Stress State and Fault Strength Variation along Xiaojiang Fault Zone Revealed by Seismicity

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Xiaojiang Fault (XJF) lies at the southeastern edge of the rhombic Sichuan-Yunnan block, and has an extent for over 400km from Qiaojia to Shanhua district. The Sichuan-Yunnan block experiences clockwise rotation and southwestward escaping from the Tibetan Plateau, producing complex fault geometry and seismicity pattern. The strong variation along fault segments provides a special opportunity to study the relationship between fault zone properties and seismicity pattern. However, the fine structure of XJF remains unknown due to the sparse observational stations.

Seismic data has its unique advantage of resolving fault zone properties at depth. We deployed 48 broad-band seismometers along XJF in order to capture detailed seismicity patterns. Our seismic network covers the northern and middle part of XJF, with an average aperture of 20km; the continuous observation from 2015 to 2019 guarantees enough data volume. We detected about 12,000 earthquakes by STA/LTA phase picking and association, and augmented the detection to over 50,000 events with template matching. The relocated catalog has lateral and vertical resolution of 500m and 1km, respectively; the magnitude of completeness (Mc) reaches ML0.3

This high-resolution catalog depicts detailed 3D fault geometry. The seismicity shows clustered lateral distribution, with the clusters' depth extension ranging from 20km at northern to 35km at southern segments. Unmapped orthogonal faults on northern XJF are illuminated by seismicity, which matches orthogonal topography characteristics. Repeating events are detected from 8 seismicity clusters, under a threshold of 5 repeating families, indicating a creeping slip mode, while the separated low-seismicity segments exhibit a high locking rate. Taking advantage of the high detectability, we got reliable b-value estimation for different segments of XJF. The low-b regions correlate well with the margins of locking patches, which points to a high stress concentration. Velocity structure extracted from ambient noise and fault zone head wave present similar spatial variation, which further proved the seismicity pattern. The high heterogeneous characteristics of XJF may produce stress barriers, preventing future earthquake rupture from propagating to a large scale.