ADUMBRATION OF AMVRAKIA'S SPRING WATER PATHWAYS, BASED ON DETAILED GEOPHYSICAL DATA (KASTRAKI - METEORA)

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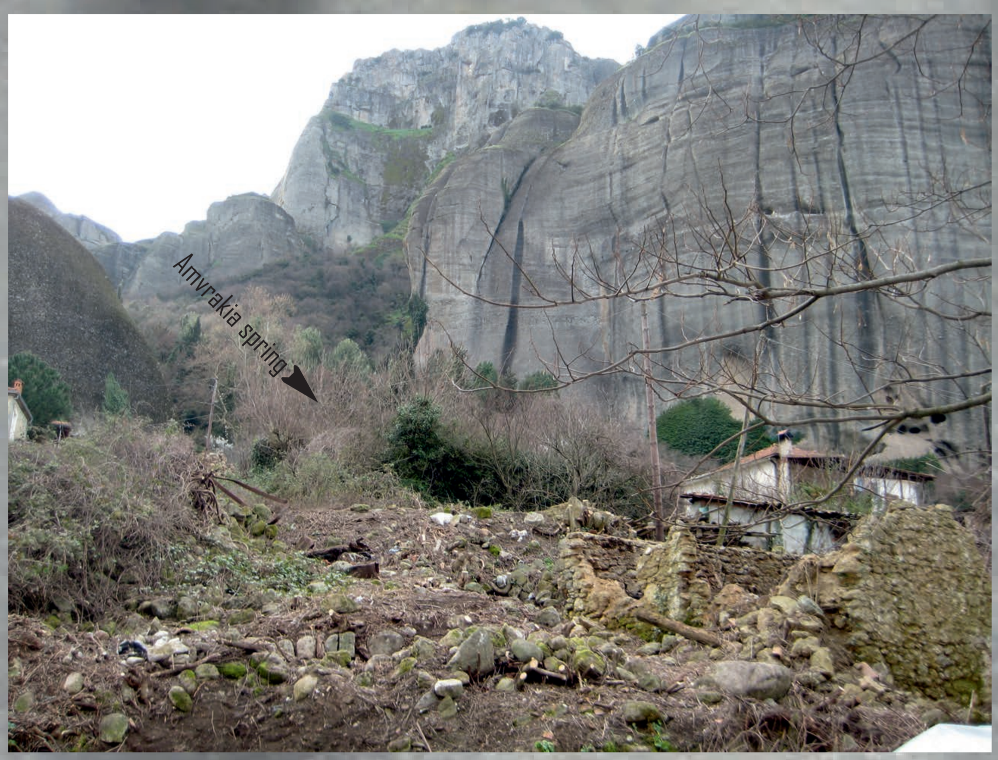
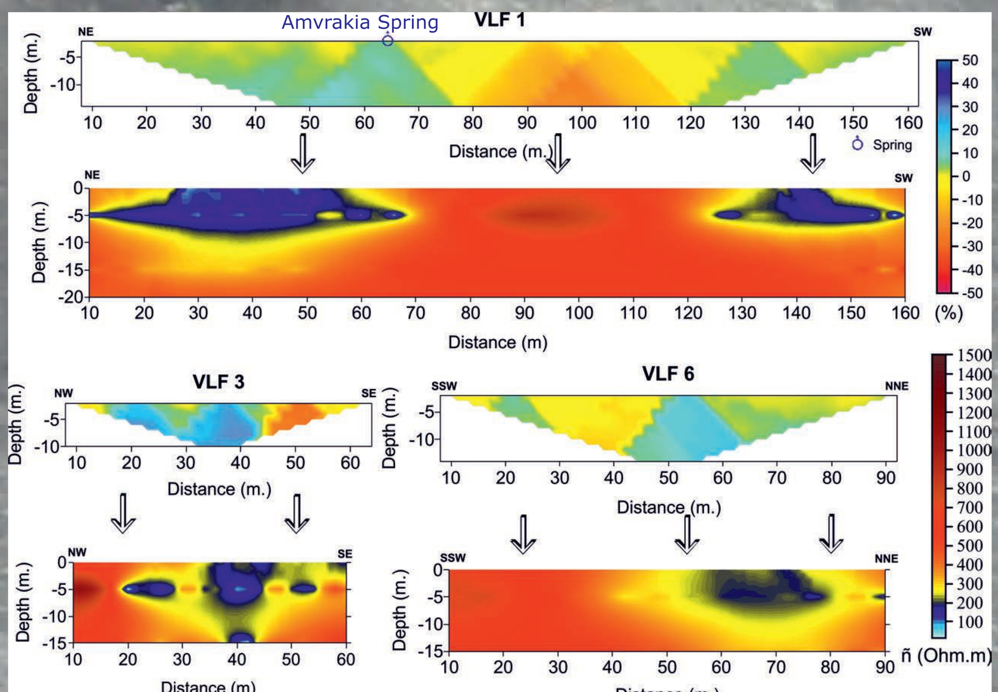


