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Fold-and-thrust belt evolution influenced by along and across strike thickness variations: new insights from brittle-ductile centrifuge analogue models

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Using a new centrifuge analogue modelling approach, 38 models were performed to study the influence of along and across strike thickness variations of a ductile-brittle layered sequence on the kinematics and deformation style of fold-and-thrust belts. Four different series, changing the brittle-ductile thickness ratio in models with i) constant thickness, ii) across strike varying thickness, iii) along strike varying thickness and iv) along and across-strike varying thickness, were performed. The brittle sedimentary cover was simulated by "Moon Sand^{TM}", regular fine-grained quartz sand coated by polymer and synthetic rubber binders, allowing layers to be placed vertically in the centrifuge (impossible with normal sand). The ductile décollement (evaporites) was simulated by silicone putty (Crazy Aaron Enterprise's Thinking Putty^{TM}). Models were run step by step in a high-acceleration centrifuge attaining 900 g, what allows to drastically reduce the experimental time. In addition to surface observation and serial cross-sections at the end of the models, CT scans portray the progressive 3- and 4-dimensional evolution of several models. With constant thickness, the increase of the brittle-ductile ratio results in the decrease of the number of structures where shortening is accommodated and the development of structures does not follow a linear sequence. Across-strike thickness variations trigger the location of deformation towards the wedge front, precluding the emplacement of structures in the hinterland. Along-strike thickness changes result in the lateral variation of the number of structure and a differential displacement of the deformation front. The occurrence of oblique structures is enhanced in wedges with across and along strike thickness variations where, in addition, rotational domains are observed.

Comparison with the South Pyrenean Central Unit, in the Southern Pyrenees, characterized by a west- and southward thinning of the pretectonic Mesozoic series, supports the experimental results. The structure of the South Pyrenean Central Unit, that thrusted over the molasse deposits of the Ebro Basin during the Eocene-Oligocene is strongly conditioned by the existence of a basal detachment in the Upper Triassic evaporites. During Pyrenean orogeny, from Late Cretaceous to Oligocene times, the Bóixols, Montsec and the Sierras Marginales thrust sheets were emplaced in piggy-back sequence. Its emplacement was accompanied with the lateral and southward migration of the Upper Triassic evaporites defining a salt province at the Sierras Marginales realm, where diapiric structures crop out. Contemporaneously with the Sierras Marginales emplacement, differential displacement triggered up to 70° of clockwise rotation of structures and sedimentaty cover in the westernmost edge of the SPCU.