

Leveraging HR-IRMS for precise $\Delta^{17}\text{O}$ of carbonates in CM chondrites

Matthieu Clog^{1*}, Paula Lingren², Martin Lee³, & Sevasti Modestou⁴

¹ University of Glasgow - SUERC

² Geological Survey of Sweden, Lund, Sweden

³ School of Geographical and Earth Sciences, University of Glasgow

⁴ Department of Geography and Environmental Science, Northumbria University

*Presenting Author Email: matthieu.clog@glasgow.ac.uk

CM carbonaceous chondrites contain minor (<3-4 vol. %) amounts of carbonate minerals which formed during aqueous alteration of the meteorite's asteroidal parent bodies early in the history of the Solar System. The conditions of aqueous alteration, including the chemical and isotopic composition of fluids and their temperatures, are recorded by the chemistry of these carbonates and in their bulk and clumped isotopic compositions. They are therefore key proxies to constrain the early aqueous and thermal evolution of these primitive asteroids.

High-precision determination of $\Delta^{17}\text{O}$ of the carbonates, beyond the current capabilities of ion probe measurements, is also necessary to calculate temperatures from typical clumped isotope methods. We use a TFS Ultra HR-IRMS to measure the triple oxygen isotope composition of CO_2 extracted from CM chondrites through acid digestion by measuring the abundances of the single Oxygen fragment ions at m/z 16, 17 and 18. Stepped acid dissolutions were used when calcite and dolomite co-existed in the same sample. The mass resolving power of the Ultra is sufficient to separate the O^+ ions from isobar species (mainly OH^+ and H_2O^+). Internal precision of ± 0.1 permil or better can be reached, even with sample sizes of less than 20 μmol of CO_2 gas. Our method uses the same aliquot of gas for the clumped and triple oxygen isotope measurements and does not require the use of fluorination or isotope exchange.

We measured 6 CM chondrites (Allan Hills 83100, Cold Bokkeveld, LaPaz Icefield 031166, Lonewolf Nunataks 94101, Murchison, Scott Glacier 06043), spanning a range of extent of asteroidal aqueous alteration. $\Delta^{17}\text{O}$ values range from -1 to -2.6‰ and crystallization temperatures range from 5 to 50°C for calcite and 75 to 100°C for dolomite. Across our samples, those with higher extent of alteration (based on their petrology) have carbonates with lower $\Delta^{17}\text{O}$ and higher crystallization temperatures, which is consistent with a prograde reaction in a largely closed system, and with dolomite forming after calcite in our samples.