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Microstructural analysis of peridotite xenoliths from Kimberley and Lesotho kimberlite pipes in South Africa

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Kimberlite pipes carry peridotite xenoliths derived from the deep upper mantle (70-250 km) beneath Archean cratons. Such xenoliths contain well-developed deformation microstructures. This study presents microstructures of peridotite xenoliths from two kimberlite pipes in South Africa: Kimberley and Lesotho.

The peridotite xenoliths of Kimberley kimberlite pipe consist of lherzolite, harzburgite and dunite. The lherzolites consist of olivine, orthopyroxene, garnet and clinopyroxene. The harzburgites consist of olivine, orthopyroxene, garnet and a minor amount of clinopyroxene. A small amount of phlogopite occurs in both rocks. These rocks are texturally divided into two types: coarse granular (granular type) and extensively sheared peridotites having obvious foliations (foliated type). The granular type peridotites show equigranular textures with slightly curved grain boundaries. The foliated type peridotites show porphyroclastic textures, which consist of coarse-grained porphyroclasts and very fine-grained neoblast matrix. These peridotites display no visible evidence of extensive metasomatism, but show some secondary serpentine alterations along grain boundaries. Major-element compositions of minerals were determined by an electron probe microanalyzer (EPMA). Mineral chemistries for the Lherzolites and the harzburgites indicate that these mantle rocks were equilibrated at similar P-T conditions regardless of their texture types. Olivine crystal-preferred orientations (CPOs) were measured in highly polished XZ thin sections using a scanning electron microscope (SEM: Hitachi S-3400N) equipped with electron back-scattered diffraction (EBSD: Oxford-HKL Channel5). The peridotite xenoliths show various olivine CPO patterns.

The peridotite xenoliths of Lesotho kimberlite pipe are grouped into two types: coarse granular type and small-grained elongated type. Olivine CPOs show intense concentrations of [010] axes normal to the foliation, with girdles of [100] and [001] axes within the plane of the foliation (AG type). In particular, the small-grained elongated peridotites show strong concentration of [010] axes. This CPO pattern may result from axial shortening. The coarse granular peridotite shows higher equilibrium temperatures than those for the small-grained elongated peridotites. It suggests that the cratonic mantle beneath Lesotho may contain a domain where the coarse peridotites alternate with the small-grained elongated peridotites at around 150 km deep.

Keywords: Kimberlite, Peridotite xenoliths, microstructure, crystal fabric analysis