The Amvrakia spring is located at the Meteora pillars area and more specifically SE of the Kastraki village. The local cultural association was planning to take advantage of the spring and use the water by drilling it. Due to the fact that during the summer the spring suspends its function, they wanted to define its water capacity and mechanism. The study area is surrounded by vertical bluffs consisted of the Meteora conglomerates. Meteora bluffs belong to the southern part of the Meso-Hellenic molassic basin, of Oligo-Miocene age, consisting mainly of the Meteora conglomerates.

ABSTRACT

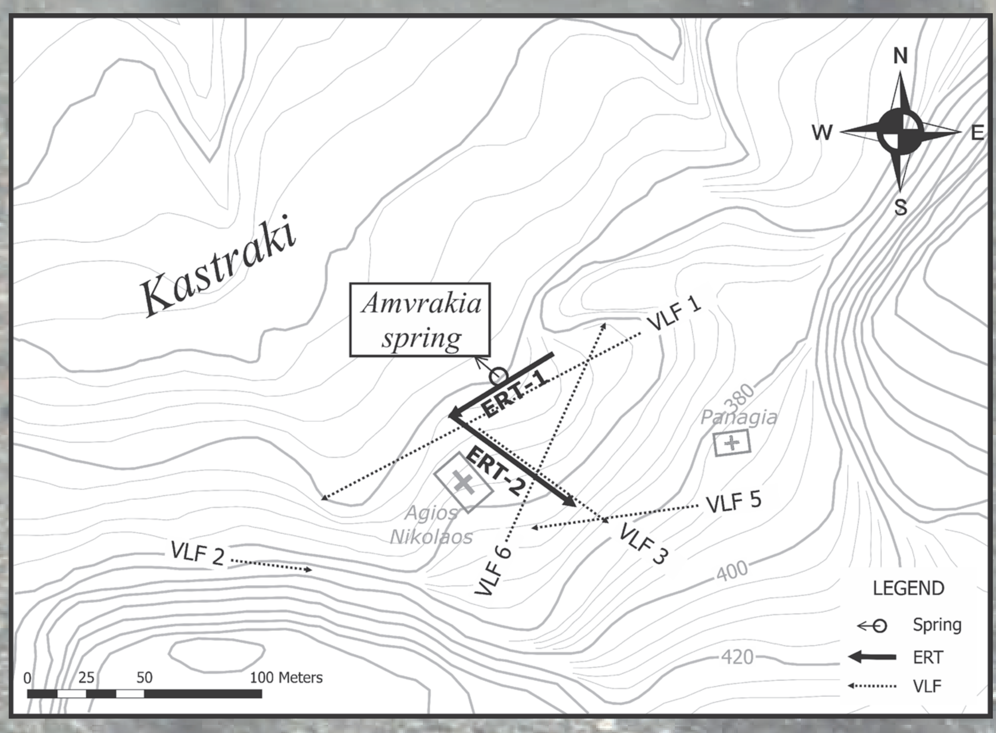
The Amvrakia spring is located at the bottom of Meteora pillars and more specifically near the village of Kastraki (Kalambaka municipality). It is a seasonal spring since it functions only during the wet period. The Meteora conglomerates which dominate the area are characterized by large discontinuities creating a network of groundwater pathways above the impermeable strata of the underlying marls. The research targets was to define these water pathways in order to understand the mechanism of Amvrakia spring, by mapping the exposed discontinuity network and define their underground extension with the contribution of geophysical techniques. Electrical Resistivity Tomography (ERT) and Very Low Frequency (VLF) methodologies were applied. The VLF method is indicated for the detection of water-bearing fracture zones, but before the application of their filters they had to be processed for topographic corrections, as the area had not smooth relief. Five (5) VLF profiles were conducted with different directions around the spring's area, in order to detect possible conductive zones in the conglomerates surrounding the study area. Moreover, two (2) ERT sections of a total length of 140m were carried out, parallel to existent VLF sections, for cross-checking the geophysical information. Both techniques revealed important conductive zones (<200 Ohm.m) from the south-eastern Meteora conglomerate pillars, possibly interpreted as discontinuities filled with water feeding the spring.

