DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Processed Strong-Motion Data for the El Salvador Earthquake of June 19, 1982

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Open-File Report 88-241

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Denver, Colorado

1988

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INTRODUCTION

The El Salvador earthquake of June 19, 1982 was located off the coast of El Salvador approximately 45 km southwest of the city of San Salvador (Fig. 1). There was extensive damage and landslides south of San Salvador, where Modified Mercalli intensities as high as VII were observed. There were at least 40 people killed and thousands left homeless in El Salvador. There was also extensive damage in southeastern Guatemala, where three were killed and 40 injured. The earthquake was also felt in Costa Rica, Honduras, and Nicaragua.

The June, 1982 monthly listing of the *Preliminary Determination of Epicenters* published by the National Earthquake Information Service (NEIS) gives the following data for the earthquake:

Earthquake Parameters:

Origin Time:	06:21:58.0 UTC
Location:	13.313°N, 89.339°W
Depth:	82 km
Magnitude:	6.2 m_b, 7.3 M_w
Moment:	1.0×10^{27} dyne-cm

Preferred Fault Plane:

Strike:	315°
Dip:	85°
Slip:	240°

P-axis:

Azimuth:	197°
Plunge:	42°

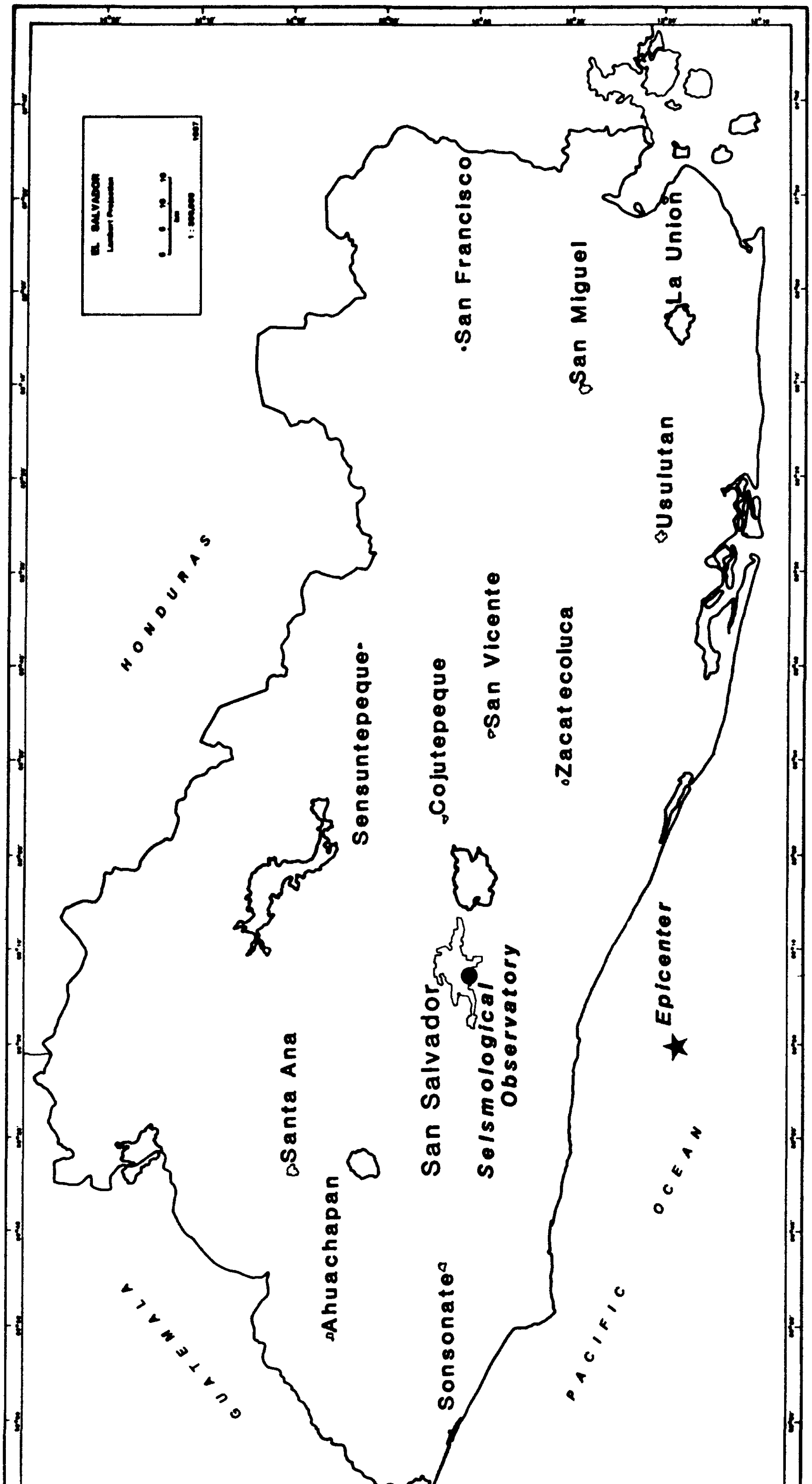


Fig. 1. Map of El Salvador showing the location of the June 19, 1982 earthquake (star) and recording site (circle).

The fault-plane solution given by NEIS is consistent with a moderately well-controlled normal mechanism with a small amount of left-lateral strike-slip motion.

STRONG-MOTION DATA

The earthquake triggered a U.S. Coast & Geodetic Survey Montana-type accelerograph located at the Seismological Observatory in downtown San Salvador. The locations of the earthquake epicenter and recording station are shown on Figure 1. The instrument is located in the basement (seismic vault) of a one-story building. The site is underlaid by fluviatile pumice deposits that range from in depth from ten to several hundred meters throughout the city (Shakal *et al.*, 1986). Site coordinates, instrument characteristics, peak amplitudes, and filter parameters for the recording are summarized in Table 1.

TABLE 1
SUMMARY OF STRONG-MOTION RECORD PROCESSING

El Salvador Earthquake of June 19, 1982
06:21:58 UTC, m_b=6.2

Seismological Observatory, San Salvador
13.680°N, 89.198°W

Description	Component		
	N-S	VERT	E-W
Instrument Characteristics:			
Sensitivity (cm/*g*)	12.2	11.6	14.7
Natural Frequency (Hz)	14.7	15.6	14.9
Damping (% critical)	59.0	46.0	59.0
Filter Parameters:			
Highcut frequency (Hz)	7.0	7.0	7.0
Lowcut period (sec)	5.0	5.0	5.0
Peak Parameters:			
Peak Accel., uncorrected (cm/sec^2)	-185.8	-125.2	188.3
Peak Accel., corrected (cm/sec^2)	-179.6	-124.1	182.4
Peak Velocity (cm/sec)	26.4	13.2	27.9
Peak Displacement (cm)	7.03	3.47	5.30

ACCELEROGRAM PROCESSING

The computer program AGRAM was used for post-digitization processing (Converse, 1984). Because the accelerogram was not digitized with the laser trace-following device used in the routine digitization of film records, four AGRAM routines--IOMTAP, BUTTER, REFORM, and SCALE--could not be used in their present form. As a result, these routines were replaced with other routines designed to perform the same functions. Details of the processing steps are summarized below.

Digitization. The accelerogram was recorded on 12-inch wide photo-sensitive paper. Because of the relatively large width of the original accelerogram, no enlargement was necessary. The original accelerogram was digitized by mounting it on a digitizing table and tracing it with a hand-held cursor. This process resulted in a nominal sample rate of 150-300 samples per second. The resolution of the digitizing table is 0.00254 cm which, when scaled, represents a time resolution of about 0.003 sec and an acceleration resolution of about 0.2 cm/sec^2 (0.0002*g*). All traces on the accelerogram were digitized, including the fixed traces. There was no timing trace on the original recording, so marks were placed on the record at 0.5 cm intervals to simulate timing pulses of 0.5 sec in duration. These simulated timing pulses were digitized along with the other traces.

Phase I. An estimate of relative time for each data point was established by interpolation of the timing pulses, and the starting times of each acceleration trace were adjusted to minimize phasing errors between traces. The baseline of each acceleration and fixed trace was adjusted so that its average amplitude was zero, after which absolute amplitudes were computed from the instrument sensitivities.

Phase II. Phase I data were interpolated to 200 samples per second, and a frequency domain instrument correction operator was applied to remove the response of the recording system. High-frequency noise was identified from ratios of the Fourier amplitude spectra of the acceleration and fixed traces. For this purpose, the ratios were plotted as a function of linear frequency to emphasize the high-frequency portion of the spectra. High-frequency noise was removed by applying a three-hertz bandwidth cosine taper in the frequency domain. Low-frequency noise was removed with a bidirectional, fourth-order Butterworth filter. This noise was identified from ratios of the pseudo-relative velocity response spectra of the acceleration and fixed traces. The ratios were plotted as a function of the logarithm of period to emphasize the long-period amplitudes of the spectra. The lowcut filter parameter was chosen to give a signal-to-noise ratio of 5:1 for the smallest horizontal component. This resulted in a signal-to-noise ratio of approximately 5:1 for each of the horizontal components and a signal-to-noise ratio of 3:1 for the vertical component. Acceleration traces were then integrated to obtain velocity, and the resulting velocity records filtered and integrated to obtain displacement. When the integration was completed, the acceleration traces were filtered to produce "corrected" acceleration records.

Phase III. Fourier amplitude spectra (FAS) and relative displacement (RD), relative velocity (RV), pseudo-relative velocity (PSRV), absolute acceleration (AA), and pseudo-absolute acceleration (PSAA) response spectra were computed from the corrected acceleration time series at 91 periods ranging from 0.04 to 15 sec. The response spectra were calculated for five values of critical damping: 0, 2, 5, 10, and 20 percent.

Data Plots. Plots of the processed data are included in the *Appendix*. These plots include the uncorrected acceleration time series generated in Phase I; the corrected acceleration, velocity, and displacement time series generated in Phase II; and the Fourier and response spectra generated in Phase III. The plots of response spectra include both a logarithmic tripartite plot of pseudo-relative velocity and a linear plot of relative velocity. Fourier spectra are plotted as both linear and logarithmic functions frequency.

REFERENCES

Converse, A., 1984, AGRAM: a series of computer programs for processing digitized strong-motion accelerograms: U.S. Geological Survey Open-File Report 84-525, 107 p.

Shakal, A.F., Huang, M.J., Parke, D.L., and Linares, R., 1986, Processed strong motion data from the San Salvador earthquake of October 10, 1986: Sacramento, California Division of Mines and Geology Rept. OSMS 86-07, 113 p.

