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3D-relationship between fault drag and fault growth

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Normal drag along faults is a well described phenomenon which has been used as shear sense criteria in structural geology textbooks. It occurs where the deflection of marker beds due to the slip on the fault is convex in the direction of shear. In contrast, where this deflection is concave in the direction of shear it is defined as reverse drag. In order to investigate the poorly understood phenomenon of complex changes in reverse and normal drag effects along faults, we reconstructed the 3D-geometry of several faults within greenshist facies metapelitic footwall rocks from the Moine thrust zone in NW-Scotland, using the discrete modelling software GOCAD. From a handspecimen 25 vertical, parallel sections have been cut at a distance of every 3-4 mm. Several isolated faults and one master fault as well as 12 continuous layers representing the foliation have been mapped in order to establish the 3D-geometry of the rock volume.

For all of the faults throw contour maps have been generated, which reveal several displacement maxima on the largest faults. These displacement maxima are interpreted as former isolated fault segments that linked during fault growth. Consequently, the master fault does not form a planar single surface but reveals a clear segmentation and bending geometry with varying dip angles. There is an obvious relationship between average fault dip and fault size as well as average fault dip and fault displacement, where average fault dip decreases with increasing fault size and fault displacement changes from normal to reverse with decreasing average fault dip. We therefore infer that faults did not maintain stable orientation during fault growth as is the case for classical fault growth models. We therefore propose that faults started to grow as steeply dipping normal faults that progressively rotated during fault linkage and have been finally reactivated as thrust faults during or after ongoing segment linkage. Reverse drag effects occur where dip changes on the fault form a maximum and where displacements form a minimum.

The phenomenon that local displacement minima and maxima become less abundant with increasing fault displacement suggests that fault growth can be better explained by an isolated fault model, in which local displacement deficits are accommodated in order to maintain a fault specific displacement maximum/length ratio, rather than by a coherent fault model.