Geophysical Research Abstracts,
Vol. 11, EGU2009-9644, 2009
EGU General Assembly 2009

The mode of lithosphere deformation leading to continental breakup and sea-floor spreading initiation

N.J. Kusznir (1), R.J. Fletcher (1), and G. Manatschal (2)

(1) Department of Earth and Ocean Sciences, University of Liverpool, Liverpool L69 3BX, United Kingdom (n.kusznir@liverpool.ac.uk), (2) CGS-EOST, Universite Louis Pasteur, 1 rue Blessig, F-67084 Strasbourg, France

We investigate two contrasting modes of continental lithosphere thinning leading to continental breakup and sea-floor spreading initiation; lithosphere thinning by pure-shear and by buoyancy assisted upwelling divergent flow. Mantle exhumation at rifted continental margins requires that rupture of continental crust and the unroofing of mantle occur before the start of significant melt production. The relative timing of the onset of ocean ridge melt production is sensitive not only to extension rate, mantle temperature and mantle depletion but also the deformation mode of continental lithosphere thinning leading to continental breakup. Two end-member modes of continental lithosphere thinning deformation have been examined: depth-uniform (pure-shear) lithosphere stretching and thinning, and lithosphere thinning by upwelling divergent flow. Horizontal tensile plate forces provide the driving force for the pure-shear deformation. Upwelling divergent flow is assumed to be driven by a combination of horizontal plate boundary forces and thermal and melt buoyancy initiated by pure-shear lithosphere stretching, and predicts a simple transition from pre-breakup lithosphere thinning to sea-floor spreading. For the N. Iberian - N. Newfoundland margins, pure-shear breakup lithosphere thinning model predicts that the onset of melt generation occurs prior to breakup rupture of the continental crust for normal mantle temperature and chemical composition. In contrast the upwelling divergent flow model predicts the onset of melt generation after continental crust rupture leading to ∼ 100 km mantle exhumation on each margin. We propose that continental lithosphere thinning leading to continental breakup and sea-floor spreading initiation is achieved by a simultaneous combination of pure-shear and buoyancy driven upwelling divergent flow within continental lithosphere and asthenosphere. The relative importance of these deformation modes is dependent on depth, pre-breakup extension rates and mantle temperature. Beneath 10-15 km depth the dominant mode of continental lithosphere thinning leading to breakup is upwelling divergent flow driven by thermal and melt buoyancy, while for depths shallower than 10-15 km (corresponding to the cooler upper lithosphere) the dominant thinning mode is pure-shear in the form of brittle faulting. While horizontal tensile plate forces provide the driving force for the pure-shear deformation, the buoyancy induced upwelling divergence flow provides the main contribution to continental lithosphere thinning. Pre-breakup continental lithosphere thinning by combined pure shear and buoyancy driven upwelling divergent flow also predicts depth-dependent stretching of continental margin lithosphere, the development of pre-breakup sag basins with a paucity of pre-breakup brittle deformation and a simple transition from pre-breakup lithosphere thinning to sea-floor spreading.