Microcraters in Disaggregated Regolith-Breccia Meteorites

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Introduction

- Abundant micrometeoroid impact craters, splash melt, and solar wind blistering have been identified in lunar soil grains and surface regolith returned from asteroid Itokawa.
- Regolith-breccia meteorites contain some grains that were directly exposed on the surface of airless bodies, which can be identified by space-weathering features on grain surfaces.
- Micrometeorites have been identified on grains from Murchison and Kapoeta meteorites (Goswami+1983, Brownlee & Rajan 1973).

Identification and FIB-TEM analyses of space-exposed grains from regolith breccia meteorites would extend our understanding of space weathering to other airless bodies in the Solar System

Here we describe our methods to gently disaggregate regolith breccia meteorites and search grain surfaces for micrometeoroid impact craters, and report our initial results and FIB-TEM analyses from Adzhi-Bogdo (LL3–6), Fayetteville (H4), and Murchison (CM2).

Freeze-Thaw Disaggregation

- Disaggregated ~0.3 g meteorite chips in an automatic, Peltier freeze-thaw device: ~3000 freeze-thaw cycles (38 days). Then powder is transferred to SEM stubs.

SE Imaging & Crater Search

- Each stub was coated with ~5 nm of Au-Pd.
- Secondary electron images collected on Tescan MIRA-3 FEG-SEM at 1–2 kV accelerating voltage to maximize surface sensitivity.
- 50 μm field-of-view, 1536 × 1536 pixels.
- Automatic brightness/contrast and autofocus.
- Two weeks to image each stub: ~15,000 SE images.
- Images were searched manually for micrometeorite craters and other surface space-weathering features.
- Crowd-sourcing and neural network computer algorithm to search images is in development.

Candidate Micrometeoroid Craters

- We identified dozens of candidate craters in Adzhi-Bogdo, Fayetteville, and Murchison.
- Freeze-thaw process oxides Fe metal, which obscures surfaces of some grains (most severe in Fayetteville (H4)).
- Fine-grained adhering material (matrix grains, organics) obscured some grains from Murchison.
- Clean grains surfaces are abundant in all samples analyzed by TEM. These analyses will provide important meteorite analogs to the returned samples from the OSIRIS-REx and Hayabusa2 missions.

FIB-TEM of Crater Candidates

We have developed techniques to identify space-exposed grains in regolith-breccia meteorites and analyze their nm-scale structure by TEM.