ERT METHODS TO DETECT KARSTIC CAVES

Antonio Bratus[1], Luca Baradello[1], Daniel Nieto Yabar[1], Paolo Paganini[1]

[1] Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – OGS, Borgo Grotta Gigante 42/c, Sgonico (TS), Italy.
E-mail: abratus@ogs.trieste.it

Introduction

In this paper we present the results obtained by earth resistivity and induced polarisation tomography methods. These geophysical methods intended to achieve several goals, i.e. to define:

- morphology and depth to the bedrock,
- features of the rock mass,
- the aquifer,
- the presence of:
    - caves,
    - loose material fillings,
    - anomalies of tectonic origin.

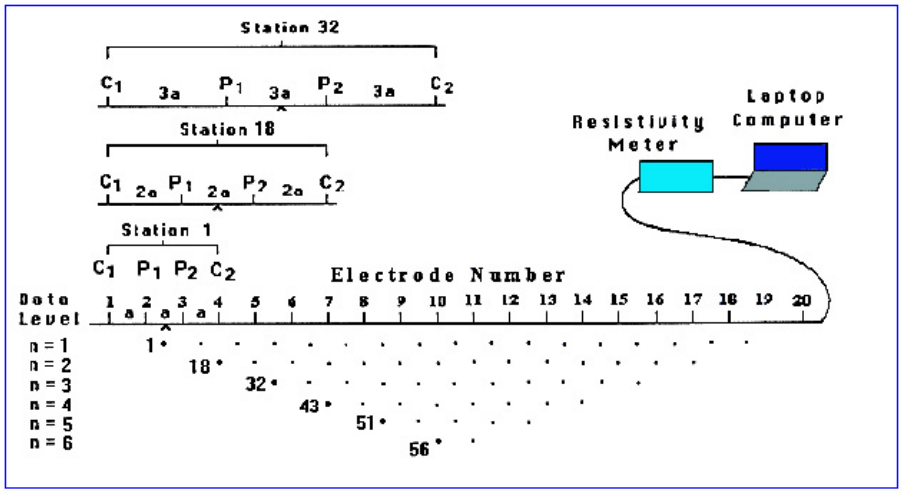

Figure 1 The arrangement of electrodes for 2D electrical survey and the sequence of measurements used to built a pseudosection with the Wenner array. C_1 and C_2 are current electrodes, P_1 and P_2 are potential electrodes. Stations 1, 18 and 32 locate three different underground measurement points, having different depth and location. (for example, in the station 32: C_1 = electrode 1, C_2 = electrode 10, P_1 = electrode 4, P_2 = electrode 7)

To collect resistivity and induced polarisation (IP) chargeability data, a Syscal R2 equipment and a set of Multinode system by Iris Instruments was employed.
The apparent resistivity and chargeability data of each profile were inverted by using RES2DINV software package by Loke (Loke and Barker, 1996), selecting the robust inversion option because of some amount of "geological" noise on the data, due to shallow inhomogeneities and sometimes to difficult ground contacts.

The site test of Iamiano

Two field test sites were chosen, the first one was in Iamiano , the second in the area of the Pocala Cave.

