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The exhumation of the (U)HP rocks of the Central and Western Penninic Alps: comparison study between thermo-mechanical models and field data

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The Central and Western Penninic (CWP) Alps form an orogenic wedge of imbricate tectonic nappes. Orogenic wedges form typically at depths < 60 km. Nevertheless, a few nappes and massifs (i.e. Adula/Cima Lunga, Dora-Maira, Monte Rosa, Gran Paradiso, Zermatt-Saas) exhibit High- and Ultra-High-Pressure (U)HP metamorphic rocks suggesting that they were buried by subduction to depths >60 km and subsequently exhumed into the accretionary wedge. Mechanically, the exhumation of the (U)HP rocks from mantle depths can be explained by two contrasting buoyancy-driven models: (1) overall return flow of rocks in a subduction channel and (2) upward flow of individual, lighter rock units within a heavier material (Stokes flow).
In this study we compare published numerical exhumation models of (1) and (2) with structural and metamorphic data of the CWP Alps. Model (1) predicts the exhumation of large volumes of (U)HP rocks within a viscous channel (1100-500 km2 in a 2D cross-section through the subduction zone). The moderate volume (e.g. ∼7 km2 in a geological cross-section of the UHP unit of the Dora-Maira) and the coherent architecture of the (U)HP nappes suggests that the exhumation through (1) is unlikely for (U)HP nappes of the CWP Alps. Model (2) predicts the exhumation of appropriate volumes of (U)HP rocks, but generally the (U)HP rocks exhume vertically in the overriding plate and are not incorporated into the orogenic wedge. Nevertheless, the exhumation through (2) is feasible either with a vertical or with an extremely viscous and dense subduction channel. Whether these characteristics are applicable to the CWP UHP nappes will be discussed in light of field observations.