CHONDRULE FORMATION MECHANISMS IN PROTOPLANETARY DISKS FROM TEXTURAL AND MINERALOGICAL EVIDENCE PRESERVED IN UNEQUILIBRATED CHONDRITES

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Introduction: Chondrules are the most abundant component of ordinary and carbonaceous chondrites, the latter with the exception of the CI chondrite group [1,2]. The origin of chondrules continues to be a complex and debated topic, but new answers are being obtained thanks to the study of the remarkable features preserved in undifferentiated meteorites, and a deeper understanding of shock wave physics in protoplanetary disks [3]. We are currently exploring distinctive chondrule features identified in several pristine chondrites by using different techniques: optical microscopy, SEM/EDX and electron microprobe. So far we have studied different undifferentiated meteorites like e.g. Semarkona, ALH77307, MIL03346, and Acfer 094 in order to deep into the mean chondrule size, the existence of chondrule rims, and porous microchondrules and fine-grained materials attached to them. Such features have been recently identified as being the legacy of ancient physical processes in the disk [4].

We will compare the chondrule size distribution seen in selected thin sections of these pristine chondrites with the expected outcome from physical processes like e.g. by splattering due to stochastic collisions, and as a consequence of thermal coagulation of micron-sized dust preserved in the matrix of these chondrites. At the same time, we have been studying the features associated with chondrule rims, particularly the existence of patches of fine-grained materials and porous microchondrules that have been recently proposed as originated as splattered melt products [5]. Unequilibrated chondrite materials could be the product of a late collisional stage of the chondrules with free-floating dust materials that formed the matrix [6]. In type 3 chondrites the matrix materials and their interrelationships with the chondrules, refractory inclusions, sulphides and metal grains can provide useful clues on the early stages of accretion [7].

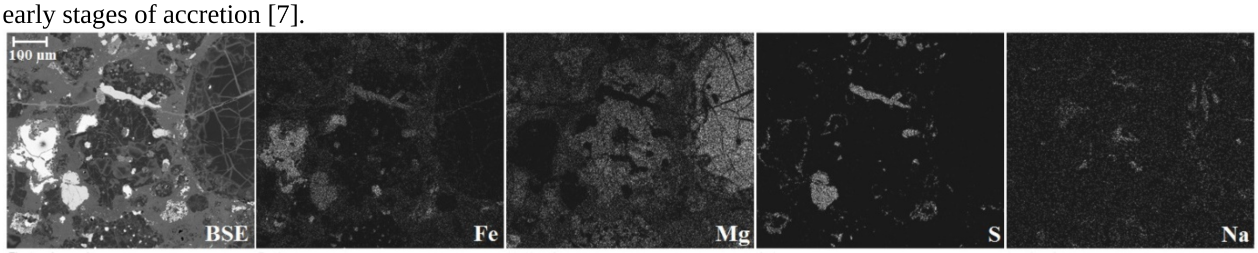

Fig. 1. BSE image and X-ray elemental mapping in the highly unequilibrated CO3 chondrite ALH 77307.

On the other hand, it is not surprising the big diversity of chondrules found in chondrites, given the variable range in formation time, location and conditions in which these glassy spherules formed in the protoplanetary disk [2-8]. Recent calculations indicate that the formation of chondrules makes sense in dense rings formed in protoplanetary disks [3], like e.g. those observed in the disk surrounding young star HL Tau [9]. Micron-sized dust particles exposed to the stellar radiation and wind drift radially inward by the Poynting–Robertson drag and, due to stellar radiation pressure, they are piled up forming rings where they are substantially heated and sublimate [3]. A clear chemical interchange with the gaseous environment is obvious, and explains certain unique isotopic characteristics of chondrite groups. For instance, growing astrophysical evidence also confirms that the amount of oxygen in vapour phase was probably highly variable and consequence of inward migration of ice-rich dust. Because water beyond the ice-line is in solid form, a concentration gradient tends to push water vapour out of the inner disk; so the its presence in the inner-disk suggests replenishment through the sublimation of inwardly migrating icy bodies [10].

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