U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

DATA REPORT FOR A SEISMIC REFRACTION/ WIDE-ANGLE REFLECTION INVESTIGATION OF THE ATLANTIC COASTAL PLAIN IN SOUTH CAROLINA

By

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OPEN-FILE REPORT 92-723

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[1] Menlo Park, CA

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Introduction

In April, 1991, the U.S. Geological Survey (USGS), in collaboration with the Department of Energy (DOE) and Savannah River Site (SRS), conducted a seismic refraction/wide angle reflection experiment in the Atlantic Coastal Plain region of South Carolina. The profile line extended east from New Ellenton, SC to Walterboro, SC crossing a region characterized by early Mesozoic rifting and sedimentation associated with the opening of the Atlantic Ocean. Portable vertical seismographs were located along this line at intervals of 1000 m. Portable horizontal seismographs were co-located with every second vertical seismograph along this line at intervals of 2000 m. Five shotpoints were located at intervals of 30 km.

This report is a compilation of the data collected by the USGS. The data have been archived at the National Geophysical Data Center in Boulder, Colorado. Tapes are available from:

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
325 Broadway
Boulder, CO 80303
(303) 497-6472

Appendix B contains a description of the tape format. Interpretations of these data will be published separately.

Geology

The seismic refraction/wide-angle reflection profile is located on the Atlantic Coastal Plain of South Carolina (Figure 1). At this latitude, the Coastal Plain is about 200 km wide with a NE-SW strike along the coast. To the northwest is the Appalachian Fold Belt. To the southeast there exist two offshore parallel belts, the Carolina Platform and Carolina Trough which form the transitional zone between the North American Continent and the Atlantic Ocean.

The Atlantic Coastal Plain is covered by Mesozoic and younger marine deposits, which lie unconformably upon Jurassic basement. The basement surface generally dips gently to the southeast. Figure 2 shows the contours of the basement surface (Maher, 1971). Along the profile, the upper sedimentary layer is 300-800 meters thick.

Seismicity

Moderate seismicity occurs in many parts of South Carolina. In the Piedmont and Upper Atlantic Coastal Plain, localized reservoir-induced seismicity is superimposed on a diffuse lower frequency background. In contrast, moderate seismicity in the middle and lower Coastal Plain region occurs within discrete seismogenic zones. The Coastal Plain region of South Carolina is important, since evidence for historic and prehistoric large earthquakes is now available. The most recent large earthquake is the 1886 event near Charleston (M = 7.6).

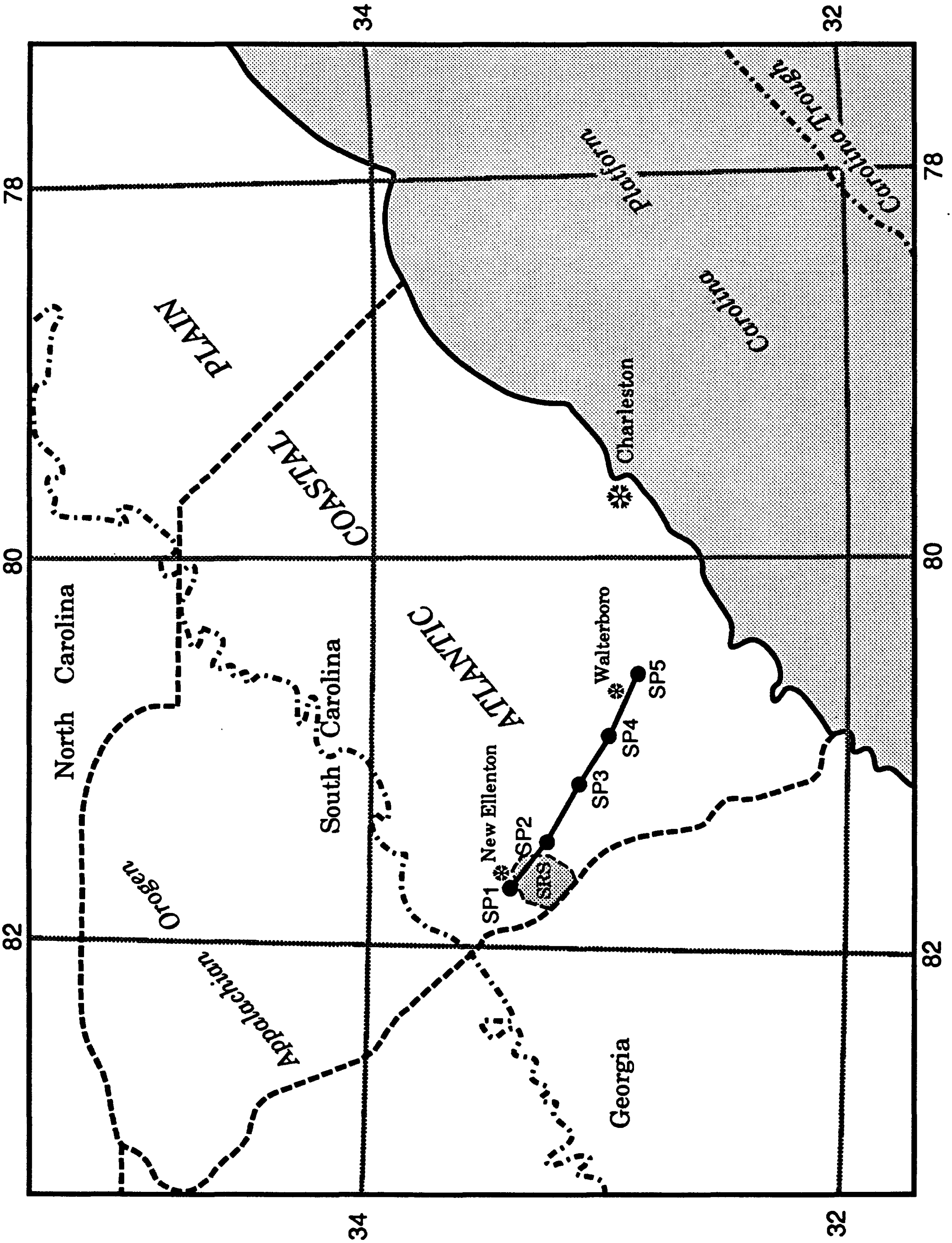

34
32
78
80
82
North Carolina
South Carolina
Georgia
Appalachian Orogen
ATLANTIC COASTAL PLAIN
Carolina Platform
Carolina Trough
Charleston
Walterboro
New Ellenton
SRS
SP1
SP2
SP3
SP4
SP5
0 50 100 km

Figure 1.

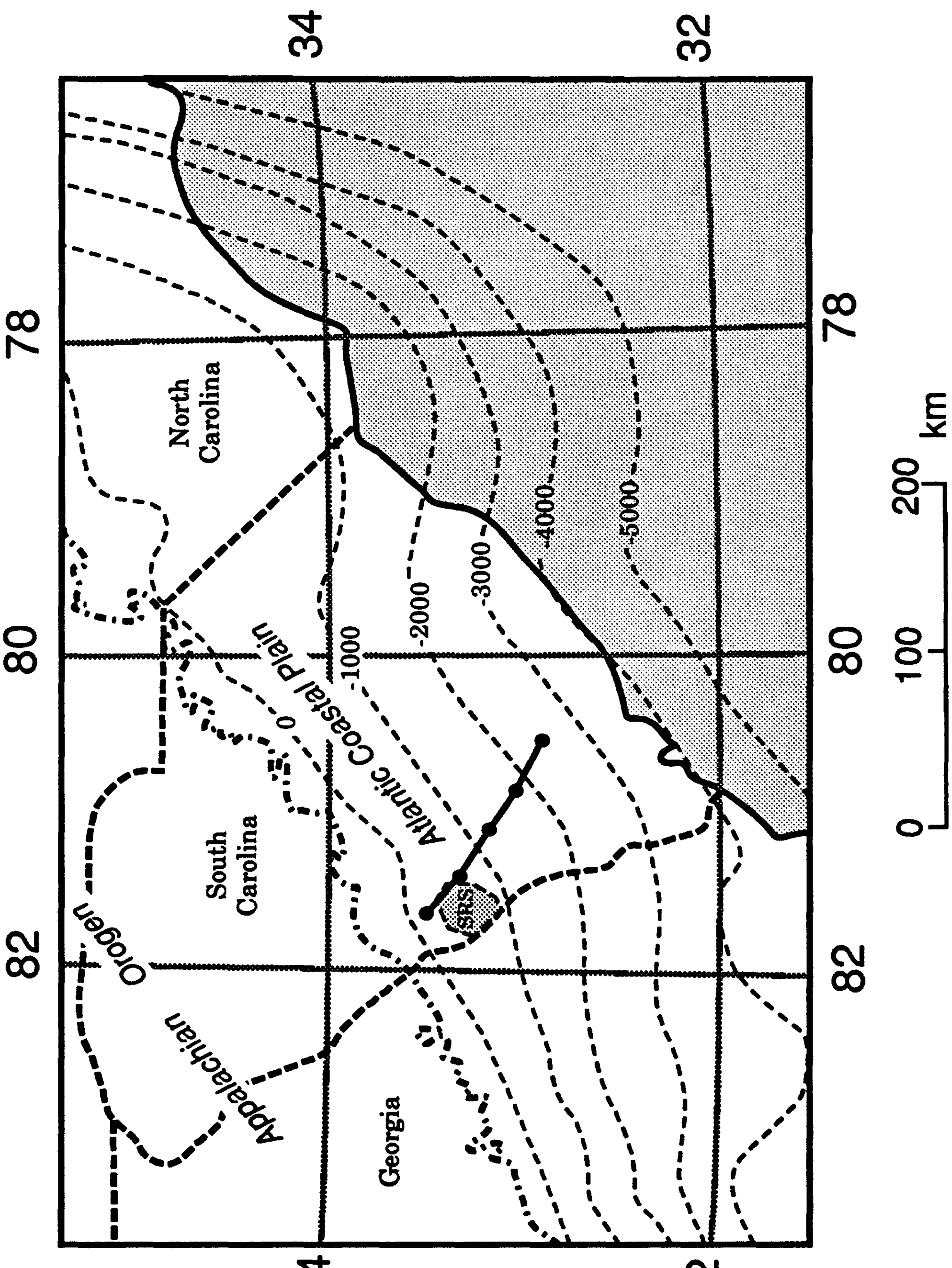


Figure 2 - Inferred contours of the basement surface in feet beneath the Coastal Plain. After Maher, 1971.

