PROTOPLANETARY DISK COMPONENTS CONTAINED IN PRISTINE CARBONACEOUS CHONDRITES

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INTRODUCTION

Carbonaceous chondrites (CCs) can be considered cosmic aggregates containing protoplanetary disk components. Modern analytical techniques allow us to identify CCs unaffected by thermal or aqueous alteration processes, having a pristine nature. Such a highly unequilibrated meteorites allow us to get clues on the early Solar System (ESS), as their components are ancient materials retentive of chemical clues on their formation. The information they contain is valuable to be applied to *proplyds (Fig. 1)*.

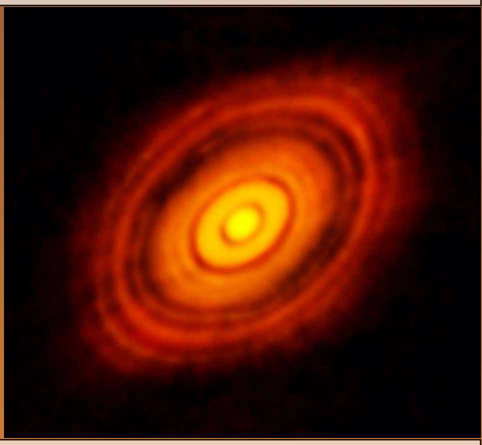


Figure 1. HL Tau protoplanetary disk imaged by ALMA. The toroidal rings might be representative of the first stages of formation of chondritic groups in our own solar system.

SAMPLES AND PROCEDURE

The Institute of Space Sciences (ICE, CSIC) in Barcelona is an international repository of the NASA Antarctic collection. We use all type of analytical techniques (SEM-EDX, microprobe, XRD, Raman, etc…) to characterize the nature of these undifferentiated meteorites. Our goal is identifying the main processes at work during the accretion and evolution of these rocks, including accretionary ones (Fig. 2-3). This effort has been realized in the framework of four Spanish research projects (AYA2011-26522, AYA2015-67175-P, PGC2018-097374-B-I00, and PID2021-128062NB-I00).

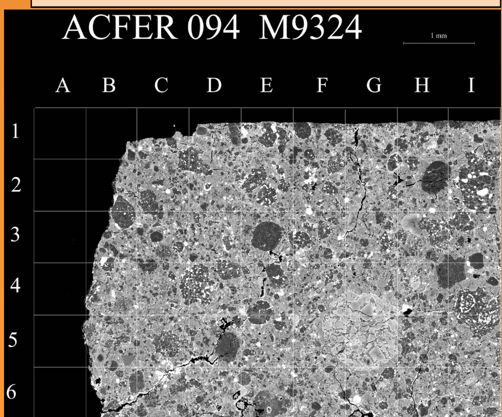


Figure 2: High resolution mosaic of a thin section of the ungrouped CM-like chondrite ACFER, identified as a pristine carbonaceous chondrite [3]. The rock is dominated by rounded spherules called chondrules. The grid is for identification purposes.

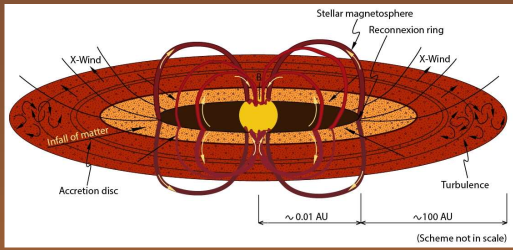
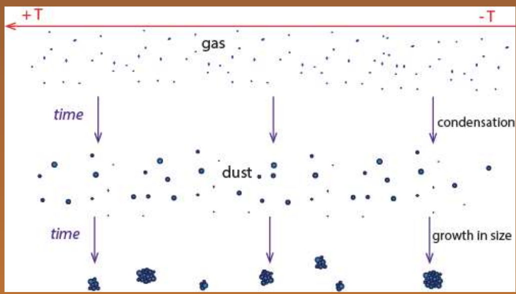


Figure 3. Top) A protoplanetary disk schematic structure, in the region of formation of refractory inclusions. Bottom) An example of particle condensation and growth in the disk over time



CHONDRITIC COMPONENTS

Chondrites can be seen as cosmic sediments retentive of ancient accretionary processes. Using a ion microprobe we can build X-ray maps to identify the main minerals, here using a MgCaAl pattern: red, green, blue.

