ACFER 182 CHONDRULES GIVE EVIDENCE FOR DIRECT CONDENSATION OF ENSTATITE-RICH LIQUIDS FROM THE SOLAR NEBULA.

M. E. Varela[1], E. Zinner[2], G. Kurat[3], D. Magnelli[1]

[1]Instituto de Ciencias Astronómicas de la Tierra y del Espacio (ICATE) Av. España 1512 sur, San Juan, Argentina.
[2]Laboratory for Space Sciences and the Physics Department, Washington University, St. Louis, MO 63130, USA.
[3]Mineralogisch-Petrographische Abteilung, Naturhistorisches Museum, Burgring 7, 1010 Wien, Austria (deceased).

42nd Lunar and Planetary Science Conference, March 7-11, 2011

Introduction: Acfer 182 is a member of the CH carbonaceous chondrites as introduced by Bischoff et al., [1]. The CH chondrites are characterized –among other features- by 1) a depletion of moderately volatile and highly volatile elements [e.g., 2-3], 2) small size of chondrules (<90 µm), with refractory inclusions making up a small fraction [1]. The low abundance of volatile and moderately volatile elements in chondrules in the CH chondrites could be the result of their formation by gas-liquid condensation in an impact vapour cloud [4], a condensation signature of chondrule precursors [5], or a sign that chondrules were efficiently removed from the chondrule-forming region prior to condensation of these elements [6]. Although extensive studies have been performed on chondrules of CH and CH-like chondrites [e.g., 6-11], those on Mg-rich cryptocrystalline (CC) chondrules are scarce [e.g., 6-7]. Here we report the results of major and trace element studies of some CC chondrules in Acfer 182.

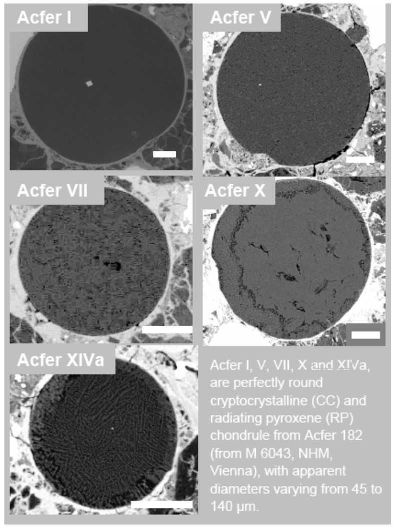

Fig. 1: Backscatter electron images of Acfer 182 CC chondrules. Scale bars are 20 µm.

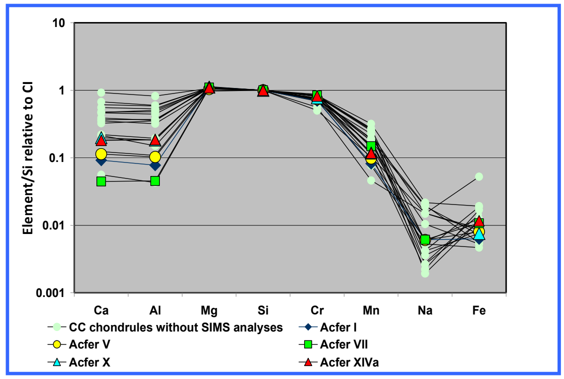

Fig. 2: Bulk composition of CC chondrules in Acfer 182 (this study). Data normalized to Si and CI chondrites are arranged in order of increasing volatility (Fe is the only exception).

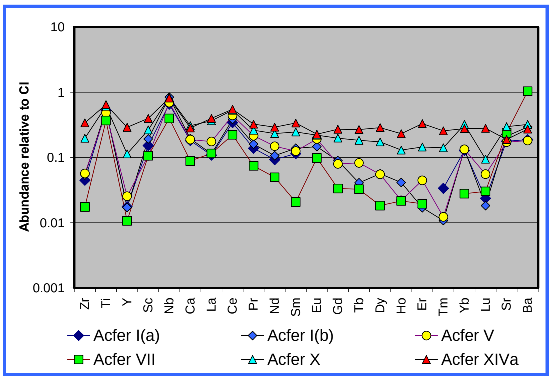

Fig. 3: CI-normalized trace element abundances in Acfer 182 CC chondrules. Variable depletions in the HREE are coupled with variable depletions in Y, Sc and the ultra-refractory Zr.

