A NEW MARTIAN BASALT SOURCE REGION MODEL COMPOSITION CALCULATED BASED ON TERRESTRIAL FERROPICRITES AS ANALOGS TO MARTIAN BASALTS. J. Filiberto[1], [1]Lunar and planetary institute, 3600 Bay Area Blvd, Houston, TX 77058, Filiberto@lpi.usra.edu.

Introduction: It is generally accepted that the geochemical signatures of the SNC meteorites (and Mars in general) and terrestrial rocks (and Earth in general) are distinct. Differences in chemistry have been observed through comparisons of bulk sample and mineral chemistry of the SNC meteorites with terrestrial igneous rocks using element abundance ratios of correlated elements [1-8]. Such ratios have been used to make predictions about planetary mantle chemistry and mineralogy [1, 2, 6, 7].

Filiberto et al. [9, 10] noted that terrestrial ferropicritic rocks, with mineralogic assemblages similar to those of the shergottites, may represent terrestrial analogs to the shergottite meteorites. They showed that bulk major element ratios, such as Fe/Mn, Al/Ti, Mg/Si, Al/Si, Ca/Si, Fe/Si, do not distinguish Martian basalts from terrestrial ferropicrites (Figure 1) nor does the volatile element chemistry (Na/Al, Na/Ti, K/La, K/Th, K/U). The Co/MgO, Ni/Mg, and Th/U are not definitive because there is some overlap between the Martian basalts and ferropicrites. The only often-used element abundance ratio that does appear to retain a distinctive difference between Martian and terrestrial materials is the Cr/Mg ratio.

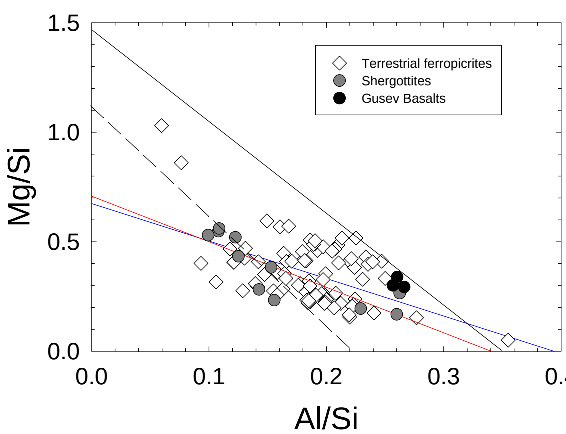

Figure 1. Variation of Mg/Si and Al/Si (wt. ratio) in basaltic and olivine-phyric shergottite bulk compositions [11, 12], Gusev basalts [13], and terrestrial ferropicrites [14-20]. The terrestrial geochemical fractionation line (solid line [1]) and the Mars crust line (dashed line [8]) as well as linear regression lines through the shergottites (red) and ferropicrites (blue) are plotted for reference.

While these ratios do not distinguish terrestrial ferropicrites and Martian basalts, there may be slight differences in the compositional ratio averages between the ferropicrites and Martian basalts (Figure 1). These small differences may be key for assessing the source region compositions of the Martian basalts, if both terrestrial ferropicrites and Martian basalts represent liquids. Therefore, I have constructed a new technique for determining source region compositions that is based on these small differences. This new model focuses on the possibility that the small differences in bulk chemistry between Martian basalts and terrestrial ferropicrites are proportionally equivalent to the differences in chemistry between the terrestrial and Martian mantle. These proportional bulk chemical differences can be used to calculate a composition based on model terrestrial upper mantle compositions.

Methodology: Calculations were conducted using ratios of element abundance ratios between terrestrial ferropicrites and Martian basalts. This gives the proportional difference between terrestrial rocks and Martian basalts. Assuming these proportional differences are the same as the proportional differences in chemistry between the terrestrial and Martian source regions, a new composition was calculated based on three previously proposed terrestrial mantle compositions [1, 21, 22]. Since the Gusev basalts and shergottites have different major element abundance ratios, chemistry, and potentially different mineralogy, calculations were performed on both the Gusev basalts and shergottites in order to give separate estimates of their major element source region compositions.

