Geophysical Research Abstracts
Vol. 18, EGU2016-8581-3, 2016
EGU General Assembly 2016

Hyper-extended continental crust deformation in the light of Coulomb critical wedge theory

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The rocks forming the wedge shape termination of hyper-extended continental crust are deformed in the frictional field during the last stage of continental rifting due to cooling and hydration. Seismic interpretation and field evidence show that the basal boundary of the wedge is a low frictional décollement level. The wedge shape, the frictional deformation and the basal décollement correspond to the requirements of the critical Coulomb wedge (CCW) theory which describes the stability limit of a frictional wedge over a décollement. In a simple shear separation model the upper-plate margin (in the hangingwall of the detachment fault) corresponds to a tectonic extensional wedge whereas the lower plate (in the footwall of the detachment fault) is a gravitational wedge. This major difference causes the asymmetry of conjugate hyper-extended rifted margins. We measure a dataset of upper and lower hyper-extended wedge and compare it to the stability envelope of the CCW theory for serpentine and clay friction. We find a good fit by adjusting fluid pressure. The main results of our analysis are that the crustal wedges of lower plate margins are close to the critical shape, which explains their low variability whereas upper plate wedges can be critical, sub- or sup- critical due to the detachment evolution during rifting. On the upper plate side, according to the Coulomb tectonic extensional wedge, faults should be oriented toward the continent. Observations showed some continentward faults in the termination of the continental crust but there are also oceanward faults. This can be explained by two processes, first continentward faults are created only over the detachment, therefore if part of the hyper-extended upper plate crust is not directly over the detachment it will not be part of the wedge. Secondly the tip block of the wedge can be detached creating an extensional allochthon induced by the flattening of the detachment near the surface, therefore continentward faults are removed from the upper plate. The CCW theory offers new perspectives to better understand complex tectono-sedimentary processes in hyper-extended margins.