CONSIDERATION OF THE MARTIAN CHLORIDE SALT-BEARING DEPOSITS AS A TARGET FOR A LOW-COST SCIENCE MISSION. M. S. Bramble[1] and K. P. Hand[1], [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA (michael.s.bramble@jpl.nasa.gov).

Introduction: Putative chloride salt-bearing deposits are perhaps one of the most compositionally-enigmatic surface features on Mars. Since their initial identification, the exact composition and provenance of these deposits have remained elusive despite over a decade of orbital and laboratory analyses. The geomorphology of these surface deposits, along with their interpreted halite-bearing composition, suggests a past of surface water activity. A landed scientific mission to explore the composition and geological history of the putative chloride salt-bearing deposits would be well-suited in scope for a low-cost mission. This mission would yield insights into the past history of surface water activity on Mars, confirm the composition of an enigmatic landform, as well as visit a landform of possible significant interest for astrobiology.

Background: Landforms with a suggestive chloride salt-bearing composition have been identified via a set of unique spectral characteristics that pair with an intriguing set of geomorphic properties. Initially, thermal infrared images from the Thermal Emission Imaging System (THEMIS) exhibited landforms with distinct spectral properties, and orbital imagery revealed light-toned, polygonally fractured materials that blanket underlying topography [1]. The chloride composition is derived by an absence of spectral absorption features for other mineral phases and distinct spectral slopes at thermal [2] and near-infrared wavelengths [3,4] that can be attributed to halides [2,5]. Mid-infrared analyses constrain the halite abundance at ~10–25% via laboratory and model studies of two component mixtures with the remainder consisting of regional martian regolith [6]. Near-infrared spectra can be explained by mixtures of anhydrous chloride salts and silicates [3,5], while other evaporites and weathering products can only be present at the level of 1–5 wt% abundance [7]. Of all the chlorides, halite is the best match to explain all the spectral and geological characteristics [6]. Despite the rigor of the cited work, the chlorides remain somewhat controversial as they remain distinguished via an absence of spectral features as opposed to the presence of diagnostic spectral absorptions.

The orbital imagery of chloride salt-bearing deposits exhibits a range of morphologies. These include occurrences in paleolake basins and in the vicinity of valley network terrains [2], as well as correlation with inverted channels and terminations at fan deposits [8]. The deposits commonly appear in local topographic lows [2,9] and their morphological characteristics suggest that they drape the local topography. They are often observed in association with underlying, darker, phyllosilicate-bearing units, in possibly stratified lacustrine deposits. Polygonal fracturing is observed at the deposits and has been interpreted as desiccation fractures or salt-related polygons [1,4]. The spectroscopic signatures suggest the deposits are well indurated but friable [6]. The majority of observations remain consistent with one of the original formation hypotheses: that these features formed via the ponding and evaporation of surface runoff or discharged groundwater [2]. Other formation hypotheses include volcanic sources, playa environments, lacustrine environments [10], hydrothermal brines, or an icy top-down melting process paired with concentration via seasonal sublimation and dehydration [11].

Science objectives: Science objectives geared towards a low-cost mission to the chloride salt-bearing deposits could include: (1) Determine the composition of one the most compositionally-enigmatic landforms. (2) Determine the geological history of these deposits and how it relates to proposed formation mechanisms. (3) Interpret the early climate history and habitability conditions during the formation of these deposits from their geological history. (4) Investigate for possible biosignatures for indicators of life.

Measurement requirements: A low-cost mission would likely be well-suited in scope to address these science objectives. Below are example measurement requirements that could address the above objectives.

A key requirement would be to distinguish the geochemistry and mineralogy of the surface materials. We know from orbital analyses that the standard VNIR and mid-infrared spectrometers commonly deployed on planetary spacecraft at Mars would not be sufficient for deciphering these surface features. Therefore, other methods would be required; these could include X-ray fluorescence or alpha particle X-ray spectroscopy. Furthermore, these could provide bulk chemistry of the sample from which the mineralogy could be derived.

