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ACTIVE TECTONIC FORCES IN THE AEGEAN AREA

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A B S T R A C T

The basic seismotectonic features of the Aegean and surrounding area as well as some geodynamic models proposed to interprete these features are described. On the basis of this information a system of tectonic forces acting at present in the Aegean and surrounding area is proposed. This system is composed of three external horizontal compressional forces which are exurted on the boundaries of this area by the adjacent lithospheric plates (Eastern Mediterranean, Apulian, Turkish) which move towards the Aegean and by extensional horizontal forces which are produced in the Aegean lithosphere by its north-south expansion.

Σ Υ Ν Ο Ψ Η

Οι βασικές σεισμοτεκτονικές ιδιότητες του Αιγαίου και των γύρω περιοχών περιγράφονται. Περιγράφονται επίσης μερικά από τα σημαντικότερα γεωδυναμικά μοντέλα τα οποία έχουν προταθεί για την ερμηνεία αυτών των ιδιοτήτων. Με βάση τα στοιχεία αυτά προτείνεται ένα σύστημα τεκτονικών δυνάμεων οι οποίες δρούν σήμερα στο Αιγαίο και τις γύρω περιοχές. Αυτό το σύστημα αποτελείται από τρεις εξωτερικές οριζόντιες συμπιεστικές δυνάμεις οι οποίες ασκούνται στις παρυφές της λιθόσφαιρας του Αιγαίου από τις γειτονικές λιθόσφαιρες οι οποίες κινούνται με κατεύθυνση το Αιγαίο (Ανατολική Μεσόγειος, Απούλια, Τουρκία) και από εφελκυστικές δυνάμεις οι οποίες ασκούνται μέσα σ' αυτή τη λιθόσφαιρα λόγω της επέκτασή της κατά τη διεύθυνση βορρά-νότου.

INTRODUCTION

It is well known that the Aegean and surrounding area (34^{o}N-43^{o}N, 18^{o}E-30^{o}E) is seismically one of the most active regions of the world. Its seismicity is the highest not only in the whole Mediterranean but in the whole West Eurasian area. Destructive shallow earthquakes with surface wave magnitudes up to 7.8

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and intermediate depth earthquakes with even larger magnitudes (~8.0) have repeatedly struck countries of this area. Almost every year at least one earthquake with magnitude 6.5 or larger occurs in this relatively small region. For this reason, a good understanding of the geodynamics of this area is of primary importance.

This region is a part of the collision zone between the Eurasian and the African lithospheric plates but its present tectonic activity is much higher than in other regions of the same zone. The most prominent features of tectonic origin in this area, from south to north, are the Mediterranean ridge, which is a compressional submarine crustal swell that extends from the Ionian Sea to Cyprus and parallels the Hellenic arc, the Hellenic trench with a maximum water depth of about 5Km, the Hellenic arc, which consists of the outer sedimentary arc and the inner volcanic arc, and the back-arc Aegean area. The Hellenic arc and the back-arc Aegean area have the main properties of the well known island arcs and marginal seas (Papazachos and Comninakis 1971).

The purpose of the present paper is to describe the basic seismotectonic and geodynamic features of this area and to present a schematic model for the forces responsible for these features.

BASIC SEISMOTECTONIC FEATURES OF THE AEGEAN AND SURROUNDING AREA

Active tectonics in the Aegean and surrounding has been investigated by several authors by the use of seismic and other geophysical data (Papazachos and Comninakis 1970, 1971, 1978, McKenzie 1970, 1972, 1978). Fault plane solutions of strong earthquakes is one of the most effective tools for investigating such properties. Papazachos and his colleagues (1986) used the most reliable fault plane solutions as well as other geophysical information to describe the main features of active tectonics in the Aegean and surrounding area. Figure (1) summarizes in a schematic way the properties of the active tectonics of the Aegean and surrounding area.

Thrust faulting is observed along the convex side of the Hellenic arc (Zante-S of Crete-S of Rhodos) except for the northernmost part of the arc where strike-slip faulting is observed.

