Electrical conductivity anomalies in the Central Andes - interpretation and open problems

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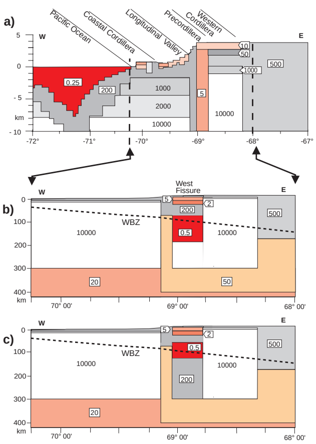
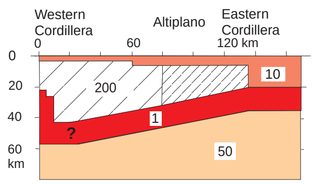
Magnetotelluric (MT) investigations revealed several zones of enhanced electrical conductivity at different depth levels in the Central Andean crust and upper mantle. While some of these zones are well studied and believed to be explainable in terms of their petrophysical and tectonic behavior, there remain manifold open questions in understanding their detailed geometry and their relation to other geophysical parameters and geological/tectonic processes. The figures below show results of two-dimensional modelling and inversion of the MT data.

- In the Coastal Cordillerra anomalies in the middle crust superimpose and even dominate the coast effect (originating from the highly conducting Pacific Ocean). Are these anomalies related to the Atacama fault system; do they hint at graphite depletion on shear zones or increased hydraulic routing in these crustal levels?



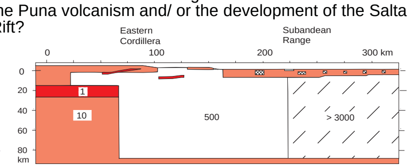
2-D model along profile C (Echternacht et al. 1997). Unlike along profiles A and B the magmatic arc <u>does not</u> display any high conductivities. In this "Pica-gap" no recent volcanism exists. A prominent, deep-reaching HCZ is connected to the Falla Oeste. b) and c) show alternative models yielding a similar fit to the data, a) emphasizes shallow structures. WBZ: Wadati-Benioff zone.

- EW-striking anomalies were recognized in the Forearc and display a certain correlation with aeromagnetic features. Does this indicate a prolongation of prominent fault zones like the El Toro-Calama lineament towards the west?
- The subducting slab is not connected with a high conductivity zone (HCZ). This is probably due to missing sediments in the trench.
- A HCZ characterizes the run of the Falla Oeste in the Precordillera in the upper and lower (!) crust. Beyond the more suggestive interpretation by ore deposits, other mechanisms like fluids or graphite must be taken into account to explain the deep seated HCZ.

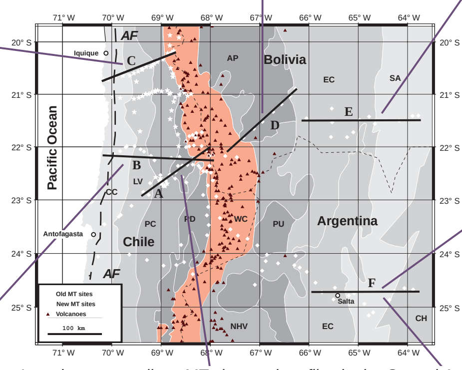


A ramp-like stucture is modelled along profile D below the Altiplano, which might image the underthrusting of the Brazilian shield below the Andean crust (modified after Schwarz & Krüger 1997).

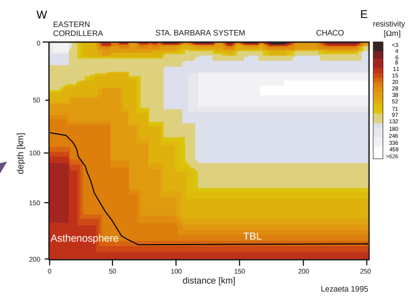
- The magmatic arc hosts the most prominent HCZ in the Central Andes at depths > 20 km. It correlates with a seismic low velocity zone, high seismic absorption and a gravity low and may be explained by vast amounts of partial melts (cf. Schilling et al. 1997). However, the anomaly strikes obliquely to the Western Cordillera and vanishes in the north at 20° S. Is there thus a correlation to the flattening of subduction towards the south and/or does it indicate recent cooling of the lower crust in the region of the Pica gap?
- Early models of a backarc conductor below the Altiplano suggest a ramp-like geometry (ascending towards the east) and may hint at the overthrusting of the Andean crust over the Brazilian craton. This important topic will be addressed during the ANCORP MT experiment.
- An ascending HCZ – interpreted as a rise of the electrical asthenosphere – was modelled below the Eastern Cordillera in NW Argentina. How does this structure – also evident from seismological observations – relate to the Puna volcanism and/ or the development of the Salta Rift?



