— NOTICE —

REPORT ON THE PRELIMINARY INVESTIGATION OF SEISMICITY NEAR LAKE KEOWEE, OCONEE COUNTY, SOUTH CAROLINA DECEMBER 30, 1977 - JANUARY 15, 1978

by

Pradeep Talwani, Principal Investigator

Don Stevenson, David C. Amick and Chaz Duc

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INTRODUCTION

While monitoring seismic activity near Lake Jocassee we noticed a series of events that appeared to be located about 15 or 20 km South of Lake Jocassee, and near Lake Keowee. The first flurry was noted on December 31, 1977 and when it persisted on January 1, 1978, a portable station was installed in the Lake Keowee area the next day. The seismicity appeared to increase, so on January 4, 1978 a network of five (5) portable seismographs was installed around the High Falls Church area (HFS in Fig. 1). This preliminary report documents the results obtained from the enlarged network for the period of December 30, 1977 to January 15, 1978.

INSTRUMENT DEPLOYMENT

The locations of stations of the lower or Keowee net are shown in Fig. 1 and given in Appendix I. The actual times (UCT) of deployment at these sites is given in Appendix II. During the course of this study the instrument at BL2 (Jocassee net) was removed on January 4, 1978 and used in the Keowee net. The other stations of the Jocassee net (KTS, BG3, PFS, and SMT) were not moved.

RESULTS

These results are necessarily preliminary and will undergo changes with more rigorous analyses.

A large number of events were recorded during the reporting period. (Table 1). To see if these were in any way related to water in the Lake Keowee, daily water level at Keowee (8 AM reading) was plotted and compared with the daily seismic energy release and daily number of events

Fig. 1

STATION LOCATIONS OF KEOWEE NET

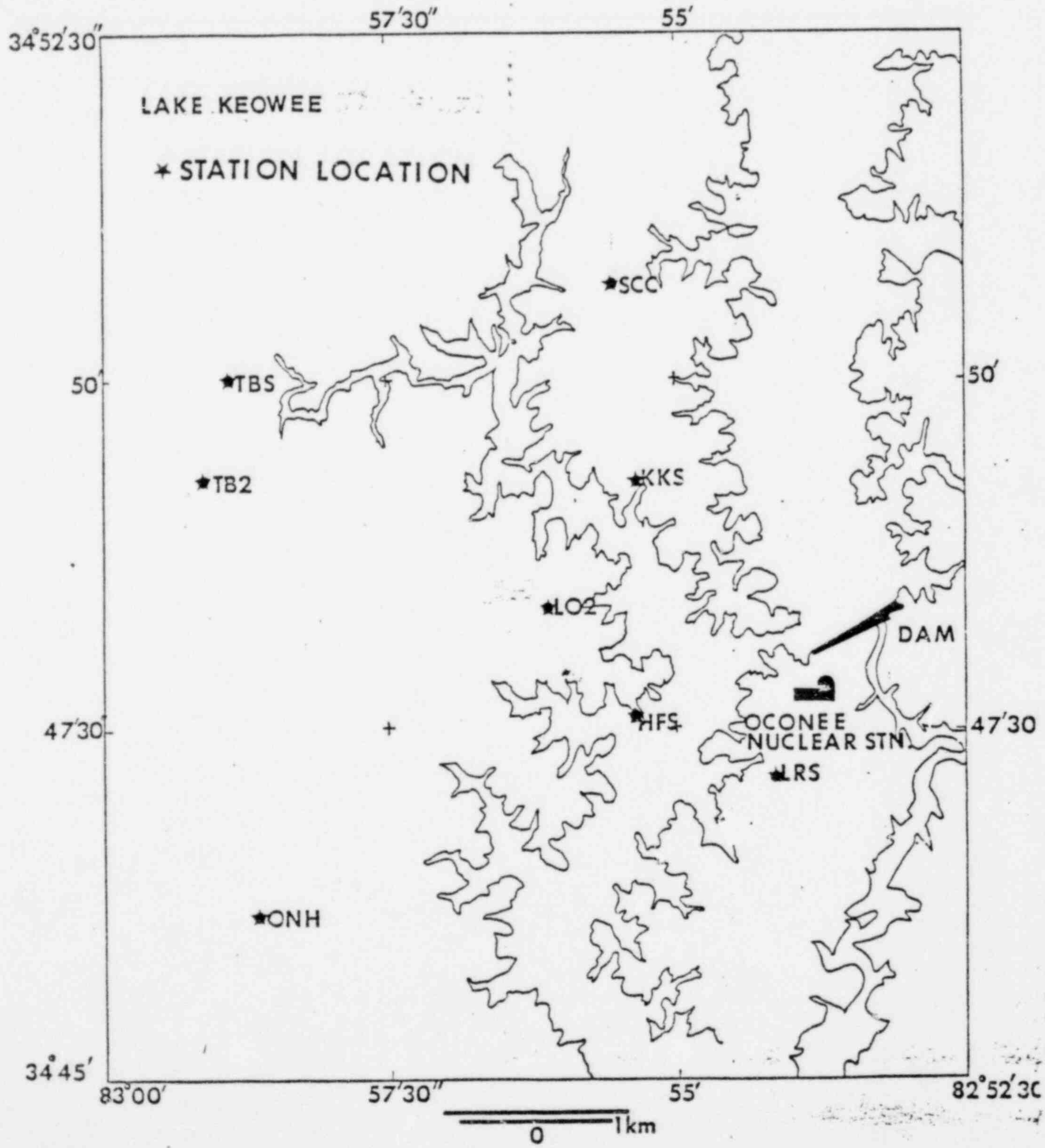


TABLE 1

NUMBER OF EVENTS IN KEOWEE AREA

DATE	NUMBER *
December 28, 1977	0
29	2
30	1
31	28
January 1, 1978	16
2	38
3	162
4	109
5	94
6	209
7	179
8	40
9	9
10	55
11	37
12	12
13	13
14	4
15	10
16	45

*Note: The number of events for the period (December 28 - January 2) are those recorded at the Jocassee net, while from January 3, 1978, events recorded in the Keowee net were used.

(Fig. 2.) For the number of events (up to 1/3) we had used those recorded on the Jocassee net (15 - 20 km away). Only the larger events were recorded, however when we consider the daily energy release the activity is large from December 30, 1977 to January 6, 1978 and then appears to die down. It appears to pick up again on January 16, 1978.

LOCATION OF SEISMIC ACTIVITY

For events occurring on December 30, 1977 - January 1 we used stations of the Jocassee net, while for later events data from both nets were used. When using only Jocassee data, we had poor depth control and computed depths were > 2 km (see Appendix III). However, when we used data from the Keowee net, most of the hypocenters were found to be ≤ 1 km deep. (Fig. 3). Though we have recorded several hundred events, only 68 were located. Some of the larger events, recorded on both networks were located by using data from both networks and from the Keowee net alone. While the locations did not change by more than 200 m, the depths changed from 30m to 1 km. So while plotting vertical cross sections and composite focal mechanisms, data from the Keowee net was used. The events plotted in Fig. 3 were chosen such that there were some events for each day.

The epicenters define a NW - SE trending elliptical zone whose axes are about 3 km and 2 km. A NW - SE vertical cross section AA' through this zone is shown in Fig. 4. The hypocenters suggests a NE striking plane, dipping about 50^0 to the SE.

GEOLOGY OF THE EPICENTRAL AREA

The seismicity lies in the middle of the U.S. Geological Survey's Old Pickens quadrangle. Griffin (1973) has mapped the geology of this

Fig. 2

Lake Level at Keowee dam, compared with daily seismic energy release andnumber of earthquakes.

