

CHEMICAL COMPOSITION AND TEXTURE OF COOPERSTOWN OUTCROPS IN GALE CRATER AS SEEN BY CHEMCAM ON CURIOSITY. L. Le Deit¹, N. Mangold¹, M. Nachon¹, V. Sautter², S. Schröder³, C. Fabre⁴, S. Maurice³, R. Wiens⁵, R.B. Anderson⁶, O. Forni³, O. Gasnault³, R. Jackson⁵, S. Le Mouélic¹, E. Léwin⁷, P.-Y. Meslin³, W. Rapin³, ¹LPG-Nantes, France (Laetitia.Ledeit@univ-nantes.fr), ²LMCM, MNHN, Paris, France, ³IRAP, Toulouse, France, ⁴G2R, Nancy, France, ⁵Los Alamos National Laboratory, USA, ⁶USGS, Astrogeology Science Center, Flagstaff, USA, ⁷ISTerre, Grenoble, France.

Introduction: The NASA's Mars Science Laboratory (MSL) rover Curiosity reached its second waypoint (informally named Cooperstown) along its way to Mount Sharp on sol 438. Here, we report our first results from the ChemCam instrument, which combines a Laser-Induced Breakdown Spectroscopy (LIBS) instrument [1, 2] and a Remote Micro-Imager (RMI) [3].

Geological setting: Cooperstown (-4.6°N, 137.4°E) is a topographic depression located at -4480 m in elevation. It is associated with the "ridged unit", which is topographically above the Yellowknife Bay Formation (YKB) investigated during the first phase of the mission [4]. Cooperstown outcrops can be divided in two units: a nearly flat-laying *Lower unit* and a *Upper unit* characterized by a small ledge of a few tens of centimeters high (*Fig. 1*). Three ChemCam targets were acquired in the *Lower Unit*: Delaware_River (sol 440), Cobleskill (sol 440), and Pine_Plains (sol 441); and three in the *Upper Unit*: Rensselaer_ccam (sol 441), Deep_Kill_ccam (sol 441), and Palisades (sol 453) (*Fig. 1*).

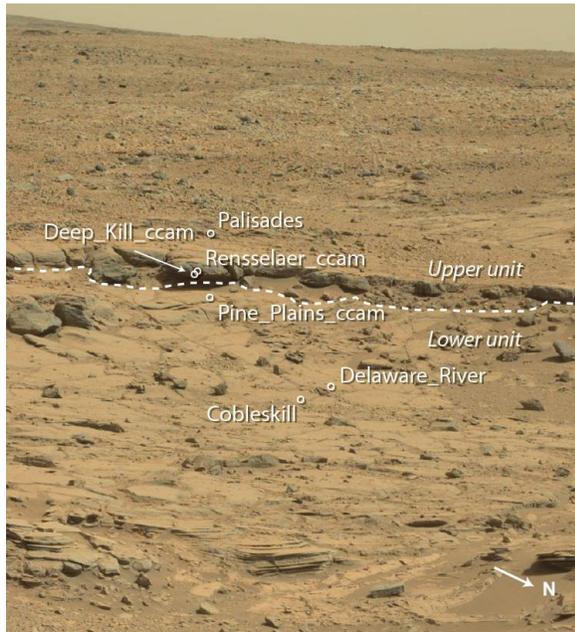


Fig. 1: Cooperstown outcrops and associated ChemCam targets (Mastcam image 0438ML1786002000E1_DXXX). The ledge is located ~30 m from the rover and the portion visible in this image is ~7 m.

