

Kimberlites vs. carbonatites: Comparison as an indicator for the chemical state of the Earth's deep interior

Ichiro Kaneoka[1]

[1] ERI, Univ. Tokyo

In order to get information on the chemical state of the Earth's interior, it is the most direct way to obtain a sample which might represent the environments and analyze it. At the JGUP 2006, as candidates for such samples, I made a comparison between kimberlites and oceanic-island basalts (OIBs)

and concluded that kimberlites would be less affected by shallow contaminations than OIBs and more directly represent the information about the chemical state of the Earth's deep interior (probably lower mantle).

Carbonatites are often referred to as related to kimberlites. To infer the chemical state of the Earth's deep interior, it is inevitable to consider the significance of similarities and differences in their properties. Distribution of kimberlites are limited in old continents like craton. Carbonatites are also found in similar areas, but some carbonatites are found in the oceanic area like Canary island. The youngest age of kimberlites are about 50Ma, whereas most recent carbonatite magma erupted in 1960 in Tanzania.

Kimberlites and carbonatites contain abundant volatiles, but there is a difference in the kind of volatiles. Both contain abundant CO₂, especially carbonatites do more than 30% of it. Although kimberlites contain more than 5-10% of H₂O, carbonatites include it with only 1%. Concerning sulphur, some kimberlites include sulfides, whereas carbonatites contain only sulfates. This is an evidence that kimberlite magma source is rather reduced state, but carbonatite magma source is oxidized. Normalized to chondrite values, REE patterns in their magmas are both highly fractionated in favor for lighter elements, but the degree of fractionation is larger for carbonatites than kimberlites. As major elements, kimberlites contain abundant Si, Fe and Mg, whereas carbonatites Ca and C. Such properties would reflect the combined effects of chemical compositions of magma sources, magma formation processes and secondary ones.

No clear difference is observed in carbon isotopes. The ³He/⁴He ratios with higher values than those of MORBs have been found in both kimberlites and carbonatites, which are considered to suggest their magma sources of the deep (probably lower) mantle origin.

However, in the Sr-Nd isotope diagram, kimberlites (group 1) concentrate around the bulk Earth value, whereas carbonatites show OIB-like values on the mantle array. This clearly indicates that carbonatite magmas are affected by mixing with some additional components.

Kimberlites include diamond and mantle xenoliths, whereas carbonatites hardly include them. This is largely related with relatively gradual movement of carbonatite magmas compared to kimberlite magmas. Furthermore, it also suggests that carbonatite magmas are likely to be affected by the surrounding materials during the uprise of a magma, which might be reflected in the distribution of data in the Sr-Nd isotope diagram. As long as solid radiogenic isotopes are concerned, we cannot say that magma sources of carbonatites are located in a similar mantle as that of the kimberlites and there remain many unsolved problems. He with high ³He/⁴He ratios might be originated from a mantle plume, but there is a possibility that carbonatite magma sources might take such He selectively from the plume. Compared to kimberlite magmas, carbonatite magmas seem to be more affected by the surrounding materials at shallow depths and more careful caution is required to apply the data to infer the chemical state of the Earth's deep interior.