Automated Subcritical Water Extraction and Analysis Platform for Martian Regolith: Remote Operation on Rover in the Atacama Desert.

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Introduction: We present a portable, multiplexed sample extractor and analysis unit that could be used to support landed robotic missions seeking chemical signatures of habitability and life on Mars. Using this instrument, inorganic and putative organic compounds were automatically extracted from approximately 1 cm^3 of regolith and drill fines by subcritical water extraction (SCWE) at temperatures up to 200 °C [1]. Following the extraction, miniaturized electrochemical sensors were used to quantify the eluate's pH, conductivity, and redox potential to characterize the sample chemistry. This system can be employed as a front-end instrument for subsequent, more sophisticated organic analyzers such as capillary electrophoresis or mass spectrometer systems.

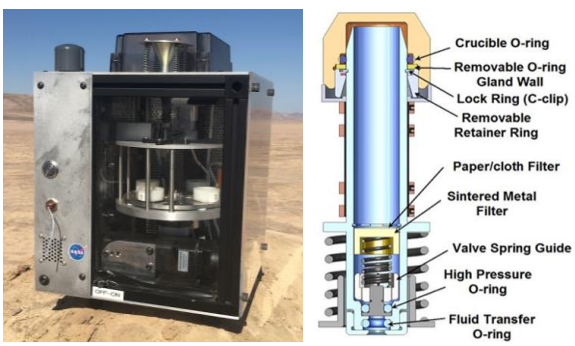

Figure 1: Subcritical Water Extractor in the Atacama Desert (left), and cross-section of a sealed extraction crucible developed together with *Ball Aerospace* (right) [4].

Approach: SCWE uses liquid water as extraction solvent at temperatures above the atmospheric boiling point of water but below its critical point. At elevated temperatures, the permittivity, viscosity, ionization constant and surface tension of water are decreased, whereas its diffusion rate increases, making it a powerful solvent for extraction of both polar and non-polar compounds. The presented automated SCWE system (Figure 1) allows for four independent extractions. The crucibles are mounted on a rotary holder and moved by a stepper motor to four positions, where: 1) the sample is filled into the extraction crucible, 2) the extraction crucible is capped and hermetically sealed by a linear motor and, 3) engaged with liquid interface to inject the extraction solution, and 4) the crucible is heated up to 200°C to initiate extraction. After concluding the extraction, the crucible engages again with the liquid interface to release the extract for downstream compositional analysis.

As part of the PSTAR project Atacama Rover Astrobiology Drilling Studies (ARADS) [2], the portable extraction and analysis system was tested under Mars-relevant conditions in the Atacama Desert in Chile to increase its overall Technology Readiness Level. The instrument suite was mounted on the NASA Ames Research Center mobile K-Rex rover platform, which includes a drill and a sample collection arm [3]. Remote operation of the device was used to perform liquid extraction and sample analysis on autonomously acquired drill samples fed into the instrument suite by the rover. To our knowledge, this is the first time automated SCWE was performed in a Mars-like environment.

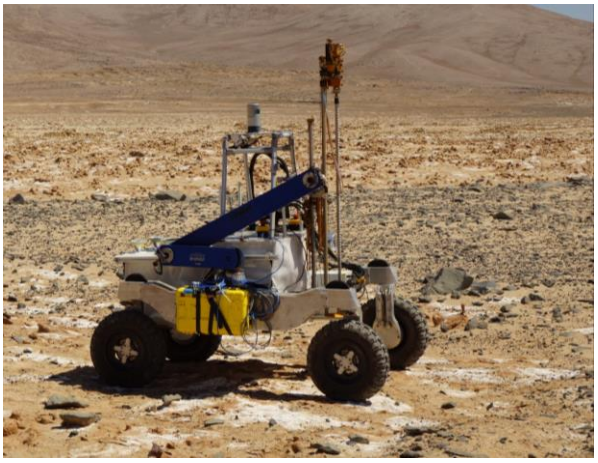

Figure 2: Subcritical Water Extractor installed on NASA Ames' Research Center mobile K-Rex rover.

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