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2D Numerical simulations of intraoceanic subduction: the case study of the Ligurian Alps.

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Intraoceanic subduction is an important part of the present and past subduction systems, and some features of such process are not yet fully understood. We therefore studied intraoceanic subduction zones with the help of 2D numerical models, analyzing the parameters influencing their evolution in time and space.

We applied the finite differences method on a rectangular grid, to calculate properties such as pressure, temperatures and velocities inside the models solving a set of equations. The latter comprise the Stokes equation of motion, the continuity equation and the heat transport equation. Temperature and velocities are computed on the nodes of the grid whereas pressures are calculated for the geometrical centers of the cells. We defined material properties such as density or viscosity on marker points, initially positioned on a regular rectangular grid. The markers and therefore the material properties are moved through the mesh according to the velocity field using the forth order Runge-Kutta method (Gerya et al. 2002).

Subduction is forced to begin at a weak zone in the lithospheric mantle within an oceanic basin of prescribed width. The effect of different arrangements of rock bodies inside the subducting lithosphere on the evolution of the process was carefully analyzed. In particular we reproduced two distinct structures of the oceanic lithosphere: i) the layered oceanic crust made up of a stratified succession typical of fast-spreading ridges and ii) the oceanic lithosphere typical of slow and ultra-slow spreading centers, where an incomplete sequence is observable. The latter structure lacks a sheeted dike complex, has a low volume of gabbros and basalts and gabbros form discrete intrusions in variably serpentinized peridotites (Lagabrielle et al., 1997; Mével, 2003). Such an “heterogeneous” structure is characteristic of the Alpine and Appennine ophiolites that characterized the Mesozoic Ligurian Tethys located between Europe and Adria.

The depth of the serpentinized horizon in an oceanic lithosphere with the “atypical” structure controls the development and size of a serpentinite channel during subduction. The channel forms between the subducting slab and the overlying mantle wedge as the result of infiltration of fluids released from the down-going plate. Circulation of slices from both the subducting and the overidding plates usually occurs inside the channel. The shape and therefore the type of flow inside the channel are influenced by several parameters such as for example the dip of the slab.

We furthermore investigated the influence of singular changes in geometric and kinematic parameters on the entire “subduction system”. We focused in detail on the development of a volcanic arc and particularly on the effects that convergence rate, initial inclination and age of the subducting slab have on its dimension, its distance from the trench and its age.

Moreover, the numerical simulations allowed us to investigate the circulation patterns inside the serpentinite channel: we modeled the P-T paths produced during burial and exhumation of rocks involved in subduction and compared them to the ones of "real" rocks.

Following this approach we have compared our model results with the present-day structure and metamorphism of the high pressure ophiolite Voltri Massif (Ligurian Alps) in order to discuss the exhumation mechanisms. We conclude that formation of a serpentinite channel likely drives the exhumation of the eclogite-facies rocks. Our model appears to fit well several aspects of the Voltri Massif evolution; particularly the gaps in P-T peak conditions attained by the various tectonic slices, the dimension of such bodies, and the involvement of sedimentary rocks from different sources (oceanic vs continental types).

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