

BULK AND MATRIX COMPOSITION OF THE PARIS CM. INFERENCES ON PARENT-BODY ALTERATION AND THE ORIGIN OF MATRIX-CHONDRULE COMPLEMENTARITY. B. Zanda^{1,2}, M. Humayun³, J.-A. Barrat⁴, M. Bourot-Denise¹ and R. H. Hewins^{1,2}, ¹MNHN & CNRS, 61 rue Buffon, 75005 Paris, France (zanda@mnhn.fr, denise@mnhn.fr); ²Dept. of Earth & Planetary Sciences, Rutgers University, 610 Taylor Rd., Piscataway, NJ, (hewins@rci.rutgers.edu); ³Dept. of Earth, Ocean & Atmospheric Science and National High Magnetic Field Laboratory, Florida State University, Tallahassee, FL 32310, USA (humayun@magnet.fsu.edu); ⁴Université Européenne de Bretagne and CNRS UMR 6538, U.B.O.-I.U.E.M., Place Nicolas Copernic, 29280 Plouzané Cedex, France (barrat@univ-brest.fr).

Introduction: The Paris CM chondrite has experienced little or no terrestrial weathering and it is less altered than other CMs known to date [1]. Paris is a breccia with varying degrees of alteration [2]: we estimate the amount of the least altered material containing well defined chondrules with abundant metal as ~40 vol%. In this abstract, we report the results of bulk chemical measurements performed both at UBO by ICP-MS and ICP-AES after wet chemistry (on 500 mg well homogenized powder from 13g rock) and at NHMFL by an in-situ rastering with LA-ICP-MS of a 0.25 cm² square in a comparatively altered region. In addition, LA-ICP-MS was used to analyze matrix in the least altered regions as well as in more altered regions resembling more typical CMs.

Results: Fig. 1 compares LA in-situ measurements with the average bulk composition of a CM2 chondrite by Wolf et al. [3], while Fig 2a compares them with the analyses of Paris performed by wet chemistry.

Figures 2b,c compare LA data for the average of 2 matrix spots (b) in somewhat altered zones and (c) in “alteration-free” zones. Equations are shown for the solid regression lines going through the data, while the dashed blue line corresponds to the bulk LA data shown in Fig. 2a.

Discussion: Figs 1 and 2a show the very good agreement between the in-situ bulk analysis of Paris and the wet chemistry data both for Paris and for the

average bulk CM, confirming the classification of Paris as a CM chondrite. They also show that no significant difference exists between the bulk of an altered zone and that of homogenized bulk rock powder although the meteorite is comprised of ~40% “alteration-free” material. This indicates that the altered zones have not been leached or contaminated, and that no significant large scale exchange between altered and non-altered zones has taken place.

Composition of the matrix in the least-altered zones (M1-M2). Figs 1 and 2c show the matrix in the least altered zones to be indistinguishable from CI chondrites. There is no correlation between Si- and Orgueil normalized concentrations of the various elements and their condensation temperatures, and the average value of the normalized concentrations is 1.

Composition of the matrix in the more altered zones (M3-M4). Figs 1 and 2b show that the matrix in the more altered zones is “intermediate” between the typical CM bulk and the chondritic matrix of the least-altered zones: there is a weak positive correlation between normalized element concentrations and condensation temperatures.

Composition of the matrix in carbonaceous chondrites and the chondrule-matrix complementarity. The composition of the matrix in the least altered regions M1-M2 suggests that pre-parent-body alteration matrix was chondritic in composition, in agreement with the

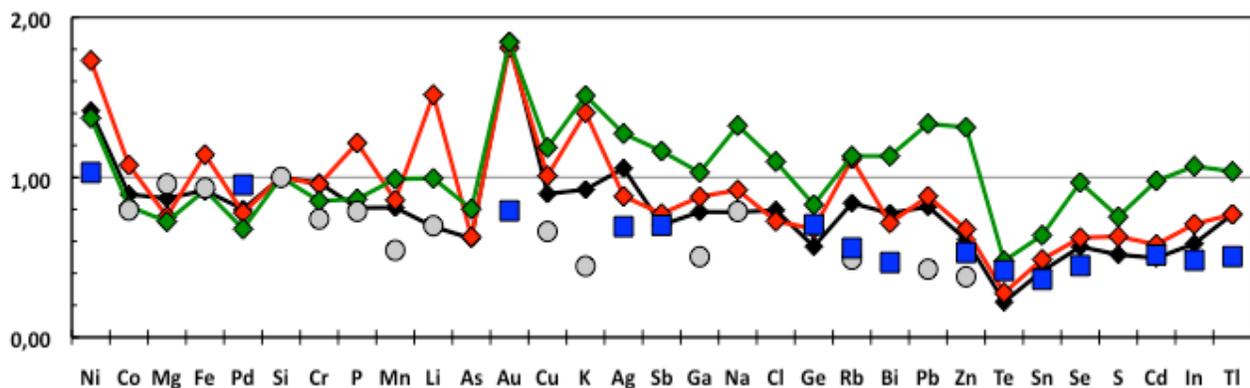


Figure 1: Comparison of Si and Orgueil normalized data for major and volatile elements in Paris with the bulk chemistry of the CM2 chondrite average (blue squares, data from [3]). Grey dots: bulk chemistry data from UBO. Diamonds and lines: LA-ICP-MS in-situ measurements from NHMFL on polished thick section Paris 2010-04. Black: bulk obtained by the rastering of 0.25 cm² in an altered region; Red: average of 2 spots in the matrix of altered regions (M3-M4); Green: average of 2 spots in the matrix of least altered regions (M1-M2).

