Technical Report 80-4

SEISMIC ACTIVITY NEAR
THE V. C. SUMMER NUCLEAR STATION

For the Period

October - December 1980

by

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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 (October 1 - December 31, 1980) shallow microearthquake activity averaged one locatable event every four days. Only one event of magnitude $\geq$ 2.0 was recorded (12/27/80) for this reporting period.

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 and a portable digital event detector (station JIM). These seismic stations are shiwn in Figure 1 and listed in Appendix I.

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 (October 1 - December 31, 1980) 23 locatable events were recorded. These are listed in Appendix III. Figure 2 shows the cumulative events recorded in October, November and December 1980. A group of events occurred in a tight cluster on the western edge of the reservoir with a loose band of events occurring in a general N-S direction between Parr and Monticello reservoirs. A cross section, 2.0 miles in width from A to B is shown in Figure 3, showing the shallow (≤ 3.0 km) character of the events. The monthly locations are shown in Figures 4 - 6. All 1980 located events are shown in Figure 7 with cross section taken along C-D (Figure 8). A cumulative (from December 1977 to December 1980) location map is shown in Figure 9. In Figures 2 - 9 only events with an RMS of ≤ 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 and minimum water levels. Figure 10 shows the comparison of water level to seismicity. The top two graphs show the average water level and also the change of water level per day. The log energy per day and number of events per day are shown on the lower graphs.

During the reporting period, seismic activity and corresponding energy release were relatively low. This can be observed more clearly by comparison with the seismic activity and energy release for the entire year (Figure 11).

b-VALUES

The b-values were obtained for events occurring in approximately two week periods. As the number of events was not large Utsu's (1971) method was used. In this method:

$$b = \frac{s \log e}{\Sigma M_i - sMs}$$

where

M_i = sum of magnitude of all earthquakes having magnitudes equal to or larger than Ms

s = total number of those earthquakes

and

$$\eta = \frac{10^{-b\Delta M}}{1 - 10^{-b\Delta M}} + \tfrac{1}{2}\, b\Delta M/\log e$$

where

η = factor for correcting the effort of the length of the magnitude interval ΔM. $b\Delta M$ is given in Table 18, p. 388 (Utsu, 1971).

The b-values for 3 month periods are shown in Figure 12.

CONCLUSION

Low level seismicity has continued to occur at Monticello reservoir. Comparing the activity of 1980 with that of 1979 there is a marked decrease in frequency of events. 1979 figures show an average of 41 events per month, excluding the October swarm. In 1980, activity has dropped even more with a total of 151 events. Of the 151, 43 occurred in the July swarm. Excluding this July activity the per month frequency rate becomes 9 events. The total number of earthquakes of magnitude > 2.0 also decreased in 1980 with a total of 8 (total of 21 in 1979).

These 1980 and 1979 data together with 1978 data indicate a decrease in the level of seismicity after initial impoundment. This continuing decay in the frequency of seismic activity coupled with the shallow nature seems to suggest further stablization of events at rather low levels.