Geophysics

The tectonic framework below the Coastal Plain sediments has been studied by a number of geophysical surveys carried out over the last several years. Earlier refraction studies by Bonini and Woollard (1960) provided information about the P-wave velocities in the basement. Reinterpretation of these data by Daniels (1974) suggested the presence of granite, mafic gneiss/schist, Triassic sediments, and basalts where Bonini and Woollard interpreted the Carolina slate belt rocks. Seismic refraction and reflection studies in the area of Charleston, SC, (*e.g.* Ackermann, 1983; Hamilton, *et al.*, 1983) provide information about the seismic velocities and structures in the post-Jurassic upper crust. Interpretation of COCORP seismic reflection data by Cook *et al.*, (1981) argues that the lower Paleozoic decollement continues below the Coastal Plain sediments.

Well data within the SRS and surrounding regions provide additional constraints on the velocities and lithologies of the basement rocks, wherever encountered. Regional gravity and aeromagnetic studies in the region (Popenoe and Zietz, 1977, Daniels and Zietz, 1978, and Daniels *et al.*, 1983) identified long wavelength anomalies which are caused by Mesozoic and older rocks below the coastal plain sediments.

Description of the Survey

Portable seismic recorders were laid out along the profile in a continuous linear pattern (Figure 1). Five shots were fired at 5 locations along the profile (shotpoints 1-5) (Table 1).

Instruments with vertical sensors were placed at a nominal spacing of 1000 meters. In addition, an instrument with a transverse horizontal sensor was co-located at every other site.

Recording instrument and shot point locations and elevations were determined using the satellite-based Global Positioning System (GPS). All the locations (Appendix A) are estimated to be accurate to within 2 meters; elevations within 5 meters.

Shotpoints 2, 3, and 4 were sited in 20 cm X 45 m drill holes (Table 1). Ammonium nitrate explosive was detonated by electric detonators (caps), detonating cord, and boosters. Shotpoints 1 and 5 (Table 1) were sited in deep drill holes at depths of 260 and 800 meters respectively. The bottom 65 meters of SP1 were in crystalline rock. SP5 was in consolidated, but non-crystalline rock. In deep holes a special explosive and detonators are required to withstand the hydrostatic pressure. In this case, we used an 80% nitroglycerin product from IRECO called Gas Well Gelatin. The explosive is packaged in a hard cardboard sleeve, 12.7 cm in diameter, 3.2 meters long, weighing 45.4 kg. From each end a wire loop extended for handling. Four detonators were used in each hole. Two for each end of the charge were connected in parallel, then connected to a 820 meter spool of assualt wire, the connection sealed with silicon gel and left overnight to cure. The wire of the spool is #20 gauge consisting of 3 strands of copper wire and 5 strands of steel wire. Each 3.2 meter explosive cartridge was lifted with a a truck mounted derrick to a vertical position and lowered into the hole to a depth where the cable of the cartridge could be attached to the .5 cm downline cable with small 'U' bolts. After the completion of attaching and lowering each of the 20 cartridges, the downline with attached cartridges was lowered to the bottom of the hole. The two cartridges with the detonators were placed 2nd from the bottom and 2nd from the top of the column of explosives. Continuity of the shot lines with detonators was carefully monitored as they were fed downhole with the downline cable. One detonator and one shot line would have been sufficient to detonate the charge; the additional detonators and line were for backup. The shotlines were connected in parallel and shot with a 2000 volt blaster. All shots were fired automatically by portable master clocks calibrated to time obtained from the GOES satellite. The reported shot times are accurate to within ± 2 milliseconds, assuming that the explosives detonated at the exact time of the cap break.

Table 1

SHOT LIST

Shot No.	Shot Point	Date	Shot Time Day:Hr:Mn:Sec	Size (kg)	Latitude (deg)	Longitude (deg)	Elev. (m)	Depth (m)
1	1	1991 4/7	97:02:00:00.000	997.9	33.411393N	81.706984W	168	260
2	2	1991 4/7	97:02:02:00.000	997.9	33.267005N	81.440724W	97	30
3	3	1991 4/7	97:02:04:00.000	997.9	33.128413N	81.161885W	101	30
4	4	1991 4/7	97:02:06:00.000	997.9	33.006499N	80.919387W	49	30
5	5	1991 4/7	97:02:08:00.000	997.9	32.883426N	80.580914W	21	800

INSTRUMENTATION AND DATA REDUCTION

Seismic Recorders

The seismic group recorders used by the USGS in this seismic-refraction survey were 180 modified single-component SGR IIIs. The SGR-III is a single channel, digital seismic recorder with a theoretical dynamic range of 156 dB. Data is sampled at 500 samples per second by a 12 bit A/D with gain ranging from 0-90 dB in 6 dB steps. The instruments have been modified to turn on at preset times instead of using the standard radio turn on. A programmable memory board in each unit allows data to be recorded during 99 predetermined time windows. Timing is provided by a temperature compensated internal oscillator that is synchronized to a USGS master clock prior to deployment. The USGS master clocks drift approximately one millisecond per week and are checked periodically against satellite clocks. The digital data and a drift rate are recorded on cartridge tape. The drift rate is used to calculate a chronometer correction at shot time. The SGR-III recorders were designed by Amoco Production Company, built by Globe Universal Sciences, Inc., and modified by the USGS.

In this investigation, 120 instruments were connected to Mark Products L4A 2-Hz vertical-component geophones. 60 instruments were connected to Mark Products L4A 2-Hz horizontal-component geophones. Horizontal geophones were co-located with vertical geophones at every second recording location.

The clocks of each recording unit were initially synchronized to a GOES master clock via a portable base receiver. Each unit was then deployed with programmable timers to initiate recording over the expected shot time window. After the deployment the GOES time signal was compared to the internal clocks for drift measurement. All data were time corrected using the GOES data assuming a linear drift rate.

Data Reduction

Following the experiment, data from all instruments was written in SEGY-LDS format and merged into shot gathers. All data have been resampled to 200 samples per second and header information has been checked for accuracy and consistency.

Record Sections

For each shot a trace-normalized record section is presented (Fig. 3-12).

All traces are normalized to their maximum deflection and plotted using reduced time, with a reduction velocity of 6.0 km/s for record sections recorded by vertical sensors and with a reduction velocity of 3.46 km/s for record sections recorded by horizontal sensors. All traces have been bandpass filtered from 2 to 20 Hz to attenuate high frequency noise bursts and ground roll. A few traces which recorded no data have been removed for clarity.

In order to make the record sections (Fig. 3-12) easier to analyze, a few traces were deleted in areas where a noisy trace obscured surrounding data.

Description of the plates

Figure 3 Shotpoint 1 recorded by instruments using vertical sensors.
Figure 4 Shotpoint 2 recorded by instruments using vertical sensors.
Figure 5 Shotpoint 3 recorded by instruments using vertical sensors.
Figure 6 Shotpoint 4 recorded by instruments using vertical sensors.
Figure 7 Shotpoint 5 recorded by instruments using vertical sensors.

Figure 8 Shotpoint 1 recorded by instruments using horizontal sensors.
Figure 9 Shotpoint 2 recorded by instruments using horizontal sensors.
Figure 10 Shotpoint 3 recorded by instruments using horizontal sensors.
Figure 11 Shotpoint 4 recorded by instruments using horizontal sensors.
Figure 12 Shotpoint 5 recorded by instruments using horizontal sensors.

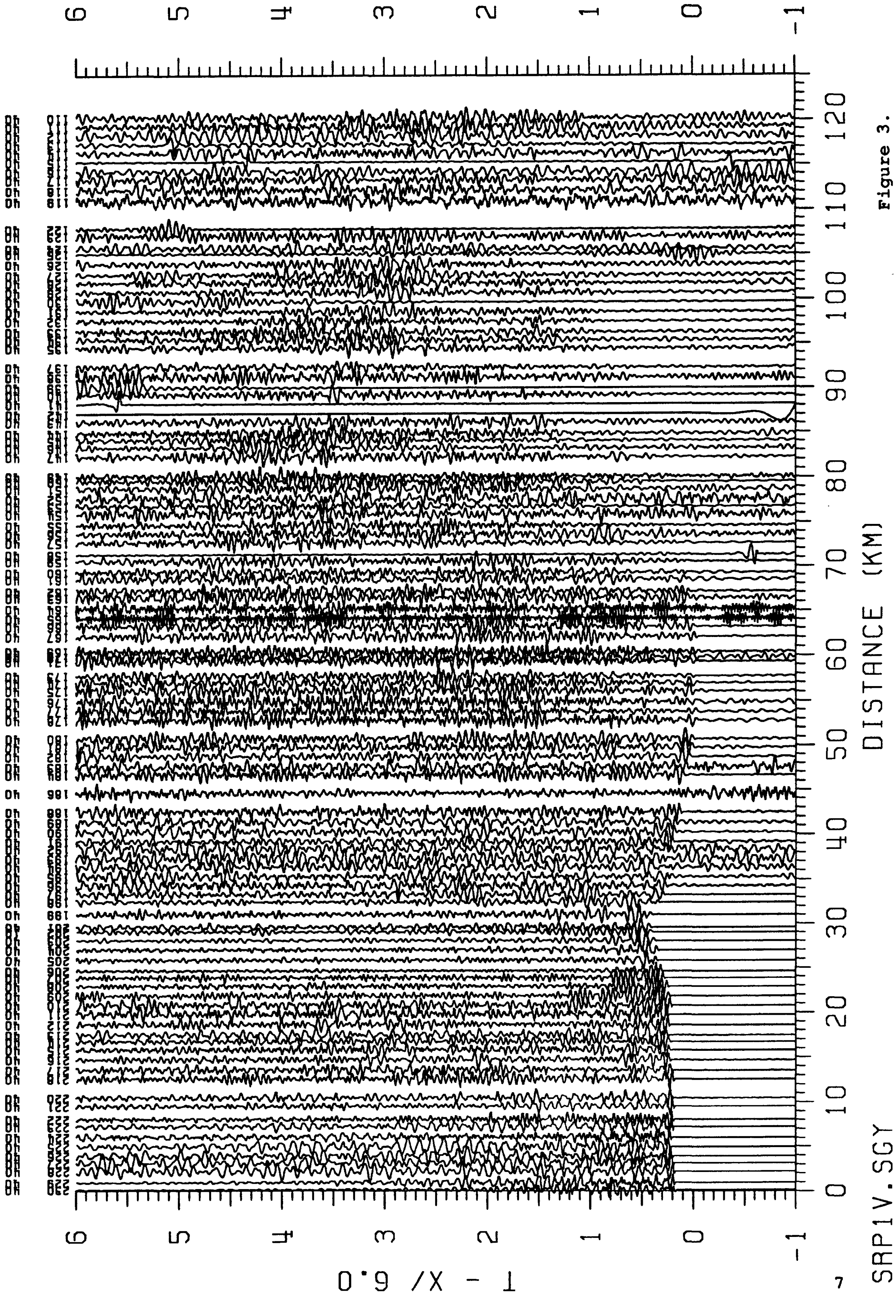


Figure 3.

