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Geoelectrical and Seismic Imaging of the Omalos Plateau, Crete, Greece

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SUMMARY

This case study presents the results of a geophysical survey that was carried out in 2008-9 at Omalos plateau in Chania, Western Crete, Greece. During this survey we applied seismic methods as well as electrical tomography in order to image the active karstic structures of the Omalos polje. The resistivity and seismic velocity sections image properly karstic structures such as a doline to the south. In addition the geoelectrical sections outline the metamorphic carbonates relief (Tripali unit and Plattenkalk group), which appears highly irregular. At Omalos polje the thickness of post-Mesozoic deposits (terra rossa, clays, sands and gravels) ranges from 40-130 m.

Introduction

Environmental and engineering investigations in karstic terrains involve the use of geophysical and borehole information for the site characterization. Sinkholes are the major hazard when developing structures at sites where the bedrock consists of carbonate rocks. The problem of imaging heterogeneities at karstic sites requires in general the integration of different geophysical methods, such as microgravity, electrical methods, GPR and others (Sumanovac & Weisser, 2001).

Electrical tomography images have been effectively used in top-to-bedrock studies, soil and rock characterization and mapping of voids and fractures in rocks. The use of different electrode arrays over karstic formations was studied by Zhou et al. (2008). They concluded that the dipole-dipole array is the most suitable for assessing dolines or sinkholes in carbonate rocks. Joint inversion of the Wenner-Schumberger and dipole-dipole array data achieves the maximum reliability of the 2D resistivity model for the detection of saltwater intrusion in karstic formations.

In this study, we present the results of a geophysical survey carried out at the Omalos Plateau, Western Crete, Greece. This survey employed electrical and seismic methods. The geoelectrical survey included measurements from resistivity sounding and electrical tomography. The objective of this survey is to image the complex morphotectonic structure of the active karstic system of the Omalos polje. Here, we present the results of the geophysical survey including preliminary results of joint inversion of seismic refraction and ERT data.

Study site

The Omalos Plateau, one of the largest morpho-structural units in Western Crete, is a typical active polje located at the White Mountains of the Crete island, and covers an area of approximately 6 km^2 (3x2 km) (Figure 1). The plateau consists mainly of marls and gravels, which lie on the "Trypali" metamorphic carbonates. The rock formations around the Omalos plateau belong mainly to the Trypali unit and the Plattenkalk group.

Geophysical survey

The geoelectrical survey at Omalos Plateau (Fig. 1) was conducted during four periods namely September 2002, September 2003, September 2008 and September 2009. The data collected during the first and second periods correspond to four VES using the Schlumberger array with maximum current electrode spacing of 1800 m (B1-B4) and four ERT lines, using the Wenner-Schlumberger array with 30 m electrode spacing (T1, T2, T3 and T5). In September 2008, we collected data along the Lines 1 and 2, using 10 m electrode spacing, the Wenner-Schlumberger array and the roll along technique. During the last period (September 2009), a grid of seven parallel ERT lines was scanned, using the same configuration as in September 2008. The rectangular area (red line) depicts a grid of seven electrical tomography parallel lines. The length of each electrical tomography line was 470 m. The Sting R1/ Swift system collected data along specific traverses. The geoelectrical sections are the outcome of the inversion of the apparent resistivity data using the least-squares generalized inversion method (RES2DINV program, Loke and Barker, 1996).

In September 2009, a seismic refraction survey was conducted in the south part of the polje along two lines namely S5 and S7. Each seismic line consisted of two spreads having 5 m geophone interval and five shots per spread; one in the middle, two near and two far offset shots. Total recording time was 512 ms and the time interval, 0.125 ms. Borehole 325 provides information about the geological sequence at the south part of the polje (Figure 2). The borehole drilled mainly a mixture of Terra Rossa and gravel within the first 10 m, marls and sands for the next 60 m, and a clay layer whose thickness is around 10 m. Marls appear again for the next 10 m on top of the carbonates.

The next sections present geophysical images from a doline which is located at the southwest part of the polje as well as from karstic structures of the Omalos Plateau.

Doline

The ERT grid at the southwest part of Omalos polje is located at a selected site for the construction of a water reservoir. A typical electrical tomography section (line 5) and its corresponding seismic velocity section are presented in Figure 3. The geoelectrical sections T3 and G1 (Fig. 2) image a portion of a doline indicating a high resistivity layer which is dipping to the south and is attributed to carbonates. According to the ERT results in this area (Figure 3) the depth of the bedrock ranges from around 15 to around 70 m.

