

Summary and Conclusions

Salient results from integrated geophysical and geological studies can be summarised as follows :

1. The present studies helped in further demarcating the area of intraplate deformation between 10°S to 4°N and 75° to 90°E. The regional and detailed investigations of the polygons in the deformation zone of CIB have revealed the blocky mosaic structure and associated small elongated hills of 15-20 m high and about 45 km wide with gentle slopes on the flanks of the deformed blocks. They act as barriers for southward flow of the Bengal Fan turbidites. Two new seamounts (at 1°42'N, 83°35'E and 0°26'N and 83°24'E) with SW-NE strike are mapped in the deformation area for the first time. The chain of seamounts of volcanic origin and the deformed blocks might have formed as a result of repeated tectonism and the associated mid-plate volcanism.
2. Magnetic isochrons 32, 32B and 34 have been mapped in the study area and spreading rates of 4.4 cm/year are estimated.
3. A free-air gravity anomaly of around -40 mGal centered around 4°S, 80°E and two large gravity anomalies of -30 mGal (0°45'N, 82°55'E) and -70 mGal (1°N, 83°45'E) are associated with topographic highs in the north. (These anomalies are explained with models of thinned crust of uplifted blocks underlain by shallow mantle considering varied tectonic causes such as increase in the density of the crystalline crust, low density of the upper mantle or their combined effect. By analogy, formation of deformed uplifted basement rises due to the intraplate deformation is suggested.

Convection in the upper mantle is primarily responsible for the mobility of the Indian plate and for intraplate deformation, whereas core-mantle convection contributes significantly to the geoid low. It is consistent that the intraplate deformation area coincides with minimum of free-air gravity anomaly and geoid minimum. The large dimension of deformation area and its correlation with global gravity minimum appears to be the near surface manifestation of deep processes in the mantle.

4. The heatflow values in CIB area vary from 44 to 161 mWm⁻². The average heatflow of 65 mWm⁻² observed in this area is higher by 12 mWm⁻² than the standard value of 54 mWm⁻² for the 70 Ma age oceanic crust of the area. (This could be due to dissipation of mechanical energy considering the two level plate tectonic model of Lobkvosky (1988) with exothermal reaction of semi-ductile serpentinite creeps of sub-crust lithosphere mantle into the lower crust and to weak zones as well as thermal energy release of the lithospheric deformation in areas of high tectonic activity.)
5. The seismic reflection investigations along the closely spaced profiles and within the polygons of the CIB decipher (a) mapping of the boundaries of the intraplate deformation area and the intrinsic minor details, for example, the style and pattern of folds within the sediments of the deformed blocks, besides the geometry of the main tectonic blocks and faults bounding them, b) in identifying partial reactivation of ancient fracture zones and fresh break up of oceanic crust and c) mapping of isopachs of sediments, regional extent of some of the unconformities and extent of seamounts.

The seismic reflection studies indicate sediment thickness in the study area varying from 1.5 to 2.2s (TWT) in the southern part to 2.3 to 2.6s in the northern part. Two prominent unconformities are identified, the lower one separating the younger syn-deformation sediments and thus marks the onset of deformation since late Miocene (7 Ma). The thickness of the pre-deformation sediments varies from 1.2 to 1.4s. The upper erosional unconformity represents the glacial and non-glacial sea level variations during the upper Pleistocene (800 Ka).

The significant seismic reflection observations are identification of pelagic layer (prefan sediments) of 0.16s thick immediately above the basement. Correlation of these data with ODP leg 116 cores suggests that the age of the fan turbidites is much older, 24 Ma (Oligocene), than the hitherto assumed age of 17.5 Ma (early Miocene).

The Eocene erosional unconformity in the study area, extends as far as 1°S. It was identified earlier by Curray and Munasinghe (1989) only upto 2°N in the northern Bengal Fan.

A three layer lithospheric model composing of upper crust, semi-ductile lower crust and quasi rigid upper mantle compatible to the two level plate tectonic model of Lobkvosky (1988), is suggested to account for the observed deformed crustal features in this area. The various stages of deformation includes the older and younger

ones. The latter are responsible for shortwave length deformations along the flanks of main deformed blocks, for example; flexural folding of the sediments forming regular E-W undulations, extensional strain on the flexural highs and compressional stress on the lows in response to increased compression, further accentuated deformation tectonics resulting in the extensional faults into the subcrustal lithosphere and upthrust tectonics along reverse faults and development of series of syngenetic faults at upper brittle crustal level. These are depicted in the schematic lithospheric model, Fig. 7.20.)

