THE CURIOSITY ROVER IS EXPLORING A KEY SULFATE-BEARING ORBITAL FACIES. W. Rapin[1], R.Y. Sheppard[2], G. Dromart[3], J. Schieber[4], B.C. Clark[5], L. Kah[6], D. Rubin[7], B.L. Ehlmann[8], S. Gupta[9], G. Caravaca[1], N. Mangold[10], E. Dehouck[3], S. Le Mouélic[10], O. Gasnault[1], J.V. Clark[11], A. Bryk[12], B. Dietrich[12], R.C. Wiens[13]. [1]IRAP/UPS/CNRS, Toulouse, France (william.rapin@irap.omp.eu), [2]JPL-Caltech, [3]Univ. Lyon, LGL-TPE, [4]DGS, Indiana Univ., [5]Space Science Institute, CO, [6]University of Tennessee, [7]UC Santa Cruz, [8]Caltech, [9]Imperial College London, [10]LPG, Nantes, [11]Jacobs-NASA JSC, [12]UC Berkeley, [13]LANL.

Introduction: Sulfate salts deposited in sedimentary basins are major geochemical markers of paleoclimate, source rocks, and dissolved gases and ions [1]. On Mars, prominent thick-layered sulfate-bearing deposits are observed at a number of late Noachian to late Hesperian locations (~3.5 Ga) [2]. Their apparent absence in older strata has led to the hypothesis that they represent the diminishing availability of liquid water on Mars [3]. In fact, a global survey of layered terrains provides a grouping of a few orbital facies, including the Laterally Continuous Sulfates (LCS) [4] a key facies of unknown origin within the Hesperian global hydrological change.

Until now, major sulfate-bearing strata documented by rover observations have been limited to the Burns fm. in Meridiani Planum, dominated by large aeolian cross-beds made of a sulfate-silicate assemblage with detrital grains, cements and later stage diagenetic features [5]. In Gale crater, the Curiosity rover is now set to explore the Layered Sulfate-bearing unit (LSu), which is a hundreds of meters thick package of LCS orbital facies within the Mt Sharp group (Fig. 1). The LSu has been mapped regionally from orbit and shows signatures of diverse poly- and monohydrated sulfate minerals and interfingering with clay-bearing strata [6].

The origin of sulfates in such strata remains unknown and the rover provides an opportunity to test formation models [7,8]. In particular, rover investigations can test whether processes are similar to the Burns fm., or distinct such as a form of primary evaporites, syndiagenetic or later stage diagenetic precipitations with different aqueous conditions.

Major change of sedimentary structures: Following mudstone-rich strata dominating the Murray fm. the Curiosity rover entered the LSu. Bedrock in the basal section is marked by diverse diagenetic overprints where sedimentary structures are less visible. In places, laminated mudstones associated with concretions and with mm-scale nodular features may present similarities to evaporitic textures previously observed in the Murray formation [9]. Further up, the rover imaged butte-forming outcrops (Fig. 1) and revealed a ~100-m-thick interval with a transition into large-scale trough cross-bedded structures, the lithology, scale and thickness of which has not ever been observed before by the rover at such close range. This interval is overlain by the "marker bed", above which sedimentary structures likely change back into fluviolacustrine depositional geometries as observed on long distance images [10].

Geochemical transition: The base of the LSu succession is marked by a sharp increase in density of bedrock nodular textures. The rover analyzed the

