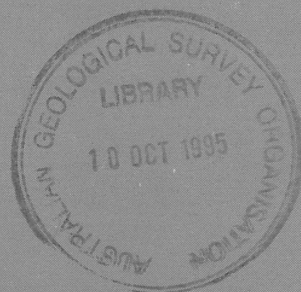


1992/88  
CA

AGSO

# PLAYBACK AND PROCESSING OF DATA FROM AGSO PORTABLE SEISMIC RECORDING SYSTEMS

BMR PUBLICATIONS COMPACTS  
(LENDING SECTION)

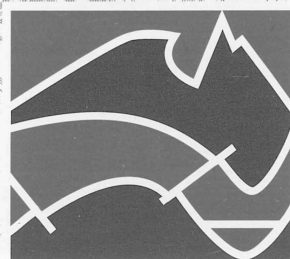


By

*C.D.N. COLLINS, R. BRACEWELL & B.J. DRUMMOND*

RECORD 1992/88

AGSO



A U S T R A L I A N  
G E O L O G I C A L S U R V E Y  
O R G A N I S A T I O N

BMR COMP  
1992/88  
CA



## **AGSO RECORD 1992/88**

# **PLAYBACK AND PROCESSING OF DATA FROM AGSO PORTABLE SEISMIC RECORDING SYSTEMS**

by

**C. D. N. COLLINS, R. BRACEWELL,  
AND B. J. DRUMMOND**

**DEPARTMENT OF PRIMARY INDUSTRIES AND ENERGY**

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Secretary: Greg Taylor

**AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION**

Executive Director: Neil Williams

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## SUMMARY

This Record documents the procedures and software used to digitise, process and display seismic data recorded by Australian Geological Survey Organisation (AGSO) portable seismic tape recording systems. The programs are only briefly described, but full listings of the Fortran 77 source code of the programs are available on request from the authors. Some examples of the final output from these processing procedures are shown. This Record also includes descriptions of programs used for reformatting long-offset seismic data recorded by digital recorders and sonobuoys so the data can be processed by the software described here. These reformatting procedures can be adapted to other similar systems which may be used in other surveys.

## INTRODUCTION

This Record documents the procedures and software used to digitise, process and display seismic data recorded by Australian Geological Survey Organisation (AGSO) portable seismic tape recording systems. These procedures can be broken down into several steps which are listed in Tables 1-8 and illustrated by Figures 1-9. Examples of input and output files used or generated by some of the processing routines are listed in abridged form in Table 9. The programs are only briefly described, but full listings of the Fortran 77 source code are available on request from the authors. Some examples of the final output from these processing procedures are shown in Figures 10-15. This Record also includes descriptions of programs used for reformatting long-offset seismic data recorded by digital recorders and sonobuoys so the data can be processed by the software described here. These reformatting procedures can be adapted to other similar systems which may be used in other surveys.

## BACKGROUND

The Bureau of Mineral Resources, Geology and Geophysics (BMR), now AGSO, has collected long-range refraction and wide-angle reflection data for many years as part of a regional study of the crustal structure of the Australian continent (Collins, 1988). Initially, large individual shots and quarry blasts were recorded by few and widely spaced seismic recorders. Later, specially drilled and fired shots were located along traverses of thirty or so identical recorders with station intervals of 5-10 km. Typically, 10-20 shots were fired and 100-200 stations occupied. In some cases over 100 quarry blasts might be recorded, but not all were useful because of duplication or small size.

The stations used are analogue FM tape recorders (Finlayson & Collins, 1980) and the analogue field tapes are played back and digitised at AGSO. The playback system was described by Liu & Seers (1982) and the digitised data stored on disc or magnetic tape with a file structure described by Drummond & Downie (1985). The playback and digitising system was based on a shared HP1000 computer. Every shot was located on tape by finding the appropriate time; time signals from both an internal clock and radio time standard (either VNG or Omega) were recorded along with the seismic signal. The shot and station parameters were entered into a header block in the record file and the shot then digitised. This was repeated manually for each shot recorded at each station.

In 1988/89 a new method of collecting long-offset seismic data was trialled in the Gippsland and Bass Basins (Collins and others, 1990). During an AGSO marine deep seismic reflection survey of these basins seismic recorders were deployed on land to record refraction and wide-angle reflection data, using the routine air-gun shots as the energy source. Twenty reflection traverses were shot, with up to 5000 shots per traverse. Six analogue and three digital recording systems were deployed at 14 stations. Not all were operating during the whole survey, but even so there were potentially about 270,000 events recorded by the land stations. Clearly the existing playback facility was inadequate for this type of data. To remedy this, a new playback system based on a dedicated PDP11 computer was developed to automate the digitising process.

New methods of processing this large volume of data were also required. Previously, the data were bandpass filtered and compiled into wiggle trace record sections. Each record section typically displayed about 60 traces (two deployments of thirty instruments). Apart from trace normalising no other signal enhancement was possible because of the large station spacing and single shots. By recording a large number of shots with a close shot spacing (less than 50 m) as in the Bass Strait survey, it was possible to enhance the signal by stacking. At large shot-station distances it becomes essential to do this because of the relatively low power of the air-gun source. The large number of traces which can be displayed in a record section also make correlation of phases easier, and the section can be further enhanced by variable area and colour amplitude displays.

Some processing procedures described here are specific to the Bass Strait survey but are included as they can be adapted to solve similar types of problems likely to be encountered in future surveys. The digital systems which were deployed during the Bass Strait survey were developed by the Department of Earth Sciences, Monash University, and were based on portable PCs. The data from these recorders were reformatted to the file structure of the digitised analogue data so the same processing could be used. The additional steps required are described here as they adaptable to other recording systems.

## **DIGITISING ANALOGUE DATA**

The analogue field tapes are digitised by a dedicated PDP11 computer linked to the tape playback system. The digitising system includes two hard disc drives, two floppy disc drives, a Cipher 9 track tape drive and a Nicolet Zeta plotter. The system operates under the Digital RSX-11M Plus operating system, and software includes a Fortran77 compiler and Calcomp plotting library. The analogue to digital conversion is performed by Data Translation hardware and library routines.

The digitising process can be semi-automated using the program TEST80. This program allows a continuous series of shots to be digitised without operator intervention provided the clock signal recorded on the field tape is sufficiently good to be read by the playback system. All fixed parameters (eg. survey description, filter settings) are contained in an input file which can be edited before each session. At the start of each digitising run initial parameters (eg. shot number, distance) are typed in before digitising starts and these are automatically updated by TEST80 as the digitising proceeds.

The digitising is triggered by the clock signal on the field tape and continues until the specified number of samples have been acquired. The data are then written to the hard disc as a separate file. The first record in each file contains the shot parameters and the fixed parameters from the input file. The file names must conform to a format which is used throughout digitising and processing. The standard file name format is AABBBB.CCC where AA is an alphabetical prefix (usually the first two letters of the station name), BBBB is the numeric four digit shot number, and CCC is the three digit extension (usually the traverse number). TEST80 updates the shot number BBBB for each shot digitised.



The total number of shots that are digitised during any one run are specified before the run. If the clock signal is good there is no limit to the number that can be digitised during a single run, though it is prudent to limit the number to several hundred at a time. If a file is not made successfully, for example because the clock signal could not be read properly because of poor recording, the program will wait a specified number of clock cycles and then attempt to digitise the next shot. All parameters are updated for the next shot as would be the case for a successful shot. The process is repeated again if the next shot is also unsuccessful, and so on. The number of such attempts to digitise a shot before the program stops can be specified before each digitising run. A reasonable number, say about ten, allows sufficient time for the clock signal to improve without allowing too many failures to occur without the cause being investigated.

Several shots can be digitised together as a single file. This is necessary if the time between shots is not sufficient for the digitising system to be able to calculate shot parameters, digitise the data, write to the disc and perform other overheads before the next shot. These can be later split into individual shot records with separate headers. Another feature of TEST80 is the continuous monitoring of the drift in recorder and/or playback tape speed. The analogue-to-digital conversion takes place at a constant clock rate so that any variation in tape speed would result in a varying sample interval. To correct for this, a correction factor is recorded in the header record of each file which is used by the later processing programs. To obtain this correction second pulses of the radio signal recorded on the field tapes are also digitised. The ratio of this absolute time standard with the digitising clock time is recorded as the correction factor.

The digitised files are written to the directory specified on either of the two hard discs. When the traverse is completed, the data are copied in RSX-11M Plus Files-11 format to 9 track tape on the Cipher tape drive. As a backup the files are also archived on 9 track tape using the RSX-11M Plus BRU tape backup utility. This latter format also permits much faster file transfer rates, so that files can be quickly restored to the disc if required. The data can be compiled into record sections on the PDP11 and plotted using the Nicolet Zeta plotter.

## PROCESSING

The digitised data can be plotted directly from the PDP11 playback and digitising system by the Nicolet Zeta pen plotter. However, the data are normally transferred to a mainframe or PC processing computer for further processing and plotting. The data are transferred via 9 track tape. The procedures and software described here are implemented for DOS PC use but are applicable, with modification, to other platforms. The processing and plotting can be rapidly performed using a 386 based PC with a coprocessor and a dot-matrix or laser printer.

The processing programs are written in Fortran 77 and compiled with a Lahey Fortran compiler (Version 4.10). Graphical output uses the Sciplot graphical library (Version 4.0), which has similar plot calls to the Calcomp plotting library. The processing of the data can be broken up into several component streams, and these are listed in Tables 1-8 and Figures 1-9.

## Transfer of files

Several programs are used for transferring data files from the PDP11 digitising system to a PC via 9 track tape (Tables 1 and 2). The PC cannot recognise the record length of these files so they must be reformatted. Figure 1 illustrates the procedures for transferring files via a VAX mainframe computer. A more direct route relies on the ability of reading 9 track tapes by a PC system connected to a 9 track tape drive, in this case using VISTA seismic processing software (Figure 2).

## Location of shots and stations

The location of shots and stations depends on the type of survey. If there are small numbers of shots and/or stations, the locations can be read into a program (such as ROBIN) which computes shot-station distances, and these can then be edited into distance files for each shot (or station). Where there are large numbers of shots (or stations) the processing stream shown in Figure 4 must be used. This begins with the raw navigation file, in this case generated by the shooting ship navigation computer. The distances to the stations are then computed and written to look-up tables for subsequent correction of data file header records.

## Timing corrections

Tables of shot and station clock errors can be generated from a) the errors between the clock and radio standard shown on the recording station comparator, b) direct measurement of this error on analogue paper records from the playback system, and c) the errors noted on the ship's seismic acquisition system clock. The processing stream shown in Figure 5 generates look-up tables of timing corrections to be applied to the data file header records. Both shot and station clock corrections are applied together. The strictly correct way of making the corrections would be to add the shot clock corrections to the shot times, and the recorder clock corrections to the start-of-digitizing times of the digitised records. However, to make changing the record headers simpler, both corrections are applied to the shot times only. (Note that the true shot times are recoverable from the shot-statistics files if something goes wrong; the start of digitising times would be irretrievably lost if they were changed, so it is an added precaution to do it this way). The definitions used and the way these corrections are applied are detailed in the description of program TRUETIME.

The digital recorders used the CPU clocks for timing. Periodically, ten-second radio pulses were recorded on top of the seismic signal so as to give an absolute time reference. The error of the CPU clock could then be measured by the difference between the clock time recorded in the file headers and the time of the nearest pulse. This is done in practice by listing the sample values and counting the difference between the first sample and the start of the first pulse. Automating this process was not warranted because the generally linear clock drift meant that relatively few error determinations were necessary. It would also be difficult when the pulses were superimposed on noisy data. The error was then calculated using the sample interval recorded in the file header.

During the Bass Strait surveys, Daylight Saving time was used initially before Standard time came into effect. Several additional processing steps were required to take this into account. Corrections were necessary in some cases where the data were digitised without taking into account that some stations were set up during Daylight Saving time (and so retained that time during the whole survey) while the ship's clock was changed to Standard time. Tables 7 and 9 list programs which address this problem and Figure 7 shows the processing stream required to correct data files digitised using the wrong time standard. These routines are included here as they are applicable to other major timing problems which may arise in future surveys, and are not restricted to the problem caused by Daylight Saving time.

