Geophysical Research Abstracts
Vol. 21, EGU2019-5956, 2019
EGU General Assembly 2019

Addressing subduction initiation: A key - but unresolved – feature of plate tectonics

Marzieh Baes (1), Stephan Sobolev (1,2), Taras Gerya (3), Sascha Brune (1,2)

(1) Helmholtz-Zentrum Potsdam, Deutsches GeoForschungsZentrum GFZ, section 2.5, Potsdam, Germany , (2) Potsdam University, Potsdam, Germany, (3) ETH Swiss Federal Institute of Technology Zurich, Zurich, Switzerland

Despite recent developments in geophysical and geological research, the formation of a new subduction zone remained an enigmatic issue so far. Investigating of how, where and when a new converging plate boundary forms will advance our understanding of plate tectonic driving forces and tectonic deformation on Earth. Recent studies (e.g., Ueda et al., 2008; Gerya et al., 2015; Baes et al., 2016) proposed a new scenario for subduction initiation that is independent of any pre-existing lithospheric weakness, which has the potential to explain the formation of Earth's first subduction zone and hence the beginning of plate tectonics. According to this scenario, the arrival of a buoyant plume beneath oceanic lithosphere can result in the development of several retreating subduction zones around a newly formed plateau. Among the yet unexplored aspects of this new scenario are the conditions leading to the formation of one-sided subduction zones. Here, using 3-d numerical models, which are carried out with the thermal-mechanical finite-difference code I3ELVIS, we aim to study the lithosphere's response to plume-lithosphere interaction and the factors controlling lithospheric deformation. We set up models based on Earth's condition in both present-day and Archean time. The aim is to study the effect of different parameters such as the mantle temperature, thickness of the crust, age of the oceanic lithosphere and the impact of regional extension on the response of the lithosphere to the plume-lithosphere interaction. The outcome of this work helps us to better understand the deformation mechanisms in natural examples of plume-lithosphere interaction such as the south-western margin of the Caribbean plate, where arrival of a buoyant plume beneath the lithosphere resulted in subduction initiation at $\sim$100 Myr ago (Whattam and Stern, 2015).
The model results show that positive buoyancy of thick plateau crust acts against plume-induced subduction initiation. In addition, lithospheric response depends on the location of the plume's head with respect to the edge of plateau. Our study also indicates that moderate extension rates facilitate formation of a new subduction zone induced by plume-lithosphere interaction. In Archean, when the mantle was hotter than that at the present, plateau-plume interaction could have lead to the periodic initiation of short-lived circular subduction zones.

References:
• Baes, M., Gerya, T., Sobolev, S.V., 2016, 3-D thermo-mechanical modeling of plume-induced subduction initiation, 453, 193-203.
• Gerya, T.v., Stern, R.J., Baes, M., Sobolev, S.V., Whattam, S.A., 2015, Plate tectonics on the Earth triggered by plume-induced subduction initiation, Nature, 527, 221-225.
• Ueda, K., Gerya, T., Sobolev, S.V., 2008, Subduction initiation by thermal–chemical plumes: numerical studies. Phys. Earth Planet. Inter. 171, 296–312.
• Whattam, S. A. & Stern, R. J., 2015, Late Cretaceous plume-induced subduction initiation along the southern margin of the Caribbean and NW South America: the first documented example with implications for the onset of plate tectonics. Gondwana Res. 27, 38–63.