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Preliminary Report on the Aftershocks of the June 20, 1978, Thessaloniki, Greece, Earthquake

By

David Carver and Ronald Henrisey

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PRELIMINARY REPORT ON THE AFTERSHOCKS OF THE JUNE 20, 1978, THESSALONIKI, GREECE, EARTHQUAKE

A magnitude-6.4 (m_b, NEIS) earthquake occurred on June 20, 1978, in north-central Greece, approximately 18 km northeast of the city of Thessaloniki. Because of the proximity of the mainshock to Thessaloniki, the second largest city in Greece, and the reported surface rupturing and structural damage in the epicentral area, a field program for aftershock monitoring was initiated. Eight portable seismograph systems were installed in the epicentral region on July 3, 1978, and two additional systems were installed the following day. This 10-station network recorded the aftershock activity until July 23, 1978. Preliminary results from the data obtained during the investigation are reported in this paper.

Forty-two earthquakes that occurred between July 3 and July 23, 1978, were selected for immediate analysis in an attempt to obtain a representative spatial and temporal sample of the aftershocks recorded. Their locations are shown in figure 1 and listed in table 2. The 42 aftershocks occurred in an irregularly shaped pattern about 18 km (E-W) by 10 km (N-S). They appear to divide into two zones: (1) a northeasterly trending lineation about 10 km long and 4 km wide located near the west end of Lake Koronia (fig. 1) and (2) a clustering about 8 km in diameter north of the west end of Lake Volvi (fig. 1). Between these two groups of aftershock epicenters is about 10 km of separation. Only