### Filtering and Stacking

The data can be bandpass filtered and stacked prior to plotting as record sections (Tables 6 and 9; Figure 6). An input file is generated by MALHAM which contains the plotting parameters and the bandpass filter settings. The amplitudes of the traces can be normalised for shot weight, distance or trace-normalised. The input file is used by RECS14 to create a plot file of the filtered data, or alternatively by RECMED which can also stack the data prior to creating the plot file. Two ways of stacking are available, namely nth-root (McFadden and others, 1987) or median. In both cases the number of traces to stack and the velocity to phase the traces before stacking can be specified. The value of the root of the stack  $n$  in nth-root stacking can also be specified. If required, the component traces can be plotted with each stacked trace.

### Plotting

The plot files created by RECS14 or RECMED are plotted by either ZCOL or ZP (Tables 6 and 9; Figure 6). The record sections produced can be wiggle trace or variable area (see Figure 10-15). If variable area, they can have filled peaks, filled troughs, or both. They can be monochrome or colour. If colour, the colour coding thresholds in terms of fraction of peak amplitude can be selected and the colour coding can be relative to individual trace maximum peak amplitude or to maximum peak amplitude of the whole section. The whole plot can be scaled and the amplitudes of the traces can be scaled. The output section can be plotted on a variety of monitors, printers and plotters or a Postscript, CGM, WordPerfect or HPGL file can be generated. Most of the plotting input and output parameters are defaulted unless otherwise requested. The program ZMON is similar, but produces variable density plots in which the traces are a constant width but the density of the traces vary according to the amplitude.

## **Program Descriptions**

The following are brief descriptions of each program listed in Tables 1-8, and additional programs associated with playback and processing of AGSO data and data recorded by PC based digital recorders. The descriptions are generally expanded from the comments listed at the beginning of each program source code. The Fortran 77 source code for these programs is available on request from the authors.

- BASREF** Reformats digital data records of air-gun data recorded by PC based digital recorders into individual shot files. The new format conforms to the AGSO refraction data standard (Drummond & Downie, 1985). The digital files are recorded in series of files, each file containing data from 10 minutes of recording, in which the file names are AABBB.OUT, where AA is the number 1 to n where n is the total number in the series, BBB is the series name (eg. PS1), OUT is the suffix. The "root name" of the series is BBB.OUT.
- Input:* Day (date) of recording, Distance file (Table 9d), root name of the digital files, number of files in the series, sample interval (optional), prefix and extension of output files. Some fixed parameters (eg. shot weight) can be reset by editing a data statement at the start of the program listing
- Output:* Individual shot files with correct header parameters
- BENZ** Splits digitised files into 20.48 Sec files. This is used when each digitised file contains more than one shot; normally the shots are digitised individually provided there is sufficient time between shots for the playback and digitising system to complete all writing and housekeeping functions. BENZ can select file names with a specified interval (ie. not every consecutive file) and can process up to 1000 files.
- Input:* Number of first original file, number of files, file number interval, prefix and suffix of new files, shot rate (s), shot interval (km), distance increasing or decreasing, make all or only first file in a group
- Output:* Individual shot files (approximate distances only)
- DIST** Creates distance files for the marine air-gun data for a specified number of shots to a specified station. The distances are calculated from latitudes and longitudes, read from a shot statistics file and a station statistics file. The shot statistics file contains shot number, lats, longs, shot times, water depths, and gravity values, and is generated by program SHOT. The station statistics already exists, and is called STAT.DAT. This version can run fully interactively, or can be given a list of shot-statistics-files plus some other information and will then run automatically, producing a file of distances for each shot file. The naming conventions for these files are: DIAA\_BBB.CCD, where AA is station number BBB is shot traverse number, CC is the increment in the shot numbers processed (eg. 01 for every shot), and D is the part number (where traverses are not a continuous group of shots). The master file of file names comprises only file names, no heading, no ending. eg:

SH001.001

SH001.002

SH021.003

*Input:* File of shot-file file names (only if running non-interactively), station number, station file (Table b) or station coordinates, shot file (Table 9c), first and last shot numbers

*Output:* Distance file (Table 9d)

## **DISTAB**

Reads a shot distance/time file and pulls out only the distances into a new file. For use with the program TRUEDIST so that the true distances are automatically put in the headers. This version reads a list of files from a file and automatically creates the distance files. The files produced have names as follows: DIAA\_BBB.CC, where AA = station number, BBB = shot traverse number, CC = part number, when there are more than one part to the traverse.

*Input:* Distance file (Table 9d)

*Output:* Distance table (Table 9e)

## **FSORT**

Reads the digital files file names file, and creates all the full file names so that the DOS directory command can sort them in order, and so generate a file of the full digital file names. Use the DOS filter and pipe command DIR|SORT>LIST

*Input:* File name of file containing root names of digital file series and number of files in each series

*Output:* Full set of files which can then be sorted

## **HEADR1**

Opens data files which are in the AGSO refraction data format (Drummond & Downie, 1985) and displays the header record. The parameters in the header record can then be changed if necessary.

*Input:* H or PDP11 files, file name, any changes (optional)

*Output:* Modified file (optional)

## **LISTF**

Displays the data in a seismic data file which is in AGSO refraction data format (Drummond & Downie, 1985).

*Input:* File name, output format required, number of data blocks to display

*Output:* On screen display of digitised data in a specified format

- MALHAM** Generates a list of file names and plotting parameters for producing record sections by programs RECS14 or RECMED
- Input:* List of file names (pre-existing or generated by MALHAM), plotting parameters, bandpass filter parameters
- Output:* File with file names and plotting parameters
- 
- NAV** Rewrites a Marine Division navigation and non-seismic file to only include the data between the times of interest. The original Julian days and hours can be retained, or Local days and hours can be specified. In this case, the Leap Year is accounted for by reading the survey number Survey 82 (1988) or Survey 90 (1989) from the navigation file. Daylight saving is included in the conversion as appropriate.
- Input:* Input file name, Initial and final Julian Days, conversion to Local Time (optional)
- Output:* File with relevant navigation data including Local Time
- 
- PIPOUT** Removes radio time pips from digitally recorded seismic data
- Input:* File name, number of samples, threshold amplitude of pips, whether to zero the pips
- Output:* File with radio pips removed
- 
- POSEST** Estimates the position of air-gun shots by interpolating the latitudes and longitudes from known locations. The output file is formatted for input directly to program ROBIN which calculates distances of the shots from a station.
- Input:* Shot numbers and positions of the known shot locations, increment in the estimated shot numbers, number and position of the recording station.
- Output:* File of estimated lats and longs
- 
- RECDAT** This program pulls out shots from digital recorder files and writes them to a continuous file.
- Input:* Shot time, distance, number of seconds per shot, sample interval (optional), delay after shot time
- Output:* File of shot data

- RECMED** Creates a plot file for plotting record sections. It also bandpass filters and stacks shots. This version can do nth-root and median stacks. The stacked trace is plotted at the central position of the group or at the location of the trace nearest the centre on the low shot (or station) side in the case of even numbers of stacked traces. Stacking parameters that can be specified are number of shots to stack, velocity to phase the stack, the root of the stack for nth-root stacks and whether to plot the component traces with the stacked trace.
- Input:* Input file generated by MALHAM, optional plotting parameters, amplitude and scaling parameters (optional), stacking parameters
- Output:* Plot file for use by ZCOL or ZP
- 
- RECS14** Creates a plot file for plotting record sections. It also bandpass filters the data.
- Input:* Input file generated by MALHAM, optional plotting parameters, amplitude and scaling parameters (optional)
- Output:* Plot file for use by ZCOL or ZP
- 
- REFILE** Program REFILE reformats seismic data files which were created on the BMR PDP11 or HP and transferred to a PC. The PC cannot recognise the record length of the original file and therefore will not open the file as 'direct access'. The record lengths required are 512 bytes, format is 'unformatted', and access is 'direct'. This program uses the Fortran extension access = 'transparent' available with Lahey Fortran, which opens the problem files with a record length of 1 byte.
- Input:* Original computer (HP or PDP11), input file name prefix and suffix, first and last file numbers, increment in the file numbers, original files
- Output:* Reformatted data files with 512 byte record lengths
- 
- REKSEK** This is a program for plotting record sections of air-gun data recorded continuously by PC based digital recording systems. It can plot whole series of data files. Includes the program SHOTSTAT at the beginning so that series of digital data files can be processed and plotted in one go with only the name of the first file in that series being input. This version includes option for removing radio pips from the data. It substitutes zeros for sample values above a specified level. Can be run interactively or by using an existing default file, and can plot a single shot from specified files in a series for quality control.

*Input:* Root name of original digital files, first, last and increment in file numbers, shot interval and rate, no of traces to plot, plotting, scaling and filtering parameters (or, supply file name of "default file" containing these parameters), sample interval (optional)  
*Output:* Record section plot of specified data

**RENFILS** Makes a list of file names to rename, so that a whole lot of files can be renamed all at once in a batch job, provided the new files can be easily derived from the old file names (that is, by specifying a constant difference between the original file numbers and the desired file numbers). This is used for data files having the standard file name format of AA1234.567 where AA is alphabetical prefix, 567 is the alphanumeric suffix, and 1234 is the shot number (ie. the file number)

*Input:* File name prefix and suffix, first and last file numbers, difference between the old and new file numbers  
*Output:* File which can be run as a DOS batch job for mass renaming of files

**RENSHOTS** Corrects the shot number in the file name by reading the true shot number from the file header. Makes a list of file names to rename, so that a whole lot of files can be renamed all at once in a batch job. Data files must have the standard file name format of AA1234.567 where AA is alphabetical prefix, 567 is the alphanumeric suffix, and 1234 is the shot number (ie. the file number)

*Input:* File name prefix and suffix, first and last file numbers, whether header shot number is greater or less than file name number  
*Output:* File which can be run as a DOS batch job to rename files

**SHOT** Creates shot statistic files (see Table 9c) for marine air-gun data. This version interpolates the latitudes and longitudes for a particular shot time from the navigation file (the navigation data is listed every minute in time), or can interpolate between two known locations if the navigation is not available.

*Input:* First, last and increment in shot numbers navigation file (generated by program NAV) or interpolate the navigation between two known locations  
*Output:* Shot file (Table 9c)

**SHOTT** Checks airgun numbers and shot times in the gun logger records are in a continuous sequence by checking the shot numbers, shot times and shot



intervals. This detects misfires and glitches in the numbering system which occur in the ship's data acquisition system.

*Input:* First, last shot numbers and times, shot rate

*Output:* Comparison of elapsed time calculated from the recorded shot times and calculated from the shot rate and shot numbers (should be the same)

**SONOREF** Program SONOREF reformats sonobuoy travel times and shot numbers digitised from a VAX workstation so the file contains distances and travel-times. The location of the sonobuoy is derived from the intercept at zero time of the closest arrivals which arrive at the water-wave velocity, 1500 m/s.

*Input:* Sonobuoy shot/distance file (Table 9d) generated by DIST from a) a "station" file consisting of the first shot number and its position b) the shot file for the traverse, original sonobuoy travel time file (Table 9k) from VAX Workstation

*Output:* Sonobuoy distance/time file (Table 9l)

**TAPEDSK2** Makes a list of file names to transfer from tape (generated on the PDP11 playback system) to PC hard disc using the VISTA system. This batch file contains all the parameters required by the utility TAPE2DSK on the VISTA system. This version skips the header and eof files associated with each data file. It skips one file initially, then two for each file.

*Input:* Prefix, suffix of file names, first and last file number

*Output:* Batch file for use by TAPE2DSK

**TEDAYSAV** Reformats time errors file for daylight saving (and corrects for 1 hour added wrongly to each time). This is applied when correcting for clock drift on those stations which were set up with daylight saving time while the ship's clock was running on standard time.

*Input:* Original standard time clock error file (Table 9f)

*Output:* Daylight saving clock error file (Table 9g)

**TEDIEROR** Reads a table of station/ship timing corrections and makes a file of shot Distance vs. Correction. This is so the error associated with a particular distance from a station can be obtained.

