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# Field analysis and analogue modelling of folds with axis oblique to the extensional direction

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Folds with axes parallel to the local extension direction are a common structure in naturally deformed rocks. In despite of the increase of theoretical and numerical studies of 3D folding, there are still uncertainties on the mechanical viability of buckle folds whose finite stretching axis ($X$) lies within the layer itself. The Variscan Belt of the Cap Creus area (East Pyrenees, Spain) is an illustrative example of a complex transpressive zone formed by several phases of heterogeneous non-coaxial and non-steady deformation. In this zone, there are abundant examples of folds with cylindrical geometries and axes closely parallel to the local lineation. This contribution presents a detailed study of shapes, geometries and attitudes of these folds.

The influence of the inclination of fold axes in regard to the extension direction was experimentally investigated by means of analogue modelling. A single layer configuration was set up, with the stiff layer embedded between a softer ductile matrix. Paraffin waxes of different melting temperatures were used as the analogue material. At experimental conditions, the material shows a strong nonlinear viscous behaviour (stress exponent $n$ ∼6-8, viscosity contrast between layer and matrix $m$ ∼30-40). The transition from folds with axes normal to extensional finite axis to folds with hinges parallel to it was investigated varying the initial layer inclination. For all the models, the maximum shortening rate lies within the layer. After a bulk shortening parallel to the layer of 50%, finite fold geometries were studied analyzing series of sections of the deformed models.

Preliminary results show that active buckle folds can develop with axes parallel to the local stretching direction, and also for layers with low viscosity contrast. The devel-

opment of folds in non plane-strain conditions is controlled mainly by the strain partitioning along the fold axes and the mechanical properties of the layers. The increase of strain (or stress) parallel to the fold hinge produces a decrease on the viscosity contrast, although a reduction of the degree of nonlinearity has been not detected from fold shape analysis. The transition from folds whose axes are parallel to the extension direction to folds with axis perpendicular to it also represents a progressive change in the style and geometry of the folds: from highly cylindrical with a limited number of instabilities amplified to double-plugging folds with multiple instabilities developed.