

**NATIONAL CENTER FOR EARTHQUAKE
ENGINEERING RESEARCH**

State University of New York at Buffalo

**NCEER STRONG-MOTION DATA BASE:
A USER MANUAL FOR THE GEOBASE RELEASE
(Version 1.0 for the SUN3)**

by

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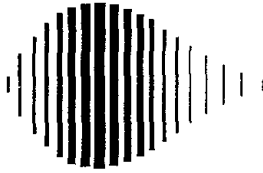
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PREFACE

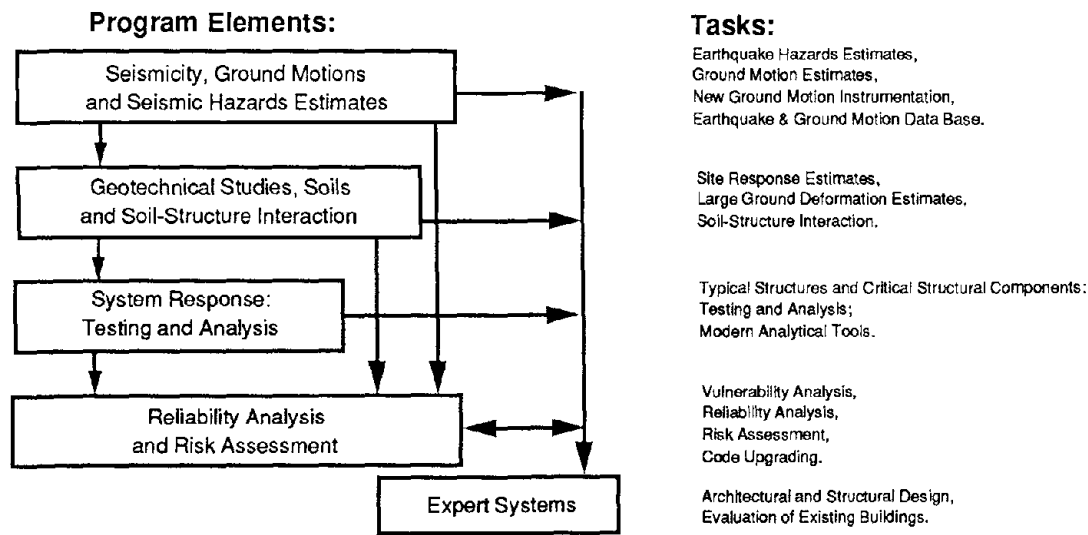
The National Center for Earthquake Engineering Research (NCEER) is devoted to the expansion and dissemination of knowledge about earthquakes, the improvement of earthquake-resistant design, and the implementation of seismic hazard mitigation procedures to minimize loss of lives and property. The emphasis is on structures and lifelines that are found in zones of moderate to high seismicity throughout the United States.

NCEER's research is being carried out in an integrated and coordinated manner following a structured program. The current research program comprises four main areas:

- Existing and New Structures
- Secondary and Protective Systems
- Lifeline Systems
- Disaster Research and Planning

This technical report pertains to Program 1, Existing and New Structures, and more specifically to seismic hazards studies.

The long term goal of research in Existing and New Structures is to develop seismic hazard mitigation procedures through rational probabilistic risk assessment for damage or collapse of structures, mainly existing buildings, in regions of moderate to high seismicity. The work relies on improved definitions of seismicity and site response, experimental and analytical evaluations of systems response, and more accurate assessment of risk factors. This technology will be incorporated in expert systems tools and improved code formats for existing and new structures. Methods of retrofit will also be developed. When this work is completed, it should be possible to characterize and quantify societal impact of seismic risk in various geographical regions and large municipalities. Toward this goal, the program has been divided into five components, as shown in the figure below:



Seismic hazard studies constitute one of the important areas of research in Existing and New Structures. Current research activities include the following:

1. Development of ground motion instrumentation and a strong ground motion data base.
2. Development of seismicity catalogs, and improved seismicity analysis methods and models.
3. Development of improved ground motion data analysis methods, computational methods and ground motion models.
4. Estimation of earthquake hazards.

The ultimate goal of projects concerned with seismic hazard studies is to provide an engineering estimation of seismic hazards and ground motion, initially for the eastern and central United States.

This technical report addresses the issue of providing researchers with ready access to strong-motion parameters and time-series data through a data base. Strong-motion data are one of the most fundamental input data into the research and practicing of earthquake hazards mitigation.

ABSTRACT

The purpose of this report is to describe the initial implementation of a strong-motion data base developed by Lamont-Doherty Geological Observatory (Lamont) under the auspices of the National Center for Earthquake Engineering Research (NCEER). The report details how to install Lamont's data base access tool, GeoBase, and how to obtain strong-motion data. NCEER's strong-motion data base combines features never before available for a single strong-motion data base. These are: (1) both parametric and time-series data are accessible over a computer network; (2) the parametric data are maintained in a relational format; (3) the time-series data are stored on-line; and (4) the time-series are stored in a consistent format (Lamont's own AH, Ad Hoc).

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The data base described in this manual would not have been possible without the hard work of many individuals affiliated with Lamont-Doherty Geological Observatory. We would like to thank each of them for their effort, particularly: Bob Bookbinder, Robert Busby, Mark Goldman, Nina Grissom, Joan Hastings, Ken Howard, Lynn Liu, William Menke, Catherine Susch, and Eugene Pekelis.

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SECTION 1

INTRODUCTION

1.1 Overview

The software package described in this report allows users of Sun 3 workstations to access data bases at Lamont-Doherty Geological Observatory (Lamont) via the Internet network. With this release, two data bases compiled by NCEER researchers at Lamont are available: a strong-motion data base that contains both parametric and time-series data and a catalog of accelerograph stations in eastern North America [1]. The former is the focus of this document. Other earthquake hazards data bases such as base maps, site-specific geotechnical borings, earthquake intensities, and earthquake catalogs may be made available in the future through the same interface. The manual first gives an overview with an explanation of the need and requirements of a strong-motion data base and Lamont's solution in terms of the data base and the access software. This is followed by: a more detailed description of the data base and the present status of the data in it (Section 2); a summary of user requirements (Section 3); an explanation of how to obtain the software (Section 4); a tutorial on how to install the software and print out the various documents (Section 5); a tutorial on how to use the software to access the strong-motion data base's parametric and time-series data (Section 6); and finally, a description of the time-series data and its related software (Section 7).

1.2 Why Another Strong-Motion Data Base?

This is a good question to ask of any new data base, but it is not too difficult to answer given the present situation regarding strong-motion data bases. At the time of this writing, several data bases that catalog strong-motion data already exist; the National Geophysical Data Center's parametric strong-motion catalog (SMCAT) [2], McMaster University's Seismological Executive (MUSE) parametric data base [3], and the United States Geological Survey's (USGS) ESM in house parametric data base [4] are just a few examples. Each of these organizations have developed parametric data bases which greatly ease the access of strong-motion parameters. Accessing the actual time-series from such data bases is another matter entirely, usually involving the time consuming process of ordering and then shipping the data in the form of a magnetic tape. Further complicating data retrieval is the problem that each agency uses its own format for data storage and transmission. The National Center for Earthquake Engineering Research (NCEER) is aware of the difficulties encountered by many in the earthquake engineering and seismological communities when accessing strong ground motion records and has devised a state-of-the-art data management and retrieval system that ends this difficulty.

The necessity of a data management and retrieval system for strong ground motion data has been stressed before; for instance the 1987 National Research Council (NRC) sponsored report titled **Recommendations for the Strong-Motion Program in the U.S.** states:

"The acquisition of larger amounts of strong-motion data by a variety of organizations results in an increasing need to develop data archiving, management, and retrieval procedures that will increase data accessibility for research and

engineering applications. The increasing amounts of data and rapidly changing computer technology suggest that a data-base management system using computer-industry-support software would be most appropriate. Preferably such a system would be based on commercially available software products to facilitate compatibility with future hardware changes. The ideal system or parts of the system should be reasonably transportable between mid-sized computers, so that the system may be maintained by appropriate agencies and research institutions. A user-friendly data-management system permitting ready access to complete strong-motion time series and spectral data bases is a fundamental need of both the scientific and engineering communities. A prime consideration is that strong-motion accelerograms be made available without delay after an earthquake to designers, researchers, and others who have a need to see the recordings."

The NRC report goes on to state that the data management and retrieval system should consist of two interactive components: first, parametric data and second, actual time-series data. Following the recommendations set forth in this document, Lamont-Doherty Geological Observatory, as a part of the NCEER program, has developed such an information system.

1.3 The Data Base

Lamont's information system combines both parametric and time-series data in a relational data base management system. A relational format was chosen for the data because it allows the most efficient means for storage and retrieval and because it provides the means with which to establish links between related data. The commercial product UNIFY is the data base management system used to store the data. The relational data base consists of four distinct tables that contain parameters about earthquakes, accelerometer stations, strong-motion records, and strong-motion time-series. Although each table is distinct, they are linked by key fields which represent interrelationships between the data. This provides researchers with the greatest possible flexibility when it comes to querying the data base. Furthermore, it was decided to focus the structure of the data base towards time-series data rather than derivative spectral data (e.g., response and Fourier spectra) since: (1) time-series are the data most requested by researchers in both the fields of seismology and earthquake engineering; (2) response spectra are not as widely available; and (3) researchers tend to prefer to derive their own spectra.

