Ancient ocean floor hidden beneath Bangladesh

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The geographical location of Kolkata, where the city now exists with a metropolitan population of over 15 million, was once on the verge of the continental margin and was also neighbouring the proto-ocean of the Bay of Bengal (BoB). As a consequence, most part of the present Bangladesh territory was under ocean water during the geological past.

Detachment of micro-continents and excessive sediment deposition on continental margins add more complexities to the ocean floor as well to continental regions, making it difficult to reconstruct precise plate tectonic history. These processes may lead to trapping of micro-continental pieces within the oceans and oceanic territories beneath land masses. As a result, one can rarely find old-aged, continental, sliver-like Seychelles micro-continent in the northwestern Indian Ocean[1,2] and Elan Bank in the southern Indian Ocean[3–6] encircled by oceanic crustal rocks; it is even more rare to find the presence of oceanic rocks beneath land masses.

The rifting of eastern part of Gondwanaland ca. 132 Ma (Early Cretaceous) led to the break-up of Greater India from the Gondwana supercontinent. Associated with this event was the opening of a new oceanic domain along the eastern margin of India called the proto BoB (Figure 1). Talwani *et al.*[7] integrated all available geophysical signatures from Bangladesh region, Western Basins of the BoB and Enderby Basin of East Antarctica, and found that the second continental break-up had occurred between the Rajmahal-Sylhet Line and the northern margin of the micro-continents (Elan Bank and parts of the Kerguelen Plateau) ca. 120 Ma (Figure 2 *a*). This break-up event is considered to have been triggered by the Kerguelen hotspot that led to eruption of Rajmahal and Sylhet flood basalts (traps), which are exposed in eastern India and on the Shillog Plateau respectively. The exposed Rajmahal Traps extend in the subsurface up to the eastern border of Kolkata metropolitan city, where it is overlain by Gangetic alluvium[8]. As the BoB continued to evolve, rivers of the Indian peninsula and the Himalaya continuously carried terrigenous material into it. The sediments discharged principally by the Ganga and Brahmaputra rivers built an alluvial cover of more than 18 km thickness in the Bengal Basin to the east of Kolkata, which constitutes a major part of the region of present-day Bangladesh[9–12].

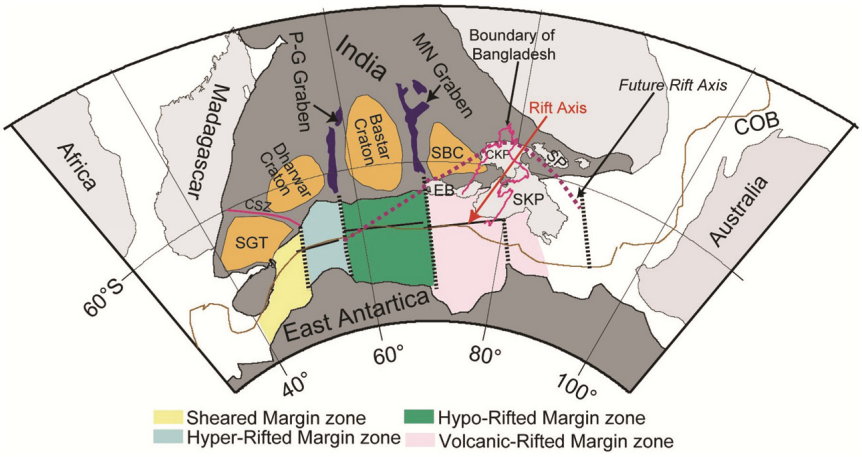

Figure 1. Schematic plate configuration model of the eastern Gondwanaland[18] depicting how segments of the Indian subcontinent, particularly with reference to its cratonic blocks, rifted from East Antarctica. The micro-continents, Elan Bank (EB) and parts of the Kerguelen Plateau (CKP and SKP) are seen as part of the Indian subcontinent during the rift phase and initial spreading process. SGT, SBC and SP represent the blocks of Southern Granulite Terrain, Singhbhum Craton and Shillong Plateau respectively. CSZ, P–G Graben and MN Graben indicate the features of Cauvery Suture Zone, Pranahita–Godavari Graben and Mahanadi Graben respectively.