DATA AVAILABILITY

A magnetic tape of the processed record described in this report can be obtained from the National Geophysical Data Center in Boulder, Colorado. All requests should be forwarded to:

National Geophysical Data Center/NOAA
World Data Center-A for Solid Earth Geophysics
325 Broadway, Code E/GC1
Boulder, CO 80303

ACKNOWLEDGEMENTS

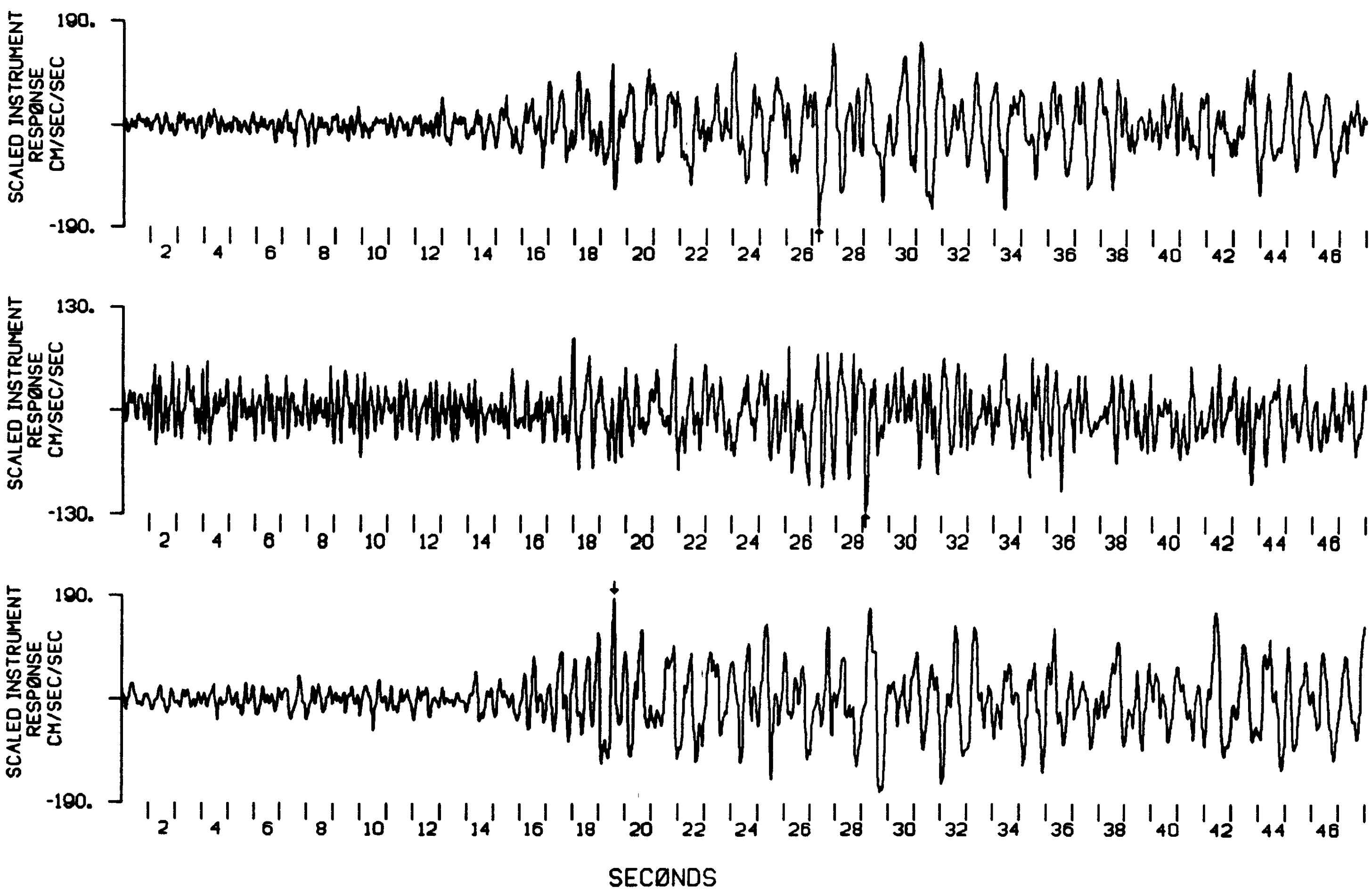
The record processing described in this report was funded by the U.S. Agency for International Development, San Salvador, El Salvador as part of a project administered by Mr. Tim Truitt and Mr. Peter Deinken. The strong-motion record was kindly provided by Ing. Julio R. Salazar M., Director, Centro de Investigaciones Geotécnicas, Ministerio de Obras Publicas, San Salvador, El Salvador. We also wish to acknowledge the assistance of Ing. Roberto A. Linares E., Consulting Engineer, San Salvador, El Salvador. The accelerogram was digitized by Dean Yanacito.

APPENDIX

PLOTS OF PROCESSED DATA

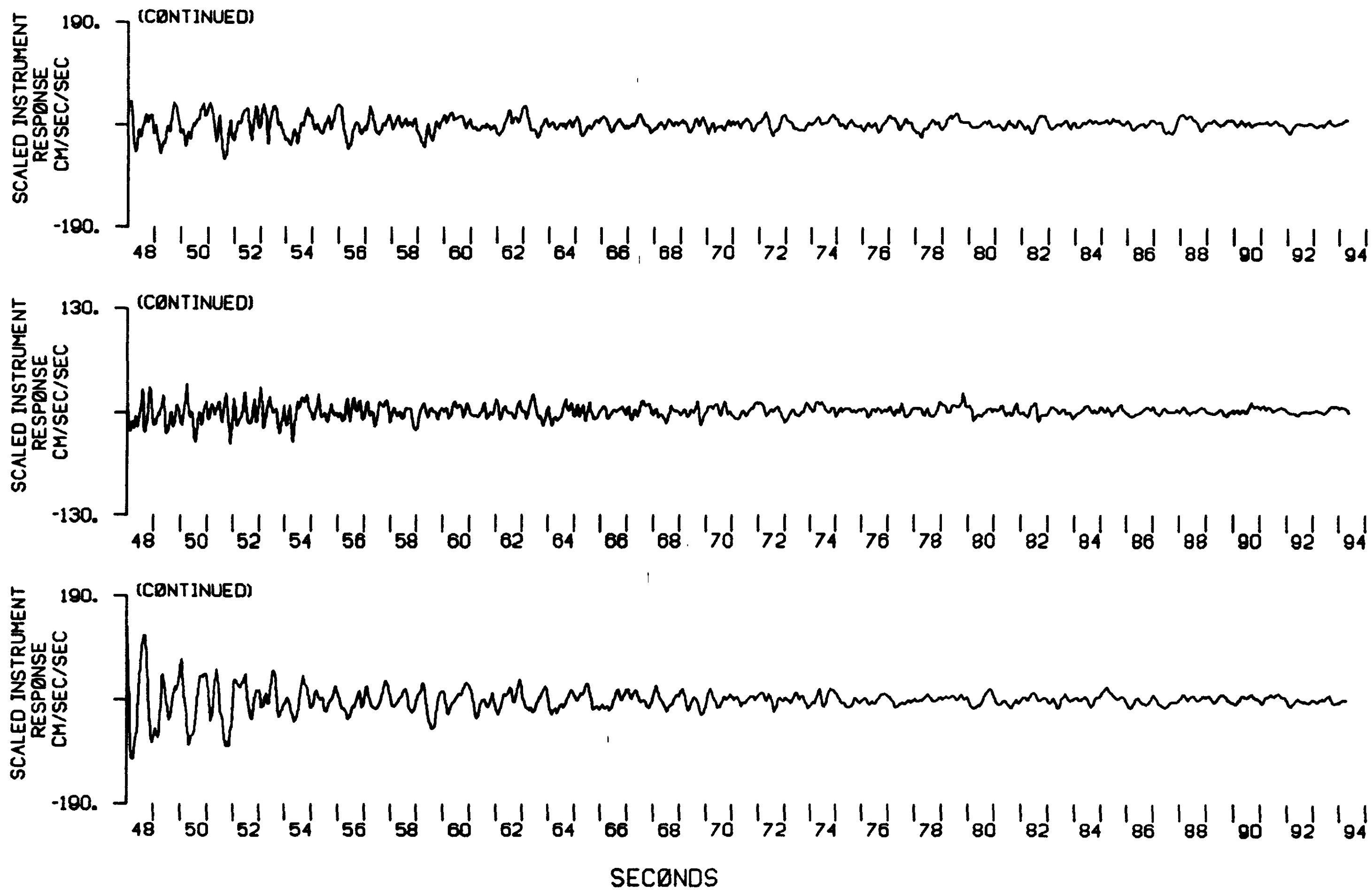
UNCØRRECTED ACCELERØGRAM
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, MB=6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, N-S, VERT, E-W

PEAK VALUES(CM/SEC/SEC): -185.78 -125.21 188.25

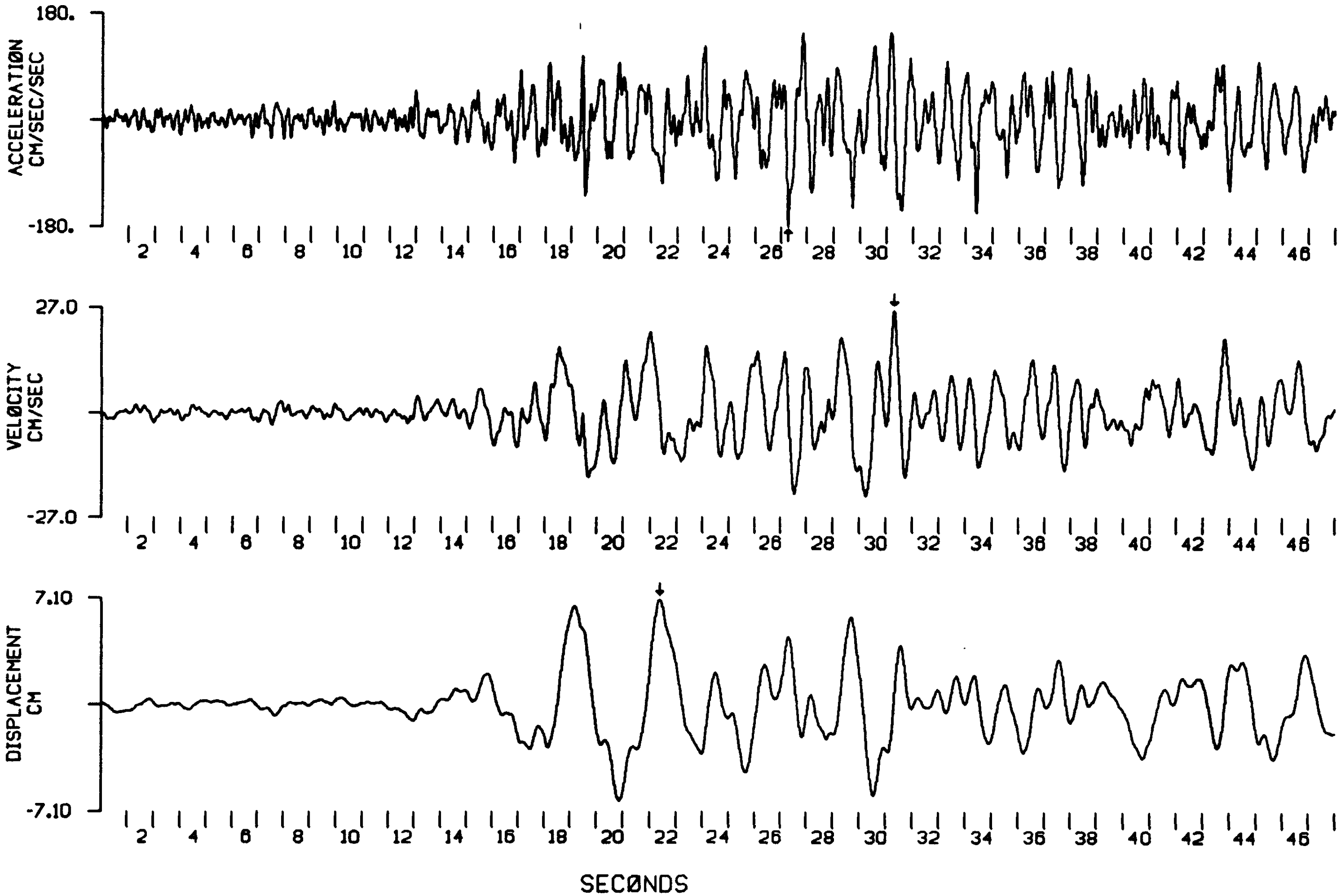


UNCØRRECTED ACCELERØGRAM
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, MB-6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, N-S, VERT, E-W

