INVESTIGATION OF THE GALE CRATER MARKER BAND (AND BEYOND) WITH THE MARS SCIENCE LABORATORY, ALPHA PARTICLE X-RAY SPECTROMETER. L.M. Thompson[1], E.S. Kite[2], J.P. Grotzinger[3], A.S. Yen[4], J.A. Berger[5], K.W. Lewis[6], W.E. Dietrich[7], J. Schieber[8], C.M. Weiss[9], C.D. O'Connell-Cooper[1], R. Gellert[10], J.G. Spray[1], M.A. McCraig[10], S.J. VanBommel[11], N. Boyd[10]. [1]lthompso@unb,ca, Univ. of New Brunswick, Fredericton NB E3B 5A3 Canada, [2]Univ. of Chicago, [3]California Institute of Technology, [4]Jet Propulsion Lab., [5]Johnson Space Center, [6]John Hopkins Univ., [7]Univ. of California, Berkeley, [8]Indiana Univ., [9] Planet. Sci. Inst., [10]Univ. of Guelph, ON, Canada, [11]Washington University in St. Louis

Introduction: A relatively smooth, dark-toned, resistant horizon has been identified and mapped from orbit across an area of Gale crater [1-3] (Fig. 1a). It is interpreted to be a single contemporaneous unit, deposited within the sulfate-bearing strata of the central mound. The Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) signature is consistent with the presence of high-Ca pyroxene and other basaltic minerals, in contrast to hydrated sulfate signatures associated with strata above and below. The authors in [3] put forward several hypotheses for the origin of the marker band, favoring one of two scenarios: (1) emplacement of a more indurated sulfate unit, resulting from primary deposition; and 2) emplacement of a volcanic ash deposit laid down during the sulfate formation period.

Curiosity has recently investigated the marker band (MB), as well as the strata immediately above and below it (Figs. 1b, c). Alpha Particle X-ray spectrometer (APXS) compositional results have implications pertaining to the origin of the marker horizon and its relationship to other units within Gale crater.

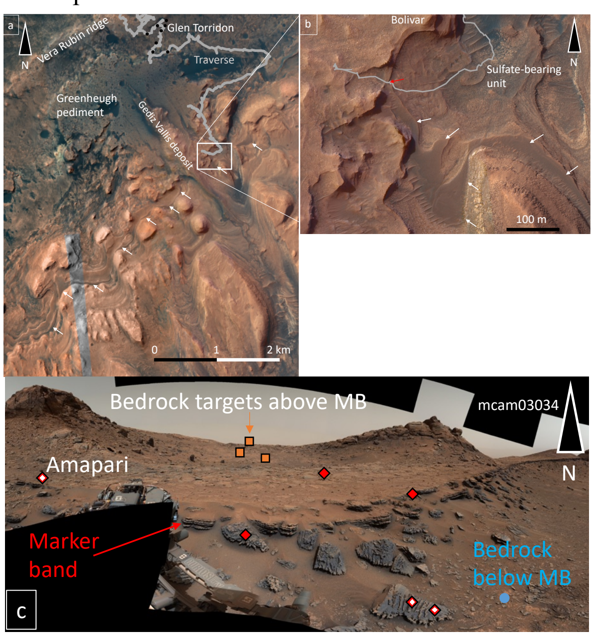

Figure 1: HiRISE imagery with a) the rover traverse since Vera Rubin ridge and the area of interest (white box), and b) zoomed in to the area of interest; white arrows point to the MB and the red arrow in b) shows the sampling location. c) part of a 360º Mastcam mosaic with MB and target locations highlighted. MSSS/JPL-CalTech/NASA

Measurement details: Different MB layers and textures [4-7] were analyzed by APXS. The lowermost layer comprises a dark toned, finely laminated, rippled unit interpreted to have formed by wave action in a shallow lake setting [4-6]. This is overlain by a rhythmically laminated unit, exhibiting hollow nodular features towards the basal contact with underlying rippled unit [4-7]. The rhythmically layered strata is hypothesized to represent the subaqueous settling of fines in somewhat deeper water [5]. Alternatively, the MB could represent a bay mouth bar, formed much later after the central mound [8]. APXS acquired compositional data for twelve targets within the rippled MB, including three powdered targets from two failed drill attempts (Amapari, Amapari2, Fig. 2). Five targets were investigated within the rhythmically layered MB. The chemistry of the strata exposed ~3 m below the MB, as well as above it (towards Gediz Vallis ridge), was also determined by APXS (Fig. 1c).

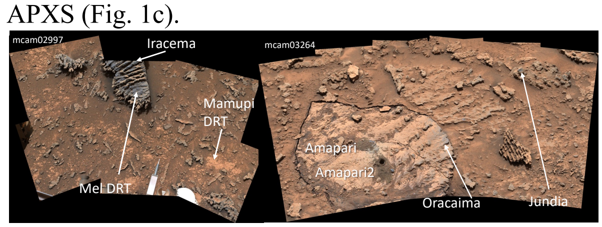

Figure 2: Examples of Mastcam workspace mosaics with rippled MB APXS targets. MSSS/JPL-CalTech/NASA

Results: APXS results from the MB indicate a generally basaltic composition, with low Ge [9] and elevated Cl, Zn and Br relative to Mars soil and sand (Figs. 3a, b). The rippled horizon is characterized by highly elevated and variable FeO, MnO and Zn (Fig. 3a; average 36.26±4.04 wt%, 1.08±0.22 wt% and 1.25±0.67 wt% respectively). The highest FeO, Zn and Br concentrations measured by APXS within Gale crater are from rippled MB targets (42.6 wt%, 2.2 wt% - also the highest Zn measured by APXS on Mars, and 0.4 wt% respectively). Significantly, the Amapari and Amapari2 drill fines have >Fe, Mn, Zn, Cl and Br abundances than their respective brushed bedrock, pre-drill targets and ~1000 ppm Cu. This indicates that the high concentrations are intrinsic to the rock and not just a surface coating. The rhythmically laminated MB targets are not enriched in Fe nor Mn relative to Mars basaltic soil and sand, but do exhibit higher Cl, Br and Zn concentrations. The Zn concentrations are not as marked as for the rippled horizon.

