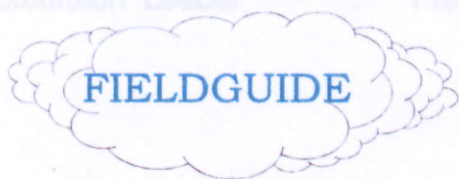




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ATHENS, GREECE

## SEMINAR ON ACTIVE FAULTS



Pre-Congress Excursion A1 of the  
XV Congress of the Carpatho-Balkan Geological Association



# THE NEOTECTONICS OF NW PELOPONNESE

## THE EARTHQUAKE OF OCT. 16, 1988

by

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### INTRODUCTION

NW Peloponnese is one of the most seismically active areas of Greece due to the fact that it is close to the Hellenic Trench, that represents the subduction of the African plate under the European one. Consequently, a large number of seismically active neotectonic fault zones, cross the canal between Zakynthos island and Killini peninsula.

A lot of destructive earthquakes have taken place in the area since 399 B.C.

The major characteristics of the seismicity of NW Peloponnese are:

- i) All major earthquakes occurred at a small depth ( $h < 20$  km).
- ii) The large macroseismic intensity.

At October 16, 1988 the Killini earthquake occurred, its magnitude was  $M_s=5.5$  R, in a depth of 4 km, and caused major damages at the Vartholomio and Killini areas. The intensity at these two areas (NW Peloponnese) was VII-VIII mercalli while at the southeastern part of Zakynthos island the intensity was V-VI.

The epicenter is located in the canal between the Zakynthos island and Killini Peninsula (Fig. 1).

According to the authorities the intensive damages were observed in an E-W direction, and more than 1500 buildings were destroyed, while 4.500 buildings were damaged.

### GEOLOGY

At the major area of Killini peninsula the following alpine formations occur (Fig. 2):

- a. **Kastro evaporites:** They consist mainly of anhydrite of Triassic age they occur 500 m western of Kastro village.
- b. **Kastro limestones:** They are white thinbedded and locally bedded calcarenite cretaceous limestones. They occur mainly at the area of Kastro village and northern of the Killini thermal springs.

From the geotectonic point of view, both formation belong to the Ionian Unit.

The post-alpine formations can be distinguished to:

- a) **Psili Rahi formations**

This is the lower Post-alpine conglomeratic formation and consists of pebbles which mainly are siliceous and secondly carbonatic. The conglomerates in many cases are characterized by graded bedding. The age of the formation is Pliocene.

- b) **Ligia formation**

The Ligia formation overlay the Psili Rahi conglomerates and consist of clays marls sands and

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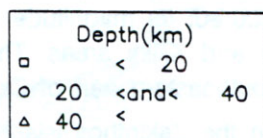
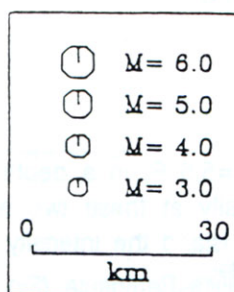
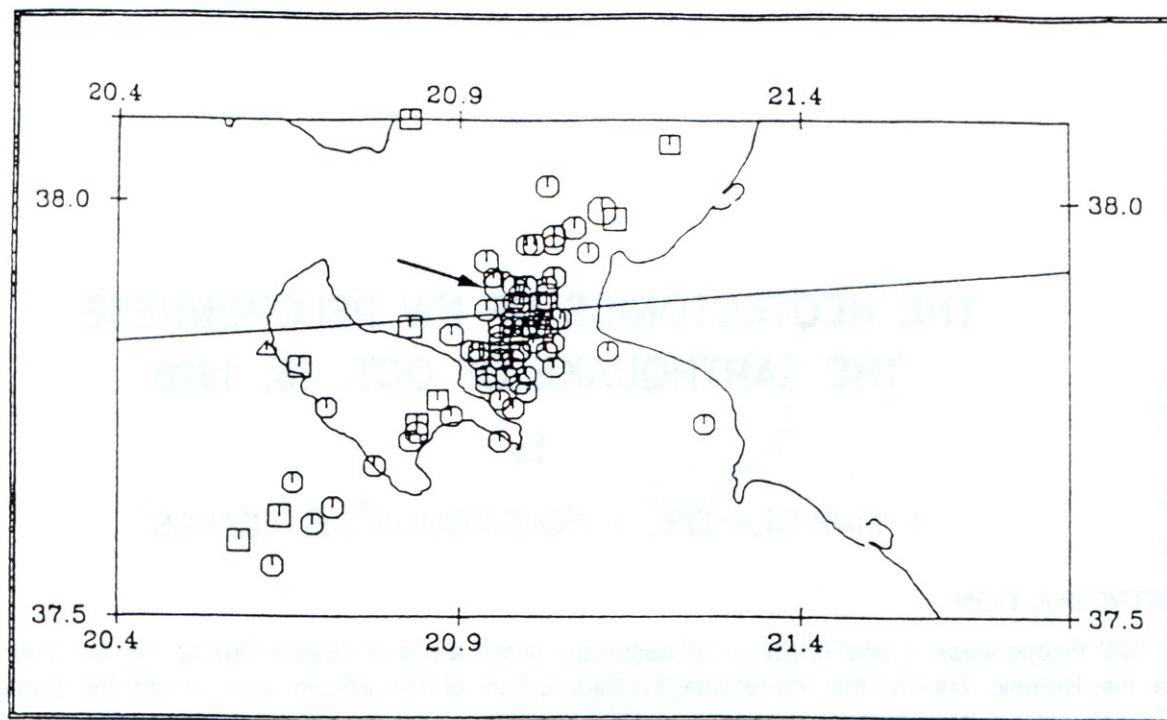


