Tectonic Disposition and Hydrocarbon Potential of 85° East Ridge in Bay of Bengal*

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Abstract

The 85° East Ridge is a very significant geological feature of the Bay of Bengal in the Indian Ocean. The present study has revealed an interesting tectonic evolution and prognosticates a very high hydrocarbon potential in successive wedge-outs on either side, as well as coralline reef complexes capping this ridge. This sinuous feature meanders along the 85° east longitude in the northern part and gently curves towards the southern tip of peninsular India in its southern part. This ridge is completely buried under the uninterrupted Tertiary succession and Quaternary Ganga-Brahmaputra submarine fan deposits. Earlier views suggested that this ridge represents a trail left by a hotspot on the northerly moving Indian Plate. The present study based on interpretation of seismic profiles generated by Pre-Stacking and Depth Migration (PSDM) techniques has suggested that this ridge has originated due to a combination of tectonic and related igneous phases. The upward reverse movement along nearly vertical faults is believed to have taken place during Cretaceous igneous activity. The ridge portion is believed to represent a felsic phase while extensive mafic volcanics on either side of the ridge represent an extrusive phase. The gravity low associated with this ridge is thus believed by the present authors to be due to this density contrast. The central axis of the ridge is incised indicating continuing extensional tectonics. Extrusive phase corresponds with colossal and pulsatory Cretaceous volcanic flows in land areas of peninsular India. In oceanic regions, these volcanics are overlain by an uninterrupted Tertiary sedimentary succession. The intrusive relationship with this succession indicates a Cretaceous-Tertiary event, where Paleocene succession is affected and its wedge-outs are conspicuously seen. The faults located on top of this ridge, form an hour-glass structure, with upward continuing intersectional region. They form several umbrella like growth of coral reef complexes. Interpretation of high resolution satellite gravity data has helped in mapping the southern extension of the 85° East Ridge. The present study has also indicated that this ridge curves around peninsular India along with other oceanic features. The study of sections across the 85° East Ridge from the PSDM seismic profiles and its lateral extension from the satellite gravity data does not support earlier views of its origin due to a hotspot.

Discussion

The 85° East Ridge is a very significant geological feature of the Bay of Bengal in the northern part of the Indian Ocean. The present study elucidates the geological and geophysical features associated with it and prognosticates the hydrocarbon potential in its contiguous region.

Other significant oceanic ridges located along 82^0E and 90^0E longitudes, as well as less prominent ridges have also been studied to understand the similarities and dissimilarities between them. An attempt is also made to explain their common tectonic origin and relationship to igneous activity. The 85°East Ridge is hidden below the sediments and was identified by Curry et.al. (1982) after processing the gravity data. They suggested that the ridge represents a trail left behind by a hotspot in the northerly moving Indian plate. Anand et al. (2008) obtained gravity and magnetic data and concluded that the ridge has resulted due to sagging of crust and ruled out the hot spot theory. Misra and Misra (2010) interpreted the seismic profiles across the ridge and brought out that the ridge has cropped up due to tectonic movements all along the length during Cretaceous times. No age difference from north to south has been found by them. This period is marked by massive volcanism in and around peninsular India (Misra, 1999, 2006, 2008 a and b, 2009). They also recognized uninterrupted Tertiary succession capping this ridge. The ridge is sinuous and meanders along the 85°E longitude in the northern part and gently curves towards the southern tip of peninsular India in southern part (Arora and Misra, 2011). The ridge portion is believed by the present authors to represent felsic phase, while extensive mafic volcanics on either side of the ridge represents extrusive phase. The gravity low associated with this ridge is probably due to this density contrast. The central axis of the ridge is incised indicating continuing extensional tectonics. (Figure 1)

