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A Geophysical Insight for the Occurrence of Mediterranean Temporary Ponds on Mts. Oiti and Kallidromo (Greece)

J.D. Alexopoulos* (National & Kapodistrian University of Athens), S. Dilalos (National & Kapodistrian University of Athens), E. Vassilakis (National & Kapodistrian University of Athens), D. Michelioudakis (National & Kapodistrian University of Athens), S. Mavroulis (National & Kapodistrian University of Athens) & P. Farangitakis (National & Kapodistrian University of Athens)

SUMMARY

A geophysical survey was performed at selected locations of Mt. Oiti and Mt. Kallidromon characterized by the hosting of priority habits of Mediterranean temporary ponds and the threatened plant species of Veronica oetaea, in order to understand the geoenvironment and contribute to the conservation of biodiversity. Primarily, the formation of these seasonal ponds, where Veronica oetaea occurs, seems to depend exclusively on the local hydrogeological regime. Thus, we investigated the subsurface structure of "Livadies" and "Nevropolis" ponds with the application of Electrical Resistivity Tomography for high accuracy information and Vertical Electrical Sounding for deeper data acquisition. Four ERT sections and 15 geoelectrical soundings in total were carried out. The combined results of their processing revealed differences at the geological structure beneath the ponds locations. At "Livadies" pond (Mt. Oiti), two geoelectrical layers were distinguished both corresponding to a folded flysch succession, contributing to the formation of this pond. On the contrary, at "Nevropolis" pond two geoelectrical layers were identified and interpreted as a surficial soil deposit stratum covering the geomorphological karst structure of a polje, created on the underlying limestones. The combined geophysical research offered significant data for the formation and the hydrogeological status of the priority habitats.

Introduction

In the context of researches for the conservation of biodiversity, geophysics can be very informative and useful, providing data for the subsurface abiotic component of habitats and ecosystems. The geophysical aspect is important for the rare and protected habitat of Mediterranean temporary ponds(Dimitriou et al 2006, Gómez-Rodríguez et al 2009,Zacharias & Zamparas 2010) where Veronica oetaea (Albach 2006, Karetsos 2011, Phitos et al 2009) a critically endangered dwarf plant occurs. The plant is restricted to the high altitude ponds of the National Park of Mountain Oiti. It needs the alteration of a wet and a dry phase in order to complete its life cycle and appears in late spring, as soon as the ponds start to dry.

Figure 1a *Veronica oetaea (May, 2013).*

Figure 1b *"Livadies" Mediterranean temporary pond (May, 2013).*

Temporary ponds are wetlands that present a seasonal hydrologic period. Ecosystem functions and the biota of the ponds depend strongly on the hydrological status. For this reason a geophysical study was carried out to investigate the subsurface geological and hydrogeological characteristics of the temporary pond of "Livadies" on Mt. Oiti where Veronica oetaea is a typical species. At the same time a respective research was performed on the vicinal Mt. Kallidromo, at the geomorphologically similar seasonal pond of "Nevropolis" in order to compare the geo-environment of these two ponds.

Geological setting of the study area

The surrounding area of Livadies pond at Mt. Oiti comprises of alpine basement rocks, mainly flysch and carbonate formations, as members of two stacked geotectonic units; the Eastern Greece overthrusted Parnassos unit (Marinos et al., 1963; Papanikolaou, 1986; Kranis and Papanikolaou, 2001; Karipi et al., 2008). The northern parts of Mt. Kallidromon (where Nevropolis pond is lying) consist of the Mesozoic carbonate sequence of Sub-Pelagonian unit on top which several members of the ophiolitic complex crop out (Papastamatiou et al., 1962; Danelian and Robertson, 1995; Kranis, 1999; Kranis and Papanikolaou, 2001; Karipi et al., 2008).

Livadies temporary pond on Oiti Mt: The small temporary pond of Livadies is located in the southwestern part of Oiti Mt. It is formed on the Eocene flysch of Eastern Greece unit. These formations comprise of coarse sandstones intercalated with shales and sandy marls overlying the Upper Cretaceous limestones of the same unit. Carbonate and conglomerate intercalations are often present throughout the stratigraphy of the flysch (Kranis, 1999; Kranis and Papanikolaou, 2001).

Nevropolis temporary pond in Kallidromon Mt: The temporary pond of Nevropolis is located in the central-western part of the Kallidromon Mt. It is formed at an area consisting of Triassic-Jurassic compact limestones of the Sub-Pelagonian unit (Papastamatiou et al., 1962; Marinos et al., 1963), covered by an impermeable soil bed of 1-2 meters thick.

