Compositional variations in a fertile mantle domain: peridotite xenoliths from the Tariat region, Mongolia

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Continental lithospheric mantle is heterogeneous in terms of modal and chemical composition. There are fundamental differences between cratonic and younger mantle (Boyd *et al.*, 1997), and non-cratonic mantle has broad compositional variations worldwide (McDonough, 1990). Xenoliths of spinel peridotites in alkali basalts are direct samples of lithospheric mantle but it may not be clear whether a single xenolith suite can provide a representative sample of the mantle in a given lithospheric unit. The range and scale of compositional variations in a mantle volume can be established by representative sampling of xenoliths from different eruption centres of a similar age. Questions of particular interest are (i) whether lithospheric mantle in individual tectonic units has limited variation ranges specific to each unit, (ii) the scale of mantle heterogeneity and spatial relationships between rock types, and (iii) the relationship between variations in modal composition (including accessory minerals), major and trace element compositions.

Samples and methods

These questions are addressed here using petrologic and geochemical data for several xenolith suites from the Plio-/Pleistocene Tariat basaltic field in central Mongolia. Press *et al.* (1986) and Stosch *et al.* (1986) provided petrologic, trace element and Sr-Nd isotope data for 12 spinel peridotite xenoliths from the Shavaryn-Tsaram site in the Tariat region. They found that the xenolith suite is dominated by 'primitive' to slightly depleted lherzolites and argued for an unusually primitive upper mantle beneath Mongolia. However their study based on a limited number of samples from a single eruption centre did not demonstrate whether these compositions are unique for that site or characterise a large mantle domain.

This work is based on a study of more than 70 spinel peridotite xenoliths from four other eruption centres in the Tariat region (Haer, Shute, Tsagan and Zala) located within 20 km of each other. All these samples were studied petrographically and their minerals analysed for major elements by electron microprobe (EMP). Whole rock major element compositions were determined for 30 xenoliths by XRF; trace element composition of clinopyroxene (cpx) in 32 xenoliths were obtained by laser ablation ICP-MS. These results are compared with published and new original data for xenoliths from Shavaryn-Tsaram.

Results

Relative position of the xenoliths in the lithospheric cross-section was estimated by projecting a temperature estimate for each xenolith on the local geotherm constructed earlier based on garnet-bearing xenolihts from Shavaryn-Tsaram (Ionov *et al.*, 1998). At two sites, Shavaryn-Tsaram and Zala, the xenoliths show the largest range of T values from ~880 to 1100°C and appear to provide continuous sampling of the spinel lherzolite facies mantle from the crust-mantle boundary to the deeper garnet lherzolite facies. At three other sites the T values do not exceed ~1000EC and correspond to the uppermost mantle only.

The xenoliths at the four new sampling sites range from fertile to moderately depleted spinel lherzolites with cpx contents between 8 and 20 wt.%. No harzburgites were found. The lherzolites from all these sites show a similar range of bulk composition, with Al_2O_3 varying from 2 to 4.7 wt.% and a more limited range of 3–4 wt.% Al_2O_3 in the majority of the samples. The average whole-rock compositions at each site are also similar, with 3.4–3.8 wt.% Al_2O_3 and 3.0–3.2 wt.% CaO; the average composition of the xenoliths from Shavaryn-Tsaram reported by Press *et al.* (1986) also falls within these ranges. Rare harzburgites and cpx-poor lherzolites have been found at Shavaryn-Tsaram where mantle xenoliths are particularly abundant, but these rock types are very subordinate. Overall, the compositional ranges and average compositions are similar for all the xenolith occurences in Tariat.

The majority of the Tariat lherzolites are coarse- to medium-grained rocks with protogranular microstructure. The xenolith suites at each site have similar textures but can be distinguished by the occurrence and relative abundance of accessory amphibole and mica, fine-grained interstitial material and fluid inclusions in minerals. Amphibole occurs only in the Tsagan xenolith suite in which it is fairly common (found in 8 samples out of 15). Phlogopite occurs in xenoliths from three sites: it is very common in xenoliths from Shute (eight out of 12) but rare in xenoliths from Haer (three out of 20) and Tsagan (two out of 15). Amphibole and mica have not been found in 25 xenoliths from Zala studied; in three Zala xenoliths more than half the clinopyroxene is replaced by spongy aggregates. Many xenoliths from Haer have abundant fluid inclusions in pyroxenes.

Clinopyroxene is depleted in light *REE* relative to heavy and intermediate *REE* in 28 xenoliths out of 32 analysed for trace elements. In the majority of the samples clinopyroxenes also have low contents of highly incompatible trace elements (Nb, Th, U). Interestingly, five of the *REE*-depleted xenoliths contain accessory phlogopite or amphibole, i.e. are modally metasomatised. Clinopyroxene coexisting with phlogopite is enrihed in *LREE* only in two xenoliths in which phlogopite is abundant and texturally equilibrated with tabular-equigranular lherzolite. Overall, the majority of the Tariat xenoliths show no geochemical evidence for significant metasomatic enrichment including some modally metasomatised samples in which the enrichment was moderate and hosted by interstitial material.

Conclusions

The Tariat peridotites from five eruption centres are charaterised by low to moderate depletion in basaltic components combined with depletion in incompatible trace elements. These results are in general agreement with earlier conclusions of Press *et al.* (1986) and Stosch *et al.* (1986) that the Tariat peridotites are more fertile than the average spinel peridotite xenolith suites worldwide. The generally fertile mantle compositions in central Mongolia broadly match those observed in xenoliths from the Baikal region in the north and suggest that the lithospheric mantle in those areas defines a large-scale fertile domain.

The mantle in the Tariat region is relatively homogeneous in terms of the contents of rock-forming minerals, major element compositions and trace element patterns in clinopyroxenes reflecting an origin in a mantle domain that has experienced only low to moderate degrees of partial melting and melt extraction and was not significantly metasomatised afterwards. Mantle heterogeneity on a kilometre scale may be expressed by the presence and different abundances of specific accessory minerals, interstitial material or fluid inclusions in minerals. These probably reflect small-scale metasomatic events induced by upward percolation of small amounts of fluids with different composition.

References

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