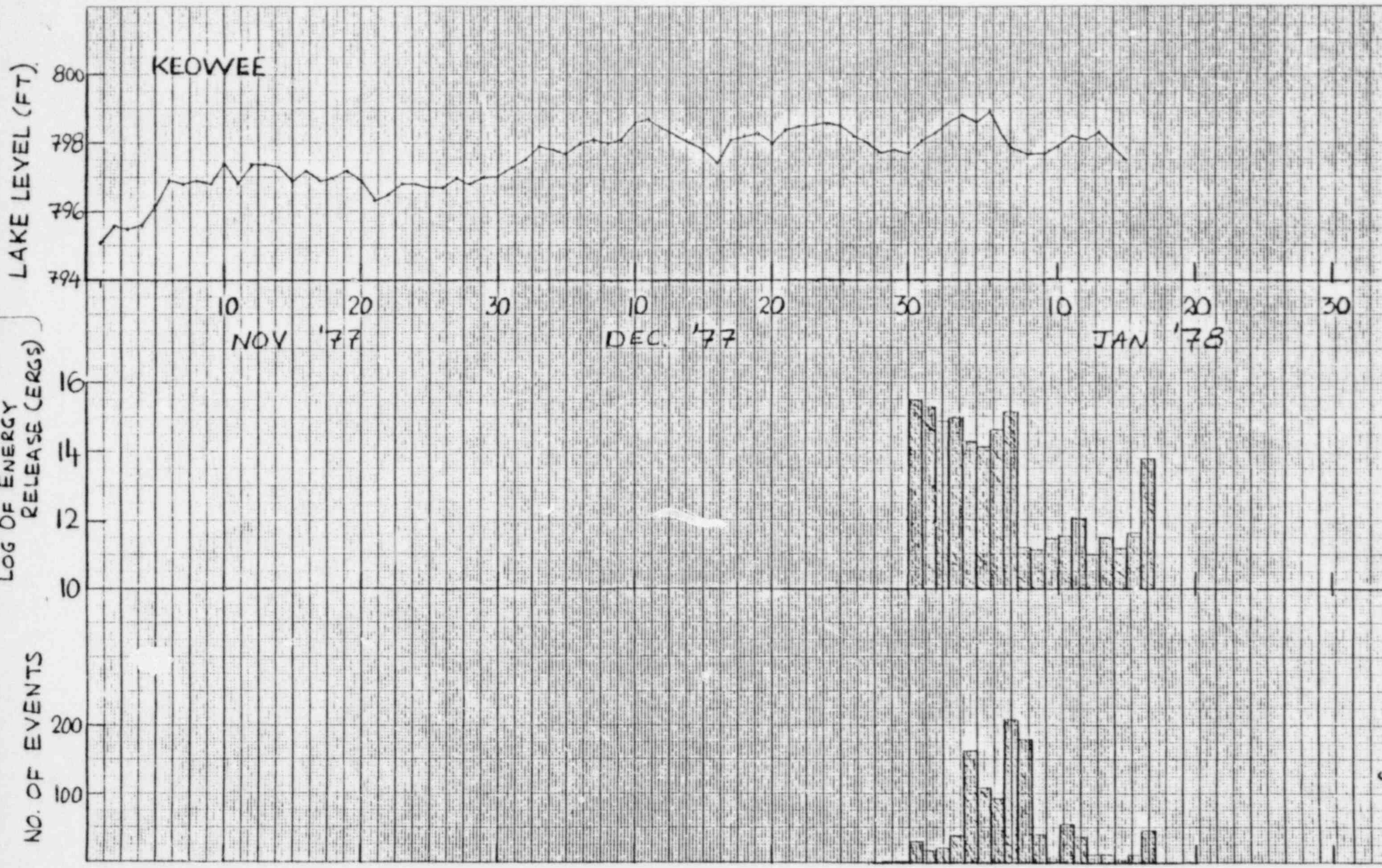
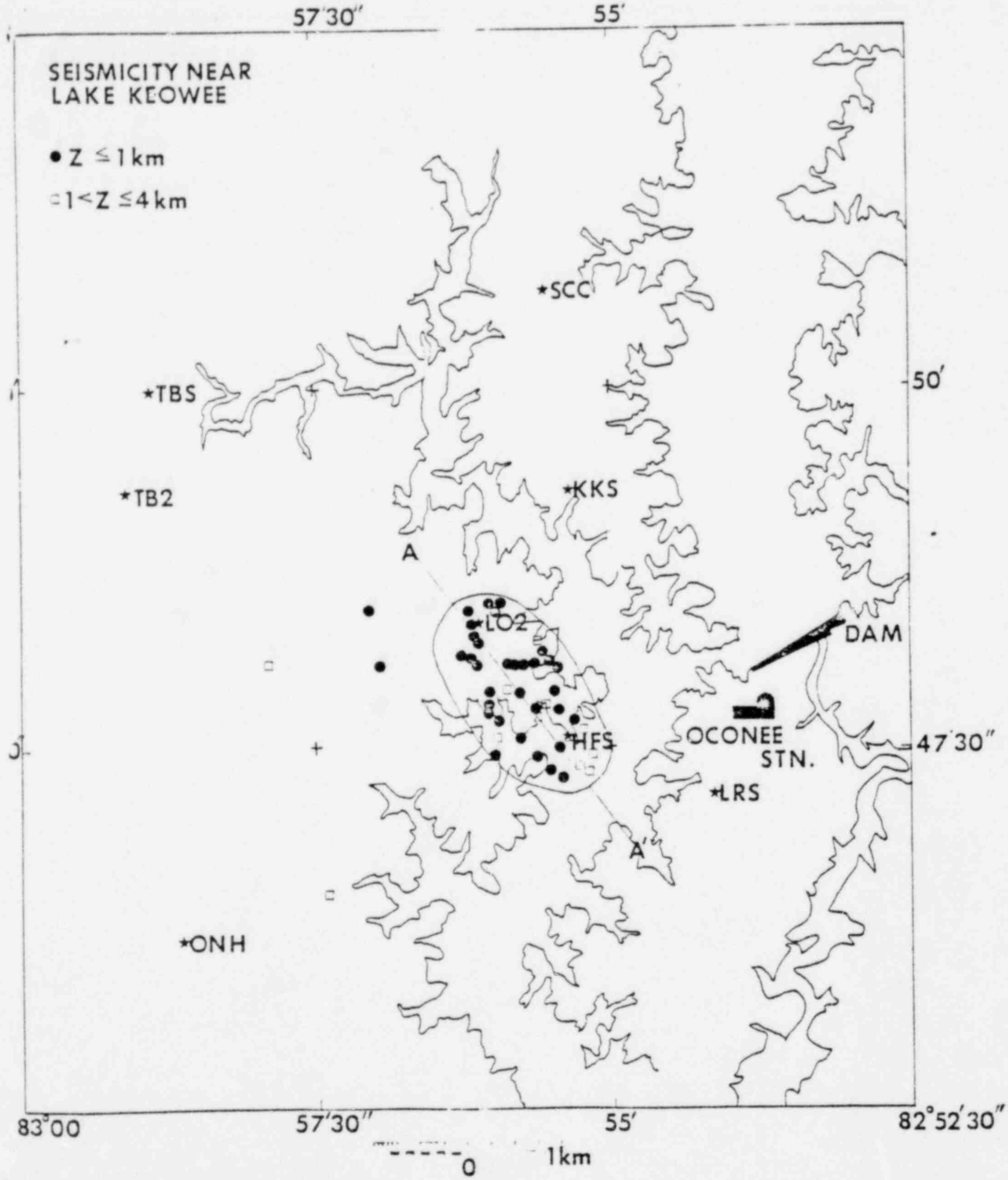


Fig.3



Locatic: of Seismic activity near Lake Keowee (December 30, 1977 - January 16, 1978)

