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SEISMIC-REFLECTION PROCESSING DEMONSTRATION

USING "EAVESDROPPER"

by

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INSTALLATION INSTRUCTIONS:

Programs and data contained on the included disk will operate in a fashion nearly identical to the full *Eavesdropper* package. The demonstration software and manual have been compiled to instruct the novice as well as allow a seasoned processor an opportunity to see and feel the flow of this seismic-processing package. Only a small sampling of the operations available with the *Eavesdropper* package are on this demo.

Four types of data are contained on the demonstration disk: 1) seismic data (extension = *.raw or *.dat), 2) sample batch files (extension = *.dek), 3) executable files (extension = *.exe), and 4) assistance files (extension = *.hlp or *.cfg). The only files that can be displayed with the DOS **type** command are the sample decks and set up files. To minimize confusion while processing this data, it is advised that two sub-directories be created. The first sub-directory should contain the executable files (extension *.exe) and should be named something like **eav**. The second sub-directory should contain the sample batch files, assistance file, and data files, and called something like **demo**. The path of your computer will need to be modified so the executable files can be called on from the **demo** directory. Once the files on the floppy disk have all been loaded into the appropriate directory, you are ready to proceed through the manual.

I. CDP PROCESSING WITH *EAVESDROPPER* FOR THE NOVICE

This document is designed to demonstrate the operation of *Eavesdropper* by providing step-by-step detailed instructions and explanations on seismic data processing from raw data to brute stack.

NOTE: This document is separated into large type (representing processing steps) and smaller type (indicative of explanation and background information).

The format of the text in this document was specifically designed to aid in identifying 1) *responses and information supplied to the user by the program upon request*, 2) **information or commands supplied to the program**, and 3) **key points (highlights) to remember**. The information supplied by the program will be in *italics* and includes error messages, file contents displayed on screen using the MS/DOS type command, messages concerning information being processed, notes to the user concerning default parameters, etc. All *italicized* text in this manual indicates information generated by the program. Information you must supply to the program is always **underlined and in bold type** and includes execution commands, parameters to input, spaces necessary, etc. Key information to remember is always in **bold type**. After processing the sample data set completely through using this manual, future data sets could be processed by referring only to the **bold-type** information. You should become quite comfortable with the material in this manual after processing the sample reflection data set.

The *Eavesdropper* seismic data-processing package is divided into three main categories: 1) **plotting and formatting**, 2) **filtering and deconvolution (FMAIN)**, and 3) **the remainder of seismic data processing (SEIS)**. The **plotting and formatting** operations are interactive requiring you to execute the program and then enter the requested information. The **filtering and deconvolution** routines are contained with the sub-program called FMAIN and are **pseudo interactive**. Processes in FMAIN will ask a series of questions and then operate on the data set. The remainder of data-processing procedures are contained within the sub-program called SEIS. The program SEIS was designed to operate in a **batch processing mode**, requiring an input job file and an output list file. The input job file contains all the operation identifiers (***AUTS, *EDKL, *SORT**, etc) along with the appropriate user assigned parameters. The output list file contains all the significant steps and processes completed during the executed batch job. The list file also contains bits of information concerning processing time, any abnormalities in the flow, any error messages, etc. **Operation of *Eavesdropper* with the assistance of this manual requires a general knowledge of what seismic reflection is as well as a working knowledge of your computer and the MS/DOS operating system. (See information that came with your computer.)**

A) GENERAL CDP SEISMIC DATA PROCESSING FLOW

The goal of digitally manipulating seismic data is to allow the maximum amount of geologic information to be extracted from a minimal amount of data with a minimal amount of effort. The processing of seismic data involves a series of steps. Each seismic processing step generally has a prerequisite step or operation. This means a basic processing flow must be used to effectively process seismic data. The exact processing flow you should use for your data set depends mainly on two things: 1) the overall quality of your data and 2) the particular information you intend to extract from the final processed section.

The processing flow we use is structured to maximize shallow high frequency CDP seismic reflection data. The general outline of our processing flow is contained in table 1. Table 1 contains all the operations we routinely use to go from raw field data to finished process sections. This manual will discuss in some detail all the operations through brute stacking of seismic reflection data. **The intention of this novice user's manual is to get a person started and somewhat familiar with the**

SEISMIC DATA PROCESSING FLOW CHART

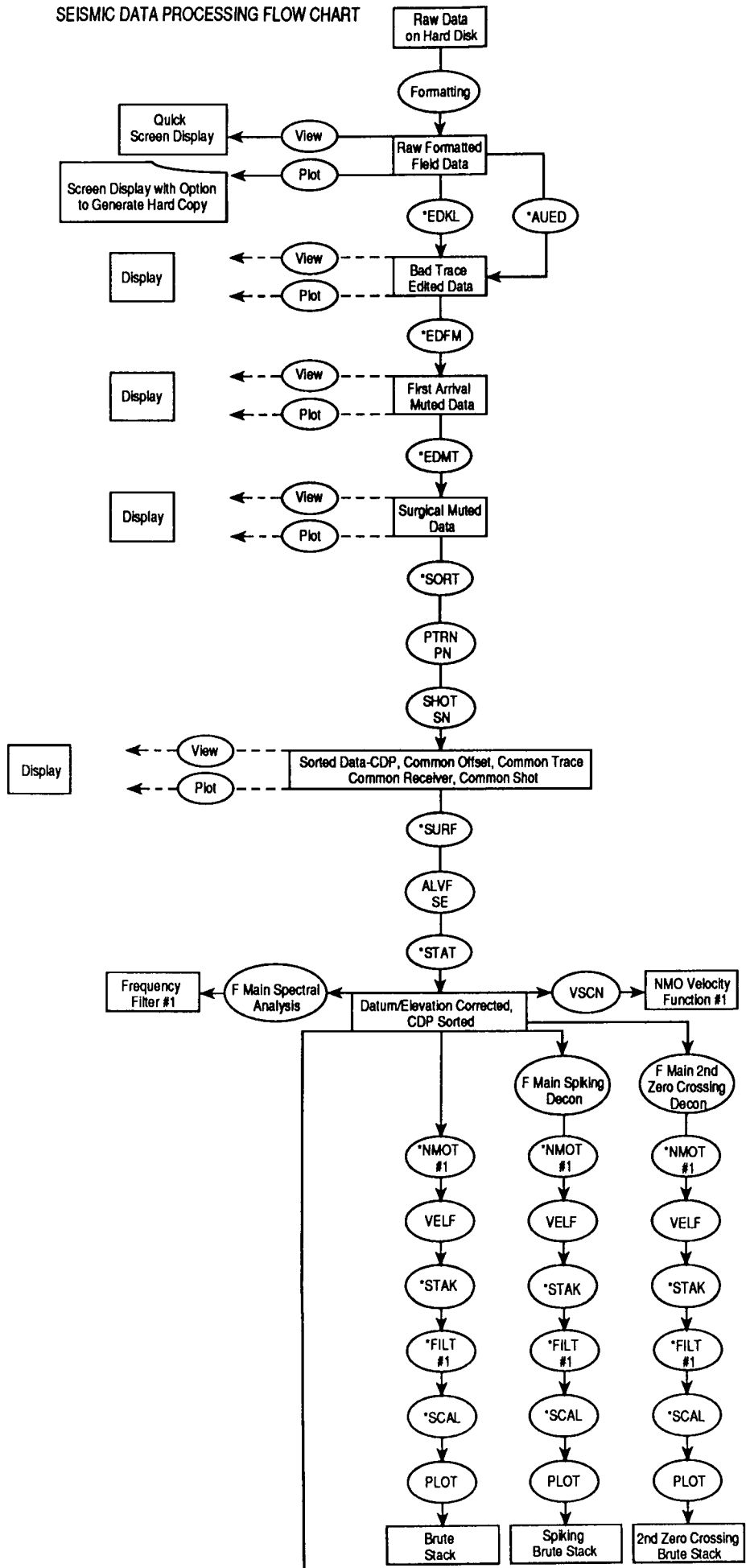


Table 1.

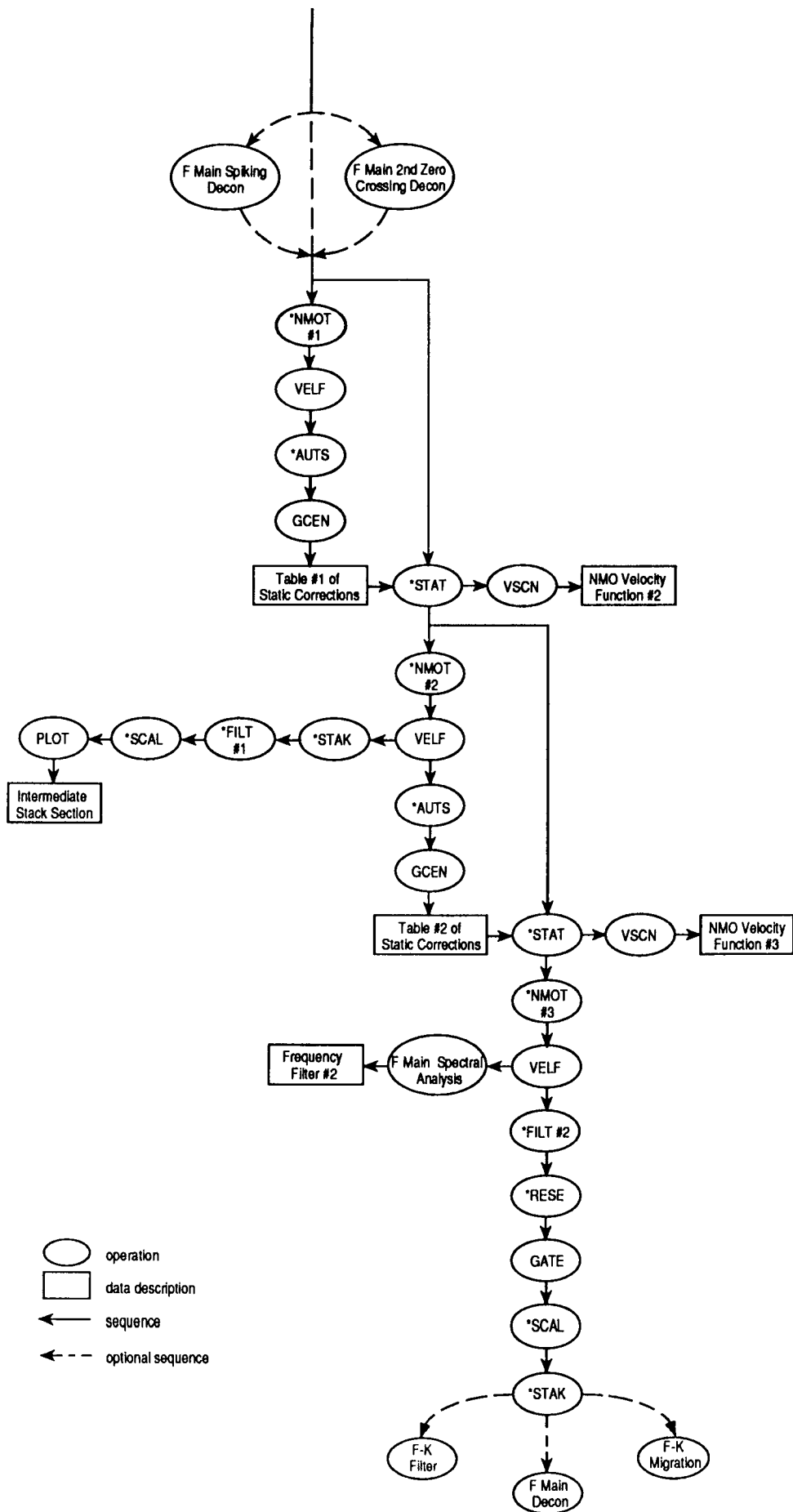


Table 1.
(continued)

organization as well as some of the rationale for key parameter selections. Each person should establish a processing flow that is somewhat tailored to both the needs of the particular survey and to existing equipment. Some operations can be reordered/removed/included/used several times/etc., and will either enhance, deteriorate, or not change the final section; however, some of the core operations (stacking, surface consistent statics, and normal moveout) do require pre-requisite operations. All processing operations require proper formatting of the input data.

Processing seismic data requires a basic understanding of acoustic-wave propagation through the earth (layered media). Attempting to process data without the necessary physics and math background will eventually result in frustration or bogus results. To assist the novice/or out-of-practice seismic data processor, a sample data set is included with this manual. The data were collected during May, 1989, in England along the Thames River. Several good quality reflectors can be interpreted directly off the raw field files. The data set will not present a significant challenge for the seasoned seismic data processor, but it will require a variety of standard processing steps properly applied to obtain a stacked section allowing the most realistic geologic interpretation.

INTRODUCTION TO

*****EXAMPLE DATA*****

The raw data include 20 field files chopped to 250 ms of record length at a sample interval of 1/2 ms. The data were acquired with an EG&G 2401 seismograph (processing 24 channels), single 100-Hz geophones, a 12-gauge buffalo gun (both the source and receiver intervals were 2.5 m), and 200 Hz analog low-cut filters. Each step in the general processing flow followed in this manual will use the England data set as the example. The field notes as well as the formatted data are included with or within this manual.

B) TRACE HEADERS

Next to the data itself the trace headers are the most essential part of digital seismic data. All acquisition information essential to future seismic data processing as well as to update information derived from intermediate processing operations is organized and stored within each trace header. The organization of trace headers is dependent only on the imagination of the programmer of the software and manufacturer of the seismograph. **The particulars with respect to size and organization of the trace header, its location with respect to the rest of the data set as well as the organization and size of each sample of data within the trace itself is what is commonly referred to as seismic data format.** The format of seismic data is critical to the effective operation of seismic data processing programs. Imagine the resulting seismic section if the programmer of the software designates a particular trace header location as the source station number and the seismograph manufacturer has designated that location as the receiver location.

A simple way to think of both the use and organization of a trace header is to compare it to a business letter. A business letter will generally have two main parts, first is the letterhead and second is the body of the letter. The critical part of the letter of course is the body. It contains the significant information, the information that makes it different from any other letter. The letterhead on the other hand is basically the same for every letter sent out by the business. The only things that change within the letterhead are date and office of origin within the business. The letterhead contains all the information necessary for someone to determine the business name, section, address, and date of the letter. A seismic data trace (in digital form) can be thought of in a similar

way. The trace header serves a similar purpose as the letterhead. The data itself are equivalent to the body of the letter.

Most, but not all, operations use the header to obtain key information about the data contained within each trace. Some operations will update the header with information, others will simply use the information to physically change the data set according to the prescribed operation and designated parameters. The trace header locations will always remain the same. The actual values within each word in the header can or will be changed in accordance with the described operation and input parameters.

The standards for formats on seismographs have changed consistently through the years. Such familiar acronyms as SEGA, SEGB, SEG Y, modified SEG Y, SEG2, etc. describe individual variations. The recent advances into non-magnetic tape storage media have caused introduction of a multitude of formats. For the most part, each manufacturer of a seismograph with non-9-track tape-storage media has a preferred trace header format. A standardized format is being considered. When a standard has been adopted, there will no longer be a need for the format conversions described in a later section.

The key information necessary to process seismic data using *Eavesdropper* is contained within the 240 byte (120-16 bit words) trace header preceding the seismic data itself which is represented by 2 bytes per sample word (i.e., 500 sample/trace data represent a block of 1000 bytes). Each header location is identified by a number (1-120). *Eavesdropper* expects to see a header at the beginning of each trace (240 bytes) followed by a data block (length dependent on number of samples). The header contains the following information at the designated word locations:

<u>16-bit Word Number</u>	<u>Description</u>
1	Data type: 0 = Raw field files 1 = CDP gather 2 = CDP stacked 3 = Record order (Record number index and trace number index based on values in trace header word 3 and 4, respectively). 4 = Velocity-scan data
2	Total recording channels
3	Trace Header Word of RECORD number for this data set where 8 = common recording channel number 12 = common depth point 19 = common offset 86 = common receiver station number 87 = common source station number 92 = common source sequence number
4	Trace Header Word of TRACE number within each record (0 = as input order of seismic input data to be sorted).
5	Trace direction flag for sorted traces within each record — 1 = ascending — 1 = descending
6	Original Field Record number
8	Recording channel number
10	Repeated shot number (at the same station)
12	CDP number
14	Trace number within each record
15	Trace identification code: 1 = seismic data 2 = dead 9 = velocity flag

16	Number of vertically summed traces yielding this trace
17	Number of horizontally summed traces yielding this trace
19	Offset (distance from source to receiver) after multiplied by word 35
21**	Receiver group elevation
23**	Source elevation
27**	Datum elevation
35	Multiplication factor for horizontal distance
50*	Source static correction (ms) (floating pt)
51*	Receiver group static correction (ms) (floating pt)
52*	Total static correction (ms) that HAS BEEN applied to this trace (zero if no static has been applied).
55	Recording delay time (ms) (floating pt)
58	Number samples in this trace
59	Sample interval in micro-seconds for this trace
70	Analog low-cut frequency (Hz) (-3 dB pt)
71	Analog high-cut frequency (Hz) (-3 dB pt)
75	Applied digital low-cut frequency (Hz)
76	Applied digital high-cut frequency (Hz)
82	Minimum receiver station number
83	Maximum receiver station number
84	Minimum source sequence number
85	Maximum source sequence number
86	Receiver station number for this trace
87	Source station number for this trace
88	Last trace flag: 0 = not last trace; 1 = last trace
89*	Surface-consistent residual receiver-static (in number of SAMPLES) that HAS BEEN applied to this trace.
90*	Surface-consistent residual source-static (in number of SAMPLES) that HAS BEEN applied to this trace.
92	Source sequence number
93	Processing history file flag: 0 = No history; non-zero = number of characters in file name to follow.
94-120	Reserved for processing history file name. Packed ASCII. Two ASCII characters per word.

* Convention for static corrections: POSITIVE value implies static shift (DOWN) away from zero-time; NEGATIVE value implies static shift (UP) toward zero-time.

** Elevation can be either absolute (i.e., positively above sea level) or relative (with reference to fixed altitude). In both cases, the orientation is such that higher elevation is positive. Therefore, increasing depth is indicated by the smaller value for elevation.

Note: ms = milliseconds

C) DATA FORMAT

Formatting of seismic-reflection data involves **organizing trace headers and data bytes into a specific pattern and sequence recognizable by *Eavesdropper***. The formatting utilities available for *Eavesdropper* require raw unformatted data to be present on hard disk. The formatting utilities (conversion routines) are designed to operate on raw data input from hard disk and output back to hard disk. Getting the raw data from the seismograph's preferred storage media (floppy disk, 9 track tape, tape cartridge, RAM, etc.) onto the hard disk requires procedures, software, and/or

hardware that can be supplied by the seismograph manufacturer. Often the transfer of raw unformatted data to a computer's hard disk requires nothing more than the MS/DOS copy command.

The particular formatting routine necessary for your raw unformatted data depends on the seismograph with which it was collected. Until a standardized format can be established and agreed upon by all seismograph manufacturers and software developers, a different conversion routine will be necessary for most new and existing seismographs. At the time of this writing, *Eavesdropper* facilitates the following data formats:

<u>Program</u>	<u>Description</u>
90002KGS	9000(Bison) to KGS
BISCONV	Geopro(Bison) to KGS
EASI2KGS	EASIDISK (EG&G seismograph) to KGS
SEGI2KGS	SEGYinteger to KGS
SEGF2KGS	*SEGYfloatingpoint to KGS
SEGPFKGS	**SEGYfloatingpoint to KGS
SV2KGS	Seisview(EG&G) to KGS
GEOF2KGS	GeoFlex(EG&G) to KGS
24012KGS	2401(EG&G) to KGS
DFSDEMUX	***SEGBdemultiplex to KGS
SEG22KGS	SEG 2 engineering format to KGS
ABEM2KGS	ABEM seismograph to KGS
DG2KGS	Data General to KGS
DHR2KGS	I/O DHR 2400 to KGS
SCIN2KGS	Scintrex seismograph to KGS

* 1) VAX/MAINFRAME

** 2) IEEE/IBM-PC

*** Available as separate package.

Raw unformatted data on your hard disk will be in the form of a sequence of files with identical prefixes and/or extensions, where each file represents a unique field file recorded on your seismograph and downloaded onto your computer's hard disk. The naming process was done during either the downloading of your data to your computer's hard disk or at the time of acquisition and storage of the data in the field. The total number of these individual sequential files will be equal to the number of field files copied onto your hard disk. Once the data are on the hard disk of your computer (in most cases this involves a simple copy command), the appropriate conversion routine should be executed to correctly format your data for future processing with *Eavesdropper* software. After completing the formatting operation, all the individual field files should be contained in a single MS/DOS file.

STEP #1

*****EXAMPLE DATA*****

Copy the contents of the floppy onto your hard disk. When you list the directory as below, the following sequence of files should be present on your hard disk:

```
>dir <return>
dplot.exe
dseis.exe
dview.exe
dengland.dat
dvscn.exe
dfmain.exe
dvelp.exe
fmain.hlp
view.cfg
plot.cfg
nmot.dek
scal.dek
edfm.dek
edkl.dek
rsrt.dek
filt.dek
process.dek
edmt.dek
sort.dek
stak.dek
surf.dek
```

The extension (*.ext) can be used for quick and easy identification of file-type. For example, files referred to in this document with an *.exe extension are executable codes, *.cfg extensions are graphics configuration files, *.dat are seismic data files, *.dek are batch processing command files, and *.lst are journal or list files.

