ABSTRACT

Title of Thesis: **Morphotectonic Evolution and Petrochemistry of Central Indian Ocean Floor**

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The study encompasses the region between 9° S and 16° S, 72° E and 80° E. The data and samples related to this study were collected from an average water depth of 5100 m. The study has been divided in to two aspects: the first aspect deals with the morphotectonic features that are detailed in two chapters; the second aspect concerning the petrochemistry of the basalts is elaborated in another two chapters. Introduction, Methodology adopted and Conclusions are the remaining chapters of this thesis.

A study using available mutlibeam map of the Central Indian Ocean Basin (CIOB) revealed 200 seamounts of variable dimension and morphology. Three categories of seamounts were recognised depending upon their summit structures. These are (1) single-peaked (2) multi-peaked and (3) composite. The study indicates that single-peaked seamounts are dominant (89%) while multi-peaked are less (8%) and composite ones are rare (3%). At a critical height above 1200 m the relation between height and basal radius do not correlate i.e., instead of an increase in the height the basal width increases due to magma flow along the slope of the seamounts. The mean height-width ratio (HW = 0.16) of the 200 seamounts implies that the height of a seamount is about one-seventh of its basal radius.

The normalised abundance of seamounts in the CIOB is 976 seamounts/10^6 km^2 but on a finer scale this value varies from 500 to 1600 seamounts/10^6 km^2, which is less than the seamount concentrations in the Pacific and Atlantic oceans (9000 to 16,000 seamounts/10^6 km^2). The variation of seamount population in the CIOB may be related with the crustal thickness, chemical composition of the rock and magma residential time below the crust. Enhanced production of seamounts between chrons A24 and A23 (56 to 49 Ma) is related to the Indo-Eurasian collision.

Eight sub-parallel N-S oriented chains were identified along which the seamounts of different categories are located. The formation of the seamount chains is related to the propagative fractures and the chains indicate crustal thinning due to the E-W extension of the oceanic crust. The role of major fracture zones apparently was insignificant in the formation of the seamounts. An overall negative free-air gravity anomaly over the CIOB oceanic crust as well as the seamounts suggests that the seamounts formed near the South East Indian Ridge.

An examination of regional stress fields, developed due to plate reorganisation, over the oceanic crust of the Indian plate reveals their influence in the formation of complex seamounts that have an elongated base. The regional stress field helped to maintain the orientation of the chains while the local stress regime affected the seamount population.

A computer program was developed using self organising map (SOM) to study the roughness parameters of the CIOB. The roughness parameter of individual depth profile has been calculated in terms of ‘β’ and ‘S’ and the individual profiles have been classified in terms of roughness. It was found that different geological provinces e.g., Central Indian Ridge (CIR) and Carlsberg Ridge (CR) have significant variation with respect to micro-topography that produced a number of segments. On the contrary, only two profiles out of fifty five from the CIOB were found to be segmented. In terms of micro-topography, the oceanic crusts generated from slow spreading ridge system (CR and CIR) have high roughness whereas the crust generated from fast to intermediate spreading ridge system (CIOB) produced a smooth seafloor. The roughness and amplitude parameters were

interlinked with the geological processes. The lesser number of segments and localised S and β values indicate a tectonically monotonous area whereas a wide variation in S and β values signifies a tectonically active region.

The rocks recovered from the CIOB are basaltic pillows and flows with thin coating of fresh to altered basaltic glass. The basalts are dominated by plagioclase while very few olivine and pyroxene are present.

The rock magnetic studies enabled to infer the presence of single domain magnetic minerals but due to their minute size (1 to 0.06 μm) they are beyond the resolution of the conventional microscope.

Analyses of basalts reveal compositionally high FeO^T (~10-18 wt%) and TiO_2 (~1.4-2.7 wt%) whereas MgO varies from ~2.8 to 7.14 wt%. The basalts have moderately high P_2O_5 (0.09-0.25 wt%) and K_2O (0.25-1.1 wt%) contents than normal mid-oceanic ridge basalts (N-MORB). The major element variation of the basalts suggests the importance of fractional crystallisation of a shallow seated parent magma which had a long residence time.

The basalts typically have high contents of incompatible elements (Zr= 63-228 ppm; Nb= ~1-5 ppm; Ba= ~15-78 ppm; La= ~3-16 ppm) and moderately enriched LREE concentration. In general, the incompatible element ratios although show variations (Zr/Nb = 25-166, Y/Nb = 7-63, Sm/La = 0.5-1.5). The U/Pb ratio is quite similar to the N-MORB whereas Ce/Pb and Ce/U ratios (1.5 to 8 and 16 to 42, respectively) are lower than the N-MORB and Primitive Mantle but Ba/Nb (12.5-53) ratio is much higher than the N-MORB (~5.7) and Primitive Mantle (9.56). The CIOB basalts have a noticeably large fraction of highly incompatible element ratios e.g., Ba/La (~1.5-17) which are higher by a factor of ~8 than N-MORB (Ba/La ~ 1.96), while moderately incompatible element ratio Sm/La (0.4 to 1.1) are very close to the N-MORB (1.04).

The chondrite normalised rare earth element (REE) variation of the CIOB basalts show an enriched Light REE and a flat Heavy REE pattern. However, the noteworthy feature of the REE is that almost all the samples have a significant negative Eu anomaly (Eu/Eu* = 0.78-1.00) that may have resulted due to the removal of feldspar and pyroxene during crystal fractionation. Although the samples show a strong negative Ce (Ce/Ce* = 0.45-1.2) anomaly but are relatively enriched in Ce than N-MORB.

$^{87}Sr/^{86}Sr$ analysis of a few samples show a variation from 0.702754 to 0.703812 and $^{144}Nd/^{143}Nd$ from 0.512796 to 0.513014 and most have positive ε_{Nd} values (~1 to 7.9). The $^{87}Sr/^{86}Sr$ ratio and ε_{Nd} of the CIOB basalts indicate enriched mantle end-members. The study indicates low (3-10%) partial melting or a heterogeneous source rock for the CIOB basalts.

A supervised neural network was designed to characterise the CIOB basalts. N-MORB, Enriched-MORB (E-MORB) and ocean island basalt (OIB) data set were used to train the network for a specific purpose. The study helped to identify that:

1) 57.11% of the CIOB basalts are typical N-MORB,
2) 19.6% of the N-MORB includes E-MORB characteristics,
3) 10.7% of the basalts are N-MORB with OIB signatures, and
4) 12.5% of the basalts have a mixed nature of N-MORB, E-MORB and OIB.

The study shows that the CIOB basalts are largely N-MORB but some bear a combination of the compositional characters of the three major types of ocean floor basalts.

The findings presented in this work have an important bearing on an understanding of morphotectonic features, basalt characters and geodynamics of the Indian Ocean in general and of the CIOB in particular.