Carbon and oxygen isotopes in CO3 chondrites

Conference or Workshop Item

CARBON AND OXYGEN ISOTOPES IN CO3 CHONDRITES.
R. C. Greenwood, I. A. Franchi, J. Gibson and C. T. Pillinger, PSSRI, Open University, Walton Hall, Milton Keynes, MK7 6AA U.K. (R.C.Greenwood@open.ac.uk)

Introduction: CO3 chondrites form a metamorphic series and have been divided into subtypes ranging from 3.0 to 3.7 [1], [2], [3]. To examine the processes and conditions prevailing during metamorphism we have undertaken a detailed investigation of the whole rock oxygen and carbon isotope systematics of CO3 chondrites.

Experimental Techniques: Oxygen isotope analyses were made using an infrared laser fluorination system [4]. All analyses were obtained on powders that were fluorinated using BrF_5 and then heated progressively for periods of up to 50 minutes. O_2 was analysed using a Micromass Prism III dual inlet mass spectrometer. Analytical precision is approximately ±0.04‰ for $\delta^{17}O$, ±0.08‰ for $\delta^{18}O$ and ±0.025‰ $\Delta^{17}O$. Carbon isotopes were determined using a Geo 20-20 mass spectrometer with an ANCA elemental analyser preparation system. Analytical precision is ±0.09‰ $\delta^{13}C$.

Results: The following CO3 chondrites have been analysed: ALH77307(3.0), Colony(3.0), Kainsaz(3.1*), Felix(3.2*), Ornans(3.3*), ALH82101(3.3), Lance(3.4*), ALH77003(3.5) Warrenton(3.6*), Isna(3.7) (figures in brackets are the metamorphic subtypes of [2], asterisks indicate a fall)

Oxygen isotopes: With the exception of Colony(3.0) and ALH77307(3.0), samples fall within an extremely restricted area of the oxygen three-isotope diagram, variation being less than that reported by [5]. If finds are excluded, and with the possible exception of Warrenton(3.6), there is a positive correlation between $\Delta^{17}O$ and metamorphic subtype. Analyses of different sub-samples of Lance(3.4) demonstrate small, but significant, levels of sample heterogeneity (up to approximately 0.2‰ for $\delta^{17}O$ and 0.5‰ for $\delta^{18}O$).

Carbon isotopes: A distinct negative correlation is displayed when $\delta^{13}C$ is plotted against metamorphic grade, the relationship being particularly well developed if finds are excluded. In addition, whole rock carbon abundance declines with increasing grade being 0.8% in ALH77307(3.0) and 0.3% in Isna(3.7).

Discussion: The suggestion that there is a correlation between whole rock oxygen isotope compositions and metamorphic subtype [3], [5] is supported by the results of this study, contrary to our initial findings [6]. Our results are consistent with the involvement of an aqueous fluid phase during metamorphism [3]. The presence of phyllosilicates within the matrices of a number of CO3 chondrites [7] lends further support to this possibility. Whole rock C isotopes show a clear negative correlation with metamorphic grade, as does C abundance. In view of the evidence that alteration took place under relatively oxidising conditions [8] whole rock C isotope systematics are consistent with high partial pressures of CO_2 in the fluid phase during metamorphism. The presence of carbonate in Warrenton(3.6), as detected in step combustion studies [9], provides additional evidence of high CO_2 levels during metamorphic alteration on the CO parent body. .

References: [1] McSween H.Y (1977) *Geochim. Cosmochim. Acta,* 41, 477-491. [2] Scott E.R.D. and Jones R.H. (1990) *Geochim. Cosmochim. Acta*, 54, 2485-2502. [3] Rubin A.E. (1998) *Meteorit. Planet. Sci.*, 33, 385-391. [4] Miller et al. (1999) *Rapid Commun. Mass Spectrom.* 13, 1211-1217. [5] Clayton R.N. and Mayeda T.K. (1999) *Geochim. Cosmochim. Acta*, 63, 2089-2104. [6] Greenwood et al (2002) *LPS XXXIII Abstract 1609*. [7] Brearley A.J. and Jones R.H. (1998) *Reviews in Mineralogy* 36(3), 1-398. [8] Keller L.P. and Buseck P.R. *Geochim. Cosmochim. Acta*, 54, 1155-1163. [9] J. Newton (1994) *Unpublished Ph.D.Thesis*, Open Uni.