NEWSLETTER

of the

EUROPEAN CENTRE ON PREVENTION AND FORECASTING OF EARTHQUAKES

ISSUE No 3
DECEMBER 1999
ATHENS

SPECIAL SECTION ON

ATHENS EARTHQUAKE

OF SEPTEMBER 7, 1999

Council of Europe
Conseil de l' Europe

- RESEARCH PROJECTS
- NEOTECTONIC MAPS
- TECHNICAL HANDBOOKS

Cover Sheet Photo:
After-shocks distribution for the period Sept. 8 - Oct. 3, 1999

NEWSLETTER

ISSUE No3 • DECEMBER 1999 • ATHENS

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EUROPEAN CENTRE ON PREVENTION AND FORECASTING OF EARTHQUAKES

(E.C.P.F.E.)

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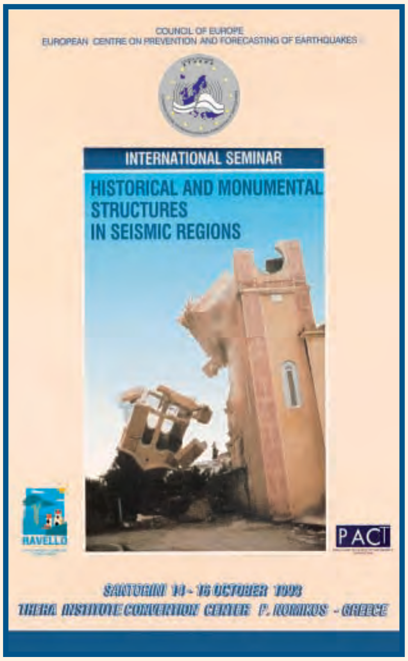
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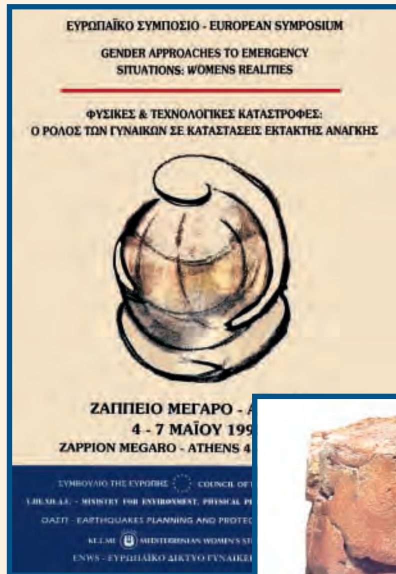
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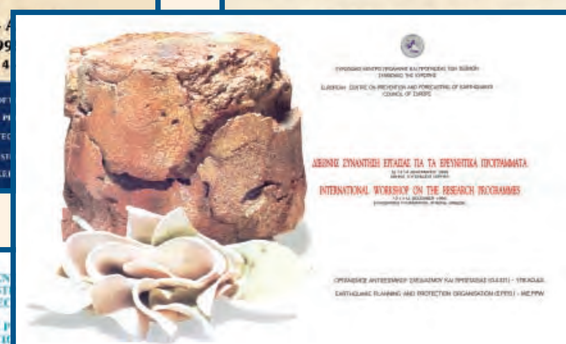
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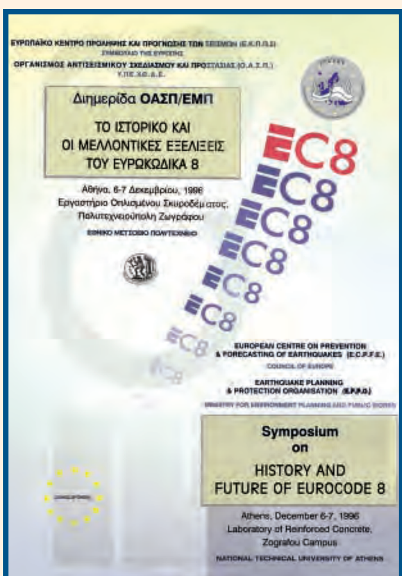
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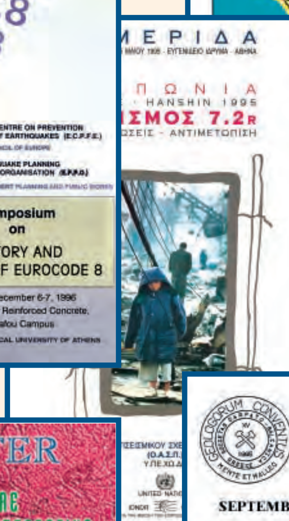
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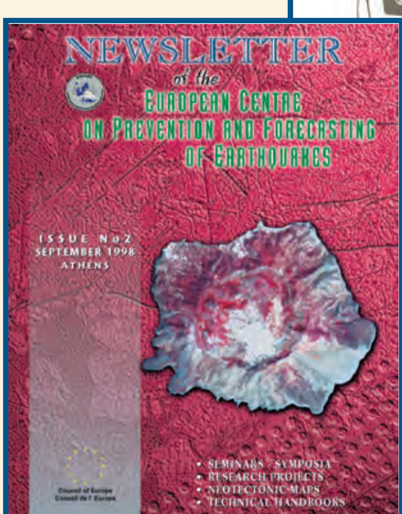
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XV CONGRESS
OF THE
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GEOLOGICAL ASSOCIATION
SEPTEMBER 17-20, 1995 • ATHENS, GREECE
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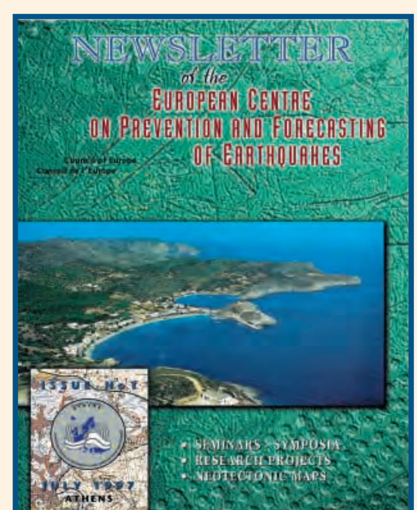
NEWSLETTER
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SEMINARS - SYMPOSIA
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C O N T E N T S

EUR-OPA MAJOR HAZARDS AGREEMENT OF THE COUNCIL OF EUROPE

(This text is part of the paper presented by Mrs. F.Tondre in the Conference "Advances on Natural Hazards Mitigation- Experiences from Europe and Japan", held in Athens, 3-7 November 1999).

The Committee of Ministers of the Council of Europe adopted Resolution (87) 2 in March 1987 establishing an intergovernmental Open Partial, Agreement.

This Open Partial Agreement has to date 23 member States: Albania, Algeria, Armenia, Azerbaijan, Belgium, Bulgaria, France, Georgia, Greece, Italy, Lebanon, Luxembourg, Malta, Republic of Moldova, Monaco, Morocco, The Former Yugoslav Republic of Macedonia, Portugal, Russia, San Marino, Spain, Turkey, Ukraine. Japan has the status of observer. The European Commission, UNESCO, WHO and the Office for Co-ordination of Humanitarian Affairs (OCHA) of the United Nations, participate in the Agreement. The International Federation of Red Cross and Red Crescent Societies is associated in its work.

The EUR-OPA Major Hazards Agreement main objectives are:

- on the one hand, to reinforce and promote co-operation between member States in a multi-disciplinary context to ensure better prevention, protection and organisation of relief in the event of major natural or technological disasters by calling upon present day resources and knowledge to ensure an efficient and interdependent management of major disasters;
- on the other hand, to use the Agreement as a suitable platform for co-operation between Eastern Europe, the South of the Mediterranean and Western Europe in the field of major natural and technological disasters.

The activities carried out within the Agreement are situated at three levels:

- the political level with the periodical meetings of the Ministers of the Agreement and of the Committee of Permanent Correspondents;
- the scientific and technical level with:
  - the ''European Network of 21 Specialised Centres''
  - the ''European Warning System''
  - the ''European Advisory Evaluation Committee for Earthquake Prediction''
- specific programmes:
  - Use of space technology to assist risk management: the STRIM Programme
  - The European programme on training in the field of risk sciences: the FORM-OSE programme;
  - The ''Communication and Information'' Programme EDRIM: Electronic discussion group for Risk Management

One of the main points of this Agreement is to have sought to ensure a direct interest and participation of the member States by fostering the creation of European Centres. These structures facilitate a concrete contribution from the different partners, with common objectives, through the implementation of European information, training and research programmes.

THE EUROPEAN CENTRE ON PREVENTION AND FORECASTING OF EARTHQUAKES

A. OBJECTIVES

The European Centre on Prevention and Forecasting of Earthquakes is involved in all aspects of earthquake prevention and forecasting. The Centre fosters research on various issues with a view to earthquake mitigation, it is interested in exploring the use of new technologies for prevention, it promotes education and training on earthquake protection.

The Centre operates within the framework of EUR-OPA Major Hazards Agreement which was ratified by the Greek Law in 1992. It belongs to the European Network of Specialised Centres and it is based in Athens, Greece.

B. ORGANISATION

The Organisation of E.C.P.F.E. is based upon the Administration and the Scientific Committee which are appointed by the Greek Government of the basis of the proposals put forward by the Council of Europe. For the time being the Centre is accommodated and run at Earthquake Planning & Protection Organisation's (EPPO) headquarters.

CHANGES IN THE ADMINISTRATION AND THE SCIENTIFIC COMMITTEE

The new administration of the Centre have been announced by the Greek Minister of Environment, Planning and Public Works in July 1999 (Ministerial Act Δ16/216/9/236/5/7.7.199) as follows:

- **Administration Committee**

President

George SRAVRAKAKIS, Researcher, Director of the Institute of Geodynamics in National Observatory of Athens, Vice President of the Administration Board of Earthquake Planning and Protection Organisation

Vice Presigent

Prokopis SIVENAS, Dr.Geologist, member of the Administration Board of Earthquake Planning and Protection Organisation

Members

Stavros THEODORAKIS, Civil Engineer, member of the Administration Board of Earthquake Planning and Protection Organisation

Cristos KOSTIKAS, Civil Engineer, member of the Administration Board of Earthquake Planning and Protection Organisation

Konstantinos SPIRAKOS, Civil Engineer, Assistant Professor in NTUA , member of the Administration Board of Earthquake Planning and Protection Organisation

Nikitas PAPADOPOULOS, Civil Engineer, Director of Earthquake Planning and Protection Organisation

Maria KAYAMANIDOU, Commission European, DG XII Science Research and Development

Jean-Pierre MASSUE, Dr. Nuclear Physics, Executive Secretary of EUR-OPA Major Hazards Agreement

Jean DUSSOURD, Director of Defense and Civil Protection, French Ministry of Interior Affairs

Alternate members

Peter SUAHADOLC, General Secretary of the European Seismological Committee

Eric BANDA, Director of the European Institute of Sciences

- **Scientific Committee**

President

Dimitrios PAPANIKOLAOU, Geologist, Professor in National and Kapodistrian Univeristy of Athens (NKUA), President of the National Centre for Marine Research

Vice President

Dimosthenis MOYNTRAKIS, Geologist, Professor in Aristotle University of Thessaloniki (AUT)

Members

Sokratis AGGELIDIS, Civil Engineer, Professor Emeritus in National Technical University of Athens (NTUA)

Kyriakos ANASTASIADIS, Civil Engineer, Professor in AUT

Olymbia VAGELATOU, Civil Engineer, General Secterary of Technical Chamber of Greece

George GAZETTAS, Civil Engineer, Professor in NTUA

Pavlos DELLADETSIMAS, Architect-Planner, Assistant Professor in Aegean University

Anastasios ZISIADIS, Civil Engineer

Nikolaos KALOGERAS, Architect, Professor in NTUA

Panayotis KARYDIS, Prof. of Earthquake Engineering in NTUA

Elias MARIOLAKOS, Geologist, Professor in NKUA

J.D. BERGIANNAKI, Phsycatrist, Associate Professor in NKUA

Taxiarchis PAPADOPOULOS, Geologist, Associate Professor in NKUA

Vassilios PAPAZACHOS, Seismologist, Emeritus Professor in Aristotle University of Thessaloniki, President of Institute of Technical Seismology and Earthquake Engineering

A. TSELENTIS, Seismologist, Professor in University of Patras

M.FARDIS, Civil Engineer, Professor in University of Patras

Apostolos CHRYSSOCHOIDIS, Electronic Engineer

Alternate members

J. BONNIN, Seismologist, European Centre for Seismic and Geomorpholofical Hazards

K.P. KOLEV, Director of Associate European Centre for School Level Training on Risk Prevention

Luis A. MENDES-VICTOR, Director of Associate European Centre for Urban Risks

Hulya ILGEN, Director of the European Natural Disasters Training Centre

Igor VESSELOV, Director of the European Centre for New Technologies in Management of Major Natural and Technological Disasters

A. VILLEVIEUILLE, President of Inter-Group UATI/FMOI, International Union of Technical Associations and Organisations, UNESCO

Fabrizio FERRUCCI, Prof. of Seismology and Volcanology

Myrna GANNACE, Dr.Phycologist, Director of Euro-Mediterranean Centre for the Medical-Phycological Support of Disaster Victims

- **Director**

C. Mr. Nikitas Papadopoulos, Director of EPPO, was appointed as the Director of E.C.P.F.E. and Ms. Miranda Dandoulaki, Civil Engineer-Regional Planner, as the Alternate Director of E.C.P.F.E.

C. PRIORITY AREAS OF ACTIVITY FOR THE YEARS 2000-2001

The first meeting of the new Administration Commitee took place at EPPO's headquarters in Athens in December 14th, 1999. Dr.J-P.Massue, Executive Secretary of the EUR-OPA, participated in the meeting. Mrs. S.Hadjiandreou, on behalf of the Greek representitive in EUR-OPA Mr.D.Katrivanos, General Secretary for Civil Protection, also took part in the meeting. The Administration Committee come to the following resolutions regarding the proposed axis for the future activity of the Centre.

RESOLUTIONS

After the recent earthquake disaster in Greece that has affected a large urban area in Athens, the earthquake protection policies and measures were re-examined in order to take into consideration the new data and lessons learned. Future seismic protection activities need to integrate the experience from the disaster of September 7th, 1999 and efforts should be focused on the following issues.

Seismic safety at schools

The earthquake has confirmed that seismic safety in schools is a priority, not only because schools house the youth of the country, but also because damage or disruption of function of a school has chain-effects to the families and to the community.

Because of the earthquake, several schools suffered serious structural damage. Nevertheless, the main issue was the non-structural damage in more then a 150 schools in the seismic area. It was this non-structural damage that caused the loss of functionality of schools and thus the disorder in the normal life of thousands of households.

On the other hand, a possitive lesson learned during the seismic period was that earthquake protection education in schools pays back, since the attitude of children during the aftershocks was in most cases better than their parents.

Concerning seismic safety at schools the following issues of priopity are proposed:

- The pre-seismic vulnerability assessment of school buildings is of great importance. The vulnerability should be addressed at both structural and non-structural elements of the building. Guidelines on the prioritisation of building inspection and on the level and time of retroffiting and seismic upgrading, should be issued. Standards regarding seismic safety design of schools should be drafted.
- Evacuation procedures and emergency plans are a non-costly immediate measure for seismic safety and should be drawn up in every school. Yet, only through regular exercises these plans are improved and preparedness is achieved. More effort is needed for the improvement of emergency plans of schools in order to integrade the experiences from the recent earthquake.
- Education and training at all school levels, as well as at the teacher and decision-maker level, are needed. New technologies are applicable for this aim and make seismic protection training more appealing for children and teenagers, yet more effort needs to be made on this.
- Education and training regarding earthquake protection of children with disabilities, must be addressed and specific measures must be taken in their schools in order to facilitate safe and fast evacuation.

Steps to tackle the problem of school safety in all the above issues are urgent and of primary importance. Greece within EUR-OPA is eager to collaborate in order to promote research regarding school safety, as well as to set up training programs for all parties involved in seismic protection of schools. Moreover, establishing European networks of collaboration among schools and institutions dealing with safety, can promote awarness and evolve prevention culture.

Risk mapping

Seismic risk assessment and mapping as a main input for decision making on risk management, is a significant step to earthquake protection.

Nevertheless, seismic hazard and risk monitoring through the application of well established traditional technics, can be expensive and time-consuming. Remote sensing techniques can offer an alternative way to Seismic Hazard Monitoring as less money and time consuming.

These technics are especially effective in detecting, delineating and describing active faults and their characteristics because of recognizing in satellite images certain morphostructures caused by faulting. Information on active tectonic structures and monitoring results integrated into G.I.S. could be well utilized by earthquake engineers while designing infrastructures, as well as by seismic risk managers at all the levels of administration (Central Government, Local and Regional Authorities) while decision making. Moreover, the application of space technics enables complete fault systems to be analyzed and monitored without travel and boundary Limits, which hold the operational possibilities of ground monitoring networks on national frontiers.

E.C.P.F.E. is the co-ordinator of a STRIM 1999 project addressing the problem of the application of Space Technologies and G.I.S. on Active Tectonic Structures, in order to demonstrate the possibility to input processed space imagery to EDRIM Network. Having the oppinion that the use of space technics could significally promote risk mapping, E.C.P.F.E. has proposed whithin the STRIM 2000 program a project tackling the monitoring of seismic surface deformations using SAR-Interferometry.

SAR (Synthetic Aperture Radar) can provide high resolution imagery of earthquake-prone areas, high-resolution topographic data, and high-resolution map of deformation (in the scale of few mm), either pre-seismic deformation generated by active tectonic stress in the stages of earthquake preparing, co-seismic deformation which is generated by an earthquake or post-seismic deformation caused by an earthquake. Information on surface seismic deformation as a result of monitoring, integrated into G.I.S., could be well utilised by earthquake engineers, while estimating risk and designing infrastructure, as well as by seismic risk managers of all the interested parts and at all levels of administration in decision-making. The proposal reefers to the application of SAR Interferometry technic which will be carried out in two areas, one in Greece (the area affected by the recent Athens earthquake) and one in Azerbaijan also affected recently by strong earthquakes.

The use of space technics in risk assessment and mapping should be continiously explored, as well as the technics to integrate this information into multi-sources systems in order to support decision-making.

Earthquake damage simulation and earthquake scenarios

Emergency planning and management, as well as earthquake mitigation can be much benefited by earthquake damage simulation and earthquake scenarios. Damage simulation though is based on the fragility curves deriving from damage data from various earthquakes and it is highly localised. Although there are several advanced GIS systems in Europe for damage simulation, some of which are tested in real situations and performed well, damage simulation needs to take very much into account the local building types and construction technics. Therefore, an effort must be made for developing realistic damage scenarios adopted to the specific characteristics of the built environment in each European country.

The recent earthquake disaster in Greece offers an opportunity to use vast damage data regarding the urban built environment, for earthquake damage simulation.

A meeting (training seminar or symposium) would offer the opportunity to present and compere the various methods for damage simulation used in the European countries, and to discuss the validity and appropriation of each method for treating data from Athens earthquake.

