BSAP3

BAIKAL 1991 & 1992 SEISMIC ARRAY PROJECT
UNIVERSITY OF WISCONSIN

Submitted by:
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PASSCAL Data Report 94-010

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1991-92 Baikal Rift seismic experiment data report

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In the summer and autumn months of 1991 and 1992, the University of Wisconsin–Madison (UW), with the Institute of the Earth's Crust, Irkutsk, and the University of California, Los Angeles, conducted a seismic array field experiment across the Baikal rift zone in south-central Siberia. The experiment consisted of deploying portable digital seismographs in a combined linear profile and areal array with spacing spacing of 35-50 km (Figure 1). The seismographs were configured to record local, regional and teleseismic events using both continuous and triggered recording modes. The UW group operated 12 UW digital seismographs and 15 IRIS/PASSCAL RefTeks. Most instruments used 3-component 1-Hz geophones, although the UW group operated two broad-band STS2s during the 1992 field season.

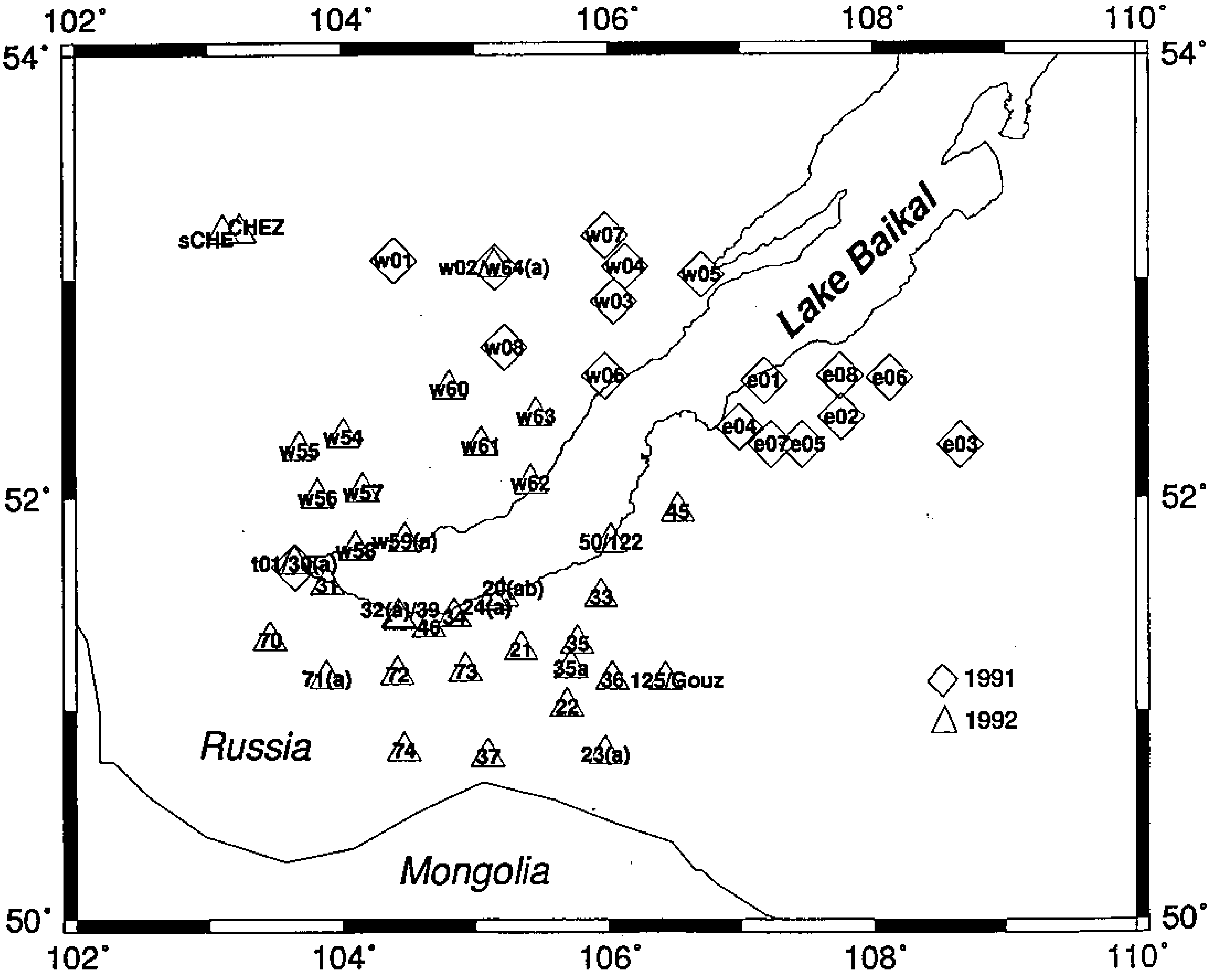
During the course of the two field seasons the UW group recorded over 20 Gb of seismic data. These data have now been completely post-processed and prepared for archiving with the Center for Seismic Studies (CSS) and the Incorporated Research Institutions for Seismology (IRIS) consortium. This report covers the station and data format information needed by other workers using to wish this dataset. The experimental plan and preliminary results have been presented to ARPA as technical reports dated February 1993 and March 1994.

1 IRIS/PASSCAL RefTek data

The RefTeks we used were model 72A-02 supplied by IRIS/PASSCAL and running operating system v2.46. A few instruments were upgraded to v2.47 during the season at stations recording STS2 data. The standard RefTek configuration is described below, but parameters were modified at different stations throughout the season. Significant changes in station operation are noted in the appendices or in the RefTek log files included on the data tapes. Note that the SEGY file name and file headers contain the serial number of the DAS (data acquisition system), which will not correspond to a physical location, e.g., DAS 108 was sited first at station 20 and then later moved to station 24.

