

CHEMICAL SIGNATURES IN PLAGIOCLASE FROM MARTIAN METEORITES. J.M. Karner, (jkarner@unm.edu), J.J. Papike, C.K. Shearer, and P.V. Burger. Institute of Meteoritics, University of New Mexico, Albuquerque, NM 87131

Introduction: Comparative planetary mineralogy studies [1-3] have shown that chemical signatures in plagioclase feldspar reflect planetary and igneous constraints on the magmas from which it crystallized. Although plagioclase forms relatively late in most crystallization sequences, it is a common mineral in nearly all basalts, and its structure incorporates several elements whose ionic radii are too large to fit into earlier crystallizing ferromagnesian minerals such as olivine and pyroxene. Therefore, the chemistry of plagioclase records the physical and chemical processes of basaltic magmatism, but utilizing different elements from those that partition into olivine and pyroxene.

Results and discussion: This paper highlights chemical signatures in plagioclase from several martian meteorites. We note that all observations here result from stoichiometric plagioclase EMP analyses, even though in most martian rocks crystalline plagioclase has been shocked to form a diaplectic glass (maskelynite). Our analyses show that in almost all cases the maskelynite retains its plagioclase stoichiometry.

Na and K in martian plagioclase: Figure 1a-e shows the K vs. Anorthite content of plagioclase from martian meteorites broken down by rock type. The plots show that plagioclase from meteorites of the same rock type are very similar in K and An% contents. The plots also show that plagioclase from the five rock types generally share the same slope of increasing K with decreasing An%. This is significant because the rock types shown here are diverse, (i.e., monomineralic cumulates to basaltic melts), and illustrates that plagioclase from martian rocks holds a planetary chemical signature despite vast differences in igneous history.

Figure 1f shows this martian plagioclase signature is different from those of the other terrestrial planets. Papike [2] and Karner et al. [3] previously noted that martian plagioclase plotted at higher Na and K values than terrestrial basaltic plagioclase and significantly higher than plagioclase from the volatile depleted bodies Moon and 4 Vesta. They suggested this systematic reflected the higher volatile (Na and K) content of the martian source reservoirs compared with those of Earth. Here we question that conclusion. Terrestrial basalt compositions are generally higher in Na and K than martian basalts; why then is plagioclase from Mars richer in Na and K than terrestrial basaltic plagioclase? The answer may be the relatively low Al content of martian basalts relative to terrestrial

basalts. Two observations help explain the observed systematics. First, albite ($\text{NaAlSi}_3\text{O}_8$) and orthoclase (KAlSi_3O_8), only require one half the Al than does anorthite ($\text{CaAl}_2\text{Si}_2\text{O}_8$). Thus in a crystallizing martian melt it is easier to form plagioclase with high Na and K contents (because of the lower Al needed). Second, the low Al activity in martian melts results in delayed nucleation of plagioclase. Sodium is quite incompatible in pyroxene; estimates of partition coefficients at $f\text{O}_2$ values of $\sim\text{IW}$ suggest D_{Na} pigeonite/melt to be ~ 0.02 and for augite/melt ~ 0.08 [4-5]. Therefore, while the mafic phases (olivine, pyroxene) are crystallizing the activity of Na is building up in the residual melt. When plagioclase crystallizes it takes up most of the Na. In summary, we believe that the high albite contents of martian plagioclase relative to terrestrial plagioclase are the result of the low Al in martian melts and the resulting delayed nucleation of plagioclase.

Geochemical reservoir signatures in martian plagioclase: Several studies have shown that martian meteorites display a significant range of trace element and isotopic characteristics [6-7]. The end members of this trace element and isotopic classification continuum are the “depleted” source basalts, ($\text{La}/\text{Yb} < 0.3$) that have low LREE concentrations and a steep slope in a CI normalized REE pattern, and “enriched” basalts which have flat REE patterns defined by $\text{La}/\text{Yb} > 0.7$. Depleted and enriched source designations are based on whole rock trace element and isotopic studies, but here we propose that martian plagioclase may hold the same clues to its source region origin.

Figure 2 plots the average La/Yb ratio of the meteorite against the plagioclase $\text{K}_2\text{O}/\text{Na}_2\text{O}$ wt.% multiplied by the Al_2O_3 wt.% of the meteorite. The plot shows that there is a strong positive correlation between La/Yb (bulk rock) and the $\text{K}_2\text{O}/\text{Na}_2\text{O}$ (plagioclase). Therefore, relatively simple EMP analyses of martian plagioclase combined with the Al content of the bulk meteorite can give a quick estimate of the type of geochemical reservoir the parental melt was derived from.

