ACTIVITIES PLANNING FOR ARTEMIS SAMPLE RETURN. B. A. Cohen[1], A. W. Needham[1], and R. A. Zeigler[3], [1]NASA Goddard Space Flight Center, Greenbelt MD (Barbara.a.cohen@nasa.gov), [2]NASA Johnson Space Center, Houston TX.

Introduction: The primary goal of Artemis extravehicular activity (EVA) science is to explore, document, and gain understanding of the field site. This activity enables real-time confirmation or refutation of hypotheses formed on the ground, which in turn guides science activities such as imaging, sampling, and instrument deployment. The Artemis Internal Science Team (AIST) is positioned within NASA to provide cross-mission Science support leadership across the Agency and across Artemis. Here we describe several activities related to sampling activities that the AIST team has been working to implement.

Artemis Samples: The Artemis III Science Definition Team (SDT) developed a candidate sample-return program to enable creation of design reference scenarios [1]. In this exercise, the SDT was constrained by several Artemis III architecture assumptions: the nominal case (100 kg total) would include 80 kg of sample and 20 kg of containment (tare), and the minimum case (35 kg total) would include 26 kg of sample and 9 kg of containment (tare). The assumptions used by the SDT to create the candidate program have evolved and will need to be revisited by the Artemis III full science team (AIST, competed science team, participating scientists, and instrument teams). The team will need to make appropriate trades to fit into the downmass and upmass allocations, aided by a "menu" of tools and containment options. These trades will need to take place alongside refinement of specific science goals and objectives for the Artemis III landing site, which will flow down into sample return requirements that may be different from those in the Artemis III SDT report.

The Artemis III SDT report was focused on the first crewed lunar landing, making clear that the Artemis III architecture assumptions are extremely limiting for achieving mission science goals and, in particular, are inadequate for sample return. Subsequent landed missions during the "sustainable" phase of Artemis should have increased capabilities. We are advocating to use these increased capabilities for improving our sample return program, including increased sample returned mass and volumes, increased tool capability (such as powered drilling), increased area of sample collection (for example, using the Lunar Terrain vehicle), and improved environmental conditioning capabilities. Understanding the origins, ages, and evolution of lunar polar volatiles are key science and in situ resource utilization (ISRU) objectives that benefit substantially from the use of environmentally controlled sample collection, stowage, and curation. Sample return at -80°C (achievable by the same technologies used in common biological specimen freezers) may enable an initial assessment of the range and abundance of volatile compounds in samples. However, many Artemis science objectives will require visiting, extracting samples, transportation, and curation at cryogenic temperatures (-200°C or lower). We are working within a cross-Directorate team to roadmap the needs for cold-conditioned sample collection, return, and curation. This activity has interesting crossover potential with groups interested in similar activities for other bodies such as comets and Ceres.

Sample Collection and Return: Field geology samples are a true generational treasure that the science community can use to address current science goals, as well as future science goals yet to be identified. This has repeatedly been shown to be true based on decades of ongoing work on samples returned from previous astromaterial sample return missions (e.g., Apollo, Stardust, Genesis). However, samples need to be considered as part of a well-rounded field geology plan, guided by hypotheses and science utility in addition to practical considerations such as mass and sample type (e.g., rock vs. bulk regolith vs. core samples). Oversampling and later triaging represent an inefficient use of precious on-planet crew resources, particularly on early missions with limited EVA time and mobility. The Artemis III SDT recognized that an optimal sample return program is built upon geologic-context observations made by well-trained astronauts, aided by modern tools and real-time communication with scientists on Earth. We are working with scientists, crew, and human activities to achieve these sampling goals [2].

The concepts of operations (Conops) for Artemis III will include many different sample types (e.g., bulk regolith, drive tube, rake, hand samples), as well as field notes and documentation activities to properly document the samples. Sample collection is an integral part of the Joint EVA Test program, where sampling activities are explicit components of mission and EVA success criteria [3]. The Conops related to sample collection for Artemis III are currently being defined, implemented, tested, and refined. Similarly, the details of what tools are best suited for use during the mission is currently being investigated and tested [4]. Upcoming work to be included in these tests will include protocols for contamination (see below) appropriate to the science and the mission constraints – for example, what observations crew can make if they pick up some rocks with gloves, how tools can be cleaned in the field if accidentally contaminated, which samples should be collected under different conditions in order to maximize the likelihood of success for a single type of measurement on that sample, etc. Mission success relies on integrating all aspects of crew safety, mission resources, and preserving scientific integrity.

