Technical Report 82-4

SEISMIC ACTIVITY NEAR THE V. C. SUMMER NUCLEAR STATION

For the Period

October - December 1982

Summary for the Year 1982

and

Review for the Period 1977-1982

by

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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 October 1 and December 31, 1982. During this period a total of 22 locatable events were recorded. The largest magnitude recorded was M_L = 1.93 on November 16, 1982.

A brief summary of the seismic activity for the entire year of 1982, as well as an update for the period from 1977-1982, is given at the end of this report.

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 are 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 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:

$$M_L = -1.83 + 2.$$ [illegible] $$D$$

where D is the signal duration (seconds).

An estimate of daily energy release is determined using a [illegible]-fied magnitude (M_L) energy (E) relation by Gutenberg and Richter, 1956.

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

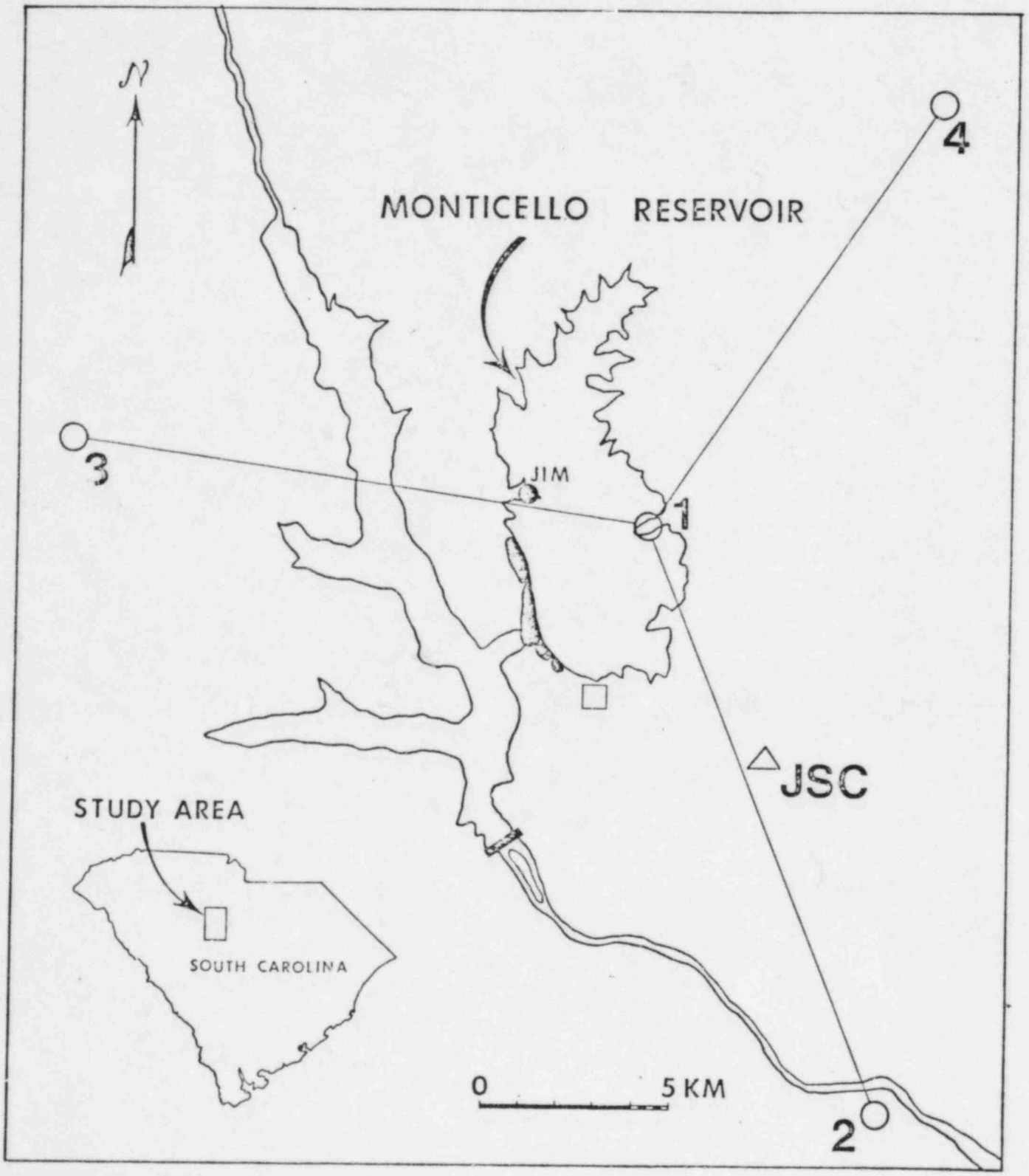

N
MONTICELLO RESERVOIR
JIM
4
3
1
JSC
STUDY AREA
SOUTH CAROLINA
0
5 KM
2

Figure 1

RESULTS

The 22 located events recorded during this reporting period are listed in Appendix III. All of the events were small ($M_L \leq 1$) except the one noted above on November 16, $M_L = 1.93$. Depth estimates indicate that 41% of the activity during this period occurred below 2.0 km depth, the deepest event being 6.65 km deep. However, our past experience in relocating these events with magnetic tape data suggests that these depth estimates may be higher than the true depths.

A cumulative plot of the epicenters located during this reporting period is shown in Figure 2 and 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 5 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 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.

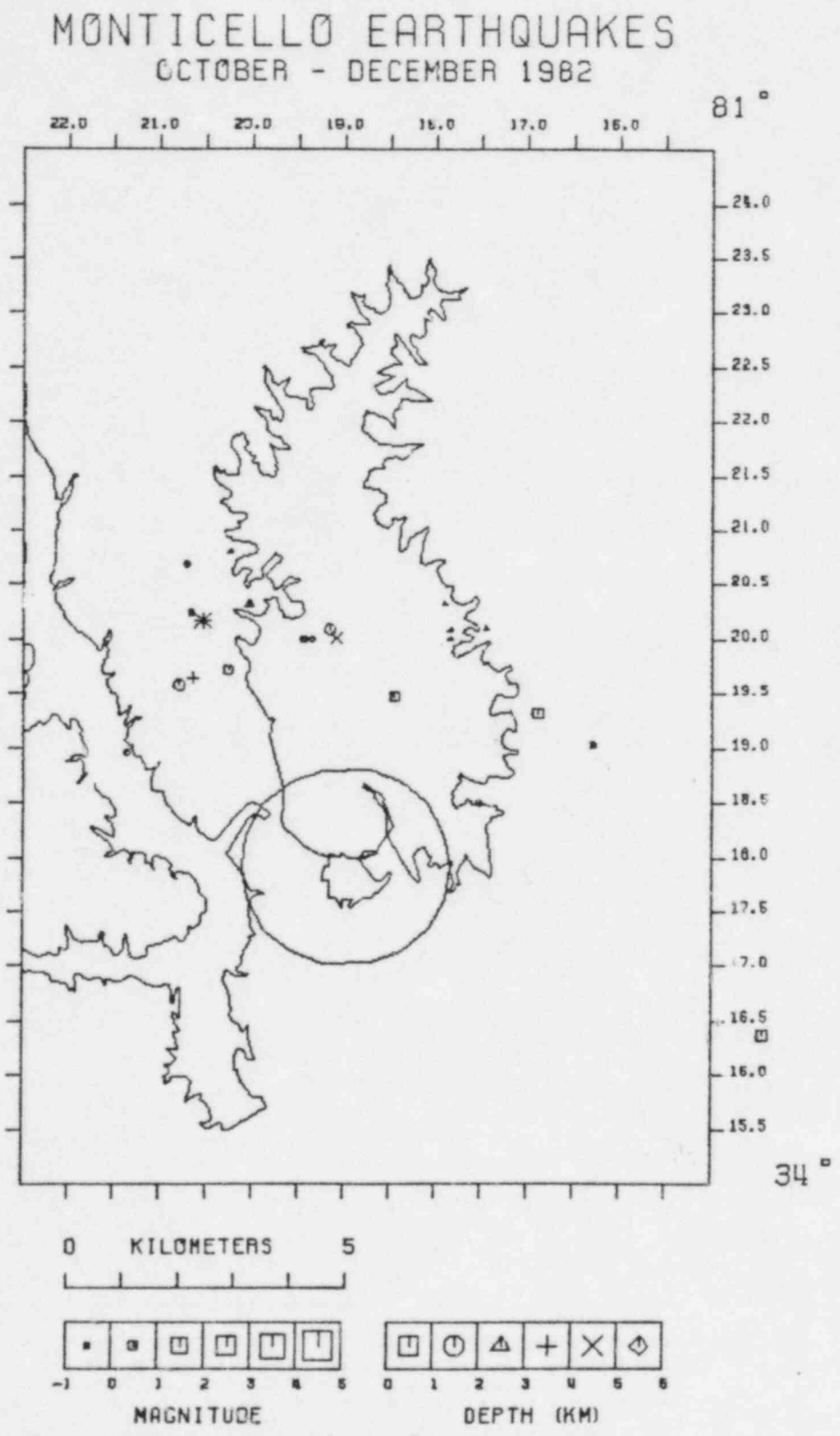

MONTICELLO EARTHQUAKES
OCTOBER - DECEMBER 1982
81°
34°
0 KILOMETERS 5
MAGNITUDE
DEPTH (KM)

