NEWSLETTER

of the

EUROPEAN CENTRE ON PREVENTION AND FORECASTING OF EARTHQUAKES

Council of Europe
Conseil de l'Europe

ISSUE No 1

JULY 1997

ATHENS

- SEMINARS - SYMPOSIA
- RESEARCH PROJECTS
- NEOTECTONIC MAPS

Cover Sheet Photo:
Typical landscape of a Greek coastal area (south Kithyra Island) with remarkable active faults.

NEWSLETTER

ISSUE No1 • JULY 1997 • ATHENS

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EUROPEAN CENTRE ON PREVENTION AND FORECASTING OF EARTHQUAKES

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

Council of Europe Conseil de l'Europe

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PREFACE

Greece is the country with the highest seismic activity in Europe, with a number of destructive earthquakes in the last decades. In order to face all aspects of earthquake protection, the Greek Government established the "Earthquake Planning and Protection Organisation" (EPPO), in 1983.

Furthermore, Greece played a leading part within the Council of Europe, in the founding of the Open Partial Agreement (EUR-OPA Major Risks-Hazards, Agreement), on Prevention of, Protection against and Organisation of Relief in, Major Natural and Technological Disasters. This is illustrated by the organisation of the first Summit of Ministers of the ten founding member-states of the Agreement in Athens in September 1986.

Since then, several countries, even non-European, have become party to the Agreement, so the number of member-states has risen to 21.

Within the frame of the Agreement, Specialised Scientific Centres were established in order to promote issues on Natural Hazards and Risks. One of the first Centres established was the "European Centre on Prevention and Forecasting of Earthquakes" (ECPFE). This Centre has operated in Athens since 1987 as a scientific organisation affiliated to EPPO.

After ten years of functioning and despite the limited financial resources available, the Centre has achieved a remarkable amount of scientific work, which has not been widely known to the scientific community and to the public yet.

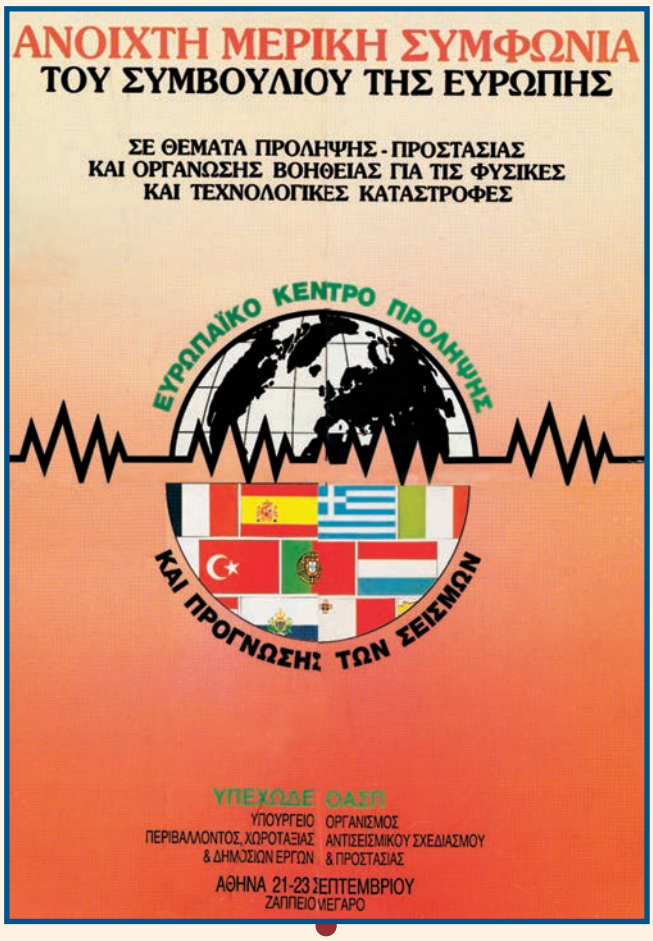
The present 1st Issue of the Newsletter of ECPFE gives a comprehensive picture and information regarding the aims and operation of the Centre. It also includes a synopsis of the initial outcome of the Centre's first accomplishments and of the completed or current Scientific Research Projects.

We hope that this Newsletter will be useful to all scientists, officials and professionals concerned, as well as to the general public, in Greece or abroad.

The President of ECPFE and EPPO

Professor D. J. Papanikolaou


Conseil de l'Europe/Council of Europe
Accord EUR-OPA risques majeurs
EUR-OPA major hazards agreement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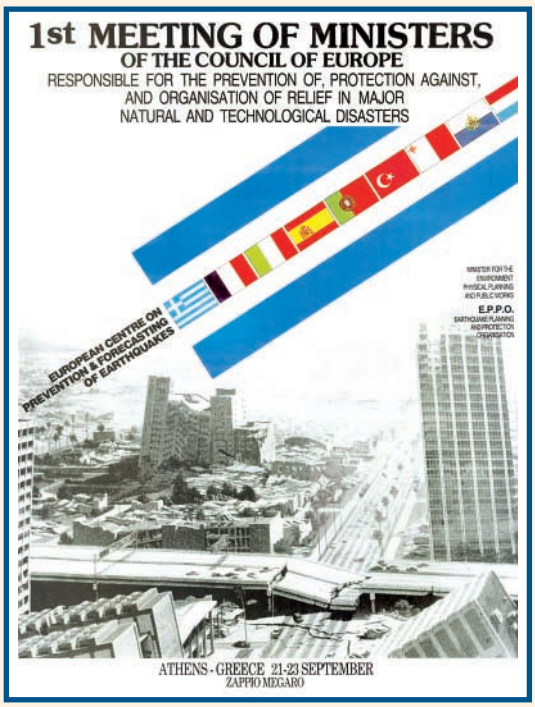

1st MEETING OF MINISTERS
OF THE COUNCIL OF EUROPE
RESPONSIBLE FOR THE PREVENTION OF, PROTECTION AGAINST, AND ORGANISATION OF RELIEF IN MAJOR NATURAL AND TECHNOLOGICAL DISASTERS
EUROPEAN CENTRE ON PREVENTION & FORECASTING OF EARTHQUAKES
E.P.P.O.
ATHENS - GREECE 21-23 SEPTEMBER
ZAPPIO MEGARO

ATHENS 1986

OPEN PARTIAL AGREEMENT OF THE COUNCIL OF EUROPE - (OPA)

The Committee of Ministers of the Council of Europe adopted an intergovernmental Open Partial Agreement (EUR-OPA Major Risks-Hazards Agreement), the aim of which was to strengthen European co-operation from a multidisciplinary point of view, on Prevention of, Protection against, and Organisation of Relief in Major Natural and Technological Disasters (Council of Europe, Resolution (87), 2) , 20 March 1987.

The EUR-OPA, Major Risks was created by France, Spain, Italy, Luxembourg, Greece, Malta, Monaco, Portugal, Democracy of San Marino and Turkey in Athens, in September 1986, in order to respond to the consequences of Major Disasters (earthquakes, volcanic eruptions, etc). The Agreement is open to both member and non-member States of the Council of Europe and currently comprises 21 States .

There are three levels of action within this Agreement :

- the political level with the periodical meetings of the Ministers of the Agreement and that of the Committee of Permanent Correspondents which determine the co-operation policy corresponding to the objectives;
- the scientific and technical level with:
  the "European Warning System"
  the "European Advisory Evaluation Committee for Earthquake Prediction"
  the network of "Specialised European Centres" of the Agreement ;
- the specific programmes whose characteristics differ in relation to the activities of the first two levels concerning calling upon voluntary financial contributions.

The Commission of the European Communities and UNESCO, the World Health Organisation and the Department of Humanitarian Affairs of the United Nations participate in the Agreement, as well.

Within the scope of the Agreement, the following activities are to be implemented in co-operation with the Specialised Scientific Centres which follow.

- programme on relief organisation : doctrines, information, simulation, assistance, etc.
- training and research

The twelve Specialised Centres in Europe are the following:

- The European Centre for Disaster Medicine (CEMEC), San Marino
- The European University Centre for the Cultural Heritage (EUCCH), Ravello, Italy
- The European Training Centre on Natural Disasters (AFEM), Ankara, Turkey
- The European Centre on Prevention and Forecasting of Earthquakes (ECPFE), Athens, Greece
- The European Centre for Geodynamics and Seismology (ECGS), Walferdange, Luxembourg
- The European Centre on Seismic and Geomorphological Risks (CESG), Strasbourg, France
- The European Centre on Insular Coastal Dynamics (ICoD), Valletta, Malta
- The European Research Centre on Information Techniques to the Public in Emergency Situations (CEISE), Madrid, Spain
- The European Observatory on Oceanology (OOE), Monaco
- The European Centre for Non-Linear Dynamics and Theory of Seismic Risk (E.C.N.T.), Moscow, Russia
- The Higher Institute of Emergency Planning, European Centre of Florival, Belgium
- The European Centre on Major Industrial Disasters, Aveiro, Portugal

EUROPEAN CENTRE ON PREVENTION AND FORECASTING OF EARTHQUAKES (E.C.P.F.E.)

A. OBJECTIVES of ECPFE

The European Centre on Prevention and Forecasting of Earthquakes (E.C.P.F.E.) is a non- profit organisation. It was established in Athens according to AP/CAT/CES (92) 2, Resolution of Council of Europe in relation to European Network of Specialised Centres.

It operates within the framework of Council of Europe's Open Partial Agreement (EUR-OPA Major Hazards Agreement), which was ratified by the Greek Law according to L. 2031/26-3-92, Government Gazette 54/A'/3-4-92.

The Centre is involved in all aspects of prevention and prediction as well as in the development of practical ways of managing earthquakes. It gathers all relevant information and supports scientific approaches with a view to mitigating the consequences of earthquakes and their impact on human life.

B. ORGANISATION of ECPFE

The Organisation of ECPFE is based upon the Administration Board and the Scientific Committee, (established accordingly by the Δ16γ/62/3/103/Γ/16-2-94 ministerial act), which are appointed by the Greek Government on the basis of the proposals put forward by the Council of Europe.

The Centre is accommodated and run at the Earthquake Planning & Protection Organisation's (EPPO) headquarters for the time being, until there is special law regulating the ECPFE.

I. - The **Administration Board**, consists of 7 members who make decisions concerning the Centre's activities, research programmes, as well as the budget.

Since 1994, the members of the Administration Board are the following :

1) Prof. D. Papanikolaou , Geologist , President of EPPO , Professor of University of Athens, as **President**
2) K. Ioannidis, Civil Engineer, Director of EPPO as **Director**
3) Chr. Kostikas, Civil Engineer, member of the Administration Board of EPPO
4) E. Logos, Geologist, member of the Administration Board of EPPO
5) Dr. J.P. Massue , Executive Secretary of Council of Europe in Open Partial Agreements' Affairs
6) Benoit Brocart , Civil Protection Director , Ministry of the Interior of France (resigned in 1996)
7) Dr. S. Zoppi , Director of Centre for Protection of Cultural Heritage of Italy, Professor of University of Torino.

II. -The **Scientific Committee**, consists of 17 prominent scientists. Its main task is the submission of research and educational proposals to the Administration Board.

The members of the Scientific Committee are the following :

1) Dr. P.Karydis, Professor of Technical University of Athens, as **President**
2) Dr. S. Agelidis, Civil Engineer, Professor of Technical University of Athens
3) Dr. K. Anastasiadis, Civil Engineer, Professor of University of Thessaloniki
4) Dr. A. Vasilikou-Dova , Assis. Professor of Physics , University of Athens (resigned in 1995)

5) Dr. J. Drakopoulos, Professor of Seismology , University of Athens
6) Dr. I. Mariolakos, Professor of Geology, University of Athens
7) Dr. D. Moundrakis, Professor of Geology, University of Thessaloniki
8) Dr. V. Papazachos, Professor of Seismology, University of Thessaloniki
9) Dr. A.Tselentis, Assoc. Professor of Seismology , University of Patras
10) Dr. M. Fardis, Civil Engineer, Professor of University of Patras
11) J. Sbokos, Civil Engineer, ex Secretary of Forests and Natural Environment
12) Dr. N. Sobolev, Professor of Seismology, University of Moscow
13) K. Hamada, Director of National Institution of Research/Geoscience and Prevention of Disasters in Japan
14) B. Massinot, Director of CEA Centre, France
15) G. Gzitrom, member of the French Inspection for Risks, Ministry of Environment, France
16) Dr. R. Caputo, Professor of Geophysics-Tectonics, University of Rome
17) Dr. J. Bonnin, Seismologist, member of Euro-Mediterranean Centre for Seismological Research of Strasbourg.

III. The **Administrative Personnel** consists of the following employees of EPPO, who are appointed by the Director of EPPO :

- Director : K. Ioannidis

Secretariat:

- Technical Assistant : A. Roditou
- Administration Secretary : Chr. Zacharia
- Economical Assistant : Har. Makri

IV. The President Dr. D. Papanikolaou has been appointed by the Greek Government, in 1994, according to Δ11δ/0/5/25/1-3-94 Ministerial Act, (E. Papazoi), as **Permanent Correspondent** in O.P.A. of E.C., and Dr. J. Papoulia as his **Deputy Permanent Correspondent** . They participate in the meetings of the Committee of Permanent Correspondents of the member-states of the Agreement.

C. SCIENTIFIC ACTIVITY

The Centre's objectives are achieved through the following Scientific Activities :

C1. Organisation of Conferences, Symposia and Seminars
C2. Research Programmes
C3. Edition of Neotectonic Maps

A series of Technical Handbooks are to be compiled and published shortly. The compilation of the first Technical Handbook for Rescue and Emergency Operations has already been assigned and is expected to be completed in the near future.
The ECPFE's Newsletter, which is to be published annually, is also among the Centre's current activities .

C1. ORGANISATION of CONFERENCES, SYMPOSIA and SEMINARS

The Centre has organised and participated in several educational and training activities at both national and international level, and has been involved in the training of Rescue Operation Teams.
In particular, the ECPFE has organised and participated in the following Seminars and Symposia :

ATHENS, NOVEMBER 12-14, 1990

International Seminar on

"Rescue Operations in Catastrophic Earthquakes"

The topics presented during this International Seminar concerned applied methodologies on Rescue Operations. The Seminar was the first of its kind world-wide. The invited speakers either originated from earthquake inflicted countries of the last decade (Mexico, Soviet Armenia, Algeria, Iran, USA) , or have participated in national missions of rescue operation teams providing assistance in inflicted countries.

The topics examined at the Seminar were the following:

The types and quality of buildings, collapse mechanisms, stabilisation and transportation of ruins. Also discussed were the administration of rescue operation at National level, risk and danger of rescue operation, transportation of emergency material, transport and international co-operation.

The participants of this International Seminar reached the following conclusions:

There should be a common European Register of existing agencies and facilities for Rescue Operations. This would be the first step towards an integrated response, drawing upon the individual expertise of each country.

This could lead to a European group for the study of disasters which would :

- liaise with UNDRO within the International Decade for Natural Hazard Reduction
- promote the study of and research into disaster preparedness and response
- disseminate the knowledge that each country has acquired
- promote training in disaster preparedness
- set common standards.

At the end of this International Seminar, a 223-page Volume of Proceedings was issued with the following contents:

1. Organisational and Technical solution on restoration of collapsed settlements. Methods of utilization of damaged constructions. Elements caused by Accidents and Earthquakes.
2. Modes of structural damage and collapse after the 1980 earthquake of El Asnam.
3. Geotechnical and structural failures due to the Northern Iran Earthquake of June 21, 1990.
4. Search and Rescue Methods for trapped people - facilities and rescue team equipment.
5. Search methods for trapped people - Rescue methods.
6. Our experience and organisation of Disaster Medicine in earthquakes.
7. Disaster Medicine on Rescue Operations.
8. Emergency Health Services during the 1985 Mexico City earthquake.
9. "South Manchester Accident Rescue Team" at the earthquake in Armenia and most recently in Iran.
10. A rapid deployment hospital - The Israeli aid to the Armenian Republic after the earthquake in December 1988.
11. Organisation of medical aid in liquidation of Armenian earthquake consequences on site.
12. Equipment and intervention of Rescue Team.
13. Urban Search and Rescue facilities and equipment.
14. National Rescue Operations Management in the United States of America.
15. The role of Seismology in rescue operation management in Israel.
16. An overview on the development of the OFDA urban search and rescue response capabilities.

