TECHNICAL REPORT 82-2

SEISMIC ACTIVITY NEAR THE V.C. SUMMER NUCLEAR STATION

For the Period
April - June 1982

by

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

Contract No. N301315

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INTRODUCTION

This report presents a summary of seismic activity near the V. C. Summer Nuclear Power Station in South Carolina for the three month period between April 1 and June 30, 1982. During this reporting period a total of 110 locatable events were recorded of which six were of magnitude 2.0 or greater.

SEISMIC NETWORK

The report is based on the data recorded by a four-station network operated by S.C.E. and G. In addition, data from a permanent station (JSC) of the South Carolina seismographic network is also used. Location of all these stations is shown in Figure 1, and their coordinates are listed in Appendix I.

DATA ANALYSIS

Location of the events is determined by using HYPO71 program (Lee and Lahr, 1972) and the velocity model given in Appendix II. The event magnitude (M_L) is determined from signal duration at Station JSC, using the following relation:

$$M_L = -1.83 + 2.04 \text{ Log } D$$

where D is the signal duration (seconds).

An estimate of daily energy release is determined using a simplified magnitude (M_L) energy (E) relation by Gutenberg and Richter, 1956.

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

RESULTS

The 110 locatable events recorded during the April 1 through June 30, 1982 reporting period are listed in Appendix III. The major portion of the seismic activity (72%) occurred in April, including the six events of magnitude 2.0 or greater (Table 1). Nineteen events were of magnitudes between 1.0 and 2.0 (Table 2), and the remaining events (77%) were small (M_L < 1.0). Depth estimates indicate that 49% of the activity during this period occurred at depths between 1.0 and 2.0 km and 33% at depths greater than 2.0 km. Two events with calculated depths greater than 7.0 km (April 7, 0947, 7.07 km; April 12, 1009, 7.17 km) were B quality events and had vertical errors of 1.0 km. However, past experience in relocating events with magnetic tape data suggests that these depth estimates may be greater than the true depths. A swarm of seven events occurred near Blair, S.C., approximately 13 km northwest of the V. C. Summer Nuclear Station, on May 7, 1982, with the main shock having a magnitude of 2.07 (Fig. 4).

A cumulative plot of the epicenters of the events located during the reporting period is shown in Figure 2. A monthly breakup of their locations is shown in Figures 3-5.

RESERVOIR WATER LEVEL AND ITS COMPARISON WITH SEISMICITY

Monticello Reservoir is a pumped storage facility. Any decrease in reservoir level associated with power generation is recovered when water is pumped back into the reservoir. There can be variations up to about 4 feet per day between the maximum and minimum water level. We have been monitoring this water level to see if there is any correlation between the daily or seasonal changes in the reservoir level and the local seismicity. Figure 6 shows the comparison of

TABLE 1

Date	Time (U.T.C.)	Magnitude
April 3	2325	2.05
April 13	0925	2.80
April 14	0529	2.58
April 16	0125	2.00
April 16	1138	2.19
April 26	1930	2.05

TABLE 2

Date	Time (U.T.C.)	Magnitude
April 1	0808	1.37
April 1	2315	1.09
April 2	0312	1.48
April 3	0408	1.18
April 3	0446	1.09
April 3	0947	1.78
April 3	2014	1.06
April 3	2326	1.46
April 3	2330	1.02
April 4	2154	1.21
April 5	0918	1.65
April 6	0858	1.34
April 6	1003	1.64
April 16	0728	1.02
April 18	2003	1.12
May 16	1211	1.21
May 16	1504	1.54
May 22	0337	1.32
May 27	1050	1.44

water level to seismicity. The top two graphs show the water level and the change of water level per day. The number of events per day and log of energy released per day are shown on the lower two graphs. The histograms showing events per day and log of energy release include also the unlocated events around the reservoir.

CONCLUSIONS

Seismic activity during this reporting period (April 1 - June 30, 1982) shows an increase similar to the increases during the same time interval for the previous two years. A deepening of seismicity as well as possible migration are also indicated by the occurrence of earthquakes at greater depths and at locations outside the immediate Monticello Reservoir area.

A histogram of the number of events per month from December, 1977 through June, 1982 (Fig. 7) suggests that seismic activity at Monticello Reservoir is continuing in a trend of discrete swarms separated by periods of low level seismicity. The April swarm can be interpreted as a continuation of this trend and the low level of activity of May and June as the beginning of a quiet period. Thus, the general level of seismicity over a longer period does not appear to be decreasing, but appears to be continuing sporadically.

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.