D) DISPLAY

Eavesdropper can display seismic data either variable-area wiggle-trace or just wiggle-trace on your CGA, EGA, or VGA CRT with a hardcopy print option. Two routines are contained within *Eavesdropper* to display data. The *dview* routine is mainly designed as a quick way to see data on the CRT without a hardcopy option. This quick display routine is most helpful during preliminary plot parameter design. The main plotting routine is called *dplot*. *Dplot* prepares and displays the data on the CRT with a hardcopy option. During your first attempts at plotting, we recommend using *dview* to select the appropriate plotting parameters, followed by *dplot* for final CRT display and hardcopy.

After your data are in *Eavesdropper* format, examination of a variable area wiggle-trace display of all the unprocessed data will allow you to verify proper formatting as well as to get a general feel for the quality and quantity of data. The processes involved with getting a display using either *dplot* or *dview* will be discussed simultaneously. This should cause no confusion since *dview* and *dplot* generate exactly the same output. The *dview* routine has no hardcopy option and, therefore, the screen display in *dview* is several times faster than *dplot*. The few minor differences in requested parameters that occur will be discussed at the appropriate time.

To set the basic plotting parameters, you will need to edit the **plot.cfg** (plot configuration) or **view.cfg** (view configuration) file. NOTE: both *.cfg files are in the EAV subdirectory and can only be altered from that subdirectory. Enter your text editor and open either the **plot.cfg** or the **view.cfg** file.

The **view.cfg** TEXT FILE will have 7 lines, with each line requiring a particular parameter, as indicated below:

<u>Line</u>	<u>Default Value</u>	<u>Description</u>
1	0	This is a dummy line not used by the dview routine.
2	350	Designates the number of pixels on the EGA screen.
3	50	Approximate vertical resolution for the EGA monitor (13"). (DOTS/INCH)
4	65	Approximate horizontal resolution for the EGA monitor (13"). (DOTS/INCH)
5	0	Whole trace gain applied in dB. This value can be either negative or positive.
6	0	Designates either variable area wiggle-trace (0) or just wiggle-trace (1) display format.
7	100	Tells dview what percentage of the allotted trace spacing the trace may occupy. For example, assume that the trace spacing is 10 per inch. Each trace has an allotted area of .1". If line 7 is 100 percent, the trace may 'wiggle' as much as .1". If line 7 is, say 200 percent, then the trace 'wiggle' may be as wide as .2". Values of 150 to 200 generally give pleasing results.
8	2	GAP between field records.

The **plot.cfg** file has strong similarities to **view.cfg**. The text file you just opened has 8 lines each with its associated default value.

<u>Line</u>	<u>Default Value</u>	<u>Description</u>
1	0	density 1=high density; 0=low density. Default is 0.
2	0	dots/line on the attached printer; generally either 960 or 1632.
3	120	Vertical resolution [dots/inch on the vertical scale (time)]; full scale on standard printers is 120.
4	144	Horizontal resolution [dots/inch on horizontal scale (distance)]; full scale on standard printers is 144.
5	0	This parameter controls the application of a constant gain (in decibels) to the data before plotting.
6	0	dplot style 0=variable area wiggle-trace; 1=wiggle-trace.
7	100	Tells dplot what percentage of the allotted trace spacing the trace may occupy. For example, assume that the trace spacing is 10 per inch. Each trace has an allotted area of .1". If line 7 is 100 percent, the trace may 'wiggle' as much as .1". If line 7 is, say 200 percent, then the trace 'wiggle' may be as wide as .2 inch. Values of 150 to 200 generally give pleasing results.
8	2	Controls the number of blank traces inserted between field records.

After editing **plot.cfg** and/or **view.cfg**, return to your working directory, and at the system prompt execute whichever display routine you desire.

or
 >**dview** <return>
 >**dplot** <return>

The first question the plot or view program will ask is:

 ("enter filename to plot"). **dengland.raw**

After you have entered the file name (**dengland.raw**), the program will respond with one or more of the following statements:

- 1) "*No processing history file available*" which means basically that no processing has been completed at this point, so the file designed to handle the processing history has not been created yet,
- 2) "*Processing history file name found*" which means basically what it says, and the result will be the printing of the current processing history at the conclusion of the plotting of the data.
- 3) "*Warning—History file—FNAME.HO1—not found*" meaning that there should be a history file called FNAME present from previous processing, but **dplot** was unable to find it.
- 4) "*Plot.cfg not found*" which means it was not able to find the **plot.cfg** file, and the predesignated default parameters will be used.

In the case of raw data such as we are displaying at this time, the program should respond with statement (1), only. This is assuming **plot.cfg** or **view.cfg**, depending on the requested routine, is present and has been updated according to the previous instructions.

If at any time you wish to return to the system prompt hit 'Ctrl C' —

Enter starting record number (default=first record found for data set) ->

Enter ending record number (default=32000) ->

*Do you want auto screen dump? 0=No/1=Yes (default=0) ->

Enter vertical display size in inches/second (default=data dependent) ->

Plot normal ? 0=off 1=on (default=0) ->

**Enter normalize scan delay in ms (default=0) ->

Enter starting time of plot in ms (0) ->

Enter trace spacing in trace/inch (default=data dependent)
(values over 24 degrade hardcopy) ->

* Only applies to **dplot** program

** Only an option when plot normalization is selected

NOTE: **data-dependent** means program calculates a value it considers to be optimum for the input data set.

NOTE: If at any time you wish to terminate the plotting process, press the space bar.

The plot normal option increases the amplitude of each individual trace by multiplying each sample by a normalization constant, independent of all other traces in the data set. The amount of this whole trace amplitude increase can be different for each trace and is related to the difference between the largest amplitude sample in the trace and the maximum possible amplitude that can be displayed.

The normalize scan delay time designates the beginning of the amplitude scan window used to determine the multiplication factor for all the samples within the trace. The utility of this option can be appreciated on data sets with abnormally high amplitude first-arrival information. Selecting the beginning scan time after a large amplitude event allows events later in time to dictate the amount of uniform whole trace amplification applied.

This program is **FIELD-SENSITIVE**, which means, **don't put spaces after a prompt and/or before the requested information unless directed by the program.**

Both **dplot** and **dview** routines will return system control after the display process is complete.

STEP #2

*******EXAMPLE DATA*******

A hard copy plot of the raw England field data should contain 20 files identified by the source sequence number in the upper right hand corner of each file. The data were collected on a 24-channel seismograph. Therefore, there will be 24 individual traces within each field file. The traces within each field file are identified by original channel numbers starting with channel 1 on the left-hand side of the field file, and channel 24 on the far right.

The field file displayed here has all the major types of seismic energy arrivals you will encounter on most seismic data sets (Figure 1). Identified on the plot of field file 5 is each trace number, time in milliseconds, refraction energy, air-coupled waves, ground roll, and of course reflection events. Of interest for later processing steps, two dead traces are identified at trace numbers 8 and 23. The field file displayed has been scaled to enhance the seismic energy, making the identification of various types of arrivals easier.

E) EDIT

The next step in a standard processing flow involves the removal of **bad traces** (generally caused by dead geophones, bad geophone plants, seismograph amplifier failure, cultural noise, or poor near-surface conditions), **bad parts of traces** (generally results from the air-coupled wave or ground roll), and **energy arriving prior to the first identifiable reflection signal** (generally refraction and direct-wave energy).

1) Manual Bad-Trace Edit

Removal of dead or bad traces is the first editing step. This can be accomplished in two different ways. The first way (the more standard technique) involves the manual entering of each trace (to be removed) into a text-editor built edit deck using the *EDKL procedure. The second way uses an automatic whole trace-editing routine *AUED procedure designed to identify (and automatically remove if specified) any trace that doesn't meet the minimum operator-specified signal-to-noise ratio (S/N). In order to develop a good working knowledge of what and how the editing process works, it is recommended that command of the manual editing technique be established prior to extensive use of the automatic editing option.

STEP #3

*****EXAMPLE DATA*****

A plot of the raw-field data is critical at this step. Careful examination of each trace of every field file will allow you to determine how much and what type of editing will be necessary. The object of this stage is to remove all traces and parts of traces with an unacceptable signal-to-noise ratio (S/N). Determination of useless traces is subjective and your ability to make that determination will drastically improve with experience. Traces 8 and 23 of the displayed source sequence file 5 (Figure 1) are bad traces. It is important to remember (all things being equal), that 2- or 3-fold of high-quality reflection data are better than 48-fold of garbage data. The confidence necessary to effectively edit will come with time and exposure to a variety of data sets.

STEP #3a

*****EXAMPLE DATA*****

The manual editing procedure is a batch-processing operation and therefore requires a batch-processing file constructed around the *EDKL identification. In order to build a batch-processing file you must use your TEXT EDITOR. NOTE: Any text editor that does not leave embedded commands will work (i.e., EDLIN, SIDEKICK NOTEPAD, XTREE, etc.).

This is the first batch processing deck described in this manual; therefore, each part will be discussed in some detail and referred to during upcoming processes.

<u>Line</u>	<u>Description</u>
1	<u>>>START</u> start simply identifies the beginning of this processing deck.
2	<u>*INPF dengland.raw</u>

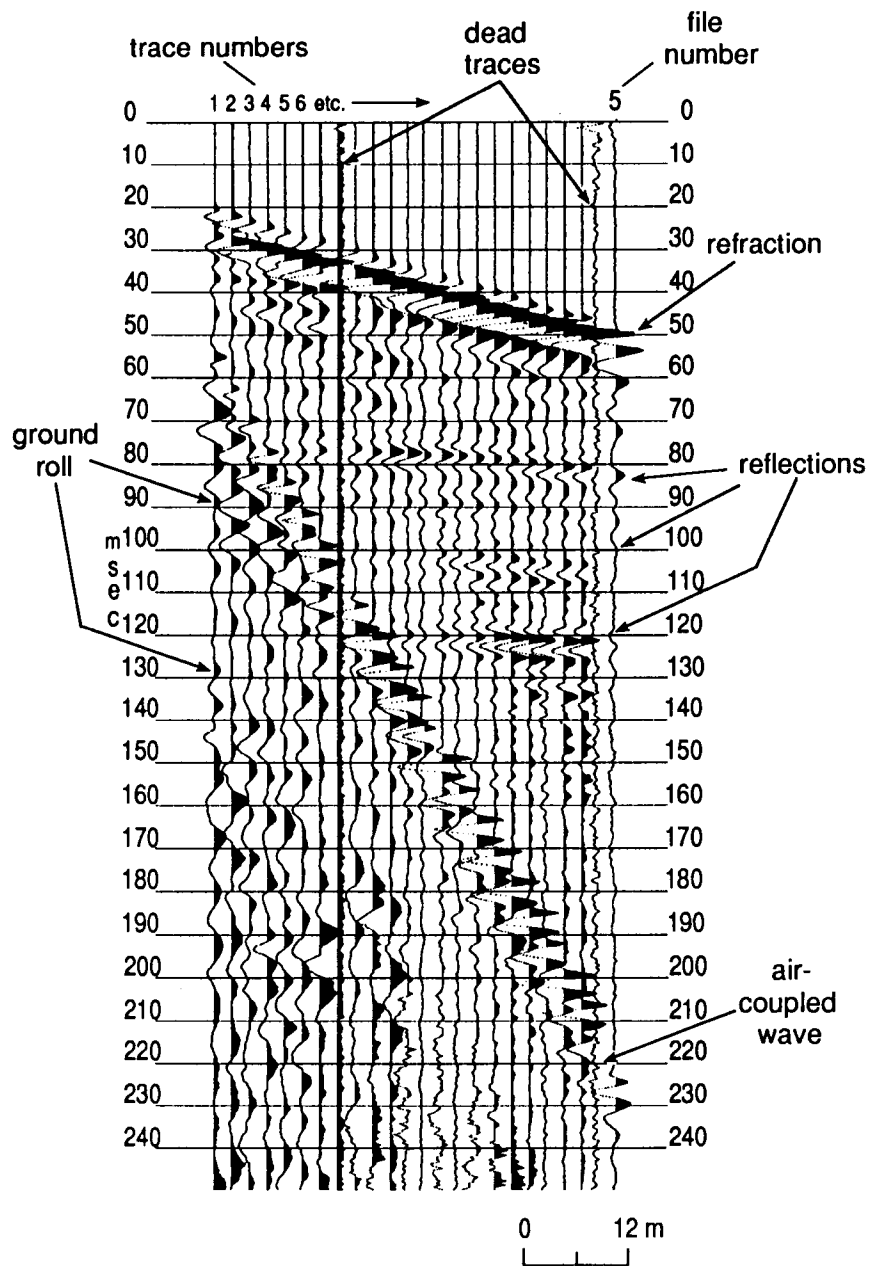


figure 1

***INPF** identifies the input files. The alpha character name of the input file, including any extension must follow ***inpf**, leaving at least one space separating the **f** in ***inpf** and the first character of the file name.

Entries following an alpha identifier (i.e., *INPF, *EDKL, *AUTS,) need only be separated by a minimum of one space. In other words, during batch processing, any input information need only be in the correct relative sequence. The program dseis is insensitive to absolute field location and small or large case (i.e., A or a).

3 ***EDKL 92 8**

EDKL calls the "kill trace" sub-routine. The traces to be removed are identified by a record-number trace-number pair [92 (SSN), 8 (field-trace number)].

Record numbers generally identify the primary grouping order. In case of raw field data, the primary grouping is by field-file number which is contained in **trace-header location 6**; for CDP gathers, the primary grouping is according to CDP number which is contained in **trace-header location 12**. Trace numbers generally identify secondary grouping order. In the case of raw field files, the secondary grouping is according to seismograph channel numbers which is contained in **trace-header word 8**. This grouping or ordering can be changed during the sorting or re-sorting operation.

These record/trace pairs can be thought of in a similar fashion to cards in a deck of playing cards; that is, the suite (hearts, clubs, spades, diamonds) can be thought of as the record number and the value (Queen, Jack, ten, nine, etc.) can be compared to the trace number, such that any trace can be identified by record number and trace number in the same fashion any playing card can be identified by suite and value.

The program allows you to select any trace-header word to be the record number portion as well as any trace header word for the trace number portion of the record-trace pair. In this case, we wish to use Source Sequence Numbers (SSN) (assigned during formatting), **header word 92**, as the **record number** portion and the trace numbers within each field record, **header word 8**, (which is the seismograph's actual channel numbers) as the **trace number**. (Assigned by seismograph during acquisition)

4 **KILL 11 12 12**

KILL is a command operation that identifies which **trace(s)** within the specified records are to be removed. In the above case, trace **12** record number **1**, will be removed.

- 5 KILL 2 2 11 11
KILL 3 3 10 10
KILL 4 4 9 9 24 24

Traces 9 and 24 of record 4 will be removed.

KILL 5 5 8 8 23 23
KILL 6 6 7 7 22 22
KILL 7 7 6 6 21 21
KILL 8 8 5 5 20 20
KILL 9 9 4 4 19 19
KILL 10 10 3 3 18 18
KILL 11 11 2 2 17 17
KILL 12 12 1 1 16 16
KILL 13 13 15 15
KILL 14 14 14 14
KILL 15 15 13 13
KILL 16 16 12 12
KILL 17 17 11 11
KILL 18 18 10 10
KILL 19 19 9 9
KILL 20 20 9 9

- 6 *OUTF EdKL.dat

*OUTF identifies the destination file name of the edited data. The file name can be any MS/DOS acceptable name with or without extension. The output file name can be the same as the input. Of course, if the input file name is the output file name, the input data will be deleted and replaced with the edited output data.

- 7 >>END

>>END identifies the last line of this batch-processing deck.

The actual bad trace edit file just created will look like the following:

```
>>start
*inpf dengland.raw
*edkl 92 8
kill 1 1 12 12
kill 2 2 11 11
kill 3 3 10 10
kill 4 4 9 9 24 24
kill 5 5 8 8 23 23
kill 6 6 7 7 22 22
```

```

kill 7 7 6 6 21 21
kill 8 8 5 5 20 20
kill 9 9 4 4 19 19
kill 10 10 3 3 18 18
kill 11 11 2 2 17 17
kill 12 12 1 1 16 16
kill 13 13 15 15
kill 14 14 14 14
kill 15 15 13 13
kill 16 16 12 12
kill 17 17 11 11
kill 18 18 10 10
kill 19 19 9 9
kill 20 20 9 9
*outf edkl.dat
>>end

```

The batch processing file you just built to edit bad traces now needs to be run through **DSEIS** to actually operate on the **dengland.raw**. In order to execute the edit job, the following sequence is necessary:

```
>DSEIS EDKL.dek EDKL.lst
```

The **EDKL.lst** file is a journal file created to document all significant information associated with the operation of the **EDKL.dek** file.

The edited data will be in the file named **EDKL.dat**. In order to see the effect of the editing on the raw data, you should first use the **dview** routine. Simply type:

```
>DVIEW <return>
```

Answer the series of self-explanatory questions (as described in the previous **dplot** and **dview** section) and check the format of the screen display. If the display is not satisfactory, make the appropriate changes to either **view.cfg** or to the responses provided to the view routine questions. Once an acceptable format has been obtained, make the appropriate changes to **plot.cfg** and then type:

```
>DPLOT <return>
```

Answer the **dplot** questions with values similar to those used for the previous **dview** routine. Using the normalization on plots will improve the usefulness of the display.

Once the bad-trace editing is complete, each field file should be missing the trace or traces you selected to remove (Figure 2). The trace is not displayed on the

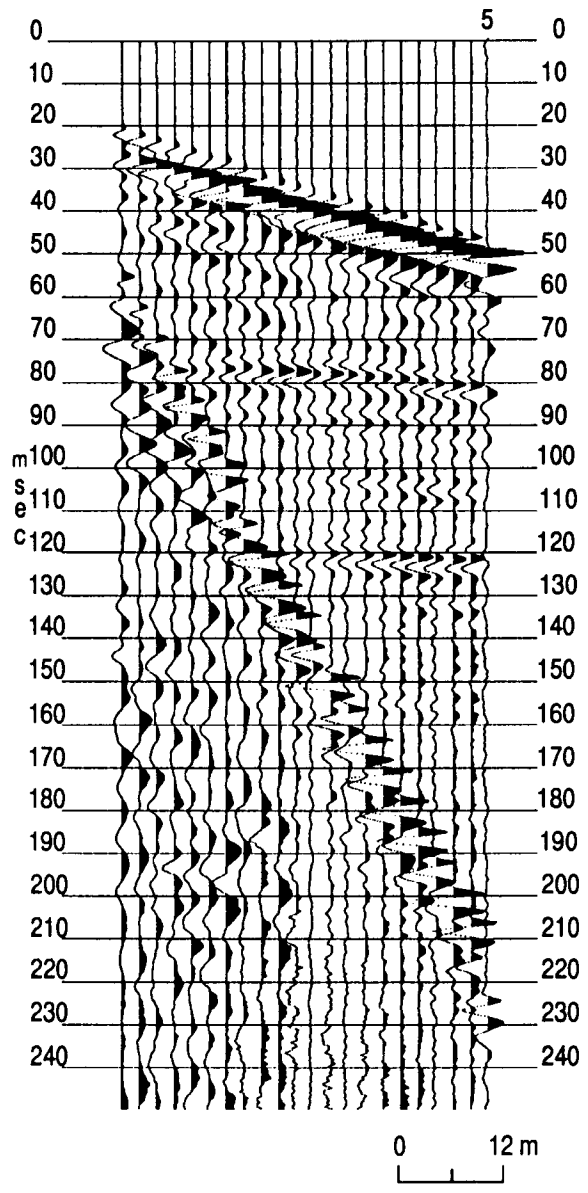


figure 2

plot because the dead-trace flag (trace header word 15) has been tripped in the trace header. The file size will not change until the data are sorted or re-sorted at which time the trace will be completely removed from the data set. The bad trace is still present in the data file after trace editing, but not visible on the plot.

Whole field files should not be removed at this time. The sorting operation, which will be discussed later, requires all source geometries be input in an uninterrupted file sequential format. This means that once the data are sequentialized (during formatting), they must remain in that order without any missing files until the assignment of source-and-receiver geometries is complete. At the time the source geometries are identified (sn or sns), entire bad files can then be removed. This is not a problem when plucking out only a few particular files from a large data set if no future processing (i.e., operations that require source-and-receiver geometries) is planned.

AT THIS POINT, IF YOU HAVE MANUALLY EDITED ALL YOUR BAD TRACES, YOU SHOULD PROCEED TO THE FIRST-ARRIVAL MUTING PORTION OF THIS MANUAL WHICH FOLLOWS AUTOMATIC EDITING (*AUED). IF TIME PERMITS, USE YOUR JUST-EDITED DATA SET TO COMPARE AUTOMATIC EDITING TO MANUAL BAD TRACE EDITING. IT MAY SERVE TO HELP YOUR CONFIDENCE AS WELL AS SAVE YOU TIME DURING PRELIMINARY BAD TRACE EDITING ON YOUR NEXT DATA SET.

2) Automatic Bad-Trace Edit

Once you have used and feel relatively comfortable with the manual editing routine (*EDKL), using the automatic editing routine (*AUED) will save time in removing obviously dead or very poor-quality traces. The *AUED routine is mainly designed to remove traces that are totally dead or possess a significant amount of background noise (i.e., wind, powerline, automobile, human traffic on line, etc.). The important parameters in this operation are the noise window length (time) and the acceptable signal-to-noise ratio (S/N) value. At this point, definitions will be helpful.

NOISE WINDOW: The noise window identifies a **pre-first-break segment (before the arrival of any seismic signal)** on each trace where the **level of background ambient noise is representative of the remainder of the trace.** The window needs to be selected so as **not to include any source generated seismic signal** (i.e., refractions, direct wave, or air wave).