The extrusive phase corresponds with colossal and pulsatory Cretaceous volcanic flows in land areas of peninsular India. In oceanic regions, these volcanics are overlain by an uninterrupted Tertiary sedimentary succession. The intrusive relationship with this succession indicates a Cretaceous event, where deposition of Paleocene succession is affected by thinning and termination. This thinning and termination suggests that during Paleocene time the ridge was forming a positive relief. Conspicuous wedge-outs have developed on either side of the ridge. The faults located on top of this ridge, form an hour-glass structure, with upward continuing intersectional region mainly in the Eocene sequence. Due to subsidence along faults several umbrella like growth of coral reef complexes has developed. Interpretation of high resolution satellite gravity data has helped in mapping the southern extension of the 85° East Ridge. The present study has also indicated that this ridge curves around peninsular India along with other oceanic features. (Figure 2)

Detailed interpretation of seismic profiles generated by Pre-Stacking and Depth Migration (PSDM), Pre-Stacking and Time Migration (PSTM) processing techniques has revealed that the oceanic ridges have evolved due to tectonic processes and associated volcanism. The study therefore does not support the idea that they represent a trail left by the hot spot below the northerly moving Indian plate but has revealed that the oceanic ridges are located along 82^0 E, 85^0 E and 90^0 E longitudes. Of these 82^0E and 85^0E are completely buried below the Tertiary sedimentary sequence while 90^0 East Ridge emerges above sediments .In disposition 90^0 East Ridge is nearly a straight feature and is the longest oceanic ridge, while 82^0 E and 85^0 E ridges are sinuous and curve around peninsular India in a southern extension along with a number of oceanic ridges and depressions. In high resolution satellite gravity data the 82^0 East Ridge has no signature. 85^0 East Ridge has a rather low gravity anomaly, while 90^0 East Ridge is marked by prominent gravity high. However, in seismic data these ridges show no dissimilarity and appear to have originated by exactly similar tectonics and associated igneous activity. Furthermore, they are corresponding with the same geological period. Integration of seismic data with drill hole data has shown that the entire ocean basin is underlain by the Cretaceous volcanic flows. These volcanic flows are followed upward by uninterrupted Tertiary sequence. Interpretation of continuous seismic profiles has also revealed that the entire sequence continues without break from eastern offshore region of peninsular India to the Andaman-Nicobar chain of islands.

The entire ocean basin in the Bay of Bengal is transected by high angle faults. The unique characteristic of these faults is that they exhibit upward bifurcation .It is rather difficult to interpret geological details below the volcanic flows due to attenuation of seismic waves. However, reflection of uniform signatures has helped in ascertaining the volcanic flows. The vertical faults displacing the volcanics and underlying layers could also be interpreted from seismic profiles. On the basis of intrusive relationship of ridge rocks with the adjoining sediments, it has been concluded by the present authors, that eruption of volcanic flows has taken place along faults where ridges are presently located. Basalts have erupted through effusive zones along these ridges. (Figure 3A, Figure 3B and Figure 4A, Figure 4B)

Conclusion

The significant findings of the present study are:

1. The entire basin is underlain by the Cretaceous volcanic flows which in turn are overlain by uninterrupted Tertiary sequence.
2. The entire basin along with all prominent ridges is studied and common origin of these ridges is explained.
3. The land areas have been constantly rising while the oceanic regions have been subsiding to accommodate the Tertiary succession.
4. The ridges are the manifestations of complex tectonic and associated igneous events.
5. The relationship of the ridges with adjoining volcanic flows which seem to have erupted along these ridges is been brought out.
6. The time of their origin is found to be the same and the entire length of the ridges and they have emerged at the same time frame of the Cretaceous.
7. The effect of tectonics is increasing in an easterly direction. The prominence of ridges is also increasing from 82^0 East Ridge to 90^0 East Ridge.
8. These tectonic ridges have developed due to extensional tectonics in the early phase and compressional tectonics in later part.
9. Extensional tectonics caused decompressional melting and first to come are products of sialic portion and resulted in felsic volcanism which are giving rise to gravity low. This gravity low is made more conspicuous due to higher density mafic flows on either side.
10. The mafic flows have erupted through these zones occupied by the oceanic ridges. These flows could flow to long distances due to high fluidity. On the other hand the felsic flows could not go farther, due to greater thickness and form the ridge portions.

