CRISM MAPPING OF CHLORIDE DEPOSITS AT CENTRAL LATITUDES ON MARS – NOACHIS TERRA.
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Introduction: Chloride deposits have been identified across the martian mid-latitudes using data from the Thermal Emission Imaging System (THEMIS) [1]. Based on the geologic context and geomorphology of these deposits, Osterloo et al. [1] concluded they are likely resultant from past ponding of surface water and/or groundwater upwelling in local, topographic lows [1]. However, they also note that identification of chloride in higher spatial resolution spectral observations, and identification of other phases associated with chloride, could provide further insight into chloride formation. Glotch et al. 2010 [2] conducted such a study in Terra Sirenum using high-spatial resolution, hyperspectral targeted data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM). They observed a spatial correlation between chloride and phyllosilicate in that region and hypothesized that the two phases were genetically related (both emplaced through hydrologic activity), but that they were likely deposited at different times given their stratigraphic relationship.

Here we conduct a similar analysis of CRISM data in the Noachis Terra region, which comprises the other major mid-latitude region on Mars in which chloride deposits are concentrated, apart from Terra Sirenum. Specifically, we report: (a) locations where we observe chloride in CRISM data and compare those locations to [1], and (b) report the identification of other alteration phases associated with chloride (i.e. in the same CRISM observation).

Methods: We examined 279 CRISM targeted observations from Noachis Terra (Fig. 1B, yellow boxes). The observations generally span the entire region populated by THEMIS-observed chloride deposits within Noachis Terra (Fig. 1A, teal polygons). It is important to note that: (a) CRISM targeted observations were selected as part of a broader mineralogic mapping study [3], whereby all observations within the latitudinal and longitudinal boundary of ~300-90°E and 10-35°S (i.e. Noachis Terra) available prior to CRISM PDS delivery 9 were included, and (b) we did not specifically denote which targets overlap locations of THEMIS-observed chloride prior to their examination (i.e., the analyst was blind as to the presence of chloride in each CRISM target during examination). Note, though we examined targets west of 330°E (left boundary of Fig. 1), no chloride was observed in those areas and they were not included in Fig. 1 for clarity.

We utilized standard RGB browse products comprised of summary parameters [4] and a custom image analysis interface to efficiently examine and identify mineral diversity within the 279 CRISM images. Extracted and ratioed spectra were compared to the Minerals Identified through CRISM Analysis (MICA) library and comparable library spectra [4] for phase identification. At CRISM wavelengths the signature of chlorides in spectra ratioed to dust is a blue slope at <0.8 µm, a red slope at 1-2.6 µm, and a weak 3-µm absorption when ratioed to surrounding materials inverted [2,5,6].

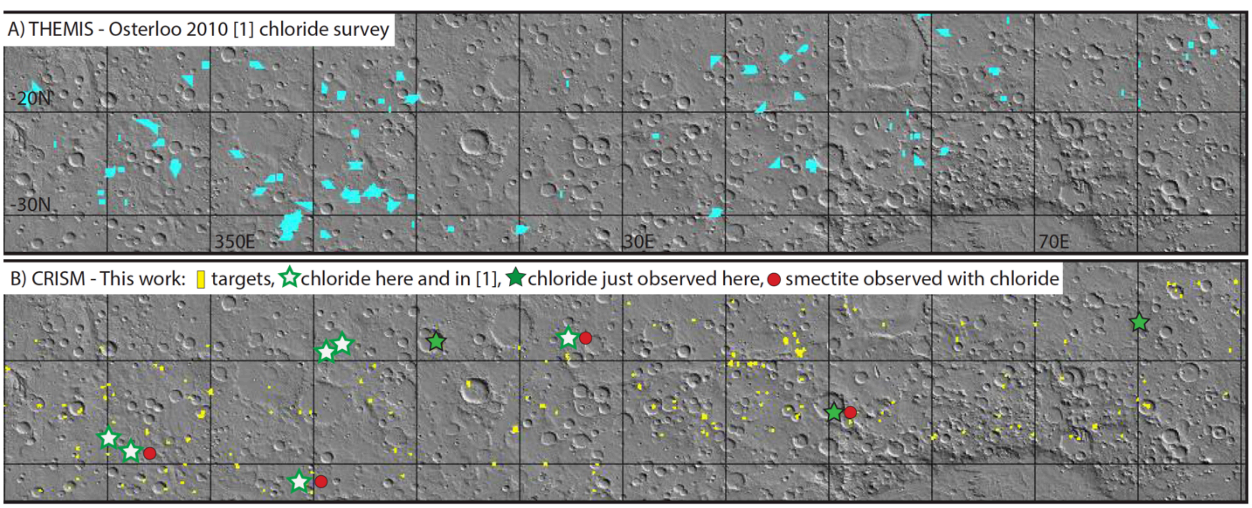

Fig 1. A) [1]'s THEMIS chloride survey, limited to Noachis Terra and B) chloride and chloride + smectite deposits observed from CRISM data (this study). Note, one green-filled star with red dot falls off the map (~101.9°E, 0.03°S) and is not shown. CRISM targeted observations from 300-330°E that were examined are also not shown; they contained no chloride. THEMIS chloride stamps were enlarged for clarity.

