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Reaction rim growth in the $MgO-Al_2O_3-SiO_2$ system under uniaxial load and 1 bar confining pressure

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We study the influence of uniaxial load on reaction rim growth in the system $MgO-Al_2O_3-SiO_2$ using a creep apparatus. Rims are synthesized in the $MgO-SiO_2$ and in the $MgO-Al_2O_3$ subsystems at temperatures ranging from 1250 to 1350^0C imposing vertical stress of 1.2 to 29 MPa at ambient pressure and under a constant flow of dry argon. We produce enstatite rims at forsterite-quartz contacts, enstatite-forsterite double rims at periclase-qaurtz contacts and spinel rims at periclase-corundum contacts. Single crystals of synthetic and natural quartz and forsterite, synthetic periclase, synthetic corundum polycrystals, and novaculite are used as starting materials. We find that rim growth under the "dry" conditions of our experiments is sluggish compared to what has been found previously in nominally "dry" piston cylinder experiments. We further observe that the nature of starting material, synthetic or natural, has a major influence on rim growth rates, where natural samples are more reactive than synthetic ones. At a given temperature the effect of stress variation is rather low, but it is larger than what is anticipated from the modification of the thermodynamic driving force for reaction due to the storage of elastic strain energy in the reactant phases. Deviations from the thermodynamically based expectations regarding the influence of stress are observed towards increased and reduced rim growth rates. We speculate that increased growth rates may be due to the generation of new grain boundaries, which is induced by the imposed uniaxial load. Increasing the number density of grain boundaries will enhance the effective component diffusivities in the reaction rim and thus accelerates reaction rim growth. Apparently slower rim growth rates than what is expected on thermodynamic grounds may simply be due to shortening of the sample in the direction of the load by creep. In our experiments rim growth is very sluggish at forsterite-quartz interfaces so that we can not give rate constants for this rim growth configuration. Rim growth is more rapid at periclase-quartz contacts, but the resulting double rims do not follow a parabolic growth law. The spinel rims that are produced at periclase-corundum interfaces show parabolic growth indicating that reaction rim growth is essentially diffusion controlled. From the analysis of time series done in the $MgO-Al_2O_3$ subsystem we derive effective diffusivities for the Al_2O_3 and the MgO components in a spinel polycrystal as $D_{MgO} = 1.5*10^{-15}$ m^2/s and $D_{Al2O3} = 3.6*10^{-16}$ m^2/s for $T=1350^0C$ and a vertical stress of 2.9 MPa.