NOT ALWAYS WET: AN ARIDIFICATION SEQUENCE IN THE ORBITAL CLAY-SULFATE TRANSITION OF AEOLIS MONS. W. Rapin[1], G. Dromart[2], J. Schieber[3], B.C. Clark[4], L. Kah[5], D. Rubin[6], S. Gupta[7], A. Roberts[7], G. Caravaca[1], L. Edgar[8], R. Y. Sheppard[9], E. Dehouck[2], S. Le Mouélic[10], A. Bryk[11], W. E. Dietrich[11], P. Gasda[12], O. Gasnault[1], N. Lanza[12]. [1]IRAP/UPS/CNRS, Toulouse, France (william.rapin@irap.omp.eu), [2]Univ. Lyon, LGL-TPE, [3]DGS, Indiana Univ., [4]Space Science Institute, CO, [5]University of Tennessee, [6]UC Santa Cruz, [7]Imperial College London, [8]USGS, [9]PSI [10]LPG, Nantes, [11]UC Berkeley, [12]LANL.

Introduction: On Mars, prominent thick-layered sulfate-bearing deposits are observed at a number of late Noachian to late Hesperian locations (~3.5 Ga) [1]. Their apparent absence in older strata has led to the hypothesis that they may represent ancient evaporites related to the global aridification [2]. In Gale crater, the Curiosity rover is exploring the sulfate-bearing unit, a regional package hundreds of meters thick of yet mostly undefined origin [3]. Curiosity's investigations can test whether the formation processes of this unit are similar to a form of primary evaporation, such as early diagenetic salt crystallization, or later stage precipitations with different conditions.

Entering the transition: After exploring the mudstone-rich and clay-bearing strata of the Murray and Carolyn Shoemaker fm. for about seven years, the Curiosity rover has explored the orbital clay-sulfate transition starting in 2021 (Fig. 1). Bedrock in the basal section is marked by diverse diagenetic overprints where sedimentary structures are less visible. Further up, the rover imaged butte-forming outcrops and revealed a >100-m-thick interval with a transition into large-scale trough cross-bedded structures (Fig 2a) [4].

Geochemistry and distribution of sulfates: The base of the clay-sulfate transition succession is marked by a sharp increase in the occurrence of bedrock with nodular texture associated with sulfate enrichments (Fig. 1). The rover analyzed the composition of three bedrock lithologic components: (i) a smooth host bedrock, which was drilled at multiple locations and revealed the disappearance of clay minerals in X-ray diffraction (XRD) [5] – the evolved gas analyses (EGA) also suggest minor Mg-sulfates and an isotopic change in sulfur compared to the clay-bearing unit below [6]; (ii) a bedrock with mm-scale nodular texture which was observed in the upper section of the clay-sulfate transition, and became abundant within the marker band valley at and around the Canaima drill locality (Fig. 2d) – revealing significant Mg-sulfate content according to both XRD and EGA [5,6]; (iii) a cm-scale nodular bedrock, which was not drilled due to its uneven surface, but shows diverse sulfate-enriched compositions as measured by ChemCam (Fig. 1). Ca-sulfates are present mostly in smooth host bedrock in variable amounts across the stratigraphy, but also sporadically as submillimeter heterogeneity within nodules. Overall, the bulk bedrock (combining smooth and nodular) in the transition shows an increase in sulfate content relative to prior strata, nodular textures being a key component of that change (Fig. 1).

Unique nodular lithologies: Unusual cm-scale and mm-scale textures have been observed within the clay-sulfate transition. At the base a regular pattern of centimetric polygonal ridges (Fig. 2) is clearly crosscut by later stage fractures. These sulfate-enriched polygonal ridges may represent the first evidence of a paleosol on Mars formed by sustained wet-dry cycles at the surface [7]. Near the top of the section, in the marker band valley, bedrock has the highest abundance of sulfates and density of nodules. At and near the Canaima drill sample hydrated Mg-sulfates are a major component of the bulk bedrock with mm-scale nodular texture, ChemCam hydrogen signal indicates ~21 wt.% associated water (Fig. 1). This enhanced hydration is also observed in the cm-scale nodular bedrock leading to the marker band surface (Fig. 2e).

