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A GEOLOGY SAMPLING SYSTEM FOR SMALL BODIES. A. D. Hood[1], A. J. Naids[2], T. Graff[3], and P. Abell[4], [1]NASA JSC Houston, TX 77058 (*anthony.d.hood@nasa.gov*), [2]NASA JSC Houston, TX 77058 (*adam.j.naids@nasa.gov*), [3]Jacobs, [4]NASA JSC

Introduction: Human exploration of Small Bodies is being investigated as a precursor to a Mars surface mission. Asteroids, comets, dwarf planets, and the moons of Mars all fall into this Small Bodies category and some are being discussed as potential mission targets. Obtaining geological samples for return to Earth will be a major objective for any mission to a Small Body. Currently the knowledge base for geology sampling in microgravity is in its infancy. Furthermore, humans interacting with non-engineered surfaces in a microgravity environment poses unique challenges. In preparation for such missions, a team at the National Aeronautics and Space Administration (NASA) Johnson Space Center (JSC) has been working to gain experience on how to safely obtain numerous sample types in such an environment. This abstract briefly summarizes the type of samples the science community is interested in, discusses an integrated geology sampling solution, and highlights some of the unique challenges associated with this type of exploration.

Science Requirements: To understand what geology tools would be required to obtain samples from these bodies, it is first important to understand the scientific objectives. In support of Asteroid Redirect Mission (ARM) the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM) put together a list of specific investigations they would be interested in performing. Some of the key findings were: contamination control is vitally important, the collection of at least 1000 g of sample from two different sites to sample the diversity of the body, and a core sample from two sites (5cm in diameter and 4cm deep).

Upon further discussions with personnel from the Astromaterials Research and Exploration Science (ARES/XI) that there are five different types of samples that would fall within the 1000 g sample mass requirement: Float, Chip, Soil, Surface, and Core. Float samples are rocks that are loosely adhered to the surface and can normally be retrieved via a grabbing action. Chip samples are small pieces forcibly removed from a parent body. Soil samples are a loose conglomerate of fine particulate that can usually be retrieved via a "scooping" action. Surface samples are defined as the fine, top layer (~1mm) of a surface. Core samples are cylindrical, masses retrieved from the interior of a surface by "drilling".

Tool Development: Over the last few years tool development has occurred in JSC Research and Technologist Studies (RATS), NASA Extreme Environmental Mission Operations (NEEMO) analog [1] and Modified Advance Crew Escape Suit (MACES) Neutral Buoyancy Lab (NBL) testing [3]. Lessons learned during these tests have culminated in an integrated geology sampling system for microgravity EVA. The system consists of a briefcase housing 4 different types of end effectors; chip, core, surface, and float/soil that interface with one of two different drivers; one powered (Figure 1) and one manual (Figure 2). This unique packaging solution separates the handle from the collection head/area, allowing a common handle to be reused with new, clean end effectors therefore minimizing cross contamination between collection sites.

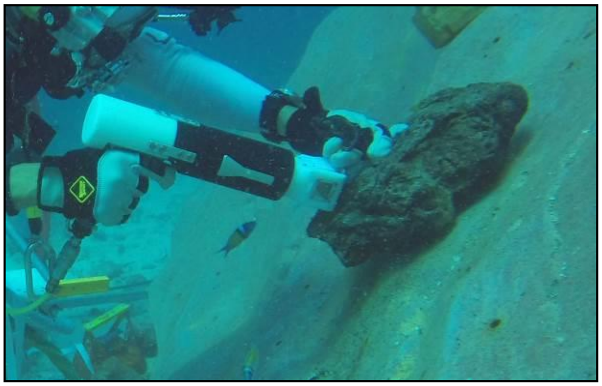

Figure 1: Powered Driver with the Chip End Effector

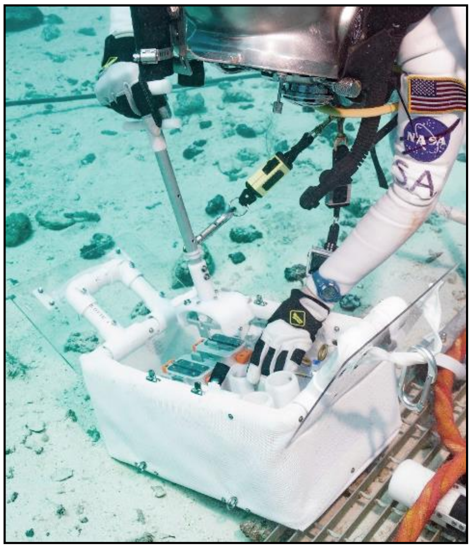

Figure 2: Manual Driver interfacing with Sample Briefcase

Field testing has identified many important features of the end effectors (Figure 3) that need to be included in future prototypes and ultimately the flight sampling tools.

