Compilation of a Relational Digital Database for Monitoring and Management of Geo-Environmental Data in Crete Region

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Abstract: - This work provides a description of data and processes used to produce a database that delineates geo-environmental related features covering the geographical context of the island of Crete in South Aegean. Since 1996, the Institute for Mediterranean Studies (IMS) of the Foundation for Research and Technology, Hellas (F.O.R.T.H.) and more recently the Department of Natural Resources & Environment (DNRE) of the Technological Educational Institute of Crete (Chania Section), have been collecting a wide range of geo-environmental data including geological, hydro-geological, hydrological, geophysical, meteorological and energy data. The data originated from maps, technical reports, research projects, bibliographic references, catalogues, and other conventional formats and have been entered into different relational databases which support a link with the geographic context of Crete, in terms of topographic, land-use and geological maps. The data cover information from different earth sciences and in their easy retrieval trough a Web portal could promote the identification and evaluation of natural resource potential, development and management, and address possible environmental concerns, such as natural hazards.

Key-Words: - Relational database, MySQL, geo-environmental data, geo-informatics, natural hazards.

1. Introduction

Due to its unique geomorphological and tectonic environmental settings, the island of Crete has been the focus of a number of studies and fieldwork projects dealing with the geo-environmental characteristics of the island. In order to create the necessary information platform upon which one could proceed in a systematic way towards the monitoring of the natural and environmental resources of the island, it was considered essential to collect all the available data and try to compile different databanks for the easier retrieval of them. This kind of information could be further refined and used for other types of analyses such as the development of risk models for the natural and environmental resources of the island. This is exactly the ultimate goal of the CRINNO-EMERIC project, funded by the Perfecture of Crete and the European Union, namely the development of a multidimensional expert system which could combine a number of digital geographically based information layers of the island of Crete, linked to other statistical and environmental databases to be used for monitoring the landscape changes and the environmental parameters.

For this reason, a consortium of several institutions, specialized in different disciplines, collaborated for collecting both published and unpublished geo-environmental data, going back as far as to the beginning of the 20th century. The data have been retrieved from different private companies and public agencies which have been active in the field of geological and environmental studies in Crete [5]. MySQL database server was the basic tool used for the construction of the databases which managed to convert historical data into a dynamic relational information databank [1,2,3,4].

The basic characteristics of the database were specified by the main requirements of the CRINNO-EMERIC project, namely the construction of a portal offering open access to a broad range of geo-

information (geological, tectonic, hydro-geological, seismic, environmental, geophysical, climatic, meteorological, etc). Except the open access to the information, the project aims to build the infrastructure for the better analysis and modeling of other geo-environmental and statistical parameters and proceed with pilot approaches and models such as those of seismic risk, erosion risk and forest fire risk. Thus, the data of the geo-environmental databank needed to include a geo-spatial component in order to become an integral part of the modeling process to follow, in conjunction to other data sources such as satellite images, digitized topographic and geological maps, etc.

The ultimate purpose of the database is to provide digital data that will contribute in identifying and evaluating resource potential, resource development and management, production, and possible environmental concerns, such as physical hazards. These data will be useful to federal, state, and local government agencies, public organizations, private industry and individual citizens in different decision-making processes dealing with the management and monitoring of the natural and environmental resources of Crete. The historical component of the database is important in showing time changes and patterns of specific phenomena and parameters and can be also used for drawing certain conclusions about the future evolution in the short time scale.

At the moment, the total number of records in the database is 2120 records, out of which 39 concern energy data, 76 are related to geophysical projects and 478 concern hydrological data. In addition to the above, 1527 technical reports on engineering geology, hydrogeology and seismology have been converted to a digital format and a short summary of them is accessible to the final users. A much larger number of entries have been registered for the meteorological and climatic data (Fig. 1). As soon as new information is becoming available, it is incorporated into the database and it is available to the users. The ultimate expectation of this effort is to introduce a digital observatory of the research work conducted in the field of geo-sciences in the area of Crete.

