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Global material recycling in the Earth's interior inferred from isotope studies

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Concerning the information on the materials in the Earth's interior, it has been obtained from various points of view using the chemical and isotope compositions of rocks and minerals. However, since chemical compositions are variable reflecting various processes such as magma formation and crystal differentiation, it is important to identify the related processes precisely in order to infer the state of the magma source. On the other hand, the variation in isotopic ratios are controlled by mass fractionation associated with the phase change or kinetic processes. Especially, the isotopic ratio including a radiogenic isotope varies due to the integrated effect of a ratio between a parent to a daughter element and time. Such isotopic ratio is not controlled by any processes except for mixing between materials having different isotopic ratios. Hence, it becomes a very powerful tool to identify the characteristics of magma sources.

Based on 87Sr/86Sr, 143Nd/144Nd, 206Pb/204Pb and noble gas isotopic ratios, the chemical structure in the Earth's interior has been estimated that the upper mantle is represented by the isotopic ratios of MORB (mid-oceanic ridge basalt) and the OIB (oceanic island basalt) source is located in the lower mantle. However, some OIB magma sources are inferred to have characteristics enriched in incompatible elements compared to the assumed whole mantle composition and it has been suggested that they should reflect

the incorporation of recycled crustal materials caused by a subducted slab into the mantle. Furthermore, it has been known that banded zones extend in the southern hemisphere which is characterized by the occurrence of MORB and OIB having more radiogenic characteristics in Sr and Pb isotopes compared to those of the northern hemisphere. These zones have been named as Dupal Anomaly by S. Hart (1984). They are regarded to represent one of the most largest heterogeneity occurred in the Earth's interior. Their real cause has not yet been solved. However, it has been inferred that custal-like materials should have existed for more than 2-2.5 b.y. in the mantle and they can be regarded to represent an example for global material recycling in the Earth's interior.

In the case of arc magma, it has been inferred on the basis of 87Sr/86Sr, 206Pb/204Pb, 11B/10B and other isotopic ratios that oceanic sediments and/or altered oceanic crusts are incorporated to form the magma.

It has been known that cosmic-ray produced 10Be (half life; 1.5 m.y.) is enriched in the shallow parts of oceanic sediments. If it is subducted with a slab and incorporated into a magma, 10Be can be found in the arc magma.

This is the most direct evidence that oceanic sediments are incorporated in forming arc magma. Investigation of 10Be in lava flows from Quaternary volcanoes in northeastern Honshu and southern Hokkaido has supported such an inference in these areas.