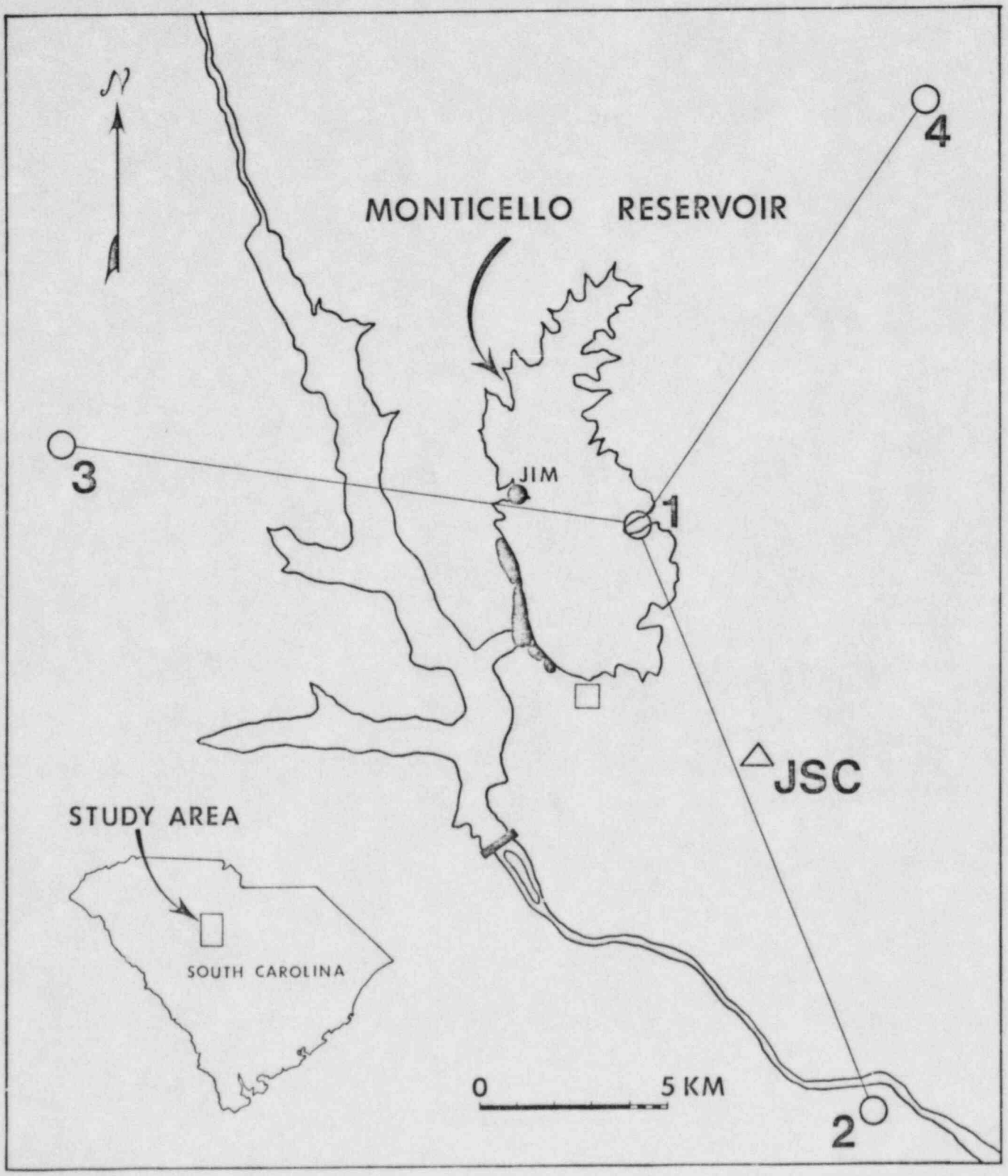
N
MONTICELLO RESERVOIR
4
3
JIM
1
JSC
STUDY AREA
SOUTH CAROLINA
0
5 KM
2

Figure 1

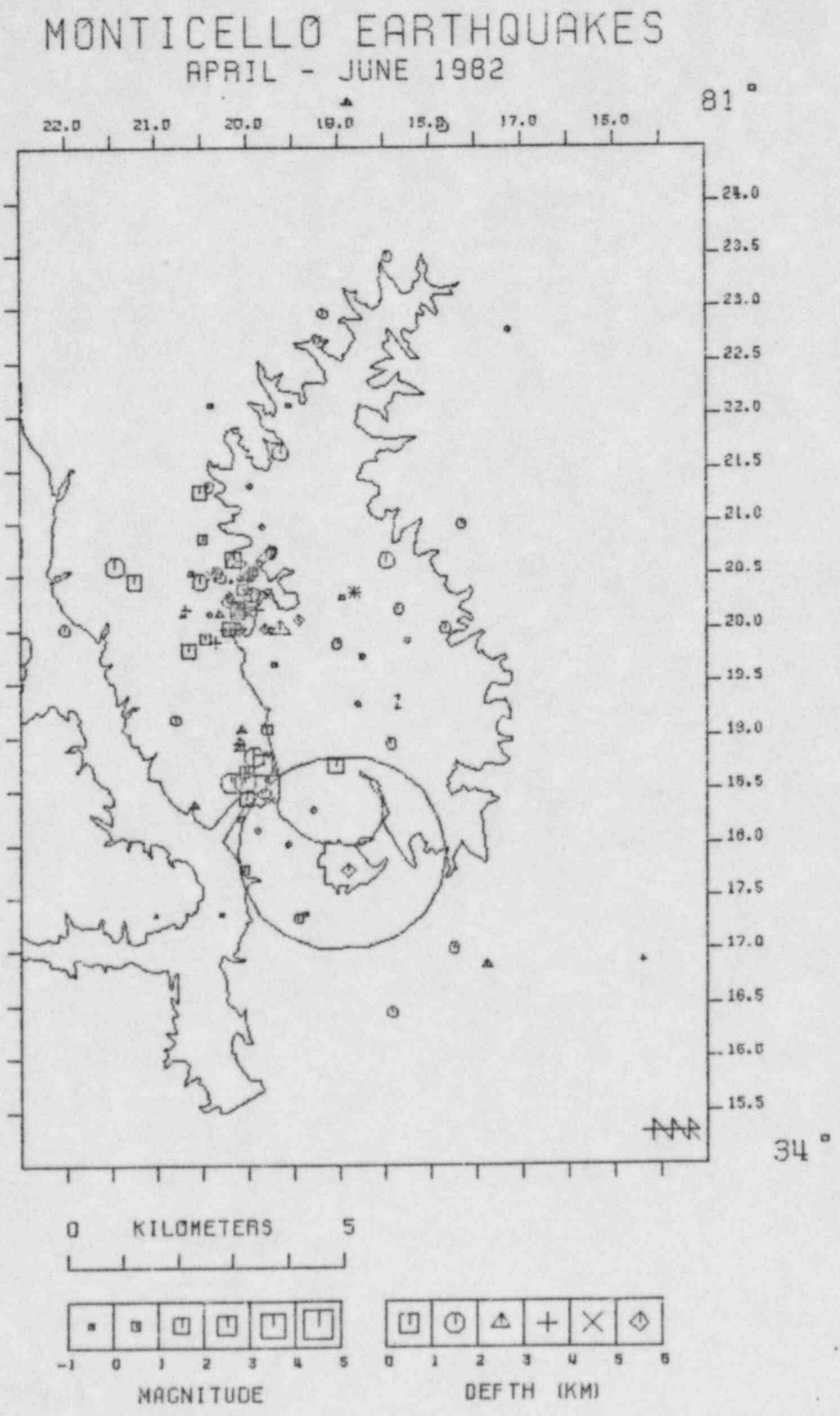
MONTICELLO EARTHQUAKES
APRIL - JUNE 1982
81°
34°
22.0
21.0
20.0
19.0
18.0
17.0
16.0
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
0 KILOMETERS 5
-1 0 1 2 3 4 5
MAGNITUDE
0 1 2 3 4 5 6
DEPTH (KM)

