RECENT DEVELOPMENTS IN THE CURATION OF COLD, VOLATILE-RICH EXTRATERRESTRIAL SAMPLES.

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Introduction: In recent years, the study of samples from cold, potentially volatile-rich Solar System bodies has increased dramatically. Returned samples from low- or cryogenic-temperature regions are highly sensitive to ambient temperatures, pressures, and materials. In order to maximize the scientific utility of such samples, they must be returned, handled, and stored under conditions that minimize sample alteration and contamination. The Johnson Space Center (JSC) Astromaterials Acquisition and Curation Office (hereafter called the Curation Office) is currently developing the ability to curate cold, volatile-rich samples [1]; this abstract summarizes these efforts for Apollo lunar samples, organic-rich meteorites, comet samples, and lunar polar samples.

New Initiatives: *Apollo Lunar Samples and Organic-Rich Meteorites.* The Apollo Next-Generation Sample Analysis (ANGSA) program has provided a mechanism for studying specially curated lunar samples, including several that have been in cold (-20°C) storage since their initial processing. Recent selections for the ANGSA program include samples of shadowed soils and vacuum-sealed samples collected during Apollo 17. In addition, recent meteorite falls into frozen terrain provide opportunities for studying organic-rich chondrites and other meteoritic materials. Both sample types require a cold (≤ 20°C), clean (ISO 6 or better) environment in which to perform curatorial preliminary examination (PE) activities. The Curation Office has recently undertaken the retrofit of a walk-in freezer and glovebox specifically for processing ANGSA and meteorite samples. When complete, this facility will allow for N_2, Ar, or He processing using specially selected materials that are both particulate clean and cold-tolerant.

Comet Samples. The 2013-2022 Planetary Decadal Survey [2] lists comet nucleus sample return as one of the top-priority missions for the coming decade. Recent studies of comet nuclei (e.g., by the Rosetta mission) have discovered a suite of volatile and organic compounds, all of which would require special curation conditions for preservation and study [e.g., 3]. To enable the study of cometary volatiles, the Curation Office is enhancing its organic-clean and sterile sample storage processes. In addition, the capabilities for gas sampling and non-destructive PE are being added to the existing (and extensive) solid sample PE repertoire. In particular, techniques such as cavity ring-down and near-infrared reflectance spectroscopy will be included to allow the identification of temperature-sensitive or reactive gases and the subsequent tailoring of storage conditions for compounds of interest.

Lunar Polar Samples. JSC recently awarded an Internal Research and Development (IRAD) award for the development of lunar polar sample simulants for both curation and ISRU studies. While initially for conceptual lunar operations, the recent announcement of the U.S. plan to send humans to the lunar south pole in 2024 focuses this work for specific mission goals. First, a high-fidelity volatile-rich simulant is being developed that includes compounds detected by the LCROSS mission [4] and other compounds not detected by LCROSS that may be stable within lunar permanently shadowed regions (PSRs) [5]; highlands [6] or mare-type [7] particles are the solid component. Storage testing under a range of temperatures/pressures will constrain alteration under non-cryogenic conditions, in addition to assessing the storage efficacy of a lunar-like (10^{-8}-10^{-9} torr, liquid-He-cooled/cryogenic) environment.

In addition to curatorial requirements, we will also outline the first sample collection and spacecraft requirements (temperatures, pressures, and materials) for sample return from the lunar poles. Several new capabilities have been or are being developed in FY19 to that end. First, a thermal vacuum chamber has been constructed and is being outfitted for liquid-He operations. This chamber will also include: 1) a cooled stage specifically designed for lunar materials, 2) a sealed sample handling system to mitigate atmospheric contamination, and 3) an in-line, gas-phase mass spectrometer for real-time compositional monitoring. In addition, a corrosion-resistant, negative-pressure glovebox will be used for safe and clean volatile-rich simulant preparation. This glovebox will also be used for materials storage testing to better constrain the design of tools and sample storage containers that will keep the sample sealed and will not chemically react with the various highly reactive compounds in the sample.

Conclusions: In recent years, the demand for a cold curation capability has increased dramatically. In particular, existing lunar samples and meteorites, along with the possibility of comet nucleus and lunar polar sample return, provide a rich catalog of materials for which targeted studies will be conducted. The Curation Office is actively preparing for these samples, facilitating both robotic and human sample return missions that will provide a wealth of scientific insights for decades to come.

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