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Geochemical Heterogeneity of the Magmatism from the Ninetyeast and Investigator Ridges

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The complex history of the opening of the Indian Ocean with the displacement of rift zones may have resulted in the development of unusual geochemical provinces. Their formation was related to magma generation at the mid-oceanic ridges that were formed by the breakup of Africa and India-Antarctica in the west, and Antarctica and India-Australia during the early spreading stage, and later Antarctica-Australia in the east. The eastern province of the Indian Ocean is of particular interest, because it contains the largest volcanic rises - the Kerguelen, Broken, Naturaliste, Ninetyeast Ridge and Investigator Ridge - formed during the early stages of the evolution of the Southeast Indian Ridge, the modern tholeiitic magmatism of which differs significantly from the magmatism of the Indian Ocean in all isotopic signatures. The aim of our study is to determine the geochemical characteristics of basalts from the central part of the Investigator Ridge and compare these basalts with the magmatism of genetically diverse magma types which build up the region 10-12ºS Ninetyeast Ridge (Figure 1). On the basis of petrochemical characteristics we divided the magmatism from the study zone of the Ninetyeast Ridge into two general genetic basalt types: the first - normal TOR-2 (Tholeiites of the Ocean Ridges) (Sobolev & Dmitriev, 1989). The tholeiitic melts of this type are generated beneath most spreading zones due to polybaric accumulative fractional melting at a depth interval of 20-8 kbar and with an aggregate melting degree of 14-16%. The second type - Si-tholeiites considerably enriched in Si and depleted in Na and Ti - shows many major-element features similar to low-titanium Gondwana flood basalts. Such magmas may have formed by the melting of the ascending diapir, and pressure decrease from 18 to 4 kbar (Suschevskaya et al., 1996). Similar tholeiitic basalts (TOR-2) were revealed at the 214 site, located 240 km south of the study zone, and were ascribed a date of 56 m.y. old (Suschevskaya et al, 1996a).

The basalts from the Investigator Ridge and Wharton Basin are also of different types. The most widespread basalt type is TOR-2, as for the Ninetyeast Ridge. There are also Fe-Ti basalts which are typical for the Ninetyeast Ridge, and alkaline basalts. The oceanic crust of the eastern part of the Indian Ocean was mainly formed by enriched basalts. The degree of this enrichment varies from slight to strong (La/Sm=0.8-3.5). The ratios of LIL elements indicate that the source of this enrichment was heterogeneous in space and time.

Wharton Basin and Investigator Ridge eruptions of enriched tholeiitic magmas of various genesis seem to be connected with the involvement of the ancient metamorphosed mantle in the melting process or with the assimilation of upwelling asthenospheric magmas through metasomatized peridotites. Such interaction gave rise to considerable enrichment in light REE, K, U, Th.

Our isotopic data (Pb, Sr, Nd) for the basalts from the Ninetyeast Ridge, Wharton Basin and Investigator Ridge show prominent differences between basalts from the Wharton Basin and Investigator Ridge and those from the Ninetyeast Ridge. The Wharton Basin and Investigator Ridge basalts have higher $^{206}Pb/^{204}Pb$ (18.82-18.85), $^{207}Pb/^{204}Pb$ (15.57-15.59) ratios at moderate values of $^{208}Pb/^{204}Pb$ (~38.4), comparable with enriched basalts of the Pacific Ocean and the northern part of the Atlantic Ocean. At the same time basalts from the Ninetyeast Ridge indicate a wide variation of isotope values i.e. in the range of the study zone we revealed both basalts with low $^{206}Pb/^{204}Pb$ (17.6-18.4) values, typical for Indian MORB, and basalts with high $^{206}Pb/^{204}Pb$ (~18.6), close to the data for St. Paul lavas. In general, the total range of variation of all isotopic signatures for basalts from the study zone overlaps the results obtained for basalts analyzed along the Ninetyeast Ridge and from different sites of the Kerguelen Archipelago (Mahoney et al., 1995).

