CALCIUM SULFATE CHARACTERIZED BY CHEMCAM/CURIOSITY AT GALE CRATER, MARS. M. Nachon[1] S. M. Clegg[2] N. Mangold[1] S. Schröder[3] L. C. Kah[4] G. Dromart[5] A. Ollila[6] J. R. Johnson[7] D. Z. Oehler[8] J. C. Bridges[9] S. Le Mouélic[1] O. Forni[3] R.C. Wiens[2] W. Rapin[3] R.B. Anderson[10] D. L. Blaney[11] J.F. Bell III[12] B. Clark[13] A. Cousin[2] M.D. Dyar[14] B. Ehlmann[15] C. Fabre[16] O. Gasnault[3] J. Grotzinger[15] J. Lasue[3] E. Lewin[17] R. Léveillé[18] S. McLennan[19] S. Maurice[3] P.-Y. Meslin[3] M. Rice[15] S.W. Squyres[20] K. Stack[15] D.Y. Sumner[21] D. Vaniman[22] D. Wellington[12], [1]LPGN, CNRS, Nantes, France [2]LANL, USA [3]IRAP, Toulouse, France [4]Dep. Earth Planet. Sci., Knoxville, USA [5]Lab. Géol. Lyon, France [6]Inst. Meteoritics, Albuquerque, USA [7]Applied Phy. Lab., Laurel, USA [8]Jacobs Tech. Inc., Houston, USA [9]Space Research Centre, Leicester, UK [10]U.S. Geol. Survey, Flagstaff, USA [11]JPL, Pasadena, USA [12]School Earth Space Explor., Tempe, USA [13]Space Sci. Inst., Boulder, USA [14]Mt Holyoke College, South Hadley, USA [15]Cal. Tech., Pasadena, USA [16]G2R, Nancy, France [17]ISTerre, Grenoble, France [18]Canadian Space Agency [19]Dep.Geosc., Stony Brook, USA [20]Dep.Astronomy, Ithaca, USA [21]Earth Planet. Sci., Davis, USA [22]Planet. Sci. Inst., Tucson, USA. [marion.nachon@univ-nantes.fr]

Introduction : Onboard the Mars Science Laboratory (MSL) Curiosity rover, the ChemCam instrument consists of :(1) a Laser-Induced Breakdown Spectrometer (LIBS) for elemental analysis of the targets **[1;2]** and (2) a Remote Micro Imager (RMI), for the imaging context of laser analysis **[3]**. Within the Gale crater, Curiosity traveled from Bradbury Landing through the Rocknest region and into Yellowknife Bay (YB). In the latter, abundant light-toned fracture-fill material were seen **[4;5]**. ChemCam analysis demonstrate that those fracture fills consist of calcium sulfates **[6]**.

ChemCam elemental analysis : The LIBS/ChemCam performs analysis typically of 350-550 µm in diameter, up to 7 m from the rover **[1]**. Spectra are commonly acquired on a number of laser points (e.g. 3x3 or 1x5 matrices) on each target, with each point being analyzed by multiple laser shots. ChemCam is able to detect most major elements and a variety of trace and minors **[7]**. Along the rover traverse, the detection of several targets showing points with enhanced Ca and S lines in concert (without other significant elements but oxygen) points toward the presence of calcium sulfates **[6]**.

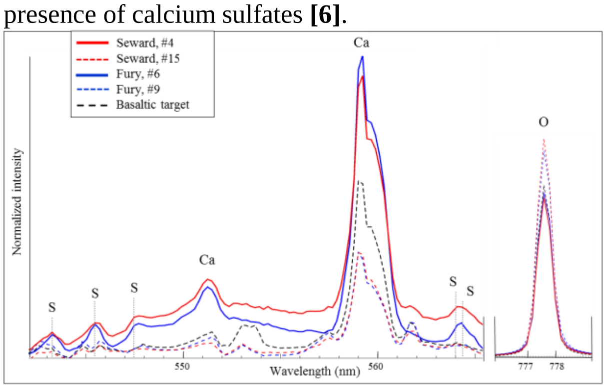

Figure 1 : Example of LIBS/ChemCam targets displaying Ca-sulfate signature (solid spectra), and surrounding points of the same target (dotted spectra) without Ca-sulfate signature. The ChemCam calibration target in black spectra is shown for comparison with a classical silicate rock.

A majority of the Ca-sulfates points also reveal a notable H-line detection, suggesting hydrated phases (either bassanite or gypsum).

