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ORIENTATION AND TYPE OF ACTIVE FAULTING IN THE AEGEAN AND THE SURROUNDING AREA

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ABSTRACT

Reliable fault plane solutions of shallow earthquakes and information on surface fault traces have been used to determine the orientation of active seismic faults in the Aegean and the surrounding area. The distribution of the focal mechanisms of the earthquakes declares the existence of thrust faulting, having a NW-SE strike, following the coastline of southern Yugoslavia, Albania and western Greece extending up to the island of Cephalonia. Along the convex side of the Hellenic arc thrust faulting also occurs, as a result of the subduction of the African lithosphere under the Aegean. In the area of Cephalonia island strike-slip faulting is observed that connects these two zones of compression. The inner part of the mainland of Greece as well as western Turkey is dominated by normal faulting. Active faulting in these areas have an approximately EW orientation. The area of the Northern Aegean is dominated by strike-slip faulting that has an NE-SW trend, in accordance with the existence of the strands of the North Anatolia fault into the Aegean. However, some of the focal mechanisms exibit stronger or weaker normal component. There is also a zone of active normal faulting, with a NS strike, that lies between the outer zone of thrusting and the inner part of normal faulting. This is considered as a suture zone connecting two major systems of thrust faults from one side and major normal faulting from the other.

1. INTRODUCTION

The Aegean and the surrounding area is considered to be one of the most seismically active regions of the world. Briefly, the most prominent features of tectonic origin are, from south to north, the **Mediterranean Ridge**, a compressional submarine accretionary prism of

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material that extends from the Ionian Sea to Cyprus, the **Hellenic trench** with a maximum water depth of 5 Km, the **Hellenic arc**, which consists of the outer sedimentary arc and the inner volcanic arc, and finally the **back-arc Aegean** area, which includes the Aegean Sea, the mainland of Greece, Albania, south Yugoslavia, south Bulgaria and western Turkey.

The knowledge of the orientation and other properties of the seismic faults in a region is very important not only from theoretical purposes (seismotectonics, etc) but also for practical purposes (seismic risk, etc) (Papazachos et al. 1984a). The determination of these properties, however, is rather difficult, since detailed mapping of surface fault traces has been performed for a limited number of strong shallow earthquakes on land. For this reason, several other indirect methods have been tried (fault plane solutions, geological and geomorphological methods, landsat photographs, distribution of aftershocks, among others). One of the most effective techniques towards this goal, is the determination of fault plane solutions of the earthquakes of a region.

In the present paper, an attempt is made to determine the orientation and the type of active faulting in the Aegean and surrounding area (34°N-42°N, 19°E-30°E) on the basis of the most reliable of the available fault plane solutions of the earthquakes that occurred in the period 1963-1986 as well as on reliable information concerning fault traces observed on surface after the occurrence of some strong earthquakes.

2. THE DATA

In a previous paper (Papazachos et al., 1991), a catalogue of the most reliable fault plane solutions of shallow earthquakes ($h \leq 60$ Km) of the Aegean and the surrounding area, has been compiled. These fault plane solutions are in most of the cases determined by waveform modelling. Figure 1 shows schematically the fault plane solutions of shallow earthquakes in the Aegean and the surrounding area. The black quadrants denote compressional first motion, while the white ones denote dilatational.

Unfortunately there is no unique and simple method by which we can decide which of the two nodal planes in each fault plane solution is the fault plane or which is the slip vector (axis A). For this reason several geophysical and geological criteria are usually applied to overcome this problem. So, in this case the information concerning the fault breaks, landsat photographs, the distribution of aftershock foci, deep tectonics, geological and geomorphological data and trends in the slip direction in each seismotectonic unit have been used. In the case of the thrust faulting along the convex

side of the arc, the planes which dip to the inner side of the arc (Papazachos and Comninakis, 1969; McKenzie 1972) and have the smaller dip angle (McKenzie, 1978) were considered to be the fault planes.

