SYNTHESIS OF CHEMICAL PROVINCES ON MARS AND THEIR GEOLOGIC INTERPRETATIONS**.** A. Rani[1,2], A. Basu Sarbadhikari[1], D. R. Hood[3], S. Karunatillake[4], and S. Nambiar[1]. [1]Physical Research Laboratory, Ahmedabad, India (alka@prl.res.in), [2]Indian Institute of Technology, Gandhinagar, India, [3]Texas A&M University, [4]Geology and Geophysics, Louisiana State University, USA.

Introduction: A trilogy of multivariate analysis methods helped to constrain a range of Martian geologic processes and delineated chemical provinces using the dataset from Mars Odyssey Gamma and neutron spectroscopy (GRS) [1-3]. However, an integrated work across those methods and reinterpretations to address the latest chemical maps is lacking. Consequently, we refined the prior methods to delineate chemical provinces with the latest chemical maps and interpret underlying geologic processes [1-3]. The present study considered all major and trace elements, volatiles (H_2O, Cl and S), and some elements essential for primary and secondary mineralogy like Al, Ca. Eight key chemical provinces are apparent from our preliminary results, overlapping with (Amazonis–Tharsis, Lunae Planum (LP), Southern Acidalia Planum (SAP), Medusae Fossae Formation (MFF), Meridiani Planum, Southern highlands, Hesperia Planum, and west of Utopia Basin) (Figure 1).

Geochemical variation has been observed across the topographic dichotomy boundary. However, a unifying hypothesis to explain such variation has not yet been posited. Therefore, we consider three provinces (LP, MFF and SAP), lying near the dichotomy boundary. These regions demonstrate the chemical diversity of the surface and can inform the contribution of local and regional sources for surficial materials.

Data and Methods: Mars Odyssey based GRS global mass fraction elemental maps are considered with approximate area coverage from ~±45^0 N projected at a resolution of $5^0 \times 5^0$. Our three distinct multivariate statistical techniques are Non-Hierarchical clustering (N-HC) [2], Hierarchical clustering complemented with Principal Component Analysis (HC-PCA) [3] and improvised student's t-test to delineate Gaussian tail cluster (t-GTC) & that exceeds an area threshold [1].

Results and Discussion: Summarily, our detailed analysis shows LP (depleted in K, Th and H_2O) may have originated from a flood basalt event that straddles the deepest strata of Mariner Valley, MFF (volatiles enriched: Cl, S, H_2O with Fe) as originating from possible global ashfall units [4,5] and SAP (enriched in K, Th with Al depletion) shows varying roles of igneous versus aqueous environments [6,7], which is a significant transition zone from highlands to lowlands of Mars.

Lunae Planum (LP): The new chemical province map (Figure 1) highlights an area of distinct geology of Early Hesperian highland (eHh) age [8]. This material lies around Echus chasma and Kasei Vallis formations, named LP provinces. Geochemically, LP is depleted in K, Th and H_2O, compared to neighbouring GTCs. SAP is enriched in K, Th, whereas, Olympus Mons lacks