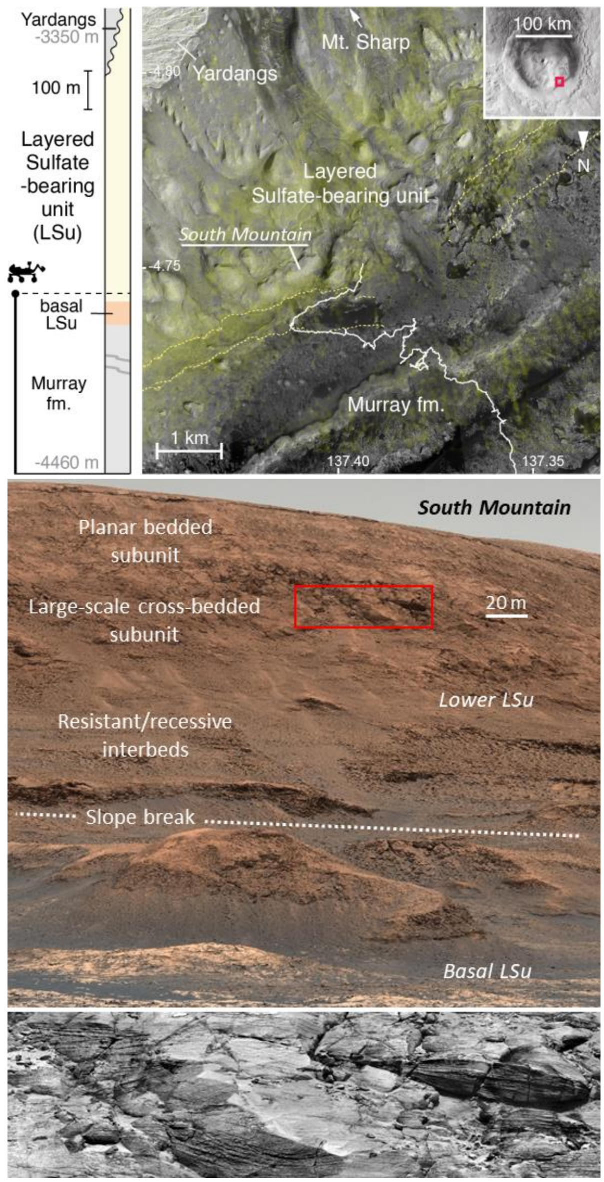

Figure 1: Context of Layered Sulfate-bearing unit (LSu) exploration by the Curiosity rover. Top to bottom: map with rover traverse and general stratigraphic column; architecture of deposits observed on South Mountain outcrop; example RMI close-up (red) showing evidence of large scale cross-bedded sedimentary structures.

