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Deep Structure Beneath the Southwestern Section of the Longmenshan Faults and Lushan *M*s7.0 Earthquake on 20 April 2013

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The Wenchuan *M*w 7.9 earthquake on 12 May 2008 occurred at the central section of the Longmen Shan faults zone, locates at eastern margin of the Tibetan plateau. Almost five years later, a magnitude *M*s 7.0 earthquake happened at the southwestern section of this faults zone. The focal depth of the Wenchuan event is 14-19km, with the main rupture on the Beichuan fault near Yingxiu, which propagated to the Pengguan fault. The maximum vertical and horizontal co-seismic displacements reached 6.5m and 4.9m[1,2], and surface rupture belts are 240-300km and 90km along the Beichuan and Pengguan faults [3-5], respectively. Neither rupture nor aftershocks of the 2008 Wenchuan main shock left any trace south to its epicenter - the southwestern segment of the Longmen Shan fault zone. However, the Lushan quake of 2013 just took place at this gap.

Magnetotelluric (MT) observations have been carried out on two profiles(L1 and L4) across the central and southwestern section of the Longmen Shan fault belt from 2009 to 2011 after 2008 Wenchuan Mw 7.9 earthquake. The former profile (L1) crossed the central section and Wenchuan epicenter and the later one (L4) crossed the southwestern section and 2013 Lushan Ms7.0 earthquake epicenter (Fig.1). The advanced techniques are used in data processing and interpretation including phase tensor and two-dimensional inversion methods[9-11] in order to obtain the acceptable 2-D electric structure.

From two image profiles of deep electric structure (Fig.2), this work achieved the following geological results. High-conductivity layers (HCL) are observed in the middle and lower crust of the Songpan-Ganzi massif west of the central and southwestern section of the Longmen Shan fault zone, which are present at depth ~20km west oft the central section, and 10-odd depth west of the southwsetrn section, respectively. High resistivity bodies (HRB) exist from the near surface down to upper mantle beneath both central and southwestern sections of Longmen Shan. The HRB extends westward horizontally to 25km at the central section, and southeastward at depth to merge with the high-resistivity basement of the Sichuan Basin. Nearby the source of the 2008 Wenchuan event, there is a local area of decreasing resistivity. While in the high-resistivity southwestern section of the Longmen Shan fault zone, no HCL is found to connect the HCL in the crust to the west, and local low-resistivity is also not detected there. Note that this is the measurement result at four years before the 2013 Lushan earthquake, and the current data do not allow us to expect whether decreased resistivity could appear around the source of the Lushan event after its occurrence. From MT observations, the two earthquakes occurred definitely at different places. The source of Wenchuan event is located nearby the core of a high-resistivity body, with seismocgenic structure as the central fault (Beichuan fault); while the Lushan shock's source lies between a high-resistivity body and a relatively low-resistivity zone in the east.

In combination with geological and other geophysical data, the HCL in the crust of the Songpan-Ganzi massive is interpreted to be a easy to deform or flow layer, also called "channel flow"[12-21]. The HCL is easy to generate shear and inflation, thus leading to detachment between upper and lower crust or crustal thickening. The deformation of the HCL is one of the possible reasons for steep topography between the Longmen Shan range and Sichuan Basin[12]. The southwestward motion of the Songpan-Ganzi massive with HCL is blocked by the rigid NE-trending Longemn Shan range with high risistivity and the Sichuan Basin in the southeast, forming a "T'-shaped pattern. Before the earthquakes, the Longmen Shan fault zone appeared as a stable structure, with a very small displacement rate[22,23], and long-term seismic quiescence[24,25]. When the accumulated stress in the

