TECHNICAL REPORT 79-2

SEISMIC ACTIVITY NEAR THE V. C. SUMMER NUCLEAR STATION

For the Period
April — June 1979

by

Pradeep Talwani
Principal Investigator
Geology Department
University of South Carolina
Columbia, S.C. 29208

Contract No. N230519

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INTRODUCTION

This report presents the analysis of seismic data recorded near the V. C. Summer Nuclear Power Station in South Carolina. During the reporting period (April 1 - June 30, 1979) shallow microearthquake activity averaged less than one locatable event per day (≈ 0.63 event/day). Two events of magnitude ≥ 2.0 were recorded on the same day (6/5/79) in the vicinity of the lake.

INSTRUMENTATION

The data were recorded by a four station seismic network operated by S.C.E. and G. Data were also obtained from JSC, a permanent station of the South Carolina seismographic network. These seismic stations are shown in Figure 1 and listed in Appendix I. Seismic data were lost due to storms during the periods April 11 - 13, 26 - 28 and June 21 - 25.

METHOD

Events were located using a computer program HYPO-71 (Lee and Lahr, 1972) and a velocity model developed for the Monticello Reservoir area (Appendix II). The event magnitudes are calculated from the signal durations at station JSC, where the duration (D) and magnitude (M_L) relation is

$$M_L = -1.83 + 2.04 \log D$$

The daily energy release was calculated using a simplified magnitude (M_L) energy (E) relation (Gutenberg and Richter, 1956)

$$\log_{10} E = 11.8 + 1.5 M_L$$

RESULTS

In the reporting period (April 1 - June 30, 1979) 57 locatable events were recorded. These are listed in Appendix III. Figure 2 shows the cumulative events recorded in April, May and June 1979. Most events occurred in a group on the western edge of the reservoir with a small portion of the events occurring in the two loose clusters in the central and southwestern parts of the reservoir. A cross section, 2.0 miles in width from A to B is shown in Figure 3, showing the shallow ($\leq$ 3.0 km) character of the events. The monthly locations and cross sections are shown in Figures 4 - 9. A cumulative (from December 1977 to June 1979) map and cross sections are shown in Figures 10 and 11. A cumulative (from December 1977 to June 1977) map of events ($M_L \geq 2.0$) is shown in Figure 12. In Figures 2 - 12 only events with an RMS of $\leq$ 0.1 sec have been plotted.

COMPARISON OF SEISMICITY WITH RESERVOIR LEVELS

Monticello reservoir is a pumped storage facility and the decrease in reservoir levels associated with power generation is recovered when water is pumped back into the reservoir. Correspondingly there can be variations up to about 5 feet per day between the maximum a d minimum water levels. Accor ingly both these are shown in Figure 13 together with the daily energy release and daily number of located events. Only events with a duration of 10 seconds ($M_L \sim 0.2$) were considered, as the seismic energy release associated with smaller events is significantly smaller.

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There were very small fluctuations in the water level in April. These were followed by more rapid fluctuations in both the maximum and minimum water levels in May and June 1979. There also appears to be a general increase in the seismicity level in May and June with two $M_L > 2.0$ events occurring on June 5, 1979.

In an effort to find the cause of the seismicity the peaks in the seismic energy release ($\geq 10^{13}$ ergs/day) were compared with water levels. There is a suggestion that seven seismicity peaks occur from 12 - 14 days after a low peak in the *maximum* water level. The corresponding peaks have been numbered. We then attempted to relate the delay to the hypocentral distance of the event from the lake edge. Preliminary data suggest a linear relationship.

In seeking a driving force for the triggering of the seismicity, the daily variation in the lake level was compared with the energy release (Figure 14). Possible correlation peaks have been numbered. The lag is smaller and not all peaks in activity match with peaks in the amount of water level change.

Thus these data suggest some relationship between lake level, its fluctuations and the seismicity, the exact nature of this relationship is not clear. However the observation that the seismicity is associated with thrust faulting supports the view that the seismicity is associated with changes in the pore pressure at hypocentral depths.

CONCLUSION

Low level seismic activity is still continuing in the area and will be further studied as well as the relationship between seismic energy and lake level.

