Carbon and oxygen isotopes in CO3 chondrites

Conference or Workshop Item

CARBON AND OXYGEN ISOTOPES IN CO3 CHONDRITES.

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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. .

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