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Two metamorphic events recorded by chemical zoning of garnet in garnet-phengite schists in the Zermatt area

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The Zermatt-Saas unit (ZSU) represents an ophiolite complex in the western Alps situated between continental basement rocks of the Monte Rosa and Dent Blanche nappes. It is build up of serpentinized mantle rocks, eclogite-fazies metabasalts, metagabbros and metasediments. These oceanic lithologies are overlain by the non-eclogitic metasediments of the Combin unit (CU), which is separated from the structurally lower rocks in the footwall by a major tectonic fault. The ZSU and the CU represent relics of the Piemonte Ligurian Ocean (Tethys) that opened in the Late Jurassic between the European continent to the NW and the Apulian plate to the SE. During subduction from the Mid Cretacous to the Eocene, the ZSU received a high-pressure metamorphic overprint. In this study, the authors investigate two Grt-Phg schists from the Theodul Glacier Unit (Zermatt), embedded within the Combin/Zermatt-Saas boundary zone. These rocks comprise a poly-metamorphic history preserved in strongly zoned garnet grains.

Electron microprobe analyses of garnet grains reveal two distinctive compositions. Standard isopleth-thermobarometry for both garnet compositions yields contrasting P/T conditions within a single garnet grain. This pressure gap, observed on a micrometer scale, cannot be attributed to a single known tectonic process. Absence of diffusional equilibration during the last metamorphic overprint is indicated by the preserved disequilibrium in a single garnet grain.

We used the software THERIA_G to calculate compositional garnet profiles along reasonable PT-paths. Modelling results yield insight into the interactions between the influence of the co-genetic metamorphic mineral assemblage, the effects of chemical fractionation and the development of garnet growth zoning. Comparing the results of measured quantitative profiles with those derived from thermodynamic modelling show that zoning pattern from the natural samples record post-growth modifications that require temperatures in the range of 625-650 °C. Diffusional equilibration depends on the mineral grain size, indicated by the complete homogenization of small grains, while large garnet grains (> 0.2 cm) preserve their primary core compositions. Because chemical composition of the large garnet cores are incompatible with the Alpine P-T path considered for our thermodynamic modelling, we propose the Grt-Phg schist have underwent two metamorphic cycles: 1) lower crustal amphibolite- to granulite-facies 2) Eo-Alpine subduction event. Furthermore, the preserved garnet textures imply slow exhumation rates for the rocks of the study area.