Acta Geologica Sinica (English Edition), 2021, 95(supp.1): 34–36

On the Origin of Crustal High Conductivity Zone in the Western Tibet Plateau

GU Jiangfan[1], DONG Hao[1, 2, *], JIN Sheng[1, 2, *], WEI Wenbo[1], YE Gaofeng[1], ZHANG Letian[1, 2], JIN Jianen[1], XIE Chengliang[1] and YIN Yaotian[1]

[1] *School of Geophysics and Information Technology, China University of Geosciences, Beijing 100083, China*
[2] *State Key laboratory of Geological Processes and Mineral Resources, Beijing 100083, China*

Citation: Gu et al., 2021. On the Origin of Crustal High Conductivity Zone in the Western Tibet Plateau. Acta Geologica Sinica (English Edition), 95(supp. 1): 34–36.

The subduction of the Indian continental lithosphere under the Asian continent caused the uplift of the Tibet Plateau, resulting in the formation of a thickened continental crust twice of the normal value and the crustal shortening of at least 1500 km. Therefore, many models have been proposed to explain the shortening and material transportation mechanism of the Tibetan Plateau, such as channel flow, subduction, and so on. Moreover, the heat generated by radioactive thermogenesis in the thickened crust of the Tibet Plateau makes it possible for partial melting which is the main explanation for the anomaly observed by the geophysical method in the mid-lower crust. However, geophysical observations gave diverse melt constraints from several percentages (Li et al., 2020) to above 50% (Xie et al., 2017) in the same area which might lead to not only different rheological properties but also distinct deformation mechanisms. Thus, research (Hashim et al., 2013; Chen et al., 2018) suggests that these constraints need to be re-evaluated. To discuss this condition in the western Tibet (Fig. 1a), we establish a 3-D resistivity model based on magnetotellurics (MT) observations, and discuss the possible mechanisms behind the electrical anomalies and other geophysical and geochemistry result.

Here, magnetotelluric data from ‘SINOPROBE’ and ‘INDEPTH’ projects in 79°–81°E (Fig. 1b) are studied, including the 117 broadband and 10 long-period stations. After analysing the dimensionality of the transfer functions, we compared the result with previous seismic studies in the region. We performed 3-D inversion using these data by the ModEM package (Kelbert et al., 2014). After 219 iterations, the RMS of our model reduced from 83 to 1.6. Our preferred model (Fig. 2) is proven to be reliable for crustal scale, with its horizontal reliable zone extending around the stations. Resistivity structure in the shallow area (0.5 km, Fig. 2a) is consistent with surface structure, as the distribution of surface high conductors is related to water-rich sediments. Sensitivity analysis also shows that: (1) there are no connections between the conductor A and B in the upper-mid crust of the Lhasa block; (2) the conductivity of A and B is higher than that of the conductor C in the middle crust of the Qiangtang block; (3) conductor C in Qiangtang block extends throughout the block and may be connected to Lhasa block's conductor B on the east side of the region.

MT data are generally believed to have better estimation for the conductance of a certain layer, instead of the actual resistivity. Therefore, it is often better to estimate the fluid fraction (and hence viscosity) by an effective bulk conductivity derived from conductance. Figure 3 shows the integrated conductance of the middle crust (20–50 km) calculated from our preferred resistivity model. The high conductivity zones (HCZs, >0.3 S/m) is located in the middle crust of Lhasa terrane, which can be interpreted as partial melting. However, there are still some observed results challenging this opinion especially in the upper-middle crust. Thus, we should consider all possible interpretation of the HCZs. Here, we apply modified Archie’s Law (Glover et al., 2000) to estimate the fluid percentage from conductivity in a two-phase medium. In the case of saline fluid, 4% fluid fraction with 1 wt% NaCl or 1% fraction with 5 wt% NaCl can result in the >0.3 S/m conductivity observed. If partial melting with water is present, it will require a full layer of melt (100% melt content) at depth of 20–30 km. In a deeper depth range of 30–60 km, the melt content needs to exceed 40% to reach the conductivity observed. The melt fraction will be comparable to the magma chamber of an active volcano, which is not realistic for the middle crust of the Lhasa Terrane. Our calculations indicate that due to the unique chemical composition, the melt conductivity in the study area may indeed be higher than that of other locations. Still, even with these conditions considered, the high conductivity cannot be properly explained. Meanwhile, higher contents of volatiles do not generally increase electrical conductivity as expected. Therefore, we must continue to investigate the origin of the HCZs.

