XENOCRYSTIC OLIVINE AND SPINEL IN THE ASUKA 12209 ANGRITE.

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Introduction: Of all the early Solar System planetesimal crustal rocks, angrite meteorites stand out from their more common basaltic equivalents. They have low silica contents (lacking low-Ca pyroxene), are rich in refractory elements (e.g. Ca, Al, and Ti, resulting in 'fassaite' pyroxene), and depleted in most alkali elements (Na, K, Rb) [e.g. 1]. Their parent body is covered by volcanic angrites [2] that host large, rounded olivine and spinel grains of different core compositions, and strong chemical zoning at irregular, resorbed margins (groundmass overgrowth and ~1-10 μm diffusion profiles) [e.g. 3, 4]. Such characteristics indicate that they were not in equilibrium with their host magmas, but are captured xenocrysts, from the angritic mantle or an isotopically similar source (suggested by oxygen isotope systematics, especially $\Delta^{17}O$; [5]). The new Asuka (A)12209 angrite [6], probably paired with the smaller A 881371, contains many large olivines and spinels, and provides an opportunity to characterize this possible mantle material in more detail.

Methods: Olivine xenocrysts were characterized for their major, minor, and trace element abundances including rare earth elements (REE) via laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) using a Teledyne CETAC Technologies Analyte G2 193 nm ArF*excimer laser ablation system coupled to a Thermo Scientific Element XR ICP-MS unit at UGent. Preliminary spinel xenocryst major and minor element compositions were obtained by micro X-ray fluorescence spectrometry by Bruker M4 Tornado at VUB.

Results: Most trace elements (e.g. V, Co, and heavy REE) are reproducible within each olivine xenocryst, although some elements seem skewed by the presence of inclusions (e.g. Ni in metal or sulfide). Xenocrystic olivine has fairly chondritic Be and Sc, slightly sub-chondritic Li, V, Cr, and Mn, and low (~0.1 × CI) Al, P, Ti, Zr, Nb, Co, and Ni. Chondrite normalized REE patterns are flat, with light- and mid-REE at ~0.1 × CI concentrations, higher heavy REE at ~0.2-0.4 × CI, and a slight positive Ce anomaly. Two different spinel types were found: hercynite (Fe- and Al-rich) and chromite (Fe- and Cr-rich).

Discussion: Few analyses of trace elements for angrite olivine xenocrysts have been reported in the literature; our results are similar to two of them ('olivinite' and 'olivine mega' in D'Orbigny; [4]) but differ from two others (in Lewis Cliff 87051 [7] and NWA 1670 [8]). Compared to groundmass olivine, xenocrysts contain less Li, P, Ti, Ca, Sc, Mn, and Co; more Cr, Al, and Be; similar concentrations of Zr, Nb, V, and Ba; and tighter light REE distributions. The more FeO-rich overgrowths or most primitive groundmass olivine are distinguished by highly variable light REE contents (~0.25 to as low as ~0.01 × CI) and very steep REE patterns (up to ~1 × CI for heavy REE) [2, 3]. High Cr in xenocrysts (1400-2900 ppm) suggests that the influence of spinel in the reduced angritic mantle is relatively small, unlike the oxidized part [1]. The significance of the chromite grain is therefore not yet understood.

At the planetesimal scale, some comparisons can be made between angrites and more commonly sampled basaltic eucrites, especially the anomalous eucrite Ibitira. The latter has: (1) relatively high Ca, Al, and Ti contents, (2) a strong depletion in Na and K, (3) sufficient volatiles to generate vesicles during eruption, and (4) isotopic compositions similar to angrites [9, 10]. Ibitira might therefore be the complementary basaltic material related to angrite xenocrysts. The relatively high heavy REE contents of Ibitira seems to match with the low contents of heavy REE in magnesian angrite xenocrysts, suggesting by mass balance that they might have had a similar source, differing only in terms of redox state. Finally, the low Co in xenocrysts indicates low fO_2 (and probably high fS_2) such that some Co was lost from olivine to a potential metal-sulfide core, along with Ni.

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