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Temperature and composition of the mantle sources of Martian basalts as constrained by MAGMARS

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Several Martian meteorites and basalts analyzed *in-situ* by rovers have a high Mg# (100×MgO/MgO+FeO, in mol.%) and are believed to represent near-primary mantle melts affected by limited igneous differentiation during their ascent through the crust. They sampled discrete mantle regions and are messengers of the interior structure of Mars and its thermochemical evolution.

Here, we use the melting model MAGMARS [1] to assess the chemical diversity and temperature of the mantle sources of these basalts. We vary the mantle composition and melting conditions systematically to identify an array of mantle sources that can produce each primitive basalt. We discuss the possible origin of their chemical compositions and the significance of their P-T melting conditions.

With one exception (NWA 7034 and paired meteorites), the mantle sources of primitive Martian basalts were likely poor in CaO and Al_2O_3 compared to the bulk silicate Mars. The mantle sources of shergottites, nakhlites-chassignites, Adirondack and Columbia Hills basalts could represent magma ocean cumulates depleted in CaO and Al_2O_3 and/or residual mantle material affected by several melting events. The concentration of elements more incompatible than CaO and Al_2O_3 (Na_2O, K_2O, P_2O_5 and TiO_2) is relatively higher and could be inherited from the trapping of late-stage melts during the crystallization of the magma ocean (enriched shergottites) or could reflect later re-fertilization by low-degree silicate melts (nakhlites-chassignites and Columbia Hills basalts).

The mantle potential temperature (T_p) of all sources sampled by primitive basalts is similar (1400–1500 ºC) despite having formed at contrasting times (from ~4.5 to ~0.2 Ga). This apparent stability of the T_p with time could result from a sampling bias. Global thermochemical evolution models show that discrete regions of the mantle can melt at similar temperatures throughout Mars's history, even while the average mantle temperature decreases by >100 ºC. A drop of >100 ºC of the average mantle temperature seems consistent with the difference in composition between Hesperian (~1600 ºC) and Amazonian (~1450 ºC) volcanic provinces, if the average mantle is assumed to have a Mg# of ~80.

[1] Collinet et al. (2021), JGR:P.