

Detailed Methodology

An 8 mm² area of Allende was mapped using a Carl Zeiss Ultra Plus field emission gun scanning electron microscope (FEG SEM) at the University of Sydney node of the Australian Microscopy & Microanalysis Research Facility. Element, phase and crystallographic data maps (Supplementary material Fig. DR1) were collected at a step size of 0.5 μm over 380 hours, using both the NordlysNano EBSD detector and X-Max 20 silicon drift detector (EDS), using 20 keV accelerating voltage and 10 nA current. This resulted in the detection of over 46 million diffraction patterns, and 7 billion x-rays. The EBSD patterns were indexing using Oxford Instruments AZtec software, and resulting orientation maps were processed using the Oxford Instruments CHANNEL 5.12 system. Data were noise reduced as per the procedure outlined by Watt et al. (2006), and grains smaller than 1.5 μm (3 x step size of 0.5 μm) were disregarded for further analysis to conservatively account for any potential mapping artefacts.

30 chondrules or chondrule rim grains within the mapped area were inspected for evidence of crystal-plastic deformation to constrain chondrule edge deformation within spatial context. For a detailed description of the chondrule deformation measurement, we direct the reader to the procedures of Forman et al., (2016).

CPO analysis required a subdivision of the mapped region into 120 grid squares to identify local and regional textures between olivine matrix grains (Fig. 1). The collective crystallographic orientations within each grid square were plotted onto lower hemisphere, equal area plots (Fig. 1) and overlain on the phase map for spatial reference (Figs. 1 & 2). One point per grain was plotted to avoid data bias. Both point and girdle maximas were observed. Point maximas are indicated by an arrow from the centre of the plot to the axes clusters (e.g. in Fig. 1), and double-ended arrows are used where the point maxima are positioned on the edge of the plot. A dotted line is used for girdle maximas. The thickness of each line specifies the intensity of the CPO present (mean uniform density (m.u.d.)). This approach allowed for an effective visual representation of the three primary crystallographic axes from ~2000 grains in one plot within their spatial context, and allowed for cross-examination of localised and overall CPOs from a broad area. To comprehend our CPO data, a comparison with shape-preferred orientation of the olivine grains was necessary (Fig. 3). The full analytical process is detailed in Figure 3 and supplementary material Figure DR2.

