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# Lithospheric tearing at STEPs and associated upper plate deformation: an analogue model approach

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Tearing of the lithosphere at the lateral end of a subduction zone is a consequence of ongoing subduction. The location of active lithospheric tearing is known as a Subduction-Transform-Edge-Propagator (STEP), and the tearing decouples the down going plate and the part of the plate that stays at the surface. STEPs can be found alongside many subduction zones, such as at the south Caribbean or the northern end of the Tonga trench. For the Caribbean, the San Sebastián/El Pilar fault zone represents the surface expression of the wide STEP fault between the Caribbean and South America, and the active STEP is located near Trinidad. However, what parts of the deeper lithosphere participate in the tearing process is largely unknown. Some constraints on the deformation of the deep part of the lithosphere are available from gravity, which suggests significant lateral variability in densities of the lithospheric mantle to the south of the STEP fault zone. A sub-crustal low-density zone beneath northern South America may result from higher sub-crustal temperatures, such as would arise from an asthenospheric window resulting from a wide STEP fault at depth. Here we investigate what controls the evolution and geometry of the lithospheric STEP.

We study the ductile tearing in the process of STEP evolution by physical analogue models, which are dynamically driven by the buoyancy of the subducting slab. In our experiments, the lithosphere as well as asthenosphere are viscoelastic media in a free subduction setup. A stress-dependent rheology plays a major role in localization of strain in tearing processes of lithosphere such as slab break-off. Therefore we developed and tested new analogue materials that can serve as mechanical analogues for the stress-dependent lithosphere rheology, such as has been inferred by rock laboratory test for dislocation creep of olivine.

We show the influence of age and integrated strength of the lithosphere and its contrasts across the passive margin, on the timing, depth, and the degree of localization of the tearing process. When tearing of the lithosphere is dominated by ductile deformation, we find that gradual necking of the passive margin precedes tearing. Furthermore, we relate the tearing at depth to deformation at the surface during the evolution of the STEP.