Box-of-Rocks Experiment II: Testing Magnetic Sampling and Grappling on Small Asteroids

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Abstract

Knowledge of the surface properties of small asteroids is important for relating astronomical observations of these objects to geologic 'ground truth', for understanding their relationships to meteorites, and for designing technologies and techniques for future robotic and human exploration, resource utilization, and impact hazard mitigation. Unfortunately, many of the interesting physical processes governing the microgravity geology of these small bodies are partially or completely masked in the 1-g environment in which we usually work and develop our 'intuitive' sense of how geologic processes work. Our Box-of Rocks Experiment II (BORE II) continues our 'hands-on' exploration of the processes in a relevant microgravity environment. Since nearly all asteroid regoliths are expected to have a substantial ferromagnetic component, magnetic sampling/grappling thus offers a novel mission concept and/or instrumentation architecture for future development.

BORE II will be effectively a reflight of the BORE experiment payload that we developed, built, and flight tested under Southwest Research Institute internal research and development funding and with participation in Blue Origin's Pathfinder Payloads flight program. BORE II is funded through NASA's REDDI Tech Flights program and will be flown on a suborbital spaceflight aboard Blue Origins' New Shepard Rocket in 2020.

BORE II consists of two transparent vacuum 'bell jars', illuminated inside by an array of neutral white LEDs, containing a granular mixture of minerals that realistically simulates a small asteroid's coarse regolith. Both vacuum containers will contain magnetic sampling hardware for flight test of a novel sampling/grappling technology. Video cameras record the jostling microgravity behavior of the regolith simulant and its interaction with and the functioning of the grappling/sampling hardware through the entire flight, including settling behavior during the onset of milli-g conditions during atmospheric entry of the vehicle. The flight test objectives of BORE II's science investigation are to simply: (1) document through video data the settling behavior and resulting morphology of a realistic small-asteroid coarse regolith; and (2) complement the results of related NASA Emerging Worlds program and NASA HERMES ISS experiments by determining the effects of particle size, number density, and composition on the aggregation of 100μm- to cm-scale grains in microgravity conditions. The Flight test objectives of BORE II's exploration technology test are to: (1) demonstrate the full sequence of exposing a magnetized sampler to an asteroid regolith analog in a long-duration, zero-g, vacuum environment, then closing and confining a collected sample within the volume of the sampler; and (2) demonstrate that the high-frequency vibration motor anti-jamming mechanism is sufficient to enable closure of the sampler 'petals' in the event of over-filling the sampler volume.