Introduction

Magnetotelluric and geomagnetic deep sounding methods allow the determination of the electrical conductivity in the crust and mantle (Section 1.1), which together with other geophysical methods can support or reject the idea of zones with weakened lithosphere interpreted in petrology and geochemistry. Laboratory experiments have shown that the electrical conductivity of rocks depends strongly on temperature; therefore an integration of heat flow measurements and magnetotellurics can be the key to understand magmatic processes.

In the subduction zone of the Central Andes several high conductivity zones (HCZ) have been detected, mostly in areas where shear zones are present and/or magmatism has occurred recently. Fluids and/or partial melting in subduction zones are the most common explanations for the observed increment in electrical conductivity. Partial melting at lower crustal-upper mantle depths is the process held responsible for generating most magmas. Fluids released from the slab facilitate the process by reducing the melting point of the rocks. A HCZ detected at mid-crustal levels can be less easily interpreted as partial melts. An anomalous hot crust, more feasible for a felsic crust which has a lower melting point, is required to initiate it. Indeed, high conductivity values (e.g., Schwarz and Krüger [1997]) together with an elevated heat flow (Springer and Förster [1998]), high P-wave attenuations (e.g., Haberland [1999]) and low P-wave velocities (e.g., Wigger et al. [1994]) observed in the Andean magmatic arc at latitudes 22-24°S support the hypothesis of partial melts in the mid-crust.

Fluids may circulate in the crust without leading to partial melting, in particular in a brittle crust which has been folded and fractured by tectonic deformation. Fluids can bring a considerable electrical conductivity enhancement provided that these are rich in minerals and that they find a pathway to circulate, which again is likelier to happen in faults zones. The magnetotelluric method can be a powerful tool in detecting saline fluids, and can bring insights into the rheological state of the crust. Furthermore, low seismic attenuation and low heat flow support the idea of a conductivity enhancement due to saline fluids in the absence of partial melting, despite having a low seismic velocity zone. On the other hand, wet rocks containing saline rich waters and good pore interconnection are highly conductive. Fluids trapped in high porosity layers can lead also to a high seismic reflection signal, characteristic which can be reconciled with magnetotelluric findings.

If at depths of the subducting slab HCZ's are identified together with observed high seismic Vp/Vs-velocity ratios, then the hypothesis of a hydrated mantle wedge can be supported (e.g., Schmitz et al. [1999]). Other weakened zones, for example, a rise of the asthenosphere (e.g., Lezaeta et al. [2000]), can be inferred from common observations of HCZ's, high seismic attenuation zones, minimum Bouguier anomalies, high surface heat flows and by petrological/geochemical evidence of a mafic crust with little crustal contamination (e.g., Schmitz et al. [1999]).

In this thesis, the goal is to obtain electric conductivity models of the crust and upper mantle of the forarc and magmatic arc in the Southern Central Andean subduction zone, at latitudes between 20°S and 21.4 °S and longitudes 66°W - 71 °W, with the aim of discussing the above mentioned magmatic/tectonic processes in consideration of other geophysical results. Magnetotelluric (MT) and geomagnetic deep sounding (GDS) measurements were carried out in different field campaigns (1993−1999), within the framework of the German Collaborative Research Programme SFB267 "Deformationsprozesse in den Anden" (SFB 267). The sites are distributed along two profiles, at latitude 20°S, the so-called Pica profile, and at latitude 21°S, the Ancorp profile. More sites between both profiles were measured to obtain a three dimensional (3-D) image of conductivity.

The most evident extremely conductive zone is the ocean, which unfortunately plays the role of a strong distorter for the MT and GDS data of measurements carried out on-shore, when the scope is to determine other high conductivity zone(s) existing in the continental crust. In addition, local 3-D conductors near the surface −the ill distorter− can significantly mislead a 2-D model interpretation of deeper conductivity structures. Data can sometimes be removed of local 3-D effects to allow further 2-D modeling, provided specific physical conditions are satisfied (Section 1.2). Therefore, data should be analyzed for dimensionality and distortion effects to scrutinize if a 2-D approach is feasible or a 3-D model for the study area is required. A useful quantity to analyze dimensionality is the skew parameter but it is subject to the error structure of the measured data. In Chapter 2 is estimated a confidence limit for the skew, which constrains the interpretation of dimensionality.

The study area is located in the east of the Pacific ocean, comprising two mega fault systems oriented sub-parallel to the coast line (∼N-S), strike slip faults associated with the oblique subduction of the Nazca plate underneath the South American plate, identified as the Atacama fault and Precordillera fault system (where the West Fissure is located). In Chapter 3 is described the principal background of the geology of the region.

The data measured in the area are presented in Chapter 4, including a preliminary description of the conductivity features that are visible with the naked eye from the raw data.

In Chapter 5, the skew parameter of dimensionality (using the confidence limits; Chapter 2) and known tensor decomposition methods (Section 1.2) are applied to the measured data. Inconsistencies are found between the different methods, where no common regional strike angle is seen for the whole region, implying that the area is much more complicated than 2-D.

Local structures sometimes can take a complicated form (in terms of electromagnetic induction) and be moreover electrically coupled with the regional structure of interest, leading to baffling raw data. This is the case in the study area. A method to recognize highly conductive elongated conductors and/or identify anomalous conductivity structures from MT data is developed in this thesis (Chapter 6). The first part introduces the theoretical concepts, which I call the "current channeling analysis" (Section 6.1), and the second part shows an efficient application of the method to the data (Section 6.3).

In Chapters 7 and 8 are developed 3-D models that represent the local anomalous conductivity structures in the near coast and the Precordillera regions, respectively, allowing the explanation of the strong distortion effects observed (applying the current channeling analysis). A scrutiny for those data which can be considered for the 2-D approach and those which should be treated as 3-D is also covered.

Two dimensional (2-D) forward and inversion modeling (Chapter 9) is performed to: Quantify the ocean effect and to study if this can be removed in the data; Determine the background conductivity values and; Analyze the sensitivity of the data to regional conductivity variations. The results are considered as *a priori* information, together with the anomalous conductivity structures obtained in Chapters 7 and 8, for the full 3-D forward modeling of the area (Chapter 10). This allowed the constraint of the large number of degrees of freedom.

In the context of other geophysical results, the conductivity features observed in the 3-D models yield to the following questions:

1) Is the oceanic slab associated with a high conductivity zone?

2) Coastal Cordillera: Is the Atacama fault a long vertical pathway for fluids through the whole crust? Are fluids released from the seismogenic zone? Are there also mineralizations in the crust?

3) Precordillera: Do the thin vertical crustal conductors reveal a fluid pathway along the western thrust fold system of the Precordillera? Where do the fluids come from? Which thermotectonic process can best explain the N-S conductivity variation observed at mid-crustal levels? Is the 3-D conductor beneath the Precordillera connected with the "Quebrada Blanca Bright Spot" seismic reflector?

4) Is the 3-D conductor beneath the Precordillera interconnected with the HCZ beneath the Altiplano? Is there a crustal partial melt zone in the Altiplano in contact with a highly conductive asthenosphere?

The points outlined above are discussed in Chapter 11.