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Regional Stresses Along the Eurasia-Africa Plate Boundary Derived from Focal Mechanisms of Large Earthquakes

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Abstract—The focal mechanism solutions of 83 European earthquakes with $M > 6$, selected from a total of 140, have been used to derive the directions of the principal axes of stress along the plate boundary between Eurasia and Africa from the Azores islands to the Caucasus mountains. Along most of the region, the horizontal P-axes are at an angle of 45° to 90° with the trend of the plate boundary. Horizontal T-axes are concentrated in central Italy and northern Greece in association with normal faulting. Large strike-slip motion of right-lateral character takes place at the center of the Azores-Gibraltar fault and the North Anatolian fault. From Gibraltar to the Caucasus the boundary is complicated by the presence of secondary blocks and zones of extended deformations with earthquakes spread over wide areas. Intermediate and deep earthquakes are present at four areas with arc-like structure, namely, Gibraltar, Sicily-Calabria, Hellenic arc and Carpathians.

Key words: Eurasia–Africa plate boundary, Mediterranean region, regional stresses, seismicity, focal mechanism, seismotectonics.

Introduction

The boundary between the lithospheric plates of Eurasia and Africa extends from west to east from the Azores islands to the Caucasus mountains where the African plate limits with the Arabia plate. From the Azores to Gibraltar the boundary is relatively simple separating oceanic lithosphere on both sides. East of Gibraltar the boundary is formed by the interaction of continental lithosphere and the oceanic parts of the Mediterranean Sea. The boundary in this region is especially complicated by the presence of small lithospheric blocks and the distribution of stresses by deformations extended over wide areas. The plate boundary must be interpreted in this region as an extended area that follows a complicated system of continental blocks, oceanic basins and orogenic belts, located between the stable parts of Europe and Africa. Earthquakes are also extended over wide areas at the boundary region and intraplate activity is also present.

Many studies have been made concerning the seismotectonic conditions of this region derived from seismicity and focal mechanisms, among them, those of

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CONSTANTINESCU *et al.* (1966), ISACKS *et al.* (1968), RITSEMA (1969), SHIROKOVA (1972), MCKENZIE (1972), UDÍAS and LOPEZ-ARROYO (1972), PAPAZACHOS (1973), PAYO (1975), UDÍAS *et al.* (1976), MCKENZIE (1978), UDÍAS (1980, 1982), JACKSON and MCKENZIE (1984), UDÍAS (1985), GRIMISON and CHEN (1986), ANDERSON and JACKSON (1987), BUFORN *et al.* (1988), JACKSON and MCKENZIE (1988), PAPAZACHOS (1988), ARGUS *et al.* (1989), WESTAWAY (1990). In this work we study the direction of the stress axes in the region as derived from the focal mechanisms of large earthquakes ($M > 6$) from 1935 to 1983. The deduction of stress directions from fault plane solutions of earthquakes is not exempt from ambiguity. As was pointed out by MCKENZIE (1969) most earthquakes happen on preexisting fault planes of weakness, and slips can occur at different angles relative to the principal axes. In fact, the maximum compressive stress may have an orientation anywhere within the dilatational quadrant, and not necessarily at 45 degrees of the fault plane. This ambiguity may be resolved using mechanisms of many earthquakes in the same area (ANGELIER, 1979; GEPHART and FORSYTH, 1984; RIVERA and CISTERNAS, 1990). However, the stress axes derived from fault plane solutions of large earthquakes may serve as an indication of their general trend for a given region. Using only large earthquakes is advantageous in that their solutions are well determined and the directions of the stresses derived from them correspond more likely to the regional stresses, since the ruptures extend along many kilometers and may not deviate strongly from the expected direction. The consistency in the stress directions found in this study confirms this point of view.

Seismicity

The distribution of epicenters for shallow earthquakes ($h \leq 60$ km) with magnitude $M \geq 4$ from 1960 to 1983 is shown in Figure 1. Earthquakes are located in a general West-East trend occupying a wide band from 30°N to 50°N. Inside this band the trend of the epicenters changes direction several times, outlining secondary blocks. The main characteristics of the seismicity may be described as follows. At the western end of the plate boundary, earthquakes are located following the trend of the Azores islands, branching from the Mid-Atlantic ridge in SE direction. From this point (24°W) earthquakes are located along a West-East transform fault, the Azores-Gibraltar fault, where large earthquakes ($M \geq 8$) are relatively frequent. From about 12°W, epicenters are spread over a wider zone in south Iberia and northern Morocco. In northern Iberia shocks are located along the Pyrenees. From northern Morocco earthquakes continue eastward along the coast of Algeria and Tunisia. From this point, epicenters change direction to the NE in the Sicily-Calabria arc and then continue in NW direction along the Apennines in the Italian peninsula. In northern Italy earthquakes form a wide arc at the Alps and continue again in SE direction along the coast of Yugoslavia and northern Greece. From

