

Memo

Albuquerque Seismological Laboratory
U.S. Geological Survey

April 14, 1998

To: Dr. Robert Kemerait, CTI
AFTAC/TT

From: Bob Hutt
USGS/ASL

C.R. H

Subject: Horizontal LP noise at GTSN stations, reduction using sand

Bob,

Here is a binder containing plots of 3-C data from the GTSN stations, as well as some GSN stations for comparison. These plots give some indication how much improvement might be expected if the broad band borehole seismometers (54000s) were surrounded with sand, as was done at VNDA.

Component names:

- BHZ: broad band vertical (20 sps)
- BHN: broad band north-south (20 sps)
- BHE: broad band east-west (20 sps)
- BH1: broad band horizontal #1 (not oriented north) (20 sps)
- BH2: broad band horizontal #2 (orthogonal to BH1) (20 sps)

There is a set of three plots for each station:

1st one: ~1.5 hours of 20 sps data low pass filtered at .05 Hz (20 sec), plotted so that all three components have the same scale factor as the largest amplitude component. The vertical scale is in digitizer counts.

2nd one: The same 1.5 hours of 20 sps data, again low pass filtered at .05 Hz, but at a fixed magnification (peak full scale $\sim 2.4E-06$ meters/sec). All of these 2nd plots in each set may be compared directly with each other. If any waveform on these plots differs significantly from essentially a straight line, there may be room for improvement.

3rd one: A combination of power spectra and unfiltered waveform data containing the first 3276.8 seconds of data from the previous two plots. One can measure the difference (in dB) from the horizontal spectra to the vertical spectrum in the long period band (typically periods greater than 20

seconds) to get a rough idea how much improvement in the horizontal noise one could expect by adding sand around the borehole instrument. This is based on the following premises:

- Horizontal noise will never be lower than the vertical noise in this band, at a given site,
- Addition of sand will eliminate the air movement that causes the horizontal noise.

There is one set of plots for each GTSN station (two sets for VNDA), and then a few sets from GSN stations. There are two sets for VNDA, one from before the sand was added, and one after the sand was added. For the GSN stations, I've included some stations that are vault-type installations instead of borehole type, so you may compare noise between the two installation types. (One reason to install in deep boreholes is to reduce horizontal LP noise, so if the horizontals from a borehole are as noisy as a shallow vault type installation, then there is a problem.)

GTSN Stations:

BDFB: Not bad, but there's room for a few dB improvement.

BGCA: Sand should also help this one, but the BHE component appears as pulses, so may not be caused by air movement.

BOSA: Sand should help this one by ~10 to 15 dB at 100 seconds.

CPUP: Time segment is less than one hour in length, but it appears that sand would help the horizontal noise by perhaps 20 dB at 100 sec. Immediately after the new instrument was installed at CPUP (Feb 1998), the horizontals were quiet. Noise has slowly increased since that time. Before the instrument was damaged by lightning, this site had very noisy horizontals (about the same as VNDA before sand was added).

DBIC: Sand should help these horizontals by ~10-15 dB.

LBTB: This is 1 sps data rather than 20. Sand should improve the horizontal noise by ~10 dB.

LPAZ: The horizontal noise here is dominant at longer periods than in most cases, but sand should reduce the noise by 15-20 dB or more.

PLCA: Sand should reduce the horizontal noise by a few dB.

SBA: Although not technically a GTSN station, I've included this site because the instrument sits in a very shallow surface vault on Ross Island, Antarctica. Note that the horizontal long period noise here is quite high, but still lower than was VNDA before sand was added. (Note also that the 2nd plot of the set is plotted at 20,000 counts peak full scale, because instrument sensitivity is 20,000 v/m/s.)

VNDA (day 1998, 096): This first set of VNDA plots is after sand was added to the borehole. The horizontals are a few dB above the vertical at 100 seconds, but this is probably the best that can be done at this particular site with this particular instrument.

VNDA (day 1997, 223): This second set of VNDA plots is before sand was added to the borehole, and demonstrates the extremely high level of the horizontal noise in the LP band. Noise reduction achieved by adding sand (see previous set of plots) was ~30 dB at 100 seconds.

GSN stations: Note that the 2nd plot of each set uses 2400 counts full scale, corresponding to the nominal instrument sensitivity of 2400 v/m/s and resulting in a full scale in terms of ground velocity of $\sim 2.4E-06$ meters/sec.

ANMO (Albuquerque, NM): This instrument is installed in sand at a depth of 500 feet. The long term “drift” seen on the first plot of the set is due to the solid earth tide signal. It can be seen on this instrument (a model 54000I, for IRIS) because we do not use the 1500 second high pass filter normally installed by the manufacturer. (This same “drift” may be seen on some of the other GSN plots as well, for the same reason.) The PSD plot indicates that the BH2 component is very close to the BHZ in the LP band, whereas the BH1 component is a few dB noisier. This is probably indicative of an inherently noisier BH1 seismometer module or feedback electronics channel.

COLA (College, Alaska): A 54000I installed in sand. A look at the PSD indicates that the BH1 noise level is actually slightly lower than that of the BHZ at periods longer than about 40 seconds.

GUMO (Guam): A 54000I installed without sand. This is a case where adding sand probably would not help much (the horizontals are already fairly quiet).

Added: SNZO (New Zealand): "No SAND" and "WITH SAND" plots added here.

SNZO (New Zealand): A 36000I installed in sand. Once again, we see that one of the horizontals is actually quieter than the vertical in a portion of the LP band.

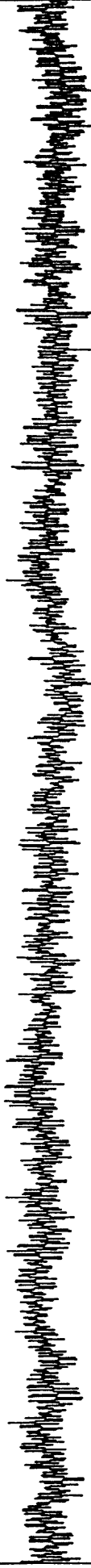
TATO (Taipei, Taiwan): A 36000I installed without sand. Sand would probably help this one by a few dB.

HKT (Hockley, Texas): A set of Streckeisen STS-1 very broad band vault type instruments installed in a salt mine at a depth of ~ 1500 feet. Most of the noise on these horizontals is due to people and heavy equipment moving in the mine, as well as the slow creep of the salt trying to close the cavity that the instruments are in.

ULN (Ulaanbaatar, Mongolia): Another set of Streckeisen STS-1 very broad band vault type instruments, installed in the basement of a building in this case. One could fill the entire vault with sand and not improve this situation much because of the shallow depth below the surface and the presence of the building above the vault. These horizontals are fairly noisy, but not nearly as bad as was VNDA before the sand was added.

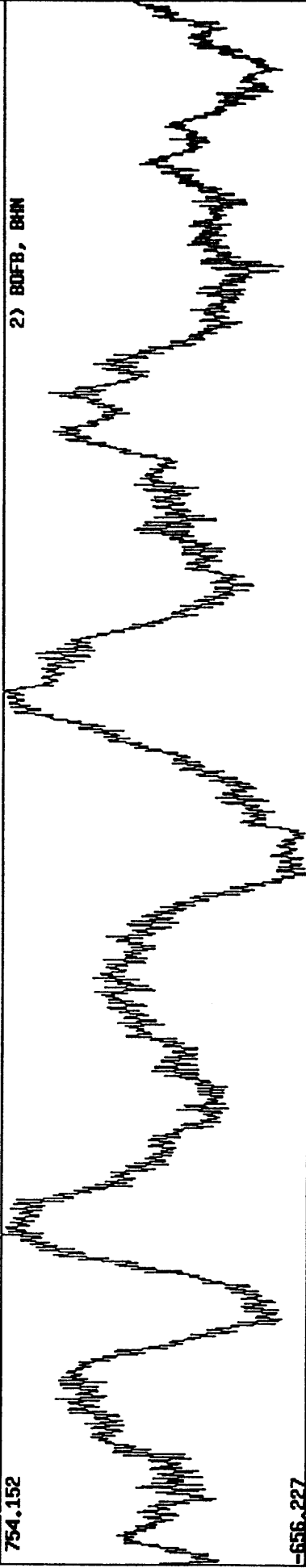
704.68

1) BOFB, BHZ



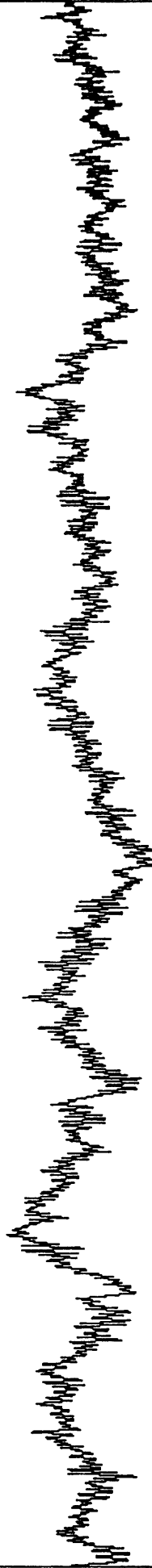
-705.689
754.152

2) BOFB, BHN



-656.227
702.005

3) BOFB, BHE



-708.374

0. start time: 1998,097,03:58:20.293 length: 1.5 hours (demean) (1p co 0.0500 n 4)

5500.

invalid options, try again
filter options (1mlp, 2mhp, 3mbp): 1 .05 4
GFS file: tele.gfs

PLI: A) plot B) sel C) ovr	handcopy	SCL: A) auto B) con C) xhvir
A) next-plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T0G: A) phases B) color C) mean	FLTR: A) 1p B) bp C) dyo	LIM: A) xlim B) ylim
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

30000.

1) BDFB, BHZ

-30000.0
30000.0

2) BDFB, BHN

-30000.0
30000.0

3) BDFB, BHE

-30000.0

0. start time: 1998,097,03:58:20.293 length: 1.5 hours (demean) (lp co 0.0500 n 4) 5500.

GFS file: tele.gfs
min and max (<ret> for auto-scale) : -30000 30000
GFS file: tele.gfs

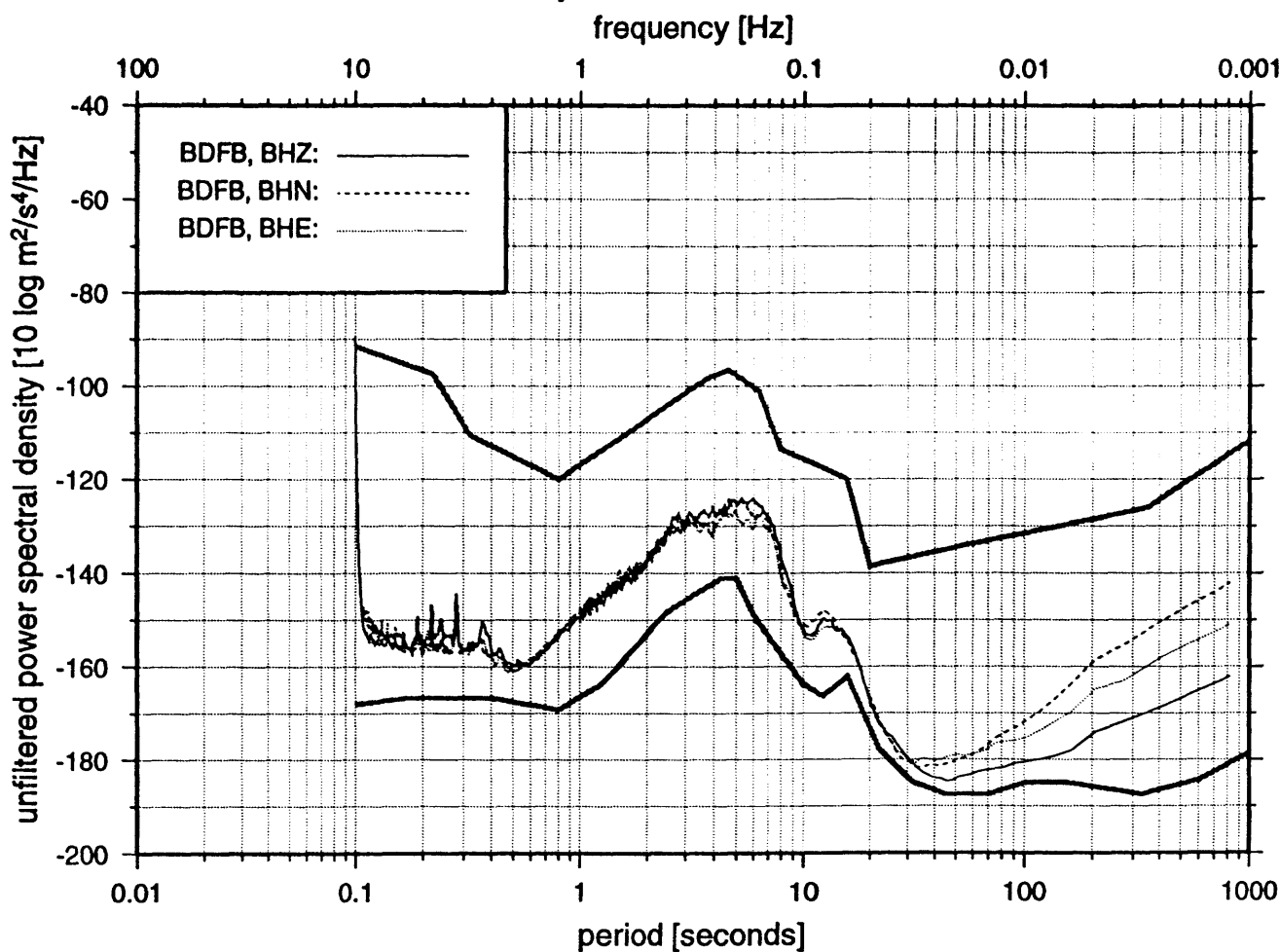
PLT: A) plot B) sel C) ovr
A) next+plot B) next C) back
TOG: A) phases B) color C) mean

DMP: A) SAC B) GFS C) ASCII
quit
PHS: A) + B) - C) EQ ID

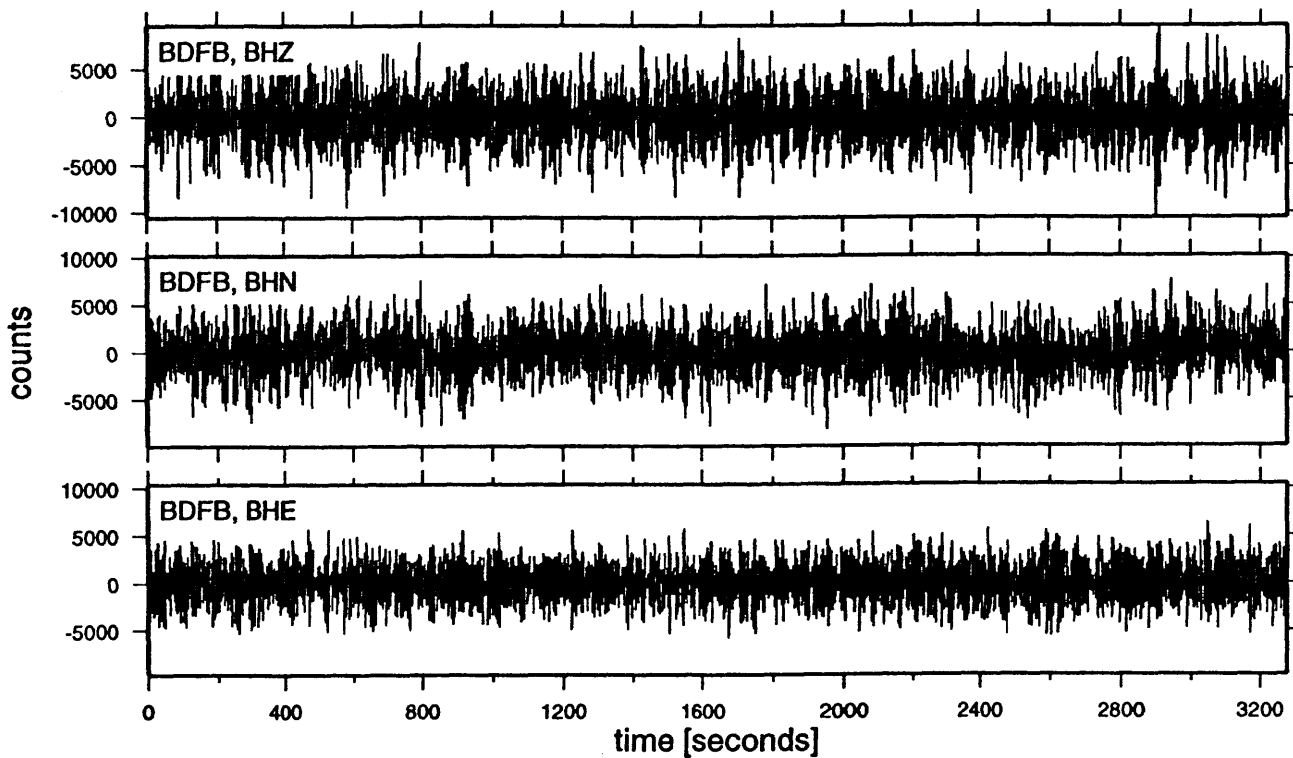
hardcopy
A) offset B) ttpick C) delpick
FLTR: A) lp B) bp C) dyo

SCI: A) auto B) com C) xhair
A) PPH B) PSD C) RESP
LIM: A) xlin B) ylin

Seismic Spectra and Waveform Plot



Start time 1998,097,03:58:20.293



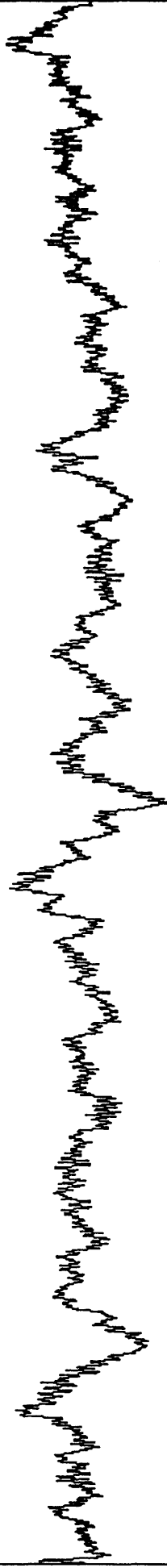
956.89

1) BGCR, BHZ



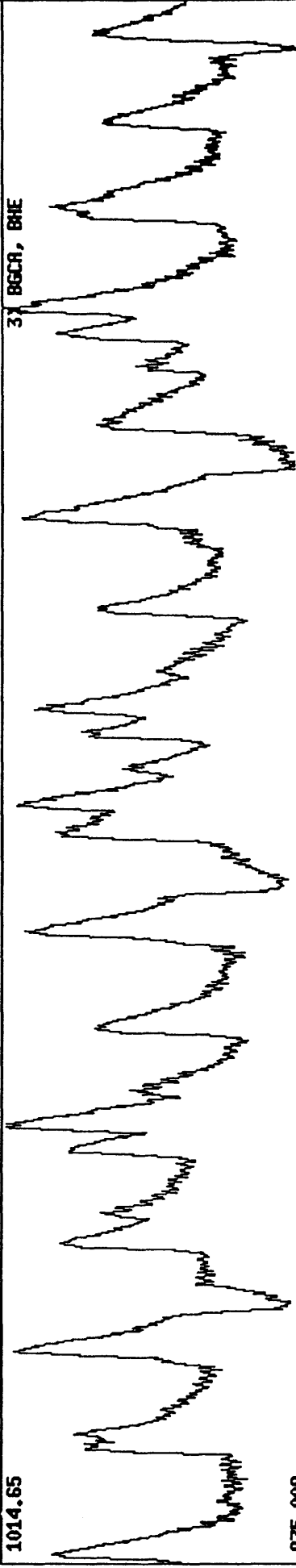
-932.771
907.527

2) BGCR, BHM



-982.136
1014.65

3) BGCR, BHE



-875.009
0.

start time: 1998,097,05:24: 0.207 length: 1.5 hours (densean) (lp co 0.0500 n 4)

5324.

station: BGCR channels: BHE BHM BHZ
filter options (1=lp, 2=hp, 3=bp): 1 .05 4
GFS file: tele.gfs

PLT: A) pLot B) se1 C) ovr	DMP: A) SAC B) GFS C) ASCII	hardcopy	SCL: A) auto B) com C) xhvalr
A) next-plot B) next C) back	quit	A) offset B) ttpick C) delpick	A) PPH B) PSD C) RESP
T06: A) phases B) color C) mean	PHS: A) + B) - C) EQ ID	FLTR: A) lp B) bp C) dno	LIM: A) xlin B) ylin

1) BGCA, BHZ

30000.

2) BGCA, BHN

-30000.0
30000.0

3) BGCA, BHE

-30000.0
30000.0

-30000.0
0.

start time: 1998.097,05:24: 0.207 length: 1.5 hours (demean) (lp co 0.0500 n 4)

5324.

GFS file: tele.gfs
min and max (<ret> for auto-scale) : -30000 30000
GFS file: tele.gfs

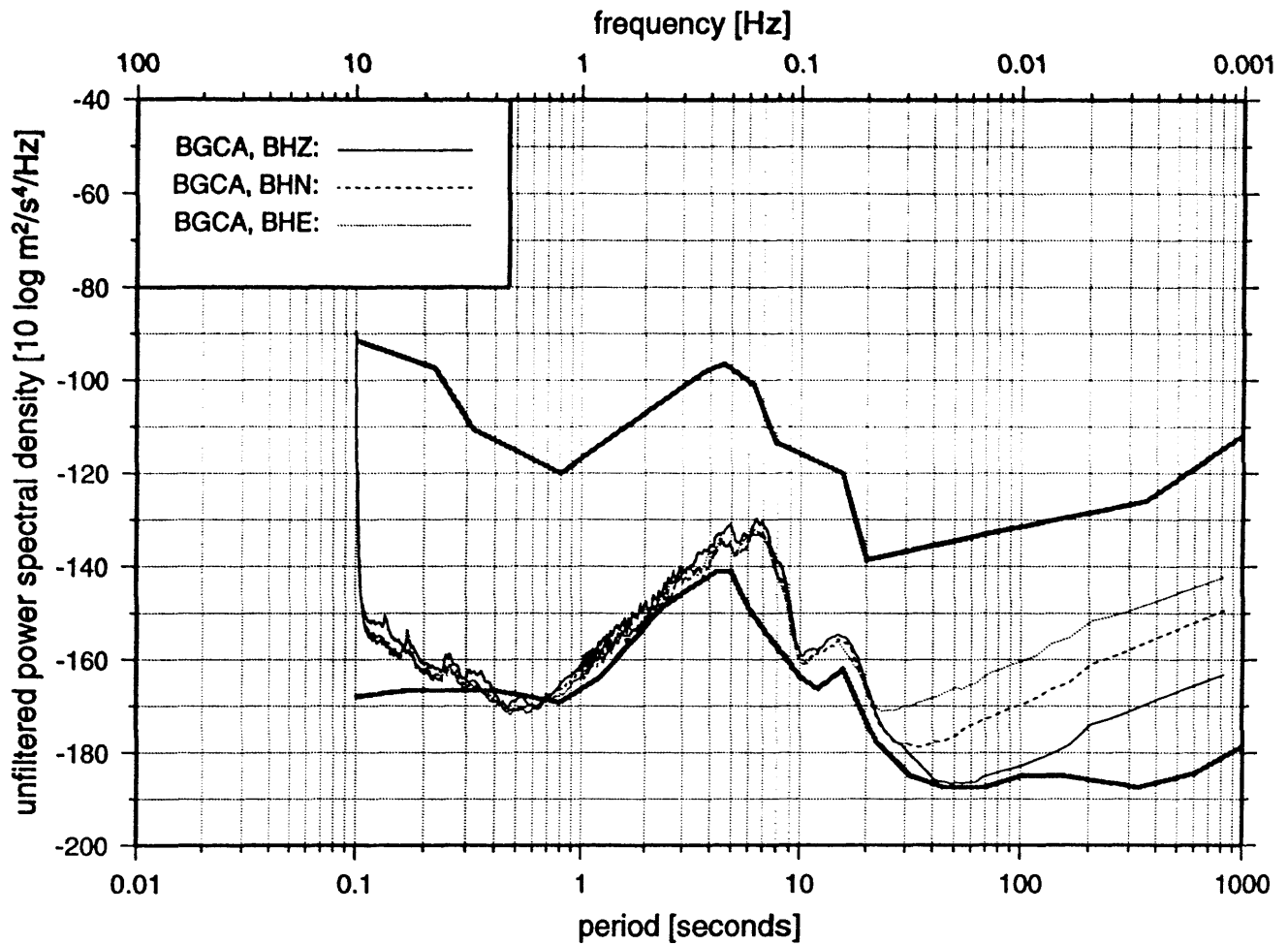
PLI: A) plot B) sel C) ovr
A) next+plot B) next C) back
TOG: A) phases B) color C) mean

DMP: A) SAC B) GFS C) ASCII
quit
PHS: A) + B) - C) EQ ID

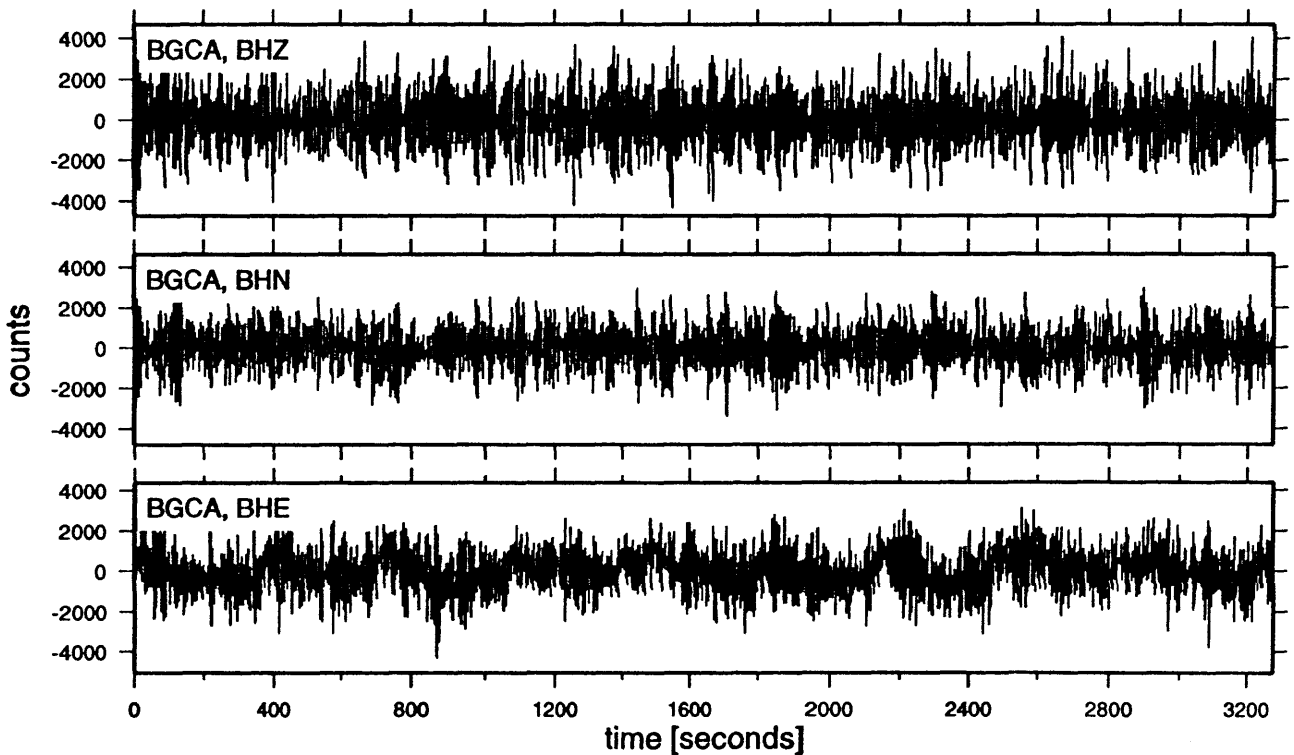
hardcopy
A) offset B) ttpick C) delpick
FLTR: A) lp B) bp C) dyo

SCL: A) auto B) com C) xhair
A) PPH B) PSD C) RESP
LIM: A) xlin B) ylin

Seismic Spectra and Waveform Plot



Start time 1998,097,05:24:00.207



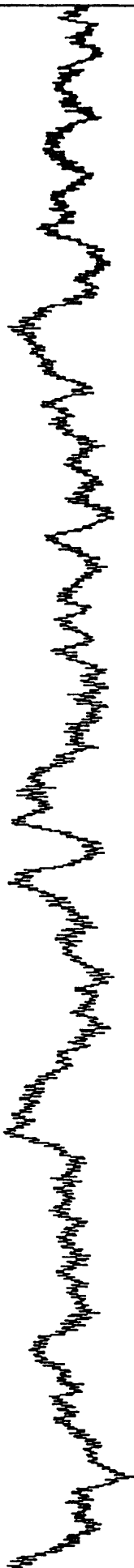
1852.2

1) BOSR, BHZ



-1392.51
1584.55

2) BOSR, BHN



-1660.24
1923.60

3) BOSR, BHE



-1321.19

0. start time: 1998,097,04:04:40.115 length: 1.5 hours (demean) (lp co 0.0500 n 4)

5494.

station: BOSR channels: BHE BHN BHZ
filter options (1=lp, 2=hp, 3=bp): 1 .05 4
GFS file: tele.gfs

PLI: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) whair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T06: A) phases B) color C) mean	PHS: A) + B) - C) EQ ID	LIN: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII	quit	
FLTR: A) lp B) bp C) dgo		

30000.0

1) BOSR, BHZ

-30000.0

30000.0

2) BOSR, BHN

-30000.0

30000.0

3) BOSR, BNE

-30000.0

0.