Results: We observe spectra consistent with chloride in 10 of the 279 targeted observations examined (~4%). Of those 10, six overlap chloride locations identified by THEMIS [1] (Fig. 1B, green-outlined stars), and four do not (Fig. 1B green-filled stars). Note, chloride deposit identified here but not in [1] lies beyond the bounds of the map (~101.9°E, 0.03°S). An example spectrum of a chloride deposit identified here but not in [1] is shown in Fig. 2C. All of the chloride deposits observed here occur in topographic lows (i.e. crater floors, depressions, etc.), some of which appear to have been subsequently modified (e.g. Fig. 2A, B).

CRISM spectra consistent with Fe/Mg-smectite were observed in five of the 10 targets containing chloride (Fig. 1B, red circles). No other alteration product was consistently observed with chloride. An example spectrum of smectite associated with chloride is shown in Fig. 2C. In most cases smectite was observed ~2-5 km away from chloride and in local, topographic lows that appear stratigraphically below chloride (e.g. Fig. 2B, top two magenta arrows), though that relationship has only been made through observation of THEMIS IR data. In one case, smectite was observed within several hundred meters to chloride (Fig. 2B, bottom magenta arrow). Note that our broader mapping study revealed numerous smectite deposits in Noachis Terra that are unassociated with chloride, and thus are not reported here. In other words, our observations suggest that in Noachis Terra the presence of chloride implies the presence of smectite in ~50% of the locations, whereas the presence of smectite does not appear to determine the presence of chloride.

Finally, there were no occurrences where THEMIS-identified chloride but we did not in the same area. Since the analyst was unaware as to the presence of chloride during analysis of CRISM images, this points to the effectiveness of the CRISM chloride browse product [4] in surveying for chloride.

Discussion: The increased spatial resolution of CRISM (18 m/pix) versus THEMIS (100 m/pix) likely resulted in the identification of the additional chloride deposits reported here but not in [1]; most newly observed chloride deposits were small (e.g. Fig. 2B), and thus may not be resolvable from THEMIS data.

All chloride deposits reported here occur in local topographic lows. This is consistent with their deposition through surface runoff and/or ground water upwelling, as previously hypothesized for martian chloride deposits [1].

The spatially associated distribution of Fe/Mg-smectite and chloride in Noachis Terra suggests a genetic relationship between the two (i.e. both formed through hydrologic activity), as proposed by [2] for the Terra Sirenum region. As in Terra Sirenum, chloride in Noachis Terra appears to lie stratigraphically above smectite and was likely deposited more recently. Further investigation of the stratigraphic relationships of the Noachis Terra chloride and smectite deposits using high-spatial resolution imagery (i.e. HiRISE) can be used to test that hypothesis.

References: [1] Osterloo et al. 2010, JGR 115:E10012. [2] Glotch et a. 2010, GRL 37:L16202. [3] Dapremont et al. 2017, LPSC this issue. [4] Viviano-Beck et al. (2014) JGR 119:1403-1431. [5] Murchie et al. (2009) JGR 114, E00D06. [6] Jensen & Glotch (2011) JGR 116, E00J03.

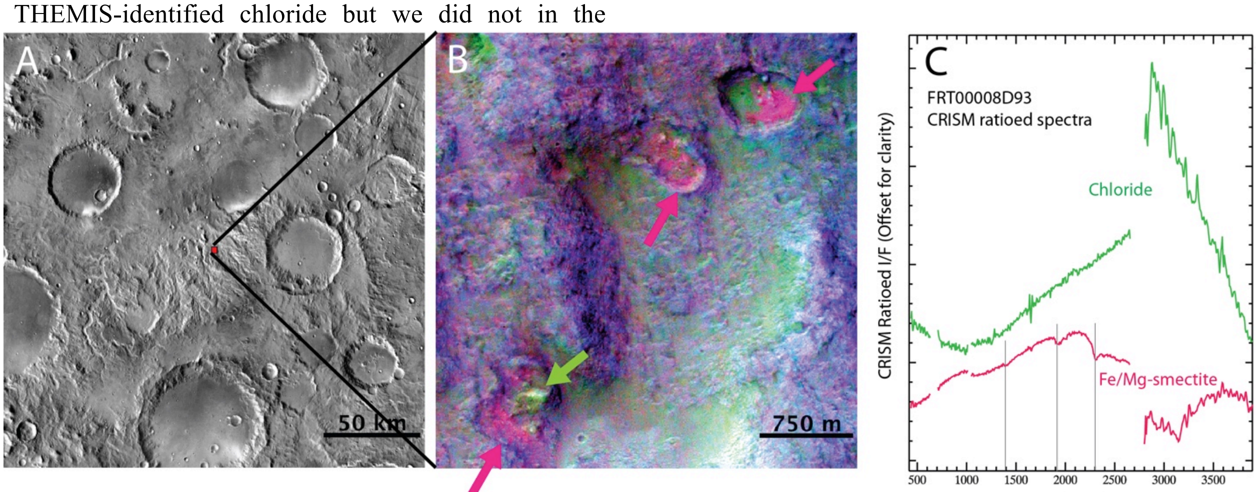

Fig 2. A) THEMIS Day IR context image, B) CRISM RGB composite (R: D2300, G: IRR2, B: BD3000) overlain on CTX image B16_015928_1815_XN_01N258W. Light green indicates chloride, magenta indicates Fe/Mg-phyllosilicate. All images centered at 101.891E, 0.009S (outside Noachis Terra). C) Extracted, ratioed CRISM spectra. Fe/Mg-Smectite: numerator pixel (column, row)=[140,235]; denominator pixel=[140,210]. ROI size: 13x9 pixels. Chloride: numerator pixel=[278,109]; denominator pixel =[278,84]. ROI size: 3x3 pixels.