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Chemo-stratigraphy at the Pahrump outcrop and Garden City Vein Complex in Gale Crater using ChemCam.

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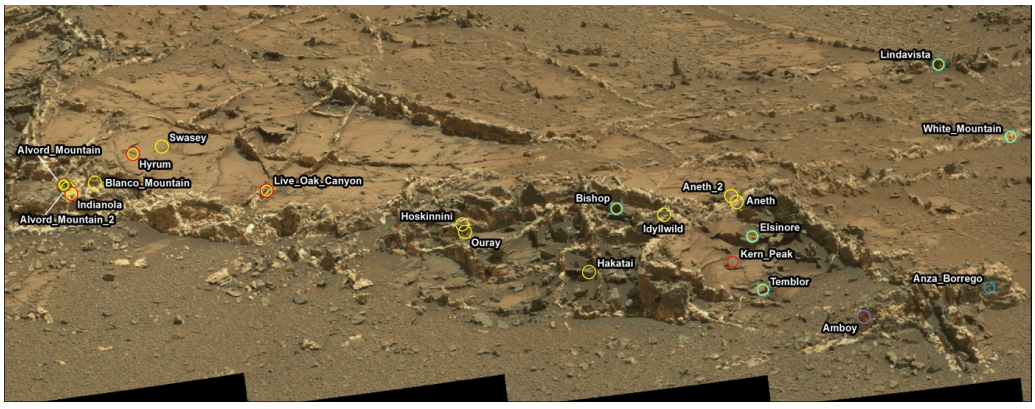
Abstract

Curiosity has completed a detailed chemo-stratigraphy analysis at the Pahrump outcrop in Gale Crater. Data from the nearby "Garden City" vein complex can be used to provide insight into the fluids that may have migrated through the section and evolved locally from water-rock interactions. From these data emerges a complex aqueous history where sediments have interacted with fluids with variable chemistry in distinct episodes.

1. Introduction

From September 2014 through April 2015 Curiosity explored the unit informally known as the "Pahrump" which has been identified based on orbital data as part of the lowermost strata of Mount Sharp (1). During this period, ChemCam systematically targeted bedrock and diagenetic features to study the chemo-stratigraphy of exposure and investigate its aqueous history and evolution. In total >540 chemical measurements at distinct locations were collected. Previous results from these data include the identification and investigation of a wide range of diagenetic features (2); average compositions of the units have variable chemical alteration indexes (e.g. 3,4) indicating variable mineralogy. Additional elemental trends also support variations in mineralogy (e.g. Al_2O_3 vs TiO_2, FeO) (e.g. 5, 6). More recent ChemCam data collected at the "Garden City" vein complex (Figure 1) can be used to provide additional constraints on the chemical evolution of the Pahrump section.

Figure 1: ChemCam measurement targets in the "Garden City" vein complex are shown in yellow. Background mosaic sol 925 Garden City Mosaic (mcam04072, credit NASA/JPL/MSSS)



2. Garden City

The "Garden City" vein complex consists of a mass of interconnected veins that are resistant to erosion compared to local bedrock. Garden City is thought be stratigraphically above the Pahrump outcrop. Thus the fluids producing the veins likely also migrated through the Pahrump sediments. The Garden City veins have distinct chemical signatures that are different from both the local bedrock and each other. Linear chemical mixing models also cannot be used to link the chemical end members measured. This implies distinct fluids forming the veins. Figure 2 shows example chemical trends in this data set using Independent Component Analysis (ICA)(7). Different subsets of analyses are grouped by color symbols. The high-albedo veins (labeled "CaSO4Vein, green") are dominated by $CaSO_4$ (e.g. White Mountain, Indianola, Hoskinnnin). The gold "Flourine" observations (e.g. Alvord_Mt2) are distinctive due to extremely high (e.g., several to > 10 wt %) fluorine concentrations and abundant Ca (8). A subset of the dark veins (labeled "Dark Vein Lower Fe, pink") has relatively low iron and high Mg suggesting a Mg-rich fluid is involved in their formation. Relatively high iron observations are seen in a subset of the dark veins (e.g., Ouray, orange) and in the resistant fins (magenta) (Hakatai, Bishop, Elsinor, Temblor). While morphologically similar to the other fins, Elsinor has lower potassium. This may indicate that the erosion resistant morphology of these features is the result of excess iron phases present.

3. Conclusions.

Given the distinct fluid chemistry at Garden City, it is likely that multiple fluid compositions interacted with the sediments at Pahrump. The vein compositions at Garden City can be used to develop insight into the overall variability of the chemistry within the Pahrump section and its aqueous evolution. The fluids can be used as end members to assess how the sediments interacted with the fluids producing the veins. These different fluid chemistries at Garden City could be the result of distinct fluids migrating through the section from a distance with a pre-established chemical signature, fluids locally evolved from water rock interactions, or both. Thus the chemical relationships between the Pahrump bedrock and the veins' chemistry can be used to constrain the origin of the fluids.

References: 1. Stack et al. 2015, 46th LPSC, Houston Texas, abstract # 1994; 2. Nachon et al. 2015, EPSC this issue; 3. Forni et al 2015 46th LPSC, Houston Texas, abstract # 2099; 4. Mangold et al. EPCS 2015 this volume; 5. Millken et al 2015 46th LPSC, Houston Texas, abstract # 2399; 6 Blaney et al 2015, 46th LPSC, Houston Texas, abstract # 2093: 7. Forni O., et al 2013, Spectrochimica Acta Part B, Vol. 86, pp. 31-41, DOI: 10.1016/j.sab.2013.05.003; 8. Forni et al EPSC 2015, this volume.

Figure 2: ICA analysis of ChemCam Garden City bedrock, veins, and resistant fins.