ΣΕΙΣΜΟΛΟΓΙΑ.— **Counterclockwise rotation of the stress pattern in the area of Greece**, *by A. G. Galanopoulos - N. Delibasis**. Ἀνεκοινώθη ὑπὸ τοῦ Ἀκαδημαϊκοῦ κ. Ἀγγέλου Γ. Γαλανοπούλου.

ABSTRACT

The counterclockwise rotation of T-axis in 14 out of 15 cases, irrespectively of the fault type mechanism, and of both principal axes in 9 cases, might be an abjustment process of the tectonic stress field, indicative of a rotational phenomenon closely related to the deformation agents being in action in the Aegean area. Counterclockwise rotation either of the underthrusting African plate or the overthrusting Aegean subplate might account for this phenomenon. However, the seismotectonic regime in Greece indicates that both these mechanisms are involved in the shaping of the regional tectonic stress field.

INTRODUCTION

1. Unusual Spreading of Earthquake Energy. A M_s $7^1/_2$ earthquake occurred on December 19, 1981, at 14 : 10 : 51 between the islands Skyros and Lesbos in the north Aegean sea (39.2° N, 25.2° E). The shock was particularly felt on Lesbos Island. Intensities of VIII degree on Mercalli - Sieberg scale were assigned to Heppion and Pamphyla and VII - VIII to Arisvi. Damages of VII degree were observed at Megalochorion, Petra, Parakoela, Pighi, Aphalonas, Anemotia and Agra. Similar damages were reported from Skyros Island (VII at Skyros). The VI degree isoseismal exceeded several lokalities on Lesbos Island, and according to Press reports some in western Turkey, encompassed the island of Psara and reached the localities Lithion, Lagada, Kardamyla and Kataraktis on Chios Island as well as Octhonia on Euboea.

The shock was felt to the south and southeast as far as Crete (IV at St. Varvara, Neapolis and Sitia, III at Zaros, Gagalae, St. Deka, Stavrochorion, Perama and Palaeochora) and Karpathos (IV at Menetas), to the west and southwest as far as Arta, Preveza, Acarnania, Elis, Messinia and

* Α. Γ. ΓΑΛΑΝΟΠΟΥΛΟΥ - Ν. ΔΕΛΗΜΠΑΣΗ, **Στροφὴ κατὰ τὴν ἀνάδρομον φορὰν τοῦ σχεδίου προσανατολισμοῦ τῶν ἀξόνων μεγίστης καὶ ἐλαχίστης τάσεως εἰς ζεύγη διαδοχικῶν σεισμῶν τοῦ Ἑλληνικοῦ χώρου.**

Laconia and to the northwest, north and northeast as far as Thesprotia, Jannina, Florina, Pella, Kilkis, Serres, Drama, Rhodope and Evros. According to Press reports it was also felt in Southern Bulgaria. The shock was not felt on the Ionian Islands. The Corfu Island, the most distant from the epicentral tract (ca. 460 km) is equidistant with Crete Island on which several localities have experienced the shock.

The same phenomenon was observed in the case of the M_s 6 $^1/_2$ aftershock (38.9° N, 24.9° E) that occurred on December 27, 1981, at 17 : 39 : 15. The shock was felt at Heraklion (III), at Malabes and Katochorion (II - III) on Crete Island, as well as on Leukas Island (III at Leukas and Karya), but not on the island of Zante, Ithaca and Corfu.

A similar M_s 7 $^1/_2$ earthquake on February 19, 1968, radiated from the same area (39.4° N, 24.9° E) was felt to the south as far as Crete (III at Neapolis). The M_s 6 $^1/_2$ earthquake in Corinthia (38.0°N, 22.4°E) on September 13, 1972, was felt over the whole island of Crete and the shaken area reached St. Isidoros on Rhodos Island. Similar observations from other earthquakes on August 28, 1962 (37.8°N, 22.9°E), March 31, 1965 (38.4°N, 22.3° E) and April 5, 1965 (37.7° N, 22.0° E) *throw much doubt on the validity of the wide-spread notion that the seismic energy experiences a strong attenuation in the area of the Aegean back-arc basin.* (Sieberg, 1933; Papazachos et al., 1971 ; Galanopoulos, 1980 ; Delibasis, 1982).

A M_s 7 earthquake occurred again in the north Aegean sea on January 18, 1982, at 19 : 27 : 24, with a focus (40.0° N, 24.3° E) not far from the source area of the 1981, December 19 major earthquake (39.2° N, 25.2° E). The new shock affected the islands of Thasos and Lesbos with a VI-degree intensity and the felt area reached the Ionian Islands (Corfu, Leukas and Zante), as well as the Cyclades (Ios and Santorin) in about the same epicentral distance.

2. Violation of Earthquake Repeat Time. The repeat time for M_s 7 $^1/_2$ earthquake based on a linear reccurrence model for a 4-square degree area centered at 39 $^1/_2$° N, 24 $^1/_2$° E ranges from 180 to 400 years. This is in striking disagreement with the unexpected occurrence of two nearby earthquakes with M_s 7 $^1/_2$ (39.4° N, 24.9° E and 39.2° N, 25.2° E) in a time interval of about 15 years (1968, February 19 and 1981, December 19). A previous earthquake with M_s 7 $^1/_2$ in the 4-square degree area cen-

tered at $39\,^1/_2$° N, $24\,^1/_2$° E dates 1905, November 8 ($40\,^1/_4$° N, $24\,^1/_4$° E). This makes 3 earthquakes with $M_s\ 7\,^1/_2$ in a time interval of 76 years, or on an average about one every 25 years[1].

