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

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1. MOTIVATION

- The Pamir orogenic belt is located at the junction of the Eurasian and Indian plates, where the dynamic interactions between the two plates are most pronounced, and seismic activity is particularly intense.
- 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. Aftershocks occurred primarily to the east and west of the main shock epicenter, mainly south of the Muji fault trace.
- To better understand the seismogenic structure and rupture process of the Muji earthquake, we investigated the crustal structure using the magnetotelluric method.

2. MT DATA

- In March 2024, 59 BBMT sites was deployed using remote reference techniques to enhance data quality.
- Recordings were carried out for 20 hours and responses were estimated using a robust processing.

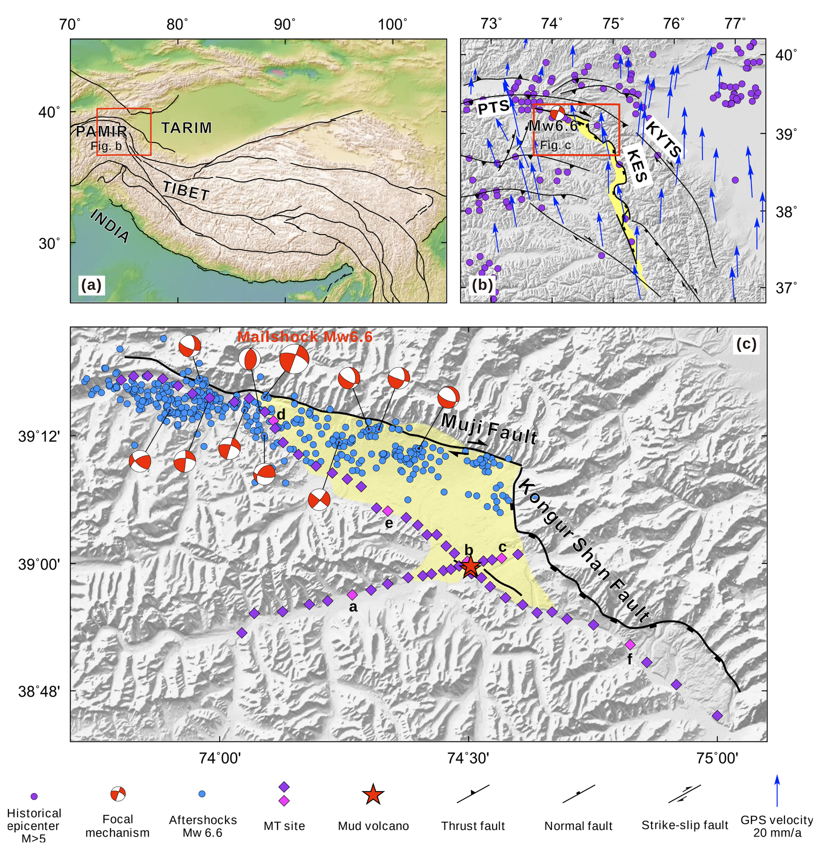

Figure 1. Tectonic and MT sites in Pamir

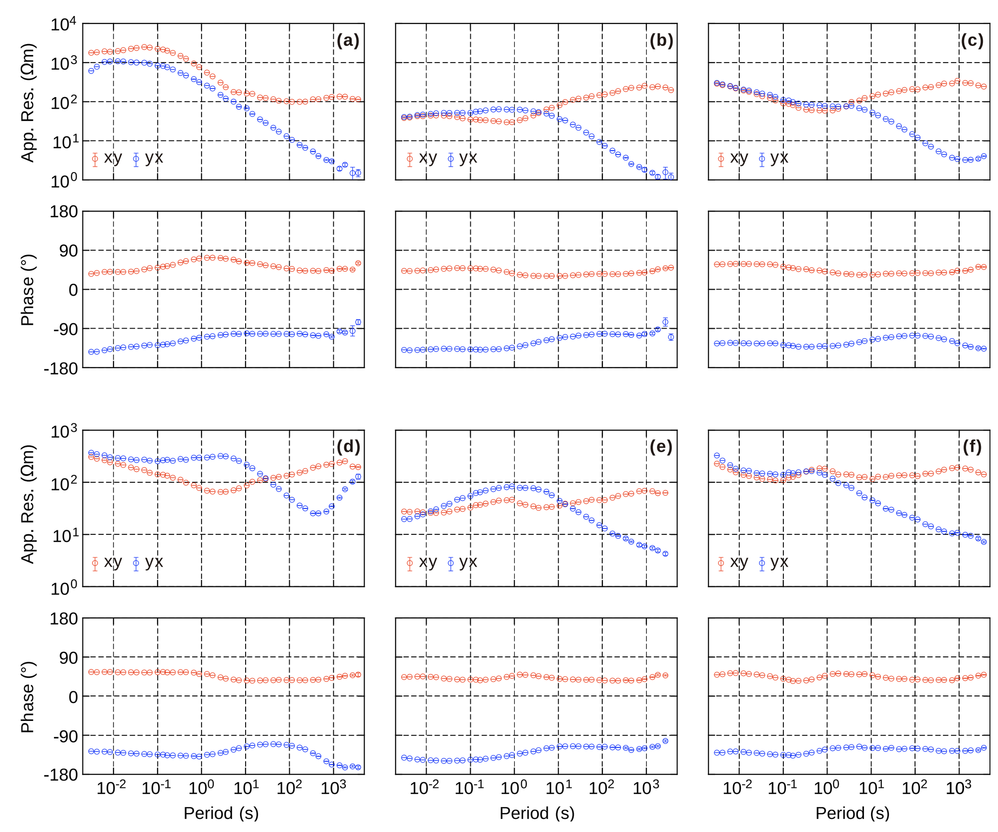

Figure 2. Sample MT responses

3. PHASE TENSOR

- The phase tensor and dimensionality (Caldwell et al., 2004) analysis indicate that the shallow part is dominated by 1D/2D structures, reflecting the sedimentary structure of the basin. In contrast, the deeper part exhibits a 3D structure, which reflects the complex feature of the fault zone.
- The high-resolution crustal electrical structures along the Muji fault are obtained through three-dimensional inversion.

