T33-320227 Geodynamic Modeling and Hydrocarbon Potentiality in Bengal Basin, Bangladesh

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Abstract

Bangladesh occupying the largest delta-basin in the world, formed at the convergent plate boundary of India and Eurasia, has been known as potential gas rich province. The Indo-Burma plate boundary divided Bangladesh into two tectonic sub-units. The western plain land formed by the 19 km thick Cenozoic sediments, derived by the Ganges-Brahmaputra-Meghna river system, represents about 88% of Bangladesh. The remaining eastern 12% is geologically defined as the Chittagong fold-thrust belt (CFTB) formed by the convergence of India and Asia plates. The CHTB is basically the western extension of Indo-Burma accretionary prism formed from the Paleo-gene-Neogene sediments accreted onto the non-subducting Burma sub-plate. The compressional crustal shortening produces folds and thrust along the eastern part which increase thermal maturity and brought the deep-sited source rocks at a shallow proximity to the potential reservoirs. Moreover, the tectonic activities create HC migration pathways from the source to the reservoir horizon. Both onshore and offshore HC exploration in Bangladesh suggests that the structural closures are only available in the accretionary prism and no structures have so far been reported in the western part. Hence, significant gas reserves have been found in the eastern structural traps, whereas no commercially viable reserves have been discovered in the western part yet. However, the full potential of natural gas has not been unearthing due to lack of enough exploration. Important to note that the proven reserves will be finished within 10 years, which is a potential threat against the ongoing development activities in Bangladesh. Petroleum geologist believe that there is significant “yet to find” natural gas in the underground and these may be recovered should a serious drive of exploration is undertaken. Recent settlement of maritime boundary with neighboring countries open a new frontier in HC exploration particularly in Offshore Bangladesh. There is a big question whether there are any HC potentials in the western part of Bangladesh. Yet as a mega delta basin Bangladesh geology is likely to be dominated by stratigraphic plays. Development of sand prone clinoforms due to delta progradation together with diversified prospects like channel sand, pinch out, thin beds, to name a few have huge potentials for HCs both in the eastern and western parts. There are ample opportunities for undertaking research studies on these to upgrade the knowledge and data base for exploration targets.

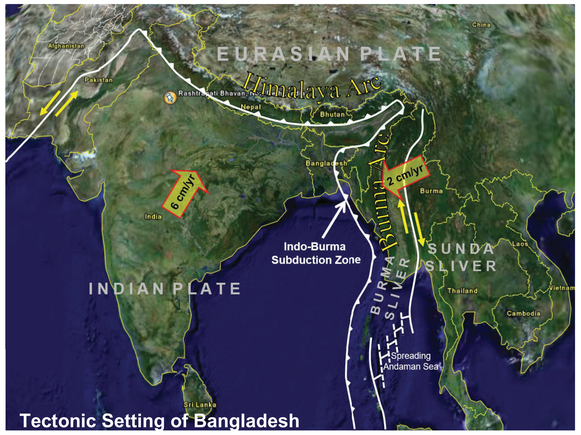


Figure 1: Bangladesh, a densely populated country in southeast Asia, is located in the northeastern part of Indian sub-continent at the head of Bay of Bengal. Tectonically, Bangladesh lies in the northeastern Indian plate near the edge of the Indian craton and at the junction of three tectonic plates – the India plate, the Eurasian plate and the Burma subplate. The collission of India with Eurasia about 50 million years ago gave rise to great Himalaya to the north and Indo-Burma Ranges to the east. These form two boundaries where plates converge– the India-Eurasia plate boundary to the north forming the Himalaya Arc and the India-Burma plate boundary to the east forming the Burma Arc. The Indian plate is moving ~6 cm/yr in a northeast direction and subducting under the Eurasian (@ 45 mm/yr) and the Burmese (@ 46 mm/yr) plates in the north and east respectively. This continuous motion is taken up by active folds and faults. The active tectonism together with sedimentation result in the development of fluvial-deltaic-marine deposits along the Indo-Burma plate boundary. As a result, Bangladesh covers the worlds largest delta basin called Bengal-Delta Basin: eastern part occupies the accretionary prism and the western part covers a thick sedimentry wedge (approximately 19 km thick basin-fill wedge)

