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Fe-, Ni-, and Cu- Sulfides in Samples from Asteroid Bennu Indicate Heterogeneous Aqueous Alteration

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Samples returned from asteroid Bennu exhibit three distinct particle morphologies: hummocky, angular, and mottled [1-3]. We analyze four representative polished sections: one hummocky (OREX-800088-9), two angular (OREX-800055-16 and OREX-800055-18), and one mottled (OREX-800023-16). Because sulfide minerals are sensitive recorders of parent body aqueous conditions [6-11], their compositions and distributions provide constraints on fluid evolution and redox conditions.

We use electron probe microanalysis to perform wavelength dispersive spectroscopy for major and minor elemental quantification, supplemented by LA-ICP-MS analysis for trace elements, electron backscatter diffraction for crystallographic characterization, and FIB-TEM for nanoscale structural analysis. The sulfide populations in all three morphologies are primarily pyrrhotites, with smaller, less abundant pentlandites. Cu-sulfides occur in angular and hummocky sections, but not in the mottled section. Hummocky section Cu-sulfides have uniform compositions consistent with cubanite (33.33 wt% Fe, 16.67 wt% Cu). Conversely, angular section Cu-sulfides range from chalcopyrite (25 wt% Fe, 25 wt% Cu) to $CuFe_4S_5$ (40 wt% Fe, 10 wt% Cu). Cubic isocubanite is also identified in angular section OREX-800055-19.

These sulfide populations vary systematically with particle morphology and record evolving fluid chemistry, varying redox conditions, and a transient temperature excursion exceeding the canonical low-temperature model for Bennu. These variations in sulfide mineralogy indicate that Bennu's three morphologies represent distinct alteration histories consistent with alteration pathways proposed for each morphology [2-5].

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