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Interplate coupling at oblique subduction zones: influence on upper plate erosion.

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In active subduction zones, when the converging plates cannot slip freely past each other, "plate coupling" occurs. The moving subducting slab and therefore the coupling/decoupling relationship between plates control both short- and long-term deformation of the upper plate. Short-term deformation is dominantly elastic, occurs at human timescales and can be directly associated with earthquakes. Long-term deformation is cumulative, permanent and prevails at the geological timescale (Hoffman-Rothe et al., 2006, Springer Berlin Heidelberg).

Here we used 3D numerical simulations to test oblique subduction zones and to investigate: 1) how long-term deformation and coupling relationship vary along the trench-axis; 2) how this relationship influences erosion and down-drag of upper plate material. Our models are based on thermo-mechanical equations solved with finite differences method and marker-in-cell techniques combined with a multigrid approach (Gerya, 2010, Cambridge Univ. Press). The reference model simulates an intraoceanic subduction close to the continental margin (Malatesta et al., 2013, Nature Communications, 4:2456 DOI:10.1038/ncomms3456). The oceanic crust is layered with a 5-km-thick layer of gabbro overlain by a 3-km-thick layer of basalt. The ocean floor is covered by 1-km-thick sediments. Plates move with a total velocity of 3.15 cm/yr; the oblique convergence is obtained using velocity vectors that form an angle of 45° with the initial starting point of subduction (weak zone in the lithosphere). After initiation of plate convergence, part of sediments on top of the incoming plate enters the subduction zone and is buried; another part is suddenly transferred along strike at shallow depths and along the subducting slab according to the direction of the along-trench velocity component of subduction. The lateral migration of sediment causes the evolution of the trench along its strike from sediment-poor to sediment-rich. As soon as subduction starts, where the sedimentary infill of the trench is almost nonexistent, short-term shallow coupling occurs and friction between the frontal sector of the overriding plate and the downgoing plate triggers upper-plate bending. In this sector, after the early short-term coupling, the overriding plate is hereafter decoupled from the subducting slab. Moving along trench-strike, where sediments amount increases, the upper plate couples with the subducting plate and is dragged coherently downwards. If a large amount of sediments is stored in the trench the overriding plate is scraped off and incorporated as fragments along the plate interface.

Our results suggest that a) one main parameter controlling coupling at convergent plate margins is the occurrence and the amount of sediment at the trench; b) the upper plate margin is dragged to depth or destroyed only where sediments thickness at the trench is large enough to promote interplate coupling, suggesting that a variation of sediment amount along the trench-axis influences the amount and style of transport of upper-plate material in the mantle.