Investigation of sedimentary deposits in the Atacama desert-Chile using loop source transient electromagnetics

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I. Introduction

The present study was conducted within the collaborative research center CRC 1211 (EARTH - Evolution at the dry limit) which aims to characterize the mutual relationship of Earth processes and biological evolution. In this context, clays in endorheic basins along the Coastal Cordillera of the Atacama desert (Chile) host unique records of the precipitation history of one of the major hyperarid deserts in the world [1-3].

This study aims to provide detailed information about the sedimentary architecture and bedrock topography of selected clayspans (PAG and PAR) for both, by a geophysical survey using the Transient Electromagnetic Method (TEM) [4,5] and Seismics. To derive suitable drilling locations for paleoclimatic research, and to better understand the deposition regime.

II. Atacama Desert Fieldwork November 2018

• Extensive fieldwork was carried out in November 2018 taking measurements in PAG and PARANAL clayspans. In both, TEM and Active Seismic methods were applied [6].
• For each station, TEM central loop array was performed with a transmitter size of 40x40 m and two receivers with effective areas of 5 m² and 200 m².
• In total, more than 50 soundings were measured per claypan distributed along with profiles with a dense site spacing of 40 m. Two seismic transects are highlighted in yellow. (Fig. 1b, ic).
• Both geophysical methods worked in a perfect coordination at the same time, keeping a rather high survey speed.

III. Data Processing and Validation

• Processing and editing of the raw data were performed. Transients were derived from a robust stacking approach.
• High-quality and long transient with strong decay at late times was observed, indicating the resistive basement (Fig. 3a).
• Marquardt and Occam 1D inversion techniques were applied to derive the thickness of the sediment deposits [6]. Induce voltage data above 3x10^{-6} V Am^{-2} and less than 20% error were used in the inversion process (Fig. 3, 4c, 5c).
• The resistive basement is at 90 m depth according to the 1D inversion of the TEM data. The upper part of the model shows a good comparison with the non-conductive resistivity data (Fig. 3b).

IV. 1D Inversion Results for PAG & PARANAL Clayspans

• Data well fitted by all the models referred to Chi (χ) values (Fig. 4b, 5b).
• In all profiles shown information until 350 - 400 m depth (DOI) derived from TEM data.

• PAG
• A clear contrast of resistivity between good conducting sediments and resistive bedrock is observed (Fig. 4a, 4c).
• Maximum sediment thickness at PAG claypan is roughly 90 m (Fig. 4c, 4d).

• PARANAL
• The boundaries of the lake sediments are identified in Profile NS. However, it is still under study if the resistive layer corresponds to an alluvial fan or the transition of the basement (Fig. 5a).
• Maximum sediment thickness at PARANAL site is roughly 140 m (Fig. 5a, 8).

V. Existence of basement at PAG?

• A modelling study at PB12-TEM data shows if the base interface is re-highlighted at 90 m depth. The base interface is re-highlighted at 90 m depth (DOI) derived from TEM data.

VI. Comparison of TEM Profiles v/s Seismic Profiles

• P-wave velocity model has been derived from the seismic data by first-arrivals traveltime tomography. Only refracted/decaying waves are used here so that the depth penetration is limited. A comparison with the TEM results is shown for PAG and PAR in Figures 7 and 8, respectively.

• An excellent correlation between the depth of the upper layer of the conductive strata from TEM profiles and the depth in which a high contrast of velocity is observable (Fig. 7, 8).

• Velocity values at lateral boundaries of the model are not well constrained due to limited ray coverage and have to be interpreted with care (Fig. 7, P4T01 and P4T08, Fig. 8, PW05 and PW04).

• Data well fitted by all the models referred to Chi (χ) values (Fig. 4b, 5b).
• In all profiles shown information until 350 - 400 m depth (DOI) derived from TEM data.

• The depth of the upper layer of the sediments (~20 m) is consistent with the velocity model (Fig. 7, between P4T02-P4T06).

• The depth of the upper layer of the sediments (~40 m) is consistent with the velocity model (Fig. 8, between WE-04).

• The lake deposits are equally distributed from West to the East.

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References