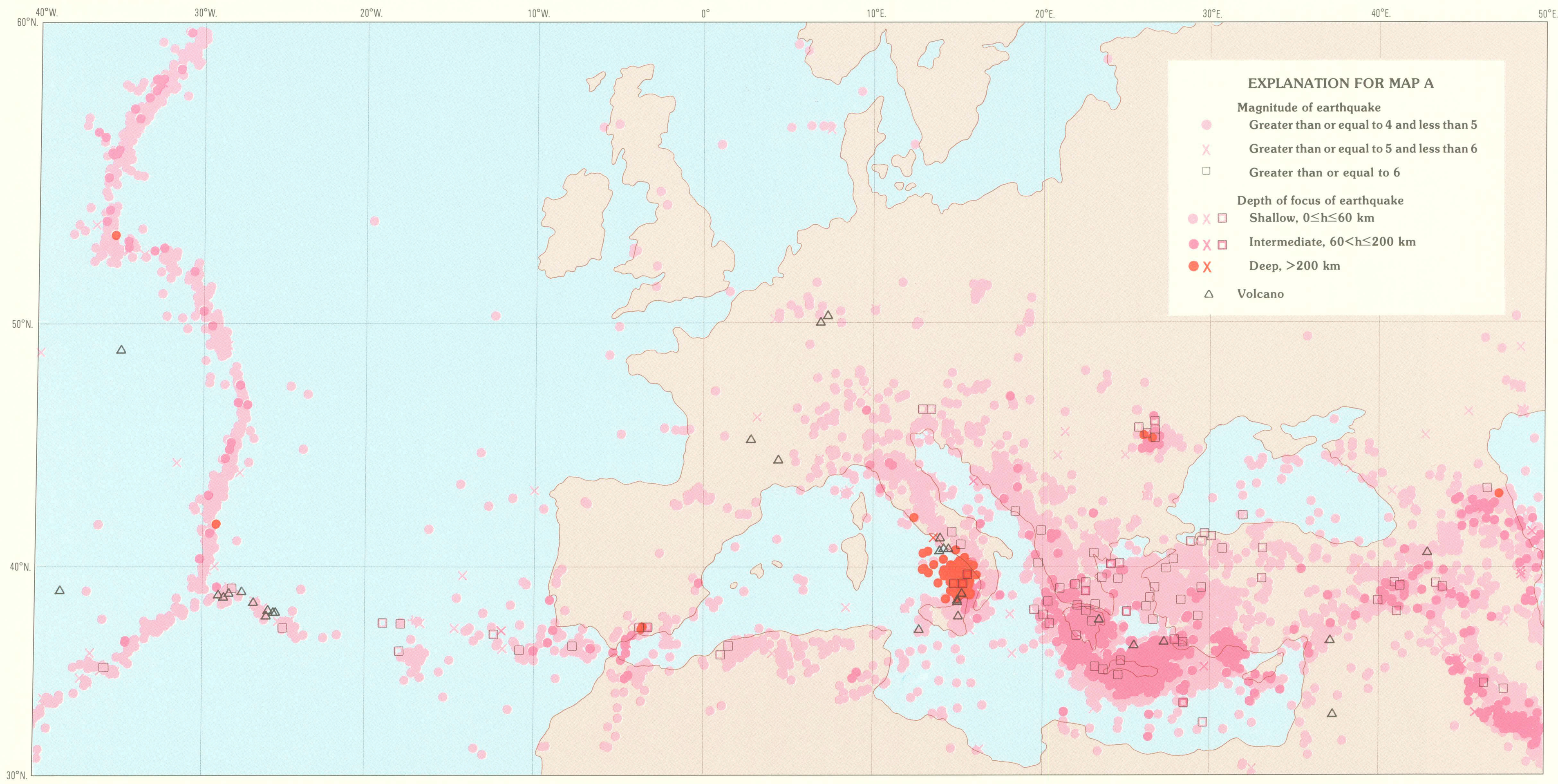
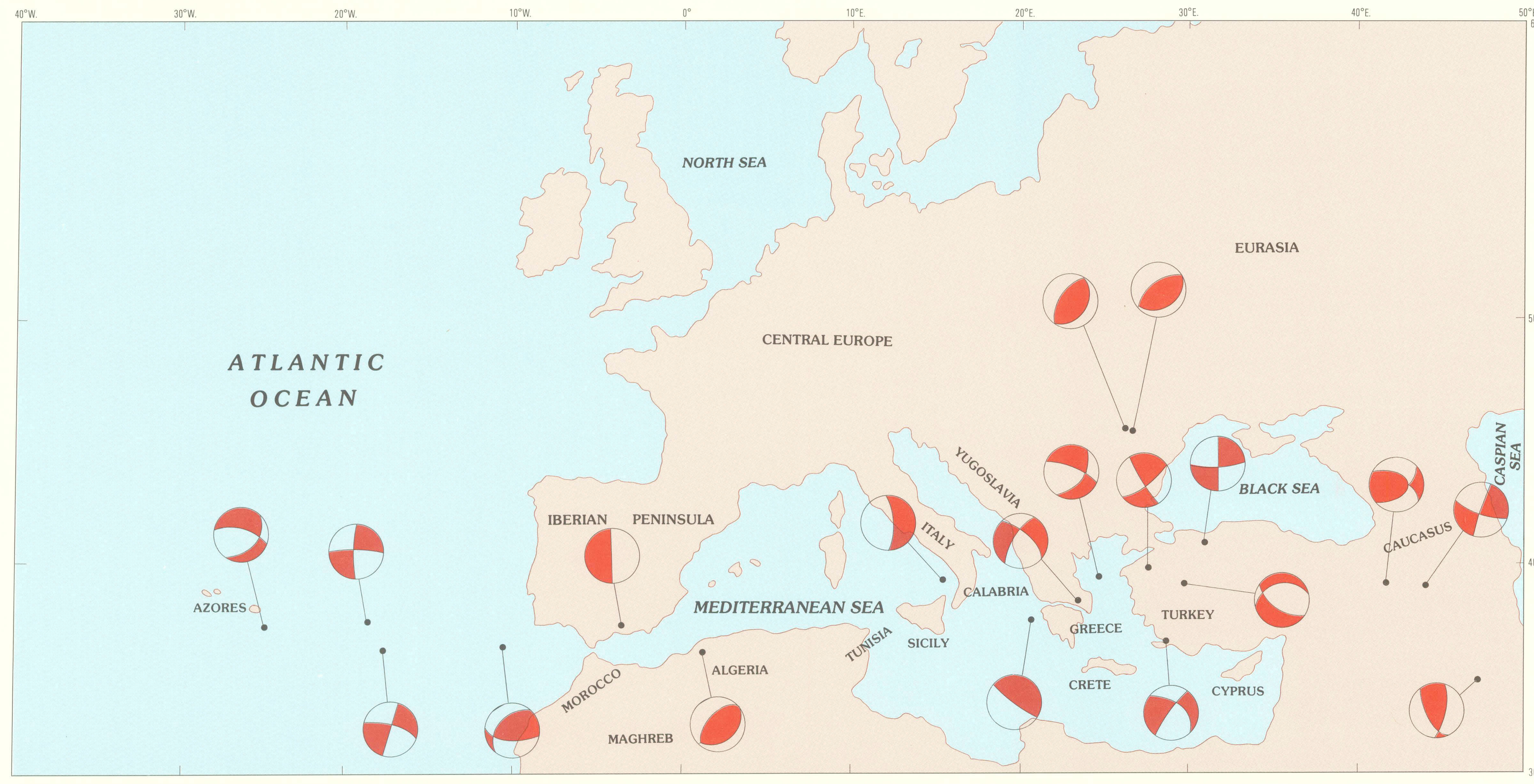
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
U.S.-SPAIN JOINT COMMITTEE FOR SCIENTIFIC AND TECHNOLOGICAL COOPERATION,
UNDER THE AUSPICES OF THE U.S. DEPARTMENT OF STATE AND THE
MINISTERIO DE ASUNTOS EXTERIORES DE ESPAÑA

