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End-member type accretion: a closed subduction channel off western Java

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We present seismic data from the western Java margin off Indonesia. A pre-stack depth migrated profile reveals features of what may be termed a classical accretionary margin: a sediment filled trench, outer wedge or frontal prism -in the Java case with intense duplex formation due to frontal accretion- and imbricate thrust faulting, and an inner wedge characterized by out-of-sequence thrusts which are periodically reactivated. This inner wedge is composed of old accreted material. Piggy-back basins form on top and active deformation occurs here. Landward a forearc basin with up to 5 km of sediment fill overlies the margin framework.

The re-processing and application of pre-stack depth migration to this MCS line reveals numerous thrust faults in the outer wedge cut through the clearly imaged former décollement down to the plate boundary, thus shutting the subduction channel. This has important implications insofar as any material that is transported beyond the frontal prism cannot exit the subduction system. Material transfer occurs mainly at the margin toe by frontal accretion, with some sediment packages eventually being underplated causing uplift of the inner wedge. Out of sequence thrusts are imaged along the entire extent of the wedge and these may periodically be reactivated to adjust the taper. The data thus provide a clear and very rare illustration of an end-member case of subduction accretion with minimal 'loss' of material through a subduction channel, which is often modeled in simulations, but seldom imaged in nature.

Furthermore, underneath the forearc basin, the transition from the active backstop to the arc framework or fossil backstop is imaged in the MCS data. Velocity information from wide-angle data support our interpretation of old consolidated material originally being accreted against the margin rock framework and formation of a bivergent taper with an asymmetrical pro- and retro-wedge. A decisive increase in seismic velocities found from the refraction data coincides with the reflective pattern of the MCS depth section. Most striking is the velocity contrast where the upper limit of the arc framework is imaged. Sediment formations above the arc framework backstop are protected from permanent shortening, whereas adjacent layers experience local permanent deformation due to overthrusting of the retro-wedge. These formations form part of today's active backstop and are thus shortened by compression against the fossil backstop.

We used quantitative DEM modeling to gain some insight into the evolution of the distinct tectonic units. In the modelling, initiation of sediment accretion occurrs against the arc rock framework which we imaged in the MCS data. Incoming sediment then causes compression of the system and a closed subduction channel as seen off Java where the thrusts faults cut down to the plate boundary enhances uplift of the evolving forearc high due to underplating of material. Imbricate thrust faulting commences near the toe where discrete thrusts start to form. All the while, the basin strata are protected from permanent deformation by the arc framework or backstop. As the prism grows, overthrusting of the forearc high then causes localisation of deformation at the transition from the forearc high to the forearc basin, as imaged in the MCS data. Localisation of deformation migrates as the prism grows outward, with episodic shifting of the thrust faults towards the prism toe to accommodate compression and shortening. The active foremost thrust migrates discretely, resulting in contrasting modes of deformation between the active frontal prism or pro-wedge and the retro-wedge. Re-activation of structures adjusts the taper as a compressively critical wedge forms. Growth of duplex structures due to frontal material accretion is observed at the toe.

Off western Java, localisation of deformation today is concentrated in the frontal prism and pro-wedge, but internal deformation results in re-activation of thrust faults in the bivergent taper to adjust to basal boundary conditions and wedge strengths. Limited, strike-slip. out of plane of section movement is observed here, but as indicated by the thrust faults cutting the entire prism down to the plate boundary, across-strike motion is limited in the inner wedge and sediment subduction is minimized at least along this section of the Sunda margin, contributing to the efficient uplift of the forearc high above the primary taper and evolution of a bivergent taper. This margin thus represents an end-member type of accretionary systems with a closed subduction channel.