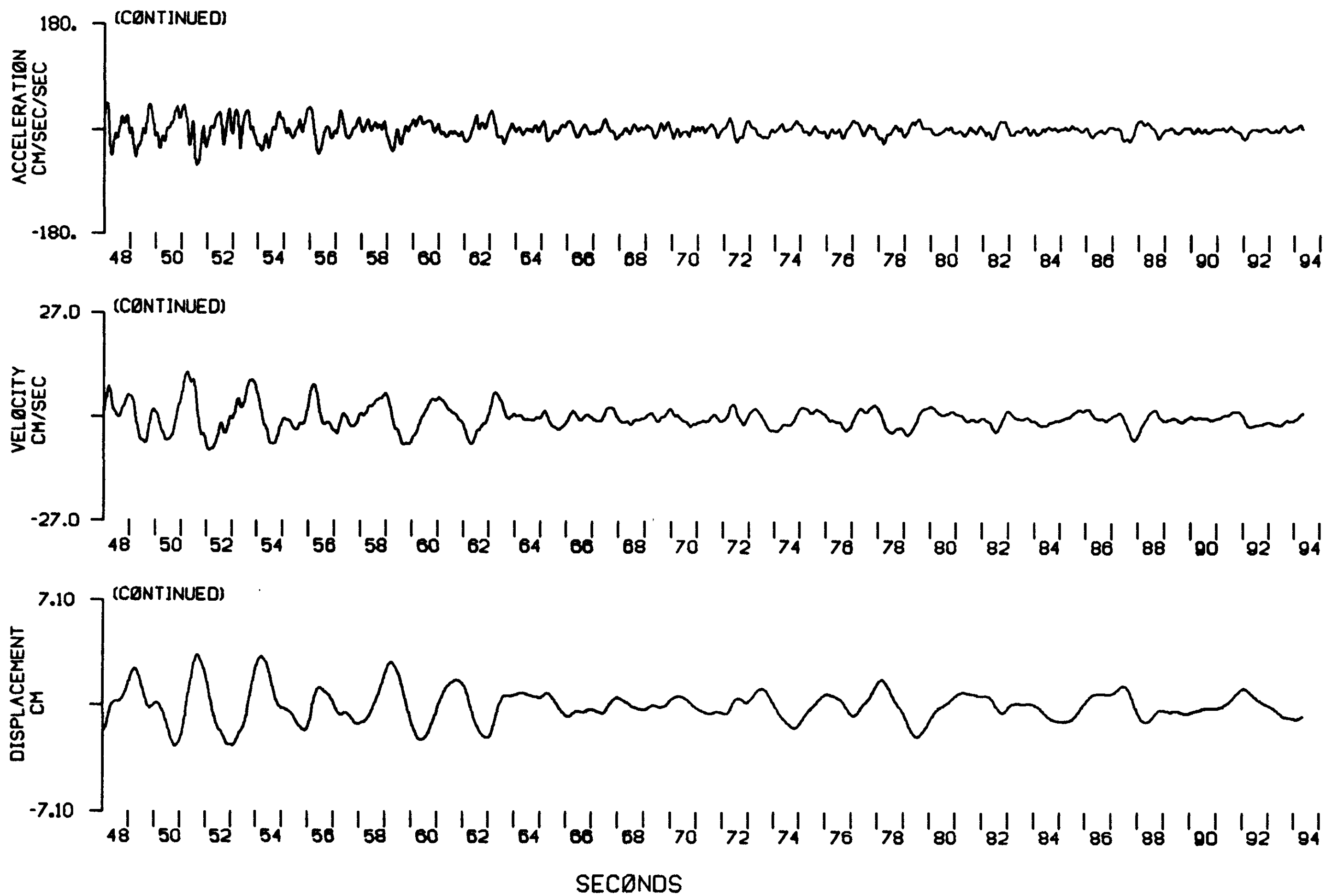
PEAK VALUES(CM/SEC/SEC): -185.78 -125.21 188.25



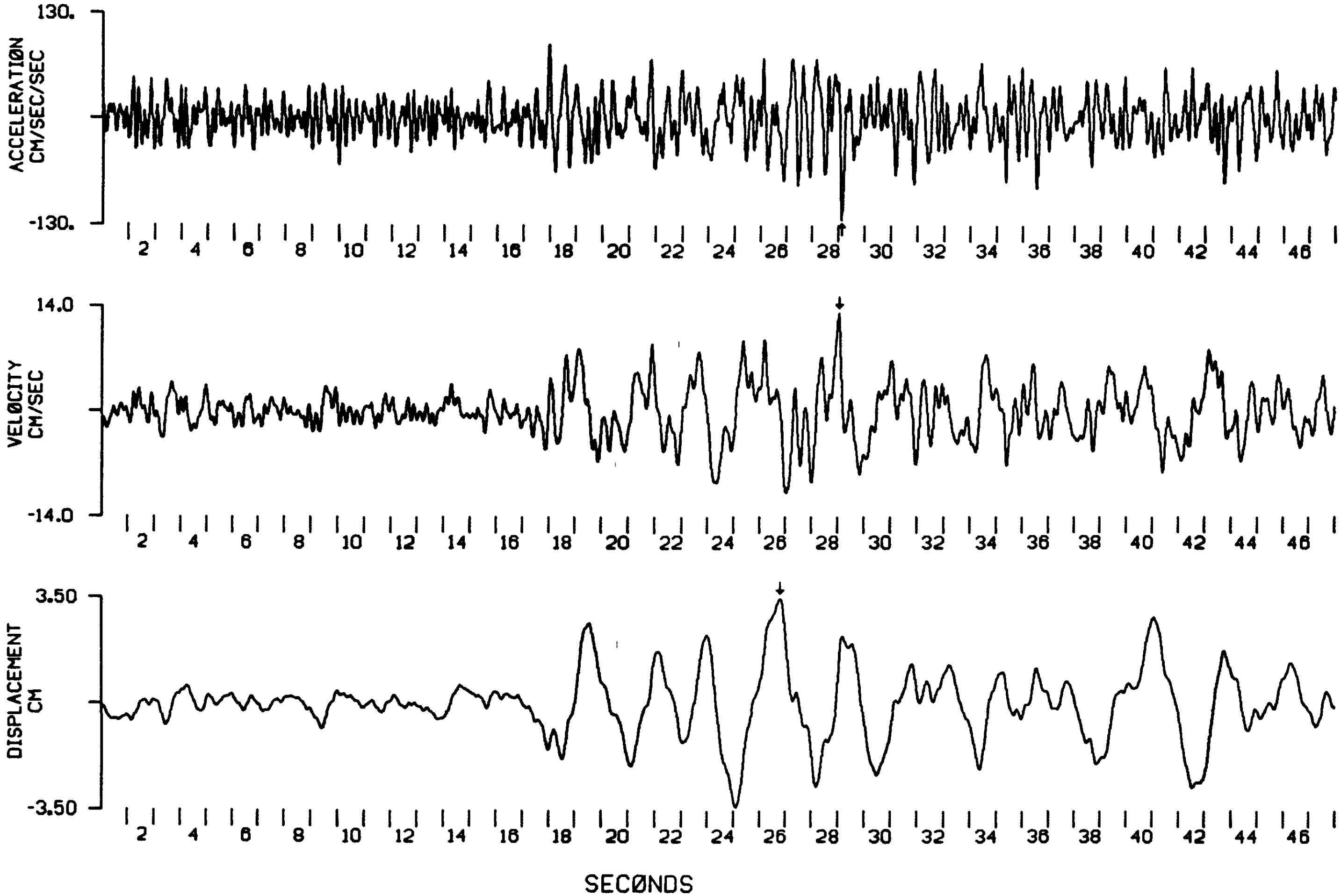
CØRRECTED ACCELERATIØN, VELØCITY, AND DISPLACEMENT 200.00 SPS
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, MB=6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, NØRTH-SØUTH
PEAK VALUES: ACCEL=-179.59 CM/SEC/SEC, VELØCITY=26.40 CM/SEC, DISPL=7.03 CM



CØRRECTED ACCELERATIØN, VELØCITY, AND DISPLACEMENT 200.00 SPS
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, MB=6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, NØRTH-SØUTH
PEAK VALUES: ACCEL=-179.59 CM/SEC/SEC, VELØCITY=26.40 CM/SEC, DISPL=7.03 CM



CØRRECTED ACCELERATIØN, VELØCITY, AND DISPLACEMENT 200.00 SPS
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, MB=6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, VERTICAL
PEAK VALUES: ACCEL=-124.14 CM/SEC/SEC, VELØCITY=13.17 CM/SEC, DISPL=3.47 CM



