Dioctahedral Smectites as Nitrogen Conveyors to the Deep Earth: Implications for the Origin of Life

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Nitrogen is the most abundant element in Earth's atmosphere and is a fundamental building block of life. Its role in the accretion time of our planet was underestimated for a long time and was addressed to late veneer, in which volatile-rich bodies (e.g. comets) delivered nitrogen to a cold and already evolved planet. However, new data from recent space missions showed that not all comets are as volatile-rich as previously thought and the isotopic signature of several volatile elements (nitrogen included) does not fit the isotopic signature of such elements on Earth. Evidences from early phases of the accretionary disk found in chondritic meteorites, revealed that nitrogen-bearing phases could have delivered this element to the Earth in the early stages of Solar System formation. If so, there must be a well equilibrated mechanism that imbalance nitrogen from the Earth's inside and the Earth's atmosphere. This must be controlled by subduction system. Our study aims to understand how nitrogen could be transported back into the mantle by subductions zones. For that we conducted a series of experiments in which ammonium-bearing dioctahedral smectite (NH_4-smectite) was undergone to a wide range of high pressure and temperature (HPHT) conditions in a 1000 tonf hydraulic press coupled with toroidal chambers. The ammonium-rich smectite simulates pelagic sediments enriched in nitrogen, speciated as ammonium. Experiments were analyzed with XRD, FTIR, and SEM, to determine the mineral assemblies formed during the experiments, the evolution of crystallographic changes suffered by the NH_4-smectite, and the presence of ammonium in the mineral phases obtained after the experiments. The results showed that nitrogen is preserved not only in the structure of smectite/mica at high pressures (up to ~270 km) but also in high pressure aluminum-rich paragenesis, such as feldspars, which contribute to the recycling of nitrogen to the deep Earth.