APPARENT ROTATION OF STRESS PATTERN

1. Recent Cases. The 1981, December 19 and 27 earthquakes had their sources in the Skyros graben. The focus of the 1982, January 18 earthquake was seated in the Sporades graben. The two grabens are separated by a horst bounded by two antithetic faults. The fault in the south strand dips to the South and the other in the north strand to the North (see Fig. 1).

Waverly P. Person, editor of the "Seismological Notes", in the BSSA gives the following fault plane solutions (1982 b, 1983 c).

For the December 19, 1981 earthquake: "The preferred fault plane solution from P-wave first motions corresponds to a moderately well controlled strike-slip type mechanism. NP1 : strike = 135 degrees, dip = 88 degrees, slip = 18 degrees. NP2 : strike = 44 degrees, dip = 72 degrees, slip = 178 degrees. Principal axes: (T) PLG = 14 degrees, AZM = 1 degree, (P) PLG = 11 degrees, AZM = 268 degrees".

For the December 27, 1981 earthquake: "The preferred fault plane solution from P-wave first motions corresponds to a moderately well controlled strike-slip type mechanism. NP1 : strike = 120 degrees, dip = 86 degrees, slip = 9 degrees. NP2 : strike = 30 degrees, dip = 87 degrees, slip = 176 degrees. Principal axes: (T) PLG = 5 degrees, AZM = 345 degrees, (P) PLG = 1 degree, AZM = 75 degrees".

For the January 18, 1982 earthquake: "The preferred fault plane solution from P-wave first motions corresponds to a moderately well controlled strike-slip fault mechanism. NP1 : strike = 340°, dip = 77°, slip = 33°. NP2 : strike = 242°, dip = 58°, slip = 165°. Principal axis : (T) PLG = 32°, AZM = 205° ; (P) PLG = 13°, AZM = 107° ".

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1. Footnote added in the proofs: Another M_s 7 earthquake in the same area (40.2° N, 24.7° E) having occurred on August 6, 1983, has made the discrepancy between the observed and the derived time of recurrence for earthquakes with $M_s \geqq 7$ much more striking.