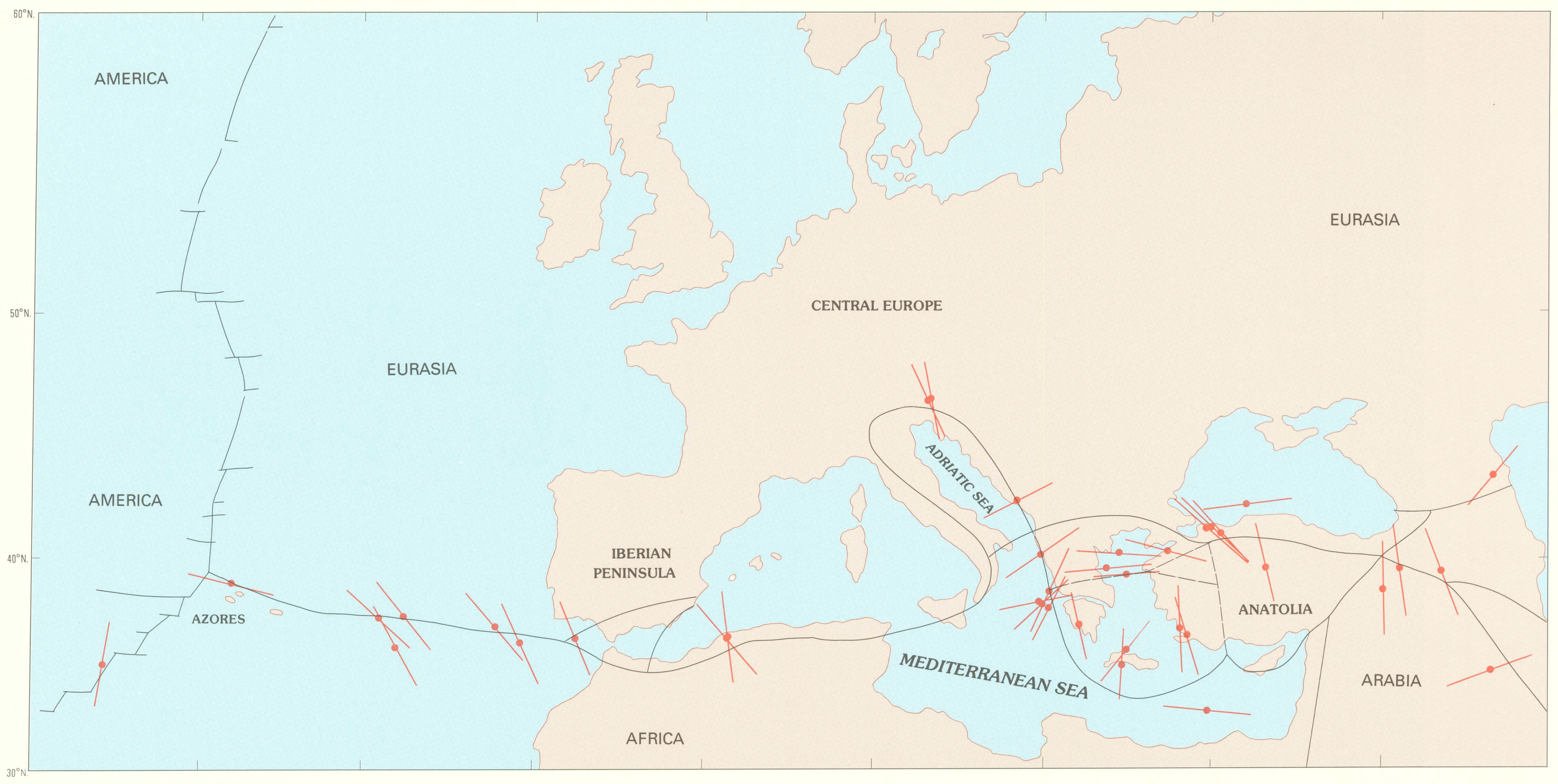
MISCELLANEOUS INVESTIGATIONS SERIES
MAP I-2363



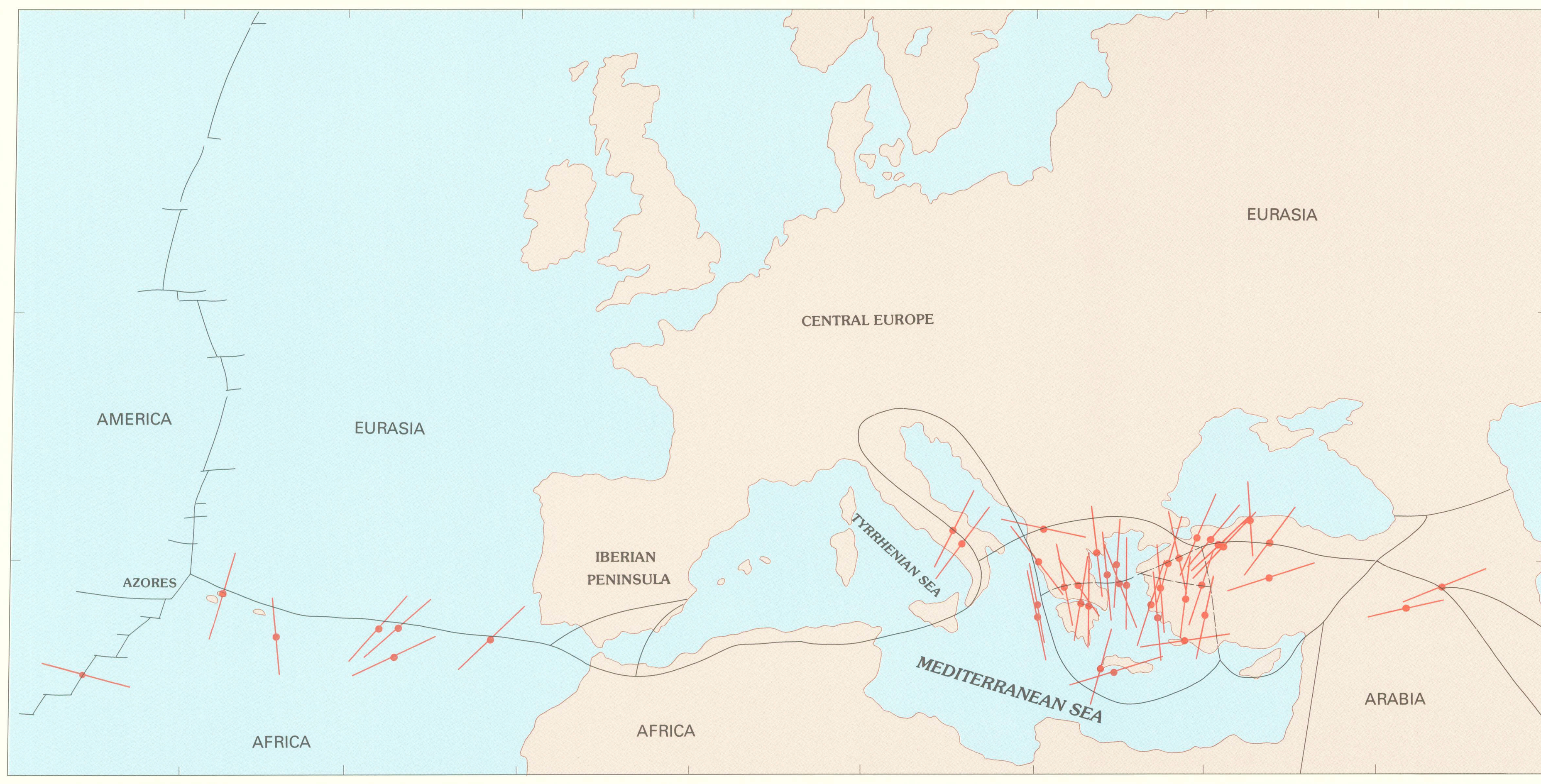
Map A. Seismicity of the Mediterranean and adjacent areas for earthquake epicenters located instrumentally from 1962 through 1991. The data base represents events with magnitude ≥4 (m_b or M_s) which have been reported by 10 or more seismological stations.



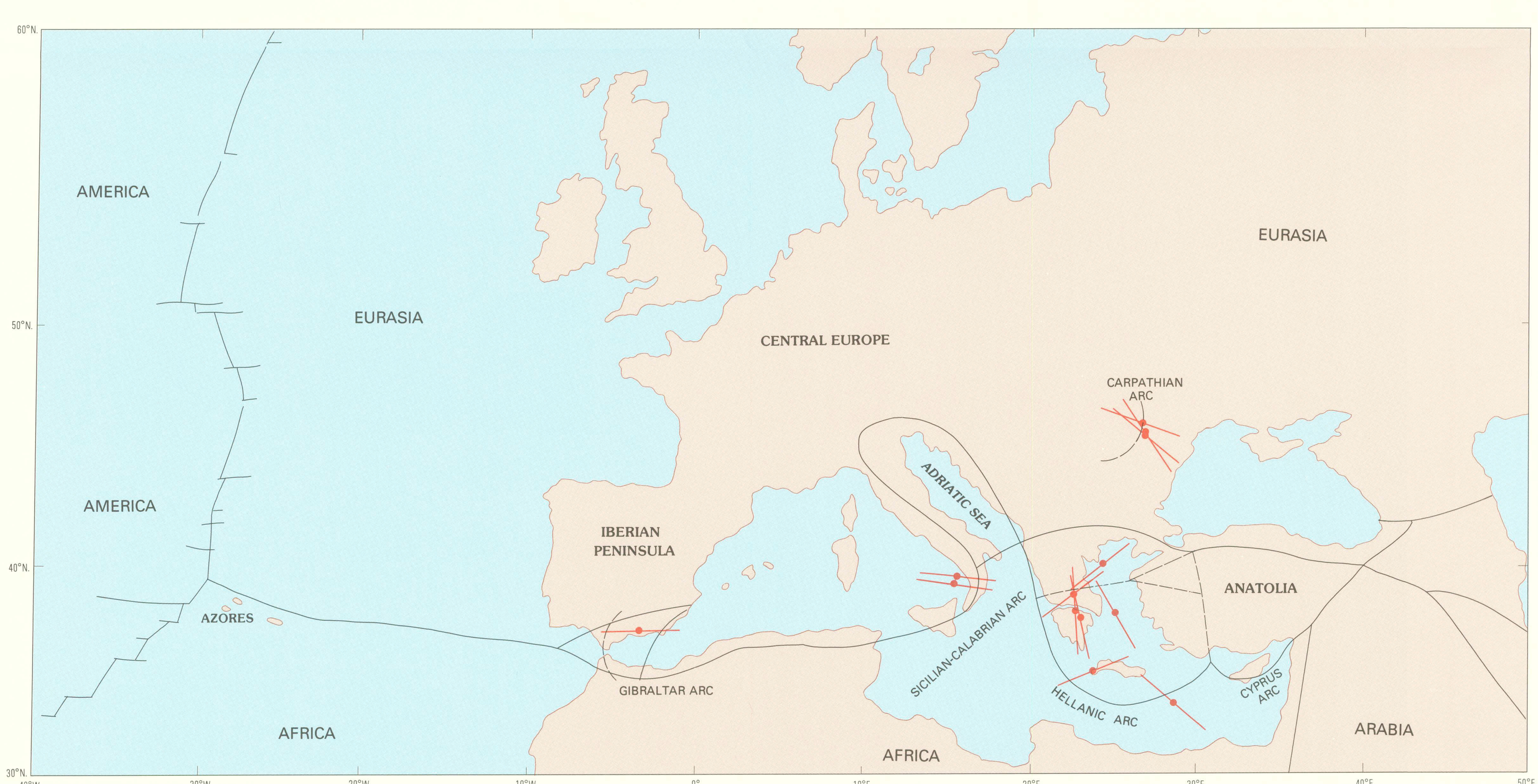
Map B. Focal mechanism solutions for the most significant earthquakes with magnitudes great than 7 which have occurred in the area of the Eurasia-Africa plate boundary. The focal mechanisms are based on P-wave observations which have been projected on the lower hemisphere of the focal sphere. The red areas denote compressions and the white areas denote dilatations; dots denote the epicenter location. The hypocenter and fault plane parameters are listed in table 1.



