THE POTASSIC SEDIMENTARY ROCKS IN GALE CRATER, MARS AS SEEN BY CHEMCAM ONBOARD CURIOSITY.

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Introduction: The Mars Science Laboratory (MSL) rover Curiosity encountered potassic sedimentary rocks along its traverse to Mount Sharp. Those rocks are primarily located in two geological units: a light-toned topographically variable, or “Rugged unit”; and overlying light-toned striated rocks forming a “Striated unit” [1]. They have been primarily analyzed by the ChemCam instrument that combines a Laser-Induced Breakdown Spectroscopy (LIBS) instrument [2, 3] and a Remote Micro-Imager (RMI) [4] at two waypoints informally named Cooperstown (sols 438 to 453) and Kimberley (sols 576 to 632). The acquisition of more than 50 ChemCam rocky targets at those two locations provides a good sampling for analyzing the spatial and stratigraphic compositional variability within the Rugged and the Striated units. Here, we report a synthesis of the chemical composition of the potassic rocks as seen by ChemCam according to their stratigraphic unit and facies at Cooperstown and Kimberley.

Stratigraphy and rock facies: Cooperstown (-4.62°N, 137.42°E) is a topographic depression located between -4495 m and -4493 m in elevation. It is associated with the Rugged unit, which is topographically above the Yellowknife Bay Formation (YKB) investigated during the first phase of the mission [1]. The Cooperstown formation can be subdivided into two members: a nearly flat-laying “Pine_Plains member” corresponding to fine-grained sandstones; and an overlying “Rensselaer member” characterized by a ledge of well-cemented pebbly sandstones containing float clasts.

Kimberley (-4.64°N, 137.4°E) is an area between -4484 m and -4479 m in elevation marked by the presence of three mounds (Fig. 1A). The Kimberley formation includes seven members, which are in stratigraphic order: the basal Point_Coulomb member constituted of breccio-conglomerates analyzed by ChemCam on sol 550 in the Violet Valley; the Liga member made up of planar-bedded very coarse sandstones containing granules; the Square_Top member corresponding to south-dipping faintly-laminated sandstones; the Dillinger member containing cross-stratified sandstones in which Curiosity drilled; the butte-forming massive sandstones of the Mt. Remarkable member; and fine-grained resistant boulders possibly related to the Hummocky Plains unit, or “Beagle member” (Fig. 1B) [5, 6]. The Dillinger and Mt. Remarkable members are associated with the Rugged unit and are located stratigraphically between the Hummocky Plains unit and the Striated unit. The Square_Top and Liga members are associated with the Striated unit (Fig. 1B).

Chemical composition: The sedimentary rocks of the Cooperstown and Kimberley formations have a basaltic-like composition according to Partial Least Squares (PLS), a multivariate regression method [7] (Fig. 2A). Those sedimentary rocks primarily differ in composition from the previously encountered...
sedimentary rocks in YKB or the conglomerates in Darwin [8] by their significantly higher content in K$_2$O not coupled to higher Na$_2$O, except for the Point_Coulomb member (Fig. 2B). The Dillinger and Mt. Remarkable members (Rugged unit at Kimberley) especially display the rocks most enriched in K (Fig. 2A). An Independent Component Analysis (ICA) [9] reveals that the Na/K ratio of the Dillinger and the Mt. Remarkable members is much lower than for the other members (Fig. 2C). The K-feldspar and illite clays identified in the Dillinger member by CheMin [10] are consistent with this enrichment in K. Overall the K abundance gradually increases between the lower Stratiﬁed unit (Liga and Square_Top members) and the Rugged unit (Dillinger and Mt. Remarkable members) in the Kimberley formation. The Rugged unit exposed at Kimberley shows a higher K content than at Cooperstown.

Hydrogen is present in all potassic rocks analyzed by ChemCam [12], which is consistent with the presence of hydrous minerals such as clays [10]. ChemCam analyses also reveals high contents in F [13], Li, Mn [14], Zn [15] and Ni in the Kimberley formation, and in Mn in the Cooperstown formation.

**Interpretation and discussion:** The sedimentary rocks encountered at Cooperstown and Kimberley differ in composition from those in YKB by their enhanced K content. Assuming a fluvial origin of those sediments [5], the progressive shift to higher K from Cooperstown to Kimberley implies a contribution of a potassic source rock with increasing effect at Kimberley. The increase in K from the lower members to the upper members at Kimberley also suggests a gradual increase of this contribution with time. The origin of this source is currently unknown [16] but could be K-rich intrusions or K-rich ash layers on the Gale rim. The stratigraphical relationships with the other sandstones (such as YKB) being unclear, it is not possible to determine if this K-rich source was incised during the overall deposition of fluvial sandstones or the final gasp from a divergence in the fluvial flow type/direction or watershed extent. The presence of F, Mn and Zn in Kimberley rocks also suggest that alteration processes, possibly pre- and post-depositional may have contributed to their enrichment in K.


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