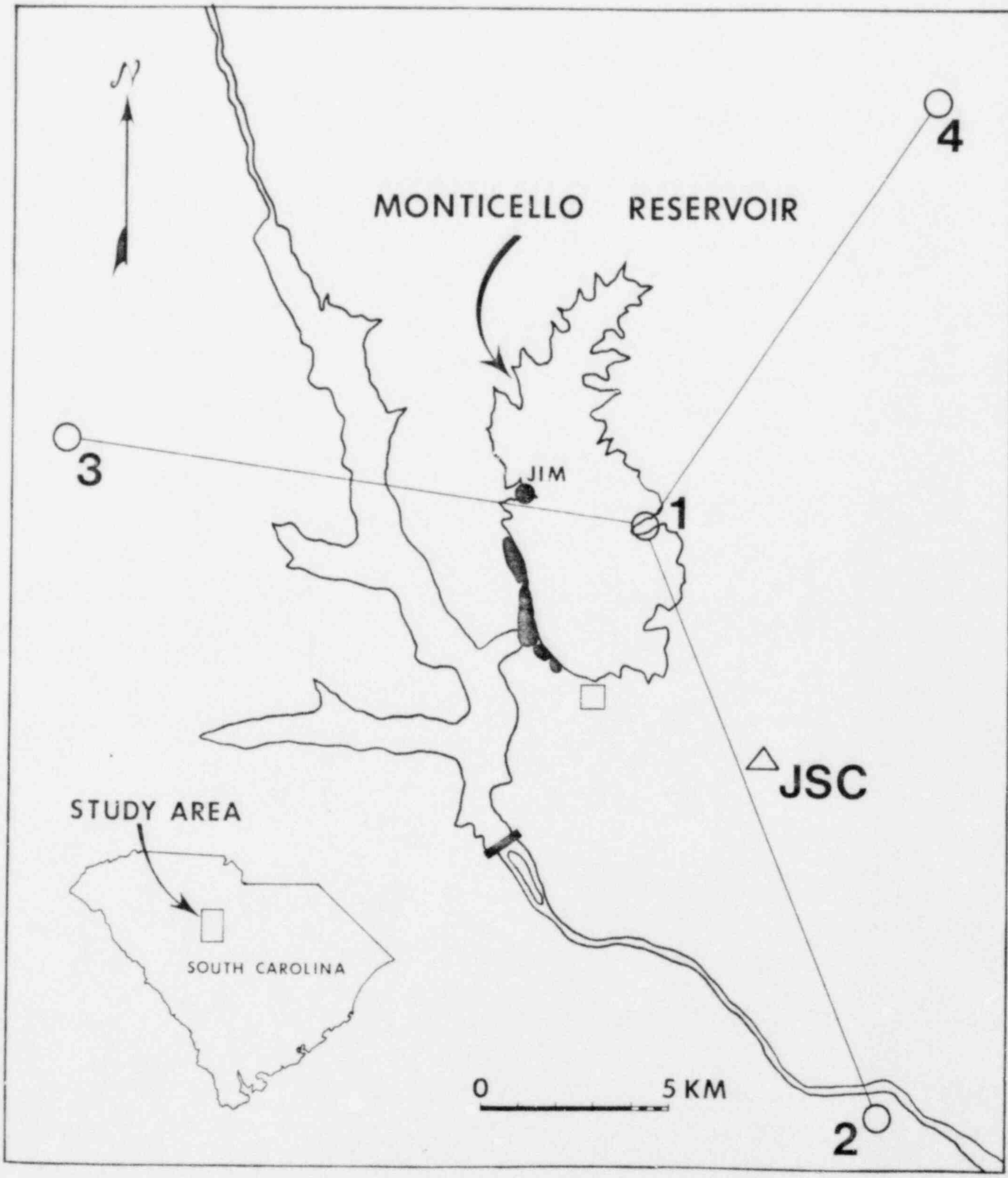
MONTICELLO RESERVOIR
JIM
1
2
3
4
JSC
STUDY AREA
SOUTH CAROLINA
0
5 KM

Figure 1

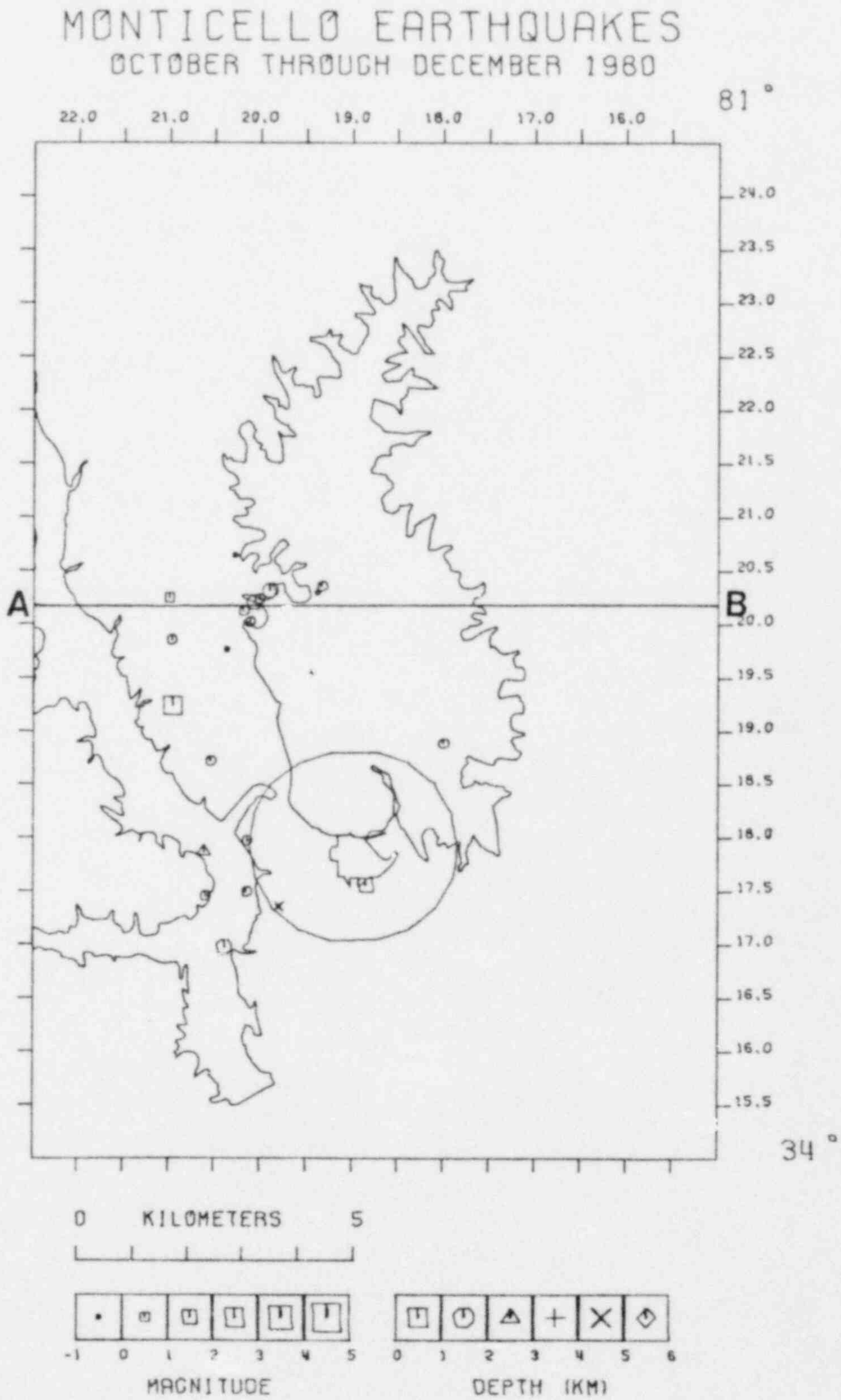
MONTICELLO EARTHQUAKES
OCTOBER THROUGH DECEMBER 1980
81°
22.0 21.0 20.0 19.0 18.0 17.0 16.0
24.0 23.5 23.0 22.5 22.0 21.5 21.0 20.5 20.0 19.5 19.0 18.5 18.0 17.5 17.0 16.5 16.0 15.5
34°
A
B
0 KILOMETERS 5
-1 0 1 2 3 4 5
MAGNITUDE
0 1 2 3 4 5 6
DEPTH (KM)