*Input:* Table of corrections generated by TETABLE (Table 9i), shot distance file (Table 9d)

*Output:* Table of distances and timing corrections

**TEREFORM** Reformats timing error files (either the ship's clock or the recorder clock) so that the errors can be plotted versus the time

*Input:* Shot error or Recorder error file (Table 9f or 9h)

*Output:* Reformatted error file

**TESHEROR** Reads a table of station/ship timing corrections and makes a file of shot Number vs. Correction. This is so the error associated with a particular shot can be obtained.

*Input:* Table of corrections generated by TETABLE (Table 9i)

*Output:* Table of shot numbers and timing corrections

**TEST80** Digitising program for digitising analog seismic data tapes recorded by AGSO FM remote tape recorders on the PDP11 playback system. It produces individual shot files automatically with no operator intervention other than to initiate the program or re-start it after a predetermined number of failures (eg. due to poorly recorded clock signal). Each shot's parameters are calculated while digitising. It produces a file of 512 byte records, unformatted. The header block is in record one. For details of the latter see Drummond and Downie (1985).

TEST80 requires an input file called INFILE.DAT. This contains all the "fixed" inputs: survey number, survey name, recorder gain, shot weight, channel digitised, station number, shot rate (sec), shot spacing (km), number of samples to digitise and number of cycles between misses. An example of an input file is shown in Table 9a.

Make INFILE.DAT using program INFILE, or use the editor. The most important parameter is the shot rate because the program updates the shot times from this. 1400 samples means 700 seismic samples (11.2 seconds for a playback sampling interval of 16 msec); the other 700 samples are digitised radio signal. The purpose of digitising the radio is so that the program can work out the conversion factor for correcting speed variations of the recorder and/or playback system and write this to the header of each shot record. 22000 cycles is a criterion for testing whether the file was not digitised successfully so that a miss is recorded and the next shot header details are updated in time for the next shot. It depends on the shot interval (eg. 18.2 sec is 18200 msec, plus some time more to allow for rounding of the timing in seconds).

TEST80 automatically updates the distance, shot time, start time and file name in the header of each shot record. It makes certain assumptions, so

conventions must be adhered to: 1) File names are of the form XX1234.456, where XX is any two letter prefix, 1234 is a number (usually the shot number), and 456 is any extension. It assumes only one shot per record is digitised.

The data acquisition section is adapted from Data Translation Software.--- See RSXLIB 'Installation Manual and Users Guide'. The drivers for the devices are : KW: programmable clock 'KWV11-C'

AK: a to d converter 'DT2781'

JB: parallel line interface 'DRV11-J'

Command file for compiling: DIGIT.CMD

Subroutines: most of them are contained in RADIO.FTN, DATA75, CLOK65

*Input:* The file "INFILE.DAT" (Table 9a), first shot number, shot time, distance, number of shots to digitise, number of misses tolerated before digitising is stopped, and directory and file name of first shot, a "reduction velocity" (this is used to delay the start of digitising after the shot time. The delay is (distance/reduction velocity) in seconds. The idea is to start digitising, say, about three to five seconds before the first arrival so that the majority of the time digitised (say, 11.2 seconds) falls after the first arrival and may record later arrivals. The velocity chosen depends on the expected travel times for the traverse. It is not critical; for Bass Strait, velocities used were around 8.0 for distances beyond 150 km, 7.5 between 100 and 150 km, 9.0 between 75 and 100 km, and 13.0 between 50 and 75 km).

*Output:* Digitised shot files stored on the PDP11 hard disc

## **TETABLE**

This program generates timing error tables which contain the corrections to be added to the shot times in the file headers. It requires a shot error file containing the clock errors on the shooting ship, and a station error file containing the clock errors of the recorder. It generates a file similar to the distance table used by program TRUEDIST. The timing corrections listed in the table account for both the shot errors and the station errors. Note that corrections are added to the raw times; they are therefore opposite in sign to the errors (-ive error means clock is slow, so the clock has to be advanced (add) by that amount). The strictly true way of making the corrections would be to add the shot-clock corrections to the shot times, and the recorder clock-corrections to the start times of the digitised records. However, to make changing the record headers simpler, both corrections are applied to the shot times only. (Note, the true shot times are always easily recoverable from the shot-statistics files if something goes wrong; the start of digitising times would be lost forever if they were changed, so it is an added precaution to do it this way!)

**Definitions:**

clock slow --- error is -ive

clock fast --- error is +ive

shot clock slow --> add        magnitude of error    to shot time  
shot clock fast --> subtract    magnitude of error    from shot time  
recr clock slow --> subtract    magnitude of error    from shot time  
recr clock fast --> add        magnitude of error    to shot time

so:

$$\begin{aligned}\text{corrected shot time} &= t(\text{shot}) - \text{error}(\text{shot}) + \text{error}(\text{station}) \\ &= t(\text{shot}) + (\text{combined correction})\end{aligned}$$

and the table of correction (correction!) Factors are values of:

$$(-\text{error}(\text{shot}) + \text{error}(\text{station}))$$

ADD these to the shot times.

*Input:* Ship clock error file (Table 9f or 9g), station clock error file (Table 9h)

*Output:* Table of timing corrections (Table 9i)

**TRUEDIST**

This program corrects the distances in the header records of the data files. The distances written in at the time of digitising are usually only approximate.

*Input:* Prefix, suffix, increment in the data file names, first and last shot numbers, distance table (Table 9e), the data files

*Output:* Data files with the correct distances in the header records

**TRUESHOT**

This program changes the shot numbers in seismic data file headers, and the shot times for the new shot numbers. The shot times have one hour added to them, so that they correspond to the start of record times. This procedure is used for those files which have been digitised with the true shot time, when in fact the recorder clock has been set to Summer Time (ie. +1 hour). The event that is in the header is as a consequence a shot which is 1 hour earlier than the shot number listed in the header. The actual shot may not be exactly 1 hour earlier (the actual time has to be a multiple of the shot rate), so the nearest shot to that time is the one recorded. The file names use the shot number as part of the name, and so they have to be changed as well. Use program RENFILES to do this as a batch job. You must know the original shot numbers and the true shot numbers to which they correspond.

*Input:* Renamed files from RENFILES, shot file (Table 9c)

*Output:* Seismic data files with correct shot numbers and times in the headers

**TRUETIME** This program applies timing corrections to the shot-times in seismic data files. Timing corrections are computed by program TETABLE and account for both recorder and shot timing errors. They are applied to the shot time in the data file header for reasons outlined in the description of TETABLE. They are ADDED to the shot times.

*Input:* Prefix, suffix, increment in shot numbers, first and last shot numbers, table of timing corrections (Table 9i)

*Output:* Seismic data files corrected for ship and recorder clock errors

**ZCOL** Plots record sections generated by program RECS14 or RECMED. These sections can be wiggle trace or variable area. If variable area, they can have filled peaks, filled troughs, or both. They can be monochrome or colour. If colour, the colour coding thresholds in terms of fraction of peak amplitude can be selected and the colour coding can be relative to individual trace maximum peak amplitude or to maximum peak amplitude of the whole section. The whole plot can be scaled and the amplitudes of the traces can be scaled. The output section can be plotted on a variety of monitors, printers and plotters or a Postscript, WordPerfect or HPGL file can be generated. Most of the plotting input and output parameters are defaulted unless otherwise requested.

*Input:* Plot file generated by RECS14 or RECMED

*Output:* Record Section plot or plot file

**ZMON** Plots record sections generated by program RECS14 or RECMED. They can be monochrome or colour. If colour, the colour coding thresholds in terms of fraction of peak amplitude can be selected and the colour coding can be relative to individual trace maximum peak amplitude or to maximum peak amplitude of the whole section. The whole plot can be scaled and the amplitudes of the traces can be scaled. The output section can be plotted on a variety of monitors, printers and plotters or a Postscript, WordPerfect or HPGL file can be generated. Most of the plotting input and output parameters are defaulted unless otherwise requested.

This version generates a variable density display in which the width of each trace is constant but the density of the trace shading (or colour) varies according to the amplitude.

*Input:* Plot file generated by RECS14 or RECMED

*Output:* Record Section plot or plot file

## **ZP**

Plots record sections generated by program RECS14 or RECMED. These sections can be wiggle trace or variable area. If variable area, they can have filled peaks, filled troughs, or both. They can be monochrome or colour. If colour, the colour coding thresholds in terms of fraction of peak amplitude can be selected and the colour coding can be relative to individual trace maximum peak amplitude or to maximum peak amplitude of the whole section. The whole plot can be scaled and the amplitudes of the traces can be scaled. The output section can be plotted on a variety of monitors, printers and plotters or a Postscript, WordPerfect or HPGL file can be generated. Most of the plotting input and output parameters are defaulted unless otherwise requested.

This version only plots amplitudes larger than a set threshold; other areas are blank. In practice, only a variable area display makes a sensible looking plot. This type of plot emphasises the signal over the background (which is blank) and also produces smaller plot files.

*Input:* Plot file generated by RECS14 or RECMED

*Output:* Record Section plot or plot file

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**MAJOR PROCESSING PROGRAMS - see Flow Charts in Figures 1-9**

**TABLE 1: Digitizing, transfer via VAX to PC and reformatting**

PROGRAM	DESCRIPTION	FIGURE
TEST80	PDP-11 digitizing program; digitizes seismic and radio channels.	1
REFILE	Reformats digitized data for processing on IBM-compatible PC	1

**TABLE 2: Digitizing, transfer via VISTA to PC and reformatting**

PROGRAM	DESCRIPTION	FIGURE
TEST80	PDP-11 digitizing program; digitizes seismic and radio channels.	2
TAPEDSK2	Creates batch file used by VISTA utility TAPE2DSK for file transfer	2
REFILE	Reformats digitized data for processing on IBM-compatible PC	2
RENSHOTS	Renames shot file names so the shot number is the same as in the header	2,8

**TABLE 3: Reformatting digitally recorded data**

PROGRAM	DESCRIPTION	FIGURE
BASREF	Reformat digitally recorded data files to AGSO format for PC processing	3



**TABLE 4: Locations and shot-station distances**

PROGRAM	DESCRIPTION	FIGURE
DIST	Creates shot-to-station distance files for each station to each traverse	4
DISTAB	Creates table of distances for each station to each traverse	4
NAV	Reformats original Marine Navigation files for relevant time periods	4
SHOT	Creates shot-statistics files from the navigation files	4
TRUEDIST	Writes correct distances into the record headers	4

**TABLE 5: Corrections for shot and recorder timing errors**

PROGRAM	DESCRIPTION	FIGURE
TEREFORM	Reformats shot and recorder clock-error files for generating error tables	5
TETABLE	Generates tables of combined shot and recorder clock errors	5
TRUETIME	Applies timing corrections to the shot record headers	5

**TABLE 6: Plotting Record Sections**

PROGRAM	DESCRIPTION	FIGURE
MALHAM	Creates an input file for generating record sections	6
RECMED	Creates record section plot files; also filters and stacks the data	6
ZCOL	Plots record sections; may be wiggle trace, variable area, and in colour	6

**TABLE 7: Correcting Data Files from Stations on Summer Time**

PROGRAM	DESCRIPTION	FIGURE
RENFILES	Creates a batch job to rename data files with the correct shot numbers	7
TRUESHOT	Corrects the shot numbers and the shot times in the shot record headers	7

**TABLE 8: Sonobuoy Time-Distance Data**

PROGRAM	DESCRIPTION	FIGURE
DIST	Create table of distances from sonobuoy and shot positions	9
SONOREF	Creates a time-distance file for each sonobuoy, with water depths, gravity	9

