IS CONTINENTAL FLOOD BASALT A POTENTIAL ANALOG FOR MARTIAN CRUST? : A GEOCHEMICAL ANALYSIS

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Introduction: Basaltic [1] volcanism on Mars is often comparable with terrestrial hotspot volcanism on Earth. The large Martian volcanic features are often attributed to partial melting above the mantle plume similar to the process generating the large igneous provinces on Earth [2]. The spectroscopic analysis using the Thermal Emission Spectrometer onboard Mars Global Surveyor found that the crustal composition of Mars strongly resembles Deccan Trap Continental flood basalts, India [3]. Additionally, the geochemical signatures of the Shergottites are also found to be similar with the Deccan CFB [4]. Until sample return, one of the best ways to constrain the volcanism and the petrochemical characters of basalts from Mars is to envisage comparative planetology. In this study, we carried out a geochemical comparison between Martian basalts with the Deccan CFB to test their similarities and constrain the possible petrogenesis.

Dataset used and Methodology: *In-situ* APXS data from Mars Exploration rovers (Spirit and Opportunity) along with major oxides and trace elemental data of Deccan basalt, Mid-Ocean Ridge Basalt (MORB) and Martian Shergottites are collected from various literature sources [5, 6, 7, 8 and 9]. These datasets were further chondrite normalized using the CI Chondrite geochemical dataset in [10] for the required geochemical plots.

Results and Discussion: In the Total Alkali Silica plot, majority of the Shergottites and Deccan Trap rocks falls on the basaltic field of the diagram (Fig. 1).

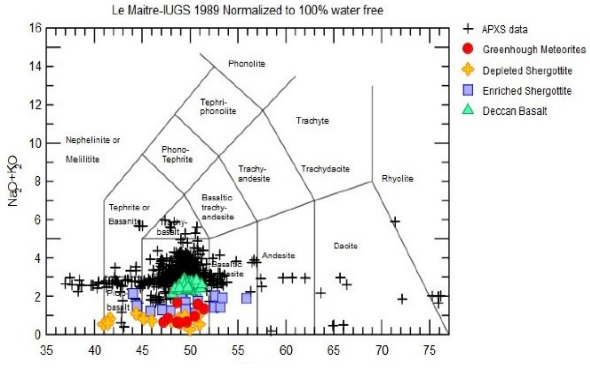

Fig. 1:-Total Alkali Silica (TAS) diagram

The Martian meteorites generally show a narrow, low total alkali content (< 2 wt.%), while the APXS data show a considerable scatter ranging from ultrabasic rocks to Rhyolite. Moreover, the APXS data also have an iron enrichment trend i.e. they are tholeiitic in nature as evident from the AFM Plot (Fig. 2), suggesting for fractional crystallization at a low fO_2 conditions.

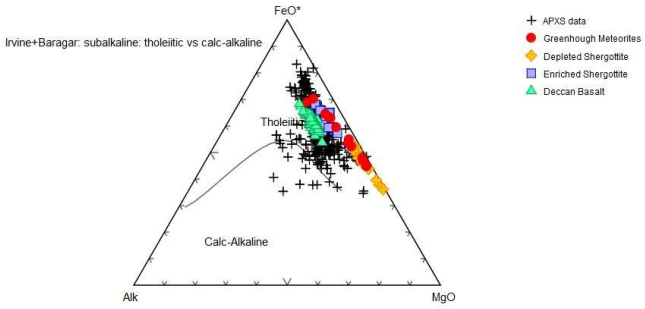

Fig. 2:- Alkali- FeO^T-MgO (AFM) triangular plot

In CaO/Al_2O_3 versus Al_2O_3/TiO_2 plot (Fig. 3), Deccan basalt shows a restricted CaO/Al_2O_3 ratio (~0.8) which is very similar to the average Global MORB data. In contrast, Martian Shergottites are relatively enriched in CaO, while the *in-situ* APXS data scatter around the Al-rich end.

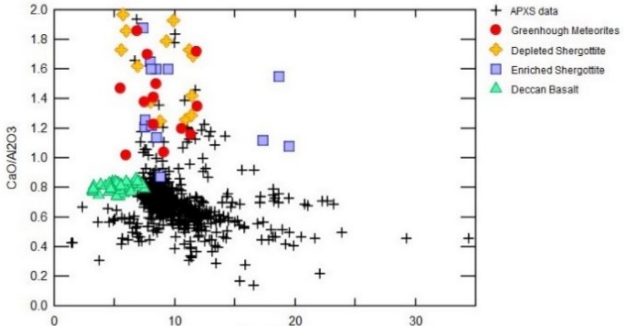

Fig. 3:- CaO/Al_2O_3 vs. Al_2O_3/TiO_2 bivariate plot

Based on the multivariate incompatible trace element Spider plot [11] (Fig. 4), the Depleted Shergottites (La<1ppm) are more depleted in incompatible elements as compared to N-MORB, while the

Enriched Shergottites (La>1ppm) fall in between N- and E-MORB.