Figure 2

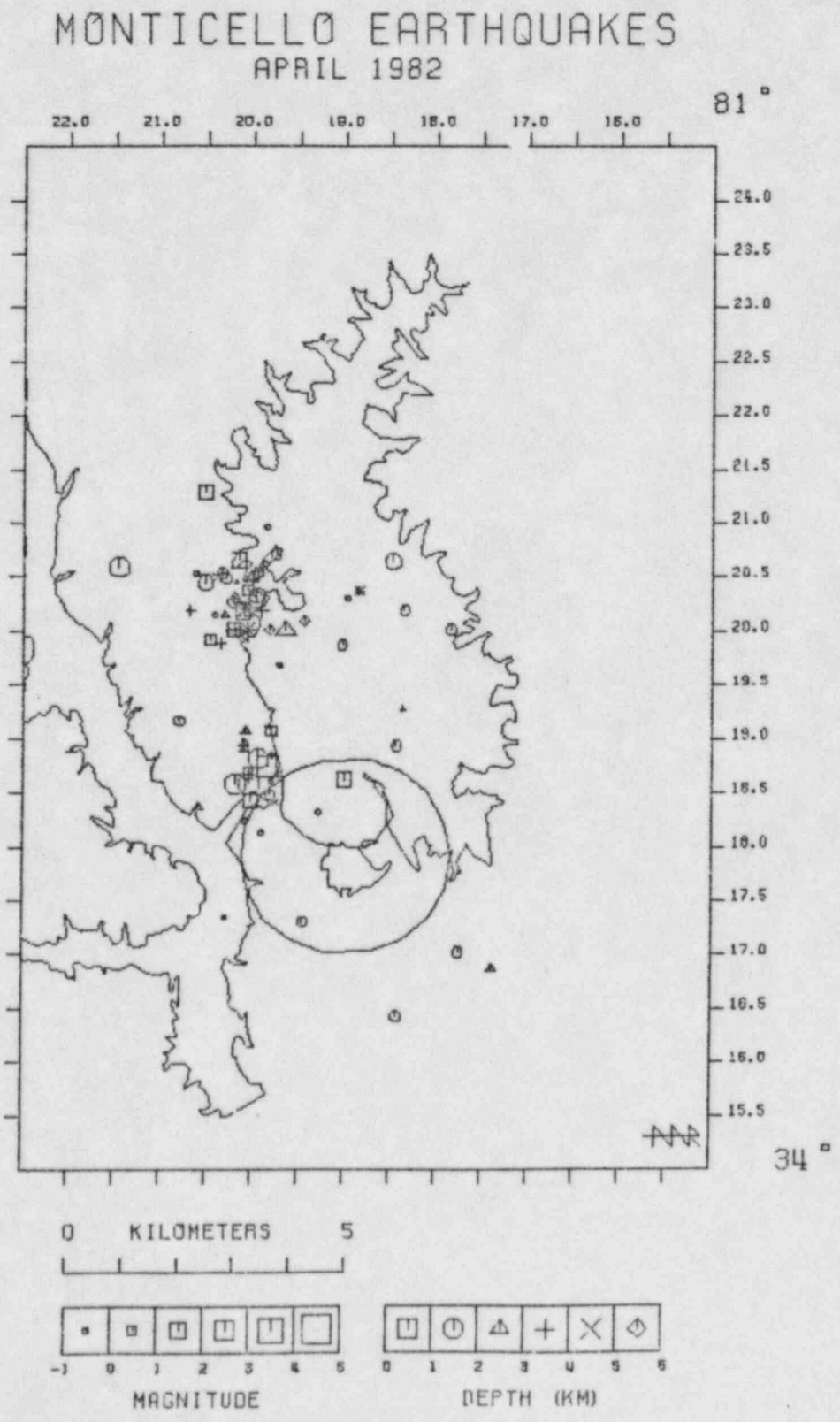
MONTICELLO EARTHQUAKES
APRIL 1982
81°
22.0
21.0
20.0
19.0
18.0
17.0
16.0
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
34°
0 KILOMETERS 5
-1 0 1 2 3 4 5
MAGNITUDE
0 1 2 3 4 5 6
DEPTH (KM)

