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A fictitious domain method for fluid/solid interaction applied to the plate folding over the 660 Km depth boundary.

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A large variety of geodynamical problems involve a mechanical system where a competent body is embedded in a more deformable medium, and hence they can be viewed as belonging to the field of solid/fluid interaction.The lithosphere/asthenosphere interaction in subduction zones is among those kind of problems which are generally difficult to tackle numerically since the immersed (solid) body can be geometrically complex and the surrounding (fluid) medium can thus undergo large deformation.

Our work presents a new numerical approach for the study of subduction zones. The lithosphere is modeled as a Maxwell viscoelastic body sinking in the viscous asthenosphere. Both domains are discretized by the Finite Element Method (FEM) and we use a staggered coupling method. The interaction is provided by a non-matching interface method called the Fictitious Domain Method (FDM). We have validated this method with some 2-D benchmarks and examples.

Through this numerical coupling method we aim at studying the effect of mantle viscosity on the cyclicity of slab folding on the 660 km depth discontinuity approximated as an impenetrable barrier. Depending on the kinematics condition imposed to the overriding and subducting plates, analog and numerical models have previously shown that cyclicity occurs.

The viscosity of the asthenosphere (taken as an isoviscous or a double viscosity-layer fluid) impacts on folding cyclicity and consequently on the slab's dip as well as the stress regime of the overriding plate.

In particular, applying far-field plate velocities corresponding to those of the South-American and Nazca plates at present, (4.3 cm/yr and 2.9 cm/yr respectively), we obtain periodic slab folding which is consistent with magmatism and sedimentalogical records. These data report cycles in orogenic growth of the order of 30-40 Myrs, a period that we reproduce when the mantle viscosity ranges in between 3 and 5 x 10^{20} Pa.s.

Moreover, we reproduce episodic development of horizontal subduction induced by cyclic folding and, hence, propose a new explanation for episodes of flat subduction under the South-American plate.

We show also preliminary results of 3-D subduction.