

## Volatiles in the Earth's deep interior-recycled or primary?

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Based on the chemical compositions of volcanic gases and eruptives, it is clear that volatiles exist in the Earth's interior. However, it is uncertain whether those volatiles are mostly recycled components once carried into the mantle together with slabs or primary components which have existed since the early history of the Earth. It is difficult to separate recycled components from primary ones by stable isotopes alone which are often used to reveal the origin of H<sub>2</sub>O and CO<sub>2</sub>, since they reflect mostly temperatures and chemical processes.

Furthermore, there are many arguments about the existence of volatiles in the upper mantle based on chemical compositions of mantle xenoliths and volcanic rocks. Many volatile elements can be explained by assuming that they are mostly recycled components. However, there exist such volatile elements as He which have been regarded to be difficult to be recycled and still degass from the Earth's interior. It is an important key to clarify the state of volatiles in the Earth's interior to reveal the distribution and behavior of these volatiles.

The lower mantle occupies about half of the Earth's total mass and the core about one third. However, we have so far no materials which surely reflect the chemical state of the lower mantle. By comparing the chemical and isotopic compositions of MORBs and OIBs and relationships with mantle plumes, the latter has been inferred to reflect the conditions at least partly and many models have been proposed based on the inference. The chemical and isotopic compositions are not directly related with pressures, but related with pressures through minerals which are controlled both chemical compositions and pressures of the forming location. The chemical compositions in the Earth's interior reflect the evolution process of the mantle, but the minerals which were formed in the deep Earth are transformed into another form at a shallow depth and it is not guaranteed that such a mineral keeps original volatiles which are mobile and behave as incompatible elements. Further, those such as OIBs which might have been affected by surrounding materials at a shallow depth have no guarantee to keep the state of the Earth's deep interior including those of volatiles. At present, it is a major approach to examine the state of volatiles in the Earth's deep interior based on laboratory high temperature and pressure experiments by studying the possible mineral forms and capability of inclusion of volatiles under the extreme conditions. However, in such an experiment, it is inevitable to assume a starting material which is inferred from the upper mantle materials. Thus, the chemical compositions should reflect those of the upper mantle. To examine the suitability of such an assumption, it is required to find some materials which might reflect the Earth's deep interior and to compare the inferences based on different approaches carefully.

The author has examined kimberlites as a possible significant candidate which might reflect the chemical state of the Earth's deep interior more directly than OIBs. To explain the signatures of solid element isotopes, it is not always required that OIBs' magma sources should be located in the lower mantle and volatiles with active chemical characteristics can be explained as recycled materials. However, He and Ne isotope compositions are different from those of the atmosphere and strongly indicate the primary components stored in the Earth's interior. Since chemically inert and quite mobile elements such as He still reside in the Earth's interior, we cannot deny the possibility that chemically active and less mobile volatiles are still remained in the Earth's deep interior. This is strongly related with the degassing of volatiles during magmatic processes through the Earth's history. However, their trapping forms, sites and amounts should be clarified further.