# Strong Motion Records from Miramichi, New Brunswick, 1982 Aftershocks

by

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Earth Physics Branch Open File Report 82-31
Ottawa, Canada, 1982

12 pp. and 83 figures



Price: $30.50

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## ABSTRACT

A magnitude 5.8 earthquake occurred in New Brunswick, Canada, on 9 January, 1982. Seven SMA-1 strong motion recorders were installed near the epicentral area within a month of the main shock. Seven earthquakes ranging from $M_N$3.4 to 4.8 resulted in 15 records at distances of 4 to 28 km. Copies of the 15 film record sections are given. Five records were of sufficient quality and amplitude to be processed with the standard strong motion package of the US National Strong Motion Data Center of the U.S. Geological Survey. For these records (15 components) we present the uncorrected and the instrument corrected, anti-aliased and filtered accelerations, velocities and displacements, as well as Fourier amplitude spectra of acceleration, and velocity response spectra. Uncorrected peak ground accelerations, both horizontal and vertical, ranged from a few per cent g to 33 %g. Prominent acceleration frequencies in the recordings averaged 24 Hz, with no dependence on magnitude. Some of the peak acceleration pulses have apparent frequencies well above the SMA-1's natural frequency where the instrument correction becomes critical, leading to amplification factors of 2 to 3 times the recorded accelerations.



## RESUME

Un séisme de magnitude 5,8 a eu lieu le 9 janvier 1982 au Nouveau-Brunswick, Canada. Sept accélérographes de type SMA-1 furent installés près de la region épicentrale moins d'un mois après le choc principal. Sept séismes de magnitude variant entre $M_N$ 3,4 et 4,8 fournirent quinze enregistrements à des distances variant entre 4 et 28 kilomètres. Des copies de ces quinze enregistrements sont présentées. Cinq de ces enregistrements étaient d'une qualité et d'une amplitude suffisamment bonnes pour être analysés par la méthode standard du centre national de données des mouvements forts des Etats-Unis appartenant au U.S. Geological Survey. Pour ces enregistrements (15 composantes) nous présentons les accélérations, les vélocitées et les déplacements non corrigés et corrigés pour les effets d'instrument, d'antirepliement et des filtres. Sont aussi présentés les spectres d'amplitude Fourier pour les accélérations ainsi que les spectres de réponse de vélocité. Les accélérations maximum du sol non corrigées, pour les composantes verticales et horizontales, s'étendent de quelque pourcent de g à 33% de g. Les fréquences dominantes d'accélération dans les enregistrements ont une moyenne de 24 Hz, indépendamment de la magnitude. Quelques impulsions d'accélération maximum ont des fréquences apparentes plus élevées que la fréquence propre de l'accélérographe où les corrections d'instrument deviennent critiques entrainant ainsi des facteurs d'amplification de deux à trois fois l'accélération enregistrée.

## INTRODUCTION

On 9 January 1982, a magnitude 5.8 earthquake occurred in New Brunswick, Canada, near 47.0°N and 66.6°W. The earthquake caused only slight damage in the epicentral area, but was felt at distances of up to several hundred kilometres. Large aftershocks of M5.1 and M5.4 occurred within a few days. Based on well-located aftershocks, this January sequence was concentrated near the main shock in an area 4 km NS x 6 km EW with depths ranging from 0 to 7 km. In an EW cross section the activity defines a "V" trend with a poorly defined eastern limb (Wetmiller et al.,1982). Most strong motion records were obtained during a second sequence that started on 31 March and was centred on the eastern limb of the January sequence, near 47.00°N, 66.57°W, in an area 2 km NS x 2 km EW with depths from 0 to 4 km. The 16 June earthquake occurred in an area 30 km west of the earlier sequences, with no earthquake activity detected between the areas (Wetmiller et al.,1982).

The Earth Physics Branch (EPB) of the Canadian Department of Energy, Mines and Resources (EMR) has operated a strong motion network in the seismically active regions of western Canada since 1961 (Rogers, Milne and Bone, 1970; Rogers, 1976; Shannon, Halliday, Schieman and Lombardo, 1981). In eastern Canada, the Division of Building Research of the National Research Council of Canada installed and maintains strong motion accelerographs in major population centers, important engineering structures, and in the well-known seismic zone of Charlevoix County, near La Malbaie, where the probability of capturing eastern Canadian strong motion data is highest. None of these instruments recorded the current New Brunswick earthquake series. When this series started EPB and the U.S. Nuclear Regulatory Commission cooperated in the installation of seven SMA-1 strong motion accelerographs. Another SMA-1 was added in May. The original installation proceeded in severe winter conditions and was completed during the period 3 to 7 February, utilizing existing hunting cabins and some less than ideal outdoor sites.(Munro and Pomeroy,1982). After the spring thaw, instrument foundation, anchoring and site improvements were made. The network has to date yielded a total of 15 records from 7 earthquakes at 6 sites. This report presents all strong motion records, and available relevant information on the earthquakes, sites and instruments.

Six of the 15 records are of sufficient amplitude and quality to justify digitization and computer processing. The last of these was recovered late in the summer and is only included in this report as a film copy. In the past, strong motion data from the EMR/EPB western network was digitized and processed in-house (Weichert and Milne, 1980). The desirability of standardized methods, algorithms and output formats, coupled with consideration of the economics of independent program development and maintenance, led to an arrangement with the US National Strong Motion Data Center (US NSMDC) in Menlo Park to utilize their existing computer programs and to include the present Canadian data in

that Center's archive of world-wide data. Copies of the raw digitized data can be obtained from the Center, or from the Division of Seismology and Geomagnetism, Earth Physics Branch in Ottawa.

## INSTRUMENTATION AND DATA

Table 1 lists the earthquakes and sites for which strong motion records were obtained. The depth of the 31 March earthquake was calculated as 4 km, but the depths of the other earthquakes were constrained to 4 km. Figure 1 shows locations of all accelerograph sites in relation to the active zones. Table 2 lists the site and instrument parameters for the sites at which records were obtained. Most instruments were well-calibrated 1 g full-scale SMA-1's, with natural frequencies near 25 Hz. The only exception was the SMA-1 at Bear Lake, site 7, which was 1/2 g full-scale, and about 18 Hz natural frequency. It also had an inoperative vertical component, and badly focused traces. The geometrical relations between earthquake epicenters, site locations and instrument axes are shown in Figure 2. Complete details of field work and logistics were described by Munro and Pomeroy (1982). Enlarged copies of the SMA-1 film records are reproduced in Figures 3 to 9, for all earthquakes and stations. Enlargement varies somewhat: the scale is 5 mm between time marks on film.

## DIGITAL DATA PROCESSING

Digital processing and plotting of the standard output traces was done in cooperation with the US NSMDC. Because of the extremely short signal duration (typically less than 1 s) and small film amplitudes, only 5 records were selected as suitable for digitization and further processing. One large amplitude record from the 31 March earthquake at Bear Lake, was rejected because of its poorly focused traces.

Digitization was done commercially by the IOM-TOWILL Co. of Santa Clara, California, with their automatic line-following laser beam device with operator interaction capability. Raw digitized data in US NSMDC-compatible format are available on 9-track computer tape. Digitization rate is approximately 600 points per second, spaced unevenly, for the 3 ground motion component traces and the reference traces.

The phases (stages) of digital processing have been described by Raugh (1980), and more detailed program descriptions are planned as an USGS Open File report. The program stages used for processing the present data have evolved from the programs developed in the early 1970's at the Earthquake Engineering Research Laboratory of the California Institute of Technology. In the first program stage, the digital data are baseline corrected and scaled into physical units, by subtracting the reference traces and multiplying by the instrument sensitivities. The time pulses are used to correct for variations of film drive speed. None of our records were longer than 8 s, so that each fitted into one digitization

frame; therefore the BUTTER procedure of joining frames together was unnecessary. Figures 10 to 14 show the accelerograms after this processing stage.

An evenly-spaced 600 pts $s^{-1}$ time series is generated in the next stage by interpolation between the unevenly spaced data points. This series is then convolved with an operator that simultaneously represents a cosine-tapered anti-alias filter, 50 to 100 Hz, and the instrument response correction for frequencies 0 to 50 Hz. The main effect of the latter is above the instrument natural frequency of about 25 Hz. Finally, the time series is decimated to 200 pts $s^{-1}$. Figures 15 to 19 show essentially the output from this stage, except for the effects of the high-pass filter discussed below.

Velocity and displacements are calculated by integration of the corrected acceleration. The linear least squares line (ramp) of velocity is subtracted from the velocity time series, and the slope of the velocity least squares line (the d.c. offset of the acceleration trace) is subtracted from the acceleration. This removes the largest part of low frequency content and offset from the integrated traces, which is due to the unknown initial conditions, or integration constants. However, further high-pass filtering is necessary. This is illustrated in Figures 20 and 21. In the unfiltered and in the 4-second filtered output, strong harmonics of the 8-second digitization window are clearly seen. There appears to be little justification to pass signal periods longer than the pulse of significant power, which is of the order of 1 s. All records were therefore high-pass filtered with a 1-second 4-th order (24 db slope) Butterworth filter. The slope was subjectively chosen to suppress the observed longer periods to an acceptable level. However, the resulting velocities and displacements, especially the latter, are still not free from spurious low frequency and dc contamination, so interpretation requires some judgement. Because of this, computer-generated and displayed peak values of velocity and displacement should be used critically. These corrected and filtered accelerations, velocities and displacements are displayed in Figures 22 to 36.

Fourier amplitude spectra of corrected and filtered acceleration are calculated by a fast Fourier transform. They are shown in Figures 37 to 66, plotted both on linear and logarithmic axes. Note that the dimensions of the abscissae have to be cm $s^{-1}$ because the intergrals are not normalized, i.e. not divided by the window lengths.

Maximum relative response spectra for various values of damping are given in Figures 67 to 81 on tripartite log-log axes. Because of the unusually high frequencies of the eastern Canadian ground motions, the conventional alternate display on linear axes is of limited usefulness, and no additional information could be shown in a redesigned output format.The spectra are cut-off at 1 Hz (1 s) because the longer periods cannot be considered reliable.

## RESULTS AND DISCUSSION

Table 3 gives an overview of some of the important parameters derived from the Miramichi strong motion records. All records are included whether digitized or not. This has led to some differences in the derivation of the parameters, notably corrected peak accelerations and frequencies. For the digitally processed records, the automatically computed accelerations and the dominant frequency from the respective Fourier amplitude spectrum are listed; for the smaller records, the maximum zero-to-peak film amplitude is used, corrected by hand for the dropoff of the acceleration response at high frequencies to give acceleration. The frequency chosen is the inverse apparent period of the same maximum half cycle. The relative acceleration amplitude response for a nominal 25 Hz accelerograph is shown in Figure 82; corrections for the actual natural frequencies were made.

This procedure does not always give corrections comparable to the computer convolution with the instrument response. An extreme example is the vertical component of site 2 for the 31 March earthquake, listed as 5.7 m $s^{-2}$ in Figure 16 and 26: a correction by hand as described above, leads to about 7.5 m $s^{-2}$ for the same peak. To illustrate the ambiguity, Figure 83 shows an enlarged film copy of this trace together with the raw digital data trace: it represents the film trace very well, with an effective frequency between the two large positive spikes of about 45 Hz. Between the peaks, the film trace fades, while the digitizer and computer have interpolated points. Since the corrected acceleration trace is the basic input for later processing steps, and since peak accelerations are still heavily emphasized in engineering design, it will be worth while to investigate the origin of such discrepancies further. For the purposes of this report it suffices to recommend caution in accepting the routine acceleration correction procedures, since many of the frequencies are closer to the corner of the anti-alias filter (50Hz) than to the natural frequency of the recording system of 25 Hz.

ACKNOWLEDGEMENT

Partial funding and encouragment for the SMA-1 installation were provided by Andy Murphy and Leon Berapan of the U.S. Nuclear Regulatory Commission. We acknowledge the enthusiastic operational support by the New Brunswick Department of National Resources, in particular by D. Foran. The assistance of the Earth Physics Branch technical group is also gratefully acknowledged. Digitization was handled commercially by Robert Pettit of IOM-TOWILL. Digital processing was done at the USGS computing centre at Menlo Park,through the good offices of Dr. R. Borcherdt. Special thanks are due to Dr. G. Brady and A. Converse for discussions on theoretical and programming aspects.

References

Munro P.S., and P. Pomeroy(1982). The New Brunswick Strong Motion Array, Chpt. 8, in Preliminary Report of the Miramichi, New Brunswick, Canada, Earthquake Sequence of 1982. A.E. Stevens ed., Earth Physics Branch, EMR, Open File Report 82-24, Ottawa.

Raugh,M.R.(1980). Seism. Soc. Am., Berkeley, Abstract only.

Rogers, G.C., W.G. Milne and M.Bone(1970). The strong motion seismograph network in western Canda. Publ. Earth Physics Branch, Vol 41-2

Rogers, G.C.(1976). A survey of the Canadian strong motion seismograph network. Can. Geotech. J. 13, 79-85

Shannon, W.E., R.J. Halliday, D.R.J.Schieman, and F. Lombardo(1981). Canadian seismograph operations-1980. Seismological service of Canada Series, No. 86,Ottawa.

Weichert, D.H. and W.G. Milne(1980). Canadian strong motion records. Earth Physics Branch Open File No. 80-1

Wetmiller,R.J., J. Adams, A.E. Stevens, F.M. Anglin, H.S. Hasegawa and J. Berube(1982). Aftershock sequences for the New Brunswick earthquakes of January 9th and 11th, March 31st and June 16th, 1982. Eastern Sect., Seism. Soc Am., Abstract only.

TABLE 1

New Brunswick Strong-Motion Records, February to July 1982

| Date (U.T.) 1982 | Epicentre | Magnitude $m_N$ | Accelerographs Triggered |
|---|---|---|---|
| Near Holmes Lake | | | |
| 31 March 21:02 | 47.00N 66.57W | 4.8 | Sites 1, 2, 3, 4 and 7 |
| 02 April 13:50 | 47.00N 66.57W | 4.3 | Sites 2 and 7 |
| 11 April 18:00 | 47.00N 66.57W | 4.1 | Site 7 |
| 28 April 06:36 | 47.00N 66.60W | 3.4 | Site 1 |
| 06 May 16:28 | 47.00N 66.60W | 4.0 | Sites 1, 2, and 3 |
| 28 July 05:35 | 47.00N 66.60W | 3.7 | Site 12 |
| Near Trousers Lake | | | |
| 16 June 11:43 | 47.01N 66.95W | 4.6 | Sites 2 and 12 |

Table 2

Site and Instrument Characteristics

| Site Name | Location (Lat N, Long W) | Installation (1982) and Kinemetrics Serial No. | Foundation/Subsoil | Sensitivity mm/G | Nat. Freq. Hz | Direction of L |
|---|---|---|---|---|---|---|
| 1 Holmes Lake | 46° 56.73'<br>66° 35.67' | 03 Feb. 20:00<br>4935 | massive concrete<br>fiveplace hearth on<br>5 m alluvium | L 18.8<br>V 19.8<br>T 19.3 | 25.5<br>26.0<br>25.0 | 18° |
| 2 Mitchell Road | 47° 02.05'<br>66° 36.62' | 04 Feb. 16:30<br>4934 | bedrock | 18.6<br>20.3<br>17.6 | 26.0<br>24.9<br>26.4 | 118° |
| | 47° 02.05'<br>66° 36.70' | 04 June 18:20 | | same | | 0° |
| 3 Loggie Lodge | 46° 58.15'<br>66° 31.74' | 04 Feb. 20:45<br>4936 | major granite boulder<br>on 5 m alluvium | 19.0<br>20.0<br>19.2 | 25.5<br>24.9<br>25.7 | 189° |
| | | 05 June 16:33 | site closed | | | |
| 4 Indian Brook | 46° 58.73'<br>66° 34.85' | 05 Feb. 20:00<br>4937 | granite boulder<br>on gravel | 19.1<br>18.7<br>18.3 | 25.5<br>26.1<br>25.7 | 321° |
| | | 06 June 15:00 | site closed | | | |
| 7 Bear Lakes | 46° 55.71'<br>66° 29.08' | 07 Feb. 18:30<br>1064 | concrete pad on<br>gravel | 38.0<br>33.6<br>36.2 | 18.8<br>17.6<br>19.1 | 170° |
| | | 07 June 13:38 | site closed | | | |
| 12 Indian Brook II | 46° 59.6'<br>66° 35.8' | 06 June 15:47<br>4937 | bedrock | same as site 4 | | 0° |

Table 3

Summary of Strong Motion Results

Abreviations and dimensions used are as follows:

L, V & T are longitudinal, vertical and transverse SMA-1 axes;

a, v & d are peak acceleration in m $s^{-2}$, velocity in cm $s^{-1}$, and displacement in cm;

F is the dominant frequency in Fourier spectrum of the digitally processed records, in Hz; for the non-digitized records it is the apparent frequency of the peak acceleration half cycle. Dist is approximate epicentral distance, and RL the approximate clockwise angle of L from the direction to epicentre.

* identifies digitally processed records

| Earthquake | | Site Name | | L | V | T | dist/RL |
|---|---|---|---|---|---|---|---|
| 31 March | 1 | Holmes Lake* | F[Hz] | 18 | 37 | 41 | |
| | | | a[m $s^{-2}$] | 1.78 | 1.51 | 3.40 | 6 km |
| | | | v[cm $s^{-1}$] | 1.31 | .53 | 1.37 | 15 deg |
| | | | d[cm] | 0.03 | .02 | .05 | |
| | 2 | Mitchell Lk Rd.* | | 18/25 | 37/43 | 22 | |
| | | | | 1.49 | 5.71 | 2.31 | 4 |
| | | | | 1.81 | 2.90 | 1.91 | 320 |
| | | | | .05 | .07 | .05 | |
| | 3 | Loggie Lodge* | | 22 | 47 | 28/35 | |
| | | | | 2.92 | 3.02 | 5.64 | 6 |
| | | | | 1.80 | 1.82 | 4.11 | 240 |
| | | | | .06 | .11 | .18 | |
| | 4 | Indian Brook* | | 24 | 25/40 | 24 | |
| | | | | 4.17 | 1.44 | 4.05 | 3 |
| | | | | 2.72 | 0.90 | 3.11 | 335 |
| | | | | 0.06 | 0.03 | 0.12 | |
| | 7 | Bear Lakes | | 25 | | 20 | |
| | | | | 0.58 | - | 1.38 | 12 |
| | | | | 0.37 | - | 1.10 | 215 |
| | | | | - | - | - | |
| 2 April | 2 | Mitchell Lk. Rd | | 33 | 33 | 25 | |
| | | | | 0.66 | 0.54 | 0.77 | 4 |
| | | | | 0.31 | 0.26 | 0.49 | 320 |
| | | | | - | - | - | |
| | 7 | Bear Lakes | | | | 20 | |
| | | | | - | - | 0.44 | 12 |
| | | | | - | - | 0.35 | 215 |
| | | | | - | - | - | |

| Earthquake | | Site Name | | L | V | T | dist/RL |
|---|---|---|---|---|---|---|---|
| 11 April | 7 | Bear Lakes | F[Hz] | 20 | - | 25 | |
| | | | a[m $s^{-2}$] | 0.41 | - | 0.77 | 12 |
| | | | v[cm $s^{-1}$] | 0.33 | - | 0.49 | 215 |
| | | | d[cm] | - | - | - | |
| 28 April | 1 | Holmes Lake | | 40 | 33 | 31 | |
| | | | | 0.74 | 0.41 | 0.56 | 6 |
| | | | | 0.29 | 0.20 | 0.29 | 350 |
| | | | | - | - | - | |
| 6 May | 1 | Holmes Lake | | 25 | 20 | 17 | |
| | | | | 0.42 | 0.24 | 0.71 | 6 |
| | | | | 0.27 | 0.19 | 0.68 | 350 |
| | | | | - | - | - | |
| | 2 | Mitchell Lk. Rd. | | 23 | 45 | 23 | |
| | | | | 0.54 | 1.76 | 0.33 | 4 |
| | | | | 0.37 | 0.61 | 0.23 | 315 |
| | | | | - | - | - | |
| | 3 | Loggie Lodge* | | 10/25 | 19 | 13 | |
| | | | | 1.15 | 0.66 | 1.46 | 7 |
| | | | | 1.36 | 0.71 | 1.76 | 245 |
| | | | | 0.03 | 0.01 | 0.08 | |
| 28 July | 12 | Indian Brook | | 25 | 25 | 25/30 | |
| | | | | 3.0 | 1.8 | 2.3 | 1 |
| | | | | - | - | - | 20 |
| | | | | - | - | - | |
| 16 June | 2 | Mitchell Lk. Rd. | | 25 | 25 | 20 | |
| | | | | 0.48 | 0.26 | 0.103 | 25 |
| | | | | 0.30 | 0.17 | 0.08 | 217 |
| | | | | - | - | - | |
| | 12 | Indian Brook | | 13 | 20 | 20 | |
| | | | | 0.15 | 0.27 | 0.17 | 27 |
| | | | | 0.18 | 0.22 | 0.14 | 85 |
| | | | | - | - | - | |

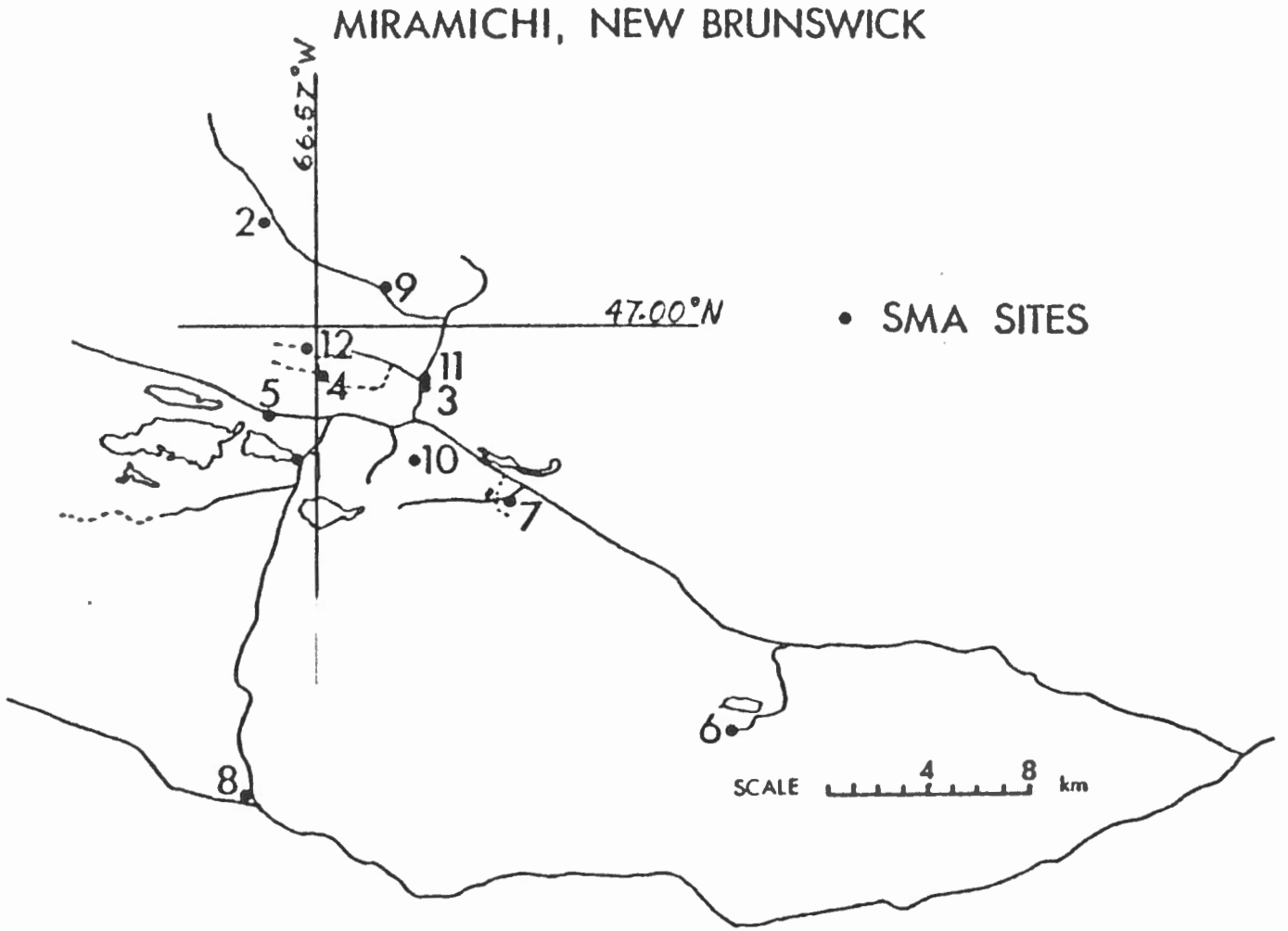



Fig. 1. Strong Motion Network and Centre of March Aftershock Activity at 47.00°N, 66.57°W

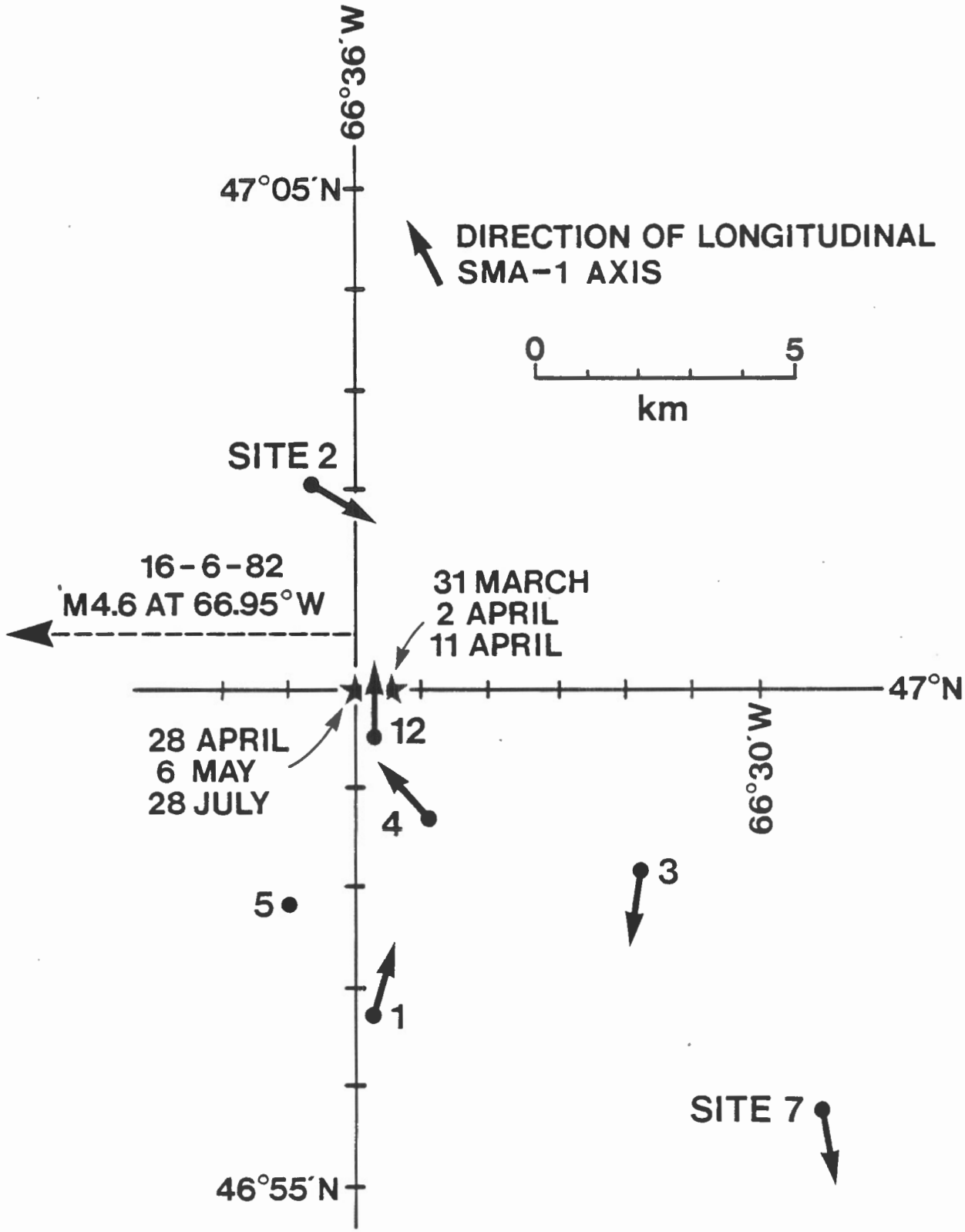



Fig. 2. Triggered strong motion sites and aftershock locations.

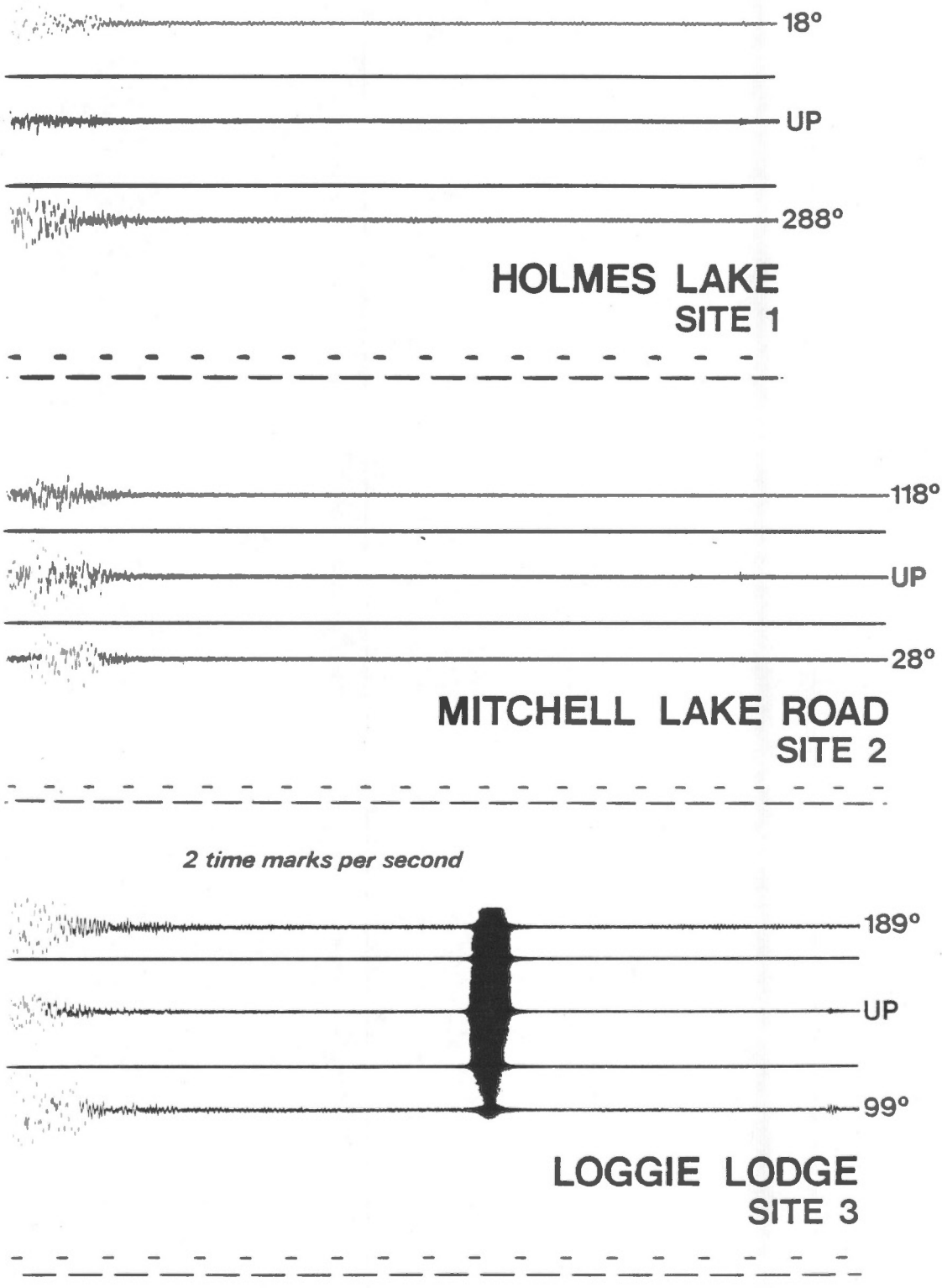



Fig. 3 31 March earthquake

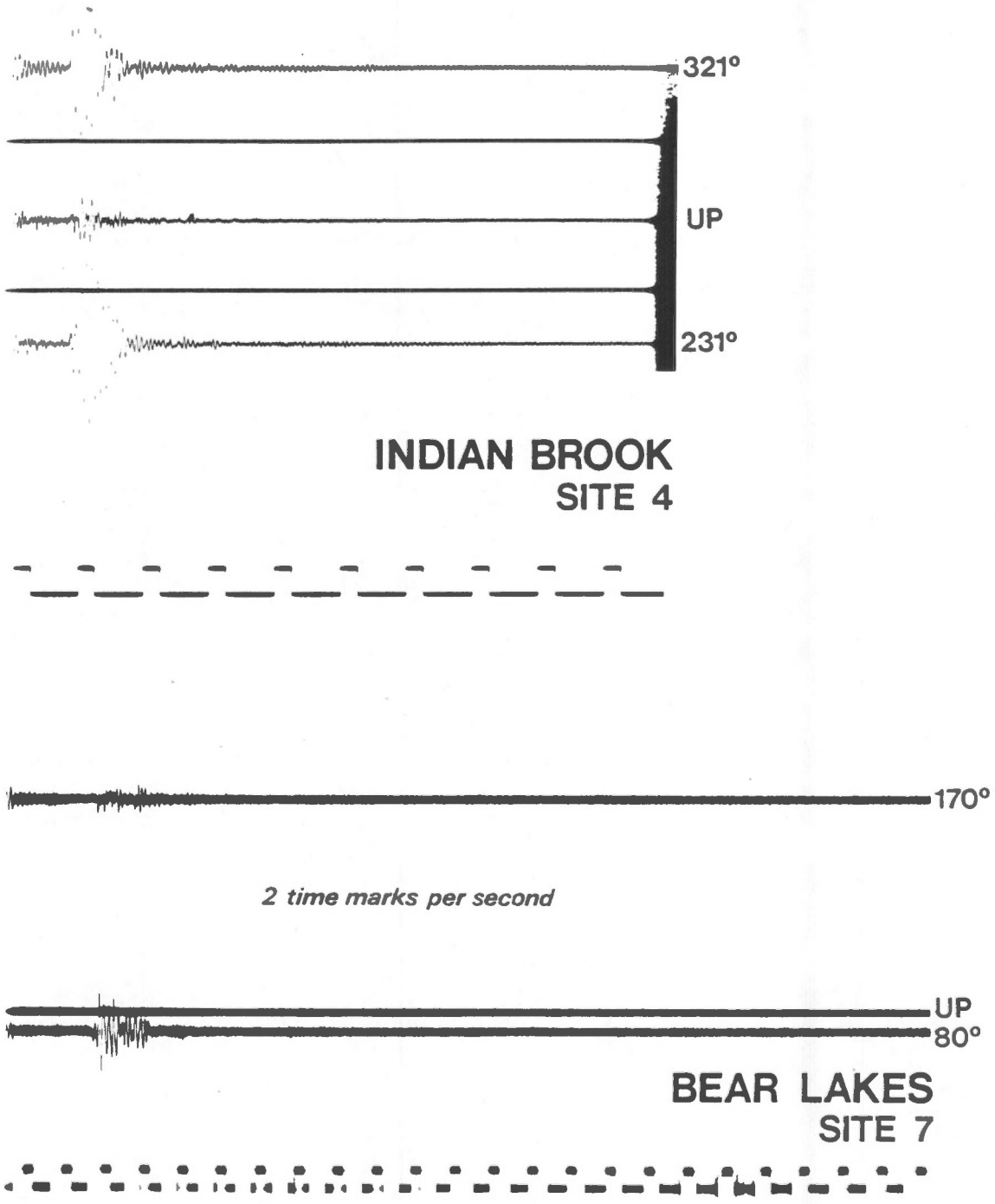



Fig. 3 cont. 31 March earthquake

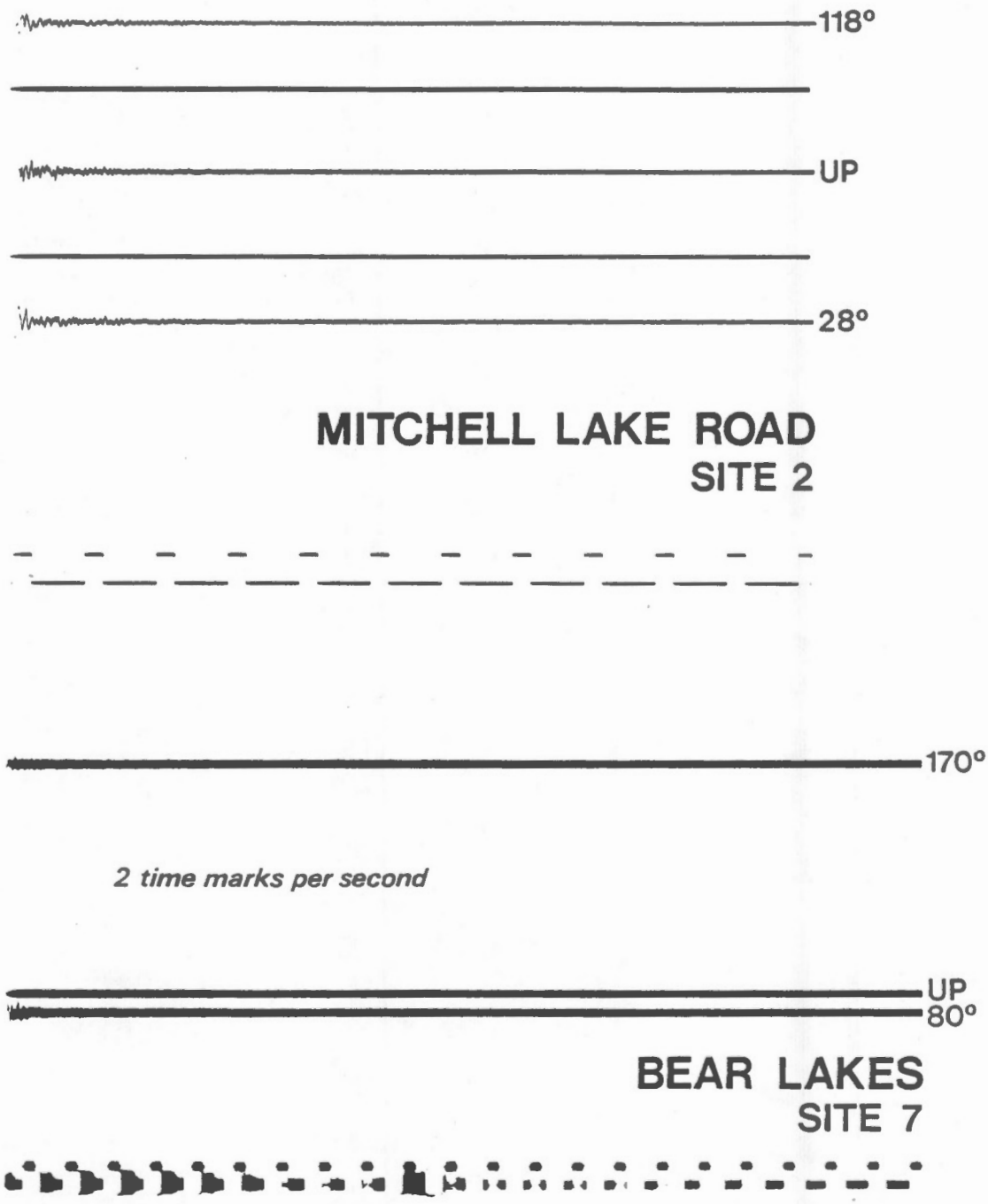
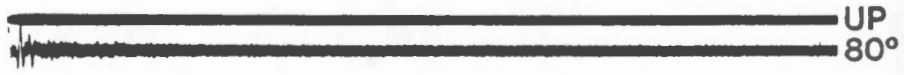



Fig. 4. 2 April earthquake


*2 time marks per second*




**BEAR LAKES**

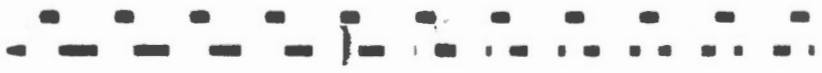
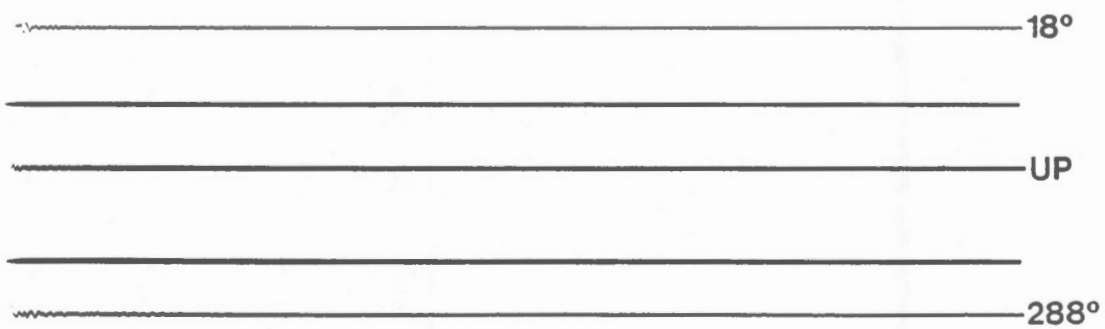


