ASSESSING THE LONGWAVE ULTRAVIOLET FLUORESCENT CHARACTERISTICS OF MARTIAN METEORITES. M.E. Minitti[1] and T.J. McCoy[2], [1]Applied Physics Laboratory (Johns Hopkins University, 11100 Johns Hopkins Rd., Laurel, MD 20723, michelle.minitti@jhuapl.edu), [2]Dept. of Mineral Sciences, National Museum of Natural History (Smithsonian Institution, Washington, DC 20560-0119).

Introduction: NASA's Mars Science Laboratory (MSL) Curiosity rover, en route to Mars, carries a suite of 10 instruments that will study the environments captured by the stratigraphy and mineralogy in Gale Crater and constrain the habitability of those environments [1]. One of these instruments is the Mars Hand Lens Imager (MAHLI), which is located on the instrument turret at the end of the Curiosity's arm. MAHLI is a color, focusable camera capable of imaging Martian materials at working distances from 22.5 mm (spatial resolution 13.9 μm/pixel) to infinity [2]. MAHLI also possesses four white light and two longwave (365 nm) ultraviolet (UV) LEDs intended to enable observations of Martian surface materials under unique illumination conditions. Given that little is known about the fluorescence characteristics of Martian surface materials, the UV illumination capability of MAHLI exists for exploratory purposes. Indeed, the only previous in-situ study of Martian surface materials under UV illumination (360-390 nm), carried out on Martian soils by the Optical Microscope on the Phoenix mission, did not positively identify luminescent particles [3]. MAHLI will have access to a wider range of Martian surface materials than Phoenix; thus, MAHLI can potentially benefit from further study of the fluorescence characteristics of Martian materials. The goal of this study is to provide MSL with pre-landing "ground truth" related to UV-induced fluorescence using known Martian samples: the Martian meteorites.

Samples and Analytical Techniques: This initial survey of UV-induced fluorescence in the Martian meteorites involved the study of four Martian meteorite thin sections loaned by the Arizona State University Center for Meteorite Studies: Lafayette, Los Angeles, Nakhla and Zagami.

The sections were first surveyed for phases that fluoresce at 365 nm, the same wavelength as the MAHLI UV LEDs. The fluorescence analyses were carried out in the Zeiss LSM 510 META confocal microscope at the Arizona State University Biodesign Institute. The fluorescence observations did not require the confocal mode of the microscope; rather, it was utilized in epifluorescence mode. A mercury lamp served as the source of the 365 nm illumination. A tungsten lamp was utilized for transmitted light imaging of the sections, which provided context for the fluorescence observations and images comparable to those obtained in binocular and electron microscopes. The lowest power objective available (10x) yielded images with a field of view ~1.5 mm across (Figure 1), significantly smaller than the ~22 mm width of MAHLI's field of view at its closest working distance (22.5 mm).

The regions of the studied sections that exhibited fluorescence that appeared correlated with specific mineral grains were then analyzed in the FEI Nova NanoSEM 600 scanning electron microscope at the Smithsonian Institution Department of Mineral Sciences. We created backscattered electron (BSE) images and elemental x-ray maps of the fluorescent areas to constrain the source of the fluorescence. We also obtained qualitative chemical analyses of grains of interest using the energy dispersive spectroscopy (EDS) detector. Analyses were made with a 10 kV accelerating voltage, ~5 nA beam current, and ~5 μm spot size.

Results: The thin sections studied consistently exhibit fluorescence originating from epoxy. The epoxy (and mineral) fluorescence is transmitted through fractures in the samples, making it challenging to distinguish mineral-based fluorescence (e.g., Figure 1a).

