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MT Studies at Sedimentary Basin of Sierras Pampeanas, Argentina

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ABSTRACT

MT data from profiles located over intermontane sedimentary basins of Sierras Pampeanas in North-West of Argentina are analyzed through 2D inversion methods.
These basins are very deep and have an important deposit of Tertiary sediments. Sediments contain Miocene to recent sequences of volcanic or continental detrial origin. Lithological variations occur from one intermontane basin to another and they lie on a basement peneplain surface formed after the middle Paleozoic and frequently exhumed on the range.
The resulting electrical models show sedimentary sequences with variable thickness (between 3 to 9 km). In all cases, a very conductive layer beneath the basement are detected.

INTRODUCTION

In 1990, a Magnetotelluric (MT) project to study sedimentary basins in Sierras Pampeanas (SP) was started in order to determine their structure, thickness and sedimentary sequences. The first stage was carried out in the Tucumán Plain (see Figure 1), a geothermal region bounded by the Sierra de Aconquija to the west and Sierra de Guasayán to the east, both of which are part of the SP (Osella, et al. 1992,1993; Pomposiello et al. 1994).In October 1998, we collected new wideband MT sites along two east-west transects. The nothern transect coincides with the industry seismic reflection data reprocessed to image structure to almost 40 km. The southern transect crosses a large, geothermal reservoir.

The second study was done in the Antinaco – Los Colorados Valley, another sedimentary basin bounded by the Sierra de Famatina-Sañogasta to the west and Sierra de Velasco to the east (Figure 1) (Pomposiello et al., 1998).

Finally, previous MT data, performed in the other sedimentary basins belonging to the (SP) were re-analyzed. The MT sites are located between Sierra de Fiambalá and Sierra de Copacabana (Tinogasta); between Sierra de Vinquis, Sierra de Belén and Sierra de Ambato (Campo de Belén – Salar de Pipanaco); between Sierra de Aconquija and Sierra de Guasayán (Tucumán Plain) and close to the eastern border of Sierra de Ancasti (see Figure 1); (Baldis et al. 1983).

TECTONIC SETTING

The Andean region is an active continental margin between the oceanic Nazca plate and the South American continent. From the Chilean trench towards the foreland, between 27º and 32ºS, the mountain belt consists of a series of north-south trending structural units: the Cordillera de la Costa, the Cordillera Principal (Non Volcanic Zone), the Precordillera, the Puna, the Sierras de Famatina, and the Sierras Pampeanas.
The Sierras Pampeanas (SP) were uplifted during the Andean orogeny (Cenozoic), and form a broad thick-skinned thrust system of moderate topography. The structural style of the foreland deformation coincides with an along-arc change in the dip angle of the subducting Nazca plate. From 24º to 28ºS a gradual change in slab geometry occurs from a more steeply dipping zone beneath Bolivia and northern Chile to another subhorizontal zone. The SP consist of basement ranges bounded by high-angle thrusts separating Neogene compressional basins. The ranges consist of Proterozoic to Paleozoic granitic and metamorphic rocks, and Upper Cretaceous and Lower Paleozoic sedimentary rocks.
Intermontane basins contain Miocene to recent sequences of volcanic or continental detrial origin. Lithological variations occur from one basin to another but the succession of red Miocene beds (Calchaquence) and pale Pliocene layers (Araucanense) is typical of the Sierras Pampeanas. The sedimentary sequences have variable thickness, for example, they reach more than 7000 m in Bolsón Bermejo and about 4000m in Villa Unión-Pagancillo. They lie on a basement peneplain surface formed after the middle Paleozoic (Paganzo Group) and frequently exhumed on the range.