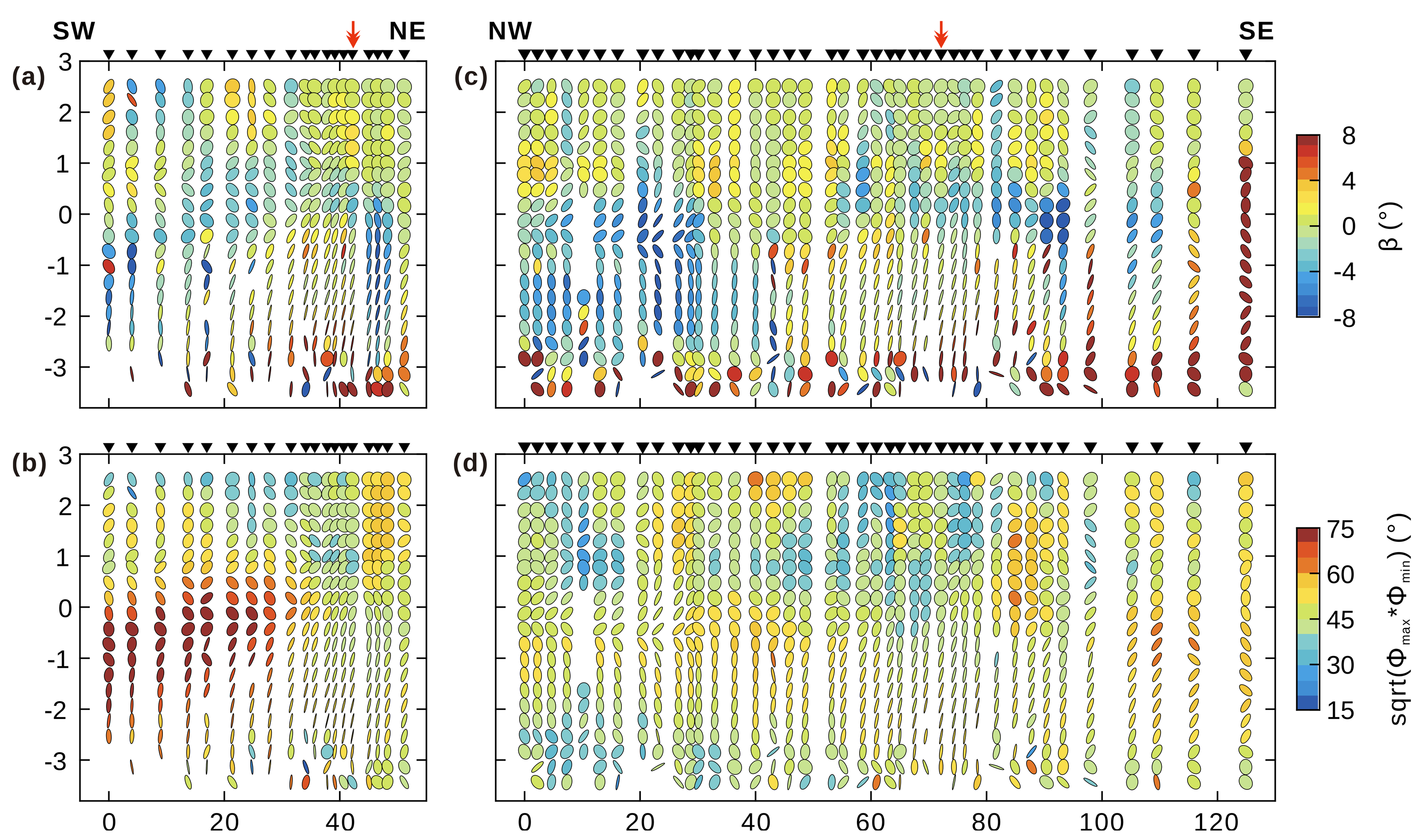

Figure 3. Phase tensor ellipses pseudo-section

4. 3-D INVERSION

- The crustal electrical structure along the Muji fault was obtained from 3-D inversion of 59 MT sites using the ModEM (Egbert & Kelbert, 2012; Kelbert et al., 2014) with the full impedance tensor.
- Topography was included in the model. The grid meshes of the model were composed of 64 (X)×94 (Y) × 84 (Z). The model smoothing parameters were set to the same value (0.3). The initial value of the regularization factor was set to 3000. A 5% error floor was applied to the data at each period. the starting model was assigned a homogeneous resistivity of 100 Ωm.
- The inversion stopped after187 iteration with final RMS of 2.0.

