

EGU21-1420, updated on 02 Dec 2021

<https://doi.org/10.5194/egusphere-egu21-1420>

EGU General Assembly 2021

© Author(s) 2021. This work is distributed under the Creative Commons Attribution 4.0 License.



Investigating the role of transient rapid trench retreat in initiating rifting of a mobile overriding plate during subduction

Zhibin Lei and Huw Davies

School of Earth and Environmental Sciences, Cardiff University, Cardiff, UK (leiz2@cardiff.ac.uk)

Trench retreat, or slab roll-back, has been proposed to account for various degrees of extensional deformation within the overriding plate in subduction zones, eg. Izu-Bonin-Mariana, Tonga etc. However, the relationship between trench retreat rate and the degree of extension has not been rigorously tested. Here we obtain a wide range of trench retreat rate by varying the initial age of subducting plate (SP, Age_{SP}^0) and overriding plate (OP, Age_{OP}^0) met at trench. Then we investigate how much trench retreat rate is needed to initiate rifting in the OP.

The results show that models would evolve from a non-steady state towards a steady state as the SP sinks to the transition zone at 660 km.

Before the SP starts to interact with the transition zone, the trench retreat rate accelerates with time reaching a maximum value (v_{max}), which can be very high but only lasts a short time (~ 0.5 Myr). For models with a given OP, v_{max} is Age_{SP}^0 -dependent. The trench retreat rate, on the other hand, determines the extensional extent within the OP. With increasing Age_{SP}^0 , a minimum trench retreat rate (v_{rift}) is needed to initiate rifting within the OP. For models with $\text{Age}_{\text{OP}}^0 = 20$ Myr and $\text{Age}_{\text{OP}}^0 = 25$ Myr, v_{rift} is ~ 19 cm/yr and ~ 27 cm/yr separately. This implies that an older OP is more resistant to extensional stress field driven by trench retreat. In all, three types of stretching states are observed within the OP in our models: i) minor extension, where $v_{\text{max}} < v_{\text{rift}}$ and the OP lithosphere has little extension; ii) rift, where $v_{\text{max}} \approx v_{\text{rift}}$ and the OP would rift but not be torn apart; iii) break-up, where $v_{\text{max}} > v_{\text{rift}}$ and the OP would rift when the trench retreat rate reaches v_{rift} , then breaks up into two parts after it exceeds v_{rift} . We note all three states involve different extents of mantle wedge erosion at ~ 100 km away from the trench underneath the OP, while rifting and break-up occur > 700 km away from the trench. In the break-up cases, the two parts of the OP can be ~ 250 km apart.

After the SP reaches the transition zone, the trench retreat rate would drop to a constant magnitude around 2 cm/yr and lose the Age_{SP}^0 -dependency. This is because the viscosity jump at the transition zone prevents the SP from accelerating into the lower mantle. Meanwhile, the Age_{SP}^0 -dependent negative buoyancy loses its dominant role in driving the trench retreat.

We discuss two driving mechanisms to relate the initiation of extension with rapid trench retreat (trench suction): 1) focused upwelling from the transition zone; 2) horizontal basal drag. We conclude that the transient rapid trench retreat can lead to an extensional stress field through

basal drag which is strong enough to initiate rifting or even break-up within a mobile overriding plate. A high negative SP buoyancy could play the driving force to generate this transient rapid trench retreat.