The seismic velocity section indicates three main seismic layers, attributed to Terra Rossa and gravels, sands-clays and marls (Figure 3). We additionally performed joint inversion of the seismic refraction and ERT data to delineate the top of the marls.

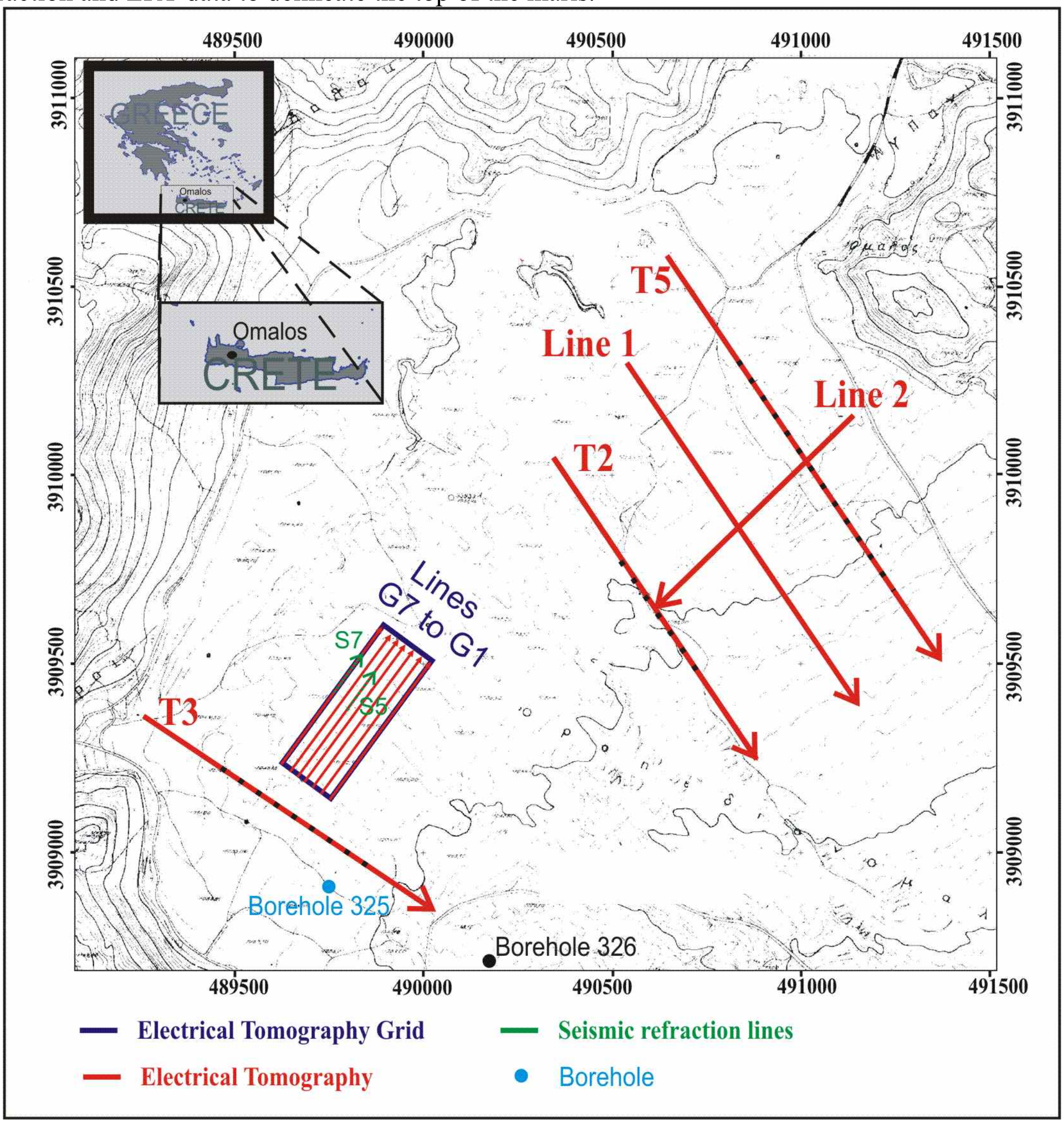

Figure 1 *Survey area at Omalos plateau. Black dots show the effective length of lines T2, T3 and T5 .*

Karstic structures

Figure 4 illustrates a 3D perspective view from the south of the ERT sections at Omalos Plateau where the carbonates (deeper high resistivity zone) exhibit a rough paleorelief. The depth of the carbonates becomes smaller to the east (red circles). The thickness of post-Mesozoic deposits ranges from 40-130 m.