Fig. 5. 11 April earthquake




**HOLMES LAKE**
**SITE 1**

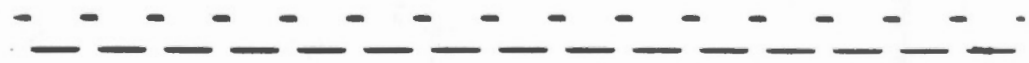


Fig. 6 28 April earthquake

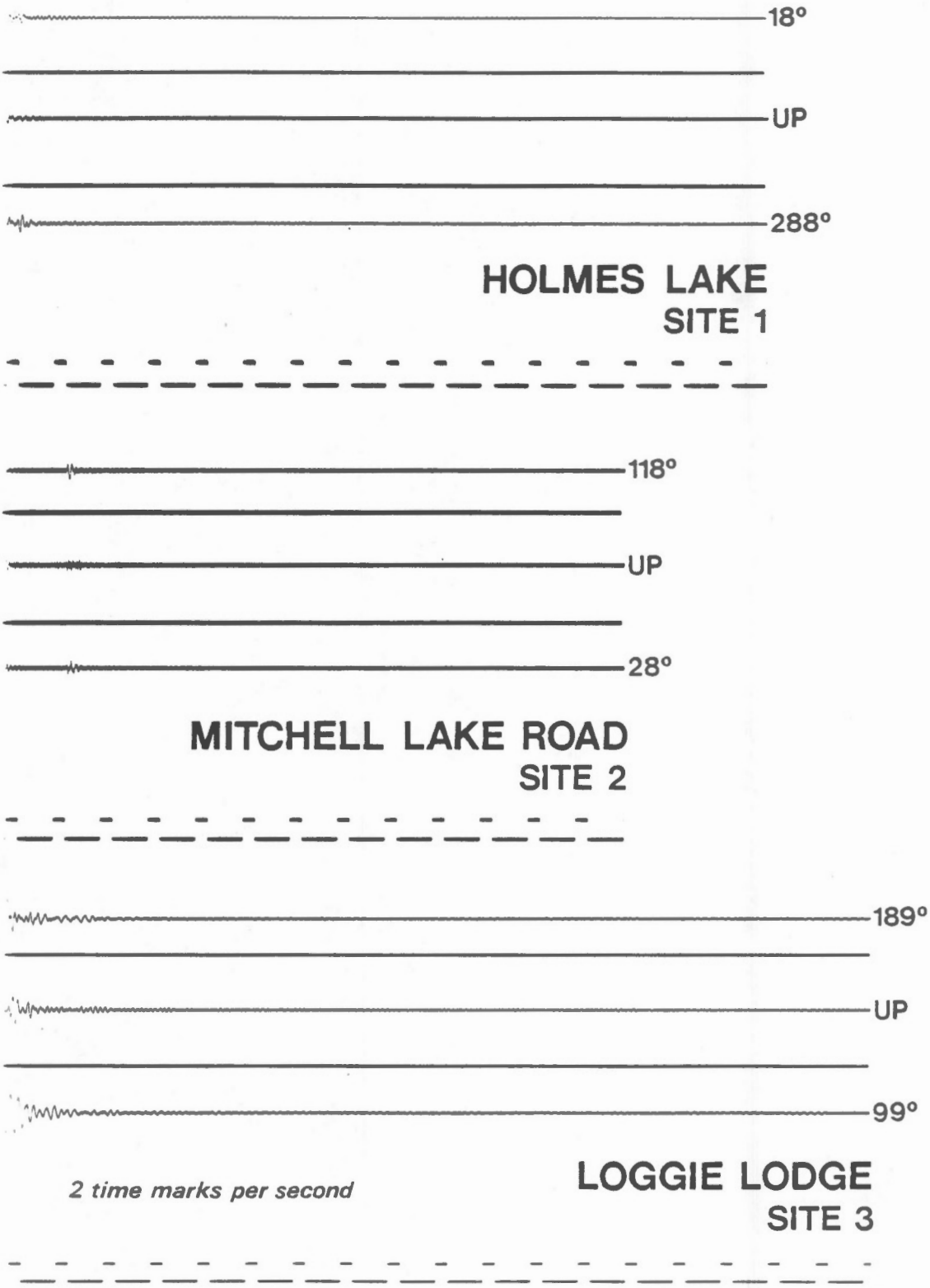



Fig. 7. 6 May earthquake

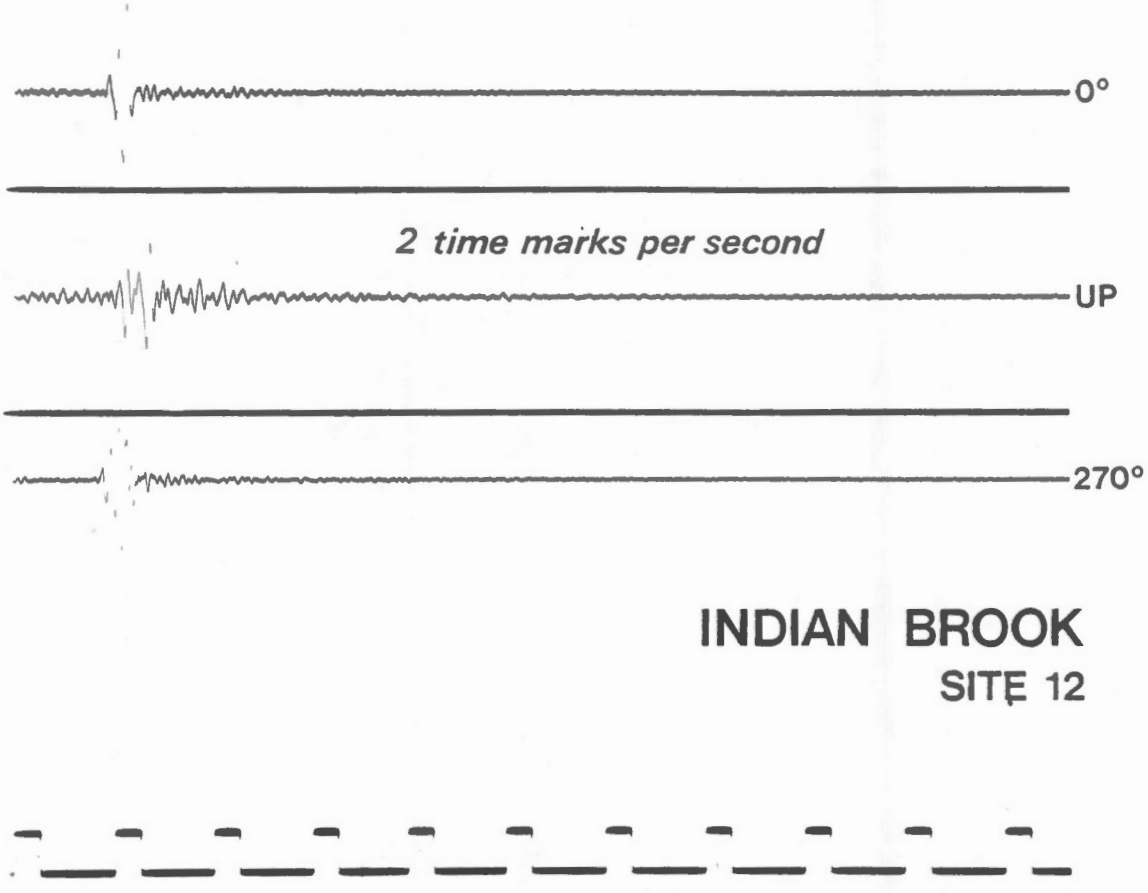



Fig. 8. 28 July earthquake

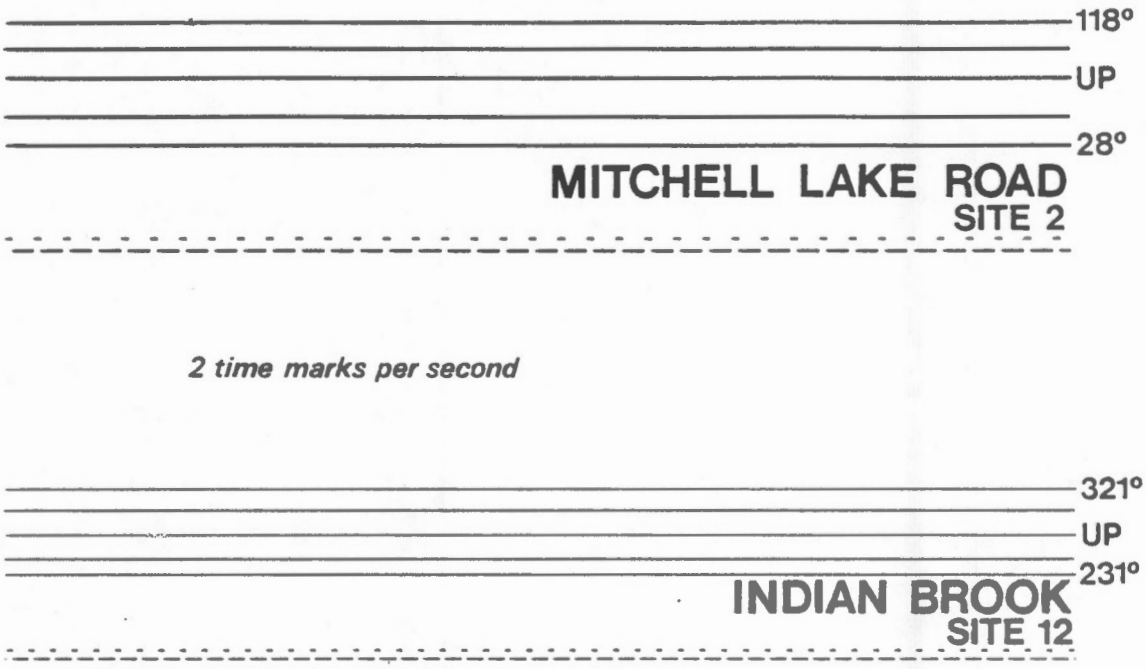



Fig. 9. 16 June earthquake

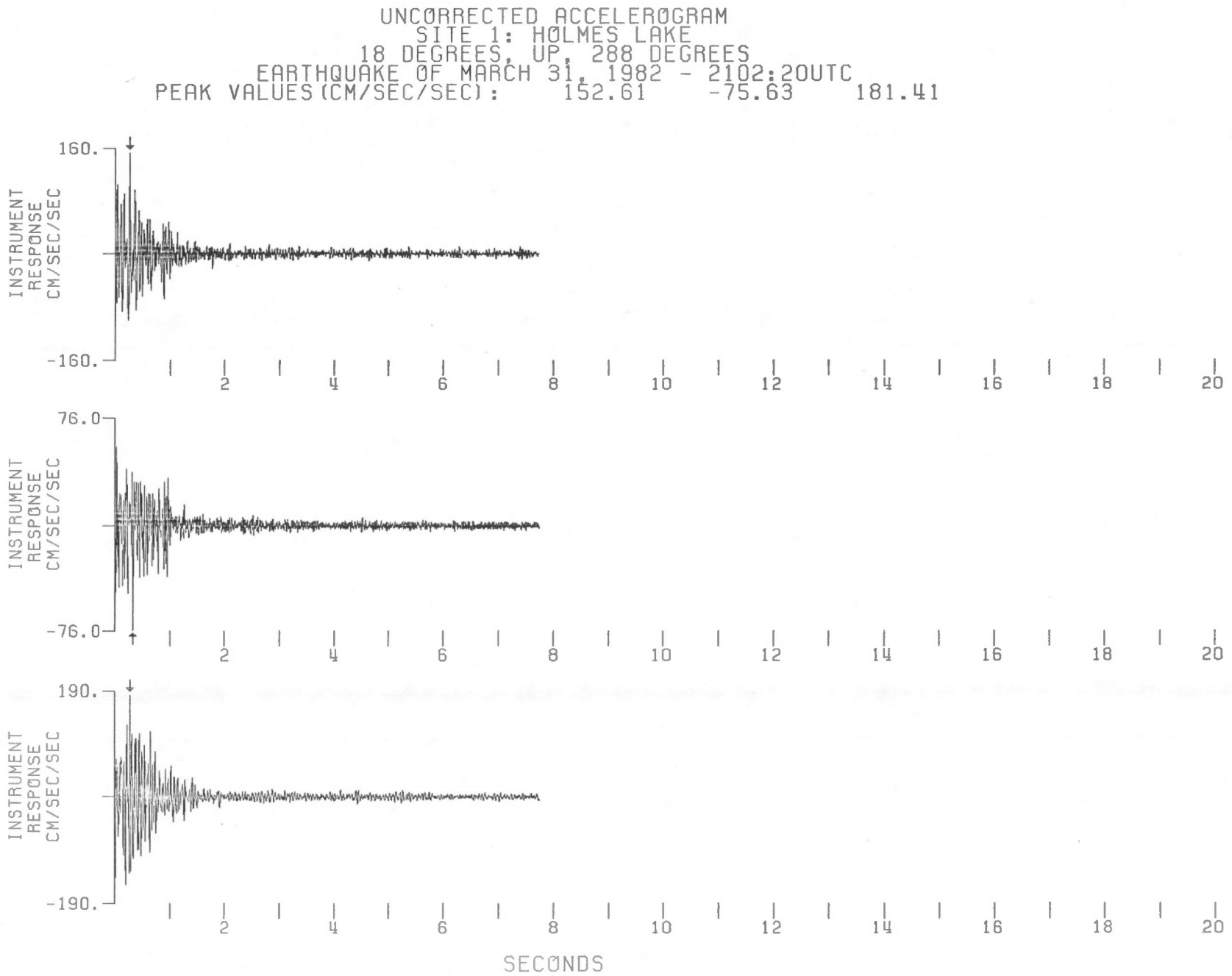

UNCORRECTED ACCELEROGRAM
SITE 1: HOLMES LAKE
18 DEGREES, UP, 288 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
PEAK VALUES(CM/SEC/SEC): 152.61 -75.63 181.41
INSTRUMENT RESPONSE CM/SEC/SEC
160.
-160.
76.0
-76.0
190.
-190.
2
4
6
8
10
12
14
16
18
20
SECONDS

Fig. 10

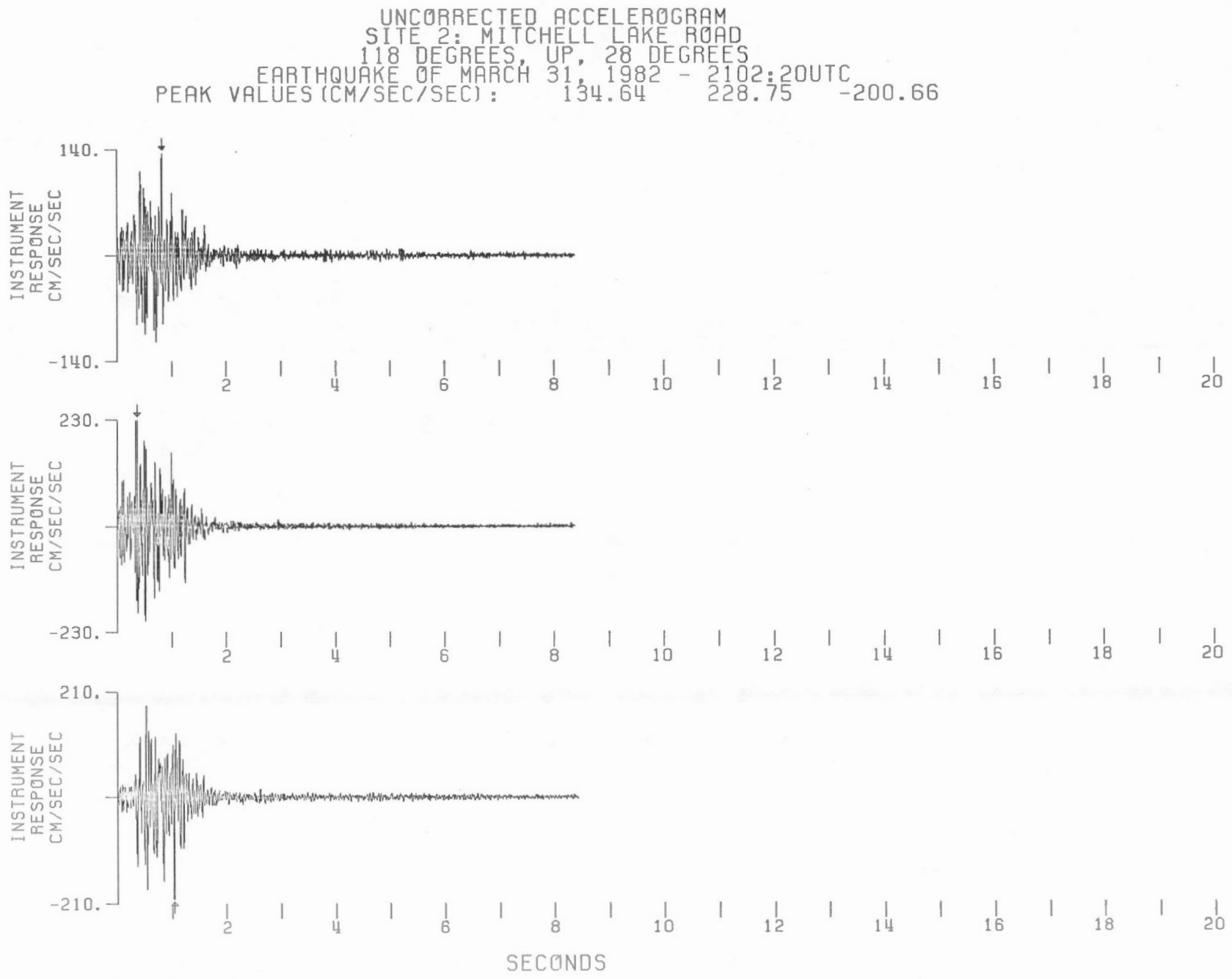

UNCORRECTED ACCELEROGRAM
SITE 2: MITCHELL LAKE ROAD
118 DEGREES, UP, 28 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
PEAK VALUES (CM/SEC/SEC): 134.64 228.75 -200.66
INSTRUMENT RESPONSE CM/SEC/SEC
140.
-140.
230.
-230.
210.
-210.
2
4
6
8
10
12
14
16
18
20
SECONDS

Fig. 11

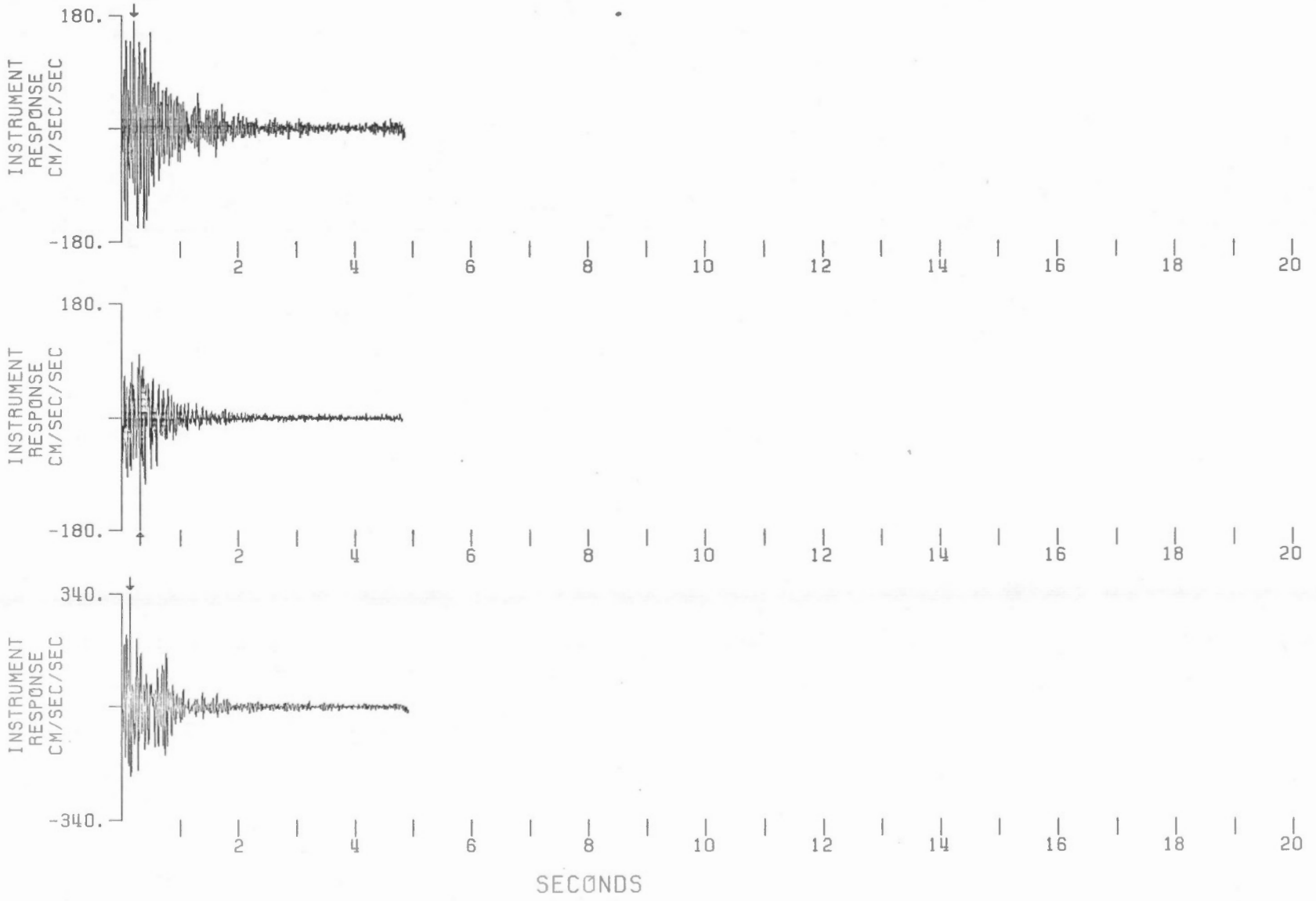

UNCORRECTED ACCELEROGRAM
SITE 3: LOGGIE LODGE
189 DEGREES, UP, 99 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
PEAK VALUES(CM/SEC/SEC): 170.77 -179.95 338.78
INSTRUMENT RESPONSE CM/SEC/SEC
180.
-180.
340.
-340.
2
4
6
8
10
12
14
16
18
20
SECONDS

Fig. 12

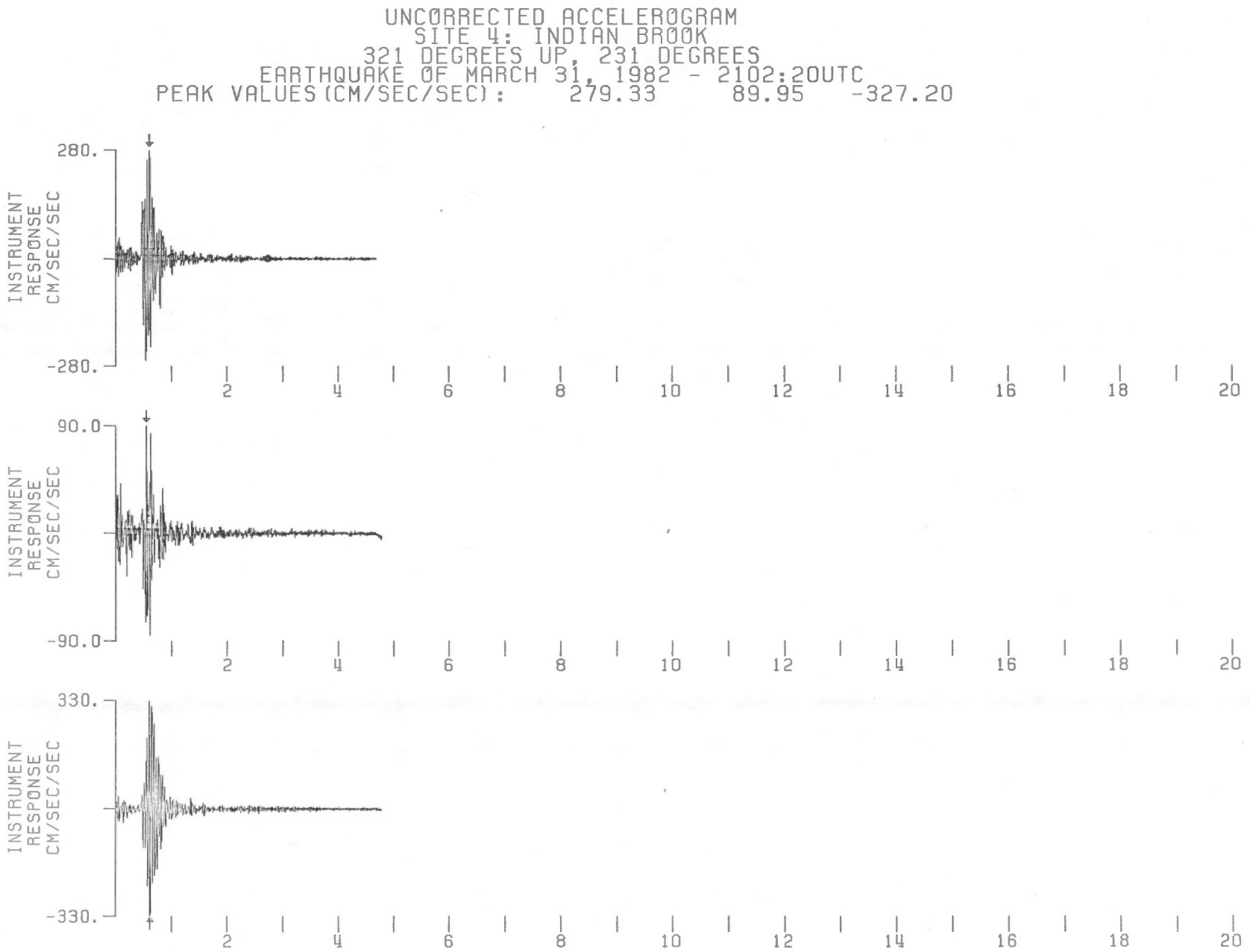

UNCORRECTED ACCELEROGRAM
SITE 4: INDIAN BROOK
321 DEGREES UP, 231 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
PEAK VALUES(CM/SEC/SEC): 279.33 89.95 -327.20
INSTRUMENT RESPONSE CM/SEC/SEC
280.
-280.
90.0
-90.0
330.
-330.
2
4
6
8
10
12
14
16
18
20
SECONDS

Fig. 13

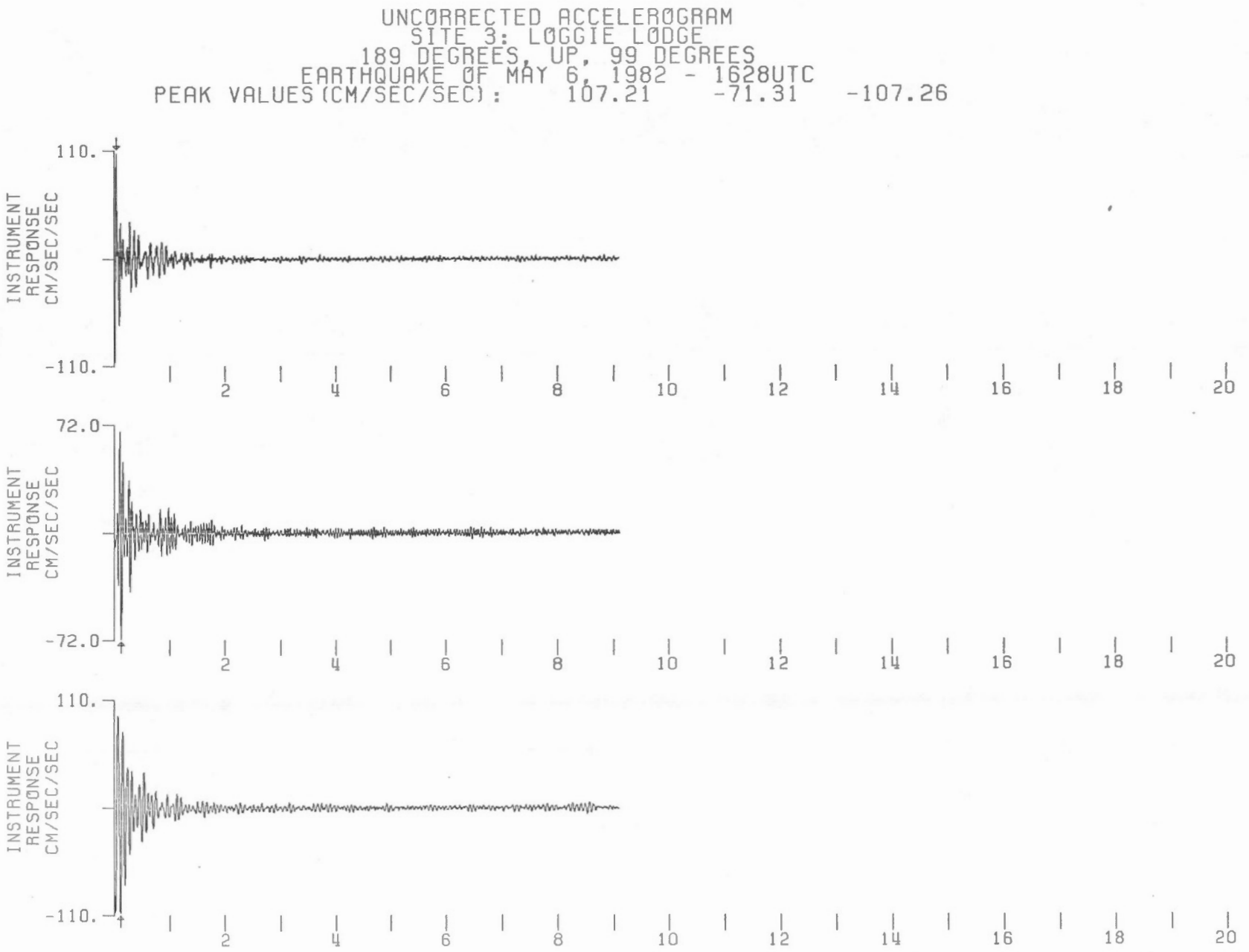

UNCORRECTED ACCELEROGRAM
SITE 3: LOGGIE LODGE
189 DEGREES, UP, 99 DEGREES
EARTHQUAKE OF MAY 6, 1982 - 1628UTC
PEAK VALUES (CM/SEC/SEC): 107.21 -71.31 -107.26
INSTRUMENT RESPONSE CM/SEC/SEC
110.
-110.
72.0
-72.0
2
4
6
8
10
12
14
16
18
20
SECONDS

Fig. 14

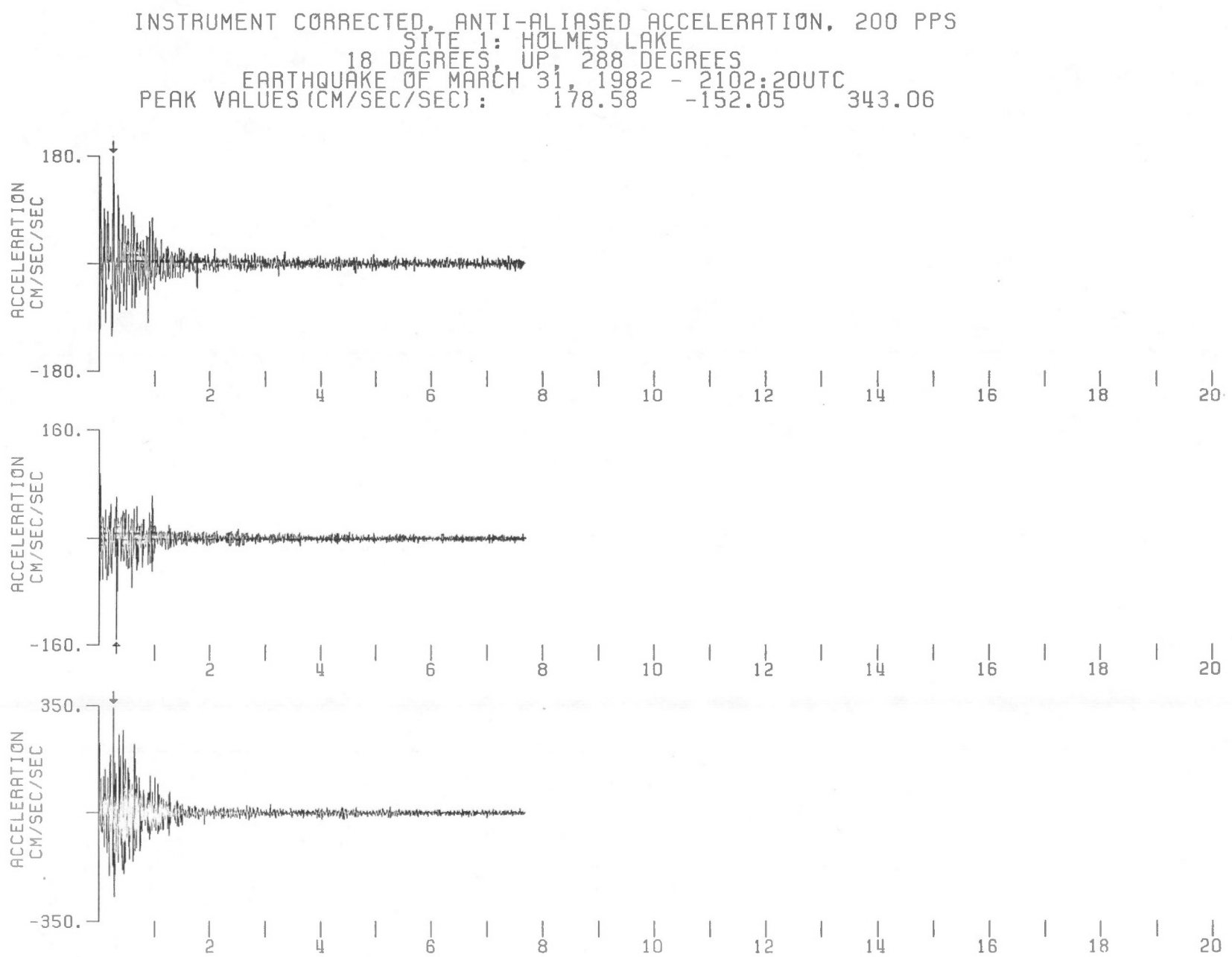

INSTRUMENT CORRECTED, ANTI-ALIASED ACCELERATION, 200 PPS
SITE 1: HOLMES LAKE
18 DEGREES, UP, 288 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
PEAK VALUES(CM/SEC/SEC): 178.58 -152.05 343.06
ACCELERATION CM/SEC/SEC
180.
-180.
160.
-160.
350.
-350.
2
4
6
8
10
12
14
16
18
20
SECONDS

Fig. 15

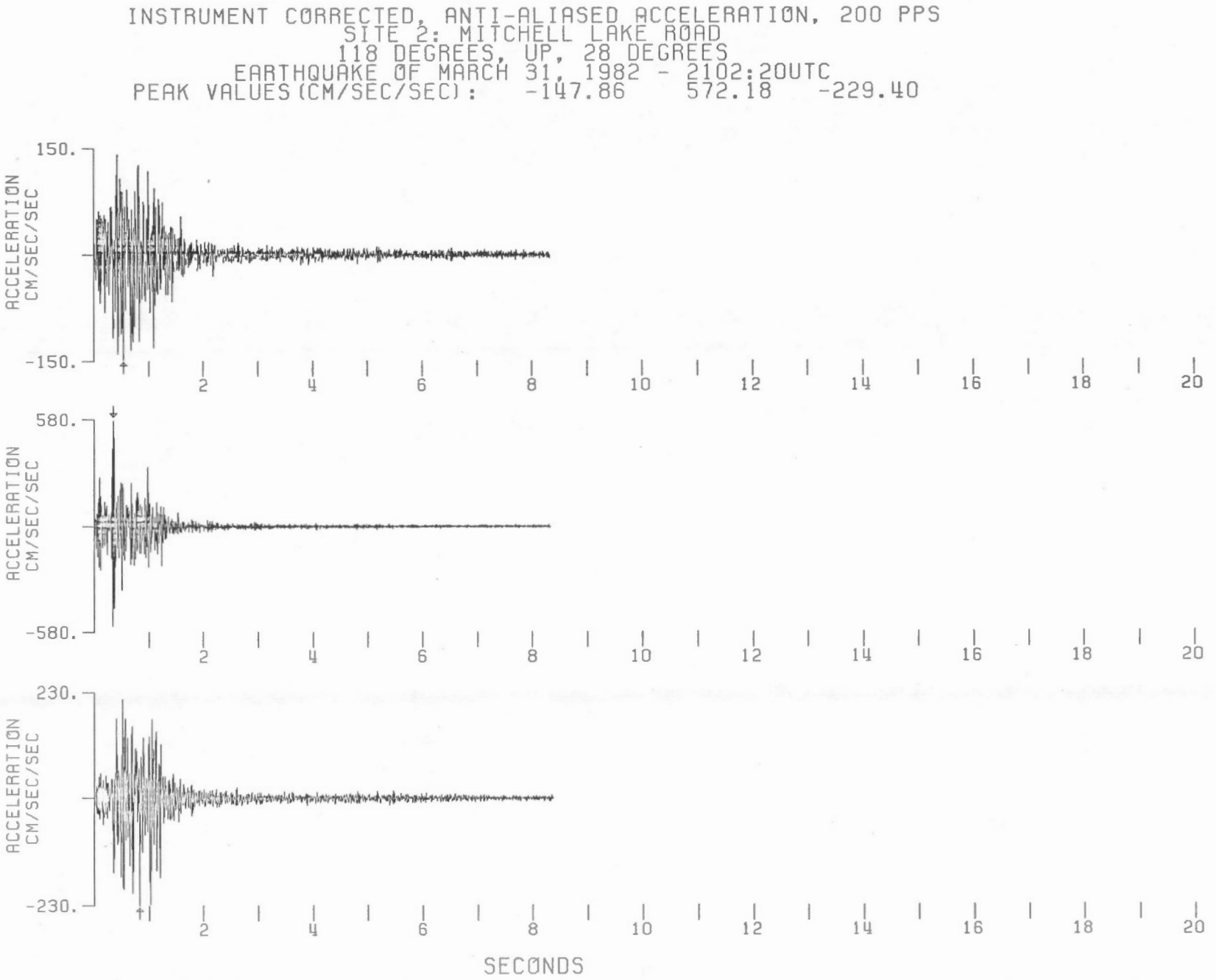

INSTRUMENT CORRECTED, ANTI-ALIASED ACCELERATION, 200 PPS
SITE 2: MITCHELL LAKE ROAD
118 DEGREES, UP, 28 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
PEAK VALUES(CM/SEC/SEC): -147.86 572.18 -229.40
ACCELERATION CM/SEC/SEC
150.
-150.
580.
-580.
230.
-230.
2
4
6
8
10
12
14
16
18
20
SECONDS

Fig. 16

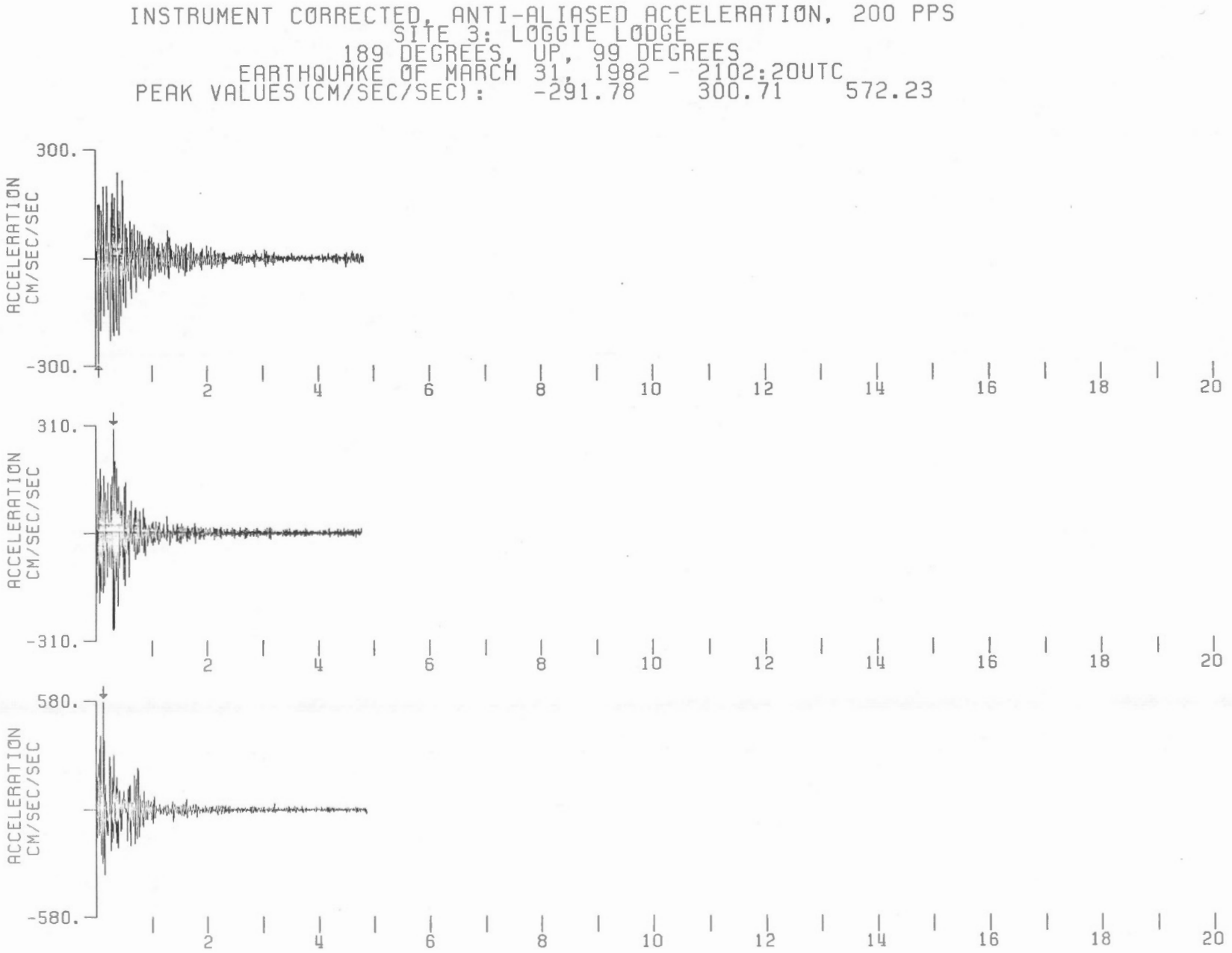

INSTRUMENT CORRECTED, ANTI-ALIASED ACCELERATION, 200 PPS
SITE 3: LOGGIE LODGE
189 DEGREES, UP, 99 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
PEAK VALUES (CM/SEC/SEC): -291.78 300.71 572.23
300.
-300.
310.
-310.
580.
-580.
ACCELERATION
CM/SEC/SEC
2
4
6
8
10
12
14
16
18
20
SECONDS

Fig. 17

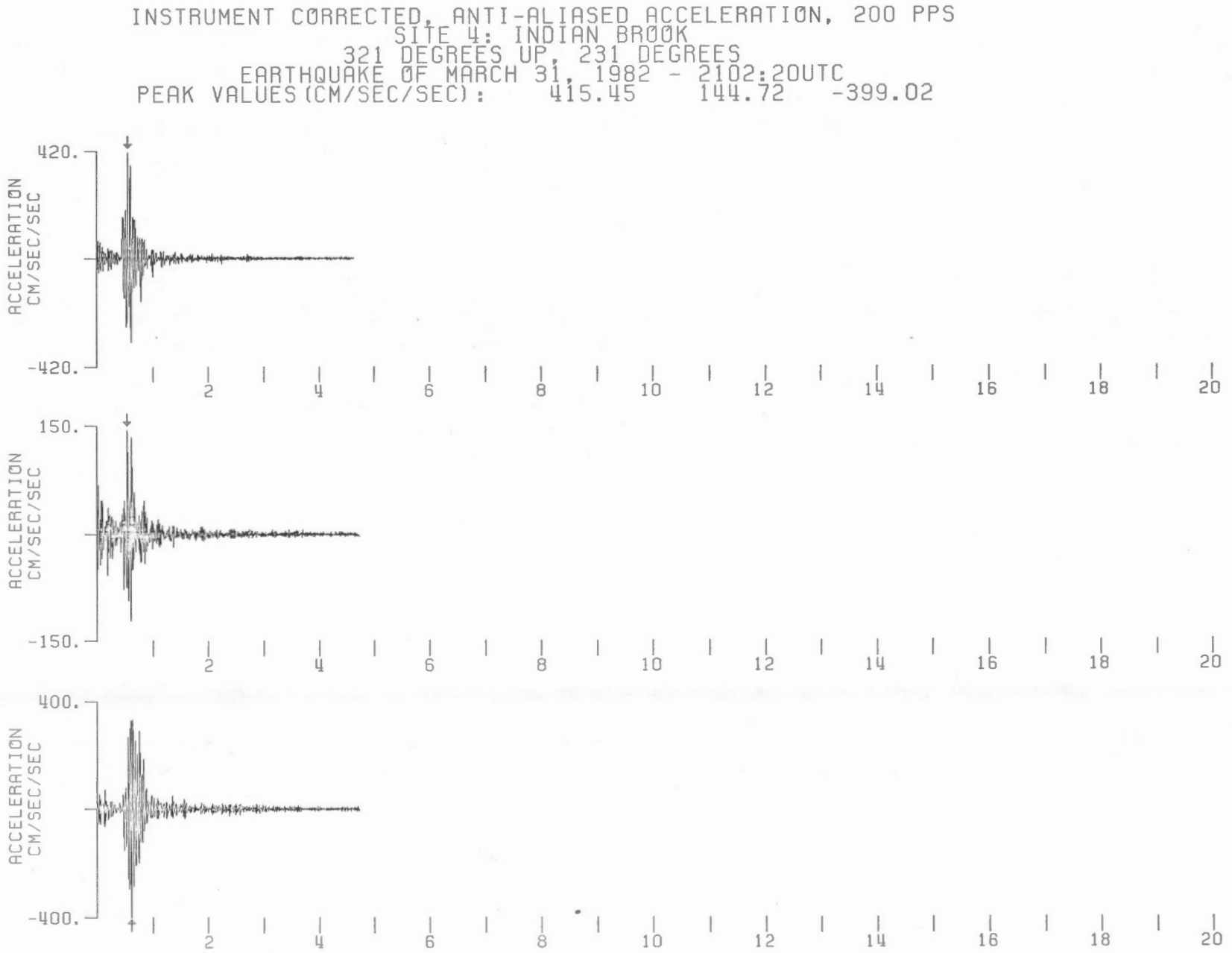

INSTRUMENT CORRECTED, ANTI-ALIASED ACCELERATION, 200 PPS
SITE 4: INDIAN BROOK
321 DEGREES UP, 231 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
PEAK VALUES(CM/SEC/SEC): 415.45 144.72 -399.02
ACCELERATION CM/SEC/SEC
420.
-420.
150.
-150.
400.
-400.
2
4
6
8
10
12
14
16
18
20
SECONDS

