

PRE-MISSION INPUT REQUIREMENTS TO ENABLE SUCCESSFUL SAMPLE COLLECTION BY A REMOTE FIELD/EVA TEAM. B. A. Cohen¹, K. E. Young², and D. S. Lim³. ¹NASA Marshall Space Flight Center, Huntsville AL 35812 (Barbara.A.Cohen@nasa.gov); ²CRESST/University of Maryland, College Park, MD, 20742 and NASA Goddard Space Flight Center, Greenbelt MD 20771; ³SETI Institute, 189 Bernardo Ave., Suite 100, Mountain View, CA 94043 and NASA Ames Research Center, Moffett Field, CA 94035.

Introduction: This paper is intended to evaluate the sample collection process with respect to sample characterization and decisionmaking. In some cases, it may be sufficient to know whether a given outcrop or hand sample is the same as or different from previous sampling localities or samples. In other cases, it may be important to have more in-depth characterization of the sample, such as basic composition, mineralogy, and petrology, in order to effectively identify the best sample. Contextual field observations, in situ/handheld analysis, and backroom evaluation may all play a role in understanding field lithologies and their importance for return. For example, whether a rock is a breccia or a clast-laden impact melt may be difficult based on a single sample, but becomes clear as exploration of a field site puts it into context.

The FINESSE (Field Investigations to Enable Solar System Science and Exploration) team is a new activity focused on a science and exploration field-based research program aimed at generating strategic knowledge in preparation for the human and robotic exploration of the Moon, near-Earth asteroids (NEAs) and Phobos and Deimos. We used the FINESSE field excursion to the West Clearwater Lake Impact structure (WCIS) as an opportunity to test factors related to sampling decisions. In contrast to other technology-driven NASA analog studies, The FINESSE WCIS activity is science-focused, and moreover, is sampling-focused, with the explicit intent to return the best samples for geochronology studies in the laboratory. This specific objective effectively reduces the number of variables in the goals of the field test and enables a more controlled investigation of the role of the crewmember in selecting samples.

We formulated one hypothesis to test: that providing details regarding the analytical fate of the samples (e.g. geochronology, XRF/XRD, etc.) to the crew prior to their traverse will result in samples that are more likely to meet specific analytical objectives than samples collected in the absence of this pre-mission information. We conducted three tests of this hypothesis. Our investigation was designed to document processes, tools and procedures for crew sampling of planetary targets. This is not meant to be a blind, controlled test of crew efficacy, but rather an effort to recognize the relevant variables that enter into sampling protocol and to develop recommendations for crew and backroom training in future endeavors.

Methods: One of the primary FINESSE field deployment objectives was to collect impact melt rocks

and impact melt-bearing breccias from a number of locations around the WCIS structure to enable high-precision geochronology of the crater to be performed [1]. We conducted three tests at WCIS after two full days of team participation in field site activities, including using remote sensing data and geologic maps, hiking overland to become familiar with the terrain, and examining previously-collected samples from other islands. In addition, the team members shared their projects and techniques with the entire team. We chose our “crew members” as volunteers from the team, all of whom had had moderate training in geologic fieldwork and became familiar with the general field setting.

The first two tests were short, focused tests of our hypothesis. Test A was to obtain hydrothermal vugs; Test B was to obtain impact melt and intrusive rock as well as the contact between the two to check for contact metamorphism and age differences. In both cases, the test director had prior knowledge of the site geology and had developed a study-specific objective for sampling prior to deployment. Prior to the field deployment, the crewmember was briefed on the sampling objective and the laboratory techniques that would be used on the samples. At the field sites (Fig. 2), the crewmember was given 30 minutes to survey a small section of outcrop (10-15 m) and acquire a suite of three samples. The crewmember talked through his process and the test director kept track of the timeline in verbal cues to the crewmember. At the conclusion, the team member conducting the scientific study appraised the samples and train of thought.

Test C was a 90-minute EVA simulation using two crewmembers working out of line-of-sight in communication with a science backroom. The science objectives were determined by the science backroom team in advance using a Gigapan image of the outcrop (Fig. 1). The science team formulated hypotheses for the outcrop units and created sampling objectives for impact-melt lithologies; the science team turned these into a science plan, which they communicated to the crew in camp prior to crew deployment. As part of the science plan, the science team also discussed their sample needs in depth with the crewmembers, including laboratory methods, objectives, and samples sizes needed. During the deployment, the two crewmembers relayed real-time information to the science backroom by radio with no time delay. Both the crew and science team re-evaluated their hypotheses and science plans in real-time.

Discussion: Upon evaluation, we found that the focused tests (Tests A and B) were successful in meeting their scientific objectives. The crewmember used their knowledge of how the samples were to be used in further study (technique, sample size, and scientific need) to focus on the sampling task. The crewmember was comfortable spending minimal time describing and mapping the outcrop. The crewmember used all available time to get a good sample.

The larger test was unsuccessful in meeting the sampling objectives. When the crewmembers began describing the lithologies, it was quickly apparent that the lithologies were not as the backroom expected and had communicated to the crew. When the outcrop wasn't as expected, the crew members instinctively switched to field characterization mode, taking significant time to characterize and map the outcrop. One crew member admitted that he "kind of lost track" of the sampling strategy as he focused on the basic outcrop characterization. This is the logical first step in a field geology campaign, that a significant amount of time must be spent by the crew and backroom to understand the outcrop and its significance.

Basic field characterization of an outcrop is a focused activity that takes significant time and training [2, 3]. Sampling of representational lithologies can be added to this activity for little cost [4]. However, we have shown that identification of unusual or specific samples for laboratory study also takes significant time and knowledge. We suggest that sampling of this type be considered a separate activity from field characterization, and that crewmembers be trained in sampling needs for different kinds of studies (representative lithologies vs specialized samples) to acquire a mindset for sampling similar to field mapping. Sampling activities should be given a significant amount of specifically allocated time in scheduling EVA activities; and in the better case, that sampling be done as a second activity to a previously-studied outcrop where both crew and backroom are

comfortable with its context and characteristics.

Our hypothesis posited that crewmember knowledge of how the samples would be used upon return would aid them in choosing relevant samples. Our testing bore this hypothesis out to some extent. We therefore recommend that crewmember training should include exposure to the laboratory techniques and analyses that will be used on the samples to foster this knowledge. There is also the potential for increasing crewmember contextual knowledge real-time in the field through the introduction of in situ geochemical technologies such as field portable XRF. The presence of field portable geochemical technology could enable the astronauts to interrogate the samples for K abundance real-time, ensuring they could collect valuable and dateable samples [5].

Though simulations such as these can teach us a fair bit about decisionmaking processes and timeline building, one EVA participant noted that when he wasn't collecting "real" samples, he wasn't at his best. This effect suggests that higher-fidelity studies involving truly remote participants conducting actual scientific studies merit further attention to capture lessons for application to future crew situations.

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