Figure 2

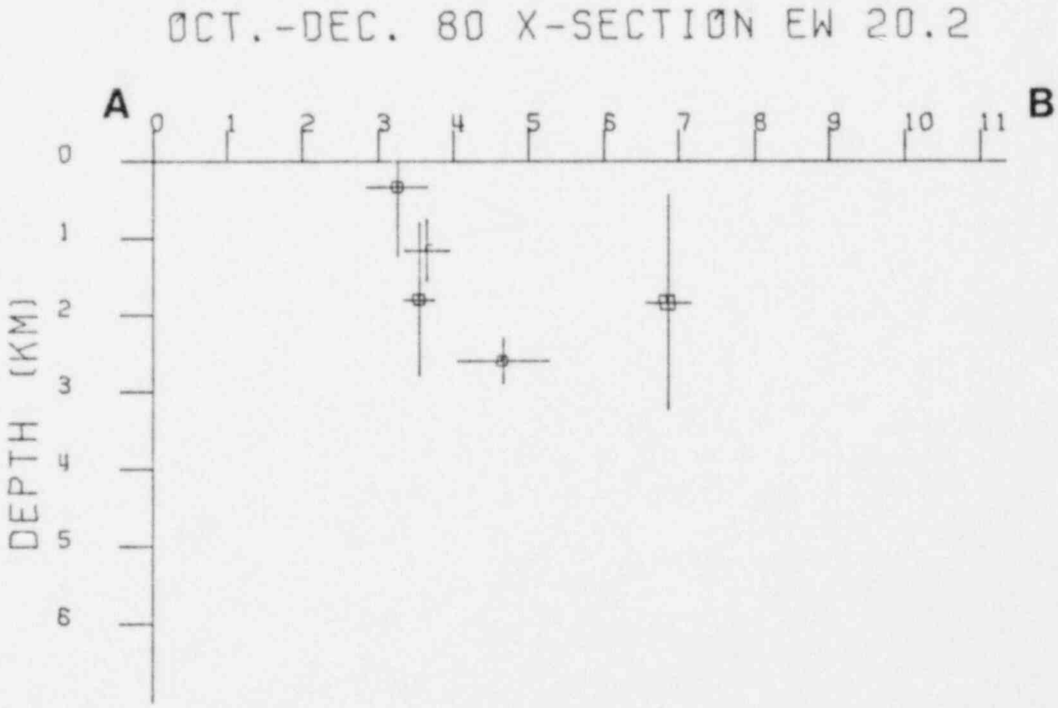

Figure 3

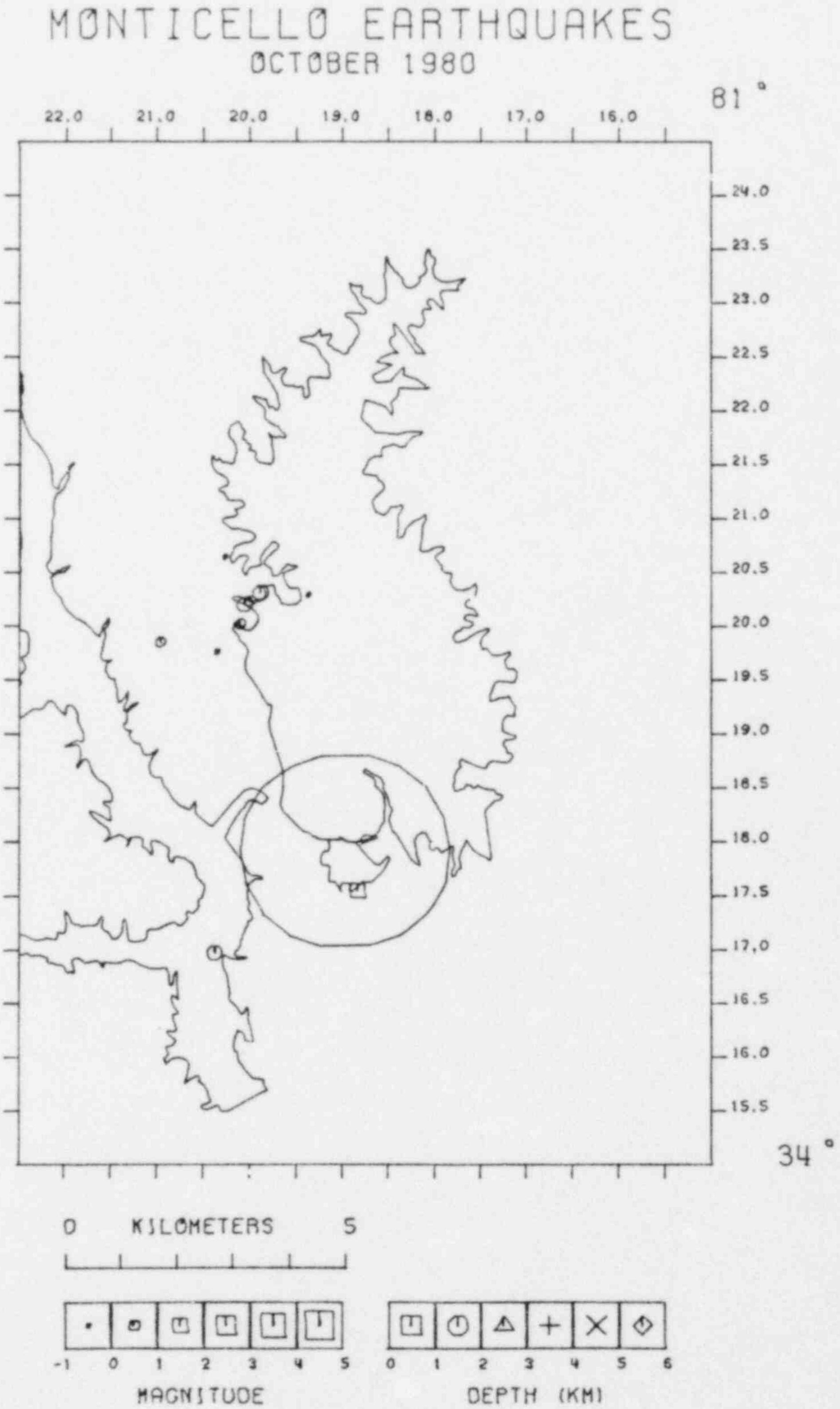
MONTICELLO EARTHQUAKES
OCTOBER 1980
81°
22.0
21.0
20.0
19.0
18.0
17.0
16.0
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
34°
0 KILOMETERS 5
-1 0 1 2 3 4 5
MAGNITUDE
0 1 2 3 4 5 6
DEPTH (KM)