Fig. 18

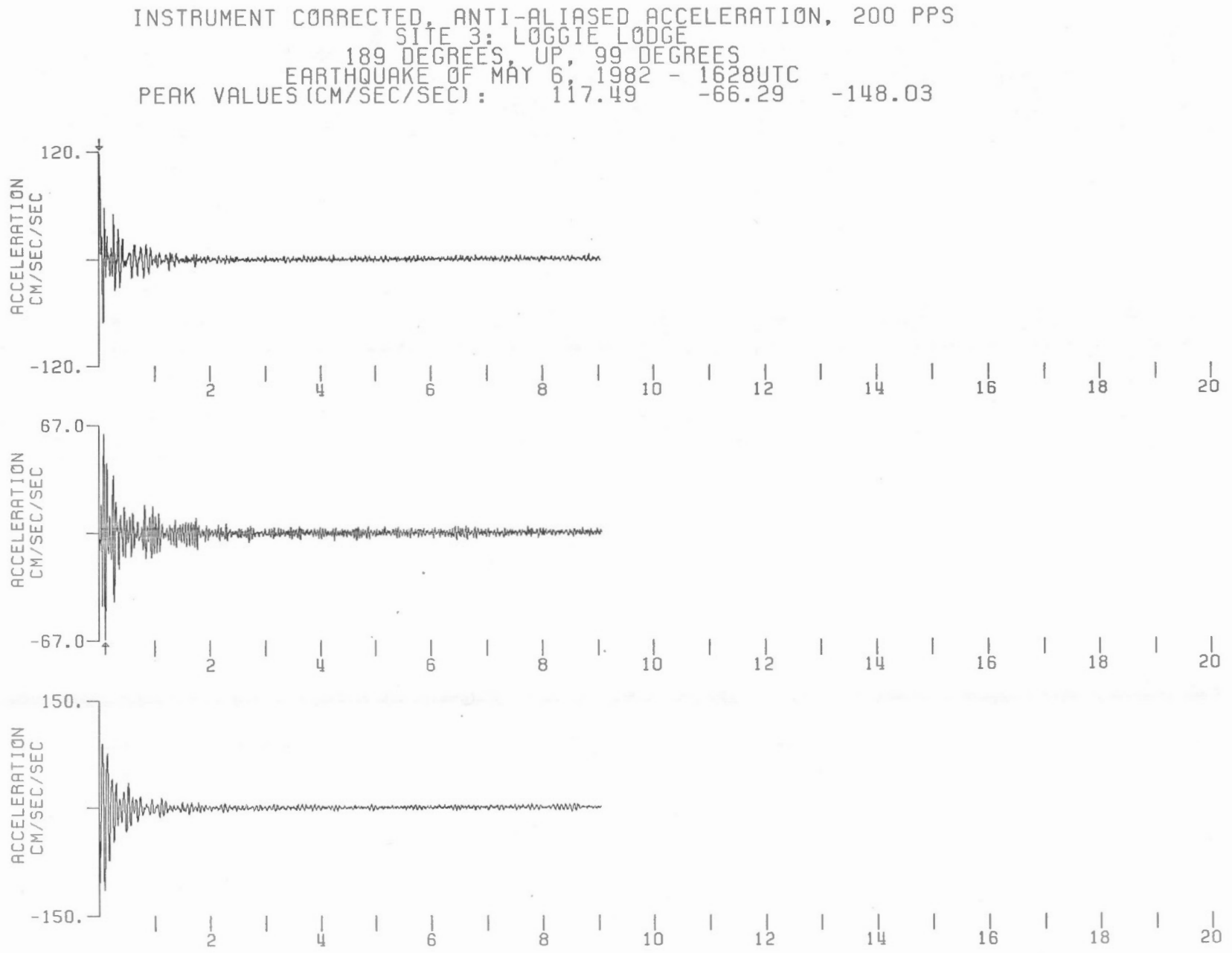

INSTRUMENT CORRECTED, ANTI-ALIASED ACCELERATION, 200 PPS
SITE 3: LOGGIE LODGE
189 DEGREES, UP, 99 DEGREES
EARTHQUAKE OF MAY 6, 1982 - 1628UTC
PEAK VALUES(CM/SEC/SEC): 117.49 -66.29 -148.03
120.
-120.
67.0
-67.0
150.
-150.
ACCELERATION
CM/SEC/SEC
2
4
6
8
10
12
14
16
18
20
SECONDS

Fig. 19

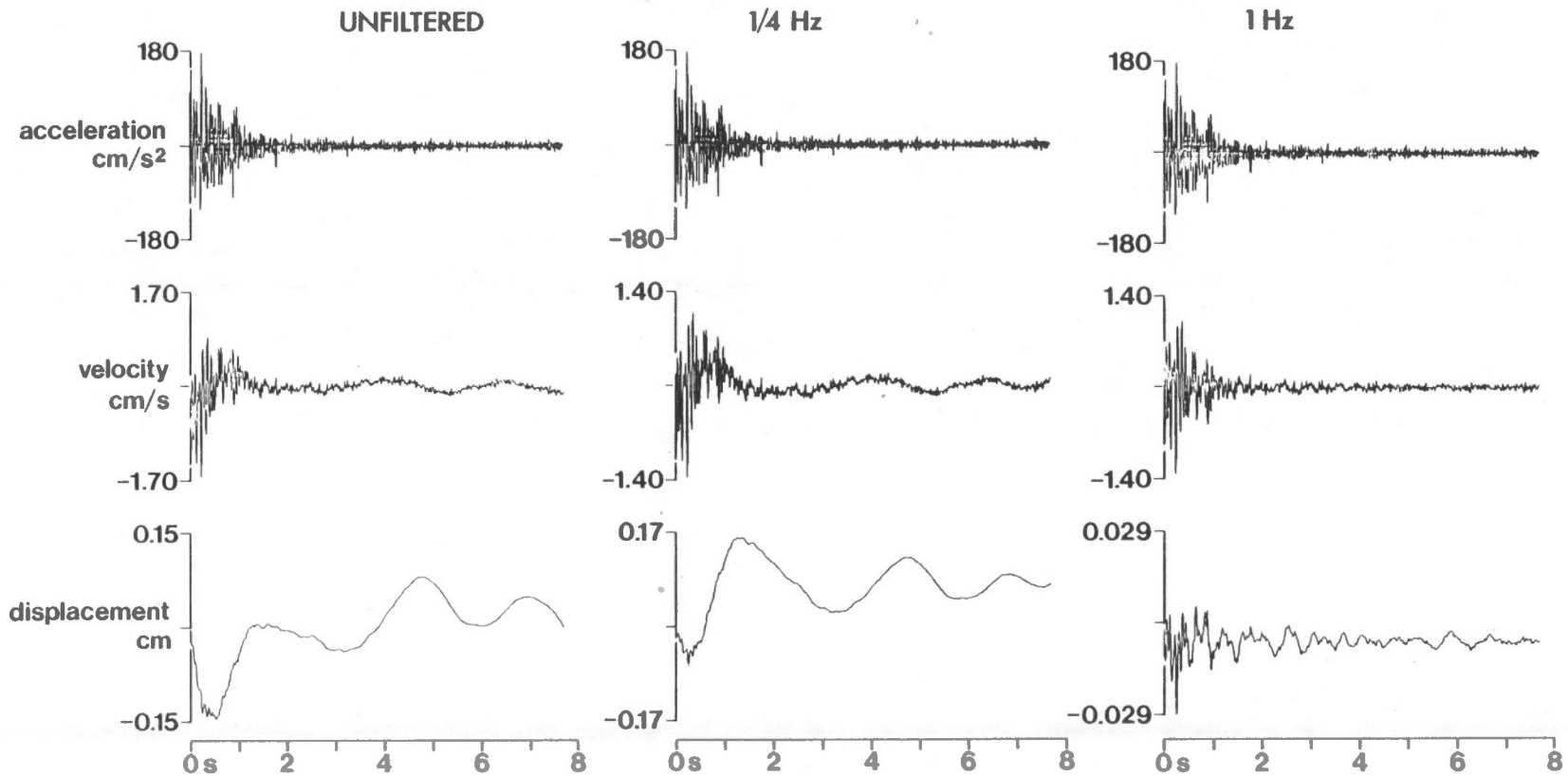



Fig. 20. Different high-pass filter choices for Holmes Lake L-component.

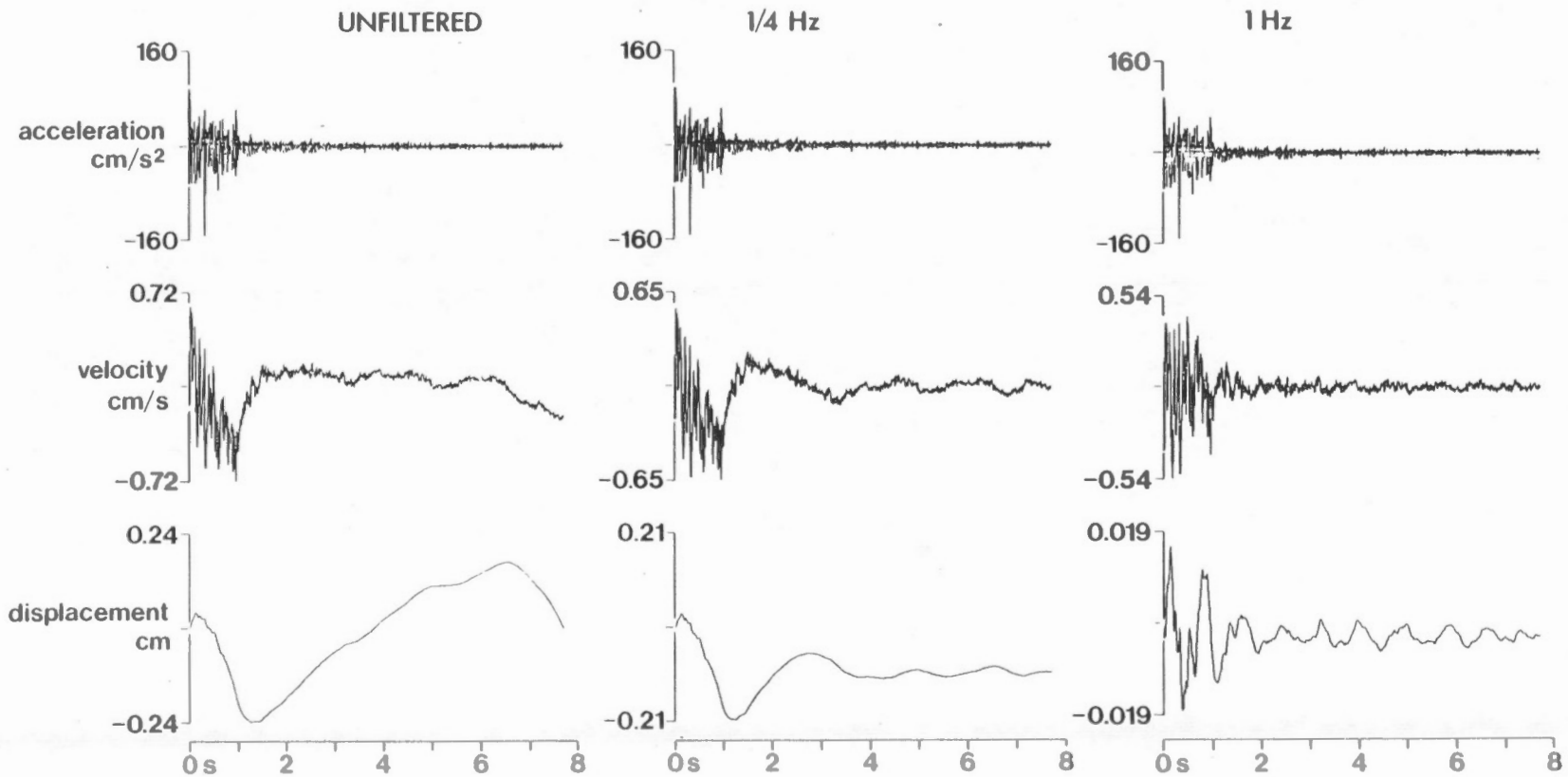



Fig. 21. Different high-pass filter choices for Holmes Lake V-component.

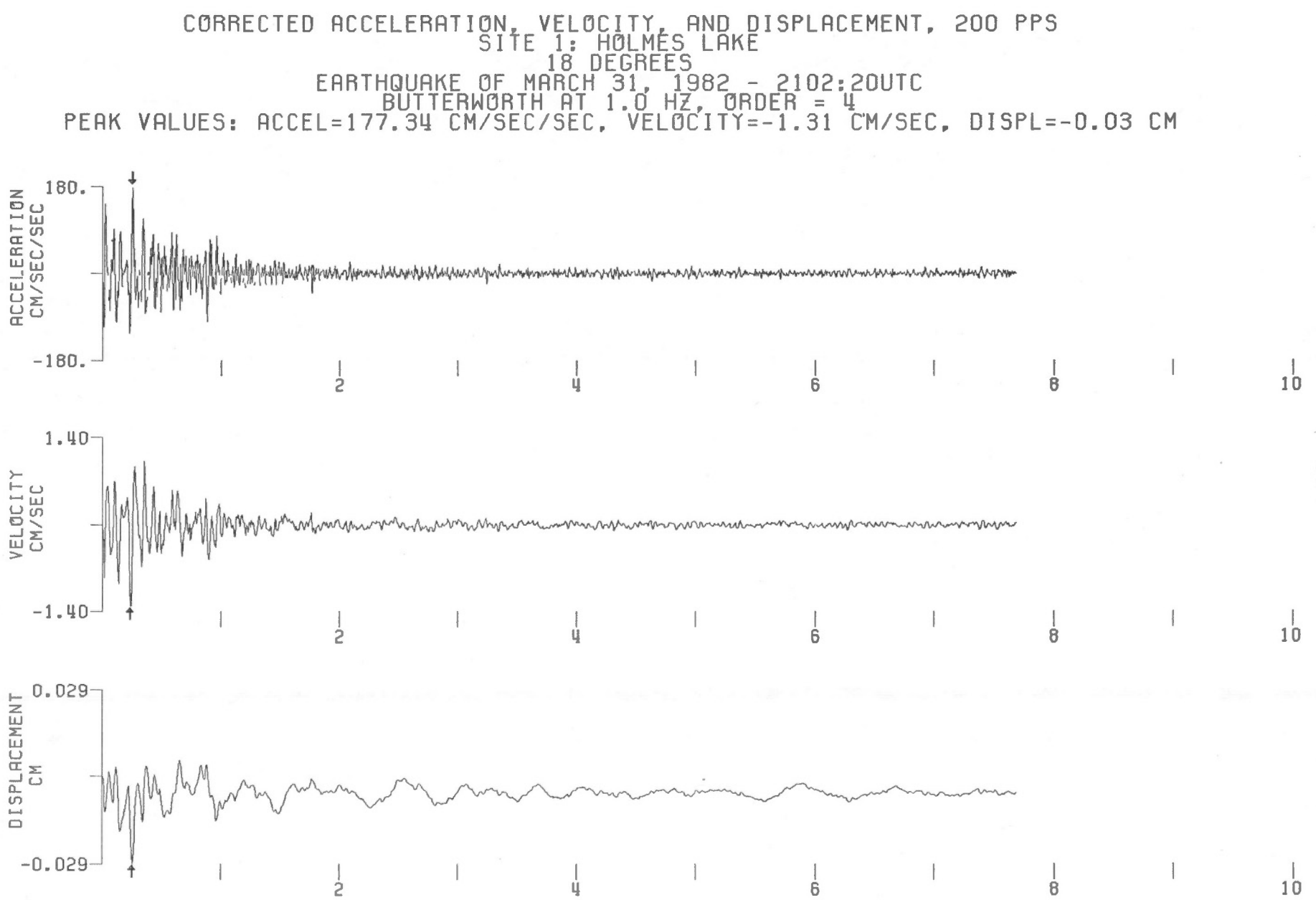

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 1: HOLMES LAKE
18 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=177.34 CM/SEC/SEC, VELOCITY=-1.31 CM/SEC, DISPL=-0.03 CM
ACCELERATION CM/SEC/SEC
180.
-180.
VELOCITY CM/SEC
1.40
-1.40
DISPLACEMENT CM
0.029
-0.029
2
4
6
8
10
SECONDS

Fig. 22

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 1: HOLMES LAKE
UP
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=-151.01 CM/SEC/SEC, VELOCITY=-0.53 CM/SEC, DISPL=-0.02 CM

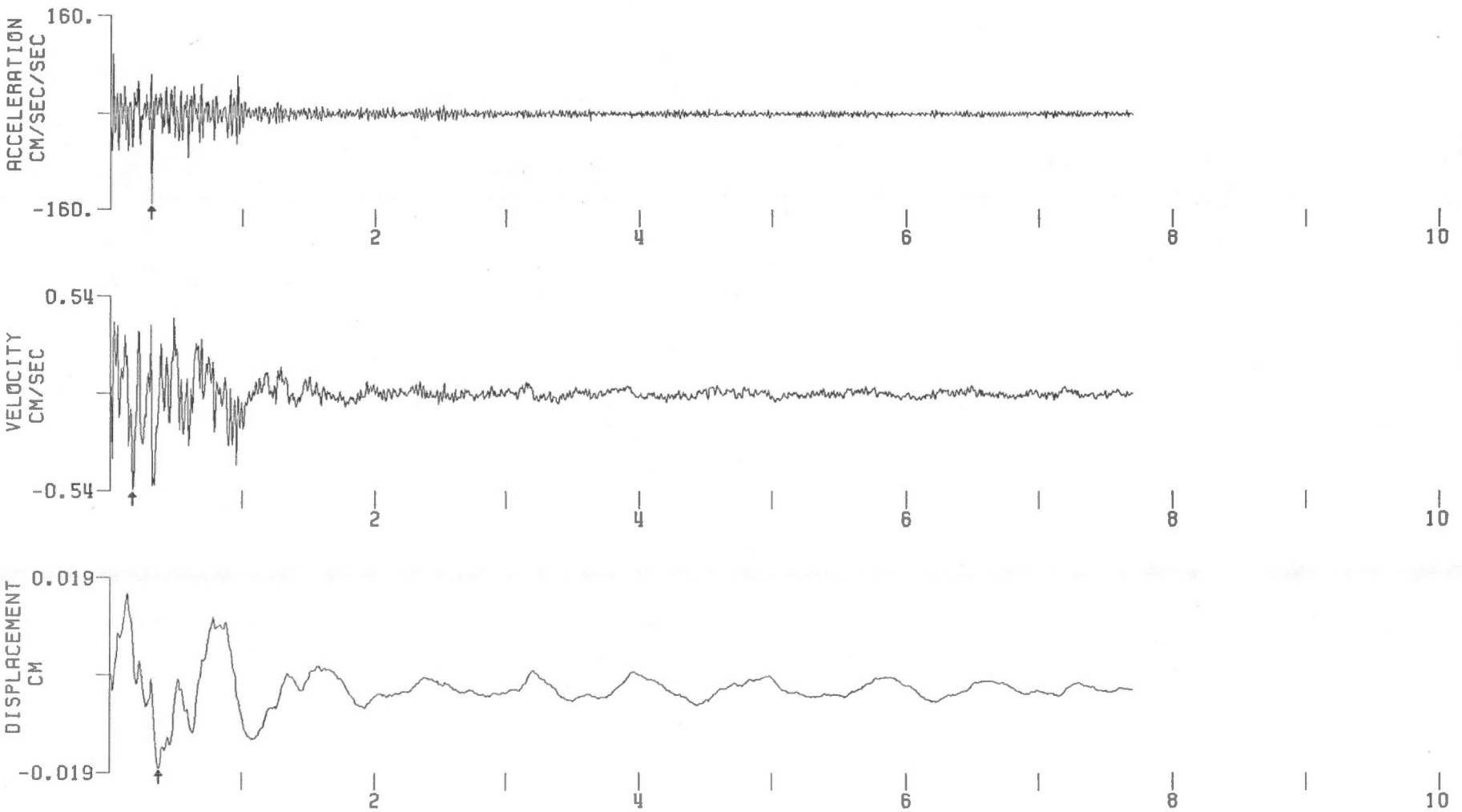



Fig. 23

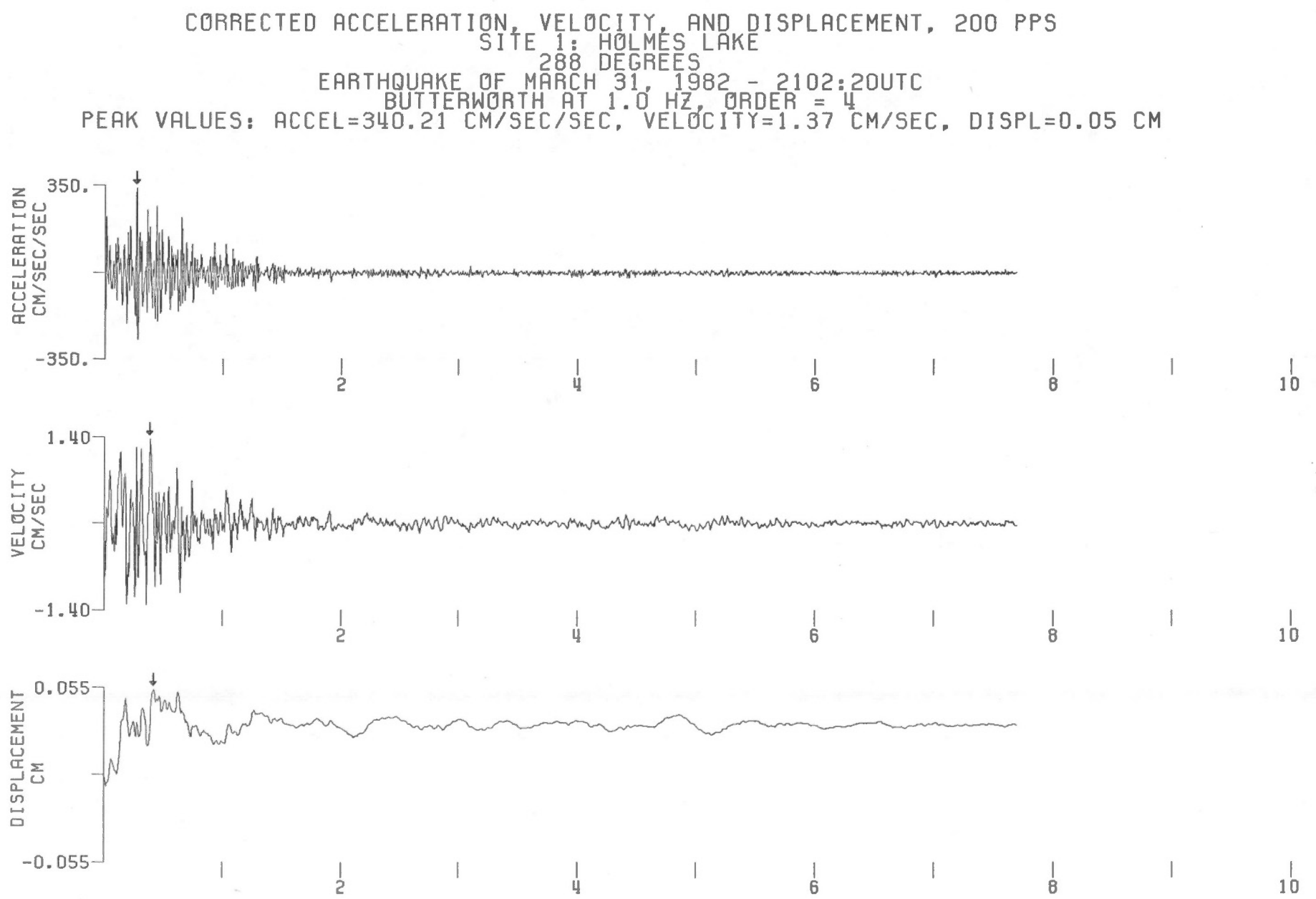

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 1: HOLMES LAKE
288 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=340.21 CM/SEC/SEC, VELOCITY=1.37 CM/SEC, DISPL=0.05 CM
ACCELERATION CM/SEC/SEC
350.
-350.
VELOCITY CM/SEC
1.40
-1.40
DISPLACEMENT CM
0.055
-0.055
2
4
6
8
10
SECONDS

Fig. 24

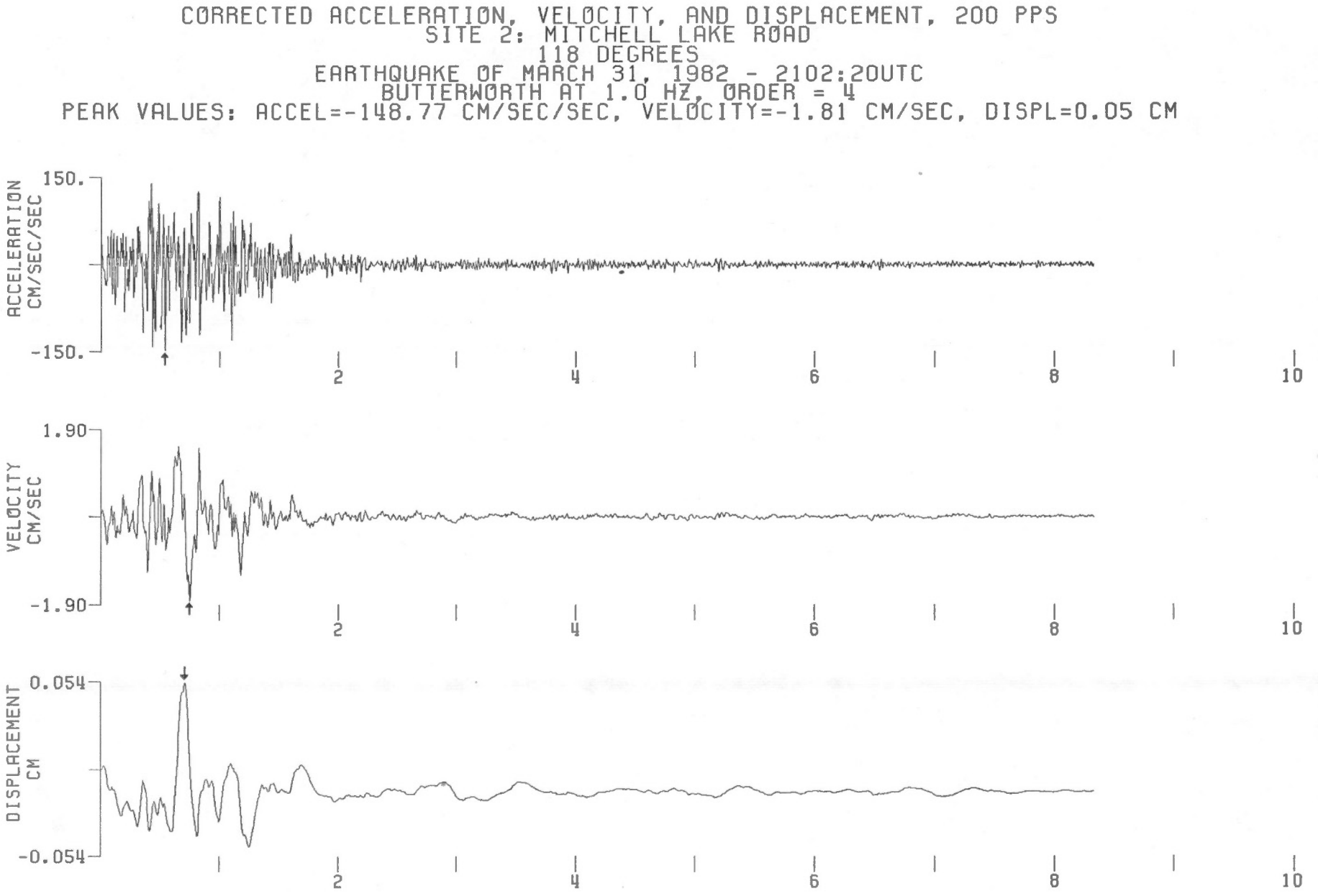

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 2: MITCHELL LAKE ROAD
118 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=-148.77 CM/SEC/SEC, VELOCITY=-1.81 CM/SEC, DISPL=0.05 CM
ACCELERATION CM/SEC/SEC
150.
-150.
VELOCITY CM/SEC
1.90
-1.90
DISPLACEMENT CM
0.054
-0.054
2
4
6
8
10
SECONDS

Fig. 25

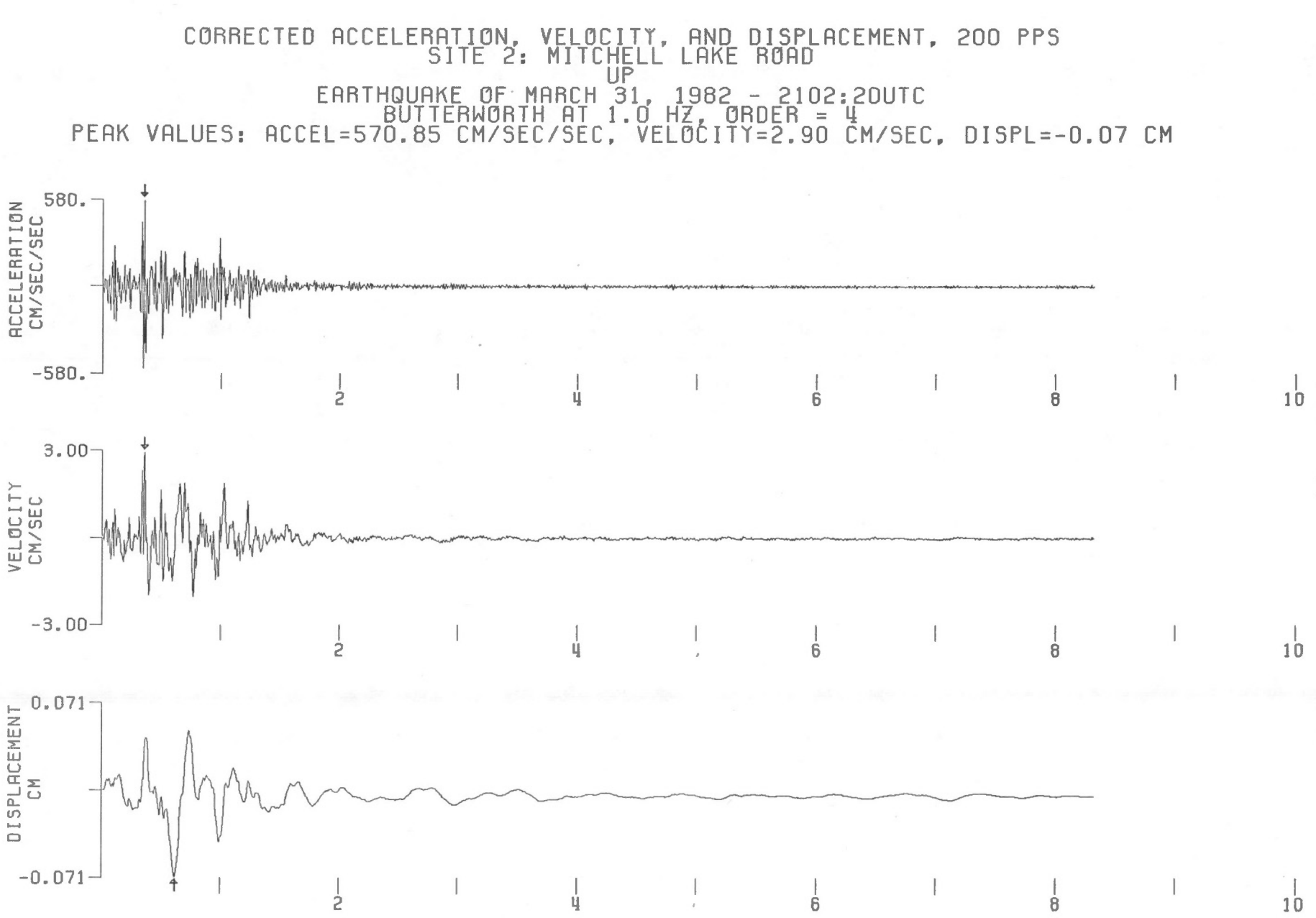

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 2: MITCHELL LAKE ROAD
UP
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=570.85 CM/SEC/SEC, VELOCITY=2.90 CM/SEC, DISPL=-0.07 CM
ACCELERATION CM/SEC/SEC
580.
-580.
VELOCITY CM/SEC
3.00
-3.00
DISPLACEMENT CM
0.071
-0.071
2
4
6
8
10
SECONDS

Fig. 26

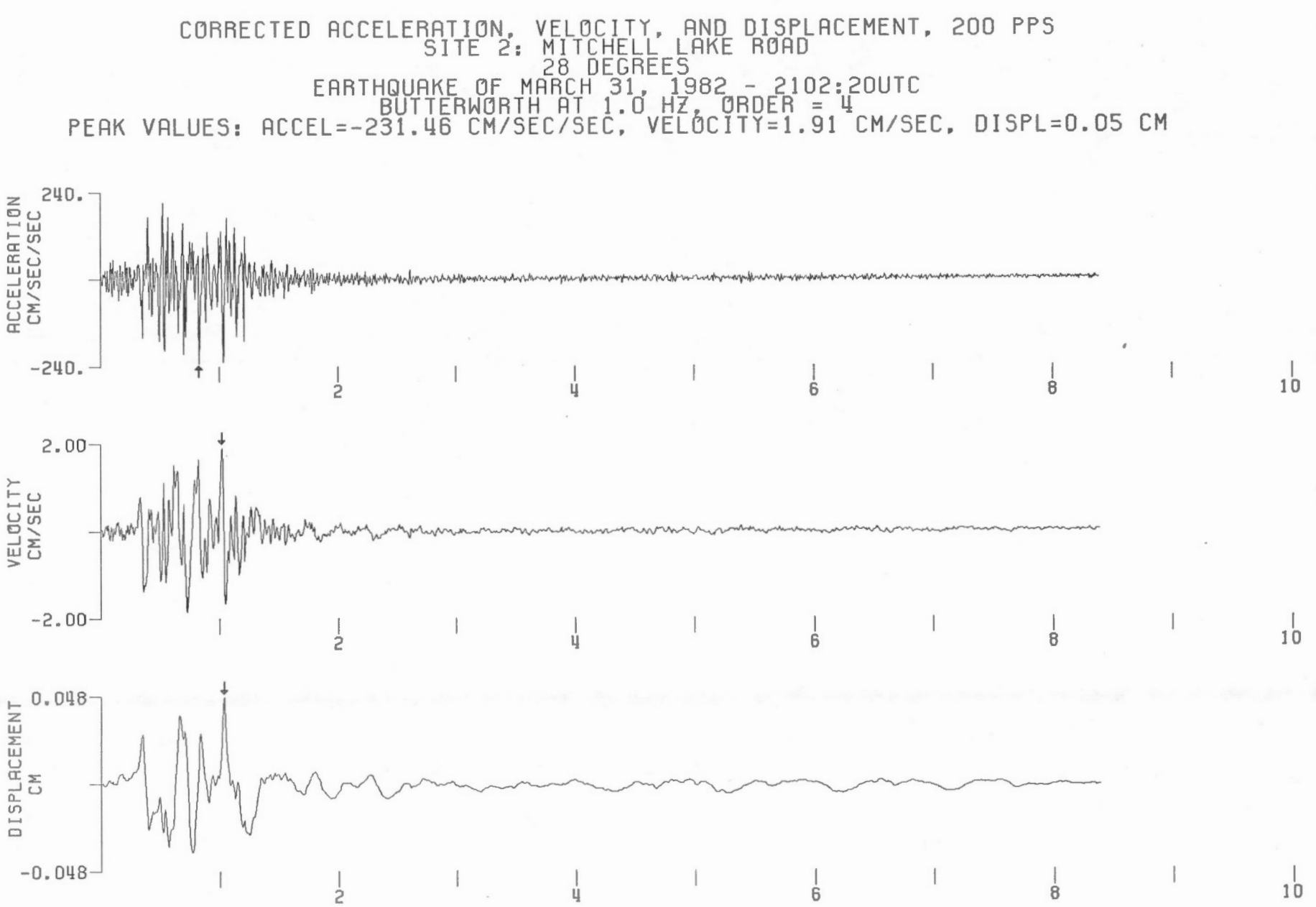

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 2: MITCHELL LAKE ROAD
28 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=-231.46 CM/SEC/SEC, VELOCITY=1.91 CM/SEC, DISPL=0.05 CM
ACCELERATION CM/SEC/SEC
240.
-240.
VELOCITY CM/SEC
2.00
-2.00
DISPLACEMENT CM
0.048
-0.048
2
4
6
8
10
SECONDS

Fig. 27

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 3: LOGGIE LODGE
189 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=-292.08 CM/SEC/SEC, VELOCITY=-1.80 CM/SEC, DISPL=-0.06 CM

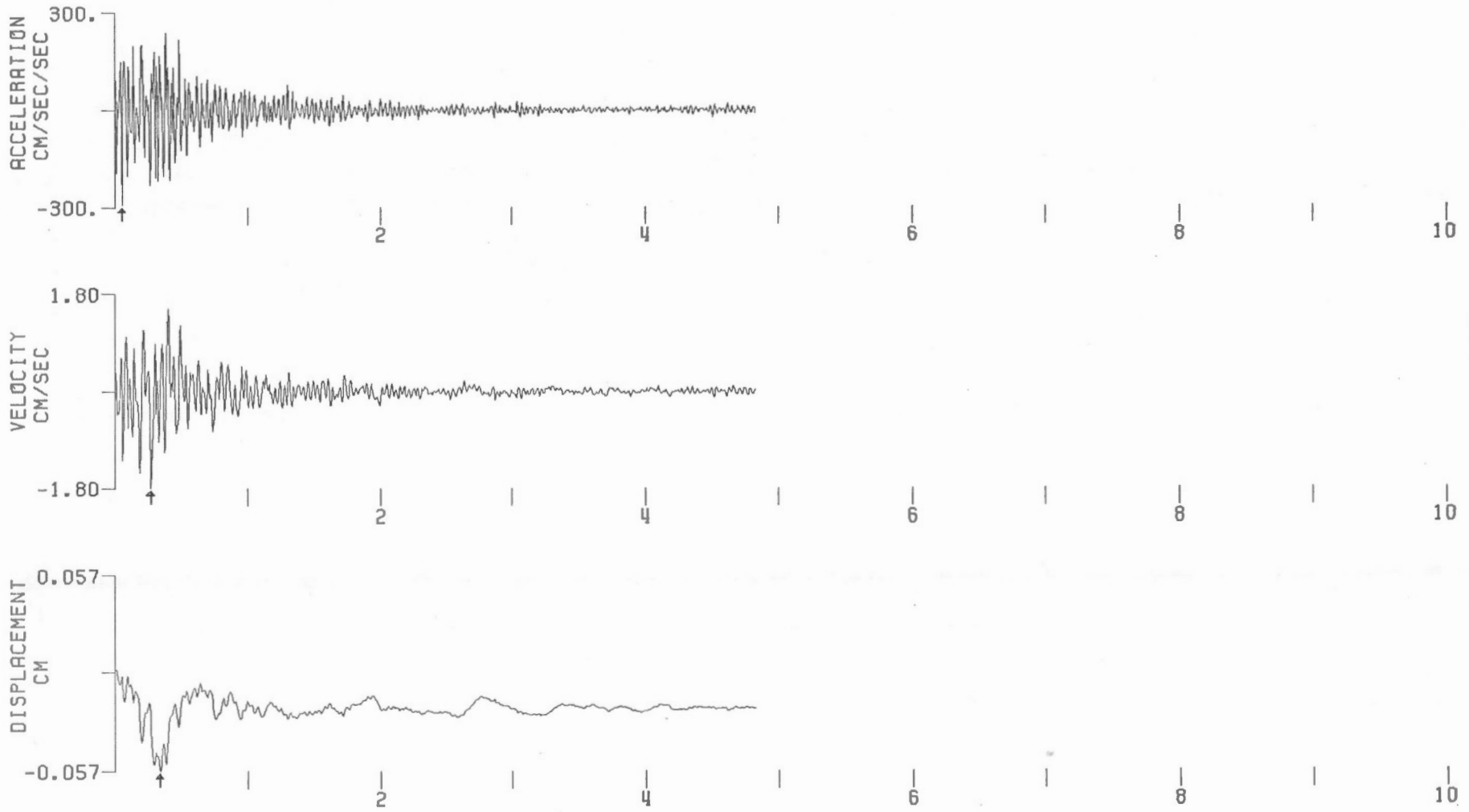



Fig. 28

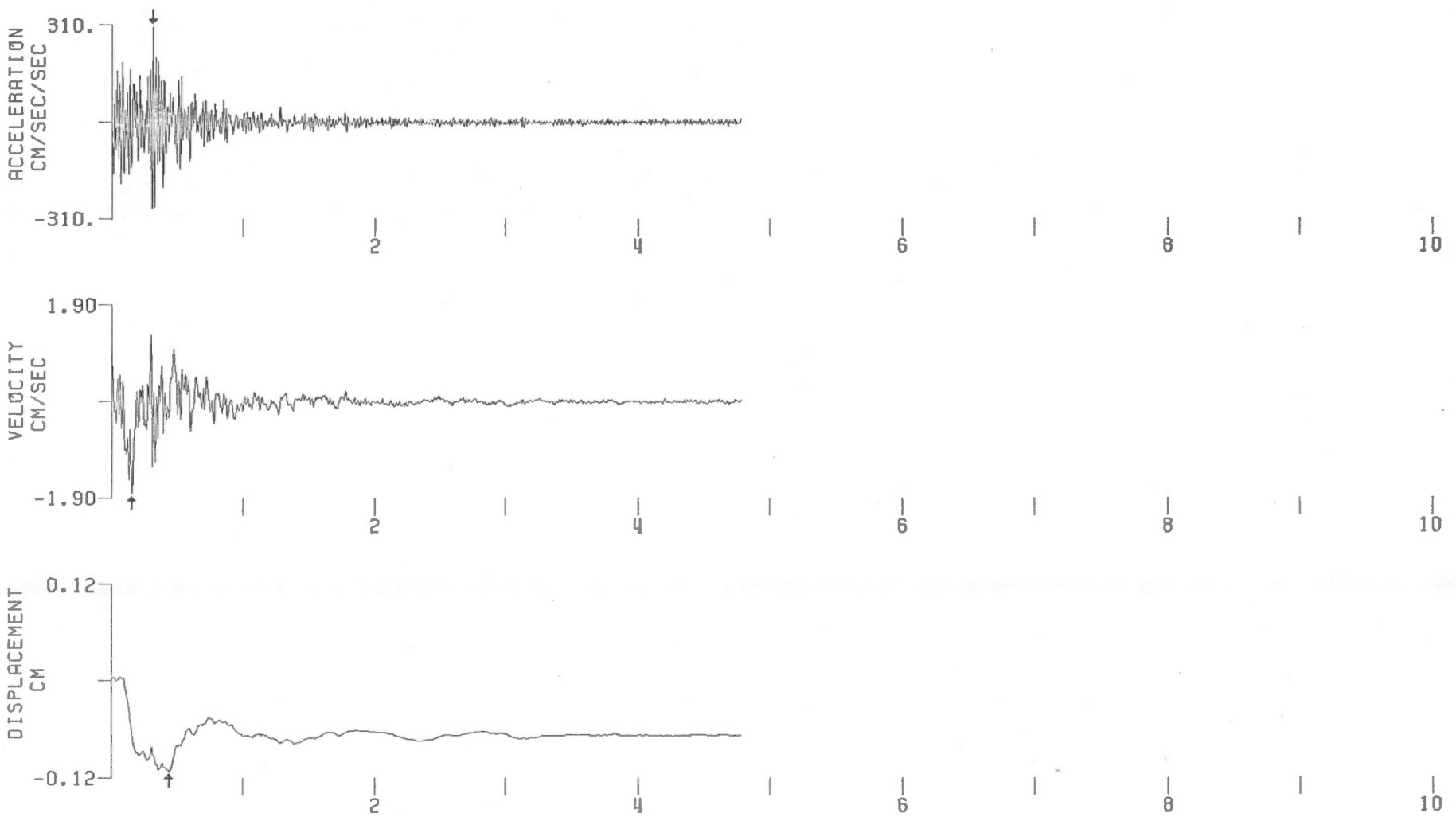

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 3: LOGGIE LODGE
UP
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=301.75 CM/SEC/SEC, VELOCITY=-1.82 CM/SEC, DISPL=-0.11 CM
ACCELERATION CM/SEC/SEC
310.
-310.
VELOCITY CM/SEC
1.90
-1.90
DISPLACEMENT CM
0.12
-0.12
2
4
6
8
10
SECONDS