Figure 3

Blair
May 1982

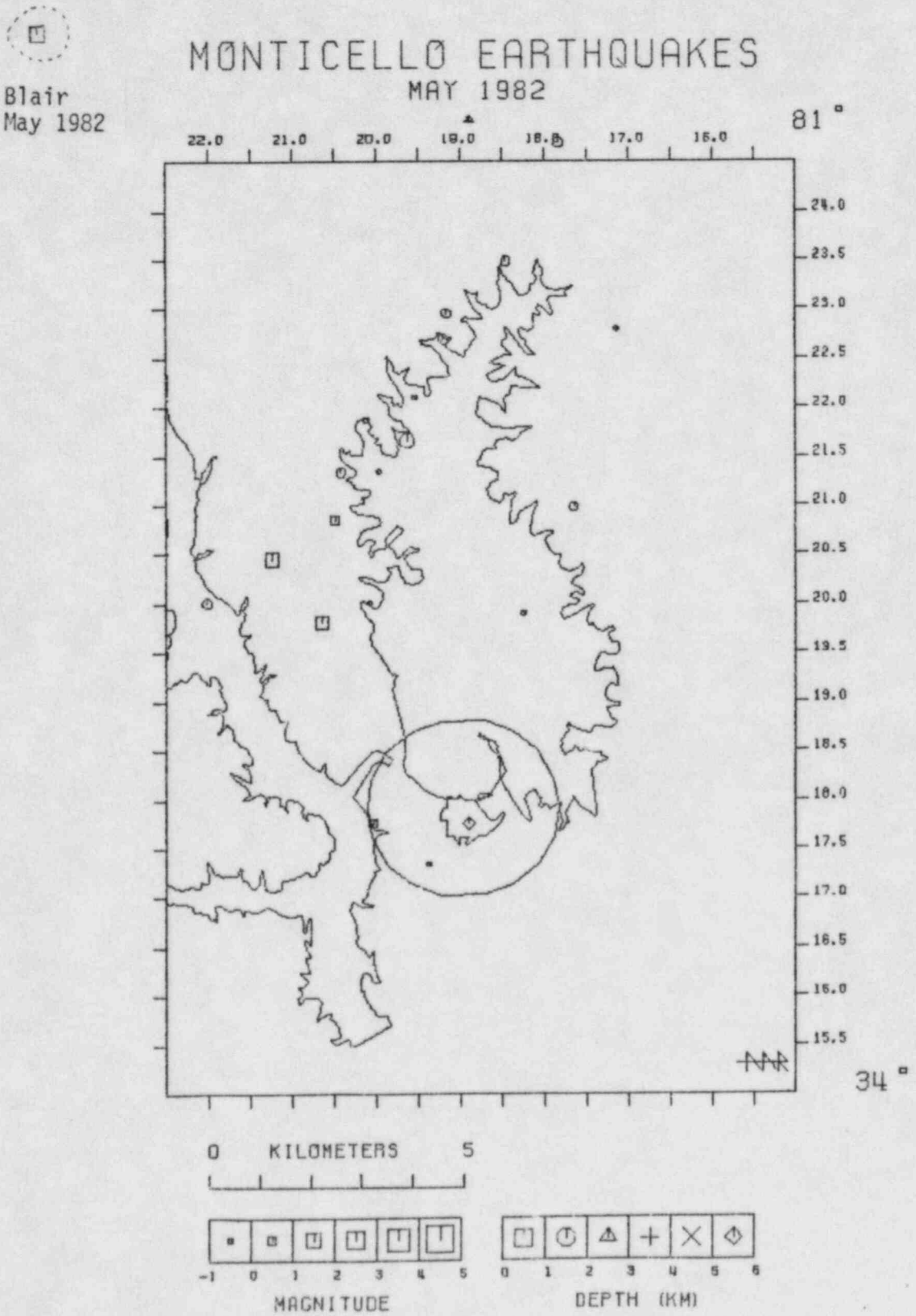

Figure 4

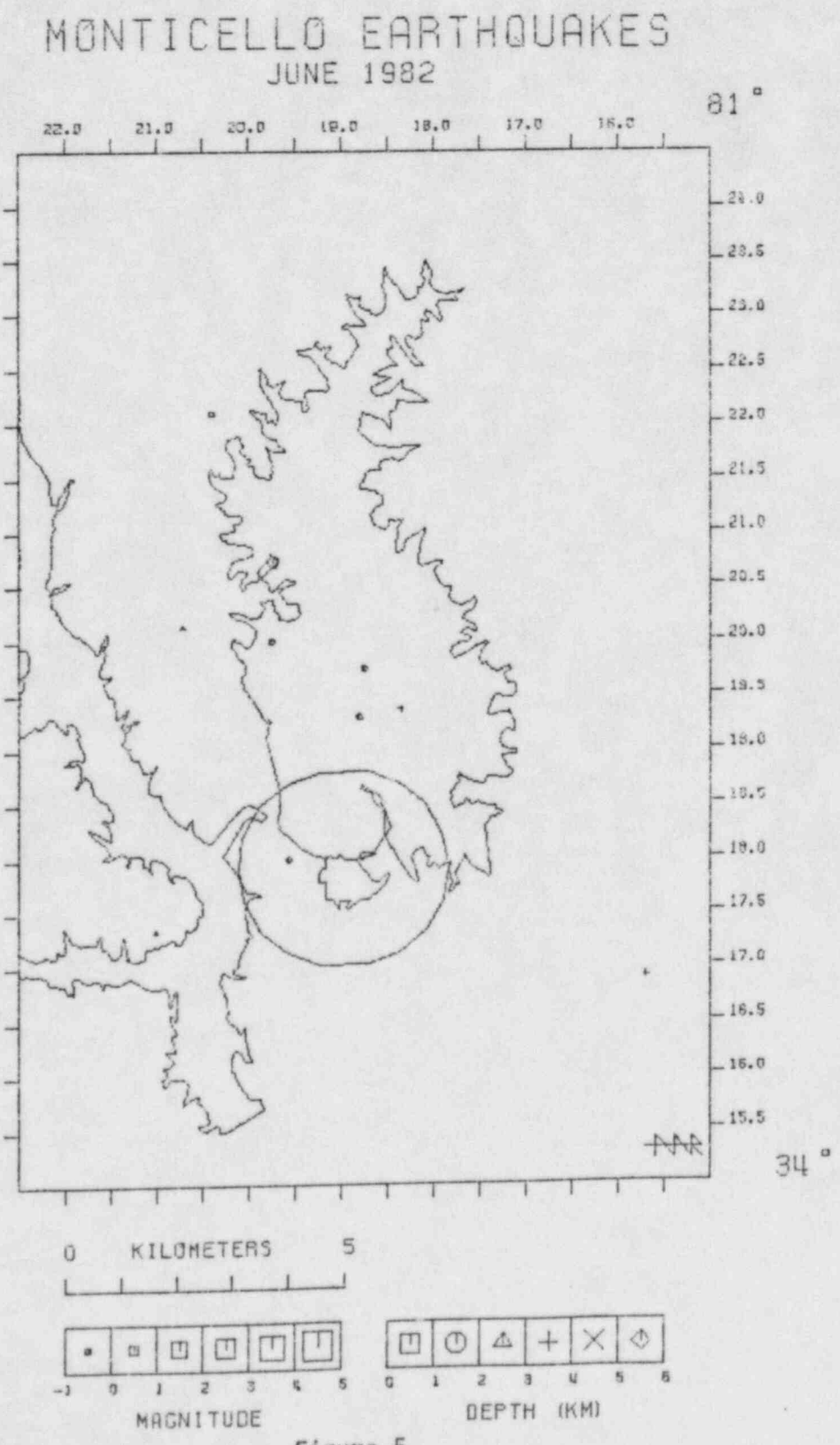
MONTICELLO EARTHQUAKES
JUNE 1982
81°
34°
0 KILOMETERS 5
MAGNITUDE
DEPTH (KM)

