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# Intrinsic and secondary noble gas components in olivine in kimberlites: how to reveal their source compositions?

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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 [1], they have not been well constrained yet [2].

We have been investigating noble gases in olivines in kimberlites to constrain the origin of kimberlite magmas. Sumino et al. [3] found plume-derived Ne in olivine phenocrysts in the Udachnaya kimberlite from Siberia and suggested that the origin of kimberlite is a plume rising possibly from the lower mantle or core-mantle boundary. Namely we may be able to use kimberlites as a window into the deep Earth.

In this study, we analyzed 7 fractions of olivines separated from 4 Udachnaya kimberlite rocks [4], 5 fractions from West Greenland kimberlites [5], and 3 fractions from Brauna kimberlite in Brazil [6]. Since magmatic noble gases are generally concentrated in fluid inclusions, stepwise crushing was applied to extract noble gases selectively from the inclusions.

$^3$He/$^4$He ratios of the Udachnaya kimberlite olivines are ca. 6 Ra (Ra = 1.4 x $10^{-6}$ for atmospheric He), which is higher than xenoliths in the same pipe (3 Ra), but similar to the Udachnaya diamonds reported by [7]. Neon and Ar isotope ratios show two different noble gas components; the plume-like one reported for kimberlite magma [3], and the other enriched in radiogenic/nucleogenic noble gases originate in Siberian subcontinental lithospheric mantle (SCLM). We also found that olivines with smaller grain size are highly affected by the SCLM component. This confirms a model proposed by [3], in which upwelling plume temporarily stayed at the base of the Siberian SCLM, formed diamonds and kimberlite magma, and then the kimberlite magma conveying diamonds ascended and erupted. It also suggests that noble gas compositions of the kimberlite magma were affected from surrounding SCLM during its ascent, resulting in addition of radiogenic/nucleogenic noble gases. This is consistent with the model that silica content of the kimberlite magma increased due to consumption of pyroxene in the surrounding SCLM [8].

In contrast to the Siberian kimberlites, olivines in the West Greenland kimberlites exhibit relatively low $^3$He/$^4$He ratios. One group is characterized by $^3$He/$^4$He values of ca. 1.5 Ra and the other much lower ratio of 0.5 Ra. Neon isotopic ratios are also different; the former is similar to the Siberian SCLM, the latter dominated by nucleogenic component. Since the West Greenland kimberlite olivines contain relatively small amounts of magmatic noble gases such as $^3$He, radiogenic/nucleogenic components would become dominant after the kimberlite emplacement (600 Ma, [9]).

In the case of the Brauna kimberlite olivines, radiogenic/nucleogenic contributions are more significant. Their $^3$He/$^4$He ratios are ca. 0.02 Ra, and no magmatic Ne was observable.

These results suggest that whether olivines in a kimberlite can preserve magmatic signature or not strongly depends on their condition in each pipe, locality or environment, and also on their histories. Even though it preserves a magmatic noble gas signature, it itself could be severely contaminated by SCLM or other components during ascent of the magma. To obtain insight into the deep Earth, we should select samples and analytical methods carefully. If possible, comprehensive study involving other constituent components such as diamonds in the same kimberlite is more beneficial to clarify the relation of kimberlite magma with surrounding SCLM.

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