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CL ZONING OF CALCITE IN CM CARBONACEOUS CHONDRITES AND ITS RELATIONSHIP TO DEGREE OF AQUEOUS ALTERATION

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Introduction: Carbonates occur in CM2 carbonaceous chondrites in a variety of phases including: Ca-carbonate (aragonite and calcite), dolomite and breunnerite [e.g. 1 and 2]. Petrographic work has revealed multiple generations of Ca-carbonates including aragonite, calcite replacing olivine/pyroxene, calcite rimmed by tochilinite and partially or completely replaced by phyllosilicates, and calcite grains that are free of inclusions and rims. In this study we have sought to understand the conditions of Ca-carbonate crystallization within the CM parent body and how they may have varied between meteorites that show different magnitudes of aqueous alteration.

Methods: This study used the following CM2 falls: Murchison, Murray, Pollen, Mighei and Nogoya. Over 300 grains were located and their textures and microstructures characterised using backscattered electron (BSE) and cathodoluminescence (CL) microscopy. Work by laser Raman spectroscopy and electron probe microanalysis (EPMA) was also undertaken for mineral identification and chemical analysis respectively.

Results and Discussion: Based on the aqueous alteration index of CM chondrites of [3], we related CL intensity and patterns of zoning in the Ca-carbonates into degree of alteration. The least altered meteorites studied (Murchison, Murray, Pollen and Mighei) contain 1.3 to 2.0 vol% of Ca-carbonate (both aragonite and calcite) that have a variety of CL characteristics. All calcite grains that have replaced olivine/pyroxene and many grains of aragonite and non-rimmed calcite have a low CL intensity and are unzoned, and this can be related to the stability of fluid composition during crystal growth. Some aragonite and non-rimmed calcite grains, and all of calcites rimmed with tochilinite, display one of three styles of CL emission: (1) Concentric zoning with a triangle-shaped seed crystal in one part, subsequent zoning of hexagonal habit, and other bands of zoning to fill the pore space. Growth of this type was controlled by the change in fluid composition and delivery of ions to the growing crystal face. (2) Grains that have only a high CL intensity throughout as a consequence of compositional stability of the fluid during the crystal growth; however this fluid was different in chemical composition to that which crystallized grains with a low CL intensity. (3) Some grains have patchy low and high CL intensity which possibly reflects a complex growth history as a result of a changeable fluid chemical compositions. Ca-carbonate grains in Nogoya, the more highly aqueously altered CM2, show no CL variation and a low emission intensity; this implies that they crystallized from fluids that were stable in chemical composition. This correspondence between CL properties and degree of alteration agrees very well with the finding by [4] that concentrations of manganese and iron in the CM2 carbonates decrease with increasing alteration of their host rock.

References: [1] Lee M. et al. 2010. *Meteoritics & Planetary Science* 45: A115. [2] Brearley, A.J. (1998) Abstract # 1246. 29th Lunar & Planetary Science Conference. [3] Rubin E. et al. 2007. *Geochimica et Cosmochimica Acta* 71: 2361-2382. [4] De Leuw S. et al. 2010. *Meteoritics & Planetary Science* 45: 513-530.