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Tectonic-magmatic processes of the Indian Ocean: Evidence on the residual mantle Bouguer gravity anomaly

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For the Indian Ocean, three classes of spreading rates have been identified: the ultra-slow spreading Southwest Indian Ridge (SWIR), the slow spreading Central Indian Ridge (CIR) and the Southeast Indian Ridge (SEIR). Many local geological features such as hotspots or plumes, large-scale fracture zones, and ocean core complexes have been found. Such systematic and regional complex geological settings provide good conditions for studying on magmatic processes at mid-oceanic ridges. Using the Indian Ocean as an example, we used the Euler Rotation method to model the initial symmetric RMBAs to discuss on-axis magmatic processes and the asymmetric RMBAs to discuss off-axis magmatic processes. We obtained the following results:

(1) Three main factors are considered to explain variations of RMBAs in our study, including crustal thickness (Hc), potential mantle temperature (T), and mantle depletion (X). The gravity anomaly induced by 5% mantle depletion is 16 mGal, the effect of 200°C thermal variation on gravity anomalies is 46 mGal, and oceanic crust has to be taken into account in regions with RMBAs variations larger than 46 mGal.

(2) Based on our results, we partition the Indian Ocean into four categories: symmetric negative RMBA (< 0 mGal) and symmetric positive RMBA (> 0 mGal), and asymmetric negative RMBA (< 0 mGal) and asymmetric positive RMBA (> 0 mGal). Symmetric negative RMBAs indicate areas that are lighter than normal due to excessive on or near-axis magmatic supplies at the initial stage of oceanic crustal formation. Asymmetric negative gravity signals then occur from the resulting enhanced off-axis melt processes. While symmetric positive

RMBAs indicate areas that are heavier than normal due to reduced on or near-axis magmatic supplies, and asymmetric positive signals then express due to reduced off-axis melt.

(3) Symmetric negative RMBAs and asymmetric negative RMBAs are associated with the Bouvet, Marion, Reunion, Kerguelen, and Balleny hotspots or plumes in the Indian Ocean: 1) When the hotspot gets close to or gets away from the ridge, the off-axis magmatism is stronger than the on-axis magmatism (the asymmetric negative RMBAs are more negative than the symmetric RMBAs), and the asymmetric negative RMBAs are observed along the hotspot tracks. 2) When the hotspot is on or near the ridge, the on-axis magmatism is stronger than the off-axis magmatism (the symmetric negative RMBAs are more negative than the asymmetric RMBAs).

(4) The negative RMBAs in the range of -46 mGal ~ 0 are result from the weak activities of the Bouvet, Marion, Reunion, Kerguelen, and Balleny hotspots or plumes in the Indian Ocean. The negative RMBAs less than -46 mGal are result from the strong activities of these hotspots or plumes, accompanied by hotspot-related crustal thickening and hotspot-related hydrothermal mineralizing system.

(5) Symmetric positive RMBAs and asymmetric positive RMBAs are associated with the oceanic core complex (OCC) in the Indian Ocean, accompanied by OCC-related crustal thinning and OCC-related hydrothermal mineralizing system.

(6) Widespread obvious asymmetric positive RMBAs are observed in the northwestern flank of the SEIR and the southern flank of the SWIR around the Rodriguez Triple Junction (RTJ) in our results, where no OCC has been investigated. We predict the exist of the OCC and the OCC-related hydrothermal mineralizing system in these areas.

(7) On the basis of the previous geology, chronology and geochemical achievements, we constructed the plate frame of the Indian Ocean since 120 Ma by the Gplates software, to reconstruct the processes of the breakup of the Gondwanaland, the extinct of the Neo-Tethys Ocean, and the formation of the Indian Ocean.

(8) Correlation analysis between along axis geochemistry and geophysics were conducted in our study: a positive correlation exists between the degree of mantle depletion and RMBA in areas (-16 mGal < RMBA < 16 mGal) that may be affected by mantle depletion, a negative correlation exists between the mantle temperature and RMBA in areas (-46 mGal < RMBA < 46 mGal) that may be affected by mantle temperature, and a positive correlation exists between the

crustal thickness and RMBA in areas (RMBA< -46 mGal and RMBA > 46 mGal) that must be affected by oceanic crust.
Key Words: the Indian Ocean, RMBA, hotspot, oceanic core complex, on-axis magmatism, off-axis magmatism