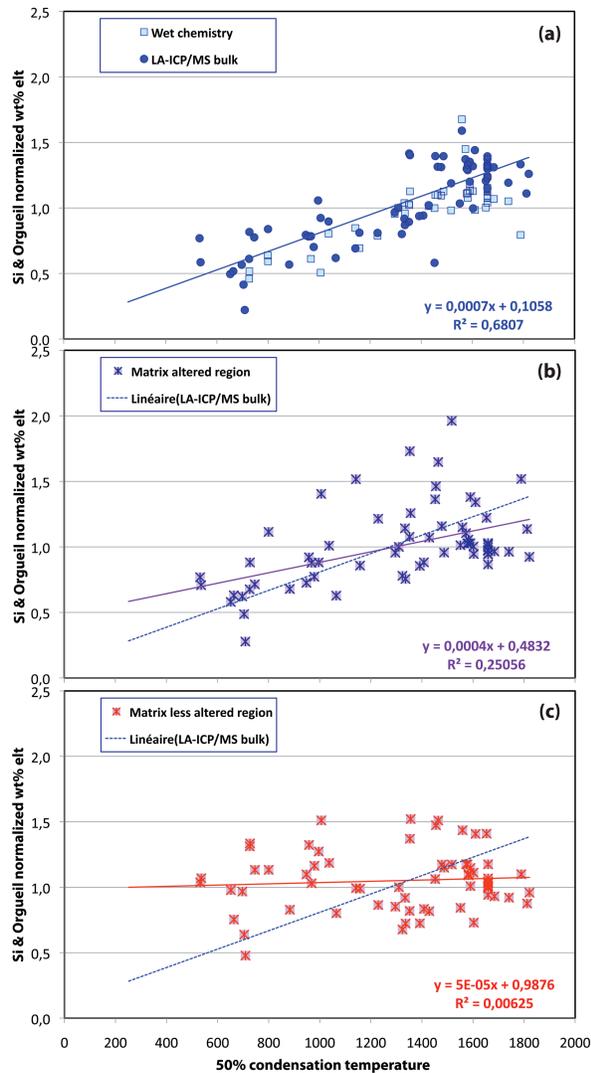


Figure 2: Si and Orgueil normalized concentrations as a function of condensation temperatures. Blue regression lines are for LA measurements. (a) Comparison of LA-ICP-MS in-situ bulk measured in an altered region with ICP-MS & ICP-AES analyses of a bulk powder. (b) Matrix in altered zones (M3-M4). (c) Matrix in the least altered zones (M1-M2).

two-component model of Anders [4] and the findings of [5,6] indicating that a common original matrix material is responsible for the budget of volatile elements and pre-solar grains of carbonaceous chondrites.

Based on the first in-situ LA measurements of carbonaceous chondrite matrices and their comparison with bulk rock chemistry, [7] argued in favor of a matrix chondrule complementarity because the CM matrices they analyzed had a “CM pattern” (ie, they were

slightly volatile depleted, but less so than CM bulks), while more volatile depleted CCs had more volatile depleted matrices (but always less depleted than their bulk counterpart). We suggest here that these patterns were established as a result of parent-body metasomatism which induced local exchange between matrix and the adjoining high T components (chondrules and RIs): in Paris, matrix in the altered regions gained Ca, V, Fe and the siderophile elements (Ni, Co, Mo, Ru, Rh, Pd, W...) from the destruction of glass and metal grains in altered chondrules, while it lost Na, S and the chalcophile elements (Zn, As, Cu, Sb, Te, Tl, Pb...) due to the destruction of its FeS and the ubiquitous formation of PCPs in the altered zones. Except for Acfer 094, all the matrices analyzed by [7] belong to chondrites which underwent some degree of parent-body transformation: the CM2s experienced more extensive alteration than the altered zones of Paris (based on a comparison of PCP compositions [1]); while the COs and CVs experienced thermal metamorphism. In contrast, matrices in the least altered zones of Paris and in the 3.0 Acfer 094 were little (if at all) affected by these processes and consequently retained their original chondritic composition ([7] for Acfer 094).

Conclusion: Our data are consistent with the two-component model of Anders [4] and the suggestion by [6] that chemical variations in CCs may be simply explained by the mixing of a unique high T component with varying amounts of a CI matrix. These results have a bearing on our understanding of the proto-planetary disk as they allow chondrules and matrix to be formed independently, which a pre-accretion complementarity between matrix and chondrules would rule out. They are thus consistent with the transport over large distances of high T components formed near the Sun to be mixed in with the matrix in colder regions of the disk.

References: [1] Bourot-Denise M. et al. (2010). *41st Lunar Planet. Sci. Conf.* #1683. [2] Zanda B. et al. (2010) *Meteoritics Planet. Sci.*, vol. 45supl. abstr. #5312. [3] Wolf R. et al. (1980) *Geochim. Cosmochim. Acta.*, vol 44, pp 711-717. [4] Anders E. (1964) *Space Sci. Rev.*, 3, 583-714. [5] Alexander C. (2005) *Meteoritics Planet. Sci.*, vol. 40, pp. 943-965. [6] Zanda B. et al. (2009) *Meteoritics Planet. Sci.*, vol. 44supl. abstr. #5280. [7] Bland P. et al. (2005) *PNAS* 102, 13755–13760.