Fig. 1. The geographical distribution of the earthquake epicenters at the Zakynthos - NW Peloponnese area for the period September - November 1988. (89 events) (after N. VOULGARIS 1981).

sandstones. This formation occurs at the largest part of the area, and its age is Pliocene-Early Pleistocene (CHRISTODOULOU 1969).

c) **Glossa formation**

The Glossa formation consists of calcitic porous sandstones. The thickness of the formation is of some meters and it overlays the Ligia formation. The age of the formation, is probably, Late Pleistocene.

d) **Alluvial deposits:**

They are unconsolidated deposits which occur all over the plain.

e) **Coastal deposits:**

They consist of unconsolidated fine and coarse material which occur along the coast of the Killini peninsula.

g) **Beach rocks**

They are cohesive sandstones and they occur very close to the coast.

h) **Old and young scree.**

They are old and young cohesive or unconsolidated scree which occur northern of the Killini



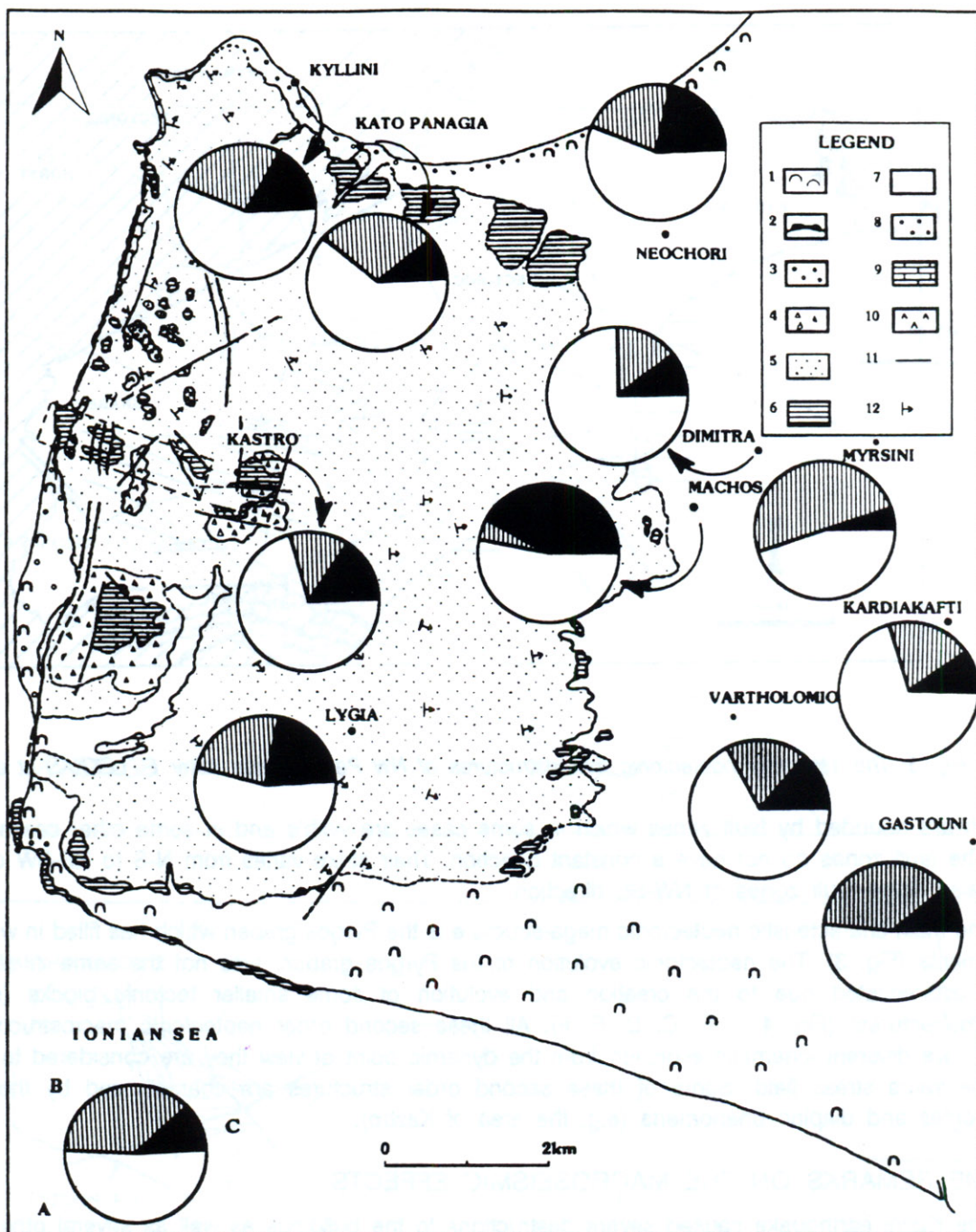


Fig. 2. Geological schema of the Kyllini peninsula demonstrating the percentage of the constructions of each village which were not destroyed (A), had a lot of damages (B), were totally destroyed (C). (1. Dunes, 2. Talus, 3. Beach Rocks, 4. Coastal deposits, 5. Alluvial deposits, 6. Glossa sandstones formation, 7. Lygia formation, 8. Psili Rachi conglomerates formation, 9. Kastro limestones, 10. Evaporites). (After E. LEKKAS et al 1990).

thermal springs and around the Kastro village.