The observed discontinuities in the area have been created after several episodes of the paleogeographic Meso-Hellenic molassic basin evolution, during Upper Eocene-Lower Miocene and their hydrogeological significance is that they usually allow the water flow. The general trending orientation of these almost vertical and open discontinuities is between N040E and N080E. The underlying marls of Eptachorion unit restrict the water flow within the discontinuities of the overlying conglomerates because of their impermeable character.

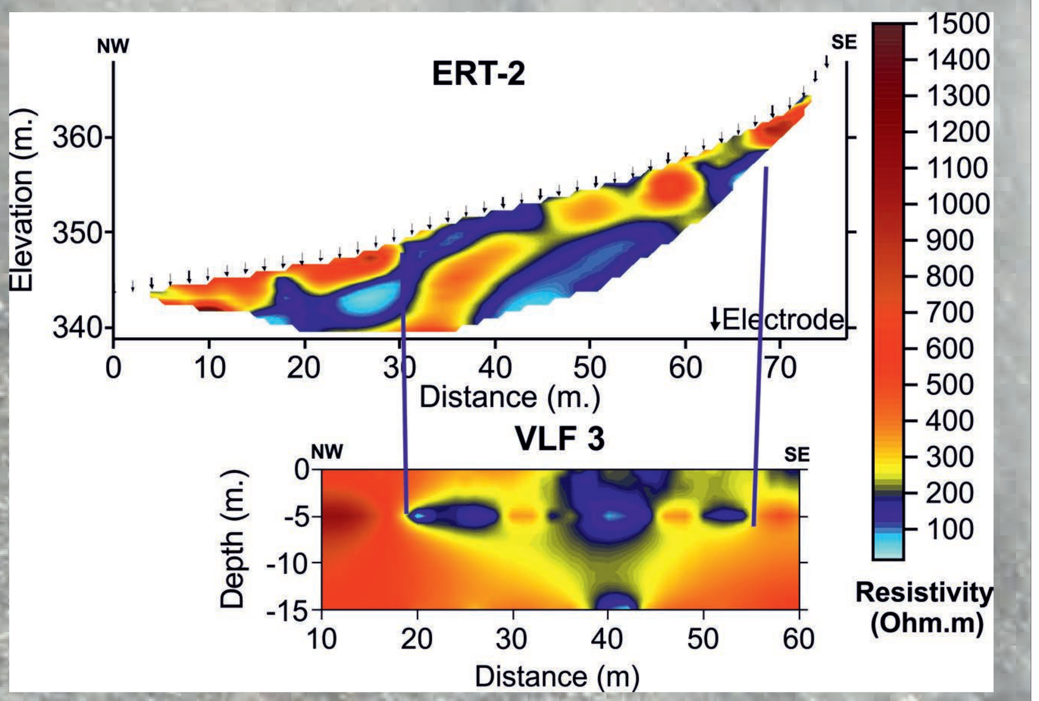


VLF processing results. The Karous-Hjelt pseudo-sections of profiles VLF 1, VLF 3 and VLF 6 are