

IDENTIFICATION OF PRESOLAR GRAINS IN QUICK LOOK SAMPLES OF ASTEROID BENNU RETURNED BY THE OSIRIS-REX MISSION. A. N. Nguyen¹, L. P. Keller¹, S. J. Clemett², J. J. Barnes³, H. C. Connolly Jr.^{3,4,5}, and D. S. Lauretta³; ¹ARES, NASA JSC, Mail Code XI3, Houston, TX 77058, USA (lan-anh.n.nguyen@nasa.gov); ²Oasis/ERC JETS, NASA JSC, Houston, TX, USA; ³LPL, University of Arizona, Tucson, AZ, USA; ⁴Department of Geology, Rowan University, Glassboro, NJ, USA; ⁵Department of Earth and Planetary Science, American Museum of Natural History, New York, NY, USA.

Introduction: The OSIRIS-REx spacecraft returned regolith sample from the B-type asteroid Bennu on September 24, 2023. The first samples to be analyzed, termed the Quick Look samples, are comprised of material collected from the avionics deck of the OSIRIS-REx sample canister. Initial mineralogical analysis of the Quick Look sample revealed a diversity of components, including hydrated and anhydrous silicates, sulfides, magnetite, phosphates, and abundant organic matter [1,2]. Each constituent has their own origin and history, and their study can inform us of the history of Bennu and its parent asteroid.

The analysis plan for asteroid Bennu samples is guided by hypotheses that address specific periods of Bennu's history, from the pre-accretionary epoch to the OSIRIS-REx epoch [3]. The pre-accretionary epoch studies aim to characterize materials that predate the formation of the solar system. One hypothesis that falls under this epoch is that Bennu contains presolar materials derived from diverse sources. These presolar materials include stardust grains that condensed from the outflows of evolved stars or the ejecta of novae and supernovae (SN), as well as organic matter that formed in the interstellar medium [4]. Here we report the identification of C-rich presolar stardust grains in the Bennu Quick Look sample. Isotopically anomalous organic matter in this sample is reported in [5].

Samples: A sample mount was produced for NanoSIMS analysis by mounting annealed and HF-cleaned Au foil onto an Al stub. The sample analyzed in this study, OREX-501018-100, was produced by transferring fragments of fine-grained material from the Quick Look sample OREX-501018 onto the Au foil mount using a glass needle. The fragments were then pressed into the Au with a sapphire window.

Analytical methods: The C and N isotopes, ²⁸Si, ³⁰Si, and ³²S were measured by raster ion imaging using the CAMECA NanoSIMS 50L at NASA JSC. An ~1.9 pA, ~200 nm, Cs⁺ primary ion beam was rastered over 20- μ m fields of view and the isotopes were collected simultaneously. The C and N isotopic ratios were corrected for instrumental mass fractionation using USG-24 graphite and KG17 kerogen, respectively. The Si isotopic ratios were normalized to the Si-rich material that did not show any isotopic anomalies.

Results: A total area of 8323 μm^2 was analyzed by NanoSIMS. Seven grains had enrichments in ¹³C between ~435–16,540 ‰ (Fig. 1). One of these grains was also enriched in ¹⁵N ($\delta^{15}\text{N} = 1025 \pm 160$ ‰). All seven grains had ²⁸Si/¹²C ratios that indicate they are SiC. We also identified one grain with a depletion in ¹³C ($\delta^{13}\text{C} = -350 \pm 25$ ‰) and low ²⁸Si/¹²C, suggesting the grain is graphite. The ³⁰Si/²⁸Si ratios of the presolar grains were indistinguishable from the surrounding isotopically normal grains, except for one grain with a 2 σ level depletion in ³⁰Si. The grains had sizes from 250–375 nm. We determine abundances of 58_{-31}^{+31} for presolar SiC and 9_{-7}^{+20} ppm for presolar graphite.