#### i) **Dunes:**

They consist of unconsolidated sands and they occur along the largest part of southern and northern coast of the peninsula.

### NEOTECTONIC MACROSTRUCTURES

The neotectonic structure of NW Peloponnese is characterized by the existence of grabens and horsts



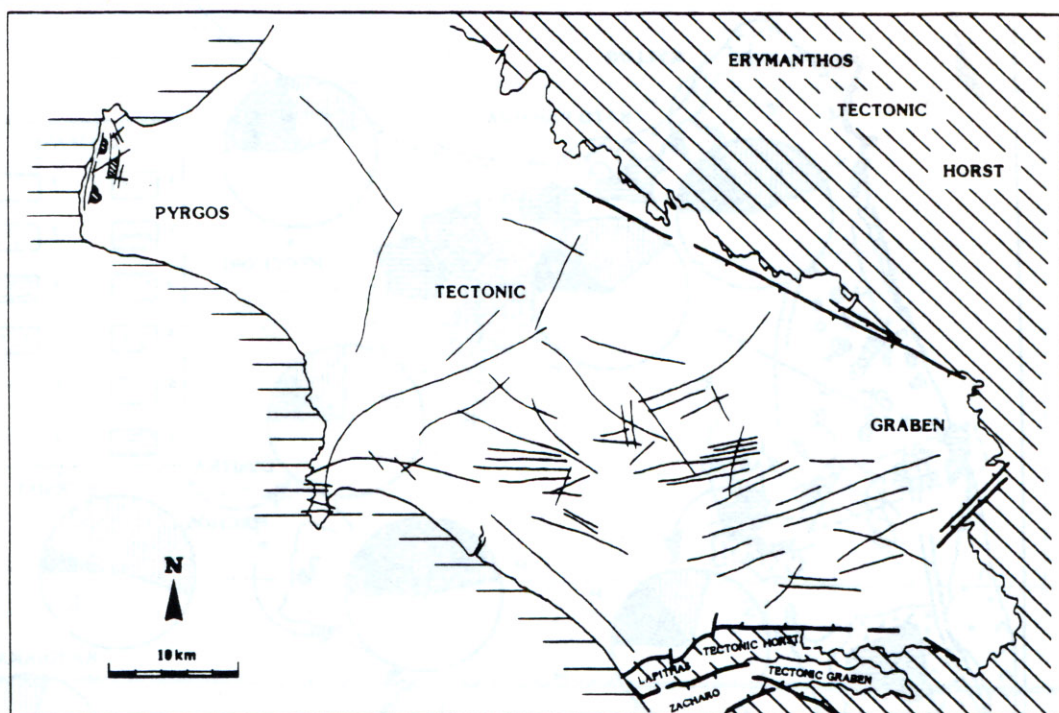


Fig. 3. The 1st order neotectonic macrostructures of NW Peloponnese (after E. LEKKAS et al. 1992).

which are bounded by fault zones which in some cases are visible and in some other cases are not (Fig. 3). The fault zones do not have a constant direction. Their strike varies from N-S to NE-SW or E-W. There are also some fault zones of NW-SE direction.

The main characteristic neotectonic mega-structure is the Pyrgos graben which has filled in with post-alpine sediments (Fig. 3). The neotectonic evolution of the Pyrgos graben, was not the same in all its extent. It was differentiated due to the creation and evolution of some smaller tectonic blocks (second order macrostructures) (Fig. 4 A, B, C, D, E, F). All these second order neotectonic macrostructures although they have different kinematic evolution from the dynamic point of view they are considered to be the result of the same stress field. Some of these second order structures are characterized by the presence of evaporites and diapiric phenomena (e.g. the area of Kastro).

## SOME REMARKS ON THE MACROSEISMIC EFFECTS

The Kyllini earthquake caused severe destructions to the buildings as well as several other geodynamic phenomena such as, reactivation of faults (seismic faults), ground ruptures rock falls, shore lines displacement, liquefaction phenomena, sands waters shaking off etc. (Fig. 5).

### 1. Destructions

Concerning the geographical distribution (Fig. 2) of the destructions, the following observations could be done:

- The percentage of the buildings which suffered severe damages or characterized beyond repair for each one of the villages of the Killini peninsula are not dependent on the geographical location of each village.
- The damages are not connected .

There is no big deviation at the percentage of the destructions in the old and the new buildings as well as there is no deviation at the percentages of the destructions in low and high buildings.

- The percentage of the buildings that suffered many damages or characterized beyond repair for each village are dependent on the geological factors and more precisely by: the foundation basement, the neotectonic deformation (faults, fault zones). In many cases, the building destructions

