An f_{O2} discontinuity across the Australian-Antarctic Discordance

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Mid-ocean ridge basalt (MORB) geochemistry shows that Earth's upper mantle is heterogeneous at the hemispheric scale [1]. Two isotopically distinct and long-lived mantle domains, "Indian" and "Pacific," are physically juxtaposed at the Australian-Antarctic Discordance (AAD) along the Southeast Indian ridge.

We used XANES to measure $Fe^{3+}/\Sigma Fe$ ratios in 77 on-axis MORB glass chips from 11 segments across the AAD. The means of $Fe^{3+}/\Sigma Fe$ ratios of isotopically-defined Indian-type and Pacific-type MORB are distinct (p-value = 0.0006): Indian-type MORB $Fe^{3+}/\Sigma Fe$ = 0.140 ± 0.004 (1σ), while Pacific-type MORB $Fe^{3+}/\Sigma Fe$ = 0.148 ± 0.005, with standard error <0.001 in each case. Indian mantle records significantly lower f_{O2} than Pacific mantle (QFM-0.28 ± 0.06 vs -0.07 ± 0.06, p-value = 0.0005) irrespective of extent of low-pressure fractionation. Indian Ocean MORB is more reduced than Pacific MORB.

The stark boundary in a major element signature opens a new window into the nature of mantle f_{O2} and the provenance of Indian-type mantle. The mantle beneath the AAD is colder than adjacent Indian and Pacific mantle [2,3]; however, in contrast to predictions by [4], lava $Fe^{3+}/\Sigma Fe$ ratios are uniformly low within and west of the ADD relative to Pacific mantle segments. We confirm that Fe^{3+} is not as incompatible as is frequently assumed during mantle melting, in agreement with global observations [5,6] and experiments [7].

We conclude that basalt $Fe^{3+}/\Sigma Fe$ ratios can serve as reliable proxies for MORB mantle source conditions and composition, as defined by isotopic ratios [8], and that the isotopically enriched source of Indian Ocean-type MORB must reflect a reduced protolith.

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