As a next step, damage simulation for Greek/Southern European cities, will be performed and the outcome will be integrated into EDRIM to support decision-making. Patra city (NW Peloponese) where a GIS was created for earthquake emergency management purposes, can be the suitable case-study for damage simulation and development of damage scenario.

Seismic Performance of Historical Buildings

Most people living in the Eastern Mediterranean have experienced with seismic disasters and have observed its consequences to the built environment and in society.

It is generally noticed that the most affected of all structures are the "old, traditionally-built" ones, such as the Monuments and traditional buildings. These buildings are mainly constructed before the ample use of reinforced concrete, with elements and technology based on the experience of the builders alone, without any structural seismic design. Nevertheless, interesting constructional technics can be detected in Greece and other European countries, throughout the prehistoric period up to the first half of the twentieth century. In addition, the aging of these structures and their wearing out due to various causes, such as humidity, ground-settlements, pollution, earthquakes, etc., as well as the lack of maintenance, make these structures much more vulnerable to earthquake action than the modern ones.

This fact was confirmed, once more, during the latest earthquakes in the regions of Perachora, Loutraki, Kiato (1981), in Kalamata (1986), in Aigio (1995), in Konitsa (1996) and in Nisyros Island (1996-1998), and also in the recent Athens earthquake, causing significant damage in the "traditionally built" buildings.

Therefore, the organisation of research on the seismic performance of traditional-historical buildings in countries menaced by earthquakes, is considered necessary. Moreover, the uniqueness of many historical buildings calls for the development of specific technics and methods of repair and retrofitting. Since construction technics and building characteristics of the traditional/historical buildings are much related to culture transfer and movement of civilizations once existing in Europe, both the above must be the outcome of cooperation between scientists and institutions from different European countries.

Promoting the co-operation with the Balkan countries

Most of the above issues are of a great interest to the Balkan countries suffering from earthquake disasters. More effort should be made on networking among the European Centres in the Balkan area as well as among various institutions working on earthquake protection. This will facilitate experience transfer and complementary activity, thus contributing to saving resources.

D. SCIENTIFIC ACTIVITIES of E.C.P.F.E. for the year 1999

D1. RESEARCH PROJECTS

1

Surveillance of Nisyros Volcano: Geophysical and geodetic measurements 1999

By: Prof. E. Lagios

National and Kapodistrian University of Athens, Faculty of Geology

GPS and Radon networks were established on Nisyros Island in June 1997, for the surveillance of its active volcano. Repeated measurements of the GPS network can provide a picture of the crustal deformation of the area due to the probable upward magma motion or/and the breakout of an intense seismic activity. Parallel to the remeasurements of the GPS network for the determination of vertical and horizontal crustal deformation of the area, the Radon network was also re-measured. The radon level variations were therefore determined, and a correlation to the observed seismic activity is aimed, especially by using the continuous time-series radon values provided by a permanently established multi-parameter radon-measuring station in Mandrakion (Nissyros), transmitting the data to Athens via satellite in real-time.

It has been shown that no significant horizontal deformation has generally taken place in Nissyros for the last two years 1998 and 1999. The presently therefore observed deformation is the one remained in Nissyros since the end of 1997, after the earthquake crisis of 1996/97, being basically controlled by two major faulting zones of the island. The previously (1997) registered uplift at all GPS stations of the network (20-40 mm) presenting a picture of a "bulge", seems to have been adjusted to previous normal levels, with the exception of the stations at the western and northern part of the island, where their uplifted character (about 20 mm) still prevails.

The radon level variation over Nisyros has not increased; on the contrary, some stations having systematically larger radon values compared to the others exhibit now half-level values than usual.

The above observations seem to be compatible with the seismicity of the area, which seems to be at a low admittedly level.

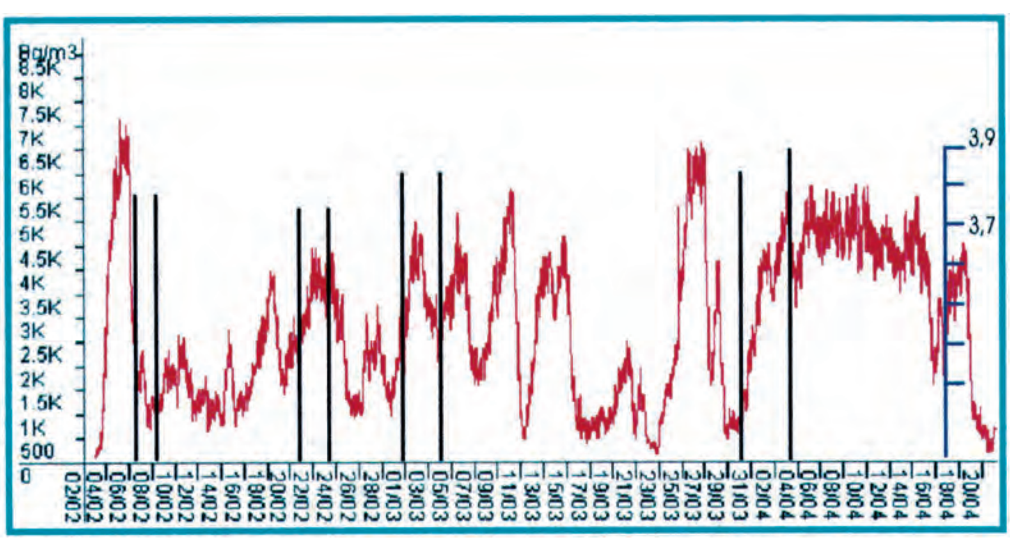


Figure 1 Radon emission measurements (02/02-20/04/1999)

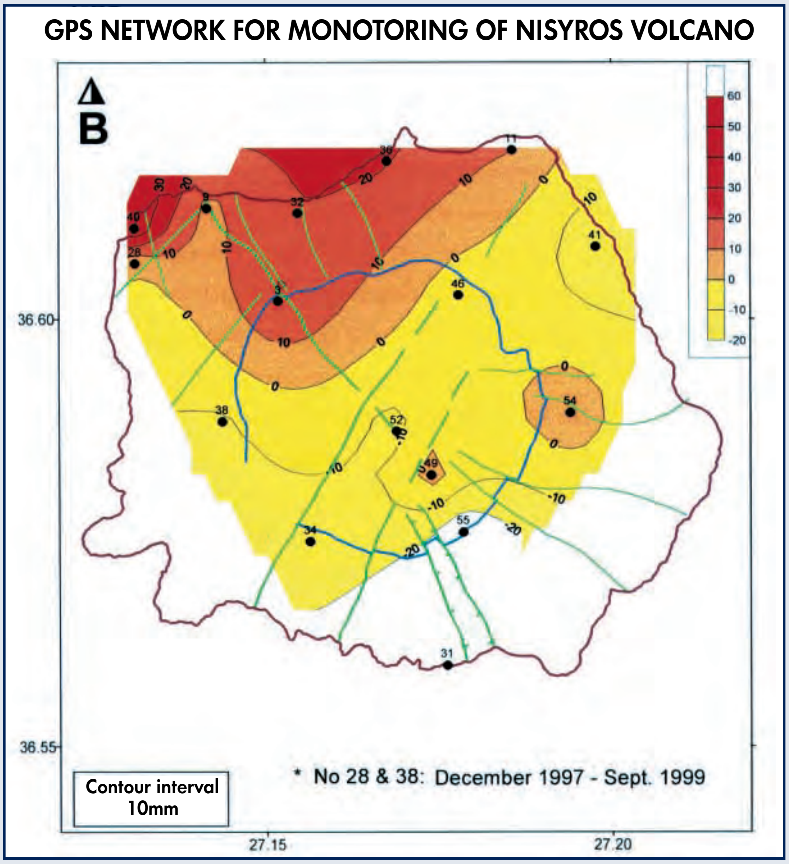


Figure 2 Vertical Displacements (June 1997 - Sept. 1999)

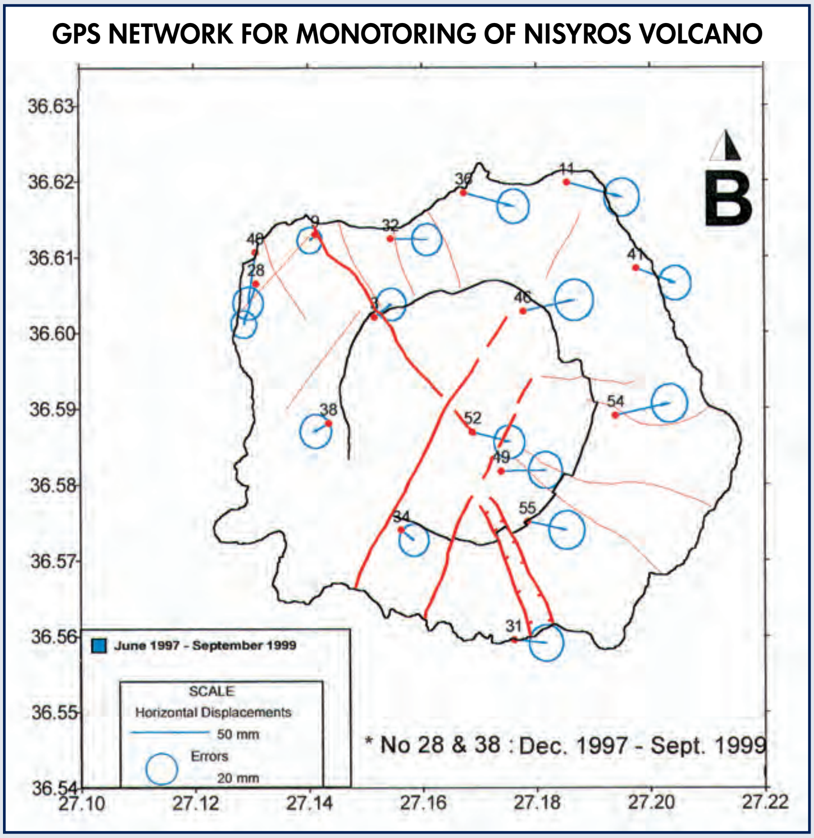


Figure 3 Horizontal Displacements (June 1997 - Sept. 1999)

2

Detection of submarine volcanoes in the Kos-Nisyros area

By: P. Nomikou and D. Papanikolaou
National Centre for Marine Research

Nisyros is an active volcano at the eastern edge of the modern Aegean Volcanic Arc, composed exclusively of Quaternary volcanic rocks. A systematic survey, especially in the submarine area between the islands of Nisyros and Kos was undertaken, aiming at defining the relations between tectonism, seismicity and volcanism. The survey comprised two cruises, one with the research vessel "ISKATEL" in October 1997, and the second in April 1998 with the research vessel "AEGAEO". A single channel seismic-reflection profiling system with air-gun as energy source was used. A representative lithoseismic profile through a submarine volcanic outcrop is shown in Fig.1.

The main results of this study are included in the two submarine maps given in Fig.2 and Fig.3 after reduction from their original scale at 1/100.000: a) The bathymetric map and b) the map of the submarine volcanic outcrops. The submarine area can be distinguished in several basins which are separated by the volcanic outcrops. The total extension of the submarine volcanoes is 3-4 times more than the known outcrops on the islands.

The overall neotectonic structure of the area is a tectonic graben of approximately E-W direction between the alpine basements of Kos island to the north and Tilos island to the south. In between, there is a mean sea-bottom level at about 600-700 m depth which is interrupted by several volcanic intrusions whose summits locally appear as small volcanic islands in the area around Nisyros and Yali. The lack of sediments overlying the volcanic domes indicates their very young age ranging between Upper Pleistocene and Holocene.

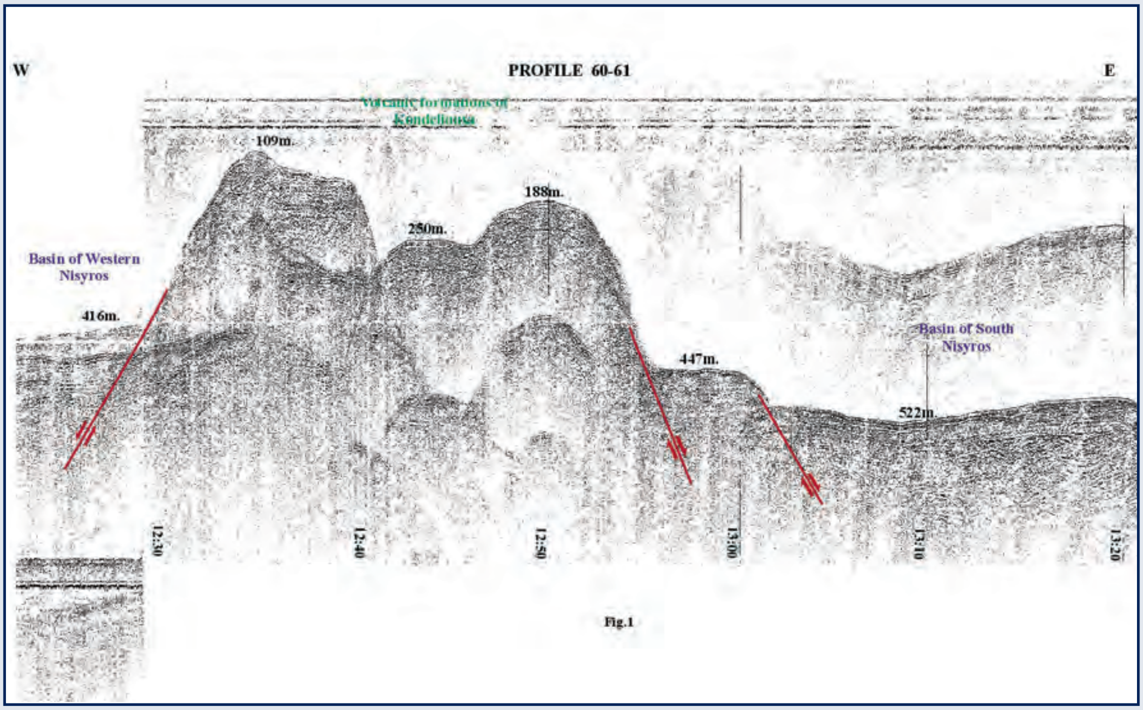


Fig. 1 Representative lithoseismic profile of a submarine volcanic outcrop, using air-gun on R/S "Aegaeo" in the area west of Nisyros Island.

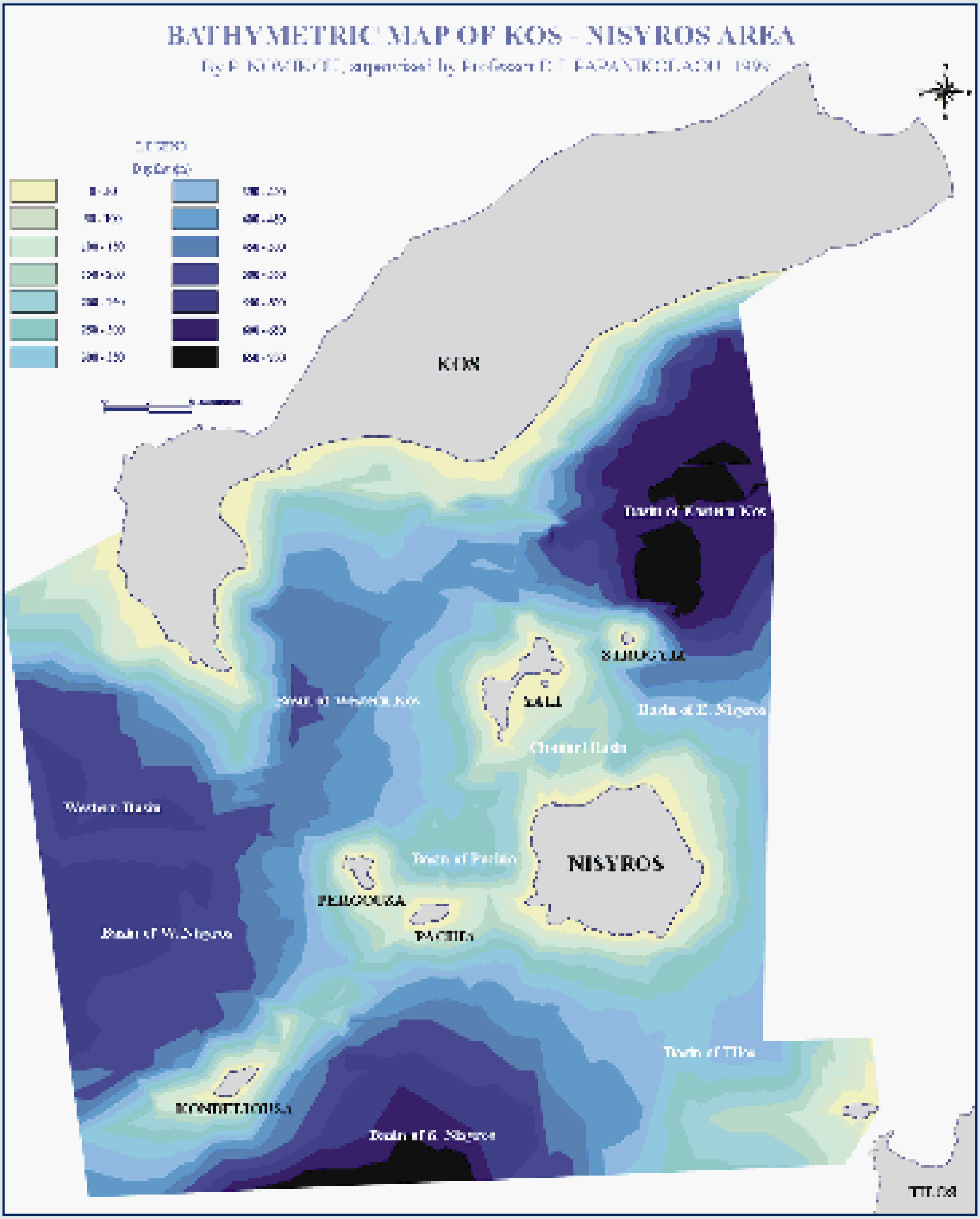
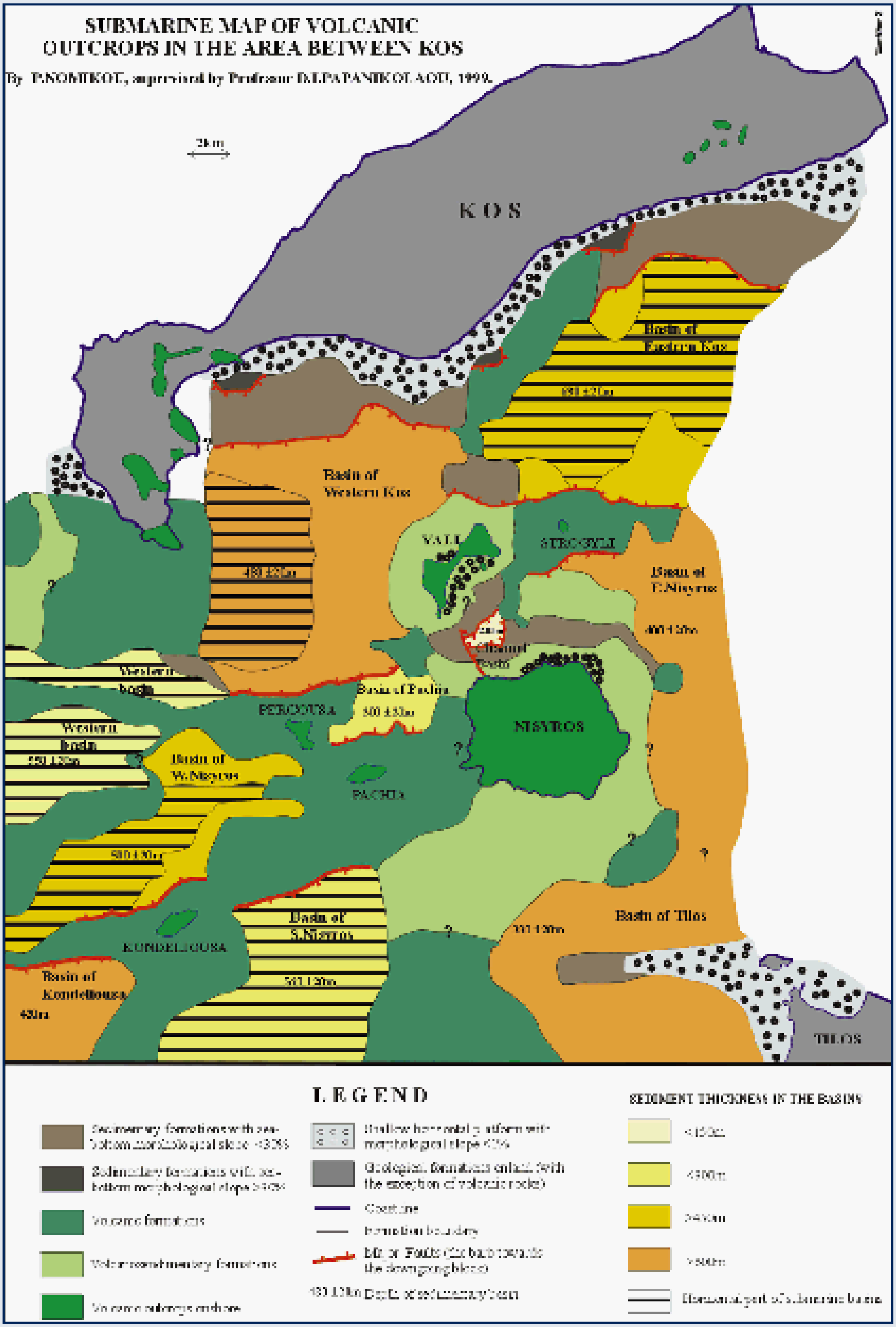

