LFASE Data Processing System Overview

by

W. S. Little

Information Processing and Communications Laboratory
Applied Ocean Physics and Engineering Department

S. T. Bolmer

and

R. A. Stephen

Geology and Geophysics Department

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts

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LFASE Data Processing System Overview

1 INTRODUCTION

This technical report provides an overview of the LFASE data processing system. This software system is made up of over twenty-five programs which are used to acquire, reduce, and analyze acoustic seismic data collected during the Low Frequency Acoustic Seismic Experiment (LFASE) (Stephen *et al*, 1989; Koelsch *et al*, 1990).

This report is directed at scientific and engineering personnel who wish to understand the overall LFASE data processing system as well as the individual processing procedures which are utilized during each stage of data reduction and interpretation. The report is also directed at programmers, data processors, technicians, and other individuals who plan to work with LFASE programs and data.

The major purposes of the LFASE data processing system are:

- To convert raw LFASE seismic data as recorded on “CGG” optical disks (CGG, 1988) into calibrated “ROSE” format time series (Latraille, 1983; Latraille and Dorman, 1983) for subsequent analyses by scientists at WHOI and elsewhere.
- To exercise quality control over the data, to eliminate questionable data, and to add related information from other data sources to the actual seismic time series data.
- To organize the ROSE files into time series of manageable length, where each file in general corresponds to a particular shot instant (explosive or air gun event) or noise interval.
- To associate accurate time and location (navigation) data with each ROSE time series.
- To produce specific “data products” such as time-series, spectra, coherence, statistics, and instrument orientation information, generally

in graphical form, which are of specific scientific or technical interest to principle investigators, sponsors, and others.

2 OVERVIEW

Figure 1 is a complete LFASE computer system diagram showing the various stages of data processing, beginning with data acquisition in the borehole instrument and ending with the generation of final data products, including time series and spectral plots. The top portion of the figure includes the Data Acquisition and Reduction stages. The bottom portion of the figure includes the Data Interpretation stages.

In the figure, the boxes with bold outlines represent the various LFASE processing stages. Within each stage there are one or more individual computer programs, data files, printer outputs, and plotter outputs which are described in the sections that follow. Dotted lines indicate places where manual intervention is required. Generally, these are points where a subjective decision is to be made based on the results of one or more earlier processing steps, and where parameters must then be manually entered into a disk file using a VAX/VMS editing program. The use of the VAX editor to create or modify PAR parameter files (or COM command files) is not shown in the figure.

2.1 Summary of Processing Stages

The purpose of the various data processing stages may be summarized as follows:

- Data Acquisition and Preprocessing

Geophone and hydrophone measurements are recorded on optical disks within the sea-floor instrument package and on the ship, previewed, edited, catalogued, and archived immediately following the experiment.

- Directory Preprocessing

Optical disks are scanned to create on-line directories of data files together with information on recording times and file lengths.

- Shot Instant Preprocessing

Navigation and shot time data from the “shooting ship” are used to determine the precise makeup of the ROSE data files which are to be produced for subsequent analyses and distribution to scientists.

- Event Time Diagram Generation

Data from various sources are combined to produce a chart showing the chronological sequence of events comprising the overall LFASE experiment.

- Navigation Chart Generation

Mercator plots showing ship, shot, and instrument locations corresponding to key experimental events are created.

- CGG File to ROSE File Conversion

The individual CGG optical disk files are converted to groups of ROSE format files on VAX/VMS magnetic disk storage, where each ROSE file contains data from a single shot or noise interval.

- Distribution Tape Input

ROSE Distribution Tapes are converted to WHOI ROSE Format.

- Synthetic Seismogram Input

Synthetic seismic data generated by numerical models may be converted to ROSE format so that these data may be analyzed using LFASE software.

- Time Series Plotting

Multi-channel and multi-shot time series plots of ROSE format data are generated for analysis and distribution to scientists.

- Selection of Event Times

The travel times of energy in selected phases from source to borehole receiver are chosen interactively for velocity analysis. These times are also used during polarization and amplitude analysis to locate specific events in the data files.

- RMS Calculations

Root mean square values for various sampling intervals are computed for use in instrument calibration and noise analysis.

- Noise Data Analysis

Spectral analyses are performed on those ROSE format time series which correspond to noise intervals, and the results plotted.

- Spectral Analysis

Spectral coherence and covariance analyses are performed on selected shot data, and frequency and time series plots are created.