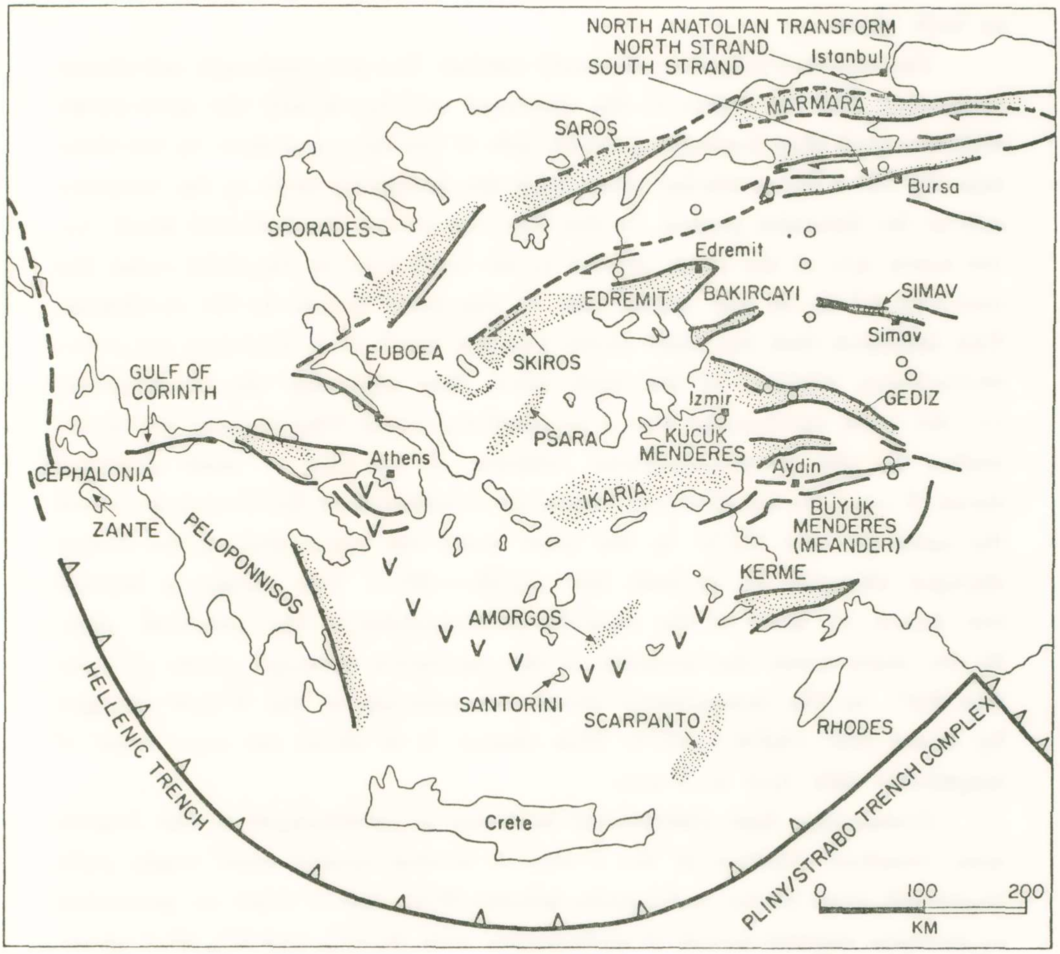

Fig. 1. Simplified summary of Aegean Tectonics after Rotstein (1983). Following Dewey and Sengör (1979). Heavy lines (broken where poorly defined) = faults; stippled = Neogene-Quaternary grabens; open circles = hot springs; heavy lines with open triangles on upper plate = subduction zone.

All the events above mentioned had a strike-slip type mechanism. From the distribution pattern of the aftershock epicenters we may designate with confidence the nodal plane given by NP 2 in the above solutions as fault plane.

The first two solutions are fairly similar. The principal axes are almost horizontal. The NP 2 dips to the southeast and has nearly the same strike with the fault that borders the north side of the Skyros graben. In the third case the NP 2 has a similar trend with the bordering fault in the southern side of the Sporades graben. In the first two events the foot-wall block, i.e. the south side of the horst, moved to the northeast; in the third event the foot-wall block in the north side of the horst moved to the southwest. This indicates that the third event was the result of a tendency for counterclockwise rotation of the fault block that separates the two grabens, i.e. the third earthquake was a sympathetic event. This surmise is corroborated by the counterclockwise rotation of the axis of least principal stress (T-axis). In the first two events the orientation of the T-axes is almost the same (1° and 345°). In the third event the orientation of the T-axis changed abruptly by at least 140° (AZM = 205°). This change is beyond the limits of error of the azimuth determination of the principal axes. In the main event the azimuth of the maximum principal stress (P-axis) was 268°. In the sympathetic event the azimuth of the P-axis changed by about 160° (AZM = 107°). This change is of about the same order of magnitude with that of T-axis.

Considering that distensional tectonics is predominant in the Aegean area, eventual rotation of the T-axis in several similar cases might yield important clues to the earthquake process. With this in mind we proceeded to examine another couple of earthquakes with M_s $6\,^3/_4$ and $6\,^1/_2$ that occurred previously on February 24, 1981, at 02 : 35 : 53 (38.2° N, 22.9° E) and March 4, 1981 at 21 : 58 : 06 (38.2° N, 23.3° E) in the area of the Gulf of Corinth. Waverly P. Person (1981, 1982 a) gives the following fault plane solutions for the second couple.

For the February 24, 1981, earthquake: "P-wave first motions correspond to a normal fault type mechanism with a strike-slip component. Moderately well controlled solution with one plane striking N 60 degrees (E) and dipping 60 degrees SE and the other plane striking N 32 degrees

W and dipping 50 degrees NE; P-axis plunges 53 degrees toward azimuth 275 degrees, T-axis plunges 6 degrees toward azimuth 177 degrees".

For the March 4, 1981, earthquake: "P-wave first motions indicate normal faulting with a component of strike slip. Moderately well controlled solution with one nodal plane striking N 30 degrees E and dipping 45 degrees SE and the other nodal plane striking S 62 degrees W and dipping 47 degrees NW; P-axis plunges 79.4 degrees toward azimuth 227 degrees, T-axis plunges 10 degrees toward 132 degrees".

Surface faulting observed in the epicentral tract and distribution pattern of aftershock epicenters point out that the first nodal plane is the fault plane in both cases. However, no matter which of the two nodal planes is the fault plane both solutions indicate normal faulting with a component of strike slip. Although the fault type mechanism in this case is different to that observed in the north Aegean sea, the principal axes seem to have been submitted to a similar rotation. The azimuth of the T-axis changed by 45° (from 177° to 132°). The change of the P-axis is of the same order of magnitude (from 275° to 227°). This counterclockwise rotation is fairly beyond the limits of error of the azimuth determination of the P and T-axes.

Going back we meet another pair of M_s $6\,^1/_2$ earthquakes with the same behaviour. Both earthquakes occurred on July 9, 1980 at 02 : 11 : 57 and 02 : 35 : 52. The earthquakes had their epicenters in the Magnesia graben (39.3° N, 22.9° E and 39.2° N, 22.6° E). The fault plane solutions obtained by the junior indicate normal faulting with a counterclockwise rotation of the T-axis by 180° (from 215° to 35°). The change of the azimuth of the P-axis by 31° (from 115° to 146°) might be within the limits of error of the azimuth determination of the principal axes.

2. Other Cases. The counterclockwise rotation of the T-axis in three recent earthquake bursts in the area of Greece aroused the suspicion, that this might not be fortuitous but a rather usual phenomenon in the Aegean area. To check this we tried to compile a list of earthquake pairs with fault plane solutions mostly well controlled by adequate number of P-wave first motion polarities.

