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Mass transport and element mobilisation during large-scale metasomatism

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Replacement textures commonly occur in relation to fluid-driven large scale metasomatism and metamorphism and these processes are often related to mineralisation. For example, the albitisation of gabbroic rocks in the Bamble District, southern Norway is associated with ore deposits. Similar albitised rocks are also characteristic of the Curnamona Province, Australia, which includes large areas of mineralisation such as the Pb, Zn, Ag of the Broken Hill deposits as well as Cu, Au and U deposits.

The main question addressed here is the mechanism of mass transport and hence element mobilisation. An indication of the former presence of fluids within a rock can be seen in mineral textures, such as porosity, replacement rims, replacement induced fracturing and crystallographic continuity across sharp compositional boundaries. Such textural observations from natural rocks as well as experimental products show that during mineral-fluid interaction, the crystallographic relations between parent and product phases control the nucleation of the product, and hence a coupling between dissolution and reprecipitation. If the rate of nucleation and growth of the product equals the dissolution rate, a pseudomorphic replacement takes place. The degree of epitaxy (or lattice misfit) at the interface, the relative solubility of parent and product phases and the molar volume changes control the microstructure of the product phase. The key observation is that these factors control the generation of porosity as well as reaction induced fracturing ahead of the main reaction interface. Porosity is generated whenever the amount of parent dissolved is greater than the amount of product reprecipitated, irrespective of the molar volume changes of the solid reactants and products. This porosity is occupied by the fluid phase during the reaction, and provides a mechanism of mass transport and fluid movement between reaction interface and the surrounding phases. The reaction-induced fracturing may be controlled by the solid phase volume changes and hence by stresses generated at the reaction interface. This fracturing enhances fluid infiltration which in turn promotes chemical changes through further dissolution-precipitation. If minerals are reactive in the presence of an interfacial fluid layer and a replacement process begins, the replacement mechanism allows for the remobilisation of elements which may be transported by the fluid phase and reprecipitated elsewhere when the physical and/or chemical conditions change.