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PRIMARSMELT: Calculating primary magma compositions for Mars

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Primary magmas are undifferentiated melts formed by mantle melting, and inferring their composition is necessary for defining mantle melting conditions. Primary magma generation has been relatively well-studied on Earth, where abundant data on mantle and crustal rocks, experimental petrology, and geophysical observations allow developing and testing primary magma models (e.g., [1–3]). More limited data exist for Mars, but the available estimates of mantle composition [4] and experimental data [5] are sufficient to develop a model for primary magmas. Here, we present PRIMARSMELT, a recalibration and update of the PRIMELT3 model for terrestrial primary magmas, customized for Mars. PRIMARSMELT estimates a primary magma composition, extent of melting, pressure-temperature melting conditions, and the mantle potential temperature in the source of Martian basaltic compositions primitive enough to have fractionated only olivine. PRIMARSMELT correctly identifies experimental batch melts of the most commonly inferred Martian mantle composition as primary magmas and accurately estimates the melt fractions in these experiments. Its application to some Martian meteorites is consistent with textural observations that interpret them as olivine-fractionated basalts or cumulates. Combined results using data from Martian meteorites and basaltic rocks analyzed by rovers suggest, within error, steady mantle potential temperatures of ~1400–1500 ºC since at least ~2.5 Ga. However, the thermal evolution is difficult to disentangle in the absence of magma crystallization ages for rocks exposed on the surface. Initial melting pressures are also highly variable and depend upon the melting model considered. Overall, solutions yield >2.5 GPa for Martian meteorites and >1.0 GPa and 2.0 GPa for Gale and Gusev craters, respectively. Further experiments at pressures higher than 2.0 GPa are required to improve our model parametrization. Also, improved geochronologic constraints on surface rocks are needed to better constrain Mars' thermal evolution.

References:

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