BATHYMETRIC MAP OF KOS - NISYROS AREA
KOS
NISYROS
PERGOUSA
PACHIA
TILOS
Western Basin
Channel Basin

Figure 2


SUBMARINE MAP OF VOLCANIC
OUTCROPS IN THE AREA BETWEEN KOS
2km
KOS
Basin of
Eastern Kos
Basin of
Western Kos
VALI
STRONGYLI
Basin of
E.Nisyros
NISYROS
Basin of Pachia
PERGOUSA
PACHIA
Western
basin
Basin of
W.Nisyros
KONDELIOUSA
Basin of
Kondeliousa
Basin of
S.Nisyros
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TILOS
LEGEND
SEDIMENT THICKNESS IN THE BASINS

Figure 3

3

Seismic behaviour of historical and traditional structures. The case of construction in areas in the Aegean Sea

By: P. Touliatos, A. Milioti, E. Tsakanika
National Technical University of Athens, Faculty of Architecture

A. Historical and traditional aseismic construction technics in Greece

All people living in Eastern Mediterranean have at a certain point and in some degree felt the phenomenon of an earthquake and have observed its consequences.

From ancient times, Greek philosophers, such as Aristoteles, Pythagoras, Hepicouros have dealt with the earthquake phenomenon and tried to interpret it.

It's estimated that today, a 50% of the annual seismic energy of Europe and a 2% of the annual world seismic energy, is released in Greece.

In this country, people live developing civilizations and construct their monuments and buildings for many thousands of years. Surviving frequent and disastrous earthquakes they got familiar with the act of observation of the damages on their structures and so understood, more or less, their behaviour during seismic action. Rebuilding them in better ways, trying to improve their resistance against the dynamic loading, the ancient constructors experimented with different materials, constructional systems, and sometimes, sophisticated detailing. Following long and hard paths of observation, experiments, failures and inventions they created local or more spread around aseismic technics, concerning basic members of a building (masonry, roof, e.t.c.), or even a complete building system.

It is a fact that it is impossible to protect completely a construction against the, sometimes out of the human capabilities limits, seismic force. In Greece, monuments, buildings, cities or even whole civilizations have been lost due to seismic or/and volcano activities, since prehistoric times to our days (i.e. Thira volcano eruption 1600 B. C., City of Argostoli complete destruction in 1953, Kalamata severe damages in 1986 e.t.c.).

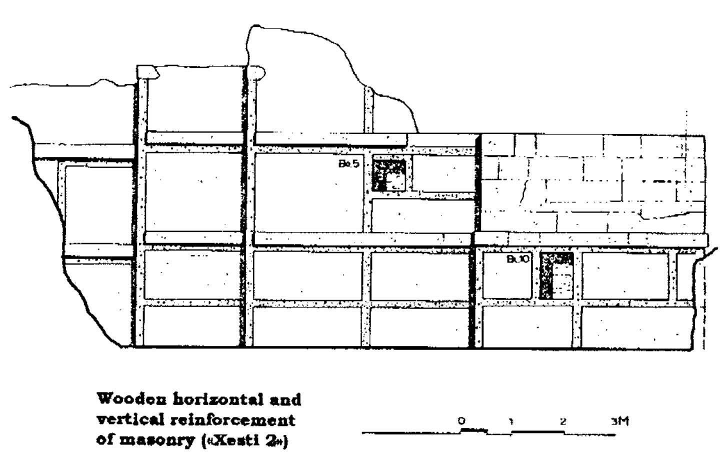


Fig. 1 "Akrotiri" settlement on Santorini island (Thira) 1650 B.C. (C. Palyvou 1988)

On the other hand many architectural monuments stand still after more then thousand years (i.e. Parthenon in Athens 438 B.C., Hagia Sofia in Istanbul (Constantinople) 537 a.d., Hosios Loukas Monastery, 955 A.D. e.t.c.) in areas with, some times high seismic risk. Traditionally constructed buildings and settlements all over Greece, exist and are used for hundreds of years surviving, repeatedly, seismic action.

In older times and despite the fact that the structural and dynamic

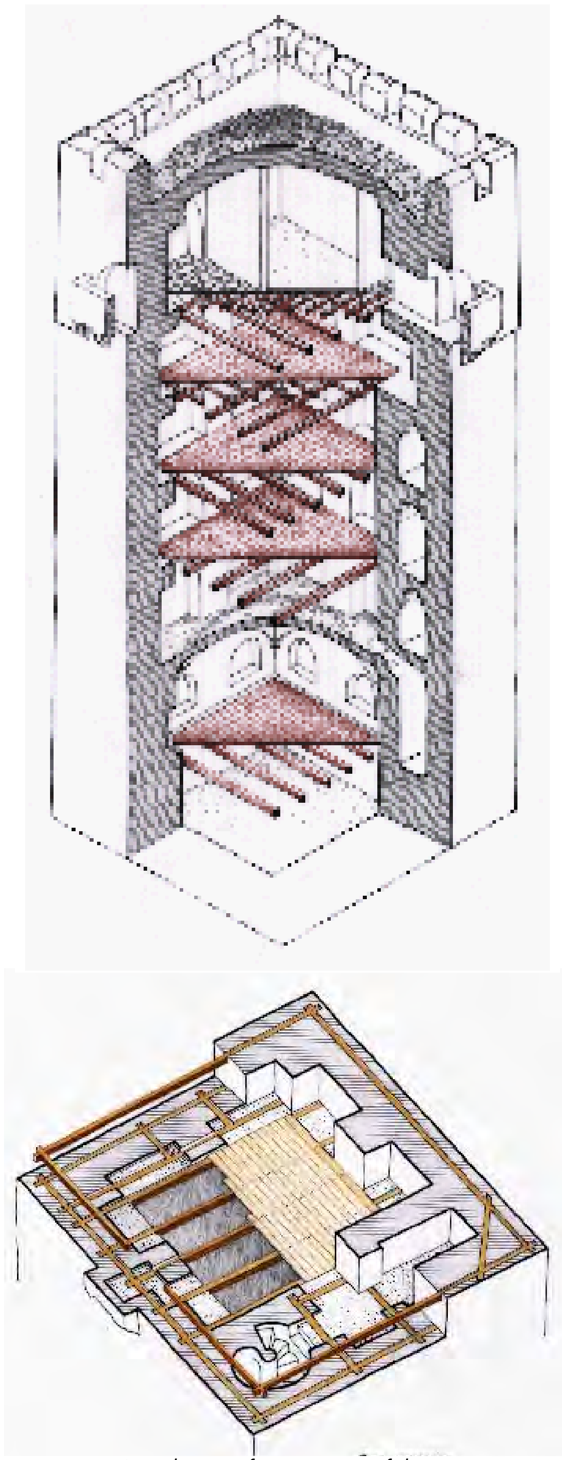


Fig. 2 Wooden reinforcements of the masonry of the "Doheiarion" Monastery's defensive tower of Mount Athos (10th-11th century). (N.T.U.A. research work, P. Touliatos, K.Kouthias, Perrakis Ph. and Voutsaras S.)

analysis methods were totally unknown, some very efficient aseismic methods and technics were developed by local, craftsmen. Nevertheless these skilled workmen had a very deep knowledge of the materials and the building systems of that time, which stayed the same and kept developing for centuries, passing on from one generation to the other. They also had a very good conception of every small detail as well as of the whole of the construction. This deep knowledge accompanied by the observation of the behaviour of structures during earthquakes and the examination and repairs of the damages led to the invention of very interesting and efficient aseismic construction systems.

It is a well established principle, that today we must strive to preserve the aseismic behaviour of those old buildings without changing their initial architectural, statical and dynamic conception in any restoration or conservation project, because the correctness of the chosen solutions has been proved several times during their existence all those years.

Our goal should be the reestablishment of their initial (at least) strength and resistance to earthquakes in the most compatible and simple way. In this procedure the best possible knowledge of the relevant aseismic technic which has been used and the aseismic design principles, is necessary.

The modern educational, social and administrative systems world-wide, don't help very much neither the understanding of the traditional local aseismic technic and design princinples, nor the development of special for each case repair and strengthening methods.

Today the specialist who desings or realizes the repair or strengthening projects of an Historical Building frequently have been educated and/or are living in different places, even countries, far away from the subject of their study and its material, loading conditions and constructional originalities. The building regulations, on the other hand, usually don't contribute very much during the procedure of understanding an old structure and deciding the proper interventions. The modern building regulations usually have been issued by reinforced concrete specialists, and ignore any specific local environmental or constructional originality. Mostly, they are trying to protect an historical building morphologically only. And of course the control systems of the proper application even of those non sufficient regulations are usually very weak.

The only way, for the specialists, the designers, the constructors, the producers of special materials and the authorities of a territory rich in traditional construction, to understand and get familiar with the problems of local historical buildings, is to develop an organised and analytical, local constructional data bank.

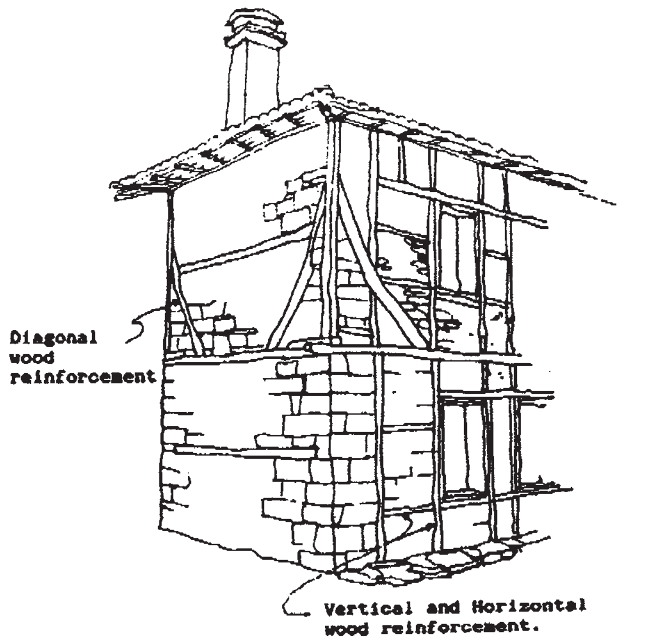


Fig. 3 Typical example of masonry's wooden reinforcements during last centuries in Greece from the island of Thassos.

Using the proper information of such a data bank the designers will be able to become aware of any originality and vulnerability of the traditional structure and to decide correct and compatible intervention methods. The constructors will succeed in organizing the proper specialists for the use of local materials and buildings systems. The authorities will be able to create local regulations, so that the respect, the preservation, the development and the correct exploitation of the cultural, constructional heritage will be a fact.

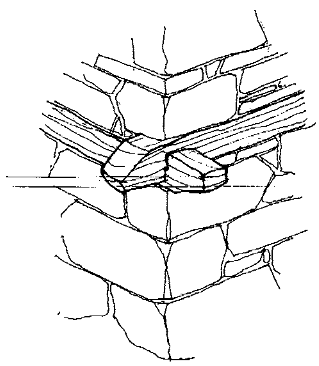


Fig. 4 Wooden masonry's reinforcements.

B. Brief description of the research project in progress

Under this framework of thinking, a research project is in progress aiming at:

- Proposing a methodology for the recording of historical structural systems. Pilot application of the method for the documentation of local structural systems of various historical periods and in both islands and coastal areas in the Aegean Sea. Special emphasis will be given in the attributes and features regarding seismic response and behaviour of the structure.
- Identifying and documentation of construction technics used in historical and traditional buildings from ancient times till today in respect to the seismic safety. Comparative study of these with construction technics used in other areas in Greece.

4

STRIM pilot project: Space technologies and G.I.S. for seismic risk monitoring on active tectonic structures. Synergy in application of space technics and G.I.S. to aid seismic risk managers in decision making

By: Prof. D. Papanikolaou, Dr. Ch. Metaxas, Dr. I. Parcharidis, Dr. S. Vassilopulou, Msc E. Basilakis

National Marine Center

a. BRIEF DESCRIPTION OF THE PROJECT

Active tectonic structures and their elements, such as active seismic faults, are the main causes of seismic disasters in urban areas and is significant infrastructure (High Dams, Refineries etc). Seismic Hazard and Risk monitoring on these active structures requires operation of dense seismological geodetic (i.e. GPS) and other networks, which are very expensive and time-consuming in the context of emergency situations management. Remote sensing techniques can offer an alternative in Seismic Hazard Monitoring as less money and time consuming and having multiple use. These technics are very effective in detecting, delineating and describing active faults and their characteristics because of recognizing in satellite images through certain morphostructures caused by faulting. Information on active tectonic structures and monitoring results integrated into G.I.S. could be well utilized by earthquake engineers while designing infrastructures, as well as by seismic risk managers of all interested parts and at all levels of administration while decision making. Moreover, the application of space techniques enables complete fault systems to be analyzed and monitored without travel and boundary issues, which hold the operational possibilities of ground monitoring networks on States frontiers.

The aim of this pilot project is to organize a practical exercise aiming at testing the cooperating capabilities of five European Centers on tackling a specific problem that is applying Space Technologies and G.I.S. to monitore seismic risk on Active Tectonic Structures with the purpose to demonstrate the possibility of inputting processed space imagery to EDRIM Network in order to aid decision-making.

The European Centers involved are:

- European Center on Prevention and Forecasting of Earthquakes (Athens, Greece),
- European Center of New Technologies for the Management of Natural and Technological Major Hazards (Moscow, Russia),
- European Center for Seismic and Geomorphological Hazards (Strasbourg, France),
- European Center on Geodynamical Risks of High Dams (Tbilisi, Georgia),
- Assosiated European Center of Training and Information of Local and Regional Autorities (Baku, Azerbaijan).

The main objectives of the project are:

1. To define and describe the parameters of active tectonic structures and associated seismic faults for two seismically active areas with developed infrastructure and characterized by different geological history, for well understanding the difference or similarity of related seismic hazard and risk parameters.
2. To assess the seismic hazard parameters which could be recognized and monitored on the basis of space images processing and interpretation by using all the available remote sensing data, optical and radar, or combined images from different sensors .
3. To integrate into G.I.S. the results of space imagery interpretation as specific informative layers with scope to aid seismic risk monitoring in given region.

4. To exchange knowledge and to transfer technologies and skill-sets in the field of space imagery processing and interpretation and G.I.S. on the problem of Seismic Risk Monitoring on an international basis, among the Centers involved.
5. To prepare in a friendly for the non-specialist end-user form the processed space imagery which on the detaction of active tectonic structures, seismic faults and seismic hazard parameters for input into the EDRIM network in order to aid decision making of seismic risk managers.

WORK CONTENT

Characteristics of main active faults, constituting active tectonic structures, have been recognized in satellite images through the related topographic and other features. To verify the results of image interpretation and to have the additional information about active faults parameters, field observations on these faults was conducted.

Informative layer on characteristics of active tectonic structures and associated seismic faults, as well as of seismic hazard parameters derived from space images, have been prepared and integrated into G.I.S. for assessment of possibilities of seismic risk monitoring on these structures using space technics.

For the purpose of the project, two test areas were selected: one in Greece and one in Azerbaijan. For the Greek test-site, the area of Heraklion prefecture, Central Crete was selected.

In order to carry out the project the following space earth observation and other ancillary data were used:

- SPOT XI, 4 bands (from visible to infrared), 20 m/pixel
- Digital Elevation Model (DEM), created from satellite SPOT PAN data, 20m/pixel
- Shaded relief map of the area, created from DEM, 20m/pixel
- Topographic maps scale 1:50,000
- Sismological data
- Tectonic information capture from already existing tectonic and neotectonic maps
- Results of field observations on neotectonic structures and their eventual affect on human infrastructures.

The space data and the thematic maps were georeferenced in the same projection system EGSA'87 (Hellenic Geodetic System). The combination and manipulation of the data were made in a G.I.S.

