ANALYZING NATURAL METEORITE EXTERIORS WITH LABORATORY LIBS FOR COMPARISON TO METEORITES ENCOUNTERED BY CURIOSITY IN GALE CRATER, MARS.

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Introduction: The NASA Curiosity rover has discovered four metallic meteorites in Gale crater, Mars [1, 2, 3]. Two of these meteorites were analyzed by the ChemCam instrument suite, Egg Rock (sol 1505) and Ames Knob (1577), and found to have abundant iron and overall compositions that are consistent with iron meteorites found on Earth [1, 2]. Meteorites found on Earth often have thin fusion crusts or, in the case of iron meteorites, oxidation layers on their surfaces [4]. The composition of these surface materials are frequently not representative of the bulk composition of the meteorite as a whole [5]. Meteorites analyzed in Gale crater may also show evidence of such surface features in LIBS data. To better understand the signatures of natural meteorite surfaces in LIBS data, it is necessary to analyze natural meteorite exteriors in the laboratory. These data may then be compared to LIBS data obtained on Mars to better understand the surface properties of meteorites discovered in Gale crater, which may have important implications for past atmospheric conditions and the weathering history of these materials.

The ChemCam LIBS instrument uses a pulsed laser to ablate small (microgram) amounts of material from targets of interest. Targets are typically interrogated in ~5-10 locations using 30 laser pulses (shots) in each location, for a total of 150-300 analyses per target. For each 30 shot sampling location, each subsequent shot ablates slightly deeper into the sample surface, providing a depth profile of composition. ChemCam samples on Mars are analyzed in situ as they are found, with no sample preparation. Samples on the surface of Mars often have a thin layer of surface dust that is analyzed and removed in the first ~5 shots [6]. If surface features such as coatings and weathering rinds are present, these materials will be also analyzed [7].

Samples: Five meteorite samples were obtained from the collection of the Institute of Meteoritics (University of New Mexico) for analysis. Three samples are metallic iron: Wabar (IIIA), Canyon Diablo (IAB), and Calico Rock (IIA). The remaining two samples are stony: Thuathe (H4) and Tissint (shergottite). The stony samples have visible fusion crusts, while the iron samples have visibly oxidized exteriors.

Laboratory experiments: Meteorite samples were analyzed with the ChemCam engineering unit. Samples were placed in a Mars chamber under 7 Torr CO_2 to simulate martian conditions. All samples were analyzed in three locations on both natural exterior surfaces and cut (epoxy-coated) interior surfaces, with 50 shots per sampling location.

Results and discussion: For the three iron meteorite samples, the exterior surfaces typically have shot-to-shot decreases in Fe, Mg, Ca, Na, K, and H. Such trends are not observed in analyses of interior (cut) surfaces. These results suggest the presence of mineralogies related to terrestrial weathering in addition to the expected Fe-dominated oxidized crust. For the two stony meteorite samples, the results were variable. For Thuathe, the abundances of Fe, Mg, and sometimes K increase with depth, with a decrease in H. For Tissint, the LIBS data do not show strong depth trends in most exterior locations, with the exception of the first sampling location where K, Na, and H decrease with depth. These results are consistent with the findings of [5], who found that fusion crust composition is strongly influenced by the composition and size of nearby mineral grains. These results are also consistent with 30-shot depth trends on Gale meteorite targets Egg Rock and Ames Knob, which also show a decrease in Mg, Ca, Na, Na, and H with depth. Some part of this trend is presumably due to surface dust [e.g., 6]. An examination of oxygen emission lines on Egg Rock and Ames Knob suggests that O may slightly decrease with depth, pointing to a potential decrease in oxidation and weathering with depth, although additional work is ongoing to clarify these observations [e.g., 1, 8]. Overall, our results suggest that the meteorites found in Gale crater may have a thin layer of dust combined with a thin oxidized layer. Images of Egg Rock show a light-toned interior within LIBS analysis pits, which suggests the presence of a darker oxidized layer on its surface. However, given that martian dust has high abundances of Mg, Ca, and H [9], it is difficult to determine whether the depth trends in these elements are related to surface dust or may instead point to oxidized surfaces similar to those observed on terrestrial meteorites Canyon Diablo, Calico Rock, and Wabar. Additional study of iron meteorite surfaces in thin section may elucidate these chemical trends and their spatial distribution on meteorite surfaces.

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