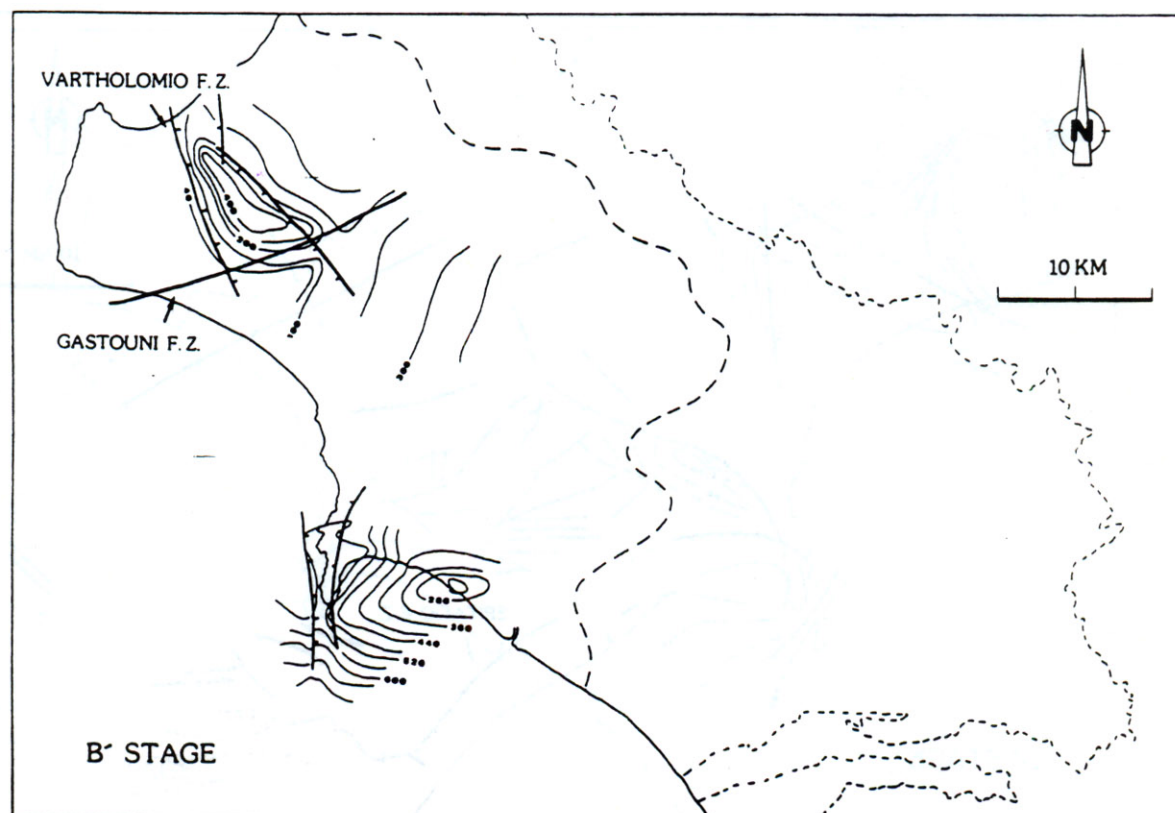
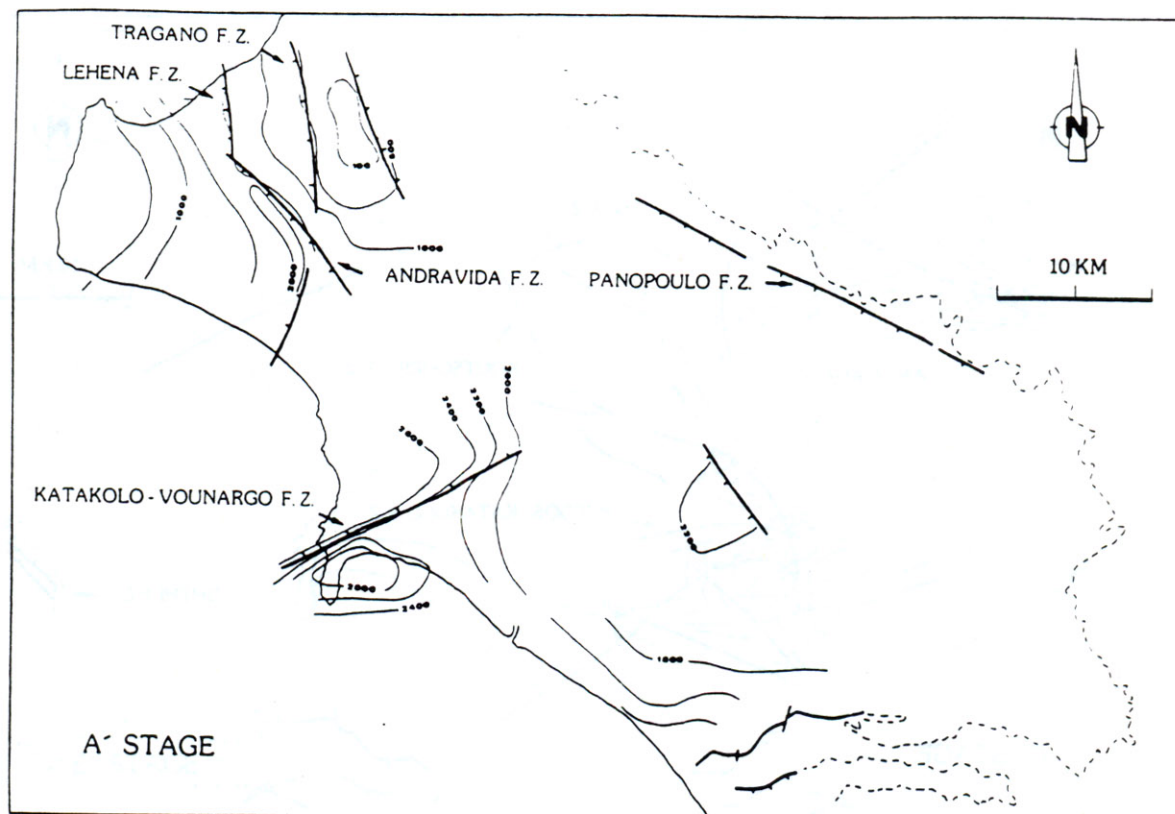