Discussion: The shapes and textures of the studied chondrules indicate that these objects once must have been liquids that were quenched, which is the basis for all major chondrule models. However, the origin of the liquids still remains unclear. The most accepted mechanisms to produce these liquids are melting of appropriate mineral precursors or direct condensation from the solar nebula. If the studied chondrules were produced by sampling and melting of precursors, we should expect some fractionation of CaO from Al_2O_3, Yb from La, and Sc from Yb as well as some fractionation among REE (e.g., a depletion of the LREE) abundance patterns according to the mineralogy of the objects. Instead, the trace element patterns of the these chondrules show a variable depletions in HREE, coupled with variable depletions in Y, Sc and in the ultra-refractory Zr (Fig. 3).

The direct condensation model predicts a chondritic Ca/Al ratio for pristine chondrules (Fig. 2). In correlation plots between Yb and La; Yb and Sc; Sc and Zr and Sc and Sm (Fig. 4a-d), the data points of the studied CC chondrules lie close the solar ratio lines. <u>This indicates that those elements were not fractionated during evolution of the objects due to a similar cosmochemical behavior.</u> The fact that La and Yb have different geochemical behaviors (La is incompatible, Yb is compatible) and that in spite of this, are not fractionated from one another, is clear evidence against geochemical fractionation. In addition, the chondritic Sc/Sm ratio excludes any magmatically produced pyroxene as precursor.

Acfer 182 CC chondrules seem to be the result of direct condensation from gas into liquid. The observed trace element patterns could reflect condensation of enstatite-rich liquids from a gas from which variable proportion of refractory phases had been removed.

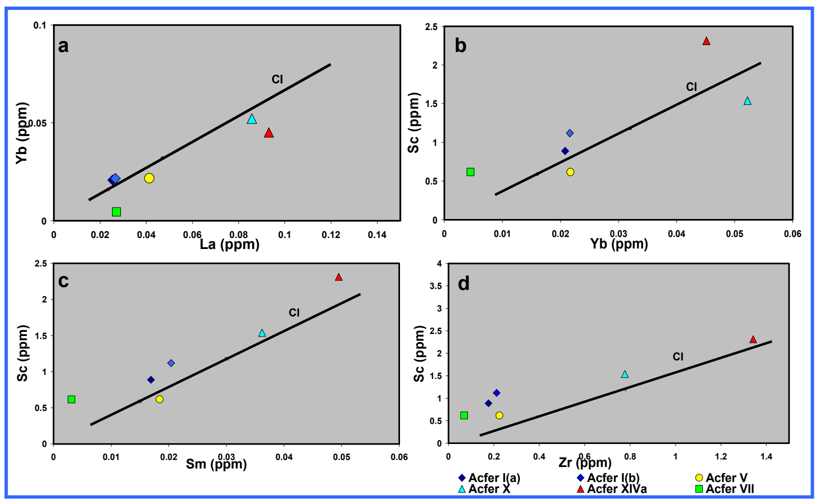

Fig. 4: The correlation between these elements, independent of their geochemical behavior, indicates that cosmochemical processes predominantly determine the elemental abundances.

References: [1] Bischoff et al. (1993) GCA 57, 2631-2648. [2] Weisberg et al. (1988) EPSL 91, 19-31. [3] Scott (1988) EPSL 9, 1-18. [4] Wasson and Kallemeyn (1990) EPSL 101, 148-161. [5] Brearley and Layne (1995) LPSC 26, 167-168. [6] Russell et al. (2000) MAPS 53 (Suppl.) A139. [7] Krot et al. (2000a) LPSC 31, #1481. [8] Krot et al. (2000b) LPSC 31, #1499. [9] Krot et al. (2002) MAPS 37, 1451-1490. [10] Krot et al. (2010) GCA 74, 2190-2211. [11] Hezel et al., (2003) MAPS 38, 1199-1215.