The RefTek instrument response and geophone characteristics are also described in Appendix D.

UW-operated stations 1991-92



1.1 Standard RefTek parameters

Recording parameters:

stream 01: 10 sps continuous

stream 02: 50 sps triggered

Channels:

gain: 42db (× 128)

channel 1: vertical

channel 2: magnetic north (0 degrees)

channel 3: magnetic east (90 degrees)

Defense Mapping Agency maps show that the magnetic declination in this region is between 2 to 4 degrees west.

Calibration pulse sequence: 40 sec interval, 20 sec step length; 5.0V step size for S13 seismometers, 1.0V step size for HS10 seismometers.

Data form: 16 bit

Geophones: Several different models were deployed at our stations. The types and nominal characteristics are:

type	nat. period	damping	sensitivity
S13	0.8 Hz	0.7	400v/m/s
L4C	1.0 Hz	0.7	200v/m/s
L22	2.0 Hz	0.7	88 v/m/s (vert. down is positive)
HS10	see Wisconsin Data (Section 2) below		
STS2	see Appendix C		

The calibration sequence describes the signal through the calibration coils of the S13s and L4Cs and, by using a bridge cable, through the main coil of the HS10s. The calibration signals are step-type waveforms of the following form:

```
   ------
  |      |
  |      |       ------                     ------
  |      |      |      |                   |      |
  |      |______|      |______       ______|      |___ . . .
|                            |      |
| = amplitude                |______|
  |<--Interval->|
  |<step>|
```

Note that the initial positive voltage step is twice the specified amplitude but that it is not repeated.

Originally, the calibration sequence was scheduled to run every two days at 1500 UT but a bug in RefTek software caused data stream 1, the continuous recording, to be written as 60- to 180-second records rather than 1800-second records. This program was discontinued on the first service round and subsequently we performed the calibration sequence only on station visits. The approximate times of these calibration sequences are listed in the station data file (Appendix B).

Timing: All RefTek used Omega navigation system radio signals to phase lock the instrument clocks. The timing accuracy depended upon the station locking onto a station at least once a day. Periods where Omega signals were lost for more than 48 hours are noted in the station data file (Appendix B).

Important: All RefTeks were configured to use 16 as the number of leap seconds since 1960. A 17th leap second occurred at 2400 on 30 June, so all time reported for the RefTek SEGY data after that point is one second fast. Subtract one second from reported time to obtain universal time.

Broadband stations: The UW group operated two STS2s during the 1992 field season. These stations had the following operating parameters:

Station 36:

Channels 1-3: L22 2-hz seismometers (vertical down is positive). Gain = 54db (× 512)

Channels 4-6: STS2 broadband seismometer. Gain = 0db (× 1)

Stream 01:

Continuous 25 sps, 32-bit resolution, Channels 4-6 (Julian day 190-192).

Continuous 10 sps, 32-bit resolution, Channels 1,4-6 (Julian day 192-00:46 – 230-01:18), Channels 2,4-6 (230-01:18 – 256-03:17), Channels 1,4-6 (256-03:17 – end).

Stream 02:

Triggered 100 sps, 32-bit resolution, Channels 1-6 (Julian day 190-192), Channel 1-6 (256-03:25 – end).

Triggered 50 sps, 32-bit resolution, Channels 1-6 (192-00:46 – 207-04:47).

Triggered 200 sps, 32-bit resolution, Channel 1-6 (207:04:47 – 209-01:54).

Triggered 50 sps, 32-bit resolution, Channels 1-6 (209-01:54 – 256-03:25).

Stream 04:

Scheduled runs, 50 sps, 16-bit, 11100 second runs, Channel 4-6 (245-13:25, 246-13:25, 247-13:25, 248-13:25).

Scheduled runs, 50 sps, 16-bit, 4000 second runs, Channel 4-6 (256-14:25, 257-14:25).

The calibration sequence was set to initiate the STS2's recentering program every seven days.

Station 99: We installed this station near the northwestern end of Lake Baikal. After the first three days of recording, the sensor drifted off level. No useful data were recorded after Julian day 218.

Channels 4-6: STS2 broadband seismometer. Gain = 0 db (× 1).

Stream 01: Continuous 10 sps, 32-bit resolution

Stream 02: Triggered 50 sps, 32-bit resolution

The calibration sequence was set to initiate the seismometer's recentering program every three days.

2 Wisconsin digital seismograph data

During the 1991 and 1992 field seasons, we deployed twelve UW digital seismographs, an instrument designed and built at the UW Geophysical and Polar Research Center (GPRC). The seismographs recorded one 3-channel data stream at 50 sps in triggered mode. The records include 120 seconds of pretrigger data and a variable amount of posttrigger data. The posttrigger length depended upon the frequency content of the trigger signal, i.e., a low-frequency trigger had a 900-second post-trigger run so that most teleseismic phase arrivals would be recorded. Other trigger signals would record 240 seconds of post-trigger data.

Instrument timing used Omega navigation signals. Each seismic record also included the Omega signal, which was then used in postprocessing to evaluate the instrument clock drift and determine the correct time. This method requires a record of Omega several times per day, so if no trigger events had occurred within a six-hour period, the instrument would save a 60-second record.

2.1 Standard seismograph parameters

Most stations operated on a set of parameters that varied little for site to site. These parameters are discussed here, site variations are noted in the station information data file (Appendix B).