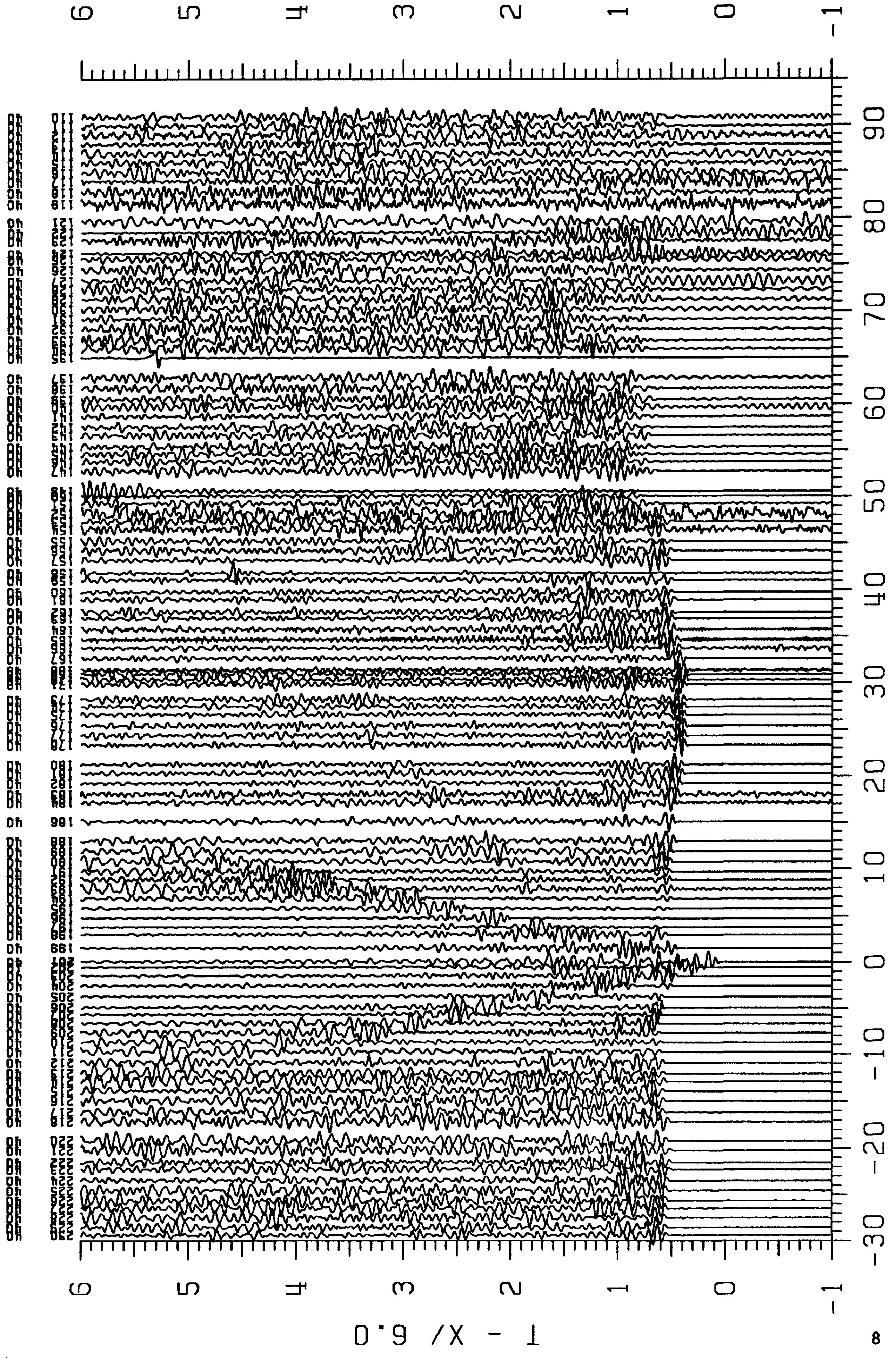


Figure 4.

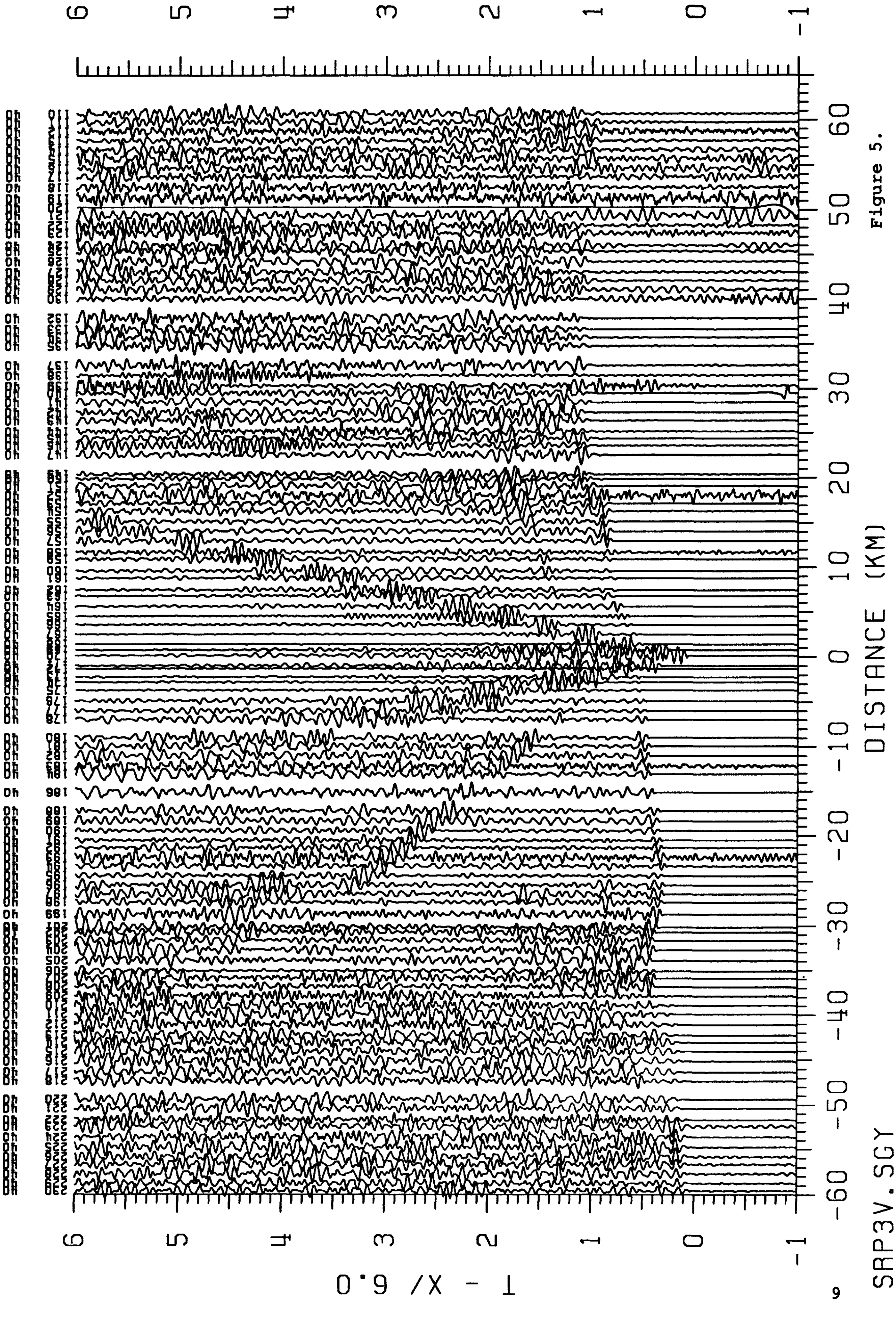


Figure 5.

