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Determination of component mobilities in bimineralic reaction rims using isotopically doped starting materials

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Rim growth experiments were performed between monticellite ($CaMgSiO_4$) single crystals and wollastonite ($CaSiO_3$) powder at 900°C and 1.2 GPa to produce bimineralic diopside ($CaMgSi_2O_6$) + merwinite ($Ca_3MgSi_2O_8$) reaction rims.

Symmetrical makeup of the internal rim microstructure implies that rims grow from the original interface towards both reactants at identical rates, indicating that solely MgO-diffusion controls overall rim growth with logD (MgO) = -16.3 $\pm$ 0.2 m^2s^{-1} (Joachim et al. 2012).

Presence of ppm-amounts of water significantly affects the internal rim microstructure. At "very dry" condition, a lamellar microstructure of alternating palisade-shaped diopside and merwinite grains elongated normal to the reaction front is generated, indicating that CaO and SiO_2-mobilities are significantly smaller compared to the MgO-mobility. In presence of minute amounts of water a segregated multilayer microstructure with almost perfectly monomineralic merwinite - diopside - merwinite layers oriented parallel to the reaction front develops, indicating a sufficient additional mobility of either CaO or SiO_2 compared to MgO.

We used isotopically doped wollastonite ($^{44}Ca^{29}SiO_3$) to identify, which component mobility, CaO or SiO_2, is enhanced in presence of ppm amounts of water. Both, ^{44}Ca stemming from the wollastonite as well as ^{40}Ca stemming from the monticellite are distributed across the entire rim. In addition to that, small amounts of ^{40}Ca are found within the wollastonite and substantial amounts of ^{44}Ca are found in the monticellite starting material.

In contrast to that, ^{28}Si and ^{29}Si remain in the regions that were originally occupied by their respective source materials monticellite and wollastonite, indicating that the SiO_2-mobility is comparatively low. This suggests that the presence of small amounts of water significantly enhances the relative mobility of CaO.

Consequently minute amounts of water may not only affect overall rim growth kinetics but also the relative component mobilities and accordingly the internal rim organization.

B. Joachim, E. Gardés, B. Velickov, R. Abart, W. Heinrich (2012) Experimental growth of diopside + merwinite reaction rims: the effect of water on microstructure development. Am Min 97, pp. 220-230.