

**KANSAS GEOLOGICAL SURVEY  
OPEN-FILE REPORT 93-56**

Imaging the Subsurface:  
Case Study of Salt Dissolution Features in Central Kansas

by

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**J.F.Hopkins and Alex Martinez  
November 1993**

## **PREFACE**

This project was undertaken with the expressed purpose of attempting to delineate shallow subsurface salt dissolution features using high resolution reflection seismic techniques. The following project summary is divided into two sections. The first gives an overview of seismic processing in general and some differences between processing shallow high resolution data versus standard seismic data. They are akin to one another, but with different personalities, like two children under the same roof. The second portion covers, in some detail, the processing package SerriaSeis. This package is powerful, but can be somewhat temperamental. The authors of this report hope that others may find this meager submission useful in their own endeavors.

The authors would like to thank all those who assisted in the completion of this project, especially: Neil Anderson, Ross Black, Ralph Knapp, and Tom Weis.

## **PART I**

### **INTRODUCTION**

During the summer of 1993 approximately four kilometres of high resolution common depth point seismic data were collected near the south central Kansas town of Punkin Center (see Fig. 1). The objective of this survey was to geophysically image several shallow features related to the natural and anthropomorphic dissolution of the Hutchinson salt . These features include the salt dissolution edge, sink holes related to salt dissolution, sink hole fill, and the normal, or non-dissolved stratigraphic section. This ongoing dissolution is of interest for two reasons: subsidence, and water quality.

### **STATIGRAPHY**

The Hutchinson salt is a member of the Wellington formation, Sumner group, Cimarronian stage, Lower Permian (Zeller, 1968). Regionally, the Hutchinson salt can be found over much of central Kansas (see Fig. 2, Merriam, 1963). This formation is retreating slowly to the west due to dissolution related to natural ground water movement. In its wake are a series of sink and slump features as the over lying rock units collapse in response to the removal of the salt. In several areas, salt dissolution has been instigated by anthropomorphic activities such as improperly drilled wells in search of hydrocarbon accumulations or waste water disposal. Knowing where the dissolution edge and remnant salt knobs are is of prime importance for the placement of future wells and construction projects.

### **DATA COLLECTION**

The data were collected, as mentioned above, during the summer of 1993 by the Kansas Geological Survey near Punkin Center (see Fig.3 for location). An E. G. & G. Model 2401X 48 channel engineering seismograph was used to record the data which was stored on 8 mm tape. Standard roll along procedure was used. This consisted of rolling



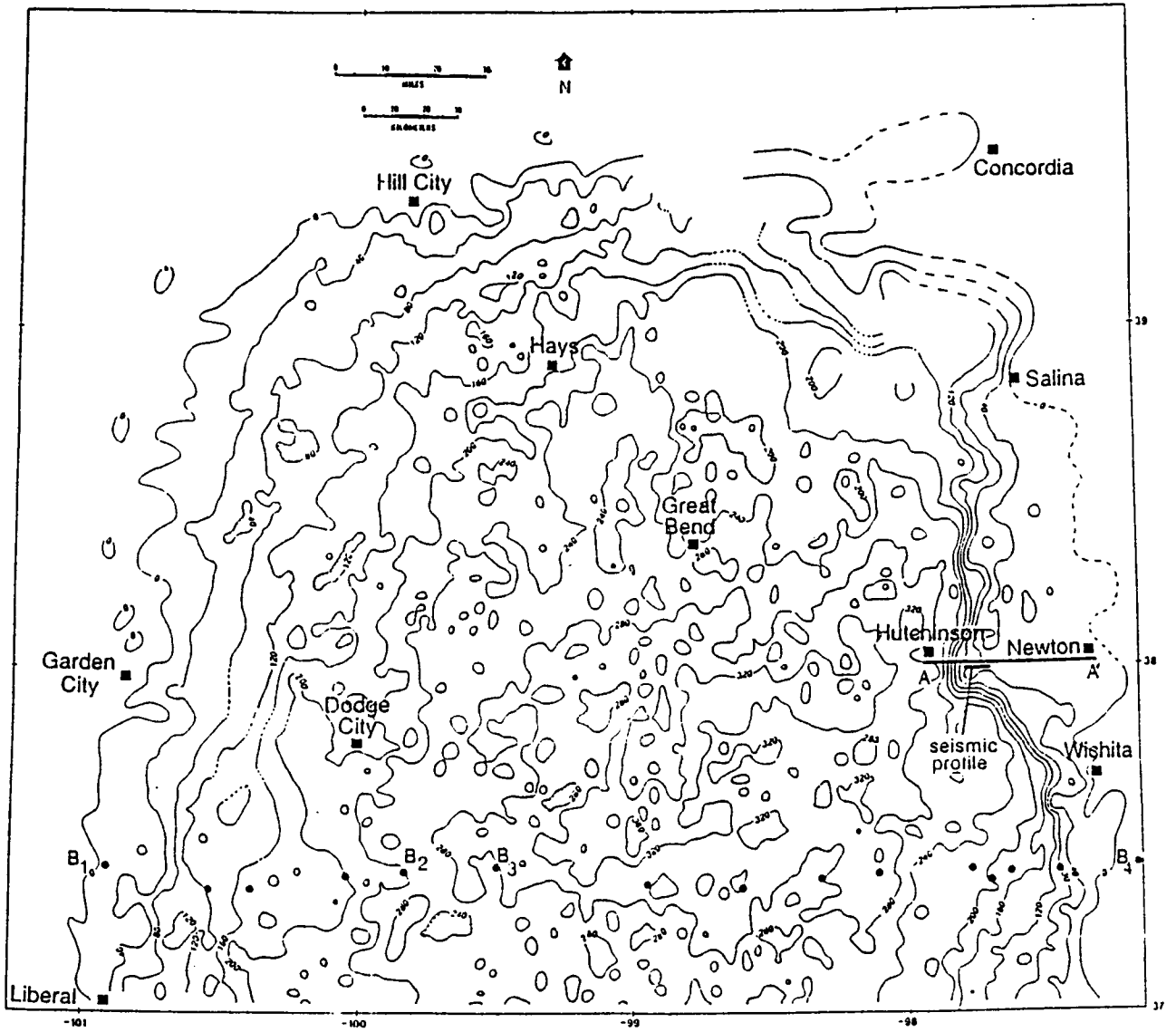


Figure 2.: Distribution of the Hutchinson Salt in Kansas ( after Watney, 1980).

