A complex thermal history of the Southern Highlands preserved in Martian meteorite NWA7533 and its pairs.

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Introduction: Martian meteorite NWA7533 and its pairs contain vestiges of the oldest Martian crust [1,2]. NWA7533 is a regolith breccia with a fine grained matrix of alkali basaltic composition that matches the composition of the Martian surface measured by orbiters and landers [1,2]. Dispersed within the matrix are course grained monzonitic clasts, clast-laden impact melt, melt spherules, and microbasaltic melt rock [1,2]. The monzonitic clasts contain zircon, baddeleyite, and apatite, all of which are appropriate for U-Pb geochronology.

Zircon and baddeleyite grains have a range in concordant U-Pb ages with populations of 4428±25 [2] (similar to 4439±17 and 4350±13 Ga [3]). One zircon also shows several nearly concordant analyses that define an age of 1441±37 Ga [3]. The zircon U-Pb data also yield upper intercept ages in the range 4.43-4.33 Ga and lower intercepts ranging between 1712±85 and 1441±37 Ga [2,3]. Apatite and merrilite have combined U-Pb ages of 1.345±0.047 and 1.357±0.081 Ga [3,4]. Additionally, there are reported whole rock ages of ~1.56 and 2089±81 Ga from Ar-Ar[5] and Rb-Sr[2], respectively. Interestingly, despite having formed prior to the Late Heavy Bombardment (LHB), which is thought to have affected all of the inner planets ca. 3.9 Ga, NWA7533 has no 3.9 Ga age in any of the phases that have been investigated.

The observed complexity of ages near both upper and lower intercepts is not surprising in a breccia as it is likely to contain constituents from several sources with distinct ages that have experienced a diverse late reworking history, the last event signifying final consolidation of the sample. Similar behaviour is demonstrated for a number of lunar breccias. For example, a similar range in U-Pb ages in zircon and phosphates has been used to constrain the thermal history of lunar breccia returned from the Apollo 15 mission [e.g., 6].

For NWA7533, the range in ancient, concordant >4 Ga, zircon age populations likely indicates a mixed source for the materials contained within the breccia. These sources have a large age range, which can be interpreted as multiple, magmatic events creating the Southern Highlands. The range in younger concordant and discordant zircon ages range likely reflect several metamorphic or impact events. U-Pb ages of phosphates [3,4] are clustered around 1.35 Ga, indicating full resetting at this time, probably from a large thermal event, such as an impact. This event likely marks the age of the final amalgamation of the breccia.

References: [1] Agee et al. 2013. *Science* 339, 780 [2] Humayun et al., 2013. *Nature* 503: 513-517 [3] Yin et al., 2014 Abstract #1320. 45th Lunar & Planetary Science Conference [4] Bellucci et al., 2014 *Science* in review [5] Cartwright et al., 2013 Abstract #2314 44th Lunar & Planetary Science Conference [6] Grange et al. 2013. *Journal of Geophysical Research Planets* 118: 2180-2197.