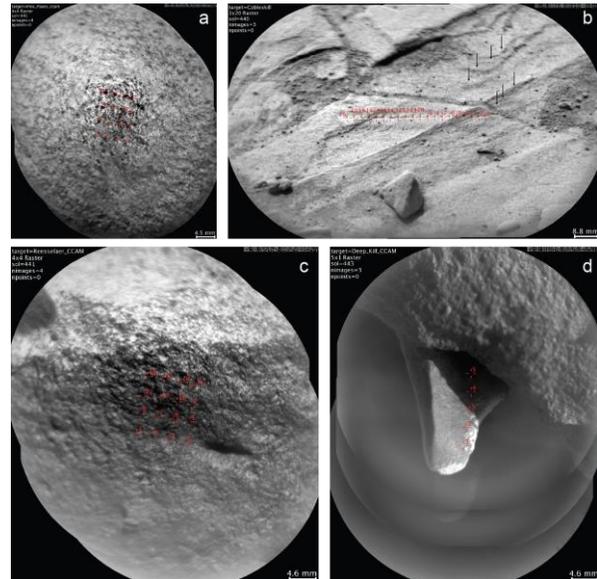


Fig. 2: RMI mosaics of Cooperstown targets. LIBS points are indicated (red). (a) Pine_Plains_ccam. (b) Cobleskill. Possible layers are indicated (black arrows). (c) Rensselaer_ccam. (d) Deep_Kill_ccam.

Texture: Targeted rocks of the *Lower Unit* present a very homogeneous and fine-grained texture (*Fig. 2a-2b*). Cobleskill seems to be finely layered (*Fig. 2b*, arrows), which would suggest that the layered outcrops in the foreground in *Fig. 1* are part of the *Lower Unit*. The *Lower Unit* outcrops appear soft, poorly consolidated, and correspond to siltstone or mudstone. The *Upper Unit* rocks are coarser-grained than those of the *Lower Unit* (*Fig. 2c*). They correspond to well-cemented pebbly sandstones containing floating clasts, like the target Deep_Kill_ccam (*Fig. 2d*).

Chemical composition: Cooperstown targets (CPT) have a basaltic-like composition with ~40-48 wt% SiO₂, ~17-19 wt% FeOT, and ~6-7 wt% CaO according to Partial Least Squares (PLS) modeling. Pine_Plains_ccam and Rensselaer_ccam targets correspond to different stratigraphical units and present a nearly similar composition in major elements (*Fig. 3a, 3c-3d*). Cobleskill displays higher proportions of alkali elements (Na and K) and Al than the other CPT suggesting a more felsic composition (*Fig. 3a, 3c-3d*).

