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More than one way to skin a continent? Modern natural analogues, findings, and future directions in delamination modelling

Kosuke Ueda (1) and Oguz H Gögüs (2)

(1) ETH Zürich, Department of Earth Sciences, Zürich, Switzerland (kosuke.ueda@erdw.ethz.ch), (2) Eurasia Institute of Earth Sciences, Istanbul Technical University (ITU), Turkey

Delamination is a continuation of subduction by other means, but only one mechanism to remove denser parts of the lithosphere in an orogenic context. Delamination (peeling off) became probably important during the Precambrian after convective removal and thermal erosion likely dominated on early Earth (and potentially boosted silicification and rise of the continents). In modern tectonics, most of the removal of dense material from the subduction-orogen system and associated surface expressions can be attributed to delamination and slab break-off, while convective removal (viscous dripping) is also suggested.

Although delamination is principally feasible and, in many orogenic systems, in good agreement with geological and geophysical observations which indicate that lithospheric mantle has been removed, the combined data set is often not sufficiently unambiguous to identify the specific process itself. Numerical models can provide a fully observable and consistent, however simplified representation of geometries and deformation over time for specific conditions. Legitimating the link of model predictions to natural observations, and the appropriateness of these specific choices remain delicate issues that should be considered separately from the principal merits of dynamic model predictions. In this contribution, we summarize recent results and critically review these predictions made by numerical models of delamination.

Some tens of modelling studies have provided insights on the dynamics of this process since the 1980s, and how natural differences (e.g., the relative motion of plates) and conceptual choices (e.g., the rheological model) would influence it. Main findings and factors such as rheological structure, and dynamic weakening and densification processes are briefly reviewed. Based on selected case equivalents, we summarize how predictions from various model match with geological analogues. The comparison covers topography, kinematics, and crustal structure, as well as new model data on magma production, sources, and three-dimensional heterogeneities. Finally, we suggest open questions and research directions that remain to be addressed in the future.