3-DIMENSIONAL CHEMICAL ANALYSES OF COMPONENTS IN THE CARBONACEOUS CHONDRITES ACFER 209 (CR) AND ALLENDE (CV). D. C. Hezel, H. Palme and C. Burkhardt, Institut für Geologie und Mineralogie, Universität zu Köln, Zülpicherstraße 49b, 50674 Köln, Germany d.hezel@uni-koeln.de.

Introduction: Components of meteorites are 3-dimensional objects, which are usually studied in 2-dimensional thin sections. One exception are recent tomographic X-ray studies of Allende volumes by [1]. This method has the disadvantage of producing only BSE-like images without detailed chemical information:

We have started to obtain 3-dimensional chemical data sets for meteoritic volumes. The results are important for a number of reasons:

(1) Calculation of accurate chemical bulk compositions of chondrules and CAIs. Such data are relatively rare, but of particular interest for a variety of important questions, such as the chondrule – matrix complementarity described by [2]. A precise knowledge of chondrules compositions is crucial for chondrule forming mechanisms. Another question related to bulk chondrule compositions is the identification of chondrule precursor components and their origin [3].

(2) Many workers have devised procedures that allow estimating bulk chondrule compositions from 2-dimensional EMP analyses. With the data obtained in this study such models can be tested. It is also important to see to what extent modal abundances in a thin section are representative for the bulk chondrules.

(3) The distribution of metal and silicate in chondrules can be studied on representative samples in much more detail.

(4) The spatial distribution and the amount of various meteoritic components like chondrules, CAIs, etc. in the bulk meteorite will be available in great detail.

(5) The procedures applied here will produce the 3-dimensional shapes of chondrules, CAIs, dark inclusions (DI), etc.

We recently started obtaining data of two meteorites by grinding them down. We began with Acfer 209 (CR) and Allende (CV). The latter is petrographically and chemically well characterized and therefore well suited to test our technique.

Technique: We use meteorite chunks, with an area of ~2 mm^2 and a thickness of 3 mm. Our goal is to grind these thick sections in stepsizes between 50 and 100 µm. However, controlling the grinding process is difficult and so the first step was at a depth of ~260 and the second at ~410 µm.

We recently finished the third step, and presently we prepare the fourth. The height-difference is measured in two ways: (1) the one inch round thick section is measured on four points using a slide gauge. (2) Two metal cones, 1.5 mm in diameter and 3 mm in height, are embedded in each thick section. The diameter of the cones can be precisely measured in each step using BSE-images. From knowing the dimensions of the cone and the diameter measured in each step, the height of the grinded material can be calculated.

At each step we take BSE-images of the whole section, and produce a photo mosaic. We then measure major and minor elements (Ca, Al, Ti, Mg, Si, Fe, Ni, Mn, Cr, Na) of chondrules, CAIs, matrix and also rare components (e.g. DI), when encountered. A JEOL 8900RL electron microprobe is used for analyses. Matrix analyses are made using a broad beam with 30 µm spot size. Bulk chondrule analyses were calculated using the simple formula:

$$element_1 = \sum\left(area_{phase1} \cdot conc.\ in\ phase\ 1\right) + \ldots + \left(area_n \cdot conc.\ in\ phase\ n\right)$$

First results: First interpretations are shown in Table 1 and Figure 1. The latter shows the same type IA chondrule in three following steps of the grinding process. The BSE-images show an increase in the modal abundance of metal, which increases from 22.4 to 47.3 vol.% (Table 1). The petrographic appearance of the chondrules also changes. In the first step one might classify the chondrule as barred olivine chondrule. But in the next two steps one would clearly identify the chondrule as a porphyritic type.

	Step-1	Step-2	Step-3	m. v.
SiO_2	51.44	56.17	55.50	54.37
TiO_2	0.14	0.25	0.12	0.17
Al_2O_3	5.51	2.00	1.43	2.98
Cr_2O_3	0.47	1.06	0.75	0.76
FeO	1.44	1.67	3.88	2.33
MnO	0.12	0.19	0.18	0.17
NiO	0.03	0.02	0.15	0.07
MgO	37.06	36.27	36.95	36.76
CaO	3.69	3.74	0.89	2.77
Na_2O	0.27	0.06	0.07	0.13
total	100.18	101.41	99.93	100.51

Table 1: Calculated bulk compositions (only silicate portion) from different sections of the type IA chondrule shown in Fig. 1.m. v.: mean value; analysis given in wt.%;

Bulk chondrule compositions (2-dimensional) and modal abundances of phases for each section are given in Tables 1 & 2. As can be seen, bulk compositions do not vary significantly (Table 1), although the modal abundances of olivine, pyroxene and mesostasis do vary significantly (Table 2). This would be a comforting result, because it means that 2-dimensional thin sections are representative for 3-dimensional objects. However, further analyses are required to confirm this result.