2. Database characteristics

The structure of the database was based on MySQL database server, mainly due to its flexibility, friendly environment of organization of the data sources, and the flexibility in upgrading the final product. MySQL database server is the world's most popular open source database. Over six million installations use MySQL to power high-volume Web sites and other critical business systems. The open source philosophy provides the database with a continuous and rapid optimisation and development with the privilege of the zero-cost. Moreover, MySQL is well-known for its operational speed and its enhanced reliability.

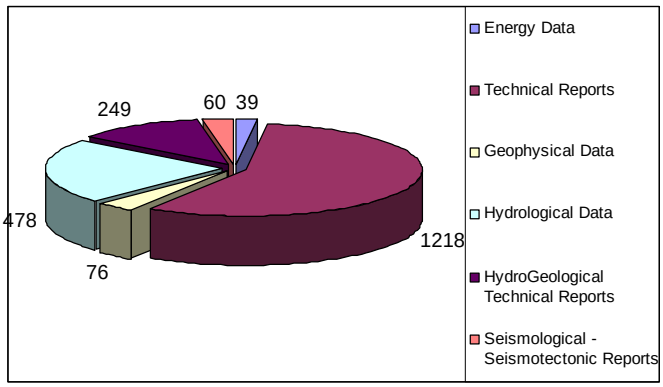

Figure 1. A pie chart showing the contribution of several geo-environmental data for the creation of the relational database.

The relational database model of MySQL offers improved capabilities in the design of complex relational data. The transfer of the data into and out of the database is fast, secure and reliable even if the number of the records saved in the database is extremely large. Furthermore, there is no limit in the size of the data that can be saved into the database (the limit comes from the capacity of the hard disk) and back-ups of all the data can be created with extremely low capacity cost and within logical frequency rates.

3. Interface characteristics

A complete database system includes also the interface with which the user can communicate with the database in order to insert, update and delete data. For this issue interface applications were generated for each individual section of the database. These applications are compatible with all the types of Windows Operational System (95, 98, 2000, XP, etc) with small capacity requirements (less than 30 MB) and low CPU and RAM usage. These applications can be installed locally to any computer, providing a communication connection with the central database at the main server which gives access to any number of remote computers. In each remote host computer, an ODBC driver is also installed and binds the central server database with the application through internet or intranet connection. This driver is based on the TCP-IP communication protocol with the potential of the SSL encrypted protocol for secure transfer of the data via the net

(internet or intranet). The user can retrieve the data and modify them appropriately and in some cases analyze them through a graphical environment (graphical charts) – spatial and temporal changes of the data. Security of these interfaces is guaranteed through the access and installation of the specific application interface, which is further protected through appropriate usernames and passwords. The content of the final databases will be ultimately open to any interested party and can be easily accessible through the internet, among with other map information.

4. Database structure

There are seven main components that comprise the geo-environmental database: Technical reports, Geophysical data, Hydrogeological data, Hydrogeological references, Seismological-Seismotectonic data, Hydrometeorological data and Energy data with approximately 70 supporting tables. Each of these tables is linked to each other, where appropriate, and all of the supporting tables are linked to one or more of these seven main components. Other kind of data such as geological or land-use data have been displayed through a graphical environment of geographical information systems (GIS), disseminated through a WEB_GIS engine (ArcIMS) which can support both Java and html interface environments. Finally, more specialized data, such as vegetation, population, forest fires, and others have been also displayed through a similar combination of databases and geographical interfaces. The following sections demonstrate the main field included in the main geo-environmental components of the CRINNO-EMERIC database.

4.1 Technical reports

More than 1200 records have been already registered in the database, consisting of scientific and technical reports, publications, books and proceedings concerning geo-environmetal data of the region of Crete. These data have been either retrieved or provided by different public and private organizations and agencies such as the Development Organization of Western Crete, the Technical Chamber of Greece – Branch of East & West Crete, the Institute of Geological and Mineral Resources, Water Resources Management Organization of Crete, the Agency for the Management of Environmental and Land-Use Planning of Crete Region, the United Association of Waste Management of Crete and private technical and geotechnical companies.

