MOBILITY OF POTASSIUM-RICH FLUIDS ON MARS: IMPLICATIONS FOR DIAGENESIS. A. S. Yen[1], R. Gellert[2], L. M. Thompson[3], A. H. Treiman[4], R. V. Morris[5], D. T. Vaniman[6], B. C. Clark[7], J. A. Berger[2], R. E. Kronyak[8], [1]JPL/Caltech (Albert.Yen@jpl.nasa.gov), [2]University of Guelph, [3]University of New Brunswick, [4]Lunar and Planetary Institute, USRA, [5]NASA-JSC, [6]Planetary Science Institute, [7]Space Science Institute, [8]University of Tennessee.

Introduction: In its traverse across Gale Crater, the Curiosity Mars rover has examined a variety of veins and other fluid alteration features that crosscut lithified sediments. By far the most common form encountered is millimeter- to centimeter-wide, light toned veins of calcium sulfates [1]. Larger, meter-scale, silica-enriched fracture-associated halos have also been studied in detail [2]. Here we describe another alteration style involving fluids rich in K and Fe.

Chemical Compositions: Data from the Alpha Particle X-ray Spectrometer (APXS) are used to compare fluid-altered zones with the host rock.

Thrumcap. In the climb towards the Vera Rubin (hematite) Ridge, Curiosity discovered a ~100 meter thick section of Murray mudstone characterized by relatively low Zn (<800 ppm vs. typically >1200 ppm) and high Fe:Mn ratio (>120 vs. <80). Drill samples from this region (Marimba, Quela and Sebina) contain ~20 wt% phyllosilicates (from CheMin X-ray diffraction data), which include tri- and dioctahedral smectites [3]. In addition to chemical and mineralogical evidence for aqueous alteration, physical features indicative of fluid activity are also found in this region. The "Thrumcap" alteration zone is a centimeter-scale, raised, lighter-toned region of Murray mudstone on either side of a central fracture (Fig. 1). APXS analyses of this feature show enrichments in K, Fe and S (Fig. 2) relative to the immediately adjacent host rock (which is fairly typical of Murray mudstone). With nearly 2 wt% K_2O, the Thrumcap target has the second highest concentration of potassium measured by APXS in the Murray formation.

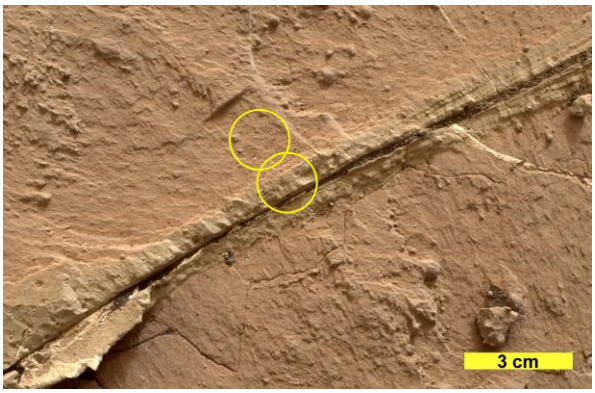

Fig. 1: *Portion of MAHLI image of Thrumcap alteration (25 cm standoff, sol 1504). Locations of APXS analyses ON and OFF the feature are shown in yellow.*