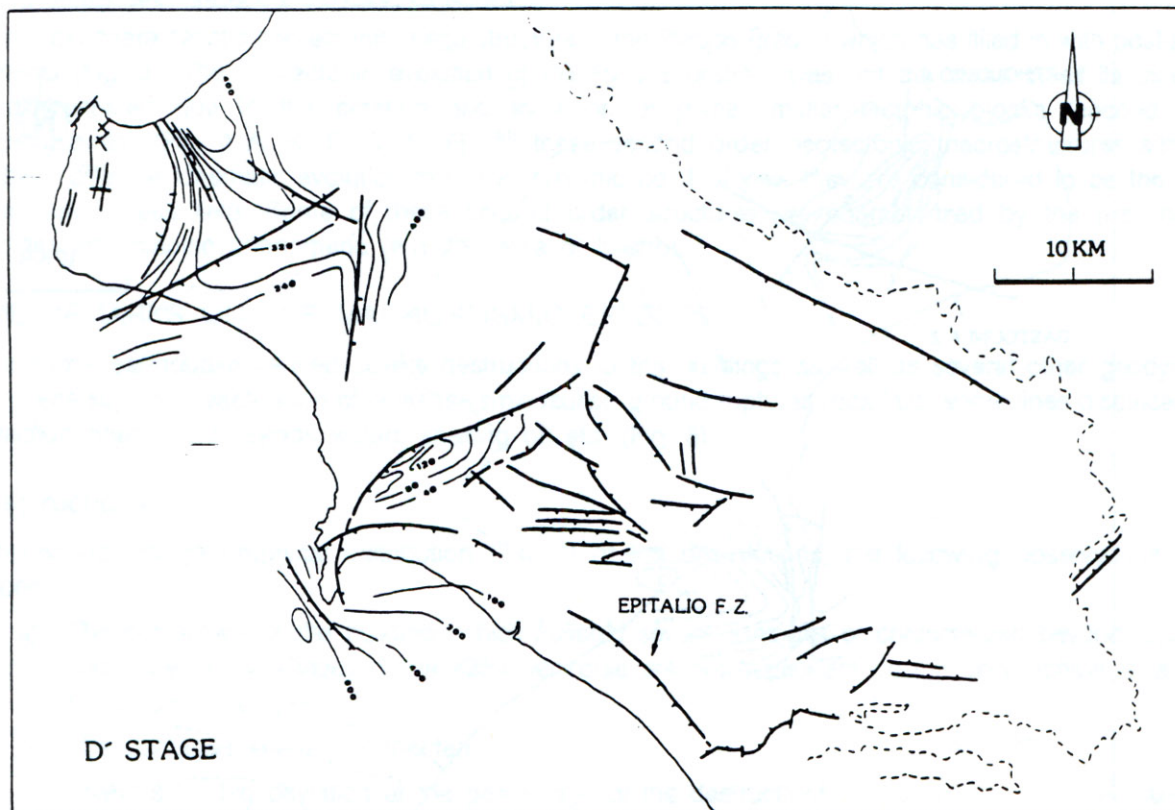
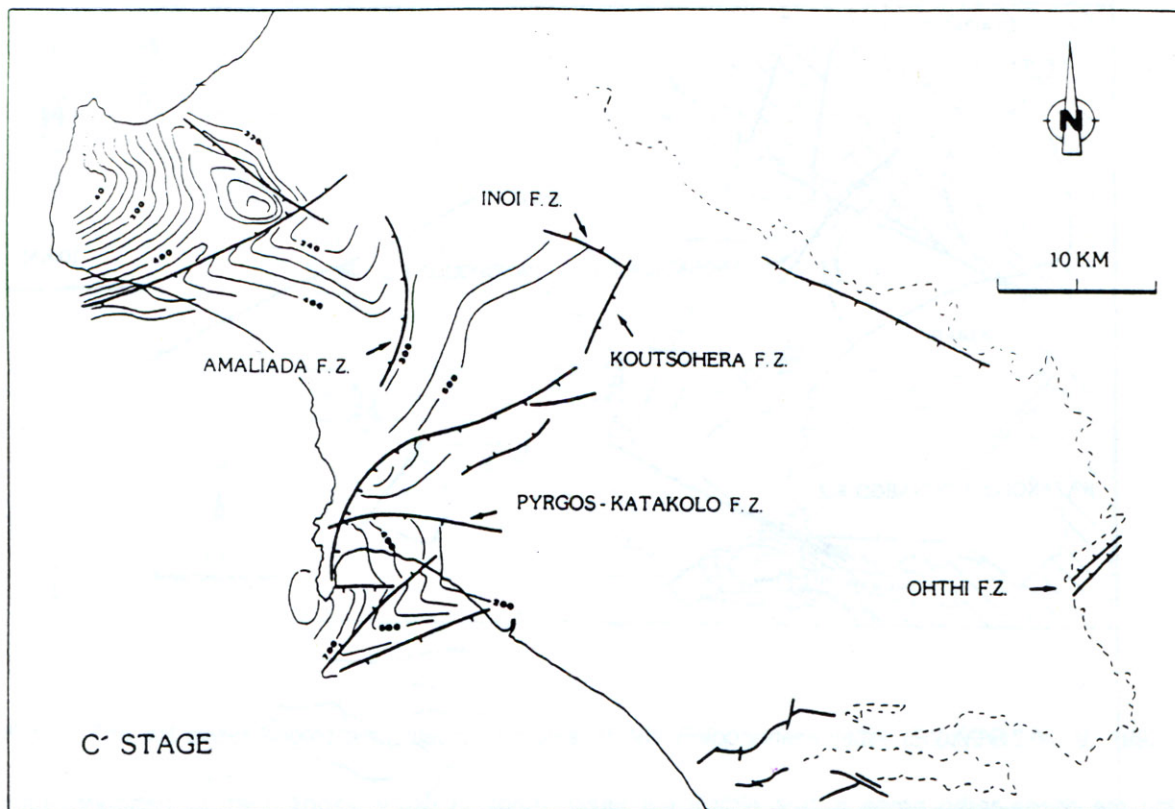
