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Transformation of lithospheric mantle through melt-peridotite reaction: direct evidence from a highly fertile composite xenolith

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The Sino-Korean Craton has attracted considerable attention over the last two decades since a dramatic change in lithospheric architecture has happened from a Paleozoic thick cratonic mantle to a Cenozoic thin oceanic mantle. This change requires considerable thinning of the lithosphere during the Phanerozoic time. The mechanism for such a change is hotly debated. Geochemical features of Mesozoic mantle-derived rocks demonstrate that the Mesozoic lithospheric mantle beneath the region was considerably different from both the Paleozoic refractory and the Cenozoic depleted ones, implying two times lithospheric compositional changes[1]. A highly fertile composite mantle xenolith entrained in Cretaceous basalt on the craton provides more direct evidence for such a compositional change. The xenolith has a lherzolite core, a sheared zone and a reactant rim. The lherzolite is coarse granular and composed of olivine, opx, cpx and spinel. The sheared zone and the reactant rim comprise oriented olivine, secondary cpx and spinel, and fine-grained olivine, cpx and spinel, respectively. No orthopyroxene exists in the sheared zone and reactant rim. Mineral compositions in this composite xenolith vary dramatically between different zones. Olivine in the lherzolite is relatively high in Mg# (85-86) and NiO and in the sheared zone and the reactant rim are low (Mg#=83-85). Clinopyroxene and spinel also shows clear compositional trend from the lherzolite to the reactant rim, with a decrease in Mg#, Cr_2O_3 and Na_2O and an increase in TiO_2. Such a compositional feature in minerals of this composite xenolith is different from that of peridotitic xenoliths entrained in both Paleozoic kimberlites and Cenozoic basalts on the craton, which have much higher Mg# (>90) in olivines. This highly fertile peridotite (i.e extremely low Mg# in constituent minerals) has never been found in lithospheric mantle beneath the worldwide cratons. We believed this xenolith was formed through peridotite-melt reaction. Thus this highly fertile composite xenolith provides direct petrological evidence for the replacement of sub-continental lithospheric mantle through peridotite-melt reaction. This replacement resulted in the transformation of the lithospheric mantle from high-Mg# peridotite to low-Mg# peridotite beneath the Sino-Korean craton and finally the loss of more than 120 km cratonic lithospheric keel in the region.

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References

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