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THE METAMORPHIC EVOLUTION OF THE MONTE ROSA NAPPE AND ITS RELATION TO EXHUMATION BY FORE- AND BACK-THRUSTING IN THE WESTERN ALPS

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Over the past thirty years, tremendous progress has been made towards a better understanding of the metamorphic and tectonic history of the Alps. However, clarifications regarding the tectonic and metamorphic evolution of the Monte Rosa nappe and other high-pressure units, and in particular their exhumation mechanism, are still necessary. The Monte Rosa nappe is one of the best-known tectonic units and a classical structural feature of the Western Alps. The Monte Rosa nappe is enveloped by two ophiolitic units: the Zermatt-Saas unit above and to the south; the Antrona unit below. The Portjengrat unit separates the Monte Rosa nappe from the Bernhard nappe.

The comprehension of the metamorphic evolution is crucial for understanding subduction and exhumation mechanisms. With the thermodynamic software DOMINO in the KFMASH and CaNaTiKFMASH systems a qualitative and quantitative approach to pressure-temperature-composition equilibrium phase diagrams for whiteschists and basic rocks has been carried out. The application of the new P-T grid to the Monte Rosa whiteschists leads to the conclusion that the characteristic assemblage talc-magnesiochloritoid, given a water activity of 0.6, was stable at approximately 23 kbar and 500°C. This is considered to be the peak of Alpine eclogite facies metamorphism in this area. Eclogitic boudins in Mesozoic sedimentary cover located in the nose of the Monte Rosa nappe confirm the above derived metamorphic conditions. Within the whiteschists from the Monte Rosa nappe, the association talc + magnesiochloritoid breaks down to a kyanite + chlorite + phengite assemblage with quartz and water in excess. This latter assemblage is replaced by chlorite + low-Si phengite in the presence of excess quartz and water. This series of mineral assemblages helps to constrain the high-pressure peak of metamorphism and the exhumation path in the Monte Rosa. The exhumation path is divided in two parts: a first near-isothermal decompression from 23 kbar and 500°C to 7 kbar and 450°C, followed by a second slow decompression with concommitant cooling.

Four major deformation-phases can be distinguished. The main foliation (S1) is axial-planar to isoclinal syn-mylonitic D1-folds. In the northwestern part of the Monte Rosa nappe the L1 stretching-lineation and D1-fold axes are parallel and dip northwestward. A second generation of isoclinal syn-mylonitic folds (D2) overprints the D1 foliation. In general, the stretching lineations and the foliations are parallel to the northwestward dipping D2 fold axes and to the D2 axial-planes, respectively. Kinematic indicators associated with the D1-2 general foliation show a top-to-the NW transport direction. D1 and D2 deformations are associated with ongoing nappe stacking. D3 represents an early phase of backfolding and backthrusting, linked to the Mischabel backfold which deforms the entire nappe stack. D3 reorientates earlier D1-D2 fold axes, particularly in the nose of the Monte Rosa nappe. The reoriented strike of the D1-D2 fold axes is W-E. In the Portjengrat unit, D3 also induces a top-to the E shearing with a stretching lineation dipping gently to the west. Postdating all the above deformations, the late SE vergent D4 Vanzone backfold deforms the entire Monte Rosa nappe a second time.

The correlation of metamorphic and structural data leads to the conclusion that D1/D2 forethrusting deformation phases are associated with the exhumation of the Monte Rosa nappe from its high-pressure peak of metamorphism (nearly 80 km depth) to approximately 7 kbar (nearly 25 km depth) and 450°C. The D3 backfolding and backthrusting stage began after this substantial amount of exhumation. This implies that most of the exhumation of the high-pressure Monte Rosa nappe occurred by near-isothermal forethrusting during D1 and D2 and is unrelated to D3 and D4 backthrusting and backfolding. The latter phase reflects a late exhumation event of relatively minor importance and occurs with concommitant cooling. The exhumation P-T path reveals two different exhumation regimes reflecting two different exhumation mechanisms.

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