Figure 2

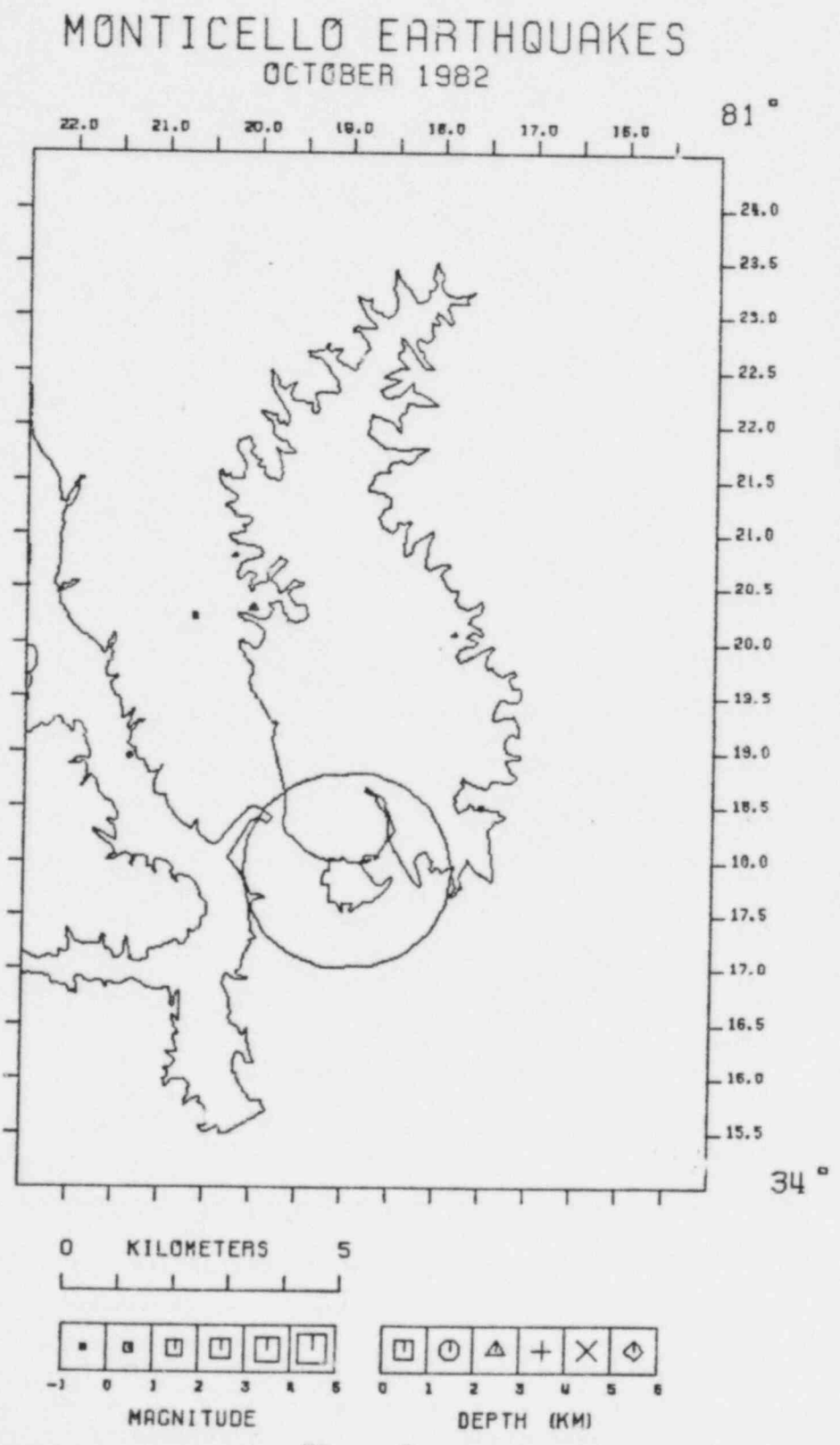

MONTICELLO EARTHQUAKES
OCTOBER 1982
81°
34°
0 KILOMETERS 5
MAGNITUDE
DEPTH (KM)

Figure 3

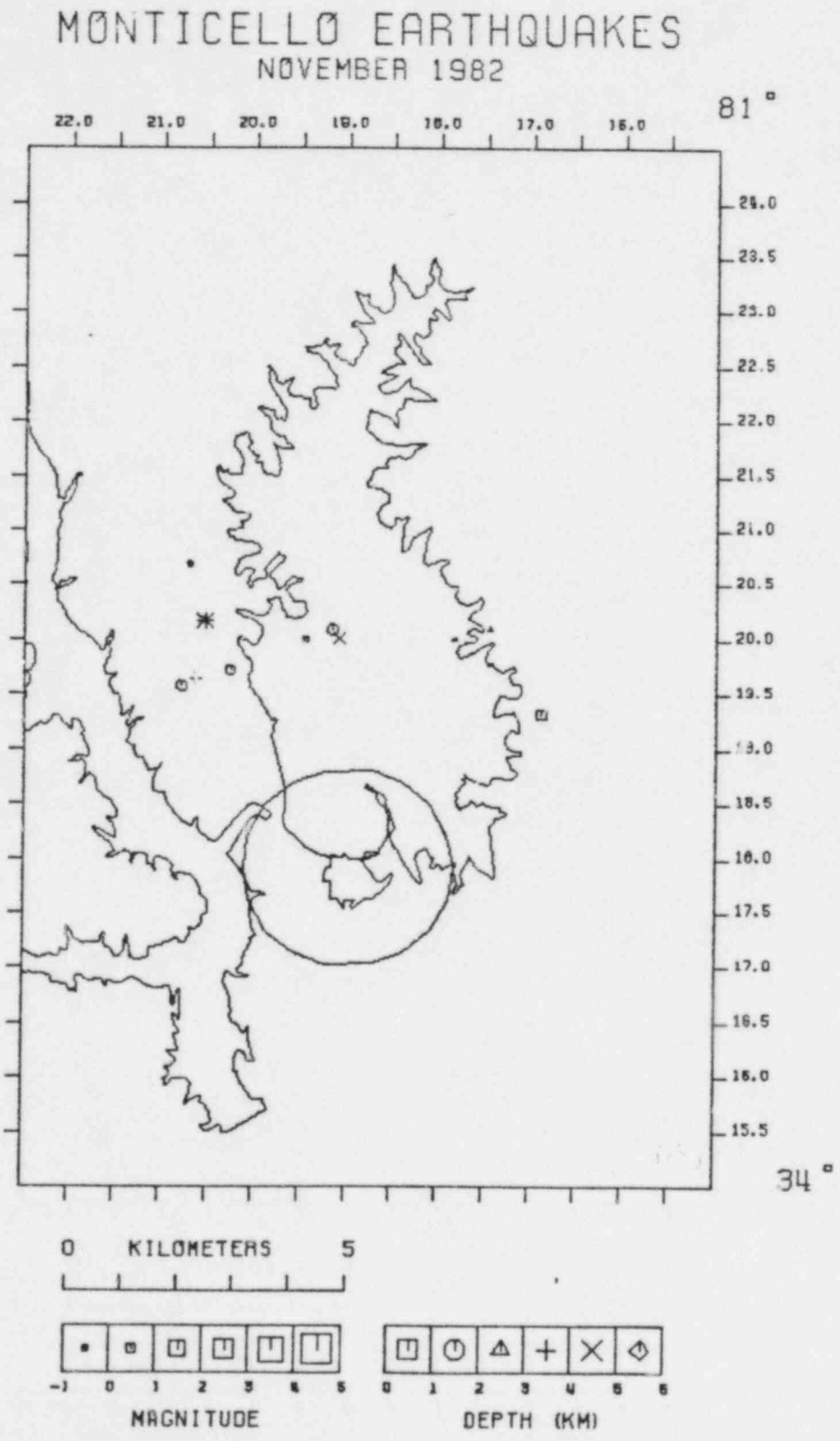

MONTICELLO EARTHQUAKES
NOVEMBER 1982
81°
34°
22.0
21.0
20.0
19.0
18.0
17.0
16.0
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
0 KILOMETERS 5
-1 0 1 2 3 4 5
MAGNITUDE
0 1 2 3 4 5 6
DEPTH (KM)

