

**AN UPDATED STUDY OF CHLORIDE DEPOSITS ON MARS: DO THEY EXHIBIT MACROSCOPIC EVIDENCE FOR DELIQUESCENT OR RECRYSTALLIZATION?** M. M. Wilson<sup>1</sup>, R. E. Milliken<sup>1</sup>, and M. M. Osterloo<sup>2</sup>, <sup>1</sup>Brown University, Box 1846, Providence, RI 02912, <sup>2</sup>Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80303.

**Introduction & Motivation:** It has been recognized for over a decade that chloride salt phases are likely present in numerous deposits scattered across the surface of Mars, primarily in the southern highlands [1–3]. First detected in Mars Odyssey THEMIS and MGS TES data [1], spectra of these deposits are characterized by a lack of vibrational features, blue (decreasing towards longer wavelengths) spectral slope, and apparent non-unit emissivity at mid-infrared wavelengths. Many of these deposits have also been observed at visible-near infrared (VNIR) wavelengths by the MRO CRISM spectrometer, which reveals they are spectrally ‘bland,’ exhibit a positive slope at NIR wavelengths, and commonly have weaker H<sub>2</sub>O features at 3 μm compared with surrounding terrains [1,4]. All spectral evidence remains consistent with the presence of (likely anhydrous) chloride salts— but not uniquely diagnostic of them [1,4,5].

Morphologically, the chloride-bearing surfaces are often light-toned, discontinuous, polygonal fractured, and exhibit a scalloped texture [6]. Deposits are typically <25 km<sup>2</sup> in area and occur in Noachian to Hesperian age terrains based on crater counts [4]. However, if these deposits are the result of near-surface precipitation (e.g., evaporative concentration) processes [1], then they may be significantly younger than the crater ages of the terrains in which they reside.

Based on geochemical considerations, it is expected that the evaporation of fluids on Mars would lead to the sequential precipitation of a series of predictable minerals that may include calcite, gypsum, and halite, followed by chlorides and sulfates, depending on the starting chemistry of the fluid. However, there have been no additional evaporite minerals identified within the chloride deposits. On Earth, salts are generally accompanied by a suite of mineral assemblages as they are a late-stage precipitate when fluids evaporate at the planet’s surface [7, 8]. It would be highly unusual for

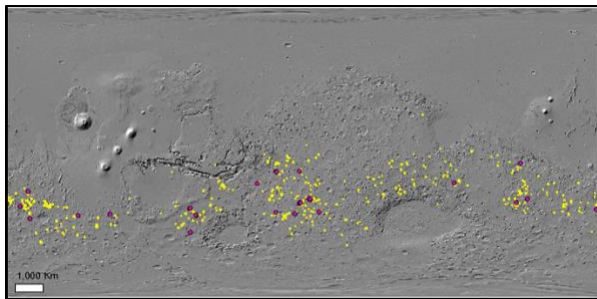


Figure 1 MGS MOLA Global Shaded Relief map showing the distribution of chloride-bearing deposits by Osterloo et al. Pink circles represent the initial detections published in 2008, and yellow polygons include additional locations of materials identified in 2010.

these globally-dispersed salt deposits on Mars to be monomineralic. Though halite and other salts have been proposed as candidates for the Martian deposits, interpretations of mineralogy based solely on current spectral data are non-unique [4]. Also, experimental work on the stability of Cl-rich salts have shown some phases are likely to experience dehydration-rehydration or even deliquescence and recrystallization under Mars-like pressure, temperature, and relative humidity conditions, whereas other phases are more likely to be stable under modern surface conditions.

We suggest that chloride salt deposits on Mars are likely to host multiple salt phases and that some of the expected salt phases may have experienced deliquescence/recrystallization. Indeed, many of the Martian chloride deposits occur in local topographic lows and some exhibit textural evidence for volume changes in the form of desiccation cracks and salt expansion/thrust polygons [3]. The presence of accessory hydrated salt phases may be investigated in detail using reflectance spectroscopy to quantify the H<sub>2</sub>O content of the bulk deposits, whereas deliquescence and recrystallization may lead to variations in the texture and morphology of the deposits.

The objectives of this study are to carry out detailed

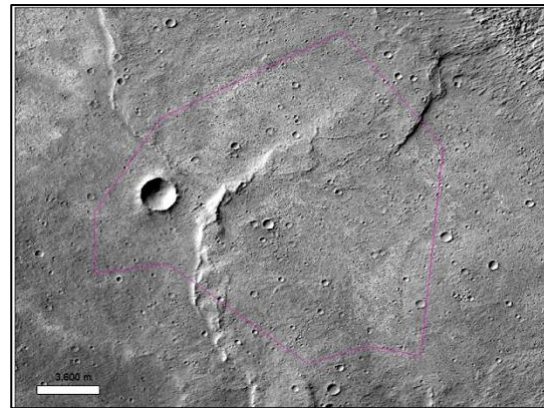


Figure 2 CTX image of our example location (Latitude - 32743°, longitude 187.912°). Chlorides are light-toned compared to their surroundings and appear to extend beyond the area of detection (represented by the purple outline).

mapping at a scale of tens of meters using CTX and HiRISE images (where available) to better characterize the morphology of these deposits and to reassess existing CRISM near-IR reflectance data for select chloride deposits. The former will attempt to quantitatively characterize the meter-scale texture of the deposits using HiRISE digital terrain models. Here, we present initial results for a comparison of two regions with numerous

chloride deposits- one which hosts outcrops of clay-bearing deposits and one in which clays are spectroscopically absent.