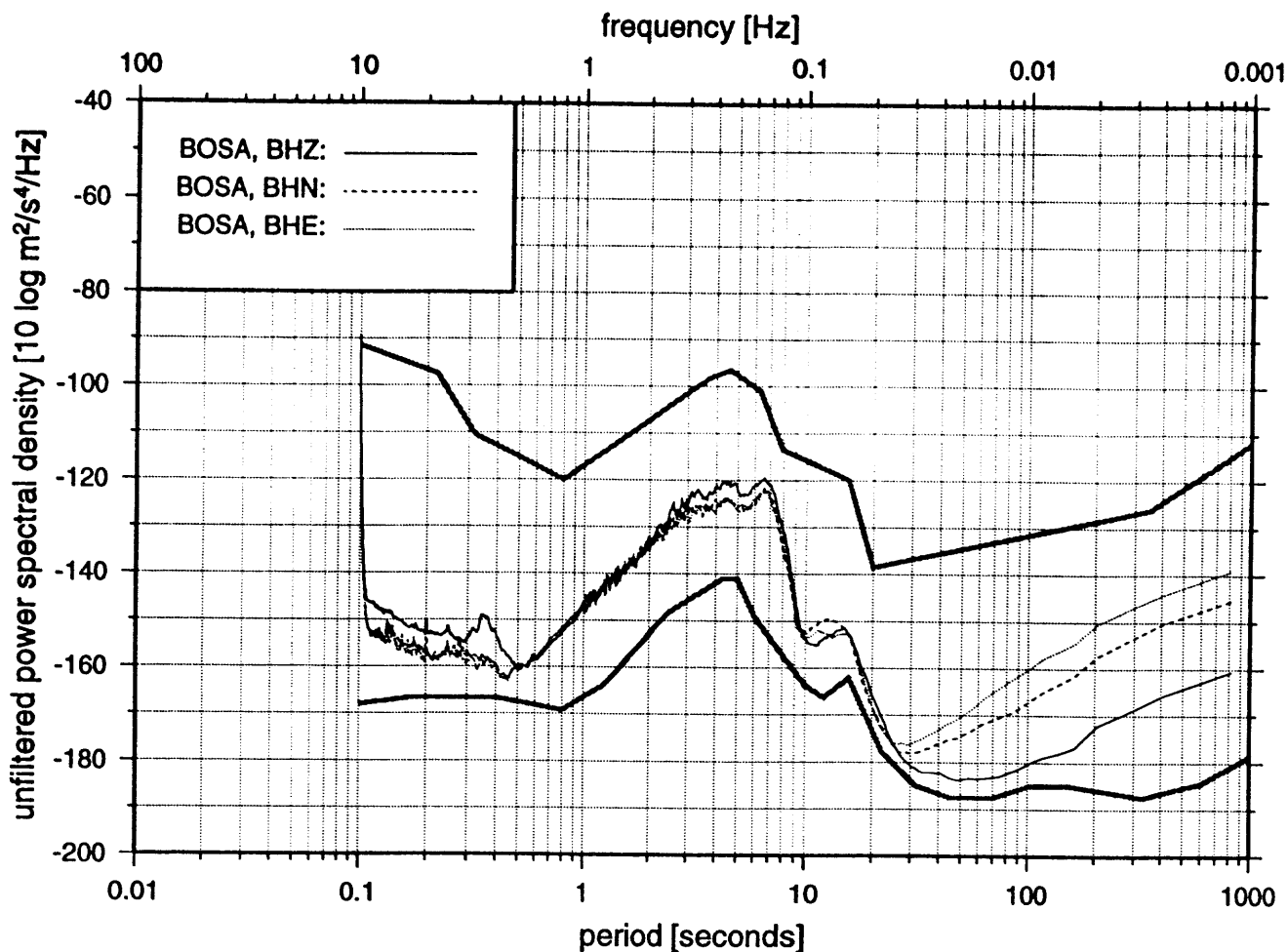
start time: 1998,097,04:04:40.115 length: 1.5 hours (demean) (lp co 0.0500 n 4)

5484.

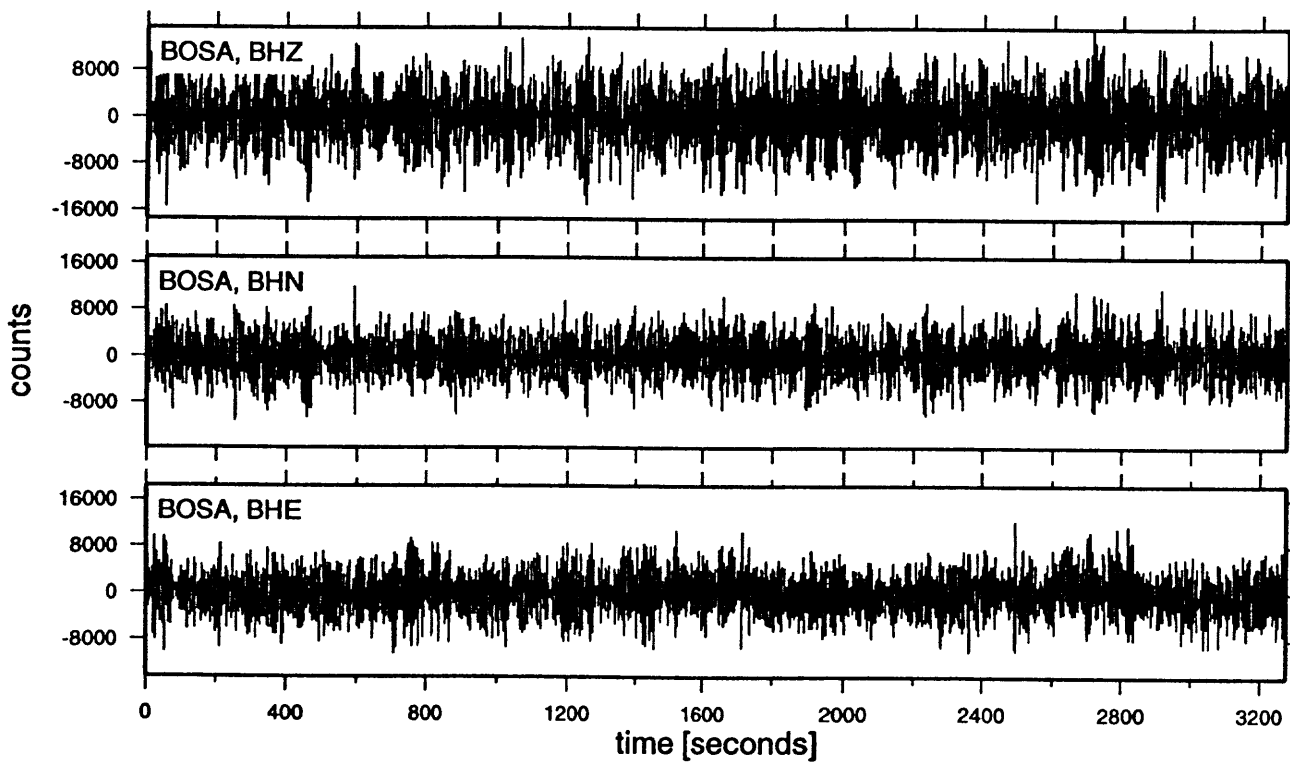
GFS file: tele.gfs
min and max (<ret> for auto-scale) : -30000 30000
GFS file: tele.gfs

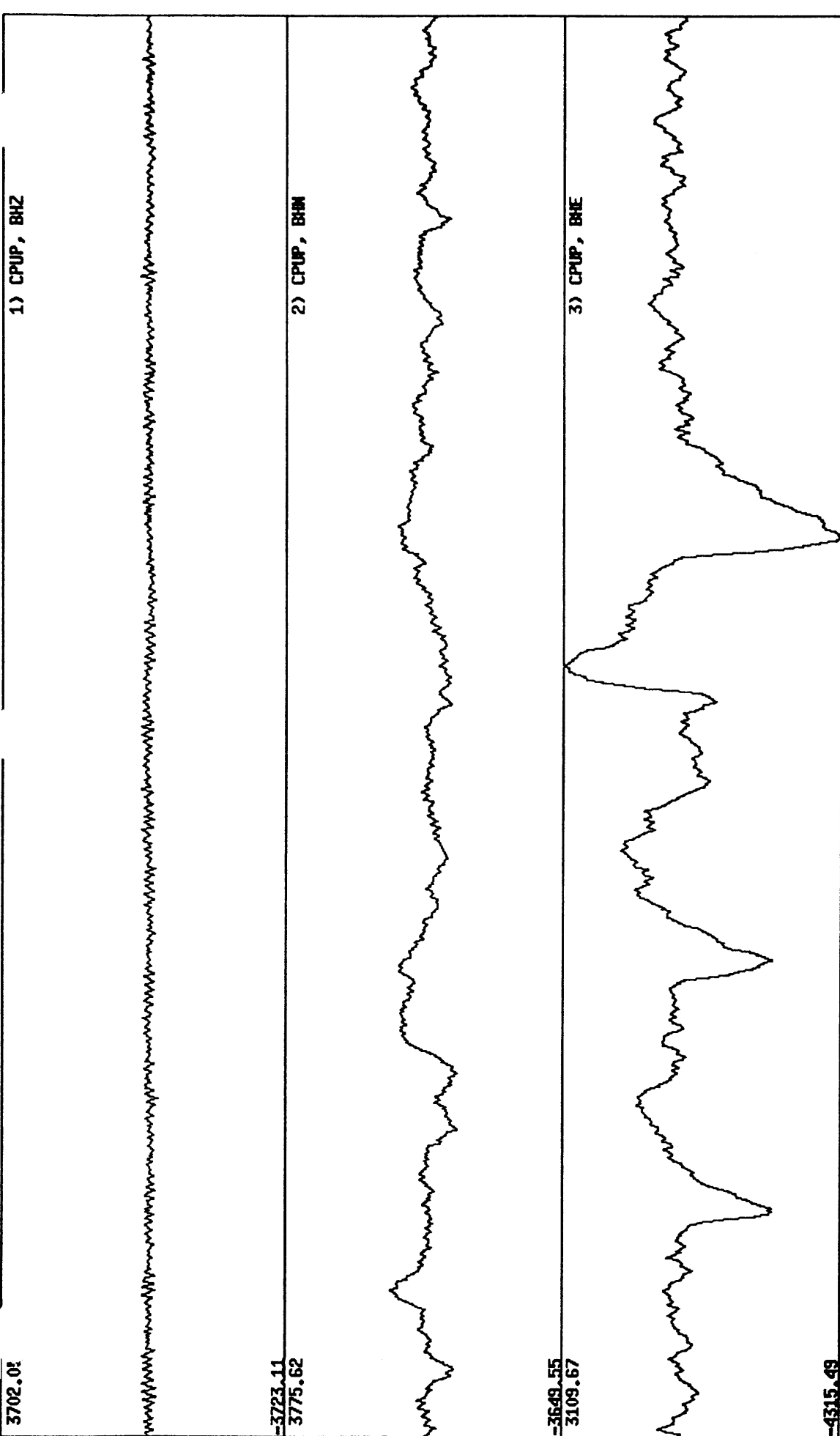
PLI: A) plot B) sel C) ovr	DMP: A) SAC B) GFS C) ASCII	hardcopy	SCL: A) auto B) com C) xhair
A) next-plot B) next C) back	quit	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
TUG: A) phases B) color C) mean	PHS: A) + B) - C) EQ ID	FLTR: A) lp B) bp C) dyo	LIM: A) xlin B) ylin

Seismic Spectra and Waveform Plot



Start time 1998,097,04:04:40.115





3115.

start time: 1998,090,04:09:41.453 length: 3115.000 seconds (lp co 0.0500 n 4)

filter options (1=lp, 2=hp, 3=bp): 1 .05 4
 GFS file: hutt_cpup.gfs

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) whalr
A) next-plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T06: A) phases B) color C) mean	FLTR: A) lp B) bp C) dyo	LIN: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

30000.0

1) CPUP, BHZ

-30000.0
30000.0

2) CPUP, BHN

-30000.0
30000.0

3) CPUP, BHE

-30000.0

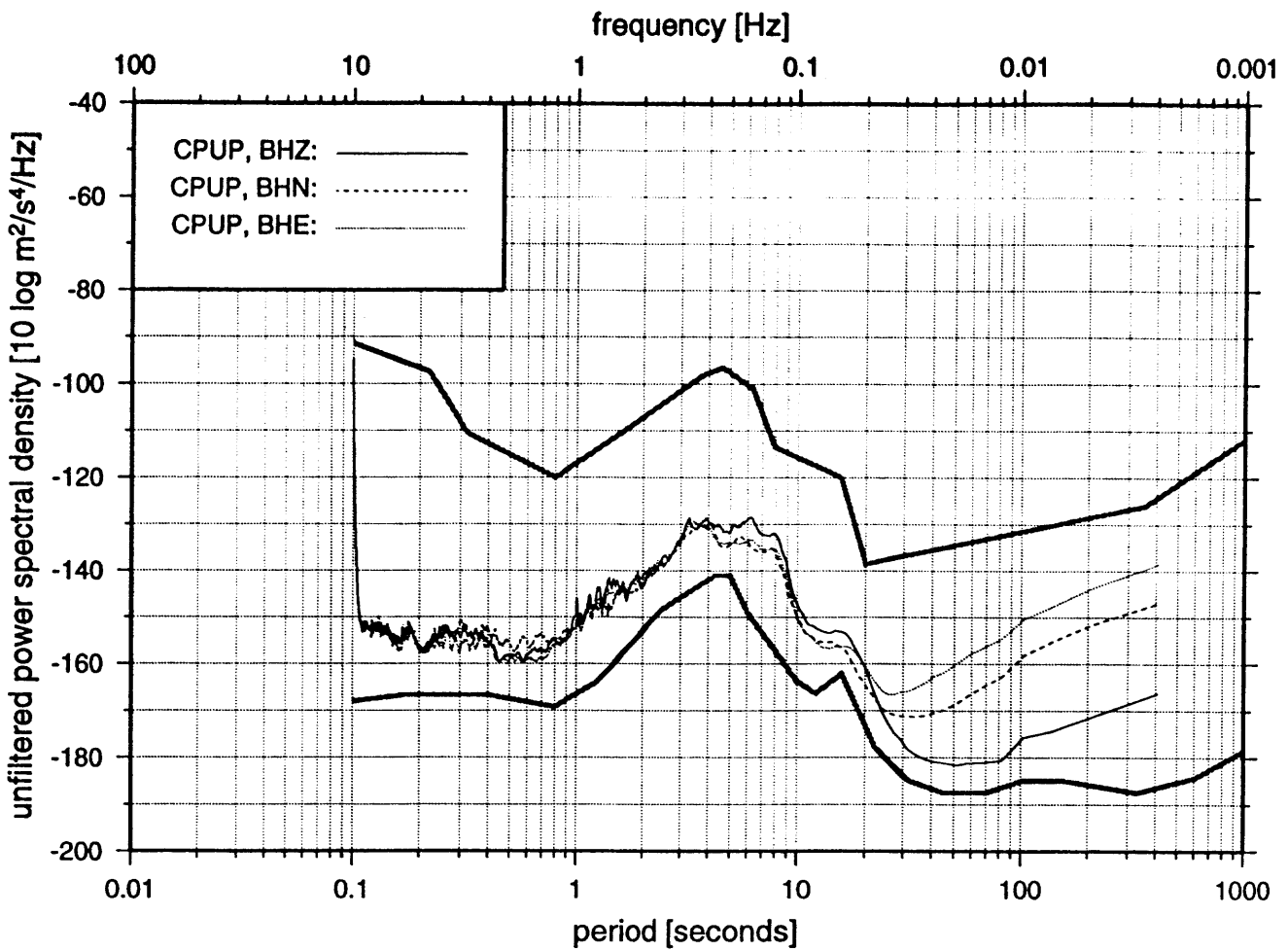
3115.

start time: 1998,090,04:09:41.453 length: 3115.000 seconds (lp co 0.0500 n 4)

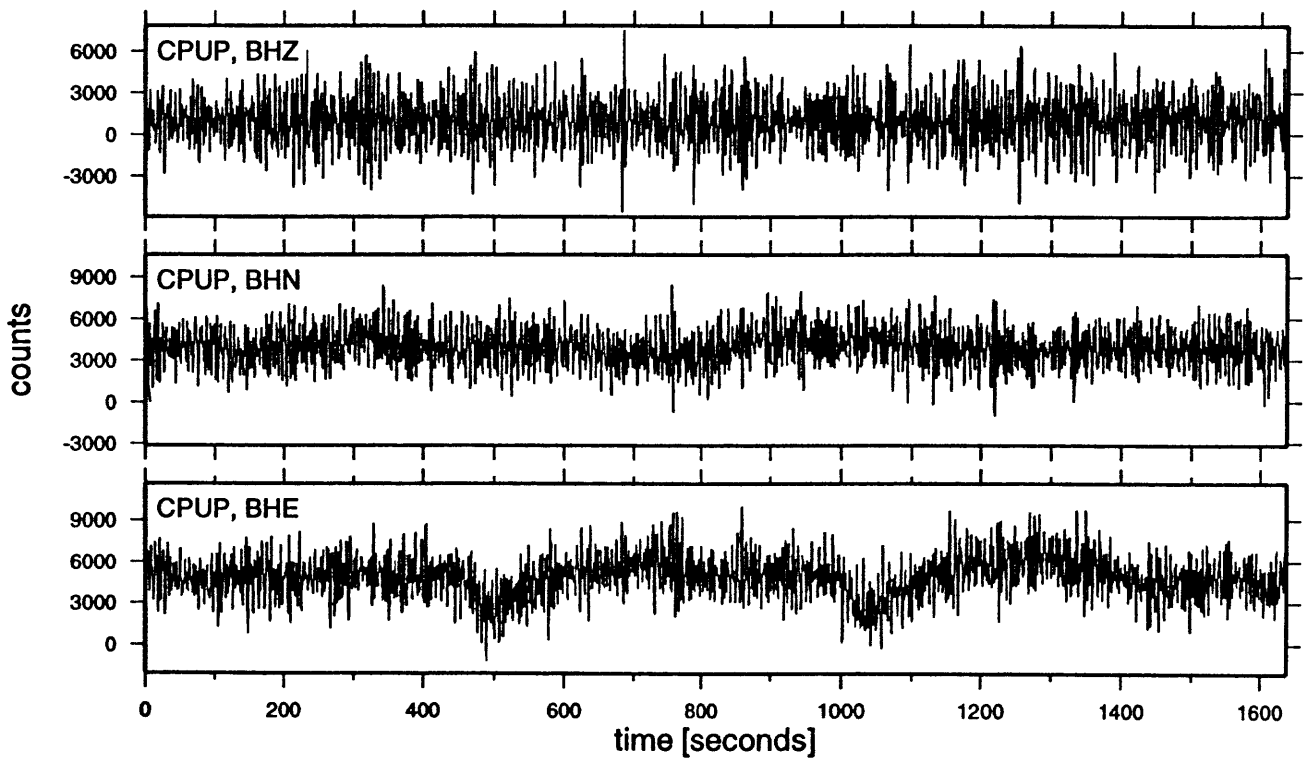
GFS file: hutt_cpup.gfs
min and max (<ret> for auto-scale) : -30000 30000
GFS file: hutt_cpup.gfs

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) whair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPH B) PSD C) RESP
T06: A) phases B) color C) mean	FLTR: A) lp B) bp C) dyo	LIM: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

Seismic Spectra and Waveform Plot

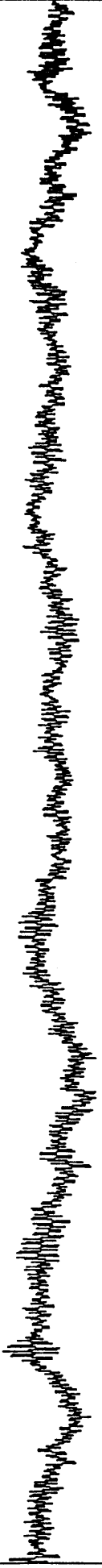


Start time 1998,090,04:09:41.453



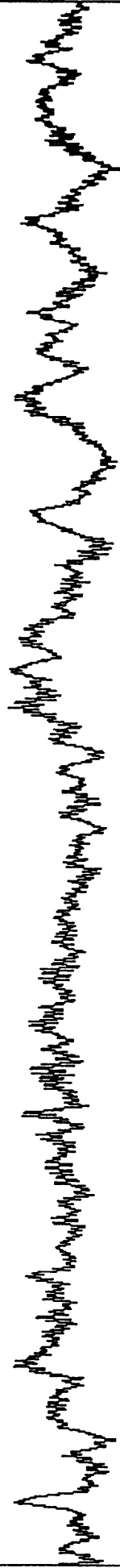
1074.58

1) DBIC, BHZ



-1083.10
1084.11

2) DBIC, BHN



-1073.58
1064.05

3) DBIC, BHE



-1093.63

5550.

0. start time: 1998,097,03:41: 8.413 length: 1.5 hours (donean) (lp co 0.0500 n 4)

station: DBIC channels: BHE BHN BHZ
filter options (1=lp, 2=hp, 3=bp): 1 .05 4
GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) xhair
A) next-plot B) next C) back	A) offset B) ttpick C) delpick	A) PPH B) PSD C) RESP
T06: A) phases B) color C) mean	FLTR: A) lp B) bp C) dno	LIN: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

30000.0

1) DBIC, BHZ

-30000.0
30000.0

2) DBIC, BHM

-30000.0
30000.0

3) DBIC, BHE

-30000.0
0.

start time: 1998,097,03:41: 8.413 length: 1.5 hours (demean) (lp co 0.0500 n 4)

5550.

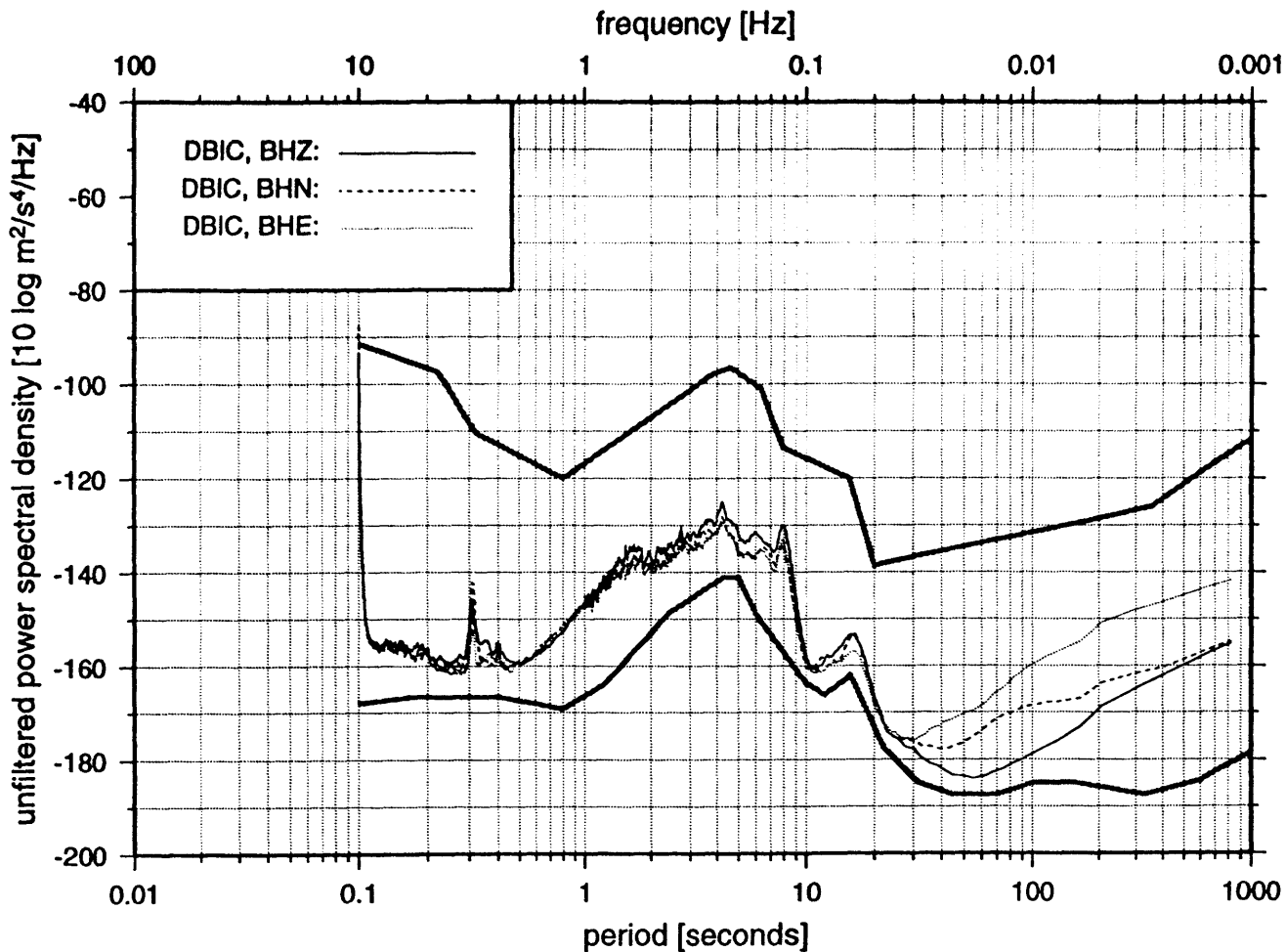
GFS file: tele.gfs

min and max (<ret> for auto-scale) : -30000 30000

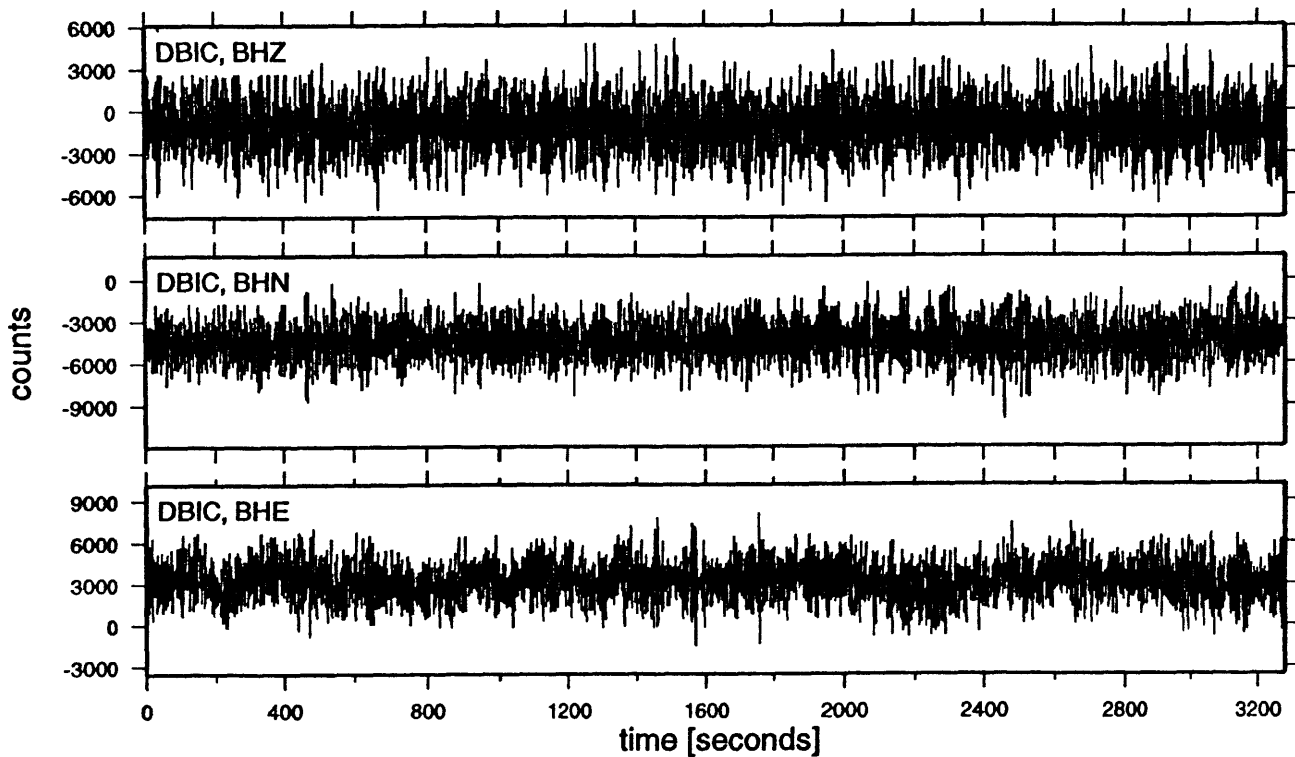
GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	DMP: A) SAC B) GFS C) ASCII	hardcopy	SCL: A) auto B) com C) xhair
A) next+plot B) next C) back	quit	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T06: A) phases B) color C) mean	PHS: A) + B) - C) EQ ID	FLTR: A) lp B) bp C) dyo	LIN: A) xlin B) ylin

Seismic Spectra and Waveform Plot



Start time 1998,097,03:41:07.090



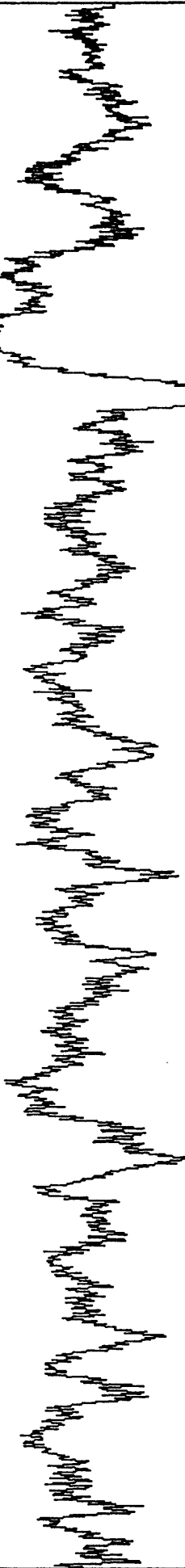
898.112

1) LBTB, LHZ



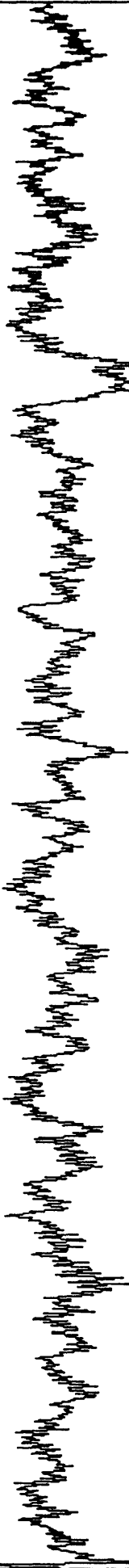
-1898.13
1091.91

2) LBTB, LHM



-1704.34
1471.06

3) LBTB, LHE



-1325.19
0.

