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Along-strike variation of strain partition modes: a case study in a regime of oblique plate convergence (External Betics, northern branch of the Gibraltar Arc)

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The Betic and Rif chains shape the northern and southern branches of the Gibraltar Arc in the westernmost Mediterranean. During the last 25 Ma, the Gibraltar Arc evolved in a kinematic setting of NNW-SSE to NW-SE convergence between Europe and Africa combined with a relative westward arc migration. Accordingly, at a first glance, the northern branch of the Gibraltar Arc as a whole could be considered as a dextral transpressive zone. Nevertheless, within the Betics, significant variations of structural associations can be observed, in terms of areal distribution and timing, which denotes that strain partition occurred. In particular, this is the case for its external wedge. Indeed, from west to east (from Gibraltar to Granada areas), three main structural domains can be identified:
a) The external wedge situated in the closest part of the Arc, the Western Gibraltar Arc, is characterized by outward radial arc-perpendicular shortening (folds and thrusts, with a W to NW dominant vergence) and coeval arc-parallel stretching. This latter is accomplished by normal fault systems striking nearly orthogonal to the main orogenic trend, conjugate strike-slip fault systems and distributed minor structures. This deformation is coetaneous with back-arc extension in the inner zone of the Gibraltar Arc system, the Alboran Domain. Nevertheless, most of the recognized extensional fault systems in central and western parts of the external wedge are due to arc-parallel stretching instead of back-arc extension. Pliocene (mainly open folds and normal faults) to recent deformation (assessed from earthquake data) seems to follow a similar pattern.
b) The "recess" zone, which links the Western Gibraltar Arc and the NE-SW to ENE-WSW trending central Betics, corresponds to the area where the structural trend line pattern of the external wedge is concave-to-the foreland. One of its most conspicuous features is situated along the boundary with the Betics internal zone (the Alboran Domain). It consists of a highly partitioned, E-W directed, dextral transpressive shear zone, built up by a set of an echelon NE-SW trending relieves, in turn affected by an array of NW-SE oriented normal conjugate faults. Numerical kinematic models suggest that their extrusion was nearly vertical and controlled by the pure shear component, as the simple shear component was mostly localized at the shear zone walls. Coeval extension is predicted by the model. This situation is still active, as earthquake focal solution data from this region indicate that dextral strike-slip earthquakes (NW-SE trending) are dominant, although they coexist with a complex network of thrust and normal fault earthquakes.
c) In the central Betics, NE-SW to ENE-WSW trending, shortening in the external wedge was accommodated by folding and thrusting. The variation of the trend line pattern between the central zone and the "recess" zone has been reproduced through analogue experiments of a rigid, concave indenter (the Alboran Domain) pushing-from-behind a sand pack floored by silicone (the Triassic evaporites). The main shortening occurred earlier than in the Western Gibraltar Arc. In this zone, extensional faulting accommodating arc-parallel stretching is nearly absent and large-scale strike-slip faults striking parallel to the main structural trend line developed.

The analysis of the variation of along strike strain partition modes in the northern branch of the Gibraltar Arc shows that several structural domains can be characterized within its external wedge, which indicates strong horizontal and vertical decoupling at upper crustal levels. Although situated in a regime of oblique plate convergence as a whole, strain partition modes indicate that only the E-W directed segment of the "recess"

zone of the Gibraltar Arc external wedge and part of the Central Betics have structural associations that reveal a transpressive character.

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