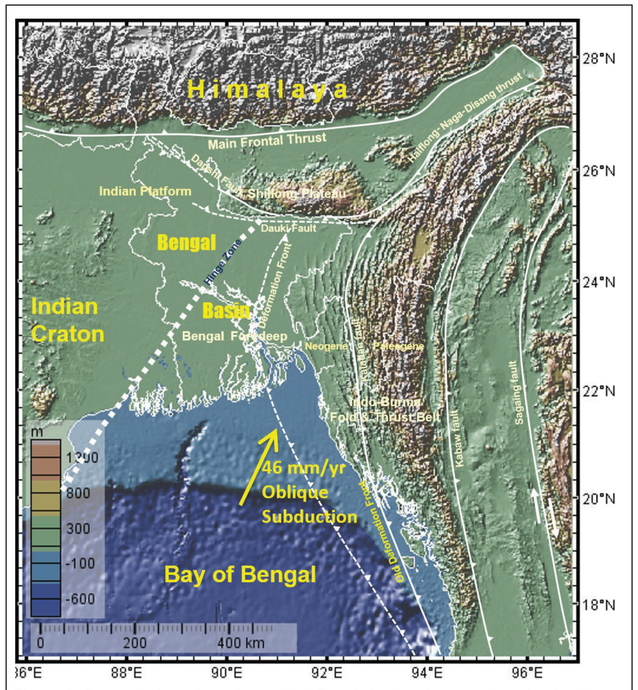


Figure 2: Conceptual geodynamic model of Bangladesh and surrounding showing the major tectonic elements. Bangladesh occupies the major part of the Bengal Basin and entirely sits on the Ganes-Brahmaputra-Meghna (GBM) Delta - the largest delta in the world. The delta is very active with rapid sedimentation and high subsidence rate. About 88% of the country is low lying flat landscape with 19 km thick sequence of Neogene and Quaternary sediments. The rest 12% landmass in eastern Bangladesh and its continuation further to the east in northeast India and Myanmar represents Tertiary hills. The Tertiary hills are characterized by 250 km wide and 1400 km long fold and thrust belt resulting from the oblique convergence of India-Burma plates. These are deformed into a series of N-S trending en echelone folds and thrust faults. It marks the subduction zone between the under-thrusting Indian plate and overriding Burma plate - a northern extension of the Sumatra–Andaman subduction zone.This fold and thrust belt evolved through a process of two generation of deformation- firstly during Paleogene in Myanmar-Mizoram segment and secondly during late Neogene in Chittagong-Tripura segment. The anticlines of Paleogene deformation are very close, tightly folded and intensely folded whereas the anticlines of Neogene deformation are widely seperated by broad synclines. The Paleogene and Neogene structures are separated by Kaladan fault represents the old deformation front. The deformation front advanced towards west into the deltaic Bangladesh. The deformation front runs near the low elevation Meghna estuary to the south and Sunamgong-Kishorgong marshes to the north.

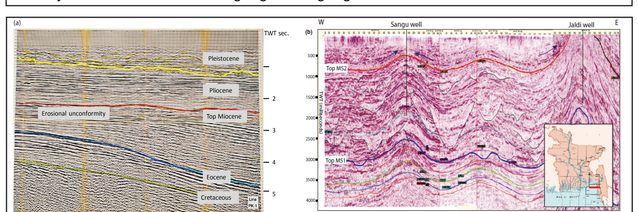


Figure 3: Section through Stable Shelf area near Hinge Zone (a) and across Hatia trough (b). The oblique convergence of India plate with Burma plate produced wide accretionary wedge. The wedge is gently folded and underthrusting to the Burma plate which facilitate formation of structural and stratigraphic traps, source rock maturation and migration pathways whereas the westenr basin fill wedge represents mild undulation and differential compaction and provides mostly stratigraphic traps.