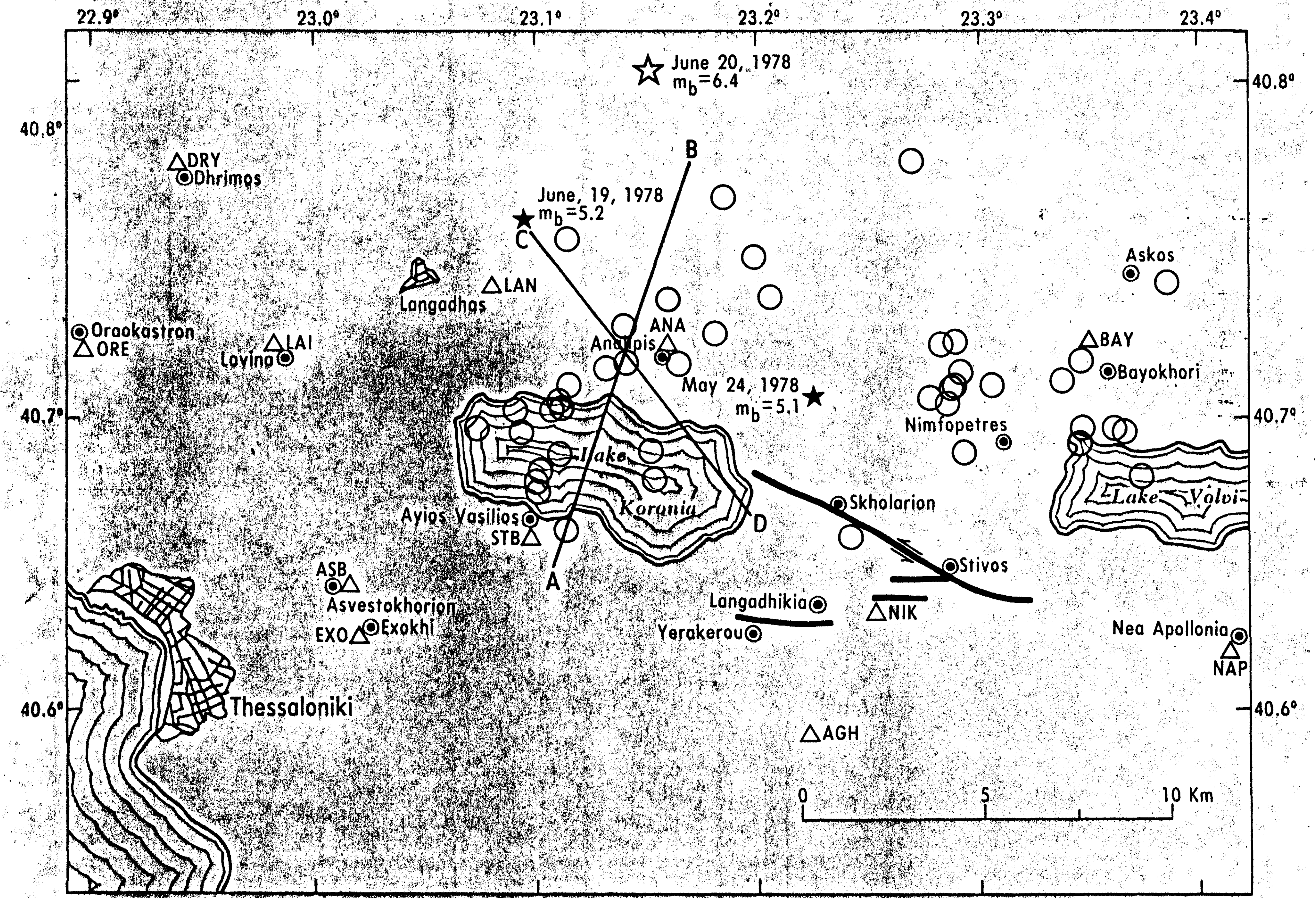

Figure 1.--Map showing the locations of aftershocks (open circles) recorded by the 10-station portable seismograph network (solid triangles). The epicenters of the mainshock (June 20, 1978) and principal foreshocks (May 24, 1978, and June 19, 1978), given by the NEIS, are shown as stars. Lines A-B and C-D indicate the location of the depth profiles shown in figures 3 and 4 respectively. Surface rupture mapped by Bufe and others (1978) is indicated by solid lines.

one of the aftershocks was located in the area between Stivos and Skholarion, the zone of highest intensity of the June 20 mainshock (Bufe and others, 1978).

A composite focal-mechanism solution (CFMS) has been obtained from the aftershock data using short-period P-wave first motions (fig. 2). It depicts a strike-slip mode of faulting on steeply dipping planes. Based upon the surface rupture observed for the mainshock (Bufe and others, 1978), (fig. 1), the nodal plane that trends N. 78° W. and dips 14° N. is probably representative of the fault plane. The indicated sense of motion is left-lateral. Our CFMS is virtually identical with focal-mechanism solutions obtained by B. C. Papazachos and G. Leventakis (written commun., 1978) for two foreshocks (May 24, 1978, m_b=5.7, National Earthquake Information Service; June 19, 1978, m_b=5.4, NEIS) and also the focal mechanism determined by A. G. Galanopoulos and others (oral commun., August 1978) for the mainshock.

Two depth profiles, one that is perpendicular to the preferred N. 78° W. striking nodal plane (fig. 3) and one that is perpendicular to the apparent northeasterly trend of the aftershocks near Lake Koronia (fig. 4), fail to define the causative fault. Here, as well as for other topics discussed in this paper, the additional data reduction and analysis that are currently in progress are needed.

Details concerning data reduction and analysis

Hypocentral locations were determined by a modified version of the HYPO71 computer program (Lee and Lahr, 1975; Tarr and Davids, 1977).