Figure 5

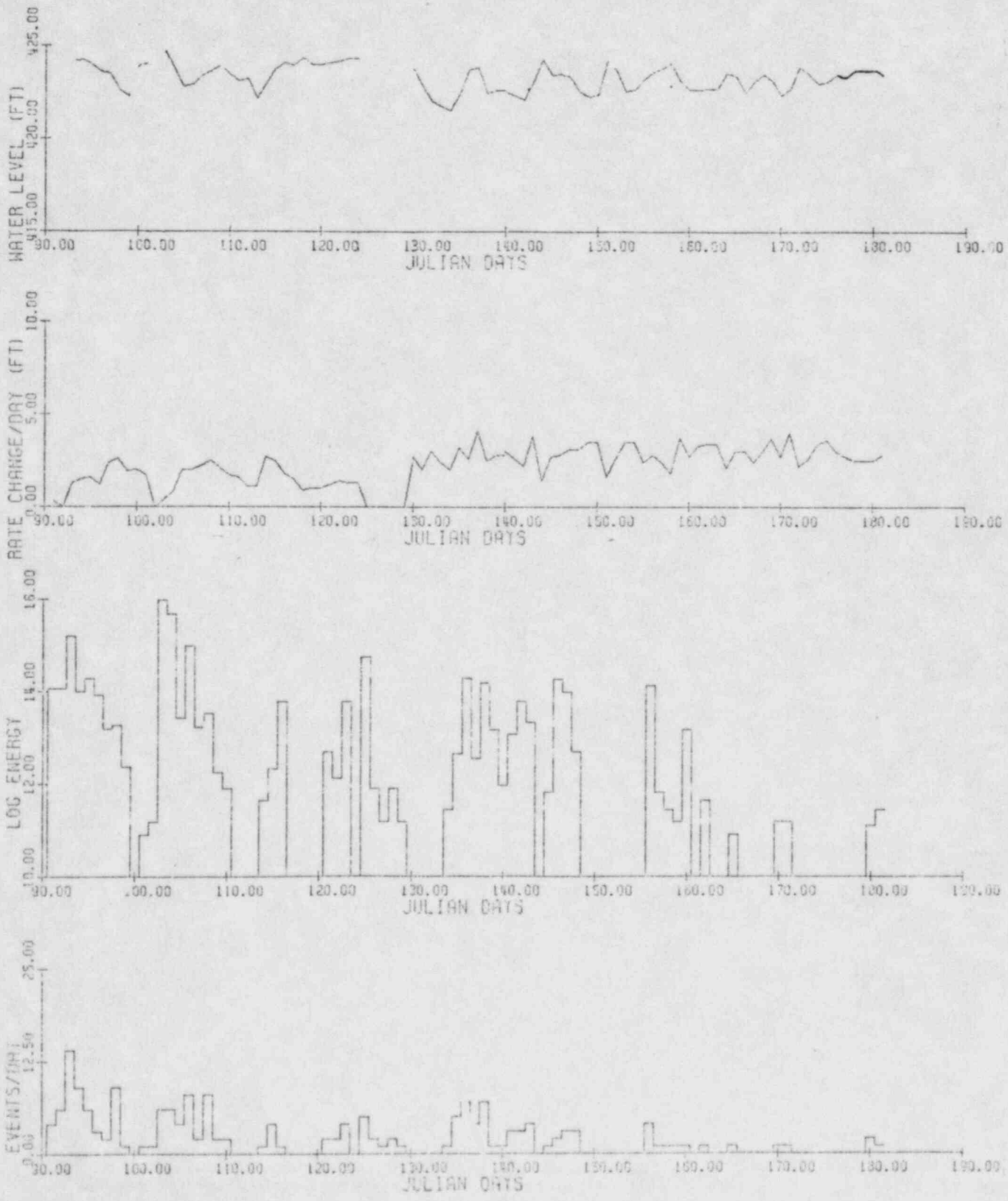
WATER LEVEL (FT)
425.00
420.00
415.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
180.00
190.00
JULIAN DAYS
RATE CHANGE/DAY (FT)
10.00
5.00
0.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
180.00
190.00
JULIAN DAYS
LOG ENERGY
16.00
14.00
12.00
10.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
180.00
190.00
JULIAN DAYS
EVENTS/HR
25.00
12.50
0.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
180.00
190.00
JULIAN DAYS