**TABLE 9: Other Processing Programs**

PROGRAM	DESCRIPTION	FIGURE
BENZ	Splits large digitized records into individual 20.48 sec shot records	-
CDPTOKM	Converts CDP numbers to distances in km from a specified station	-
FSORT	Creates a filenames list of the digitally recorded data files	-
HEADR1	Displays and modifies headers of files in AGSO refraction format	-
LISTF	Displays data in files which are in AGSO refraction format	-
PIPOUT	Removes Omega time signal pulses from digitally recorded data	-
POSEST	Estimates positions of shots by interpolating from known locations	-
RECDAT	Pulls out shots from digitally recorded data and rewrites to a file	-
REKSEK	Plots record sections of digitally recorded data	-
RECS14	Creates record section plot files; also filters the data	-
SHOTT	Checks air-gun shots are in a continuous time sequence	-
TEDAYSAV	Reformats clock time error files for daylight saving time	-
TEDIEROR	Creates a table of shot distance vs. timing corrections	-
TEREFORM	Reformats timing error files for plotting errors vs. time	-
TESHEROR	Creates a table of shot numbers vs. timing corrections	-
ZMON	Plots variable density record sections in colour or monochrome	-

ZP	Plots only the filled peaks of variable area record sections	-
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**TABLE 10: Input/output data files - Examples**

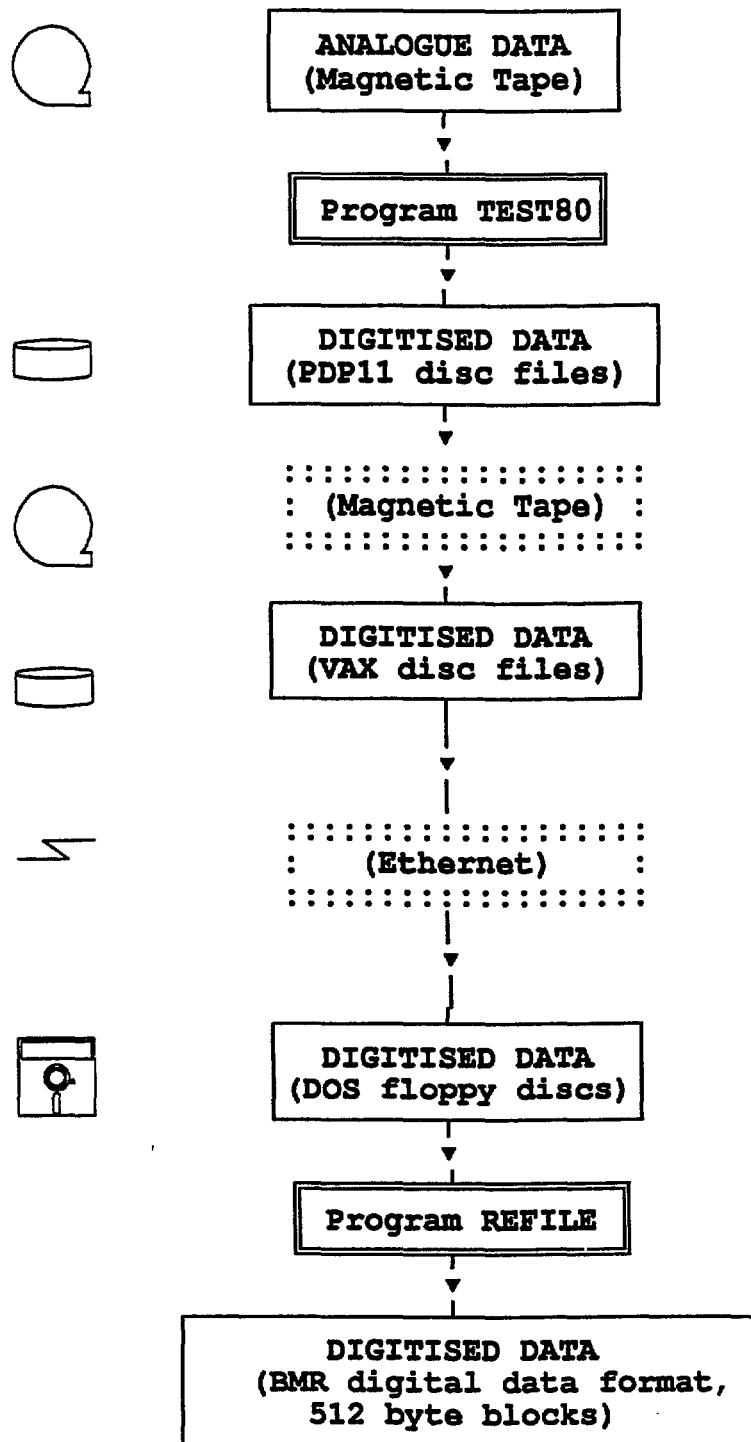
a) INFILE used by TEST80	
	221188 BASS STRAIT 96 1.0 2 01 18.2 0.0375 (-ive for approaching ship) 1400 22000
b) Station File	
TABLE 1. Onshore Refraction Stations 1 37 34.58 148 32.94 2 38 03.44 146 35.02 3 38 16.28 146 56.60 4 39 07.76 146 23.97 5 38 27.98 146 12.15 <b>etc...</b>	
c) Shot file	
SHOT FILE - LINE 90/007, NO. 1, SHOTS 2433-4854, LAT,LON,W DEPTH,GRAV 2433 39 23.938 147 18.410 -56.8 22 13 56 42 10 977507.9 2434 39 23.925 147 18.426 -56.8 22 13 57 0 30 977507.6 2435 39 23.912 147 18.443 -56.8 22 13 57 18 50 977507.4 2436 39 23.899 147 18.460 -56.7 22 13 57 36 70 977507.2 2437 39 23.886 147 18.477 -56.7 22 13 57 54 90 977506.9 <b>etc...</b>	

**TABLE 10: Input/output data files - Examples (Contd.)**

d) Distance File
<p>STATION 01, LINE 90/007, DISTANCES, AZIMUTHS, TIMES, W DEPTH, GRAV</p> <p>2433 229.515 207.8 22 13 56 42 10 -56.8 977507.9</p> <p>2434 229.483 207.8 22 13 57 0 30 -56.8 977507.6</p> <p>2435 229.450 207.8 22 13 57 18 50 -56.8 977507.4</p> <p>2436 229.417 207.8 22 13 57 36 70 -56.7 977507.2</p> <p>2437 229.385 207.8 22 13 57 54 90 -56.7 977506.9</p> <p><b>etc...</b></p>
e) Distance Table
<p>LINE 90/007, NO. 1, SHOTS 2433-4854 (FIRST NO, LAST NO, DIST)</p> <p>2433 0</p> <p>229.515 229.483 229.450 229.417 229.385 229.350 229.318 229.284 229.251 229.217</p> <p>229.184 229.152 229.120 229.087 229.054 229.021 228.987 228.953 228.919 228.886</p> <p>228.851 228.818 228.784 228.749 228.715 228.682 228.650 228.617 228.585 228.552</p> <p>228.519 228.485 228.450 228.418 228.383 228.350 228.316 228.282 228.248 228.213</p> <p><b>etc...</b></p>
f) Clock Error File (Ship)
<p>DAYS VERSION OF: Clock Errors, Survey 90 - LARGE ERRORS, EDITED</p> <p>17.06528 -0.033</p> <p>17.06875 -0.002</p> <p>17.72431 0.079</p> <p>18.31389 0.048</p> <p>19.02569 0.009</p> <p><b>etc...</b></p>
g) Clock Error File (Ship) - Daylight Saving Version
<p>DAY. SAV. VERSION OF: Clock Errors, Survey 90 - LARGE ERRORS, EDITED</p> <p>17.10695 -0.033 !This version has 1 hour added to the times (eg. true time on the</p> <p>17.11042 -0.002 !ship was 17.06528, but on recorders set up during Daylight</p> <p>17.76598 0.079 !Saving, the time was 18.06528). This file is to be used or</p> <p>18.35556 0.048 !correcting records from stations set up during Daylight Saving</p> <p>19.06736 0.009 !because the shot times and arrival times on the records are</p> <p>19.20000 0.001 !Daylight Saving Time.</p> <p><b>etc...</b></p>

**TABLE 10: Input/output data files - Examples (Contd.)**

h) Clock Error File (Stations)									
DAYS VERSION OF: Station Clock Errors - 999.999 = VNG, 888.888 = NO VALUE									
1	23.000	999.999							
1	31.292	888.888							
111	16.619	0.002	! 111 indicates the second deployment (Surv 90) at Stn 01						
111	30.519	0.553							
2	16.814	0.001							
etc...									
i) Timing Correction Table									
TIMING CORRECTIONS - STN 01, LINE 90/007 - ADD THESE TO SHOT TIMES									
1215	4849								
0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283
0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283
0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283
0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283
etc...									
j) Sonobuoy Locations									
SONOBUOY 1, LINE 002									
1448	38	24.958	148	0.777					
k) Sonobuoy Travel Times (Original data from VAX Workstation)									
.001									
60	1451	1							
80	1452	1							
116	1453	1							
140	1454	1							
188	1455	1							
etc...									
l) Sonobuoy Distance/Travel Times									
SONOBUOY 1, LINE 002, DIST(KM),TIME(S),SHOT NUM,WATER D, GRAVITY									
0.112	0.060	1451	-61.9	976589.9					
0.148	0.080	1452	-61.9	976590.5					
0.186	0.116	1453	-61.9	976591.1					
0.226	0.140	1454	-61.9	976591.6					
0.264	0.188	1455	-62.0	976592.1					
etc...									



**FIGURE 1.** Digitising analogue data, transferring digitized data via VAX mainframe computer and reformatting for applications programs on DOS computer.

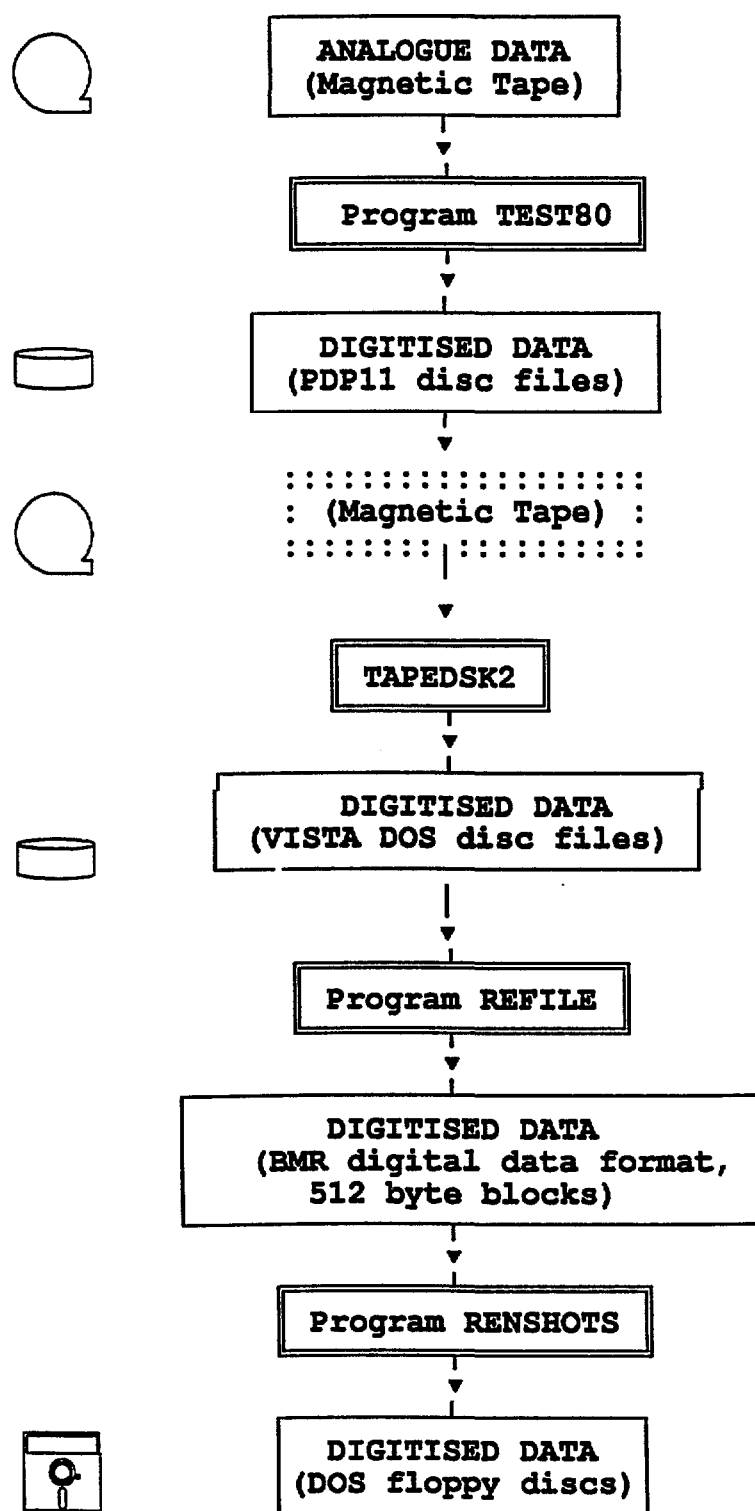
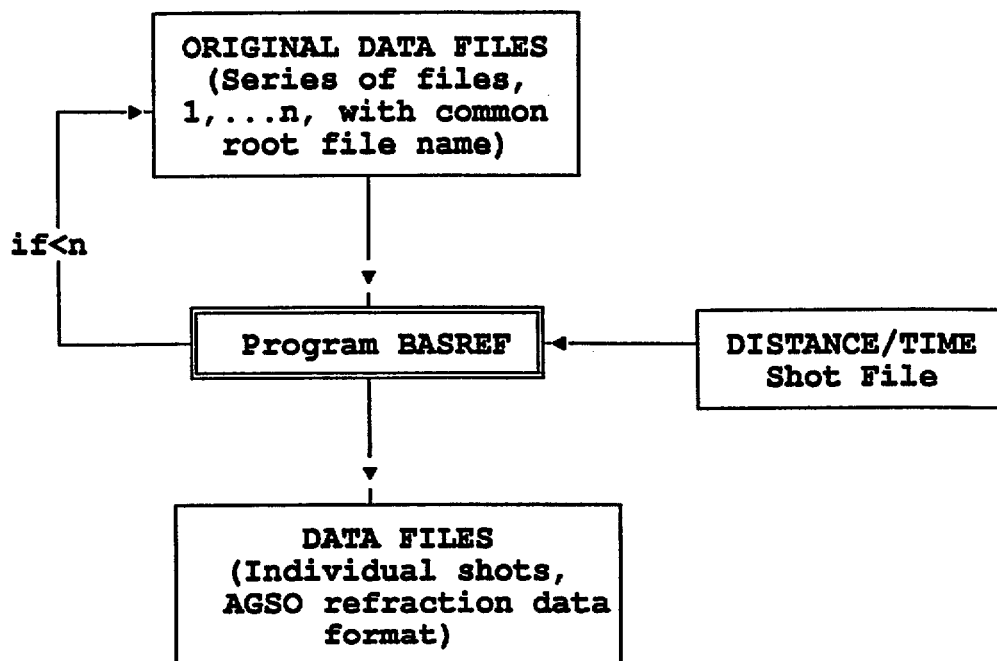