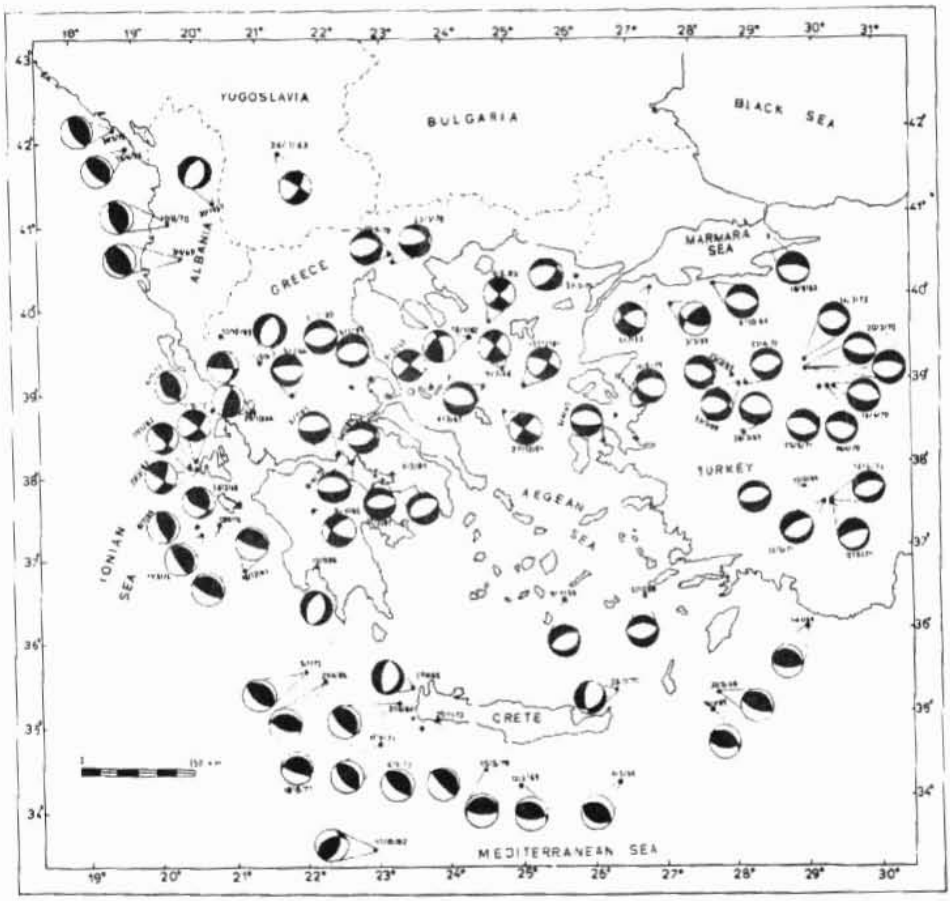

Fig.1. Fault plane solutions of shallow earthquakes of the Aegean and the surrounding area.

In addition to the most reliable fault plane solutions, which are listed in a table published by Papazachos et al., (1991), reliable information on surface fault traces of 13 major earthquakes (1861, 1894, 1932, 1953, 1964, 1969, 1970, 1971, 1978, 1980, 1981, 1981, and 1986) have been used for the purpose of the present study. This information has been taken from the book of Papazachos and Papazachou (1989).

3. ORIENTATION AND TYPE OF FAULTING IN THE AEGEAN AREA

Figure 2 is a schematic map which shows the orientation and the type of faulting for the strong earthquakes for which reliable data are available (fault plane solutions, surface fault traces). Active seismic faults are represented by thick lines. The lines with the smallest length represent faults produced by earthquakes in the magnitude range of 5.5 - 6.5 while the lines with the larger length represent all faults produced by events with magnitude larger than 6.5. The arrows indicate the direction of the dip in each case. The number near the faults represents the year of occurrence of the causative event. The following areas, according to the type of the faults, can be identified:

3.1 Thrust faulting

It is seen, that the area along the Dalmatian coast of Yugoslavia, western Albania, westernmost part of the mainland of Greece is dominated by a zone of thrust faulting striking parallel to the coast (NNW-SSE). The fault planes are those with the smallest dip angle. This zone of thrust faulting which is the result of the collision of two continents, with no evidence of subduction, terminates near the island of Cephalonia.

Further south along the convex side of the Hellenic arc, low angle thrust faulting occurs due to the subduction of the African lithosphere under the Aegean. The subduction takes place in an about SW-NE direction (Papazachos and Comninakis, 1969, 1971; McKenzie, 1970, 1972, 1978; LePichon and Angelier, 1979; Papazachos et al., 1991). Taking this into account we considered as faults those planes for which the slip direction is from SW to NE, that is, from the Mediterranean to the Aegean. The trend of the P axes is normal to the arc at its western part and keeping the same trend tends to become parallel to the arc at its eastern part.