Figure 4

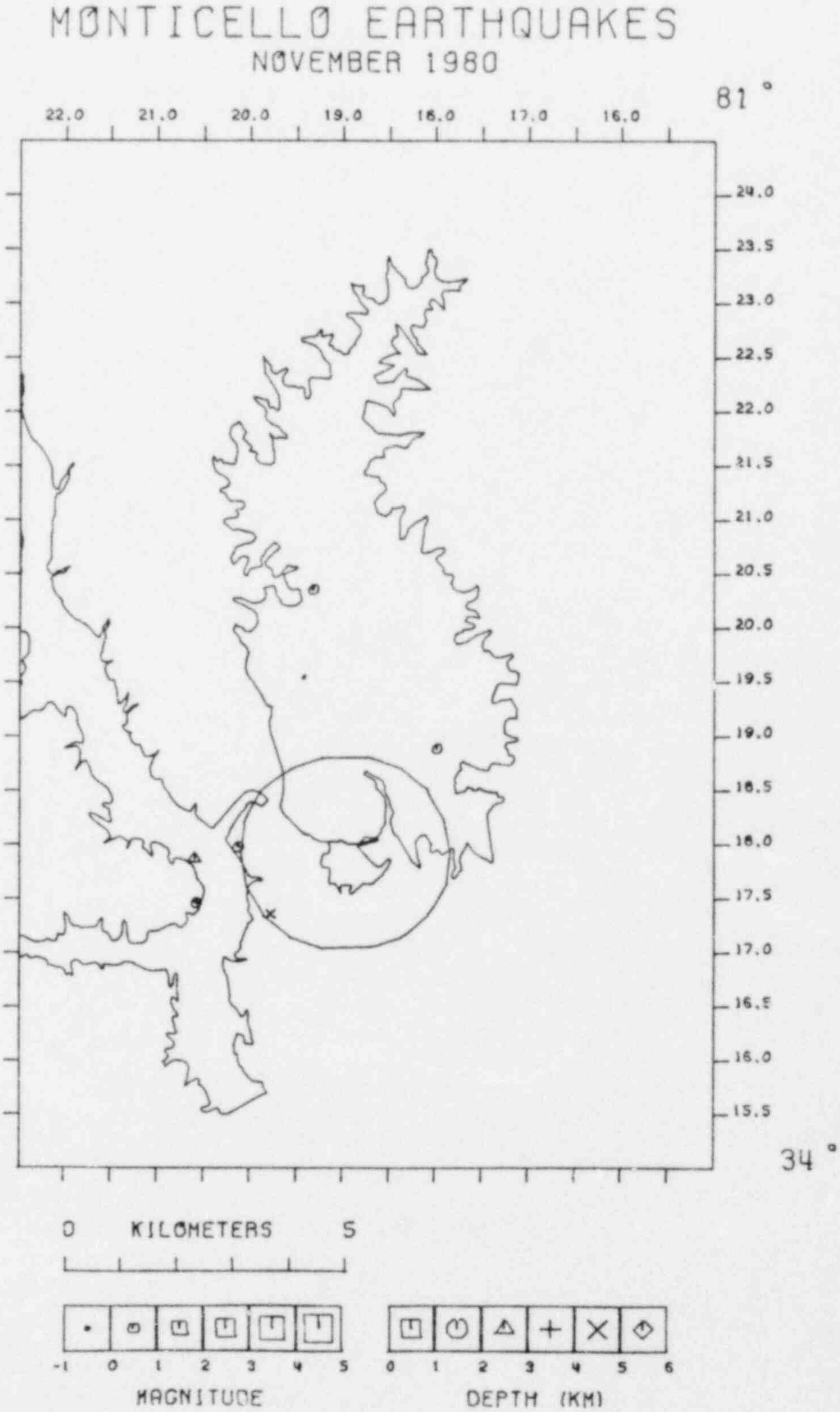
MØNTICELLØ EARTHQUAKES
NØVEMBER 1980
81 °
22.0
21.0
20.0
19.0
18.0
17.0
16.0
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
34 °
0 KILOMETERS 5
-1 0 1 2 3 4 5
MAGNITUDE
0 1 2 3 4 5 6
DEPTH (KM)

Figure 5

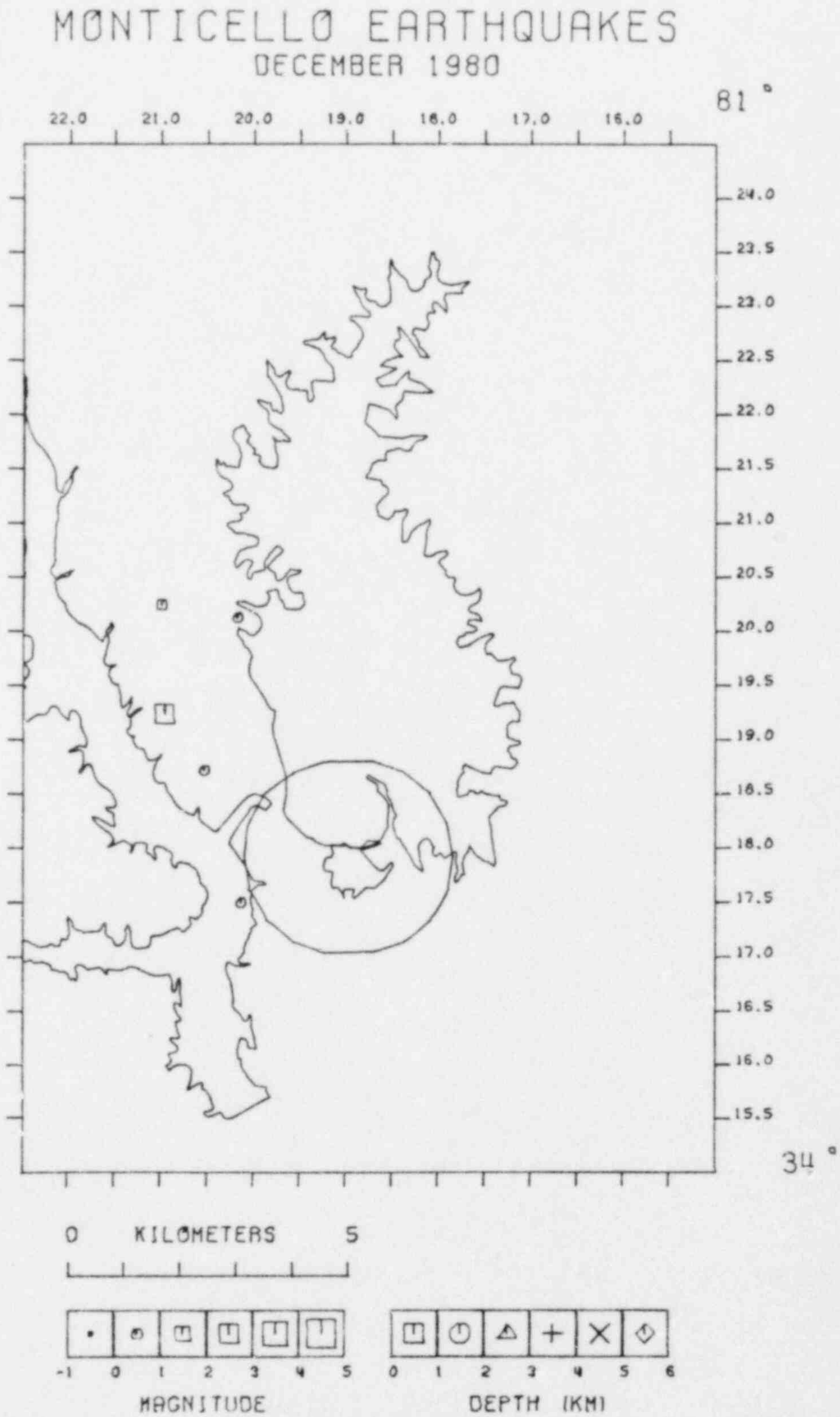
MONTICELLO EARTHQUAKES
DECEMBER 1980
81°
22.0
21.0
20.0
19.0
18.0
17.0
16.0
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
34°
0 KILOMETERS 5
-1 0 1 2 3 4 5
MAGNITUDE
0 1 2 3 4 5 6
DEPTH (KM)

