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Overpressure during indentation and the origin of ultra-high-pressure rocks in the Alps

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Ultra-high-pressure (UHP) rocks in the Dora Maira Massif (Western Alps) record metamorphic pressures of >30 kbar and are commonly interpreted to indicate burial of crustal rocks to depths of >100 km. Tectonic models that explain these high pressures assume that rocks were taken to great depths by subduction processes, and were subsequently exhumed at least as fast as Alpine subduction. This kinematic interpretation raises the question of whether it is mechanically possible to achieve such extreme displacements in the restricted space of the Alpine Tethys. We propose an alternative mechanically consistent model, whereby UHP metamorphism results from the build up of overpressure during indentation related to collision. We apply the concept of contained plasticity in contact mechanics in numerical models of large scale continental collision, and demonstrate that overpressures associated with vertical thickening and strike-slip movements is much larger than so far predicted. Our results show that UHP metamorphism in the Dora Maira Massif could have occurred at considerably shallower depths (by more than a factor of 3) than previously suggested, therefore questioning the extremely fast burial and exhumation processes during Alpine convergence.