Figure 4

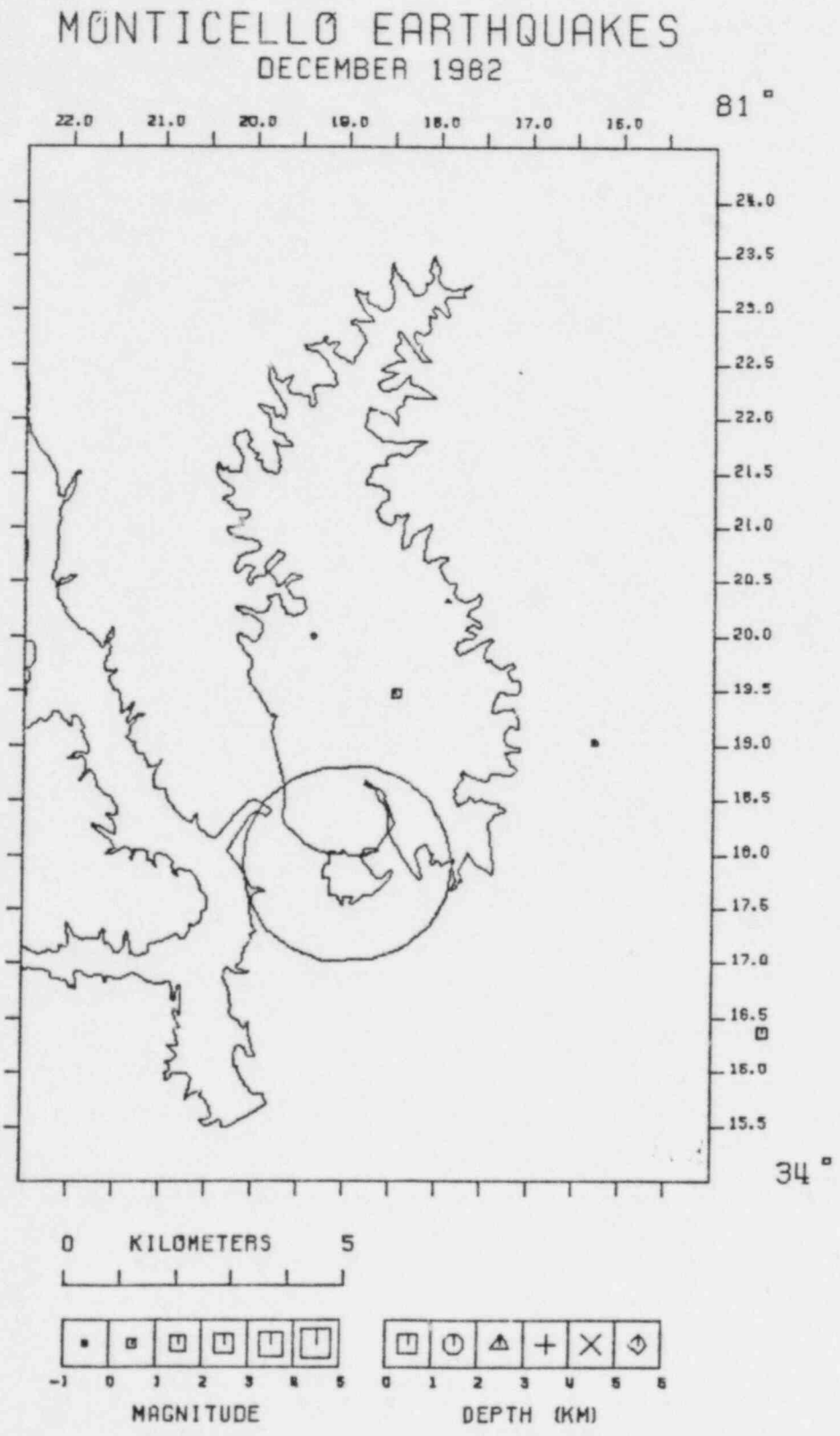

MONTICELLO EARTHQUAKES
DECEMBER 1982
81°
34°
22.0
21.0
20.0
19.0
18.0
17.0
16.0
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
0 KILOMETERS 5
-1 0 1 2 3 4 5
MAGNITUDE
0 1 2 3 4 5 6
DEPTH (KM)

Figure 5

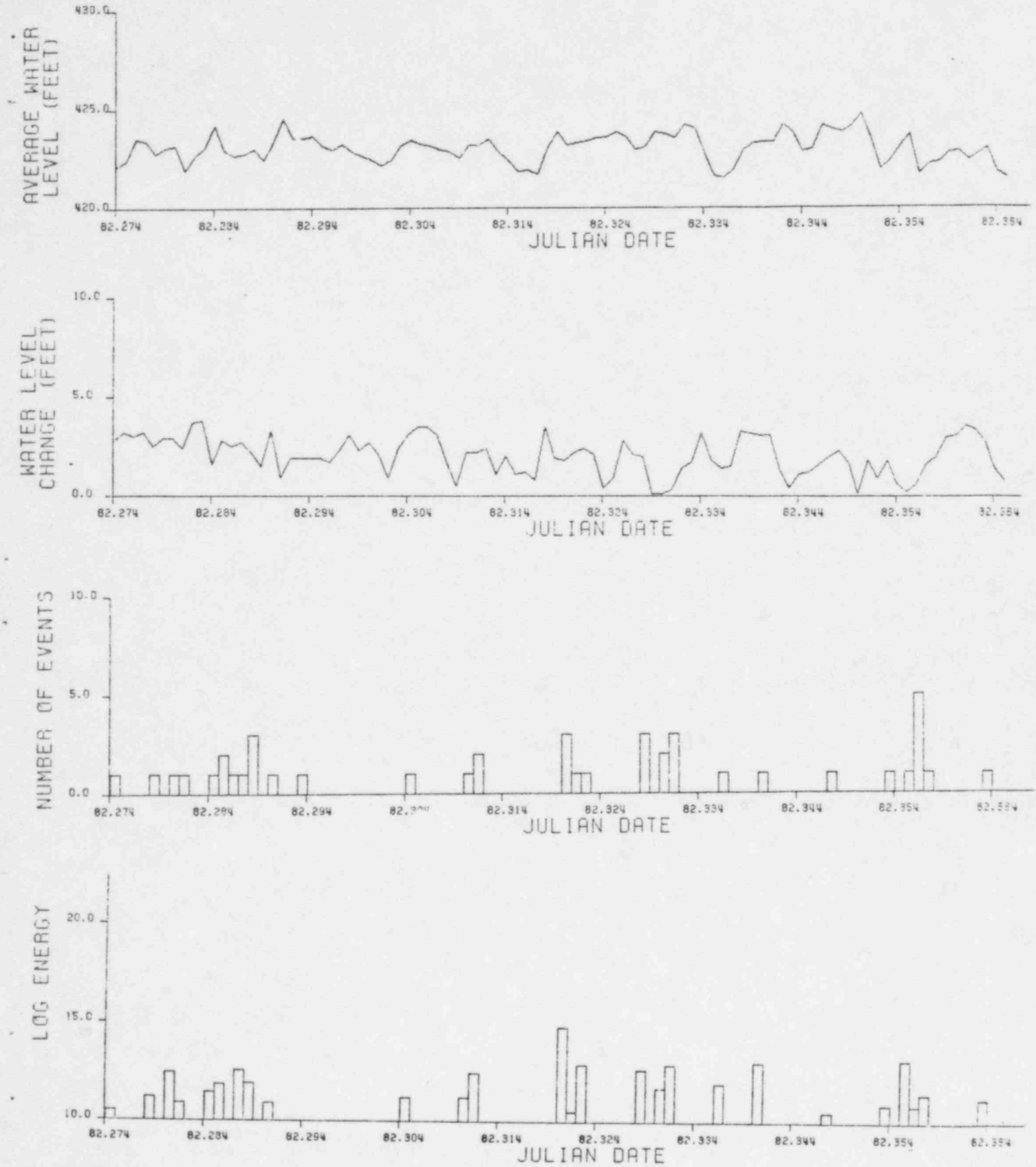

AVERAGE WATER LEVEL (FEET)
430.0
425.0
420.0
82.274
82.284
82.294
82.304
82.314
82.324
82.334
82.344
82.354
82.364
JULIAN DATE
WATER LEVEL CHANGE (FEET)
10.0
5.0
0.0
JULIAN DATE
NUMBER OF EVENTS
10.0
5.0
0.0
JULIAN DATE
LOG ENERGY
20.0
15.0
10.0
JULIAN DATE

Figure 6

SUMMARY OF THE 1982 SEISMIC ACTIVITY

A histogram of seismic activity for the year 1982 is presented in Figure 7, showing the total number of events per day. A total of 271 locatable events were recorded during the year. Their epicentral locations are shown in Figure 8, and cross sections are shown in Figure 9. No depth correlation is noted. The 8 events with magnitudes greater than 2.0 are listed in Table 1, and the 38 events with magnitudes between 1.0 and 2.0 are listed in Table 2. The remaining 225 events were small (M_L < 1.0). Most of the seismic activity for the year occurred during a swarm from February through April. This can be seen in Figure 10 by two epicentral location maps: (a) the year excluding February through April, and (b) February through April. Earthquakes occurring during February - April account for 56% of the total activity for the whole year of 1982, including all eight events with magnitudes greater than 2.0 and 71% of the events with magnitudes between 1.0 and 2.0.

Two swarms occurred outside the Monticello Reservoir area during the year, one near Blair, S.C. in May, the other near Newberry, S.C. in July and August. The major portion of the activity for the year was concentrated in a broad east-west band located in the center and the western side of the lake.

