TECHNICAL REPORT 80-2

SEISMIC ACTIVITY NEAR THE V.C. SUMMER NUCLEAR STATION

For the Period April — June 1980

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, 1980) shallow microearthquake activity averaged less than one locatable event per day (≈ 0.32 event/day). Two events of magnitude $\geq$ 2.0 were recorded 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 or DW1). These seismic stations are shown in Figure 1 and listed in Appendix I.

METHOD

Events were located using a computer program HYPO71 (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, 1980) 29 locatable events were recorded. These are listed in Appendix III. Figure 2 shows the cumulative events recorded in April, May and June 1980. Most events occurred in a loose band through the center of the reservoir with a small number occurring to the southwest. A cross section, 2.0 km 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 are shown in Figures 4 - 6. A cumulative (from December 1977 to June 1980) map is shown in Figure 7. In Figures 2 - 7 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 8 feet per day between the maximum and minimum water levels. Figure 8 shows the comparison of water level to seismicity. The top two graphs show the 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 there was only one seismicity peak, occurring in April.

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 2 week periods (Figure 9) suggests a slow increase in the b-value which began in mid April.

CONCLUSION

During this reporting period seismicity was at a low level with a relatively large seismicity peak occurring in April (Figure 8, Events/day). During the end of July and the first of August, there was an increase in seismicity. This increased activity is presently being studied and will be covered in the next report.