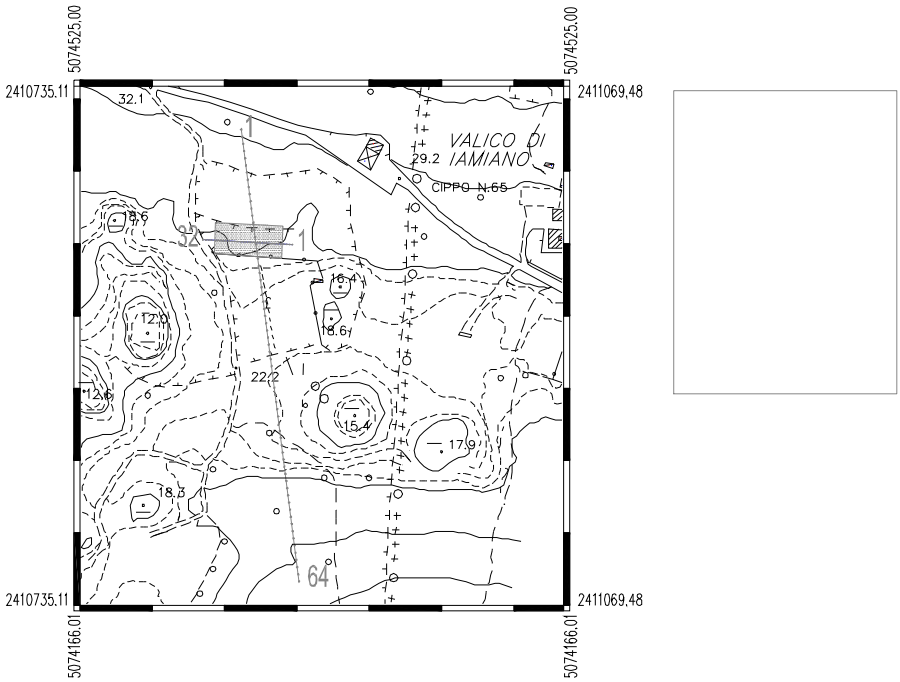

Figure 2. Location of the Iamiano field test area

The Iamiano test site is located in the interior of a valley, oriented E-W (figure 1), and is characterised by black bituminous limestone, finely and fairly stratified, laying at shallow depth and often sub-outcropping, and gently dipping at 320°/30°. The high karsting degree of the lithotype determines grizas and karren to be abundantly present at surface and suggests that a lot of caves may very probably be present at depth. Water table is located at some tens of m below earth surface.

The first step of the experiment was devoted to the definition of the most proper measurement array geometry, comparing Wenner, Schlumberger and polar dipole-dipole arrays. As expected, the last one yielded a much more detailed image of the subsurface, which is essentially composed of a highly inhomogeneous overburden and a bedrock.
In figure 2 and 3 the resistivity image of the N-S profile labelled 1-64 (see figure 1) is reported as an example. Its main features are the following. Within the carbonatic bedrock, a sequence of highly resistive, distinct bodies is detected, at depths of 5 to 10 m below earth surface. These anomalies can be interpreted as caves, formed along strata. Moreover, in the left part of the model, a remarkable resistivity decrease is detected, at a depth of 35 m below earth surface., most probably related to the saturated zone, which is laterally confined toward South by variations of the bulk permeability. In the right part of the ERT image, between abscissas 200 and 240 m, the resistivity maximum is elongated toward depth, and is probably associated with a known tectonic discontinuity.