1977-1982 SUMMARY OF SEISMICITY

The level of seismicity increased rapidly from a pre-impoundment average (1973-1977) of 1 event per week to 81 events per week in 1978, and since then the pattern has been characterized by one or more discrete swarms every year (Figure 11). A cumulative plot of epicenters is shown in Figure 12, and the variation in epicentral locations can be seen in

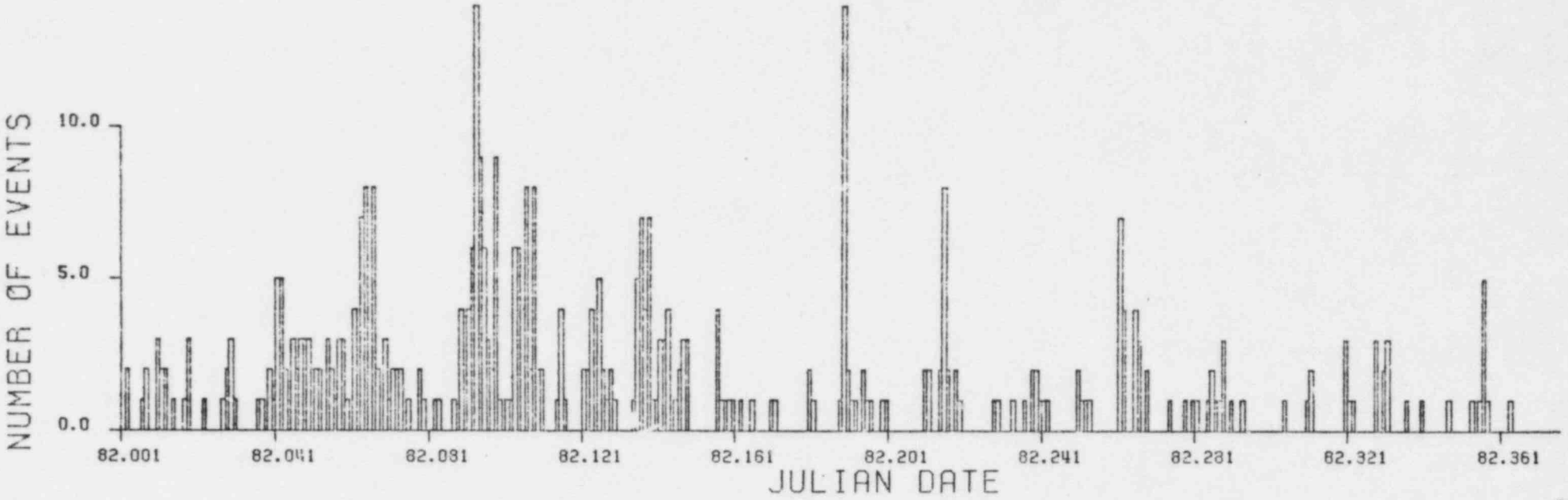

NUMBER OF EVENTS
10.0
5.0
0.0
82.001
82.041
82.081
82.121
82.161
82.201
82.241
82.281
82.321
82.361
JULIAN DATE

Figure 7

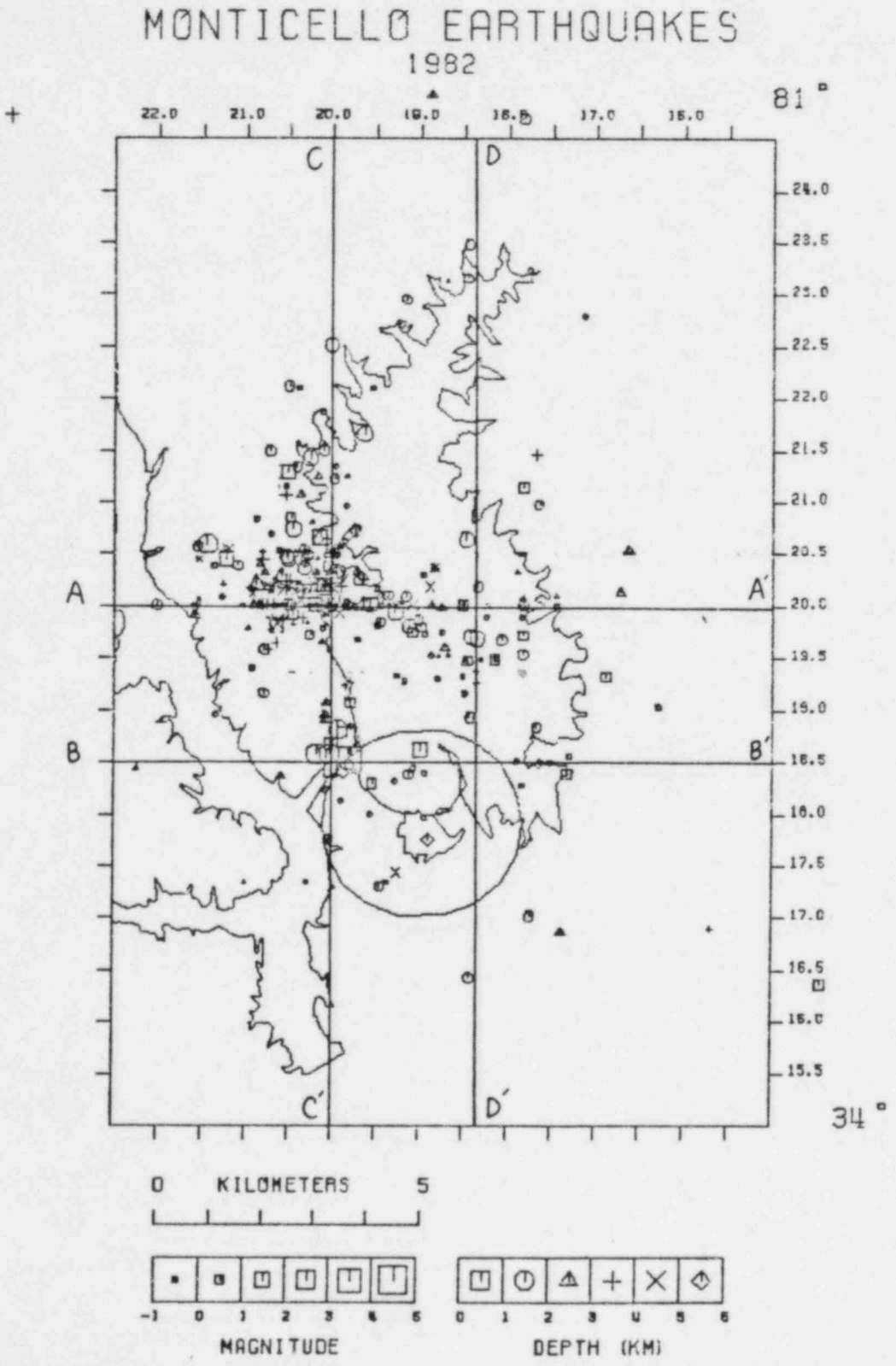

MONTICELLO EARTHQUAKES
1982
81°
34°
22.0
21.0
20.0
19.0
18.0
17.0
16.0
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
A
A'
B
B'
C
C'
D
D'
0 KILOMETERS 5
-1 0 1 2 3 4 5
MAGNITUDE
0 1 2 3 4 5 6
DEPTH (KM)

Figure 8

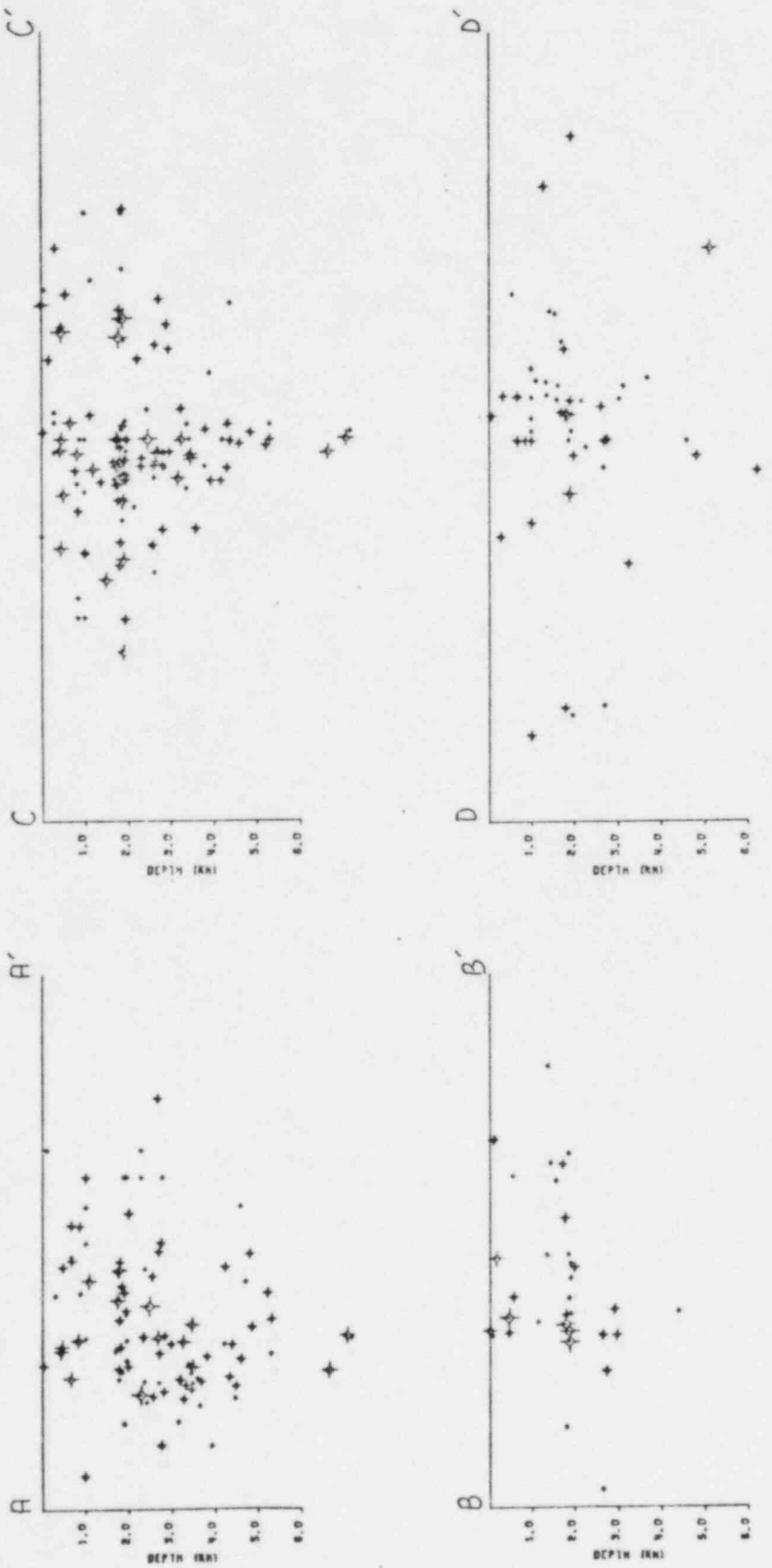


Figure 9

TABLE 1

$M_L \geq 2.0$

Date	Magnitude
March 2	2.69
March 30	2.00
April 3	2.05
April 13	2.80
April 14	2.58
April 16	2.00
April 16	2.19
April 26	2.05

