DISCUSSION

DEEP CRUSTAL STRUCTURE OF THE WEST BENGAL BASIN DEDUCED FROM GRAVITY AND DSS DATA by Manoj Mukhopadhyay, Jour. Geol. Soc. India, v.56, pp.351-364 (2000).

D.N. Avasthi, Specialised Petroleum Services Consultants, C-190, Sarita Vihar, New Delhi - 110 044 comments:

The interpretation model from the compiled data as given in Fig.8, is not very convincing. While the Bouguer map shown in Fig.5 depicts the western margin fault, the gradient of the contours bordering the Calcutta High (assigned to Eocene hinge zone in the paper) is not that steep, except near Debagram. Here the contours get crowded in a fashion, which appears to represent a plug of high-density material more than a linearly (approx.) striking fault. It appears that the velocity structure of Kaila et al. (1992) has been adopted to fit in the velocity-density relationship of Nafe and Drake (1963); but in this process, certain unusual disposition of rock densities has got emplaced in the model, which may fit in the gravity profile by mathematical calculations, but defies common perception of crustal variations. While the LVL (5.6 km/s) below the basement (6.0-6.2 km/s) has been given a density contrast of -0.14 kg/l (following Nafe and Drake), 10 km thick lower velocity zone of 5.3-5.45 km/s below about 5 km thick 6.1 km/s velocity zone has a density contrast of +0.13 kg/l. Further, the existence of about 20-25 km thick lower crustal rock of lower density (density contrast -0.08) than the overlying higher density crustal rock (seismic velocity 6.4 km/s) makes it obvious that he had to choose one of the two choices. The author had to either increase significantly the negative density contrast or increase the thickness of a low density rock to fit in the observed gravity low. He had chosen to increase the thickness and keep the negative density contrast to a small value, for reasons of obvious common perception. Similarly, further east, the gravity high could not be explained except by introducing rocks of higher density (density contrast +0.06 kg/l), even when the seismic velocity contrast is almost negligible (6.4 km/s vs. 6.5 km/s), as lifting the Moho to higher than 30 km below sea level would have been an inadvisable proposition. However, the genesis of the two types of rocks existing side by side is an unexplained riddle.

The gravity high may be explained by the emplacement of higher density rock formed out of magma coming from the upper mantle, in the crust above. Mall et al. (1999) and Raval (1989) have indicated the possibility of this part of the Indian plate passing over a mantle plume (Kerguelen hotspot) during its early movement towards north after separation from Gondwanaland. The map of marine magnetic anomalies in the northeastern Indian Ocean presented by Krishna et al. (1995) clearly shows that the general trend of NE-SW striking ocean floor magnetic anomalies have been superimposed by N-S trending magnetic anomalies, which have been identified with N-S trending fracture zones and ridges, prominent among them being 90° E Ridge. The magnetic anomalies lose much of their character in the Bay of Bengal because of the enormous thickness of sediments (up to 22 km, Curray et al. 1982) overlying the ocean floor. However, the seismic section shows 90° E Ridge as a broad basement high feature (Fig.3d; Gopala Rao et al. 1994). It may, therefore, be surmised that the plume could pierce through the older sea floor and emplace new, denser material to form a new ocean floor. From the paleo-reconstructions of the initial separation of Indian landmass from the Gondwanaland (Mishra et al. 1999; Agrawal and Pandey, 1999), it would appear that the axis of the plate separation was almost E-W. Consequently, the initial strike of ocean floor spreading was also E-W. The anti-clockwise rotation of the Indian plate during its journey to the north caused the older ocean floor fracture zones to be oriented to NNE-SSW, as represented by the trend of magnetic anomalies in the NE Indian Ocean today. Subsequently, another set of fracture zones and plume traces along with ocean floor spreading on N-S axis, have obliquely cut through the older fabric of the ocean floor. The NNE-SSW trending gravity high passing through Kolkata may be the remnant of older ocean floor spreading type ridge. Gravity and magnetic data would not be able to fully answer the riddle. What is required is very reliable deep sounding seismic profiling using vibroseis as seismic source. In vibroseis alone, the frequency band of the input energy can be controlled and tuned to the nature of crustal fabric, which can discriminate between continental and oceanic crust with very high resolution.

Manoj Mukhopadhyay, Indian School of Mines, Dhanbad-826 004 replies:

We thank Avasthi for showing interest on our paper.

