MONO LAKE ANALOG MARS SAMPLE RETURN EXPEDITION FOR AMASE. P. G. Conrad[1], A. Steele[2], P. Younse[3], M. DiCicco[3], A. R. Morgan[3], P. Backes[3], J. E. Eigenbrode[1], D. Marquardt[4], H. E. F. Amundsen[5] [1]NASA Goddard Space Flight Center, Code 699, Greenbelt, MD 20771, [2]Geophysical Laboratory, Carnegie Institution of Washington, Washington, DC 20015, [3]Jet Propulsion Laboratory, Pasadena, California 91109, [4]California Dept. of Parks, Mono Lake Station, Lee Vining, CA, [5]Earth and Planetary Exploration, Jac Aals Gate, Oslo Norway.

Introduction: We explored the performance of one robotic prototype for sample acquisition and caching of martian materials that has been developed at the Jet Propulsion Laboratory for potential use in the proposed MAX-C Mars Sample Return architecture in an environment, rich in chemical diversity with a variety of mineralogical textures. Mono Lake State Tufa Reserve in Mono County, CA (Fig 1) possesses a variety of minerals including a variety of evaporites, volcanic glass and lava, and sand and mudstones. The lake itself is an interesting chemical system: the water is highly alkaline (pH ~10) and contains concentrations of Cl, K, B, with lesser amounts of S Ca Mg, F, As, Li, I and W and generally enriched HREEs [1]. There are also traces of radioactive elements U, Th, Pl [2].

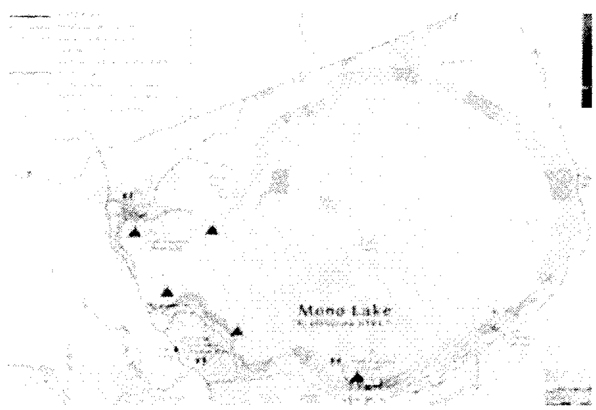

Fig. 1 The Mono Lake Field Site is shown by the pink flag. Samples were also collected from other sites bordering the lake.

Previous work. The Arctic Mars Analog Svalbard Expedition (AMASE) has typically been an amalgam of numerous science and technical activities during a two-week expedition to various field sites on Svalbard. A small number of rover operations have always been a component of the AMASE field work, and these operations have involved both stand-alone objectives as well as participation in tactical planning exercises. Because the rover has been operated semi-autonomously with varying degrees of sequencing for each maneuver, the operations have been lengthy, sometimes 12 or 13 hours in a given day. Thus the number of days expended on rover operations has had to be limited and the weather on Svalbard during the late arctic summer is often unpredictable, and the rovers could not been by deployed in rain and heavy mist or fog. For these reasons, and because objectives involving the acquisition and caching of samples are now fundamental to AMASE, the 2010 field season included a separate domestic rover expedition for one week of continuous deployment.

In AMASE 2009, a scooping system was tested [3] from an MER class rover platform and the scientific objectives were focused on the maintenance of sample cleanliness with respect to both planetary protection and organic cleanliness. For the 2010 Mono Lake expedition, the following were the ultimate goals:

• Determination of maximal rover operation parameters including terrain roughness, slope, communication, slip imaging and sample acquisition.
• Determination of the best sample handling and encapsulation protocols for use in field instruments, including an assessment of weathering effects on sample quality.
• Evaluation of the performance of integrated rover and instrument deployments for meeting science objectives
• Development of protocols for sample targeting by a remote science team in the field.

Objectives: As with a mission we developed objectives and requirements. Specific objectives were:

1. Collect two cores of a sandstone sedimentary rock with cross-bedded structure of laminae no thicker than 1 cm (to see the sedimentary structures in the core)
2. Collect two cores of a sulfate evaporite facies
3. Collect two cores of a fine grained Ca carbonate and two cores of a coarse grained Ca carbonate
4. Collect two cores of a dolomite
5. Collect two cores of clay deposit (well lithified)
6. Collect two cores of basalt
7. Collect two cores of poorly lithified sands (TBD type)
8. Cache and seal all of the above
9. Demonstrate organic cleanliness and microbial cleanliness of hardware
10. Demonstrate level of cross contamination between samples

The level one science requirements included:

- L1-1: The mission will collect cored samples of geological material with a variety of compressive strengths.
- L1-2: The cored samples shall be cached in containers that are organically clean to TBD concentration of total organic carbon and consistent with planetary protection # of viable organisms per cm^2.
- L1-3: The mission shall provide pan cam and nav cam images at TBD resolution and TBD field of view suitable for making approach decisions in the tactical planning exercise.
- L1-4: The rover shall be capable of acquiring a micro-

scopic image of the spot on the target prior to and after coring with resolution of 30 μm/pixel (or better) and TBD field of view.