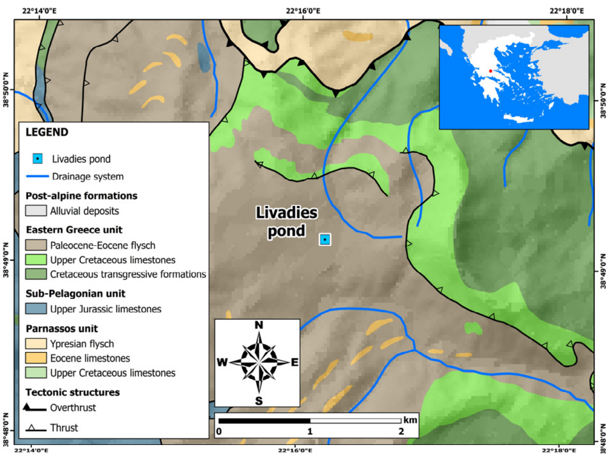

__Figure 2a__ Geological map of the "Livadies" pond surrounding area.

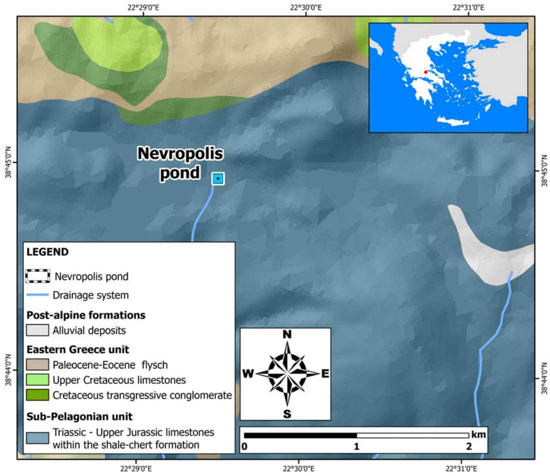

__Figure 2b__ Geological map of the "Nevropolis" pond surrounding area.

Geophysical Survey and Results

Geoelectrical techniques were applied in order to investigate the subsurface geological structure of the temporary ponds Electrical Resistivity Tomography (ERT) was selected for shallow but high detail investigation combined with Vertical Electrical Soundings applied for deeper investigation.

At the area of "Livadies" pond (Mt. Oiti), two (2) perpendicular ERT sections were carried out with 400m total length and 2.5m electrode spacing. Along with them, nine (9) Vertical Electrical Soundings with the Schlumberger array (maximum AB/2 was 215m.), were executed, distributed on a regularly planned grid (50m distance between each VES centre). At "Nevropolis" pond (Mt. Kallidromo), two (2) ERT sections were carried out with total length of 480 along and 3m electrode spacing. Six (6) Vertical Electrical Soundings with the Schlumberger array (maximum AB/2 was 215m) were added to the measurement data.

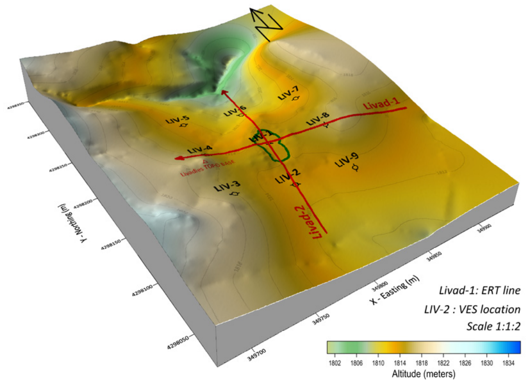

__Figure 3a__ Geophysical locations at "Livadies" pond.

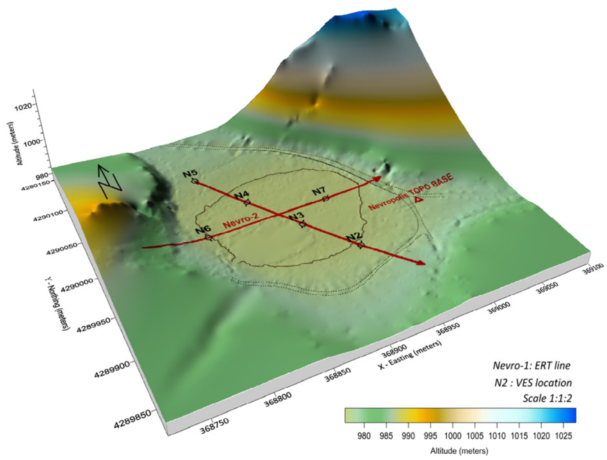

__Figure 3b__ Geophysical locations at "Nevropolis" pond.

The ERT measurements were processed with the Res2DInv software, while the Vertical Electrical Soundings with the Ix1D software and their 1-D geoelectrical models have been specified. For a combined interpretation, these models have been embedded in the final inversion model of the ERT (Fig. 4).

At the area of Livadies pond, two main geoelectrical layers have been revealed. The first layer appears with resistivity values of 105-115 Ohm.m a 10-15m thickness, while the second underlying layer has values of 300-400 Ohm.m. Their geoelectrical boundary seems to have a smooth tilt towards north. As far as the Nevropolis pond collected data, the combined geophysical results indicate 3 geoelectrical layers. The upper layer is determined at 14-20 Ohm.m resistivity and almost 15 m thickness. The deepest investigated layer appears with relatively high resistivity up to 500-900 Ohm.m, but it seems to tilt almost symmetrically towards the centre of the section which coincides with the centre of the pond. The top of this layer is defined at depths 10-40m.

