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Crustal structure of the Sunda-Banda arc transition: results from marine geophysical investigations offshore eastern Indonesia

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The Sunda-Banda arc transition, the easternmost portion of the Indonesian convergent margin, presents a probably unique natural laboratory to study lower plate variability and related upper plate deformation in the so-called 'subduction factory' for a deeper understanding of forearc evolution. In neighboring margin segments, we can observe strong changes of the incoming plate (transition from an oceanic to a continental lower plate, increasing plate age to the East, presence/absence of an oceanic plateau, variability in plate roughness) as well as a wide range of corresponding forearc structures, including large sedimentary basins and an accretionary prism/outer arc high of variable size and shape. During RV Sonne cruise SO190 in 2006 (SINDBAD: Seismic and Geoacoustic Investigations along the Sunda-Banda Arc Transition), we acquired a combination of seismic wide-angle OBH/OBS refraction, multichannel streamer and gravity data in order to study the seismic velocity structure of the subducting crust and the overriding island arc along a number of trench normal corridors located between 113°E and 121°E. Additionally, a number of trench parallel profiles were conducted which mainly focus on the internal structure of the large sedimentary basins and which were also intended for further clarifying the type of underlying forearc crust and mantle respectively.

We used a tomographic approach for refracted and reflected phases to obtain seismic velocity models which again were used for prestack depth-migration of the MCS data. In turn, we incorporated the highly resolved sedimentary portions as a priori structure in our tomography. The results show the seismic velocity structure of the incoming plate, starting 100 km seaward of the trench, and the adjoining forearc down to depths of 20-28 km, i.e. well into the upper mantle, and at the same time fit the gravity data very well, using simple velocity-density relations.

In the Argo abyssal plain, the models show 8.0-8.5 km thick oceanic crust. The velocities in the crust and uppermost mantle are reduced within distances of ∼50 km seaward of the trench, which coincides with the onset of normal faulting on the incoming oceanic plate. Anomalously low mantle velocities of 7.5 km/s directly beneath the Moho are possibly due to the intrusion of seawater and subsequent serpentinisation of mantle peridotite.

Landward of the trench in the outer arc high, velocities do not exceed 5.5 km/s down to the top of the subducting slab, which can be traced over ∼70 km length beneath the forearc down to ∼13 km depth. The plate boundary is of irregular shape, obviously imprinted by the complex deformation of the oceanic basement prior to subduction, which is further amplified as response to thrusting/downbending of the dissected oceanic blocks. Offshore Lombok island, our models reveal the geometry of the Lombok basin as well as the forearc Moho in ∼16 km depth. Reduced upper mantle velocities suggest a hydrated shallow mantle wedge for this corridor.

Further east offshore Sumba island, where the Java trench terminates and the transition to the collisional regime further east occurs, our models show a subducting oceanic plate of similar thickness and structure. But different to the situation offshore Lombok, we find no evidence for a shallow mantle wedge beneath the forearc; crustal-type velocities are found down to depths of ∼20 km. The different forearc regime is most likely related to the collision with the Sumba block. Our results give a detailed view into the complex structure in both the deeper and shallower portions of this convergent margin.