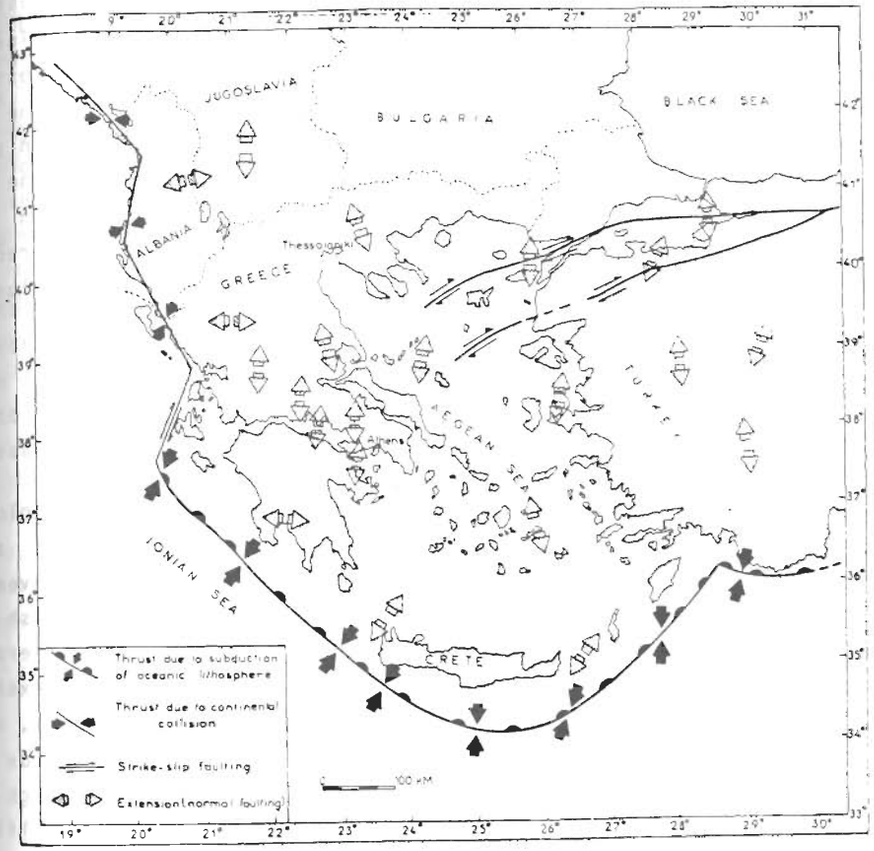

Fig. 1. Schematic representation of the main seismotectonic features of the Aegean and surrounding area (Papazachos eta al.1986).

Σχ. 1. Σχηματική παράσταση των κύριων σεισμοτεκτονικών χαρακτηριστικών του Αιγαίου και των γύρω περιοχών (Παπαζάχος και συνεργάτες 1986).

This is in full agreement with subduction of the eastern Mediterranean lithosphere (front part of the African lithospheric plate) under the Aegean lithosphere (front part of the Eurasian litnospheric plate).

The thrust faulting continues to the north in the land along the western coast of the central mainland of Greece and of Albania and Yugoslavia. In this case, however, there is no evidence for subduction (no Benioff zone, etc) and collision between two continental lithospheres (Eurasian-Apulian) occurs.

Normal faulting is observed in the whole inner partof the Aegean area, from Crete in the south to Bulgaria in the north and

from eastern Albanic and central Greece in the west to all western Turkey in the east. However, in the northwestern part of Turkey and in the northernmost part of the Aegean Sea strike-slip dextral faulting with thrust or normal component is also observed. The tensional field (axis T) in the Aegean has an almost North-South trend but close to the boundary with the outer thrust zone in the western part of the area change direction and the axis T has an almost East-West direction. The fault plane solution of the recent Kalamata earthquake (September 13, M=6.0) supports this conclusion (Papazachos et al. 1988).

GEODYNAMIC MODELS

Models proposed to interprete geophysical, geomorphological and geological properties of the Aegean and surrounding area assume external forces, that is, forces due to horizontal movements of adjacent lithospheric plates (westward movements of Turkish plate, northward movement of the eastern Mediterranean lithosphere , etc), internal forces (gravitational sliding) and forces exerted in the bottom of the Aegean lithosphere (convection currents, etc).

McKenzie (1970, 1972) suggested that relative motion between several lithospheric plates is the main cause of the high seismic activity in the Mediterranean area. Except for the big lithospheric plates of Eurasia, Africa, and Arabia, he considers four other relatively small plates (Aegean plate, Turkish plate, etc). He believed that the fast motion of the Aegean and Turkish plates relative to Africa and Europe and the subduction along the Hellenic arc can account for most of the seismic activity in the area.

Dewey and Sengor (1979) believed that the westward movement of the Anatolian (Turkish) plate from the Bitlis suture in North Arabia to consume oceanic lithosphere in the Eastern Mediterranean can explain most of the seismic and other properties of the area. The result of this westward motion was the generation of the northern Anatolian strike-slip dextral transform fault. In the northwestern Anatolia, the fault is branched in two strands which bend southwesterly south of the western end of the Marmara Sea and reach northern Aegean. The bending of these strands results to a

locking orientation in the northern Aegean that obstracts the western motion of the Anatolian plate relative to Greece and Balkans. These authors also believe that the western Anatolian graben system, situated on a very broad dome, may owe its origin to the locking geometry of the north Anatolia transform strands. That is, the East-West compression is relieved by north-south extension on a smaller scale in western Anatolia.

Rotstein (1985) assumes that Anatolia and the Aegean are parts of one plate complex which undergoes counter-clockwise rotation (fig.2.). At present, however, free and undisturbed rotation is possible only for the Anatolia block (excluding western Anatolia) where the motion is accommodated by subduction along the Cyprean arc. Due to a local obstruction caused by a "side arc collision" of the Hellenic arc with the Turkish plate near Rhodos, a separate Aegean block is created which is not separated from the Turkish plate and for this reason this block cannot move freely. Under this condition the greatest extension is expected along the suture zone between the two blocks and especially in the northeastern part of the Aegean block where the motion relative to Anatolia must be greatest.

