

## An island chain lost in the Bay of Bengal

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A voyage from Chennai across the Bay of Bengal takes one eventually to the Andaman Islands. But it was a different situation in the geologic past during the Late Cretaceous (80–68 m.y. BP). There was a chain of islands somewhere midway which currently lies as the buried 85°E Ridge beneath enormously thick sediments discharged by the Ganges and Brahmaputra river systems.

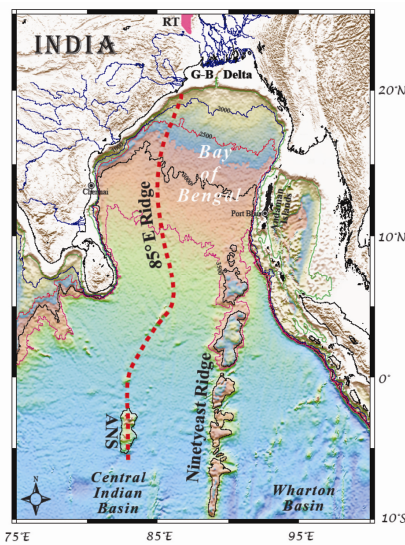
The 85°E Ridge, located in the Bay of Bengal extends from the Mahanadi Basin in north Bay of Bengal to the Afanasy Nikitin seamounts in equatorial Indian Ocean for a distance of about 2500 km (Figure 1). This is an enigmatic geological feature as it possesses inexplicable gravity and magnetic signatures. The ridge structure in the Bay of Bengal is associated with prominent negative free-air gravity anomaly<sup>1</sup>, despite its excess mass and alternative streaks of unevenly distributed positive and negative magnetic anomalies<sup>2</sup>. Therefore, the 85°E

Ridge is an unusual oceanic feature and contrasts its geophysical signatures from that of many other well-studied global seamount chains. In spite of more than three decades of research carried out by scientists from different countries, the origin of the Ridge still remains a conundrum. Recent research carried out on the 85°E Ridge has brought out some intriguing yet new insights on the style of accretion of the Ridge, and its burial under the Bengal Fan sediments and subsidence caused by plate cooling and overburden loads<sup>2-7</sup>.

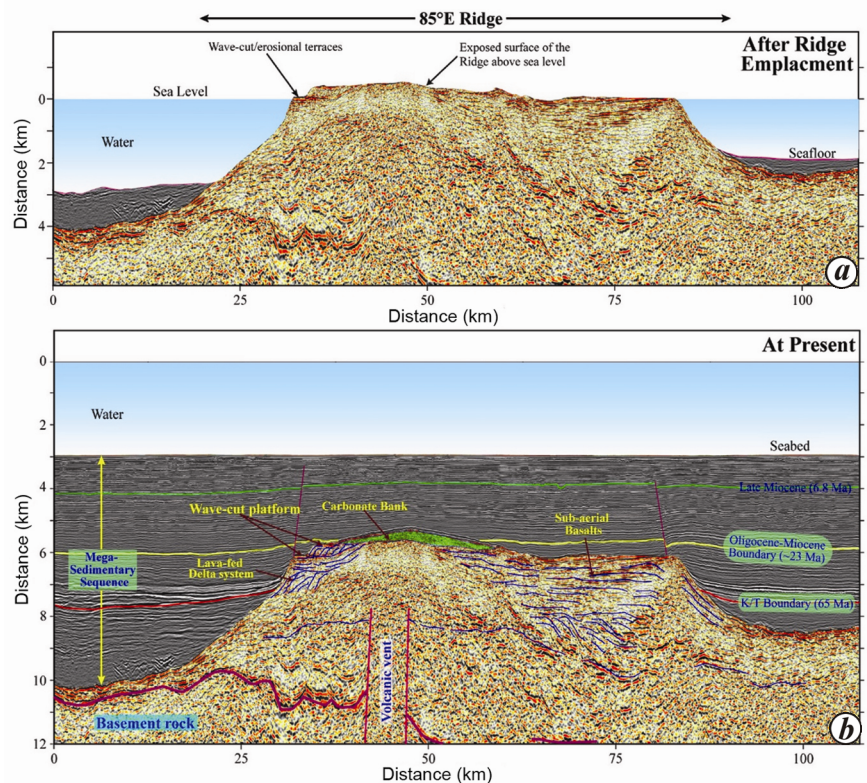
Evolution of ocean floor in western part of the Bay of Bengal commenced during the Early Cretaceous when the Greater India and Australian–Antarctic continental blocks began to separate<sup>5,8-10</sup>. Soon after at ~118 Ma, two smaller continental fragments – Elan Bank and southern part of the Kerguelen Plateau – detached from the northeastern margin of India and Rajmahal–Sylhet line respec-

tively. This led to formation of ocean floor in the eastern part of the Bay of Bengal. Later, during northward drift of the Indian plate, mantle sources left their footprints over the existing ocean floor of the Bay of Bengal as linear volcanic constructs, viz. 85°E and Ninetyeast ridges. While the structure and tectonics of the Ninetyeast Ridge were clearly deciphered<sup>11-13</sup>, in case of the 85°E Ridge, the debate particularly on source is still continuing.

