

PoDS: A POWDER DELIVERY SYSTEM FOR MARS *IN-SITU* ORGANIC, MINERALOGIC AND ISOTOPIC ANALYSIS INSTRUMENTS. C. P. Saha¹, C. E. Bryson¹, P. Sarrazin², and D. F. Blake³,
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Introduction: Many Mars *in situ* instruments require fine-grained high-fidelity samples of rocks or soil. Included are instruments for the determination of mineralogy as well as organic and isotopic chemistry. Powder can be obtained as a primary objective of a sample collection system (e.g., by collecting powder as a surface is abraded by a rotary abrasion tool (RAT)), or as a secondary objective (e.g. by collecting drill powder as a core is drilled). In the latter case, a properly designed system could be used to monitor drilling in real time as well as to deliver powder to analytical instruments which would perform complementary analyses to those later performed on the intact core. In addition, once a core or other sample is collected, a system that could transfer *intelligently collected sub-samples* of powder from the intact core to a suite of analytical instruments would be highly desirable. We have conceptualized, developed and tested a breadboard *Powder Delivery System* (PoDS) intended to satisfy the collection, processing and distribution requirements of powder samples for Mars *in-situ* mineralogic, organic and isotopic measurement instruments.

PoDS principle: The PoDS is based on vacuum advection of particles, utilizing a pneumatic driving force. Powder samples of rock or soil can be generated by an abrasion tool (RAT), driller/corer (USDC), or other such device. The powder samples are collected and transported to an analytical instrument or instruments as an aerosol of ambient gas and powder. The particles are separated from the gas using a size-selective pneumatic filtration device called a *gas cyclone*. Gas cyclones have been used as particle collectors or separators since the early 20th century [1] and have been optimized for a variety of pressure and temperature conditions including those extant on the Mars surface. They can be tuned to collect particle sizes ranging from one to several hundred microns.

PoDS breadboard: The PoDS breadboard is shown in Figure 1. The PoDS consists of a sample acquisition and transfer tube connected in series to two gas cyclones and a Venturi pump. During operational testing, the open end of the sample acquisition and transfer tube is placed in a sample dish filled with powdered rock. The system is operated by supplying pressurized air to the Venturi pump from a laboratory source of compressed air.

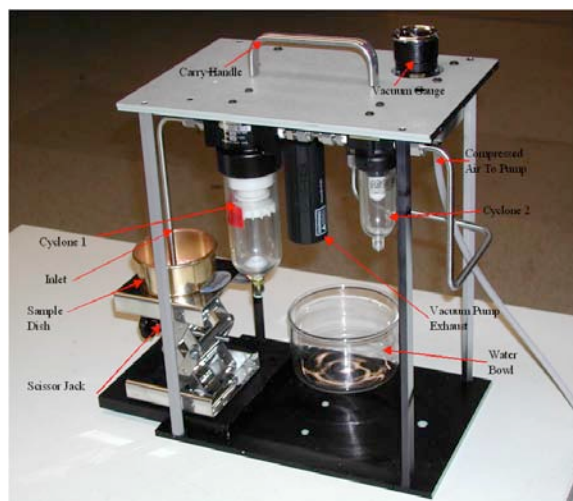


Figure 1: PoDS breadboard

Experiments with the PoDS breadboard: The following sample transfer experiments have been performed with the PoDS breadboard shown in figure 1.

(a) *Particle Size Distribution (PSD) of powder collected by the system:* Prepared rock powder (apatite) of known PSD was transferred and collected by the PoDS. A total of 5 experiments were performed in which initial and collected PSDs were measured. The results of these experiments are shown in figure 2. Slight differences in initial and collected PSDs of the apatite powder are the result of the break up of grain aggregates present in the initial powder sample.

An additional series of experiments was performed using glass beads of known PSD. Results from these experiments show that there is no damage to the beads during collection and that the PSD of the beads is unchanged between the initial and transferred samples.

(b) *Sample cross-contamination measurements:* Experiments were performed to evaluate cross-contamination between samples transferred using the PoDS. First, iron powder (starting quantity about 5 gms) of known PSD was transferred and collected 5 times without cleaning the components between transfers. The results of these transfers are shown in figure 3a. At the end of 5 transfers, about 20% of the initial iron powder remained in the system as contamination. Next, 5 gms of quartz powder having a similar PSD to the iron was transferred 5 times without cleaning. After each quartz sample transfer, iron contamination from the previous experiments was separated from the

quartz with a magnet and weighed. This measurement allowed us to quantify the extent of iron contamination in the quartz sample during subsequent transfer of quartz. At the end of 5 quartz transfers, $\ll 1\%$ of iron contaminant was measured in the collected quartz. The results of these experiments are shown in figure 3b. By optimizing the component configuration to reduce or eliminate cracks, crevices, threaded couplers and constrictions, the contamination level should be controllable to any arbitrary limit. It requires less than 60 seconds to transfer 5 gms of powder. The system energy demand for a single transfer can be as little as 1.75 watt-h per minute.