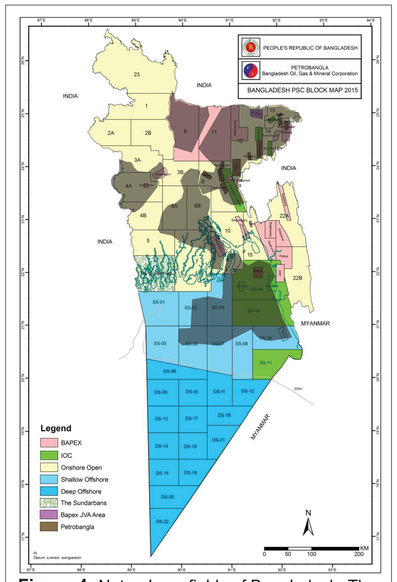


Figure 4: Natural gas fields of Bangladesh. The gas fields so far discovered has been found in the anticlinal structures. These structures are located in accretionary wedge and are buried anticlines of the fold and thrust belt. The amplitude of these burried anticlines is much less than the exposed anticlines. The western parts of Bangladesh do not indicate large scale HC exploration due to lacking of structural traps, deeply burried source rocks and uncertainty of migration pathways. Hydrocarbon exploration (Grey shades) in Bangladesh is mostly concentrated at onshore areas.

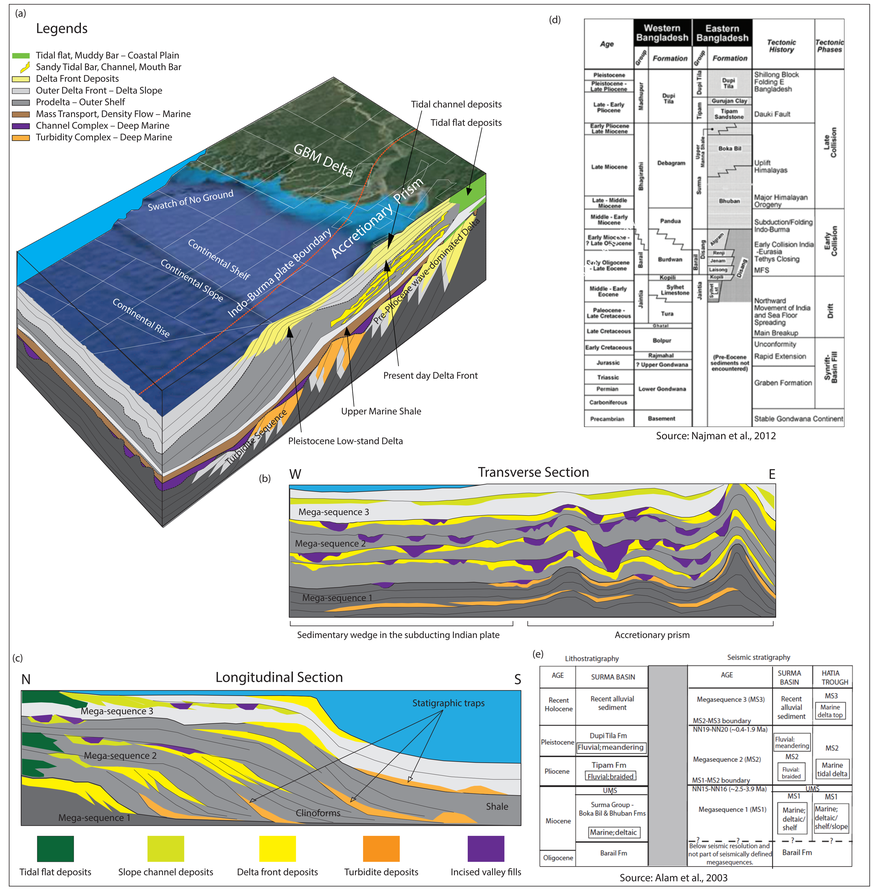
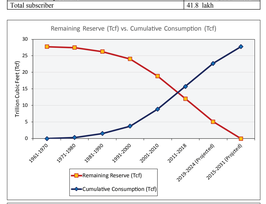