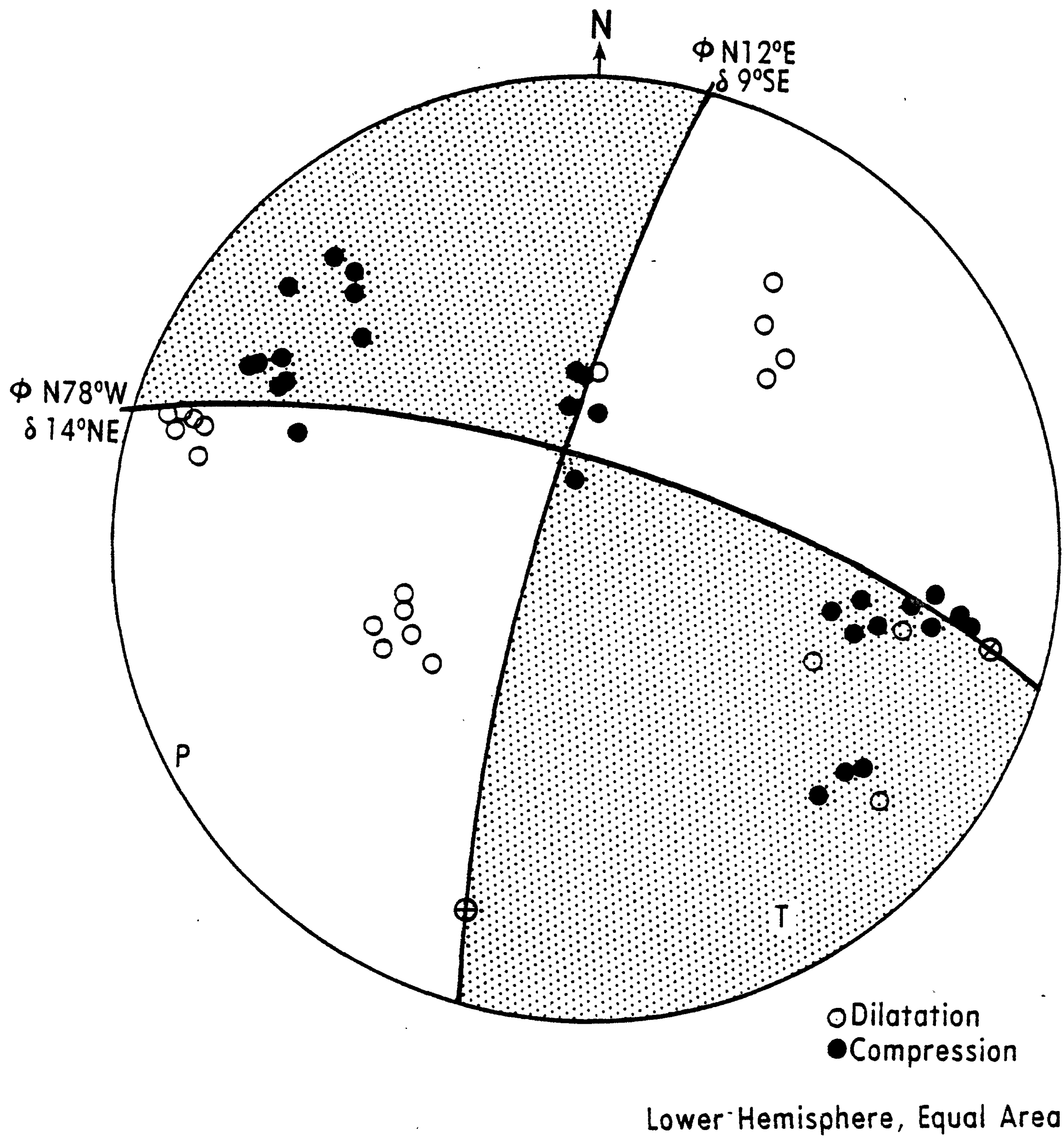

Figure 2.--Composite focal-mechanism solution of several selected aftershocks that occurred in the Lake Koronia area. This mechanism was computed from short-period P-wave first-motion data. Compressional quadrants are shaded; P & T denote pressure and tension axes, respectively; θ indicates nodal plane poles.