6. The ocean bottom seismometers seismic refraction measurements identified the variation in the seismic velocity and thickness of crust of the blocky mosaic structures in the deformation area. (The velocity and structure models for the CIB, Cocos-West-Australian Basins and all Indian Ocean Basins are proposed for the first time from seismic refraction results. The intense deformed blocks usually have abnormal properties of the crust in comparison to the seismic model for typical oceanic crust. The structure of these blocks is complicated and seismic velocities reduce with increase of sediment thickness. Under some blocks the abnormal (low velocity) uppermost mantle was revealed.
7. Bottom seismological observations in northern CIB area revealed unusual high micro-seismicity more than 100 weak earthquakes in ten days with epicenters located predominantly inside the east-west trending blocky mosaic structures. The high seismicity can be related to the tectonic activity and episodic intraplate deformation.
8. The lithology, stratigraphy and geochemistry of the sediments of
 - a) Central Indian Basin revealed the early stage sediments, consisting of hemi-pelagic, pelagic muds with rare layers of limestone in the north and metalliferous carbonates, pelagic clays in the south. In the later stage, the coarse fine detrital sediments mostly derived from the erosion of Himalayas are deposited above the early stage sediments. An early to late Oligocene turbidites appear to mark the beginning of the fan sedimentation in the area.
 - b) the Afanasy Nikitin Seamount revealed migration of seamount's location from high latitudes to subtropical to present position, progressive sinking of the volcanic edifice which was above the sea level, at the time of formation in early Cretaceous. The seamount's structure was altered by later reactivation of volcanism, hydrothermal activity due to intraplate deformation.)
9. The Polycyclic Aromatic Hydrocarbon (PAH) of the organic matter structure of the sediments of CIB are 26 to 180 $\mu\text{g/g}$ (of dry sediments). They are widespread and typical of hydrothermal

solutions and volcanic emanations. The PAH can be used as important indication in searching for hydrothermal sources.

10. The effusive volcanic rocks at various depths of the flanks of the Afanasy-Nikitin Seamount collected during MIR submersible dives are formed near the transform faults or at their intersection with ridge axis and are composed of subalkaline transitional basalts, similar to the continental Deccan basalts. Further volcanic activity at the rises resulted in the trachy-basaltic rocks of the area.
11. The tectonic deformation in the Central Indian Basin (CIB) is connected to the lithospheric deformation at the Himalayas, as explained in the two level plate tectonic model of Lobkovsky (1988), consisting of brittle upper crust, the upper part of the lower crust of the ductile nature and the underlying cold part of the crust and the quasi rigid core of the upper mantle. The layers at the top and bottom with elastic core in between, yielding to the compression. The viscous lower crustal material, serpentinites gets injected into the vicinity of the suture zones, thus causing thickening of the lower crust. The significant characteristics of the intraplate deformation such as the east-west trending geoidal anomalies, increasing to the north with increasing age of the oceanic crust, and other geophysical signatures such as, high seismicity, anomalous heatflow, blocky mosaic of the deformed blocks bounded by faults, anomalous crustal velocity and density structure, can possibly be better explained by the two level plate tectonic model.

Recommendations for further investigations:

1. Lateral extent of the early deformation fabric confined to the basement and the later stages of deformation that occurred in the basement as well as the overlying sediments is to be demarcated to assess the relative magnitude at different periods. This might help in understanding the global tectonics and its impact on oceanic and atmospheric realms.
2. Synthesis of the seismicity data in an area of reactivated faults is necessary to study the neo-tectonic activity along the reactivated faults and the depth extent of these faults.
3. Deep crustal and upper mantle studies are suggested deploying magnetotelluric stations and OBS in order to further validate the two-level plate tectonic model.
4. Detailed studies on the episodic and periodic nature of deformation in CIB, through study of MCS data are needed over a large area covering CIB.