The so-called chondrules are the most ubiquitous components of chondrites (Fig. 4), but are 2-3 Myrs younger than the Ca-Al rich Inclusions (CAIs) formed 4.568 Myrs ago [4], refractory particles coming from the inner disk, affected by overheating processes

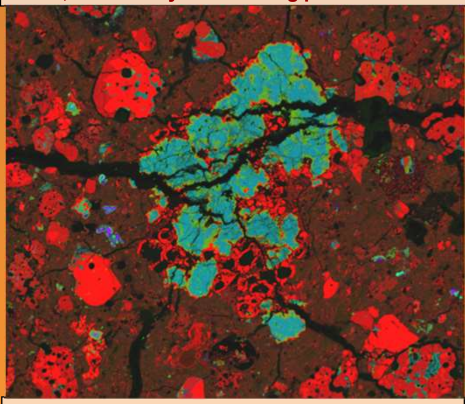
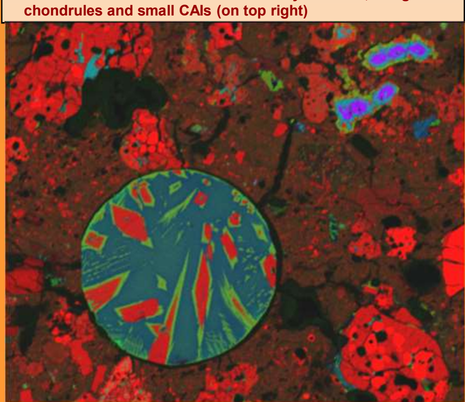


Figure 4. Top) A 500 μm-sized CAI surrounded by chondrules and matrix In ACFER 094. Notice that the particle has an aggregate-like structure. Bottom) A 200 μm Al-rich chondrule surrounded by matrix, Mg-rich chondrules and small CAIs (on top right)



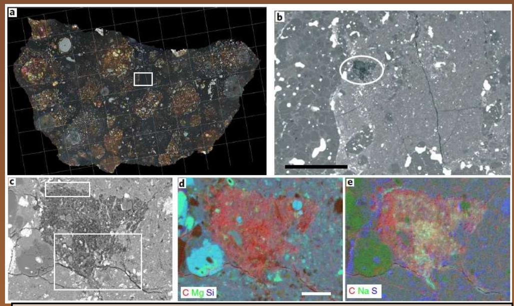
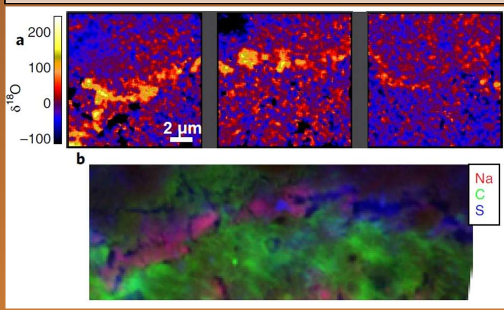


Figure 5. Top) A 100 microns xenolith discovered in the interior of LAP 02342 CR chondrite. It has an unusual chemistry probably representative of an ancient comet or Kuiper Belt Objects [5]. Bottom) $\delta^{18}O$ images showing anomalous ^{16}O-poor grains near the upper border of the xenolith formed by carbonates and Na-rich sulphides. That boundary was once an icy mantle, when the xenolith got stacked into the matrix.



CONCLUSIONS

Highly unequilibrated CCs contain the materials available in the disk, representing the primordial building block of planetesimals. They preserved unique clues on the early environment, being useful to interpret astrophysical environments. The analyses of CC allow us to reach the following conclusions:

- By studying fine grained materials in the chondrite matrices, chondrules, CAIs, and other chondritic components we get valuable information on the chemical and isotopical compositions of the materials formed in the ESS.
- An ancient xenolith in the matrix of LAP 02342 (Fig. 5) indicates that inward transport also affected the late stages of planetesimal accretion, allowing a connection between comets and C-rich asteroids, that we have also recently proposed [6]
- Sample return missions have the potential of obtaining further discoveries to interpret the origin of some of our better preserved CCs [1,7]

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