Figure 6

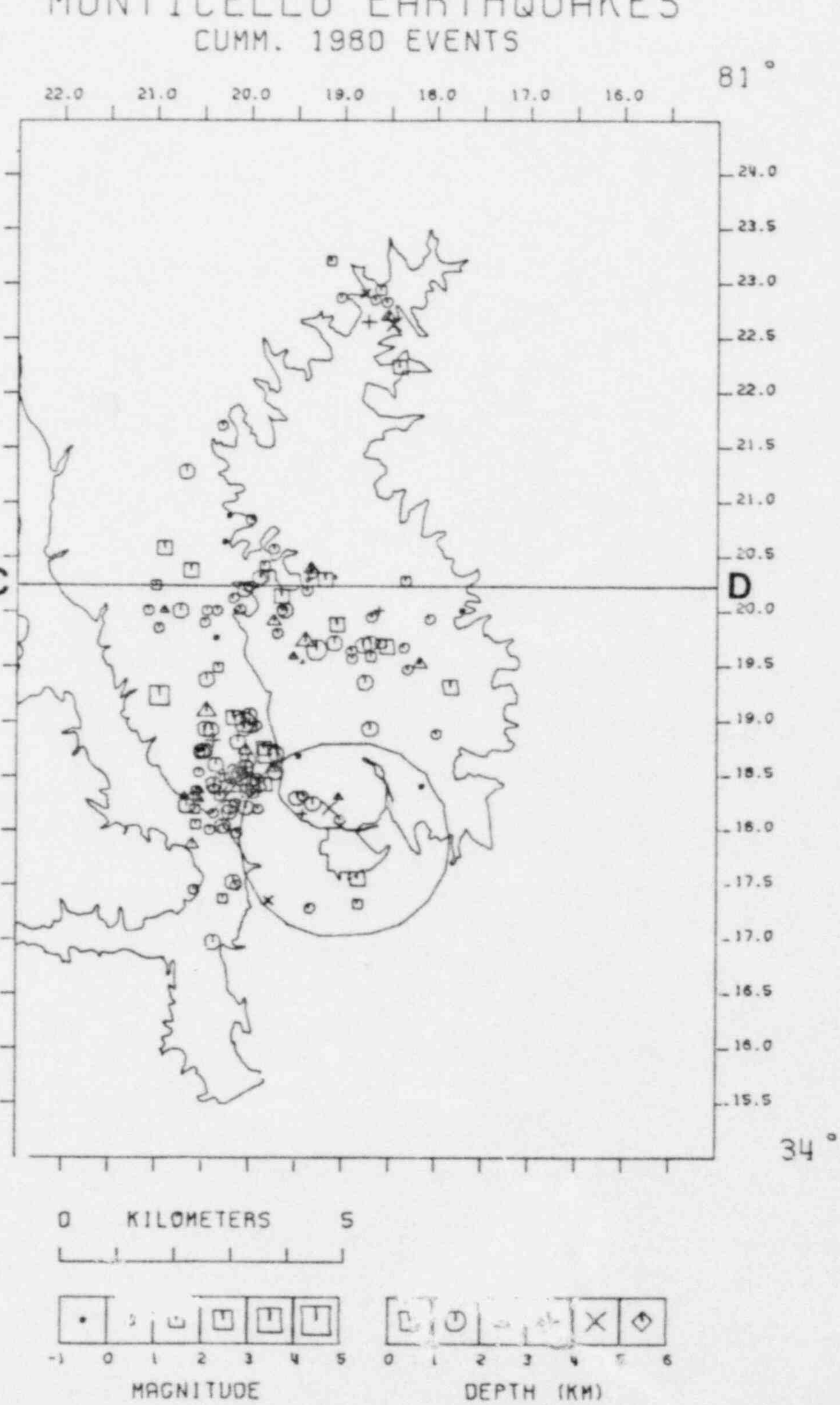
MONTICELLO EARTHQUAKES
CUMM. 1980 EVENTS
22.0
21.0
20.0
19.0
18.0
17.0
16.0
81°
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
C
D
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
34°
0 KILOMETERS 5
-1 0 1 2 3 4 5
MAGNITUDE
0 1 2 3 4 5 6
DEPTH (KM)