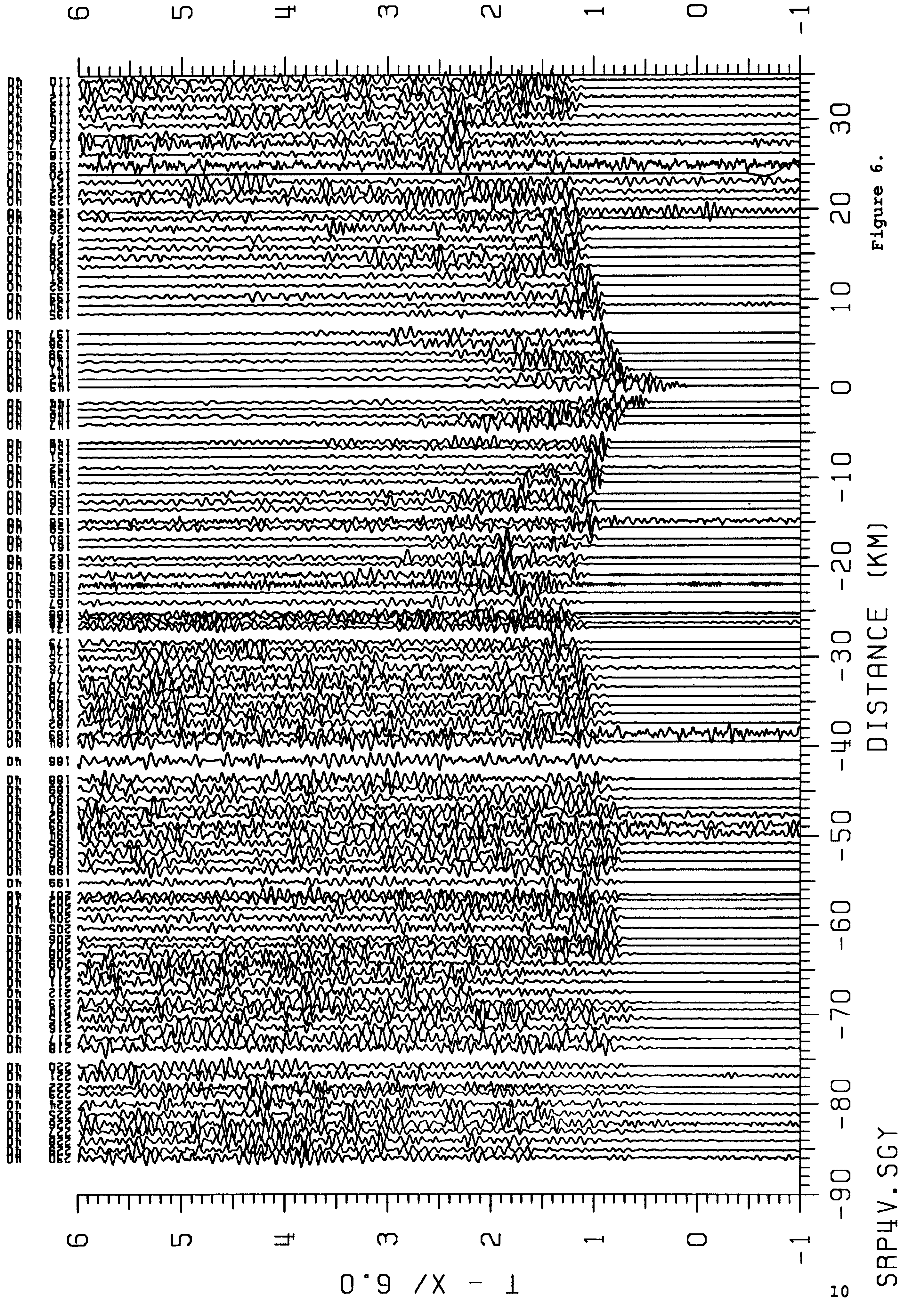
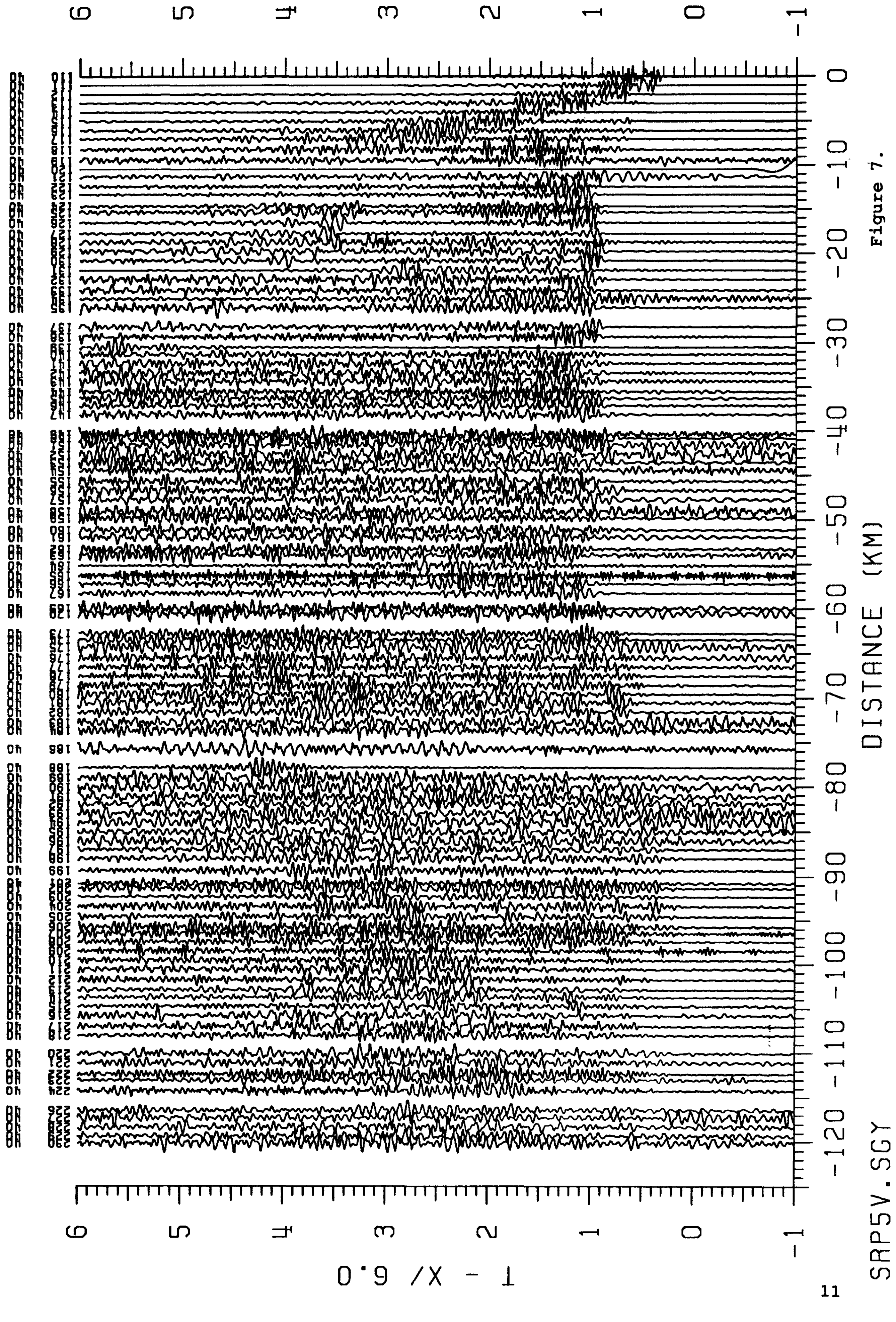


Figure 6.



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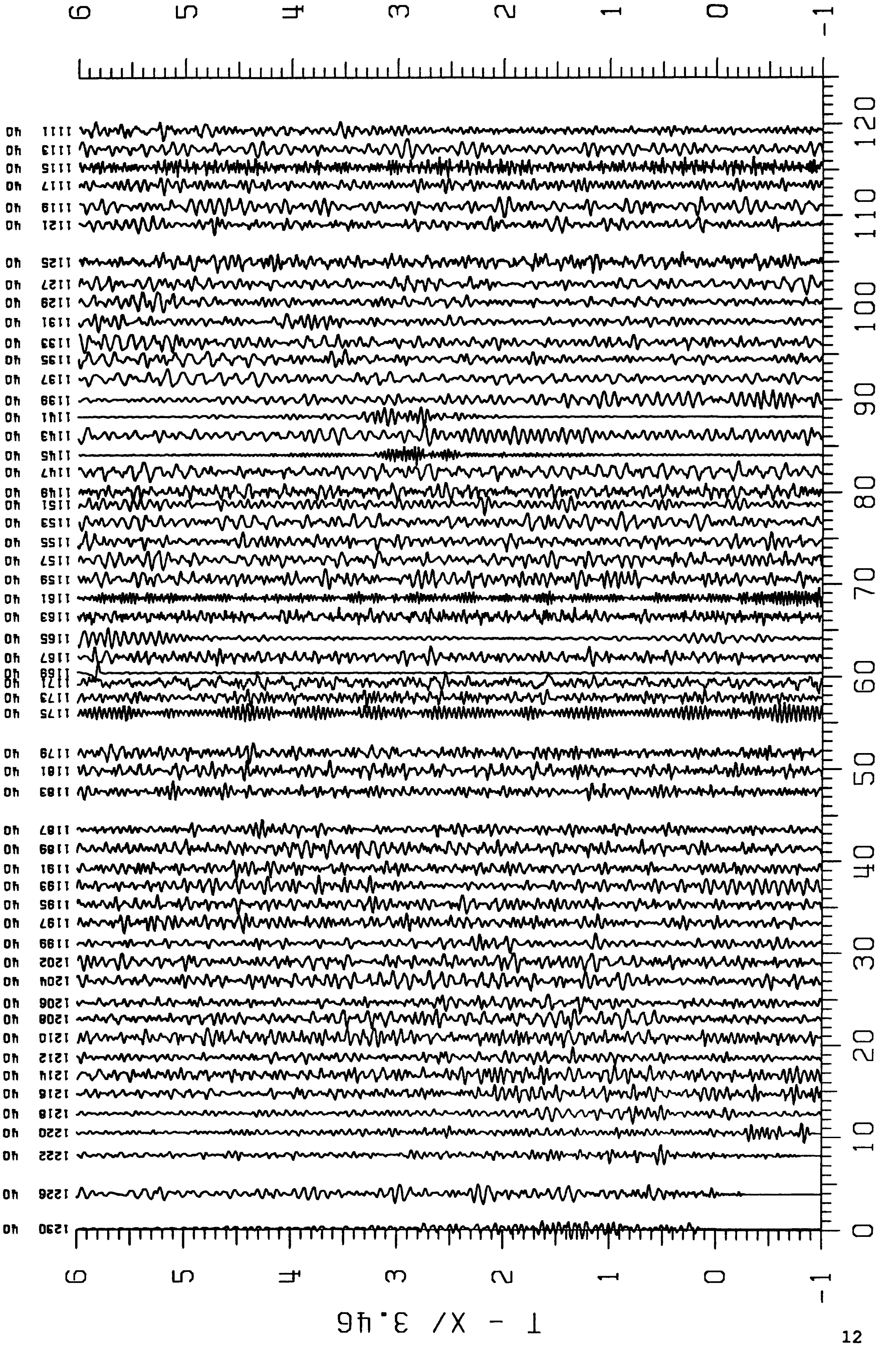

