SURFACE PROCESS ON AIRLESS SOLAR SYSTEM BODIES PRESERVED ON SAMPLES RECOVERED BY HAYABUSA 2.

T. Noguchi[1], R. Okazaki[2] and T. Osawa[3], [1]Faculty of Arts and Science, Kyushu University (744 Motooka, Nishi-ku, Fukuoka 819-0395, Japan; tnoguchi@artsci.kyushu-u.ac.jp), [2]Department of Earth and Planetary Science, Kyushu University (744 Motooka, Nishi-ku, Fukuoka 819-0395, Japan; okazaki.ryuji.703@m.kyushu-u.ac.jp), [3]Material Sciences Research Center, Japan Atomic Energy Agency (2-4 Shirakata Shirane, Tokai, Ibaraki, 319-1195, Japan; osawa.takahito@jaea.go.jp).

Introduction: In 2020, Hayabusa 2 spacecraft will return the surface and sub-surface samples from the asteroid (162173) Ryugu, a C-type asteroid. We will have an opportunity to investigate pristine materials from a C-type asteroid. First priority of the mineralogical studies is to assess the similarity of the return sample and the known carbonaceous chondrites such as CM chondrites. Carbonates formed by aqueous alteration would serve to determine the age of aqueous alteration like the case of carbonates in CM chondrites [1]. If the samples contain large halides including fluid inclusions would give their formation ages and the nature of aqueous fluid that formed halides like those in H chondrite breccias [2-6]. Space weathering will be observed on the samples. In this talk, we discuss two microstructures that may be observed on the surface of fine-grained Ryugu grains.

Aqueous processes estimated by water soluble crystals: Although two ordinary chondrite regolith breccias, Monahans (1998) H5 and Zag H3-6, contain halite and sylvite that can be identified by naked eyes [2-6], only sub-microscopic halides were reported from CM chondrites based on TEM observation [7]. The size difference may be related to the different breaking strength between ordinary and CM chondrites because compressive strength of Murchison CM chondrite, 50 MPa, is considerably smaller than those of ordinary chondrites [8, 9]. The sizes of halide crystals in the regolith of Ryugu, if any, may have been reduced by comminution during regolith gardening. Because sub-micrometer-sized sylvite crystals were found on the surface of an Itokawa grain [10], halides may be found on the surface of the return sample from Ryugu. In the case of sylvite in the Itokawa grain, they appeared as <500-nm grains on the surface of the Itokawa grains and coated by Na- and O-rich material (Na carbonate?). Unfortunately, it was unable to prove their extraterrestrial origin. On the other hand, the sealing of the capsule was greatly improved in the case of Hayabusa 2 [11]. Therefore, it would be promising to investigate asteroidal halides on the surface of Ryugu grains. Halides in the Ryugu grains would be authigenic, most of which were formed by the pervasive aqueous alteration. On the other hand, halides on the Itokawa grains is not necessarily authigenic. Therefore, it is expected that the occurrences of halides on the Ryugu grains are different from those on the Itokawa grain. In addition, water/rock ratio, timing of formation of halides would affect the occurrences of halides.

Surface modification produced by solar wind irradiation: The author and colleagues have been studying surface modification (space weathering) on the Itokawa grains [e. g. 12, 13]. Our studies and studies by other researchers [e. g. 12-15] indicate that the surface modification found on the Itokawa grains were promoted mainly by the solar wind irradiation. It is highly likely that irradiation effects are found on the surface of Ryugu grains as well as the effects of micrometeoroid impacts [16]. We performed irradiation of 4 keV He^+ ions on Murchison CM chondrites. The irradiated samples were observed by field-emission scanning electron microscope (FE-SEM). When the sample was irradiated by He^+ with a fluence of 5×10^{16}, there was no remarkable difference in surface morphology when compared with un-irradiated sample. On the other hand, the surface irradiated with a fluence of 5×10^{17}, the surface of both matrix and chondrules was degraded and blistering-like textures were also observed in places. The fluence of He^+ corresponds to ~10^3-year irradiation for Ryugu. Although no H^+ was irradiated on the surface, it is difficult to form remarkable blistering by irradiation of only H^+. The flux of H+ is almost 10 times higher than that of He^+, H^+ easily escapes from the surface before modifying surface microstructure and forming blistering. Solar wind He^+ is the most important to modify the surface. Observation by transmission electron microscope will be performed in the near future. Surface modification observed on the surface of the irradiated Murchison meteorite may be found on the surface of the Ryugu grains.

Conclusion: We discussed two surface textures that may be found on the surface of Ryugu grains. The search for halides and another water soluble minerals on the surface of the Ryugu grains will serve to understand the aqueous alteration process and the chemistry of aqueous fluid on Ryugu. Surface modification formed by solar wind irradiation may serve to understand spectral changes of C-type asteroids.

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