Hyper extended rifted margins: a computational procedure for stretching-thinning factors estimation

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ABSTRACT: Crustal extension mechanisms controlled rifted margins formation. During these extensional processes the crust stretched and thinned can following non-uniform and also non-symmetric patterns. Modeling of main features of these processes are a relevant issue, as well as its quantification by the calculation of the stretching-thinning factors along the margins. This work presents a computational procedure for both, reproducing the crustal extension process and estimating the evolution of extension-thinning factors. This procedure uses an algorithm based in geological hypotheses, dynamic analysis results and kinematic relationships.
It is generally accepted that crustal thinning is greater than extension caused by brittle faulting. There is no agreement that this thinning can be explained by simple Andersonian faulting and coupled shear-flexural mechanisms or if some other mechanism such as detachment faulting if must be considered. This study focuses on pure-shear extension models simulation, where stretching is based on Andersonian faulting formation only. The proposed procedure is supposed to be applied in two-layer (upper/lower) crust configurations in two ways: a) including a new active fault; b) reactivating a previously activated fault. Kinematics relationships consider area conservation for the upper crust. The first step is the application of a crustal extension increment. This increment activates the faulting by simple shear in the upper crust and induce plastic distributed pure-shear deformation in the lower crust. This double effect generates a local thinning of both upper and lower crust. Slip-in-fault also occurs as part of the thinning deformation. Additionally, a dynamic analysis was carried out with an in house developed program, based in the Finite Element Method. This approach, coupled with advanced constitutive models is useful for reproducing stress-strain-temperature evolution during the crustal stretching. In this analysis a two-layer crust model with one single fault was stretched. It was considered the upper crust with brittle behavior, according to Mohr-Coulomb constitutive model with softening cohesion. To the lower crust was used a Power Law Creep model to simulate the ductile behavior. In this approach, the fault was implicitly described with interface elements and augmented penalty conditions to contact. As a consequence of the dynamic analysis, rules was added to the kinematic relationships: variable thinning zone, nonlinear thinning configurations, variable slip/extension ratio, shoulder uplift and out-of-section fault pivot. These characteristics play an important role defining crustal thinning and mantle uplift patterns, and also in the accommodation space that will be created in the rift basin. In order to demonstration, the procedure was applied for reproducing a crustal extension of a hyper extended margin by a sequence of some extension-faulting steps. The procedure estimated thinning and extension factors, as well as basin accommodation space. The results showed that this procedure is a powerful tool for reproducing qualitatively crustal extension configuration in a simple way.

KEYWORDS: KINEMATIC MODELING, DYNAMIC ANALYSIS, CRUSTAL STRETCHING.