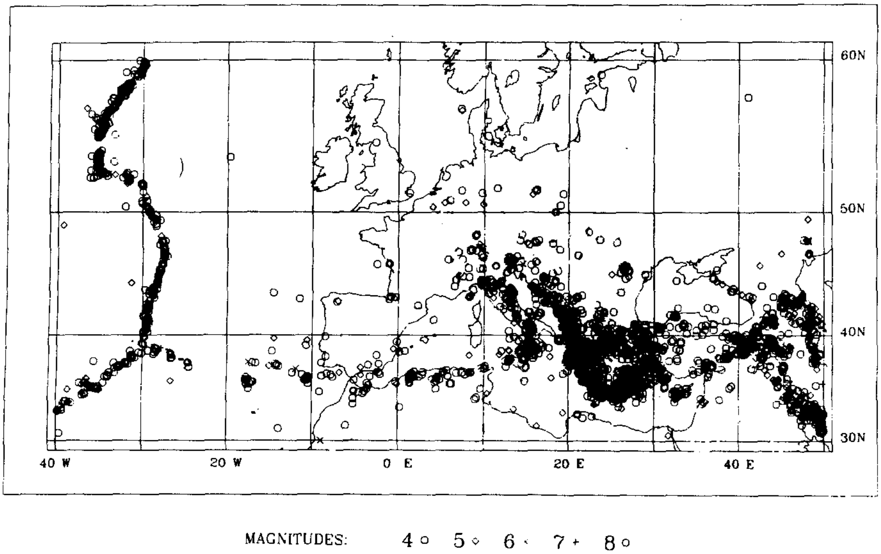

Figure 1
Epicenter distribution for shallow earthquakes ($h < 60$ km) and $M > 4$, 1962–1985 (USGS Hypocenter Data File).

here the earthquakes form a wide arc, the Hellenic arc, with the highest intensity of seismic activity in the whole region. The arc in convex to the south and behind it in northern Greece and western Turkey another region of high activity is present with E-W trend. To the east of the Hellenic arc, the arc of Cyprus, a smaller and less active arc, is located. Two alignments of earthquakes are located in the Anatolia peninsula. One at the north in E-W direction along the north Anatolian fault and the other in SW-NE. Both merge at about 40°E where earthquakes continue W-E in the Caucasus and NW-SE along the border of the Arabian plate.

The location of intermediate and deep earthquakes ($h > 60$ km) for the period 1910–1979 and $M > 4$, is shown in Figure 2. They are located at four distinct areas and related to the arc-like structures of Gibraltar, Sicily-Calabria, Hellenic and Carpathian arcs. Deep activity associated with the Gibraltar arc is revealed mainly by the deep Spanish earthquake of 1954 with $M = 7$ and depth 640 km. Two smaller shocks have occurred at the same depth. Some shocks of intermediate depth ($60 < h < 150$ km) are also present in south Spain and north Morocco. Deep earthquakes in the Sicily-Calabria arc are located at its concave side and extend to a depth of 450 km. Most are concentrated between 200 and 350 km with only a few shocks at greater depth. The distribution of shocks and their depth define a subduction zone that trends roughly N-S and dips about 60° in a westerly direction under the Tyrrhenian Sea. A gap of seismic activity is present between 60 and 200 km depth. Deep seismic activity associated with the Carpathian arc is located in a rather small region, known as the Vrancea seismic zone. Most shocks are located

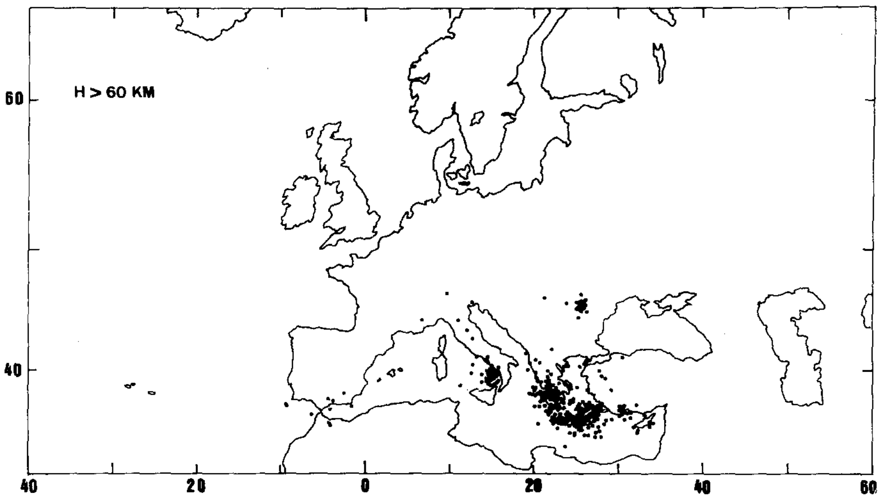

Figure 2
Epicenter distribution for intermediate and deep earthquakes ($h > 60$ km) and $M > 4$, 1910–1985 (USGS Hypocenter Data File).