The relative highly resistive body (D) located in the lower crust of the Lhasa terrane matches the previous seismic tomography results, which suggests the anomaly may be related to the subducted India lower crust. The differences of conductivity between Lhasa and Qiangtang blocks indicate that their rheological properties are likely different. The Bankong–Nujiang Suture Zone separates the HCZs located in Lhasa and Qiangtang blocks, which may due to the different movement direction of the crustal

* Corresponding author. E-mail: donghao@cugb.edu.cn; jinsheng@cugb.edu.cn

http://www.geojournals.cn/dzxbcn/ch/index.aspx
https://onlinelibrary.wiley.com/journal/17556724

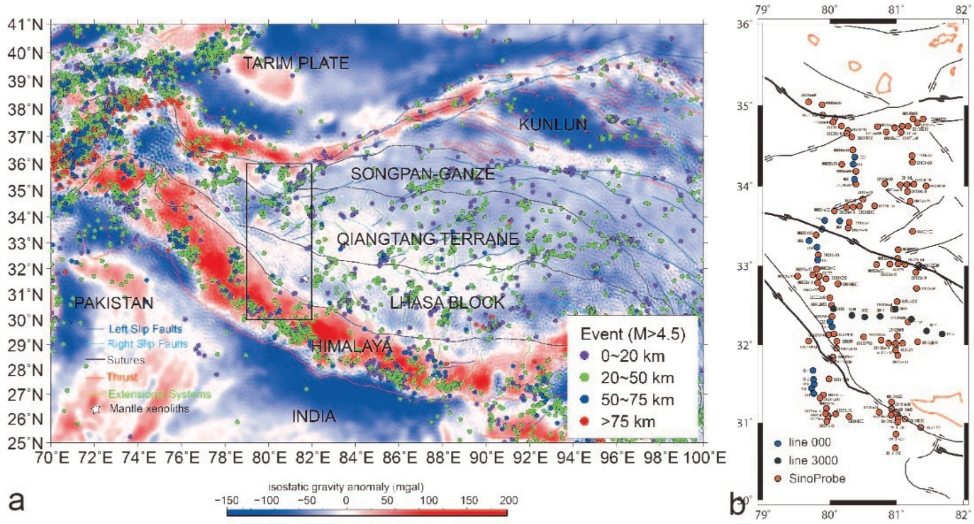

Fig. 1. Tectonic map with MT site location (modified after Yin and Harrison, 2000; Balmino et al., 2012; Ekström et al., 2012).

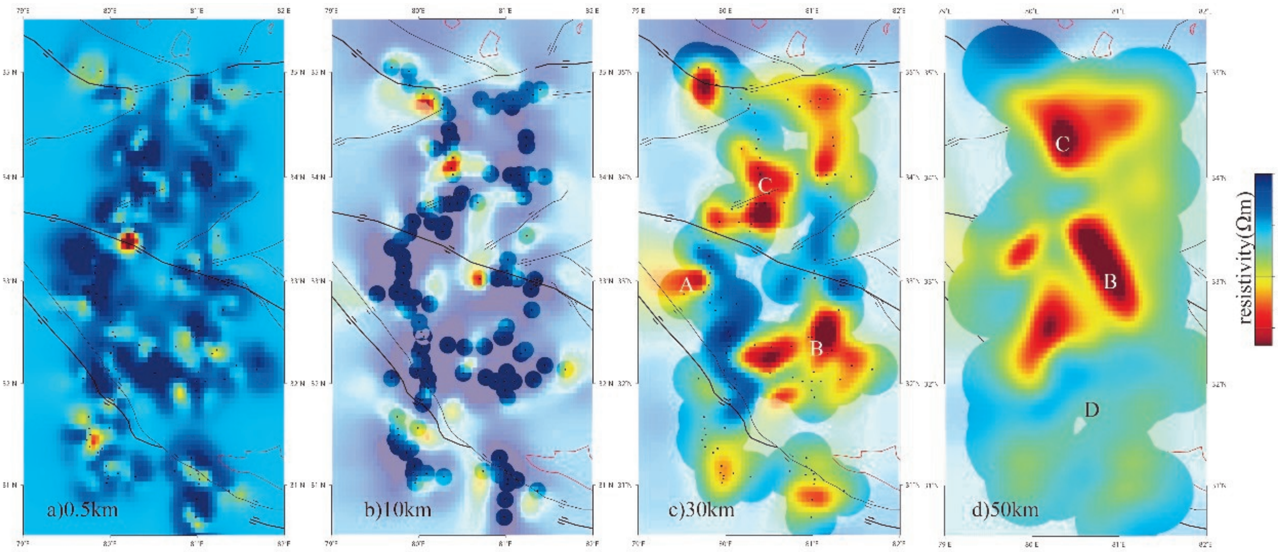

Fig. 2. Horizontal slices of electrical model.