TABLE 2

$1.0 \leq M_L \leq 2.0$

Date	Magnitude	Date	Magnitude
January 21	1.50	April 3	1.06
February 10	1.02	April 3	1.46
February 12	1.87	April 3	1.02
February 16	1.72	April 4	1.21
February 24	1.75	April 5	1.65
March 5	1.18	April 6	1.34
March 7	1.32	April 6	1.64
March 10	1.32	April 16	1.02
March 14	1.18	April 18	1.12
March 23	1.37	May 16	1.21
March 28	1.60	May 16	1.54
March 30	1.42	May 22	1.32
March 30	1.64	May 27	1.44
April 1	1.37	July 29	1.42
April 1	1.09	July 29	1.12
April 2	1.48	July 30	1.15
April 3	1.18	August 27	1.32
April 3	1.09	September 18	1.44
April 3	1.78	November 16	1.93

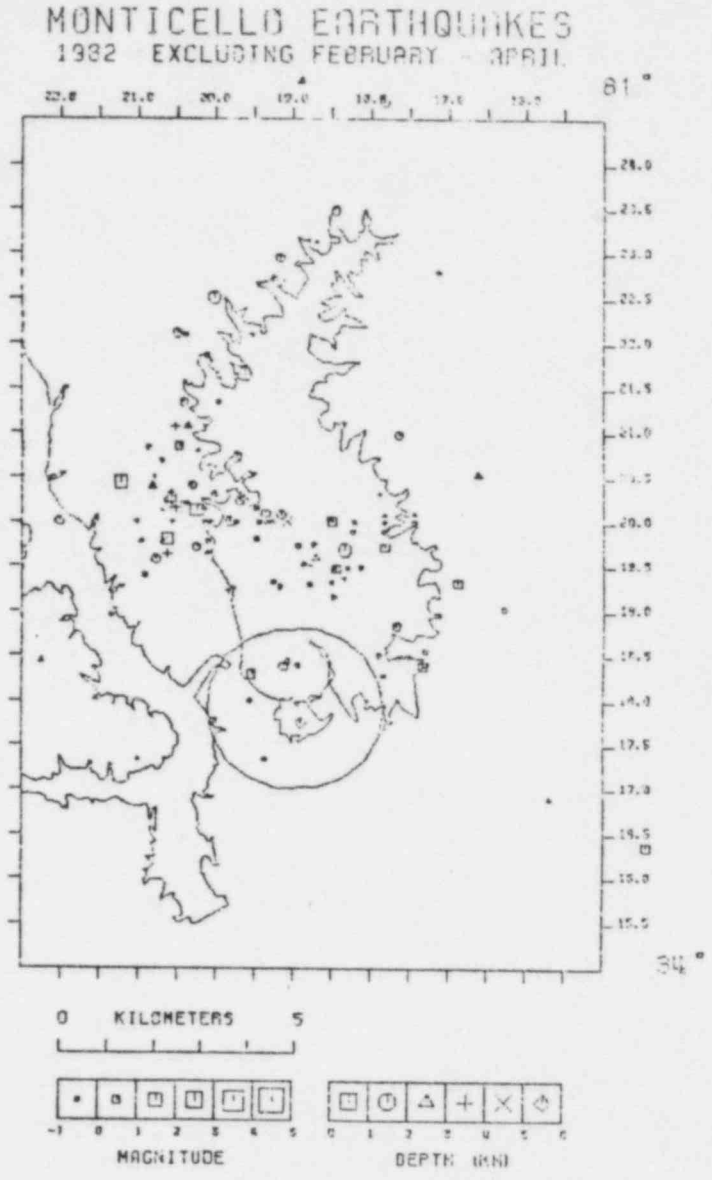


Figure 10a

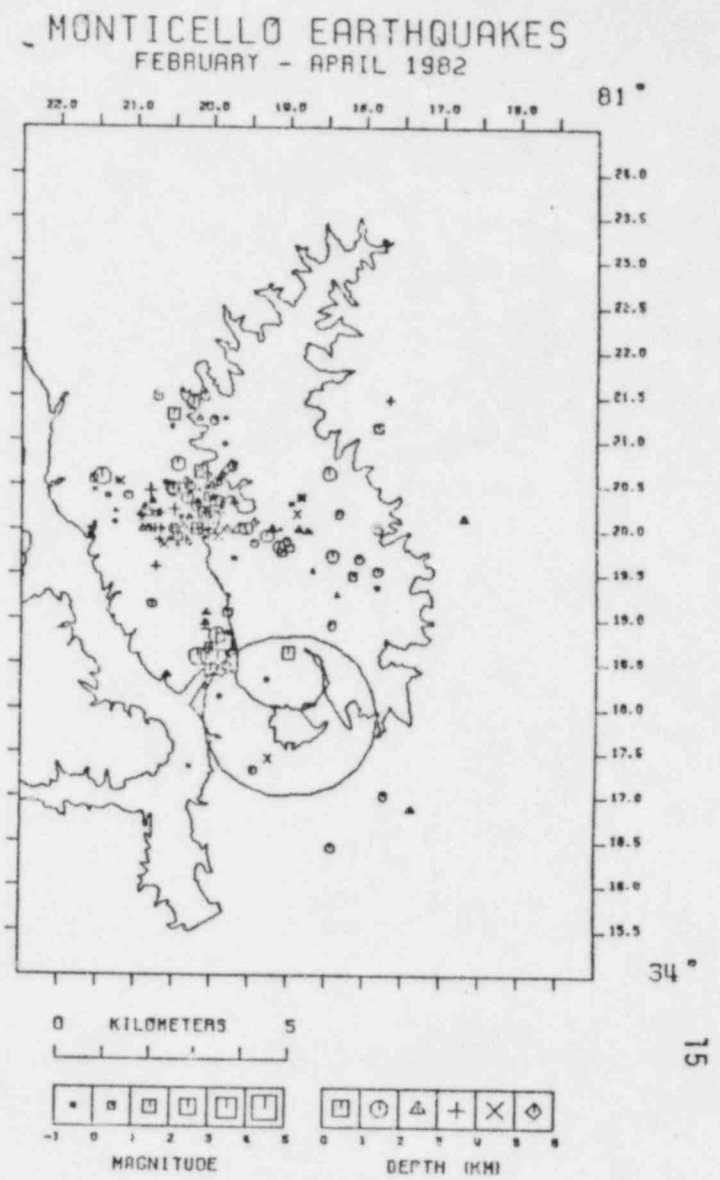


Figure 10b

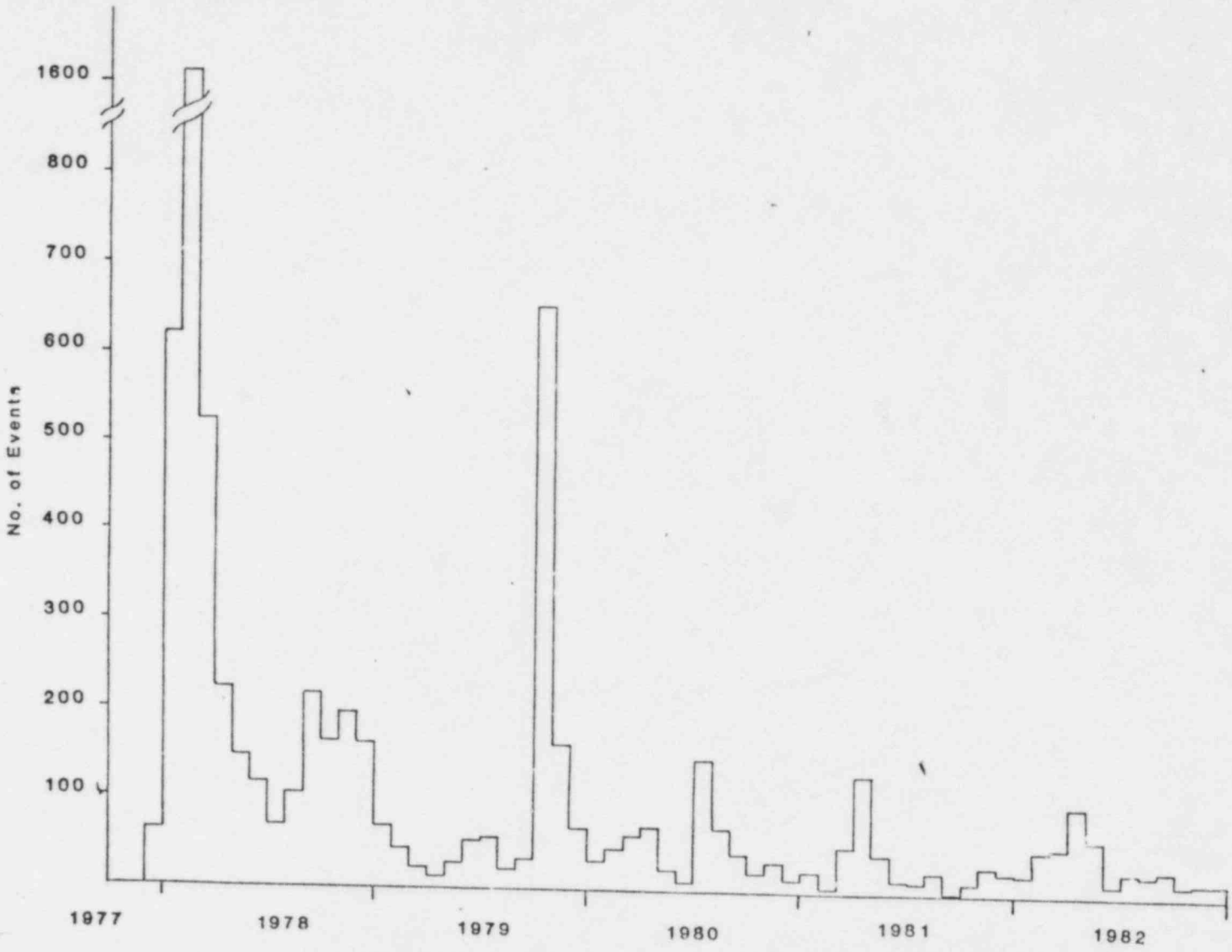

1600
800
700
600
500
400
300
200
100
No. of Events
1977
1978
1979
1980
1981
1982

Figure 11

MONTICELLO EARTHQUAKES
1977 - 1982

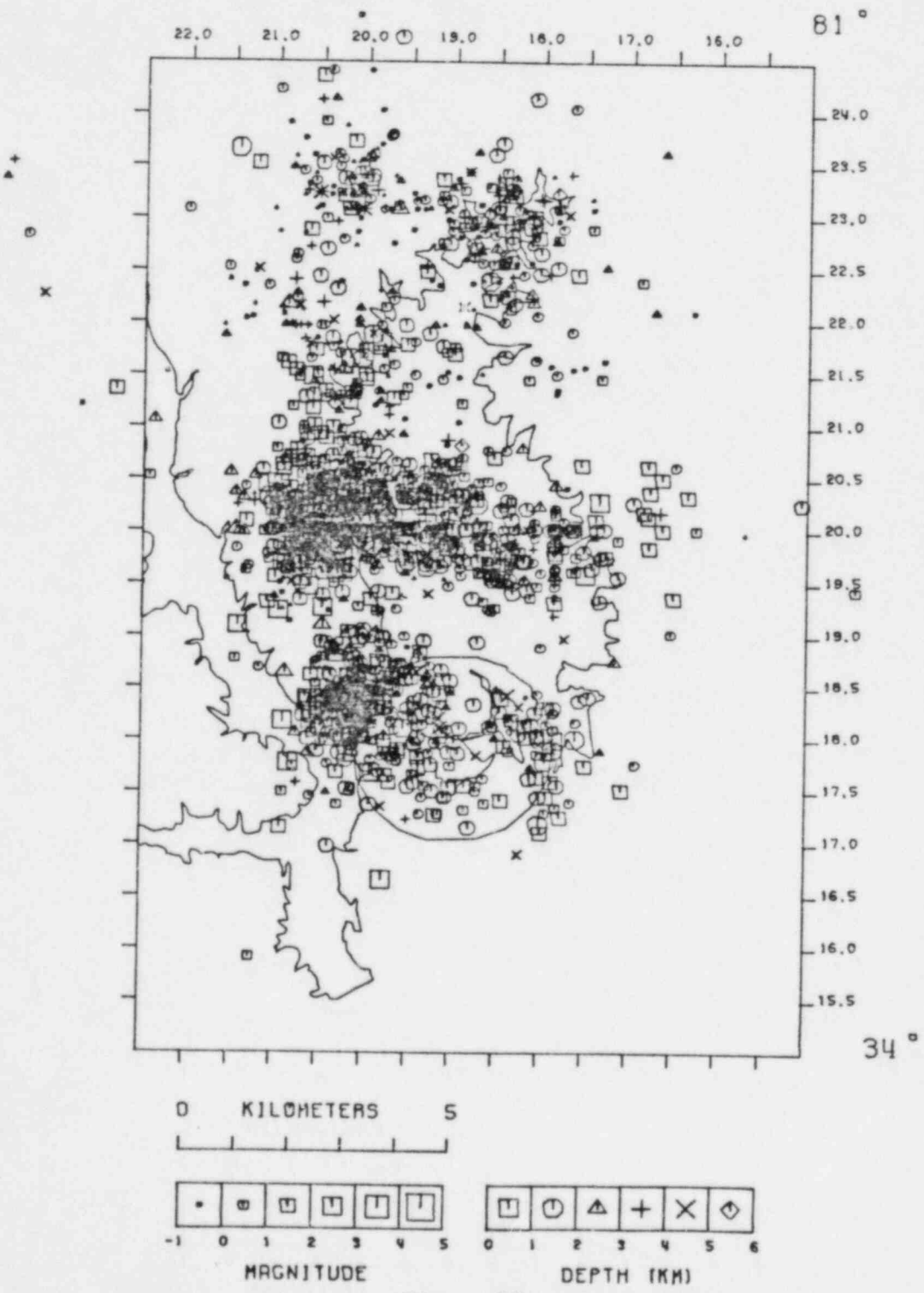


Figure 12

Figure 13. Figure 13a shows the seismicity in 1978 occurring in three clusters, to the north, middle, and southern edge of the reservoir. Variations in epicentral locations are demonstrated by envelopes drawn around the 1978 activity which were then reproduced on the 1979 map of earthquake locations (Figure 13b). An envelope of 1978 and 1979 activity was copied onto a map of 1980 earthquakes (Figure 13c) and so forth (Figs. 13d and 13e). Comparison of these figures indicates most of the activity continues to occur in the same epicentral area and a gradual filling in of the area between the central and southern bands.

Depth variations using only quality B or better events are shown in Figure 14. In Figure 14a, depth ranges were divided into 0.5 km increments up to 3.0, and events occurring deeper were grouped in the 3.0 to 3.5 km category. Figure 14b shows the percentage change with respect to 1978, and the percentage change in each depth increment for the five-year period is shown in Figure 14c. In 1978, over 40% of the activity was within the top 1.0 km. The largest fraction of events occurred in the 1.5 to 2.0 km range for the entire period, but the percentage increased from 1978 to 1980 and decreased in 1981 and 1982. An apparent deepening of activity occurred in 1981 and 1982 as shown in Figures 14b and 14c.

CONCLUSIONS

Seismic activity during the October through December 1982 reporting period was low as in the previous three-month period. A plot of the total number of events per month from December 1977 through December 1982 (Figure 11) suggests a continuous trend at Monticello Reservoir of