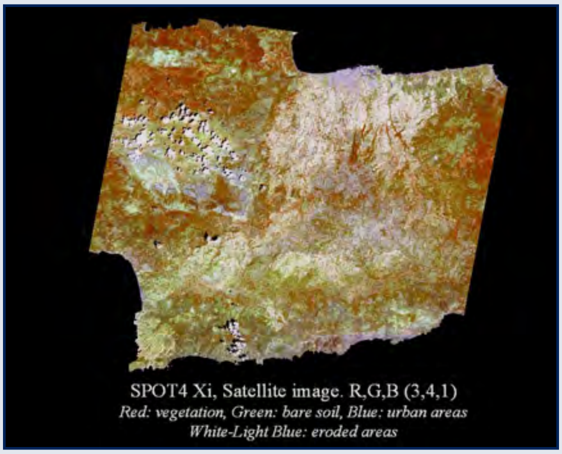
RESULTS AND CONCLUSIONS

The prospect results of this project could be summarized as following:

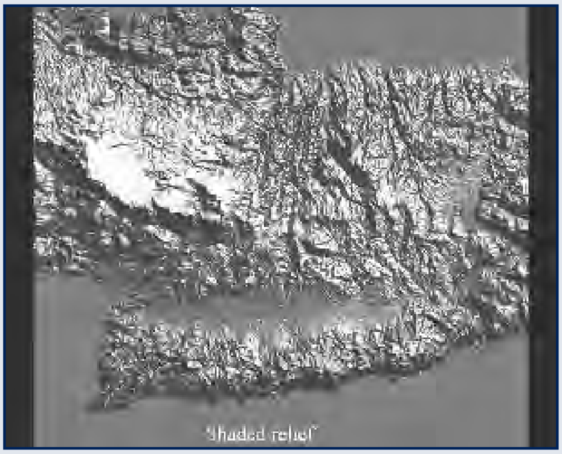
- The satellite imagery may be used in a fully understandable way in a system made for decision making by non-specialists on space technics matters.
- The best synergy of Earth Observation data and other related thematic maps as well as databases that describe the objects of the thematic maps was the main task we tried to achieve. In the project we used the best offered (spatial and spectral resolution) satellite multispectral data. An important progress should be achieved using the new very high-resolution data (IKONOS) which will expand the applications and the quantity and quality of the capture information. Regarding the descriptive information as databases, they should be analytical and often updated.
- Final products are displayed in a way that could be ''readable'' also by non-specialists, using the Geographic Information Systems, in this case ARC- VIEW s/w. Further effort should be on the technic of image processing and displaying the results, because the most simple image for the specialist is very difficult to be interpreted by the non-specialist. The problem becomes more difficult when not optical but radar data are to be used. More steps must be done on this matter.

- New commercial satellites are getting into orbit in the near future and the new space images are going to have better characteristics for processing and interpretation and finally to become more palpable. It is more mature nowadays to use new remote sensing technics such as SAR Interferometry, as they are getting more and more into operational projects.
- It is significant to overcome an endogenous, but very important obstacle of the project regarding the partnership between the involved European Centers that is the communication difficulties. Our experience on this matter points out that communication between the Centers needs improvement.

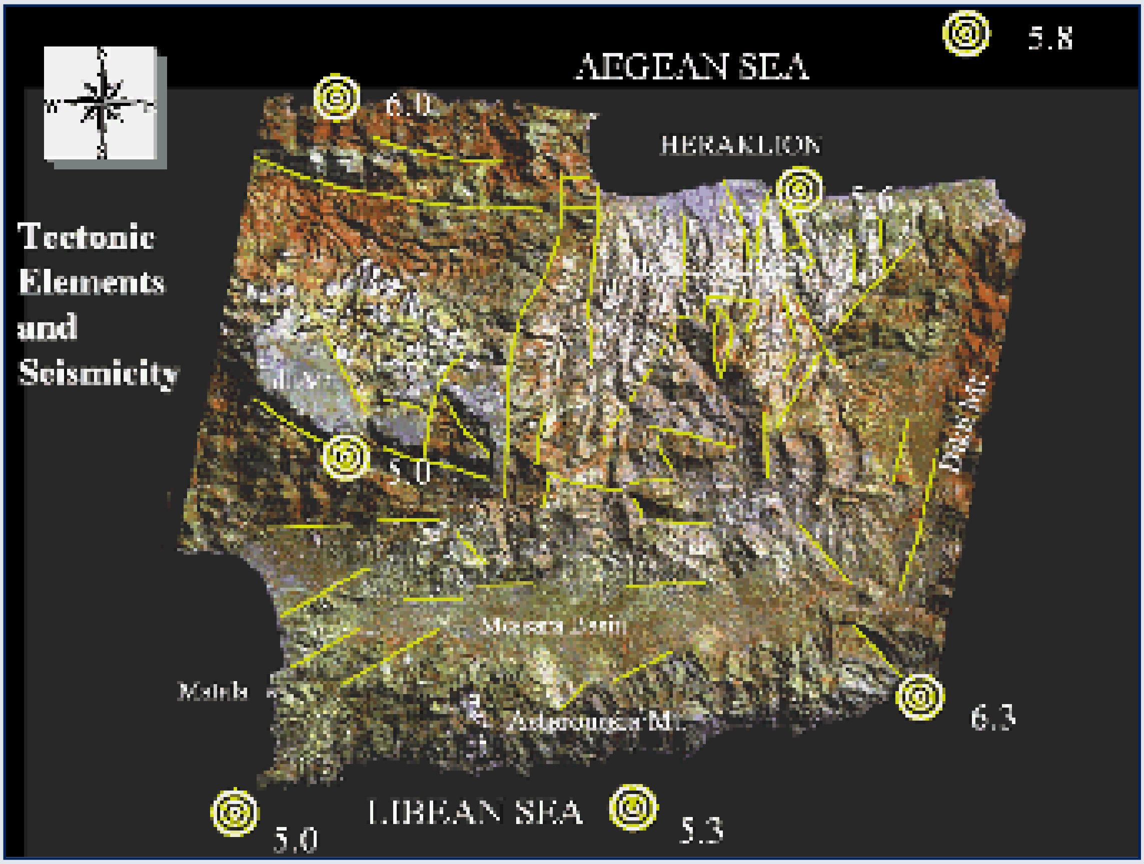
The results of the project are presented in the multimedia CD available in E.C.P.F.E.



SPOT4 Xi, Satellite image. R,G,B (3,4,1)
Red: vegetation, Green: bare soil, Blue: urban areas
White-Light Blue: eroded areas



"shaded relief"



D2. NEOTECTONIC MAPS

1

Neotectonic Map of Greece, scale 1:100.000
Sheet "Filiatra"

By: I. Mariolakos, I. Fountoulis, V. Sabot, A. Markopoulou-Diakantoni, R. Mirkou
National and Kapodistrian University of Athens, Faculty of Geology

Campilation procedure

The compilation of the neotectonic map involved:

- Collection of all available data on the geology, seismology, engineering geology, and hydrogeological conditions of the area. The data included research papers and publicantions, geological maps, air-photos and satellite images.
- Initial evaluation of the available data.
- Study of air-photos (1:33,000 scale) and compilation of photogeological map.
- Compilation of 1/50,000 tectonic map.
- Compilation of 1/100,000 geomorphological - morphotectonic map.
- Field work.

General Geological - Neotectonic characteristics

The study area lies at the south-western part of Peloponnessos, which is located at the south-western extremity of the Hellenic arc, adjacent to the Ionian trough, between 21°30′-22°00′ E and 37°30′ N. It is bounded to the north by Mt. Lapithas, to the east by Mt. Lykeo and Ano and Kato Messinia basins, to the south by the morphological depression of Pylos - Velika. The Ionian Sea forms the western boundary of the area.

The neotectonics of Peloponnessos includes large-scale fault blocks (horsts and grabens) of mean E-W (in western and northern Peloponnessos) and NNW-SSE trends (in central and eastern Peloponnessos). The study area is located at the junction point between these two prevailing trends.

Conclusions

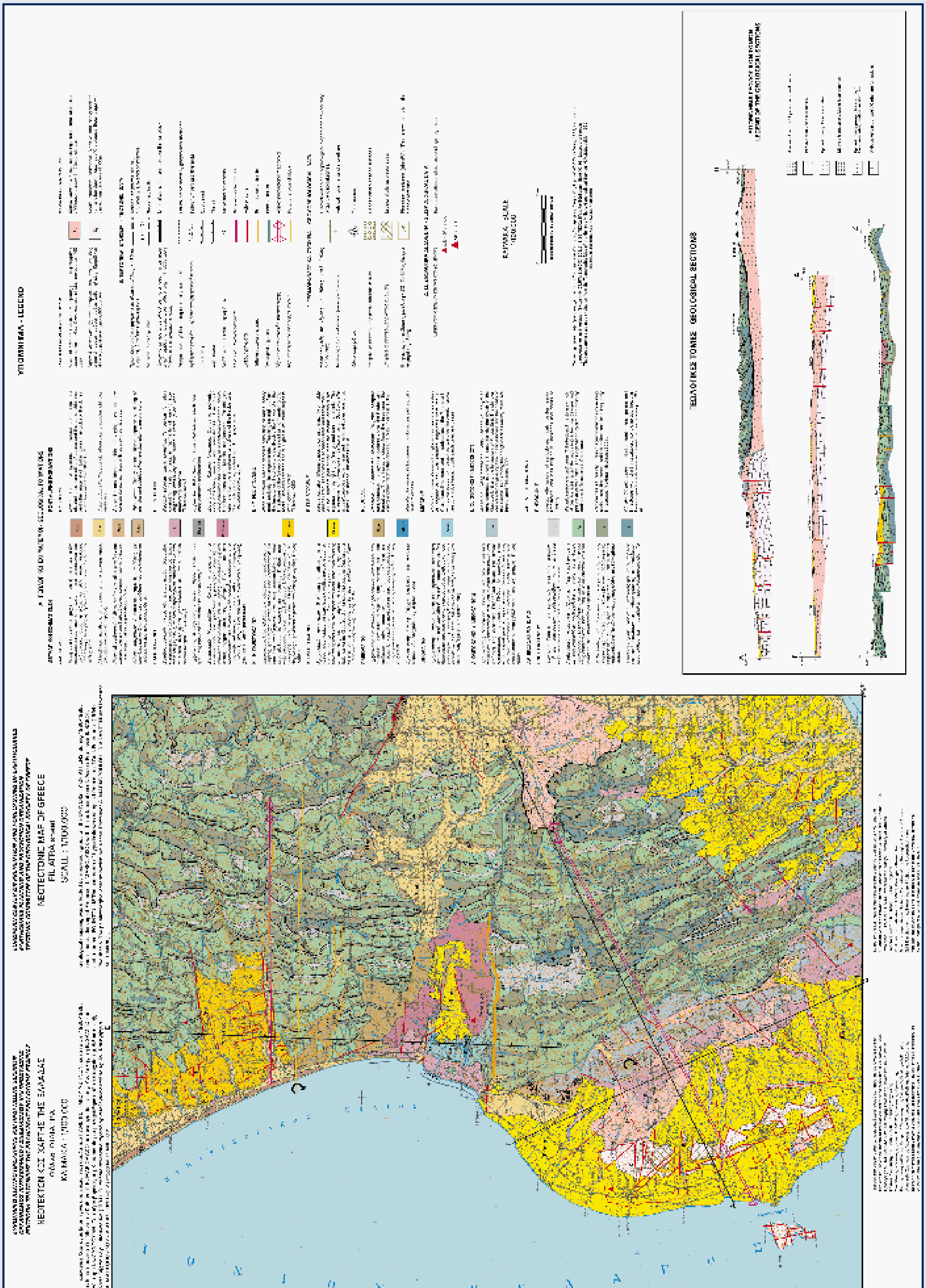
The following can be said on the area covered by "Filiatra" 1/100,000 sheetσ

- Both Alpine and post-Alpine formations crop out.
- The post-Alpine formations occur in six main basins, bounded by large fault zones, each of which has its own neotectonic evolution. These areσ
  - Neda and Filiatra grabens are filled exclusively with marine deposits. Age: Lower - Middle Pleistocene for the former and Lower Pleistocene the latter.
  - Kyparissia - Kalo Nero and Filiatra grabens, are filled with terrestrial, lacustrine and marine deposits, the age of which spans from Miocene until the Holocene. In both grabens, marine deposits represent the Early Pleistocene.
  - Dorio and Ano Messinia grabens are filled with Plio-Pleistocene terrestrial deposits.
- Unconformities, lateral transitions and facie interchanges are frequent phenomena in the palaeographic evolution of the basins.
- The alpine rocks of Pindos Unit form the main mountain masses of the area.

- The faults and fault zones in the area can be grouped according to their offset in (i) faults and fault zones with offset >100m. and (ii) secondary faults with an offset of a few tens of metres.

  According to their activity the faults can be classified inσ

  Seismic faults
  Active faults
  Possibly active faults
  Inactive faults
- The neotectonic setting of the area is characterised by the occurrence of large multifaulted blocks (horsts and grabens) bounded by large fault zones, each of which displays particular seismotectonic features.
- Minthi, Tetrazio and Kyparissia horsts are the most relatively "stable" locations in the study area. They are crossed by numerous faults, however, do not appear to be active. Only their margins show signs of activity.
- Lepreo - N. Figalia fault zone, which forms the margin between Neda graben and Minthi horst, is active.
- Neda fault zone, the margin between Neda graben and Tetrazio horst has an active segment, the one that lies within the graben and a possibly active one, at the east.
- Kyparissia - Aetos fault zone, the margin between Kyparissia - Kalo Nero graben and Kyparissia horst is possibly active throughout its western part, from Kyparissia to Aetos, and inactive further to the east.
- The kinematic analysis of the fault zones, faults and the large-scale open folding ("warping") of the area, in combination with a multitude of tectonic and geomorphologic features, shows the deformation type during the neotectonic period that is of brittle-ductile character. The stress field associated with this deformation is that of a rotational couple.
- The vertical (uplift and subsidence) movements, deduced from the study of shoreline displacement during Quaternary, coupled with geodetic data, confirm the above-mentioned view and prove that kinematically and dynamically the same condition is valid for the current deformation regime.
- The morphotectonic features (drainage networks, stream incision, planation surfaces, topographic discontinuities) are characteristic indicators for the determination of the long-term kinematic regime in tectonically active regions.
- The areas with pronounced tectonic features have dispalyed high seismicity since the historical times.
- The prevailing engineering geological conditions, in combination with the expected mechanical behaviour of each geological formation during earthquake events and quiescence periods, can indicate the possibility of occurrence of destructive subsidiary effects (landslides, rock falls, etc.) and determine the expected seismicity rating for each type or rock that outcrops in the area.


NEOTECTONIC MAP OF GREECE
GEOLOGICAL SECTIONS

D3. TECHNICAL HANDBOOKS-TRAINING

1

Issuing of Technical Handbook: “Post-earthquake rapid usability assessment of buildings”

Objectives

During the last decades several disasterous earthquakes have struck many regions around the world. The gained experience and the technological progress made on this field, are yet to be transformed into useful information, in the form of practical, step-by-step, instructions to the experts who are involved in the post-earthquake response. The Technical Handbooks are basic tools for the education process of disciplines and agencies involved in the earthquake relief phase and in emergency operations.

The programme for Technical Handbooks issuing is:

- “Search and Rescue Operations in Earthquakes” (1997 activity of ECPFE)
- “Temporal Propping, Structural Supporting and Withdrawal of Risk Elements” (1998 activity of ECPFE)
- “Post-earthquake Rapid Usability Assessment of Buildings” (1999 activity of ECPFE)
- “Post-earthquake Building Evacuation and Emergency Shelter Provision for the Population” (2000 activity of ECPFE)

The Technical Handbook “Post-earthquake rapid usability assessment of buildings”, now in process of issuing, reffers to the first degree inspection of buildings which is conducted immediately after an earthquake. The existing conditions and the often shortage of human resources, as well as the lack of the specific experience and the exact knowledge of on the spot engineers, make these operations especially difficult. Considering all the above, sound and step--by-step instructions should be given, in the form of a Technical Handbook, regarding the organisational and technical aspects of the inspection process produced in 1999.

The proceedings of an International Seminar on “Post earthquake emergency damage and usability assessment of buildings”, held in Athens in Sept. 22-24, 1993, will provide useful input for this Handbook. Moreover, the Greek experience of about 250.000 inspections carried out after the Athens earthquake of Sept. 7th, 1999 and the lessons learnt, are still to be integrated into the final outcome.

Program contents

The content of the Technical Handbook are:

- Categories of buildings usability and an indicative description of damages for each category,
- The Inspection Form and instructions on “how to fill it in”,
- Guidelines on emergency safety measures after building inspection,
- Posting on buildings,
- Setting up the inspection teams (personnel, equipment, duties list),
- Organisational aspects and procedures of the post-earthquake rapid buildings usability assessment,
- Legal and administrative issues,
- Appendix with photographs showing buildings correspondently to usability category.

2

Contribution of E.C.P.F.E. to a PACT 19 Workshop in Nisyros island

E.C.P.F.E. participated in the 6th scientific –training workshop on "Historical buildings in seismic areas" organized by PACT 19 in Nisyros island on July 14-21, 1999.

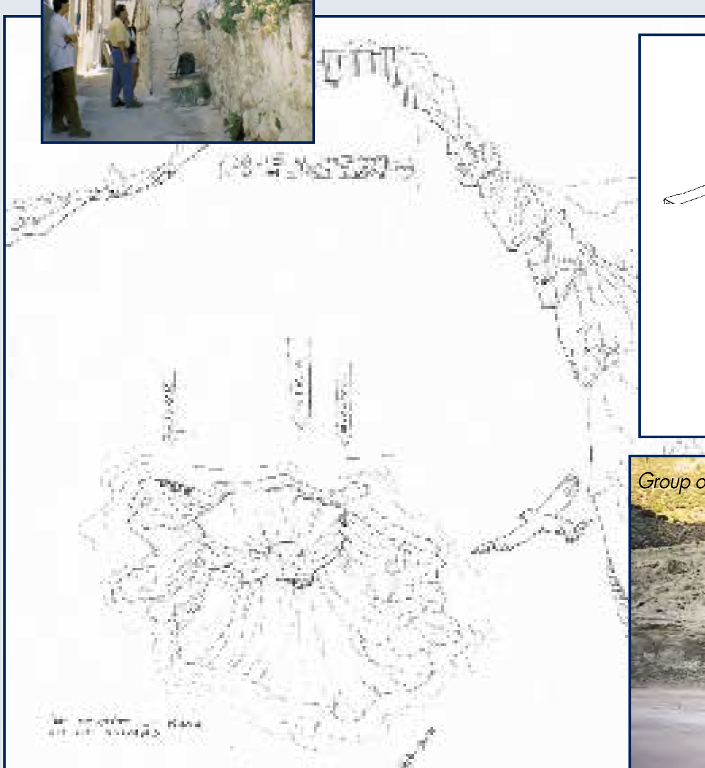
Nisyros is one of the islands of Dodecanese in the South-Eastern Aegean Sea. It is a part of the Aegean volcanic arc and it is considered as one of the most active areas in terms of volcanic reactivation. In 1996 seismic activity started causing damage of historical buildings in Mandraki.

