

DIGITAL DISPLAY AND PROCESSING OF SEISMIC DATA

Objective:- To examine common ways of plotting and manipulating seismic field data.

Outline - Given a multitrace digital seismic recording of a single shot (shot gather) recorded along a straight profile, apply the VISTA70 seismic processing software package on the Geophysics Laboratory PC's to investigate the information content of this data .

See "GETTING STARTED" before doing anything on the computer.

Note:- VISTA is proprietary software. Copying it without permission is a serious offense.

Introductory remarks:- The report you submit for this exercise should consist mainly of a set of plots with captions or other explanatory notes attached to them. Use the VISTA HARD (copy) screen dump command to produce the plots on the laser printer.

Each of your plots should be supplied with a caption. It should outline the processing and plotting parameters which were used to produce the plot. Also, you should include some descriptive comment on what the plot shows (or does not show); eg. how this particular presentation of data compares with some other presentation.

The objective of the exercise is to familiarize you with various ways seismic data can be presented for analysis, and to introduce you to the potential of digital processing tools. The exercises prescribed below are not meant to be rigid. If you wish to explore some particular aspect of VISTA, go ahead. However, make sure that your level of effort is comparable to that suggested below. You may work in pairs to produce a basic suite of plots. However, the report and plot captions should be your own.

1. Presentation of Raw Seismic Data as a "Shot Gather:- Learn how to bring digital data sets into Vista and plot seismic traces the screen (or to specified parts of it) (READ, PLOT); also how to control plot scales and the type of plot with SET. How many traces are in your gather? How many time samples per trace? Investigate different ways of plotting the traces (eg. wiggle, wiggle + variable area fill, variable density, etc.). The default method of plotting automatically scales the trace data to the plotting window. Note that some traces may be skipped to prevent overcrowding. Learn how to plot a selection of traces, and to GRAPH a single trace.

2. Scaling of Amplitudes:- Often, one part of a trace is of very high amplitude, but an equally important part is of much lower amplitude and gets lost graphically if an amplitude plotting scale suitable for the strong event is used. VISTA provides a variety of ways to adjust the amplitude of the traces. The scaling can be controlled by a mathematical function of time whose parameters you set (GAIN) or it can be adjusted from trace to trace such that the average rescaled amplitude is unity (MEAN), or can be adjusted continuously by an automatic gain control function (AGC) which rescales the amplitude of each trace point according to the average of the (original) trace amplitude in a specified time window around that point. The AGC time window moves along the data trace (and from trace to trace) as the scaling proceeds. Experiment with some of these scaling functions, and describe their effects on the data.

3. Identifying Types of Waves:- Interpretation of seismic data usually focusses mainly on the identification of patterns in the seismic records, and tracing of these patterns in the $x-t$ plane (i.e. the plotting plane of arrival time vs receiver distance). The various linear or curving elements of the pattern each correspond to different seismic waves, either of different fundamental type (P, S, Raleigh, Love) or having different propagation paths. For this identification, correlation of the ground motion from one trace to the next is the key. On a suitable data plot, identify the first arriving P waves and determine their apparent velocity of wave travel along the geophone spread. Identify slower surface waves and some reflected P waves coming from deep strata.

4. Amplitude Spectrum:- An important characteristic of a trace (or a selected part of a trace) is its frequency content. This can be examined by calculating the Fourier Transform (a complex function) of all (or a part) of the trace and then displaying the absolute amplitude or the power (= amplitude²) of the transform (i.e., the amplitude of each different pure frequency component in the signal) as a function of frequency. This is called the amplitude (or power) spectrum of the signal. Try this (AMPL). Plot the amplitude spectrum of one trace on linear and/or logarithmic (decibel) scales using GRAPH or DBGR. Note that the spectrum is computed at half as many frequencies as there were points in the original time series, and that the highest frequency has a period equal to twice the time series' sampling interval. Compare the spectrum of a trace dominated by surface waves with one dominated by reflections. (It is usually best to have applied a GAIN or AGC to the record first. Why?)

5. Band Pass Filtering:- Bandpass filtering can help with the identification of wave patterns on a seismic section. (This is somewhat like adjusting the high and low frequency tone controls on a sound system). For instance, try to create a record in which the surface waves are suppressed and the reflections enhanced by removing lower frequencies from your record using the command FILTER.

Experiment to find a suitable low frequency cutoff. Does the sharpness of the cut off have much effect on the result? (Try a totally sharp cutoff, to see.) Examine the first arrivals on the filtered and unfiltered records to see if the filtering process generates any "artifacts" of in your result? Can you explain them? Look also for possible "wrap around" from before zero time into the end of the record. Why does this occur with digital fourier transformation?.