The adopted list (see Table I) consists of 15 earthquake pairs[1]. Of these pairs 4 had solutions corresponding to normal faulting, 5 to reverse type faulting and 2 to trunscurrent or strike-slip type mechanism. The other 4 had one solution corresponding to normal faulting and the other to reverse type faulting or vice versa (see Fig. 2).

The solutions of all the earthquake pairs but one (no 6) indicate a counterclockwise rotation of the T-axis from 45° to 180°. The solutions of the pair no 6 indicate clockwise rotation of the T-axis by 16° and counterclockwise rotation of the P-axis by 103°. Considering that compressional tectonics is dominant in the area of the Ionian Islands (Mercier, 1981), the exception indicated by the fault plane solutions of the earthquake pair no 6 might be atributed to the above mentioned reason.

The solutions of the earthquake pairs no 3, 4, 7 (normal and reserve type faulting), 1, 8, 9, 10, (reverse type faulting), 14 (normal faulting) and 15 (strike - slip type mechanism) indicate counterclockwise rotation of both axes (P and T). The solutions of the earthquake pairs no 11, 12, 13 (normal faulting), 2 (normal and reverse faulting) and 5 (transurrent type mechanism) indicate clockwise rotation of the P-axis only. It might be noted that the azimuth change of the P-axis in the pair no 5 (by 5°) is too small to be reliable.

DISCUSSION AND CONCLUSION

The counterclockwise rotation of the T-axis in 14 out of 15 cases, irrespectively of the fault type mechanism, and of both axes in 9 cases, might be an adjustment process of the tectonic stress field, indicative of

1. Footnote added in the proofs: Another pair of recent earthquakes (1983, Jan. 17 and March 23) might be added to Table I. From the fault plane solutions published by W. J. Person (BSSA: Vol. 73, No 6, p. 1958, Dec. 1983 and Vol. 74, No 1, p. 355, Febr. 1984) we have: for the first shock (38.0° N, 20.2° E, $M_s = 7$) a reverse fault type mechanism with principal axes: (P)PLG = 35°, AZM = 230° ; (T)PLG = 55°, AZM = 50°. And for the second shock (38.3° N, 20.3° E, $M_s = 6\,^1/_4$) a strike-slip fault type mechanism with principal axes : (P) PLG = 3°, AZM = 266° ; (T) PLG = 20°, AZM = 357°. The earthquake pair shows a counterclockwise rotation of 53° for the T-axis and a clockwise rotation of 33° for the P-axis. The fault type mechanisms are R and S, respectively. It is worth noting the consistency in the counterclockwise rotation of the T-axis in 15 earthquake pairs out of 16 compiled.

TABLE I

Pairs of earthquakes showing counterclockwise rotation of the principal axes.

No	Date		Location		M_s	P-AXIS		T-AXIS		Type	Reference
			φ_N°	λ_E°		PLG	AZM	PLG	AZM		
1a	1953,	Aug. 11	38.0,	20.7	6 ³/₄	15	80	75	260	R	Ritsema
1b		Aug. 12	38.3,	20.8	7 ¹/₄	20	65	75	223	R	McKenzie
2a	1954,	Apr. 30	39.3,	22.2	7	52	89	24	214	N	Papazachos
2b		May 25	39.5,	22.2	5 ³/₄	5	240	85	60	R	Ritsema
3a	1956,	July 9	36.7,	25.9	7 ¹/₂	25	21	15	284	N	Aki
3b		July 10	36.8,	26.2	5 ³/₄	8	325	9	234	R	Delibasis
4a	1957,	Mar. 8	39.3,	22.6	6 ³/₄	55	189	6	288	N	Ritsema
4b		Mar. 28	39.3,	22.7	5 ³/₄	3	50	11	141	R	Ritsema
5a	1957,	Apr. 25	36.4,	28.7	7 ¹/₄	25	163	19	252	S	Ritsema
5b		Apr. 26	36.2,	28.9	6 ¹/₂	26	168	5	76	S	Ritsema
6a	1959,	Nov. 15	37.8,	20.8	7	37	240	48	28	R	Ritsema
6b		Dec. 1	38.0,	20.1	5 ³/₄	4	137	19	44	R	Ritsema
7a	1965,	Mar. 31	38.4,	22.3	6 ¹/₂	27	235	60	30	R	McKenzie
7b		Apr. 5	37.7,	22.0	6	68	153	21	345	N	Ritsema

Table I (continued)

