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Localised Folding and Axial Plane Structures

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The development of folds in layered rocks is commonly analysed using Biot's theory of folding. This theory expresses the deflection, w, of a single layer embedded in a weaker medium in terms of the equation $\frac{\partial^4 w}{\partial x^4} + P\frac{\partial^2 w}{\partial x^2} + F\left(w, x\right) = 0$ where x is the distance measured along the layer, P is a function of the mechanical properties of the layer and $F(x)$ is a function that represents the reaction force exerted by the embedding medium on the layer arising from the deflection of the layer. In Biot's theory $F(w,\ x)$ is a linear function of w and is independent of the wavelength of the deflection. The result is strictly sinusoidal folding even at high strains with, most importantly, no localised deformation in the embedding medium and hence no development of axial plane structures. However, if the embedding medium weakens as the layer deflects or shows other more complicated deformation behaviour then F is no longer linear and can depend on the wavelength of the deflection. We explore the resulting behaviour in this paper.

For a simple weakening response of the embedding layer to deflection, the initiation of folds follows Biot's theory and the initial folding response is sinusoidal. However, as the folds grow and weakening develops in the embedding material the fold profile ceases to be sinusoidal and the folds localise to form packets of folding along the layer. This behaviour is reflected in the embedding medium as a series of localised deformation zones parallel to the deflection direction, $\boldsymbol{w}$sghat is, parallel to the axial plane of the folds. These zones constitute micro-lithons, or in an initially finely layered material, crenulation cleavages.

We also explore the situation where a layering arising from metamorphic differentiation forms oblique to folding multi-layers early in the folding history. Now the function F also depends on x and a variety of localised folds with associated axial plane structures develops. An important observation is that shear displacements form parallel to the axial plane structures during folding.

Our conclusion is that the response of the embedding medium to deflection of the layer(s) to be folded is fundamental in controlling the style of folding and the types of axial plane structures that form and future research should concentrate on the forms of these responses. Most importantly, these axial plane structures form parallel to the deflection vector, $\boldsymbol{w}$, and hence are controlled by the kinematics of the deformation and are not parallel to a principal plane of strain.