**DEVELOPING INITIAL GEOLOGY SAMPLING TOOLS FOR THE ARTEMIS PROGRAM.** A. J. Naids[1], H. R. Bergman[1], A. D. Hood[1], M. L. Walker[1], T. G. Graff[2], J. L. Mitchell[1], K. E. Young[3], T. George[4], [1]NASA Johnson Space Center, 2101 NASA Pkwy, Houston, TX, 77058 (corresponding author email: adam.j.naids@nasa.gov), [2] Jacobs at NASA JSC, 2101 NASA Pkwy, Houston, TX, 77058, [3]NASA Goddard Space Flight Center, 8800 Greenbelt Rd., Greenbelt, MD, 20771, [4]The Aerospace Corporation at NASA JSC, 2101 NASA Pkwy, Houston, TX, 77058.

**Introduction:** Humans are set to return to the Moon for the first time since 1972 with the National Aeronautics and Space Administration's (NASA) Artemis Program. One of the primary objectives will be the collection and return of lunar samples. To support this objective the Extravehicular Activity (EVA) Tools Team at the Johnson Space Center (JSC) has started developing an initial set of next-generation lunar geology sampling tools. The EVA Tools Team are experts in the hardware certification process for space hardware and have been working on planetary surface tools for nearly a decade. Funded by the EVA Office at JSC, the Artemis tools project began on October 1, 2019 and has the goal of holding a Critical Design Review (CDR) for the initial tools by September 30, 2020. Nine tools are part of this development cycle with more tools and equipment expected in future years. This abstract describes how this project is defining requirements, what tools are being developed, and the schedule for this work.

**Science Requirements:** The team is working an aggressive schedule of performing the first human lunar landing of the Artemis Program in 2024. The EVA community understands that geologic sampling and return will be a major part of this exploration program; therefore, the work has started as early as possible on sample tool development. The team is working with the Astromaterials Research and Exploration Science (ARES) Division at JSC to ensure these tools are designed to meet anticipated lunar science community objectives. ARES is providing geology expertise and is working to ensure the larger lunar science community has a chance to submit input. As of this publication a joint Lunar Exploration Analysis Group (LEAG) and Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM) Action Team are working to develop community-agreed-upon science requirements. A draft science requirements have been created by experts within the lunar science community at NASA allowing the EVA Tools team to press ahead quickly to meet an aggressive schedule, with the expectation of official requirements to follow.

**The Tools:** The focus of this project is to develop a baseline geology sampling tool kit building on the lessons of Apollo. The team has researched Apollo to understand what designs were used on the lunar surface, why they were used, what designs weren't used, what worked well, and what designs changed throughout the mission profiles and why.

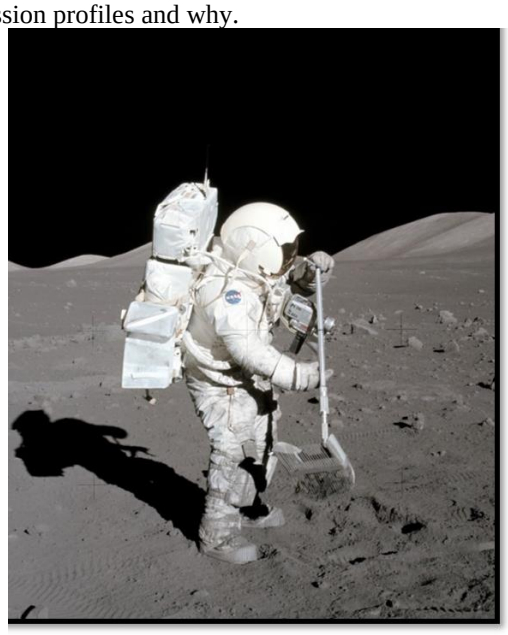

**Figure 1 (above):** Apollo astronaut using the rake on the lunar surface.

Out of this research the team selected nine pieces of high-priority equipment for accomplishing the Artemis geology sampling objectives. These nine tools are not meant to be an all-inclusive list of the tools that would be needed, but rather a starting point in lunar sampling capability. These nine pieces of hardware include: Common Extension Handle, Contingency Sampler, Documented Sample Bags, Drive Tube, Hammer, Rake, Sample Return Container, Scoop, and Tongs. This suite of tools will enable the collection of float, chip, regolith, and regolith-core samples. The Documented Sample Bags will house the sample while the crew is on an EVA and the Sample Return Container will house the bagged samples for the return trip to Earth. Taking what was learned in Apollo, the design team is looking for ways to improve designs with an emphasis on minimizing mass, compensating for the lunar polar environment and simplifying tool operation.

The team is employing a "test-often" strategy. The goal is to manufacture multiple prototypes quickly, integrate them into testing facilities with stakeholders (astronauts, planetary geologists, EVA Operations, human factors, the Exploration Extravehicular Mobility

Unit (xEMU) team, and Safety), and ultimately iterate designs based on feedback.

**Figure 2 (above):** ESA and JAXA astronauts evaluating early tool prototypes during the Neoteric eXploration Technologies Familiarization Mission in August 2019.

Furthermore, a Contamination Control Plan is being developed and will build on lessons learned from other extraterrestrial sample return missions of the previous decades.

**Additional Sampling Equipment:** Separate from these nine tools, the EVA Tools team is also beginning work on powered drilling equipment and vacuum sealed containers. This work is being handled through a collaboration with industry experts. The powered drilling work will support deep core drilling objectives on the lunar surface. The vacuum-sealed containers are being created to support special containment requirements for specific samples (e.g. those containing volatiles or scientific and resource interest.

**Project Schedule:** This project is following a modified version of NASA's system engineering process. A kickoff meeting was held at JSC on October 23, 2019 to share the scope of the project with the stakeholders. The next milestone is a Technical Interchange Meeting (TIM) for the Requirements which is planned for the end of February 2020. Then, the CDR will be held at the end of September 2020. These are all the major milestones currently planned. Toward the end of the fiscal year, the team will be working with the EVA Office on next steps for this project and others.

**Forward Plan:** The team is keeping a list of other tools and equipment that may be needed to support lunar sample collection and return. Some items currently on this list are:

- Tool carrier
- Spring scale for weighing lunar samples
- Camera for documentation
- Gnomon for scale, color bar, and local gravity field
- Dust mitigation tools

There will likely be additional equipment that is needed; those will be identified as the operations concept and science objectives are finalized.

**Conclusion:** The development of geology sampling tools for the Artemis Program is now underway. The EVA Tools Team is engaged with the planetary science community to ensure the proper requirements are being levied on the tools. The team is looking forward to working with all of the stakeholders to meet the major milestones that are currently funded and developing the rest of the tools and equipment needed to support human exploration of the moon.