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Supporting Information for

The temperature and composition of the mantle sources of Martian basalts

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2. MAGMARS results used in figure 3 to match the GRS volcanic provinces of Baratoux et al. (2011) (data repository)
3. MAGMARS scripts and files used to produce figure S1–S2 (data repository)

   data repository: https://doi.org/10.5281/zenodo.7691390

S1 Non-uniqueness and model uncertainties

MAGMARS uncertainties are discussed in detail in section 3.2 of Collinet et al. (2021) and propagated by combining analytical, experimental, and model uncertainties. They are provided as fixed average uncertainties for the composition of melts produced by melting any mantle composition, at any pressure and temperature: ± 1.3 wt.% SiO_2, 0.21 wt.% TiO_2, 0.38 wt.% Al_2O_3, 0.11 wt.% Cr_2O_3, 0.85 wt.% FeO, 0.06 wt.% MnO, 0.75 wt.% MgO, 0.61 wt.% CaO, 0.28 wt.% Na_2O, 0.12 wt.% K_2O, 0.12 wt.% P_2O_5, for lherzolite melting. To quantify the uncertainties on the mantle composition and melting conditions that can produce a specific primary basalt, we run a large number of simulations while varying systematically the parameter space (black contours in Figure S1). We retain only the simulations that produce a melt identical to the basalt Fastball (representative example) within the model uncertainties stated above (blue circles). Figure S1 can be compared to Figure 2 and shows that despite the substantial uncertainties associated with the method, the conclusions of the study remain unchanged.

Another large set of simulations is filtered assuming that the model uncertainties are smaller than reported in Collinet et al. (2021) (Figure S2). While it is possible that the MAGMARS model uncertainties are overly conservative, the goal here is simply to isolate model uncertainties and non-uniqueness. Even assuming a small model uncertainty, there is a large array of possible mantle sources and melting conditions that can produce nearly identical basaltic melts (the composition of Fastball in this case).

For a given basaltic melt (e.g., Fastball), the most refractory mantle sources are associated with the lowest melt fraction and lowest mantle temperatures due to the smaller release of latent heat of melting (Fig. S1a,b). To produce the same average basaltic liquid by polybaric melting as by isobaric melting, melting must start deeper and extend to a shallower region of the mantle, where the solidus temperature is low. The T_{p} is therefore lower compared to the isobaric case (Table S2, Fig. S1a, S2a, also see Fig. 2 in Collinet et al., 2021).

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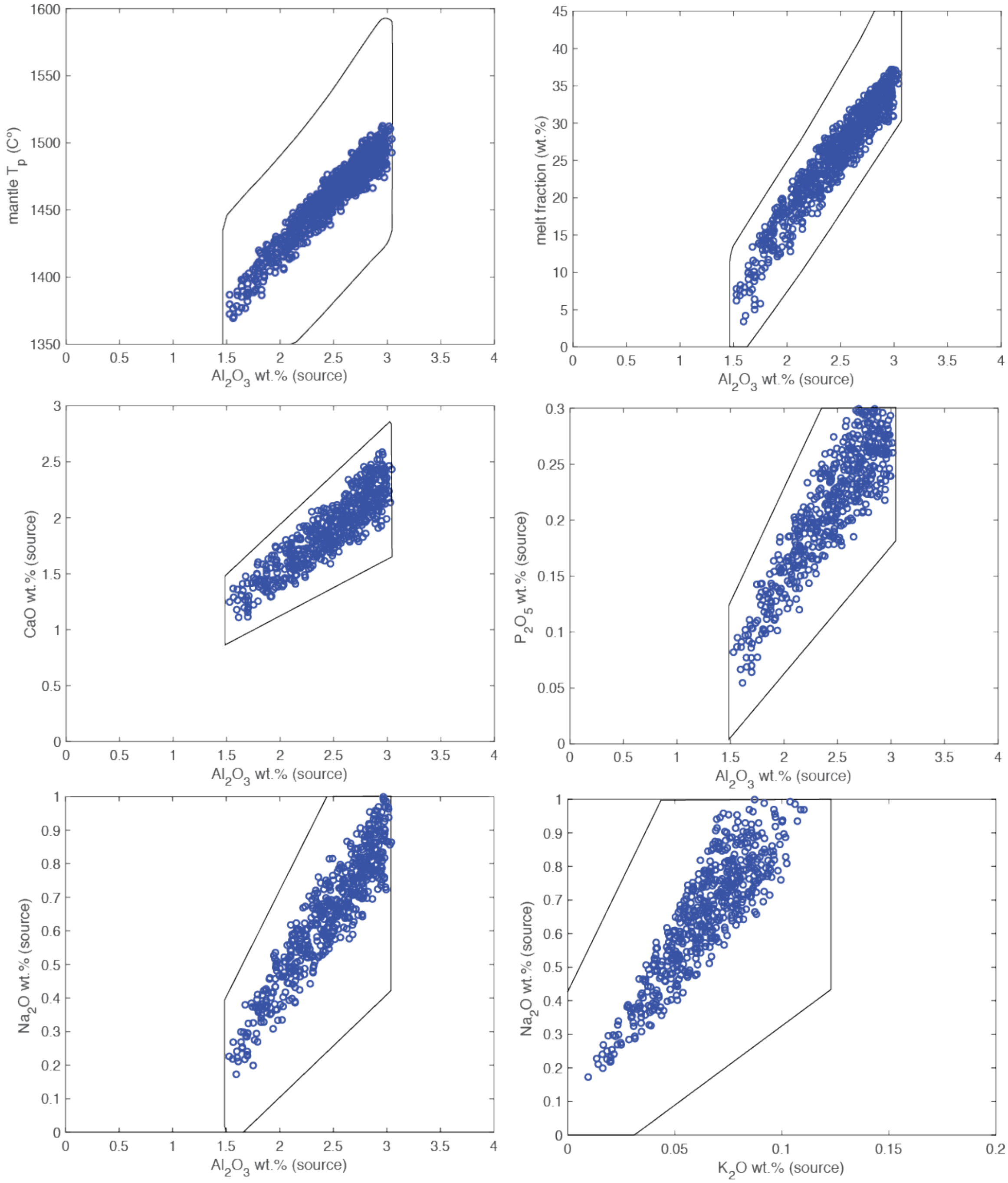

