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Landward vergence at the toe of the NW Sumatra accretionary wedge: implications for the rheology of the decollement in the source region of the 26 Dec. 2004 Sumatra earthquake

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The 26 dec. 2004 Sumatra earthquake (Mw 9.3) is the strongest earthquake recorded in the last 40 years. This megathrust earthquake ruptured a 1200 km long segment of the plate boundary in the Sumatra-Andaman subduction zone, most of which had not experienced a substantial thrust earthquake in the past 300 years. The mechanics of locked seismogenic zones is not entirely understood and the rheology of the incoming sedimentary section likely plays an important role.

We report on seismic data documenting the mechanics of the fold and thrust region at the toe of the accretionary wedge. The sedimentary section off Sumatra is imaged in industry seismic profiles as a roughly 3 km (2.5 s TWT) thick unit. These profiles reveal a highly unusual landward vergence along a 200 km long segment of the NW Sumatra margin (present in less that 1% of all accretionary wedges worldwide). The morphology observed in bathymetric images from the HMS Scott confirms that the two frontal thrusts are systematically directed towards the NE. This structural style is also observed in the Cascadia subduction zone offshore Washington, USA, where a large locked seismogenic zone is also present producing great (M8.5-9) earthquakes at long recurrence intervals (300-1500 years).

Analog modeling is presented which successfully reproduces landward vergent thrusting behavior, using granular materials overlying a ductile basal layer, exhibiting a Newtonian fluid type rheology. This unique rheological behavior of the basal layer and the implications for earthquake and tsunami generation are discussed.