CONSTRAINING THE SURFACE EXPOSURE AGE OF ASTEROID BENNU USING COSMOGENIC RADIONUCLIDES IN AN OSIRIS-REx AGGREGATE SAMPLE AND INDIVIDUAL PARTICLES. K. C. Welten[1], K. Nishiizumi[1], M. W. Caffee[2], J. Masarik[3], J. J. Barnes[4], A. N. Nguyen[5], H. C. Connolly[4,6,7], and D. S. Lauretta[4]. [1]Space Science Laboratory, University of California, Berkeley, CA 94720, USA (kcwelten@berkeley.edu); [2]Department of Physics & Astronomy, Purdue University, West Lafayette, IN 47907, USA, [3]Comenius University, Bratislava, Slovakia, [4]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, USA; [5]Astromaterials Research and Exploration Science, NASA Johnson Space Center, Houston, TX 77058, USA; [6]Department of Geology, Rowan University, Glassboro, NJ 08027, USA; [7]Department of Earth and Planetary Science, American Museum of Natural History, New York, NY 10024, USA.

Introduction: Observations by NASA's OSIRIS-REx spacecraft of asteroid Bennu revealed evidence that this small rubble-pile asteroid experiences several active surface processes that likely control its recent surface exposure history [1–6]. In October 2020, the spacecraft collected a surface sample from a relatively young ~20 m diameter crater (Hokioi) on asteroid Bennu [7], and the sample was successfully delivered to Earth on September 24, 2023.

Based on the population of craters >50 m diameter, Bennu's surface is 0.1–1 Ga old [4], but the old surface is affected by recent processes including smaller meteoroid impacts, mass movement, and particle ejections. The sampling location within Hokioi crater was selected based on its relatively flat surface devoid of large boulders, but the crater floor is also believed to be one of the youngest surfaces on asteroid Bennu, with an age of <100 kyr. As the crater is ~2 m deep [8], the samples that were collected by OSIRIS-REx may have been relatively shielded from cosmic rays during most of its recent history. This scenario is different from the samples that were collected by Hayabusa2 from asteroid Ryugu, where cosmogenic noble gas and radionuclides indicate cosmic-ray exposure (CRE) ages of ~5 Myr near the surface [9].

Our goal is to understand the recent exposure history of surface samples of asteroid Bennu utilizing radionuclides (^{10}Be, ^{26}Al, ^{36}Cl, ^{41}Ca) produced by both galactic (GCR) and solar (SCR) cosmic rays. With half-lives ranging from 0.1 to 1.36 million years (Myr), the concentrations of these cosmogenic nuclides provide information on the duration and exposure conditions (irradiation depth) of these samples on a timescale of a few Myr. This work will test one of the OSIRIS-REx mission's driving hypotheses about asteroid Bennu's recent evolution: that Hokioi crater is part of a population of small (25 m) spectrally red craters on Bennu that are less than 0.1 Myr old [10].

Samples: We received 11.5 mg of aggregate sample, OREX-803014-0, which consists mostly of fine (<100 µm) and intermediate particles (100–500 µm), with a few up to ~1 mm. We picked five of the larger particles (Fig. 1), sample numbers OREX-803048-0 to OREX-803052-0, with masses ranging from 0.24 to 0.68 mg.

Analytical Methods: We dissolved each particle along with 0.15 mg Be and 1.0 mg Cl carrier in HF/HNO_3 mixture. We also dissolved 1.00 mg of a powdered sample of the Orgueil CI chondrite (MNHN-Paris) as comparison. After dissolution we separated Cl as AgCl for analysis of cosmogenic ^{36}Cl by accelerator mass spectrometry (AMS) at Purdue University [11]. A small aliquot of the dissolved samples was split for chemical analysis by inductively coupled plasma optical emission spectrometry (ICP-OES). We then added 0.7 mg of Al carrier and separated Be and Al from the remaining solution for analysis of cosmogenic ^{10}Be and ^{26}Al by AMS [10].

