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Fault interactions and growth in an outcrop-scale system

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Fault geometries and strike-slip displacements in a moderately dipping (~50º) multi-layer sequence have been analysed to constrain the evolution of an outcrop-scale fault system in coastal New Zealand. Displacements and geometries of small faults (lengths 1-200 m and maximum displacements 0.007-3 m) were sampled from a horizontal shore platform up to 120 m wide and 1.5 km long with near 100% exposure. Displacement profiles have variable shapes that mainly reflect fault interactions, with individual faults being both hard- and soft-linked. Variable displacement profiles produce an average profile for all faults that is near-triangular, with displacement gradients (and displacement-length ratios) increasing by an order of magnitude from smallest to largest faults. Within fault zones these gradients are accompanied by secondary faults, which are typically of greatest density close to fault intersections, in relay zones and at fault tips. Horsetail and synthetic splays confined to the regions around fault tips are incompatible with gradual fault propagation for the duration of growth. Instead, fault displacements and tip geometries are consistent with growth initially dominated by fault propagation followed by displacement accumulation and approximately stationary fault tips. Retardation of propagation is thought to arise due to fault interactions and associated reduction of tip stresses, with the early change from propagation- to displacement-dominated growth stages produced by fault-system saturation (i.e. all faults are interacting). Initial rapid fault propagation succeeded by displacement-dominated growth accounts for different fault types over a range of scales suggesting that this fault growth model has wide application.