Figure 6

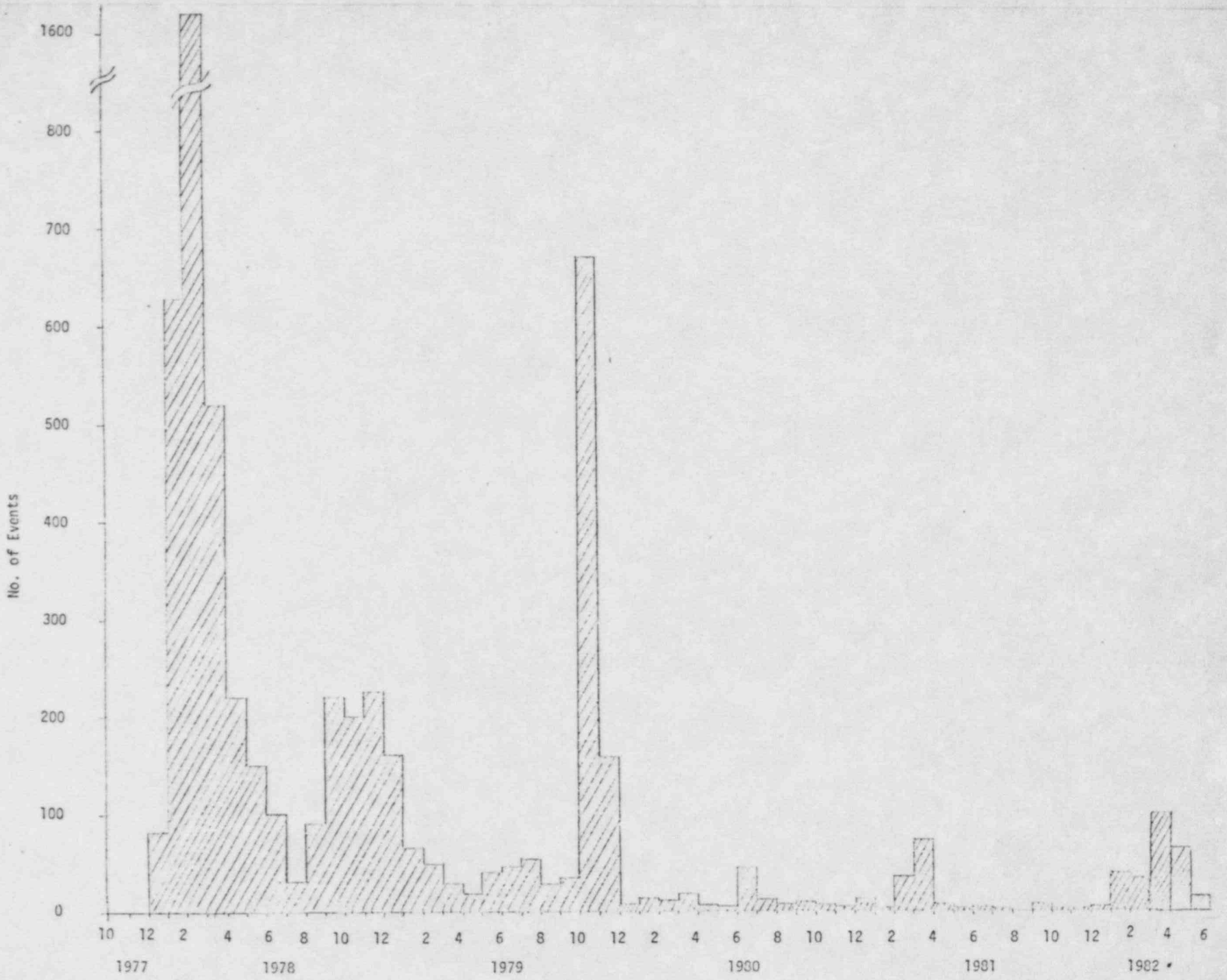
1600
800
700
600
500
400
300
200
100
0
No. of Events
10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6
1977
1978
1979
1980
1981
1982

Figure 7

APPENDICES

APPENDIX I

STATION LOCATION

NO.	STN.	LAT. N.	LONG. W.
1	001	34°19.91'	81°17.74'
2	002	34°11.58'	81°13.81'
3	003	34°21.09'	81°27.41'
4	004	34°25.72'	81°12.99'
5	JSC	34°16.80'	81°15.60'
6	008	34°24.53'	81°24.55'

