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A discussion of the (re)activation of basement structures during multi-phase shortening in thin- and thick-skinned styles

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Shortening in fold-and-thrust belts can be accommodated with little or substantial basement involvement, with the former, thin-skinned, style arguably being the more common (Pfiffner, GSA Special Paper, 2006). Experimental studies on thin-skinned fold-and-thrust belts have confirmed critical taper theory and have highlighted the roles of bulk rheology, embedded weak layers, décollement strength, and surface processes in structural evolution. However, analogue models of thick-skinned fold-and-thrust belts are less common, which may be related to practical challenges involved in shortening thick layers of brittle materials. Here we focus on basement fault reactivation, which has been suggested for several fold-and-thrust belts, such as the Swiss Alps, the Laramide belt in North America and the Sierras Pampeanas in South America, which show evidence of deep-rooted thrust systems, pointing to a thick-skinned style of shortening.

Within an orogenic system, the shortening style may change between thin- and thick-skinned in space (foreland to hinterland) and time. This raises the question how inherited structures from one shortening phase may influence the next. We aim to use analogue experiments of multi-phase shortening to discuss the effects of deep-seated shortening-related inherited structures, such as thrusts and basement topography, on the structural evolution of fold-and-thrust belts.

We employ a push-type experimental apparatus that can impose shortening in both thick- and thin-skinned style. The device has two independently moving backstops, permitting to change between these shortening styles over time, allowing the simulation of multiple contractional scenarios. We start with an initial stage of thick-skinned shortening, followed by either thin- or thick-skinned reactivation. We use quartz sand to simulate crustal materials and microbeads for embedded weak (sedimentary) layers. Surface and lateral strain, as well as topography, is quantified using a high-resolution particle imaging velocimetry and digital photogrammetry monitoring system.

We will present preliminary results of this innovative experimental approach with the objective of discussing to what extent pre-existing conditions in the basement control the geometric, kinematic, and mechanical evolution of thick-skinned and basement-involved thin-skinned tectonics. In this presentation, we hope for a discussion of mechanisms of localisation of shortening in brittle analogue models, of sequences of thin- and thick-skinned deformation expected during multi-phase shortening, and comparisons to ongoing research and natural observations. Questions we aim to discuss are: Can weaknesses and anisotropies within the

basement influence and control later structural evolution? Are pre-existing structures, such as thrusts or shear zones within the basement, responsible for subsequent fault nucleation, thin-skinned folding or basement uplift? What role does the rheology of the basement-cover interface play in the reactivation of basement thrusts? Can we model these reactivations with an analogue setup?