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Cuffaro, M.; Miglio, E.; Penati, M.;Viganò, M.

MOX, Dipartimento di Matematica
Politecnico di Milano, Via Bonardi 9 - 20133 Milano (Italy)

mox-dmat@polimi.it http://mox.polimi.it

Mantle upwelling driven by asymmetric sea-floor spreading at northern Mid–Atlantic ridge

Marco Cuffaro†, Edie Miglio∘, Mattia Penati∘, and Marco Viganò∘*

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† Istituto di Geologia Ambientale e Geoingegneria, CNR, Rome, Italy
∘ MOX – Dipartimento di Matematica, Politecnico di Milano, Milan, Italy

Abstract

Numerical modeling at spreading centeres provides useful information on mantle upwelling and geodynamic processes beneath mid-ocean ridges. We computed mantle thermal structure at northern Mid-Atlantic ridge using numerical simulations with asymmetric spreading rates and ridge migration as initial conditions. We explored the use of different lateral boundary conditions in numerical models such as velocity and velocity and stress to evaluate differences in mantle velocity field, temperature and depth of the thermal base of the lithosphere versus domain width. We propose additional boundary conditions (i.e., namely stress-only) choosing a proper tangential stress at the bottom of the domain and on lateral boundaries, taking into account ridge migration. When stress-only conditions are imposed, we obtain lower differences with respect to the expected solution and errors are minimized in simulation domains with intermediate width, also saving computational costs. Moreover, dimension analyses of governing equations result in that heat generation due to work of the viscous forces can not be neglected in the computations. Consequently, we provide an application to a geodynamic realm (e.g., northern Mid-Atlantic ridge at the reference latitude of 43 °N) of such an integrated numerical model that reveals a region of hot upwelling mantle beneath the ridge axis, and shows that the base of the lithosphere reaches the top of the domain. The use of asymmetric spreading and ridge migration accounts for an asymmetric accretion of the oceanic lithosphere.

*now at ENI, Milan, Italy