- Distribution Tape Output

ROSE format disk files are transformed to 9-track 6250 bpi magnetic tape files, and individual sample values are converted from VAX Integer*4 to IEEE standard floating point format.

- Covariance Calculations

The orientations within the borehole of instrument packages 1, 2, and 4 are determined by comparing the signal strengths recorded by the two horizontal geophones.

- Power Calculations

The power in selected arrivals is computed. These data are plotted at the locations of the source shots, and contour plots are created showing signal power as a function of bearing.

- Particle Motion Calculations

Plots are produced showing the 2-dimensional "particle motion" trajectories in three orthogonal planes during the passage of specific phases.

- **SAC Data Processing**

ROSE files are converted to Seismic Analysis Code (SAC) format and processed using SAC software (SAC, 1989).

- **Other Analyses**

Provision are made for further analyses using programs which have yet to be fully developed.

2.2 Computer Configuration

Except for the programs in the Data Acquisition and Preprocessing stage, and some of the programs in the Synthetic Seismogram Input and SAC Data Processing stages, all LFASE programs described in this report execute on a microVAX computer system running the VMS operating system. The VAX is equipped with a Mountain Optech optical disk drive, a Viking SCSI interface, a Cypher M990 tape drive, a DEC VR260 (emulating a Tektronix 4014 graphics terminal), and up to 1900 Mbytes of magnetic disk storage.

2.3 Graphics

The computer graphics software utilized by program PICKPLOT is the Tektronix PLOT10 package which requires a Tektronix 4014-type computer terminal with cross-hair input capability. All other graphics software is based on the Calcomp basic subroutine library and WHOI's Calcomp-based XYPLOT plotting utility program which generates most of the LFASE graphical output.

All of the Calcomp-based programs actually send indirect commands to WHOI device independent "deferred plotting" files, which are then post processed by device-specific output programs to produce hard copy or screen graphics. The deferred plotting files and the post processing steps are implied but not shown in Figure 1. The graphical output shown in the figure corresponds closely to the deliverables in the original "Data Analysis Plan" (JHU/APL, 1989) provided by scientists to LFASE sponsors.

3 PROCESSING STAGES

3.1 Data Acquisition and Preprocessing

Geophone and hydrophone measurements taken by the sensors in the borehole are digitized and encoded in the instrument electronics package, and then recorded on optical disks by an MS-DOS computer (Koelsch *et al*, 1990). In the case of autonomous operation, the instrument is connected directly to the computer which is above the borehole on the sea floor. In the case of tethered operation, the instrument is connected to a shipboard computer by means of a serial data link.

Each of the eleven geophones and the single hydrophone in the instrument package measures the velocity of vibrations in the surrounding medium. Measurements are taken every 8 milliseconds (i.e., at a rate of 125 samples/second). Geophone measurements in nanometers/second, and hydrophone measurements in microPascals, are converted to 16-bit digital values, combined with other digital values describing the time-of-day, state of the instrument, scaling of the data, and scan count are transmitted to the instrument computer. An individual data value consists of a 12 bit mantissa and a 4 bit characteristic, thus giving the instrument wider dynamic range than would be possible with unscaled data (CGG,1988a). Every 8 milliseconds the computer receives a "scan" containing 32 bytes (12 samples times 2 bytes/sample plus 8 bytes of engineering data).

Figure 1 shows the Multilock control unit which is associated with the CGG instrument subsystem (CGG, 1988b; Géomécanique, 1988). The Multilock has built-in firmware to perform signal processing and statistical operations, instrument calibration, and troubleshooting.

The instrument computer is an MS-DOS based IBM PC compatible computer, either a specially built low-power system encased in a pressure housing for sub-surface acquisition, or a shipboard NEC Powermate 2 (or equivalent) for tethered seafloor-to-surface acquisition. The computer blocks the data into 2Kbyte records and writes the blocks to Mountain Optech optical disks. At the beginning of each prespecified interval, the computer opens a new optical disk file, writes certain header information

to the file, and then begins recording data blocks. At the end of each interval, the computer stops writing data blocks, writes some trailer information, and then closes the optical disk file.

At the completion of an experiment, the optical disks are checked for file completeness, consistency of recording times and file lengths, incrementing scan counter values, and proper "engineering data" values. In some cases, built in quality control information can be used to correct files and data that have been improperly recorded, using the program CGGEDIT. In any case, quality assessments of each recorded time series can be made. Original data files can be copied to new optical disks to provide backup of valuable data, and to reorganize and combine related data onto single disks. Selected time series may be displayed and plotted with the program QUICKLOOK. These operations are performed on an MS-DOS computer, typically the same computer used for tethered data acquisition.