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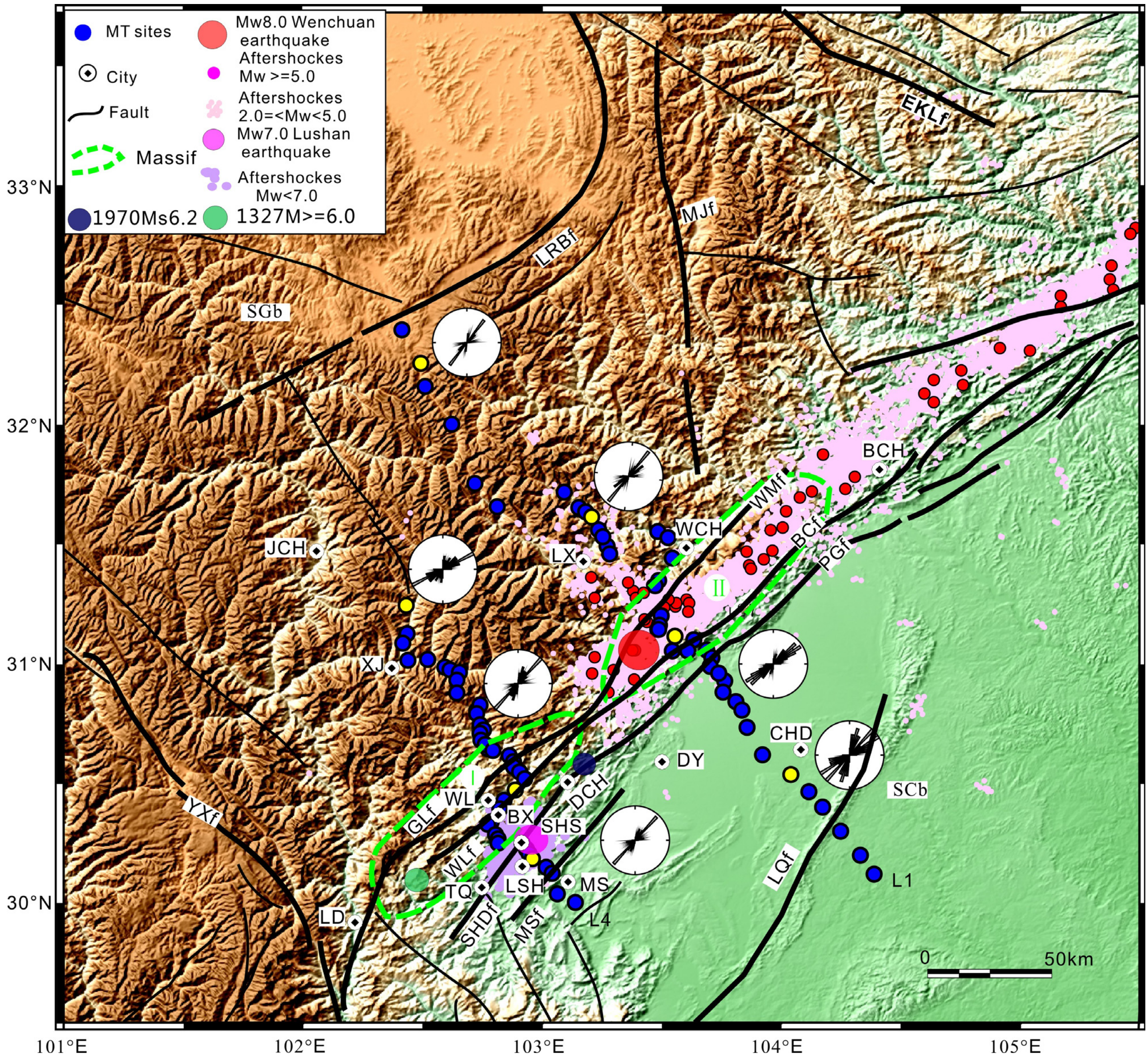

Fig.1 Map showing topography, tectonics and MT sites in the Longmen Shan area

Fault：GLf-Gengda-Longdong fault，WLf-Wulong fault，SHDf-Shuangshi-Dachuan fault，MSf-Mingshan fault，WMf-Wenchuan-Maoxian fault，BCf-Beichuan fault，PGf-Pengguan fault，YXf-Yushu-Xianshuihe fault，EKLf-East Kunlun fault，LRBf-Longriba fault，MJf-Mingjiang fault，LQf-Longqian Fault[6]；Block：SGb-Songpan-Ganzi block，SCb-Sichuan basin；City：CHD-Chengdu，WCH-Wenchuan，BCH-Beichuan，WL-Wulong，BX-Baoxin，TQ-Tianquan，SHS-Shuanshi，DCH-Dachuan，LSH-Lushan，MS-Mingshan，DY-Dayi，LD-Luding，XJ-Xiaojin，LX-Lixian，JCH-Jinchuan；Massif：Ⅰ-Baoxing massif，Ⅱ-Penguanmassif[7]；The rose diagrams of the geoelectric strike show NE；Wenchuan earthquake and its aftershocks[5]，Lushan erthqaule and its aftershocks[8].

fault reached its limit of rock fracture, great earthquakes were generated suddenly.

The common mechanism for the Lushan and Wenchuan earthquakes is the interaction between the Songpan-Ganzi massive and Longmen Shan fault zone. And the difference in their generation processes is associated with different tectonic settings and deep structures of their sources, as well as the variable interactions between fault sections and the massive in the northwest. For these two events, different source locations and physical properties of the media around the sources can account for their varied surface expressions.