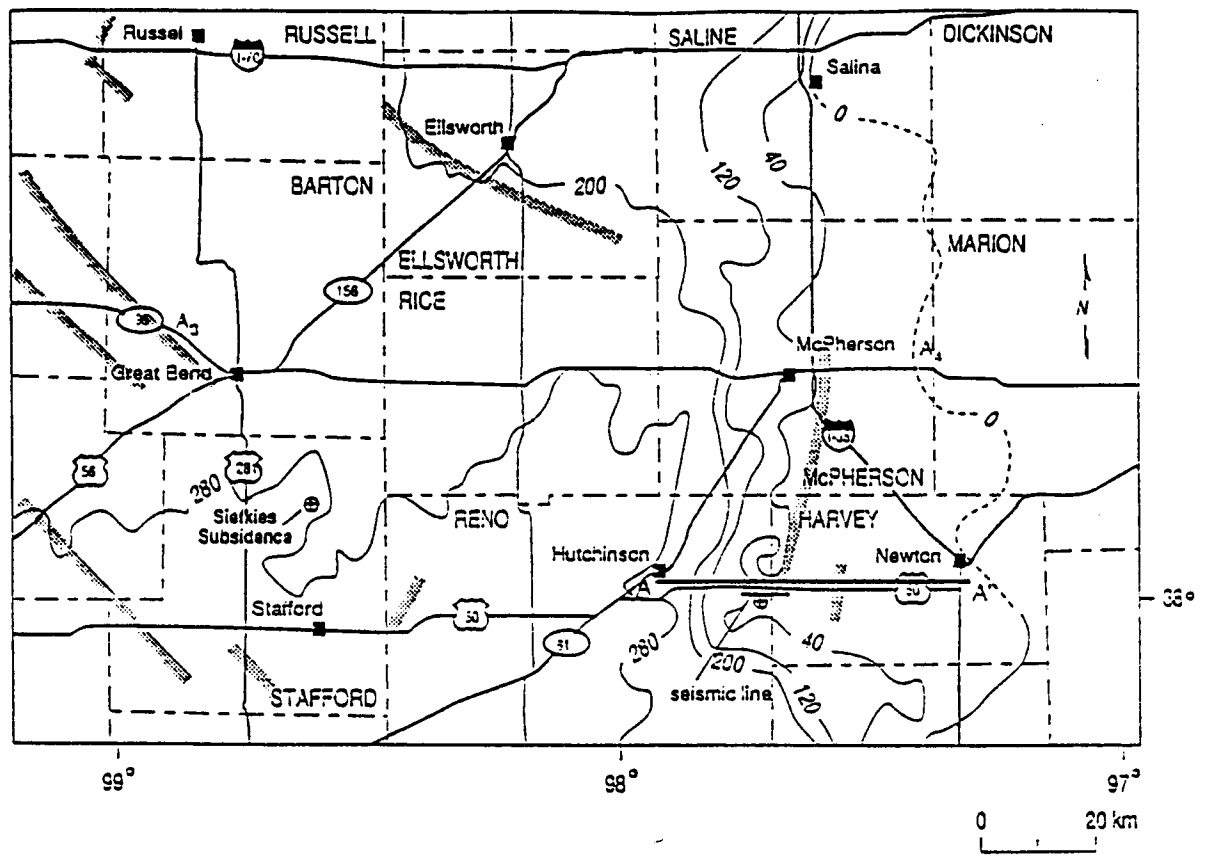


Figure 3.: Location of the Punkin Center Seismic line ( Anderson, in press ).

into a 48 geophone cable until the 24th station was reached, then the data were shot with a standard split-spread geometry. This procedure has several advantages: it builds fold quickly and minimizes initial layout time.

The geophone layout consisted of single geophone groups at five metre intervals. The geophones were Mark Products L40A with a natural frequency of 100 Hz. Total cable spread was 240 metres. A total of 780 stations were shot, with a data length of 512 ms, sample interval of 0.5 ms. The source was a single .50 caliber round fired into the ground. Sources were fired between stations with a lateral offset of nine to eleven metres (see Fig. 4).

## **PROCESSING**

The digital processing of shallow high resolution seismic data is similar to processing "normal" industry data, but it differs in several important aspects. Industry data is normally concerned with imaging relatively deep zones below about 200 ms. (mostly deeper) and is therefore shot with different parameters which include: long near offsets, longer group/source interval, geophone groups rather than a single geophone, lower sample rate (normally 2 ms as compared to 0.5 ms), lower anti-aliasing filters, and lower frequency sources. These differences in the way shallow versus deep seismic data are shot translate to some differences in processing techniques.

Processing was performed on a Sun Sparc station running SerriaSeis 1.5.5. Processing began by converting the data from field format to a format usable by the processing package. This was done in two steps for our data. First we converted from the field format to a standard SEG-Y readable by SerriaSeis then to SerriaSeis "house" format. Once the data was in this format it remained stored in the system's hard drive. This speeded up processing by making the data easily and quickly accessible.

Once the data were converted and stored in the system processing began. Although we used a fairly normal process sequence several, steps turned out to be iterative including trace editing, velocity analysis, and statics.

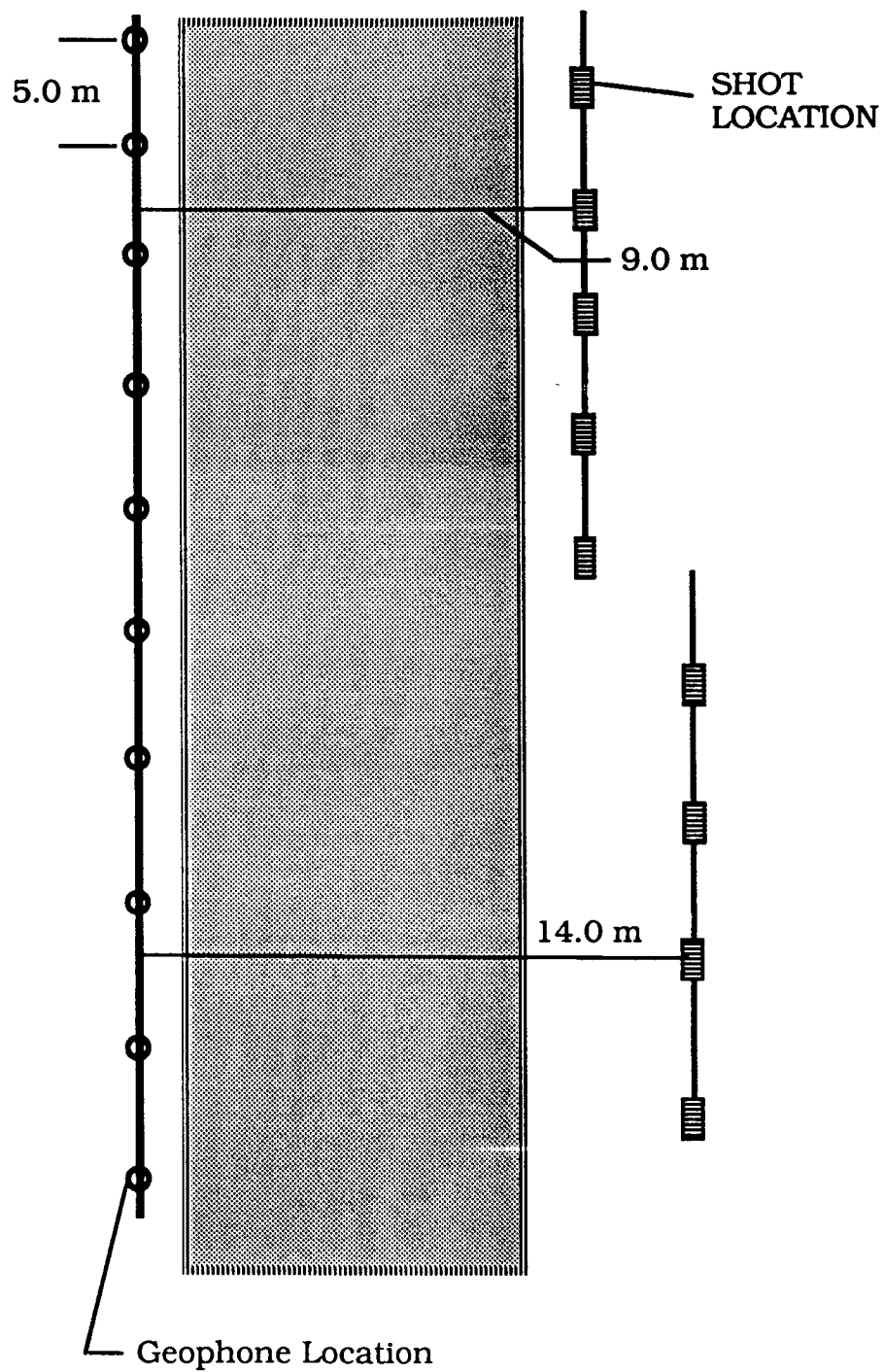


Figure 4.: Shot geometry used for Punkin Center seismic line.

## **Trace Editing**

The importance of thorough trace editing should not be underestimated. The main concern in trace editing is to eliminate bad data from the processing stream as early as possible. Critical to the success of shallow high resolution seismic data is low signal to noise ratio. The single greatest aid in achieving this is trace editing. The procedure used consists of displaying shot records at a convenient scale and then deciding which traces to edit. The records were displayed with a 50 ms sliding window Automatic Gain Control (AGC) applied to boost both the signal and the noise of the traces. Criteria used to decide whether a trace is "bad" or "good" are highly subjective and difficult to quantify. The procedure consists of comparing traces to one another for similarity and signal content. Typical bad traces are those with either very low or very high frequency contents or a general lack of reflections evident as compared to neighboring traces or both (see Fig. 5 for typical shot record with bad traces). Although trace editing is labour intensive, it is worth doing right and worth spending a good deal of time on.

## **Geometry**

Proper definition of field geometry is also critical to seismic processing in general and even more so in the case of shallow high resolution reflection data. Geometry data consists of station location, elevation (survey notes) and cable-shot-station relationships (observer's records). The processing package uses this information for muting, C.D.P. gathering, static corrections ("statics"), and nearly every other process performed on the data. The importance of having accurate, thorough field notes cannot be stressed enough. However, it is of even greater importance that the geometry data is formatted and input properly into the processing package. The geometry file is the very foundation of all subsequent processing. The file used for the Punkin Center data can be found in Appendix I of this report.

