

Incorporation of nitrogen into the lower-mantle minerals under high pressure and high temperature

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Nitrogen occupies about 80% of the Earth 's atmosphere and had an impact on the climate in the early Earth. However, the behavior of nitrogen especially in the deep Earth is still unclear. Nitrogen is depleted compared to other volatile elements in deep mantle (Marty et al., 2012). "Missing" nitrogen is an important subject in earth science.

In this study, we compared nitrogen incorporation into lower-mantle minerals (bridgmanite, periclase and stishovite) from high-temperature high-pressure experiment using multi-anvil apparatus installed at Geodynamics Research Center, Ehime University under the conditions of 27 GPa and 1600°C-1900°C. In these experiments, we used Fe-FeO buffer in order to reproduce the redox state of the lower mantle. Two types of starting materials: a powder mixture of SiO₂ and MgO and a powder mixture of SiO₂, MgO, Al₂O₃ and Mg(OH)₂ were used for starting materials. Nitrogen in recovered samples was analyzed using NanoSIMS installed at Atmosphere and Ocean Research Institute.

A series of experimental results revealed that stishovite and periclase can incorporate more nitrogen than bridgmanite. This suggests that periclase, the major mineral in the lower mantle, may be a nitrogen reservoir. Furthermore, the results suggest that stishovite, which is formed by the transition of the SiO₂-rich oceanic crustal sedimentary rocks transported to the lower mantle via subducting slabs, can incorporate more nitrogen than bridgmanite (20 ppm nitrogen solubility reported by Yoshioka et al. (2018)). Our study suggests that nitrogen would continue to be supplied to the lower mantle via subducting slabs since approximate 4 billion years ago when the plate tectonics had begun, forming a "Hidden" nitrogen reservoir in the lower mantle.