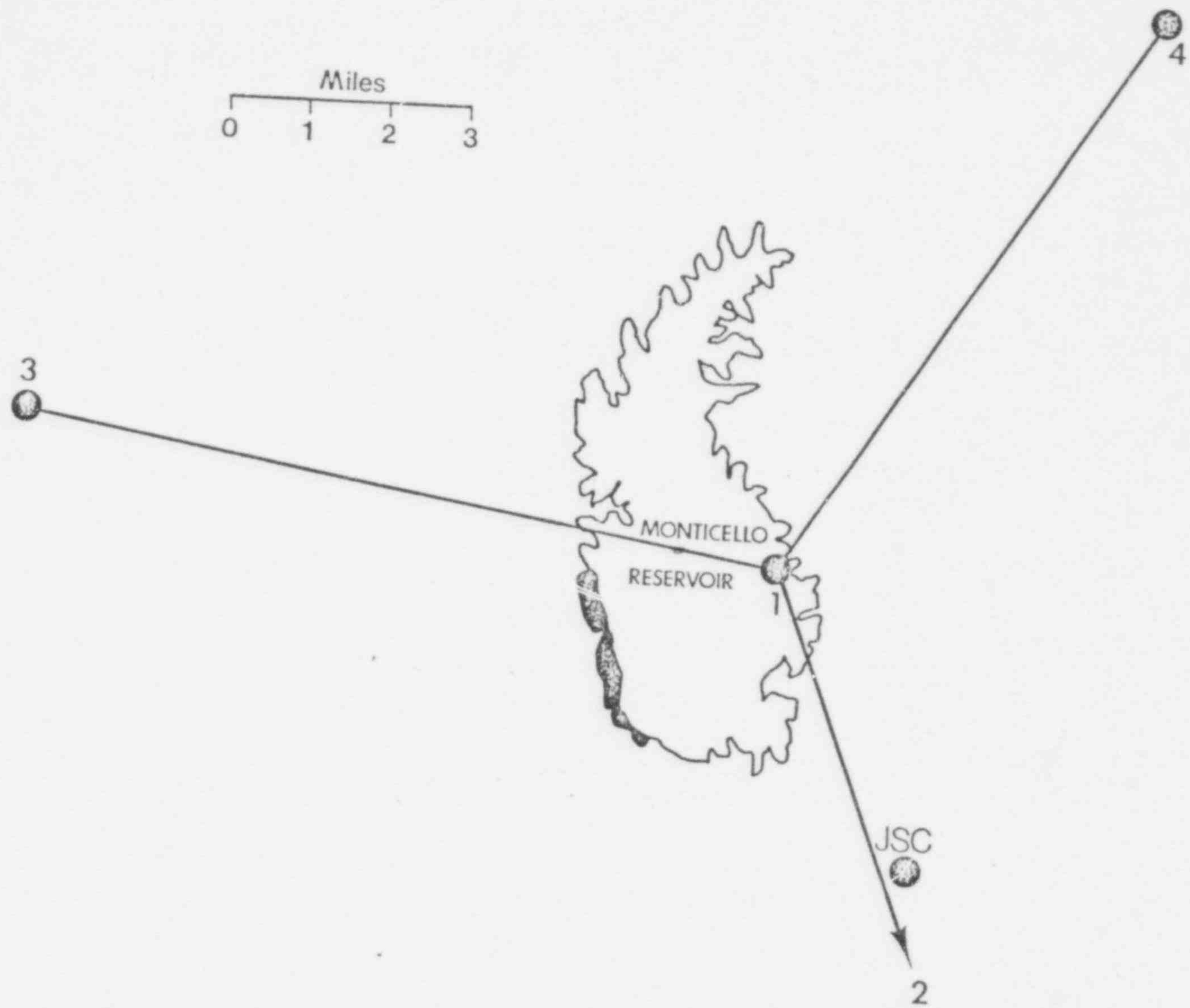

Figure 1

MØNTICELLØ EARTHQUAKES

APRIL-JUNE 79

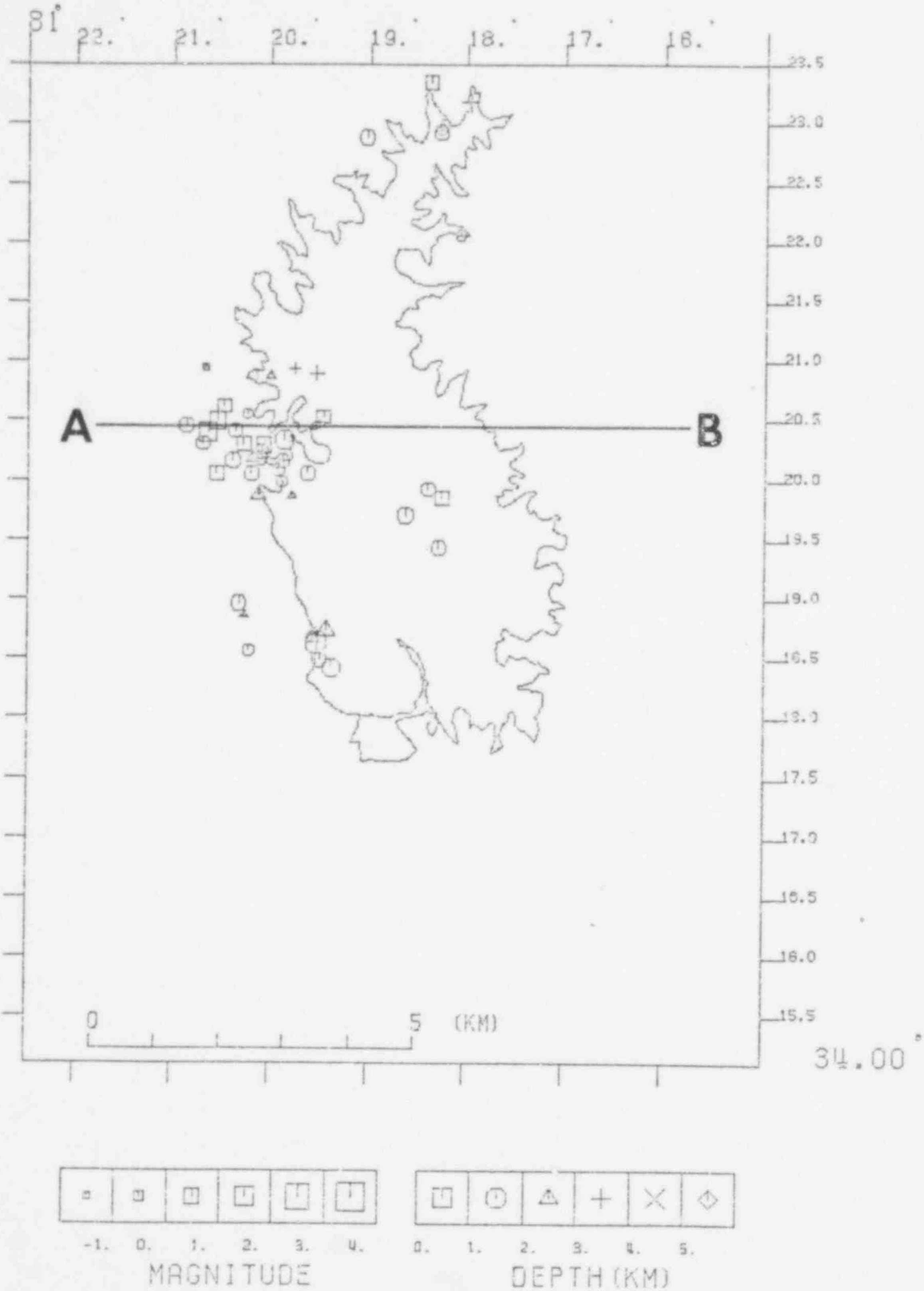

Figure 2

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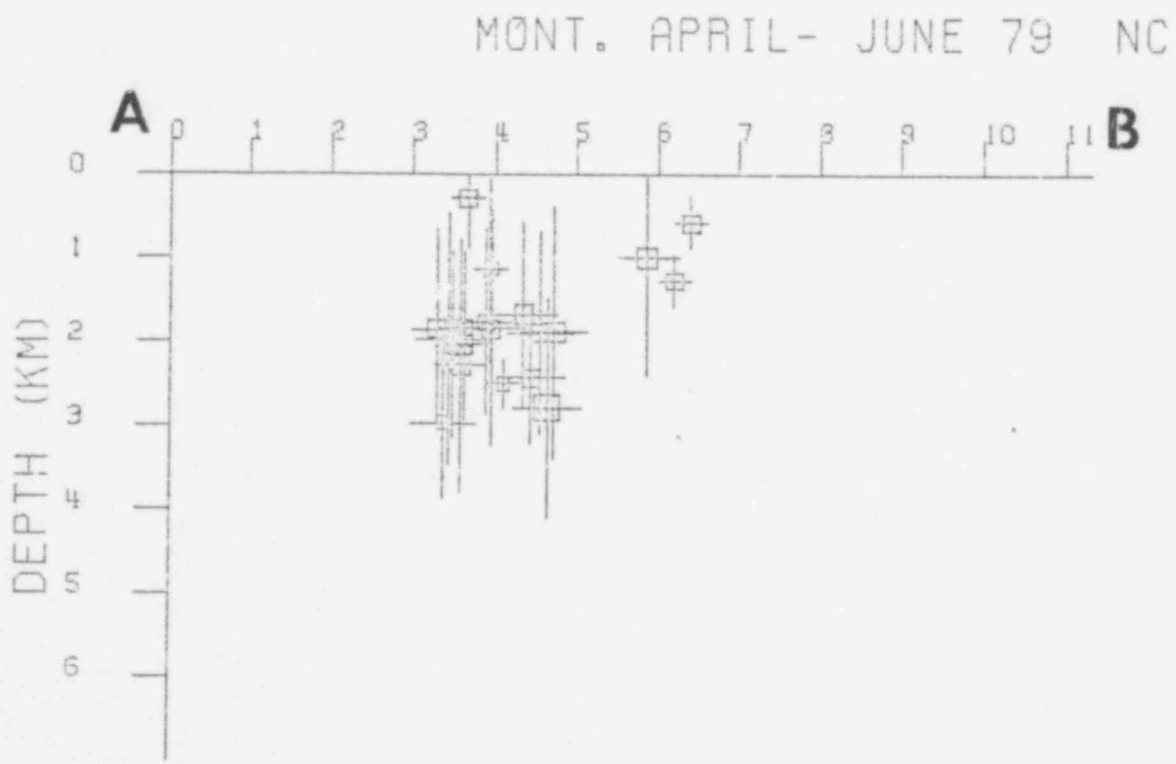