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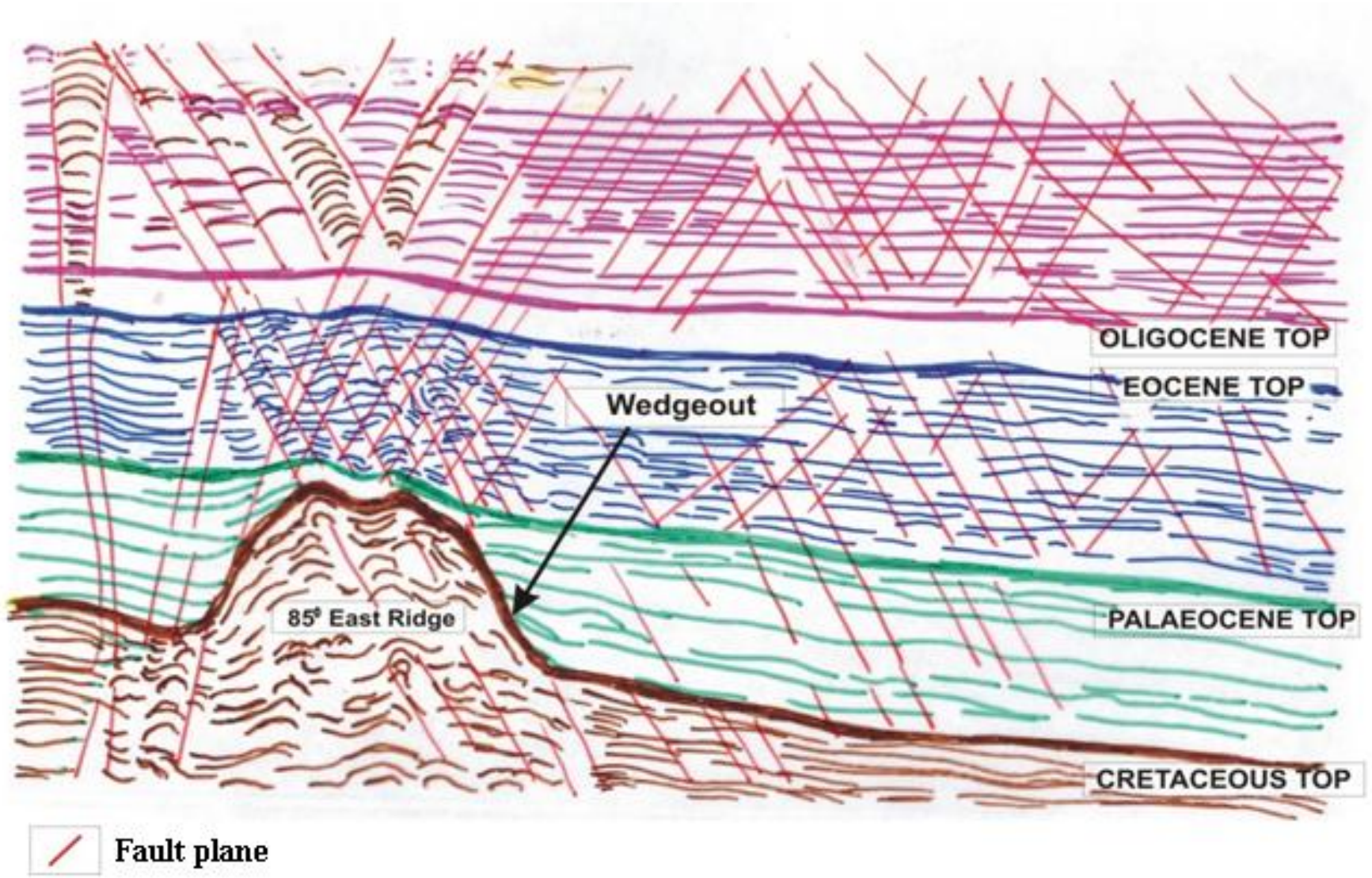

Figure 1. Interpretation of seismic profile across 85^0 East Ridge.