The technical report database provides information on the technical projects (studies and/or fieldwork campaigns), which were carried out in the area of Crete. Registered records include the provider of the data, title of the project, the municipality and city or village where the project was realized, the year of execution, type of report, name contractor, publisher, a short description of the report and an extended description of the project in PDF format (Fig. 2). A quick search machine is also available, based on multiple field entries.

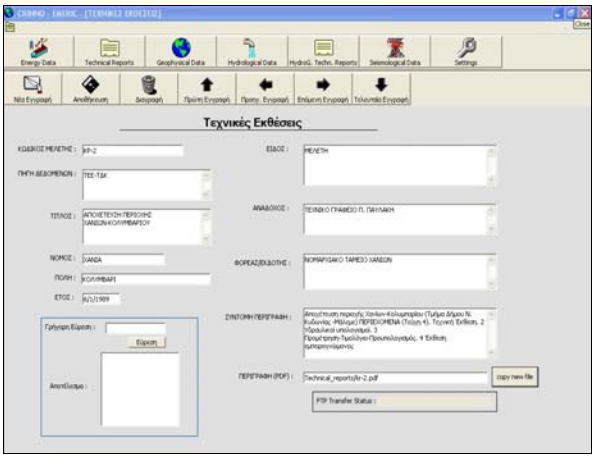

Figure 2. Layout of the information retrieval concerning the technical reports related to geo-environmental studies and fieldwork in the wider area of Crete.

4.2 Energy data

Electrical power information, provided by the Energy Centre of Crete Region, has been also included in the database. Data refer to the energy and load data of Crete since 1964 and include information about the net energy production, the load peak and the load coefficient in percentage for each year. The increment per year in a percentage basis for energy and load data is also provided (Fig. 3).

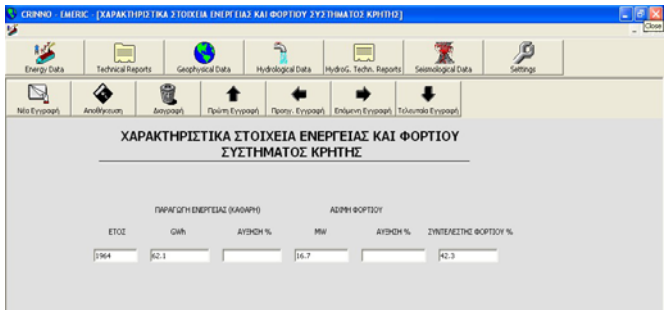

Figure 3. Table used for the presentation of all the available energy data of Crete Region.

4.3 Hydro-meteorological data

The use of hydro-meteorological data concerning climatic information originating from ground meteorological stations is of main importance in any kind of environmental study that needs to be conducted in terms of large scale construction works or other technical study. For this reason, the meteorological data collected from sixty-five meteorological stations of the National Meteorological Service and the Department of Hydrology of the Ministry of Agriculture have been also included in the database. These data concern the monthly average values of rainfall, evaporation, sunlight and maximum and maximum average temperature measurements for the time period of 1950 to 2002. The database has also included information related to the location of the meteorological stations (latitude, longitude, elevation) which were transformed to the local projection system of Greece (EGSA'87) and will be used for the mapping of the climatic data and their presentation in a WEB_GIS environment (Fig. 4.).

