Evolution of the crust and upper mantle structure in Northern Tibetan Plateau from INDEPTH magnetotelluric data

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SUMMARY

Magnetotelluric (MT) data from the Phase III of INDEPTH (International Deep Profiling of Tibet and Himalaya) project were re-analyzed and re-modelled in preparation for the MT Phase IV of the project focusing on the northern margins of the Tibetan plateau.

Although, in general, the dominant features are the same as the prior models, the new models are geometrically more complex exhibiting greater lateral variability. The South Kunlun Fault (SKF) can be identified as a boundary between a conductive middle crust weakened by partial melt, and a dry and cold resistive crust north of the fault, and can be reasonably concluded to be a rheological boundary.

The mid-crustal conductive features exhibit an interesting correlation with the surface thrusting of the northern Tibetan plateau, implying structural control of the conductivity distribution. This correlation raises an interesting issue concerning the time relation between the tectonic features of the area and partial melt, which we will explore with the new data.

Keywords: Magnetotelluric, INDEPTH, Partial melt, Kunlun Fault

INTRODUCTION

The overarching objective of INDEPTH Phase IV is to develop a better understanding of the structure and evolution of the northern margins of the Tibetan plateau. During Phase III in 1999, broadband (BBMT) and long period (LMT) magnetotelluric data were collected in Northern Tibet across the Kunlun Shan. The MT stations, placed along the northern part of the Lhasa to Golmud highway, defined the so-called “600-line” profile extending from the middle of the Qiangtang Terrane to the southern edge of the Qaidam Basin (Fig. 1). Previous inversions of the data from the 600-line used the MT TE-mode, TM-mode and vertical magnetic field data to derive minimally smooth models (Unsworth et al., 2004). The final smooth model obtained was characterized by a uniform mid-crustal conductor extending from the Kunlun Shan to the south end of the 600 profile and ending abruptly at the Kunlun Fault. The high conductivity of the middle lower crust south of the Kunlun Shan was interpreted as due to partial melting.

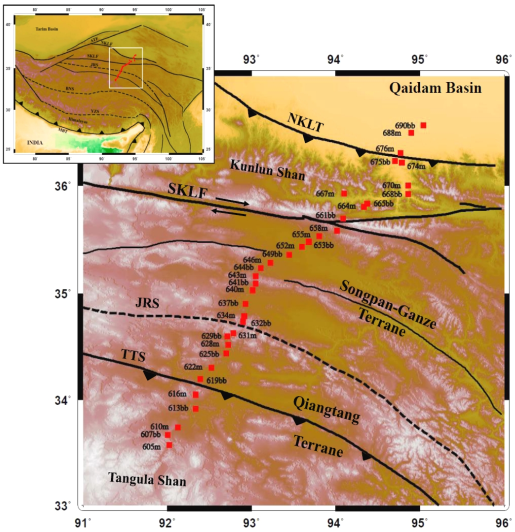

Figure 1. Tectonic settings of the studied area. NKLT - North Kunlun Thrust, SKLF - South Kunlun Fault, JRS - Jinsha River Suture, TTS - Tangula Thrust System.

As part of Phase IV, seismic data crossing again the Kunlun Shan were already acquired east of the 600 line. In late Spring 2010, the long-period MT (LMT) acquisition of INDEPTH Phase IV started, including a profile east of the 600 line to complement the seismic data. In anticipation to this survey, the existing MT 600-line data were re-analyzed and re-modelled.

GEOELECTRIC STRIKE ANALYSIS

Strike analyses revealed differences in geoelectric strike between the upper crust and the lower crust - upper mantle. Different considerations in the strike analyses led us to adopt 85° as the profile geoelectric strike.

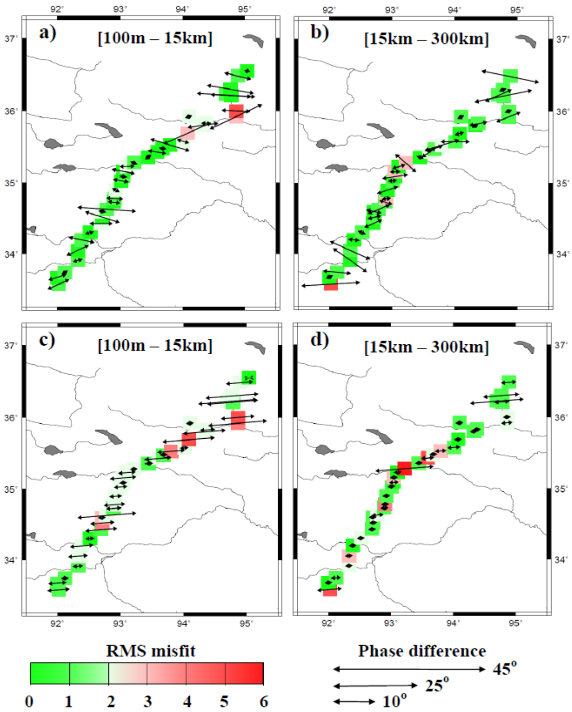

Figure 2. RMS misfit for the *Groom and Bailey (1989)* decomposition of single MT sites using the *McNeice and Jones (2001)* strike method.
a) and b) – no constrain on the decomposition.
c) and d) – strike angle constrained to 85°.

