REGIONAL GAMMA RAY SPECTROMETER (GRS) DATA FOR MARS AND COMPARISON TO GALE CRATER MARS SCIENCE LABORATORY ANALYTICAL DATA.

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Introduction: The region of Mars along the dichotomy boundary, containing the landing sites for the Curiosity Rover in Gale crater and the Spirit rover in Gusev crater, provides an excellent location to test the origin of both highlands and volcanic terrains, with data from the Gamma Ray Spectrometer (GRS) on the Mars Odyssey Spacecraft. The GRS provides regional chemical data for lithophile (Al, Ca, Cl, K, Si, Th), siderophile (Fe), chalcophile (S), and atmophile (H) elements for known geological units that can be used to determine the affinity of materials sampled by the rovers. We determined elemental compositions for ten homogeneous areas, and compare the compositions to data from Gale and Gusev Craters. Our objective is to understand the nature of the bedrock and surficial materials on the surface of Mars from the GRS signal, and the geological relationship between GRS provinces and Gale Crater.

Data and Methods: The Mars Odyssey GRS instrument suite with a footprint of several hundreds of kilometers (not collimated) uniquely reveals the chemistry of large regions of the Martian surface [1]. For convenience, the data are expressed as sums over different size latitude and longitude boxes “pixels”. Unlike the statistical methods to identify geochemical provinces [2], we defined our geologic regions within the study area based on homogeneity of elemental abundances for contiguous pixels. The geologic regions represent relatively similar physical (e.g. thermal inertia, albedo, elevation) and elemental abundance properties and therefore account for both bedrock and surficial material. We used data away from the geological unit boundaries to determine the concentration of the elements in well-defined geologic-geographic regions, without incorporating too much signal from other areas. For pixels used within each geologic region, the mean of elemental abundance is calculated by maximizing the probability for the entire dataset yields for the presence of heteroscedasticity [3]. Elemental composition from Gale crater [4-6] and average Martian global soil composition [7] is plotted for comparison.

Results: Two classes of elements with spatial distributions that are different from each other have been used: elements (e.g. Ca, Mg, Fe, Th, Si) and elements S, Cl and H. Elements S, Cl and H are considered to be mainly derived from volcanic aerosols. We have identified 10 geologic regions near the dichotomy boundary (30°N~30°S, 90°E~210°E) ranging from volcanic terrains to highlands (Figure 1, red polygons show the regions selected for certain element composition) based on the composition of elements Ca, Si, Th, K and Fe. In order to compare the mobile element abundances in typical Highlands and volcanic terrains and Gale, Gusev craters, we have identified four regions for S, H and Cl (Figure 1. Polygons with dashed lines), with relatively constant abundances, which are Hesperia volcano, central Medusae Fossae, Gale crater area and Gusev crater area.

Compared with GRS data, the FeO/SiO_2 abundance of Gale crater from igneous rocks is highly variable and ranges from highlands to higher than Elysium Planitia (Figure 2.A). In the plot of K_2O/SiO_2 the Gale crater igneous concentrations based on APXS and ChemCam data are closer to the elemental abundance of Highlands, (Figure 2.B). For CaO/SiO_2, Gale rocks fall below the GRS abundances of most of the regions (Figure 2). For soil composition in Gale crater, CaO is higher than in igneous rocks (Figure 3); FeO is similar to Elysium East and central Medusae Fossae (Figure 3.A); K_2O is lower than GRS data (Figure 3.B).

Discussion: The igneous rocks in Gale crater (Figure. 2) have a geochemical affinity with the highlands crustal regions south of the dichotomy boundary. The Gale crater data for igneous rocks expanded the diversity of igneous processes occurring in rover landing sites, but still has a generally Highlands signature. Compared to Gusev crater, the basaltic rocks in Gale may have originated from different mantle reservoirs or undergone more extensive fractional crystallization than those observed in Gusev crater [4]. In Gale crater, the in situ observation of slightly higher CaO in soil (about 7 wt% [5]) compared to igneous rocks (about 5.3 wt% [4,6]) may be due to mass transport. The soil materials may transport from the Elysium volcano or central Medusae Fossae sediment based on the similar CaO abundance of soil in Gale crater and GRS data. This is also as indicated by the presence of visible streaks due to prevailing winds [8], coupled with in situ analysis of dust pockets previously analyzed by the instruments on the MSL rover.

References: [1] Boynton W. V. et al. (2007) *JGR, 112*. [2] Taylor E. F. et al. (2010) *Geology, 2,* 183-186. [3] Karunatillake S. et al. (2011) *Journal of Scientific Computing, 3,* 439-451. [4] Cousin A. et al. (2017) *Icarus, 288,* 265-283. [5] O’Connell-Cooper C.D. et al. (2017) *JGR, 122,* 2623-2643. [6] Mangold N. et al. (2017) *Icarus, 284,* 1-17. [7 Taylor G.J. and Mclennan. S.M. (2009) *Planetary Crusts*.