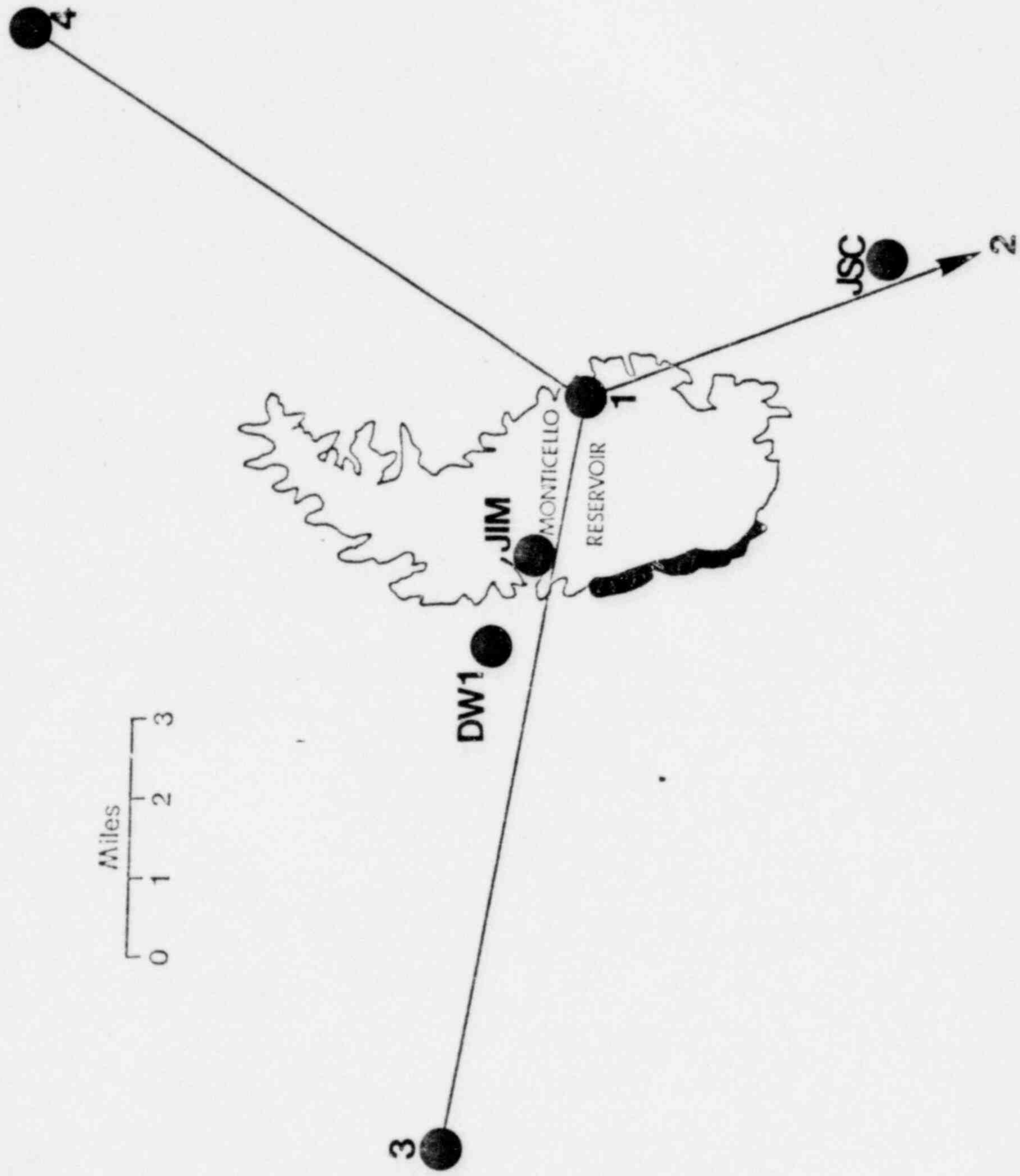


Figure 1

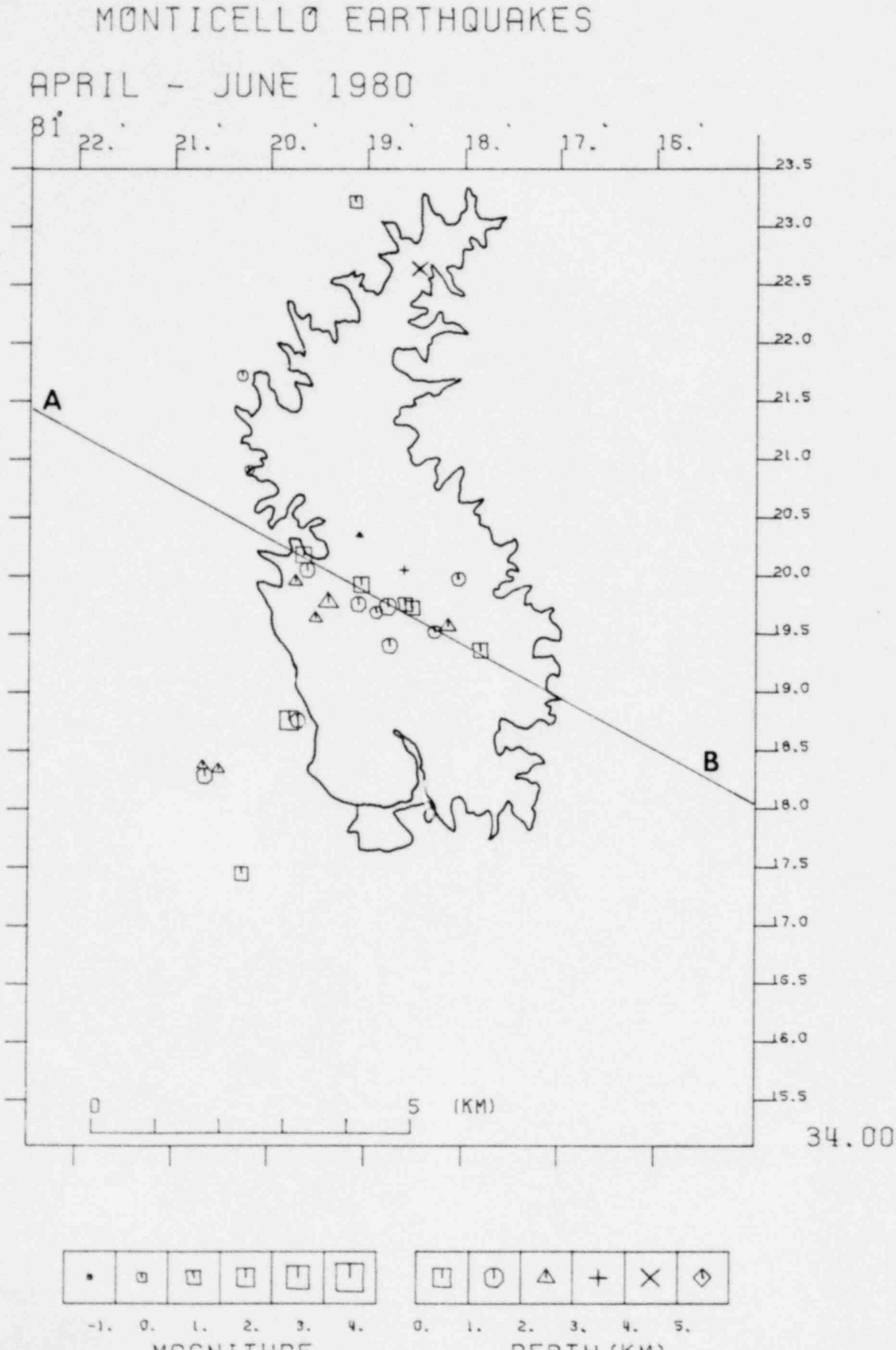

MONTICELLO EARTHQUAKES
APRIL - JUNE 1980
81
22.
21.
20.
19.
18.
17.
16.
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
A
B
0
5 (KM)
34.00
-1.
0.
1.
2.
3.
4.
MAGNITUDE
0.
1.
2.
3.
4.
5.
DEPTH (KM)