Sample rate: 50 samples/second

Band-pass filter:

2 poles of RC response hi-pass at 0.09 Hz

4 poles Butterworth response lo-pass at 12.5 Hz

Analog-digital converter: 50000 counts/volt

Timing: Omega navigation signals used to post-process instrument time. Record headers in results.cord files list start time, time standard deviation and correction applied to instrument time during post-processing

Geophones: Geospace HS-10, 1-Hz nominal natural frequency, 0.6 nominal damping, 1000-ohm coils, 7.4-kohm load resistance,
160 volts/meter/sec nominal sensitivity.

Calibration sequences: At 1500 UT every even Julian day, the instrument performed an automatic calibration sequence. The sequence started with calibration pulses of 1 microamp current steps applied and removed from the main coil through a Wheatstone bridge. Calibration sequence recording is contaminated by both the inductive component and DC component of bridge unbalance. The sequence of calibration pulses was followed by a pseudorandom signal.

2.2 UW data format

The UW data format uses headerless 32-bit integer data files for seismic data. Linking the data file to a start time and station site is accomplished by the directory structure and a suite of ASCII tables. For example, the station data recorded at one site, w55, would be stored under the following directory structure:

```
bkl92/
    w55/
        dp07v01.204/
                a0001/
                    raw-1
                    raw-2
                    raw-3
                    raw.w
                a0002/
                    raw-1
                    ...
                a0003/
                ...
                a0227/
                results.cord
                heads
                lengths
                times
                ...
        dp07v02.225/
        dp07v03.246/
    w56/
```

The directory tree above reflects the organization of UW data. In this example, 'w55' is the station, which recorded to a disk volume called dp07v01.204 (dp07=digital package 07; v01 = volume 1; 204 = volume opened Julian day 204). The volume has one directory (a001, a0002, ..., a0227) for each record, and each record directory has four traces, raw-1(vertical), raw-2(n-s), raw-3(e-w), raw.w(Omega). These files are headerless. All the information about start time, sample rate, record length and so on are contained in the other files in the volume directory, particularly the file 'results.cord'. These files are described on an attached sheet.

A description of these files is included in the man/ directory of the tarfile. You will need these files if you want to find records associated with particular events.

CONVERTING UW FORMAT TO SEGY FORMAT: This assumes you have tar'd in the UW volumes to a station directory. That is, you have a directory structure similar to the one outlined above. If you have not brought every record onto disk, then edit the 'results.cord' files to so it contains lines only for those records on disk. Then,

- Compile the files in the 'cluster' directory and the 'segy' directory.
- Make sure you are in the directory where the station directories are, e.g., the 'bkl92' directory in the directory tree above.
- Execute `dpclusprep Sta/Vol | dx2segy -`. This will create WJJJ directories containing the segy files.

2.3 1991 UW data

The UW group operated 13 seismographs in the Baikal region in 1991. The seismographs were still using a digital tape recording system with a 20-MB capacity, so the data volume from the first season is far less than for 1992. The data from the 1991 season are here included only as clustered event files both in SAC and UW format. All stations used HS-10 seismometers.

A Data tape contents

The following pages list the contents of the DAT cassettes by tar file. Each line lists the a) tar file number, b) tar file name as project-das#-station, c) approximate file start time, d) approximate file end time, and e) any comments or calibration sequence times.