Figure 3

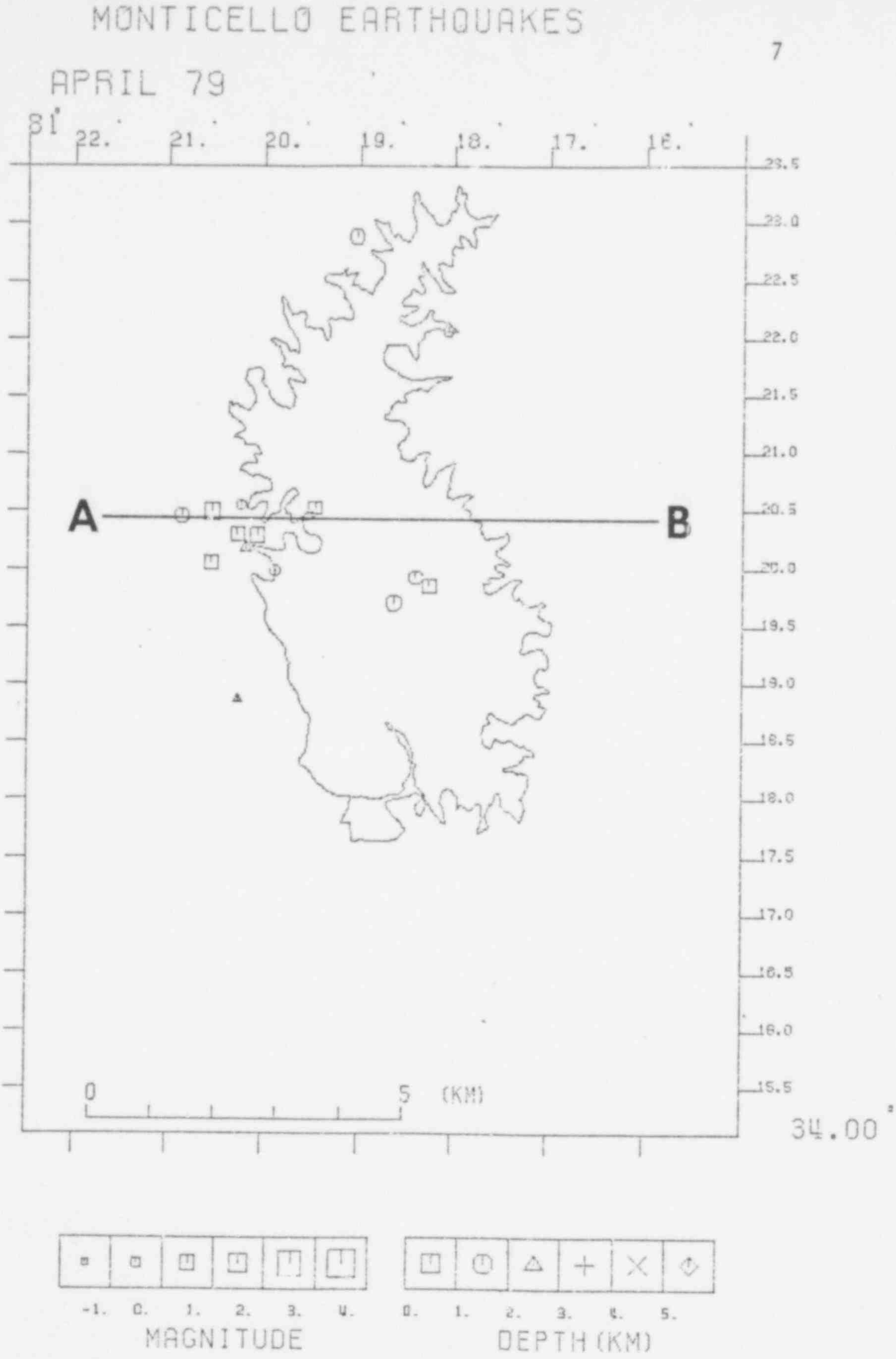

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Figure 4

POOR ORIGINAL

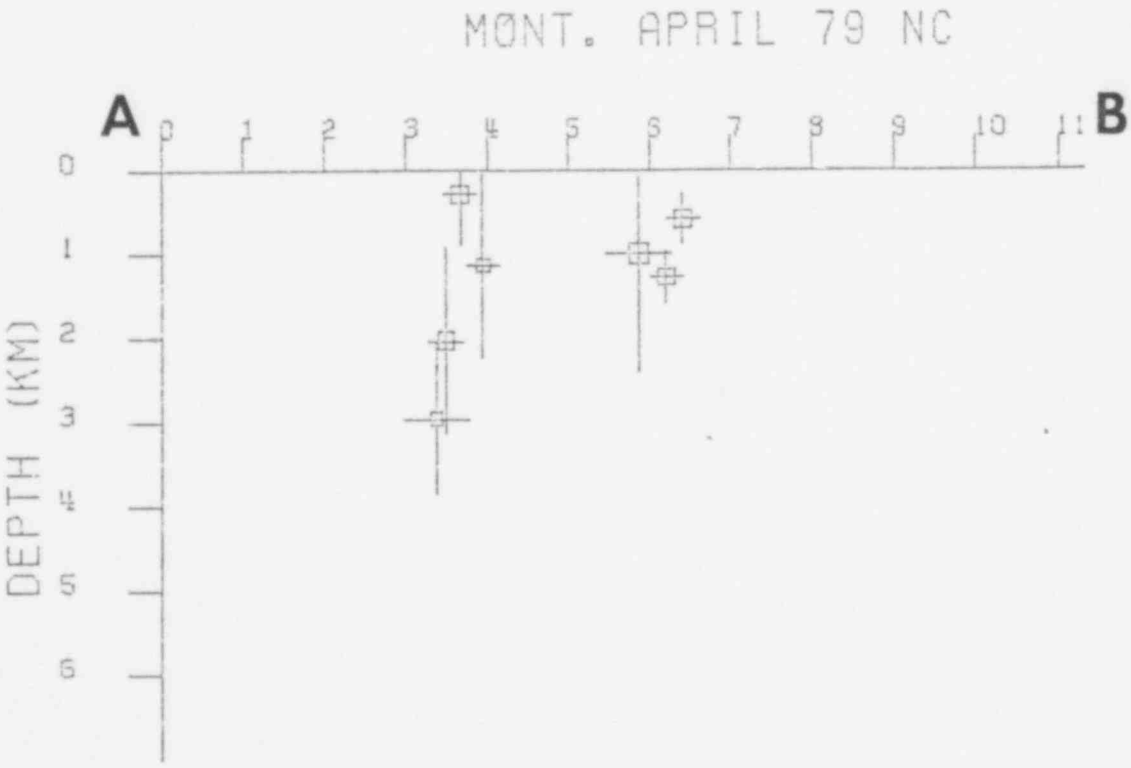

Figure 5

MONTICELLO EARTHQUAKES

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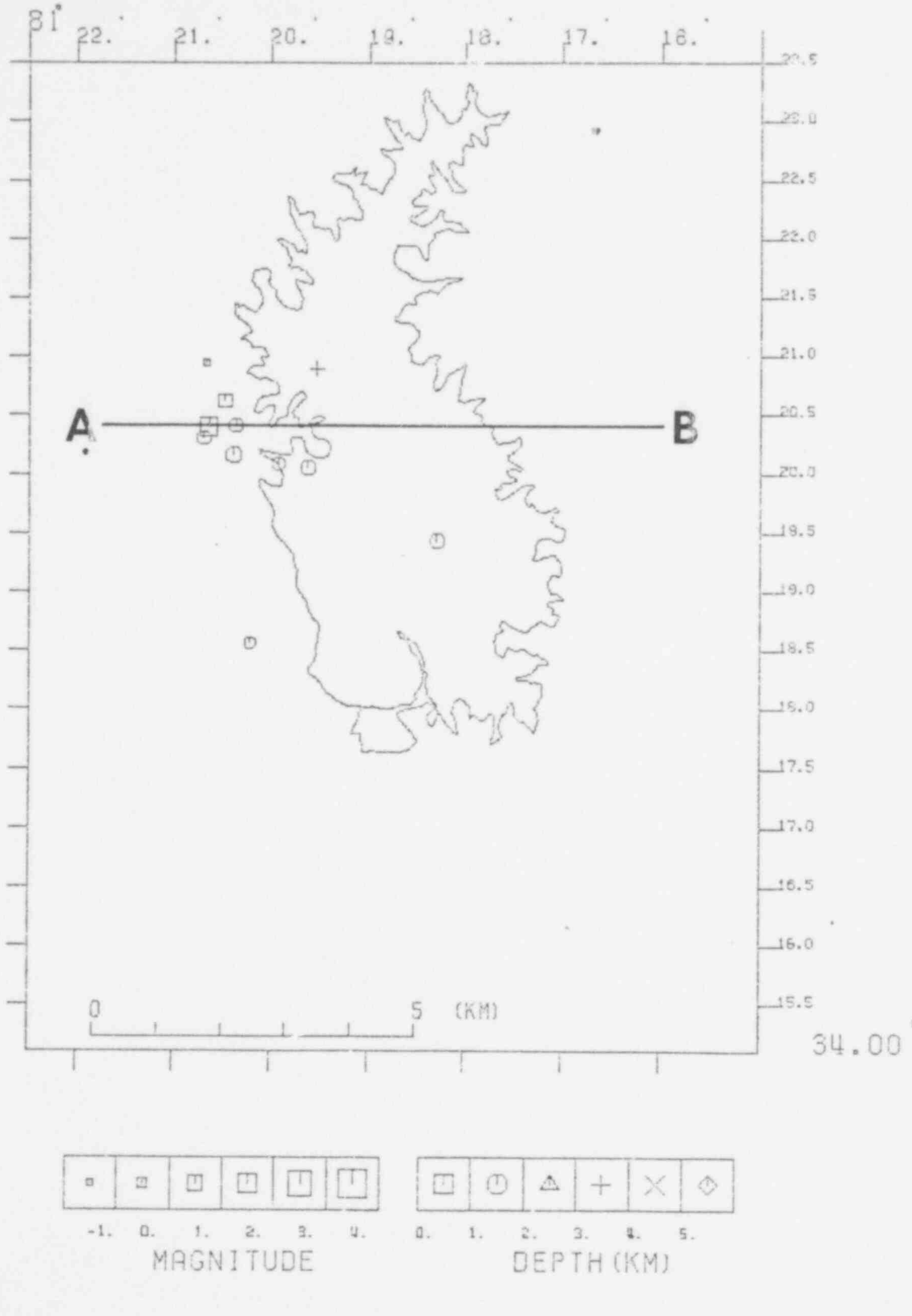