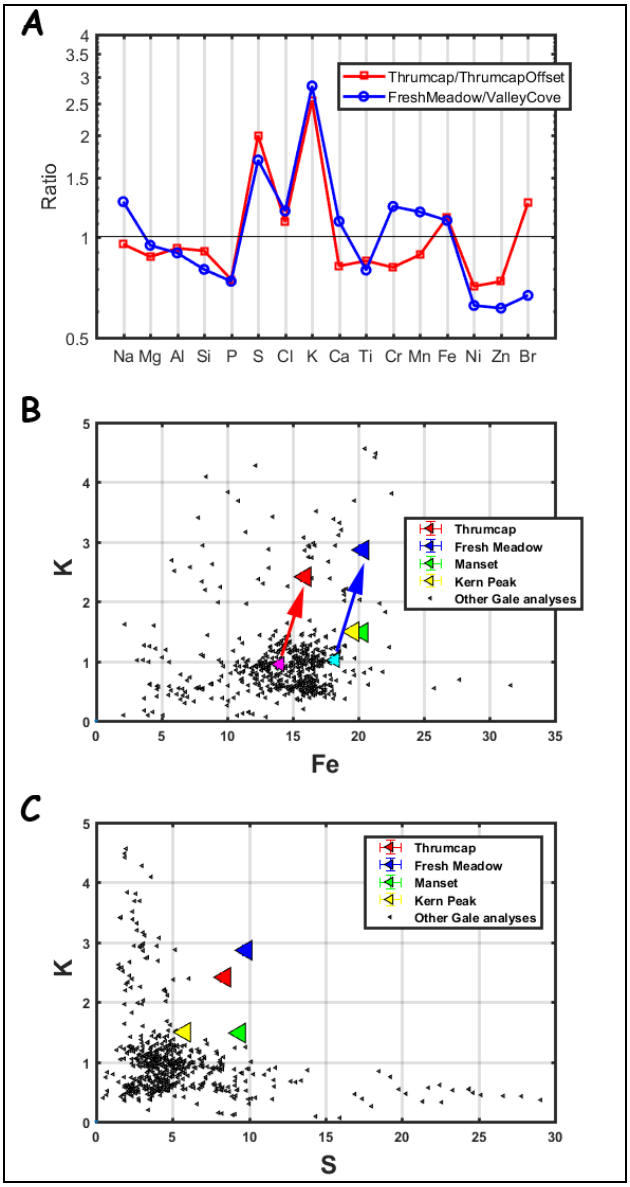

Fig. 2: *(a) Chemical ratios comparing altered zones with parent material indicating enrichments in K, Fe and S. Note that the minor percentage increase in Fe represents >2 wt% difference in FeO. (b) Molar K versus Fe; arrows depict increases in K and Fe for the targets ratioed in (a): Thrumcap Offset (magenta) to Thrumcap and Valley Cove (cyan) to Fresh Meadow. (c) Molar K versus S illustrating the unique region (elevated K, elevated S) occupied by the samples discussed here.*

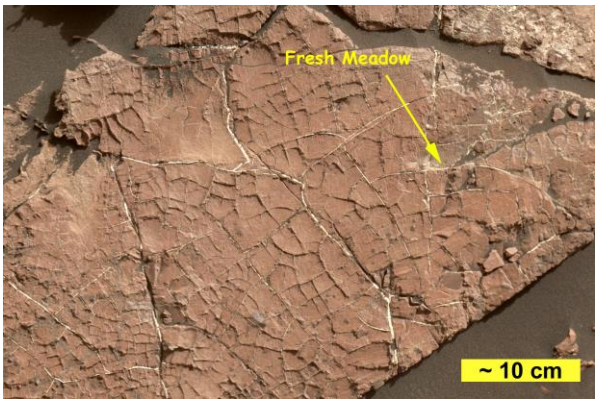

Fig. 3: *A portion of the MAHLI mosaic (sol 1566) of the "Old Soaker" rock containing a network of raised ridges interpreted as desiccation cracks [4].*

Fresh Meadow. The highest concentration of K_2O measured by APXS (2.3 wt%) in the Murray mudstone was in the "Fresh Meadow" target (Fig. 3), located <300 meters from Thrumcap and in the zone of low Zn and high Fe:Mn. The intent of this analysis was to target a greyer portion of the "Old Soaker" rock, but the field-of-view included a mix of sand, light-toned material in and adjacent to a fracture, and the grey rock. A comparison between the Fresh Meadow target and another APXS analysis on the same block shows enrichments in K, Fe, and S similar to those found in Thrumcap (Fig. 2). These enhancements cannot be attributable to contamination by dust and/or sand, as the Fresh Meadow target has much higher concentrations of S (2-3 times dust) and K (4-5 times dust). The ChemCam instrument also detected enrichments of K in raised ridges adjacent to Fresh Meadow [5]. The proportions of additional K:Fe:S are roughly 1:2:5 (molar) for Fresh Meadow as well as Thrumcap, suggesting the possibility of potassium-iron-sulfates. Minor increases in Cl are apparent but are insufficient (K:Cl ~5:1) to account for the K enrichment as KCl.

