COMPOSITION AND MORPHOLOGY OF IRON METEORITES FOUND IN GALE CRATER, MARS.

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Introduction: Meteorites observed robotically on Mars are of interest to understand a) the distribution of classes of meteorites on Mars in comparison to Earth, especially given their long preservation time on Mars, b) what they may reveal about the atmosphere through which they passed, and c) the Mars weathering environment. Since 2013, while exploring Gale crater (5°S, 222.5°W), the Mars Science Laboratory Rover, *Curiosity*, has imaged a number of iron meteorites along its 17 km traverse, and made elemental composition measurements on two of them. On Sol (mission day) 1505 we imaged and made compositional observations of "Egg Rock" [1], followed by "Ames Knob" (Sol 1577; informal names). Two big iron meteorites found 4.3 km earlier, and smaller likely iron meteorites, have been found in Mastcam images. These join a number of meteorites observed on Mars by the MER rovers (22 finds with pairs, including 8 iron meteorites [2-3]). Here we focus on "Egg Rock" and "Ames Knob", as they are the only ones *Curiosity* analyzed for composition, but we include an overview of the others that were imaged by *Curiosity*.

Morphology and Reflectance Spectra: "Egg Rock" is nearly hemispherical, at 4 x 5 cm, viewed from only one direction. "Ames Knob" is somewhat larger (7.5 x 8 cm) and a bit more irregular in shape. Assuming a density of ~7.8 g/cm^3 both meteorites are <1 kg in mass, well below the masses of the iron meteorites observed earlier by MER and *Curiosity*, all of which were >50 kg. While "Ames Knob" appears relatively solid, the smaller "Egg Rock" has a number of depressions, some elongated and some oval shaped, likely regmaglypts from ablation during atmospheric entry, but also possibly due in part to weathering of less resistant portions of the meteorite. Mastcam color images reveal the presence of subtle purple-hued surface patches on "Egg Rock", consistent with ferric materials, while other regions have reflectance spectra [1, 4] that are consistent with laboratory spectra of fresh iron meteorites. Faint banding on "Egg Rock" may indicate large kamacite/taenite crystal boundaries. The laser pits appear very shiny on both meteorites suggesting they have not experienced significant aqueous weathering.

Compositions: "Egg Rock" was analyzed by ChemCam laser-induced breakdown spectroscopy (LIBS) over a 3x3 point raster, while "Ames Knob" was probed with a 1x3 raster. Each observation point is ~0.4 mm diameter and was probed with 30 laser pulses, each returning a spectrum. "Egg Rock" points 1-8 show very similar spectra dominated by Fe peaks but including Ni peaks. Comparison of spectra with kamacite phases of several iron meteorites observed with a replica of ChemCam in the laboratory at IRAP indicate that these observations probed kamacite with ~8 wt. % Ni. Point #9 is located right on the edge of an elongated cavity and shows significantly higher Ni abundance along with P, consistent with schreibersite, $(Fe,Ni)_3P$. Point #6, on the opposite edge of the cavity shows a low concentration of P as well. This phase, or the phase it was delimiting, may have preferentially weathered out.

Interestingly, all three ChemCam observation points of "Ames Knob" have Ni/Fe peak ratios that are nearly identical to Chinga, an ataxite with 16.7 wt. % Ni [5] that was analyzed with LIBS for comparison, suggesting that "Ames Knob" might be the first ataxite observed on Mars. It also indicated that these two finds are not paired, despite their close vicinity (350 m), consistent with Gale Crater's floor being a deflationary surface.

The 30 successive spectra retrieved from each observation point allows investigation of the weathering surface. The meteorite is covered in dust, and so the first several shots have a signature of Mars dust. It becomes difficult to decipher possible weathering products, e.g., akaganeite, from the signature of hydrated Mars dust mixed with the meteorite signal. Overall, the Gale iron meteorites appear significantly less weathered than those of Meridiani Planum (Heat Shield Rock) [4]. Another study is being done, reported here [6] on LIBS analyses of terrestrial meteorite fusion crusts for potential comparison.

Other Meteorites Observed by *Curiosity*: "Lebanon" and "Littleton" (Sol 637), are meter-size irons whose Mastcam reflectance spectra are consistent with iron meteorites, although they were not analyzed with LIBS [7]. In addition, Mastcam observed a number of small clasts whose reflectance spectra were consistent with iron meteorites, including several small, potentially paired clasts (Cottonwood plus other unnamed targets) observed in the Marias Pass area (sols 994-1032), and small clasts near APXS target Penobscot (Sol 1512) and at the base of Ireson Hill (Sol 1610). The potential meteorites in the multispectral dataset are > 10 cm dia., and many, including those mentioned above, are < 5 cm. Their small sizes and lack of distinct regmaglypt or otherwise unusual morphologies (due perhaps to fragmentation and/or aeolian erosion) result in non-detection in Navcam and Bayer color imaging.

References: [1] Meslin et al. (2017) LPSC #2258; [2] Schröder et al. (2008) JGR, doi:10.1029/2007JE002990; [3] Ashley et al. (2011) JGR, doi:10.1029/2010JE003672; [4] Wellington et al. (2017) LPSC #2885; [5] Buchwald V.F. (1975) Handbook of Iron Meteorites, U. California Press, 1418 pp.; [6] Lanza et al. (2017) this meeting; [7] Johnson et al. (2014) AGU, #P51E-3989.