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Her Desher and Nirgal Vallis phyllosilicates: Pedogenesis or groundwater sapping?

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Abstract

A widespread phyllosilicate-bearing layer has been identified in a distinct region in northwest Noachis Terra [1,2,3]. This layer is exposed along the length of two valley systems in the region, as well as crater rims/walls. It has been suggested that the phyllosilicates were produced by pedogenic weathering fed by meteoric water or melted snow [2]. However, the geomorphology of the valley systems is consistent with formation due to groundwater sapping [4,5,6], opening the possibility that the phyllosilicates formed by interaction with groundwater, not surface water.

1. Introduction

Noachis Terra is a highland cratered plain on Mars, extending from 20º to 80ºS latitude and 55ºW to 30ºE longitude. Two small valley systems incise NW Noachis Terra: Her Desher and Nirgal Valles (Fig. 1). Nirgal Vallis is a tributary of Uzboi Vallis, joining the larger system to the south of Holden crater. Her Desher Vallis is an isolated valley that does not obviously connect to any outlet, e.g., craters or other valley system.

Mosaicked CRISM multispectral mapping data (~230 m/pixel) suggest that a phyllosilicate-bearing layer outcrops along the length of both valley systems and in the interior rims of many craters in the region [1,3]. Further inspection of high resolution CRISM hyperspectral targeted observations (20-40 m/pixel) of the walls of Her Desher and Nirgal Valles confirm the presence of phyllosilicates [1,3]. Spectral analyses indicate that these phyllosilicates are iron-magnesium smectites; the shape and position of the absorptions at 2.3 and 2.4 microns is consistent with either a physical mixture of nontronite (Fe-smectite) and saponite (Mg-smectite) or perhaps an intermediate composition [1,3]. The mineralogy of the layer is generally consistent along the length of both valleys, a total distance of ~600 kilometers [1,3]. This distinct phyllosilicate-bearing layer is located only a few meters below the surface cap material and is laterally contiguous with a uniform apparent thickness of ~10 meters. HiRISE observations of these layers show the smectite-bearing materials to be polygonally fractured, which is morphologically similar to other phyllosilicates identified on Mars [7].

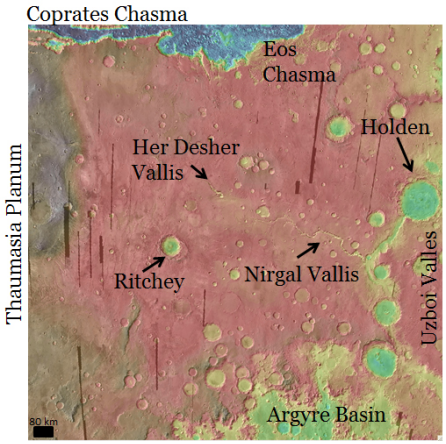

Figure 1: MOLA topography draped over THEMIS daytime IR of NW Noachis Terra. Boundary regions and both Her Desher and Nirgal Valles are identified.

Several high resolution hyperspectral CRISM observations of craters near the valley systems also show a phyllosilicate-bearing layer of similar composition. As in the valleys, these phyllosilicates extend laterally and are located a comparable distance below the surface. HiRISE data indicate that phyllosilicates exposed in craters have the same polygonal morphology as those in the valleys.

2. Discussion

A sequence of Al-smectites over Fe/Mg smectites was mapped as part of a formation named “Plateau Phyllosilicates” by [2], and extends from our study area to the north of Valles Marineris. This sequence

was proposed to have formed by pedogenesis [2], a process of weathering volcanic soils by percolating water which usually results in accumulation of Fe/Mg smectites in the lower horizons while Al-smectites remain in the upper horizons [8,9]. The source of the water was proposed to have been derived from either precipitation or melted snow [2], both forms of overland flow.

