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FLUIDS IN THE CRUST

The mechanism of infiltration of metamorphic fluids recorded by hydration and carbonation of epidote-amphibolite facies metabasaltic sills in the SW Scottish Highlands†

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Abstract

In this study we investigate a group of metabasaltic sills from the SW Scottish Highlands metamorphosed at epidote-amphibolite facies conditions that provide useful insight into the mechanisms and characteristics of fluid infiltration during metamorphism. The sills are amphibole and garnet bearing and exhibit a strong foliation in the sill margins that developed pre- to syn-peak metamorphism. Fluid infiltration caused hydration and carbonation in the sills, expressed as (1) replacement of garnet and amphibole by chlorite and calcite and (2) replacement of amphibole and epidote to form chlorite and calcite. Using garnet-amphibole and garnet-chlorite geothermometers we show that these reactions occurred after peak metamorphism at $T = 290$ to 400 °C. Reaction textures show that the fluid infiltration into the sill that caused hydration and carbonation occurred in the absence of deformation. The fluid infiltration was mineralogically controlled with greater fluid access in areas of abundant fine-grained elongate minerals such as amphibole and chlorite. The replacement of garnet by chlorite most likely occurred by an interface-coupled dissolution-precipitation mechanism as evidenced by perfect pseudomorphic textures of garnet, porosity generation behind the reactive interface and fracturing ahead of this interface. Porosity generated in the product chlorite enhanced fluid access to the replacement front. The study shows that deformation was not required for extensive fluid infiltration and alteration during metamorphism. Fluid flow uses a pre-existing foliation to gain access to the rock, taking advantage of the anisotropic shape of the aligned minerals.

Keywords: Hydration, carbonation, deformation, metamorphic fluid flow, epidote-amphibolite facies metamorphism, fluid infiltration mechanisms