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Aqueous alteration in chondritic asteroids and comets from the study of carbonaceous chondrites

JOSEP M. TRIGO-RODRÍGUEZ[1,2]

[1] *Institute of Space Sciences (CSIC), Campus UAB, Facultat de Ciències, Torre C5-parell-2ª, 08193 Bellaterra, Barcelona, Spain, e-mail: trigo@ice.csic.es*
[2] *Institut d'Estudis Espacials de Catalunya (IEEC), Edif. Nexus, c/Gran Capità, 2-4, 08034 Barcelona, Spain*

Asteroids and comets comprise a diverse range of undifferentiated bodies that are currently of much interest in terms of space exploration. The meteorites called chondrites provide us with a valuable source of information on the origin and evolution of their parent bodies. From careful study of these meteorites the primordial mineralogy can be inferred by keeping in mind that these bodies suffered thermal metamorphism and/or aqueous alteration just after their formation. In this context, newly available instruments allow us to extract chemical, isotopic, and mineralogical information on the components of primitive meteorites. This is essential to better understand the physico-chemical processes operating during the different evolutionary stages experienced by the parent bodies of chondrites.

1. Introduction: searching for Solar-System primordial materials

The most primitive rocks reaching the Earth's surface are meteorites called chondrites. This name originates from their main constituent: rounded silicate spherules, or chondrules. The Pb-Pb isotopic chronometer indicates that these rocks consolidated ~4.56 Ga ago (Amelin *et al.,* 2002). At this time the Solar System comprised a young star surrounded by a flattened cloud of billions of particles that constituted the protoplanetary disk. This disc was the precursor of planetesimal formation. Planetesimals are the first km-sized bodies that formed in the inner disk, and a few tens of millions of years later participated as the building blocks of the current planets. Bodies a few hundred km in size did not differentiate as they irradiated efficiently their primordial heat (the sources of the heat are returned to later). From these primitive bodies come the chondrites, authentic cosmic aggregates containing the materials that were forming the protoplanetary disk at the particular heliocentric distance and time where they accreted (certainly not identical to all known meteorites).

The first bodies that accreted in the outer region of the Solar System inherited physico-chemical properties that are unusual from a terrestrial perspective (Blum *et al.,* 2006). We find some minerals that are similar to those on Earth, but others formed in very diverse environments, as revealed by their unusual isotopic signatures (Anders and Zinner, 1993; Zinner, 2003; Trigo-Rodríguez *et al.,* 2009a). Current evidence indicates that very different materials made up the outer protoplanetary disk

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