RELICT FORSTERITE IN UNEQUILIBRATED ENSTATITE CHONDRITES.

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Introduction: Enstatite chondrites (ECs) are thought to represent the material present in the accretion regions of the terrestrial planets [1]. However, ECs contain unique mineral assemblages which indicate that they formed under much more reduced conditions than Earth. It has long been assumed that ECs formed from material condensed at supersolar C/O ratios, however, recent trace element work suggests that ECs may instead be derived from precursors that formed in a more oxidising environment [2]. Later processing of these precursors in an unusually S (and other volatile)-rich and O-poor environment may then explain the highly reduced nature of ECs [2, 3].

We are analysing relict grains to test the hypothesis of an evolving nebular composition recorded in unequilibrated ECs. Relict forsterite grains did not crystallise in-situ with their host melt [4], instead forming by reduction of a more FeO-rich olivine, either before or during the formation of the host chondrule [5, 6, 7]. Relict grains in some ordinary and carbonaceous chondrites have been observed to have a "dusty" texture [4, 5, 8, 9, 10]; dusty grains contain micron-sized blebs of essentially Ni-free metal. Isolated dusty forsterite grains have been observed to exhibit blue cathodoluminescence (CL) [11] in disequilibrium with their host chondrule, therefore suggesting a relict origin. Forsterite grains with red-CL cores and blue-CL rims suggest relict cores that have been equilibrated at lower temperatures before chondrule formation [8] with an overgrowth of a chondrule melt enriched in trace elements [12]. The cores of these grains may or may not have a dusty texture but are assumed to have a similar formation process [4], suggesting that most forsterite grains within type I porphyritic olivine-pyroxene (POP) chondrules could be considered relict grains [13].

Method: Polished sections of Dominion Range 14021 (EH3; section #11) and Larkman Nunatak 12156 (EH3; section #6) were studied using a ZEISS Evo 15LS SEM. Large area elemental mapping was carried out with an Oxford Instruments Aztec EDS system to locate olivine grains. High-resolution cathodoluminescence (CL) imaging has been performed with a Gatan ChromaCL system, at 10kV accelerating voltage, 3nA beam current and at a distance of ~1 mm from the CL detector.

Findings: Forsterite grains were identified and imaged in 37 chondrules in DOM 14021,11 and 28 chondrules in LAR 12156,6 (~20% / ~25% of chondrules in the samples respectively); forsterite was found to occur as anhedral to subhedral grains poikilitically enclosed in enstatite. Forsterite abundance within the chondrules ranged from ~2% to ~30% for DOM 14021,11 and from ~2% to ~15% for LAR 12156,6. The largest forsterite grain in each sample measured ~0.2×0.2 mm and ~0.26×0.33 mm respectively. Based on the size and morphology of their forsterite grains, 22 POP chondrules in DOM 14021,11 and 9 POP chondrules in LAR 12156,6 were further imaged using the CL detector. All chondrules analysed are type I, FeO-poor with $Fo_{(>98.7)}$; 1 chondrule in DOM 14021,11 (~30% forsterite) is more ferroan with $Fo_{96.55}$. Red and blue CL observed in the chondrules of both samples indicate varying concentrations of trace elements in the forsterite grains. Isolated dusty forsterite grains exhibiting blue CL and grains exhibiting red-CL cores surrounded by blue-CL rims were identified in both samples.

Implications: Several isolated dusty forsterite grains in DOM 14021,11 and LAR 12156,6 exhibit blue CL, in disequilibrium with their host chondrule and suggesting a relict origin [11]. Forsterite grains with red-CL cores surrounded by blue-CL rims were also identified, indicative of relict cores with an overgrowth of a chondrule melt enriched in trace elements [12]. Our work will advance to the analysis of trace element concentrations and oxygen isotopic variations of the relict grains. This analysis will provide further understanding of the origin and history of relict grains and subsequently the evolving composition of the EC formation region.

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