



Controls on the evolution of symplectite microstructures

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Symplectites, a common phenomenon in magmatic and metamorphic rocks, are peculiar reaction microstructures, where a relatively fine-grained, two- or polyphase mineral aggregate with characteristic vermicular or lamellar intergrowth replaces a homogeneous precursor phase at a sharp reaction front. Typically, the phase alternation within a symplectite shows a characteristic length scale, ranging from hundreds of nanometres to tens of micrometres. In addition, the symplectite phases may show characteristic grain-internal compositional zoning. Here a thermodynamic model for symplectite formation is presented, which accounts for chemical segregation within the reaction front and for sluggish interface reaction as the two possible rate-limiting processes. It is found that both, the characteristic length scale of phase alternation and the extent of grain-internal compositional zoning of the symplectite phases is controlled by the coupling between the two potentially rate-limiting processes. Although the entire continuum between interface-reaction control and diffusion control is relevant, it is instructive to consider the two extreme scenarios: If interface reaction is rate limiting, the characteristic spacing is large, and the symplectite phases are chemically homogeneous assuming the equilibrium compositions. If, chemical segregation by diffusion within the reaction front is rate limiting, the characteristic spacing of phase alternation is small and symplectite phases show characteristic internal compositional zoning with the equilibrium compositions only attained at the phase boundaries. Using synthesis experiments in the CaO-MgO-SiO₂ system and natural myrmekites it is shown that symplectite formation tends to be interface reaction controlled, whereas at low temperatures diffusion control takes over. As a consequence, the characteristic length scale of phase alternation increases with increasing temperature, and characteristic grain-internal compositional zoning is restricted to formation at relatively low temperatures. The temperature dependence of the characteristic lamellar spacing and the temperature-time dependence of overall reaction progress, have potential for applications in geo-thermometry and geo-speedometry.