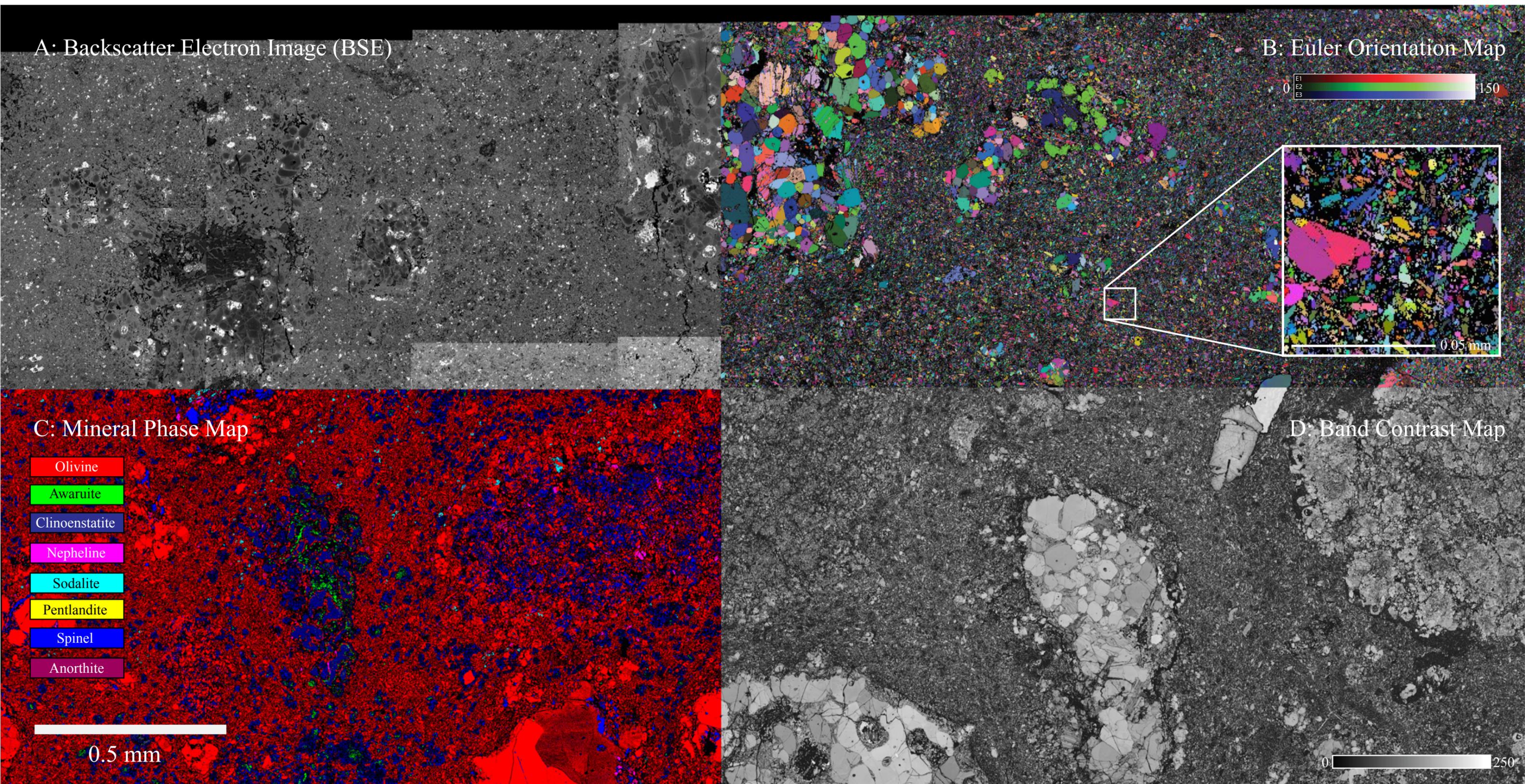
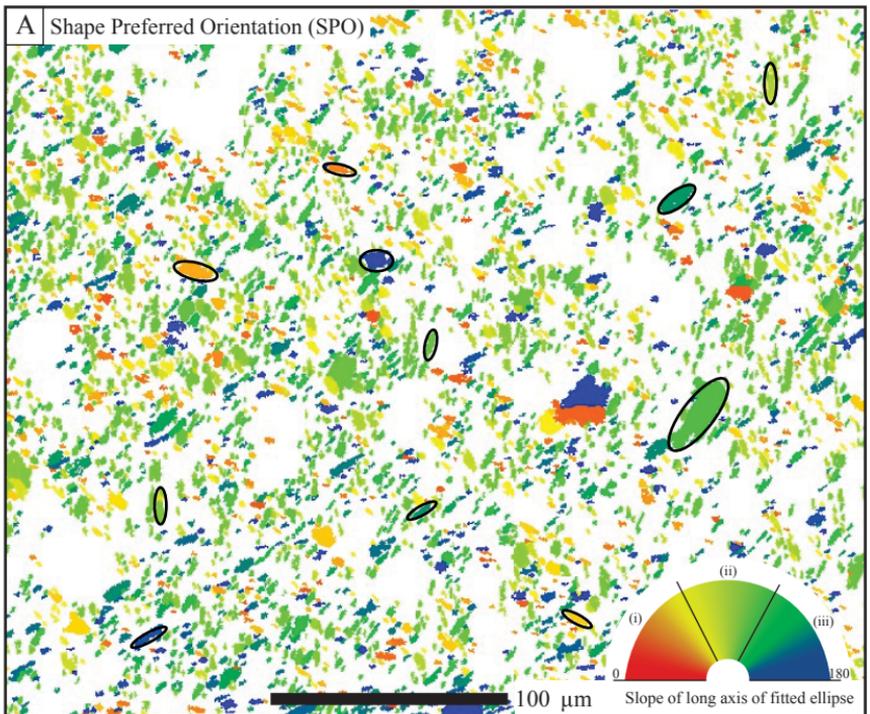


Figure DR1: Map of Allende shown with four different imaging techniques- a) backscatter electron image (BSE), b) all euler orientation map, colour coded to reflect collective crystallographic orientation with respect to the three primary crystallographic axes of each grain, c) mineral phase map, and d) band contrast map, where bright regions indicate a strong diffraction pattern and dark regions indicate a weak or absent diffraction pattern.



B (i) Crystallographic Preferred Orientation (CPO)

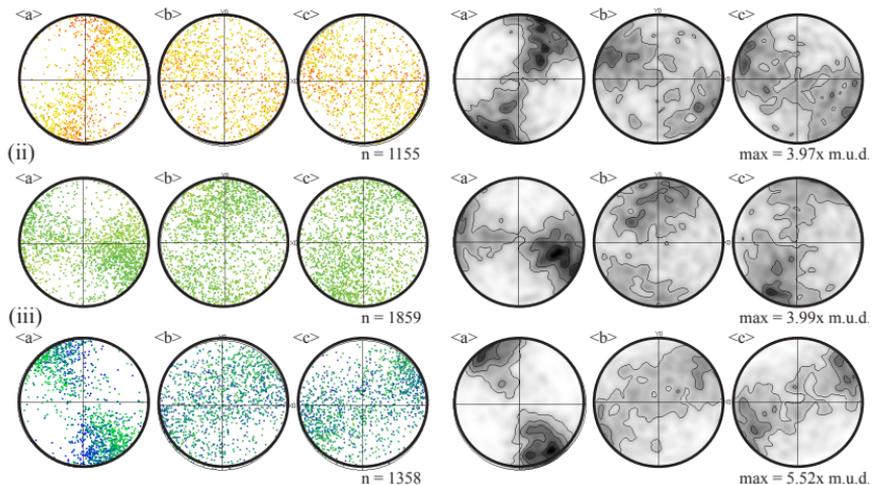


Figure DR2: Shape analysis of matrix olivines- a) map colour coded to indicate orientation of long axis of the fitted ellipse for each matrix olivine, b) grains divided into subsets i, ii and iii. Lower hemisphere, equal area plots show one point per grain for each grain in the subset on the left, and the contoured data is displayed on the right.