Hardware: The sample handling, encapsulation, and containerization subsystem (SHEC), described fully in a separate report), consisted of a commercial rotary percussive coring drill and a sample caching system that captured the rock cores in small tubes (Fig 3).

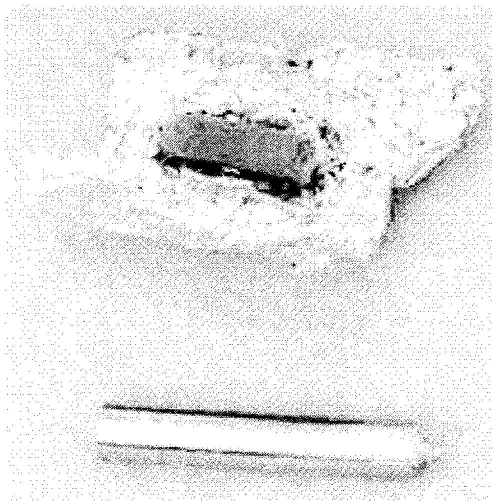

Fig. 3. Sample cache tube and a core. Inner dimensions of the tubes are 1 x 5 cm.

While the coring and caching system can store at least nineteen samples in its carousel, we recovered the sample cores for subsequent scientific analysis.

At this stage in the development of the coring and caching hardware, the arm of the MER class Pluto rover could only accommodate a micro-imager (MI) and no additional contact instruments. The field plan was to include contact measurements with micro-Raman spectroscopy and X-Ray fluorescence spectroscopy, however we had to make those measurements subsequent to the core acquisition due to an unexpected number of early winter storms in the first week of October 2010. in the Mono Basin.

Procedures: Before sampling, the coring bits, sample tubes and tube plugs were sterilized using a modified version of the decontamination and sterilization protocol of Eigenbrode et al. [4]. Rock targets were pre-selected to represent different textures and chemical character, and in the case of two rock targets, the rocks had to be brought to a secure site for the rover due to bad weather. At one site we were able to core the rock in situ. The procedure followed for sample acquisition is summarized as follows:

•Image rock with mast cameras, then approach rock
•Image rock with fwd hazcam
•Transfer empty tube into bit, then manually place in drill
•Position MI on rock & Image rock with fwd hazcam
•MI rock
•Perform additional sensor readings (Temp)
•Image rock with fwd hazcam
•Core target
•Image rock with fwd hazcam
•Retract drill from rock and check for core retention
•Manually remove bit and place in coring tool
•Encapsulate
•Position MI onto same sample location on rock
•Image rock with fwd hazcam

Results: Nine samples were acquired from three different tufa rock outcrops over the course of three days. Here are highlights: •The temp was measured by IR thermometry and no significant increase was observed in all cases. • Some cores over-filled the caching tubes and presented difficulty in sealing. •Rock facies with a high clay content were sticky and presented a coring challenge; these materials may require special handling. •Subsequent XRF analysis does not reveal elemental migration. •Raman analysis of mineral stress at core boundaries is presently under way.

Expedition Team: M. Glamocjlia, A. Steele. H. Bortman, P. Backes, D. Marquardt, D. Bower, P. Younse, M. DiCicco, P. Conrad, B. Lieberman, J. Eigenbrode, V. Starke, R. Morgan, and N. Steinhauser

References: Use the brief numbered style common in many abstracts, e.g., [1], [2], etc. References should then appear in numerical order in the reference list, and should use the following abbreviated style:

[1] Johannesson, K. H. and Lyons, W. B. (1994) *Limnol. Oceanogr.*, ***39***, 1141–1154. [2] Anderson, R. F. et al. (1982) *Sci.*, ***216***, 514-516. [3] Younse, P. et al., (2010) *Abscicon, April 2010.* [4] Eigenbrode, J. et al. (2009) *Astrobiology*, ***9***, 455-465.

Acknowledgements: Funding from NASA ASTEP, PI: A. Steele. Additional funding from JPL RTD fund for development of the SHEC (PI: P. Backes)