Original, backup, and corrected copies of optical disks are at this point available for LFASE post-processing. Throughout this report, these files are collectively referred to as CGG files.

3.2 Directory Preprocessing

A VMS-based microVAX computer is used to scan the optical disks from the instrument computer in order to generate disk directories, a master directory of all data files, and lists of the starting times of each file as measured by the various instrument clocks.

CGG optical disks are preprocessed using the programs STRIPDUC0, CGG2ROSE2 (MODE 4), and VMS COPY to create on-line directories of individual disks, and a composite directory of all CGG files written during the LFASE experiment. Also generated is an on-line listing of the start times associated with every CGG file, as recorded by the electronic clocks in the instrument package. During later processing stages, these information will be correlated with clock data and navigation data from the shooting ship in order to provide a chronology of experimental events that occurred in the borehole, on the measuring ship, on the shooting ship, and at the explosive source.

3.3 Shot Instant Data Preprocessing

Shot times, shooting ship navigation data, and information describing the location and depth of the shot are sent from computer systems aboard the shooting ship to the VAX post processing computer by means of electronic mail. These data, which are in four dissimilar formats, are extracted from E-mail files and combined using the VAX editor to produce data files containing air gun and explosive shot instant information in standard format. Together with the CGG master directory, these edited shot files are read by the program NORDAMERGE and used to produce a complete chronology containing entries for every significant event that occurred during the experiment. The file includes:

- shot times, navigational data
- optical disk start times (open times)
- optical disk stop times (close times)

NORDAMERGE performs corrections to the different clock values contained in the various input data files so that all times are accurately correlated to the time standard for the experiment (GMT obtained from the satellite navigation system). In particular, the program corrects for known instrument clock drift.

At this point the data analyst checks the file for consistency and accuracy, makes necessary corrections and adjustments, enters corrective information into the appropriate parameter file, and then reruns NORDAMERGE to produce a revised event chronology. This process is repeated until anomalies such as erroneously overlapping files and spurious shot information are eliminated.

NORDAMERGE produces several other output files. It writes two alternate chronology files corresponding to explosive shots only and airgun shots only. It writes files containing information for producing a concise time-diagram (milestone chart) showing shot times and recording intervals. It writes ship navigation information to a file for subsequently creating navigation diagrams to better illustrate the relative positions of ships, shots, and the instrument.

The corrected chronological information is next processed by the program TIMESORT. TIMESORT produces a master listing of the precise starting times of all of the ROSE format output files which the data analyst wishes to create from the combined CGG disks from the entire LFASE experiment. The intent is to accurately divide up many CGG files (containing millions of samples overall) into hundreds of separate ROSE files, each of which corresponds to a single shot event or noise interval. In effect, TIMESORT achieves this by producing a "script" which tells CGG2ROSE2 how to split up CGG files into ROSE files.

TIMESORT requires as input the corrected NORDAMERGE chronology file, the file specifying NORDAMERGE file length corrections, and optionally a third file specifying "file-gaps", that is, time intervals during which shots occurred but shot instant data are not readily available. TIMESORT writes the ROSE start-time master list. It also writes a file containing information on shots which were never actually recorded in CGG files.

3.4 Event Time Diagram Generation

Two data files created by TIMESORT are used by program XYPLOT to produce a diagram which plots the occurrences of shots and other events such as earthquakes, together with CGG disk file events such as opens and closes, as a function of time during the entire LFASE experiment. This diagram is useful in helping the data analyst organize and select ROSE file time series for further processing.

3.5 Navigational Chart Generation

The program NAVSTRIP extracts shot numbers and navigational data from files created by either of the programs NORDAMERGE or TIMESORT. NAVSTRIP produces a data file in "MBATR" format which is then processed by the WHOI navigation plotting utility program CHART.

The CHART program plots geophysical data along ship tracks. (Several versions of CHART exist at WHOI. LFASE presently uses an older version

of CHART because the new version is not compatible with the LFASE input file format.) CHART requires two input parameter files in addition to the MBATR data file, a “sense switch” file containing general plotter options, and a “run-time” file containing data-specific options.

