Reactions at mineral-fluid interfaces : from experiment to nature – from the nanoscale to the macroscale.

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When a mineral reacts with an aqueous solution with which it is out of equilibrium the first step of any reaction sequence is the dissolution of the mineral surface. The dissolution of even a few monolayers of the parent surface may result in a fluid boundary layer which is supersaturated with respect to a more stable solid phase. Nucleation of this product phase on the parent surface will depend on nucleation kinetics and will be enhanced if there is a degree of epitaxy (i.e. structure matching) between the two solids. The nucleation of the product on the surface of the dissolving parent enhances the dissolution rate of the parent which in turn increases the growth rate of the product. Such an autocatalytic reaction leads to a feedback mechanism between dissolution and precipitation such that their rates become equal.

Continuation of the transformation (replacement) reaction depends on keeping open fluid transport pathways to the reaction interface between the parent and product solids. In other words porosity must be generated in the product phase. The generation of porosity depends on two factors: the relative molar volumes of the two solid phases, and even more importantly, the relative solubilities of the two phases in the fluid i.e. their relative stabilities under the conditions of the experiment.

These simple ideas, encompassed in the term "interface-coupled dissolution-precipitation" have very wide application to mineral-fluid reactions in the earth as well as in industrial processes. Central to the whole concept is the importance of the mineral-fluid interface because this is where all the action is. The fluid at this interface can become supersaturated while the "bulk fluid" away from the interface plays no role in the reaction except as a fluid reservoir.

Examples of mineral-fluid reactions will be given, starting from the simplest model system of replacing a single crystal of KBr by a single crystal of KCl. We will then move to more complex experiments, always relating these to equivalent reactions in rocks. We will touch on topical issues such as metasomatism and granites, fluids in metamorphism and finally the mechanism of rock deformation.