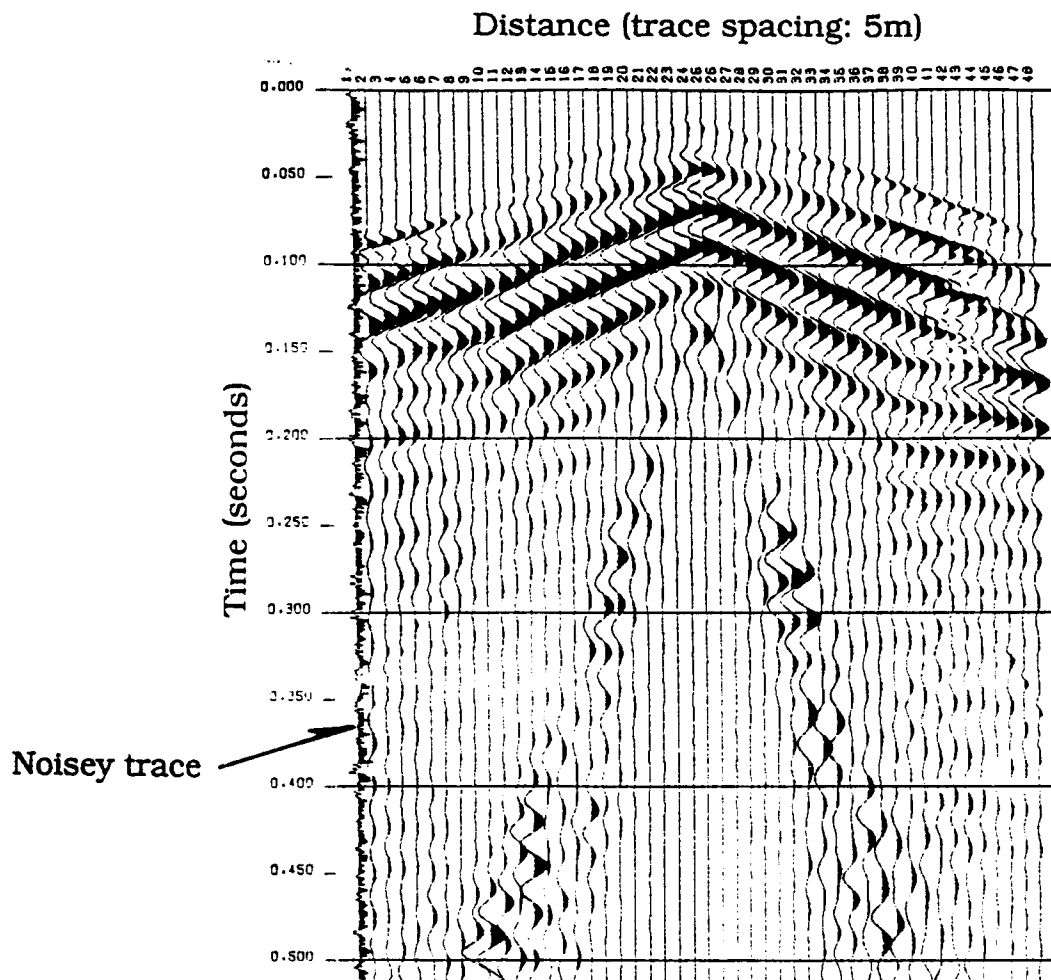


Figure 5.: Typical shot record before processing.

## **Muting**

After geometry definition, three types of mutes were applied to the shot files to remove ground roll, air blast, and spurious events prior to the first breaks ( see Fig. 5 for a typical shot record prior to muting). The over all goal of muting is to improve the signal to noise ratio in the shot records. This is as important to data quality as careful trace editing. The shot records are inspected and various noise trains analyzed to determine the optimum muting procedures for each event. Ground roll is removed from the record using a standard tail mute. The character of this noise train varied spatially in velocity and shape. Therefore, the tail mutes applied changed as the ground roll signature changed. Noise generated from the air blast is best muted by a velocity mute. Velocity muting removes noise by "zeroing" samples in a window which lies along a slope corresponding to a given velocity. Only one velocity mute was needed for this data set because the air blast changed little in character along the seismic line (Figure 6 shows the effect of velocity muting on the data). Spurious noise prior to first arrivals is muted using a front end mute. This mute has the effect of cosmetically improving the data. A final muted shot record is shown in Figure 7 . What remains on this record are refractions, reflections, and random noise.

## **Spectral Shaping**

Preliminary stacked sections of the Punkin Center data did not reveal the position or geometry of several known sink holes. To enhance data resolution, spectral analysis and shaping were performed on the data. Results from this analysis showed that the high frequency data (80-90 Hz) were drowned out by a preponderance lower frequency data (40-60 Hz; see Fig. 8 ) Several normal filters were run on the data. The results of the test runs were analyzed in both the frequency and time domains to determine which of filter enhanced high frequency signal the most.

Although all standard filters applied worked to a greater or lesser extent, frequency deconvolution was tested on the data. This process

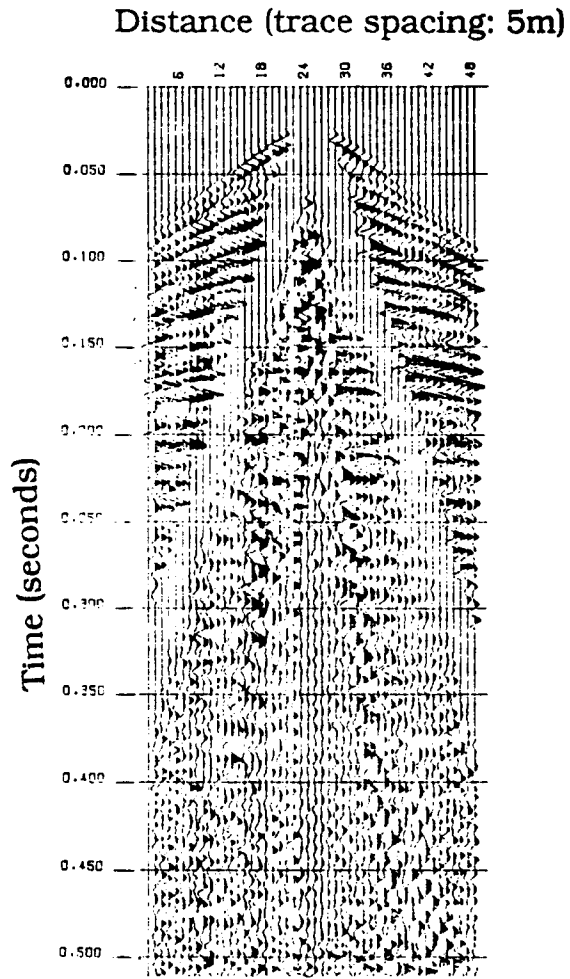


Figure 6.: Shot record after velocity muting and frequency deconvolution.

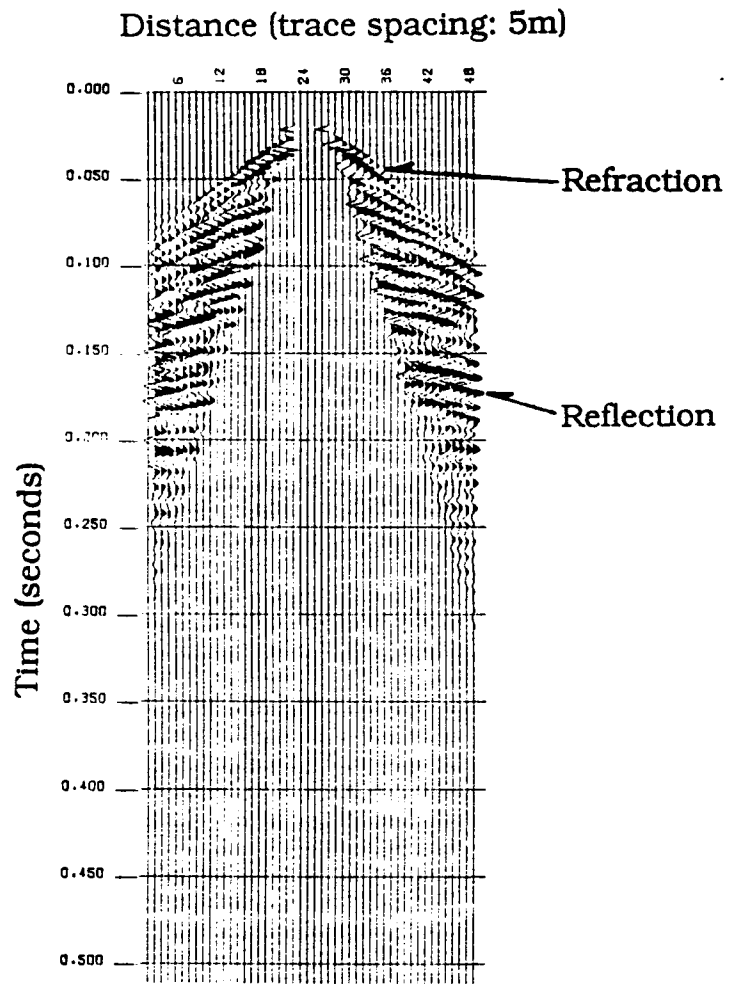


Figure 7.: Fully muted shot record with frequency deconvolution applied.