6. Reflection Events:- Reflections from horizontal strata exhibit a $t - x$ arrival time curve which is hyperbolic, or nearly so. (Prove this for yourself.) The apex of the hyperbola is under the shot location at a time equal to the two-way vertical travel time through the strata. The asymptotes of the hyperbola have an x/t slope that estimates an average of the velocity through the strata (actually the root-mean-square vertical velocity, time-averaged from the surface down to the reflector). Use the measuring device DIFF to fit a hyperbola to a selection of the reflections visible on your gather and estimate their depths and RMS velocities. (Note that DIFF was designed for a different purpose than we use it for here. To be correctly calibrated in velocity, it needs to be given a value of the trace separation of 16.5 m which is half its true value of 33 m).

GETTING STARTED IN VISTA

1. **BACKGROUND** VISTA manipulates digital data "records" that contain sets of "seismic traces"; i.e, sets of time-sampled values of seismic amplitude at one or more recording point, along with some "header" information that identifies the shot and receiver (seismometer) locations, etc. A VISTA record usually contains many traces, but all traces will have the same time duration and number of time samples. Also, the records you work with initially all will have the same number of traces. VISTA keeps the data records that currently are being processed in "registers" labelled A to Z, and it provides a large list of commands which can execute various operations on an input data record and (generally) will write a new register as a result. Consult the abbreviated manual to get started or use the on-line help via the function keys F1 and F2.

2. **COMPUTING ENVIRONMENT** The computers in the lab are of the INTEL/MICROSOFT type, and use the WINDOWS 95 operation system. You need to familiarize yourself with the basic operating functions in such a computer; for instance, exploring the file system with Windows Explorer, moving and deleting files, starting programs. VISTA70 is a "DOS" program (designed for older generations of this computer operating system) and operates in these computers in the so-called DOS shell. DOS is case insensitive and restricts file names to 8 characters.

Seismic data for the laboratory exercises are in "folders" in the directory C:\SEISDATA. The records used in this exercise are in the folder \NTRO and are named Sgxxx.sgy. We do not want these files corrupted by accident or design. Therefore, copy them into the temporary working directory---C:\USERS\TEMP. This directory should be empty when you start and cleaned out when you finish your lab work. If necessary, clear it yourself before starting anything. If any file is to be kept between lab sessions, you should copy it to your personal diskette or to a personal directory in C:\USERS. VISTA will create temporary as well as permanent files in the \TEMP directory, and will clean up after itself if you exit from the program by the usual EXIT route.

You should start VISTA70 from the icon on the desk-top or from the Start-Programs-list. This will define your working directory as USERS\TEMP. Otherwise, you may need to find your current working directory with the VISTA command CWD and use the command CUR to alter it to the desired one. Then you will be able to read the SEG Y seismic data files in USERS\TEMP without any directory references.

When VISTA begins, it will show you a list of VISTA modules. Choose the "Analysis" module by typing <enter>.

3. VISTA INTRODUCTION

The most important VISTA commands, to start with, are READ and PLOT.

READ transfers a data record written in an "archival" data file format called SEG Y (Society of Exploration Geophysicists Y format) to one of VISTA's internal "registers".

PLOT displays the contents of a designated internal register to the screen.

Exit from any operation with <escape>. Exit from VISTA and clear your registers with QUIT or EXIT. Exit temporarily with DOS.

Function keys 1 and 2 provide on-line help. F2 help can be applied to the command list provided by F1, by typing it after F1, or you can get full help on specific commands by typing <command name> <return> <F2> on the VISTA command line. Use "Help" to find commands and understand the syntax associated with them, or examine the posted Command List (also the printed manuals), if this seems easier.

You can enter a VISTA command by typing the name followed by <rtm>. You then receive a series of prompts for more information. Or you can use the full command syntax which typically is

<COMMAND> <a> put <parameter> <parameter>

Only the first three or four letters of the command are necessary. The first referenced register contains the data to be processed, the second specifies where the result is to be put. Use the prompting method initially.

It is not necessary to process all the data in the input register. You can select a trace or a range of traces by adding a square bracket to the register name, e.g., a[1-20] , b[5] , etc. In some cases you can also select a time range by supplying one or more time parameters in the command sequence.

Experiment with processes by plotting the input and the output register in the same way (side by side is often good). To help yourself understand the function of a VISTA process, try it with greatly different parameter values. Be sure to keep track of what processing steps have been applied to the data as various new registers are generated.

BEFORE LEAVING THE LAB, PLEASE CLEAN UP USER\TEMP AND ANY OTHER DIRECTORIES YOU HAVE USED.