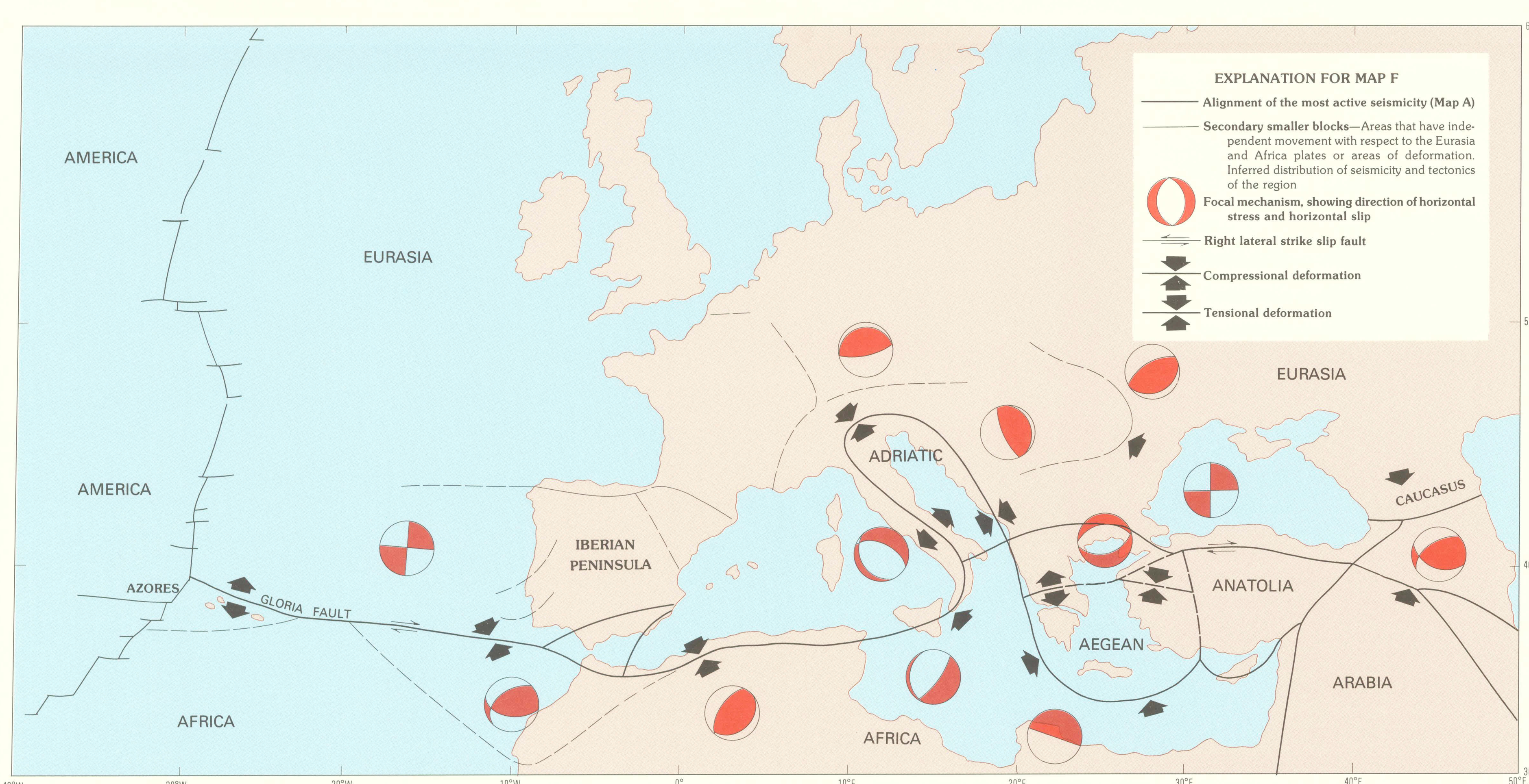
Map C. Horizontal projection of the P-axes, with plunge less than 45°, for shallow depth-of-focus earthquakes (h≤60 km) with magnitudes greater than 6 in the Mediterranean and adjacent areas. Location of the mid-Atlantic ridge and the simplified Eurasia-Africa plate boundary are shown as a solid continuous line. Table 1 shows list of hypocenters and fault plane parameters.



Map D. Horizontal projection of the T-axes, with plunge less than 45°, for shallow depth-of-focus earthquakes (h≤60 km) with magnitudes greater than 6 in the Mediterranean and adjacent areas. Location of the mid-Atlantic ridge and the simplified Eurasia-Africa plate boundary are shown as a solid continuous line. Table 1 shows list of hypocenters and fault plane parameters.



Map E. Horizontal projection of the P-axes for intermediate and deep depth-of-focus earthquakes (h>60 km) and with magnitudes greater than 6 in the Mediterranean and adjacent areas. Location of the main four arcs referred to in the text are shown and the location of the main plate (solid line) and micro-plate (dashed line) boundaries are identified. Table 1 shows list of hypocenters and fault plane parameters.



Map F. Seismotectonic framework of the Mediterranean and adjacent areas along the Eurasia-Africa plate boundary from its intersection with the American plate near the Azores to its intersection with the Arabian plate.