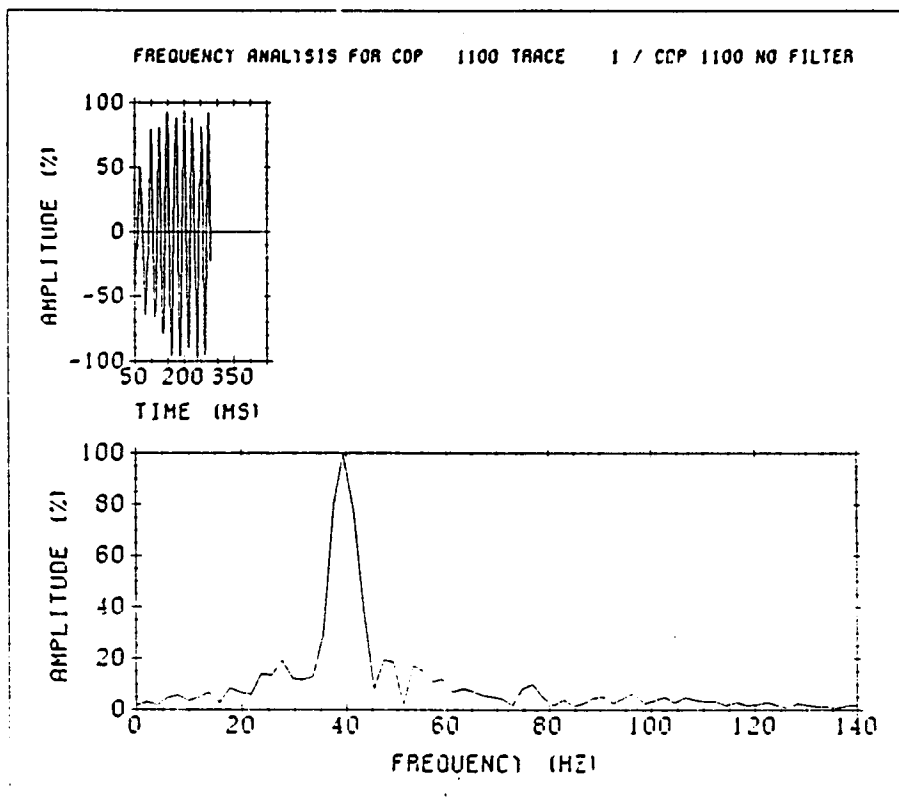


Figure 8.: Frequency spectrum of CDP 1100 before frequency deconvolution.

proved to provide the greatest enhancement of high frequency data in the target zone (0-250 ms; see Fig. 9 ) The result of this process allows definition of the very shallow portions of the section as well as improved vertical and lateral resolution of the sink holes. This data improvement did however have a price: resolution in the deeper parts of the section were sacrificed. The deconvolution processor removed nearly all lower frequency data, which made up most of the signal from deeper portions of the section. The loss was deemed acceptable in light of the improved resolution in the target zone. The only other significant problem with frequency deconvolution observed was run time. It took approximately one and a half hours to process the 780 shot files. In an attempt to avoid this problem, frequency deconvolution was also performed on stacked data, but the results were significantly poorer than the pre-stack procedure.

### **Velocity**

Velocity control is often cited as critical to the success of seismic data processing. This is generally true of standard oil industry data. The main reasons for this are long source to receiver offsets ( 5000 feet to 15000 + feet) and the long record length (5-6 seconds as opposed to 0.5 seconds in our case). Long offset data yields reflections with correspondingly large amounts of hyperbolic move out. If proper correction velocities are not applied, the resulting stack contains smeared reflections. Long record lengths generally add to the complexity of the velocity field due to changes in lithology and compaction. So normally, one encounters velocities that increase significantly with depth over several seconds. In the special case of shallow high resolution seismic, the offsets and data length are not great enough to yield very large amounts of move out or changes in the velocity field. This can be seen by looking at a typical shot record for the line (Fig. 7). The reflection hyperbolas display nearly the same move out from top to bottom. Major changes in curvature occur at around 100 ms where the lithology changes from Quaternary fill to Permian bedrock. The velocities do increase with depth, but the magnitude of the change is less than that encountered in industry seismic.

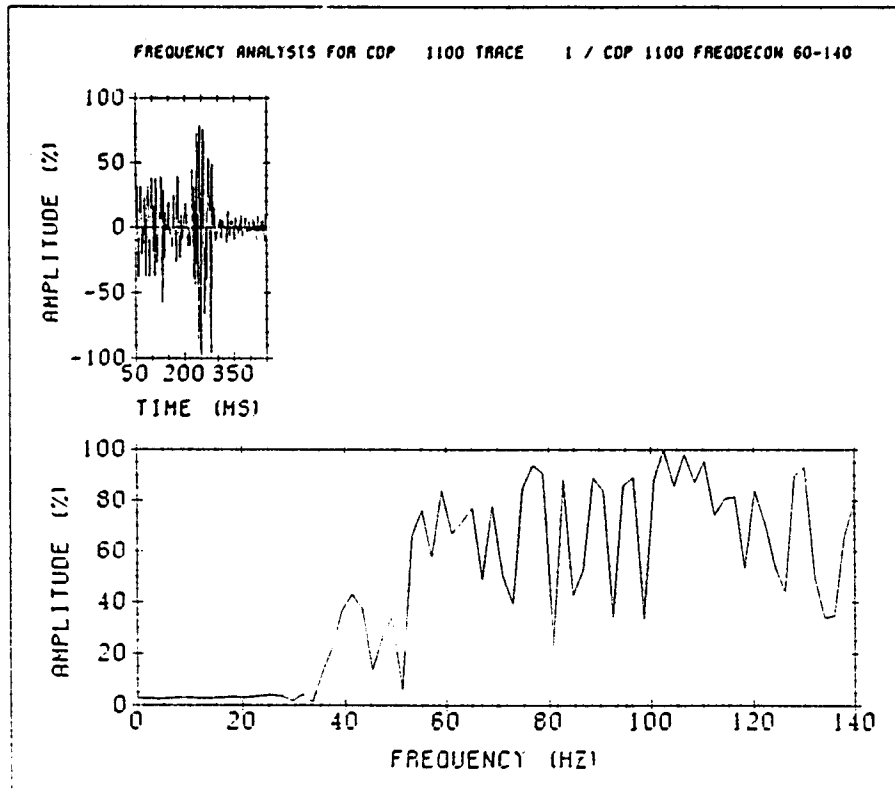


Figure 9.: Frequency spectrum of CDP 1100 after frequency deconvolution.

The data collected is not very sensitive to changes in stacking velocities. This has occurred for the reasons listed above. In Figure 10 one portion of the line have been stacked several times with a single velocities ranging from 600 m/s to 1000 m/s. Changes in reflection coherency are not strong contrary to what one would expect.

The velocities we used were derived from near by well information and from the data itself. Depth to bedrock was obtained from nearby wells. Approximate two way travel time to the same horizon was obtained from a preliminary stack processed by Tom Weis. Velocities were also estimated from the shot records using a straight line approximation for the hyperbolic reflections. This method is erroneous, yielding velocity estimates which are too large, yet within reasonable limits. Caution should be used when applying such velocities.

### **Stacking**

Stacks were created at different stages of processing. The main reason for this was quality control. Stacks were created to test: muting, geometry, velocity, and spectral shaping. In this aspect, the processing became iterative and allowed for experimentation with various parameters. It was during this process that it was decided to effectively shorten the record length to 300 ms by harsh muting. After frequency deconvolution, very little data was left below 300 ms. Since the window of interest lay above that, we eliminated the extraneous data. The result was a cleaner stack and decreased run time. A preliminary stack was also necessary for the static correction processors.