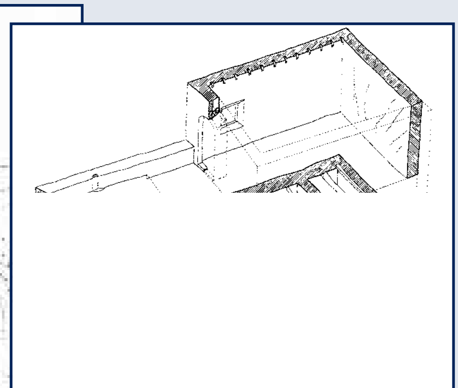
More than 40 people (students, academics, researchers and practitioners) from five European institutions from Italy, Spain, France, Belgium and Greece, took part in the workshop. They attended lectures on seismic response of traditional and historical buildings and most important, worked on documentation and evaluation of the local structural system taking into consideration seismic safety. Three multi-national working groups examined buildings in the three villages of the island (Mandraki, Emporio and Nikia).

It was a remarkable outcome of the work the identification of various structural systems on the small island. This could be explained by the long seismic history of the island, as well as the existence of the volcano on Nisyros, forcing changes into construction technics and structural system.


Nikia

The outcome of the field work and of the seminar was gathered in a volume containing drawings, photographs and texts with all the documentation on the identification and analysis of local structural systems of Nisyros. It was exposed to the local authorities and the people of Nisyros in an open presentation on Tuesday July 20th, 1999. A CD with the findings on Nisyros local structural system will be produced shortly.




Emporio


Group of participants in the volcano.

THE ATHENS EARTHQUAKE OF SEPTEMBER 7TH 1999

1

Some seismological aspects of the Athens earthquake of Sept. 7, 1999

By: George N. Stavrakakis

Director of the Institute of Geodynamics, National Observatory of Athens

On September 7, 1999 at 11:56 GMT (14:56 local time) a moderate earthquake of moment magnitude M_w = 5.9 (M_s = 5.9, M_L = 5.4) occurred at a distance of about 18 km north of the city of Athens.

The earthquake caused 143 fatalities, 700 injuries, and more than 70.000 people become homeless. The mostly damaged area was located in the northwestern suburbs of the city. Thirty buildings collapsed and thousands suffered major or minor damage.

The mainshock was preceded by some foreshocks starting at 11:38 GMT with a small event of local magnitude M_L = 3.2 followed by two other smaller shocks at 11:40 and 11:43 GMT both of M_L = 2.5. It followed by intense aftershock activity.

The fault plane solution proposed by Harvard University (strike = 114°, dip = 45°, rake = -73°) sugests a WNW - ESE trending, almost south-dipping normal fault.

The Institute of Geodynamics of the National Observatory of Athens installed a seismic network of eight analog seismographs to monitor the aftershock activity. In addition to that a digital network of 20 stations was also installed in collaboration with the Institute of Geophysics, University of Hamburg. In the following, some preliminary results based on the analogue portable network are shown. More information about seismotectonics, focal process, source parameters and strong ground motion are given by Pavlides et al., 1999; Papadopoulos et al., 1999; Papanastassiou et al., 1999; Stavrakakis et al., 1999; Kalogeras and Stavrakakis, 1999; Margaris et al., 1999.

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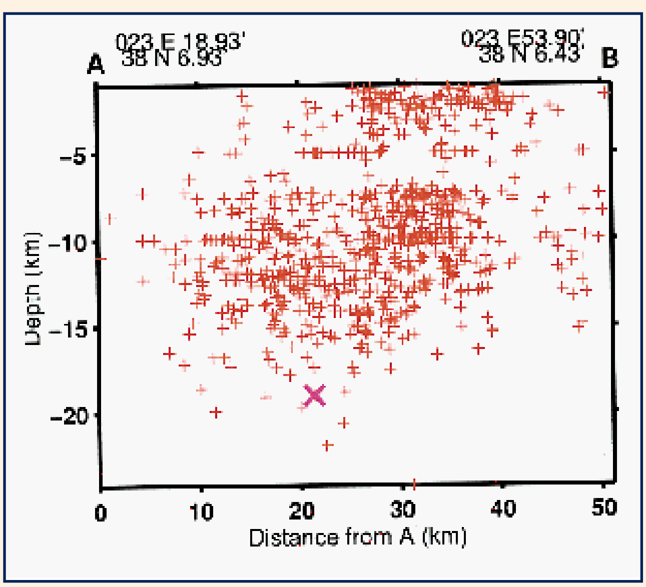
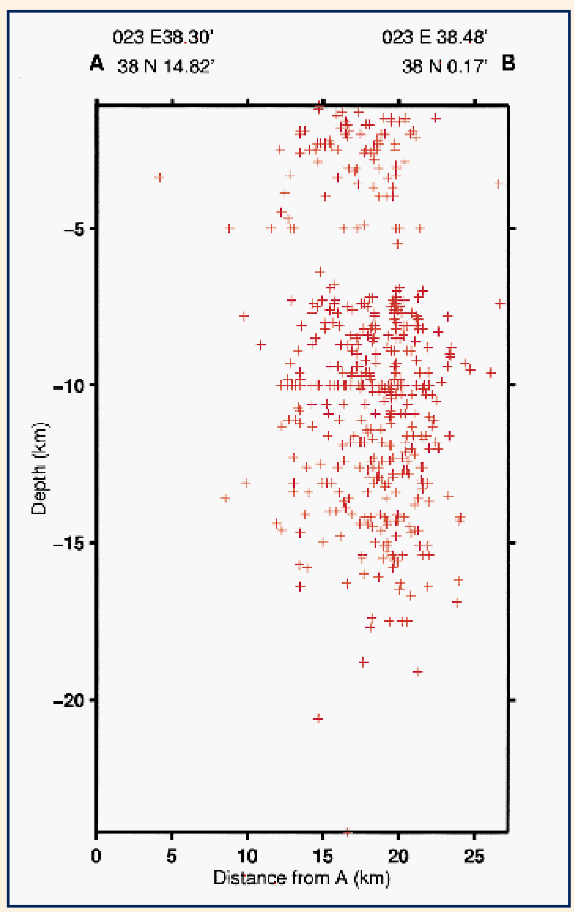
Figure 1.
Aftershocks distribution of the well locate aftershocks for the time period Sep. 08 - Oct. 03, 1999, indicating a trending WNW - ESE in consistency with the proposed fault plane solution.

Figures 2 and 3. The cross sections (E-W and N-S) that verify the south-dipping of the fault plane. The cross symbol depicts the focal depth of the mainshock.





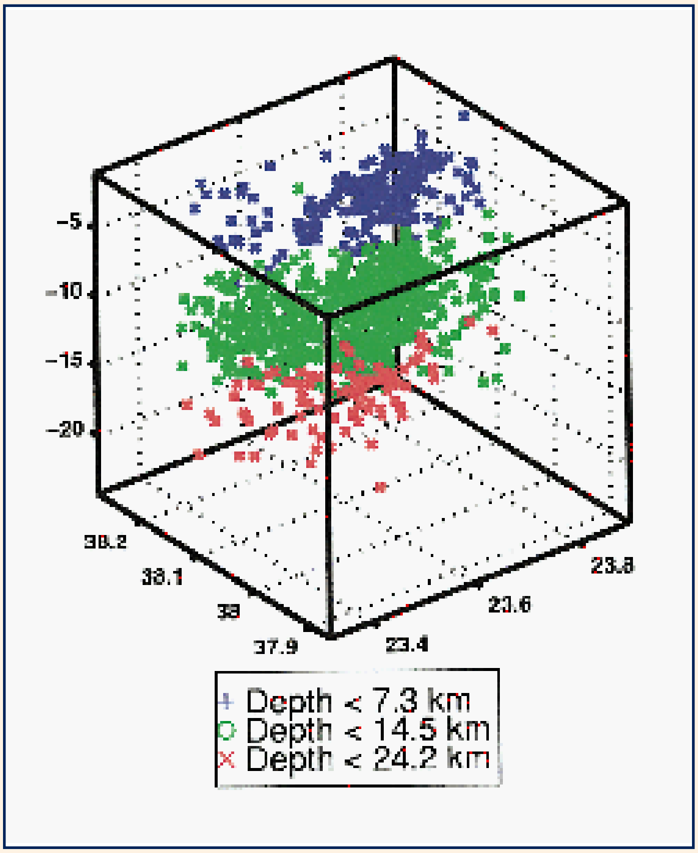


Figure 4. The 3-D distribution of the aftershocks. It is evident that the majority of the aftershocks occurred at a depth range between 5 and 15 km. Some of them took place deeper up to 25 km.

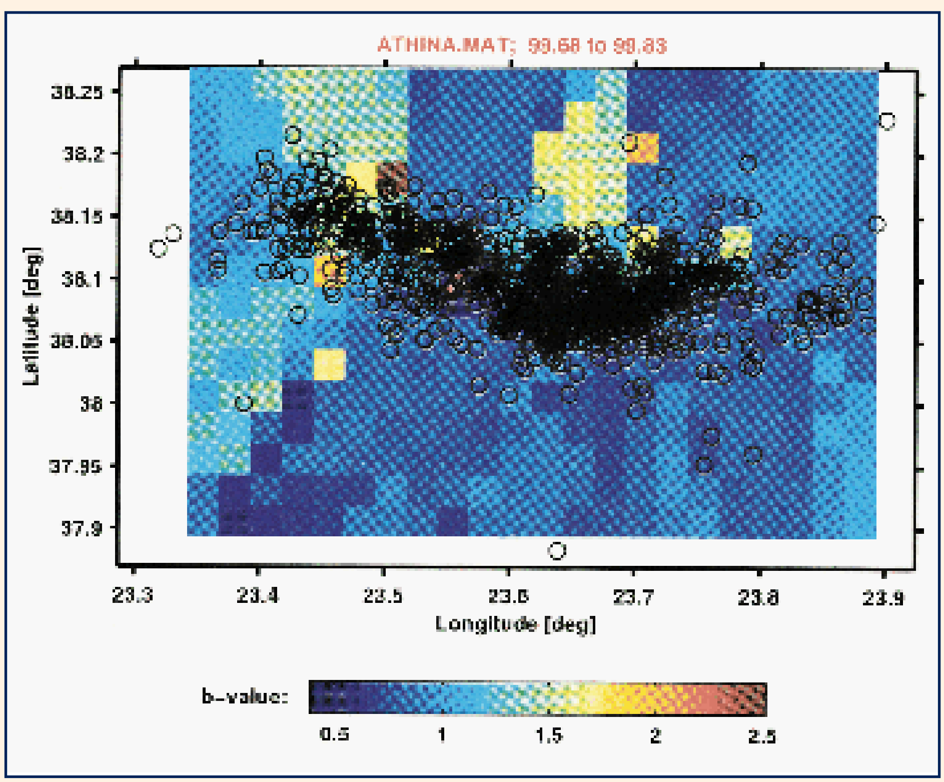


Figure 5. The b-value distribution with the aftershocks. The value b = 1 is obtained for the focal region, which is a common value for aftershock sequences in the area of Greece.

TABLE 1
Strong motion records data

No	CODE	SITE	GEOLOGY	PLACE	EPICEN DIST. Km	Max ACCELER., g L	V	T
1	MNSA1	Monastiraki	Schist of bad quality, black soft phyllite, archaeo logical deposits, underground caves	Free field	17	0.273	0.223	0.534
2	ATHA1	Neo Psychiko	Tertiary deposits	Basement, 3 story bldg	18	0.053	0.121	0.104
3	DMK1	Ag. Paraskevi	Limestone	Free field	19	0.032	0.042	0.073
4	FIX1	Syngrou FIX	Limestone / Sandstone of good quality	Metro station, level 1	19	0.085	0.046	0.122
5	SMGA1	Syntagma	Limestone / schist	Metro station, level 1	15	0.140	0.051	0.239
6	SMGB1	Syntagma	Limestone / schist	Metro station, level 3	16	0.115	0.068	0.092
7	SPLA1	Sepolia	Deposits of Kifissos river	Metro station, level −1	15	0.248	0.050	0.226
8	SPLB1	Sepolia	Deposits of Kifissos river	Basement 2-story steel bldg	15	0.353	0.204	0.326
9	DFN1	Dafni	Schist	Metro station, level −2	21	0.058	0.041	0.112
10	PNT1	Papagos	Tertiary deposits	Metro station, level −2	19	0.096	0.057	0.080
11	ATH02	Chalandri	Alluvial deposits	Basement, 2-story bldg	17	0.133	0.100	0.110
12	ATH03	Piraeus str. - KEDE	Alluvial deposits	Ground floor, 1 story bldg	16	0.290	0.050	0.590
13	ATH04	Kypseli	Schist	Basement, 4-story bldg	10	0.140	0.120	0.050
14	KERA	Keratsini	Soft rock	Basement, Administr. bldg	15	0.186	0.220	0.157

Table 1. The peak ground accelerations for the mainshocks at different locations. The No.1 - No.10 are stations deployed by the Institute of Geodynamics in collaboration with the Attico Metro S.A., the stations No.11 - No.13 were deployed by ITSAK, while No.14 was set up by DEH (Power Electric Corporation).

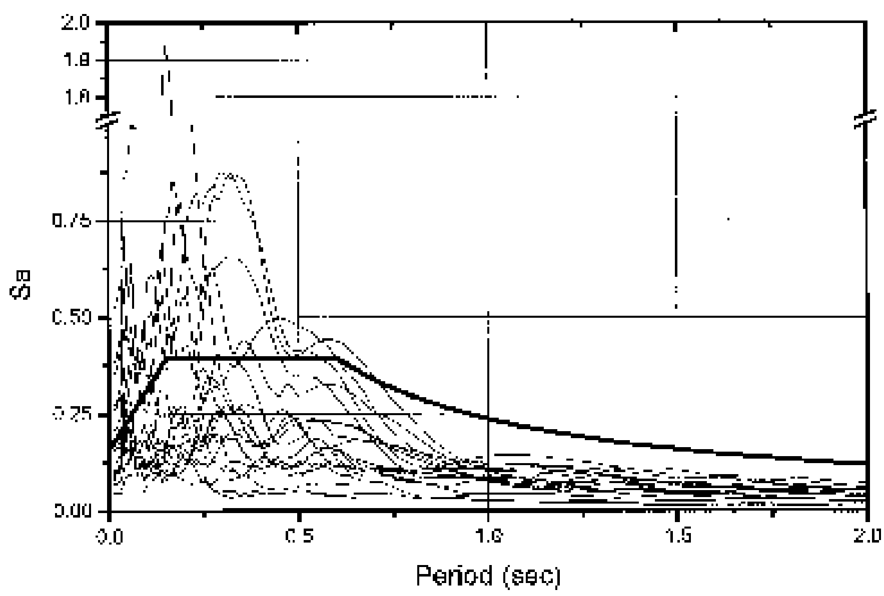


Figure 6. The corresponding spectra, while the dashed line represents the response spectrum adopted by the New Seismic Design Code.

2

Geology and tectonics of Western Attica in relation to the 7-9-99 earthquake

By: Professor D.I. Papanikolaou
in collaboration with: Dr. E. Lekkas, Dr. Ch. Sideris, Dr. I. Fountoulis, Dr. G. Danamos, Dr. Ch. Kranis, Dr. L. Lozios and at the contribution of: I. Antoniou, E. Vassilakis, S. Vasilopoulou, P.Nomikou, I. Papanikolaou, E. Skourtsos and K. Soukis
Department of Dynamic, Tectonic and Applied Geology, University of Athens

1. Introduction

Immediately after the 5,9 magnitude earthquake of Sept.7 1999 which stroke the NW area of the Athenian basin, a coordinated investigation on the geology and tectonics of the area was set up. The research was focused to a preliminary assessment of the geologic-tectonic-geomorphologic conditions of the area in correlation with the specific characteristics of this earthquake and its effect on the structures. This study was accomplished in collaboration with Professor P.Marinos and co-workers of the Technical University of Athens, according to the instructions of the Minister of Environment, Planning and Public Works.

Past of this work was based on studies and research previously undertaken by members of the scientific team, mainly during the elaboration of the Neotectonic Map of Eastern Attica since 1993.

Since the very beginning of the earthquake event, the scientific team checked several areas of the northwestern part of the Athenian basin from the Aegaleo Mt. up to the southern slopes of Parnitha Mt., through systematic field surveying. The field work was complemented by laboratory data including areal photographs and satellite images at various scales. The presentation of the preliminary conclusions of this research was made on maps at scale 1/25.000, which are given at reduced scale in this report.

2.Geology and Tectonics of Attica

The geological structure of Attica comprises two groups of alpine basement rocks and post-alpine sediments (Fig.1):

a) The upper group is made mainly of Mesozoic carbonate rocks (limestones and dolomites of Triassic and Jurassic age) overlying a clastic formation of shales and sandstones including olistholites of Permian limestones. Some ophiolitic rocks are locally preserved over the carbonate platform which were tectonically emplaced during the palaeoalpine orogeny of Late Jurassic-Early Cretaceous. Upper Cretaceous shallow water carbonates and early Tertiary flysch cover the previous formations, which belong to the geotectonic unit of Eastern Greece (composed of the Sub-Pelagonian palaeotectonised Unit, the ophiolite nappe of the Axios-Vardar oceanic basin and the Upper Cretaceous transgressive platform). This upper unit extends only to the northwestern part of Attica, forming the major mountain range of Parnitha and other minor mountains like Aegaleo in the western side of the Athenian basin.

b) The lower group is made mainly of metamorphic rocks, including marbles, micaschists e.t.c cropping out in the area of Penteli mountain to the east and Imittos mountain to the south of the Athenian basin.

The tectonic contact between the two groups of the alpine basement strikes in the NE-SW direction and dips towards the NW. Although this tectonic contact is usually covered by post-alpine sediments its position is marked approximately by Kifisos River which is outfloating in the area of Pireaus.

The post alpine sediments comprise mainly neogene lacustrive lignite bearing deposits and continental quaternary formations.

