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Analysis of forearc morphology along accretionary and erosive margins in the contexxt of Coulomb wedge mechanics

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The taper of outer forearc wedges varies systematically along convergent margins as a function of the rate of accretion vs. erosion. Along margins with slow convergence rates and thick incoming sediment piles (i.e., accretionary margins– Sumatra, Makran, Cascadia, S. Barbados, Nankai), surface slope and taper are generally lower than along margins with rapid convergence rates, thin sediment piles, and extensive slope aprons (i.e., erosional margins– Middle America, S. America, Japan, Tonga). This observation can be explained in the context of non-cohesive critical Coulomb wedge behavior (Dahlen, 1984). For any given surface slope (or basal dip), there are two possible solutions for the critical taper (i.e., the maximum and minimum tapers), or the taper at which a wedge is everywhere at the verge of failure while sliding on a weak basal decollement. Along accretionary margins, trench sediments deform until the minimum taper is attained, the wedge slides at the verge of failure, and the locus of deformation shifts to the subcritical material of the protothrust zone. Along erosive margins where where material is removed from the upper plate preferentially updip along the plate boundary, the taper can exceed the minimum taper because there is no mechanism for maintaining the wedge at the lowest possible taper, and the wedge can slide as long as the taper is at or less than the maximum taper. Given the fact that these margin wedges are typically composed of basement of upper plate or old accreted material, it is unlikely that the greater taper is due to maintenance of minimum taper with a weaker wedge, although the basal friction could be larger. Thus, accretionary prisms and erosional margin wedges have significantly different cross-sectional geometries that relate to adjustments of a critical wedge to fluxes at the boundaries. In cross section, most forearc wedges have convex upward surface slopes. One explanation for this morphology is that arcward increasing strength within the wedge due to lithification and porosity reduction leads to a narrower minimum critical taper. An alternative argument is that the basal dip increases arcward. In such a case, the surface slope must decrease or even reverse direction arcward for a wedge of constant taper. These concepts are developed this presentation with reference to accretionary margins (Kodiak, Sumatra) and erosive convergent margins (Japan, Costa Rica).

Keywords: Coulomb mechanics, accretionary wedge, critical wedge, forearc, taper