Figure S1: MAGMARS simulations able to reproduce the composition of Fastball (blue circle) assuming the average model uncertainty of Collinet et al. (2021): ± 1.3 wt.% SiO_2, 0.21 wt.% TiO_2, 0.38 wt.% Al_2O_3, 0.11 wt.% Cr_2O_3, 0.85 wt.% FeO, 0.06 wt.% MnO, 0.75 wt.% MgO, 0.61 wt.% CaO, 0.28 wt.% Na_2O, 0.12 wt.% K_2O, 0.12 wt.% P_2O_5. The black envelope represents the conditions sampled by 105000 MAGMARS simulations.

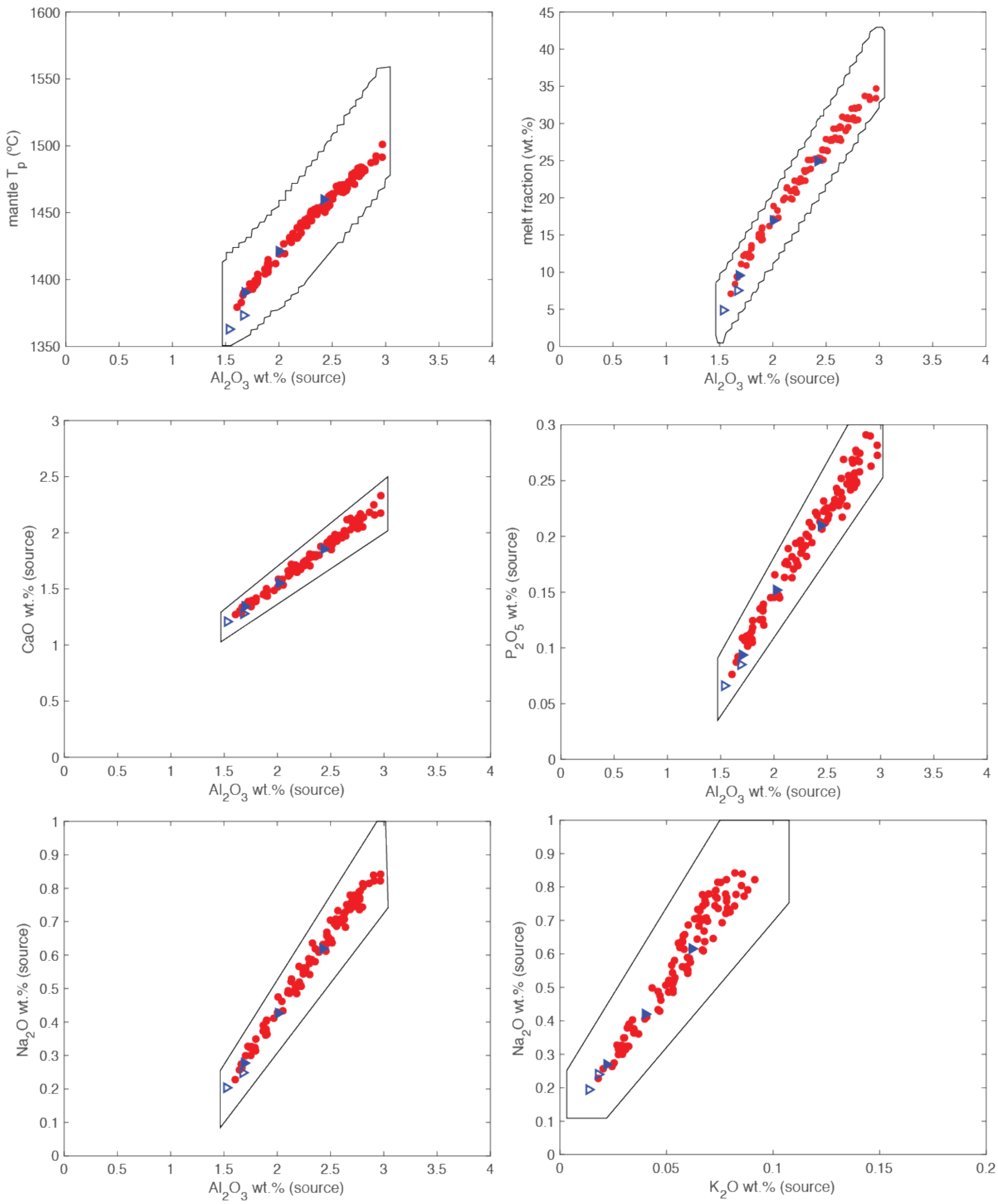

Figure S2: MAGMARS simulations able to reproduce the composition of Fastball assuming a low uncertainty of ± 0.5 wt.% SiO_2, 0.05 wt.% TiO_2, 0.15 wt.% Al_2O_3, 0.11 Cr_2O_3, 0.25 wt.% FeO, 0.06 MnO, 0.25 wt.% MgO, 0.15 wt.% CaO, 0.07 wt.% Na_2O, 0.03 wt.% K_2O, 0.05 wt.