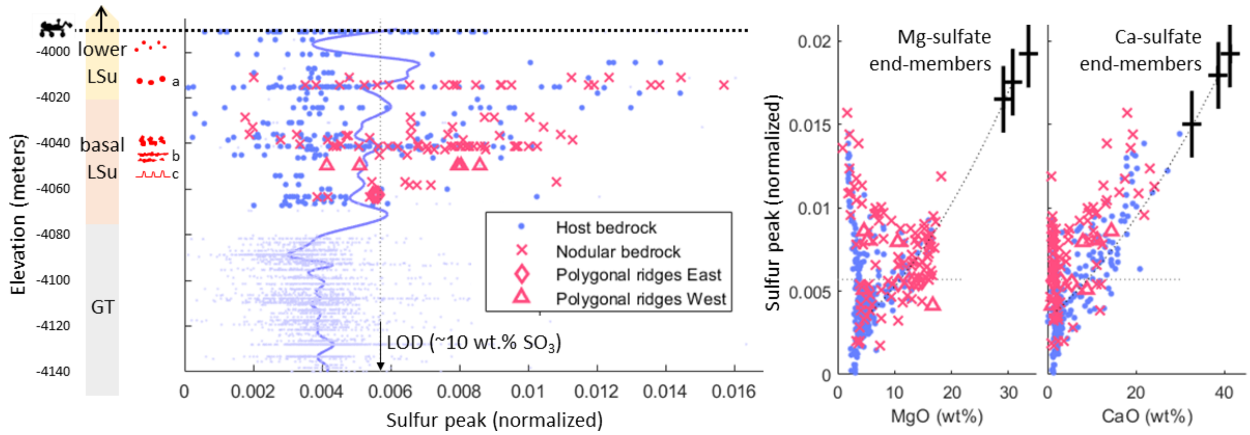

Figure 2: Geochemical transition into the sulfate-bearing unit as recorded by the ChemCam instrument on bedrock with both host and nodular textures. From left to right: Normalized sulfur signal [15] on bedrock targets with elevation within Glen Torridon (GT), basal and lower LSu, and example nodular bedrock (Fig. 3 a, b, c), blue line shows bedrock average (host and nodular) highlighting a significant change of bedrock sulfur composition associated with the LSu; Sulfur as function of MgO and CaO content highlights the presence of Mg and Ca-sulfates in bedrock.

composition of two bedrock components: (i) *smooth host bedrock* was drilled revealing the disappearance of clay minerals by X-ray diffraction [11] – the evolved gas analysis is consistent with this result, and also suggests the presence of Mg-sulfates and an isotopic change in sulfur compared to Glen Torridon [12], yet only minor change of bulk chemistry is observed [13]; (ii) *nodular bedrock* was not drilled due to its uneven surface, yet it was analyzed, mostly by ChemCam, and reveals diverse sulfate-enriched compositions (Fig. 2). At ChemCam's sub-millimeter scale, smoother host bedrock also shows sulfur heterogeneities. Average bedrock (smooth and nodular) shows increase of sulfate content and variability relative to prior strata, nodular textures being a key component of that change (Fig. 2).

Unusual nodular bedrock lithologies have been observed in the basal LSu, including a regular pattern of polygonal ridges (Fig. 3), clearly crosscut by later stage fractures, pointing to multiple phases of diagenetic alteration. These sulfate-enriched polygonal ridges may represent the first evidence of a paleosol on Mars formed by sustained wet-dry cycles at the surface [14].

Discussion: The LSu shows multiple signs of marked changes in the sedimentary and geochemical record of the Mt Sharp group as the rover progressively explores this unit which has regional and potentially global (LCS) significance. The large-scale cross-bedded sulfate-bearing strata soon to be explored —most likely of eolian origin—may allow a direct comparison with the Burns fm. model. Current exploration could help test whether the drying-upward transition reflects internal basin controls on the evolution of ancient Gale lake or external, possibly global, climatic controls.

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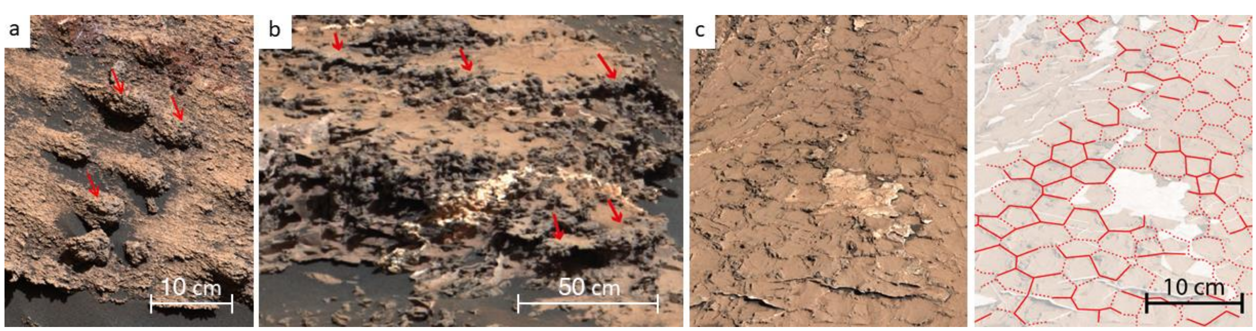

Figure 3: Remarkable nodular bedrock in the basal LSu highlights the diversity of textures observed within a short stratigraphic range with distinct sulfate-enriched composition. Decimeter-sized concretions (a); dark-toned nodular beds (b); regular pattern of polygonal ridges (c).