Figure 2

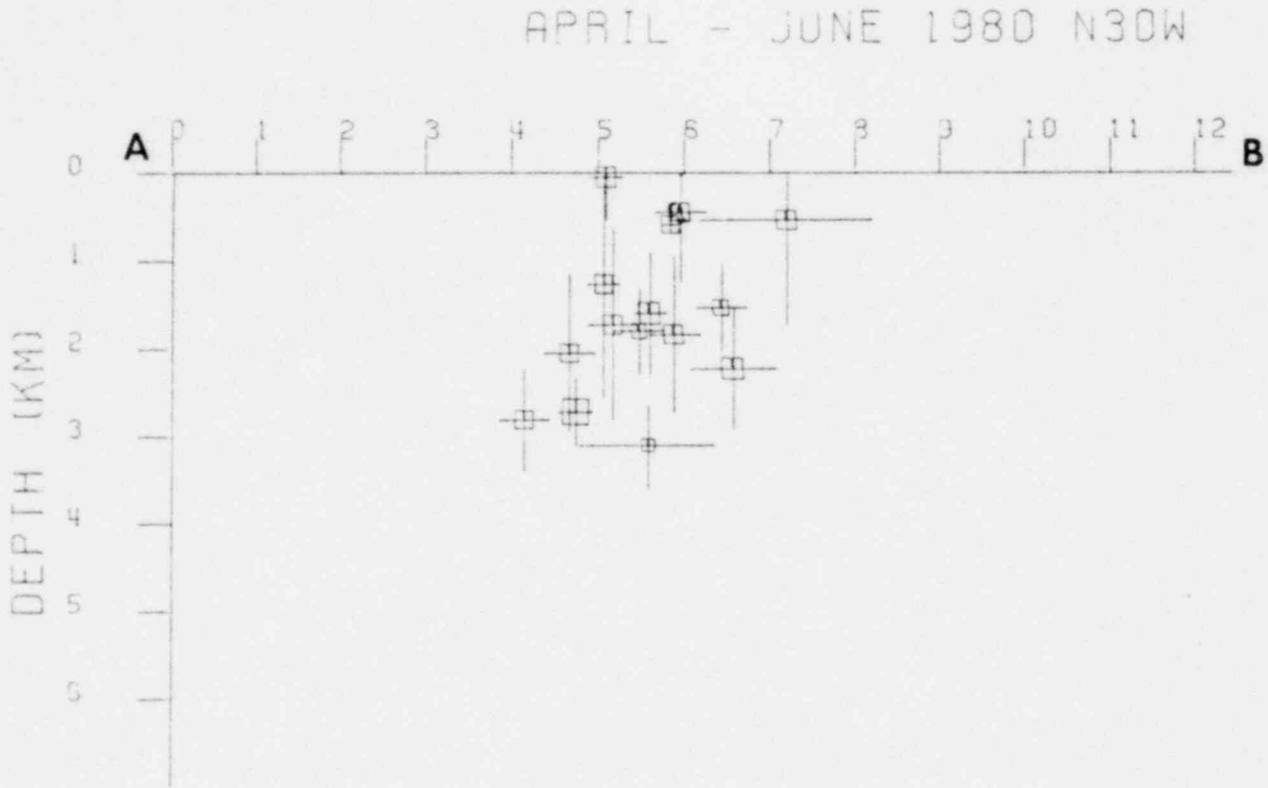


Figure 3

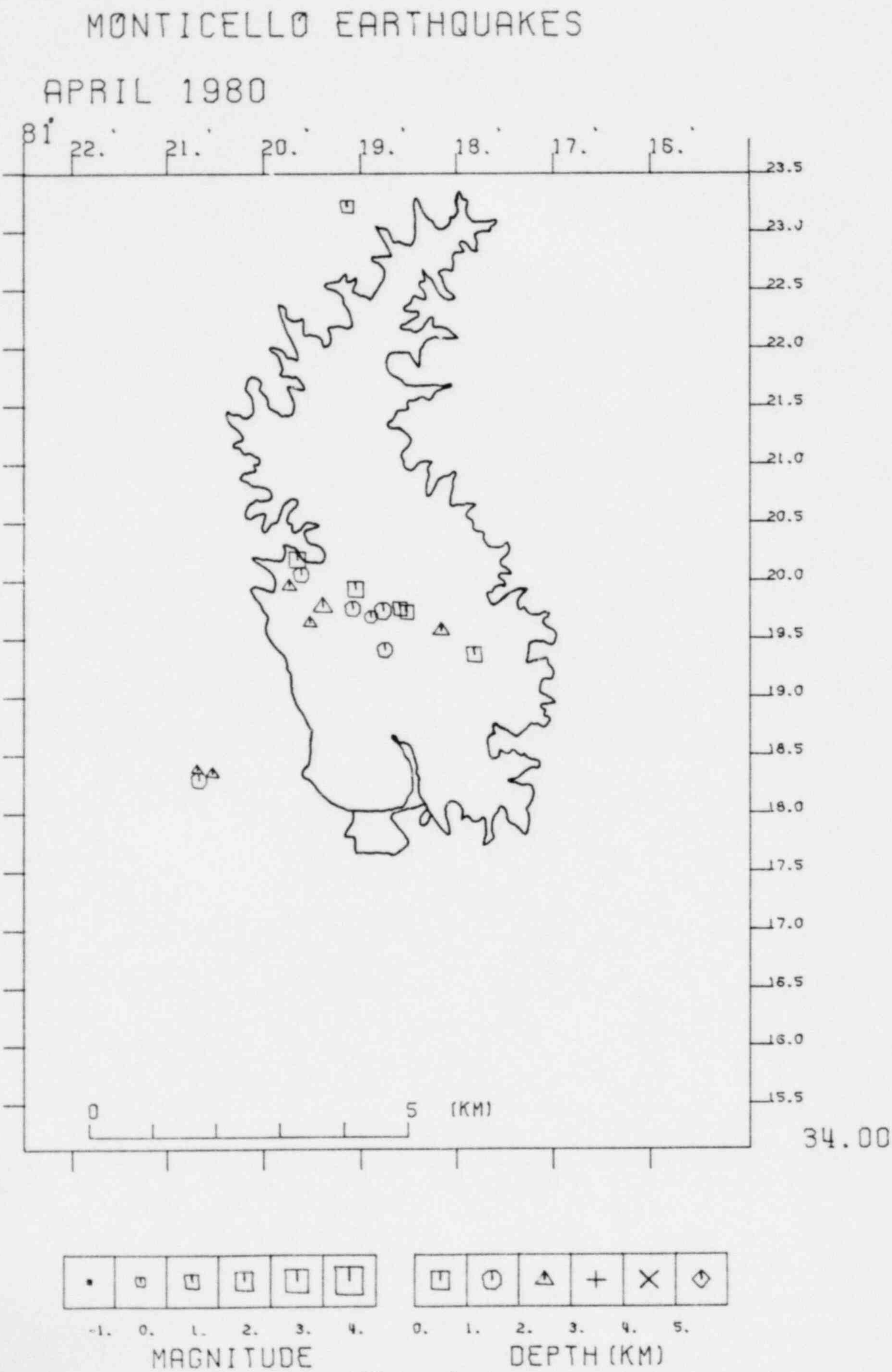

MONTICELLO EARTHQUAKES
APRIL 1980
81
22.
21.
20.
19.
18.
17.
16.
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
0
5 (KM)
34.00
-1.
0.
1.
2.
3.
4.
MAGNITUDE
0.
1.
2.
3.
4.
5.
DEPTH (KM)