SIGNAL-TO-NOISE (S/N): The signal-to-noise value is the ratio of the whole trace average amplitude and the **average amplitude of signal in the noise window.** A S/N value of 1 will retain any trace with a whole trace average amplitude equal to or greater than the average amplitude of the signal in the noise window.

Experimentation with this routine is the **best teacher.** A few test runs varying the S/N value for a given noise window will give insight into both the utility and the limitations of this routine. A batch-processing file for doing automatic editing should look about like the following:

<u>Line</u>	<u>Description</u>
1	>>START see manual edit *EDKL for details on >>start.
2	*INPF dengland.raw see *EDKL for details on *INPF.

3 ***AUED 20 0.28 1 1 1**

***AUED** calls the auto-edit sub-routine. The **first requested parameter** is the **noise window**. Here 20 ms is used, indicating that no source-generated signal arrives on any trace before 20 ms. The **second requested parameter** is the **signal-to-noise ratio (S/N) value**. A signal-to-noise ratio of 0.28 means any trace not possessing an **average whole-trace amplitude at least 0.28 times the average pre-first-break amplitude** will be flagged. The **third requested parameter** instructs the program to **print (1) or not to print (0) the calculated average whole trace signal-to-noise ratios (S/N) in the list file**. The **fourth requested parameter** instructs the program to **print (1) or not to print (0) the flagged bad traces in the list file**. This fourth option gives you the opportunity to **examine the traces the program suspects as being bad**. The fifth and final option lets you **delete the flagged bad traces (1) or save all the traces as inputted (0)**. This allows examination of the suggested bad traces and readjustment of parameter 1 (noise window) and 2 (signal-to-noise ratio), or both. If the 0 option is chosen for the fifth parameter, no output file need be named.

4 ***OUTF Aued.dat** see ***EDKL** for details on ***OUTF**.

5 **>>end** see ***EDKL** for details on **>>end**

The batch-processing file AUED.DEK you just saved looks like the following:

```
>>start
*inpf dengland.raw
*aued 20 0.28 1 1 1
*outf Aued.dat
>>end
```

In order to execute the automatic editing operation on the raw input data, the following sequence again will be necessary:

>DSEIS AUED.DEK AUED.LST

The AUED.LST file monitors and records the sequence of processing events.

The following information is included to allow you to check the contents of your list file with what should be there:

List of example of signal-to-noise ratio of SSN 4:

4:	3.24	2.43	3.39	3.10	5.60	3.26	0.62	1.45	0.23	1.42	0.81	1.47
	0.32	0.94	0.44	0.92	2.45	1.26	1.42	0.64	2.11	1.14	0.71	0.21

List of bad traces for SSN 4 from automated editing:

4: 9 24

The edited data will be in the file named AUED.dat. In order to see the effect of the editing on the raw data, you should first use the **dview** routine. Simply type:

>DVIEW <return>

Answer the series of self-explanatory questions (as described in the display section of this manual) and check the format of the screen display. If the display is not satisfactory, make the

appropriate changes to either `view.cfg` or to the responses provided to the view routine questions. Once an acceptable format has been obtained, make the appropriate changes to `plot.cfg` and then type:

```
>DPLOT <return>
```

Answer the `dplot` questions with values similar to those used for the previous `dvview` routine.

3) First-Arrival Mute

The next step in the processing flow involves the **muting of refracted and direct-wave energy (*EDFM)**. This is necessary on most data sets to ensure that refracted and/or direct-wave energy does not appear coherent on CDP stacked sections. The high amplitude as well as the coherent nature of moved-out and stacked refraction energy is inviting, and in some situations it can easily be misinterpreted as shallow-reflection energy.

Complete identification of refracted energy is sometimes difficult on CDP stacked data. Refraction energy has theoretically linear moveout on field files. The NMO velocity correction applied to compensate for non-vertically incident reflection energy is hyperbolic. When refraction wavelets, generally non-minimum phase and rarely broad band, are NMO corrected and stacked, they can misalign in such a way as to appear as multiple, broad band, coherent reflection events very dissimilar from the original refraction wavelets on the raw-field data. The appearance of refraction energy on CDP-stacked data can many times entice the creative interpreter and/or geo-contractor into a fatal pitfall. Unmuted refracted energy from a subsurface layer that varies in depth, can appear to be a structurally significant, coherent reflection event on CDP stacked data. This illusion on stacked data results from the changes in the critical refraction distance and time intercept as the depth to the refracting interface varies. This pitfall many go unnoticed on some data sets, since in some geologic conditions stacked refractions many be representative, in a gross sense, of actual shallow structure. Such stacked refractions typically have lower frequency than shallow reflections.

Any editing operation that requires the defining of a time window or beginning and/or ending points for the zeroing of data will require the defining of a taper length (TAPR). The taper is intended to allow the gradual attenuation of the trace amplitudes to zero without generating an abrupt truncation point and the associated apparent high frequencies. If the trace is filtered at any time in the processing flow without a taper, the abrupt truncation of signal resulting from a mute will produce a complex sine function with maximum amplitude at the truncation point decaying to near zero within the muted zone. The frequency and decay length of the sinusoid is dependent on the defined filter. This decaying sinusoid is an artifact of the Fast Fourier Transformation (FFT) which is part of the spectral filtering process. Frequency filtering is often necessary to remove or attenuate unwanted noise. Choosing a taper length is a very data-dependent undertaking. At least one cycle of the dominant-reflection frequency or center frequency of the digital band-pass filter designed for this data set is a good starting point for defining a taper length. Fine tuning of a mute taper generally is not necessary, but in certain instances returning to this step in the processing flow to better define a taper length may be necessary. During future processing operations involving a taper, reference to this paragraph will be made. In *Eavesdropper*, the taper is defined according to Figure 3.

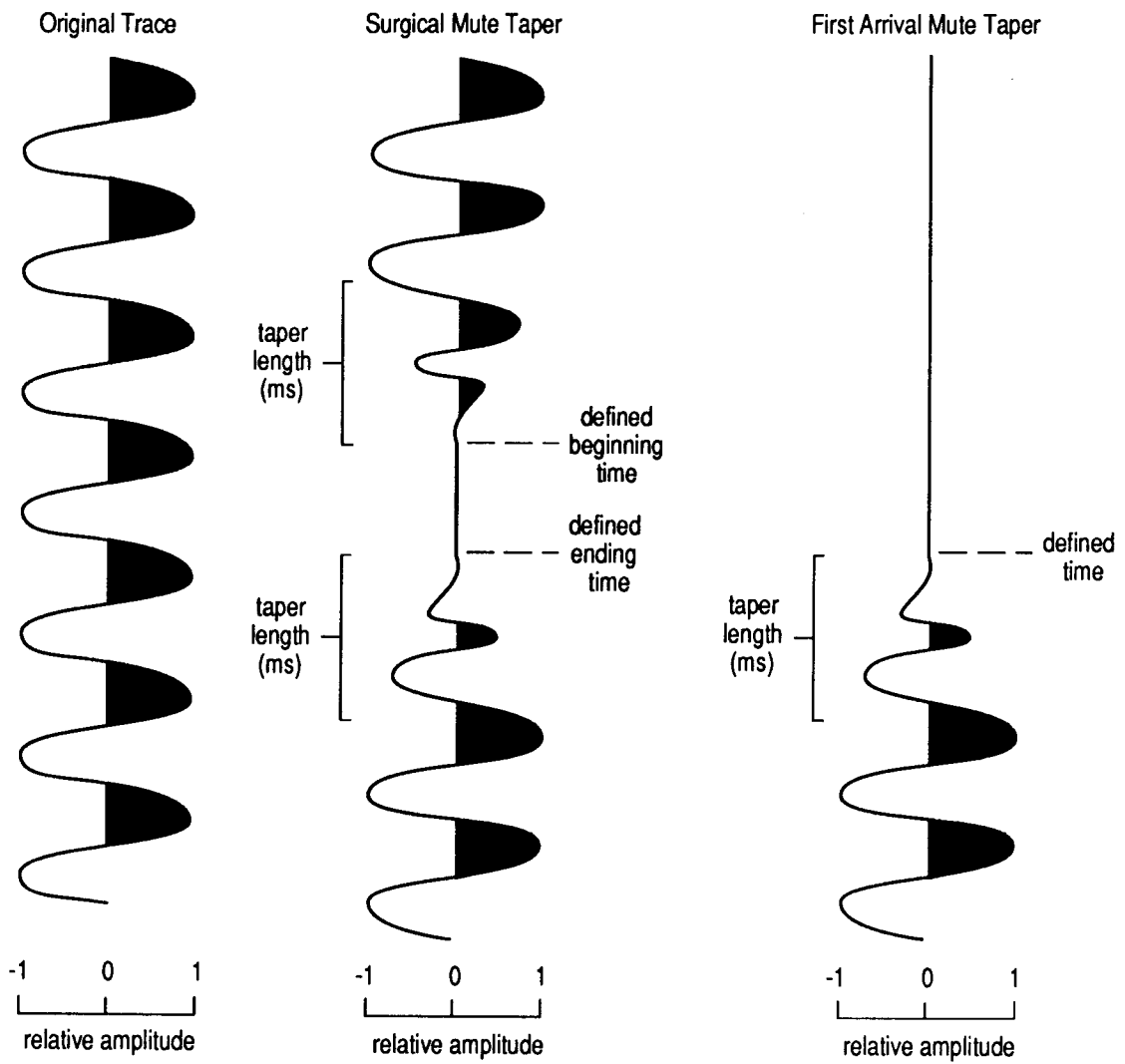


figure 3

STEP #4

*****EXAMPLE DATA*****

The first step in the **first-arrival muting** process is to identify refracted and direct-wave energy on your raw-field plots (Figure 1). Once a definite identification is made, the appropriate mute can be designed. Once the mute window for each field file has been determined, a batch processing sequence similar to the following should be created.

<u>Line</u>	<u>Description</u>
1	>>START see *EDKL for description of >>START
2	*INPF EDKL.dat see *EDKL for description of *INPF
3	*EDFM 92 8 *EDFM identifier calls the first-arrival mute subroutine. The two requested parameters are trace-header words that identify the record/trace pairs (as described during the *EDKL routine). The first requested parameter identifies the primary groups or records (in this case the SSN's trace-header location 92 identifies the record portion of the record-trace pair). The second requested parameter is the trace-header word that identifies the secondary groups or traces location within the record (in this case the channel numbers of the seismograph, trace-header location 8, identifies the trace portion of the record-trace pair).
4	TAPR 10 tapr sets the taper length. The length is in ms. The taper slope is linear and is designed to allow a gradual transition from unaffected data to 100 percent mute. The taper's 0 percent point (total attenuation) is at the user-defined first-arrival mute value and the 100 percent point (no attenuation) is at the defined mute time plus the taper length. In this case, if the first-arrival mute extended to 30 ms on trace 1, the taper would attenuate 90 percent of the signal at 31 ms, 80 percent of the signal at 32 ms, 70 percent of the signal at 33 ms, etc. until at 39 ms 10 percent of the signal was attenuated.
5a	<u>FARM 1 1 30 2 32 3 33 4 35 5 36 6 38 7 39 8 41 9 42 10 44 11 45 12 47 13 48 14 50 15 51 16 53 17 54 18 56 19 57 20 59 21 60 22 62 23 63 24 65</u>
	FARM defines first arrival mute times according to SSN and trace number. The farm operation is designed to interpolate both in time and space. This interpolation process makes the entry on line 5b the same as the entry on line 5a. If only line 5a or 5b farm was defined, the entire data set would be

first-arrival muted according to the defined record number-time windows. The actual mute defined by line 5a or 5b would include the entire data set and delete all data between time zero and 30 ms on trace 1, from time zero to 32 ms on trace 2, from time zero to 33 ms on trace 3, etc. out to trace 24 which will be muted from time zero to 65 ms. If more than 24 traces are present in this data set, each trace beyond trace 24 will be muted as trace 24 was. This means that trace 25 will be muted from time zero to 65 ms, trace 26 will be muted from time zero to 65 ms, trace 27 will be muted from time zero to 65 ms, etc.

5b **FARM 1 1 30 24 65**

This defines exactly the same first-arrival mute as line 5a.

+ 6a **FARM 2 1 0 24 0**

+ 6b **FARM 3 1 30 24 65**

+ 6c **FARM 4 1 0 24 0**

+ 6d **FARM 3 1 30 24 65 25 0**

† Not appropriate for this data set—used only as an example .

If only one file of several is to be first-arrival muted (farm), the series of entries on lines 6a, 6b and 6c would be necessary. The linear interpolation process is automatic. The only way to stop the interpolation is to define 0 mute times just before and just after the defined mutes. The farm defined by lines 6a, 6b, and 6c will mute file (SSN) 3 only, with trace 1 muted from time zero to 30 ms trace 2 from time zero to 32 ms, etc. out to trace 24 which will be muted from time zero to 45 ms. If you wish to stop the mute process after trace 24, therefore, retaining all the information in traces 25 to the last trace (48, 96, or whatever the number of traces on your seismograph), line 6d would be entered in place of line 6b.

7 ***OUTF EDFM.dat** see *EDKL for description of *OUTF

8 **>>END** see *EDKL for description of >>END

In order to display on the screen the previously defined first-arrival mute batch process, simply enter:

>TYPE EDFM.dek <return>

>>start
*inpf edkl.dat

```
*edfm 92 8
tapr 10
farm 1 1 30 24 65
*outf edfm.dat
>>end
```

Now, to run the previously defined first-arrival mute, you need to type the following:

```
>DSEIS EDFM.dek EDFM.LST
```

As before, EDFM.LST is simply a journal file. The muted data will be in the file named EDFM.dat. In order to see the effect of your mute on the input data EDKL.dat, you need to use the `dview` routine. Simply type:

```
>DVIEW <return>
```

Answer the series of self-explanatory questions (as described in display section) and check the format of the screen display. If the display is not satisfactory, make the appropriate changes to either `view.cfg` or to the responses provided to the view routine questions. Once an acceptable format has been obtained, make the appropriate changes to `plot.cfg` and then type:

```
>DPLOT <return>
```

and answer the questions in a similar fashion as you view responses that resulted in the appropriate display.

The first-arrival mute defined by the previous batch file will result in a mute on all files of the sample data set. First-arrival information on file 5 will begin at 30 ms on trace 1 and 65 ms on trace 24 with a 10 ms taper (Figure 4). This field file is displayed identical to the file in Figures 1 and 2 allowing direct comparison of before and after.

4) Surgical Mute

The final editing step involves the surgical removal of bad trace segments (`*EDMT`). Noises resulting from the air-coupled wave, electronic interference other than power line frequencies, and ground roll are generally constrained to isolated portions of a trace. High-amplitude noise obviously dominating a well-defined time window should be removed. However, care need be taken when removing these low S/N portions of traces since significant seismic signal could be present on unprocessed data at an amplitude level below the dynamic range of the plot and therefore invisible to the eye. If the amplitude of the unwanted noise is low in comparison to signal at equivalent times on other traces, occasionally the multi-trace stacking process necessary to generate a CDP stacked section will suppress noise to an acceptable level. Also, many times various filtering operations (discussed later in the processing flow) can attenuate noise that has unique spectral and/or phase

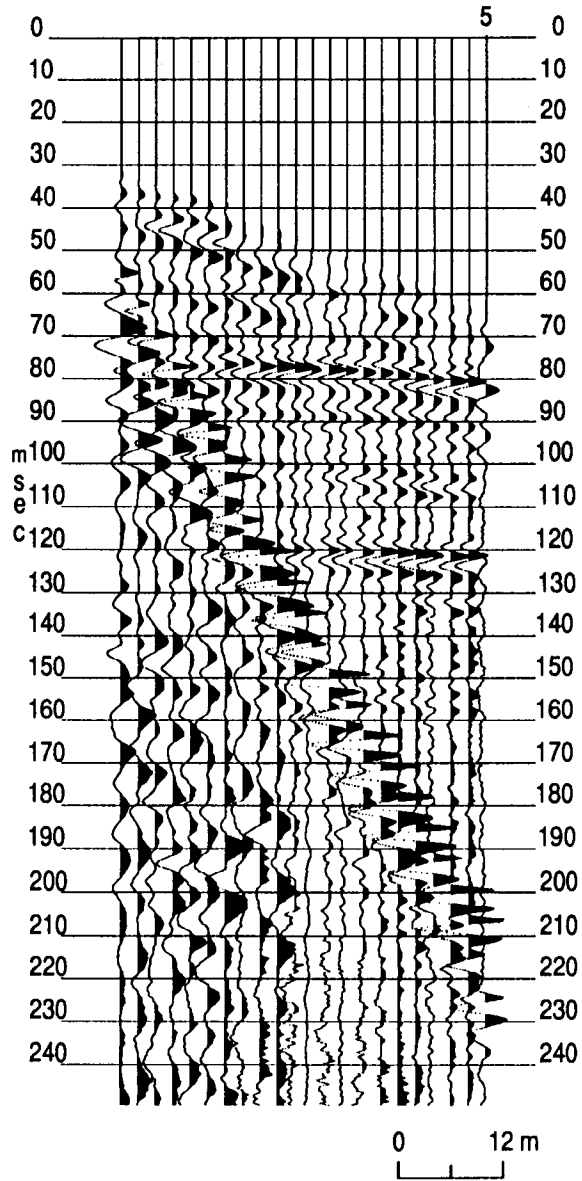


figure 4

characteristics. It must be kept in mind that removal of noise and enhancement of seismic signal to allow an accurate geologic interpretation is the ultimate goal. There is no replacement for good judgement during the preliminary stages of seismic data processing.

STEP #5

*****EXAMPLE DATA*****

The plot of the first-arrival muted data needs to be carefully studied and appropriate time and trace pairs selected to remove the air-coupled wave. Once the desired mute windows on the data have been defined and the trace time pairs recorded, the mute batch file needs to be created. The following sequence of entries is appropriate for the sample data set:

<u>Line</u>	<u>Description</u>
1	<u>>>START</u> see *EDKL for description of >>START
2	<u>*INPF EDFM.dat</u> see *EDKL for description of *INPF
3	<u>*EDMT 92 8</u>

*EDMT identifier calls the surgical muting subroutine. The two requested parameters are the trace header words that identify the record-trace pairs (as described during the *EDKL and *EDFM routines). The first requested parameter is the trace-header word identifying the primary groups or records (in this case the SSN, (trace-header location 92) identifies the record portion of the record-trace pair). The second requested parameter is the trace-header word that identifies the secondary group or trace location within the record (in this case the channel number of the seismograph (trace-header location 8) identifies the trace portion of the record-trace pair).

4 TAPR 10

TAPR sets the taper length as described in Figure 3. The units of taper length are ms. The taper slope is linear and is designed to allow a gradual transition from unaffected data to 100 percent mute. The taper's 100 percent point (total attenuation) is at the user defined first-arrival mute value and the 0 percent point (no attenuation) is at the defined mute time plus (or minus depending on the which end of the mute zone) the taper length. In the case of a 10 ms taper on a mute window starting at 57 ms and ending at 70 ms, the data would experience 0 percent signal attenuation at 47 ms increasing linearly to 100 percent attenuation at 57 ms (with 100 percent attenuation between 57 and 70 ms) the attenuation would then decrease linearly from 100 percent at 70 ms to 0 percent at 80 ms.

5a MUTE 5 1 57 70 24 222 235 (preferred option and technically identical to line 5b)

5b MUTE 5 1 57 70 2 64 77 3 71 84 4 78 91 5 86 99 6 93 106 7 100 113 8 107 120 9 114 127 10 122 135 11 129 142 12 136 149 13 143 156 14 150 158 171 16 165 178 17 172 185 18 179 192 19 186 199 20 193 207 21 200 214 22 207 221 23 214 228 24 222 235

The mute procedure identifiers on lines 5a and 5b define a surgical mute for the entire data set. The program will linearly interpolate between all defined windows throughout the entire data set. The interpolation process is automatic and can only be terminated by entering zeros (beginning and ending) within the time ranges. For the mute defined on lines 5a and 5b the entire data set will be muted with all trace 1's zeroed (all digital information removed and replaced by zeros) between 57 and 70 ms, all trace 2's zeroed between 64 and 77 ms, all trace 3's zeroed between 71 and 84 ms, etc. out to all trace 24's zeroed between 222 and 235 ms. If more traces are present on the records they will be muted according to the trace 24 defined mute (i.e., all trace 25's will be muted between 222 and 235 ms; all trace 26's will be muted between 222 and 235 ms, etc.).

† 6a MUTE 4 1 0 0 24 0 0

† 6b MUTE 5 1 57 70 24 222 235

† 6c MUTE 6 1 0 0 24 0 0

† 6d MUTE 19 1 57 70 24 222 235 25 0 0

† Not appropriate for this data set—used only as an example .

The mute sequence defined by lines 6a through 6c will operate on only record (SSN) 5. Mutes defined for records 4 and 6 will terminate the interpolation process. The operation of the mute in regard to interpolation is very similar to farm as defined in the previous section (*EDKL). Any traces within this record greater than 24 will be muted as 24. In order to stop the interpolation beyond trace 24 a zero mute window needs to be defined for trace 25. Line 6d defines a mute exactly the same as 6b except it terminates the muting of traces beyond trace 24.

7 *OUTF EDMT.dat see *EDKL for description of *OUTF

8 >>END see *EDKL for description of >>END

At this point you need to exit your text editor according to the instruction included with your text-editor software.