Discussion and interpretations: The terrains orbitally defined as part of the clay-sulfate transition and leading upward to the sulfate-bearing unit show multiple signs consistent with marked changes towards drier paleoenvironments both in the sedimentary and geochemical record. Within the large-scale cross-bedded strata of most likely eolian origin, sulfates occur in the form of diverse lithologies mostly related to nodular bedrock. The abundance of nodules and related sulfates is highly variable within the stratigraphy.

Within the transition, features within specific intervals have already been identified as indicators of locally and intermittently wet environments, such as polygonal ridges in the basal section or lenses with wave ripple laminae in the upper section, and within the marker band itself [8]. The surrounding dry eolian strata adjacent to these features are also marked by the enhanced occurrence of nodular lithologies (Fig. 1). This association and the general stratigraphic control on the distribution of sulfate-enriched nodules is consistent with their formation within the sediments due to evaporation where a sulfate-rich water table reached or came close to the surface in a variably dry climate.

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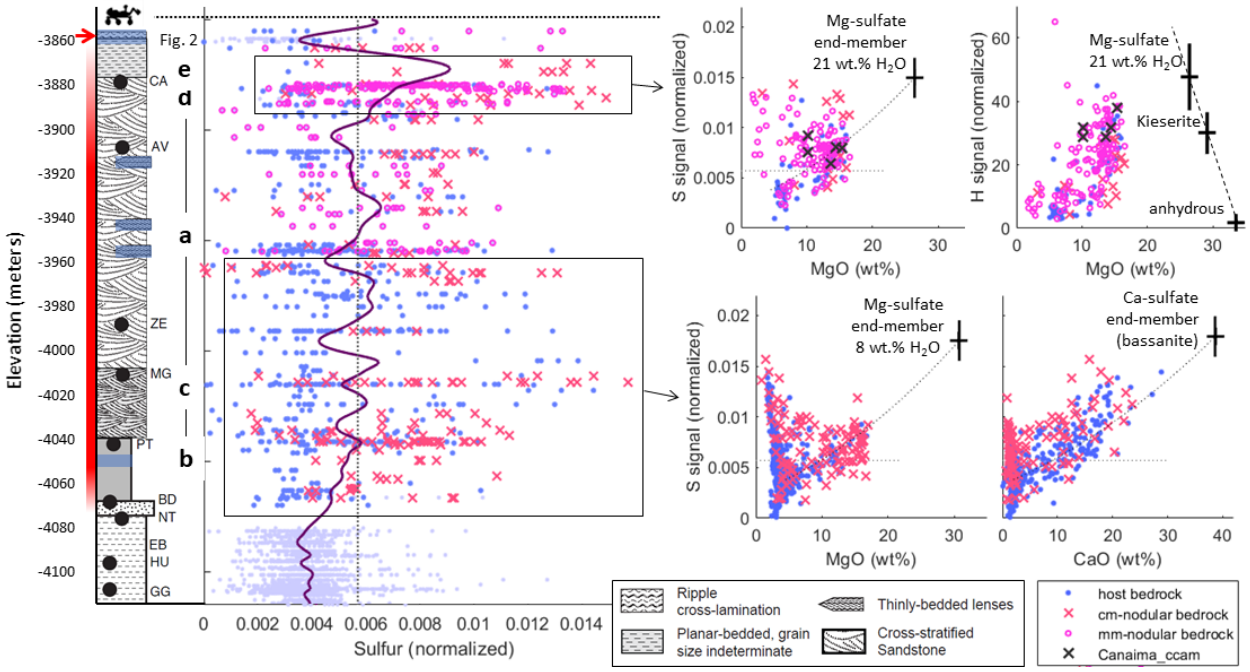