CØRRECTED ACCELERATIØN, VELØCITY, AND DISPLACEMENT 200.00 SPS
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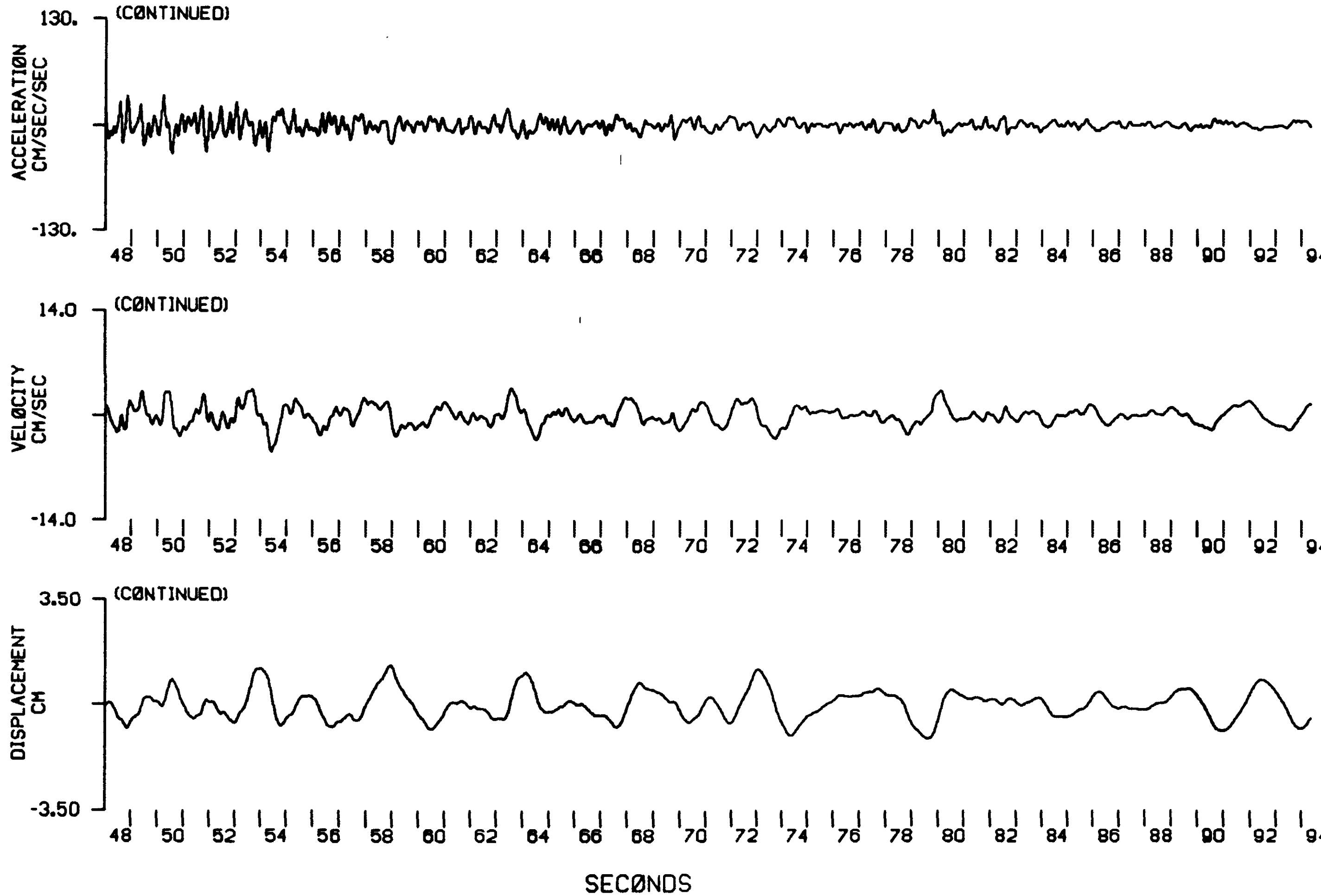
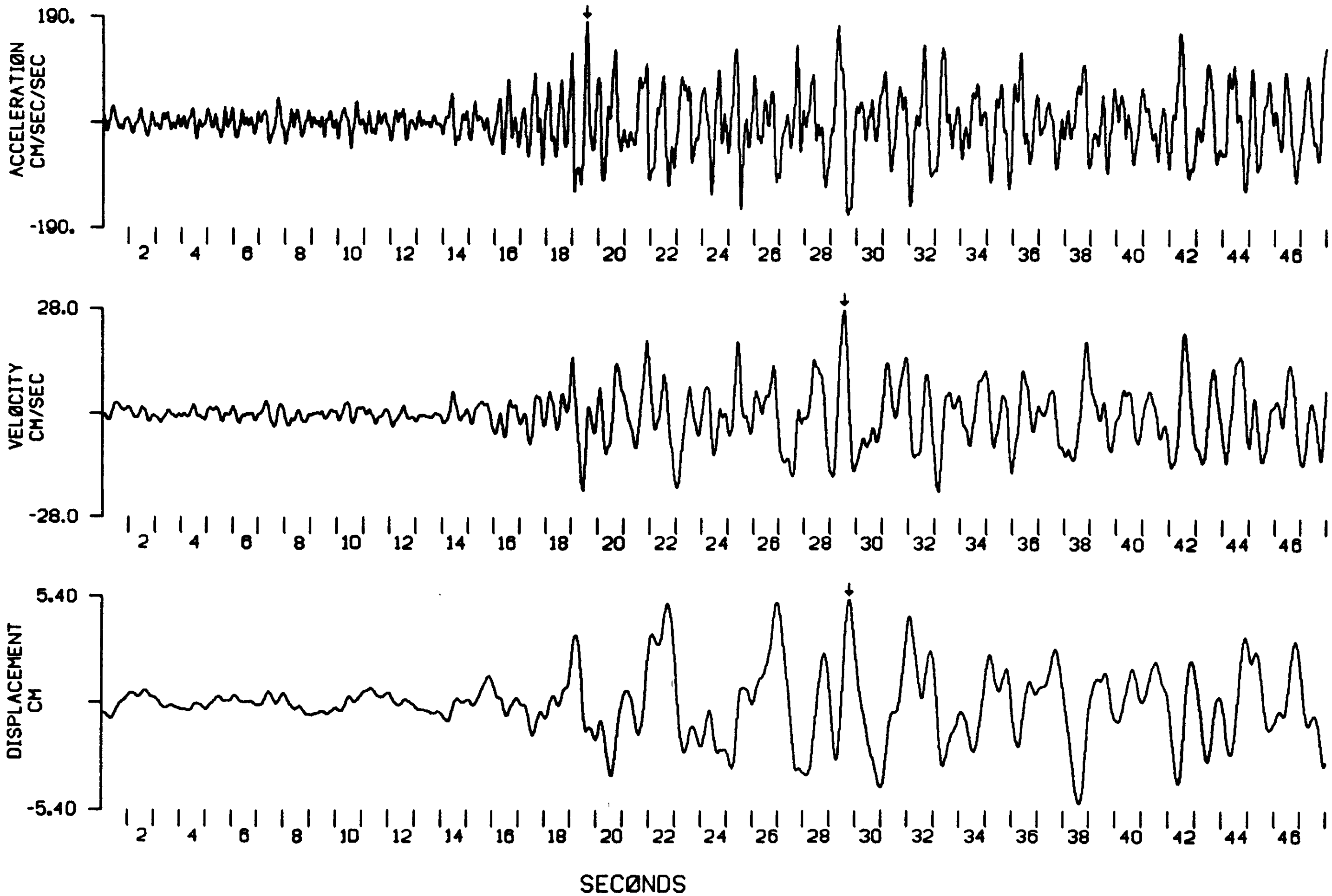
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, VERTICAL
PEAK VALUES: ACCEL=-124.14 CM/SEC/SEC, VELØCITY=13.17 CM/SEC, DISPL=3.47 CM



CØRRECTED ACCELERATIØN, VELØCITY, AND DISPLACEMENT 200.00 SPS
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, MB=6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, EAST-WEST
PEAK VALUES: ACCEL=182.42 CM/SEC/SEC, VELØCITY=27.86 CM/SEC, DISPL=5.30 CM



CØRRECTED ACCELERATIØN, VELØCITY, AND DISPLACEMENT 200.00 SPS
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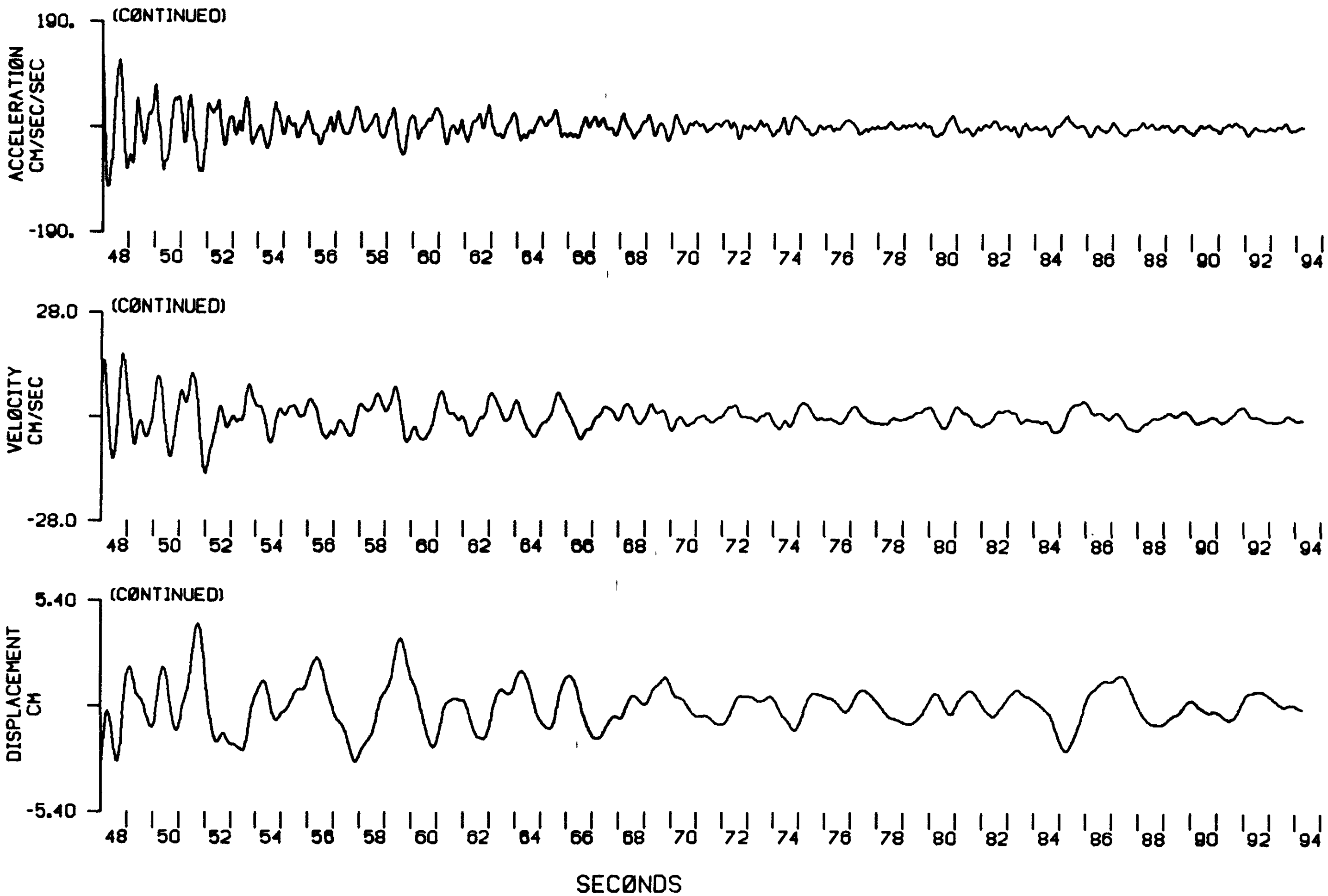
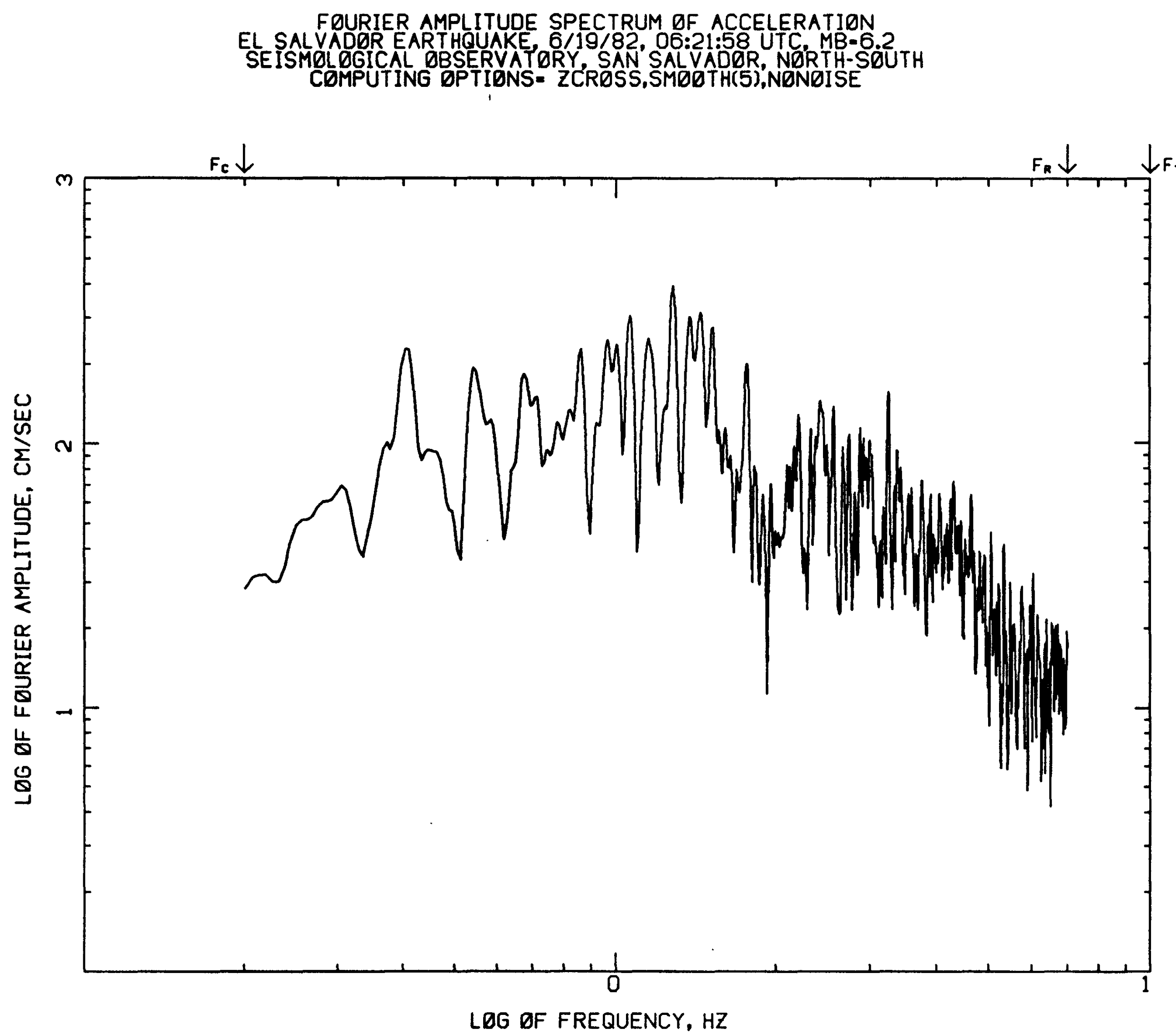
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, EAST-WEST
PEAK VALUES: ACCEL-182.42 CM/SEC/SEC, VELØCITY-27.86 CM/SEC, DISPL-5.30 CM




