Incorporation of nitrogen into the lower-mantle minerals under high pressure and high temperature -Transportation and storage of nitrogen in the deep earth-

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Nitrogen occupies about 80% of the Earth 's atmosphere and is an essential element of life. Moreover, it is suggested that nitrogen had an impact on the climate in the early Earth (e.g. Goldblatt et al., 2009; Wordsworth and Pierrehumbert, 2013). From these backgrounds, nitrogen is a very important volatile element in discussing the early Earth evolution process and origin of the life. However, we still cannot fully understand the behavior of nitrogen in the deep Earth. For example, nitrogen is depleted compared to other volatile elements in deep mantle (Marty et al., 2012). This is so-called "Missing" nitrogen and it is an important subject in earth science.
In this study, we compared nitrogen incorporation into lower-mantle minerals (bridgmanite, periclase and stishovite) by high-temperature high-pressure experiment using multi-anvil apparatus installed at Geodynamics Research Center, Ehime University under the conditions of 27 GPa and 1600 ℃-1900 ℃. 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 SiO_2 (quartz) and MgO and a powder mixture of SiO_2, MgO, Al_2O_3 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 SiO_2 -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. (2016)). 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. Furthermore, this “Hidden” nitrogen reservoir may play a role in decreasing high-concentration nitrogen which enhanced greenhouse effect in the early atmosphere (Goldblatt et al., 2009) to the present nitrogen concentration level.

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