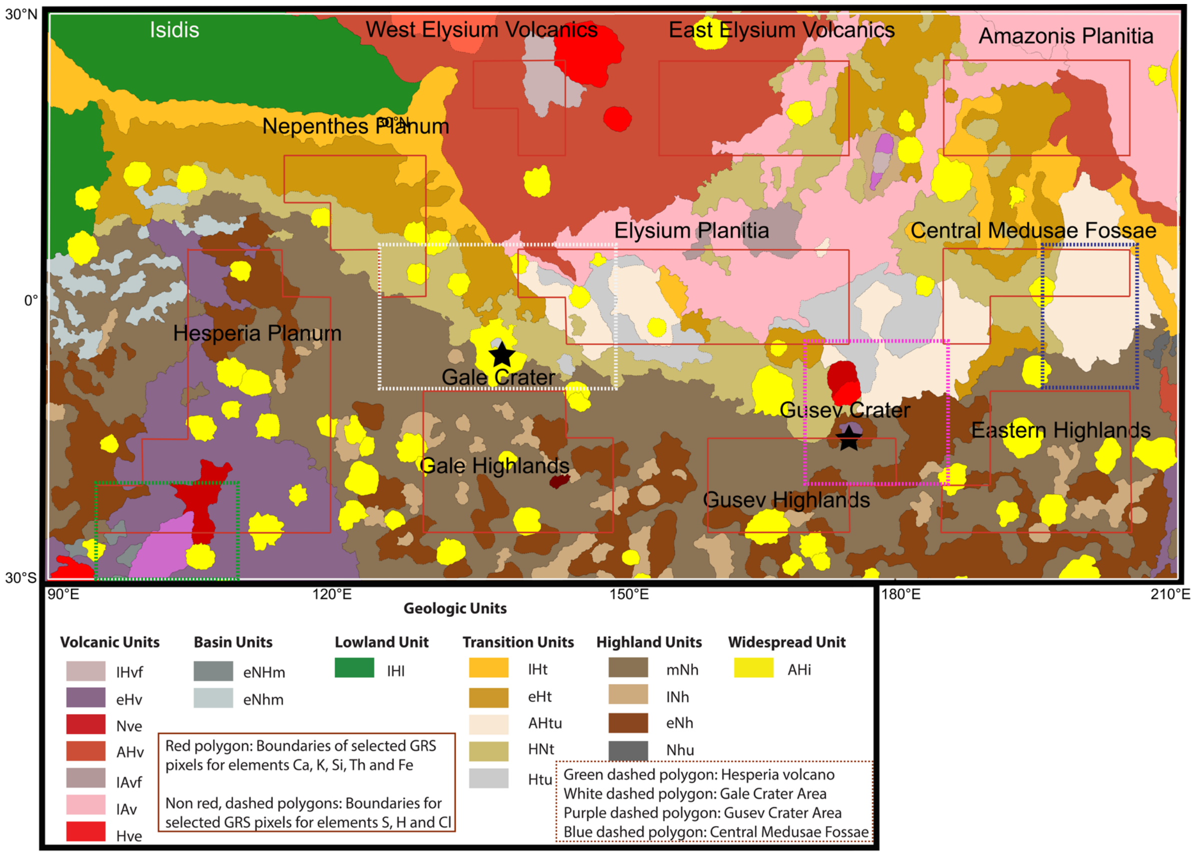

Figure 1. Geological regions identified for this study overlain on the geological map.

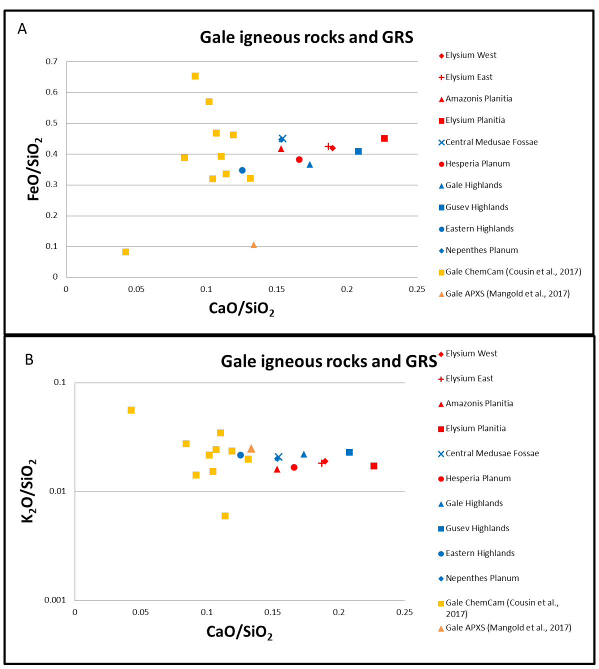

Figure 2. Igneous rock chemistry from published ChemCam and APXS data at Gale crater compared with GRS derived chemistry for geologic regions.

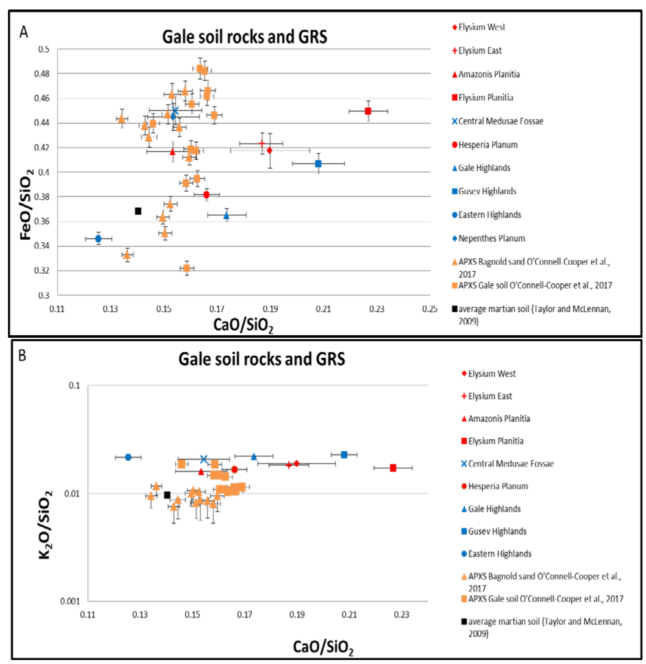

Figure 3. Soil chemistry from published ChemCam and APXS data at Gale crater compared with GRS derived chemistry for geologic regions.