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Magma sources and isotopes

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A volcano is formed as an extrusion of magma on the surface. However, magma is not always extruded to the surface and often cooled down to form dykes or intrusive bodies under the surface. Magma is generally considered to be formed by partial melting of peridotites in te mantle and represent the physical and chemical circumstances of the site. High pressure and temperature experiments try to realize the magma and mineral compositions observed in the field assuming a starting material. Before about 1970, the starting material was generally adopted among some mantle xenoliths which might have been regarded to represent the chemical composition of the mantle. However, chemical compositions of volcanic rocks reflect not only the magmatic differentiation, but also the secondary effects such as contamination of crustal materials. It is difficult to identify such effects clearly only by the results of high pressure and temperature experiments and chemical compositions of volcanic rocks.

On the other hand, such isotopes as Sr, Nd, Pb, Hf, Os and noble gases which include radiogenic isotopes depend on the parent/daughter ratios and geological time, but they are independent of chemical processes. Hence, it is possible to clarify the difference of magma sources by using them, which cannot be separated by chemical compositions alone. At present, it is difficult to imagine to discuss the magma sources without taking such such isotopes into acoount. However, such situation was quite different several tens of years ago.

For example, in petrology it was quite common to assume some garnet-bearing peridotite and/or pyroxenite among mantle xenoliths as a source material for Hawaian volcanic rocks and tried to explain various types of volcanic rocks sed on high pressure and temperature experiments. The author clarified the difference between the olivine and pyroxene phenocrysts of Hawaiian volcanic rocks and mantle xenoliths in noble gas isotopes and argued that the source material of the Hawaiian magma should be originated in the deeper mantle compared to that as assumed in petrology (Kaneoka and Takaoka, 1980). Afterwards, it has been generally regarded that the source materilas of Hawaiian magmas are located in the deep mantle related to the mantle plume based on various kinds of isotope ratios. Without information of isotopes, it is difficult to discuss such issues.

Furthermore, in Japanese volcanic rocks, it is sometimes observed that the increase of their SiO2 contents correlate with those of 87Sr/86Sr ratios even in the same area. In such a case, it suggests an incorporation of materials with high 87Sr/86Sr ratios such as old crustal materials.

Thus, information of isotopes is inevitable to clarify the magma sources and their chemical circumstances nowadays, but it is not always easy to understand the meaning of their message. Hence, it is an important issue to understand them and how to utilize them properly.

Keywords: magma source, isotope, volcannic rock, chemical circumstance