ANALYSIS, INVERSION AND MODELLING OF MAGNETOTELLURIC OBSERVATIONS BETWEEN THE CORDILLERA ORIENTAL AND EL CHACO (NW ARGENTINA)

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INTRODUCTION

During the past years several magnetotelluric (MT) studies have been carried out in the Central Andes (Argentina, Bolivia and Chile) - e.g., Muñoz et al., 1992; Schwarz et al., 1994. Some of these studies have revealed high electrical conductivity anomalies beneath the volcanic arc and surrounding areas. The determination of the electrical resistivity of structures in the Andean foreland is greatly endeavoured for understanding the tectonic processes affecting the region. Preliminary results of MT soundings carried out between the Cordillera Oriental and El Chaco were presented by Krüger (1994). In this abstract we present a new electrical model for the region based on a rigorous analysis of the former MT soundings and using a variety of inversion algorithms and forward modelling codes.

MT SOUNDING PROFILE

The MT measurements examined in this study were carried out by the Research Group of Magnetotellurics of the Free Universty of Berlin. The MT soundings were undertaken in the Andean foreland at 24.5 - 25.5°S and 63 - 65.5°W (NW Argentina) along roughly an E-W profile of 220 km long. Distance between soundings ranges from about 6 to 20 km. The profile traverses the Cordillera Oriental (CO) and the system of Sta. Bárbara (SB), reaching the western area of El Chaco province (C). The MT fields were recorded in the period range 50 - 15,000s. The depths of investigation lie from about 5 - 10 km to 130 - 260 km. The location of the sounding sites along the profile (Col...Vin) is shown in Fig.1 (see the last page of this abstract).

DATA ANALYSIS AND DISTORTION EFFECTS

The main objects of the analysis are to determine the departure of the sounding data from two-dimensionality (2D) and to individuate the distortion effects of three-dimensional (3D) anomalies. A full account of the analysis of the MT soundings is presented in the work of Lezaeta (1995) and only some few remarks will be presented here.

According to the classification of distortion types carried out by Bahr (1991) only Pal sounding site could be regarded as belonging to class 1 (regional 2D structure with the impedance tensor Z free from distortion effects). Most of the sounding data belong to class 5 (local 3D anomaly within a 2D regional space; strong telluric distortion) for periods generally larger than 500 - 1000 s, and to class 7 (regional 3D anomaly) for lower periods. Particularly, data for periods <1100 s from sites in the eastern area of the profile between SB and C were seen to correspond to a 3D structure.

The regional strike angle was determined by means of the decomposition of the impedance tensor Z as proposed by Groom and Bailey (1989). Chi-square errors resulting of assuming a superimposition model (shallow local 3D anomalies within a 2D regional space) in the decomposition of Z, twist and shear parameters were encountered for each sounding site throughout the data spectrum. It was found that the strike of the 2D structure may be considered to lie in the North-South direction. Subsequently it was observed that the correction for the effects of telluric distortion did not change the original impedance tensor significantly.

Static distortion due to shallow heterogeneities was examined in the data corrected for telluric distortion. A regional apparent resistivity was firstly obtained and the static shift for each TE apparent resistivity curve was achieved thereupon. The same static shift is relevant for the TM curves. The apparent iso-resistivities and iso-phases (corrected and not corrected for static shift) were graphically represented (e.g., Jones and Dumas, 1993) and it was observed that the static correction decreases vertical trends in the iso-values: this ensures the correctness of the former procedure.

INVERSION AND FORWARD MODELLING

Several 2D models were obtained and their responses compared with apparent resistivities and phases of the impedance tensor corrected for distortion. The modelling was undertaken following two-dimensional synthesis of 1D inversions carried out using the method of Vozoff and Jupp (1975), 1D Occam's inversions (Constable et al., 1987), RRI-rapid relaxation inversions (Smith and Booker, 1991) adopting two-dimensional forward algorithms, and 2D Occam's inversions (deGroot-Hedlin and Constable, 1990). The complete results are presented in Lezaeta (1995).