Manset. Other analyses in the zone of low Zn and high Fe:Mn also show chemical signatures suggestive of (K, Fe)-sulfates. The "Manset" analysis (sol 1524), for example, shows abundant S (13 wt% SO_3), K (1.2 wt% K_2O), and Fe (~25 wt% FeO, among the highest FeO concentrations measured by APXS at Gale Crater). This rock has insufficient Ca (6 wt% CaO) to be the only cation for the sulfate.

Garden City. Elsewhere, the Garden City vein complex (Fig. 4), which crosscuts Murray mudstone in the Pahrump Hills section, also contains evidence of K and Fe mobility. The light-toned veins consist of Ca-sulfates, as is typical for Gale, but the dark fins and rock fragments are chemically distinct and likely represent different episodes of alteration. The Kern Peak analysis is from a dark fragment (Fig. 4). Relative to the surrounding rock, it has elevated K (1.2 vs. 0.8 wt% K_2O), Fe (23 vs. 16 wt% FeO), S, Cl and P. The Garden City veins exhibit elevated levels of several trace elements (e.g., Pb, Cu, Ge, Ga) which are commonly, though not uniquely, associated with hydrothermal alteration.

Potassium Mobility: The compositions of these alteration features in Murray mudstone show that fluids rich in K, Fe, and S migrated through fractures after lithification of the sediments and that some of these fluids may have been at elevated temperatures. While jarosite has been identified at the ~1% level in most of the Murray drill samples, the mineralogical host(s) of the K-Fe-S enrichments in the crosscutting features is unknown. Possible phases include jarosite, yavapaiite, krausite, goldichite, voltaite, and mereiterite. No obvious single mineral satisfies the observed K:Fe:S ratio, so a combination of phases is likely. Amorphous material may also be the host of the enrichments. Most of the above sulfates are products of acid alteration or fumaroles, suggesting that the alteration may have resulted from interactions with low pH solutions.

Conclusions: Sediments found within Gale crater have experienced aqueous alteration of several types at different times: In the source region, concurrent with deposition, and in one or more episodes after lithification. Alteration features crosscutting Murray mudstone indicate at least one generation of late-stage, K-rich fluids, likely associated with (K, Fe)-sulfates. Given indications for the mobility of potassium within the Gale Crater basin, sediments with elevated concentrations of K need to be considered as possible diagenetic products.

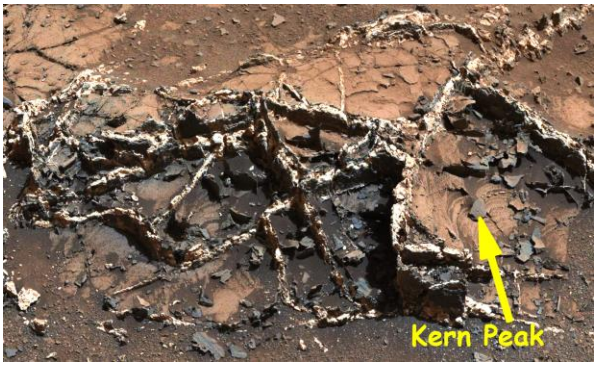

Fig. 4: *Portion of mcam04073 (sol 926) showing the dark and light-toned portions of the Garden City veins cross-cutting the Murray mudstone.*

References: [1] Nachon et al. (2017) *Icarus, 281*, 121-136. [2] Yen et al. (2017) *EPSL, 471*, 186-198. [3] Bristow et al. (in revision) *Sci. Adv.* [4] Stein et al. (2017) *48th LPSC*, 2387. [5] Mangold et al. (2017) *48th LPSC*, 1908.