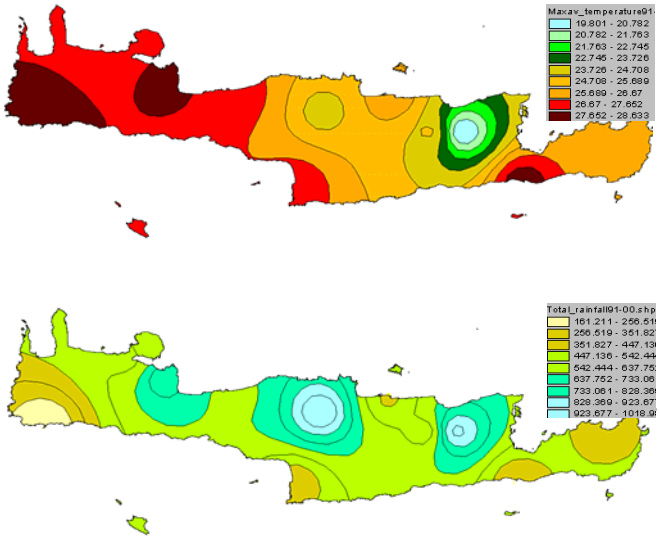

Figure 4. Geographical Information Systems were used to plot the meteorological stations, interpolate the average values of the meteorological measurements for a period of years and produce a time series of the change of the climatic parameters. Maximum Average Temperature (1991-2000) (above) and Total Rainfall (1991-2000) (below).

Since a number of meteorological stations from both the National Meteorological Service and the Department of Hydrology of the Ministry of Agriculture are located in similar location but they have different recording systems, both datasets are displayed for comparison reasons (Fig. 5).

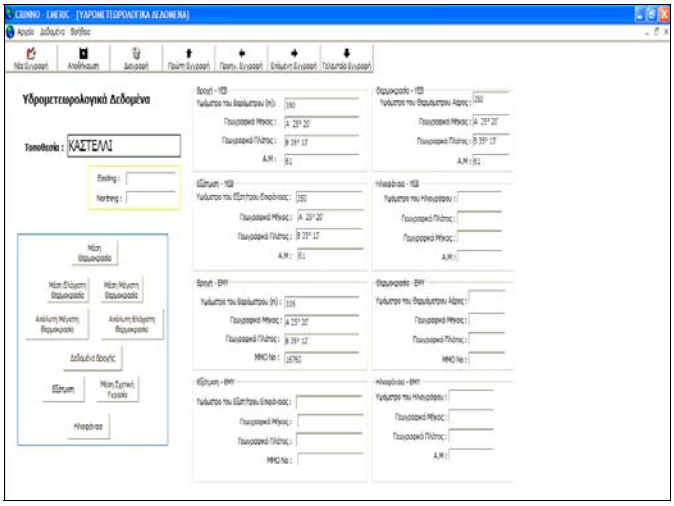

Figure 5. The application form used for the insertion, updating and deleting of the Hydro-meteorological data.

Moreover, the final user of the system is able to produce graphical charts of the variation of the meteorological parameters in time (Fig. 6) for both data providers.

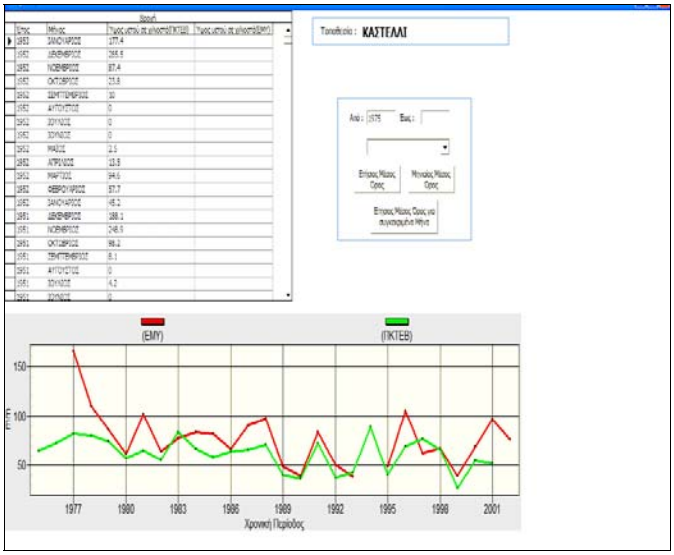

Figure 6. The graphical chart of the rainfall data for Kastelli region from 1975 until today, as it has been recorded by two different sources (red and green lines), namely the National Meteorological Service and the Department of Hydrology of the Ministry of Agriculture.