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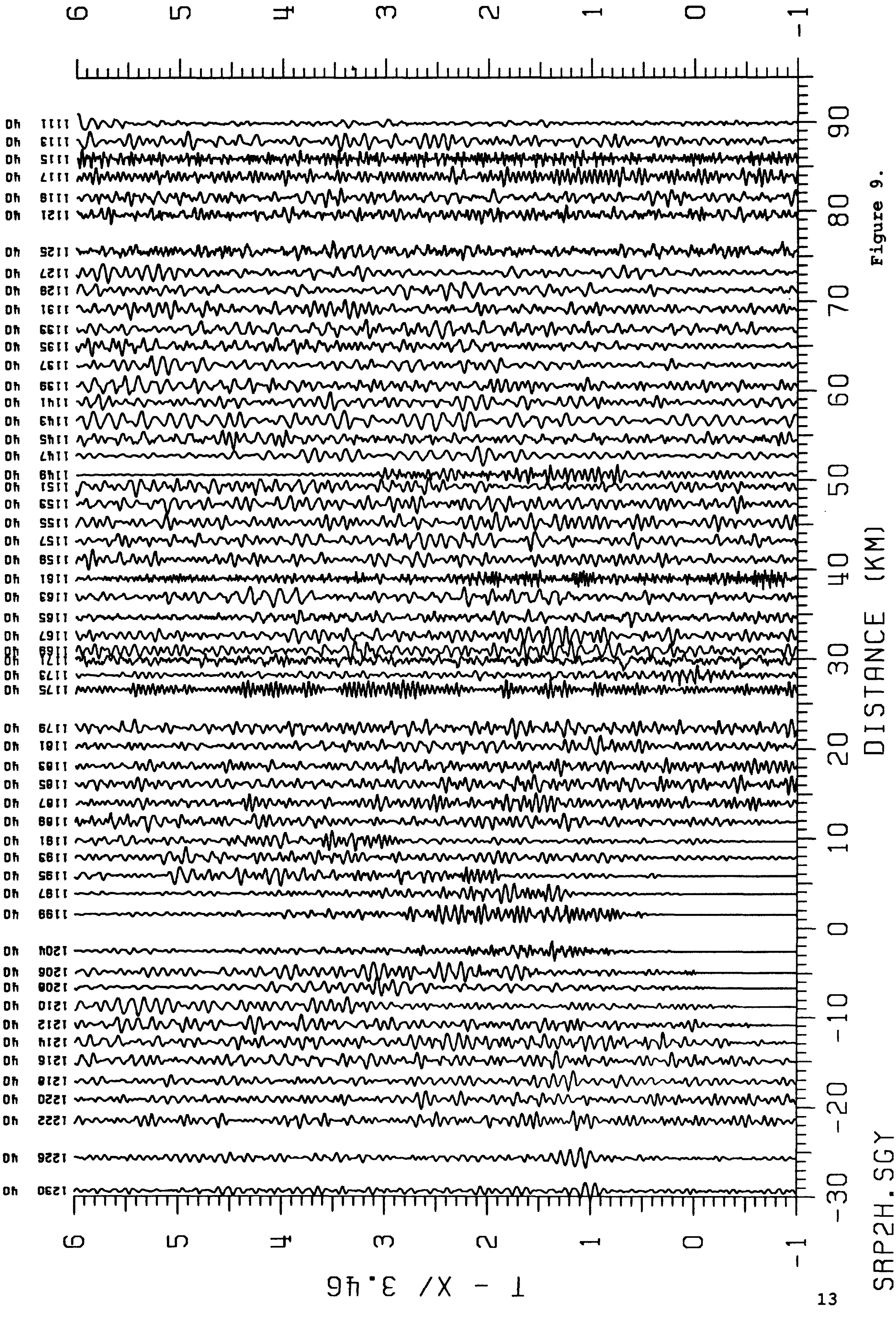

Figure 9.

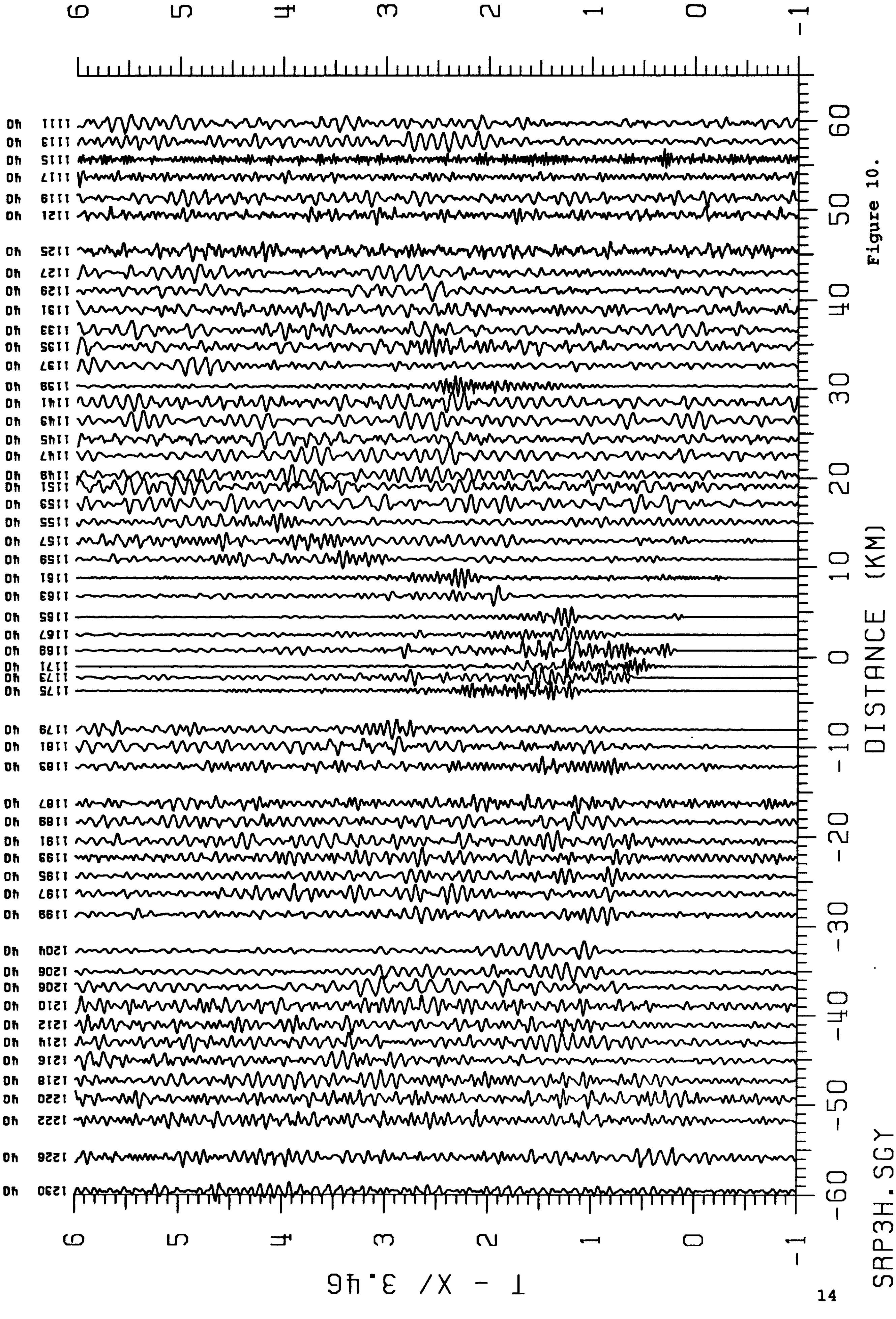

Figure 10.

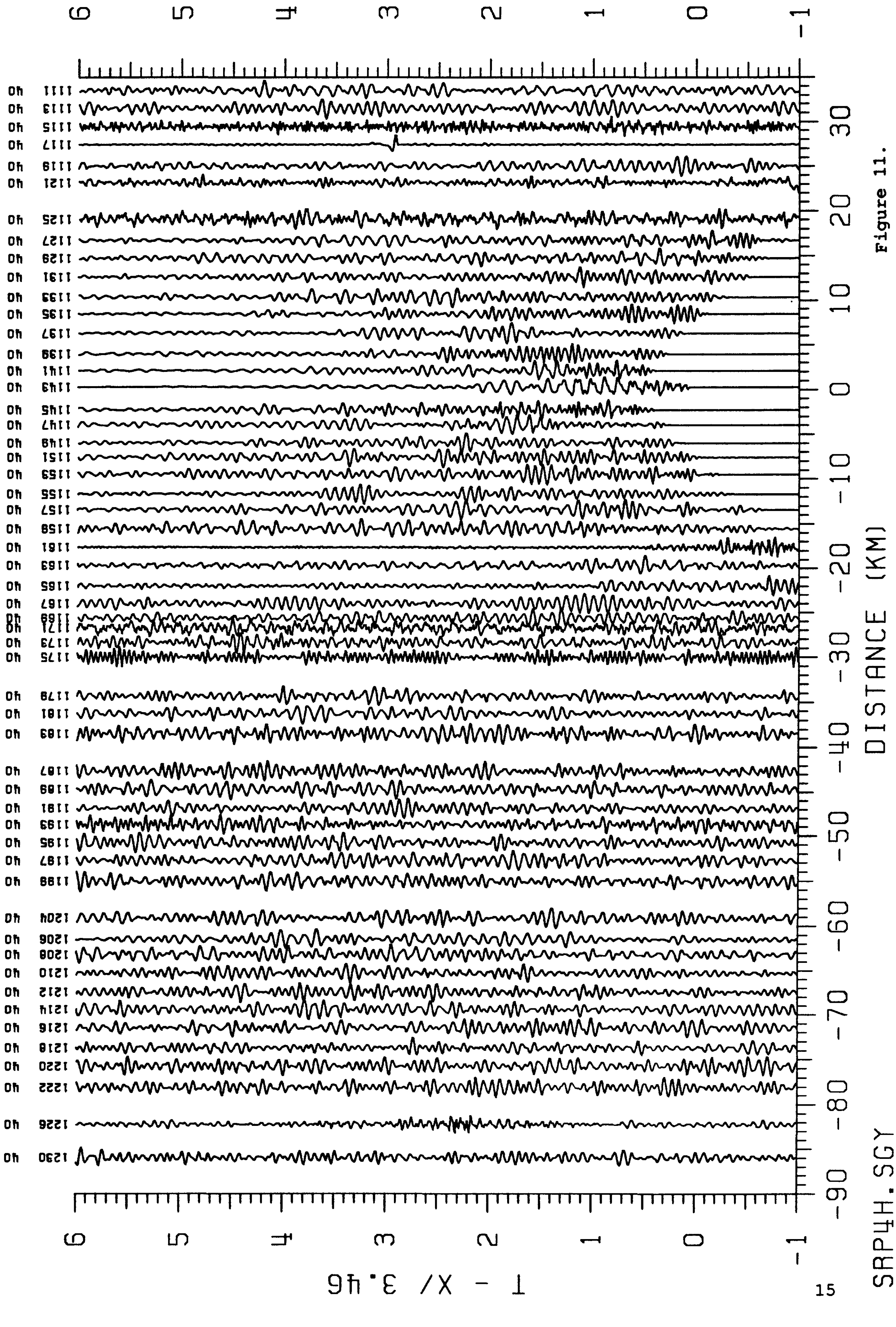

Figure 11.