illustrated. The respective resistivity section derived from inversion with Inv2DVLF software is also included (Initial resistivity 500 Ohm.m with 20 iterations. RMSVLF 1 =1.16%, RMSVLF 3=1.82%, RMSVLF 6=0.95%). Frequency: 23.4 Khz.

In VLF 1 pseudo-section, a main conductive zone is located between 30-75m, after the starting point, probably due to the spring (located at 65m) and a smaller one at 125-140m. VLF 3 pseudo-section indicates a conductive zone at 25-55m, while VLF 6 pseudo-section indicates a main conductive zone between 40-70m and a smaller one at 15-30m.

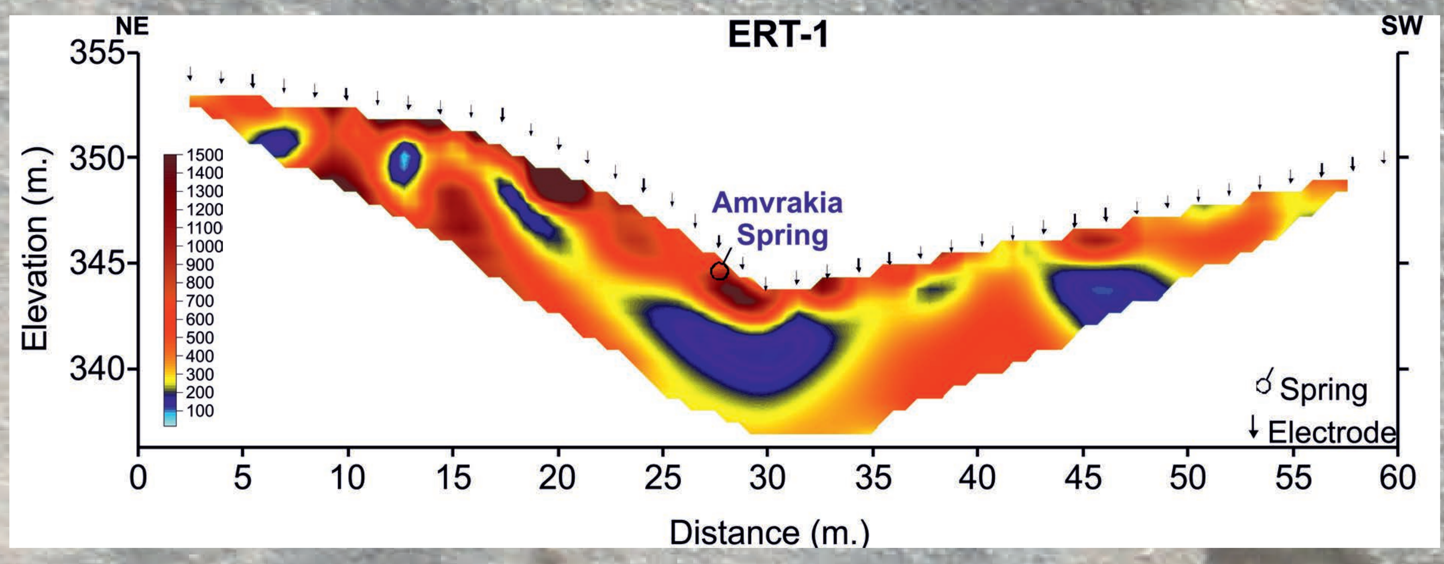


Topographic sketch map with the ERT and the VLF geophysical sections.



