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Evidence for Preserved dikes intruding the Noachian Crust and Major Geologic Transitions in the Walls of Valles Marineris, Mars

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Abstract

Valles Marineris is a unique vertical section through the uppermost kilometers of the martian crust; its location, east of Tharsis bulge, and its water-related history, suggest a great diversity of rock types in this area. HiRISE and CRISM data available over the walls of the canyon were analyzed to infer the importance of volcanism and sedimentary processes through time. A typical succession of horizontal units of distinct morphologies and mineralogies was observed in the Eastern part of Valles Marineris, including basaltic lavas, phyllosilicate-rich boulders and a LCP (Low-Calcium Pyroxene)-rich basement. This basement, interpreted as being an uniquely preserved outcrop of pristine Noachian crust [1], is intruded by dikes [2]. One CRISM observation is available on a dike, showing an olivine-rich signature at its location. Preserved and emplaced Noachian crustal material is rare on the martian surface and such detections bring precious information about early igneous processes. All the aforementioned detections are generally limited to eastern Valles Marineris, while the western part of the canyon system seems cut in a different material, with no obvious mineralogical signature, but consistent with volcanic material [1,3]. The occurrence of early crustal material and multiple mixed hydrated mineral detections contribute to the need for future martian exploration in Valles Marineris.

1. Introduction and methods

Previous studies [4] show that the upper parts of the walls of Valles Marineris are likely composed of layered stacks of lavas, related to Tharsis volcanism, in most of the chasmata. Beneath these lavas are exposures of Noachian crust [1]. Exposures of walls in the whole Valles Marineris area were investigated with both HiRiSE and CRISM data. All the CRISM data publicly available over the Valles Marineris area at the date of March 1st, 2011 were corrected as described in [1,5] and co-registered with their corresponding HiRISE observation in a GIS.

2. Mineralogic and morphologic observations

2.1 Eastern Valles Marineris

Four different spectral types have been identified using the CRISM dataset: dust, pyroxene, olivine and phyllosilicates. These four spectral types are present on CRISM hyperspectral observation FRT00009DB4 which is given as an example in figure 1.

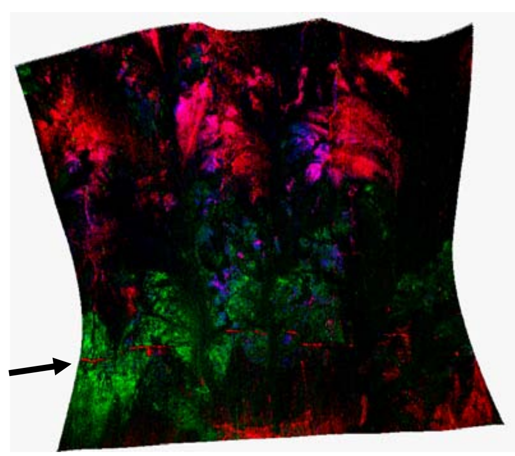

Figure 1: CRISM FRT00009DB4 RGB color composite of summary parameters. R= OLINDEX2, G=LCPINDEX, B=HCPINDEX. Phyllosilicates appear in magenta, LCP in green and olivine in red. The black arrow points out at the olivine-rich dike.

Aforementioned detections are vertically stratified in eastern Valles Marineris, as they are associated with the different morphologic units; mineralogic and morphologic transitions generally coincide.

The first spectral type has a strong blue slope (decrease in reflectance with increasing wavelength) with no visible diagnostic absorptions and is interpreted as dust [1,6]. It is commonly observed on the upper walls, which are however morphologically consistent with a stack of lava floods. Dusty signatures are also common in the middle walls where a talus slope is present. The second spectral type is characterized by a broad 1.9 µm absorption, consistent with pyroxenes [1,6]. The position and shapes of the bands argue for a low calcium pyroxene (LCP). LCP detections are generally associated with a bright, massive and heavily fractured bedrock at the very bottom of the walls. Olivine is also identified with a strong VNIR 1 µm crystal field absorption [1,6]. Olivine is observed at different locations in the walls and on the canyon floor, but is especially detected in some dark linear features intruding the lower walls bedrock, that are interpreted as dikes [2]. Finally, the fourth spectral type is identified with narrow absorptions near 1.4, 1.9, and 2.31 µm. Comparison with laboratory spectra is consistent with Fe/Mg phyllosilicates [1,5]. Contrary to the Al-phyllosilicates, which have a diagnostic absorption band at 2.20 µm, Fe-OH and Mg-OH bonds are respectively responsible for vibration around 2.28-2.29 µm and 2.30-2.31 µm [5]. The shape of the spectra and the position and width of the 1.4 and 2.3 µm absorption bands of these detections could indicate the presence of a Mg-smectite such as saponite. This phyllosilicate-rich layer appears to correspond to an alteration layer composed of dark boulders rather than a sedimentary layer; no distinct sedimentary layers were actually found within the walls [1].

2.2Western Valles Marineris

The composition of the walls of western Valles Marineris remains unclear. They are often masked by avalanches or ILD deposits, and they have not been well targeted with CRISM and HiRISE. They haven't shown any diagnostic mineralogical signature on most of their length, thus far. Morphologies are clearly different from eastern Valles Marineris; they are consistent with layered volcanic material such as pyroclastic deposits of lava floods, on the entire wall cross-section [1]. No bedrock has been observed and no LCP detection has been reported west of Coprates Chasma [1,3].

These results support the observations of Quantin et al. [3; *this meeting*] who surveyed the composition of the central peaks of Valles Marineris surrounding craters.

3. Key points and preliminary conclusions

We realized a complete morphologic and mineralogic survey of the entire walls of all of the Valles Marineris chasmata [1]. While the composition of western Valles Marineris remains unclear, eastern Valles Marineris walls show a typical succession of units along their length [1]. No sedimentary layers were observed within the walls thus far, but preserved Noachian crustal material is exposed in the lower walls. This pristine bedrock is intruded by olivine-rich dikes that have characteristics in agreement with the Valles Marineris tectonic style [1,2].

References

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