at depths between 70 and 160 km. Distribution of shocks with depth suggests a nearly vertical subduction zone with earthquakes concentrated within a small volume. The largest concentration of intermediate and deep earthquakes is located along the Hellenic arc, which spans an area from the western coast of Greece to the southern coast of Turkey. The distribution of shocks and their depth indicate a well developed Benioff zone that dips from the convex side of the arc, reaching a maximum depth of 200 km. A second smaller arc associated with intermediate earthquakes is located near the island of Cyprus.

Regional Stresses

Recently, UDÍAS *et al.* (1989) have published a catalogue of focal mechanisms of European earthquakes with magnitudes $M > 6$ for the period 1906 to 1985, including solutions for 140 earthquakes. From these data a selection has been made of 83 earthquakes for which the mechanism is thought to be well determined and reliable. In order to make the selection, solutions in the catalogue have been classified according to classes A, B and C. Earthquakes belonging to class A have several solutions, all of them in agreement. Earthquakes belonging to class B have several solutions with the majority in agreement or only one solution determined by more than one type of data or with a very large number of data ($N > 100$). Finally, to class C are assigned earthquakes with only one solution, based on only one type of data or several solutions that do not agree with each other. In order to avoid dispersion in the data from the poorly determined solutions, only those of class A and a selection of class B have been selected. The hypocentral parameters of the 83 selected shocks are given in Table 1. For each event one solution has been selected. The P and T axes, quality of the solutions and references are given in Table 2.

In order to study the orientations of the horizontal components of the principal stresses, we represent those for P and T axes in separate figures. In both cases only those dipping less than 45° are represented. The directions of the horizontal projections of the pressure axes for shallow earthquakes ($h < 60$ km) are shown in Figure 3. In the same figure the trend of the simplified plate boundary, as derived from the seismicity trends, is given (McKenzie 1972: Udías, 1982; Jackson and McKenzie, 1988; Westaway, 1990). The first conclusion from Figure 3 is that the data are very consistent and the majority of the horizontal projections of the P axes are nearly normal to the plate boundary. In particular from Azores to Tunisia P axes form an angle from 60° to 90° in a consistent NNW-SSE direction. They correspond to strike-slip and thrust mechanisms. Along the coast of Yugoslavia and northern Greece P axes are normal to the trend of the coast in NEE-SWW direction. In the Hellenic arc, data are more scattered, but a direction normal to the arc is common. Behind the arc, between Greece and Turkey, P axes have E-W direction. Along the north Anatolian fault the direction is NW-SE corresponding to strike-slip mechanisms. In the Caucasus region a nearly N-S trend is found normal to the boundary of the Arabian plate corresponding to thrust mechanisms.

Horizontal projections of the tension axes for shallow earthquakes are shown in Figure 4. Since only those dipping less than 45° are given, the axes represented

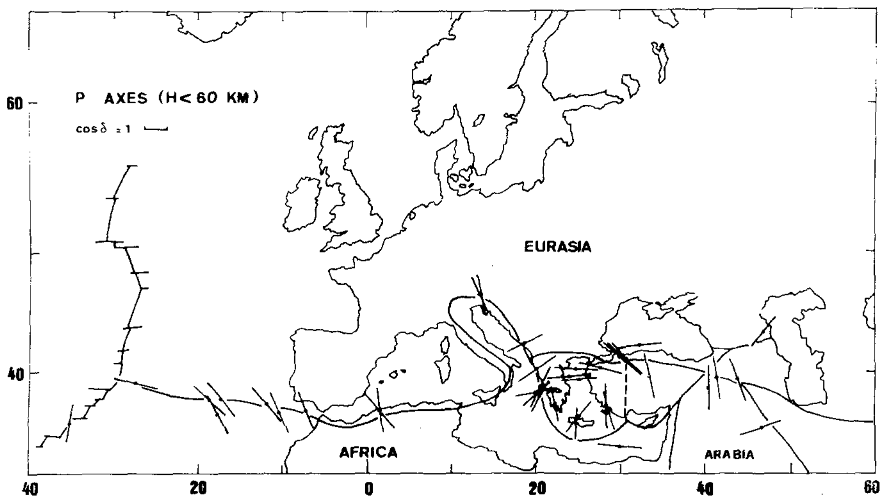

Figure 3
Horizontal projection of P axes with plunge less than 45° for shallow earthquakes ($h < 60$ km) and $M > 6$.