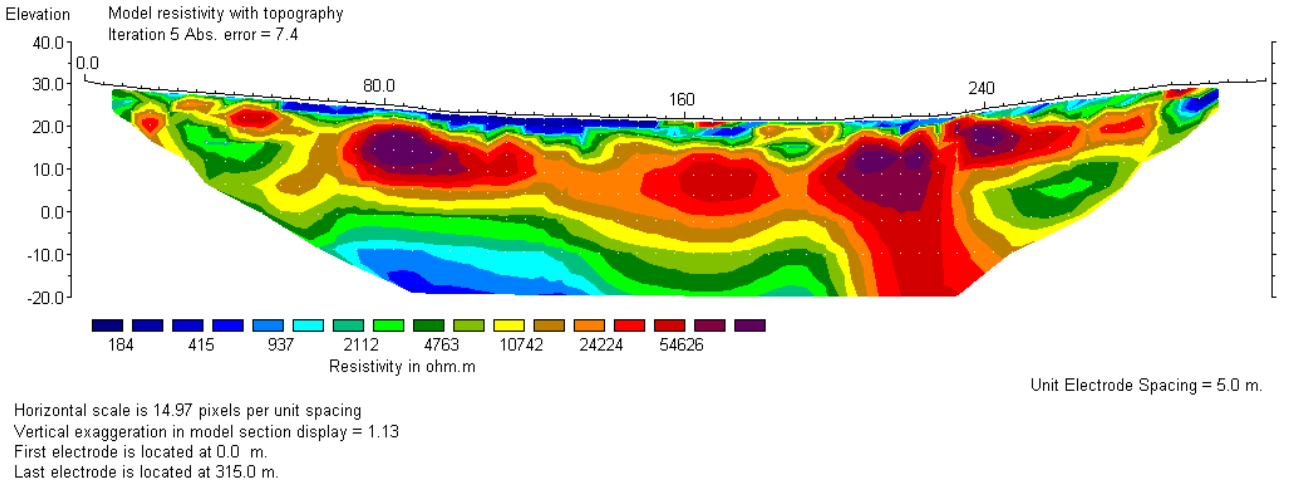

Figure 3 The resistivity model of the 64 electrodes line of Iamiano

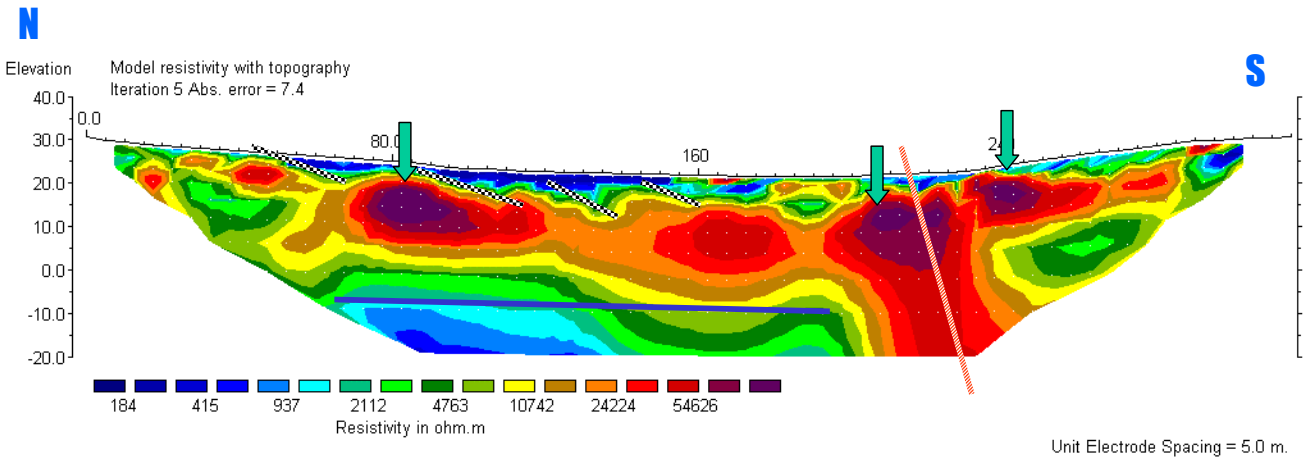

Figure 4. Interpretation of the 64 electrodes line

The corresponding chargeability image, not presented here for brevity, gives relatively high values near surface, correlated to possible trenches, filled by sediments enriched in metallic oxides, mainly ferrous (Fe_nO_m), as their reddish colour suggests.

The Pocala Cave site test

In the Pocala Cave a 64 electrodes line was positioned. The indication for the survey direction was given by the Civico Museo di Storia Naturale staff. A GPS system was used to define the position of the lines. This work was carried on by Alessandro Sgambati of the Corpo Forestale Regionale.
The first line of 64 electrodes, having a length of 315 m, has a SE-NW direction. The centre of the line is in the grass, near the entrance of the Antonella cave. The NW end is in the big dolina near the motorway (fig. 4).
Analysing the section four big high resistivity anomalies are noted. They are probably due to the presence of different cave systems, the biggest is located in the NW of the Antonella Cave (fig.5).

