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Another putative Hesparian-aged crater-related hydrothermal site in Syrtis Major, Mars

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Abstract

Here we describe an ~22-km diameter unnamed crater in northeast Syrtis Major, Mars. The central peak complex shows evidence of several phyllosilicates, as well as, the wall of the northern rim. This crater is ~40 kilometers away from Toro crater, which has both morphological and mineralogical evidence for resampling of pre-impact altered materials and post-impact hydrothermal alteration [1]. The mineral phases and their distribution are similar to those observed in Toro crater possibly suggesting that similar processes may have also occurred at this site [1].

1. Introduction

Hydrated silicates, particularly phyllosilicates, have been identified on Mars by the spectrometers MEx/OMEGA [2] and MRO/CRISM [3]. These minerals are indicative of the interaction of water and rocks early in the history of the planet (e.g., [1] and references therein). Global mapping shows that phyllosilicates are widespread and geographically restricted to the heavily cratered and ancient Noachian terrains (e.g., [2]). The 40-km Toro crater, on the northern edge of Syrtis Major, appears to be one possible exception to this Noachian-restriction. The Hesperian-aged Toro crater shows both spectral and morphologic evidence that is consistent with a resampling scenario (i.e., excavation of preexisting phyllosilicate-bearing materials), but more importantly, impact-induced hydrothermal activity as well [1]. Hydrothermalism is mainly based on extensive hydrated silicate deposits (a mineral suite including prehnite, chlorites, smectites, and opaline materials) and correlations of such hydrated materials specifically with a complex network of structural features caused by fluid interactions along fractures and joints, and both vent-like and conical mound structures found only in the central uplift complex.

We have identified an unnamed crater near Toro, located at 73.1°E, 17.1°N and just 40 km east that presents similar mineralogical and morphological characteristics. Given its proximity and smaller diameter, this crater presents a unique opportunity to assess both resampling and hydrothermal scenarios, which are both affected by crater size and crucial towards understanding the origins of Martian phyllosilicates.

2. Context and Morphology

The crater occurs near the northern margins of the lava flow field of Syrtis Major, one of the major volcanic provinces on Mars, that lies just to the west of the Isidis basin, and south of Nili Fossae grabens. The nearby Toro crater age is found to be 3.6 Ga, consistent with the youngest estimates for the lavas in the region [1]. The recently identified 22.3 km complex crater has a maximum rim-to-floor depth of 1.5 km. It displays a well-preserved interior and exterior with a relatively sharp rim, terraced walls and ejecta blanket.

The central peak complex is ~6 km across; like Toro crater to the west, it possesses excellent bedrock exposures, but in this case they are potentially more aerially extensive then those observed in Toro. The quality and extent of exposed bedrock is consistent with THEMIS nighttime thermal infrared brightness temperature images that show 1:1 correlations between HiRISE-observed bedrock and warmer (~10K higher than surroundings) nighttime temperatures. Also like Toro, the bedrock of the central uplift is texturally characterized by extensive megabreccias in HiRISE images, but includes a large, highly fractured exposure of massively textured bedrock with minimal or incipient brecciation (e.g., ~350 - 600 meters; Fig. 1). Although some megabreccias may represent crater-formed deposits that once lined the transient cavity and now drape the central peak, these textures both reflect the complexities of the pre-impact target stratigraphy that underlies the layered volcanics of the Syrtis

Major (also consistent with observations from Toro).