4.4 Hydrological - Hydrogeological data

The hydrological and hydro-geological database includes all the available information about wells, springs and shafts of the lowland of the broader area of Chania in Crete. These data were collected from

the Hydro-Geological study of Chania and provided from the Department of Hydrology of the Ministry of Agriculture. The database consists of eleven fields containing all the available information of each registered record, providing also access to the digital form of the above mentioned data (wells, springs and shafts) (Fig. 7).

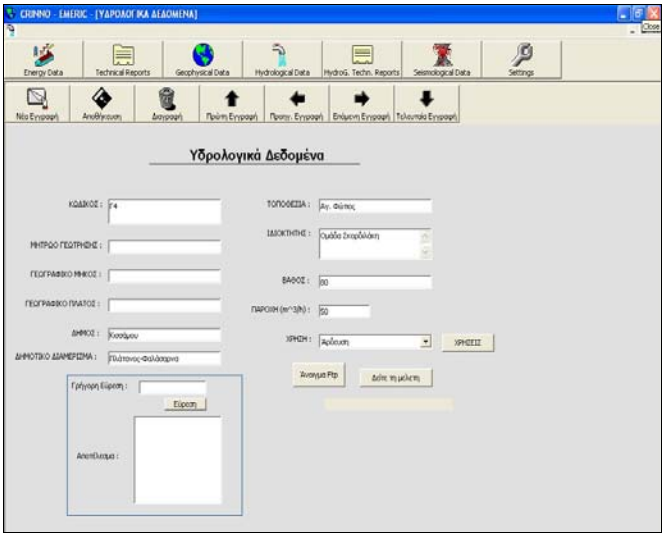

Figure 7. The application form used for the insertion, updating and deleting of the Hydrological and Hydrogeological data.

Information such as the geographical coordinates of the data (latitude, longitude, elevation), the municipality and city or village from where these data have been acquired, the maximum depth of the data (drilling depth, etc.), the water supply and the usage potential of it, are all provided through a digital retrieval of the already registered data, as well as in their original record form in a PDF format (Fig. 8).

The inventory bulletin of the supplied data contains important information such as the record code, the geographical coordinates of the data, the municipality and the close-by city or village, the maximum depth of the data (tubing depth, diameter of the tube, drilling depth, depth of the groundwater level, etc.), the water supply, the usage, the geological stratigraphic sketch of the data with a short lithological description and an in-situ time sequence of measurements related to the depth of ground water, temperature and chemical characteristics of the water (Cl^{-1} ions, EC-electrical conductivity) (Fig. 9).

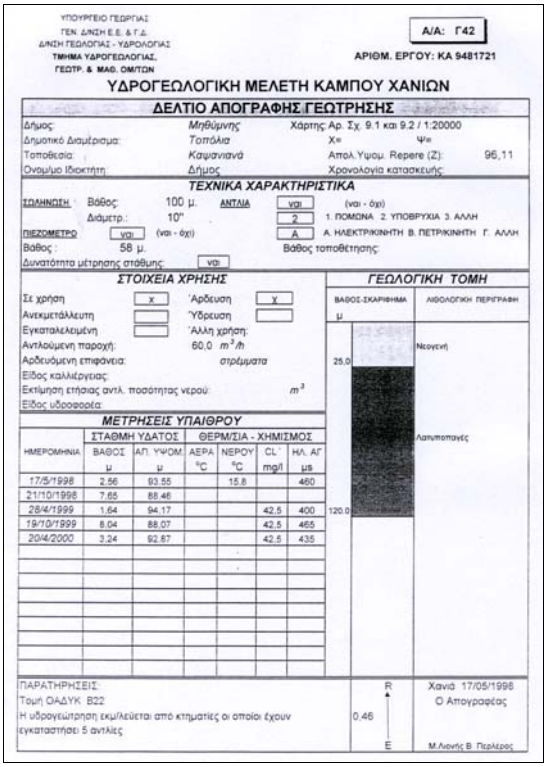

Figure 8. The registration form of the available Hydrological and Hydrogeological data. Card inventory of Hydrowells.

