Thermal history of lithospheric mantle: Mantle xenolith from Colorado Plateau in North America continent revisited

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Mantle convection plays an important role in heat and mass transportation from the deep earth to the surface. It is thus important to understand the thermal state of the mantle and its temporal changes, direct information of which may be obtained from fragments of the mantle brought to the surfeace by magmas, usually called "mantle xenoliths". We study the mantle xenolith from continental lithosphere to reveal dynamics of chemical and thermal interaction taking place near the lithosphere asthenosphere boundary in the continental region. The target area is the Thumb in the Navajo volcanic field in the Colorado Plateau of the North America continent (Ehrenberg,1982). Five xenolith samples from the Thumb were thoroughly examined by using optical microscope, electron probe micro analyzer (EPMA), and field-emission secondary election microscope(FE-SEM). Our strategy is quantitative comparison of microstructures and mineral chemical compositions among examined xenolith to reveal their depth variation of thermal, chemical, and rheological properties

Examined five samples are two garnet lherzolite, garnet harzburgite, without fine-grained portions, and the other contains fine-grained recrystallized olivine in various amounts. Previous study (Ehrenberg,1982) argued that the mantle xenolith from the Thumb are equilibrated at various temperature with almost no systematic variation in the depth of xenolith derivation. The five samples analyzed this study show a wide variation in CaO contents in olivine from 0.02~0.08 wt.%. A garnet lherzolite sample with lower CaO contents in olivine (0.03~0.04 wt.%) contains clinopyroxene and orthopyroxene with strong zoning characterized by enrichment of Al and Ca towards the rim. Garnet grains in the sample shows extensive decomposition via reaction with olivine into aggregates consisting of spinel and pyroxenes with diverse size change: coarse in the outer margin (~several tens of micrometer) and very fine near the contact with relict intact garnet (~1 micrometer). The pyroxene zoning and breakdown texture of garnet suggest that the xenolith underwent heating or decompression before this mantle xenolith was brought to the surface by the host minett. Preliminary geothermobarometry has revealed pressure-temperature correlation, from which the xenoliths records the temperature variation of ~200℃ over the pressure range of ~25GPa. The estimated pressure correlates with various textural features, such as size of recrystallized olivine, which decreases with depth . They also show correlations with mineral chemical parameters, such as forsterite content of olivine, which increases with depth, suggesting that the lithosphere is more depleted with depth .

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