However, both Nirgal and Her Desher Valles are geomorphically more similar to valleys formed by groundwater sapping, not overland flow [4]. Nirgal Vallis has a uniform valley width [4,5], not an increasing valley width as is expected for a valley fed by overland flow. It also has U-shaped cross-sections (not V-shaped) and amphitheatre-headed source regions/tributaries [4,5,6]. There is also evidence of strong circum-Tharsis structural control of the networks [4,6], whereas a valley formed by overland flow would be controlled by topography.

It has been shown that tectonic events can result in pressurization of surrounding aquifers [10,11]. Source regions for the circum-Chryse outflow channels high up on the Tharsis bulge [10] would likely also feed groundwater flow through fracture systems in northwest Noachis Terra, providing a source of water to form Her Desher and Nirgal Valles.

It is possible that the Nirgal and Her Desher phyllosilicates could have formed pedogenically and then been exposed by valleys formed due to groundwater sapping, but the immaturity of the soil profile does not support this sequence of events. A mature pedogenic profile would find Al-phyllosilicates overlying Fe/Mg phyllosilicates [8,9]. Similarly, the flow of groundwater through pre-existing Fe/Mg phyllosilicates should further weather the soils, creating Al-phyllosilicates. However, in Nirgal and Her Desher Valles there are only Fe/Mg phyllosilicates. We thus suggest that groundwater may have caused the formation of the exposed phyllosilicates as well as the valleys, as the water weathered the basaltic soils it was flowing through.

3. Summary and Conclusions

In conclusion, the geomorphic evidence shows that Nirgal and Her Desher Valles were formed by groundwater sapping. We suggest that this allows for the possibility that the phyllosilicates exposed in the valley walls are not formed by top-down weathering, but rather by interaction with groundwater.

References

[1] Buczkowski, D. et al.: Extensive phyllosilicate-bearing layer exposed by valley systems in Northwest Noachis Terra, Abs. 1458, Lunar Planetary Sciences Conference, 1-5 March 2010, Houston, USA, 2010.

[2] LeDeit, L. et al.: Extensive surface pedogenic alteration of the Martian Noachian crust by plateau phyllosilicates around Valles Marineris, Journal Geophysical Research, doi: 10.1029/2011JE003983, 2012.

[3] Buczkowski, D. et al.: Evidence for multiple widespread buried phyllosilicate-bearing layers between Argyre and Valles Marineris, Abs. 2331, Lunar Planetary Sciences Conference, 18-22 March 2013, Houston, USA, 2013.

[4] Jaumann, R. and Reiss, D.: Nirgal Vallis: Evidence for extensive sapping, Abs. 1579, Lunar Planetary Sciences Conference, 11-15 March 2002, Houston, USA, 2002.

[5] Harrison, K. and Grimm, R.: Groundwater-controlled valley networks and the decline of surface runoff on early Mars, Journal Geophysical Research, Vol. 110, E12S16, 2005.

[6] Glines, N. and Fasset, C.: Evidence for groundwater sapping on Mars from junction angles of Nirgal Vallis tributaries, Abs. 2011, Lunar Planetary Sciences Conference, 18-22 March 2013, Houston, USA, 2013.

[7] McKeown, N. et al.: Abs. P43D_1458, American Geophysical Union Fall Meeting, 14-18 December 2009, San Francisco, USA, 2009.

[8] Altheide, T., Chevrier, V., and Noe Dobrea, E.: Mineralogical characterization of acid weathered phyllosilicates with implications of secondary martian deposits, Geochimica et Cosmochimica Acta, 74, pp. 6232-6248, 2010.

[9] Noe Dobrea, E. and Swayze, G.: Acid pedogenesis on Mars? Evidence for top-down alteration on Mars from CRISM and HiRISE data, Abs. 2620, Lunar Planetary Sciences Conference, 1-5 March 2010, Houston, USA, 2010.

[10] Hanna, J. and Phillips, R.: Hydrological modeling of the Martian crust with application to the pressurization of aquifers, Journal Geophysical Research, Vol. 110, E01004, 2005.

[11] Hanna, J. and Phillips, R.: Tectonic pressurization of aquifers in the formation of Mangala and Athabasca Valles, Mars, Journal Geophysical Research, Vol. 111, E03003, 2006.