

The Search for Evidence of Aqueous Activity in Putative Paleolake Basins on Mars using CRISM Spectral Data

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Abstract

Putative paleolakes in Martian impact craters have been the subject of local and regional studies as valuable targets for exploration (see [1] and references therein). Martian paleolakes have been suggested as landing sites for *in situ* and sample-return missions since they should provide information about the dynamics of the sedimentary processes and the climate under which they were formed. Putative lakes represent environments providing conditions favorable to preserving biomarkers, and hence are good candidates as locations for their detection.

Forsythe and Blackwelder [2] define a closed basin as having an input channel(s) and no outflow channel(s). Water can enter the closed basin as episodic, non-sustained, or as sustained flows, provided climatic and local hydrographic conditions permit [1]. In the absence of an outflow channel removal of groundwater entering the basin is due to evaporation, sublimation, and/or percolation into the subsurface.

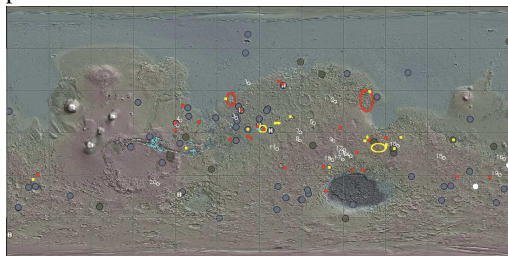


Figure 1. Selected putative paleolakes (white open circles with numbers) on MOLA data. Long.: -180° (left) to 180° (right) and Lat.: 90° (top) to -90° (bottom). Dunes within craters are solid circles, and those with an H indicate phyllosilicates [4]. Areas indicating phyllosilicates (red and yellow ellipses and dots) and sulfates (cyan) from Bibring et al. [5].

We initially identified 167 sites from the 222 sites suggested by Orofino et al. [3]. For each, an

analysis of the morphologic properties, altimetry, and diameter was performed. Only sites appearing well-developed with regular and well-defined edges; no evidence of subsequent impact events; and with diameters >20 km and inlet channels with a length > the diameter were selected. These restrictions left the 20 sites shown in Figure 1.

We report our initial analyses of CRISM observations of putative paleolakes on Mars to evaluate the evidence for the presence of mineral spectral signatures indicative of the past presence of water at these sites. Such minerals include hydrated/hydroxylated silicates, hydrous sulfates, and hydrous and/or anhydrous carbonates. CRISM is a hyperspectral imager operating in the 0.36–3.9 μm spectral range with a spectral sampling of $\sim 0.0065\text{--}0.012$ $\mu\text{m}/\text{channel}$ [6]. CRISM operates in a variety of observing modes to provide $\sim 20\text{--}200$ m/pixel spatial sampling. Publicly available data for the sites of interest were obtained. Initial atmospheric corrections use the volcano scan approach [7–8]. Once the atmospheric, cosmetic (de-stripe and de-spike), and geo-referencing procedures are complete, the data are ready for spectral analyses using the spectral parameters of Pelkey et al. [9].

Preliminary analyses were performed for 4 putative paleolakes (sites 7, 14, 16, and 17) using data spanning the $\sim 1\text{--}2.5$ μm range. As illustrated in Figure 2 there is a broad spectral feature centered near 2 μm for all sites. It is identified within and outside the putative paleolake basins. So, it is not unique to the putative paleolakes.

One possible explanation for this feature is the presence of calcium-rich pyroxene. Such an assignment can be further validated by investigating the presence of an associated spectral feature that should occur near 1 μm [e.g. 10] and will involve future evaluation of the CRISM data

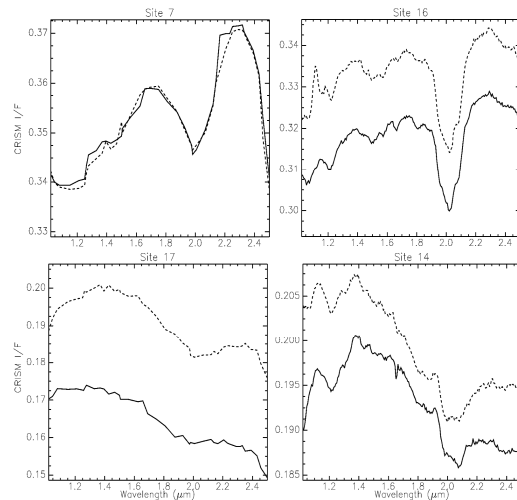
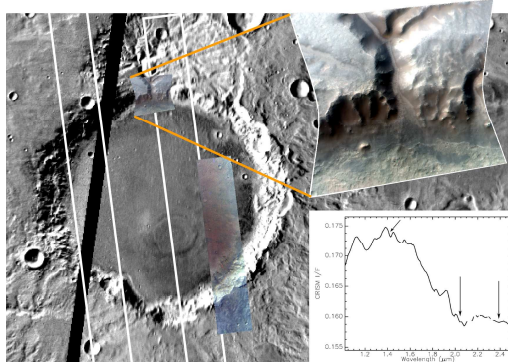


Figure 2. This figure shows two spectra from each site; one from within the putative paleolake (solid lines), and one from the surrounding region (dashed lines). The spectra have different spectral resolution and spatial sampling at each individual site.

spanning the 0.4-1 μm region. A second possibility is the presence of molecular water, associated with surface minerals, giving rise to a spectral feature near 2 μm [e.g. 11]. To reiterate, the 2 μm feature occurs both within and outside the putative paleolake. So, alone it can not be used to provide definitive evidence of water activity within the putative paleolake.



As shown in Figure 3, in addition to the 2 μm feature, spectra from site 14 provide evidence for additional features near 1.4 and 2.38 μm . Such features in CRISM data have previously been attributed to hydrated minerals on Mars [e.g. 5,7]. Also shown in Fig. 3 is the spatial locations delineated by these spectral features. They are

closely associated with the inflow channel dissecting the rim of the crater in which the putative paleolake resides. This is the strongest evidence for sustained aqueous activity from among the four sites investigated to date. However, complete confirmation of this assignment and potential identification of the mineral(s) requires more detailed spectral analysis beyond the initial effort described here.

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Figure 3. CRISM observations of Site 14. Underlying THEMIS data provides context. The white outlines are MSP observations. Observation FRTA26B is shown in more detail in the upper-right inset. One of the spectra showing a signature near 2.38 μm of hydroxylated materials is shown as lower-right inset. This spectrum was extracted from all pixels in FRTA26B with a band depth near 2.3 μm >0.

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