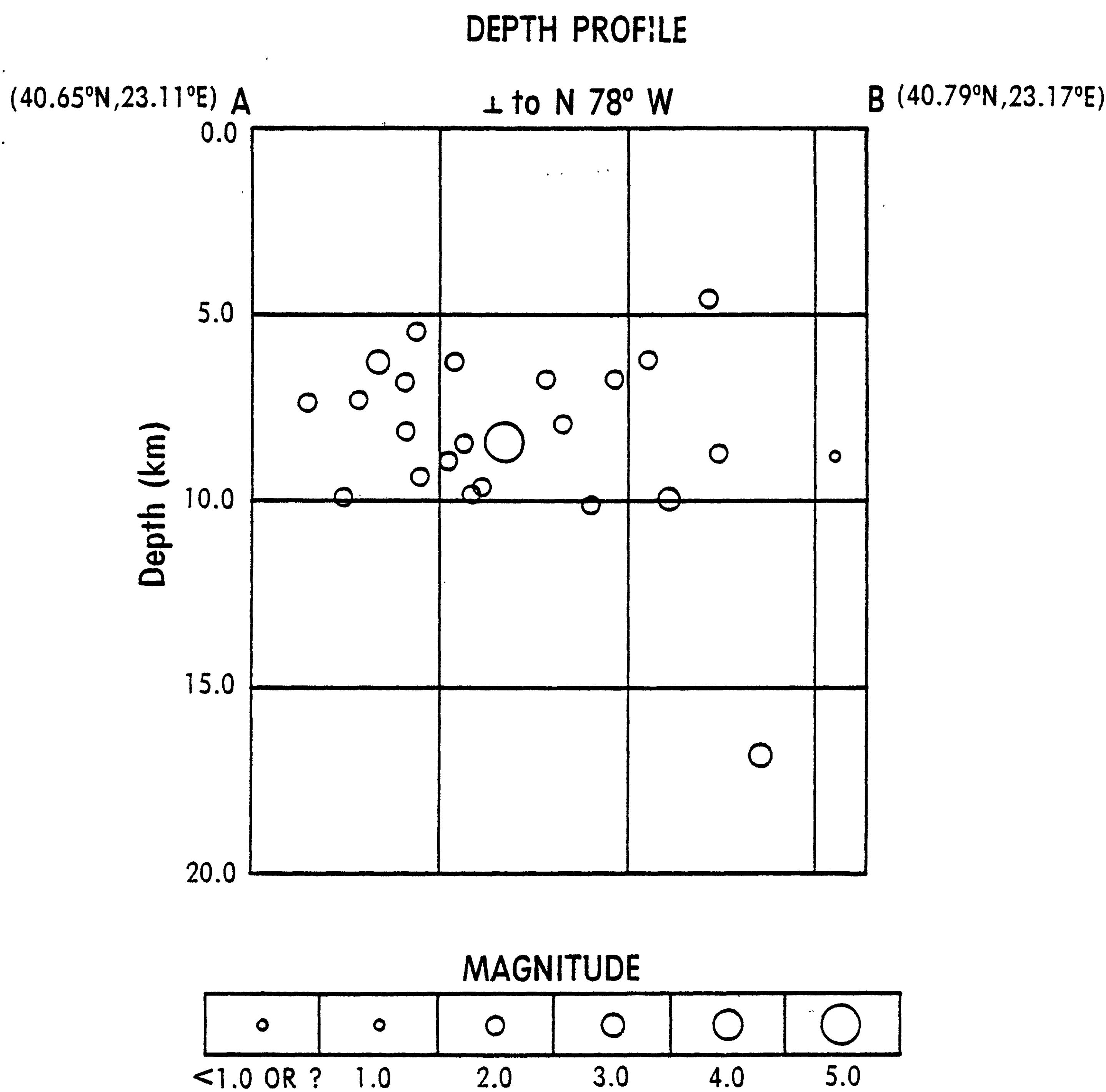

Figure 3.--Depth profile A-B (location in fig. 1) showing aftershocks that occurred in the Lake Koronia zone. The profile was plotted perpendicular to the preferred fault plane N. 78° W. of the composite focal mechanism shown in figure 2.