The SEGY files comprising this dataset follow the standard PASSCAL naming conventions. The UW data files were tar'd from the station directory level.

```
::::::::::::::
tapeABC.0
::::::::::::::
0 bk192-380-das.s30      202:08.30         210:08.09 ch2=rev.polarity(jd185-210)
1 bk192-380-das.s30      210:08.29         223:05.36
2 bk192-380-das.s30      165:07.47         194:12.31       176:19  185:09
3 bk192-338-das.s30a     239:12.07         245:04.42
4 bk192-150-das.s31      200:23.30         210:04.37
5 bk192-150-das.s31      227:06.01         235:22.36
6 bk192-150-das.s31      248:13.29         248:13.29
7 bk192-150-das.s31      210:04.58         227:04.36
8 bk192-150-das.s31      248:14.05         261:22.42
9 bk192-150-das.s31      261:22.52         278:10.05
10 bk192-150-das.s31     165:13.09         198:05.03
11 bk192-145-das.s32     166:05.33         188:08.03       175:09  185:06
12 bk192-229-das.s33.0   192:09.36         209:11.04
13 bk192-229-das.s33.1   229:03.58         254:11.26
14 bk192-229-das.s33.2   254:11.36         276:23.24
15 bk192-229-das.s33.3   169:04.18         192:05.30
16 bk192-078-das.s34.0   194:08.33         210:02.30 ch4=vert-hs10;ch2,3=s13
17 bk192-078-das.s34.1   210:02.58         228:04.13
18 bk192-384-das.s35.0   192:05.59         209:07.27
19 bk192-384-das.s35.1   255:09.02         255:10.00
20 bk192-384-das.s35.2   229:07.06         250:19.47
21 bk192-384-das.s35.3   250:19.55         251:06.20
22 bk192-384.das.s35.4   169:10.14         192:05.30 180:20.00  189:04.00
23 bk192-384-das.s35a.0  255:02.58         271:10.46
24 bk192-384-das.s35a.1  271:11.16         277:02.49
25 bk192-114-das.s37     171:04.17         178:21.39
26 bk192-387-das.s70.0   181:03.06         209:07.55
27 bk192-387-das.s70.1   209:08.29         227:07.44
28 bk192-387-das.s70.2   227:08.41         256:06.31
::::::::::::::
tapeD.0
::::::::::::::
0 bk192-114-das.s37a.0   231:03.03         246:08.22
1 bk192-114-das.s37a.1   208:02.51         231:02.33
2 bk192-114-das.s37a.2   246:08.48         274:11.02
3 bk192-107-das.s36.0    192:00.47         207:07.30
4 bk192-107-das.s36.1    200:00.26         207:23.51
5 bk192-107-das.s36.2    230:01.29         247:23.59
6 bk192-107-das.s36.3    209:02.00         219:16.35
7 bk192-107-das.s36.4    256:03.17         265:22.58
8 bk192-107-das.s36.5    190:05.11         192:00.31
9 bk192-338-das.s71.0    181:04.04         227:06.42
::::::::::::::
tapeE.0
::::::::::::::
0 bk192-084-das.s71a     227:07.11         256:01.17
1 bk192-241-das.s72      181:05.38         227:03.43
2 bk192-241-das.s72      227:04.02         251:14.04
3 bk192-241-das.s72      209:05.29         227:03.43
4 bk192-241-das.s72      174:09.09         181:05.21
5 bk192-344-das.s73      181:06.45         227:02.55
6 bk192-344-das.s74      227:05.31         277:05.59
7 bk192-344-das.s73      205:12.43         227:02.55
8 bk192-344-das.s73      205:12.43         227:02.55
9 bk192-344-das.s73      174:07.28         176:08.13
10 bk192-338-st50        245:13.00         245:17.49
11 bk192-338-st50        246:03.39         248:01.13
```

```
12 bk192-078-das.s45.81 233:05.03       260:07.41
13 bk192-078-das.s45.81 260:08.48       273:08.0
14 bk192-372-das.s99    213:03.39       214:13.04
15 <<<empty file>>>
16 bk192-372-das.s99    214:13:30
17 bk192-235-s122       254:14.24
18 bk192-391-das.s125.0 259:02.39       259:11.14
19 bk192-338-das.sGOU.0 253:02.56       256:00.59
20 bk192-391-das.GOUZ.0 260:01.43
21 bk192-241-das.CHEZ.0 272:06.33       272:07.39
22 bk192-367-das.sCHE.0 262:04.24       262:07.00
::::::::::::::
tapeF.0
::::::::::::::
0 bk192-147-das.s20(a)  168:00.00       173:22.00
1 bk192-108-das.s20(b)  173:23.00       181:08.00       177:15  180:02
2 bk192-371-das.s21.0   181:08.23       209:02.30
3 bk192-371-das.s21.1   209:02.59       227:02.14
4 bk192-371-das.s21.2   227:02.31       263:22.37
5 bk192-371-das.s21.3   227:02.31       263:22.37
6 bk192-371-das.s21     174:05.00       177:05.00
7 bk192-375-das.s22.0   190:12.30       207:08.26
8 bk192-375-das.s22.1   230:05.58       256:08.30
9 bk192-375-das.s22.2   256:09.37       273:21.48
10 bk192-375-das.s22.3  172:07.57       189:04.45
11 bk192-391-das.s23.0  191:11.03       208:07.39
12 bk192-391-das.s23.1  230:10.01       258:06.10
13 bk192-391-das.s23    172:03.00       208:07.00
14 bk192-108-das.s23a.0 258:06.43       274:08.06
15 bk192-108-das.s24.0  193:13.29       210:01.03
16 bk192-108-das.s24.1  210:01.29       214:06.30
17 <<<empty file>>>
18 bk192-108-das.s24    187:03.00       193:09.00
19 bk192-380-das.s24a.0 228:10.48       229:12.11 calibration left on
20 bk192-380-das.s24a.1 233:10.32       242:14.37
21 bk192-380-das.s24a.2 253:09.29       261:03.27
22 bk192-380-das.s24a.3 261:04.39       278:03.28
::::::::::::::
tapeG.0
::::::::::::::
0 bk192-w54-vol         204     225
1 bk192-w54-vol         225     246
2 bk192-w54-vol         246     end
3 bk192-w55-vol         203     224
4 bk192-w55-vol         224     246
5 bk192-w55-vol         246     end
6 bk192-w56-vol         202     203
7 bk192-w56-vol         203     224     not complete
8 bk192-w56-vol         224     247
9 bk192-w56-vol         247     end
10 bk192-w56-vol        203     224
11 bk192-w57-vol        202     224
12 bk192-w57-vol        224     247
13 bk192-w57-vol        247     end
14 bk192-w58-vol        199     218
15 bk192-w58-vol        218     251
16 bk192-w58-vol        271     275
17 bk192-w58-vol        251     271
18 bk192-w59-vol        198     218
::::::::::::::
```

```
tapeH.0
::::::::::::::
0 bk192-w59a-vol        218     251
1 bk192-w59a-vol        251     end
2 bk192-w60-vol         189     206
3 bk192-w60-vol         189     189
4 bk192-w60-vol         206     259
5 bk192-w60-vol         259     end
6 bk192-w61-vol         189     189
7 bk192-w61-vol         189     189
8 bk192-w61-vol         189     206
9 bk192-w61-vol         206
10 bk192-w62-vol        190     190
11 bk192-w62-vol        190     207
12 bk192-w62-vol        207     238
13 bk192-w62-vol        238
14 bk192-w63-vol        190     190
15 bk192-w63-vol        190     207
16 bk192-w63-vol        207     238
17 bk192-w63-vol        238     248
18 bk192-w63-vol        248     end
19 bk192-w64-vol        191     237
20 bk192-w64a-vol       237     259
21 bk192-w64a-vol       259     end
22 bk192-32a-vol        250     277
::::::::::::::
tapeI
::::::::::::::
0       ./91.station.locations  #useful files for working with this dataset
        ./92.station.locations
        ./Logs
        ./bin
        ./inc
        ./man
        ./src
        ./tape.contents
        ./uw91.catalog
        ./uw92.catalog
1       bk191-uw-clusters       #uw data in cluster directories for 384 events
2       bk191-uw-clusters       #uw data in cluster directories for 384 events
3       bk191-uw-clusters       #uw data in cluster directories for 384 events
4       uw-bk191-sac-files      #UW data in SAC format
5       uw-bk191-sac-files      #UW data in SAC format
6       uw-bk191-sac-files      #UW data in SAC format
```