Figure 4

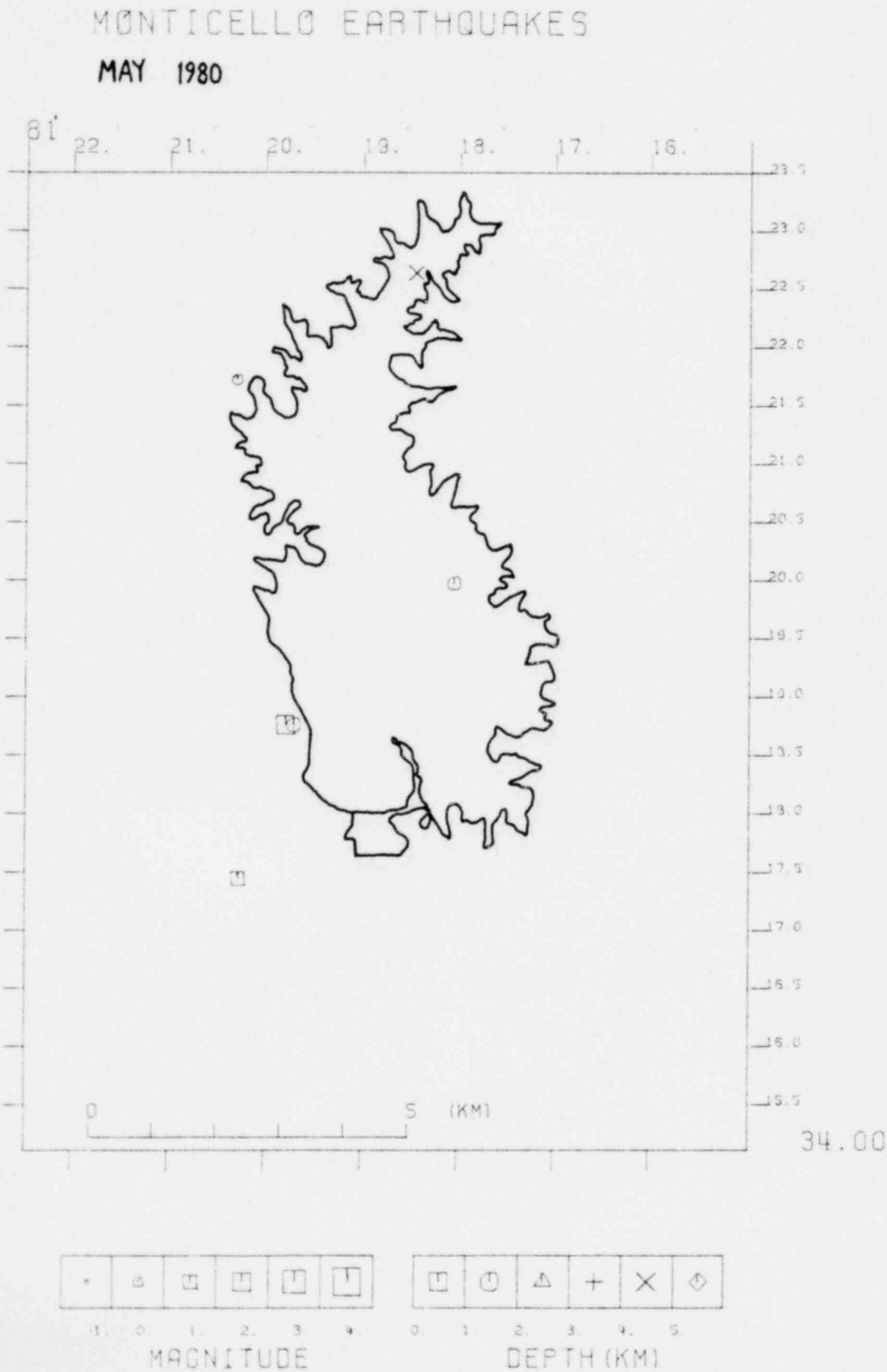

MONTICELLO EARTHQUAKES
MAY 1980
81
22.
21.
20.
19.
18.
17.
16.
34.00
0
5 (KM)
MAGNITUDE
DEPTH (KM)

