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Deep Geophysical Structure Research on Middle Section of the Longmen Mountain Tectonic Belt

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1 Electrical Structure of Crust and Upper Mantle at Middle Section of Longmen Mountain and Adjacent Regions

At northeast of the Qinghai-Tibet Plateau, two magnetotelluric sounding profiles that are distributed at Songpan tectonic belt, middle section of Longmen Mountain tectonic belt and Sichuan Basin, the electrical structure of crust and upper mantle at this region is obtained (Fig.1). Luqu-Zhongjiang profile south from Zhongjiang, across Beichuan, Songpan and Ruoergai to Luqu, overall length is 480km. The overall length of Anxian-Suining section of Songpan-Shaoyang profile is 271km.

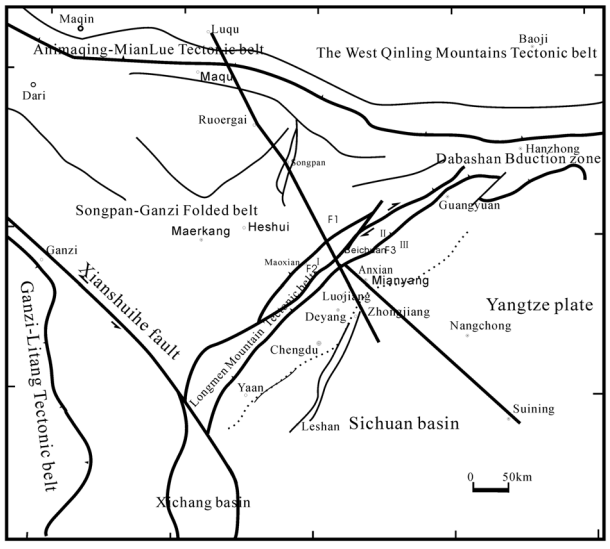

Fig.1. Location map of the magnetotelluric sounding

1.1 Trichotomous feature of regional structure

The inversion map of the Luqu-Zhongjiang profile (Fig.2) shows clearly the trichotomous feature of the structure units including the Songpan-Ganzi block, Longmen Mountain tectonic belt and west Sichuan foreland basin from west to east. The electrical structure of the Songpan-Ganzi block can be divided into two blocks including Ruoergai block and Songpan-Ganzi folded belt. Songpan folded appears to be a dual structure. The Longmen Mountain tectonic belt has a long outspread west-inclined low resistivity belt at the depth of 10-20km; based upon the conjecture, it is deep distribution state of the Longmen Mountain thrust fault system. Beichuan-Yingxiu fault and Anxian-Guanxian fault have trend of combining with each other at the deep part which possibly extends into the high conductivity layer in the crust; and deep part of the Maoxian-Wenchuan fault may extend gently along the detachment surface at bottom of the upper crystalline basement. The electrical structure of deep part of Sichuan Basin having a dual zonation structure is featured with low resistivity at shallow part and high resistivity at deep. Basement of the basin is a high resistivity layer consisting of metavolcanite series, and it is a high resistivity stable block formed by middle-lower crust crystalline basement and granite.

1.2 Internal microscopic structure of Sichuan Basin

The inversion map of Anxian-Suining profile (Fig.3) clearly shows that the secondary tectonic units including Longmen Mountain tectonic belt, west Sichuan foreland hollow belt and Sichuan block. From the longitudinal perspective, resistivity of the overall Longmen Mountain tectonic belt is high, and resistivity of the Sichuan block is low in shallow part and high in deep, while resistivity of the overall west Sichuan foreland hollow belt is relatively low. The electrical structure belt of the west Sichuan foreland hollow belt can be divided into upper, middle and lower layer of electrical structure belts with uneven thickness. It can be divided into the following four

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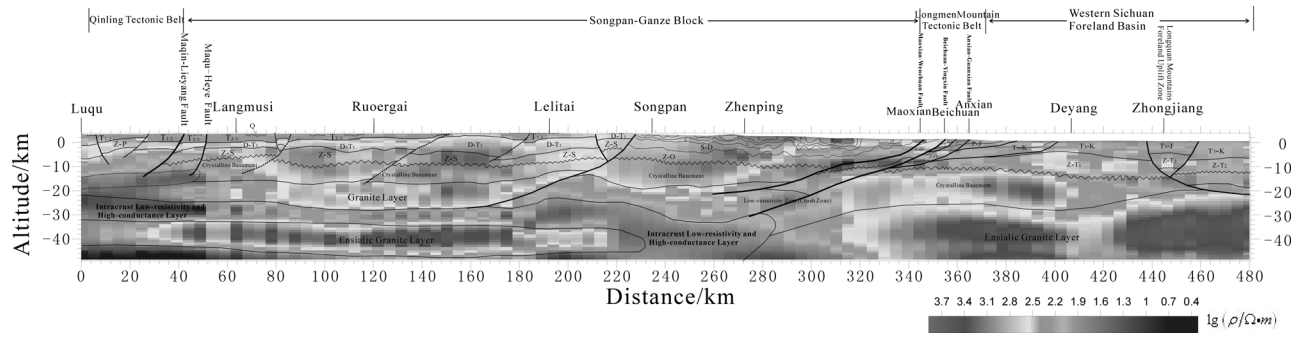