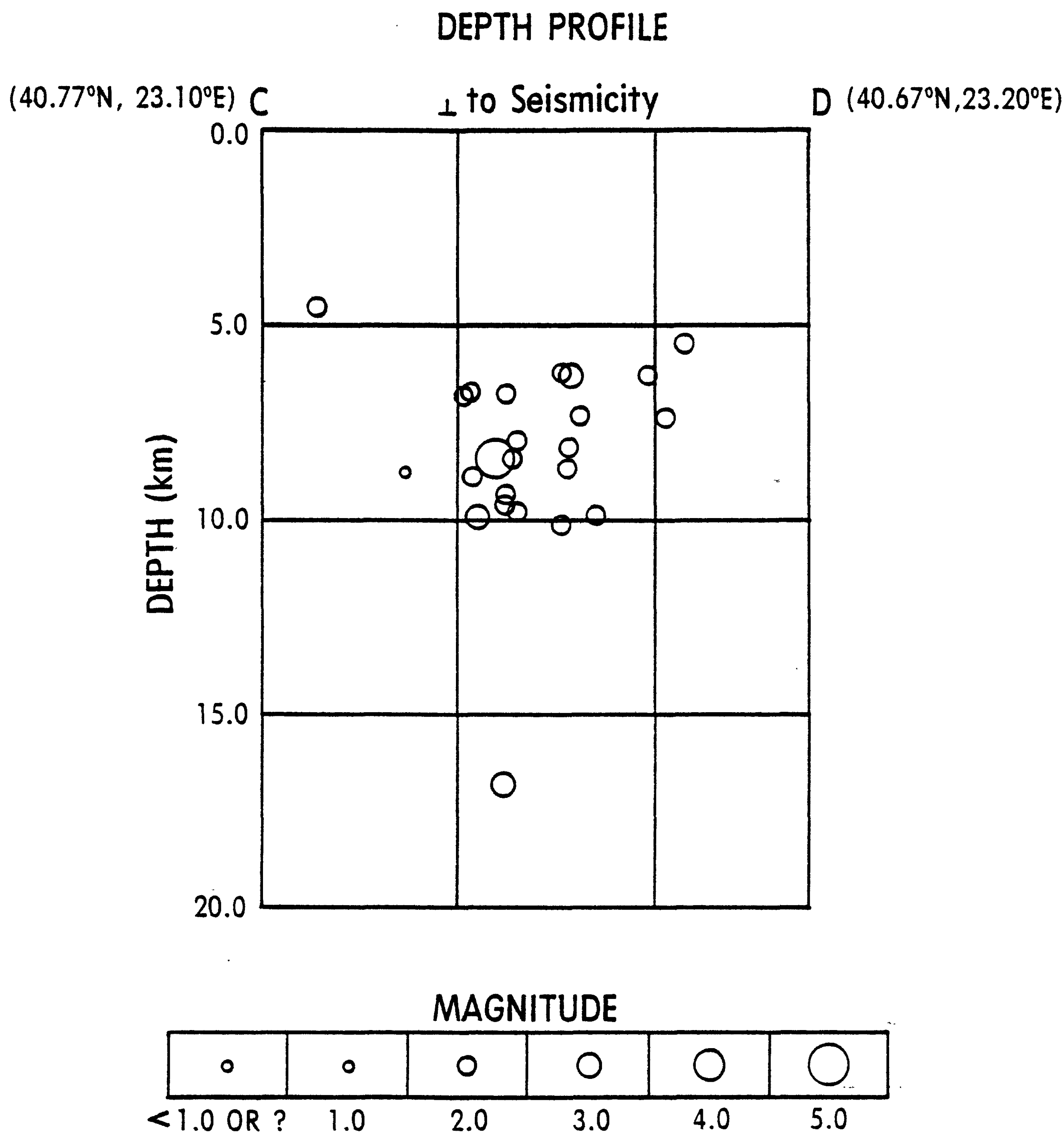

Figure 4.--Depth profile C-D (location in fig. 1) showing aftershocks that occurred in the Lake Koronia zone. The profile was plotted perpendicular to the apparent northeasterly trend of the seismicity in this zone.

