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A workflow for 3D model building in fold-thrust belts

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3D geological models can be used in fold-thrust belts for many purposes such as analysing geometric variation in folds, kinematic modelling to restore fold surfaces, generating strain distribution maps and predicting fracture network distribution. We present a workflow for 3D model building using outcrop bedding data, geological maps, Digital Terrain Models (DTM's), air photos and field photographs. We discuss the challenges of software limitations for 3D kinematic restoration and forward modelling in fold-thrust belt settings. We then discuss the sensitivity of model building approaches to the application of 3D geological models in fold-thrust belts for further analysis e.g. changes in along strike fold geometry, restoration using kinematic and geomechanical modelling, strain prediction and Discrete Fracture Network (DFN) modelling.

To create 3D models geological maps and bedding data are digitised using Move software; digitised maps and data are then draped onto DTM's. A series of closely spaced cross section lines are selected; the orientation of these is calculated by determining the average orientation of bedding dip direction. Fault and horizon line intersections, along with bedding data from within a narrow margin of the section lines are projected onto each cross section. Field photographs and sketches are integrated into the cross sections to determine thrust angles at the surface. Horizon lines are then constructed using bedding data. Displacement profiles for thrusts are plotted to ensure thrust displacements are valid with respect to neighbouring cross section interpretations; any discrepancies are alleviated by making minor adjustments to horizon and thrust lines, while ensuring that resultant cross section geometries still adhere to bedding data and other field observations. Once the cross sections have been finalised, 3D surfaces are created using the horizon and thrust line interpretations on each cross section. The simple curvature of 3D surfaces are analysed to identify anomalous regions; these anomalies can be reduced by altering the fold and thrust lines on cross sections in the anomalous regions, again ensuring lines still adhere to surface bedding data. 3D surfaces are finally resampled to create a smaller mesh size to ensure the results of any modelling applied to the 3D surfaces are at a high enough resolution. The final 3D model can then be utilised for analysis and modelling purposes. The workflow used is an iterative approach but ensures the final result is geologically realistic and reduces the potential for model-related errors to be carried forward into further modelling and analysis.