5291.

start time: 1998,099,01:05:25.874 length: 1.5 hours (lp co 0.0500 n 4)

station: LBTB channels: LHE LHM LHZ
filter options (1=lp, 2=hp, 3=bp): 1 .05 4
GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) xhslr
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
TOG: A) phases B) color C) mean	FLTR: A) lp B) bp C) dno	LIM: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

30000.0

1) LBTB, LHZ

-30000.0
30000.0

2) LBTB, LHN

-30000.0
30000.0

3) LBTB, LHE

-30000.0

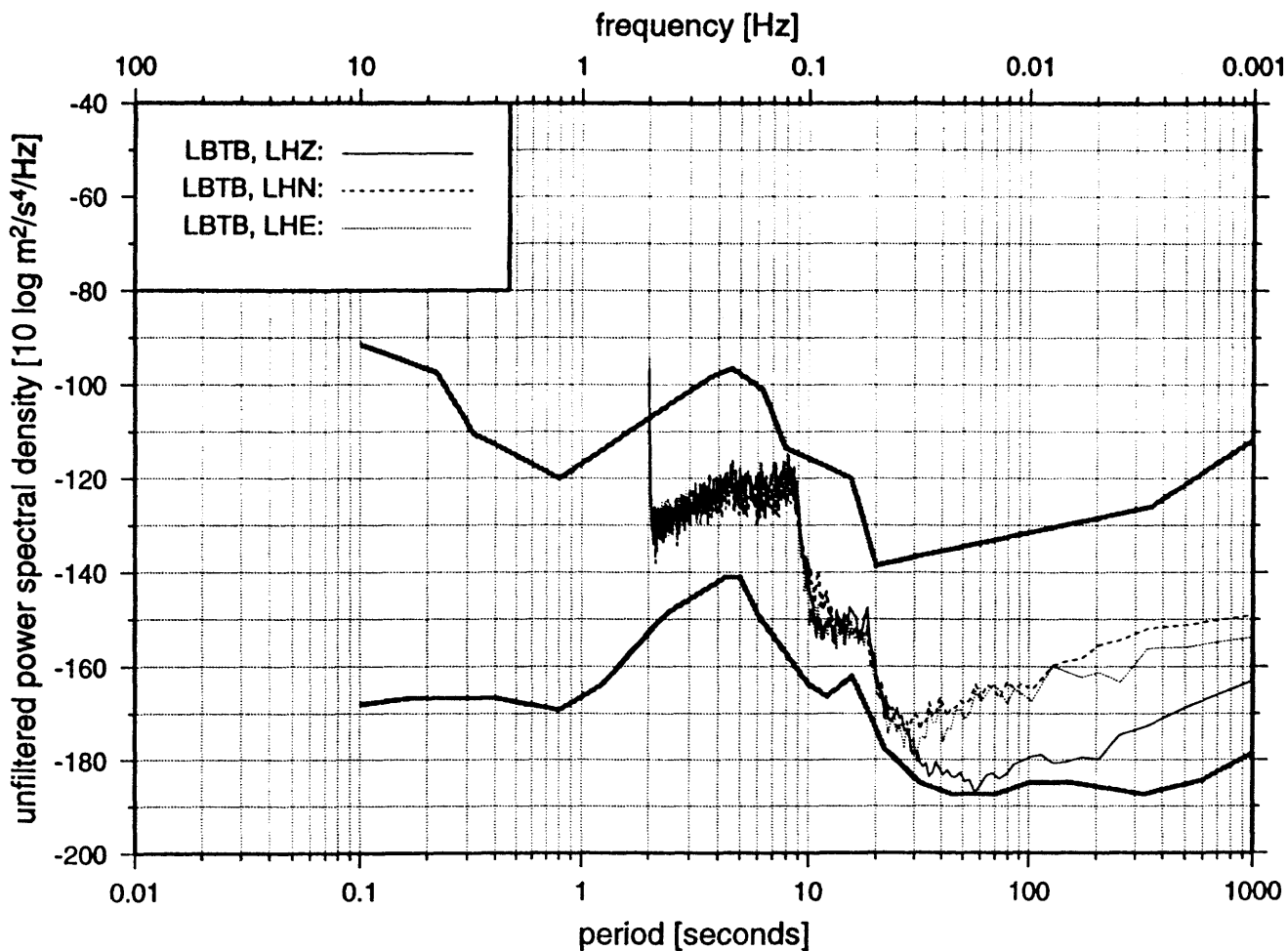
0. start time: 1998,099,01:05:25.874 length: 1.5 hours (lp co 0.0500 n 4)

5291.

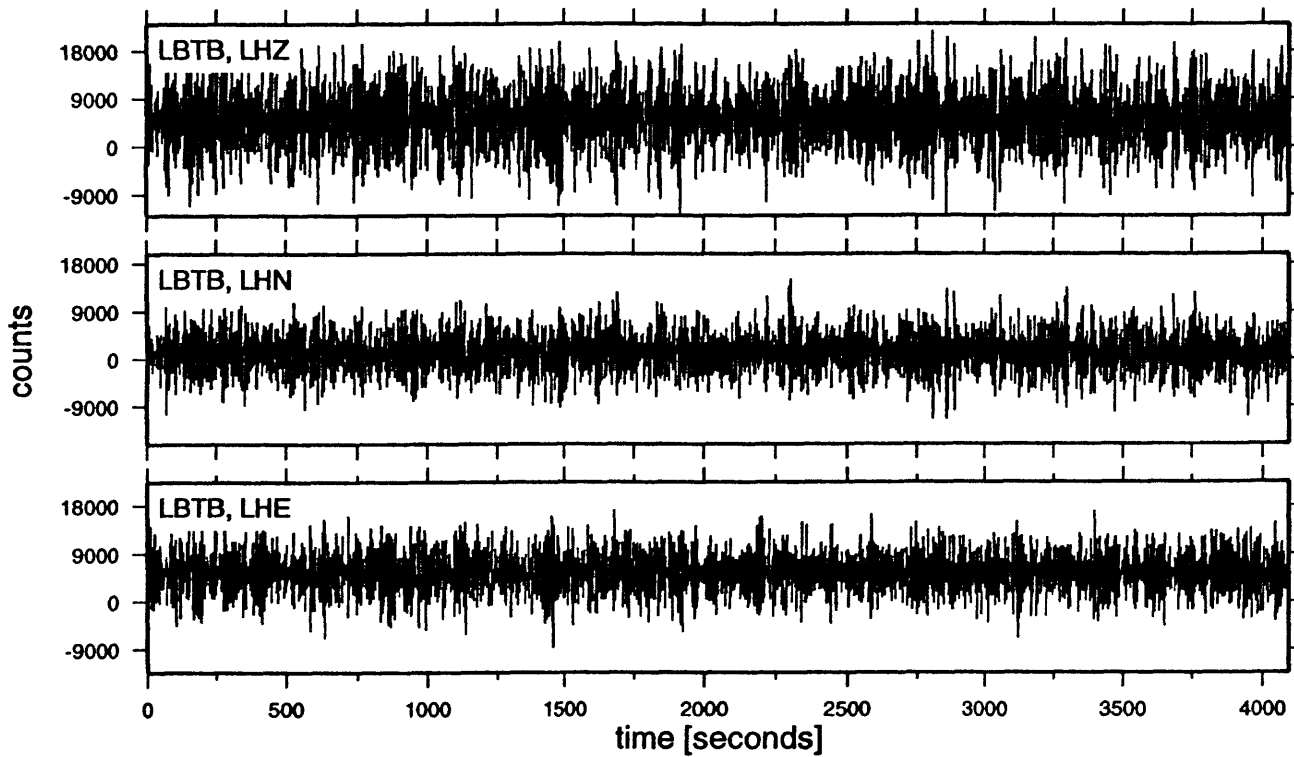
GFS file: tele.gfs
min and max (<ret> for auto-scale) : -30000 30000
GFS file: tele.gfs

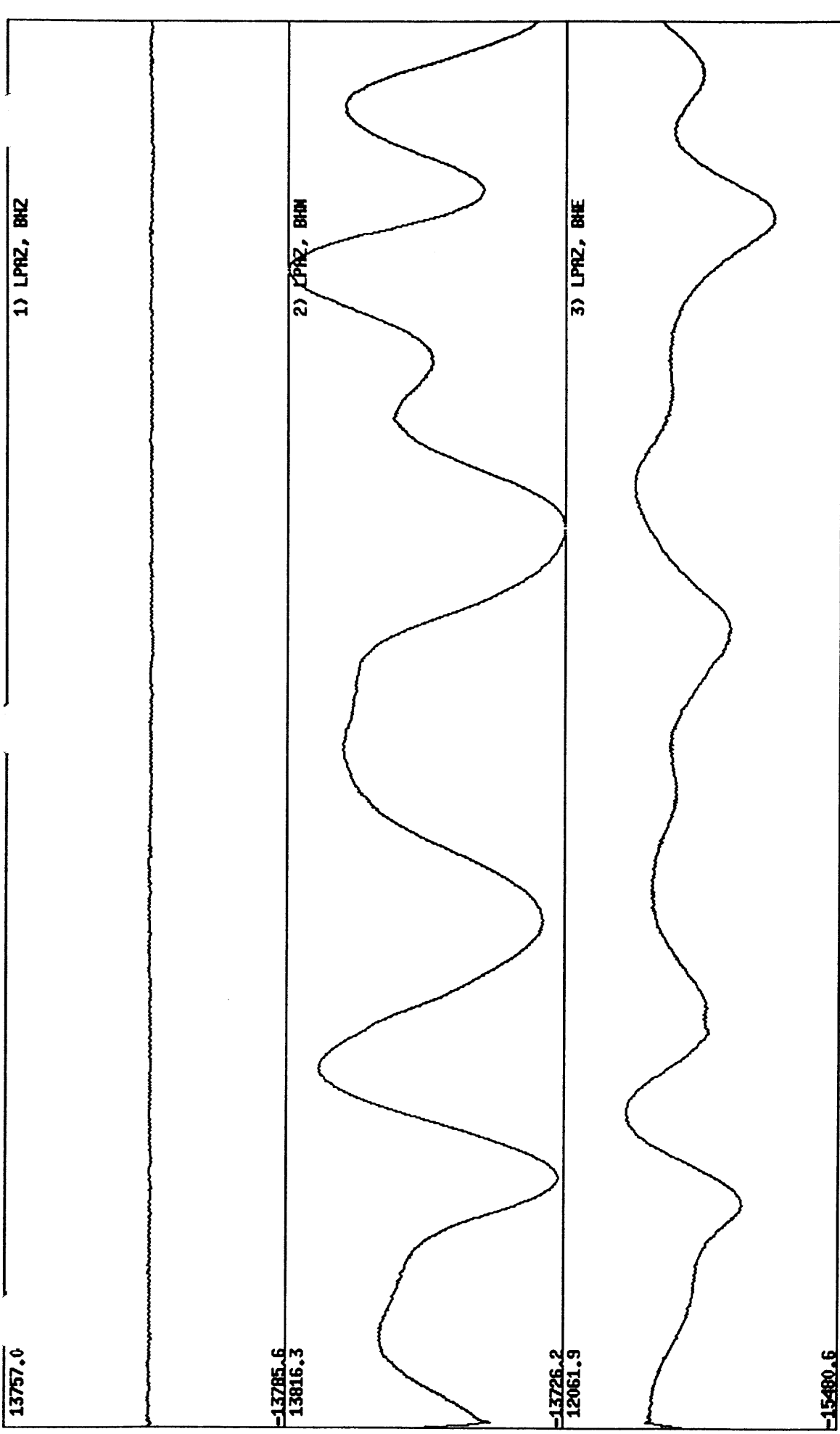
PLI: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) xhair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
TOG: A) phases B) color C) mean	FLTR: A) lp B) bp C) dgo	LIN: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

Selsmic Spectra and Waveform Plot



Start time 1998,099,01:05:25.874





5562.

start time: 1998,097,06:12:12.967 length: 1.5 hours (demean) (lp co 0.0500 n 4)

station: LPRZ channels: BHE BHN BHZ
 filter options (1=lp, 2=hp, 3=bp): 1 .05 4
 GFS file: tele.gfs

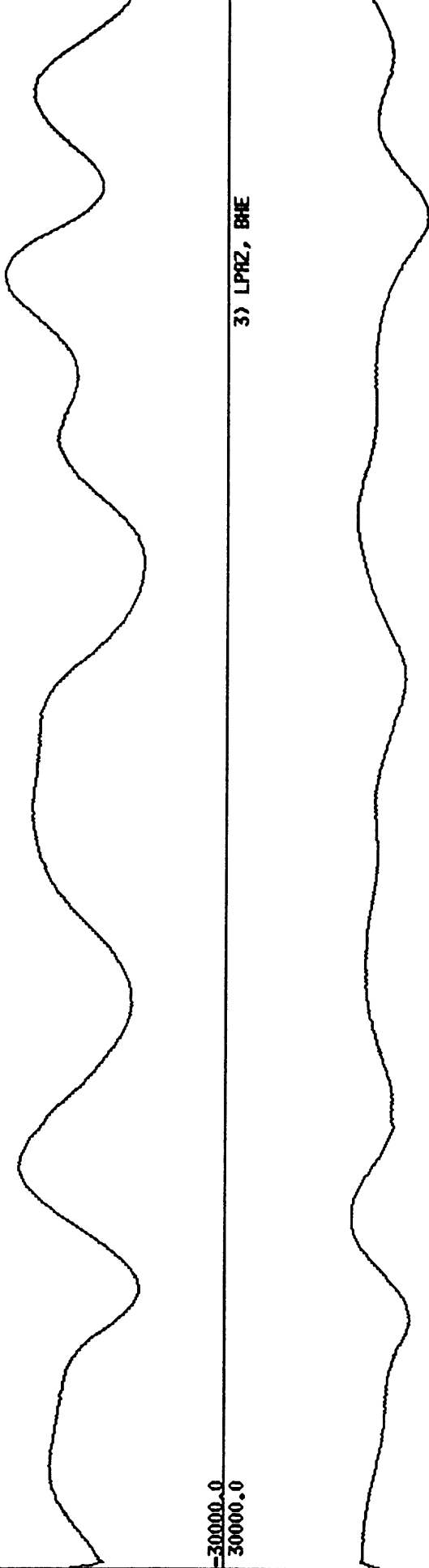
PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) con C) xhair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPN B) PSD C) RESP
TOG: A) phases B) color C) mean	FLTR: A) lp B) bp C) dyo	LIM: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

30000.0

1) LPAZ, BHZ

-30000.0
30000.0

2) LPAZ, BHN



-30000.0
30000.0

3) LPAZ, BHE

-30000.0
0.

start time: 1998,097,06:12:12.967 length: 1.5 hours (densean) (lp co 0.0500 n 4)

5562.

GFS file: tele.gfs
min and max (<ret> for auto-scale) : -30000 30000
GFS file: tele.gfs

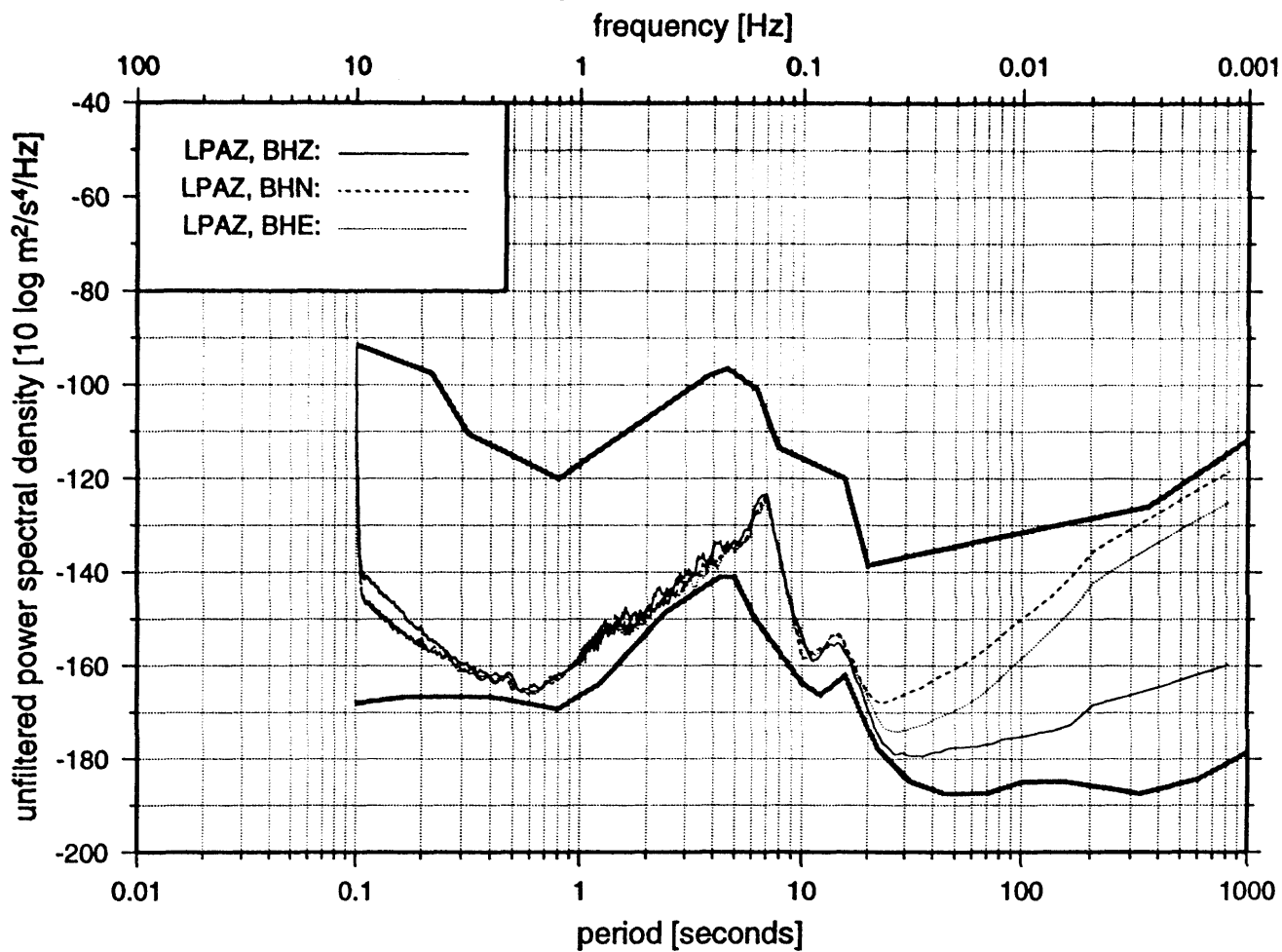
PLT: A) plot B) sel C) ovr
 A) next-plot B) next C) back
 T06: A) phases B) color C) mean

DMP: A) SAC B) GFS C) ASCII
 quit
 PHS: A) + B) - C) EQ ID

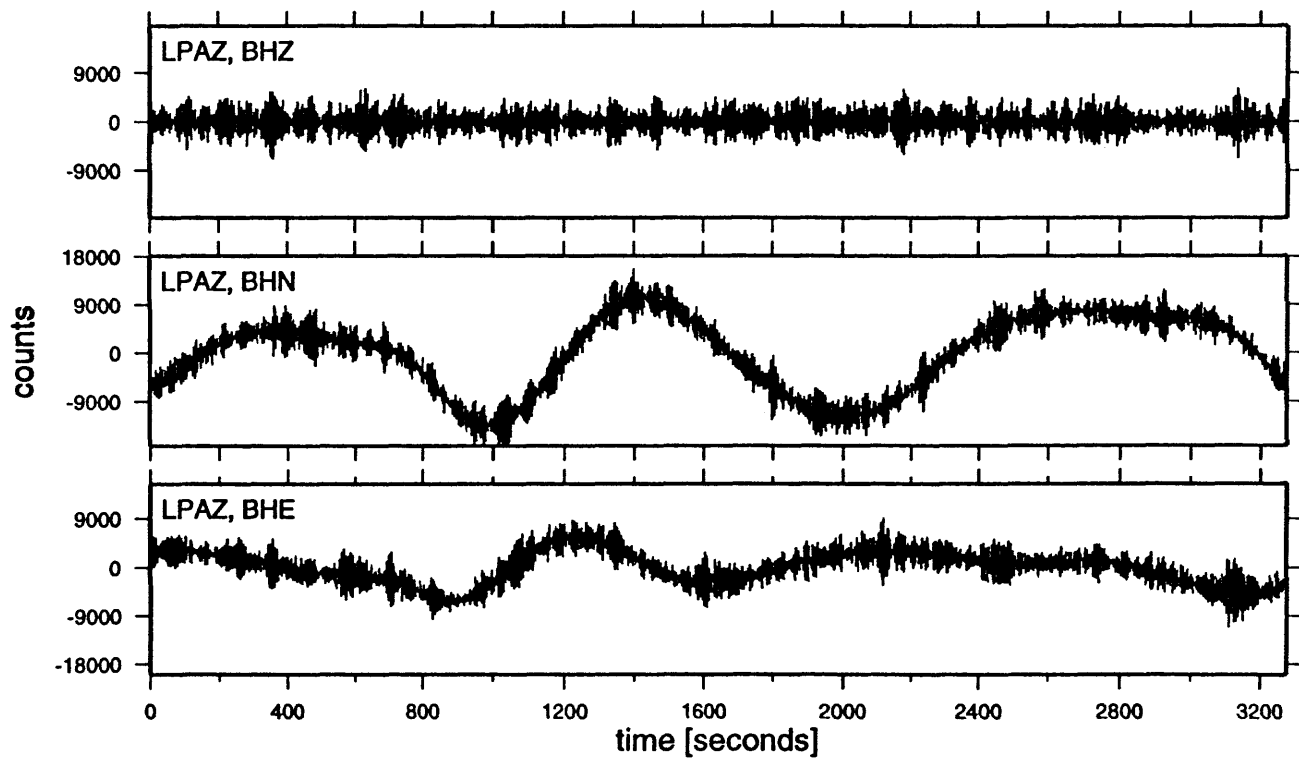
hardcopy
 A) offset B) ttpick C) delpick
 FLTR: A) lp B) bp C) dlyo

SCL: A) auto B) com C) xhair
 A) PPH B) PSD C) RESP
 LIM: A) xlin B) ylin

Seismic Spectra and Waveform Plot



Start time 1998,097,06:12:12.967



1166.87

1) PLCA, BHZ



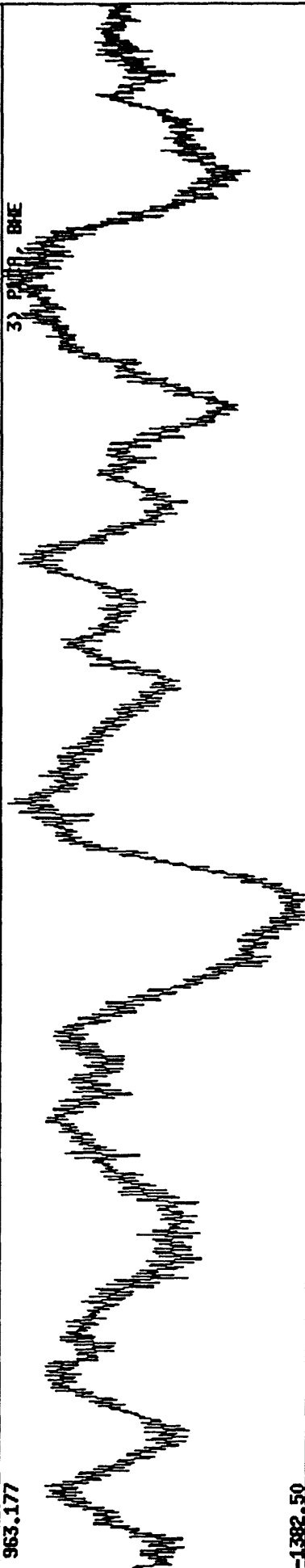
-1178.80
-1110.22

2) PLCA, BHN



-1235.46
-963.177

3) PLCA, BHE



-1382.50

0. start time: 1998,096,17:11:42.281 length: 1.5 hours (demean) (lp co 0.0500 n 4)

5261.

station: PLCA channels: BHE BHN BHZ
filter options (1=lp, 2=hp, 3=bp): 1 .05 4
GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) xhair
A) next-plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T0G: A) phases B) color C) mean	FLIR: A) lp B) bp C) dgo	LIN: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

30000.0

1) PLCA, BHZ

-30000.0
30000.0

2) PLCA, BHN

-30000.0
30000.0

3) PLCA, BHE

-30000.0
0.