MERCATOR PROJECTION
SCALE 1:25,000,000
0 500 1000 1500 2000 2500 MILES
0 500 1000 1500 2000 2500 3000 3500 4000 KILOMETERS

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1994

Color design by Virginia D. Scott
Graphic design by Thomas L. Loesch
Cartography by Bill Ary

Table 1. *Hypocenters and fault plane parameters for the earthquakes used in this study*
[Leaders (--) indicate no information available]

No.	Date yr-mo-day	Time (UTC)	Lat-N. in degrees	Long in degrees	Depth in km	M/Ms	P-Axes(°) Trend/Plunge	T-Axes(°) Trend/Plunge	Ref.
1	1935-02-25	02 51 37	35.75	25.00E	80	6.75	344/21	212/60	20
2	1938-04-13	02 45 46	39.20	15.20E	270	6.75	280/35	80/55	21
3	1938-04-19	10 59 15	39.50	33.50E	--	6.75	348/14	254/16	14
4	1939-05-08	01 46 50	37.00	24.50W	--	7.10	234/49	233/24	4
5	1939-09-22	00 36 32	39.00	27.00E	--	6.50	70/74	146/05	20
6	1940-02-29	16 07 42	35.50	25.50E	--	6.00	220/30	40/60	20
7	1940-10-22	06 37 00	45.75	36.50E	150	6.50	130/10	162/75	13
8	1940-11-25	01 39 09	45.75	36.50E	130	7.40	303/11	140/78	20
9	1941-11-25	18 03 55	37.50	18.50W	25	8.40	133/11	42/04	4
10	1943-06-20	15 32 53	41.00	30.00E	--	6.25	132/10	40/10	16
11	1945-09-02	11 53 57	33.75	28.50E	80	6.50	130/00	00/90	20
12	1945-09-07	15 48 22	46.00	26.75E	100	6.50	290/10	182/59	20
13	1946-04-05	20 54 05	35.25	23.50E	100	6.00	249/31	69/59	20
14	1947-06-04	00 29 55	40.00	24.00E	80	6.00	232/25	88/59	20
15	1947-10-06	19 55 37	37.00	22.00E	--	7.00	168/35	258/01	22
16	1948-06-30	12 21 11	38.50	20.50E	--	6.40	205/04	301/57	20
17	1949-07-23	15 03 30	38.50	26.50E	--	6.75	102/45	197/05	16
18	1951-08-13	18 33 30	40.80	33.40E	--	6.70	302/21	37/11	16
19	1953-03-18	19 06 11	40.00	27.50E	--	7.25	284/02	15/11	16
20	1954-03-29	06 17 05	37.00	3.50W	640	7.00	87/43	279/46	12
21	1954-04-30	13 02 36	39.30	22.20E	--	6.87	51/72	253/17	20
22	1954-09-09	01 04 37	36.20	1.60E	--	6.75	171/15	11/74	8
23	1955-07-16	07 07 08	37.50	27.00E	--	6.75	261/57	354/02	16
24	1955-09-12	06 09 20	32.50	30.00E	--	6.50	276/05	180/52	16
25	1956-02-01	15 10 46	39.50	16.00E	200	6.20	324/62	118/25	5
26	1957-04-25	02 25 42	36.47	28.56E	53	7.10	163/25	262/19	20
27	1957-05-26	06 33 34	40.67	30.86E	--	7.10	312/05	43/12	16
28	1957-05-27	11 01 26	40.50	31.00E	--	6.25	329/14	234/18	22
29	1957-12-13	01 45 05	34.41	46.67E	42	7.25	71/01	340/62	16
30	1959-05-14	06 36 56	35.14	24.58E	--	6.50	182/44	76/16	20
31	1959-11-15	17 08 43	37.83	20.47E	--	6.60	22/37	235/50	1
32	1960-01-03	20 19 30	39.50	15.50E	250	6.20	278/59	95/32	10
33	1960-05-26	05 10 05	40.00	20.00E	--	6.30	57/16	324/12	20
34	1961-05-23	02 45 16	36.60	28.30E	49	6.25	179/17	359/73	16
35	1962-08-21	18 19 33	41.40	15.50E	34	6.00	331/81	205/06	16
36	1962-08-28	10 59 56	37.82	22.89E	100	6.70	179/01	87/68	16
37	1963-09-18	16 58 13	40.90	29.20E	33	6.38	134/57	23/17	14
38	1964-03-15	22 30 26	36.20	7.60W	27	6.88	158/25	304/61	4
39	1964-10-06	14 31 19	40.30	28.20E	10	6.00	354/80	174/10	15
40	1965-03-09	17 57 54	39.40	24.00E	18	6.38	265/00	175/03	16
41	1965-03-31	09 47 31	38.60	22.40E	78	6.75	235/27	80/60	16
42	1965-07-06	03 18 43	38.40	22.40E	20	6.25	358/59	177/31	16
43	1966-02-05	02 01 46	39.10	21.70E	22	6.25	143/67	350/20	1
44	1966-08-19	12 22 11	39.20	41.60E	33	6.70	353/04	259/42	22
45	1967-01-04	05 58 54	38.44	22.01E	10	6.00	170/45	350/45	22
46	1967-03-04	17 58 06	39.22	24.62E	33	6.88	328/82	212/04	16
47	1967-07-22	16 56 33	40.70	30.80E	4	6.00	138/06	228/01	22
48	1967-11-30	07 23 52	41.50	20.50E	29	6.60	140/75	282/12	1
49	1968-09-03	08 19 52	41.79	32.31E	5	6.60	84/01	174/36	14
50	1969-02-28	02 40 33	36.01	10.57W	22	8.00	165/04	67/64	4
51	1969-09-06	01 48 30	38.59	28.45E	9	6.40	6/96	186/21	20
52	1969-09-06	14 30 40	36.94	11.89W	33	6.00	138/14	47/07	4
53	1970-03-28	21 02 23	39.18	29.49E	20	7.10	84/61	200/14	20
54	1790-04-08	13 50 27	38.43	22.66E	17	5.90	346/64	187/25	18
55	1970-05-14	18 12 28	43.03	47.09E	44	6.50	40/29	225/61	14
56	1970-11-18	12 23 18	35.15	35.74W	33	6.00	190/18	283/01	4
57	1971-05-12	06 25 13	37.59	29.76E	23	6.30	34/78	144/04	21
58	1972-05-04	21 40 09	35.12	23.61E	46	6.30	196/49	16/41	17
59	1972-09-13	04 13 21	37.93	22.39E	83	6.00	355/10	92/56	17
60	1972-09-17	14 07 16	38.28	20.34E	33	6.30	260/29	258/14	1
61	1975-05-26	09 11 51	25.99	17.65W	33	7.90	151/09	246/10	4
62	1975-09-06	09 20 11	38.47	40.72E	26	6.70	359/01	91/62	14
63	1976-05-06	20 00 12	46.36	13.28E	9	6.50	168/30	342/60	1
64	1976-07-28	20 17 42	43.17	45.60E	21	6.10	354/34	174/56	14
65	1976-09-15	03 15 20	46.30	13.20E	10	6.00	155/10	268/66	1
66	1976-11-24	12 22 19	39.12	44.03E	36	7.30	340/12	71/11	14
67	1977-03-04	19 21 54	45.77	26.76E	94	7.20	323/17	151/73	11
68	1978-06-20	20 03 21	40.74	23.23E	3	6.40	315/83	177/15	3
69	1978-11-04	15 22 20	37.71	48.95E	34	6.10	90/25	270/65	14
70	1979-05-24	17 23 18	42.24	18.75E	5	6.40	244/25	64/65	1
71	1980-01-01	16 42 40	38.80	27.80W	10	6.70	104/15	194/02	4
72	1980-07-09	02 35 52	39.23	22.59E	20	6.10	112/82	344/02	19
73	1980-10-10	12 25 24	36.20	1.30E	10	7.30	320/09	106/80	7,8,9
74	1980-10-10	15 39 10	36.22	1.61E	10	6.10	130/15	310/75	9
75	1980-11-23	18 34 54	40.90	15.40E	--	6.90	183/68	37/18	6
76	1981-02-24	20 53 37	38.22	22.97E	18	6.60	298/76	181/07	25
77	1981-02-25	02 35 54	38.17	23.12E	30	6.30	270/83	153/03	25
78	1981-03-04	21 58 07	38.24	23.26E	32	6.40	33/86	154/02	25
79	1981-12-19	14 10 51	39.22	25.25E	10	7.20	255/35	357/16	19
80	1981-12-27	17 39 13	38.91	24.92E	10	6.50	78/06	168/02	19
81	1983-01-17	12 41 30	38.07	20.24E	14	7.00	225/38	44/52	1
82	1983-03-23	23 51 05	38.23	20.29E	13	6.20	249/19	348/25	1
83	1983-08-06	15 43 52	40.14	24.74E	2	6.90	272/04	02/05	18
84	1983-10-17	19 36 22	37.59	17.41W	10	6.30	320/04	50/01	4

