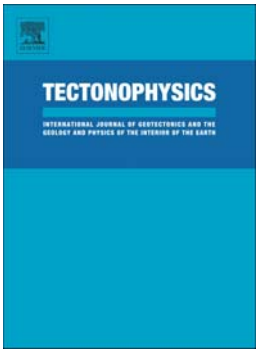

Slab breakoff: insights from 3D thermo-mechanical analogue modelling experiments

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Slab breakoff: insights from 3D thermo-mechanical analogue modelling experiments

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Abstract

The detachment or breakoff of subducted lithosphere is investigated using scaled three-dimensional thermo-mechanical analogue experiments in which forces are measured and deformation is monitored using high-speed particle imaging velocimetry (PIV). The experiments demonstrate that the convergence rate in a subduction zone determine if and when slab detachment occurs. Slow subduction experiments (with scaled convergence rates $\sim$1 cm yr^{-1}) have lower Peclet numbers and are characterised by lower tensile strength subducted lithosphere, causing detachment to occur when the downward pull force exerted by a relatively short subducted slab is relatively low. When continental collision is preceded by slow oceanic subduction, the subducted lithosphere therefore need not be very long or extremely negatively buoyant to cause detachment because the subducted oceanic lithosphere is hot and weak. Under such conditions detachment may occur sooner after the onset of continental subduction than previously predicted. In contrast, if a collision is preceded by rapid subduction ($\sim$10 cm yr^{-1}), breakoff will be delayed and occur only when the convergence rate slowed sufficiently to thermally weaken the slab and cause its eventual failure. The analogue experiments further confirm that slab detachment occurs diachronously as it propagates along the plate boundary. Stereoscopic PIV reveals a characteristic strain pattern that accompanies the detachment. Horizontal contraction and subsidence (with scaled values up to 1200 m) in the trench and forearc area preceeds the passage of the detachment, which is followed by horizontal extension and uplift (up to 900 m). High-frequency monitoring captures rapid propagation of the detachment along the plate boundary at rates of up to 100 cm yr^{-1}. However rate is not constant and interaction between the slab and lower mantle or opening of a backarc basin in the upper plate can reduce or stop slab breakoff propagation altogether.

Keywords: analogue modeling, subduction, slab detachment, plate tectonics

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