POTENTIAL MAGMATIC DIVERSITY ON MARS. M. L. Whitaker[1], H. Nekvasil[1], and D. H. Lindsley[1], [1]Dept. of Geosciences, Stony Brook University, Stony Brook, NY 11794-2100, matthew.whitaker@sunysb.edu.

Introduction: Most of the experimental and theoretical petrological studies of possible Martian magmatic processes and resulting rock compositions have been based on the assumption that the Martian mantle has a composition that is high in Fe and low in Al [e.g. 1-3]. This assumption was based on the SNC meteorites, which are mainly composed of cumulate minerals, predominantly pyroxene and olivine. Recently, this assumption has been reevaluated.

Experimental studies on hypothesized Martian melt compositions have been unable to replicate the specific assemblage found in melt inclusions within the cumulate olivines of the Chassigny meteorite, while experiments on *terrestrial* materials were able to do so [4]. The results of this work show that the Chassigny melt inclusion assemblage can be produced by crystallizing a hawaiite liquid at 9.3 kbar under hydrous conditions (2 wt. % H_2O) at ~1050°C [4].

Recent discovery and analysis of the Yamoto 980459 shergottite meteorite has also led workers to reevaluate the high-Fe low-Al hypothesis. The cores of the olivine phenocrysts found in this meteorite are far more magnesian (Fo_{84}) [5] than those found in any other SNC meteorite to date. This is similar to olivines found in mantle xenoliths and primitive basalts on Earth, which suggests that Mars may have a mantle more similar to that of Earth than originally thought.

Recently published MER data also suggest that there may be more similarity between the rocks on Earth and Mars than previously believed [6, 7]. Removal of ~20-25% accumulated olivine from the bulk compositions of several Martian rocks results in liquid compositions that are similar to common terrestrial tholeiitic basalts.

Since more evidence is pointing toward similarity between Martian and terrestrial magmatism, the common processes that affect the nature and composition of igneous rocks on Earth may also be applicable to Mars. The present lack of plate tectonics on Mars suggests that terrestrial intraplate magmatism would be of most relevance to Mars. Intraplate magmas on Earth are commonly found as a part of suites of diverse rocks ranging in composition from basalt to rhyolite or phonolite. The spatially and temporally related rocks in these suites define four primary compositional trends, or liquid lines-of-descent.

We have experimentally investigated the possibility that the diverse rock types of these four trends could be generated by fractionation of a continental tholeiite under different conditions of pressure and bulk water content. If this diversity can arise from a typical olivine tholeiite, then there is the possibility that Martian igneous systems may likewise be quite compositionally diverse. Crystallization experiments were carried out in a piston-cylinder apparatus, using graphite capsules to house the sample powder. The starting material was a Snake River Plain olivine tholeiite.

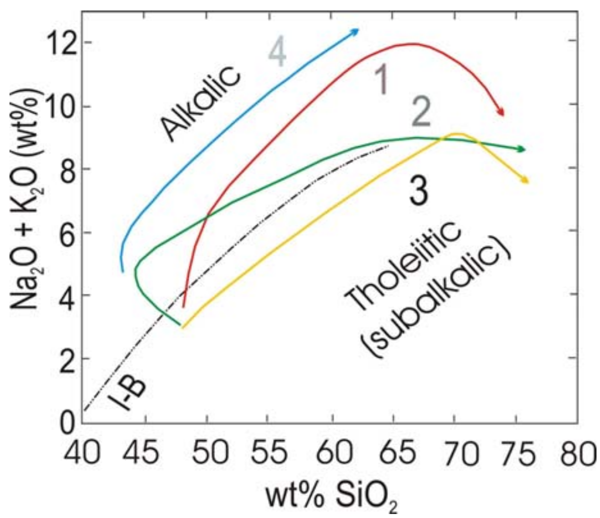

Figure 1. Total Alkalis vs. Silica Diagram showing four major trends found in terrestrial intraplate magmatic suites: (1) silica saturated sodic alkalic, (2) silica saturated potassic alkalic, (3) ocean island tholeiitic, and (4) silica undersaturated sodic alkalic trends. The dashed line is the boundary between tholeiitic and alkalic rocks defined by Irvine & Baragar [8].

Results: Fractionation of continental tholeiite at 14.3 kbar (1.43 GPa) with moderately low bulk water content (~0.35 wt. %) gives rise to the silica-undersaturated sodic alkalic series, consisting of the rocks alkali basalt, nepheline hawaiite, nepheline mugearite, and phonolite [9] (**Trend 4** in Fig. 1). Recent experiments have shown that this trend can also be replicated at pressures as low as 12.3 kbar. Rocks of this trend are characterized by silica-undersaturation, high-Fe contents in the rocks with the lowest Si, and highly elevated alkali contents.

