

LOOKING FOR EVIDENCE OF PAST LIFE ON MARS: CLUES FROM VERA RUBIN RIDGE AND GLEN TORRIDON, GALE CRATER, MARS. N. A. Carman¹, E. M. Hausrath¹, E. B. Rampe², P. D. Archer³, C.T. Adcock¹, M. Millan⁴, and J.V. Clark³ ¹UNLV, Las Vegas, NV 89154, carman1@unlv.nevada.edu, ²NASA Johnson Space Center, Houston, TX 77058, ³Jacobs, NASA Johnson Space Center, Houston, TX 77058, ⁴Georgetown University, Washington D.C. 20057

Introduction: Organic biosignatures have a record of up to 3.8 billion years old on Earth in the form of ancient refractory organic matter. [1]. This 3.8Ga time period corresponds to a time of potential habitability on Mars, which could therefore enable a similar detection of ancient life on Mars, if it was present. Examination of organic matter also allows an assessment of both exogenous and endogenous abiotic sources of organic carbon. Exogenous sources of organic carbon include meteorites and interplanetary dust [2-3]. Endogenous sources that were potentially present in the past include hydrothermal environments, organic synthesis in the atmosphere, and life [4-5].

Organic molecules have been previously detected in Gale crater, Mars by the MSL *Curiosity* rover in variable concentrations and compositions [4]. In particular, results from the analysis of the Glen Torridon (GT) samples indicated the presence of S-bearing organic compounds including aliphatics: dimethylsulfide (DMS) (or ethanethiol), dithiapentane and aromatics: thiophenes, dithiolane and trithiane [7]. Vera Rubin Ridge (VRR) is believed to be stratigraphically equivalent to parts of the GT trough, but has likely encountered multiple fluids with different pH, salinity and temperatures during late diagenesis [8]. The comparison between these two locations therefore allows an examination of the impacts of diagenetic conditions on the preservation of organic matter, and the potential identification of signatures of high organic preservation potential.

To assess possible signatures of organic preservation potential, we are examining the geochemical and Evolved Gas Analysis (EGA) data of samples from the Vera Rubin ridge (VRR) and Glen Torridon (GT) sites. We are focused on (1) H₂ and SO₂, because low-temperature SO₂ release may indicate sulfide minerals [9], and H₂ is a reduced gas and (2) Fe and Mn concentrations because they can be valuable indicators of oxidation state [10].

Methods: To observe S-containing gas release from relevant sulfide minerals, we synthesized rambergite (MnS) using protocol B of [11] and purchased alabandite (MnS) from Minerals Unlimited. A Proto AXRD Powder Diffraction System was used to confirm the structure of these two minerals.

Using an agate mortar and pestle, rambergite and alabandite were each powdered before being sieved to <150-μm. A Setaram Labsys EVO connected to a

Pfeiffer ThermoStar mass spectrometer at NASA JSC, configured to operate similarly to SAM on MSL, was used to measure evolved gases from the manganese sulfide minerals. We then compared the evolved gases from the manganese sulfide minerals to evolved gases from Gale crater samples [9] and examined Alpha Particle X-ray Spectrometer (APXS) data for Fe and Mn concentrations for comparison.

Results:

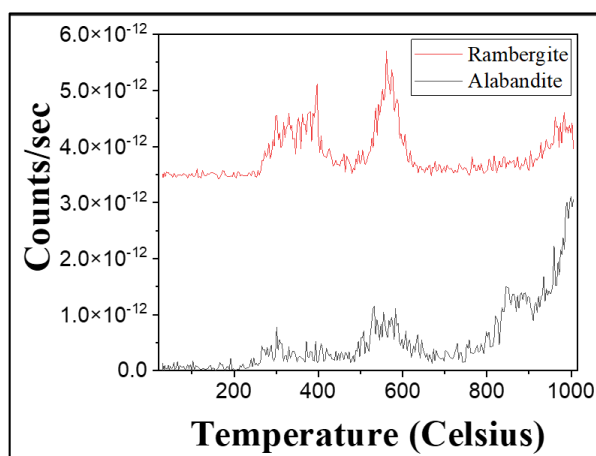


Figure 1: SO₂ (m/z 66) concentration from laboratory EGA of rambergite and alabandite.

