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Intra-continental subduction and contemporaneous lateral extrusion of the upper plate: insights into Alps-Adria interactions

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A series of physical analogue experiments were performed to simulate intra-continental subduction contemporaneous with lateral extrusion of the upper plate to study the interferences between these two processes at crustal levels and in the lithospheric mantle. The lithospheric-scale models are specifically designed to represent the collision of the Adriatic microplate with the Eastern Alps, simulated by an intra-continental weak zone to initiate subduction and a weak confined margin perpendicular to the direction of convergence in order to allow for extrusion of the lithosphere. The weak confined margin is the analog for the opening of the Pannonian back-arc basin adjacent to the Eastern Alps with the direction of extension perpendicular to the strike of the orogen. The models show that intra-continental subduction and coeval lateral extrusion of the upper plate are compatible processes. The obtained deformation structures within the extruding region are similar compared to the classical setup where lateral extrusion is provoked by lithosphere-scale indentation. In the models a strong coupling across the subduction boundary allows for the transfer of abundant stresses to the upper plate, leading to laterally varying strain regimes that are characterized by crustal thickening near a confined margin and dominated by lateral displacement of material near a weak lateral confinement. During ongoing convergence the strain regimes propagate laterally, thereby creating an area of overlap characterized by transpression. In models with oblique subduction, with respect to the convergence direction, less deformation of the upper plate is observed and as a consequence the amount of lateral extrusion decreases. Additionally, strain is partitioned along the oblique plate boundary leading to less subduction in expense of right lateral displacement close to the weak lateral confinement. Both oblique and orthogonal subduction models have a strong resemblance to lateral extrusion tectonics of the Eastern Alps, where subduction of the adjacent Adriatic plate beneath the Eastern Alps is debated. Our results highlight that both indentation and subduction of Adria are valid collisional mechanisms to provoke lateral extrusion-type deformation within the Eastern Alps lithosphere, i.e. the upper plate. Moreover, the insights suggest that the Oligocene to Late Miocene structural evolution of the Eastern Alps is best described by phases of oblique and subsequent orthogonal subduction which is in line with Miocene rotations of the Adriatic plate. Furthermore, oblique subduction of the Adriatic plate provides a viable mechanism to explain the rapid decrease in slab length beneath the Eastern Alps towards the Pannonian Basin, also implying that the Adriatic slab can behave and form independently with regards to the adjacent subduction of Adria beneath the Dinarides.