Fractionation of continental tholeiite at 9.3 kbar with relatively high bulk water contents (1-2 wt. %) reproduces the silica-saturated sodic alkalic series, and yields the rocks alkalic basalt (silica-saturated), hawaiite, mugearite, benmoreite, trachyte, and sodic rhyolite (**Trend 1** in Fig. 1). This trend is characterized by alkali enrichment (Figs. **2a, b**) along with Ti and P depletion (Figs. **2e, g**).

Trend 2 in Figure 1 represents the rocks of the silica-saturated potassic alkalic series which consists of such rocks as olivine tholeiite, ferrobasalt, trachyandesite, and potassic rhyolite. This trend can be divided into silica-depletion and silica-enrichment segments. Fractionation of continental tholeiitic parent melt at 9.3 kbar with low bulk water contents (<0.4 wt. %) leads to the development of the silica depletion segment [10], which starts with olivine tholeiite in the subalkalic field, and moves into the alkalic field with decreasing silica content (Fig. **1**). Along with SiO_2-depletion, there is simultaneous strong Fe, Ti, and P enrichment leading to the generation of ferrobasaltic liquids (Figs. **2e, g, h**), with silica contents close to 40 wt. % and FeO contents as high as 22 wt. %.

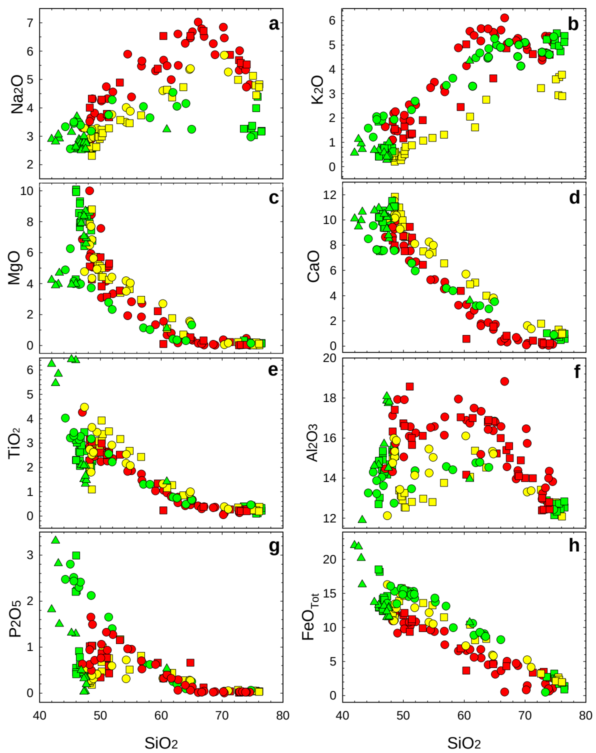

Figure 2. Harker Variation Diagrams showing natural terrestrial rock compositions, color coded by trend as defined in Fig. 1. Red: silica saturated sodic alkalic trend (1). Green: silica saturated potassic alkalic trend (2). Yellow: ocean island tholeiitic trend (3). For clarity, only the rocks of the silica-saturated series (Trends 1-3 in Fig. 1) are presented here.

Fractionation of the tholeiitic parent liquid at 4.3 kbar with moderate bulk water contents (>~0.3 wt. %) replicates the silica-enrichment segment of **Trend 2** [11]. This part of the trend continues from ferrobasalt through trachyandesite to potassic rhyolite.

Low pressure (0 kbar) fractionation of continental tholeiitic parental liquid gives rise to the rocks of the silica-saturated ocean island tholeiitic series, which consists of rocks like olivine tholeiite, ferrobasalt, icelandite, and sodic rhyolite (**Trend 3** in Fig. 1). This trend is characterized by the sub-alkalic nature of all its constituents (Fig. **1**), and initial mild Fe-Ti-P enrichment followed by depletion of these elements as silica enrichment continues (Figs. **2e, g, h**).

Summary: The results of this experimental work have shown that under different conditions of fractionation, typical terrestrial olivine tholeiite parent liquid can give rise to an astounding array of magmatic diversity without calling upon plate tectonic processes. The presence of tholeiitic rocks on Mars suggests that it is possible that Martian igneous rocks may show great compositional diversity similar to that found in terrestrial rocks.

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