T-05 Groundwater resources assessment using audiomagnetotelluric and seismic data: the fluvial deltaic Tordera aquifer unit (NE Spain)

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INTRODUCTION

Deltaic aquifer systems are complex, and their geological and hydrogeological characterization is a difficult task when only scattered information is available. In order to complement this information and to obtain a more accurate image of the physical properties of these systems, the use of surface geophysical methods has increased during the last years (Schwinn and Tezkan, 1997; Krivochieva and Chouteau, 2003; Meju, 2004; Pedersen et al., 2005; Unsworth et al., 2000).

Groundwater research and management require the understanding of subsurface properties and constrain of multiscale heterogeneities. This work presents a multidisciplinary study focused on the characterization of hydrogeological parameters and processes of the Tordera aquifer unit using geophysical methods. We will use geophysical methods particularly sensitive to water presence, namely audiomagnetotellurics (AMT) and seismic reflection, as well as well log data. Given the different degree of resolution and sensitivity to the presence of water of each method, joint interpretation of data will optimise the final model. Finally, the models obtained are compared with the hydrogeological (permeability) model used for the management and control of the aquifer system.

HYDROGEOLOGICAL SETTING

The Tordera basin, Figure 1, is located 80 km north of Barcelona; the river has a total length of 65 km and it forms a small delta of 8 km^2 of Quaternary materials confined by granite rocks of Paleozoic age. Quaternary sediments are stratigraphically controlled by 1) torrential deposits forming confined terraces, and 2) a fluvio-deltaic depositional system with continental to marine facies.

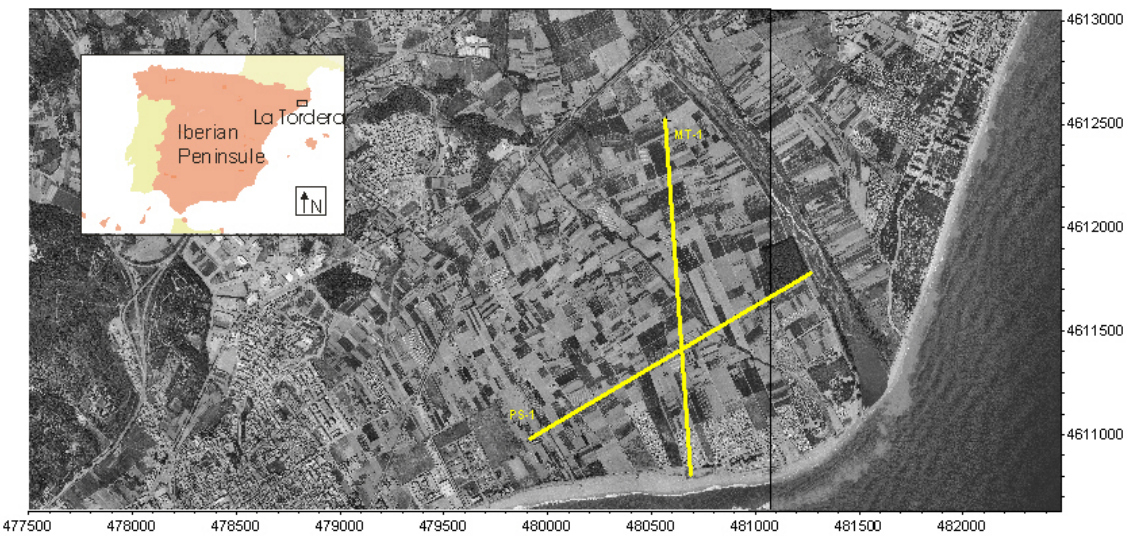

Figure 1. Map location of the Tordera River delta. Yellow lines: geophysical profiles PS-1 and MT-1.

Both formed up of detritic materials, with high granulometric variability: silt, clay, fine sands and coarse gravels. This aquifer system plays a strategic role on the tourist and industrial development of this area, and the excessive withdrawals of groundwater have aggravated the environmental hazard.

The hydrogeological model of this system is presented on Figure 2, it is composed by three main units (MOPU 1985; ACA, 2000): 1) near surface free aquifer, that covers all the Delta, with medium and coarse gravels, its thickness varies between 6-20 meters; 2) the acquitard, or zone of low permeability with clay, silt and fine sands, the maximum thickness of 25 meters is reached close to the coast; this level has important discontinuities, in both lateral and vertical directions; 3) a deep confined aquifer, composed by medium and coarse gravels (ACA, 2002). The whole system is limited in its base and laterally by a granite basement that can locally show a high degree of alteration in its surface.

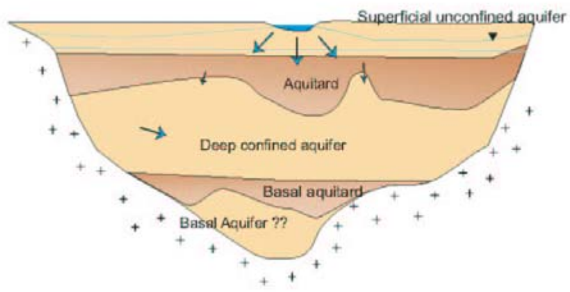

Figure 2. Conceptual model of the system.

Several local and regional agencies had been collecting information on this area since the late 60's, and a big effort has been done during the last years to obtain a high quality database. Using this data a hidrogeological model was constructed for the management of the aquifer.

Seawater intrusion on the Baixa Tordera aquifer system is localized at the deep aquifer, which supports most of the water extractions for urban and industrial applications. The only two sample points that reach the deep aquifer located 1 and 2 km inland respectively show a value of 1500 ppm of Cl- in february 2003.