STRASBOURG, OCTOBER 15-18, 1991

International Conference on

"Earthquake Prediction: State-of-the-Art"

in co-operation with the European-Mediterranean Seismological Centre of Strasbourg- France and participation of UNESCO.

The papers presented and the discussions that followed during the Conference clearly showed that earthquake prediction research is developing rapidly. We are still far from the goal of providing deterministic or high probability prediction in a limited time frame. It has been emphasised that scientists should not conceal negative prediction results, but rather be encouraged to present them in order to improve the overall understanding of the process of earthquake occurrence .

Currently, short term predictions are associated with relatively low probabilities .

Geosciences have been able to reach higher confidence and probability levels in predicting earthquakes within a larger time period of years and decades.

It has become common place that the abilities to predict earthquakes could be further improved when based on observation, correlation and interpretation of a variety of different precursory phenomena. Data acquisition and correlation are facilitated if sensors for different precursors (such as seismicity variations, seismic anisotropy, various geophysical fields, ground deformation, ground water level variations, physical and chemical measurements in rocks and rock fluids), are recorded simultaneously. Thus, the strategy of multidisciplinary earthquake prediction programme in test-sites is recommended in addition to global studies .

Some observations have to be performed with borehole instruments . Test-sites should be established to provide a focus for coordination, collaboration and mainly cross-checking results and methods, through a wide variety of disciplines.

Special emphasis should be given to the revolutionary increase in information density with respect to crustal deformation which can be

obtained with space-borne methods.

Strategies should be developed torwards an effective combination of this high density information of regional and global character, and of results from local terrestrial networks of multidisciplinary activities.

It has also been pointed out that earthquake catalogues are essential for medium- and long-term prediction : this requires strengthening of collection , standardisation and quality assessment of parametric data. Although earthquake parameters are the most common data available, attention should also be paid to deformation , seismic sources, etc.

On the other hand, it becomes clear that predictions based on physico-mathematical models are promising ; new approaches, for example in the probabilistic domain and in non-linear dynamics , are required . This applies in particular to identification of anomalies in seismicity patterns.

It was also demonstrated during the meeting, that further development of time-dependent seismicity models and related observations (especially when treated in the probabilistic way) can be of practical use.

A 606-page Volume of the Scientific - Technical Contributions of this International Conference was issued with the following table of contents:

1. Seismicity and Theory
2. Geochemistry and Ground Waters
3. Geophysics
4. Crustal Deformation
5. Integrated Projects
6. Evaluation and Strategy
7. Social and Economic Impacts

SANTORINI ISLAND, GREECE, THERA INSTITUTE CONVENTION CENTRE, OCTOBER 13, 1993

International Workshop on

"Construction Techniques in Seismic Regions in Prehistoric Times"

The Workshop was organised by the European Centre on Prevention and Forecasting of Earthquakes(ECPFE) in co-operation with the European University Centre for Cultural Heritage of Ravello and the Scientific Network PACT, with the following topics:

- Background knowledge *of* the construction techniques in prehistoric times, especially in seismic regions;
- Construction techniques in Akrotiri, Santorini;
- Current state and pathology of the structures and materials of Akrotiri; vulnerability to seismic loading and possible reinforcement and repairing of the structures.

SANTORINI , GREECE,
OCTOBER 14-16, 1993

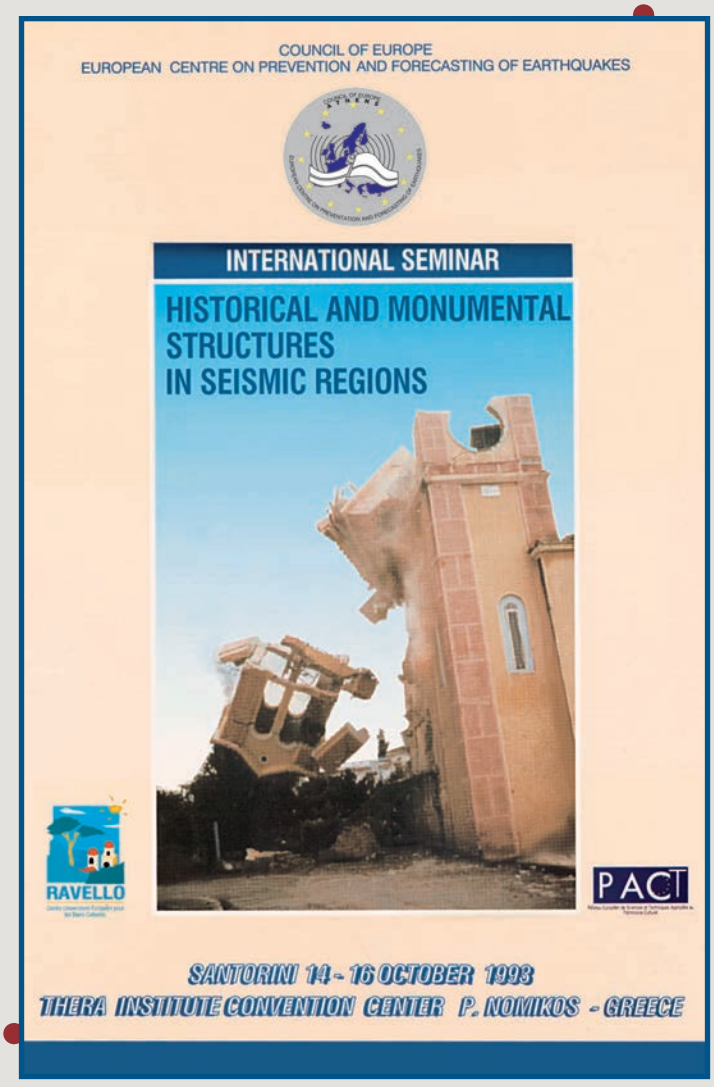
International Seminar on

"Historical and Monumental Structures in Seismic Regions"

included the following topics :

- Recognition of seismic phenomena in historical and ancient times ;
- Seismic awareness in historical and ancient times as seen through structural and constructional evidence ;
- Estimation of seismic response of historical and monumental structures;
- Methods of reinforcement as well as repairing and restoration of historical and monumental structures.

At the end of this international Seminar, a 128-page Volume of the Proceedings was issued in the English and Greek language.



ATHENS, MAY 4-7, 1995

European Symposium on

"Natural and Technological Disasters : The role of Women in Emergency Situations"

The European Symposium on the role of women in emergency situations was organised by the Mediterranean Women's Studies Centre (KEGME), (President Mrs K. Lazari).

It was held in Athens, on May 4-7 , 1995 , under the auspices of the Ministry of Environment, Urban Planning and Public Works and with the collaboration of the Council of Europe, which was represented by its executive secretary Dr. J-P Massue, the ECPFE, the EPPO, the European Network for Woman's Studies (ENWS) and the Friedrich Ebert Foundation.

The Symposium aimed at:

- the presentation of the role of women in emergency situations caused by natural and technological disasters;
- the study and analysis of women's experience in matters of health and life quality, women's strategies in emergency cases, women's participation in decision bodies, and their contribution to issues of environment, international organisations and relevant social and political actions.

The Symposium's conclusions and proposals were presented in the Beijing United Nations Congress for Women on "Equality, Development and Peace", in September 1995.

ATHENS, MAY 15, 1995

A one-day Seminar concerning

"The Dramatic Earthquake Disaster in Kobe"

Japan, on January 17th, 1995.

"The Seminar was organised by the ECPFE and EPPO".

During the Seminar an outline of response activities and disaster measures was presented, after the Hanshin-Awaji earthquake, as well as a number of data concerning the damage of buildings and lifelines. Such presentations were made by Japanese and Greek experts and scientists. The Seminar was attended by engineers, policy makers and practitioners involved in emergency response.

In addition, a technical meeting was held on May 16th, during which there was an exchange of experiences between the Japanese guests, delegates of Agencies and Organisations dealing with lifelines, and senior staff from EPPO. Also, representatives of Public Electricity Corporation, Water Supply Corporation and Gas Public Corporation participated and exchanged views and useful information on the issue of protection and prevention of damage to lifelines.

ATHENS, SEPTEMBER 17-20, 1995

Symposium on

"Seismicity of the Carpatho-Balkan Region"

On the occasion of the organisation of the XV Congress of the Carpatho-Balkan Geological Association, and the special interest of the European Centre for Prevention and Forecasting of Earthquakes , a Symposium on the Seismicity of the Carpatho-Balkan Region was held in Athens , aiming at providing the present state of research in the field of earth sciences and engineering applied to seismic problems. All in all, 35 papers on a variety of subjects were presented at the Symposium reflecting the response of the Scientific Community in the Carpatho-Balkan and other European countries. The program of the Symposium was divided into the following topics :

- Geodynamical process-Lithospheric stress and structure
- Seismic source parameters and modelling
- Seismicity, seismotectonics and active faulting
- Seismic hazard and risk assessment - Engineering seismology
- Earthquake prediction - Instrumentation of seismic networks and earthquake catalogues

The presented papers reflected different approaches to the earthquake problem, focusing mainly on the study of active faults, their correlation with earthquake activity and the importance of detailed microzoning studies based on all available data and multidisciplinary methods.

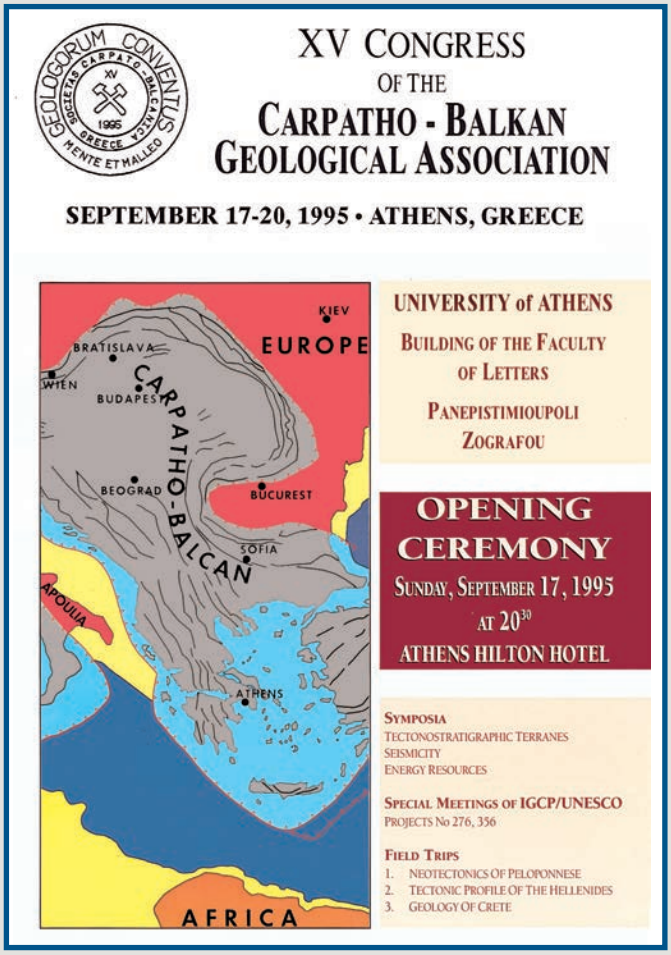
Emphasis was put on the development of a closer cooperation among specialists with different cultural background in order to reach practical operational solutions to the earthquake problem. Specifically, the participants of the Symposium, recommended that close cooperation among seismologists, geologists, geophysicists and other geoscientists is essential for solving the actual problems related to earthquake hazard, risk assessment and earthquake prediction , and adopting the following Resolutions:

- An effective cooperation between seismologists and geologists in order to refine the concepts of active faults and seismogenic structures and to better monitor their geodynamical behaviour.
- An increased cooperation among specialists in earthquake hazard and risk assessment and in earthquake prediction in order to improve significantly the corpus of available data, both in quantity and quality (earthquake catalogues, instrumental and historical : palaeoseismicity data ; deformation data) for seismic zonation purposes , in low seismicity areas as well , based on all available data .
- Development of channels to make data easily accessible to any potential user in favouring competitive, yet concerted interpretation .
- Survey of marine zones, presently poorly monitored, to improve the knowledge on their seismotectonic behaviour, since these areas cover a significant portion of the territory.
- With particular consideration to the crucial problem of earthquake prediction and its social impact , the participants in the Symposium observed that significant improvement has been achieved recently in long and medium term prediction and such an approach has offered an important tool to the authorities to develop aseismic codes to minimise human losses and economic consequences . However, further efforts should be devoted to short term earthquake prediction , since this field is still at a state of basic

research and should be submitted to standard evaluation practices in scientific matters .

The organisation of the Symposium fulfilled its goals in terms of presenting the state-of-the-art of research in the field of seismicity and seismic hazard evaluation in the Carpatho-Balkan Region, giving the directions and identifying the priorities addressed towards practical solutions that are most important in the earthquake problem.

At the end of the Symposium a 239-pages Volume of Proceedings was issued with the following contents:



1. Geodynamical process - Lithospheric stress and structure

- Seismotectonic Pattern of the Contact Zone between the West Carpathians and the Bohemian Massif (V. Schenk, Z. Schenkova)
- Earthquake versus tectonic movements (D. Prochazkova)
- Tectonic factors for the seismicity of SW Bulgaria (M. Matova, S.Shanov, G. Nikolov,Kurtev)
- Seismic character of Yugoslavian Carpatho-Balkanides (D.Sunaric, Sl.Nedelkovic, N.Popovic)
- Type of faulting and seismic deformation in the Hellenic arc (B.C. Papazachos, A.A. Kiratzi)

A traverse of the margin of the Ionian basin to the Hellenides : Coincident seismic and earthquake location survey (M.Sachpazi, A.Hirn, M.Loukoyannakis, STREAMERS Group)

2. Seismic source parameters and modeling

- Seismic source moment measurements from waveform inversion (J.Sileny, P. Campus, G.F. Panza)
- Size determination of weak Vrancea (Romania) earthquakes (Radulian, L. Ardeleanu, P.Campus, J.Sileny, G.F.Panza)
- Partial derivatives of synthetic seismograms of P-SV waves with respect to the structural parameters, (Urban,F.Vaccari)
- Rayleigh wave group and phase velocity measurements in the Pannonian basin, (Bondar, Z.Bus, M.Zivcic, G.Costa, A.Levshin)
- Site effects estimation based on source and path modeling of macroseismic intensities in the area of Greece, (A.S.Savvaidis, C.B.Papazachos, P.M.Hatzidimitriou)
- Focal properties of the 13 May 1995 large (Ms=6.6) earthquake in the kozani area-North Greece (B.C.Papazachos, D.G.Panagiotopoulos, E.M.Scordilis, G.F.Karakaisis, C.A.Papaioannou, B.G.Karacostas, E.E.Papadimitriou, A.A.Kiratzi, P.M.Hatzidimitriou, G.N.Leventakis, Ph.S.Voidomatis, K.I.Peftitselis, A.Savvaidis, T.M.Tsapanos)

- Source parameters of the Arnea, Kozani and Aigion earthquakes based on digital data (G.Stavrakakis, G.Chouliaras)
- The 13 May 1995 Western Macedonia (Greece) earthquake. Preliminary results on the seismic fault geometry and kinematics (D.Mountrakis, S.Pavlides, N.Zouros, A.Chatzipetros, D.Kostopoulos)
- The violent earthquake of the May 13, 1995 at Kozani-Grevena (NW Greece) (D.Papanastasiou, G.Drakatos, I.Kalogeras, J.Papis, M.Kourouzidis, G.Stavrakakis)
- Preliminary results of the catastrophic earthquake of June 15, 1995 at Aigio (N.Peloponnesus) (D.Papanastasiou, J.Baskoutas, D.Makaris, G.Panopoulou, G.Stavrakakis)