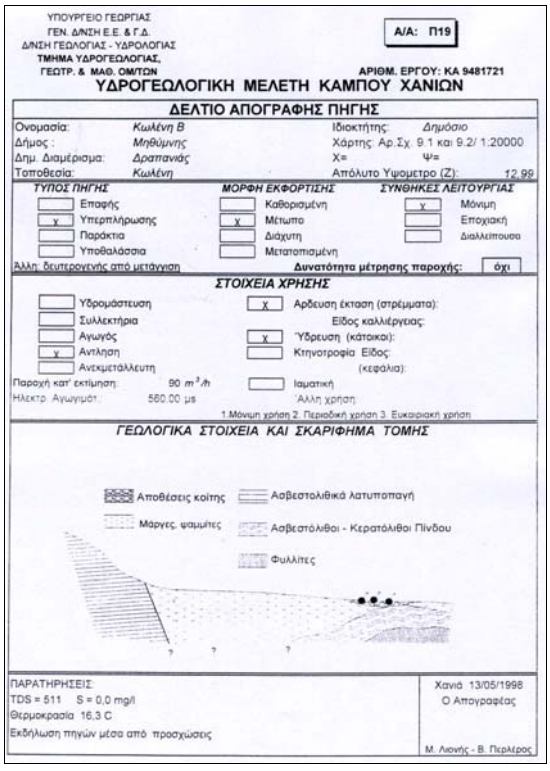

Figure 9. The registration form of the available Hydrological and Hydrogeological data. Card inventory of Springs.

4.5 Geophysical data

Until now, seventy-six geophysical studies have been entered in the database concerning the geophysical applications and fieldwork studies that deal with the wider region of Crete. Fieldwork covers a wide range of applications spanning from geophysical prospection of archaeological sites to geotechnical investigations. These studies were conducted mainly by the Technological Educational Institute of Crete, the Institute of Mediterranean Studies, the Technical University of Crete, the Institute of Geological and Mineral Resources, the Geology Department of the University of Thessaloniki, the University of Athens and other agencies.

The registered records contain a general description of the particular study and its results, the spatial focus of the research, the year of execution, the title of the project, the contractor and authors of the report, the publisher, the institution, the geophysical methods and techniques applied in the fieldwork activities and laboratory analyses, and other related information. A short description of the report and an extended description of the project in PDF format is also provided (Fig. 10).

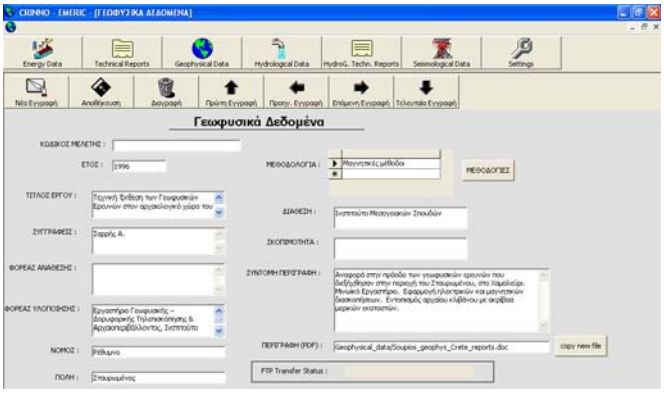

Figure 10. Retrieval form of the geophysical studies, which have been realized in the region of Crete.