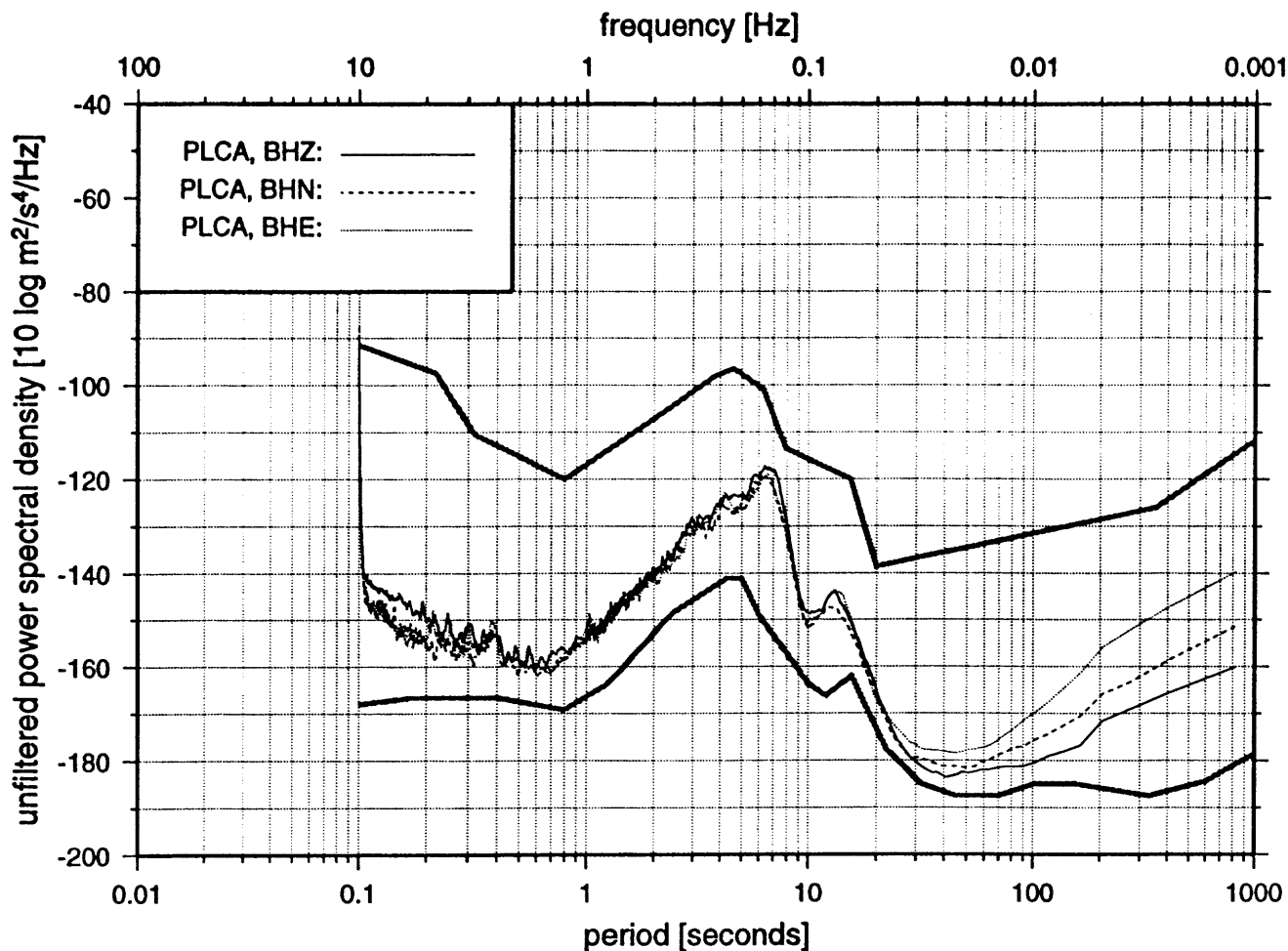
start time: 1998,096,17:11:42.281 length: 1.5 hours (demean) (lp co 0.0500 n 4)

5261.

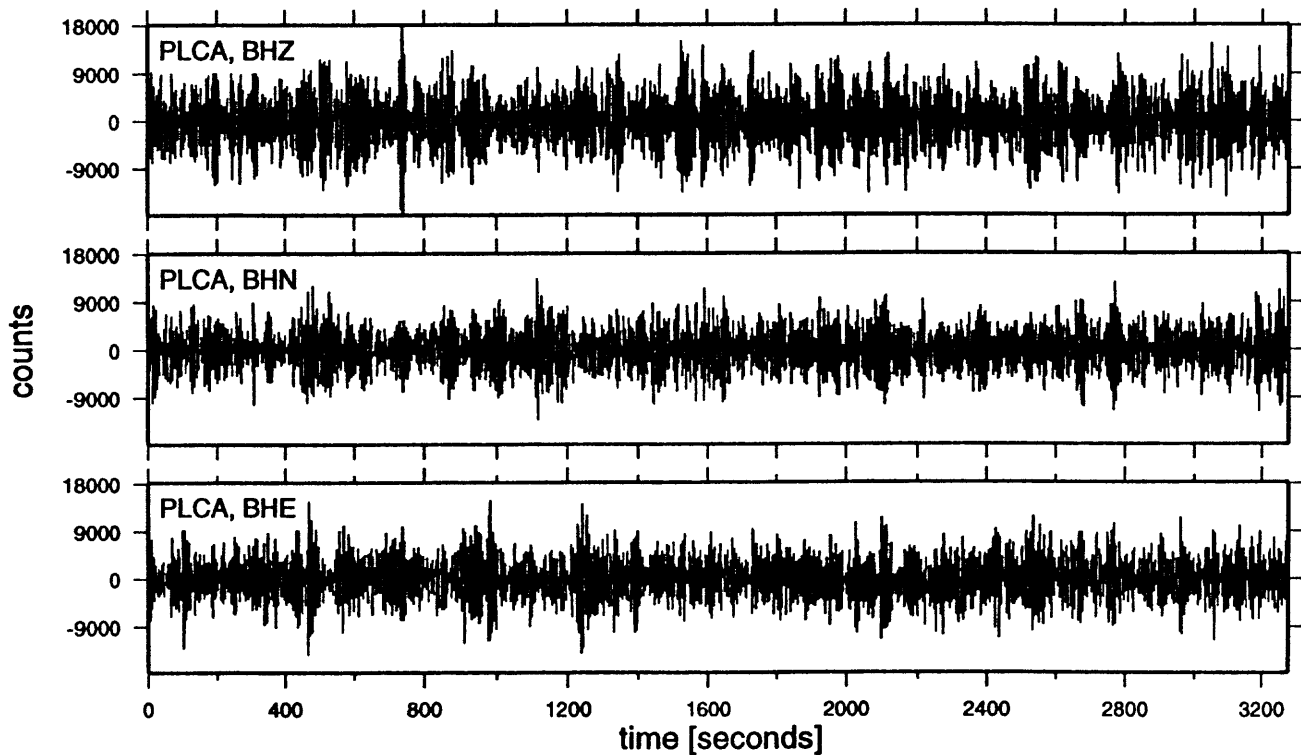
GFS file: tele.gfs
min and max (ret) for auto-scale) : -30000 30000
GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) whair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T0G: A) phases B) color C) mean	FLTR: A) lp B) bp C) dyo	LIN: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

Seismic Spectra and Waveform Plot



Start time 1998,096,17:11:42.281



4423.42

1) SBR, BHZ



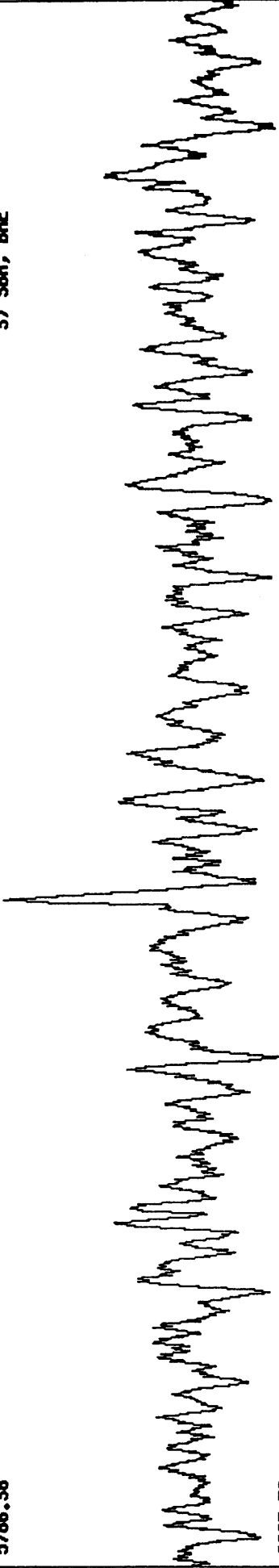
-4328.71
4243.25

2) SBR, BHN



-4508.89
5786.38

3) SBR, BHE



-2965.76

start time: 1998,096,23:21:45.177 length: 1.5 hours (demean) (lp co 0.0500 n 4)

5289.

station: SBR channels: BHE BHN BHZ
filter options (l=lp, 2=hp, 3=bp): 1 .05 4
GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) xhair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T0G: A) phases B) color C) mean	FLTR: A) lp B) bp C) dgo	LIN: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

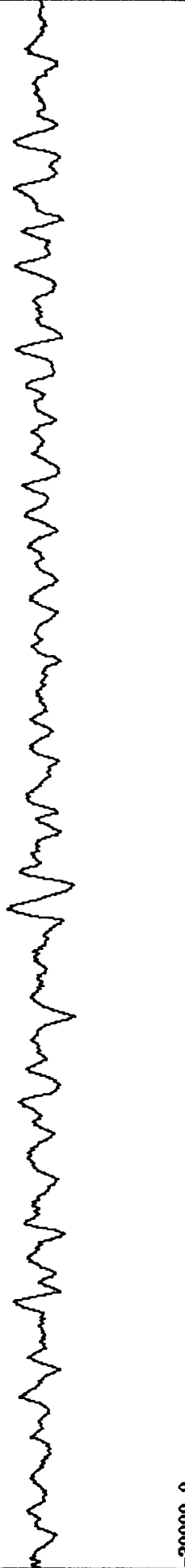
20000.0

1) SBR, BHZ



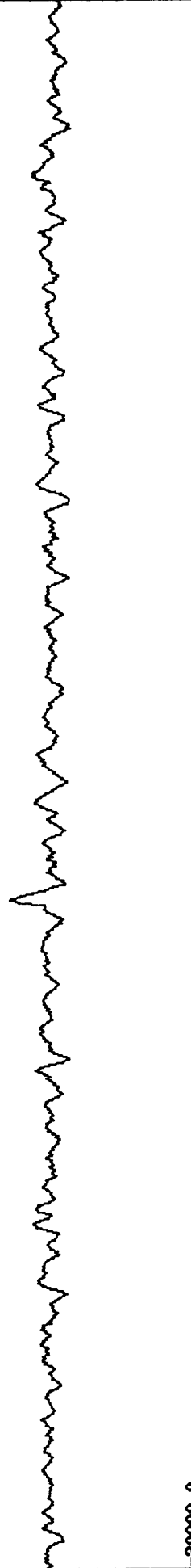
-20000.0
20000.0

2) SBR, BHN



-20000.0
20000.0

3) SBR, BHE



-20000.0
0.

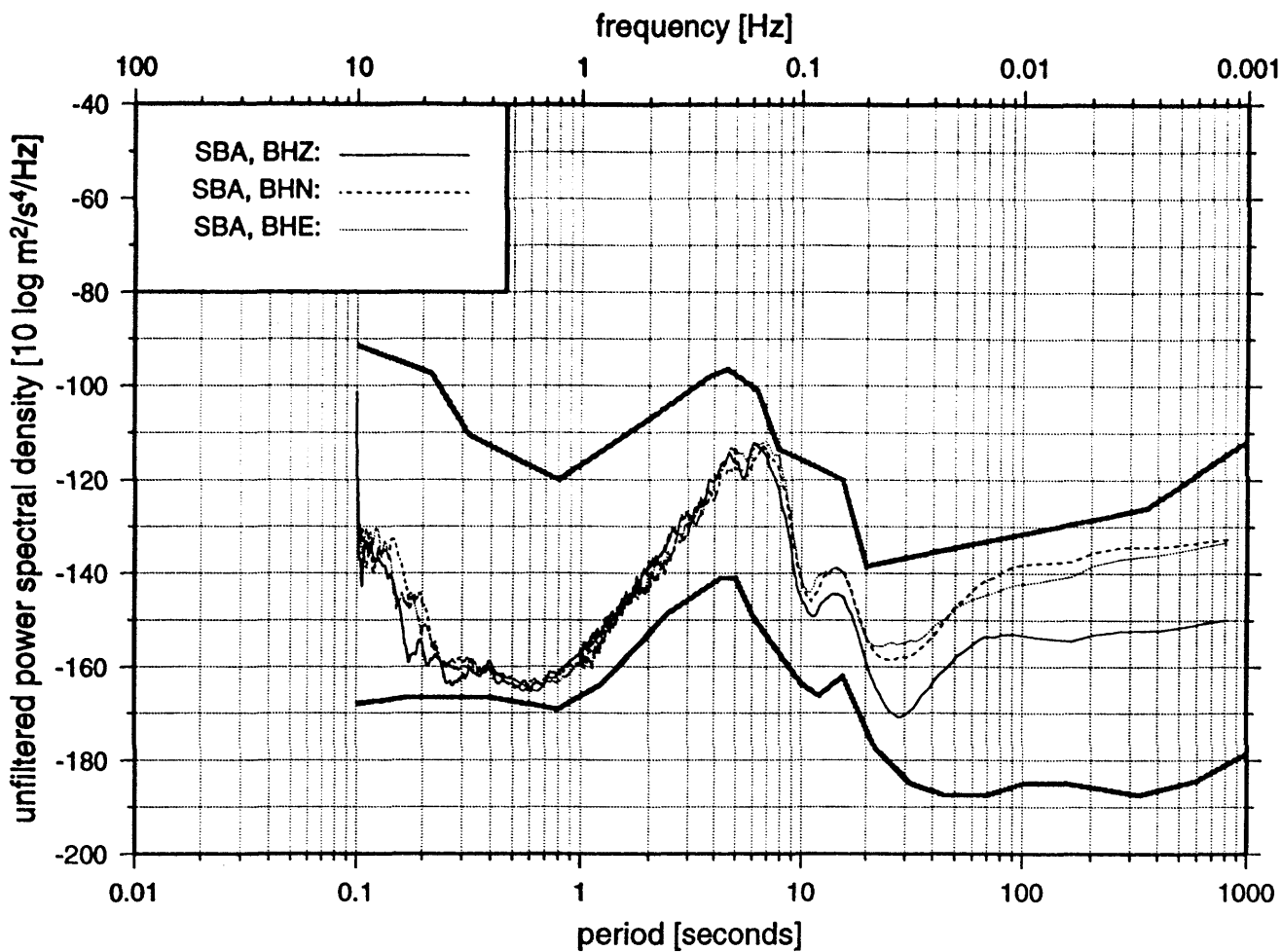
start time: 1998,096,23:21:45.177 length: 1.5 hours (densean) (lp co 0.0500 n 4)

5289.

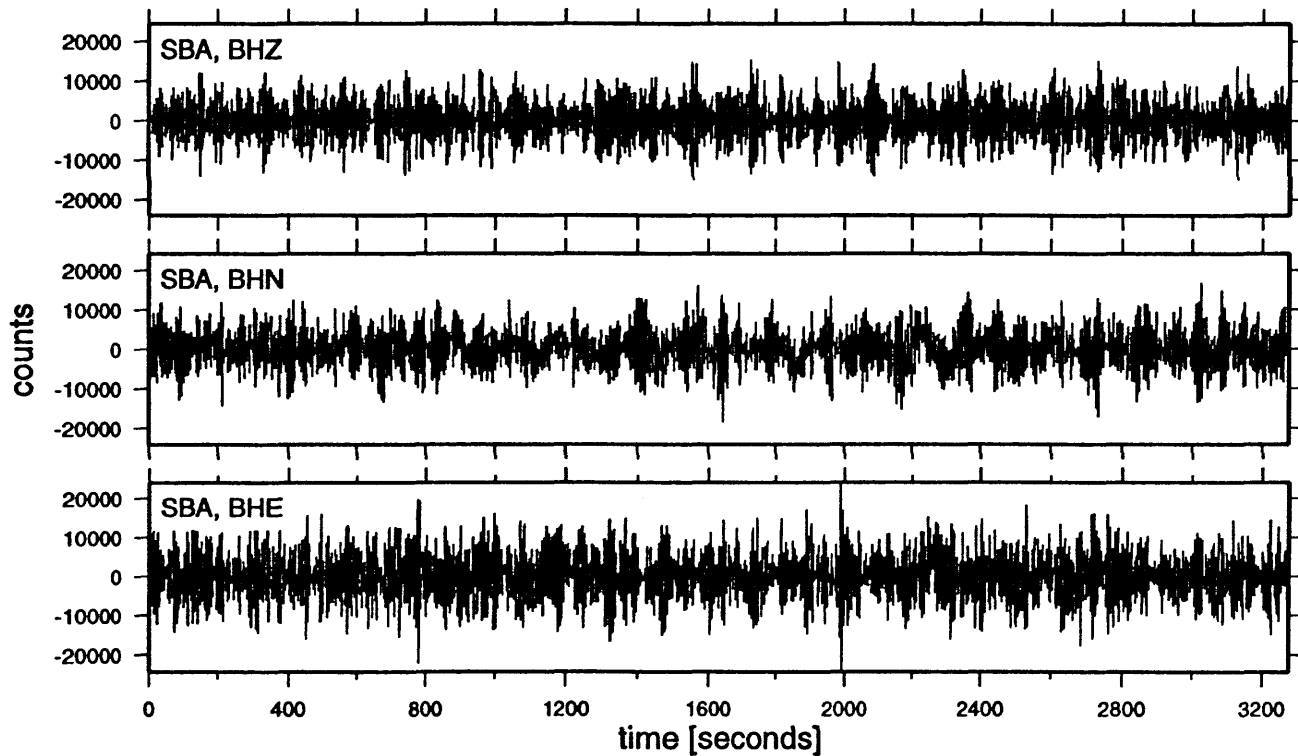
GFS file: tele.gfs
 min and max (<ret> for auto-scale) : -20000 20000
 GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) con C) xhair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPH B) PSD C) RESP
T06: A) phases B) color C) mean	FLIR: A) lp B) bp C) dyo	LIM: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
	quit	
PHS: A) + B) - C) EQ ID		

Seismic Spectra and Waveform Plot

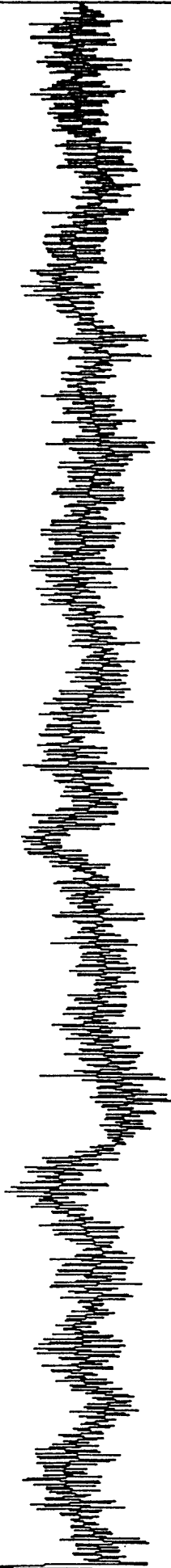


Start time 1998,096,23:21:45.177



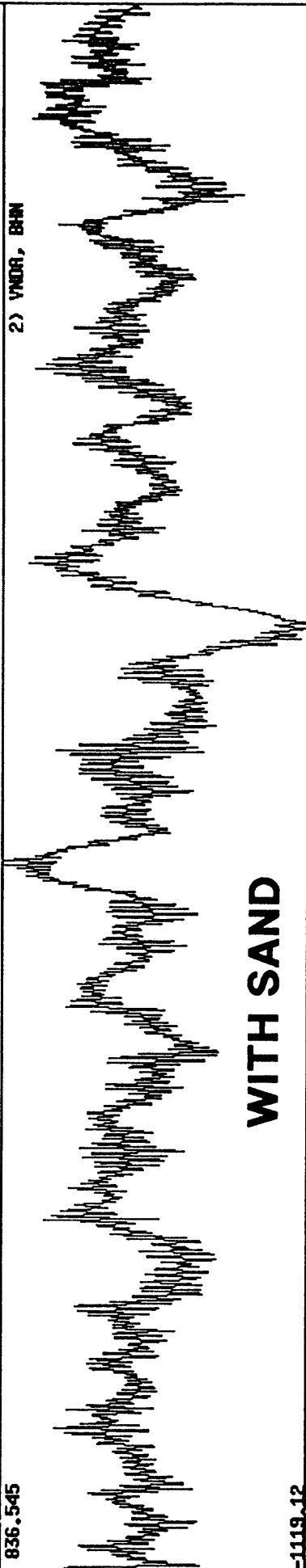
1194.59

1) VMDR, BHZ



-761.068
836.545

2) VMDR, BHN



WITH SAND

-1119.12
1037.04

3) VMDR, BHE



-918.621

0. start time: 1998,096,20:32:22.141 length: 1.5 hours (demean) (lp co 0.0500 n 4)

5406.

station: VMDR channels: BHE BHN BHZ
 filter options (l=lp, 2=hp, 3=bp): 1 .05 4
 GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) con C) xhair
A) next+plot B) next C) back	quit	A) PPM B) PSD C) RESP
T06: A) phases B) color C) mean	DMP: A) SAC B) GFS C) ASCII	LIM: A) xlin B) ylin
	PHS: A) + B) - C) EQ ID	
	A) offset B) ttpick C) delpick	
	FLTR: A) lp B) bp C) dyo	

30000.0

1) VMDA, BHZ

-30000.0
30000.0

2) VMDA, BHM

-30000.0
30000.0

3) VMDA, BHE

WITH SAND

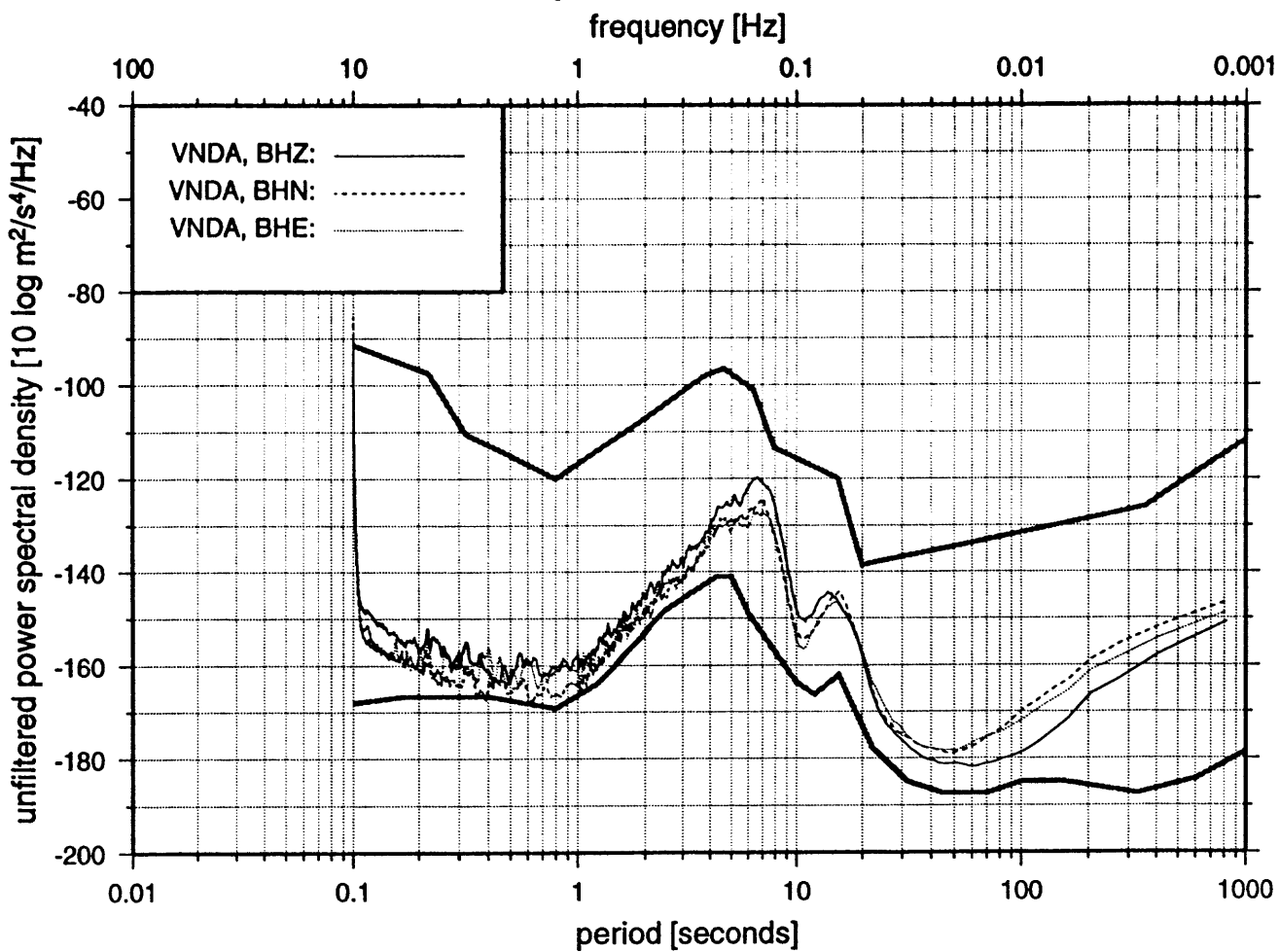
-30000.0

0. start time: 1998,096,20:32:22.141 length: 1.5 hours (demean) (lp co 0.0500 n 4) 5406.

