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Interface-controlled epitaxial replacement processes resulting in a mechanism of fluid transport and element mobilization within the Earth

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Fluid-mineral reactions involve the replacement of one mineral by another, by a mechanism which involves a coupled dissolution and reprecipitation process taking place at the fluid-mineral interface. Observations from natural rocks as well as experimental products show that the crystallographic relations between parent and product phases control the nucleation of the product, and hence the 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 and the relative solubility of parent and product phases controls the microstructure of the product phase. In this case the microstructure involves not only the textural relations between the parent and product determined by crystallography, but also the porosity generated when the amount of parent dissolved is greater than the amount of product reprecipitated. 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. Previous explanations for the movement of aqueous fluids through rocks have concentrated on the availability of pre-existing pathways, such as grain boundaries and stress fractures (Kostenko et al., 2002). Such pathways undoubtedly play a major role in allowing easy access for fluid transport. However, the replacement mechanism described here provides fluid pathways through minerals, which are reactive in the presence of an interfacial fluid layer

(Putnis et al., 2005; Putnis and Putnis, 2007). Such a mechanism also allows for the remobilisation of elements which may be transported by the fluid phase and concentrated as an ore deposit. To demonstrate the mechanism we use time-lapse photography to observe replacement and fluid movement through a single crystal of a simple salt at room T and P and suggest that more complex mineral systems, which show similar textural and compositional equilibration features react in the same way.

Replacement textures commonly occur in relation to fluid-driven regional metamorphism and large scale metasomatism and these processes are often related to mineralisation, such as the gabbro - scapolite rock transition, south Norway, where albitisation and scapolitization of gabbro is associated with many ore deposits. Similar albitised rocks are also characteristic of the Curnamona Province, Australia, which includes the Broken Hill deposits. This suggests that dissolution-reprecipitation is an important mechanism behind large-scale crustal processes.

References:

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