

Reappraising Accretion to Vesta and the Angrite Parent Body Through Mineral-Scale Platinum Group Element and Osmium Isotope Analyses

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Introduction: Platinum group element (PGE) abundances and Os-isotope compositions determined for magmas of Earth, the Moon, Mars, and asteroidal bodies place important constraints on planetary evolution and these data are fundamental to our understanding of the addition of material to silicate mantles following core formation [e.g., 1-3]. The absolute abundances and broadly chondritic relative proportions of PGEs reported for Earth's mantle, and the mantles of other planetary bodies, are widely considered to be inconsistent with core formation alone [4]. PGEs, therefore, place critical constraints on protracted accretion of chondritic materials to differentiated silicate bodies within 2-10 Myrs of the condensation of the first Solar System solids and after the ~4.5 Ga Moon-forming giant impact. However, existing planetary PGE and Os-isotope data have largely focused on investigations of bulk powders. New methods presented here enable quantitative determination of mineral-scale PGE-abundances and Os-isotope compositions in meteorite materials. This data allows the determination of PGE partitioning behavior during crystallisation and, combined with textural records, traces post-crystallisation contamination by impactor material.

Petrography and Mineralogy: The studied angrite portions (NWA 4590, NWA 4801, and NWA 8535) are distinct from those described by [5] and provide larger surface areas for the present study. Wafers (~150 µm depth) of diogenites NWA 7284, NWA 7831, and NWA 7977 were prepared for this work along with a large slice of NWA 5480 (8.6 cm × 3.6 cm). In each case, samples were subjected to electron micro-probe analyses at the University of Edinburgh, UK, and imaged using SEM facilities housed at the University of Glasgow, UK.

New petrographic and mineral-compositional data indicate that metals in distinct portions of the studied coarse-grained angrites and diogenites are kamacite grains <50 µm in maximum dimension with minor volumetric proportions of exsolved taenite. Fe-Ni metals in the studied samples have been grouped based on their textural characteristics. Group-1 metals commonly occur in clusters or trails in close association with interstitial troilite (generally ≤150 µm) and small oxide grains. Group-2 metals are disseminated alloys located in cracks or at grain boundaries and do not appear in close association with sulphide or oxide. Group-3 metals are isolated alloys enclosed within silicates.

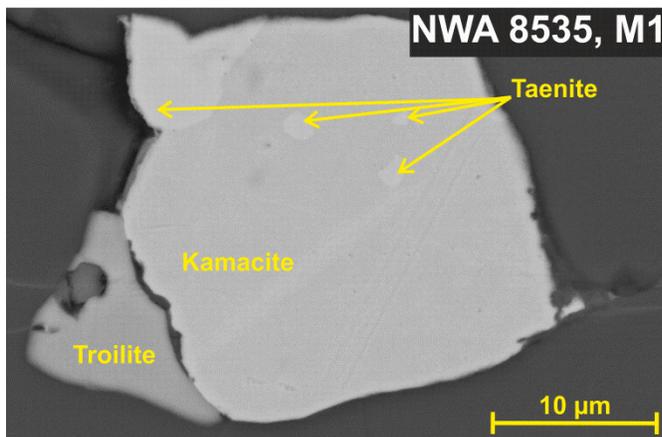


Figure 1: Example kamacite grain with taenite exsolution in angrite NWA 8535. This FeNi alloy occurs in close proximity to sulphide and is one grain among a cluster.

Advances in Grain-Scale Os-Isotope and PGE Protocols: The petrographic and mineralogical data reported here correspond to grains for which Os-isotope compositions ± PGE-abundances have been obtained using a NuWave microdrill. Extensive blank tests and new grain-scale data are compared to measurements previously made on multiple powder fractions of many of the studied angrites and diogenites [1-2,5], thereby providing a means of quantitatively assessing this new mineral-scale approach. Importantly, texturally distinct FeNi metal associations were identified and examples of all petrographic groups of these alloys were sampled. These innovative protocols enable us to assess potential non-magmatic PGE contributions and have implications for theories of heterogeneous accretion and incomplete mixing in the mantles of the angrite and HED parent bodies.

References: [1] Dale et al., 2012, *Science*, 336, 72-75. [2] Day et al., 2012, *Nat. GeoSci.*, 5, 614-617. [3] Brandon et al., 2012, *GCA*, 76, 206-235. [4] Walker, 2009, *Chemie der Erde*, 69, 101-125. [5] Riches et al., 2012, *GCA*, 353-354, 208-218