NITROGEN’S GLOBAL CYCLE: THE RELATION BETWEEN TECTONICS AND EARLY LIFE UNDER EXPERIMENTAL OPTICS

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SUMMARY: Nitrogen is one of the most important elements for maintenance and evolution of life. Its concentration on Earth’s atmosphere is anomalous when compared to other inner planets, such as Mars and Venus. Plate tectonics is, most likely, the process responsible for the recycling of nitrogen (and other volatiles) from the atmosphere to the mantle and from the deep Earth back to the surface. For that, a mineral phase must be able to imprison nitrogen during subduction process. Clay minerals, such as smectites, could act as such transporters since nitrogen (speciated as ammonium) can easily be incorporated into the clay mineral structure, substituting K^+ or Ca^{+2}. We used a natural montmorillonite (+ quartz), doped with NH_4^+, as starting material for the high pressure and high temperature (HPHT) experiments, which were performed in a 1000 tonf hydraulic press with coupled toroidal chambers. We investigated the behaviour of NH_4-smectite at 2.5, 4.0, and 7.7 GPa (corresponding to ~70, ~130, and ~270 km depth) and temperatures ranging between 200°C and 700°C. The results were analysed *ex situ* with X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM). XRD data shows that smectite can resist to ~300°C at 2.5 GPa, and ~200°C at 4.0 and 7.7 GPa. In higher temperatures the material develops a mixed-layer illite-smectite structure and, in temperatures higher than 400°C at 2.5 and 4.0 GPa, and 300°C at 7.7 GPa, tobelite (an ammonium analogue of muscovite) appears. This micaceous phase can efficiently hold ammonium up to 7.7 GPa and 700°C. At 7.7 GPa and 300°C buddingtonite (an ammonium analogue of K-feldspar) appears, as a result of the reaction between tobelite and quartz. Buddingtonite also holds significant amounts of ammonium. FTIR was used to qualitatively determine the presence of NH_4^+ in the bulk sample, and SEM was used to determine the quality of experiments and the morphology of crystallized phases (specially clay and micaceous phases). When we cross our experimental data with geotherms from existing subduction zones we noted that in a cold subduction system, nitrogen could efficiently be transported to deep levels in to the Earth’s mantle (at least up to ~270 km). However, in a hot system, partial melting of the material would occur in the first ~40 km of subduction, releasing nitrogen and other volatiles back to the atmosphere. Also, new isotopic evidences from diamonds and from comets show that nitrogen was delivered to Earth (and the other inner planets) at earlier stages of the Solar System evolution. This means that this recycling process could be happening long before the establishment of modern plate tectonics (during Hadean and Archean a distinct interaction process between mantle and atmosphere was developed) and this interaction between endogenous and exogenous systems could have been fundamental for the development of life.

KEYWORDS: NITROGEN; SUBDUCTION ZONES; EXPERIMENTAL PETROLOGY.