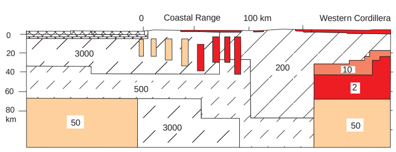
The lower crust below the Brazilian shield is resistive, while the Eastern Cordillera west of the Subandean Ranges is characterized by a HCZ (cf. Schwarz & Krüger 1997, profile E).



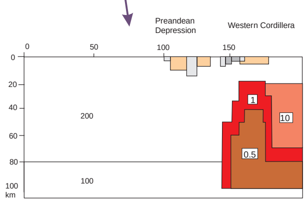
Location map outlines MT sites and profiles in the Central Andes.



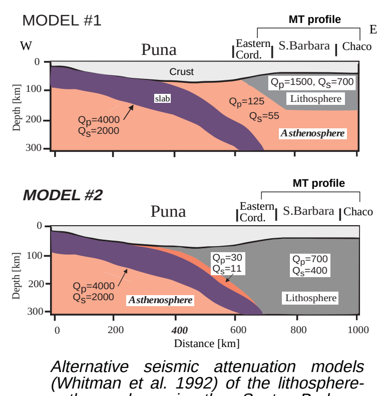
In the Santa Barbara-System a rise of the electrical asthenosphere is postulated by 2-D inversion of MT data below the Eastern Cordillera (profile F). TBL: Thermal Boundary Layer (Temperature = 1,500 K). Modified after Lezaeta (1995, unpubl. MSc. thesis) and Lezaeta et al. 1997.



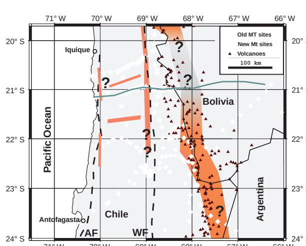
2-D model along profile B. Dike-like structures in the forearc were introduced to account for anisotropy and image the Atacama fault system as a good conductor; the HCZ below the magmatic arc hints at partial melts in the lower crust (modified after Schwarz et al. 1997).



2-D model along profile A. A "chimney"-like conductor in the magmatic arc requires large amounts of partial melts in the lower crust. After Massow (1994, unpubl. diploma thesis).



Alternative seismic attenuation models (Whitman et al. 1992) of the lithosphere-asthenosphere in the Santa Barbara-System. The MT study favors model # 1. Q-values are given for P- and S-waves.



Synoptical representation of high conductivity zones in the forearc and the magmatic arc of the Central Andes. Question marks indicate regions where lacking of data or poor data quality do not permit a higher resolution. The green line marks the seismic reflection profile ANCORP, where magnetotelluric investigations will be carried out in the end of 1997.

Conducting vs. resistive magmatic arc

The very high electrical conductivities below the magmatic arc throughout the Central Andes can me regarded as a normal feature and even characteristic for most volanic chains. The most likely interpretation is the assumption of large amounts of partial melts (14-28 vol.%, cf. Schilling et al. 1997).

However, in the region of the Pica gap, no HCZ is observed (see fig. on the left). Here, except of minor centers, the volcanism is less recent, i.e. in general older than 3 Ma.

It has been emphasized by Vigneresse et al. (1996), that a minimum of 20-25% melt is needed to allow for segregation and transport of (felsic) magma. On the other hand, during crystallization, the system becomes locked at 72-75% solidification (i.e., at 25-28% melt). The missing conductor below the Pica gap may thus hint at a relative cooling of the lower crust/upper mantle compared to regions further south and may be connected to the steepening of the subducting slab.

This view is also supported by the significant oblique strike of the HCZ (which roughly follows the 125 km depth line of the Wadati-Benioff zone) with respect to the volcanic chain further south.

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