Further Measurements of the Zonar Distribution of ^{18}O in Synthetic Quartz Crystals

A. Klemm, K. Röller[a], and S. Hoernes[b]

Max-Planck-Institut für Chemie (Otto-Hahn-Institut),
Postfach 3060, D-55020 Mainz
[a] Institut für Geologie der Ruhr-Universität, D-44801 Bochum
[b] Mineralogisch-Petrologisches Institut der Universität Bonn,
Poppelsdorfer Schloss, D-53115 Bonn

Reprint requests to Prof. A. K., Fax: +49 6131 305388

Z. Naturforsch. **54a,** 763–764 (1999);
received November 22, 1999

The isotop effect $\delta^{18}O_F - \delta^{18}O_S$, measured between the face F and the solvent S of synthetic quartz crystals, grown at 1 kbar and 550–700 K, has been estimated to be 5.4, ^{18}O being enriched in the solid.

Key words: Oxygen Isotope Effect; Synthetic Quartz Crystal.

The concentration of the isotope ^{18}O in an industrial synthetic quartz crystal was found in [1] to increase linearly towards the surface of the crystal. It was, however, not possible to determine the oxygen-isotope-effect occuring at the surface of the growing crystal because the concentration of ^{18}O in the growth solution was not known.

In the following we report on some results we have now got using the remains of quartz-crystal-growth-experiments performed by one of us and published in his dissertation [2]. We determined the ^{18}O-concentration in the nutrient quartz chips used in [2], the ^{18}O distribution in the crystal QH-AF-51 of [2], and the ^{18}O-content of the remaining aqueous growth solution of the crystal QH-AF-53 in [2]. Both crystals were grown at 1 kbar from an aqueous solution containing NH_4F as mineralizer. The orientation of the seed was {0001}, as in [1].

The $\delta^{18}O_N$ value of the nutrient quartz was found to be 14.2. For the crystal QH-AF-51, grown at 700 K, $\delta^{18}O_F$ in its dependence on the distance of the face of the crystal from the seed was obtained as shown in Fig. 1, and for the crystal QH-AF-53, grown at 550 K, $\delta^{18}O_S$ of the growth solution at the end of the crystal was found to be −6.2.

Though the shapes of the two crystals are different, as are the temperatures of their growth, faute de mieux we used the measured δ^{18}O values as if they were stemming from one and the same crystal growth. Then, in view of Fig. 1 our results can be summarised as

	$l = 0$ mm	$l = 8.3$ mm
$\delta^{18}O_N$	14.2	14.2
$\delta^{18}O_F$	−3.9	−0.8
$\delta^{18}O_S$		−6.2

The resulting isotope effect $\delta^{18}O_F - \delta^{18}O_S = 5.4$ is somewhat high, cf. Fig. 1 in [3].

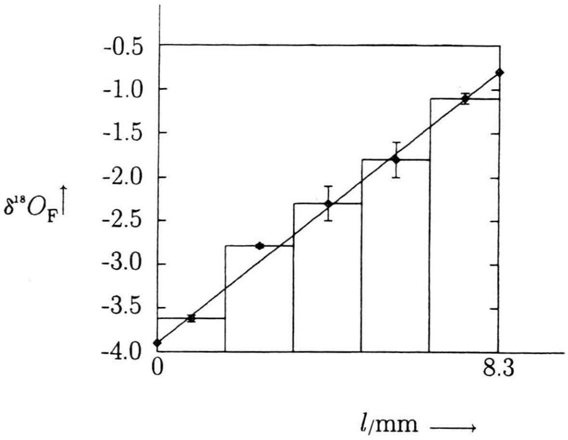

Fig. 1. Measured dependence of $\delta^{18}O_F$ at the face {0001} of the growing crystal QH-AF-53 of [2] on the distance l of the face from the seed plate.

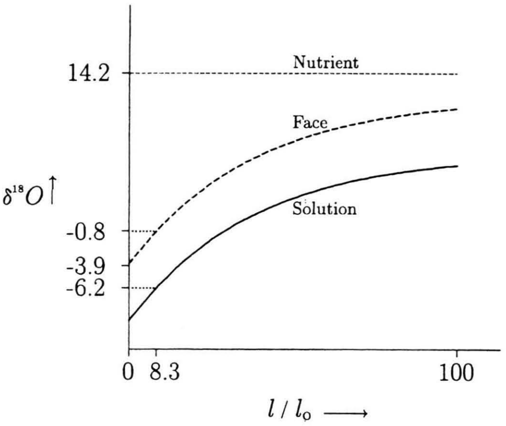

Fig. 2. Estimated change of δ^{18}O at the face and of the solvent on future growth of the crystal QH-AF-53 of Figure 1. In order to display δ^{18}O versus l/l_0, l_0 = 1 mm is assumed.

The dependence of $\delta^{18}O_F$ on l, which is almost linear in our case since $(\delta^{18}O_F)_l - (\delta^{18}O)_o < 3$, can for large differences be taken from (4) and (6) in [1]. There $\lambda = l/l_0$ and

$$l_0 = c_S V_S / c_F A_F,$$

where c_S and c_F are the concentrations of oxygen in the solution and the face, V_S is the volume of the solution and A_F the area of the face.

In the crystal growth described in [1] it was justified to consider l_0 to be constant. This is not the case in the present growths, but if it is taken to be true also here, the system would develop according to Fig. 2, where the value of l_0 is constant but unknown.

We started in [1] our research on a synthetic quartz crystal in the hope to learn something about the different incorporation of ^{18}O in different faces of the crystal. This was frustrated, however, by the fact that the ^{18}O concentration of the growth solution changed during the growth of the quartz crystal.

In further research one should chose the ^{18}O content of the growth solution such that it is in ^{18}O exchange equilibrium with the nutrient quartz chips. Then the ^{18}O concentration of the growth solution would not change during the growth, the concentration of the isotope ^{18}O would not increase towards the surface of the crystal, and it should be possible to see how the incorporation of ^{18}O in the growing quartz depends on the structure of the different quartz-faces and the velocity of their growth.

[1] A. Klemm, K. Röller, and S. Hoernes, Z. Naturforsch. **52a,** 789 (1997).

[2] K. Röller, Dissertation 1991, Fakultät für Geowissenschaften an der Ruhr-Universität, Bochum, Germany.

[3] R. Richter and S. Hoernes, Chem. Erde **48,** 1 (1988).