GRANULAR FLOW IN LOW GRAVITY AND VACUUM FOR ICEBREAKER SAMPLE PROCESSING TESTS. A. Davé1, B. Glass1, D. Bergman1, H. Modi1, H.D. Smith1, K. Zacny2, E. Quigley, M. Guzman, J. Naugh-тон, C.P. McKay1. 1NASA Ames Research Center, Moffett Field, CA 94305, USA, Email: arwen.i.dave@nasa.gov , 2Honeybee Robotics, Pasadena, CA 91103, USA.

Abstract: The granular flow of icy sample in low gravity poses a challenge to Icebreaker’s search for biomarkers and signs of past or extant life on Mars near the Phoenix site. Ongoing tests to bound challenging sample regimes include transfer of icy drill cuttings in Honeybee’s Mars Chamber and on NASA’s Parabolic campaign of December 2015. Five years of developing a system that can transfer sticky cuttings, generated by the Icebreaker drill and fed to instrument intakes, has led to testing the benefits of sieves at points along the dirt-to-data chain. There appears to be a sieve clumping phenomena at discrete grid sizes that precludes flow while allowing it through smaller or larger sizes: in particular, 1-2mm grids. This phenomena was seen in both vacuum and low-gravity regimes.

References, dirt to data, icebreaker paper, phoenix papers.

Introduction: The Icebreaker life search payload suite has proved to be diverse in its sample requirements. Candidates include SOLID, which can analyze biosignatures attached to 1mm cuttings, WCL, which can accept the occasional larger particle into its wet chemistry beaker, and LDMS, which has strict level surface requirements for its organics volatilizing laser. One commonality is that all prefer to receive particles smaller than 1mm. Several methods to achieve a sample of drill cuttings < 1mm have been considered; including the Brazil Nut Effect [1] utilizing the percussive energy of the Icebreaker drill, altering the auger flutes to produce smaller cuttings (see Figure 1), and sieves that use the percussive energy of the drill to create flow. Phoenix [2], Viking 2 [3], and Curiosity [4] missions all utilized sieves, with various positive displacement mechanisms to drive the smaller particles through, and with varying degrees of success. Most notably for Icebreaker, WCL’s 2.3 mm screen successfully allowed icy Phoenix soil to be analyzed and science data returned [5]. Ongoing test efforts therefore include efforts to sieve out cuttings of greater than 1.5 mm in diameter.

Seiving Approach and Results: two types of test results are presented here. Thermal vacuum: stacked sieves have been attached to the drill for operation in the Mars chamber, so that cuttings pushed off the auger sit on top of the coarsest screen, and are driven through the screens by the percussive hammering of the drill operations. Screens of 2, 1, 0.5, 0.25, 0.15, 0.125, and 0.053 mm were used. Cuttings made it all the way through the stack during the drilling operations used to excavate the cuttings. A tendency to clump on the screen rather than passing through was seen on the 1mm screen (Figure 2). Parabolic flight: a 2.3 mm screen was sent packed with Antarctic Dry Valley cuttings from the Icebreaker drill, saturated with 20% water. A scraper passed across the sample during Lunar gravity parabolas, and before and after images showed ~ 10% of sample passed through the screen (Figure 3).

Figure 2. Clumping of ice cuttings on 1mm sieve in vacuum chamber. Photo credit: Honeybee Robotics

Fig. 1. Pins added to sampling auger can reduce cuttings size to < 1mm. Photo credit: Honeybee Robotics
Conclusions: Sieving in both partial gravity and in thermal vacuum conditions is challenging when icy soil conditions exist. 1-2 mm sieve clumping phenomena requires further study to understand and mitigate the mechanism.


Fig. 3. Antarctic Dry Valley clumped sample (a) after and (b) before lunar parabola sieving (December 2015).