NEWSLETTER

of the

EUROPEAN CENTRE ON PREVENTION AND FORECASTING OF EARTHQUAKES

ISSUE No 3
DECEMBER 1999
ATHENS

SPECIAL SECTION ON

ATHENS EARTHQUAKE OF SEPTEMBER 7, 1999

- RESEARCH PROJECTS
- NEOTECTONIC MAPS
- TECHNICAL HANDBOOKS

Council of Europe
Conseil de l' Europe

2

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

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

1. Introduction

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

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

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

2.Geology and Tectonics of Attica

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

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

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

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

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

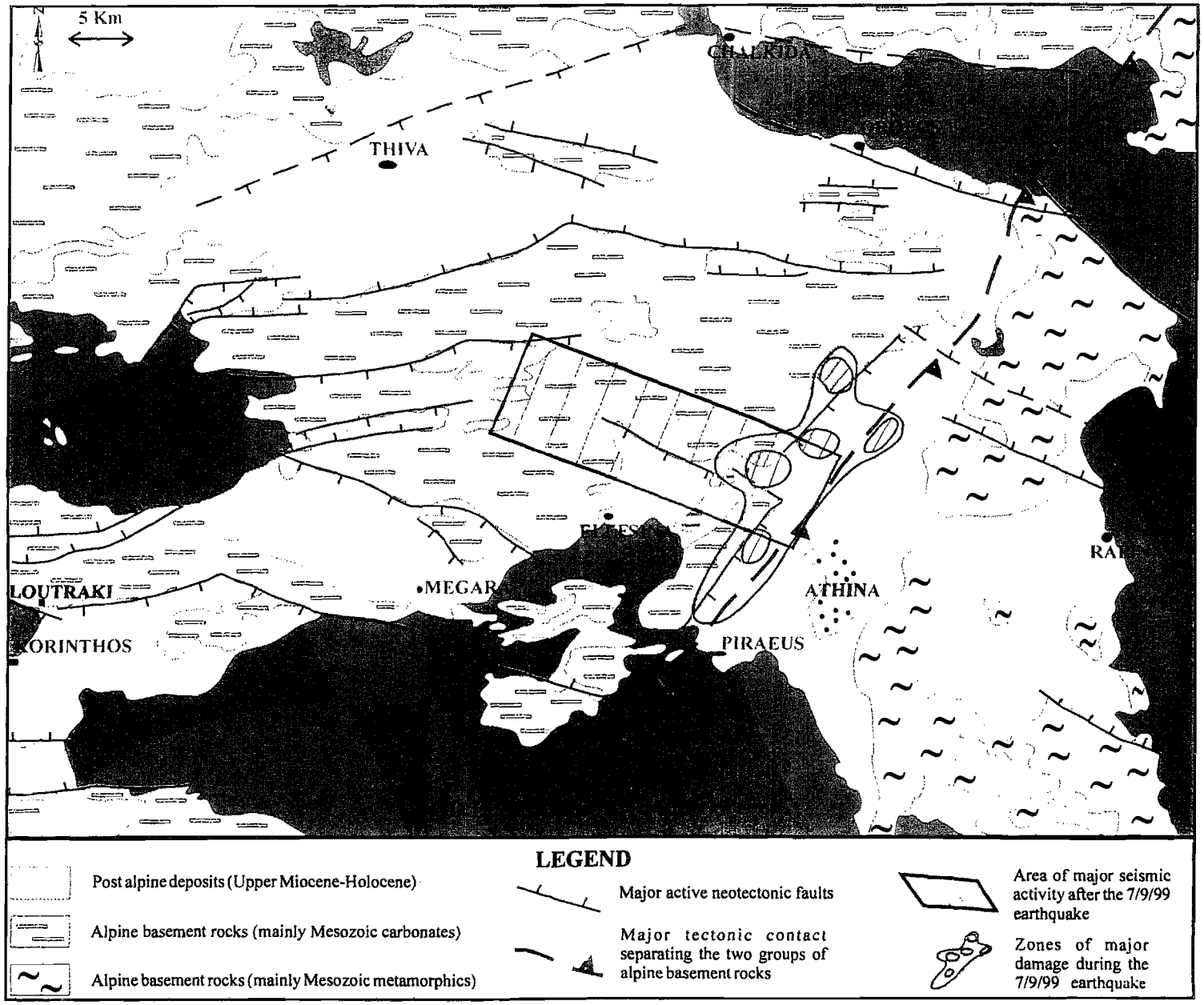

Figure 1

CENTRE ON PREVENTION AND FORECASTING OF EARTHQUAKES • COUNCIL OF EUROPE • EUROPEAN

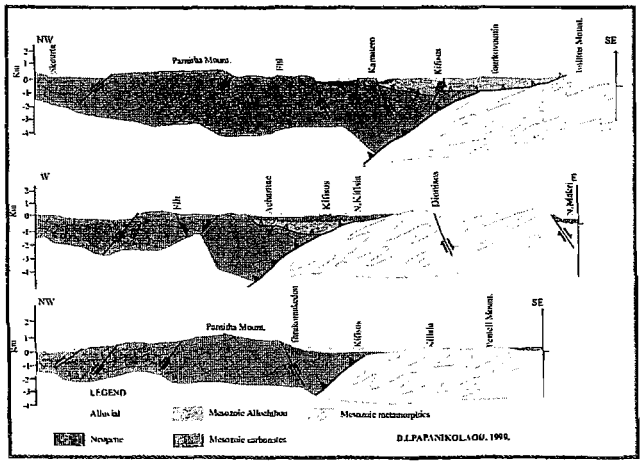

Figure 2

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

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

3.The Earthquake of September 7, 1999.

