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Rheological weakening by grain-size reduction as a possible origin of asymmetric extension associated with reactivation of rifting

T. Yamasaki

Dublin Institute for Advanced Studies, Dublin, Ireland (yamasaki@cp.dias.ie / Fax: + +353-1-662 1477 / Phone: +353-1-662 1333)

The mechanisms determining the style of extension of the lithosphere, pure shear or simple shear, have not been revealed yet. The most important difference between the two models seems to be related to the presence of shear zone within the lithosphere. In fact, many deep seismic images suggest the presence of shear zones in the crust and upper mantle beneath the extensional sedimentary basins, which might be responsible for the asymmetric structure of the basins. Although there is such evidence for localization of deformation during extension, its mechanism is still discussed. The occurrence of such localized deformation would be attributed to localized rheological weakening, and therefore mechanism for reducing the rock strength at a limited part will required. In this study I propose that thermal relaxation in postrift phase may be important for localized rheological weakening in ductile regime developed by grain-size reduction as a result of spinel- to plagioclase-lherzolite reaction. For the temperatures more than the critical value, the ductile yield stress becomes to be mostly insensitive to grain-size, and the lower boundary for the localized weak zone diminishes. The thermal diffusion during inter-rifting period can produce an apparent strength contrast of localized weak zone through the reduction of geothermal gradient. During earlier rifting event the grain-size reduction takes place significantly by spinel-to plagioclase-lherzolite reaction, and then the following extensional event occurs after the critical thermal relaxation time, 10 Ma for dry condition and 20 Ma for wet condition. If the localized rheological weakening really plays an important role in the onset of localized deformation, the asymmetric extension would occur if the rifting is reactivated after the critical thermal relaxation time.