B Station locations

The station information below is also included in the data tapes as ascii data files. See Appendix A.

```
Mar 22 17:48 1994  91.station.locations Page 1


e01    52.5369  107.180  580
e02    52.3699  107.759  632
e03    52.2413  108.654  645
e04    52.3246  106.986  762
e05    52.2452  107.463  718
e06    52.5486  108.120  543
e07    52.2463  107.231  644
e08    52.5593  107.751  850
w01    53.0891  104.386  634
w02    53.0576  105.146  751
w03    52.8997  106.040  761
w04    53.0621  106.128  784
w06    52.5588  105.977  886
w05    53.0246  106.701  619
w07    53.2025  105.973  693
w08    52.6895  105.217  664
t01    51.6803  103.644  560
```

```
# Baikal 1992 UW Station Locations and Spans
# 13 October 1993 -- P. Burkholder
# This file replaces all previous station location and das siting
# reports.  Normally, any das's file from a ondate or offdate can be from
# only one location, with the following exceptions:
#       das 0384 pulled from s35 255:03:00; put in s35a at 255:05:00
#       das 0344 pulled from s73 227:03:02; put in s74 at 227:05:32
#       das 0145 pulled from s32 186:08:09; put in s39 at 186:09:43
# uw stations were not renamed when siesmographs were swapped.
# format: station lat lon elev das ondate offdate comment
20a 51.542653 105.195007 470 0147 168 173 s13
20b 51.542653 105.195007 470 0108 173 187 s13
21 51.292168 105.339417 1632 0371 174 277 hs10
22 51.021307 105.682067 1057 0375 170 275 hs10
23 50.790800 105.969607 1022 0391 172 258 hs10
23a 50.790800 105.969607 1022 0108 257 274 hs10
24 51.526113 105.121362 467 0108 187 228 s13
24a 51.526113 105.121362 467 0380 228 278 hs10
30 51.697944 103.643444 580 0380 164 223 hs10 ch2=rev.polarity
30a 51.697944 103.643444 580 0338 239 245 hs10
31 51.597772 103.887408 509 0150 165 278 hs10
32 51.434890 104.428267 580 0145 166 186 hs10
32a 51.434890 104.428267 580 dp13 250 278 hs10
33 51.541248 105.942382 1049 0229 169 277 hs10
34 51.447083 104.838648 541 0078 194 228 s13+hs10
35 51.320218 105.760572 1004 0384 169 255 hs10
35a 51.203848 105.713750 689 0384 255 277 hs10
36 51.148583 106.025767 801 0107 190 275 sts2+122
37 50.779817 105.088483 1304 0114 171 274 hs10
39 51.443932 104.416542 618 0145 186 20 hs10
45 51.939642 106.520545 560 0078 233 273 s13

46 51.398025 104.646892 423 0148 000 000  hs10
50 51.7986   106.0146  465 0338 245 248 hs10

70 51.336147 103.458372 1878 0387 181 269 l4c ch2,3 azimuth=12deg,102deg
71 51.153425 103.877400 1922 0338 181 227 l4c
71a 51.153425 103.877400 1922 0084 227 269 l4c
72 51.172673 104.407690 1895 0241 174 269 l4c
73 51.188933 104.922362 1835 0344 174 227 l4c
74 50.808360 104.459448 1828 0344 227 277 l4c
99 56.288697 113.354933 888  0372 213 214 sts2

122 51.7986   106.0146  465 0235 254 257 hs4/122 ch2=rev. polarity
125 51.1471   106.423 536 0391 259 259 hs10
sGOU 51.1471  106.423 536 0338 253 256 122 Pereval?
GOUZ 51.1471  106.423 536 0391 259 259 hs10
sCHE 53.2105 103.109 546 0367 262 262 hs10 Omega+GPS-location
CHEZ 53.2152 103.238 518 0241 272 272 l4c assuming-2nd-location
```

```
w54 52.278970 104.013718 524 dp07 202 273 hs10
w55 52.219125 103.684480 700 dp10 203 273 hs10 ch2=rev.polarity
w56 52.00258  103.817958 685 dp01 202 272 hs10
w57 52.029007 104.154783 663 dp06 202 272 hs10
w58 51.760643 104.098532 527 dp12 199 275 hs10
w59 51.800987 104.464668 470 dp13 198 218 hs10
```

```
Mar 28 12:15 1994  92.station.locations Page 2


w59a 51.800987 104.464668 470 dp13 218 275 hs10
w60 52.497955 104.805197 694 dp08 189 279 hs10
w61 52.239380 105.042597 848 dp02 189 280 hs10 ch1=rev.polarity
w62 52.068897 105.412855 559 dp14 190 281 hs10
w63 52.374677 105.452350 601 dp15 190 281 hs10
w64 53.058072 105.143350 628 dp11 190 206 hs10
w64a 53.058072 105.143350 628 dp04 206 279 hs10
```

C Streckeisen STS2 broadband seismometer specifications

8) SPECIFICATIONS

8)1) General

Principle of operation	Force Balance
Mechanical sensors	3 identical inertial pendula in a cube-corner geometry. The mechanical free period is virtually infinite.
Seismic output signals	2 horizontal (X, Y) and vertical (Z) Broad-band velocity response
Size	Cylindrical package 235 mm dia., 260 mm high
Weight, complete with "host-box"	13 kg
Environmental protection	Vacuum-tight, low-stress construction

