Gruppo Nazionale di Geofisica della Terra Solida

Atti del 40° Convegno Nazionale

27 - 29 GIUGNO 2022

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POST-RIFT THERMAL SUBSIDENCE: SHOULD WE ACCOUNT FOR THE LATERAL HEAT TRANSFER? A NUMERICAL EXPERIMENT IN PALEO-BATHYMETRY RECONSTRUCTION

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Assessing how past topographies and bathymetries evolved provides a critical constrain in paleo-climatic reconstruction. The available direct observations of the geologic record of elevation changes, e.g. from deep-drilling campaigns, are hindered by erosion, sedimentation, and the superposition of tectonic processes - including the lithospheric response to loads (sedimentary infills, water, and ice), the ongoing tectonic movements, dynamic topography, and thermal subsidence. Through data collection and/or modelling of vertical movements due to these concurrent phenomena, the changes in bathymetry and topography can be reconstructed through time - each of the involved terms is accounted for cumulatively. This procedure, implemented through iterative de-compacting and removal of overlying sediments layers, is referred to as “backtracking”.

Among these terms, thermal subsidence describes the vertical contraction of the lithosphere due to post-rift cooling. The model of McKenzie (1978) provides a simple and effective analytical description of the subsidence, under the assumptions that rifting is instantaneous and heat transfer occurs only through vertical conduction. It has been shown that a range of finite extension durations can be modelled as instantaneous - the smaller the stretching factor, the longer the extensional phase that can be modelled as instantaneous, with acceptable omission respect to a time-evolving rift model. The 1-D conduction hypothesis, however, is likely to introduce non-negligible discrepancies: first, significant horizontal temperature gradients can be expected to develop in the directions normal to the extensional axis, resulting in deviations from vertical conduction; second, subsidence results in mass movement and consequent heat transfer, due to solid advection.

Therefore, we set up a 2-D thermophysical model of the lithosphere undergoing cooling, through conduction and advection, thickening and deformation. This allowed us to assess the amount of omitted subsidence, due to the 1-D conduction approximation, and its sensitivity to different parameter combinations (e.g. crust-mantle density, thermal diffusion and expansion parameters, stretching factor). In addition, it enabled defining a tentative criterion to deem the 1-D analytical model acceptable (under a range of conditions), in a similar way as it is done for the extension duration.

We implement this, using the open source Underworld2 modelling code (Mansour *et al.*, 2020), which relies on the Lagrangian integration point finite element approach (Moresi *et al.*, 2003) and provides a Python API to construct, run, and visualize the output of geodynamic models.

Our ultimate aim is to integrate the subsidence output of our numerical model in the comprehensive backtracking procedure of the open source software PALEOSTRIP (Colleoni *et al.*, 2021), replacing the 1-D thermal subsidence term and assessing the effect of including lateral heat transfer on the overall result.

Since thermophysical modelling comes at the cost of increased computational effort, we also propose an alternative approach to integrate 2-D thermal subsidence in PALEOSTRIP, based on an empirical fit on a set of numerical experiments. The benchmark data we rely on consists in the ANTOSTRAT data atlas (Brancolini *et al.*, 1995), using the depth of the mid-Miocene unconformity as the target of the backtracking procedure. In this region, located at the northwestern end of the West Antarctic Rift System, extension occurred in two main episodes: a regional thinning associated with the breakup of New Zealand and Australia from Antarctica in the Cretaceous, and more focused extensional episodes during the Cenozoic, with the locus of extension moving progressively from east to the west.

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