The variability in Al_2O_3 and CaO is probably the result of inhomogeneous chondrule mesostasis caused for example by intergrowth of different tiny phases. We will therefore analyze the mesostasis more thoroughly in further steps.

Unfortunately no CAI was encountered in Allende so far and only one in Acfer 209, which is chemically homogeneous up to now. The complementary chondrule – matrix relationship in Allende and Acfer 209 found by [2] is in agreement with our recent data.

We also plan to analyze minor and race elements in the near future, using LA-ICP-MS.

	Step-1	Step-2	Step-3
metal	22.4	43.6	47.3
Ol	41.32	11.33	2.3
Px	36.36	75.39	86.2
Meso	22.32	13.28	11.5

Table 2: Modal abundance of phases in the type IA chondrule in Acfer 209 from different sections. Analysis given in vol.%.

References: [1] Ebel et al. (2004) *MAPS* #5153 [2] Klerner S. & Palme H. (2000) *MAPS, 35* #A89 [3] Hezel et al. (2004) *Workshop on Chondrites and the Protoplanetary Disk* #9095

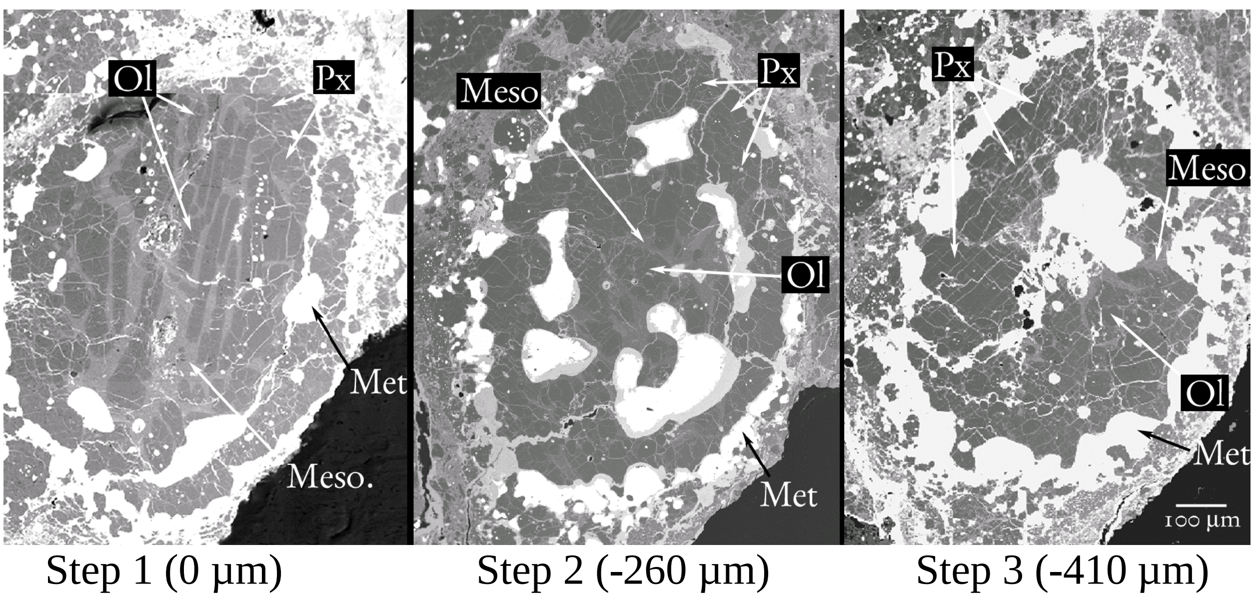

Figure 1: BSE-images of the same type IA chondrule from three different steps during grinding. The increase in metal abundance can clearly be seen. Ol: olivine; Px: pyroxene; Meso: mesostasis; Met: metal.