FØURIER AMPLITUDE SPECTRUM ØF ACCELERATIØN
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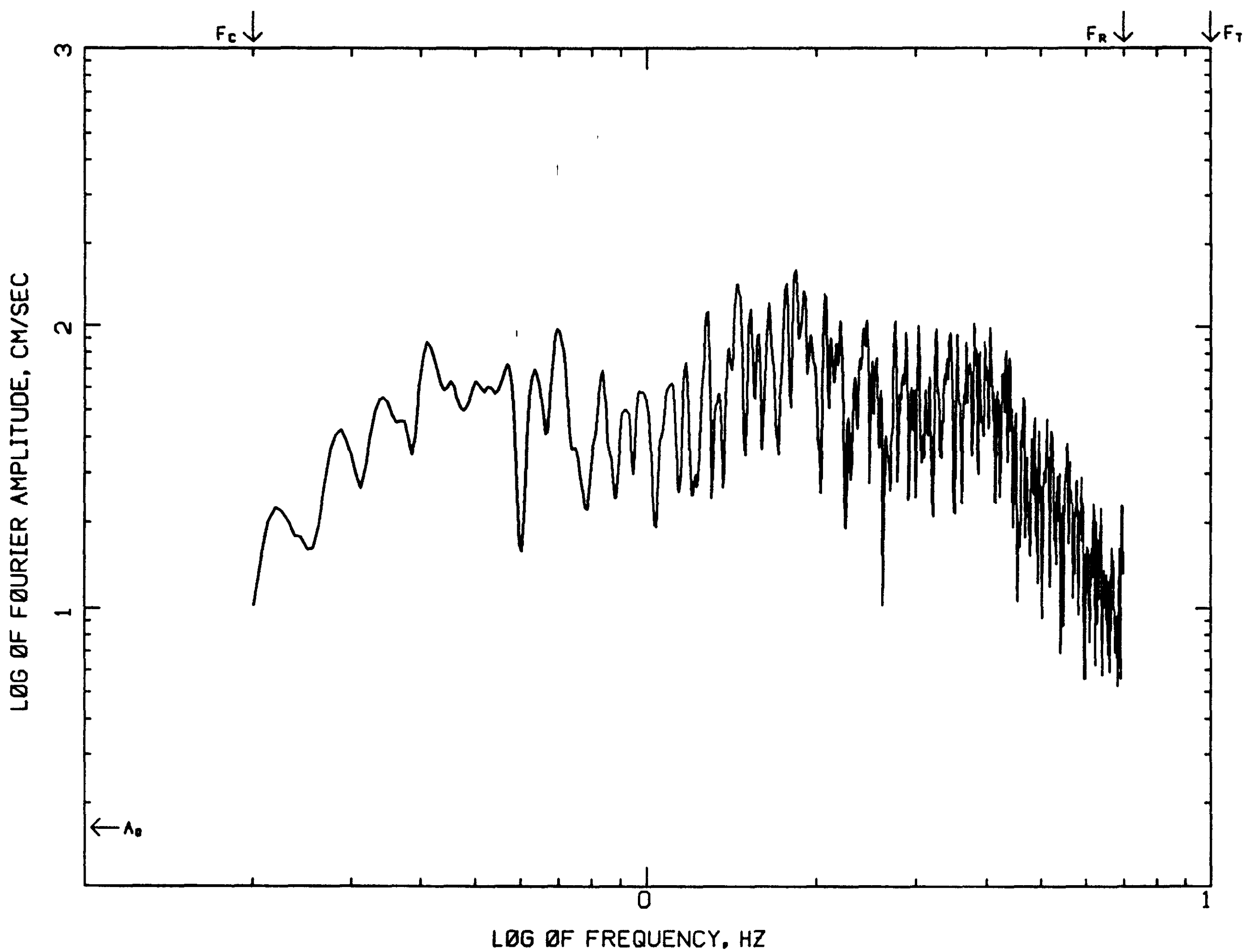
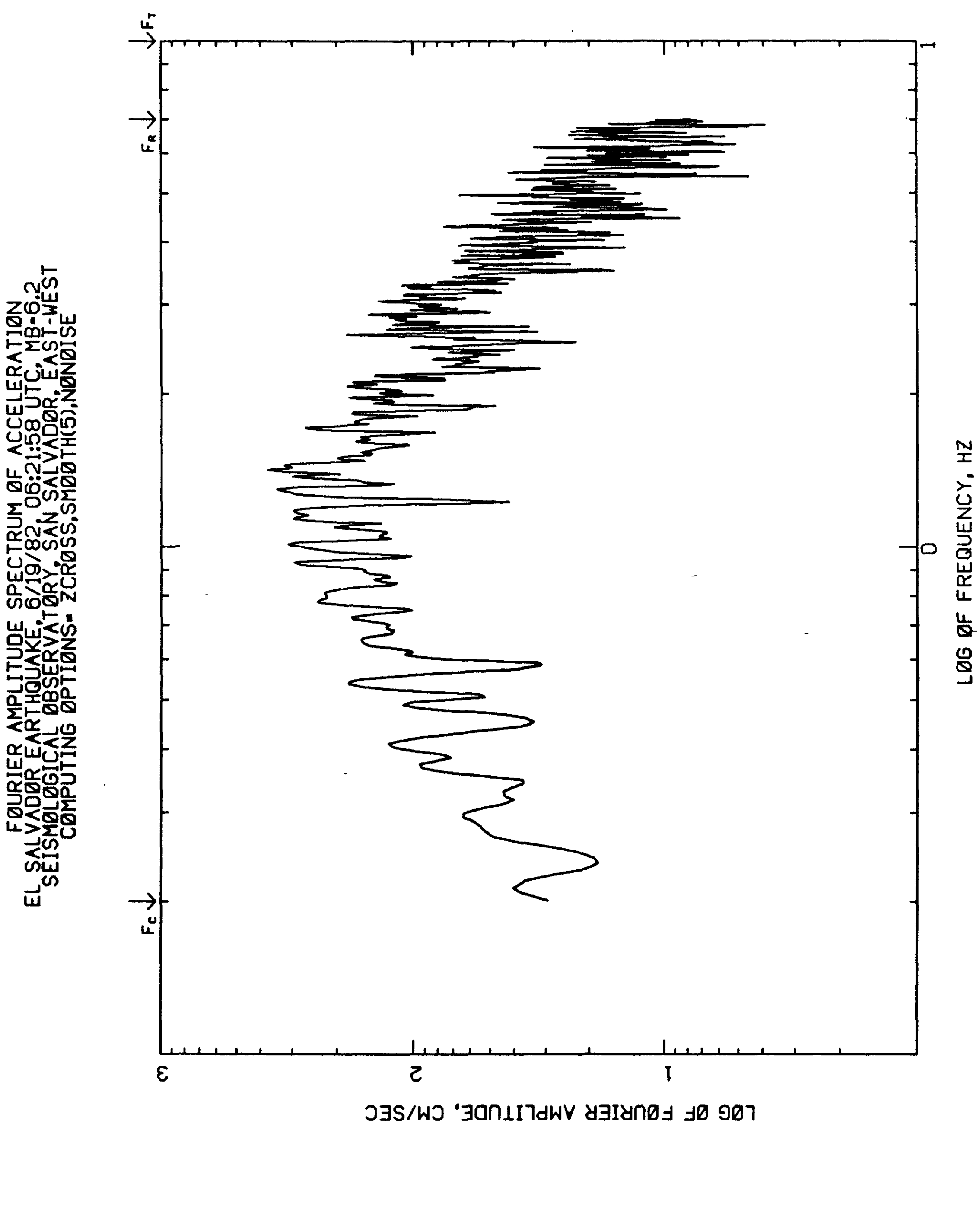
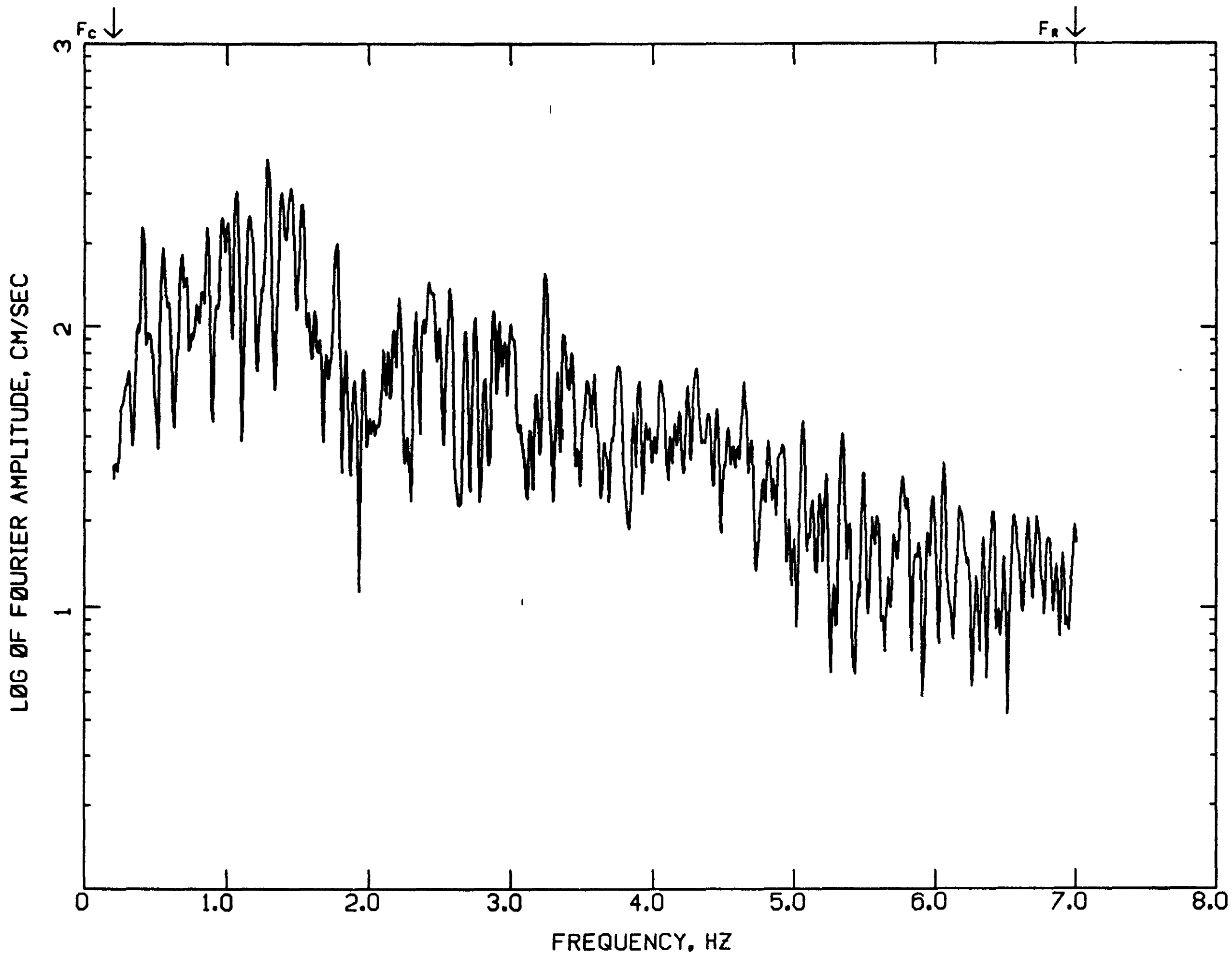
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, NØRTH-SØUTH
CØMPUTING ØPTIØNS= ZCRØSS,SMØØTH(5),NØNØISE
F_C
F_R
F_T
3
2
1
LØG ØF FØURIER AMPLITUDE, CM/SEC
0
1
LØG ØF FREQUENCY, HZ

