Petrology and geochemistry of xenoliths from the Orapa kimberlites, Botswana

Yosuke Uehara[1], Kei Hirose[2], Shigenori Maruyama[3]

[1] Earth and Planetary Sci., Tokyo Inst. of Tech., [2] Dept. Earth & Planet. Sci., TIT, [3] Earth and Planetary Sci., Tokyo Institute of Technology

The diamondiferous Orapa kimberlites are intruded into a mobile belt between Kaapvaal craton and Zimbabwe craton about 90Ma in the period of upper Cretaceous (Davis, 1977). Xenoliths in kimberlite diatremes provide a window into the underlying crust and upper mantle and, with the aid of detailed petrological and geochemical study, can help us understand characteristics of the deeper mantle. Orapa is famous for the best productivity and good qualities of diamonds. On the other hand, the locality is unique as commented above that almost all of diamondiferous kimberlites in the world intruded into surfaces of cratons but Orapa is not. Moreover, a majorite inclusion in diamond was found from this site. Those facts remain the possibility of existence of deeper mantle xenoliths from Orapa than those from other pipes.

To provide relevant data on the deep mantle under the eastern Botswana we have studied peridotite xenoliths from the Orapa kimberlites. No report has been published concerning peridotites from Orapa kimberlites and this is the first to report. The mantle-derived xenolith suite in Orapa kimberlites includes peridotites, pyroxenites, eclogites, megacrysts of garnet or pyroxene and ilmenites. The total number of the samples in this study reaches 2,200. The proportion of peridotites is approximately 60%. Most peridotite xenoliths are represented by garnet harzburgites and lherzolites as well as spinel harzburgites and lherzolites. Most peridotites are coarse-grained, but some show intensely deformed texture. Some peridotites are variably metasomatized and show the formation of metasomatic phlogopite, clinopyroxene and ilmenite. A suite of metasomatized peridotite xenoliths from Orapa kimberlites forms a metasomatic sequence from garnet peridotite to garnet phlogopite peridotite to phlogopite peridotite. The Fo-value of peridotite xenoliths from Orapa, especially of lherzolites and harzburgites, ranges from 90 to 94%. Orthopyroxenes and clinopyroxenes of peridotite xenoliths from Orapa are enstatitic, ranging from En90 to En95, and diopsidic, ranging from 38wt% to 52wt% in Mg/(Ca+Mg) respectively. On the other hand, garnets of peridotite xenoliths from Orapa are consist of pyropes and both G9 and G10 garnets exist.

Calculated temperature-depth relation estimated by clinopyroxene-orthopyroxene geothermometer and orthopyroxene-garnet geobarometer(Brey & Kohler, 1990) shows a well-developed correlation between the textures of xenoliths and P-T conditions. Namely, the peridotites with the deformed texture have higher temperature and pressure signature than that of coarse-grained. This is comparable to xenoliths from Kaapvaal craton(Boyd, 1973). The P-T data indicates the presence of lithospheric mantle beneath Orapa, which is at least 150km thick and had a 40-45mW/m2 continental geotherms at the time of emplacement of Orapa kimberlite pype. Such continental geotherms are lower than non-cratonic continental geotherms and restrict the thickness of the cratonic keel.