Establishing Itokawa's water contribution to Earth

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Japan's Hayabusa mission returned with more than 1500 particles from the S-type asteroid 25143 Itokawa and provided us with a plethora of information on small (≤20 km) undifferentiated bodies. Different from C-type asteroids, S-type asteroids are supposed to have originated in the inner solar system [1]; and we asked the question: Could Earth have acquired its volatiles from S-type asteroid bodies like Itokawa? Water, as we know, is critical to the formation of terrestrial planets and the origin of life. Most of the inner solar system objects contain at least 200 ppm water [2-4]. Earth is unique and contains abundant liquid water with 330–1200 ppm in its primitive mantle [4]. The origin of water on Earth is highly debated. To shed light on this issue, we measured water contents and D/H ratios in low-calcium pyroxenes (LPx) from Itokawa collected from Muses sea.

The water concentrations of two Itokawa grains are 700 ± 50 ppm (2σ) and 988 ± 50 ppm (2σ). These numbers have been corrected for galactic-cosmic-ray spallation events based on the reported 8 Ma exposure age of Itokawa [5], and the H and D production rates [6, 7]. We developed a thermal-diffusion model based on the one-dimensional Fick's law to correct for water-loss events, namely thermal metamorphism and impacts [8]. Based on the mineral proportions in Itokawa (67.2 wt.% olivine, 18.1 wt.% LPx and 2.6 wt.% high calcium pyroxene) [9], the estimated water content of Bulk Silicate Itokawa (BSI) ranges from 330 to 1570 ppm. The δD values of the Itokawa LPx grains after galactic-cosmic-rays spallation correction are -61 ± 16 ‰ (2σ) for RA-QD02-0057 and -35 ± 12 ‰ (2σ) for RA-QD02-0061. The Itokawa D/H ratio is indistinguishable from those of terrestrial and lunar samples, ordinary chondrites, carbonaceous chondrites, and meteorites from Vesta and Mars. Therefore, based on the estimated BSI water contents and δD values of Itokawa, we infer that the original planetesimals, e.g. S-type asteroids, in inner solar system are hydrous and could be a potential contributor to the total water budget of Earth or inner solar system bodies.

We will present the H isotope data on Itokawa particles and LL6 LAR12036 and LL5 LAR12241 ordinary chondrites, introduce our new thermal diffusion model, and discuss the implications of these results at the meeting.

References

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