DETECTION OF CARBONATE BEARING-ROCKS IN CRATERS UPLIFTS OF TYRRHENA TERRA, MARS.
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Introduction: The occurrance of carbonates on Mars has long been debated. Their formation requires a water-rich environment and large amounts of carbon dioxide in the atmosphere that today the planet does not have. In fact, although the carbon dioxide is the dominant gas into the atmosphere, its average pressure is only of ~6 mb. Only recently, remote sensing and in situ analysis have revealed their presence in some areas located on the oldest terrains [1-8]. The observation of these minerals suggests that Mars in its early history has hosted a CO_2-rich atmosphere consistent with a wet and warm environment.

In this work we report the putative orbital detection of carbonates in the uplift of two unnamed craters in Tyrrhena Terra using CRISM data.

Method: CRISM is an imaging spectrometer on board MRO that acquires hyperspectralimages in the 0.4-4.0 µm range with a spatial resolution up to ~18 m/pixel. In this paper, we describe the results obtained from the analysis of three CRISM orbits: FRT00009e58, FRT0000c339 and HRL000082e8. The spectra are converted to I/F, corrected by the cosine of solar incidence angle and then the atmospheric correction provided by [9] is applied. We remove residual noise using the method of [10]. Spectra showing hydration features are selected and ratioed to a spectrum in the same column near the spectra of interest in order to remove systematic artifacts and highlight and resolve spectral features. In order to identify the minerals, we use ASTER, CRISM, USGS and RELAB spectral libraries. The presence of two orbits (FRT00009e58 and FRT0000c339) that cross the same area allows to compare the results [Fig. 1, 2].

Results: CRISM spectra in the uplift of both craters exhibit the evidence for carbonates. In Fig 3 the CRISM spectra together with the library ones are shown.

Absorptions centered near 1.91-1.92, 2.31-2.32 and 2.52-2.54 µm and the general spectral behavior suggest the presence of Fe and/or Ca carbonates such as siderite and ankerite. The occurrence of an additional weak feature near 1.42 µm and a deeper band depth at 1.92 µm imply also the presence of other minerals, such as phyllosilicates. Best candidates are Fe-rich smectites, which having a feature near 2.30 µm can also cause a shift of the typical siderite and ankerite band at 2.33 µm to the observed wavelenghts (2.31-2.32 µm).
In many spectra a mixture is supported by the presence of a very weak spectral signature at 2.25 µm, typical of smectites or in general hydrated silicates (spectra 1 and 8 in the upper panel of Fig. 3).

Sepiolite, an Mg-phyllosilicate, also show all the bands present in the spectra of Fig. 3, bottom panel, but the broad absorption at 1 µm observed in the CRISM spectra is absent. However, it is not possible to exclude the occurrence of this phase. Similar considerations could be valid for the zeolite analcime that show ab-

