10th Biennial International Conference & Exposition

P 282

Identifying Continental-Oceanic boundaries in the Eastern margin of India by Seismic and Gravity- Magnetic data.

D.V. Reddy, B.S.R Krishna, G.V. Reddy, Dr. B.S. Josyulu*

Summary

The limits of oceanic, transitional and continental crusts have been identified in this paper by gravity, magnetic and seismic data. Bouguer anomaly plot indicates continuous rise of gravity value in areas of oceanic crust towards east which is reflected in the gravity model by rising of mantle. This oceanic crust area indicated by gravity anomaly is seen on seismic with increase in amplitude at the reflector corresponding to basement, corrugated nature of the basement reflector and near absence of reflections below the basement. This is in sharp contrast with continental crust areas which is characterized by horst-graben morphology. Interval velocities extracted between basement (8.0sec) and a reflector below basement (10.2sec) indicate very high velocities suggesting below basement reflector to be that of Moho discontinuity. The seismic imaging on a regional line also indicates the Moho discontinuity which is seen to rise towards east. The transitional area is characterized by stretched/thinned continental crust which at places is invaded by volcanic intrusions. The oceanic crust, being a low thermal conductor, has implications on maturation of sediments for thermo genic hydrocarbon generation.

Introduction

East Coast of India is a passive continental margin that evolved during Late Jurassic-Early Cretaceous fragmentation of Gondwana land. The initial failed rifting during Permo-Carboniferous period had resulted in formation of Gondwana basins orthogonal to the present day East Coast of India. Subsequent successful rifting that took place during Late Jurassic-Early Cretaceous was parallel to the coast. This fragmentation of eastern Gondwanaland into India, Antarctica and Australia had initiated the formation of Mesozoic rift basins along the eastern coast of India. The present day Indian east coast is shown in **Fig.1**

Interpretation of regional seismic and GM data in this deep water region helped in understanding the regional geological setting of the area. It is observed from seismic and gravity data that the prominent 85° E ridge is buried below Neogene sediments in ultra-deep waters of Bay of Bengal. The low gravity anomaly along the East coast corresponds to thick rift fill sediments whereas the low gravity anomaly on 85° E ridge is believed to be caused by flexuring of mantle. The observations seen on gravity and seismic data have been used to broadly demarcate the continental oceanic boundary.

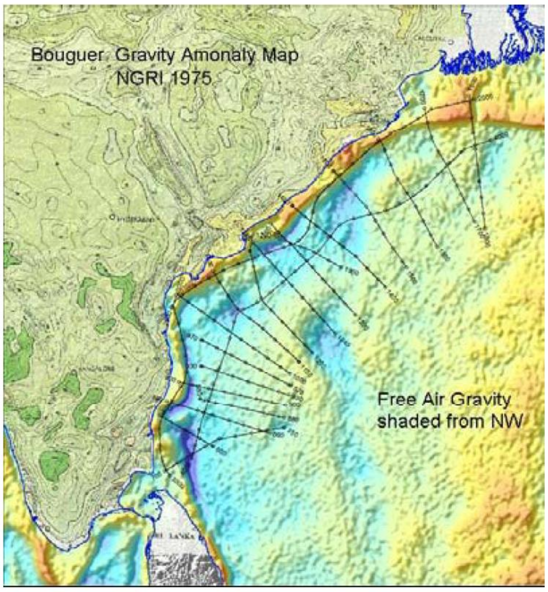

Fig.1 Location map of present day Indian east coast with overlay gravity anomaly

XI th Floor West Wing, CMDA Tower-1, No.1 Gandhi-Irwin Road, Egmore, Chennai-600008,
e-mail: dvredd@gmail.com

Methodology

The study area encompassing about one lakh square kilometres has been covered with 2D seismic data in 3x3 km grid and parts of this 2D area has been covered with 3D also.