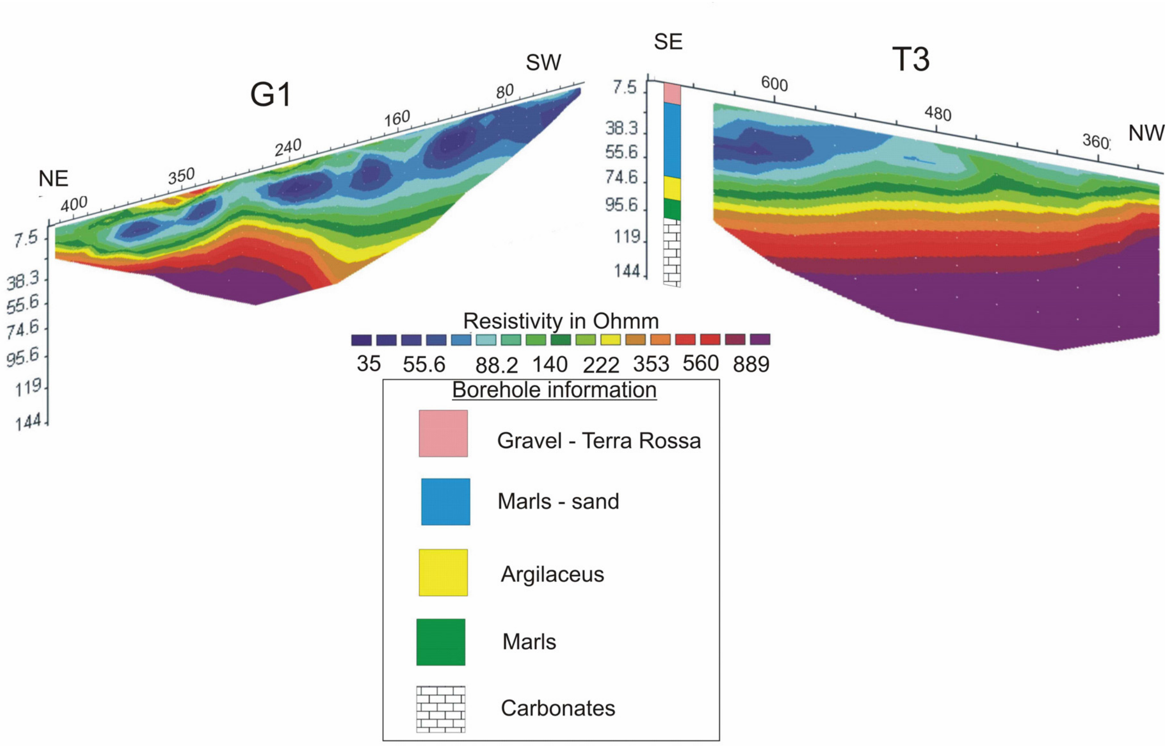

Figure 2 *3D representation of electrical tomography sections T3 and G1 and borehole 325 which image the south part of a doline. A high resistivity layer (> 500 Ωm) is dipping to the south and is attributed to carbonates.*

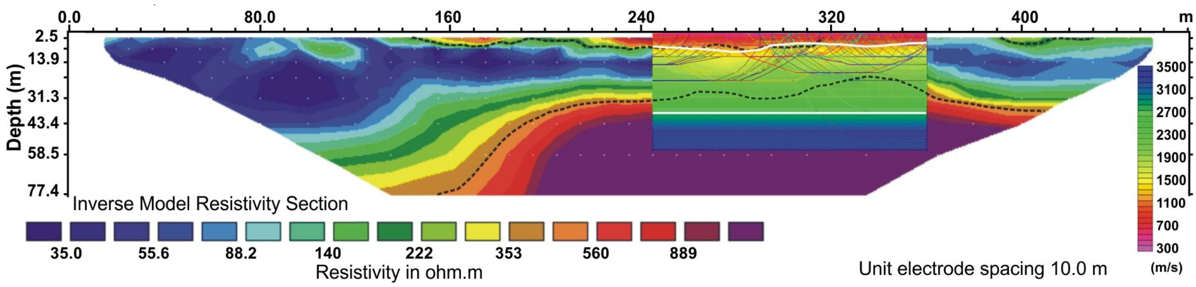

Figure 3 *The electrical tomography section G5 and seismic velocity section S5 indicate that the depth of the bedrock ranges from around 15 to around 70 m.*

Conclusion

The resistivity and seismic velocity sections imaged properly karstic structures at Omalos plateau such as a doline to the south where the depth of the bedrock ranges from around 15 to around 70 m.. The geoelectrical images also outlined deeper karstic structures at Omalos Plateau which form a highly irregular relief of the metamorphic carbonates (Tripali unit and Plattenkalk group).