8)2) Electro-mechanical

Generator constant	2 * 750 Vsec/m
Response	Ground velocity between corners 8.33 mHz (120 sec) and >50 Hz. See section 9 for details.
Seismic signal output	+- 20 V differential range, 100 ohms serial resistance per line
Auxiliary outputs	+- 10 V single-ended, 100 ohms serial
Electronic self-noise	approx. 6 dB below USGS low-noise model between 8.33 mHz and 10 Hz
Clip level	+- 13 mm/sec ground velocity equivalent to the following accelerations: g peak-peak — at Hz 0.17 — 10 0.017 — 1 0.0017 — 0.1 0.00055 — 0.03
Dynamic range	see figure "STS2 SEISMOMETER NOISE AND CLIP LEVEL"
Parasitic resonances	vertical: >140 Hz, horizontal: >80 Hz
Power	< 1.8 W at 10 - 30 V DC, galvanically isolated
Control inputs (REMOTE connector)	"high": 3 - 30 V, 0.5 mA; "low": < 0.5 V; optically isolated

Calibration inputs	Calibration coils 30 Ohms each, approx. 0.002 g / mA (oblique), maximal current 50 mA each
Temperature range	+- 10 C without mass recentering
Mass centering	automatic on external command

9) RESPONSE

(See figures "STS2 VELOCITY RESPONSE" and "STS2 PHASE RESPONSE")

a) frequencies below 1 Hz

At low frequencies the STS-2 seismometer may simply be considered as a long-period, velocity-transducer, three-component seismometer with a free period of 120 sec and damping 0.707 of critical. These parameters are factory-adjusted to within 1 percent. The response of the seismometer to ground displacement at frequency f is described by the transfer function

T(f) = 2*pi*i*f*S / (1 - 2*i*f0*h/f - (f0/f)**2)

where

S = generator constant, 1500 V sec / m
f0 = corner frequency, 0.00833 Hz
h = fraction of critical damping, 0.707

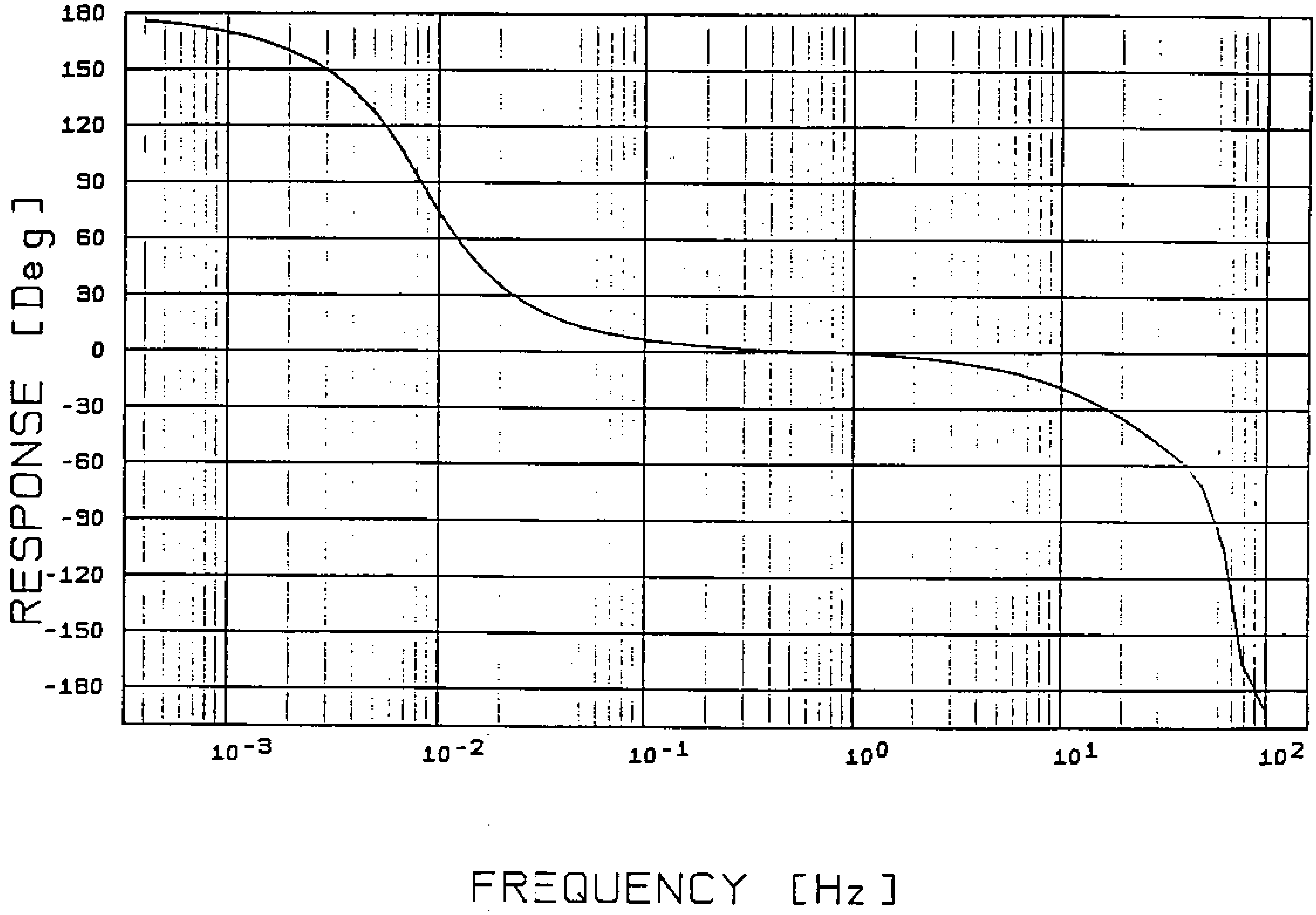
b) frequencies between 1 and 10 Hz

Between 1 and 10 Hz, the velocity response of the STS-2 is flat within +- 0.15 dB (about +- 1.5 % in amplitude). The group delay time in this frequency range is nearly constant, about 4 +- 1 msec.

