POTENTIAL LINK BETWEEN HIGH-SILICA DIAGENETIC FEATURES IN BOTH EOLIAN AND LACUSTRINE ROCK UNITS MEASURED IN GALE CRATER WITH MSL. P. J. Gasda[1] J. Frydenvang[1,2] R. C. Wiens[1], J. P. Grotzinger[3], J. A. Watkins[3], N. Stein[4], K. S. Edgett[5], H. Newsom[6], B. Clark[7], R. Anderson[8], N. Bridges[9], S. Clegg[1], S. Maurice[9], and the MSL Team, [1]LANL (gasda@lanl.gov), [2]U. Copenhagen, [3]CalTech, [4]Washington U., [5]MSSS, [6]UNM, [7]SSI, [8]USGS, [9]JH/APL, [9]IRAP/CNES

Introduction: The Curiosity rover first observed high-silica (>75 wt.% SiO_2) with the ChemCam instrument in outcrops in the Murray formation at Marias Pass on sol 991 [1]; the Buckskin drill target provided mineralogy with the CheMin instrument [2]. High silica was also found associated with fracture-adjacent diagenetic halos of the Stimson formation in the Bridger Basin [1] up to sol 1155. The Meeteetse area in Bridger Basin may provide a critical link between the high-silica diagenetic features of the Murray and Stimson formations.

Murray strata explored thus far has been interpreted as a lacustrine mudstone [3], while Stimson is a (mostly eolian) sandstone unit [4] that unconformably overlies the Murray [5]. Fig 1 shows an area just to the east of the Meeteetse area, within an area of bedrock in Bridger Basin (Fig 1, inset) between Marias Pass and the Bagnold Dunes of Gale Cater. The area has been characterized by Curiosity's Alpha Particle X-ray Spectrometer (APXS), ChemCam, Mastcam, NavCam, and Mars Hand Lens Imager (MAHLI) instruments.

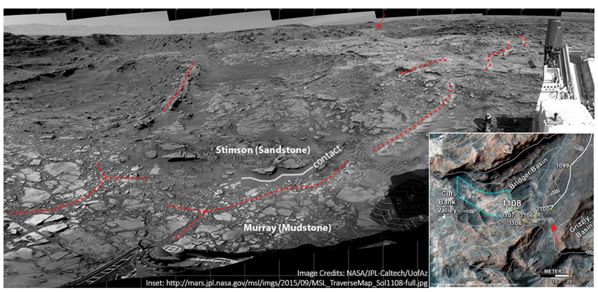

Fig 1: NavCam mosaic to the right and behind the rover on sol 1108 showing diagenetic halo features (red dotted lines) in the Stimson formation crossing into the Meeteetse area and continuing to into the right side of Fig 2. Inset shows rover traverse and location; the light-toned Murray formation of the Meeteetse area is outlined in blue.

Figure 2 shows the immediate area around the Meeteetse target in a color-stretched Mastcam mosaic. The stratigraphic context and sedimentologic textures of the Meeteetse area (outlined in blue in Fig 1 inset) suggests that these rocks are part of the Murray formation. This area is within a depression, an exposure of Murray surrounded by the Stimson formation. MAHLI images show that the nearby Cody_DRT APXS target (Fig 2, yellow diamond), brushed with the dust removal tool, is very fine grained (<70 µm) with scattered erosion-resistant ~0.4–1.2 mm nodules (some ellipsoidal, some rhomboidal) that are surrounded by narrow, less-resistant zones. The grain size of the bulk rock and nodules, as well as the presence of abundant veins filled with light-toned material, are characteristics similar to other Murray formation rocks [3].

Results: ChemCam targets in Fig 2 are represented by pink rectangles and APXS targets are represented by yellow diamonds. Orange lines show the approximate paths of diagenetic fractures while blue lines outline the diagenetic halos parallel to fractures. Text in Fig 2 summarizes the major-element oxide ranges derived from ChemCam spectra [6] for the light and dark-toned targets. Red dotted lines in Fig 1 trace additional possible diagenetic halos. A red arrow points to a feature seen in both the NavCam and the inset HiRISE traverse map.

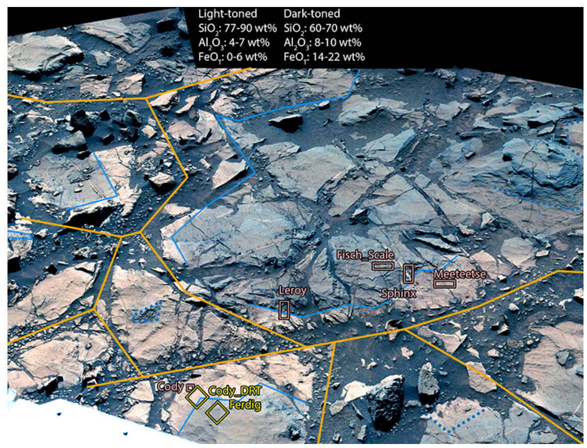

Fig 2: Color-stretched MastCam mosaic of the Meeteetse area targets just in front of the rover just to the left of the image shown in Fig 1.

Figure 3 provides a compositional comparison between the Meeteetse area targets and Marias Pass targets. Fisch_Scale, a dark-toned target adjacent to the Meeteetse target (Fig 2, right of center) is chemically similar to previous dark-toned Murray targets in Marias Pass (e.g., Mission). Meeteetse and Cody (Fig 2) are light-toned and chemically similar to the highest-silica Murray targets in Marias Pass (e.g., Elk) [1]. Comparing the average light-toned and dark-toned bedrock to each other, the light-toned bedrock has ~15 wt.% greater silica, and half of the alumina and a quarter of the total iron oxide (FeO_T) abundance. ChemCam data from both Murray mudstone and Stimson sandstone units indicate that Murray tends to have 0.9–1.5 wt.% K_2O while Stimson has 0.2–0.9 wt.% K_2O. All targets in the Meeteetse area have a Murray-like K_2O composition.

