Geophysical and Geochemical Study of Geropotamos Aquifer in the North-central Coast of Crete, Greece

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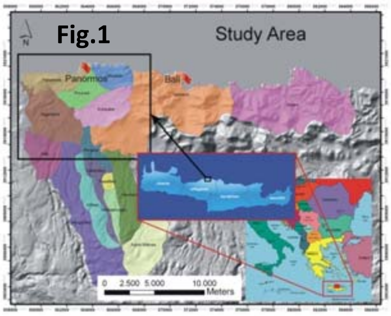
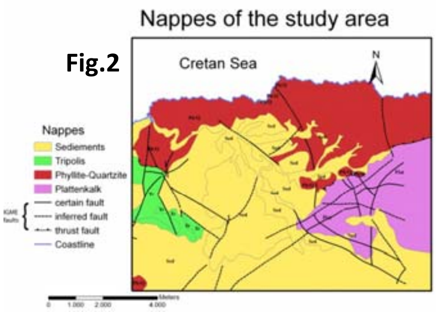
ABSTRACT

The geological setting of Geropotamos aquifer on the north-central coast of Crete, Greece, is considered complex, while the local tectonic regime of the study area is characterized by two sets of faults orientated NW-SE and NE-SW. Investigation of the aquifer using the Transient ElectroMagnetic method (TEM) has resulted initially in 1D models of geoelectric structures and a final 3D geoelectrical model was constructed, depicting the zones of salination of groundwater in the aquifer. Groundwater samples were analysed and the most important chemical parameters were determined to provide an independent dataset for comparison with the TEM results, while Groundwater Quality Maps were produced. TEM and geochemical data correspond and provide verification of the TEM approach. As a result, saline intrusion is likely to occur along fractures in a fault zone through bedrock, and this work emphasises the critical role of fracture pathways in salination problems of coastal aquifers.



Geropotamos catchment is located on the north-central coastline of Crete (Fig.1). The geological setting of the study area is considered complex and composed mainly by some of the oldest rocks in Crete (Phyllite/ Quartzite and Plattenkalk nappes) covered by Neogene and Quaternary deposits. The local tectonic regime of the study area is characterized by two sets of faults orientated NW-SE and NE-SW (Fig.2).

The overall purpose of this paper is to apply geophysical & geochemical methods to a poorly understood area of limited groundwater resources, in order to assess the status of those resources used by an increasing local population. In 2009 the area was identified as problematic (Kalisperi, 2009), where seawater is the principal source of groundwater contamination of Geropotamos aquifer.



Geoplysical Approach The geophysical measuring tool used to observe electrical conductivity changes with depth is Transient Electromagnetic technique (often shortened to TEM). For the acquisition of the TEM data, the TEM-Fast 48 system from AEMR Ltd was used. TEM data were collected over a period of 3 months (June, July, and August of 2008). In total 1179 TEM soundings were acquired in 372 different locations in a detailed survey grid (about 200-250 m in X and Y dimension) using mainly a single loop 50 x 50 m.

First, 1D inversion models were extracted for all the TEM locations. Thereafter, since 1D modelling is not enough to reconstruct the subsurface, a 3D model was constructed for calculating the TEM response.

Geochemical Analysis Three water samplings took place during 2008: a) first week of June, b) end of July, and c) 1st of October, that is to say approximately every 2 months. At each sampling, samples from 22 boreholes and 2 springs were analyzed and a total of 16 physical and aggregate properties, metals and inorganic nonmetallic constituents were determined (including Electrical Conductivity (EC), chloride, Magnesium, etc). After that, spatial distribution maps were constructed using the results of the determination of the chemical parameters (e.g. EC distribution for October's sampling in Fig. 3b). In the context of the special interpretation of the results of the geochemical analysis, groundwater quality maps were generated: Groundwater Quality Index (GQI) (Babiker, 2007) and Groundwater Quality Map based on Civita et al. (1993) classification (see Fig. 3c and Fig. 3d accordingly).

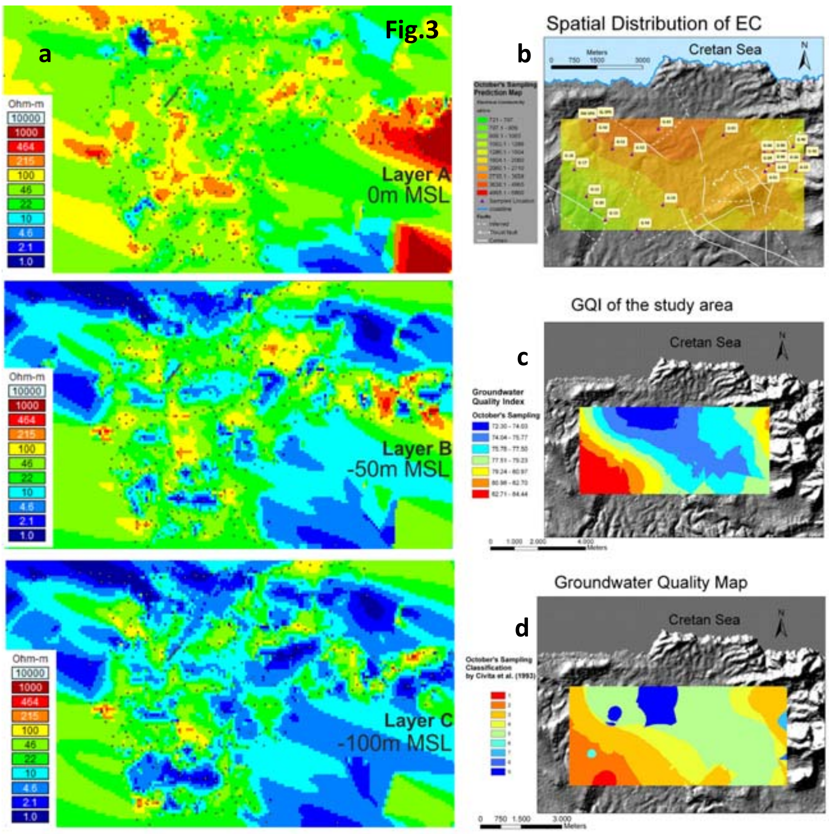


Figure 3:

a) 3D model of TEM data. Geoelectrical interpretation of intervals to a depth of -100 m MSL is presented. Hot colours (red) represent high resistivity formations, while the cold colours (blue) depict the low resistivity units,
b) Spatial distribution map of Electrical Conductivity (μS/cm) for October's 2008 sampling. Red triangles specify the 22 sample locations,
c) GQI map of the study area as proposed by Babiker et al. 2007 (maximum groundwater quality=100), and
d) Groundwater Quality Map of the study area based on Civita et al. (1993) classification. Both maps are superimposed to the DEM. Hot colours indicate the good water quality, while the cold colours indicate the bad water quality.

Evidence that groundwater of Geropotamos aquifer has already been contaminated by seawater encroachment is presented in this work.

TEM technique provides a crude model of the aquifer (qualitative characteristics) since geophysical measurements are on multi-face materials (aquifer and hosted rocks). Geochemical analyses proved the most accurate for groundwater quality determination, but samplings can take place only where boreholes exist. In the contrary, with TEM geophysical technique dense grid can be created. In complex environments, like Geropotamos area, the interpretation of geophysical results does not always lead to single interpretations and needs experience, due to resistivity values overlapping.

To sum up, geophysical and geochemical data are in great agreement and the interpretation showed the source of contamination, as well as the qualitative and quantitative characteristics of the groundwaters.

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