Coupling GeoEnvironmental Research & Education: Examples from the Technological Educational Institute of Crete

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Abstract: - This work presents a coupling between research and education using as a teaching tool the undergraduate research projects which are being carried out at the Laboratory of Geophysics and Seismology of the Department of Natural Resources and Environment, Technological Educational Institute of Crete, Greece. Laboratory of Geophysics and Seismology covers a wide area of expertise and being fully equipped provides high level of knowledge to undergraduate students, making them capable of measuring, analyzing and processing geophysical data, getting them ready for applying to many seismological, geophysical, geological and geotechnical job opportunities. Moreover, the Laboratory of Geophysics and Seismology offer to the student the tools to support civil protection services. Furthermore, the students gain research experience since the scientific results of some of the undergraduate research projects are accepted for publication in journals and are presented in scientific conferences.

Key-Words: -Education, undergraduate research projects, geophysics, seismology.

1. Introduction

Nowadays, the need for scientists with high level of knowledge and experience is more than ever a necessity for both seismological (in the frame of natural hazard management) and geophysical, geological and geotechnical companies. The Laboratory of Geophysics and Seismology of the Technological Educational Institute of Crete in Greece, work in order to keep up-to-date with the need of such personnel, provides, under the research projects of undergraduate students, the opportunity to learn, gain experience in both theoretical and practical considerations of seismology, geophysics, and even more. Covers a wide area of interests, starting from geophysical prospecting with almost all modern methods applied, seismic analysis, geological, hydrogeophysical considerations, drilling techniques, up to environmental studies. Furthermore, the students are getting familiar with modern methods of analysis of geo-risk and hazards and thus they are able to apply them in future jobs in civil protection agencies. Students of the Institute experience fieldwork with all instrumentations and analysis and processing of data back at the lab, making them capable of handling by their own almost all of the projects an individual company may have.

2. Teaching Seismology to Environmental Scientists

One of the distinctive features at the Laboratory of Geophysics and Seismology is training students in understanding current topics of Earthquake Seismology, such as inverse methods for tomographic images of whole earth structure, seismic hazards analyses, earthquake locations, focal mechanisms, magnitude and the use of high frequency and broadband seismic data recorded on modern digital networks. The course consists of equal parts of lectures and lab and focuses on the applied aspects of seismology. Special analyses emphasize the seismotectonic regime and seismic hazard assessment of the island of Crete and the surrounding areas.

2.1 Seismological Network

Laboratory exercises focus on the interpretation and analyses of digital earthquake data using digital seismograms, analyses of local earthquake data on a workstation, plotting and interpretation of earthquake record sections. Emphasis is made on earthquake hazard analyses, strong ground motion, attenuation, and time series analyses for engineering applications. Students learn how to use the Seismic Network Data

Processor (SNDP), a computer program which provides real-time data collection, processing, and interactive analysis of seismological data registered by spatially-distributed networks of sensors.

They also become familiar with instrumentation, since the Laboratory is equipped with state of the art instrumentation (Reftek-130 DAS and Guralp and Sercel seismometers).

Near and far field representations of earthquake sources, or in other words the use of earthquakes in determining Earth structure provide to our students the necessary knowledge towards civil protection and damage mitigation in case of strong earthquakes (fig. 1, 2) [29, 30, 33, 34, 35].

