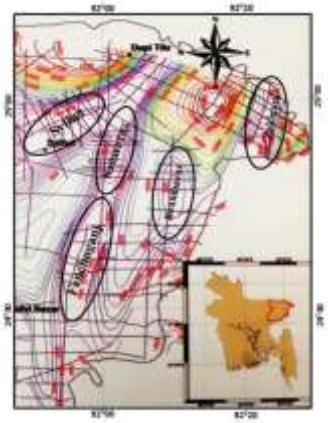

Figure 7: Two way time contour map for Upper Marine Shale in Sylhet basin (i,e. Top Bokabil Formation; modified from the data Assmann et al. 1983, Baqi et al. 1985 and Biswas et al., 2005). The available seismic grid has been overlain on the time contours in order to mark the density of seismic investigation in basin.

5. Conclusion

The main stratigraphic sequences observed in Fenchuganj wells can be correlated to the Zakiganj prospect area confirming that both areas share the same basic geology. It can therefore be inferred that the formation of NE to SW Zakiganj and google image with sub surface contour maps indicates the possibility of hydrocarbon in the equivalent sedimentary sequence, since Zakiganj area being more closer and down dip towards the kitchen area both in the east and west. The best possible trapping areas might be against transverse fault which indicate good chance to trap hydrocarbon. The Upper Marine Shale is recognized from contour map and supposed to be a regional vertical seal in Zakiganj prospect and Sylhet Basin. From overall interpretation, southern portion of Zakiganj structure displays prospect separated by transverse fault.

6. Recommendations

Further improvement could be achieved by generating AVO, 3D seismic data and well data and other factors of petroleum system (e.g. reservoir property, seal capacity, fluid substitution model) review in more detail with referring near field property.

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Author Profile

Rabeya Basri received the B.S. and M.S. degrees in Geological Sciences from Jahangirnagar University, Savar, Dhaka in 2005 (held in 2007) and 2006 (held in 2009), respectively. From 2009 to present time, she is continued her job as a Geophysicist in Seismic data Interpretation, Geophysical Division, BAPEX using of different softwares (Petrel, Geotrace, Hampson Russell, Platte River Associates etc.).