Three-Dimensional Electrical Structure in the Northwestern Corner of the Sichuan-Yunnan Diamond Block

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Summary

To understand the distribution material flow at the eastern margin of the Tibetan Plateau and the northwestern boundary of the Sichuan-Yunnan diamond block, we established a magnetotelluric (MT) profile cross the northwestern corner of the diamond block. This profile extends from Chazha Township in Ganzi County, Sichuan Province, to Luomai Township in Gongjue County, Tibet Autonomous Region. Using three-dimensional magnetotelluric inversion technology, we obtained reliable electrical structures. Our analysis suggests that the northwestern boundary of the Sichuan-Yunnan diamond block is the Dedeng-Batang-Riyu Fault, and the material flow within the block does not reach the lower crustal depths.

Keywords: Magnetotelluric; Sichuan-Yunnan Diamond Block; Boundary

Introduction

The Sichuan-Yunnan (CD) diamond block is an important channel for material flow from the Tibet Plateau . For a long time, studies on the electrical structure and dynamics of the block have mainly focused on the Lijiang-Xiaojinhe Fault in southern of the block. In order to understand the spatial spreading characteristics of linear structures and the deep extension of faults in the northwestern part of the block, we set up a 204 km profile from Chazha Township, Ganzi County, Sichuan Province to Luomai Township, Gongjue County, Tibet Autonomous Region (CM) with 17 broadband Magnetotelluric (MT) station. The survey line crosses the Ganzi-Litang Fault Zone, the Dalangsonggou Fault, the Maisu Fault, the Jinshajiang Fault Zone, the Dedeng-Batang-Riyu Fault, and the Zigasi-Deqin Fault in turn.

Methods

Data Collection

The data was collected in October 2020 using the MTU-5A from Canadian Phoenix Company. The acquisition method was 5-component (two orthogonal horizontal electric fields, two orthogonal horizontal magnetic fields and one vertical magnetic field, with horizontal components arranged along the north-south and east-west directions) broadband MT observation (high frequency 2400Hz, medium frequency 150Hz, low frequency 15Hz). To ensure data quality, a continuous observation reference station was set up in Etuoke Front Banner, Inner Mongolia, which is 1050 kilometers away from the measurement area (107° 49′ 40.31″ N， 38° 1′ 27.33″ E). The electromagnetic environment of this station is excellent and there is almost no human interference. The data collection time for each measurement point was more than 40 hours, and remote reference technology and non-Robust technology (Zhang et al. 2022) were used for time series processing. The phase curves of the apparent resistivity of each measurement point are relatively smooth and the data quality is high. The effective period range of most measurement points is 1/320s~2000s, among which the effective periods of CM06, CM08 and CM17 are close to 10000s (Figure 1).

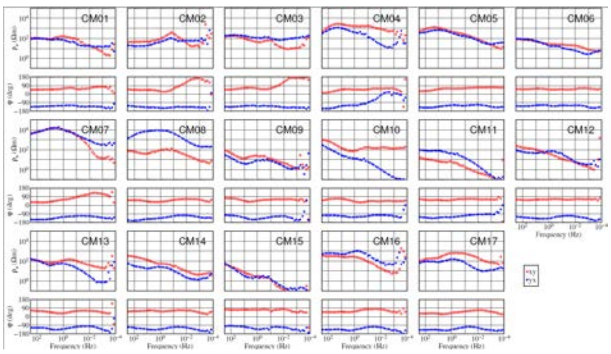

Figure 1. Apparent resistivity and impedance phase curves

Three-Dimensional Inversion

We used the MT inversion program ModEM (Kelbert et al. 2014) to perform three-dimensional inversion with terrain data. The process of establishing the initial model and setting various inversion parameters was simplified using the visualization geoelectric three-dimensional inversion software system toPeak (Liu et al. 2022). In the inversion of apparent resistivity and phase, the threshold error of apparent resistivity is 5%, and that of impedance phase is 1.432°. A uniform half-space with a resistivity of 100Ωm was initially used as the initial model. Subsequently, the reliability analysis was carried out on the inversion results. The high-conductivity and high-resistance bodies in the results were respectively removed for forward verification, which proved that the three-dimensional inversion results were reliable.

