Geological and geophysical study of saltwater contamination at Stylos, Crete

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Hamdan Ali Hamdan
Technical University of Crete

George Panagopoulos
Technical University of Crete

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I. Michalakis, N. Economou, H. Hamdan, A. Vafidis, E. Manoutsoglou, G. Panagopoulos and S. Roubedakis
Department of Mineral Resources Engineering, Technical University of Crete, Hania, Greece

C. Vozinakis
Water Resources Department, Hania Perfecture, Greece

S. Lampathakis and E. Dassyra
Western Crete Development Organization, Hania, Greece

ABSTRACT

A geological and geophysical study was conducted at the area of Stylos, Hania in order to study the possible mechanisms of saltwater contamination. A new detailed geologic map in scale 1:5,000 was combined with the results of a time lapse geophysical survey using seismic and electrical methods. A fault system in the N-NE direction possibly favors the saltwater intrusion.

1. INTRODUCTION

During exploration drilling conducted by the Western Crete Development Organization, the presence of saline (brackish) water was observed during the annual period of 1981-82. The drilling took place in a polje located approximately 1300m N-NW of Stylos, in the region of Apokorona, Chania (Figs. 1-3). The scope of this investigation is to determine the causes that led to the qualitative degradation of the waters

Figure 1: Map of Souda bay which shows the area under investigation (grey rectangular) and the location polje.

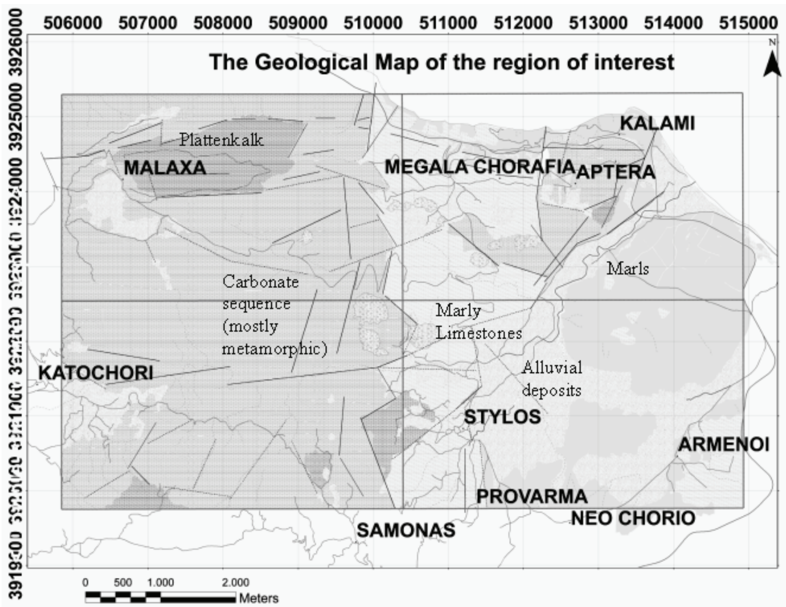

Figure 2: Geological map of the wider region of interest.

in this region of interest.

The main goal of this paper is the description of the geological structure that dictates the present increase in Cl^- of the groundwater of the region. The initial source of geologic information was a geological map of the area under investigation (map sheet of Hania, scale 1:50,000, I.G.M.E). The absence of gypsum, anhydrite, or mineral salt formations in the region led to the hypothesis that the most probable cause for the groundwater salinization is seawater intrusion. North of the polje, the seashore of Souda bay is located at a distance of 2900m. The seashore is also to approximately 4000m away from the polje along the Koiliaris river to the northeast.

2. METHODOLOGY

The methodology that was chosen for the determination of the causes for the observed phe-

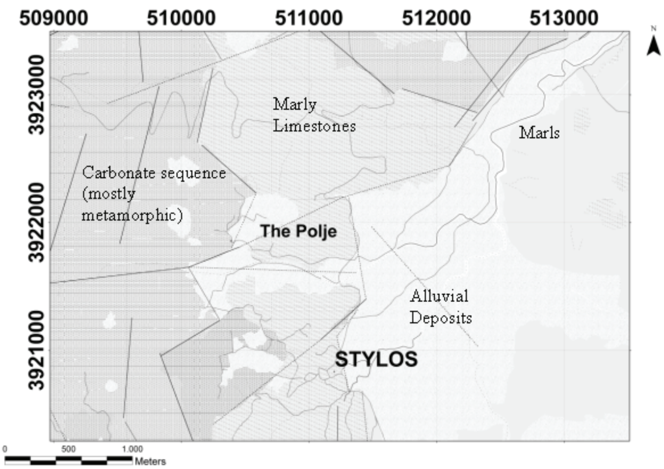

Figure 3: Geological map around the polje north of Stylos.

nomenon included detailed geological mapping (scale 1:5,000) in addition to the use of geophysical methods for imaging the seawater front.