Time-series data are not stored directly within the relational data base structure, only a pointer to their location on the disk at Lamont is stored (e.g. their filename). Integrity of the data was the main purpose for doing this. All of the data are maintained on-line through the use of a 600 Mbyte hard disk; optical disk drives (WORM 2.6 gigabyte) are available for future storage of time-series data. All of the time-series are maintained in a uniform format. The format the time-series data are stored in was developed at Lamont, and is known as AH (Ad Hoc). It was chosen for two reasons: first, because of the extensive processing and analysis software package that exists for it; and second, it is stored in a binary format (XDR; eXternal Data Representation) which is machine independent. The former provides a large body of public domain software, which includes conversion programs that provide transformation of data in AH format into a variety of widely used formats (e.g. SEED, SEG-Y, PING, AGRAM, ASCII, etc.). Thus, researchers can continue to use their existing seismic analysis software or they may opt to use Lamont's package. The use of the XDR binary format in

AH, provides the ability to more efficiently store the data and, more importantly, to transmit it to other researchers without the problem of incompatibility of computer architectures.

1.4 The Data Base Interface: GeoBase

Earth scientists are constantly confronted with the need to access diverse data which commonly are geographically indexed. Lamont's solution to the problem of manipulating an abundance of data has been to develop an interactive state-of-the-art data access tool that is geographically oriented, easy to use, and very versatile. Any data set indexable by latitude and longitude can be quickly and easily accessed using this tool. More importantly, researchers need access to data that is not located locally on their computer or at their institution. This factor was also taken into consideration when Lamont's data access tool was designed.

The tool Lamont developed is known as **GeoBase** and interfaces with either of three different data base managers. They are two commercial data bases; UNIFY and DBVISTA; and Lamont's own network accessible data base manager known as DM (a flat table data base). GeoBase does not perform the actual data base management, the data base management packages perform that function. It only acts as a front-end for the user to access the data. One of the primary features of GeoBase is its transparency of data access. The user need not know where the data are located; they may be in a data base at the user's institution or they may be located thousands of miles away across a network. GeoBase communicates over any network that supports the TCP/IP protocol suite, principally the Internet.

The Internet is a wide area network that comprises several regional networks (NSFNET, MILNET, NYSERNET, etc.), hundreds of campus networks, and thousands of smaller local area networks. At last count it connected over 20,000 computers [5]. It has revolutionized the way researchers work by increasing the speed and efficiency of collaboration and data exchange. Its primary function is that of a research tool, and it is as such that GeoBase uses it.

Since GeoBase is a front-end tool and was destined for an audience with a wide variety of computer skills it was designed to be very easy to use. GeoBase allows user friendly interaction on a high resolution graphics screen via a pointer, more commonly known as a "mouse", and pull-down menus similar to the Apple Macintosh. GeoBase's versatility is that it accepts any geographically indexed data set given to the data base packages and allows quick and most important, easy and uniform access to it. Furthermore, GeoBase allows access to any number of data bases simultaneously. Once data are retrieved they may be examined, plotted on a map, and transferred to a file to be used by other programs. In short, GeoBase is a very powerful tool that allows mathematical manipulation, plotting, and extraction of geographical data.

Not only is GeoBase very advanced in its interactive and data base interfacing capabilities, it is also portable and technologically sophisticated. It was written in C language under UNIX on the Sun Operating System (SunOS 3.5 & 4.0) using the Sun graphics package SunView. GeoBase is also available in the network extensible X windows environment of MIT. Both versions have only been tested on Sun Workstations (specifically the Sun3 models). However, since it was written in C and has a version that uses X windows, porting it to other platforms should be relatively easy. Work is

currently underway to port GeoBase to Sun4s. Furthermore, GeoBase has been used extensively at Lamont for over two years and its Internet networking capabilities have been tested remotely from as far away as Buffalo, New York, Menlo Park, California, and Austin, Texas.

Since GeoBase has proven itself to be such a useful tool at Lamont and elsewhere, it allows network access to a variety of data base managers, and was designed to operate on 'mid-sized computers' (i.e. work stations), it was chosen as the primary tool for distribution of data in the NCEER Strong-motion data base.

1.5 Future Directions

The version of GeoBase described in this manual has at present one major limitation. The temporary limitation is that only sites with Sun3 workstations with Internet connections will have access to the data base. For those users who do not have access to the necessary Sun hardware, a sophisticated dial-up capability will be provided for parametric strong-motion data. This dial-up facility, known as Strongmo, is currently under development and should be released sometime in the spring of 1990. Like GeoBase, it too is menu-driven; queries are formulated using menu selections to simplify data access. Unlike GeoBase however, it is not able to provide high-resolution graphics plots of the data, because it is configured to operate on any computer or 'dumb-terminal'. Strongmo will be accessible by telephone and modem as well as the Internet. Transmittal of the time-series will also utilize the Internet through the electronic-mail and file-transfer-programs. Since current telecommunication lines limit dependable transmission of data to 2400 baud, retrieval of actual time-series will be limited. Retrieval of time-series data over the phone line will be done through the use of Columbia University's Kermit communication program.

SECTION 2

STRONG-MOTION DATA BASE

2.1 Strong-Motion Data Base Design

The design of any data base begins with a consideration of the actual data to be stored in it. Data for the NCEER strong-motion data base, principally free-field U.S. and world strong-motion records, comes from two sources: (1) the L-DGO/NCEER strong-motion instrumentation program, and (2) magnetic tapes from strong-motion data archiving agencies such as the California Division of Mines and Geology (CDMG), the Geological Survey of Canada (GSC), the National Geophysical Data Center (NGDC), the United States Geological Survey (USGS), and a plethora of smaller groups that collect and archive their own data.

The L-DGO/NCEER strong-motion instrumentation program started in the fall of 1987 with the deployment of digital instruments in the eastern United States. There are currently 20 digitally-recording strong-motion instruments, Kinematics model SSA-1, operated by Lamont located throughout the eastern United States and Canada. This array of accelerographs has, so far, provided 20 records in the eastern United States. The high quality digital data range from a magnitude 1.9 observed at less than 10 kilometers epicentral distance to the Mw 6.0 Saguenay, Quebec earthquake observed at 9 L-DGO/NCEER stations from 200 to 800 kilometers epicentral distance. A temporary deployment of instruments around the Tennant Creek area in the Australian shield has provided an additional 10 records of earthquakes. The most recent record came from a Lamont operated SSA-1 in Sand Point, Alaska which was triggered by the Mw 6.9 earthquake on September 9, 1989. This data set, although small in comparison to the volume of data collected by other archiving agencies, is a significant step towards filling the long standing hole of free-field strong-motion data in the eastern United States.

Lamont has also acquired 60 magnetic data tapes from various archiving agencies, principally (>90%) from NGDC. NGDC archives strong-motion data from many agencies, both National and International. The tapes contain strong-motion data in various stages of processing from raw-uncorrected to corrected-filtered data and response spectra.

The data from these two sources are very different:

- (1) The data vary in degrees of completeness. The data from the NCEER instruments is well documented and is essentially complete, where as the archiving agencies obtain some of their data from sources outside their control and may be incomplete.
- (2) The data vary in computer format. NCEER's instruments provide data in a consistent digital format that is easily manipulated. On the other hand, data on the magnetic tapes come in at least 20 different ASCII formats and can fall into any or all of the three common stages of processing.

- (3) The digital NCEER instruments provide immediate access via a dial-up capability. For instance, the magnitude 6 Saguenay, Quebec earthquake of last fall triggered all nine NCEER instruments in the northeastern United States. The data were retrieved within 24 hours, and a data report was issued less than one week later.

Using constraints developed from both seismological and engineering view points, as well as the three considerations listed above, a relational parametric data base that holds both the data from the archived magnetic tapes and the L-DGO/NCEER instruments was devised. The data base structure was constructed to accommodate: time-series data in various stages of processing, characteristics of the accelerometer sites, complete specifications of an earthquake, and, more or less complete, specifications of the data. This is a preliminary version of the data base and may be subject to later revisions as the data set becomes more complete and feedback from the research community is obtained.

The NCEER relational strong-motion data base consists of four tables which hold information pertinent to: events (earthquakes) for which strong-motion data was recorded, strong-motion records, individual traces (time-series), and accelerometer sites at which measurements were made. The four tables, respectively named **event**, **record**, **trace**, and **site**, hold unique entries which are all interrelated through key fields. The relationships between data in each of these tables is shown in Figure 2-1 below. Although the principal data set included in this data base are earthquakes for which strong-motion data have been recorded, each table in the data base was given a very general name (event vs. earthquake) so that varied data sets could be accommodated.

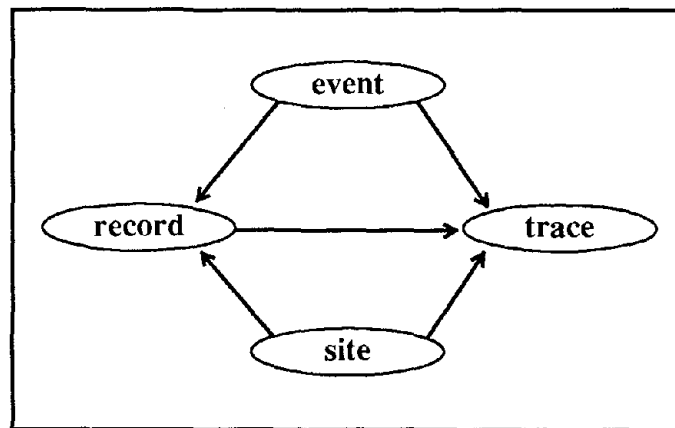


Figure 2-1 NCEER Strong-Motion Data Base tables (ovals) and their relationships (arrows). The direction of the arrow indicates a parent-child or one-to-many relationship between the tables.