GFS file: tele.gfs
min and max (<ret> for auto-scale) : -30000 30000
GFS file: tele.gfs

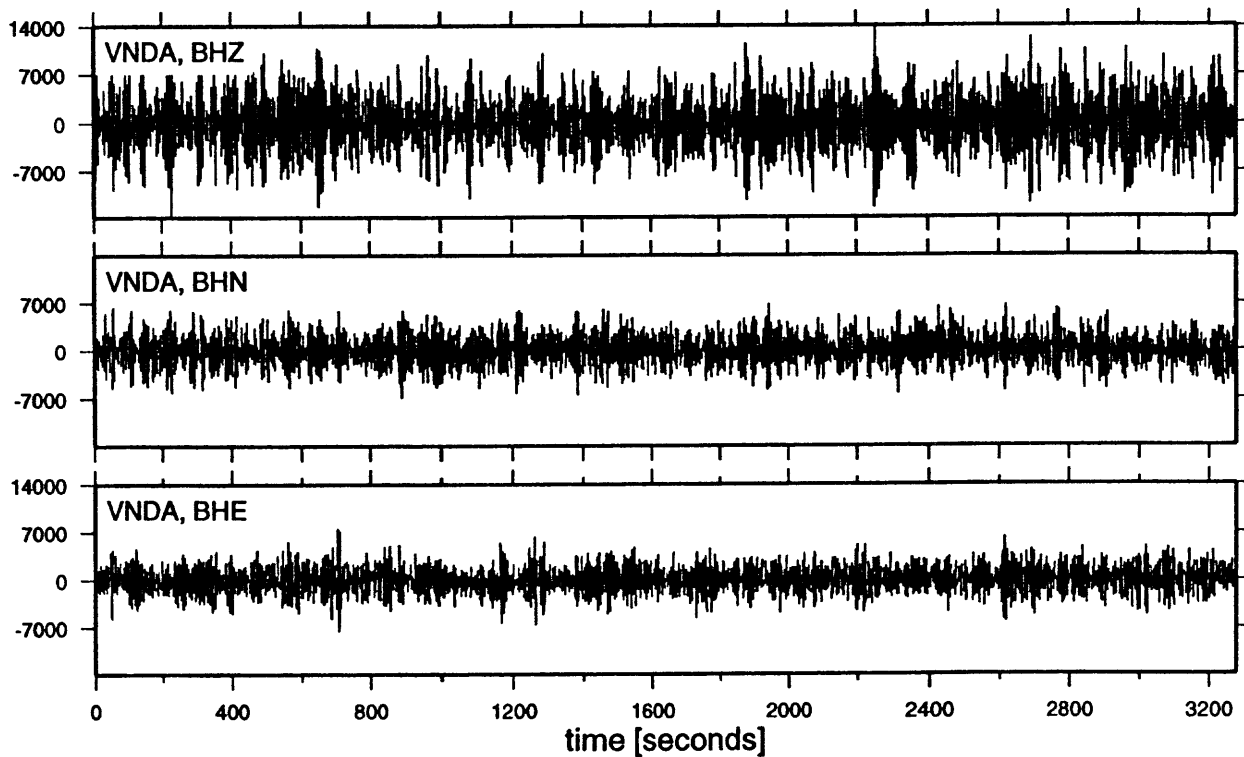
PLT: A) plot B) sel C) ovr	DMP: A) SAC B) GFS C) ASCII	hardcopy	SCL: A) auto B) con C) xhair
A) next+plot B) next C) back	quit	A) offset B) ttpick C) delpick	A) PPH B) PSD C) RESP
T06: A) phases B) color C) mean	PHS: A) + B) - C) EQ ID	FLTR: A) lp B) bp C) dyo	LIM: A) xlim B) ylim

Seismic Spectra and Waveform Plot



WITH SAND

Start time 1998,096,20:32:22.141

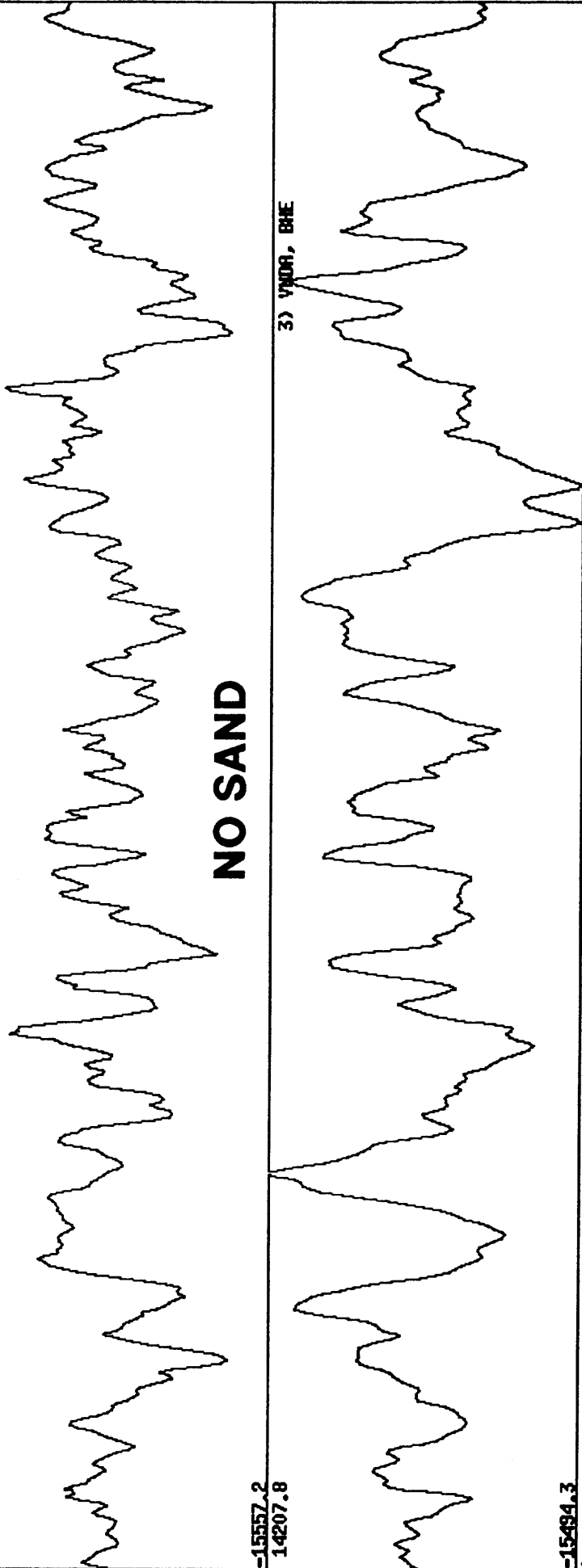


14845.4

1) VNOA, BHZ

-14856.7
14144.9

2) VNOA, BHN



NO SAND

-15557.2
14207.8

3) VNOA, BHE

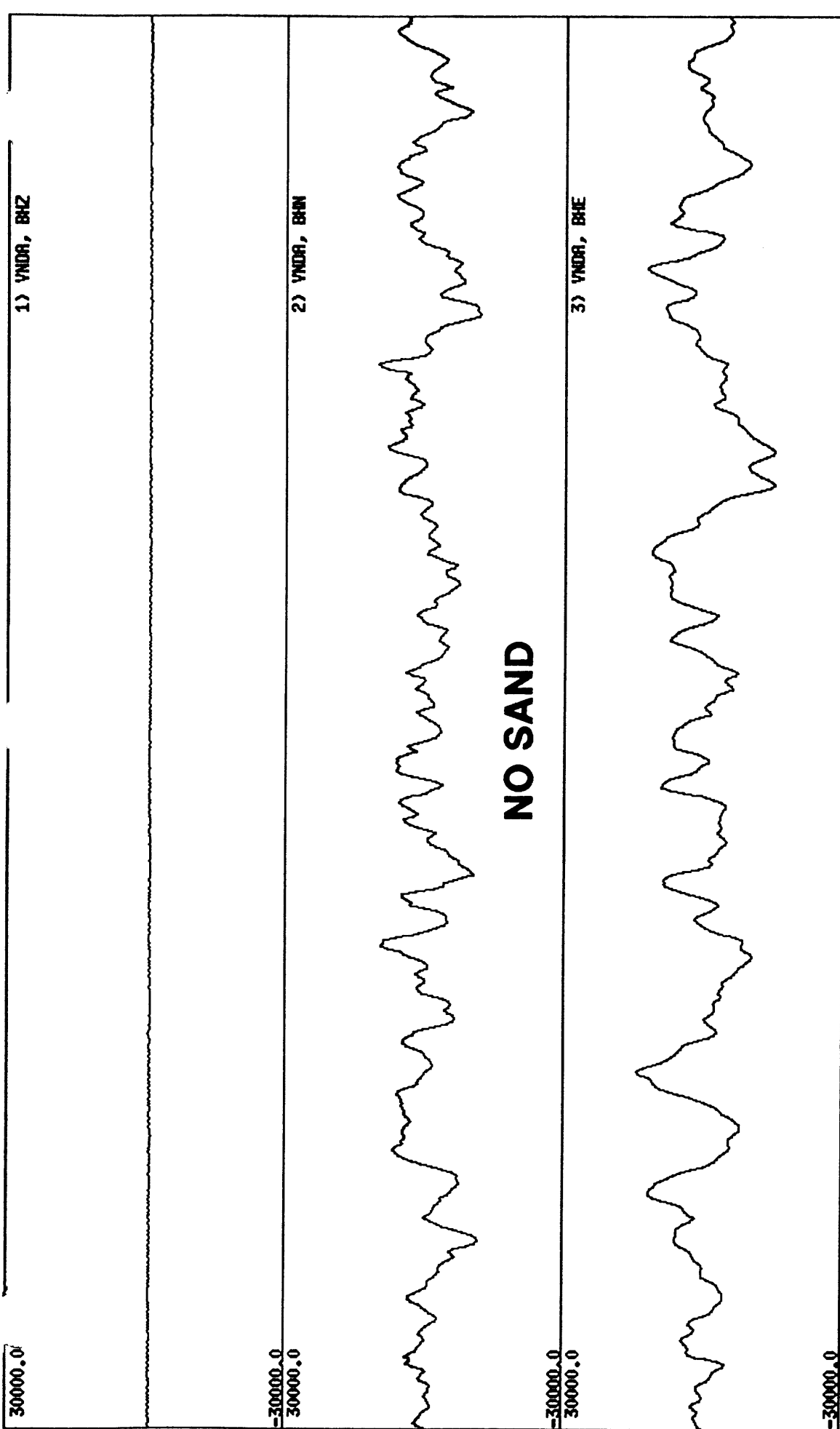
-15484.3
0.

start time: 1997,223,05:11:51.455 length: 1.5 hours (demean) (lp co 0.0500 n 4)

5358.

station: VNOA channels: BHZ BHN BHE
filter options (1=lp, 2=hp, 3=bp): 1 .05 4
GFS file: hutt_aftac.gfs

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) whair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
TOG: A) phases B) color C) mean	FLTR: A) lp B) bp C) dyo	LIN: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
	quit	
PHS: A) + B) - C) EQ ID		

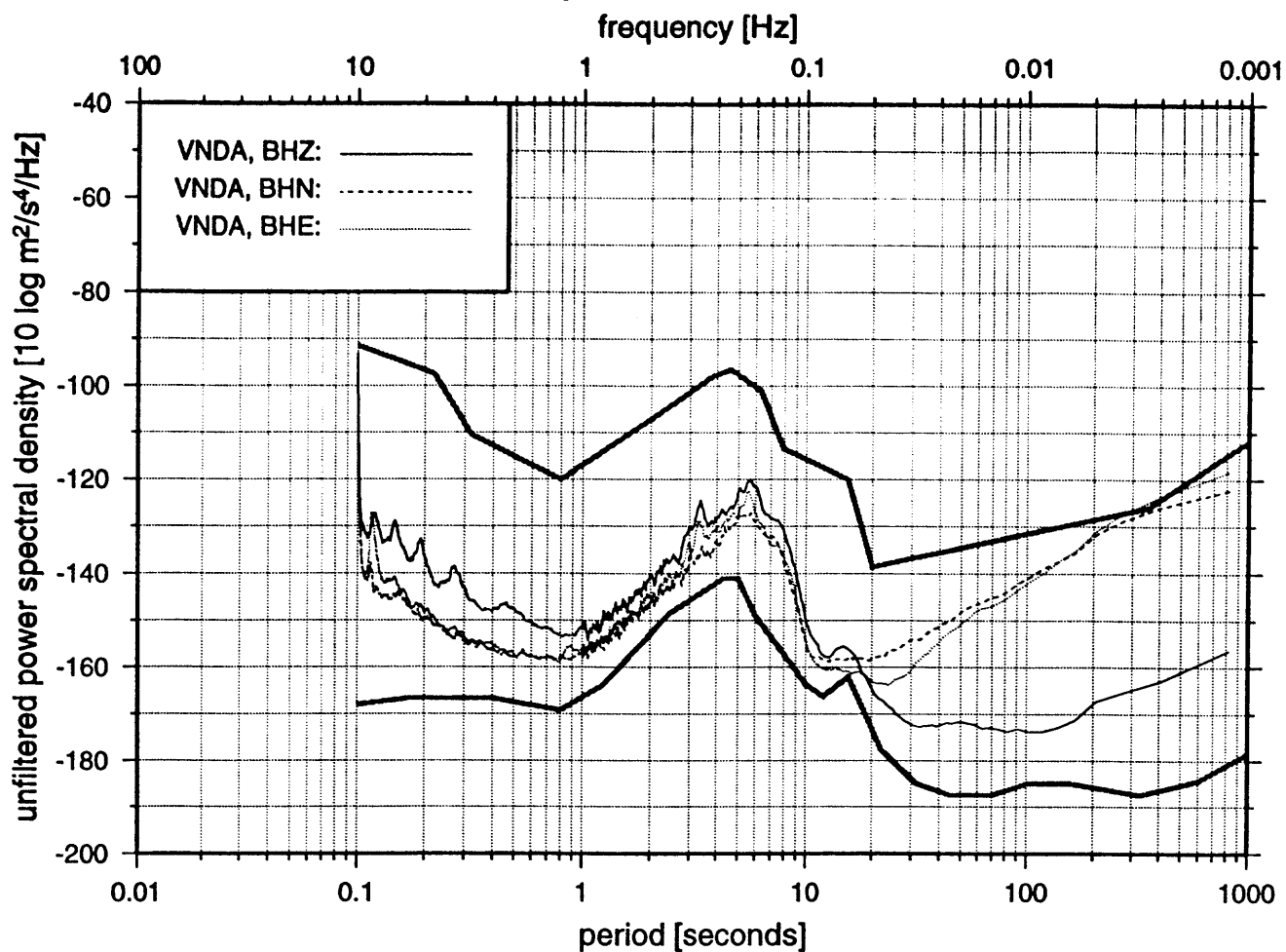


start time: 1997,223,05:11:51.455 length: 1.5 hours (demean) (lp co 0.0500 n 4) 5358.

GFS file: hutt_after.gfs
 min and max (<ret> for auto-scale) : -30000 30000
 GFS file: hutt_after.gfs

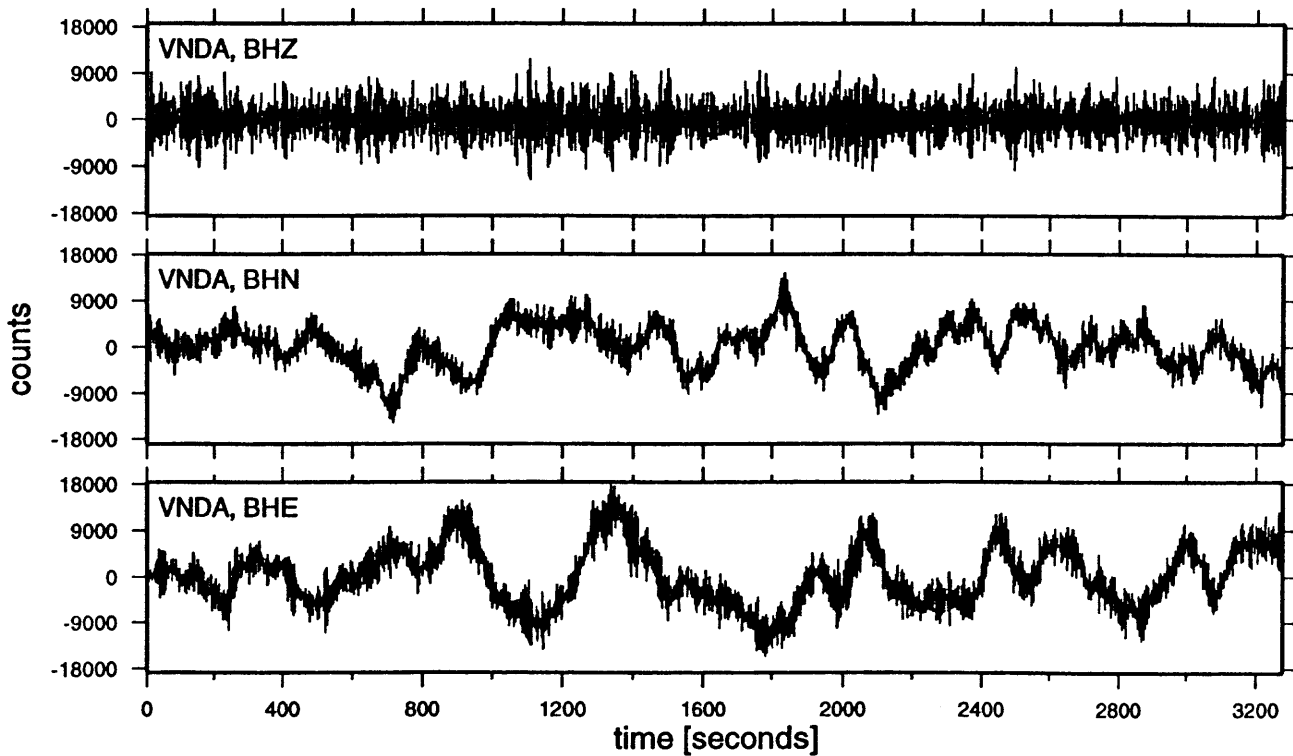
PLT: A) Plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) xhair
A) next+plot B) next C) back	quit	A) PPM B) PSD C) RESP
T0G: A) phases B) color C) mean	PHS: A) + B) - C) EQ ID	LIM: A) xlin B) ylin

Seismic Spectra and Waveform Plot



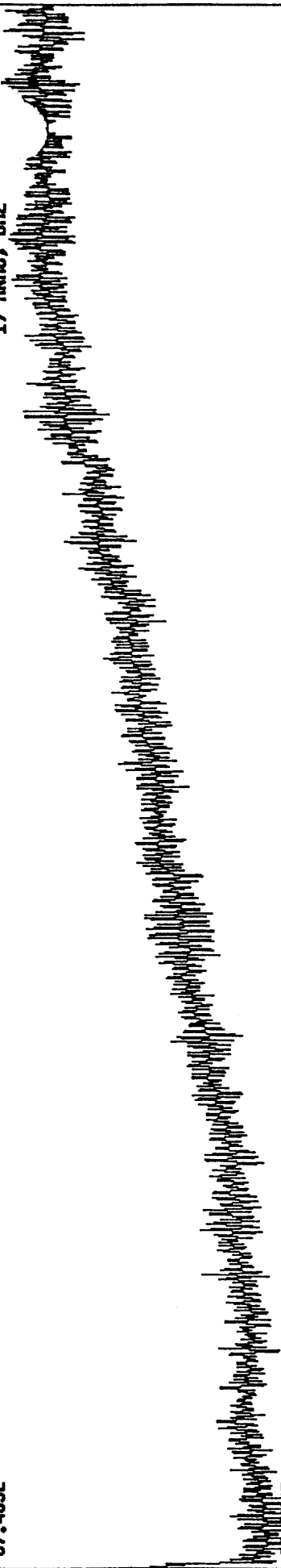
NO SAND

Start time 1997,223,05:11:51.455



87.4652

1) RAMP0, BHZ



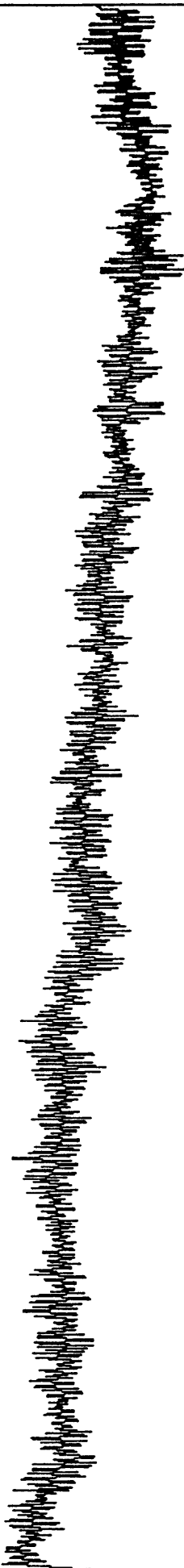
84.7396

2) RAMP0, BHZ



83.5002

3) RAMP0, BHZ



88.3723

start time: 1998,096,15:14:18.566 length: 1.5 hours (lp co 0.0500 n 4)

5509.

filter options (1=lp, 2=hp, 3=bp): 1 .05 4
 filter options (1=lp, 2=hp, 3=bp): 1 .05 4
 GFS file: tele.gfs

PLI: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) con C) xhair
A) next+plot B) next C) back		A) PPH B) PSD C) RESP
T0G: A) phases B) color C) mean	quit	LIM: A) xlin B) ylin
	DMP: A) SAC B) GFS C) ASCII	
	FLIR: A) lp B) bp C) dno	
	PHS: A) + B) - C) EQ ID	

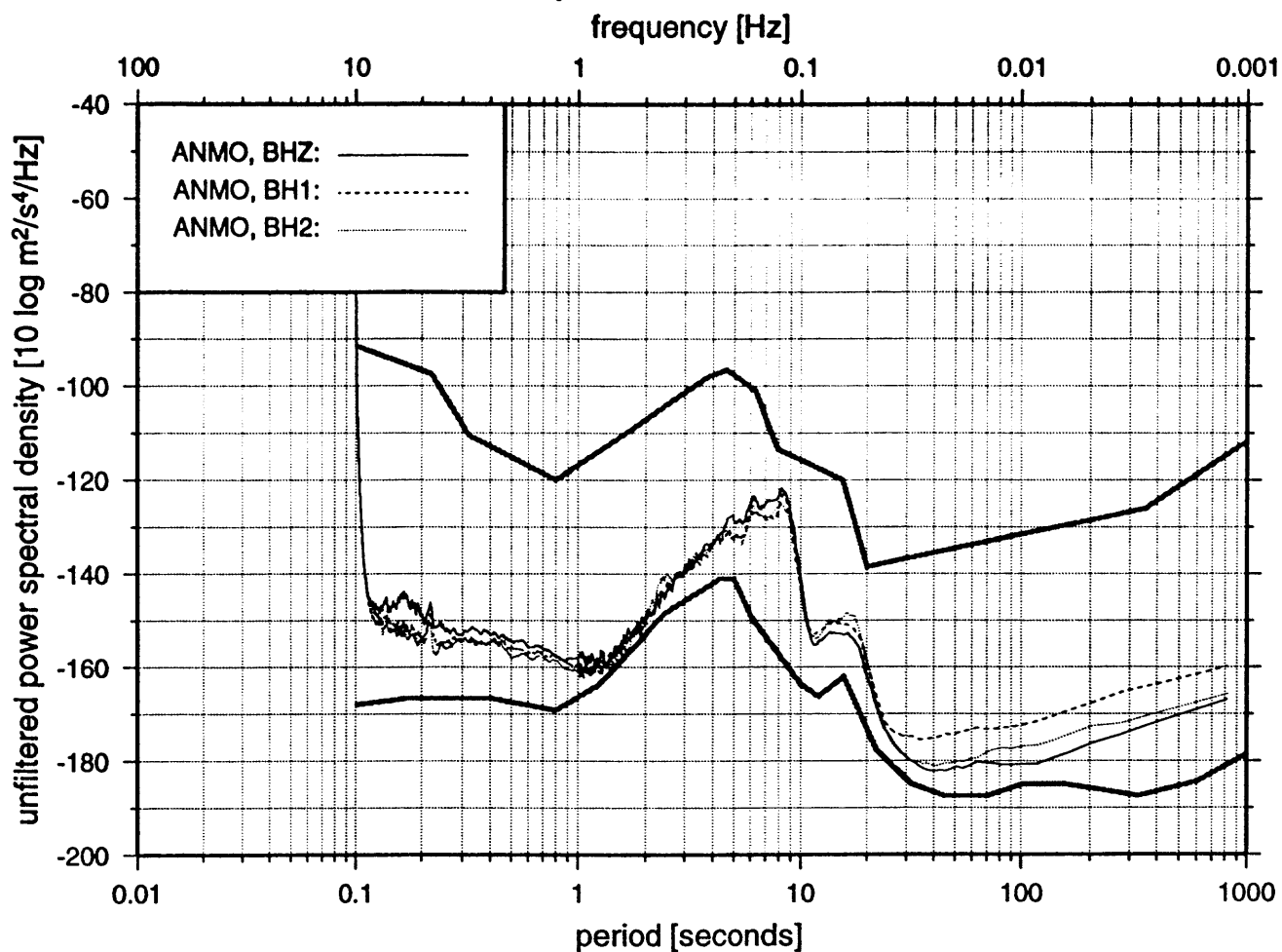
2400.00	1) ANMO, BHZ
-2400.00	
2400.00	2) ANMO, BH1
-2400.00	
2400.00	3) ANMO, BH2
-2400.00	

0. start time: 1998,096,15:14:18.566 length: 1.5 hours (lp co 0.0500 n 4) 5509.

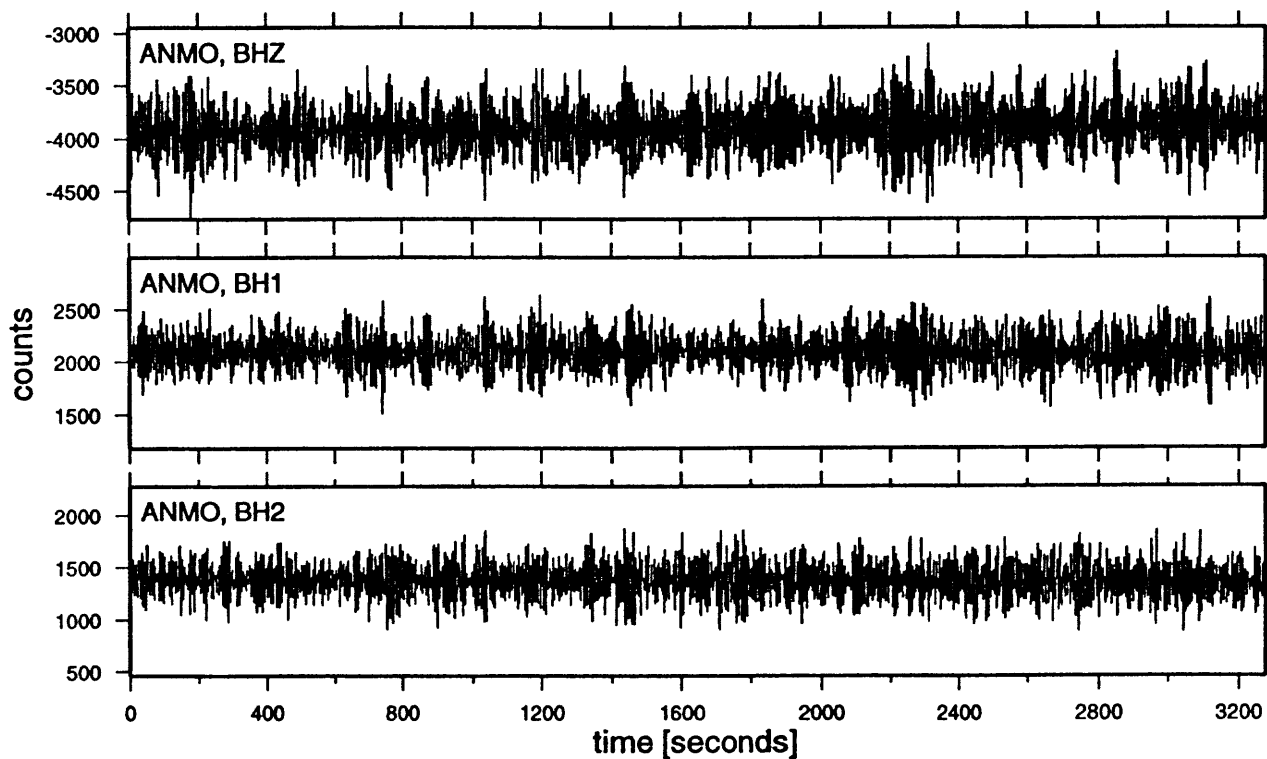
GFS file: tele.gfs
min and max (<ret> for auto-scale) : -2400 2400
GFS file: tele.gfs

PLI: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) whair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
TOG: A) phases B) color C) mean	FLTR: A) lp B) bp C) dno	LIN: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