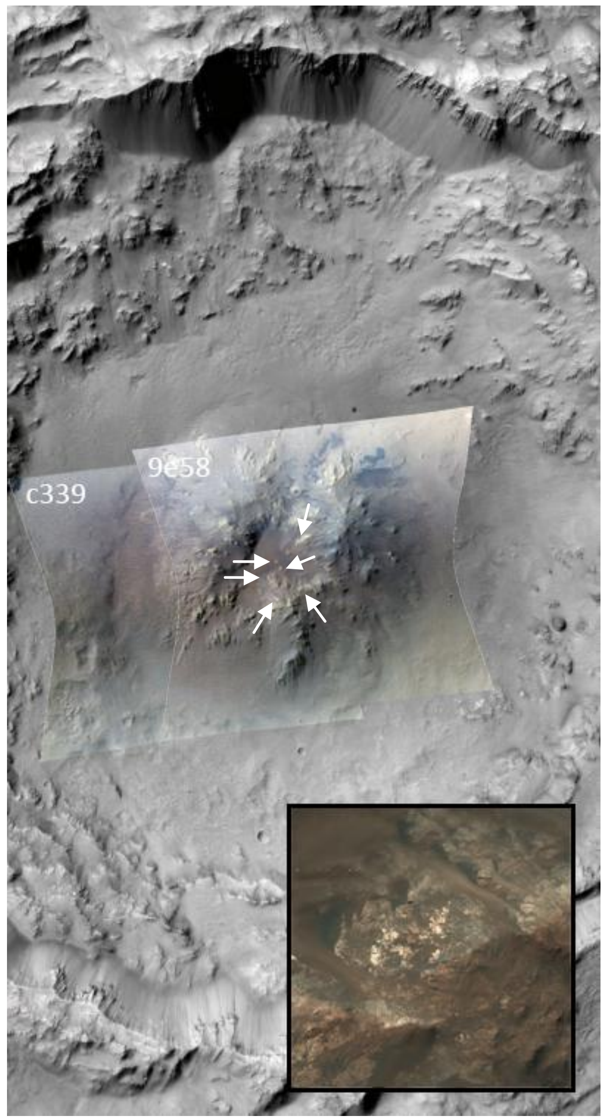

Fig. 1. FRT00009e58 and FRT0000c339 CRISM images superimposed on the CTX image. Carbonates are present in the bright outcrops of the CRISM image along the internal walls of the uplift and indicated by the arrows. At the bottom, RGB HiRISE close-up image shows one of the outcrops where carbonates are found (ESP_015981_1615).

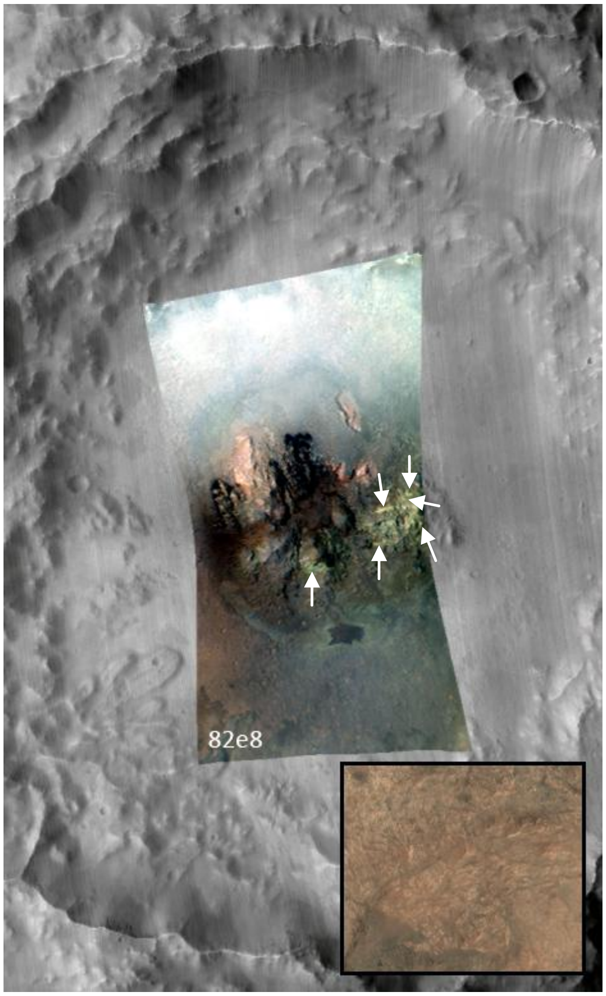

Fig. 2. HRL000082e8 CRISM image superimposed on the CTX image. Carbonates are found in the green materials of the uplift and indicated by the arrows in the CRISM image. At the bottom, RGB HiRISE close-up image of one of the outcrops where carbonates are found (ESP_011458_1640).