In order to inspect the batch processing file you just constructed to surgically mute the air-coupled wave of the sample data set, type the following at the system prompt:

```
>TYPE EDMT.dek <return>
```

```
>>start  
*inpf edfm.dat  
*edmt 92 8  
tapr 10  
mute 5 1 57 70 24 222 235  
*outf edmt.dat  
>>end
```

Now, in order to run the job through the seis program, you need to enter the following at the system prompt:

```
>DSEIS EDMT.dek EDMT.lst <return>
```

As before, while the program is running, it will keep you abreast of where it is in the processing sequence described in **EDMT.dek**. The **EDMT.lst** file is simply a journal file keeping track of the same information that you will see on the screen during the actual running of seis. To see what has been saved in the journal file, use the **MS/DOS type** command. It is always good to at least briefly look at all the data after any operation. To see what the effect of your mute has been on the input data **EDFM.dat**, use the view routine as described in previous sections, and then if there is a need to carefully inspect a hard copy, use the plot routine as described in the display section.

Our sample data set was muted to remove the air-coupled wave. Anytime a mute is applied to seismic data it should be as well defined and tight as possible. This is to avoid removing subdued signal. The muting process zeros samples, and once a sample is zeroed, the information contained within that sample has gone to the "great bit bucket in the sky." **Care should be taken when defining and applying a mute.** The plot of SSN 5 clearly shows the effect of the mute as well as the narrowness of our defined mute window (Figure 5).

F) SORTING (GATHERING) INTO CDP FORMAT

The way data are organized for display and analysis is the heart of any seismic-reflection program. Having flexibility to look at data in a variety of ways, whether according to receiver location or common subsurface point, is critical for future digital enhancement as well as discrimination of subtle features. The actual sorting routine is not particularly difficult from a conceptual point of view, but it does require a significant amount of information relating to the acquisition geometries of your multichannel data. The sheer number of parameters and geometric configurations that need to be defined make sorting potentially the most mistake-prone part of

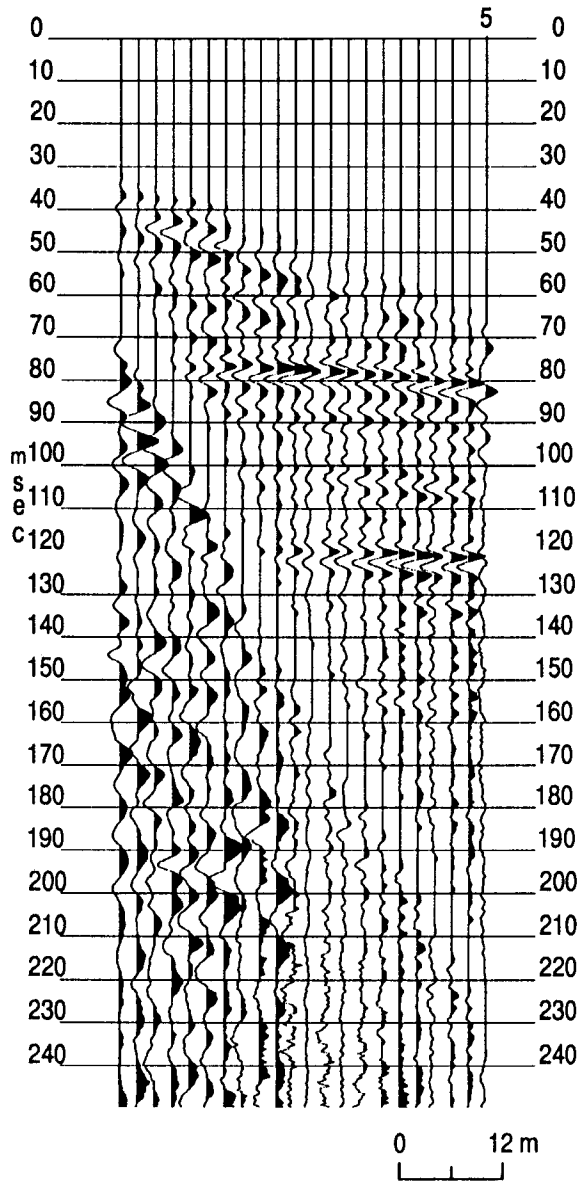


figure 5

processing seismic data. Built into the sorting operation are several ways to cross-check the accuracy of the information you have input. However, they are not completely automated—you must request and check the output of these operations to verify the correctness of your parameter and geometry assignments.

Sorting your seismic data can be thought of as very similar to playing gin rummy. The main goal is to order your data or cards into a sequence likely to be of the most use to you later. For example, in rummy you may be collecting by suit; with seismic data you may be collecting by receiver locations. In rummy you may be collecting by face value; in seismic you may be collecting by common-mid-points. With the card game, the identification [value (numeric or other) and suit] are displayed on the face of each card; with seismic data, the identification (location and size) is contained within each trace header. In order for the data to be brought together in a meaningful fashion, you must select which particular identification (parameter) is most significant for this data set and future processing routines. The data can be gathered together, ordered, and reordered a variety of times and ways.

The two most commonly used parameters to sort are CDP (common-depth-point) sometimes referred to as CMP (common-mid-point), and common source-to-receiver offset (common offset, for short). Sorting according to common source-to-receiver offset is exactly what it sounds like. All traces are gathered according to like distances from source-to-receiver. For example, each of the 24 traces recorded within each field file to our sample data set is offset from the source by a unique distance. Therefore, gathering according to a common offset distance will result in 24 different primary groups (each with unique source-to-receiver offset) each containing 20 traces. In good data areas once the appropriate corrections are made for offset and elevations, common-offset data (if collected within the optimum window) can be viewed as a geologic cross-section without future digital enhancement. However, seldom will common-offset data yield as much or as detailed information as a properly processed CDP stacked section. *Eavesdropper* is specially designed to enhance reflection information once your data are in a sorted CDP format.

Good, complete field notes are critical to correct and accurate defining of source and receiver geometries, surface features, and events significant to future analysis. The information that must be contained in the field notes for each recorded shot at each shotpoint includes:

- 1) shotpoint station number
- 2) live receiver station numbers relative to seismograph channel numbers
- 3) roll switch number
- 4) individual digital file name/number

The remainder of the items listed need to be included but only once, unless they change during acquisition of the data.

- 5) sample interval/number of samples
- 6) analog-to-digital filter settings
- 7) anti-alias filter
- 8) type, number, and relative orientation of sources and receivers
- 9) profile location and purpose
- 10) any unusual offsets (inline or offline)
- 11) space for comments
- 12) time
- 13) weather conditions
- 14) system (seismograph) error messages
- 15) reminder to do system QC checks

An example of a field notebook that we have used quite successfully for several years is displayed in Figure 6.

All significant information about the source and receiver geometries as well as acquisition parameters for our example data set are logged in the field notes (Figure 7). The 20 field files used for this example data set (615-634) were extracted from a larger data set containing 39 files (601-639). Building a batch processing file to define source and receiver geometries for our example data set requires geometrically relating the 20 shotpoints and the 43 receiver locations used during the acquisition of the section of the line used as our sample data set.

The primary task associated with sorting your data relates to the assignment of geometries and parameters. Trace-header information plays a significant roll in this operation. The trace-header words most important to commit to memory are:

<u>Header Word #</u>	<u>Identifies</u>
6	the field file number/name under which this trace was stored in after it was recorded
8	this trace's number within the field file it was collected under (also is equivalent to the channel number this trace was recorded at)
12	this trace's corresponding CDP number (usually about twice the associated station location)
14	the order of this trace within the appropriate CDP
19	distance this trace is from the source
86	station number of the receiver that recorded this trace
87	station number of the source associated with this trace
92	(the source sequence number of this trace, which sequentially relates it to individual field files collected for a particular profile)

A helpful aid in defining the geometries and to double check the accuracy of your field notes is a stacking chart (Figure 8). The layout of the stacking chart (by design) allows visual correlation between the field notes and the sort batch file. It will simplify both visualizing and defining geometries for particular Source Sequence Numbers (SSN).

STEP #6

*****EXAMPLE DATA*****

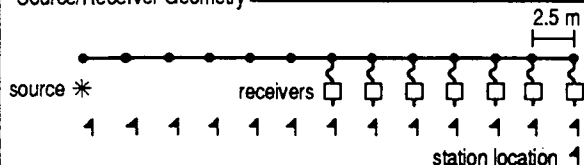
The upper portion of the chart built for our example data set (Figure 8), defines station locations on the x axis and field file numbers as the y axis. Each individual field record (file) number (y axis) has an associated set of 24 recording channels and a shotpoint. The shotpoint location for a particular field record is identified by an x located beneath the appropriate station location (x axis). Along with this x (defining the shot location) is the assigned source sequence number (SSN). Each live receiver location is represented along the x axis by the appropriate seismograph channel number. Notice the step-by-step progression of the shot and receivers across the line.

The lower portion of the chart identifies the locations and SSN, original field channel pairs as well as fold (redundancy, percent coverage) for each CDP.



OBSERVATION FORM

Tape UK BUFF 589
 Location / Purpose Thames River Valley, G. B.
 Contractor/Coordinator Chris Leach EG & G Split-Spread End-On
 Energy Source 12-Gauge Buffalo Gun End-On
 Gap 7 No. Stacked Per File 1
 Source Spacing 2.5 m P-Wave Single Source
 Geophone Freq. 100 Hz S-Wave Multi-Source
 Take-Out Spacing 2.5 m Array Single Phones
 Source/Receiver Geometry _____



Amp. No.	1	3	5	7	9	11	13	15	17	19	21	23	File No.	Alten. Freq.
	2	4	6	8	10	12	14	16	18	20	22	24		
Test Oscil.													<input type="checkbox"/> F1	<input type="checkbox"/> F2
Operating Gains	Floating Pt Amps													

Amp. Scan Delay 0 Damper Box: In Out
 Filters: High Cuts 500 Hz Low Cuts 200 Hz
 60 Hz Notch Sample Int. 1/2 msec.
 Alias
 No. of Samples 1024 Record Length 512 msec.
 Rec. Start Delay 0 Amps.: IA5 IA6
 Control Level N/A Temp. 23°C
 Wind 0-5 KmPH
 Soil Conditions dry sod

tape error	SEISMIC GEOMETRY										Line Name <u>EG & G England 1</u>	Observer <u>Don S.</u> Date <u>5/10/89</u>
	Shot Point No.	Tape File No.	Roll Switch No.	Flag No. of Trace				Dead Traces	(Time)	Remarks		
				1	12	13	24					
	108	001	75	115					12			
	109	002	76	116					11			
	110	003	77	117					10			
	111	004	78	118					9, 24			
	112	005	79	119					8, 23			
	113	006	80	120					7, 22	3:02		
	114	007	81	121					6, 21			
	115	008	82	122					5, 20			
	116	009	83	123					4, 19	airplane noise		
	117	010	84	124					3, 18	airplane noise		
	118	011	85	125					2, 17			
	119	012	86	126					1, 16	automobile noise		
	120	013	87	127					15			
	121	014	88	128					14			
	122	015	89	129					13			
	123	016	90	130					12	3:12		
	124	017	91	131					11			
	125	018	92	132					10			
	126	019	93	133					9			
	126	020	93	133					9	second shot in hole		

33

figure 7

station location		132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156
18	19	20	21	22	23	24																				
17	18	19	20	21	22	23	24																			
16	17	18	19	20	21	22	23	24																		
15	16	17	18	19	20	21	22	23	24																	
14	15	16	17	18	19	20	21	22	23	24																
13	14	15	16	17	18	19	20	21	22	23	24															
12	13	14	15	16	17	18	19	20	21	22	23	24														
11	12	13	14	15	16	17	18	19	20	21	22	23	24													
10	11	12	13	14	15	16	17	18	19	20	21	22	23	24												
9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24											
8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24										
7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24									
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24								
5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24							
4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24					
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		

263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282

...	10,24																											
...	...	11,24																										
...	...	...	12,24																									
...	...	...	...	13,24																								
...	...	...	...	...	14,24																							
...	...	...	...	...	...	15,24																						
...	...	...	...	...	...	...	16,24																					
...	...	...	...	...	...	...	...	17,24																				
...	...	...	...	...	...	...	...	...	18,24																			
20,5	20,6	20,7	20,8	20,9	20,10	20,11	20,12	20,13	20,14	20,15	20,16	20,17	20,18	20,19	20,20	20,21	20,22	20,23	20,24									
11	11	10	10	9	9	8	8	7	7	6	6	5	5	4	4	3	3	2	2									

The lower portion of the stacking chart was derived from the upper part. The CDP numbers identified along the x axis on the lower part are exactly double the surface location defined directly above on the upper portion of the chart. The number pairs beneath each CDP location identify the SSN and seismograph channel number for the trace(s) sampling this particular midway point between source and receiver (CDP). As an example, locate SSN 5 and seismograph channel number 10 on the upper portion of the stacking chart. Next, find the point which is midway between the shot for SSN 5 and the associated seismograph channel 10. Finally, extrapolate that point straight down into the lower portion of the chart and you will find the number pair 5, 10 as the fifth set of number pairs beneath CDP location 240. The bottom set of numbers running parallel to the x axis identify the fold of the associated CDP. The fold can be figured by simply adding the number of SSN/trace number pairs beneath each CDP location.

The program `dseis` has an option to print a table which will allow you to directly compare your hand-generated stacking chart directly from the field notes with a computer-generated chart reflecting the geometries and parameters you defined for the `*sort` operation. Our computer-generated chart for the sample data set will be compared to the hand-generated chart (Figure 8) after our sort deck is complete.

A stacking chart may not always be necessary, but until a great deal of experience is gained processing seismic data, it is a wise aid in assuring the data you are preparing to gather and stack is properly identified and ordered.

Once you have a complete set of field notes and know how you would like to order your data for future digital enhancement and display, you are ready to create a batch process file to sort your data. As with other operations, start building your batch file by typing the following at the system prompt:

STEP #6a

*****EXAMPLE DATA*****

The following deck is built for CDP sorting of an example data set which is composed of 20 shots recorded on a 24-channel seismograph across 44 receiver stations, each separated by 2.5 m. The source-to-closest-receiver distance is 17.25 m and the source stations are coincident with the receiver stations. The data were collected using a CDP-type roll-along technique. The relative source-to-receiver orientation was end-on.

<u>Line</u>	<u>Description</u>
1	<u>>>START</u> see *EDKL for description of >>START
2	<u>*INPF EDMT.dat</u> see *EDKL for description of *INPF

3 ***SORT 12 19**

The *SORT procedure calls the subroutine responsible for **collecting traces according to indicated header words**. We have described a sorting operation here which will gather together all traces with **equivalent midpoints between shot and receiver**. The **first value** (header-word number) input designates the **primary sort grouping (trace header word 12, CMP or CDP number)**. The **second value** (header-word number) requested designates the **secondary grouping (trace header word 19, distance from source to receiver)**. The secondary grouping simply designates the ordering of the trace display within the primary grouping. With unprocessed field data, the primary grouping is file or source-sequence number, and the secondary grouping is according to individual trace or channel numbers.

4 **PTRN 2.5 24 1**

PTRN operation defines the **distance between surface stations and physical seismograph parameters**. This operation must always precede the *SORT procedure definition. The **first requested input** is the distance between station locations (2.5 m). The **second value** to be identified is the **total number of recording channels on your seismograph (24)**. And the **final value** represents the **units of length** used during the acquisition of the data (1 = meters, 0 = feet). This operation (ptrn) is the lead-in for the next line(s) (pn) which will identify all the different source and receiver geometries used throughout the collection of this data set.

5a **PN 1 108 115 24 1**

S	1	24	trace/channel
#	*****		
108	115	138	surface station

Note: A piece of the stacking chart is represented above to help equate the station numbers to the actual source and receiver patterns. A stacking chart allows you to visualize the relative location of the shots and receivers.

pn defines each unique relative **source-to-receiver geometry**. The pattern described on line 5a is designated as **pattern number 1** (it will be referenced by that number (1) later in this batch job). It defines a **source location (108)** and its associated **first receiver location (115)** as well as indicates **consecutive receiver locations (24)**. The **fifth value** designates the amount each surface station was **incremented after each shot**. In this case, **stations were incremented by 1**. In other words, station 115 equates to trace/channel 1 of your seismograph; station 116 equates to trace/channel 2 of your seismograph.

If your source was occupying (being fired) every station location but your receivers were located (live) at every other surface station, you would have

used a 2 for the fifth input value to indicate the receiver spacing was twice the surface-station spacings. Then surface station 115 would equate to trace/channel 1 and station 117 would have equated to trace/channel 2, etc. Another possibility is that your roll switch is wired reverse to this sequence which means your trace/channel 1 is at surface station location 138 when surface stations 115 to 138 are selected. If this is the case, you would want to designate a negative one (-1) incrementation of surface-station locations as the fifth value input of the **pn** definition. The correct **pn** definition for a reversed roll-switch would look like line 5b.

```

+ 5b PN 1 108 138 24 -1      S  24                      1  trace/channel
                                #  *****
                                108 115                      138  surface station

```

This definition indicates the surface station location of the shot was 108, trace/channel 1 was 138, and **incrementing of station locations is negative (-1) with respect to the positive increasing trace/channel numbers**. Therefore, channel/trace 1 is surface station 138, channel/trace 2 is surface station 137, channel/trace 3 is surface station 136, etc.. Here the same source-to-receiver maximum and minimum offsets are defined (source 108, minimum offset 115, maximum offset 138) as on line 5a, the exception of course being the decrementing surface station numbers with respect to the incrementing trace/channel numbers. This is a critical difference when the source-to-individual-receiver distances are calculated later in this batch job. All the information necessary to determine exactly how to define the trace/channel orders is contained within the trace header and is easily viewed using the trace-header-dump (trhd) routine previously discussed.

```

+ 5c PN 1 95 99 2          S  1                      24  trace/channel
                                #  *****
                                95  99                      122  surface station

```

The sorting routine **doesn't care what the actual numbers input for the source (108) and receiver (115) locations are; it only looks at relative differences**. What that means is the **pn** definition on line 5a is identical to the **pn** definition on line 5c. It is not necessary to define existing station numbers. Most of the time it is advisable to identify real station numbers just to avoid confusion if problems crop up later.

This definition of pattern is exactly the same as the one defined on line 5. The station numbers of the shot and receivers need only be relative to each other and do not need to be related to the actual values used in the field. Any arbitrary numerical representation will work.

```

+ 5d PN 1 114 101 12 1 116 12 1  1          12  S  13          24  trace/channel
                                *****      #  *****
                                101          112  116          127  surface station

```

This definition is of a split-spread pattern. This definition does not apply to the acquisition parameters and geometries being defined here, but is included as an example in case you encounter a split-spread source-receiver geometry. Briefly, this is the first pattern defined (1), the shot station number is 114, the first trace/channel station number is 101, there are 12 consecutive trace/channels defined across 12 sequential surface station locations, then a 3-station skip to station location 116 which is trace/channel 13 where the remaining 12 channels are defined starting at 116 to 127, inclusive, each sequential increase of (1) in trace/channel number corresponds to a sequential increase of 1 in the surface-station location.

† Not appropriate for this data set—used only as an example.

6 **SHOT**

This alpha character description (shot) simply identifies the succeeding series of sn or snsn definitions as related to the shot location and source sequence numbers (SSN). This operation must follow the ptrn operation.

7 **SN 1 108 1 0 0 1**

The SN definition input is required for each field file (source sequenced file). This operation matches a source-sequenced file with its appropriate shotpoint's surface station location and source/receiver geometry, as described by the ptrn operation. In this case, the (Source Sequence Number) SSN is 1, the shot station location is 108, the source/receiver geometry is defined in pn 1. The fourth entry is related to inline offset (0), this is simply the distance from the defined surface station location to the actual location of the shot recorded along the line of the survey (parallel offset). The fifth entry (0) is also related to the actual location of the shot recorded at this surface location (109), and it defines the distance off the line between the shot and actual surface station location (perpendicular offset). The sixth value (1) identifies the repeat shot number. Since we are only recording one shot per surface location 1 is the appropriate sixth value. The repeat shot number simply identifies which shot this file represents at this location. If multiple shots are recorded individually at this location on different files, the program is capable of identifying which shot this file represents and then allows the option to later sort according to particular repetitive shot number at each location.

8 **SN 2 109 1**

This SN definition as with the previous one (line 7) is required to describe the source station number and it's associated live receiver pattern. This must be done for each defined SSN. The only difference between this sn

definition and the one previous is SSN 2 is defined which has shot location 109, whereas the previous one was for SSN 1 which had shot location 108. The last three parameters were omitted on this definition because the default values were appropriate.

The line format was purposely changed on line 8 simply to demonstrate the flexibility of formatting within the program. This shows the program is not field sensitive with respect to the number of spaces between input parameters. However, it should be kept in mind that the order of the input values is critical. If you wish to input values not identified as default values for the sixth and seventh requested parameters but your fourth and fifth are the same as the default values, you must input all values from the first requested to the seventh, regardless of the default values. (See line 10).

9 SNSN < 3 19 1 > < 110 126 1 > 1

The SNSN definition permits the assignment of field geometries to large numbers of sequential field files possessing identical shot and receiver patterns as well as source offsets and bad traces. The < > are treated as entry parameters and therefore need to be separated from other entries by a space. Here we are defining the shot patterns for SSN 3 through 19 which related to shot locations 110 to 126. Both shot location and SSN's increment by 1 as the source and receivers move down the survey line. Therefore, the first set of bracketed values represent the SSN's and their incrementing while the second set of bracketed values represent the associated shot locations and their incrementation pattern. The information within the first set of brackets is equivalent to the first entry on a normal SN definer. The second set of bracketed values which are equivalent to the second entry on the normal SN definer. All parameters beyond the first two of the SNSN definers are identical to those of the ordinary SN definer.