Table 1

Hypocenters Parameters

No.	Date	Time	Lat-N	Long-E	Depth	M/M_s
1	1935–02–25	02 51 37	35.75	25.00	80	6.75
2	1938–04–13	02 45 46	39.20	15.20	270	6.75
3	1938–04–19	10 59 15	39.50	33.50		6.75
4	1939–05–08	01 46 50	37.00	−24.50		7.10
5	1939–09–22	00 36 32	39.00	27.00		6.50
6	1940–02–29	16 07 42	35.50	25.50		6
7	1940–10–22	06 37 00	45.75	26.50	150	6.50
8	1940–11–10	01 39 09	45.75	26.50	130	7.40
9	1941–11–25	18 03 55	37.50	−18.50	25	8.40
10	1943–06–20	15 32 53	41.00	30.00		6.25
11	1945–09–02	11 53 57	33.75	28.50	80	6.5
12	1945–09–07	15 48 22	46.00	26.75	100	6.50
13	1946–04–05	20 54 05	35.25	23.50	100	6
14	1947–06–04	00 29 55	40.00	24.00	80	6.00
15	1947–10–06	19 55 37	37.00	22.00		7
16	1948–06–30	12 21 11	38.50	20.50		6.4
17	1949–07–23	15 03 30	38.50	26.50		6.75
18	1951–08–13	18 33 30	40.80	33.40		6.70
19	1953–03–18	19 06 11	40.00	27.50		7.25
20	1954–03–29	06 17 05	37.00	−03.50	640	7.00
21	1954–04–30	13 02 36	39.30	22.20		6.87
22	1954–09–09	01 04 37	36.20	01.60		6.75
23	1955–07–16	07 07 08	37.50	27.00		6.75
24	1955–09–12	06 09 20	32.50	30.00		6.50
25	1956–02–01	15 10 46	39.50	16.00	200	6.20
26	1957–04–25	02 25 42	36.47	28.56	53	7.10
27	1957–05–26	06 33 34	40.67	30.86		7.10
28	1957–05–27	11 01 26	40.50	31.00		6.25
29	1957–12–13	01 45 05	34.41	46.67	42	7.25
30	1959–05–14	06 36 56	35.14	24.58		6.50
31	1959–11–15	17 08 43	37.83	20.47		6.6
32	1960–01–03	20 19 30	39.50	15.50	250	6.20
33	1960–05–26	05 10 05	40.00	20.00		6.30
34	1961–05–23	02 45 16	36.60	28.30	49	6.25
35	1962–08–21	18 19 33	41.40	15.50	34	6.00
36	1962–08–28	10 59 56	37.82	22.89	100	6.70
37	1963–09–18	16 58 13	40.90	29.20	33	6.38
38	1964–03–15	22 30 26	36.20	−07.60	27	6.88
39	1964–10–06	14 31 19	40.30	28.20	10	
40	1965–03–09	17 57 54	39.40	24.00	18	6.38
41	1965–03–31	09 47 31	38.60	22.40	78	6.75
42	1965–07–06	03 18 43	38.40	22.40	20	6.25
43	1966–02–05	02 01 46	39.10	21.70	22	6.25
44	1966–08–19	12 22 11	39.20	41.60	33	6.70
45	1967–01–04	05 58 54	38.44	22.01	10	6
46	1967–03–04	17 58 06	39.22	24.62	33	6.88
47	1967–07–22	16 56 33	40.70	30.80	4	
48	1967–11–30	07 23 52	41.50	20.50	29	6.60

Table 1 (*Contd*)

