

## Unraveling the effects of aqueous alteration on primary nebular materials: Electron microbeam study of matrices of CR chondrites

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CR chondrites are considered to be one of the most primitive of the carbonaceous chondrite groups [1]. Despite their primitive characteristics, CR chondrites have undergone different degrees of aqueous alteration and span the range from petrologic type 1[2] through type 3 [3]. However, mineralogical and chemical studies of CR matrices are limited [e.g. 4,5]. As a consequence, there is little agreement on the characteristics of matrices in this group or the conditions of aqueous alteration [6]. The goal of this project is to use electron microbeam techniques to study fine-grained materials in CR chondrites in order to determine the degree to which asteroidal processes modified their record of nebular processes and to assess the onset of aqueous alteration. The matrices and fine-grained rims of Antarctic CR chondrites EET 92042 and GRA 99177 were studied.

EET 92042 and GRA 95229 matrices and rims record levels of aqueous alteration intermediate between pristine CR3 (e.g. MET 00426 – [7]) and moderately altered CR2 chondrites (Renazzo – [e.g. 5]). Primitive features include some Fe-rich regions such as matrix clasts in GRA 95229, abundant nano-sulfides, and some amorphous silicates. Aqueous alteration is reflected by a progressive decrease in the Fe content of the matrix, formation of rounded and framboidal magnetite, and the development of phyllosilicates. Based on comparison of EET 92042 and GRA 95229 with very altered and pristine CR chondrites, the following criteria to assess the degree of aqueous alteration are proposed: (1) Fe-content, distribution and Fe/Si ratios in matrix; (2) abundance of magnetite; (3) preservation of amorphous silicates; and (4) presence of phyllosilicates.

[1] Krot *et al.* (2005) *Ap. J.* **622**, 1333-1342. [2] Weisberg M. K. & Huber H. (2007) *M&PS* **42**, 1495-1503. [3] Weisberg M. K. (2001) [4] Weisberg M. K. *et al.* (1993) *GCA* **57**, 1567-1586. [5] Zolensky *et al.* (1993) *GCA* **57**, 3123-3148. [6] Krot *et al.* (2002) *MAPS* **37**, 1451-1490. [7] Abreu & Brearley (2006) *M&PS* **41**, A13.

## Modeling the interaction between geochemical and hydraulic processes during evaporation in tailings

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The evolution of reactive porous media (e.g. tailings composed by pyrite and other sulfide and aluminosilicate minerals) during evaporation is determined by the complex interactions between geochemical, hydraulic and thermal processes. Evaporation may lead frequently to the formation of very concentrated pore brines and to the precipitation of secondary minerals. In turn, these minerals modify porosity, permeability and other thermal and hydraulic soil properties. These physical changes also affect the multiphase flow and, thus, the evaporative processes that trigger the system evolution in the first place.

In order to gain insight into the complex and multiple couplings between the different types of processes, a fully coupled model for simulating reactive transport and multiphase flow in unsaturated porous media was developed. The 1-D model was implemented with the assistance of the code package RETRASO-CODEBRIGHT [1]. The model was able to treat simultaneously the existence of several dissolution and precipitation reactions (approached both by equilibrium and by kinetics) taking place in concentrated brines (Pitzer ion-interaction formalism), and modifying most of the hydraulic and thermal properties of the tailings.

The suitability and robustness of the model was checked against experimental results obtained in unsaturated laboratory columns [2]. The results matched the evolution of the measured brine composition and mineral sequence at different depths. The model allowed the quantification of most of the described processes, such as the mass fluxes, the kinetics of dissolution and precipitation reactions, and the formation of a surface crust. A downwards vapor diffusion and subsequent condensation led to the dilution of the pore brine at depth.

[1] Saaltink *et al.* (2004) *Geol. Acta* **2**(3), 235-251. [2] Acero *et al.* (2007) *GCA* **71**, 5325–5338.