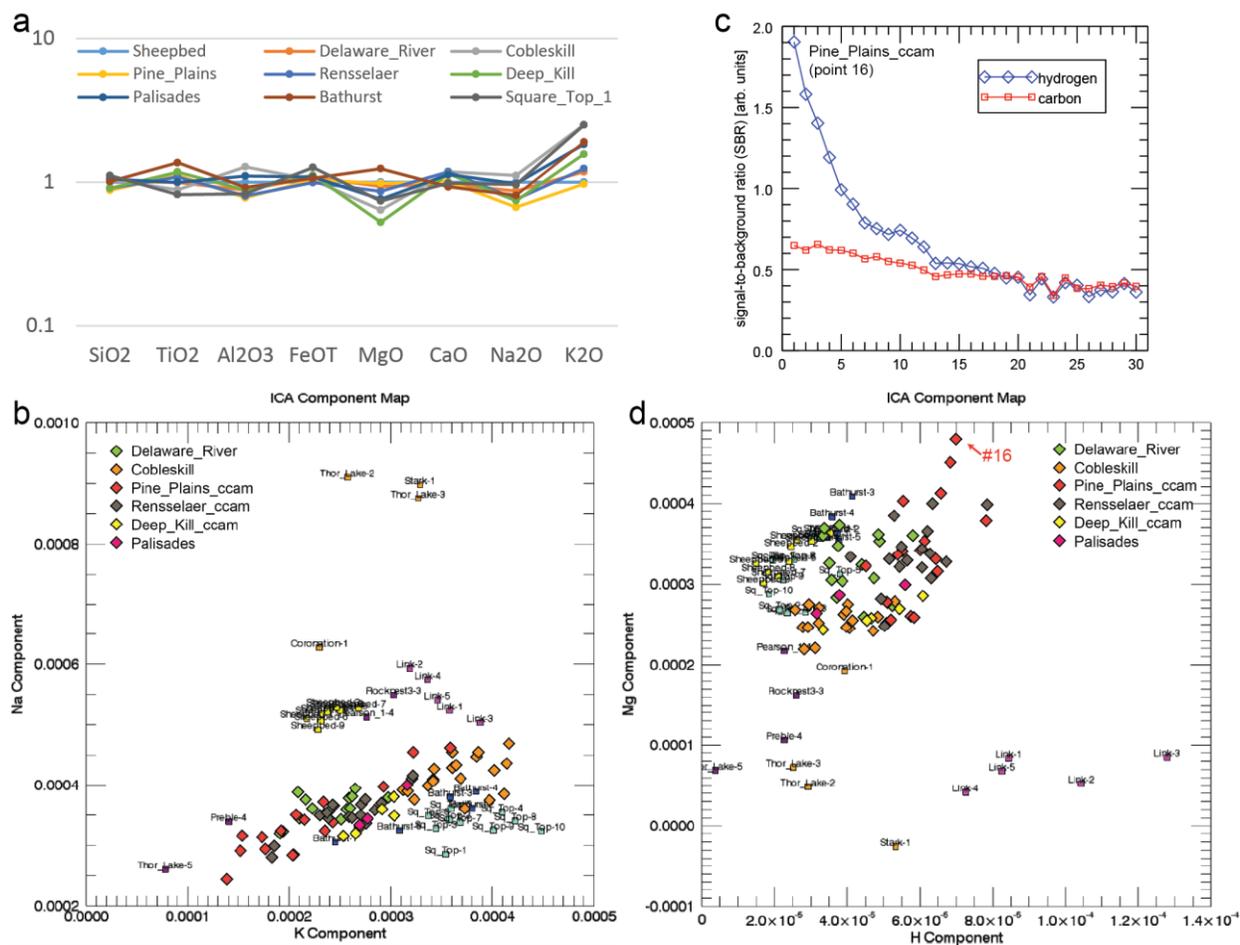


Fig. 3: Chemical composition of ChemCam Cooperstown targets compared to reference targets. (a) Average major-element compositions of Cooperstown, Bathurst, and Square_Top_1 (Kimberley) targets normalized to Sheepbed (Wernecke) target determined by PLS. (b) ICA score plot of K component versus Na component. (c) Shot-to-shot H and C signal to background ratios of Pine_Plains_ccam (point 16). H is present at depth. (d) ICA score plot of H component versus Mg component.

In general, CPT present an average composition close to the Yellowknife Bay (YKB) composition, but with significant differences (**Fig. 3a**). CPT compositions are also close to those of Kimberley targets (KT), which are currently under investigation since sol 576. CPT and KT have higher proportions of K on average than YKB rocks (**Fig. 3a**). An Independent Component Analysis (ICA) indicates that CPT and KT present a K/Na ratio close to that of Bathurst, and different from Sheepbed and the conglomerate Link (**Fig. 3b**).

Hydrogen is present in all CPT, which indicates the presence of hydrous minerals [6], probably mixed with cements (e.g., **Fig. 3c**). Some points in Pine_Plains_ccam and Rensselaer_ccam targets have both high H and Mg emissions, suggesting the presence of Mg-rich hydrated phases (**Fig. 3d**). This characteristic is also observed for Darwin waypoint conglomerates [7].

Conclusion: Cooperstown outcrops are characterized by basaltic-like compositions with significant hydration and distinct composition from the fluvio-lacustrine sediments encountered at Yellowknife Bay [4]. Further investigation of their chemical composition, texture, and geological context will be conducted in order to further constrain their origin and relationships.

References: [1] Wiens et al. (2012) *Space Sci. Rev.*, 170, 167-227. [2] Maurice et al., (2012) *Space Sci. Rev.*, 170, 95-166. [3] Le Mouélic et al., *Icarus*, in review. [4] Grotzinger et al. (2013) *Science*, 10.1126/science.1242777. [6] Schröder et al., *Icarus*, submitted. [7] Mangold et al., this meeting.

Acknowledgement: This work is supported by the Centre National D'Études Spatiales (CNES), France and by the NASA Mars Program Office.