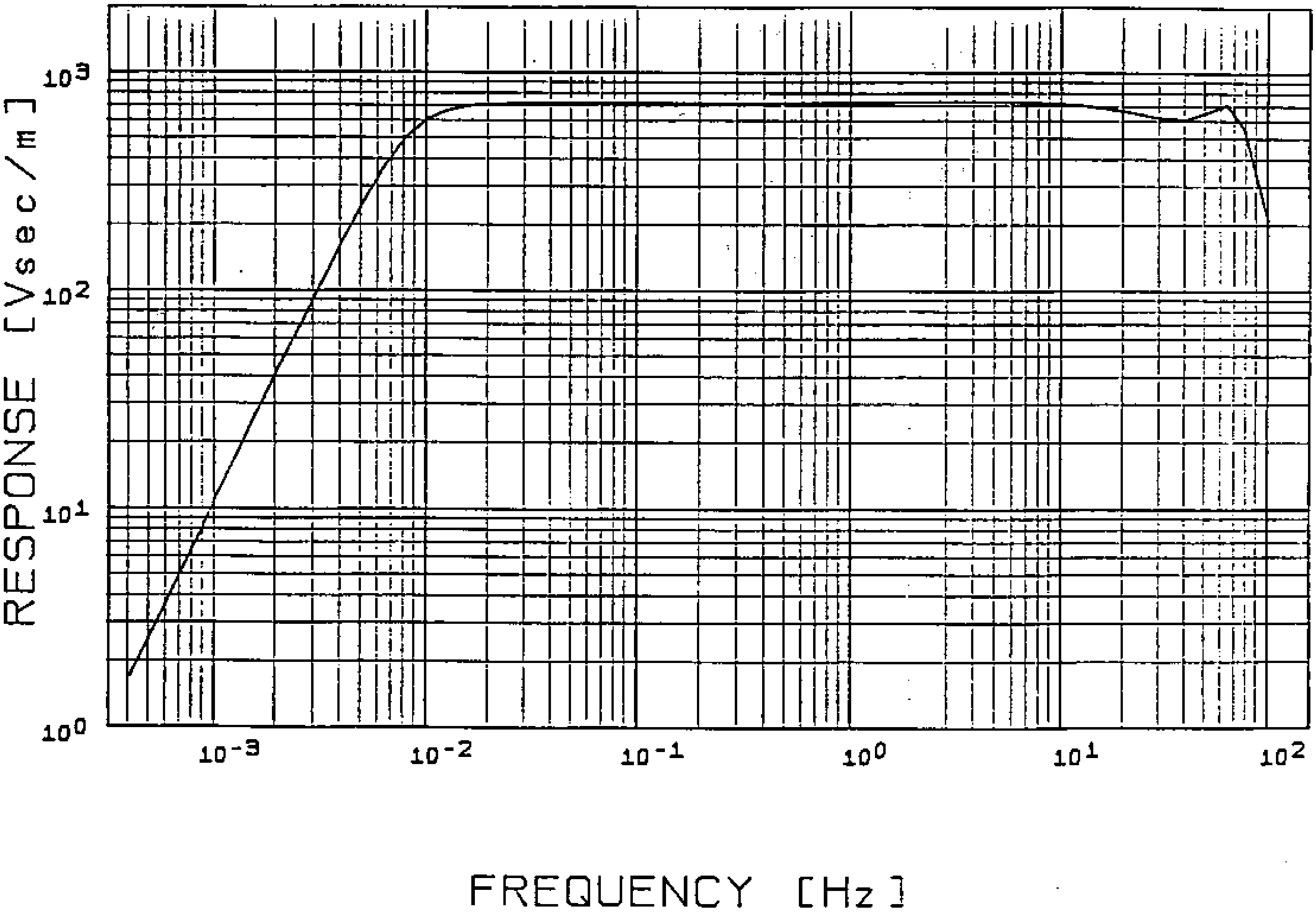
c) frequencies above 10 Hz

The flat velocity response of the STS-2 extends somewhat beyond 50 Hz. However, the overall response at high frequencies depends not only on the seimometer but also on its coupling to the ground. While coupling may influence the amplitude and the phase of the transfer function noticeably, its influence on the signal delay time is small. The group delay time observed on a shake table is a nearly constant 3 +-1 msec at frequencies between 10 and 50 Hz. The amplitude response may be expected to be constant within +- 1.5 dB (15 % in amplitude).

STS2 PHASE RESPONSE



STS2 VELOCITY RESPONSE



D Reftek characteristics

PASSCAL Data Acquisition System Response

PASSCAL data acquisition system uses only one analog filter, a six pole Butterworth lowpass filter at 250 Hz. This filter is the only filter used when the sample rate is 1000 samples per second. For sample rates below 1000 samples per second digital finite impulse response (FIR) filters are used to prevent aliasing. The FIR filters are all zero phase filters, therefore most of the phase introduced into the signal will be due to the Butterworth filter.