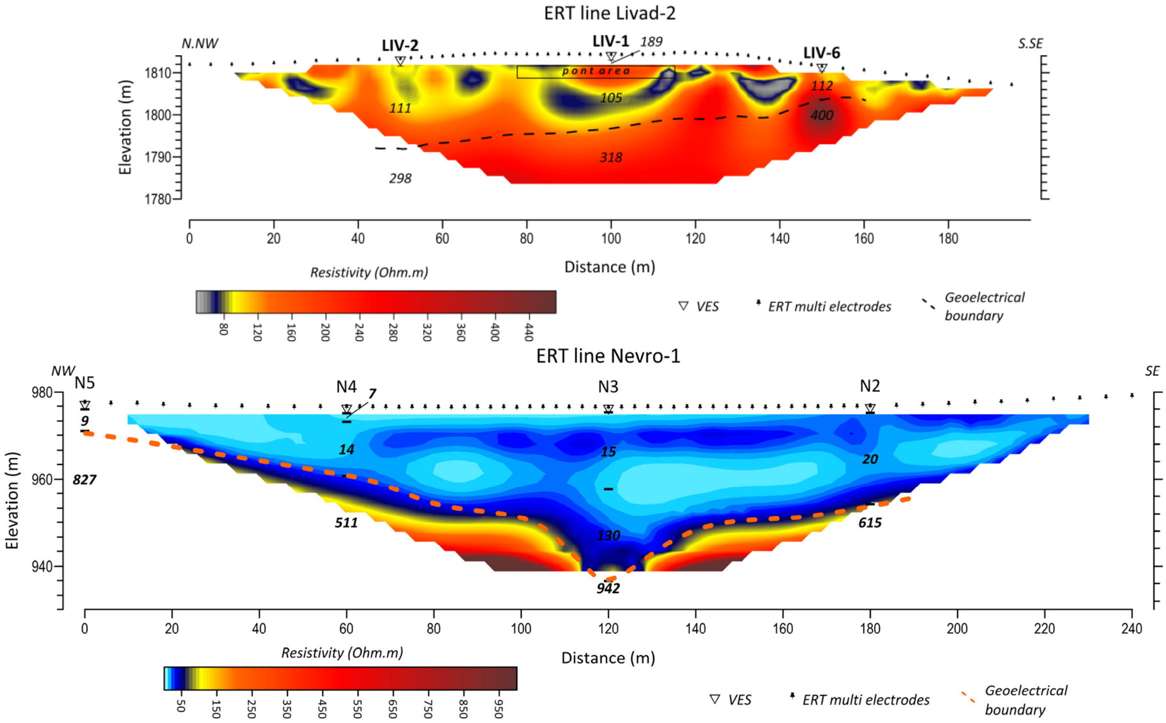

Figure 4 *ERT inversion models with embedded VES 1-D interpretation* ***Up****: ERT-2 from "Livadies" pond (RMS=4.6%, 6th iteration).* ***Down****: ERT-1 from "Nevropolis" pond (RMS=4%, 7th iteration).*

Interpretation

For the interpretation of the combined geophysical results of both ponds we took into account their surface geological setting. At Livadies pond the first geoelectrical layer (105-115 Ohm.m) could correspond to the sandstones intercalations within the flysch formation, saturated secondarily with water and the deeper but more resistive formation (300-400 Ohm.m) could represent the shales within the flysch. The shales, as a non-permeable formation, restrain the water infiltration. As it is illustrated on the ERT inversion model, this formation seems to be smoothly folded, which is in full agreement with the observations made during the field mapping. More specifically, a synform of flysch formations sequence is outlined exactly under the pond itself, which probably contributes to the formation of the temporary pond.

At the area of Nevropolis pond, the regime is slightly different. The upper relatively conductive geoelectrical layer (14-20 Ohm.m) could correspond to recently deposited soil formations (e.g. terra rossa), since the water infiltration in this pond is quite small because even during the summer the pond holds water at several spots. The most interesting information of this section is the geomorphological relief of the deepest resistant (500-900 Ohm.m) layer, as it is adumbrated clearly from both the ERT and VES processing results. It is interpreted as the geological layer of the limestones cropping out throughout the surrounding area, forming a kind of polje, due to their erosion during the geological period they were exposed to the surface. Moreover, based on the 2D approach of the VES measurements (Apostolopoulos 2008) where we take advantage of the greater investigation depth, a tectonic structure (possible fault) seems to reveal justifying this geomorphological structure.

Conclusions

The combined application of the Electrical Resistivity Tomography (ERT) and the Vertical Electrical Soundings (VES) techniques, confirmed by in situ geological data, proved to be quite efficient for the investigation of the hosting locations of the significant *Mediterranean temporary ponds* as well as the occurrence of "*Veronica oetaea*" along their perimeter. Considerable geological and hydrogeological data for the subsurface structure beneath the ponds were indicated, proving that geophysical methods can provide useful information either for the biological science.

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