Figure 5

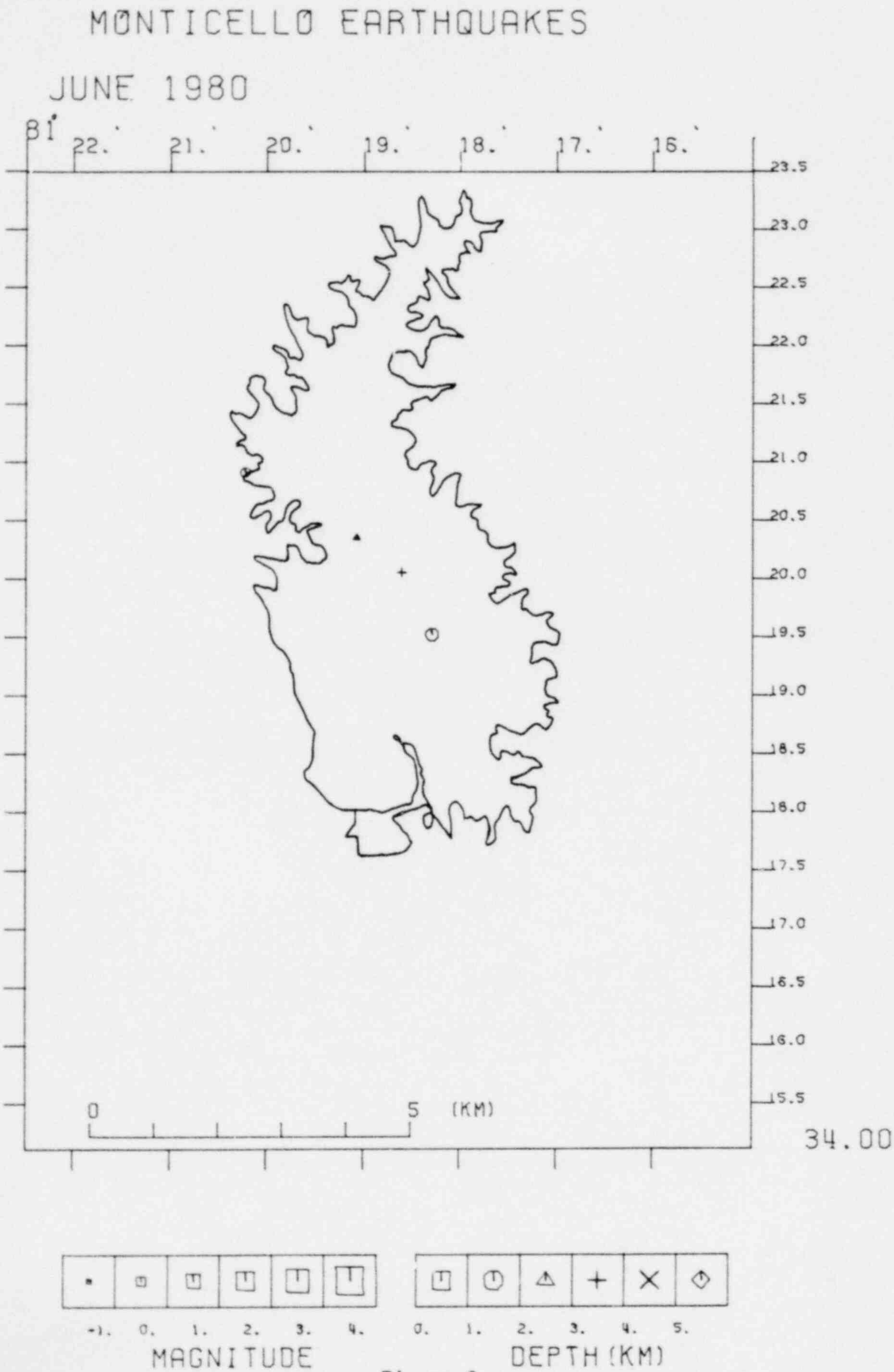

MONTICELLO EARTHQUAKES
JUNE 1980
81
22.
21.
20.
19.
18.
17.
16.
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
0
5 (KM)
34.00
-1.
0.
1.
2.
3.
4.
MAGNITUDE
0.
1.
2.
3.
4.
5.
DEPTH (KM)

Figure 6


MONTICELLO EARTHQUAKES
DECEMBER 1977 - JUNE 1980
81°
22.
21.
20.
19.
18.
17.
16.
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
0
5 (KM)
34.00
MAGNITUDE
DEPTH (KM)

