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Thrust fault segmentation and downward fault propagation in accretionary wedges: New Insights from 3D seismic reflection data

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The shallow parts of subduction megathrust faults are typically thought to be aseismic and incapable of propagating seismic rupture. The 2011 Tohoku-Oki earthquake, however, ruptured all the way to the trench, proving that in some locations rupture can propagate through the accretionary wedge. An improved understanding of the structural character and physical properties of accretionary wedges is therefore crucial to begin to assess why such anomalously shallow seismic rupture occurs. Despite its importance, we know surprisingly little regarding the 3D geometry and kinematics of thrust network development in accretionary prisms, largely due to a lack of 3D seismic reflection data providing high-resolution, 3D images of entire networks. Thus our current understanding is largely underpinned by observations from analogue and numerical modelling, with limited observational data from natural examples.

In this contribution we use PSDM, 3D seismic reflection data from the Nankai margin (3D Muroto dataset, available from the UTIG Academic Seismic Portal, Marine Geoscience Data System) to examine how imbricate thrust fault networks evolve during accretionary wedge growth. We unravel the evolution of faults within the protothrust and imbricate thrust zones by interpreting multiple horizons across faults and measuring fault displacement and fold amplitude along-strike; by doing this, we are able to investigate the three dimensional accrual of strain. We document a number of local displacement minima along-strike of faults, suggesting that, the protothrust and imbricate thrusts developed from the linkage of smaller, previously isolated fault segments. Although we often assume imbricate faults are likely to have propagated upwards from the décollement we show strong evidence for fault nucleation at shallow depths and downward propagation to intersect the décollement. The complex fault interactions documented here have implications for hydraulic compartmentalisation and pore fluid pressure along the shallow parts of the megathrust.