RASP SAMPLE ACQUISITION ON THE PHOENIX MARS SCOUT MISSION. G. H. Peters, G. S. Mungas, G. H. Bearman, L. W. Beegle, J. A. Smith, Jet Propulsion Laboratory, California Institute of Technology (M/S 183-601 4800 Oak Grove Dr., Pasadena, California 91109).

Introduction: Scheduled to launch in 2007, Phoenix will land on the arctic plains of Mars. Using its Robotic Arm (RA) with an attached scoop, it will dig through a desiccated regolith layer to reach the permafrost table. Martian permafrost, at –87 $^{\circ}$C can reach compressive strengths up to 45MPa, equivalent to structural concrete. In order to cut away and provide permafrost samples to the instruments, the mission will rely on a RASP (Rapid Active Sampling Package) to acquire permafrost samples. Named the Icy Soils Acquisition Device (ISAD), the RASP system on Phoenix uses a single bit that is spring-loaded outwardly protruding though a slot in the bottom of the catch-container. The RA will position the catch container (located in the heel of the primary scoop) so that it pre-loads the rasp bit against the permafrost surface. When the rasp is powered, the cuttings it produces will be pitched into the catch container.

Using the Phoenix Mission rasp bit configuration and environmental parameters we have measured the alteration of collected samples when rasping under Martian conditions.

RASP description: A rasp is a simple tool that may be used to sample rock, permafrost or ice. It uses a rotating rasp-bit (or two counter rotating bits) residing inside or above a catch container. The container has an open slot to allow the cutting bit to extend outside the container and to allow cuttings to enter. When the slot and rasp bit are in contact with the substrate, the bit is plunged into the substrate. The plunging mechanism may rely on a spring or may be actively controlled. As the bit spins, its teeth cut the material and launch the cuttings into the catch container via the slot (Figure 1).

The rasping operation powderizes materials while it is cutting them free. In a few seconds and in a single operation, rasp systems cut away strong materials, process them to sizes that are instrument-ingestible, and capture them in a catch container.

Sublimation: During the Phoenix mission the scoop will remove a desiccated regolith layer exposing the frozen permafrost layer. Once exposed, the uncovered ice will sublime at a rate governed by the local atmospheric conditions (passive sublimation) [1]. The RA will then place the RASP onto the ice layer to actively cut away and sample the permafrost. This interaction increases the sublimation rate due to conversion of mechanical energy into thermal energy (active sublimation). Passive sublimation then continues as the dominant water loss mechanism.

Experiments: RASP systems effectively impart the energy needed to break the physical bonds of permafrost and rocks. To place an upper bound on the energy input into permafrost samples we measured the excavation specific energy per unit volume, E_{exc}, for the RASP operating in a water-saturated Mars analog permafrost medium. as a function of the permafrost temperature. These were performed at low Mars ambient (5 torr) over the temperature range of -86 to – 11 $^{\circ}$C at ~6, 000 rpm and the E_{exc} appeared to be constant (Figure 2). E_{exc} was derived by integrating the power consumed by the RASP during excavation and measuring the volume post-excavation by massing the quantity of microspheres required to fill the excavated volume.

During the above experiments we determined the water loss of each permafrost sample during collection (Figure 4). Water-saturated ice/dirt pucks were frozen at -80 $^{\circ}$C. These pucks are sealed with aluminum foil (not shown) to negate passive sublimation during the pump-down of the vacuum chamber. Upon reaching the proper temperature and pressure, the RASP was initiated and the sample collected on a scale located below the RASP. (Figure 3 - Scale, collection shield and sample not shown.) This sample was then desiccated and the mass of water was determined and compared to that in the unsampled portion of the permafrost puck. Figure 5 shows the water loss as a function of temperature due to active sublimation. There is a trend towards increases water loss with increasing temperature. We attribute this to the lower energy required to heat the water in the warmer pucks to the minimum sublimation temperature.

Conclusions: Rasping with the current ISAD RASP bit design can remove a significant fraction of H_2O in permafrost samples. This is on top of passive sublimation that takes place as the sample is transferred to the instruments to be analyzed [1].

Future optimized RASPS designs for icy samples can likely mitigate water loss by increasing the generated particle size (hence reducing both E_{exc} and the exposed particular surface area for sublimation) and providing active control of the bit to reduce the load on bit and the volumetric excavation rate (hence reducing the thermal power generation rate for sample heating).

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References: [1] Taylor, P.A., et al., (2006) Icarus, 181, 375-387.

