ADVANCED CURATION PREPARATION FOR MARS SAMPLE RETURN AND COLD CURATION. M. D. Fries[1], A. D. Harrington[1], F. M. McCubbin[1], J. Mitchell[1], A. B. Regberg[1], C. Snead[1], [1]NASA Curation, Johnson Space Center, Houston TX 77058. Email: marc.d.fries@nasa.gov

Introduction: NASA Curation is tasked with the care and distribution of NASA's sample collections, such as the Apollo lunar samples and cometary material collected by the Stardust spacecraft. Curation is also mandated to perform Advanced Curation research and development, which includes improving the curation of existing collections as well as preparing for future sample return missions. Advanced Curation has identified a suite of technologies and techniques that will require attention ahead of Mars sample return (MSR) and missions with cold curation (CCur) requirements, perhaps including comet sample return missions.

MSR Technology & Protocol Development: MSR planning currently includes a multi-mission approach, starting with sample caching by the Mars 2020 rover operated by the Jet Propulsion Laboratory (JPL). The rover will collect samples, place them in tubes, and store the tubes in cache depots on the martian surface for up to 10 years before they would be retrieved by a future mission and transported back to Earth. Consequently, planning for an MSR receiving/curation facility needs to reach a level of maturity that will be able to accommodate samples as soon as the late 2020's. Furthermore, sample-handling and storage technologies that will be unique to MSR must be identified prior to the final design phases of an MSR receiving/curation facility.

As an update to the Planetary Protection Draft Test Protocol [1], the 2012 Workshop on Life Detection in Extraterrestrial Samples produced a report [2] that outlined an analysis sequence for MSR samples. The sequence proceeded from contextual data collection on Mars, through analysis of material on the outside of sample containers, retrieval of head space gases, to analysis of solid samples prior to and following removal from their returned sample containers. This sequence is very useful for identifying technologies and protocols needed for MSR curation. Some techniques, such as removal from containers and solid rock processing, already exist in a proven state from previous NASA missions such as Apollo and Stardust. Others can be adapted from other experience, such as collection of headspace gases, but need to be proven on MSR hardware and samples. A third category of techniques does not yet exist in NASA experience and needs to be developed. The latter two categories are the focus of this abstract.

Curation of martian samples includes some features that are unique to this application. Detection of biosignatures is particularly difficult, given that three NASA missions (Vikings 1&2, MSL) capable of ppb-level detection of potentially biogenic organics have all had great difficulty in detecting organic compounds on Mars. For MSR samples, definitive biosignature detection will include detection of organic compounds at ppb level or possibly lower [3]. Achieving definitive results with statistically robust signal/noise is strongly dependent upon the level of contamination (or noise) present in the samples. For this reason, an important Advanced Curation focus centers on ppb-level organic cleanliness in all aspects of MSR sample curation. Topics include but are not limited to:

- Techniques for cleaning, verifying, monitoring, and maintaining sample processing equipment at sub-ng/cm^2 total organic carbon (TOC) for "Tier 1" and ng/cm^2 for "Tier 2" compounds outlined in [3]
- Quantify alteration of perchlorate-bearing Mars analogous materials to understand degradation behavior under extended storage
- Collect, store, and process gas samples collected at Mars ambient pressure
- Quantify organics latency in glove boxes at the ppb level to prevent cross-contamination
- Handling of small particles on the outside of sample containers (prior to opening containers) and the insides (after sample removal). This task will draw from Curation experience in the Stardust mission to comet 81P/Wild-2.
- Biological containment under BSL-4 conditions in an organically clean (see above) environment

Cold Curation Technology & Protocol Development: Cold Curation is an important pathway forward for curation research and development. Several near-term, potential NASA missions include a CCur element, such as the recently-announced New Frontiers AO which lists comet surface sample return as one of the allowable mission proposals. Other sample return missions from volatile-bearing locales may also emerge as future NASA-led sample-return missions to sites such as the lunar south pole/Aitkin Basin, icy worlds such as Europa, Enceladus, and to Ceres. Sample handling for such missions features similarities and differences from MSR that are useful for curation planning. Volatiles and organics are likely to be far more abundant than those on the oxidized martian surface, but fundamental science drivers such as the need to preserve organic compounds and collect head space gases remain similar.

A sample handling analysis sequence for CCur, similar to that for MSR in [2], is helpful in identifying areas where Advanced Curation attention is needed. For CCur, all techniques must be adapted, with the assumption that samples are processed at -20° C and stored at liquid nitrogen temperatures. Sample storage and processing hardware must be designed to minimize or eliminate thermal gradients, which promote migration of volatile species.

CCur collections are unique in that there is a likelihood that sample degradation rates will be relatively high for species of high scientific interest, regardless of the level of care provided. Ices, light organic species, and other materials with high vapor pressures will migrate from, and through, the samples. One means for controlling this is to maintain a controlled level of humidity, and if this method is chosen then a study is required to assess the chemical and isotopic changes imparted in the samples over time. Previous work has shown that CCur features unique curation challenges [4].

CCur Advanced Curation research is needed in the following areas, among others:

- Production and testing of a generic comet simulant material, tailored to replicate the chemical and physical composition of cometary material for use in analogue studies
- Long-term sublimation/evaporation/alteration change (SEA change) studies to characterize the chemical, physical, and isotopic degradation rates of a comet sample simulant
- Develop and optimize sample processing protocols for handling, cataloguing, and shipping samples at -20° C and colder
- Experiments to document useful lifetime of cold samples, and of scientifically important components. Prioritization of scientific analyses will be derived from these results.

Development of "Canary Sample Suites": Experience with existing NASA collections has shown that it may be useful to dedicate a suite of blanks, standards, and even a sub-suite of samples for monitoring changes in the collection over long periods of time. When samples are used over a span of decades or generations, the issue arises as to whether even minor alteration factors may accumulate sufficiently to affect scientific analyses. This applies mostly to aspects of a sample suite which mobilize or chemically react over time, and so would be especially pertinent for MSR and CCur collections. Even with carefully curated samples with low degradation rates, cumulate degeneration can become scientifically important for ppb-level organics analyses in MSR samples, for example. A set of standards and sample(s) could be designated as the "Canary Samples" and analyzed in the same manner over a period of days, months, and then years to track alteration in the samples for future generations of scientists. These data can be used to build quantitative measures of alteration similar to time-temperature-transition (TTT) diagrams used for relatively slow chemical and physical changes. These canary samples would be used to determine the viability of various components within individual sample collections. These viability analogs could be used to determine the "shelf-life" of each collection with respect to answering specific scientific questions. Consequently, these shelf-life estimates could be used to prioritize science questions for each collection.

Summary: Advanced curation efforts within the NASA curation office at JSC continue to enhance and broaden the capabilities of NASA's current astromaterials collections. In addition, we will continue to prepare for future sample return missions by incorporating new technologies that will expand our present sample handling and storage capabilities as new destinations for sample return are prioritized.

References: [1] Rummel, J.D., *et al* (2002). NASA Pub. CP-2002-211842. [2] Kminek, G., Conley, C., *et al*, (2014) *Life Sci. in Space Res.*, *2*, pp.1-5. [3] Summons, R.E., *et al* (2014). *Astrobiology*, *14*(12), pp.969-1027. [4] Herd, C.D., Hilts, R.W., Skelhorne, A.W. and Simkus, D.N., (2016). *MAPS* 51(3).