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Numerical modelling of lithospheric flexure at subduction zones: what controls the formation of petit-spot volcanoes?

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Petit-spot volcanoes were discovered fifteen years ago by Japanese researchers at the top of the down going plate in front of Japan (1). The location of these small lava flows is unusual, and seems related to the plate flexure in front of the subduction zone. Their formation seems, therefore, not to correspond to any classical type of volcanism such as MORB generation at mid ocean ridges, arc volcanism in subduction zones or intraplate volcanoes classically associated to deep mantle plumes. The discovery of petit-spot volcanoes is of great significance as it demonstrates, for the first time, that tectonic processes could generate intraplate volcanism and supports the existence of small-degree melts at the base of the lithosphere.
First models for the formation of petit-spot volcanoes suggest that plate bending produces extension at the base of the lithosphere, thus allowing large cracks to propagate across the lithosphere. These cracks promote the extraction of low degree melts from the base of the lithosphere (2). However, the study of petit-spot mantle xenoliths from Japan (3) demonstrates that low degree melts are not directly extracted to the surface, but percolate and metasomatize the oceanic lithosphere.
The aim of this study is to better understand the physical processes associated with the formation of petit-spot volcanoes. These thermo-mechanical processes will be studied using upper-mantle scale numerical simulations based on a 2D finite difference code. The numerical model considers viscoelastoplastic deformation; combination of laboratory-derived flow laws (e.g. diffusion and dislocation creep, Peierls creep) and heat transfer. The first step is to quantify the deformation processes that occur in the lithosphere and at the Lithosphere-Asthenosphere Boundary (LAB). The aims are to investigate, in particular, extensional deformation at the base of the lithosphere which is induced by plate flexure in front of a subduction zone. This study focuses on quantifying stresses, strain rates, and viscosities to evaluate the thermo-mechanical conditions which are important for the percolation of melt initially stocked at the base of the lithosphere.

References
(1) Hirano et al., 2006. Science 313, 1426–1428.
(2) Yamamoto et al., 2014, Geology 42, 967-970.
(3) Pilet et al., 2016, Nature Geoscience 9, 898–903.