PRE-MISSION INPUT REQUIREMENTS TO ENABLE SUCCESSFUL SAMPLE COLLECTION BY A REMOTE FIELD/EVA TEAM. D. S. S. Lim[1,2], B. A. Cohen[3], K. E. Young[4], A. Brunner[5], R. E. Elphic[3], A. Horne[3], M. C. Kerrigan[6], G. R. Osinski[6], J. R. Skok[7], S. W. Squyres[8], D. Saint-Jacques[9], and J. L. Heldmann[2], [1]NASA Ames Research Center; [2]BAER Institute; [3]NASA Marshall Space Flight Center, Huntsville AL 35812; [4]CRESST/University of Maryland and NASA Goddard Space Flight Center; [5]Arizona State University; [6]University of Western Ontario; [7]SETI Institute; [8]Cornell University; [9]Canadian Space Agency.

Introduction: The FINESSE (Field Investigations to Enable Solar System Science and Exploration) team, part of the Solar System Exploration Virtual Institute (SSERVI), is a field-based research program aimed at generating strategic knowledge in preparation for human and robotic exploration of the Moon, near-Earth asteroids, Phobos and Deimos, and beyond [1]. In contrast to other technology-driven NASA analog studies, this 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. We used the FINESSE field excursion to the West Clearwater Lake Impact structure (WCIS) [2] as an opportunity to test factors related to sampling decisions. We examined the in situ sample characterization and real-time decision-making process of the astronauts, with a guiding hypothesis that pre-mission training that included detailed background information on the analytical fate of a sample would better enable future astronauts to select samples that would best meet science requirements [3].

We conducted three tests of this hypothesis over several days in the field. Our investigation was designed to document processes, tools and procedures for crew sampling of planetary targets. This was not meant to be a blind, controlled test of crew efficacy, but rather an effort to explicitly recognize the relevant variables that enter into sampling protocol and to be able 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 [2]. 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 locations within the crater. 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, but were not experts on impact cratering or geochronology.

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 (Fig. 1). 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, the crewmember was given 30 minutes to survey a small

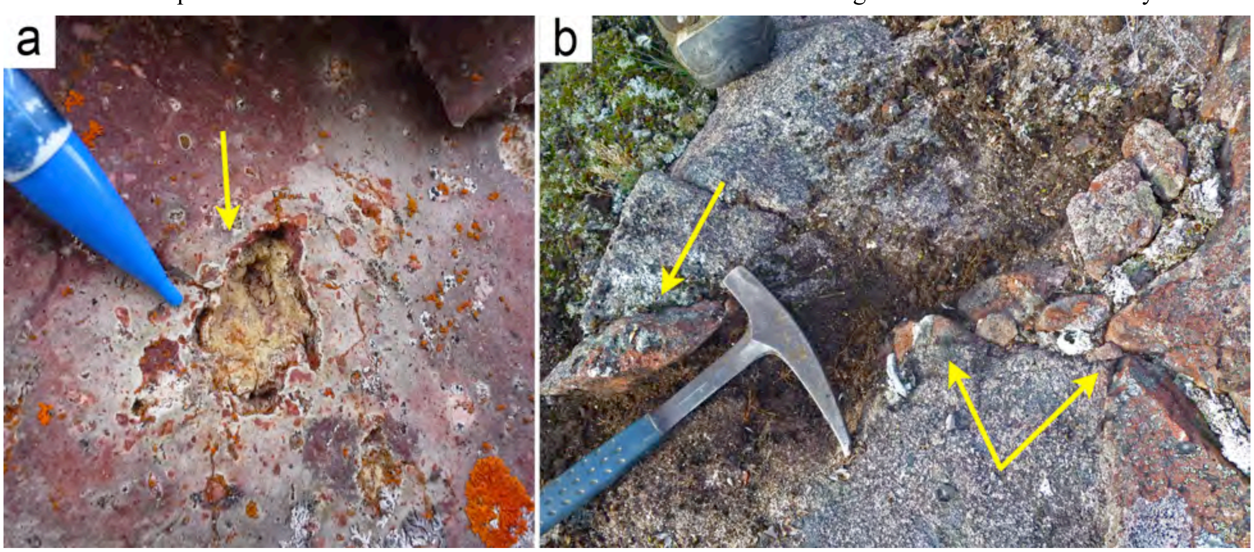

Figure 1: Test A and Test B sites characterized by the Test Director and backroom scientist prior to crew member arrival: a) yellow arrow points to hydrothermally-deposited minerals filling vugs in the outcrop (pen for scale); b) yellow arrows point to a contact between diabase (gray) and impact melt-bearing lithic breccia (red).

