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Global recycling of materials in the Earth's interior and noble gas isotopes

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Based on isotope ratios including radiogenic isotopes, it has been inferred that global recycling of surface materials in the Earth's interior through such processes as generation of plates at ridges, igneous process including volcanic eruption and subduction of slabs around island arc areas. Furthermore, seismic tomography indicates an image of subduction of slabs into the mantle.

However, there remain many issues to be solved such as details of the depth and the state of recycling of materials. For example, it has been argued that dehydration from the surface of a slab would contribute to produce an arc magma. But among researchers, there are large differences in their images about the degree of related materials and the effect of remained materials to the deeper mantle.

Since noble gas is chemically inert, its behavior can be regarded to be controlled only by physical processes. Furthermore, it is well known that the elemental and isotope compositions of noble gases are significantly different between those of the atmosphere and the Earth's interior. Since noble gases are volatile, it has been known that most materials formed near the surface exchange noble gas compositions from those of original one in a magma to the atmospheric ones. Hence we can identify surface materilas from the signature of the atmospheric compositions except for radiogenic components. By combining noble gas isotope signatures such as 3He/4He and 40Ar/36Ar, we can also identify different magma sources.

By applying noble gas signatures, many trials have been performed to investigate the state of the Earth's interior and it is inferred that the magma source of OIBs should be located deeper than that of MORBs based on 3He/4He and 40Ar/36Ar isotope systematics. Furthermore, it is commonly accepted that He is not recycled into the Earth's interior. Noble gases become a useful tool to get information on recycling of materials in the Earth's interior by applying their properties. For example, heavier noble gases such as Ar, Kr and Ar are regarded to be recycled with H2O and it has been reported that rcycled atmospheric noble gases play an important role in the magma source of OIBs associated with seawater. If it is, recylced materials contribute much to the magma sources of OIBs and island arc basalts, but not so much in case of the magma source of MORBs. Furthermore, atmospheric components spread over the region of the source of OIBs and their effects are reflected in the isotope compositions of noble gases of OIBs. However, no clear relation is observed between the degree of atmospheric contribution and the isotope signatures of solid elements. On the other hand, in case of He, which is regarded to have much larger mobility than those of heaier noble gases, OIBs with the 3He/4He lower than those of MORBs are regarded to be affected by recycled materials and they also show signatures of solid element isotopes by effect of recycled materials. Such characteristic 3He/4He signature suggests that the effect of recycled materilas is limited in case of He isotopes. Since even mobile He shows its effect to be limited in case of recycled materilas, it is likely that the observed atmospheric components of heavier noble gases in OIBs might contain the components not only of recycled materials but also the other kinds of sources. Thus, in order to investigate the effcte of recycled materilas based on noble gas isotopes, it is important to clarify the source of signatures observed in samples and should be reconsidered carefully.

Keywords: Global recycling, Earth's interior, Noble gas, Isotope