CONVERSION FACTORS

Multiply	By	To obtain
centimeters (cm)	0.3937	inches (in)
meters (m)	3.2810	feet (ft)
kilometers (km)	0.6214	miles (mi)

INTRODUCTION

The boundary between the lithospheric plates of Eurasia and Africa extends west to east from the Azores to the Caucasus where it intersects 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 the continental lithosphere and the oceanic lithosphere of the Mediterranean Sea. The boundary in this region is especially complicated by the presence of small lithospheric blocks and by the distribution of stresses 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. Earthquake activity occurs over wide areas in the boundary region and intraplate activity is also present.

REGIONAL SEISMICITY

The distribution of epicenters for shallow (h ≤ 60 km), intermediate (60 < h ≤ 200 km), and deep (h > 200 km) earthquakes with magnitude M ≥ 4, which occurred between 1962 and 1990 and were reported by 10 or more seismological stations is shown on map A. In addition to the distribution, depth of focus, and magnitude of each earthquake, the volcanoes located in the regions of active subduction in the Mediterranean region are shown. The seismicity associated with the Eurasia-Africa plate boundary trends generally west-east in a wide band extending from lat 30° N. to 50° N. Inside this band the trend of the epicenters changes direction several times, outlining secondary tectonic blocks. The main characteristics of seismicity along the plate boundary are described from west to east. At the Azores, a triple junction marks the boundary of the Eurasian, African, and American plates. East of the Azores (long 24° W.), earthquake epicenters are located along the east-west trending Azores-Gibraltar transform fault. Epicenters extend over a wider zone east of long 12° W. in southern Iberia and northern Morocco. In northern Iberia there is a band of epicenters located along the Pyrenees. From northern Morocco, the trend of the epicenters continues eastward along the coast of Algeria and Tunisia. From about long 10° E., the trend of the epicenters changes direction to the northeast to form the Sicilian-Calabrian arc, changing again to a northwest direction along the Apenines in the Italian peninsula. In northern Italy earthquake epicenters form a wide arc throughout the Alps, along the coast of Yugoslavia and northern Greece the trend is to the southeast. Long 20° E., is approximately the western edge of the Hellenic arc, the area with the greatest amount of seismic activity in the entire region; the arc is convex to the south. In northern Greece and western Turkey, just northeast of the Hellenic arc is another area of high activity that trends east-west. To the east of the Hellenic arc, a smaller and less active arc, the Cyprus arc, is located. Two lineaments of earthquake epicenters are located in the Anatolia peninsula; one in the northern part of Turkey that trends east-west along the north Anatolian fault and one in the south that trends southwest-northeast. Both lineaments merge at about long 40° E. From this point on, earthquakes continue with a east-west trend in the Caucasus and a northwest-southeast trend along the northern border of the Arabian plate.

Intermediate and deep earthquake epicenters are located in five distinct areas related to the Gibraltar, Sicilian-Calabrian, Carpathian, Hellenic, and Cyprus arcs. Deep activity associated with the Gibraltar arc became evident during the Spanish earthquake in 1954 which had magnitude M = 7 and depth of 640 km; two other smaller events have occurred since then at about the same depth. Southern Spain and northern Morocco have experienced additional earthquakes at depths of 60–150 km. Deep earthquakes associated with the Sicilian-Calabrian arc occurred along its concave side and extend to a depth of 450 km. Most of these epicenters are concentrated between 200 and 350 km, with only a few at greater depths. The distribution of earthquakes and their depths define a subduction zone that trends roughly north-south and dips about 60° to the west under the Tyrrhenian Sea; a seismic gap occurs at depths between 60 and 200 km. Deep seismic activity associated with the Carpathian arc is located in a rather small region, known as the Vrancea seismic zone, where depths from 70 to 160 km are known. The distribution of these events at depth suggests a nearly vertical subduction zone where the seismic activity is concentrated in a small volume. The largest concentration of intermediate and deep earthquakes is associated with the Hellenic arc, which spans an area from the western coast of Greece to the southern coast of Turkey. The distribution of earthquake depths defines a well developed Wadati-Benioff zone that dips from the convex side of the arc, down to a depth of 200 km. A second smaller arc associated with intermediate earthquakes is located near the island of Cyprus.

