# STRATIGRAPHIC DISTRIBUTION OF VEINS OBSERVED BY THE CURIOSITY ROVER AT GALE CRATER, MARS, AND IMPLICATIONS FOR SUBSURFACE HABITABILITY.

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**Introduction:** Gale crater is the landing site of the Mars Science Laboratory (MSL) NASA mission, where the Curiosity rover has been operating since August 2012. During the mission, which has extended beyond 1500 Sols (martian days), several sedimentary formations have been explored (Figure 1) on the flank of Mount Sharp, a ~5 km thick set of stratified deposits. Here we describe the distribution of mineral-filled veins, that cut through the sedimentary rocks observed along Curiosity's traverse; they were first observed at Yellowknife Bay (Figure 1) **[1]**, and mostly appear to be filled with calcium sulfate phases e.g. **[2]**. These veins record specific fluid circulation in the subsurface that may have contributed to maintaining subsurface habitability on Mars.

**Methods:** In order to constrain which units were affected by vein-forming fluid circulation, we systematically cataloged veins visible in Curiosity's images, and plotted their occurrences within the local stratigraphic context. We used the Curiosity data released regularly from the NASA Planetary Data System (http://pds-geosciences.wustl.edu/missions/msl/), including MastCam images and their geometric characteristics (azimuth, location) as well as the rover localization (coordinates and elevation).

**Observations and Discussion:** We show that light-toned veins are present within the Murray Formation from the most basal (Confidence Hills) **[3]** up to the highest exposed units in released data, representing more than 80 meters in elevation (Fig.1). Light-toned veins are present at the Murray contact with **[**e.g. **4]** and within the Stimson Formation, which lies unconformabily on the Murray Formation **[**e.g. **5]**. At least some of these veins represent a later fluid circulation, occurring after the deposition and lithification of the Stimson sedimentary rocks. Given the distribution of veins, ground water was likely present from the deposition of the Murray Formation through its erosion prior to Stimson Formation deposition, and continuing after its lithification.

The Ca-sulfate mineral phases in these veins record possible evidence of an ancient habitable subsurface environment, where ground water reacting with host rocks might provide a small amount of energy. Sulfate in ancient groundwater could provide a source of energy for reaction with potential organics, and because sulfate reacts slowly, would provide an energy source favorable for heterotrophic activity. However, sulfide minerals, a common by-product of microbial sulfate reduction, have not been identified in association with the sulfate-filled veins.

**Conclusion :** Constraining (a) the formation timing of these veins (e.g. compared to other diagenetic features such as fracture-related halos **[6]**), (b) their compositional variations **[7]** (including the track for sulfides), and (c) their spatial extend will improve our understanding of the original ground waters and their implication for subsurface habitability.

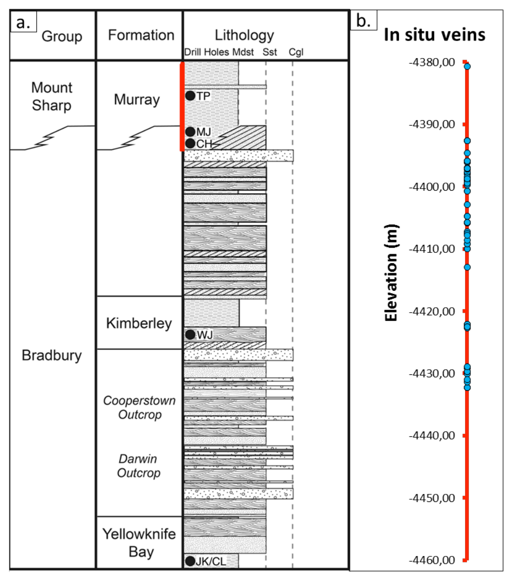


*Figure 1: (b) Light-toned veins (observed in MastCam images) distribution in the Murray Formation, within the stratigraphic column (a, from Grotzinger et al., 2015) of sedimentary deposits encountered at Gale crater by the Curiosity rover up to Sol 1300.*

**References:** [1]Grotzinger J. et al.,(2013)*Science*. [2]Nachon M. et al.,(2014)*JGR Planets*, doi:10.1002/2013JE004588. [3]Nachon M. et al.,(2016)*Icarus*, dx.doi.org/10.1016/j.icarus.2016.08.026. [4]Kronyak R.,(2017)*LPSC* abstract. [5]Banham S. et al.,(2016)*GSA* abstract, Session140. [6] Watkins J. et al.,(2017)*LPSC* abstract. [7]L'Haridon J. et al.,(2017) *LPSC* abstract.