Fig. 29

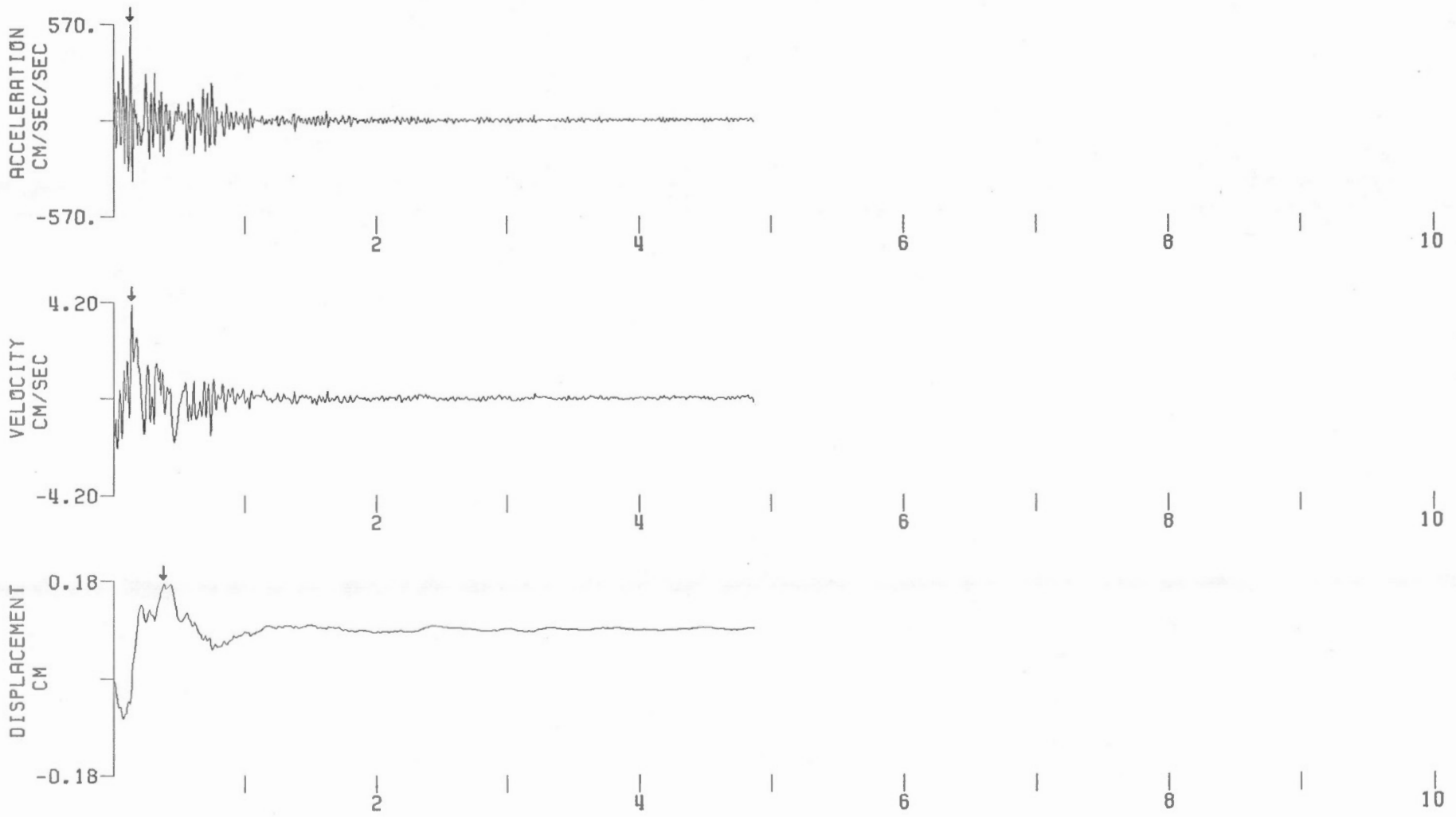

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 3: LOGGIE LODGE
99 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=564.22 CM/SEC/SEC, VELOCITY=4.11 CM/SEC, DISPL=0.18 CM
ACCELERATION CM/SEC/SEC
570.
-570.
VELOCITY CM/SEC
4.20
-4.20
DISPLACEMENT CM
0.18
-0.18
2
4
6
8
10
SECONDS

Fig. 30

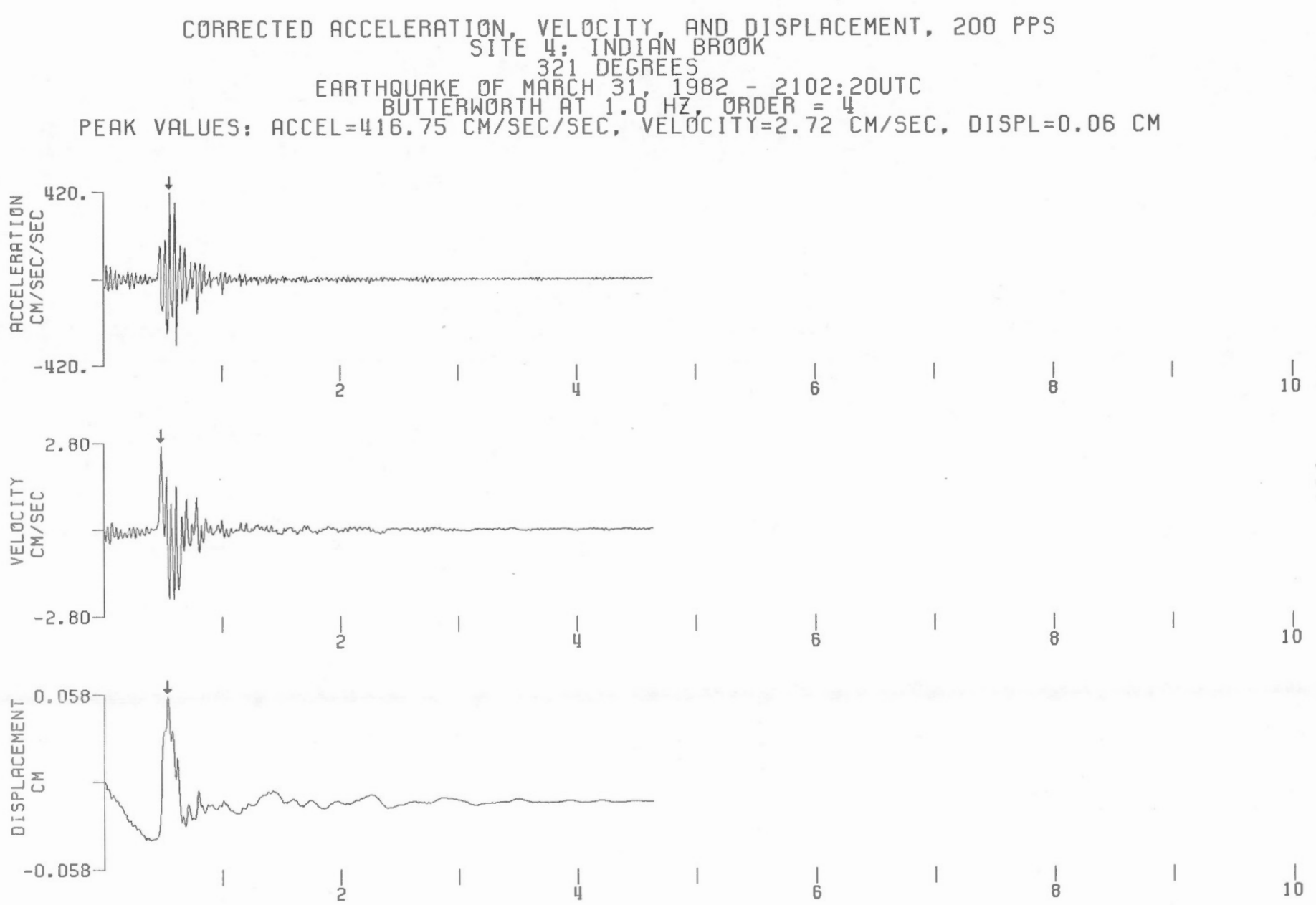

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 4: INDIAN BROOK
321 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=416.75 CM/SEC/SEC, VELOCITY=2.72 CM/SEC, DISPL=0.06 CM
ACCELERATION CM/SEC/SEC
420.
-420.
VELOCITY CM/SEC
2.80
-2.80
DISPLACEMENT CM
0.058
-0.058
2
4
6
8
10
SECONDS

Fig. 31

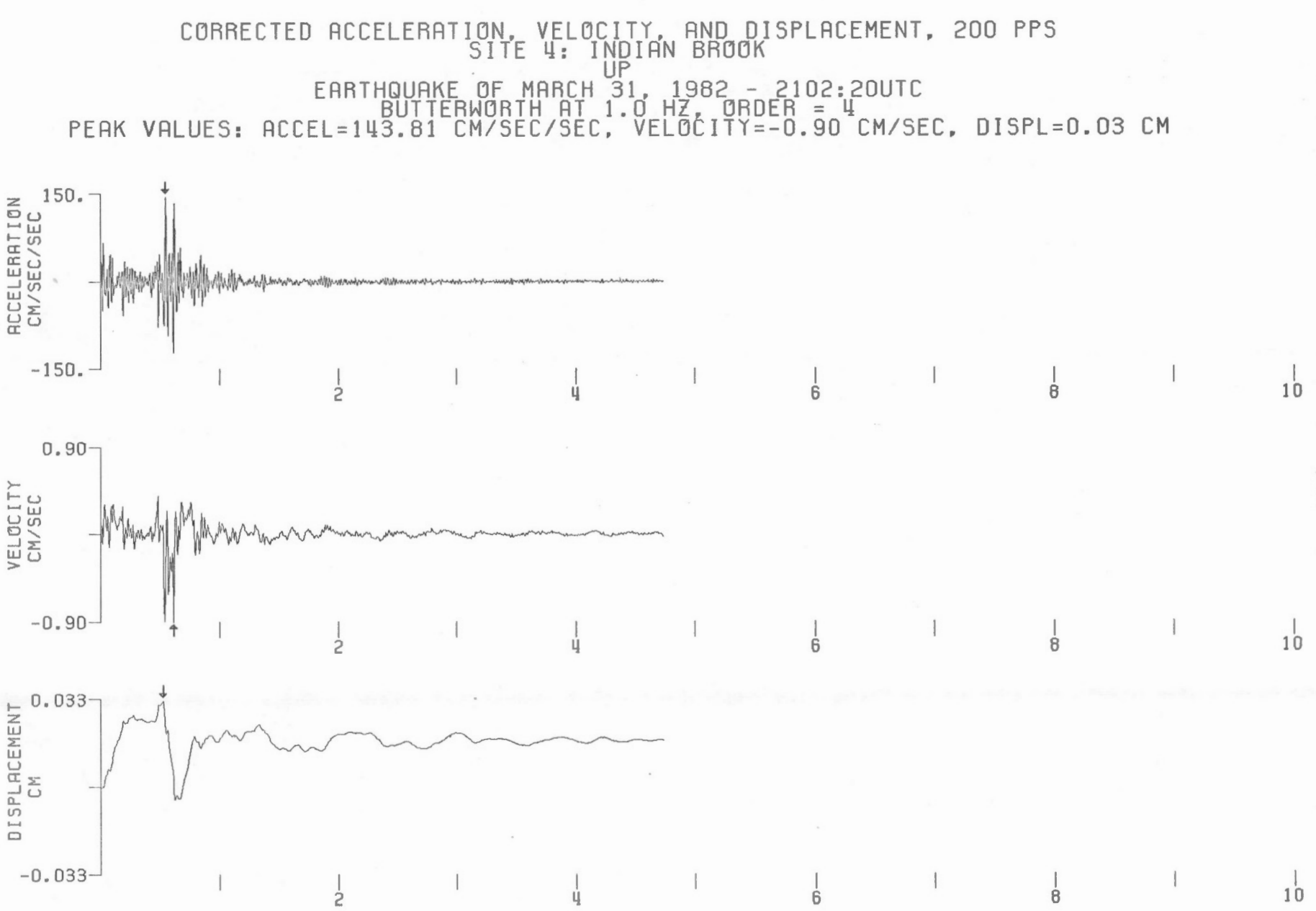

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 4: INDIAN BROOK
UP
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=143.81 CM/SEC/SEC, VELOCITY=-0.90 CM/SEC, DISPL=0.03 CM
ACCELERATION CM/SEC/SEC
150.
-150.
VELOCITY CM/SEC
0.90
-0.90
DISPLACEMENT CM
0.033
-0.033
2
4
6
8
10
SECONDS

Fig. 32

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 4: INDIAN BROOK
231 DEGREES
EARTHQUAKE OF MARCH 31, 1982 - 2102:20UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=-405.05 CM/SEC/SEC, VELOCITY=-3.11 CM/SEC, DISPL=-0.12 CM

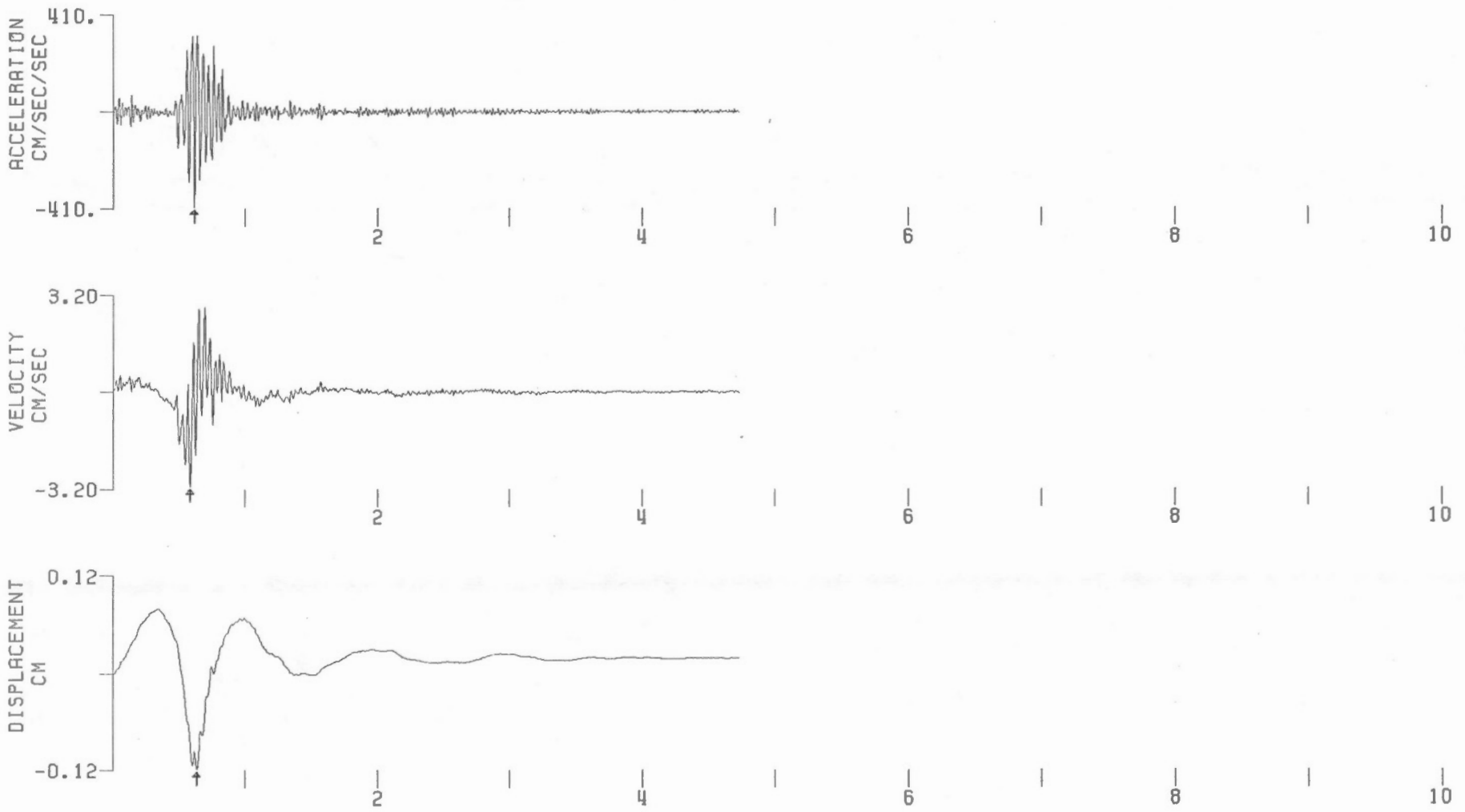



Fig. 33

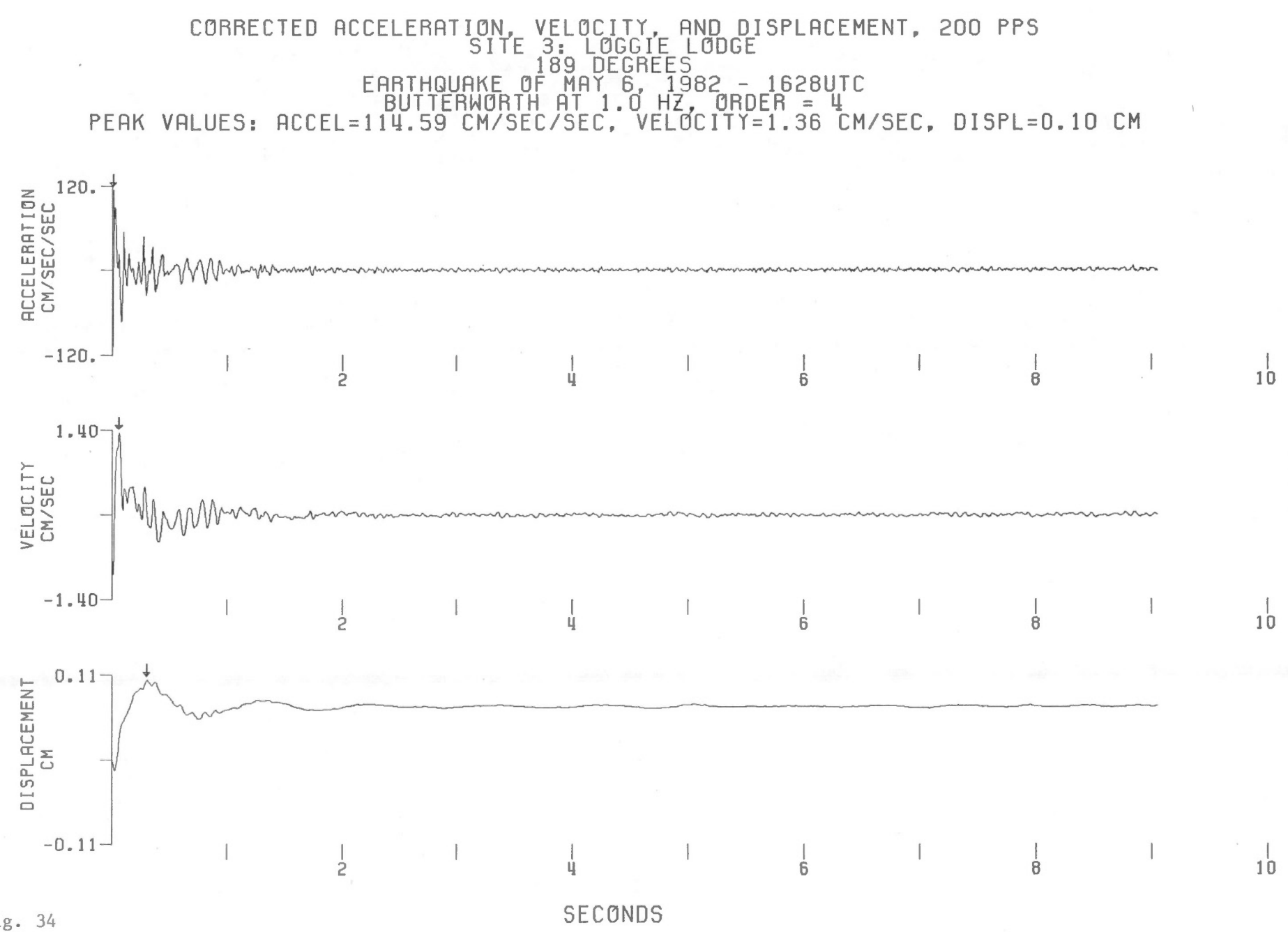

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 3: LOGGIE LODGE
189 DEGREES
EARTHQUAKE OF MAY 6, 1982 - 1628UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=114.59 CM/SEC/SEC, VELOCITY=1.36 CM/SEC, DISPL=0.10 CM
ACCELERATION CM/SEC/SEC
120.
-120.
VELOCITY CM/SEC
1.40
-1.40
DISPLACEMENT CM
0.11
-0.11
2
4
6
8
10
SECONDS

Fig. 34

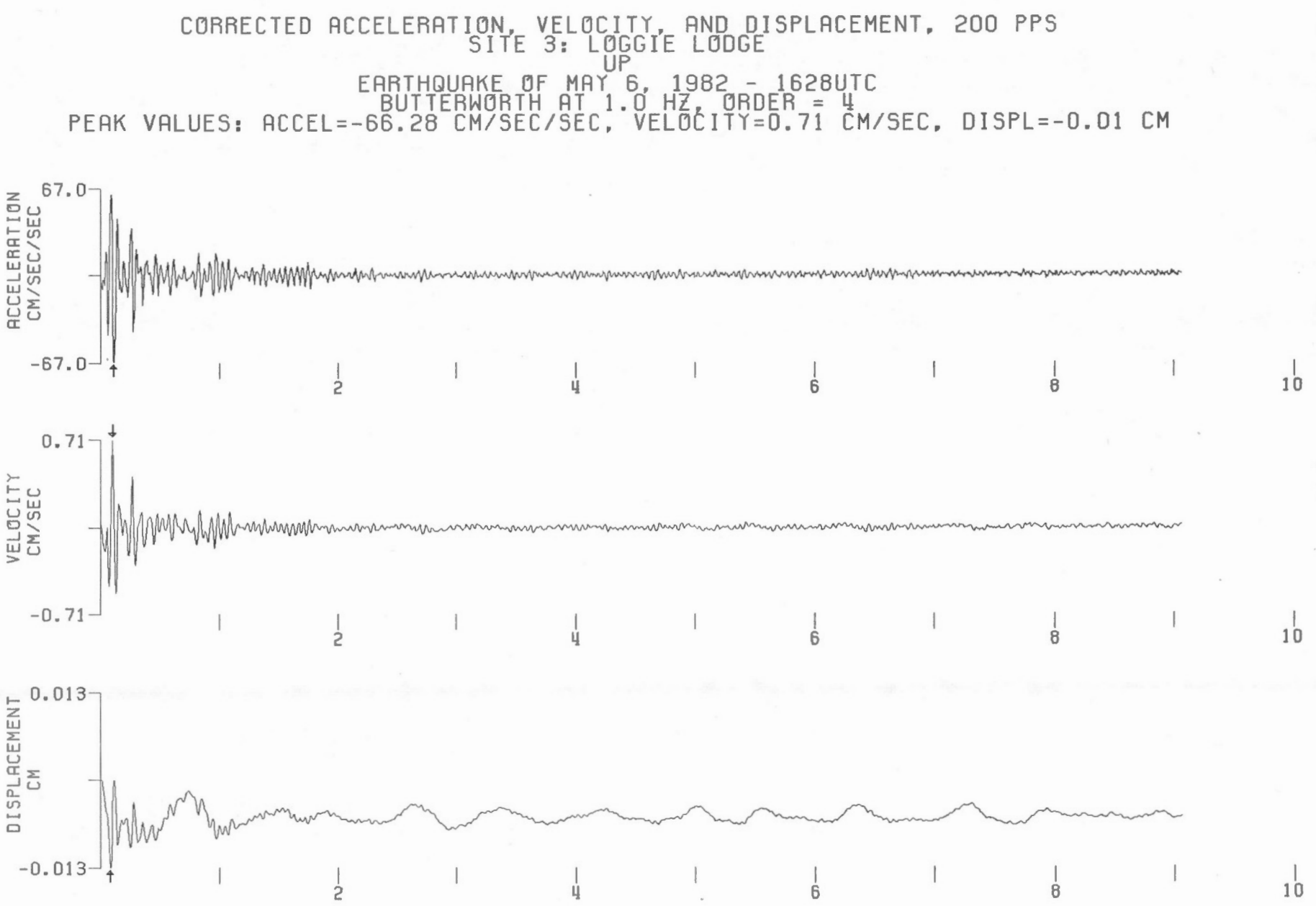

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 3: LOGGIE LODGE
UP
EARTHQUAKE OF MAY 6, 1982 - 1628UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=-66.28 CM/SEC/SEC, VELOCITY=0.71 CM/SEC, DISPL=-0.01 CM
ACCELERATION CM/SEC/SEC
67.0
-67.0
VELOCITY CM/SEC
0.71
-0.71
DISPLACEMENT CM
0.013
-0.013
2
4
6
8
10
SECONDS

Fig. 35

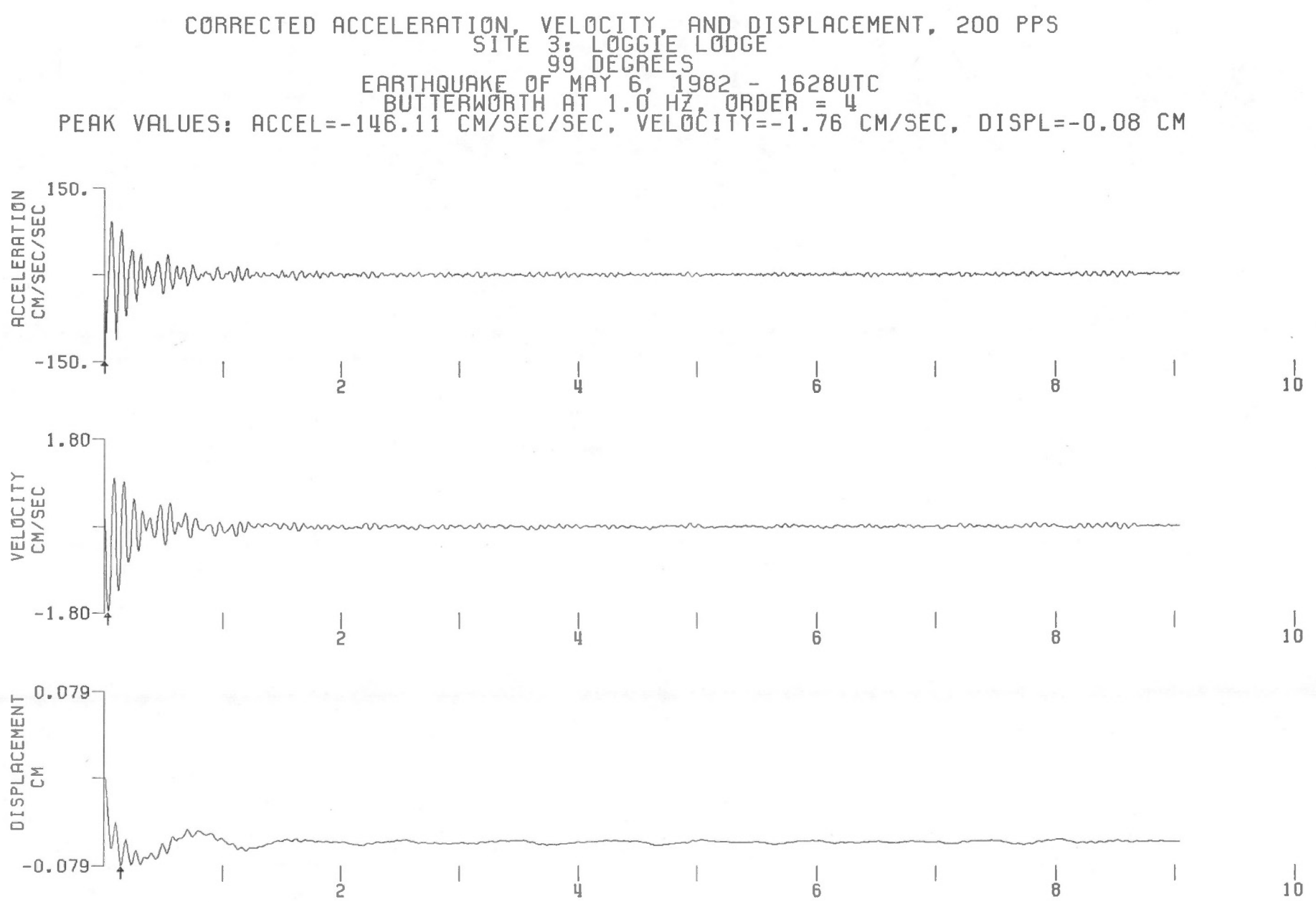

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT, 200 PPS
SITE 3: LOGGIE LODGE
99 DEGREES
EARTHQUAKE OF MAY 6, 1982 - 1628UTC
BUTTERWORTH AT 1.0 HZ, ORDER = 4
PEAK VALUES: ACCEL=-146.11 CM/SEC/SEC, VELOCITY=-1.76 CM/SEC, DISPL=-0.08 CM
ACCELERATION CM/SEC/SEC
150.
-150.
VELOCITY CM/SEC
1.80
-1.80
DISPLACEMENT CM
0.079
-0.079
2
4
6
8
10
SECONDS

Fig. 36

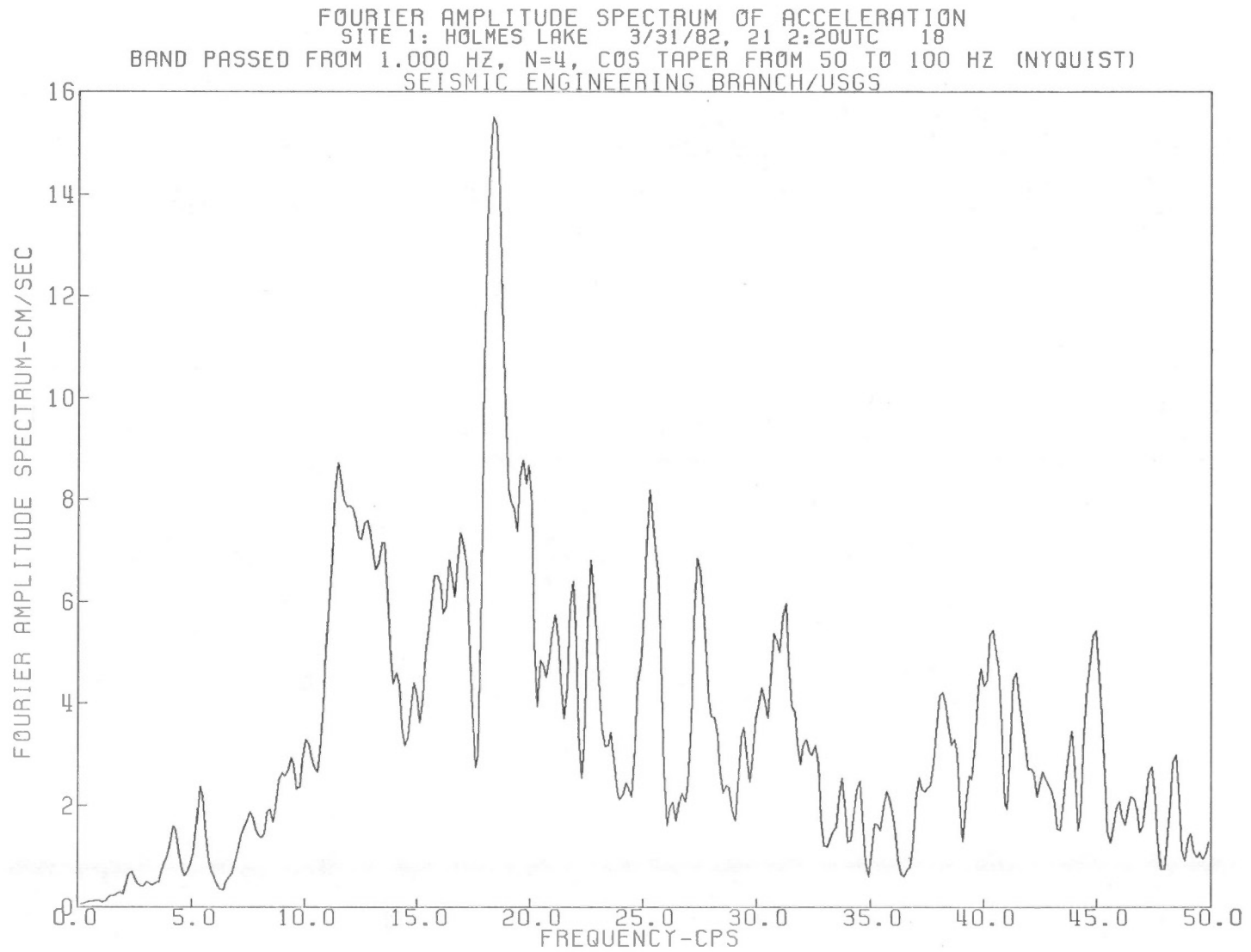

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 1: HOLMES LAKE 3/31/82, 21 2:20UTC 18
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
2
4
6
8
10
12
14
16
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 37

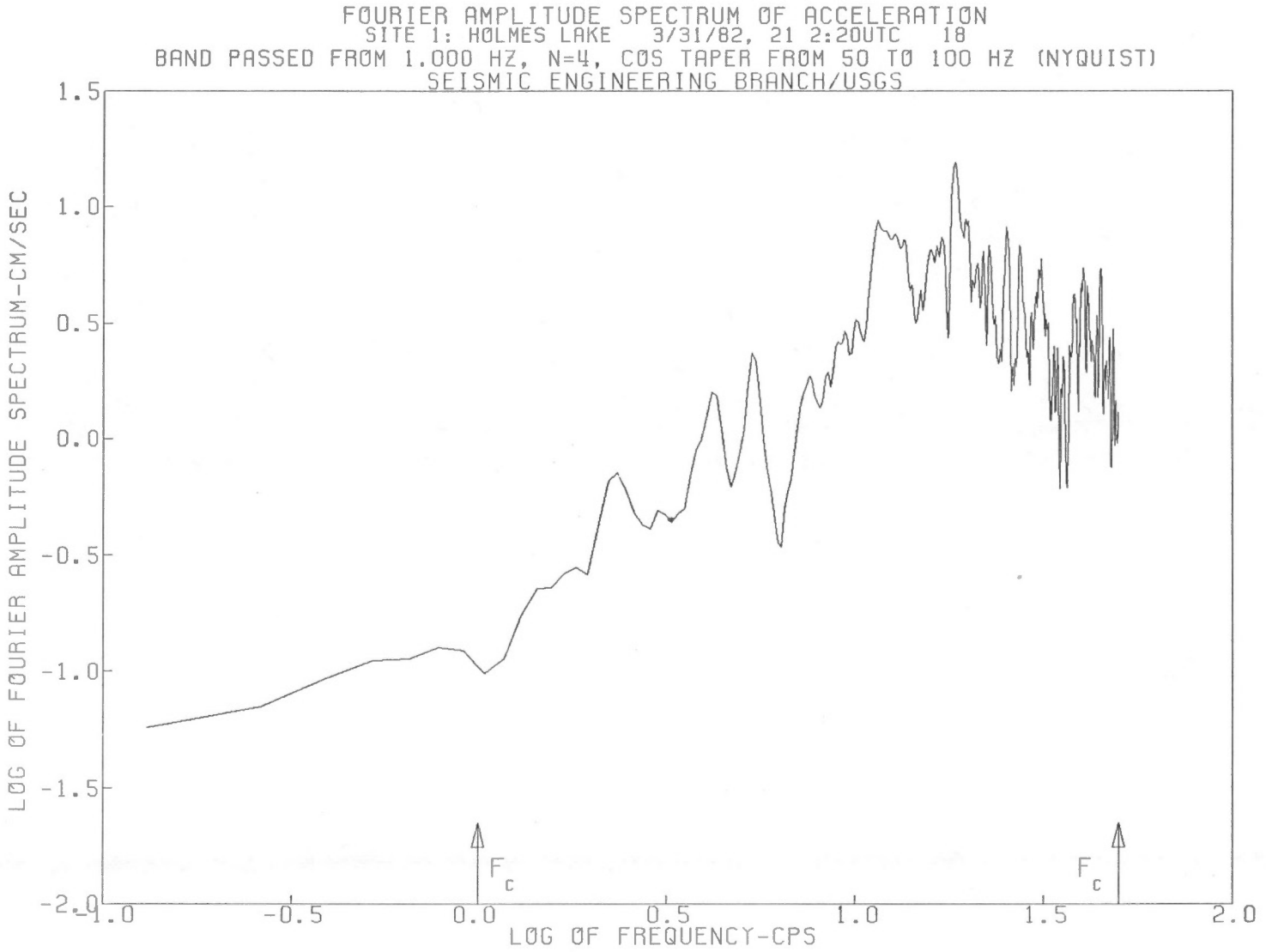

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 1: HOLMES LAKE 3/31/82, 21 2:20UTC 18
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS
Fc
Fc

Fig. 38

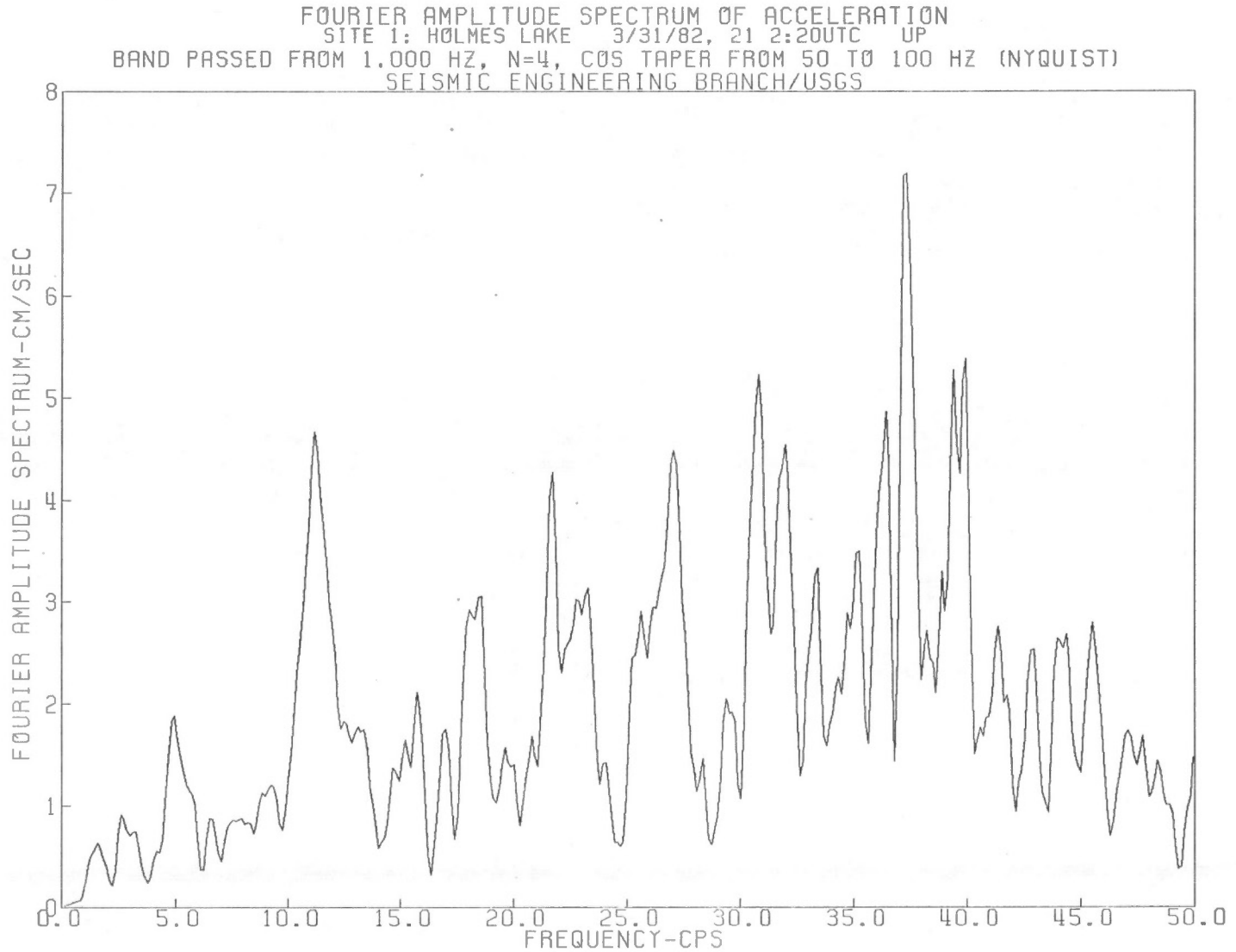

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 1: HOLMES LAKE 3/31/82, 21 2:20UTC UP
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
1
2
3
4
5
6
7
8
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 39

