Quantifying fold and fracture attributes using Real-Time Kinematic (RTK) GPS

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In areas of folding there is generally assumed to be a correlation between fold curvature (eg. gaussian curvature, principal curvature directions) and the orientation, distribution and density of related fault and fracture systems. The ability to analyse curvature magnitudes and directions over small-scale fold structures offers a powerful new method of investigating the relationships between folding and fracturing. This has important implications for a range of academic and applied endeavours, including the prediction of sub-seismic scale reservoir characteristics.

Case studies of well-exposed natural folds can provide essential information regarding sub-surface fold geometry and the distribution of fracture networks. However, conventional methods of field-based data collection are largely incapable of capturing, preserving and quantifying spatial variation over folded surfaces with adequate precision. Real-Time Kinematic (RTK) GPS can be used to collect a dense network of georeferenced points across structures exposed in the field, and allows cm-scale fracture networks to be surveyed with great accuracy. The resultant spatial precision (typically <1cm horizontal, <2cm vertical) permits a rigorous and quantitative analysis of fold and fracture properties.

We present two associated datasets collected over single folded bedding surfaces, and use these to evaluate the spatial relationships between surface curvature and fracturing: 1) Data points collected with regular spacing (30-50cm) across the fold surfaces were used to construct gridded Digital Elevation Models, which form the basis for a comparison of curvature analysis techniques using GoCAD, Matlab, ArcGIS and 3D-Move. Variations of curvature magnitude are used to identify regions of high and low curvature, corresponding to invariant fold properties such as hinge- and inflection-lines. 2) Data points representing fracture locations across the folded surfaces are used to analyse attributes such as fracture spacing and fracture linkage. Where possible, we recorded additional information such as aperture width and vein fill. The spatial precision of RTK GPS allows the curvature models and fracture datasets to be combined and compared. Fracture attributes in 1-D and 2-D can be compared with principle curvature magnitudes whilst the orientation of open fractures can be compared with variations in principal curvature directions.