No	Date	Location		M_s	P-AXIS		T-AXIS		Type	Reference
		$\overset{\circ}{\varphi}_N$	$\overset{\circ}{\lambda}_E$		PLG	AZM	PLG	AZM		
8a	1969, Apr. 16	35.3,	27.7	6	21	187	64	327	R	Ritsema
8b	May 1	35.4,	27.7	6	10	90	26	186	R	Ritsema
9a	1972, Apr. 29	34.8,	24.7	5 ³/₄	4	230	50	126	R	Ritsema
9b	May 4	35.1,	23.6	6	42	196	45	15	R	McKenzie
10a	1972, Sept. 17	38.3,	20.3	6 ¹/₄	18	262	9	169	R	Ritsema
10b	Oct. 30	38.3,	20.3	6	10	184	24	90	R	Ritsema
11a	1975, Mar. 17	40.5,	26.1	6 ¹/₄	44	183	26	65	N	Delibasis
11b	Mar. 27	40.4,	26.1	6 ¹/₂	57	262	3	351	N	McKenzie
12a	1978, May 23	40.7,	23.2	6 ¹/₂	1	251	1	350	N	Soufleris
12b	Juna 20	40.8,	23.2	6 ¹/₂	44	264	34	170	N	Soufleris
13a	1980, July 9	39.3,	22.9	6 ¹/₂	65	115	4	215	N	Delibasis
13b	July 9	39.2,	22.6	6 ¹/₂	60	146	11	35	N	Delibasis
14a	1981, Febr. 24	38.2,	22.9	6 ³/₄	53	275	6	177	N	Person
14b	Mar. 4	38.2,	23.3	6 ¹/₂	79	227	10	132	N	Person
15a	1981, Dec. 19	39.2,	25.2	7 ¹/₂	11	268	14	1	S	Person
15b	1982, Jan. 18	40.0,	24.3	7	13	107	32	205	S	Person

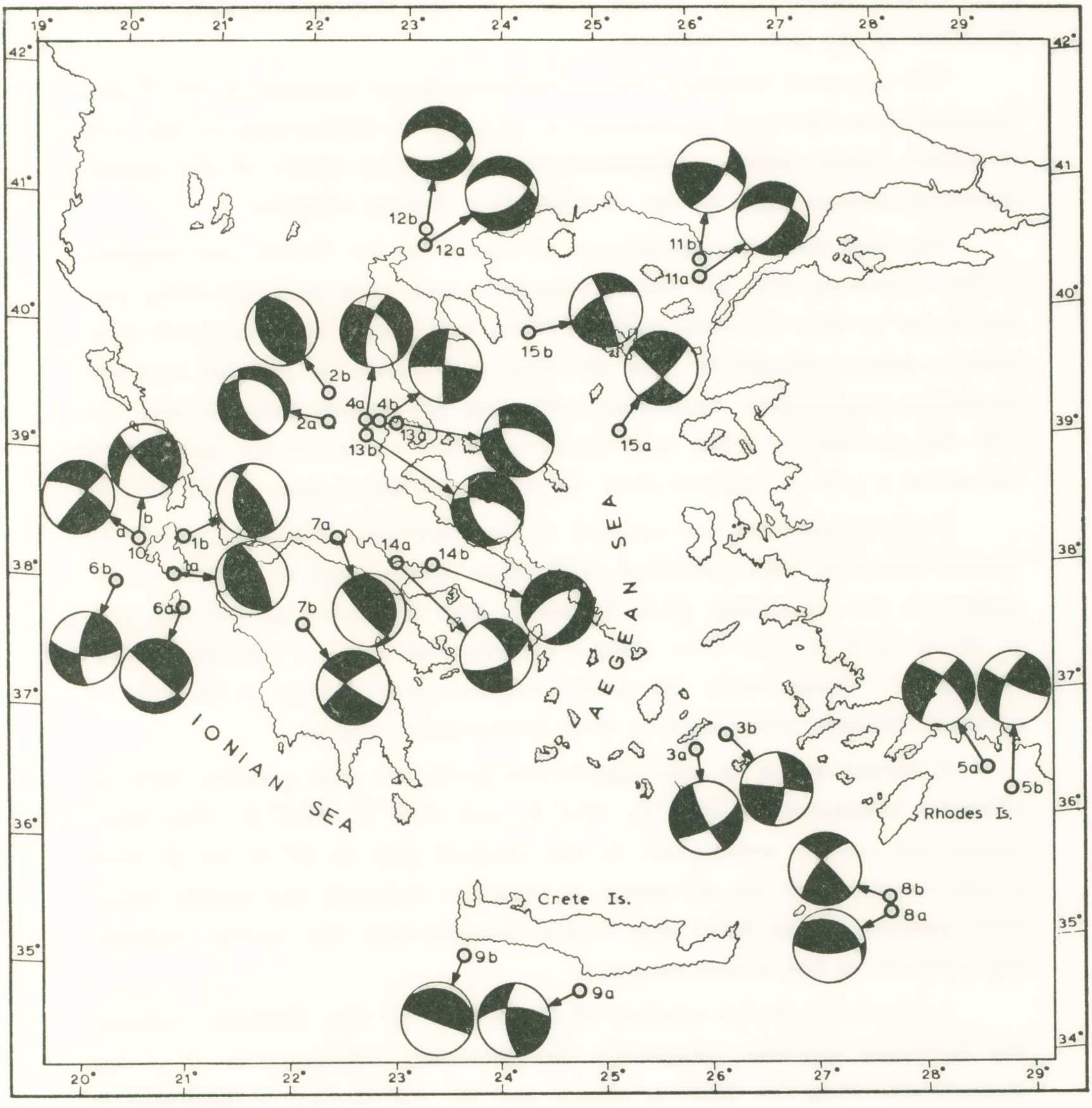

Fig. 2. Balloon diagrams show lower hemisphere fault - plane mechanisms from Aki (1964, event 3a), Delibasis (1982, events 3b, 11a, 13a, 13b), McKenzie (1972, events 1b, 7a; 1978, events 9b, 11b), Papazachos (1969, event 2a), Person (1981, event 14a; 1982, events 14b, 15a, 15b), Ritsema (1974, events 1a, 2b, 4a, 4b, 5a, 5b, 6a, 6b, 7b, 8a, 8b, 9a, 10a, 10b) and Soufleris (1980, events 12a, 12b). Shaded quadrants indicate compressional - first motions.

a rotational phenomenon closely related to the deformation agents being in action in the area considered.

