Geophysical Research Abstracts, Vol. 8, 02356, 2006
SRef-ID: 1607-7962/gra/EGU06-A-02356

Contrasting “solid-state” and “dissolution-precipitation” processes and the development of texture.

A. Putnis and C.V. Putnis

Institut für Mineralogie, University of Münster, Germany

(putnis@nwz.uni-muenster.de)

Mineral reequilibration due to changing physico-chemical conditions involves a wide range of possible processes, from intercrystalline solid state processes (e.g cation ordering and exsolution), to changes in the chemical composition while retaining the basic crystal structure (e.g. ion-exchange processes), to intracrystalline reactions between minerals, producing new mineral phases. A key consideration in all of these cases is the strain produced due to the changes in the molar volumes of the phases involved, as well as the mass transport mechanisms operating. In solid state processes such as exsolution, the principles governing the textural (microstructural) development are well established : the crystallographic relationships between the exsolving phase and its matrix determine the shape of the exsolved phase and its orientation within the matrix, such as to minimise the strain energy. The strain energy is compensated by a free energy drive due to departure from equilibrium.

“Ion exchange” processes, such as might occur within a granulitic garnet being reequilibrated to an eclogitic garnet, or a crystal of augite in a basalt being converted to an omphacite during subduction, are different in that the crystal itself is not a closed system, and so the reaction is locally metasomatic. The question of how to write a balanced equation for such a reaction has been discussed since the early papers of Lindgren (1912, 1918) and by Carmichael (1969). Recent research has shown that in the cases studied, ion-exchange processes in the presence of a fluid phase take place by a coupled dissolution-reprecipitation reaction in which it is possible to replace one single crystal by a new single crystal, retaining crystallographic relationships as well as the external form of the crystal, i.e. pseudomorphism (Putnis et al., 2005), even when the external shape of the parent is not constrained in a rock. This represents one end of a whole spectrum of possible scenarios in which crystallographic relations between parent and product, as well as their relative solubilities in the fluid determine the textural development. A key issue is that, in dissolution-reprecipitation processes, porosity may develop in the product phase even if it has a higher molar volume than the parent, since the fluid itself can incorporate some components from the parent (i.e. more material may be dissolved than reprecipitated in a pseudomorphic reaction). Reactions in which the crystal structures of parent and product are sufficiently different so that topotaxy between them is not possible, may result in a polycrystalline product. Depending on the composition of the intergranular fluid and its supersaturation with respect to more stable phases, the product may also be a two-phase intergrowth in which the two phases have a symplectic textural relationship. The prevailing principles are the same in each case.

The criteria which have been used to define a solid state reaction also apply in coupled dissolution-reprecipitation reactions, and issues such as interfacial strain and its role in textural development apply equally in both.

Lindgren W. The nature of replacement. Econ. Geol. 8, 521-535 (1912)

Lindgren W. Volume changes in metamorphism. J. Geol. 26, 542-553 (1918)

Carmichael D.M. On the mechanism of prograde metamorphic reactions in quartz-bearing pelitic rocks. Contrib. Mineral. Petrol. 20, 244-267 (1969)