LOCATIONS AND MULTISPECTRAL FEATURES OF DISTINCT CLASSES OF DIAGENETIC FEATURES WITHIN THE MURRAY FORMATION, GALE CRATER, MARS. J. K. Ando1, R. Y. Sheppard2, A. A. Fraeman2, V. Sun1. 1Swarthmore College Dept. of Physics and Astronomy, jando1@swarthmore.edu, 2Jet Propulsion Laboratory, California Institute of Technology.

**Introduction:** As the Mars Science Laboratory (MSL) Curiosity Rover has ascended Mt. Sharp it has observed significant evidence of diagenetic activity [1]-[5]. Understanding diagenesis at Gale Crater has implications for its ancient habitability, and how past chemical, mineralogical, or biological signals may have been altered or erased. One particular type of diagenetic feature is diagenetic nodules: high-relief, small-scale instances of cementation of sediment. Four distinct concretion morphologies and their chemistry were described and cataloged by [1] for 300 m of the Murray formation, observed during sols 749-1900. These classes—irregular, spherule, flat, and dendrite—were found to vary in dominance, implying multiple distinct diagenetic events. In this study, we apply the methods and classifications documented by [1] to characterize the distribution, type, density, and size of diagenetic concretions observed by Curiosity, sols 1900-3049, encompassing the Vera Rubin ridge (VRR) and Glen Torridon (GT) regions. We contextualize concretion presence using Mt. Sharp stratigraphic members, as well as the geomorphic units of the region [6]. Moreover, we examine the multispectral properties of diagenetic concretions (across sols 2575-3049) and identify potential spectral classes. Combining these approaches, we attempt to further piece together Gale crater’s complex diagenetic history.

**Methods:** We cataloged diagenetic features, especially concretions, by visually examining images from MAHLI and Mastcam [7]-[8]. Our dataset consisted of MAHLI focus-stacks and Mastcam mosaics from the designated sols. Concretions were measured in MAHLI using custom Python code, and density was determined qualitatively in Mastcam mosaics. With Mastcam multispectral data, we used MERspect to compute spectra of all datacubes, sols 2575-3049. We visually categorized all spectra into classes based on spectral features, as well as a new set of observed concretion morphologies.

**Concretion Morphologies and Distribution:** In MAHLI and Mastcam images, four classes of concretion morphology were observed: spherule, irregular, dendrite, and flat (Fig 1). We also cataloged the existence of calcium-sulfate veins—diagenetic features observed throughout Curiosity’s traverse—and lamination enhancing features (Fig. 1). We found that, while light-toned veins were present throughout regions, diagenetic concretions disappeared for a large range within Glen Torridon, approximately across elevation range -4146.92 to -4124.1 m. This is consistent with other observations of a lack of diagenesis within the early part of GT [10-12]. Concretions begin to appear when entering the Knockfaril Hill member, and increase in frequency in Glasgow.

Of the concretion morphologies, irregular concretions were the most common, followed by spherules, although spherules were more frequently the dominant morphology in scenes where both irregular and spherule concretions were present. Flat concretions and dendrites were both rare. Flat concretions appeared mostly in the lead up to the clay-sulfate transition and dendrites appeared only a handful of times without consistency.

When comparing concretion occurrence in this region to other contexts, we found no strong correlation between CRISM mineralogy and concretion occurrence or type. We did note a strong correlation between transitions between geomorphic units [6] and concretion occurrence (Figure 2d). Diagenetic features appear most frequently in the Fractured Intermediate Unit (FIU) and its sub-unit FIU-rubbly, as well as some in the butte and smooth-ridged rubbly units.
Multispectral Classes: In examining concretions in multispectral data, we identified 5 distinct spectral classes, with 9 total subclasses (Figure 3). We also note new morphological categories that further subdivide the common spherule/irregular categories. The spectral subclasses divide the classes by concretion morphology, with 1a and b corresponding to extruded and rough irregular morphologies, while 2a, b, and c correspond to discrete, coating, and embedded respectively.

Discussion: Five distinct classes of diagenetic concretions are observed in sols 1900-3049. Notably, all concretions are absent in the clay-bearing Glen Torridon region, specifically elevations -4146.92 to -4124.1 m. This may be consistent with increased abundance of fine-grained clay minerals decreasing porosity and permeability of this stratigraphic region, decreasing diagenetic fluid flow. Ca sulfate veins are seen crosscutting other diagenetic concretions, confirming that they are a relatively late diagenetic event, consistent with previous work [1], [2], [5]. Indeed, Ca sulfate veins are the only diagenetic features present in elevation X-Y, suggesting their distribution is largely governed by processes different from the classes of concretions. When comparing feature abundance with geomorphology [9], we find that feature density increases in fractured and rubbly units. This may suggest that diagenesis during burial made this stratigraphic region more susceptible to breakup during and/or post-exhumation, leaving the bedrock rubbly and fractured at the modern surface.

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Figure 2: a) Stratigraphy column for observations of diagenetic concretions. Data from Sols 746-3049 provided by Sun et al. (2019). b) Dominant concretion morphology mapped along Curiosity’s traverse (Sun, Calef III and Parker). c) Qualitative concretion density.