Field-based fault architecture of fold-thrust belts: an example from the Qaidam basin, northeast Tibetan Plateau

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Understanding the detailed fault architecture of reverse faulting is not only critical for revealing the processes involved in fold-thrust belts as well as predicting the relationship between folds and faults, the distribution of strain, and sub-seismic faulting deformation, but also important for understanding fault related compartmentalisation and fluid flow behaviour both along and/or across thrust fault zones. The Lenghu5 fold-thrust belt, provides an exceptionally well-exposed outcrop example of a reverse fault-related fold. Detailed stratigraphic logging coupled with high-resolution cross-sections provides a unique insight into the 3D geometry of a thrust fault at both basin and outcrop scale.

In this study we observed 85 - 90% of the estimated throw is accommodated on the main fault zone (i.e., the Lenghu5 thrust fault), which has sufficient throw to be imaged on a seismic profile, while 15-20% of the throw is accommodated on smaller scale folds and faults that are beyond seismic resolution. The Lenghu5 thrust fault, a seismically resolvable fault with up to ~800m of throw, exhibits a large variation of fault architecture and strain distribution along the fault zone. As meso-scale (1-100 m) structural features are normally beyond the seismic resolution, high-resolution outcrop in-situ mapping (5-10 cm resolution) was employed to study the deformation features of the Lenghu5 thrust fault zone. The excellent exposure of outcrops enables detailed investigation of its fault zone architecture. Multiple structural domains with different levels of strain were observed and are associated with the fault throw distribution across the fault. Based on previously proposed models and high-resolution outcrop mapping, an updated fault zone model was constructed to characterize the structural features and evolution of the Lenghu5 thrust fault.

The possible parameters that impact fault architecture and strain distribution, including fault throw, bed thickness, lithology and mechanical heterogeneity were evaluated. Fault throw distributions and linkages control the strain distribution across a thrust fault zone, with local folding processes contributing important elements in the Lenghu5 thrust fault especially where more incompetent beds dominate the stratigraphy. Mechanical heterogeneity, induced by different layer stacking patterns, controls the details of the fault architecture in the thrust zone. The variations in bed thicknesses and mechanical property contrasts are likely to control the initial fault dips and fault/fracture density. Large fault throws are associated with wide strain
accommodation and damage zones, although the relationship between the development and width of the fault zone with the throw accumulation remains to be assessed.

By presenting the high resolution mapping of fault architecture this study provides an insight into the sub-seismic fault zone geometry and strain distributions possible in thrust faults and reviews their application to assessing fault zone behaviour.