RESULTS

After multiple inversions to eliminate local extremum, the final inversion RMS was 1.06. Figure 2 shows that there is a high-conductivity layer in the upper crust of the northwest Sichuan secondary block in the north of Sichuan-Yunnan diamond block, with a thickness of about 20km, which extends to the Bayanhar terrane in shallow depth; there is also a high-conductivity layer with shallow depth and a thickness of about 10km at the eastern margin of Qiangtang block; these two high-conductivity layers are discontinuous in the deep part of Dedeng-Batang-Riyu fault.

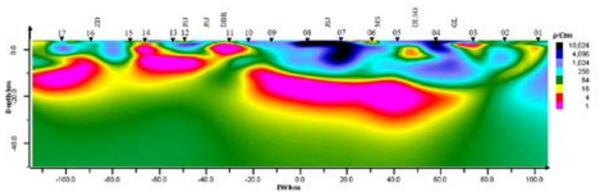

Figure 2. Deep electrical structure in profile CM. ZD = Zigasi-Deqin Fault; JSJ = Jinshajiang Fault Zone; DBR = Dedeng-Batang-Riyu Fault; MS = Maisu Fault; DLSG = Dalangsonggou Fault; GL = Ganzi-Litang Fault Zone.

DISCUSSION

Based on Figure 2, it can be observed that there is a low-resistivity layer in the upper crust at the northwest corner of the Sichuan-Yunnan diamond block, and its thickness is relatively thin. This observation differs from the results of the two-dimensional inversion in this region (Bai et al. 2010). However, the MT two-dimensional inversion has limitations in identifying high-conductivity bottom interfaces, whereas the currently popular three-dimensional inversion techniques have significantly improved the vertical resolution of MT inversions. Therefore, we infer that the material flow has not reached the lower crustal depth. The high-conductivity under CM11 are not connected, indicating that this location is the boundary of the electrical structure of the diamond block, specifically identifying the Dedeng-Batang-Riyu Fault as the northwest boundary of the Sichuan-Yunnan diamond block. There is a complete high-resistivity within the block, providing evidence that the diamond block is an independent deforming block. The shallow high-resistivity body beneath CM15-17 indicates the presence of a fracture zone at the boundary of the diamond block, which is consistent with the block locations delineated by Zhang et al(2003). Since these high-conductivity layers are shallowly buried, thin in thickness and small in scale, they are not enough to drive block movement. We infer that these high-conductivity layers may be decoupling surfaces in middle-upper crust.

CONCLUSION

(1) The northwestern boundary of the Sichuan-Yunnan diamond block is Dedeng-Batang-Riyu Fault belongs to a branch of the Jinshajiang fault zone.
(2) There is a high-conductivity material flow within the Sichuan-Yunnan diamond block, but its distribution is relatively shallow and does not reach the lower crust.

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REFERENCES

Bai D, Unsworth M J, Meju M A,et al. (2010) Crustal deformation of the eastern Tibetan plateau revealed by magnetotelluric imaging. Nature Geoscience 3: 358–362. doi:10.1038/ngeo830

Kelbert A, Meqbel N, Egbert G D, et al. (2014) ModEM：A modular system for inversion of electromagnetic geophysical data．Computers & Geosciences，66: 40-53. doi:10.1016/j.cageo.2014.01.010

Liu Z, Chen X, Cai J, et al. (2022) The design and application of topeak: a three-dimensional magnetotelluric inversion cloud computing system (in Chinese). Seismology and Geology, 44(3): 802-820. doi:10.3969/j.issn.0253-4967.2022.03.015

Zhang P, Deng Q, Zhang G, et al. (2003). Active tectonics blocks and strong earthquakes in the continent of China (in Chinese). Science in China (Series D), 33(B04):12-20. doi:10.3321/j.issn:1006-9267.2003.z1.002

Zhang Y, Wang P, Chen X, et al. (2022) Magnetotelluric time series processing in strong interference environment(in Chinese). Seismology and Geology, 44(3):786-801. doi:10.3969/j.issn.0253-4967.2022.03.014