3. Seismicity, Seismotectonics and Active Faulting

- Some aspects of the Albanian seismicity, (E.Sulstarova)
- Romania's seismicity: Pre-instrumental data, (V.Marza)
- An example of a geological multidisciplinary research aimed at seismotectonic zonation of southern Latium (Central Italy), (C.Carrara)
- The main results of the seismological observations in the Aegean Sea, (S.A.kovacheva, I.P.Kuzin, L.I.Lobkovsky, A.V.Sonkin)
- Faults of big earthquakes (Ms>8.0) in the Hellenic Arc, (B.C.Papazachos)

Neotectonic fault segments and footwall geomorpholgy in eastern Greece from Landsat TM data,(A.Ganas,K.White)

4. Seismic hazard and risk assessment-engineering seismology

- Input data for seismic hazard assessment of the Adriatic region, (D.Slejko)
- Deterministic estimates of the seismic hazard in Bulgaria, (I.M.Stanishkova, G.Kosta, F.Vaccarri, P.Suhadolc)
- A linear and bayesian source model for seismic hazard estimation along subduction zones,(J.Papoulia, G.Stavrakakis, S.Kavadas)
- On the validity of the regional time and magnitude predictable model in Greece and Italy, (B.C.Papazachos, G.F.Karakaisis, E.E.Papadimitriou)
- Relationships between some seismicity parameters obtained by different methods in the Eurasian seismic belt, (T.Tsapanos)
- Time dependent seismicity along the Hellenic Arc, (B.C.Papazachos, C.A.Papaioannou, G.F.karakaisis)
- Some problems of the seismic structural design, (L.Tzenov)
- Ductility demand of reinforced concrete irregular frames, (E.Vasseva)

5. Earthquake prediction-instrumentation of seismic networks and earthquake catalogues

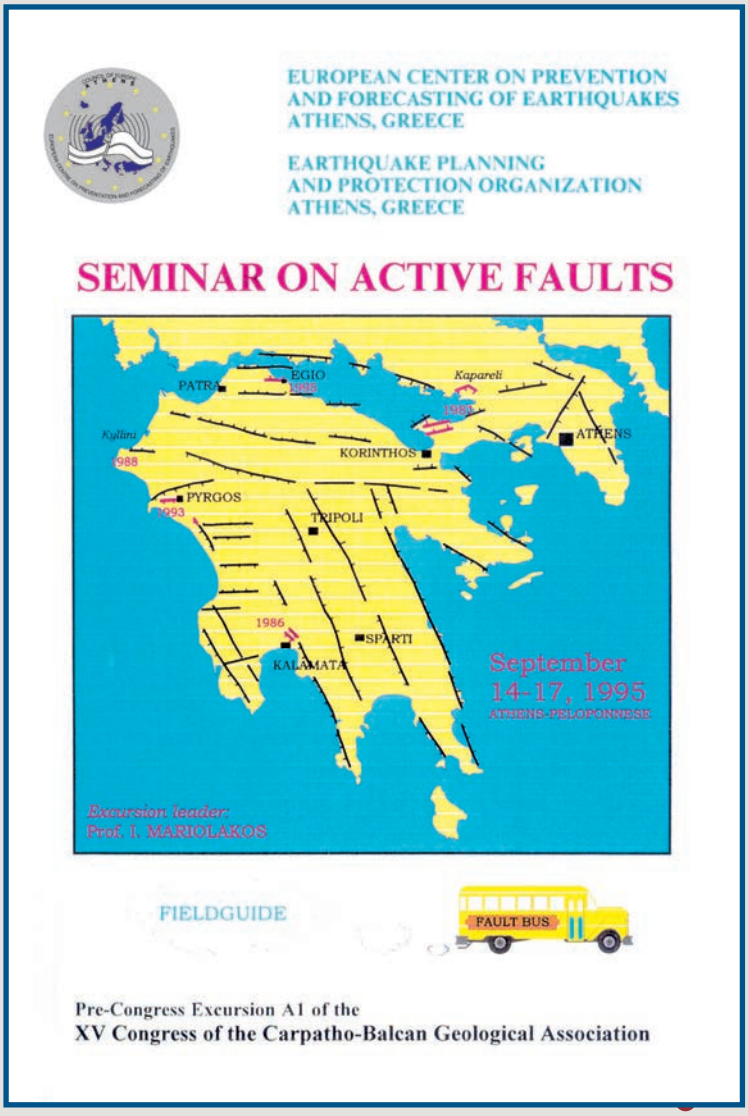
- Monitoring of the preparation of strong intermediate-depth earthquakes in Vrancea, Romania, using the CN algorithm, (O.Novikova, I.A.Vorobieva, D.Enescu, M.Radulian, I.Kuznetzov, C.Moldoveanu, G.F.Panza)
- Use of strong motion data in the relocation of earthquakes occurred in the area of Greece, (D.Papanastasiou)
- An earthquake catalogue for the Circum-Pannonian basin, (R.M.W. Musson)

ATHENS, THE PELOPONNESE, SEPTEMBER 13-17, 1995

"Seminar on Active Faults"

The programme of the Seminar included lectures given in the first day in Athens, and a four-day field-trip in several places with active and seismic faults mainly in the Peloponnese.
At the end of the Seminar, an 80-page Volume of Proceedings was issued with the following contents :

1. An introduction to the Geology of Peloponnese (Southern Greece), (D.Papanikolaou)
2. The present geodynamic regime of the Hellenic territory, (I.Fountoulis)
3. The deformation of the area around the eastern Korinthian Gulf, affected by the earthquakes of Feb.-Mar. 1981, (I.Mariolakos, D.Papanikolaou, N.Simeonidis, S.Lekkas, Z.Karotsieris, Ch.Sideris)
4. A proposed tectonic model for the evolution of the Gulf of Korinth, (I.Mariolakos)
5. The neotectonic evolution of the Isthmus of Korinthos area, (I.Mariolakos, E.Stiros)
6. Neotectonic faults and seismicity in the ancient Eliki area, (N.Mouyiaris)
7. The neotectonics of NW Peloponnese - The earthquake of Oct.16,1988, (I.Mariolakos, I.Fountoulis, E.Lekkas)
8. The Pyrgos earthquake- the geological and geotechnical conditions of the Pyrgos area, (W.Peloponnese, Greece), (E.Lekkas, D.Papanikolaou, I.Fountoulis)
9. Geomorphology of the area around Kalamata, (V.Sabot)
10. The neotectonic macrostructure of southern Peloponnesus. The earthquakes of Sept.13,1986, (I.Mariolakos, S.Lozios, E.Logos)
11. Description of the itinerary, (I.Mariolakos, I.Fountoulis)



ATHENS, DECEMBER 6-7, 1996

The Symposium on

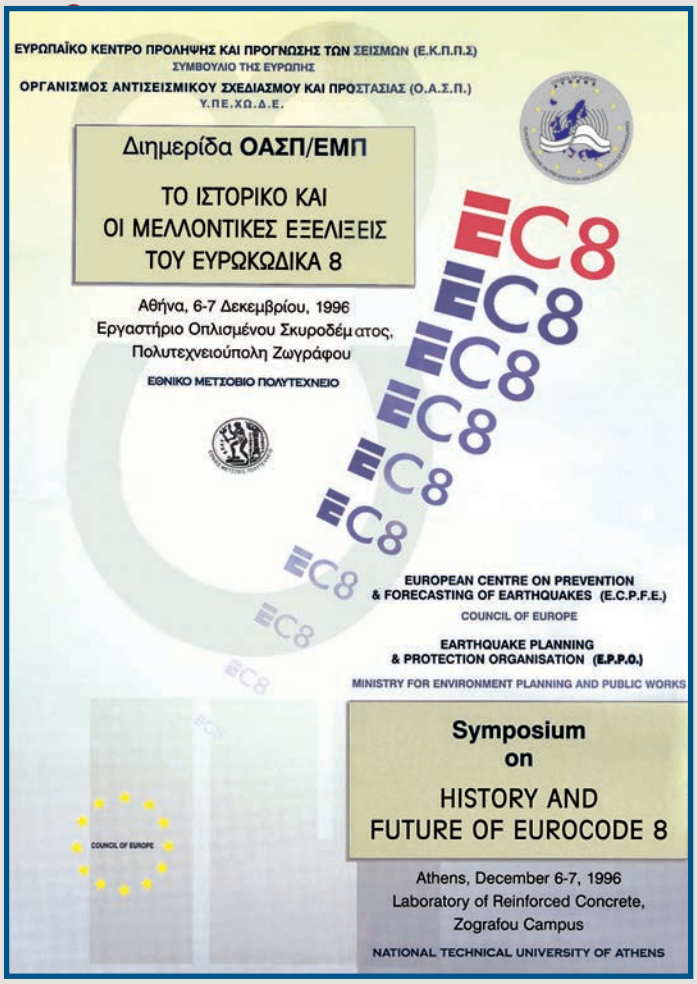
"History and Future of Eurocode 8"

was organised by the European Centre on Prevention and Forecasting of Earthquakes (ECPFE) and the Greek Earthquake Planning and Protection Organisation (EPPO) in co-operation with the Laboratory of Reinforced Concrete of National Technical University of Athens (Director Prof. Th. P. Tasios).

The aim of this Symposium was to provide the European Engineers, as well as those responsible for drafting National Codes, with information related to the scientific, legal and organisational environment of the European Aseismic Code.

Moreover, European Engineers will be able to take advantange of a global presentation of the European Aseismic Code, which also includes chapters that are not covered by National Codes in Europe. On the other hand, this event offered the possibility to discuss the conditions under which the European Union is going to plan future procedures for the finalisation of EC8.

The speakers were selected among who have contributed to the preparation of EC8, and those who are dealing with the organisation of future development of EC8 (collection of final comments, evaluation, legal status)



A 375-page Volume of Proceedings was issued, with the following contents:

1. The History of EC8, (H.Bossenmayer)
2. The actual state of EC8, (P.Pinto)
3. About the future of EC8, (E.C.Carvalho)
4. The framework of Eurocodes in Greece, (A.Placas)
5. Reinforced concrete structures (M.Fardis)
6. Steel structures, (I.Vayas)
7. Masonry structures, (E.Vintzileou)
8. Composite structures, (A.Karamanos)
9. Soil, (G.Gazetas)
10. Repair and strengthening, (T.P.Tasios)
11. Bridges, (V.Kolias)
12. Towers, Masts, Chimneys, (G.Gross)

ATHENS, DECEMBER 12-14, 1996

"International Workshop on the Research Programmes for Prevention and Forecasting of Earthquakes"

The International Workshop concerning the presentation of research programmes, was organised and sponsored by the European Centre on Prevention and Forecasting of Earthquakes (ECPFE) and Earthquake Planning and Protection Organisation(EPPO).
The presented research programmes covered subjects of seismotectonic, earthquake resistance design and social earthquake defence.
In particular, the results presented were of the following research programes:

- Presentation of the Neotectonic Map of 'Thessaloniki-Lagadas', (D.Moundrakis)
- Presentation of the Neotectonic Map of 'Korinthos', (D.Papanikolaou)
- Geological-Geotechnical-Neotectonic research in archaeological areas - monuments, (I. Mariolakos)
- A multidisciplinary study of earthquake precursors at the Eastern part of Central Greece (Thessalia), (E.E.Papadimitriou)
- Stress measurements using tomographic methods in boreholes, (A.Tselentis)
- Analysis of existing recordings of the Earth's electric field for the detection of long period variations as earthquake precursors, (A.Tselentis)
- Pilot study: Earthquake emergency plan for the Municipality of Athens, (I.Vasenhoven)
- Operational emergency plan for the Municipality of Herakleion in response to seismic disaster situations, (P.Delladetsimas)
- Earthquake behaviour of Ancient Greek and Roman monumental structures. Preliminary study of ancient monuments in Macedonia and Thrace, (G.Manos)
- Criteria for the evaluation of local soil effects on seismic motions, (G.Boukovalas)
- Stusy of the influence of infill walls in the seismic response of buildings and proposals for the improvement of their response, (P.Karydis)
- Eurocode 8 in the form of Expert System, (B.Koumousis)
- Torsional ground motion of the base and torsional response of buildings, (E.Mitsopoulou)
- Seismic behaviour and design of masonry buildings and infill reinforced concrete frames, (M.Fardis, E.Vintzileou)
- The last day of the International Workshop, a geological field trip to the faults of Korinthos area took place, leaded by Prof. D.Papanikolaou.

C2. RESEARCH PROJECTS of ECPFE

The ECPFE has undertaken a variety of research projects including: earthquake prediction research and studies on the seismic response of structures and their improvement of earthquake resistance design . Also two Pilot Studies on Emergency Planning for earthquake disaster in urban areas at the municipal level have been completed.

More specifically, the following scientific programmes have already been carried out:

1

"Multidisciplinary study of earthquake precursors at the eastern part of Central Greece (Thessalia)

Starting date of the Project : 20.1.92

Completion date of the Project : 11.4.94

By E.E. Papadimitriou (1), G.N.Stavrakakis (2), E. Lagios (3).

(1) Laboratory of Geophysics, University of Tessaloniki, GR54006 Thessaloniki, Gr.

(2) Seismological Institute, National Observatory of Athens, GR11810 Athens, Greece

(3) Department of Geothermy & Geophysics of Athens, GR15784 Athens, Greece

S U M M A R Y

Seismicity parameters have been determined for two seismogenic sources in which the Thessalia (Central Greece) area has been divided. Instrumental data concerning events which occurred during the present century have been used for this determination. The repeat times of the stronger (Ms>5.5) earthquakes have been estimated and used for the long term prediction in this area, on the basis of the time predictable model (Papazachos and Papadimitriou, 1993). Adopting the lognormal distribution as provided better fit to the T/Tt data, were T is the actual and Tt the theoretical repeat time, the probabilities P10, for the occurrence of strong (M ≥ 6.0) mainshocks during the next decade have been calculated for each seismogenic source. The magnitude, Mf, of the expected mainshock is also given.

An attempt was made to identify the Times of increased Probability (TIPs) of occurrence of moderate earthquakes ($M_L \geq 5.5$) by premonitory intermediate term seismic activation in lower-magnitude range, based on the algorithm M8 (Latoussakis, Stavrakakis and Drakopoulos, 1993). By scanning the territory of Greece and adjacent areas four regions are diagnosed as candidate for earthquakes of $M_L \geq 5.5$ since they had already entered the TIPs. One of these areas is that of Central Greece. Monitoring of their seismicity would provide further insight to the ongoing research on localisation of the impending earthquakes within TIPs.

With the purpose to reveal any precursory seismicity changes before strong earthquakes in the area under study, all earthquakes which occurred since 1901 in this area and were larger than certain cut-off magnitudes were taken under consideration (Karakasis, 1993). It was found that the 1980 Magnesia earthquake (Ms=6.5) had been preceded by an increased seismic activity which started about four years before the 1980 earthquake. On the other hand, trying to identify the current phase of the seismic cycle in Thessalia by using small magnitude seismicity data for the period 1981-1991, it was found that the seismicity rate shows no significant precursory variation while no earthquake with magnitude $M_L \geq 3.6$ occurred there since 1988.

A new method describing seismicity patterns in the space and time domain, namely the 'v-value' method, which is closely related to the apparent interaction between two successive earthquakes, has been applied to the earthquakes which occurred in the area of central Greece (near Volos) during the last 25 years (Papanastassiou and Stavrakakis, 1993). The 'v' parameter was derived on the basis of the Weibull distribution and its values characterise the earthquake sequence as being periodical (v>0.5), clustered (v<0.5) or random (v=0.5).

The determination of the relative site amplification factors at the recording stations of the telemetric seismological network, , has been made and operated by the Laboratory of Geophysics of the University of Thessaloniki at northern Greece (Hatzidimitriou,1993). For this purpose the properties of coda waves were used by applying the single S to S back-scattering model. We used data of local earthquakes occurred during the period 1983-1989 and which was recorded by the eight stations of the network. Spectral ratios of coda amplitudes have been calculated for lapse times between 30 sec and 60 sec and for frequencies of 1.5, 3.0, 6.0 and 12.0 Hz. The average site amplification relative to the means of all stations is calculated. All of stations show no or very low amplification and a stability over all frequencies.