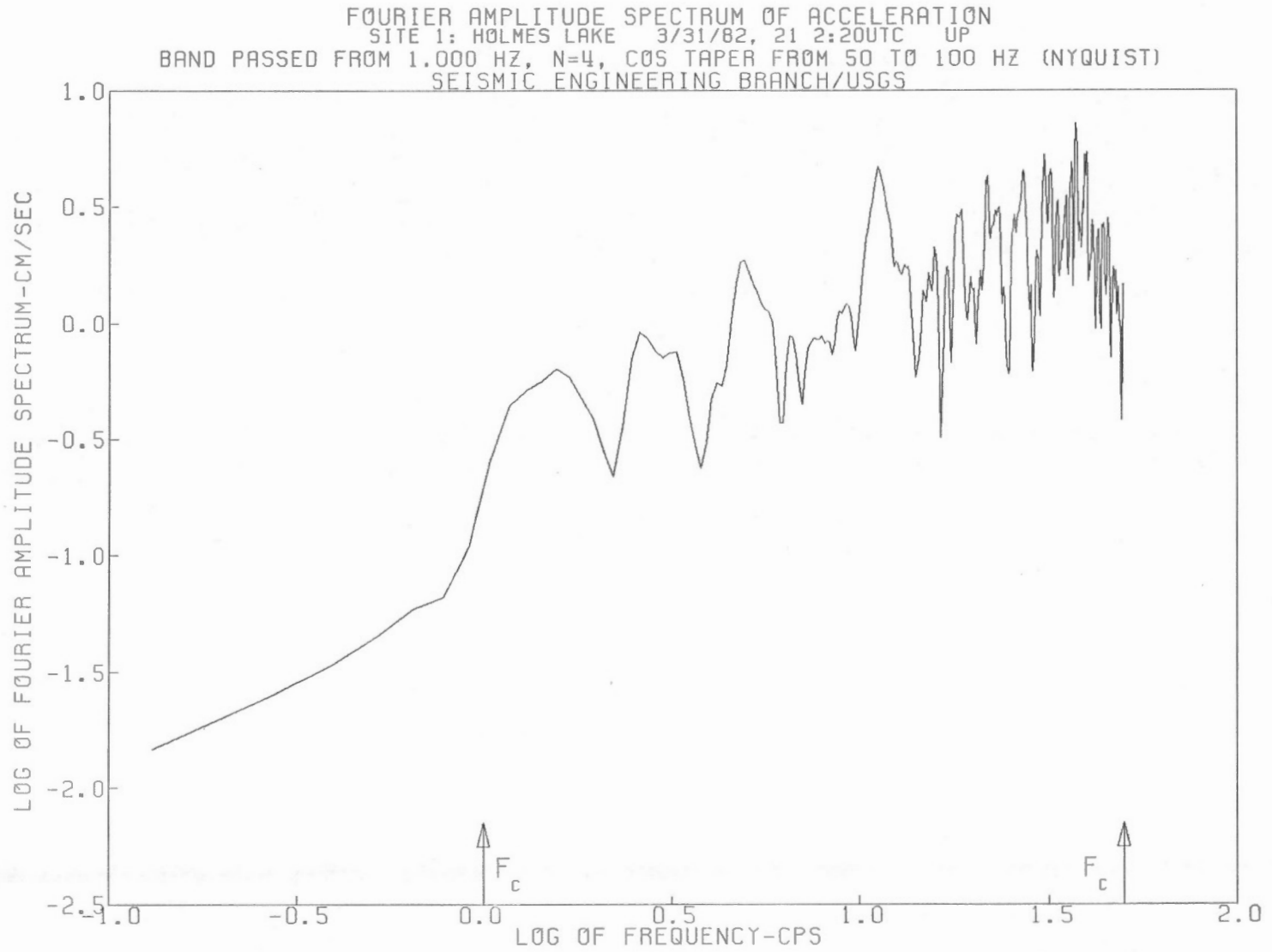

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 1: HOLMES LAKE 3/31/82, 21 2:20UTC UP
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS
$F_c$
$F_c$

Fig. 40

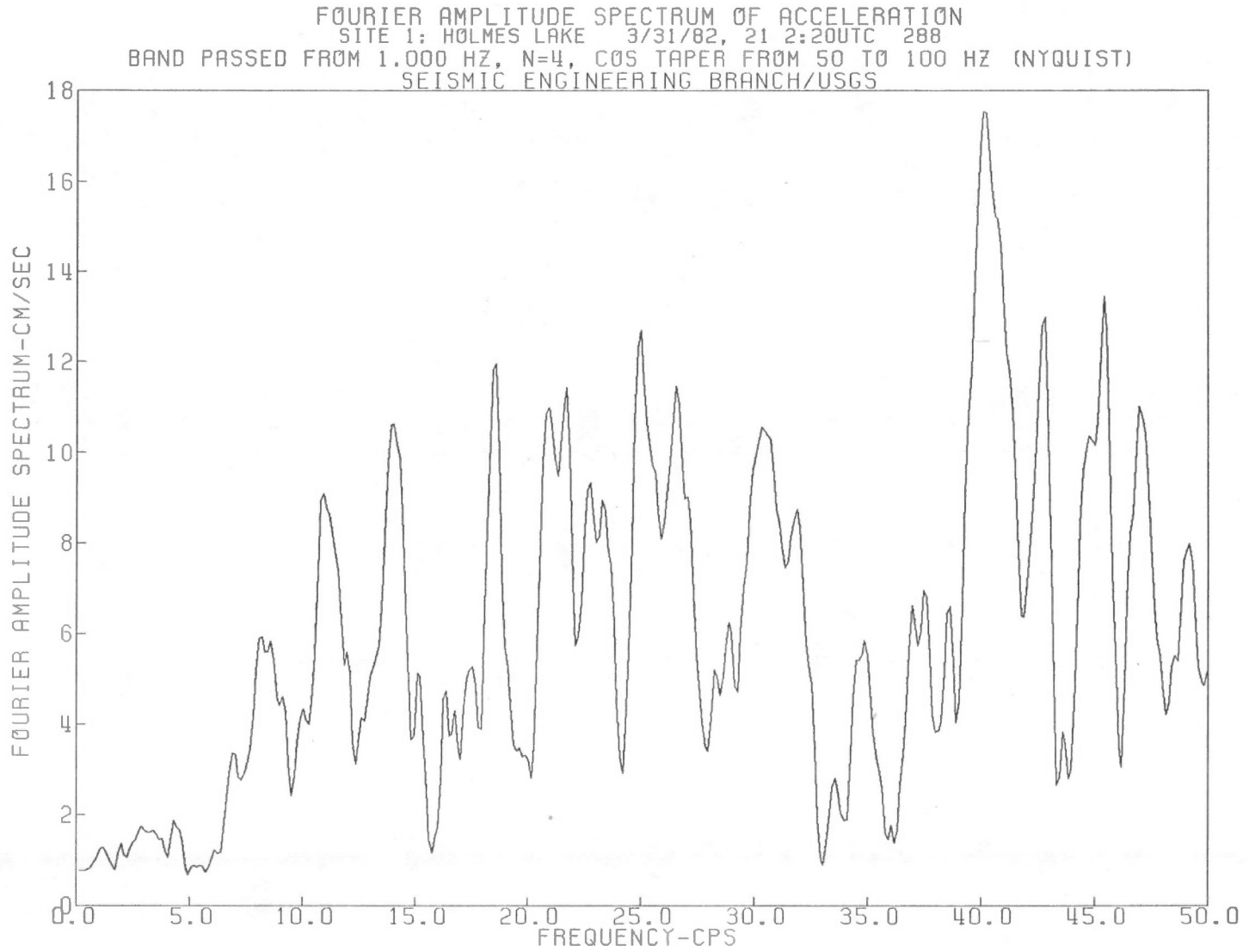

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 1: HOLMES LAKE 3/31/82, 21 2:20UTC 288
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
2
4
6
8
10
12
14
16
18
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 41

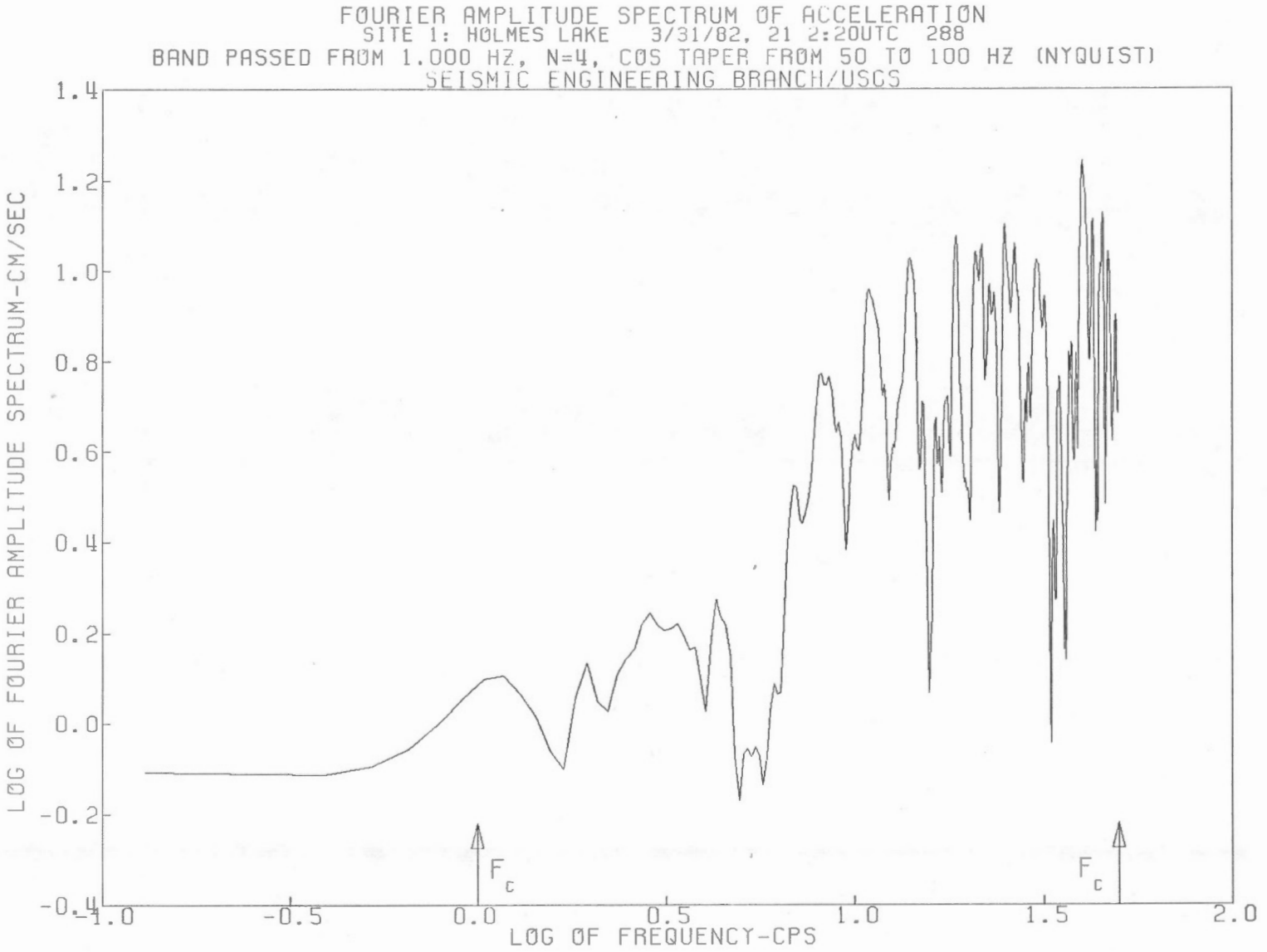

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 1: HOLMES LAKE 3/31/82, 21 2:20UTC 288
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS
$F_c$
$F_c$

Fig. 42

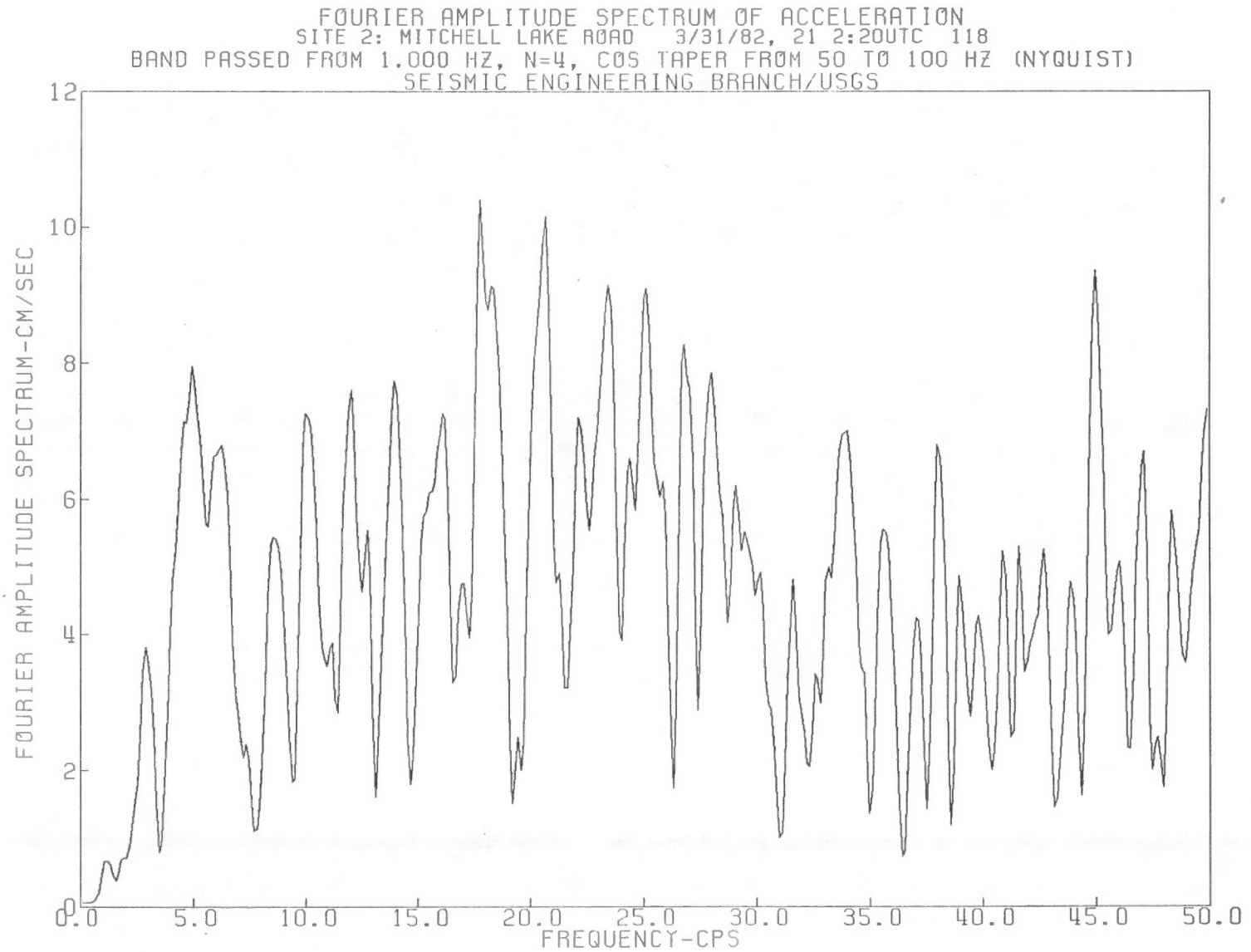

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 2: MITCHELL LAKE ROAD 3/31/82, 21 2:20UTC 118
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
2
4
6
8
10
12
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 43

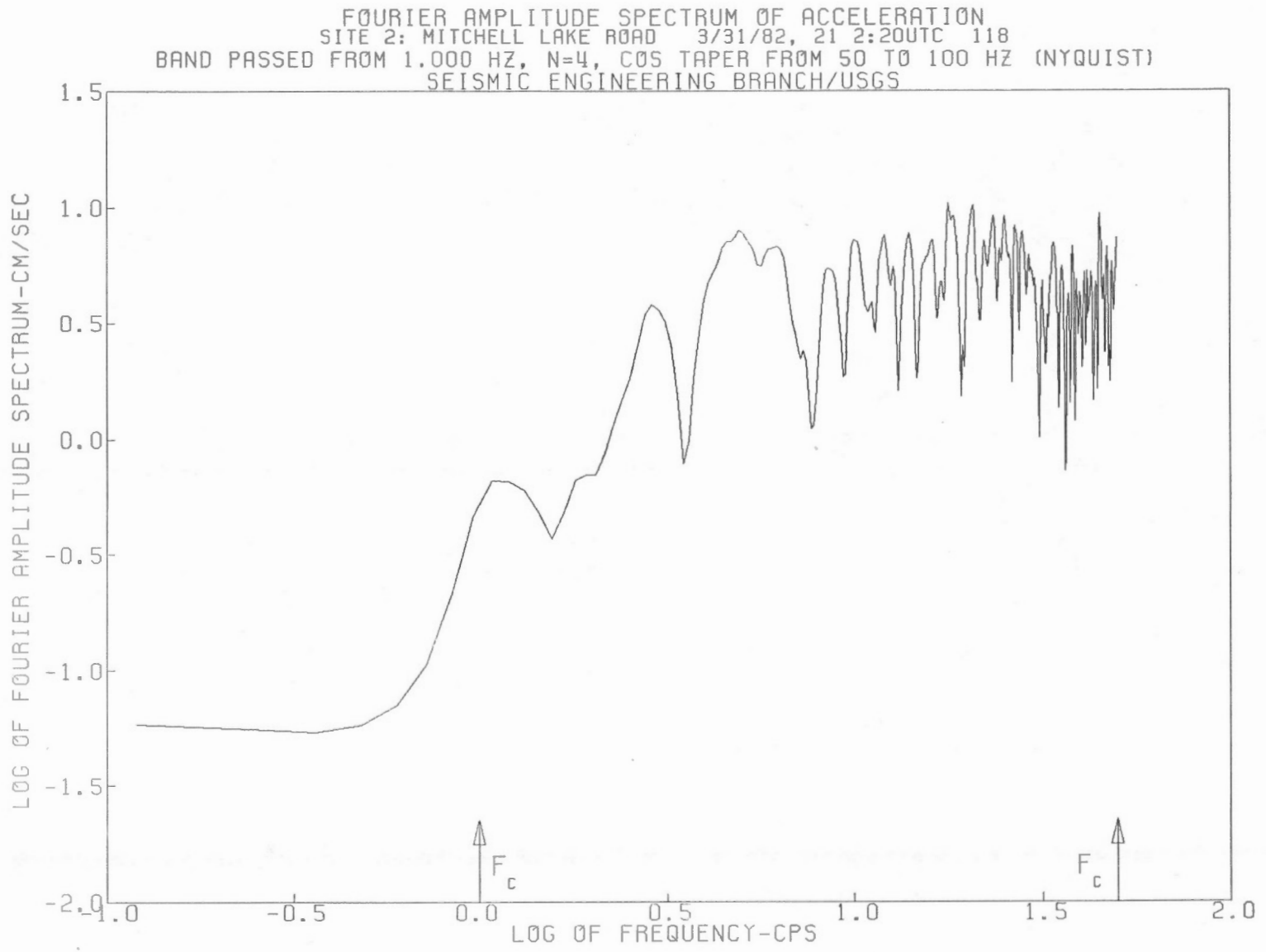

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 2: MITCHELL LAKE ROAD 3/31/82, 21 2:20UTC 118
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS
$F_c$
$F_c$

Fig. 44

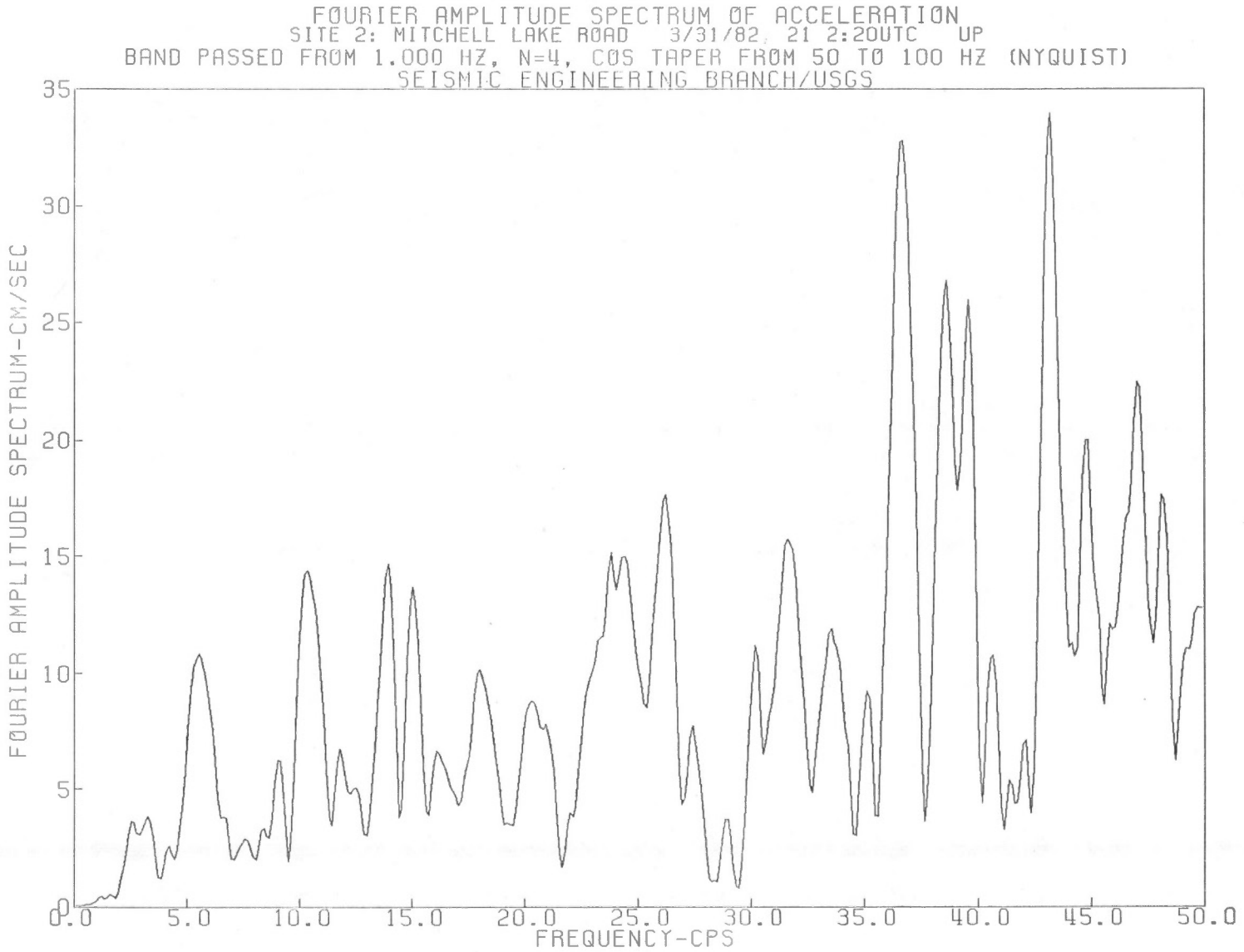

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 2: MITCHELL LAKE ROAD 3/31/82, 21 2:20UTC UP
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
5
10
15
20
25
30
35
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 45

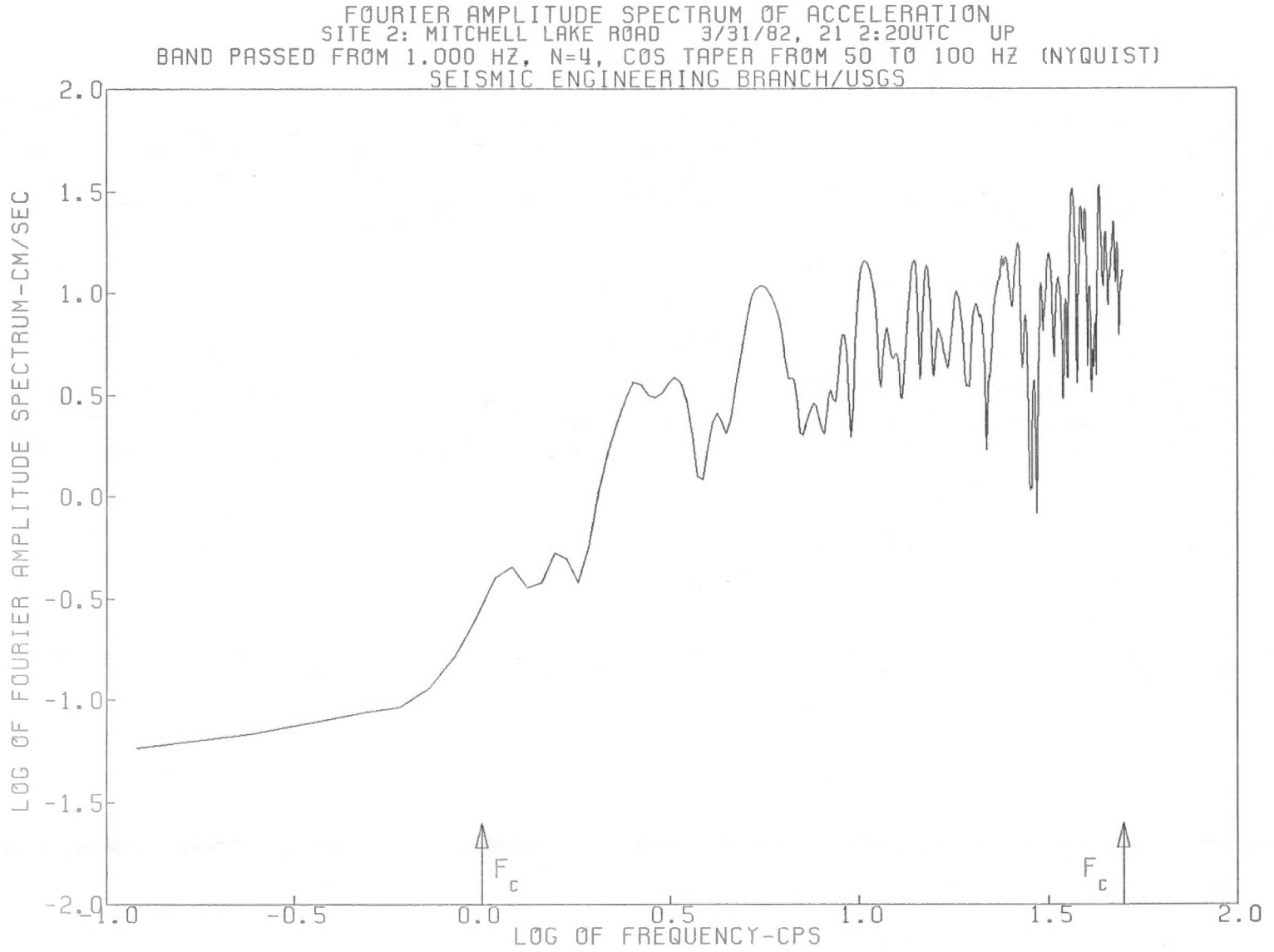

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 2: MITCHELL LAKE ROAD 3/31/82, 21 2:20UTC UP
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS
$F_c$
$F_c$

Fig. 46

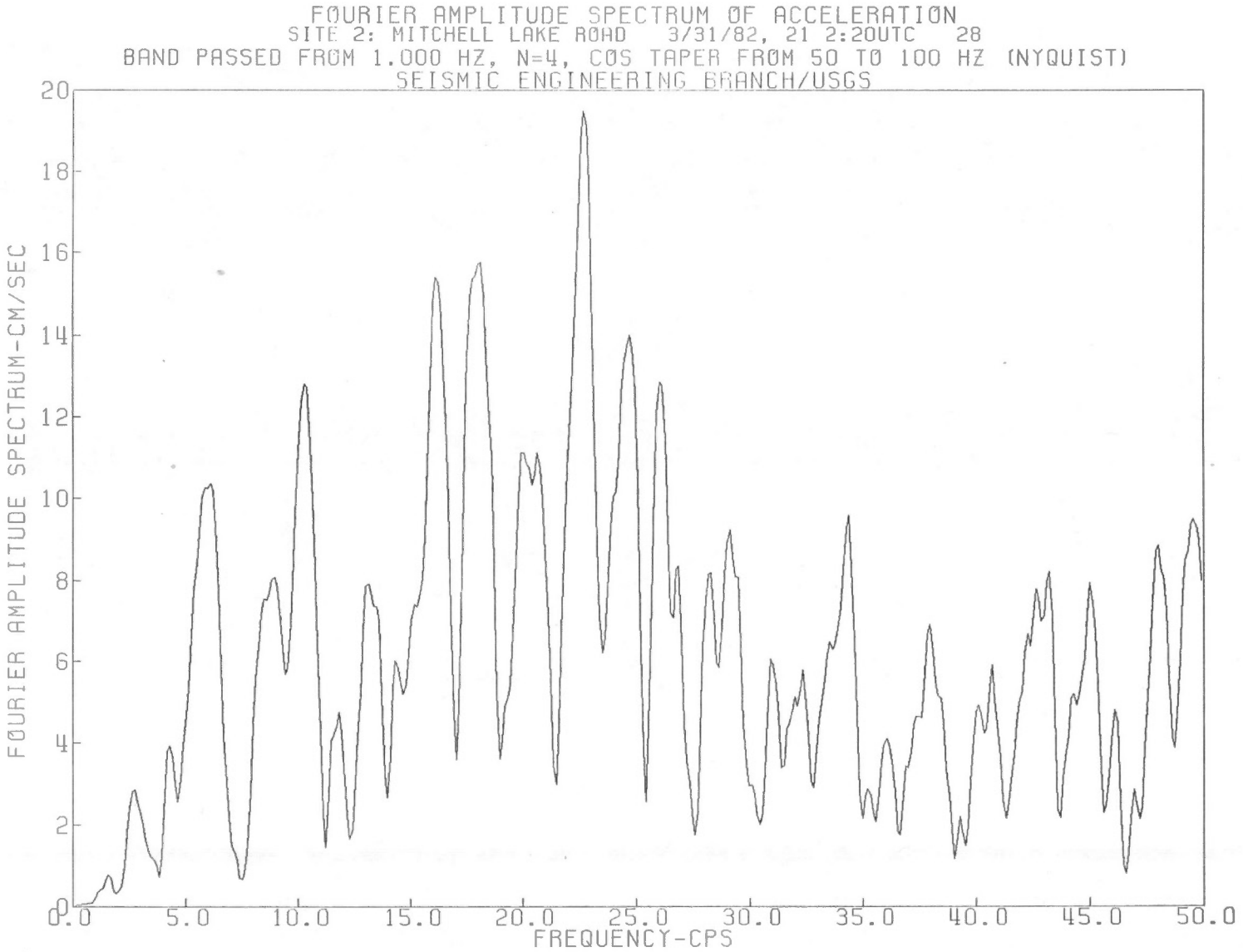

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 2: MITCHELL LAKE ROAD 3/31/82, 21 2:20UTC 28
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
2
4
6
8
10
12
14
16
18
20
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 47

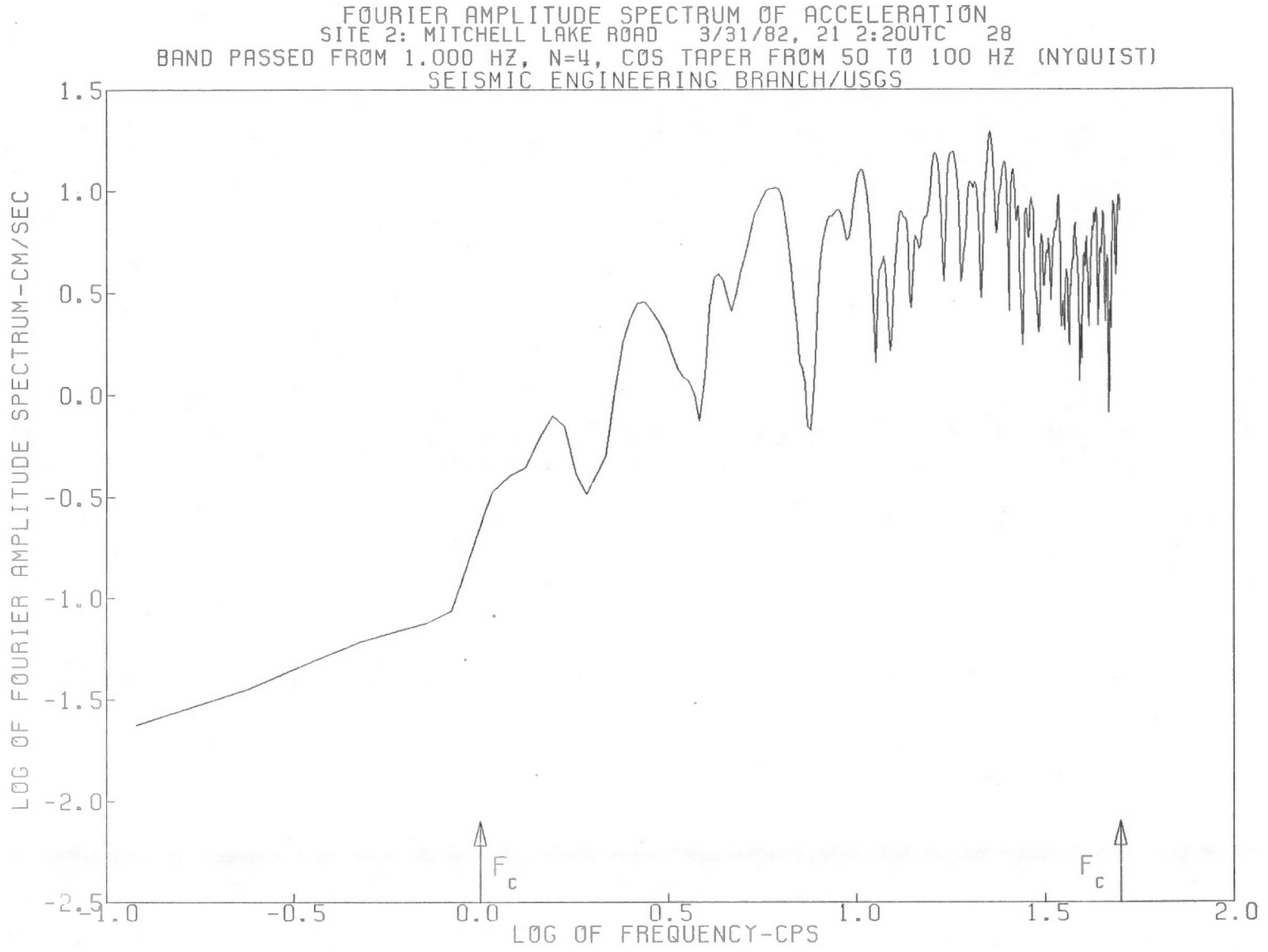

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 2: MITCHELL LAKE ROAD 3/31/82, 21 2:20UTC 28
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS
Fc
Fc

Fig. 48

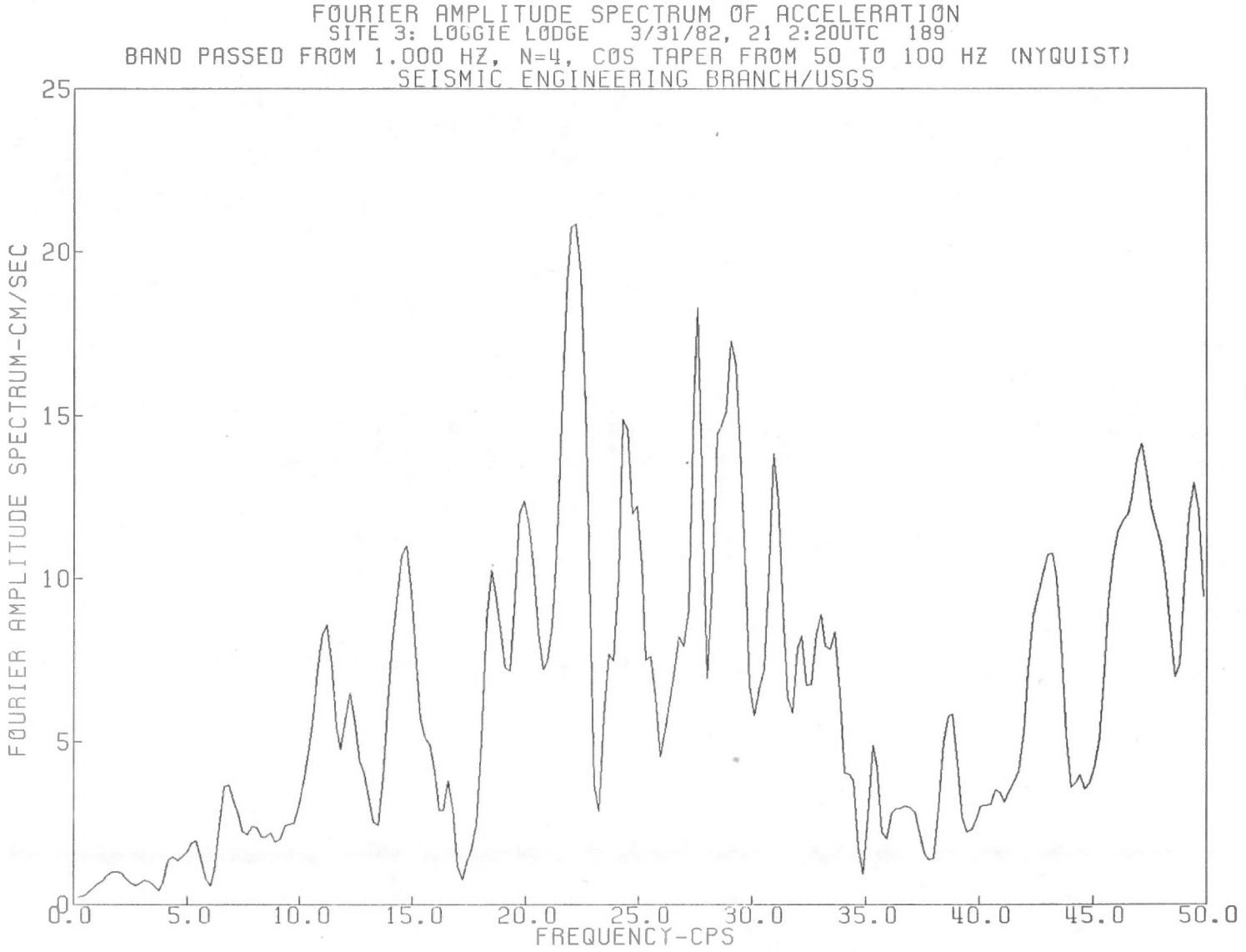

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 3: LOGGIE LODGE 3/31/82, 21 2:20UTC 189
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
5
10
15
20
25
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 49

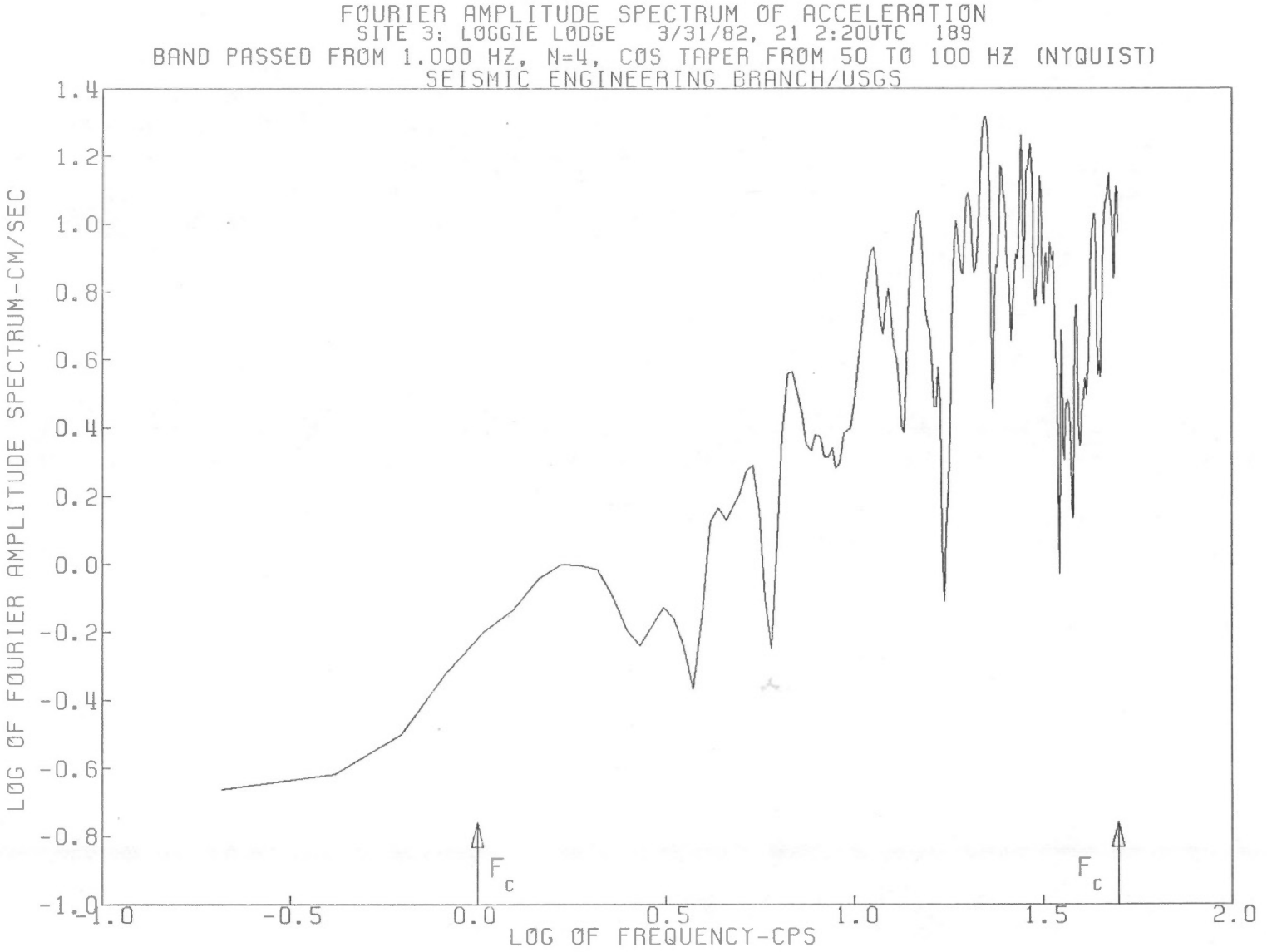

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 3: LOGGIE LODGE 3/31/82, 21 2:20UTC 189
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS
$F_c$
$F_c$