The apparent tendency for a counterclockwise rotation of the T-axis surmised from the focal mechanism of 14 pairs of earthquakes in the area of Greece might reflect a counterclockwise rotation either of the underthrusting African plate or the overthrusting Aegean subplate.

The first rotational model was advanced by Le Pichon and Angelier (1979). Assuming that the Ionian trenches result from underthrusting perpendicular to their direction, whereas Pliny and Strabo trenches result from relative motion parallel to their direction and taking for granted that the transverse topographic lineaments offsetting the Ionian trenches and the SW-NE portions of Pliny and Strabo trenches are transform faults they calculated a pole of rotation close by to the northwest near 38° N, 20.5° E.

Furthermore from the azimuth of the horizontal projection of 14 slip vectors compiled from published fault plane mechanisms of shallow earthquakes at the consuming plate boundary they computed an eulerian pole at 40° N, 17.8° E. The least squares solution has given a standard deviation of 20°. Consequently the second eulerian pole is close to the pole of rotation obtained independently from bathymetric trends.

A second set of 50 slip vectors has given the pole position with an alternate treatment at 41.5° N, 16.1° E and 39.5° N, 18.5° E. The theoretical slip vectors correspond to the adopted pole at 40° N, 18° E. Such a pole accounts for the difference in structure between the mostly transform portions of the Pliny and Strabo trenches and the purely consuming portions of the Ionian trenches.

A counterclockwise rotation of about 30° of the Hellenic consuming boundary explains adequately the geometric configuration of a slab underthrust along the Hellenic trench and the distribution of intermediate seismicity.

Based on the age of the volcanics on Crommyonia and Milos Le Pichon and Angelier were led to adopt an average rate of rotation for the sinking slab of 2 - 3°/m.y. It is assumed that the present phase of underthrusting started at the latest in Serravallian - Tortonian times, roughly 13 - 12 m.y. ago.

The second rotational model put forward recently by Yair Rotstein (1983) is based on the assumption that the Aegean and Anatolia are parts of one plate complex undergoing counterclockwise rotation.

The rotation is accomodated by subduction along the eastern Mediterranean with the overthrust of Aegean - Anatolia over Africa. Rotstein believes that the combined effect of transform motion on the North Anatolia fault zone and obstruction of normal subduction in southwestern Turkey results in a modified rotation of the Aegean with the pole of rotation in the zone of obstructed subduction near Rhodes. The rotation away of Rhodes is still counterclockwise but the pole of rotation is probably the zone of side arc collision.

Any mechanism proposed to explain the unusual tectonics of the Aegean region must, if it is to be generally accepted, account for the two centers of higher earthquake activity observed in the area of Greece (Galanopoulos 1963, 1973). The first center in the area of Cephalonia - Zante is associated with crustal activity. The second center in the southeastern Aegean has mostly a subcrustal origin (Galanopoulos, 1971). The centers of higher activity should be associated with the peripheral regions of the rotating block.

The Cephalonia - Zante center is rather close to the rotation pole of the Le Pichon - Angelier's geodynamical model. Consequently the first center of crustal seismicity is not compatible with the above model. On the contrary internal deformation in the peripheral subducted region of the rotating oceanic block might well account for the subcrustal activity of the southeastern Aegean center.

On the other hand the rotation pole of the Rotstein's geodynamical model is too close to the southeastern center of higher tectonic activity. Therefore Rotsteins's model is not consistent with the Aegean seismic center. On the contrary internal deformation in the peripheral overthrusting region of the rotating continental block may easily explain the Cephalonia - Zante center of crustal activity.

It might then be reasonable to assume that both these mechanisms are active in the area of Greece. The tensional grabens of Patras and Corinth with the common apex in the area of Rion and a shape facing at opposite directions might be indicative of two rotational patterns of deformation.

If both these mechanisms are indeed in action one can easily explain not merely the regional geological and geophysical trends, but also much of the details of the Aegean complex tectonics.

ΠΕΡΙΛΗΨΙΣ

Οἱ μηχανισμοὶ γενέσεως τῶν δύο τελευταίων σφοδρῶν σεισμῶν πού συνέβησαν εἰς τὸ βόρειον Αἰγαῖον, μὲ μέγεθος 7 καὶ ἄνω, τὴν 19 Δεκεμβρίου 1981 (39.2° N, 25.2° E) καὶ τὴν 18 Ἰανουαρίου 1982 (40.0° N, 24.3° E) φαίνεται ὅτι ὠφείλοντο καὶ οἱ δύο εἰς ὁριζοντίαν διάρρηξιν τῆς νοτίας καὶ βορείας παρυφῆς τεκτονικῆς προεξοχῆς πού χωρίζει δύο τάφρους.

