Highly correlated lead, strontium, and helium isotopes in Mid-Atlantic Ridge basalts from a dynamically evolving spreading centre at 31–34°S

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We report Pb, He, and Sr isotopic analyses of MORB glasses from four southern MAR ridge segments from 31° to 34°S. The segment centered at 33°S (32.52°–33.47°S) is the central of three segments that are separated by left lateral offsets and bounded by the Cox and Meteor fracture zones. The remaining segment is located just north of the Cox fracture zone. The 33°S segment is the longest and shallowest segment and has lengthened by ridge propagation at both ends over the past 3.5 m.y. to 100 km. Maxima in ridge axis elevation, K/Ti, $^{206}Pb/^{204}Pb$ and $^{87}Sr/^{86}Sr$, minima in $Na_{8.0}$ and $^{3}He/^{4}He$, and a pronounced 'bulls-eye' Bouguer gravity low occur simultaneously near 33°S (Fig. 1). The average extent of melting for the 33°S segment, determined from major element chemistry, is slightly greater than that of adjacent segments.

Previously we have shown that the asthenosphere from 2°S to 47°S has been polluted by the off-ridge hotspots of Circe, St. Helena, and Tristan da Cunha, Gough, and Discovery (TGD). Variations in isotopic and incompatible element ratios along the ridge coincide with anomalous elevations of 'zero age' crust (Schilling *et al.*, 1985; Hanan *et al.*, 1986, Graham *et al.*, 1992). Basalts from ridge-sections having spike-like geochemical anomalies define distinct binary-mixing vectors in Pb/Pb isotopic space between the off-ridge hotspots and the LILE-depleted asthenosphere. Basalts that would be considered normal MORBs by their $(La/Sm)_N < 0.63$, from ridge-sections between these anomalous areas, are also contaminated with respect to Pb isotopes. There is a broad maximum in $^{206}Pb/^{204}Pb$ and minimum in $^{3}He/^{4}He$ opposite

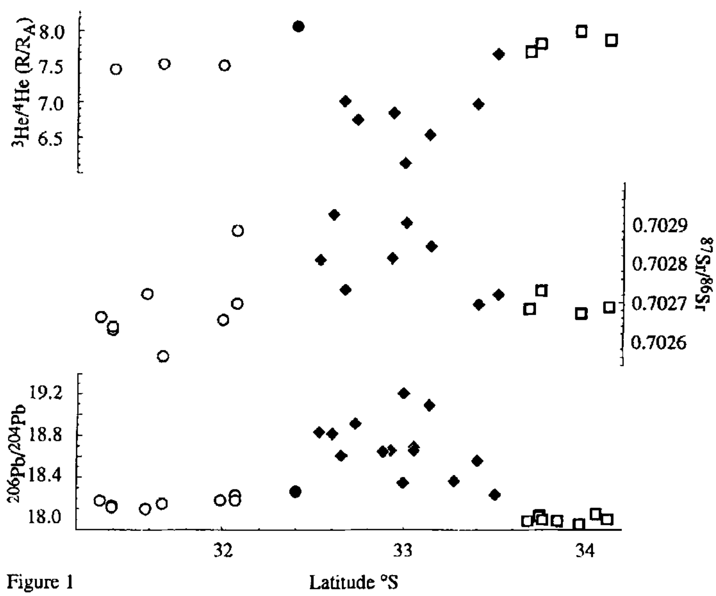

FIGURE 1.

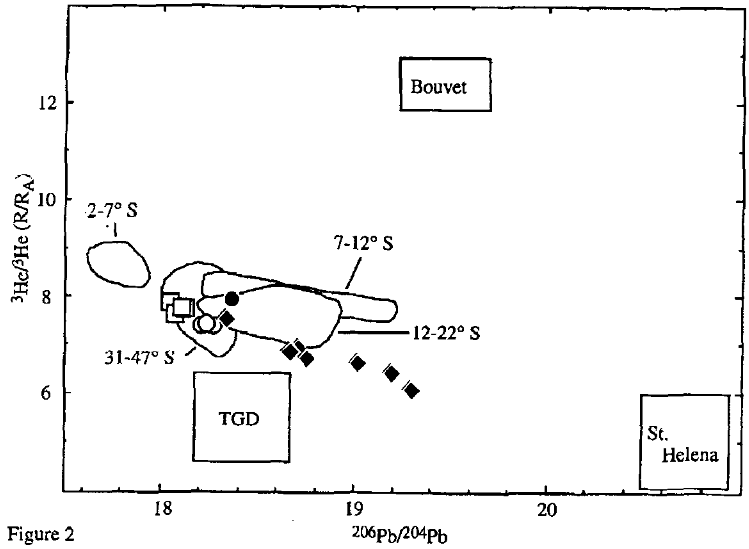

FIGURE 2.

the ^{206}Pb-rich St. Helena plume, while $^{208}Pb/^{204}Pb$ is maximum opposite the ^{208}Pb-rich TGD hotspots. We interpret this discrepancy between $(La/Sm)_N$ and radiogenic Pb and He to result from broad pollution of the asthenosphere by dispersion of these plumes during the time when they were intraplate, prior to being over-ridden by the migrating MAR (Hanan *et al.*, 1986).

The 33°S geochemical anomaly has a short wavelength, high-amplitude spike-like profile superimposed on the broad, long wavelength trend. The anomalous enrichment shown by Pb and He isotopes, relative to the regional trend, is restricted to the 33°S segment, where $^{206}Pb/^{204}Pb$ increases to 19.3, $^{87}Sr/^{86}Sr$ to 0.7029 and $^3He/^4He$ decreases to 6.3 R_A. The $^{206}Pb/^{204}Pb$ (18.0–19.3) and $^3He/^4He$ (8.2–6.3 R_A) variations encompass much of the global range for MORB erupted away from the influence of known hotspots; $^{87}Sr/^{86}Sr$ ranges from 0.7025 to 0.7029. The $^{206}Pb/^{204}Pb$, $^{87}Sr/^{86}Sr$, and $^4He/^3He$ ratios are highly correlated, show good correlation with K/Ti, poor negative correlation with $Na_{8.0}$, and lack correlation with $Fe_{8.0}$ or Mg#. All of the other ridge segments have distinct isotope signatures, suggesting that their magma sources are isolated from each another. Although the 33°S anomaly is similar to other MAR anomalies caused by hotspot-ridge interaction, the correlations in Pb, Sr, and He isotopic space are not consistent with binary mixing between the MORB asthenosphere beneath the 33°S segment and the off-axis TGD hotspots. Instead, an enriched source with $^{206}Pb/^{204}Pb$ greater than 19.3 is required. The combined Pb, Sr, and He isotope signature of the 33°S anomaly is distinct relative to the South Atlantic hotspots, and may reflect the drawing up by the migrating ridge system of a relatively small scale passive mantle domain, apparently unrelated to the South Atlantic hotspots at this time.

References

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