Discussion: The ICP-OES measurements show that the five Bennu particles have very similar concentrations of major elements (Na, Mg, Al, S, Ca, Mn, Fe, Ni) as aggregate sample OREX-803015-0 [12] and the Orgueil CI (except for slightly enhanced Fe, Ni and S). AMS measurements of the cosmogenic radionuclides are in progress; results will be presented at the meeting. Since the cosmogenic radionuclide production rates vary with depth, the measured radionuclide concentrations of the Bennu samples will indicate at what depth the samples were exposed to cosmic rays during the last few half-lives of each radionuclide. If Hokioi crater formed <0.1 Myr ago, as suggested by the relatively unweathered reflectance spectra of the crater [5], then the cosmogenic radionuclides (which mainly represent production during the last few hundred kyr to a few Myr) will reflect irradiation at a depth of >2 m. On the other hand, if Hokioi crater is older than 5 Myr, then the radionuclide concentrations in the Bennu samples will mainly reflect production near the surface. By measuring multiple radionuclides with different half-lives, we expect to be able to constrain the formation age of Hokioi crater.

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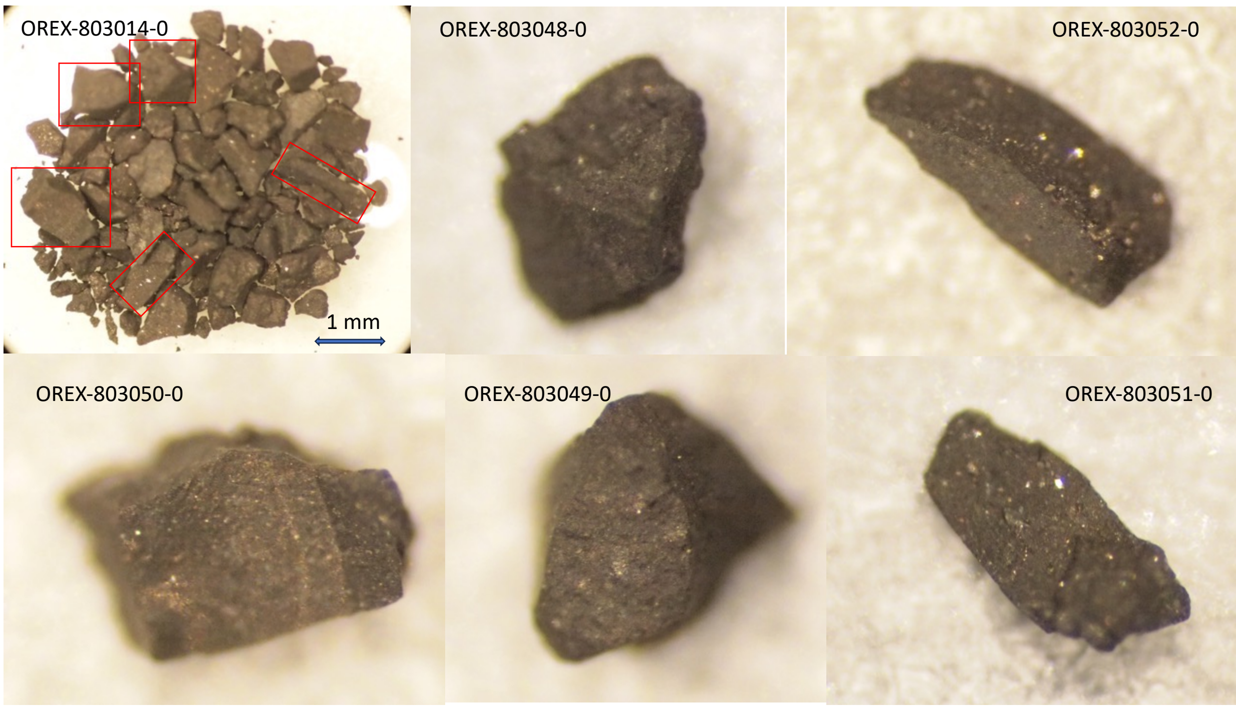

Figure 1. Optical images of aggregate sample, OREX-803014-0 and five of the largest particles, 803048-0 (0.41 mg), 803049-0 (0.68 mg), 803050-0 (0.66 mg), 803051-0 (0.31 mg) and 803052-0 (0.24 mg), that were selected for cosmogenic radionuclide analysis.