OXYGEN ISOTOPE VARIATION OF CM AND RELATED CHONDRITES: MULTIPLE PARENT BODIES OR A SINGLE HETEROGENEOUS SOURCE?

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Introduction: CMs are the largest group of carbonaceous chondrites (CC), comprising ~35% of observed CC falls [1]. The CMs display evidence for significant aqueous alteration, with considerable variation in the nature and amount of secondary minerals reported across the group. Indeed, many CMs are complex breccias containing a range of different lithologies, often showing significant mineralogical variation [e.g. 2, 3]. Here we present the results of an extensive oxygen isotope study of a wide range of CMs and related meteorites. Our aim is to explore the diversity and linkages within and between samples in order to understand the nature of the CM parent body(s). The results of this work will have important implications for the forthcoming detailed investigation of samples returned by Hayabusa2 and OSIRIS-REx from their respective C-type target asteroids.

Materials and Methods: O-isotope data were obtained at the Open University using laser-assisted fluorination [10]. Some results have been previously published, or samples were provided from other investigations, including CM1 and CM1/2 chondrites [5], CM2s [6,7,8,9] and CO3s [10]. The mineralogy of typical CMs pose particular problems for laser fluorination analyses due to pre-reaction with BrF_5 at room temperature and therefore most analyses were obtained with a modified technique where just one sample and one standard are loaded into the system [9].

Results and Discussion: The CM2s analysed by the new method reveal a range of O-isotope compositions along a mixing line with slope ~0.7 (Fig 1), which is almost identical to that observed previously using a reaction bomb method [11]. With the exception of MCY 05231, the CM1s and CM1/2s (not shown) plot along a separate mixing line, with slope ~0.48, that appears to represent the effects of interaction with ^{18}O-depleted Antarctic water [12]. While the CM2s display a broad overall pattern of increasing δ^{18}O with increasing alteration, the pre-terrestrial composition of the CM1s and CM1/2s appears to be rather restricted and within, but not beyond the range of the less altered CM2s, indicating that these meteorites likely suffered different alteration conditions rather than just an increase in severity/duration of that experienced by the CM2s.

A link between the CO3s and CM2s was suggested by [11], despite a large gap between the two groups. However, there is a population of C2 ungrouped meteorites that have O-isotope whole-rock compositions that fall in this gap. It is also apparent that some of the mineralogical variation observed within individual samples is reflected in O-isotopic variation between different sub-samples (Fig 1). Sub-samples of some individual meteorites extend across the entire range of CO and CMs. This suggests that CMs, COs and C2 ungrouped meteorites experienced similar alteration processes and raises the possibity that they are derived from a common parent body. These results also highlight the need for careful characterization of CM-like samples prior to O-isotope analyses in order to properly relate mineralogy and bulk isotopic information. Small clasts present in some samples [e.g. 2] pose additional challenges. However, new analytical protocols permit high precision O-isotope measurements on such samples (<100 µg). Samples returned from Ryugu and Bennu will provide constraints on the variation in CM/CI-like bodies and help define the number of parent bodies that contributed to the CO-C2 ungrouped-CM association.

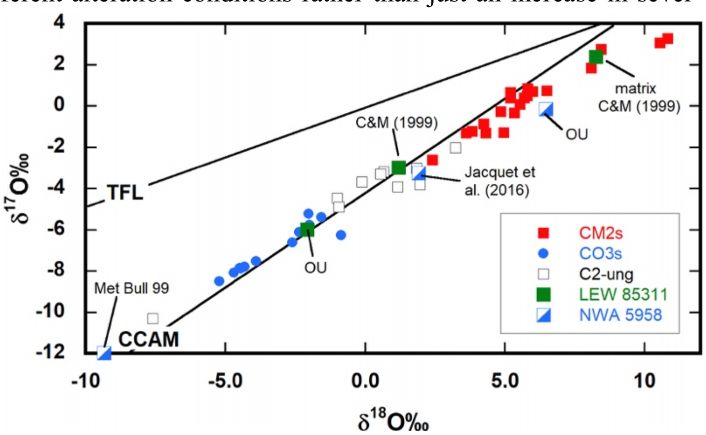

Fig 1: O-isotope plot of C2 ungrouped [also 1,11, 13], CM and CO meteorites. Analyses of different clasts of LEW 85311 [also 1] and NWA 5958 [also 1,13] show large variation.

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