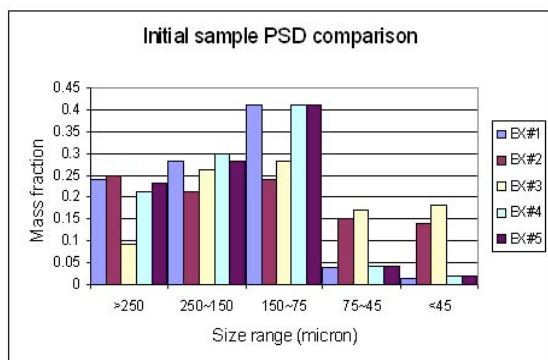


Figure 2a: PSD of initial apatite powder sample for 5 experiments

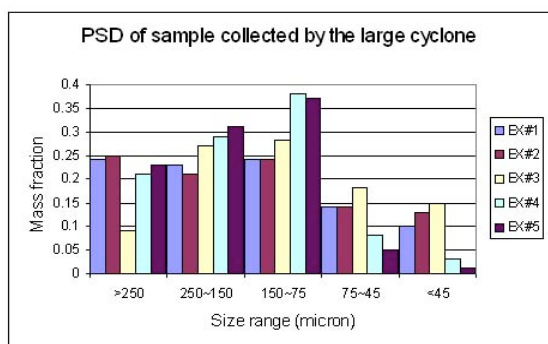


Figure 2b: PSD of apatite powder sample collected by the first cyclone.

(c) *Transfer of living organisms:* Experiments were performed in which 0.5 gm of live yeast (obtained from a commercial source) mixed with 4.5 gm of glass beads was transferred with the PoDS. Both initial and transferred samples were fermented in warm sugar water. The amount of evolved metabolic CO_2 from initial and collected samples was equivalent. This experiment demonstrates that living organisms and the organic materials they contain can be transferred quantitatively without damage using the PoDS.

All of these experiments were performed using off-the-shelf components which were not optimized for the PoDS application. An improved prototype, integrating

the USDC with PoDS is being developed. We will design and build the individual components of this prototype utilizing all metal components with smooth and continuous inner surfaces. Also, comparative analytical, experimental and Computational Fluid Dynamics (CFD) studies of aerosol properties under terrestrial and Martian conditions are in progress. These studies are necessary for designing and performance scaling of PoDS for deployment under Martian surface atmospheric conditions.

For Mars *in-situ* applications we will explore the technique of adsorption compression of atmospheric CO_2 by diurnal temperature swing [2].

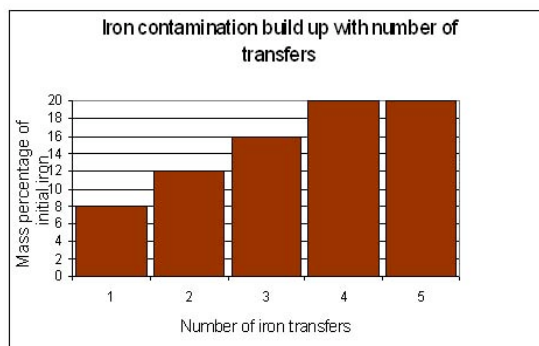


Figure 3a: Buildup of iron contamination in the PoDS during 5 successive sample transfers.

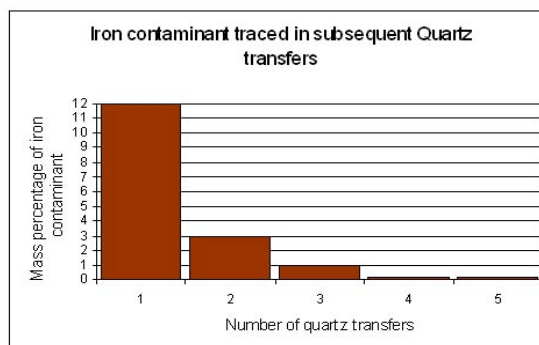


Figure 3b: Percentage of iron contaminant in subsequent quartz transfers.

References:

- [1] Leith D. *et al.* (1973) "Cyclone Performance and Design", *Atm. Environment*, Vol. 7, 527-549.
- [2] Finn J. E. *et al.* (1996) <http://stl.ame.arizona.edu/publications/961597.pdf>

Acknowledgements: We thank the Mars Instrument Development Program for support under a grant awarded to DFB. We thank Mr. Richard Ziegler of RZE, Mountain View, for his generous help in assembling the PoDS prototype.