Figure 6

575 257

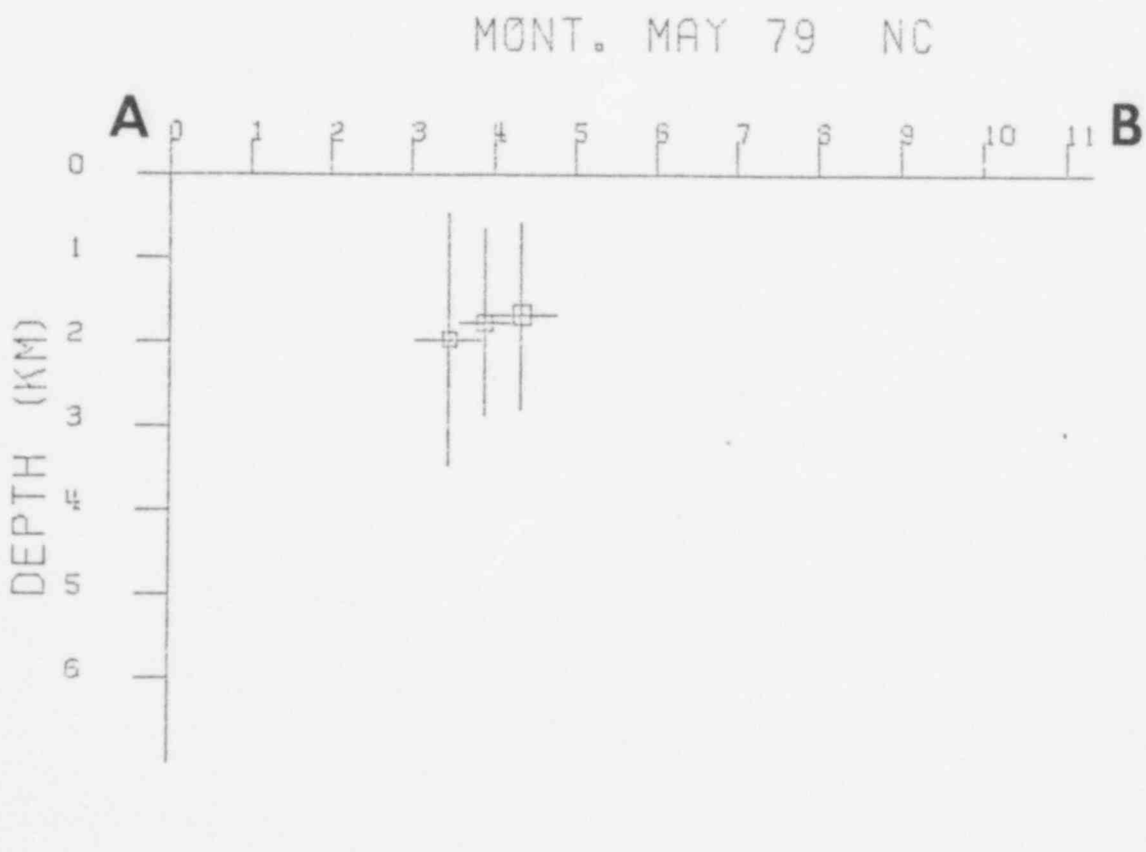

Figure 7

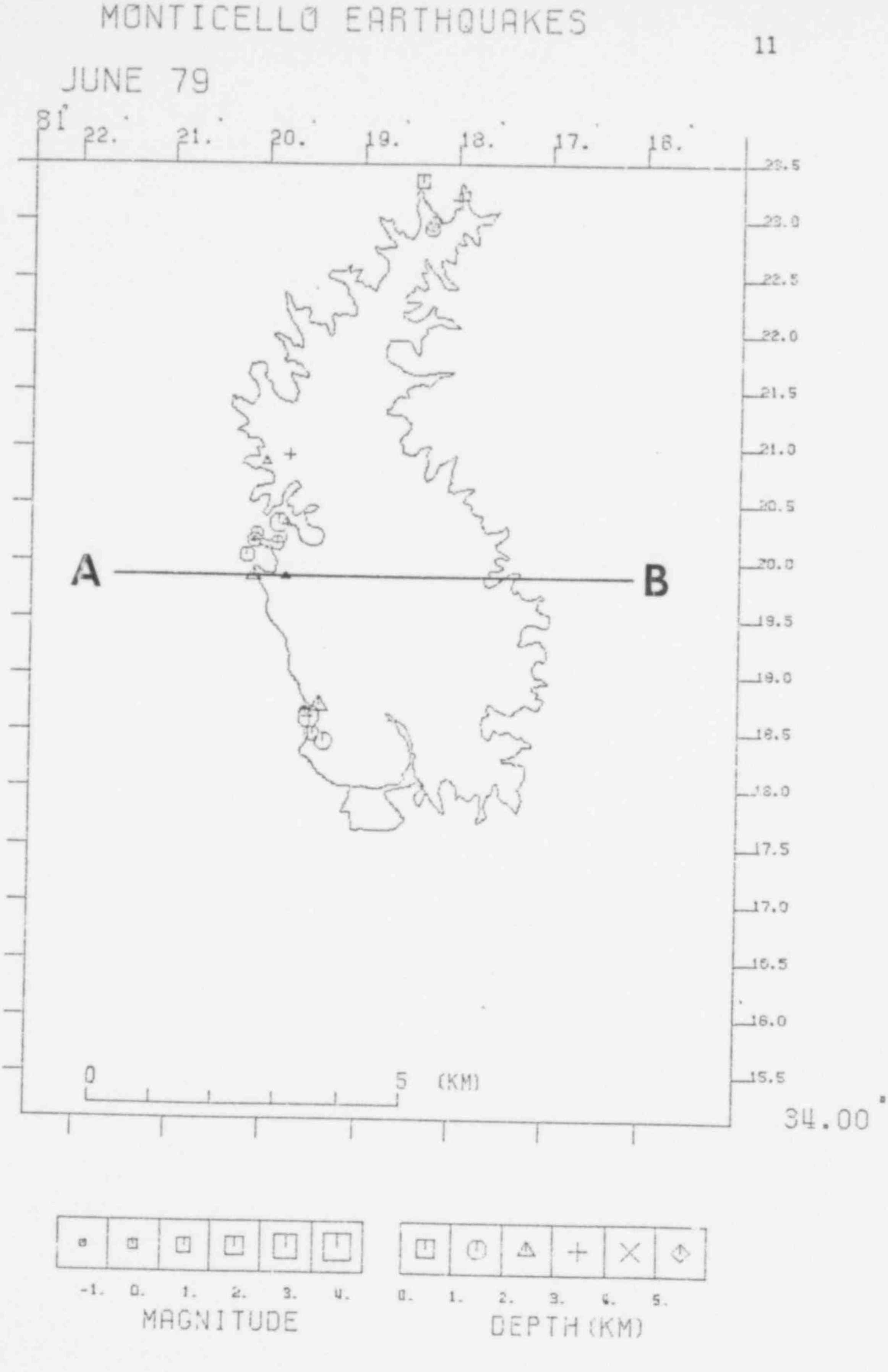

Figure 8

575 259