Fig. 50

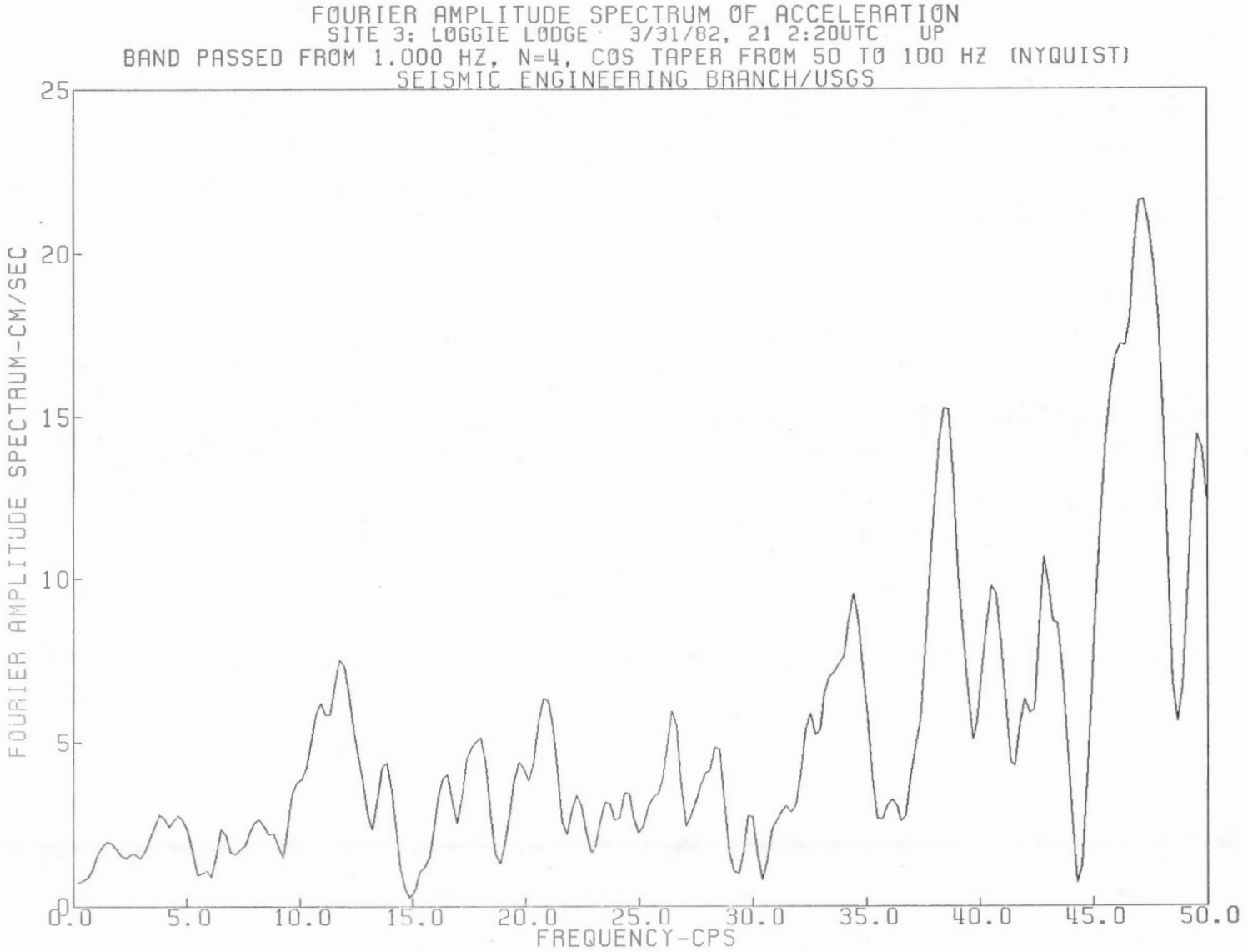

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 3: LOGGIE LODGE 3/31/82, 21 2:20UTC UP
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
5
10
15
20
25
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 51

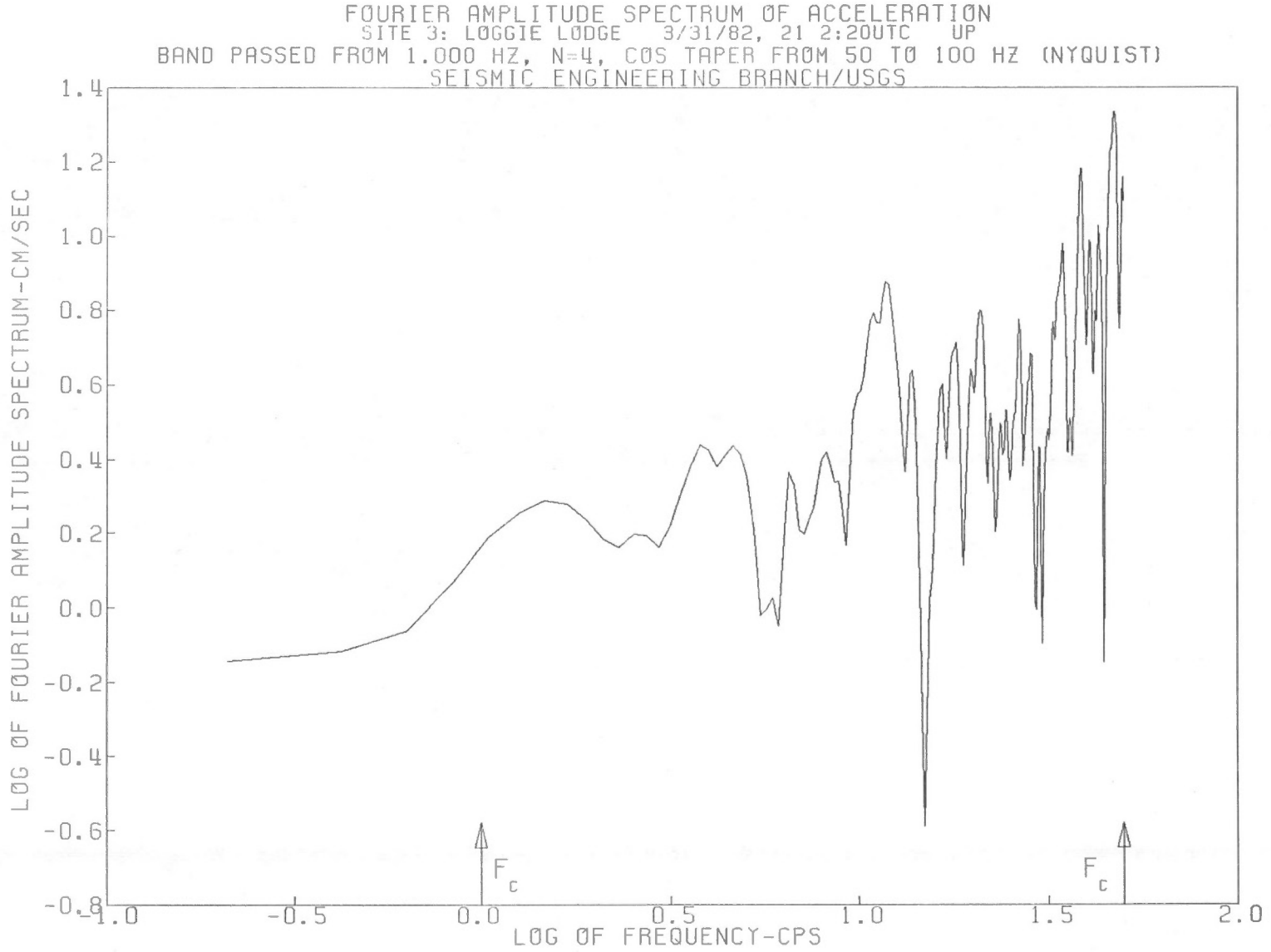

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 3: LOGGIE LODGE 3/31/82, 21 2:20UTC UP
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS
Fc
Fc

Fig. 52

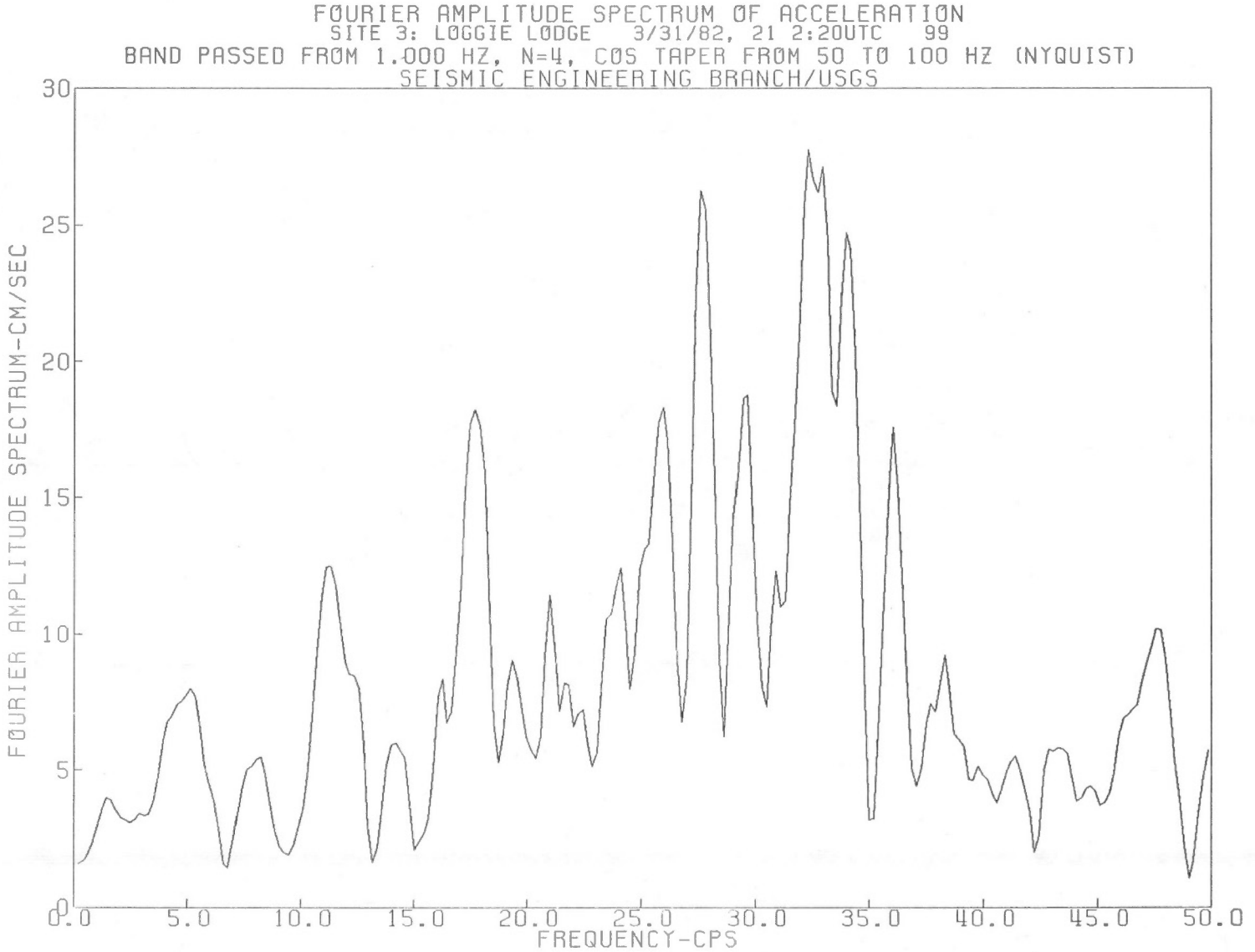

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 3: LOGGIE LODGE 3/31/82, 21 2:20UTC 99
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
5
10
15
20
25
30
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 53

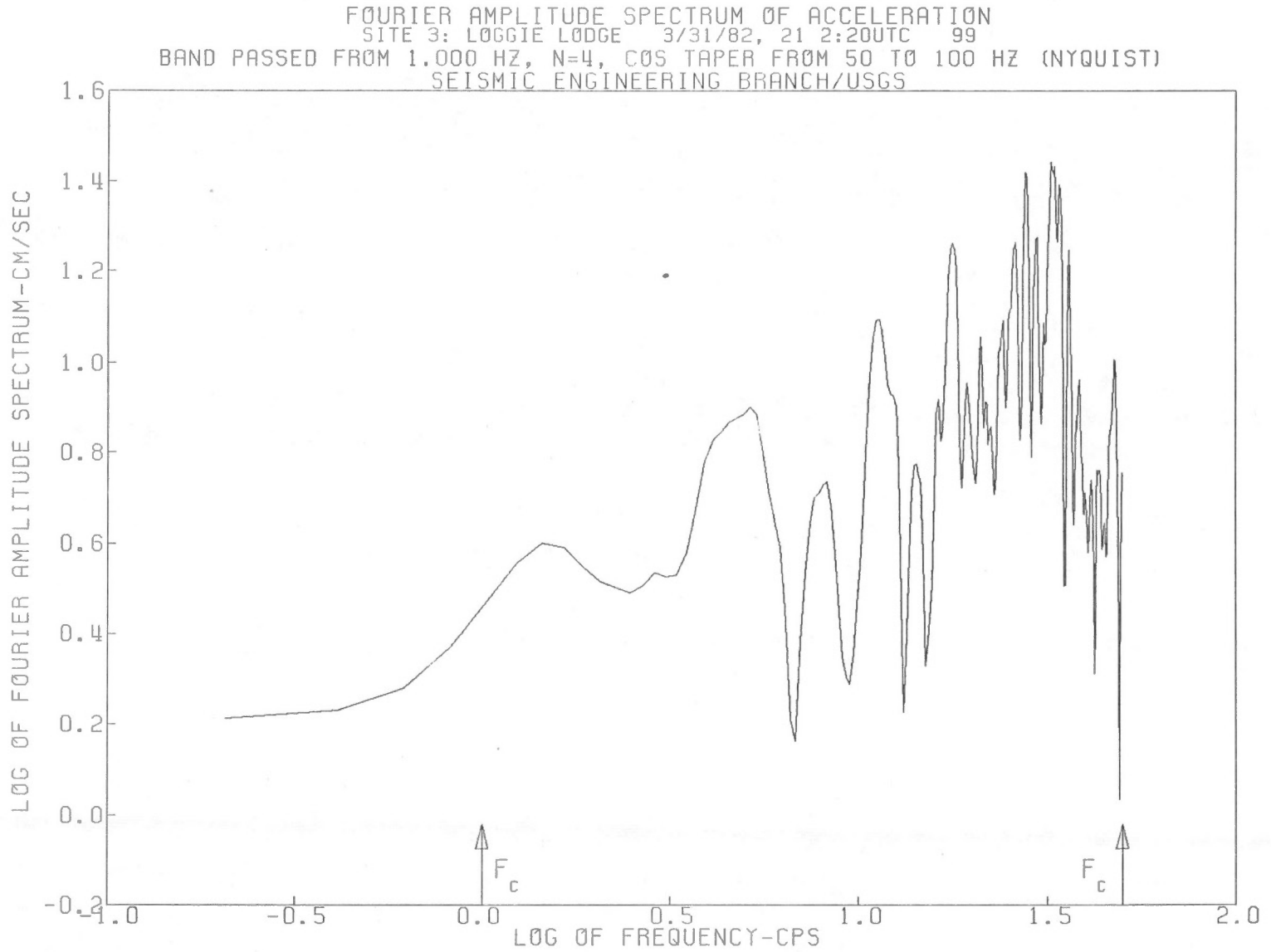

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 3: LOGGIE LODGE 3/31/82, 21 2:20UTC 99
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS
$F_c$
$F_c$

Fig. 54

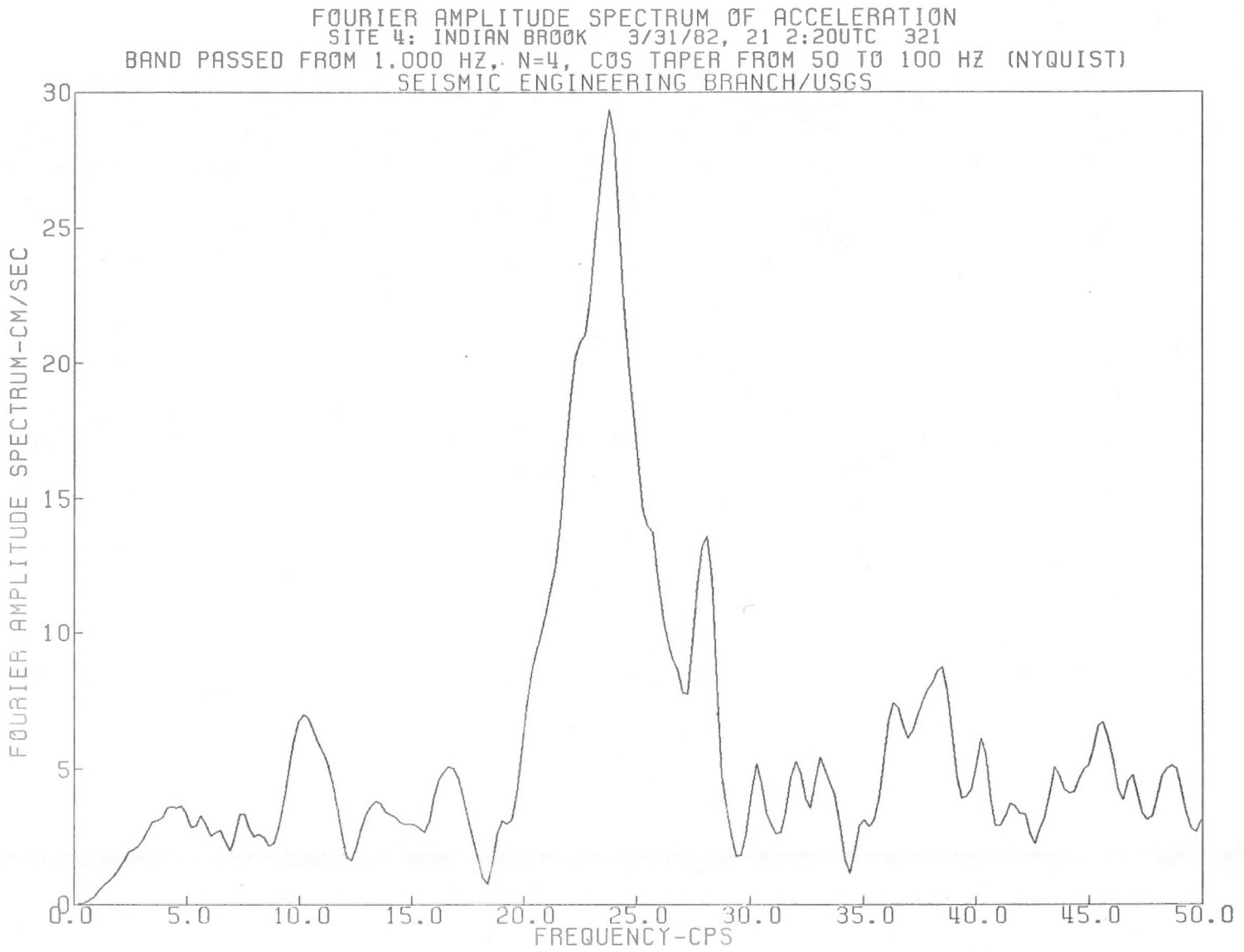

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 4: INDIAN BROOK 3/31/82, 21 2:20UTC 321
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
5
10
15
20
25
30
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 55

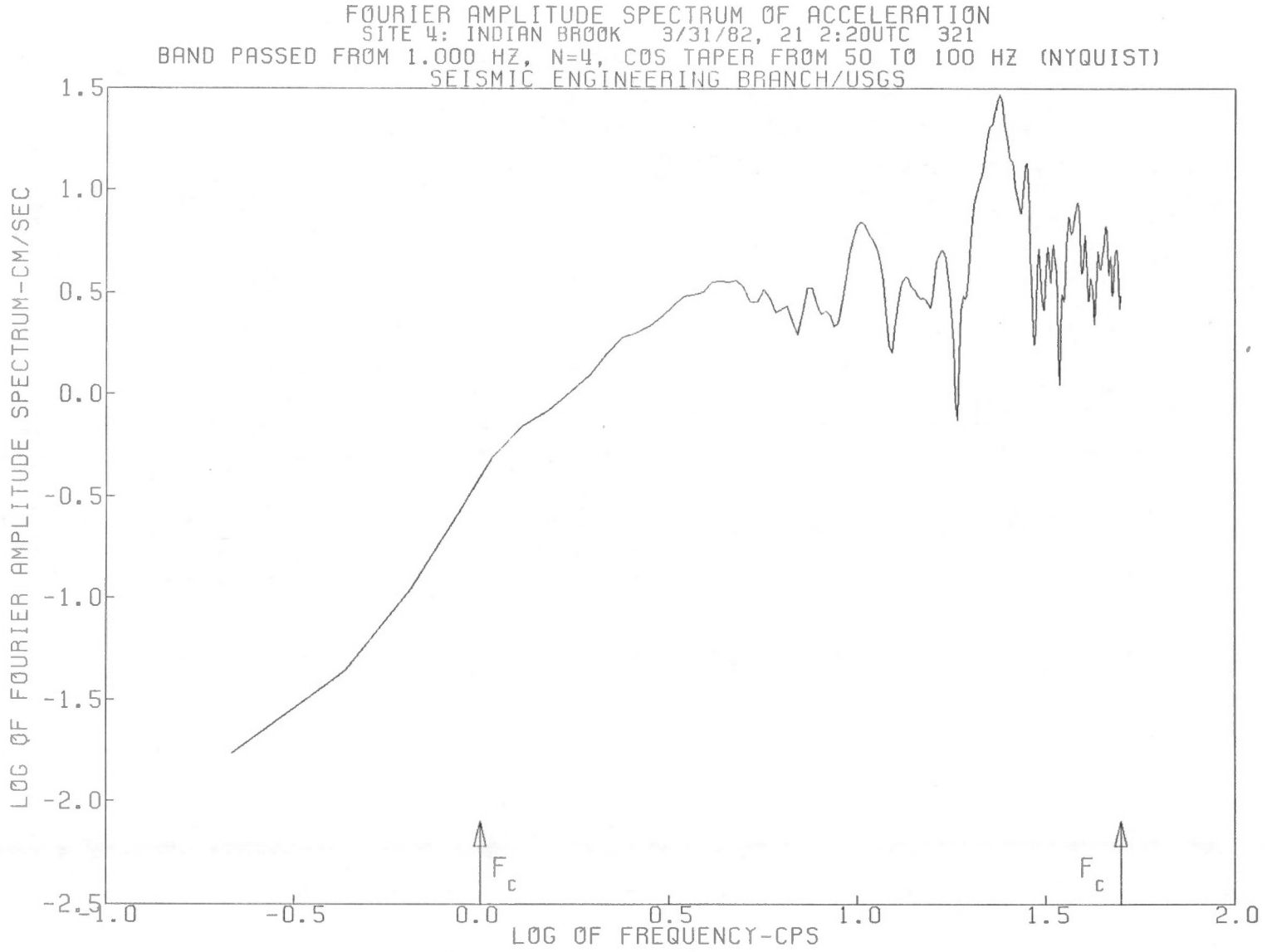

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 4: INDIAN BROOK 3/31/82, 21 2:20UTC 321
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS
Fc
Fc

Fig. 56

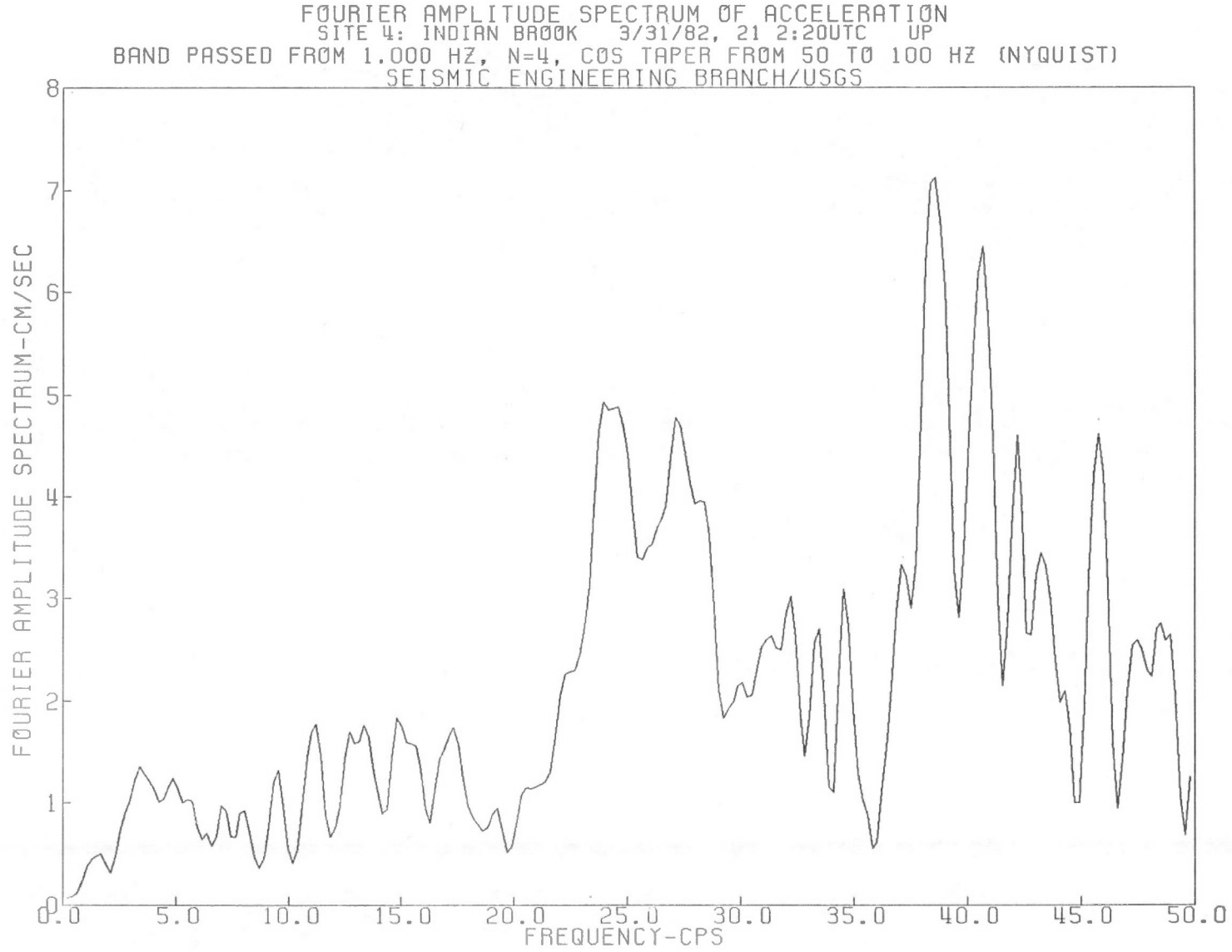

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 4: INDIAN BROOK 3/31/82, 21 2:20UTC UP
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
1
2
3
4
5
6
7
8
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 57

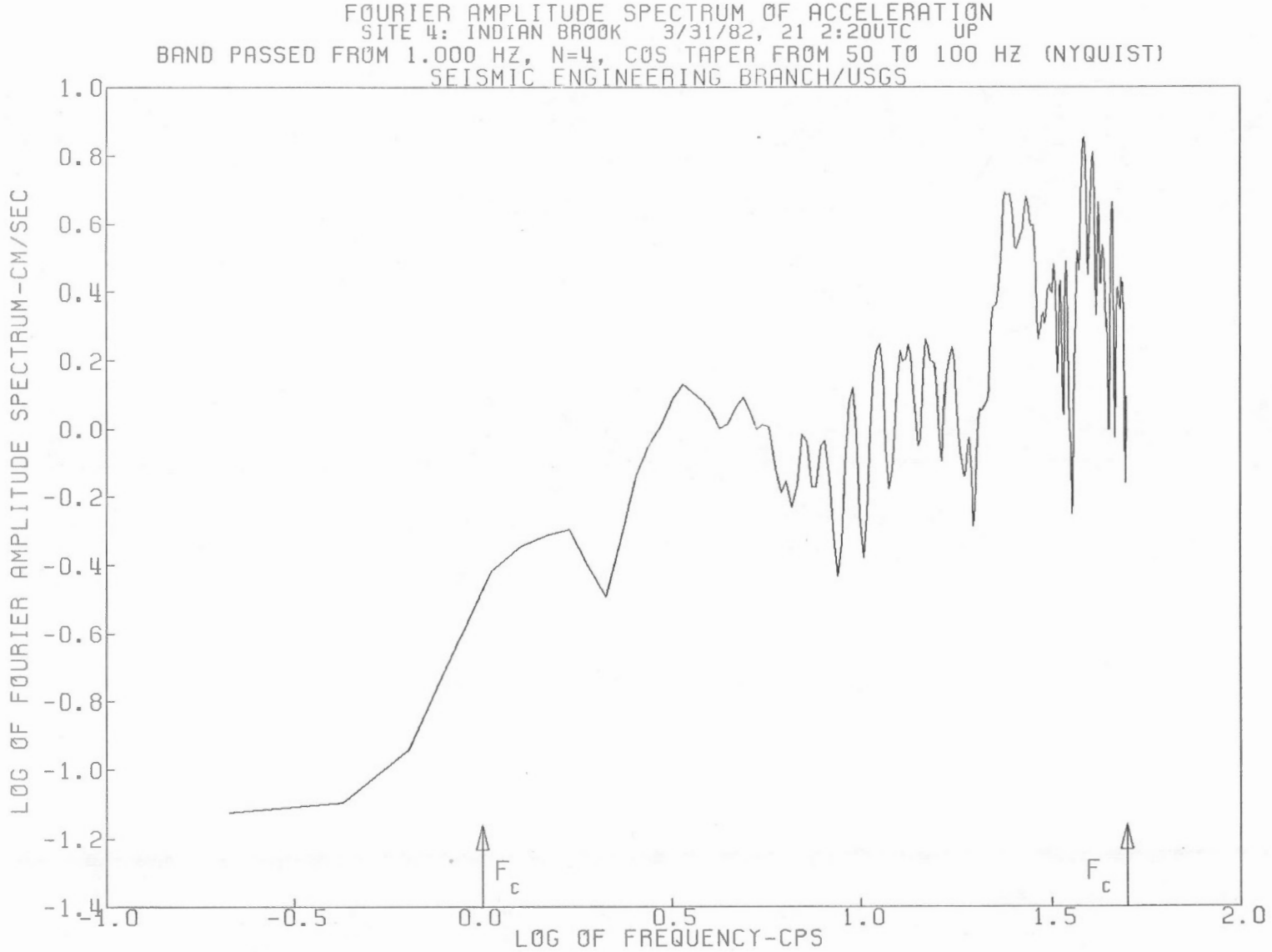

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 4: INDIAN BROOK 3/31/82, 21 2:20UTC UP
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS
Fc
Fc

Fig. 58

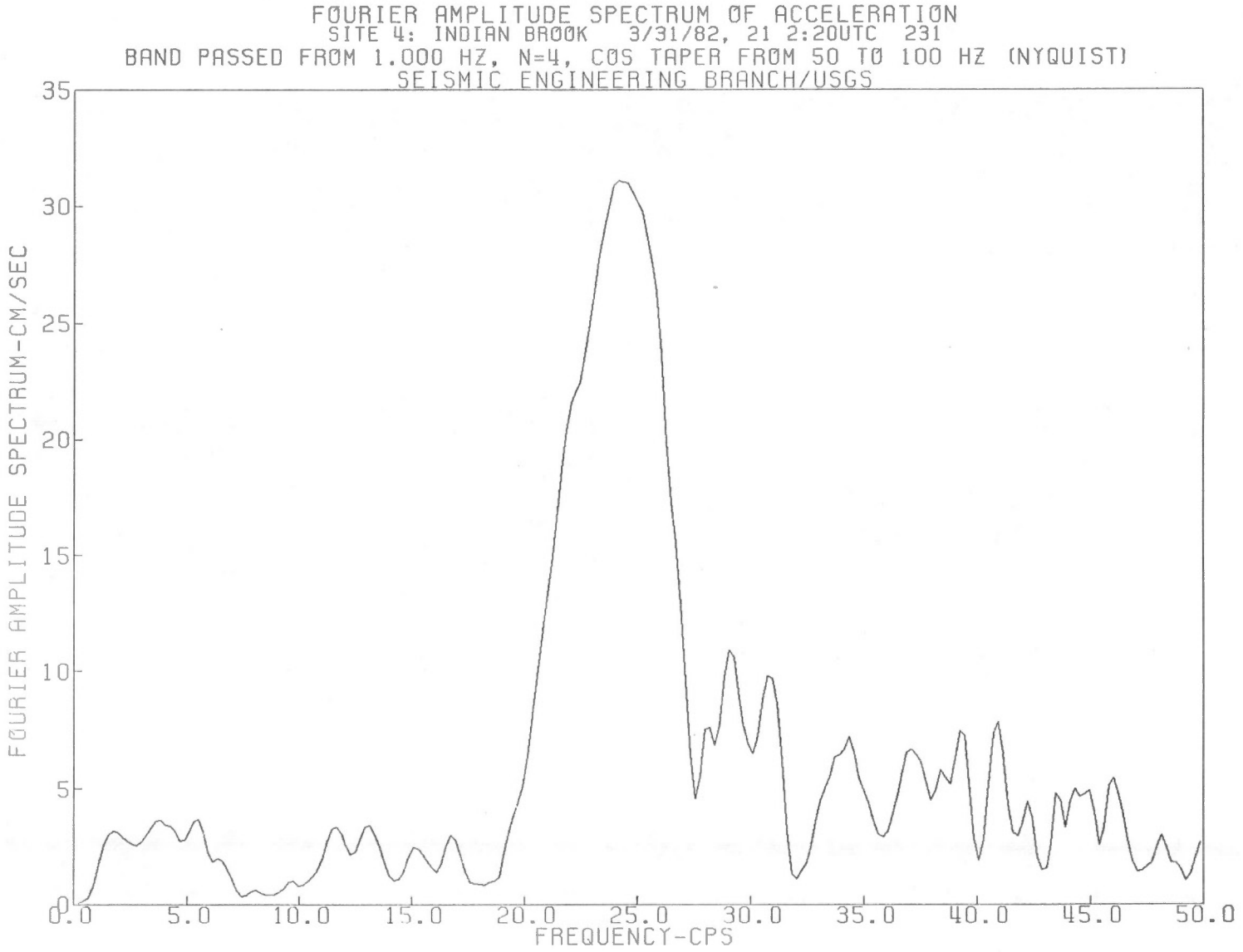

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 4: INDIAN BROOK 3/31/82, 21 2:20UTC 231
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
5
10
15
20
25
30
35
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 59

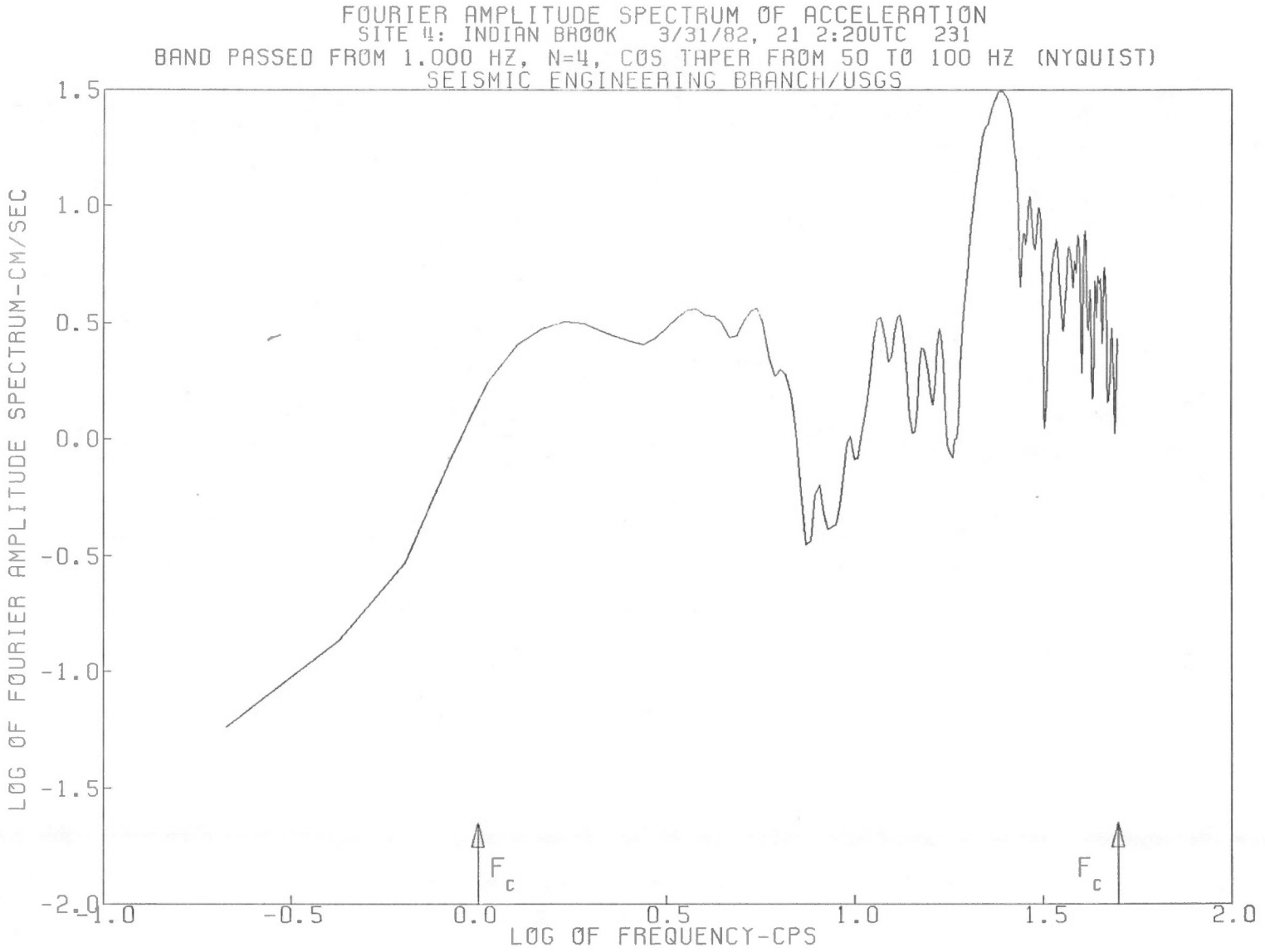

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 4: INDIAN BROOK 3/31/82, 21 2:20UTC 231
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS
Fc
Fc

Fig. 60

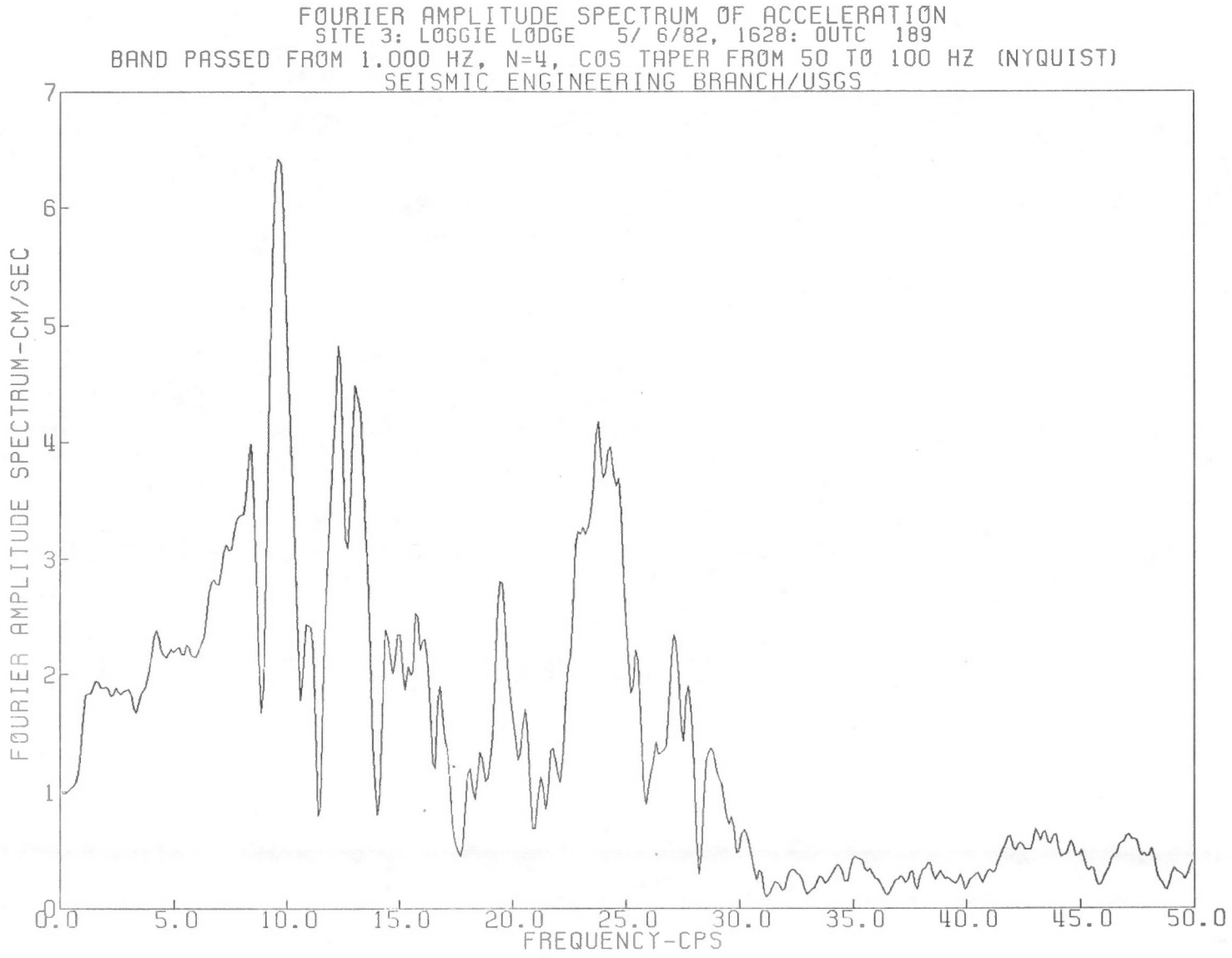

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 3: LOGGIE LODGE 5/ 6/82, 1628: OUTC 189
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
1
2
3
4
5
6
7
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 61

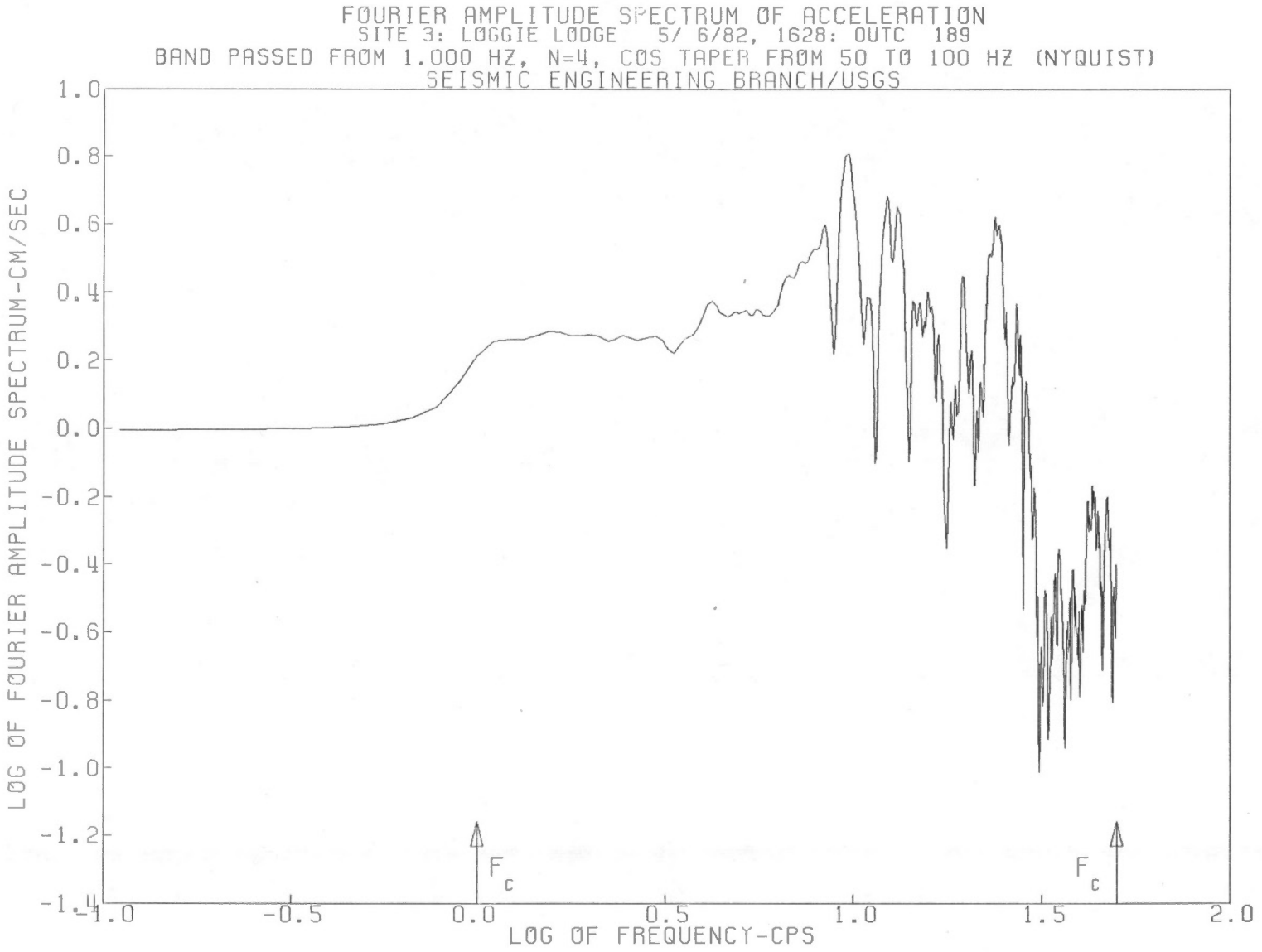

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 3: LOGGIE LODGE 5/ 6/82, 1628: OUTC 189
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS
$F_c$
$F_c$