The transfer function for a normalized 6 pole Butterworth filter is given by:

$$H(s) = \frac{1}{\prod_{k=1}^{k=6} (s-s_k)}$$

where

$$s_k = e^{i\pi(\frac{1}{2}+\frac{(2k-1)}{12})} \qquad k=1,2,..,6$$

Converting the normalized $\omega=1$ to a cutoff of $\omega_c=250\pi$ we get:

$$H(s) = \frac{\omega_c{}^6}{\prod_{k=1}^{k=6}(s-\omega_c s_k)}$$

The poles for this function are located at:

$$s = -406.55 \pm 1517.27i$$

$$s = -1110.72 \pm 1110.72i$$

$$s = -1517.22 \pm 406.55i$$

The numerator constant is equal to:

$$k = 1.5022E+19$$

Data Acquisition System transfer function

The Reftek data acquisition system uses only 1 analog filter, a 6 pole Butterworth lowpass filter at 250 Hz. Anti-alias filtering is done digitally using FIR filters.

Here is the transfer function for a 6 pole Butterworth lowpass filter:

$$T(s) = \frac{1}{s^6 + 3.864s^5 + 7.464s^4 + 9.141s^3 + 7.464s^2 + 3.864s + 1}$$

The denominator can be expressed in factored form:

$$T(s) = \frac{1}{(s^2 + .5176s + 1)(s^2 + 1.4142s + 1)(s^2 + 1.9318s + 1)}$$

Converting the normalized $(\omega = 1)$ transfer function to the cutoff frequency of the filter, ω_c, we get:

$$\frac{1}{(s^2 + .5176\,\omega_c s + \omega_c^2)(s^2 + 1.4142\,\omega_c s + \omega_c^2)(s^2 + 1.9318\,\omega_c s + \omega_c^2)}$$

Solving for the roots, with $\omega_c = 2\pi \cdot 250\text{Hz} = 1.57079 \times 10^3$, gives the poles:

$$\frac{-813.0 \pm \sqrt{661035 - 9869524}}{2}$$

$$= \frac{-813.0 \pm 3034.5i}{2}$$

$$= \boxed{-406.5 \pm 1517.2i}$$

D2

$$\frac{-2221.4 \pm \sqrt{4934667 - 9869524}}{2}$$

$$= \frac{-2221.4 \pm 2221.4}{2}$$

$$= \boxed{-1110.7 \pm 1110.7i}$$

$$\frac{-3034.4 \pm \sqrt{9207899 - 9869524}}{2}$$

$$= \frac{-3034.4 \pm 813.4i}{2}$$

$$= \boxed{-1517.2 \pm 406.7i}$$

To summarize, the 6 poles of the Reftek 250 Hz lowpass filter are:

Re	Im
−406.5	1517.2
−406.5	−1517.2
−1110.7	1110.7
−1110.7	−1110.7
−1517.2	406.7
−1517.2	−406.7

E UW digital seismograph characteristics

To: Wisconsin digital seismograph operators
From: Lee Powell
Date: June 30 1985
Revised: June 20 1991
Subject: Instrument configuration operation and options

Theory of operation

Sample rate, delay memory size, trigger source, and trigger averaging times and attenuation are parameters which can be configured through the keyboard of the instrument. The configuration is recorded on the tape along with the instrument serial number, and the settings of the gain (GSW) and the trigger ratio (TSW).

In the following discussion I refer to register digit [ba98]. These hex numbers come from to old microprocessor keyboard system. The new microprocessor has a format of:

```
CONFIG: sn ba 98 gt
        |  || || ||__trigger ratio
        |  || || |___gain
        |  || ||_____digit #8 sample rate
        |  || |______digit #9 delay memory
        |  ||________digit #a trigger source
        |  |_________digit #b trigger atten & time constant
        |____________Instrument serial number
```

Use: $ba98 CONFIG! to set the config digits to the desired values.
i.e. $2983 CONFIG! for tele trig 25 sps

Configuration options available

Configuration register digit 8: conversion rate control

KEY	RATE	TAPE SPEED	ALIAS FILTER
0	100	15/16	24
1			
2			
3	25	15/64	6
4	50	15/32	12
5	100	15/16	24
6	200	1-7/8	48
7	400	3-3/4	96
8-f	repeats the above pattern with a single channel ADC scan distributed on the four tape tracks.		

Configuration digit 9: pre-event delay and recording mode

number of ADC inputs scanned

pre-event delay	4 channel		8 channel	
512 samples	0	1	2	3
1024 samples	4	5	6	7
2048 samples	8	9	a	b
no delay	c	d	e	f
	on	off	on	off

error correction recording

KEY

Configuration digit A: trigger source with four channel ADC scan

KEY	ADC CHANNEL	SOURCE
0 - 7	1	Vertical phone
8	2	In-line phone
9	0	Tele-trigger filter
a	3	Transverse phone
b	1	Vertical phone

Configuration digit B: trigger time constant and attenuation

LTA time constant in seconds

trigger attenuator	5	10	20	40
0 db	0	1	2	3
-6db	4	5	6	7
-12db	8	9	a	b
trigger off	c	d	e	f
	2.5	5	5	5

STA time constant in seconds

KEY

Station configuration

```
                  _______________> g digit    db gain
                 |                    0        66
                 |                    1        60
                 |                    2        54
                 |                    3        48
                 |                    4        42
                 |                    5        36
                 |                    6        30
                 |                    7        24
        snba98gt
---------------------
e01t01  14698345
e01t02  02698345
e02t01  11698345
e02t02  11698335
e03t01  12698345
e03t02  12698335
e04t01  14698345
e05t01  15698345
e06t01  13698345
e06t03  13698325
e07t01  14698325
t01t01  13698335
t01t02  13698335
w01t01  07698335
w01t02  07698345
w01t03  07698335
w02t01  01698335
w02t02  01698336
w02t04  01698336
w03t01  08698345
w03t02  08698345
w03t03  08698335
w03t04  08698325
w04t01  04698345
w04t02  04698345
w05t01  10698335
w05t02  10698335
w06t01  03698335
w06t02  03698335
w06t03  03698325
```

E3