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ARAGONITE IN THE CM CARBONACEOUS CHONDRITES: A PROXY FOR THE MAGNITUDE OF AQUEOUS ALTERATION

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Introduction: The degree of aqueous alteration of CM carbonaceous chondrites can be tracked by changes in properties including in the volume of fine-grained matrix, the volume and chemical composition of its constituent phyllosilicates, and the extent of alteration of chondrules [e.g. 1-3]. The carbonate minerals aragonite, calcite and dolomite were also formed during alteration and whereas calcite is seen in all CMs, dolomite has been recorded only from the more highly altered meteorites [e.g. 4] and little is known about the occurrence of aragonite. Here we have sought to understand better the significance of the correspondence between carbonate mineralogy and degree of alteration by undertaking a systematic study of inter-meteorite differences in the abundance and properties of aragonite.

Methods: Six CM2s were studied, namely Pollen, Murray, Mighei, LON 94101, Nogoya and QUE 93005 (listed in the approximate order of increasing degree of alteration), together with the CM1 SCO 06043. Dolomite was identified by SEM imaging and X-ray microanalysis, and aragonite was distinguished from calcite using electron backscatter diffraction and Raman spectroscopy.

Results: Aragonite occurs in the matrices of five of the meteorites studied and is absent from the most highly altered samples (i.e. QUE 93005 and SCO 06043). Only Nogoya contains both aragonite and dolomite. The approximate abundance of aragonite, expressed as grains/mm², is: Pollen (0.20), Murray (0.30), Mighei (0.23), LON 94101 (0.10), Nogoya (0.17). The mean sizes of these aragonite grains are also similar: Pollen (21 µm), Murray (22 µm), Mighei (33 µm), LON 94101 (25 µm), Nogoya (14 µm). The largest grain (101 µm) was found in Mighei. Unlike calcite, the aragonite grains usually lack serpentine-tochilinite rims, although many of them have been partially replaced by matrix phyllosilicates. Most of the crystals occur in loose clusters and their *c* axes have a common alignment.

Discussion: As aragonite crystals are embayed by phyllosilicates they formed prior to the end of aqueous activity, and their common alignment suggests crystallization under uniaxial lithostatic pressure at depth within the parent body. Given that aragonite occurs only in the less altered meteorites and dolomite in the more highly processed CMs, with the crossover at Nogoya (classified as CM2.2 by [2]), these minerals track the degree of aqueous alteration by their presence or absence. We suggest that crystallization of aragonite rather than calcite is favoured in solutions with Mg/Ca >~1, and significantly higher Mg/Ca ratios will yield dolomite. If aragonite and dolomite crystallized after calcite, then the Mg/Ca of bicarbonate rich solutions must have increased with time, and reached significantly greater values in those meteorites that were more highly altered overall.

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References: [1] McSween, H.Y. 1979. *Geochimica et Cosmochimica Acta* 43:1761–1770. [2] Rubin A.E. et al. 2007. *Geochimica et Cosmochimica Acta* 71:2361–2382. [3] Howard K.T. et al. 2009. *Geochimica et Cosmochimica Acta* 73:4576–4589. [4] Johnson, C.A. and Prinz, M. 1993. *Geochimica et Cosmochimica Acta* 57:2843–2852.