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Numerical Modelling of Subduction Zones: a New Beginning

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Subduction zones are one of the most studied although still controversial geodynamic process. Is it a passive or an active mechanism in the frame of plate tectonics? How subduction initiates? What controls the differences among the slabs and related orogens and accretionary wedges? The geometry and kinematics at plate boundaries point to a “westerly” polarized flow of plates, which implies a relative opposed flow of the underlying Earth’s mantle, being the decoupling located at about 100-200 km depth in the low-velocity zone or LVZ [1]. This flow is the simplest explanation for determining the asymmetric pattern of subduction zones; in fact “westerly” directed slabs are steeper and deeper with respect to the “easterly or northeasterly” directed ones, that are less steep and shallower, and two end members of orogens associated to the downgoing slabs can be distinguished in terms of topography, type of rocks, magmatism, backarc spreading or not, foredeep subsidence rate, etc.. The classic asymmetry comparing the western Pacific slabs and orogens (low topography and backarc spreading in the upper plate) and the eastern Pacific subduction zones (high topography and deep rocks involved in the upper plate) cannot be ascribed to the age of the subducting lithosphere. In fact, the same asymmetry can be recognized all over the world regardless the type and age of the subducting lithosphere, being rather controlled by the geographic polarity of the subduction. All plate boundaries move “west”.

Present numerical modelling set of subduction zones is based on the idea that a subducting slab is primarily controlled by its negative buoyancy. However, there are several counterarguments against this assumption, which is not able to explain the global asymmetric aforementioned signatures. Moreover, petrological reconstructions of the lithospheric and underlying mantle composition, point for a much smaller negative buoyancy than predicted, if any [2,3]. Therefore we attempt to generate a different model setup in which are included both a decoupling at the lithosphere base and the “westward” drift of the lithosphere that implies a relative “eastward” mantle flow. The method used for this task is an implementation of I2VIS code, a 2D thermomechanical code incorporating both a characteristics based marker-in-cell method and conservative finite-difference (FD) schemes [4]. The implementation involves both the integration of the LVZ and the application of an incoming and outgoing mantle flow through the lateral boundaries of the rectangular box (that represent the basic setup of the models). This new insight in numerical modelling of subduction zones could help to have a more accurate comprehension on what is actually influencing subduction zones dynamics in order to successively explain what are the causes of this fundamental process and what are its implications on plate tectonics dynamics.

References:

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