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Mimicking structures in the Jura Mountains fold-and-thrust belt: dynamics at pre-existing basement faults from analogue models

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The Jura Mountains lie in the northern foreland of the European Alps and form a thin-skinned fold-and-thrust belt (FTB), that developed during Late Miocene and Early Pliocene. The basal décollement of the FTB happened in Middle and Upper Triassic evaporites. Prior to the formation of the FTB, continental Europe was extensively pre-structured by Palaeozoic faults that have been reactivated under subsequent stress fields during Mesozoic and Cenozoic times. The most prominent systems in the surrounding of the Jura Mountains are Permo-Carboniferous grabens and the European Cenozoic Rift System (ECRIS). The latter defined the frontal extent of the FTB to a high degree. Many structural orientations (lineaments) observed within the Jura Mountains cannot be explained by the Late Miocene stress fields alone. Lineaments are parallel to pre-Miocene faults in adjacent grabens and the FTB seems to have deformed along similar inherited lines. Therefore, we interpret lineaments as mimicking structures in the detached cover, triggered by structures in the basement that predate the Jura FTB formation.
Cross-sections constructed along transects in the external Jura reveal different structural elevations of plateaus and the footwall seems to consist of offset blocks that show a tendency to subside stepwise towards the hinterland. We estimate typical downthrows of 50-350 m and a relatively regular spacing between NE and NNE trending mimicking structures of 9-12 km.
In a further step, we designed a series of analogue models to test the structural situation observed in the Jura FTB. A viscous layer of silicone (polydimethylsiloxane) was used to simulate the detachment in Triassic salts and sand represented the Mesozoic cover of carbonates and marls. Pre-Miocene fault reactivation was simulated by vertical displacement of two rigid base plates and the Late Miocene basement-detached deformation was simulated by horizontal shortening of the sand. We tested pre-existing faults which are perpendicular, 60° and 45° oblique to the direction of transport and we varied the throws of these faults. In this way, we investigated Late Miocene mimicking structures at pre-existing basement faults that constitute frontal and oblique ramps.
Our models show the temporal evolution of mimicking structures. Furthermore, we can conclude on the geometry of pre-existing faults from mimicking structures in nature. The comparison of our results to the Jura FTB indicates oblique ramps caused by structures in the footwall of the highly deformed internal Jura. We propose an important reactivation of Palaeozoic faults prior to the formation of the Jura Mountains due to flexural extension during the subduction of Europe. Therefore, the structural situation of the Jura may apply to FTB's next to peripheral foreland basins worldwide.