Seismic Spectra and Waveform Plot

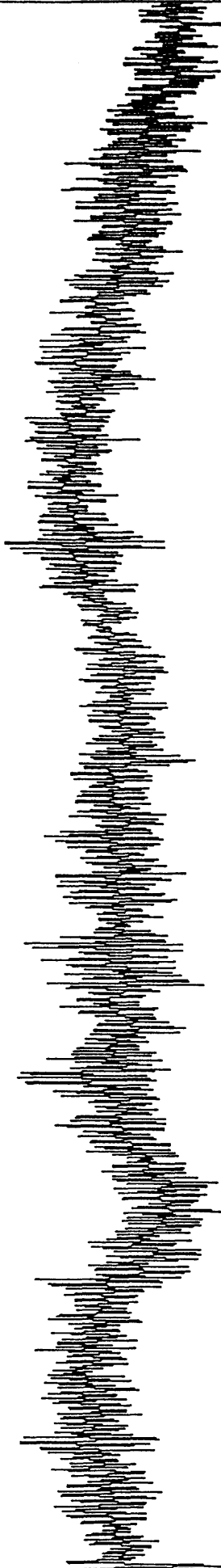


Start time 1998,096,15:14:18.566



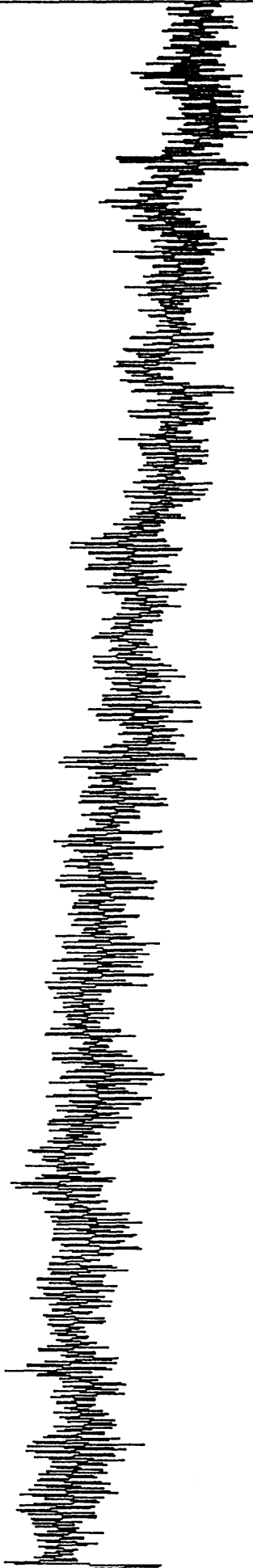
76.8634

1) COLA, BHZ



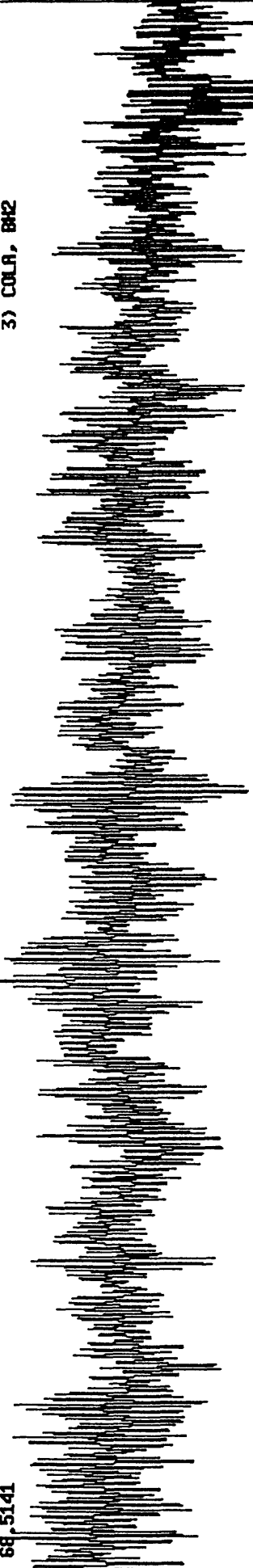
-79.0221
75.9572

2) COLA, BH1



-79.9283
69.5141

3) COLA, BH2



-87.3713

0. start time: 1998,096,11:51:10.991 length: 1.5 hours (lp co 0.0500 n 4)

5418.

station: COLA channels: BH1 BH2 BHZ
 filter options (1=lp, 2=hp, 3=bp): 1 .05 4
 GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) con C) xhair
A) next-plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
TUG: A) phases B) color C) mean	FLTR: A) lp B) bp C) dyo	LIM: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

2400.00	1) COLA, BHZ
-2400.00	
2400.00	2) COLA, BHI
-2400.00	
2400.00	3) COLA, BHZ
-2400.00	

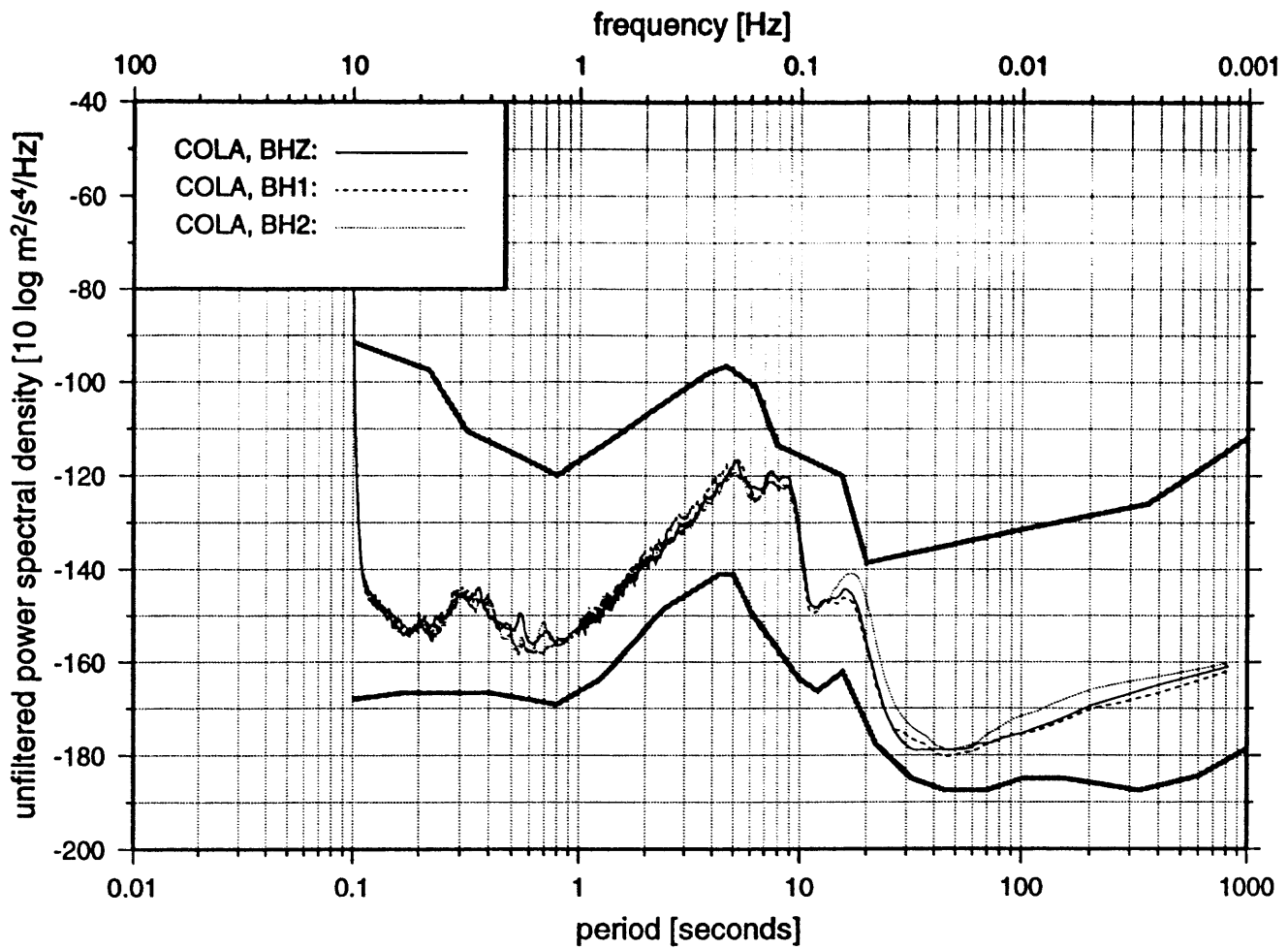
5418.

start time: 1998,096,11:51:10.991 length: 1.5 hours (lp co 0.0500 n 4)

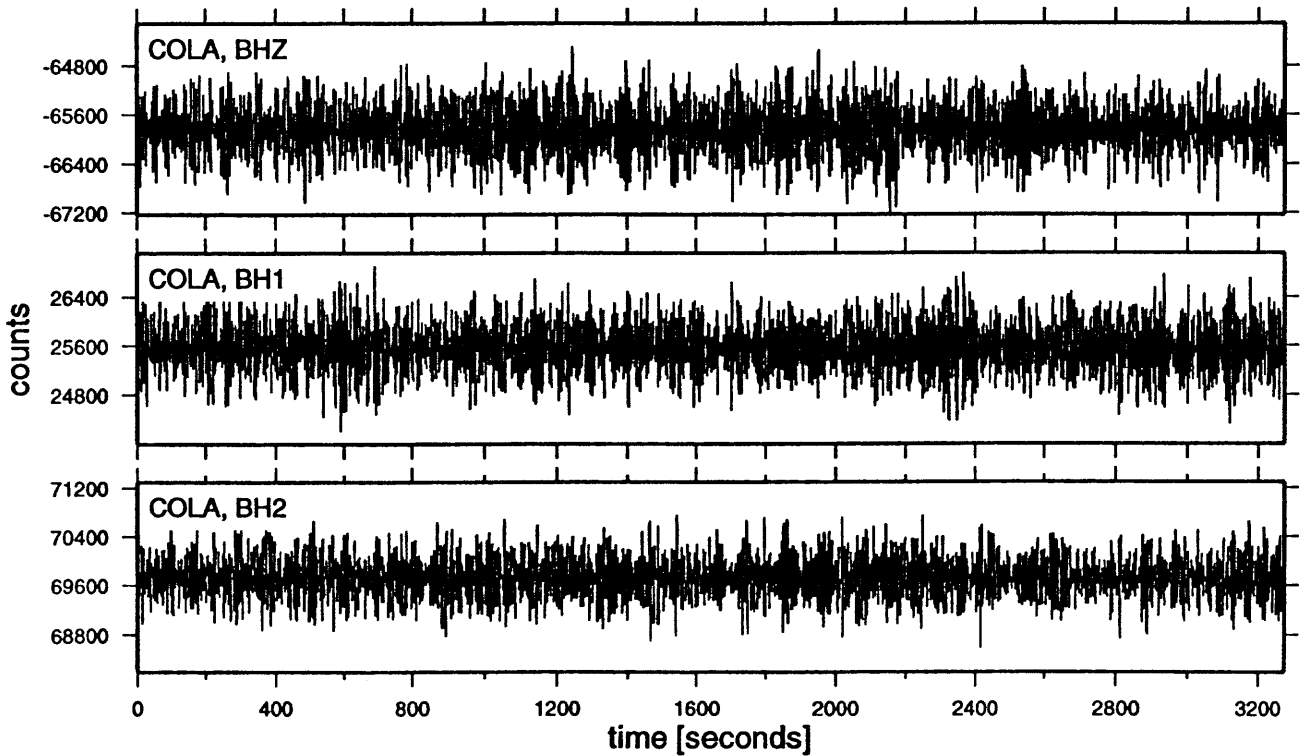
GFS file: tele.gfs
 min and max (<ret> for auto-scale) : -2400 2400
 GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	DMP: A) SAC B) GFS C) ASCII	hardcopy	SCL: A) auto B) com C) xhair
A) next-plot B) next C) back	quit	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
TUG: A) phases B) color C) mean	PHS: A) + B) - C) EQ ID	FLTR: A) lp B) bp C) dyo	LIM: A) xlin B) ylin

Seismic Spectra and Waveform Plot



Start time 1998,096,11:51:10.991



44.3518

1) GUM0, BHZ



-118.932
74.2914

2) GUM0, BHM



-88.9921
108.633

3) GUM0, BHE



-54.6505
0.

5065.

start time: 1998.096,12:26: 3.251 length: 1.4 hours (demean) (lp co 0.0500 n 4)

station: GUM0 channels: BHE BHM BHZ
filter options (1=lp, 2=hp, 3=bp): 1 .05 4
GFS file: tele.gfs

PLI: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) con C) xhair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T0G: A) phases B) color C) mean	FLTR: A) lp B) bp C) dyo	LIM: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

2400.00

1) GUM0, BHZ

-2400.00
2400.00

2) GUM0, BHN

-2400.00
2400.00

3) GUM0, BHE

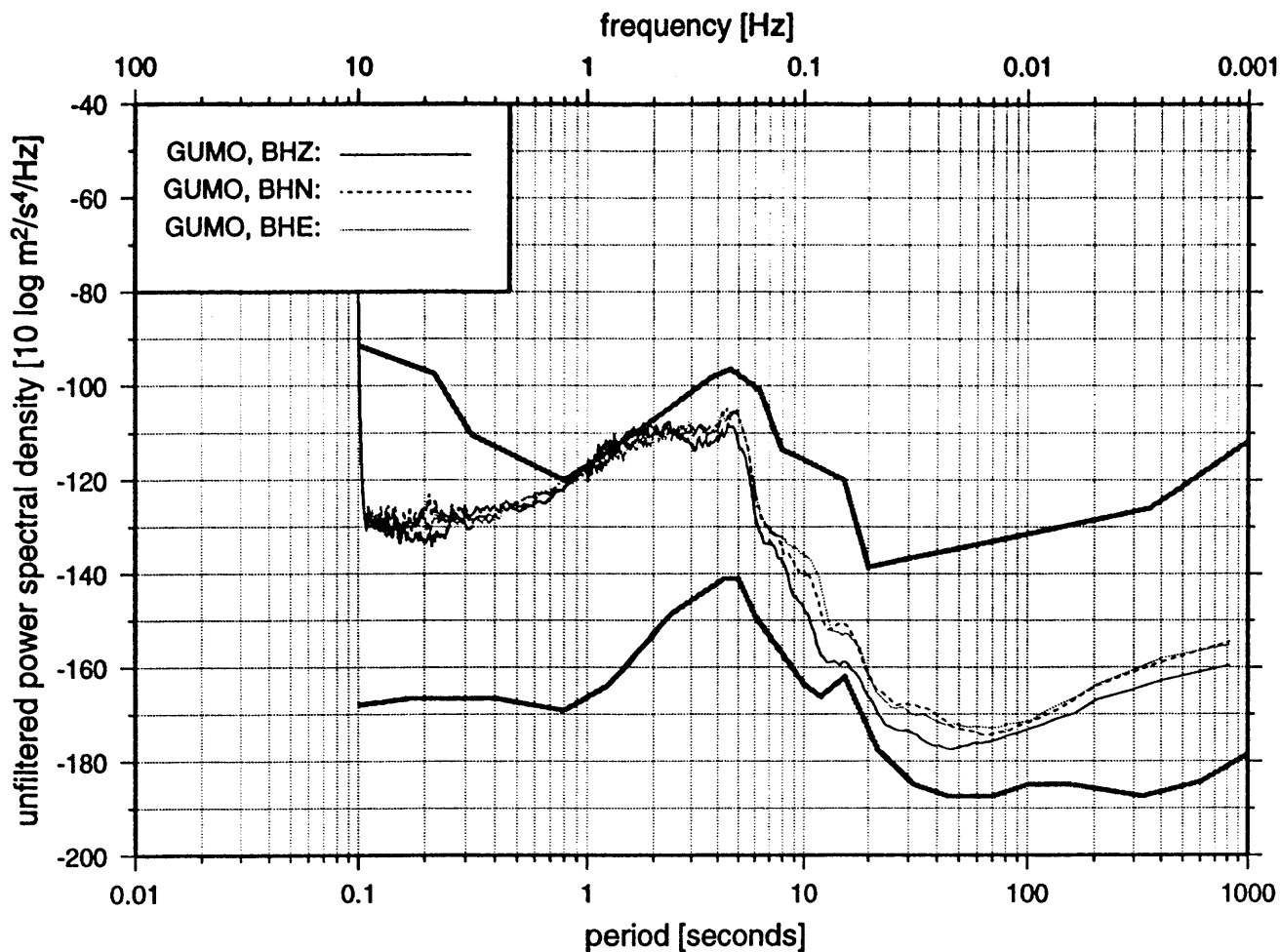
-2400.00

0. start time: 1998,096,12:26: 3.251 length: 1.4 hours (demean) (lp co 0.0500 n 4) 5065.

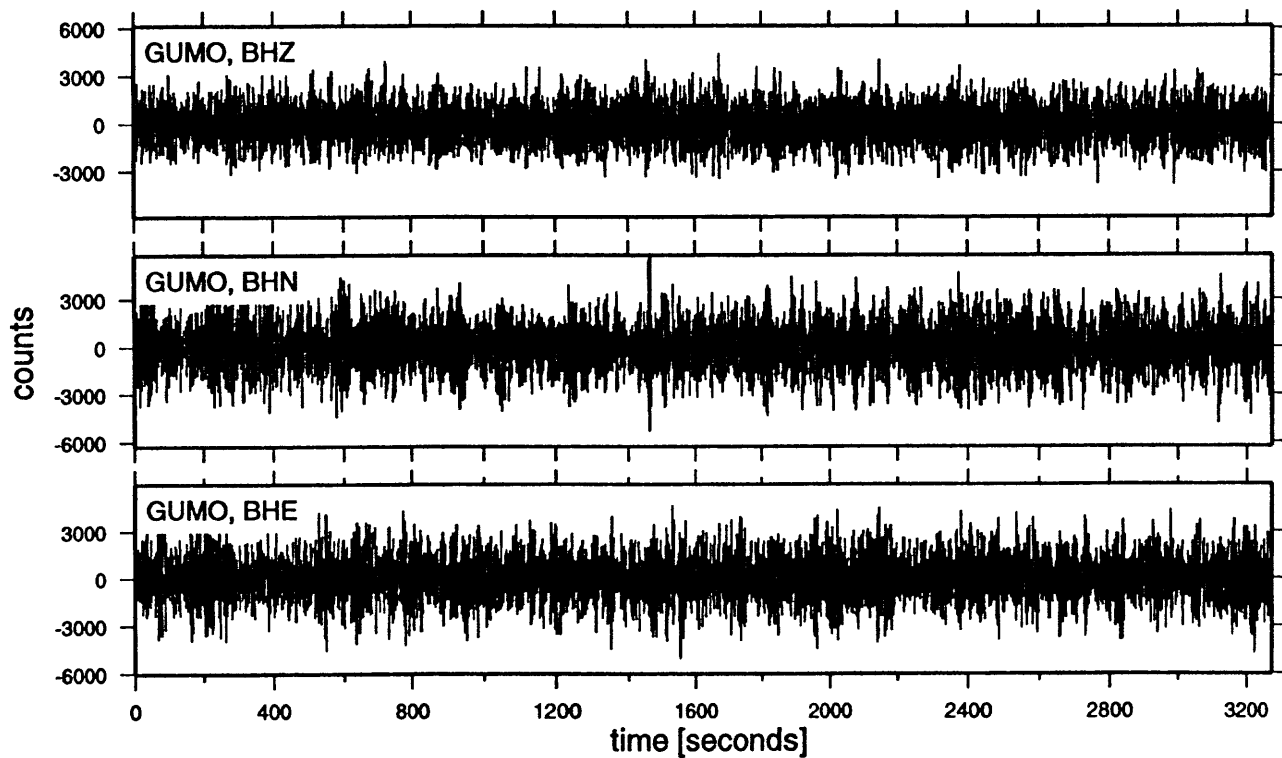
GFS file: tele.gfs
min and max (<ret> for auto-scale) : -2400 2400
GFS file: tele.gfs

PLI: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) xhair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T0G: A) phases B) color C) mean	FLTR: A) lp B) bp C) dyo	LIM: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

Seismic Spectra and Waveform Plot



Start time 1998,096,12:26:03.251



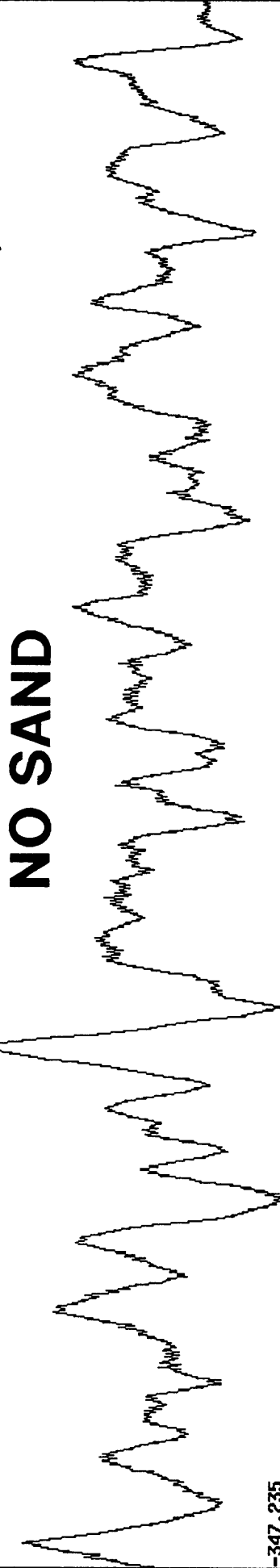
438.318

1) SNZO, BHZ



-372.660
463.743

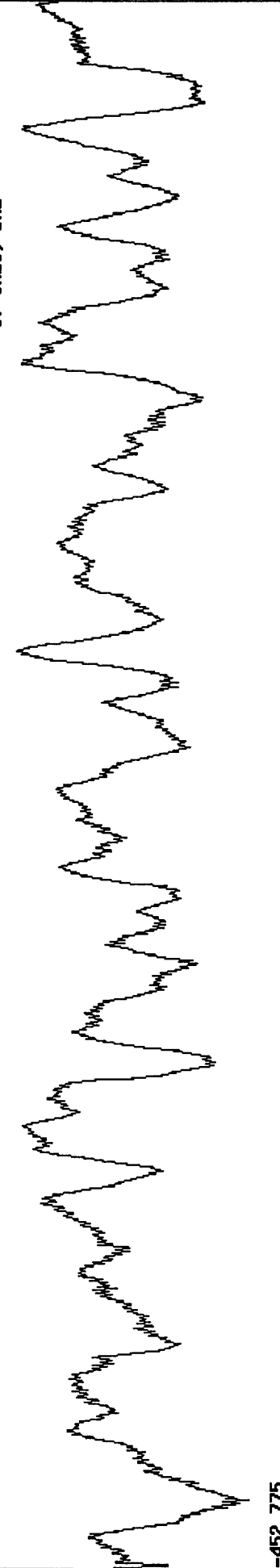
2) SNZO, BHN



NO SAND

-347.235
358.203

3) SNZO, BHE



-452.775

start time: 1997,020,00:46:33.310 length: 1.5 hours (lp co 0.0500 n 4)

5557.

station: SNZO channels: BHE BHN BHZ
GFS file: data.USER_TYLER.SNZO

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) con C) xhair
A) next+plot B) next C) back	A) offset B) ttpick C) de1pick	A) PPM B) PSD C) RESP
TOG: A) phases B) color C) mean	FLTR: A) lp B) bp C) dgo	LIM: A) xlim B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

2400.00

1) SNZ0, BHZ



-2400.00
2400.00

2) SNZ0, BHN

NO SAND



-2400.00
2400.00

3) SNZ0, BHE



-2400.00

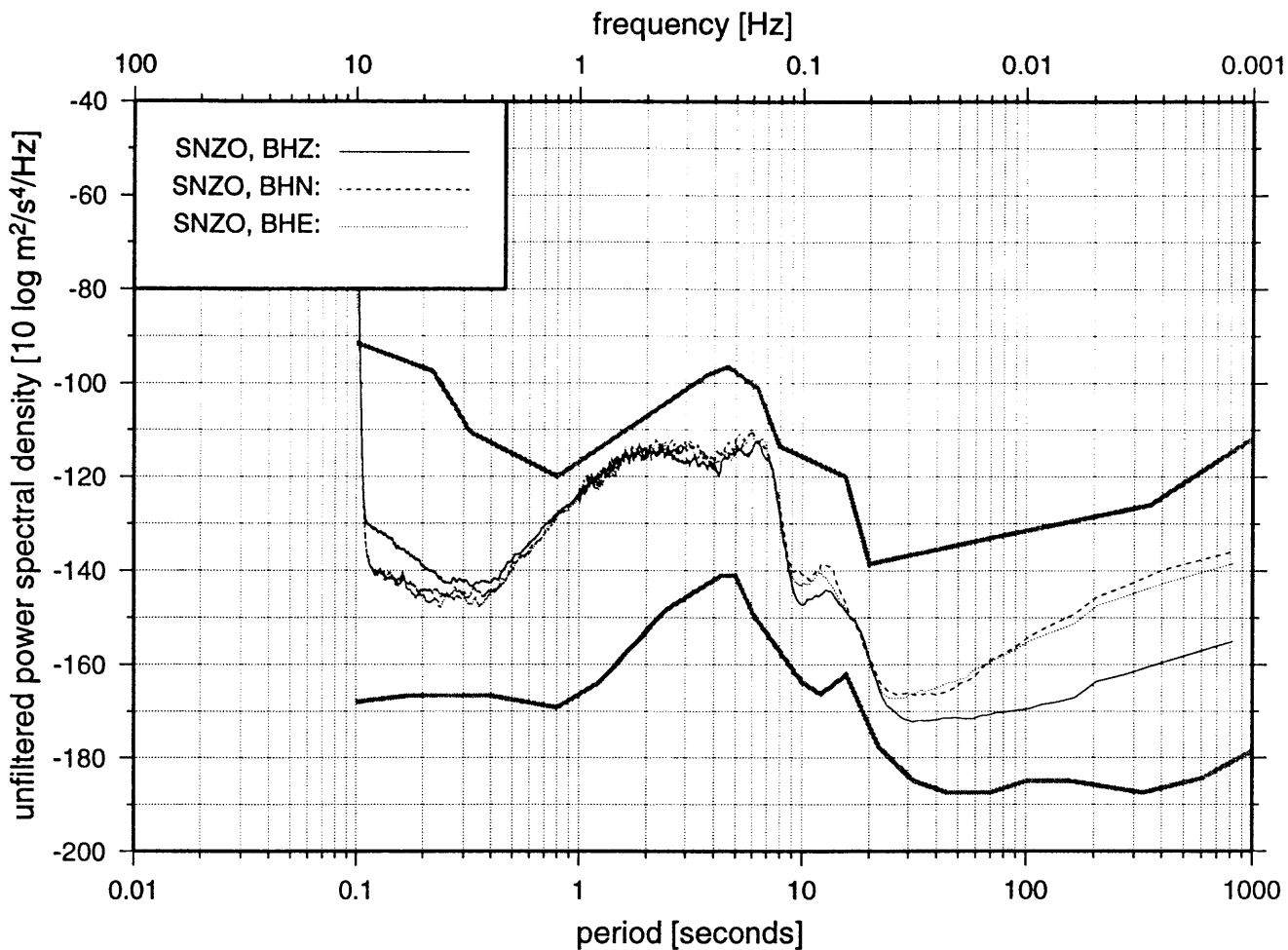
5557.