We thus conclude that the opening of the eastern part of the Indian Ocean was linked with the formation of a huge superplume, split into satellite plumes in the upper horizons of the asthenosphere (Maruyama, 1994), which in their turn reached the basement of Gondwana and destroyed it. Melting of different parts of the lithosphere resulted in the appearance of notable geochemical heterogeneity in the tholeiitic magmatism along the "proto"-SEIR.

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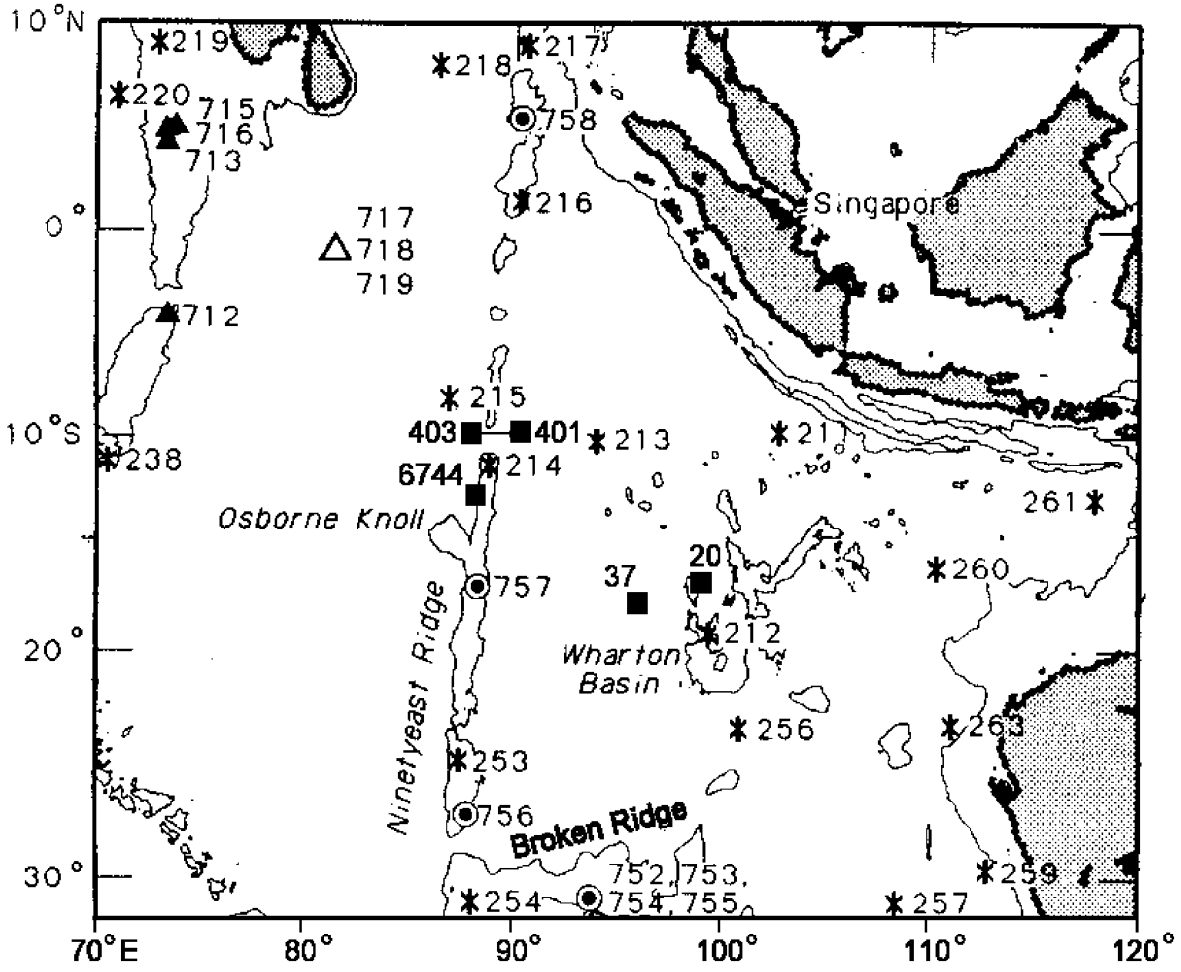

Figure 1: Location map of the Indian Ocean showing DSDP and ODP sites and stations of the present study (solid squares).

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