10 SN 20 127 1 0 0 1 1 24

This shotpoint definition has a couple extra entries in comparison to the previous sn definers. The SN definition's seventh value is the first dead trace/channel number and eighth value (24) is the last dead trace/channel number. From the field notes for our sample data, the 19th and 20th shots were recorded at the same location. In order to retain equal weighting of all shot locations across the line, one of the duplicate shots must be removed. In this case, the second shot was deleted using the 7th and 8th values in the SN definition. The program will interpolate between the seventh and eighth input values. This means, if the seventh value is 19 and the eighth value is 22, the program will omit 19 thru 22, inclusive. The previous SN definers have had the same inline and offline offsets as well as repeat shot number. The information was not entered because the default values are

appropriate (in other words if you do not enter anything for the required values the program assumes the default values are correct).

11 **TABL 1 1**

The **tabl** operation is optional and allows you to **cross-check** your **defined geometries** with the actual field geometries. The two input values are flags. The first (1) designates that you wish to have the receiver diagram plotted out, and the second (1) signals the printing of the **sort table**. The entire **table** will be **contained** within the journalization file (i.e., **DSEIS SORT.dek TABLE.lst** where **TABLE.lst** is your journal file and it can be typed out or printed using standard MSDOS operations)

12 ***OUTF SORT.dat** see *EDKL for description of *OUTF

13 **>>END** see *EDKL for description of >>END

At this point you need to exit your text editor. In order to see the batch processing file you have created to sort seismic data into a CDP format, type the following commands at the system prompt:

```
>TYPE SORT.dek <return>
```

```
>>start  
*inpf edmt.dat  
*sort 12 19  
ptrn 2.5 24 1  
pn 1 108 115 24 1  
shot  
sn 1 108 1 0 0 1  
sn 2 109 1  
snsn < 3 19 1 > < 110 126 1 > 1  
sn 20 127 1 0 0 1 1 24  
tabl 1 1  
*outf sort.dat  
>>end
```

Now, in order to run the sorting batch job you just typed out, enter the following series of commands at the system prompt:

```
>DSEIS SORT.dek TABLE.lst <return>
```

As with the other batch operations already run, the program will continuously update the screen with pertinent information regarding the present status of the batch job. The **TABLE.lst** file is again a journal file that will contain not only the blow-by-blow account of the processing sequence, it will also contain

the geometries and sorting sequences applied in accordance with the input information. This is intended to allow you the option to compare your stacking chart developed from the field notes with the actual information you coded into the various operations in the batch processing file. The journal file will be contained in the subdirectory in which you are running the seis program in and can be viewed either in hard copy or on the CRT.

The stacking chart, generated by the program (assuming you used the `tabl` option) with the information input during the sort operation, is displayed below:

SORTED RECORD TABLE (SHOT #1)

RCRD	FOLD	SN-TR	SN-TR	SN-TR	SN-TR	SN-TR	SN-TR	SN-TR	SN-TR	SN-TR	SN-TR	SN-TR	SN-TR
223	1	1-1											
224	1	1-2											
225	2	2-1	1-3										
226	2	2-2	1-4										
227	3	3-1	2-3	1-5									
228	3	3-2	2-4	1-6									
229	4	4-1	3-3	2-5	1-7								
230	4	4-2	3-4	2-6	1-8								
231	5	5-1	4-3	3-5	2-7	1-9							
232	5	5-2	4-4	3-6	2-8	1-10							
233	6	6-1	5-3	4-5	3-7	2-9	1-11						
234	6	6-2	5-4	4-6	3-8	2-10	1-12						
235	7	7-1	6-3	5-5	4-7	3-9	2-11	1-13					
236	7	7-2	6-4	5-6	4-8	3-10	2-12	1-14					
237	8	8-1	7-3	6-5	5-7	4-9	3-11	2-13	1-15				
238	8	8-2	7-4	6-6	5-8	4-10	3-12	2-14	1-16				
239	9	9-1	8-3	7-5	6-7	5-9	4-11	3-13	2-15	1-17			
240	9	9-2	8-4	7-6	6-8	5-10	4-12	3-14	2-16	1-18			
241	10	10-1	9-3	8-5	7-7	6-9	5-11	4-13	3-15	2-17	1-19		
242	10	10-2	9-4	8-6	7-8	6-10	5-12	4-14	3-16	2-18	1-20		
243	11	11-1	10-3	9-5	8-7	7-9	6-11	5-13	4-15	3-17	2-19	1-21	
244	11	11-2	10-4	9-6	8-8	7-10	6-12	5-14	4-16	3-18	2-20	1-22	
245	12	12-1	11-3	10-5	9-7	8-9	7-11	6-13	5-15	4-17	3-19	2-21	1-23
246	12	12-2	11-4	10-6	9-8	8-10	7-12	6-14	5-16	4-18	3-20	2-22	1-24
247	12	13-1	12-3	11-5	10-7	9-9	8-11	7-13	6-15	5-17	4-19	3-21	2-23
248	12	13-2	12-4	11-6	10-8	9-10	8-12	7-14	6-16	5-18	4-20	3-22	2-24
249	12	14-1	13-3	12-5	11-7	10-9	9-11	8-13	7-15	6-17	5-19	4-21	3-23
250	12	14-2	13-4	12-6	11-8	10-10	9-12	8-14	7-16	6-18	5-20	4-22	3-24
251	12	15-1	14-3	13-5	12-7	11-9	10-11	9-13	8-15	7-17	6-19	5-21	4-23
252	12	15-2	14-4	13-6	12-8	11-10	10-12	9-14	8-16	7-18	6-20	5-22	4-24
253	12	16-1	15-3	14-5	13-7	12-9	11-11	10-13	9-15	8-17	7-19	6-21	5-23
254	12	16-2	15-4	14-6	13-8	12-10	11-12	10-14	9-16	8-18	7-20	6-22	5-24
255	12	17-1	16-3	15-5	14-7	13-9	12-11	11-13	10-15	9-17	8-19	7-21	6-23
256	12	17-2	16-4	15-6	14-8	13-10	12-12	11-14	10-16	9-18	8-20	7-22	6-24
257	12	18-1	17-3	16-5	15-7	14-9	13-11	12-13	11-15	10-17	9-19	8-21	7-23
258	12	18-2	17-4	16-6	15-8	14-10	13-12	12-14	11-16	10-18	9-20	8-22	7-24
259	12	19-1	18-3	17-5	16-7	15-9	14-11	13-13	12-15	11-17	10-19	9-21	8-23
260	12	19-2	18-4	17-6	16-8	15-10	14-12	13-14	12-16	11-18	10-20	9-22	8-24
261	11	19-3	18-5	17-7	16-9	15-11	14-13	13-15	12-17	11-19	10-21	9-23	
262	11	19-4	18-6	17-8	16-10	15-12	14-14	13-16	12-18	11-20	10-22	9-24	
263	10	19-5	18-7	17-9	16-11	15-13	14-15	13-17	12-19	11-21	10-23		
264	10	19-6	18-8	17-10	16-12	15-14	14-16	13-18	12-20	11-22	10-24		
265	9	19-7	18-9	17-11	16-13	15-15	14-17	13-19	12-21	11-23			
266	9	19-8	18-10	17-12	16-14	15-16	14-18	13-20	12-22	11-24			
267	8	19-9	18-11	17-13	16-15	15-17	14-19	13-21	12-23				
268	8	19-10	18-12	17-14	16-16	15-18	14-20	13-22	12-24				
269	7	19-11	18-13	17-15	16-17	15-19	14-21	13-23					

```

270  7  19-12 18-14 17-16 16-18 15-20 14-22 13-24
271  6  19-13 18-15 17-17 16-19 15-21 14-23
272  6  19-14 18-16 17-18 16-20 15-22 14-24
273  5  19-15 18-17 17-19 16-21 15-23
274  5  19-16 18-18 17-20 16-22 15-24
275  4  19-17 18-19 17-21 16-23
276  4  19-18 18-20 17-22 16-24
277  3  19-19 18-21 17-23
278  3  19-20 18-22 17-24
279  2  19-21 18-23
280  1  19-22 18-24
281  1  19-23
282  1  19-24
>>end

```

The output from the **tabl** option will generate a table similar to the above table which contains the SSN-trace pairs with their associated RCRD (CDP #) and appropriate fold. Checking this table (program generated) against the one you constructed (Figure 8) will help verify the correctness of the sort file as well as assure you the data geometries are input into the trace header correctly.

It should be kept in mind that the stacking chart generated by the sorting operation (**tabl**) does not check the real input data to identify traces designated as bad. Therefore, the SSN trace pairs, output with its associated CDP number, will include values previously deleted. If your hand-generated stacking chart is correct, it will also include the dead or bad traces.

It will be beneficial at this point to generate a hard copy plot of the entire sorted data set. This will allow you to cross check your stacking chart with your sorting table printout as well as the actual sorted data. Many times problems, not obvious on a sorting table, will be quite obvious on a hard-copy plot of CDP sorted data.

STEP #6b

*****EXAMPLE DATA*****

The principal (higher amplitude) reflections identified on our raw field file (Figure 1) are still interpretable on the gathers of CDPs 245 and 246 (Figure 9). These two gathers represent the subsurface points located beneath station locations 122 1/2 and 123. Careful examination reveals the zeroed-out portions of the traces previously occupied by the air-coupled wave. The traces are ordered within each CDP according to original source-to-receiver offset distance (trace header word 19 as defined by the ***sort**). The location of the traces within each CDP are also identified by a trace header word (14). Header word 14 designates the order within the CDP gather. The numbering of traces within the CDP is from left to right with the far left trace of CDP 245 possessing a 1 at trace header location 14 while the trace on the far right possesses an 11 at trace header location 14. Header word 14 is totally unrelated to header word 8 (original seismograph channel number) and may or may not be the same value.

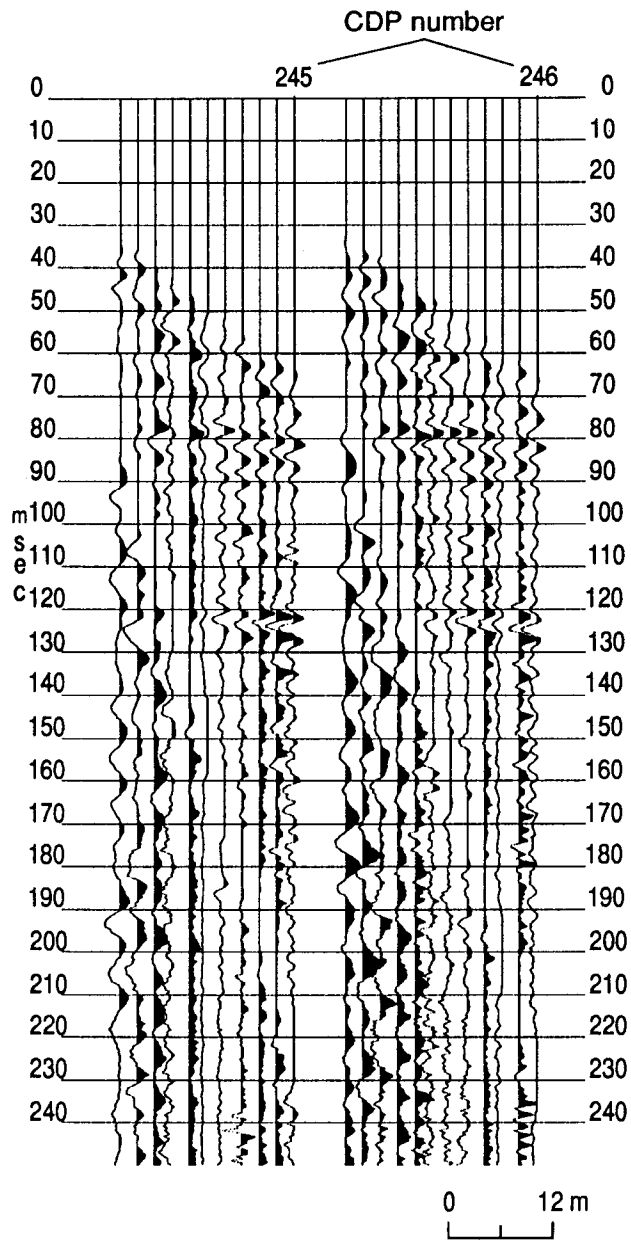


figure 9

G) ELEVATION CORRECTION/DATUM ASSIGNMENT

Correcting your data for a variable near-surface can be one of the most difficult problems encountered while processing seismic-reflection data. Most areas on a seismic-reflection section possessing poor signal-to-noise ratios or that have resulted in an incorrect structural interpretation are pigeon-holed as related to "static problems." These problems can be the result of anything from incorrect compensation for surface topography to uncompensated velocity irregularities in the near surface.

On any data set, the first step in eliminating static effects requires adjustment of the data to a datum. A datum is simply a reference line with some absolute correlation to sea level or, in some cases average slope of the ground surface (sloping datum). Generally on conventional data, the datum is chosen beneath the weathered and within the subweathered zone. Defining the datum within the subweathered zone is necessary to insure **all non-uniform near-surface material is above the datum**. The correction conceptually involves **removal of all material above the datum**, which in turn ultimately allows accurate time-to-depth conversions relative to sea level on interpreted CDP stacked sections. Correcting for both surface topography and a non-uniform weathered layer requires at least **relative station elevations** and a somewhat detailed knowledge of the **near-surface velocity and depth structure**. The datum correction is generally perceived as a first guess approximation and is intended to remove major static anomalies associated mainly with relative elevation changes. Discrepancies between the calculated datum correction and true datum correction are generally addressed using iterative numerical techniques at a later stage in the CDP processing flow.

Shallow high-resolution reflection profiles generally target geologic features within what conventional wisdom would suggest is the weathered zone. Correcting for elevation and near-surface irregularities on shallow profiles therefore becomes quite complicated in comparison to the previously described conventional procedure for datum corrections. Detailed knowledge of shallow velocity and depth information is critical for accurate datum corrections on shallow-reflection surveys. Subtle changes in the velocity of very near-surface material can drastically affect the spectral as well as spatial properties of higher frequency data. For example, if you are looking for structure on the bedrock surface at a depth of 12 m with an NMO velocity of 400 m/s and dominant reflection frequencies around 200 Hz, an uncompensated 0.3-m variation in elevation or a 10 m/s velocity anomaly can result in a 100 degree phase shift in the recorded reflection wavelet. A gradual horizontally increasing near-surface velocity can be misinterpreted as a slope on the bedrock surface.

The selection of a datum for shallow-reflection surveys can greatly influence the outcome and validity of the final interpretation of your data. Many times reflection information of interest will be removed if a flat datum is chosen within the subweathered layer followed by conventional calculated removal of all overlying material. For most **shallow-reflection profiles, a datum should be chosen equal to the highest topographic feature** on the survey line. Then the **time adjustment** to compensate for the missing material should be **added to each trace** in accordance to the velocity/depth function. In areas with alluvium over bedrock, generally a direct-wave velocity can be used to determine the appropriate time correction. In areas with either a thin layer of weathered material or no weathered material at all overlying outcropping or subcropping units, a more detailed velocity function is necessary to reconstruct the material between the present ground surface and the datum. For shallow-reflection data, the datum represents a pseudo ground surface composed of actual material beneath topographic highs and the virtual material used to compensate for the distance between the ground surface and topographic lows and the datum. The sum is the time between the ground surface and the allowing depth calculations to bedrock or other layers.

The **most inaccurate** part of the datum correction for shallow surveys involves the **assignment of depth/velocity pairs** to each surface station. The best way to determine these values is through

uphole/downhole surveys in strategically placed boreholes. The *Eavesdropper* software will generate a near-surface model along the survey line by incorporating all the uphole-determined velocity and depth information with the spatial distribution of the holes. Without uphole data, the only information available to approximate the near-surface velocity/depth structure is **direct- and refracted-wave** information. In some cases, the values obtained using this information are sufficient to generate an acceptable near-surface model. The closer to a true near-surface velocity/depth model you can define for the datum correction, the less dependant you will be on iterative numerical statics routines and the more confidence you will be able to put in your depth calculation during the interpretation portion of your survey.

Determining the appropriate values to input into, and the usefulness of the output of the *SURF operation requires a thorough understanding of the geologic situation as well as certain physical properties of the near-surface materials. The input **velocity function** will be **interpolated** across the entire expanse of the defined profile line. **Elevation data** input for each station location need only be **relative** within the survey (absolute elevation data are not necessary). If the datum was assigned above the highest topographic feature on the survey line, the outputted **static correction** for each receiver and shot station will be **necessary** during the later interpretation stages to calculate depths. If the datum was assigned within the subweathering zone, **time-to-depth conversions** can be made **without** knowledge of the amount of the **static correction** (material removed). This is because the relative elevation of the datum is known, which in turn allows accurate determination of time values between the datum and event of interest.

The necessary datum/elevation correction for our sample data set only modifies a small portion of the line. The data were collected in a river valley. River valleys often (as with this case) do not have significant changes in elevation. The majority of the sample data set was collected across a flat-lying pasture with little or no surface evidence to suggest areas of potential static anomalies. At the extreme east end of the line, however, the line crossed a wash-out extending approximately 6 m with a maximum relative depth of 1 m. If not for the washout spot on the line, no datum correction at this time would be necessary or possible. However, with the elevation change present as a result of the wash-out, the *SURF operation is necessary on this line.

STEP #7

*******EXAMPLE DATA*******

Determination of the velocity within the very-near surface using the information provided with and contained within the sample data set is not straight forward. Therefore, we will provide you with the velocity information as well as the relative elevation data necessary to properly calculate and apply the datum correction. An uphole velocity survey in conjunction with your seismic-reflection survey is advisable whenever possible to accurately determine the near-surface velocity model.

AVERAGE VELOCITY FROM THE SURFACE TO APPROXIMATELY 3-METERS OF DEPTH IS: 770 M/S

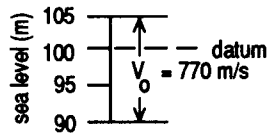
CRITICAL ELEVATION INFORMATION INCLUDES THE FOLLOWING:

<u>STATION LOCATION</u>	<u>RELATIVE ELEVATION (M)</u>
136	0
137	0.3
138	0.6
139	0
140	-1
141	-0.3
142	-0.6
143	0

Once as much information as possible is obtained about the near-surface materials, a batch processing file must be created to calculate the appropriate static values for each shot and receiver station. This operation (*SURF) does not apply the calculated shifts. This routine calculates the appropriate shift and updates the trace headers. In order to apply this static shift, a *STAT 1 operation must follow the *SURF operation. This can be accomplished either in the same or a separate batch job file. The following sequence of entries represent a batch processing file to calculate and apply datum corrections to our sample data set.

<u>Line</u>	<u>Description</u>
1	>>START see *EDKL for description of >>START
2	*INPF SORT.dat see *EDKL for description of *INPF
3	*SURF 100 *SURF identifier calls up the terrain correction subroutine from within DSEIS. The required input value relates to defining the datum. The value of the datum is arbitrarily assigned as 100. In this case, think of the data as representing absolute elevation relative to sea level.
4	ALVF 105 770 90 alvf defines the average velocities and their associated depths. For the sample data set, we are defining a single velocity across the entire line and therefore the first entry identifies the maximum surface elevation (105) of the defined velocity function. The second entry (770) defines the average velocity from the maximum surface (105) to a maximum depth identified by the third entry (90).

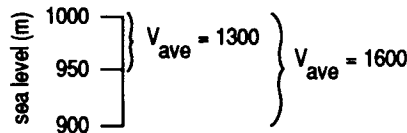
We have determined the following near-surface configuration:



For a case with multiple depth velocity pairs—

† 4a ALVF 1000 1300 950 1600 900

alvf operation defines the velocity model for the near-surface material down to a depth necessary to correct all station locations to the defined datum. The values requested for the ALVF operation are: the **surface elevation (1000)** of the defined velocity function, the **average velocity (1300)** from the surface (1000) to the elevation defined by the third numeric value (950), then the **average velocity (1600)** from the surface (1000) to the elevation defined by the fifth numeric value (900). This sequence of average velocity/depth pairs continues until your entire velocity function is defined. An important note at this point: the velocities defined here (ALVF) are **AVERAGE VELOCITIES FROM THE SURFACE TO THE DEFINED DEPTH**. The program will calculate **interval velocities** for the defined intervals (1000-950, 950-900). This program works most effectively with uphole/downhole check shot velocity information.



† Examples not applicable to our sample data set.

5 SE 126 97 100

se operation defines each **station location** and its associated **source and receiver elevations**. The defined values are **station location (108)**, **source elevation (97)**, and **receiver elevation (100)**. The receiver elevation need not be defined if it is the same as the source elevation. A shot elevation defined at a station where no shot was recorded will be sorted out by the program and properly handled. The program interpolates horizontally and vertically between defined values and, therefore, station 108 through 125 are not defined since they are all the same as 126.

6 SE 127 100

7 SE 136 100

- 8 **SE 137 100.3**
- 9 **SE 138 100.6**
- 10 **SE 139 100**
- 11 **SE 140 99**
- 12 **SE 141 99.6**
- 13 **SE 142 100.6**
- 14 **SE 143 100**
- 15 ***STAT 1**

***STAT operation applies static correction values defined in the trace headers. These static header words are updated by other operations (*auts, *surf, or user input values). The *STAT operation can be executed within the batch job where the actual static correction values are determined or later in a separate batch job either independently or with any other operation(s). The only required input value (1) designates the type of operation used to define static shift values.**

- 16 ***OUTF SURE.dat** — see *EDKL for description of *OUTF
- 17 **>>END** — see *EDKL for description of >>END

At this point you have completed the building of an executable file for the generation and application of static shifts to sorted data for the correction of elevation and near-surface irregularities across the profile. In order to quickly check to make sure all the values and operations you just identified during the surf operation, type the following at the system prompt:

>>TYPE SURE.DEK <return>

You should see the following if the above deck is what you entered:

```
>>start
*inpf sort.dat
*surf 100
alof 105 770 90
se 126 97 100
se 127 100
se 136 100
se 137 100.3
se 138 100.6
```

```

se 139 100
se 140 99
se 141 99.6
se 142 100.6
se 143 100
*STAT 1
*outf surf.dat
>>end

```

The next step is to run your elevation correction job through the DSEIS program. At the system prompt type the following:

>DSEIS SURE.dek SURE.lst <return>

As before, while the program (*dseis*) is running, it will keep you abreast of where it is in the processing sequence. If later you want to study each step of the job that you ran, simply type out the journal file *surf.lst*. If you wish to see what effect your datum correction had on the sorted data, follow the series of steps described for plotting earlier in this manual.