0. start time: 1997,020,00:46:33.310 length: 1.5 hours (lp co 0.0500 n 4)

GFS file: data.USER_TYLER.SNZ0
 min and max (<ret> for auto-scale) : -2400 2400
 GFS file: data.USER_TYLER.SNZ0

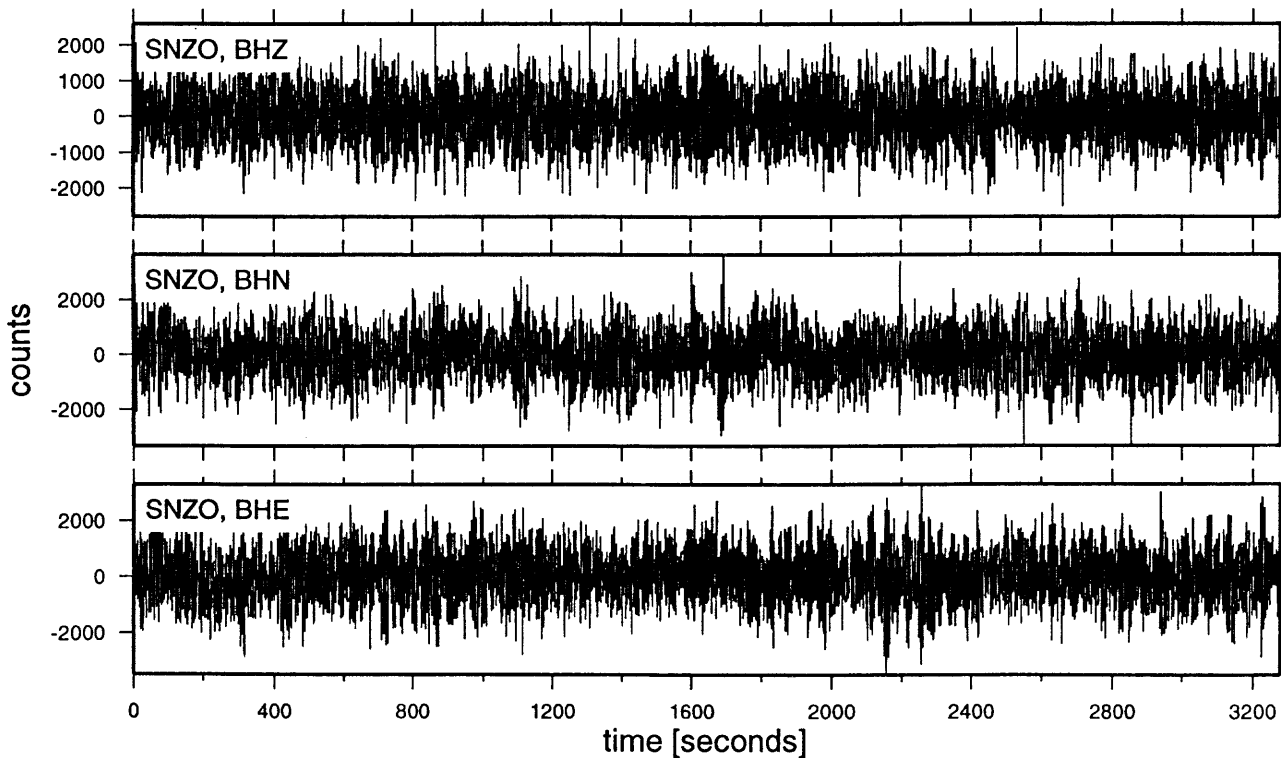
PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) con C) xhair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T0G: A) phases B) color C) mean	FLTR: A) lp B) bp C) dyo	LIM: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

Seismic Spectra and Waveform Plot



NO SAND

Start time 1997,020,00:46:33.310



135.605

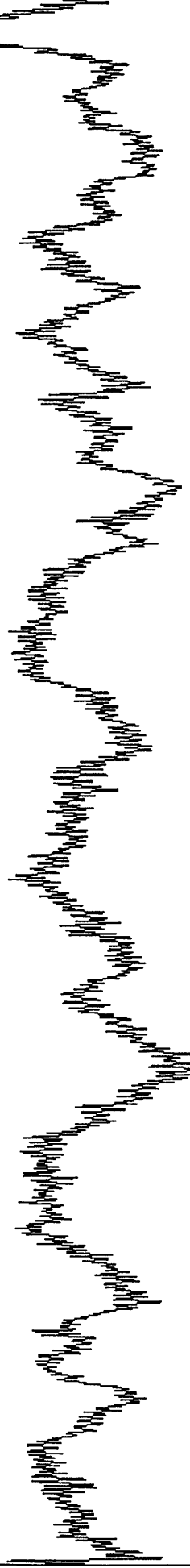
1) SNZ0, BHZ



-134.777
151.080

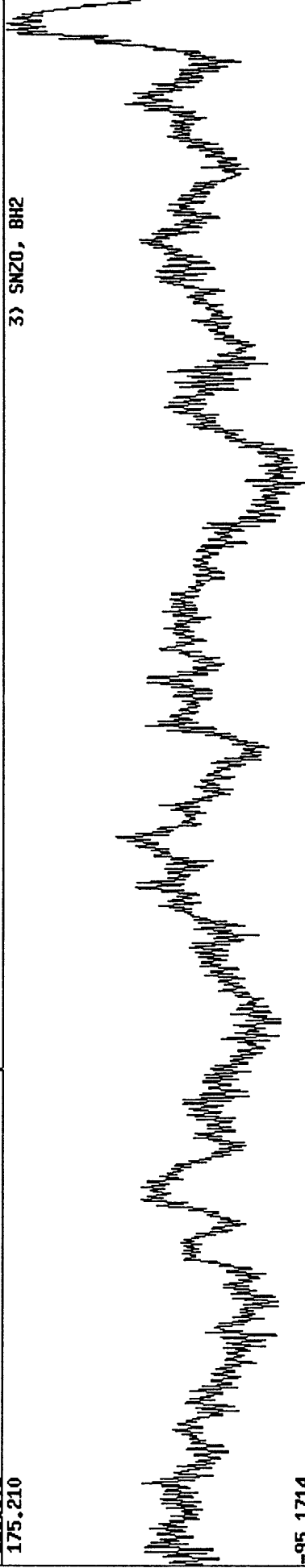
2) SNZ0, BH1

WITH SAND



-119.302
175.210

3) SNZ0, BH2



-95.1714

5465.

0. start time: 1998,117,05:17:47.398 length: 1.5 hours (denan) (lp co 0.0500 n 4)

station: SNZ0 channels: BH1 BH2 BHZ
GFS file: tele.gfs

PLT: A) pLot B) sel C) ovr	hardcopy	SCL: A) auto B) con C) xhair
A) next+pLot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
TOG: A) phases B) color C) mean	FLTR: A) lp B) bp C) dgo	LIM: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

2400.00

1) SNZO, BHZ

-2400.00
2400.00

2) SNZO, BH1

WITH SAND

-2400.00
2400.00

3) SNZO, BH2

-2400.00

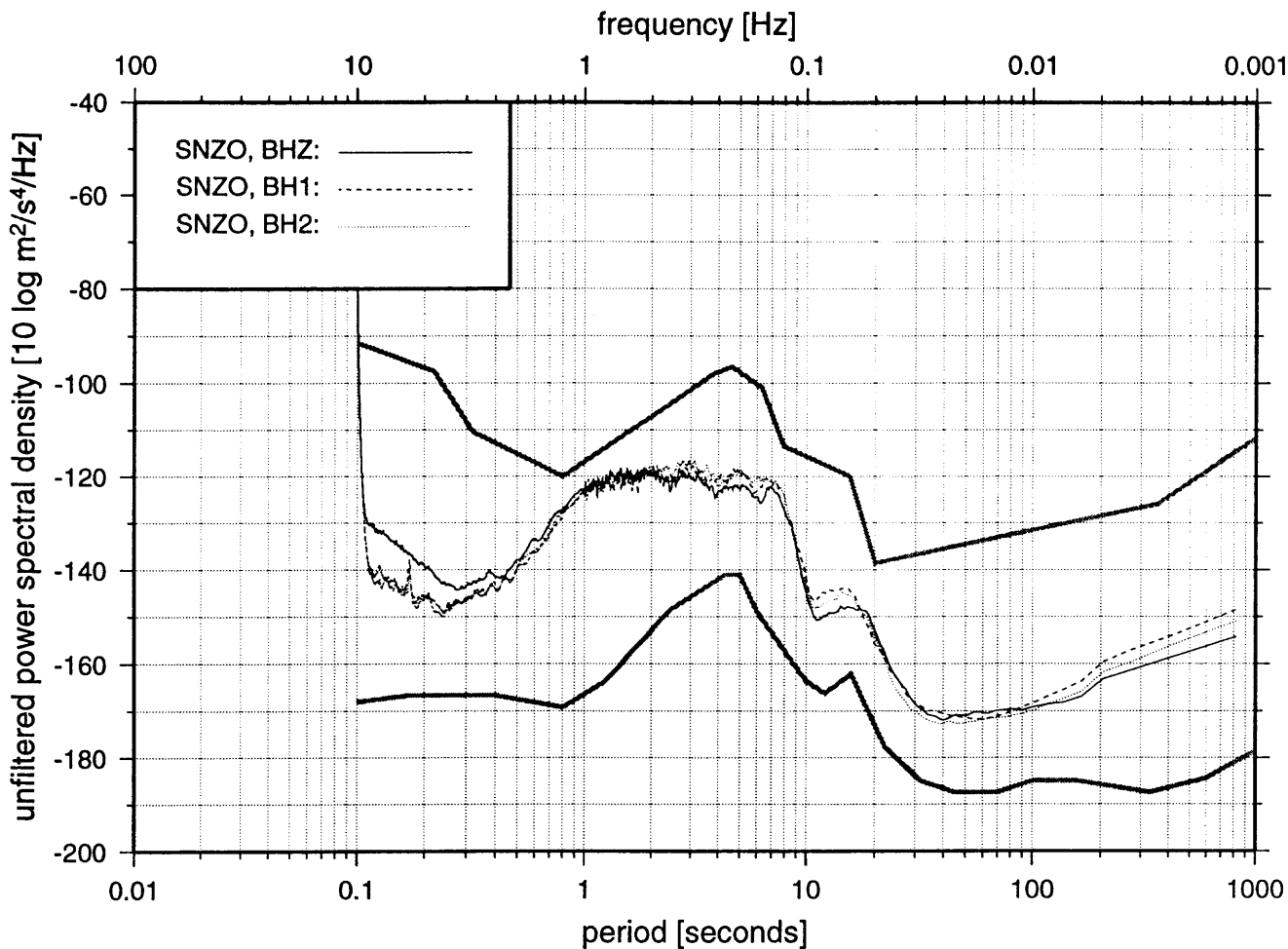
5465.

start time: 1998,117,05:17:47.398 length: 1.5 hours (demean) (lp co 0.0500 n 4)

GFS file: tele.gfs
min and max (<ret> for auto-scale) : -2400 2400
GFS file: tele.gfs

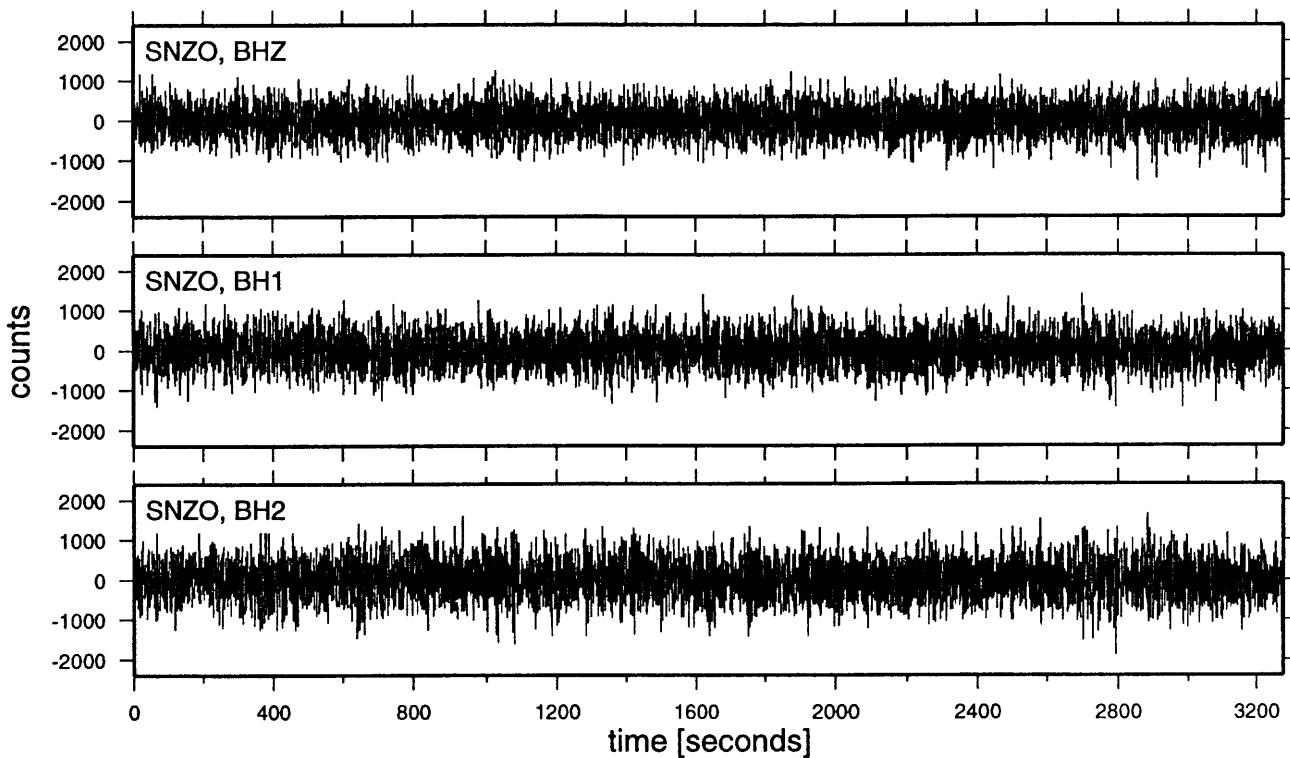
PLI: A) plot B) sel C) ovr	DMP: A) SAC B) GFS C) ASCII	hardcopy	SCL: A) auto B) com C) xhair
A) next-plot B) next C) back	quit	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
TOG: A) phases B) color C) mean	PHS: A) + B) - C) EQ ID	FLTR: A) lp B) bp C) dyo	LIM: A) xlin B) ylin

Seismic Spectra and Waveform Plot



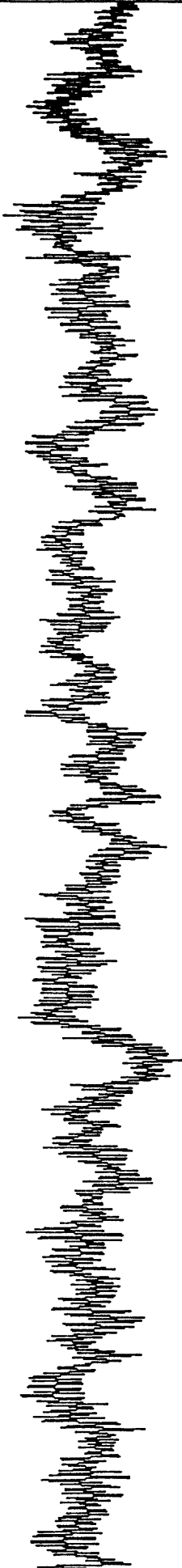
WITH SAND

Start time 1998,117,04:57:18.136



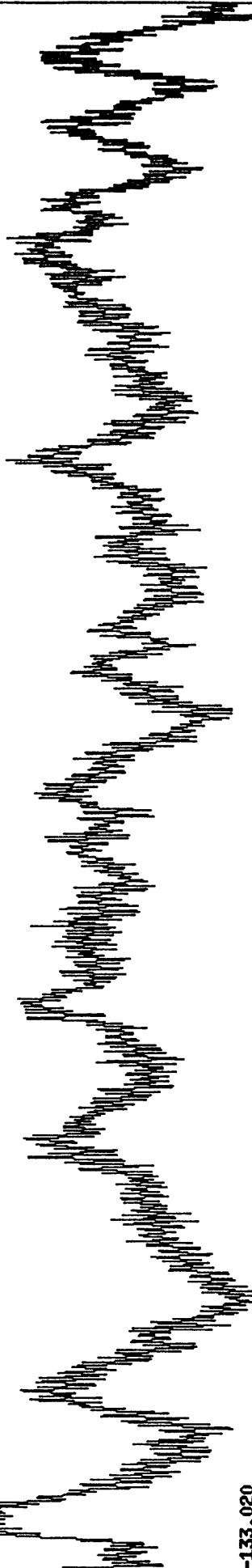
143.732

1) SNZ0, BHZ



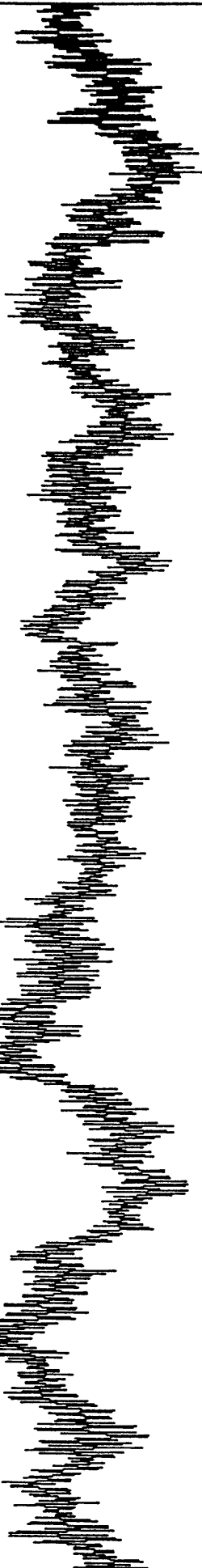
-151.009
161.721

2) SNZ0, BH1



-133.020
114.374

3) SNZ0, BHZ



-180.366
0.

start time: 1998.096,21:03: 8.183 length: 1.5 hours (lp co 0.0500 n 4)

5444.

station: SNZ0 channels: BH1 BH2 BHZ
 filter options (1=lp, 2=hp, 3=bp): 1 .05 4
 GFS file: tele.gfs

With Sand

PLI: A) plot B) sel C) ovr	hardcopy	SCI: A) auto B) con C) whair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T06: A) phases B) color C) mean	FLTR: A) lp B) bp C) dno	LIN: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

1) SNZO, BHZ

2400.00

2) SNZO, BHI

-2400.00
2400.00

3) SNZO, BHZ

-2400.00
2400.00

-2400.00

start time: 1998,096,21:03: 8.183 length: 1.5 hours (lp co 0.0500 n 4)

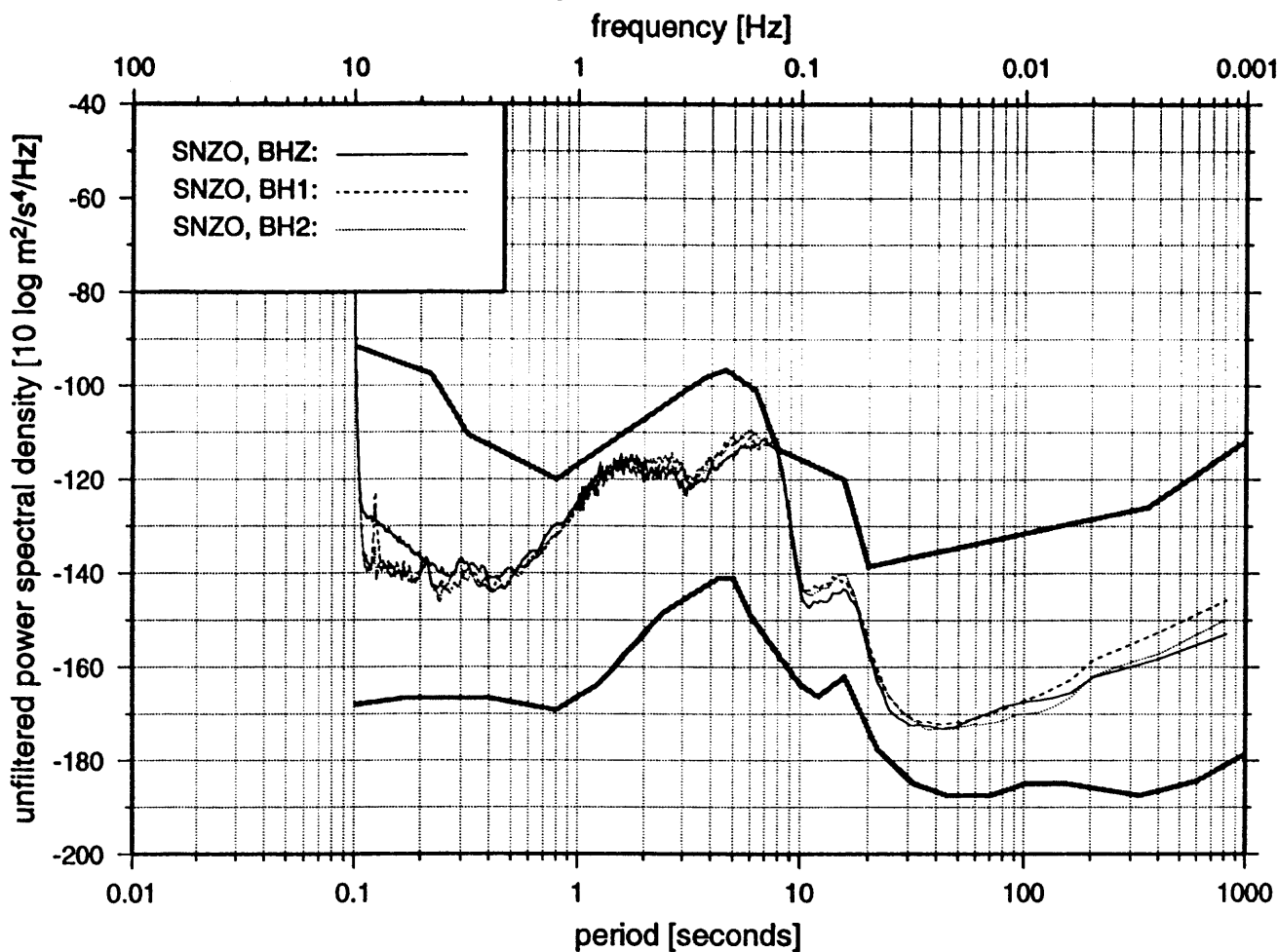
5444.

GFS file: tele.gfs
min and max (ret) for auto-scale) : -2400 2400
GFS file: tele.gfs

With Sand

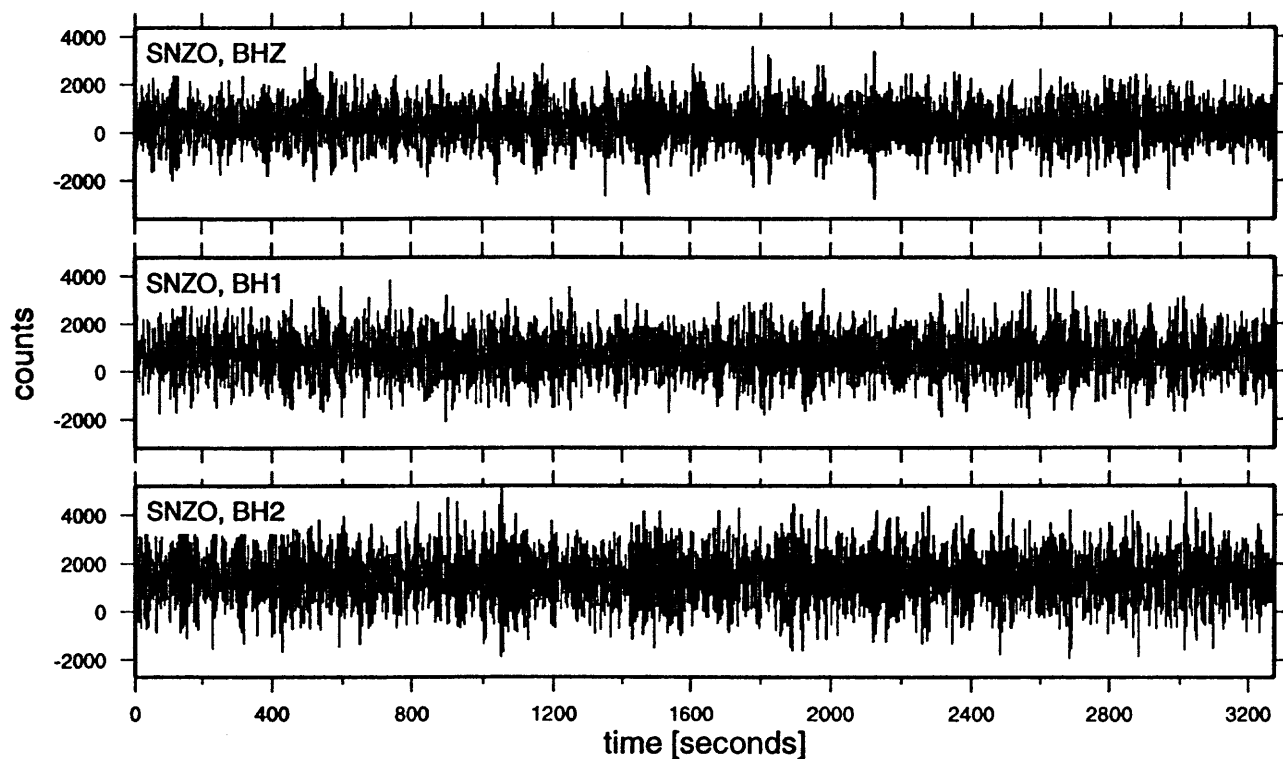
PLI: A) plot B) sel C) ovr	DMP: A) SAC B) GFS C) ASCII	hardcopy	SCL: A) auto B) com C) xhair
A) next+plot B) next C) back	quit	A) offset B) ttpick C) delpick	A) PPH B) PSD C) RESP
T06: A) phases B) color C) mean	PHS: A) + B) - C) EQ ID	FLTR: A) lp B) bp C) dyo	LIM: A) xlin B) ylin

Seismic Spectra and Waveform Plot



With Sand

Start time 1998,096,21:03:08.183



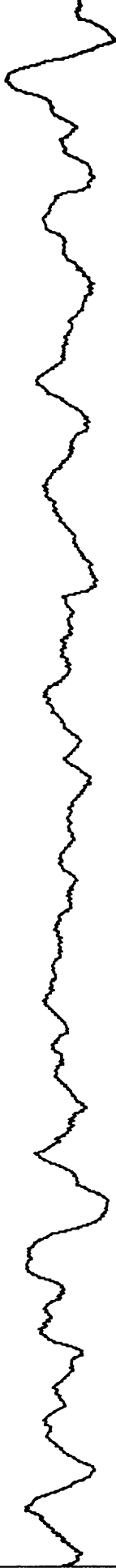
450.586

1) TATO, BHZ



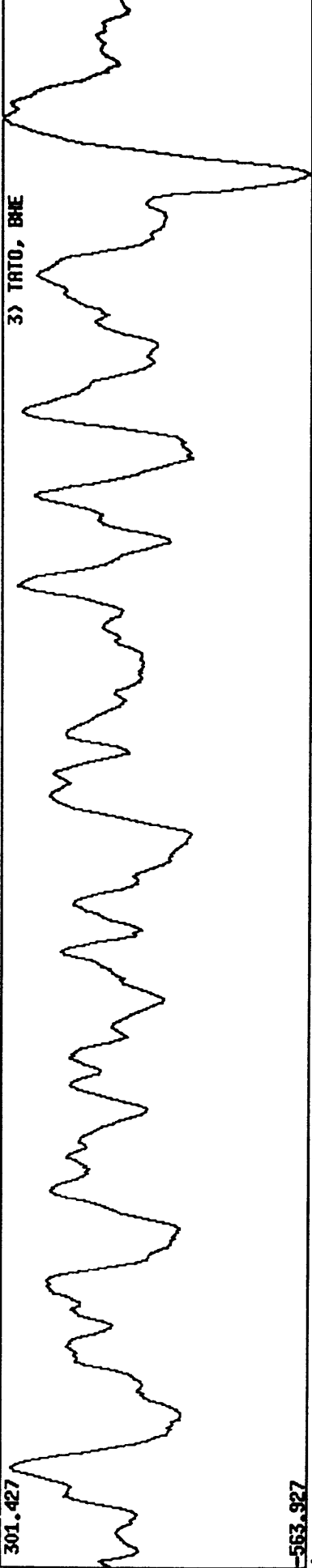
414.768
446.861

2) TATO, BHN



418.493
301.427

3) TATO, BHE



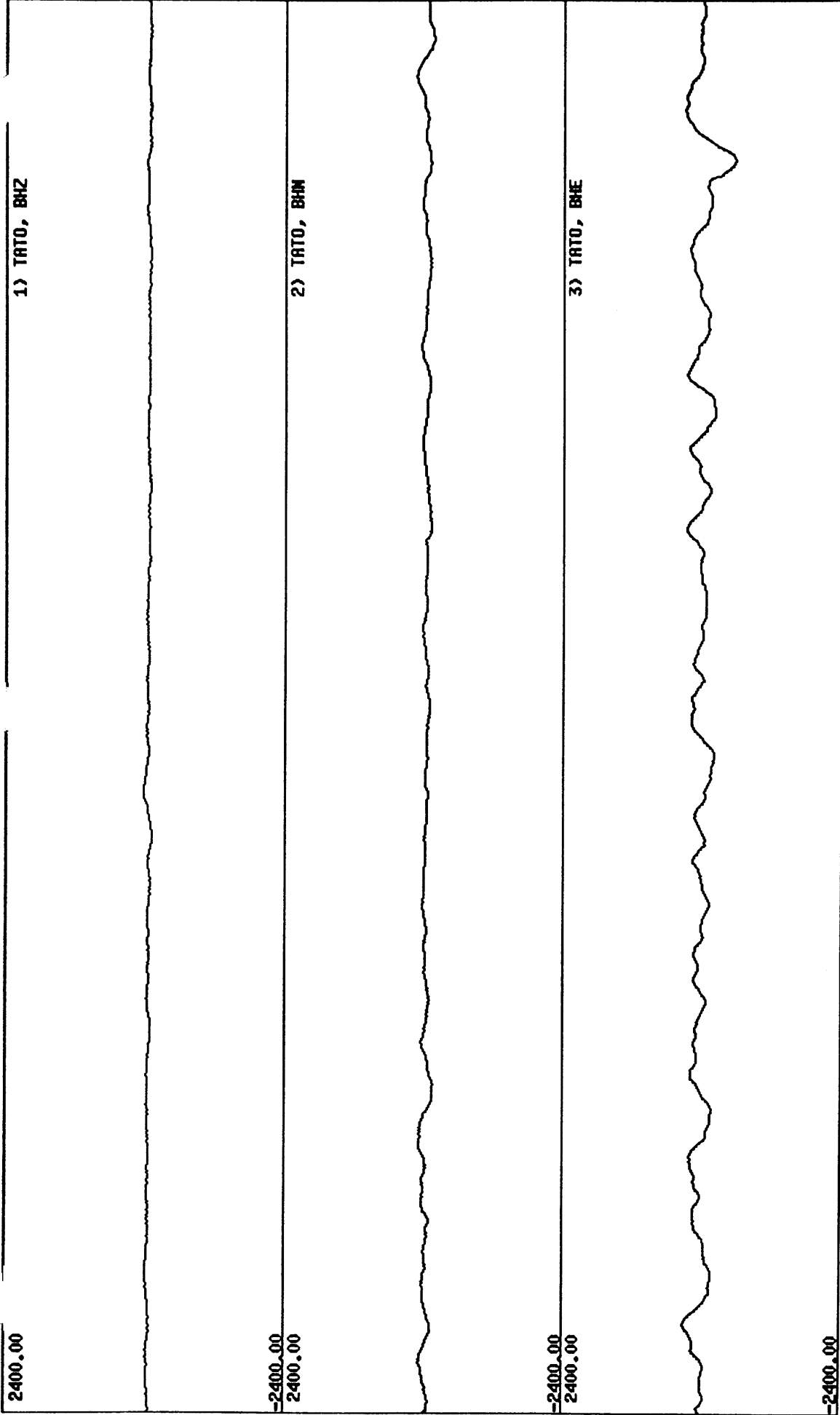
563.927

0. start time: 1998,096,17:09:40.302 Length: 1.5 hours (demean) (lp co 0.0500 n 4) 5432.

