CHEMICAL EVIDENCE FOR AN EPISODE OF ACIDIC LEACHING AT THE BASE OF MOUNT SHARP, GALE CRATER, MARS, AS SEEN BY THE APXS. R.Gellert[1], J.A.Berger[2], N.Boyd[1], J.L.Campbell[1], E.D.Desouza[1], D.W.Ming[3], R.V.Morris[3], G.M.Perrett[4], M.Schmidt[5], L.Thompson[6], S. VanBommel[1], A.S.Yen[7]. [1]Univ. of Guelph (Guelph, ON, N1G2W1, Canada; rgellert@uoguelph.ca), [2]Western Univ., London, ON, [3]NASA JSC, Houston, TX, [4]Cornell Univ., Ithaca, NY, [5]Brock Univ., St. Catharines, ON, [6]Univ.of New Brunswick, Fredericton, NB, [7]Jet Propulsion Lab, Pasadena, CA

Introduction: The MSL Alpha Particle X-ray Spectrometer (APXS) [1] is the third generation of chemical in-situ instruments of its kind onboard a NASA Mars rover. Over the first 1200 sols at Gale Crater the MSL APXS has measured ~275 spots on 240 distinct samples along the traverse.

After detailed investigations of the foothills of Mount Sharp at Pahrump, on its way uphill Curiosity encountered a geologic contact with heterogeneous composition that suggests acidic alteration with elevated Si, S and Ti, evidence for higher Fe^{3+}/Fe^{total} and a significant loss of the soluble elements Ni and Zn.

Murray-Stimson Contact: At Marias Pass a contact identified from orbit was investigated and yielded a sharp compositional transition from upper-Pahrump-like to an average-Mars-like composition. The samples Ronan (Stimson) and Wallace (Murray), both brushed with the DRT, differ significantly in composition albeit just some 10 cm apart on each side of the visible contact. Fig 1. shows the logarithmic ratio of the standard 16 elements the APXS quantifies to the soil Portage. Ronan deviates much less than 10% from the typical soil or average Mars crustal composition, while Wallace shares a lot of characteristics with SantaAna, one of the targets in the upper Pahrump section.

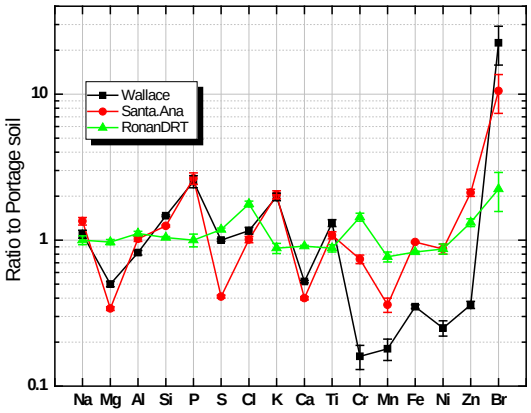

Figure 1 Chemistry at the contact
Wallace shares several of the distinct elemental patterns with Pahrump - elevated Si, lower Mg and Ca. Most prominent is the similarity in elevated P, up to 2.5% P_2O_5 and a consistently high Fe/Mn ratio, which is known from MER to follow the Fe3+ content. However, Wallace is distinct from Pahrump with lower Mn, Fe, Ni and Zn, possibly continuing an uphill trend that was already observed in the 10 m section at Pahrump.

Traverse beyond Pahrump: The APXS measured about 40 samples since leaving GardenCity, a complex vein system on top of Pahrump [2]. The ~2 cm FOV is uniquely suited to determine an average composition for drill samples analyzed by SAM and CheMin, to follow broader elemental trends along the traverse and to provide ground truth for orbiters. In Fig. 2, the trends of SiO_2 content with other elements are shown.

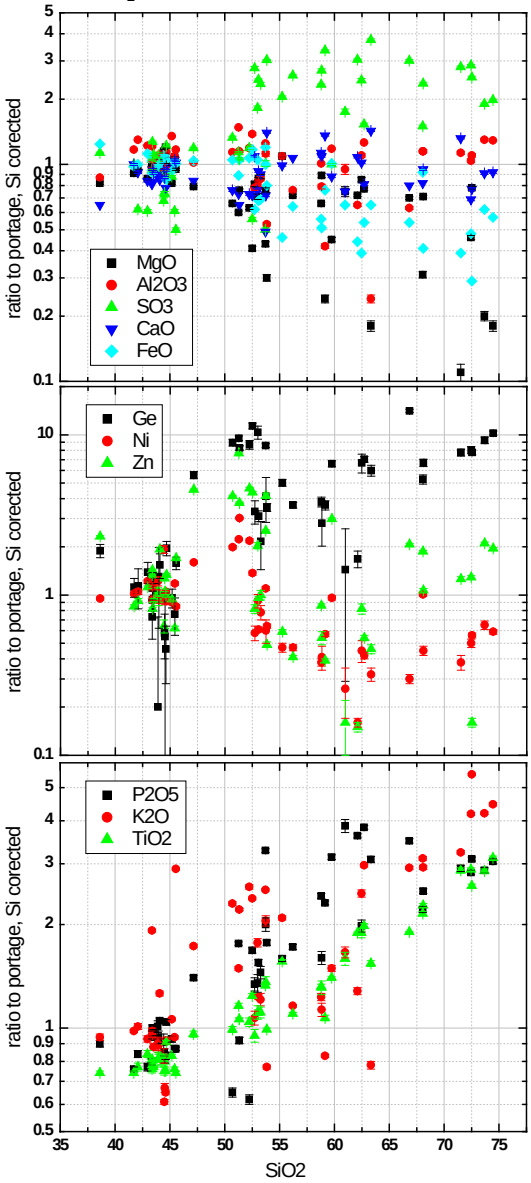

Figure 2 Compensated ratios for the non-SiO_2 content. A simple addition of pure SiO_2 would give flat trends.