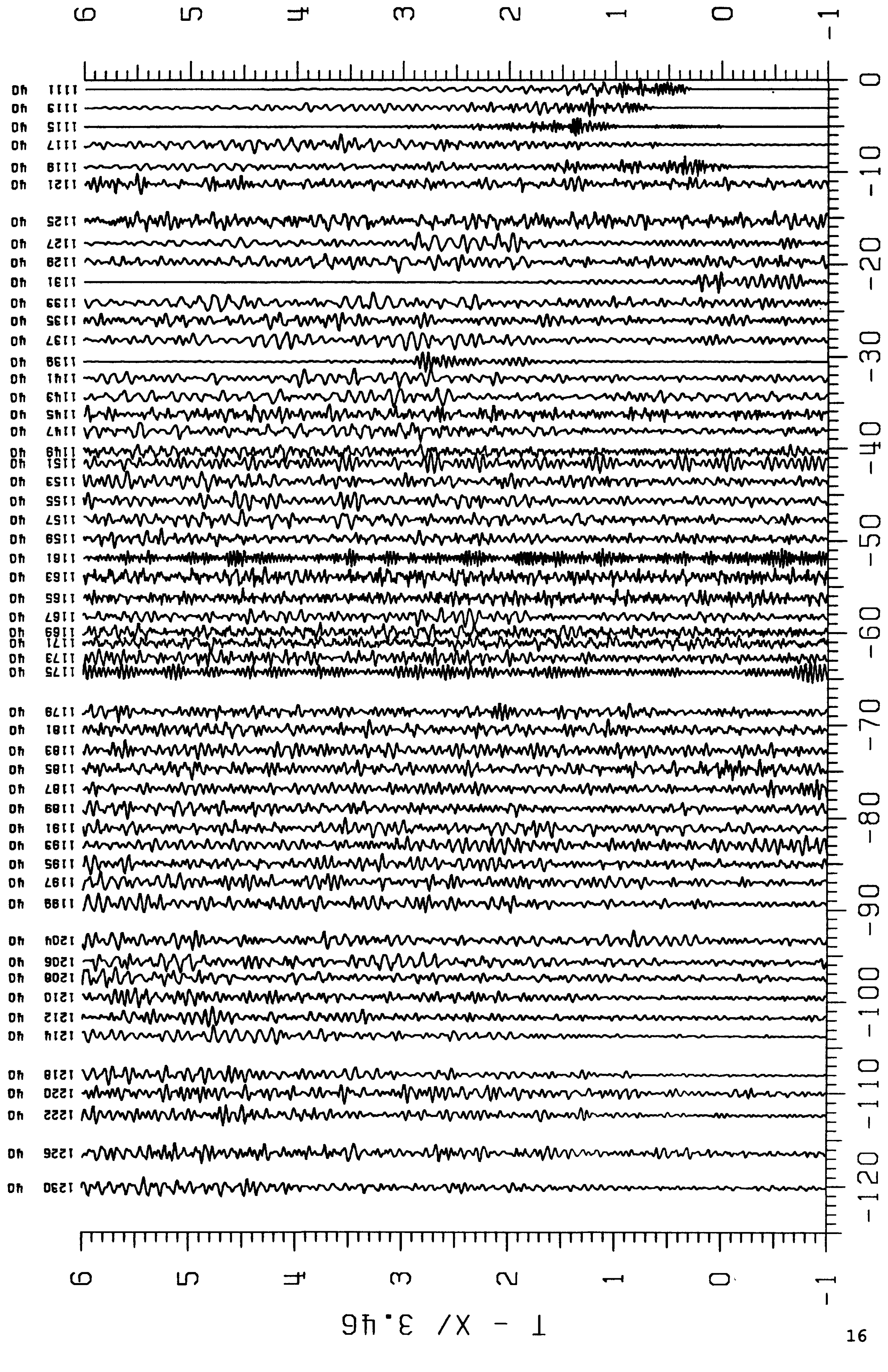

Figure 12.

Acknowledgments

The authors would like to express their appreciation to Dale Stephenson and the Savannah River Technology Center in the Environmental Science section of the Savannah River Company and to the members of the USGS field crew for their assistance in making the field operations successful.

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Appendix A

Instrument site locations

Location	Lat. (N) deg	Long. (W) deg	Elev. meters	Location	Lat. (N) deg	Long. (W) deg	Elev. meters
110	32.883400	80.581091	25	160	33.088783	81.070826	105
111	32.889436	80.588983	25	161	33.092671	81.078086	67
112	32.895054	80.597578	30	162	33.097793	81.091211	72
113	32.896079	80.609376	35	163	33.103368	81.096130	104
114	32.896606	80.621324	36	164	33.111672	81.105536	82
115	32.897741	80.632438	59	165	33.114060	81.117511	99
116	32.904192	80.641509	49	166	33.115966	81.127403	105
117	32.907154	80.650807	65	167	33.122959	81.136392	102
118	32.909769	80.663264	11	168	33.129357	81.147340	102
119	32.913475	80.675756	57	169	33.126978	81.154218	103
120	32.920717	80.683719	55	170	33.127438	81.161219	101
121	32.924592	80.691917	52	171	33.123196	81.170689	91
122	32.932614	80.700860	56	172	33.126489	81.175836	97
123	32.930509	80.712613	45	173	33.130811	81.185695	187
124	32.938187	80.724308	19	174	33.139431	81.188840	121
125	32.937241	80.732581	30	175	33.149989	81.192303	87
126	32.943498	80.742861	40	176	33.157068	81.202158	119
127	32.945099	80.756315	42	177	33.163401	81.210910	119
128	32.945591	80.767158	40	178	33.166228	81.221614	124
129	32.949869	80.777051	60	179	33.170399	81.231774	69
130	32.953098	80.787577	49	180	33.174863	81.240932	126
131	32.958870	80.797151	62	181	33.179215	81.249789	58
132	32.964606	80.806439	63	182	33.184031	81.259672	43
133	32.970649	80.817265	51	183	33.189603	81.270341	62
134	32.972128	80.827440	74	184	33.194279	81.278356	150
135	32.974238	80.837758	73	185	33.199330	81.288351	141
136	32.977325	80.847134	50	186	33.204116	81.297412	131
137	32.983371	80.858191	44	187	33.209830	81.307568	117
138	32.988705	80.868518	61	188	33.212590	81.317539	129
139	32.993038	80.880233	61	189	33.216005	81.329156	149
140	32.995484	80.888669	58	190	33.221750	81.338819	142
141	32.999793	80.898341	49	191	33.224677	81.350005	155
142	33.007060	80.907377	61	192	33.228594	81.357411	80
143	33.008466	80.917602	35	193	33.236772	81.364773	48
144	33.019162	80.925821	65	194	33.238026	81.375948	38
145	33.024227	80.932036	62	195	33.242788	81.385791	107
146	33.029269	80.938620	62	196	33.244274	81.397415	105
147	33.031726	80.949410	62	197	33.252416	81.403761	145
148	33.028473	80.967121	73	198	33.246774	81.419228	121
149	33.035611	80.973471	77	199	33.257264	81.428930	127
150	33.045149	80.973417	69	200	(no site)		
151	33.055062	80.976596	66	201	33.266717	81.440301	77
152	33.063788	80.984287	69	202	33.268225	81.446338	110
153	33.063992	80.994731	55	203	33.273579	81.454501	109
154	33.069392	81.002053	76	204	33.276915	81.465588	109
155	33.078513	81.011119	81	205	33.281019	81.477419	141
156	33.078356	81.023643	98	206	33.289057	81.486578	144
157	33.074619	81.038514	81	207	33.293681	81.492861	124
158	33.084649	81.048372	34	208	33.299344	81.500748	122
159	33.086960	81.056079	54	209	33.304084	81.510528	152

Appendix A

Location	Lat. (N) deg	Long. (W) deg	Elev. meters	Location	Lat. (N) deg	Long. (W) deg	Elev. meters
210	33.307467	81.521296	147	220	33.350218	81.621485	110
211	33.312207	81.530490	159	221	33.352386	81.632908	79
212	33.317465	81.541209	148	222	33.365649	81.639872	93
213	33.322359	81.552238	148	223	33.377662	81.640481	102
214	33.320916	81.563233	146	224	33.380663	81.653225	166
215	33.322255	81.574639	134	225	33.384401	81.664479	197
216	33.329084	81.583119	141	226	33.388150	81.675421	198
217	33.332832	81.595533	151	227	33.391101	81.683746	197
218	33.337333	81.605033	104	228	33.394683	81.693990	157
219	33.344673	81.611318	107	229	33.406338	81.698826	166
				230	33.410521	81.706196	171

Appendix B - SEGY Data File Format

The data from this experiment are archived in an extended version of the standard SEGY seismic data format. Data is organized by shotgathers; one SEGY file per shotpoint. SEGY data files are sequentially written to tape with intervening End-Of-File marks.

```
c
c     INCLUDE FILE FOR FORTRAN PROGRAMS TO READ SEGY DATA FILES
c
c This file is an implicit definition of SEGY format with additions
c for refraction work. It is the SEGY standard of Barry et al
c Geophysics (1975) with extensions labelled LDS USE and USGS use
c for refraction work. When used as an include file for a FORTRAN
c program, all variables will be set after reading arrays SEGY1A,
c SEGY1B, and SEGYDB.
c
c Character code is EBCDIC unless IEEE data format (see variable icode)
c If IEEE, then the character code is ASCII.
c
c Written by Carl Spencer and Isa Asudeh  4/2/86 original specification
c This version is compatible with the final Lithoprobe version dated 5/12/87.
c
c
c Maximum number of bytes allowed in a trace (system dependent)
c MAXLEN = ((max trace length) * (sample rate) * (bytes per sample)) + 240
c
      parameter (MAXLEN=16620)
c
c
c SEGY REEL IDENTIFICATION HEADER PART 1
        byte   segy1a(3200)
c SEGY REEL IDENTIFICATION HEADER PART 2
        byte   segy1b(400)
c SEGY TRACE DATA BLOCK
        byte  segydb(MAXLEN)
        common/segycom/iiopen,segy1a,segy1b,segydb
c
c EBCDIC CARDS
        character*80  cards(40)
        equivalence   (segy1a(1),cards(1))
c
c TRACE IDENTIFICATION HEADER
        byte  thead(240)
        equivalence   (segydb(1),thead(1))
c
c DATA WORDS
        integer*2     iidata((MAXLEN-240)/2)
        integer*4     jdata((MAXLEN-240)/4)
        real*4       rdata((MAXLEN-240)/4)
        equivalence   (segydb(241),iidata(1),jdata(1),rdata(1))
c
```

Appendix B

```
c
c--------------------------------------------------------------
c Binary area of file (or reel) Identification Header starts here
c--------------------------------------------------------------
c
c
c
c Job Identification number                         SEGY STANDARD
      integer*4  jobid
      equivalence  (segy1b(1),jobid)
c
c Line number                                       SEGY STANDARD
      integer*4  lineno
      equivalence  (segy1b(5),lineno)
c
c Reel number                                       SEGY STANDARD
      integer*4  reelno
      equivalence  (segy1b(9),reelno)
c
c Number of data traces per record                  SEGY STANDARD
      integer*2  ntrace
      equivalence  (segy1b(13),ntrace)
c
c Number of auxiliary traces per record             SEGY STANDARD
      integer*2  nauxt
      equivalence  (segy1b(15),nauxt)
c
c Sample interval in microseconds - this data       SEGY STANDARD
      integer*2  sint
      equivalence  (segy1b(17),sint)
c
c Sample interval in microseconds (in field)        SEGY STANDARD
      integer*2  sint2
      equivalence  (segy1b(19),sint2)
c
c No of samples per trace - this data               SEGY STANDARD
      integer*2  nsam
      equivalence  (segy1b(21),nsam)
c
c No of samples per trace (in field)                SEGY STANDARD
      integer*2  nsam2
      equivalence  (segy1b(23),nsam2)
c
```