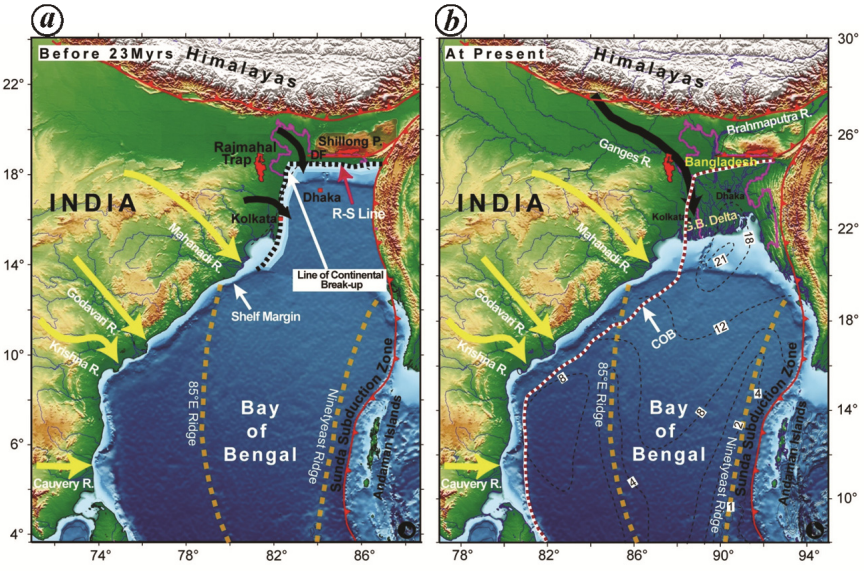

Figure 2. ***a***, Configuration of the Indian subcontinent and Bay of Bengal (BoB) prior to 23 Myr ago. Thick black dashed line shows location of the line of continental break-up that occurred at about 120 Ma and also the northernmost coastline of BoB. ***b***, The present-day configuration of the Indian subcontinent and BoB. The ancient ocean floor of the BoB was completely buried under the terrigenous sediments derived from the Himalaya. The white dashed line running parallel to the east coast of India and into the Bangladesh region indicates the boundary separating the continental rocks from the oceanic rocks. Thin black dashed contours represent the total sediment thickness.

Accumulation of such tremendous thickness of sediments completely carpeting the attenuated continental and undeformed oceanic rocks is a rare or unique feature on the earth's crust.

Earth scientists have been curious to know what kind of crust lies beneath this great thickness of sediments in Bangladesh and adjacent areas. Are the basement rocks continental, similar to those that exist along the eastern margin of India up to east Kolkata, or in the northwestern part of Bangladesh and the Shillong Plateau, or are they rocks of the oceanic crust found in the BoB? Recent geophysical researches in Bangladesh and the BoB using different geological and geophysical proxies show that oceanic, not continental type of crust lies beneath the alluvial cover over most parts of Bangladesh[7,8,13]. Seismic experiments in Bangladesh point to the presence of seaward-dipping reflectors that are considered a unique feature of volcanic rifts[14,15]. Prominent magnetic anomaly doublets and negative free-air gravity anomaly strip observed between Kolkata and Chotanagpur Plateau marks the boundary of the rift zone with the adjacent continental crust[8]. Passive experiments such as teleseismic receiver function analysis and Rayleigh-wave dispersion analysis in the onshore Bengal Basin have brought out contrasting crustal models, indicating the presence of continental rocks in the western region of the Bangladesh and oceanic rocks in the east[16,17]. The boundary separating the continental crust from the oceanic crust runs close to Kolkata city in the western part of the Bengal Basin and south of the Shillong Plateau.

Ismaiel *et al.*[13] studied industry-quality seismic reflection data together with magnetic and gravity data of the entire eastern margin of India, the Bangladesh margin and adjacent deep-water regions for unravelling the mode of rift evolution terminating the Indian Shield continental rocks in the offshore and onshore regions. They examined new and more trustworthy proxies related to rift structures, basement trends, continuity of onshore structures (grabens/shear zones) into offshore region, depths to the Moho boundary and crustal thickness beneath East India and Bangladesh margins. The study revealed that while the rift bounding the BoB truncates the shear zones of Southern Granulite Terrain, Dharwar Craton and Eastern Ghat Mobile Belt, surprisingly, beneath Bangladesh no rift-related structures representing the fracturing of continent are observable, implying that the line of continental breakup must be far to the north of the present-day Bangladesh coastline. Using the new proxies, Ismaiel *et al.*[13] demarcated the boundary that separates much older continental rocks from the younger oceanic rocks. It runs nearly parallel to the coastline of peninsular India all the way up to the north of Mahanadi Basin, but takes an orthogonal turn going through east of Kolkata and joins the Rajmahal–Sylhet Line in the onshore Bengal Basin (Figure 2 *b*). Absence of rifted continental crustal blocks on the Bangladesh coast and continuity of the continent–ocean boundary onshore along Rajmahal–Sylhet line suggest that the present Bangladesh region was under marine conditions at least until the beginning of Bengal Fan sedimentation about 23 million years ago (Figure 2 *a*). The proposed tectonic model goes well with the presence of granitic rocks in Maddhapara mining in the northern part of Bangladesh. A petroleum company, drilled more than 70 wells in Bangladesh region, but could not recover basement rocks as the sediments reach up to 18 km thickness[11].

It is evident that oceanic rocks were accreted by seafloor spreading up to Kolkata and towards north up to Rajmahal–Sylhet line in the West Bengal Basin. The primitive oceanic rocks of the BoB, are buried under large volumes of terrigenous sediments brought by the Ganges and Brahmaputra river systems from the Himalaya that are exposed over a major part of Bangladesh. Presence of continental slivers in global oceans either completely buried under the sediments or surviving as islands is commonly known. However, extension of oceanic crust well within the land mass appears to be a rare feature. The Bengal Basin region constitutes a good example.

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