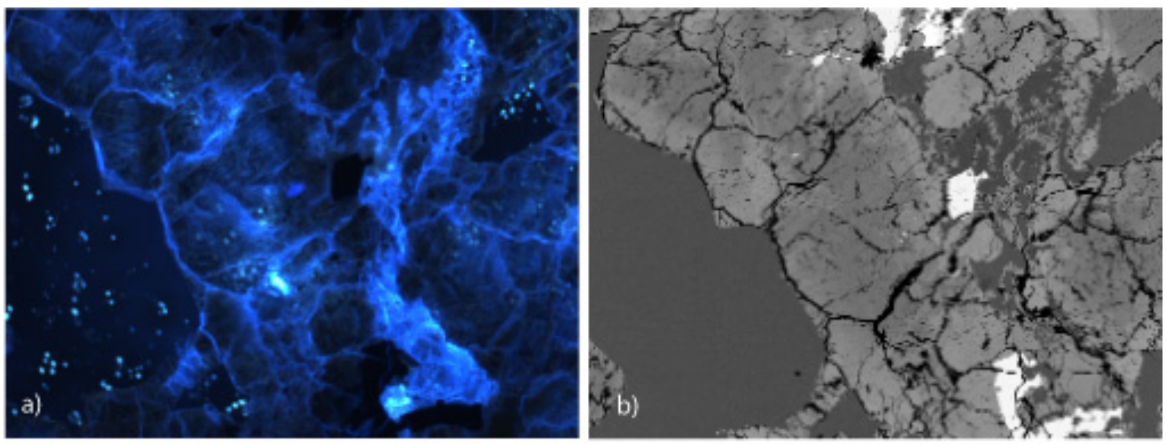
In the Zagami thin section, however, coherent fluorescent areas are readily observed that can be correlated with individual mineral grains (Figure 1). Figure 1a shows a representative example of UV-induced fluorescence originating from an isolated mineral. The compositional contrast of the fluorescent mineral is low enough to make it difficult to identify in BSE images (Figure 1b). However, elemental x-rays maps are capable of identifying the general composition and extent of the fluorescing mineral (Figure 1c). In the case of Zagami, the fluorescent phase is phosphate. The presence of Na in the EDS analyses of the fluorescent phosphates indicates that they are whitlockite rather than apatite, both of which are known in Zagami [4,5].

The only other potential fluorescent signal observed in the meteorites originated from plagioclase in Lafayette. Confirmation of this observation will require further analyses. In the limited area of the Los Angeles and Nakhla meteorites represented by the studied thin sections, no mineral-related fluorescence was observed.

This study demonstrates that 1) known Martian minerals fluoresce under 365 nm illumination, and 2) the UV illumination capability of MAHLI has the potential to identify unique, water-related minerals in Martian materials.

Future Work: We intend to follow up this initial survey by looking for further examples of mineral fluorescence in additional Martian meteorites. In particular, we will investigate if fluorescence is a consistent characteristic of Martian phosphates. We plan to conduct a similar fluorescence survey of meteorites at spatial resolutions appropriate to MAHLI observations. We will also support our meteorite investigations by looking for the occurrence and significance of UV-induced fluorescence in Martian analog minerals (e.g., sulfates, opal) that are available in the Smithsonian mineral collection.

References: [1] Vasavada A.R. and the MSL Science Team (2009) *LPSC XL,* Abstract #1441. [2] Edgett K.S. et al. (2009) *LPSC XL,* Abstract #1197. [3] Goetz, W., et al. (2012) *PSS*, submitted. [4] McCoy T.J., et al. (1992) *GCA* 56, 3571-3582. [5] McCoy T.J., et al. (1993) *LPS XXIV,* 947-948.



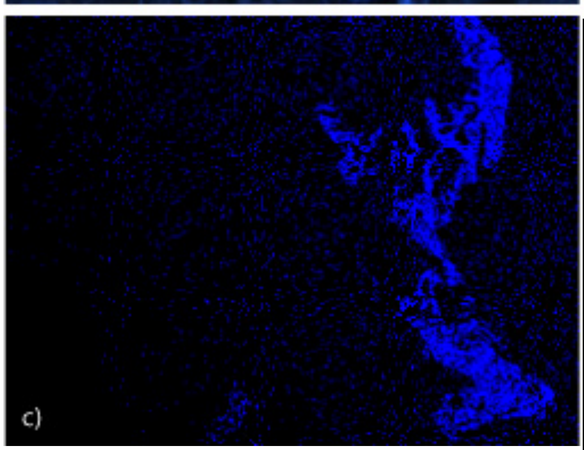


Figure 1: a) UV-induced fluorescence in a region of a Zagami thin section. The fluorescent phase forms a coherent pool vertically across the center right of the image. Image is ~1.5 mm across. b) Backscattered electron image of the same area of Zagami in a). Low compositional contrast makes it difficult to distinguish the fluorescent phase. c) X-ray map of P in the same area of Zagami in a) demonstrating the correspondence between the fluorescent phase in a) and phosphate in Zagami. EDS analyses of the phosphate indicate that it is whitlockite.