Key Words: Longmenshan fault belt, Lushan earthquake, deep structure, crustal high conductivity layer, development environment of the earthquake

References

[1]Xu X，Wen X，Yu G，et al. Coseismic reverse and oblique-slip surface faulting generated by the 2008 Mw 7．9 Wenchuan earthquake，China．Geology，2009，37：515–518

[2]Pei-zhen Zhang，Xue-ze Wen，Jiu-hui Chen．Oblique high-

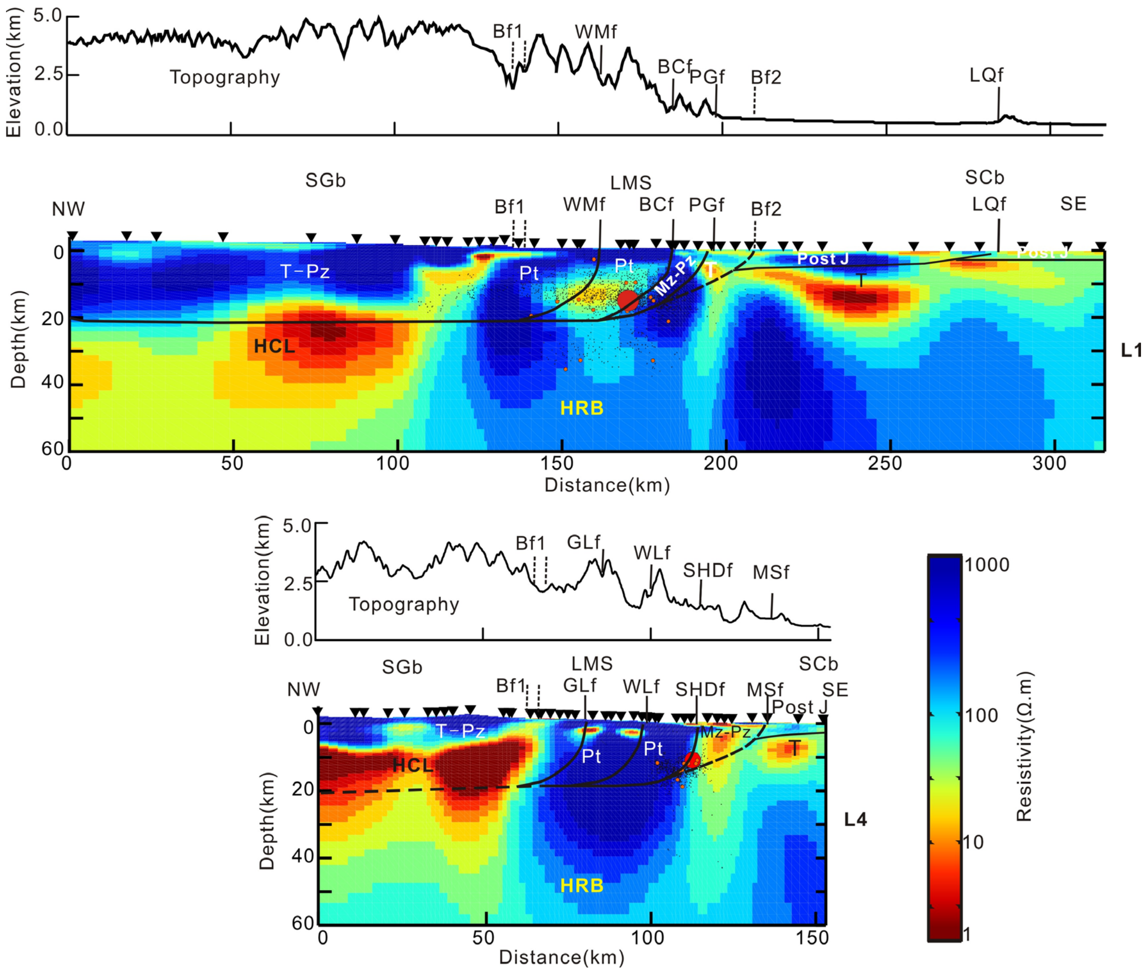

Fig.2 Two-dimensional electric structure along MT profile L1 (upper) and L4 (lower)
HCL-high conductivity layer, HRB-high resistivity body.
Notations of faults are same as Fig.1

angle listric-reverse faulting and associated development of Strain: the Wenchuan Earthquake of May 12 2008 Sichuan, China. Annu Rev Earth Planet Sci, 2010, 38: 353-382.