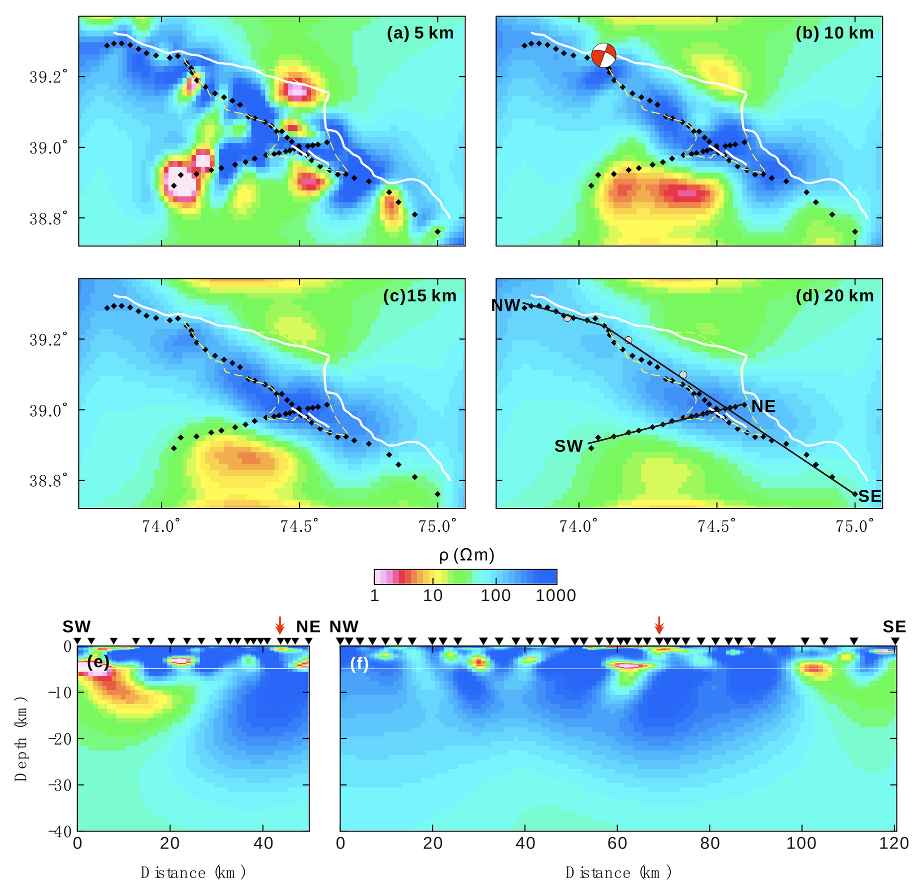

Figure 4. Horizontal slices and Vertical slice of the preferred 3-D electrical model

