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Testing the critical Coulomb wedge theory on hyper-extended rifted margins

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Deformation of hyper-extended continental crust and its relationship with the underlying mantle is a key process in the evolution of rifted margins. Recent studies have focused on hyper-extension in rifted margins using different approaches such as numerical modelling, seismic interpretation, potential field methods and field observations. However many fundamental questions about the observed structures and their evolution during the formation of hyper-extended margins are still debated. In this study an observation driven approach has been used to characterise geometrical and physical attributes of the continental crust termination, considered as a hyper-extended wedge, in order to test the applicability of critical Coulomb wedge theory to hyper-extended margins.

The Coulomb wedge theory was first developed on accretionary prisms and on fold and thrust belts, but it has also been applied in extensional settings. Coulomb wedge theory explains the evolution of the critical aperture angle of the wedge as a function of basal sliding without deformation in the overlying wedge. This critical angle depends on the frictional parameters of the material, the basal friction, the surface slope, the basal dip and the fluid pressure. If the evolution of hyper-extended wedges could be described by the critical Coulomb wedge theory, it would have a major impact in the understanding of the structural and physical evolution of rifted domains during the hyper-extension processes.

On seismic reflection lines imaging magma-poor hyper-extended margins, the continental crust termination is often shown to form a hyper-extended wedge. ODP Sites 1067, 900 and 1068 on the Iberian margin as well as field observations in the Alps give direct access to the rocks forming the hyper-extended wedge, which are typically composed of highly deformed and hydrated continental rocks underlain by serpentinised mantle. The boundary between the hydrated continental and mantle rocks corresponds to a decollement level. In order to test the critical Coulomb wedge theory on hyper-extended magma-poor rifted margins, we have analysed a number of high quality seismic sections from present-day margins (e.g Iberia, Newfoundland, Porcupine, Angola, Brazil, South China Sea). We have measured, in the brittle hyper-extended crust, the wedge angles (α) of the top-basement surface and the basal dip angle (β) of the crust-mantle interface. Preliminary results from this analysis show that the hyper-extended wedge aperture angle (α+β) ranges between 4° and 18°. Most hyper-extended wedges on the footwall of the detachment (lower plate margin) present aperture angles around 10-11° whereas aperture angles in the hanging-wall are more scattered. This observed difference may be linked to the direction of the basal shear in the conjugate wedges. While the applicability to hyper-extended rifted margins of critical Coulomb wedge physics has to be numerically tested, initial results suggest a promising new approach to investigate the hyper-extension processes.