DETECTING OXALATE MINERALS ON MARS USING CRISM AND IN-SITU SPECTROSCOPY. L. M. Aaron1, A. Steele2, S. Shkolyar2, K. Seelos3, C. Viviano3, D. Applin4, E. Cloutis4, 1Johns Hopkins University, Department of Earth and Planetary Science (Laaron2@jhu.edu), 2Carnegie Geophysical Laboratory, 3Johns Hopkins University Applied Physics Laboratory, 4Department of Geography, University of Winnipeg, Winnipeg, Canada.

Introduction: Three and a half billion years ago, Mars was a water-rich planet just like Earth [1]. We know this by looking at landforms such as dried up riverbeds, valleys and channels. Like Earth, Mars obtained its water from degassing volcanoes as part of a much more active, water cycle than today [2]. It is hypothesized that Mars must have had a carbon dioxide-rich atmosphere that interacted with liquid water at the surface, and therefore the surface should contain significant amounts of carbonates [1]. However, only relatively limited occurrences have been observed. One explanation for this may be that carbon dioxide was sequestered in another way. Through alternative processes, like electrochemical reduction reactions [3], carbon dioxide could have formed minerals known as oxalates in lieu of carbonates [4].

The aim of this research is to understand the implications of three questions: Has the postulated missing carbon dioxide on Mars been incorporated into oxalate minerals in stead of carbonates? If so, is it possible that the Mar-tian oxalates adsorbed into iron-oxides on the surface? Are oxalates located where limited amounts of carbonates have been detected?

Oxalates are organic minerals that form through the process of combining dicarboxylic acids (oxalic acid) with naturally occurring metals. On Earth, their formation and presence is widespread in nature, quite commonly in plants, algae, and bacteria, just to name a few. Because their degredation is dependant on biological processes, they are more common in extreme desert regions, like the Atacama [5]. On Mars, oxalate minerals can result from oxalic acid carried on carbonaceous chondritic meteorites and exposed to oxidative diageneis on the surface. Pyrolysis experiments from Viking, Phoenix, and MSL have produced results that have been re-interpreted as a possible detection of oxalate minerals by [6]. These experiments lead to the possibility of a widely distributed presence of oxalate minerals.

Hydrated oxalates have prominent absorptions within the visible and near-infrared near 1400, 1900, 2500 and 3000 nm, with slight variations depending on the type of oxalate. This paper will focus on the spectral properties of the oxalate minerals glushinskite, whewellite, and humboldtine (Fig. 1). Spectral research has been done [7] on oxalate samples before and after being placed in a simulated Martian environment to collect their spectral signatures for comparative analysis.

Three locations are ideal for searching for oxalates based on the presences of carbonates, abundant iron-oxide (leading to the adsorption of oxalates), and previous possible detections of oxalates by the Phoenix lander. Because of the similarities in formation processes between carbonates and oxalates, locations that contain small traces of carbonates are suitable in determining if the processes resulting in oxalates were due to the introduction of oxidation during the process of becoming a carbonate. Interactions between particle surfaces and organic matter containing dicarboxylic acid groups influence many processes un natural waters and soils, making iron-oxide rich areas suitable for analysis.

Methods: Mineral spectral detection parameters were created at Johns Hopkins University Applied Physics Laboratory (JHUAPL) by Christina Viviano to detect hydrated minerals on Mars, such as carbonates, phyllosilicates, and sulfates. Creating new parameters needed to detect organic minerals, by collaborating with Scott Murchie, Christina Viviano, and Kim Seelos at JHUAPL would be necessary to continue with this research. This work has the potential to add improvements to the CRISM Analysis Tool (CAT).
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**Results:** The custom parameters used for the carbonate-rich CRISM image made it possible to highlight minerals containing an absorption at 1983 nm. This band depth is indicative of Mg(C₂O₄)₂(H₂O). The custom parameter will increase the likelihood of an oxalate absorption being detected and not mistaken for other minerals. A small signal was detected around the outer parts of the crater in the location that previously identified the two carbonates. If oxalic acid were to form on Mars, it may bond with Fe, Mg, or Ca and so may be found in association with carbonates.

A second location containing the iron-oxide absorptions utilized the custom parameter of 1993 nm, which is the signal common for Fe²⁺(C₂O₄)₂(H₂O). No signals were detected that would indicated the presence of this mineral. However, a lack of detection is not the absence of evidence. Further changes to the custom parameter values used to analyze the images can be made to optimize for oxalates.

**Discussion:** The custom parameters used for the carbonate-rich example area made it possible to highlight minerals containing an absorption at 1983 nm, suggestive of Mg(C₂O₄)₂(H₂O). If oxalic acid were to form on Mars, it would bond with Fe²⁺, Mg, or Ca. Oxalates have a clear association with life on Earth, forming in environments that are conducive to Martian climate [5]. Because of this, they have the potential to preserve past and present life on Mars. They may also play a role in the geochemical processes on Mars due to their ability to preserve organic carbon and nitrogen at the near surface resulting in the formation of CH₄ and OH via hydrothermal and photochemical reactions. Ultimately, since meteoritic impacts would have occurred during the same period when Mars was a hydrated planet, this research could lead to the detection of finding past life on the surface of Mars.

**Future Work:** Analysis will continued to be performed on the three locations on Mars from an orbital and landing scale, if applicable. If not applicable, two additional sites have been selected based on possible oxalate findings at the Viking 2 landing site and Gale Crater for in-situ analysis. In addition to the Martian surface, locations that exhibit similar climate to Mars have been selected as a analogue site study using both remote sensing and in-situ analysis. Ultimately, this research could lead to the use of other applications besides ENVI to optimize data collection from multiple images in a mosaic.

**Images:**

Images from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [7] on board the Mars Reconnaissance Orbiter (MRO) were used to look for oxalate minerals. Hyperspectral visible-near infrared CRISM data were processed using the CRISM Analysis Toolkit (CAT) [8], to compensate for atmospheric and photometric effects, as well as to calculate parameters that summarize scene spectral content [9]. However, CAT does not contain parameter specific to the detection of oxalate minerals, or a comparison laboratory-derived spectral library for oxalate minerals. Instead, a visible-infrared spectral library was provided by D. Applin and E. Cloutis, obtained from standard oxalate minerals and mixtures containing carbonates, Fe-oxides, and other oxalate minerals. The reflectance spectra spanned the 0.35-20 micron range.

Existing spectra parameters BD1400, BD1900r, and BD3000 are used in an red-green-blue (RGB) combination to highlight the location of potential oxalate. However, this combination also highlights many other hydrated minerals; a custom parameter formulation was therefore developed to encode an absorption at 1983 nm that is more specific to oxalates. We applied this to a CRISM image with carbonate-bearing gullies [10] in an unnamed crater approximately 61 km across located at 37.07°S, 178.23°W.

**References:**