ELEMENTAL DISTRIBUTIONS OF BENNU SAMPLES USING A STIGMATIC LG-SIMS. N. Sakamoto[1,*], N. Kawasaki[2], H. C. Connolly Jr.[3,4,5], D. S. Lauretta[5] and the OSIRIS-REx Sample Analysis Team. [1]Institute for Integrated Innovations, Hokkaido University, Sapporo, Japan; [2]Dept. of Earth and Planetary Sciences, Hokkaido University, Sapporo, Japan; [3]Dept. of Geology, Rowan University, Glassboro, NJ, USA; [4]Dept. of Earth and Planetary Sciences, American Museum of Natural History, New York, NY, USA; [5]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA.*Email: naoya@cris.hokudai.ac.jp

Introduction: The OSIRIS-REx mission collected regolith samples from the asteroid Bennu's surface [1]. This study presents elemental distributions within polished sections of these samples, analyzed using secondary ion mass spectrometry (SIMS).

Samples: The analyzed samples include OREX-803111-0, OREX-803112-0, OREX-803113-0, OREX-803114-0-1, OREX-803114-0-2, OREX-803114-0-3, OREX-803114-0-4, OREX-803114-0-5, OREX-803114-0-6, and OREX-803114-0-7. Each sample was embedded in 1-inch resin disks using Buhler EpoxiCure2 and polished using diamond slurry with an automatic polishing machine (Musashino Denshi MA-200e), with the procedures described in [ref. 2]. The disks were cleaned using a minimal amount of ethanol (> 99.5%) to avoid the use of water. A conductive coating was applied to the polished sections for scanning electron microscopy–energy-dispersive X-ray spectroscopy (SEM-EDS) and SIMS analyses.

Analytical Methods: Elemental distributions were analyzed using a magnetic sector SIMS instrument at Hokkaido University (ims-1270e7) after conducting SEM-EDS measurements (JEOL-7000F + XMax150). The SIMS instrument features stigmatic ion optics and a two-dimensional ion detector (SCAPS) [3]. A square-shaped O^- ion beam (100 µm × 100 µm) of 20 nA, generated by a DuO plasma source, was irradiated onto the sample surface using a Köhler illumination system. The mass-separated secondary ion images sputtered from sample surface were visualized using SCAPS.

Results and Discussion: Figure 1 shows SIMS elemental maps obtained for the matrix of OREX-803114-0-1, containing Mg-phosphate identified by SEM-EDS. The Mg-phosphate grain consists of H-rich interior and Na-rich rim. The Fe map is useful for correlating the positions of the SIMS map with the backscattered electron (BSE) image, which indicates magnetite particles within the Mg-phosphate grain. The H-rich interior exhibits a fractured texture, while the Na-rich rim shows no clear features. The Ca and Mn maps not only show intense spots indicative of carbonates, observable in SEM-EDS, but also reveal bright and dark areas along cracks in the matrix, identified through high-sensitivity analysis using SIMS.

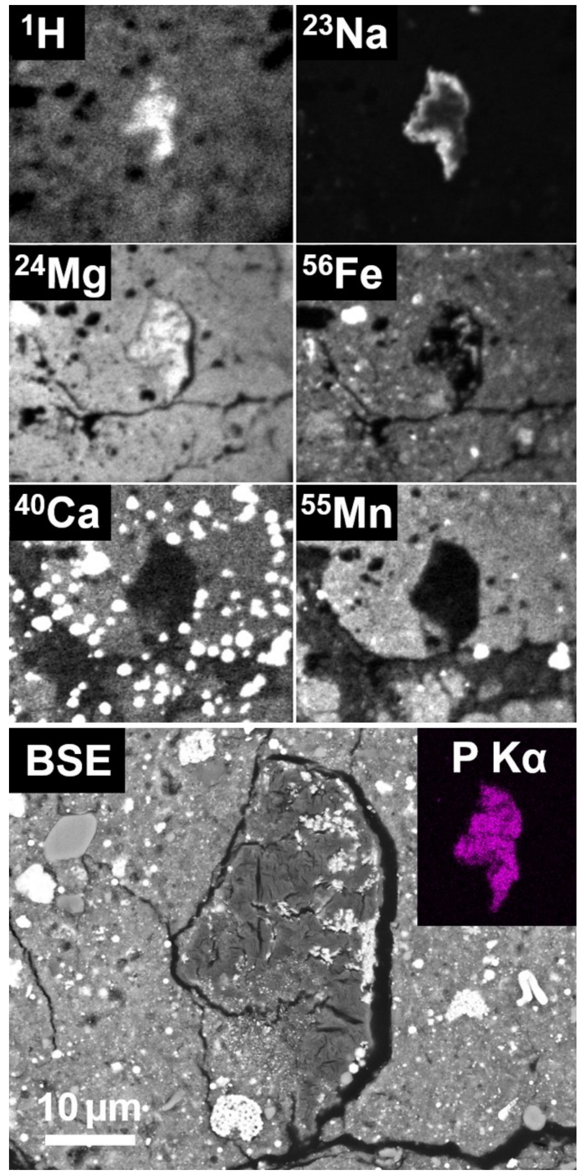

Figure 1. Elemental maps of the matrix area of the particle OREX-803114-0-1 for hydrogen (^{1}H), sodium (^{23}Na), magnesium (^{24}Mg), iron (^{56}Fe), calcium (^{40}Ca), and manganese (^{55}Mn) obtained using SIMS. The lower section shows a magnified BSE image and a phosphorus (P) Kα map of the Mg-phosphate grain obtained using SEM-EDS.