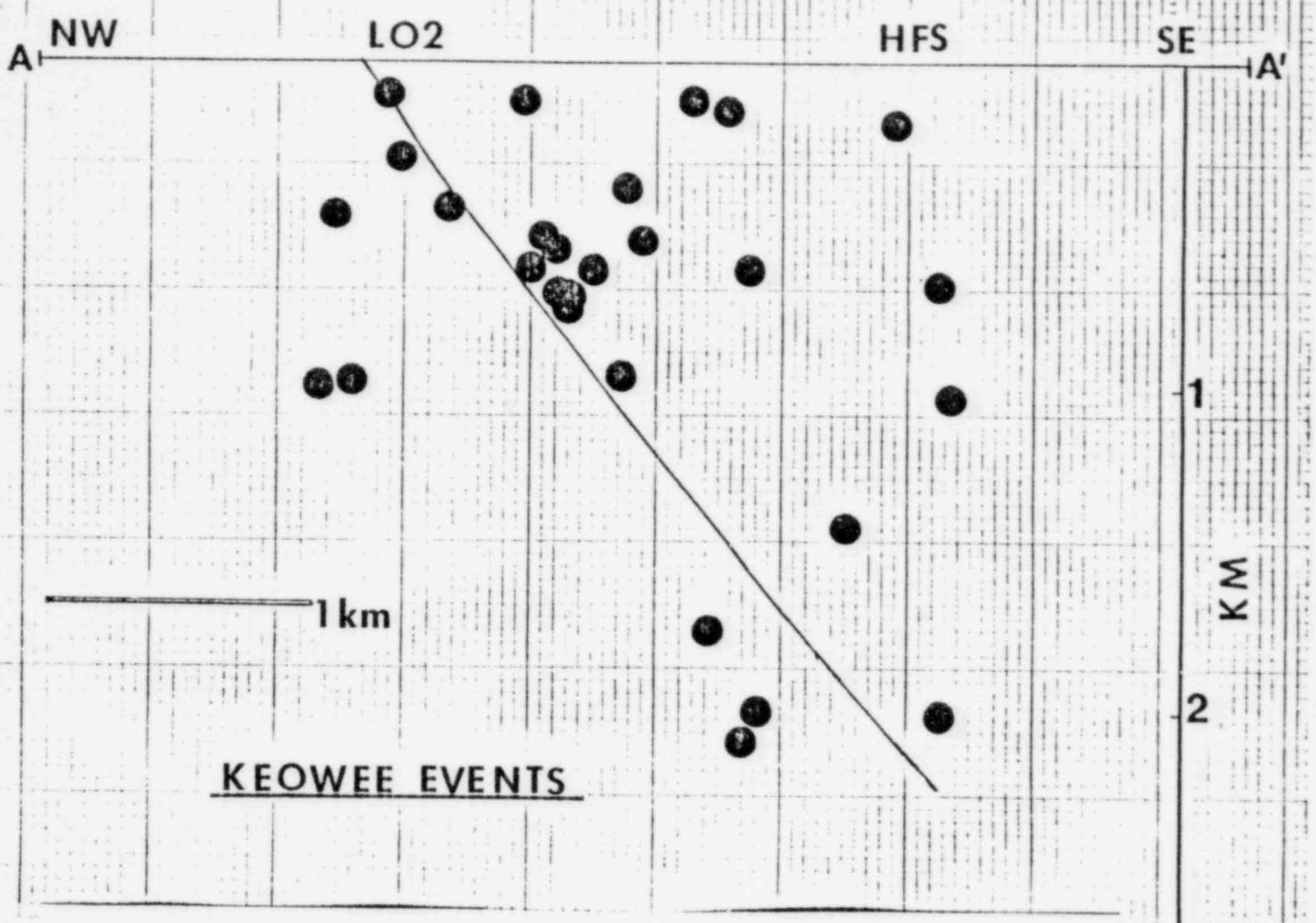


Fig. 4 VERTICAL CROSS SECTION ALONG AA'

quadrangle. In the epicentral area the rocks are primarily amphibole and granitoid gneisses. A look at the geologic map does not suggest any feature to which seismic activity could be associated. (Fig. 5) A geologic cross section along a line parallel to AA' and about 500 m to its NE is shown in Fig. 6. It is not easily apparent if the seismicity is associated with the contact of the amphibolite (and amphibole gneiss) and granitoid gneiss units. The seismicity is perhaps associated with jointing of rocks. Bryant (as reported in Griffin, 1973) studied the joints along the Little River, about 2 km south of the epicentral area. He found that the joints are separable into systematic and nonsystematic sets. The systematic joints consist of four sets of conjugate shear joints. The strongest set strikes N 45^0 E and dips 58^0 NW. The next strongest set strikes N36^o W and dips 75^o SW. The two lesser systematic joint sets have strikes of N55^{0}E and N85^{0}E. Generally, these joints are steeply dipping.

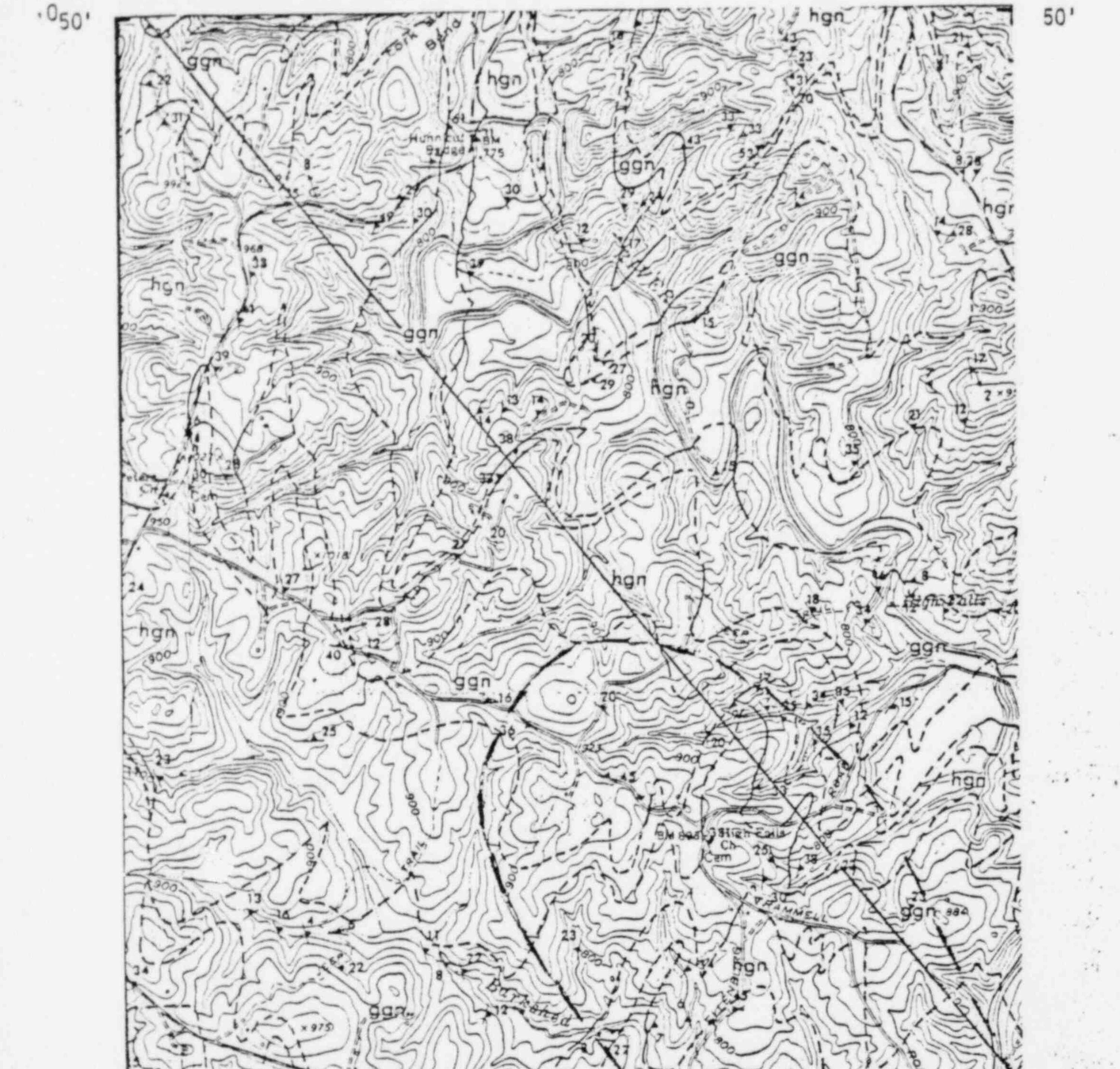
COMPOSITE FAULT PLANE SOLUTION

A composite fault plane solution using events lying on a plane indicated in Fig. 4 is shown in Fig. 7. It indicates normal faulting along a plane striking NE.

EARLIER SEISMIC ACTIVITY IN THE EPICENTRAL AREA

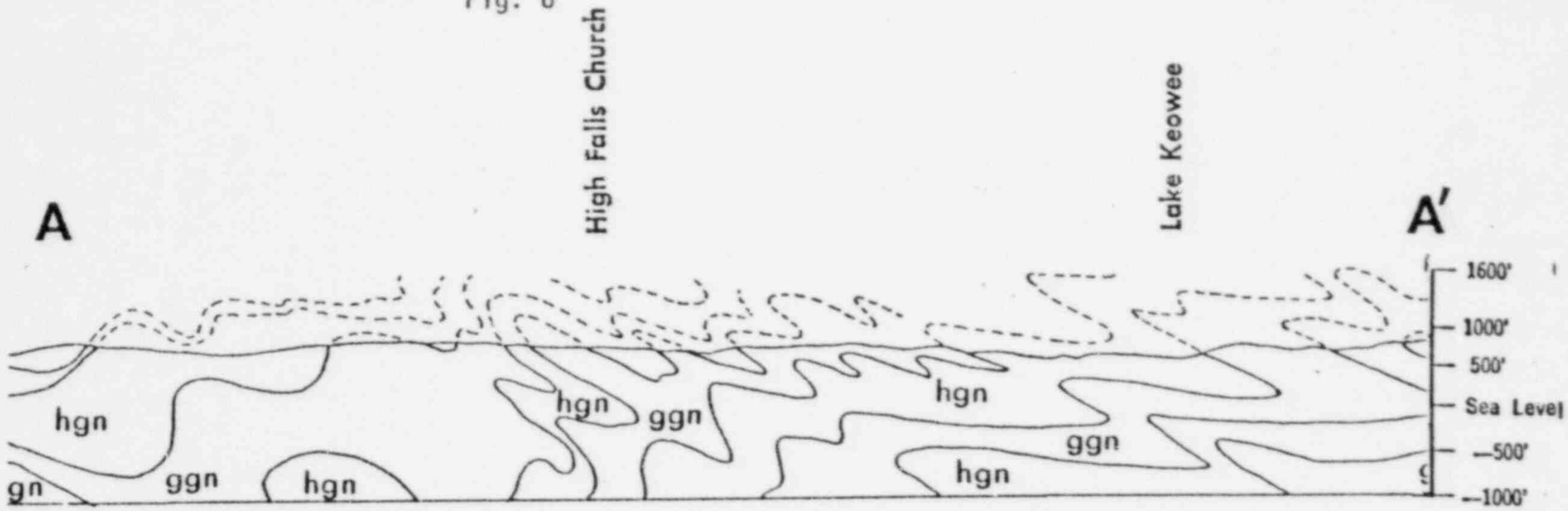
The seismic activity reported above appeared to have started suddenly. Though only low level seismicity was observed ($M_l \leq 2.2$), its proximity to the Oconee Nuclear Station and Keowee Dam (about 3 km to the East) prompted a search for earlier activity in the area.

