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Environmental Implications of Copper Sulfide Mineralogy in Angular and Hummocky Bennu Particles

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On September 24, 2023, 121.6 grams from asteroid (101955) Bennu was delivered to Earth by NASA's OSIRIS-REx mission [1]. Sulfides are ubiquitous in these samples [1,3]; their compositions and textures offer insight into mineral formation and alteration [2,4], providing a basis for comparing the three distinct Bennu particle types — hummocky, angular, and mottled [1]. This study examines copper sulfides in one section from a hummocky particle and two sections from an angular particle.

We used electron probe microanalysis to collect backscatter electron images and perform wavelength-dispersive spectroscopy for elemental quantification. The sulfide populations in all three sections are primarily Fe- and Cu-sulfides, with smaller, less abundant Ni-sulfides. The Cu-sulfides in the hummocky sample, OREX-800088-9, largely have compositions resembling cubanite (33.33 wt% Fe, 16.67 wt% Cu). The compositions of Cu-sulfides in angular samples OREX-800055-16 and OREX-800055-18 range from chalcopyrite (25 wt% Fe, 25 wt% Cu) to $CuFe_4S_5$ (40 wt% Fe, 10 wt% Cu).

The detection of $CuFe_4S_5$ is the first reported instance of this compound in any astromaterial. However, the existence of a mineral with this stoichiometry remains a subject of debate [6], and follow-on structural analysis is planned. This phase occurs as part of a larger sulfide assemblage encased in carbonate, suggesting low-temperature precipitation from a fluid.

Cubanite can help confirm or refine constraints on Bennu's parent body environment, as its structure serves as an effective thermometer [5]. The wider range of Cu-sulfide compositions in angular samples suggests that they experienced more extensive alteration than the hummocky sample. Additionally, the $CuFe_4S_5$ grain offers new insights into Cu-sulfide mineralogy and may help refine the existing Cu-Fe-S phase diagram [5,6]. This study advances our understanding of Bennu's history and contextualizes the samples within previous analyses.

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