ADAPTING APOLLO-ERA INSTRUMENTATION FOR COLD SAMPLE PROCESSING WHILE MAINTAINING CURATORIAL STANDARD PRACTICES.

Cecilia L. Amick[1], Ernest K. Lewis[2], Julie L. Mitchell[3], Sergio A. Leal[1], Darren R. Locke[4], Richard E. Davis[1], Roland Montes[1], Darvon L. Collins[1], Anthony B. Farrell[1], Rigoberto Resendez[1], James E. Brown[3], Ryan A. Zeigler[3], Francis M. McCubbin[3]
[1]Jacobs, NASA Johnson Space Center, Houston, TX 77058
[2]Texas State University – Jacobs JETS Contract, NASA Johnson Space Center, Houston, TX 77058
[3]NASA Johnson Space Center, Houston, TX 77058, Julie.L.Mitchell@nasa.gov
[4]HX5 – Jacobs JETS Contract, Johnson Space Center, Houston, TX 77058

Introduction: The goal of the Apollo Next Generation Sample Analysis (ANGSA) Program is to study "specially curated samples," that is, unstudied Apollo samples that have been preserved under unique conditions. A subset of the funded ANGSA work includes the study of Apollo samples stored under cold conditions since their return from the Moon. Ongoing ANGSA processing and future returned samples require cold curation strategies to preserve the integrity of organic and other temperature-sensitive constituents within those samples. Standard Apollo curation processing hardware and procedures are designed for room temperature operations, not cold conditions. This abstract details the major modifications of a heritage lunar cabinet in preparation for the first cold curation processing at Johnson Space Center. Future publications will provide greater detail on the low temperature materials and operation procedures. This work not only supports Apollo but also future cold sample return missions.

Background: Processing cold Apollo samples requires a reassessment of the materials used in sample cabinetry (glovebox), instrumentation, and procedures. Initial efforts have focused on adapting an Apollo-era glovebox into a cold-compatible ANGSA sample processing facility while complying with curation cleanliness and materials restrictions. For ANGSA, a modified, heritage Apollo wiresaw glovebox will be installed in a walk-in freezer to allow for sample processing at -20°C. Strict material constraints will preserve the chemical and physical integrity of samples by limiting contamination (e.g. from potential outgassing of gasket material). In addition, safe operating conditions for the humans performing cold sample processing will be accomplished through procedures, hardware selection, and environmental monitoring.

Material Challenges and Sample Handling Limitations: Materials were limited to 304 and 316 stainless steel, 6061 aluminum, cold-rated Teflon, and Lexan. Other materials such as copper, mixed metal alloys, and materials incompatible with extreme cold temperatures (i.e. Viton gaskets) were eliminated to meet strict Apollo-allowed material guidelines.

For room-temperature Apollo sample processing, Viton is used to seal gloveboxes from the outside environment. However, the type of Viton gasket used in existing Apollo gloveboxes is not cold-tolerant. The replacement of the gasket material to a cold compatible, acceptable material presented a significant challenge. Specifically, non-adhesive, flexible, expanded Teflon strips were chosen to replace the heritage Viton gaskets. The choice to use highly compressible Teflon strips presented a challenge in establishing a gas-tight seal with the original cabinet design. Minor part adjustments, such as milling the glove ports, were necessary to generate the required compression of the Teflon gaskets. The milling and other parts adaptations were completed without commonly used machining oils to reduce contamination.

Figure 1. Before and after pictures of the modifications made to the Apollo-era lunar cabinet.

A gas-tight seal with cold-rated gaskets is necessary for two reasons: preserving the integrity of the frozen sample kept under an inert gas atmosphere, and the safety of the human processor working within a confined space (the walk-in freezer). The gaskets allow the positive-pressure environment inside the glovebox to be maintained, preserving the sample by isolating it from the laboratory atmosphere. Any significant leaks from the positive-pressure glovebox could dilute the oxygen to potentially dangerous levels; therefore, leaks needed to be minimized. The aforementioned modifications made to the glovebox greatly reduced nitrogen leaks, lengthening the time a processor can safely work with the samples under cold conditions.

The gas leaks from the cabinet with new Teflon gaskets were quantified using a pressure decay test at various points during the development process. The pressure decay over time relates directly to the cumulative nitrogen leak rate from the cabinet. The leak rate directly relates to the maximum time that an operator can stay in the walk-in freezer without compromising their safety.

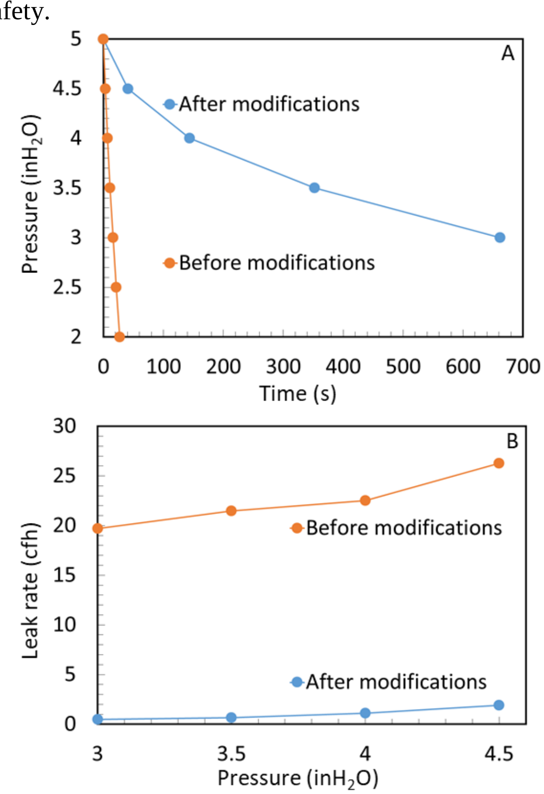

Figure 2. Pressure decay and leak rate of nitrogen before and after modifications made to the Apollo-era lunar cabinet.

In addition to materials selection, a modular clean room will be attached to the walk-in freezer to reduce external contamination. This clean room will be used for donning/doffing of personal protective equipment and for staging samples prior to freezer ingress. Additional, detailed cleaning procedures have been developed for the walk-in freezer, clean room, and Apollo cabinet to limit contamination from organics, particulates, and the natural environment of Houston, TX.

Additional processing procedures will require three people at a minimum. Two processors will work with the samples in the freezer while the third person monitors the operation from the modular clean room. The operator in the clean room is also responsible for monitoring oxygen levels, freezer temperature, and the time the two processors spend in the - 20°C environment. A three-person operation provides significant operational flexibility while limiting the time spent working in cold conditions.

Results and Discussion: The transition from a room-temperature Apollo-era glovebox into a modern, cold, sample processing facility has presented both challenges and opportunities. Redesigning the heritage equipment into an operational cold curation facility while maintaining the established cleanliness and materials requirements has been accomplished. Extensive knowledge gained from this project on the design aspects and capabilities will be used for future cold sample curation efforts.

References: [1] Herd, C. D. K., et al. (2016). *Meteoritics and Planetary Science*, *51*(3), 499–519. [2] *ROSES 2018 Amendment C.24 Apollo Next Generation Sample Analysis Program*. (2018). Houston: NASA Johnson Space Center.