Mantle dynamics beneath Mongolia: Implications from Cenozoic and Mesozoic alkalic basalts

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Scattered Cenozoic and Cretaceous alkali basalts occur across an area of 180,000 km^2 in Central Mongolia. The volcanism relates to two distinct tectonic settings: one of localised extension associated with strike-slip faults, Gobi (33–30 Ma); the other relating to small-scale rifts adjacent to an uplifted dome, the Hangai (6–0.004 Ma). Mesozoic magmatism (117–95 Ma) is restricted to the Gobi region, and pertains to a phase of rifting most active in the late Jurassic-Early Cretaceous.

Asthenosphere *vs* lithosphere *vs* crustal contamination?

Mg no. <65 in Cenozoic lavas and <67 for some Mesozoic basalts, indicate the sample suite is relatively primitive and unfractionated. Furthermore, a plot of $^{87}Sr/^{86}Sr$ *vs* Sr (ppm), shows that the data has not significantly assimilated continental crust (Fig. 1) except in the earliest Cretaceous lavas. La/Ba *vs* La/Nb ratios in all basalts are similar to ocean island basalts. High La/Yb (25.0–30.5) ratios in lavas from both Cenozoic tectonic settings indicate residual garnet in the source; whereas Mesozoic samples have lower La/Yb ratios (10.3–18.9), suggesting little or no residual garnet. Thus, the data indicate an increase in the average depth of melting since the Mesozoic.

A plot of $^{143}Nd/^{144}Nd$ *vs* $^{87}Sr/^{86}Sr$ (Fig. 2) for all basalts, compared with published crustal xenolith data, indicate that the basalts are from a less depleted source than most of the xenoliths. One explanation is that the basalts were produced by mixing lithosphere-derived melts (i.e. low εNd-high εSr) with continental crust. However, given that major element and Sr isotope systematics suggest little, if any, crustal contamination, we believe that these basalts are derived by interaction of enriched lithosphere and asthenosphere-derived melts as they ascend to the surface.

Mantle dynamics in Mongolia

Prolonged activity and widespread volcanism in Mongolia has been attributed to many models: a distant effect of the India-Asia collision (Molnar and Tapponnier, 1975); a newly arrived mantle plume centred beneath Hangai (Windley and Allen, 1993); and a long-lived plume (Yarmolyuk *et al.*, 1990). The absence of progressively aged volcanism or high heat flow, coupled with $^{3}He/^{4}He$ ratios of $6.5-10.5 \pm <30\%$ (R/Ra higher than MORB, but lower than deep mantle plumes), implies that volcanism may be derived from normal OIB-like mantle (T.L. Barry and G. Davies, unpublished data). Thus, the main control on volcanism may be tectonic thinning or fracturing of the lithosphere above an otherwise

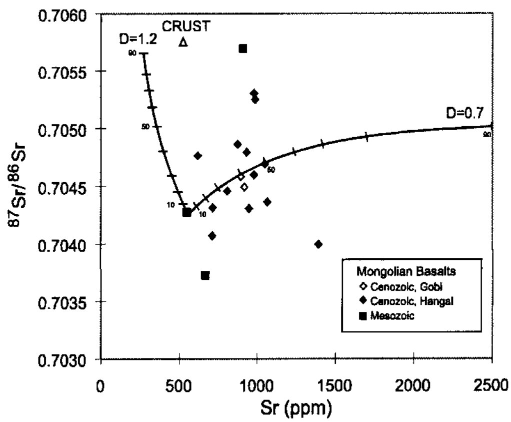

FIG. 1. $^{87}Sr/^{86}Sr$ *vs* Sr (ppm). Crustal end-member, Stosch *et al.* (1995). Mongolian basalts not lying on any AFC modelling curves (DePaolo, 1981) show that crustal contamination is not a significant process in their petrogenesis.

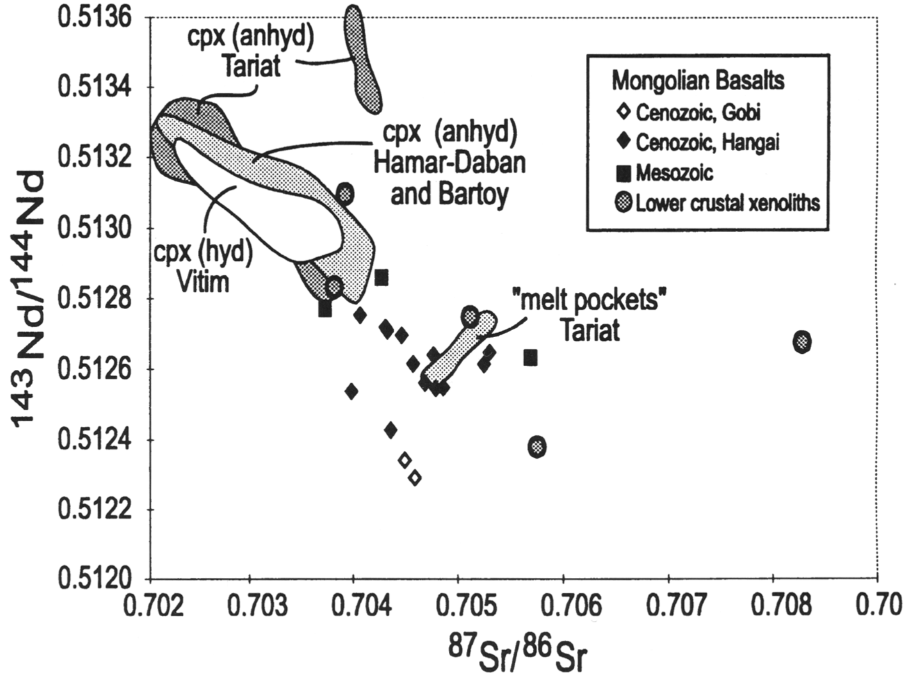

FIG. 2. Plot of $^{87}Sr/^{86}Sr$ *vs* $^{143}Nd/^{144}Nd$ for Mongolian basalts and peridotite data from surrounding areas in Mongolia and Baikal; data sources available from T.L. Barry on request.

homogeneous thermal anomaly that may have been present since the Mesozoic.

Changes in $^{143}Nd/^{144}Nd$ throughout time define a sequence of events: firstly, low Nd isotope ratios in the earliest Cretaceous basalts (~0.5126) are interpreted as crustal contamination during a time of lithospheric extension. Later, in the Mid-Cretaceous less crust was assimilated and OIB-like ratios are seen (i.e. 0.5128–0.5129). After a 70 m.y. hiatus, the Gobi lavas erupted, with very low $^{143}Nd/^{144}Nd$ ratios; this deviation to low ratios is not well understood, but as discussed above, it does not appear to be related to crustal contamination. Instead, the Gobi basalts appear to be derived from enriched lithospheric mantle. Younger Cenozoic Hangai basalts have Nd isotope compositions intermediate between Gobi and Mesozoic lavas. This trend to higher Nd ratios in the youngest lavas may also relate to thinning of the crust and lithospheric mantle. That is, as magmatism proceeded during the Cenozoic, the enriched portions of lithosphere were progressively removed, leaving behind a more depleted, asthenosphere-like source. A similar model has been proposed for the evolution of Cenozoic lavas from the western U.S.A (Kempton *et al.*, 1991) suggesting parallels in some aspects of the tectonic evolution of these two regions.

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