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

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

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

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

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

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

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

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

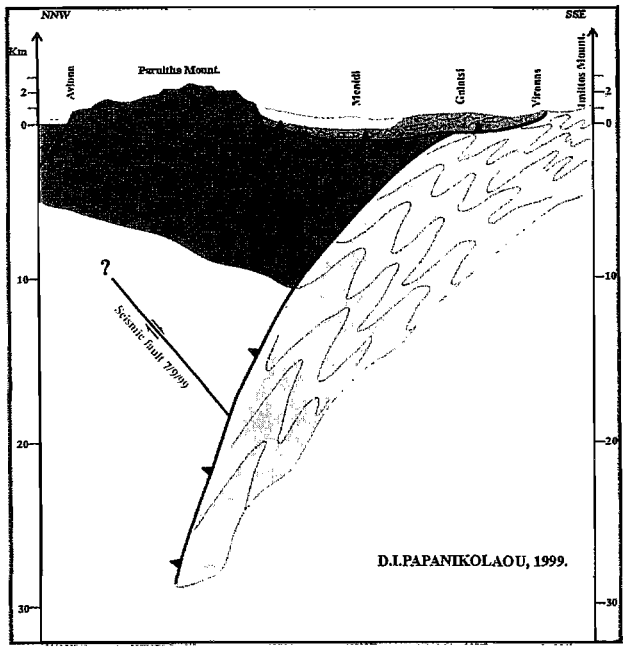

Figure 3

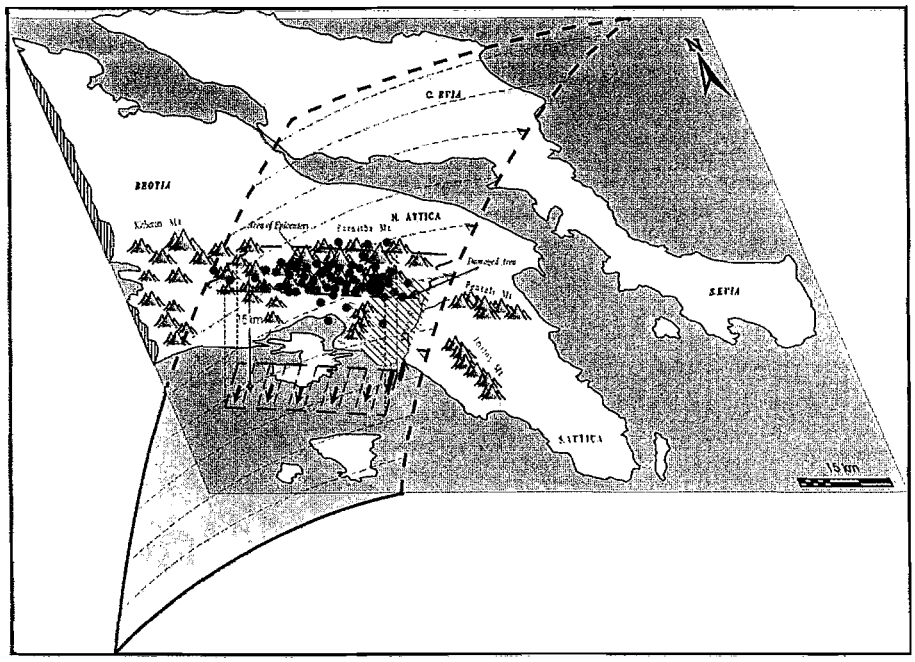

Figure 4

References

Lepsius, R.1893. Geologie von Attica. Berlin.

Papanikolaou D. 1986. Geology of Greece (in Greek). 240p.

Papanikolaou, D., Mariolakos, I., Lekkas, E. & Lozios, S. 1988. Morphotectonic observations of the Asopos Basin and the coastal zone of Oropos. Contribution to the neotectonics of Northern Attica. Bull. Geol. Soc. Greece, XX/1, 251-267.