References: [1] Papike (1981) In BVTP, LPI, Houston, TX, pp. 340-363. [2] Papike (1998) RIM 36, 7-1 to 7-11. [3] Karner et al. (2004) Am. Min. 89, 1101-1109. [4] Karner et al. (2007) Am. Min. 92, 2002-2005. [5] Karner et al. (2008) MAPS 43, 1275-1285. [6] McSween (1994) MAPS 29, 757-779 [7] Borg et al. (2002) GCA 66, 2037-2053.

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Figure 1.

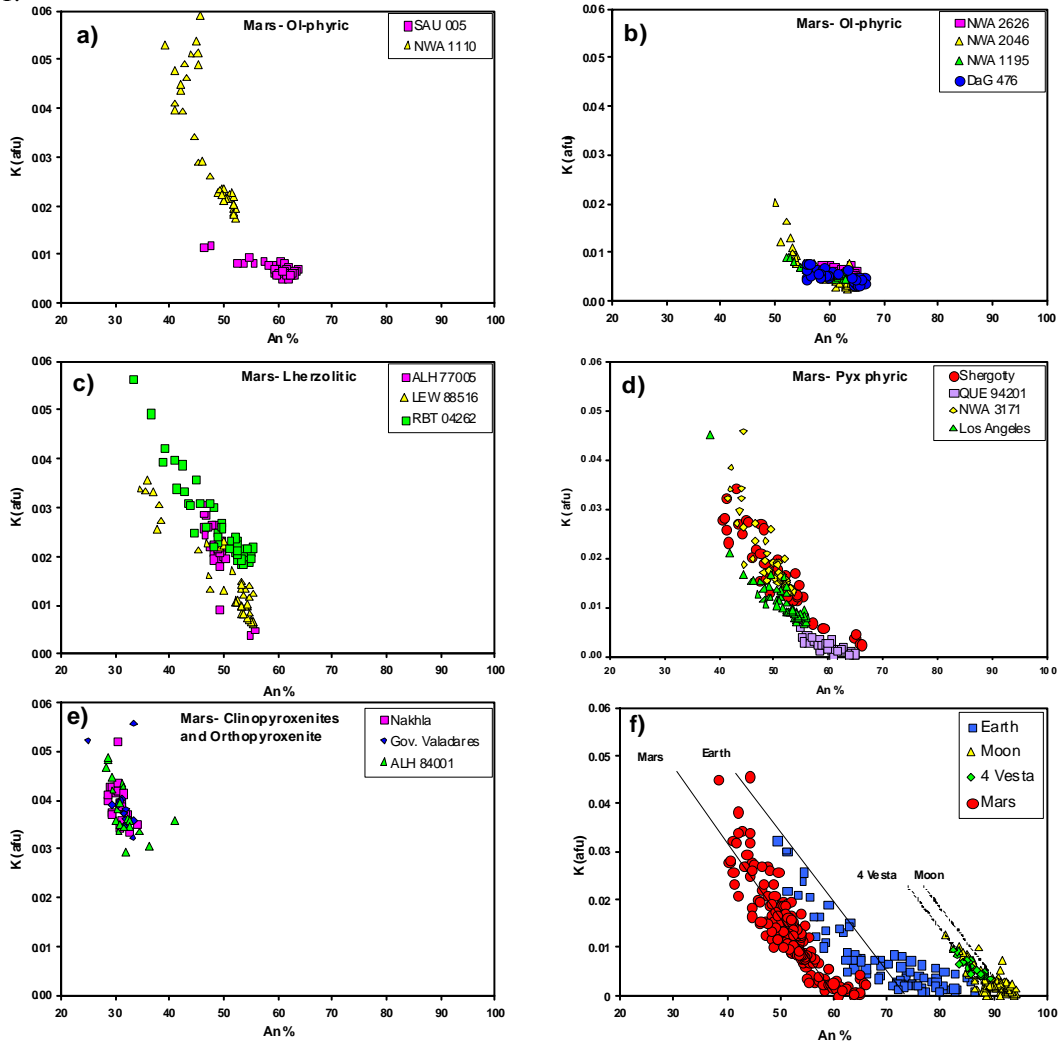


Figure 2.