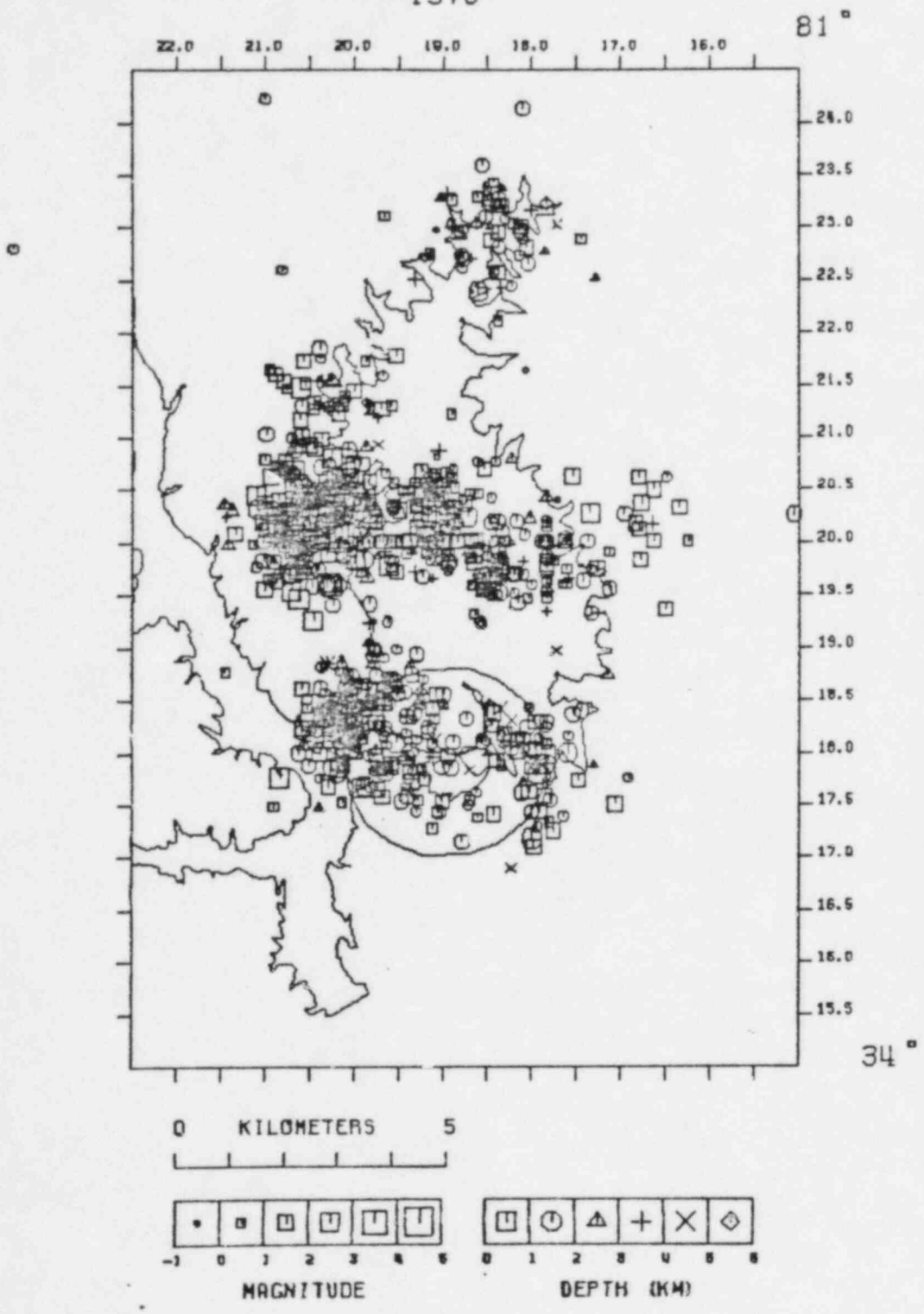
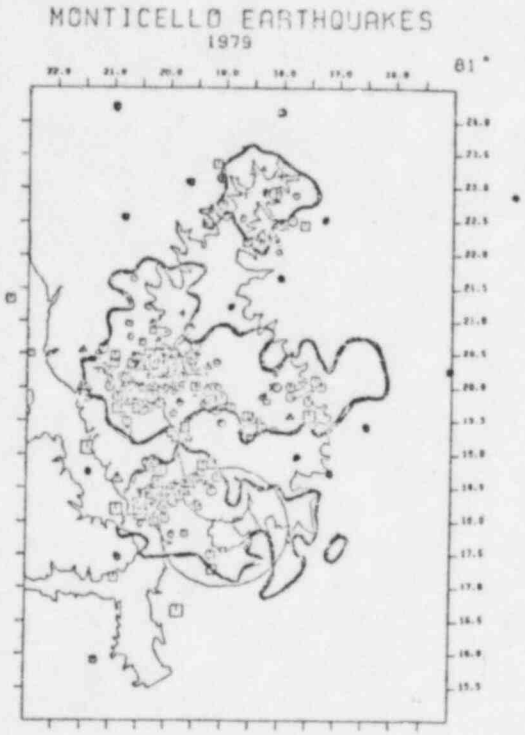
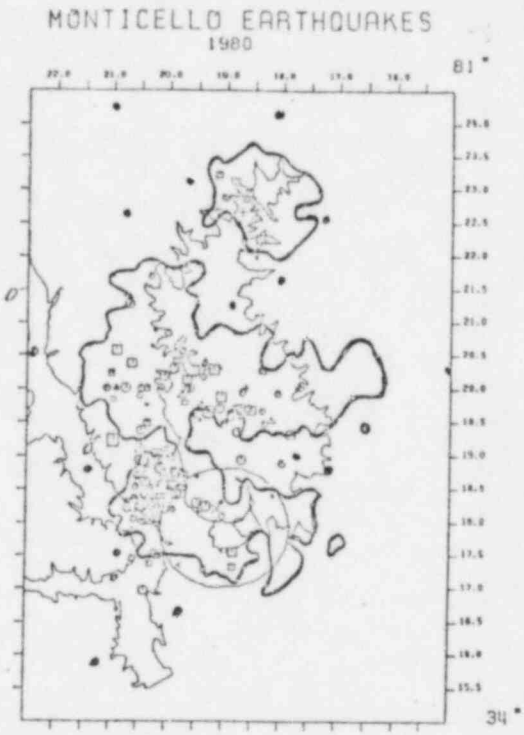

MONTICELLO EARTHQUAKES
1978
81°
34°
22.0
21.0
20.0
19.0
18.0
17.0
16.0
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
0 KILOMETERS 5
-1 0 1 2 3 4 5
MAGNITUDE
0 1 2 3 4 5 6
DEPTH (KM)

