FIRST TOPOGRAPHIC HIGH-RESOLUTION DATA OF CARBONACEOUS CHONDRITE MATRICES USING FEG SEM. D. C. Hezel and L. E. Howard IARC, Natural History Museum, Department of Mineralogy, Cromwell Road, SW7 5BD, London, UK. d.hezel@nhm.ac.uk.

Introduction: Matrix is one of the two major components in chondritic meteorites. Its origin is crucial to understanding the conversion of interstellar material into the constituting materials of primitive chondrites. Yet, the origin of matrix is highly debated. Early chondrite studies suggested matrix consists entirely of solar nebular condensates [e.g. 1]. Subsequent, more advanced studies, conclude matrix to be a mixture of presolar material, solar nebular condensates and chondrule fragments [e.g. 2]. Additionally, there is a much debate as to the pristine nature of many matrix phases, with several phases argued to have a secondary origin as a result of thermal and aqueous alteration.

Matrix grain sizes are typically <1 µm in most chondrites, thus conventional SEM or EMP with magnifications of 1-2k are unable to resolve and analyse individual matrix grains. Most knowledge about chondrite matrix comes from TEM studies [e.g. 3,4]. TEM typically acts on a scale of >100k magnification and provides very detailed information of matrix mineralogy and local chemical processes. In order to understand structural and petrological relationships between matrix grains (e.g. grain-size distributions, porosity, grain textures etc.) on a broader scale, an intermediate resolution of 10-100k magnification is required. Such information allows an understanding of the formation and agglomeration processes of matrix grains as well as chemical processes acting across larger areas of matrix, and hence, will allow us to further constrain the origin of matrix minerals.

To our knowledge, no such study of chondrite matrices currently exists. We are in the process of conducting a systematic study of a large suite of all types of carbonaceous chondrite matrices to better understand their origin and formation.

Technique: High resolution images of chondritic matrix were acquired using a Carl Zeiss Ultra Plus thermal field emission gun scanning electron microscope at The Natural History Museum, London. Images were taken at 5 kV, 20 µm aperture, 4.1 mm working distance, using an Everhart-Thornley secondary electron detector. EDX analyses were performed at 5kV, allowing to detect Na, Mg, Al, Si, S K- and Fe and Ni L-lines.

Results: Figure 1 displays 8 images out of a large sample suite we are currently studying. CV chondrite matrices have a sintered texture, with a significant amount of pore space between grains. Olivine grains <1 µm often appear to be broken fragments of larger olivine grains. Olivine is sometimes tightly intergrown with, or entirely enclosed by, feldspar. Magnetite occurs in these structures, but no pyroxene. Matrix olivines in Allende (plate a) have substantial internal porosity, unlike chondrule olivines. Thus it is unlikely that matrix olivines are derived from the fragmentation of chondrules. Matrix olivines in Mokoia (plate b) also contain internal porosity and abundant inclusions, usually Ni-rich sulfide, probably pentlandite.

Plate c illustrates extraordinary detail of the Kainsaz matrix. It has a porous aggregate structure. Individual idiomorph grains down to only a couple of 100 nm in size are clearly distinguishable from each other.

Plate d displays a sulfur-rich portion of the Murchison matrix. The structure is generally compact and fibrous with minimal porosity. Individual crystals or minerals cannot be identified. In the portion shown here, a network of S-rich material encloses silicates. The S was probably mobilised by a metamorphic event on the parent body.

CR chondrites also have a very compact, fibrous matrix with only minor porosity. Shown here (plate e) is a region in Renazzo with a darker vein cross-cutting lighter silicate material. The vein contains sulfide grains with sizes <1 µm. No individual silicate grains can be identified.

CB and CH chondrites typically contain only little and highly altered matrix material. Plate f displays a compact and very dense matrix vein in Isheyevo with no pore space at all. No individual grains are visible.

The last chondrite image of plate g shows the CI chondrite Ivuna. It has a highly porous structure with embedded larger silicate grains. This is in stark contrast to the dense structures of Murchison, Isheyevo or Renazzo, which are most probably the result of hydrous activity. Thus, it is possible that Ivuna did not experience high degrees of hydrous alteration. However, it is important to note that the grains imaged closely resemble Al_2O_3 polishing agent (plate h). We are currently investigating to what degree Ivuna has been contaminated by polishing material.

Conclusions: Matrices of CM, CR, CH and CB chondrites are fibrous and dense, indicating significant secondary alteration. Matrices of CO and CV chondrites possibly preserve primitive material that agglomerated into a porous structure.

References: [1] McSween (1979) *Rev. Geophys. Space Phys* **17**: 1059-1078; [2] Scott et al. (1988) in *Meteorites & Early Solar System*, Kerridge & Matthews (eds); [3] Brearly & Jones (1998) in *Planetary Materials*, Papike (ed.), 398p. [4] Chizmadia LJ & Brearley AJ (2008) GCA 72: 602.

Figure 1: ol:olivine, pt: pentlandite, sul: sulfide.