How do metamorphic fluids move through rocks?

An investigation of timescales, infiltration mechanisms and mineralogical controls

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Abstract

This thesis aims to provide a better understanding of the role of mountain building in the carbon cycle. The amount of CO_2 released into the atmosphere due to metamorphic processes is largely unknown. To constrain the quantity of CO_2 released, fluid-driven reactions in metamorphic rocks can be studied by tracking fluid-rock interactions along ancient fluid flow pathways. The thesis is divided into two parts: 1) modeling of fluid flow rates and durations within shear zones and fractures during greenschist- and blueschist-facies metamorphism and 2) the assessment of possible mechanisms of fluid infiltration into rocks during greenschist- to epidote-amphibolite-facies metamorphism and controlling chemical and mineralogical factors of reaction front propagation.

On the island Syros, Greece, fluid-rock interaction was examined along a shear zone and within brittle fractures to calculate fluid flux rates, flow velocities and durations. Petrological, geochemical and thermodynamic evidence show that the flux of CO_2-bearing fluids along the shear zone was 100-2000 times larger than the fluid flux in the surrounding rocks. The time-averaged fluid flow velocity and flow duration along brittle fractures was calculated by using a governing equation for one-dimensional transport (advection and diffusion) and field-based parameterization. This study shows that fluid flow along fractures on Syros was rapid and short lived.

Mechanisms and controlling factors of fluid infiltration were studied in greenschist- to epidote-amphibolite-facies metabasalts in SW Scotland. Fluid infiltration into metabasaltic sills was unassisted by deformation and occurred along grain boundaries of hydrous minerals (e.g. amphibole) while other minerals (e.g. quartz) prevent fluid infiltration. Petrological, mineralogical and chemical studies of the sills show that the availability of reactant minerals and mechanical factors, e.g. volume change in epidote, are primary controls of reaction front propagation.

Keywords: *Metamorphic fluid flow, fluid-rock interaction, fluid infiltration mechanisms, fluid flux rates, thermodynamic modeling, reaction front propagation, fluid flux calculation.*

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