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Incongruent melting of garnet during garnet-spinel transition and its implication for lithospheric exhumation

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Abstract

The phase transition of garnet-spinel is one of the major parameters that affect lithosphere dynamics. The transition processes of garnet to spinel, however, remain unclear. Spinel-pyroxene symplectites around garnet from one olivine-websterite xenolith hosted by the Cenozoic Xilinhot basalts in northeast China were investigated in this study to decipher the transition processes of garnet to spinel and their implications for the Cenozoic episodic lithospheric exhumation of northeast China. Symplectites occur as two concentric coronae surrounding relict garnet or as pseudomorphs of garnet grains. The outer symplectite is made of relatively coarse-grained assemblages of orthopyroxene + spinel + clinopyroxene and exhibits a large range of mineral and bulk chemical compositions. It contains more Mg and less Al relative to relict garnet. The inner symplectite is a radial arrangement of intergrown fine-grained orthopyroxene + spinel ± glass ± clinopyroxene. Mineral and glass compositions show wide variations within each inner symplectite, but the bulk compositions are relatively homogeneous and show close affinities to the garnet relics. These observations demonstrate that the outer symplectite was formed by a slow reaction between garnet and olivine, whereas the inner symplectite is inferred as a rapid isochemical breakdown product of garnet. The Na- and K-poor glass in the inner symplectite could be the in situ melt from the decomposition of garnet, providing the first physical evidence of incongruent melting during the garnet-spinel transition. Combined with geothermobarometer and *P-T* pseudosection calculations, a slow-to-fast phase transition from garnet to spinel was discerned in the lithospheric mantle beneath northeast China during the Cenozoic, resulting from heating and decompression. These processes could be induced by asthenosphere upwelling and lithospheric extension associated with the Pacific subduction during the Cenozoic. We speculate that outer symplectite formed before the Miocene, whereas the inner symplectite has only begun to form since the Miocene due to enhanced lithospheric extension. Therefore, the two-stage phase transition in the lithospheric mantle could reflect the two-stage lithospheric exhumation of northeast China during the Cenozoic.

Keywords: Incongruent melting, garnet breakdown, garnet-spinel transition, lithospheric exhumation, symplectite formation