**Methods & Results:** Polygons outlining the 642 chloride deposits of [4] were used to define regions to examine CTX (6m/pixel) and HiRISE (30cm/pixel) mosaics of regions in close association with phyllosilicates. The ESRI ArcGIS software was then used to map distinct morphologic terrain types (map units) that included the chloride deposits and surrounding units. Albedo, texture, relative stratigraphic position, relief, and other morphological features as observed in CTX and HiRISE images were used to define distinct map units, thus the current map units are best thought of as ‘morphological’ or ‘textural’ units rather than being associated with different emplacement

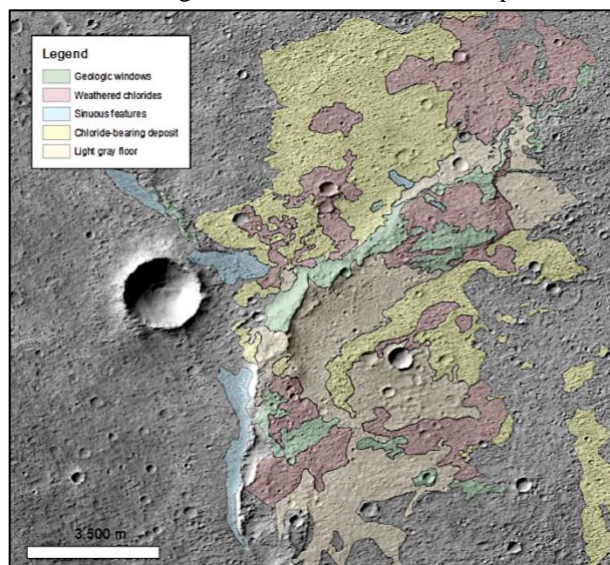


Figure 3 Map of a chloride-bearing deposit overlain onto CTX mosaic tile (E-174\_N-34). Units were selected by identifying changes in albedo, topography, and morphology.

processes (Fig. 3).

Preliminary mapping resulted in five distinct units. The proposed chloride-bearing materials (Fig. 4-A) are light-toned and commonly overlie terrain that is scalloped and appears highly degraded (physically weathered). Consistent with previous studies, the chloride-bearing terrains appear to be relatively thin beds and extend into relatively darker-toned materials close to their boundaries, as seen in Fig. 4-B & D, where the distinct, scalloped weathering patterns are still observable. Within the chloride-bearing unit, we also see small outcroppings of sinuous features suggestive of aeolian processes. In general, there is a wide range in the styles of erosion and fracturing observed within the chloride unit. This is promising in that it suggests future quantitative measurements of the surface textures based on HiRISE DTMs will reveal differences between chloride deposits.

**Future Work:** Once morphologic mapping is complete, we will integrate spectral properties from newly processed CRISM map tiles with the morphologic maps. The Multispectral Reduced Data Record (MRDR) data processing team is currently generating noise-reduced global mapping tiles of hydrated mineralogy spectral parameters that will provide nearly complete spectral coverage of our study regions. We intend to re-assess full resolution targeted (FRT) CRISM observations of select chloride deposits as well to search for evidence of accessory salt phases. This will focus on the strength and shape of the fundamental H<sub>2</sub>O stretching vibration modes at ~3 μm that is most sensitive to changes in total water content that may indicate mixing of different hydrous phases.

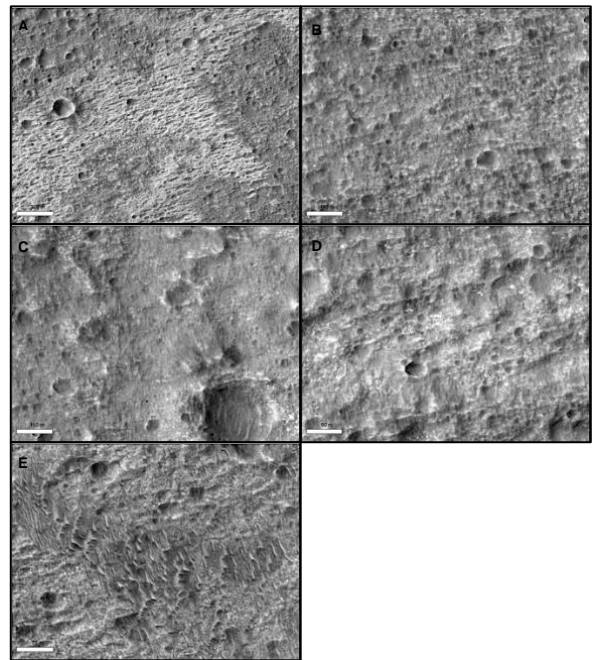


Figure 4 HiRISE images of the units mapped in Fig 2: (A) chloride-bearing deposit, (B) highly weathered chloride deposit, (C) light-toned, gray floor unit, (D) chloride deposits observed as bright material within geologic windows, (E) sinuous features observed within the main chloride-bearing unit.

**Acknowledgments:** CTX mosaic tiles were pulled from the CTX global mosaic provided by Bruce Murray Laboratory for Planetary Visualization (<http://murray-lab.caltech.edu>).

**References:** [1] Osterloo M. M. et al. (2008) *Science*, 319, 1651-1654. [2] Glotch T. D. et al. (2010) *Geophys. Res. Lett.*, 37, L16202. [3] El-Maarry M. R. et al. (2014) *Icarus*, 241, 248-268. [4] Osterloo M. M. et al. (2010) *JGR*, 155, E10012. [5] Wray J. J. et al. (2009) *Geology*, v37, no.11, 1043-1046. [6] El-Maarry M. R. et al. (2013) *JGR: Planets*, 11, 2263-2278. [7] Ye C. and Glotch T. D. (2019) *JGR: Planets*, 124, 209-222. [8] Tosca N. J. and McLennan S. M. (2006) *Earth Planet. Sci. Lett.*, 241, 21-31.