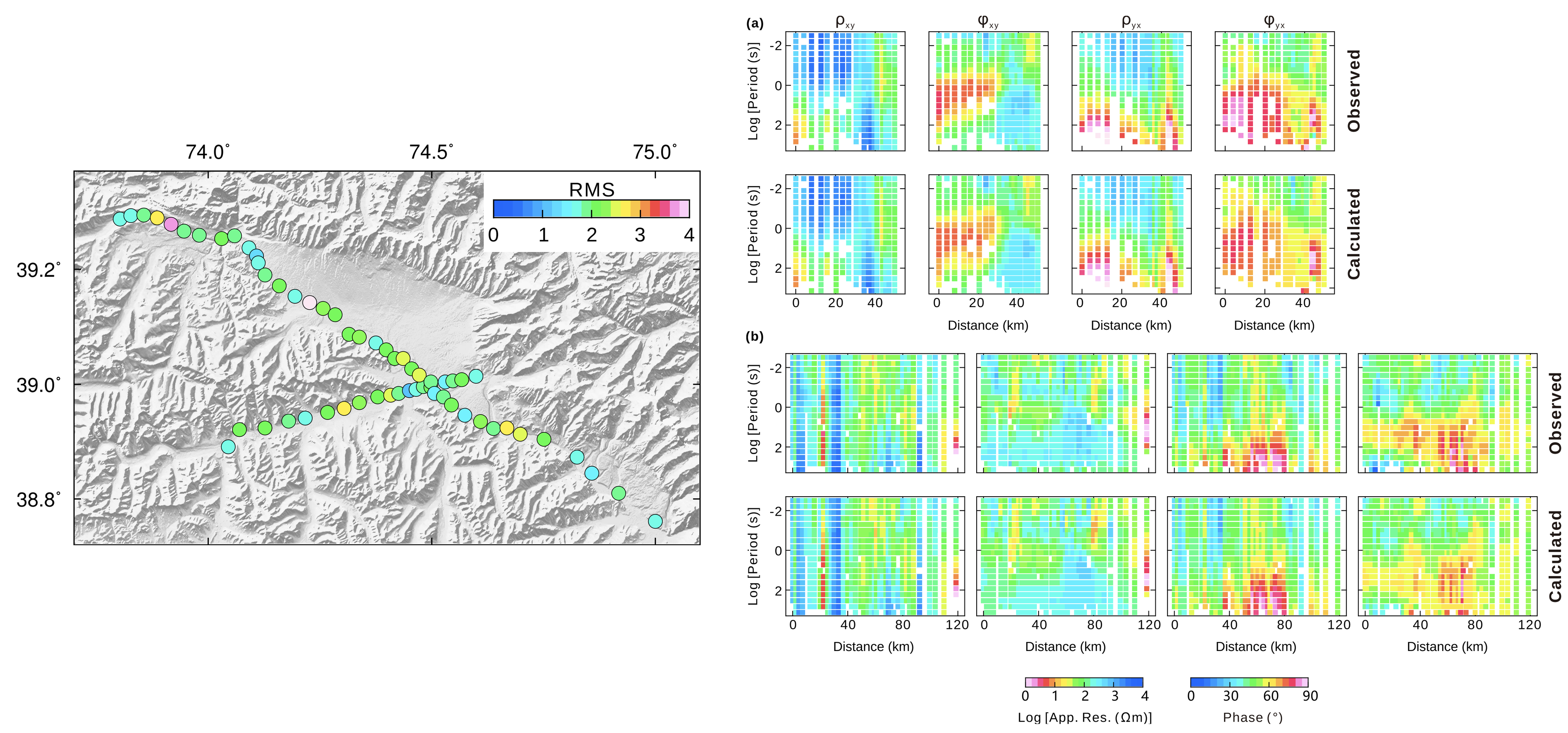

Figure 5. RMS values and Data fit for the best-fitting model

5. CONCLUSION

- 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 coseismic slip during the Muji earthquake (Bie et al., 2018) shows a strong correlation with high resistivity anomalies, indicating that the heterogeneity of the fault interface controls the earthquake rupture process.