Understanding the geologic context of samples is critical information to make real-time changes to preplanned surface activities due to unexpected circumstances and to interpret science discoveries from the samples [2]. This includes, but is not limited to: (1) physical characteristics of the sampling sites (chipped from a boulder, taken in shade, etc.); (2) crew position relative to the lander, field features, each other, and to sampling or imaging locations; (3) sample characteristics (size, shape, color, friability, sorting, etc.). Extensive photo and video documentation will be taken during the mission to provide much of this information (e.g., station panoramas, before and/or after sampling photos). Nevertheless, verbal field notes during EVAs will provide important details that might not always be obvious from the photography.

Contamination Control and Contamination Knowledge: Contamination concerns arise when any mission activity causes a perturbation (usually an increase) in specific elements or compounds of interest to the analysis of those samples. The Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM) Lunar Science Subcommittee in 2020 generated a table that encompasses the kinds of analyses the community performs on lunar samples, the elements of interest for those analyses, and the general elemental abundances. Such studies are being used to help the Artemis hardware design, tools, and operations communities understand what the lunar science community is most interested in, and why contamination from all sources needs to be considered throughout the mission lifecycle from design to sample return to Earth.

Procedures for contamination control (CC) and contamination knowledge (CK) for multiple sample return missions (e.g., Stardust, Genesis, OSIRIS-REx, Mars 2020) have continued to develop and build on lessons learned early in the Apollo program, though no sample return mission between Apollo 17 and Artemis III included humans. Astronaut presence and activities, the potential for return of volatile-bearing samples, the evolution of materials used in mission hardware, the expansion of commercial activities within/aligned with Artemis, as well as continual improvements in analytical techniques in terrestrial laboratories (e.g., improved spatial, chemical, and isotopic resolutions), all contribute to guiding CC and CK activities for Artemis.

The potential presence of volatiles and organics in PSRs is perhaps the greatest distinction between Apollo and Artemis CC/CK requirements. Firstly, the propellants and crew habitable environments (cabin, spacesuits) bring a plethora of hydrogen-, hydrous-, and organic-laden compounds, that could be scientifically detrimental to PSRs in ways that they were not for nominally anhydrous/inorganic lunar regions sampled by Apollo. Secondly, while anthropogenic contaminants are primarily considered in CC/CK activities, intra-sample contamination becomes a much more significant concern for volatile-rich samples than for wholly solid and/or inorganic samples. Temperature and pressure changes can affect mobility of lunar volatile and organic compounds, either as liquids or gases, meaning that the context of true lunar reservoirs (mineral associations or residence in structural features such as surfaces/interiors/fractures) may be compromised or lost altogether if the samples are not preserved at the temperatures that they were collected. Significant work (and innovation) will be needed to minimize contamination for volatile-rich/cold sample return.

Curation: The Artemis Curation Lead will serve as the primary interface between NASA's Astromaterials Acquisition and Curation Office and the Artemis Science Team during mission planning and implementation. This will include working to prepare the curation facilities to house the Artemis samples that meet the cleanliness requirements for the samples as defined by the Artemis Science Team, within the time, level-of-effort, and budgetary constraints imposed by the mission itself. The Artemis Curation Lead, in concert with the Artemis Sample Curator and members of the Artemis Science Team, will work on modernizing, refining, and developing the preliminary examination (PE) plans for the various sample types returned by the Artemis missions, similar to the work done to modernize the PE plan for drive tubes as part of the recent Apollo Next Generation Sample Analysis Program [4]. The Artemis Curation Lead will be responsible for writing the Artemis Curation Plan. Once the samples have been returned, the Artemis Curation Lead will work as part of the team led by the Artemis Sample Curator to perform the PE on the samples and prepare the catalogs for the samples; these catalogs will then be used by the community to request the Artemis Samples.

References: [1] Artemis III Science Definition Team report (https://www.nasa.gov/sites/default/files/atoms/files/artemis-iii-science-definition-report-12042020c.pdf) [2] Evans, C. A. et al. (2023) LPSC 53, this volume. [3] Young, K. et al. (2023) LPSC 53, this volume. [4] Graff T. G. et al. (2023) LPSC 53, this volume. [5] Gross, J. A. et al. (2022) A17-ANGSA Workshop, Abstract #2012.