Crustal structure of the eastern margin of the Tibetan Plateau from magnetotelluric data

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Introduction

The ongoing collision between India and Asia causes both crustal thickening and strike slip motion on the northeastern and eastern margins of the Tibetan Plateau. Deformation of the crust in this region occurs by a range of processes that includes (a) brittle deformation on major strike slip faults and (b) continuous deformation in the subsurface, including crustal flow. Magnetotelluric (MT) exploration is a powerful tool for imaging crustal structure in regions undergoing active tectonics (Unsworth, 2010). This study presents two new magnetotelluric datasets that have been used to study the geoelectric structure of the Northeastern (HY area) and Eastern (LMS area) margins of the Tibetan Plateau (Fig.1).

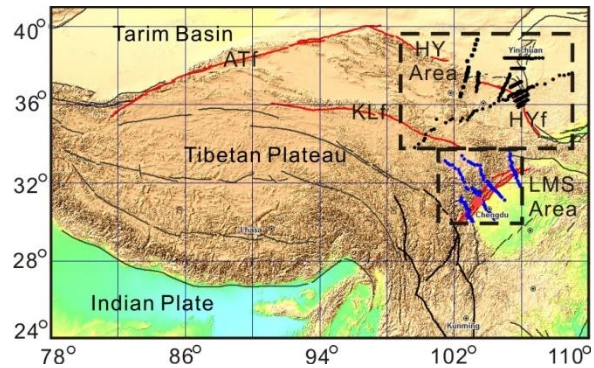

Figure 1 : Map of the India-Asia collision zone showing the two study areas. ATf = Altyn Tagh fault; KLf = Kunlun fault; HYf = Haiyuan fault

Haiyuan area - the Northeastern Margin of the Tibetan Plateau

Surface deformation in Northeastern Tibet is dominated by motion on a series of major strike-slip faults that accommodate the eastward motion of the crust (Altyn Tagh, Kunlun and Haiyuan Faults) (Tapponnier and Molnar, 1977; Burchfiel et al., 1991; Zhang et al, 2004). The Haiyuan fault is the most northerly of these faults (Deng et al., 1984; Li et al., 2009) and has generated a number of major earthquakes in the last century, such as Ms = 8.5 Haiyuan earthquake in 1920 and Ms = 8.0 Gulang earthquake in 1927 (Deng et al, 1986; Gaudemer et al., 1995). The variable topographic gradients of the eastern margin of the Tibetan Plateau have been explained on the basis of crustal flow occurring in regions with weakened lithosphere, and blocked by regions of strong lithosphere (Clark and Royden, 2000; Duvall and Clark, 2010). The tectonics of this area were investigated by a detailed MT survey from 1999 to 2005. The layout of the survey is shown in Figure 2. Data were processed using standard techniques and 2-D inversion was used to generate resistivity models which revealed a mid-crustal low resistivity layer to the south of the Haiyuan fault zone. However, it was absent to the north of the Haiyuan Fault.

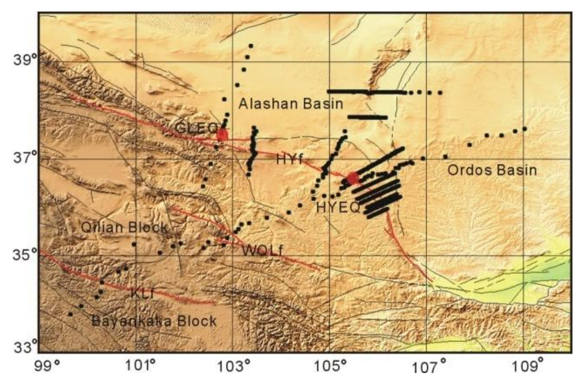

Figure 2 : Map of the Haiyuan MT study area. Black dots mark locations of MT stations. (KLf: Kunlun fault; WQLf: West Qinling fault; HYf: Haiyuan fault.

Longmenshan area-the Eastern Margin of the Tibetan Plateau

In contrast to Northeastern Tibet, the Longmenshan is characterized by a steep topographic boundary between the Eastern Tibetan Plateau and the Sichuan Basin. This steep gradient has been explained on the basis of lower crustal flow being blocked by the strong lithosphere of the Sichuan Basin (Clark and Royden, 2000). There is strong evidence for crustal flow west of the Sichuan Basin from evidence for uplifted landscapes (Clark et al., 2005). Despite the slow convergence rates, sufficient stress accumulated to cause the 2008 Wenchuan earthquake (Burchfiel et al., 2008). After the 2008 earthquake, MT data were collected on a number of profiles that crossed the Longmenshan, in order to understand the mechanisms that caused the earthquake, as shown in Figure 3.The MT data were used to generate 2-D resistivity models. These revealed a major mid-crustal low resistivity layer beneath the Eastern Tibetan

Plateau, similar to that observed beneath large areas of Eastern and Southern Tibet (Unsworth et al., 2005; Zhao et al., 2008; Bai et al., 2010). The resistivity of this layer implies a weak layer that could flow over geological timescales (Rippe and Unsworth, 2010). This weak layer terminated some 20-30 km west of the Longmenshan, which is a zone of high electrical resistivity. This observation clearly supports the hypothesis that uplift of the Eastern Tibetan Plateau has been caused by lower crustal flow (Clark et al.,2005; Burchfiel et al.,2008). Structural studies of the Longmenshan show evidence of folding (Hubbard and Shaw, 2009) but cannot explain the high topography west of the Longmenshan. Locally, a zone of low resistivity is observed surrounding the hypocentre region of the 2008 Wenchuan earthquake. However station spacing and data quality were not sufficient to fully define the geometry of this feature.

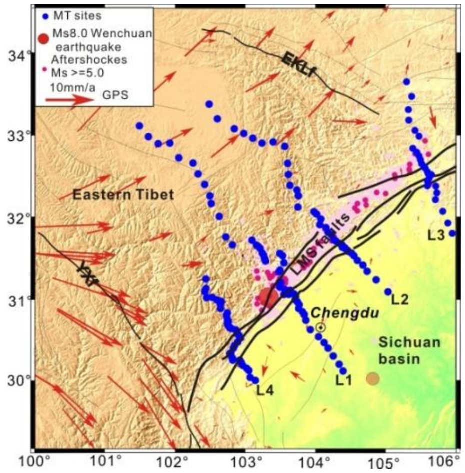

Figure 3. Map of Longmenshan MT study. Blue dots mark locations of MT stations. (YXf:Yushun-Xianshuihe fault; EKLf: East Kunlun fault; LMS faults: Longmenshan faults; GPS vectors are from Shen et al., (2009)

Summary

The study has revealed that a crustal low resistivity layer is observed beneath the northeastern and eastern Tibetan Plateau. The properties suggest that it could flow as suggested by geodynamic models. The layer terminates on the margins of the plateau, as predicted by the geodynamic models and it can explain the pattern of seismicity observed in the area.

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