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Superposed Cenozoic fault patterns in Sichuan, China – record of relative anticlockwise rotation of eastern Tibetan crust between the Xianshuihe Fault and the Longmen Shan thrust belt

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Post-collisional convergence of India with Eurasia since post-Eocene times and the associated uplift and ESE-WNW extension of the Tibetan Plateau account for the E- to S-directed flow of eastern Tibetan crust around the Eastern Himalayan Syntaxis. In the upper crust of the eastern Tibetan Plateau, this material flow is accommodated by lateral transfer along strike-slip faults and either crustal thickening at the NE' and E' front of the plateau (along the Nan Shan, Kunlun, and Longmen Shan thrust belts), or by southward extrusion without dominant internal crustal thickening. As a result, the upper crust of the eastern Tibetan Plateau is highly segmented and deformation partitioned among several large-scale (Altyn Tagh-, Kunlun-, Xianshuihe-, Red River- and Sagaing Faults) and innumerous smaller-scale strike-slip and associated thrust and normal fault systems. The extensive interaction, multiple reorientation, and successive reactivation of faults accounts for the rotation and translation of upper crustal segments of various sizes.

A detailed field survey in the Danba region, located between the sinistral Xianshuihe Fault, the SE-directed Longmen Shan thrust belt and the sinistral Kunlun Fault, revealed a complex superposition of ductile (D1, D2), semi-ductile (D3, D4) and brittle structures (D5a-c, D6a,b). They deform Sinian to Paleozoic continental basement and cover of the Yangtze craton and the overlying Triassic Songpan Ganzê flysch. Whereas the dense network of brittle D5 and D6 faults is clearly Cenozoic in age, ductile (D1, D2) and possibly also semi-ductile structures (D3, D4) might be inherited from the Late Triassic Indosinian orogeny, although the latter are active in the Cenozoic.

Ductile deformation formed under up to amphibolite facies metamorphic conditions and resulted in two superposed phases of synmylonitic folds (D1, D2) and the formation of the composite main foliation of the region. This was followed by a period of tectonic quiescence, as evidenced by the unaligned growth of amphibolite facies index minerals. The renewed onset of shortening under up to upper greenschist facies conditions accounted for three superposed sets of suborthogonal, conjugate thrusts and folds (D3, D4, D5). The fold superposition gave rise to basin and dome structures from micro- to kilometer-scale (e.g. Danba dome). The reactivation of older and formation of new brittle faults from D5 onwards led to an intense segmentation of the rocks with a fault density estimated at $0.1/m^3$ outside to $30/m^3$ within major fault zones. The conjugate N- and E-striking oblique D5 thrusts were overprinted by conjugate sets of sinistral NW- and dextral NE-striking strike-slip faults (D6a). During D6b, older faults were reactivated as normal faults and new conjugate sets of ENE- and ESE- striking normal faults formed. D6a and D6b are active at present, with non-cohesive fault breccias along their fault planes, and are interpreted to record stick-and-slip movement.

Kinematic analysis of the D5-D6 fault-slip datasets yields evidence for the relative anticlockwise rotation of $\sim 120^\circ$-170° about a subvertical axis of at least part of the crustal segment between Xianshuihe Fault, Longmen Shan thrust belt and Kunlun Fault. Due to the lack of paleomagnetic data, an absolute anticlockwise rotation of crust, or a clockwise rotation of the stress trajectories through a “fixed” crustal block cannot be distinguished. Rotation must be accommodated by differential shortening across the Longmen Shan thrust belt.