The main stage of the geological mapping involved defining the boundaries of the geologic formations on the 1:5,000 scale topographical maps sheets (M.G.S., 1972).

A Geodatabase was built in GIS using all the available validated information in a common mapping coordinate system. This database proved useful during field work which involved the collection of the initial data for the creation of the finer scale geological map of the region. In particular the use of the orthophotomaps, the instant confirmation of the photointerpretation, the immediate and accurate localization of the initial data made the use of GIS essential for the creation of the final map.

The geophysical investigation provided images of the subsurface based on the spatial distribution of resistivity (geoelectrical tomography section) and seismic wave velocity (seismic tomography section). These images are combined in order to generate a final interpreted section.

3. GEOLOGICAL MAPPING

The geological mapping was performed in the area shown in Figure 1 (grey rectangular). The western part of the area is covered by carbonates which according to 1:50,000 geological map belong to Tripolis zone and Neogene formations (Fig. 2). This carbonate sequence according to the detailed mapping consists of three tectonic units: the lowermost is the Plattenkalk group, the Trypali unit in the middle and a cover of brecciated carbonates (Neogene or Quaternary age).

It is worth noting that this mostly metamorphic carbonate sequence is also outcropping at Aptera. Poljes are observed on this karstified formation. The boundary of the carbonates and the marly limestones located at the center of the geologic map (Fig. 2) is a normal fault in the NS direction.

Thin Phyllite layers are mapped north of Malaxa village where the Plattenkalk formation outcrops.

Metacarbonates of the plattenkalk group are also mapped at an abandoned quarry NE of Aptera. A major normal NE-SW fault is related to the Aptera horst as well as to the Koiliaris river valley where marls and marly limestones are in contact with the plattenkalk formation.

The eastern part of the area is covered by Neogene sediments which evolve in discordance, over the metasediments. The main lithotypes of the Neogene sediments are marls, marly limenstones and biogenic limestones.

Figures 3 and 4 show a portion of the detailed geological map and the orthophotomap in the area around the polje respectively, where the

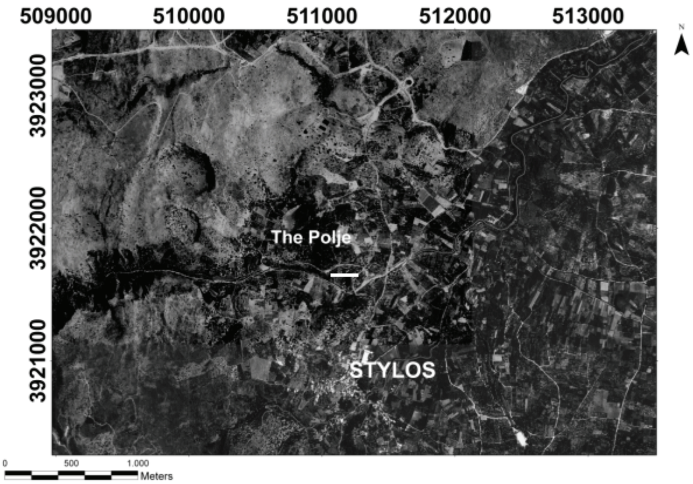

Figure 4: Ortho-photomap around the polje. The thick white line indicates the location of the electrical tomography time lapse experiment.