The proportional differences between the shergottites and Gusev basalts and ferropicrites were first multiplied by representative terrestrial mantle element abundance ratio compositions [1, 21, 22] in order to estimate the element abundance ratios of the Martian source regions. Next, in order to estimate the bulk chemistry the silicon content was assumed to be that of the terrestrial mantle (20.37 %, [21]). The assumed 20.37 % Si is similar in composition to previously proposed Martian mantle compositions [23, 24].

Finally, in order to calculate the bulk major element (Fe, Al, Mg) composition, the calculated Martian element abundance ratios were multiplied by the assumed silicon content to give element concentrations of the Martian source regions. Slight variations in Si content (20-22 %) have small effects on the overall calculated composition. The Ca/Al ratio was multiplied by the calculated Martian Al content to calculate the Martian Ca content. For Ti, the calculated Al was divided by the calculated Martian Al/Ti to generate a new composition. Iron was then recalculated to FeO_T and multiplied by the calculated MnO/FeO ratio which produced the MnO content of the Martian source region.

Discussion: The Martian source region compositions calculated based on the Gusev basalts are all enriched in Al even compared with the terrestrial mantle, which is unreasonable for a planet which has produced the Al-depleted shergottites. Without detailed petrography of the Gusev basalts it is unjustified to compare them with terrestrial ferropicrites in order to make predictions about planetary geochemistry, since this technique requires that the rocks being compared have similar mineralogy and petrologic history. Therefore for this reason, we discard these compositions.

However, the olivine-phyric and basaltic shergottites have mineralogy similar to the ferropicrites and, therefore, give more reasonable estimates of the Martian source region composition. Three new compositions have been determined based on different terrestrial mantle compositions (SP1: [21]; SP2: [22]; SJ1: [1]). The three new calculated compositions are similar to the previously proposed compositions in terms of Ti, and Ca, however they are dissimilar in Fe, Al, Mn, and Mg (Table 1).

Table 1	SP1	SP2	SJ1
SiO_2	42.7	44.4	44.1
TiO_2	0.3	0.1	0.1
Al_2O_3	6.5	6.5	6.5
FeO	8.7	8.5	8.3
MgO	39.1	38.2	38.1
CaO	2.0	2.4	2.6
MnO	0.7	n.d.	0.2
total	100.0	100.0	100.0

The composition SP1 based on the Green and Ringwood [21] model is the most terrestrial like composition. It has a slightly enriched MgO content compared to that of the terrestrial mantle composition. Yet, it is still enriched in Fe and depleted in Al compared with the terrestrial mantle. However the differences in Fe and Al are no longer as extreme as previously proposed. The other two compositions SP2 and SJ1 based on Ringwood [22] and on Jagoutz et al. [1] have MgO contents approximately equal to that of the terrestrial mantle compositions and Ca contents slightly higher than those of the previous calculated model.

This model does not constrain the MnO content of the Martian mantle very well but gives a range from 0.7 to 0.2 wt% for the Martian mantle. Notably, this range in composition is enriched compared with the terrestrial mantle.

All three (SP1, SP2, SJ1) compositions calculated are rather similar and are much more terrestrial-like in nature than previously proposed Martian mantle compositions. The calculated compositions are in accord with recent experimental work by Agee and Draper [23] which suggested that the Martian mantle may not be as enriched in Fe and Musselwhite et al. [25] that suggested that the Y-909459 source region is Mg-rich compared with previously proposed mantle compositions. Agee and Draper [23] state that without more detailed information about the internal structure and density distribution within the Martian crust, mantle, and core the current moment of inertia calculations cannot give unique solutions. Therefore, moment of inertia calculations do not preclude a lower-Fe, higher-Al Martian mantle composition, similar to the newly calculated compositions.

Concluding Remarks: Element abundance ratios which have previously been used to calculate the Martian mantle composition do not uniquely distinguish Martian basalts from terrestrial ferropicrites. Therefore, a new technique to calculate the shergottite source region composition was developed. This technique emphasizes small differences between Martian basalts, and terrestrial ferropicrites. The calculations produced compositions which are similar to the terrestrial mantle, yet still slightly enriched in Fe and depleted in Al.

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