FIGURE 2. Digitising analogue data, transferring digitized data to VISTA PC, and reformatting for applications programs on DOS computer.





**Figure 3. Reformatting digital data files recorded on PC digital recorders. New files are individual shot records in AGSO refractin data format.**

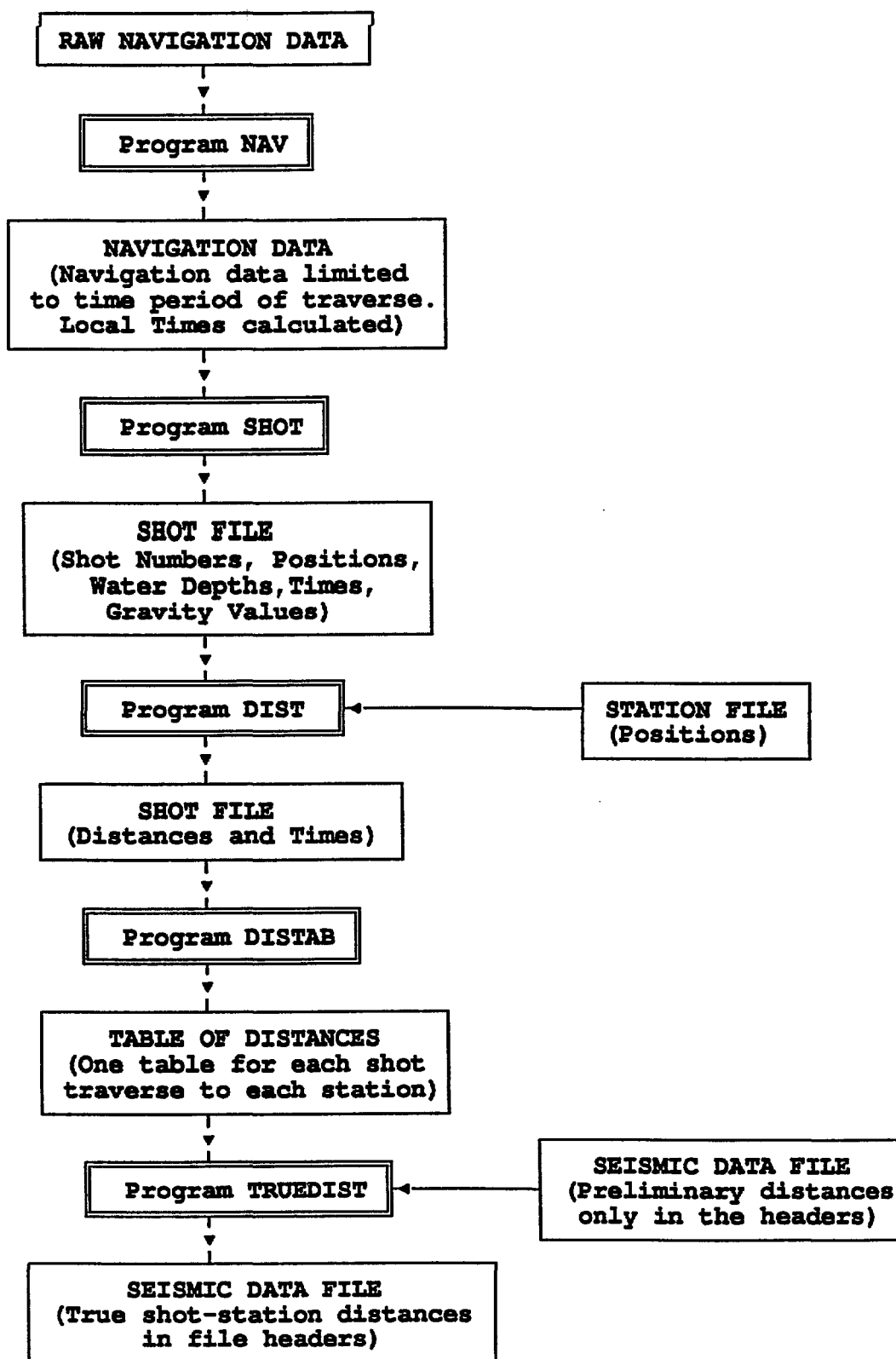


FIGURE 4. Compute shot-to-station distances and write to seismic data file headers.

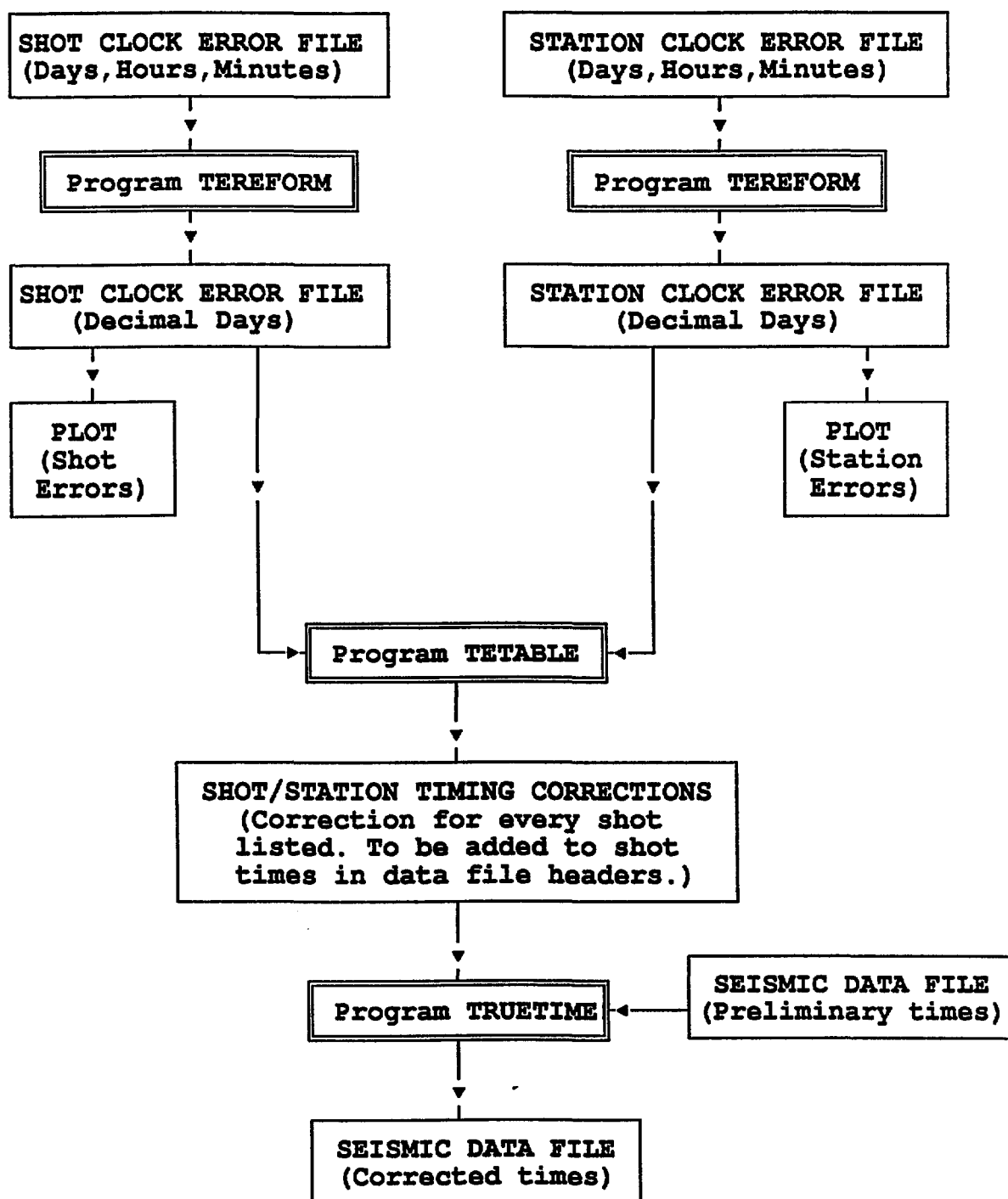
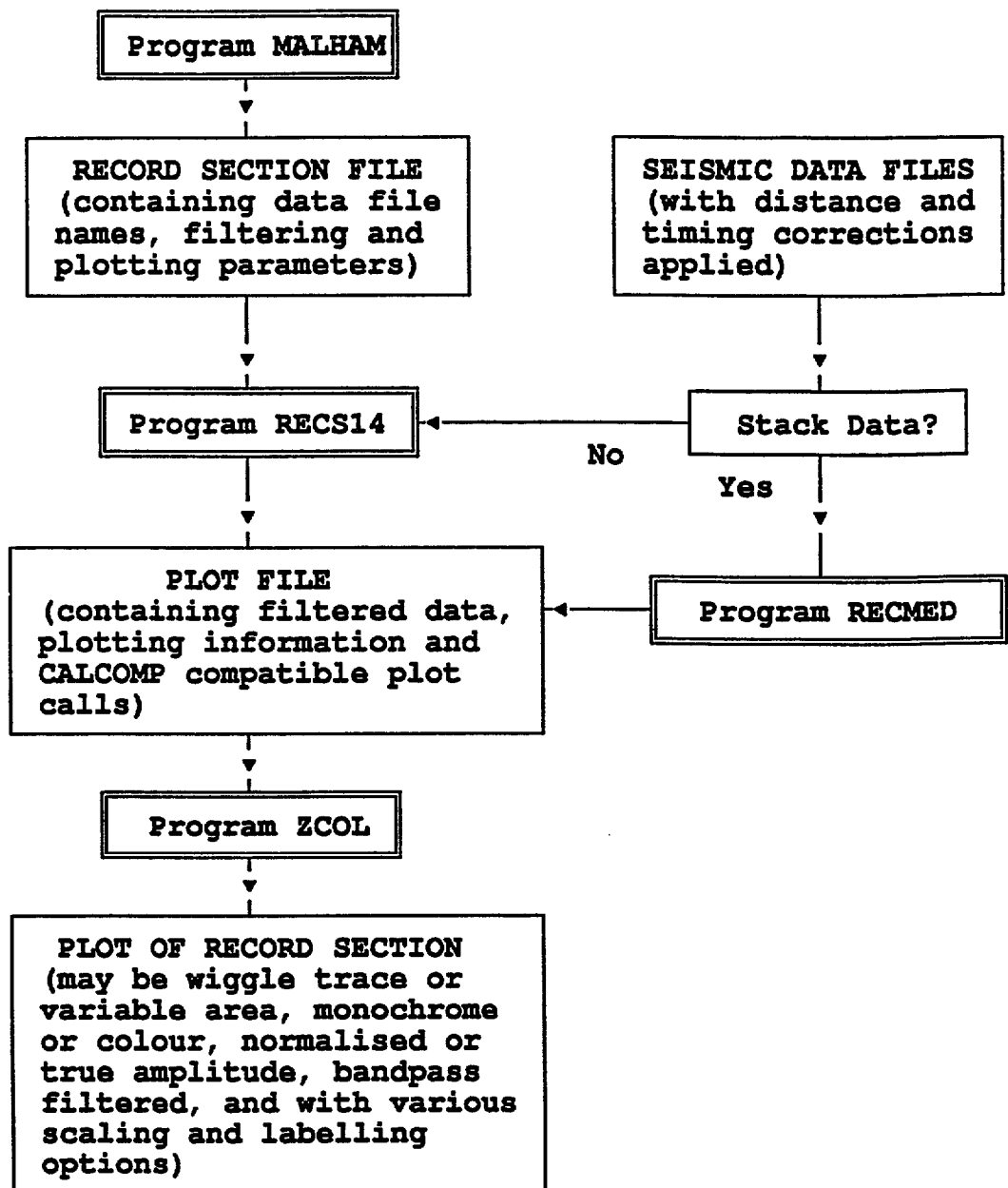