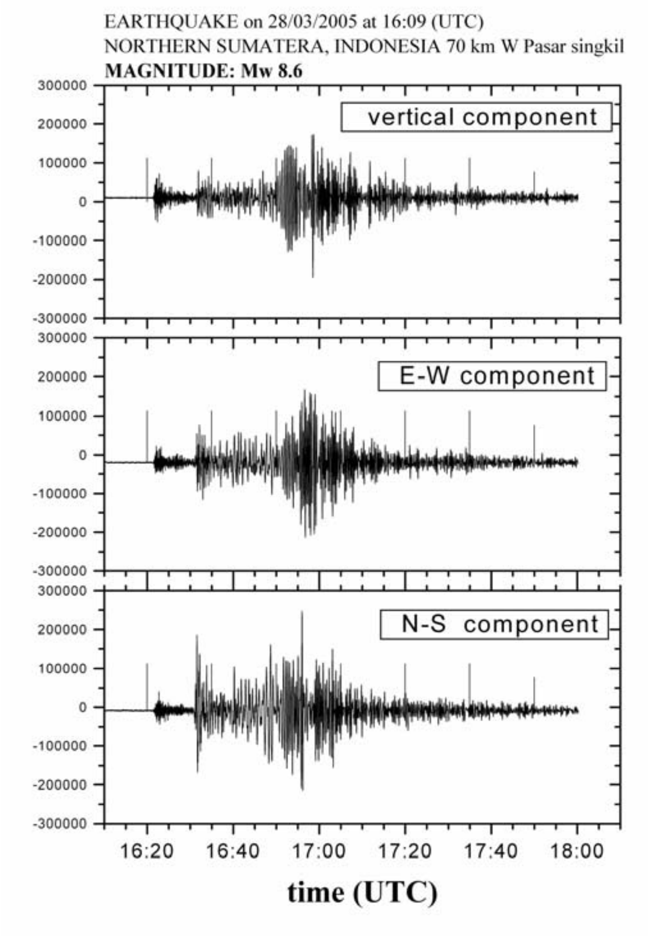


Figure 1. Sumatra Earthquake recording from the broadband seismometer located in the Technological Institute of Crete, Chania

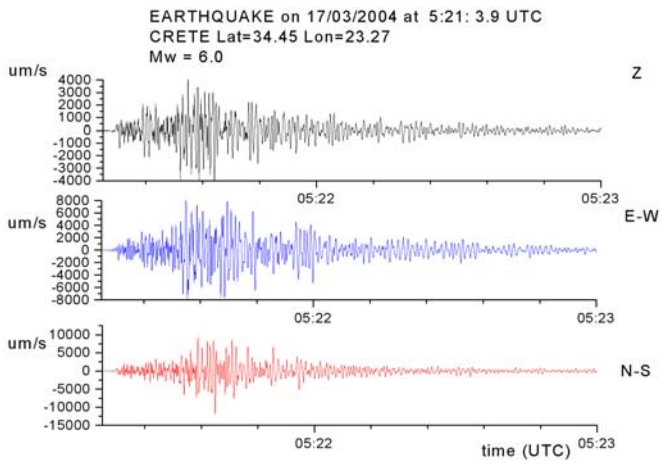


Figure 2. Earthquake recording from the SP seismometer located in Palaiochora (SW Crete)

2.2 Seismological Modeling

In order to model real seismic wave propagation in the Earth, an algorithm that simulates seismic waves was used for the production of synthetic seismograms in complex media. The purpose was to combine synthetic seismograms with real recordings in amplitude and phase (fig. 3).

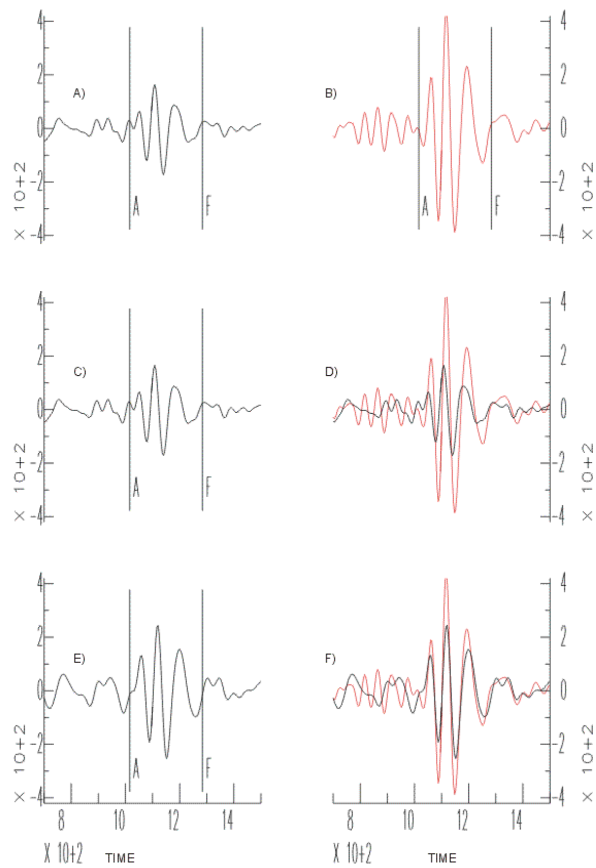


Figure 3: Simulation of seismograms using modern algorithms.

2.3 Engineering Seismology

Measurements of ambient noise are part of microzonation studies, in order to determine the resonance frequency of the subsurface. Such measurements were carried out in the urban area of the city of Chania as an undergraduate research project, indicating zones of different sediments and rock. From the results we obtained useful information that could be concluded in a wider study about seismic hazard in the urban area (fig. 4) [4, 5, 13, 14, 37].