Fig. 62

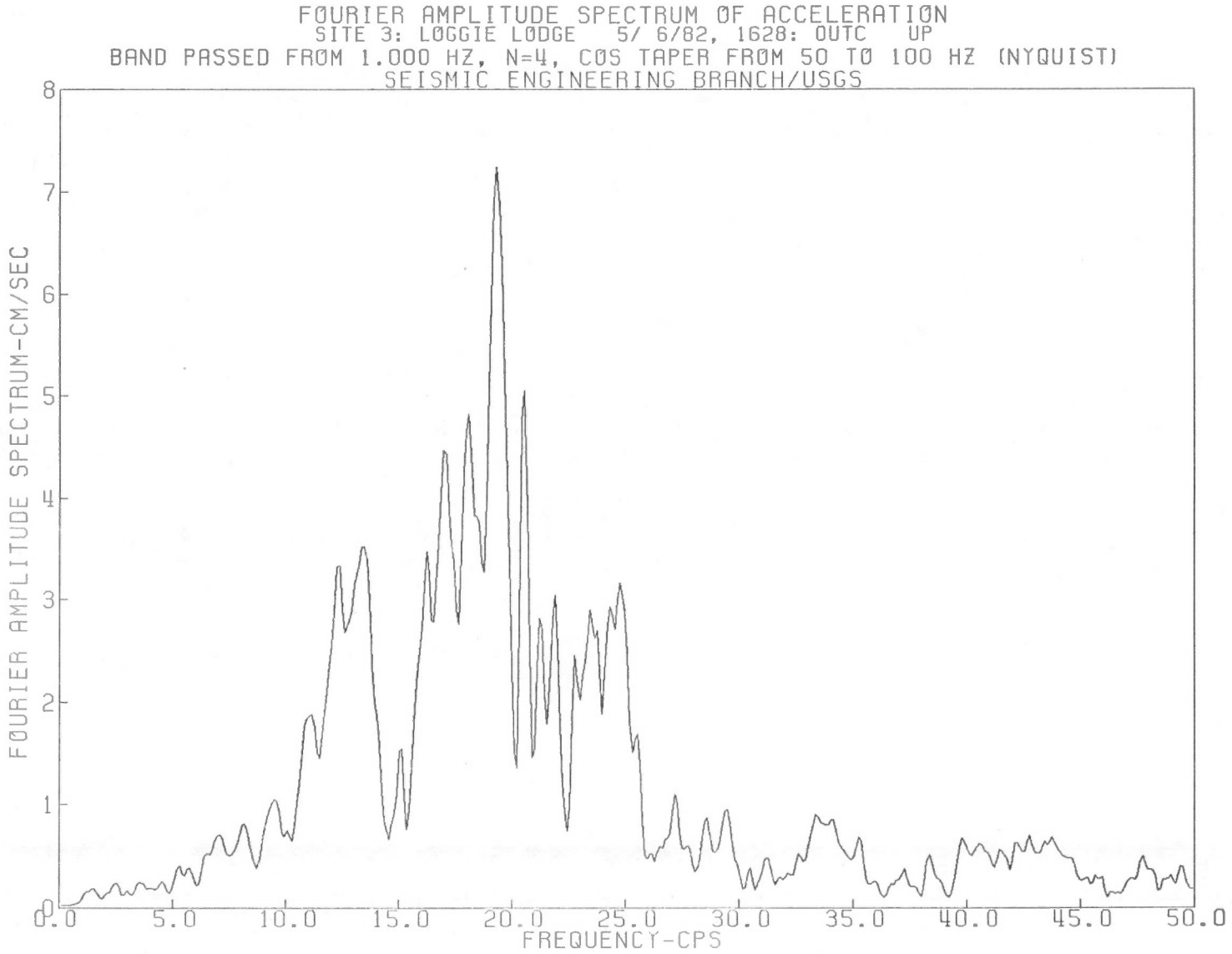

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 3: LOGGIE LODGE 5/ 6/82, 1628: OUTC UP
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
1
2
3
4
5
6
7
8
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 63

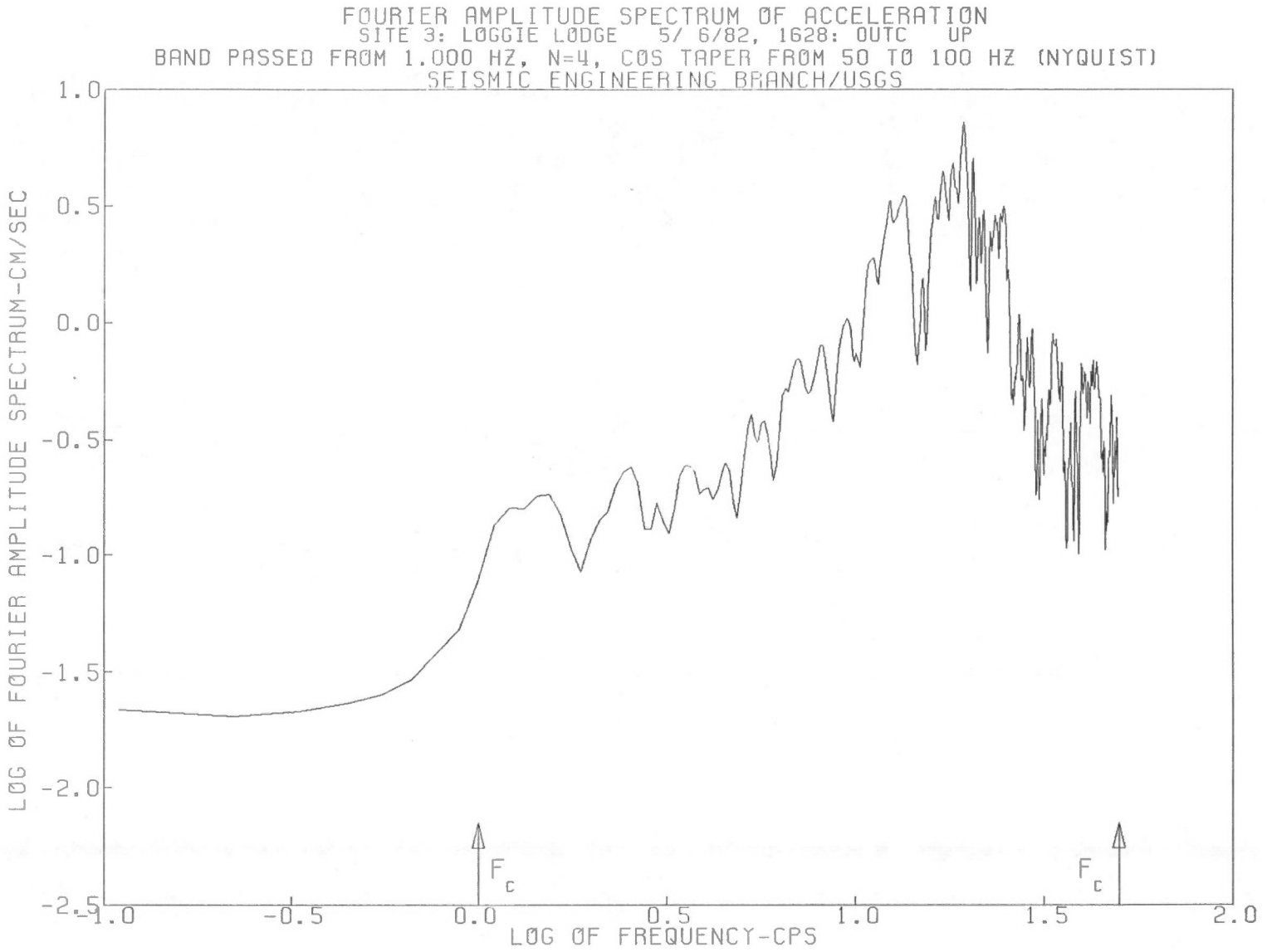

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 3: LOGGIE LODGE 5/ 6/82, 1628: OUTC UP
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
$F_c$
$F_c$
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS

Fig. 64

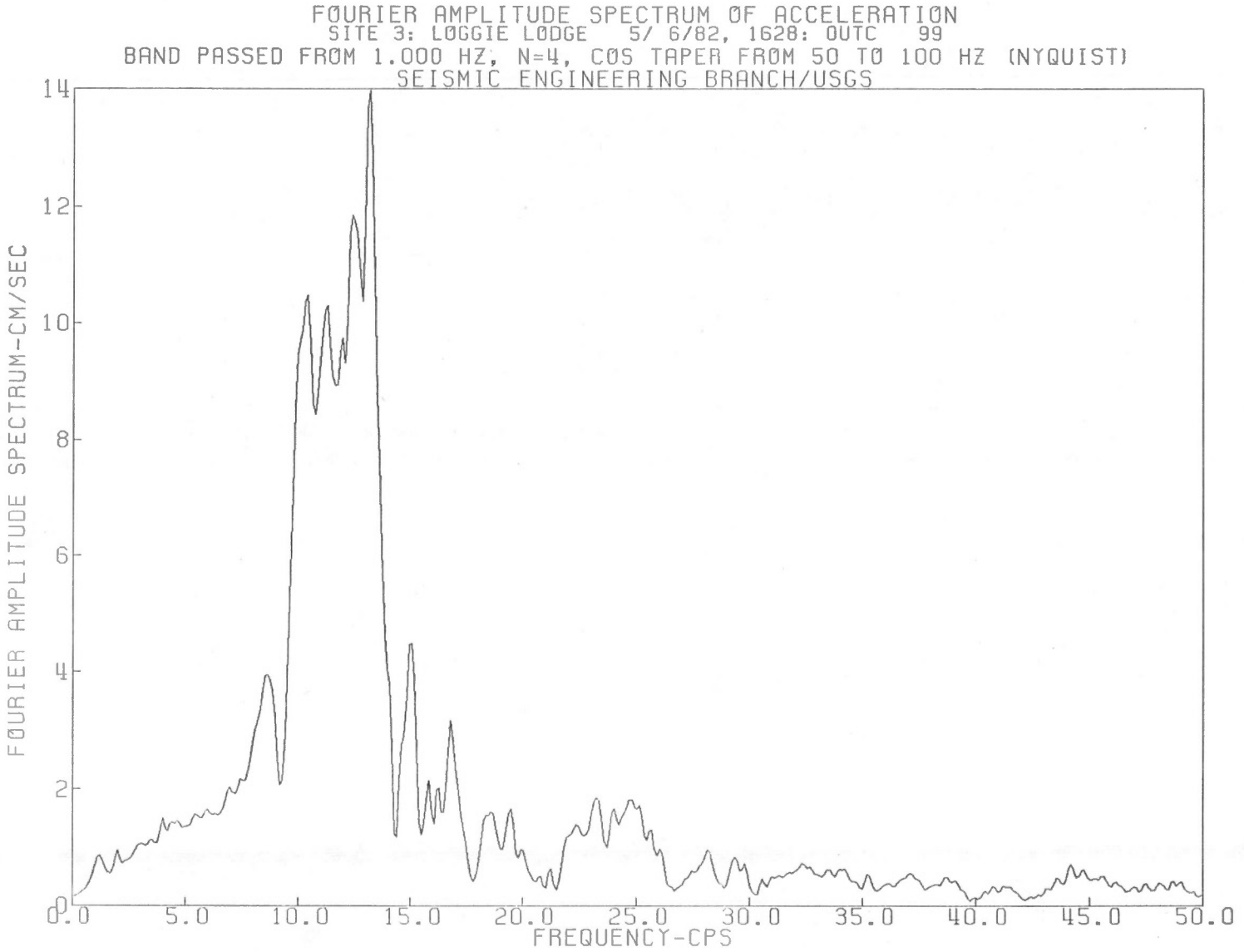

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 3: LOGGIE LODGE 5/ 6/82, 1628: OUTC 99
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
FOURIER AMPLITUDE SPECTRUM-CM/SEC
0
2
4
6
8
10
12
14
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
FREQUENCY-CPS

Fig. 65

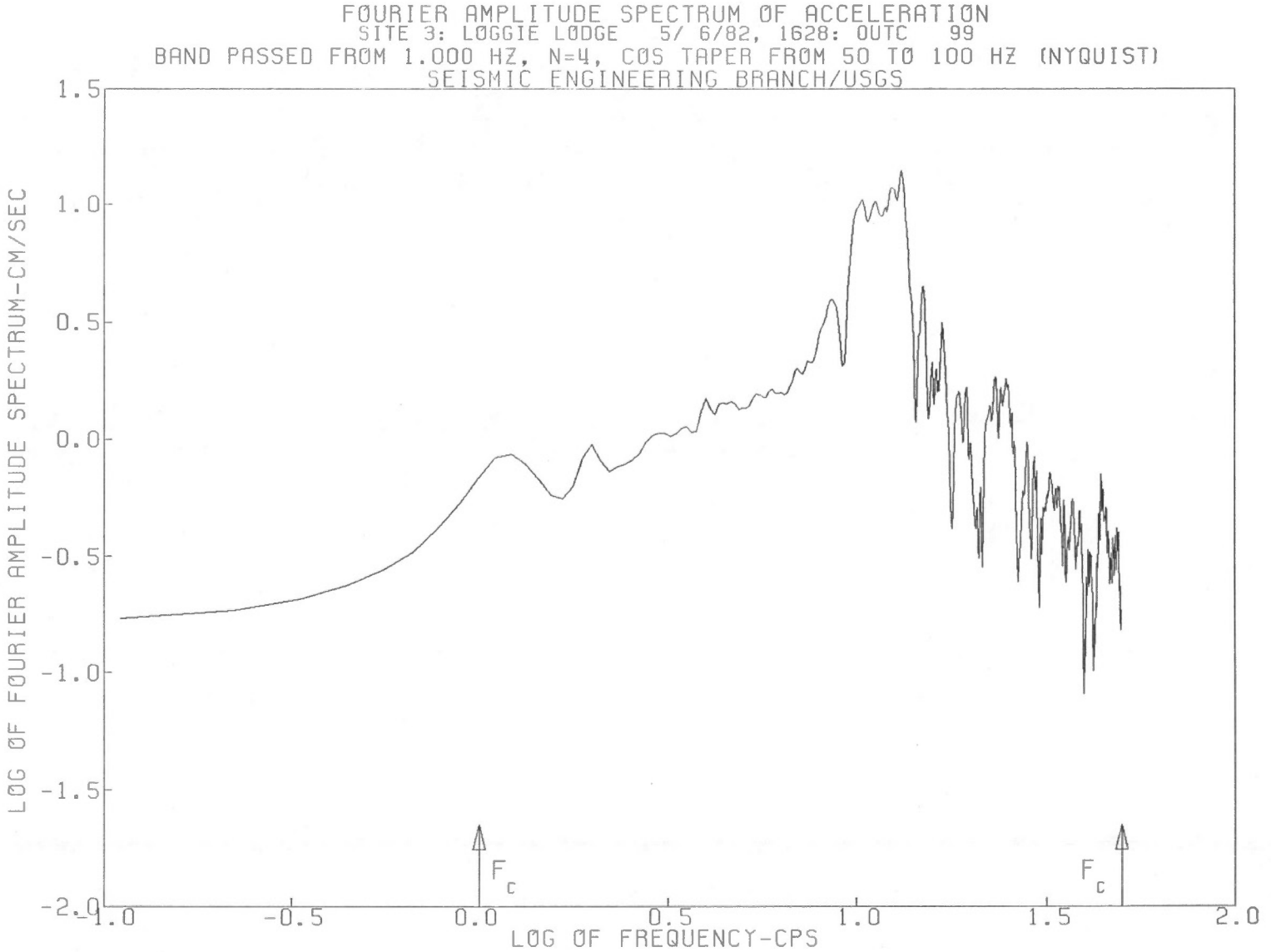

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
SITE 3: LOGGIE LODGE 5/ 6/82, 1628: OUTC 99
BAND PASSED FROM 1.000 HZ, N=4, COS TAPER FROM 50 TO 100 HZ (NYQUIST)
SEISMIC ENGINEERING BRANCH/USGS
LOG OF FOURIER AMPLITUDE SPECTRUM-CM/SEC
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
LOG OF FREQUENCY-CPS
$F_c$
$F_c$

Fig. 66

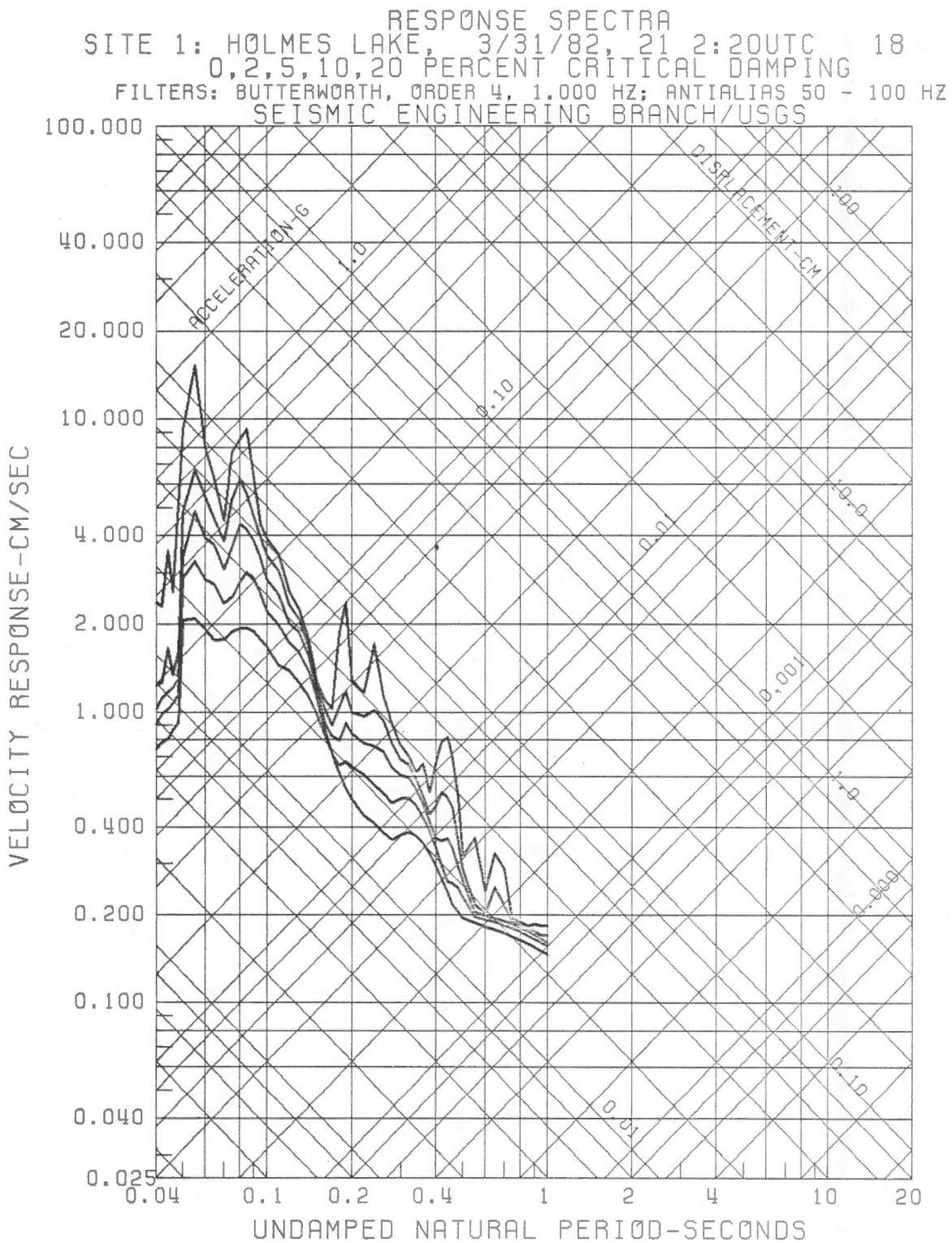

RESPONSE SPECTRA
SITE 1: HOLMES LAKE, 3/31/82, 21 2:20UTC 18
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
100.000
40.000
20.000
10.000
4.000
2.000
1.000
0.400
0.200
0.100
0.040
0.025
0.04
0.1
0.2
0.4
1
2
4
10
20
1.0
0.10
0.01
0.001
100
10.0
1.0
0.10
0.01

Fig. 67

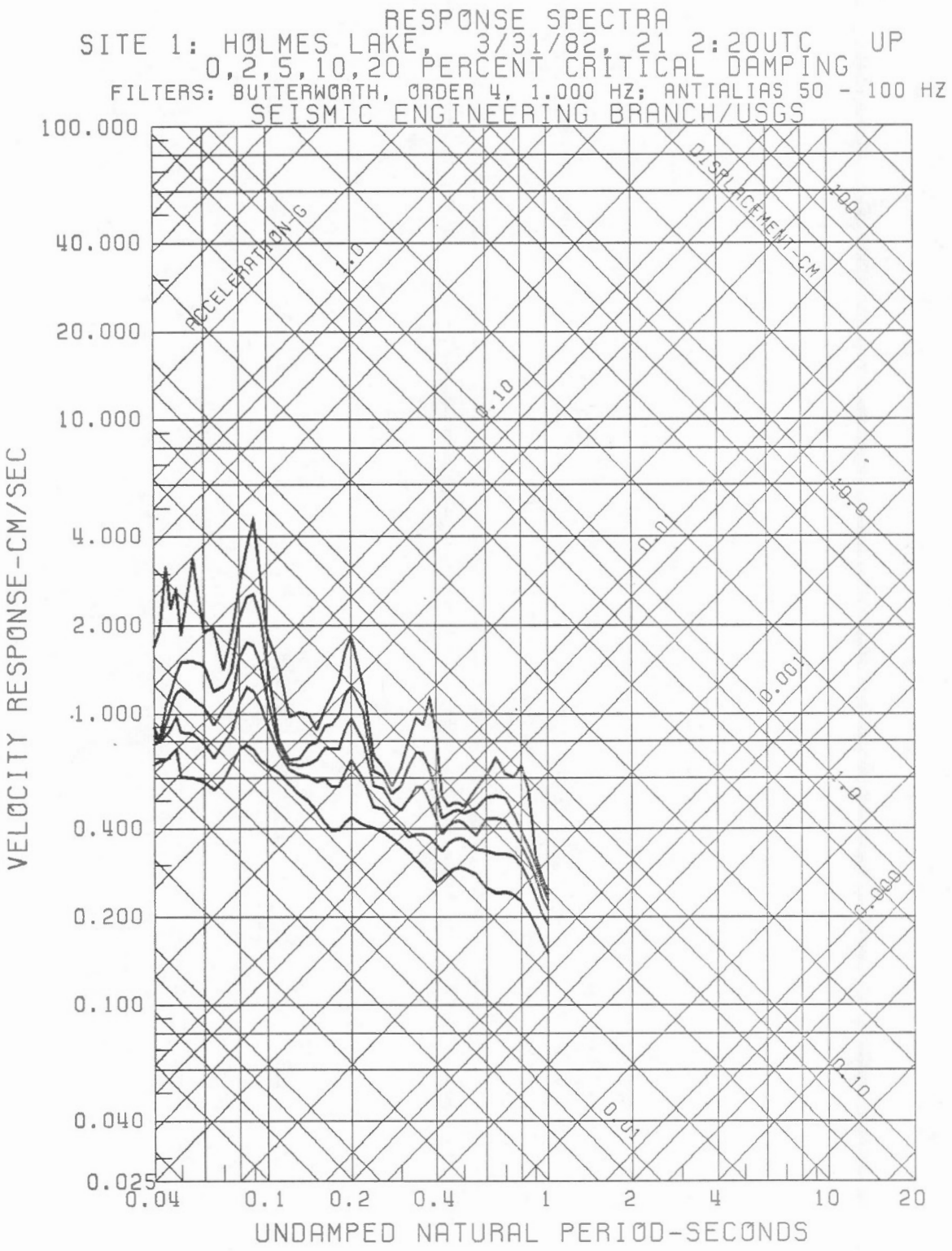

RESPONSE SPECTRA
SITE 1: HOLMES LAKE, 3/31/82, 21 2:20UTC UP
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
100.000
40.000
20.000
10.000
4.000
2.000
1.000
0.400
0.200
0.100
0.040
0.025
0.04
0.1
0.2
0.4
1
2
4
10
20
1.0
0.10
0.01
0.001
100
10.0
1.0
0.100
0.10
0.01

Fig. 68

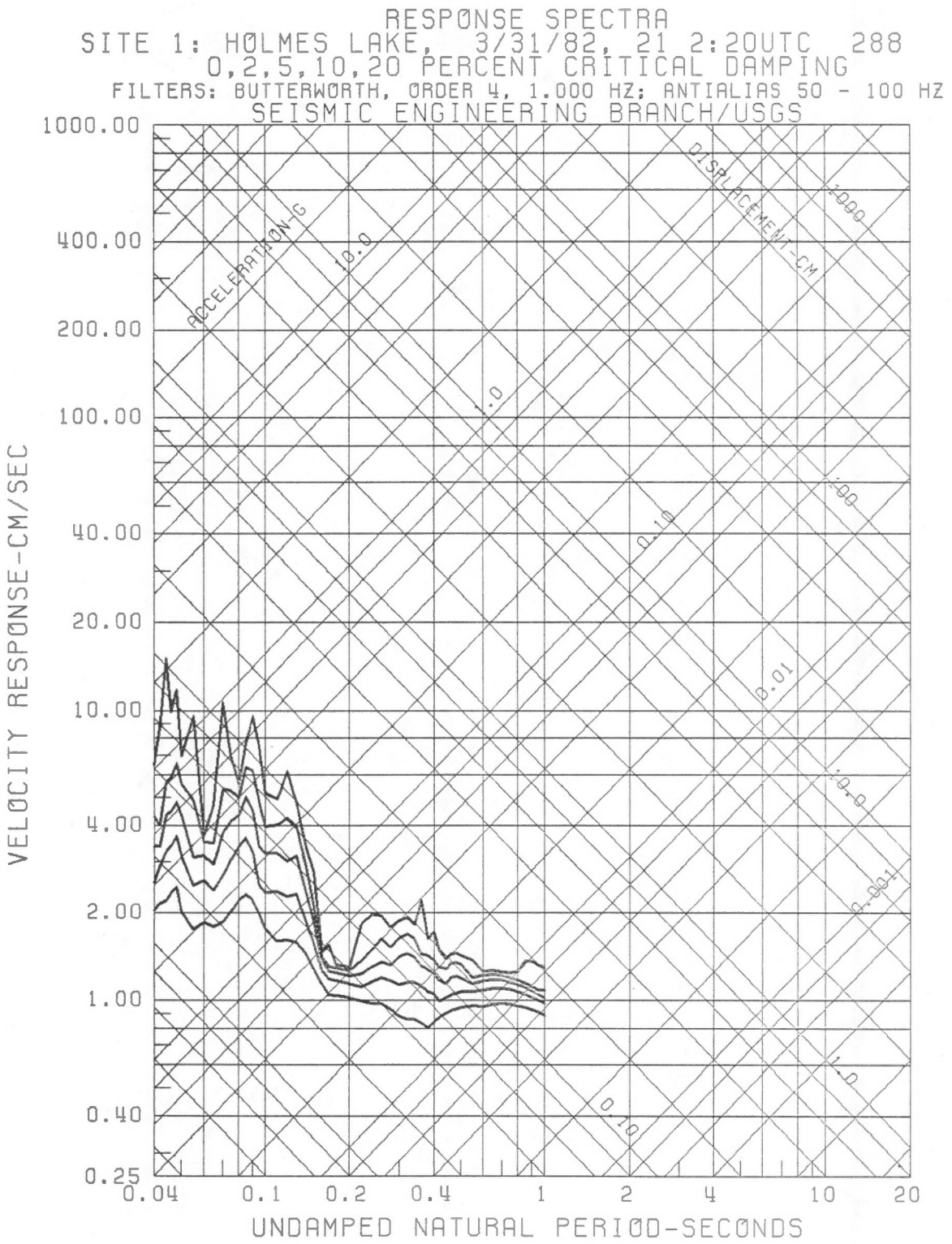

RESPONSE SPECTRA
SITE 1: HOLMES LAKE, 3/31/82, 21 2:20UTC 288
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
0.40
0.25
0.04
0.1
0.2
0.4
1
2
4
10
20
10.0
1.0
0.10
0.01
0.001
1000
100
10.0
1.0
0.10
0.01
0.001

Fig. 69

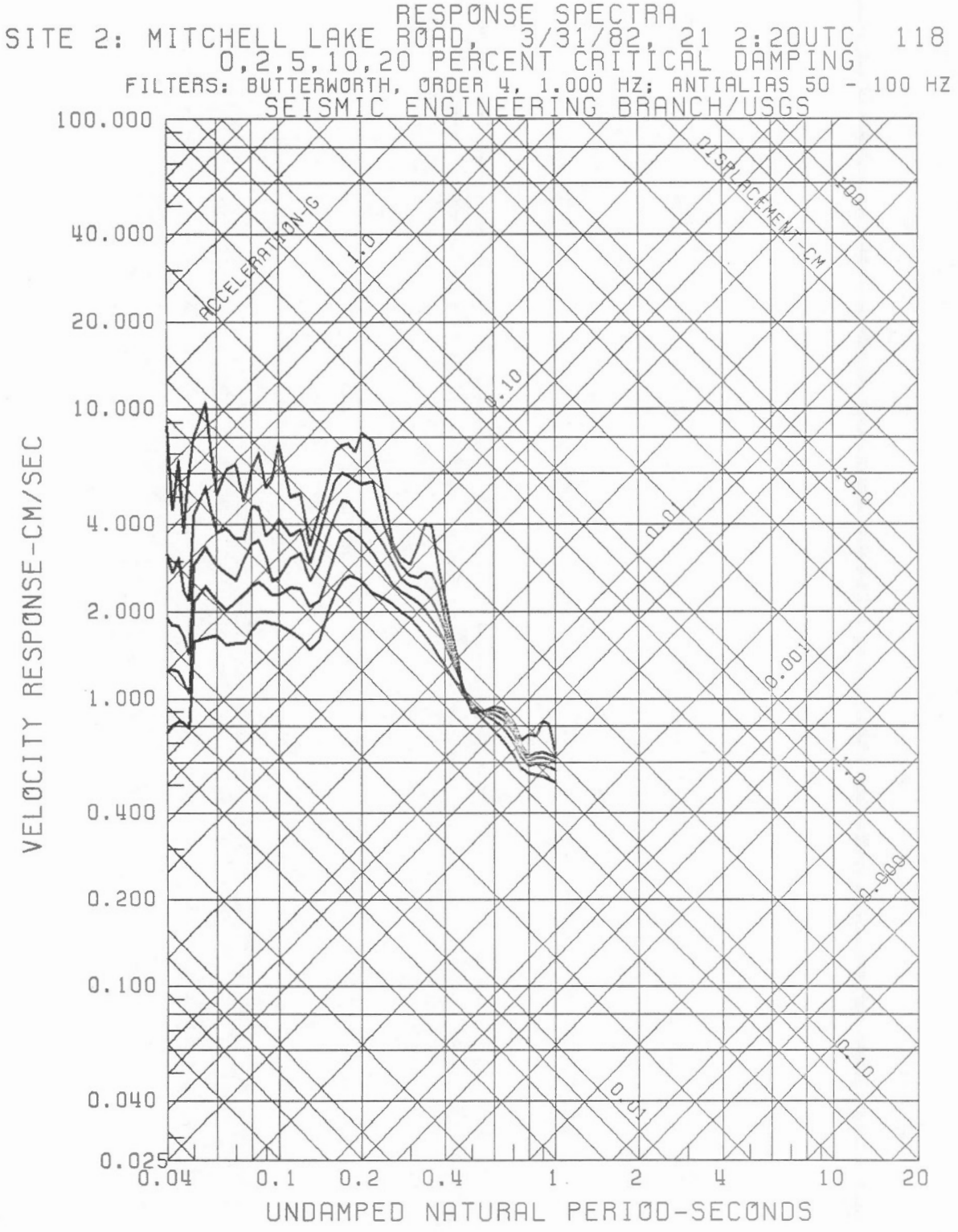

RESPONSE SPECTRA
SITE 2: MITCHELL LAKE ROAD, 3/31/82, 21 2:20UTC 118
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
100.000
40.000
20.000
10.000
4.000
2.000
1.000
0.400
0.200
0.100
0.040
0.025
0.04
0.1
0.2
0.4
1
2
4
10
20

Fig. 70

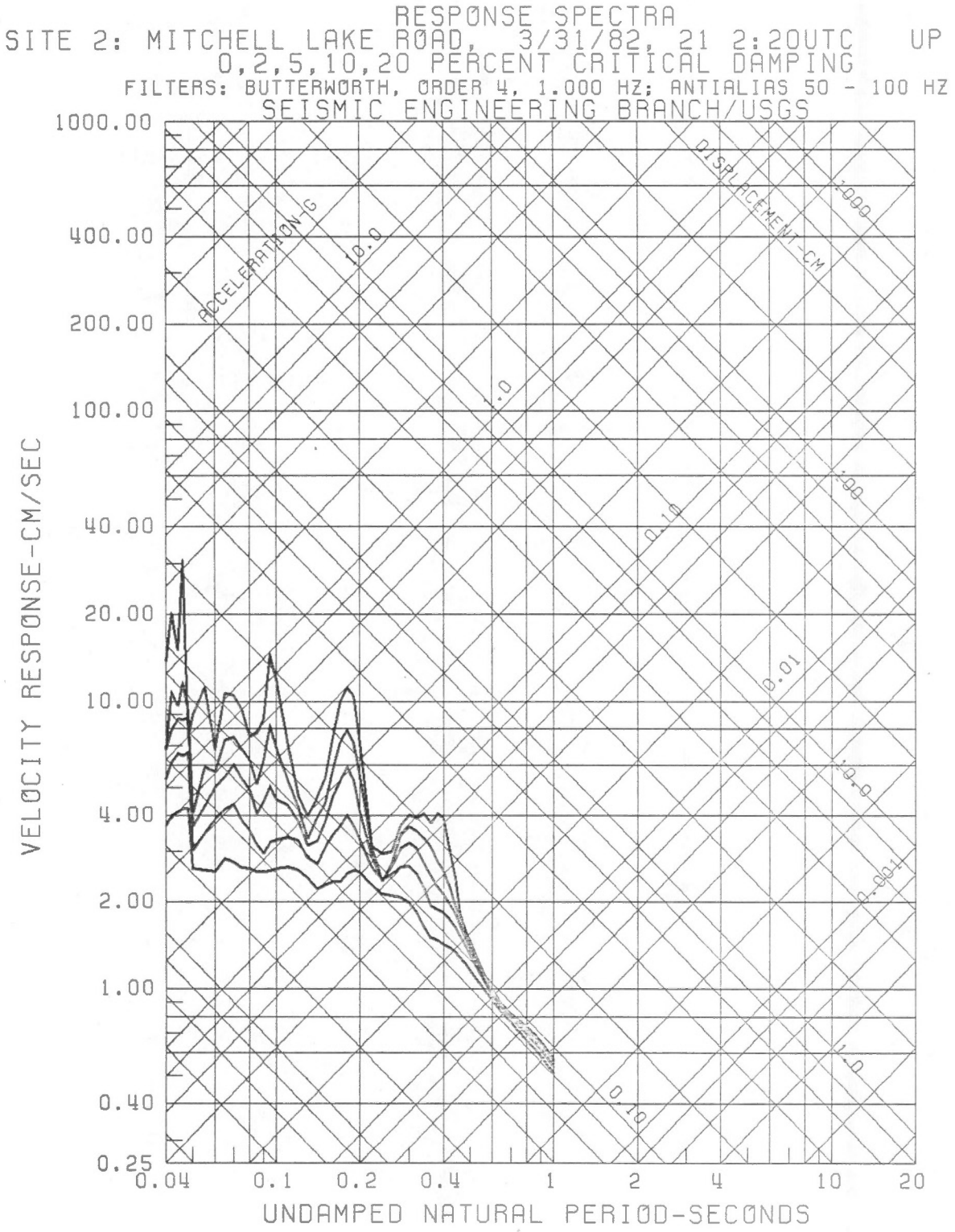

RESPONSE SPECTRA
SITE 2: MITCHELL LAKE ROAD, 3/31/82, 21 2:20UTC UP
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
0.40
0.25
0.04
0.1
0.2
0.4
1
2
4
10
20

Fig. 71

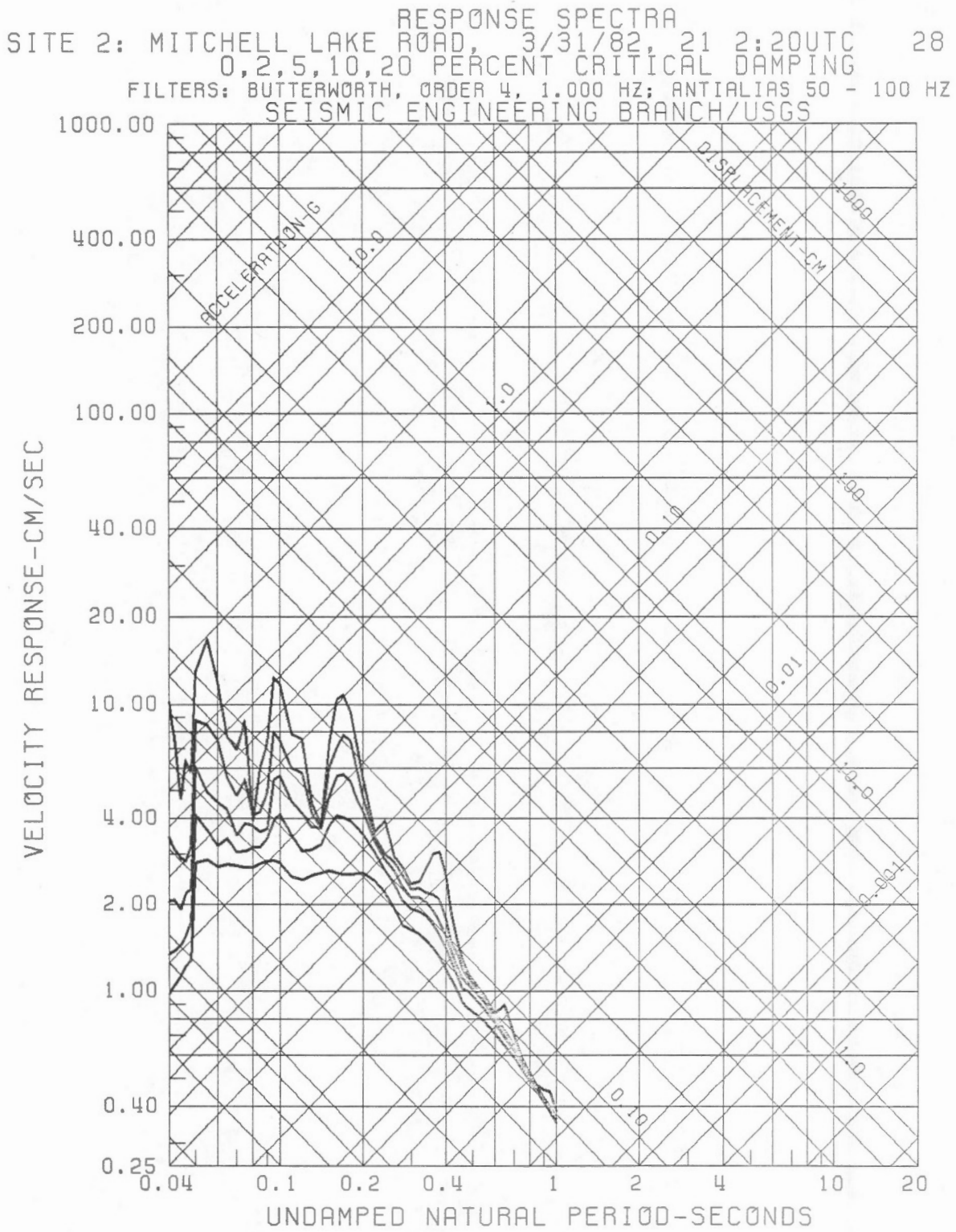

RESPONSE SPECTRA
SITE 2: MITCHELL LAKE ROAD, 3/31/82, 21 2:20UTC 28
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
0.40
0.25
0.04
0.1
0.2
0.4
1
2
4
10
20
ACCELERATION-G
10.0
1.0
0.1
0.01
0.10
DISPLACEMENT-CM
100
10
1.0
0.1
0.01
0.001