Comparison of resistivity sections originated from the inversion of the ERT-2 data (up) and from the VLF-3 data inversion with Inv2DVLF (down).The ERT technique had been performed in order to validate the conductive zones, detected from VLF measurements in high detail. With this procedure, we investigated the lateral and vertical resistivity distribution.

The above figure also illustrates the resistivity section originated from the inversion of the ERT-2 data, compared with the resistivity section originated from the VLF-3 data inversion with Inv2DVLF. The ERT section, obviously illustrates the conductive zones in more detail than the VLF measurements.



Electrical Resistivity Tomographies, including topographic relief (ERT-1: 10th iteration, RMS: 2.38%, ERT-2: 11th iteration, RMS: 2.74%).

The ERT measurements were processed with the RES2DINV software of GeoTomo. Except for the raw resistivity data, topographic measurements of each section were provided into the software due to the relatively intense relief of the study area. The inverse 2D model resistivity sections, derived from this interpretation are illustrated in the above Figure.

In ERT-1, a conductive (<200 Ohm.m) curvy area has been revealed in the center of the section (15-35m), underneath the spring (overflow mechanism). Another conductive zone (smaller) seems to have been investigated at the distance of 45m. In ERT-2, two parallel conductive zones (<200 Ohm.m) have been investigated, with a clear tilt to NW, towards the spring. These could be interpreted as water-bearing discontinuities of the conglomerates.

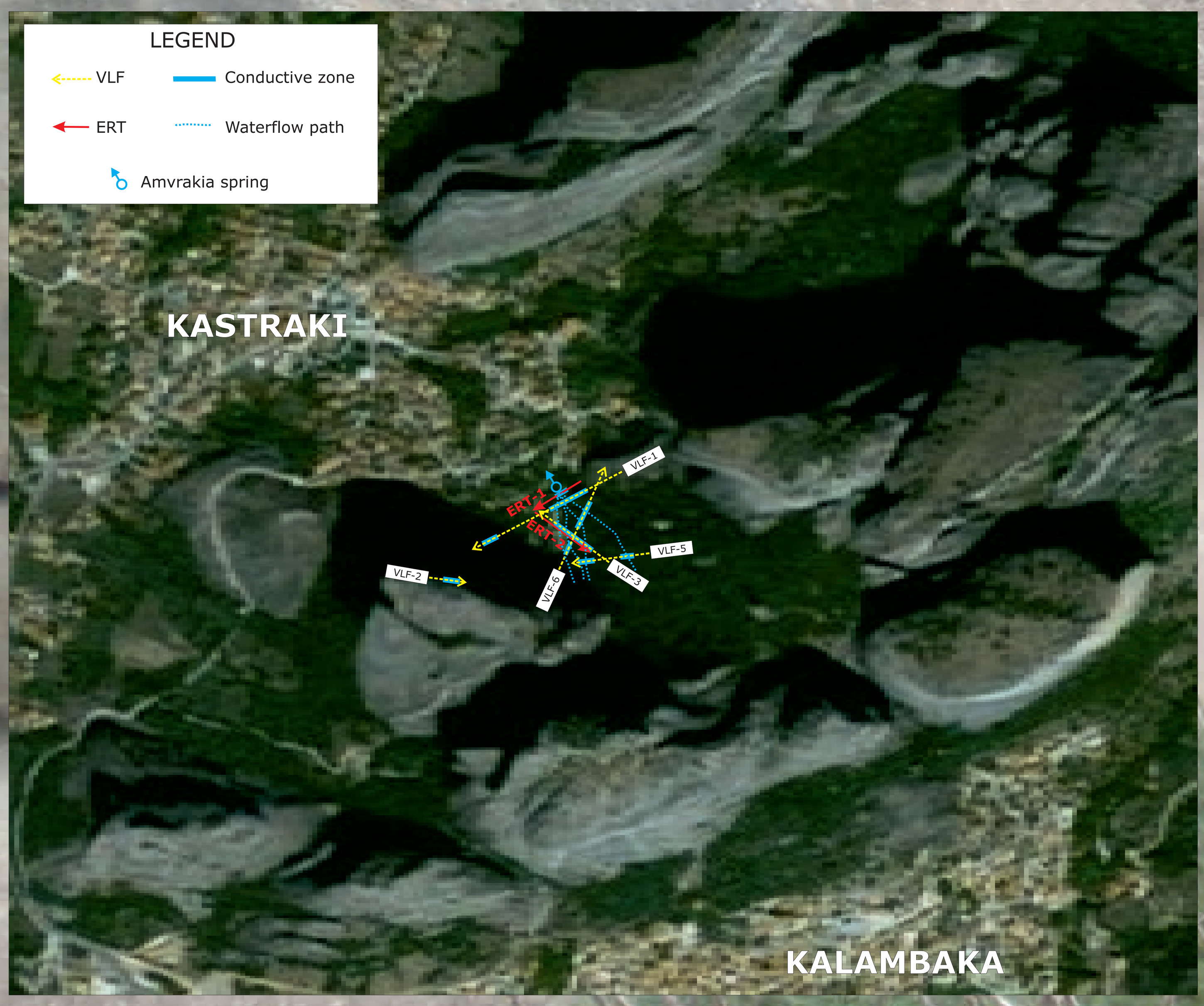
Several difficulties had to be overcome for applying geophysical techniques. The dense vegetation, the increased arduous accessibility and the relatively intense relief were the most significant problems that needed to be solved at the fieldwork. In spite all that, VLF measurements are proved to be ideal for detecting possible vertical to sub-vertical conductive zones or karstic structures for hydrogeological investigations.