As seen in the trends in Fig 2, for the major elements, only S increases, Ca and Al remain about constant while Mg and Fe significantly decrease with increasing SiO_2. The trace elements Ni and Zn, highly enriched at lower Pahrump with values of more than 1000 ppm, drop sharply with increasing SiO_2. Ge is uniformly enriched, like in most bedrocks in Gale. Of the minor elements, K, Ti and especially P exhibit a clear positive trend with SiO_2. The highest P_2O_5 of 2-3% belongs to a group of samples with ~60% SiO_2. These samples are similar in most elements (Fig. 3) and have been encountered over kilometers in Hidden Valley, upper Pahrump, Marias Pass and beyond [3], possibly indicating a common, large scale origin.

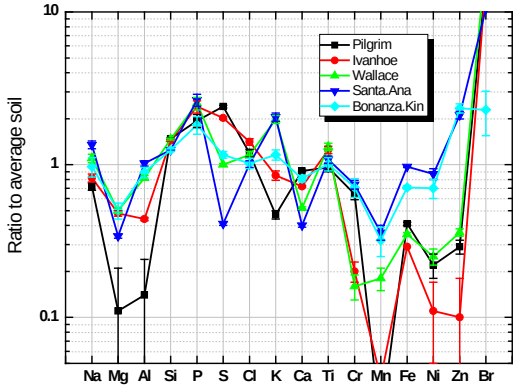

Figure 3 Si and P rich samples along the traverse

So far, possibly the cleanest endmember of the overall trends can be seen in the Mini-drill at Pilgrim, nearby the full drill at Greenhorn. This area was found to be very heterogeneous, lateral and in depth, even on a sub centimeter scale. The ~10 mm deep Mini-drill represents the best bulk chemistry available for this material. 95% of Pilgrim is made up of SiO_2, SO_3, CaO, FeO, P_2O_5, TiO_2 and Cl. On the other hand, Na_2O, MgO and Al_2O_3 are very low, all together less than 4%. The quite high 13.5% SO_3 can be only balanced by nearly all of the Ca and Fe. So, there is little chemical evidence for significant amounts of igneous minerals in this sample.

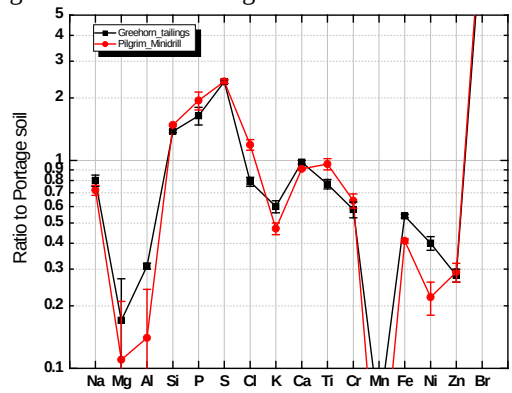

Figure 4 Comparison of Pilgrim and Greenhorn

Fig. 4 shows the similarity of Pilgrim and Greenhorn. Both samples belong to the group of medium SiO_2 compositions of ~60% with elevated P and show the highest Fe/Mn ratio, i.e. Fe alteration index. Mn is nearly absent in these samples, indicating a complete alteration and removal of original Fe bearing igneous minerals. The dissolved Mn might have been deposited downhill, possibly in vein systems similar to GardenCity, where elevated Ca, Mn and Ge was found [2].

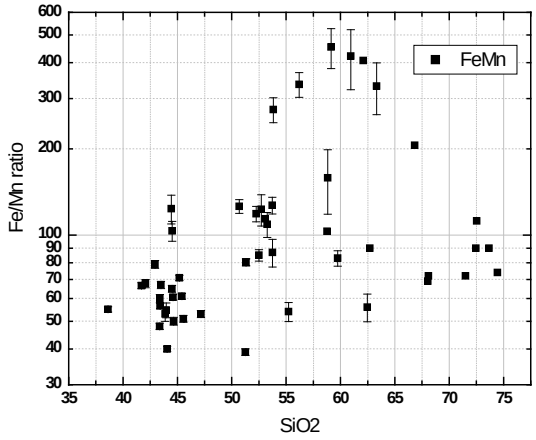

Figure 5 Fe/Mn ratio versus SiO2

Summary: Elevated SiO_2 and S, indications for altered Fe^{3+} minerals, significantly changed bulk chemistry, mobilized Ni and Zn as well as elevated TiO_2 point towards an episode of large scale acidic leaching. This bulk chemistry interpretation is consistent with the mineralogy findings by CheMin [4,5,6], although also other interpretations of APXS data are discussed, e.g SiO_2 precipitation [7]. In all cases, this episode of aqueous alteration is very different geochemically than the environment in Yellowknife Bay that formed Fe/Mg-smectite, where S is low and the chemistry is similar to average Mars crustal compositions [8]. Further insights into the changing environmental conditions on early Mars are expected when Curiosity will continue to ascent Mount Sharp.

References: [1] Gellert and Clark, *Elements* (2015), [2] Berger at al., *AGU* (2015), [3] Thompson at al., this conference, [4] Morris et al., this conference, [5] Rampe et al., this conference, [6] Yen et al., this conference, [7] Hurowitz et al., this conference, [8] Grotzinger et al., *Science*, (2014).

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