### **Statics**

Three types of static corrections were applied to the data: geometry, non-surface consistent, and surface consistent statics. Geometry statics were applied after preliminary stacks were generated and some estimate of the velocity field was made. This static correction accounted for differences in elevation between the geophone and source locations. The data needed for this correction are elevations of geophone and shot location and an estimate of the near surface velocity

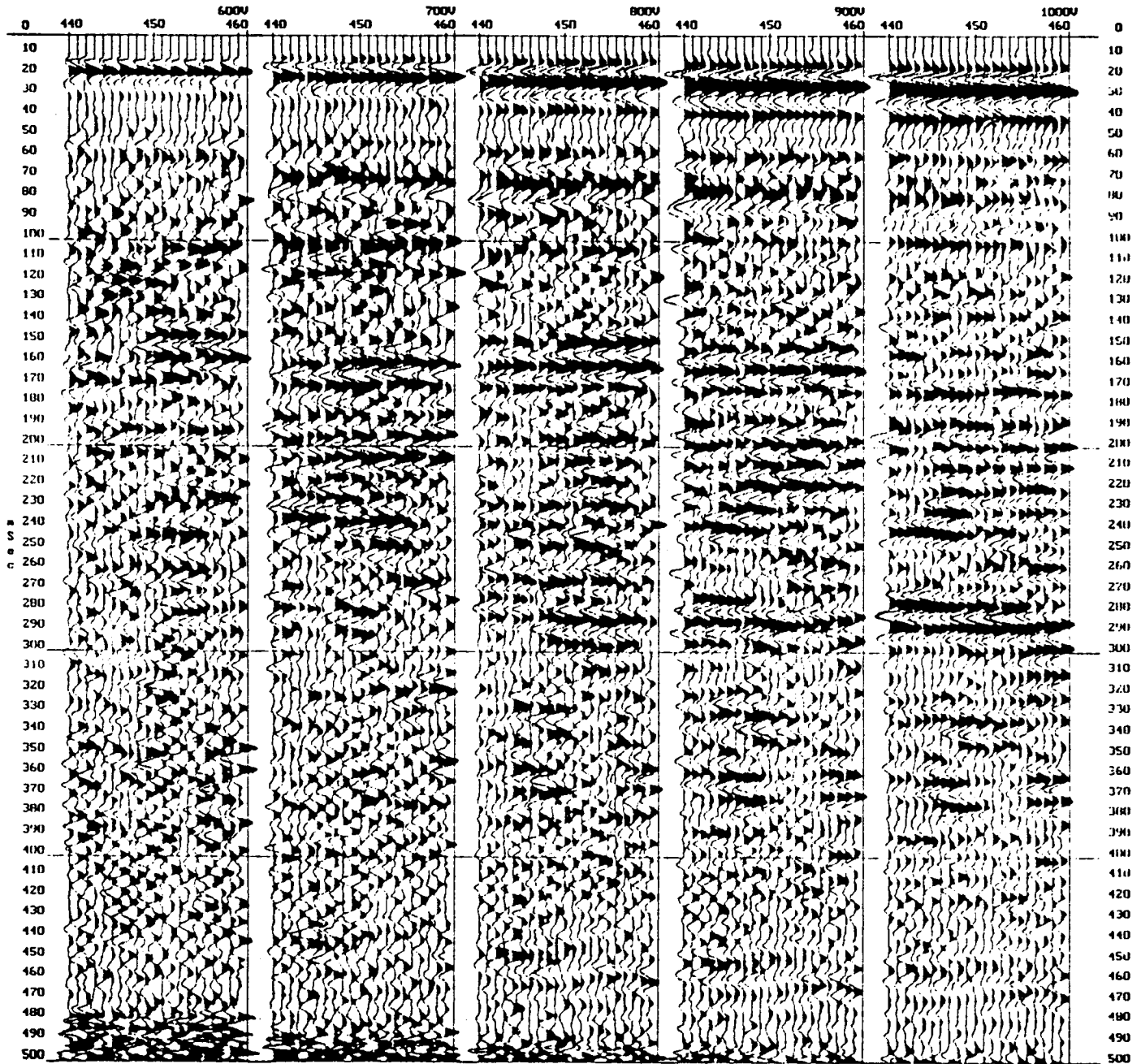


Figure 10. : Velocity panels of CDP's 440 -460 courtesy of Tom Weis.

(weathering velocity). We used the first break velocity as an estimate for the velocity of the near surface materials. Survey information pertaining to this line consisted of measurements of relative elevations at geophone locations. No elevation information was collected for shot locations. After consulting a topographic map of the area, it was decided to estimate the missing elevations by using the elevations of the geophone stations. This procedure is approximate and can lead to significant error if the elevations of the shot and receiver differ greatly. We estimated that there was less than one metre difference between the geophone location (measured elevation) and the shot location. The estimate for the near surface velocity was 1800 m/s. This generates a maximum error in the geometry static calculation of  $\pm 0.56$  milliseconds. We deem this an acceptable error.

After the geometry statics were applied, non-surface consistent and surface consistent statics were applied to the line. Non-surface consistent statics adjust the stacked traces to enhance lateral reflection continuity. The program averages several traces (in our case 5) to create a pilot trace. The pilot trace is then used in a cross correlation with the next data trace. Output from the cross correlation is a time shift that, within a window specified by the processor, will most greatly enhance reflection continuity.

To adjust for any error introduced by the non-surface consistent statics operator, surface consistent statics were run. This operator uses elevation information to re-adjust the traces so that they not only line up well with one another, but are also consistent with surface topography.

Statics are an iterative procedure, once the geometry corrections are applied. Several runs of non-surface and surface consistent statics are normally required before the data converge on an solution. To judge when this happened we compared the old static shift values to the new both numerically and visually. When these values showed little to no change it was considered a sign that a convergent solution had been reached. We strongly recommend that close monitoring be maintained throughout statics application. Statics, if improperly used, can create false structure or remove structural elements from the data.

The final stacked section is shown in Figure 11. It includes all the processes named above, but does not include or reflect directly all