FIGURE 5. Corrections for shot and station clock errors.



**FIGURE 6. Plotting record sections**

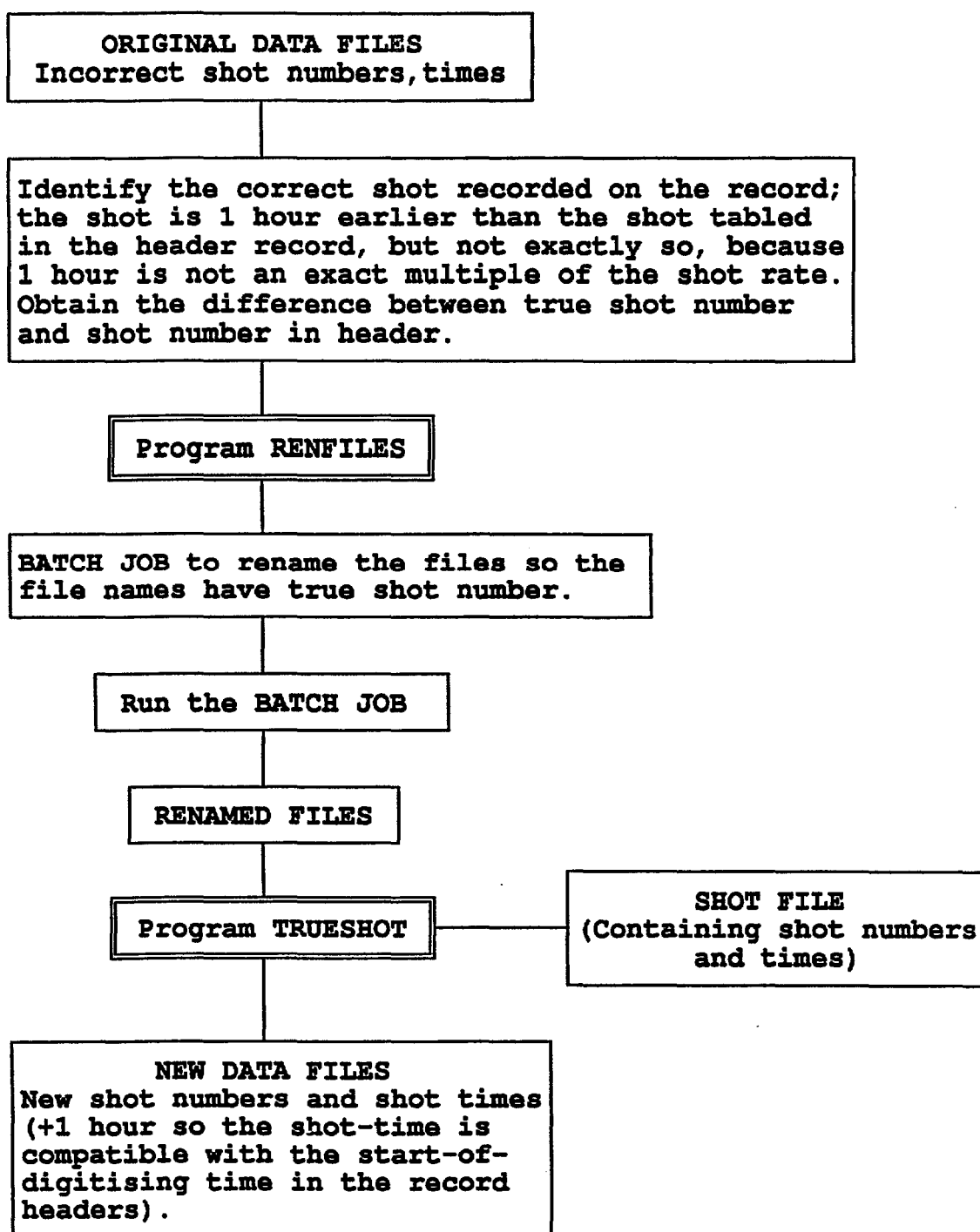
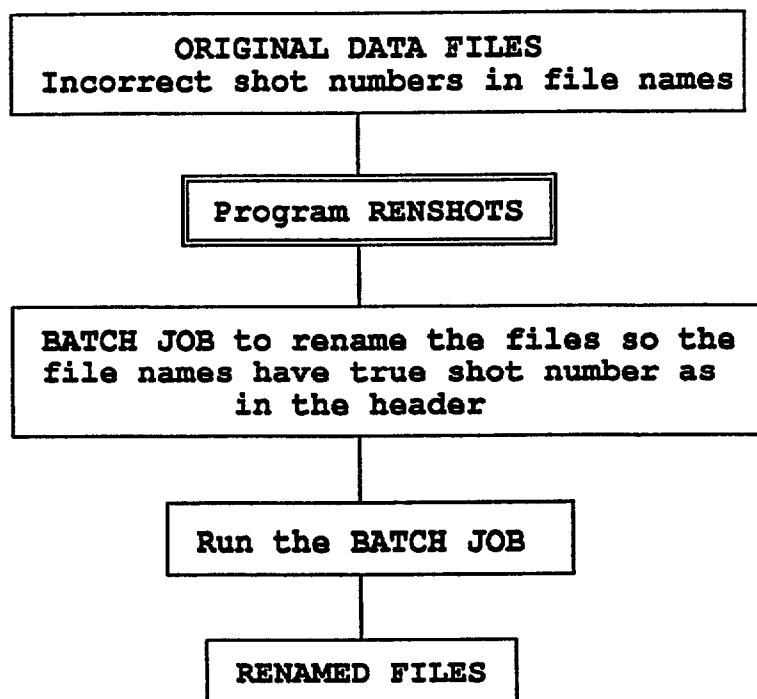


FIGURE 7. Correcting data files which were digitised assuming the recorder and shots were both on Eastern Standard Time, when the recorder was in fact still on Daylight Saving Time. This resulted in i) the shot numbers in the file headers being for shots approximately 1 hour later than the actual events recorded, ii) the file names having the incorrect shot numbers, and iii) the shot times in the headers being incorrect.



**FIGURE 8.** Renaming data file names so that the shot numbers in the file names are the same as the shot numbers in the headers of the files, ie. are the true shot numbers. The file names may have the wrong numbers when data is transcribed from tape to disc assuming an unbroken sequence of shots; each file transcribed is assumed to be the next shot, with the shot number incremented by one, and the file is named accordingly.