The area is covered with Gravity-Magnetic data also. Gravity and magnetic modelling has been carried out to estimate the depth to basement, crust-mantle boundary and also to understand the broad lithological variations within the basin. Variations such as reflection amplitude at basement, corrugated nature of basement reflector, absence/presence of faults and events below basement and variations in the interval velocity have been used in conjunction with the observations on gravity-magnetic modelling for identifying the continental-oceanic boundary. The seismic sections displayed at **Fig.2**, is from a Q-marine 3D data set which indicates a clear reflection of events corresponding to basement at 8.0sec two-way-time(TWT) and crust-mantle boundary (Moho) at around 10.2sec that roughly corresponds to the depth of about 12km.

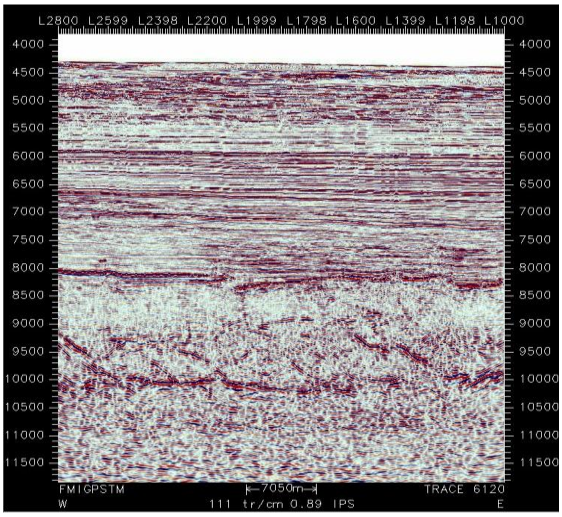

Fig.2. Q-Marine seismic data showing clear events corresponding to basement and mantle-crust boundary

Reflection corresponding to Basement is observed at TWT of about 8.0 Sec. A series of high angle dipping events are noticed between the basement and Moho which could be the manifestations of intruding magma through fissures in the thinned/stretched continental part. A similar looking seismic transect could be seen in Gascoyne margin of Western Australia. The schematic view of the evolution of Gascoyne margin vis-à-vis Greater India is shown at **Fig.3**.

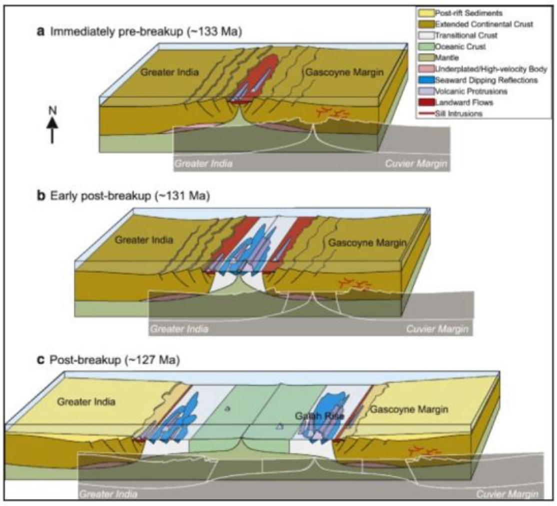

Fig.3. Schematic view of the evolution of Gascoyne margin vis-à-vis Greater India

The two seismic sections, one from eastern India and the other from Western Australia when put opposite to each other **(Fig.4)**, broadly indicate very similar below basement signatures that come from conjugate margins(?).

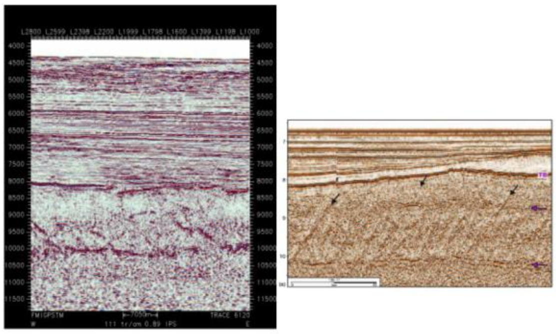

Fig.4 Comparison of events from below basement at conjugate margins

NW-SE seismic sections **(Fig.5, 6),** spanning about 300 km length from east coast of India up to 85$_{0}$E ridge indicates the broad divisions of continental, transitional and oceanic crust areas. The reflector corresponding to top of basement is characterized by increase in amplitude due to high acoustic contrast offered by recent crust. This new crust is broken due to extensional tensions and acquires a rugged, corrugated nature. There is a marginal rise of the basement at this boundary. Further, the rise of Moho towards east is clearly manifested in the form of good image on this long offset section**.** The section below the basement is characterized by transparent zone.