Discussion: Presolar grains represent some of the building blocks of our solar system and are found as trace components in primitive chondritic samples. Presolar SiC grains, the most extensively studied presolar phase, are subdivided into different types based on their isotopic compositions and, correspondingly, their likely stellar sources [6]. The majority of presolar SiC grains derive from low mass asymptotic giant branch (AGB) stars. The isotopic compositions of five of the seven presolar SiC identified in OREX-501018-100 are most consistent with origins around AGB stars of ~solar or one-third solar metallicity.

The presolar SiC with the largest ¹³C enrichment (Fig. 1) falls into the type AB classification of presolar SiC. These grains could have origins in J-type C stars, born-again AGB stars, and type II SN [6]. The SiC with the largest ¹⁵N enrichment and moderate ³⁰Si depletion likely derived from a type II SN explosion. The ¹³C depletion of the presolar graphite suggests an AGB star origin, but a SN origin cannot be ruled out.

It was hypothesized that the abundances of presolar grains in Bennu would be similar to CI and CM chondrites [3,4]. In these chondrites, the abundance of presolar SiC range from ~15–60 ppm [7-10] and the presolar graphite abundance is ~10 ppm [7, 10]. The main lithology of CI-like asteroid Ryugu samples returned by JAXA's Hayabusa2 mission contains ~34 ppm of presolar SiC and 12 ppm of presolar graphite [10,11]. We find abundances of presolar SiC and graphite in OREX-501018-100 to be comparable to the abundances in these samples, and we have determined that the grains derive from diverse stellar sources.

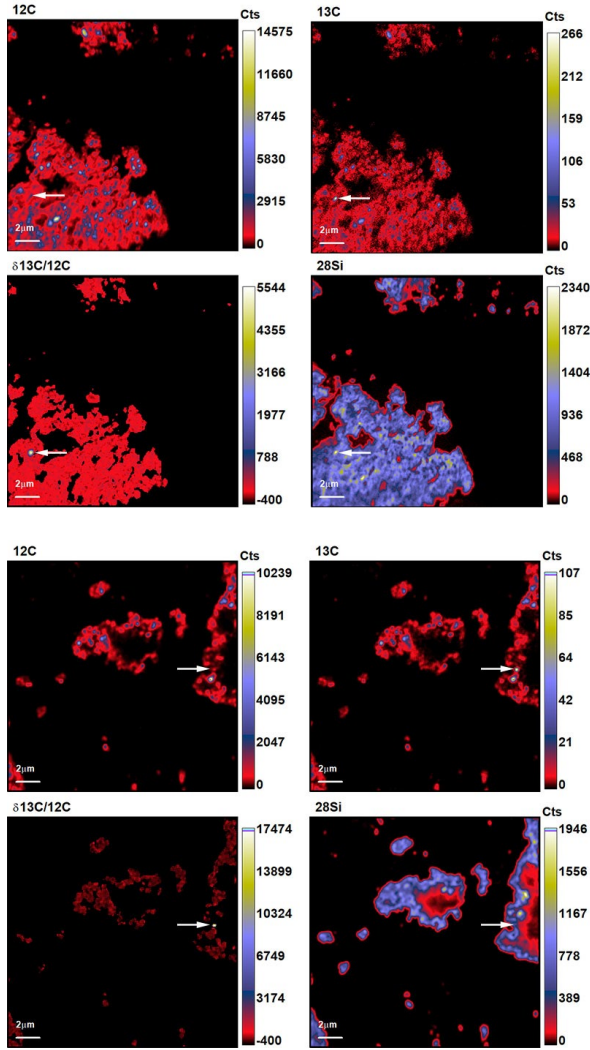


Figure 1. NanoSIMS ^{12}C , ^{13}C , and ^{28}Si ion images and $\delta^{13}\text{C}/^{12}\text{C}$ ratio images for two analysis regions in OREX-501018-100. The region shown in the top 4 panels contains a presolar SiC grain (indicated by arrows) that is enriched in ^{13}C and likely originated from a low mass AGB star. The region in the bottom 4 panels contains a presolar SiC of type AB (arrows), which are postulated to come from J-type C stars, born-again AGB stars, and type II SN.

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