Fig. 5



Portion of the geology map of the old Pickens quadrangle (due to Griffin, 1973). The location of seismcity is shown by the ellipse.

Fig. 6



EXPLANATION

hgn	AMPHIBOLITE AND AMPHIBOLE GNEISS
ggn	GRANITOID GNEISS

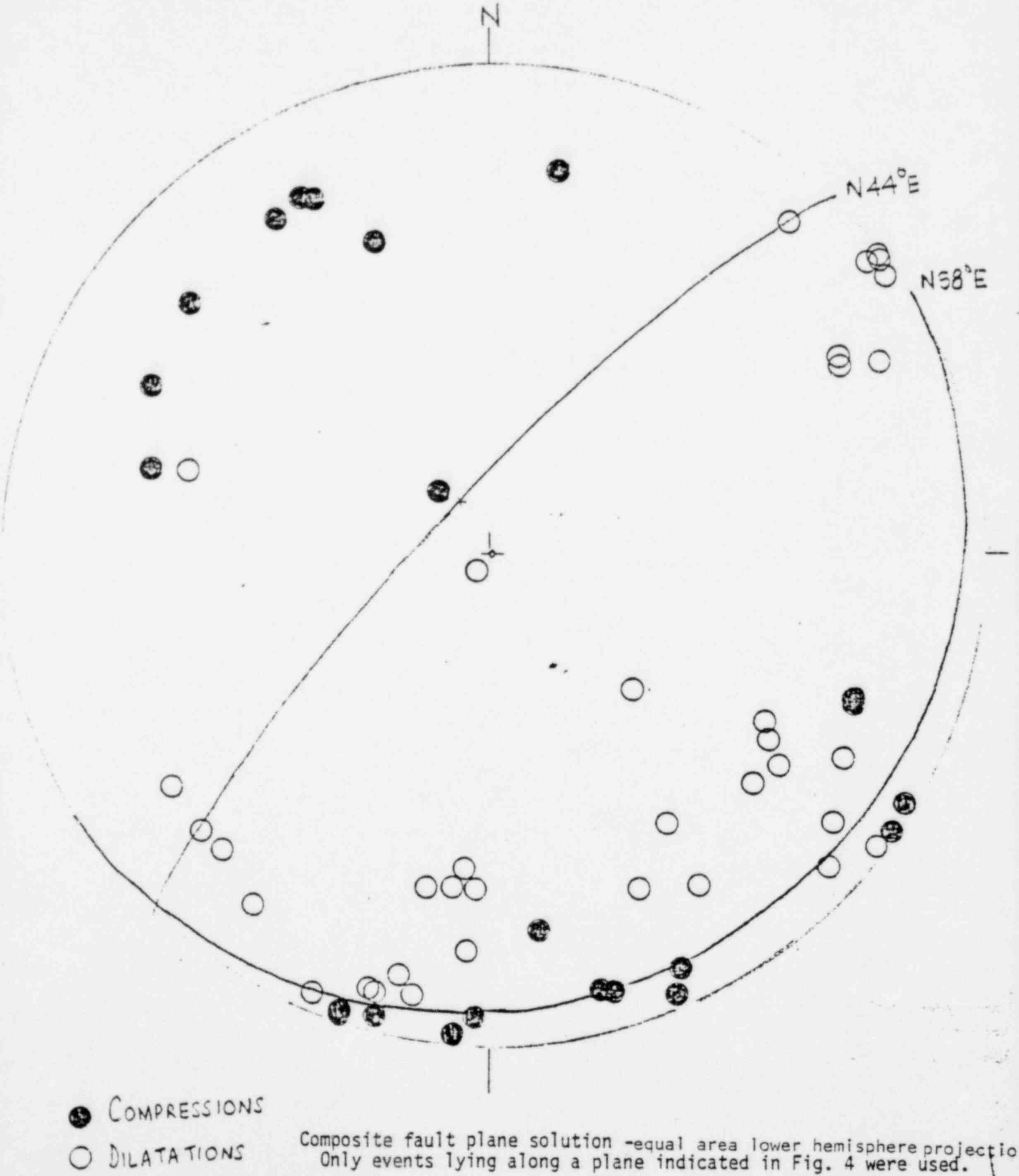
GEOLOGICAL CROSS SECTION ALONG A LINE PARALLEL TO AA' AND 500 ft. TO THE NE.

FROM:

GEOLOGY OF THE OLD PICKENS QUADRANGLE, OCONEE AND PICKENS COUNTIES, SOUTH CAROLINA 1973

Geology by Villard S. Griffin, Jr., with field assistance from Thomas M. Goforth, Furman D. Bryant, and Louis L. Acker

Fig. 7



Composite fault plane solution -equal area lower hemisphere projectio
Only events lying along a plane indicated in Fig. 4 were used.

We have been recording seismic activity near Lake Jocassee for over two yesrs. Events in the Lake Keowee area near the High Falls church write characteristic signals on the seismographs of the Jocassee seismographic network with a S-P time of about 2 seconds. So we examined our records for the past two years for events recorded by the Jocassee network that might have come from Lake Keowee area. The detection threshold is about M_l= 1.0. This then provided an idea of background activity at that threshold level. A list of events is given in Table 2. The last four events with $M_l \sim 0$ were detected on two or more stations and were comparable in detail with those recorded in January 1978. We note there were 9 events with $M_l > 1.0$ in 1977, although 7 of them were concentrated in a three week period (July 5- July22, 1977). This indicates the possiblility of an earthquake swarm in July 1977 in the same epicentral region.

THE "SENECA" EARTHQUAKE OF JULY 31, 1971

The cause of the swarms in January 1978 and July 1977 was an enigma till we examined closely some of the data pertaining to the 'Seneca' earthquake of 1971.

The descriptions of this event which occurred at 07:42 (EST) on July 1[illegible], 1971 has been examined from various sources. A MM intensity VI was assigned to the event by USGS (Appendix IV) based primarily on the report of a cracked chimney near Newry, about 10 km south of the present epicentral area. A detailed examination of the buildings and chimneys by Sowers and Fogle (1978) convinced them that the chimneys in question had been broken and in a state of disrepair before the shock. They assigned an intensity IV (MM) to the shaking at Newry. IntensityIV was also assigned to areas west of the Keowee dam, the site of the present activity, see

TABLE 2

POSSIBLE KEOWEE EVENTS RECORDED AT SMT

S- P 1.90 - 2.20 seconds

DATE	TIME	MAGNITUDE
760622	06:36:29	1.64
760705	23:02:08	1.64
760711	01:17:15	1.18
760714	04:00:00	1.65
	12:15:00	1.74
760717	01:49:00	1.06
760720	23:51:00	1.06
760722	15:00:00	1.32
760916	19:55:00	1.44
770404	10:28:08	1.54
770715	22:08:47	0.01
771212	06:21:03	0.01
771217	23:37:04	0.01
771219	10:38:21	0.01

Fig. 8 which is taken from their report. Bollinger (1972) also assigned a MM intensity IV to this event (Fig.9). From the intensity map prepared by Sowers and Fogle (1978) based on interviews at 32 locations, it appears that the area of maximum intensity (IV) is located at the same place as that of the present activity. The agreement suggests that the present epicentral area has had a history of activity.

Based on the intensity map, Bollinger (1973) estimated the epicenter to be at 34.7°N 82.9° W, while Long (1974) obtained 34.76° N 82.88°W. The latter location was based on the recordings at ATL, BLA (WWSSN stations) and one portable recorder kept at the Visitor's Center near Keowee Dam. The location accuracy (Long, personal communication) is ±15 km, and the epicenter locates about 7 km SE of the present activity.