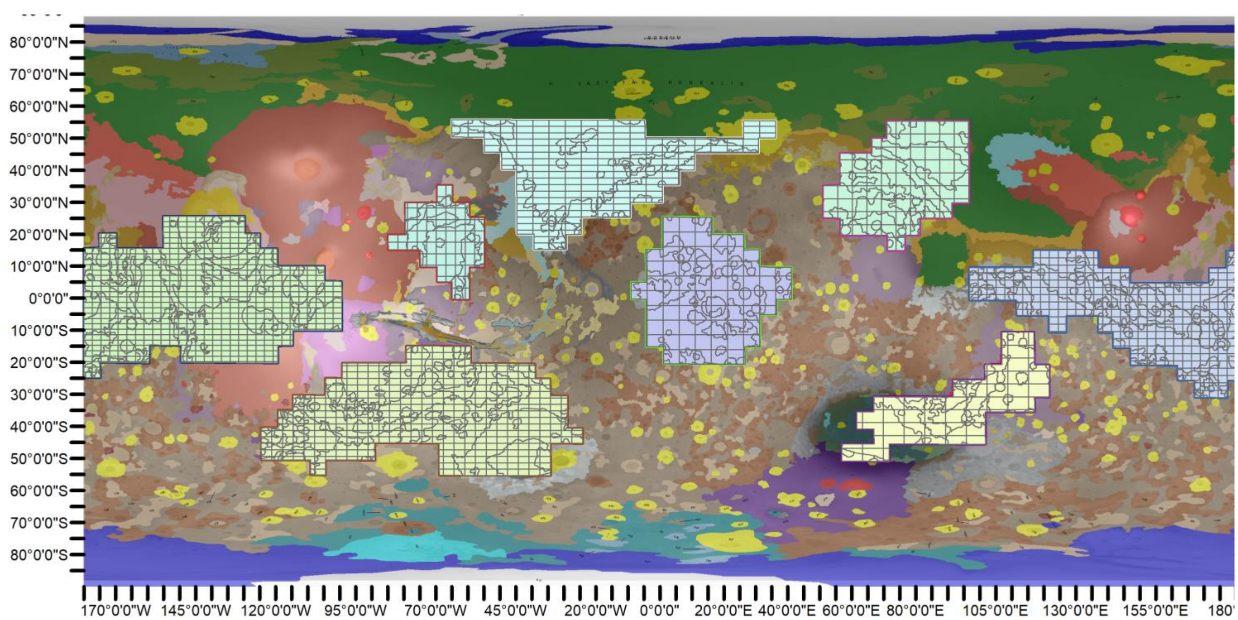

Figure 1: *Eight highlighted distinct geochemical provinces resulting from various multivariate analysis techniques, superimposed on the Mars geological map and the Mars Orbiter Laser Altimeter (MOLA) map.*

any deviation w.r.t Martian crust. However, LP shows similar depletion in K and Th as the other Hesperian provinces viz. Syrtis Major (SM), Hesperia Planum and Thaumasia Planum (TP) (Figure. 2). LP hosts similar K/Th ratio distribution as in SM and TP. However, along with K/Th ratio LP hosts similar H_2O and Si depletion trend as of TP [9]. This depletion of H_2O at LP and TP could be related to mantle compositions, fitting best with Martian mantle evolution models [10]. Hence, the LP has the same overlapping of K, Th and H_2O depletion with TP, falling along the Martian surface K/Th trendline. This finding argued for volcanic origin with a least or negligible aqueous alteration.

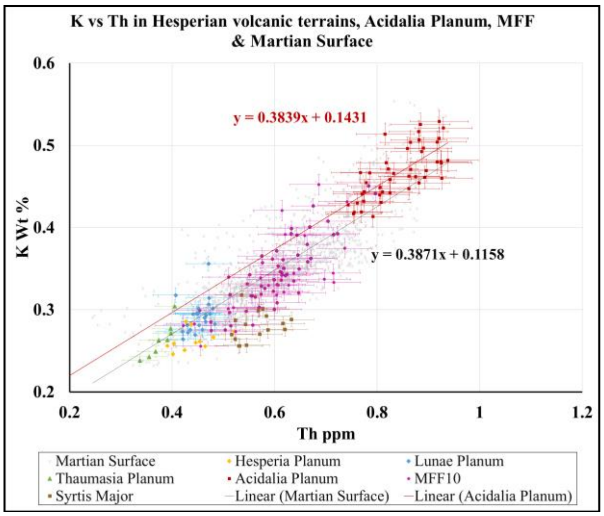

Figure 2: *K wt% vs. Th ppm in various regions on the Martian surface derived from geochemical mapping*.

Southern Acidalia Planum (SAP): This region is consistent with previous geochemical maps [1-3], lying at resurfaced northern lowlands. Geochemically, SAP is highly enriched in K, Th, and Fe, Si and highly depleted in Al relative to the Martian crust. Because of the most enriched abundance of these incompatible elements (K and Th), it is essential to understand the secondary modification processes (e.g., erosion or aqueous solutions). However, the quantified observation of K/Th ratio with box whisker analysis and Figure 2, depicts a similar trend like the Martian crust. The variation in numerical abundances of these elements over the Martian surface supports the variations in melt generation [6-8] and is plausible with a lower degree of partial melting of the undepleted mantle. Mineralogical observation also supports SAP igneous origin hypothesis [11]. However, the pH-dependent solubility of Al concentration may challenge the possibility of igneous processes. For example, Al is immobile at moderate pH, whereas low pH processes reverse the mobility of Al, which leads to the depletion in Al.

Medusae Fossae Formation (MFF): The discrete wind-sculpted outcrops of MFF are extended along the Martian equator with the likely deposition ages starting from Late Hesperian [12]. The MFF's origin is debatable; however, the most recent study favors loose and dry pyroclastic deposition [4,5]. Geochemically, MFF shows high enrichment in Fe, Ca, S, Cl, and H_2O relative to the global Martian crust. Iron enrichment in soil either reflects bedrock provenance, weathering at low pH, or fractionation of dense Fe-minerals by aeolian processes [13]. Although H_2O and Cl concentrations are highly correlated on the Martian surface, MFF is distinguished by more enrichment of Cl than H_2O. The high S and Cl content, fine-grained nature and morphologic features of MFF indicate extensive erosion, suggesting that MFF is the source for the global dust reservoirs of Mars [5]. The abundance of K, Th, Al, Si, and K/Th ratio is consistent with the Martian crust. The MFF region is well-aligned with the general trend of K and Th variation of Mars. The absolute abundance of these large ion lithophile elements in MFF is neither high like SAP nor low like LP (Figure 2). The higher absolute abundances of K and Th in MFF than LP can be interpreted as loose volcanic (pyroclastic) materials in MFF compared to the LP volcanic lava flow.

References:

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