RELICT FORSTERITE IN UNEQUILIBRATED ENSTATITE CHONDRITES

N. V. Almeida[1], P. F Schofield[1], K. Geraki[2] and S. S. Russell[1], [1]Planetary Materials Group, Natural History Museum (London, SW7 5BD, U.K., n.almeida@nhm.ac.uk), [2]Diamond Light Source Ltd. (Chilton, OX11 0DE, U.K.)

Introduction: Enstatite chondrites are notable for their reduced mineralogy [1] and chemical similarity to the inner Solar System; indeed, they are considered isotopic twins of the Earth [2]. Solar and cosmogenic noble gas compositions also support heliocentric distances of EC parent bodies at 1-1.4 AU [e.g. 3]. While most authors have assumed that the ECs formed from material condensed at high C/O [e.g. 4], recent trace element work suggests that EC chondrule precursors may have formed in a more oxidising environment and were later reduced by exposure to a reducing Si- and S-rich gas [5]. This gas reduced the olivine to Mg-rich pyroxene and formed sulphides, thus EC chondrules record an evolving nebular composition from oxidising to reducing conditions. We have made a detailed study of relict olivine in primitive enstatite meteorites in order to test this model.

Methods: Sections of Kota Kota (EH3; BM. 1905,105; P22810), MAC 88136 (EL3; 106) and Qingzhen (EH3; BM.1999,M27; P22813 & P22814) were studied. Element mapping by EDS (Zeiss EVO 15LS SEM) was used to locate olivine, followed by cathodoluminesece (CL) imaging and EPMA (Cameca SX100 microprobe) for mineral compositions. Synchrotron XRF maps and Ti-XANES data were acquired at beamline I18, Diamond Light Source.

Findings: Relict forsterite grains were identified in all three meteorites, appearing as anhedral to subhedral cores in chondrules surrounded by enstatite. The grains exhibit different CL properties across the UEC in this study, broadly fitting into four groups: i) consistently red throughout; ii) red interiors rimmed by strong blue CL; iii) mixed CL appearing purple; iv) consistently blue throughout. Blue olivine differs from red olivine with lower Ca, Mn, and Cr, and higher Fe, Al and Ni concentrations. An example is included in *Figure 1*: chondrule C2 contains an almost intact forsterite grain and two others that are more progressively altered, all showing bright red CL. The grains are surrounded by enstatite with blue CL (Ca, Al, Ti, Cr, Mn-poor) and the whole central relict is surrounded by a later generation of chondrule growth – enstatite grains with red CL (Ca, Al, Ti, Cr, Mn-bearing). Consistent differences in Ti-XANES spectra are observed between the relict forsterite and surrounding enstatite.

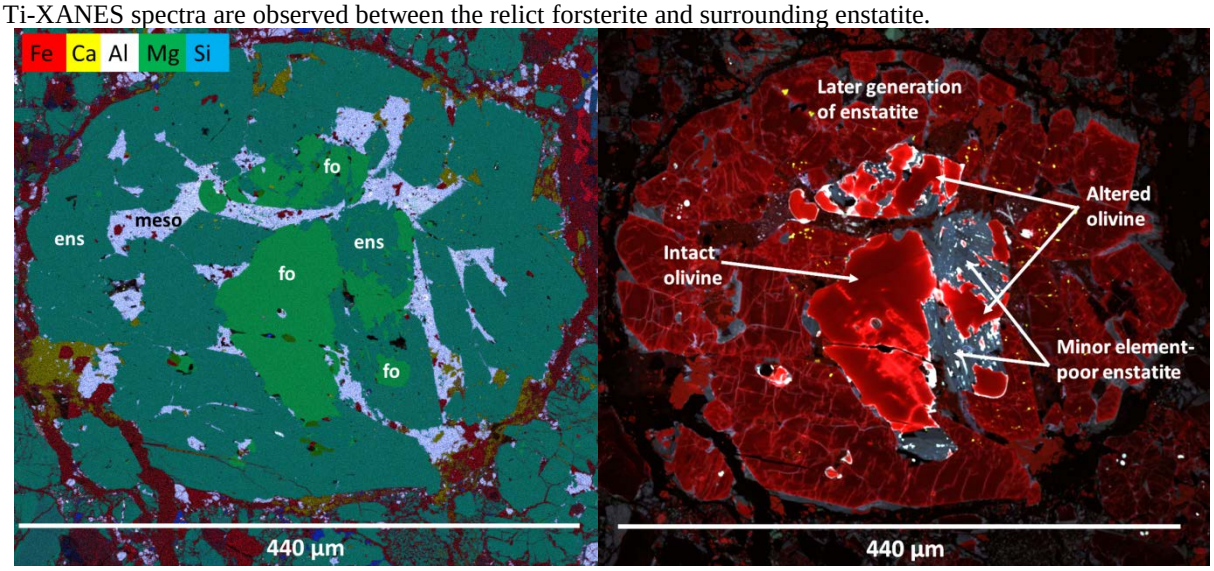

Figure 1: Composite element map (left) and CL image (right) of chondrule C2 in Kota Kota (P22810).

Implications: The model of evolving nebular compositions is supported by our petrological observations, suggesting the chondrules were once more similar to those in carbonaceous and ordinary chondrites. If the enstatite chondrules did indeed originally form under more oxidising conditions, they could plausibly be more closely related to the Earth and other terrestrial planets on the one hand, and to other chondrite groups on the other, than previously thought.

Next steps: Our work on relict forsterite will advance to oxygen and chromium isotopic analyses to constrain the formation region of the relict material, and dating via the Al-Mg system.

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