[3]Huang Yuan, Wu Jianping, Zhang Tianzhong et a1. Relocation of the M8. 0 Wenchuan earthquake and its aftershock sequence. Science China(Series D), 2008, 51 (12): 1703-1711

[4]Zhang Yong, Feng Wanpeng. Xu Lisheng et a1. Spatio—temporal rupture process of the 2008 great Wenchuan earthquake. Science in China(Series D), 2009, 52(2): 145-154

[5]Zhu, A L, Xi X W, Diao G L, . et al. Relocation of the Ms8. 0 Wenchuan earthquake sequence in part: preliminary seismotectonic analysis. Seismology and Geology (in Chinese), 2008, 30 (3): 759-767
(6): 97

[6] Yang X, Jiang B, Song F M, et al. The evidence of the south Longmenshan fault zones cutting late quaternary stratum. Seismology and Geology (in Chinese), 1999, 21 (4): 341-345

[7]Wang E Q, Meng Q R. Discussion on the Longmen Shan Mesozoic and Cenozoic tectonic evolutionScience in China (Series D) 2008, 38 (10): 1221-1233

[8]Wu J P et al. Lushan erthqaule and its aftershockes. 2013. 4

[9]Caldwell G. T. , Bibby, M. H. and Brown C. The magnetotelluric phase tensor. Geophysical Journal International. 2004, 158: 457-469

[10]John R Booker. Magnetotellutic phase tensor evolution. 21st Electromagnetic (EM) Induction Workshop, 25th to 31st July, 2012, Darwin, Australia

[11]Rodi W and Mackie R L. Nonlinear conjugate gradients algorithm for 2-D magnetotelluric inversion. Geophysics, 2001, 66: 174-187

[12]Zhao Guoze, Martyn J. Unsworth, Yan Zhan, et al. Crustal structure and rheology of the Longmenshan and Wenchuan Mw 7. 9 earthquake epicentral area from magnetotelluric data. Geology, 2012, 40 (12): 1139–1142

[13] Zhao G Z, Chen X B,Wang L F et al. Evidence of crustal 'channel flow' in the eastern margin of Tibetan Plateau from MT measurements.*Chinese Science Bulletin*.June 2008, 53 (3): 45-350

[14]Zhao Guoze, Martyn J. Unsworth, Yan Zhan, et al. Crustal structure and rheology of the Longmenshan and Wenchuan Mw 7. 9 earthquake epicentral area from magnetotelluric data. Geology, 2012, 40 (12): 1139–1142

[15]Wei W.，Unsworth M J.，Jones A G.，et al. Detection of wide spread fluids in the Tibetan crust by magnetotelluric studies. Science，2001，292：716-718
[16]Unsworth M J，Jones A G，Wei W，et al. Crustal rheology of the Himalaya and Southern Tibet inferred from magnetotelluric data. Nature，2005，433：78-81
[17]Bai D，Unsworth J M，Meju A M， et al. Crustal deformation of the eastern Tibetan Plateau revealed by magnetotelluric imaging. Nature Geoscience，2010，3：358-362
[18]Zhang Z J，Wang Y H，Chen Y，et al. Crustal structure across Longmenshan fault belt from passive source seismic profiling. Geophysiacal Research Letters，2009，36，L17310，doi：10. 1029/2009GL039580
[19]Robert A，Pubellier M，Sigoyer J，et al. Structural and thermal characters of the Longmen Shan (Sichuan，China). Tectonophyics，2010，491：165-173
[20]Clark，M. K.，and Royden，L. H. Topographic ooze： Building the eastern margin of Tibet by lower crustal flow. Geology，2000，28：703–706
[21]Leigh H. Royden，B. Clark Burchfiel，Robert W. et al. Surface Deformation and Lower Crustal Flow in Eastern Tibet. Science，1997，276：788-790
[22]Shen Z K，J Lu，M Wang and R Burgmann. Contemporary crustal deformation around the southeast borderland of the Tibetan Plateau. J. Geophys. Res.，2005，110，B11409，doi：10. 1029/2004JB003421
[23] Wang Y Z，Wang E N，Shen Z K. GPS-constrained inversion of present-day slip rates along major faults of the Sichuan-Yunnan region, China，Science in China(Series D)，2008，38（5）：582-597
[24]Zhang Y X，Wang H M，Wang L Y. North China, Northeast Area 2009 earthquake trend prediction, China Earthquake Trend Prediction，Beijing：Seismological Press，2008，326-366
[25]Yi G X，Long F，Qiao H Z，et al. The eastern margin of the Qinghai-Tibet Plateau Nancy segment Longmen Shan fault zone seismic hazard analysis，Developments in World Seismology，2012，6：97