Appendix B

```
c Data sample format code                                  SEGY STANDARD
c  icode=0001   (1)     IBM FLOATING POINT                SEGY STANDARD
c  icode=0002   (2)     FIXED POINT (4 bytes)             SEGY STANDARD
c  icode=0003   (3)     FIXED POINT (2 bytes)             SEGY STANDARD
c  icode=0004   (4)     FIXED POINT WITH GAIN             SEGY STANDARD
c  icode=0100   (256)   FLOATING POINT - IEEE             VERITAS STANDARD
c  icode=0200   (512)   FIXED POINT (4 bytes) - IEEE
c  icode=0300   (768)   FIXED POINT (2 bytes) - IEEE
c  icode=0500   (1280)  LUNCHBOX FORMAT                   LDS USE
c  icode=0600   (1536)  VAX R*4 FORMAT                    LDS USE
      integer*2  icode
      equivalence  (segy1b(25),icode)
c
c Number of traces in CDP ensemble                         SEGY STANDARD
      integer*2  ncdp
      equivalence  (segy1b(27),ncdp)
c
c Trace sorting code                                       SEGY STANDARD
c  itsort=1   as recorded                                  SEGY STANDARD
c  itsort=2   CDP ensemble                                 SEGY STANDARD
c  itsort=3   Single fold continuous                       SEGY STANDARD
c  itsort=4   Horizontal stack                             SEGY STANDARD
c  No LDS or USGS use.
      integer*2  itsort
      equivalence  (segy1b(29),itsort)
c
c Vertical sum code                                        SEGY STANDARD
c   vcode=n sum on n traces
      integer*2  vcode
      equivalence  (segy1b(31),vcode)
c
c Start sweep frequency (hz)                               SEGY STANDARD
      integer*2  ssweep
      equivalence  (segy1b(33),ssweep)
c
c End sweep frequency (hz)                                 SEGY STANDARD
      integer*2  esweep
      equivalence  (segy1b(35),esweep)
c
c Sweep length in milliseconds                             SEGY STANDARD
      integer*2  sleng
      equivalence  (segy1b(37),sleng)
c
c Sweep type                                               SEGY STANDARD
c  stype=1   Linear                                        SEGY STANDARD
c  stype=2   Parabolic                                     SEGY STANDARD
c  stype=3   Exponential                                   SEGY STANDARD
c  stype=4   Other                                         SEGY STANDARD
c  stype=5   Borehole source                               LDS USE
c  stype=6   Water explosive source                        LDS USE
c  stype=7   Airgun source                                 LDS USE
      integer*2  stype
      equivalence  (segy1b(39),stype)
```

```
c
c Trace number of sweep channel                         SEGY STANDARD
      integer*2  nts
      equivalence  (segy1b(41),nts)
c
c Sweep trace taper in milliseconds at start            SEGY STANDARD
      integer*2  stts
      equivalence  (segy1b(43),stts)
c
c Sweep trace taper in milliseconds at end              SEGY STANDARD
      integer*2  stte
      equivalence  (segy1b(45),stte)
c
c Taper type                                            SEGY STANDARD
c  ttype=1   Linear                                     SEGY STANDARD
c  ttype=2   cos**2                                     SEGY STANDARD
c  ttype=3   Other                                      SEGY STANDARD
      integer*2  ttype
      equivalence  (segy1b(47),ttype)
c
c Correlated data traces                                SEGY STANDARD
c  cort=1 no  2 yes
      integer*2  cort
      equivalence  (segy1b(49),cort)
c
c Binary gain recovered                                 SEGY STANDARD
c   bgr=1  Yes. For USGS data, the data has also been demeaned.
c   bgr=2  No
      integer*2  bgr
      equivalence  (segy1b(51),bgr)
c
c Amplitude recovery methods                            SEGY STANDARD
c  arm=1 none  2 spherical  3 AGC  4 other
      integer*2  arm
      equivalence  (segy1b(53),arm)
c
c Measurement system                                    SEGY STANDARD
c  isys=1 meters  2 feet
      integer*2  isys
      equivalence  (segy1b(55),isys)
c
c Polarity                                              SEGY STANDARD
c  ipol=1 Upward movement gives neg. number             SEGY STANDARD
c  ipol=2 Upward movement gives pos. number             SEGY STANDARD
      integer*2  ipol
      equivalence  (segy1b(57),ipol)
c
c Vibrator polarity code                                SEGY STANDARD
      integer*2  vpc
      equivalence  (segy1b(59),vpc)
c
```

```
c Number of traces in the file                              LDS USE
c   Used for disk files.
      integer*2  notif
      equivalence  (segy1b(61),notif)
c
c  Attribute  information                                   LDS USE
c  attri=0    velocity/displacement  data
c  attri=1    instantaneous  amplitude
c  attri=2    instantaneous  frequency
c  attri=3    instantaneous  phase
c  attri=4    slowness  (m/ms)
c  attri=5    semblance  (0-1000)
      integer*2  attri
      equivalence  (segy1b(63),attri)
c
c Mean  amplitude  of  all  samples                         LDS USE
c    in all traces in file      Used for disk files.
      real*4  meanas
      equivalence  (segy1b(65),meanas)
c
c Domain  of  data                                          LDS USE
c   domain=0 Time - distance domain
c    domain=1 Frequency - wavenumber domain
c    domain=2 Intercept time - slowness domain
      integer*2  domain
      equivalence  (segy1b(69),domain)
c
c     Bytes 71, 72 unused to align four byte boundaries.
c
c Reduction  velocity  meters/sec  if  data  is  reduced    LDS USE
      integer*4  vred
      equivalence  (segy1b(73),vred)
c
c Minimum  of  all  samples  in  file.                      LDS USE
      real*4  minass
      equivalence  (segy1b(77),minass)
c
c Maximum  of  all  samples  in  file.                      LDS USE
      real*4  maxass
      equivalence  (segy1b(81),maxass)
c
c Recording  instrument  type                               USGS USE
c  iinstr=1     EDA  lunchbox  recorder
c  iinstr=2     USGS  seismic  cassette  recorder
c  iinstr=3     GEOS
c  iinstr=99    Mixed
      integer*2  iinstr
      equivalence  (segy1b(85),iinstr)
c
c File creation date - Last two digits of year              USGS USE
      integer*2  cryear
      equivalence  (segy1b(87),cryear)
c
```

```
c File creation date - Month of year                         USGS USE
      integer*2   crmnth
      equivalence   (segy1b(89),crmnth)
c
c File creation date - Day of month                          USGS USE
      integer*2   crday
      equivalence   (segy1b(91),crday)
c
c   Bytes 93-398 of the binary File Identification Header are not used
c
c  Format version number (x100)
c  Version 0.99        "Discussion version", October 1986.
c  Version 1.00        "Final version", December 5, 1987
      integer*2   fvn
      equivalence   (segy1b(399),fvn)
c
```

Appendix B

```
c--------------------------------------------------------------
c Trace Identification Header (total of 240 bytes) starts here
c--------------------------------------------------------------
c
c Trace sequence number within line                    SEGY STANDARD
      integer*4  tsnl
      equivalence  (thead(1),tsnl)
c
c Trace sequence number within file                    SEGY STANDARD
      integer*4  tsnt
      equivalence  (thead(5),tsnt)
c
c Original field record number                         SEGY STANDARD
c For LDS use this will be sequential shot number      LDS USE
      integer*4  ofrn
      equivalence  (thead(9),ofrn)
c
c Trace number within original field record            SEGY STANDARD
      integer*4  tnofr
      equivalence  (thead(13),tnofr)
c
c Energy source point number                           SEGY STANDARD
      integer*4  espn
      equivalence  (thead(17),espn)
c
c CDP number                                           SEGY STANDARD
      integer*4  cdp
      equivalence  (thead(21),cdp)
c
c Trace number within CDP                              SEGY STANDARD
      integer*4  tncdp
      equivalence  (thead(25),tncdp)
c
c Trace identification code                            SEGY STANDARD
c  1 = Seismic data,   2 = Dead,     3 = Dummy         SEGY STANDARD
c  4 = Time break,     5 = Uphole,   6 = Sweep         SEGY STANDARD
c  7 = Timing,         8 = Water break                 SEGY STANDARD
c  9 = Deleted trace                                   USGS USE
c  10 = Long Period data (see thead(117),isi)          USGS USE
      integer*2  tic
      equivalence  (thead(29),tic)
c
c Number of vertically summed traces
c      yielding this trace                             SEGY STANDARD
      integer*2  nvs
      equivalence  (thead(31),nvs)
c
c Number of horizontally stacked traces
c      yielding this trace                             SEGY STANDARD
      integer*2  nhs
      equivalence  (thead(33),nhs)
c
```

```
c Data use (1=production 2=test)                           SEGY STANDARD
      integer*2 duse
      equivalence (thead(35),duse)
c
c Distance from source to receiver                         SEGY STANDARD
      integer*4 idist
      equivalence (thead(37),idist)
c
c Receiver group elevation                                 SEGY STANDARD
      integer*4 irel
      equivalence (thead(41),irel)
c
c Surface elevation of source                              SEGY STANDARD
      integer*4 ishe
      equivalence (thead(45),ishe)
c
c Shot depth                                               SEGY STANDARD
      integer*4 ishd
      equivalence (thead(49),ishd)
c
c Datum elevation at receiver                              SEGY STANDARD
      integer*4 delr
      equivalence (thead(53),delr)
c
c Datum elevation at source                                SEGY STANDARD
      integer*4 dels
      equivalence (thead(57),dels)
c
c Water depth at source                                    SEGY STANDARD
      integer*4 wds
      equivalence (thead(61),wds)
c
c Water depth at receiver                                  SEGY STANDARD
      integer*4 wdr
      equivalence (thead(65),wdr)
c
c Scalar multiplier/divisor for bytes 41-68                SEGY STANDARD
      integer*2 smul1
      equivalence (thead(69),smul1)
c
c Scalar multiplier/divisor for bytes 73-88                SEGY STANDARD
      integer*2 smul2
      equivalence (thead(71),smul2)
c
c Source coordinate X or longitude (East positive)         SEGY STANDARD
      integer*4 ishlo
      equivalence (thead(73),ishlo)
c
c Source coordinate Y or latitude (North positive)         SEGY STANDARD
      integer*4 ishla
      equivalence (thead(77),ishla)
c
```

