CHEMCAM OBSERVATIONS OF THE MARKER BAND, GALE CRATER, MARS. P. J. Gasda (gasda@lanl.gov)[1]; N. Lanza[1]; W. Rapin[2]; J. Frydenvang[3]; W. Goetz[4]; S. P. Schwenzer[5], W. E. Dietrich[6]; C. Weitz[7]; A. Bryk[6]; E. Kite[8]; K. Lewis[9]; J. Schieber[10]; W.W. Fischer[11]; C. Mondro[11]; J. Johnson[9]; E. Dehouck[12]; H. E. Newsom[13]; A. Essunfeld[1,14]; J. Lasue[2]; O. Gasnault[2]; S. Clegg[1]; D. Delapp[1]; [1]LANL; [2]IRAP; [3]U. Copenhagen; [4]U. Göttingen; [5]Open U.; [6]U. Berkeley; [7]PSI; [8]U. Chicago; [9]JHU; [10]U. Indiana; [11]Caltech; [12]U. Lyon; [13]UNM; [14]Yale

Introduction: The "Marker Band" is a unique resistant feature that spans Mt Sharp, the central sedimentary mount within Gale crater, Mars [1]. From orbital observations, the Marker Band appears darker and more resistant to erosion, exhibits a high-Ca pyroxene signature, and varies in thickness [1]. NASA *Curiosity* rover data confirm the variable thickness of the Marker Band and observe a change in texture just below the Marker Band which may be attributed to diagenesis [2–7]. The sedimentary textures of the units above and below the Marker Band appear to be the same, suggesting the Marker Band is only a thin interval in the Mount Sharp group (MSg) sequence [1–7].

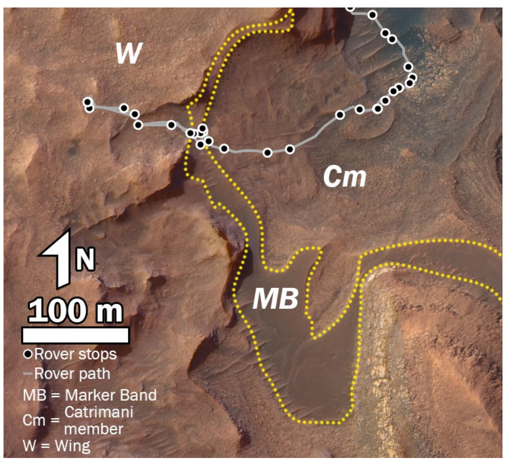

Fig 1: Overview map of the Marker Band crossing.

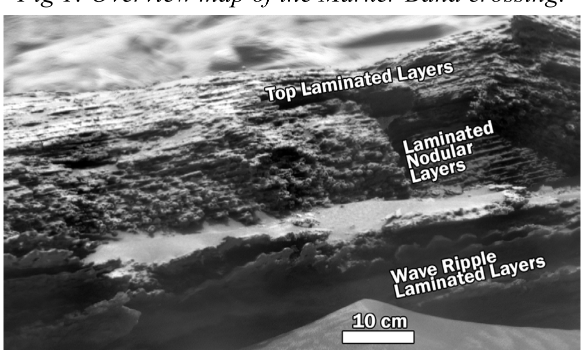

Fig 2: Marker Band layers seen by ChemCam.

Methods: *Curiosity* crossed from the Catrimani member (Cm) over the Marker Band on sol 3645, into the 'Wing strata' and then returned on sol 3668 (Fig 1). This work focuses on ChemCam chemistry results and long distance remote micro images.

Results: The Marker Band in this region is composed of layers of thinly laminated resistant material (lowest to highest): ripple layers, nodular layers, and rhythmic layers (Fig 2). Just below the Marker Band, two ChemCam targets of the bedrock reveal a high frequency of sulfate veins. Above the Marker Band ('Wing strata'), the materials have MSg-like laminated textures.

