

The behavior of mineral inclusions during host decomposition. A SEM-STEM study of rutile inclusions at a natural propagating corundum-spinel interface.

Lisa Baldwin, Chen Li, Gerlinde Habler, and Rainer Abart
University of Vienna, Lithospheric Research, Austria (lisa.baldwin@univie.ac.at)

When two neighbor phases are not in chemical equilibrium, they may react and produce a reaction rim at their interface, separating the mutually incompatible phases. At constant P-T-X conditions, such a reaction will continue until one of the reactants is completely consumed. Reaction rim growth involves transfer of chemical components across the growing rim by long-range diffusion and localized interface reactions on either side of the growing rim. Consequently, the thickness of the reaction rim will be a function of time. Yet, in order to quantify and interpret such corona structures and to define a reaction rate law, the kinetics and mechanism of rim formation must be well constrained. In particular, the coupling between long-range diffusion, and interface reaction must be known. In this contribution we focus on potential complexities associated with interface reactions. Many natural minerals contain inclusions of other phases, which in turn may influence the reaction interface propagation kinetics during host phase decomposition (Ashby et al. 1969), as a propagating reaction interface dissipates more free energy when bypassing a mineral inclusion, resulting in a locally decelerated reaction rate. Here, we report results of a SEM-STEM study of the interface between natural rutile-bearing corundum and a polycrystalline ferromagnesio-aluminate spinel that grew topotactically with respect to the corundum precursor as a consequence of its reaction with FeO and MgO from basaltic melt. Electron Backscatter Diffraction (EBSD) crystal orientation imaging revealed that the spinel rim is polycrystalline and exhibits (111) twinning that is parallel to the corundum (0001) plane. The rutile inclusions in corundum are elongated perpendicular to the corundum [0001] axis and are randomly oriented in the (0001) plane. Furthermore, they follow an oscillatory grain size distribution zonation with grain sizes being either a few tens of nanometers, or about 500 to 800 nanometers in the elongated axis. The behavior of the rutile inclusions as they are encountered by the propagating corundum-spinel reaction interface strongly depends on the inclusion size. The nano-inclusions are incorporated into the spinel rim, where –after a recrystallization and coarsening step at the reaction interface– they have a size of > 1 micrometer. There, rutiles form inclusions within spinel grains or accumulate at grain- or twin boundaries within the spinel reaction rim. In contrast, larger inclusions in corundum are collected at the reaction interface, leaving behind a largely rutile-free spinel rim. From our investigations, we conclude that the inclusion size plays an important role in the effective mechanisms of interface propagation during precursor phase decomposition. Contrastingly, the reactive interface orientation with respect to certain crystallographic planes of corundum seems not to influence the inclusion behavior.