

Exploring the martian mantle through the micro-scale examination of the geochemical, fO_2 , and kinetic crystallization history of olivine in shergottites. C.K. Shearer¹, P. Aaron¹, P.V. Burger¹, A. Bell¹, Y. Guan², and J.J. Papike¹. ¹Institute of Meteoritics, University of New Mexico, Albuquerque, New Mexico 87131. ²Division of Earth and Planetary Sciences, California Institute of Technology, Pasadena, California 91125.

Introduction: A striking geochemical feature of the shergottites is the large range in initial Sr isotopic ratios and initial ϵ^{Nd} values [i.e. 1-4]. Within this range, the shergottites do not form a radiogenic isotopic continuum, but instead fall into three discreet subgroups. Each subgroup has distinct geochemical characteristics (i.e. bulk rock and phosphate REE patterns, stable isotopes, fO_2) [4-8]. These characteristics have been linked to different reservoirs in the martian mantle and crust and their interactions during shergottite magmatism. Two end-member models have been suggested to account for these ranges in geochemical characteristics. In one model, the shergottites are products of melting of two distinctly different mantle sources; a reduced ($<IW+1$), depleted mantle and an oxidized ($\sim IW+3.5$), enriched mantle. The second model suggests that shergottites that are reduced-depleted reflect the martian mantle, whereas the more oxidized and enriched shergottites reflect interactions between mantle-derived basalts and the martian crust [4-8]. Using high beam current electron microprobe x-ray mapping, nano-SIMS trace element analyses (including multi-valent trace elements such as V), and XANES analyses of V valence state, we are reconstructing the geochemical, fO_2 , and kinetic crystallization history of olivine megacrysts in depleted (i.e. Y980459) and enriched (i.e. NWA1183) shergottites. This reconstruction will allow us to determine the origin of these megacrysts and provide additional insight into the martian mantle.

Previous interpretations of olivine megacrysts: Numerous studies [i.e. 8-10] have determined that megacryst cores from depleted shergottite Y98 are in chemical equilibrium with the Y98 whole-rock composition based on exchange K_D^{Fe-Mg} between olivine and the bulk rock. Therefore, they concluded that these megacrysts are phenocrystic in origin and that the mantle source for Y98 was at an fO_2 of $IW+1$. Usui et al. [10] argued that the olivine megacrysts in Y98 crystallized at slightly more reducing conditions than the groundmass olivine. On the other hand, Herd [11] observed that in NWA 1086/1110 (=NWA1183) the earliest phases (i.e. chromite, olivine cores) crystallized at an fO_2 of $IW+1$, whereas late-stage phases (i.e. titanian-spinel rims, olivine rims) crystallized at far more oxidizing conditions (i.e. QFM + 0.3). Herd [11] concluded that the fO_2 calculations and textural observations are indicative of a xenocrystic origin for the olivine megacrysts and that this supports a model in which martian basalt fO_2 is determined by mantle-source redox conditions.

Observations and interpretations: Our observations reveal a more complex crystallization history for both basalts. As shown in Fig. 1, whereas the Fe x-ray map indicates a simple crystallization history for Y98, the P map illustrates a P-rich reabsorbed core surrounded by oscillatory P zoning. Vanadium is not correlated to P-enrichments. There may be a slight increase in fO_2 from the absorbed core to the rim [10]. Conversely, NWA1183 does not exhibit any textural features that indicate absorption of xenocrystic olivine. Rather, it exhibits a euhedral core surrounded by oscillatory P zoning. In this case, V is correlated to P. The difference in the behavior in V between Y98 and NWA

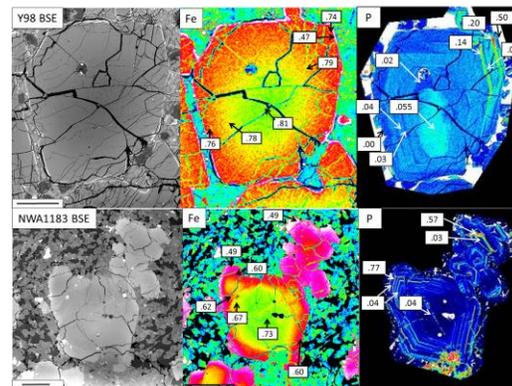


Fig. 1. BSE, Fe, P x-ray maps of olivine in Y98 and NWA1183. Values in Fe maps are Mg# and wt.% P_2O_5 in P maps.

1183 can be attributed to differences in fO_2 which influences the valence state of V (V^{3+} in Y98; $V^{4+,5+}$ in NWA 1183) and the nature of V substitution into olivine. This suggests that during the formation of the oscillatory zoning in NWA1183, the fO_2 was perhaps near the conditions suggested by [11]. Olivines in both basalts record a process of oxidation during crystallization. The increased oxidation is more pronounced in NWA1183. One interpretation is that suggested above by Herd [11]. Alternatively, the changing fO_2 could be a product of auto-oxidation during degassing of Cl-bearing aqueous volatiles [12]. One implication of the latter interpretation is that the source regions for all shergottites are at an fO_2 more reducing than $IW+1$.

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