FØURIER AMPLITUDE SPECTRUM ØF ACCELERATIØN
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, MB=6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, VERTICAL
CØMPUTING ØPTIØNS= ZCRØSS,SMØØTH(5),NØNØISE




FØURIER AMPLITUDE SPECTRUM ØF ACCELERATIØN
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, MB=6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, EAST-WEST
CØMPUTING ØPTIØNS= ZCRØSS,SMØØTH(5),NØNØISE
LØG ØF FØURIER AMPLITUDE, CM/SEC
LØG ØF FREQUENCY, HZ
3
2
1
0
1
F_C
F_R
F_T

FØURIER AMPLITUDE SPECTRUM ØF ACCELERATIØN
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, MB=6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, NØRTH-SØUTH
CØMPUTING ØPTIØNS= ZCRØSS,SMØØTH(5),NØNØISE



FØURIER AMPLITUDE SPECTRUM ØF ACCELERATIØN
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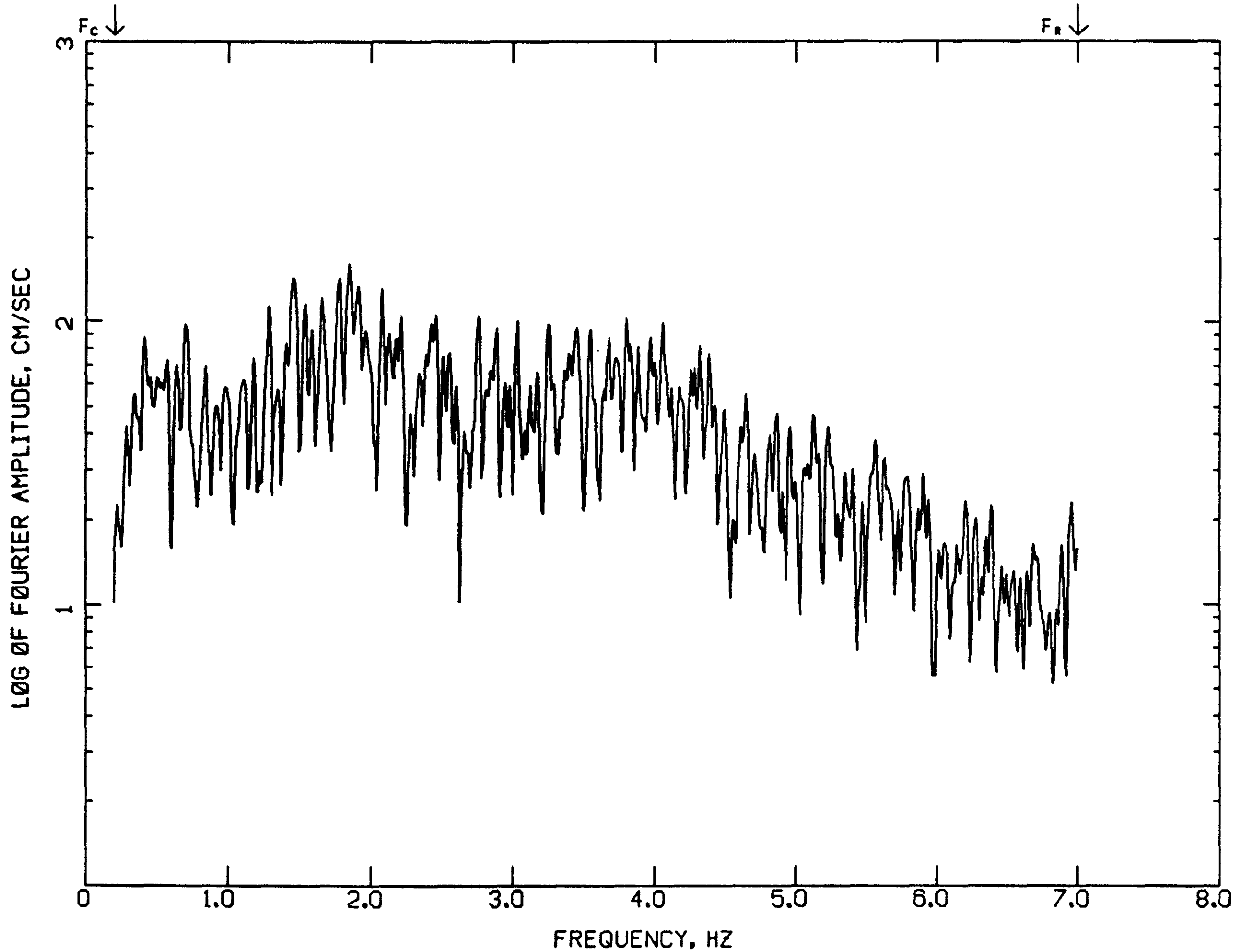
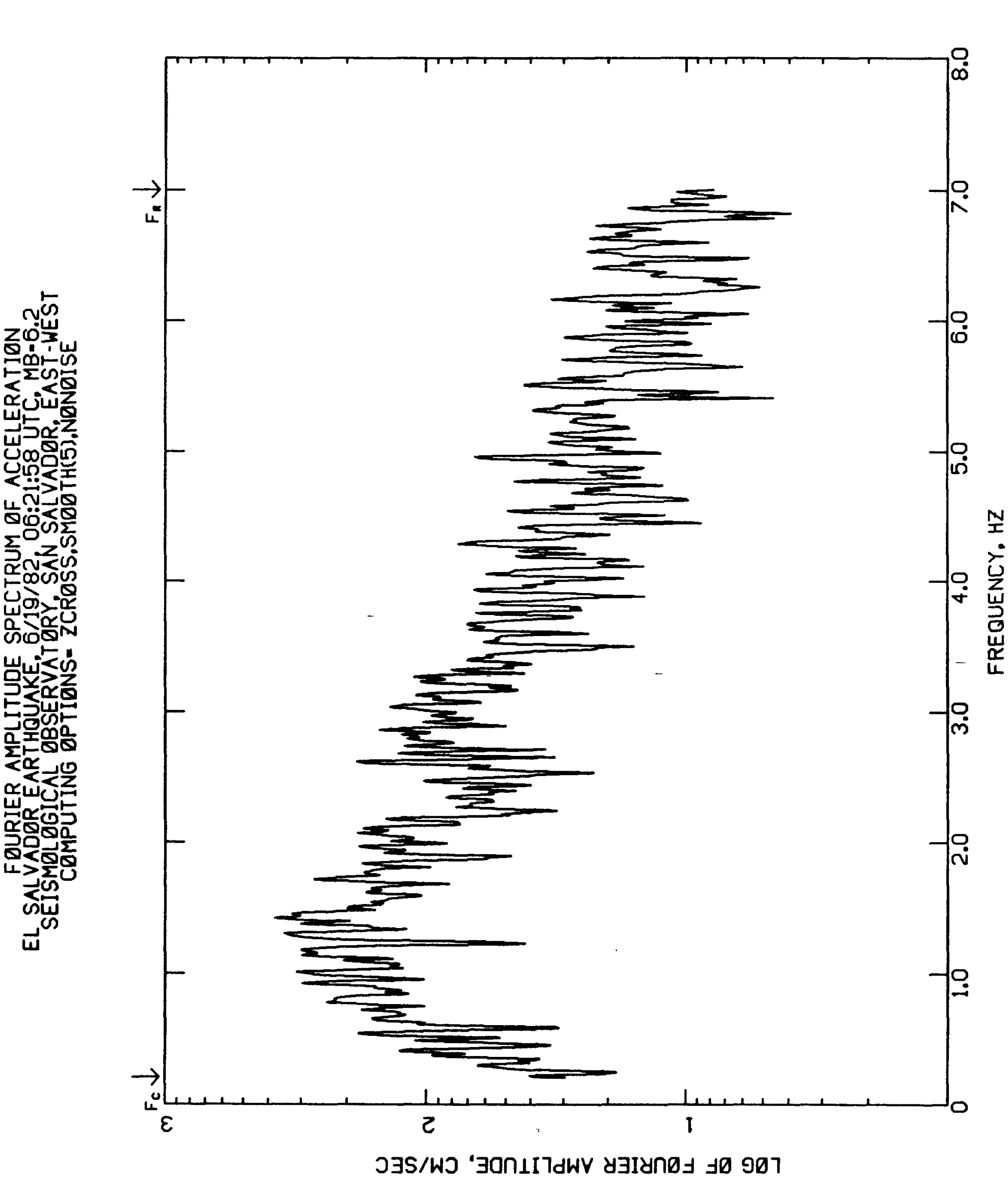
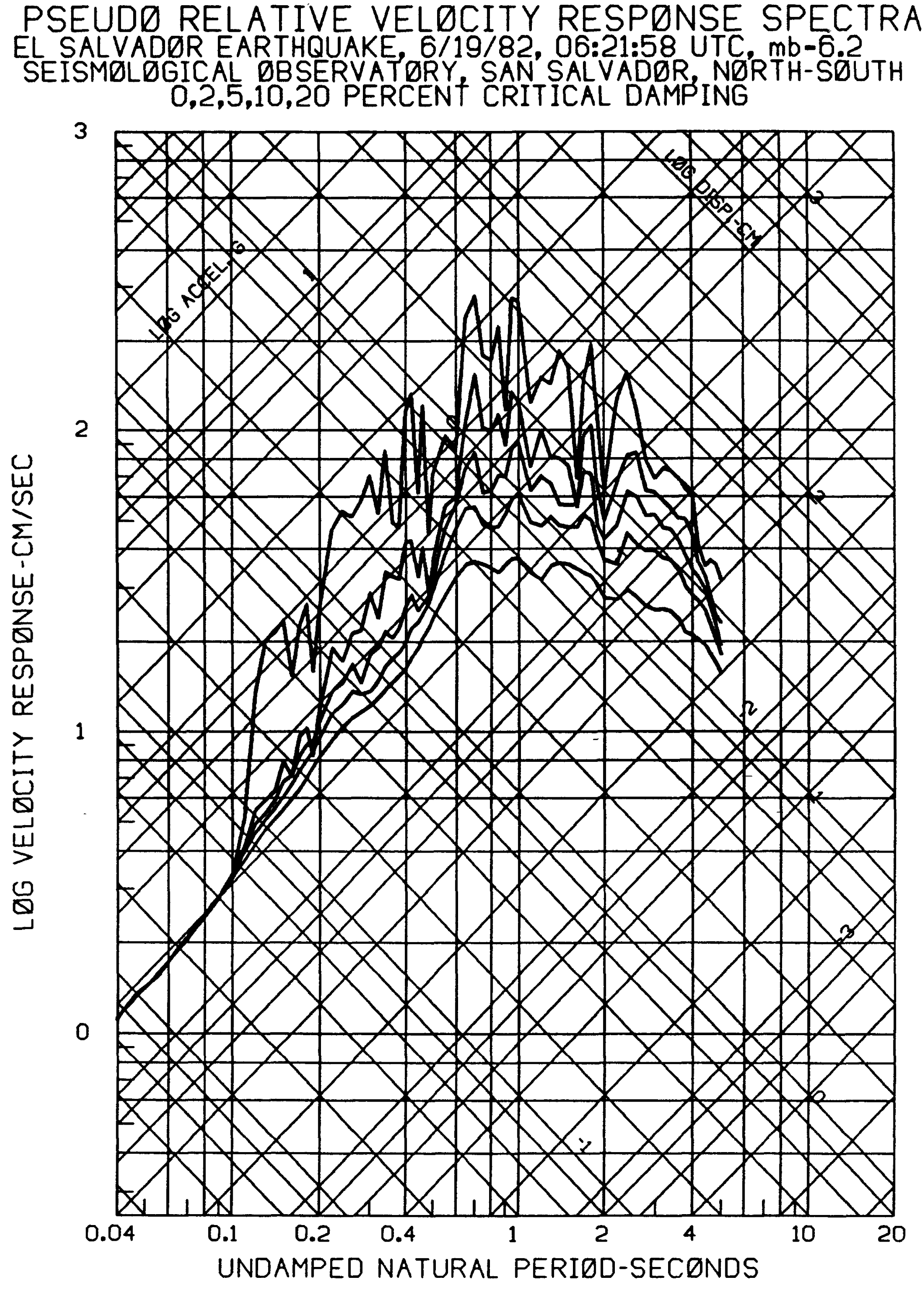
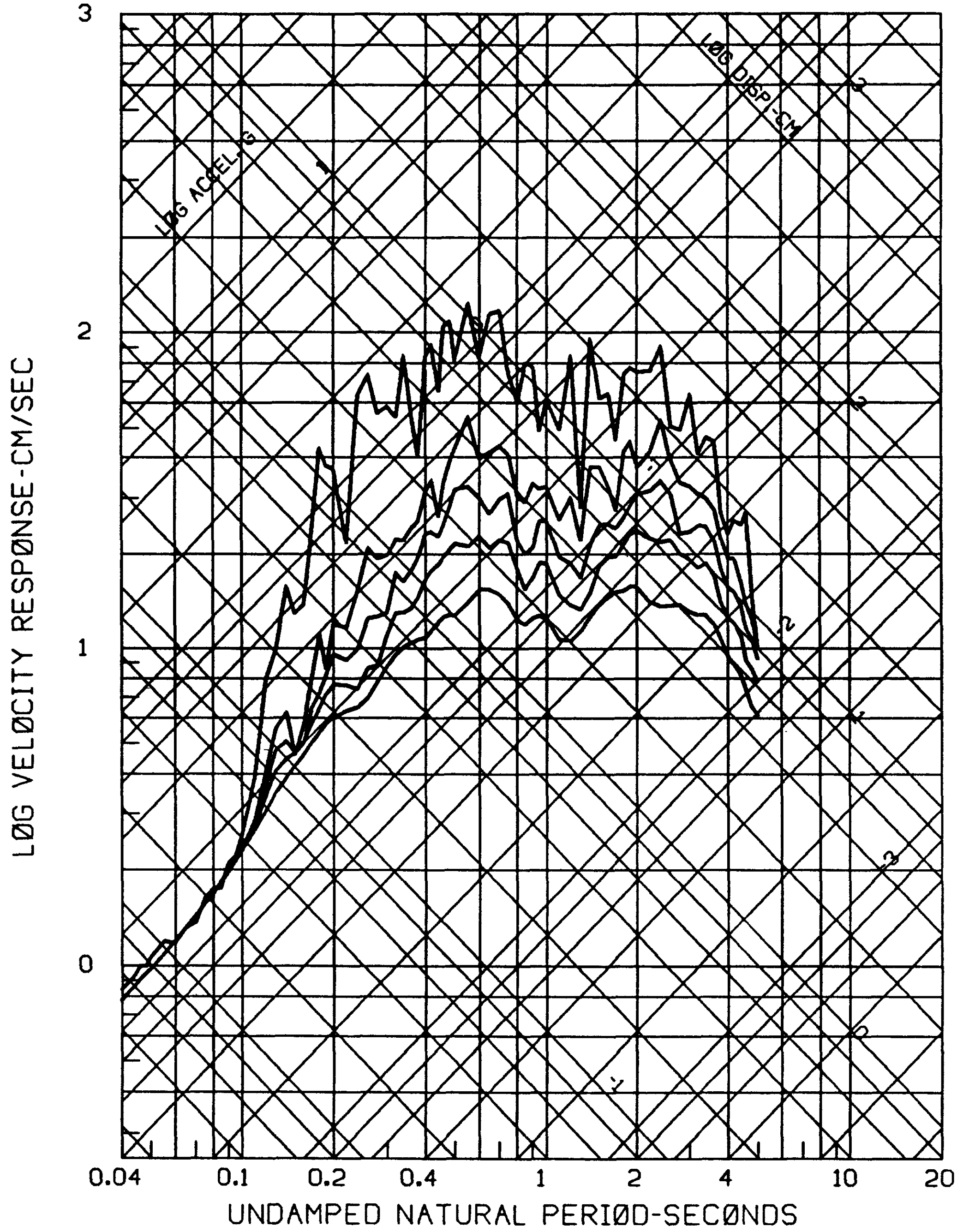
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, VERTICAL
CØMPUTING ØPTIØNS= ZCRØSS,SMØØTH(5),NØNØISE