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

MONTICELLO EARTHQUAKES
APRIL - JUNE 1982

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	QM
820401	8 8 22.97	34-18.62	81-19.00	0.16	1.37	9	141	3.1	0.07	0.3	0.9	B1
820401	8 9 12.85	34-20.01	81-17.84	1.00	0.21	6	237	0.2	0.09	1.6	0.9	C1
820401	816 36.79	34-20.46	81-20.10	2.62	-0.40	5	153	3.9	0.05	0.4	1.0	C1
820401	1010 7.30	34-19.16	81-20.80	1.91	0.91	10	147	4.9	0.09	0.4	1.7	B1
820401	1329 34.15	34-20.53	81-20.62	0.83	-0.40		171	4.6	0.09	0.7	1.4	C1
820401	1440 1.59	34-19.27	81-18.37	3.69	-0.40		244	1.5	0.03	0.3	0.2	C1
820401	2315 13.35	34-21.29	81-20.52	0.45	1.09	8	147	5.0	0.06	0.2	0.7	B1
820402	312 15.61	34-20.33	81-19.96	1.76	1.48	10	130	3.5	0.07	0.3	0.9	B1
820402	313 15.31	34-20.15	81-20.31	2.71	0.21	7	161	4.0	0.09	0.5	1.2	B1
820402	350 14.83	34-19.89	81-20.35	3.82	-0.12	5	192	4.0	0.03	0.7	1.9	C1
820402	1243 35.91	34-20.15	81-20.02	1.95	-0.24	4	183	4.1	0.01	0.0	0.0	C1
820402	1243 57.46	34-20.30	81-18.98	1.00	-0.11	3	196	2.0	0.00	0.0	0.0	C1
820402	1457 33.87	34-20.30	81-25.14	1.00	0.21	3	277	15.6	0.01	0.0	0.0	C1
820403	118 58.64	34-19.42	81-20.47	0.04	0.21	5	135	4.2	0.02	0.1	0.4	B1
820403	236 15.90	34-20.19	81-20.68	3.18	0.29	6	133	4.5	0.05	0.3	1.0	B1
820403	249 50.12	34-20.27	81-20.22	1.80	0.95	8	130	3.9	0.08	0.4	1.4	B1
820403	4 8 14.72	34-20.47	81-20.01	3.18	1.18	6	169	3.6	0.03	0.4	0.7	B1
820403	436 21.59	34-20.32	81-20.20	2.61	0.91	10	131	3.8	0.08	0.3	0.8	B1
820403	446 17.80	34-20.45	81-20.52	1.89	1.09	10	133	4.4	0.05	0.2	0.5	B1
820403	456 41.80	34-20.01	81-19.82	5.32	0.21	8	130	3.2	0.06	0.3	0.5	B1
820403	947 4.07	34-20.01	81-20.06	7.07	1.78	9	132	3.6	0.09	0.5	1.0	B1
820403	1937 43.10	34-20.19	81-18.35	1.99	0.82	6	242	7.6	0.07	2.2	1.2	D1
820403	2014 10.71	34-20.64	81-18.48	1.90	1.08	6	245	8.4	0.09	2.8	0.9	D1
820403	2325 51.67	34-20.59	81-21.45	1.86	2.05	5	138	5.8	0.06	0.8	0.6	B1
820403	2326 53.81	34-20.01	81-20.21	0.46	1.46	9	132	3.8	0.09	0.4	1.2	B1
820403	2327 36.25	34-20.54	81-20.34	1.78	0.82	9	134	4.2	0.07	0.3	1.2	B1
820403	2330 5.72	34-20.18	81-20.12	0.83	1.02	9	130	3.7	0.07	0.3	0.9	C1
820404	623 44.91	34-18.93	81-18.44	1.77	0.63	7	154	5.9	0.02	0.1	0.8	B1
820404	649 54.61	34-20.01	81-20.27	1.69	-0.40	6	133	3.9	0.08	0.5	3.1	B1
820404	651 16.06	34-20.17	81-20.06	2.83	0.12	6	146	3.3	0.06	0.4	2.8	C1
820404	659 56.49	34-19.32	81-19.29	1.90	-0.40	5	146	3.8	0.02	0.3	1.1	C1
820404	1225 23.96	34-20.38	81-20.06	0.79	0.91	6	131	3.5	0.09	0.4	1.6	C1
820404	1231 37.82	34-20.37	81-18.85	0.21	0.12	7	126	3.3	0.04	0.1	0.6	B1
820404	2154 9.49	34-20.29	81-19.97	1.82	1.21	10	129	3.5	0.06	0.3	1.1	B1
820405	130 45.31	34-20.35	81-20.01	4.33	0.01	5	143	3.6	0.03	0.1	0.3	C1
820405	755 21.50	34-20.23	81-20.08	2.33	0.29	8	129	3.6	0.07	0.3	0.8	B1
820405	918 57.02	34-20.19	81-19.91	3.47	1.65	10	129	3.4	0.05	0.2	0.5	B1
820405	944 26.37	34-20.59	81-19.82	3.38	-0.11	9	134	3.6	0.07	0.2	0.5	B1
820405	1055 22.82	34-20.51	81-19.99	1.39	0.21	7	140	3.3	0.07	0.4	0.9	B1
820406	858 51.53	34-20.01	81-20.15	3.26	1.34	8	150	3.7	0.09	0.5	0.9	B1
820406	9 0 33.24	34-20.03	81-20.18	4.40	0.87	7	150	3.8	0.07	0.3	0.9	C1
820406	916 6.23	34-20.96	81-19.85	1.87	-0.11	7	139	3.6	0.07	0.3	1.1	B1
820406	10 3 31.23	34-20.17	81-20.09	2.67	1.64	9	130	3.1	0.04	0.7	1.8	C1
820408	814 42.93	34-19.68	81-19.71	0.30	-0.86	5	273	2.7	0.00	0.0	0.0	C1
820408	857 0.59	34-16.87	81-17.39	2.83	0.12	4	204	3.3	0.04	0.2	1.1	C1
820408	1013 6.79	34-17.02	81-17.75	1.29	0.91	5	148	3.4	0.05	0.3	1.0	B1
820408	1014 4.43	34-16.43	81-18.43	1.94	0.01	5	228	4.2	0.05	0.3	0.9	D1
820408	1337 33.76	34-20.50	81-20.40	4.18	0.01	6	143	4.2	0.06	0.5	0.9	B1
820409	7 1 36.58	34-19.87	81-19.03	1.78	0.37	10	128	2.0	0.08	0.4	1.0	B1
820412	10 9 12.96	34-19.92	81-20.03	7.17	-0.11	8	133	3.9	0.08	0.4	1.9	B1
820413	752 21.96	34-20.49	81-20.30	1.95	0.44	7	133	3.9	0.08	0.4	5.7	C1

