

FE-ISOTOPIC COMPOSITION OF CHONDRULES, CAI, MATRIX AND BULK METEORITE IN MOKOIA AND GROSNAJA CV-CHONDRITES. D. C. Hezel¹, A. W. Needham² and S. S. Russell¹. ¹IARC, Natural History Museum, Department of Mineralogy, Cromwell Road, SW7 5BD, London, UK. ²University of Oxford, Department of Earth Sciences, Parks Road, OX1 3PR, Oxford. d.hezel@nhm.ac.uk.

Introduction: The Fe-isotopic composition of solar system materials fall on a single mass-fractionation line in the Fe-3-isotope plot [e.g. 1-4]. This requires effective homogenisation of Fe-isotopes throughout the solar nebula prior to chondrule formation. Chondrules have a comparatively large spread in Fe-isotopic composition, ranging from $\delta^{56}\text{Fe}$ -1.33 to +0.65 [2-4 and this study]. This spread might be explained by (i) heterogeneities among chondrule precursor grains [3], (ii) reduction of Fe-rich chondrules during chondrule formation [5], (iii) evaporation and re-condensation of FeO during chondrule formation [6] and (iv) Fe-redistribution on the meteorite parent body due to e.g. aqueous alteration. The study by [6] concluded that extensive evaporation is improbable, as the authors could not observe large mass fractionation as expected from theoretical considerations. However, the in-situ technique required for their studies is accompanied by comparatively large errors ($2\sigma \leq 1-2\%$).

In order to disentangle which one of the aforementioned processes was dominant, we analysed the Fe-isotopic composition of 16 chondrules and CAI-like objects as well as matrix and bulk chondrite from the two CV_{ox} chondrites Mokoia and Grosnaja. These meteorites have recently been classified as of petrologic type 3.6 [7]. A second aliquot of each of the 16 objects is currently being measured for Si-isotopes. The measurements are accompanied by petrologic studies using SEM and EMP of bits of the objects that have been embedded and polished. Further, we currently set up a computer code that allows us to simulate the various processes that potentially changed the Fe-isotopic compositions of chondrules as mentioned above. A comparison of various theoretical scenarios with the results of the isotope measurements will show which of the processes were dominant.

Techniques: All objects that appeared round under the optical microscope have been mechanically separated from the host meteorite. Only comparatively large objects are used in this study in order to simultaneously measure Fe- and Si-isotopes as well as the petrology of each object. Measurements of Si-isotopes are currently being undertaken. So far Fe-isotopes have been measured and chondrules have been studied using SEM (BSE-images & qualitative EDX spectra, Fig. 1).

Fe-isotopes have been measured using a Nu-instrument MC-ICP-MS. The IRMM-14 standard has

been used. The column chemistry and analytical procedure are the same as in [4].

The computer model is programmed using Mathematica 5.1. The code consists of independent modules, each describing or calculating a change in the different chondrule properties like for example chondrule radius, chondrule grain size, elemental composition and isotopic composition. Each of the modules can be easily exchanged and/or switched on or off to implement different boundary compositions, fractionation models, etc. This allows us to run various scenarios of chondrule isotopic evolution.

Results & Discussion: Figure 1 displays our results and Fig. 2 shows BSE-images of a few samples. The error bars of some Fe-isotope measurements are comparatively large due to some analytical problems during some of the runs. Qualitative SEM studies indicate that 5 of the objects studied are CAIs.

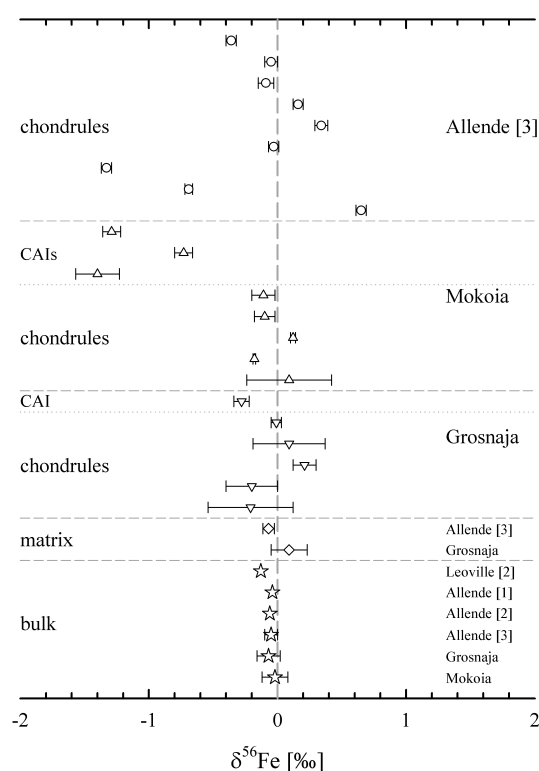


Fig. 1: Compilation of $\delta^{56}\text{Fe}$ data from this study and literature.

The CAIs appear more altered than the other chondrules and have particularly low $\delta^{56}\text{Fe}$ -values, between -0.28‰ and -1.40‰ . Chondrules range from -0.21‰ to $+0.21\text{‰}$ $\delta^{56}\text{Fe}$. Chondrules measured include: 7 type IA, 1 IB and 1 IIB chondrule. The small range in isotopic composition might be because we chose to analyse only large chondrules, in order to simultaneously study petrology and also measure Si-isotopes on the same chondrule. There is a positive correlation between decreasing chondrule size and decreasing $\delta^{56}\text{Fe}$ which indicates that smaller chondrules will significantly extend the isotopic range currently observed. We therefore plan to include smaller chondrules in a second measurement session. Contamination from matrix can be excluded as we did not find matrix attached to chondrules when these showed a rim portion in the BSE-image.