Appendix B

```
c Group coordinate X or longitude (East positive)        SEGY STANDARD
      integer*4  irlo
      equivalence  (thead(81),irlo)
c
c Group coordinate Y or latitude (North positive)        SEGY STANDARD
      integer*4  irla
      equivalence  (thead(85),irla)
c
c Coordinate units                                        SEGY STANDARD
c  1:   meters/feet
c  2:   seconds of arc (smul2 holds multiplier)
c  N:   mod   100 = TX zone
c       div   100 = RX zone
      integer*2  cunits
      equivalence  (thead(89),cunits)
c
c Weathering velocity (m/s?)                              SEGY STANDARD
      integer*2  wvel
      equivalence  (thead(91),wvel)
c
c Subweathering velocity (m/s?)                           SEGY STANDARD
      integer*2  swvel
      equivalence  (thead(93),swvel)
c
c Uphole time at source                                   SEGY STANDARD
      integer*2  utimes
      equivalence  (thead(95),utimes)
c
c Uphole time at group                                    SEGY STANDARD
      integer*2  utimeg
      equivalence  (thead(97),utimeg)
c
c Source static correction (ms?)                          SEGY STANDARD
      integer*2  sstati
      equivalence  (thead(99),sstati)
c
c Group static                                            SEGY STANDARD
      integer*2  gstati
      equivalence  (thead(101),gstati)
c
c Total static                                            SEGY STANDARD
      integer*2  tstati
      equivalence  (thead(103),tstati)
c
c Lag time A                                              SEGY STANDARD
      integer*2  istime
      equivalence  (thead(105),istime)
c
c Lag time B                                              SEGY STANDARD
      integer*2  ibtime
      equivalence  (thead(107),ibtime)
c
```

Appendix B

```
c Delay recording time (reduced start time) (msec)        SEGY STANDARD
      integer*2  ictime
      equivalence  (thead(109),ictime)
c
c Mute start time                                         SEGY STANDARD
      integer*2  mtimes
      equivalence  (thead(111),mtimes)
c
c Mute end time                                           SEGY STANDARD
      integer*2  mtimee
      equivalence  (thead(113),mtimee)
c
c No of samples in this trace                             SEGY STANDARD
      integer*2  length
      equivalence  (thead(115),length)
c
c Sampling interval in microseconds                       SEGY STANDARD
c If (thead(29),itic) = 10, in milliseconds               USGS STANDARD
      integer*2  isi
      equivalence  (thead(117),isi)
c
c Gain type (1=fixed 2=binary 3=floating)                 SEGY STANDARD
      integer*2  gaint
      equivalence  (thead(119),gaint)
c
c Gain constant                                           SEGY STANDARD
      integer*2  gc
      equivalence  (thead(121),gc)
c
c Instrument or initial gain in DB                        SEGY STANDARD
      integer*2  gidb
      equivalence  (thead(123),gidb)
c
c Correlated 1=no 2=yes                                   SEGY STANDARD
      integer*2  tcorr
      equivalence  (thead(125),tcorr)
c
c Start sweep frequency (hz)                              SEGY STANDARD
      integer*2  tsswee
      equivalence  (thead(127),tsswee)
c
c End sweep frequency (hz)                                SEGY STANDARD
      integer*2  teswee
      equivalence  (thead(129),teswee)
c
c Sweep length in milliseconds                            SEGY STANDARD
      integer*2  tsleng
      equivalence  (thead(131),tsleng)
c
```

Appendix B

```
c Sweep type                                         SEGY STANDARD
c  stype=1   Linear                                  SEGY STANDARD
c  stype=2   Parabolic                               SEGY STANDARD
c  stype=3   Exponential                             SEGY STANDARD
c  stype=4   Other                                   SEGY STANDARD
c  stype=5   Borehole source                         LDS USE
c  stype=6   Water explosive source                  LDS USE
c  stype=7   Airgun source                           LDS USE
      integer*2 tstype
      equivalence (thead(133),tstype)
c
c Sweep trace taper in milliseconds at start        SEGY STANDARD
      integer*2 tstts
      equivalence (thead(135),tstts)
c
c Sweep trace taper in milliseconds at end          SEGY STANDARD
      integer*2 tstte
      equivalence (thead(137),tstte)
c
c Taper type                                         SEGY STANDARD
c  ttype=1  Linear                                   SEGY STANDARD
c  ttype=2  Cos**2                                   SEGY STANDARD
c  ttype=3  Other                                    SEGY STANDARD
      integer*2 tttype
      equivalence (thead(139),tttype)
c
c Antialias filter frequency                         SEGY STANDARD
      integer*2 aif
      equivalence (thead(141),aif)
c
c Alias filter slope                                 SEGY STANDARD
      integer*2 ais
      equivalence (thead(143),ais)
c
c Notch filter frequency                             SEGY STANDARD
      integer*2 nif
      equivalence (thead(145),nif)
c
c Notch filter slope                                 SEGY STANDARD
      integer*2 nis
      equivalence (thead(147),nis)
c
c Low cut frequency                                  SEGY STANDARD
      integer*2 flc
      equivalence (thead(149),flc)
c
c High cut frequency                                 SEGY STANDARD
      integer*2 fhc
      equivalence (thead(151),fhc)
c
c Low cut slope                                      SEGY STANDARD
      integer*2 slc
      equivalence (thead(153),slc)
```

Appendix B

```
c
c High cut slope                                          SEGY STANDARD
      integer*2  shc
      equivalence  (thead(155),shc)
c
c Year of start of trace                                  SEGY STANDARD
      integer*2  tyear
      equivalence  (thead(157),tyear)
c
c Day of start of trace                                   SEGY STANDARD
      integer*2  tday
      equivalence  (thead(159),tday)
c
c Hour of start of trace                                  SEGY STANDARD
      integer*2  thour
      equivalence  (thead(161),thour)
c
c Minute of start of trace                                SEGY STANDARD
      integer*2  tmin
      equivalence  (thead(163),tmin)
c
c Second of start of trace                                SEGY STANDARD
      integer*2  tsec
      equivalence  (thead(165),tsec)
c
c Time basis code  1=local 2=GMT                          SEGY STANDARD
      integer*2  tbcode
      equivalence  (thead(167),tbcode)
c
c Trace weighting factor                                  SEGY STANDARD
      integer*2  twf
      equivalence  (thead(169),twf)
c
c Geophone group no. on roll switch first position        SEGY STANDARD
      integer*2  ggrp1
      equivalence  (thead(171),ggrp1)
c
c Geophone group no. trace position 1                     SEGY STANDARD
c    on field record
      integer*2  ggtp
      equivalence  (thead(173),ggtp)
c
c Time code translator error light                        USGS USE
c   1=No error  2=Error
      integer*2  errlt
      equivalence  (thead(175),errlt)
c
c Distance-azimuth calculation algorithm                  USGS USE
c     1 = Sodano algorithm.  The program utilizes the Sodano and Robinson
c         (1963) direct solution of geodesics (Army Map Service, Tech Rep
c        #7, Section IV).
      integer*2  daca
      equivalence  (thead(177),daca)
```

Appendix B

```
c
c Earth dimension code                              USGS USE
c   1 = Fischer spheroid (1960),
c           OMEGA & NASA datums                     6378166.      298.30
c   2 = Clark ellipsoid (1866),
c           N. American datum 1927                  6378206.4     294.98
c   3 = Ref ellipsoid (1967), S. American datum     6378160       298.25
c   4 = Hayford International Ellipsoid (1910)      6378388.      297.00
c   5 = World Geodetic Survey Ellipsoid (1972)      6378135.      298.26
c   6 = Bessel (1841), Tokyo datum                  6377397.      299.15
c   7 = Everest (1830), India datum                 6377276.      300.80
c   8 = Airy (1936),
c           Ordnance survey of Great Britain        6377563.      299.32
c   9 = Hough (1960), Wake-Eniwetok                 6378270.      297.00
c  10 = Fischer (1968), Modified Mercury            6378150.      298.30
c  11 = Clarke (1880)                               6378249.      293.47
      integer*2 edc
      equivalence (thead(179),edc)
c
c Microseconds of trace start time                  LDS USE
      integer*4 mst
      equivalence (thead(181),mst)
c
c Millisecond of timing correction                  LDS USE
      integer*2 cor
      equivalence (thead(185),cor)
c
c Charge size in kg                                 LDS USE
      integer*2 charge
      equivalence (thead(187),charge)
c
c Shot time - Year                                  LDS USE
      integer*2 syear
      equivalence (thead(189),syear)
c
c Shot time - Day                                   LDS USE
      integer*2 sday
      equivalence (thead(191),sday)
c
c Shot time - Hour                                  LDS USE
      integer*2 shour
      equivalence (thead(193),shour)
c
c Shot time - Minute                                LDS USE
      integer*2 shmin
      equivalence (thead(195),shmin)
c
c Shot time - Second                                LDS USE
      integer*2 sseco
      equivalence (thead(197),sseco)
c
```

Appendix B

```
c Shot time - Microsecond                                LDS USE
      integer*4  ssmic
      equivalence  (thead(199),ssmic)
c
c Azimuth of receiver from shot (minutes of arc)         LDS USE
      integer*2  azimut
      equivalence  (thead(203),azimut)
c
c Azimuth of geophone orientation axis with
c respect to true north in minutes of arc                LDS USE
      integer*2  geoazi
      equivalence  (thead(205),geoazi)
c
c Angle between geophone orientation axis and
c vertical in minutes of arc                             LDS USE
      integer*2  geover
      equivalence  (thead(207),geover)
c
c Time to be added to recorded trace time to get
c actual trace start time.  To be used when data
c has been reduced but start time is not updated
c so that the actual time can be recovered even if
c distance and shot time have changed
c (microseconds)                                         LDS USE
      integer*4  ttrace
      equivalence  (thead(209),ttrace)
c
c Recording instrument number                            LDS USE
      character*4  scrs
      equivalence  (thead(213),scrs)
c
c Deployment name                                        LDS USE
      character*4  deploy
      equivalence  (thead(217),deploy)
c
c Shotpoint name (shotpoint number)                      LDS USE
      character*4  spname
      equivalence  (thead(221),spname)
c
c Receiver site name (station number)                    LDS USE
      character*4  rstnam
      equivalence  (thead(225),rstnam)
c
c Shot name (shot number)                                LDS USE
      character*4  shotid
      equivalence  (thead(229),shotid)
c
```

```
c Line name                                          LDS USE
      character*4   lineid
      equivalence   (thead(233),lineid)
c
c Geophone orientation eg R40,Z                      LDS USE
      character*4   geoor
      equivalence   (thead(237),geoor)
c
c   End of Trace Identification Header
```