Figure 1: The clay-sulfate transition (red interval) as recorded by the ChemCam instrument on bedrock with smooth and nodular textures. Left: General stratigraphy (credit: MSL sed-strat team) against sulfur signal [9], with the marker band (red arrow) and identified features marking intermittently wet paleoenvironments (shaded blue). Dark red curve represents bedrock average (smooth host and nodular). Right: Sulfur and hydrogen as function of MgO and CaO content with hydrated Mg/Ca-sulfates references. MgO and CaO content in the transition are preliminary compositions derived from MOC [10] and renormalized to accommodate estimated SO_3 and H_2O content based on S and H signal [9,11].

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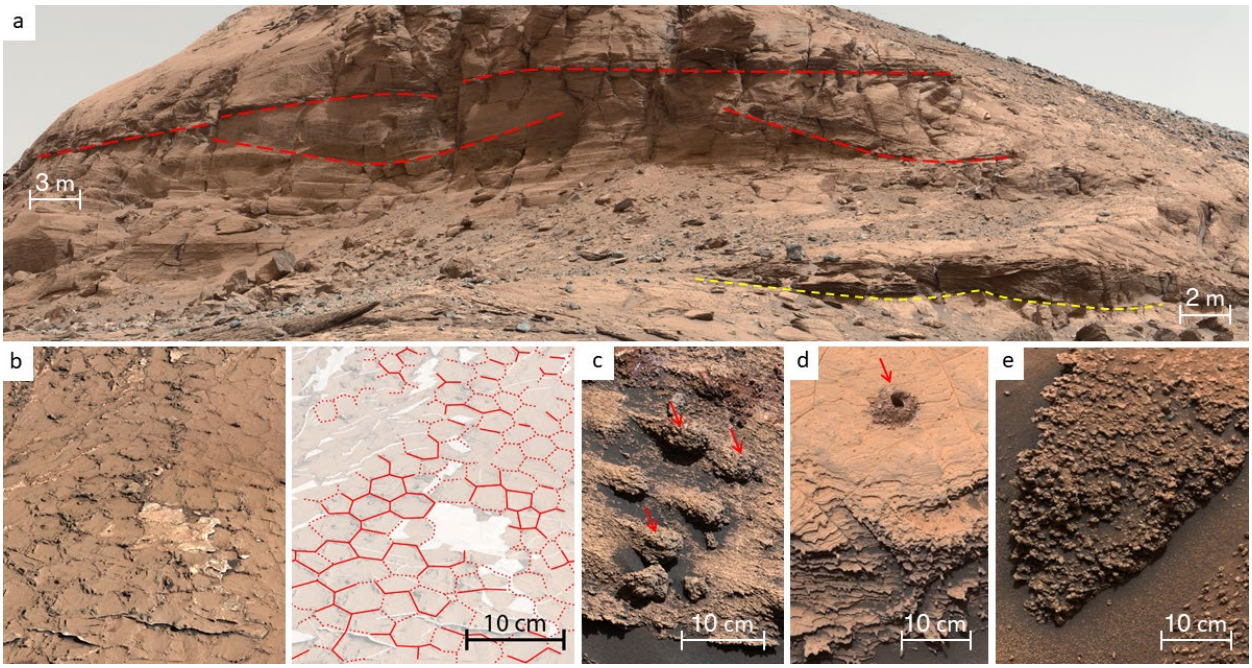

Figure 2: Mirador butte with large-scale crossbedding and diverse bounding surfaces (dashed red) consistent with eolian deposition and example of contact with interdune lens deposits (dashed yellow) (a). Remarkable nodular bedrock (b-e) also highlights the diversity of textures observed with distinct sulfate-enriched composition. Regular pattern of polygonal ridges (b); concretions (c); drill sample at Canaima (arrow) with mm-nodular texture (d); bedrock with a saturated density of hydrated Mg-sulfate-rich cm-scale nodules below the marker band (e).