SAMPLE TUBE SEALING AND SAMPLE INTEGRITY ANALYSIS FOR FUTURE SAMPLE RETURN MISSIONS. Paulo Younse1, Katherine Accord1, David Aveline1, Xiaqi Bao1, Luther Beegle1, Dan Berisford1, Pradeep Bhandari1, Charles Budney1, Erol Chandler1, Fei Chen1, Nicole Chen1, Moogega Cooper1, Shirley Chung1, Patrick DeGrosse1, Emma Dodd1, Matthew Fuller1, Don Lewis1, Kim Lykens1, Mimi Parker1, Rebecca Smith1, 1Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, paulo.j.youse@jpl.nasa.gov.

Introduction: A Mars sample caching rover mission designed to collect, document, and package samples in a cache for future collection and return to Earth was recommended as the highest priority mission for the decade 2013-2022 by the 2011 Planetary Decadal Survey. The Mars 2020 Mission may potentially fulfill the role of the sample caching rover, as proposed by the Mars 2020 Science Definition Team (SDT) [1]. The SDT recommended a caching system capable of storing 31 samples of rocks and regolith approximately 8 cc in volume, replacing up to 25% of the samples in the cache over the course of the mission (or expanding the cache to contain up to 38 samples with the ability to replace them), and separately encapsulating them with a maximum Helium leak rate of 1 x 10⁻⁷ atm-cc/sec He. Additional attributes related to sample integrity include a baseline of 10 ppb maximum organic contamination, with potential requirements on inorganic contamination, magnetic field exposure, and maximum temperature exposure deferred to the Mars 2020 project for evaluation. This work describes the development, testing, and characterization of sealing methods designed to encapsulate and preserve the science integrity of samples in thin-walled sample tubes compatible with proposed Mars Sample Return architectures.

Seal Designs: Six sealing designs were selected following a survey of the state-of-the-art sealing techniques [2]. Several seals were eliminated based on factors such as seal hermeticity, sample integrity, and dust tolerance resulting in a set of 3 Phase-II seal designs. Three seal prototypes are based on the Shape Memory Alloy (SMA) technology and the fourth seal mechanism is torque-actuated (Figure 1). Each SMA cap and plug uses expanding fins/ring to create a seal with the tube. It was important to have a non-heat based option, which the expanding torque plug fulfilled.

Seal Testing: Seal integrity is being assessed through measuring ultimate mechanical strength, burst pressure, and leak rate after subjected to thermal cycles, vibration, shock, abrasion, and dust. Each test was performed in triplicate using tubes which were dusted with Mojave Martian Simulant (MMS) and an additional test using one clean tube for comparison. Results show that all three seals survive up to 1000 N of force before failure.

Thermal Cycle Testing: A custom built thermal chamber has the ability to perform He leak tests over temperature and pressure ranges of interest on dusty tubes filled with solid core samples. The chamber operates between -135°C and 80°C with a pressure from atmosphere down to 10⁻⁴ Torr.

Material Compatibility: Materials used to construct the sample tube and seal were selected based on their compatibility with potential Martian sample minerals and organic molecules (Figure 2). Accelerated corrosion tests were performed on coupons to determine the lifetime of the material of interest in the target environment. Furthermore, organic compatibility was assessed using the corresponding assay to determine if the target biomolecule was altered over the course of the accelerated corrosion test. Initial results show that ATP, LPS, and Lysene are not altered over time in Mars Regolith Simulant. Furthermore, we show that we are able to minimize organic contamination to a level below 3 ng/cm² in the case of pyrolyzed nitrilol.