European Mineralogical Conference
Vol. 1, EMC2012-631, 2012
European Mineralogical Conference 2012

Searching for the cause of the chondrule-matrix complementarity: an interactive real-time modelling approach

D. C. Hezel (1) and H. Palme (2)

(1) Institut für Geologie und Mineralogie, Universität zu Köln, Zülpicherstrasse 49, Germany (dominik.hezel@uni-koeln.de), (2) Forschungsinstitut und Naturmuseum Senckenberg, Senckenberganlage 25, D-60325 Frankfurt am Main, Germany.

Carbonaceous chondrites are chemically close, in some cases (CI-chondrites) even almost identical, to the chemical composition of the solar system. These meteorites are therefore pivotal for the understanding of the formation of the Solar System and the evolution of the Earth.

Carbonaceous chondrites are conglomerates of distinct components that formed individually in the solar nebula. The two major components with a combined abundance of up to 95 vol% are chondrules and matrix. Chondrules formed as up to ∼1 mm sized melt droplets during brief high-T events. The formation of matrix is unclear. It has been reported by various authors that bulk chondrules and bulk matrix have different chemical compositions (Hezel & Palme, 2010 and references therein). For example, element ratios such as Si/Mg or Fe/Mg are different in bulk chondrules and matrix. Intriguingly, these ratios are almost CI-chondritic in the bulk meteorites. As chondrules and matrix dominate the bulk chondrite chemical composition for most elements, there must be a genetic relationship between chondrules and matrix. This relationship is called the chondrule-matrix complementarity, because the compositions of bulk chondrules and matrix are complementary with respect to the bulk chondrite composition, which is close to solar.

Although there is no doubt regarding the observation of the chondrule-matrix complementarity, there is much debate regarding the cause of the complementarity (e.g. Bland et al. 2005, Zanda et al. 2006, Hezel & Palme 2008,2010, Palme & Hezel, 2011). There are three principle explanations: (1) The formation of chondrules and matrix from the same reservoir that has CI-chondritic element ratios. The complementarity was established by the preferential incorporation of high-temperature condensates in one of the components, e.g. forsteritic olivine into chondrules. (2) The coupled exchange of e.g. Mg and Fe between chondrules and matrix on the parent body established the complementarity. (3) Chondrules and matrix formed in different reservoirs with a different chemical composition and were mixed together during parent body accretion.

Here we employ interactive real-time modelling to study the entire sensible parameter range involved in any of these possibilities. From these we exclude possibilities (2) & (3). Possibility (1) then provides one of the most important constraints of chondrite component formation, which is: the formation of chondrules and matrix in the same nebula region and from the same chemical reservoir. The models and these implications will be presented at the meeting.

Preliminary iterations of the real-time models we used and with the possibility to interactively use them are available from http://geomodeling.uni-koeln.de, and then 'Complementarity' from the list on the left.

References

Bland PA, Alard O, Benedix GK, Kearsley AT, Menzies ON, Watt LE, Rogers NW (2005) Volatile fractionation in the early solar system and chondrule/matrix complementarity. PNAS 103, 13755–13760.

Hezel DC & Palme H (2010) The chemical relationship between chondrules and matrix and the chondrule-matrix complementarity. EPSL 294:85-93.

Hezel DC & Palme H (2008) Constraints for chondrule formation from Ca-Al distribution in carbonaceous chondrites. EPSL 265:716-725.

Palme H & Hezel DC (2011) Matrix-chondrule relationship and the origin of chondrules. Formation of the First Solids in the Solar System #9088.

Zanda B, Hewins RH, Bourot-Denise M, Bland PA, Albarède F (2006) Formation of solar nebula reservoirs by mixing chondritic components. EPSL 248:650–660.