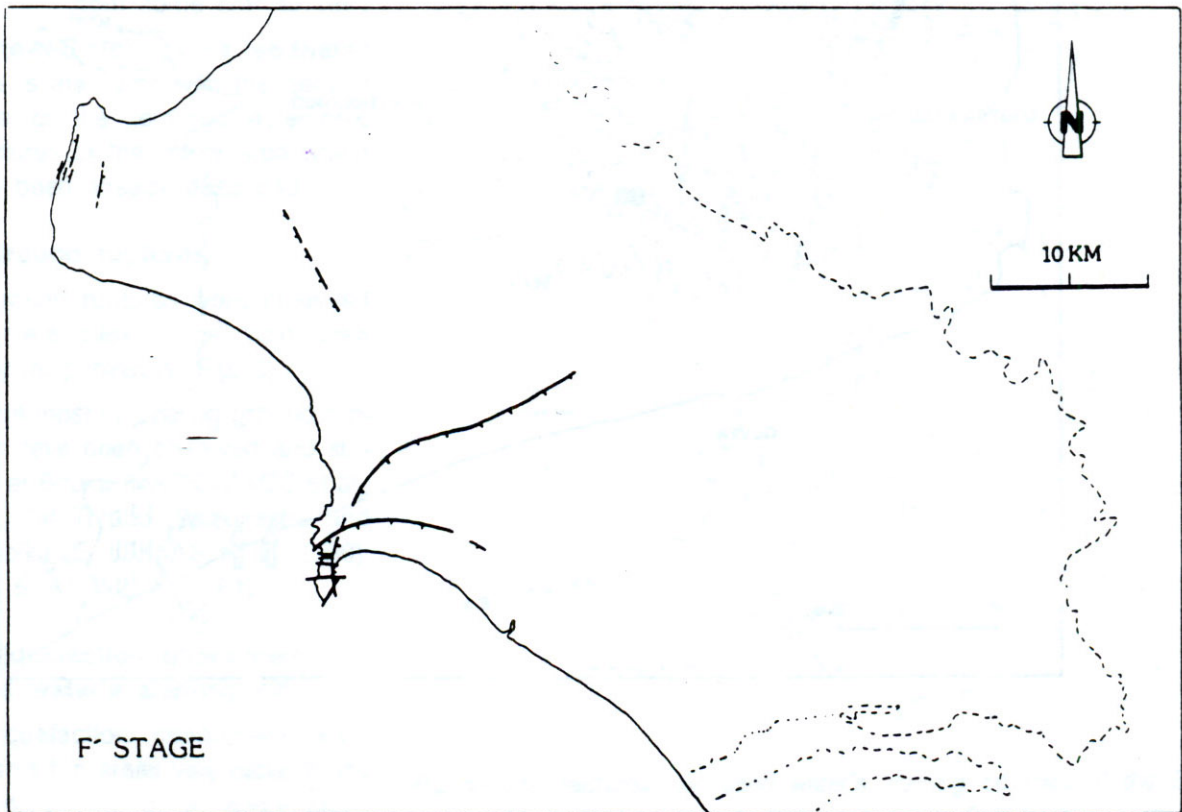
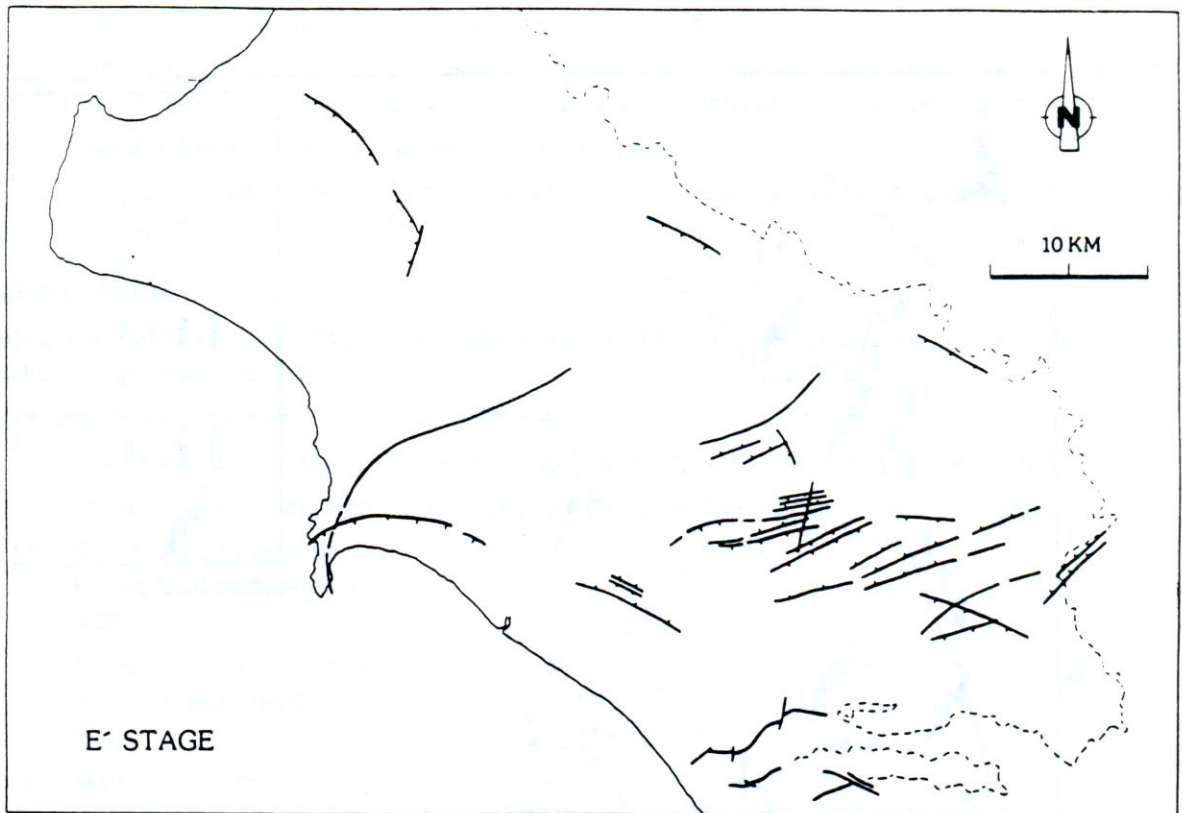