Λόγῳ τῆς φιλοξενίας τῶν ἑστιῶν των εἰς τὴν αὐτὴν τεκτονικὴν μονάδα ἀνεμένετο τὸ σχέδιον προσανατολισμοῦ τῶν δύο πρωτευόντων ἀξόνων μεγίστης καὶ ἐλαχίστης τάσεως νὰ ἦτο περίπου τὸ ἴδιον. Παραδόξως ἀμφότεροι οἱ ἄξονες οὗτοι παρουσίασαν στροφὴν ἀντίθετον πρὸς τὴν φορὰν τῶν δεικτῶν τοῦ ὡρολογίου κατὰ 150 - 160°, πού εἶναι πολὺ μεγαλυτέρα οἱουδήποτε πιθανοῦ σφάλματος καθορισμοῦ τῆς διευθύνσεως τούτων.

Ἀνάλογον φαινόμενον παρουσιάσθη καὶ εἰς τοὺς δύο ἰσχυροὺς σεισμοὺς μεγέθους $6^1/_2$ καὶ ἄνω πού συνέβησαν εἰς τὴν ἀνατολικὴν πλευρὰν τοῦ Κορινθιακοῦ κόλπου τὴν 24 Φεβρουαρίου (38.2° N, 22.9° E) καὶ τὴν 4 Μαρτίου 1981 (38.2° N, 23.3° E). Ἀμφότεροι οἱ σεισμοὶ οὗτοι ὠφείλοντο εἰς κανονικὴν διάρρηξιν τοῦ αὐτοῦ τεκτονικοῦ τεμάχους. Ἡ μόνη διαφορὰ πού παρουσιάζουν οἱ μηχανισμοὶ γενέσεώς των εἶναι εἰς τὸ σχέδιον προσανατολισμοῦ τῶν πρωτευόντων ἀξόνων. Ἀμφότεροι οἱ ἄξονες οὗτοι παρουσιάζουν κατὰ τὸν δεύτερον σεισμὸν στροφὴν μὲ ἀνάδρομον φορὰν κατὰ 45 - 48°. Καὶ ἡ στροφὴ αὐτὴ εἶναι μεγαλυτέρα τοῦ πιθανοῦ σφάλματος εἰς τὸν καθορισμὸν τῆς ἀζιμουθιακῆς διευθύνσεως τῶν ἀξόνων P καὶ T.

Οἱ δύο σεισμοὶ μεγέθους $6^1/_2$ τῆς 9 Ἰουλίου 1980 πού συνέβησαν εἰς τὸ ρηξιγενὲς πεδίον τῆς Μαγνησίας (39.3° N, 22.9° E) καὶ (39.2° N, 22.6° E) ὠφείλοντο καὶ αὐτοὶ εἰς κανονικὴν διάρρηξιν. Εἰς τὸν δεύτερον σεισμὸν ὁ ἄξων μεγίστης τάσεως (P) ἐστράφη κατὰ τὴν ὀρθὴν φορὰν κατὰ 31°. Ἀντιθέτως ὁ ἄξων ἐλαχίστης τάσεως (T) παρουσιάζει στροφὴν κατὰ τὴν ἀνάδρομον φορὰν κατὰ 180°.

Ἔχοντες ὑπ' ὄψιν ὅτι εἰς τὴν Αἰγαίαν ὑποπλάκα ἐπικρατοῦν τάσεις ἐφελκυσμοῦ, ἡ στροφὴ κατὰ τὴν ἀνάδρομον φορὰν τοῦ ἄξονος ἐλαχίστης τάσεως (T) εἰς τρία ζεύγη διαδοχικῶν σεισμῶν ὑπέβαλε τὴν ὑποψίαν ὅτι ἐνδέχεται τὸ φαινόμενον τοῦτο νὰ μὴν εἶναι τυχαῖον. Διὰ τὸν ἔλεγχον τῆς ὑποψίας ταύτης κατηρτίσθη πίναξ τῶν θέσεων τῶν πρωτευόντων ἀξόνων ποὺ ἔχουν εὑρεθῆ ἀπὸ διαφόρους ἐρευνητὰς διὰ 15 ἐν συνόλῳ ζεύγη διαδοχικῶν σεισμῶν ποὺ τὸ μέγεθός των ἦτο ἴσον ἢ μεγαλύτερον ἀπὸ $5\,^3/_4$, ὥστε οἱ μηχανισμοὶ γενέσεώς των νὰ παρουσιάζουν ἐπαρκῆ ἀξιοπιστίαν.

Εἰς τὸν παρατιθέμενον πίνακα 4 ζεύγη ὠφείλοντο εἰς κανονικὴν διάρρηξιν, 5 εἰς ἀνάστροφον καὶ 2 εἰς ὁριζοντίαν. Τὰ ἄλλα 4 ζεύγη ὠφείλοντο ἐναλλὰξ εἰς κανονικὴν καὶ ἀνάστροφον διάρρηξιν, ἢ καὶ ἀναστρόφως.