The "Seneca" earthquake was assigned M_{lg} 3.79 and M_{evs} 3.06 by Bollinger (1972) (See also Appendix V).

We suggest that the epicentral location based on detailed macroseismic studies by Sowers and Fogle (1978) is perhaps more accurate than those based on instrumental - mailed questionnaire data of Bollinger (1972). This location coincides with that of the present activity, suggesting that the activity in the Lake Keowee area has been occurring at least since July 1971.

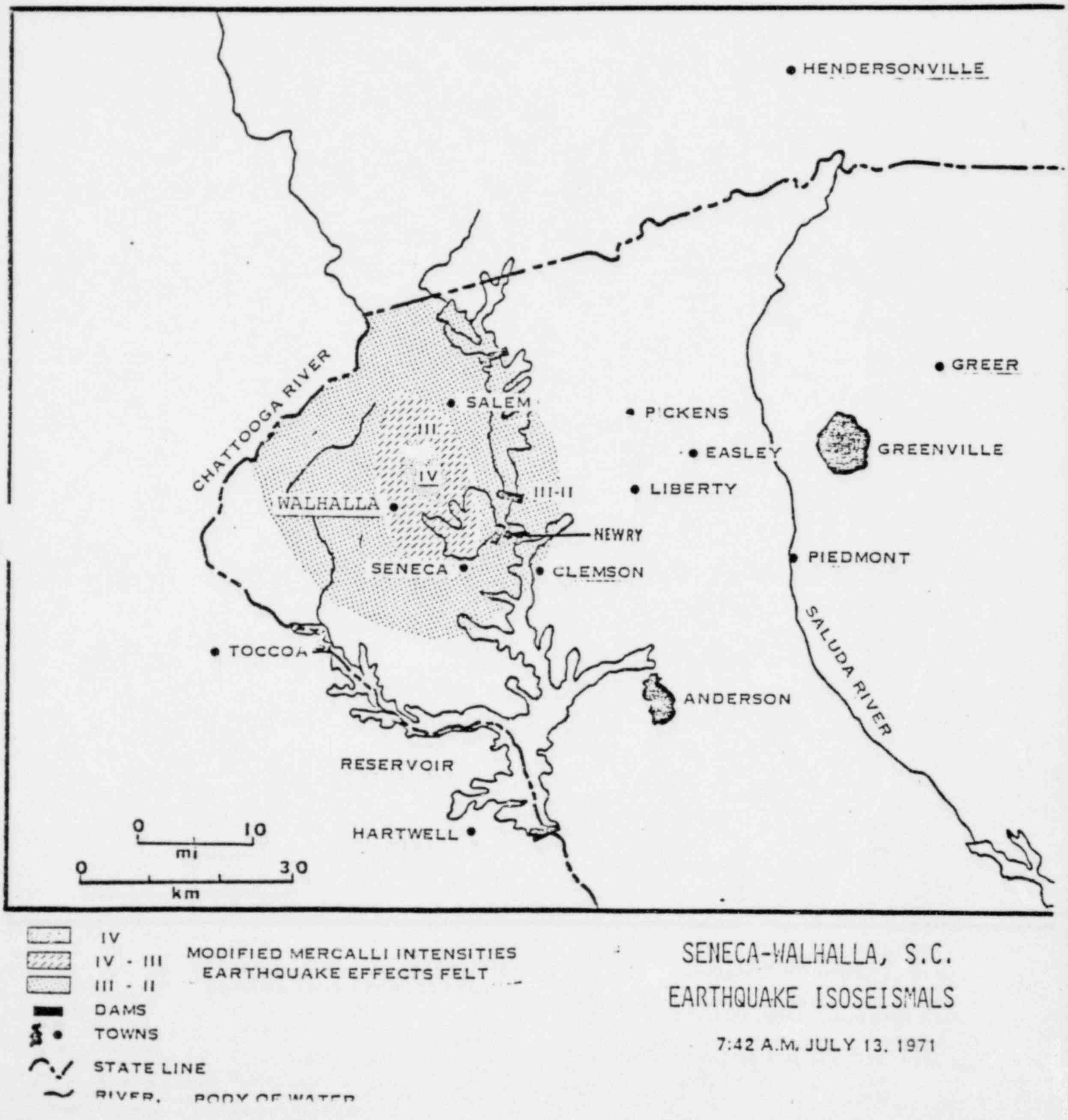
The July 13, 1971 event at 07.42 AM EDT was preceded by a felt shock at about 4:15 AM EDT and followed by at least one felt aftershock at 7:45 AM (Sowers and Fogle, 1978).

ON THE CAUSE OF THESE EARTHQUAKES

A brief search revealed that in addition to the event on July 13, 1971, a felt tremor was felt in the same area on Dec 13, 1969. That tremor had been associated with slumping of land on the shores of Keowee river.

We examined the filling history of Lake Keowee which consists of two sub-impoundments formed by separate dams on the Keowee and Little Rivers and

Fig. 8



SENECA-WALHALLA, S.C.
EARTHQUAKE ISOSEISMALS

7:42 A.M. JULY 13, 1971

From Sowers and Fogle (1978)

HISTORICAL AND RECENT SEISMIC ACTIVITY IN SOUTH CAROLINA

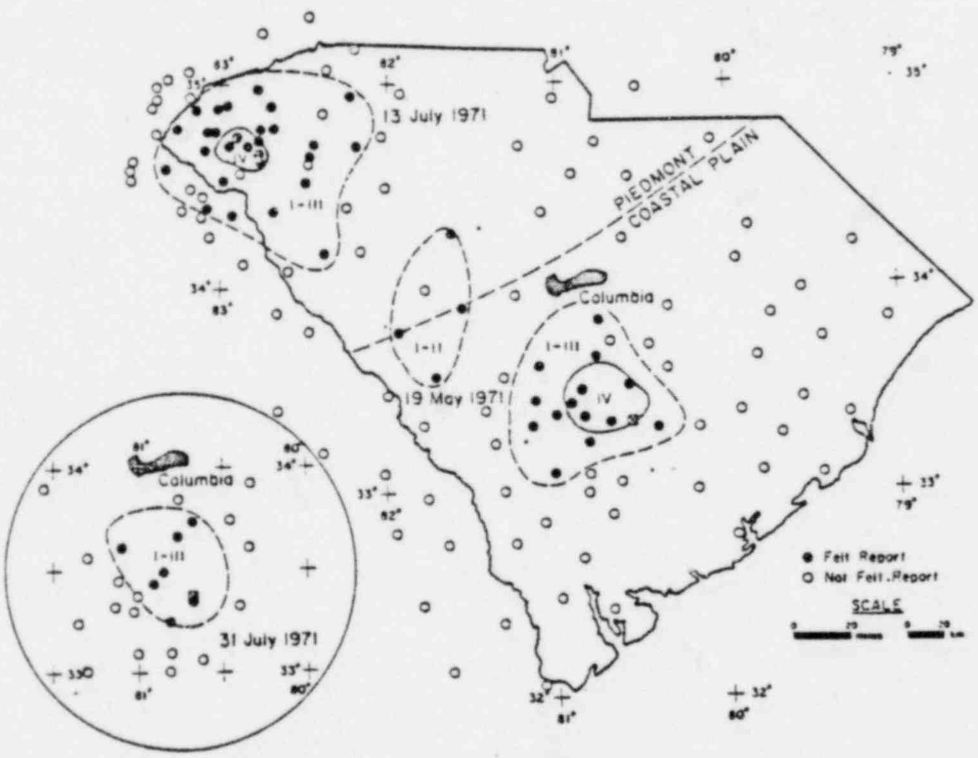


Fig. 9 Isoseismal maps for three of the 1971 South Carolina earthquakes. ⊠ indicates instrumental epicenter.