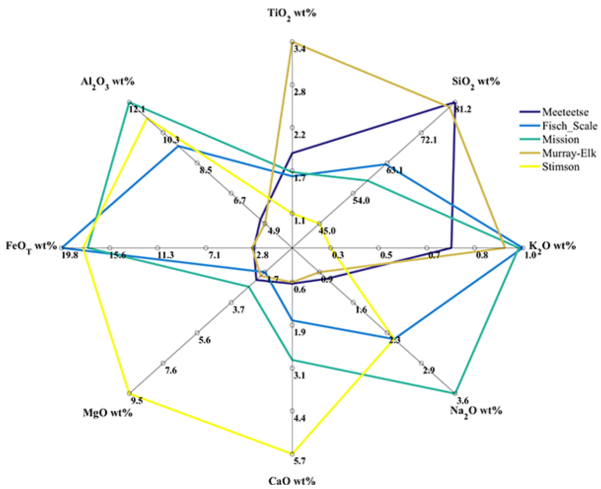

Fig 3: A radar plot where each axis is scaled to the min and max composition of each element oxide, comparing targets from Meeteetse area with the Stimson formation and with the Murray formation at Marias Pass.

Discussion: The Meeteetse area is the first instance where fracture-associated diagenetic halos with high-silica compositions are clearly observed in Murray bedrock (Fig 2). In Fig 1, fracture-associated diagenetic halos (red dotted lines) can be seen in the Stimson sandstone cutting down into the Meeteetse area behind and along the right side of the rover. They continue into the right side of Fig 2. Diagenetic halos are observed in the Stimson formation at Marias Pass, but are not evident in the Murray formation at Marias Pass.

The Mastcam mosaic in Fig 2 shows that the light and dark-toned bedrock appears to be a part of the same rock unit, but the color of the unit changes dramatically from dark to light close to certain fractures. In multiple locations, the transition from light to dark tones crosses layers rather than being parallel to bedding. In some places, the transition occurs sharply at a vein; when no vein is present, the transition is smooth. Light-toned bedrock, interpreted as diagenetic halos, run parallel to the fractures, not the bedding. Meeteetse and Cody both occur along the same diagenetic halo feature and have very similar high-silica compositions. Hence, we are confident that the light to dark-toned transition is caused by diagenesis, centered on the fractures, rather than an effect of deposition of the bedrock.

The sharp transitions between light-to-dark toned bedrock at the veins imply that vein-filling material blocked the fluid that produced the diagenetic halos in the Meeteetse area bedrock, or that the veins localized along mechanical boundaries between rock types. ChemCam observations of the Leroy target determined that the veins are filled by calcium sulfate. If the calcium sulfate is a diagenetic halo product, we would expect calcium sulfate in the Meeteetse target, but we do not. Rather, the Meeteetse and Cody have silica enrichments, very low calcium oxide, and less calcium oxide than Fisch_Scale, the target outside the diagenesis halo (Fig 3). The calcium sulfate filled veins imply multiple fluid episodes are recorded in the Meeteetse area, and the interpretation that calcium sulfate blocked fluid flow may constrain fluid composition and pH.

ChemCam measurements of the fracture-related diagenetic halos of nearby Stimson sandstone targets [1] are similar those in the Meeteetse area. Fracture-related diagenetic halos in Stimson ~20 m southwest of Meeteetse (Big_Sky/Greenhorn drill target area) are high-silica, trending up to 90 wt.%. Stimson sandstone targets within diagenetic halos have very low FeO_T and alumina abundances, much like the Meeteetse target and the highest-silica targets at Marias Pass.

The chemistry of the Murray at Marias Pass and at the Meeteetse area are very similar (Fig 3). Bedrock unaltered by diagenetic halos, Fisch_Scale (west of Meeteetse in Fig 2), Piegan, and Mission (both Marias Pass targets), have similar ranges of silica, alumina, and FeO_T. Meeteetse and Cody targets (within the diagenetic halos) have very similar chemistries to each other and to the highest-silica targets measured in Marias Pass (e.g., Elk) [1]. The similarity in chemistry measured with ChemCam suggests that the style of diagenesis at Marias Pass, if diagenesis indeed occurred there, might be related to fracture-associated diagenesis observed at the Meeteetse area.

Conclusions: In Murray bedrock in Bridger Basin, we observe fracture-associated diagenetic halos. The same diagenetic features are observed in the nearby Stimson formation cutting down into the underlying Murray formation in the Meeteetse area. In both cases, these diagenetic halos produce high-silica compositions, despite very significant differences between the origin of these two units. The Murray formation at Bridger Basin and Marias Pass have chemically similar dark-toned bedrock and chemically similar light-toned bedrock, suggesting the style of diagenesis might be similar. However, there is no consensus on the mechanism for diagenesis along the fractures or at Marias Pass [1,2,7,8]. But based on evidence presented here, we hypothesize that the Meeteetse area may provide a link between diagenesis in the Stimson formation in Bridger Basin with the possible diagenesis seen in the Murray formation at Marias Pass.

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References: [1] Frydenvang et al., *this meeting,* [2] Morris et al., *this meeting,* [3] Grotzinger et al., 2015 *Science* 350, [4] Banham et al., *this meeting,* [5] Watkins et al., *this meeting,* [6] Clegg et al., *in prep*., [7] Yen et al., *this meeting,* [8] Rampe et al., *this meeting,*