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Propagation of a fold-and-thrust belt over a basement graben

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Abstract

We demonstrate the mechanical feasibility of the propagation of a thin-skin deformation front on a décollement previously cut and lowered by a normal fault. Using a numerical implementation of the limit analysis theory, we confirm the common understanding that any discontinuity of the décollement layer will trigger the formation of a ramp conducting the slip to the surface. Upon further remotely applied shortening, we show with both numerical and analogue models that the growing relief created by the ramp will reach a height and a horizontal extent such that the *lower* portion of the décollement will eventually be activated, and the belt will resume its growth further along its initial décollement layer even though it is deeper. The required extra-relief depends mainly on the friction angles of the bulk material and of the existing faults. The analogue experiments show that the step in the décollement acts as a temporary catching point in the propagation of the deformation front, resulting in a characteristic tectonic style composed of a stack of faults above the step separated from the following structures by a long and flat, partially buried syncline. The thin-skin Jura fold-and-thrust belt developed during Mio-Pliocene times on a Triassic décollement locally lowered by reactivation of earlier grabens. With a dedicated mechanical prototype we show that realistic friction values are compatible with the propagation of deformation across these grabens, along the depressed zones of the Triassic décollement, without having recourse to thick-skinned tectonics.

Keywords: Basement topography, décollement, limit analysis, fold-and-thrust belt, mechanics

1. Introduction

The general shape of a fold-and-thrust belt in cross-section is that of a wedge with a surface topography dipping to the foreland, and a basal décollement layer becoming proportionnaly shallower. This shape, well described by the critical Coulomb wedge theory (Suppe, 1983; Davis et al., 1983; Dahlen, 1984), is the result of the sensitivity to pressure of the cold, frictional material composing the belt. It corresponds internally to the stacking of thrust sheets from below, each new sheet being delimited by a thrust ramp forming at the tip of the wedge (Reade, 1908; Goguel, 1948; Chapple, 1978; Davis et al., 1983; Cubas et al., 2010; Graveleau et al., 2012; Buiter, 2012). This regular internal organisation of thrust sheets is perturbed where the decollement surface is folded, or shifted by faulting in the basement as proposed by Laubscher (1986) using the example of the Mandach structure at the eastern termination of the Jura (Fig. 1a). One or several thrust ramps form near the point of discontinuity of the décollement and reach the surface, creating a new relief

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