Fig. 9

From Bollinger (1972)

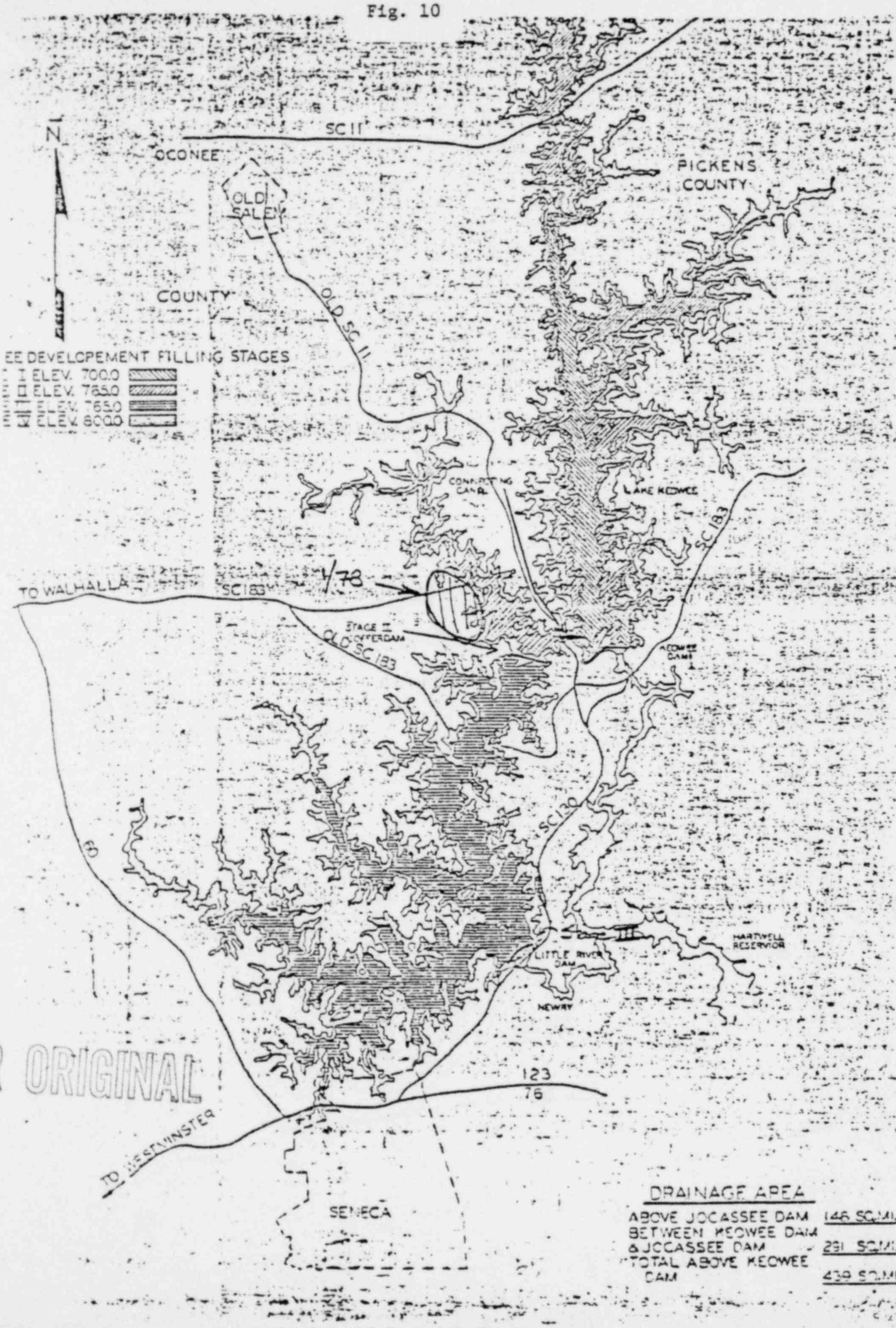
a connected by a canal through a natural saddle to form a single large reservoir (Fig. 10). Reservoir filling was done in four stages.(See also Fig. 11).

Stage I: The connecting canal was excavated to elevation 700, after which cofferdams above the Keowee damsite were closed and raised to elevation 725. This closure took place on May 1, 1968. By May 11, 1968, water impounded in the Keowee basin rose to elevation 700 so that the entire flow of the Keowee was diverted into the Little River. During this stage the Keowee Dam was completed to elevation 775, the Keowee intake was completed and closed with cylinder gate, and the spillway at Keowee was completed and made operable.

Stage II: A cofferdam was placed across the Little River downstream of the connecting canal and raised to elevation 775. Closure of this Stage II cofferdam took place on April 1, 1969, after which water impounded in the Keowee basin and the upper Little River basin rose to elevation 767 by June 15, 1969. Surplus flow was discharged through the spillway to hold the level at about 767+ until October 11, 1969, when the water elevation was lowered to 752.5 due to opening of the Stage II Regulator.

Stage III: With Stage II cofferdam reducing the flow into the lower Little River basin, closure of the cofferdam above the Little River damsite was made on April 24, 1969. Construction of the Little River Dam was completed to elevation 815 on October 1, 1969. Placement of riprap and other slope protection on Little River Dam and paving of S.C. Highway 130 across dam continued through 1969 construction season. On October 11, 1969, the water elevation rose to 752.5 due to the interconnection and leveling of Stages II and III pools.

Fig. 10



LAKE KEOWEE FILLING PLAN

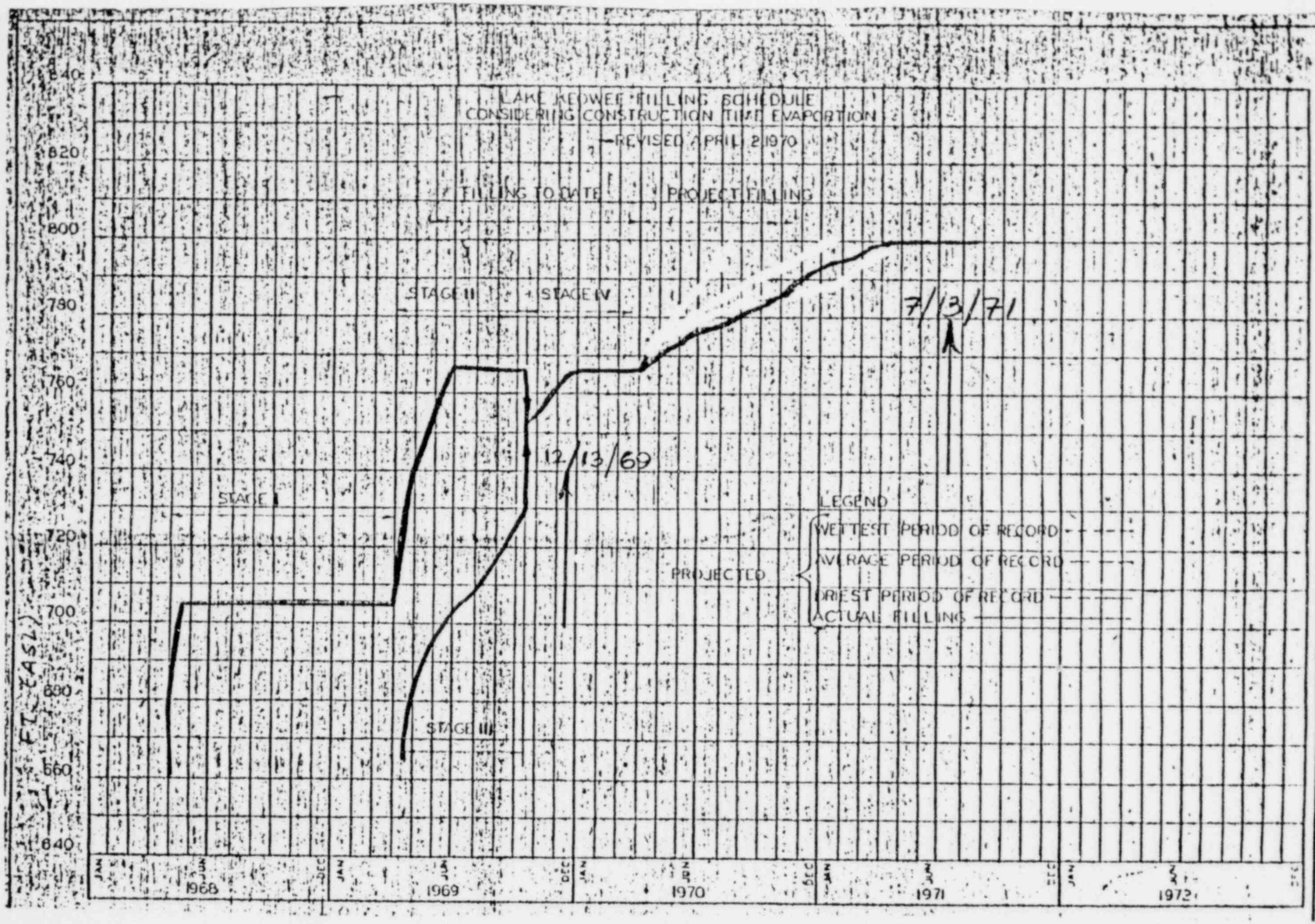


Fig. 11

POOR ORIGINAL

<u>Stage IV</u>: The reservoir began filling as a unit on October 11, 1969. The reservoir water level was maintained at elevation 767$\pm$ by manipulating the spillway gates from mid-December 1969 to April 2, 1970, when all the spillway gates were closed. The reservoir reached its full elevation of 800 by mid-April 1971.