No.	Date	Time	Lat-N	Long-E	Depth	M/M_s
49	1968-09-03	08 19 52	41.79	32.31	5	6.60
50	1969-02-28	02 40 33	36.01	−10.57	22	8.00
51	1969-03-28	01 48 30	38.59	28.45	9	6.40
52	1969-09-06	14 30 40	36.94	−11.89	33	6.00
53	1970-03-28	21 02 23	39.18	29.49	20	7.10
54	1970-04-08	13 50 27	38.43	22.66	17	5.90
55	1970-05-14	18 12 28	43.03	47.09	44	6.50
56	1970-11-18	12 23 18	35.15	−35.74	33	6
57	1971-05-12	06 25 13	37.59	29.76	23	6.3
58	1972-05-04	21 40 09	35.12	23.61	46	6.30
59	1972-09-13	04 13 21	37.93	22.39	83	
60	1972-09-17	14 07 16	38.28	20.34	33	6.3
61	1975-05-26	09 11 51	35.99	−17.65	33	7.9
62	1975-09-06	09 20 11	38.47	40.72	26	6.70
63	1976-05-06	20 00 12	46.36	13.28	9	6.5
64	1976-07-28	20 17 42	43.17	45.60	21	6.10
65	1976-09-15	03 15 20	46.30	13.20	10	6
66	1976-11-24	12 22 19	39.12	44.03	36	7.30
67	1977-03-04	19 21 54	45.77	26.76	94	7.20
68	1978-06-20	20 03 21	40.74	23.23	3	6.40
69	1978-11-04	15 22 20	37.71	48.95	34	6.1
70	1979-05-24	17 23 18	42.24	18.75	5	6.4
71	1980-01-01	16 42 40	38.80	−27.80		6.70
72	1980-07-09	02 35 52	39.23	22.59	20	6.1
73	1980-10-10	12 25 24	36.20	01.30		7.30
74	1980-11-23	18 34 54	40.90	15.40		6.90
75	1981-02-24	20 53 37	38.22	22.97	18	6.6
76	1981-02-25	02 35 54	38.17	23.12	30	6.3
77	1981-03-04	21 58 07	38.24	23.26	32	6.4
78	1981-12-19	14 10 51	39.22	25.25	10	7.2
79	1981-12-27	17 39 13	38.91	24.92	10	6.5
80	1983-01-17	12 41 30	38.07	20.24	14	7
81	1983-03-23	23 51 05	38.23	20.29	13	6.2
82	1983-08-06	15 43 52	40.14	24.74	2	6.9
83	1983-10-17	19 36 22	37.59	−17.41	10	6.3

correspond to the regions under horizontal tensional regime. In the Azores T axes are normal to the volcanic alignment. Along the Azores-Gibraltar fault, horizontal T axes in NE-SW correspond to the horizontal P axes, resulting in strike-slip right-lateral motion along the fault. Horizontal T axes are present in the Apennines, Italy in NE-SW direction, normal to the trend of the mountain chain and corresponding to normal faulting. A large concentration of horizontal T axes in a general N-S direction is present behind the Hellenic arc, in Greece and western Turkey. Along the north Anatolian fault, horizontal T axes in NE-SW direction correspond to the also horizontal P axes in agreement with the strike-slip motion along the fault.

Table 2

Fault-Plane Solutions

No.	P Trend	P Plunge	T Trend	T Plunge	*Q*	Ref.
1	344	21	212	60	B	18
2	280	35	80	55	B	19
3	348	14	254	16	A	11
4	234	49	355	24	B	3
5	70	74	176	05	B	18
6	220	30	40	60	B	18
7	130	10	162	75	A	10
8	303	11	140	78	A	18
9	133	11	42	04	A	3
10	132	10	40	10	A	15
11	130	00	00	90	B	18
12	290	10	182	59	A	18
13	249	31	69	59	B	18
14	232	25	88	59	B	18
15	168	35	258	01	B	20
16	205	04	301	57	B	18
17	102	45	197	05	A	15
18	302	21	37	11	A	15
19	284	02	15	11	A	15
20	87	43	279	46	A	9
21	51	72	253	17	A	18
22	171	15	11	74	A	15
23	261	57	354	02	A	15
24	276	05	180	52	B	15
25	324	62	118	25	A	4
26	163	25	262	19	A	18
27	312	05	43	12	A	15
28	329	14	234	18	B	20
29	71	01	340	62	A	15
30	182	44	76	16	A	18
31	22	37	235	50	A	1
32	278	59	95	32	A	7
33	57	16	324	12	A	18
34	179	17	359	73	A	15
35	331	81	205	06	A	15
36	179	01	87	68	A	15
37	134	57	23	17	A	11
38	158	25	304	61	A	3
39	354	80	174	10	A	20
40	265	00	175	03	B	15
41	235	27	80	60	A	15
42	358	59	177	31	A	15
43	143	67	350	20	B	1
44	353	04	259	42	A	20
45	170	45	350	45	B	20
46	328	82	212	04	A	15
47	138	06	228	01	A	20

Table 2 (*Contd*)

	P		*T*			
No.	Trend	Plunge	Trend	Plunge	*Q*	Ref.
49	84	01	174	36	A	11
50	165	04	67	64	A	3
51	6	96	186	21	A	18
52	138	14	47	07	A	3
53	84	61	200	14	A	18
54	346	64	187	25	A	14
55	40	29	225	61	B	11
56	190	18	283	01	A	3
57	34	78	144	04	B	19
58	196	49	16	41	A	14
59	355	10	92	56	A	14
60	260	29	258	14	B	1
61	151	09	246	10	A	3
62	359	01	91	62	A	11
63	168	30	342	60	B	1
64	354	34	174	56	B	11
65	155	10	268	66	B	1
66	340	12	71	11	A	11
67	323	17	151	73	B	8
68	315	83	177	15	A	2
69	90	25	270	65	B	11
70	244	25	64	65	A	1
71	104	15	194	02	A	3
72	112	82	344	02	A	17
73	320	09	106	80	A	6
74	183	68	37	18	A	5
75	298	76	181	07	A	21
76	270	83	153	03	A	21
77	33	86	154	02	A	21
78	255	35	357	16	A	17
79	78	06	168	02	A	17
80	225	38	44	52	A	1
81	249	19	348	25	A	1
82	272	04	02	05	A	16
83	320	04	50	01	A	3

