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The effect of sediment fluxes on the dynamics and style of convergent margins

Adina E. Pusok and Dave R. Stegman
Scripps Institution of Oceanography, UCSD, La Jolla, USA (apusok@ucsd.edu)

Subduction zones represent the only major pathway by which continental material can be returned to the Earth's mantle. Quantifying the sediments mass flux through subduction zones is not only important to the general problem of petrogenesis of continental crust (i.e. Dewey and Windley, 1981, Plank and Langmuir, 1993), but also to the understanding whether large volumes of existing continental crust are ever recycled back into the mantle over long periods of geologic time.

When sediments are considered, convergent margins appear to fall into one of two classes: accretionary and erosive (Clift and Vannucchi, 2004). Accretionary margins are dominated by accretion of thick piles of sediments (>1km) from the subducting plate, while tectonic erosion is favored in regions where the sedimentary cover is <1 km. However, as data help define geometry of the global subduction system, the consequences of the two styles of margins on subduction dynamics remain poorly resolved. In this study, we run systematic 2D numerical simulations of free-subduction to investigate how sediment fluxes influence subduction dynamics. We aim to understand the factors that cause convergent margins to either accrete continental material delivered by the subducting plate or, alternatively, to subduct the trench sediment pile and even erode the basement of the upper plate.

We parameterize the effect of weak sediments by varying the thickness and viscosity of the sediment layer and upper plate. Our results show 3 modes of subduction interface: a) Tectonic erosion margin (high viscosity sediment layer), b) Low angle accretionary wedge margin (low viscosity, thin sediment layer), and c) High angle accretionary wedge margin (low viscosity, thick sediment layer). We find that the properties of the sediment layer modulate the extent of viscous coupling at the interface between the subducting and overriding plates. When the viscous coupling is increased, an erosive style of margin will be favored over an accretionary style. On the other hand, when the viscous coupling is reduced, sediments are scrapped-off the subducting slab to form an accretionary wedge. By increasing the thickness of the sediments, more sediment is available to create a thicker wedge (high angle and width). The velocity field at the subduction interface suggests internal counter-flow inside high-angle wedges, different from low-angle accretionary or tectonic erosion margins.