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Numerical modelling of induced subduction initiation: thermal control exerted by plate ages in polarity reversal during plateau docking

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While continental break-up, formation of Atlantic-type (i.e. passive) margins and subduction dynamics are now fairly well understood, a comprehensive understanding of the full dynamics of subduction initiation is yet to be achieved.
This is mainly because there is no ongoing evidence of spontaneous subduction initiation (Stern and Gerya, 2017) and that our rheological understanding of passive margins shows that they are too strong to founder spontaneously (Gurnis, Hall and Lavier, 2004).

2D/3D numerical modelling results of subduction polarity reversal in an ocean-ocean setting are here presented for the first time. The main setup consists of gravity-driven subduction models (i.e. fully dynamic models not subjected to any imposed external forces), in which a positively buoyant lithospheric plateau is set to arrive at an ocean-ocean subduction trench.

The age of both overriding and subducting oceanic plates (used as a proxy for the rheological thermal dependent model structure) was systematically investigated, to evaluate its influence in the development of a new subduction zone as a consequence of plateau docking. We also investigate the role of mantle stress by varying its max strength (i.e. Peierls yield) between 300 and 900 MPa, as well as the role of far-field forces in 2D.
This was done by prescribing a scaled velocity field simulating the existence/absence of a non-cylindrical subduction scenario with a finite plateau's width, approaching 3D conditions. Numerical simulations were conducted using Underworld, a state-of-the-art geodynamic particle-in-cell parallel computational framework developed at Monash University.

The obtained model results show that any subducting plate older than 70 Ma only allows plateau accretion to occur. Additionally, frictional stress resistance is shown to control the likelihood of polarity reversal. Lower values cause earlier slab break-off and accretion of the plateau, while higher values allow for later break-off that aids in the bending of the overriding plate and initiation of its subduction.
Finally, the presence of a lateral slab pull force further increases the likelihood for polarity reversal by forcefully emplacing the plateau. This creates a bend on the overriding plate that can be used to trigger subduction initiation.

2D results were backed up by 3D simulations.

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