His comments consist of mainly two points (a) seismic velocity distribution in the West Bengal basin crust and utilizing the velocity values to infer the corresponding density values in deeper crust for use in gravity modelling and (b) on the probable sources of magma generation involving plume model and tectonics of NE Indian Ocean. We have the following explanation to offer:

(a) Certain drafting error has inadvertently entered into Fig.8 of our paper. This was corrected through publication of a corrigendum which appeared in v.57, p.84, (2001). The corrigendum also explains that relevant text descriptions on seismic velocity values and their use for density conversion employing Nafe and Drake (1963) relationship remain fully valid and unchanged as presented in the original paper, and are in no way affected by the drafting error. The drafting error also now stands corrected. Comments given by Avasthi under (a) are therefore duly taken care of by the explanation given here.

(b) Our main focus in the present paper was to study the gravity field for the West Bengal basin and try to explain the major anomaly zone with constraints derived from DSS results. The gravity-derived model supports a highly stretched crust at the Indian shield margin. Scope of our work was rather limited, and any full-length discussion on the 'probable sources of magma generation involving plume model or tectonics of NE Indian Ocean' was clearly beyond the purview of our work. Lack of data prevented us to examine this interesting possibility of hotspot-related volcanism below the West Bengal basin. We made only a passing reference to the study made by Subrahmanyam et al. (1999) for the Bay of Bengal. Avasthi has presented some interesting ideas regarding the mantle plume and tectonics of NE Indian Ocean, and has also provided a list of references. We hope this should be useful for any future study on the region. Lastly, we completely agree with him on the need for a 'very reliable deep seismic sounding profiling using vibroseis as seismic source' to throw more light on the nature of crustal fabric for the West Bengal basin.

References

Agrawal, P.K. and Pandey, O.P (1999) Was there an intracontinental rift betwen India and Sri Lanka? Jour. Geol. Soc. India, v.54, pp.237-249.

Curray, J.R. (1991) Possible greenschist metamorphism at the base of a 22 km sedimentary section, Bay of Bengal. Geology, v.19, pp.1097-1100.

Gopala Rao, D., Bhattacharya, G.C., Ramana, M.V., Subrahmanyam, V., Ramprasad, T., Krishna, K.S., Chaubey, A.K., Murty, G.P.S., Srinivas, K., Desa, M., Reddy, S.I., Ashalata, B., Subrahmanyam, C., Mital, G.S., Drolia, R.K., Rai, S.N., Ghosh, S.K., Singh, R.N. and Majumdar, R. (1994) Analysis of multichannel seismic reflection and magnetic data along 13°N latitude across the Bay of Bengal. Marine Geophy. Res., v.16, pp.225-236.

Kaila, K.L., Reddy, P.R., Mall, D.M., Venkateshwarlu, N., Krishna, V.G. and Prasad, A.S.S.S.R.S. (1992) Crustal structure of West Bengal basin, India, from deep seismic sounding investigations. Geophy Jour. Int., v.111, pp.45-66.

Krishna, K.S., Gopala Rao, D., Ramana, M.V., Subrahmanyam, V., Sarma, K.V.L.N.S., Pilipenko, A.I., Shcherbakov, V.S., and Rahakrishna Murthy, I.V. (1995) Tectonic model for the evolution of oceanic crust in the northeastern Indian Ocean from the Late Cretaceous to the Early Tertiary. Jour. Geophy. Res., v.100, pp.20011-20024.

Mall, D.M., Rao, V.K. and Reddy, P.R. (1999) Deep sub-crustal features in the Bengal basin: Seismic signatures for plume activity. Geophy. Res. Lett., v.26, pp.2545-2548.

Mishra, D.C., Chandra Sekhar, D.V., Venkata Raju, D.Ch., and Vijaya Kumar, V. (1999) Crustal structure based on gravity-magnetic modelling constrained from seismic studies under Lambert Rift, Antarctica and Godavari and Mahanadi rifts, India and their interrelationship. Earth and Planet. Sci. Lett., v.172, pp.287-300.

Nafe, J.E. and Drake, C.L. (1963) Physical properties of marine sediments. The Sea, v.3, Wiley, New York, pp.794-815.

Raval, U. (1990) On hotspot, Meso-Cenozoic tectonics and possible thermal networking beneath the Indian continent. *In:* Advances in Geophysical Research in India. Proc. IGU Symposium, pp.314-330.