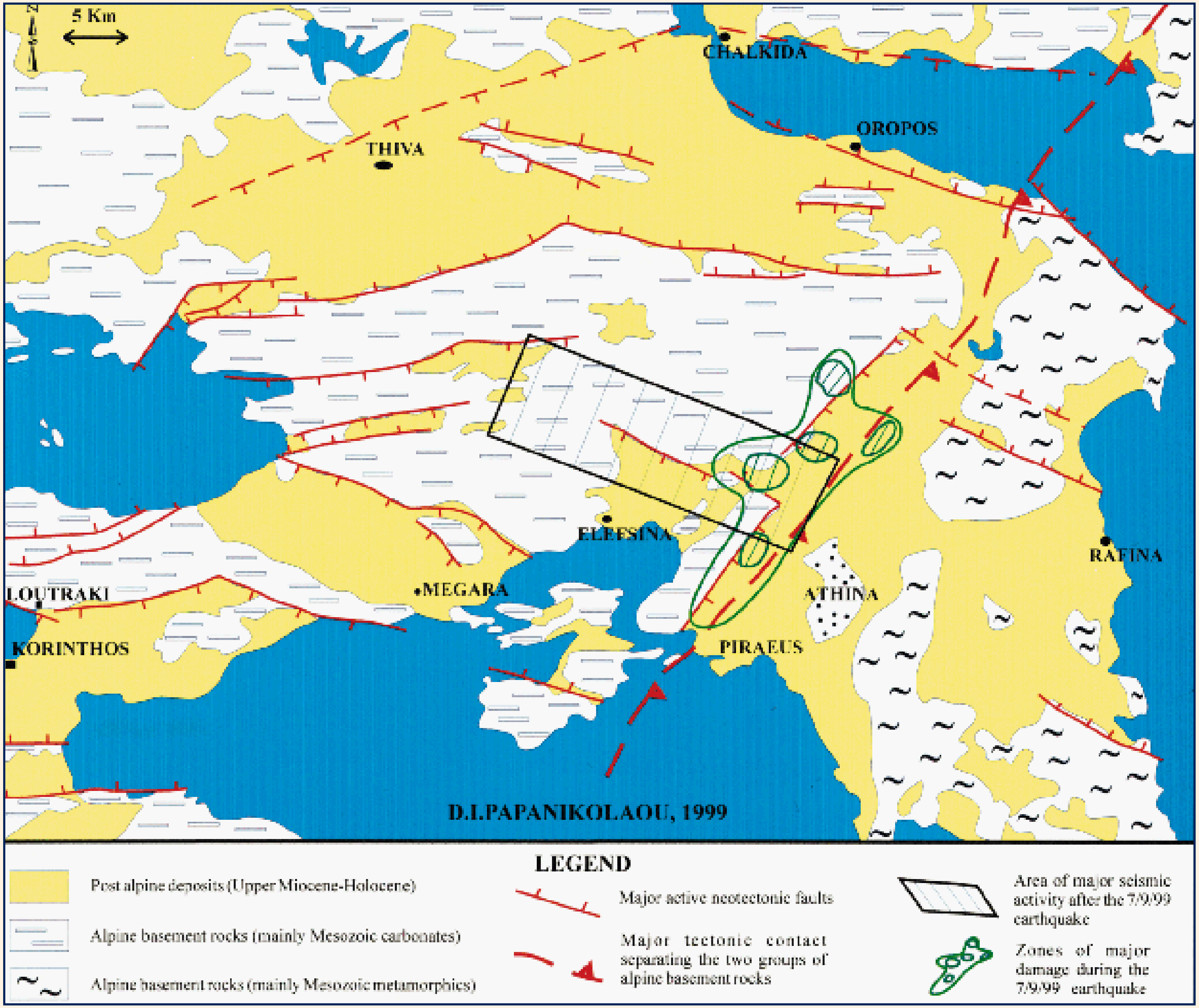

N
5 Km
CHALKIDA
OROPOS
THIVA
LOUTRAKI
KORINTHOS
MEGARA
ELEFSINA
ATHINA
PIRAEUS
RAFINA
D.I.PAPANIKOLAOU, 1999
LEGEND
Post alpine deposits (Upper Miocene-Holocene)
Alpine basement rocks (mainly Mesozoic carbonates)
Alpine basement rocks (mainly Mesozoic metamorphics)
Major active neotectonic faults
Major tectonic contact separating the two groups of alpine basement rocks
Area of major seismic activity after the 7/9/99 earthquake
Zones of major damage during the 7/9/99 earthquake

Figure 1

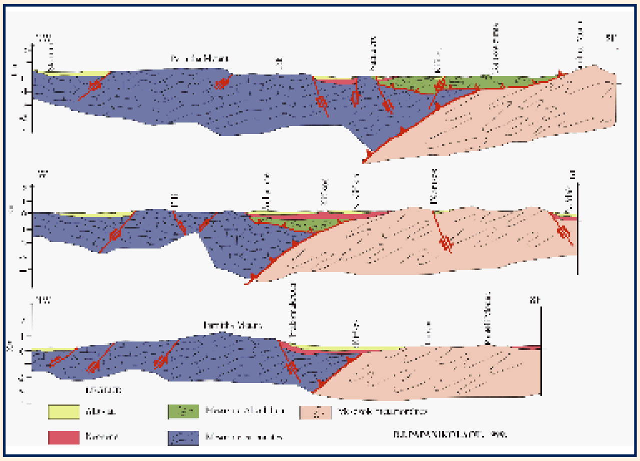


Figure 2

The neotectonic structure of Attica comprises a number of major faults striking in the E-W and NW-SE direction. The simplified map of Fig.1 includes only the most active neotectonic faults whose length is exceeding 7-8 Km with a seismic potential of magnitude >5. The ENE-WSW to E-W neotectonic trend in western Attica between Korinthiakos and Saronikos gulfs is related to large earthquakes of magnitude 6,5 to 7, like those of 1981. On the contrary, the NW-SE neotectonic trend in eastern Attica, extending also along the western coast of the Southern Evoikos gulf is related to smaller earthquakes of M ≃ 6.0 about 6, like the Oropos earthquake in 1938.

The tectonic profiles of Fig.2 show the above alpine and neotectonic structure on both sides of the Athenian basin.

3.The Earthquake of September 7, 1999.

The systematic survey of the area after the earthquake of September 7, 1999 and especially along the neotectonic faults together with the available seismological data from the Geodynamic Institute of the National Observatory lead to several conclusions which can be summarized as following:

1. The seismic rupture of the main shock had a WNW-ESE direction with a dip of about 40 degrees towards SSW. The movement of the fault was normal, with subsidence of the SW block, which is located beneath the Saronikos Bay area. The above general fault geometry of the main shock was confirmed also by the distribution of the epicentres of the aftershocks, which delineate a rectangular frame shown on Fig.1 and Fig.4, below western Parnitha Mt.
2. The seismic fault was generated at a depth of about 15-20 Km, without surface rupture. The only minor seismic rupture was observed in the SW area of Parnitha Mt. to the NW of Phyli within the alpine basement, along several hundreds metres with occurrence of linear significant rock falls in the adjacent areas. It is remarkable that this seismic rupture has a WNW-ESE orientation, similar to that of the seismic fault at depth but an opposite dip towards NNE. All the rest ruptures that have been observed in the wide region did not correspond to seismic ruptures but to local fissures due to unstable soil slopes or cracks opened along previous rock discontinuities.
3. The large neotectonic faults of the wide area were not activated even though precisely in the area of the epicentral zone a neotectonic fault of the same geometry as the seismic fault occurs. This fault runs parallel to the eastern boundary of Thriasio basin and is almost parallel to the seismic fault at depth with approximately 15 Km difference in elevation (Fig.3 and 4).

4.The damage distribution in relation to the geology and tectonics

The damage distribution shows a general NE-SW trend , which is almost perpendicular to the direction of the WNW-ESE seismic zone of the 7.9.99 earthquake (Fig. 1,4 and also map of Marinos and co-workers). This particular trend follows the tectonic boundary between the metamorphic and non metamorphic rocks of the alpine basement of Attica, which runs along and beneath Kifisos River. This tectonic boundary together with the sub-parallel marginal faults of the Athenian basin running along the eastern slopes of Aegaleo and Parnitha Mts. have shaped the zones of major damage.

The neogene marginal faults of the Athenian basin controlled the linear distribution of damage even in areas where they are covered by Quaternary slope breccias as in the area of Thrakomakedones, where young well constructed structures were severely affected by the earthquakes.

In general, the damage zones were mainly shaped passively by the NE-SW tectonic structures cutting through the Athenian basin from the area of Pireas up to the pass between Penteli and Parnitha Mts. and only secondarily by the energetic action of the WNW-ESE seismic fault that was activated at depth. It is remarkable that the seismic zone appears to end towards the ESE along the Kifisos River (Fig.1,4). Thus, it seems that the seismic energy was reflected from the seismic zone along the NE-SW major alpine tectonic contact up to the surface in the area of Liossia, Menidi and Thrakomakedones.

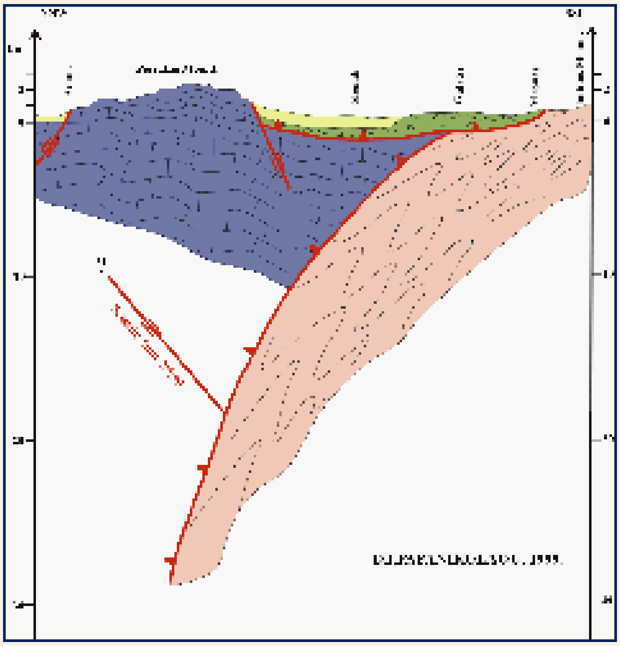


Figure 3

The role of the geological basement as foundation soil is important but not determinative, since in soils of similar quality we observe extreme differentiations of the degree of damage over constructions of similar quality. Nevertheless, it seems that only slight damage is observed in constructions built on alpine basement rocks. Significant differentiation of damage is observed also in areas with important changes in morphological slope.

The general conclusion is that the damage distribution is a combination of several factors, besides the foundation soil, including the older tectonic structures and the geomorphological discontinuities.

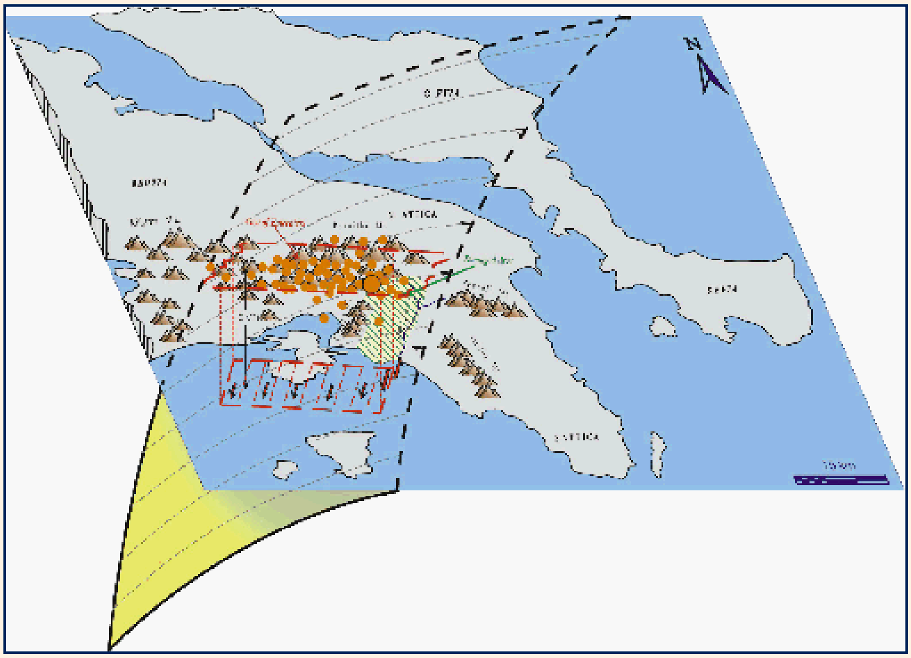


Figure 4

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Papanikolaou, D. & Lozios, S. 1990. Comparative neotectonic structure of high (Korinthia-Beotia) and low rate (Attica-Cyclades) activity. Bull. Geol. Soc. Greece, XXVI, 47-65.

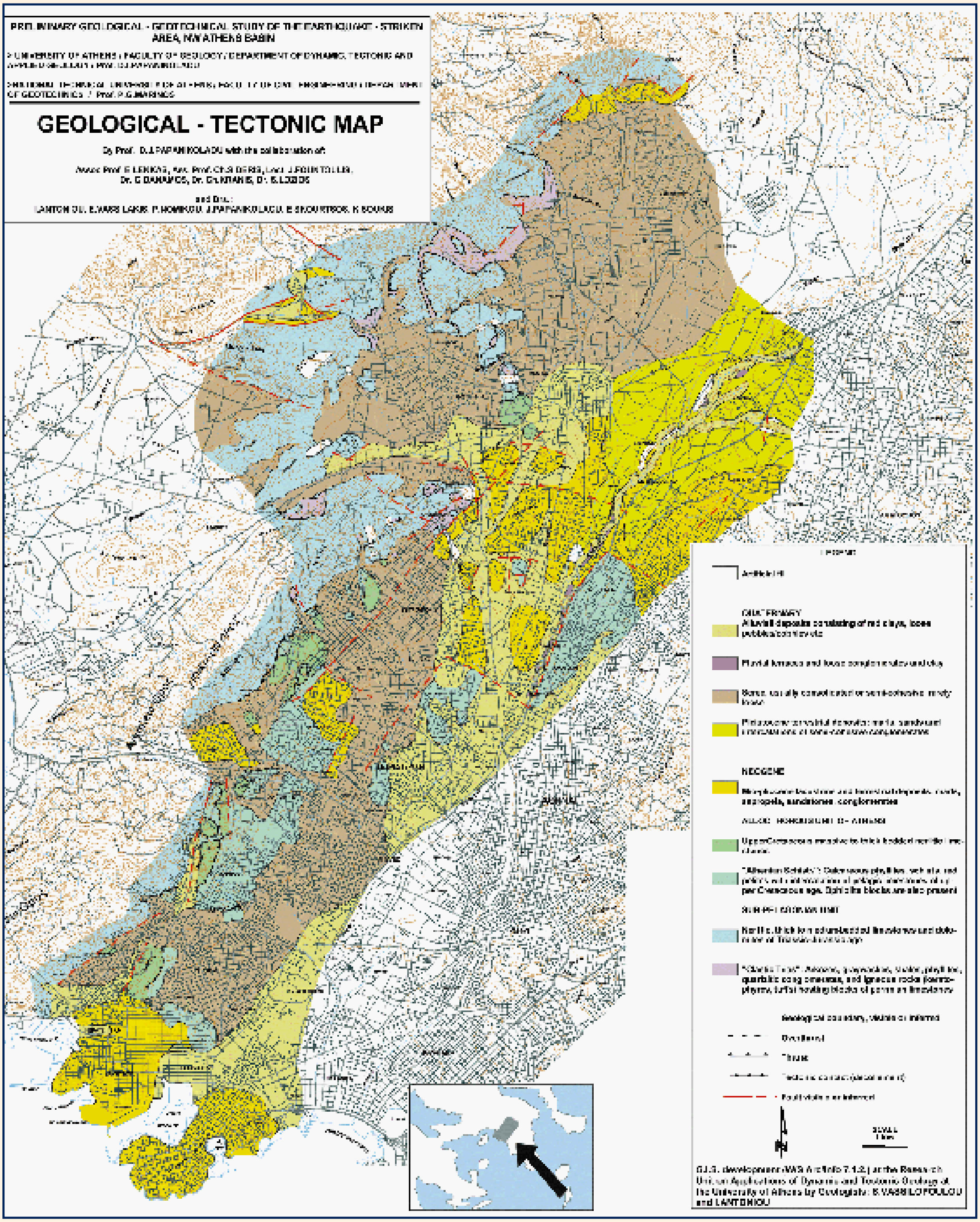

GEOLOGICAL - TECTONIC MAP
AREA, NW ATHENS BASIN
QUATERNARY
NEOGENE

Figure 5

3

Active tectonic structures of Attica and geodynamic situation related to Athens earthquake

By: Dr. D. Foundoulis, Dr. Ch. Metaxas, Dr. S. Lalechos, Dr. A. Kourou

Earthquake Planning & Protection Organisation (E.P.P.O.)

On September 7 1999 at 14:56 local time, a moderate (M_s =5.9) but devastating earthquake struck the districts of Athens in Western Attica and was followed by an aftershock sequence with magnitude range of $M_s \leq 4.7$.

Most of research seismological institutions locate the main shock within the Thriasio neotectonic basin on S_w slope of Parnitha mountain ridge with coordinate Lat.: 38.08°N, Lon.: 23.61°E and at depth interval 9-20 km. The focal mechanism solution, determined by USGS and HARVARD, suggested a NW-SE trending normal fault (114°-123°) with left-lateral horizontal component, dipping to SW about 45°-55°, with subhorizontal extensional axis oriented NNE (about 208°). The greatest observed intensity was IX of MM-Scale according to G. Protonotarios, N.T.U.A..

A scientific team from E.P.P.O. carried out the field microtectonic observations in the mesoseismal area starting the next day of Athens earthquake. Earthquake induced phenomena (ground fissures, rock falls) were recorded at 46 points in total all over the affected area.

Some of the observed characteristics of the earthquake, which could be considered as unusual, are:

- relative high macroseismic intensity with respect to event magnitude and depth,
- absence of sufficient surface expression of seismogenic fault along with intense rock falls and serious road damages in the Parnitha mountain,
- discordance between the geometry and kinematics of ground fissures and seismogenic fault.

The geological, remote-sensing (Landsat-5 TM images) and gravity data, as well as the results of field microtectonic observations were analysed in order to understand the active tectonic structure of Attica and the corresponding geodynamic situation during the main shock.

Considering the distribution of main shock stress tensor and principal stress tensor of concomitant geodynamic phenomena together (Fig.1) as well as some peculiarities of surface faulting, derived from Landsat-5 TM satellite image, and deep faulting, determined on the Gravity Anomaly Map of Greece published by Lagios et al., 1994, in Bouguer reduction (Fig.2), the following conclusion can be drawn.

- There is a number of blocks of relatively small (up to 10-15 km) cross-sizes in Attica, which have been accommodated by successive alpine and post-alpine deformations (compressive and tensional) of the area.
- Horizontal axes σ_2 and σ_3 of observed stress tensor of Athens earthquake concomitant ground fissures are both tensional and more of less equal in absolute value, whilst the axis σ_2 coincides with the axis T of the main shock source mechanism but not the axis σ_3 as could be expected.
- During the main shock of Athens earthquake sequence several microblocks have moved each in its own way, along the activated by earthquake pro-existed bordering faults, in accordance with one of tensional axes, σ_2 or σ_3.
- This geodinamic situation, in association with blocks geometry, testifies the existence of spread tension and suggests the prevailing of vertical movements in the under study area during the main shock of Athens earthquake sequence.
- Some of fault zones, due to their lengths, can cause serious events. Therefore, these faults, most of them with unknown behavior, have to be studied further in order to assess seismic hazard and corresponding risk parameters for Athens Metropolitan Area and the adjacent areas.