The mean azimuth of the thrust faults is 311° and their mean dip 23°.

3.2 Normal faulting

It is seen from figure 2 that the mainland of Greece as well as western Turkey are dominated by the existence of mainly EW striking normal faults. Recent large earthquakes that produced major faulting

on land (Magnesia 1980, Thessaloniki 1978, Corinth 1981), further support this observation. There are field observations also for some past events. The event of December 26, 1861 in the Corinthiakos Gulf, the earthquake of April 24, 1894 in the Evoikos Gulf, and the event of September 26, 1932 in the Ierissos of Chalkidiki, have been

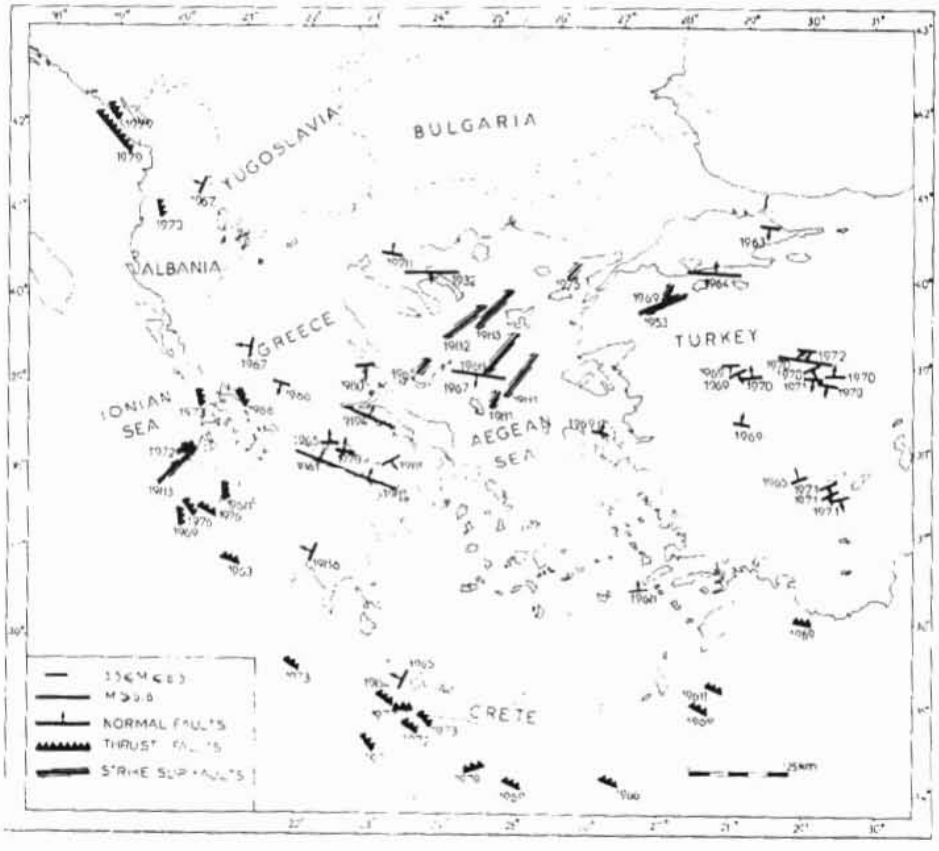

Fig.2. Orientation and type of faulting of the shallow earthquakes of the Aegean and the surrounding area.

produced by normal faulting with an approximately EW strike (Papazachos and Papazachou, 1989). Moreover, the study of the above mentioned recent sequences declared that normal faulting in the mainland of Greece tends to be of the listric type occuring at very shallow depths.

Figure (3) shows the poles of the fault planes on an equal area projection. Black and open circles show earthquakes in the western part (Greece) and eastern part (Turkey) of the area, respectively. It is seen that all poles are in a north-south direction, which in turn implies that the faults have an east-west strike.