Figure 6: Tectono-Sedimentation Model of Bangladesh (a), transverse (b) and longitudinal (c) sections across the Tectono-Sedimentary model, traditional Stratigraphic succession in western and eastern part of Bangladesh (d) and Seismo-stratigraphic succession in the accretionary Prism of Bangladesh (e). The Indo-Burma plate boundary divided Bangladesh into two tectonic sub-units. The western plain land formed by the 19 km thick Cenozoic sediments, represents about 88% of Bangladesh. The remaining eastern 12% is geologically defined as the Chittagong fold-thrust belt (CFTB) formed by the convergence of India and Asia plates. The CHTB is basically the western extension of Indo-Burma accretionary prism formed from the Paleogene-Neogene sediments accreted onto the non-subducting Burma sub-plate. In the eastern part tectonic activity increased the thermal maturity and brought the deep-seated source rocks at a shallow proximity to the potential reservoirs. Moreover, the tectonic activities create HC migration pathways from the source to the reservoir horizon. Both onshore and offshore HC exploration in Bangladesh suggests that the structural closures are only available in the accretionary prism and no prominent structures have so far been reported in the western part. Hence, significant gas reserves have been found in the eastern structural traps, whereas no commercially viable reserves have been discovered in the western part yet. However, plenty of stratigraphic traps might be encountered in the eastern accretionary prism as well as in the western sedimentary wedges. The stratigraphic traps include delta-front sand deposits and deep marine turbidite sequences. The prodeltaic and outer fan shales are important source of biogenic gas reserves for the potential stratigraphic traps. Recent discovery of Shwe gas filds in the Rakhine Basin is a good example of Biogenic gas reserves.

Gas exploration, reserves and consumption in Bangladesh (Source: Petrobangla, updated in 2018)

Content	Number(s)/Amount
Total gas fields	27 nos.
Gas fields in production	19 nos.
Number of total wells in production	110 nos.
Current gas production capacity	2,750 mmcfd
Maximum gas production date (06 May, 2015)	2,785.8 mmcfd
Total estimated gas reserves (Proven + Probable)	27.77 TCF
Cumulative gas production from startup (up to December'17)	15.22 TCF
Remaining gas reserves (Proven +Probable)(up to January'18)	12.54 TCF
The current daily demand	more than 3,996 mmcfd
Total subscriber	41.5 lakh



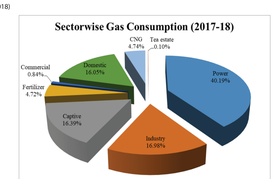


Figure 5: Gas exploration activities, remaining reserves and yearly production, sectorwise and yearly consumption scenarios in Bangladesh (Source: Petrobangla, updated in 2018). The predicted consumption and production scenarios indicate that so far discovered gas reserve may fullfil the demand until 2031. In order to address the inreasing demand to achieve sustainable development in Bangladesh, a huge drive for HC exploration is necessary. The area covering the eastern accretionary prism is the ideal place for extensive HC exploration. Exploration in the western part is also equally important.

Conclusion

Bangladesh has huge potentiality of gas reserve and significant gas reserves have been found in the structural traps particularly in the accretionary prism. Gas demand-consumption scenario indicate a rapid depletion of known reserve. However, the full potential of natural gas has not been unearthing due to lack of enough exploration. There is significant “yet to find” natural gas in the underground and these may be recovered should a serious drive of exploration is undertaken, particularly in the offshore accretionary prism. Exploration in the western part is equally important to address the increasing demand and depletion of gas reserve. There are ample opportunities of research studies on these to upgrade the knowledge and database.