Electromagnetic images of colliding continents: a magnetotelluric survey of the Tsangpo Suture and surrounding regions of Tibet

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Summary

A deep-probing natural-source electromagnetic survey, using the magnetotelluric technique, was undertaken in southern Tibet in 1995. High frequency soundings by the Chinese group probed the upper and mid-crust, whereas the longer period soundings of the North American groups sampled the mid- and lower crust.

The measurements were made along two profiles. The main profile extended over 300 km from the Tethyan Himalayas to the southern part of the Lhasa block, crossing the surface location of collision, the Tsangpo suture. The second profile crossed the hydrothermally active Yangbajain graben to determine the cause the "bright spots" observed on the seismic reflection profiles.

Models fitting the observations will be shown, and conclusi ons regarding collisional tectonics drawn.

Introduction

In coordination with the INDEPTH seismic studies of the India-Asia collision zone (Zhao et al., 1993, Nelson et al., 1996), natural-source electromagnetic experiments, using the magnetotelluric (MT) technique, took place from April to July of 1995 along two profiles designed to study lithospheric structures at all scales. The primary goal was to try to differentiate between the two well-established, dichotomously-opposed, end-member models to account for the thickened crust of Tibet, invoking either underplating of the Asian crust by Indian crust and lithosphere (Argand, 1924), or compressional contraction of Asian crust (Dewey and Burke, 1973).

Two previous MT studies have taken place in Tibet. In the first, a Sino-French group collected data in southern Tibet in the early 1980s (Pham et al., 1986). In the second, data were collected as part of the Golmud to Yadong Global Geoscience Transect (Guo et al., 1990) activities. Both of these surveys used widely-spaced sites, a narrower frequency bandwidth than the systems we utilized, and data processing, analysis and modeling techniques that are now consider primitive owing to recent advances in these areas.

The new MT experiment was a tri-national effort between scientists at the University of Washington (UW), the Geological Survey of Canada (GSC), and the China University of Geosciences (CUG) in Beijing. The North American groups were responsible for acquisition of low frequency MT data at thirty-five locations, whilst the Chinese group recorded higher frequency data at the same locations and in between. The time series data from both systems have been processed and merged to yield MT responses for each site covering seven decades of frequency. The responses have been analyzed for electric field distortions, dimensionality, and strike direction, and the two datasets of regional responses, one for each of the two acquisition lines, have been modelled using modem, least-structure two-dimensional inversion algorithms. We report on these initial models and their interpretation.

Data Acquisition

The main suture-crossing profile, the *"100-line"*, extended across the Tsangpo suture (TS), from Yadong in the south to nearly Yangbajain in the north, for a total of almost 300 km N-S (Fig. 1). The principal objective of this profile was to determine the lithospheric thickness variation from the Tethyan Himalayas to the Lhasa block (south to north), and to map the modification of crustal structures on either side of the TS. The second profile, the "200-line", crossed the NE-SW-trending Yangbajain graben obliquely, from Dagze in the south, through Damxung on the graben itself, to north of Nam Tso (Nam Lake) and Thak, to study both the thermal regime of the graben, and any modification that the graben has at depth on crustal features.

The MT data were acquired using two systems: CUG scientists used a 5-component commercial wide-band system (Phoenix' V5) for high frequency (0.003 - 100 Hz) data acquisition, and UW/GSC scientists deployed twenty GSC-designed 5-component LIMS systems (Long period Magnetotelluric System) for low frequency (0.0003 - 0.05 Hz, or 20 s - 30,000 s periodicity) data acquisition. Recording durations at a site were usually 20-30 hours with the V5, and 3-7 weeks with each LIMS, and at the majority of sites both systems used the same electrode array. Initial processing occurred in the field to ensure that significant conductivity features were not spatially undersampled. Subsequently, the time series data were robustly analyzed (using methods 6 and 8 in Jones et al., 1989) and merged together to form MT and GDS tensor estimates over seven decades of frequency. The LIMS data for the 100-line used station 201 at Dagze as a remote-reference. For the 200-line data the LIMS data were referenced against each other. The V5 data were not remote-reference processed as only one system was available.

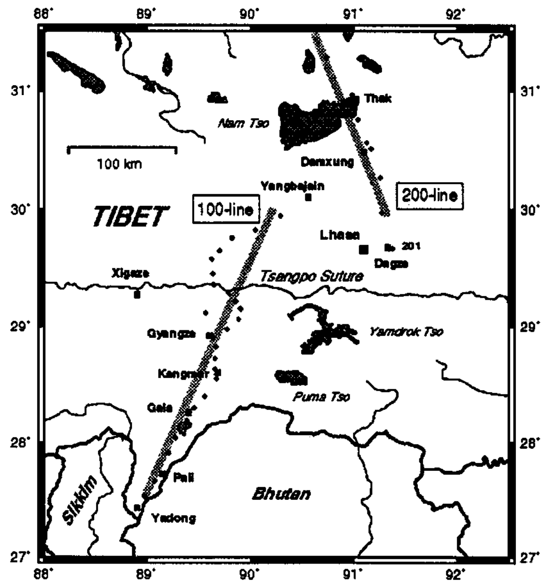

Figure 1: Locations of combined LIMS-V5 MT sites

Distortion Analyses

Tensor decomposition, using the approach advocated by Groom and Bailey (1989), was applied to the data, both in single-frequency, single-site and in multi-frequency, multi-site modes, to determine the dimensionality of the data and derive the dominant geoelectric strike direction. The fits of the distortion models to the data are generally acceptable, which implies that a 2D description of the regional structure is a valid assumption for most of the data from most of the sites.

Regional Responses

For both the 100- and 200-lines, the regional phases, in both the TE- and TM-modes, are above 45° at virtually all sites and all periods, and increase with increasing period. This is a very strong indicator that electrical conductivity increases (electrical resistivity decreases) with increasing depth.

Inversion

The data were modelled using 2D inversion algorithms which simultaneously searched for the smoothest as well as best-fitting models (deGroot-Hedlin and Constable, 1990; Smith and Booker, 1991). Thus, more structure is possible than displayed in these models, and still result in an acceptable misfit, but less structure would result in an unacceptable increase in the misfit measure.

Conclusions

The models that fit the data will be shown, and tectonic implications drawn.

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