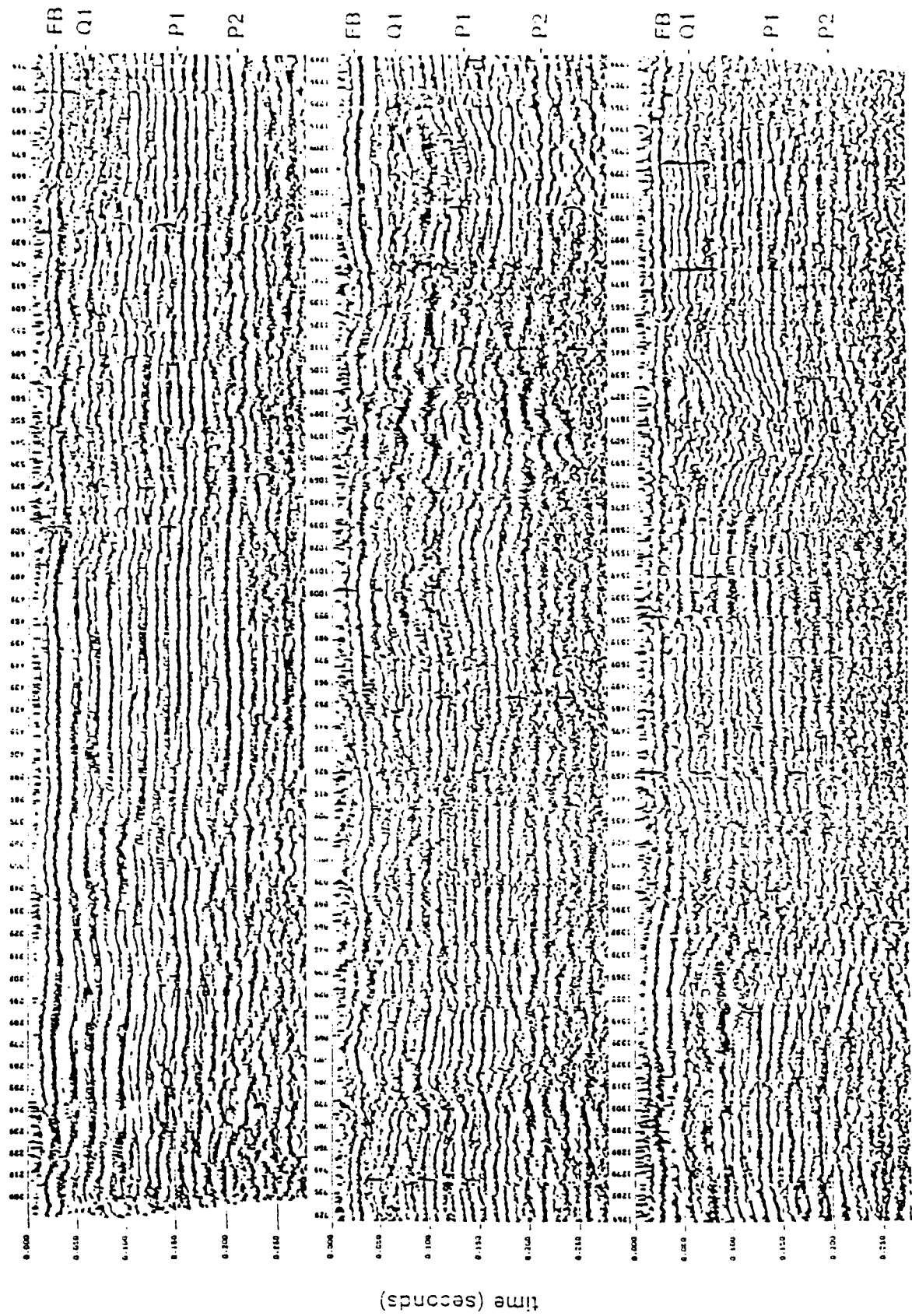


Figure 11: Final stacked section.

processes which were tested on the data. The labeled horizons are those which hold geological significance and are laterally continuous on the section. The horizon labels are: FB first breaks; Q1 Quaternary marker; P1 the first Permian marker; and P2 the second Permian marker. Features of note are the sink holes located around CDP's 1209, 1409, and 1603. The line has been displayed with only a 50 ms A. G. C.. Work is currently in progress to further enhance imaging with post stack procedures.

**PART II : Serria Seis**

## Introduction

SierraSEIS is a UNIX based seismic processing system owned by Haliburton, Incorporated. A copy of this program is located at the University of Kansas on a Sun 10 workstation in the geology department under the care of Dr. Ross Black.

What follows is a general description of the computer systems used, the processing flow from data entry to a final stacked section, and some processing tips. Included in Appendix 1 are sample job cards to assist those wishing to process with the SierraSEIS system. Refer to these for examples of processors mentioned in the text below.

## Computers Used

All work was performed using X-Windows on a UNIX based workstation. The X-Windows environment is relatively easy to learn, due to it having a built-in dictionary of commands. To access this dictionary use the command "xman".

Below is a listing of computer system names, addresses, and functions which were used. In order to access these computers, you must have an account and password on them.

Communication between the three different systems is accomplished using both telnet and file transfer protocol (ftp) through ethernet. Telnet is used for viewing files and working within a system, while ftp transfers files from one system to another. The format for telnet is "telnet <address>". For example, to get into seismic2 from crudel you type "telnet 129.237.236.2" and then log into your account. The ftp function operates in the same manner. If difficulties arise during the usage of telnet or ftp, type "help" and a listing of commands will appear.

Sometimes it is necessary to stop the computer while it is running a job. This is accomplished by typing "c" while holding down the control button. If this does not work, it is then

necessary to "kill" the job. This is done by typing "ps -ax", which will print a list of all jobs currently running on the computer. Each job has its own identification number and a brief description of its flow path. Find the job that you wish to stop and type "kill <job number>". This will stop the job. More information on the kill function can be found by using xman. Only the jobs running under your account can be stopped, you will be denied access to all other jobs.

Table 1: Accessing SierraSEIS and the computer systems.

\* Computer addresses

<u>system name</u>	<u>number</u>	<u>usage</u>
crudel	129.237.140.24	data storage, remote access
seismic1	129.237.236.1	plotting
seismic2	129.237.236.2	processing

\* Functions

<u>function</u>	<u>command</u>	<u>usage</u>	<u>for help</u>
ftp	ftp<number>	transfer files	help
telnet	telnet<number>	remote access	help
ps -ax	ps -ax	kill jobs	xman

## General Information

SierraSEIS has numerous processors to achieve the users' processing goals. These processors are controlled by job cards, which access subroutines. Job cards can be written using any text editor, such as the file manager within X-Windows or a word processor linked to seismic2 by ethernet. Do not use tabs when writing jobs, because they cause SierraSEIS to abort initialization. Each job card must begin with the /JOB command and end with \$EOJ.

The use of job cards within SierraSEIS is very similar to fortran programming. In fortran you write code, compile it and then run it. With SierraSEIS, you write a job card, initialize it

and then execute it. You initialize a job card by typing "ssinit" (in lower case letters), entering the job card file name and then a four-letter maximum job sequence identifier. If the job card initializes without any errors, new files will be created. Of these files, SS<job name>00.IPR (IPR) has important information about the job card just initialized. If the job card does not initialize, it will give you a general error message saying it cannot initialize. A more detailed description of what is wrong with the job card is given in the IPR file. The error message numbers correspond to those listed in Appendix 1 of the SierraSEIS users' manual, Volume one. If new data output files are created by the job card during the initialization phase before the job aborts, it is necessary to delete them before attempting to rerun the ssinit command.

Next you must execute, or run, the job card. This is done by using the command "ssexec" (in lower case letters) and entering the four-letter job sequence identifier previously used for the initialization phase. This will execute the job card and create more files, of which SS<job name>00.EPR (EPR) is the most important. The EPR file contains what was done to the data and any error messages. In addition, the execution phase will create raster files (for displaying data) if the job card so specifies.

When writing a job card it is sometimes necessary to use what is called "delta notation". This is merely a shorthand method of entering data. Its format is a "D" followed by a starting number, an ending number and an increment. Examples of the delta notation can be found in the sample jobs given in Appendix 1.

Sometimes problems with job cards occur when the parameters of a processor are located on the same line as the processor command. Difficulties with the reverse possibility also occur at times. Attempt to change the position of the parameters when it appears nothing else will work.

SierraSEIS can run multiple processors in a single job card. In fact, an entire stacked section can be produced from raw data by

just one job card, as shown in the job card "HUGE.JOB" in Appendix 1. The combination of processors in job cards increases the processing speed, because everything runs at once.

Save the data files after every major processing step. This way you do not have to repeat past processes to run a new job. For example, save the data after importing it, trace editing, muting, and again after the final finishing touches are performed.

Table 2: Important SierraSEIS commands and suffixes.

\* Commands

<u>command</u>	<u>what it does</u>	<u>if problems arise</u>
ssinit	checks for errors	check IPR file
ssexec	runs the job card	check EPR file

\* Suffixes

<u>suffix</u>	<u>file contents</u>
DIO	data, SierraSEIS internal format
EPR	ssexec information
IPR	ssinit information
LGM	geometry information for the processors
RAS	graphics
SGY	data, segy format

## Data Entry

The data was originally in Kansas Geological Survey (kgs) format. It was transformed from kgs to segy format and then imported into SierraSEIS. Format conversion programs are available from either Dr. Black or the Exploration Services department of the Kansas Geological Survey. The formatting programs use the following format: <program name> <file to be transformed> <new filename for transformed file>. For example, to change the data file "PUNKIN.KGS" from kgs format to segy format you would type "kgs2sgy PUNKIN.KGS PUNKIN.SGY" after the command prompt.

The process of merging multiple data files can be performed using either a command within UNIX or within SierraSEIS. Combining

data files in UNIX works best for data without reel headers. To combine the data use the CAT command which has the format CAT <files to be merged> <new filename>. This is the easiest method of merging data files if renumbering of field files is not necessary. Merging files within SierraSEIS is discussed in the users' manual.

To enter segy formatted data into SierraSEIS you make use of the /SEGYDIN processor. See the job card "HUGE.JOB" in Appendix 1 for an example of its usage.

Once the data is in SierraSEIS there are several further steps that must be taken. The conversion programs sometime do not work properly, and therefore it behooves you to check the data after it is entered. This is done using the /PRMODCOM processor to print out the trace headers for the data. If problems are discovered, the /PRMODCOM processor can also be used to correct the header values. A complete listing of trace header parameters is given in Appendix 3 of the SierraSEIS users' manual.

One importing problem encountered was the failure of SierraSEIS to acknowledge that the data set was given in units of meters instead of feet. This caused delays in processing until it was discovered.

Table 3: Conversion programs.