Monitoring of a few geophysical fields which show an abnormal behaviour associated with earthquakes was attempted. Electromagnetic methods were employed and quantities like the magnetic induction and the natural potential are recorded. It is well known that the referred to fields show time and space dependent variations of precursory nature (Vargemezis and Tsokas, 1993). However, it is also well known that these signals do not appear in a regular pattern. Furthermore they strongly differ in magnitude, duration and occurrence time.

The magnetotelluric (MT) method of geophysical prospecting has been applied to detect possible changes in the electromagnetic properties in the Volos-Almyros area (22°E-23.5°E and 39°N-39.8°N) prior to the occurrence of a strong earthquake. Preliminary MT measurements were conducted in several sites in the region of interest, in order to establish noise free data (Chouliaras and Stavrakakis, 1993). These measurements showed that the MT results are in good agreement with the seismotectonics of this area and with other MT results from different tectonic regimes. A state of the art MT observatory was installed and operated in the area. In this manner, continuous magnetotelluric data have been recorded in order to detect any possible changes in the earth's electric field (resistivity, geoelectric currents, etc.). For this purpose, a software package has been developed and tested for the analysis of the recorded MT data.

A tectonomagnetic experiment in the broader area of Aghialos (eastern-central Greece) was conducted (Lagios, Sotiropoulos, Tsokas, Vargemezis and Papazachos, 1993). A network of 10 total field magnetic stations, distributed along the almost E-W trending fault system, was established in the area and remeasured a few times. Simultaneous data recording was performed at both the base and the other stations of the network in order to establish magnetic differences. A pattern of significant amplitude of magnetic differences was observed at the western part of the network, ranging between 20-180 nT, decreasing gradually to the east, where the magnetic differences attain negative values of about -15nT. The strong amplitude of the observed magnetic change at the western distribution of the stations should rather be attributed to the abundant ophiolite outcrops, which are expected to be connected at depth. It is difficult to interpret these magnetic field changes in terms of the seismomagnetic effect and make any other assessment related to earthquake prediction phenomena without longer period observations and detailed consideration of the local seismicity pattern.

2

"Analysis of existing recordings of the earth's electric field for the detection of long period variations as earthquake precursors"

Starting date of the Project : 20.1.92

Completion date of the Project : 7.12.94

By A.Tselentis, Ass.Prof. Univ.of Patras, G.Ikonomou Lect., A. Ifantis

SUMMARY

There are strong indications that there might be a relation between variations of the Earth's electric field and the seismic activity in a region, due to the accumulation of geotectonic stresses. The objective of this project was to investigate this phenomenon using the already existing recordings of the VAN group. In Greece, systematic observation of the earth's electric field changes were conducted since 1981 by a network of stations.

We collected all the available VAN recordings for a time period of 3 weeks before and one after two major earthquakes (Ms>6), that took place in the Greek territory. Data were in analogue form (chart paper recordings) and were subsequently sampled and digitised to facilitate processing. This was done for eight and six VAN stations which were in operation at each time and for the two orthogonal components of the Earth's electric field (East-West and North-South). Approximately 800m of chart paper were used. For the processing of these signals we developed special software based on linear and non-linear techniques. Print outs of the digitised signals before and after filtering are included in the report.

High frequency noise is filtered out first and subsequently the trend of the signal is detected. Differencing we are able to produce a signal that indicates the anomalous deviation of the electric field. Comments are made regarding its behaviour in each case and the resulted field components are positioned in vector form on a two dimensional map of Greece. For each earthquake, it's epicentre area and the location of the operating VAN stations are indicated.

In almost all of the stations a long period variation of the Earth's electric field was observed, starting 10-15 days before the earthquake. An attempt was made to assess the azimuthal direction of the epicentre region and the results show that in some of the cases it was possible to infer the focal region of the impending earthquake from the direction of the total electric field.

3

"Study of the influence of infill walls in the seismic response of buildings and proposals for the improvement of their response"

Starting date of the Project : 20.1.92

Completion date of the Project : 20.2.96

By: P.Karydis, Prof. of Earthquake Eng., Nat. Techn. Univ. of Athens- G. Ioakimidis- M.Vougoukas- Ch. Mousakis-I.Taflabas-A. Kotsopoulos-D.Benedetti- G. Benzoni- G.Gentile

SUMMARY

The subject and the scope of this research project was the investigation of the influence of infill walls on the seismic response of structures and to submit proposals for the amelioration of their response.

The influence of infill walls on the seismic response of structures has been, continue and will continue to be for a long period of time. The subject of scientific and technical interest, because :

- infill walls considerably influence the seismic responce of buildings in some cases favorably and in others unfavorably
- the geometry, the quality and the structural relationship between the infill walls and the load bearing system of a structure present a great variation
- the mechanical characteristics of infill walls can not easily be measured.

They have a marginal reliability and they present a great variability. As a result, a reliable mathematical model for infill walls can not be compiled.

It is indisputable that a large number of damages, injures and human losses are due to the failure of infill walls and to the consequences they have on the load bearing system of the structures.

Unfortunately, the respective codes do not give the adequate relevant guidelines, neither for construction nor for analysis, so that infill walls may be reliably included in the analytical calculations of the design.

Since, as it has been stated above, there are numerous combinations between the infill walls and load bearing systems, and given the rather limited funding of the present project, the research work was limited to the investigation of the following: An infill wall with the geometry of the letter H, with dimensions being 2.80 m along the web of the H and 1.50 m along the two flanges. The wall was placed in a four column steel frame. The steel frame simulated an intermediate storey of a common multi-storey block of flats. The same steal frame carries the necessary masses that will create the respective inertia forces during the seismic excitation.

The total number of the specimens were eight (8). Half of them had a width of the wall of 9 cm, while the other half had a width of 19 cm. In half of them a reinforcing beam was placed at midheight. Half of them were seismically excited along the web of the H and the other half along the flanges. The experiments were carried out in full scale.

It is considered that the cases under investigation constitute a good representation of real cases.

A result of the investigation is the determination of the percentage increase of the funtamental period of the structure, according to the damages incured in its infill walls, as well as the conclusion of more general observations about their earthquake responce. Of equal importance is the assessment of structural defects that are observed at the construction sites, and further, the proposal of the adequate structural details. An important also conclusion is that the infill walls must be well confined at their top side. Any gap due to settlements during the curing of the mortar at the first days must be filled with nonshrinkable mortar.

4

"Seismic Behaviour & Design of Masonry Buildings & Infilled Reinforced Concrete Frames"

Starting date of the Project : 20.1.92

Completion date of the Project : 9.8.95

By: Prof. M. N. Fardis, Univ. of Patras

Prof. E. Vintzileou, Nat. Techn. Univ. of Athens

SUMMARY

The project comprises two parts : The first refers to buildings with load-bearing masonry walls and the second to masonry- infilled reinforced concrete frames. These two construction types are predominant in the seismic regions of Europe.

The first part covers stone-masonry buildings, like the traditional ones, as well as brick-masonry buildings with concrete floors, of more recent or present construction. On the basis of the available test results on masonry consisting of solid, isotropic blocks, a new failure criterion was developed for isotropic masonry under multiaxial (biaxial or triaxial) stresses. Moreover, a thorough literature survey has identified the most complete among the available models for the ultimate strength of orthotropic brick masonry (i.e. for different properties of the masonry blocks in the two directions, as, e.g. in perforated clay units) under biaxial stresses, taking into account various alternative failure modes (tensile or compressive failure of the bricks, shear failure of the bed joints, etc.).These models were numerically implemented for use in conjuction with the Finite Element Method or other methods of analysis, so that the percentage of exceedance or non-exceedance of the masonry ultimate limit state under biaxial stresses can be computed at any point of the wall. In this way the seismic response of three typical stone masonry buildings (two storeys plus basement, timber floors and roof) was computed and assessed through comparison with recorded seismic damage. In addition to the Finite Element Method, the Equivalent Space Frame and the simple Method of Piers was applied for the analysis of the three buildings. In contrast to the Finite Element Method, the results of which are in good agreement with the magnitude and the location of observed damage, the Equivalent Space Frame model gives predictions in complete disagreement to the damage and to the Finite Element results. This regardless of whether the joint regions of piers and spandrels are considered as rigid only in the vertical members of the Equivalent Frame or only in the horizontal ones. The disagreement persists in the Method of Piers, which, however, despite neglecting the contribution of out-of-plane forces to the wall stresses, provides better agreement with the Finite Element results regarding the magnitude of the most critical biaxial stress state over the entire building.

After verification of its reliability, the Finite Element Method was used to quantify the effectiveness of various strengthening techniques of stone-masonry buildings and of combinations thereof. This effectiveness is measured as the average reduction in the wall biaxial stress state, either throughout the building or over the regions where wall failure is predicted prior to strengthening, relative to the unstrengthened building. Replacement of wooden floors by concrete slabs, in conjuction with the construction of concrete belts at the top of the walls, came up as almost equally effective as the construction of double-sided shotcrete jackets. Horizontal or vertical prestressing, one-sided jackets, and other common individual strengthening techniques, were found to be of low effectiveness and need to be

combined among themselves or to others, for satisfactory strengthening to be achieved.

Brick masonry buildings with concrete slabs were found, through the Finite Element Method, to have large differences from similar stone-masonry buildings, as far as their dynamic characteristics and response are concerned:

The response is dominated by translational modes of vibration and not by flexural ones in the walls, while the fundamental periods are shorter and are excited less by the usual seismic motions, in comparison to what happens in stone-masonry buildings. Moreover, due to their lower total mass and to its distribution mainly to the floors instead of the walls, these buildings were found to have very much superior seismic performance in comparison to the stone-masonry ones. Their seismic performance and safety is reduced though by the anisotropy of the masonry, which makes it vulnerable to shear sliding along the bed joints.

The results of alternative modelling and analysis of brick masonry buildings verified the conclusions of the analyses of the stone-masonry ones: the Method of Piers approximates the most critical biaxial stress state in the building walls much better than the Equivalent Space Frame approach in any of its variants.

The part of the project regarding infilled frames includes an extensive critical review of the cyclic test results on single-bay single-storey infilled frames and of the analytical/computational models of this behaviour, which were available until 1993. The input data and the results of the tests are systematically tabulated and the results are statistically processed. In addition, a new refined model of infilled frames was developed on the basis of the Boundary Element Method, considering Elastic materials with a no-tension and (shear) sliding interface between the frame and the infill. Parametric analyses using this model show insensitivity of the results to the frictional properties of the interface, as well as a significant reduction in lateral stiffness due to the loss of contact. In order to fill the identified gaps in the state-of-the-Art regarding the effects of infills on the global seismic response, most of this part of the project was devoted to numerical modelling to the global response of fully or partially infilled RC structures. A simple nonlinear hysteretic infill model of the bidiagonal equivalent strut type was developed specifically for this purpose, capable of describing the infill cyclic behaviour even under post-ultimate conditions. After calibrations on the basis of tests results, the model was implemented in a general purpose program for nonlinear static or dynamic response analysis in 3D, and was applied for the study of the sensitivity of the seismic response of a 4-storey building to the conditions and the properties of infilling. The modeling was verified through comparisons with the pseudodynamic test results of a full-scale 4-storey structure. The parametric studies covered the effect of the strength and stiffness of infills and of their presense or not in the ground storey. The results of nonlinear dynamic analyses of the response to motions up to 3 times stronger than the design ground motion of the bare frame (i.e.up to 0.9g effective peak acceleration) have shown that:

a) in contrast to conventional wisdom, the the effective lateral stiffness of the infilled structure is very little affected by the infills and is controlled by the stiffness of the cracked frame; b) due to the large energy absorption in the infills, fully infilled structures develop not only smaller displacements but also lower lateral forces than the corresponding bare ones, and their RC members remain elastic; and c) infilled buildings with open ground storey develop a strong localisation of damage in the open storey columns. The stronger the upper storey infills, the more intense is this localisation of damage. Nevertheless, while if the upper storeys infills are strong and the motion intensity is very high the ground storey damage may cause failure and collapse of the building, if the infills are relatively light and the motion does not exceed significantly in intensity the design motion, structural damage in the ground storey is limited. Finally, the

peak out-of-plane inertia forces on the infills were computed and very recent (1995) pertinent experimental results and models were used to assess the potential of out-of-plane collapse, which may lead to soft storey formation in the in-plane direction. The likelihood of this was assessed to be negligible for typical wall slenderness ratios and strengths.

Overall, it was concluded that, with few exceptions, the effects of infills on the seismic response are beneficial.

5

Pilot study: Earthquake emergency plan for the Municipality of Athens.

"Emergency Operation Plan against Seismic Disasters for the Municipality of Athens"

Starting date of the project :30.12.94

Completion date of the Project : 10.1.97

By : L.Vassenhoven, Prof. of Urban and Regional Planning, Nat.Techn.Univ. of Athens- A.Aravantinos, Prof. of Nat. Techn. Univ. of Athens- K.Sapountzaki, PhD in Urban and Regional Planning- E. Kiriazis, Civil Eng.- M. Dandoulaki, Civil Eng., Msc in Urban and Regional Planning, EPPO empoyee.

S U M M A R Y

Earthquake emergency planning in Greece is mainly based on the prefectural administration. Nevertheless, experience shows that in many cases Municipalities struck by an earthquake disaster, participate actively in emergency response and gain a role far more important than the one assigned by the Emergency Plan of the Prefecture. In such cases, co-ordination problems arise, as well as complications and delays in decision making procedures. Hence, it is important to plan the involvement of the Municipalities in emergency response in a way compatible with the Prefectural Emergency Plan.

In this framework, a pilot study has been conducted attempting to plan the emergency response of the Municipality of Athens after an earthquake disaster.

Outcomes of this study are expected to be:

- Determination of the Municipality role in an earthquake emergency and description of the tasks and activities to be undertaken.
- Allocation of Municipal Resources (human and technical) to respond to the above tasks.
- Suggestions of preventive measures concerning the Municipal area about the following:
  - a) Location and management of open space (parks, parking space, yards, etc.) taking into account the need to shelter the population evacuated after the earthquake and to relocate the public and health care services.
  - b) Traffic adjustments to facilitate emergency operations.
  - c) Usage and management of Municipal buildings and institutions after an earthquake disaster.
- A monitoring system of the resources available and operations in progress with a data base, necessary for continuity and effectiveness in emergency response process.
- An informative data base for emergency planning purposes and efficiency control checklists for the Municipal Services.

- Guidelines leading to the compatibility of the Municipal Emergency Plan with the Emergency Plan of the Prefecture.

The above Program was financed by E.C.P.F.E., E.P.P.O. and Municipality of Athens.

6

"Torsional ground motion of the base and torsional response of buildings"

Starting date of the Project : 14.4.95

Completion date of the Project : 17.9.97

By: E. Mitsopoulou, PhD. Civil Eng., Prof. of Aristotle Univ. of Thessaloniki-

I.Doudoumis, PhD. Civil Eng., Ass. Prof. of Aristotle Univ. of Thessaloniki -

D.Koumouras, Civil Eng.

S U M M A R Y

The object of the present project is the consistent consideration of the torsional component of the seismic action at the base of the buildings, as a result of spatially non-uniform ground motions and the estimation of the participation of this component to the final stress state of the building.

The torsional response of a building subjected to seismic excitation depends on the following :

a. Nonsymmetric-plan of the building

b. The torsional components of the earthquake motion (about a vertical axis) at the base of the building

c. Accidental construction inaccuracies in the mechanical characteristics of the building (stiffnesses, masses, etc.)

The rotational ground motion in many cases affects significantly the seismic response of structures (see A. Rutenberg and A.C. Heidebrecht, (1)). The structural response under rotational ground motion can be studied only if the rotational component of the motion is known. Since there are few direct measurements of this motion the most investigators develop torsional response spectra through the traveling wave methods, by which torsional accelerograms are developed first and then torsional response spectra are obtained (2), (3), (4), (5).

