OXYGEN ISOTOPES IN CHONDRULES FROM THE MURCHISON CM2 CHONDRITE AND EVIDENCE FOR A CO–CM LINK

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Introduction: CM carbonaceous chondrites (CCs) experienced intense secondary aqueous alteration processes. However, they display numerous similarities with the anhydrous CO3 group [1–3], hence the CO-CM clan proposed by [4]. Recent oxygen 3-isotope analyses of bulk CM chondrites [2] show a linear trend that intersects the field of CO3 falls reported by [5], suggesting common high temperature components in CM and CO chondrites. We present here SIMS O-isotope measurements of chondrules from the Murchison CM2 chondrite, which can be directly compared to those of [6] in order to test the plausible CM-CO link.

Samples and Methods: Based on chondrule Mg# in olivine and pyroxene, we selected 12 Type I (most of them are POP) and 3 Type II chondrules among 3 sections of Murchison for O-isotope analysis. SEM-BSE-SEI and EDS analysis were obtained using a Hitachi S-3400N electron microscope, while quantitative analyses were performed on a CAMECA SX-Five FE. Oxygen 3-isotope ratios of olivine and pyroxene within chondrules were measured using the WiscSIMS CAMECA-IMS 1280 ion microprobe using multi-collector Faraday cups as described by [7] and with spot sizes of ca. 12 μm. Based on bracketing measurements of San Carlos olivine, the external reproducibilities (2SD) are 0.2‰, 0.3‰, and 0.3‰ for δ^{18}O, δ^{17}O, and Δ^{17}O, respectively. In order to investigate the internal heterogeneity of O-isotopes within 15 chondrules, a total of 119 high-precision spots were obtained (n=7–9).

Results and discussion: Oxygen isotope ratios of olivine and pyroxene plot between the CCAM [8] and the Y&R [9] lines, close to the PCM [10] line (Fig. 1). These results are similar to those reported for chondrules in CCs [e.g., 6,10,11]. We found 16 relict olivine grains in six chondrules that deviate in Δ^{17}O values more than the 3SD external reproducibility from the average of each chondrule. Excluding these relict grains, the average Δ^{17}O values of individual chondrules range from –6‰ to –4‰ and from –3‰ to –2‰ for Mg# phenocrysts >98 and 96–53%, respectively (Fig. 2). This bimodal distribution, as well as the Mg#-Δ^{17}O relationship, are very similar to those found in the Yamato 81020 CO3.05 chondrite [6]. While the parent body of aqueously altered CM chondrites might accreted water-ice in colder regions of the disk, chondrules are dominated by highly reduced types (Mg#≥99) and share common isotope reservoirs to CO chondrites from asteroid that did not accrete significant amount of water-ice. Two parent bodies may have been spatially separated across the snow line, or formed at different timing [12].

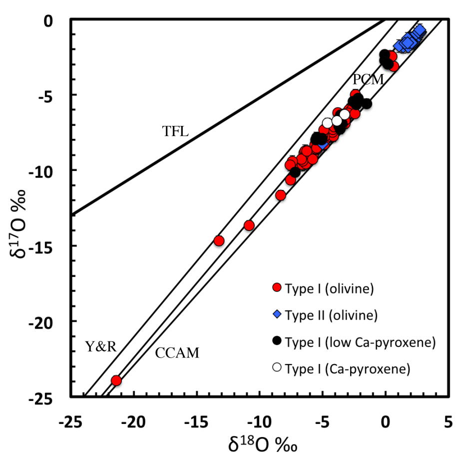
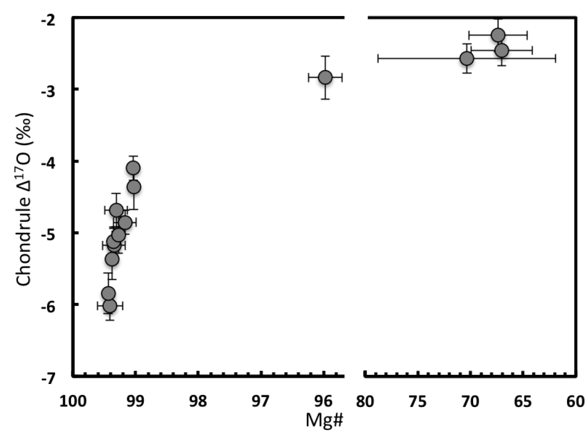


Fig. 1: Oxygen 3-isotope diagram of all olivine and pyroxene grains analyzed.

Fig. 2: Averaged Δ^{17}O vs. Mg# of chondrules calculated excluding relict grains.



Conclusion: Our results strongly support previous suggestion that CO and CM are genetically linked. Bulk CM isotopic compositions [2] should reflect a mixing between ^{16}O-poor (i.e., hydrous phases in matrix) and ^{16}O-rich (i.e., chondrules) components similar to those in COs [1]. In term of both Mg# and O isotopes, CM and CO contain a similar chondrule poplation. This result suggest that the isotope reservoirs common to CM and CO chondrules were widely distributed near the snow line where many asteroids formed.

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