CHART plots are useful in synthesizing and analyzing LFASE data because they give a concise geographic overview of part or all of the experiment. This allows the investigator to cross-check various data gathered by many instruments and computers, and entered by many individuals. Shot numbers, shot times, and instrument locations may be conveniently displayed along with ship and shot locations so that incorrect data (such as latitude/longitude values with the wrong sign indicating the wrong hemisphere, or azimuths that are accidentally 180 degrees off) may be readily corrected. In addition, data corresponding to groups of shots such as “lines” or “circles” can be quickly identified and their shot numbers grouped together for subsequent processing. In general, CHART plots aid the investigator in organizing and exercising quality control over large amounts of data, and ultimately in “fine tuning” the information that is to be placed in the ROSE file headers

3.6 CGG File to ROSE File Conversion

The program CGG2ROSE2 (Little *et al*, in press) converts each optical disk CGG formatted data file to a series of one or more ROSE format files on VAX/VMS magnetic disk storage. CGG data values are de-multiplexed into separate sensor channels, converted to VAX Integer*4 values, divided into sections corresponding to time periods that are required for output ROSE files, blocked into ROSE file buffers, and written to each ROSE file, channel by channel. CGG2ROSE2 uses the ROSE start time script file created during the Data Directory Preprocessing Stage to determine at what point to terminate the current ROSE file and begin a new ROSE file.

CGG2ROSE2 writes a standard ROSE header record at the beginning of each ROSE file, followed by blocked data for channel 1, blocked data for channel 2, and so forth, ending with blocked data for channel 12. CGG2ROSE2 then closes this ROSE file, opens a new ROSE file, and

repeats the process until all CGG files have been converted.

CGG2ROSE2 creates a log file, a condensed output listing, and a file containing copies of the individual ROSE file headers that were written to all of the actual ROSE files during the current computer run. This "alternate header file" is useful in making later corrections to the original ROSE file headers, for example, when revised shot instant data become available. (Currently the precise ROSE header replacement technique has not been specified.)

CGG2ROSE2 checks each CGG data scan to insure that the value of the scan counter field is incrementing by 4 (modulo 16384) with each successive scan. If the scan counter is not incrementing properly, a scan counter error message is written to the output log. Scan errors are generally detected during the data acquisition and preprocessing stage, and in most cases can be corrected using the MS-DOS program CGGEDIT. Those found by CGG2ROSE2 can be re-edited with CGGEDIT and then reprocessed with CGG2ROSE2.

3.7 Distribution Tape Input

ROSE format magnetic tapes from other organizations may be converted from ROSE Exchange Format to WHOI ROSE Format so that these data may be analyzed using the LFASE processing system. This is the inverse of the process of creating ROSE Distribution Tapes (Section 3.14).

3.8 Synthetic Seismogram Input

LFASE processing software may be used to analyze "synthetic" seismic data generated by numerical models. Subroutine libraries exist which allow modelling programs to write 12 channel ROSE format output files.

3.9 Time Series Plotting

The plotting of time series is accomplished using the program LFAZO which is a derivative of the WHOI seismic plotting program BONZO dating back to the ROSE experiment. LFAZE-specific modifications to the earlier program were made to produce plots of 12-channel data which are arranged into four groups corresponding to the configuration of sensors within the four "satellites" which make up the borehole instrument package.

LFAZO utilizes an input parameter file and a shot number file which together describe the format of the graphical output, the scaling of the plotted data, and the location and number of ROSE files to be processed. In addition to producing plotter output in specialized LFAZE format, the program LFAZO creates log and listing files.

LFAZO time series plots of shot and noise data are used for many of the "Data Analysis Plan" products which have been requested by the LFAZE investigators and sponsors. LFAZO plots are also useful in the event time selection stage of processing.

3.10 Selection of Event Times

During this stage, the programs PICKPLOT and PICKUT are used to select instants at the beginning of the time series segments of specific interest (e.g., compressional and shear wave arrivals), and to create disk files containing information about the selected events for use by subsequent analyses programs.

The first program PICKPLOT uses a Tektronix 4014 computer graphics terminal, or an equivalent terminal emulator. It employs interactive graphics software which is based on the Tektronix PLOT10 library. The PICKPLOT program allows the user to display selected ROSE file time series on the screen, and then designate starting points for events of interest using cross-hair cursor, mouse, and arrow keys.

Information pertaining to the selected ROSE file, ROSE header, sensor channel, and "event" start time are written to a "PIK" file by PICKPLOT. A series of PIK files is then read by the program PICKUT which combines

and reformats the information to produce a standard file called a P2O pick file. P2O pick files are used as input to COVAR12, POWCALC, POLAR, and other programs during later processing stages. PICKUT also produces plots of spectral plots and time series plots.