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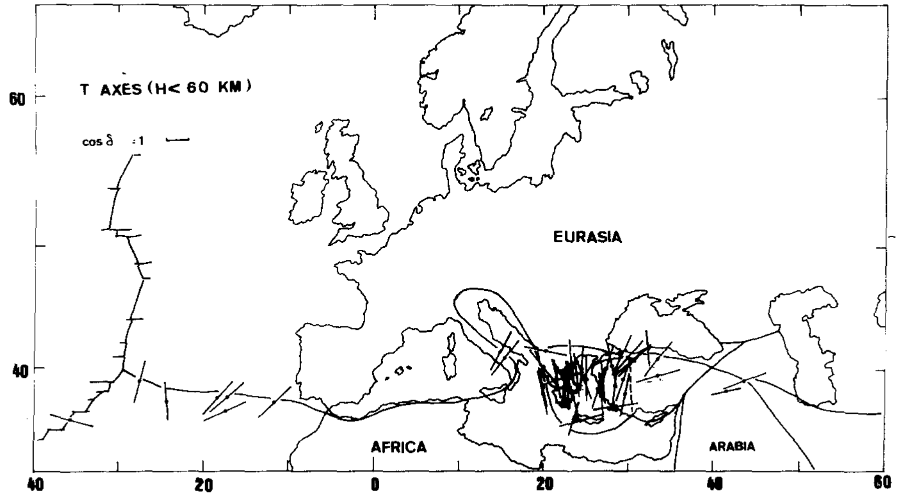

Figure 4
Horizontal projection of T axes with plunge less than 45° for shallow earthquakes ($h < 60$ km) and $M > 6$.

For intermediate and deep shocks, directions of the horizontal projections of P axes are shown in Figure 5. In south Spain, the very deep earthquake (640 km) has the P axis in E-W direction. In Sicily-Calabria, P axes are normal to the trend of the arc and the same is the case in the Carpathian arc. Intermediate shocks in the Hellenic arc have a greater dispersion. Two trends nearly perpendicular in NNW-SEE and NE-SW directions are present. Vertical projections of the P axes for each

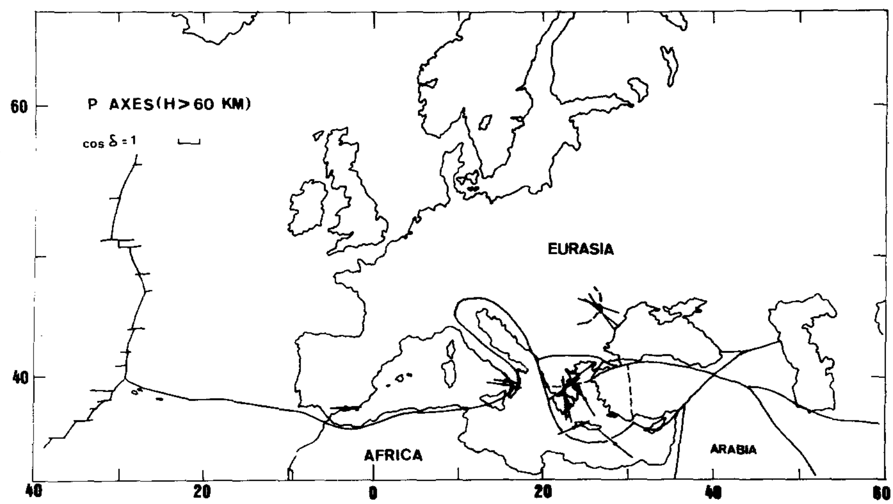

Figure 5
Horizontal projection of P axes for intermediate and deep earthquakes ($h > 60$ km) and $M > 6$.