Fig.2. The result of MT inversion and geological interpretation map of Luqu-Zhongjiang profile

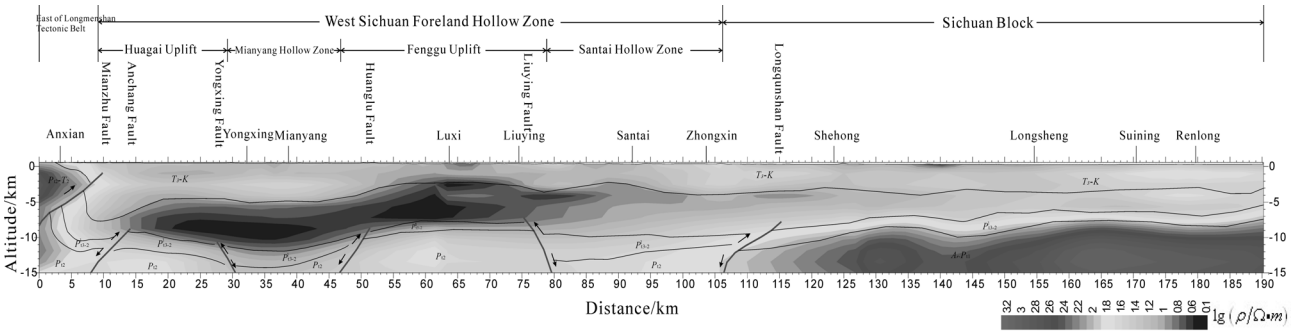

Fig.3. The result of MT inversion and geological interpretation map of Anxian-Suining profile

electrical structure sub-belts: Huagai, Mianyang, Fenggu, Santai. The Sichuan electrical structure belt is featured with obvious stratification and stable extension, and the resistivity does not change a lot in horizontal direction.

1.3 Coexistence of difference and correlation of deep structure

The west extension of Longmen Mountain thrust tectonic fault zone forms two anti-symmetrical dual electrical structure with upper part higher than lower part at west side and lower part higher than upper part at east side. Relation between Longmen Mountain fault and Songpan-Ganzi block is closer than the relation between Longmen Mountain fault and basin which would be one of the key points of geophysical research at this area. The integrity trend of high resistivity granite layer deeper than 25-30km of the whole profile indicates that the ancient Yangtze block was possibly connected together with the Songpan-Ganzi block in the geological history, and there was an extensive ancient successive Yangtze block having wider range.

1.4 New cognition to deep structure

According to overall structure, although the horizontal trichotomous property is very obvious, the lower crustal layer below depth of 30km to the west of Songpan is very similar to the crustal layer of Sichuan Basin below depth of 25-30km, which indicates that the Ruoergai basement is similar to basement of Sichuan Basin, and the Songpan-Zhenping section between the former is divided by low resistivity belt, possible reason is separation of ancient Yangtze block. Despite of being in connection with the fault belt formed by downward extension of the Longmen Mountain fault, which influences the connection of high conductive layer at lower part of Songpan-Zhenping block with the Sichuan Basin, the existence of successive intracrustal high conductive layer at this region can still be deduced.

2 Gravity and Magnetic Feature of Longmen Mountain Tectonic Belt and Adjacent Regions

By collecting 1:1,000,000 gravity and aeromagnetic data of the study area, re-explain the data with academic ideas including thrust structure, basin-mountain coupling as guidance.

Gravity field feature：The high gravity anomaly zone in the basin is generally to the east of Pingwu-Panzhihua, it is featured in high gravity anomaly with almost equiaxial morphological rule. The low gravity anomaly zone at western Sichuan plateau is to the west of the Songpan-Shimian, with relatively low value anomaly, and the more to the west, the gravity anomaly has a trend to negative value. Longmen Mountain-Daxue Mountain gravity anomaly gradient belt is a North-South oriented anomaly belt with dense isoline between the above two anomaly zones. The above Bouguer gravity anomaly distribution feature completely reflects the deep tectonic

framework of Longmen Mountain area formed after complex geologic structure action.