According to Rutenberg and Heidebrecht the torsional response spectra can be derived directly from the corresponding translational response spectra through an harmonic relationship. In the present paper a torsional response spectrum was defined by using this relationship in conjuction with the proposals of Newmark Nathan and Mackenzie (1), (7) and the tranlational response spectrum of the Greek seismic code.

The most seismic codes take into account the two different sources of torsional response of a building b and c (torsional ground motion and accidental discrepancies of the mechanical characteristics), by introducing the so-called "accidental eccentricity ".

Using the harmonic relationship between the translational and the torsional response spectra, an estimate of the accidental eccentricity is made and this eccentricity is compared with the given fixed eccentricity value of the seismic code.

A proper modification and extension of existing software (program SUPER-ETABS (9)) was made, in order to consider both the translational and the torsional components of the seismic action at the base of the building, when using the spectral method of dynamic analysis. By using the modified program numerical study of characteristic single-storey buildings is made in order to estimate the results of the torsional action.

7

"Earthquake behaviour of ancient classic and Hellenistic monumental structures - Preliminary study of ancient monuments of Macedonia and Thrace"

Starting date of the Project : 1.5.95

Completion date of the Project :

By : George C. Manos, Professor, Earthquake Simulator Facility, Dept. of Civil Engineering of Aristotle University of Thessaloniki, Greece.

Milton Demosthenous, Dr. Civil Engineer, Earthquake Simulator Facility of Aristotle University, and Institute of Eng. Seismology and Earthquake Engineering (ITSAK)

SUMMARY

Most of the representative ancient monuments of the Classic and Hellenistic periods have as their basic structural system the colonnade; this together with the stone-walls are the basic elements that resist both the gravity loads and the earthquake forces. Many of these monuments are at present in ruins as a result, among other things, of the seismic activity that these monuments have been subjected to from the time of their erection till today.

In the first phase of this research program the morphology of such ancient monuments was examined which are located in Macedonia and Thrace, in the North of Greece. Monuments that incorporate the colonnade as basic component in their structural system were selected. From the numerous archaeological sites in the Northern part of Greece the monuments of this study were selected from ancient cities of Vergina (famous capital of ancient Macedonia), Pella (the capital of Macedonia during Alexander the Great), Dion (the sacred city of Macedonia), Thessaloniki (the famous city surviving till today, named after the sister of Alexander the Great), Amphipoli (a city renown for its part in the Peloponesian war as well as during the expansion of the Macedonia Empire), Philippi (a city named after the Macedonia Kings, renown for the famous battle of the Roman Civil-War functions as well as of the Christian lore for the visit of St. Paul), Thasos (a city famous for its part in the Athenian Empire), and Samothraki (a sacred island with its history going back in the time to Orphic-lore).

From the examination of the selected ancient monuments in these cities, three types of columns were identified, that are also typical of monuments all over Greece, e.g. Doric, Ionic and Corinthian. During the second phase of this research, an effort was made to correlate the present state of ruin for these monuments with the seismic activity through the years, from 500 B.C. till today. This was done through both research of bibliography as well as in-situ observations. For the cities of Dion, Pella, Philippi and the ancient agora of Thessaloniki the correlation of the present state of ruin for these monuments and the seismic activity is clearly supported by both observations as well as references in the historic sources. For the rest of the examined archaeological sites there are strong indications from the in-situ observations for

such a correlation, although direct historical reference was not possible to be obtained by our research.

The earthquake behaviour of these type of ancient monuments is significantly influenced by the seismic performance of the colonnades. The basic unit forming a colonnade is the individual column. Such a column can be either monolithic or composed of a numbed of drums. The monolithic columns are, of course, the simplest structural form. They are free standing at the base without using any connecting mortar-type material. These structural elements, when the horizontal earthquake forces exceed certain amplitude, can either slide or rock at their base or slide and rock simultaneously. The rocking response depends, part from the amplitude of the excitation, on the natural rocking frequency and the coefficient of restitution. The column's natural rocking frequency can be obtained from its mass, the polar moment of inertia with respect to the rocking pole and the distance of the centre of mass from the rocking pole. As coefficient of restitution, a parameter is defined that is the statistical average ratio of the kinetic energy after a rocking impact with the kinetic energy prior to that impact. For the successful prediction of the rocking response of such type of columns it is necessary to estimate the coefficient of restitution with a certain degree of accuracy, because the rocking response is a non-liner phenomenon that is influenced significantly by variations in the value of this parameter. Various methods have been proposed up to now in order to obtain an estimate of this coefficient. It is the author's opinion that the most reliable methods are the ones employing experimental measurements together with valid numerical solutions of the basic differential equations governing the rocking response of this structural system for relatively simple forcing conditions (e.g. free vibration response).

During the third phase, from the various types of columns that were identified during the first phase of this research one of them, being of the Doric type, was selected as a representative case-study. A marble column of this representative geometry was then reproduced again, employing a local marble mason. This specimen was next transported at the earthquake simulator facility of Aristotle University of Thessaloniki, where its dynamic properties were investigated under rocking conditions, particularly the value of the coefficient of restitution.

Finally, during the fourth phase of this investigation a new procedure was developed aimed at obtaining a realistic estimate of the coefficient of restitution from dynamic measurements of the rocking response, which will perhaps find practical in-situ application. This new procedure makes use of the rocking acceleration response measurements in order to obtain the value of the coefficient of restitution. The validity of this procedure is checked from correlation studies whereby the value of the coefficient of restitution is the result of two independent ways, one of them utilising the acceleration response measurements whereas the other measurements of the displacement response. The practical significance of this new procedure is the fact that the acceleration sensors can be deployed in-situ in a relatively simple way as compared to the displacement sensors.

8

"Stress assessment from seismic tomographic measurements"

Starting date of the Project : 2.5. 95

Completion date of the Project : 12.9.97

By Prof. A. Tselentis, Seismologist- P. Tsarpalis - D.Paliatsas, MsSc. Eng.Geophysics

Coordinator of the Project : K. Grivas, Geologist

S U M M A R Y

The purpose of this project was to develop a methodology to assess tectonic stress variations at a region surrounding a fault zone from measurable variations of parameters of artificially generated seismic waves.

It is obvious that there is a close relation between the stress, elastic parameters and seismic velocities. By developing a tomographic inversion algorithm we have tried to relate these parameters. We have also developed a technique to quantitatively assess these variations by evaluating the transfer function of the medium. This technique is based on the comparison of the seismic amplitude spectra at two sites and the presentation of the corresponding standard deviations along 6 symmetric planes. This form of presentation permits the immediate recognition of even minor changes in the wave field. The tomographic algorithm which has been developed over-exceeds the 15.000 lines and has been successfully tested in various models.

The last stage of the project is devoted on the application of the technique along a well known fault zone and the use of a specially designed shear wave seismic hammer both for surface and borehole measurements.

9

"Geological-Geotectonic-Neotectonics Research on Archaeological Sites and Monuments"

-Minoan Palace of Kato Zakros

-Mycenae

Starting date of the Project : 1.6.95

Completion date of the Project : Project in progress

By Prof. I. Mariolakos - Prof. C. Sideris - Dr. I. Fountoulis, Geologist - E. Logos, Geologist (Dynamic, Tectonic, Applied Geology Division - University of Athens)

S U M M A R Y

The aim of this project was the investigation of geologic-geotechnic-neotectonic conditions and the influence they have on the archaeological sites of Kato Zakros (Minoan Palace), and Mycenae (Acropolis of Mycenae).

Archaeological Sites of the Minoan Palace in Kato Zakros

The Palace of Kato Zakros is the fourth largest among all the Minoan Era mansions. It was first built in

1900 BC. However, the ruins we find today are of a later period. They are the remains of the Palace built in 1600 BC which was reputedly destroyed by "fire induced by unknown causes" in 1450 BC.

The palace lies on the south-eastern foot of a hill overlooking a cove at the eastern coast of Crete.

The morphological depression feature of Kato Zakros corresponds to a neotectonic E-W trending graben; the bounding horsts feature characteristic planation surfaces (paleo-coasts). Seventeen paleocosts have been identified on the northern horst and thirteen on the southern one. The graben of Kato Zakros is normal compared to the much larger N-W graben of Zakros.

The geological formations that outcrop in the area are : a) ***Alpine formations of Tripoli Unit*** (a mesozoic carbonate sequence and flysch) and, b) ***post-Alpine formations.***

The palace is mainly situated on the folded flysch of Tripoli Unit.

The following observations have been made, after on-site research in and around the archaeological sites :

- There are important fractures that cut the construction stones for which the formation remains to be clarified .

- Fractures were also observed in various layers of the constructions.

- Certain buildings, as the ***Circular Reservoir*** or the ***Borne* Spring** which have been used for the collection and storage of water, are now found submerged 1.3 and 1.75 m. respectively below present sea surface.

-Two generations of fractured beach rocks were found at depths 1.5 and 3 m.

- Man-made constructions have also been found at similar depths : however, in this case their age or usage could be determined.

Taking into account all these observations, coupled with the fact that during that period, the area of the Mediterranean was under a climatic optimum (which means that the sea-level was higher than it is now) we are led to conclude that, apart from any geotechnical problem the structures should have experienced vertical movements. It is seismic activity that has drastically affected the vertical displacement rates and magnitude of the area, which has been undergoing subsidence.

Archaeological Site of the Acropolis of Mycenae

Mycenae, the town of legends, is one of the most important towns of the Mycenean Era of Ancient Greece (1580-1100 BC)

According to archaeological data, the town wall *was* built around 1340 BC, while the ***Gate of Lions*** and part of the western town are more recent, built around 1250 BC.

The ***Acropolis of Mycenae*** lies on a 280 m-high hill, two kilometres northeast of the modern village of Mycenae, at the north-west of Mt. Sora. A torrent (Havos or Chaos?) flows next to *the Acropolis*, south-west of Mt. Harvati (Profitis Ilias).

The outcropping geological formation in the area are:

(I) The alpine rocks of ***Sub-Pelagonian*** and ***Pindos Geotectonic Units*** (mesozoic carbonates, schist-chert-sandstone formation and flysch, respectively).

(II) ***post-alpine deposits*** comprising L. Pliocene-Pleistocene marls, conglomerates and sandstones, and Quaternary talus cones.

The Acropolis is mainly founded on the Triassic-Jurassic carbonate rocks of the Sub-Pelagonian Geotectonic Unit.

It should also be noted that Gate of Lions is cut by a large polished surface of an active fault.

The main problems encountered in the constructions of the archaeological site are of geotechnical nature, connected with the weathering of construction material, while the systematic fractures found cutting flagstones could be attributed to earthquake activity.

10

"Criteria for the evaluation of Local Soil Effects on Seismic Motions"

Starting date of the Project : 20.7.95

Completion date of the Project : 24.3.97

By : G.D.Boukovalas, Ass.Prof.of Nat. Tech.Univ. of Athens- D. Eglezos, Civil Eng.

Coordinator: A. Karamanos, Civil Eng., EPPO employee.

SUMMARY

The objectives of this project is to establish empirical criteria for preliminary estimation of local soil effects on seismic motions, based upon specific geological and mechanical soil properties which are commonly available or may be collected easily (e.g. geological maps and sections, conventional geotechnical profiles). Application of these criteria aims to decrease the time and cost required for the analysis of soil effects in seismic hazard studies of residential areas, commonly refered to as Microzonation Studies.

Preliminary findings : Initially, an extensive literature survey has been performed, for relevant empirical criteria to estimate soil effects on seismic motion parameters. From this survey, two practical groups of criteria were identified :

(a) Geological criteria

(b) Criteria based on the mean shear wave velocity $V_{s,30}$, over the top 30m of soil.

In addition, from vibration theory of one - and multi - degree of freedom systems, the importance of three additional basic parameters became obvious : the fundamental period of soil deposit, Ts, the prevailing period of the seismic vibration, Tsv, and finally, the intensity of the seismic motion expressed via the maximum acceleration a_{max}.

For the evaluation of the existing empirical methods, as well as the development of new improved criteria, one-dimensional analyses of seismic ground response were performed with the aid of appropriate computer software. More specifically, thirty-two soil profiles in Greece where analyzed, for two actual accelerograms from Pirgos (1993) and San Ysidro (1979) earthquakes. The sites analyzed correspond to the town of Pirgos (18 sites), from the Aktion-Preveza straits (4 sites), and from the main route of the Natural Gas Pipeline (10 sites). For all these sites, data from geological and geotechnical cross-sections as well as from Cross-hole in situ tests, are available. The total number of analyses performed so far, for different combinations of the basic soil and earthquake parameters identified earlier, exceeds 150.

The analysis method and the evaluation of the results are presented in detail in the article (submitted for

publication) "Prediction of Soil Effects on Seismic Motions- a Comparative Study". In the same article, the analytical predictions are compared with empirical predictions based upon either geological criteria or the mean soil profile velocity $Vs_{,30}$. These comparisons reveal the very approximate character of the existing empirical methods , especially when the vibration is quite intense (a_{max}>0.10g) and the soil behaviour is anelastic.

From the analytical work performed, it appears that it is feasible to establish general criteria for the estimation of soil effects, based upon the fundamental period of soil deposit and the prevailing period of the seismic vibration. As far as these parameters are concerned, the prevailing seismic period Tsv depends exlusively on the vibration under consideration. In contrast, the fundamental soil period Ts, is a function of the local soil conditions, as well as the intensity of shaking. Hence, to aid practical applications, all relevant analytical relations were collected from the literature and presented in manual form.

11

"Operational Emergency Plan for the Municipality of Heraklion in Response to Seismic Disaster Situations"

Starting date of the Project : 23.10.95

Completion date of the Project : 23.6.97

Scientific Coordinator: P.M. Delladetsimas, Senior Lecturer University of the Aegean- E. Kiriazis, Civil Eng.- E. Briasouli, Ass. Prof. of Univ. of Aegaeon, Urban and Regional Planning - N. Soulakellis, Lect.of Univ. of Aegaeon.

S U M M A R Y

The aim of this research programme which is still in progress, was the formulation of an overall seismic safety-urban planning policy and implementation procedure, which allow for an effective response to possible seismic emergency situations. More specifically the programme consists of :

a) An evaluation of the local preparedness level.

b) The development of an urban vulnerability analysis methodology and formulation of a vulnerability map of the City of Heraklion.

c) Reorganisation and adjustment proposals of the municipal administration structure in order to meet emergency demands.

d) Determination of proposals for reorganising basic geographical and urban planning elements which compose the physical support system of an emergency plan.

Thus, the first section of the research programme involves an extended elaboration of existing material related to seismic safety policy in the City of Heraklion and an evaluation of all policy documents which directly or indirectly deal with the matter (e.g. emergency plans launched by the police and fire departments, health care and first aid provision and also micro-zoning studies, land-use plans, transportation studies, etc.)

The second section of the programme consists of an attempt to quantify seismic vulnerability variations in the urban geographical setting. The core section of this phase is the formulation of a vulnerability map

based on the elaboration of parameters such as : densities, building-floor space indices, quality and age of building assets, land-uses, soil and structural characteristics and transportation volumes.

The third section concentrates on the study of the internal organisational-administrative structure of the municipality (administrative responsibilities, available staff, available technical and technological infrastructure, etc.). The aim here is to develop specific policy proposals, which lead to the maximisation of the local operational capabilities in order to meet emergency seismic disaster demands.

The fourth and final phase of the programme concerns the study of all urban and geographical elements of the City which compose the physical support system of an emergency plan; that is, the road and pedestrian network, open areas, the location of emergency policy institutions, areas and buildings of major population concentration etc. The study therefore, will produce specific planning proposals for the determination of evacuating routes, refuge areas, emergency aid provision areas and also appropriate location sites for the emergency policy institutions.