ChemCam texture analysis : The RMI panchromatic black and white images allow the localization of the laser shots. Every Ca-sulfate detection corresponds to light-toned material distinct from surrounding rocks (Figs. 2,3). Their texture can be divided into : (1) elongated fracture fills, veins cross-cutting the rocks in various orientations (e.g. Fig. 2a, Fig. 3a) ; (2) individual or series of nodules, that in many cases align along fractures (e.g. Fig. 2g, Fig. 3c) ; (3) polygonal texture (Fig. 2j, Fig. 3d.2).

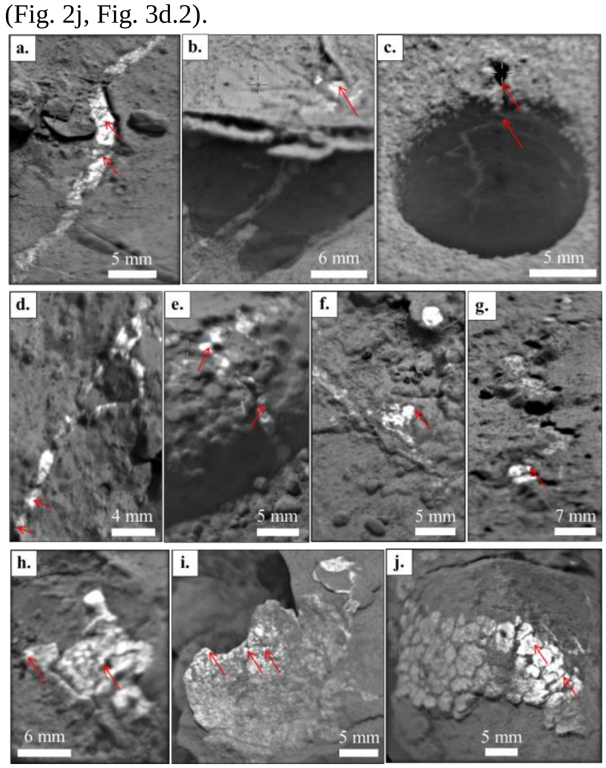

Figure 2 : Diversity of Ca-sulfates textures within the Sheepbed member of Yellowknife Bay formation. Red arrows indicate LIBS Ca-sulfate detections.

Geological setting of calcium sulfates : The large majority of Ca-sulfates detections occurs within the sediments series of YB. The following analysis occured on sol 407 (target Tingey) ; light-toned veins were observed more recently (e.g. taget Mell, sol 530), although not analyzed.

The YB formation consists of a ~5 m thick succession of various faciès, from predominant mudstone (lowermost Sheepbed member), to sandstone (Gillespie member), to the uppermost Glenelg member consisting of heterogeneous outcrops of interbedded siltstone and sandstone (Shaler-type), and resistant dark-toned pebbly to vuggy faciès (Point Lake-type) **[8-10]**. Within the Glenelg member, Ca-sulfate veins are uncommon (Fig. 3a-c). The Selwyn outcrop (Fig. 3d.1) shows that veins cut through the contact between Sheepbed and Gillespie, implying a formation of these veins subsequent to the deposition of the uppermost layers. Ca-sulfates detections are by far predominant within the Sheepbed member (Figs. 2,4).

