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Rotation of inequidimensional rigid inclusions in a viscous medium under coaxial vs. non-coaxial bulk shear regimes: comparative analogue and numerical modelling results

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The geological relevance of rotating rigid inclusions embedded in a viscous matrix has been profusely addressed in the literature (e.g. Ghosh and Ramberg 1976; Passchier and Trouw 1996; Marques et al. 2014 and references therein), in which it has been shown that the mechanics of such systems bears within critical tectonic implications, since their structural-kinematic interpretation at microscopic (e.g. porphyroclast systems) and macroscopic scale (rotating boudins) often serves the main argument for establishing local and regional shear sense indicators.

Such interpretation is generally based on the recognition of key geometric associations/patterns between the rotating rigid inclusion and the matrix, assumed to be the result of the specific kind of ductile matrix perturbation that a rigid inclusion with a specific axial ratio, a determined original position, and rotating under a certain (e.g. coaxial or non-coaxial) shear regime might originate.

In the present work we employ comparative analogue and numerical modelling to specifically analyse the process through which a ductile matrix is perturbed by a rotating rigid particle under coaxial vs. non-coaxial bulk shear regimes. In our experiments we consider an inequidimensional rigid inclusion (with an axial ratio R = 1.9), with an original angular position at 45º (counter-clockwise) from the main shear plane. We further investigate the influence of the geometry of the inclusion (rectangular vs. elliptical) in the obtained results.

Our preliminary results show that, for relatively low strain conditions, rigid inclusions rotating under bulk coaxial flow (orthogonal flattening, pure shear regimes) can originate structural patterns with monoclinic symmetry typically ascribed to non-coaxial shear, based on which shear sense interpretations (often sustaining local, or even regional large-scale tectonic transport) are generally acknowledged.

Additionally, the comparison between the obtained analogue vs. numerical results shows that the consideration of a 3D approach is critical to fully understand the type of matrix perturbation pattern produced around the rigid inclusion. Despite the fact that such a pattern is generally observed in 2D, generally along the plane of a thin section or along the surface of an outcrop, its generation is shown to involve poloidal and toroidal-like flow in 3D around the rotating inclusion, which is key to understand the resulting pattern in 2D.

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