820413	935	20.11	34-18.58	81-20.04	1.88	2.80	5	149	4.3	0.00	0.0	0.1	C1
820413	934	55.60	34-18.54	81-19.79	1.90	-0.24	8	144	7.5	0.06	0.3	2.3	C1
820413	1136	12.59	34-20.03	81-19.86	1.00	-0.24	3	271	9.6	0.01	0.0	0.0	C1
820413	1551	33.70	34-19.06	81-20.08	2.23	0.82	8	143	8.0	0.02	0.1	0.7	B1
820414	529	35.37	34-18.58	81-20.19	1.89	2.58	5	150	4.5	0.05	0.8	3.8	C1
820414	712	59.54	34-18.95	81-20.09	2.96	0.82	8	145	4.0	0.04	0.2	0.5	B1
820414	22 0	23.09	34-18.13	81-19.90	1.14	-0.24	6	165	4.7	0.07	0.6	4.6	C1
820415	1047	40.41	34-18.41	81-19.76	4.40	-0.40	10	149	4.2	0.08	0.4	0.8	B1
820415	1415	31.99	34-18.66	81-19.73	2.91	0.91	10	146	3.8	0.04	0.2	0.4	B1
820415	2046	47.82	34-20.09	81-19.45	5.23	0.82	7	127	2.6	0.05	0.3	0.5	B1
820416	125	13.36	34-18.74	81-19.84	0.46	2.00	8	145	3.9	0.05	0.3	1.1	B1
820416	310	52.02	34-19.07	81-19.80	0.17	0.01	8	165	3.5	0.09	0.4	1.2	B1
820416	311	18.96	34-18.48	81-19.81	1.80	0.68	10	148	4.1	0.08	0.3	1.4	B1
820416	728	52.48	34-18.42	81-20.02	0.01	1.02	10	151	4.4	0.06	0.2	0.1	B1
820416	1138	50.84	34-18.81	81-19.94	1.79	2.19	10	145	3.9	0.07	0.4	2.0	C1
820416	1954	45.05	34-18.24	81-20.09	0.07	-0.24	7	184	4.7	0.09	0.4	1.1	C1
820416	2235	25.49	34-18.90	81-20.09	2.64	0.90	10	145	4.1	0.05	0.2	0.6	B1
820417	930	55.74	34-18.68	81-20.05	0.46	0.95	10	148	4.2	0.03	0.1	0.5	B1
820418	458	24.49	34-20.71	81-19.75	1.91	0.12	8	135	3.4	0.06	0.3	0.7	B1
820418	20 3	32.49	34-20.66	81-20.16	0.51	1.12	10	135	4.0	0.09	0.4	1.4	B1
820418	20 4	40.56	34-20.54	81-19.95	1.73	0.21	10	133	3.6	0.08	0.3	1.2	B1
820419	017	42.33	34-20.48	81-20.08	1.69	-0.11	8	133	3.7	0.07	0.3	1.3	B1
820419	533	29.76	34-18.36	81-20.59	2.73	0.21	9	155	5.2	0.08	0.3	1.3	B1
820420	1645	05.30	34-18.61	81-19.80	1.80	-0.40	9	147	4.0	0.09	0.4	2.1	C1
820425	218	46.90	34-20.50	81-19.95	3.95	0.12	10	132	3.6	0.05	0.2	0.4	B1
820425	1112	6.17	34-17.34	81-20.30	1.85	-0.60	8	166	6.2	0.09	0.6	3.7	C1
820425	1620	53.27	34-17.30	81-19.46	1.87	0.01	9	159	5.5	0.06	0.3	1.5	B1
820426	1930	34.17	34-20.01	81-19.65	2.47	2.05	6	129	2.9	0.08	0.4	0.8	B1
820507	737	6.30	34-24.92	81-18.89	2.66	0.44	10	264	5.1	0.09	1.0	1.8	C1
820507	845	26.26	34-17.34	81-19.38	1.00	-0.11	7	161	0.6	0.04	0.3	0.8	B1
820508	418	24.68	34-20.01	81-20.09	1.00	-0.40	3	187	3.6	0.05	0.0	0.0	C1
820514	1137	7.82	34-21.87	81-20.12	0.85	-0.24	4	232	5.1	0.03	0.0	0.0	C1
820515	051	2.19	34-21.34	81-19.98	1.06	-0.24	4	220	4.3	0.01	0.0	0.0	C1
820515	1641	56.59	34-20.85	81-20.49	0.85	0.01	4	200	4.6	0.05	0.0	0.0	C1
820516	521	55.76	34-20.98	81-17.66	1.00	0.21	3	247	8.4	0.02	0.0	0.0	C1
820516	939	5.26	34-21.34	81-20.42	1.00	0.29	4	215	4.9	0.04	0.0	0.0	C1
820516	1211	4.11	34-19.81	81-20.65	0.67	1.21	4	195	4.5	0.04	0.0	0.0	C1
820516	15 4	21.14	34-21.66	81-19.64	1.50	1.54	4	233	4.4	0.06	0.0	0.0	C1
820517	1027	42.95	34-19.90	81-18.25	1.00	-0.11	3	190	0.8	0.00	0.0	0.0	C1
820518	1 9	37.09	34-23.48	81-18.46	1.00	0.01	3	278	6.7	0.01	0.0	0.0	C1
820518	328	11.33	34-22.69	81-19.21	1.00	0.87	3	260	5.6	0.00	0.0	0.0	C1
820518	752	0.53	34-22.79	81-17.14	1.00	-0.40	3	291	5.4	0.04	0.0	0.0	C1
820519	9 3	39.28	34-22.95	81-19.17	1.00	0.91	3	264	6.0	0.00	0.0	0.0	C1
820520	154	37.71	34-24.69	81-17.84	1.00	0.12	3	293	8.8	0.00	0.0	0.0	C1
820521	349	11.24	34-22.10	81-19.55	1.00	-0.40	3	244	4.9	0.03	0.0	0.0	C1
820522	337	49.12	34-20.45	81-21.24	0.02	1.32	4	163	5.5	0.08	0.0	0.0	C1
820523	454	45.52	34-20.01	81-22.02	1.00	0.82	3	192	6.6	0.09	0.0	0.0	C1
820526	724	34.46	34-17.76	81-20.05	0.32	0.12	5	159	5.3	0.07	0.1	0.5	C1
820527	1050	13.18	34-17.75	81-18.91	5.11	1.40	4	150	4.4	0.00	0.0	0.0	C1

820605	2142	16.14	34-16.90	81-15.70	3.39	-0.24	5	167	0.2	0.07	1.4	0.8	C1
820606	326	49.53	34-2 .73	81-:9.74	1.78	0.01	9	135	3.4	0.08	0.4	1.1	B1
820607	124	29.05	34-20.14	81-20.72	2.70	-0.24	10	134	4.6	0.06	0.2	0.7	B1
820608	150	30.96	34-18.00	81-19.57	1.87	-0.40	9	152	4.5	0.08	0.4	1.7	B1
820611	132	42.25	34-17.33	81-21.02	2.00	-0.11	8	172	6.9	0.04	0.2	1.3	B1
820619	1313	54.10	34-19.37	81-18.35	3.12	-0.40	9	129	1.4	0.07	0.3	0.7	B1
820620	4	0 53.70	34-22.10	81-20.40	0.85	-0.40	8	159	5.7	0.04	0.2	54.2	C1
820629	0	0 31.62	34-19.75	81-18.76	1.00	-0.24	7	245	1.6	0.07	1.0	1.7	C1
820629	643	19.77	34-19.30	81-18.81	1.11	-0.11	10	132	2.0	0.06	0.2	0.8	B1
820630	355	25.97	34-20.01	81-19.76	1.93	-0.40	8	255	3.1	0.07	0.9	1.2	C1