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Tectonic overpressure may reconcile the structural and petrological records of the Adula nappe (Central Alps)

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The Penninic Alps are the result of progressive underthrusting of oceanic and continental domains below the Adriatic microplate. Situated in the internal part of the Alpine orogen, they expose basement and thinned cover nappes which have been metamorphosed to variable degree, among them several units which were subjected to ultrahigh-pressure metamorphism. Due to the more or less strong nappe-internal deformation of these units, cross sections through the Penninic Alps cannot be restored kinematically by area or line balancing techniques. Instead, such restorations attempt to consistently reconcile geochronological and structural data and petrological pressure-temperature estimates. Pressure data are usually converted into depth assuming that they were lithostatic which puts the ultrahigh-pressure units to subcrustal depths. Tectonic exhumation of a unit from such a depth by whatever mechanism requires a large-scale normal fault with several tens of kilometres of displacement in the hanging wall of the unit. However, for all Penninic ultrahigh-pressure units (Dora Maira unit, Zermatt-Saas zone, Monviso unit, Adula-Cima Lunga nappe), the oldest mappable post-peak-pressure structures are related to top-to-the-foreland shearing, i.e. thrusting. There are two potential solutions to this dilemma. The first one is that either the exhumation was indeed accommodated by a large-scale normal fault which became completely overprinted during later deformational stages. The other one is that peak pressures were not lithostatic. To our knowledge, the first solution is applied to all kinematic models of the Alps so far. In order to explore the feasibility of the second solution, we performed a purely structural restoration of the NFP20-East cross section without lithostatic pressure-to-depth-conversions. This cross-section comprises the ultrahigh-pressure Adula nappe (up to ca. 30 kbar) and relies on quantitative strain data from the overlying units. The result shows that, in accordance with the structural record, the Adula nappe can be restored to maximum depths of up to ca. 60 km. For individual points of the Adula nappe in the restored cross section, corresponding to the sporadic occurences of (ultra)high-pressure rocks, lithostatic pressures are exceeded by petrological peak-pressure data by about 40% to 80%. Such amounts of tectonic overpressure are within the limits of theoretical considerations and numerical modelling results. For the other units comprised in the cross section, and for subsequent tectono-metamorphic stages of the Adula nappe, negligible amounts of overpressure (around 10%) are determined from the restoration. We conclude that (1) the NFP20-East cross section can be kinematically restored by using only structural data, (2) the dilemma mentioned above can be solved by admitting realisting amounts of tectonic overpressure, and (3) significant amounts of overpressure were established only locally and episodically.