Bulk chondrite and matrix $\delta^{56}\text{Fe}$ reproduce previous reports on matrix and bulk CV chondrites (Fig. 1). Bulk chondrite and matrix $\delta^{56}\text{Fe}$ compositions are indistinguishable within errors. This requires that average bulk chondrule composition must be very close or the same as bulk chondrite and matrix compositions. Assuming that chondrules initially had the same isotopic composition as bulk chondrite/matrix, the isotopic evolution of chondrules must have produced

higher but also lower than initial chondrule isotope compositions. A reduction process as proposed by [5] drives the composition to a higher values ($+\delta^{56}\text{Fe}$), but cannot account for the low values. The same is true for evaporation/re-condensation and parent body processes, however, it is noted that the latter potentially drives the chondrule isotopic composition to lower compositions ($-\delta^{56}\text{Fe}$). Heterogeneities among chondrule precursor grains have the problem that they easily disturb correlations like for example size and $\delta^{56}\text{Fe}$. In addition the initial heterogeneities needs an explanation as well as the large chondrule precursor grains that are required to preserve the precursor heterogeneities in the subsequently formed chondrules [8].

Preliminary runs of the computer simulation indicate that we can reproduce the observed Fe-isotopic composition of chondrules by some combination of evaporation/recondensation and parent body processes.

References: [1] Zhu X. K. et al. (2001) *Nature*, 412, 311-313. [2] Kehm K. et al. (2003) *GCA*, 67, 2879-2891. [3] Mullane E. et. al. (2005) *EPSL*, 239, 203-218. [4] Needham A. W. (2007) *PhD-thesis*, 189 p. [5] Cohen B. A. et al. (2006) *GCA*, 70, 3139-3148. [6] Alexander C. M. O'D. and Wang J. (2001) *MAPS*, 36, 419-428. [7] Bonal L. et al. (2006) *GCA*, 70, 1849-1863. [8] Hezel D. C. and Palme H. (2007) *GCA*, 71, 4092-4107.

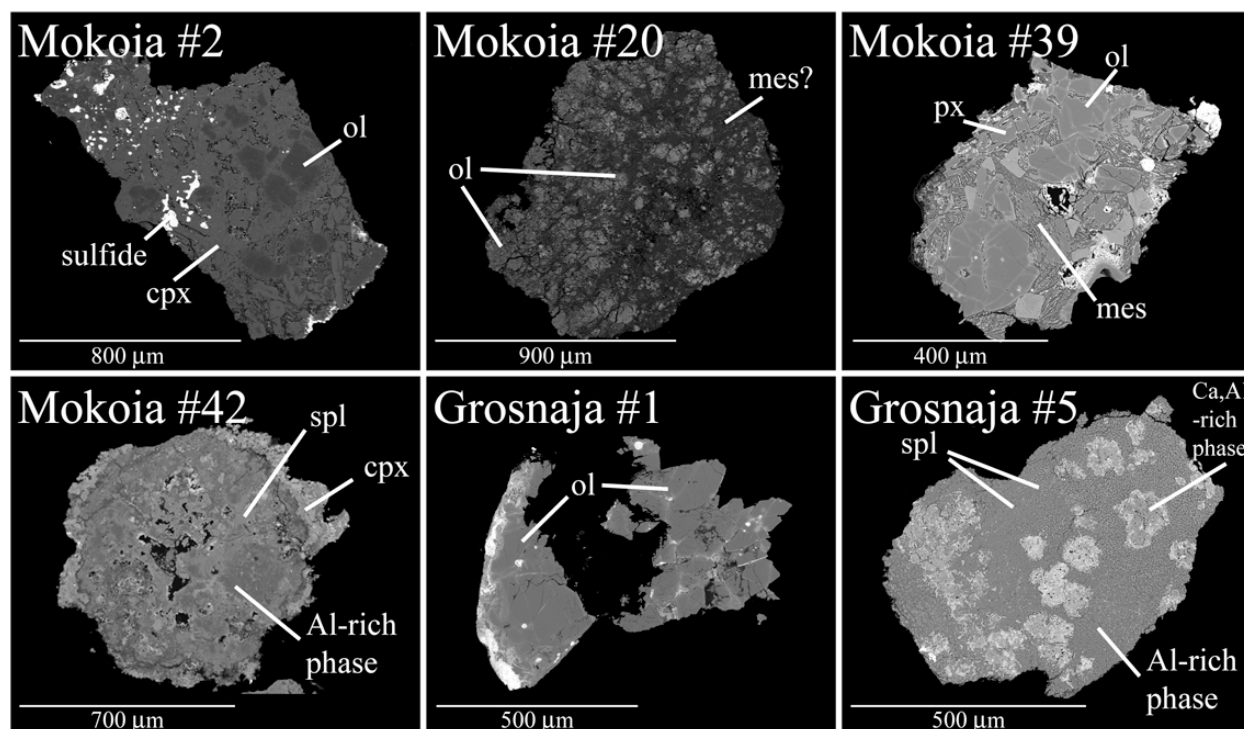


Fig. 2: Mokoia #2: probably a type IAB chondrule with sulfide; Mokoia #20: probably a type IIB chondrule; Mokoia #39: a type IA chondrule; Mokoia #42: Al-rich chondrule or CAI; Grosnaja #1: a type IA chondrule; Grosnaja #5: Al-rich chondrule or CAI. ol: olivine; cpx: clinopyroxene; mes: mesostasis; px: pyroxene; spl: spinel.