Figure 7

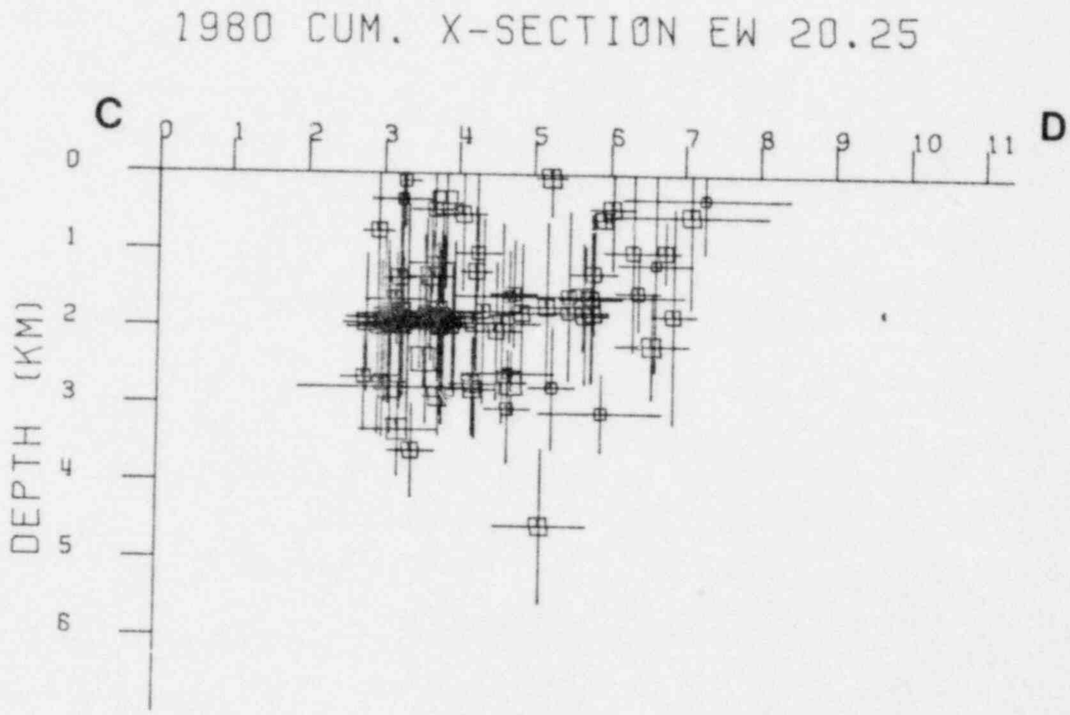

Figure 8

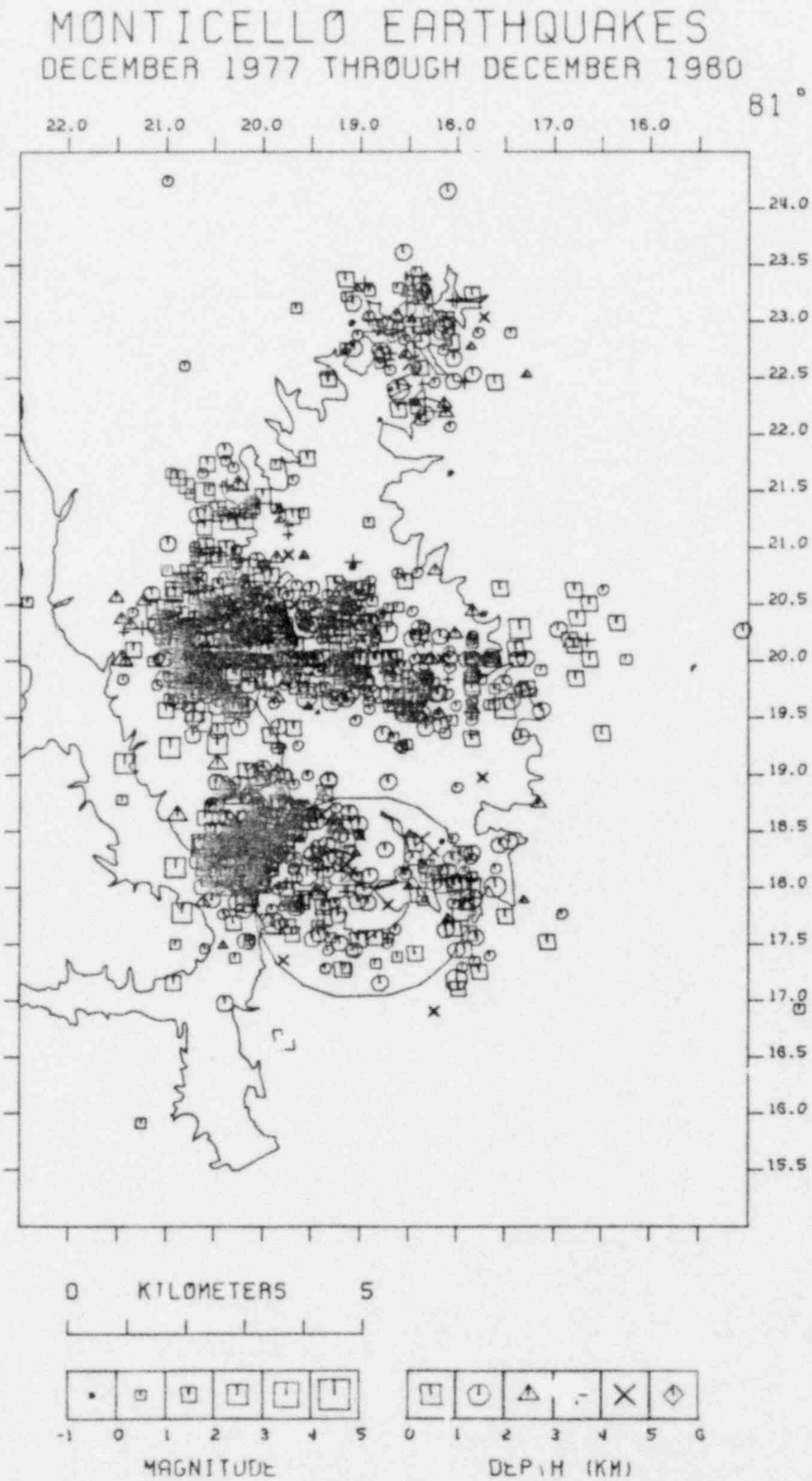
MONTICELLO EARTHQUAKES
DECEMBER 1977 THROUGH DECEMBER 1980
81°
22.0
21.0
20.0
19.0
18.0
17.0
16.0
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
34°
0 KILOMETERS 5
-1 0 1 2 3 4 5
MAGNITUDE
0 1 2 3 4 5 6
DEPTH (KM)

Figure 9

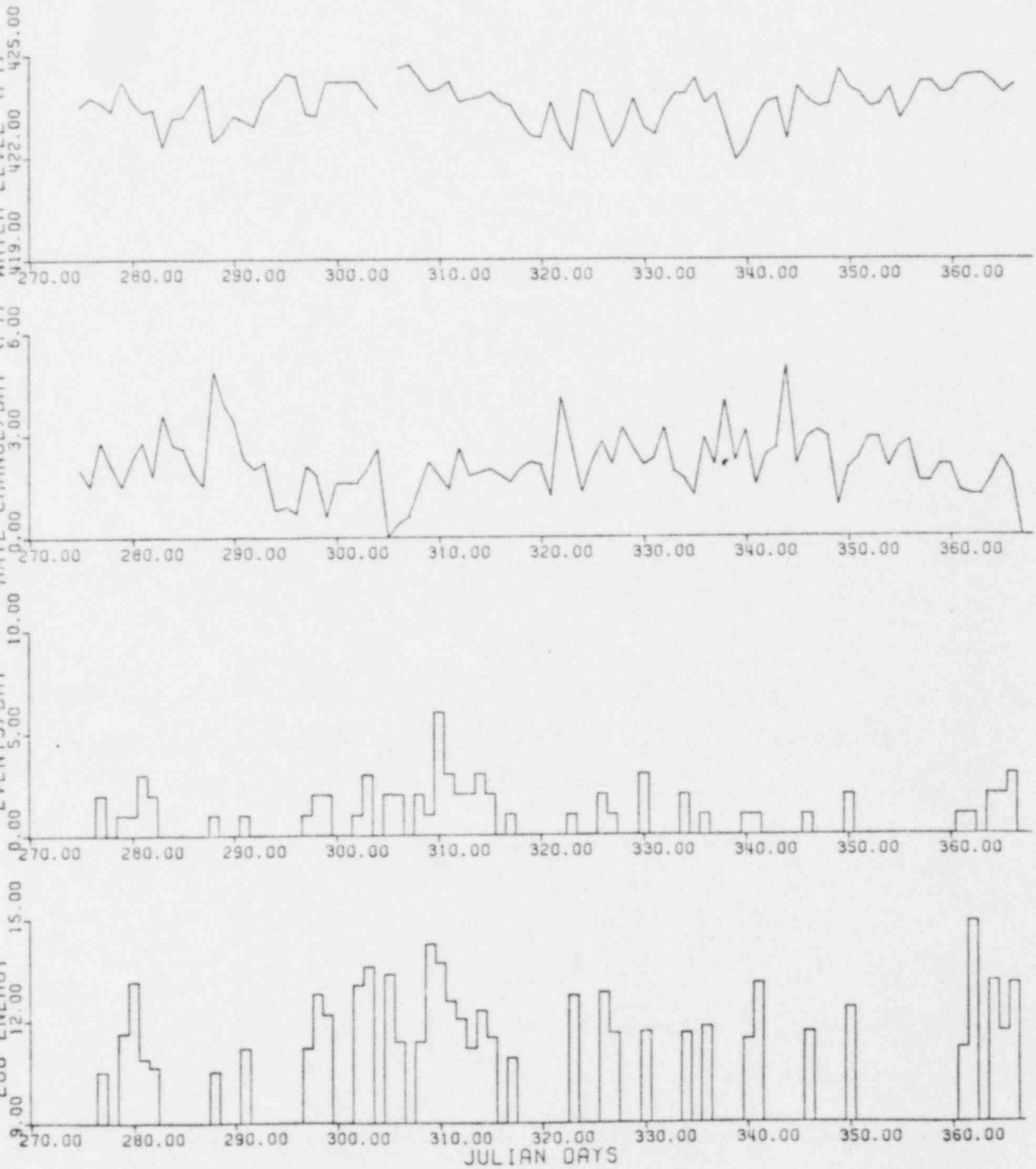
WATER LEVEL (FT)
419.00
422.00
425.00
RATE CHANGE/DAY (FT)
0.00
3.00
6.00
EVENTS/DAY
0.00
5.00
10.00
LOG ENERGY
9.00
12.00
15.00
270.00
280.00
290.00
300.00
310.00
320.00
330.00
340.00
350.00
360.00
JULIAN DAYS

