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Analogue and Numerical Models Investigating the Formation of Parallel-dipping Normal Fault Arrays

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Extension of the continental upper crust is often accommodated by an array of normal faults. These faults either have alternating dip directions that define horst and graben structures or dip predominantly in the same direction. Arrays of parallel-dipping normal faults are observed in the extending domains of, for example, offshore Norway, the Basin and Range Province, the Galicia margin, and offshore Angola. Such settings inspired us to investigate factors and mechanisms that favour the formation of an array of parallel-dipping normal faults over a sequence of horst and graben structures.

We use numerical models and analogue experiments and compare these to field observations and interpretations of seismic sections. The numerical experiments use two-dimensional finite element models that can achieve large deformation with free surface behaviour. The three-dimensional analogue experiments are built of (brittle) sand and (viscous) silicone and their internal deformation is visualised in an X-ray scanner. All models are on the scale of the upper crust. Previous studies have already pointed to the difficulty of simulating arrays of parallel faults in models. Our first models are, therefore, simple and generic in character, examining triggers for parallel-dipping fault array formation. We distinguish between fault arrays that form in initial extension and those that form on mature passive margins. Fault arrays in early extension stages can in the simplest manner be formed by extension of a thin viscous layer overlain by a thicker brittle layer. However, parallel-dipping faults only occur in a limited model space as defined by model rheology and setup (Nagel and Buck, 2006). Gravity gliding or -spreading of brittle sediments over a weak viscous detachment (as for example formed by salt or shales) can lead to parallel fault arrays dipping either up slope or

down slope. The dip direction is controlled by the basal shear stress at the brittle-viscous interface, which is in turn controlled by the relative spreading velocities of both materials.

We aim to build on our generic models to investigate whether a preferred sense of propagation of faulting exists, how isostasy and faulting interact and to examine the sensitivity of fault arrays to rheological layering, surface processes, fault weakening and multi-phase extension.

Reference

Nagel, T. and Buck, R. 2006. Channel flow and the development of parallel-dipping normal faults. Journal of Geophysical Research, vol. 111, B08407, doi:10.1029/2005JB004000