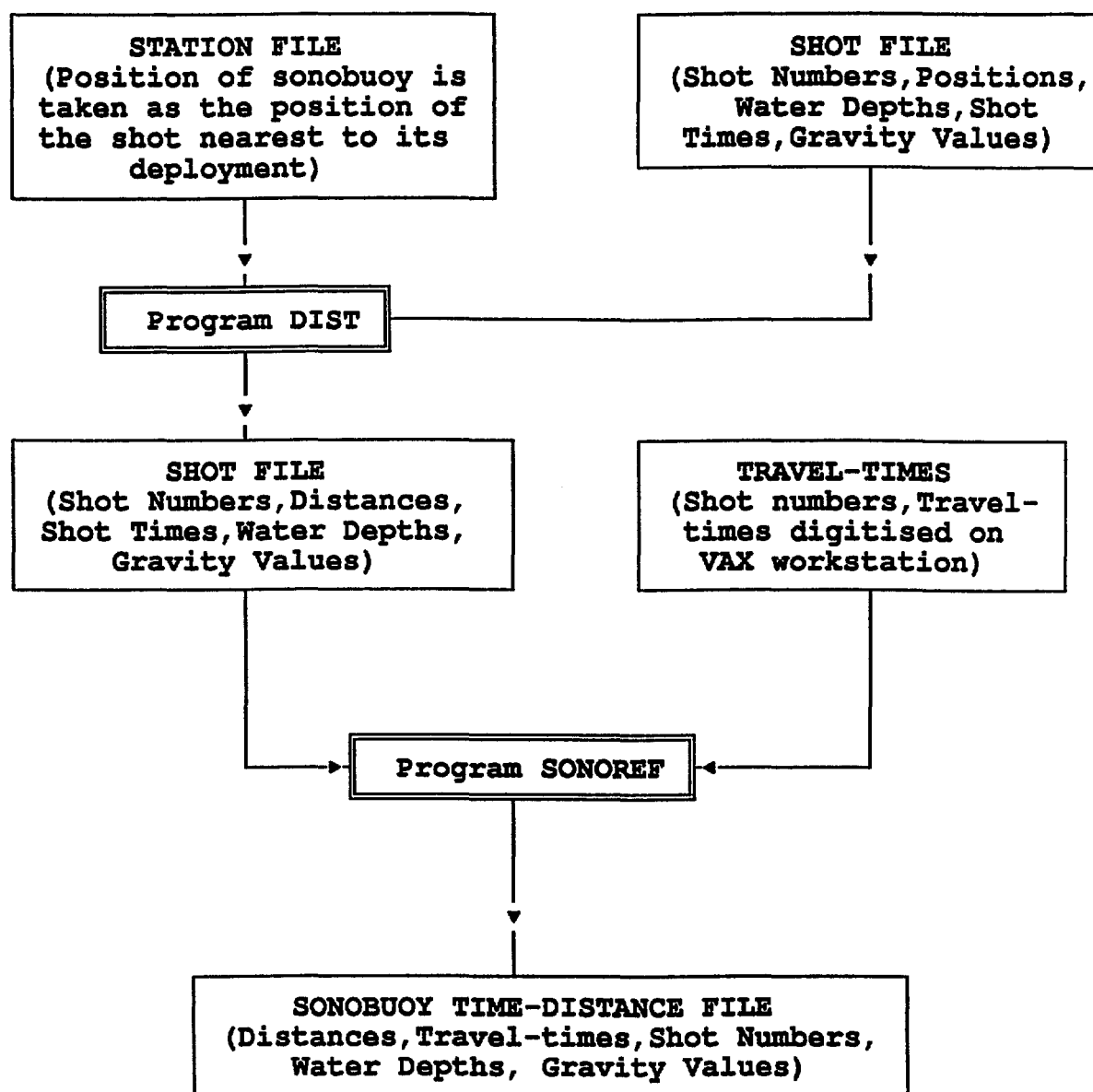
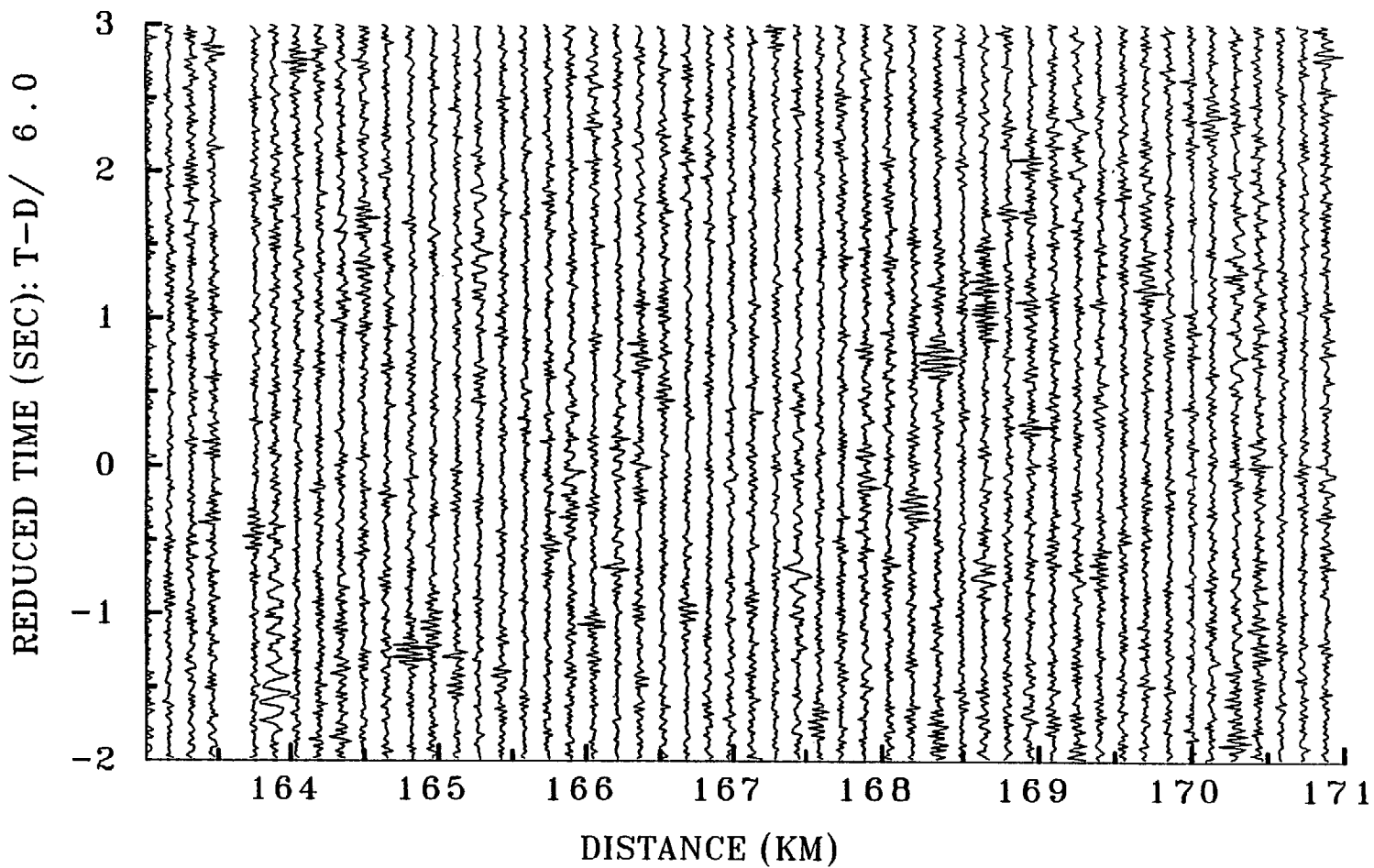


FIGURE 9. Sonobuoy Time-Distance data.

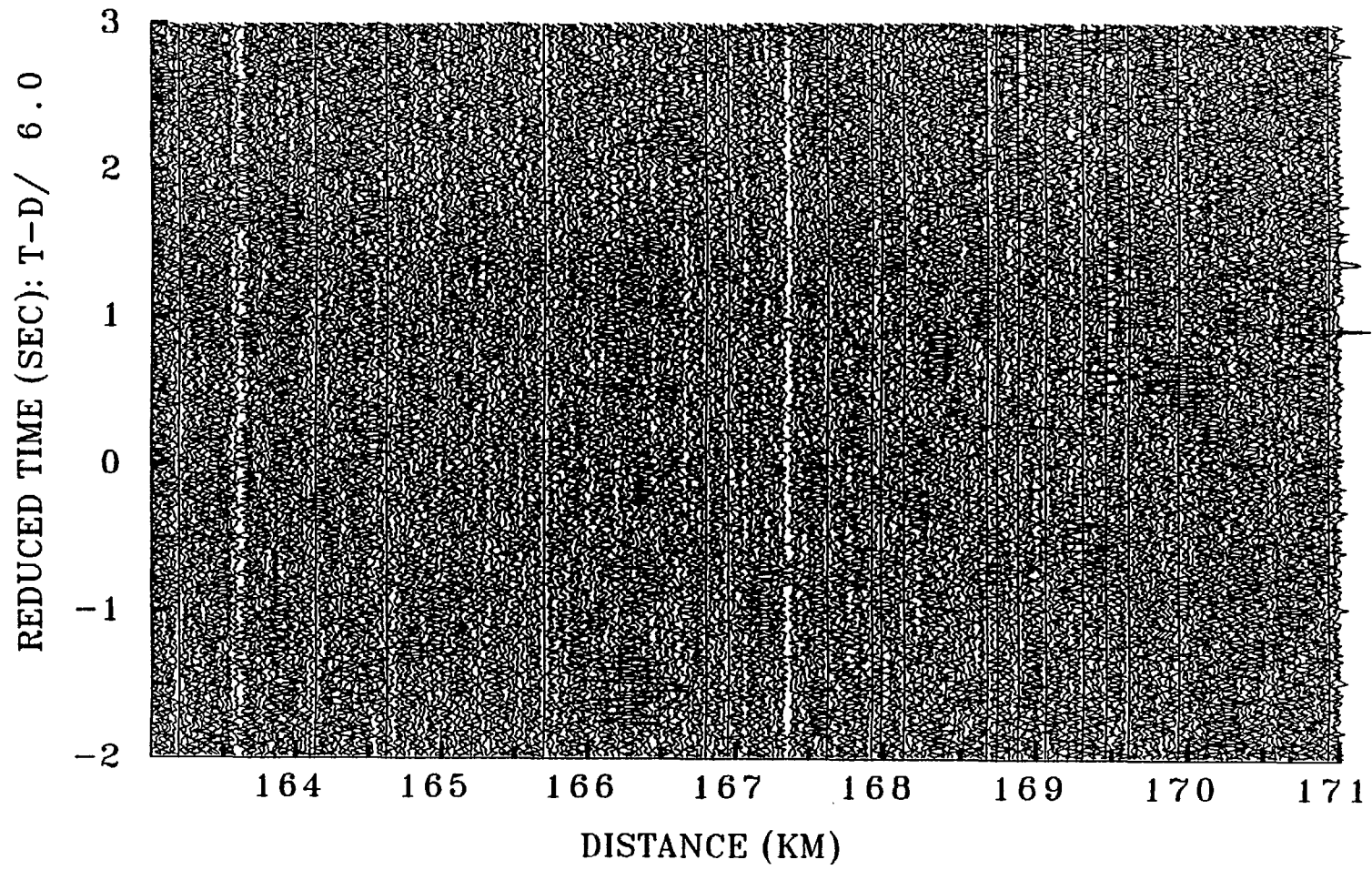
# STN 04, 90/007, RAW DATA



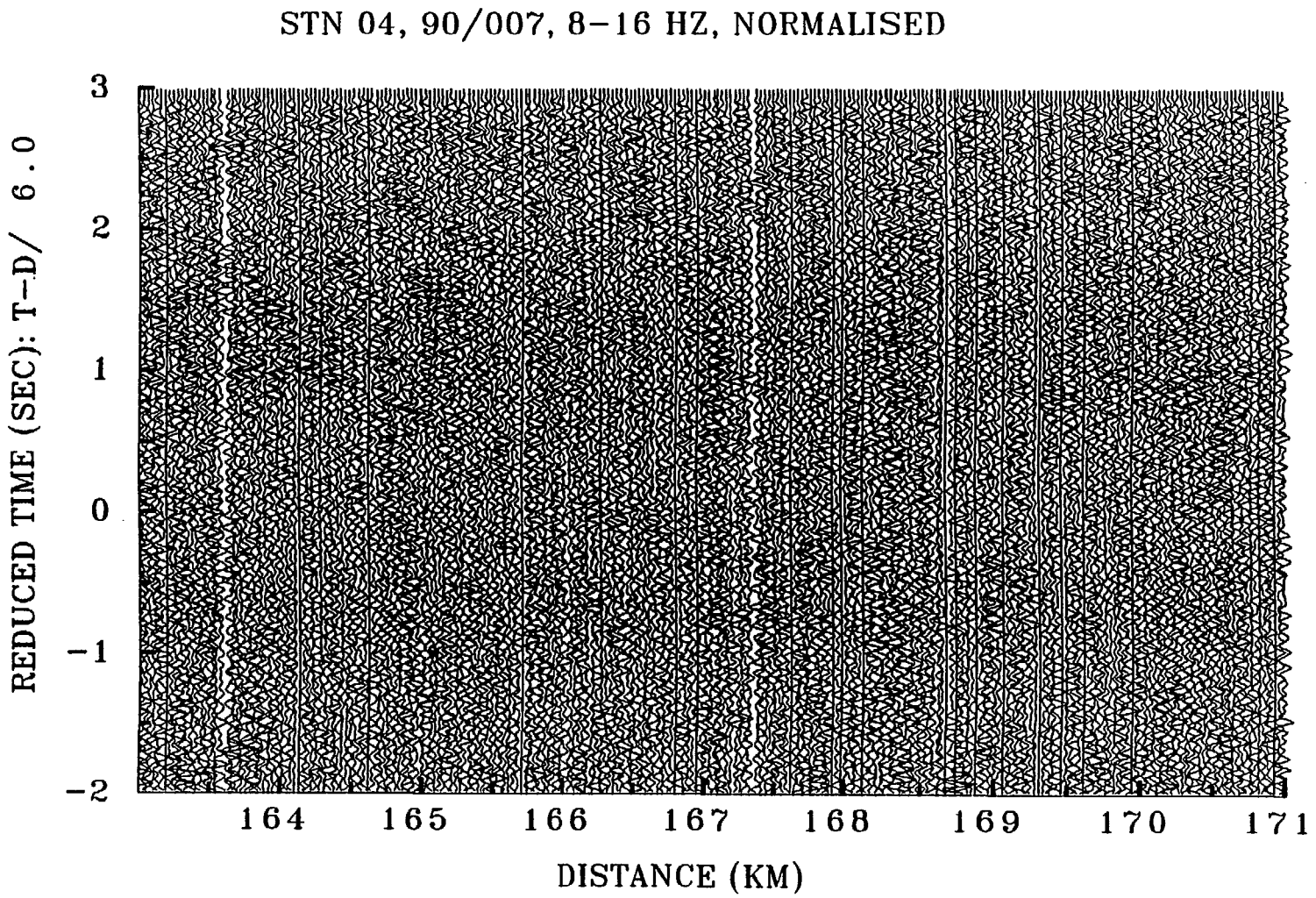
10. Record section of raw data; no filter, true relative amplitude, every 5th shot plotted