The Na distribution and the occurrence of magnetite in the Mg-phosphate grain are consistent with the observations by [ref. 4]. Such Mg-phosphates are also found on the outer regions of the Bennu particles. The Na-rich rim of Mg-phosphate surrounds the fractured, H-rich interior, suggesting that the H-rich interior formed first, followed by the Na-rich rim, which likely

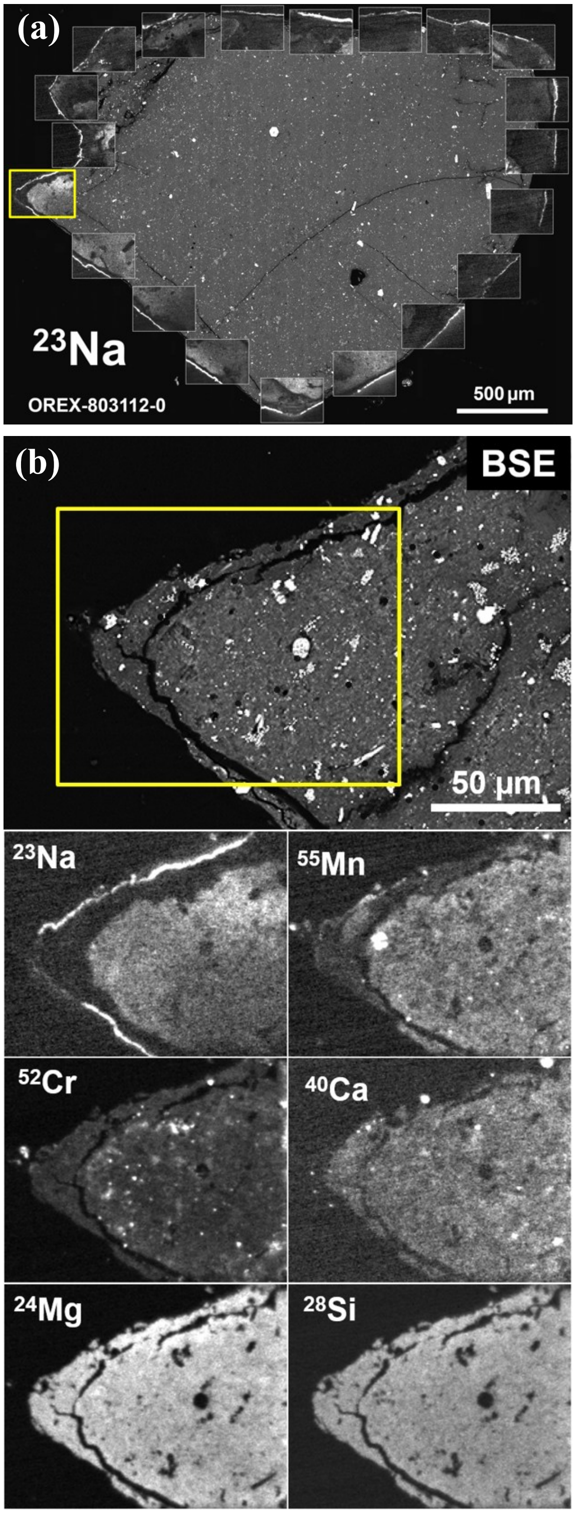

Figure 2. (a) BSE image overlaid with the sodium (^{23}Na) elemental map of the OREX-803112-0 particle. A sodium-enriched layer surrounding the outer edge of the particle is observed. The yellow rectangle indicates the region selected for detailed analysis. (b) BSE image of the highlighted region from (a) with corresponding SIMS elemental maps.

formed through the evaporation of fluid, leading to the concentration of salts.

Figure 2 shows the elemental maps focusing on the outer rim of the OREX-803112-0 particle. Sodium is enriched over the entire surface of the particle compared to the interior of the particle. Inside the Na-enriched layer, another distinct layer depleted in Na and Mn is observed, where Ca is also patchily depleted. The localized enrichment of Cr seen in the inner regions is not observed in the outer layers. Similar to Na, enrichment of K is also observed at the particle rim.

The depletion of Ca and Mn along cracks or veins (Fig. 1) is also observed in the OREX-803111-0 particle. These regions are also particularly depleted in Na. These elements, being more water-soluble compared to Mg or Si, were likely leached out when water infiltrated the cracks or surrounding areas. Such depletion is also observed in the subsurface of OREX-803112-0 (Fig. 2), implying that fluid activity occurred after the particle acquired its current shape. The different degrees of depletion among the elements may reflect differences in the chemical composition of the fluids.

The surface enrichment of Na and K, observed throughout the Bennu particles except for OREX-803111-0, is likely to have occurred after the particles acquired their present shape. This enrichment can be attributed to a salinization process similar to that occurring in arid regions on Earth. In such a process, water moves from the ground to the surface by capillary action, accompanied by water-soluble components, and evaporates on the dry surface, concentrating elements such as Na and K. If this process occurred on the surface of asteroid Bennu, the Na and K distributions of the Bennu particles suggest the possible presence of subsurface water, since the outer surface of asteroid Bennu would have been in an environment drier than that of Earth. Similar observations on Ryugu [5] imply that this phenomenon may be common on C-type asteroids. These findings underscore the importance of preserving the pristine surface conditions of asteroid regolith particles in sample return missions.

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References: [1] Lauretta D. S. & Connolly H. C. Jr. et al. (2024) *MaPS, 59,* 2453–2486. [2] Kawasaki N. et al. (2022) *Sci. Adv., 8,* ade2067. [3] Yurimoto H. et al. (2003) *Appl. Surf. Sci., 203*‑*204,* 793. [4] McCoy T. J. et al. (2025) *LPSC, this meeting*. [5] Sakamoto N. et al. (2022) *JpGU,* PPS08-08.