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# Overriding plate deformation and topography during slab rollback and slab rollover: insights from subduction experiments

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Overriding plate deformation (OPD) and topography vary at different subduction zones, with some subduction zones showing mainly overriding plate extension and low topography (e.g. Mariana, Tonga, Izu-Bonin subduction zones), while some showing mainly shortening and elevated topography (e.g. Makran, southern Manila subduction zones). Here we investigate how different subduction modes, namely trench retreat and trench advance, affect OPD and generate corresponding topography with fully dynamic analogue models of time-evolving subduction in three-dimensional space. We conduct two sets of experiments, one of which is characterized by trench retreat and slab rollback, and the other characterized by trench advance and slab rollover. We compute the mantle flow, the overriding plate strain and topography during subduction using the particle image velocimetry technique (PIV). The overriding plate in the experiments showing continuous trench retreat experiences overall extension, while in the experiments with trench advance following trench retreat it experiences overall shortening. The overriding plate in both trench retreat and trench advance subduction modes present fore-arc shortening and intra-arc extension. Our experiments indicate that the overall OPD except in the fore-arc region is mainly driven by the horizontal mantle flow at the base of the OP inducing a viscous drag force ($F_D$), and is determined by the gradient of the horizontal mantle flow velocity ($dv_x/dx$). Furthermore, a large-scale trenchward overriding plate tilting and an overall subsidence of the overriding plate were observed in the experiments showing continuous trench retreat, while a landward tilting and an overall uplift of the overriding plate were observed during long-term trench advance. The two types of topography during the two different subduction modes can be ascribed to the large-scale trenchward and landward mantle flow, respectively, and thus represent forms of dynamic topography. Our models showing trench advance provide a possible mechanism for OPD in the Makran subduction zone, which has experienced overall trench-normal tectonic shortening in the overriding plate, but shows extension in a local region of the coastal Makran that is spatially comparable to that in our experiments. In addition, these models might also provide an explanation for the regional topography at the Makran subduction zone, which shows a long-wavelength topographic high in the overriding plate near the trench that decreases northward.