Displaying a data set after **surf* will probably not be an effective use of time or resources. The more advisable way to check to make sure your corrections were applied the way you had intended is to run the trace header dump routine (*trhd*) previously described.

An alternative way to apply your datum/elevation statics is to use the **STAT* operation and directly input the amount of time shift necessary to compensate for variability in velocity and/or elevation to each station location across the line. This way is very straight forward from an input point of view, but it does require significantly more work prior to interaction with the program DSEIS. Described below is the appropriate way to correct your datum using the **STAT* operation and the sample data set:

<u>Line</u>	<u>Description</u>
1	>>start see previous description of >>start
2	*inpf sort.dat see previous description of *inpf
3	*stat 4

**stat* identifies a time static operation. The only entry necessary to do datum corrections is the first (4). The 4 simply indicates that the 4 option applies station corrections for both source and receiver.

4 **rece 137 -0.3**

rece identifies the trace header location that relates to the defined static shift. The first entry (137) is the receiver station location of the defined shift (-1) which is the third entry. The only requirement of the *rece* definitions is that the numbers increase and that they be in sequential order.

- 5 **rece 138 -0.6**
- 6 **rece 139 0**
- 7 **rece 140 1**
- 8 **rece 141 0.3**
- 9 **rece 142 -0.6**
- 10 ***outf stat.dat** see previous description of ***outf**
- 11 **>>end** see previous description of **>>end**

As with all the batch files, it is advisable to type (list) them out after they have been constructed in a text or line editor. The following is what the file **stat.dek** should look like:

```

>>start
*inpf sort.dat
*stat 4
rece 137 -0.3
rece 138 -0.6
rece 139 0
rece 140 1
rece 141 0.3
rece 142 -0.6
*outf stat.dat
>>end

```

Either the **stat 4** or **surf** operation are valid ways to correct for variability across the seismic line. Which operation you use with various data sets other than the sample provided with this manual is dependant on the amount of static, other information available, and probably most important, which operation you are most comfortable with.

H) VELOCITY ANALYSIS

The compressional wave (P-wave) velocity through an elastic media is related to Lamé's constants divided by the density of the media. Normal moveout (NMO) velocity information derived from the curvature of reflection events on seismic data is used to correct each reflection wavelet for a non-vertical incident travel path. The NMO velocity derived in this fashion can also be used as a rough approximation for the average velocity allowing a first-guess approximation of reflector depth. This correction for non-vertical incidence reflectors on seismic data (NMO correction) is one of the most critical parts of the preliminary processing flow. The summing of multi-fold data is meaningless unless all traces are corrected for their particular source-to-receiver offset to effectively simulate vertical incident energy (i.e., source and receiver located at the same point on the earth's surface).

Determining the appropriate stacking velocity (loosely NMO velocity) can be accomplished in a variety of ways. A constant velocity stack is the most commonly used (probably because it does not require a significant amount of thought or understanding of the physics of the matter) way to determine the stacking velocity of particular reflecting events on multi-fold seismic data. A constant velocity stack simply moves out and stacks all traces within a CDP gather at a predetermined

velocity. Generally, a data set will be moved out and stacked at each of a consecutive group of velocities (in some cases as many as 20). The analysis technique at that point simply involves visual inspection to determine which velocity is "best" for a particular reflector. The velocity can and many times does vary both horizontally and vertically (time). The resultant velocity function is defined by CDP, time, and velocity. Multiple reflectors should be identifiable at most CDPs on seismic reflection data collected in a geologic environment conducive to the propagation and recording of reflection energy. The velocity function for each CDP will have an optimum stacking velocity paired with the appropriate time window for each identifiable reflector. The velocity function defined for a group of reflecting events at a particular CDP may not be appropriate for the same set of reflecting events at other CDPs across the profile (as a result of horizontal variability). Stacking velocities must be analyzed using the constant velocity stack and inputting large groups of CDPs across the entire expanse of the line. It is possible and many times advisable to analyze groups of CDP from various spots across a seismic line until trouble spots or areas with need for a more detailed analysis can be located.

1) Interactive Velocity Picking

The most fundamental way to determine an approximate NMO velocity for a reflector is by using the exact NMO equation and a seismic field record. This process involves defining arrival time and source-to-receiver offset distance pairs and then inputting them into the appropriate equation (for the appropriate equation see Telford et al., 1976). In order to streamline this process, *Eavesdropper* has an interactive operation that allows you to graphically determine the NMO velocity for a particular reflection event (VELP).

To start the process of determining the appropriate velocity function for our sample data set, we first will need to input a file into the VELP program and determine an approximate velocity. This will allow us to optimize computer and analysis time during the constant velocity stack portion where we will define our first pass velocity function. The VELP program requires the input data to already have the field geometries in the trace headers. To be consistent with the previous portions of this manual, we will use field-file 5 to determine the velocity of our primary reflectors. To get field file 5 into the correct format, we will need to resort the data from CDP to field-file format. In this way the required header information is present. With field-file data as opposed to CDP gathers we will have 24 traces allowing us significantly more trace-to-trace coherency. More traces will also improve the statistical determination of velocity.

STEP #8

*****EXAMPLE DATA*****

First, we must resort the CDP sample data. The following sequence in a batch file will accomplish this:

<u>Line</u>	<u>Description</u>
1	<u>>>START</u> see previous descriptions of >>START
2	<u>*INPF surf.dat</u> see previous descriptions or *INPF
3	<u>*RSRT 92 8</u>

***RSRT** operation resorts data according to any trace-header word requested. The first entry (**92**, which is the header word defining the SSN) defines the primary sort operation, that is the major groups to collect traces into (e.g., field files are grouped according to 6 or 92, CDP gathers are grouped according to 12; common offset gathers are grouped according to 19, etc.). The second entry (**8**, which is the header defining the trace number within the original field file) defines the secondary sorting operation, that is the order of the traces within each of the major groups defined by the first entry (channel number with each original field file are grouped according to 8; traces with each CDP are grouped according to 14; traces within common offsets are usually gathered according to header word 6, 87, or 92).

- 4 ***OUTF rsrt.dat** see previous descriptions of ***OUTF**
- 5 **>>END** see previous descriptions of **>>END**

The resort batch file you just created should look similar to the following when displayed on the CRT of your computer:

```
>>start
*inpf surf.dat
*rsrt 92 8
*outf rsrt.dat
>>end
```

As with the previous batch jobs, the following sequence will initiate the resorting operation:

```
>dseis rsrt.dek rsrt.lst <enter>
```

At this point, the file **rsrt.dat** is in field-file format. One option at this point is to peel off only file 5 and input it into the **VELP** program. In the **VELP** program, the option exists to select the desired field file on which to work. We will remove only file 5 as an exercise in using the ***inpf** definer. The following operation will result in an MS/DOS file being created containing field-file 5 only:

<u>Line</u>	<u>Description</u>
1	<u>>>START</u> see previous description of >>START
2	<u>*INPF rsrt.dat 5 5 100</u>

The three entries after the input data-file (**5 5 100**) identify the beginning and ending file number to operate on and record length in ms. The primary sort order of the data dictates file designation. This means that if the data are in

field-file format, you can select particular field files to operate on, i.e., 5. If the data are in CDP format, you can select a particular sequence of CDPs to operate on. In this case, the **input data (rsrt.dat)** are in **field-file format**, allowing us to directly select field-file 5. It is not possible, however, to select a particular CDP or group of CDPs from this particular input data file (**rsrt.dat**) since it is in field-file format.

- 3 ***OUTF ff5.dat** see previous description of ***OUTF**
- 4 **>>END** see previous description of **>>END**

To extract field-file 5 from the rest of the data set, the previous batch processing file needs to be run as input to the program seis. The following sequence must be entered:

>DSEIS rsrt.dek rsrt.lst <enter>

Now, field-file 5 is the lone file in the MS/DOS file **ff5.dat**.

To use the **VELP** program for a first guess approximation of the stacking velocity of reflections identifiable on field file 5, the program must be executed and questions answered in the following sequence:

>VELP <enter>

*enter seismic data field file (<cr> to quit) = **ff5.dat** <enter>*

The input data must have the geometries input into the appropriate trace-header locations. The program will respond with the following set of messages for our file:

*Data being scanned.....please wait.....
CDP Numbers from Input CDP-gather Data:
First CDP = 5 Last CDP = 5*

*Enter Record# (<cr> to quit) = **5** <enter>*

Enter starting time in ms. to display data (DF=0) = <enter>

DF means default in this program.

*AGC function 1=on / 0=off (DF=0) = **1** <enter>
† Enter AGC Window length in ms (DF=10) = **150** <enter>*

† The option to choose an AGC window length only comes up if the AGC function is QN. Otherwise, this question will not appear.

ENTER NUMBER OF BITS TO DISPLAY (7) -> <enter>

Number of bits to display is simply a whole trace normalization routine that rounds to the nearest bit. In other words, if 7 bits are selected, any 7-bit sample will be represented with full deflection of the wiggle-trace. Whatever gaining was necessary (- or +) to produce this full deflection in the 7-bit sample will be equally and uniformly applied to all other samples. If the largest word in the data set is 8, and 7 bits is selected as the display amplitude, all samples with a word size of 8 will have the most significant bit clipped off (if the largest word size is 9, the two most significant bits will be clipped off, etc.). This parameter is necessary due to potential mismatches in resolution between data and display hardware (printer and CRT).

At this point, you can use the **arrow keys** to move the cross-hairs around, and the **f1** function key to select the appropriate time/offset pairs. You should get a value of approximately 2400 m/s for the NMO velocity of the reflection at 75 ms which equates to a depth reflector of approximately 90 m.

2) Constant Velocity Stack

Once you have established a ballpark velocity for the major reflecting events you should be able to efficiently run the constant velocity stack routine (VSCN) to fine-tune the velocity function for this data set. The VSCN program is pseudo interactive, that is, it will ask you a series of questions interactively, and then once all the appropriate information is entered, it will operate on the input data as requested in a batch-type format.

STEP #8a

*****EXAMPLE DATA*****

The DVSCN routine is a module operating outside of **dseis**. To generate a constant velocity stack for our sample data set, the following series of commands and information must be inputted:

>DVSCN <enter>

KGS Banner and assorted descriptive information will be displayed.

Input CDP-gather data file = surf.dat <enter>

Scanning input data, please wait.....

Input Data :
First CDP = 223
Last CDP = 282
Record Length = 250 ms

This information is supplied to allow cross-checking of what you know about your input data with what the programs finds in the trace headers.

Output (VSCN) data file = **VSCN.dat** <enter>
First CDP (of CDP group#1) ? ->current = 223 : <enter>
Last CDP (of CDP group#1) ? ->current = 282 : <enter>
of (CDP) Groups to be processed ? ->current = 1 : <enter>

The number of (CDP) groups to be processed often allows you to skip through the line and do velocity analysis on sequential groups of CDPs. If we wanted to do velocity analysis in an area we deemed to have velocity problems, or if we only wanted to do reconnaissance velocity analysis on certain portions of the line, several groups of CDPs could be selected for analysis. If velocity problems were present between CDPs 230 and 240 and between CDPs 260 and 270, a constant velocity stack on just those two sequential groups of CDPs could be performed using the following sequence:

† *First CDP (of CDP group#1) ?* ->current = 223 : **230** <enter>
 † *Last CDP (of CDP group#1) ?* ->current = 282 : **240** <enter>
 † *# of (CDP) Groups to be processed ?* ->current = 1 : **2** <enter>
 † *CDP group increment* ->current = 20 : **30** <enter>

† This information is not necessary for this data set and is provided as simply an example of the program's operation.

Effectively, the program increments 30 from the first CDP of the first group to determine where to begin the process for the second group. Therefore, in this case the second group would start with CDP 260 and 11 CDPs would be processed (240 - 230 = 11) up to and including CDP 270. Likewise, if sufficient data existed, the third group would have started with CDP 290 and ended with CDP 300. If 15 had been selected as the increment value, CDP 245 would be the first CDP of the second group and CDP 255 would be the last. As well, the third group (of the 15-increment example) would have started with CDP 260 and ended with CDP 270.

Record length (ms)? ->current = 250 : <enter>

This allows the option to process a small chunk of data (starting at time zero, of course). This will be especially useful when more data are acquired than is really necessary.

Allowable sample stretch ratio
(greater value gives deeper mute)

(min=0.2: max=0.99) ->current = 0.50 : 0.60 <enter>

Sample stretch ratio defines the amount you are willing to allow your wavelet to stretch as a result of the dynamic NMO correction before it is muted. This parameter requires a great deal of care and careful thought before and after application. Artifacts will be generated on stacked data if this parameter is not properly selected. The result of an improper mute can range from apparent high-frequency coherent events to anomalous low-frequency shallow wavelets. Experience and care will keep you out of trouble with this parameter. With the extremely site-dependent nature of velocity functions, a simple rule of thumb is not possible. This is a case where having the appropriate experience or academic background to understand the mathematics of the operation will greatly enhance your ability to properly select mutes and to know from inspection of stacked data if the mute was not properly assigned.

Stack? (0=DO NOT STACK: 1=STACK: ->current = 0 : 1 <enter>

This allows you to inspect your data after moveout either in a stacked or unstacked form. The unstacked form is very helpful in some cases because it will let you see exactly how much each trace was moved out and the associated contribution of each trace of the final stacked section.

Enter trial velocities (<cr> to end: max=20) :

*#1velocity = 1800 <enter>
#2velocity = 1900 <enter>
#3velocity = 2000 <enter>
#4velocity = 2100 <enter>
#5velocity = 2200 <enter>
#6velocity = 2300 <enter>
#7velocity = 2400 <enter>
#8velocity = 2500 <enter>
#9velocity = 2600 <enter>
#10velocity = 2700 <enter>
#11velocity = 2800 <enter>
#12velocity = 2900 <enter>
#13velocity = 3000 <enter>
#14velocity = <enter>*

When inputting trial velocity values, no set pattern or limits (except for maximum number of trial velocities) need be adhered to.

At this point the program will take control and begin to process the constant velocity stacks in the precise fashion we described above. The program will keep you abreast of where it is in the sequence of velocities and CDP numbers as prescribed above. The program can be interrupted at any time with a ctrl c command. The ctrl c command will terminate the operation; however, any

processing completed at the time of termination will be accessible with view or plot.

Displaying your constant velocity stacks is critical and will be the first real glimpse of what a stacked section may look like once you have completed your processing flow. It is important to generate a hard copy of the velocity scans. This will give you a perspective of the relative quality of each reflector on each CDP at each of the selected velocities. Picking a velocity function is the most significant, pure judgement call made yet in our processing of this sample data set. You will need to select the best velocity function (which could involve several CDP, time, and velocity groups across the expanse of the line) for the entire line. It should also be noted that at this point, a general knowledge of the geologic environment is critical to selecting a meaningful velocity model. This is mainly due to the variety of ways some reflection (or worse, noise) energy will "stack in" at different velocities. Distorting (creating) reflections as a result of incorrectly processing your data is not only possible, it is very easy if care is not taken during each step of the processing flow.

STEP #8b

*******EXAMPLE DATA*******

The display format for the constant velocity stacks groups all the CDPs according to stacking velocity (Figure 10). The constant velocity panels will be either stacked or unstacked depending on what you selected. The move-out velocity of each panel will be displayed in the upper right hand corner of the group of CDPs processed. The 75 ms reflection in our sample data set changes velocity from about 1925 m/s to 2600 m/s across a distance of about 70 m. There was no surface feature that would suggest such an extreme variability. This in itself should encourage care during the velocity-analysis portion of the processing flow.

The selection of the appropriate velocity function from constant velocity stacks is to some degree a qualitative judgement based mainly on experience and a fundamental knowledge of seismology and the site geology. The odds of avoiding bogus reflecting events are increased by studying constant-velocity gathers. Moved out gathers at this point in the processing flow are for the most part trace-by-trace the same (except for the extreme cases with a slight static shift) as the original recorded data. The only difference is the whole trace dynamic test moveout compensation (which is the variable you are testing). Analysis of data in this fashion allows you to go back to your original field files and actually follow identifiable reflection information through the velocity analysis. The velocity function that is chosen in this fashion should possess a high level of reliability once the data are actually stacked, and will reduce some of the qualitative aspects of the selection routine.

STEP #8c

*******EXAMPLE DATA*******

The optimum stacking velocity should remove the hyperbolic curvature of a reflecting event. The result of the correct velocity on raw field files is trace-by-trace consistency in the time and wavelet characteristics of the reflecting event (Figure 11).

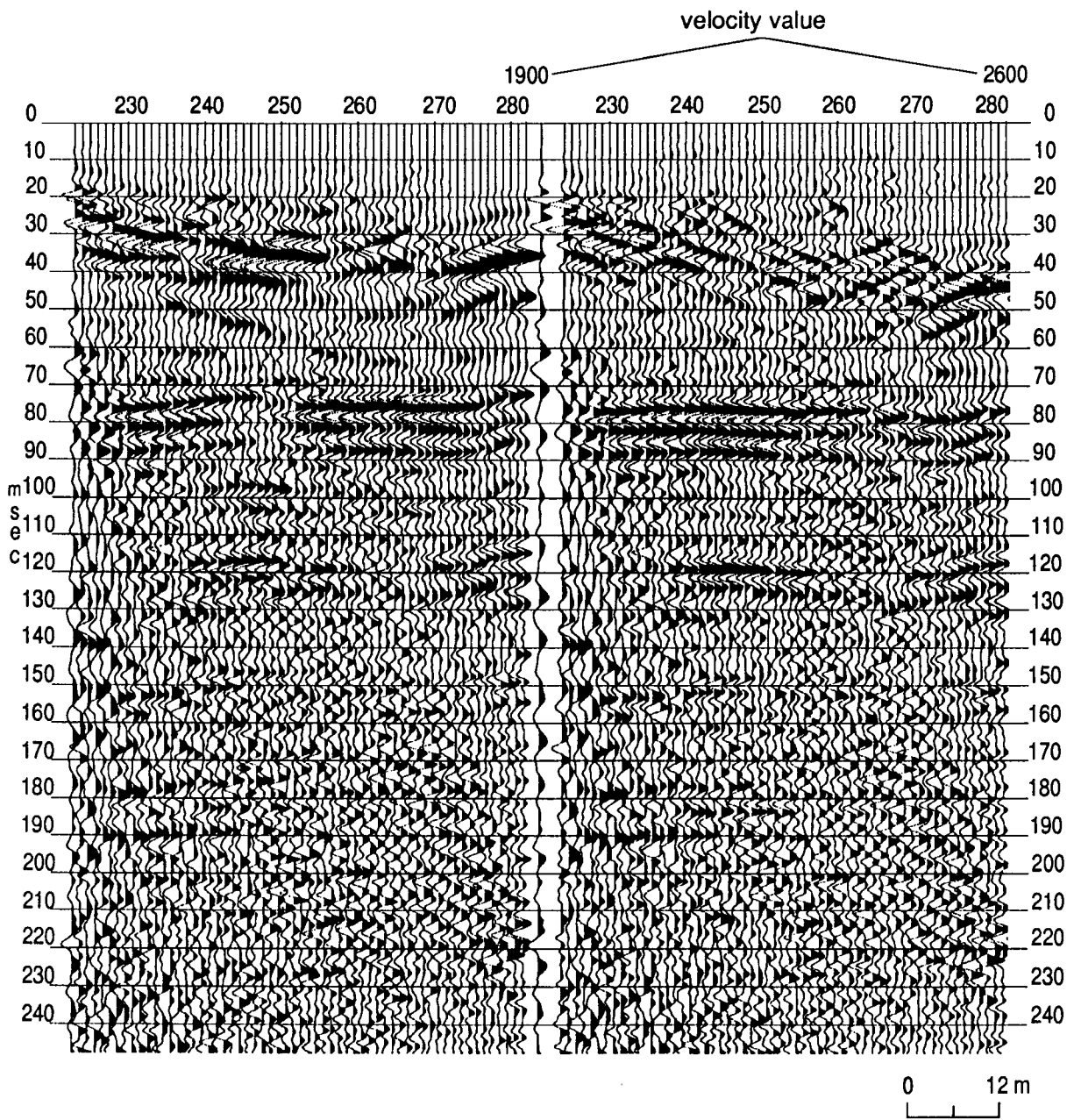


figure 10

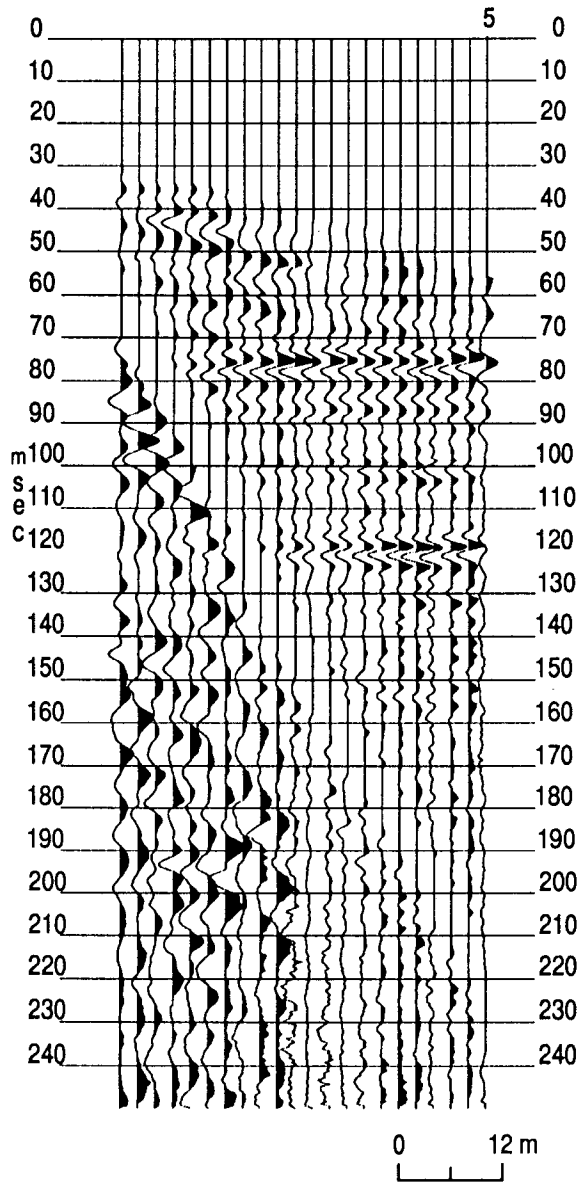


figure 11

3) Time-Spatial Varying NMO

The velocity function we choose for this data set is listed below:

