DUNITE CLAST IN LUNAR METEORITE NORTHWEST AFRICA (NWA) 14900: MANTLE DERIVED?

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Introduction: It has been inferred from experimental modelling that lunar dunites, olivine-rich rocks, crystallized as early stage cumulates from the lunar magma ocean (LMO) and make up a significant fraction of the lunar mantle [1-2]. Although basin-forming impact events on the lunar surface could have exposed lunar mantle rocks [3-4], dunite clasts are rarely observed in both Apollo [4-6] and lunar meteorite samples [7-9]. Most dunite clasts previously examined are suggested to originate either as cumulates of basaltic magmas from a shallow crustal source [4-5], or more commonly, as cumulates of Mg-suite magmas from a deep crustal source [8-9]. As it would be of great importance to identify lunar dunite clasts that are unequivocally mantle-derived [10], we investigated the petrology of a dunite clast from lunar fragmental breccia Northwest Africa (NWA) 14900 in order to constrain either a crustal or mantle source.

Petrography: The 2.2 mm dunite clast is sub-angular in appearance and is crosscut by an interconnected network of cracks and veins containing terrestrial carbonate weathering products. The dunite clast is almost entirely monomineralic, consisting of ~99.2 vol. % olivine and ~0.8 vol. % chromite. It exhibits a fine-grained, granular texture (120° triple junctions are moderately observed along olivine grain boundaries) composed of interlocking, fractured olivine grains (Av. grain size ~110 µm, up to ~290 µm) enclosing sub-rounded, elongate grains of chromite (Av. grain size ~20 µm, up to ~50 µm).

Geochemistry: Olivine grains in the dunite clast appear unzoned in both major and minor elements, and are compositionally uniform (Fa9.1±0.1, range Fa9.0-9.1, Mg#=91, CaO and Cr_2O_3 wt. % = <0.1, FeO/MnO=80±10, n=8); chromite grains appear unzoned and are compositionally uniform (Cr#=79.3±0.3, Mg#=51.3±1.0, n=2).

Olivine-Spinel Geothermometry: The equilibration temperature of the dunite clast was calculated using the average Cr# of chromite grains, the average Sp-Ol $K_D^{Fe\text{-}Mg}$ of the dunite clast, and the olivine-spinel geothermometer equation derived from [11]; this resulted in an equilibration temperature for the dunite clast of 967±11°C. However, this temperature represents a lower limit estimate of the initial magmatic crystallization temperature for the dunite clast, since the deviation of Sp-Ol $K_D^{Fe\text{-}Mg}$ from the Ol-Sp equilibrium line of [9] indicates that sub-solidus re-equilibration of the dunite clast had taken place following crystallization.

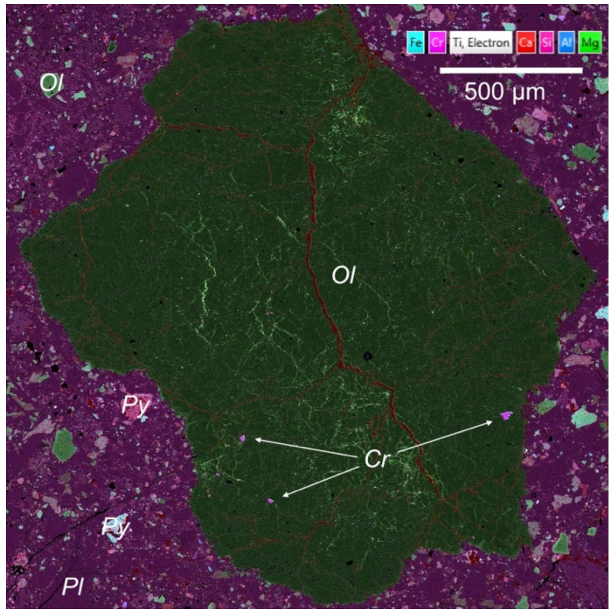

Fig. 1. False color EDS + BSE chemical map of dunite clast. *Ol*= olivine, *Py*= pyroxene, *Pl*= plagioclase, *Cr*= chromite).

Discussion: Compared with other lunar dunite clasts, the texture, grain size, and unzoned, equilibrated nature of olivine grains in the dunite clast from NWA 14900, and its calculated equilibration temperature, are most similar to that of a hypothesized mantle-derived lunar dunite clast reported in NWA 11421 [7]. However, the absence of plagioclase and pyroxene in this dunite clast combined with it having a higher olivine Mg# indicates that this dunite clast crystallized at a higher temperature than the dunite clast in [7], likely at a greater depth. Olivine compositions from the dunite clast are most similar to those reported in lunar Mg-suite dunites (Mg#~85-90) [8-9], but the chromite Cr# of the dunite clast is noticeably higher when compared to lunar Mg-suite dunites (Cr#~61-72) [8-9], indicating crystallization of this dunite clast from either a more primitive Mg-suite parent magma, or a non-Mg-suite-related magma. In summary, the dunite clast in NWA 14900 is texturally and chemically distinct from other dunite clasts reported in both Apollo and lunar meteorite samples, and likely represents either 1) a fragment derived from the lunar mantle (an early LMO cumulate or an Mg-suite partial melt residue), or 2) the most primitive Mg-suite dunite sampled thus far.

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