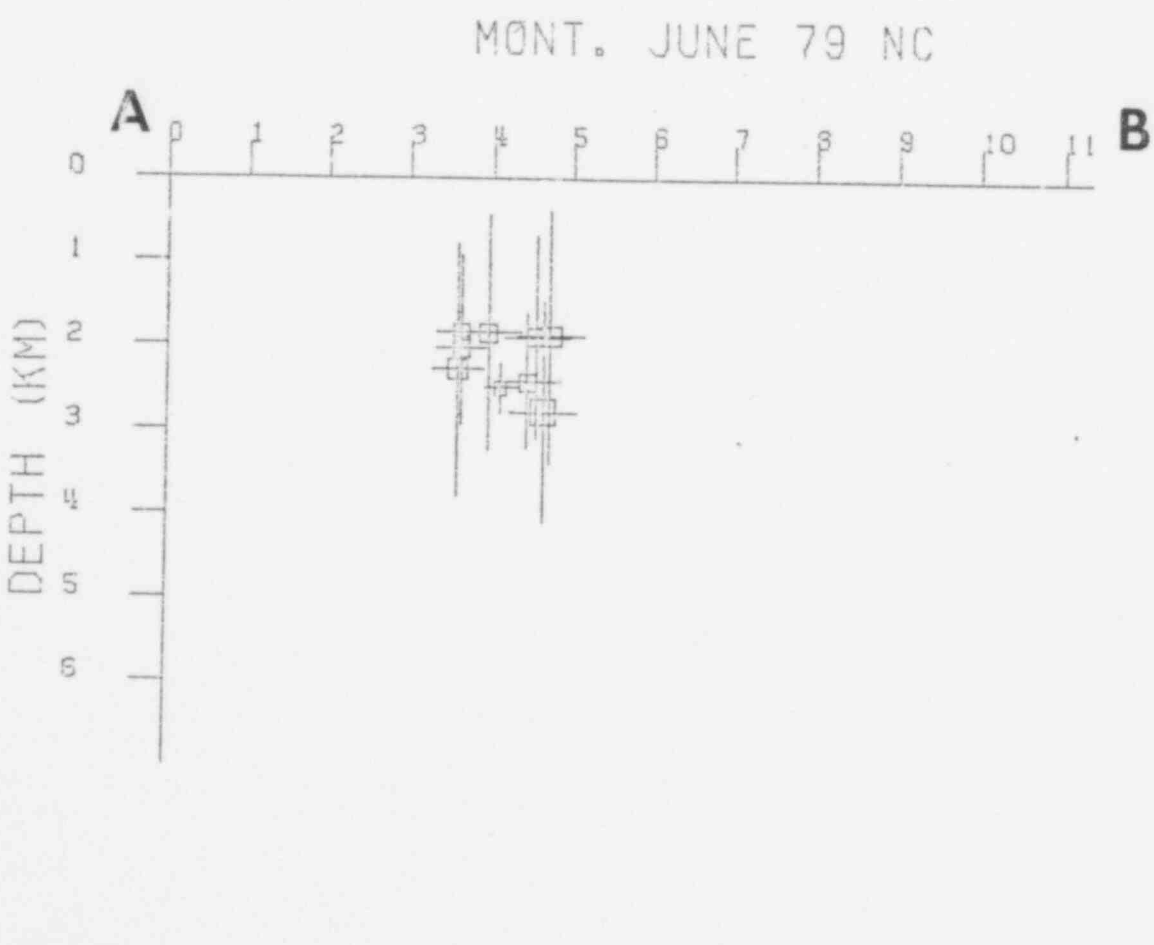

Figure 9

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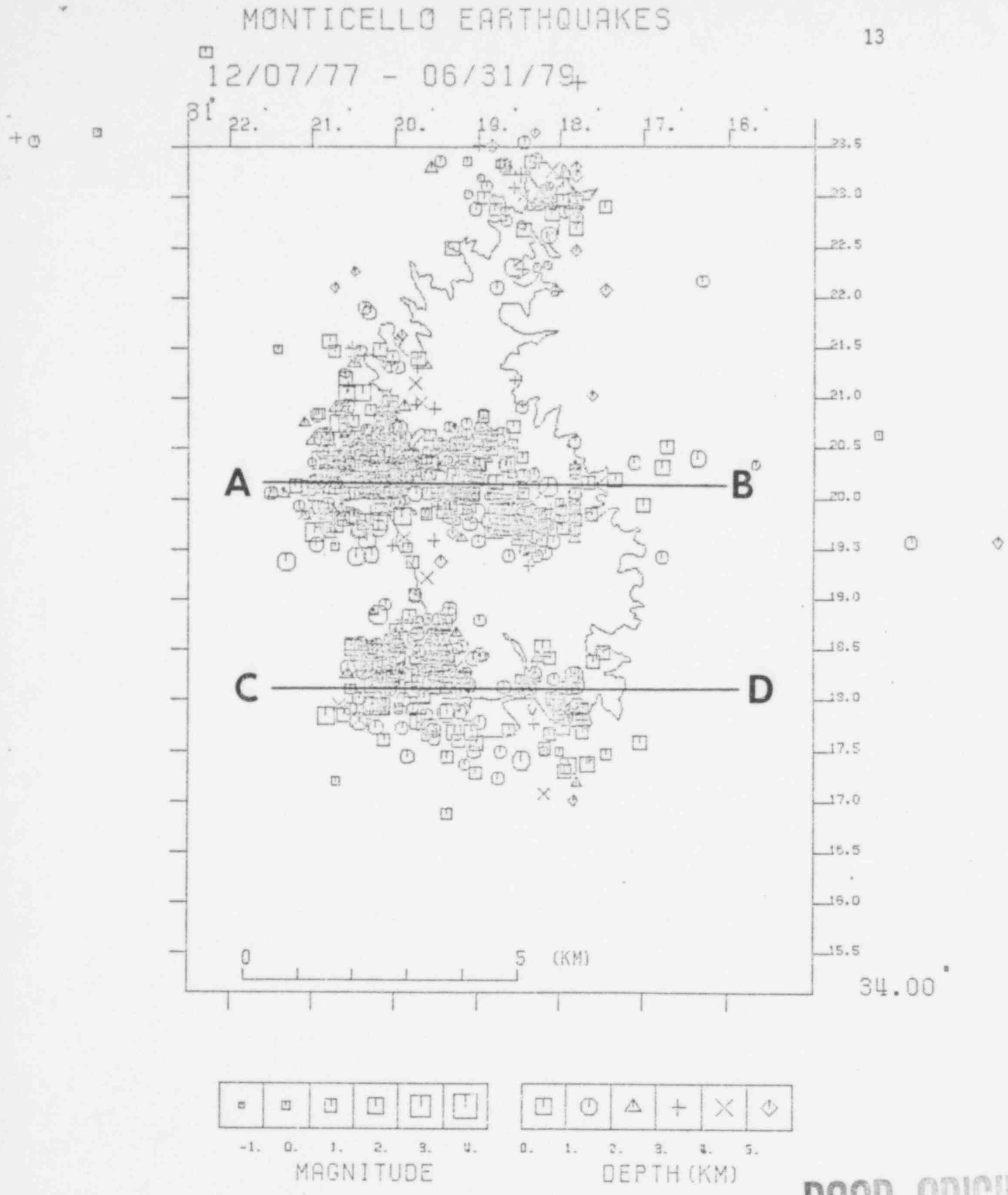