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

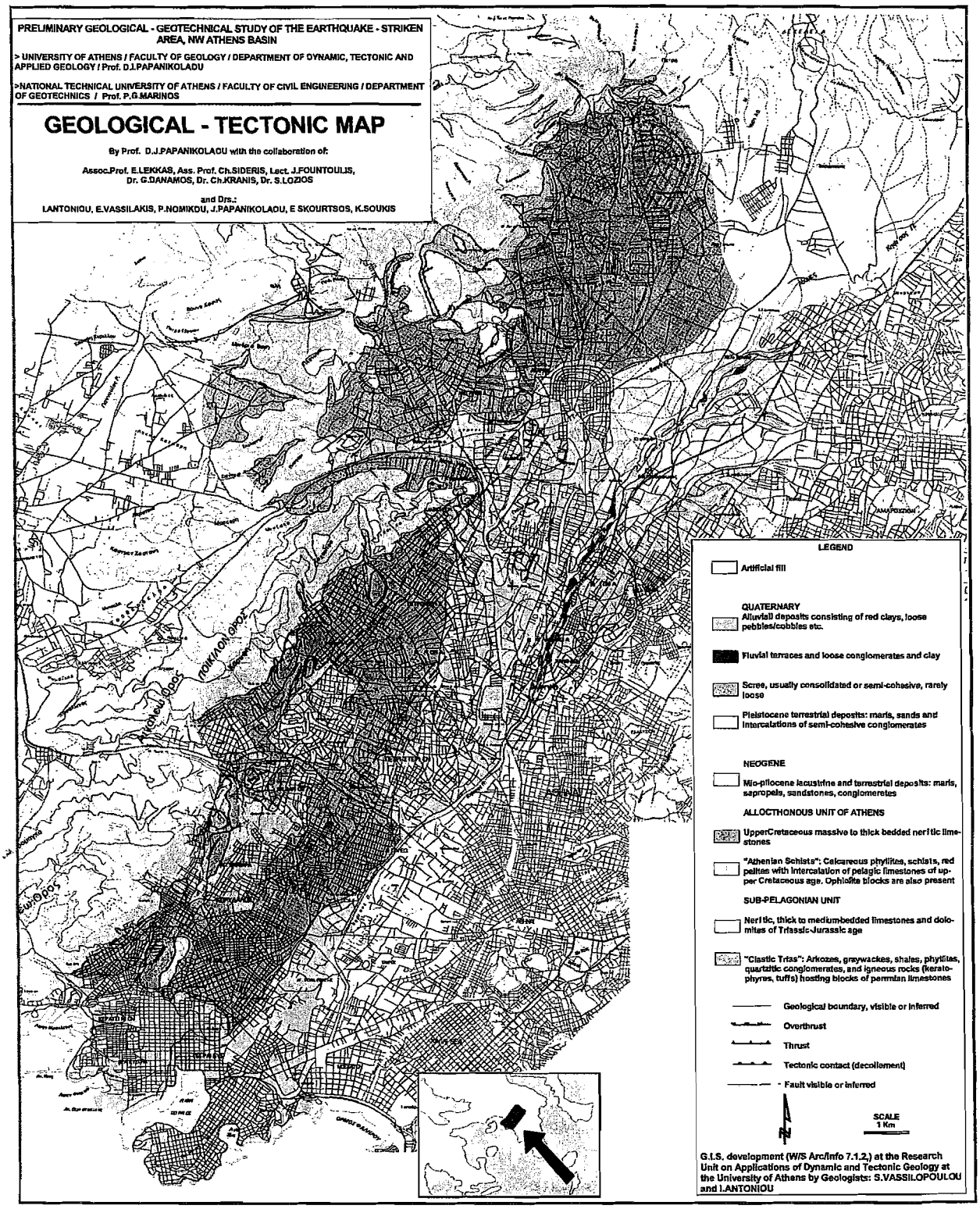
PRELIMINARY GEOLOGICAL - GEOTECHNICAL STUDY OF THE EARTHQUAKE - STRIKEN AREA, NW ATHENS BASIN
> UNIVERSITY OF ATHENS / FACULTY OF GEOLOGY / DEPARTMENT OF DYNAMIC, TECTONIC AND APPLIED GEOLOGY / Prof. D.J.PAPANIKOLAOU
>NATIONAL TECHNICAL UNIVERSITY OF ATHENS / FACULTY OF CIVIL ENGINEERING / DEPARTMENT OF GEOTECHNICS / Prof. P.G.MARINOS
GEOLOGICAL - TECTONIC MAP
By Prof. D.J.PAPANIKOLAOU with the collaboration of:
Assoc.Prof. E.LEKKAS, Ass. Prof. Ch.SIDERIS, Lect. J.FOUNTOULIS, Dr. G.DANAMOS, Dr. Ch.KRANIS, Dr. S.LOZIOS
and Drs.:
LANTONIOU, E.VASSILAKIS, P.NOMIKOU, J.PAPANIKOLAOU, E SKOURTSOS, K.SOUKIS
LEGEND
Artificial fill
QUATERNARY
Alluvial deposits consisting of red clays, loose pebbles/cobbles etc.
Fluvial terraces and loose conglomerates and clay
Scree, usually consolidated or semi-cohesive, rarely loose
Pleistocene terrestrial deposits: marls, sands and intercalations of semi-cohesive conglomerates
NEOGENE
Mio-pliocene lacustrine and terrestrial deposits: marls, sapropels, sandstones, conglomerates
ALLOCTHONOUS UNIT OF ATHENS
UpperCretaceous massive to thick bedded neritic limestones
"Athenian Schists": Calcareous phyllites, schists, red pelites with intercalation of pelagic limestones of upper Cretaceous age. Ophiolite blocks are also present
SUB-PELAGONIAN UNIT
Neritic, thick to medium-bedded limestones and dolomites of Triassic-Jurassic age
"Clastic Trias": Arkoses, graywackes, shales, phyllites, quartzitic conglomerates, and igneous rocks (keratophyres, tuffs) hosting blocks of permian limestones
Geological boundary, visible or inferred
Overthrust
Thrust
Tectonic contact (decollement)
Fault visible or inferred
SCALE 1 Km
G.I.S. development (W/S ArcInfo 7.1.2,) at the Research Unit on Applications of Dynamic and Tectonic Geology at the University of Athens by Geologists: S.VASSILOPOULOU and I.ANTONIOU

Figure 5