

# Fluid pathways and fluid-rock interaction mechanisms during high pressure metasomatism

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Metasomatic rock transformations are among the few petrological processes that have a significant social impact. For example, element enrichment in surface-near rocks can lead to the formation of ore deposits or cause an unwanted concentration of elements harmful to human health. Despite their importance rate controlling processes during metasomatism are not very well understood in detail, i.e. the intra-crystalline and surface kinetics of the reactant, the inter-crystalline element transport as well as the surface kinetics at the product mineral. There is still an ongoing debate about quantification of all of these rate controlling parameters in metasomatic rocks. However, the observation that natural constraints on metasomatic mineral reaction rates span over a range of up to nine orders of magnitude indicates that each of these processes might be rate-controlled by different mechanisms that can be active at the same time. Recent developments in analytical techniques allow for the observation of element exchange during mineral reactions down to the nano-scale, which yielded new insight into rate-controlling processes and led to the discovery of entirely new reaction pathways among solids and fluids.

We present examples from natural rocks, which clearly indicate that:

- (1) lattice defects, such as dislocation walls in the reacting mineral, induced during metasomatic reactions, allow for very fast intracrystalline element transport and very high dissolution rates of the reactant,
- (2) reaction induced transient and interconnected porosity enables effective element transport during rock transformation,
- (3) the formation of an amorphous transport medium during mineral reactions, that is thermodynamically decoupled from an inter-crystalline aqueous solution, leads to enhanced element transfer between reactant and product, and
- (4) re-polymerization of that amorphous phase at the product surface further enhances the crystallization rate during metasomatism.

All of these observations indicate that metasomatic mineral reactions might follow different pathways with different reaction rates, which might be much more effective and faster than previously thought. It is noteworthy that subduction related low temperature/high pressure rocks are the most valuable sources of information about metasomatic reaction pathways as peak temperatures experienced by these rocks are sufficiently low to allow for the preservation of reaction textures, whereas high fluid fluxes and peak pressures allow for large chemical potential differences hence still invoking mineral reactions.