Figure 7

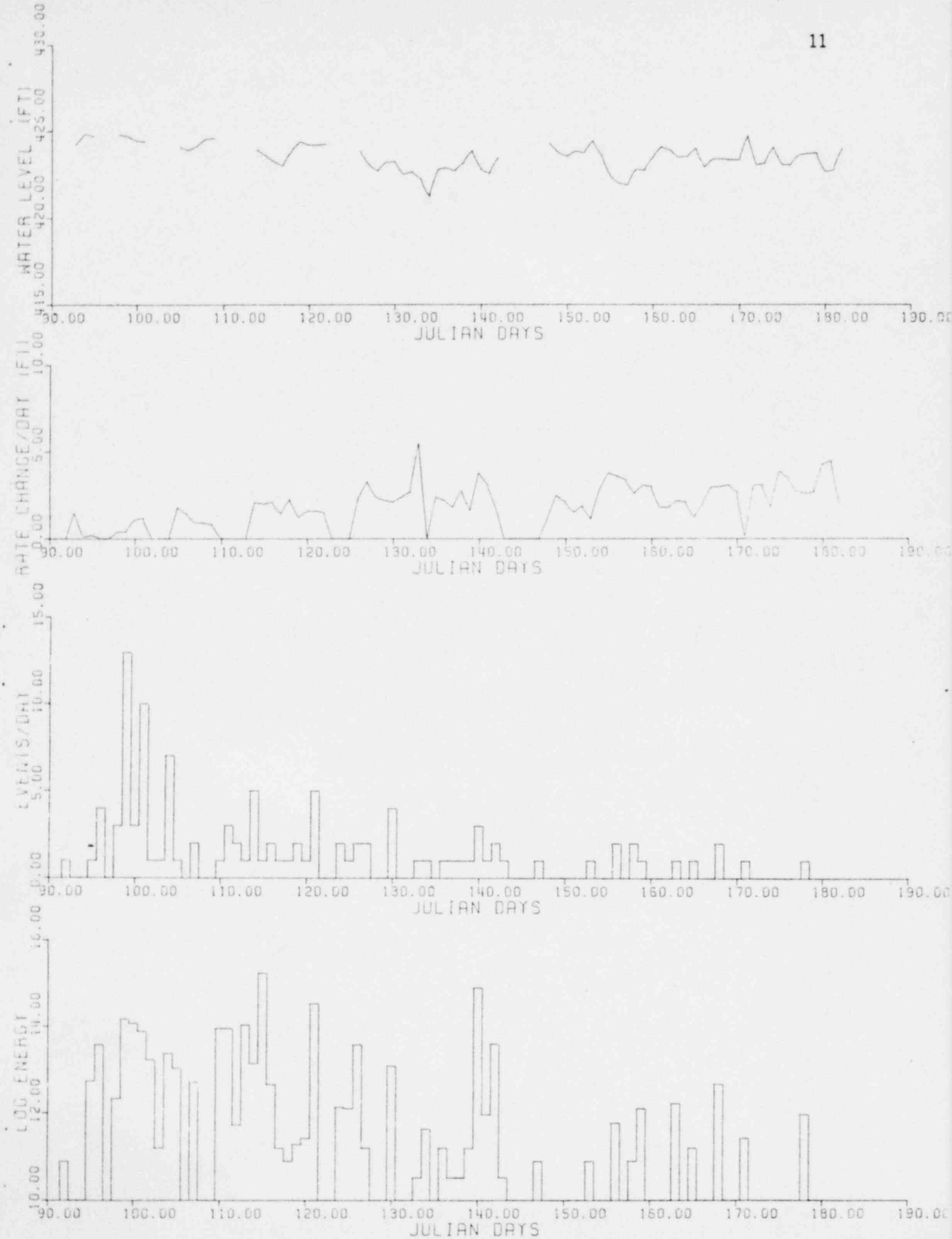
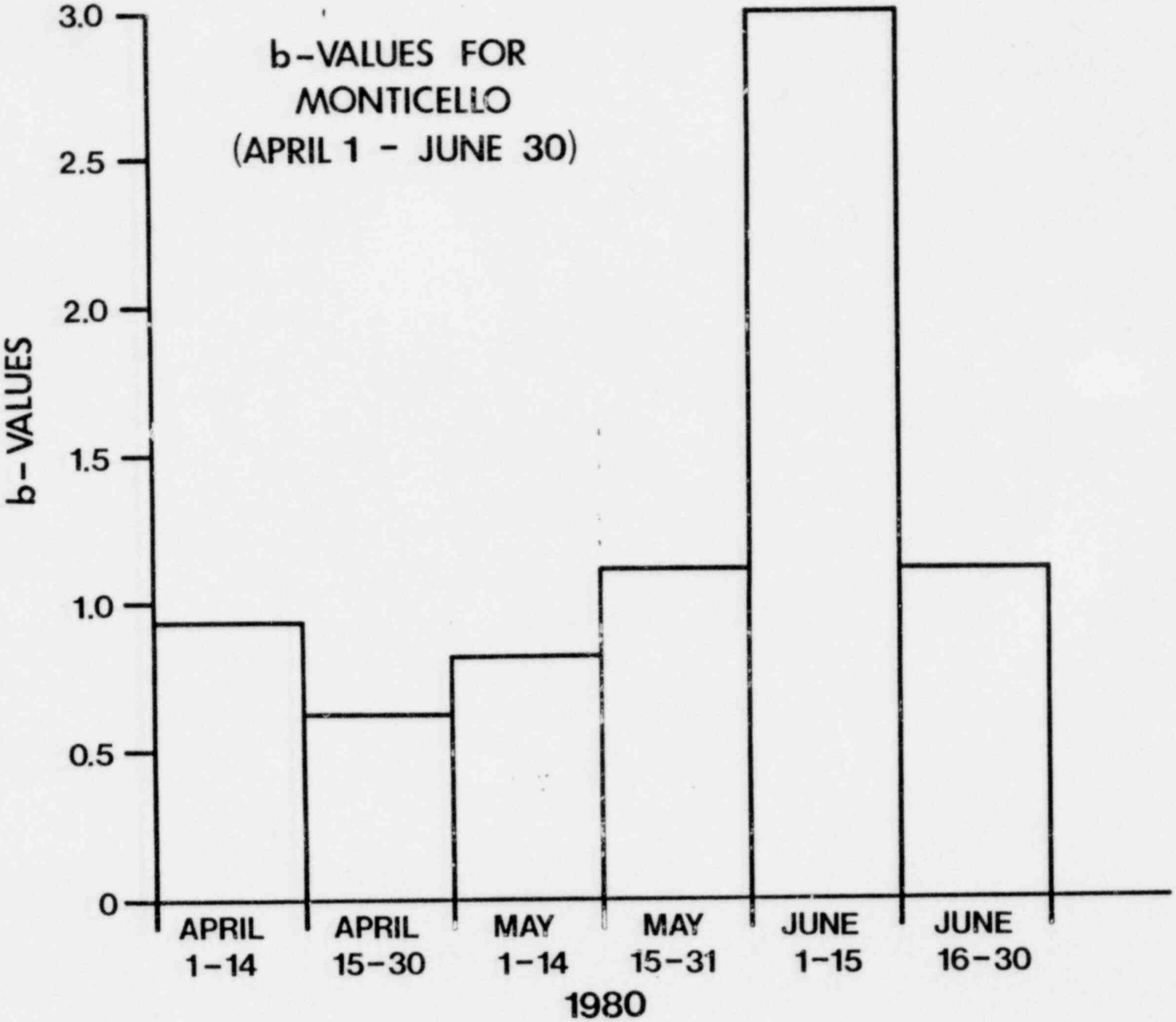

WATER LEVEL (FT)
415.00
420.00
425.00
430.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
180.00
190.00
JULIAN DAYS
RATE CHANGE/DAY (FT)
0.00
5.00
10.00
JULIAN DAYS
EVENTS/DAY
0.00
5.00
10.00
15.00
JULIAN DAYS
LOG ENERGY
10.00
12.00
14.00
16.00
JULIAN DAYS

Figure 8



b-VALUES FOR
MONTICELLO
(APRIL 1 - JUNE 30)
3.0
2.5
2.0
1.5
1.0
0.5
0
b-VALUES
APRIL
1-14
APRIL
15-30
MAY
1-14
MAY
15-31
JUNE
1-15
JUNE
16-30
1980

Figure 9

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	$34^{o}20.21'$	$81^{o}19.47'$
7	DW1	$34^{o}20.50'$	$81^{o}20.42'$

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 FROM

April 1 - June 30, 1980

Computer printout of HYPO71 showing data for location of events.