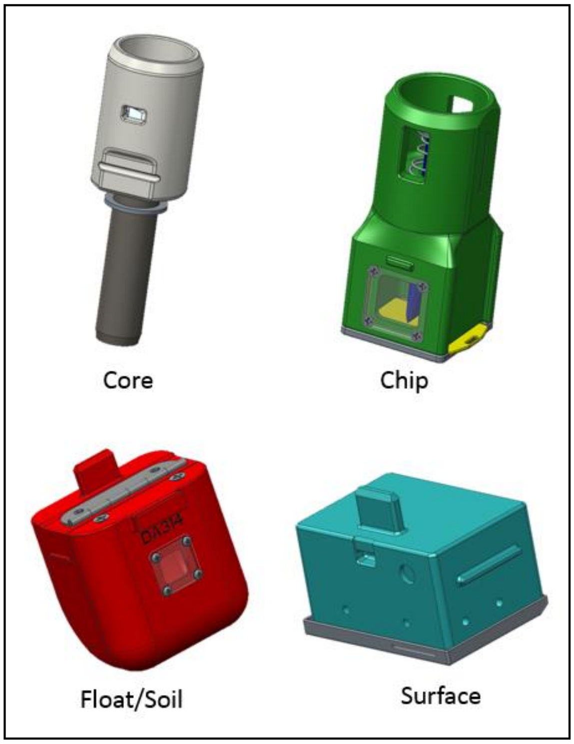

Figure 3: Prototype End Effectors

For a Chip sample a primary concern is the creation of projectiles which is eliminated by a protective shroud that in integrated into the end effector. The end effector also includes a retractable chisel, containment door, and view windows for sample collection verification. The size of the Chip end effector needs to be small enough that a crewmember can easily position the chisel for sample collection, large enough to collect the chips created, and small enough to stow easily. These trade-offs warrant further investigation.

For a Shallow Core many of the challenges were addressed by Honeybee Robotics Spacecraft Mechanisms Corp. through the Asteroid Redirect Mission Broad Agency Announcement (BAA) focusing on their "NanoDrill and Caching System" [4].

For a Float/Soil sample a conventional shovel does not work in a microgravity environment as the scooping action would result in losing the sample and create a debris cloud. To minimize the amount of debris and maximize the collection volume, a clamshell style end effector was designed which included a view window and a color/scale bar.

For a Surface sample a stamp-like device similar to the Apollo missions is used which has a folding door [1, 2].

It is important to note that utilization of these collection devices in the microgravity environment relies on adequate body stabilization. Some existing methods of body stabilization include Portable Foot Restraints (PFR) and Body Restraint Tethers (BRT) which rely on engineered structures.

Challenges of Small Body EVA: There are a number of challenges that still exist to successfully perform the sampling in a microgravity environment. Some specific challenges include the temporary, rapid deployment and retrieval of Sample Markers (similar to the Lunar Gnome [2]) at a worksite site without the aid of gravity, general anchoring of science packages both temporary and permanent to a non-engineered surface, and design impacts to allow for easy cryogenic storage during sample return.

A Deep Core sample presents additional challenges and currently stands apart from the integrated sampling kit. The potential torques and power requirements of a deep core system lean toward a non-hand held solution. A deep core system must also include a segmented core string to allow for stowage during launch and return.

Further prototype iterations are necessary to move closer to a flight design along with continued work in test environments such as NEEMO and the NBL.

References: [1] Todd *et al.* (2015) NEEMO 20 Post-Mission Report and Preliminary Findings. [2] Allton, J. Catalog of Apollo Lunar Surface Geological Sampling Tools and Containers (1989). [3] Bowie *et al.* Asteroid Redirect Crewed Mission Space Suit and EVA System Maturation (2015). [4] NASA, Asteroid Redirect Mission Broad Agency Announcement (2013).