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The Nature of Nanophase Inclusions in Space Weathered Bennu Samples

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Space weathering modifies the chemical composition and microstructure of particles on the surfaces of airless bodies. Evidence for space weathering has been observed in samples returned from the carbonaceous asteroid Bennu by the OSIRIS-REx mission, including amorphous and nanocrystalline rims on particles, microcraters, and impact melt deposits with embedded vesicles and nanoparticles [1]. Understanding the size and mineralogy of these nanoparticles has important implications for the resulting spectral characteristics of the samples. Here we examine the nature of nanophase inclusions in space weathered Bennu samples and explore how these phases might influence the asteroid and sample spectral characteristics [2].

Several particles (OREX-507017-0, OREX-803081-0, and OREX-803164-0) were mounted on conductive tape for examination in scanning electron microscopes (SEM) at NASA Johnson Space Center (JSC) and Purdue University. We identified melt splashes attributed to micrometeoroid impacts on the surfaces of each particle and prepared electron transparent thin sections of the melts via focused ion beam (FIB) milling at JSC. The FIB sections were analyzed using the transmission electron microscope (TEM) at the University of Arizona.

TEM data shows the melt deposits are amorphous and range in thickness from a few hundred nanometers to >5 μm. The melts include nanoparticles distributed throughout that range from a few nanometers to >500 nm in diameter, with mean and median sizes that are larger compared to their counterparts from asteroid Ryugu [3]. The nanoparticles are generally spherical, but can include hollow, core-shell, and pitted morphologies, similar to [3]. While dominated by Fe-S, some nanoparticles include heterogeneously distributed Ni and others exhibit <30-nm-thick Fe-oxide rims. High-resolution TEM images indicate that the nanoparticles are predominantly crystalline. These observations indicate that there are polymineralic nanoparticles with unique morphologies and compositions in space weathered samples from Bennu which could have an important influence on the spectral properties of the samples.

[1] Keller L. P., & Thompson, M. S. et al. (2025). *Nat. Geosci*., 18: 825-831. [2] Lauretta, D. S. & Connolly, H. C. Jr et al. (2024) *MAPS,* 59, 2453–2486. [3] Laforet S. et al. (2025) *MAPS,* 60: 1480-1501