One of the most important aspects of the NCEER data base is that, aside from the parameters, the strong-motion time-series themselves are stored on-line and in a uniform format. Time-series data are not stored directly within the data base. Instead, they are stored in a file with a pre-defined binary format and only the location of the file is maintained within the parameter data base.

We acknowledge that there are certain aspects of the NCEER data base design that are not consistent with the rules of normalized relational data bases. These inconsistencies will be introduced as the tables are described below, but are mainly the result of the implementation of the data base within Lamont's access tool, GeoBase. One such example is that for most relational data bases, a piece of information within one table, unless it is the key or it establishes a relationship, need not be duplicated in other tables. GeoBase however, since it is a geographically oriented tool, requires that each record (entry) within a table have a latitude and longitude associated with it. Therefore, the NCEER data base has duplication of latitude and longitude information. While this duplication may not be the most efficient in terms of storage, it allows the user to more easily access the data and visualize its spatial relationships with other data by having it plotted on a map.

Some conventions that hold throughout the data base are that: strings are all in upper case lettering; "UNKNOWN" is the default for string fields (meaning the information was not available); and 0 is the default for numerical fields (also meaning that the information was not available), unless otherwise stated. Each table has a field named comments (a string of up to eighty characters in length) that may be used to describe some detail about the entry not mentioned elsewhere. The following subsections briefly describe the four tables, their contents, and their relationships.

2.1.1 Event Table

In the NCEER data base, the event table holds information specific to events for which strong-motion data have been recorded. Events are most typically, but not always, earthquakes (e.g., quarry blasts, nuclear tests, etc.). Information in the table about an event includes; its name, epicentral coordinates, depth, moment, mechanism, country, and state (if applicable); various magnitude determinations; and sources of origin for the various information that comprise an entry. One requirement of a relational data base is that the key or primary field in a table be unique. In the event table, the primary key by which all event entries are distinguished is a combined-key consisting of the date and origin time of the event and a numerical identifier (a positive integer). The numerical identifier, known by the field name event_number, is required to allow aftershocks of indeterminate origin time to be associated with the main shock. Events whose origin time is unknown, such as an aftershock that occurs immediately after a major earthquake, are given the corresponding parameters for the main shock, with a comment to that effect placed in the comments field.

Each table in the data base is related to the others via a specific field, most often the key field of the table. An entry in the event table is linked to its corresponding entries in the record and trace tables by the combined-key of event origin-time described above (composed of the fields event_year, event_month, event_day, event_hrmn, event_second, and event_number). This link is very important since it allows a user to access the records or traces associated with a set of selected events. It is referred to as a one-to-many relationship, since for each event there may be one or more related record and trace entries. The usage of this relationship and other subsequent ones will be elaborated upon further in the discussion on the implementation of the data base in GeoBase in Section 2.2 and the GeoBase tutorial of Section 6.

The event table's field-names and their contents are described in detail below:

event_year, event_month, event_day: These three integer fields describe the date when an event occurred. All dates are given in the Coordinated Universal Time (UTC). An example date would be event_year=1988, event_month=11, and event_day=25 for November 25, 1988.

event_hrmn, and event_second: These two fields describe the origin time of an event in UTC. The integer field event_hrmn describes the hours and minutes of the origin time through a 24 hour clock notation. For instance, eleven thirty-one PM would be described by event_hrmn=2331 and one AM would be represented by event_hrmn=100. The event_second field is in decimal format and represents the seconds of the event's origin time down to millisecond precision (e.g., if such precision is available).

event_number: Since the date and origin time of the event must be unique if they are to represent the key, then there must be some way to allow for duplicate entries where the time is identical or unknown (as is the case with some aftershocks). The event_number field is an integer identifier supplied by NCEER to overcome this problem. Major earthquakes and earthquakes that are nearly singular in time are given an event_number of 1; subsequent event entries for aftershocks are given event_numbers incremented by one.

event_name: This field holds a character string of up to eighty characters in length which describes the name of an event. An event's name typically describes the location of an earthquake. It is often named after the closest population center or the nearest geographic feature. For example, Canadian earthquakes are sometimes named after the closest body of water (e.g. lake, or river as in the case of the Saguenay Quebec earthquake) if no major cities exist nearby. Additionally, the event_name may contain information on the type of event (e.g., whether it is an aftershock, "IMPERIAL VALLEY AFTERSHOCK") or a more general description of the location if a more detailed description was not available (e.g., "ALASKAN SUBDUCTION ZONE EARTHQUAKE").

country: This field is a character string of length 20 that describes the country in which the event occurred. Typical entries for data presently in the data base are: USA, CANADA, RUMANIA, PERU, CHILE, and USSR.

state: This field contains a two-character code that represents the state in which the event occurred, if and only if the country field is equal to "USA"; otherwise the string is empty. Strings are based on the U.S. postal code; some examples of state codes are: CA=California; MT=Montana; WA=Washington; MO=Missouri; SC=South Carolina; MS=Mississippi; and NH=New Hampshire.

latitude, longitude: These two fields describe the latitude and longitude of an event's (earthquake's) surface projection (epicenter) in units of decimal degrees. The epicenter determination is usually taken from the USGS National Earthquake Information Center's Preliminary Determination of Epicenters (PDE) catalog or the

International Seismological Center's (ISC) epicenter catalog; which catalog was used is indicated by the entries "PDE" and "ISC" in the location_source field, respectively. Negative values in these fields are used to represent West longitudes and South latitudes, and positive values signify East longitudes and North latitudes (this convention is used for latitude and longitude in each of the other three tables as well). If an event's exact location is unknown, it is given an approximate location and a statement to that effect is noted in the comments field of the event table.

depth: This field describes the depth, in units of kilometers, determined for an event.

location_source: Aside from knowing what the values are for parameters of an earthquake, it is also helpful to know from where the values originated. For this reason several 'source' fields were devised to hold this information. The location_source field is a string of up to eight characters in length that holds an abbreviation which represents the source of the information used for an event's epicenter, depth, and origin time. Typically the source entry will be the abbreviations PDE or ISC, however if the origin of this information is unknown and yet it comes from the magnetic tape off of which the strong-motion data was read, then the entry will be "TAPE". Other abbreviations for sources of information are detailed in Appendix A. All of the other 'source' fields in the event table are of the same length and use equivalent codes as the location_source field. This also holds for the operator field in the site table and the agency fields in the record table.

mag_l, mag_l_source: The mag_l field describes the local or Richter magnitude determined for an event and mag_l_source holds an abbreviated name of the agency or 'source' where the determination originated from. See the above description of location_source for more details on the abbreviated source code.

mag_s, mag_s_source: The mag_s field describes the surface wave magnitude determined for an event and mag_s_source holds an abbreviated name of the agency or 'source' where the determination originated from. See the above description of location_source for more details on the abbreviated source code.

mag_b, mag_b_source: The mag_b field describes the body wave magnitude determined for an event and mag_b_source holds an abbreviated name of the agency or 'source' where the determination originated from. See the above description of location_source for more details on the abbreviated source code.

mag_w, mag_w_source: The mag_w field describes the moment magnitude determined for an event and mag_w_source holds an abbreviated name of the agency or 'source' where the determination originated from. See the above description of location_source for more details on the abbreviated source code.

moment_mantissa, moment_exponent, moment_source: The first two of these three fields holds the description in scientific notation ($\text{mantissa} \times 10^{\text{exponent}}$) of the event's

seismic moment in units of dyne-cm. The `moment_source` field holds an abbreviated name of the agency or 'source' that made the determination. See the above description of `location_source` for more details on the abbreviated source code.

mechanism, mechanism_source: These two fields hold a character string that describes the focal mechanism of the event and the source of the information, respectively. Possible entries for the mechanism include: "STRIKE-SLIP"; "DIP-SLIP"; "THRUST"; "REVERSE"; and "NORMAL". The `mechanism_source` field follows the same rules outlined above for the `location_source` field.

bin: The `bin` field is an integer that represents the unique one degree of latitude by one degree of longitude region on the earth's surface where the event is located. Its only purpose is for use by GeoBase so that data for a particular region of interest may be rapidly accessed. Given a latitude and a longitude for an event, its bin is calculated as follows:

$$\text{bin} = (\text{int}) (\text{latitude} + 90.) \times 360 + (\text{int}) (\text{longitude})$$

where `latitude` and `longitude` are in decimal degrees and follow the sign convention's specified above and the notation `(int)` casts the following value into an integer (rounding down to the nearest whole value). Thus, if an event has a north latitude of 36.7 degrees and an east longitude of 112.3, then its bin number is 45472. The `bin` field is found in each of the other three tables.

comments: The `comments` field holds additional information specific to an event that would not fit in any of the other fields provided. The total length of the comment may be eighty characters and sub-comments are separated by semicolons.

2.1.2 Record Table

The record table provides a place holder for information which is common to a group of ground motion data that are related to one another. The data, for now only time-series, may be related to each other by a recording of an accelerometer or by an analysis process (e.g. double-integration of acceleration time-series into velocity and displacement). Information about a record in this table includes its: starting (trigger) time; processing stage; archived magnetic tape; digitizing, processing, and archiving agency; digitizing type; and epicentral distance and azimuth to the event.