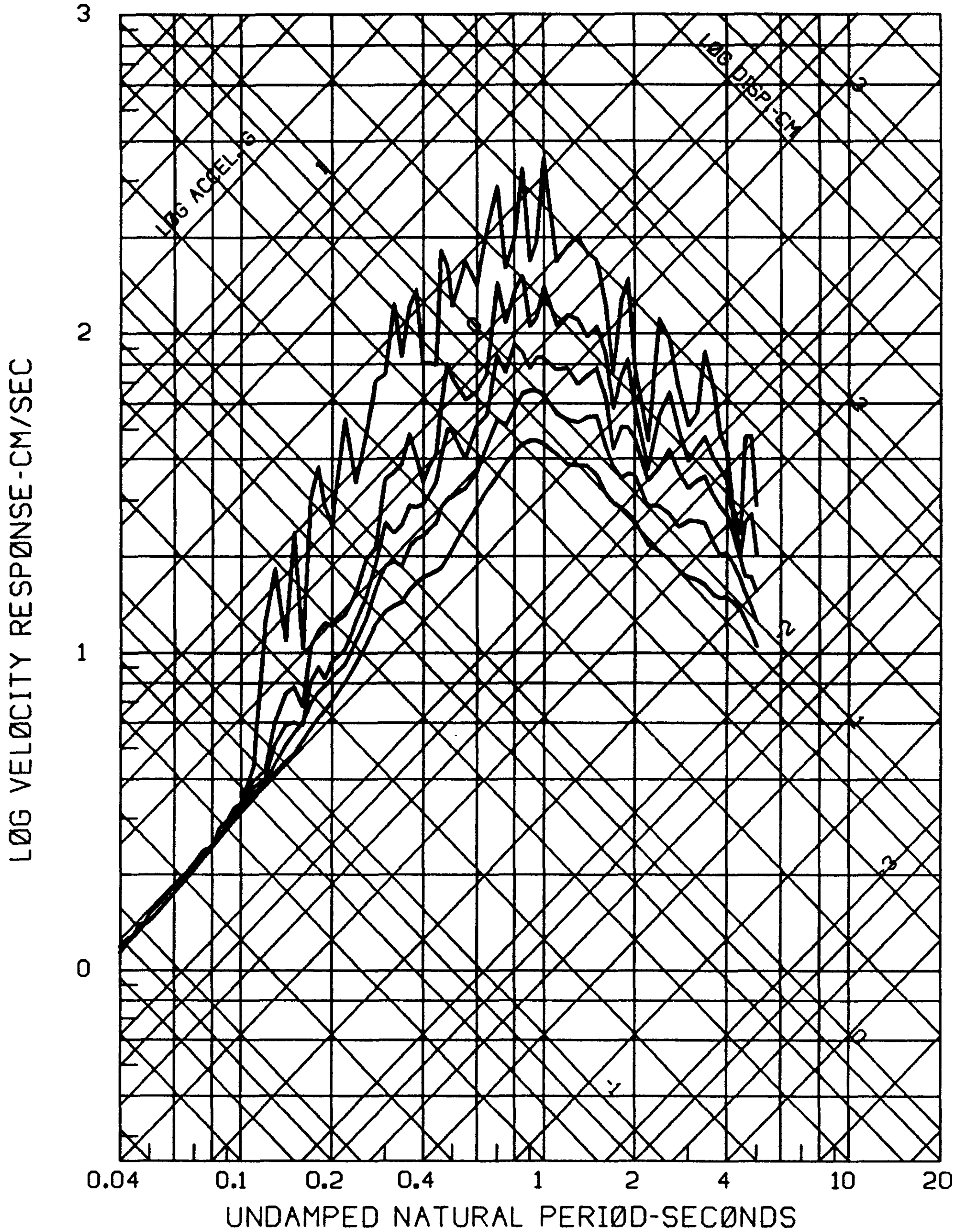

FØURIER AMPLITUDE SPECTRUM ØF ACCELERATIØN
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, MB=6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, EAST-WEST
CØMPUTING ØPTIØNS= ZCRØSS,SMØØTH(5),NØNØISE
LØG ØF FØURIER AMPLITUDE, CM/SEC
3
2
1
FREQUENCY, HZ
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Fc
FR