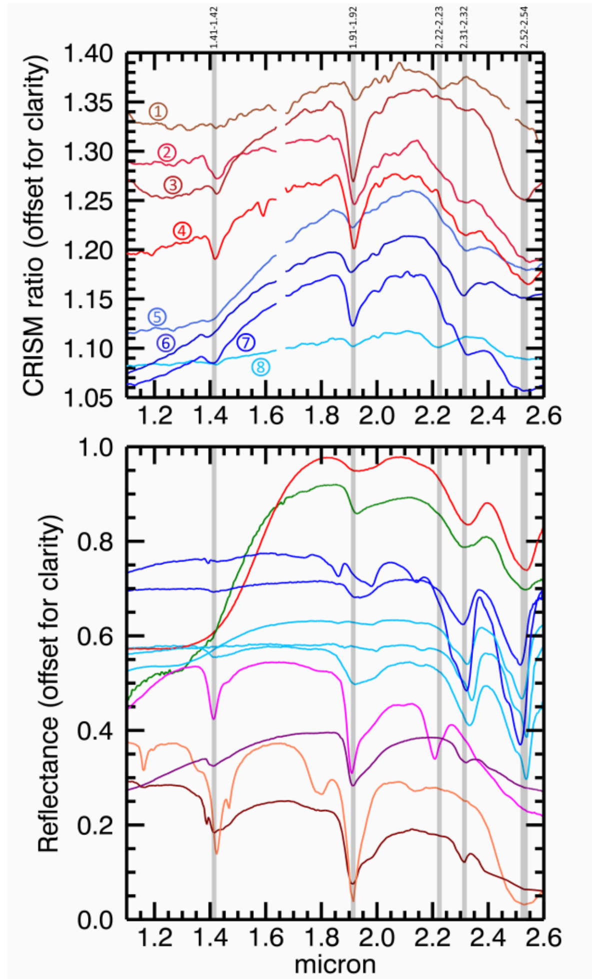

Fig 3. Examples of ratioed CRISM spectra taken from orbits 9e58 (upper panel, red-like 1-4) and 82e8 (upper panel, blue-like 5-8) compared to the library ones (bottom panel). The library spectra are rescaled: siderite (red), ankerite (green), dolomite (blue), calcite (cyan), montmori. (magenta), saponite (purple), analcime (coral), sepiolite (maroon).

sorptions at 1.42, 1.92, 2.53 µm.

Alternative carbonates can be calcite and dolomite. They have bands respectively near 2.33-2.34, 2.53-2.54 µm and near 2.31-2.32, 2.51-2.52 µm. In library spectra the band observed at 1.92 µm is absent or weak if it is compared to the band at longer wavelenghts (see cyan and blue spectra in Fig. 3, bottom panel). Also in this case, a mixture with hydrated silicates can increase the spectral contrast of this band. Iron-rich calcite and dolomite are the best candidates for the presence of a broad absorption around 1 µm. The spectral results described here are consistent with [5] and [7]. The additional analysis of the spectral range after 3 µm (not yet performed) could help understanding the composition of the rocks in the uplifts, but the higher noise in these wavelengths makes difficult to study this spectral region [8]. Some outcrops show spectral features in the ranges 1.41-1.42, 1.91-1.92 and 2.22-2.23 or 2.30 µm consistent respectively with the presence of clay such as montmorillonite, palygorkite, beidellite or clay such as nontronite, hectorite, saponite, sepiolite, vermiculite.

The spectral variety observed in these two craters is similar to that observed on other places on Mars of the same epoch. This fact suggests that the same chemical-physical processes occurred, at least at regional level on Mars, during Noachian.

References: [1] Ehlmann B. L. et al. (2008) *Science*, 322, 1828-1832 [2] Boyton W. V. et al. (2009) *Science*, 325, 61-64 [3] Palomba E. et al. (2009) Icarus, 203, 58-65 [4] Morris, R. V. et al. (2010) *Science*, 329, 421-424 [5] Michalski J. R. and Niles P. B. (2010) *Nature Geoscience*, 751-755. [6] Perry et al. (2010) *LPSC XLI*, Abstract #2605 [7] Wray J. J. et al. (2011) *LPSC XLII*, Abstract #2635 [8] Carter J. and Poulet F. (2012) *Icarus*, 219, 250-253 [9] McGuire P. C. et al. (2009) *Planet. Space Sci.*, 57, 809-815, 0903.3672. [10] Parente M. (2008) *LPSC XXXIX*, Abstract #2528.