\* Programs (these are available from the KGS)

<u>program</u>	<u>original data</u>	<u>converts to</u>
90002kgs	bison 9000 seismograph	kgs
kgs2sgy	kgs	seggy

\* Formats

All use the following format:

<program> <data file> <new data file>

## Geometry

The /GEOMETRY processor allows SierraSEIS users to enter their own field geometries into the computer. The processor is rather

flexible, allowing complex geometries to be entered. This is one of the most important portions of the data processing flow, because incorrect information here can lead to serious problems later. Therefore, it is highly recommended that users of SierraSEIS carefully read the description of the /GEOMETRY processor in chapter four of the SierraSEIS users' manual, Volume one. You must fully familiarize yourself with the various parameters and functions associated with the /GEOMETRY processor before attempting to use it.

The /GEOMETRY processor creates a geometry information file which has the suffix LGM. This contains all geometry information used by the program for processing purposes.

Users must enter station numbers and then locate the source and receiver positions in relation to them. This may be done by either picking an arbitrary line or by specifying x-y coordinates. The x-y coordinate system works best with very complex geometries.

Several /GEOMETRY parameters allow users to verify the accuracy of the geometry information entered. These parameters include PRST, PRRANGES and PRINFOLD. These create tables listing static correction information, the distance between each receiver and shot point, and the stacking fold, respectively.

Another helpful tool to check the accuracy of geometry information is the /PLGEOM processor, which creates plots, tables and diagrams. With it, you create raster files of diagrams showing the locations of sources, receivers and common depth points. An example of both the /GEOMETRY and /PLGEOM processors is in Appendix 1 in the job card "GEOMETRY.JOB".

One difficulty encountered with the /GEOMETRY processor was with the DISTDIR parameter, which specifies the orientation of receivers. Although it is not stated in the users' manual, east (90 degrees) is considered to be the x direction, and north (0 degrees) is the y direction. Incorrectly entering the line direction can cause problems with source offset.

## Trace Editing and Muting

In order to save paper during trace editing, it is best to create a raster image of the files to be edited. Proper scaling is very important when using the raster files. It is very easy to miss bad traces if the files not displayed properly. In order to achieve an optimum size, use the /DISPLAY processor with the HORZ (traces per inch) and VERT (inches per second) parameters, experimenting until a satisfactory scale is reached. Picking bad traces in this manner works best if the computer has two monitors, rather than one, so you can directly enter the information into a job card. This method of trace editing was used for the Punkin Center data set.

The /ZERO processor is used to zero out traces deemed unworthy of processing. An example of its usage is shown in Appendix 1 in the job card "HUGE.JOB". When zeroing unwanted traces it is sometimes useful to use the delta notation and auxiliary data streams if the same trace is bad in multiple files. Note that for almost all processors, the file or cdp numbers must be in increasing order. Other trace editing processors, such as /RPOL (reversing a trace's polarity), can be applied and are discussed in the users' manual.

Muting within SierraSEIS is easy to accomplish. There are three basic types of mutes available to users: front-end mutes (FMUTE), tail-end mutes (TMUTE) and surgical mutes. For FMUTE and TMUTE, you select starting and ending times and distances. There are several types of surgical mutes which are available within SierraSEIS. The one used in the Punkin Center data processing was a velocity mute (MUTVEL) which removes events with specific velocities, such as the air wave. See job card "HUGE.JOB" in Appendix 1 for examples of these mutes.

## Filtering and Deconvolution

As with muting, SierraSEIS has numerous spectral shaping features available. Examples include space and time varying

filters (/STVF), f-k filters (/FKFILT) and frequency deconvolution (/FRQDECON). A complete listing of filters and deconvolution processors is given in the SierraSEIS users' manual. Difficulties were encountered using the /FKFILT processor to create a plot, and these problems were never overcome.

With filter processors, the user creates a "library" of available filters and then applies them. Each filter has a number assigned to it by the user (1, 2, etc.), and is not applied to the data until the APPLY parameter is used.

## **Gathering, Velocity Analysis, NMO and Stacking**

Gathering of data into useful groups is accomplished by the /GATHER processor. It can group the data into numerous sets, which are called data orders. These include common depth point (cdp), common offset, shot files with geometry information, and common receiver gathers (data orders 2,3,4,5 and 6, respectively). To use the /GATHER processor you must specify which type of data you wish to group together by using the OUTSORT <data order> parameter.

The /VELOCITY processor must be applied before data can be normal move-out corrected by the /NMO processor. SierraSEIS has several useful processors for selecting velocities. These include creating velocity panels (/VELPANEL), velocity tables (/VELTABLE) and semblance plots (/VELS).

To use the /VELOCITY processor, enter the files you wish to apply velocities to followed by time and velocity pairs. These pairs must be entered in order of increasing time. Users may specify units with the UNITS parameter.

The /NMO and /SNMOM processors both apply normal move-out corrections to the data. The /SNMOM processor also applies the statics and muting, helping to reduce processing time. These processors had difficulties applying the static corrections to the Punkin Center data. Neither would compile with the statics applied as specified in the SierraSEIS users' manual. This problem was circumvented by applying the static corrections as shown in the job

card "MEGA.JOB" in Appendix 1.

You use the /STACK processor to stack the data. This must be preceded by the /GATHER processor with the data in a suitable data order.

It is recommended to use the /DISPLAY processor during the gathering and stacking process in order to view the results of application of the processors. It may be necessary to use a gain function in order to amplify later events. This is done by applying the /AGC processor. For this processor, you must specify a window length with the WINDOW parameter.

## Viewing Raster Files With RASVUE

Use the program RASVUE to display raster files created by the /DISPLAY processor. In order to use RASVUE, you type "rasvue" within the same directory as the file you wish to view, and a new window will appear on the screen. This window has a menu along the bottom where you enter the filename of the file to be viewed. You may also change the size of the picture by choosing the "decimate" option, decreasing the image from 2 to 10 times in size. If the image is larger than the window, you can scroll within it by clicking your mouse on the bars on the sides of the window.

In order to run the RASVUE graphics package when remotely logged into the system from another UNIX based workstation, you must do two things. First, on the system you are on type "xhost +" to allow another computer to run the graphics package. Then, on the remote system you are logged into type "setenv DISPLAY <pseudo internet address>:0". For example, to allow seismic2 to run the graphics remotely on crudel, you would type "setenv DISPLAY crudel.kgs.ukans.edu:0".

RASVUE can be used to view raster files while they are being created by the /DISPLAY processor. This is very useful when iterating through long processing steps, as it allows you to quickly determine if the job card is performing as wished, and you may stop the job if necessary.

It must be noted that the RASVUE program is very temperamental and "crashes" easily. Care must be taken when entering filenames and scrolling through the pictures. If the program does crash, use the "ps -ax" UNIX function to determine which job to stop.

## Plotting and Printing

To plot SierraSEIS output you have two options. For large sets of field files or a stacked section you can use a Versatec plotter. For small (8-1/2" x 11") raster files you can use a postscript printer. The programs allowing output from the plotter and printer were written by Dr. Black.

In order to use the plotter you must do several things. First, output the data to be saved in segy format using the /SEGYDOUT processor. Then transfer the file from seismic2 to seismic1 using ftp.

Once the file is on seismic1, run the program "traceprep". This transforms the data from standard segy format into a format usable by the plotter. Its format is "traceprep <filename> <new filename>". A good way to keep track of files is to have the first in capital letters and the second with the same name in lower case letters. Traceprep asks for the number of samples per record. Entering an incorrect number will cause the program to crash.

Next, use the program "traceplot2" to create a plotter file. This program asks for numerous parameters, such as traces per inch (tpi), inches per second (ips) and trace header values. Important trace header values available for use are listed in the table below. Traceplot2 also allows the user to specify the record length to be plotted. This is a very time-consuming program to run for large plots. Every time traceplot2 is used, it overwrites the previous plotter file. Once the program finishes running, type "vraster" and the plotter will produce output.

In order to create plots from a postscript printer you must first create a raster file using the /DISPLAY processor. This raster file must be able to fit reasonably well on a 8-1/2 x 11

inch sheet of paper. Once the raster file is created, transfer it to seismic1 and run the program "traceplotp" to create a postscript file. Then transfer the file to a graphics program and print it with a postscript printer. This process has some difficulties with accurately reproducing the raster file and can result in having multiple images of the picture printed in the final copy.

Table 4: Header index numbers.

