



Geodynamics of divergent double subduction: 3-D numerical modelling of a Cenozoic example in the Molucca Sea region, Indonesia

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Subduction of oceanic plates is the most important process for exchange of mass and energy between Earth's surface and interior. Occurrence of subduction on both sides of a single oceanic plate (i.e. divergent double subduction, DDS) can be geophysically observed or inferred from geological records. DDS may play an important role in plate tectonics, for instance, it potentially serves as an effective mechanism that enhances closure of an oceanic basin and accretion of magmatic arcs onto continental margins.

The Molucca Sea subduction zone in eastern Indonesia features collision of magmatic arcs and occurrence of intense earthquakes in response to ongoing subduction of the Molucca Sea plate on its eastern and western sides, thus known as a Cenozoic example of DDS and provides opportunity for further investigations. Geophysical observations reveal an inverted U-shape of the subducting Molucca Sea plate as a consequence of its unusual way of subduction. The geodynamics behind this unique form of subduction was still poorly constrained and lack sufficient discussions.

In this study, we carry out 3-D numerical modelling to investigate how DDS occurs. Results show that subduction of an oceanic plate can drive convergence of overriding plates and arc-arc collision; morphology of the subducting plate and convergence of the overriding plates can be controlled by order of subduction initiation on both sides, or depends on if the overriding plates are mobile. Our results suggest that: (1) the earlier subduction initiation on the western Sangihe side with respect to the eastern Halmahera side may have predominantly led to formation of the present-day asymmetrical shape of the subducting Molucca Sea plate; (2) the relative immobility of the western overriding Eurasian plate promoted westward migration of the Halmahera arc; (3) bending of the arcs was a consequence of the toroidal mantle flow induced by rollback of slabs.

We also highlight the importance of trench-parallel mantle flow in enabling escape of the slab-trapped mantle. This space problem may hinder sustainability of DDS (including other forms of double subduction) if the subducting slab is too wide (measured in trench-parallel direction). We therefore infer that DDS, due to space problem, is probably confined to narrow and short oceanic plates in tectonic setting like accretionary orogenic belts. Therefore, large-scale DDS may be rare but the frequency of occurrence and geodynamic importance of localised DDS in geologic time may have been underestimated.