Atacama Rover Astrobiology Drilling Studies Project: Final Year

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Introduction: The Atacama Rover Astrobiology Drilling Studies (ARADS) project, a simulated Mars rover biomarker detection mission, was iteratively developed over four years from 2015 - 2019, including three NASA centers, the Centro de Astrobiologia, Johns Hopkins University, Honeybee Robotics, Maxar and the University of Antofagasta. The final (4th) ARADS field season, in 2019, tested an integrated mobile life-prospecting platform loosely inspired by the 2000's Astrobiology Field Laboratory concept, with a 1m rotary-percussive drill and sample transfer robot arm that fed three astrobiology instruments operating in-situ on the KREX2 medium rover prototype. A fourth instrument was field tested earlier in 2019 due to flight mission requirements.

In the final ARADS field deployment in September 2019, the project conducted a remote mission operation simulation (Stoker 2022) demonstrating sample drilling, acquisition and transfer into the rover instruments (while minimizing cross-contamination), performing in-situ analysis of the samples, and returning the results to a remote science operations team (which commanded the daily science goals and uploaded operations sequences).

Project Approach: The original ARADS payloads included four flight-prototype astrobiology instruments, to be operated on the payload deck of the KREX2 rover, opposite from an attached Honeybee Robotics 1m drill and a Maxar sample transfer arm with an actuated scoop. These instruments included two "habitability instruments", the Ames/JPL Wet Chemistry Laboratory (WCL) and (half of the ExoMars MOMA instrument) the GSFC Laser Desorption Mass Spectrometer (LDMS). Two biosignature instruments were (from INTA in Spain) the Signs Of Life Detector (SOLID) immunoassay instrument, and (from JPL) the Chemical Laptop-derived microfluidic life analyzer (MILA), capable of differentiating amino acid chiralities (biogenic vs abiotic). In a series of increasing-capability demonstrations at a high-fidelity Mars-analog site (in the Atacama Desert, Chile), ARADS integrated these instruments, along with the rover and drill, and by 2018 had already demonstrated in-situ "dirt to data" capability (Dave 2018) finding biosignatures in and under the surface at Yungay.

Year 4 Results: In the 2019 remote mission simulation (**Fig. 1**), SOLID, MILA and WCL were operated in-situ on the ARADS rover deck, with robotically drilled and transferred samples (Moreno-Paz 2022, Kehl 2019, Mora 2020). MILA demonstrated supercritical water extraction and microchip

Fig. 1. The ARADS rover and instruments in Chile, directed daily by a remote science team in 2019.

electrophoresis, successfully conducting amino acid analysis; SOLID identified multiple biosignatures; and WCL performed soil physical-chemical analysis, each from their autonomously drilled and delivered samples. The LDMS could not be fielded in September as the required MOMA avionics unit was not available for integration (due to ExoMars test conflicts) but it was demonstrated at Yungay, standalone, in March 2019.

The ARADS project concluded its final field season with a 6-day remote operations simulated astrobiology mission, at a novel Atacama field study location not studied in previous tests. A local science team evaluated bioburdens/contaminates and conducted local parallel sample analyses as a quality control. (Stoker 2022) The ARADS operations flow was directed from a remote Mission Operations Center at NASA-Ames, uploading daily commands and sequences and downloading data batches via satellite communications.

References: Stoker C. et al. (2022) *AbSciCon*; Dave A. et al. (2018) *ASCE Earth and Space*; Moreno-Paz M. et al. (2022) *AbSciCon*; Kehl, F. et al. (2019) *AbSciCon*; Mora M. et al. (2020) *Analytical Chemistry*.