How does a subduction initiate at an oceanic transform fault? Counter-intuitive insights from numerical experiments

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The process of subduction initiation, especially at an oceanic transform fault or fracture zone, is still poorly constrained and caused a great deal of controversy such as: Can subduction initiate there without any external forcing? Is the thicker plate really the more likely to subduct? To try to answer the first question, we present a parametric study of the feasibility of "spontaneous" subduction initiation, i.e., lithospheric gravitational collapse, at a transform fault (TF). Candidates from recent subduction initiation events at an oceanic TF that could fulfill the criteria of spontaneous subduction are identified, including Izu–Bonin–Mariana, Yap, and Matthew and Hunter. An extensive exploration of conditions allowing for the spontaneous sinking of the older oceanic plate at a TF using 2-D thermo-mechanical simulations is then performed. The parametric study better delimits the ranges of mechanical properties necessary to achieve the old plate sinking (OPS). We characterize the OPS conditions in terms of the reasonable vs. unrealistic values of the mechanical parameters. The parameters that exert the strongest control over whether OPS can occur or not are the brittle properties of the shallow part of the lithosphere, which affect the plate resistance to bending, the distance away from the TF over which weakening is expected, and the crust density. One mechanical parameter at least has to be assigned an unrealistic value and at least two other ones must be tuned to extreme ranges to achieve OPS, which we do not consider realistic. We point out inconsistencies between the process and consequences of lithospheric instability as modeled in our experiments, and records of subduction infancy, for the 3 geological candidates of « spontaneous » subduction initiation, to conclude that this process of « subduction initiation at a TF is unlikely in modern Earth conditions. Next, we simulate normal convergence imposed symmetrically on the two oceanic plates and study the mode of subduction iniation. We find that the success of initiation, as well as the subduction polarity (defined by the incoming plate) strongly depend on the plate age offset and the initial geometry of the transform fault. The results of the numerical experiments are finally compared to a new and exhaustive compilation of Cenozoic subduction initiations.

Mots-Clés : subduction initiation, numerical simulations, gravitational lithospheric collapse, transform faults.

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