Fig. 72

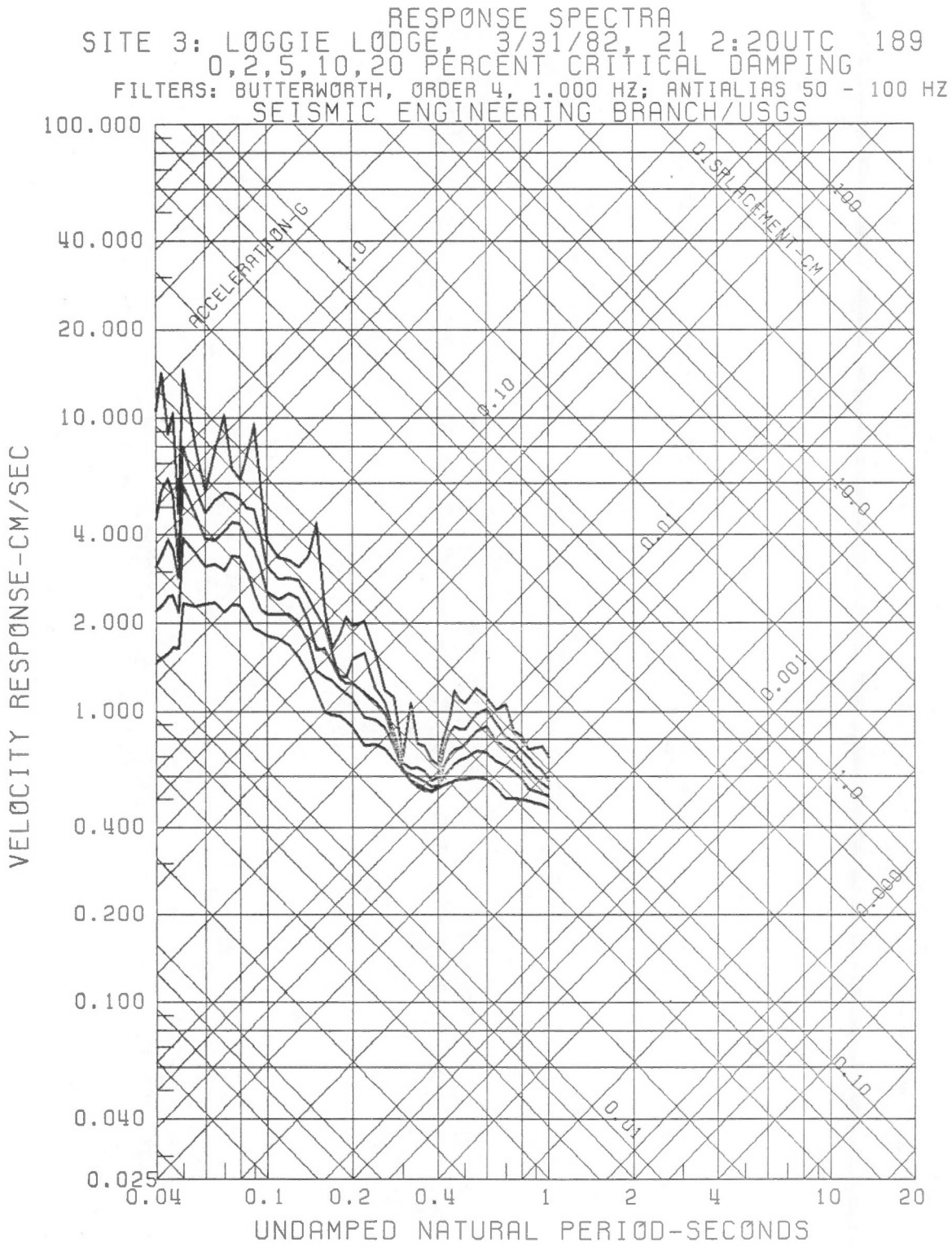

RESPONSE SPECTRA
SITE 3: LOGGIE LODGE, 3/31/82, 21 2:20UTC 189
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
ACCELERATION-G
DISPLACEMENT-CM
1.0
0.10
0.01
0.001
100.000
40.000
20.000
10.000
4.000
2.000
1.000
0.400
0.200
0.100
0.040
0.025
0.04
0.1
0.2
0.4
1
2
4
10
20
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS

Fig. 73

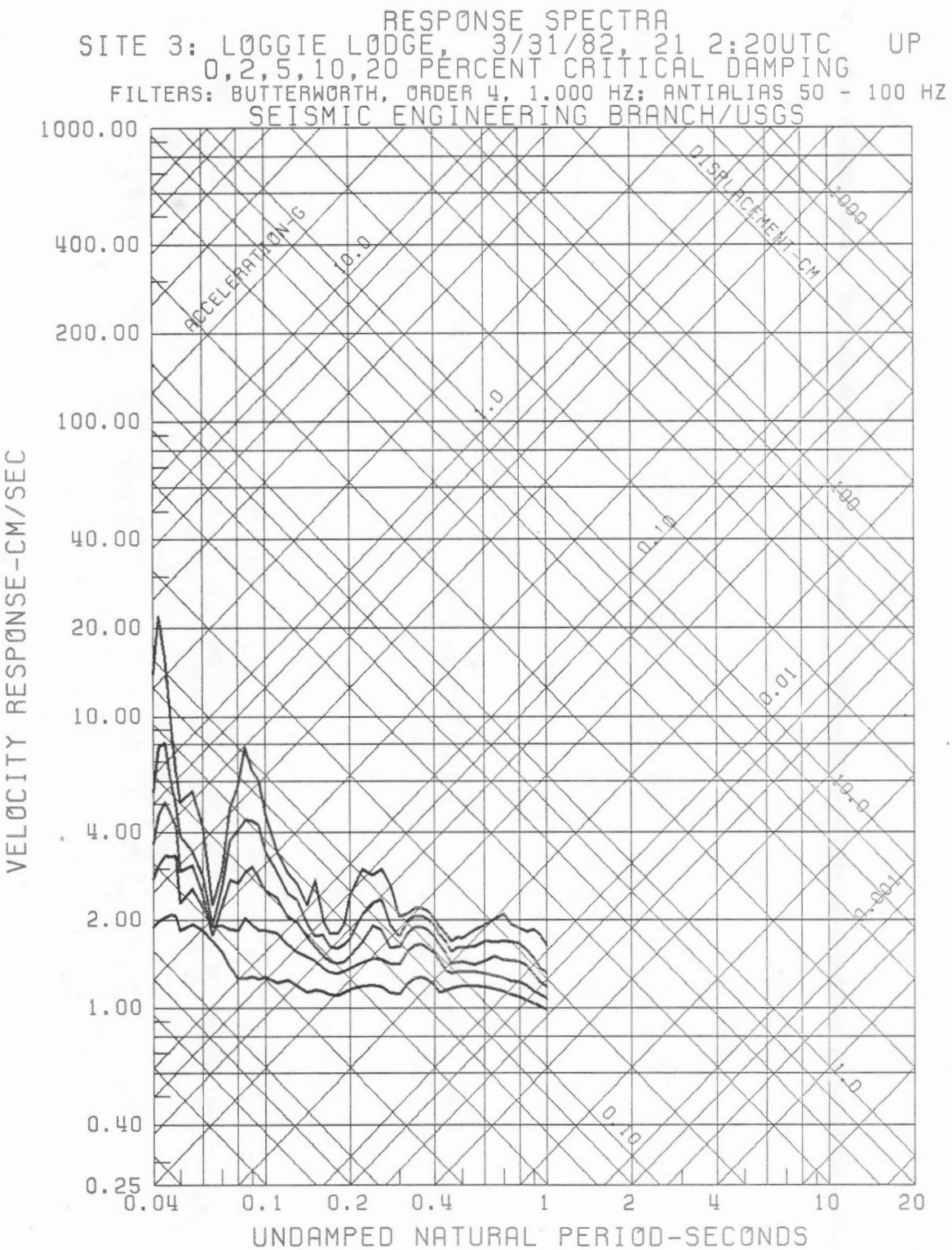

RESPONSE SPECTRA
SITE 3: LOGGIE LODGE, 3/31/82, 21 2:20UTC UP
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
0.40
0.25
0.04
0.1
0.2
0.4
1
2
4
10
20
ACCELERATION-G
10.0
1.0
0.1
0.01
0.10
DISPLACEMENT-CM
1000
100
10.0
1.0
0.001

Fig. 74

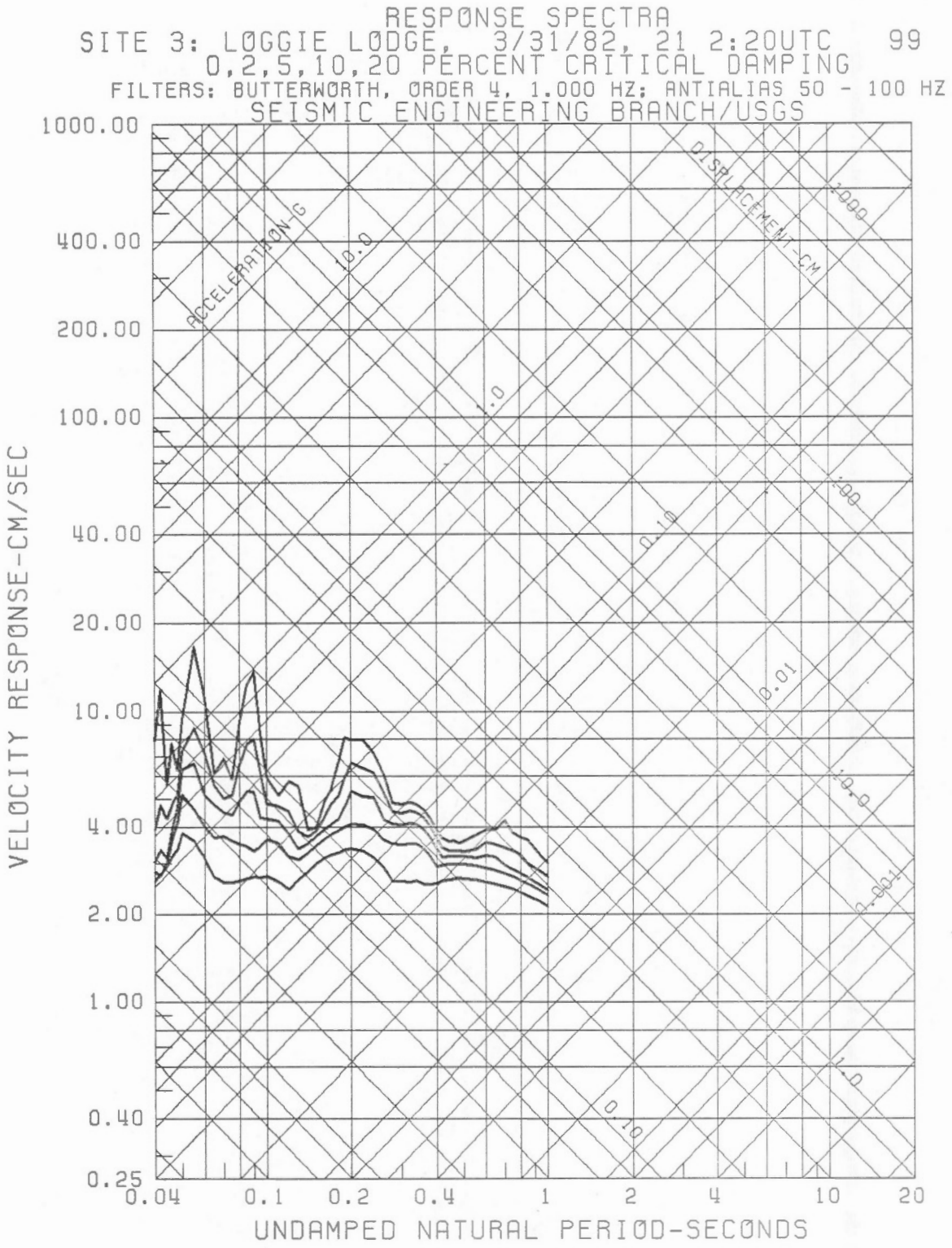

RESPONSE SPECTRA
SITE 3: LOGGIE LODGE, 3/31/82, 21 2:20UTC 99
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
0.40
0.25
0.04
0.1
0.2
0.4
1
2
4
10
20
ACCELERATION-G
10.0
1.0
0.10
0.01
DISPLACEMENT-CM
1000
100
10.0
1.0
0.10

Fig. 75

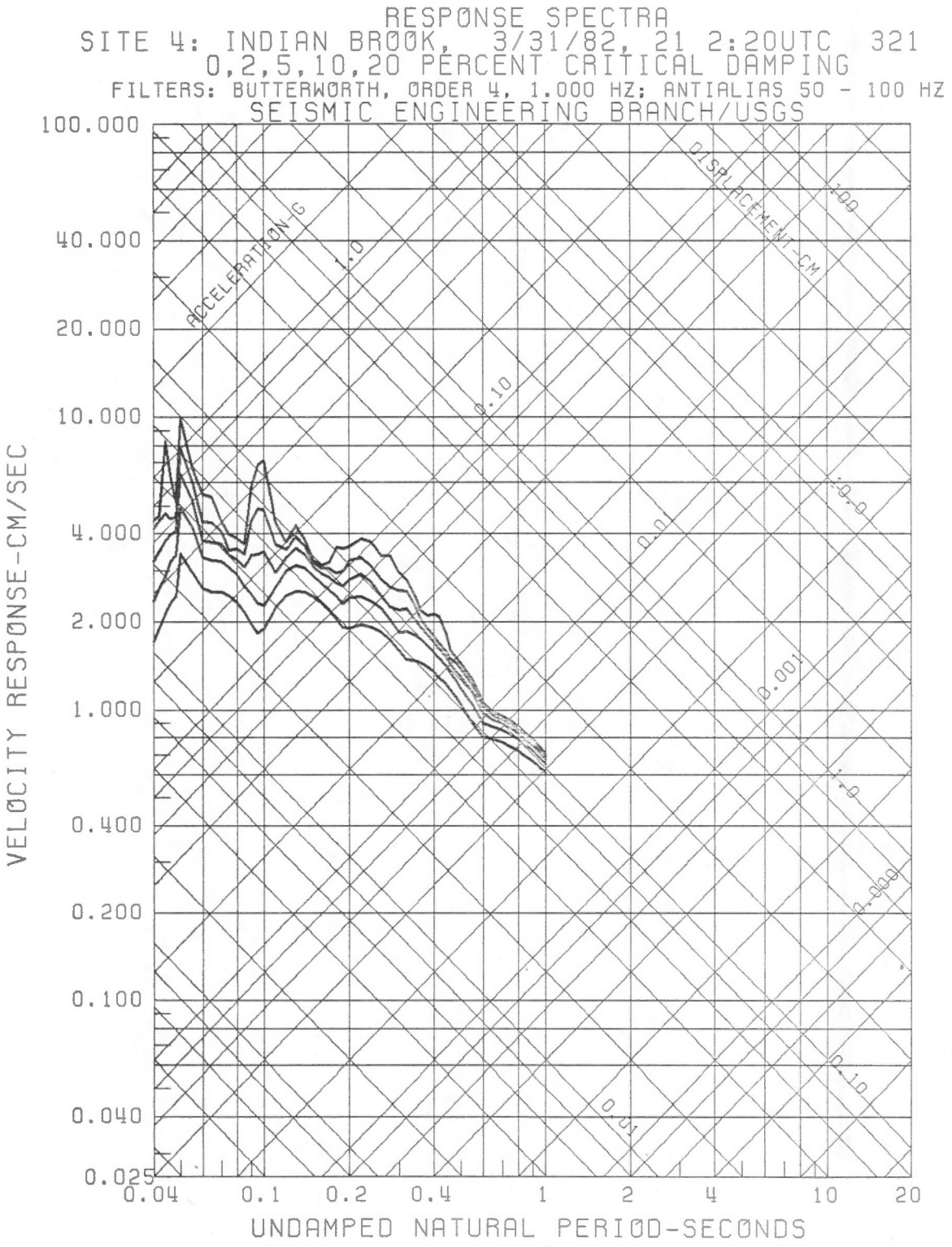

RESPONSE SPECTRA
SITE 4: INDIAN BROOK, 3/31/82, 21 2:20UTC 321
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
100.000
40.000
20.000
10.000
4.000
2.000
1.000
0.400
0.200
0.100
0.040
0.025
0.04
0.1
0.2
0.4
1
2
4
10
20
1.0
0.10
0.01
0.001
100
10.0
1.0
0.100
0.10
0.01

Fig. 76

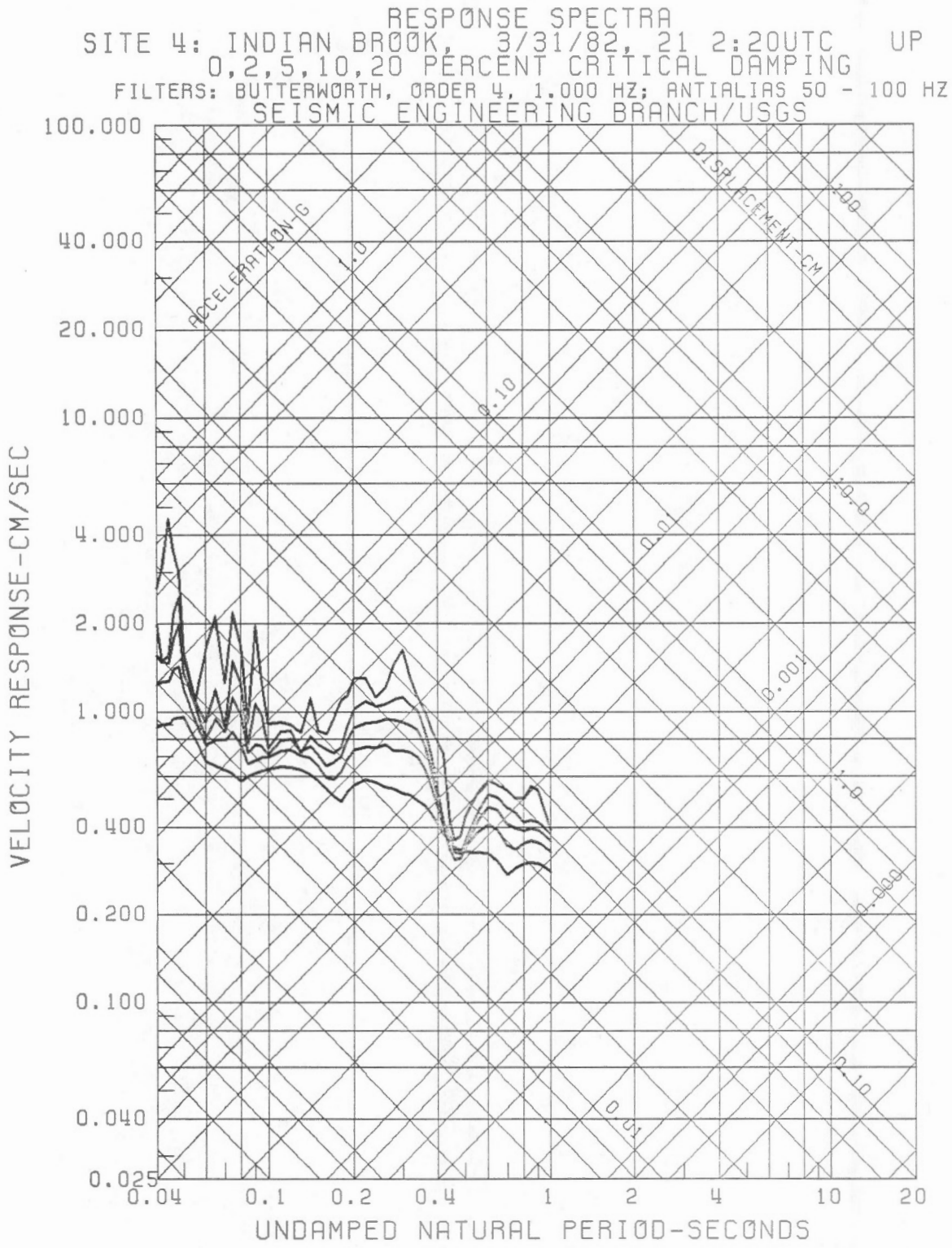

RESPONSE SPECTRA
SITE 4: INDIAN BROOK, 3/31/82, 21 2:20UTC UP
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
100.000
40.000
20.000
10.000
4.000
2.000
1.000
0.400
0.200
0.100
0.040
0.025
0.04
0.1
0.2
0.4
1
2
4
10
20

Fig. 77

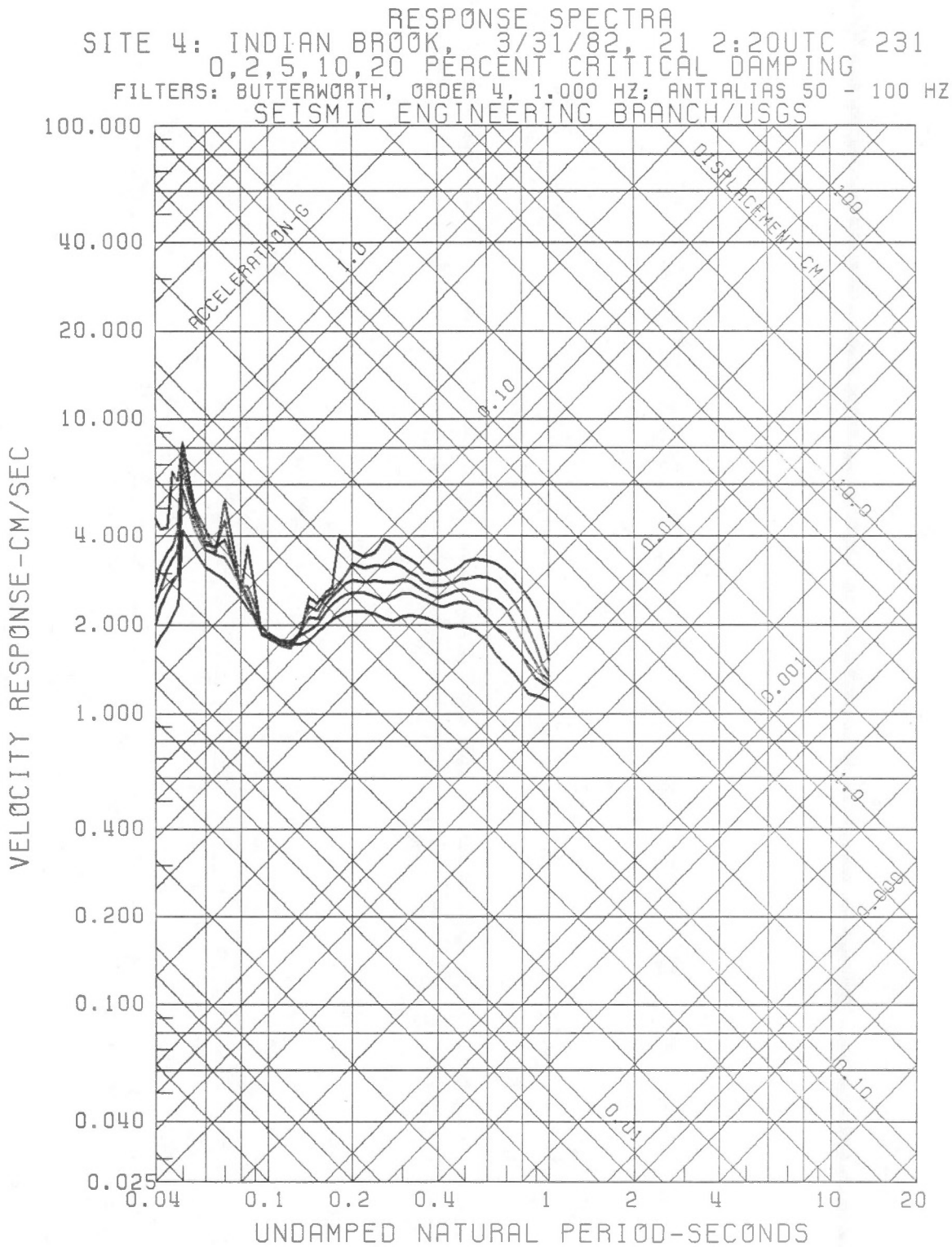

RESPONSE SPECTRA
SITE 4: INDIAN BROOK, 3/31/82, 21 2:20UTC 231
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
100.000
40.000
20.000
10.000
4.000
2.000
1.000
0.400
0.200
0.100
0.040
0.025
0.04
0.1
0.2
0.4
1
2
4
10
20
ACCELERATION-G
1.0
0.10
0.01
0.001
DISPLACEMENT-CM
200
10.0
1.0
0.10
0.01

Fig. 78

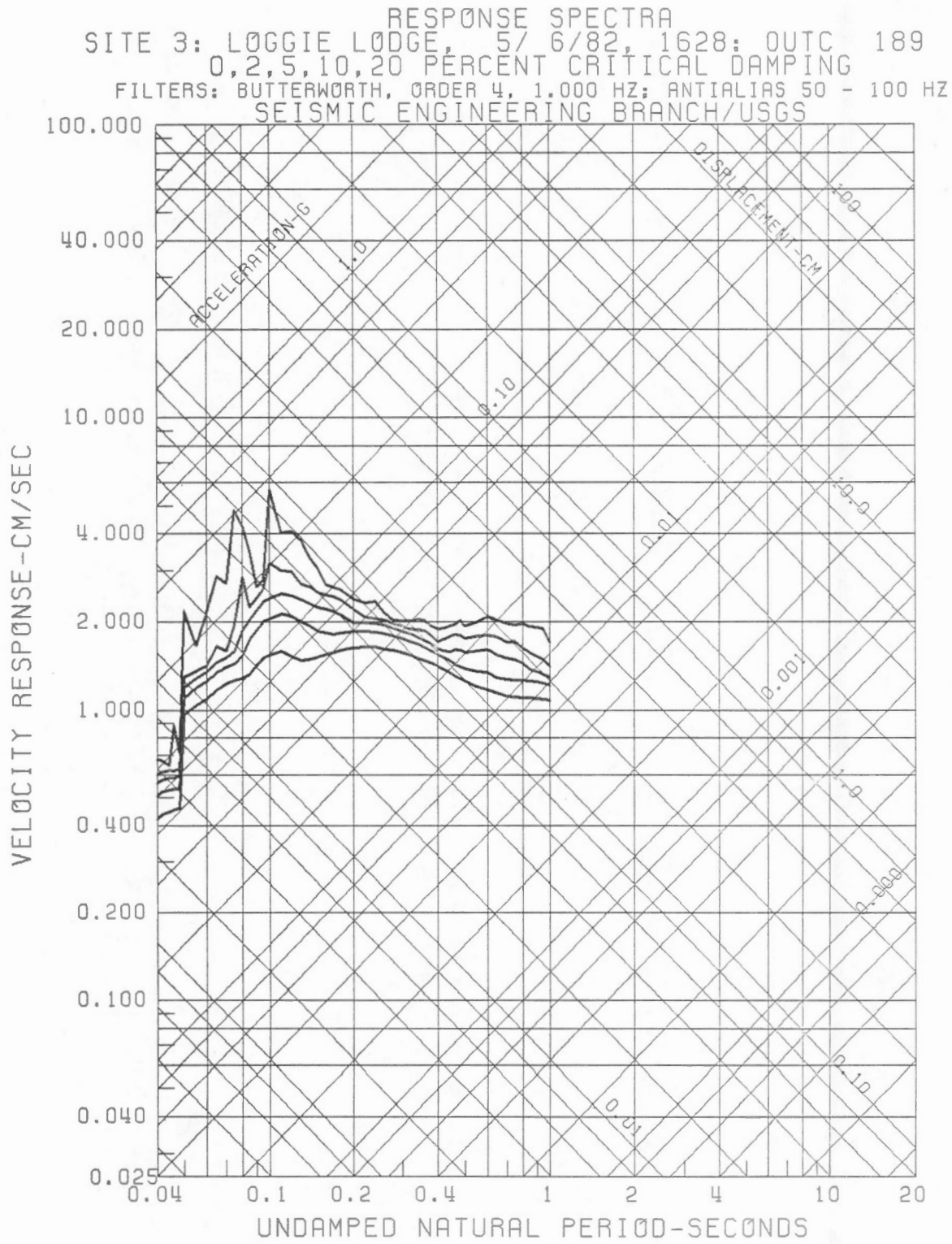

RESPONSE SPECTRA
SITE 3: LOGGIE LODGE, 5/ 6/82, 1628: OUTC 189
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
100.000
40.000
20.000
10.000
4.000
2.000
1.000
0.400
0.200
0.100
0.040
0.025
0.04
0.1
0.2
0.4
1
2
4
10
20
ACCELERATION-G
1.0
0.10
0.01
0.001
0.0001
DISPLACEMENT-CM
100
10.0
1.0
0.100
0.010
0.01
0.10

Fig. 79

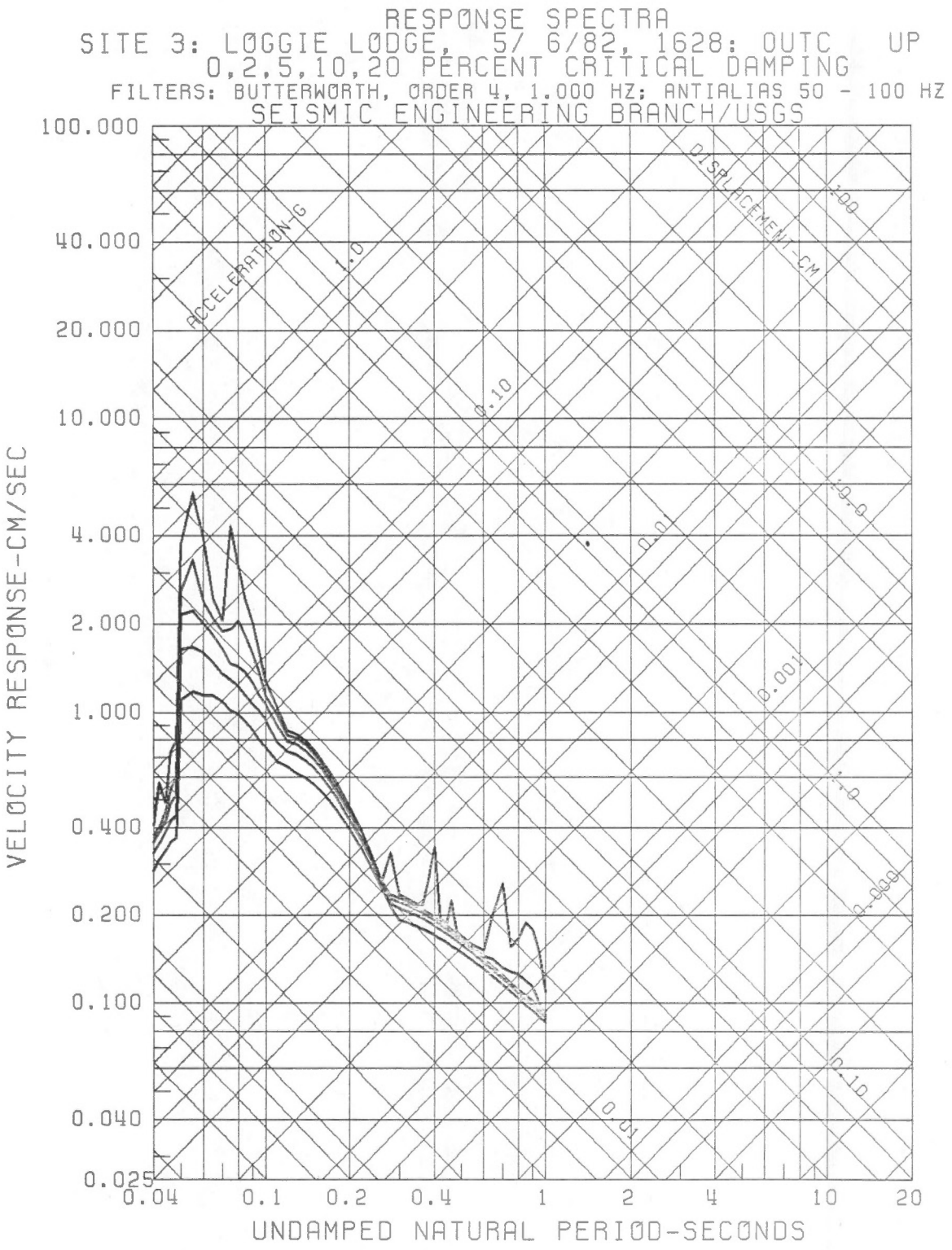

RESPONSE SPECTRA
SITE 3: LOGGIE LODGE, 5/ 6/82, 1628: OUTC UP
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
100.000
40.000
20.000
10.000
4.000
2.000
1.000
0.400
0.200
0.100
0.040
0.025
0.04
0.1
0.2
0.4
1
2
4
10
20
1.0
0.10
0.01
0.001
100
10.0
1.0
0.100
0.10
0.01

Fig. 80

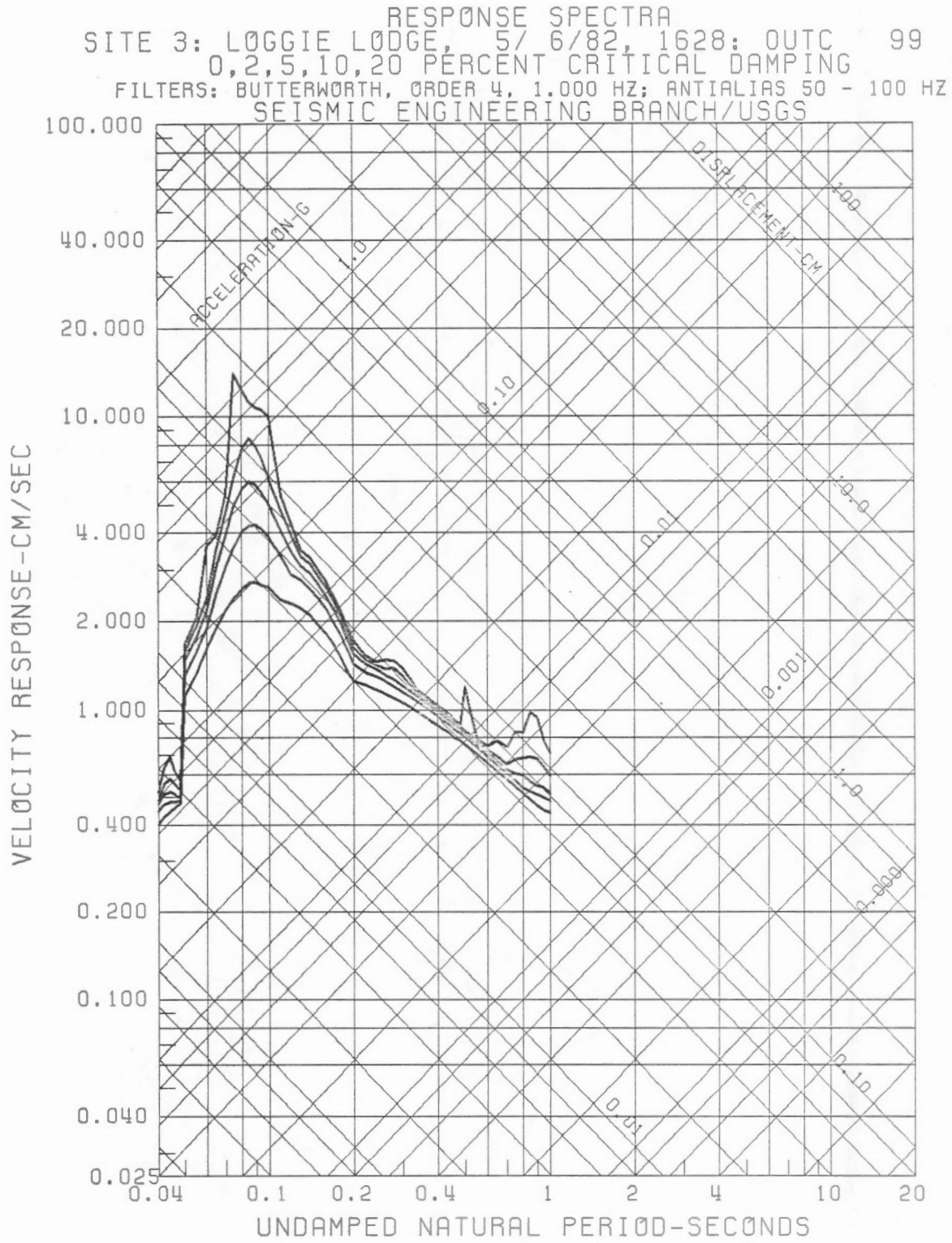

RESPONSE SPECTRA
SITE 3: LOGGIE LODGE, 5/ 6/82, 1628: OUTC 99
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 1.000 HZ; ANTIALIAS 50 - 100 HZ
SEISMIC ENGINEERING BRANCH/USGS
ACCELERATION-G
1.0
0.10
0.01
0.001
DISPLACEMENT-CM
100
10.0
1.0
0.100
0.010
100.000
40.000
20.000
10.000
4.000
2.000
1.000
0.400
0.200
0.100
0.040
0.025
0.04
0.1
0.2
0.4
1
2
4
10
20
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS

Fig. 81

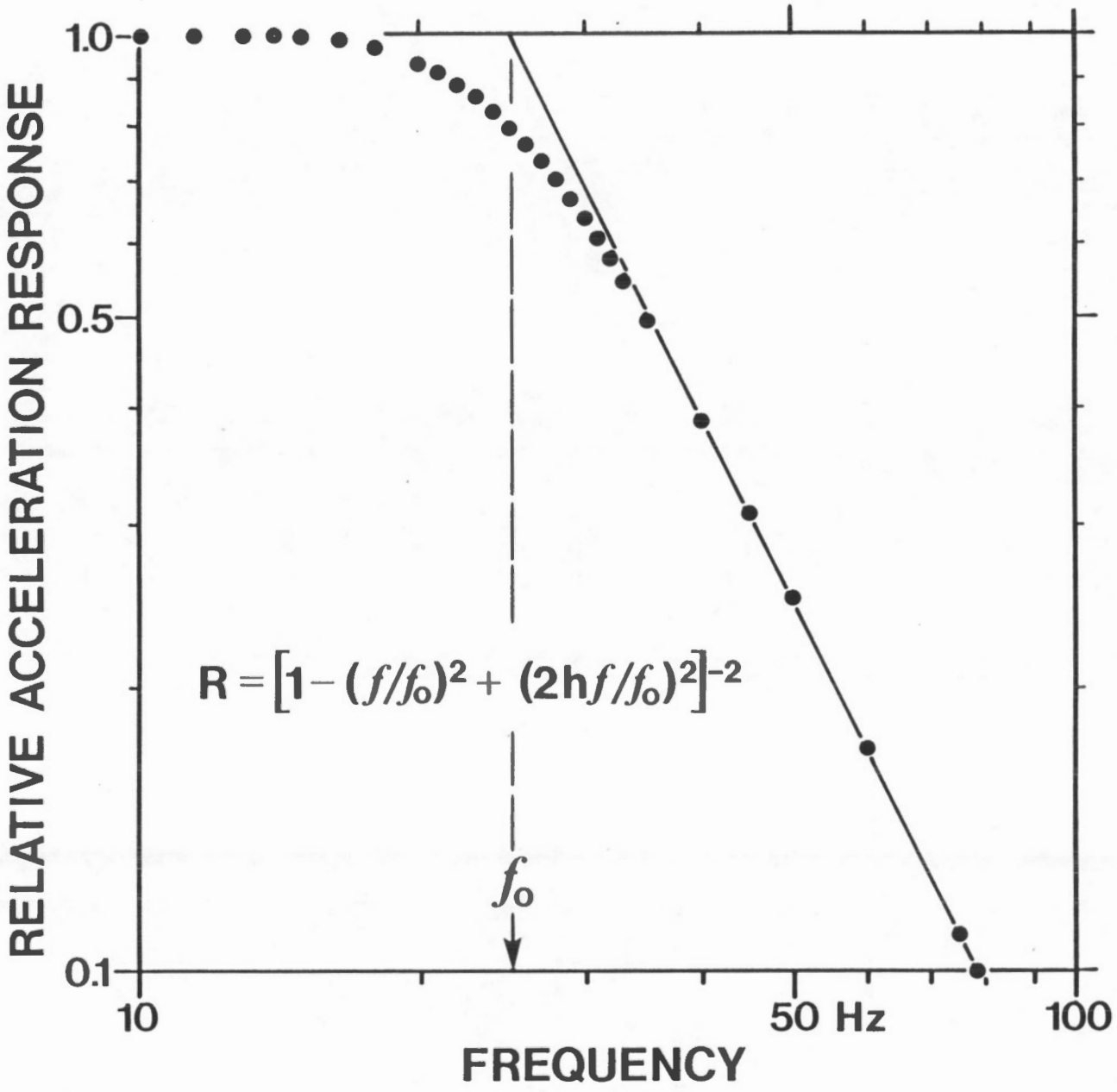



Fig. 82 Amplitude response of accelerograph of 25 Hz natural frequency and 60% critical damping

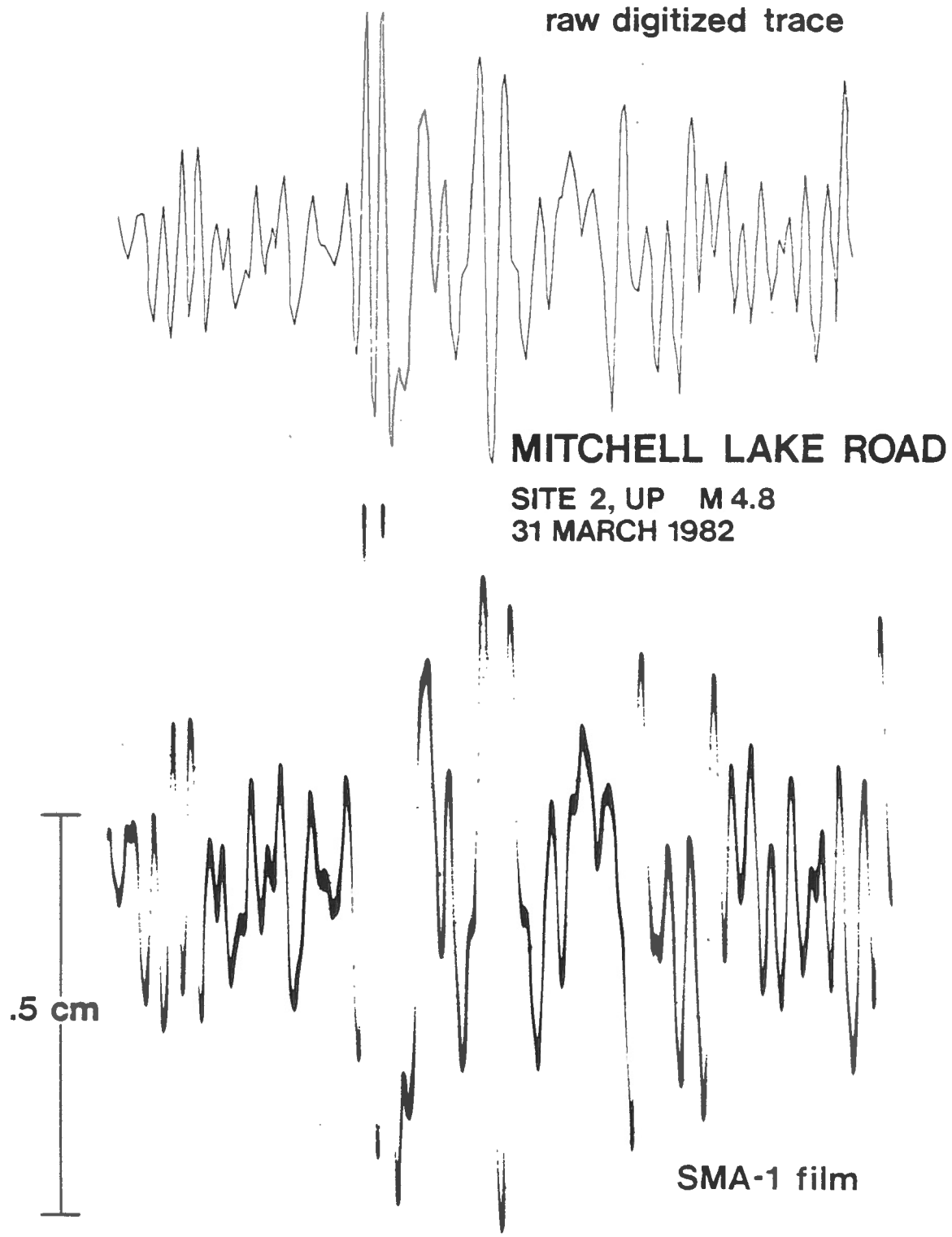

raw digitized trace
MITCHELL LAKE ROAD
SITE 2, UP M 4.8
31 MARCH 1982
.5 cm
SMA-1 film

Fig. 83.