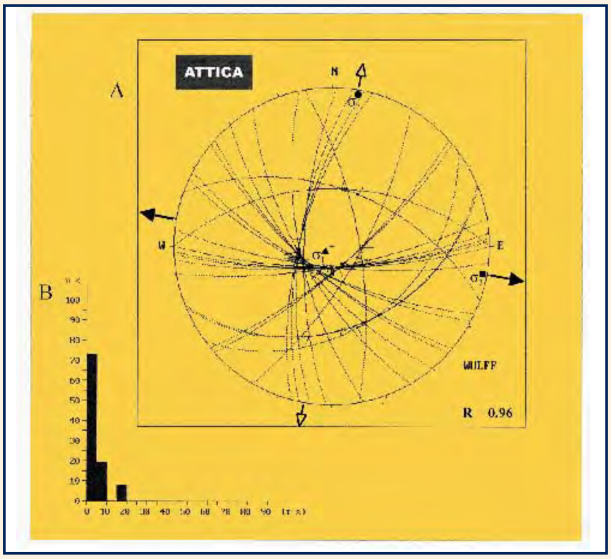


Fig. 1 Kinematic analysis of seismic ground fissures
A) Spatial distribution of planes with measured (s) and predicted (τ) slip vectors (Wulff stereonet, lower hemisphere),
B) Histogram of deviations between measured and predicted slip vectors for each plane

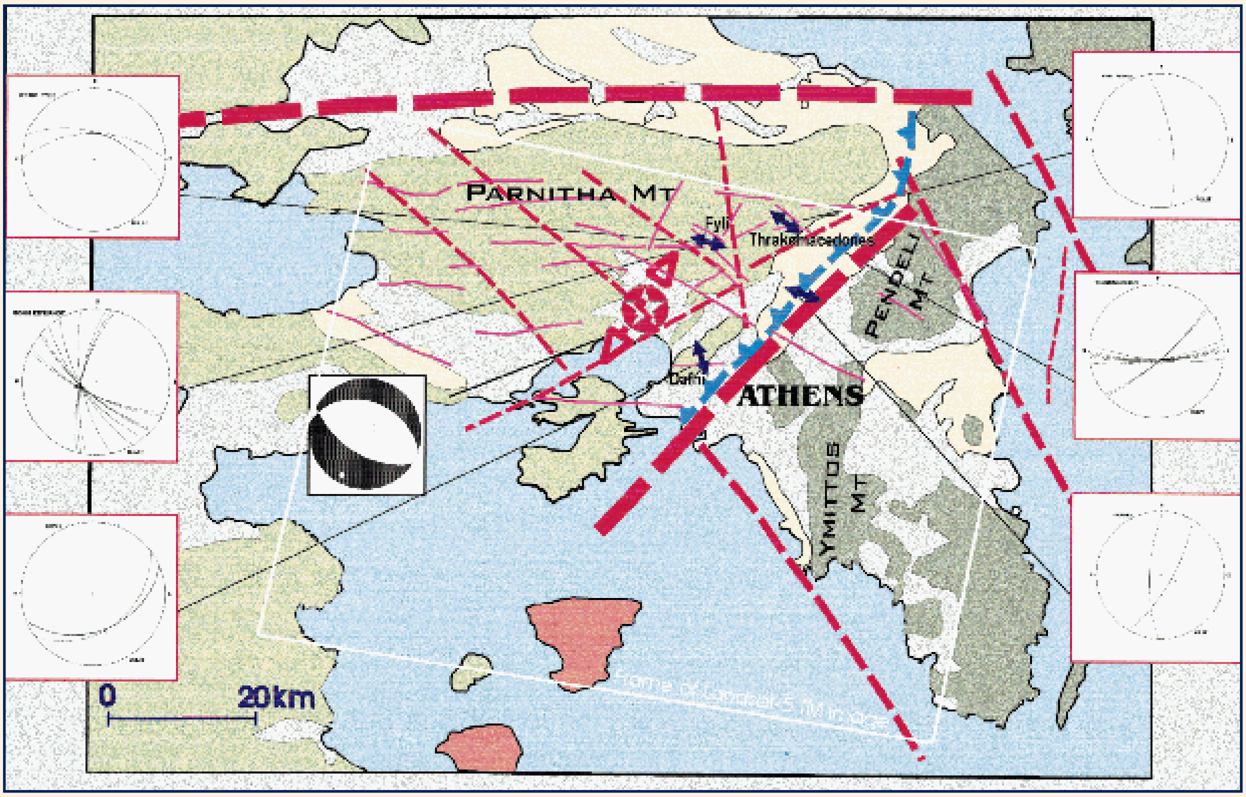


Fig. 2 Model of active tectonic structure of Attica and geodynamic model related to Athens earthquake.
Post-alpine units:

- Quaternanry deposits
- Neogene formations
- Alpine units: 3-Pelagonian zone
- Attico-cycladic zone
- Magmatic rocks
- Upthrust
- Main surface faults derived from IANDSAT-5 TM satellite image; Deep faults determined in gravity field;
- Major deep faults of couple, bordering the Parnitha tectonic structure and constituting the framework of Athens earthquake sequence,
- Other major deep faults,
- Minor faults
- Fault mechanism of the main shock
- Tensional direction associated with fault mechanism of the main shock
- Spatial distribution of seismic rupture planes
- Tensional directions associated with seismic surface ruptures.

4

Damage distribution in the western part of Athens after the 7-9-99 earthquake

The text and maps are taken from Part B. "Soil classification due to earthquakes, of Western Athens area" of the study "Preliminary geological - geotechnical study of the disaster area (of Athens earthquake of Sept 7th, 1999) in NW Athens Basin" conducted for the Ministry of Environment, Planning and Public Works. Part B. of the study was carried out by P.Marinos, G. Boukovalas, G. Tsiambaos, G. Protonotarios, N. Sabatakakis and collaborators (N.T.U.A., Faculty of Civil Engineering, Dpt. of Geotechnical Engineering)

Figure 1 presents the map of damage distribution in the area of the western Attica Basin between Kifisos river and the mountains Parnitha and Aegaleo. Table I gives a brief description of the four categories of damage used for the preparation of the map.

The mapping of damages is not finished yet, and in many cases was based only on the external inspection of the building and on the results of the first degree, rapid, post-earthquake inspection. Thus it gives a rough picture of damage in western Attica Basin. This image allows us to get to some conclusions on the seismic wave propagation, the possible site effect or of other mechanisms due to local characteristics that must be considered in the reconstruction and the future construction. A more accurate picture will be obtained when the mapping of damage will be completed and the results from the second degree damage assessment of buildings will be taken into account.

TABLE I CATEGORIES OF DAMAGE*

Color	Description
Light blue	Slight damage
Yellow	Moderate damage (e.g. fine cracks to the walls)
Orange	Severe damage (e.g. large cracks or diagonal cracks on the masonry walls, fine cracks in structural members)
Red	Heavy damage (e.g. large cracks in structural members, collapse)

* This classification was made with the purpose of intensity distribution and not of the building usability assessment.

In the following the principal conclusions that came out of the damage distribution map are presented. It should be noticed that the soil conditions in the examined areas, as well as the epicentre position of the main earthquake as it was published by the National Geodynamic Institude of Athens (38.10°N, 23.56°E, depth 19km), were taken into account.

a) The severe and heavy damage (orange and red color on the map) were concertrated in the areas of Ano Liosia, Axarnes and Thrakomakedones, at a distance of 6 to 12 km from the epicentre.The accelerations in these areas are not known, since there were not any recordings of accelerations there. Nevertheless, it is obvious that these should have been high because of the small distance from the epicentre.

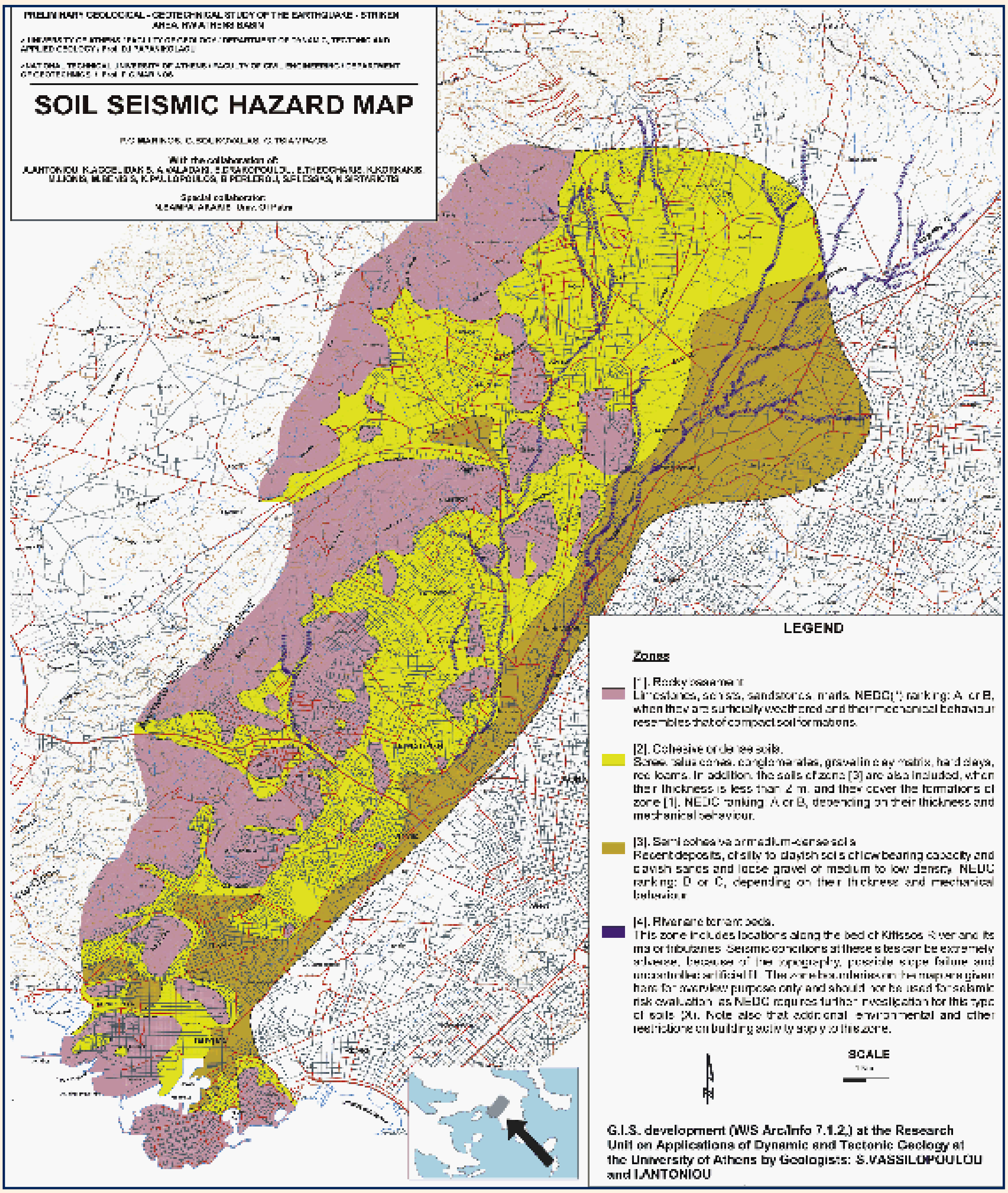
b) Severe and in some cases heavy damage (orange and red color on the map) was observed in scaterred areas far away from the epicentre, such as Adames, N. Liosia, Western Metamorfosi, Anthoupoli, Dasos Xaidariou, Lioumi and Prosfygika of Aigaleo. In these areas damages cannot be associated only with the close distance from the epicentre. On the contrary, damage in these areas indicates that there are also other factors that caused local amplification of the earthquake groundmotion. These factors could have been the soil conditions, the topography, the direction of the rupture and the particularities of a significant underground geological structure of the bedrock in the broader area. (More details about the last factor are given in the Report of Prof. D.Papanikolaou and his team, of the Geological Department of the University of Athens).

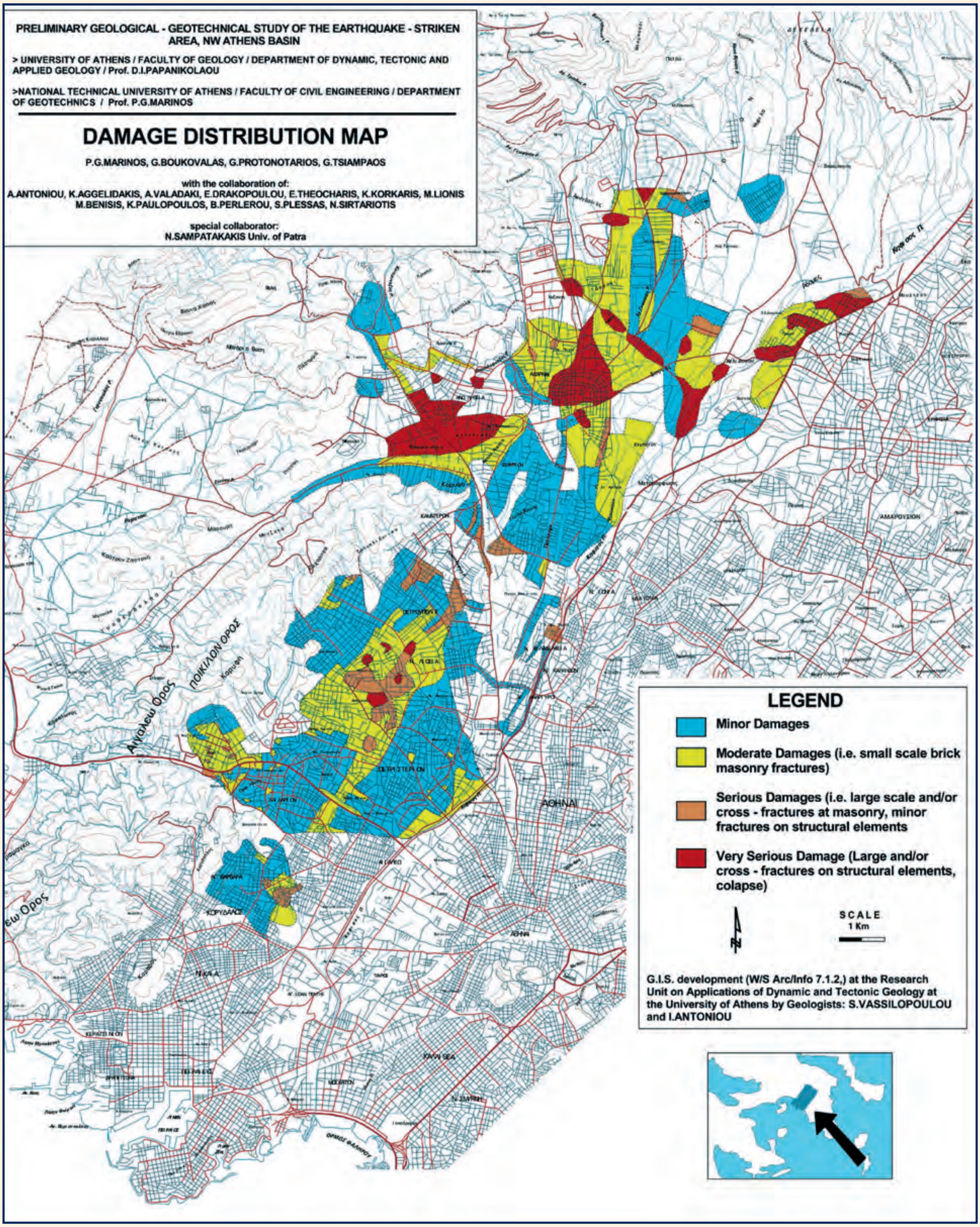
c) The indications for local amplification of the earthquake groundmotion in recent deposits, reculting from the comparative examination of the geological and damage distribution maps are many, in the epicentric zone as well as out of it. Some of these are mentioned as follows:

- In the Acharnes area there is a clear seperation between the north area where the damage was heavy and the south area where there was moderate damage.The limit between these two areas is more or less in accordance with the limit between the recent, more loose, soil deposits in the north area and the rock structure in the south.

- In Ano Liosia heavy damage and the collapses are found in the broader area of Zone 2 of Limni and of the central Ano Liosia, where the alluvium deposits prevail.
- In Nea Liosia the severe and heavy damage is concetrated in areas where the soils are cohesive and thick and they are bounded perimetrically by indications of rock structure on the surface of Zone 1.

d) In several cases there are strong indications of the influence of topography on local amplification of groundmotion and therefore on the damage. It is characteristic that heavy damage occurred in buildings, especially industrial buildings, on Tatoiou Avenue, which were built on the top of West slope of Xelidonous stream (between the Stream and Tatoiou Avenue). The same factor could have affected the occurrence of severe damage in the areas Adames, between the National Road and Helidonous stream.




PRELIMINARY GEOLOGICAL - GEOTECHNICAL STUDY OF THE EARTHQUAKE - STRIKEN AREA, NW ATHENS BASIN
> UNIVERSITY OF ATHENS / FACULTY OF GEOLOGY / DEPARTMENT OF DYNAMIC, TECTONIC AND APPLIED GEOLOGY / Prof. D.I.PAPANIKOLAOU
>NATIONAL TECHNICAL UNIVERSITY OF ATHENS / FACULTY OF CIVIL ENGINEERING / DEPARTMENT OF GEOTECHNICS / Prof. P.G.MARINOS
DAMAGE DISTRIBUTION MAP
P.G.MARINOS, G.BOUKOVALAS, G.PROTONOTARIOS, G.TSIAMPAOS
with the collaboration of:
A.ANTONIOU, K.AGGELIDAKIS, A.VALADAKI, E.DRAKOPOULOU, E.THEOCHARIS, K.KORKARIS, M.LIONIS
M.BENISIS, K.PAULOPOULOS, B.PERLEROU, S.PLESSAS, N.SIRTARIOTIS
special collaborator:
N.SAMPATAKAKIS Univ. of Patra
ΠΟΙΚΙΛΟΝ ΟΡΟΣ
Αιγαλέω Όρος
ΑΘΗΝΑΙ
LEGEND
Minor Damages
Moderate Damages (i.e. small scale brick masonry fractures)
Serious Damages (i.e. large scale and/or cross - fractures at masonry, minor fractures on structural elements
Very Serious Damage (Large and/or cross - fractures on structural elements, colapse)
SCALE
1 Km
G.I.S. development (W/S Arc/Info 7.1.2,) at the Research Unit on Applications of Dynamic and Tectonic Geology at the University of Athens by Geologists: S.VASSILOPOULOU and I.ANTONIOU

5

Disaster response and reconstruction measures after the Athens Earthquake of September 7, 1999 (M=5.9)

By: V. Andrianakis, *President of E.P.P.O.*
M. Dandoulaki, *Alternate Director of E.C.P.F.E.*
N. Papadopoulos, *Director of E.P.P.O.*

The main characteristics and primary effects of the earthquake

At 14:57 on September 7th, 1999 there was a severe earthquake of Ms=5,9, 18 km NW of Athens. The earthquake affected a large area, part of which is Athens Metropolitan Area, causing intensities up to X-MM Scale in some areas. Tens of buildings collapsed, among them six factories. Since the earthquake took place during working hours, hundreds of people were trapped in the ruins. A number of 143 people died either in damaged buildings or by falling objects or of heart attacks. About 7,000 people were injured and more than 70.000 households became homeless. The power went off in many areas, this contributing to huge traffic jams. The telephone communication system was blocked by overuse (telephone panic) for several hours. The population in all Attica was alarmed and emergency evacuation of buildings took place.