4.6 Hydrogeological technical reports

Hydrology plays a critical factor in shaping the environmental policies of the island of Crete. For this reason a large number of large and smaller scale studies have been conducted concerning the hydrogeological properties of the island. Two hundred forty nine hydrological and hydrogeological technical reports have been already registered in the database. These reports are mainly provided by the Development Organization of Western Crete and the Institute of Geological and Mineral Resources and more are expected to be entered to the database concerning East Crete in the following months. The type of information that has been entered includes title of the project, scientific responsible of the project and the editing of the report, the institution/s which carried out the study, the area of study, the year of execution, the publisher of the report and a short description of the project (Fig. 11).

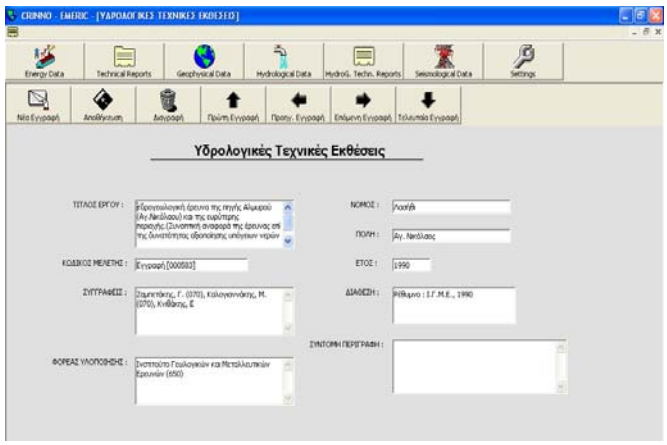

Figure 11. The database form used for the retrieval of information regarding the hydrological and hydrogeological data.

4.7 Seismological – Seismo-Tectonic data

Fifty-five seismological and seismo-tectonic studies have been already inserted in the database. Data comprise of scientific and technical reports and related publications which were provided by the Technological Educational Institute of Crete, the Technical University of Crete, the Development Organization of Western Crete, the Institute of Geological and Mineralogical Resources and other international references. Data include project code, the authors of the technical reports, the responsible institution, spatial focus of the study, the year of execution, the publisher of the report and a short description of the project (Fig. 12).

Other seismological data, mainly originating from measurements that have been conducted along the CRINNO-EMERIC project have been also entered and are retrieved through a WEB_GIS environment. Similar type of graphical display has been designed for the seismic data of the region, as they have been retrieved from the National Observatory of Athens Web site (http://www.gein.noa.gr/services/cat.html). These data concern the seismic activity in the region of Crete, including the location of their epicentre, depth and magnitude, since 1950.

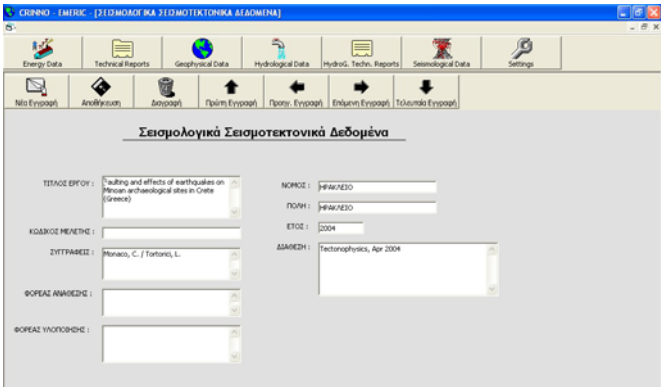

Figure 12. The database form used for the presentation of the seismological and seismotectonic data.

The geographic coordinates of their epicenter (latitude, longitude) were transformed into Easting and Northing of the Greek Geodetic Reference System 1987 (EGSA'87) and they were mapped in the layout of Crete (Fig. 13).