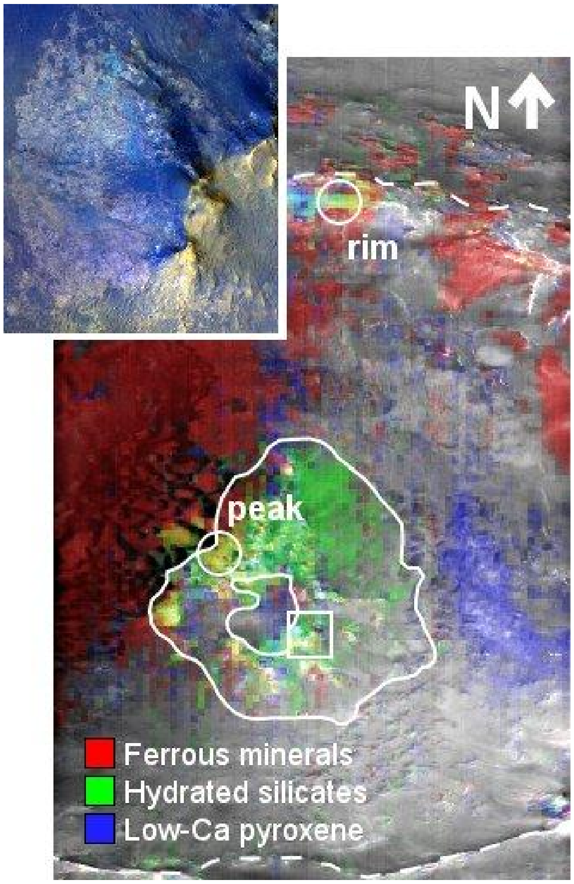

Figure 1: Mineral distribution map overlaying IR albedo obtained from CRISM HRL00013FD3 (not map-projected). Dashed and solid lines indicate the rims and the central uplift complex (and pit), respectively. Circles are the locations where the spectra have been extracted. The square indicates the location of the inset. The inset is a portion of HiRISE ESP014096 showing fractured exposure of textured bedrock.

3. Spectral characteristics

CRISM is a hyperspectral imager that measures reflected radiation in the visible and near infrared (VNIR) from the surface of Mars [3]. Similar to Toro, the unnamed crater shows hydrated silicate-bearing materials both within the central peak and exposures on the northern crater wall/terraces (Fig. 1). Two representative spectra were selected from those regions by averaging at least 16 pixels and were fit with linear models of reflectance spectra from the CRISM spectral library (Fig. 2). We found that both spectra can be modeled as a mixture of various hydroxylated phyllosilicates. The spectrum from the central peak is modeled by a mixture of phases such as chlorite, illite, prehnite, and talc in roughly equal proportions, while the spectrum from the rim is can be modeled by a simpler mixture of talc and serpentine, in ~5/1 proportions. Prehnite, chlorite, and possibly illite, are consistent with the mineralogy found in Toro crater [1]. Serpentine is a phase that has been reported as widespread in Nili Fossae [4] and talc is another common product of hydrothermal alteration.

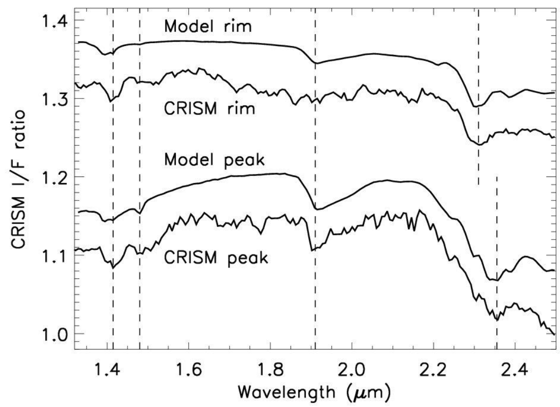

Figure 2: CRISM I/F averages from the locations in figure 1. The I/F ratios are obtained following a procedure described by [1]. Linear models are offset by +0.05. The spectrum from the central peak and rim are consistent with a mixture of several hydroxylated pyllosilicates, and talc and serpentine, respectively.

4. Conclusions

The similarities in the mineralogy and the distribution of the hydrated phases with respect to crater and bedrock morphology suggests, that like Toro, the hydrated phases in this new site can be explained by both resampling of pre-existing deposits and post-impact hydrothermal processes. Hydrothermal sites may provide both liquid water and energy – the main requirements to support life. At the same time, biological activity, if any, in such environments should be recorded in these water-related deposits making these Martian spots sites of extreme interest in search for extinct life.

References

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