12

"Eurocode 8 in the form of Expert System"

Starting date of the Project : 20.11.96

Completion date of the Project : Project in progress

By: V.Koumousis, P.Georgiou, Ch.Gantes, C.Dimou

SUMMARY

Structural design codes are used in standard text format by engineers in everyday design work. Eurocode 8 contains the design provisions for earthquake resistance of structures, and is issued by the Commission of the European Communities as part of the Eurocodes . This code is complementary to other codes and refers frequently to the Eurocodes that cover design specifications for different materials like concrete, steel, timber masonry etc. Eurocode 8 is divided into five different parts and Part 1 in four main sections. Part 2 to 5 refer to specific types of structures such as bridges, masts and towers, foundations etc.

Today, most of the design work is performed in the computer and many engineers prefer to have an electronic access to these documents and a more direct answer to their problems arising during design. This need is covered by transforming structural codes in the form of hypertext and expert systems. In this form the information contained in the code is stored in a structured way offering better retrieving capabilities. Moreover, cross-links with relevant topics are available and search through an index can be very effective.

Hypertext systems are using much of the expert system technology to navigate the user through a tree structure of the provisions that correspond to specific cases. Therefore, the non-applicable provisions are skipped and only important information is displayed. The nodes of the tree that the system is interrogating may contain text, graphs video, voice and all kinds of different data structures of modern multimedia systems. In addition these systems have the ability to customize their functionality by incorporating personal notes, examples etc.

Another important aspect of these systems is to reveal the algorithmic part of the code provisions that give answers to questions of " How to " type. More specifically, in Eurocode 8 answers are provided in

the form of " How to Analyze" and " How to Design" specific structures and structural components made of a particular material.

Initially this system was based on the previous version of the Eurocode 8 and covered only three main Parts, i.e. 1-1,1-2 and 1-3. Recently, the program was extended to cover the same parts of the last release of the code (ENV 1998-1-1-October 1994). Therefore, the new version of the system is still under developent and in the future will be extended to cover the remaining parts of the Eurocode 8 . The new version incorporates also new developments in preparing these type of information systems. It is based on Windows 95 help system capabilities that prepare stand alone application.

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C3. NEOTECTONIC MAPS

1

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

Starting date of the Project : 20.12.94

Completion date of the Project : 6.12.96

By : D. Mountrakis, A. Killas, S. Pavildes, G. Koufos, E. Vavilakis, A. Psilovikos, L. Sotiriadis, Th. Astaras, M. Tranos and N. Spyropoulos Department of Geology, Aristotie University of Thessaloniki.

In the framework of the «national neotectonic map of Greece on a scale of 1:100,000» the group of geoscientists from Aristotie University of Thessaloniki attemp.ted to formalize a model for neotectonic mapping, using standard criteria for the classification of recent and active faults, geomorphological, remote sensing and seismotectonic data, as well as the international experience on the subject.

Two sheets of the region (1:000,000), including the city of Thessaloniki (1,000,000 population) and the seismogenic area of the 1978, M=6.5 earthquake, have been mapped. As the neotectonic mapping is a multidisciplinary approach, the collection of the original field data based on: a) stratigraphic study of the middle-upper Miocene, Pliocene and Quaternary sediments; b) geometry and kinematics of the faults; c) Alpine and pre-alpine structures, which are associated with active structures; d) geomorphological analysis and morphotectonic interpretation; e) photogeology and remote sensing analysis (both satellite imagery and aerial photographies were used); f) location of thermal springs; g) seismological data (epicenter, size, depth) arose both from remote seismological stations and from local and portable networks.

Problems arising during collecting and interpreting data are mainly:

a) recognition of active faults affecting basement rocks (Alpine and pre-Alpine formations); b) lack of complete geophysical data; c) multisense of fault movements, due to pre-existing polyphase tectonics (more than two famillies of striae, dip-slip and strike-slip), including that of inverse tectonics; d) distinction between geomorphological anomalies related to fault action and that related to geomorphological process, e) recognition of active faults along urban and cultural affected areas etc.

Finally, emphasis has been given on the geodynamic interpretation of the available neotectonic data in association with already existing ones of the broader region, as well as on the immediate application of the neotectonic information.

The structures in Central Macedonia show complex tectonic pattern characterized by four faulting directions. The area is mainly dominated by NW-SE normal faults with sinistral strike-slip component and E-W pure dip-slip normal faults. The state of the stress in the area, which has been calculated in detail by kinematic indicators, is extensional (directed N-S) under the influence of strike-slip movements of the North Aegean Trough Fault system.

Development of basins

The breakage of the initially uniform Miocene planation surface was the result of the later faulting. This faulting produced a fracture pattern of large fault-bounded blocks presented within the generally mature and very low elevation morphology of the area.

As mentioned above, some of the fault bounded blocks were estimated (using geomorphological criteria) to have been uplifted about 300-400m during Neogene and Quaternary times, forming several horsts such as the Vertiskos and Chortiatis ones.

In contrast, other fault blocks subsided, forming the present depressions of the area, such as the Axios-Thermaikos and Anthemountas basins which have filled up with Neogene and Quaternary sediments. Two tectonic stages can be inferred for the evolution of both the above mentioned basins taking into account the sedimentary, geomorphological and stratigraphic observations:

(1) the first tectonic stage caused the initial break up of the uniform planation surface into large blocks. These blocks have subsided individually since the early-middle Miocene, giving rise to several depressions that have been filled with mainly continental sediments intervening with some brackish to marine ones. This sedimentation process outlasts the Villafranchian period. The total thickness of the sediments in the Axios-Thermaikos and Anthemountas basins is estimated to reach about 3000m and 350m respectively.

(2) the second tectonic stage onsets the latest Villafranchian and produced some smaller depressions, which were filled up with Quaternary sediments.

As shown in the Table I, although individual evolution is recognized for each graben or depression, we can state that the subsidence of the grabens in the area of Gallikos, Axios, Loudias and Aliakmonas alluvial deltaic fields was about 400-600m during the Quaternary, whereas the subsidence of the smaller depressions (Anthemountas, Langadas, Volvi, Vromolimnes, Zangliveri, Marathousa, Doumbia, Chortiatis, Sochos) was much less and varied from 50m to 160m.

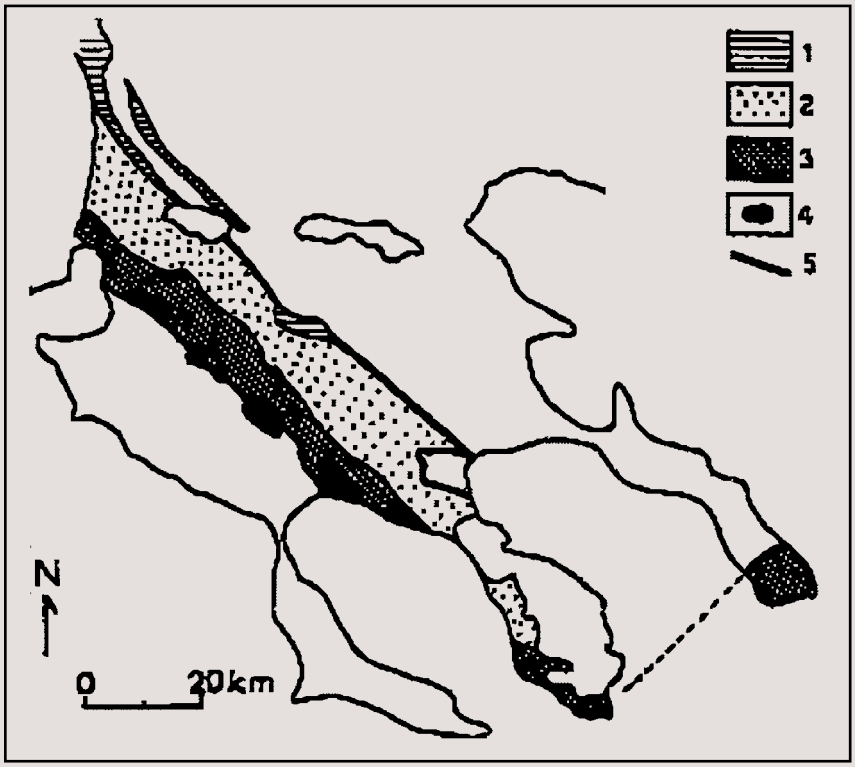


Fig. 1. Sketch-map of the Circum Rhodope Belt showing the three units of it and the most significant ophiolitic outcrops. 1: Deve Koran-Doumbia Unit, 2: Melissochori-Cholomontas Unit, 3: Aspri Vrisi-Chortiatis Unit, 4: ophiolites, 5: boundary between the Circum. Phodope belt and the Serbomacedonian massif (Mountrakis 1985, modified from Kockel et al. 1971, 1976).

The total vertical movements (including uplift and subsidence) of the Pre-Mygdonian and Anthemountas basins were abot 800-900m during the neotectonic period, whereas the total subsidence of the Axios-Thermaikos basin might have been as much as 3500m.

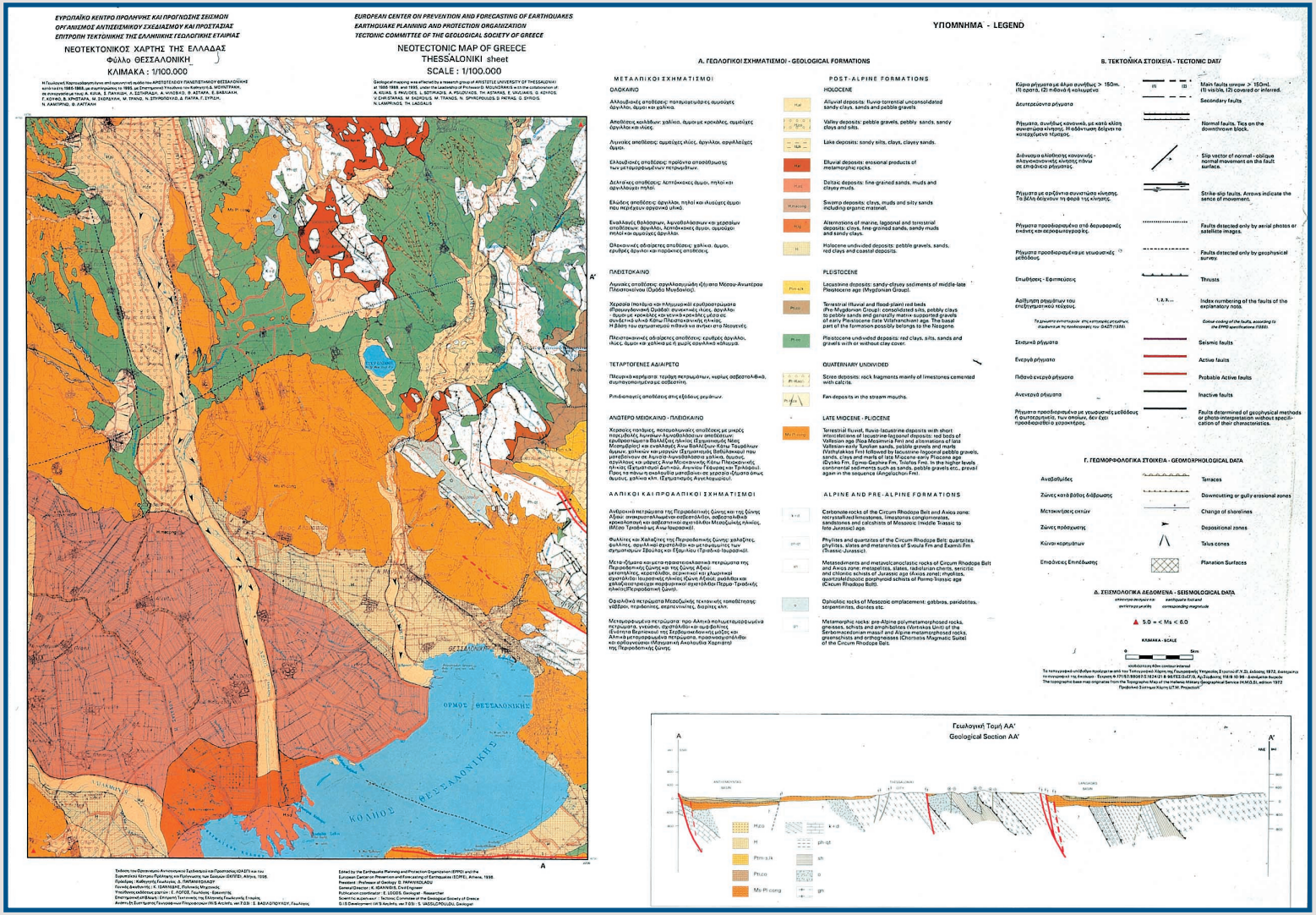
The subsidence as well as the sedimentation rates of the grabens of the area are considered very high, being $5X10^{-2}$ to $6X10^{-1}$mm/y during the Quaternary, whereas during the Neogene they were $2.3X10^{-2}$ to $2X10^{-1}$mm/y.

Neotectonic setting

Since the Miocene the area of Central Macedonia, where this neotectonic sheet is located, has been intensely faulted, forming many tectonic grabens and depressions such as the Axios basin, the Anthemountas and Mygdonian grabens etc. These depressions are the result of a fairly continuous extensional deformation, which was mostly associated with pure normal to oblique-normal faults trending mainly E-W, WNW-ESE and NE-SW. In addition, some long N-trending faults complete the general fracture pattern. Most of the above mentioned faults have been active at least since the Miocene, while some of them (mainly the E-trending faults) are associated with the present seismic activity or have a verified activity since the Quaternary.

It is worth noting that the Serbomacedonian massif is the most seismically active zone of the internal Hellenic domain.

"Thessaloniki Sheet"



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Φύλλο ΘΕΣΣΑΛΟΝΙΚΗ
ΚΛΙΜΑΚΑ : 1/100.000

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TECTONIC COMMITTEE OF THE GEOLOGICAL SOCIETY OF GREECE

NEOTECTONIC MAP OF GREECE
THESSALONIKI sheet
SCALE : 1/100.000

ΥΠΟΜΝΗΜΑ - LEGEND

Α. ΓΕΩΛΟΓΙΚΟΙ ΣΧΗΜΑΤΙΣΜΟΙ - GEOLOGICAL FORMATIONS

ΜΕΤΑΛΠΙΚΟΙ ΣΧΗΜΑΤΙΣΜΟΙ

ΟΛΟΚΑΙΝΟ

Αλλουβιακές αποθέσεις: ποταμοχειμάρειες αμμώδεις άργιλοι, άμμοι και χάλικες.

Αποθέσεις κοιλάδων: χαλίκια, άμμοι με κροκάλες, αμμώδες άργιλοι και ιλύες.

Λιμναίες αποθέσεις: αμμώδεις ιλύες, άργιλοι, αργιλλώδεις άμμοι.

Ελλουβιακές αποθέσεις: προϊόντα αποσάθρωσης των μετασχηματισμένων πετρωμάτων.

Δελταϊκές αποθέσεις: λεπτόκοκκες άμμοι, ηλοί και άργιλλοιμοί ηλοί.

Ελώδεις αποθέσεις: άργιλλοι, ηλοί και ιλυώδεις άμμοι που περιέχουν οργανικά υλικά.

Εναλλαγές θαλάσσιων, λιμνοθαλάσσιων και χερσαίων αποθέσεων: άργιλλοι, λεπτόκοκκες άμμοι, αμμώδεις ηλοί και αμμώδεις άργιλλοι.

Ολοκαινικές αδιάκριτες αποθέσεις: χάλικοι, άμμοι, ερυθρές άργιλλοι και παρόμοιες αποθέσεις.

ΠΛΕΙΣΤΟΚΑΙΝΟ

Λιμναίες αποθέσεις: αργιλλαμμώδη ιζήματα Μέσου-Ανωτέρου Πλειστοκαίνου (Ομάδα Μυσδονίας).

Χερσαία ποτάμια και πλημμυρικά ερυθροσαρμάρα (Πανομηνιακά Σχιστά: συνεκτικές ιλύες, άργιλλοι - άμμοι με κροκάλες και ισχνά κροκάλες μέσα σε συνεκτικό ιλυώδη Κόκκινο Πλειστοκαινικής ηλικίας. Η βάση του σχηματισμού πιθανά να αντίκει στο Νεογενές.