% P_2O_5 (red circles). The open and closed blue triangles represent the sample sources reported in Figure 2 and Table S2. The black envelope represents the conditions sampled by 375000 MAGMARS simulations.

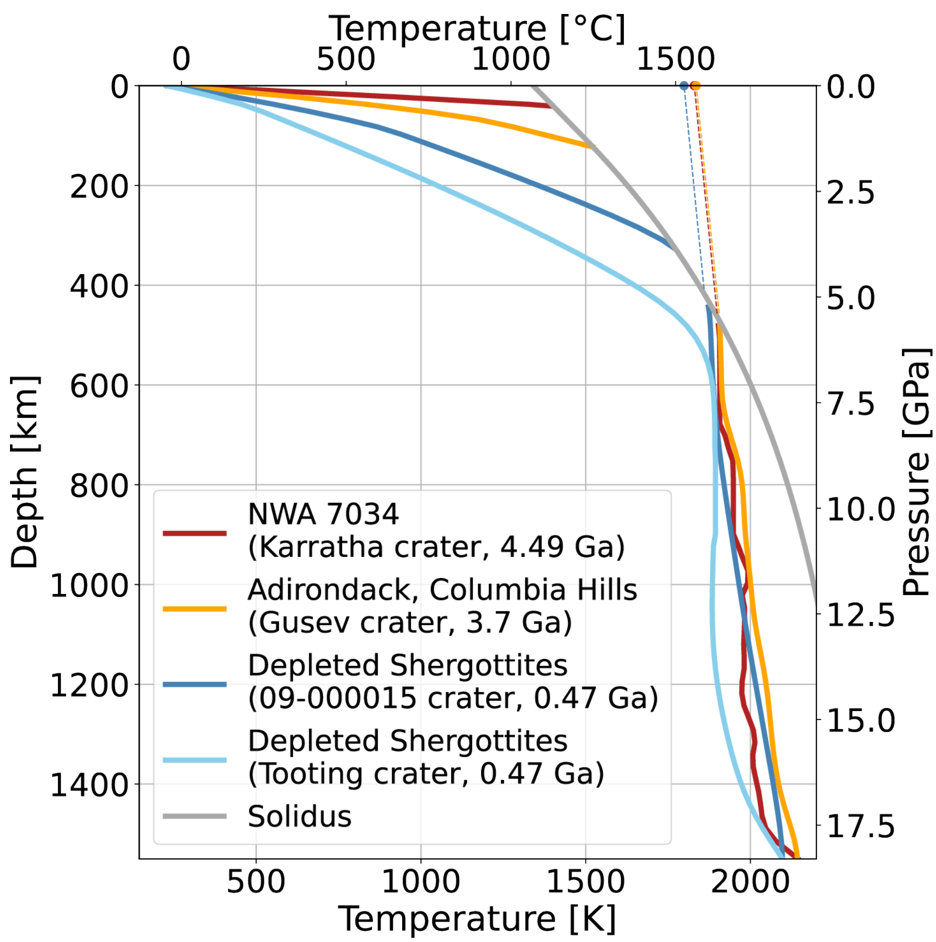

Figure S3: Temperature profiles of the mantle below Gusev crater, and the possible location of the sources of depleted shergottites (09-000015, Tooting; Lagain et al. (2021)) and NWA 7034 (Karratha; Lagain et al. (2022)) at the time of their crystallization, from the thick-crust model of Plesa et al. (2022). The mantle below Tooting crater does not reach the solidus of Ruedas and Breuer (2017) (grey line). Below the other 3 craters, the solidus is crossed at ∼5 GPa and the mantle potential temperatures are nearly identical (filled circles on the upper temperature axis): 1556 ℃ (Karratha), 1562℃ (Gusev) and 1525 ℃ (09-000015).