Analogue models of progressive arcs: strain partitioning and localization in fold-and-thrust belts developed over ductile layer of different geometry

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Although analogue models have successfully simulated many different types of arcuate fold-and-thrust belts, we were able to design a backstop whose curvature ratio diminished and its protrusion grade increased during experiments reproducing several kinematic features of progressive arcs never seen before 2016. General models were made up of an homogeneous silicone layer, where detachments tend to localize, overlain by a sand layer. They accomplished to simulate the overall structure and kinematics of fold-and-thrust belts of Mediterranean Arcs, especially that of the Gibraltar arc: (1) highly divergent thrust transport directions, (2) arc-perpendicular normal and strike-slip faults accommodating arc-lengthening, (3) transpressive and transtensional bands oblique to the main trend located in the lateral zones, (4) vertical axis-rotations up to 70º and (5) block individualization that rotated independently clockwise and counterclockwise in the left and right arc limbs, respectively.

However, the ductile layer is neither continuous nor homogeneous in natural cases, such that pinch-outs and diapirs previous to deformation are frequently found across and along strike. Thus, we have modified our original set-up including silicone pinch-outs and different sizes of silicone diapirs. Where silicone pinch-outs were subparallel to the apex movement, differences in the structural style along the foreland thrust-belt occurred. A forward thrust system over frictional detachments (no silicone), or wide, double verging thrust-systems over ductile detachments (with silicone) developed. Differential displacement between both types of thrust-belts was accommodated by transfer zones. Where silicone pinch-outs were perpendicular to the apex movement, the deformation front propagated up to the pinch-out, where it stopped and the thrust-system thickened up to its subsequent collapse. In models with pre-existing diapirs, first thrust and strike-slip faults nucleated close to diapirs and linked them. When deformation proceeded, all diapirs were added and deformed within the fold-and-thrust belts.

We also made experiments to analyze the ductile deformation and the influence of the brittle layer (sand) thickness. In only silicone models, a homogeneous deformation was observed at the grid scale, where each square was deformed by mostly simple shear in the lateral parts whilst by
mostly pure shear in its most frontal part of the models. When a sand layer was sieved on top of the silicone layer, discrete structures developed. Although all models showed strain partitioning between arc-perpendicular shortening and arc-parallel stretching, as the brittle layer thickness increased, fold wavelength increased.

All these models show the high complexity derived from the different strain partitioning modes and the strain localization along and across-strike fold-and-thrust belts in progressive arcs. They can be extremely helpful to better understand this kind of arcuate orogens that are also the most frequent in nature. Even though these models were previously carried out to simulate the evolution of fold-and-thrust belts of Mediterranean arcs, they can also shed lights for the evolution of many others progressive arcs.