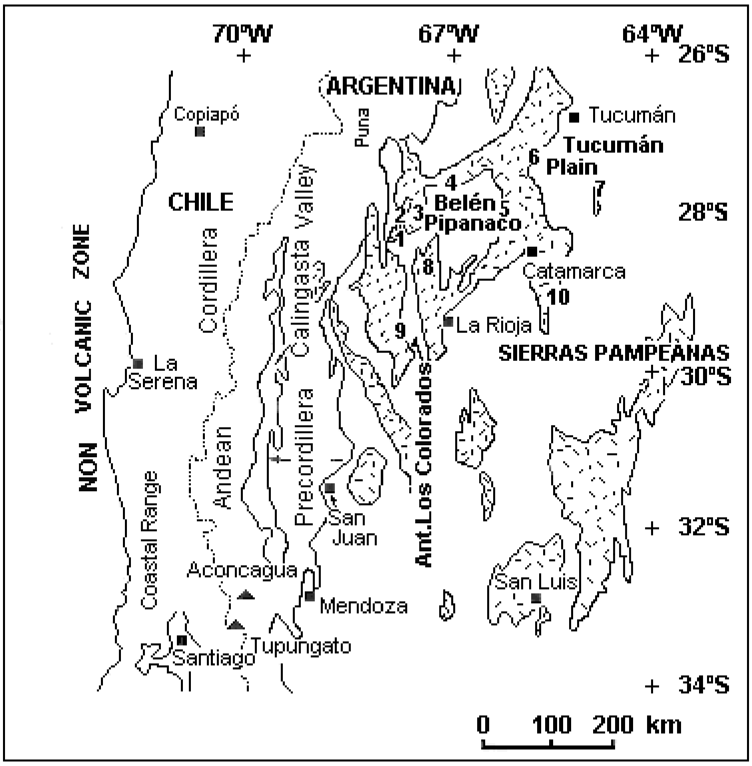

Figure1. Map of Andean region between 26º and 34ºS showing location of study sedimentary basins in the Sierras Pampeanas. Main ranges: 1:Sierra de Copacabana, 2: Sierra de Fiambalá, 3: Sierra de Vinquis, 4: Sierra de Belén, 5: Sierra de Ambato, 6: Sierra de Aconquija, 7: Sierra de Guasayán, 8: Sierra de Velasco, 9: Sierra de Famatina-Sañogasta, 10: Sierra de Ancasti. The principal cities are shown as boxes and the Argentine-Chilean border as a dashed line.

MAGNETOTELLURIC STUDIES

Tucumán Plain

The southeastern edge of the Tucumán Plain is a geothermal region bounded to the west by Sierra de Aconquija and to the east by Sierra de Guasayán, both of them being part of the Sierras Pampeanas. The great number of hot water bearing boreholes establishes the limits of an important thermal area, where temperatures of about 51ºC have been obtained in 300 m deep boreholes. Audio-magnetotelluric studies indicate shallow layers of high conductivity, in agreement with the enhancements of the thermal gradients measured in the boreholes, which were found to be twice the expected values (Osella et al., 1992; 1993; Pomposiello et. al., 1994). The 2D inversion of MT data indicated the presence of a very conductive basin, with sediment fill of about 3 km and very anomalous high layer at depth ranging from 8 to 25 km.
In the northern line the model shows a very low resistivity structure (below 1 ohm-m), beginning at 10 km and perhaps extending to the Moho. To the east, the top of the low resistivity dips steeply eastward to the Moho and continues in weaker form horizontally under the resistive cratonic crust.

Antinaco-Los Colorados Valley

This basin is located at ~29ºS, and surrounded by Sierra de Famatina-Sañogasta to the west and Sierra de Velasco to the east.
This area covers about 3850 km^2 with altitudes near 1000 m to the north, and around 800 m to the south, and is divided by Sierra de Paiman-Chilecito into two valleys, the narrow western one known as Famatina-Chilecito, and the broad eastern plain, named Antinaco-Los Colorados. The large number of wells spread along the valley suggests the importance of the aquifers for irrigation and the need for a more accurate delineation of the aquifer in order to improve the exploitation of the reservoir.
AMT and MT data acquired along an east-west profile provided an insight into the shallow sedimentary sequence and afforded a description of the location of the aquifer. Data were processed using robust methods and the resulting curves have been corrected for local distortions. The apparent resistivity and phase curves have been first modeled using direct and then inverse 2D codes. Finally, we have interpreted the resulting model according to the tectonic features of the region (Pomposiello et al., 1998). A thick sedimentary basin containing Miocene to recent sequences was found, laying over a Middle Paleozoic unit. This block is highly conducting and probably responsible for current channeling and 3D

effects detected in the data.

New analysis of previous data

From 1980, many MT soundings were performed in the main sedimentary basins (Tinogasta, Campo de Belén - Salar de Pipanaco, Tucumán and Frías, from Baldis et al., 1983; Fournier et al., 1994).
We re-analyzed these data using 1D and 2D inversion methods. The resulting models can be generalised as giving a first conductive structure, associated with the sedimentary cover lying over a more resistive layer corresponding to the crystalline basement. In all cases, a very conductive layer beneath the basement was detected. This layer was also found at the sites located close to the borders of the basins. The values attained for thickness of the sedimentary cover and the depth of the deep conductive layer are shown in the map.

CONCLUSIONS

An anomalously high conductive structure beneath the basement appears in all cases at depths which decrease from 25 km at Tinogasta, about 15 km at the Salar de Pipanaco and as shallow as 8 km at the Tucuman Plain from west to east.
There are many evidences that the electrical conductivities increase at mid-crustal depths (15-20 km) and different causes have been proposed to explain these enhancements including: 1) saline fluids; 2) carbon grain-boundary films; 3) conducting minerals; and 4) partial melts (Jones, 1992).
The phenomenon of interconnected carbon films seems to be temperature and depth-dependent, since it requires temperatures which do not exceed the corresponding rock crystallization depths which allow graphite saturation. The shallow depth of the conductive layer does not seem to fit with this explanation. Moreover, since the area of volcanism is far to the west (68.5ºW-69ºW) and no evidence of conducting minerals have been found, the last two causes do not seem to be responsible for that electrical anomaly.
On the other hand, it is well known that in active subduction zones, at depths less than 40 km, there is a large amount of free water available from mineral dewatering reactions as the slab subducts. The hypothesis of a crustal model with a zone of interconnected saline fluids trapped beneath an impermeable layer seems to be acceptable for areas of active subduction (Brown, 1993), and for this area. Unfortunately, no seismic data are available to confirm the presence of a reflective horizon at appropiate depths so the question about the origin of the anomalously high conductive layer remains open.

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