REGIONAL STRESSES

Many studies have been made on the seismotectonic conditions of this region, two of which include Argus and others (1989) and Udías and Buforn (1991). The direction of the stress axes in the region as shown on the P- and T-axes maps, was derived from focal mechanisms for earthquakes with magnitudes equal to or greater than 6 that occurred in 1935–83. Stress directions can be derived from analysis of fault plane solutions, however, this determination may not correspond to the real situation. Most earthquakes occur on pre-existing faults and slips can occur at different angles relative to the principal axes; the maximum compressive stress may have an orientation anywhere within the dilatational quadrant and not necessarily at 45° to the fault plane. This ambiguity may be resolved when large earthquakes are used because their solutions are well determined and the derived stress directions correspond more closely to the region stresses. The consistency in the stress directions obtained from fault plane solutions of large earthquakes shown on maps C, D, and E confirm this hypothesis.

Udías and others (1989) published a catalogue of focal mechanisms of 140 earthquakes with magnitudes greater than 6 that occurred in Europe in 1906–85. From this database 84 earthquakes were identified with well determined and reliable parameters; the hypocentral and focal mechanism parameters for these earthquakes are given in table 1.

The orientations of the horizontal components of the principal stresses for the P- and T-axes, with plunge less than 45°, are shown for shallow earthquakes (h ≤ 60 km) on map C. The simplified trend of the plate boundary as shown is inferred from many seismicity studies. The data are very consistent and the majority of the horizontal projections of the P-axes are almost normal to the plate boundary. From the Azores to Tunisia the P-axes form angles of 60°–90° in a consistent northnorthwest-southsoutheast direction which correspond to strike-slip and thrust fault mechanisms. Along the coast of Yugoslavia and northern Greece, the P-axes are normal to the coast in a northeast-southwest direction. In the area of the Hellenic arc, the data are more scattered, but the P-axes directions are commonly normal to the arc. Northeast of the Hellenic arc, between Greece and Turkey, the P-axes trend east-west. Along the north Anatolian fault the P-axes direction is northwest-southeast corresponding to strike-slip fault mechanisms. In the area of the Caucasus, the P-axes trend almost north-south which is normal to the boundary of the Arabian plate and corresponds with thrust mechanisms.

Horizontal projections of the T-axes for shallow earthquakes are shown on map D. Only those with plunge of less than 45° are shown highlighting the regions which are under a horizontal tensional regime. In the Azores, the T-axes are normal to the volcanic alignment. Along the Azores-Gibraltar fault, horizontal T-axes in a northeast-southwest direction correspond to the horizontal P-axes resulting in strike-slip right-lateral motion along the fault. Horizontal T-axes are present in the Apenines of Italy, in a northeast-southwest direction, normal to the trend of the mountain chain and corresponding to normal faulting. A large concentration of horizontal T-axes in a general north-south direction is present north of the Hellenic arc, in Greece and western Turkey. Along the north Anatolian fault, the horizontal T-axes have a trend in a northeast-southwest direction corresponding to strike-slip motion along the fault.

For intermediate and deep earthquakes, the directions of the horizontal projections of the P-axes are shown on map E. In southern Spain, the very deep earthquake (640 km) has the P-axis in an east-west direction. In Sicily and Calabria, the P-axes are normal to the trend of the Sicilian-Calabrian arc; the same orientation prevails in the Carpathian Mountains region. Intermediate events in the area of the Hellenic arc have a greater dispersion; there are two trends almost perpendicular in a north-northwest-south-southeast and a northeast-southwest direction in this area.

SEISMOTECTONIC FRAMEWORK

Map F is a simplified summary of the zone of deformation along the Eurasian-African plate boundary which is based on seismicity, focal mechanism solutions, and the regional tectonics. The alignment of the most active seismicity (map A) is in a broad sense, a simplification of the actual location of the plate boundary, but includes broad areas of deformation that cannot be reduced in a simple manner to the motion of rigid blocks. The predominant type of focal mechanism in each region, the directions of the horizontal stresses, and the horizontal slip are shown on map F.

From west to east the general characteristic of the Eurasia-Africa plate boundary can be summarized in the following general manner. At the Azores triple plate boundary junction, the boundary between the African and Eurasian plates is a ridge and is under horizontal normal tension. From about long 23° W. to 12° W., the boundary takes the form of a transform fault with strike-slip, right-lateral motion, that is, the African plate has moved west relative to the Eurasian plate. Near long 12° W., the motion changes to reverse faulting with the African plate moving under the Eurasian plate. This type of motion is also found in Algeria and may extend as far east as long 10° E. These changes, in such a short distance along the plate boundary, are consistent with a pole of rotation for Africa, not far from the boundary itself at about lat 21° N., long 20° W. The seismicity in the Atlantic, off the coast of Portugal, in Portugal, southern Spain, and northern Morocco and Algeria indicates the existence of small blocks or areas of deformation on both sides of the plate boundary. The earthquakes in the Pyrenees and the northern part of Spain suggests that the stable part of the Iberian peninsula may form a block semi-independent from the Eurasian plate (Udías and Buforn, 1991).

In the area of the Sicilian-Calabrian arc, the lithospheric material of the African plate is subducted, pushed from the southeast and there is seismic activity to a depth of about 350 km. In the subducted African plate, the stresses dip steeply to the northwest. The adjacent Adriatic block which is separated from the rest of Eurasian in the Apenines along a belt of normal faulting has a motion that differs from the motion of the African plate. These different motions result in reverse faulting and compressional stresses in a northeast-southwest direction along the coast of Yugoslavia. In the northern part, however, the block pushes in a north to northwest direction producing 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. There is seismic activity related to the Carpathian region; coincident with a small vertical subducted block with compressional stresses which is pushing from the southeast. This area of deformation extends to the northwest, and may be considered as formerly part of the secondary block complex forming the plate boundary that is now locked inside the Eurasian plate.

The area of the Hellenic and Cyprus arcs is quite complex. The arcs are under compressional stresses, and the lithospheric material of the African plate is subducted from the south to depths of about 200 km. North of the Hellenic arc, the lithosphere is under tensional north-south stresses and predominant normal faulting occurs. As a result the lithospheric material is stretched and a back arc basin is formed; this zone of extension covers Greece and western Anatolia. The remainder of Anatolia moves westward along the north Anatolian fault, with large horizontal right-lateral strike-slip motion. The result of this movement is that the northern part of the back arc basin is subjected to an east-west horizontal pressure as shown on map C. As the Arabia plate moves northward, it causes movement along the east side of the Anatolian block and compression of the broad Caucasus region. In this region, there is horizontal compression in a north-south direction and the predominant motion occurs on reverse faults.

