H, C AND N ISOTOPE SYSTEMATICS OF CI, CM AND CR CHONDRITES: CLUES TO THE ORIGIN OF WATER

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Introduction: One explanation for the O isotopic composition of inner Solar System bodies is that there was a massive influx of ^{16}O-poor water ice from the outer Solar System. This ice should have been very D-rich, like comets, and would have been accompanied by abundant organic matter. The O isotopic compositions of secondary minerals in chondrites suggest that the altering fluids were ^{16}O-poor. Thus, one might expect these fluids to have been D-rich and, if alteration occurred in a closed system, the water content to be correlated to that of the organics, particularly the insoluble organic matter (IOM), and the bulk O isotopes. Previously, we showed in a suite of CMs that H contents and isotopic compositions correlated with petrologic indicators of alteration [1]. However, the H is not D-rich. Also, the O isotopic compositions of the CMs do not correlate with H content. We have since extended this bulk H (and C and N) work to additional CMs, as well as Orgueil and CRs.

Methods: The meteorites were crushed to <106 μm, and aliquots stored in a desiccator for days to weeks prior to analysis. The H, C and N abundances and isotopes were determined as described in [2].

Results: The bulk H results for the new CMs are consistent with our earlier results, although Bells (δD≈300‰), like Essebi, is clearly an outlier. Orgueil (δD≈80‰) is isotopically heavier than CMs, particularly CM1s, but is still much lighter than cometary water. The CRs generally have bulk H isotopic compositions that are heavy (δD≈580-760‰) and exhibit a limited range of H contents (~0.4-0.6 wt.%). The one exception is the CR1 GRO 95577 (1.3 wt.% and 270‰). There is no apparent correlation between bulk H contents and O isotopes.

Discussion: The bulk H measurements are a mix of components – primarily organics and hydrated silicates. The IOM is the most abundant known organic component. Subtraction of the D-rich IOM H from the bulks significantly reduces the δD values of the residual H. If it is assumed that the range of IOM δD values is due to isotopic exchange and the most D-rich IOM composition is subtracted, the residual δD values are reduced still further (CI -180‰, CMs -170 to -370‰, CRs 130-550‰, Bells -40 to 120‰, Essebi 70‰). The range within CMs and CRs may at least partially reflect isotopic fractionation associated with Fe-oxidation and/or the presence of an as yet unidentified H-bearing phase [1, 2]. The H contents of CMs or CRs do not correlate with IOM contents or bulk O isotopes, suggesting that alteration did not occur in closed systems. Redistribution of water within the parent bodies could also produce some H isotopic fractionation.

Conclusions: There is little evidence for comet-like water in the CIs and CMs. The CRs are isotopically heavier, but this could be largely due to the oxidation of Fe. At present, it seems that the water accreted by the CI, CM and CR chondrites formed or re-equilibrated in the inner Solar System. This may have significant implications for the transport and the isotopic evolution of materials in the nebula.

References: [1.] C. M. O'D. Alexander, et al. 2011. *Lunar Planet. Sci.* **42**, #1869. [2] C. M. O'D. Alexander et al. 2010. *Geochim. Cosmochim. Acta* **74**, 4417.