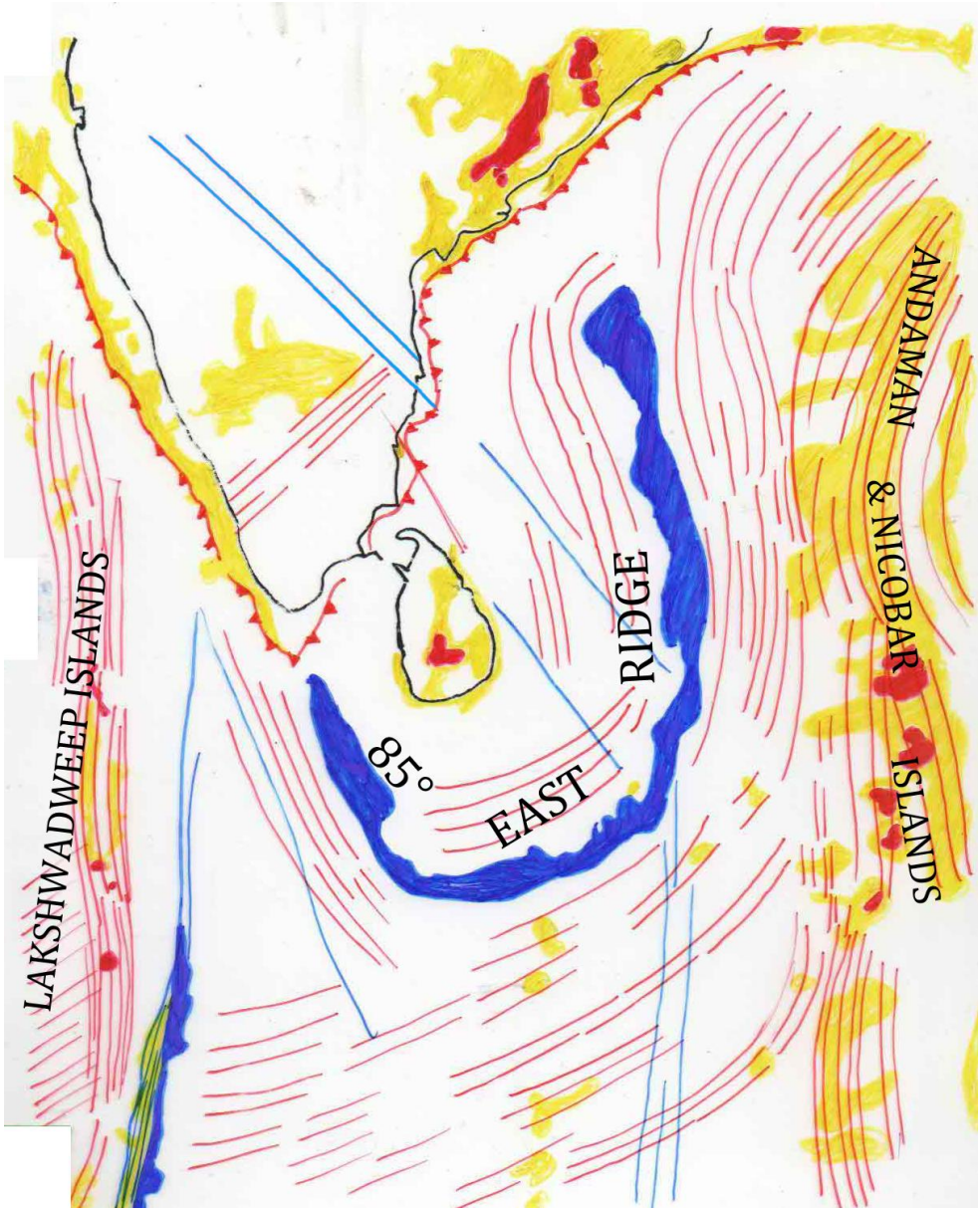

Figure 2. Map showing interpretation of high resolution gravity data of the Indian peninsula and northern part of the Indian Ocean. The curving nature of 85° East Ridge along with gravity trends can be seen. Major faults emanating from continental regions to oceanic regions are also obvious.

