MACROSEISMIC OBSERVATIONS IN GREECE: DEVELOPMENT OF A DATABASE FOR EXTRACTION OF NEW KNOWLEDGE.

I. Kalogeras¹, M. Kourouzidis¹, Z. Schenkova², V. Schenk², and G. Stavrakakis¹
¹Geodynamic Institute, National Observatory of Athens, P.O.Box 20048, 11810 Athens, Greece, Tel: +30-2103490172, FAX: +30-2103490173, e-mail: i.kalog@gein.noa.gr
²Institute of Rock Structure and Mechanics, Czech Academy of Sciences, V. Holesovickách 41, 18209 Prague 8, Czech Republic, Tel: +420-266009337, FAX: +420-284680105, e-mail: zdschenk@irsm.cas.cz.

ABSTRACT
Geodynamic Institute updated the procedure of collecting and evaluating macroseismic observations within the frame of various research projects. The whole procedure is based on the development of a database running under MsAccess. The questionnaire was improved, including more detailed description of damage without affecting the grading according to the MM intensity scale. Three main tables are included in the database with one-to-many relationships: Table SITE involves administrative information on the municipalities and communities, as well as the coordinates, the dominant surface geology and the reference seismic hazard zone, table QUAKES includes the seismic parameters of strong earthquakes of Greece (Mₛ ≥ 5.5) occurred after 1900 and the description of the seismogenic fault and table EFFECT gives the macroseismic intensity observed at each site for each earthquake, the epicentral and hypocentral distances, the azimuth and the peak ground motions, if any. Other tables are incorporate including supplementary information: Tables INFO (photographs, descriptions and bibliography), FLINN (geographical area of sites and epicentres) and COUNTRY (launching a possibility to involve macroseismic observations from other countries).

By SQL programming different queries can be applied to combine the different parameters included and to attain various relationships, while a visualization manager maps the different database information and/or the results of different queries (maps of epicentres, sites, intensities, geology, earthquake hazard, peak ground motions etc). In the near future a subset of the database will be exposed in the web, for any user to be able for data mining and extraction of new knowledge.

INTRODUCTION
Geodynamic Institute collects and evaluates macroseismic observations for more than 100 years. The observations are published in the monthly bulletins and distributed to the scientific community, comprising the primary material for research studies in seismology and earthquake engineering.

Macroseismic data as multidimensional ones, they are needed to be stored and recovered by special techniques, which are more complex compared to those used for the traditional alphanumerical data. Under this point of view spatial entities referred to temporal periods or moments referred to layers of geographical information are under investigation within the frame of Database Management Systems. Furthermore data warehouse techniques are used to unify the different sources of seismological data (available through internet, for example). The data management systems incorporate different layers of thematic information to extract new knowledge through the data mining (Theodoridis, 2003). Macroseismic observations are convenient for these activities because they include source properties, propagation path characteristics, site properties, and moreover they allow information on historical events for which no instrumental records exist to be obtained.

In this study the development of a macroseismic database is described, aiming to two targets. Firstly, a semi-automatization of the observations collection and, secondly, a manipulation of information connected to the macroseismic intensities.
DEVELOPMENT OF MACROSEISMIC DATABASE

During the last years, within the frame of various research projects, Geodynamic Institute updated the whole procedure of macroseismic observations management, concerning the following items:

The questionnaire has been improved, including more detailed description of damage to help the observers to answer the questions. These changes did not affect the grading evaluation according to the intensity scale used till now (Modified Mercalli, MM). Each of the answers has its own code number, to introduce the answers to statistical analysis. The questionnaire is included in the Geodynamic Institute web site, for anybody to answer if and how he felt the earthquake and if and what damage he observed.

