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Metamorphic veining and mass transfer in a chemically-closed system: a case study in Alpine metabauxites (Western Vanoise)

Anne Verlaguet (1), Bruno Goffé (2), Fabrice Brunet (3), Christophe Poinssot (4), Olivier Vidal (3), Nathaniel Findling (3), and Denis Menut (5)

(1) ISTEP, Univ Paris 6 - UPMC, Paris, France (anne.verlaguet@upmc.fr), (2) CEREGE, Aix-en-Provence, France, (3) ISTerre, Univ Grenoble 1, Grenoble, France, (4) DEN, CEA Marcoule, Bagnols-sur-Cèze, France, (5) DEN, CEA Saclay, Gif-sur-Yvette, France

During prograde metamorphism, aqueous fluids released in the course of successive dehydration reactions are expected to influence rock rheology, as well as kinetics of metamorphic reactions and mass transfer. Mineralized veins, ubiquitous in metamorphic rocks, are preserved witnesses of the fluid-rock interactions and can provide insights into the origin of both fluid and vein material, as well as on the scale of fluid circulation during metamorphic processes. However, it is often difficult to separate the influence on vein mineralization of external fluid infiltration versus locally derived fluid. The aim of this study is to investigate the vein-forming processes during local fluid-rock interactions, in relation to dehydration reactions, fluid/mass transfer and rock deformation, and to place constraints on fluid availability and distribution in the rock throughout the metamorphic cycle. Therefore, we focused on metamorphic veins developed in karstic pockets (metre scale) of Triassic metabauxites embedded in thick carbonate units, that have been isolated from large-scale fluid flow (field and geochemical evidences) during high-pressure low-temperature Alpine metamorphism (western Vanoise, French Alps). A cumulated amount of $\sim$13 vol% of water is inferred to have been produced locally by successive dehydration reactions, and part of this fluid remained in the bauxitic lenses during most of the metamorphic cycle. It is proposed that the internally-derived fluid has promoted the opening of fluid-filled open spaces (as attested by the euhedral habits of vein minerals) and served as medium for mass transfer from rock to vein. Indeed, the vein infill is obviously the result of chemical interactions, at the mm-to-cm scale, between the rock minerals and the locally-produced aqueous fluid. Based on mineralogical and textural features, two vein types can be distinguished: (1) some veins are filled with newly formed products of either prograde (chloritoid) or retrograde (chlorite) metamorphic reactions; in this case, fluid-filled open spaces seem to offer energetically favourable nucleation/growth sites; (2) the second vein type is infilled with cookeite or pyrophyllite, that were present in the host rock prior to the vein formation. In this closed chemical system, the components for the vein infill minerals have been transferred from rock to vein through the fluid, in a dissolution-transport-precipitation process, possibly stress-assisted. These different vein generations all contain Al-rich mineral infills, suggesting that Al was a mobile element (cm scale) during metamorphism. In these HP rocks, fluid flow may have been restricted and if so mass transfer occurred by diffusion in an almost stagnant fluid. Metamorphic veins can be seen as witnesses of fluid and mass redistribution that partly accommodate the rock deformation (lateral segregation).This study enhances the idea that rock deformation may be intimately linked to mass transfer towards fluid-filled open spaces.