Figure 10

575 261

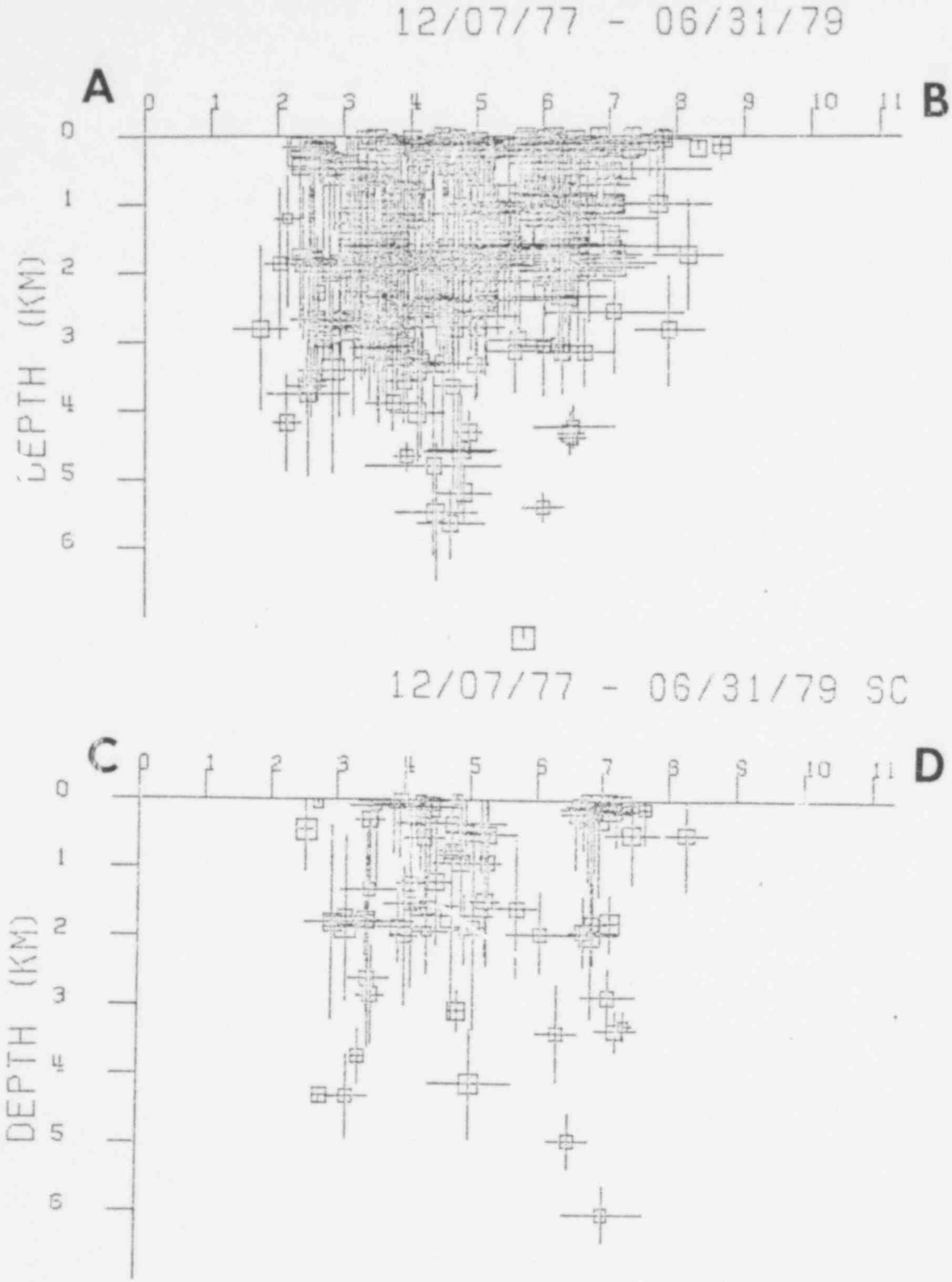

Figure 11

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MONTICELLO EARTHQUAKES

12/07/77 - 06/31/79 $M_L \geqslant 2.0$

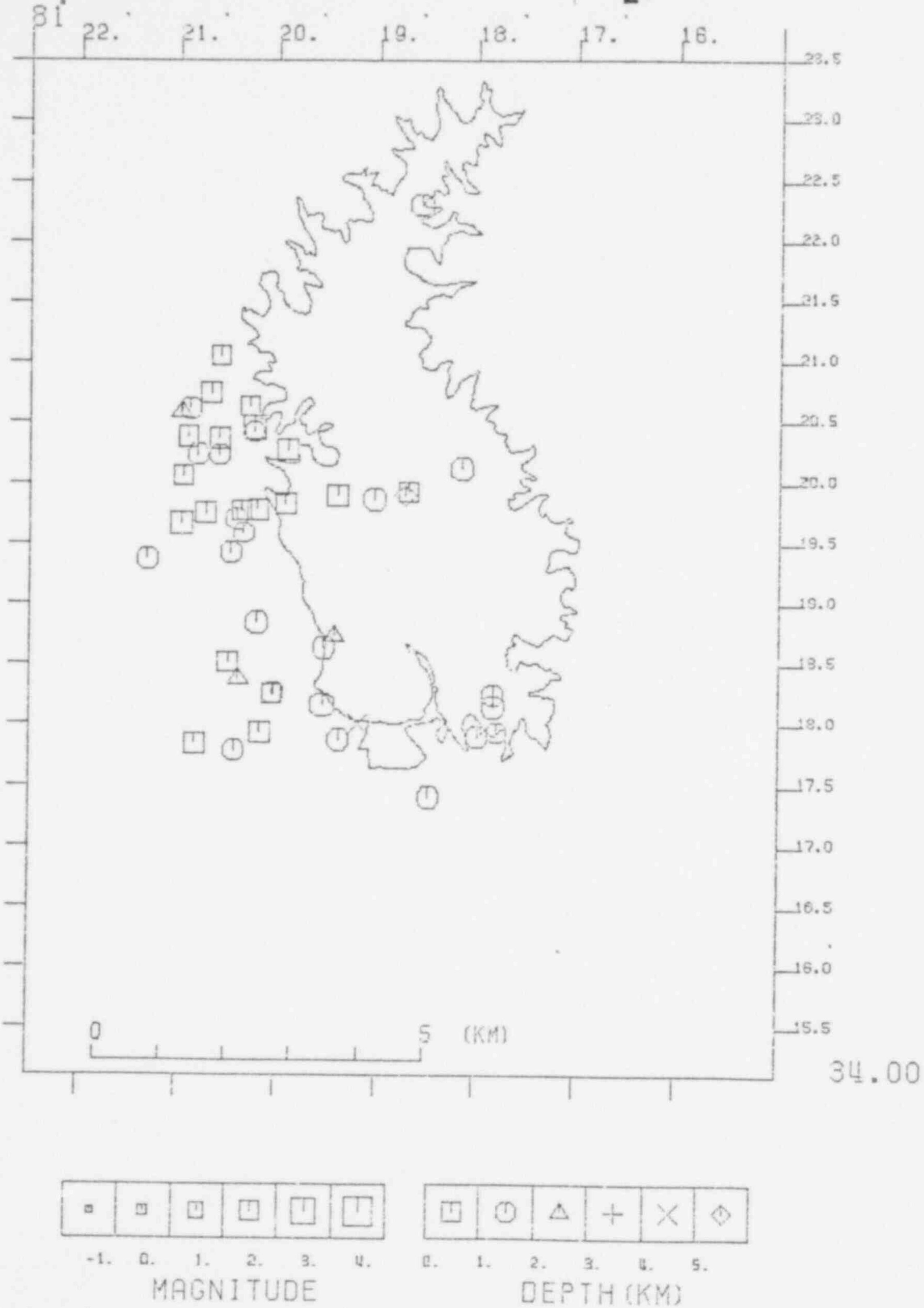

Figure 12

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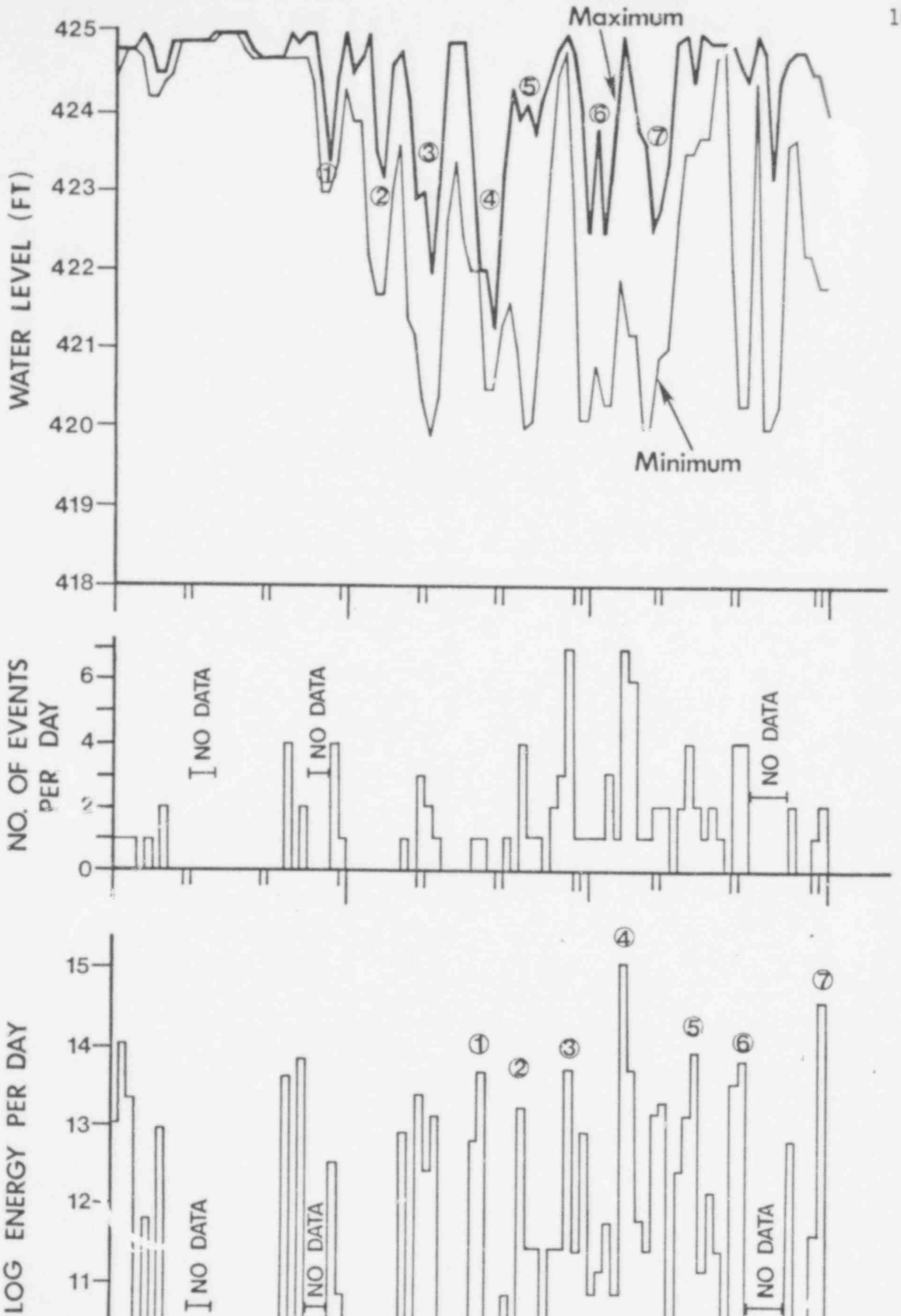

Figure 13

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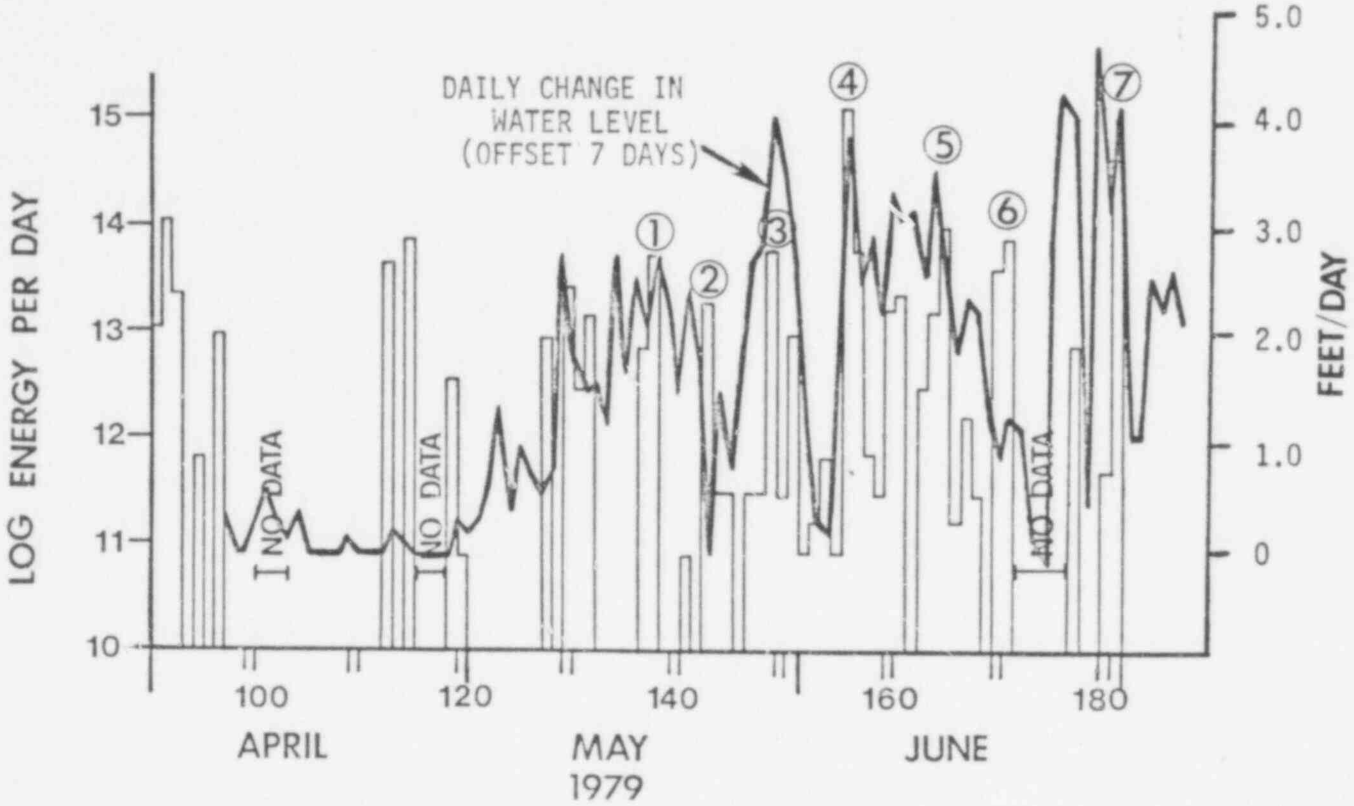

Figure 14

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REFERENCES

Gutenberg, B. and Richter, C. F. (1956). Magnitude and energy of earthquakes, Ann. Geof. 9, p. 1-15.

Lee, W. H. K. and Lahr, J. C. (1972). A computer program for determining hypocenter, magnitude and first motion pattern of local earthquakes, Revisions of HYPO 71, U.S.G.S. Open-file report, 100 pp.

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APPENDICES

APPENDIX I

STATION LOCATION

NO.	STN.	LAT. N.	LONG. W.
1	001	$34^{\circ}19.91'$	$81^{\circ}17.74'$
2	002	$34^{\circ}11.58'$	$81^{\circ}13.81'$
3	003	$34^{\circ}21.09'$	$81^{\circ}27.41'$
4	004	$34^{\circ}25.72'$	$81^{\circ}12.99'$
5	JSC	$34^{\circ}16.80'$	$81^{\circ}15.60'$

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APPENDIX II

VELOCITY MODEL

Velocity km/sec	Depth km
1.00	0.00
5.40	0.03
5.90	0.18
6.10	0.46
6.30	0.82
8.10	30.00

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APPENDIX III

LOCATION OF EVENTS FROM

January 1 - March 31, 1979

Computer printout of HYPO71 showing data for location of events.

Column 1	Date.
Column 2	Origin time (UCT) h.m.sec.
Column 3	Latitude (N) degrees, min.
Column 4	Longitude (W) degrees, min.
Column 5	Depth (km).
Column 6	Local duration magnitude.
Column 7	No. of station readings used to locate event. P and S arrivals from same stations are regarded as 2 readings.
Column 8	Largest azimuthal separation in degrees between stations.
Column 9	Epicentral distance in km to nearest station.
Column 10	Root mean square error of time residuals in sec. RMS $=\sqrt{R_i^2/NO}$, where R_i is the time residual for the ith station.
Column 11	Standard error of the epicenter in km*.
Column 12	Standard error of the focal depth in km*.

