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On the role of horizontal displacements in the exhumation of high pressure metamorphic rocks

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High pressure metamorphic rocks exposed in the core of many mountain belts correspond to various types of upper crustal materials that have been buried to mantle depths and, soon after, brought back to surface at mean displacement rates up to few cm/y, comparable to those of plate boundaries. The vertical component of HP rock exhumation velocity back to surface is commonly well constrained by pressure estimates from petrology and geochronological data whereas the horizontal component remains generally difficult or impossible to estimate. Consequently, most available models, if not all, attempt to simulate exhumation with a minimal horizontal component of displacement. Such models, require that the viscosity of HP rocks is low and/or the erosion rate large –i.e. at least equal to the rate of exhumation. However, in some regions like the Aegean, where the exhumation of blueschists and eclogites is driven by slab rollback, it can be shown that the horizontal component of exhumation related displacement, obtained from map view restoration, is 5 to 7 times larger than the vertical one, deduced from metamorphic pressure estimates. Using finite element models performed with FLAMAR, we show that such a situation simply results from the subduction of small continental blocks (< 500km) that stimulate subduction rollback. The continental block is dragged downward and sheared off the downgoing mantle slab by buoyancy force. Exhumation of the crustal block occurs through a one step Caterpillar-type walk, with the block's tail slipping along a basal décollement, approaching the head and making a large buckle, which then unrolls at surface as soon as the entire block is delaminated. Finally, the crustal block emplaces at surface in the space created by trench retreat. This process of exhumation requires neither rheological weakening of HP rocks nor high rates of erosion.