

# Experimental Studies of Oxygen Isotope Exchange between Calcite and Tremolite in the Absence and Presence of Fluid

Y. -F. Zheng (yfzheng@ustc.edu.cn)<sup>1</sup>, M. Satir<sup>2</sup> & P. Metz<sup>2</sup>

<sup>1</sup> Department of Earth and Space Sciences, University of Science and Technology of China, Hefei 230026, PR China

<sup>2</sup> Institute for Mineralogy, Petrology and Geochemistry, University of Tuebingen, Wilhelmstr. 56, D-72074 Tuebingen, Germany

Two types of exchange experiments were carried out between calcite and tremolite at high temperatures and pressures. One was done in a two-phase system without fluid for two sets of companion experiments either at 1 GPa and 680 °C for 7 days or at 500 MPa and 560 °C for 20 days. The other was conducted in a three-phase system containing a large amount of fluid (CO<sub>2</sub> + H<sub>2</sub>O) at 500 MPa and 560 °C for 5, 10, 20, 40, 80, 120, 160, and 200 days. Extrapolated equilibrium fractionations between calcite and tremolite from the two-phase system exchange experiments are significantly lower than the previous empirical estimates and experimental determinations in the presence of small amounts of fluid, but closely match the calculated values by means of the increment method for framework oxygen in tremolite. This may point to experimental complexities such that oxygen isotope exchanged on the different sites of amphiboles in different types of experiments. The three-phase system exchange experiments shows that the oxygen isotope compositions of calcite and tremolite were relatively homogenized in the first 20 days and the fractionations for both mineral-mineral and mineral-fluid systems change rapidly. Thereafter the fractiona-

tion between calcite and tremolite changes very slowly and seems in a steady state, whereas the fractionations between the minerals and the fluid slowly approach equilibrium. Hence, the materials do not monotonically approach equilibrium as is the case for isotopic exchange in the simple two-phase systems. In fact, oxygen isotope exchange between calcite and tremolite is indirect in the three-phase system and thus much slower, whereas oxygen isotope exchange between the minerals and the fluid is direct and much faster because the fluid is a major exchange component of the system. Oxygen isotope exchange between minerals and fluid proceeds in two stages: first through a mechanism of dissolution-recrystallization and very rapid; second through a mechanism of diffusion and very slow. Synthetic calcite shows a greater rate of isotopic exchange with fluid than natural calcite in the first stage. The rate of oxygen diffusion in calcite is approximately equal to or slightly greater than that in tremolite in the second stage. Grain-boundary diffusion may be the dominant transport mechanism of oxygen between the recrystallized minerals and the fluid in the later stage.