References

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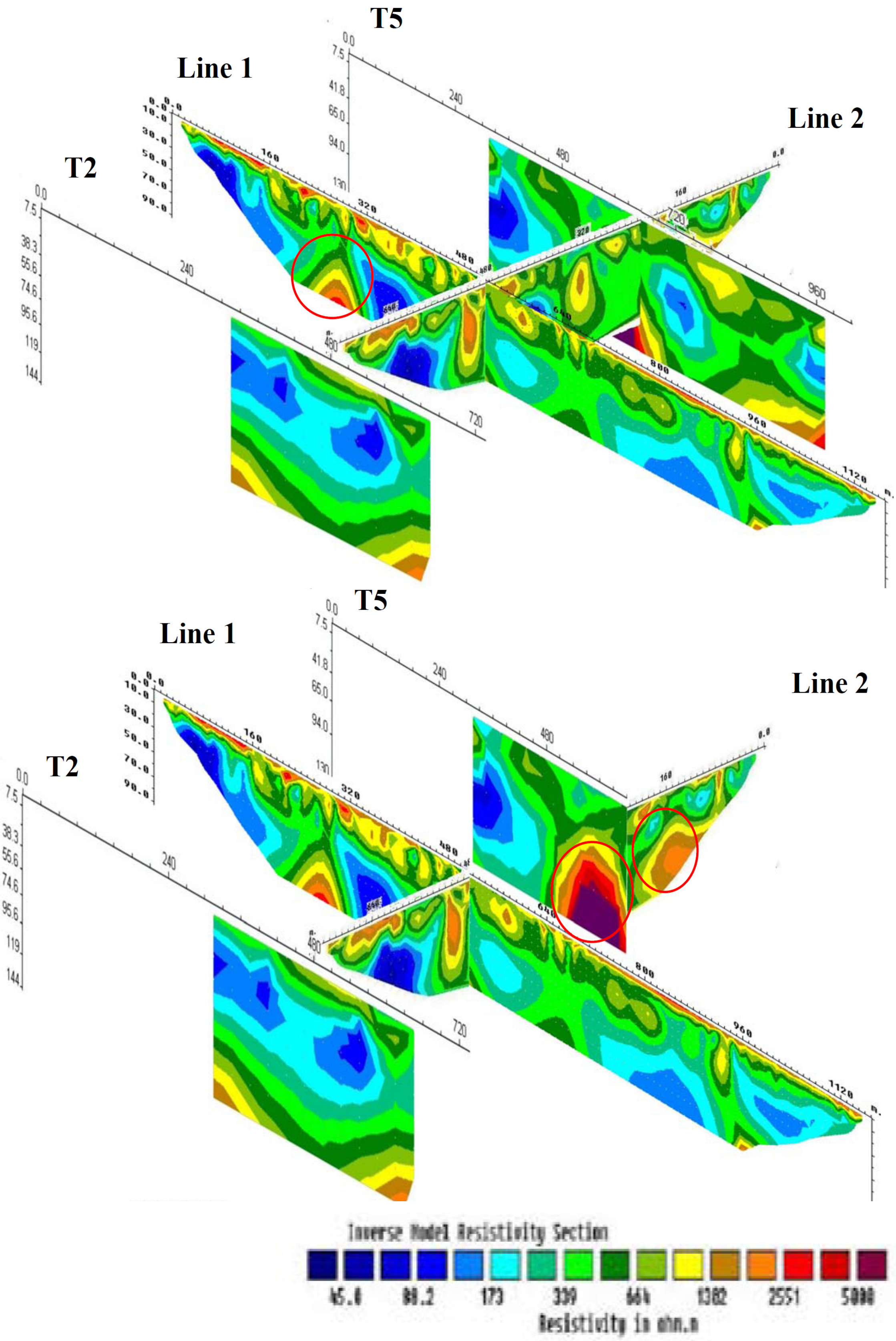

Figure 4 *3D representation of electrical tomography sections at Omalos plateau. The carbonates (deeper high resistivity zone ρ > 500 Ωm) exhibit a rough paleorelief.*