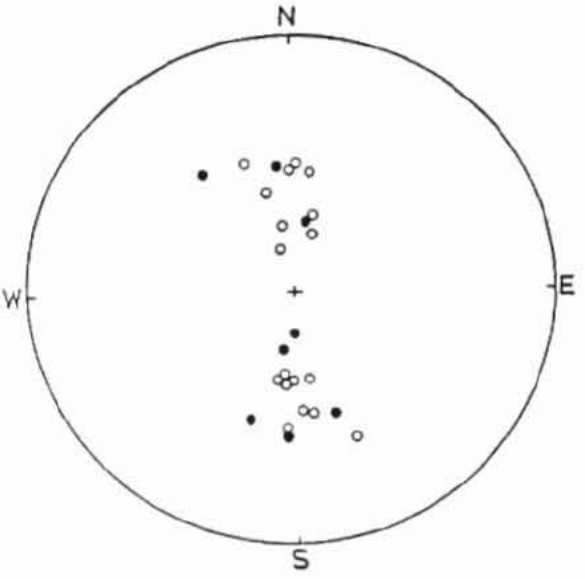

Fig. 3. Equal area projection of the poles of the fault planes of the shallow earthquakes of the Aegean and the surrounding area. Black circles denote the poles of the faults of the western part (Greece) and the open circles of the eastern part (Turkey).

The mean azimuth of the normal faults in the mainland of Greece is 283° and their mean dip is 36° while the corresponding values for western Turkey are 269° and 33°, respectively.

There is a suture zone, between the outer zone of thrusting and the inner one of the normal faulting, with an about EW trend, which shows normals faults with an about NS orientation (Papazachos et al., 1984a). This zone starts from Albania (event of Nov 11, 1967) runs through the westernmost part of the mainland of Greece (events of Febr 9, 1967 and September 15, 1986) and continues up to the

northwestern coast of Crete (event of April 27, 1965). There is evidence from the study of microseismicity that this zone continues easternwards parallel to the coast of northern Crete (Hatzfeld et al., 1990) and is probably responsible for the peninsulas in the NW and NE corners of Crete (Taymaz et al., 1990).

3.3 Strike-slip faulting

Strike slip faulting, based on the data available so far, exists in two areas: in the area of Cephalonian islands (Scordilis et al., 1985; Kiratzi and Langston, 1991) and in the Northern Aegean trough (Papazachos et al., 1984b; Rocca et al., 1985; Kiratzi et al., 1991). In both cases the motion is dextral in planes that strike NE-SW. In the Northen Aegean area there is one event, which ocurred on March 4, 1967 that shows normal faulting. This area of the Northern Aegean is very complicated from the seismotectonic point of view because is affected by two prevailing tectonic regimes: the NS extension that the whole Aegean is undergoing and the NE-SW strike-slip motion of the continuation of the North Anatolian fault into the Aegean. It is probable that the type of faulting in that area is controlled by the most prevailing of these tectonic regimes at the specific time.

4. CONCLUSIONS

The study of the type and the orientation of active seismic faults showed that in the Aegean and the surrounding area the seismicity is caused by thrust, normal and strike-slip faults.

Analytically, along the coastal region of Yugoslavia-Albania-western Greece the faults are of thrust type. The strike is parallel to the coastline.There is no evidence of subduction in this area. Low-angle thrust faults are also observed along the convex side of the Hellenic arc, with strike which seems to remain stable all along the entire length of it (NW-SE).

Shallow normal faulting occurs in the mainland of Greece and in western Turkey. The orientation of the faults, in both regions, is mainly EW, which is shown by the fault plane solutions, by field observations as well as by the distribution of the aftershocks. The conclusion of Taymaz et al., (1991) that the normal faults in Greece and Turkey have a NW to NNW strike and their model of broken slats attached to margins that rotate, is not supported by the most reliable observations concerning fault plane solutions and surface fault traces.

Apart from these EW normal faulting there is also normal faulting in NS striking planes that form a zone which runs from Albania in the north, all through westernmost part of Greece, southern Peloponese and ends in NW Crete.

Strike-slip dextral faulting occurs in the Ionian islands

(Cephalonia) and in Northen Aegean. In both cases the motion is in NE-SW trending planes. The strike-slip faulting in the area of the Ionian islands connects two zones of thrusting, one that is due to the collision of two continental lithospheres (along the Dalmatian coast, western coast of Greece) and one that is due to the subduction of the African lithosphere under the Aegean. In Northern Aegean the strike-slip faulting is attributed to the continuation of the North Anatolian fault into the Aegean. This strike-slip faulting seems to terminate, rather abruptly, towards the normal faults of the mainland of Greece. As a concluding remark we would like to say that though the Aegean and the surrounding area is a rather complex area, there are some well defined patterns to satisfy the scientists who like formalism!

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