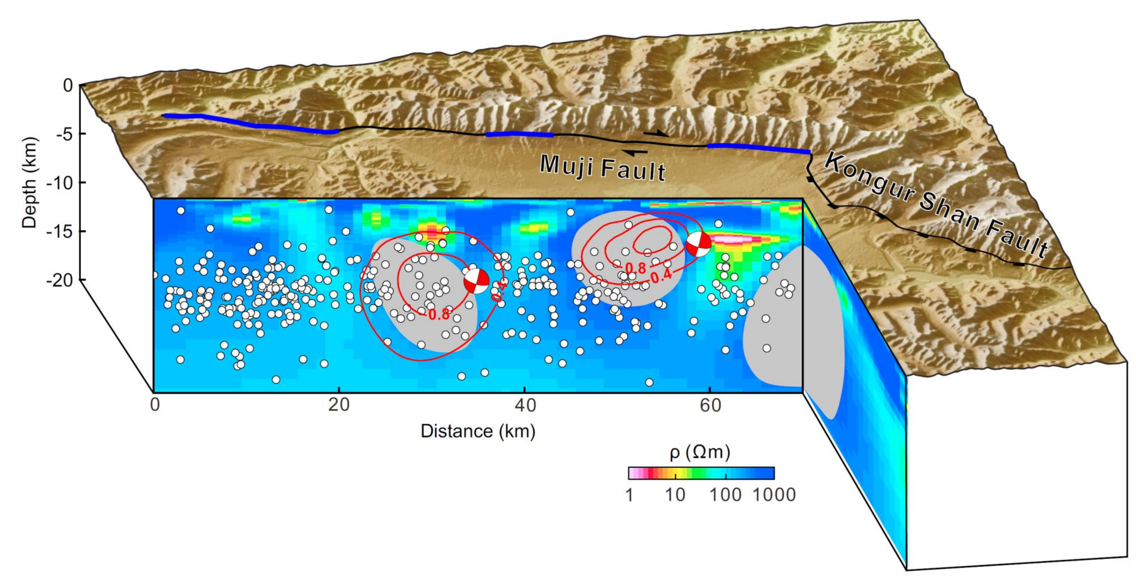

Figure 6. The electrical structure along the Muji fault correlated with the section-view Muji earthquake sequence (white circle) and coseismic slip distribution (red contours with 0.4m intervals. Blue lines mark seismic gaps on the Muji fault that were not ruptured by the 2016 Muji earthquake.

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