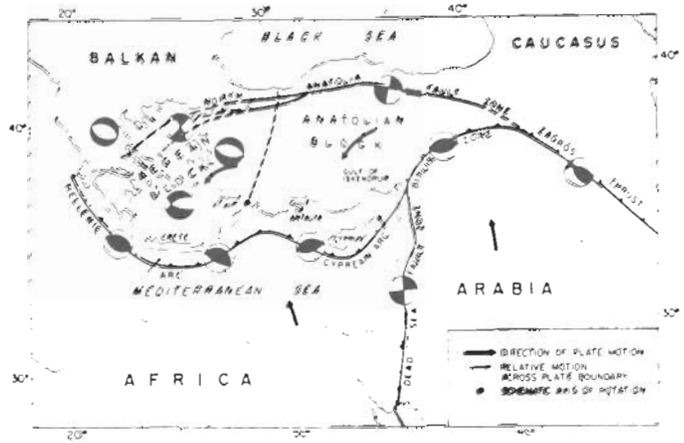

Fig. 2.Model proposed by Rotstein (1985).
Σχ. 2.Μοντέλο προτεινόμενο από τον Rotstein (1985).

Makris (1976, 1978) to interprete geophysical data assumed that at the center of the Aegean a lithological system of low compressional velocity and density ascending from the asthenosphe-

gion for the last 13m.y. They suggested that subduction along the Hellenic arc occurs by rotation of the sinking slab by 30° around 40°N, 18°E pole during the last 13m.y. (fig.4). They do not accept neither the idea that the strain pattern in the Aegean is due to forces acting at the bottom of the lithosphere nor the idea that the generalized extension within Aegean is due to the extrusion of Turkey to the west, but they agree that gravitational spreading is responsible for the extensional field in the Aegean.

On the basis of all available information, the forces acted on the Aegean and surrounding lithosphere are schematically shown in figure (5). These are:

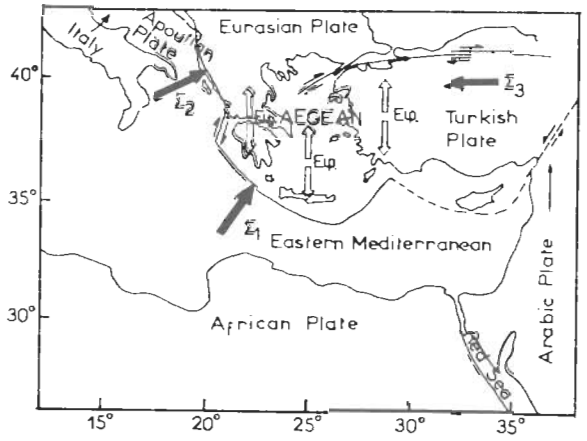

Fig. 5. Schematic representation of the compressional forces, Σ_1 Σ_2, Σ_3 and of the tensional forces, E_φ, acting on the Aegean lithosphere and surroundings.

Σχ. 5. Σχηματική παράσταση των συμπιεστικών δυνάμεων, Σ_1, Σ_2, Σ_3 και των εφελκυστικών δυνάμεων E_φ, οι οποίες ενεργούν στην λιθόσφαιρα του Αιγαίου και στις γύρω περιοχές.

a) Compressional forces excerted by the northwestward relative motion of the eastern Mediterranean lithosphere, Σ_1, by the anticlockwise rotation of the Apoulian lithosphere, Σ_2, by the westward motion of the Turkish lithosphere Σ_3. b) Tensional forces, E_φ, acting in the Aegean lithosphere.

The compressional force Σ_1 is due to the convergence of the Aegean lithosphere (front part of the Eurasian lithospheric plate) with the Eastern Mediterranean lithosphere (front part of the African lithospheric plate) along the convex side of the Hellenic arc. Such a convergence, with subduction of the Eastern Mediterranean lithosphere under the Aegean, has now been well established (Papazachos and Comninakis 1970, 1971, Papazachos et al. 1986, Mckenzie 1970, 1972, 1978) and is in agreement with the schematically represented in figures (2,3,4) geodynamic models (Rotstein 1985, Papazachos and Comninakis 1978, Le Pichon and Angelier 1979).

The compressional force Σ_2 is due to the convergence, without subdution, of the Apulian lithosphereric plate with the front part of the Eurasian lithosphere along the coast of Yugoslavia, Albania and northwestern Greece. All well determined fault plane solutions show horizontal compression almost normal to this coast (Papazachos et al 1986).

The compressional force Σ_3 is due to the westward movement of the Turkish litnospheric plate wnicn is very well established (Dewey and Sengor 1979).

The extensional forces Eφ in the Aegean and surroundings with a north-south direction have been determined by fault plane solutions (McKenzie 1972,1978) and are in full agreement with the schematically represented in figures (2,3) geodynamic models (Rotstein 1985, Papazacnos and Comninakis 1978). Such an extensional field is almost generally accepted today but there are different opinions in regard to the causes wnicn produce this field.

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