An entry in the record table most often corresponds to a single data file on the magnetic tape since a file is often a convenient common denominator among individual time-series. For example, the file format for most 'corrected' data (acceleration time-series which are instrument-corrected, filtered, interpolated, and integrated to velocity and displacement) is data blocks for three time-series separated by blocks of header information. Thus, for corrected data, each file corresponds to a single component of ground motion at a site (see section 2.1.3 for the definition of a site) and its entry in the record table would consist of information about three time-series (one for acceleration and one for each of the resultant velocity and displacement). For 'uncorrected' data (acceleration

time-series that are a direct result of the digitized time-series), which typically have all of the data for three components of motion for a given station in one file, an entry in the record table will correspond to a 'record' of ground motion in the traditional sense. That is, where three components of acceleration are recorded on a single piece of film.

As shown in Figure 2-1 above, the record table has relationships with each of the other three tables in the data base. The key field in the record table is a unique record number assigned by NCEER to each entry or 'record'. This field is called `record_num` and relates the record table to the trace table in a one to many relationship. That is, for every record entry there exists one or more related entries in the trace table. A similar one to many relationship is present between the event table and the record table through the combined key of event origin time described above. Thus, the event origin-time fields of the event table are also present in the record table. Alternatively, an entry in the record table is related to a single entry in the site table (known as a many to one relationship) through the `site_id` field which is the unique key in the site table. Therefore, the `site_id` field is also present in the record table.

The names of fields in the record table and their contents are described in detail below:

record_num: The record number field holds an integer value which is unique for each record in the table. It is generated by NCEER and serves only to relate a record to its corresponding traces.

event_year, event_month, event_day, event_hrmn, event_second, event_number: These six fields are the combined key that relates a record to its corresponding event. See their description in Section 2.1.1 for more details.

start_year, start_month, start_day, start_hrmn, start_second: These five fields describe the starting date and trigger time of the record. The date and time are in UTC and follow the same format as specified for the event origin date and time (See Section 2.1.1).

tape_name: This field describes the name of the tape at Lamont off of which the data was retrieved. The tapename usually corresponds to the NGDC or CDMG tape names (i.e. USACA01, WHITTIER-IG). If the data is from a digital instrument operated by Lamont the tapename contains the filename of the record (i.e. h9345001.ssa).

site_id: The site identifier field is a character string of up to eighty characters which describes the location and code of the station that recorded the record. It is the field that establishes the relationship between the record and the site tables. See section 2.1.3 for a more detailed description of this field.

latitude, longitude, bin: As with all data accessed through GeoBase, each entry must have a geographic location described by its latitude and longitude in degrees and a bin number. These three fields correspond to the location of the site which recorded the record. For details about the format of these fields see Section 2.1.1.

For details about the origin of the information that enters these fields see Section 2.1.3.

epicentral_distance, forward_azimuth, backward_azimuth: These fields hold values for the great circle distance between the epicenter of the event and the site, the azimuths from the event to the site and from the site to the event, respectively. Distances are in kilometers and azimuths are in degrees from north clockwise positive. All values were determined using a reference ellipsoid for the earth.

processing_stage: The processing_stage is a letter code which describes the stage of processing that a record has undergone. Presently there are only two codes which are possible, "U" for uncorrected and "C" for corrected. If the code for processing_stage is "U" this indicates that the data for this record has only been scaled to the proper units and is a raw digitized record. The code "C" refers to data that have been filtered and corrected for instrument response.

processing_agency: The processing_agency field holds a code which describes the institution which produced the record. This field and all other 'agency' fields in the record table are identical in nature to the 'source' fields of the event table and subsequently use the same codes (See the Appendix A for a list of agency/source codes).

archiving_agency: This field describes the agency from which NCEER acquired the data. Possible values for archiving agency are "EMR/GSC", "NGDC", "CDMG", "USGS", and "MCMASTER". See the above description of processing_agency for more details on the agency code.

digitizing_agency: This field describes the agency which digitized the data unless it was done by the instrument (i.e. the original record was analog film or magnetic tape). The value for digitizing_agency is "NONE" if the digitizing_type is "DIGITAL INSTR" indicating that the recording instrument is digital. This field also uses an abbreviated code for the agency (See the Appendix A for a list of agency/source codes).

digitizing_type: This field is a string of characters which gives the description of how the record was digitized. Most of the values for this field correspond to those found in headers of data from the compilation of strong-motion records by the California Institute of Technology (CIT) [6]. Possible values and their corresponding descriptions are given below:

DIGITAL INSTR	Digital instrument (i.e. SSA1).
ENLARGED NEG	Enlarged negative used for digitization (CIT).
ENLARGED POS	Enlarged positive used for digitization (CIT).
NEGATIVE	Photographic negative used for digitization.
POSITIVE	Photographic positive used for digitization.
ORIGINAL	Original record used for digitization.
SPECIAL	Special CIT digitization.
MAGNETIC TAPE	Digitization from analog magnetic tape.

HAND DIGITIZED
LASER POSITIVE
LASER NEGATIVE
UNKNOWN

Digitized by hand.
Digitization by laser scanning of film positive.
Digitization by laser scanning of film negative.
Type of digitization unknown.

comments: The comments field holds additional information specific to a record. The total length of the comment may be eighty characters and sub-comments are separated by semicolons. A typical entry in the comments field describes in more detail the type of processing or the digitization of a record.

2.1.3 Site Table

In the NCEER data base 'site' is used to represent the location of a single instrument (3- component sensor and recorder). An entry in the site table holds information about a single instrument which produced a record of strong-motion data. Therefore, only sites for which data have been recorded are present in the data base. In most cases the sensor (3-component acceleration transducer) is a part of the recorder, but there exist instruments where many sensors may be connected, via cables, to a centrally located recorder. For these instruments, a site will correspond to the sensor package and a comment stating such will be placed in the comments field. Information about a site includes: the instrument's type, installation and removal dates, and location; the structure which houses the instrument; the subsurface geology of the site; and, the status and operator of the instrument. The key-field for the site table is its site identifier (site_id) which is a possible combination of station code, location, or instrument type. It relates an entry in the site table to its corresponding entries in the trace and record tables.

It should be mentioned that there are a couple of minor inconsistencies in the site table. First, instrument parameters such as gain, damping, and natural period are not included. The reason for this is to keep the table manageable because the values are subject to change with time. Yet these values are necessary for processing uncorrected data or for knowing the limitations of corrected data. Instead these three parameters are stored in the trace table since they are directly related to the time-series. Second, in cases where more than one instrument is present at the same location, there will be duplication of some location information (i.e. state, country, latitude, longitude, and bin number). This limitation is acceptable since most strong-motion sites have only one instrument and the number of entries where this is not true is small.

What follows is a detailed description of the fields found in the site table:

site_id: This field is a string up to eighty characters in length that represents a single site. Each site_id was created by NCEER to serve as a unique identifier for a given site as defined above. To be more informative than just a simple number, the identifier for a site is constructed from its code and location. Instrument type may be included in a few site_ids. A few examples of some site_ids are shown below:

5056 E01 - EL CENTRO ARRAY 1, BORCHARD RANCH, EL CENTRO, CA
1065 ALX - ALEXANDER BLDG, BASEMENT, SAN FRANCISCO, CA
54214 - LONG VALLEY DAM (CENTRAL RECORDER) - LEFT CREST
138 WPB - WATER AND POWER BUILDING, 7TH FLOOR, LOS ANGELES, CA

2170 SAB - ARMY BASE, SEATTLE, WA
2627 FFD - FRANKLIN FALLS DAM, NEW HAMPSHIRE: CREST
2739 KDS - KODIAK, ALASKA
279 PCD - PACOIMA DAM, CA

status: This field describes the operational status of the instrument at the site. Values for the status may be either "OPEN", "CLOSED", or "UNKNOWN". This field is closely related to the site fields 'start_...' and 'end_...' which hold the dates when a site was opened and closed, respectively.

operator: This field holds a string that represents the operator of the instrument. It uses the same codes as the 'source' and 'agency' fields from the event and record tables, respectively. See Appendix A for a list of abbreviated codes which are used for this field.

code: Most sites have associated with them a station number or code. This field is the place holder for such a code. For a given operator this code uniquely identifies a strong-motion station where one or more instruments are located. The codes could not be used as the key field since they are often not unique to a single instrument. For example, some sites in California have both a CDMG site number designation as well as a USGS station code.

state, country: These two fields describe the state and country in which the instrument is located. Both fields follow the same convention that is used in the event table for the fields of the same name.

location: This field describes the location of the instrument. It can include specific information such as the point in a structure where the instrument is attached (i.e. BASEMENT, ROOF, GROUND FLOOR, DAM CREST, DAM ABUTMENT, FREE FIELD) to more general information like street address and city (i.e. 633 EAST BROADWAY, MUNICIPAL SERVICE BLDG., GLENDALE). The maximum length of the location string is sixty characters.

latitude, longitude, bin: These fields describe the geographic coordinates of the site. They follow the same convention as the respective fields in the event table. Moreover, all three are duplicated in the record and trace tables because of the GeoBase implementation.

elevation: This field holds the elevation above sea-level of a site (in meters).

structure: This field is a string of up to forty characters which holds a description of the structure in which the instrument is housed. Although this field may contain very specific terms about the structure (e.g., 2-STORY WOOD FRAME, REINFORCED CONCRETE, EARTHEN, BOLTED TO CONCRETE PAD, FREE-FIELD, SEISMIC VAULT, etc...), it may be searched for common terms like BLDG (short for building), DAM, or UTILITY. It was designed to be a very flexible description and does not hold to any rigid format.

