

Experimental determination of the oxygen isotope fractionations in the systems kyanite–calcite and talc–carbonate–water

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Introduction

Earlier attempts to use Al_2SiO_5 -polymorphs for oxygen isotope thermometry were hampered by their sluggish reaction during fluorination and by the fact that no experimentally determined fractionation factors were available. There is increasing demand for these data since the O-isotope analysis of these phases is facilitated by LASER-fluorination.

Talc appears as an interesting phase for the determination of the fractionation behaviour due to its large temperature stability and occurrence in very different rock systems. In addition the experiments should provide the control of previous theoretical and empirical calculations.

Experimental methods

The following experimental methods were applied: 1. the direct exchange between calcite and mineral developed by Clayton *et al.* (1989), 2. the O-isotope exchange between mineral and water, 3. mineral syntheses and 4. achievement of isotopic equilibrium by heterogeneous reactions.

The experiments involving kyanite were performed according to method 1 using a piston-cylinder apparatus with NaCl-pyrophyllite assemblies and silver and gold capsules, respectively. The conditions are: reaction time 120 hours, pressure 19 kbar and temperatures between 600 and 900°C. Starting materials were one synthetic and two natural calcites with different isotopic

compositions and one natural andalusite. The natural minerals were grinded and sieved to grain sizes $< 32\mu\text{m}$. Further grain size reduction was achieved by grinding this fraction.

The exchange experiments including talc have been performed essentially according to method 2 hydrothermally at reaction times between 15–240 days, a pressure of 3 kbar and a temperature of 650°C. As starting materials synthetic and natural talc in combination with isotopically different waters were applied. To obtain more information on the exchange mechanisms we made additional experiments using the methods 3 and 4 at the same physical conditions.

Oxygen isotope analysis was done using the phosphoric acid technique for the carbonates and the fluorine technique for the silicates. After the phosphoric acid treatment calcium phosphates detected by X-ray examination of the solid reaction residuals were removed by adding hydrochloric acid (conc.) to the solution. The residual silicates were washed in distilled water. 8–10 mg of the silicates were reacted with purified fluorine (2bar) for 12 hours at 650°C.

Results

First results indicate that the oxygen isotope fractionations between calcite and kyanite at 725 and 775°C are only slightly higher than those predicted by theoretical attempts (Zheng 1993, Smyth 1989, Hoffbauer *et al.* 1994), Table 1.

The results of the exchange experiments between talc and water are shown in Fig. 1. It

TABLE 1.

temperature	1000 ln $\alpha_{\text{cc-ky}}$ Zheng 1993	1000 ln $\alpha_{\text{cc-ky}}$ Smyth 1989	1000 ln $\alpha_{\text{cc-ky}}$ Hoffbauer <i>et al.</i>	1000 ln $\alpha_{\text{cc-ky}}$ this study
725 °C	2.31	2.39	2.49	2.65
775 °C	2.11	2.17	2.26	2.45

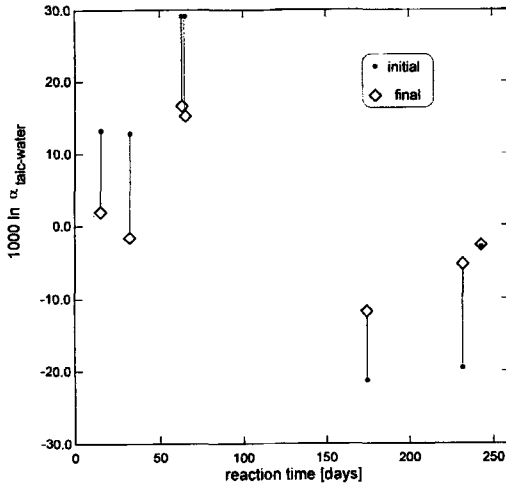


FIG. 1.

becomes apparent that the extent of the exchange increases only slightly with time and that the major amount of exchange occurs in the very first stage. The equilibrium fractionation is best approached by the run with the longest reaction time where the initial fractionation was already close to the equilibrium. This result was corroborated by synthesis experiments.

References

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