

TESTING THE GENETIC RELATIONSHIP BETWEEN FLUID ALTERATION AND BRECCIATION

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Introduction: Brecciation is a common features of chondrites and attests for collisional activity in the asteroid belt [1]. Among the different chondrite groups, CM carbonaceous chondrites are known to be the most represented xenolithic clasts in other families [1], suggesting an intense collisional history of their parent-body(ies). In addition, CMs represent the largest group of hydrated meteorites and span a wide range of conditions, from less altered (i.e., CM2) down to heavily altered (i.e., CM 1) [2,3]. However, their shock-related properties are generally not taken into account for their classification. The CM2 chondrite Boriskino is constituted of diverse CM-clasts with different degrees of alteration (Fig. 1) that make it an object of choice to study the genetic relation between brecciation and alteration. Here we present a mineralogical, chemical and isotopic study of 4 sections of the Boriskino meteorite.

Methodology: All sections were characterized by SEM and electron microprobe operating at 10nA and 15kV. Bulk oxygen isotopic composition were measured by conventionnal method while *in-situ* measurements of oxygen isotopes were conducted with a SIMS 1280HR.

Results: Bulk O-isotopic measurements yield $\delta^{17,18}\text{O}$ values of (7.50;1.70 ‰) and (9.03;2.27 ‰) that are consistent with the the bulk CM trend [4,5,6]. Six different lithologies were identified in two sections. Lineations are visible at the contact between the different zones. Five of these regions experienced fluid alteration with chondrules exhibiting varying degrees of alteration, characterized by tochilinite-cronstedtite intergrowths (TCIs) and Ca-carbonates. The last lithology is completely altered as attest the lack of anhydrous silicates. Dolomites are the only carbonates observed and TCIs are lacking. O-isotopic composition of Ca-carbonates display two distinct populations characterized by average compositions of $\delta^{17,18}\text{O} = (7.3 \pm 0.5 \text{ ‰}; 18.8 \pm 0.9 \text{ ‰}; n=14)$ and $\delta^{17,18}\text{O} = (16.9 \pm 0.8 \text{ ‰}; 34.0 \pm 1.4 \text{ ‰}; n=10)$. Dolomites show lighter O-isotope compositions with average $\delta^{17,18}\text{O} = (4.6 \pm 0.4 \text{ ‰}; 14.7 \pm 1.8 \text{ ‰}; n=6)$.

Discussion: The *in situ* oxygen isotopic compositions of Ca-carbonates define a linear trend with $\delta^{17}\text{O} = (0.622 \pm 0.028) \times \delta^{18}\text{O} - (4.49 \pm 0.76)$ (2σ , $r^2 = 0.98$) that is similar to that determine from 9 other CM chondrites [7]. Within errors, the Boriskino trend is parallel to the CM water line that recorded the evolution of the O-isotopic composition of water upon the course of alteration [7]. Consequently, the average precipitation temperature of Borskino's Ca-Carbonates is similar to other CMs (110°C, [7]) and no significant temperature differences can be estimated between the different lithologies. As for other CMs, the O-isotope compositions of Ca-carbonates in Boriskino is mainly controlled by O-isotopic equilibrium between ¹⁶O-rich anhydrous silicates and ^{17,18}O-rich water. This implies that all lithologies in Boriskino were characterized by similar initial O-isotopic compositions of anhydrous silicates and water. The important variations of alteration extents in Boriskino could thus result from heterogenous accretion of water ice grains, which would induce varying water/rock (w/r) ratio in the Boriskino's parent body. Isotopic mass balance calculations are consistent with such a hypothesis as they yield w/r ratios varying from 0.6 to 1.1.



Figure 1 – Photograph of the Boriskino meteorite. Centimetrical subhedral angular clasts of various hue can be distinguished. Multiple fractures crossing diverse clasts are present.

[1] Bischoff, A., et al. (2006), *Meteorites and the early solar system II*, 679-712. [2] Rubin A.E. et al. (2007) *Geochemica et Cosmochemica Acta* 71: 2361-2382 [3] Zolensky M.E. et al. (1997), *Geochemica et Cosmochemica Acta* 63:5099-5115. [4] Clayton R.N. and Mayeda T.K. (1999), *Geochemica et Cosmochemica Acta* 63:2089-2104 [5] Benedix G.K. et al. (2003), *Geochemica et Cosmochemica Acta* 67:1577-1588 [6] Tyra M.A. (2012), *Geochemica et Cosmochemica Acta* 77:383-395. [7] Verdier-Paoletti M. J. et al. (2017). *Earth and Planetary Science Letters* 458: 273-281.