Geophysical Research Abstracts
Vol. 18, EGU2016-8639, 2016
EGU General Assembly 2016

Upper crustal mechanical stratigraphy and the evolution of thrust wedges: insights from sandbox analogue experiments

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Crustal mechanical stratigraphy i.e. alternating mechanically weaker and stronger layers within the crust, plays a key role in determining how contractional deformations are accommodated at convergent plate boundaries. In the upper crust, evaporites typically provide preferential décollement layers for fault localization and foreland ward propagation, thus significantly influencing evolution of thrust-fold belts in terms of mechanical balance, geometries, and chronological sequences of faulting. Evaporites occur at the base of many passive margin successions that underwent positive inversion within orogenic systems. They typically produce salient geometries in deformation fronts, as in the Jura in the Northern Alps, the Salakh Arch in the Oman Mountains, or the Ainsa oblique thrust-fold belt in the Spanish Pyrenees. Evaporites frequently occur also in foredeep deposits, as in the Apennines, the Pyrenees, the Zagros etc. causing development of additional structural complexity. Low-friction décollement layers also occur within sedimentary successions involved in thrust-fold belts and they contribute to the development of staircase fault trajectories. The role of décollement layers in thrust wedge evolution has been investigated in many experimental works, particularly by sandbox analogue experiments that have demonstrated the impact of basal weak layers on many first order features of thrust wedges, including the dominant fold vergence, the timing of fault activity, and the critical taper. Some experiments also investigated on the effects of weak layers within accreting sedimentary successions, showing how this triggers kinematic decoupling of the stratigraphy above and below the décollements, thus enhancing disharmonic deformation. However, at present a systematic experimental study of the deformation modes of an upper crustal mechanical stratigraphy consisting of both low-friction and viscous décollement layers is still missing in the specific literature. In this contribution we present the results of such a study, where a three-décollement mechanical stratigraphy has been deformed in the sandbox at the same boundary conditions. Different rheological properties were assigned to the three décollements in different experiments, up to testing all possible mechanical stratigraphies. Implications on thrust propagation and slip rate history and cross-sectional thrust wedge architecture are discussed and compared with natural cases.