geology: This field, like structure, also is a string of up to forty characters. It describes the geology of a site. This field is also designed to be very flexible in its description of the geology and therefore does not follow any rigid format. Information about the geology may be very specific as to rock or sediment type, even so far as providing layer thicknesses. Some common terms that may be searched for are BEDROCK, SOIL, or ALLUVIUM. In the future, additional information about the site geology will be placed in a file. This file will contain more specific parameters about the geology and geophysics of a site (i.e., shear wave velocity, blow counts, density, type of material) in a standardized format. The borehole field in the data base, not yet provided for public access, is a place holder for the location of this file.

instrument: This field is a character string of up to twenty characters that describes the instrument at a site. An instrument refers to the type or serial number of the recording device and/or the transducer that measures acceleration. Some typical entries in the instrument field are: SMA-1 NO.0834; SMAC-B; SMAT-1; AR-240; TT350 NO.1001.; SFSS; S-M FS44; CRA-1 S/N 0118; RFT-250.

time_device: This field also contains a character string up to twenty characters long. It, however, describes the type of timing device present at a site. There are very few entries where this is known, so most entries contain the default value of UNKNOWN. If it is known that a timing device does not exist, then the entry will be NONE. The most common timing devices are Omega and WWV receivers or on-board clocks such as the Kinometrics TCG-1a and TCG-1b.

start_year, start_month, start_day: These three fields represent the date when a site was established for a particular instrument (i.e., the instrument began operation). If all of the values are zero then the starting date was unknown.

end_year, end_month, end_day: These three fields represent the date when a site was closed for a particular instrument (i.e., the instrument ceased operation). If all of the values are zero then the closure date is unknown. The status field is the true indicator of whether a site is closed or not.

comments: The comments field holds additional information specific to a site. The total length of the comment may be eighty characters and sub-comments are separated by semicolons.

2.1.4 Trace Table

An entry in the trace table holds parameters specific to strong-motion time-series data. No stipulations are made as to its origin; only that it is related to a single event, record, and site. It is the most important of all the tables in the NCEER data base since it provides a link to the actual on-line data. This link is established through the key-field of the trace table, filename. Filename contains the location (i.e. the absolute pathname in UNIX) of the AH data file on the disk drive at Lamont.

Information about a time-series that are stored in the trace table are its: format; orientation of the transducer; units and type of motion; peak and rms values; filename; total and strong-motion durations; and filtering and instrument parameters. The trace table is a subtable of each of the other tables (See Figure 2-1). Since the trace table is related to each of the other tables, their key fields (event origin-time, record number, and site identifier) are also stored in it. The names of fields in the trace table and their contents are described in more detail below:

record_num: The record number field holds an integer value which is unique for each record in the table. It may be used to find information about the record which contains this trace or which other traces are associated with the same record.

event_year, event_month, event_day, event_hrmn, event_second, event_number: These six fields are the combined-key that relates a trace to its corresponding event. See their description in Section 2.1.1 for more details.

filename: This field contains a string of up to 100 characters that represents the absolute pathname of the AH time-series data file. Each filename entry is unique. This field is not designed to be queried and its only purpose is as a pointer to the time-series data.

site_id: This field is a pointer to the corresponding entry in the site table. It uniquely describes the site which recorded a given trace. See Section 2.1.3 for more details about the site_id field.

latitude, longitude, bin: These fields describe the geographic coordinates of the site. They are duplicated from the respective fields in the site table.

orientation: This integer field describes the orientation of the accelerometer which generated the trace. It is more typically referred to as the component. Values for the orientation follow a similar convention that was started by CIT [6]. For the horizontal components values range from 0 to 360, and represent a clockwise from North azimuth in degrees. Vertical components are 500 for up, 600 for down, and 400 for vertical components whose direction is unknown. For horizontal components given as East-West the value is 700 and for North-South it is 800. Most often the component is given with the correct polarity (e.g. the orientation corresponds to the direction of positive ground motion). For cases where the polarity is in question, a comment to that effect is entered in the comments field. This is the only field where a value of zero does not indicate that the value is unknown, a value of 999 does.

type_of_trace: The type_of_trace field is a three letter code which describes the type of ground motion. There are only three possible values at present, ACC for acceleration, VEL for velocity, and DIS for displacement.

unit_of_data: This field is a character string which represents the units the data are in. In all cases the units are in cgs. Thus, the values for this field are CM, CM/SEC,

and CM/SEC² (where ^ represents power). The unit_of_data field is provided as a supplementary field to the type_of_trace field should there be a need to change units in the future.

type_of_data: This numeric field describes whether the data are interpolated or not (i.e. raw digitized data). A value of 1 indicates that data are time interpolated and a value of 2 indicates the data are in a XY format (time, amplitude).

trace_length: This field contains the duration of a trace in seconds. From this and the time_step field you can approximate the size in bytes of the binary AH file (trace_length / time_step * 4 + 1080).

sm_duration: This field holds a very rough approximation to the duration of strong-ground motion found in a trace. The duration in seconds is based on a sliding one second window where the rms acceleration is greater than 0.1 g. It is only calculated for acceleration data.

time_step: This field holds the time interval, in seconds, between successive amplitude values for interpolated data.

rms_of_data: The rms_of_data field holds exactly what it says it does, the root mean square value of an entire time-series.

peak_value, time_of_peak: These two fields hold the absolute value of the peak amplitude, in units of unit_of_data and its position in time from the beginning of a trace in seconds, respectively.

sensitivity: This field holds the sensitivity of traces that originated from analog film records. The units are in cm/g. It is used primarily for uncorrected data to convert from digitized distance units into units of acceleration.

frequency, damping: These two values represent the natural frequency (in Hertz) and damping (in percent of critical) of the transducer which generated the trace. They are necessary for deconvolving the instrument response from an uncorrected trace.

low_pass, high_pass, filter_type: If the data have been filtered, as is the case with most of the corrected data, the first two fields will contain the low and high pass corner frequencies (in Hertz) of the respective filter. The last field, filter_type, holds a string of characters (up to 40) which describes the type of the filter used. If no filter was used the filter_type will be NONE and if the type of filter is unknown it will be UNKNOWN. Some examples of filter_type entries in the data base are:

```
BUTTERWORTH OF ORDER 4  
BAND PASS; TYPE UNKNOWN  
BAND PASS; ORMSBY  
BAND PASS; LP .1-.2, HP 35-45
```

ORMSBY; LP .05 -.25, HP 23-25
UNKNOWN
NONE

comments: The comments field holds additional information specific to a trace. The total length of the comment may be eighty characters and sub-comments are separated by semicolons. The most common comment in the trace table describes the polarization of the data (the direction of ground movement versus oscillator movement) with respect to the value in the orientation field.

2.2 GeoBase Access of the Strong-Motion Data Base

Although, the NCEER strong-motion data base was implemented using the commercial data base UNIFY, access to it is through Lamont's GeoBase tool. GeoBase functions by making calls over the network (Internet or Local Area Network depending upon where the user is located with respect to the data base) to retrieve data from the data base. Local files tell GeoBase what the format of the data is and where it is located. The version of GeoBase released with this manual is limited to operating on Sun3 workstations. A newer version, currently under development, will allow users of other Sun models (4 and SPARC) and hopefully other manufacturers workstations (if communication standards evolve to a higher state) to access the data base. This manual will be updated and new software will be released when the new version is completed. For the remainder of this section, the discussion will focus on the implementation of the data base within the existing version of GeoBase.

A typical session of GeoBase, regardless of which data bases are examined, involves: selecting a geographic region of interest from a map of the world; finding out what data bases are available for that region; querying one of them for data; plotting, examining, and rearranging the selected data; and finally, outputting it to a file for further analysis. This process is described in detail for a specific example in the tutorial of Section 6 and in more general terms in the GeoBase user manual gb.man (to obtain a copy, see Section 5.3).

There are several features about the implementation in GeoBase that should be mentioned. First, GeoBase provides access to each of the four tables in the data base separately. That is, a user may retrieve data from each table independent of the others. Second, since GeoBase is geographically oriented (map based) queries to the data base are limited to geographic regions of interest. The entire data base is not searched when a query is performed, only the portion of the data base that corresponds to the region that user is interested in is. Of course GeoBase may be applied to the entire world, but GeoBase is not the preferred tool to use if the user is interested in such a query. Strongmo, the dumb-terminal access tool mentioned in Section 1.5, however, would be the tool to use since it provides access to the entire data base. Third, GeoBase allows for some simple relational queries (a join operation) to be formulated between certain tables. With this version of GeoBase the only relationship that may be queried is a one to many type (e.g., event to record, event to trace, record to trace, site to record, or site to trace). For example, given data retrieved from the event table you can only retrieve the records and/or traces that correspond to it; the reverse operation is not always possible. The Strongmo access tool and the newer version of GeoBase will overcome this limitation. Finally, access to the actual time-series are performed through the use of

Sun Microsystems Network File System (NFS). The disk on which the time-series are located is virtually 'mounted' at a user's site using NFS. Therefore, to the user it would appear as if the entire disk were actually present at their site. However, the only operation that remote user's are permitted to perform on this disk is reading.