station: TATO channels: BHE BHN BHZ
filter options (1mlp, 2mhp, 3mbp): 1 .05 4
GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) xhair
A) next-plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T06: A) phases B) color C) mean	FLTR: A) lp B) bp C) dyo	LIN: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

2400.00
1) TATO, BHZ



-2400.00
2400.00
2) TATO, BHM

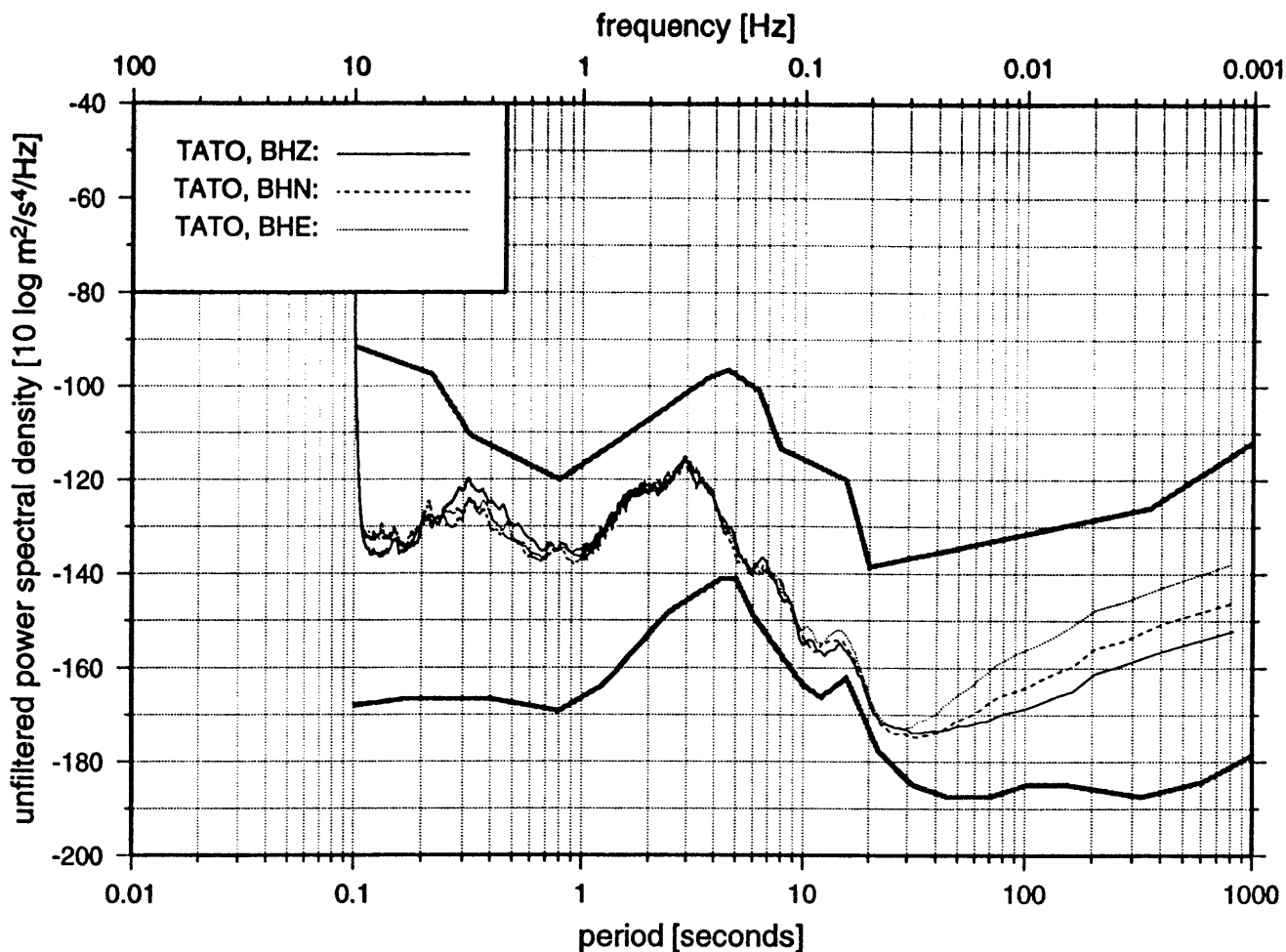
-2400.00
2400.00
3) TATO, BHE

0. start time: 1998,096,17:09:40.302 length: 1.5 hours (demean) (lp co 0.0500 n 4) 5432.

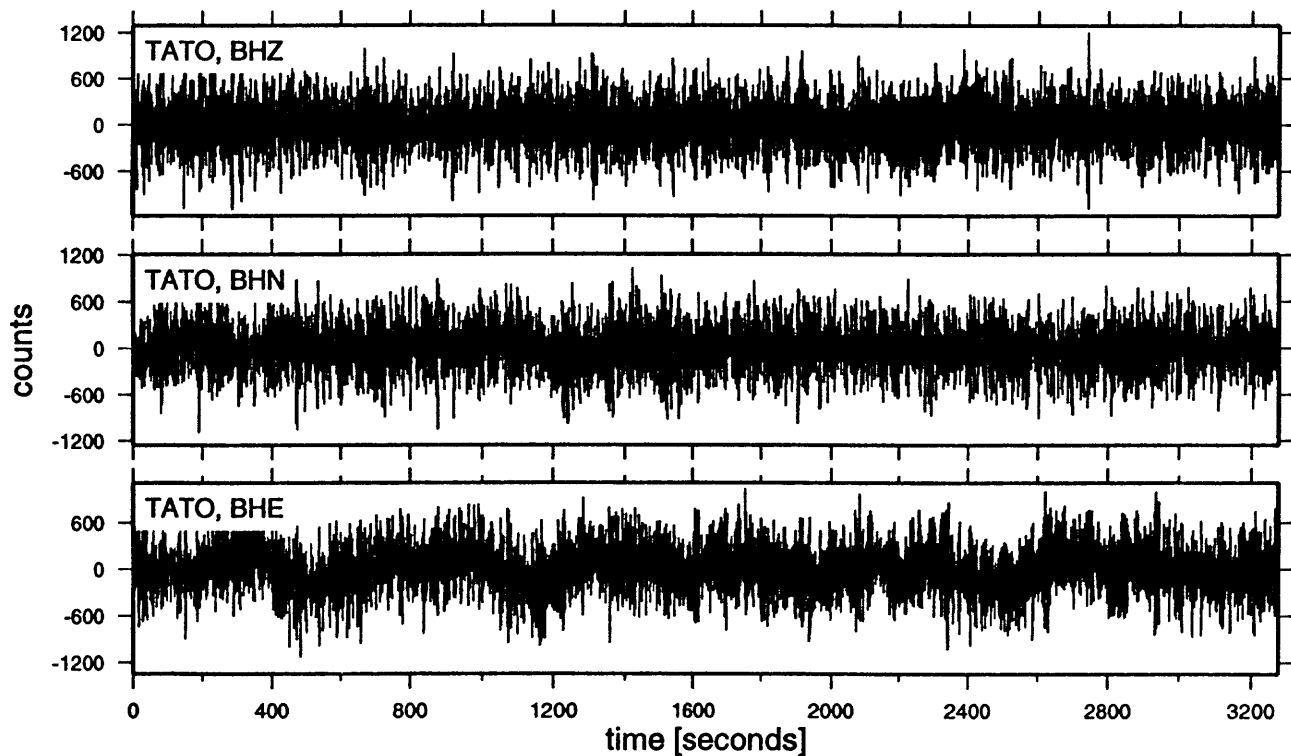
GFS file: tele.gfs
min and max (ret) for auto-scale) : -2400 2400
GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	DMP: A) SAC B) GFS C) ASCII	hardcopy	SCL: A) auto B) com C) whair
A) next+plot B) next C) back	quit	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T06: A) phases B) color C) mean	PHS: A) + B) - C) EQ ID	FLTR: A) lp B) bp C) dgy	LIN: A) xlin B) ylin

Seismic Spectra and Waveform Plot



Start time 1998,096,17:09:40.302

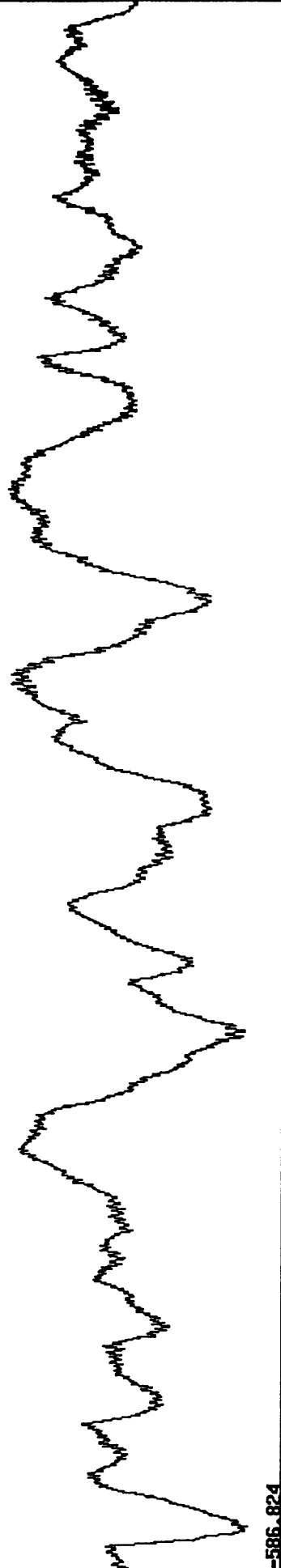


552.729

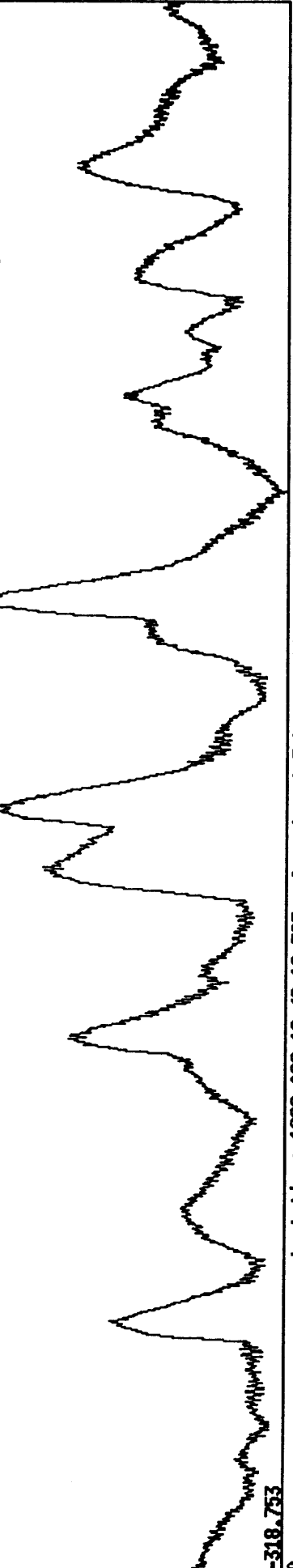
1) HKT, BHZ



2) HKT, BHN



3) HKT, BHE



5517.

start time: 1998,096,12:42:12.395 length: 1.5 hours (demean) (lp co 0.0500 n 4)

invalid range - try again
 filter options (1=lp, 2=hp, 3=bp): 1 .05 4
 GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) con C) xhair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T06: A) phases B) color C) mean	FLTR: A) lp B) bp C) dyo	LIM: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

2400.00

1) HKT, BHZ

-2400.00
2400.00

2) HKT, BHM

-2400.00
2400.00

3) HKT, BHE

-2400.00

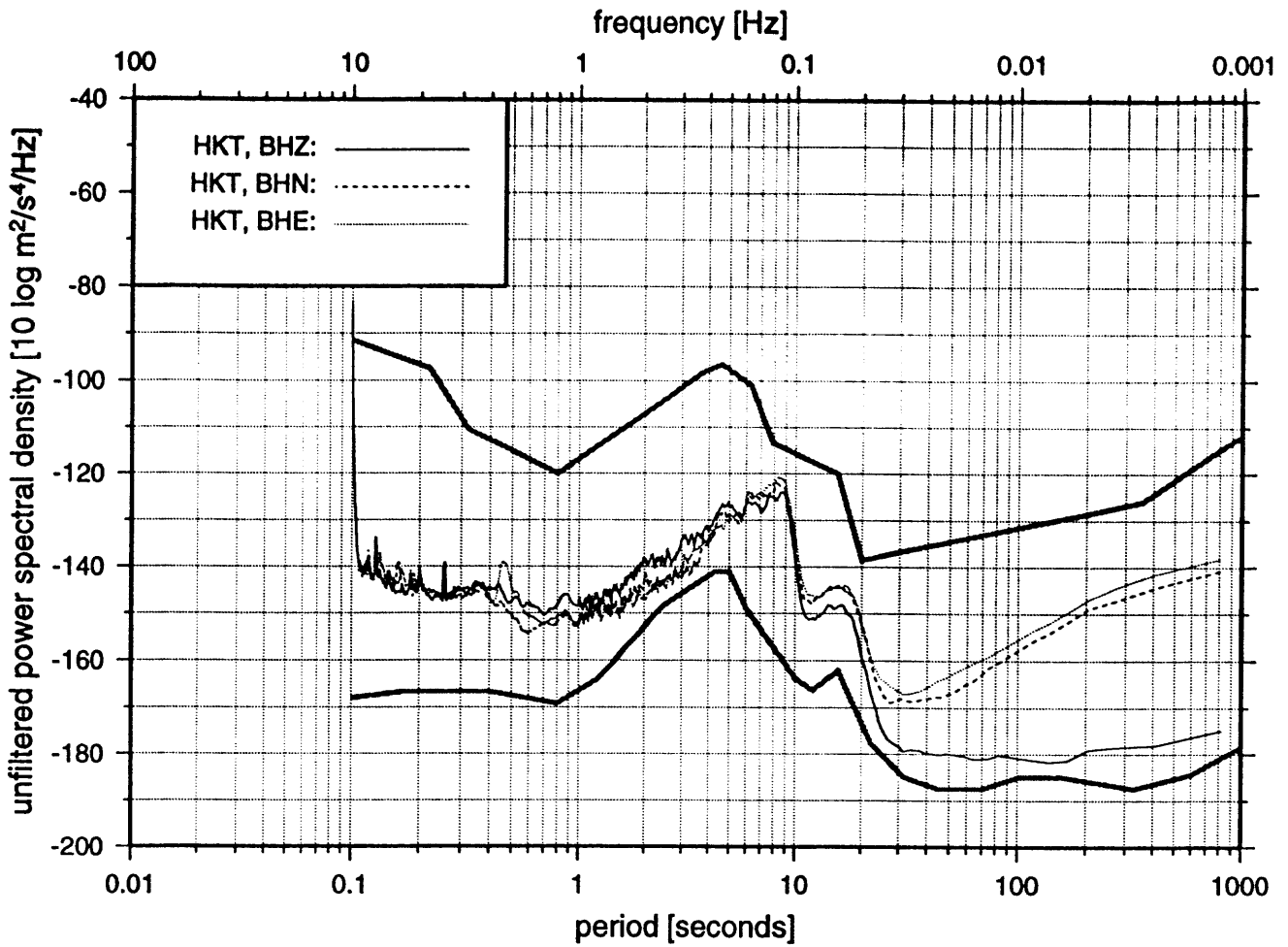
5517.

start time: 1998,096,12:42:12.395 length: 1.5 hours (demean) (lp co 0.0500 n 4)

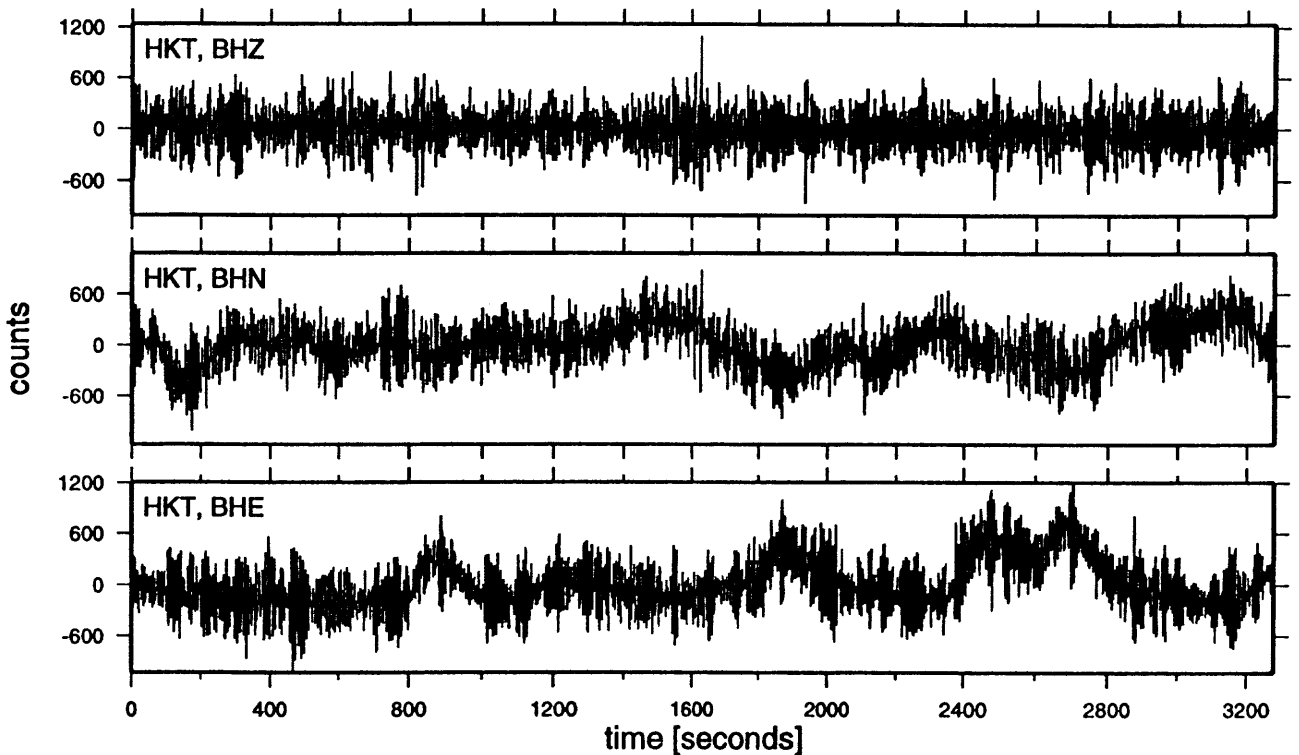
filter options (l=lp, 2=hp, 3=bp): 1 .05 4
min and max (<ret> for auto-scale) : -2400 2400
GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	DMP: A) SAC B) GFS C) ASCII	hardcopy	SCL: A) auto B) com C) whair
A) next+plot B) next C) back	quit	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
TOG: A) phases B) color C) mean	PHS: A) + B) - C) EQ ID	FLTR: A) lp B) bp C) djo	LIN: A) xlin B) ylin

Seismic Spectra and Waveform Plot



Start time 1998,096,12:42:12.395



414.322

1) ULN, BHZ



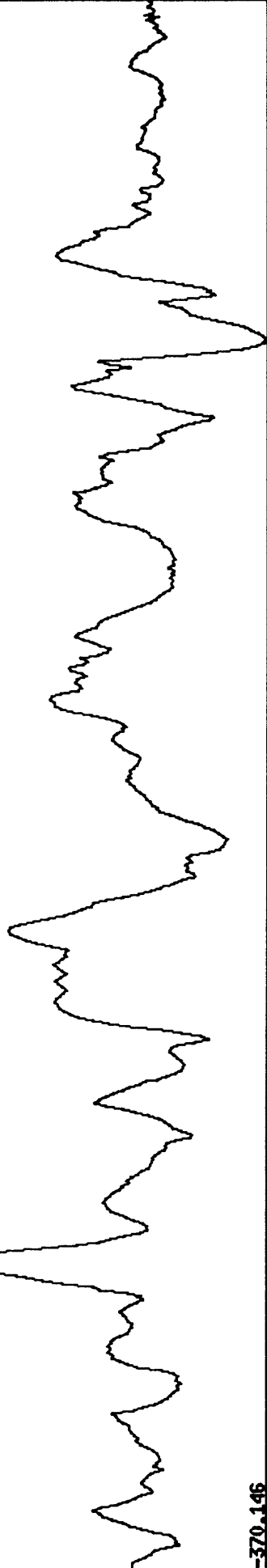
421.536
422.223

2) ULN, BHN



413.735
465.812

3) ULN, BHE



370.146

start time: 1998,096,06:29:21.136 length: 1.5 hours (lp co 0.0500 n 4)

5505.

station: ULN channels: BHE BHN BHZ
 filter options (1=lp, 2=hp, 3=bp): 1 .05 4
 GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	hardcopy	SCL: A) auto B) com C) whair
A) next+plot B) next C) back	A) offset B) ttpick C) delpick	A) PPH B) PSD C) RESP
TUG: A) phases B) color C) mean	FLTR: A) lp B) bp C) dyo	LIM: A) xlin B) ylin
DMP: A) SAC B) GFS C) ASCII		
quit		
PHS: A) + B) - C) EQ ID		

2400.00

1) ULM, BHZ

-2400.00

2400.00

2) ULM, BHN

-2400.00

2400.00

3) ULM, BHE

-2400.00

0.

start time: 1998,096,06:29:21.136 length: 1.5 hours (lp co 0.0500 n 4)

5505.

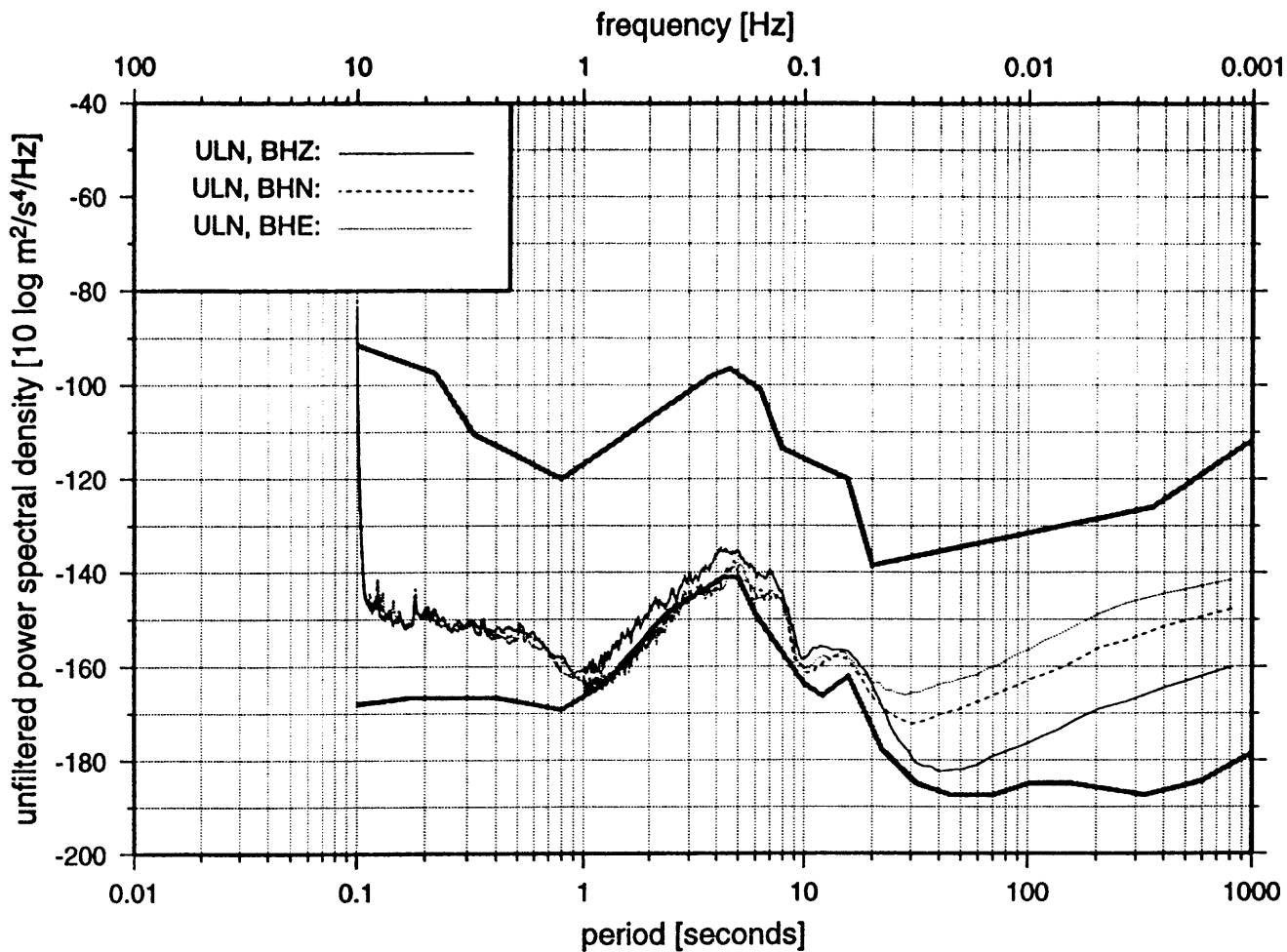
GFS file: tele.gfs

min and max (<ret> for auto-scale) : -2400 2400

GFS file: tele.gfs

PLT: A) plot B) sel C) ovr	DMP: A) SAC B) GFS C) ASCII	hardcopy	SCL: A) auto B) con C) xhair
A) next+plot B) next C) back	quit	A) offset B) ttpick C) delpick	A) PPM B) PSD C) RESP
T06: A) phases B) color C) mean	PHS: A) + B) - C) EQ ID	FLTR: A) lp B) bp C) dyo	LIM: A) xlin B) ylin

Selsmic Spectra and Waveform Plot



Start time 1998,096,06:29:21.136

