Oxygen isotope fractionation between calcite and forsterite formed via reaction from dolomite and tremolite at 680°C

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Abstract: The partitioning of oxygen isotopes between calcite and forsterite at 680°C and 500 MPa has been directly measured using the reaction of dolomite plus tremolite to produce calcite, forsterite, CO2 and H2O. The results give a mean fractionation of 3.91 ± 0.25 ‰ between calcite and forsterite, which is interpreted to represent equilibrium fractionation. Carbon isotope equilibration is also achieved between CO2 and calcite of the reaction product, with a mean fractionation of 3.36 ± 0.16 ‰ at 680°C. Apparently, oxygen and carbon isotope equilibration can be obtained between the product phases of a completed reaction. Mineral reactions usually involve the breakdown and formation of chemical bonds and thus large changes in free energy. This is probably a fundamental cause for the isotopic equilibration among the product phases. Therefore, reactions can be used as a direct approach to calibrate isotopic fractionation between product phases.

Key-words: equilibrium fractionation, oxygen isotopes, carbon isotopes, calcite, forsterite, carbon dioxide.

Introduction

It is well-known that the equilibrium partitioning of stable isotopes between two minerals is a function of the temperature of their coeval formation (Urey, 1947; Clayton, 1981; O’Neil, 1986). A large number of oxygen isotope analyses of mineral pairs have been performed in the past few decades for the purpose of geothermometry. Numerous attempts have been made to calibrate the temperature dependence of the 18O/16O partitioning between common minerals. Although the desired data are mineral-pair fractionations, it is commonly not practical to equilibrate a pair of silicate phases directly, since the fine grain size necessary to achieve adequate isotopic exchange rates makes clean physical separation of the run products extremely difficult.

Earlier experimental determinations of mineral-pair fractionations were generally made by isotopic exchange of single minerals with water and then combining two sets of such experimental data for different minerals to get mineral-pair fractionations (e.g. Bottinga & Javoy, 1973; Clayton, 1981; Matthews et al., 1983). As pointed out by Clayton et al. (1989), there are

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