How does a subduction initiate at an oceanic transform fault undergoing compression? Role of the fault structure and of the brittle-ductile transition depth

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Résumé

It has recently been shown that among the subduction zones initiated in the Cenozoic era, the subducting oceanic lithosphere could have any age, and was as often older than the overriding plate as younger than it. To try to explain this observation, we consider the simple setup of an oceanic transform fault and perform 2D thermomechanical experiments by applying the same convergence velocity (0.5 cm/yr) on the two plates. We combine a non-Newtonian viscous rheology and a pseudo-brittle behavior. We focus on the influence of the initial fault structure, by varying the fault gouge depth, z_wz, and the width of the thermal transition between the lithospheres, that can be adjusted to mimic a transform fault or a fracture zone. In most of our experiments, the mode of convergence accommodation is basically a function of the gouge depth, z_wz. We observe three main behaviors: (1) failure of subduction initiation if z_wz is quite shallow, (2) old plate subduction, that is best favored for moderately shallow fault gouges and low age offsets, and (3) young plate subduction if z_wz is quite deep, whatever the age offset. The thermal transition width only has a second-order effect. Compressive forces are excessively high (10ˆ13 N/m) if at least one plates is older than 30 Myr. The success of a young plate subduction and, to a lesser extent, of an old plate subduction, can be predicted by comparing z_wz at convergence onset to the depth of the brittle-ductile transition in the future upper plate. The subduction success and polarity depend on the possibility to form a low shear stress plane. We predict that only the young plate subduction can initiate at an active transform fault, while the old plate subduction is restricted to the setup of an old fracture zone where the relatively age offset is small. The modeled predominance of the thin plate underthrusting results from the strong influence of the plate strength contrast when lithospheres are stiff. Our results are consistent with the records of subduction initiation at the Mussau and Hjort Trenches, as well as at the Gagua ridge (W Pacific).

Mots-Clés: subduction initiation, oceanic transform fault, numerical simulations

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