EPSC Abstracts
Vol. 8, EPSC2013-60, 2013
European Planetary Science Congress 2013

Putative desiccation cracks in chloride-rich terrains on Mars: Results from mapping and spectroscopy

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1. Introduction

Chloride-rich terrains have been identified and mapped by [1]. These terrains display cracking patterns of various scales, which were interpreted to be potential desiccation cracks caused by the drying out of lakes or brines [1]. In addition, spectral data show distinct clay signatures, in particular those of Fe/Mg smectites, associated with the chlorides in many locations [2].

We map the putative chloride-rich terrains (hereinafter referred to as chloride deposits) using high spatial-resolution images, mainly from HiRISE, to investigate the occurrence, morphology and geologic setting of cracking patterns within the chloride deposits and assess the clay-chloride relation. The clays are identified and mapped in relation to the chloride deposits using spectral cubes from the CRISM instrument. This work is part of an ongoing research theme regarding non-periglacial polygonal cracking patterns on Mars that are potentially of desiccation origin [3–5] using mapping, numerical simulations, terrestrial analog field studies, and experiments on analog wet simulants.

2. Results

2.1. Mapping

The global mapping of the entire chloride data set [2] has yielded 66 locations that contain cracking patterns close to, or directly associated with the chloride deposits. While this value represents only ~10% of the global data set (642 locations), it in fact represents more than 75% of the locations that are mapped by HiRISE (Fig. 1), which was the principle instrument used for detecting the cracking patterns.

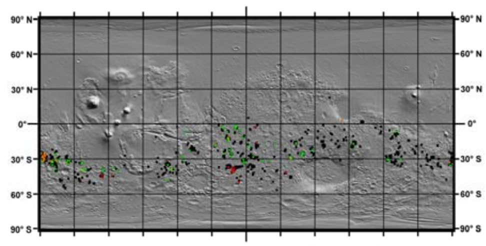

Figure 1: Global MOLA shaded relief map showing the locations of the putative chloride-rich terrains. Colored squares represent the locations that have been investigated in this study using HiRISE images (86 regions) and indicate presence of cracking (green), lack of it (red), and putative cracking (orange).

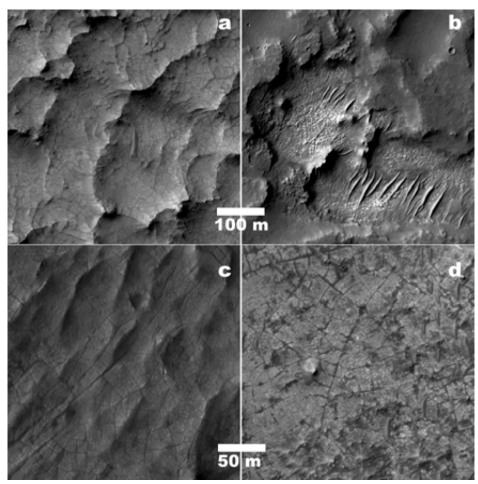

Figure 2: Typical polygonal cracks associated with chloride-rich deposits as seen using the HiRISE camera. Image IDs: (a) ESP_016057_1515, (b) ESP_018831_1545, (c) PSP_003160_1410, (d) ESP_016354_1745.

The polygonal patterns are generally flat, with no raised rims or centers (Fig. 2). The fractures themselves are usually 1–2 meters-wide. The spacing between the fractures (or polygon width) is highly variable across the global data set and, occasionally, within a single location. Regarding the regional setting, the cracking patterns tend to form within bright patches and exhumed outcrops in plains or low depressions such as impact craters, and sometimes in sinuous valleys.

2.2. Spectral analysis

To characterize the mineralogical diversity associated with the chloride deposits, we investigated the locations displaying cracking patterns that have CRISM cover (46 out of the 66 locations). Our mapping reveals that ~45% of the cracked regions display a strong Fe/Mg-rich or iron-rich phyllosilicates signal, such as smectites. We group our findings into 3 main classes in terms of the chlorides/clays association and presence/absence of fracturing:

a. Fractured chlorides and fractured clays in close proximity (Fig. 3).
b. Fractured chlorides with no clay signature.
c. Non-fractured chloride mantles overlying, or in proximity to, fractured clays.

3. Discussion and Summary

Our analysis of the morphometry, geologic setting and mineralogical association of the chloride-rich terrains indicates that most of the chlorides display cracking patterns. In most instances, the cracking can be attributed to clays (generally Fe/Mg smectites) that are interrelated or in contact with the chlorides. Smectites are a special class of phyllosilicates that have high swelling tendencies (i.e. can incorporate a considerable amount of water into their chemical structure), which would lead to significant loss of volume upon desiccation and the formation of cracking patterns similar to what is seen in this study [4]. This association suggests that most of the chlorides have been laid down by evaporation of lakes or brines as opposed to other modes of formation. Furthermore, this analysis potentially increases the data base of locations containing clay outcrops in the southern highlands of Mars that have not been detected by spectral methods due to the presence of an overlying thin desiccated layer or duricrust (i.e., chloride salts).

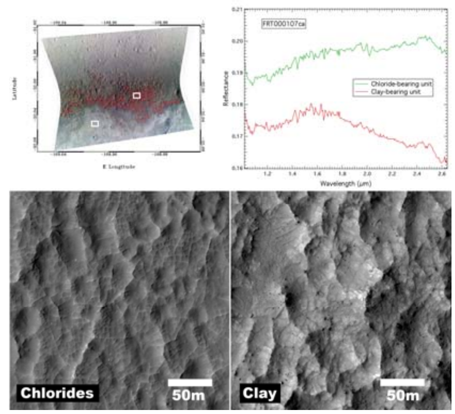

Figure 3: CRISM full-targeted color image [a] of a location contatining fractured chlorides (bright whitish deposits) and clays (red color index) in close proximity. White boxes represent the locations of the spectra [b] and HiRISE images for the fractured chlorides [c] and clays [d]. Image IDs: [a] FRT000107ca, [c,d] ESP_011547_1475.

Acknowledgements

This study was supported by funding from the Swiss National Science Foundation (SNSF).

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