Figure 10

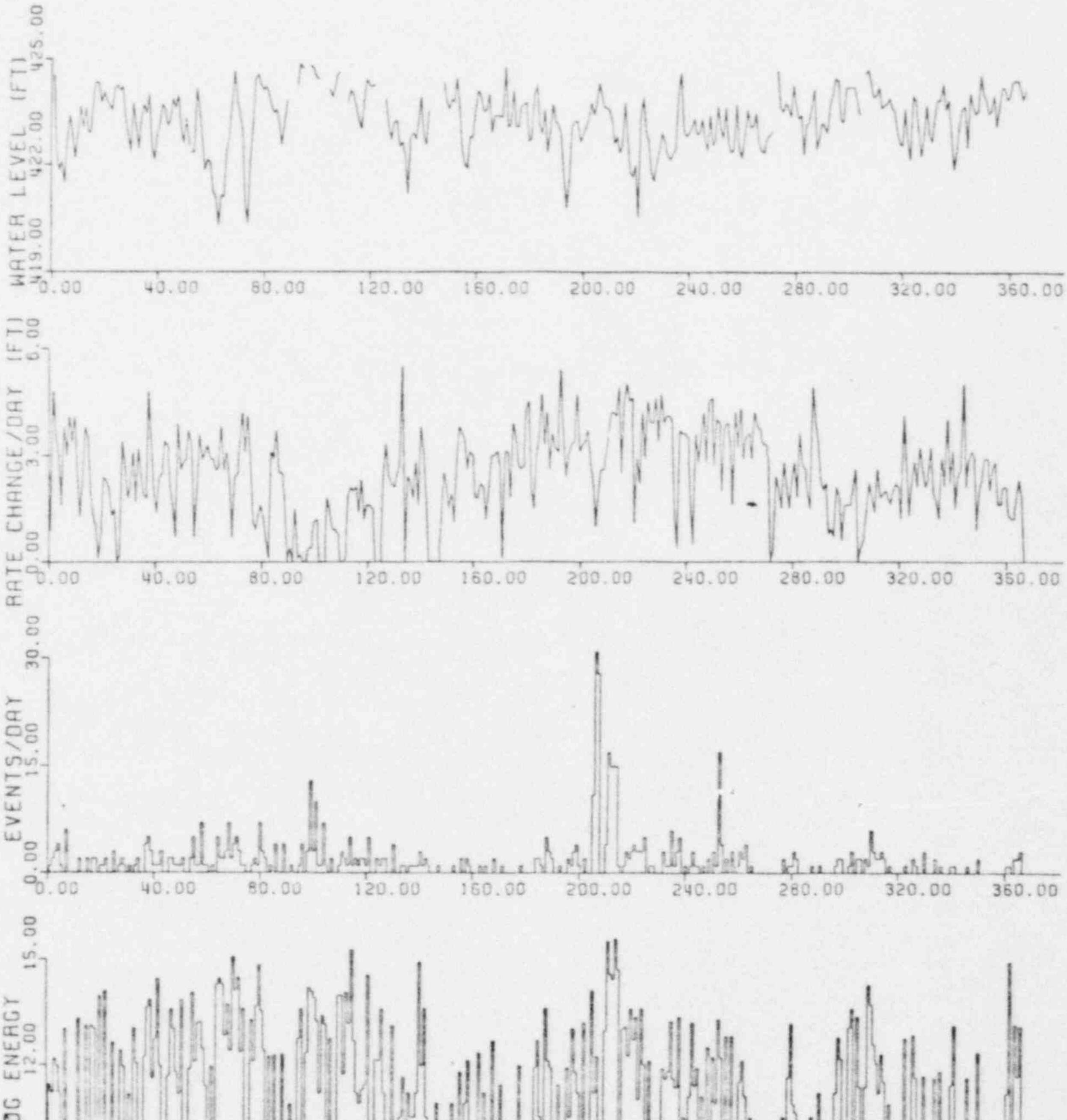

Figure 11

POOR ORIGINAL

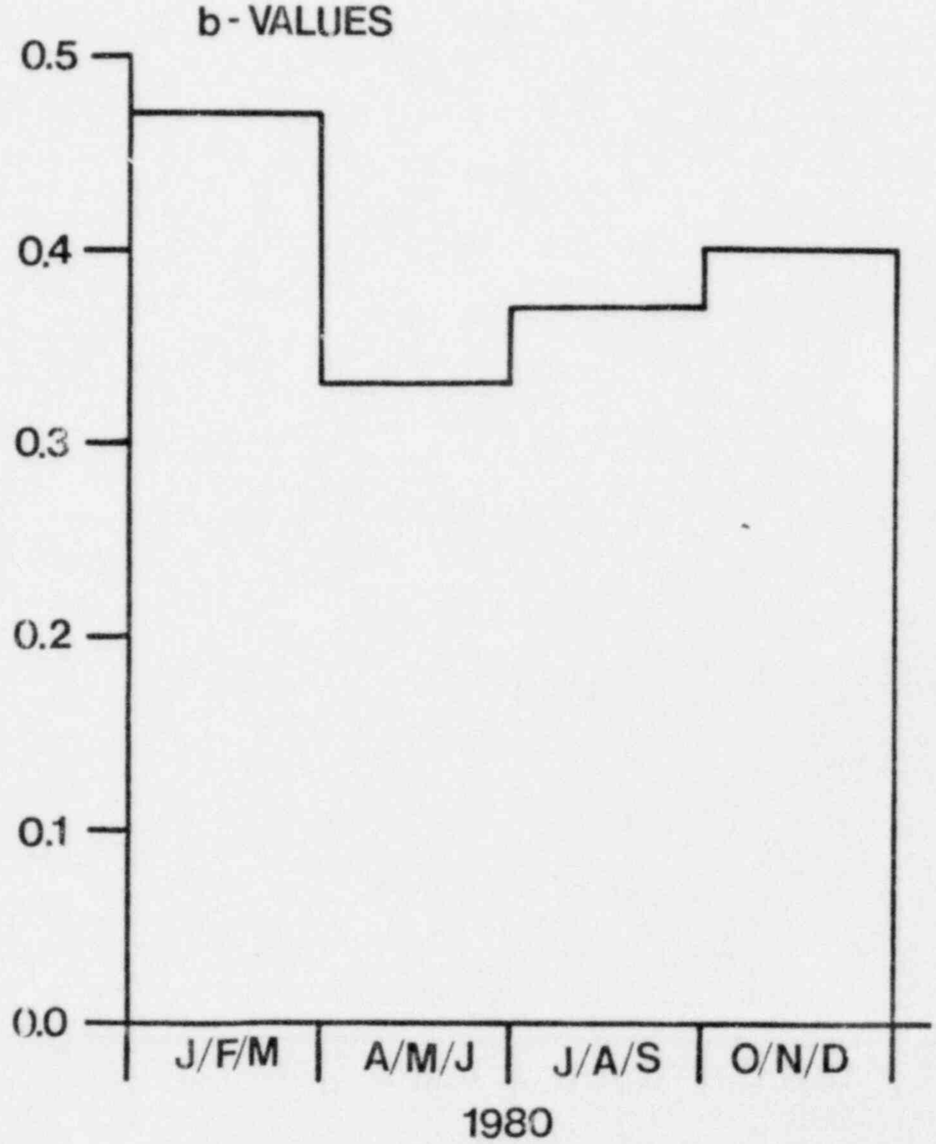

Figure 12

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.

Utsu, T. (1971). Aftershocks and Earthquake Statistics (III); Analysis of the distribution of earthquakes in magnitude, time, and space with special consideration to clustering characteristics of earthquake occurrence (1): Journal of the Faculty of Science, Hokkaido Univ. Series VII (Geophysics), 3, no. 5.

APPENDICES

APPENDIX I

STATION LOCATION

NO.	STN.	LAT. N.	LONG. W.
1	001	$34^{o}19.91'$	$81^{o}17.74'$
2	002	$34^{o}11.58'$	$81^{o}13.81'$
3	003	$34^{o}21.09'$	$81^{o}27.41'$
4	004	$34^{o}25.72'$	$81^{o}12.99'$
5	JSC	$34^{o}16.80'$	$81^{o}15.60'$
6	JIM	$34^{o}20.21'$	$81^{o}19.47'$

APPENDIX II

MONTICELLO RESERVOIR

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

APPENDIX III

LOCATION OF EVENTS

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.

POOR ORIGINAL

OCTOBER THROUGH DECEMBER 1980

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	QM
801006	1830 54.25	34-17.55	81-18.84	0.20	1.27	7	236	4.7	0.06	1.3	2.0	C1
801010	1313 11.63	34-19.85	81-20.98	1.87	0.44	9	139	5.0	0.03	0.4	2.1	C1
801016	20 3 41.70	34-20.02	81-20.11	1.15	0.12	11	132	1.1	0.06	0.3	0.4	B1
801017	5 8 21.58	34-16.97	81-20.39	1.98	1.64	10	171	6.8	0.08	0.5	2.5	C1
