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Coupled/decoupled lithospheric drips and their surface expression with insights from analogue modelling

Julia Andersen (1), Tasca Santimano (1), Oguz Gogus (2), Russell Pysklywec (1), Nathan Stoikopoulos (1), and Erkan Gun (1)

(1) University of Toronto, Department of Earth Sciences, Toronto, Canada, (2) Eurasia Institute of Earth Sciences, Istanbul Technical University, Maslak, Turkey

Lithospheric drips may develop at the lowermost portion of the mantle lithosphere (colder/denser mantle lithosphere) and sink into the underlying sub-lithospheric mantle. Inferred mainly from a series of geological and geophysical interpretations (i.e. surface subsidence, uplift, and shortening) this process is responsible for the removal or thinning of the lithosphere in intraplate (e.g., North China Craton) and active orogenic regions (e.g., Cordilleran magmatic arcs, Tibet, Anatolia). Previous studies focused on the surface impacts of the dripping mantle lithosphere and were mainly in a 2D geometry. In this study, we have conducted a series of scaled 3D analogue/laboratory experiments with quantitative analyses using the high-resolution Particle Image Velocimetry (PIV) technique. We explore how the coupling vs. decoupling of a lithospheric drip to the upper part of the mantle lithosphere evolves, and additionally how the surface crust responds to the deeper lithospheric removal process. The model includes a sub-lithospheric mantle (PDMS), mantle lithosphere (PDMS and plasticine) and upper crust (silica spheres and e-spheres in a Plexiglass box. Model results show that a decoupled lithospheric drip only yields subsidence, with no evidence of shortening; whereas lithospheric drip coupled to the crust will produce subsidence followed by thickening/shortening of the upper crust. At the later stages of the coupled drip-mantle lithosphere experiments, the drip thins and necks and the surface topography uplifts. In models with a lower viscosity mantle lithosphere ($\sim 2.1 \times 10^4$ Pa s) opposed to a higher viscosity model ($\sim 2.9 \times 10^4$ Pa s), several secondary drips develop in addition to the primary lithospheric downwelling. The models show a variety of tectonic features comparable to areas where lithospheric drips have been postulated on Earth (e.g., circular sedimentary basins that developed distant from plate boundaries) and for other planets that show no significant evidence for surface plate tectonics but still have deformed crusts (e.g., coronae formation on Venus).