On Fig. 11 we have also indicated the time of two felt events on December 13, 1969 and July 13, 1971. Both the events followed periods of rapid filling, and there is a suggestion of a relationship between the two.

CONCLUSIONS

The activity has decreased markedly from its peak in the first week of January 1978. If some of the above observations are valid, then we have a situation where seismicity followed impoundment. Its apparent dormancy in the following six years could perhaps be attributed to a lack of seismic instruments in the area. The cause of the swarm like activity is not readily apparent, local geology certainly does not offer immediate clues. It is possible that the jointed nature of rocks is responsible - but we need to study various parameters in detail before the cause of the activity is understood. However from the swarmlike nature of the activity and its low level size ($M_l < 2.5$) it does not appear to be of any danger to the Oconee Nuclear Facility.

REFERENCES

Bollinger, G.A. (1972) Historical and recent seismic activity in South Carolina, Bull. Seism. Soc. Am. 62, 851-864.

Coffman, J.L. and von Hake, C.A. (1973) Ed. U.S. Earthquakes in 1971. 176 pp.

Griffin, V.S., (1973), Geology of the Old Pickens Quadrangle South Carolina MS-18 Div. of Geology, S.C. State Development Board, Columbia, S.C.

Long, L.T. (1974) Earthquake Sequences and b values in the South East U.S., Bull. Seism. Soc. Am., 64, 267-273.

Sowers, G.F., and Fogle, G.H. (1978) Seneca, South Carolina Earthquake, July 13, 1971 (submitted to Earthquake Notes).

A P P E N D I C E S

APPENDIX I

STATION LOCATIONS OF KEOWEE NET

No.	Stn.	Lat. N.	Long. W.
1	ONH	34°46.19	82°58.64
2	KKS	34°49.29	82°55.33
3	TBS	34°49.97	82°58.89
4	SCC	34°50.69	82°55.53
5	LOG	34°48.46	82°56.61
6	LO2	34°48.35	82°56.15
7	TB2	34°49.27	82°59.11
8	LRS	34°47.16	82°53.64

APPENDIX II

SEISMOGRAPH DEPLOYMENT AT LAKE KEOWEE

DATE	ONH DN	ONH UP	KKS DN	KKS UP	TBS DN	TBS UP	TB2 DN	TB2 UP	SCC DN	SCC UP
JANUARY										
1										
2		18.44								
3	19.25	19.51		18.24						
4	20.11	20.23	18.51	18.53		13.19				13.59
					18.26	18.30			20.44	20.48
5	19.34	19.36	20.59	21.01	19.09	19.17			21.55	22.49
6	17.57	18.01	17.38	17.41	17.33	17.36			17.15	
7	16.30	16.33	17.23	17.25	15.53		16.13	----		
8	18.05	18.12	17.00	17.06			18.20	18.44		
9	18.47	DOWN	18.38	18.39			18.29	19.33		
10	DOWN	17.22	17.50	17.55			16.53	16.58		
11	15.40	15.45	16.24	16.27			15.23	15.27		
12	15.48	15.58	16.44	17.00			16.30	16.34		
	21.53	22.33								
13	17.00	17.12	17.40	17.50			16.40	16.42		
14	18.51	18.54	18.16	18.19			18.44	19.13		
15	19.26..		20.02				19.07			

DATE	LO2 DN	LO2 UP	HFS DN	HFS UP	LRS DN	LRS UP
JANUARY						
1						
2						
3						
4		19.53				
5	20.04	20.08		20.22		
6	18.20	18.22	18.01	18.05		
			21.04	21.07		
7	17.05	17.11	16.52	16.54		
8	17.24	17.33	17.44	17.47		
9	19.09	19.27	05.00			20.42
10	17.07	17.09			16.53	16.55
11	16.05	16.13			16.39	16.45
12	16.18	16.32			17.23	17.25
13	17.28	17.32			18.04	18.06
14	18.32	18.35			18.02	18.05
15	19.46				19.41	

APPENDIX III

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 assuptions 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
771230	2226 58.36	34-50.52	82-55.62	2.81		5	306	10.6	0.02	2.4	3.6	C1
771231	1321 8.17	34-45.70	82-55.12	3.79		5	329	19.3	0.02	7.0	7.1	D1
780101	4 3 42.99	34-38.88	82-58.36	3.90		5	341	31.4	0.08	19.9	18.4	D1
780101	1419 22.68	34-36.51	82-54.49	2.83		5	343	36.1	0.02	25.2	31.3	D1
780102	1552 6.84	34-56.10	82-55.44	1.00		5	171	3.6	0.41	5.6	59.4	D1
780102	1911 32.26	34-46.29	82-58.73	3.83		4	212	0.2	0.42			D1
780103	058 30.39	34-46.29	82-55.50	7.34		5	256	4.8	0.07	14.9	24.6	D1
780103	121 21.38	34-48.07	82-57.18	1.00		3	189	4.1	0.00			C1
780103	137 7.59	34-45.07	82-56.53	1.00		3	288	3.8	0.03			C1
780103	139 4.83	34-47.55	82-55.97	3.46		5	222	4.8	0.02	0.2	0.7	C1
780103	156 25.42	34-46.46	82-57.42	0.73		5	234	1.9	0.09	5.8	30.3	D1
780103	442 20.52	34-47.64	82-55.23	1.93		5	231	5.8	0.01	1.1	6.6	D1
780103	1150 18.32	34-47.47	82-55.13	3.81		5	235	5.8	0.02	2.7	8.1	D1
780103	1218 56.36	34- 8.84	82-55.98	0.72		5	353	69.2	0.26	588.05	75.2	D1
780103	1251 58.24	34-47.36	82-55.21	1.99		4	324	16.3	0.07			C1
780103	1655 46.96	34-50.67	82-55.99	1.00		3	304	10.8	0.00			C1
780103	2027 17.17	34-47.73	82-55.70	0.97		5	223	2.9	0.05	1.5	3.3	C1
780103	2329 27.40	34-48.09	82-55.43	0.98		5	221	2.2	0.02	0.8	1.2	C1
780104	026 50.28	34-48.16	82-55.57	0.75		5	217	2.1	0.00	0.0	0.0	C1
780104	046 26.40	34-47.89	82-55.43	0.17		4	224	2.6	0.03			C1
780104	1339 34.80	34-47.78	82-55.54	1.75		7	224	2.8	0.02	0.4	0.6	C1
780104	1341 35.12	34-47.87	82-55.77	1.00		3	220	2.7	0.01			C1
780105	048 55.87	34-47.96	82-56.01	0.27		5	208	0.7	0.01	0.1	0.1	C1
780105	457 27.98	34-48.11	82-56.25	0.08		5	193	0.5	0.02	0.3	0.5	C1
780105	457 28.01	34-47.97	82-56.25	0.19		7	198	0.7	0.08	0.8	0.8	C1
780105	525 44.86	34-48.22	82-56.18	0.04		6	192	0.2	0.01	0.1	0.2	C1
780105	525 44.87	34-48.16	82-56.13	0.07		8	196	0.4	0.03	0.3	0.4	C1
780105	6 1 1.90	34-48.17	82-56.14	0.29		5	195	0.3	0.01	0.2	0.2	C1
780105	659 44.09	34-48.06	82-55.87	0.11		6	211	0.7	0.03	0.4	0.5	C1
780105	7 0 45.84	34-48.33	82-56.16	0.45		5	188	0.0	0.01	0.1	0.1	C1
780105	1433 16.12	34-48.08	82-56.25	0.35		5	194	0.5	0.02	0.3	0.3	C1
780105	1838 5.46	34-48.08	82-56.18	0.34		5	197	0.5	0.01	0.3	0.2	C1
780105	1838 5.46	34-48.04	82-56.15	0.40		7	199	0.6	0.01	0.1	0.1	C1
780105	1856 46.24	34-47.54	82-55.76	0.64		5	229	1.6	0.02	0.4	1.2	C1
780105	1856 46.22	34-47.51	82-55.70	0.91		8	227	1.7	0.02	0.3	0.4	C1
780105	20 5 0.36	34-48.24	82-55.60	2.80		4	219	2.0	0.00			C1
780105	20 5 0.40	34-48.10	82-55.43	1.81		7	220	2.2	0.06	0.9	1.1	C1
780105	23 7 46.32	34-48.09	82-55.62	0.75		6	148	0.9	0.02	0.2	0.3	B1
780105	23 7 46.30	34-48.09	82-55.48	1.00		9	157	0.9	0.06	0.6	0.8	B1
780106	053 30.79	34-48.45	82-56.25	1.00		9	98	0.2	0.20	1.5	2.2	B1
780106	053 30.82	34-48.13	82-55.73	0.59		6	136	0.8	0.02	0.1	0.3	B1
780106	2 0 17.93	34-48.10	82-55.70	0.57		6	138	0.8	0.01	0.1	0.3	B1
780106	2 0 17.90	34-48.08	82-55.61	1.01		8	145	1.0	0.04	0.3	0.5	B1
780106	2131 18.57	34-48.07	82-55.75	0.57		7	132	0.8	0.02	0.2	0.4	B1
780107	2229 57.19	34-47.77	82-56.06	0.65		5	126	1.1	0.01	0.2	0.4	C1
780107	2240 6.79	34-47.71	82-56.04	0.16		4	214	1.2	0.01			C1
780107	2250 16.75	34-47.69	82-55.94	0.52		5	134	0.9	0.04	0.7	2.6	C1
780108	0 6 35.84	34-47.70	82-56.25	1.00		3	207	1.2	0.17			C1
780108	4 3 50.25	34-47.69	82-55.48	1.00		5	136	0.2	0.06	1.3	1.5	C1
780108	431 46.43	34-47.87	82-56.00	0.33		5	113	0.9	0.00	0.1	0.1	C1
780110	444 13.34	34-47.45	82-56.03	0.16		4	207	1.7	0.03			C1
780110	625 16.34	34-48.10	82-55.73	0.71		4	174	0.8	0.00			C1
780110	850 40.14	34-47.17	82-56.25	1.00		3	274	2.2	0.04			C1
780110	1229 7.95	34-47.67	82-56.25	1.00		3	279	1.3	0.02			C1
780110	1930 30.56	34-47.62	82-55.42	2.13		5	134	1.8	0.00	0.1	0.2	C1

