GEOCHEMICAL AND TEXTURAL ANALYSIS OF METAL PARTICLES ENTRAINED IN IMPACT MELT IN CBa CHONDRITE GUJBA. T. A. Harvey[1], K. H. Joy[1], R. H. Jones[1] and A. Gholinia[2], [1]Department of Earth and Environmental Sciences, University of Manchester, Manchester, M13 9PL, UK, (thomas.harvey@postgrad.manchester.ac.uk), [2]Department of Materials, University of Manchester, Manchester, M1 3BB, UK.

Introduction: Impacts are central to the formation and evolution of planetary and asteroidal bodies, via accretion, surface modification and, in some cases, eventual breakup. A range of physical (e.g. impact angle, target and impactor size, density, and state of the target body's atmosphere and hydrosphere) and chemical (e.g. target and impactor mineralogy, local pressure-temperature-fO_2 conditions and volatile abundance) parameters can influence the effects of a given impact [1].

We aim to understand the effects of chemical parameters with a focus on the behaviour of metal within impact melts. Some metal forms as a result of impact processes, and some metal is inherited from precursor (target and impactor) lithologies. For impact melt environments, processes such as reaction pathways, and effects of pressure-temperature-fO_2 conditions, are not completely understood. We are investigating the geochemistry and textures of metal particles in contrasting impact melt environments, on the Moon and in chondrites. We plan to use observed compositions of impactor-derived metal to constrain the type of impactor that caused the collision [2]. This would help to understand whether Solar System impactors have varied over time [3]. However, it requires an understanding of the effects of incorporation of impactor metal into impact melts.

CB chondrites: The CB chondrites are a group of meteorites that may have formed from an impact melt-vapour plume resulting from collision of two asteroids [4,5]. They are characterised by (sub-)millimetre-to-centimetre scale, metallic particles (60-80 vol. %) and crypto-crystalline and barred chondrules (20 vol. %) [6-8]. Within the CB group, samples are classified into the CBa and CBb subgroups. Meteorites from the CBa subgroup typically contain larger (up to centimetre scale) particles, whilst the CBb subgroup contain much smaller (millimetre scale) particles, but a higher volume of metal. Metal particles within the CBa subgroup meteorites exhibit a range of morphologies, with meteorites such as Gujba containing predominantly well-rounded particles, Weatherford containing angular particles, and Bencubbin containing both [8]. Metal particles contain arcuate sulphide inclusions which define metal subgrain boundaries [6-8].

Impact history: Despite debate regarding the initial origin of the metal particles, it is apparent that the CB parent body experienced further collisions after forming, as evidenced, for example, by Ar-Ar ages from Bencubbin glass that show multiple major shock events occurring after accretion [8,11-13].

Veins of impact melt matrix are observed within all CBa chondrites, especially so in Gujba [5]. In addition, high pressure phases such as coesite, majorite and wadsleyite have been observed in Gujba, as well as plastic deformation of barred chondrules [5,12]. The Fountain Hills meteorite, a metal bearing meteorite interpreted to be a CB chondrite, may represent material modified to an even greater degree, with recrystallised chondrules and metal which is entirely interstitial instead of in discrete particles [11,14]. The CBa chondrites appear to preserve a record of modification of metal by impact melt to a range of degrees which makes them a useful candidate for understanding how metal behaves during impact melting processes.

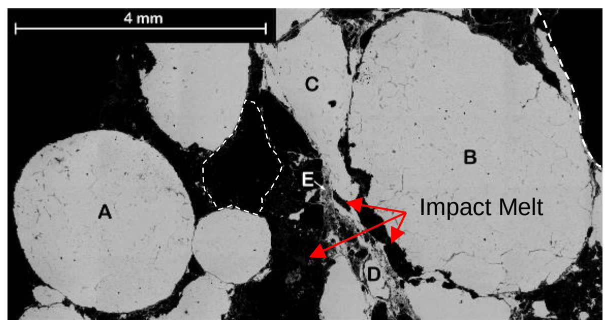

Figure 1: Back scattered electron micrograph of Gujba Sample 1 illustrating morphological classification of metal particles. Dashed white lines indicate presence of silicate chondrules.

Analytical Method: We studied two samples of Gujba. Sample 1 is a 1.5 x 2.0 cm polished thick section with abundant metal particles up to 4 mm in size. Sample 2 is a 3.0 x 1.5 cm polished block with abundant metal particles up to 6 mm in size. We collected quantitative compositional data on Sample 1 using a Cameca SX 100 Electron Microprobe. Back-scattered electron imaging and major element X-ray mapping were carried out on an FEI QUANTA 650 FEG-ESEM. We performed electron backscattered diffraction (EBSD) analysis on Sample 2 using a TESCAN MIRA3 SEM equipped with an OI Symmetry EBSD detector, to investigate the microstructure of the metallic particles.

