Oxygen isotope analysis of quartz using ArF-laser

J. Fiebig — Geochemisches Institut, Göttingen, Germany

U. Wiechert — Geophysical Laboratory, Carnegie Institution of Washington, Washington D.C., USA

J. Hoefs — Geochemisches Institut, Göttingen, Germany

The KrF laser has been established as a powerful tool for oxygen isotope preparation of minerals (Wiechert and Hoefs, 1995). In contrast to IR-laser (CO_2 and Nd:YAG laser) based preparation (e.g.Sharp 1992; Elsenheimer and Valley 1993) no isotopic fractionation is induced by the laser because oxygen is released by electronic excitation (vapourization) rather then by heating and reaction with fluorine. The latter is used only to prevent recombination of metal atoms with oxygen during condensation of the laser plasma. However, a drawback is that such an important mineral like quartz cannot be atomized in detectable amounts due to high transparency of quartz for 248 nm light. Investigations with an ArF laser (193nm) demonstrate that quartz can be analysed with very high reproducibility. Transparency of quartz at 193 nm is still in the range of 90% so that next to an atomization an expulsion of very small fragments (explosive ablation) occurs. The latter can be minimised by operating with highest possible energy density. Oxygen isotope analyses of vacuum melted homogenized quartz powder are reproducible within $\pm 0.2‰$ (Fig. 1) and coincide with $\delta^{18}O$ values obtained with two conventional preparation lines and CO_2-laser ablation. Additionally, CO_2- and ArF-laser data of a magmatic quartz from the Weinsberg granite, Bohemian Massif, are identical in the range of the quartz's heterogeneity. This all implies that excimer laser data is accurate even if ablated quartz is not vapourized and converted to O_2 completely. The presence of feldspar showed only negligible influence, if at all.

The unique ability of the ArF laser for in situ studies is demonstrated on a hydrothermally grown quartz from Usingen, Rhenish Massif, Germany. Three quartz crystals, prepared as thick sections, have been analysed by more than 100 shots. In Fig. 2 a typical zonation profile is shown. Values of $\delta^{18}O$ range from 15.5 to 19.0‰. Cloudy growth zones are systematically higher in $\delta^{18}O$ than clear zones. Two types of primary inclusions occur, frequent high salinity (12–20 wt.% NaCl) and rare low salinity inclusions (0–5 wt.%) (Behr *et al.*, 1987).

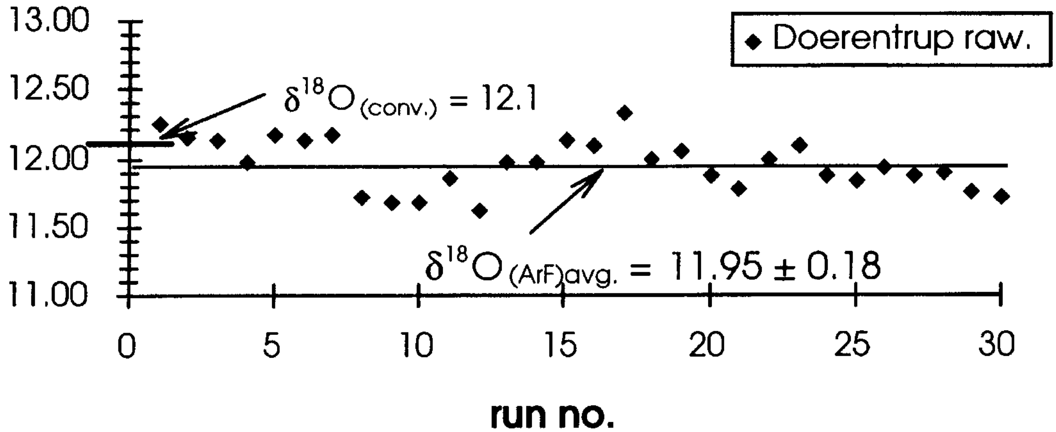

FIG. 1. Long term reproducibility for $\delta^{18}O$ measurements of amorphous Doerentrup-quartz used as a standard from June to September 1997. The averaged value is 11.95 with a standard deviation ($1\ \sigma$) of 0.18.

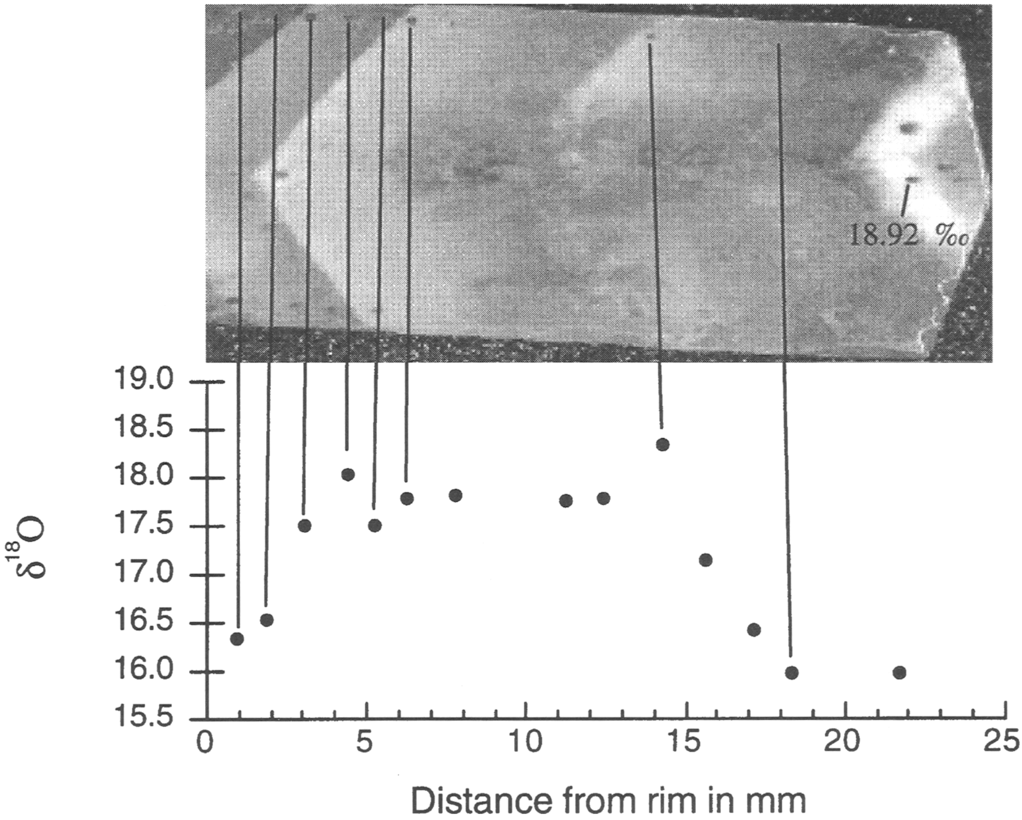

FIG. 2. Oxygen isotope profile of a quartz crystal analysed as thick section.

Combination of these data enables two models of vein growth: A temperature controlled precipitation from fluids of different origin, namely Na- and Ca-rich brines and sulphate/bicarbonate water (Behr *et al.*, 1987), and/or a precipitation from an original low salinity fluid due to isothermic pressure drops and boiling.

So far we have been successful in analysing olivine, garnet, pyroxenes, feldspar, biotite, amphibole, epidote, spinel, and quartz using the ArF laser and there is good reason to believe that this is the first laser which can be applied to vapourize and study oxygen isotope composition of all types of silicate minerals.

References

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