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Fluid migration and reaction fronts during wallrock metasomatism: An example from the Crummock Water tourmalinites (English Lake District)

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Tourmalinization around Crummock Water occurred in association with retrograde contact metasomatism and took place in wallrocks enclosing a series of faults (and joints). In this way the original Skiddaw Group metapelites were transformed by metasomatic alteration into rocks consisting nearly exclusively of tourmaline and quartz and forming metasomatic "veins" ranging in thickness from less than a cm to a few m.

Thin section petrography, whole rock analyses of major and trace elements and electron microprobe data reveal that there are actually three fronts associated with the tourmalinization.

The first one is not macroscopically or microscopically detectable but manifests itself by weak to strong systematic depletions of Mg, Mn, Na, Ni, LREE and locally LFSE. The systematic nature of the depletions is expressed by strong depletions close to the tourmalinite veins, quickly decreasing on m-scale with increasing distance to the veins. These depletional trends are interpreted as reflecting a migration of the concerning elements towards the veins with the outermost depleted rocks marking the end of the zone where fluids in association with the tourmalinization were chemically active.

The second front is only microscopically visible and is represented by a silicified edge of maximum a few mm thick bordering the tourmalinites. This feature is not omnipresent, and where absent, a transition zone of about the same size can be seen in thin section. Because microprobe analyses indicate higher amounts of SiO_2 in this transition zone, an overall Si-enrichment at the edges of the tourmalinite veins seems likely. Mass balance calculations, based on whole rock analyses, show a mass increase of 31 % in the tourmalinites, mainly accounted for by Si-enrichment. It can therefore be argued that the tourmalinizing fluid was rich in both Si and B, and that by the end of the tourmalinization process silicification went further on for a while. Probable causes are that the system had run out of B but not of Si or that the temperature had become to low to allow further tourmalinization, but was still high enough for silicification.

The third one is the tourmalinization front. The tourmalinized zone is characterised by a strong alteration of the original metapelite mineralogy into a fine-grained mosaic of tourmaline and quartz combined with several depletions and/or enrichments of major and trace elements.

2.5.25

Interplay between fluid infiltration, deformation, and diffusion during eclogitization in the Mte. Mucrone quartz diorite, Italy

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The Mte. Mucrone quartz diorite and its metamorphic assemblages are a classic example of eclogitization that took place in response to metamorphic overstepping of reactions and fluid infiltration during subduction. In this study we examine samples from a single shear zone and combine these results with extensive previous work to try to understand the roles of diffusion, deformation, and fluid infiltration and their influence on the evolution of microstructures and rheologic properties of the shear zones. In order to accomplish this, forward modeling of previously determined bulk compositions reflecting changes resulting from fluid infiltration is used to determine equilibrium assemblages and detailed composition mapping is used to assess the degree of re-equilibration with increasing strain in the shear zone.

Forward modeling of the assemblages was completed using PERPLE_X in the KCNFMASH system. The stable assemblage for the undeformed bulk composition, consistent with estimates by previous workers is garnet-omphacite-phengite-zoisite-quartz. These assemblages agree with those seen in low-strain part of the shear zone but compositional mapping indicates that these areas have strong chemical gradients and mineral compositions are not in equilibrium. Modeling of bulk compositions from deformed and best-equilibrated samples yields the stable assemblage garnet-omphacite-phengite-paragonite-zoisite-quartz, which is observed in the central part of the shear zone. The minerals, modes, and compositions predicted by the model for the bulk compositions from the best-equilibrated samples agree well those observed in the strongly deformed samples.

These differences in assemblages seen this single shear zone are similar to changes observed in different shear zones observed by previous workers. They may reflect the degree to which the infiltrating fluids have modified the original bulk composition of the quartz diorite and provide a single mechanism to explain the variation in assemblages.