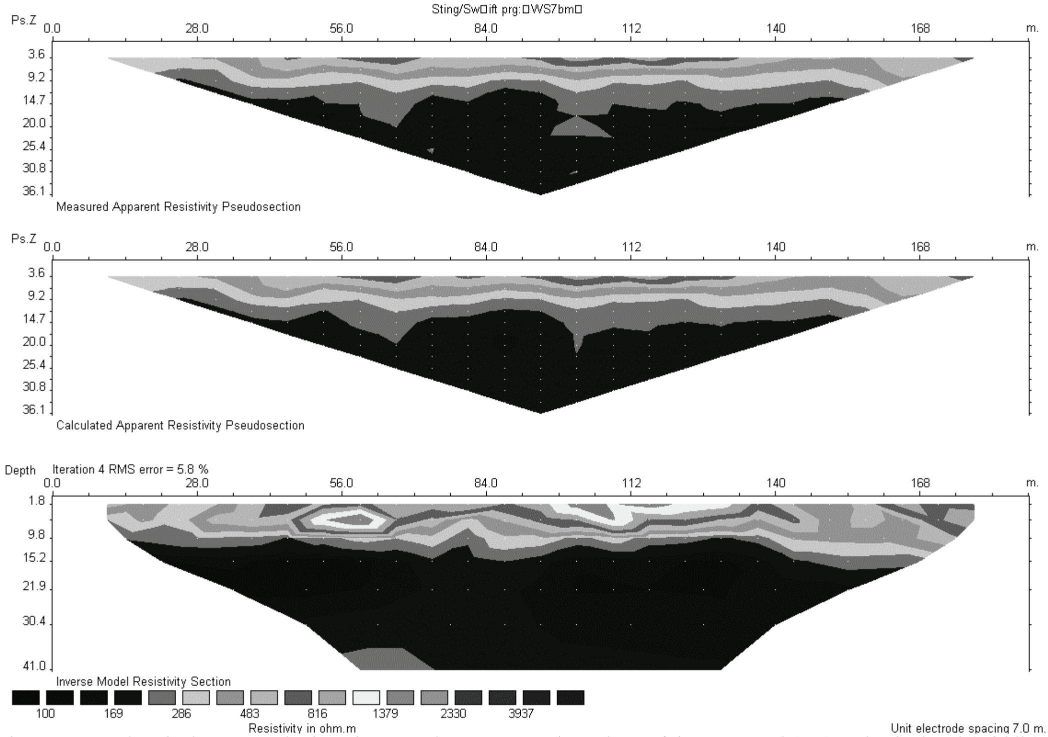

Figure 5: Geoelectrical tomography imaging on July 2005. Pseudosections of the measured (top) and calculated (middle) apparent resistivity. On the geoelectrical section (bottom) the water layer is located at depth greater than 10 m (low resistivity layer, dark grey).

presence of saline (brackish) water was observed during the annual period of 1981-82.

4. GEOPHYSICAL SURVEY

A geophysical survey was conducted in order to image the saltwater intrusion. The area under investigation was initially scanned using the electrical tomography and seismic refraction methods.

A time-lapse geoelectrical experiment was realized in July 2005 and March 2006 along a 200m survey line (Fig. 4). The Wenner-Schlumberger array was utilized with 7 m electrode separation. Preliminary results indicate that the depth of the water layer does not change significantly throughout the year along the electrical tomography line (Figs. 5-6).

5. CONCLUSION

According to the data from the new detailed geological map of the area of interest and the time lapse geophysical experiment, lead to the conclusion that a normal fault system in the N-NE direction favors possible saltwater intrusion.

ACKNOWLEDGMENTS

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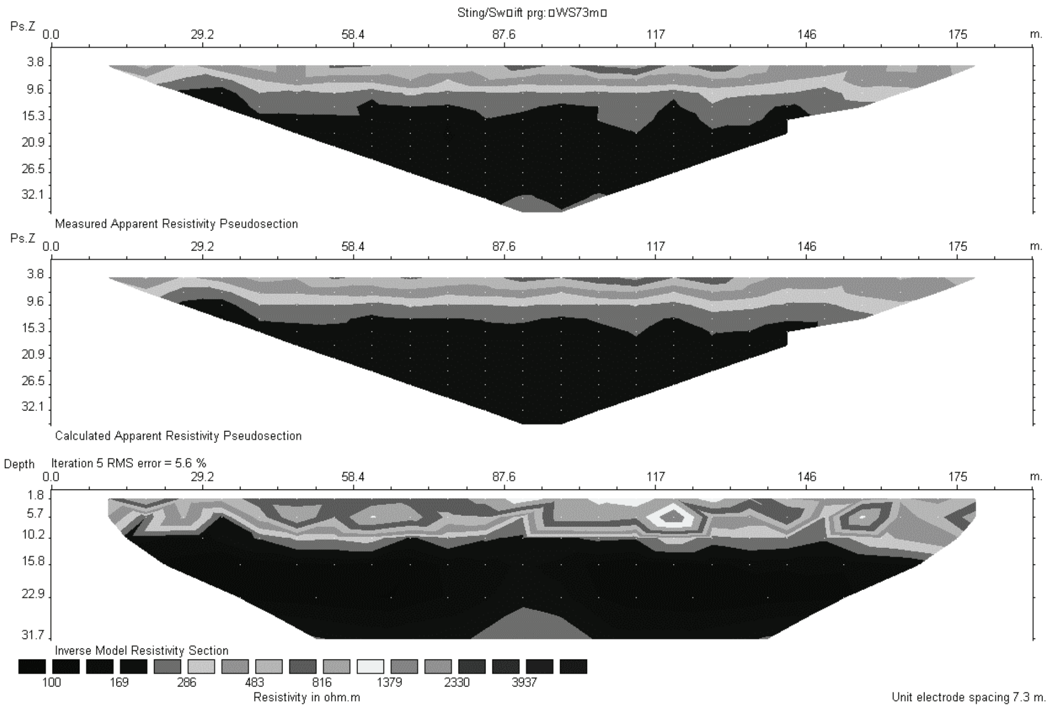

Figure 6: Geoelectrical tomography imaging on March 2006. Pseudosections of the measured (top) and calculated (middle) apparent resistivity. On the geoelectrical section (bottom) the water layer is located at depth greater than 10 m (low resistivity layer, dark grey).