Solid Earth Discuss.,
doi:10.5194/se-2017-14-SC1, 2017

Solid Earth Discussions

SED

Interactive comment

Interactive comment on "Breaking supercontinents; no need to choose between passive or active" *by* Martin Wolstencroft and Huw Davies

L. Dal Zilio

luca.dalzilio@erdw.ethz.ch

Received and published: 15 March 2017

The research paper presents novel and interesting results and corresponds to the scope of the Solid Earth. I consider this review very interesting and timely study in which the authors use numerical simulations to propose that supercontinent breakup events should always involve both active mantle upwelling and extensional stresses in the lithosphere. Overall, the paper is quite short, but very well-written, pretty balanced, and the illustrations are to the point. It provides a modern perspective on the topic.

I have some comments to the article:

1) An important aspect that should be mentioned is the mantle structure. In particular,

Printer-friendly version

Discussion paper

should be mentioned that the temporal evolution of the convective wavelength is still an enigmatic question, and it has important implications for the location of major mantle upwellings and the initiation of continental breakup. The present-day Earth's mantle structure is dominantly at spherical harmonic degree-2. However, how mantle structure may have evolved in the geological past is still unclear (Zhong et al., 2007). Also, phase transformations in the mid-mantle–which are often ignored in mantle convection simulations–introduce buoyancy forces and thermomechanical effects in the convective mantle system that can fundamentally affect the patterns of mantle convection (Faccenda & Dal Zilio, 2017).

2) I am intrigued by the discussion about the source of these far-field extensional stresses. The authors should consider that subduction and subsequent roll-back of oceanic plates at continental margins have been invoked to support the occurrence of large-scale, long-term extensional stresses (Bercovici & Long, 2014; Lowman & Jarvis, 1996). Also, numerical simulations indicate that downgoing slabs play a central role in establishing the location and formation of subcontinental mantle plumes (Tan et al., 2002; Heron & Lowman, 2011; Heron et al., 2015; Lenardic et al., 2011; Zhang et al., 2010; Zhong et al., 2007).

3) During the last years, the role of deep slab dynamics appears central to triggering breakup of continents. Penetration of the slab into the lower mantle may generate a surge of compression at the plate boundary because (i) trench migration slows down (Goes et al., 2008; Faccenna et al., 2017), and (ii) because the upper plate is dragged against the subduction zone by a large-scale return flow. This return flow seems to be the key ingredient to triggering supercontinent breakup: subduction of lithosphere in the lower mantle reorganises the mantle flow into a wide cell, thereby localising extensional stresses at greater distances from the trench (Dal Zilio et al., 2017), which eventually may culminate in the breakup of supercontinents.

I hope my comments contribute the authors to improve the manuscript.

Best regards, Luca Dal Zilio

References 1) Bercovici, David, & Long, Maureen D. 2014. Slab rollback instability and supercontinent dispersal. Geophysical Research Letters, 41(19), 6659–6666. 2) Dal Zilio, Luca, Faccenda, Manuele, Capitanio, Fabio A. 2017. The role of deep subduction in supercontinent breakup. Tectonophysics. 3) Faccenda, Manuele, & Dal Zilio, Luca. 2017. The role of solid–solid phase transitions in mantle convection. Lithos 268: 198-224. 4) Faccenna, C., Oncken, O., Holt, A. F., & Becker, T. W. 2017. Initiation of the Andean orogeny by lower mantle subduction. Earth and Planetary Science Letters, 463, 189-201. 5) Goes, Saskia, Fabio A. Capitanio, and Gabriele Morra. 2008. Evidence of lower-mantle slab penetration phases in plate motions. Nature 451.7181: 981-984. 6) Heron, Philip J, & Lowman, Julian P. 2011. The effects of supercontinent size and thermal insulation on the formation of mantle plumes. Tectonophysics, 510(1), 28–38. 7) Heron, Philip J, Lowman, Julian P, & Stein, Claudia. 2015. Influences on the positioning of mantle plumes following supercontinent formation. Journal of Geophysical Research: Solid Earth, 120(5), 3628–3648. 8) Lenardic, Adrian, Moresi, L, Jellinek, AM, O'neill, CJ, Cooper, CM, & Lee, CT. 2011. Continents, supercontinents, mantle thermal mixing, and mantle thermal isolation: Theory, numerical simulations, and laboratory experiments. Geochemistry, Geophysics, Geosystems, 12(10). 9) Lowman, Julian P, & Jarvis, Gary T. 1996. Continental collisions in wide aspect ratio and high Rayleigh number two-dimensional mantle convection models. Journal of Geophysical Re- search: Solid Earth, 101(B11), 25485–25497. 10) Tan, Eh, Michael Gurnis, and Lijie Han. Slabs in the lower mantle and their modulation of plume formation. Geochemistry, Geophysics, Geosystems 3.11 (2002): 1-24. 11) Zhang, Nan, Zhong, Shijie, Leng, Wei, & Li, Zheng-Xiang. 2010. A model for the evolution of the Earth's mantle structure since the Early Paleozoic. Journal of Geophysical Research: Solid Earth, 115(B6). 12) Zhong, Shijie, Zhang, Nan, Li, Zheng-Xiang, & Roberts, James H. 2007. Supercontinent cycles, true polar wander, and very long-wavelength mantle convection. Earth and Planetary Science Letters, 261(3), 551–564.

Interactive comment on Solid Earth Discuss., doi:10.5194/se-2017-14, 2017.

Printer-friendly version

Discussion paper