Earlier Krishna<sup>3</sup>, and Sreejith *et al.*<sup>4</sup> had concluded that around 80 m.y. ago, the 85°E Ridge was emplaced on 35-Myr-old pre-existing oceanic crust. Considering thermal subsidence of the ocean floor and effects of volcanic and sediment loads, we show seismic structure of the 85°E Ridge for two different stages – emplacement time (~80 Ma) and Present (Figure 2). At the time of ridge emplacement, the ocean floor existed at about 4 km depth from sea level and was



**Figure 1.** General bathymetry map of the northeastern Indian Ocean showing location of the 85°E Ridge between 20°N and 5°S lat. The part of the ridge in the Bay of Bengal is completely buried under the Bengal Fan sediments, whereas the southern part is intermittently exposed to the seafloor. The map also includes northern part of the Ninetyeast Ridge, Central Indian Basin and Wharton Basin. G–B Delta and ANS represent Ganges–Brahmaputra Delta and Afanasy Nikitin seamount respectively.



**Figure 2.** Seismic structure of the 85°E Ridge shown for two different ages: **a**, Emplacement time (~80 Ma); **b**, Present. The seismic profile crosses the Ridge approximately along 15°N lat.

covered with thin veneer of sediments. The sediments on the western flank of the Ridge were relatively thicker reaching to about a kilometre (Figure 2 a), as most sediments flowed during this period from the eastern peninsular India to deep sea region<sup>6</sup>. In fact, the Ridge feature stood as a structural boundary for sediments to move to the other side (east) of the Ridge.

Recently, Ismaiel *et al.*<sup>7</sup> have carried out volcano-stratigraphy of the 85°E Ridge to understand its stage-by-stage build-up through geologic time. They found that the Ridge structure consists of volcanic vent, packs of prograding clinoforms, eroded wave-cut terraces, lava delta fronts, etc. (Figure 2). They further concluded that volcanism began during the Late Cretaceous (~85 Ma) and continued up to 80 Ma under sub-aerial conditions. Once the volcanic activity ceased, the Ridge summit height ranging from 500 to 1000 m may have existed above sea level (Figure 2 a); subsequently the Ridge feature subsided due to thermal subsidence and volcanic load. Following the subsidence curve of Detrick *et al.*<sup>14</sup>, the Ridge summit lying above the sea level may have taken about 6–12 Myr to subside all the peaks of the Ridge below the sea level. During this submergence process, edges of the Ridge summit may have been subjected to the actions of waves leading to formation of eroded flat surfaces (Figure 2 a). When the Ridge summit was passing through or remained for a short span of time in shallow water conditions, a lenticular shape carbonate sequence was formed over the apex of the Ridge (Figure 2 b). The features of wave cut-based erosional platforms and carbonate build-up are strong evidences to indicate that the Ridge peak remained above sea level as an island for a short period during the Late Cretaceous. Subsequently, the sediments deposited up to Oligocene–Miocene (~23 Ma) totally covered the Ridge structure, and from then onwards the

feature remained below the seafloor and buried under the Bengal Fan sediments (Figure 2 b).

From the above deductions, it appears that the 85°E Ridge remained as a series of island mounts with variable reliefs in the middle of the Bay of Bengal during the Late Cretaceous and got completely submerged below the sea level by 68 Ma. The inferred nature of volcanism, presence of wave-cut terraces at different levels and lava deltas strongly support the inference of sub-aerial nature of the 85°E Ridge. Additionally, interpreted carbonate bank also supports the above inference that the Ridge remained in shallow water conditions for quite a long time. The processes of thermal subsidence and sedimentation and load put together placed the island chain (85°E Ridge) below the sea level, and then below the thick pile of Bengal Fan sediments. In case such submergence did not happen, the 85°E Ridge would have remained an island chain analogous to present day Maldives Islands in the Indian Ocean and Hawaiian Islands in the Pacific Ocean. Then it would have acted as a 'natural geo-wall' protecting the mainland of India from devastating tsunami waves generated near the Sunda subduction zone. Now, an important question arises whether India lost additional land part under her territory and the answer is probably an unfortunate 'yes'.

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