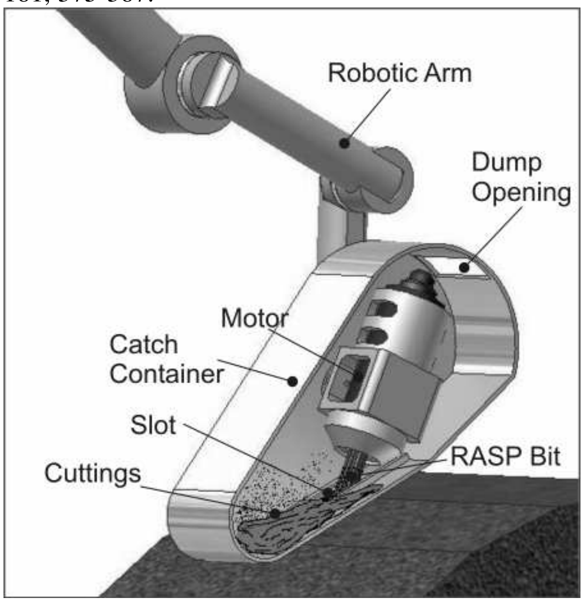

Figure 1. Diagram showing RASP on a robotic arm with collected sample.

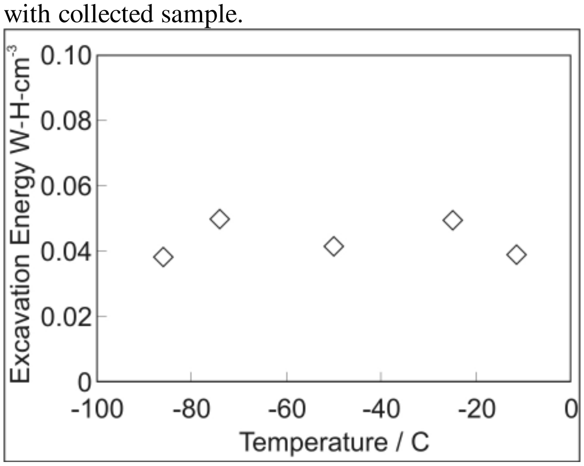

Figure 2. RASP excavation energy per unit volume.

Figure 3. Experimental RASP setup. The white disc is the sample puck holder.

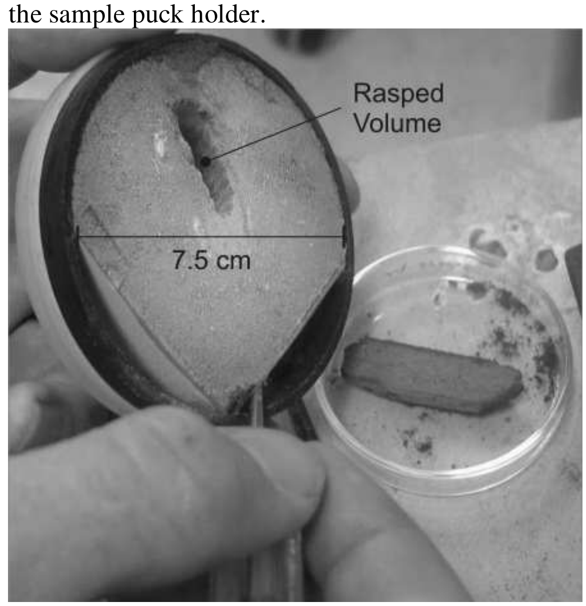

Figure 4. Sample puck showing Rasped hole and the portion of the sample used to measure water content in the Petri in the lower right.

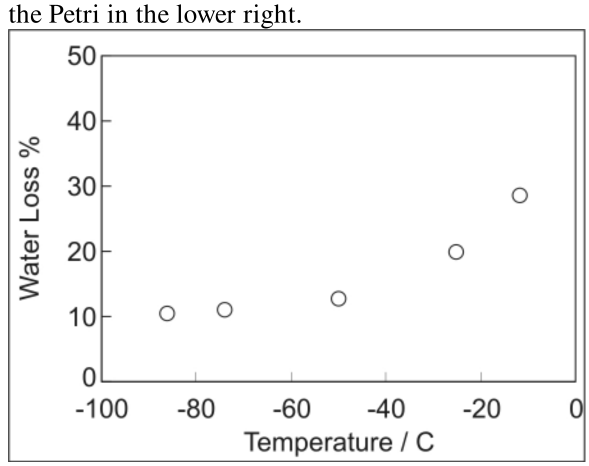

Figure 5. Water loss percentage vs. temperature for saturated (~23% water wt/wt) permafrost pucks.