3.11 RMS Calculations

The program VRMS calculates root mean square voltages over selected data intervals. These values are useful in checking instrument calibration and verifying that LFASE software is correctly converting data to physical units. The output of VRMS may be compared with statistical and calibration data provided by the Multilock portion of the data acquisition system.

3.12 Noise Data Analysis

Those ROSE files which pertain to noise windows may be processed using the program NOISE1 which creates plots of spectra and related information such as noise power in selected frequency bands. NOISE1 generates much of the graphical data required for the LFASE Data Analysis Plan.

NOISE1 utilizes an input parameter file containing information regarding ROSE file names, start times and durations, number of windows to use in performing noise calculations, and plotting parameters. The plotting utility XYPLOT is used to plot data created by NOISE1. XYPLOT uses a parameter file which may be created automatically using the preprocessing program NOISEPLOT.

NOISE1 writes a log file and six kinds of intermediate output files. These are the NCOHER, NPOWER, SPEC, TS, CHNSPEC, and COHER files. Each of these files may be used as input to XYPLOT to produce plots which show multiple time series or spectra as a function of shot number, azimuth, range, or channel (sensor) number.

The NCOHER file contains coherence data for all twelve channels for six specified frequency bands. (The program can be modified in a straightforward manner to use the NCOHER file for either cross-correlations or power values instead of correlations.) The NPOWER file contains noise

power values for all twelve channels for six specified frequency bands. Either NCOHER or NPOWER may contain information from several ROSE files.

Optionally, NOISE1 creates a SPEC file for each specified channel for each shot of interest. Each SPEC file contains the spectral values for a single wide band averaged over several data windows.

NOISE1 also optionally creates a TS file for each specified channel for each shot of interest. Each TS file contains the calibrated data making up the time series in the specified windows. A single run can produce many SPEC and TS files for each of several ROSE input files.

For each ROSE file, NOISE1 generates a file of spectral power values for each of the six specified frequency bands, as well as a file of coherence, power, and cross-correlation values for each of these bands. These are the CHNSPEC and COHER files respectively.

COVAR12 requires an input parameter file describing which ROSE files to process and which narrow frequency bands to utilize.

(COVAR12 also requires a dummy input file; the program is often used to process non-LFASE data in a manner that utilizes this input file.)

3.13 Spectral Analysis

The program SPEC is essentially a subset of the program NOISE1. SPEC is easier to operate than NOISE1, but can only process one ROSE file in a single run. Like NOISE1, SPEC generates spectral plots and time series. Unlike NOISE1, SPEC can not perform a 6-band frequency analysis. SPEC analyzes only one event at a time. SPEC creates data files which are then plotted with XYPLOT.

3.14 Distribution Tape Output

The program ROSETOUT2 converts "WHOP" ROSE format magnetic disk files to ROSE Exchange Format magnetic tape files for distribution to scientists and other interested individuals. Each data value is converted from

VAX Integer*4 format to IEEE standard floating point (single precision) format which is compatible with many other hardware and software systems.

3.15 Covariance Calculations

The program COVAR12 determines the orientation of the instrument package in the borehole by comparing the amplitudes of two horizontal signal components during arrival of a phase with rectilinear particle motion. COVAR12 reads ROSE files and P20 pick files to obtain the arrival times of the compressional and direct waves.. From the relative strengths and directions (+ or -) of the p-waves (or the direct waves) measured by each pair of horizontal geophones, COVAR12 computes the azimuth of the radial component, the rectilinearity (degree to which the particle motion approaches linearity), power of the arriving pulse over a 0.1 - 0.2 second window, and various covariance statistics. COVAR12 utilizes eigenanalysis to find the principle axes of particle motion. The orientation of the horizontal geophones is then computed from the azimuth of the shot.

COVAR12 writes a file of results which may be input to programs COVCONT and COVSTAT. COVCONT produces plots showing computed azimuthal instrument orientation for a number of shots plotted on a latitude/longitude chart. COVSTAT performs further statistical analyses for use in determining which instrument orientation calculations are likely to be unreliable.

3.16 Power Calculations

The program POWCALC reads ROSE files and P20 pick files, and then calculates signal power in a 0.1-0.25 second window following selected phase arrivals. It then writes a file of spectral power data for further analysis by program COVCONT.

COVCONT reads data files produced either by POWCALC or COVAR12 and generates diagrams of power or geophone orientation for each shot plotted on a latitude/longitude chart.

COVCONT diagrams, together with the statistics calculated by COVSTAT, help the user determining the probable instrument orientation. This determination is required in order to establish the axes to be used in the particle motion plots.