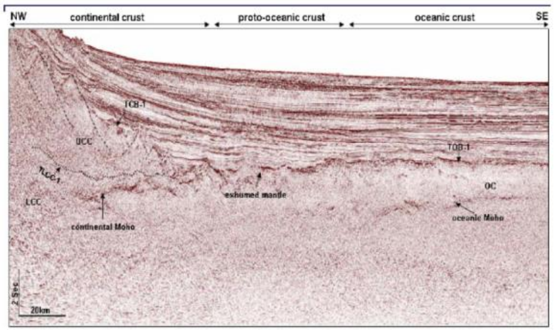

Fig.5 NW-SE seismic section from east coast of India towards east indicates the broad divisions of continental, transitional and oceanic crust areas.

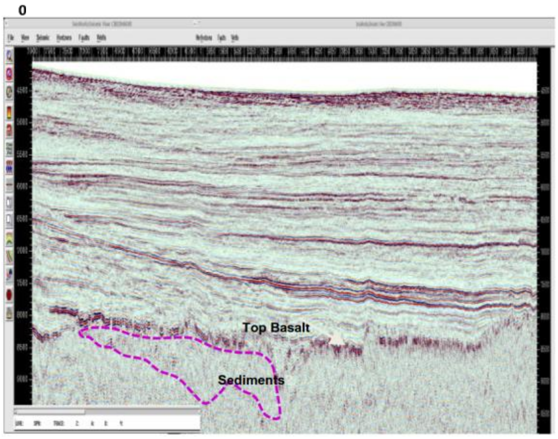

Fig.6 NW-SE seismic section from east coast of India up to 85^0E ridge indicating rugged topography of basement

Based on the attributes of amplitude, rugged character and rise at the level of basement, the approximate limit of oceanic crust has been marked on seismic sections in the entire area spanning about one lakh square kilometers **(Fig.7).**

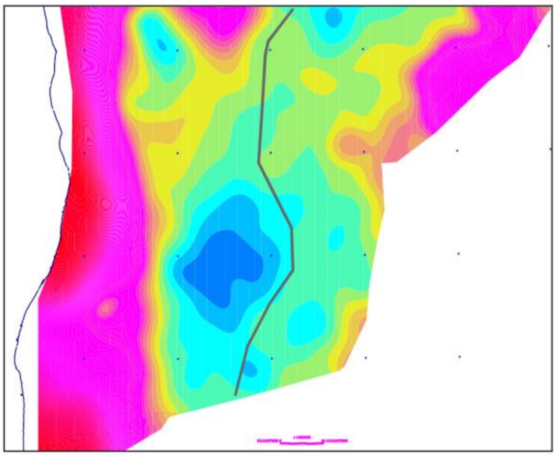

Fig.7 Map showing the limit of Continental-Oceanic boundary (COB) on basement map

Towards coast in the West, the seismic signatures corresponding to the continental crust are clearly seen in the form of series of faults resulting into horst-graben morphology (Fig.8). Whereas, the intermediate part is characterized by transitional crust as evidenced by intrusion activity of magma due to crustal stretching and thinning.