STN 04, 90/007, RAW DATA

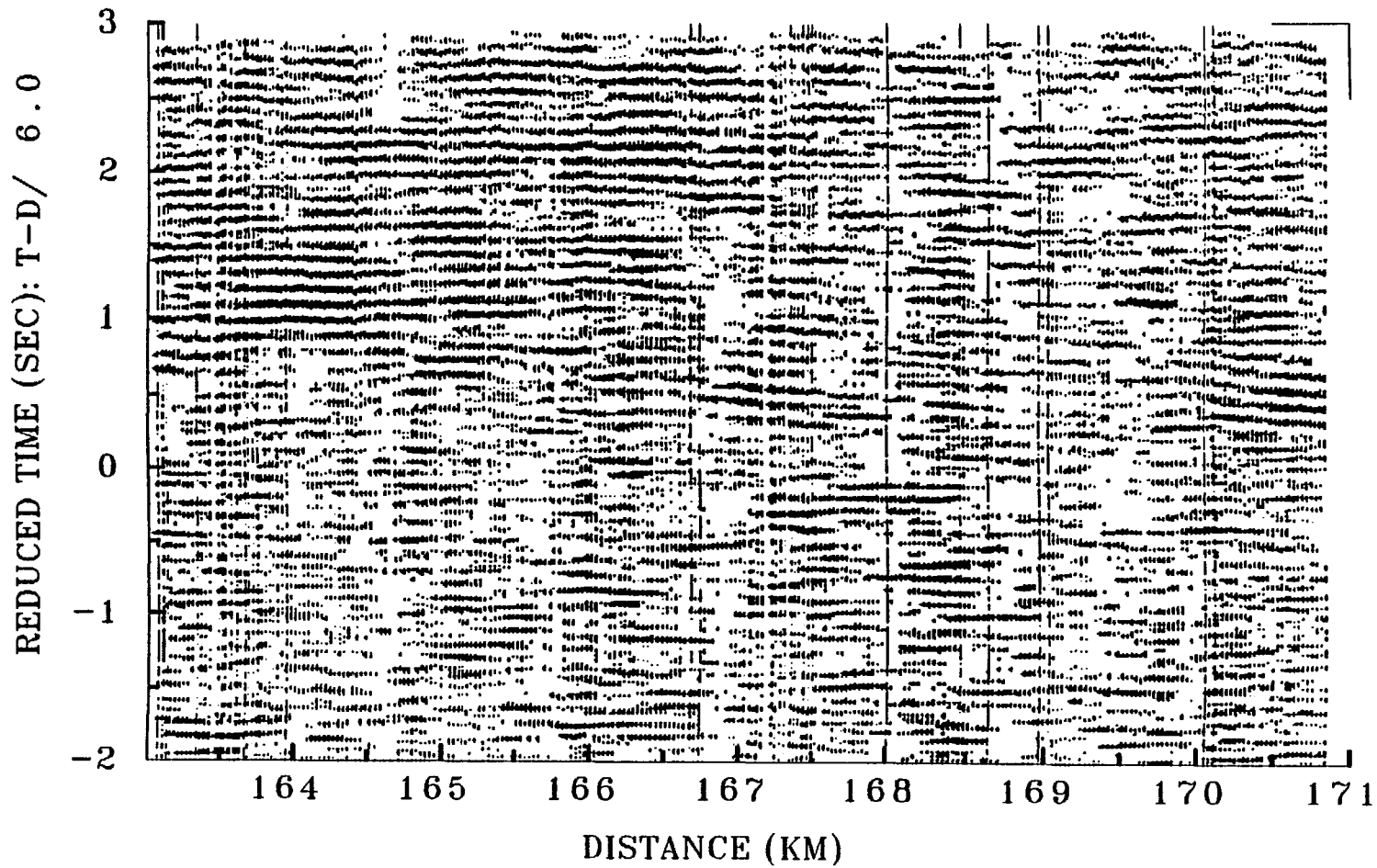


11. Same data as Fig 10, raw data; no filter, true relative amplitude, every shot plotted

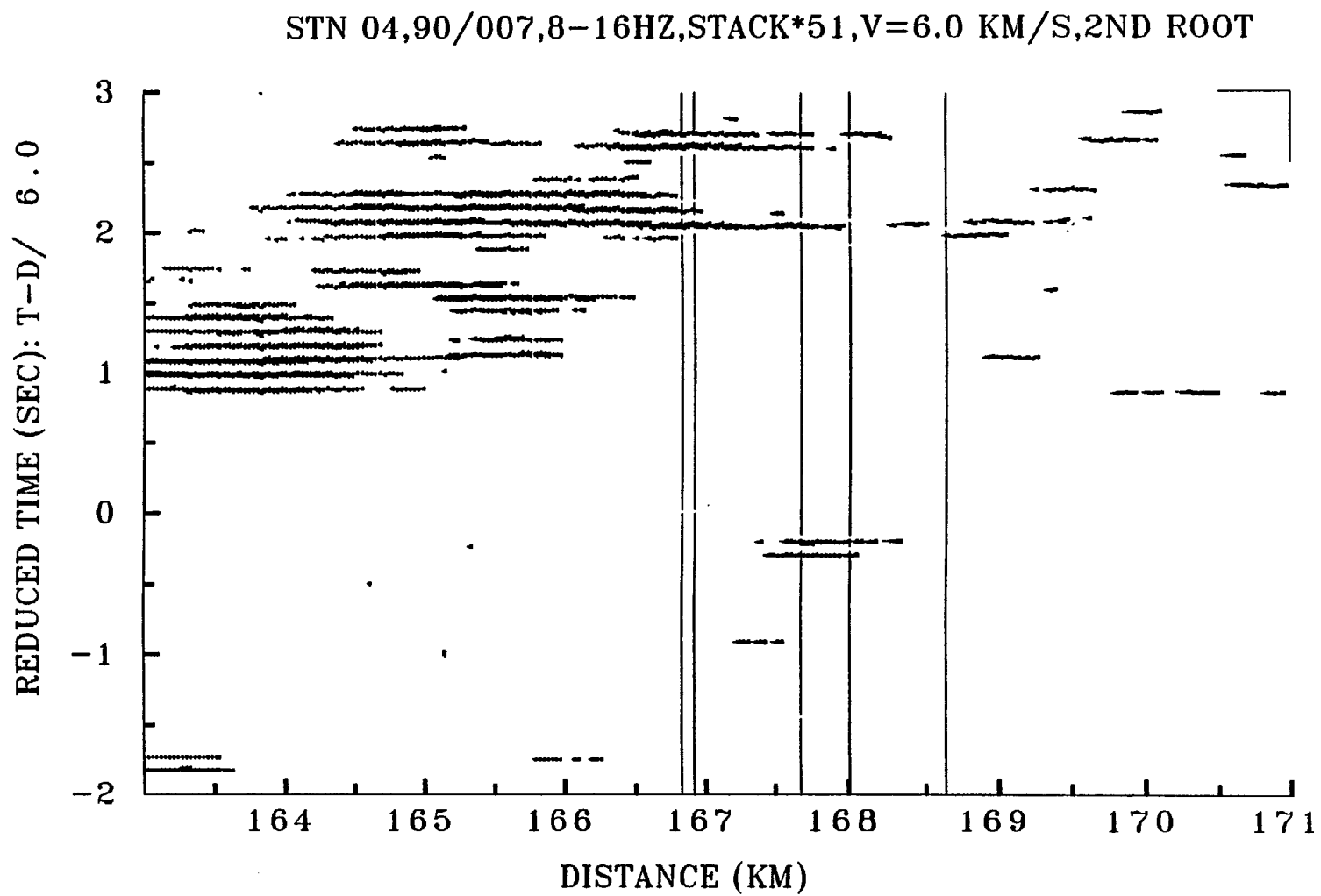


12. Same data as Fig 11, bandpass filtered 8-16 Hz, trace normalised, every shot plotted

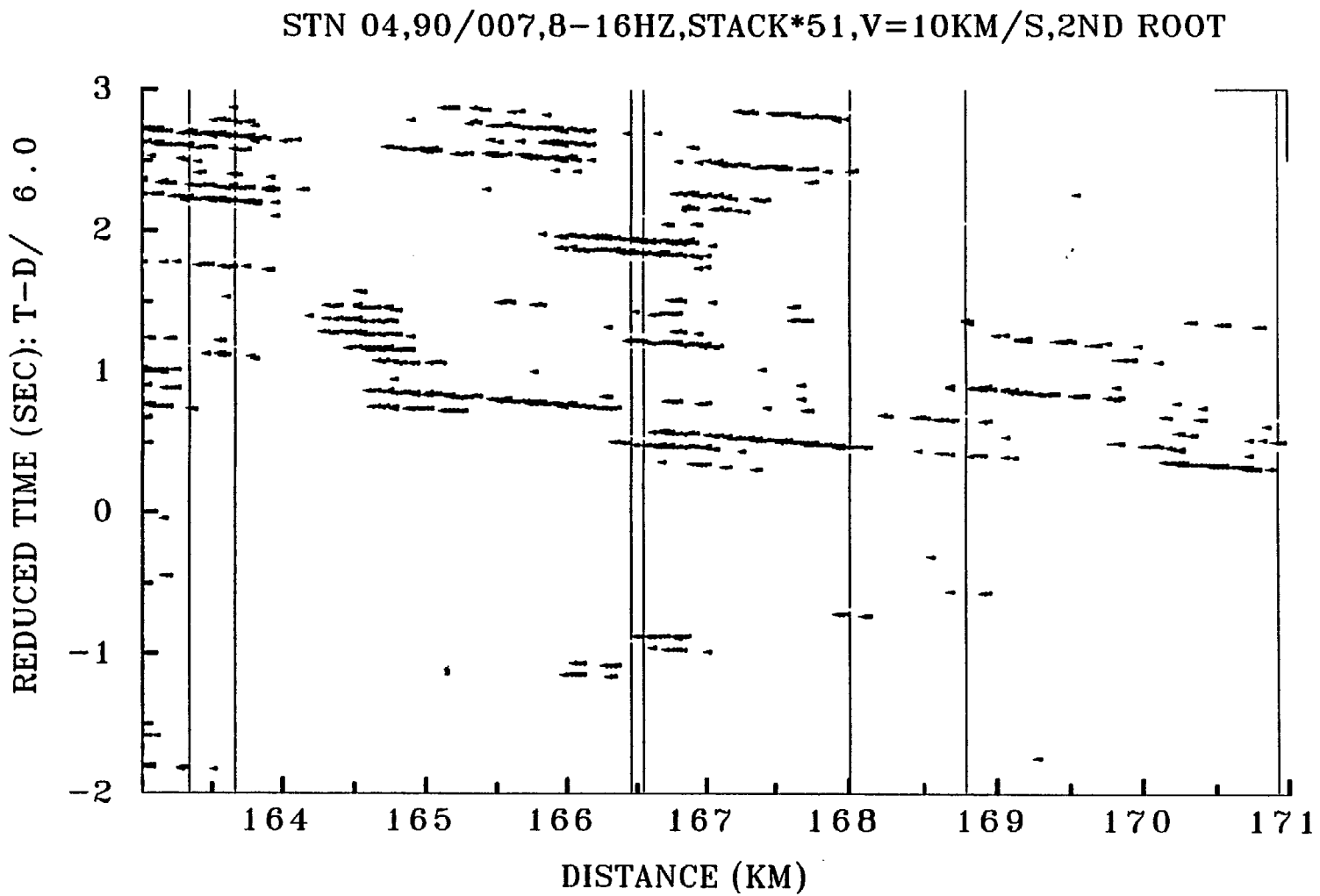
STN 04,90/007,8-16HZ,STACK\*11,V=6KM/S,MEDIAN



13. Same data as Fig 11, bandpass filtered 8-16 Hz, trace normalised, median stack of 11 traces per trace phased at a velocity of 6km/s, variable area display



14. Same data as Fig 11, bandpass filtered 8-16 Hz, trace normalised, 2nd-root stack of fifty-one traces per trace phased at a velocity of 6 km/s,variable area display



15. Same data as Fig 11, bandpass filtered 8-16 Hz, trace normalised, 2nd-root stack of fifty-one traces per trace phased at a velocity of 10 km/s, variable area display