Aeromagnetic anomaly feature：Aeromagnetic anomaly feature is distinct in intensity gradation, obvious in zoning feature, and it clearly reflects magnetic field features of geological tectonic units at the Longmen Mountain area. The magnetic field at Longmen Mountain area can be divided into east and west parts. The intensity of magnetic anomaly at east and south parts is high, while west and north is low, with Longmen Mountain-Muli as general boundary. To the east of the boundary, the magnetic field is mainly of high-value positive anomaly and in shape of belt or block, the distribution direction is mainly North-East and South-North orientation. To the west of the boundary, the magnetic field is mainly of low-value negative anomaly.

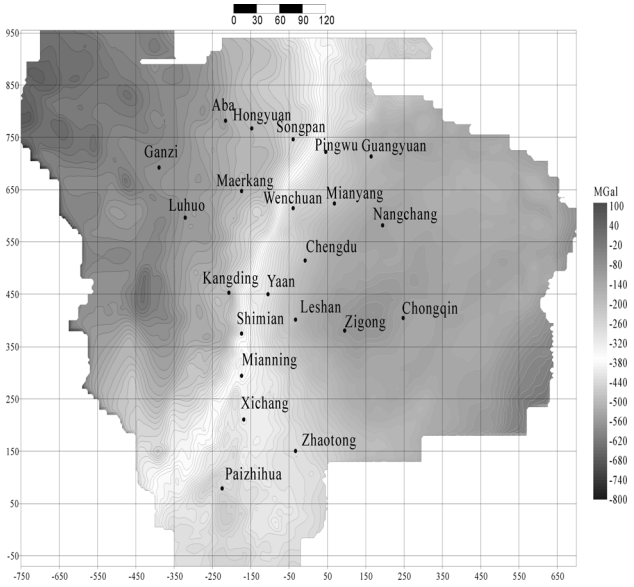

Fig.4.The Bouguer gravity anomaly

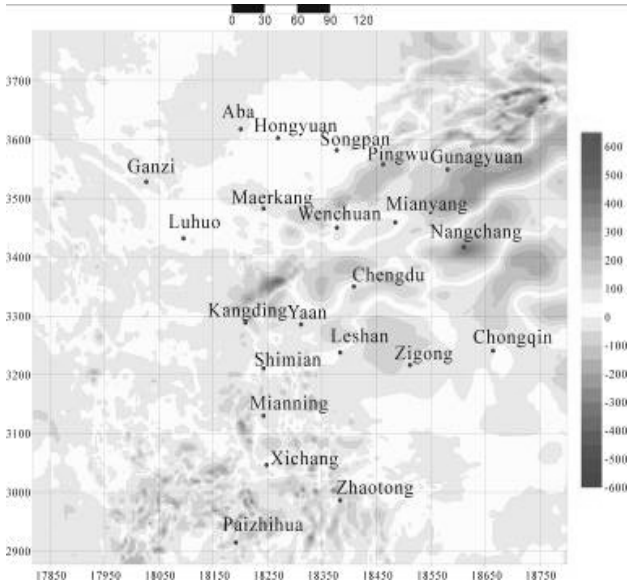

Fig.5. Aeromagnetic anomaly,map of Longmen mountain

3 Upper Mantle Velocity Structure at Longmen Mountain and Adjacent Regions

3.1 Sichuan Maowen-Chongqing Gongtan two-dimensional structure profile

The profile, with its west from Sichuan Heishui, through, Suining, and Chongqing to Chongqing Gongtan, has a length of about 600km. The profile passes through the tectonic units including Songpan-Ganzi block, Longmen Mountain tectonic belt and upper Yangtze block from west to east. The crustal structures of the areas are as follows: Thickness of the Songpan-Ganzi block is increased to 65.0km to the northwest, but decreased to 46.5km rapidly to the southeast. Between upper and middle crust of the Songpan block, there is common existence of intracrustal low-velocity low-resistivity layer. At the west Sichuan foreland hollow zone, the late Proterozoic rift zone is developed between Mianyang and Santai, there is folded basement overlaying on the crystalline basement.

3.2 Qinghai Huashi Gorge-Sichuan Jianyang Two-Dimensional Structure Profile

The profile with Maoxian-Wenchuan fault zone as boundary, west part of this profile belongs to Songpan-Ganzi block and the east part belongs to Longmen Mountain tectonic belt, west Sichuan foreland hollow zone and Sichuan block. Within the Songpan-Ganzi block, being thickened crust. The crustal thickness of the west margin of the Yangtze block is decreased to about 45km rapidly. In the deep of Longmen Mountain tectonic belt, there are two crust-mantle horizontal velocity changing belts nearby the mohorovicic's discontinuity, namely the ductile shear zone.