GEOPHYSICAL EXPERIMENTS

Control Source AudioMagnetoTelluric (CSAMT) data has been acquired in the whole delta. Here we present two profiles, profile PS-1 coincident with a seismic reflection and refraction experiment (PS-1), and profile MT-1 almost perpendicular to the coast forming a 60 degrees angle with the former.

The data was acquired with a Stratagem system whose frequency ranges from 10 Hz to 92,000 Hz. CSAMT method allows to obtain the electrical resistivity distribution of the subsurface, which is a parameter that can be linked with hydrogeological properties. 2D models have been constructed inverting the apparent resistivity and phases of the determinant of the impedance tensor, with the algorithm of Siripunvaraporn and Egbert (2000) following the modifications and scheme proposed by Pedersen and Engels (2005). The error floor of the impedance data was 5%, and the final models are show in figure 3.

Seismic data were acquired using 48-channel digital seismograph, 40-Hz geophones and 5 m shot and receiver spacing. A roll-along system allowed keeping an end-shooting geometry along the profile. Some center spread shots were additional carried out for refraction purposes. Low-energy explosives (pyrotechnic noisemakers) were employed as seismic source. The total profile length was 1460 m, (Teixidó, 2000).

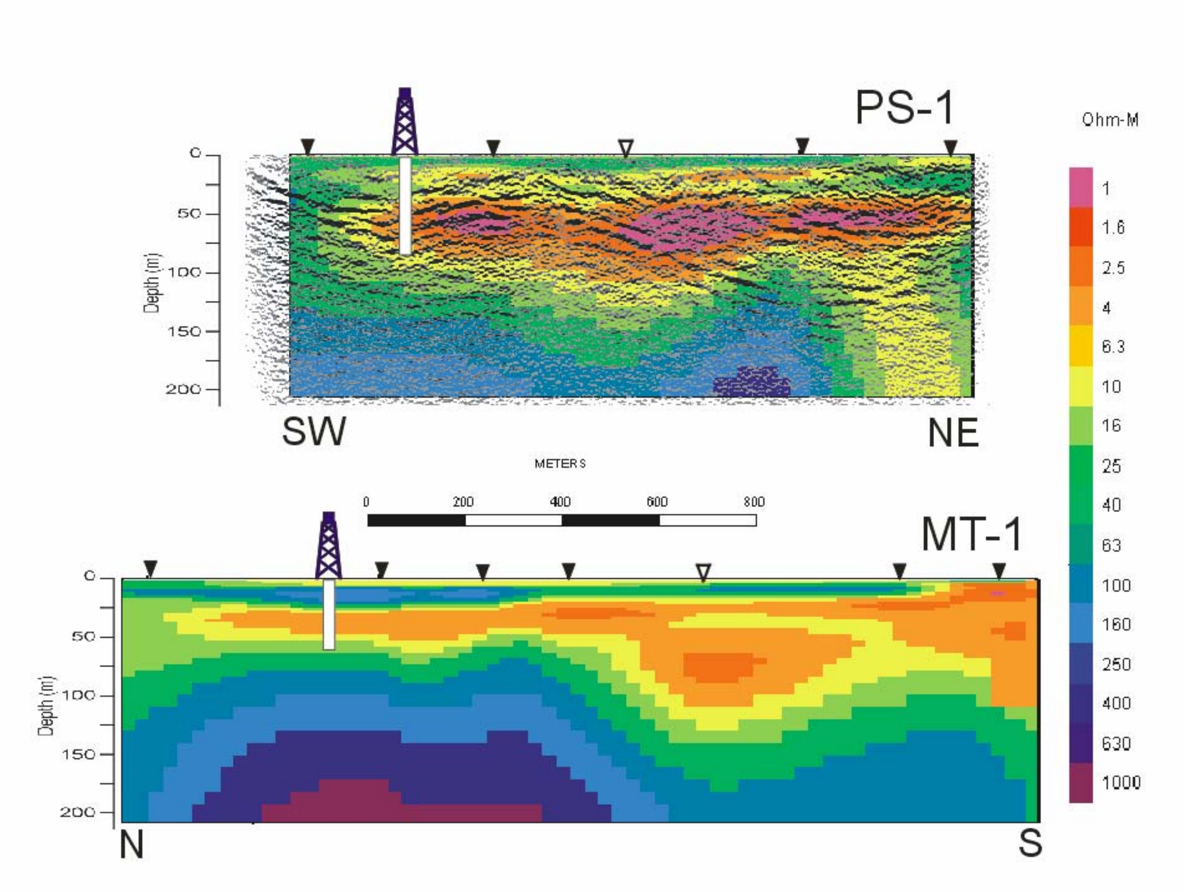

Figure 3. Top: Electrical resistivity model of line PS-1 and seismic reflection data on top. Inverted triangles: CSAMT stations. The well represents the depth to the granite basement. Bottom: Electrical resistivity model along line MT-1. White inverted triangles represent the crossing point of booth electrical models.

CONCLUSIONS

For the two CSAMT sections obtained in this work we have represented on top the depth to the basement obtained in two wells. It is obvious that the basement coincides with an increase of the electrical resistivity. Comparison between seismic reflectors and the electrical conductivity model shows some lack of correlation mainly in the contact with the basement. This appears clearer in the electrical resistivity model than in the seismic section. The electrical resistivity model along line MT-1 shows clearly the sea water wedge that is limited in depth by the granite basement geometry. The geometries determined by the electrical resistivity models can be used to improve the hydrogeological model used for the management of the aquifer.

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