Based on that and taking into account the tectonic analysis and orientation of the exposed fractures, five (5) profiles were conducted with several directions around the spring's area, in order to detect the conductive zones in the conglomerates surrounding the study area. The spacing of the measurement stations was 2 meters, as a more detailed investigation needed to be carried out.

A main VLF source frequency of 23.4 KHz was used, due to the good signal and alignment, towards the direction of the expected anomalies (westwards inclination).

The ERT technique had been performed in order to validate the conductive zones, detected from VLF measurements in high detail. With this procedure, we investigated the lateral and vertical resistivity distribution.

In the study area, two (2) ERT sections with crossed directions were carried out, with a total length of 140m, under very difficult circumstances due to dense vegetation. These were both parallel to previously performed VLF sections (VLF 1 and VLF 3), in order to combine results of both geophysical methods. A 41-electrode system providing Wenner array (190 measurement points of apparent resistivity) with electrode spacing up to 2m was applied, along with topographic leveling measurements.



Both the geophysical techniques applied in the study area, indicated conductive zones, which was the target of this study. In the two places where we had ERT and VLF sections together, we can also see that the detection of the conductive zones is identical, confirming the results.

Considering the geology of the area and that the massive conglomerates of the area are resistant (>500 Ohm.m) formations, we were able to identify these conductive zones as the most probable water-bearing discontinuities, trending towards the Amvrakia spring. ERT-2 indicates a tilt of these underground pathways to NW (better shown on ERT section), where the spring is located, while the section of ERT-1 indicates a local concavity, which is in agreement with the mechanism of an overflow spring.

In the satellite image above, all the conductive zones are illustrated along with the delineated water pathways leading towards the spring, corresponding to the discontinuities of the south-eastern Meteora conglomerate pillars arising impressively above the survey area. We have to point out that the spring's water should not be potable, since these adumbrated water pathways run nearby the small cemetery of the neighboring abandoned Agios Nikolaos church.

The seasonal water flow of Amvrakia spring. One year after the geological-geophysical report, the local authorities decided to perform a regeneration of the place (inset figure).

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