ChemCam observed an abrupt change in chemistry at the Marker Band, where the ripple and nodular layers increase from ~17.5 wt% FeO_T in Cm to ~27 wt% FeO_T (Fig 3). Many points are highly enriched in MnO up to ~6 wt%, and a clear FeO_T and MnO trend is observed (Fig 3). CaO in the bedrock increases, and MgO decreases compared to Cm. Within some points, ChemCam observes an increase in Zn, Cu, and Cl, as does APXS [7]; e.g., the Coimin nodular target has elevated Fe, Mn, Zn, and Cu in the same two observation points.

Within the Wing strata above the Marker Band, FeO_T and MnO decrease to MSg-like compositions, while CaO remains elevated (Fig 3). MgO increases but remains much lower than the Mg-sulfate rich material of Cm [9]. The Marker Band top layers have similar composition to the Wing strata (Fig 3).

Sulfate chemistry shifts from a Mg-sulfate (+/- Ca and Fe sulfate) dominated regime in Cm to a Ca-sulfate regime (with minor Mg sulfate) in Wing strata. In Cm and the ripple layers, veins are largely absent. Cm sulfates are embedded in the bedrock matrix. In Wing strata, sulfates occur mainly within veins.

Discussion: Compared to previously observed ripple laminated below Cm (The Prow [4]), and nodular materials (Mary Anning and Groken (MAG) [10,11]; Harlaw [11]), the Marker Band has the highest FeO_T content (Fig 4). MAG had up to ~6 wt% MnO observed in nodules [4,5]. MAG bedrock had higher MgO, but typical FeO_T, and so its MnO-rich nodules also have the highest MgO content (Fig 4). Both MAG nodules and the Marker Band have high MnO in nodular material, but the Marker Band has a distinct MnO-FeO_T relationship. At the Prow, ~0.25 wt% MnO was observed, which is slightly enriched compared to normal MSg materials. High MnO was also observed in Harlaw nodules, but these had less MgO, and fit between MAG and Marker Band compositions (Fig 4). Trace element chemistry in MAG [11] is different from the Marker Band as well, suggesting a different source of fluids emplaced the MnFe materials in the Marker Band.

Prior to the in situ investigations, the hypotheses for Marker Band formation mechanisms proposed by [1,2] include an airfall volcanic ash deposit or sandstone deposited during dry periods. From chemical and morphological observations, deposition of these materials during a dry period can likely be ruled out in favor of a combination of primary deposition, likely in a lake due to the local presence of the ripples [3–7], followed by secondary diagenesis that hardened the rock. It is unclear from the chemistry alone if the Marker Band represents an indurated form of Cm [1,2].

The Marker Band nodules bear many similarities to shallow water deposits in terrestrial lake systems. FeMn nodules typically form in shallow water lakes and marine environments on Earth due to exposure to the highly oxidizing atmosphere or in the subsurface along sharp redox boundaries [12]. On Earth, Zn is observed in FeMn nodules, where it adsorbs to $Mn^{3+,4+}$ oxides, e.g., in birnessite [e.g., 13]. If Mn is indeed an oxide mineral, then it suggests these materials formed in very oxidizing aqueous conditions at pH>4.

The Wing strata has a more mafic composition than MSg materials from lower in the stratigraphy (e.g., Carolyn Shoemaker formation) [14]. Previous observations found that bedrock composition transitions to a more mafic composition over a few meters of strata (rather than sharply at a boundary) when the rover crossed onto the Greenheugh pediment over sols 3345–3461). Similar compositions were also observed at the Avanavero drill hole location (sol 3509). The Marker Band's top layers appear to be more closely related to the Wing strata, but with higher CaO, and could be consistent with elevated high-Ca pyroxene observed from orbit [1].

Conclusions: Further investigation of the Marker Band is needed to understand its formation mechanisms. The rover is expected to cross the Marker Band again to the south as it continues its traverse. The ripple textures suggest these layers formed in a very shallow lake [3], more extensive than the small lake inferred for the Prow [4], which has implications for Gale's aqueous history when Mars was experiencing a drying climate. This could imply a small shallow lake followed by a deep short-lived crater-scale lake [3]. Groundwater brines, rich in Fe, Mn, Zn, Cu, Cl, deposited nodules in the ripple layers in highly oxidizing neutral to alkaline conditions either during this event, or after during groundwater diagenesis, cementing the rock.