To support the geochemical analyses, the lander would need to distinguish grain sizes, grain textures, and petrographic-scale mineralogy. This would be best achieved with a form of microscopic imager. Mid-infrared laboratory data when paired with THEMIS data suggests that 63 to 180 μm particle sizes are consistent with regions of coarse particulate surfaces in orbital data, and particle sizes of <10 μm in cases with regions of fine-particulate surfaces [6]. Near-infrared laboratory data tell a similar story with labradorite-halite mixtures >10 µm in particle size matching observed spectral characteristics, and halite-basalt mixtures matched observed characteristics for grain sizes of 63–90 and 125–180 µm with ≤25% halite abundance [5]. Therefore, we may expect salt particles in the 50–200 µm range with the possible addition of smaller coatings from friable particles.

Lastly, context measurements observing the vicinity of the other measurements would address a suite of questions related to the science objectives. For example, multiple hypotheses exist for the formation mechanism of the polygonal fracturing observed from orbit. When paired with the above geochemical, mineralogical, and microscopic imagery data, the requisite data to distinguish these hypotheses could be met with context imagery provided by cameras that observe the workspace and the vicinity of the lander. The surface around the lander would need to be imaged likely within a radius of a few tens of meters at a scale that provides context of the spot size of the microscopic imager. This data would also be imperative to pair the *in situ* measurements with the orbital data sets.

Landing site selection: The chloride salt-bearing deposits as a mission target provides several possible candidate landing sites even with engineering constraints of other missions. Of the ~640 distinct sites reported in the data base of Osterloo et al. [2], ~125 remain after the Mars 2020 landing site selection engineering constraints are applied (**Figure 1**). This may likely serve as a useful proxy for site exclusion based on factors such as latitude and altitude that would apply to a future low-cost mission. Of all the chloride salt-bearing deposits, two are larger than, and ~7 more would fill about half of the area of the final landing ellipses for Mars Exploration Rovers [12].

These sites can scale from flagship class mission science (as was argued for MSL and Mars2020) to focused, targeted science questions in a low-cost mission. While these sites are likely not equal in all aspects, the distribution of these sites across the surface may help facilitate the possibility of a chloride salt-bearing deposit mission being part of a multi-small-payload mission in a ride-along form [13]. Additionally, having a suite of sites would allow for the selection of one that may perhaps facilitate science of another small spacecraft mission.

Conclusion: A landed mission to the chloride salt-bearing deposits would address several outstanding questions of martian geological history and provide constraints on the past habitability and climate history. If a halite composition is confirmed and the abundances match the orbital analysis, this terrain would be unlike any other explored on the surface to date. Additionally, ancient salt deposits on the Earth have demonstrated the capability of entombing and preserving microbial fossils and other biomarkers, which leads to the intriguing possibility of preserved biosignatures from early Mars in the chloride salt-bearing deposits. The lander would likely be exploring the last stages of a wetter Mars as the planet dried out, and understanding this drying out phase is critical to understanding the evolution of the early martian climate.

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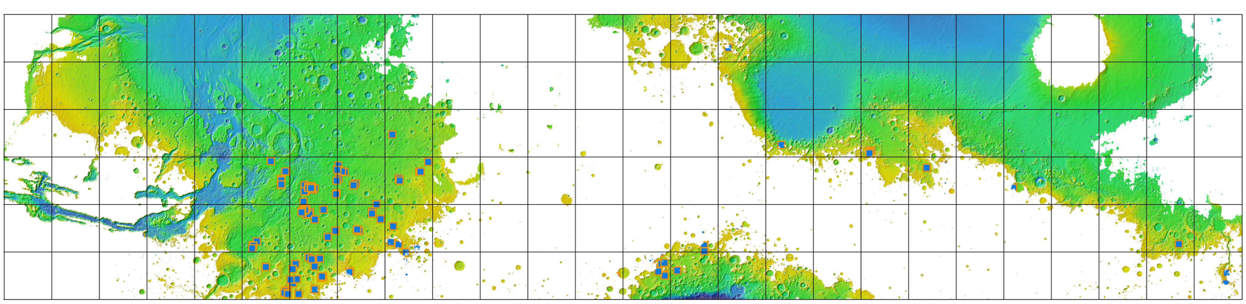

Figure 1: The surface of Mars as viewed through the engineering constraint masks of the Mars 2020 rover (white). The blue squares represent chloride salt-bearing deposits [2] that are not masked out. The basemap is the colorized MOLA elevation map [14].