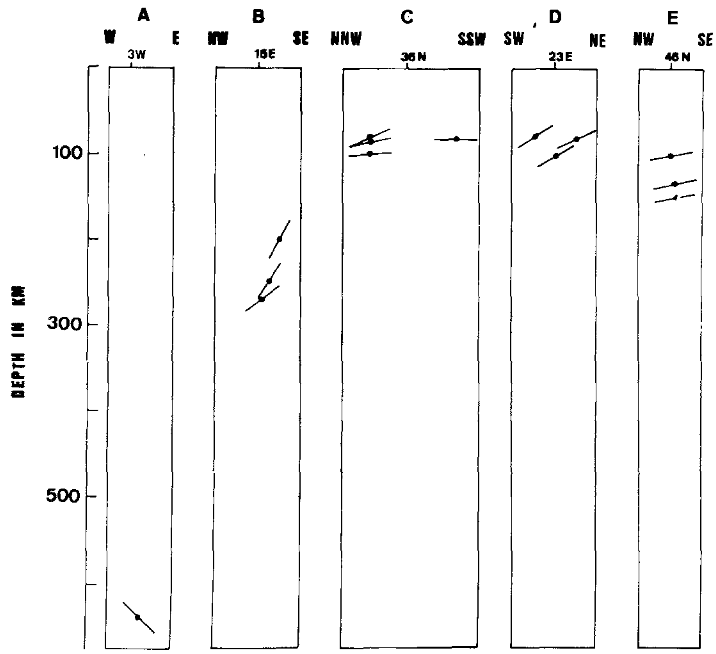

Figure 6
Projection on a vertical plane, of the P axes for intermediate and deep earthquakes, containing their average direction for the regions: A—Gibraltar, B—Sicily-Calabria, C and D—Hellenic arc, and E—Carpathians.

of the four regions are given in Figure 6. In this figure the axes are projected on a vertical plane containing the average direction of the axes. For the Hellenic arc, two planes are used, one in NNW-SSW and the other in SW-NE direction, according to the two sets of orientations found. The deep Spanish earthquake (A) is the only one with the axis dipping 45° to the East, all the other dip to the NW or SW. In Sicily-Calabria (B) the shocks at depths between 200 and 300 dip steeply to the NW. In the Carpathian region (E) the P axes are nearly horizontal, dipping slightly to the NW. In the Hellenic arc (C and D) the shocks are at about 100 km depth and their P axes are nearly horizontal. Those of set D with dips to the SW have somewhat larger dips.

Slip Vectors

In Figure 7 the directions of the slip vectors for the shallow shocks are shown corresponding to the African plate. In order to select the fault plane, we have assumed that the motion in the strike-slip faults is in the E-W direction and in the dip-slip faults, corresponding to down going of Africa with respect to Eurasia.

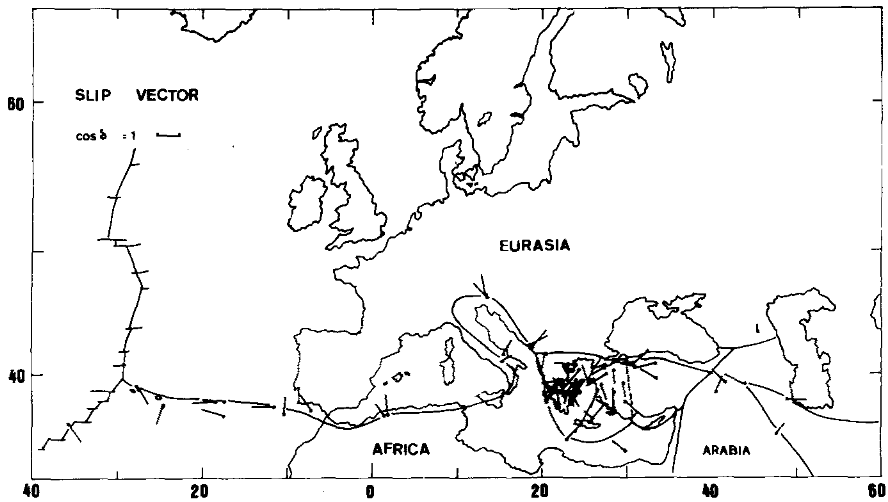

Figure 7
Horizontal projection of the slip vectors corresponding to the Africa plate.

From Azores to Tunisia, the slip vector rotates from south to west and finally to north. These directions of the slip vectors are consistent with a location of the pole of counterclock rotation of the Africa plate with respect to Eurasia plate near the Canary islands (21°N, 20°W) (ARGUS *et al.*, 1989). In central Italy (Adriatic block) the slip is directed NE, the same direction found for the shocks in the coast of Yugoslavia. In north Italy, however, the slips are in NNW direction. This situation is the main argument (ANDERSON and JACKSON, 1987) for the independent motion of the Adriatic block about a different pole of counterclock rotation at about 46°N, 10°E with respect to Eurasia.

Along the Hellenic arc, Africa moves to the north in a way consistent with the subduction process. Behind the arc, slip vectors on the Aegean block, including the western part of the Anatolian peninsula, have a consistent trend to the south. In the Anatolian block, however, the slip vectors point to the west. These two blocks must move, then, differentially with respect to Europe and Africa. Finally, the slip vectors on the Arabia plate all have a northerly trend.