<u>CDP LIMITS</u>	<u>TIME (ms)</u>	<u>VELOCITY (m/s)</u>
200 - 232	0.0-50	1850
	50-100	2600
	100-135	2900
	135-250	3000
232 - 246	0.0-50	1850
	50-100	2450
	100-135	2900
	135-250	3000
246 - 253	0.0-50	1850
	50-100	2450
	100-135	2900
	135-250	3000
253 - 278	0.0-50	1850
	50-140	1900
	140-250	2250
278 - 290	0.0-50	1850
	50-100	2450
	100-250	2900

The above described velocity function needs to be applied to the sorted, datum corrected data. In order to accomplish this a normal-moveout operator needs to be used. The batch processing file (nmot.dek) used to apply the normal-moveout correction to our sample data set is created and dissected below:

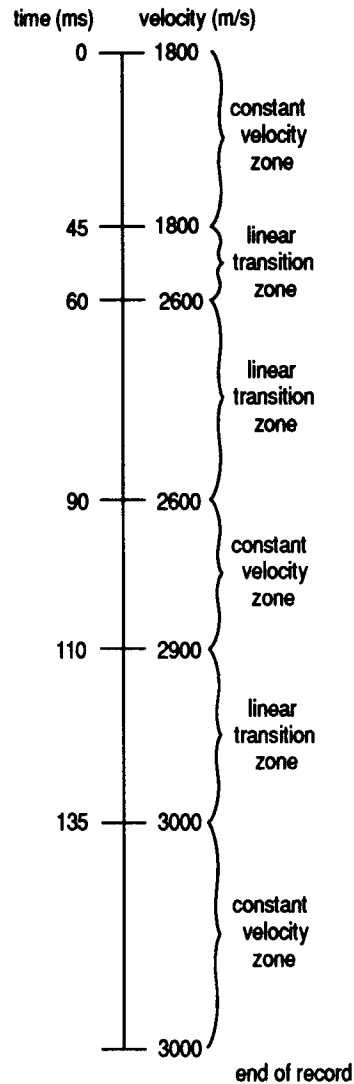
<u>Line</u>	<u>Description</u>
1	>>START see previous description of >>START
2	*INPF surf.dat see previous description of *INPF
3	*NMOT 0.6

*NMOT operator adjusts each sample of each trace (dynamic correction) for a specific velocity function described by the VELF definer. The only entry required for the NMOT operator is the value of the **sample stretch ratio**

(0.6). This value specifies the amount of mute to apply to a trace to suppress the stretching of the reflection wavelets resulting from the correction of non-vertically incident ray paths. By correcting to vertical incidence, all traces should be geometrically equivalent and whole trace addition within a particular CDP should result in enhancement of reflection energy. As discussed during the DVSCN operation a proper nmo stretch mute is critical to generating a realistic stacked section. **An incorrectly designed and applied stretch mute can generate (depending on whether the mute is too extreme or too subtle) anything from high-frequency spikes to very distorted low-frequency wavelets.** The stretch mute is most evident on shallow low-velocity reflections. This is because the most extreme stretch results from lower nmo velocities (as is intuitively obvious from a hyperbolic curvature perspective). The more severe hyperbolic nmo curvature (lower average velocity) is generally associated with the low velocity material in the near surface.

4 **velf 230 45 1850 60 2600 90 2600 110 2900 135 3000**

The **velf** definers are grouped according to CDP locations. The velocity function is input in time/velocity pairs. The first entry after the **VELF** definer is the **CDP number (230)** which this velocity function is defined for. The **second (45, in units of ms)** and **third (1850, in units of m/s)** entries identify the **first time/velocity pair** of the velocity function at this CDP. The program uses the first pair to define a consistent velocity window from 0 ms to the first identified time (45). The velocity function is then interpolated between 45 and the third entry (60), which is the time value for the second time/velocity pair, with 1850 m/s defined as the velocity at 45 ms, gradually changing sample by sample until at 60 ms the **NMO velocity is 2600 m/s**. This process continues in exactly the same fashion for all the defined time/velocity pairs down to the bottom of the record. In this case, the **velocity is constant (2600 m/s) between 60 and 90 ms**. Then **between 90 and 110 ms, the nmo velocity changes from 2600 fm/s to 2900 m/s**. Finally, **between 110 ms and 135 ms the nmo velocity is defined to change from 2900 m/s to 3000 m/s** where it remains constant to the end of the record. It should be noted that the last time/velocity pair initiates a **constant velocity correction** that begins at the last time identified and continues **to the end of the record**.



As you can see the velocity function as it is defined here is not identical to the velocity function determined from the constant velocity stacks (listed in the table at the start of section H3). The reason for this is related to the interpolation process operating both vertically in time and horizontally in space. Analysis of the data suggested specific time windows where the stacking velocity seems to be relatively constant and other time windows where simply from a physically realistic point of view, the average velocity through the rock must be changing at a significant rate. With this in mind, the program must be instructed as to which time windows have relatively constant velocities and which windows have a significant amount of change/unit time (depth). The assigning of a realistic velocity function that possesses significant variability in time and space is a skill (knack) that will come with time and experience.

5 VELF 235 45 1850 60 2450 90 2450 110 2900 135 3000

The velocity function for this **velf** definer is for CDP 235. The vertical (time) interpolation process is identical here as it was with line 4 (previous **velf** definer). The significant thing to note here is the **interpolation between CDP 230 and 235**. The interpolation process is uniform between lines 4 and 5 with the velocity defined at **60 and 90 ms gradually changing at each CDP between 230 and 235 from 2600 to 2450 m/s**. This will be true for all velocities defined at each **velf** definer. The velocity will be interpolated in both time and space.

6 VELF 250 45 1850 60 2300 90 2300 110 2900 135 3000

7 VELF 255 45 1850 60 1900 110 1900 150 2250

8 VELF 275 45 1850 60 1900 110 1900 150 2250

9 VELF 280 45 1850 60 2450 90 2450 110 2900

10 *OUTF nmot.dat see previous description of *OUTF

11 >>END see previous description of >>END

It is wise to list each deck after you exit your line/text editor to ensure that the batch file has been created and saved the way you had intended. Your file, when displayed on the CRT, should look like the following:

```
>>start
*inpf surf.dat
*nmot 0.6
velf 230 45 1850 60 2600 90 2600 110 2900 135 3000
velf 235 45 1850 60 2450 90 2450 110 2900 135 3000
velf 250 45 1850 60 2300 90 2300 110 2900 135 3000
velf 255 45 1850 60 1900 110 1900 150 2250
velf 275 45 1850 60 1900 110 1900 150 2250
velf 280 45 1850 60 2450 90 2450 110 2900
*outf nmot.dat
>>end
```

Applying the defined velocity function (making the dynamic correction for non-vertical incidence) requires the execution of the batch processing file we just created called **nmot.dek**. The following sequence of commands will initiate the processing:

```
>DSEIS nmot.dek nmot.lst <enter>
```

As before, the program will keep you advised as to its progress. In order to see the results of the velocity correction, use the view routine on the CDP gather. If you need to have a hard copy then, of course, use of the plot routine will be necessary. In most cases, inspection on the CRT will suffice. The velocity function we just applied will correct the reflection for non-vertical incidence. The result of this dynamic correction is quite evident when comparing corrected to uncorrected field files (Figure 23).

I) SPECTRAL ANALYSIS

The spectral characteristics of a raw seismic data trace are dependent on the acquisition parameters (and equipment) as well as the surface and subsurface characteristics of the site. During the spectral analysis portion of the processing flow, the frequency characteristics are determined with respect to the various types of seismic energy present on the data. A frequency filter is then designed to enhance the favorable spectral characteristics and attenuate the undesirable ones. The amount and type of spectral analysis necessary for a particular data set is totally dependent on that data set.

1) Frequency vs Amplitude

Depending on the data set, the first step in determining the spectral characteristics of seismic data is to define the dominant frequency and bandwidth of the entire data set. This is most effectively done with an amplitude versus frequency display. This analysis technique relies on an FFT to compute the amount (amplitude) of information on a seismic trace at each particular frequency. This operation will become less necessary (depending on the data set) as you gain more experience looking at seismic data and identifying particular types of energy and their dominant frequencies. But for now, you probably should use an amplitude versus frequency-plot to determine the spectral characteristics of the air wave, ground roll, refractions, and reflections.

The spectral analysis routines are within the program called DFMAIN. This subset of the *Eavesdropper* package contains all operations that take place in the frequency domain. To obtain a display of amplitude versus frequency of field file 5, trace 18, the following procedure will need to be followed:

```
>DFMAIN <enter>
```

A menu will then appear on the screen giving you the option to select any one of several procedures. In our case, we will select option number 2 which is the spectral analysis routine. Once option 2 is selected, you will be asked to give the input data file. Here the raw data will be analyzed so our input file name will be whatever you named your raw input data. For the sample data it was called *England.raw*. Once the input data file name is input, <enter> you will skip down to the output file name which, for the purpose of spectral analysis, is not important and you can call it whatever you want. Once you <enter> after the output file name has been given, the program will indicate it is copying the file. When that process is finished, a series of parameters will be displayed. The F3 function key will put you into change mode allowing any selectable parameter [after the total number of samples (sample size)] to be modified. After the appropriate changes have been made, the F4 function key will initiate the analysis. The message *please wait* will be displayed while the program is working.

After the spectral information has been calculated, it will automatically be displayed on your CRT if you have a math coprocessor on your computer. If you wish to plot the amplitude-vs-frequency information displayed on your screen, type the letter p. After you are finished studying the spectral plot, press <enter>. This will return you to the previous level where you may again select a different SSN trace-pair, analysis time, or display parameters. After you have finished your spectral analysis, press the esc key twice and you will return to the standard system prompt.

STEP #9

*****EXAMPLE DATA*****

The spectral analysis for our sample data set should proceed as follows:

>DFMAIN <enter>

MAIN MENU

F1 : FILTERING
F2 : SPECTRUM ANALYSIS
F3 : DECON
F4 : FILTER CHARACTERISTICS
F5 : CHANGE FILES
F6 : COMPARE DATA FILES
F7 : MANUAL STATIC EDIT
(CDP FILE ONLY)
Esc : EXIT
Alt-H: HELP

COMMAND: ? F2 (function key)

At this point, the screen will scroll and the following question will appear:

INPUT DATA FILE: dengland.raw <enter>

OUTPUT DATA FILE: IUNK.dat <enter>

At this point, the following message will be displayed:

Wait while copying a data file

The second level of the program will appear at this point. In order to select the trace to be analyzed, press the F3 function key and make the changes as indicated below:

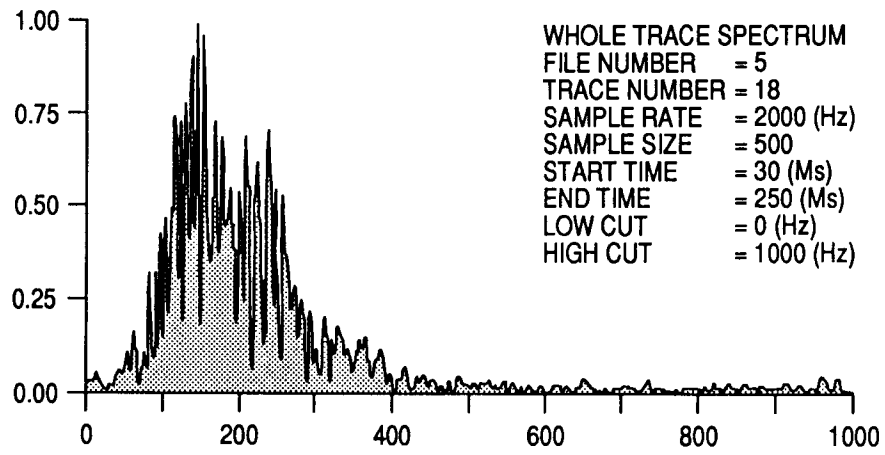


figure 12

If a plot is desired, press the **p** key. After the plotting is complete, **<enter>** and return to the second level and begin your entry sequence in the same fashion as previously described.

The following set of plots are examples of a good series of analysis runs necessary for helping decide on the appropriate digital filter. Figure 13 is predominantly air-wave energy. Figure 14 is predominantly ground-roll energy. Figure 15 is predominantly refraction energy. Figure 16 is predominantly reflection energy.

2) Filtering

Analysis of the spectral plots allows the designing of an appropriate digital filter to enhance reflection energy. The most common type of digital filter and the most appropriate for our sample data set is a digital band-pass filter. This filter by its nature will attenuate all energy with spectral values outside a defined window. The window is defined in the frequency domain and is shaped in accordance with predefined front and rear slopes (Figure 17). All of the filtering options available in *Eavesdropper* have front and rear slopes that can be thought of in a very similar fashion as the taper previously discussed for the muting operation. Without these slopes, when the transformation from the frequency domain to the time domain is made after filtering, sinusoidal artifacts will be injected into the seismic data. The frequency of these artifacts will be related to the frequency of the defined high- and low-cut filter values of the bandpass.

STEP #9a

*****EXAMPLE DATA*****

For our sample data set, it appears from spectral analysis that the dominant frequency of the reflection information is approximately 250 Hz. The bandpass filter we design must not attenuate any signal within one-half octave of that frequency. The air-wave information ranges from about 50 to 400 Hz. Of course, that frequency band is coincident with the reflection information. The muting operation performed early-on in the processing flow removed the majority of the air-coupled waves. The ground-roll frequencies on the other hand fall mainly within a band from about 25 to 250 Hz. With the amplitude of the high-frequency ground roll small relative to the reflection information, the low-cut side of a band-pass filter should attenuate the majority of the ground roll. The refraction energy is large amplitude and possesses about the same spectral characteristics as the reflection signal. Once again, muting was essential, this time in removing the effects of the refracted energy. From the spectra of the various types of seismic energy arrivals, the optimum digital bandpass filter for our sample data set will be something in the range of 125 to 400 Hz band pass.

As with most seismic data processing, selecting a band-pass filter, whether from spectra plots or directly off raw field data, becomes easier with experience and a broader knowledge of the basic

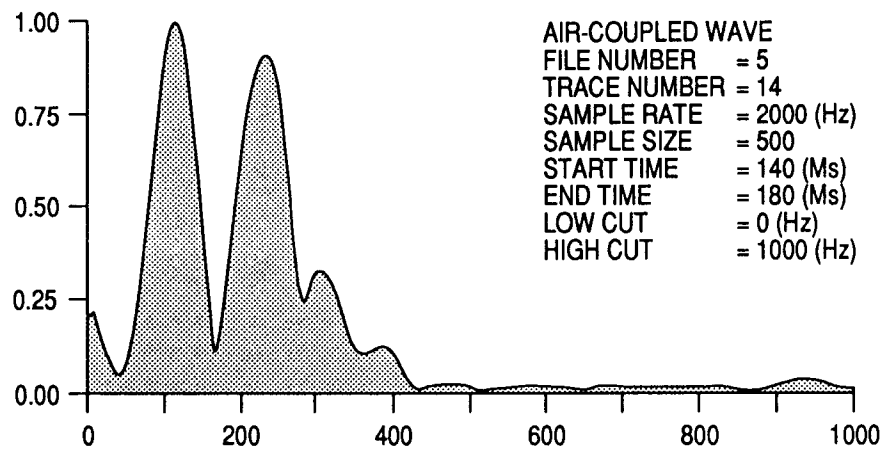


figure 13

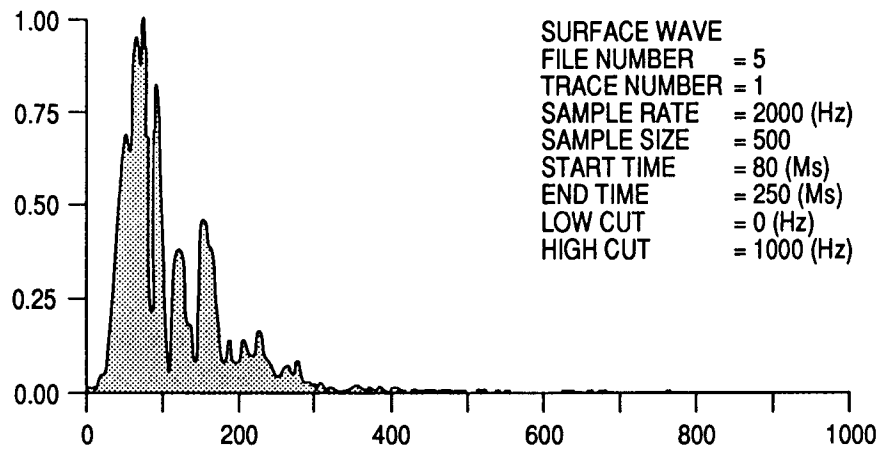


figure 14

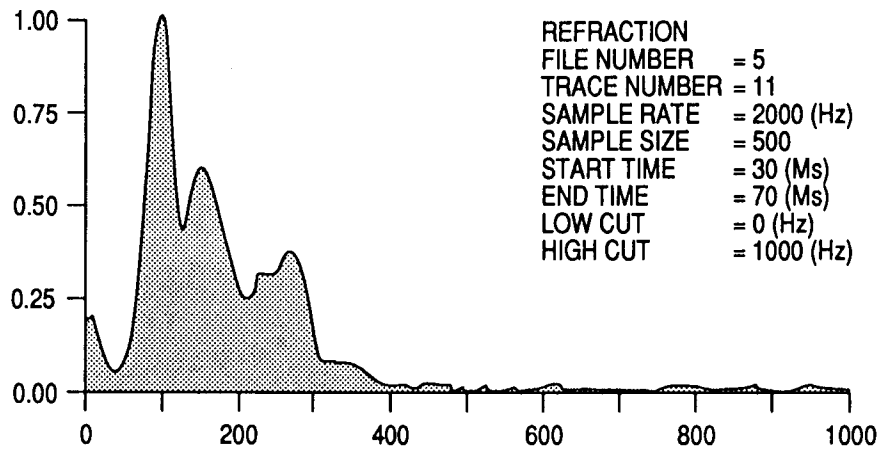


figure 15

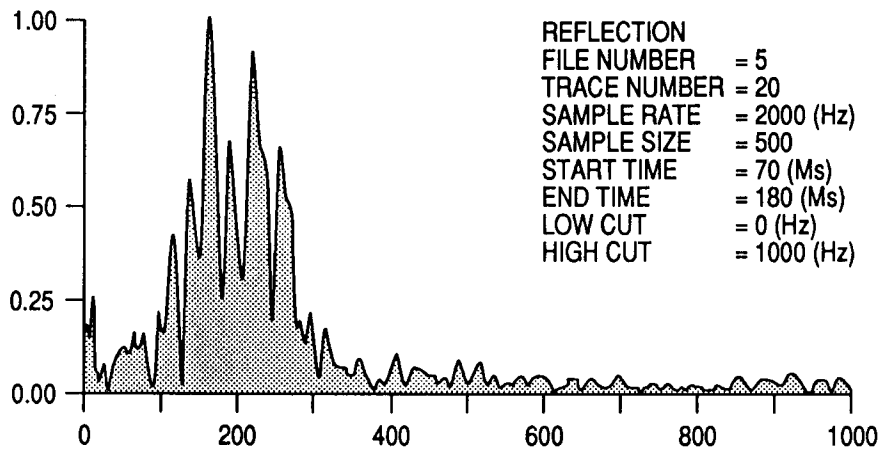


figure 16

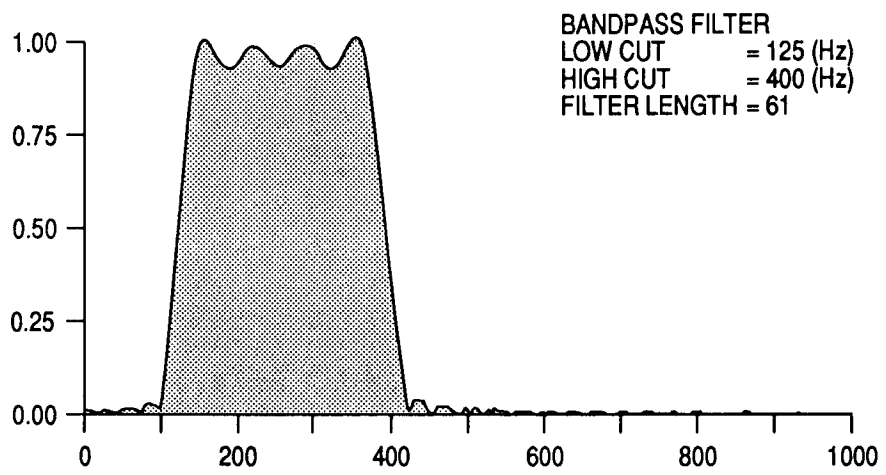


figure 17

physical principles of seismic data processing. There is no substitution for a proper math and physics background.