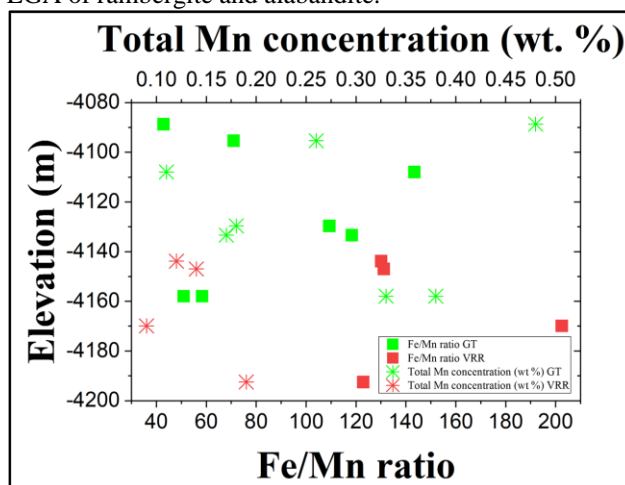


Figure 2: Fe/Mn ratios in VRR are generally higher than those in GT, and Mn concentrations are generally higher in GT than in VRR.

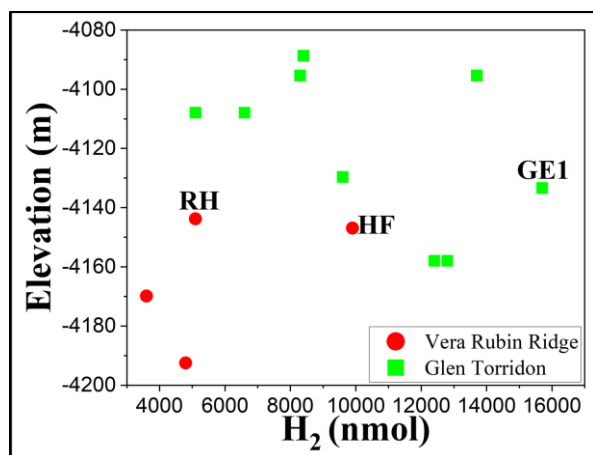


Figure 3: Total H₂ concentration evolved from samples from VRR and GT.

Discussion and Conclusions: EGA analyses of the manganese sulfide minerals rambergite and alabandite indicate that SO₂ is evolved within the same temperature range as from samples from the GT and VRR regions (350°C-575°C, Figure 1). This result is therefore consistent with the potential presence of Mn sulfides in the samples measured by SAM in Gale crater, Mars.

Mn concentrations are generally higher in GT than in VRR, and Fe/Mn ratios are generally higher in VRR than in GT (Figure 2). These results are consistent with the potential presence of Mn sulfides in GT, which would increase the Mn concentration and decrease the Fe/Mn ratio. On Earth, higher concentrations of Mn have also been observed in reducing lacustrine environments [22-23].

GT samples also generally show higher concentrations of H₂ than samples from VRR (Figure 3). The presence of this reduced gas may also be a potential indicator of reduced conditions that may contribute to the preservation of organic matter. Work is ongoing to determine the releases at each temperature for H₂, SO₂, CS₂, and COS; examine the variability of different samples for evidence of signatures of organic preservation potential; and perform geochemical modeling of the past environments present at GT and VRR to better understand the processes occurring in these environments that may preserve organic matter.

Acknowledgments: This work was supported by a grant from the Nevada Space Grant Fellowship and the UNLV TTDGRA. We would like to acknowledge NASA's Planetary Data System Geoscience Node (<https://pds-geosciences.wustl.edu/missions/msl/sam.htm>).

References: [1]Suess, (1979) *GCA* 43, 339-352. [2]Flynn, (1996) *EMP* 72, 469-474 [3]Steele et al. (2012) *Science* 337, 212-215 [4]Chyba and Sagan (1992) *Nature* 355, 125-132. [5]Miller (1998) *CUP*. [6]Eigenbrode et al. (2018) *Science* 360, 1096-1101. [7] Millan et al. (2021) *LPSC*, 52, #2548. [8] Rampe et al. (2020b) *JGR*, 125, e2019JE006306. [9]McAdam et al. (2020) *JGR*, 125. [10]Yen et al. (2010) *LPSC* 41, #2546. [11] Michel et al. (2006) *ACS* 18, 1726-1736. [12]SAM Science Team (2020) *PDS GEO Node*. [13]Mahaffy et al. (2012) *SSR*, 170, 401-478. [14] Glavin et al. (2013) *JGR*, 118, 1955-1973. [15] Archer et al. (2014) *JGR*, 119, 237-254. [16] Sutter et al. (2017) *JGR*, 122, 2574-2609. [17] Wong et al. (2020) *JGR* 125. [18] Wilhelm et al. (2019) *LPSC* 50, Abstract # 2597. [19]Boyle (2002) *ES*. [20]Naeher et al. (2013) *CG* 352, 125-133. [21]Scholtysik et al. (2020) *Biogeochemistry* 151, 313-334. [22] Schaller and Wehrli (1996) *AG* 2, 359-378. [23]Fukumoto et al. (2015) *QI* 374, 15-33.