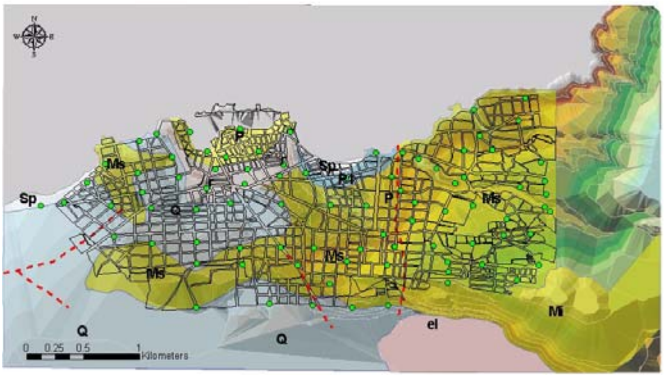


Figure 4. Map of the city of Chania. With green dots are the measurement points, colours indicate different geological formations.

3. Teaching Geophysics to Environmental Scientists

Laboratory of Geophysics and Seismology is fully equipped with modern instruments for electric and seismic tomography, magnetic and electromagnetic prospecting, and ambient noise recordings, constituting it as one of the best equipped Laboratory of Geophysics and Seismology in Greece. Students so far under their research projects have worked on applications in the construction of wind parks, artificial lakes and dams, environmental studies in landfills, water resources, waste management geotechnical applications, microzonation studies and more. Some of these research projects are accepted for publication in conferences and journals.

3.1 Engineering Geophysics

Case 1: Geophysics in Wind parks

Due to the construction of wind generators in a wind park, several electric tomographies were conducted, in order to define any karsts at the study area. The results indicated several targets right under the construction area, which are denoted in figure 1 as the deep purple areas with high resistivity (fig. 5) [16, 32].

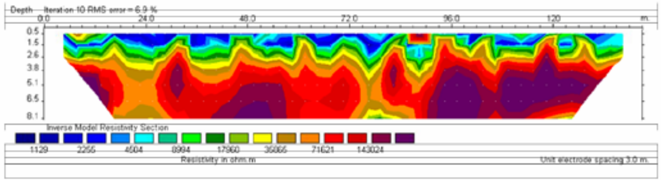


Figure 5. Results from electric tomography, indicating with deep purple color areas with very high resistivity, possible karsts.

Case 2: Geophysics for Bridge construction

Seismic tomographies at boreholes were conducted for the determination of velocity models of subsurface layers before the construction of a bridge in Nestos river. The results show the velocity profiles of the subsurface layers in comparison with geotechnical boreholes (fig. 6) [24].

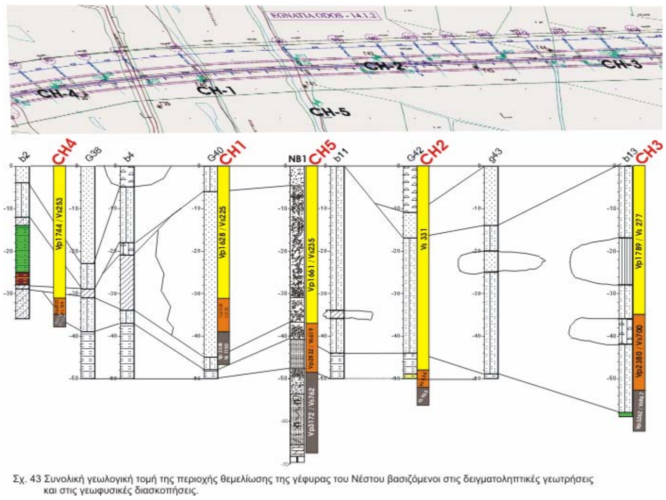


Figure 6. Results from seismic tomography measurements indicating the velocity profiles of the study area.

Case 3: Shallow Engineering Geophysics

Due to a building foundation, inside the city of Chania electric tomographies and electromagnetic survey was conducted, in order to define the subsurface material properties. The results indicated an old well which was revealed after the excavation. In the same area, three drills for geotechnical evaluation were made, but failed to reveal the complexity of the subsurface (fig. 7) [23].