*Statistical interpretation of standard errors involves assumptions which may not be met in earthquake locations. Therefore standard errors may not represent actual error limits.

If ERH or ERZ is blank, this means that it cannot be computed, because of insufficient data.

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	DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	QM
1	790401	127 21.57	34-19.02	81-20.33	1.11	0.91	9	146	4.3	0.50	2.6	32.8	C1
2	790401	1919 18.72	34-20.46	81-20.56	0.97	1.50	9	134	4.4	0.04	0.2	7.7	C1
3	790402	820 13.03	34-20.25	81-20.08	0.29	1.18	7	129	3.7	0.04	0.2	0.6	B1
4	790403	1840 52.70	34-20.26	81-20.29	0.91	1.02	10	130	4.0	0.10	0.4	8.6	C1
5	790406	631 41.63	34-19.88	81-18.41	1.28	0.82	6	124	1.0	0.02	0.2	0.3	B1
6	790407	2 3 14.78	34-20.49	81-19.47	0.06	0.82	8	131	2.9	0.05	0.2	0.6	B1
7	790407	332 57.80	34-20.52	81-20.25	1.92	0.01	9	134	4.0	0.08	0.4	1.5	B1
8	790410	251 5.32	34-19.81	81-18.27	0.59	0.82	7	124	0.8	0.03	0.2	0.3	B1
9	790421	312 42.01	34-22.88	81-19.05	1.83	1.12	8	165	5.9	0.07	0.4	2.3	C1
10	790421	1238 2.34	34-20.01	81-20.57	0.92	0.82	8	134	4.3	0.07	0.4	7.5	C1
11	790422	952 12.20	34-22.05	81-18.09	1.79	0.21	10	156	4.0	0.06	0.3	0.9	B1
12	790422	1035 43.17	34-18.80	81-20.28	2.97	0.21	10	146	4.4	0.08	0.4	0.9	B1
13	790422	1634 15.74	34-20.14	81-20.20	2.04	0.87	9	131	3.8	0.08	0.2	1.1	B1
14	790423	1931 6.91	34-20.42	81-20.88	1.99	1.18	7	134	4.9	0.05	0.4	1.3	B1
15	790424	949 56.39	34-19.66	81-18.64	1.00	1.39	8	128	1.5	0.08	0.4	1.4	B1
16	790429	924 46.91	34-19.94	81-19.90	1.14	0.21	8	132	3.3	0.03	0.2	1.1	B1
17	790508	1119 51.77	34-20.36	81-20.66	0.03	1.80	5	132	4.6	0.05	0.8	2.1	C1
18	790508	1831 25.87	34-20.27	81-20.71	1.92	0.82	8	149	4.6	0.06	0.3	1.6	B1
19	790510	2328 41.77	34-20.37	81-20.38	1.67	0.78	10	132	4.1	0.06	0.3	1.2	B1
20	790511	6 3 14.31	34-18.50	81-20.23	1.97	0.37	10	151	4.6	0.08	0.4	1.5	B1
21	790512	218 9.74	34-19.38	81-18.30	1.00	0.91	9	128	1.3	0.09	0.4	2.3	B1
22	790515	225 33.60	34-20.59	81-20.47	0.49	0.73	7	136	4.4	0.05	0.4	1.5	B1
23	790517	1411 56.49	34-20.04	81-19.94	1.76	0.68	9	131	3.4	0.07	0.3	1.1	B1
24	790518	942 26.40	34-22.09	81-18.79	1.92	1.27	8	254	4.3	0.09	1.2	1.5	C1
25	790518	1740 24.77	34-20.01	81-19.63	1.68	1.18	8	129	2.9	0.07	0.4	1.1	B1
26	790521	026 19.30	34-20.92	81-20.66	0.71	-0.60	9	141	4.9	0.05	0.3	1.6	B1
27	790523	9 1 2.63	34-20.87	81-19.54	3.04	0.99	9	136	3.3	0.04	0.2	0.5	B1
28	790524	0 0 3.33	34-20.12	81-20.40	1.07	1.27	9	132	4.1	0.07	0.4	4.6	B1
29	790529	341 51.09	34-20.40	81-20.54	0.85	0.91	8	133	4.4	0.07	0.4	101.2	C1
30	790529	1224 22.11	34-18.90	81-20.33	1.85	1.06	10	147	4.4	0.07	0.3	1.2	B1
31	790605	937 44.23	34-18.57	81-19.54	1.92	2.41	6	145	3.7	0.08	0.7	2.9	C1
32	790605	940 2.10	34-18.67	81-19.44	2.79	2.33	7	144	3.5	0.06	0.4	1.3	B1
33	790605	944 44.52	34-18.27	81-19.45	1.01	1.06	6	178	6.5	0.09	1.2	31.9	C1
34	790605	10 2 2.58	34-18.35	81-19.38	1.69	1.44	10	147	3.8	0.08	0.4	1.5	B1
35	790606	639 28.09	34-18.60	81-19.57	2.42	0.99	10	145	3.7	0.08	0.4	0.8	B1
36	790606	859 44.71	34-20.14	81-20.13	1.95	1.18	9	130	3.7	0.10	0.4	2.2	B1
37	790607	17 0 29.98	34-20.01	81-20.21	1.78	1.02	8	150	3.8	0.08	0.5	1.8	B1
38	790609	915 23.26	34-20.28	81-20.01	0.02	0.91	8	129	3.5	0.14	0.7	0.2	B1
39	790610	1156 40.46	34-18.42	81-19.50	1.90	0.99	10	147	3.9	0.08	0.4	1.2	B1
40	790612	143 53.44	34-20.91	81-19.77	3.36	0.44	10	138	3.6	0.09	0.4	0.7	B1
41	790613	9 4 38.42	34-20.20	81-20.11	1.83	0.51	10	130	3.7	0.07	0.3	0.9	B1
42	790613	1024 12.50	34-20.16	81-20.11	2.03	0.82	10	130	3.7	0.07	0.3	0.9	B1
43	790614	752 12.17	34-19.83	81-20.14	2.28	1.54	9	134	3.7	0.07	0.3	1.5	B1
44	790616	1022 7.94	34-19.82	81-19.79	2.50	0.01	7	150	3.2	0.02	0.2	0.3	B1
45	790619	1 5 53.72	34-23.18	81-18.00	3.28	1.80	8	164	6.1	0.03	0.2	0.7	B1
46	790619	1 9 39.06	34-23.35	81-18.40	0.73	0.73	7	169	6.4	0.06	0.4	1.8	B1
47	790619	112 0.55	34-22.89	81-17.84	1.86	0.21	6	236	5.5	0.08	1.2	2.5	C1
48	790619	113 22.54	34-22.95	81-18.30	1.87	0.21	4	246	5.7	0.01	0.0	0.0	C1
49	790620	225 25.53	34-20.11	81-19.89	1.64	1.02	10	130	3.3	0.09	0.4	1.4	B1
50	790620	1457 7.89	34-20.01	81-18.82	1.52	1.18	6	247	1.7	0.10	2.2	1.6	C1
51	790620	2110 48.57	34-22.92	81-18.30	1.62	0.82	6	161	5.6	0.07	0.5	3.1	C1
52	790620	2324 46.47	34-22.99	81-18.27	1.19	0.29	6	162	5.8	0.05	0.8	10.8	C1
53	790621	1126 51.89	34-20.30	81-19.79	2.84	0.01	8	129	3.2	0.09	0.6	0.8	B1
54	790622	931 41.69	34-19.46	81-19.86	0.46	0.37	6	209	3.4	0.10	1.8	9.4	D1
55	790626	1027 5.65	34-20.57	81-19.99	0.24	0.68	9	134	3.7	0.12	0.6	1.6	B1
56	790626	1027 41.71	34-20.85	81-20.01	2.20	0.0	10	138	3.9	0.09	0.4	1.2	B1
57	790630	135 9.24	34-20.29	81-19.87	1.24	1.87	7	129	3.3	0.05	0.4	2.6	B1

POOR ORIGINAL

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