# Magnetotelluric evidence for crustal heterogeneity controlling earthquake ruptures along the Muji Fault, Northeastern Pamir Orogen

Yuanzhi Cheng, Yanlong Kong, Zhongxing Wang

Institute of Geology and Geophysics, Chinese Academy of Sciences

The occurrence of earthquakes is not solely dictated by fault geometry and stress accumulation; it is also intricately linked to the structure of the surrounding medium, with resistivity being a key parameter. When the accumulated tectonic stress within the rock surrounding a fault surpasses its critical threshold, the rock fractures, leading to the instantaneous release of stress near the fault and triggering an earthquake. The intricate geometry and heterogeneous nature of faults contribute to the diversity of seismic sources. The widely used asperity model elucidates the seismic-generating mechanism and rupture process of earthquakes. However, accurately determining the deep geometry and stress state of faults remains challenging. Geophysical methods offer a solution, providing insights into the medium's structure. By utilizing techniques such as seismic imaging and electromagnetic surveys, researchers can infer crucial information about fault zones and potential earthquake sources based on variations in properties like resistivity, seismic velocity, and density. Integrating these geophysical observations with fault mechanics models refines our understanding of earthquake processes and enhances hazard assessment efforts.

On November 25, 2016, a magnitude 6.6 shallow earthquake ruptured the Muji fault in western Xinjiang, China. This event marked the first large instrumentally recorded earthquake on the Muji fault. The epicenter was surrounded by the main Pamir thrust to the north, the Karakul graben (Karakul Lake) to the west, the right-lateral strike-slip Rongkul fault to the south, and the right-lateral strike-slip and normal segments of the Muji fault to the east. Aftershocks occurred primarily to the east and west of the main shock epicenter, mainly south of the Muji fault trace. However, the seismogenic structure and rupture process of this earthquake remain debated.

To better understand the seismogenic structure and rupture process of the Muji earthquake, we investigated the crustal structure using the magnetotelluric method. In March 2024, we surveyed more than 59 sites using remote reference techniques to enhance data quality. After careful visual inspection, 59 sites were deemed to have high-quality data. The intensive model testing stations provided high-resolution crustal electrical structures along the Muji fault through three-dimensional inversion. The model reveals a strong correlation between resistivity interfaces and seismic source locations, reflecting the accumulation and uneven distribution of stress along the fault. The spatial distribution of slip during the Muji earthquake shows a strong correlation with high resistivity anomalies, indicating that the heterogeneity of the fault interface controls the earthquake rupture process.