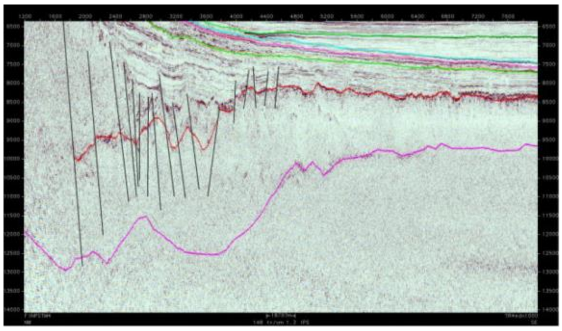

Fig.8 Seismic section passing through continental crust area indicated by series of horst-graben features

Interval velocity analysis from the seismic data has been carried out along a seismic line passing through 85^0E volcanic ridge. Pronounced difference in the interval velocities are observed for intervals within the ridge (.>5000m/s) and away from ridge (<4000m/s) as shown in Fig.9 which indicates that the area is in the volcanic province.

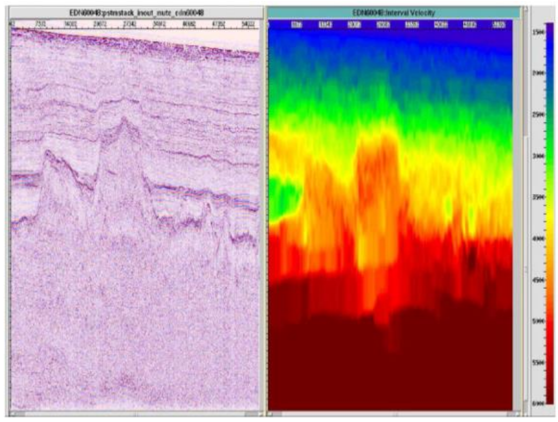

Fig.9 Comparison of Interval velocities along a seismic line passing through volcanic ridge

The observed Bouguer gravity anomaly has been modelled which shows good fit between calculated and observed gravity and magnetic anomalies. The rise of mantle having density of 3.13gr/cc towards east could be the possible reason for increase in the gravity anomaly towards east. This model is in strong agreement with inference obtained based on seismic data **(Fig.10).**

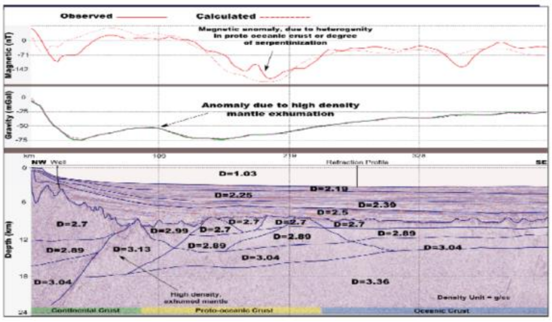

Fig.10 Gravity-Magnetic model along a NW-SE section showing a good fit between observed and calculated anomalies

Conclusions

1. Seismic signatures corresponding to the basement reflector have been used for inferring the Continental– Oceanic boundary. Analogues from part of eastern India and Gascoyne margin of Western Australia are seen.

2. Corrugated nature of the basement, increased reflection amplitude and absence of reflections below basement are considered to be the characteristic features of oceanic crust.

3. Moderate reflection amplitude at basement reflector and basalt signatures below basement are inferred to be the areas corresponding to transitional crust.

4. Basement with faults indicating horst-graben morphology are taken as continental crust areas.

5. The observations seen on seismic are in broad agreement with those on Gravity-Magnetic modeling.

6. Seismic interval velocity variations point to the prevalence of volcanic intrusions.

7. Oceanic crust is a low thermal conductor and hence the sediments above may not attain maturity for generation of thermo genic hydrocarbons. However, this does not preclude the generation of biogenic hydrocarbons.

8. Identification of transitional/oceanic boundary may help in charting out future exploration strategies for hydrocarbon exploration.

Acknowledgements

The authors wish to express their sincere gratitude and thanks to Director (Exploration) for allowing to submit this paper with ONGC data.

References

Nicholas G. Direen et al., Variations in rift symmetry: cautionary examples from the Southern Rift System (Australia -Antarctica)

Sebastian Scheel Rey et al., Seismic volcano stratigraphy of the Gascoyne margin, Western Australia