The Figure 2 shows that for both considered depth bands, the chosen strike appears to be a good compromise between the shallow and deep parts of the profile. Furthermore, even for a non-constrained decomposition, the shallow structures of the north part of the profile show more significant 3D effects.

2D MODELLING

As found previously, south of the Kunlun Shan the middle and lower crust are conductive, and north of the Kunlun fault the crust and the upper mantle are resistive. However, the new model (Fig. 3) is geometrically more complex, exhibiting greater lateral variability. In general the dominant features are the same as the prior models, but in detail spatial correlation with surface thrusting implies structural and/or lithological control on the enhanced conductivity.
An alternative model was considered by adding a more conductive upper mantle (10 Ohm.m) below the crustal conductor to simulate a direct melt transfer from the mantle to the crust. Both models show significant differences in the forward signals at longer periods. Those differences are difficult to be highlighted with direct comparison with the real data, but they would affect the RMS misfit difference between both models. Moreover, most of the Niblett-Bostick approximated penetration depths are deeper than the crustal conductor and give support that sensitivity of some stations extends below the crustal conductor. Those different considerations validate the view that a upper mantle average resistivity close to 100 Ohm.m, as seen on the main model (Fig. 3), is indeed in agreement with the data.

CONCLUSIONS

The Kunlun Fault can be characterized as a rheological boundary in the middle and lower crust of the northern Tibetan plateau, between a crust weakened by partial melting and a more stable (dry, cold) crust north of the fault. The lateral resistivity changes along the profile are representative of changing conditions, such as lithology, temperature, water content variability or dehydration processes affecting the crustal rheology. This particular behavior of the crust may be linked to the thrusting history of the north part of the Plateau and the high thickness of the crust leading to particular conditions of pressure and temperature. Furthermore, the apparent correlation between partial melt and the surface thrusting raises an interesting issue concerning the time relation between the tectonic structures and the partial melt present in the crust.

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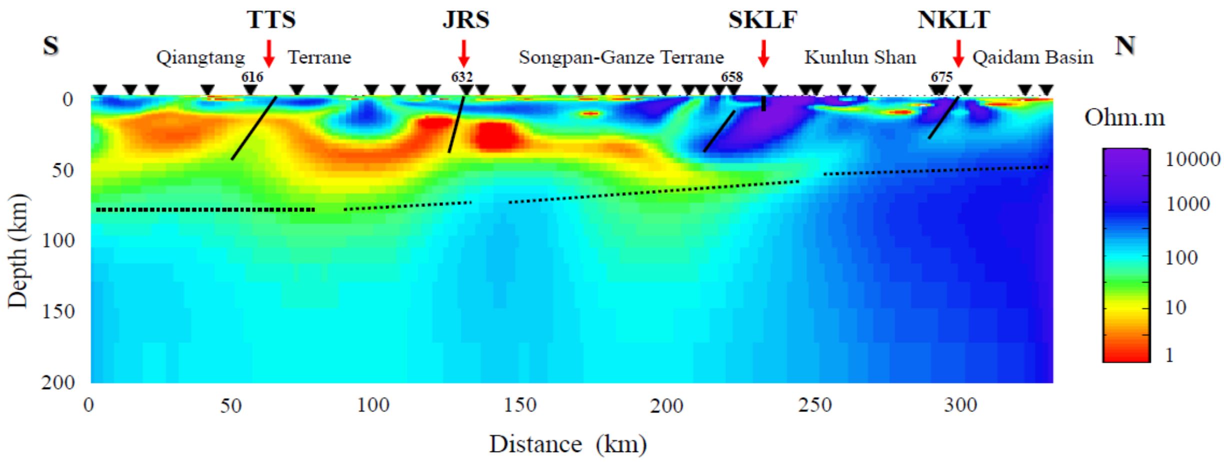

Figure 3. Resistivity model of the 600-line obtained using WinGLink (Rodi and Mackie, 2001).
NKLT - North Kunlun Thrust, SKLF - South Kunlun Fault, JRS - Jinsha River Suture, TTS - Tangula Thrust System.
The different lines on top of the models highlight the apparent correlations between the surface thrusting and the geometry of the conductive structures. The dotted line represent the moho depths taken from *Jimenez-Munt et al (2008)*.