I131-P015 **Room: Poster Session Hall** **Time: May 18**

Origin of Mg and Si rich cratonic mantle; does the Earth's deep mantle consist of pyrolite?

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Mantle peridotite xenoliths from kimberlite pipes, which derived from the deep upper mantle up to about 250km depth from Archean cratons, give us some direct information about the geochemical evolution of crystal and mantle materials in interior of our planet.

These peridotite xenoliths sometimes have unusual chemical, modal, and textual compositions (e.g., Boyd, 1989; Boullier and Nicolas, 1975). In this study, I research the mantle-derived peridotites obtained as xenoliths of kimberlite from Lesotho and Botswana (Uehara, 2005MS) in African craton and consider about the geochemical evolution of the Earth's mantle.

Garnet peridotites from more than 80 km in depth at Lesotho and Botswana areas have quite different with chemistry from shallow mantle, such as oceanic and arc area (e.g., Dick et al., 1984; Boyd, 1986; Arai, 1994). For example, in oceanic peridotites from mid-ocean ridges, the chemical variation of shallow mantle can be explained by process of partial melting of pyrolitic lherzolite and subsequent melt extraction at depth of 30-80 km. The estimated maximum degree of melting (about 30 %) of residual peridotite and the chemical feature of the constituent minerals, that was depleted in incompatible element (SiO_2, Al_2O_3, CaO) with respect to compatible elements (MgO, Cr_2O_3), indicate that the partial melting occurred at almost dry condition. On the other hand, the cratonic peridotites mainly consist of olivine, orthopyroxene, garnet and clinopyroxene, and characterized the extremely high amount of orthopyroxene (= high amount of SiO_2 component) with high Mg# (= Mg/(Mg + Fe) atomic ratio) (e.g., Boyd, 1989). These high Si and Mg harzburgite/lherzolite could not explained as residue of dry partial melting and melt extraction process (Walter, 1998). Several models for the origin of unusual Si-rich peridotites has been proposed (e.g., Herzberg et al., 1988; Kelemen et al., 1998; Walter, 1999). In all of these models, the formation of continental deep peridotites involves a process (or processes) of Si addition other than partial melting.

Here, I suggest two other possibilities of origin of Si- and Mg-rich continental deep peridotites: (1) residues of partial melting of pyrolitic lherzolite at H_2O-saturated condition at higher pressure at depth of 200-300 km, (2) residues of partial melting of Si-rich primitive material(s) of depth 80-250 km. If the first model is the answer, the Earth's mantle is very heterogeneous in water content, and water was one of the important components for formation of continental craton at early Earth. If the second model is correct, it suggest that the