Fig. 4. The main stages (A, B, C, D, E, F) of the neotectonic evolution of Pyrgos graben (after E. LEKKAS et al., 1992)









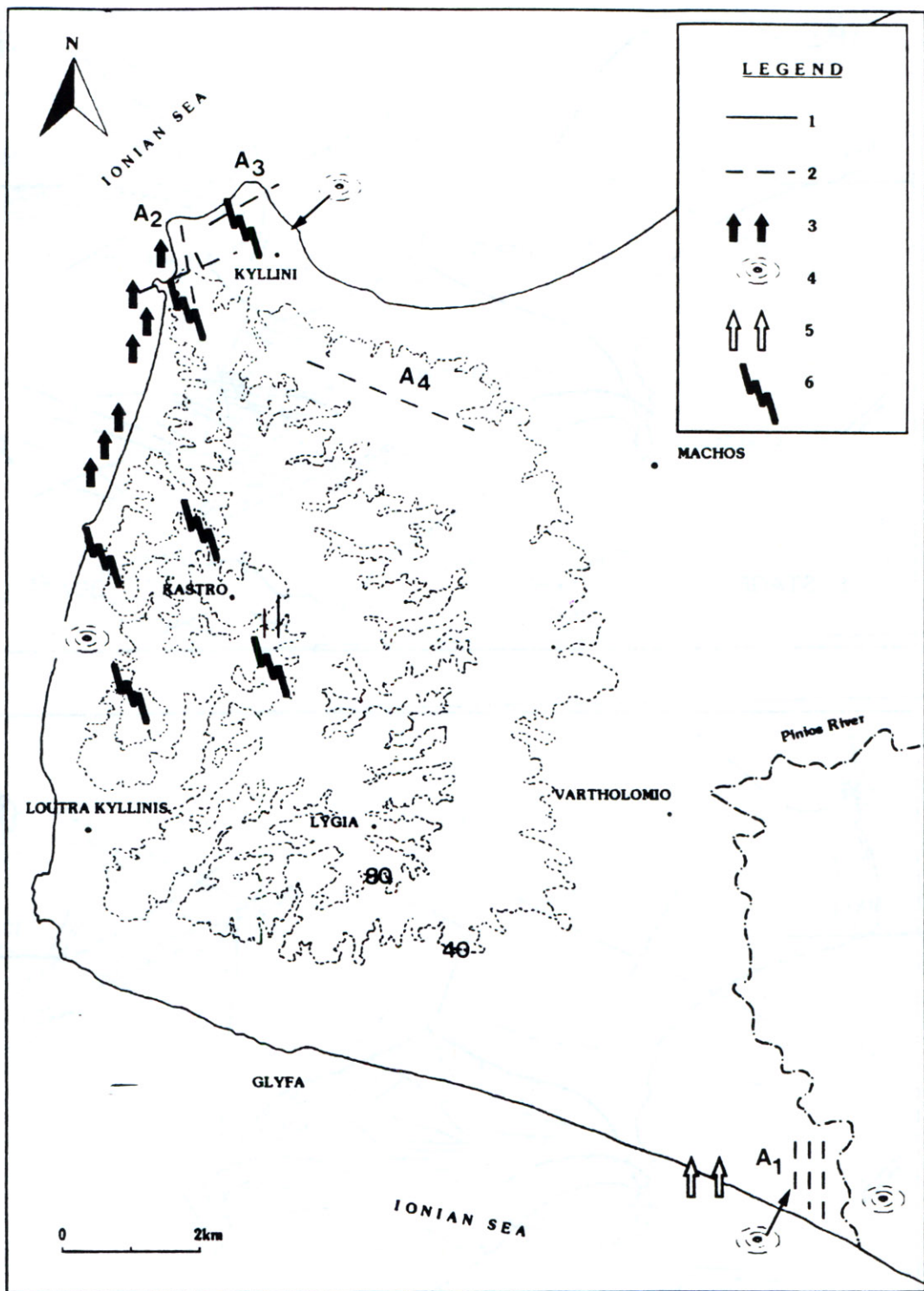


Fig. 5. Synthetic map with the macroseismic observations at Kyllini peninsula. (1. Seismic faults, 2. Ground ruptures, 6. Rockfalls, 3. Shoreline displacements, 4. Liquefaction phenomena, 5. Water's and Sand's Shaking off).

are connected directly to seismic fractures or to fault reactivation.

