Investigation of “Martian nitrogen cycle” and its evolution: The case of a young meteorite, Tissint

*Mizuho Koike[1], Ryoichi Nakada[2], Iori Kajitani[3,4], Haruna Sugahara[3], Tomohiro Usui[3]

1. Hiroshima Univ., 2. JAMSTEC, 3. JAXA, 4. Univ. Tokyo

Geological and geochemical records on the surface of Mars indicate that, in ancient times, this Red Planet possibly had persistent liquid water and denser atmosphere [e.g., 1]. Question of “past (or present) life on Mars” has driven intensive studies based on the planetary explorations and the laboratory analyses of Martian meteorites. To date, we have a large collection of Martian meteorites, which sample various timings from ~4.4 billion years ago (Ga) to ~160 million years ago (Ma) and locations of Mars. Especially, a unique Martian meteorite named Allan Hills (ALH) 84001 is known to contain carbonate minerals that precipitated from aqueous fluid at the Martian near-surface system at ~4.0 Ga [2, 3]. Our recent study [4] investigated these carbonates with a new in-situ analytical technique for nitrogen (N) speciation and revealed that the 4-Ga Martian carbonates preserved nitrogen(N)-bearing organic matter, which plausibly originated from ancient Mars. Koike et al. [4] also reported the apparent absence of nitrate (or NO_x salts) in these carbonates. Such two findings strongly infer the importance of reduced forms of N at the Martian near-surface system during Noachian period. The past “Martian nitrogen cycle”, where N cycled between various reservoirs (i.e., atmosphere, hydrosphere, sediments and possible biosphere) with changing its chemical forms (i.e., N_2, NO_2, NH_3, organics…), probably affected the early-stage environments and the habitability of Mars. It is quite important to understand this “Martian nitrogen cycle” and its long-term evolution. Here, we investigate another Amazonian-aged Martian meteorite named Tissint (~600 Ma [5]), by applying the analytical technique developed in [4].

Shock-melted glassy phases in the polished chip of Tissint were carefully picked up using FIB-SEM at Extraterrestrial Sample Curation Center, JAXA. The N K-edge X-ray absorption near-edge structure (μ-XANES) analyses of this sample with various N-bearing reference compounds were conducted at BL27SU, SPring-8. Our N-XANES spectra of Tissint glass show the heterogenous presence of nitrate (NO_x) and atmospheric N_2, whereas contribution of the N-bearing organics is minor or ignorable in this young meteorite. Further analyses including N-isotopic ratio ($^{15}N/^{14}N$) will reveal the long-term evolutions of Martian nitrogen over 4 Ga.

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