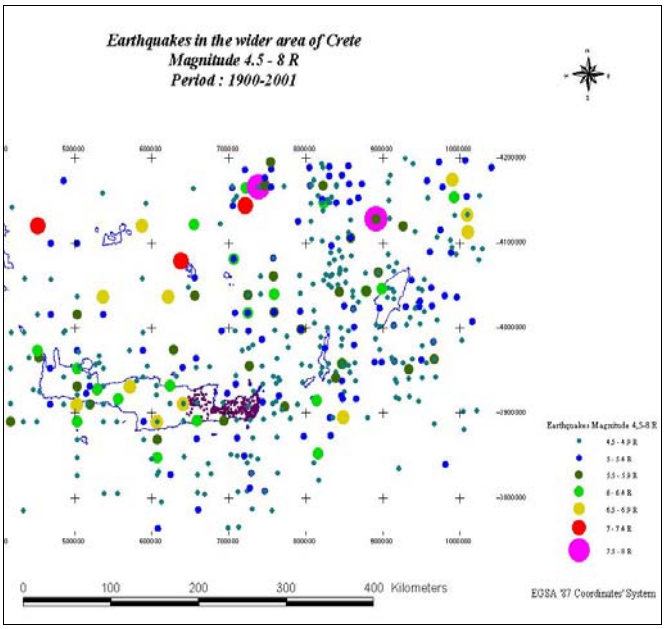

Figure 13. Mapping of the epicentres of the higher magnitude earthquakes (>4.5R) in the wider area of Crete.

These data will be processed in the future for computing the seismic frequency of the island and correlate them with the existing faults (Fig. 14). It has to be noted that only earthquakes with magnitude larger than 4.5 Richter scale were entered in the geographical database and they were classified in 8 main categories, based on their magnitude (4.5 - 4.9 R, 5 - 5.4 R, 5.5 - 5.9 R, 6 - 6.4 R, 6.5 - 6.9 R, 7 - 7.4 R, 7.5 - 7.9 R and >7.9 R).

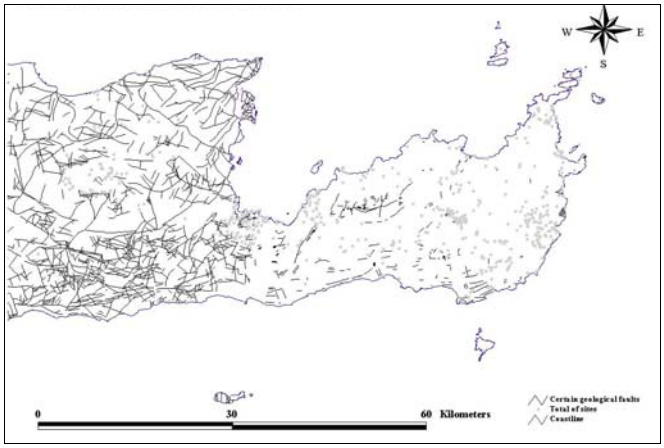

Figure 14. Details of the digitized faults in the area of Lasithi, originating from the geological maps of IGME. In the future, the geo-databases will try to link different datasets and cartographic material aiming to explore the degree of correlation among them.

5 Conclusions

For more than 2-3 decades, geo-sciences produced a number of high-valued and well-appreciated results, which contributed significantly in the decision making policy of the environmental strategy of the island of Crete. Taking in account the recent tendency of the society towards a sustainable community, it is understood that geo-sciences could continue to play a critical role in defining the natural and environmental parameters which influence different sectors of the society, spanning from large scale construction works to hazard assessment and protection of the natural resources. In most cases however, researchers and technical companies are facing a varying degree of difficulty to incorporate the results of previous research in their studies, mainly due to the fact of lack of information originating by the increasing number of agencies activated in the specific field.

One of the goals of the CRINNO-EMERIC project is to create an Observatory portal, which will be able to update the information regarding the geo-environmental data and studies and provide open access to the interested parties. The future directions of the project include among others the creation of similar databases regarding the forest fires, the active faults, the generalized geology of the region, etc. Most of them will be accessible in both a database and cartographic environment through the Web.

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