Results: We classified metal particles according to their morphology and their relationship with the impact melt in which they are entrained (Fig. 1):

A. Rounded particles with predominantly smooth edges.

B. Predominantly rounded particles with some ragged edges.
C. Sub-angular particles that are not distinguishably rounded, with predominantly ragged edges.
D. Sub-angular metal entrained in impact melt.
E. Fine grained (<10 μm) metal entrained in impact melt.

We performed analyses on each of these categories to investigate variations in composition and microtexture. EPMA data for Ni, Co, P and Cr concentrations seem to discriminate between the morphological categories (Fig. 2). Metal of type D/E morphologies exhibit a wider range of Co and Ni concentrations than type A. Meanwhile, metal of type A and B morphologies exhibit a wider range of P concentrations than types C and D/E.

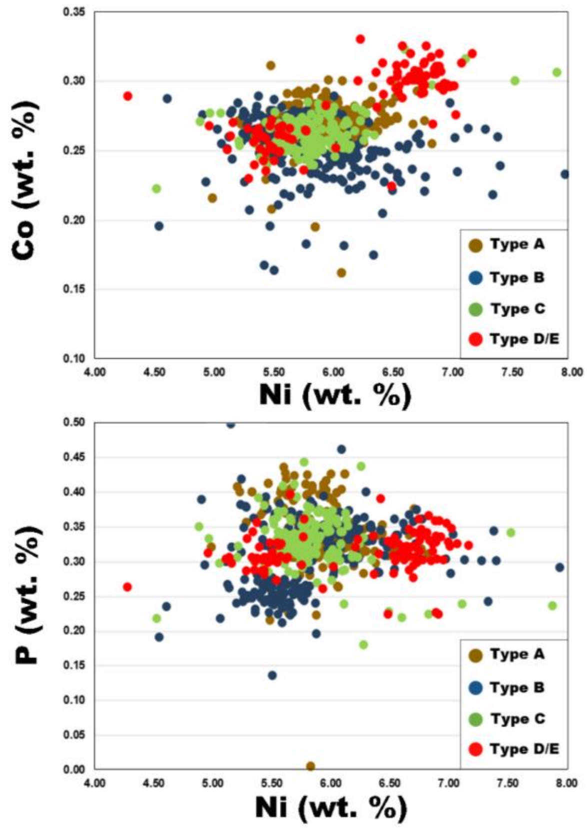

Figure 2: Quantitative major element data for Gujba metal, illustrating compositional variation between defined morphological categories (Type A: 215 analyses over two grains, Type B: 246 analyses over two grains, Type C: 165 analyses over two grains and Type D/E: 108 analyses over two regions of deformed metal).

Preliminary analysis of the EBSD data shows that particles of all categories are recrystallised, with myriad subgrain boundaries and complex variation in crystallographic orientation and size range of subgrains (Fig. 3). Further analyses will explore these observations to attempt to link them together, although recrystallization may reflect a later thermal overprint.

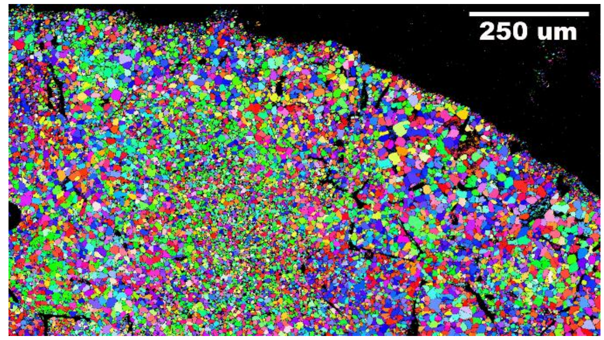

Figure 3: EBSD map showing complexity of microstructure in a small portion of one metal particle from Gujba Sample 2.

Interpretation: Metal in Gujba has clearly interacted with the impact melt. Based on our preliminary data, it appears that physical deformation is accompanied by chemical variations among metal particles. We also measured zoning profiles at particle edges but have not observed any changes in composition attributable to interaction with impact melt. Further analyses on a broader sampling of grains will help to interpret the process(es) that are controlling this observation.

Further work: Using our improved understanding of the geochemistry and microstructure of metal in CBa chondrite Gujba, we will use the same techniques to analyze metal within impact melt rocks from ordinary chondrite and lunar settings. This will provide a comparison with impact melts that formed under different conditions, such as melt composition, pressure, temperature and oxygen fugacity.

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