ACKNOWLEDGMENTS

We would like to thank the critical review and comments made by several colleagues at the U.S. Geological Survey and at the Univ. Complutense. We are also grateful to S. J. Kropschot, K.S. Rukstales, and D. N. Jones for providing assistance in the making of this map.

REFERENCES

1. Anderson H., and Jackson, J., 1987, Active tectonics of the adriatic region: Royal Astronomical Society Geophysical Journal, v. 91, p. 937–983.
2. Argus, D.F., Gordon, R.G., DeMets, C., and Stein, S., 1989, Closure of the African-Eurasian-North American plate motion circuit and tectonics of the Gloria faults: Journal of Geophysical Research, v. 94, p. 5585–5602.
3. Buforn, E., 1985, Estudio estadistico de la direccion de esfuerzos principales en terremotos: Madrid, Spain, Universidad Complutense, Tesis Doctoral, 219 p.
4. Buforn, E., Udías, A., and Colombas, M.A., 1988, Seismicity, source, mechanics and tectonics of the Azores-Gibraltar plate-boundary: Tectonophysics, v. 151, p. 89–118.
5. Canitez, N., and Ucer, S., 1967, Computer determinations for the fault plane solutions in and near Anatolia: Tectonophysics, v. 4, p. 235–244.
6. Cello, G., Guerra, I., Tortorici, L., Turco, E., and Scarpa, R., 1982, Geometry of the neotectonic stress field in southern Italy—Geological and seismological evidence: Journal of Structural Geology, v. 4, p. 385–393.
7. Deschamps, A., Gaudemer, Y., and Cisternas, A., 1982, The El Asnam, Algeria, Earthquake of 10 October 1980—multiple-source mechanism determined from long-period: Seismological Society of America Bulletin, v. 72, p. 1111–1128.
8. Espinosa, A.F., 1981, The Algerian earthquake of October 10, 1980, A preliminary report: Earthquake Information Bulletin, v. 13, Jan.-Feb., p. 23–33.
9. Espinosa, A.F., and Lopez-Arroyo, A., 1984, Inconsistencies in the Modified Mercalli Intensity scale, El Asnam, Algeria, Earthquake: Proceedings of the International Conference on Seismic Microzonation, Alger, Algeria, v. 1, p. 51–65.
10. Gasparini, C., Iannaccone, G., and Scarpa, R., 1983, Fault plane solutions and seismicity of the Italian peninsula: Tectonophysics, v. 117, p. 59–78.
11. Giardini, D., Dziewonsky, A.M., Woodhouse, J.W., and Boschi, E., 1984, Systematic analysis of the seismicity of the Mediterranean region using the centroid-moment tensor method: Trieste, Italy, The Observatorio Geofisico Sperimentale, Silver Anniversary Volume, p. 121–141.
12. Hodgson, J.H., and Irma Cock, J., 1956, Direction of faulting in the Spanish Earthquake of 1954: Tellus, v. 8, p. 321–327.
13. Isacks, B., and Molnar, P., 1971, Distribution of stresses in the descending lithosphere from a global survey of focal-mechanism solutions of mantle earthquake: Review of Geophysics and Space Physics, v. 9, p. 1–17.
14. Jackson, J., and McKenzie, D., 1984, Active tectonics of the Alpine-Himalayan belt between western Turkey and Pakistan: Royal Astronomical Society, Geophysical Journal, v. 77, p. 185–264.
15. Kanamori, H., and Given, J.W., 1981, Use of long-period surface waves for rapid determination of earthquake-source parameters: Physics of the Earth and Planetary Interiors, v. 27, p. 8–31.
16. McKenzie, D., 1972, Active tectonics of the Mediterranean region: Royal Astronomical Society, Geophysical Journal, v. 30, p. 109–185.
17. McKenzie, D., 1978, Active tectonics of the Alpine-Himalayan belt—the Aegean Sea and surrounding regions: Royal Astronomical Society, Geophysical Journal, v. 55, p. 217–254.
18. Papazachos, B.C., Comninadis, E.E., Papadimitriou, E.E., and Scordillis, E.M., 1984, Properties of the February-March 1981 seismic sequence in the Alkyoinides Gulf of central Greece: Annales Geophysique, v. 2, p. 537–544.
19. Papazachos, B.C., Kiratzi, A.A., Voidomatis, P., and Papaioannou, C., 1984, A study of the December 1981-January 1982 seismic activity in northern Aegean Sea: Bulletino di Geofisica Teorica e Applicata, v. 26, p. 101–113.
20. Ritsema, A.R., 1974, The earthquake mechanisms of the Balkan region: Koninklijk Nederlands Meteorologisch Instituut, De Bilt, 105 p.
21. Riuscetti, M., and Schick, R., 1975, Earthquakes and tectonics in southern Italy: Bolletino de Geofisica, v. 17, p. 59–78.
22. Stewart, G.S., and Kanamori, H., 1982, Complexity of rupture in large strike-slip earthquake in Turkey: Physics of the Earth and Planetary Interiors, v. 28, p. 70–84.
23. Udías, A., Buforn, E., and Ruiz de Gauna, J., 1989, Catalogue of focal mechanisms of European earthquake: Madrid, Spain, Universidad Complutense, Department of Geophysics 274 p.
24. Udías, A., and Buforn, E., 1991, Regional stress on the Eurasia-Africa plate boundary derived from focal mechanisms of large earthquakes: PAGEOPH, v. 136, p. 433–448.
25. Won-Young Kim, Kulhanek, O., and Meyer, K., 1984, source processes of the 1981 Gulf of Corinth earthquake sequence from body-wave analysis: Seismological Society of America Bulletin, v. 74, p. 459–477.

MAPS SHOWING SEISMICITY AND TECTONIC STRESSES ALONG THE EURASIA-AFRICA PLATE BOUNDARY

By
A. Udías,[1] A.F. Espinosa,[2] and E. Buforn[1]
1994

[1] Universidad Complutense, Facultad de Ciencias Físicas, Departamento de Geofísica, 28040 Madrid, Spain
[2] U.S. Geological Survey, Box 25046, MS 908, Denver Federal Center, Denver, CO 80225-0040, USA

Manuscript approved for publication April 23, 1992