780110	1931	44.26	34-48.50	82-56.96	1.00	3	209	1.3	0.00			C1
780110	1934	27.24	34-47.49	82-55.47	1.38	4	141	1.9	0.00			C1
780110	1956	21.63	34-47.48	82-55.57	0.06	4	141	1.8	0.03			C1
780111	347	2.86	34-46.77	82-55.29	1.00	5	184	2.6	0.04	0.8	5.0	C1
780111	837	7.63	34-47.33	82-55.50	0.19	4	150	2.1	0.01			C1
780111	846	2.52	34-47.42	82-55.62	0.37	5	145	1.9	0.04	0.4	0.8	C1
780111	1410	55.65	34-47.86	82-55.77	0.37	5	123	1.1	0.06	1.1	1.8	C1
780112	028	22.16	34-48.45	82-56.25	1.00	4	181	0.2	0.13			C1
780112	7 5	49.42	34-48.03	82-56.25	1.00	3	196	0.6	0.02			C1
780112	1641	44.22	34-48.45	82-55.99	1.00	3	191	0.3	0.02			C1
780113	923	50.74	34-48.45	82-55.70	1.00	3	301	0.7	0.03			C1
780113	1038	3.78	34-48.45	82-56.25	1.00	3	260	0.2	0.22			C1
780113	1410	42.17	34-47.57	82-55.72	1.99	4	137	3.2	0.04			C1
780113	18 6	1.25	34-48.45	82-55.92	1.00	3	195	0.4	0.03			C1
780114	541	37.06	34-48.45	82-57.09	1.00	3	210	1.4	0.08			C1
780114	1216	50.87	34-47.42	82-55.88	0.16	4	144	1.8	0.01			C1
780115	1850	48.64	34-47.29	82-55.43	0.70	5	153	2.2	0.04	0.1	0.8	C1
780115	19 3	57.17	34-48.25	82-56.32	1.00	3	282	0.3	0.00			C1
780115	1937	0.44	34-47.72	82-55.94	1.00	3	239	1.2	0.01			C1

APPENDIX IV

July 13: 03:15, 06:42:26.0 (CSC). Western South Carolina. VI. The main shock at 06:42 was felt over approximately 5,200 sq. km. (2,000 sq. mi.) of South Carolina and northeastern Georgia. A chimney cracked and furniture moved about at Newry, about 40 km. southwest of Greenville, S.C.

INTENSITY VI:

Newry.—Felt by and awakened all in community; frightened many. One chimney cracked (observer also reported no damage); furniture shifted. Entire house shook. Hanging objects swung violently. Very loud earth noises. "This was the strongest quake ever felt at Newry. Several families are making plans to move and leave their homes. . . because we are directly below this 185-foot earth dam [Little River Dam]."

INTENSITY V:

Anderson, Clemson, Norris, Pendleton, Princeton, Salem, and Westminster.

INTENSITY IV:

Belton, Cateechee, Central, Fair Play, Fountain Inn, La France, Mountain Rest, Pickens, Sandy Springs, Sunset, Tamassee, Wahalla, and West Union.

INTENSITY IV IN GEORGIA:

Hartwell and Toccoa.

INTENSITY I—III:

Cleveland, Greer, Liberty, Longcreek, Richland, Seneca, Six Mile, and Starr.

FROM U.S. Earthquakes in 1971 Ed. Coffman and von Hake

APPENDIX

Long (1971) conducted an aftershock survey in the Seneca area during July 16 to 20, 1971. He recorded approximately 40 events in the magnitude range $-0.3 < M_L < 1.2$. His WWSSN-ATL seismograms for July 13th showed 14 earthquakes in the magnitude range $2.0 < M_L < 3.2$ as either foreshocks or aftershocks of the main event.

TABLE 2*

EPICENTER DETERMINATIONS

Location and Date	VPI and SU	NOAA
Orangeburg, May 19, 1971	33.2°N-80.5°W 12h53m59.6s No. of stations, 6 S.D., 0.5sec Depth, surface (restricted)	33.3°N-80.6°W 12h54m03.4s No. of stations, 8 Depth, 25 km
Seneca, July 13, 1971	34.7°N-82.9°W estimated from Intensity Map. Readings would not converge—probably because of a small foreshock that interfered with the P wave arrival. L. T. Long (personal communication) gave an instrumental epicenter at 34.76°N-82.98°W. 89	
Orangeburg, July 31, 1971	33.2°N-80.6°W 20h16m51.7s No. of stations, 7 S.D., 0.3 sec Depth, surface (restricted)	33.4°N-80.7°W 20h16m55.6s No. of stations, 11 Depth, 25 km
Orangeburg, Aug. 11, 1971	Not enough readings to compute epicenter. Arrival times and $S-P$ intervals at BLA and ATL indicate Orangeburg Area. See Figure 9.	

TABLE 3

MAGNITUDE DETERMINATIONS

Location and Date	Station	Δ (km)	P_n A (mμ)	P_n T (sec)	M_{bn}*	Lg A (mμ)	Lg T (sec)	M_{bLg}†
Orangeburg, May 19, 1971	BLA	429.8	—	—	—	500	1.0	4.00
	ATL	351.8	28.8	0.6	3.50	395	0.7	3.88
	ORT	447.9	—	—	—	507	0.6	4.16
	CPO	524.0	—	—	—	260	0.3	4.31
Orangeburg, Jul. 31, 1971	BLA	427.0	12.5	0.3	3.63	373	0.8	3.84
Orangeburg, Aug. 11, 1971	BLA	430.0	—	—	—	182	0.9	3.53
Seneca, Jul. 13, 1971	BLA	430.0	11.2	0.6	3.06	480	1.0	3.79

* Evernden (1967).
† Nuttli (1969).

TABLE 4

INTENSITY SURVEYS

Orangeburg, May 19, 1971	Mailed questionnaires plus newspaper questionnaire printed courtesy of *The Times and Democrat* of Orangeburg. Felt reports, 32; Not felt reports, 131. Intensity IV in Orangeburg, Rowesville, Bowman, Elloree and Cordova where the typical effects were: houses shook; dishes, windows and other household objects rattled; a burglar alarm set off; rumbling sounds. Unconfirmed reports of one case of a cracked plate-glass window and of one case of cracked plaster. Isolated felt area to NW of main felt area, 3,?00 square miles (see Figure 10).
Seneca, July 13, 1971	Mailed questionnaires. Felt reports, 31; not felt reports, 50. Intensity IV in Seneca, Pendleton, Mountain Rest and Newry where the typical effects were: rattling of lamps, pictures and dishes; buildings and windows shook; canned goods knocked off store shelves; people awakened by the shaking of buildings and roaring sounds. Unconfirmed report of damage to old and weak chimneys in Newry. Felt area, 3,200 square miles (see Figure 10).
Orangeburg, July 31, 1971	Mailed questionnaires. Felt reports, 7; not felt reports, 60. Intensity III in Bowman, Cordova and North where the typical effects were: rattling of windows and doors, houses shaking. Felt area, 1,300 square miles (see Figure 10).
Orangeburg, August 11, 1971	No survey.

From: Bollinger (1972)