Emergency response

Immediately after the event all human and material resources of the key response services were mobilized. The National Emergency Operations Centre at General Secretariat for Civil Protection was activated, as well as the Operational Centres of critical Services, i.e. Fire Services, Earthquake Planning and Protection Organisation, National Centre for Emergency Health Care (EKAB).

Of great significance was to obtain information on the situation as soon as possible. Given that all phones including the cellular ones, were blocked, initial information came from police and fire departments through their radiocommunication network. Disaster assessment teams were sent all over Attica. Helicopters were used for aerial survey. The media also communicated a rough picture of the situation.

Communications between disaster assessment teams and the Operation Centres were established soon after, through hand radios. Volunteers were used to facilitate radiocommunications.

Search and rescue was the first priority. Rescue operations took place in 32 collapsed buildings. The Greek rescue team, Fire Brigade, volunteers, engineers from EPPO and medical personel from the National Centre for Emergency Hearth Care, took part in search and rescue operations. Rescue teams from Cyprus, France, Germany, Hungary, Israel, Russian Federation, Switzerland and Turkey, arrived the next day in order to assist in search and rescue.

Informing the population was also vital and urgent. The media were very helpful at informing people, on the other hand they put pressure on decision makers and disaster managers requesting constantly information. In less than an hour after the earthquake official instructions were disseminated through the media on what people should do and not do during the emergency situation.

At the same time, a series of emergency operations took place. Some of these were:

- Safety inspection of buildings housing critical facilities (hospitals, police stations, fire departments, emergency operation centres, specific public functions e.t.c.). Temporary accomodation of critical facilities, if nessecary.
- Traffic control.
- Damage inspection and re-operation of life-lines.
- First aid and medical care
- Safety inspection of public buildings
- Distribution of drinkable water, food and other items of immediate need.
- Installation of portable toilettes
- Shelter provision

Rapid safety evaluation and damage assessment of buildings

The next day the first degree, rapid safety assessment of buildings started, aiming at warning the occupants about the unsafe buildings. The standard method for rapid inspection of buildings issued by Earthquake Planning and Protection Organization in 1998, was used. Buildings were categorized in three categories and posted accordingly as:

Red: Unusable - Dangerous. No entry.
Yellow: Temporarily unusable. Limited entry at own risk.
Green: Possibly damaged but usable.

The operation was coordinated by the Ministry of Environment, Regional Planning and Public Works and it was carried out by groups of engineers either public servants or volunteers. More than 250.000 inspections were carried out in the wider area of Athens, were inspected. Approximately 50% of the buildings were deemed not safe to be occupied.

A few weeks later the second degree damage assessment of buildings was carried out at approximately 220.000 apartments and business premises in about 65.000 buildings. Damage was found in approximately 94.000 of them, 7% of which have been characterized as "Dangerous – Beyond repair".

Industrial buildings in the hardest hit areas also suffered serious damage and several collapsed (RICOMEX, FOURLIS, FARAN, etc.).

Serious damage resulting in the interruption of operations was suffered in several hospitals. Serious damage occurred in the hospitals of Voula, Nikea, and Sotiria. Lesser damage occurred in 27 other hospitals.

About 150 school buildings in Attica suffered non-structural damage resulting in the interruption of their operation. Serious

damage that could be repaired however, occurred in several schools in Attica.

In addition, serious damage occurred in 80 day-nurseries under the responsibility of the Ministry of Health and Welfare, while an additional 18 were jadged to be demolished.

Monuments also suffered from the earthquake. Serious damage occurred in the Dafni Monastery (11th century), the Fortress of Fili (5th century B.C.), the wall of Elefsina (5th century B.C.). A large number of engineered buildings housing cultural activities or objects of cultural value, including the National Theatre, the National Opera and the Archaeological Museum, was seriously damaged.

MEASURES FOR IMMEDIATE SUPPORT AND AID PROVISION

A series of measures were taken for the support of the population suffered by the earthquake, the most important of which are:

a: *Accomodation in tents and in hotels*

For the immediate accommodation of the earthquake victims the Ministries of Health and Welfare and National Defense offered 20.000 tents and those made homeless were accommodated In hotels belonging to the National Tourism Organisation (EOT) and the Union of Greek Hotel Owners.

b. *Special financial aid to earthquake victims*

Earthquake victims categorized as homeless by the first rapid safety inspection of buildings, were given special financial aid of GRD 200.000. Up to day, this aid has been given to more than 120.000 families.

c. *Special aid to pensioners, workers and the unemployed*

Pensioners, workers and the unemployed in areas hit by the earthquake, were given special financial aid ranging from GRD 100.000 to 120.000.

d. *Special regulations for dues to the State and to Health Funds*

Earthquake victims owing to the State had their current dues postponed for a time period of six months to two years.

e. *Contribution of the Public Institutions responsible for utilities and life-lines*

The Public Power Corporation (DEI) is paying for the necessary works (network, sub-stations and supply) for the supply of electricity to the organized tent camps and to the organized settlements of prefabricated houses. Electricity bills issued after 7 September 1999 for buildings hit by the earthquake will not be delivered. The Hellenic Telecommunications Organisation (OTE) has offered at its own expense free local and long distance telephone calls via card phones throughout the earthquake-stricken areas for a whole month, as well as the immediate and free transfer and reconnection of telephone networks and the suspension of collection of bills in earthquake-stricken areas. The Urban Transport Organisation (OAS) and the Athens-Piraeus trolley-buses are extending their routes to serve the organized settlements of prefabricated houses.

f. *Indemnification for the families of earthquake victims*
   The families of dead or seriously injured victim of the earthquake are given special aid of GRD 2.000.000.

g. *Compensation for loss of household*
   Families whose houses collapsed on the day of the earthquake are given compensation for replacement of their household up to the amount of GRD 2.000.000.

TEMPORARY HOUSING PROVISION

For the temporary accommodation of homeless until their houses are repaired or rebuilt, the Ministry of Environment, Planning and Public Works has introduced the following measures:

a. *Rent or shared lodgings subsidy*

This measure provides a rent subsidy for all homeless households renting a house, or a subsidy for shared lodgings to everyone put up in a house with friends or relatives, with sums ranging from GRD 60.000 to 120.000 per month.

b. *Creation of organized settlements with prefabricated or mobile homes*

   About 7.500 prefabricated or mobile homes for the temporary accommodation of families made homeless by the earthquake are established in organized settlements. The homes comprise approximately 100 settlements allocated to the region hit by the earthquake, and all the necessary infrastructure such as flood controls, water supply, sewerage, electricity networks and telecommunications is constructed for these settlements.

MEASURES FOR THE REPAIR OF DAMAGED BUILDINGS

Measures for the repair or reconstruction of damaged buildings provide for the granting of a Housing Assistance to the owners of buildings. Out of the replacement or repair cost, a 33% is a free state relief bonus and the rest is an interest free loan (with a rate of Interest subsidized 100% by the Greek State).

The main points of the measures regarding homes provide for:

a. For the reconstruction of houses that have collapsed or are deemed beyond repair, there is granted Housing Assistance of GRD 130.000 per square meter of the demolished house. The upper limit of the area eligible for loan is 120 square meters.

b. For the repair of houses that have been damaged but have been characterized as repairable, there is granted Housing Assistance up to amount of GRD 65.000 per square meter of the house to be repaired, on the above terms.

Similar measures are also foreseen for business premises, churches, etc.

MEASURES FOR LAND USE PLANNING AND INDUSTRIAL REGENERATION

In the areas hit by the earthquake, land use planning and industrial regeneration programmes are in progress, with the creation of special industrial areas to which industrial and manufacturing companies will be relocated. In addition, land use planning studies are drawn up for areas where it seems that there are problems of earthquake safety or where there is a large number of illegal buildings.

MEASURES FOR RISK MITIGATION AND EARTHQUAKE PROTECTION

The earthquake protection policy, falling under the responsibility of the Earthquake Planning and Protection Organisation (E.P.P.O.) and of the Ministry of the Environment, Planning and Public Works, has three main targets:

a. To **improve the seismic safety of buildings and infrastructure** by accelerating the enactment of seismic design code and building regulations as well as by the creation of the necessary statutory framework safeguard the quality of public works, and to standardize the specifications for control of building materials.

b. To **ensure the preparedness of the state and of local authorities** to manage an earthquake disaster and to provide aid, with the elaboration of the emergency plan, known as the ''Xenocrates-Earthquakes'' plan.

c. To **inform the public on earthquake protection** at home, at school and at work, and especially to train the school community in ways of protection, in order to develop earthquake awareness.

The main actions regarding the above mentioned issues are analysed in brief as follows :

A) The drawing up and enactment of updated building regulations, principaly of the New Greek Earthquake Design Code. The Code was established in 1995 and is being revised in 1999. In parallel, the Reinforced Concrete Regulation is also being elaborated by a special committee. Eurocodes comprise the third intrvention regarding issues of technical regulations.

   In additional, the Concrete Technology Regulation and the regulation on Steel Reinforced Concrete Technology are being worked on, as are special regulations, from the official scientific committees of E.P.P.O..

B) Significant interventions have been made during recent years regarding the issue of vulnerability assessment and safety of public buildings and infrastructure works in a pre-seismic stage.

   Special E.P.P.O. Programmes aim at the drawing up of technical guidelines for vulnerability assessment of existing public buildings, as well as of bridges.

C) Other programmes that are in progress are the drafting of an Earthquake Building Design Regulation, the New General Building Code with special antiseismic provisions, the elaboration of specifications for the microzonation studies, the elaboration and edition of neotectonic maps recording the active faults in Greece, the installation and operation of the National Seismograph Network and of the National Accelerograph Network.

D) Regarding earthquake education, training programmes for the directors of elementary schools and high schools are in progress, organized by E.P.P.O. in collaboration with the Ministry of Education. Also, information pamphlets that address the general public and the pupils, are edited and educational material is created with contemporary audiovisual methods for the information mainly of the pupils in issues of seismic protection.

The above programmes will be continued and added to with issues such as the evaluation and investigation of the effect of the earthquake on the buildings of Athens and its impact of the social and financial life of the areas that have been struck.

6

Psychosocial consequences of earthquakes in Greece

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Earthquakes are not infrequent and together with fires consist the principal type of disasters that hit Greece. Nowadays, it is well known that apart from the material damage and the life losses or physical health problems, destructive earthquakes cause serious psychological reactions that have considerable impact on society as a whole (1).

Based on the results of various international studies the intensity and the quality of the psychological reactions are determined by factors that relate to the seismic event itself (extent, duration, degree of material and human losses), to the characteristics of the individual (personality traits, previous experiences), and to the social environment (organization of the afflicted group, level of readiness and efficacy of action taken by local authorities, expected support and outside help actually provided) (2).

Regarding the advent of a disaster there are distinct periods that are characterized by specific psychological reactions. Especially for earthquakes, the phases of psychological reactions exhibit some particular features, because the immediate post-disaster period coincides with the pre-disaster period of a potentially intense after-shock, as well as because the late post-impact period may be considered as a pre-disaster period whenever the area that was hit is characterized by high earthquake activity. The adaptation of individuals to the different phases of a disaster is followed by behaviours that can be differentiated to effective or ineffective. To these behaviours, the psychosocial consequences from the catastrophic event should be added, such as grief, social pathology and the secondary psychosocial stress (2).

The earthquake that hit Athens on the 7th of September 1999 was the second stronger earthquake over the last twenty years and in certain areas it caused exceptionally large material and human losses. Almost the third of the total population is located in the capital, a fact that manifold increases any eventual psychosocial consequences caused by such a grave seismic event. In the heavier affected areas, immediately after the disaster most of the psychological support agencies of the public, university or other sector, were on the spot. At the time of preparation of this manuscript, only 4 months after the catastrophic event, the city population is still in the late phase of the immediate post-impact period. For this reason there is a lack of definitive evaluation of data pertaining to the psychosocial consequences of this disaster. However, there is a prevailing feeling (mostly recorded during the first days through the mass media) that the affected population had an increased need for psychological support.

As reported in the scientific literature, similar disastrous events are followed by comparable reactions and this seems to be a universal phenomenon. Thus, one could appraise previous studies conducted in Greece after prior catastrophic earthquakes and extract correlations between their psychosocial consequences and these expected to be due to the recent earthquake in Athens. Immediately after intense seismic events, three quarters of the population is expected to develop some psychologic reactions and will notably change their daily habits as well as their living practices. The after-shocks, that last several days after the principal earthquake, are the source of severe apprehension and a large portion of the population prefer to remain in safe places outdoors for a variable time period. This is a phenomenon observed both abroad (3) and after the 1978 earthquake in Salonika (4) and the 1981 earthquake that hit the wider metroipolitan area of Athens and caused considerable damage. In 1981, most people hit by the earthquake in Athens and living outdoors, returned to their homes after the intense after-shocks had ended. Some individuals, however, reported a protracted period of apprehension and remained in the tents for more than two months. This fear was named "seismophobia" and has been regarded as a specific syndrome that develops after the immediate post-disaster period in individuals who experienced severe psychopathological and psychophysiological reactions during the earthquake that lasted over a protracted period (5). Several predictive factors for the development of the above syndrome have been identified such a low level of education, pre-existing high levels of anxiety and concomitant use of psychotropic medication for minor psychiatric causes. Furthermore, these individuals exhibited a particular profile in the development of psychophysiological reactions during and immediately after the event with increased tremor and urgency to urinate rather than tachycardia (5). During the first two weeks of the post-disaster period in Athens, a decrease of the number of hospital admissions for suicide attempts was recorded. On the other hand, the number of traffic accidents of all kinds did increase during that period (6).

During an earthquake in Egion (1995, 6.1R) a significant increase in anxiety levels was observed in nearly the total population hit by the earthquake in the form of reactions of the psychosomatic type such as startle reaction, difficulties in concentrating, continuous irritability, and problems in initiation of sleep; also 50% reported an intense fear of dying. Nearly 60% developed a mild to severe acute stress reaction that positively related to the intensity of the fear of dying that the individuals had experienced during the earthquake (7). During the late phase of the immediate post-disaster period an increase of anger and family, financial and social problems was also observed. Clear-cut psychopathology of the type of post-traumatic stress disorder was detected in 25% of the subjects (7).

In the 1986 Kalamata earthquake, besides the development of the well-known psychhophysiological reactions, the quantity and quality of sleep was reduced in a part of the population. Subjects who tended to have sleep disturbances that lasted for over two months had experienced intense psychhophysiological reactions during the disaster i.e. tachycardia, excessive sweating, shortness of breath, dizziness, and faintness. Moreover, they exhibited increased obsessivity-compulsiivity, depression and anxiety, a fact that wasn't necessarily related to the pre-existing anxiety levels. Poor sleep quality in predisposed individuals among the disaster victims was not related to the presence of long-standing anxiety but presumably its development was a direct consequence of the disaster (8).

During the late post-impact period an overall decrease of psychosomatic reactions and concomitant anxiety is observed, although anxiety is still higher than that during the pre-disaster period (7,9). In the Egion earthquake the post-traumatic stress reaction slightly subsider but was detected in 20% of the individuals assessed. This reaction was found to positively relate to the feelings of anger and wrath that an individual develops after a disaster and the level of pre-existing anxiety as a personality trait (7). Post-traumatic stress disorder appears to be protracted for several months or even years after the traumatic event, although it usually fades over time.

The extent and the impact of a serious and permanent psychopathology in the victims of an extensive disaster on the long run have not been yet sufficiently studied either in Greece or elsewhere.

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7

A comment on school protection

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According to the Greek Earthquake Design Code, school buildings are not considered as buildings of primary significance, as the hospitals or the power plants or the museums. Out of the four grades of significance of buildings according to their use (S1 to S4, S4 representing the higher significance) school buildings belong in the S3 grade. Nevertheless on the one hand they do shelter a large number of people and on the other hand their function is a requisition for the normality of everyday life in the city.

Right after the earthquake the Organisation for School Buildings started a thorough inspection of all school buildings in the broader Athens area. The outcome of the inspection was that only a small percentage of school buildings suffered structural damage. A large number of buildings though, suffered non-structural damage mainly in infill walls, pipelines, glass etc. Therefore, had the earthquake happened in school hours, a large number of students might have been injured.

By observing the type of damages it became clear that much of the damage would be expected if specialized engineers had inspected the building prior to the earthquake to perform vulnerability assessment.

In fact, the necessity for vulnerability assessment of buildings housing large numbers of people, was confirmed by the earthquake. This was encouraging to the group of engineers already working on setting together a methodology and procedure for vulnerability assessment of public buildings.

A first and relatively easy step is the assessment of vulnerability resulting from building content and some non-structural elements. A step-by-step procedure to perform this task is already elaborated and taught to the directors of schools though an ongoing train-the trainers program now in progress. The program aims at the training of the vast majority of the directors of elementary schools and highschool in the country in earthquake protection at schools, and it is conducted by Earthquake Planning and Protection Organisation in collaboration with the Ministry of Education.

8

Earthquake disasters bringing countries closer

By: Miranda Dandoulaki

Alternate Director of E.C.P.F.E.

In August 17th, 1999 at 3:01 local time, a magnitude7.4 earthquake struck NW Turkey leading to a major disaster. The scale of the disaster called for international support in response to the immediate and urgent needs. Thus, the Greek rescue team composed by rescuers from the Fire Services, engineers and geologists, doctors and paramedics, arrived in Istanbul the disaster day in the afternoon. The rescue team took part in rescue operations in Avcilar, area in Istambul, for two days and then moved to the epicentre area in Golcuk. Turkish volunteers (AKUT) assisted and orientated the Greek rescue team in the disaster area.

Turkey August, 1999.

At night on Friday August 20th, after 13 hours of efforts, the Greek rescuers together with Turkish volunteers (TOFAS) rescued a 9 years old boy trapped in a collapsed building in Degirmendere.

During the stay of the Greek rescue team, feelings of friendship and gratitude were expressed by Turkish people struggling with the tragic disaster in every opportunity and in various ways. At the same time the response of Greek people to aid request was overwhelming and there was an outpouring of towns, institutions, clubs, that kept sending donations.

In least than a month later in September 7th, 1999 at 14:54, Attica suffered a strong earthquake of 5.7 magnitude which caused extensive damage and the collapse of tens of buildings. Search and rescue operations started immediately. This time it was the Turkish rescuers (AKUT) who joined the intense efforts to save trapped people and it was the Greek people who responded with their gratitude and friendship.

RICOMEX factory, Greece September, 1999.

And again after the main aftershock (M=7,2) on November 12, 1999 near Duzce in Turkey, the Greek rescue team went back to Turkey to assist in search and rescue. The same day, a delegate from the Technical Chamber of Greece that was working with Turkish engineers on engineering aspects of the earthquake of August 17th, went to the disaster area to help the emergency response operations.

Thus, out of an acute disaster context, experienced by the two countries, "a window of opportunity" was opened leading to the strengthening of humanitarian and friendship relations which under normal conditions have found limited chanels to be expressed.

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