Figure 13a

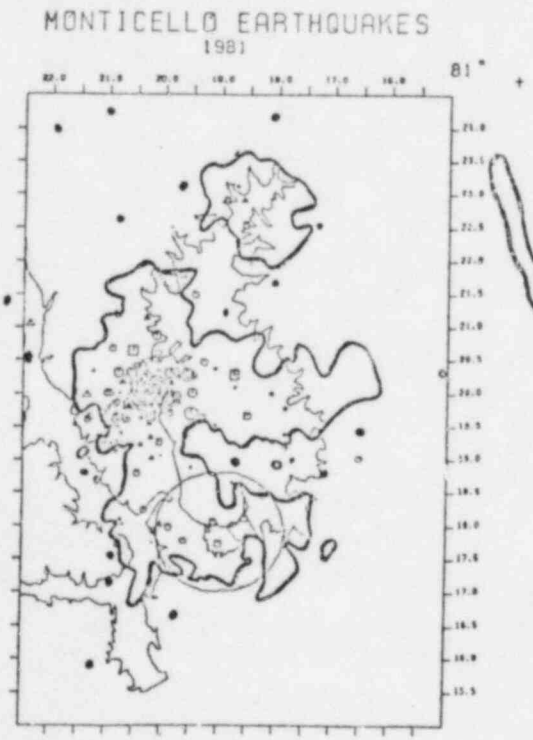


13b

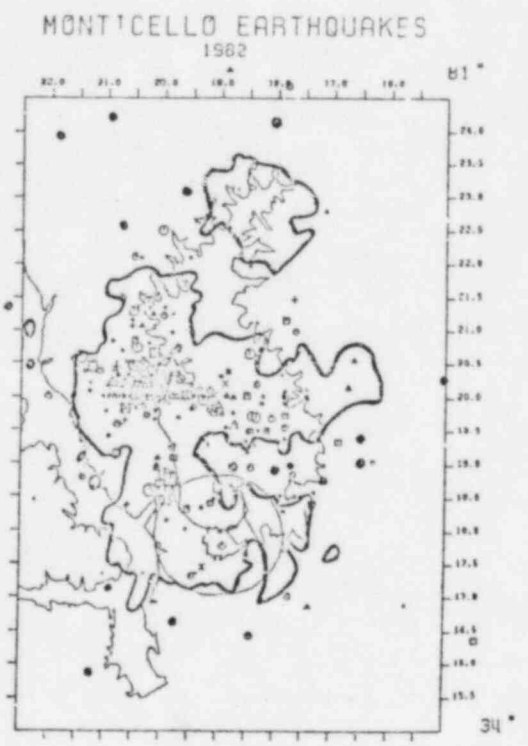


13c

E BLAIR



13d



13e

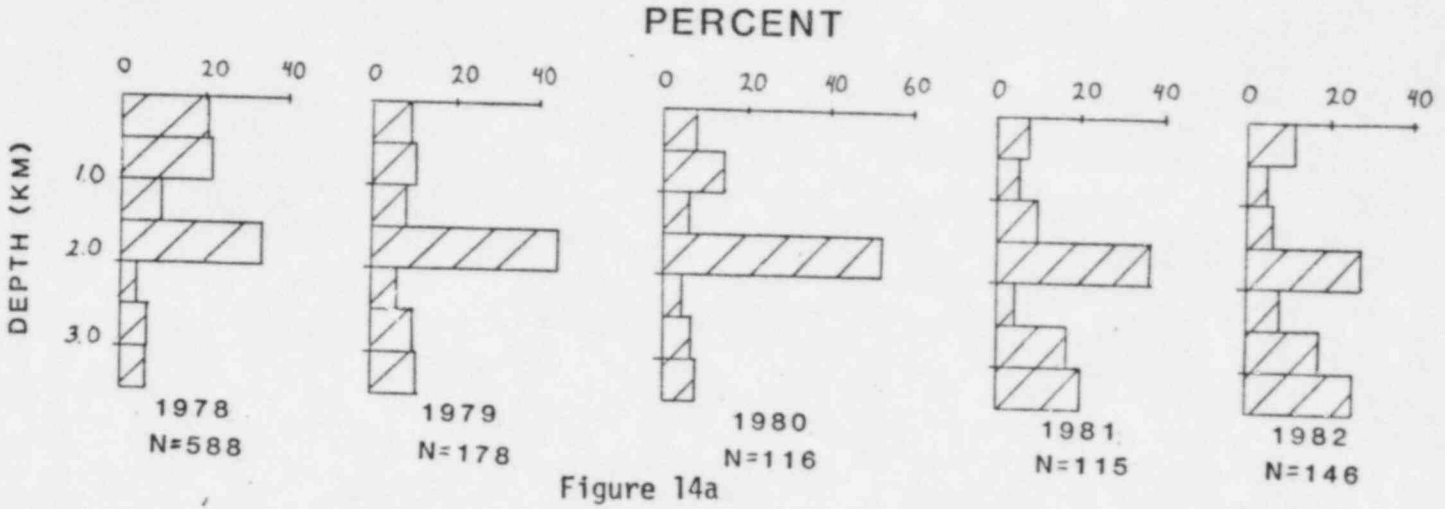


Figure 14a

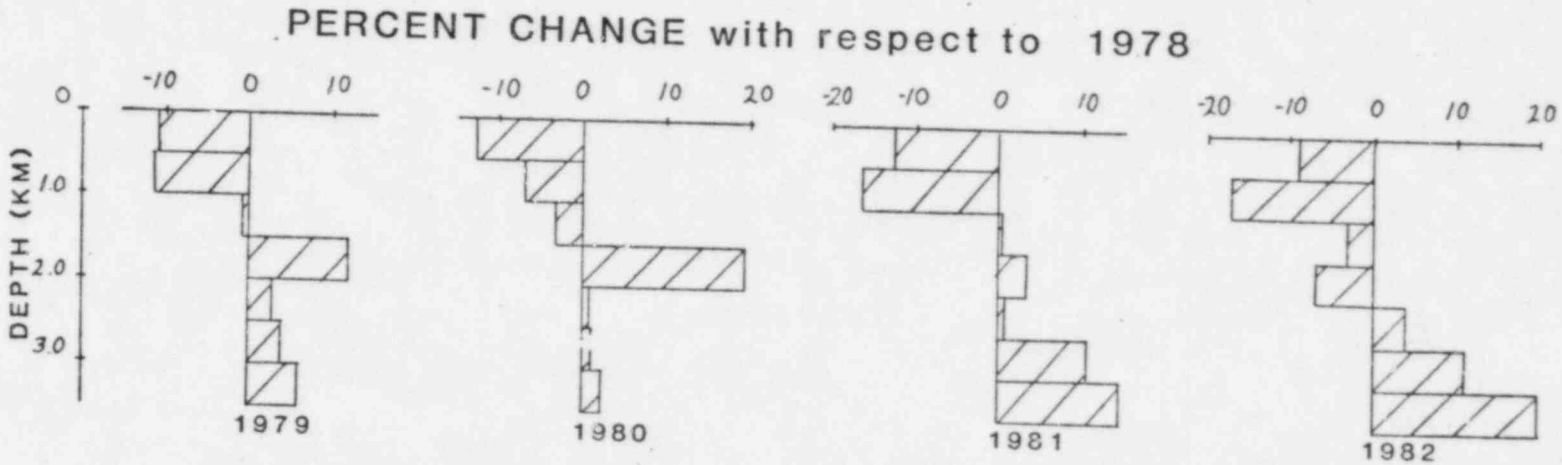


Figure 14b

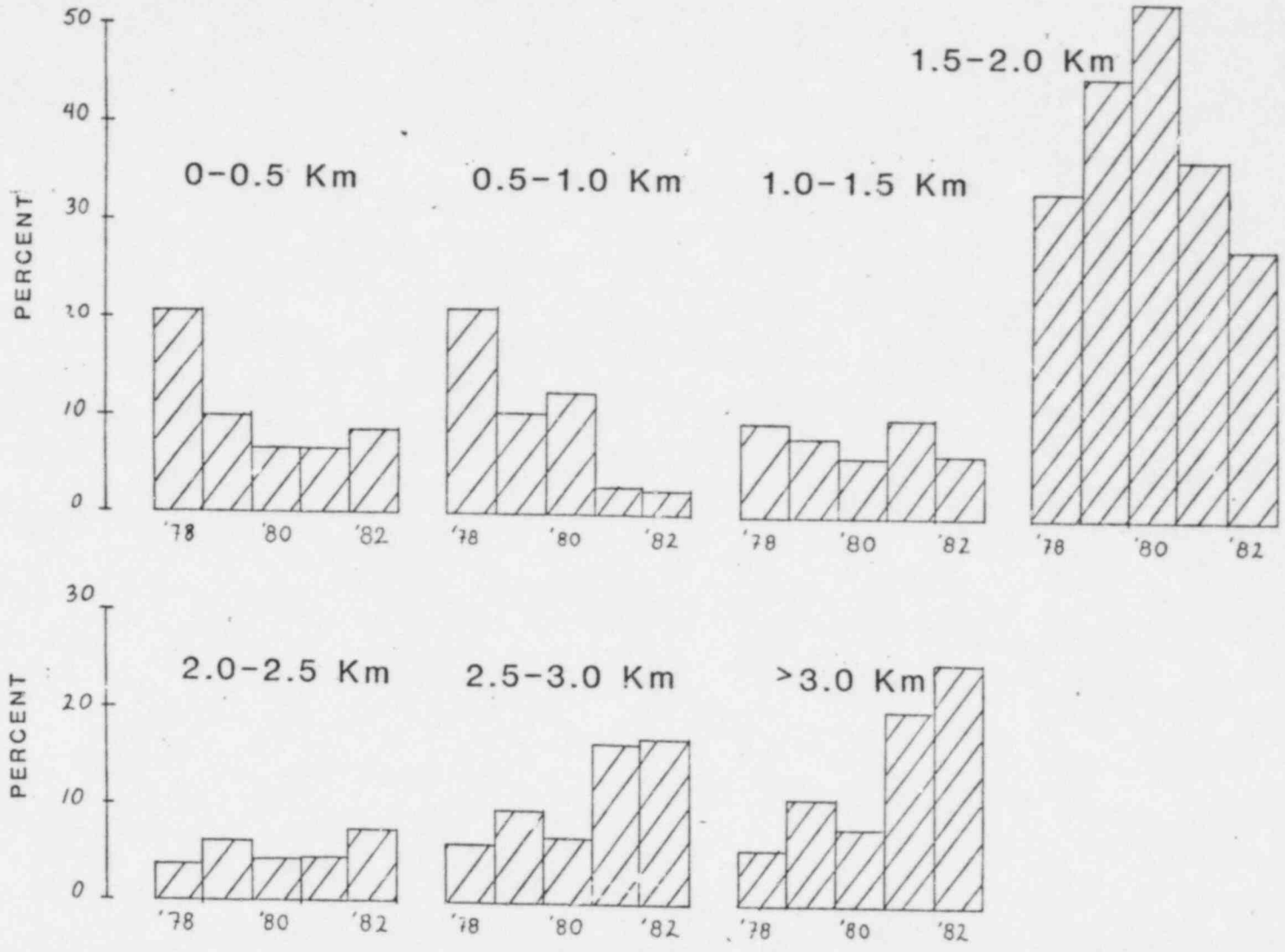

PERCENT
50
40
30
20
10
0
0-0.5 Km
0.5-1.0 Km
1.0-1.5 Km
1.5-2.0 Km
'78
'80
'82
PERCENT
30
20
10
0
2.0-2.5 Km
2.5-3.0 Km
>3.0 Km
'78
'80
'82

Figure 14c

discrete swarms of seismicity separated by relatively quiet periods. However, the overall trend shows a decrease from peak levels in 1978 and 1979, to lower levels in 1980-82. The apparent deepening of seismicity bears careful monitoring; however, our past experience in relocating these events with magnetic tape data suggests that these depth estimates may be higher than true depths.

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.

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
OCTOBER - DECEMBER 1982

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	QM
821011	859 27.16	34-18.96	81-21.37	1.81	-0.24	8	179	5.8	0.07	0.5	1.9	B1
821014	432 19.00	34-20.32	81-20.05	2.82	0.51	9	130	3.6	0.07	0.3	1.3	B1
821015	848 58.56	34-20.81	81-20.25	2.15	-0.60	8	138	4.2	0.02	0.1	0.2	B1
821015	850 17.13	34-20.25	81-20.67	1.77	-0.86	9	132	4.5	0.06	0.3	1.2	B1
821017	349 42.62	34-18.50	81-17.53	1.85	-0.60	9	132	2.6	0.05	0.3	0.5	B1
821020	540 51.46	34-20.09	81-17.84	2.27	-0.40	7	237	0.4	0.05	0.8	0.4	C1
821107	3 7 52.22	34-19.32	81-16.89	0.33	0.37	9	130	1.7	0.05	0.2	0.6	B1
821116	1545 51.81	34-20.17	81-20.55	6.65	1.93	11	132	4.3	0.09	0.4	2.2	B1
821116	1934 48.75	34-19.72	81-20.27	1.13	0.87	10	136	3.9	0.07	0.3	0.2	C1
821118	1150 4.11	34-20.11	81-17.46	2.27	-0.40	10	122	0.6	0.09	0.4	0.3	B1
821124	815 0.23	34-20.01	81-17.84	2.77	-0.86	10	119	0.2	0.06	0.3	0.3	B1
821124	930 56.97	34-20.01	81-19.09	4.24	0.29	12	126	2.1	0.09	0.4	0.5	B1
821124	1022 4.32	34-20.09	81-19.17	1.74	0.44	10	126	2.2	0.06	0.2	0.5	B1
821126	616 8.79	34-20.01	81-19.46	0.88	-0.60	8	175	2.6	0.07	1.1	7.0	C1
821126	914 52.08	34-20.69	81-20.72	1.84	-0.11	8	193	4.8	0.03	0.4	2.5	C1
821127	1340 14.52	34-19.58	81-20.80	1.81	0.51	6	163	4.7	0.04	0.8	0.5	C1
821127	1450 52.97	34-19.65	81-20.65	3.25	0.57	8	160	4.5	0.02	0.1	0.3	B1
821202	13 6 0.61	34-19.48	81-18.46	0.33	0.12	7	242	1.4	0.04	0.5	0.5	C1
821219	1120 7.61	34-20.01	81-19.36	1.82	-0.60	7	128	2.5	0.04	0.2	0.5	B1
821221	1643 17.15	34-16.37	81-14.45	0.30	0.95	5	286	1.9	0.02	0.6	0.8	C1
821223	931 14.20	34-19.03	81-16.30	1.37	-0.24	6	142	2.7	0.06	0.6	1.8	B1
821229	155 44.55	34-20.33	81-17.91	2.67	-0.40	6	122	0.8	0.09	0.6	0.7	B1