The velocity model used (table 1) was obtained from B. C. Papazachos (written commun., 1978).

Table 1.--Velocity model.

Velocity (km/sec)	Depth (km)
3.5	0.0
5.5	1.0
6.1	6.0
6.8	21.0
8.0	36.0

Each station's average travel-time residual for aftershocks that occurred on either the east or west side of 23.25° E. was subtracted from the individual arrival times. This method corrects for systematic variation in travel-times from the source to the station. The computed standard errors (table 2) average ±0.4 km in the horizontal plane and only slightly more, ±0.7 km, in depth for the 42 aftershocks. The root mean square travel-time residuals of the computations range between 0.04 and 0.13 seconds and have an average value of 0.07 seconds. Eighty-eight percent of the aftershocks have at least one station closer to the epicenter than the calculated depth, an indication that the earthquakes are precisely located. Reading accuracy of the P-waves is considered to be within ±0.03 sec, and the reading accuracy for S-wave times is about ±0.07 sec. S-phases were identified at two or

Table 2.--List of hypocentral parameters of aftershocks (cont.)

Date July, 1978	Origin (UTC)	Lat. N (deg)	Long. E (deg)	Depth (km)	No.[1] Obs.	DMIN[2] (km)	RMS[3] (sec)	Standard Errors[4] DLAT (km)	DLON (km)	DZ (km)	QF[5]	M_L[6]
15	1 42 3.04	40.707	23.286	6.2	10	7.7	0.11	0.4	0.7	1.4	A	3.2
15	4 24 26.92	40.697	23.074	6.8	15	5.1	0.09	0.2	0.4	0.6	A	2.2
15	5 27 32.23	40.718	23.291	5.0	11	7.1	0.06	0.2	0.3	0.5	A	3.1
16	18 57 2.57	40.728	23.289	9.1	9	7.4	0.01	0.1	0.1	0.2	A	2.4
16	19 21 55.64	40.698	23.366	8.2	9	2.6	0.03	0.2	0.3	0.5	A	2.8
17	5 47 59.58	40.722	23.346	5.2	11	2.6	0.06	0.3	0.4	0.3	A	2.4
17	19 17 12.94	40.662	23.243	13.5	12	4.2	0.08	0.2	0.5	0.8	A	2.3
18	18 42 51.73	40.714	23.288	6.5	12	7.5	0.04	0.1	0.3	0.5	A	2.3
19	2 9 14.21	40.731	23.182	6.2	15	0.8	0.10	0.2	0.4	0.4	A	2.0
19	13 1 32.28	40.743	23.206	8.7	14	3.1	0.08	0.2	0.3	0.4	A	2.1
20	3 7 50.43	40.714	23.306	10.9	10	5.9	0.03	0.2	0.3	0.6	A	2.0
20	7 43 33.52	40.699	23.347	5.3	9	9.2	0.10	0.5	1.1	1.0	B	2.1
20	15 54 17.87	40.733	23.140	6.7	16	3.3	0.07	0.1	0.2	0.3	A	2.0
21	7 35 45.30	40.749	23.385	5.7	12	3.2	0.12	0.8	0.8	0.8	B	3.0
21	16 29 15.29	40.691	23.294	10.9	15	6.4	0.07	0.1	0.3	0.4	A	2.2
22	16 24 42.62	40.713	23.290	7.2	13	7.3	0.04	0.1	0.2	0.4	A	2.2
22	17 37 42.09	40.663	23.115	7.3	14	0.1	0.11	0.2	0.4	0.7	A	2.4

[1]No. Obs.--refers to the number of observations used to obtain hypocentral solutions.
[2]DMIN--distance to the closest seismograph station.
[3]RMS--root mean square errors of travel-time residuals.
[4]Standard Errors--refers to the indices of precision relating to the values and distribution of the unknown errors in the hypocentral solution where DLAT = error in latitude, DLON = error in longitude, and DZ = error in depth.
[5]QF--a measure that is intended to indicate the general reliability of the hypocentral solution where A = excellent epicenter, good focal depth; B = good epicenter, fair focal depth; C = fair epicenter, poor focal depth; D = poor epicenter, poor focal depth.
[6]M_L--local magnitude estimate of aftershock (Lee et al., 1972).