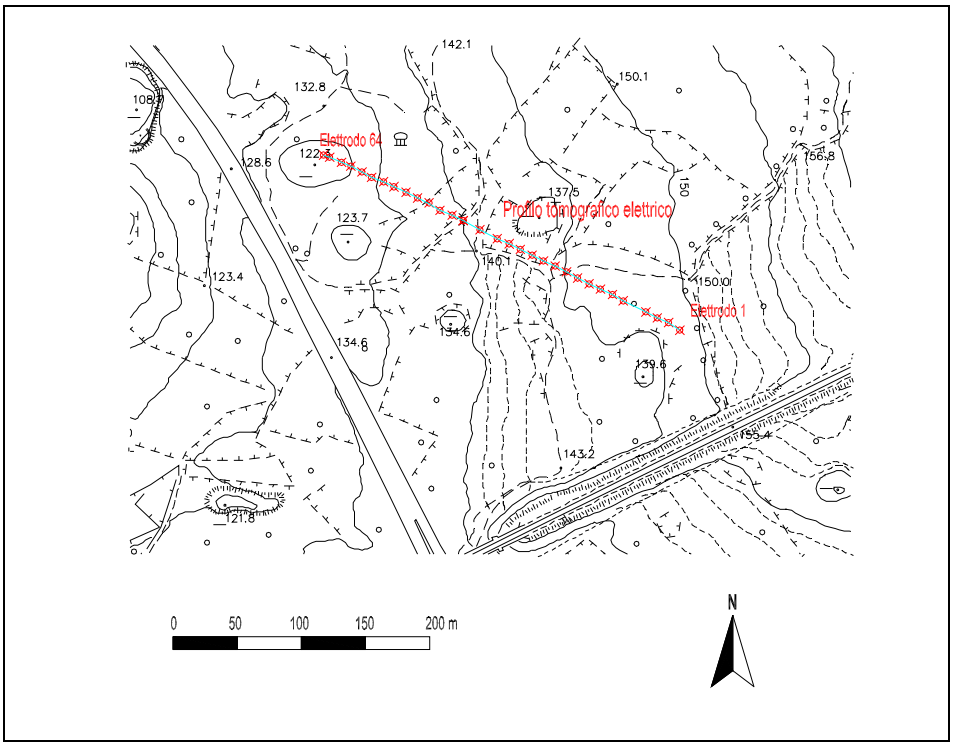

Figure 5. The 64 electrodes line in the Pocala Cave

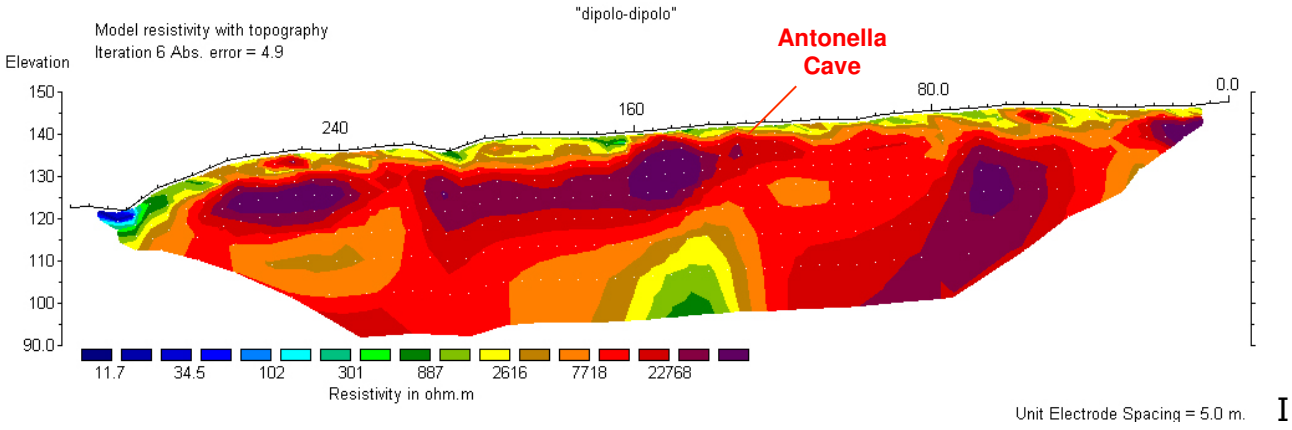

Figure 6. The NW-SE section of the Pocala Cave area.

In particular the high resistivity body detected just under the grass is at a depth of about 5 m and has a dimension of about 10 m in height and 10 m in length. It seems to be connected to a system horizontally NW elongated for about 70 m, deep about 10 m. From the progressive 240 to the dolina edge another high resistivity body at a depth of about 7 m is detected. It elongates horizontally for about 30 m. A discontinuity on the top of the bedrock is noted just on the dolina edge. Its tectonic origin is really probable.
The low resistivity body at the end of the section indicates the dolina sediments.
Describing the firs part of the section, near the progressive 80, at a depth of about 15 m from the surface, a mainly vertically high resistivity anomaly is located. It probability describes another cave.
A second line with a N-S direction is in project

Conclusions

The results demonstrate that ERT is really an efficient geophysical method to detect caves in the karst area. The use of different electrode spacing allow to study both in detail and in depth the cavity features. But ERT is powerful too in the definition of the bedrock depth, the presence of water table and the characterization of the rock mass.

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