Conclusions

Figure 8 shows a simplified summary picture of the situation along the plate boundary, based on the stress and slip directions presented in this work. The broad line of the figure follows the alignment of the most active seismicity (Fig. 1) and represents, in a broad sense, the location of the plate boundary. This line, however,

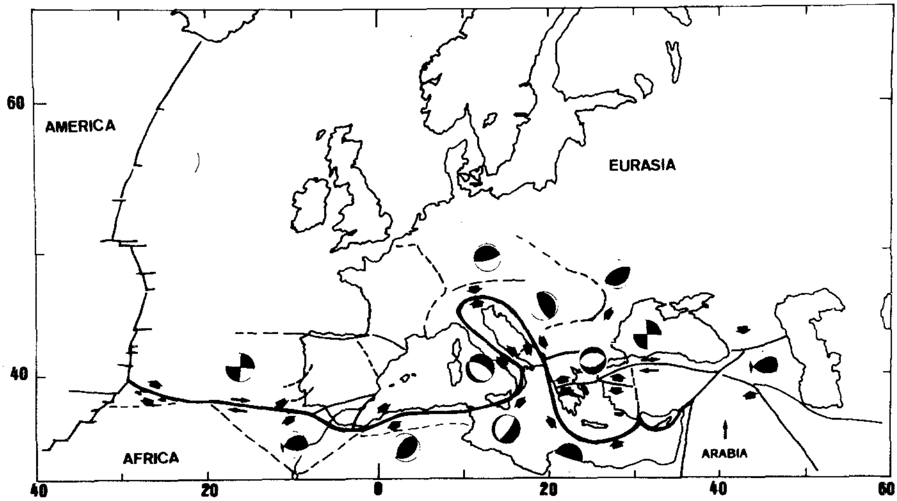

Figure 8
Seismotectonics of the plate boundary between Eurasia and Africa showing the direction of the regional stresses and predominant focal mechanism.

must be understood as a simplification of the actual situation that involves broad areas of deformation and cannot be reduced totally to the motion of rigid blocks. Thinner and dashed lines represent the limits of areas that form secondary small blocks which have independent or semi-independent movement with respect to the two main plates, or areas of deformations, and are based on the distribution of seismicity. The predominant type of focal mechanism in each region, the directions of the horizontal stresses and of the horizontal slip are also shown in Figure 8.

From West to East, the main characteristics of the plate boundary region are the following: At the Azores triple junction, the boundary between Africa and Eurasia has a ridge nature and is under horizontal normal tensions. From about 23°W to 12°W, the boundary is formed by a transform fault with strike-slip, right-lateral motion, with Africa moving West with respect to Eurasia. Near 12°W the motion changes to reverse faulting with the Africa plate moving under Eurasia. This type of motion is found in Algeria and may extend to 10°E. These changes at such a short distance along the boundary are consistent with a pole of rotation for Africa, not far from the boundary itself at about 21°N, 20°W. The presence of earthquakes extending into the Atlantic in front of the coast of Portugal, in Portugal, south Spain and northern Morocco and Algeria points to the presence of small blocks or deformable areas at both sides of the boundary. The earthquakes in the Pyrenees and northern Spain suggest that the stable part of the Iberian peninsula may form a block semi-independent from the Eurasia plate.

In the Sicily-Calabria arc, the lithospheric material of the Africa plate is subducted, pushed from the SE and reaching about 350 km in depth. In the subducted plate, the stresses dip steeply to the NW (Fig. 6). The Adriatic block has a motion that, as previously stated, does not agree with the motion of Africa. Along the Apennines, the block moves to the east from the other side of Italy, due to normal faulting. This motion causes reverse faulting and compressional stresses in NE-SW direction along the coast of Yugoslavia. In the northern part, however, the block pushes in N to NW direction producing also reverse faulting. This compression is transmitted to the broad region of the Alps. North of the Alps, a line of deformation extends even further along the Rhine graben. Also inside the Eurasia plate, the seismic activity related to the Carpathian region with a small vertical subducted block with compressional stresses pushing from the SE is located. The region of deformation extends further to the NW. This region may be considered as a former plate or block boundary that is now locked inside the Eurasia plate.

The region related to the Hellenic and Cyprus arcs is quite complex. The arcs themselves are under compressional stresses and lithospheric material of the Africa plate is subducted from the South to depths of about 200 km. Behind the Hellenic arc, the lithosphere is under tensional N-S stresses and predominant normal faulting. This results in stretching of the material and the formation of a back arc basin. This zone of extension covers Greece and western Anatolia. The rest of Anatolia moves westward along the north Anatolian fault, with large horizontal motion of strike-slip rigth-lateral character. This causes the northern part of the back arc basin to be subjected to E-W horizontal pressure (Fig. 3). The Arabia plate moves northward and causes, in one side, the motion to the West of the Anatolia block and the compression of the broad Caucasus region. In this region horizontal compressions have N-S direction and predominant motion takes place on reverse faults.

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