3.17 Particle Motion Calculations

Rose file and P20 pick files are used by program POLAR to generate particle motion plots. These plots show the trajectory followed by a particle of the medium surrounding the sensor in response to each shot. Generally the motion caused by each explosion or airgun shot is plotted in the form of three graphs showing the radial horizontal vs. transverse horizontal motion, the vertical vs. radial horizontal motion, and the vertical vs. transverse horizontal motion, each plotted over a short (0.1 -0.2 second) time interval.

In order to resolve the horizontal motion into its radial and transverse components, sensor orientation information from COVAR12 and COVCONT must be manually entered by the investigator. The relative sensor and shot locations are calculated from ROSE header and shot instant data.

3.18 SAC Data Processing

ROSE files may be converted to a format which is compatible with either VAX or SUN versions of the SAC seismic processing software. This software may then be used for further data analysis and display.

3.19 Other Analyses

Provisions have been included in the overall LFASE data processing scheme for further processing of ROSE files (and associated P20 pick files) by other analysis programs as yet unspecified. The formats of the various input files used in the other stages of processing are sufficiently general that they can be readily adapted to new analysis programs as they are developed. The plotting utility XYPLOT is sufficiently general to be utilized by new analysis programs as well. Figure 1 shows a generic analysis program labeled OTHER.

4 CONCLUSION

The suite of programs described above constitutes the complete data processing system used to prepare and present LFASE borehole seismic data in a form suitable for general use by scientists and program sponsors, instrument designers, data analysts, and other parties. At the time of this writing, all programs are operational except COVCONT, and POLAR. These two programs exist in earlier forms which are suitable for processing up to three simultaneous data channels. Currently, program upgrades are being made to handle the twelve channels required for LFASE processing.

The complexity of the LFASE processing system is rivaled by the size of the raw data set acquired during a typical experiment. In the case of the original LFASE experiment, a seven day experiment (the shooting phase) resulted in the acquisition of over 65 hours of data at 125 samples/second, and generated 945 Mbytes of optical disk data spread over eight optical disks. From these raw data, 1900 Mbytes of ROSE format data will be created and converted to one set of twenty-five 6250 bpi 9-track tapes. Copies of the tape set will be distributed to scientists and other users of the LFASE data.

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References:

- A. Compagnie Générale de Géophysique, 1988a. Multilock - Interface Unit - WHOI Version. CGG, 1 rue Léon Migaux - BP S6, 91301, Massay, France. Ref. 64W03.
- B. Compagnie Générale de Géophysique, 1988b. Multilock - Operators Guide - WHOI Version. CGG, 1 rue Léon Migaux - BP S6, 91301, Massay, France. Ref. 64W01
- C. Koelsch, D. E., Goldsborough, R. G., Berteaux, H. and Stephen R. A., 1990. A multi-node three component seismic system for Deep Sea Drilling Project (DSDP) boreholes. Proceedings of the Marine Technology Society Marine Instrumentation '90 meeting, San Diego, California.
- D. Latriaille, S. L., 1983. Archiving and exchange of a computerized marine seismic database: the ROSE data archive system. Hawaii Institute of Geophysics, HIG-83-3.
- E. Latriaille, S. L. and Dorman, L. M., 1983. A standard format for storage and exchange of natural and explosive-source seismic data. The ROSE format. Marine Geophysical Researches, 6, 99-105.
- F. Stephen, R. A., Koelsch, D. E., Bibee, D., Farrell, W. E., Pattee, W., and Spiess, F. N.. A borehole seismic array in the deep sea floor. Fall AGU, San Francisco, 1989, EOS, 70, 1216.
- G. Géomécanique, 1988. Multilock - WHOI Version - NRE Report (Software). Géomécanique, 212 avenue Paul Doumer, 92508 Rueil Malmaison, Cedex, France.
- H. Little, W. S., Galbraith, N. A., and Bolmer, S. T., in press. LFASE data transcription software: CGG2ROSE2. WHOI Technical Memorandum.
- I. Johns Hopkins University Applied Physics Laboratory, 1989. LFASE Data Analysis Plan. JHU/APL, Laurel, Maryland 20707.
- J. SAC - Seismic Analysis Code User's Manual, Revision 2. Tull, J. E., Los Alamos National Laboratory, April 27, 1989.

FIGURE 1: LFASE DATA PROCESSING

FIGURE 1b: LFASE DATA INTERPRETATION

W. S. LITTLE 5/17/90