801024	454 21.09	34-20.31	81-19.89	1.00	1.29	12	129	0.7	0.09	0.5	0.5	B1
801024	548 57.93	34-20.29	81-19.38	1.95	-0.40	9	127	0.2	0.08	0.4	0.4	B1
801029	311 24.94	34-20.64	81-20.28	1.92	-0.11	9	136	1.5	0.07	0.4	0.6	B1
801029	1240 45.93	34-19.76	81-20.37	0.33	-0.11	11	136	1.6	0.07	0.4	0.9	B1
801029	1245 16.88	34-20.20	81-20.06	1.40	1.44	10	129	3.6	0.09	0.4	1.7	B1
801031	1338 46.28	34-20.23	81-20.01	1.78	0.99	8	129	3.5	0.08	0.4	2.4	B1
801105	655 5.18	34-17.86	81-20.62	2.41	1.24	9	162	5.8	0.05	0.3	1.1	B1
801105	1149 49.95	34-17.35	81-19.79	4.[illegible]	0.73	6	161	6.5	0.03	0.3	0.8	B1
801106	1046 33.75	34-17.97	81-20.14	1.91	0.44	6	190	5.1	0.04	0.3	1.4	C1
801107	329 44.16	34-17.45	81-20.60	1.91	0.21	7	167	6.3	0.05	0.5	3.1	C1
801109	647 1.29	34-20.35	81-19.33	1.87	0.37	9	128	2.6	0.07	0.4	0.9	B1
801112	2116 55.05	34-19.54	81-19.44	2.59	-0.11	5	251	2.7	0.02	0.6	0.3	C1
801113	1531 2.67	34-18.88	81-17.99	1.83	0.78	7	131	1.9	0.07	0.3	1.4	B1
801210	19 6 12.49	34-25.11	81-23.57	1.93	0.87	9	228	9.5	0.09	0.6	4.0	C1
801215	5 9 12.75	34-18.71	81-20.54	1.85	0.87	8	151	4.8	0.09	0.4	2.2	C1
801226	1 0 43.21	34-20.12	81-20.18	1.79	0.01	8	131	3.8	0.06	0.2	1.0	B1
801227	840 27.53	34-19.23	81-20.97	0.05	2.23	5	147	5.1	0.04	0.5	10.3	D1
801229	2228 40.85	34-17.49	81-20.14	1.92	0.87	9	163	5.8	0.05	0.2	1.1	B1
801231	651 5.32	34-20.24	81-21.01	0.83	0.91	10	134	5.1	0.09	0.4	116.4	C1