The questionnaire-mailing-procedure, as well as the management of the answers are based on the development of a database under MsAccess environment. The database includes three main tables with on-to-many relationships: Table SITE includes the administrative information of the municipalities and communities gathered after Greek law for local authorities (“Kapodistrias” law) and the recent inventory of the Hellenic Statistical Service, like the name of the municipality, the prefecture, the population, the mail and electronic address, phone numbers, as well as coordinates, the dominant surface geology (IGME maps, 1:50000) and the seismic zone according to the Greek Earthquake Resistant Code 2000 (2001). Each of this table’s records has its own unique code number. The spatial distribution of the sites to which the questionnaire has been sent after the strong earthquake can be checked for homogenized coverage of the area. Table QUAKES includes the seismic parameters of the earthquakes within the area 33°N - 42°N and 19°E - 29°E having a magnitude $M_s \geq 5.5$ occurred during the period 1900 – today. The table is updated continuously with every new strong earthquake. Each record of this table has its own code number, while a column is dedicated to a notification about the existence or not of macroseismic observations. Description of the seismogenic fault is also included. Table EFFECT includes the macroseismic intensity observed at each site for the different earthquakes. Other data included here are the epicentral and hypocentral distances and the azimuth (the angle between the direction of North and the site-epicentre direction counted in the clockwise sense). Each of the observations is characterized by the combination of the site code and the earthquake code. In case of strong motion record existence at the specific site the peak ground acceleration, velocity and displacement are included (Theodulidis et al., 2004).

Other tables are incorporated including supplementary information. Table INFO includes photographs of damage, descriptions of earthquakes (for example, newspaper clips) and bibliographic references. Table FLINN and table COUNTRY introduce the geographical description of sites and earthquakes according to Flinn et al. (1974) and the possibility of incorporation of macroseismic observations from other countries (earthquakes located in Greek territory but affected sites of neighbouring countries or earthquakes located at neighbouring countries with effects on Greek sites). Figure 1 shows the different entities included in the database and their relationships, while figure 2 shows an example of database screens.

By using SQL programming language the user can apply different queries to combine the different parameters included within the database and result to various relationships. For example, the user can ask for the damage at a specific site due to earthquakes with magnitude larger than 7 located in distances no more than 30 km and combine these parameters to the local geology, the azimuth in which the earthquake is located and the focal mechanism.

A visualization manager maps the different information of the database or the results of the different queries (Figure 3). For example the map of the site and earthquake locations, as well as the macroseismic intensity map for each earthquake existed. Geological map, earthquake hazard map, map of the peak ground accelerations recorded, etc., are also included. The majority of these maps are dynamic ones, i.e. they are updated automatically once that new data are included in the database.
DISCUSSION

During the last years the importance of knowledge of macroseismic data substantially increased because of the reliable assessment of strong and destructive earthquakes and their application to earthquake hazard studies. Macroseismic observations might include all the information concerning these strong earthquakes, namely the source, the propagation path and the site characteristics, as well as information about the structure behaviour. Thus their incorporation within data management systems aiming to combine different information and extracting new knowledge using the recent visualization tools helps to solve the scientific tasks.

The Schenk et al. procedure (2004) for isoseismal drawing after Kriging method (a geospatial data interpolation operation), taking into account also the geology and tectonics, is incorporated in the database, thus the isoseismal maps are also included (Figure 3).

For the near future a subset of the database will planned to be exposed in the web, for any user to be able to get information or to extract new knowledge through the data mining. More over the database will be enriched not only with new earthquakes (for example extension to the past to include historical earthquakes), but with new parameters as well.

Acknowledgements
This study has been partially supported by the General Secretariat for Research and Technology (Greece) and by the Ministry of Education, Youth and Sport (Czech Republic) within the frame of Greek – Czech bilateral cooperation 2003-2005, under the project “Network for rapid information about Strong Motion and macroseismic INTensities from strong earthquakes of Greece”.

Figure 1. Diagram showing the entities included in the database and their relationships.
Figure 2. Example of different screens of the database. Screen of the QUAKES table (top), screen of SITE table (middle) and screen of EFFECT table (bottom).
Figure 3. Example of maps produced by the macroseismic database. Spatial distribution of the earthquakes with $M_s \geq 6.0$ during the period 1970 – 2003, observed intensity and isoseismal map for the event of June 15, 1995 ($M_s = 6.1$) at Aigio and the acceleration, velocity and displacement time histories of the strong motion instrument (T-component) installed at Aigio.
References


