AGE OF ENRICHED GABBROIC SHERGOTTITE NORTHWEST AFRICA 6963 AND ITS SI-RICH MESOSTASIS.

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Introduction: The enriched shergottite Northwest Africa (NWA) 6963 has been classified as a gabbroic shergottite due to its coarse-grained groundmass-forming minerals [1,2]. Fine-grained Si-rich mesostasis occurs interstitial to the groundmass minerals [1]. Such Si-rich mesostasis is common in enriched shergotites, however, it is disputed whether the mesostasis was formed by impact [3] or by magmatic processes [1,4,5]. To our knowledge no crystallization age has so far been published for NWA 6963. We use LA-MC-ICP-MS U–Pb measurements of minerals within the Si-rich mesostasis and of late-stage magmatic merrillite within the coarse-grained groundmass to derive U–Pb ages for both, Si-rich mesostasis and coarse-grained merrillite. The ages provide a crystallization age for NWA 6963 and can be used to address the question of Si-rich mesostasis formation.

Methods: Isotope analyses were performed at the Frankfurt Isotope and Element Research Center (FIERCE). We used a Thermo Scientific Neptune Plus multi collector ICP-MS, coupled to a RESOlution 193nm ArF Excimer (CompexPro 102, Coherent) laser ablation system equipped with an S-155 two-volume ablation cell (Laurin Technic, Australia). Reference materials were NIST SRM-614, USGS basaltic glass GSC-G, Durango apatite, Mudtank zircon, and Diamantina apatite (Minas Gerais). The JEOL Hyperprobe JXA-8530F Plus field emission electron microprobe at the Goethe-Universtiät Frankfurt was used for qualitative WDS and EDS mappings, and quantitative WDS element analyses. Small mesostasis grains were measured with an acceleration voltage of 10 kV, and larger groundmass grains (merrillite) with 15 kV. The beam current was set to 20 nA. A focused spot (<100 nm) was used for mesostasis grains, except for feldspar, which was measured with a defocused spot of 8 µm in diameter. Merrillite was measured with spot sizes between 1 and 10 µm.

Results: The fine-grained, Si-rich mesostasis mainly consists of silica and feldspar intergrowths (tens of micrometers in grain size) with the small accessory phases tranquillityite, Cl-apatite, pyroxene, Fe-Ti oxide, iron sulfide and baddeleyite (micrometers to tens of micrometers in grain size). We mainly used tranquillityite, next to Cl-apatite, baddeleyite and feldspar for U–Pb dating. The U–Pb age derived for Si-rich mesostasis minerals is 172.4 ±6.1 Ma (2σ, MSWD = 0.61, n = 30). Merrillite is observed with or without apatite intergrowths or rims and with grain sizes up to 1000 µm. The grains contain melt inclusions, appearing either as small (1–11 µm), circular inclusions aligned in linear arrays parallel to the long axis – or as larger circular (up to 30 µm in diameter) or elongated (up to 120 µm in length) melt inclusions. U–Pb dating was performed on 11 merrillite grains (20 spots) avoiding intergrown apatite, as confirmed by BSE images and EPMA-measuerements next to each ablation spot. The derived U–Pb age for merrilte is 178.3 ±10.6 Ma (2σ, MSWD = 0.68, n = 20).

Discussion and Conclusion: We interpret the U–Pb age of the Si-rich mesostasis as the age of magmatic crystallization. This age is indistinguishable from the U–Pb age derived from merrillite, and both are in agreement with published crystallization ages for enriched shergottites [6,7]. Different ages for the late-stage magmatic merrillite and Si-rich mesostasis would be expected, if the latter was formed during impact-induced melting, and we found no evidence that merrillite was produced by shock [8]. Thus, our results are in favour of a late-stage magmatic formation of the Si-rich mesostasis in NWA 6963 [1] and possibly also for Si-rich mesostas in other enriched shergottites. The contrast in grain sizes between late-stage merrillite and Si-rich mesostasis implies an abrupt change in cooling rates, perhaps related to the transport of the magma from a deep-seated crustal chamber into the shallow Martian subsurface [2]. A crystallization age for NWA 6963 can be given with 173.9 ±5.3 Ma (weighted mean of the two derived ages, 2σ). Our results imply that Si-rich melts on Mars were produced until at least that time.

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