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THERMAL STATE AND TRACE ELEMENT SIGNATURE OF LITHOSPHERIC MANTLE ERODED BY UPWELLING ASTHENOSPHERE: EVIDENCE FROM PERIDOTITE XENOLITHS FROM NUSHAN, E CHINA

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ABSTRACT

On the basis of geothermobarometric investigations and geological and geophysical observations, it is generally accepted that the mantle lithosphere beneath the Sino-Korean Craton was drastically thinned (loss of > 120 km) since the late Mesozoic (Menzies et al., 1993; Griffin et al., 1998). To characterize the thinned lithospheric mantle and constrain the mechanism envisaged for thinning (e.g., thermomechanical erosion by upwelling asthenosphere), we have analyzed hydrous (amphibole-bearing) and anhydrous spinel peridotites from the Nushan Quaternary volcanic cone, at the southern edge of the craton.

Our results indicate that these two suites are markedly distinct in term of deformation/recrystallisation, thermal state and geochemistry. The anhydrous peridotites have predominantly fine-grained (~ 1 mm), deformed textures whereas most of the amphibole-bearing peridotites are coarse-grained (> 3 mm) and less deformed. Electron microprobe analyses indicate that the pyroxenes of the anhydrous suite are chemically homogeneous and equilibrated at temperatures of 990-1110°C. In contrast, the pyroxenes of the amphibole-bearing peridotites are compositionally zoned and record cooling from 1050°C to 850-900°C, down to 750°C in some cases. Such relationship between temperatures and textures is the opposite of the one generally observed in mantle xenoliths and implies a multi-stage thermal evolution. The anhydrous suite would record an early thermal event, probably related to lithospheric thinning during early Tertiary. During this event, peridotites with varied textures were equilibrated at similar temperatures of about 1000-1100°C, as already noted by Xu et al. (1998) for the Wangqing xenolith occurrence. The amphibole peridotites would record a later thermal event, probably coeval with the Quaternary volcanic activity.

The anhydrous suite can be subdivided in two groups with respect to trace elements in cpx. The first one is characterized by LREE-depleted (N-MORB), chondrite-normalized REE patterns. The highly incompatible trace elements show increasing degree of depletion on normalized diagrams, from Nb-Ta to Rb-Ba, through Th-U. The second group is somewhat enriched in Fe and shows lower HREE content in cpx, compared with the first group. The chondrite-normalized REE patterns are either convex-upward or "spoon-shaped". Only a slight depletion of the HFSEs (Zr, Hf, Nb and Ta) is noted in a few samples.

The hydrous suite displays a very wide range of LREE variation in cpx (La_N = 5-58.6), in contrast with the restricted range of HREE contents (Yb_N=10-10.8). The REE patterns vary from U-shaped to steadily enriched from HREE to LREE, and the LREE/HREE ratio is roughly correlated with the abundance of amphibole. LREE enrichment is coupled with a strong enrichment of Th and U, whereas the HFSEs (especially Nb and Ta) display marked negative anomalies on the normalized diagrams. The normalized patterns of these samples are similar to those generally ascribed to carbonate-melt metasomatism.

Geochemical variations such as the one observed in the "enriched" ($La_N/Yb_N \geq 1$) Nushan xenoliths - i.e., from relatively flat normalized trace-element patterns, without marked HFSE anomalies, to strongly fractionated patterns with elevated LILE/HREE ratios and negative HFSE anomalies - have been previously observed, both in suites of mantle xenoliths (e.g., Bedini et al., 1997) and in a metasomatized wall rock of the Lherz orogenic peridotite (Bodinier et al., this issue). In both cases, these variations were ascribed to a single metasomatic event involving progressive chemical evolution of melt infiltrated in lithospheric peridotites and gradually solidifying down a thermal gradient. However, the correlation between geochemistry and mineralogy/textures in Nushan xenoliths is strikingly different from the correlations observed in other suites of mantle xenoliths and in the Lherz wall rock. For instance, in the xenoliths from the East African Rift studied by Bedini et al. (1997), the peridotites with flat REE patterns are characterized by a coarser texture than the enriched ones; in the Lherz wall-rock, the peridotites with flat REE patterns contain amphibole whereas the enriched ones are devoid of this mineral.

Therefore, a model involving two distinct metasomatic processes is preferred for the Nushan xenoliths, consistent with the existence of two different thermal evolutions. In the hydrous suite, LILE enrichment coupled with amphibole precipitation was probably associated with relatively diffuse migration of volatile-rich, small melt fractions. In the anhydrous suite, limited REE enrichment in Fe-rich compositions is better explained by local processes such as metasomatic aureoles around veins. Similar to the temporarily distinct thermal evolutions recorded by the two suites of xenoliths, the two inferred metasomatic events were possibly disconnected in time and related to separate geodynamic events.

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