4 Crust Structure Model of Longmen Mountain

Based on the crustal thickness evolution, combined with the study of the three-dimensional structure of the crust, the crust of the study area is divided into continental craton crust and thickened crust of Qinghai-Tibet plateau.

Thickened crust structure of Songpan-Ganzi block: Surface layer of Songpan-Ganzi block mainly is triassic shallow metamorphic sedimentary rock series, and secondly is Paleozoic shallow metamorphic sedimentary rock series. The seismic sounding result shows that, at east section of Songpan-Ganzi block average upper crust thickness is 24.94km, middle crust is 16.03km, and lower

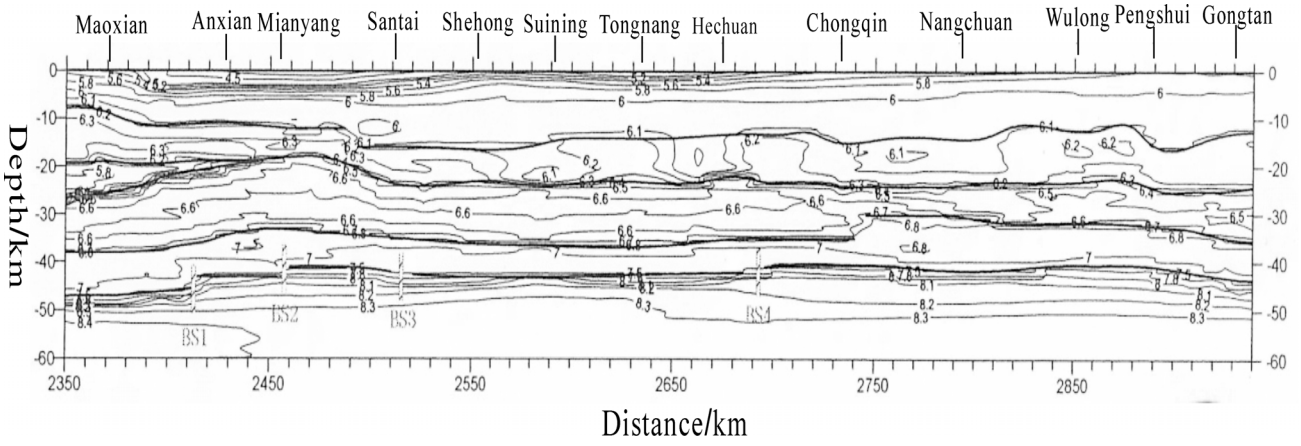

Fig.6. The velocity profile of Sichuan Maowen - Chongqing Gongtan

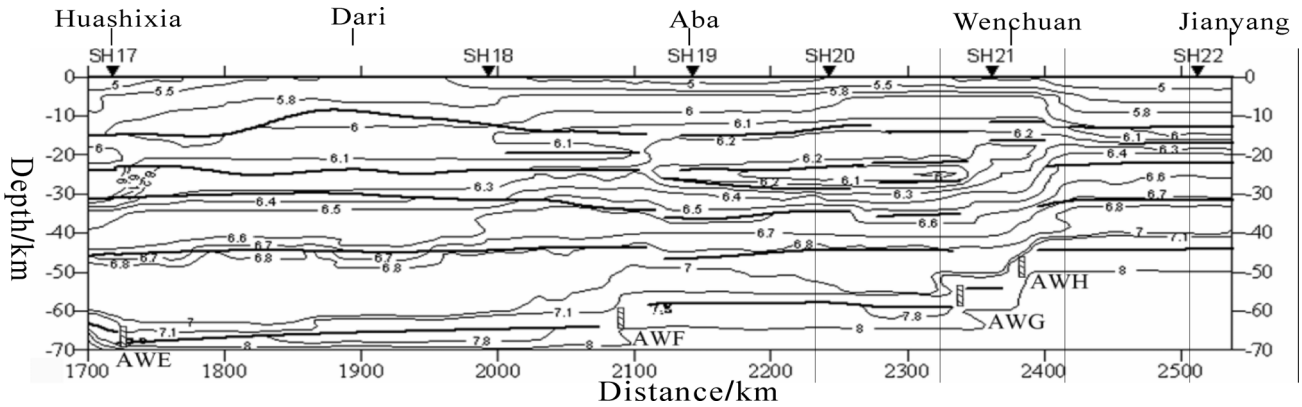

Fig.7. The velocity profile of Qinghai,Huashixia-Sichuan Jianyang

crust is 21.42km. Compared to the cratonic crust, in the thickened crust of Songpan-Ganzi block, the upper crust and lower crust are thickened mainly. Magnetotelluric sounding (Fig.2) indicates that electrical structure zontation of Songpan-Ganzi block is obvious, and the extension is stable.

