Nitrogen solubility in stishovite under high P-T: formation of “hidden” nitrogen reservoir in the deep mantle via subducting slabs

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Nitrogen occupies about 80% in the Earth's atmosphere and is one of essential elements of life. For these reasons, nitrogen is an important volatile element in various aspects of geoscience. However, we couldn't have still understood details of behavior in the Earth's interior like "missing" nitrogen.

In this research, in order to investigate how much nitrogen is incorporated into stishovite and bridgmanite, we conducted high-pressure and high-temperature experiments using multi-anvil apparatus installed at Geodynamics Research Center, Ehime University. Pressure condition in all experiments was 28 GPa and temperature conditions ranged from 1400 ℃ to 1700 ℃. Fe-FeO buffer was used to control the redox state equal to the lower mantle. Nitrogen in recovered samples were analyzed using NanoSIMS installed at Atmosphere and Ocean Research Institute, The University of Tokyo. Nitrogen implanted standard samples were prepared at National Institute for Materials Science for estimating nitrogen solubility in silicate minerals.

A series of experimental results revealed that stishovite can incorporate 39-418 ppm nitrogen which is notably higher than nitrogen solubility in bridgmanite (5-50 ppm nitrogen solubility reported by Yoshioka et al. (2018)). Stishovite is mainly formed by the transition of nitrogen-rich sedimentary rocks transported to the lower mantle via subducting slabs. Our study suggests that nitrogen would continue to be transported into the lower mantle via subducting slabs since the plate tectonics had begun. This implies that formation of "hidden" nitrogen reservoir was initiated in the lower mantle approximate 4 billion years ago. Furthermore, this " hidden" nitrogen reservoir may originate from high-concentration nitrogen which had enhanced greenhouse effect in the early atmosphere (e.g. Goldblatt et al., 2009).