STEP #9b

*****EXAMPLE DATA*****

To build the batch processing file to operate on the seismic data from our sample data, the following sequence of parameters needs to be defined:

<u>Line</u>	<u>Description</u>
1	<u>>>START</u> see previous description for >>START
2	<u>*INPF nmot.dat</u> see previous description for *INPF
3	<u>*FILT 125 400 1 0 60</u>

***FILT** operation initiates the frequency-filtering operation. The first input parameter (125) designates the **low-cut (high pass)** frequency. The second parameter (400) designates a **high-cut (low pass)** frequency. The third input (1) identifies the type of filtering you wish to do. In our case, we are doing a **band pass**, but in certain instances, the enhancement of reflection signal may involve the rejecting of a particular frequency window. In such a case, the **band reject filter (0)** option for the third entry would be appropriate. The **forth entry (0)** determines whether a 60-dB down **60 Hz notch filter** is to be applied. The notch filter is design to drastically attenuate the effects of electrical power lines. The notch is only necessary when the effects of 60-Hz noise are noticeable on the field data. The **final input parameter (60)** determines the **length of the filter operator**. Due to the limited amount of time and space in this document, a detailed explanation of this parameter would best be obtained from a basic filter theory text book. From a crude practical sense, the **longer the filter** (max less than 1/2 record length) the **"better" the filter works**. On the other side, the longer the filter the **more computer time** that is necessary to complete the filter operation. A happy medium needs to be determined in order to properly filter your data without taking a significant amount of CPU time.

4	<u>*OUTF filt.dat</u> see previous description of *OUTF
5	<u>>>END</u> see previous description of >>END

As with all other batch processing files, to operate on the data, the file must be run through DSEIS.

>DSEIS filt.dek filt.lst <enter>

Again, the program will keep you apprised of its progress through the input data set. As with previous operation, the list or journal file `filt.lst` will still possess all the processing history as well as any errors or abnormal terminations. Once complete, the `dview` or `dplot` routine should be used to display at least a couple of files to ensure the results of the filtering operation were what was desired. The cleaning up of the data after should be quite evident (Figure 18).

The bandpass filtering of our sample data set not only improved the signal-to-noise ratio, it also removed DC bias present on the raw field data. DC bias is related to wander in the analog side of the seismograph and appears on raw field data as over or under shading of the variable area wiggle-trace. The removal of DC bias is critical to the effective stacking of seismic data. Comparing Figures 11 and 18, it is possible to identify the DC bias. The amplitudes of the reflection wavelets have much more trace-to-trace consistency after the filtering operation. The low-cut filter is actually responsible for the removal of the DC bias.

J) AMPLITUDE BALANCING

The relative amplitude of each sample recorded on a seismic trace is dependent on several properties and parameters. The properties that dictate amplitude response are related to the earth and the propagation of acoustic waves through the earth. The parameters that influence the amplitude of any one sample are related to acquisition equipment and the settings of that equipment. Therefore, to generate a CDP stacked section with relatively equal contributions from all traces summed within a particular gather, some trace-equalization is necessary. It should be noted at this point that for some analysis techniques (AVO, amplitude vs offset) retaining absolute amplitude with increased offset is critical. Correction for spherical divergence is necessary, but global trace equalization as is suggested for our sample data set would be detrimental to meaningful conclusions.

1) Automatic Gain Control (scale)

An Automatic Gain Control (AGC) should next be applied to the sample data to boost the amplitudes of the reflection information relative to the higher amplitude, ground roll, air-wave, and refraction energy. The purpose of this scaling operation is to maximize the potential of the stacking process to enhance the reflection information. This can be clearly visualized by plotting the raw data without any normalization or scaling. Display with no normalization or scaling is called plotting relative. This means that true amplitude information is preserved and present on the plot. By using the `plot.cfg` or the + or - keys during plotting, you can boost the display gain uniformly for the entire data set until it is up to a desirable level. Now observe the amplitude of the reflection event at 75 ms on all 24 of the traces. It is quite clear that if all 24 traces were added together and their amplitudes divided by 24, a disproportional amount of the final stacked data is from the contribution of the few traces on the inside with significant amounts of high-amplitude ground roll and air-coupled waves. The best way to correct for this inequality is by applying a time-varying trace-by-trace gaining function. In the *Eavesdropper* package, this operation is called `*SCAL` (meaning scale).

Selection of the appropriate AGC window is at least partially qualitative requiring experience and a thorough understanding of the mathematics of the operation. Assigning the AGC

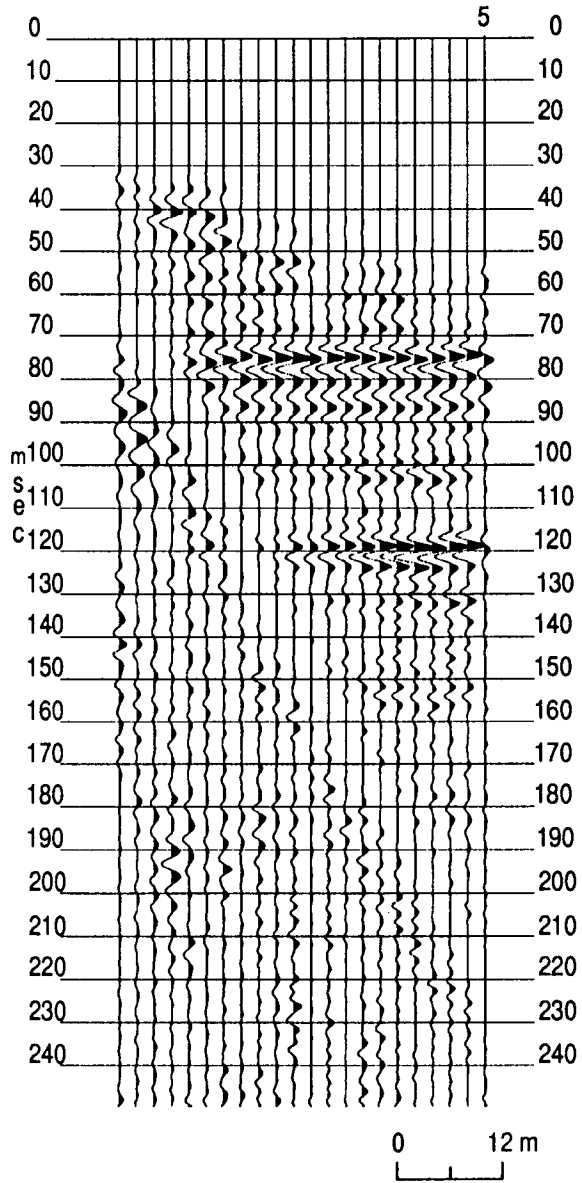


figure 18

window to be about twice the repetition time of identifiable reflecting events is a rule of thumb that we have found to generally be effective.

STEP #10

*****EXAMPLE DATA*****

In the case of our sample data set, the strong reflecting events at approximately 75, 100, 120, and 150 ms seem to have a repetition time of around 25 to 30 ms. This suggests, in order for the AGC window to detect the presence of at least three of the reflecting events within a single window, the window size should be somewhere around 50 ms. So, 50 ms will be used for a first-pass trial scaling window. Basically, the scale window must be small enough that subtle reflecting events don't get overpowered by the more high-amplitude events, yet large enough that localized comparisons of relative amplitude between reflecting events at various times can be made. Final interpretation of the stacked data must be made with the AGC processing parameters taken into consideration.

A couple of warnings: 1) An inappropriate AGC window can generate artifacts on stacked seismic data. Most notable are the effects of a window that is around twice as long as the time difference between the high-amplitude first-arrival and ground roll or air-wave information. Due to this longer window, the contribution of the lower-amplitude energy located between the first arrival and ground roll or air wave is insignificant in comparison to the effects of the first arrival and ground roll or air wave. The resulting stacked data could possess a high-amplitude band of information with spotty coherency that is nothing more than stacked ground roll or air wave. 2) An AGC is most effective when the amplitude of noise is high on a few traces relative to signal at an equivalent time on other traces. In such a case, not using the AGC on unstacked data could result in data with a significantly lower signal-to-noise ratio than is truly representative of the data.

STEP #10a

*****EXAMPLE DATA*****

For our sample data set, the following batch processing file will most effectively boost the signal-to-noise ratio, retain some relative amplitude information, and improve the interpretability of some of the subtle reflecting events identifiable on the field files.

<u>Line</u>	<u>Description</u>
1	<u>>>START</u> see previous description of >>START
2	<u>*INPF filt.dat</u> see previous description of *INPF
3	<u>*SCAL 50</u>

***SCAL** identifier initiates the scaling operation within **SEIS**. The first entry (**50**) determines the **window length** of the scaling operation. This value is in units of ms. There are other entries associated with the scaling operation but for the data set we are processing here the default values are adequate. One of the other potential variable parameters allows you to choose either **absolute value mean** or **root mean square**, with a user definable reference mean. The particular type of statistical technique used to determine the amount of gain necessary for each sample results in subtle difference on most data sets. A discussion relating to which type is best and for which type of data is not appropriate for this manual. The **reference mean** is a **value set for 16 bit data** and variation of this value will effect the amount of gaining necessary relative to maximum possible deflection. The third parameter relates to delay time in the initiation of the scaling operation.

- 4 ***OUTF scal.dat** see previous description of ***OUTF**
- 5 **>>END** see previous description of **>>END**

As before, the batch processing file just created to automatically gain individual samples relative to nearby samples on the same trace within the defined window will operate on the previously filtered data by using the following commands:

>DSEIS scal.dek junk.lst <enter>

The effect of the scaling operation are probably not worth plotting the entire data set to see. The **dview** display routine will give you a sufficient look at the data to determine if your window is correct and if the operation was complete and correct. The effect of the scaling is actually quite evident on our sample field file (Figure 19).

K) STACK

The CDP stacking or summing process is the culmination of most modern digital seismic data processing. CDP stacked multi-fold seismic data are generally the most useful and most common final form of seismic reflection data. A properly processed stacked section can be used to interpret a significant amount of geologic information. The stacking process, if all previous processing operations and parameters have been appropriate and in a logical sequence, will enhance seismic-reflection information. The processing flow prior to stacking is solely intended to manipulate and prepare reflection information to be added constructively while all other energy (noise) adds destructively.

The CDP stacking of reflection data amounts to the summing all traces with the same midpoint between source and receiver (after correcting for different source-to-receiver distances), and dividing by the number of traces summed (or some other logical dividing screen). This process is conceptually quite simple.

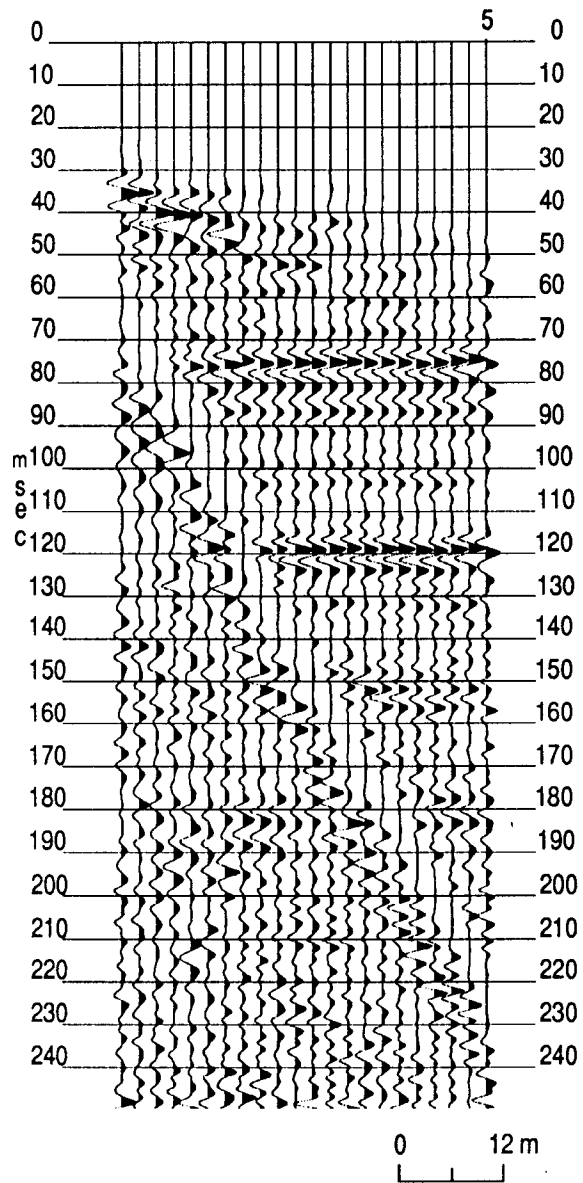


figure 19

STEP #11

*****EXAMPLE DATA*****

For our sample data set, the following batch processing sequence would result in a CDP stacked section:

<u>Line</u>	<u>Description</u>
1 >>START	see previous description of >>START
2 *INPF scal.dat	see previous description of *INPF
3 *STAK 1	
	*STAK operator initiates the CDP stacking process. The first entry (1) identifies the divisor after the summation process necessary to return the amplitude levels to near pre-stack values. The divisor can be selected as the actual number of input traces (fold) or the square root of the fold. The square root-option will simply result in increase the relative significance (from an amplitude perspective) of higher fold gathers.
4 *OUTF stak.dat	see previous description of *OUTF
5 >>END	see previous description of >>END

In order to verify your the correctness of your batch processing deck you should list it out. It should look like:

```
>>start
*inpf scal.dat
*stak 1
*outf stak.dat
>>end
```

Your CDP stacking file operates on the scaled data as follows:

```
>dseis stak.dek stak.lst <enter>
```

Plotting your output is a must (especially since this is the conclusion of this basic processing flow). The plotting parameters used on stacked data are very dependent on interpretation preference. That is, everyone likes to look at stacked seismic data displayed with particular parameters. The larger the number of traces per inch the more apparent coherency on the stacked section. Also, the larger the number of seconds per inch the less apparent subtle variation in reflector depth and the lower the apparent resolution. Simply, it is good to experiment with the

plotting parameters on the finished stacked section until they are aesthetically pleasing to you or your interpreter.

The final stacked data set you have just plotted should be quite similar (except for possible differences in the resolution of your plotter) to the one displayed in Figure 20.

Simply to show the true power of *Eavesdropper* and the batch-processing mode of operation the following batch processing file could have been set-up for the sample data set at the very beginning and executed. The input to this batch job is the raw formatted data and the output is a stacked section all in one deck. The appropriate sequence would look like:

```
>>start
*inpf dengland.raw
*edkl 92 8
kill 1 1 12 12
kill 2 2 11 11
kill 3 3 10 10
kill 4 4 9 9 24 24
kill 5 5 8 8 23 23
kill 6 6 7 7 22 22
kill 7 7 6 6 21 21
kill 8 8 5 5 20 20
kill 9 9 4 4 19 19
kill 10 10 3 3 18 18
kill 11 11 2 2 17 17
kill 12 12 1 1 16 16
kill 13 13 15 15
kill 14 14 14 14
kill 15 15 13 13
kill 16 16 12 12
kill 17 17 11 11
kill 18 18 10 10
kill 19 19 9 9
kill 20 20 9 9
*edfm 92 8
tapr 10
farm 5 1 30 24 65
*edmt 92 8
tapr 10
mute 5 1 57 70 24 222 237
*sort 12 19
ptrn 2.5 24 1
pn 1 108 115 24 1
shot
```

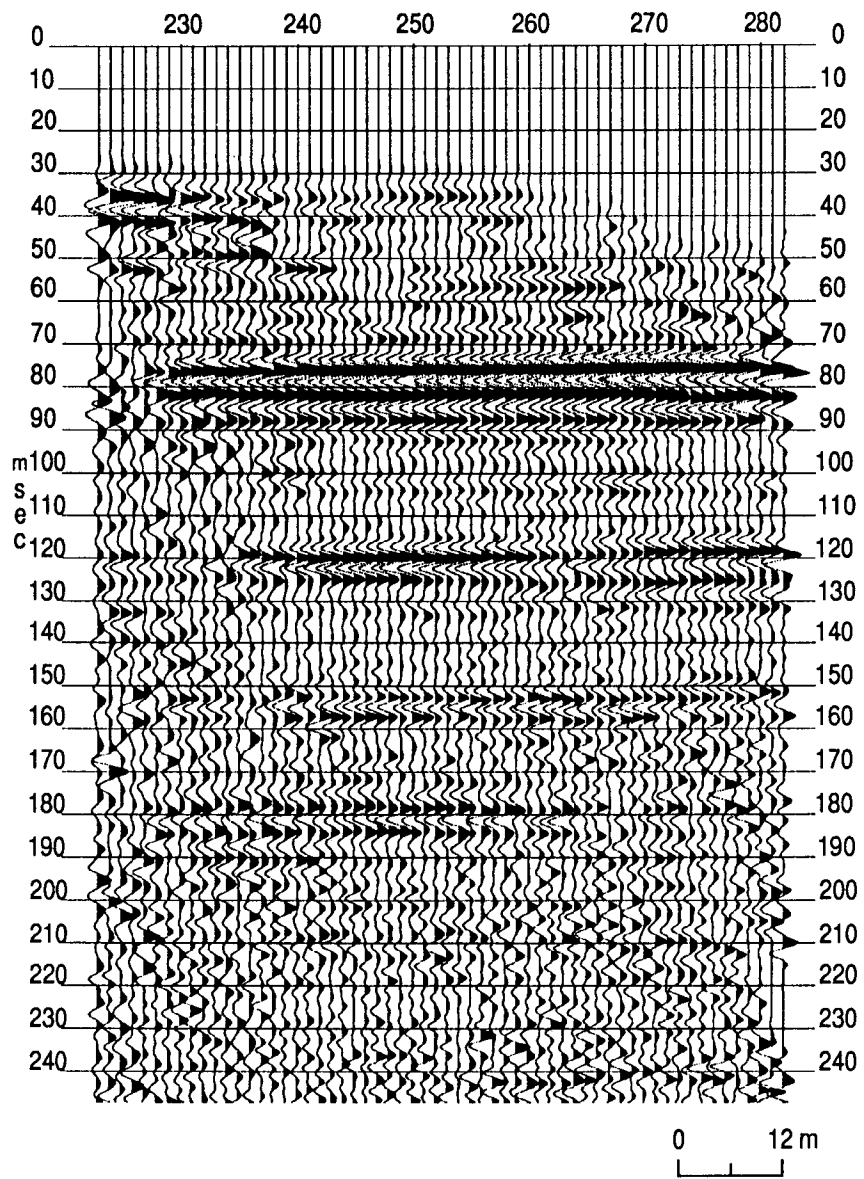


figure 20

```

sn 1 108 1 0 0 1
sn 2 109 1
sn < 3 19 1 > < 110 126 1 > 1 0 0 1
sn 20 127 1 0 0 1 1 24
tabl 1 1
*surf 100
alvf 105 770 90
se 126 99 100
se 127 100
se 136 100
se 137 103 100.3
se 138 106 100.6
se 139 100
se 140 99
se 141 99.6
se 142 100.6
se 143 100
*nmot 0.6
velf 230 45 1850 60 2600 90 2600 110 2900 135 3000
velf 235 45 1850 60 2450 90 2450 110 2900 135 3000
velf 250 45 1850 60 2300 90 2300 110 2900 135 3000
velf 255 45 1850 60 1900 110 1900 150 2250
velf 275 45 1850 60 1900 110 1900 150 2250
velf 280 45 1850 60 2450 90 2450 110 2900
*filt 125 400 1 0 60
*scal 50
*stak 1
*outf stak.dat
>>end

```

This batch file is on the demo disk and can be run using the following command line:

DSEIS_PROSS.dek PROSS.lst

II FURTHER PROCESSING/ADVANCED TECHNIQUES

Other operations available in *Eavesdropper* include: deconvolution, surface-consistent statics, residual statics, f-k migration, and f-k filter.

In summary, a wide variety of processing-flow options is available with *Eavesdropper* after the data have been sorted. Inexperienced analysts are encouraged to refer to books on seismic-data processing and to experiment with the program prior to processing data that are critical to some project. The technical user's manual will provide the necessary mechanical guidance to work through the many program options. However, it is not appropriate to use the program without some knowledge of why various processes are used.

Suggested Reading

- Mayne, W. H., 1962, Horizontal data stacking techniques: Supplement to *Geophysics*, 27, p. 927-938.
- Robinson, E. A., and Treitel, S., 1980, *Geophysical signal analysis*: Prentice-Hall, Inc., Englewood Cliffs, NJ, 466 p.
- Waters, K. H., 1987, *Reflection seismology—A tool for energy resource exploration*, 3rd ed.: John Wiley and Sons, New York, 538 p.
- Yilmaz, O., 1987, *Seismic data processing*, S. M. Doherty, ed.; in series: *Investigations in Geophysics*, no. 2: Soc. Explor. Geophys., 526 p.