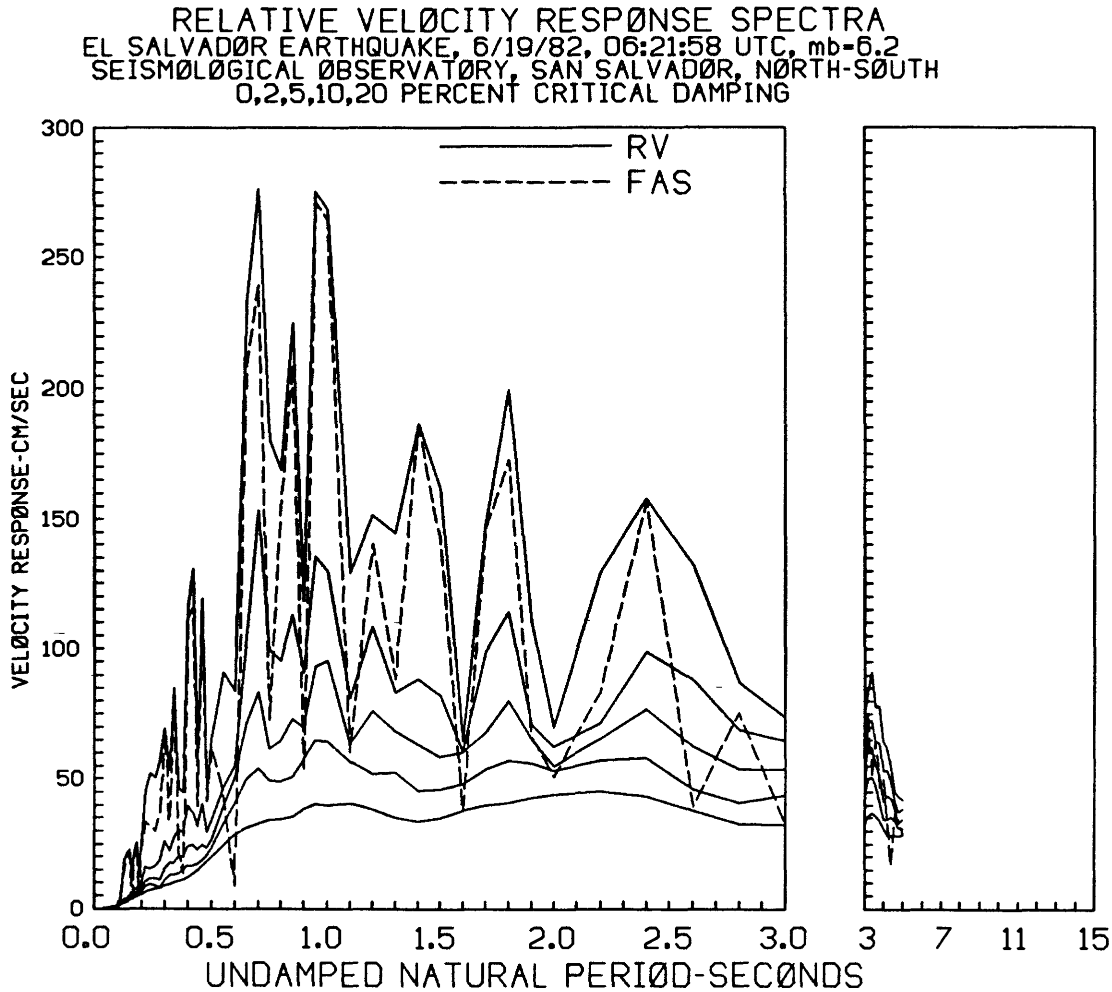

PSEUDØ RELATIVE VELØCITY RESPØNSE SPECTRA
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, mb-6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, NØRTH-SØUTH
0,2,5,10,20 PERCENT CRITICAL DAMPING
LØG ACCEL-G
LØG DISP-CM
LØG VELØCITY RESPØNSE-CM/SEC
3
2
1
0
0.04
0.1
0.2
0.4
1
2
4
10
20
UNDAMPED NATURAL PERIØD-SECØNDS

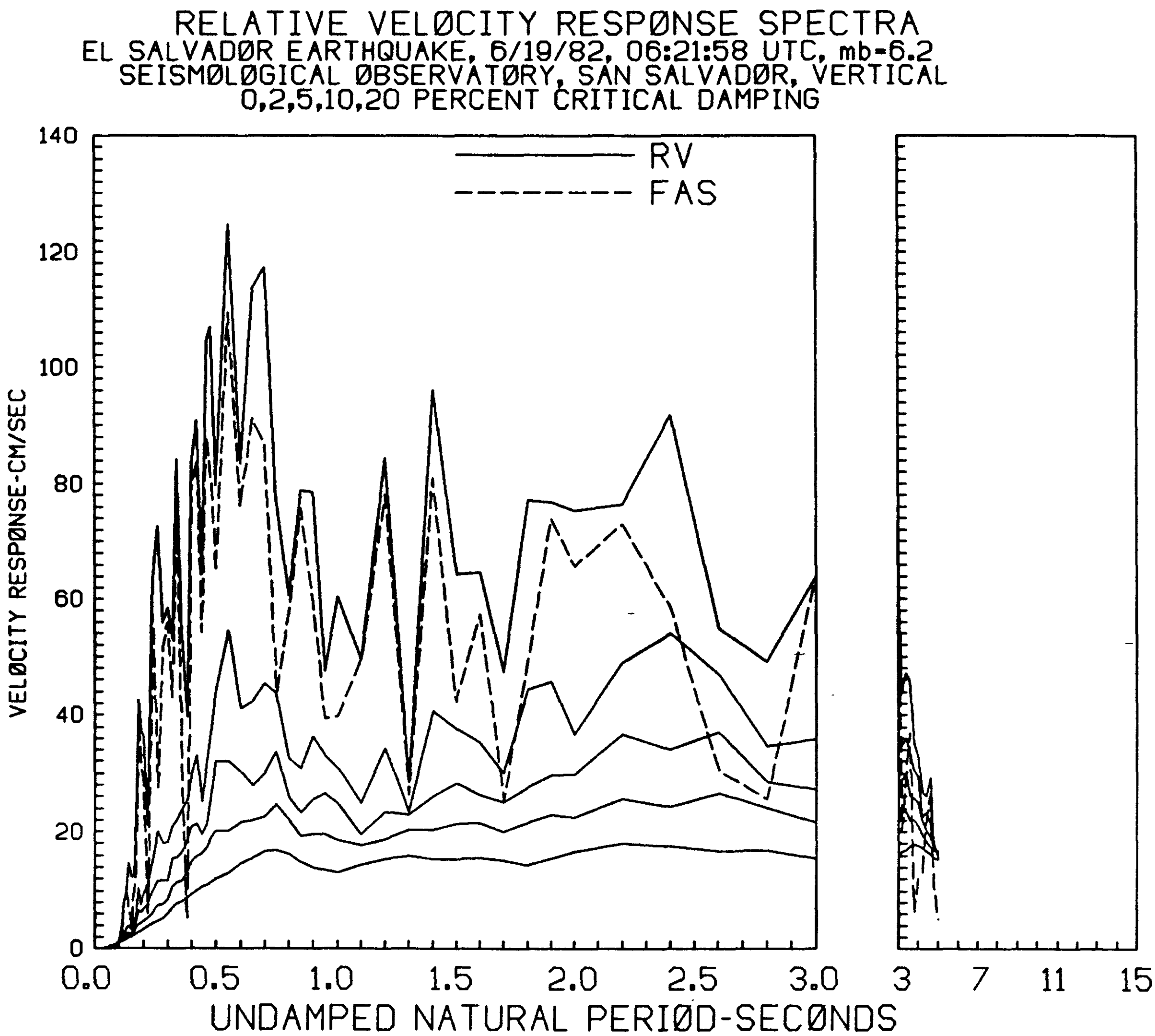
PSEUDØ RELATIVE VELØCITY RESPØNSE SPECTRA
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, mb-6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, VERTICAL
0,2,5,10,20 PERCENT CRITICAL DAMPING

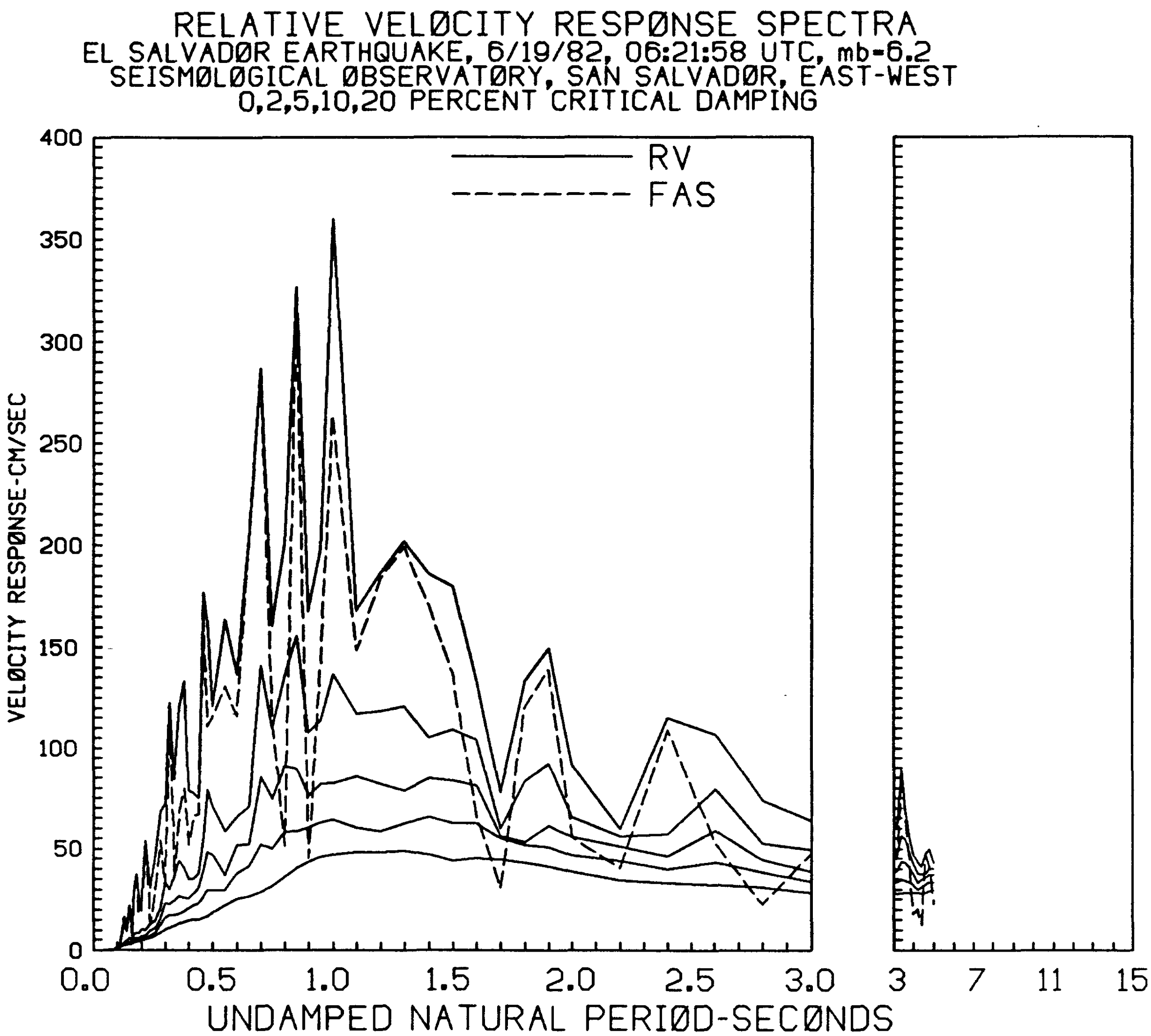


PSEUDØ RELATIVE VELØCITY RESPØNSE SPECTRA
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, mb-6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, EAST-WEST
0,2,5,10,20 PERCENT CRITICAL DAMPING




RELATIVE VELØCITY RESPØNSE SPECTRA
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, mb=6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, NØRTH-SØUTH
0,2,5,10,20 PERCENT CRITICAL DAMPING
RV
FAS
VELØCITY RESPØNSE-CM/SEC
300
250
200
150
100
50
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIØD-SECØNDS


RELATIVE VELØCITY RESPØNSE SPECTRA
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, mb-6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, VERTICAL
0,2,5,10,20 PERCENT CRITICAL DAMPING
RV
FAS
VELØCITY RESPØNSE-CM/SEC
0
20
40
60
80
100
120
140
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIØD-SECØNDS



RELATIVE VELØCITY RESPØNSE SPECTRA
EL SALVADØR EARTHQUAKE, 6/19/82, 06:21:58 UTC, mb-6.2
SEISMØLØGICAL ØBSERVATØRY, SAN SALVADØR, EAST-WEST
0,2,5,10,20 PERCENT CRITICAL DAMPING
RV
FAS
VELØCITY RESPØNSE-CM/SEC
0
50
100
150
200
250
300
350
400
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3
7
11
15
UNDAMPED NATURAL PERIØD-SECØNDS