- d) The percentage of the buildings that suffered many damages or characterized beyond repair in every village are depended on the geotechnical factors:
- (i) The nature of the foundation formations and their geomechanical values as f.e. the cohesion, the dynamic and static stability, their resistance to tension and to compression, etc.
- (ii) The presence or not of the aquifer and its depth,
- (iii) The occurrence of some formations which may cause geotechnical problems like liquefaction, sinking etc.

## 2. Seismic faults

During the earthquakes of October 16, 1988 some small faults which occur in a quarry south-southeastern of Kastro village were reactivated. (Fig. 5)

More specifically, the followings were observed:

- a) Traces of recent movement on three fault surfaces with slickensides striking N-5.
- b) Three fault surfaces with slickensides, which strike N-S traces of recent movement.
- c) The throw of these reactivated fault surfaces was 5-20 cm.
- d) A light yellow mylonite along these fault surfaces.
- e) Many rock falls along these fault surfaces. The size of the rocks varies from some  $\text{cm}^3$  to  $1\text{m}^3$ .

The N-S strike of the reactivated faults is the same with the general strike of the tectonic-neotectonic structures of the major area which have been already described.

## 3. Ground ruptures

Ground ruptures were observed in several sites at the major area of Kyllini peninsula (Fig. 5).

The most interesting ground ruptures have been observed and studied at Bouka (MARIOLAKOS et al., 1991), at Trypito, Paleokastro and Vytineika (E. LEKKAS et al., 1990). (Fig. 5. A1, A2, A 3, A4).

## 4. Liquefaction phenomena - Sand water's shaking off

Liquefaction phenomena were observed in areas very close to the seashore (Fig. 5) in some cases sand water's shaking off was observed (Fig. 5. A1, Fig. 6).

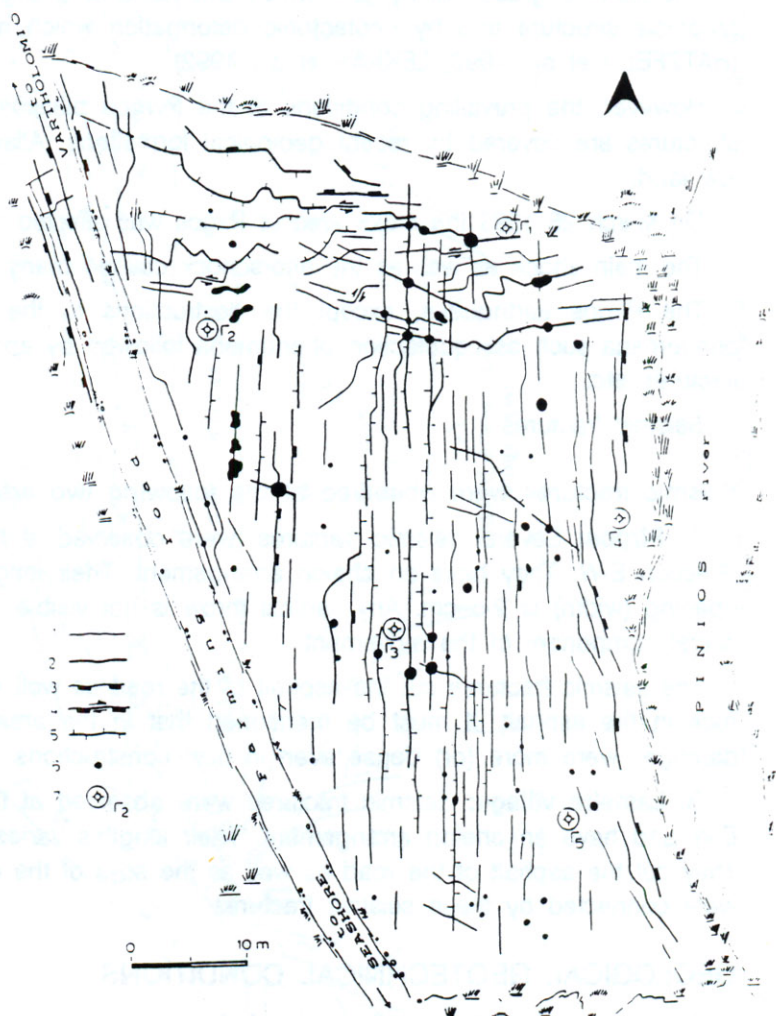


Fig. 6. Soil fractures and sand water's shaking off map of the Bouka (Vartholomio) area. 1: Soil fracture, 2: Soil fractures with wide opening, 3: Soil fractures with vertical throw, 4: Soil fracture with horizontal component of displacement, 5: Sand water's shaking off along soil fracture, 6: Crater, 7: Shallow drilling points.