

TEMPERATURE PRECIPITATION OF CA-CARBONATES IN CM CHONDRIES INFERRED FROM IN-SITU OXYGEN ISOTOPES

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Introduction: CM carbonaceous chondrites all experienced aqueous alteration to diverse degrees of intensity. The raise of interest for these objects during the last decades unraveled a considerable amount of information on this process in asteroidal parent-body(ies). However conditions in which it occurred, such as Water/Rock ratio, duration and temperature, are still subject to debate but can be appreciated *via* the study of secondary phases. Attempt to estimate the temperature of alteration processes were made but yield contrasting results: 0-20°C on average up to 71 and 120°C [1,2,3]. *In-situ* O-isotopic measurements of secondary phases can help to constrain: (i) the range of temperature experienced by CM chondrites, (ii) the relative chronology of secondary phases and (iii) the conditions of fluid-roch interactions. Here we present results from *in-situ* O-isotopes analyses of Ca-carbonates from CM1 and CM2 chondrites.

Samples: 9 CM chondrites spanning different alteration degrees from 1 (ALH 88045) to 2.7 (Paris) were considered [4]. They all contain Ca-carbonates with typical sized in the range 20 µm up to 100 µm, even the most heavily altered. Although CM are known to be breccias, our samples exhibited few chemical and/or textural variations to consider multiple lithologies.

Methodology: BSE and X-ray elemental maps of each section were acquired to identify carbonate phases. Microprobe analyses with a 10nA electron beam accelerated at 15 kV were conducted on each mineral to discriminate Ca-carbonates from more complex carbonates (dolomite, breunnerite). *In-situ* O-isotopic measurements of Ca-carbonates were conducted at the CRPG-Nancy using a Cameca 1280HR with a Cs⁺ primary beam (15 keV, ~0.4 nA) coupled to an electron flow parallel to the surface of the sample for charge compensation. ¹⁷O⁻ and ¹⁸O⁻ were detected with electron multipliers (EMs) while ¹⁶O⁻ was measured with a Faraday cup (FC). Exit slit was adjusted to obtain a mass resolving power ≈6000 and an N₂ trap was used to reduce contribution from ¹⁶OH. Each spot was then verified by SEM and excluded if overlapping an adjacent phase.

Results: A total of 57 carbonates were studied leading to 91 measurements. O-isotopic compositions in a single sample either describe a continuum or two distinct populations as already observed by [5]. Their O-isotopic composition fall exactly in the range of previous studies with δ¹⁸O values from 16.1±0.4 ‰ (2σ) to 38.7±0.7 ‰ and δ¹⁷O varying between 5.8±0.6 ‰ and 23.1±0.6 ‰. Furthermore, they describe a trend with a slope of 0.66±0.05 and an intercept of -4.7±1.5 (R²=0.87, MSWD= 3.3) that almost perfectly aligns with Bulk/Matrix measurements, suggesting the existence of a single continuum hereafter called BMC (for Bulk-Matrix-Carbonates) [6].

Discussion: Data of the oxygen isotopic composition of CM water (hereafter, CMW) are available and describe another trend almost perfectly parallel to the BMC ($\delta^{17}\text{O}=0.69 \times \delta^{18}\text{O} - 2.12$, R²=0.99). The fact that all CM chondrites and their components constitute an homogenous continuum parallel to the CMW suggests they all experienced the same thermal evolution [6]. If one considers the CM parent-body to be a closed system, the O-isotopic compositions of carbonates depend only on the O-isotopic composition of the precipitating water and temperature. Therefore, as precipitation is a mass-dependant process, we were able to retrieve both of these information using the CMW. Contrary to what could have been expected more than 50% of our carbonates experienced temperatures above 100°C and more than 75% precipitated above 50°C. Additionnaly, following the same methodology, we estimate the temperature formation of serpentines to be 74°C which is consistent with pseudomorphisation of carbonate by serpentine suggesting a more tardive formation of phyllosilicates [6].

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