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Transport controlled reactions and reaction induced stress, mutual feedback

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Reaction rims or coronas between mutually incompatible mineral assemblages indicate that reaction rates are controlled by material transport. During reaction band formation the reactant minerals become progressively separated by a growing layer of product phases. In general, layer growth requires material transfer between the two reaction interfaces. In an isothermal isobaric equilibrium system the chemical potentials of the system components are fixed at the reaction interfaces. In rim growth experiments component fluxes may be determined from rim growth rates. Knowledge of both component fluxes and chemical potential gradients allows the diffusivities of the mobile components to be determined.

Usually reaction band formation involves a volume change. This, in turn, induces heterogeneously distributed differential stress on a grain scale. Existence of reaction induced stress is corroborated by micro-structural and textural evidence such as palisade structures, polysynthetic twins, strain contrast centres and lattice preferred orientation in natural and synthetic reaction rims. Spatial variations in the stress state feed back into chemical potentials. The feedback is such that reaction induced stress tends to slow down reactions. This effect is particularly pronounced if stress relaxation is slow relative to reaction rates as may be the case for mechanically “strong” materials. Reaction induced stress is minimized if replacement occurs at constant volume. In the context of reaction band formation this would fix relative component mobilities. Vice versa systematic differences in reaction induced stress between corresponding reaction interfaces may shed light on relative component mobilities. Externally imposed deviatoric stress may impose an anisotropy on local stress states. Such an anisotropy feeds back into chemical potentials and may lead to asymmetric rim growth. Directional dependence of rim thickness potentially provides a paleo piezometer.