The differentiation of the Martian highlands from NWA 7533

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The discovery of a remarkable set of paired stones (NWA 7034, NWA 7533, etc.) that are breccias of basaltic composition of Martian origin has opened new windows on the early differentiation of Mars [1]. First, their major element composition is similar to that of rocks from Gusev crater and quite distinct from SNC meteorites making these meteorites representative of the Martian crust [1]. NWA 7533 has a siderophile element content comparable to the highest values observed in lunar highlands breccias, which together with the petrological and compositional evidence for compacted soil, establish it as a regolith breccia probably of highlands origin [2]. Further, high abundances of siderophile elements reveal that many of the igneous textured clasts are impact melts. Zircons from NWA 7533, occurring either in igneous-textured clasts or as isolated mineral clasts, yield U-Pb ages that define a discordia line on the Concordia plot, with a crystallization age of ~4.4 Ga and an annealing age of ~1.7 Ga [2]. Zircon ages from NWA 7034 extend this range to 4.44-4.35 Ga and ~1.4 Ga [3]. Oxygen isotope compositions of NWA 7533 zircons span the widest range of $\Delta^{17}O$ yet measured in Martian rocks or their alteration products [4]. Despite the high MgO+FeO of NWA 7533, it contains only a trace of olivine occurring in impact melt spherules, while it has an olivine-normative composition (prior to oxidation). A combination of oxidative weathering of the original olivine to form magnetite and free silica, followed by impact melting that removed any forsterite by reaction with free silica to form orthopyroxene, provides a useful model of the present mineralogical composition [5]. The enrichment factor of lithophile incompatible elements enables a geochemical estimate of the thickness of the Martian highlands crust of ~50 km [2].

[1] Agee *et al* (2013) *Science* **339**, 780-785. [2] Humayun *et al* (2013) *Nature* **503**, 513-517. [3] Yin *et al* (2014) *LPSC* **XL**, abstract #1320. [4] Nemchin *et al* (2014) *LPSC* **XL**, abstract #1720. [5] Humayun *et al* (2014) *LPSC* **XL**, abstract #1880.