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 on an outcrop that none of the science team or crew had seen previously. A set of science objectives were set by a science backroom team in advance using a Gigapan image of the outcrop (Fig. 2). The science team formulated hypotheses for the outcrop units and created sampling objectives for impact-melt lithologies and turned these into a science plan, which they communicated to two crew members 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 outcrop and crewmembers were out of sight of the science team; the crew 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. The 90-minute time limit for the EVA imposed moderate time pressure on both the crew and the science team.

Discussion: The focused tests (A and B) were successful in meeting the scientific objectives. The crewmembers each 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. They were comfortable spending minimal time describing and mapping the outcrop, instead using the available time to get samples that met the objectives.

The larger test (Text C) 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. The crew members instinctively switched to field characterization mode, taking significant time to describe and map the outcrop. One crew member admitted that he "kind of lost track" of the originally-proposed sampling strategy as he focused on the basic characterization. This is the logical first step in a field geology campaign; a significant amount of time must be spent by the crew and backroom to understand the outcrop and its significance.

Field characterization of an outcrop takes significant time and training [4,5]. Sampling of representational lithologies can be added to this activity for little cost [6]. 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 EVA timelines; ideally, sampling should be done as a follow-up to a previously-studied outcrop (either by humans or robotically) where both crew and backroom have become comfortable with its context and characteristics.

References: [1] Heldmann, J. L., et al. (2016) *LPSC* **47**, this issue. [2] Osinski, G.R., et al. (2015) *LPSC* **46**, #1621. [3] Cohen, B. A., et al. (2015) *Journal of Human Performance in Extreme Environments* **12**, http://dx.doi.org/10.7771/2327-2937.1071 [4] Lofgren, G.E., Horz, F., Eppler, D. (2011) *GSA Special Papers* **483**, 33-48. [5] Bleacher, J.E., et al. (2014) *LEAG*, #3033. [6] Hurtado Jr, J.M., et al. (2013) *Acta Astronautica* **90**, 344-355.

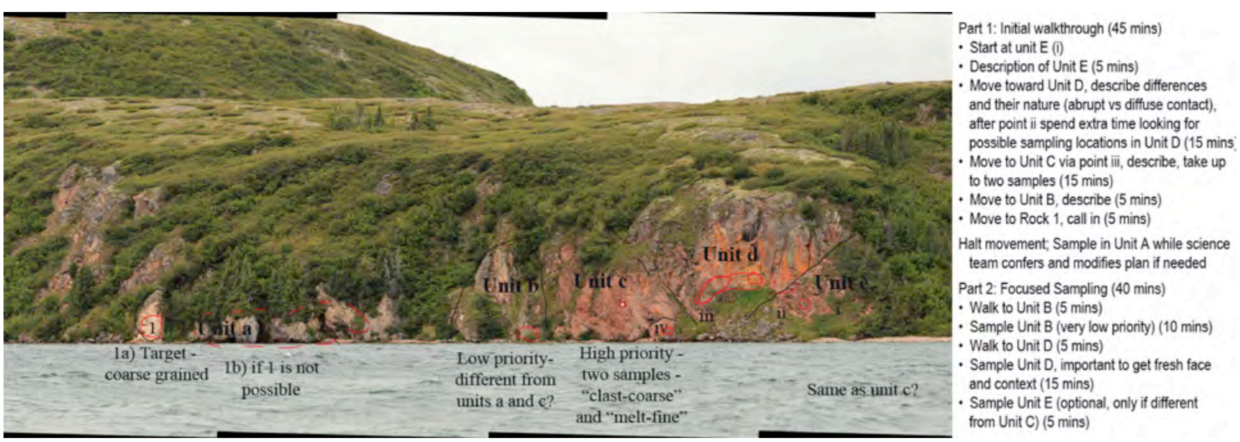

Figure 2: Science Team annotated Gigapan for Site C, used to create science plan (right).