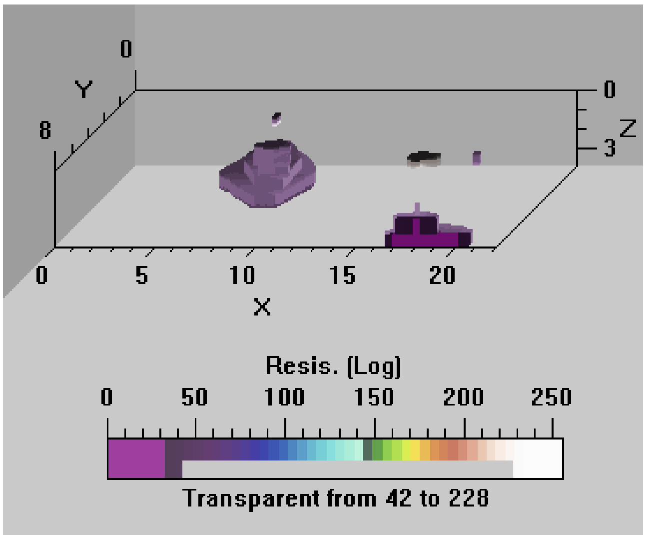


Figure 7. Results of pseudo-3D inversion of electric tomography data, indicating the old shaft.

3.2 Environmental Geophysics

In an already working waste deposit, several electric tomographies were made, in order to define if there are any karts under the area of deposition, possible leaks due to faults, and the determination of palaeo-relief (fig. 8). From the results, which were concluded in a wider environmental study, containing geologic, hydrogeologic and seismotectonic information about the wider study area, we were able to reveal faulting in the area, which was omitted during the construction of the waste deposit [22, 25, 26, 28].

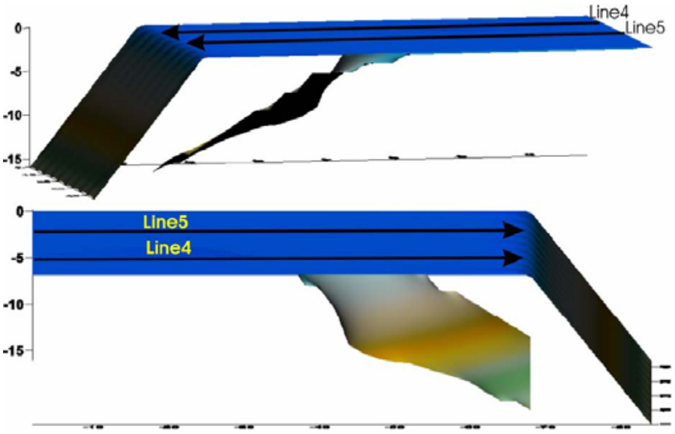


Figure 8. Reconstruction of the palaeo-relief using the results of the electric tomographies.

3.3 HydroGeophysics

Case 1: Geophysical methods for water resources detection

Electric soundings were conducted in order to delineate the water table. Measurements were made from the students, and moreover older results from similar studies at the same area were reprocessed. From the results we were able to determine the depth of the sub base, and investigate the depth of the water table. Results were presented to local authorities indicating the hydrogeological information about the study area, helping them to make drilling with accuracy (fig. 9).

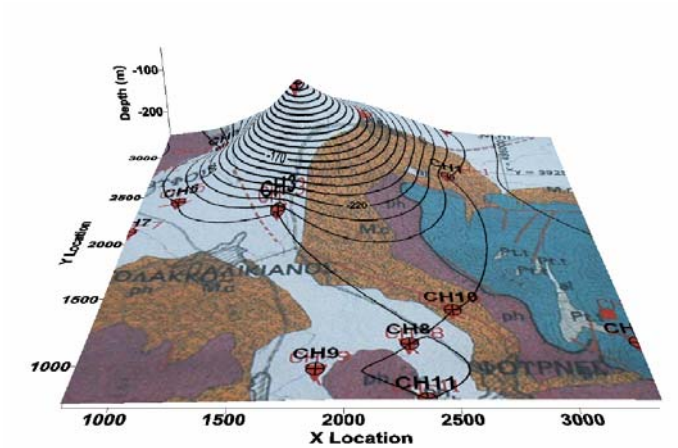


Figure 9. Final results from geophysical investigation in order to determine the water table. Ισοδυναμικές indicate the depth of the water table.

Case 2: Study for the construction of an artificial lake

A hydrological study has been conducted from our students, for the construction and domestic use of an artificial lake, which was proved extremely useful to local authorities to understand the importance of the construction. The research project included geological, seismotectonic, hydrological, meteorological, and environmental parts, making it a complete study presented to various public agencies and private companies (fig. 10).