2.3 Data in the Strong-Motion Data Base

As mentioned earlier, data being placed in the data base comes from two sources: the L-DGO/NCEER digital strong-motion network and magnetic data tapes obtained from archiving agencies. The majority (>99%) of the data is contained on the tapes. This amounts to some 8,000 files of uncorrected data, 3,000 files of corrected, and 2,400 files of response spectra. A major effort was undertaken to convert the corrected data from the tapes into time-series of AH format and parametric tables suitable for the data base. At the time of this writing over half of the corrected strong-motion data sets are on-line, they include:

- Alaskan Subduction Zone Earthquakes 1960 to present.
- Caltech Series (e.g. San Fernando Earthquake, 1971) 1935 to 1971.
- Portland, Oregon Earthquake of November 5, 1962.
- New Madrid, Missouri earthquakes from 1975 to 1977.
- Charleston, South Carolina Earthquakes (1978).
- Imperial Valley Earthquake and aftershocks (Calif., 1979).
- Mammoth Lakes Earthquakes (Calif., 1980).
- Franklin Falls Earthquake, (New Hampshire, 1982).
- Miramichi Earthquakes (New Brunswick, 1982).
- Coalinga Earthquake and aftershocks (Calif., 1983).
- Morgan Hill Earthquake (Calif., 1984).
- Nahanni, N.W.T. Canada Aftershocks 1985.
- Whittier Narrows Earthquake, (Calif., 1987).
- Armenia Earthquake of December 7, 1988.
- Saguenay, Quebec Earthquake (November 25, 1988).
- ALL NCEER DIGITAL SSA-1 DATA* (>20 records; 1988-1989).

There are a large amount of UNKNOWN entries in particular fields in the current data base. For instance, for the site table, almost none of the headers contain information on geology, and information about structures is often vague or absent. Although we have tried to type in this information by hand when it was readily accessible, not all of the entries have completely filled fields. Another effort must be made to find and enter the missing information by searching the literature and contacting knowledgeable individuals.

The NCEER strong-motion data base is continuously being updated. Once the corrected data set is completed, work will begin on loading some of the more relevant uncorrected data, and possibly reprocessing it with more up-to-date methods. Corrected strong-motion records from the following list will be made available in the future:

- *ALL FUTURE L-DGO/NCEER DIGITAL SSA-1 DATA*
- Various Eastern U.S. earthquakes 1973 to 1976.
- Hawaiian earthquakes in 1973 and 1975.

- Superstition Hills, Calif. earthquake of 1987.
- Loma Prieta Earthquake, October 17, 1989.
- INTERNATIONAL DATA from:
 - Canada
 - China (PRC)
 - El Salvador
 - Fiji
 - Italy
 - Japan
 - Mexico
 - New Guinea
 - New Zealand
 - Nicaragua
 - Peru
 - Soviet Union
 - Taiwan

SECTION 3

GeoBase and User Requirements

3.1 GeoBase: Hardware and Software Requirements

Hardware requirements of the GeoBase software described in this report are: (1) a Sun3 workstation; (2) approximately 5 megabytes of disk space; and (3) an Internet network connection. The only software requirement is that the user's Sun3 be running version 3.5 or 4.0 of the Operating System. The next step is to install the software package on site.

3.2 GeoBase User Requirements

To use GeoBase and its related software, familiarity with the UNIX operating system, its concepts and its environment is required. At a minimum, the user should be familiar with the file system's structure, how to manipulate files (rm, cp, mv, more, etc.), change and create directories (cd, mkdir, etc.), and execute programs. Equally as important, the user should be familiar with the suntools (Sun View) environment, particularly its look and feel; how to manipulate the cursor (via the optical mouse), access menus (usually via the right mouse button), and manipulate windows (open, close, move, resize, etc.). The GeoBase tutorial in Section 6 assumes familiarity with the basic window operations in suntools.

3.3 Tutorial Conventions

In the tutorials of this report, certain conventions are followed: (1) any prompts given by the UNIX command interpreter, which from now on are referred to as the shell, will appear as **example%** {where example is the name of the host machine}; (2) all UNIX commands typed by the user will appear in *italicized Courier* font; and (3) any responses from the shell will appear in the regular Courier font. For example:

```
example% ls junk  
junk  
example%
```

In this case, the shell prompted for input, the user typed the UNIX command *ls* with one argument, *junk*, the command echoed *junk* to the screen, and the shell prompted for further input.

SECTION 4

HOW TO OBTAIN GeoBase

4.1 Via the Internet Network

To obtain a current copy of the GeoBase software package (including the latest copy of this report), use the UNIX command *ftp* (which stands for *f*ILE *t*RANSFER *p*ROTOCOL). It is a standard file transfer program provided with most UNIX workstations, including Suns. To access the package via *ftp*, familiarity with the UNIX operating system and its environment is required. The following *ftp* access tutorial is provided for users not familiar with *ftp*.

First, initiate a call to the host *lamont* (ethernet address: *lamont.lidgo.columbia.edu* 129.236.10.30) at Lamont-Doherty by issuing the *ftp* command and answering the prompts for *Name:* with *anonymous* and for *Password:* with the user's name as is done in the example below (note that for *Password:* no entry appears on the screen):

```
example% ftp 129.236.10.30
Connected to 129.236.10.30.
220 lamont FTP server (Version 4.169 .....) ready.
Name: anonymous
Password:
```

If this was successful, the log on to *lamont* occurred and the *ftp* prompt should appear as it does below:

```
331 Guest login ok, send ident as password.
230 Guest login ok, access restrictions apply.
ftp>
```

Next, the following sequence of commands should be issued to set a communication parameter and change to the proper directory:

```
ftp> cd nceer
250 CWD command successful.
ftp> binary
200 Type set to I.
ftp>
```

Finally, issue the *ftp* command *get* to retrieve a copy of the compressed tar file *lamont.tar.Z*. This file holds the software package and everything else needed to install and access data from the NCEER data base at Lamont. Type in the command as it is written below:

```
ftp> get lamont.tar.Z
200 PORT command successful.
150 Opening data connection for lamont.tar.Z (binary mode) (XXXXXXX bytes).
226 Transfer complete.
XXXXXXX bytes received in XX.X seconds (XXXXXXX Kbytes/s)
ftp>
```

To exit ftp type *quit*:

```
ftp> quit
221 Goodbye.
example%
```

A copy of the compressed tar file lamont.tar.Z has now been transferred to the disk of the user's workstation, if everything went as described above. Since the tar file is very large, the network transaction will occasionally fail. If this occurs, try *get* on the file a second time. If persistent problems with ftp are encountered, seek help from your system administrator. The installation procedure for the software is described in the next Section.

4.2 Mail

If the site is not yet connected to the Internet, but soon will be, the quickest way to obtain a copy of the software package is to mail a blank tape (9-track 1/2" or 1/4" data cartridge format) along with a check for \$25 (\$50 if Lamont is to provide the tape) made out to "The Trustees of Columbia University" to the address listed below:

Lamont-Doherty Geological Observatory
Attention: Paul Friberg
Seismology Department
Route 9W
Palisades, New York 10964

SECTION 5

HOW TO INSTALL GeoBase

5.1 Installing GeoBase: Attention System Administrators

This section explains how to install the GeoBase Strong-Ground Motion Data Base access package on a Sun3 workstation. The installation tutorial uses the same conventions set forth at the beginning of the Section 3. A major portion of the package is a user-interface known as GeoBase. It is a front-end tool that uses SunView graphics and allows its users network access (via BSD Socket and NFS communication over the Internet) to earthquake data located at Lamont (Internet address: lamont.lidgo.columbia.edu). To install GeoBase, the user's site must have an Internet connection. Other files in the package include: five executables which accompany GeoBase (used for manipulating and examining time-series data), README pages with brief descriptions of files, documentation, and data base description files (these are used exclusively by GeoBase).

In brief, the installation of GeoBase consists of: (1) making a directory to house the software; (2) extracting the files from tape or the file lamont.tar (see the previous section) using the tar command; (3) running an installing script; (4) adding two lines to the /etc/hosts file (and pushing it via make if the site is running Yellow Pages); and (5) mounting a disk from lamont via NFS (or automounting). If all or any of this sounds foreign, then it would be wise to consult the on-line man pages or the SunOS Manuals first. The only requirement for installation is that the user have super user (root) privileges on the host onto which the software will be installed.

At Lamont the Sun workstations are all interconnected via ethernet as part of a local area network (LAN). Access to data on disks at Lamont is made possible through Sun's Network File System (NFS). Hence, data on a file system in one building is accessible on a machine in another. This mechanism saves innumerable amounts of disk space by not requiring duplication of files for each workstation. It is especially helpful at a scientific institution, like Lamont, where data sets are very large. GeoBase was developed in such a networked environment and therefore needs access to certain files that are stored in its installation directory. What this means is that if a user is to successfully execute GeoBase, the installation directory must be mounted on their workstation via NFS. Since this is the case, the data base should be installed on a single workstation in a directory that will be NFS mounted on each workstation at which a user might wish to run GeoBase. This is preferred, because multiple GeoBase installations will waste space.