<u>number</u>	<u>meaning</u>
6	field file number
8	field file trace number
12	common depth point (cdp) file number
14	common depth point (cdp) trace number

## Getting help

There are two methods of getting help with SierraSEIS. The first is to contact Dr. Black and ask for assistance. He is very familiar with the system. The second method is to call the SierraSEIS hotline listed in the users' manual. The SierraSEIS personnel are very helpful and knowledgeable. It is always good to remember that the help center is located in California and therefore has a two hour time difference from Kansas. If the office there does not respond, you may be transferred to the Haliburton offices in Great Britain.

## Conclusion

Overall, SierraSEIS is a powerful seismic data processing software package. It is hoped that this paper will allow others to begin to use SierraSEIS effectively, without having to struggle with difficulties concerning basic processor and parameter nuances.

**APPENDIX I**

(\*\*\* GEOMETRY.JOB \*\*\*)

(\* This job creates a geometry file for SierraSEIS to use during  
(\* processing.

/JOB ACCT 'PUNKIN CENTER' SCAN 72 METERS

/GEOMETRY

GEOMFILE 'PCGEOM3'

(\* The following parameters print geometry information in the EPR file.

PRRANGES

PRINTALL

PRINFOLD

SURVEY

STBASE 1.0

(\* This is a list of shot points.

SPLIST D1.0 487.0 1

D242 487.0 1

D489 787 1

(\* This parameter tells the computer which direction the line is going.

(\* It is very important to get this correct.

DISTDIR 99 5.0 90

(\* The following commands tell the computer where each shot and receiver

(\* were, relative to station numbers. The INC parameter allows you to

(\* increment the numbers, rather than entering them in individually.

SHOT 1.0 AT 99.0 INTO D101 148 1

SHOT 2.0 AT 100.5 INTO D101 148 1

SINC 1 CINC 0 TO SHOT 26.0

SHOT 27.0 AT 125.5 INTO D102 149 1

INC 1 TO SHOT 158.0

SHOT 159.0 AT 258.5 INTO D234 281 1

INC 1 TO SHOT 241.0

SHOT 242.0 AT 341.5 INTO D317 364 1

INC 1 TO SHOT 288

SHOT 289.0 AT 389.5 INTO D365 412 1

INC 1 TO SHOT 332.0

SHOT 333.0 AT 434.5 INTO D410 457 1

INC 1 TO SHOT 380.0

SHOT 381.0 AT 482.5 INTO D459 506 1

INC 1 TO SHOT 473.0

SHOT 474.0 AT 576.5 INTO D553 600 1

INC 1 TO SHOT 487.0

SHOT 489.0 AT 590.5 INTO D567 614 1

INC 1 TO SHOT 612.0

SHOT 613.0 AT 715.5 INTO D692 739 1

INC 1 TO SHOT 633.0

SHOT 634.0 AT 737.5 INTO D714 761 1

INC 1 TO SHOT 664.0

SHOT 665.0 AT 769.5 INTO D746 793 1

INC 1 TO SHOT 710.0

SHOT 711.0 AT 816.5 INTO D793 840 1

INC 1 TO SHOT 768.0

SHOT 769.0 AT 874.5 INTO D845 892 1

SINC 1 CINC 0 TO SHOT 787.0

(\* Source offset from the line. Not all offsets are shown.

SHOFFSET 1 11 180

2 11 180

3 11 180

4 11 180

5	11	180
6	11	180
7	11	180

(\* Shot location and elevations)

PROF

GPELX

(\* These are listed by station number and relative elevation. Not all  
(\* are shown.

99 -0.3443

100 -0.3443

DATUM -1

DVEL 1000

SPD R0,786

TUH R0,786

(\* This creates raster files with geometry information.

/PLGEOM

GEOMFILE 'PCGEOM3'

SURF

STAK 1

DEAD

\$EOJ

(\*\*\* HUGE.JOB

(\* This job imports segy formatted data and produces a stacked section.

(-----

(\* Job name and account. This is needed for every job.

/JOB ACCT 'PUNKIN CENTER' SCAN 72 METERS

(-----

(\* This calls in the segy formatted data and modifies the trace headers.

(\* There are four files, PC3A, B, C and D. Only PC3A is shown below.

(\* The others are imported using the same format

/SEGYPIN

FILENAME 'PC3A' BYTES 4336

/PRMODCOM INITPR

MODIFY KNSHOT SET 196

MODIFY KRECS SET 48

MODIFY KNTR SET 48

MODIFY KTRACS SET 9408

/PRMODCOM

MODIFY KNSHOT SET 196

MODIFY KRECS SET 48

MODIFY KNTR SET 48

MODIFY KTRACS SET 9408

/DOUT FILENAME 'PC3A'

(-----

(\*Renumber and merge the data files.

/DIN FILENAME 'PC3A'

RESEQIT 1

FILENAME 'PC3B'

FILENAME 'PC3C'

FILENAME 'PC3D'

(\*Change the units to meters.

/PRMODCOM

PR 'KSHOT'

PR 'KTRACE'

PR 'KUNITS'

/PRMODCOM

MODIFY 'KUNITS'

SET 1

/PRMODCOM

PR 'KSHOT'

PR 'KTRACE'

PR 'KUNITS'

/DOUT FILENAME 'PUNKIN'

(-----

(\* Apply the geometry file created by GEOMETRY.JOB.

/GEOMETRY GEOMFILE 'PCGEOM3' USE

(-----

(\* Get rid of bad traces. Only a few of the entire 790 files are shown.

/ZERO

FILES D1 790 1 TRACES 1

FILES 10 TRACES 36

FILES 15 TRACES 37

FILES 44 TRACES 2

FILES 45 TRACES 2

FILES 54 TRACES D2 7 1  
FILES 57 TRACES 2, 3, 4, 5, 6, 7, 8, 47, 48

(\* This smooths the data in case of large spikes.

/DESPK

(\* Create a raster file of every 40th edited field file using an  
(\* auxillary data stream. Note that each auxillary data stream must  
(\* begin with an /AUX statement and end with and /ENDAUX.

/AUX

FILE D1 790 40 TRACES D1 48 1

/DISPLAY

HORZ 10

VERT 20

/ENDAUX

(-----)

(\* This applies a frequency deconvolution to the data to assist in the  
(\* delineation of the various horizons.

/FRQDECON

BANDPASS 50,20,140, 36

SMOOTH 20

ZONE 1

DESIGN 995, 0 25 500

DESIGN 1355, 0 25 500

/DOUT FILENAME 'PUNKFRQ2'

/STVF

BYFILE

BANDPASS ZERO

FILT 1,60,30,140,20

APPLY 1, 2, 1 0, 790 0

(-----)

(\* This applies the statics to the data. They are applied again later  
(\* in the job.

/STATAPLY

(-----)

(\* Apply mutes to the data. Not all mutes are shown.

/MUTE

BYFILE

(\* A front-end mute.

FMUTE 1, 2.5 15, 117.5 75

(\* A tail-end mute.

TMUTE 24, 2.5 20, 97.5 500

(\* A velocity mute to remove the air wave.

/MUTVEL

TAPER 64

MVEL 350

LWIN 40

(-----)

(\* Gather the data into cdp gathers.

/GATHER

OUTSORT 2

NODUMMY

(\* Apply an automatic gain control function with a window of 250 ms

/AGC  
WINDOW 250

(-----  
(\* Assign a set of time/velocity pairs to the cdp gathers. Not all  
(\* velocities are shown below.

/VELOCITY  
VEL 4, 199, 5, 20 1100, 90 1400, 200 2000, 250 2900, 300 4000  
VEL 705, 1610, 5, 20 1100, 120 1300, 200 2000, 250 2500, 400 4000  
VEL 730, 1660, 5, 20 1100, 90 1300, 200 2000, 250 2500, 400 4000  
VEL 750, 1700, 5, 20 1100, 90 1300, 200 2000, 250 2500, 400 4000  
UNITS M MSEC

(\* Apply the statics to the data. This was necessary to do again due  
(\* to a SierraSEIS programming flaw.

/STATAPLY

(\* Apply normal move-out to the data.

/SNMOM

(\* Create a stacked section of the data.

/STACK

(\* A post stack AGC window of 25 helps to delineate the finer features of  
(\* the stack.

/AGC WINDOW 25

(-----  
(\* Apply a bandpass filter to the stacked data.

/STVF

BANDPASS ZERO  
FILT 1, 60, 30, 140, 20  
APPLY 1, 2, 200 0, 1800 0

(-----  
(\* Create a raster file of the stacked data.

/DISPLAY

HORZ 60  
VERT 7.5  
WINDOW 0, 400  
TIMELINE 10, 50, 100

(-----  
(\* The end of job card. This command is needed in every job.

\$EOJ

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