Experimental growth of complex reaction rims in the system CaO-MgO-SiO2

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A mixture of periclase (MgO) and wollastonite ($CaSiO_3$) was exposed to conditions where merwinite($Ca_3MgSi_2O_8$) and diopside ($CaMgSi_2O_6$)are stable. The latter two phases are expected to form at wollastonite-periclase contacts by a reaction of the type $2\,MgO + 2\,CaSiO_3 => 1\,Ca_3MgSi_2O_8 + 1\,CaMgSi_2O_6$. Experiments were performed in a piston cylinder apparatus at 1 GPa for 42 h at various temperatures in the range of $850°C$ to $950°C$. As starting materials we used synthetic periclase grains (0.1-0.2 mm), which were embedded into a fine-grained wollastonite matrix. Charges were nominally dry. Presence of minute amounts of water mainly adsorbed at the surface of the wollastonite powder could not be avoided.

Complex reaction rims were formed around the periclase grains in all run products. with the distinctive sequence of mineral layers:

Periclase // Forsterite // Monticellite // Merwinite // Wollastonite

MgO // Mg_2SiO_4 // $CaMgSiO_4$ // $Ca_3MgSi_2O_8$ // $CaSiO_3$

The individual mineral layers are basically monomineralic, indicating that rim growth is primarily transport-controlled. However, several very small forsterite and merwinite inclusions are present within the monticellite rim, suggesting that transport may have been particularly fast along grain- or phase boundaries and less efficient into the pre-existing mineral grains. The spatial distribution of forsterite and mervinite inclusions indicates that monticellite consumed both merwinite and forsterite. Merwinite in turn consumed wollastonite, and forsterite consumed periclase. This implies that the original Wo-Per boundary is located within the monticellite layer.

The identity and spatial sequence of the mineral layers is interpreted in terms of irreversible thermodynamics (Joesten 1977), applying mass balance considerations and formulation of partial reactions at the respective interfaces. The layer sequence and relative layer widths then allow for estimation of the diffusive fluxes of exchanged components under the simplified assumption that transport was diffusion-controlled. For example, the existence of forsterite indicates that the relative mobility of SiO_2 is higher than that of CaO. Phenomenological diffusion coefficients for MgO, SiO_2 and CaO are derived.

Joesten R (1977) Evolution of mineral assemblage zoning in diffusion metasomatism. Geochim Cosmochim Acta 41:649-670

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