Acknowledgements: NASA Mars Exploration Program, JPL, CNES **References:** [1] Weitz, C. M., et al. (2022). JGR:P, 127(4) [2] Rapin et al. (2021) *Geology* 49(7), 842–846 [3] Weitz et al., this meeting [4] Gupta et al., this meeting [5] Dietrich et al., this meeting [6] Lewis et al., this meeting [7] Roberts et al., this meeting [8] Thompson et al., this meeting [9] Rapin et al., this meeting [10] Lanza et al., (2022) LPSC #2689 [11] Gasda et al., (2022) JGR:P, 12(127) [12] Muller et al. (2002) ES&T, 36(3), 411–420 [13] Marcus et al., (2004) GCA, 68(14), 3125–3136 [14] Dehouck et al. (2022) JGR:P

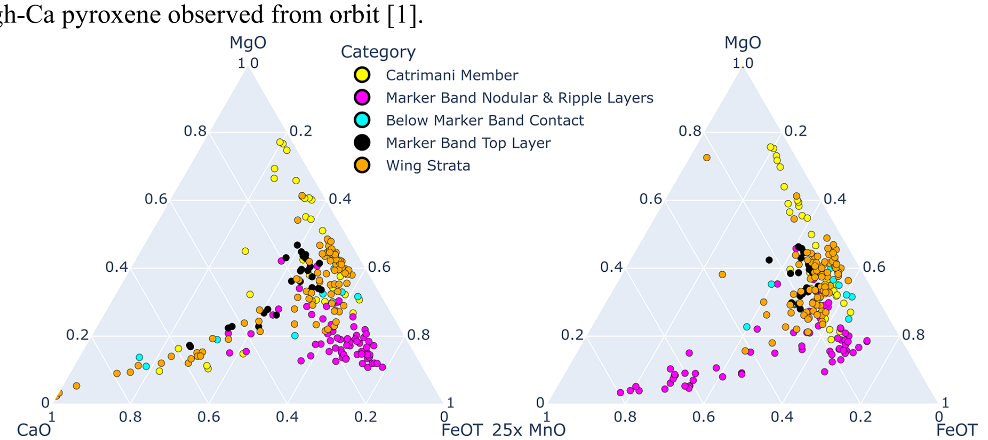

Fig 3: Marker Band compositions compared to materials above and below the Marker Band.

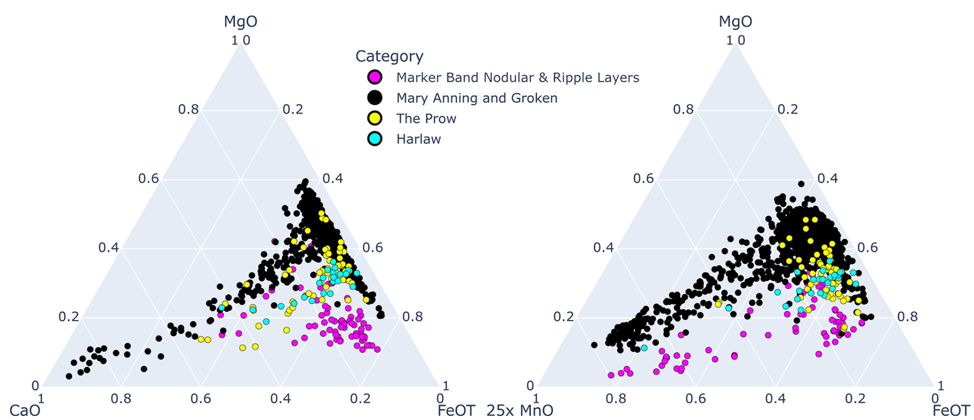

Fig 4: Marker Band comparison with similar Gale crater materials.