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Containers, sensors and samples to understand desert weathering

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SAMPLING AT THE MARS DESERT RESEARCH STATION (UTAH, USA) - CONTAINERS, SENSORS AND SAMPLES TO UNDERSTAND DESERT WEATHERING. S. P. Schwenzer¹, Barnes¹, J. J., Charlier², B. L., Grady¹, M. M., Hall¹, C., Melwani-Daswani¹, M., Morse¹, A., Olsson-Francis¹, K., Patel¹, M., Pearson¹, V., Pilling¹ J.M., Preston¹, L. J., Sheridan¹, S., Sherlock², S. C., Steer¹, E. D., Summers¹, S., Verchovsky¹, S., Dove-Jay⁴ A. S., Jewell⁵, S., and Musilova⁶, M. – ¹Department of Physical Sciences, CEPSAR, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK; susanne.schwenzer@open.ac.uk; ²Department of Earth Environment and Ecosystems, CEPSAR, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK ³Faculty of Engineering, Queen's Building, University of Bristol, BS8 1SS, UK; ⁴International Space University, 1 rue Jean-Dominique Cassini, Illkirch-Graffenstaden, 67400, France; ⁵Glaciology Centre, School of Geographical Science, University of Bristol, BS8 1 TR, UK.

Introduction: Our study is motivated by two aspects: i) the scientific motivation is to a) expand on previous studies of heavy noble gases in samples from terrestrial hot and cold deserts [1-4], thus to collect surface and subsurface (20 cm depth) samples from wind-blown desert soil and to b) study clay rich soil horizons for their microbiology and potential to serve as Mars analogue; and the ii) technological motivation is to field-test a prototype sampling container for crew-based sample return missions to Mars, the Moon, or other celestial bodies.

Location and Crew: The Mars Desert Research Station is located in the Utah Desert and is run by the Mars Society [5]. The habitat is located in an area that resembles a Martian landscape, consisting of wind-blown desert surfaces, dry river beds and layers of clay-rich sediments. All have previously been studied for their geology, mineralogy, and biology, allowing for a wide range of literature studies to link our research to [e.g., 6,7]. The station hosts several crews per season, whereby each crew performs an analogue mission that consists of a wide range of tasks. During their mission they live in a habitat and only leave through and air-lock system, wearing 'space suits' with gloves and helmets, which makes handling of tools and sampling kit more difficult and thus realistic for testing spaceflight equipment. Crew 134, led by A. S. Dove-Jay, (formerly A. S. Dale), performed the sampling for this study on the 11th day of their simulation, 29th January 2014 [8,9]. This date was chosen to allow the ground to dry off as much as possible after earlier snowfall in the area, which caused surface water to be present in the area at the beginning of the analogue mission (reported on 18th January 2014).

Instruments: The OU team sent a set of three tasks to be carried out by the analogue astronaut crew: 1) collection of dry desert samples from the surface and the subsurface into prototype smart containers, 2) monitoring UV exposure during the mission with a set of two UV sensors, and 3) collecting clay samples with a set of 12 small standard corers.

'Smart' containers: Sample return from Mars by crew will have to satisfy several requirements - from

planetary protection to sample integrity. In this study, we built a first phase prototype of a sample container for the collection and return of samples by a manned mission. The requirements were to return a sample uncontaminated for geochemical studies, including a wide variety of stable isotopes (C, N, Sr...), and elements, including noble gases, through an all metal design. We chose an all metal design to avoid nitrogen and carbon contamination. The prototype containers were manufactured from copper and brass, but we aim at stainless steel - or titanium, depending on the application - for future development. Monitoring of sample status during shipping further insured sample integrity.

Our container consists of three pieces: the metal container, a lid and a gas canister. For this prototype study, sensors to measure pressure, temperature and moisture levels were used from commercial suppliers/pre-existing in-house materials, and added separately. In a more advanced version, those sensors will be built into the canister. The procedure for the analogue astronaut crew was to insert the sensors, then the sample (for details see below), and the gas canister into the container and screw the lid closed. A pin in the lid was designed to puncture the gas canister after sealing was achieved. The gas canister can be filled with He (to avoid any heavy noble gas adsorption, because He as the lightest of the noble gases does not significantly adsorb to any surface) but any other gas as required by the experiment could be used. Unfortunately, because of airline shipping restrictions, no pressure could be added for this field test.

UV detectors: Two UV-detectors were deployed to monitor the irradiation environment during the mission. The first detector was deployed on the ground in an unshaded area and recorded data throughout the mission. The second detector was mounted on the rover [10] to record exposure difference of hardware compared to overall UV irradiation.

Standard corers: A set of 12 standard corers for sediment sampling were used to sample a nontronite bearing horizon for a combined C, N, noble gas and biological study.

Sand samples: Sand samples were collected on 29th January 2014 near an area with a surficially indurated sandy surface (Fig. 1). The surface sample was taken by scratching the surface with a trowel in order to collect the uppermost cm of the sediment. Then a hole was dug and the second sample was taken at 20 cm depth. The second sampling took considerable time and effort from the analogue astronaut crew, because it turned out to be physically heavy work, made more complicated by the restrictions of their EVA suits.

Both samples are of light beige colour and appear dry. The surface sample contains small indurated soil pieces and loose material, whereas the subsurface sample is loose material made up of individual grains. Samples are stored in the containers, which are only opened in adequate laboratory environments, e.g., laminar flow boxes, to avoid contamination.



Fig. 1. Sampling location for the sand samples. Note that the surface is indurated, whereas the lower parts of the soil are loose.

Clay samples: 12 cores were sampled, to obtain samples of the nontronite rich clay horizons (Fig. 2), which will be investigated for their biologic inventory, this includes counting viable cells, and tested as analogue for Martian clay rich sediments, e.g. as found by the Curiosity rover [11].



Fig. 2. Sampling location for core samples, after taking core 12, diameter of core 5 cm.

Results: At the time of writing, data analysis was still under way. Preliminary results are as follows:

Container performance: The crew reported that handling was straightforward, and inspection of the gas canister showed that in both containers the canister was punctured successfully. Readings of the sensors shows that temperature and humidity varied between +25 and -4 °C, whereby the lowest T occurs during airline transportation. Notably, humidity stabilizes at ~ 40 % Rh (at ~ 20 °C) 14 days after sampling.

UV detectors: The first of the two UV detectors monitored the UV exposure during the expedition, which is especially valuable in the light of the fact that the crew arrived in very wet conditions. The second detector monitored the exposure of a rover mounted device, whereby the difference between the two is a measure for exposure of instrumentation (and by extension astronauts) to the environment while not in the habitat or otherwise protected.

Mineralogy: The sand samples consist of predominantly quartz grains, which are ~100 to 500 µm in size, and moderately sorted. The smaller grains are angular and the larger grains are well rounded. Traces of feldspar, carbonate grains and sulfate grains were observed. The surface sample is cemented by carbonate; the subsurface sample contains carbonate coated grains, but the material is not consolidated. The clay samples consist of a very fine grained, clay rich matrix and contain grains of sulfate and carbonate.

Future work: The sample container study is progressing towards a smaller, lightweight design. In the next phase, the sensors will be hosted inside the container. We will also carry out laboratory based tests with pressurized containers.

Samples will be fully characterized and studied for their biologic content, stable isotopes and noble gases. This will allow us to compare them to other hot and cold desert samples to deduce weathering signatures and assess their habitability. We will present results from the studies currently under way, including full mineralogy, and initial biologic and volatile inventory.

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