5.2 Installation Tutorial

To install GeoBase, login as root, and make a directory named lamont on the file system where GeoBase is to be installed (it can be anywhere but it is placed beneath the directory /example/src in the following example):

```
example% cd /example/src
example% mkdir lamont
```

Next, extract the GeoBase files from the compressed tar file lamont.tar.Z:

```
example% zcat lamont.tar.Z | tar xf -
```

or from the tar file lamont.tar:

```
example% tar xf lamont.tar
```

or from the tape:

```
example% tar xf /dev/rmt0h
```

There should be three subdirectories beneath the lamont directory: bin, gb, and docs. To install GeoBase, change directory to gb and run the installing script *gbininstall*. Gbininstall will only operate on files that are in the directories lamont/gb and lamont/bin. That is, it does not modify any system files in the /etc directory. The script prompts you to make the necessary changes to the /etc/fstab and /etc/hosts files; it will not make the changes. What follows is an example of a typical gbininstall execution:

```
example% cd lamont
example% ls -F
README  bin/      docs/     gb/
example% cd gb
example% gbininstall
gbininstall: installing GeoBase for NCEER data base version: V1.0
VERSION NUMBER: V1.0
-----
Add the following lines to the /etc/hosts file:

129.236.10.50    duke.ldgo.columbia.edu
129.236.10.70    miles.ldgo.columbia.edu

IF YOU ARE RUNNING UNDER yp (Yellow Pages) then
you must make the change on the host that is a master yp server,
then cd to yp and make hosts!

hit <Return> when made
-----
Add the following line to the /etc/fstab file if
users wish to access the time-series data files:

duke.ldgo.columbia.edu:/duke/nceer_data /duke/nceer_data \
nfs,ro,bg,hard,intr
```


ALSO MAKE THE MOUNT POINT /duke/nceer_data and then mount the directory by typing:

```
mount duke.ldgo.columbia.edu:/duke/nceer_data /duke/nceer_data
```

```
hit <Return> when finished <CR>
```

```
GeoBase installed on machine: example
```

```
example%
```

GeoBase would now be installed on the host named example. The installing script created some necessary files and then moved the executable shell script *GeoBase* into the bin directory. GeoBase should now be tested by executing the script of the same name from the lamont/bin directory while in the **suntools** environment (or sunview for SunOS 4.0):

```
example% cd ../bin
```

```
example% ls
```

```
GeoBase          ah2nceer  gb.sunview.sun3  ql  
README          ahuncat   logger           sgp
```

```
example% GeoBase
```

```
example%
```

If no problems occurred with the installation and the instructions echoed by the shell script were followed (making the necessary /etc/hosts and /etc/fstab changes) GeoBase will execute without problems. Running GeoBase will place an entry in a log file (gblog in the lamont/gb directory) and then start GeoBase running in the background. In order to keep track of GeoBase usage, a log file is maintained in the installing directory lamont/gb. The file gblog should be purged periodically as it may become large. To eliminate the logging entirely, edit the GeoBase script and change the first argument to the logger program to /dev/null.

A few seconds after the logging command is completed, a window will appear in the upper left hand corner of the screen. This window, known as the GeoBase Control window, is the user's prompt for each run of GeoBase. To test the installation further, proceed to Section 6. To quit GeoBase, place the cursor (using the mouse) on the border of the control window, hold down the right button (a menu should appear), slide the cursor over the menu option **FRAME** to the right, another menu will appear. Next, while still holding the button down, slide the cursor down and choose the menu option **Quit** by releasing the mouse button while the cursor is directly over it.

5.3 Documentation

There are five documents contained in the installation package. One is a PostScript copy of this manual (nceer.ps) and the rest are nroff format user's manuals to GeoBase (gb.man) and the ancilliary programs (ah.man, ql.man, and sgp.man). All five are located in the lamont/docs directory. Instructions for viewing them are given in the README file in the same directory. The three documents ql.man, ah.man, and sgp.man will be useful for Section 7. The document gb.man is the original user manual for GeoBase and is useful, but not necessary, for following the tutorial of Section 6.



SECTION 6

HOW TO USE GeoBase TO ACCESS DATA

6.1 A Practical Tutorial

This section describes how to use GeoBase to access data in the NCEER Strong-Motion Data Base. This is done through step-by-step examples interleaved with important details in which actual parameters and time-series are retrieved. Although there are many features available in GeoBase, only a necessary subset are reviewed here. It is recommended that you explore GeoBase's other features, through the more specific GeoBase manual provided (*gb.man*, Section 5.3), only after becoming familiar with its basic functions. The example GeoBase session presented below accesses strong-motion data for the recent Saguenay, Quebec Earthquake. Before proceeding, check with the system administrator as to which workstations have access to the software and where it is located. A brief tutorial on examining and converting the time-series data retrieved in this Section is presented in Section 7.

6.1.1 Starting Out

From a shell window in *suntools*, type in the command *GeoBase* (or the proper path given by your system administrator). Make sure there is write permission in the directory where GeoBase is executed because later in the tutorial, files will be written to it. In the upper right hand corner of the *suntools* desktop will appear the GeoBase Control window. This window contains a title with a copyright and three buttons entitled **NEW MERCATOR MAP OF THE WORLD**, **NEW MAP OF N POLE**, and **NEW MAP OF S POLE** (Figure 6-1). The Control window has a pull down menu that controls the opening and closing of all GeoBase windows, the access to personal data bases, the setting of certain defaults, and the ability to exit GeoBase.

In GeoBase, like in *suntools*, all menus are accessible from a window's edge. By placing the cursor on the edge of a window and holding down the *right mouse button* a window's menu will appear. To select an item from the menu, drag the cursor over the item of interest and release the mouse button. From now on this process will be referred to as a **menu selection**. If a menu item contains a right arrow, then access to a **pull right menu** is available. Performing a menu selection on a pull right menu is the same as described above, except to access a pull right menu item slide the cursor to the right, over the arrow, while pressing the right mouse button.

Once the control window is present, select the map of interest by **pointing** (moving the cursor, using the mouse, over the appropriate item) and **clicking** (a quick press and release of the *left mouse button*). For now, choose the **NEW MERCATOR MAP OF WORLD** button. After pointing and clicking on the appropriate map, a Confirmation window will appear in the middle of the desktop. This window will present two buttons (**YES** and **NO**) and ask the question: "NEW MERCATOR WORLD MAP?" Choose YES to continue by pointing and clicking on it.

After a few seconds, a new window will appear on the desktop, the World Map window (Figure 6-1). This window contains a scrollable mercator projected image of the world; the grey bars along the top and left sides of the window are scroll bars. The image may be scrolled by placing the cursor in the top/left scroll bar and clicking the left mouse button to scroll West/North and the right mouse button to scroll East/South. From this window, choose a geographic region of interest.

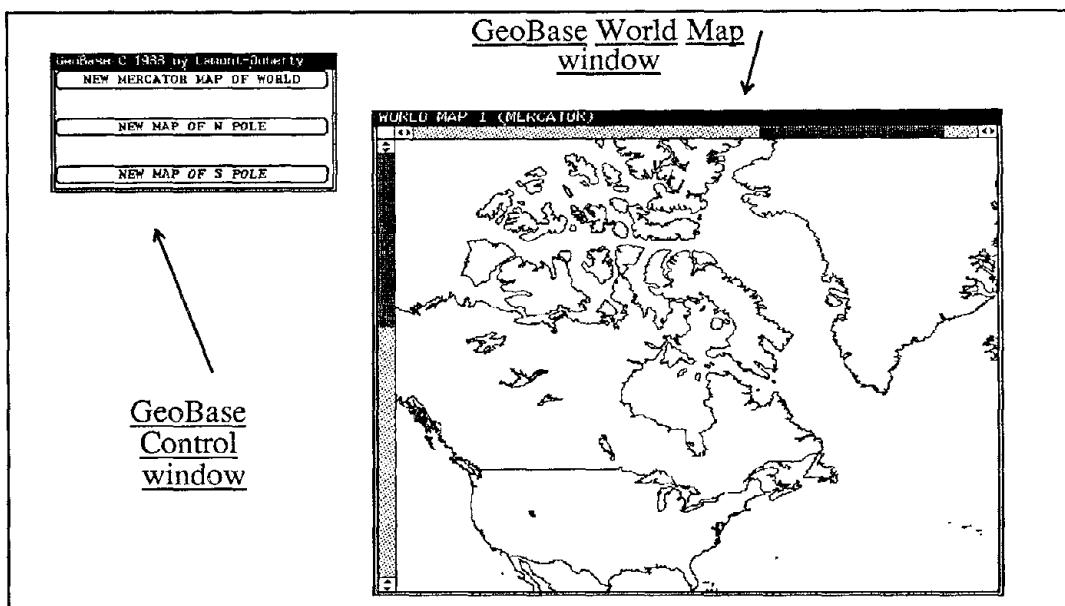


Figure 6-1 GeoBase Start-up Windows.

6.1.2 Specifying a Region of Interest

Specifying a region of interest (ROI) is done either by defining a rectangle with the cursor or by typing in the coordinates of the area's boundaries. To define a ROI with the cursor: (1) in the world map window point to the northwest corner of the region desired; (2) hold down the left mouse button; (3) drag the cursor to the southeast corner of the region; and (4) release the mouse button. During the time the mouse button is depressed, a rectangle will expand or contract with the cursor position. As soon as the mouse button is released the rectangle will disappear. To initiate the ROI, select the item **NEW REGION** from the menu of the World Map window. The next prompt is a Confirmation window that specifies the left, right, top, and bottom coordinates of the region selected. All GeoBase coordinates are in degrees of latitude (-90. to +90.) and longitude (0. to 360. or +/- 180.). Edit the coordinates to refine the ROI; when satisfied, select one of the two buttons displayed at the bottom of the window, OK or CANCEL. Selecting OK will proceed to the next phase of GeoBase and CANCEL will abort the ROI selected. The other option is to define a ROI by immediately specifying the coordinates of its boundaries. To do this, select the menu item **NEW REGION** instead of dragging a rectangle with the cursor, enter the coordinates, and select the OK button.