Cratonic crust structure of upper Yangtze block: Crotonic crust of upper Yangtze block including Longmen Mountain tectonic belt, west Sichuan foreland hollow zone and Sichuan block. The seismic sounding result shows that, at northwest margin of the upper Yangtze block, the average thickness of the upper crust is 18.80km, the middle crust is 10.50km, and the lower crust is 15.30km. At the west side of Longmen Mountain tectonic belt, influenced by the continental thickened lithosphere crust of Qinghai-Tibet Plateau, the thickness of the crust can be up to about 53.5km. Magnetotelluric sounding result (Fig.2) shows that, the area of Longmen Mountain tectonic belt from 10km to 15km is high resistivity layer, with a thin low resistivity layer there between, and burial depth of the thin low resistivity layer is about 10-15km and inclined to northwest. This may reflect the deep extension of the Beichuan-Yingxiu fault and Maoxian-Wenchuan fault. The structure of Anxian-Suining (Fig.3) shows that there is alternating arrangement feature of low resistivity block and relatively high resistivity block in the west Sichuan foreland hollow zone, which proves the seismic sounding deduction.

Distribution of intracrustal low-velocity low resistivity high-conductivity layer**:**Seismic sounding and magnetotelluric sounding show that intracrustal low-velocity low resistivity layer is commonly developed between middle and upper crusts to the west of Longmen Mountain tectonic belt. Seismic sounding shows that there is not development of the intracrustal low-velocity low-resistivity layer in the cratonic crusts of the west Sichuan foreland hollow zone and Sichuan block. In the magnetotelluric sounding structure profile, there is not development of the intracrustal low-velocity low resistivity layer in the west Sichuan foreland hollow zone and Sichuan block. In conclusion, development of the intracrustal low-velocity low-resistivity layer provides one of important dynamic boundary conditions for strong structure deformation of Longmen Mountain collisional orogenic belt at the east margin of Qinghai-Tibet Plateau.

5 Dynamic Study of Wenchuan Earthquake

Researches show that subduction-collision-wedging dynamic effect of the Australia plate and the Indian plate to the Eurasian plate from south to north is the most basic geodynamics situation of the south central lithosphere of the Asian continent, and it is also one of the most basic dynamic conditions of the Wenchuan magnitude-8 earthquake. The Songpan-Ganzi block has the same forward motion situation with the upper Yangtze block. The geological structure research of Songpan-Ganzi block crust surface shows that strike-slip-thrust nappe structure of Longmen Mountain is of thrust nappe slip from north to southeast, which forms typical thrust nappe structure. In conclusion, the upper Yangtze block and the Songpan-Ganzi block have same motion feature since the late Cainozoic era.

During the continuous collision-wedging process of west margin of upper Yangtze block towards Longmen Mountain tectonic belt lithosphere at east margin of Qinghai-Tibet Plateau, it is deduced according to seismic sounding and magnetotelluric sounding that obduction nappe of the rocks and substances at surface of crust at east margin of Qinghai-Tibet Plateau towards Longmen Mountain orogenic belt along the intracrustal low-velocity low-resistivity layer occurs. At the same time, subduction of the middle and lower crusts east margin of Qinghai-Tibet Plateau and top of the upper mantle towards deep of the lithosphere at west margin of upper Yangtze block and Longmen Mountain tectonic belt occurs. As a result, the focal fault, namely the crust-mantle ductile shear zone, which makes the Longmen Mountain collisional orogenic belt lithosphere cut mohorovicic's discontinuity expands towards the middle and upper crusts, and the stress is highly concentrated and energy is released and burst rapidly at the deep metamorphic rock area at the margin of high-velocity high-resistivity block, thus the Wenchuan magnitude-8 earthquake is formed.

6 Conclusion

Structural analysis of geographical structure and magnetotelluric sounding, gravity and magnetic and seismic sounding shows the deep geophysical structure of Longmen Mountain tectonic belt, and shows that Beichuan-Yingxiu thrust fault zone and Anxian-Guanxian thrust fault zone at the lithosphere crust surface of Longmen Mountain tectonic belt should be the earthquake fault of the main earthquake region. This work has important scientific and practical significance to research on the cause of earthquake, dynamic mechanism and earthquake prevention and disaster reduction.