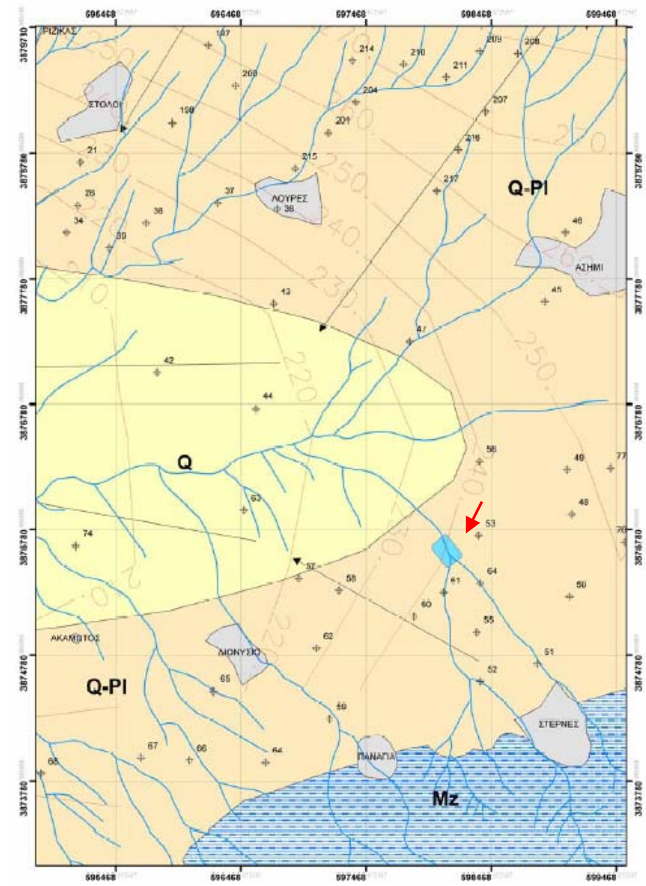


Figure 10. Geological map of the study area containing the existing drainage network. With the red arrow we show the proposed construction area.

3.4 Automatic Monitoring Systems

In association with the Department of Electronics, a leak detection system was designed and constructed, in order to simulate the subsurface of a waste deposit, and to monitor any possible leaks from the waste deposit towards the natural environment. In order to know how, the support of an individual company was provided, proving that science and efficiency can be obtained (fig. 11) [6, 9, 10, 11, 15, 27].

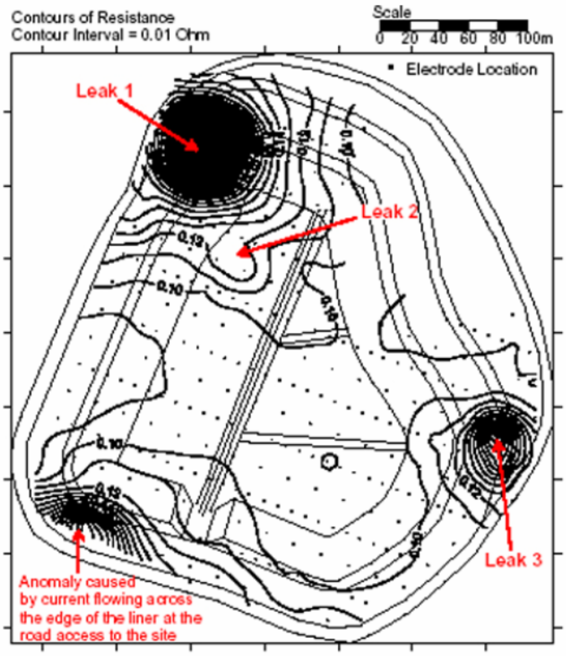
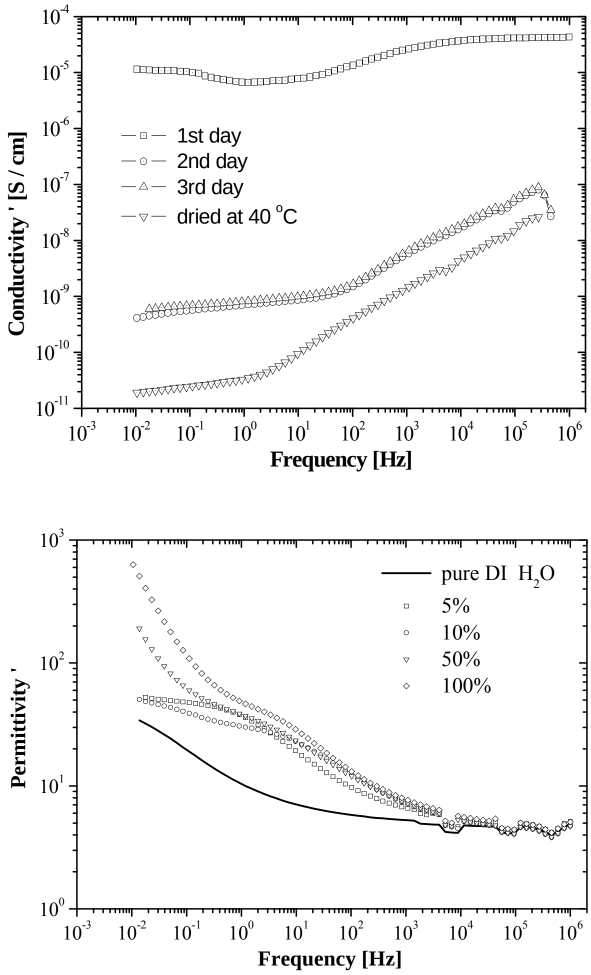