Πλειστοκαινικές αδιάκριτες αποθέσεις: ερυθρές άργιλλοι, ιλύες, άμμοι και χάλικοι με ή χωρίς αργιλλικό κάλυμμα.

ΤΕΤΑΡΤΟΓΕΝΕΣ ΑΔΙΑΙΡΕΤΟ

Πλευρικά κορήματα: τεφρά πετρώματα, κυρίως ασβεστόλιθοι, συμπαγοποιημένα ασβεστίτη.

Ριπιδοειδείς αποθέσεις στις εξόδους ρεμάτων.

ΑΝΩΤΕΡΟ ΜΕΙΟΚΑΙΝΟ - ΠΛΕΙΟΚΑΙΝΟ

Χερσαίες ποτάμιες, ποταμοχειμάρειες αποθέσεις με μικρές προσχώσεις λιμναίων-λιμνοθαλάσσιων αποθέσεων: ερυθροπράσινα ιζήματα Βαλλαΐζης οδικού (Σχιστόλιθοι Νέας Μεσημβρίας) και εναλλαγές Άνω Βαλλαΐζιων-Κάτω Τσαμάλων άμμων, χαλικιών και μαργών (Σχιστόλιθοι Βαθύλακκου) που μεταβαίνουν σε λιμνο-λιμνοθαλάσσια χάλικα, άμμους, άργιλλους και μάργες Άνω Μειοκαινικής-Κάτω Πλειοκαινικής ηλικίας (Σχιστόλιθοι Δωτίου, Λιγνίτες Γέφυρας και Τριλόφου). Προς τα πάνω η ακολουθία μπορβαίνει σε χερσαία ιζήματα άκρως άμμους, χάλικα κλπ. (Σχιστόλιθος Αγγελοχωρίου).

ΑΛΠΙΚΟΙ ΚΑΙ ΠΡΟΑΛΠΙΚΟΙ ΣΧΗΜΑΤΙΣΜΟΙ

Ανθρακικά πετρώματα της Περιροδοπικής ζώνης και της ζώνης Άξιού: αναμορφωμένοι ασβεστόλιθοι, ασβεστολιθικά κρυσταλλοσχιστόλιθοι και ασβεστιτικά σχιστόλιθοι Μεσοζωϊκής ηλικίας (Μέσο Τριαδικό ως Άνω Ιουρασικό).

Φυλλίτες και Χαλαζίτες της Περιροδοπικής ζώνης: χαλαζίτες, φυλλίτες, αμμώδη σχιστόλιθοι και μεταψαμμίτες των σχηματισμών Σφουτζά και Εξαμυλίου (Τριαδικό-Ιουρασικό).

Μετα-ιζήματα και μετα-πυριτοκλαστικά πετρώματα της Περιροδοπικής ζώνης και της ζώνης Άξιού: μεταπηλίτες, κερατεόλιθοι, σερικιτικοί και χλωριτικοί σχιστόλιθοι ιουρασικής ηλικίας (ζώνη Άξιού), ραδιολάρια και χλωριτοσερικιτικοί σχιστόλιθοι πορφυρικοί σχιστόλιθοι Περμο-Τριαδικής ηλικίας (Περιροδοπική ζώνη).

Οφιολιθικά πετρώματα Μεσοζωϊκής τεκτονικής τοποθέτησης: γάββροι, περιδοτίτες, σερπεντινίτες, διορίτες κλπ.

Μεταμορφωμένα πετρώματα: προ-Αλπικά πολυμεταμορφωμένα πετρώματα, γνεύσιοι, σχιστόλιθοι και αμφιβολίτες (Ενότητα Βερτίσκου της Σερβομακεδονικής μάζας και Αλπικά μεταμορφωμένα πετρώματα, πρασινοσχιστόλιθοι και αμφίβολιτικοί (Θηγαιακή Ακολουθία Χορτιάτη της Περιροδοπικής ζώνης).

POST-ALPINE FORMATIONS

HOLOCENE

Alluvial deposits: fluvio-torrential unconsolidated sandy clays, sands and pebble gravels

Valley deposits: pebble gravels, pebbly sands, sandy clays and silts.

Lake deposits: sandy silts, clays, clayey sands.

Eluvial deposits: erosional products of metamorphic rocks.

Deltaic deposits: fine-grained sands, muds and clayey muds.

Swamp deposits: clays, muds and silty sands including organic material.

Alternations of marine, lagoonal and terrestrial deposits: clays, fine-grained sands, sandy muds and sandy clays.

Holocene undivided deposits: pebble gravels, sands, red clays and coastal deposits.

PLEISTOCENE

Lacustrine deposits: sandy-clayey sediments of middle-late Pleistocene age (Mygdonian Group).

Terrestrial fluvial and flood-plain) red beds (Pre-Mygdonian Group): consolidated silts, pebbly clays to pebbly sands and generally matrix supported gravels of early Pleistocene (late Villafranchian) age. The basal part of the formation possibly belongs to the Neogene.

Pleistocene undivided deposits: red clays, silts, sands and gravels with or without clay cover.

QUATERNARY UNDIVIDED

Scree deposits: rock fragments mainly of limestones cemented with calcite.

Fan deposits in the stream mouths.

LATE MIOCENE - PLIOCENE

Terrestrial fluvial, fluvio-lacustrine deposits with short lacustrine-lagoonal sediments: red-green formations (Late Vallesian age: Nea Messimvria fm) and alternations of late Vallesian-early Turolian beds, pebble gravels and marls (Vathylakkos fm) followed by lacustrine-lagoonal pebble gravels, sands, clays and marls of late Miocene-early Pliocene age (Dytiko Fm, Egnatia-Gephira Fm, Triotia Fm). In the higher levels continental sediments such as sands, pebble gravels etc., prevail again in the sequence (Angelochori Fm).

ALPINE AND PRE-ALPINE FORMATIONS

Carbonate rocks of the Circum Rhodope Belt and Axios zone: recrystallized limestones, limestones conglomerates, sandstones and calcshists of Mesozoic (middle Triassic to late Jurassic) age.

Phyllites and quartzites of the Circum Rhodope Belt: quartzites, phyllites, slates and metarenites of Svoula Fm and Examili Fm (Triassic-Jurassic).

Metasediments and metavolcanoclastic rocks of Circum Rhodope Belt and Axios zone: metapelites, slates, radiolarian cherts, sericitic and chloritic schists of Jurassic age (Axios zone); rhyolites, quartzporphyric porphyroid schists of Permo Triassic age (Circum Rhodope Belt).

Ophiolitic rocks of Mesozoic emplacement: gabbros, peridotites, serpentinites, diorites etc.

Metamorphic rocks: pre-Alpine polymetamorphosed rocks, gneisses, schists and amphibolites (Vertiskos Unit) of the Serbomacedonian massif and Alpine metamorphosed rocks, greenschists and orthogneisses (Chortiatis Magmatic Suite) of the Circum Rhodope Belt.

Β. ΤΕΚΤΟΝΙΚΑ ΣΤΟΙΧΕΙΑ - TECTONIC DATA

Κύρια ρήγματα με άλμα συνήθως > 150m. (1) ορατά, (2) πιθανά ή καλυμμένα
Main faults since > 150m). (1) visible, (2) covered or inferred.

Δευτερεύοντα ρήγματα
Secondary faults

Ρήγματα, συνήθως κανονικά, με κατά κύριο συνιστώσα κίνησης. Η εδαφόπτωση δείχνει το καταρρέυσα τμήμα.
Normal faults. Ticks on the downthrown block.

Διάνυσμα ολίσθησης κανονικής - πλαγιοκανονικής κίνησης πάνω σε επιφάνεια ρήγματος.
Slip vector of normal - oblique normal movement on the fault surface.

Ρήγματα με οριζόντια συνιστώσα κίνησης. Τα βέλη δείχνουν τη φορά της κίνησης.
Strike slip faults. Arrows indicate the sence of movement.

Ρήγματα προσδιορισμένα από αεροφωτογραφίες και αεροδιαστροφικές εικόνες
Faults detected only by aerial photos or satellite images.

Ρήγματα προσδιορισμένα με γεωφυσικές μεθόδους
Faults detected only by geophysical survey.

Επωθήσεις - Εφιππεύσεις
Thrusts

Αρίθμηση ρηγμάτων του επεξηγηματικού τεύχους.
Index numbering of the faults of the explanatory note.

Τα ρήγματα αντιστοιχούν στις κατηγορίες ρηγμάτων σύμφωνα με τις προδιαγραφές του ΟΑΣΠ (1986).
Colour coding of the faults, according to the EPPO specifications (1986).

Σεισμικά ρήγματα
Seismic faults

Ενεργά ρήγματα
Active faults

Πιθανά ενεργά ρήγματα
Probable Active faults

Ανενεργά ρήγματα
Inactive faults

Ρήγματα προσδιορισμένα με γεωφυσικές μεθόδους ή φωτοερμηνεία, των οποίων δεν έχει προσδιορισθεί ο χαρακτήρας.
Faults determined of geophysical methods or photo-interpretation without specification of their characteristics.

Γ. ΓΕΩΜΟΡΦΟΛΟΓΙΚΑ ΣΤΟΙΧΕΙΑ - GEOMORPHOLOGICAL DATA

Αναβαθμίδες
Terraces

Ζώνες κατά βάθος διάβρωσης
Downcutting or gully erosional zones

Μετακινήσεις ακτών
Change of shorelines

Ζώνες πρόσχωσης
Depositional zones

Κώνοι κορημάτων
Talus cones

Επιφάνειες Επιπέδωσης
Planation Surfaces

Δ. ΣΕΙΣΜΟΛΟΓΙΚΑ ΔΕΔΟΜΕΝΑ - SEISMOLOGICAL DATA

επίκεντρα σεισμών με αντίστοιχα μεγέθη
earthquake foci and corresponding magnitude

5.0 =< Ms < 6.0

ΚΛΙΜΑΚΑ - SCALE

0 5km

Το τοπογραφικό υπόβαθρο προέρχεται από τον Τοπογραφικό Χάρτη της Γεωγραφικής Υπηρεσίας Στρατού (Γ.Υ.Σ.), έκδοσης 1972, διασχισμένο σε συγχρονισμό της έκδοσης - Έγκριση Φ.1715/18/86Φ13.1(Ε)Κ21 & Φ5/ΓΕΣ/ΔΙΟΤ/Β, Αρ.Διάφορης 1128 10-86 - Διανομέας Φυλλίου
The topographic base map originates from the Topographic Map of the Hellenic Military Geographical Service (H.M.G.S), edition 1972
Προβολικό Σύστημα Χάρτη UTM. Projection

Γεωλογική Τομή ΑΑ'
Geological Section AA'

Τυπώθηκε στο Ωρολογιακό Αντιτυπικό Σχεδιασμού και Προστασίας (ΟΑΣΠ) και του Ευρωπαϊκού Κέντρου Πρόληψης και Πρόγνωσης των Σεισμών (ΕΚΠΣΠ). Αθήνα, 1998.
Πρόεδρος : Καθηγητής Ευαγγελίδης, Δ. ΠΑΠΑΝΙΚΟΛΑΟΥ
Γενικός Διευθυντής : Κ. ΙΩΑΝΝΙΔΗΣ, Πολιτικός Μηχανικός
Υπεύθυνος εκδόσεων χαρτών : Σ. ΛΟΡΟΣ, Γεωλόγος - Ερευνητής
Επιστημονικοί συνέδρους : Επιτροπή Τεκτονικής της Ελληνικής Γεωλογικής Εταιρείας
Ανάπτυξη βάσης δεδομένων Γεωγραφικών Πληροφοριακών (GIS) & Δικτύου, υπ' Γ.Ο.Σ. : Σ. ΒΑΣΙΛΟΠΟΥΛΟΥ, Γεωλόγος

Edited by the Earthquake Planning and Protection Organization (EPPO) and the European Center on Prevention and Forecasting of Earthquakes (CEPEC). Athens, 1998.
President : Professor of Geology D. PAPANIKOLAOU
General Director : K. IOANNIDIS, Civil Engineer
Publication coordinator : S. LOZIOS, Geologist - Researcher
Scientific supervisors : Tectonic Committee of the Geological Society of Greece
G.I.S Development (at) & Archive, under T.O.S : S. VASSILOPOULOU, Geologist

2

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

Starting date of the Project : 20.12.94

Completion date of the Project : 6.12.96

By : D. Mountrakis, A. Killas, S. Pavildes, G. Koufos, E. Vavilakis, A. Psilovikos, L. Sotiriadis, Th. Astaras, M. Tranos and N. Spyropoulos Department of Geology, Aristotie University of Thessaloniki.

The need for a better picture of the seismic hazard in the wider Thessaloniki area inspired the detection,mapping and description of the area's faults, which resulted in the neotectonic sheet below. With this aim in mind the research group of the Department of Geology and Physical Geography of the Aristotle University of Thessaloniki has made a detailed fault study, dividing the faults according to the international standards into Seismic, Active, probable Active and inactive faults.

More precisely, according to the international standards for faults, the following have been adopted for this area :

- Seismic faults are those that have been definetly connected with particular earthquakes. In the case that this connection is not so unambiguous the fault is characterized simply as an Active fault and not as a Seismic fault.
- Active faults are those that have been active since the late Pleistocene.
- Probable Active faults are those that where active from late Pliocene to late Pleistocene .

Inactive faults are those that have not presented any slip activation later than the early Pleistocene or those which show no indication of a recent reactivation.

Apart from the above limitations due to the international standards the faults where also characterized using the following field tested criteria :

- the existence of fresh and resent natural fault slickensides
- the possible connection between the epicentres of the microearthquakes and the faults
- linear develompent of several thermal springs along faults
- the continuation of a fault with another certain active fault

specific geomorphological criteria related to faults such as triangular facets, recent tectonic terraces, fault (line) scarps, linear and/or hanging valleys, river captures and diversifications, areas with intense erosion, e.t.c.

It is important to mention that the major faults in the area have greatly interasted us because they are considered the most likely sources of probable future seismic activity .

Finally some covered faults within the large basins have been cautiously adopted and mapped from the already published geophysical survey.

Development of basins

The breakage of the initially uniform Miocene planation surface was the result of the latter faulting. This faulting produces a fracture pattern of large fault-bounded blocks presented within the generally mature

and very low elevation morphology of the area.

As mentioned above some of the fault bounded blocks were estimated (using geomorphological criteria) to have been uplifted about 300-400m during Neogene and Quaternary times, forming several horsts such as the Vertiskos and Chortiatis ones.

In contrast, other fault blocks subsided, forming the present depressions of the area such as the Pre-Mygdonian, Anthemountas and Strymonas basins which have filled up with Neogene and Quaternary sediments. Two tectonic stages can be inferred for the evolution of the above mentioned basins, taking into account the sedimentary, geomorphological and stratigraphic observations:

(1) the first tectonic stage caused the initial break up of the uniform planation surface into large blocks. These blocks have subsided individually since the early-middle Miocene, giving rise to several depressions that have been filled with mainly continental sediments intervening with some brackish to marine ones. This sedimentation process outlasts the Villafranchian period and was mainly of continental type. For the Pre-Mygdonian and Anthemountas depressions the estimated thickness of these deposits is about 350m.

(2) the second tectonic stage onsets the latest Villafranchian and produced some smaller depressions which were filled up with Quaternary sediments.

As shown in the Table I, although individual evolution is recognized for each graben or depression, we can state that the subsidence of the grabens in the area of Gallikos, Axios, Loudias and Aliakmonas alluvial deltaic fields was about 400-600m during the Quaternary, whereas the subsidence of the smaller depressions (Anthemountas, Langadas, Volvi, Vromolimni, Zangliveri, Marathousa, Doumbia, Chortiatis, Sochos) was much less and varied from 50m to 160m.

The total vertical movements (including uplift and subsidence) of the Pre-Mygdonian and Anthemountas basins were about 800-900m during the neotectonic period whereas the total subsidence of the Axios-Thermaikos basin might have been as much as 3500m.