Table 2.--List of hypocentral parameters of aftershocks

Date July, 1978	Origin (UTC)	Lat. N (deg)	Long. E (deg)	Depth (km)	No.[1] Obs.	DMIN[2] (km)	RMS[3] (sec)	Standard Errors[4] DLAT (km)	DLON (km)	DZ (km)	QF[5]	M_L[6]
4	22 19 27.12	40.742	23.160	9.9	10	9.7	0.04	0.2	0.3	0.9	A	3.0
4	22 23 28.29	40.712	23.116	8.4	11	5.4	0.06	0.2	0.5	0.9	A	5.3
4	22 27 54.83	40.718	23.132	6.7	12	3.9	0.13	0.3	0.8	2.1	B	2.2
5	0 5 26.45	40.707	23.112	9.6	10	5.4	0.03	0.2	0.3	0.8	A	2.8
5	8 36 59.86	40.704	23.113	9.7	9	4.7	0.06	0.3	0.4	1.3	A	2.4
5	16 16 59.06	40.703	23.109	8.4	11	4.5	0.08	0.3	0.6	1.2	A	2.2
5	19 54 2.77	40.682	23.374	5.2	10	4.3	0.05	0.2	0.2	0.3	A	2.6
6	2 23 1.61	40.721	23.165	10.1	13	1.1	0.06	0.2	0.4	1.2	A	2.1
6	18 43 10.92	40.696	23.094	9.3	11	4.1	0.09	0.3	0.5	1.0	A	2.1
7	8 17 48.25	40.712	23.287	9.7	13	7.6	0.10	0.3	0.4	0.7	A	2.4
7	17 2 51.46	40.699	23.362	8.7	12	2.7	0.09	0.4	0.5	1.0	A	2.3
7	19 10 37.82	40.693	23.346	8.8	12	4.0	0.08	0.3	0.4	0.8	A	2.1
8	12 0 49.51	40.675	23.102	9.8	10	1.7	0.15	0.5	1.0	1.2	B	2.9
9	4 1 59.15	40.728	23.283	11.1	10	7.8	0.04	0.2	0.2	0.5	A	2.6
9	9 38 10.31	40.688	23.111	8.1	10	2.8	0.10	0.4	0.7	0.8	A	2.5
9	22 28 26.10	40.715	23.337	4.7	11	3.4	0.05	0.2	0.2	0.3	A	2.4
10	12 45 18.93	40.690	23.153	6.2	8	4.4	0.13	0.5	0.9	1.3	B	2.7
10	13 30 59.61	40.778	23.185	8.7	10	5.9	0.06	0.3	0.7	0.6	A	1.9
11	16 58 24.21	40.763	23.114	4.5	10	6.8	0.13	0.4	1.0	1.5	B	2.4
11	19 41 37.08	40.720	23.141	7.9	10	3.1	0.06	0.2	0.4	0.4	A	2.9
12	21 56 33.14	40.704	23.091	8.9	12	5.0	0.04	0.1	0.2	0.4	A	2.6
13	4 29 51.46	40.680	23.154	5.4	12	3.9	0.05	0.1	0.2	0.2	A	2.1
13	17 25 57.26	40.683	23.103	6.2	11	2.4	0.05	0.2	0.2	0.4	A	3.4
14	3 45 24.73	40.756	23.198	16.8	11	12.6	0.08	0.4	0.8	1.3	A	3.2
14	18 14 25.37	40.679	23.101	7.3	12	2.1	0.05	0.2	0.3	0.4	A	2.9

more stations for each earthquake. Owing to the absence of S-velocity data, a P-S velocity ratio of 1.73 was assumed.

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