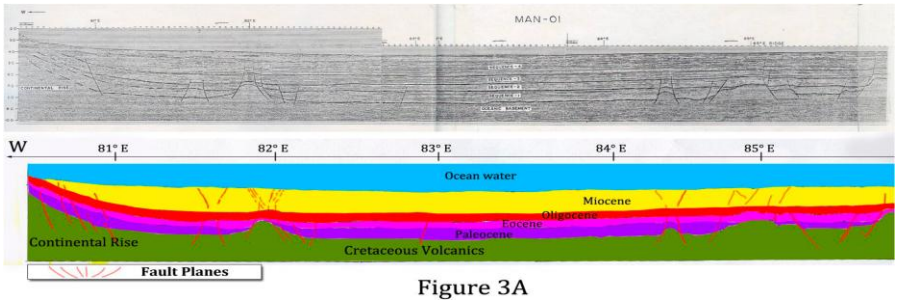

Figure 3A

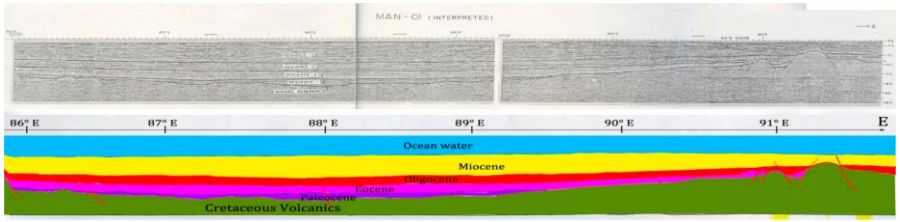

Figure 3B

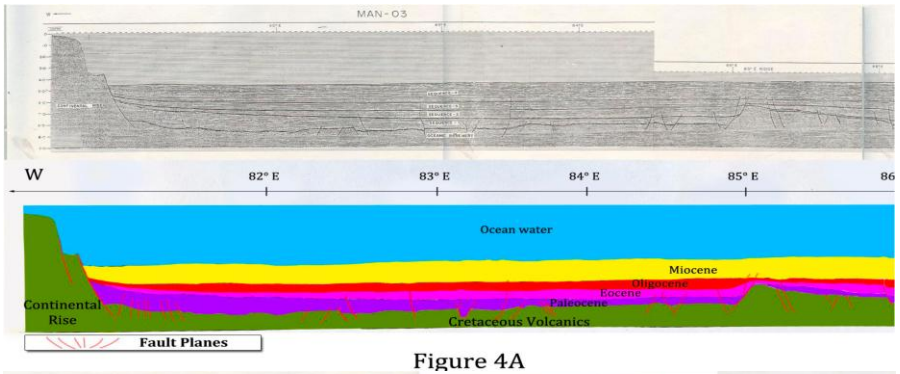

Figure 4A

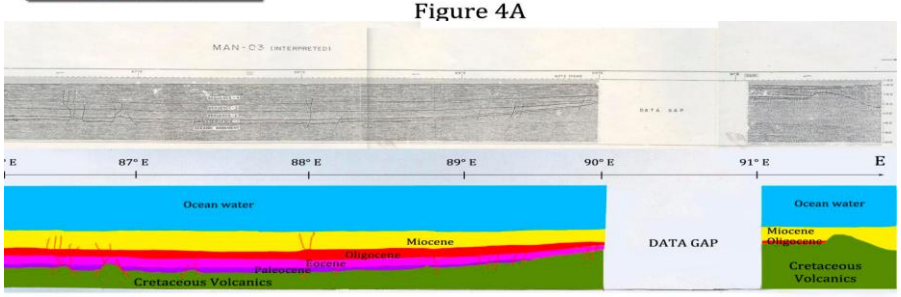

Figure 4B

Figure 3A, Figure 3B, Figure 4A, Figure 4B. These Figures represent a continuous sequence of Tertiary Period over Cretaceous volcanics. This ridge formed a positive feature for most of the Paleocene succession. The high angle faults converging either in upward or downward direction can also be seen intersecting each other mostly during Eocene rocks. The ridge is emplaced during the Cretaceous and prominent wedge outs have also formed on the entire side.