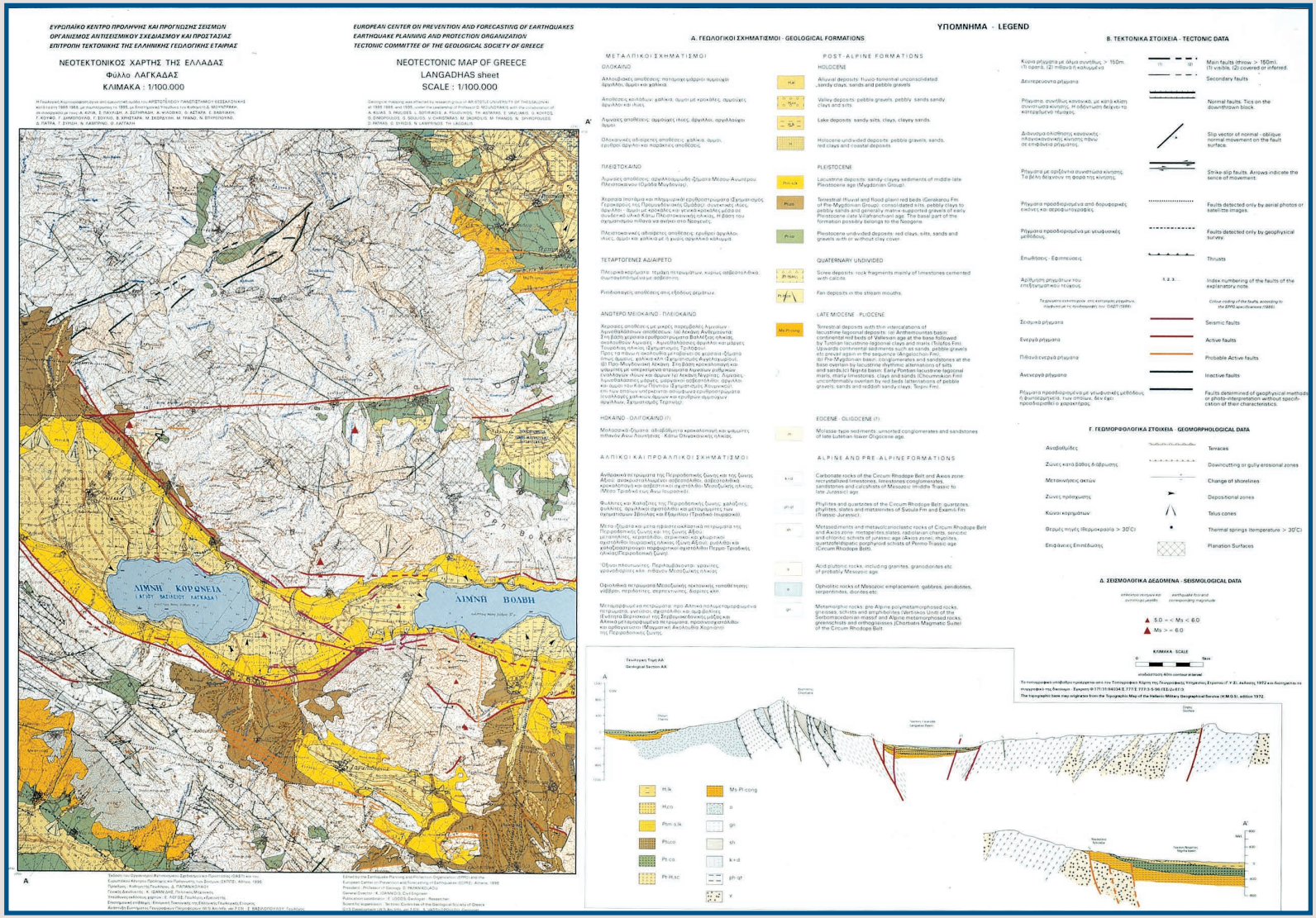
The subsidence as well as the sedimentation rates of the grabens of the area are considered very high and being $5X10^{-2}$ to $6X10^{-1}$ mm/y during the Quaternary, whereas during the Neogene they were $2.3X10^{-2}$ to $2X10^{-1}$ mm/y.

Neotectonic setting

Since the Miocene the area of Central Macedonia, where this neotectonic sheet is located, has been intensely faulted, forming as a rule many tectonic grabens and depressions such as the Axios basin, the Anthemountas and Mygdonian grabens etc. These depressions are in fact the result of a fairly continuous extensional deformation, which was mostly associated with pur normal to oblique-normal faults trending mainly E-W, WNW-ESE and NE-SW. In addition, some long N-trending faults complete the general fracture pattern. Most of the above mentioned faults have been active at least since the Miocene, while some of them (mainly the Etrending faults) are associated with the present seismic activity or have a verified activity since the Quaternary.

It is worth noting that especially the Serbomacedonian massif is the most seismically active zone of the internal Hellenic domain.

"Langadha Sheet"



3

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

Starting date of the Project : 16.2.95

Completion date of the Project : 13.1.97

By : Prof. D.J. Papanikolaou, E.K. Logos, Dr S.G. Lozios and As. Prof. Ch. Sideris

The region of "Korinthos Sheet" from the neotectonic point of view, represents one of the most important areas in Central Greece since a great number of earthquakes (some of them destructive) have been recorded during the historical times (i.e. the destruction of the Ancient City of Korinthos) and the present century (i.e. Alkyonides earthquakes, February-March 1981). From geotectonic point of view the region lies at the western edge of the recent volcanic arc and represents the point where three neotectonic gulfs are met (Eastern Korinthiakos, Argolikos and NW Saronikos Gulfs).

The post-alpine formations of the area comprise Plio-Quaternary sediments distributed in three neotectonic basins: the "Western Korinthos", "Eastern Korinthos" and "Argos". The paleogeographic evolution of each basin is different during the neotectonic period. The basin of "Western Korinthos" is comprised of marine sediments (mainly Gilbert-type deltas and deep-sea deposits) with a total thickness of more than 1.000 m. Their stratigraphy can be easily comprehended only if the partial stratigraphic sequences are distinguished according to their characteristic paleo-environment. They are characterized by lateral transitions, internal unconformities and truncations which presuppose important changes of the paleoenvironment both in space and time. On the contrary, the sediments of "Eastern Korinthos" basin are characterized mainly by lacustrine and continental facies and to a lesser degree by marine sediments. The basin of "Argos" shows a composite character which the northern part is composed of marine sediments (mainly delta facies) and the central and southern part of alluvial deposits.

The alpine formations crop out at the mountainous areas between the three previous basins (Lyrkion, Artemisio and Arachnaio mt.) and they are represented by the following 5 alpine geotectonic units (from top to bottom): "Eastern Greece", "Western Thessaly-Beotia", "Pindos", "Tripolis" and "Arna".

The neotectonic structure of the area is characterized by the presence of first order tectonic horsts and grabens bounded by important faults and fault zones with different seismotectonic behavior during the neotectonic period.

The "Lyrkion-Artemisio" horst, at the western part of the sheet, represents the most "stable" area since it is bounded and intersected by non active faults and fault zones.

The "Argos" graben is situated at the southern part of the map and it is bounded by NNW-SSE faults. The western border is represented by the "Kefalari-Argos-Platani" fault-zone, the southern part of which define the western coasts of Argolikos Gulf and presents an active character. The eastern border of the basin is characterized as non active and only at the southern part (NE coasts of Argolikos Gulf, major area of Nafplion) some NNW-SSE faults appear which are characterized as active or probably active.

The horst of "Arachnaio Mt." lies at the eastern border of the sheet and the central and southern part of it represent a relative stable area since only two active second order faults appear near the Arachnaio village. The northern part of the horst presents a very different behavior since it is characterized by the

presence of a great number of second order continental basins which are bounded by E-W active faults.

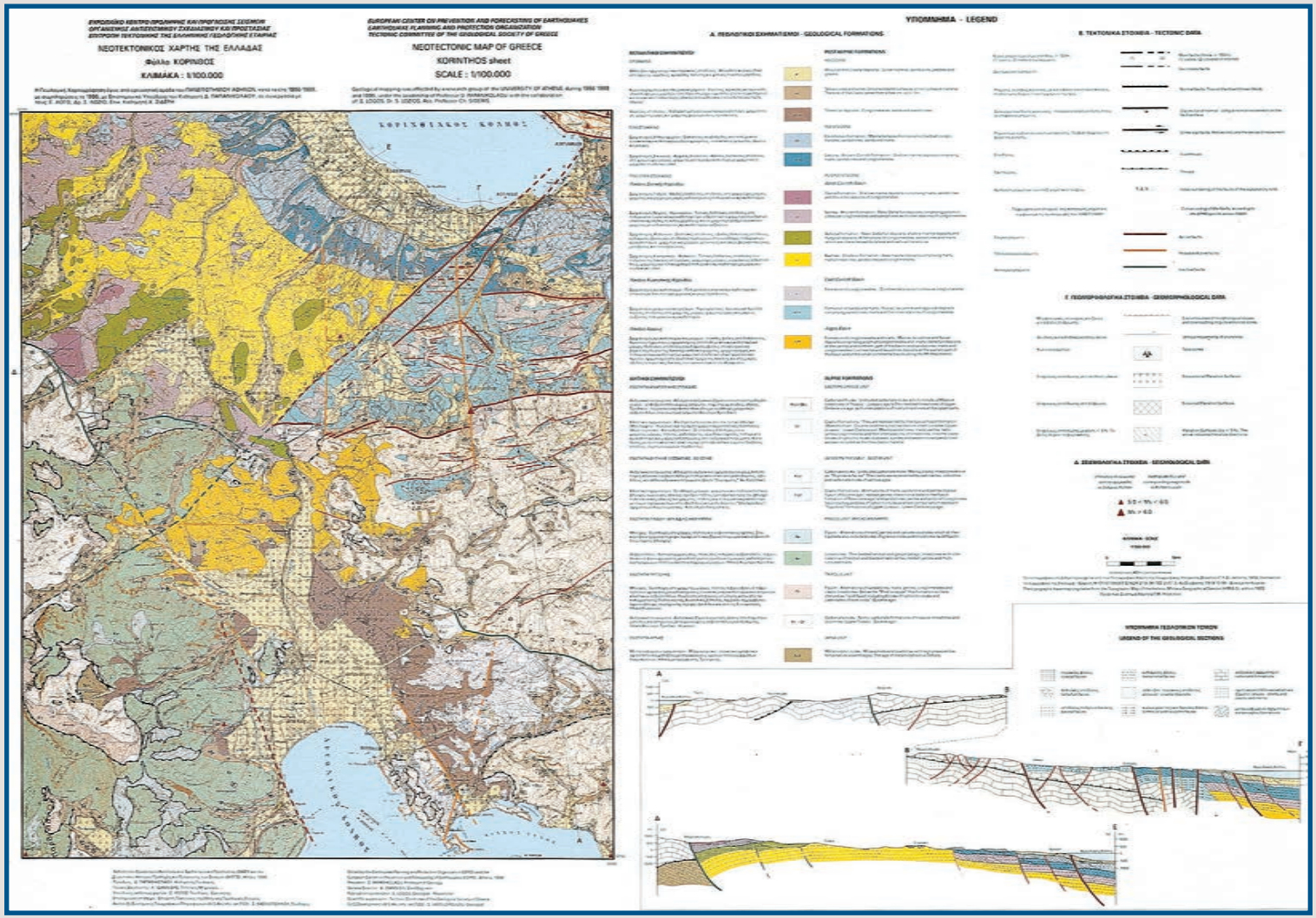
The graben of "Eastern Korinthos" and the SW border of the horst of "Gerania Mt." lie at the NE part of the sheet. Together with the above mentioned northern part of "Arachnaio Mt." horst represent the most active areas of the map since they are intersected by a great number of E-W active faults and fault zones which separate the area in a number of second order macrostructures (horsts and grabens). Detailed structural analysis of some of these grabens showed that during the first stages of their formation in Late Miocene - Early Pliocene they could be regarded as pull apart basins, created within the shear zone of en echelon vertical and/or inclined strike-slip faults. Younger slip motions indicate a gradual change towards oblique-slip faults, whereas finally most recent slip motions indicate dip-slip normal faults. The overall stress-field seems to be constant throughout the neotectonic evolution (Late Miocene - Present) with a mutual change of the position between σ1 and σ2 principal stress axes Thus, (i) in the early stages σ1 was sub-horizontal in the E-W direction whereas in the late stages it became sub-vertical, (ii) σ2 was sub-vertical and became sub-horizontal in the E-W direction (iii) 63 remained constant in sub-horizontal position around the N-S direction. This change is attributed to the gradual westward migration of the Hellenic arc in relation to the role of depth of deformation and especially to the probable relation of the Korinthiakos fault zone from a paleotransform fault zone.

The graben of "Western Korinthos" is extended at the northern part of the map and it is characterized by the absence of active faults, since the present neotectonic activity is localized at the southern border of Korinthiakos Gulf which is defined by important E-W active faults. The paleogeographic evolution of the graben during the Plio-Quaternary is controlled by the geodynamic environment of the Korinthiakos paleo-gulf which is mainly expressed by vertical neotectonic movements. The geodynamic analysis of the sediments reveals a very important and rapid migration of the Korinthiakos paleo-coasts during Pliocene and Late Pleistocene, from the zone of the marginal paleo-faults, to the south of Nemea and Trikala regions, at the present position of the Korinthiakos Gulf. It is also remarkable that the present arrangement of the geodynamic environments is similar to the one of Pliocene times, showing a migration of the whole structure of about 15-20 km to the North. Therefore, the active fault zones of the southern paleo-margin of the Korinthiakos Gulf, become gradually inactive during the northward migration of the active southern margin of the Korinthiakos Gulf.

This complex neotectonic regime is also confirmed by: (i) the study of shore line displacements, (ii) the present situation of archaeological sites submerged or immerged, (iii) the geodetic data and (iv) the observations during recent earthquakes.

The morphological features of the area, as they result from the study of the planation surfaces, the formation of intense ravins, the morphological discontinuities and the geometry of the hydrographic network, show that they are controlled by the neotectonic activity, in each active or less active neotectonic block.

"Korinthos Sheet"



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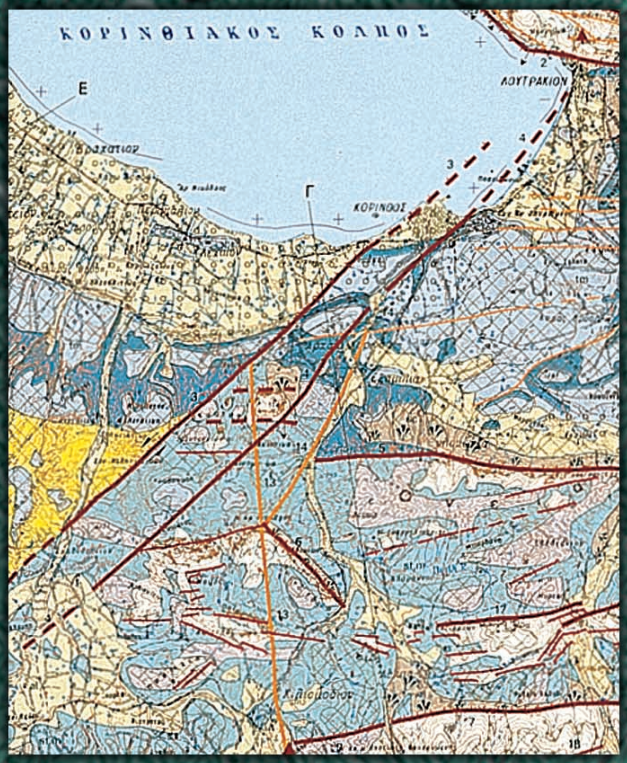
ΛΙΜΝΗ ΚΟΡΩΝΕΙΑ
(ΑΓΙΟΥ ΒΑΣΙΛΕΙΟΥ ΛΑΓΚΑΔΑ)
ΛΙΜΝΗ ΒΟΛΒΗ



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