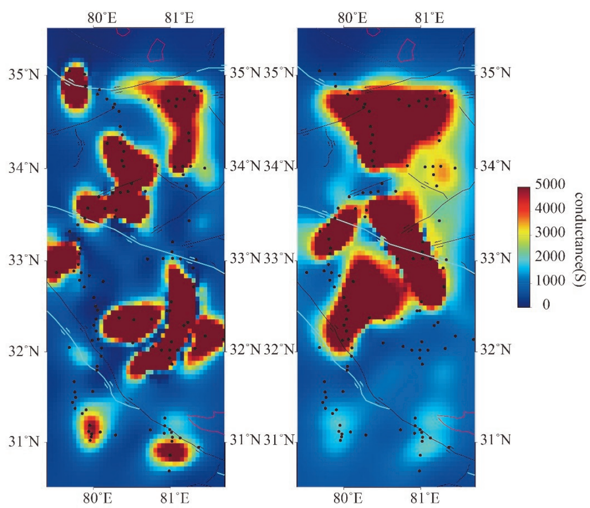

Fig.3. Conductance map of 20–35 km (left), 35–50 km (right). Red part means the average conductivity > 0.3 S/m

material in the two blocks. Moreover, a ~15 km depth high resistivity layer is revealed beneath the Karakoram fault, which suggests that the east end of Karakoram fault is not a lithospheric scale structure as previously discussed. This indicates that the role of the Karakoram fault might change during the different geologic period.

Key words: three-dimensional resistivity model, high conductivity zone, West Tibet plateau

Acknowledgments: This study was funded by the SinoProbe project (Sinoprobe-02-04).

References

Balmino, G., Vales, N., Bonvalot, S., and Briais, A., 2012. Spherical harmonic modelling to ultra-high degree of Bouguer and isostatic anomalies. Journal of Geodesy, 86(7): 499–520.

Chen, J.Y., Gaillard, F., Villaros, A., Yang X.S., Laumonier, M., Jolivet, L., Unsworth, M., Hashim, L., Scaillet, B., and Guillaume, R., 2018. Melting conditions in the modern Tibetan crust since the Miocene. Nature Communications, 9

(1): 3515.
Ekström, G., Nettles, M., and Dziewoński, A.M., 2012. The global CMT project 2004–2010: Centroid-moment tensors for 13,017 earthquakes. Physics of the Earth and Planetary Interiors, 200–201: 1–9.
Glover, P.W.J., Malcolm, J.H., and Jaume, P., 2000. A modified archie's law for two conducting phases. Earth and Planetary Science Letters, 180(3–4): 369–83.
Hashim, L., Gaillard F., Champallier, R., Breton, N., Arbaret, L., and Scaillet. B., 2013. Experimental assessment of the relationships between electrical resistivity, crustal melting and strain localization beneath the Himalayan-Tibetan belt. Earth and Planetary Science Letters, 373: 20–30.
Kelbert, A., Meqbel, N., Egbert, G.D., and Tandon, K., 2014. ModEM: A modular system for inversion of electromagnetic geophysical data. Computers and Geosciences, 66: 40–53.
Li, L., Murphy, M.A., and Gao, R., 2020. Subduction of the Indian plate and the nature of the crust beneath western Tibet: Insights from seismic imaging. Journal of Geophysical Research: Solid Earth, 125(8): 1–13.
Xie, C.L., Jin, S., Wei, W.B, Ye, G.F., Zhang, L.T., Dong, H., and Yin, Y.T., 2017. Varying Indian crustal front in the southern Tibetan Plateau as revealed by magnetotelluric data. Earth, Planets and Space, 69:147.
Yin, A., and Harrison, T.M., 2000. Geologic evolution of the Himalayan-Tibetan orogeny. Annual Reviews of Earth and Planetary Sciences, 28: 211–80.

About the first author

GU Jiangfan, female, born in 1992, doctoral student. Her research interests are deep geophysics. E-mail: gujiangfan@outlook.com.

About the corresponding authors

DONG Hao, male, born in 1984, associate professor. His expertise lies in electromagnetic numerical simulation and inversion. E-mail: donghao@cugb.edu.cn.

JIN Sheng, male, born in 1970, professor. His expertise lies in deep geophysical exploration and electrical exploration. E-mail: jinsheng@cugb.edu.cn.