Figure 11. Application of the electrode grid method as a leak detection system on an active small scale landfill.

3.5 Study of Geomaterials for GeoEnvironmental Purposes

Dielectric and conductivity measurements are carried out to a close collaboration with the Department of Electronics of the Technological Education Institute of Athens, over a wide frequency range (a few μHz to MHz) in low and high porosity geomaterials (marbles, sandstones, etc), contaminated with different kinds of organic or inorganic pollutants (for example, leachates form a landfill). The objective of the experiments is to investigate a possible application of dielectric spectroscopy to the detection and quantification of subsurface contamination. Analysis of dielectric and conductivity spectra can provide information in molecular dynamics (relaxation mechanisms) of the materials under test, which may be related to different concentrations of contaminations in solid – fluid systems (fig. 12) [2, 20, 21, 31, 36].



a

b

Figure 12. (a) Conductivity spectra of 100% leachates-impregnated sandstone sample, during drying and (b) dielectric permittivity (real part) spectra of dried sandstone samples at different leachates' concentrations.

3.6 Remote Sensing and GIS

Being in a close cooperation with the new-established Geoinformation Laboratory of the Department of Natural Resources & Environment, we provide undergraduate research projects with primary aim the integration of Geographic Information Systems and Remote Sensing with hydrological, hydro-geological, meteorological and elevation data in order to create several thematic maps of the Western Crete as well as to estimate the water budget since it is an essential and crucial task for the formulation of sustainable water management scenarios of the study area [1, 3, 7, 8, 12, 17, 18, 19].

In a further approach we will proceed to the integration of the geological and tectonic structures, bedrock topography, drift thickness, lithology and slope of drainage basins in order to investigate the role of geomorphological and geological factors in the evolution of streams in the Chania prefecture area (fig. 13).

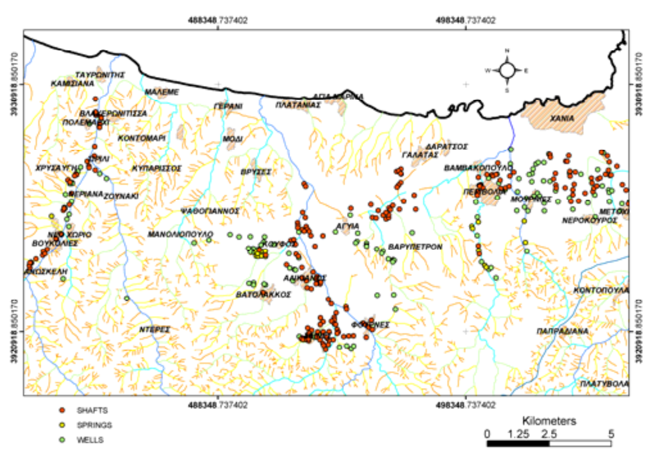


Figure 13. Detail of the ordering (according to Strahler's system) of the digitized drainage network originated from the 1:20000 hydrological maps of the study area.

4 Conclusions

Laboratory of Geophysics and Seismology provides undergraduate thesis in order to keep up-to-date students of the Educational Institute of Crete in Geophysics and Seismology. Students gain experience in geophysics and seismology, both practice and theory, in order to be able to apply to job opportunities relevant with environment, geology, seismology and geophysics.

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