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Geological study of the hydrated formations on the plateaus around Valles Marineris, Mars: Implications for the evolution of geochemical conditions through time

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Abstract

We realized a geological study of the hydrated formations located on the plateaus around Valles Marineris based on the analysis of HiRISE and CRISM data. We showed that the upper part of the Noachian basement locally displays an Al-phyllosilicate-rich formation, which is topographically and stratigraphically above a Fe/Mg-phyllosilicate-rich formation. This mineralogical stratigraphy is consistent with the aqueous alteration of the Noachian plateaus by pedogenesis under alkaline to neutral conditions. These formations are overlain by the sulfate/opaline silica-rich formation, which was formed under acidic conditions at the Hesperian time or later.

1. Introduction

Geological formations enriched in different hydrated minerals including Fe/Mg phyllosilicates, Al phyllosilicates, opaline silica, and Fe sulfates are exposed on the Noachian and Hesperian-aged plateaus around Valles Marineris [1-11]. We studied their geological context, their spectral characteristics, and their stratigraphical relationships in order to better constrain the evolution of the geochemical environments through time.

2. Study area and method

Our study area is located between 0ºS and 40ºS in latitude, and 30ºW and 70ºW in longitude, and includes east Thaumasia Planum, northwest Margaritifer Terra, Ophir Planum and south Lunae Planum. This region displays a representative sample of the variety of hydrated materials exposed on the plateaus around Valles Marineris. Each HiRISE image and CRISM targeted observation of this area were analyzed and compared with the geological map of Witbeck et al. [12] and Scott and Tanaka [13]. The hydrated formations are presented below.

3. Fe/Mg-phyllosilicate-rich formations

The Fe/Mg-phyllosilicate-rich formations occur in three different geological settings: (1) impact breccia and excavated material in central pits, uplifts, and ejecta of impact craters; (2) sedimentary infillings in valleys and other depressions; and (3) near-surface layer exposed along scarps. They are enriched in Fe/Mg smectites and/or vermiculite (CRISM spectra exhibit absorption bands at 1.4 μm, 1.9 μm, and 2.3 μm) consistent with a formation in alkaline to neutral environments.

The type (3) outcrops consist of a dark-toned material exposed along the upper parts of Noachian basement, mainly the Npl2 unit composed of volcanic material and impact breccias (Figure 1). The formation crops out at different elevations along impact crater rims, valley rims (e.g., Her Desher Vallis) [9], as well as chasma walls (Coprates Catena [4], Eos Chasma, and Ganges Chasma). Reddish on HiRISE IRB color images, it displays polygonal fractures similar to that observed in Mawrth Vallis. This formation (3) does not display well defined layers, and it probably corresponds to the alteration of the basement by percolating waters during the Noachian time or later.

4. Al-phyllosilicate-rich formation

The Al-phyllosilicate-rich formation is exposed at different elevations on the plateaus (Ophir Planum, Thaumasia Planum, Margaritifer Terra) and along scarps of the Noachian basement, topographically

and stratigraphically above the Fe/Mg-phyllosilicate-rich formation (3) (Figure 1). Exposed where a dark mafic cap rock has been removed, the Al-rich formation appears light blue to green on HiRISE IRB color images, and displays polygonal fractures. It is locally incised by valleys. The Al-phyllosilicates correspond to Al-smectites and/or kaolinite (CRISM spectra display absorption bands at 1.4 µm, 1.9 µm, and a narrow band at 2.2 µm). The Al-smectites and the kaolinites were possibly formed by leaching of the basement or Fe/Mg-phyllosilicate-rich formations under alkaline to neutral conditions during the Noachian time or later. On the other hand, the kaolinites may also form in slightly acidic conditions [14, 15].