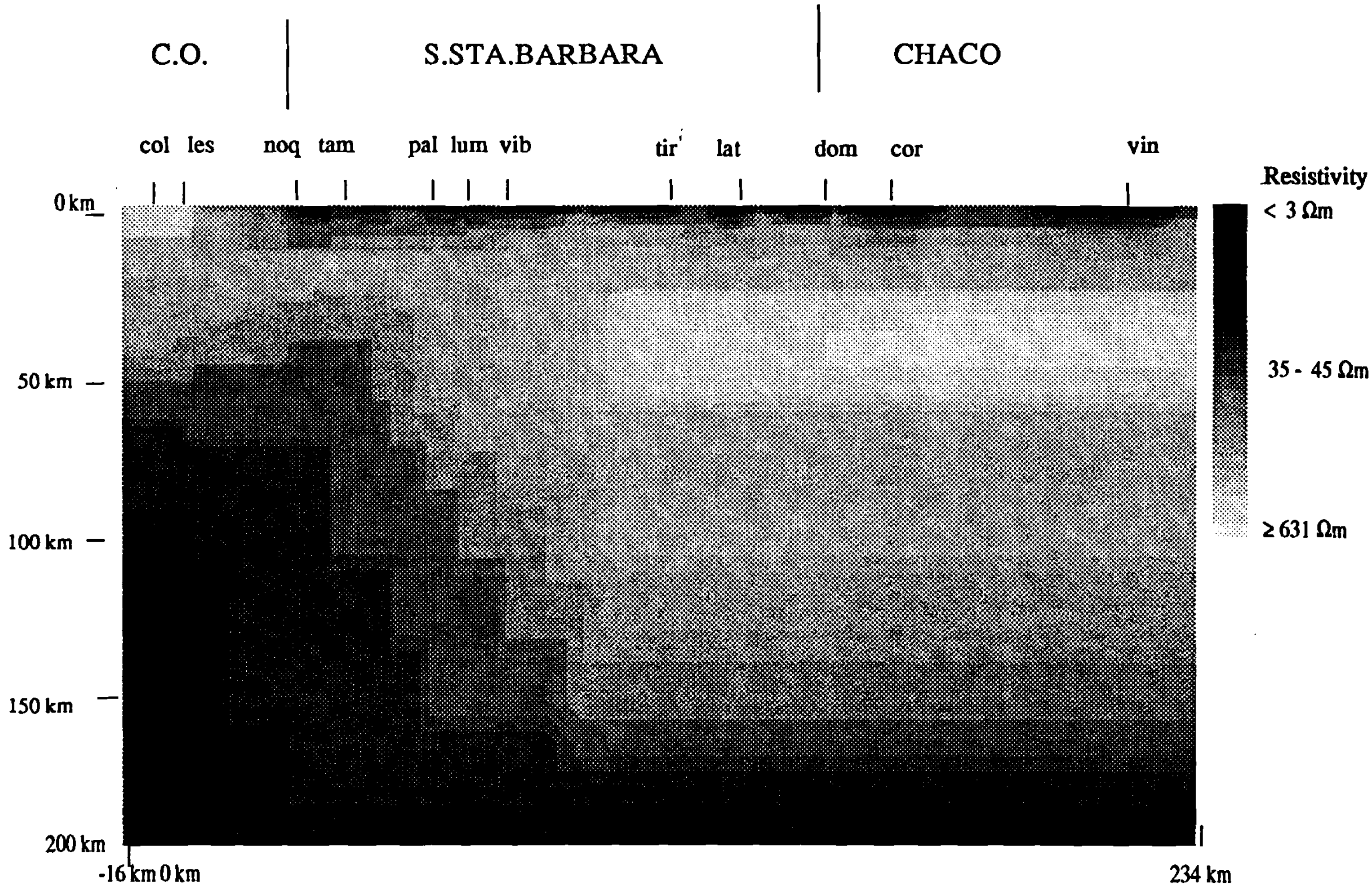
The models obtained using 1D inversions are similar but dependent on the initial parametrization. 2D inversion is subject to instabilities making difficult the attainment of convergence; this may be partly due to data that show departure from responses expected for 2D structures. Fitness between data and model responses is higher for soundings carried out between the Cordillera Oriental (CO) and the Sta. Bárbara system (SB), where they classify as corresponding to a 2D structure. The rapid relaxation inversions (RRI) were observed to be very sensitive to frozen resistivity vertical sections imposed on the inversion process.

The most reliable former modelling results were adopted to obtain a final model (Fig.1) by using the finite-element forward modelling code of Wannamaker et al.(1987). The best fitness between the corrected data and model responses was obtained for the TE polarization mode. A model based on the representation of multilayered of multilayered structures by analytical functions (Osella and Martinelli, 1993) was attained also. The major features of resistivity distribution are similar in both these models.

DISCUSSION AND CONCLUSIONS

The final MT model of resistivity distribution (Fig.1) shows that the middle crust has low resistivity (35-100Ωm) in the western area of the profile between Cordillera Oriental and the Sta. Bárbara system. The lower crust is generally conductive all along the profile -this result is in agreement with the observation of Hyndman et al. (1993) about the conductive character of the lower crust in almost any area. A zone of very low resistivity (≤10Ωm) is encountered beneath the western border of the MT profile at 80 km depth; the conductive layer is at about 180 km depth beneath the areas between the Sta. Bárbara system and El Chaco. The whole conductive layer is referred as constituing the electrical asthenosphere. According to empirical relationships between heat flow and depth to the conductive layer in the mantle (e.g., Kaufman and Keller, 1981; Levi and Lysak, 1986) and considering the heat flow distribution in the area (Muñoz and Hamza, 1996) and the electrical properties of mantle rocks (e.g., Shankland and Waff,1977; Hjelt and Korja, 1993) the temperature of this layer may be of about 1200°C.

Examination of the vertical geothermal gradients along the MT profile on the basis of the former results -and taking into account the electrical properties of crustal rocks (e.g., Shankland and Ander, 1983; Hyndman and Shearer, 1989; Glover and Vine, 1994)- has led to some insights on the rheological regime of the crust and upper mantle in this region. The lower crust is ductile all along the western part of the


C.O.
S.STA.BARBARA
CHACO
col
les
noq
tam
pal
lum
vib
tir
lat
dom
cor
vin
Resistivity
< 3 Ωm
35 - 45 Ωm
≥ 631 Ωm
0 km
50 km
100 km
150 km
200 km
-16 km
0 km
234 km

profile while it is in a brittle-ductile transition regime between the Sta. Bárbara system and El Chaco. The critical isotherm (600± 50°C) for the rheologic transition in the mantle (e.g., Chen and Molnar, 1983; Anderson, 1995) is largely surpassed in the western area where the Moho is at about 50 km depth; beneath the eastern areas where the Moho is at about 35-40 km depth the uppermost mantle is in a transition regime that converts into a ductile rheology at about 70-90 km depth. The foregoing insights indicate that the hybrid form of models of seismic attenuation as proposed by Whitman et al. (1992) is a suitable one for the region of the MT traverse (sections at 24.5°S in Whitman et al., 1992). The low resistivity zone -in ductile regime- uprising in the western side of the magnetotelluric model seems to be related to the neighbouring active volcanic arc in direction to the Puna.

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