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Aqueous deposition and alteration in Coprates Catena, Mars: Fans and phyllosilicates

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Abstract

We have studied the geomorphology and geochemistry of two stepped fans and associated deposits in Coprates Catena, Mars. We see evidence for two separate stages of formation: an early lake environment with deltaic and alteration processes, followed by later sub-aerial stepped fan processes. The presence of surface water and phyllosilicates in probable Hesperian-era deposits has important implications for understanding the history of water on Mars.

1. Introduction

We have studied two fan systems and associated deposits in Coprates Catena. Our goal was to understand the likely aqueous history, both locally and regionally. Previous hypotheses for the formation of stepped fan systems include end-member methods of alluvial, sheetflood-dominated deposition [1] or deltaic deposition [2] processes. Rapid water release events have also been suggested for other stepped fan systems on Mars [3], although syntectonic deposition could also account for the stepped appearance [e.g. 4].

2. Data and Methods

We used stereo CTX and HiRISE observations to create DTMs of two different resolutions using ISIS and SocetSet software packages [5]. These DTMs were combined in a GIS environment with multi-spectral CRISM data processed using the CRISM Analysis Toolkit in ENVI [6,7].

3. Observations

Our study region is located in the Coprates Catena region of South-East Valles Marineris. The two study fans, hereafter named Fan 1 and Fan 2, are located in separate but adjacent closed troughs. Both troughs have channel-like features that cut into the surrounding plains and appear to terminate in the trough depressions.

3.1 Geomorphology and Structure.

Both fans are made up of material that lies at the end of a channel and in the base of a closed trough. The fan deposits can be split into proximal and distal units based upon their layering characteristics and structure. Both fans have a distinctive stepped appearance, with individual layers dipping gently away from the source channels. The layers in Fan 1 are exposed throughout the fan, whereas those in Fan 2 are confined to the proximal deposits. Beyond the stepped deposits at both fans are digitate ridges, interpreted as inverted channels. Using a method of manually removing the fan from the elevation datasets to derive a pre-fan surface [8], we calculate estimates of the volumes of Fans 1 and 2 of 6.1 and 0.8 km^3 respectively.

3.2 Geochemistry.

Our studies of the geochemistry are limited to a single half-resolution long CRISM observation (HRL0001B8AE) of a small area of Fan 2 and some light-toned deposits (LTDs). The overall dominant alteration spectral signature here is that of phyllosilicates. The strongest alteration signatures are centered at 2.3 μm and confined to LTDs exposed both in the bottom of the trough and in isolated outcrops in the walls at the top of the trough. Absorption features centered at 2.2 μm occur only in LTDs located on the plains outside the trough, and appear to be outcropping directly above the 2.3 μm material towards the top of the trough walls.

The LTDs in the trough have absorption features similar to Fe/Mg phyllosilicates such as saponite or nontronite, as does the thin band of LTDs outcropping in the top of the trough walls. Material found outside the trough in the surrounding plains has a spectrum similar to Al phyllosilicates such as montmorillonite or kaolinite.

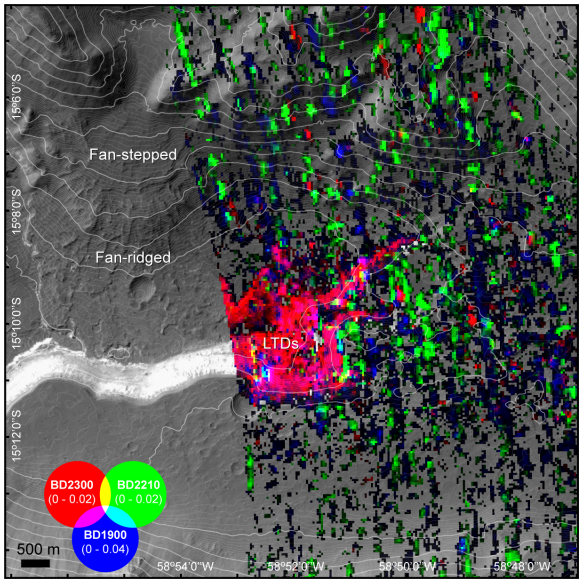

Figure 1. CRISM phyllosilicate spectral parameter map with CTX stereo DTM contours and orthoimage.

3.3 Crater Counting Surveys.

To estimate the absolute age of different surfaces we used CTX images and standard crater counting techniques outside the troughs. A large area (26,000 km^2) count of craters > 100 m in diameter gave a model age of 3.7 Ga for the exterior plains. Smaller area counts of craters with diameters > 50 m in diameter in 4 separate areas (~4000 km^2) produced ages from Middle Noachian (3.8 Ga) to Early Amazonian (2.6 Ga). There are three top-level age observations: (1) overall the main surface of each representative plains unit ranges in age from Middle Noachian (3.8 Ga) to Early Amazonian (2.63 Ga), (2) surfaces immediately surrounding the trough at Fan 1 appear to be younger than those surrounding Fan 2, and (2) inter-trough surfaces appear to be older than cratered plains surfaces. Regardless of location, all surfaces in this study appear to have undergone some resurfacing or crater removal events, as indicated by kinks in the crater frequency histograms.

4. Summary and Conclusions

The identification of possibly-related fans and phyllosilicates in the neighboring troughs of both Fan 1 [9] and Fan 2 suggests that fluvial and/or diagentic processes might have been widespread in this region of Valles Marineris. The likely Hesperian formation age of the closed troughs raises the importance of these fan-related phyllosilicates, particularly if the chemistry is indicative of in situ rather than externally-derived detrital material, which is unknown at present. The combined geomorphology and geochemical evidence suggests two main periods of activity in this region: (1) shallow lake leading to delta formation and in situ phyllosilicate formation, and (2) subsequent alluvial fan formation leading to stratigraphically-higher stepped deposits.

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