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Discovery of a complex, chemically and isotopically zoned detrital zircon from NWA 7533 – insights into crust-mantle evolution on Mars

SIW AMANDA FALK EGDALEN[1], MARTIN J. WHITEHOUSE[2], MATTHEW HORSTWOOD[3], ALEXANDER A. NEMCHIN[4], JAMES N. CONNELLY[1] AND MARTIN BIZZARRO[1]

[1]Centre for Star and Planet Formation, Globe Institute, University of Copenhagen
[2]Swedish Museum of Natural History
[3]British Geological Survey
[4]Curtin University of Technology

Presenting Author: siw.egdalen@sund.ku.dk

Zircon is a key mineral allowing for in-depth investigation of the formation timescale and evolution of crustal and mantle reservoirs in terrestial planets. Recent work has established that the NWA 7533 martian regolith breccia contain various zircon age groups, including a younger detrital population (<2 Ga) derived from the Tharsis volcanic province[1], which is modelled to reflect volcanism associated with a deep-seated mantle plume[2]. The chondrite-like initial Hf isotope compositon of these grains is in line with the interpretation that they sampled the primitive, convecting deep Martian mantle. We report the discovery of a complex detrital zircon from NWA 7533, typified by chemically and isotopically distinct domains. The grain, dubbed DT-2, is a clear, ~150µm x 77µm euhedral zircon. Back-scattered electron and cathodeluminescence imaging of DT-2 indicate the presence of a ~40µm x 50µm core, surrounded by a chemically zoned ~20-50µm rim. In situ SIMS U-Pb analyses of the core and rim domains, return concordant $^{207}Pb/^{206}Pb$ ages of 1750±32 Ma and 400±50 Ma, respectively. These ages are consistent with that observed for the NWA 7533 young detrital zircon population. The initial eHf value of the core of DT-2, determined by LA-MC-ICPMS, is -0.6±2.3, establishing that its original crystallization occurred from a melt derived from the primitive Martian mantle. Moreover, the rare earth element distribution and Ti thermometry of DT-2 suggest that crystallization of the core occurred under oxidising conditions typified by DFMQ ~+2. Such oxidising conditions are consistent with the inference that zircon saturation occurs after extensive fractional crystallization of initially mafic melts on Mars[2]. The initial eHf value of the rim is -12.5±1.7, indicating crystallization from an isotopically enriched melt. Relative to the Hf signature and age of the core, the $^{176}Lu/^{177}Hf$ ratio of the source reservoir required to account for the rim composition corresponds to ~0.02, consistent with a mafic composition. We conclude that the event recorded by the rim crystallization at 400±50 Ma, reflects partial remelting of a mafic crustal reservoir formed at 1750±32 Ma with a chondrite-like initial Hf isotope composition.

1-Costa et al. (2020), *PNAS*, 117 (49), 2-Day et al. (2018), *Nat. Commun.* **9***,* 4799