5. Sulfate/opaline silica-rich formation

This formation consists of layered deposits unconformable above Noachian and Hesperian terrains (Figure 1). Due to the large spatial coverage of this formation and its location on high elevated plateaus, it has been interpreted as consolidated airfall dust and/or volcanic ash, which was locally eroded and transported by fluvial processes [7, 11]. In our study area, it is exposed west of Juventae Chasma and Ganges Chasma. These materials are 50m to 20-40m thick on average [11], and they are composed of two main units in these regions: a thin light polygonally fractured basal unit composed of opaline silica or Al-phyllosilicate-rich layers (e.g., kaolinite) [11], and the main unit consisting of alternating light and dark layers composed of hydroxylated ferric sulfates [1, 3, 7, 8, 11] (Figure 1). No minerals were identified in this main unit for the outcrops west of Ganges Chasma due to a dust cover. The mineralogical composition and the stratigraphic relationships of this formation are consistent with its acidic weathering during the Hesperian time or later.

6. Discussion and conclusion

The sulfate/opaline silica-rich formation suggests that geochemical conditions were acidic during the Hesperian time in this region. Hence, the kaolinite-rich outcrops of the Al-phyllosilicate-rich formation were possibly formed coevally to the sulfate/opaline silica-rich formation during the Hesperian time, but on Noachian terrains.

The Al-phyllosilicate-rich formation and the Fe/Mg-phyllosilicate-rich formation (3) attest of widespread surface alteration of the Noachian basement on the region probably by pedogenesis. This kind of formations is also observed in other regions of Mars including Mawrth Vallis [14, 15], Nili Fossae [16], Meridiani Planum [17], and northeast Noachis Terra [18]. This suggests a global-scale surface alteration since the Noachian time.

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References

[1] Milliken R. E. et al., Geology, 36, 847-850, 2008.[2] Mustard J. F. et al., Nature, 454, 305-309, 2008. [3] Bishop J. L. et al., JGR, 114, E00D09, 2009. [4] Murchie S. L. et al., JGR, 114, E00D06, 2009. [5] Carter J. et al., LPS XL, Abstract #2028, 2009. [6] Quantin et al., LPS XL, Abstract #1651, 2009. [7] Le Deit et al., LPS XL, Abstract #1856, 2009. [8] Weitz C. M. et al., Icarus, 205, 73-102, 2010. [9] Buczkowski et al., LPS XLI, Abstract #1158, 2010. [10] Le Deit et al., LPS XLI, Abstract #1146, 2010. [11] Le Deit L. et al., Icarus, in press, 2010. [12] Witbeck N. E. et al., USGS I-2010, 1991. [13] Scott D. H. and Tanaka K. L., USGS I-1802-A, 1:15M scale, 1986. [14] McKeown N. K. et al., JGR, 114, E00D10, 2009. [15] Noe Dobrea E. Z. Et al., JGR, in press. [16] Ehlmann B. L. et al., JGR, 114, E00D08, 2009. [17] Wray J. J. et al., GRL, 36, L21201, 2009. [18] Wray J. J. et al., Geology, 37, 1043-1046, 2009.

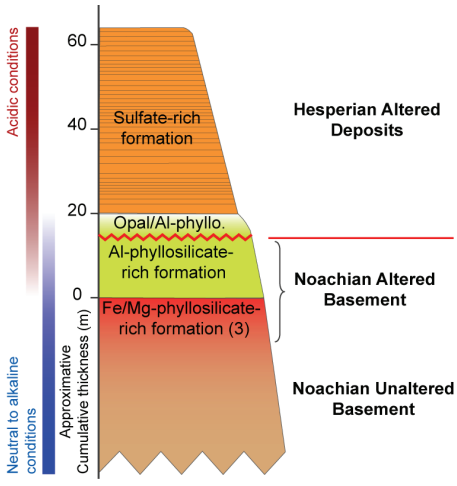

Figure 1: Stratigraphic log of the upper part of the plateaus around Valles Marineris. The Fe/Mg-phyllosilicate-rich formations (1) and (2), and the Hesperian basement are not represented.