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Failed oceanic transform models: experience of shaking the tree

Taras Gerya
ETH-Zurich, Institute of Geophysics, Department of Earth Sciences, Zurich, Switzerland (taras.gerya@erdw.ethz.ch)

In geodynamics, numerical modeling is often used as a trial-and-error tool, which does not necessarily requires full understanding or even a correct concept for a modeled phenomenon. Paradoxically, in order to understand an enigmatic process one should simply try to model it based on some initial assumptions, which must not even be correct… The reason is that our intuition is not always well "calibrated" for understanding of geodynamic phenomena, which develop on space- and timescales that are very different from our everyday experience. We often have much better ideas about physical laws governing geodynamic processes than on how these laws should interact on geological space- and timescales. From this prospective, numerical models, in which these physical laws are self-consistently implemented, can gradually calibrate our intuition by exploring what scenarios are physically sensible and what are not. I personally went through this painful learning path many times and one noteworthy example was my 3D numerical modeling of oceanic transform faults. As I understand in retrospective, my initial literature-inspired concept of how and why transform faults form and evolve was thermomechanically inconsistent and based on two main assumptions (btw. both were incorrect!): (1) oceanic transforms are directly inherited from the continental rifting and breakup stages and (2) they represent plate fragmentation structures having peculiar extension-parallel orientation due to the stress rotation caused by thermal contraction of the oceanic lithosphere. During one year (!) of high-resolution thermomechanical numerical experiments exploring various physics (including very computationally demanding thermal contraction) I systematically observed how my initially prescribed extension-parallel weak transform faults connecting ridge segments rotated away from their original orientation and get converted into oblique ridge sections… This was really an epic failure! However, at the very same time, some pseudo-2D "side-models" with initial strait ridge and ad-hock strain weakened rheology, which were run for curiosity, suddenly showed spontaneous development of ridge curvature… Fraction of these models showed spontaneous development of orthogonal ridge-transform patterns by rotation of oblique ridge sections toward extension-parallel direction to accommodate asymmetric plate accretion. The later was controlled by detachment faults stabilized by strain weakening. Further exploration of these "side-models" resulted in complete changing of my concept for oceanic transforms: they are not plate fragmentation but rather plate growth structures stabilized by continuous plate accretion and rheological weakening of deforming rocks (Gerya, 2010, 2013). The conclusion is – keep shaking the tree and banana will fall…

Gerya, T. (2010) Dynamical instability produces transform faults at mid-ocean ridges. Science, 329, 1047-1050.
Gerya, T.V. (2013) Three-dimensional thermomechanical modeling of oceanic spreading initiation and evolution. Phys. Earth Planet. Interiors, 214, 35–52.