APPLICATIONS AND LIMITATIONS OF SYNCHROTRON X-RAY RADIATION METHODS IN THE STUDY OF JAROSITE IN MARTIAN METEORITES. J.K. Hong[1], C.D.K. Herd[2], R.G. Cavell[3], [1,2]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB, Canada, jkhong1@ualberta.ca, [3]Department of Chemistry, University of Alberta, Edmonton, AB, Canada.

Introduction: The recent discovery of the mineral jarosite ($KFe_3(OH)_6(SO_4)_2$) in the Miller Range (MIL) 03346 martian meteorite [1,2], has provided an opportunity for researchers to study aqueous alteration minerals in the laboratory. Jarosite is a hydrous sulfate mineral that forms from acidic, oxidizing water [3]; assuming it formed on Mars, this discovery is strong evidence for surface water on Mars at one time in the past. Our study aims to use a combination of various analytical techniques to characterize the chemical and structural properties of the jarosite in order to determine the depositional environment and conditions of its formation.

Due to the rare nature of martian meteorite samples, the need to explore non-destructive analytical methods is necessary. The high resolution spot size offered by modern synchrotron facilities is ideal for the study of the micron-scale jarosite veins occurring in the MIL 03346 martian meteorite. This technique offers a non-destructive way to characterize this mineral in situ, and allows for an opportunity to see whether such analyses can provide insights into the origin of the jarosite. Using synchrotron radiation, we have conducted XRF and XRD analyses on the MIL 03346 specimens to determine the limitations of these methods in the study of martian meteorites and analogue type investigations.

Methods: In this study, two MIL 03346 specimens (sections 165 and 190) and two terrestrial jarosite samples were analyzed using the same techniques. Specimens were first studied in detail using a Cameca SX-100 electron microprobe at the University of Alberta. Backscattered electron images were taken to locate the areas of aqueous alteration within the two MIL 03346 specimens. X-ray mapping of K, Fe, and S was done to locate the jarosite and quantitative analysis on these areas was carried out. Figure 1 shows an area of section 165 that was studied using this technique. Two light sources, the Advanced Photon Source (APS) at Argonne National Laboratory and the Canadian Light Source (CLS) were used to provide X-ray fluorescence and X-ray diffraction analyses. The beamlines used at both light sources are capable of spot sizes of 3-5 microns. The purpose of XRF was to determine the minor and trace element concentrations in both the terrestrial and martian jarosite samples. Trace elements and REE data for terrestrial jarosite has been shown to be a valuable recorder of fluid interactions [4]. Direct comparison with the jarosite in the meteorite will show if similarities to terrestrial occurrences exist, and if so, how the distribution of trace elements fit with current models of the martian paleoenvironment. If a significant difference from terrestrial occurrences is observed, the data would lend support to a pre-terrestrial origin. XRD analysis was used to study the structural properties of the jarosite, in order to determine, at minimum, the degree of crystallinity, and also provide evidence for element substitution and vacancies within the structure [5].

Results: *Electron Microprobe*. BSE images with K+Fe+S X-ray maps superimposed show distinct areas of alteration occurring in both the veins cutting augite (Figure 1) and the neighboring mesostasis. Areas of alteration vary from a few microns in width in the veins to larger spots nearly 100 microns wide within the mesostasis. Elemental oxide abundances of the jarosite in the MIL 03346 meteorite are similar to the terrestrial samples.

X-ray Fluorescence. XRF mapping of the two terrestrial samples only shows measurable abundances of As. The multivalent elements V, Ce, and Eu, which are able to trace changes in pH and fluid chemistry [4], either fall below the limits of the detector or are lost in the noise of the abundant Fe signal. The MIL 03346 specimens also show no detectable trace elements of interest. XRF maps of K and Fe taken in the same jarosite alteration areas are consistent with X-ray maps from the electron microprobe.

X-ray Diffraction. XRD mapping of the MIL 03346 specimens provided diffraction peak images of the jarosite. Peaks in most areas were not clear although select areas in the wider veins showed distinguishable peaks. More involved processing of the XRD results is in progress.

Discussion: The initial studies using the electron microprobe showed that the jarosite in the MIL 03346 martian meteorite is common but not widespread throughout the entire specimen. The distribution of the jarosite precipitate provides evidence that the K and S were mobilized by outside waters flowing through the host rock during jarosite formation. The use of synchrotron radiation to obtain quantitative XRF trace element data of the martian meteorites was not successful due to the overshadowing Fe signal in the jarosite. Attempts to eliminate this issue using an Al pass filter were not enough to attenuate the Fe signal. XRD images of the jarosite diffraction peaks were difficult to obtain. Possible reasons for this could be that the beam was too large to generate a clear signal on the small areas of alteration or that the jarosite itself is not crystalline enough. This study shows that even with the recent advancements in modern synchrotron capabilities, the application of these techniques to analyze jarosite within the martian meteorites is limited and requires further experimentation.

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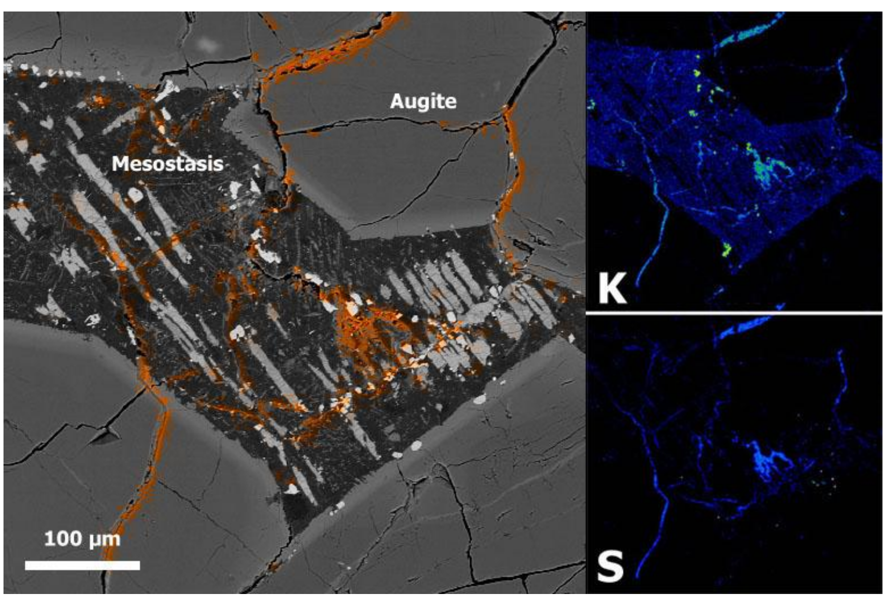

Figure 1: Composite image of an area within MIL 03346, section 165. Jarosite (shown in false color orange). X-ray maps on the right side show abundances of K and S (brighter areas represent higher concentrations).