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Characterization of 3D fault curvature

T. D. Wright, J. P. Turner

University of Birmingham, School of Geography, Earth & Environmental Sciences (Earth Sciences), Birmingham B15 2TT, UK.

(txw879@bham.ac.uk)

Curvature is an intrinsic property of faults that forms early in their development as a consequence of mechanical and structural heterogeneities within the host rock. Relations between fault geometry and hanging wall deformation have been a major research focus in structural geology. Most approaches thus far have tended to concentrate on 2D fault geometry i.e. curvature as seen in cross-sections or mapview. This project seeks to characterize the three-dimensional curvature of normal faults and relate variations in their curvature to wall rock strain.

Normal fault surfaces are known to exhibit a wide variety of curvatures from localized asperities to large-scale (e.g. wavelengths of hundreds of metres) corrugations. This study concentrates on structures whose dimensions exceed $1x10^{-3}$ of fault length. By contrast asperities consist of localized excrescences. Two main categories of curvature occur in natural fault systems defined on the basis of their mutually orthogonal axes of principal curvature: i) one of the principal axes of 2D-curved surfaces is zero, hence they are restorable to a planar surface without changing the area of the surface (e.g. cylindrical folds, corrugations); ii) both the principal axes of curvature of 3D curved surfaces are finite and, depending on whether the ratio of the long to short axis is positive (e.g. hemisphere) or negative (e.g. saddle),they will result in various strains in the adjacent wall rocks. Consideration of particle motions within a homogeneously deforming wall rock volume translated over a curved fault surface suggests that 3D-curved surfaces induce divergence/convergence of particle motions in the wall rocks. Thus, a premise that this project seeks to test is that the location, geometry and kinematics of folds, fault splays, fracture zones, pressure solution zones, etc. are controlled by the curvature of fault surfaces over which they have been translated.

Interpretation of 3D seismic data from the Niger Delta combined with field studies in northern Spain, southwest UK and central Greece suggest that corrugations are ubiquitous features occurring across a range of scales spanning four orders of magnitude. Corrugations are aligned parallel to slip direction and commonly display superimposition of different corrugation wavelengths. Three-dimensional features, including ribs, saddles, undulations, hollows and closed ridges, are common at all scales. Extensional faults in the Niger Delta exhibiting regions of pronounced 3D fault curvature exhibit significant associated wall rock strain such as localized lensoid depressions with radii up to 500m. Field observations suggest that curvature-related deformation is manifested primarily as brecciation and splay faulting with associated folding, cleavage development and stylolitization.