Ἀνεξαρτήτως τοῦ εἴδους διαρρήξεως, οἱ μηχανισμοὶ τῶν 14 ἀπὸ τὰ 15 ζεύγη δεικνύουν αἰσθητὴν στροφὴν τοῦ ἄξονος Τ κατὰ τὴν ἀνάδρομον φοράν. Εἰς 9 ἀπὸ τὰς 14 περιπτώσεις ἡ στροφὴ κατὰ τὴν ἀνάδρομον φορὰν παρουσιάζεται καὶ εἰς τοὺς δύο ἄξονας Ρ καὶ Τ. Μόνον εἰς 1 περίπτωσιν ἀπὸ τὰς 15 ὁ ἄξων ἐλαχίστης τάσεως (Τ) παρουσιάζει μικρὰν στροφὴν (16°) κατὰ τὴν ὀρθὴν φοράν, καὶ ὁ ἄξων μεγίστης τάσεως (Ρ) μεγάλην στροφὴν (103°) κατὰ τὴν ἀνάδρομον φοράν. Ἡ περίπτωσις ὅμως αὕτη ἀναφέρεται εἰς ζεῦγος σεισμῶν ποὺ συνέβησαν ἔξωθεν τῆς περιοχῆς τῆς Αἰγαίας ὑποπλάκας, εἰς τὴν περιοχὴν τῶν Ἰονίων νήσων, ὅπου ἔχει δειχθῆ ὅτι ἐπικρατοῦν τάσεις συμπιέσεως.

Ἡ φαινομένη τάσις στροφῆς τοῦ ἄξονος ἐλαχίστης τάσεως (Τ) κατὰ τὴν ἀνάδρομον φορὰν εἰς 14 ζεύγη διαδοχικῶν σεισμῶν ἐπὶ τῆς Αἰγαίας ὑποπλάκας εἶναι πιθανῶς ἐκδήλωσις ἐσωτερικῆς παραμορφώσεως ἐξ ἀναλόγου στροφῆς τῆς ὑποκειμένης λόγῳ καταδύσεως πλάκας τῆς Ἀφρικῆς, ἢ τῆς ὑπερκειμένης λόγῳ ἐπωθήσεως ὑποπλάκας τοῦ Αἰγαίου.

Εἰς τὸ γεωδυναμικὸν ὑπόδειγμα τῶν Le Pichon - Angelier ὁ πόλος στροφῆς τῆς Ἀφρικῆς ἐν σχέσει πρὸς τὸ Αἰγαῖον εὑρίσκεται εἰς τὴν περιοχὴν τοῦ Τάραντος (40° N, 18° E). Εἰς τὸ γεωδυναμικὸν ὑπόδειγμα τοῦ Rotstein ὁ πόλος στροφῆς τῆς Αἰγαίας ὑποπλάκας ὡς πρὸς τὴν Ἀφρικὴν εὑρίσκεται εἰς τὴν περιοχὴν τῆς Ρόδου.

Τὸ πρῶτον ὑπόδειγμα στροφῆς δικαιολογεῖ τὸ κέντρον ηὐξημένης, ἐνδιαμέσου κυρίως, σεισμικῆς δράσεως ποὺ παρουσιάζεται εἰς τὸ νοτιοανατολικὸν Αἰγαῖον, ἀλλὰ ἀδυνατεῖ νὰ ἐξηγήσῃ τὴν ἐγγὺς τοῦ πόλου στροφῆς μεγάλην ἐπιφανειακὴν σεισμικὴν δρᾶσιν ποὺ παρατηρεῖται εἰς τὴν περιοχὴν Κεφαλληνίας - Ζακύνθου. Τὸ δεύτερον κινηματικὸν ὑπόδειγμα στροφῆς δικαιολογεῖ τὴν παρουσίαν τοῦ κέντρου ηὐξημένης σεισμικῆς δράσεως Κεφαλληνίας - Ζακύνθου εἰς τὴν περιφερειακὴν περιοχὴν τῆς στρεφομένης κατὰ τὴν ἀνάδρομον φορὰν ὑποπλάκας τοῦ Αἰγαίου, ἀλλὰ ἀδυνατεῖ νὰ ἐξηγήσῃ τὴν παρουσίαν πλήθους μεγάλων ἐνδιαμέσων σεισμῶν εἰς τὸ νοτιοανατολικὸν Αἰγαῖον ποὺ εἶναι ἐγγὺς τοῦ πόλου στροφῆς τοῦ ὑποδείγματος τούτου.

Οἱ ἀνωτέρω λόγοι φαίνεται νὰ συνηγοροῦν ὑπὲρ τῆς ἐκφραζομένης εἰς τὴν παροῦσαν ἐργασίαν ἀπόψεως, ὅτι καὶ ἡ ὑποκειμένη πλάκα καὶ ἡ ὑπερκειμένη ὑποπλάκα στρέφονται πράγματι κατὰ τὴν ἀνάδρομον φορὰν πέριξ τῶν ἀναφερθέντων πόλων. Ὁ συνδυασμὸς τῶν δύο αὐτῶν ὑποδειγμάτων στροφῆς φαίνεται νὰ δικαιολογῇ ἐπαρκῶς ὄχι μόνο πλεῖστα γεωλογικὰ καὶ γεωφυσικὰ χαρακτηριστικὰ τῆς περιοχῆς, ἀλλὰ καὶ τὴν κατὰ γενικὴν ὁμολογίαν πολύπλοκον τεκτονικὴν τοῦ Αἰγαίου.

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