Column 1	Date.
Column 2	Origin time (UCT) h.m.sec.
Column 3	[illegible]e (N) degrees, min.
Column 4	[illegible]gitude (W) degrees, min.
Column 5	Depth (km).
Column 6	Local duration magnitude.
Column 7	[illegible]c. 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.

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	QM
800404	215 30.95	34-23.21	81-19.15	0.73	0.63	7	171	6.5	0.04	0.1	0.6	B1
800405	322 42.11	34-19.60	81-19.54	0.44	1.02	9	127	1.3	0.08	0.3	0.8	B1
800408	14 4 58.82	34-19.71	81-19.19	1.72	1.12	7	130	2.1	0.06	0.3	1.1	B1
800408	2159 11.30	34-19.98	81-19.07	0.94	1.39	8	128	2.0	0.04	0.2	0.5	B1
800409	1037 6.55	34-19.69	81-18.79	1.59	1.52	8	128	1.7	0.04	0.2	0.7	B1
800410	355 10.22	34-19.91	81-19.75	2.80	1.12	10	131	3.1	0.07	0.3	0.6	B1
800410	539 7.64	34-19.35	81-18.77	1.83	1.12	8	132	1.9	0.08	0.3	0.9	B1
800410	539 34.31	34-19.71	81-18.61	0.58	0.91	7	244	1.4	0.01	0.1	0.1	C1
800413	1739 46.71	34-20.91	81-19.63	1.91	1.12	7	129	2.9	0.06	0.4	1.6	B1
800414	1611 13.18	34-19.59	81-19.54	2.04	0.99	9	134	2.8	0.08	0.3	0.9	B1
800419	11 1 36.79	34-20.14	81-19.67	0.46	1.44	9	128	3.0	0.07	0.3	1.0	B1
800420	449 2.86	34-19.52	81-18.10	2.22	1.54	9	126	1.0	0.09	0.5	0.7	B1
800422	2332 24.39	34-18.22	81-20.68	1.94	1.27	11	158	4.2	0.06	0.3	0.9	B1
800423	441 47.29	34-18.32	81-20.54	2.72	0.82	9	156	5.2	0.05	0.3	0.7	B1
800423	451 15.94	34-19.31	81-20.70	2.65	0.57	8	187	5.4	0.04	0.3	0.7	C1
800424	610 57.24	34-19.73	81-19.41	2.[illegible]1	2.37	7	122	2.6	0.02	0.2	0.4	B1
800425	448 24.36	34-19.64	81-18.91	1.79	0.51	10	129	1.9	0.06	0.3	0.5	B1
800430	1626 14.25	34-19.31	81-17.84	0.53	1.[illegible]8	6	211	1.1	0.05	1.0	1.2	C1
800503	23 6 11.86	34-21.70	81-20.31	1.62	0.21	11	152	2.2	0.06	0.2	0.6	B1
800505	1048 16.46	34-22.63	81-18.43	4.14	1.10	6	249	5.2	0.03	0.5	0.5	C1
800509	23 6 5.02	34-19.93	81-18.07	1.00	0.82	9	121	0.5	0.04	0.2	0.4	B1
800519	1124 19.91	34-18.79	81-19.81	0.74	2.05	6	146	3.9	0.05	0.5	1.8	B1
800521	3 5 37.56	34-18.70	81-19.72	1.26	1.02	10	145	3.8	0.06	0.2	1.3	B1
800521	1414 24.58	34-17.37	81-20.29	0.74	0.95	9	165	6.1	0.05	0.2	1.1	B1
800604	5 6 25.73	34-20.88	81-20.23	1.77	-0.11	10	130	0.8	0.05	0.2	0.3	B1
800613	2227 14.94	34-20.31	81-19.09	2.42	-0.40	8	127	2.2	0.07	0.3	0.6	B1
800616	938 13.43	34-19.47	81-18.31	1.53	0.57	10	127	1.2	0.07	0.3	0.5	B1
800619	1143 17.14	34-20.01	81-17.72	0.31	-0.24	7	205	0.2	0.05	1.1	0.7	C1
800626	323 47.39	34-20.01	81-18.63	3.10	0.12	9	124	1.4	0.08	0.3	0.5	B1