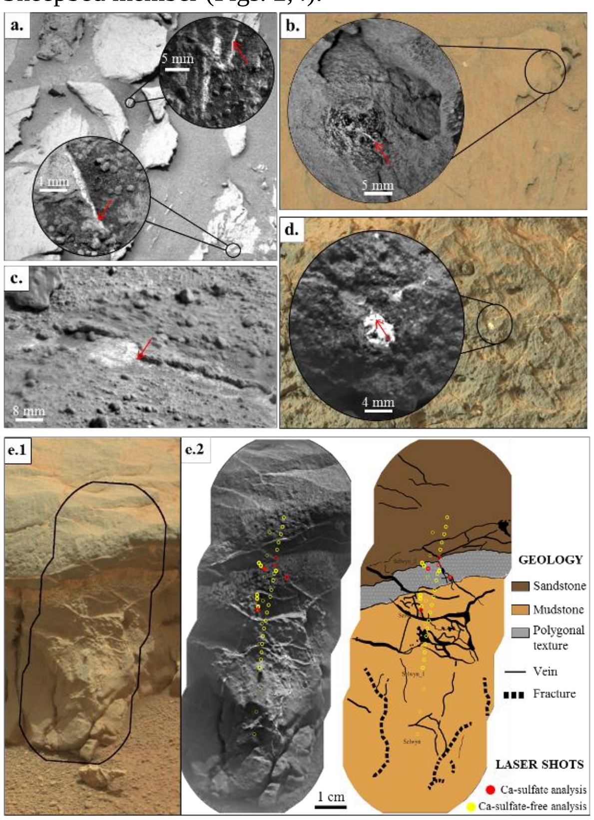

Figure 3 : Ca-sulfates detected by ChemCam (red arrows and circles) within (a) the Shaler member, (b & d) the Point Lake member, (c) on sol 407, (e) at the Sheepbed and Gillespie members interface. Close-ups are RMI images; backgrounds are MastCam (b,d, e.1), and NavCam images (a).

At the outcrop-scale, vein infilling occurs primarily within broadly planar fractures. Sulfate filled fractures are visible in a variety of lengths (1≤ x ≤60 cm), and are observed to penetrate up to tens of cm of vertical section. Where visible, changes in fracture orientation occur abruptly.

Discussion and perspectives : We interpret the assemblage of veins crossing the sediments as the result of a fluid circulation inside fractures, this Ca-sulfates infill being a late-diagenetic phase, postdating the sedimentation and partial cementation of the ~5 m thick YB sedimentary formation.

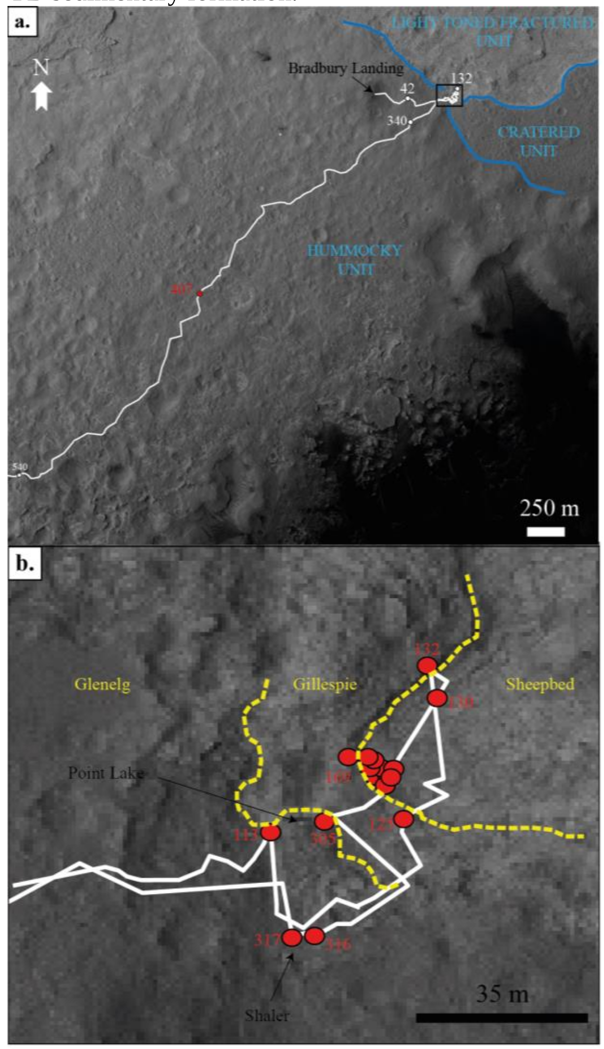

Figure 4 : distribution of the Ca-sulfates targets analyzed by ChemCam (red dots), along the Curiosity route (white line). Numbers indicate the corresponding sol.

Further sulfates detections are expected at least at the base of the Mount Sharp, where CRISM data point towards the presence of sulfates, locally associated with clays **[11]**.

References : [1] Maurice *et al.*, Space Sci. Rev. 170, 95-166, 2012. **[2]** Wiens *et al.*, Space Sci. Rev., 170, 167-227, 2012. **[3]** Le Mouélic *et al.*, Icarus, submitted. **[4]** McLennan *et al.*, Science, 2013. **[5]** Nachon *et al.*, EPSC 2013-534. **[6]** Nachon *et al.*, JGR, submitted. **[7]** Wiens *et al.*, Spectrochim. Acta B, 2013. **[8]** Grotzinger *et al.*, Science, 2013. **[9]** Vaniman *et al.*, Science, 2013. **[10]** Mangold *et al.*, JGR, submitted. **[11]** Milliken *et al.*, Geophys. Res. Lett., 2010.