Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SGC55-03 Room:101B Time:May 23 09:30-09:45

Two noble gas components in the Udachnaya kimberlite magma, Siberia

KITAMURA, Fumihiko[1*], SUMINO, Hirochika[1], MATSUFUJI Kyosuke[1], NAGAO, Keisuke[1], KANEOKA, Ichiro[2], KAMENETSKY, Vladimir S.[3], KAMENETSKY, Maya S.[3]

[1]GCRC, Grad. School Sci., Univ. Tokyo, [2]ERI, Univ. Tokyo, [3]Univ. Tasmania, Australia

Kimberlites are unique igneous rocks which occasionally brought diamonds from deep in the Earth. Although their origins are considered to be deeper than 150 km in the mantle based on the P-T stability of diamonds (e.g., Haggerty, 1994), they have not been well constrained yet (e.g., Smith, 1983).

We are continuing noble gas analyses for minerals from kimberlites to constrain their origins. Sumino et al. (2006) showed that olivine phenocrysts in the Udachnaya kimberlite from Siberia contain plume-derived Ne. This data strongly suggest that the origin of kimberlite is a plume rising from deep mantle, possibly from the lower mantle or core-mantle boundary.

We analyzed seven fractions of olivines separated from four Udachnaya kimberlite rocks to further investigate the composition and evolution of noble gas characteristics of the Udachnaya kimberlite magma. To clarify crystal size dependence of noble gases trapped in olivines, one fraction was composed of only olivines 0.25 ~ 0.5 mm in size while the other fractions consisted of 0.2 ~ 2 mm olivines. Two mantle xenoliths included in the Udachnaya kimberlite were also analyzed. Since magmatic noble gases are generally concentrated in fluid inclusions, stepwise crushing method was applied to extract noble gases selectively from the inclusions.

$^{3}He/^{4}He$ ratios decreased with progress of the stepwise crushing, due to increase in contribution of radiogenic ^{4}He located in the olivine mineral lattice and/or in the solid phase of inclusions. Therefore, $^{3}He/^{4}He$ ratios of the magma at the point of entrapment of the fluid inclusions in olivines are deduced from the relatively constant $^{3}He/^{4}He$ ratios of the first several crushing steps. Most samples showed $^{3}He/^{4}He$ ratios ranging from 5.4 to 6.5R_A for magmatic He. In the meanwhile only the small-grained sample yielded lower $^{3}He/^{4}He$ ratio of 3.8R_A, which is close to those of the xenolith samples (2.5 ~ 3.2R_A).

Ne isotope ratios show two different trends in a plot of $^{20}Ne/^{22}Ne$ vs. $^{21}Ne/^{22}Ne$; one is the kimberlite magma trend reported by Sumino et al. (2006), and the other deviates from it toward rightward implying larger contribution of nucleogenic ^{21}Ne. The latter trend is similar to that reported for subcontinental lithospheric mantle (SCLM) of European continent (Buikin et al., 2005), but differs from that for mid ocean ridge basalt (MORB) representing isotopic composition of convecting upper mantle. Small-grained olivine fraction belongs to the latter group, which exhibits strong SCLM affinity.

According to petrologic observation by Kamenetsky et al. (2008), true olivine phenocrysts entirely crystallized from the kimberlite magma should be smaller than 0.2 mm, while larger grains have core of olivine xenocryst which could have been derived from surrounding mantle. If this is the case the lower $^{3}He/^{4}He$ in the small olivine phenocrysts implies later crystallization after noble gases in kimberlite magma had significantly exchanged with those in surrounding SCLM. On the other hand, the large phenocrysts must have cores with low noble gas concentrations and their rim grew from the magma with noble gases less affected by SCLM.

This work clarified relation between two noble gas components in the Udachnaya kimberlite magma, one was intrinsic to the magma and the other derived from SCLM. The stepwise crushing experiment on different sized olivines revealed crystallization process under different degree of noble gas contribution from surrounding SCLM to the kimberlite magma.

References

Buikin A. et al. (2005) Earth Planet. Sci. Lett. 230, 143-162.
Haggerty E.H. (1994) Earth Planet. Sci. Lett. 122, 57-69.
Smith C.B. (1983) Nature 304, 51-54.
Sumino H. et al. (2006) Geophys. Res. Lett. 33, L16318.
Kamenetsky V.S. et al. (2008) J. Petrol. 49, 823-839.

Keywords: noble gas, kimberlite, olivine, Udachnaya, Siberia, plume, subcontinental lithospheric mantle