Changes in the location of the nucleation point of slip events on ancient normal faults

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The lack of an unambiguous method for determining the propagation direction of slip events on faults over significant time periods limits our understanding of the long-term stability of fault slip propagation directions. A geological means for determining the propagation direction of slip events during the growth of faults is provided by mutually cross-cutting faults and bed-parallel slip-surfaces in the Ptolemais Basin, northern Greece.

In the Kardia lignite mine, Ptolemais Basin, bed-parallel slip surfaces intermittently offset the Quaternary faults as they grew to form discontinuities on otherwise continuous fault surfaces. Subsequent fault slip increments bypassed these discontinuities to re-establish a continuous fault trace and leave an associated ‘dead’ splay. The geometry and displacement distributions at these fault/bed-parallel slip intersections record the fault displacement at the time of bed-parallel slip and whether the next fault slip increment had an upwards or downwards component to its local propagation vector.

A database (N = 88) of slip propagation directions and fault throws was derived from continuous mapping of mine faces during lignite extraction over an eight year period. The data demonstrate a clear relationship between slip propagation direction and the accumulation of fault displacement on individual faults. During the early stages of fault growth, slip events propagated almost exclusively upwards through the mined sequence, but later stages of growth are marked by slip events showing both upward and downward components of propagation. The data therefore demonstrate that the location of the point of initiation of fault slip events on these Quaternary faults varied over the fault surfaces as the faults grew.

The emergence of systematic results from our analyses suggests that cross-cutting relationships between other synchronously active structures (e.g. conjugate faults) can provide a robust means for determining the propagation directions of slip events on ancient faults at outcrop.