The Mamupi DRT bedrock target analyzed ~3m below the MB (Fig. 2) does not show the same elevated elemental concentrations and is not basaltic in composition. Instead it shares compositional characteristics with the underlying Mount Sharp grp, including typical ~100 ppm Ge [9]. However, it does not exhibit the elevated Mg and S associated with $MgSO_4$, manifest in the underlying Canaima drill and associated targets [10].

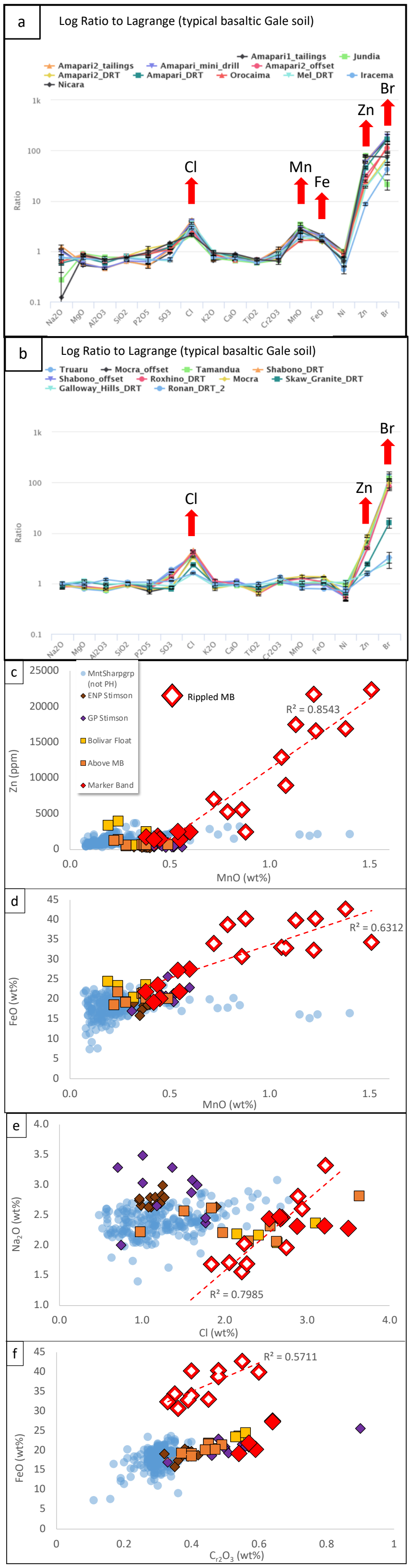

Figure 3: a) rippled MB targets, and b) rhythmically laminated MB targets - log ratioed to basaltic Gale soil, Lagrange. c) Zn vs MnO, d) FeO vs MnO, e) Na_2O vs Cl, and f) FeO vs Cr_2O_3 plots for MB targets, above MB bedrock, Bolivar float blocks, basaltic Stimson fm from the Emerson/Naukluft plateaus (ENP) and Greenheugh pediment (GP), and brushed Mount Sharp grp bedrock (not including Pahrump Hills (PH)).

Multiple bedrock targets analyzed by APXS above the marker band reveal chemistries related to both typical Mount Sharp grp rocks (with Ge >30 ppm detection limit [8]) and basaltic Siccar Point grp rocks, and the rhythmically layered MB targets (Figs. 3c-f), again with no $MgSO_4$ signature. They are compositionally similar to a number of float blocks encountered as Curiosity drove by the Bolivar butte to the N of the marker band investigation area (Figs. 1b, 3c-f).

Discussion: MB targets compositions are consistent with the source sediment being derived from a generally basaltic protolith (Figs. 3c-f). This could fit with a volcanic ash scenario [3], albeit with deposition into a shallow lake (to account for the ripples). The composition (and texture) of the MB is not consistent with it representing a more indurated version of the underlying strata. The chemistry of the bedrock targets so far analyzed above the MB, indicate that after initial deposition of the basaltic MB, there was mixing of basaltic and Mount Sharp grp protolith sediment.

Taken collectively, MB targets define positive correlation trends between Zn and Mn, and Fe and Mn. However, the very high Fe, Mn and Zn, rippled MB targets do not exhibit as strong correlations (Figs. 3c, d). In particular, the rippled targets show no correlation between Fe and Mn. Furthermore, neither the Fe, Mn, nor Zn follow any correlation trends with Cl or Br, and Fe and Zn do not correlate. This indicates that the elemental enrichments associated with the rippled MB are not the result of concentrations of detrital mineralogy. We propose that the high Fe, Mn and Zn are associated with either; 1) syn-depositional interaction of lake water and/or upwelling groundwater with the sediment, or 2) post-depositional fluid flow through the strata, whereby the permeability of the rippled MB strata may have controlled the concentration of these elements at this horizon. Elevated Cl and Br in the majority of MB and above MB bedrock targets investigated to date indicate that Cl- and Br-rich brines may have played a role. However, any introduction of brines must post-date the deposition of both the MB and overlying sediment, which would support post-depositional alteration, or a separate, later, unrelated event being responsible for the enrichment in Cl and Br.

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