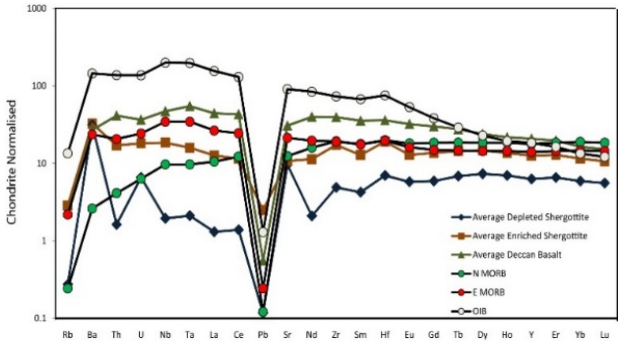

Fig. 4:-Trace element Spidergram

Moreover, based on the compatible versus incompatible trace element plot (e.g. Cr vs. Th plot; Fig. 5), depleted and enriched members of Shergottites fall at different regions of the plot. Depleted Shergottites show least variability of Cr while Th concentration varies. However, there is a curvilinear mixing trend apparently existing between them. [12].

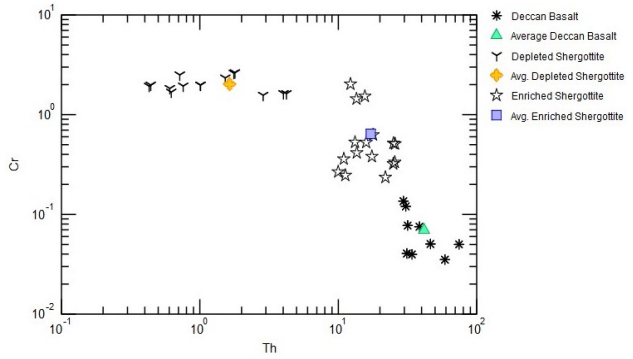

Fig. 5:- Cr vs. Th bivariate plot

In the Th/Yb vs. Nb/Yb plot i.e. a conservative and non-conservative trace elemental ratio plot [13 & 14] (Fig. 6), the Shergottites fall along the Global MORB-OIB array. The Enriched Shergottites and Deccan CFB fall close to E-MORB vis-à-vis the Depleted Shergottites fall close to the depleted N-MORB, indicating that the Depleted and the Enriched

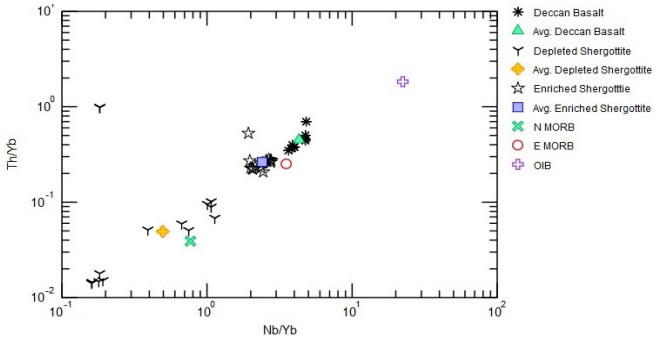

Fig. 6:- Th/Yb vs. Nb/Yb bivariate plot

Shergottites are not cogenetic in nature and corresponding to different source region of mantle.

Our study suggests that the Fe- enrichment i.e. tholeiitic trend is common for both terrestrial CFB and Martian basalt arguing for fractional crystallization. The highly silicic nature of the Martian crust as evident from the in-situ APXS instrument is really intriguing and may suggest the possibility of recycled continental crust (?). However, understanding the enrichment process of Martian mantle is still constrained. The geochemical similarities between Deccan Basalt and Global MORB data suggest that the terrestrial CFBs evolved from a MORB-like source, however the former is comparatively enriched with incompatible elements, often resulting due to crustal contamination or enriched mantle source. Based on the trace element systematics, it can be inferred that the Depleted and Enriched Martian basalts represent at least two different source reservoirs and corroborates possible existence of mantle heterogeneity on Mars. Again the similarity of the E-MORB and Enriched Shergottite data suggests that plate tectonics may not be essential for generation of E-MORB. Furthermore, incompatible trace elemental ratios of Martian Enriched Shergottites resemble that of the Deccan CFB, suggesting similar igneous process may be responsible for the generation of basaltic magmas. Thus, our preliminary geochemical study indicates an apparent similarity in the geochemistry of the Deccan Basalts and Martian Shergottites, however, a more robust discussion is necessary, especially using the experimental phase diagram and uniform trace element ratio, to better constrain the basaltic volcanism on Mars.

References:

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