ELECTRON BACKSCATTER DIFFRACTION OF SILICATE/METAL RELATIONSHIPS IN AMOEBOID OLIVINE AGGREGATES

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Introduction: Amoeboid olivine aggregates (AOAs) are thought to be primary condensates that incorporate calcium-aluminum-rich inclusion-like (CAI-like) nodules, based on isotopic and chemical evidence [3]. Some AOAs contain metal grains surrounded by forsterite (Fo) [3,4,6]. These grains are observed to occur primarily at the outer edges of such AOAs and represent a critical link between metal and silicates in the early Solar System. We conducted electron backscatter diffraction (EBSD) on such olivine-rimmed metal grains in an AOA in Renazzo (CR2, AMNH #588-t1-sB3-ps1A) to determine if any crystallographic orientation relationship (COR) exists between the two phases.

Methods: Samples were polished similarly to the methods of [1] but with diamond suspensions instead of Al_2O_3. Initial WDS stage maps were collected for 10 elements and 1 µm/pixel resolution, as described in [2]. High-resolution quantitative analyses were performed using the AMNH electron microprobe. The thick section was then ion milled before EBSD was conducted on a FEG SEM at the Metropolitan Museum of Art using an Oxford Nordlys system with a 70° tilt angle, 25 kV accelerating voltage, 300 µm aperture, 25 Pa of pressure, and variable step size. Data reduction was completed using Aztec Crystal software.

Results: Multiple 2-5 micron subgrains of Fo (<3 wt% FeO) surrounding FeNi metal show no preferred orientation (Fig. 1). Fig. 1A shows most of the target AOA and Fig. 1B shows the band contrast (BC) and inverse pole figure (IPF-z) for a sub-area. Gray areas either have no solution or are another phase (e.g., CAI minerals). Kamacite (Kam) orientation is dominated by two large grains and one small subgrain, as illustrated by pole figures for relevant Miller indices of Kam and Fo (Fig. 2). The second largest Kam grain shows overlap in the NE quadrant of the {101} pole figure with the {100} pole of the largest Fo grain. No other grains show clear signs of co-orientation. Fo grains show clear triple junctions.

Discussion: The presence of multiple small Fo subgrains, with no common orientation, indicates that the olivine shell was not deposited in a single layer. Instead it was likely formed by multiple instances of individual Fo grains accreting to the core Kam grain. The presence of triple junctions in the Fo grains indicates at least some degree of annealing occurred. Co-orientation between the largest Fo grain and Kam (indicated with stars on Fig. 1B) could be random chance or attributed to a number of factors. It is possible that the Fo shell cooled too quickly to reach an equilibrium orientation with the host grain. It is also possible that the orientation relationship between Fo and Kam favors multiple orientations at the cooling rates, temperatures, and pressures of AOA formation. The near-uniform orientation of the Kam grain in the core (approximately outlined in black in Fig. 1B) indicates that it was formed as a single unit. Smaller subgrains within it are still present, ruling out igneous formation and giving further credence to formation via condensation and hierarchical accretion from the protoplanetary nebula. The principle of superposition supports an interpretation that the common appearance of olivine surrounding CAI-like material and metal grains in AOAs is due to condensation at total pressure $>10^{-3.5}$ bar [5].

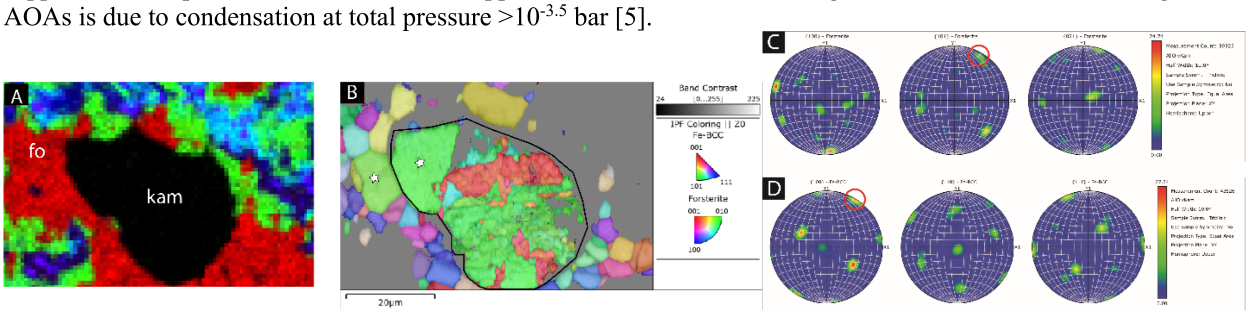

Fig. 1 – A) WDS (R-G-B=Mg-Ca-Al) map of AOA sub-grain in Renazzo. B) IPF-z plus BC map of Kam and Fo in the sub-area indicated in A. C) Pole figures for {100}, {101}, and {021} for all Fo grains in B. D) Pole figures for {100}, {110}, and {111}for all Kam grains in B.

References: [1] Daly L. et al. (2019) *Science* 5:EAAW5549. [2] Alpert S. A., et al. (2021) *Meteoritics & Planetary Science* 56:311-330. [3] Krot et al., (2004) *Chemie de Erde* 64: 185-239. [4] Weisberg M. K. et al. (2004) *Meteoritics and Planetary Science* 39:1741-1753. [5] Ebel (2006) *MESS-II*. [6] Ebel et al. (2022) This conference #6161.