The region of interest selected in this tutorial corresponds to an area encompassing the Saguenay earthquake in northern Quebec. The region has the following coordinates: left longitude of 283° (77° West); right longitude of 293° (67° West); top latitude of 50°; and bottom latitude of 44°. Once the OK button is selected from the NEW REGION Confirmation window, two new windows will appear on the desktop: the Outline window and the Region Of Interest window (Figure 6-2).

6.1.3 ROI and Outline Windows

The Outline window describes the data that has been selected for the ROI. Each line in the Outline window contains the data's name, type (Point or Raster), quantity, plot option (yes or no), and comments (figure 6-2). By default when a region is selected, data from the grid_lines (one degree by one degree latitude and longitude bounds) and the coastlines (political boundaries and coastlines of the world) data bases are retrieved. As shown in figure 6-2, the coastlines data are plotted in the ROI window (as indicated by the yes plot option) and the grid_lines are not (as indicated by the no plot option). The plotted symbols for a line of data in the Outline may be turned on or off by pointing and clicking once on the line's plot option (this option toggles between yes and no).

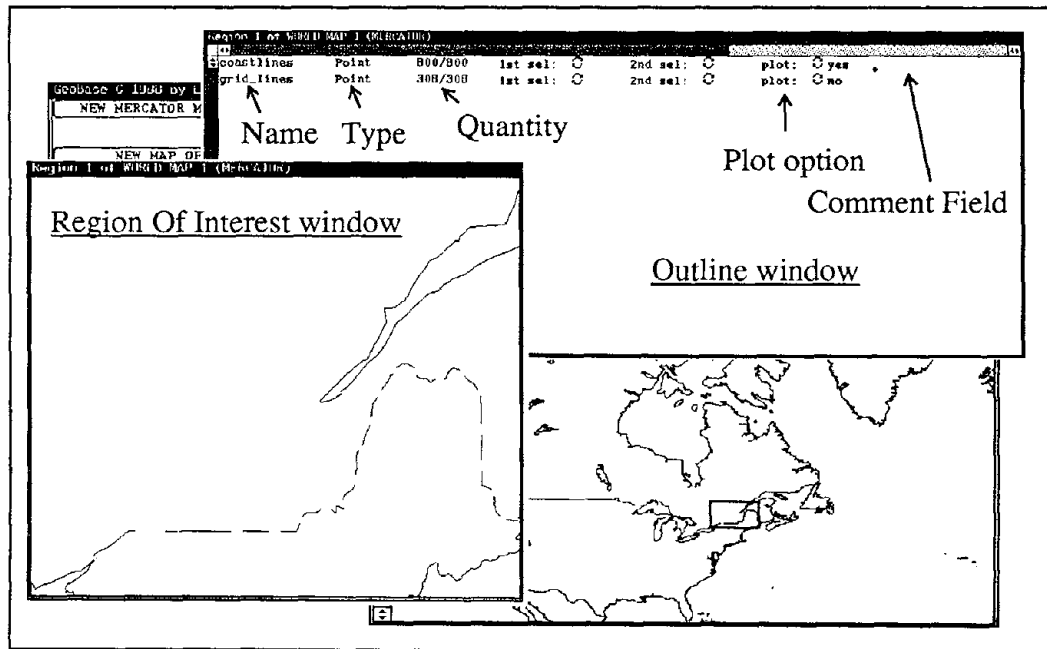


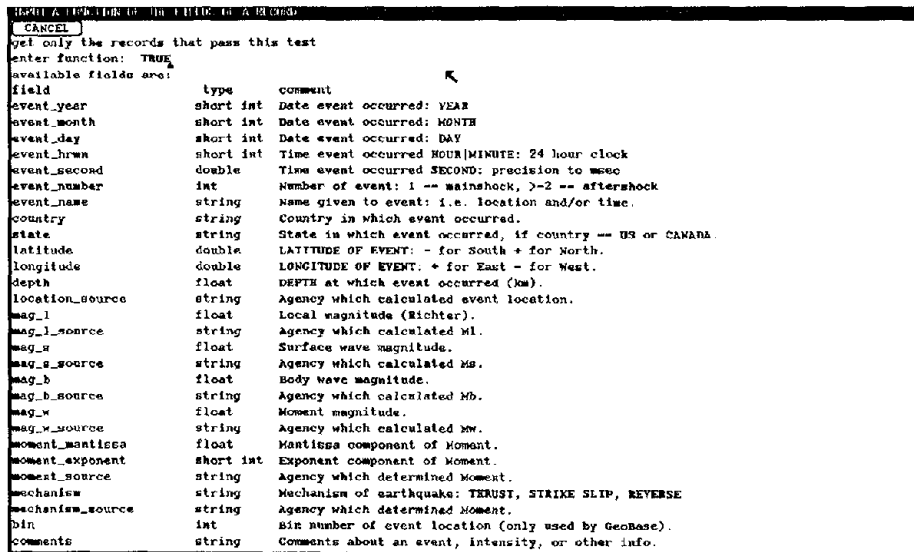
Figure 6-2 Outline and Region of Interest Windows.

The purpose of the ROI window is to display, in map form, those data whose plotting option in the Outline window is yes. In figure 6-2 the Maine coastline, the St. Lawrence seaway, and the U.S./Canadian border are displayed in the ROI window. All plotting of data by GeoBase is done with an exclusive or (XOR) operation. This facilitates rapid plotting and removal of a single data set by not having to redraw the entire window. A major limitation of the XOR plotting method is that if an even number of data points possess nearly the same geographic coordinates their plotted symbols will overwrite one another and not be displayed (a test of this would be to get the same data set three times and try different combinations of the plot option). Beware of this limitation for there exist data in the NCEER data base that meet these criteria (i.e. more than one 'site' per location, as with instrumented buildings)

6.1.4 Getting Data

Now that the region of interest has been defined, the next step in a GeoBase session is to find out which data bases are available and to query them for data. From either the ROI or Outline window's menus, examine the pull-right menu of the menu item entitled **DATABASE**. In it are three sub-items: **GET DATABASE INFORMATION**, **GET DATA FROM DATABASE**, and **GET SUBTABLE**. Selecting the **GET DATABASE INFORMATION** item will provide a window containing a list of buttons, each of which is labelled with the name of a data base that is available for the region. For this region, eight buttons will appear in a window; they are labelled: **NCEER_EVENT**; **NCEER_RECORD**; **NCEER_TRACE**; **NCEER_SITE**; **ENAM_SM_STATIONS**; **USA_STATE_MAP**; **coastlines**; and **gridlines**. Upon selecting a data base, by pointing and clicking on its respective button, a window of information about the data base will appear. Try this with each of the data bases.

Now actually get some data from the NCEER data base by choosing the menu item **GET DATA FROM DATABASE**; an identical array of buttons will appear. Since the objective is to obtain data on earthquakes, point and click on the **NCEER_EVENT** button. A data base Query window for the **NCEER_EVENT** table will appear in the center of the desktop (Figure 6-3). It displays the



```

      CANCEL
get only the records that pass this test
enter function: TRUE
available fields are:
field      type      comment
event_year short int  Date event occurred: YEAR
event_month short int  Date event occurred: MONTH
event_day  short int  Date event occurred: DAY
event_hrwn short int  Time event occurred HOUR|MINUTE: 24 hour clock
event_second double    Time event occurred SECOND: precision to msec
event_number int       Number of event: 1 -- mainshock, >2 -- aftershock
event_name string     Name given to event: i.e. location and/or time.
country    string     Country in which event occurred.
state      string     State in which event occurred, if country == US or CANADA.
latitude   double    LATITUDE OF EVENT: - for South + for North.
longitude  double    LONGITUDE OF EVENT. + for East - for West.
depth      float     DEPTH at which event occurred (km).
location_source string    Agency which calculated event location.
mag_l      float    Local magnitude (Richter).
mag_l_source string   Agency which calculated ml.
mag_w      float    Surface wave magnitude.
mag_s_source string   Agency which calculated Ms.
mag_b      float    Body wave magnitude.
mag_b_source string   Agency which calculated Mb.
mag_m      float    Moment magnitude.
mag_m_source string   Agency which calculated Mw.
moment_mantissa float    Mantissa component of Moment.
moment_exponent short int Exponent component of Moment.
moment_source string   Agency which determined Moment.
mechanism string    Mechanism of earthquake: THRUST, STRIKE SLIP, REVERSE
mechanism_source string   Agency which determined Moment.
bin        int       Bin number of event location (only used by GeoBase).
comments   string   Comments about an event, intensity, or other info.

```

Figure 6-3 Query window for the **NCEER_EVENT** table. Note the default query of **TRUE**.

fields of the table, their type, and a comment about what they contain. The Query window allows for the formulation of a logical test (query) on the fields using a C language style syntax (see page 21 of the *gb.man* document for all of the details regarding this syntax; only a few are reviewed here). Although a complex query could be typed in at this point, issue the default query of **TRUE** by hitting the Return key (the query **TRUE** will get all of the data for a region). After a few seconds, if the Internet is functioning properly (possibly minutes, depending on your site's location and Internet connection), a new line, representing the data retrieved, will appear in the Outline window.

For this region there was one record present in the NCEER_EVENT table (at the time this tutorial was written), the Saguenay Earthquake; the earthquake's epicenter is plotted as a cross in the ROI window (Figure 6-4)..

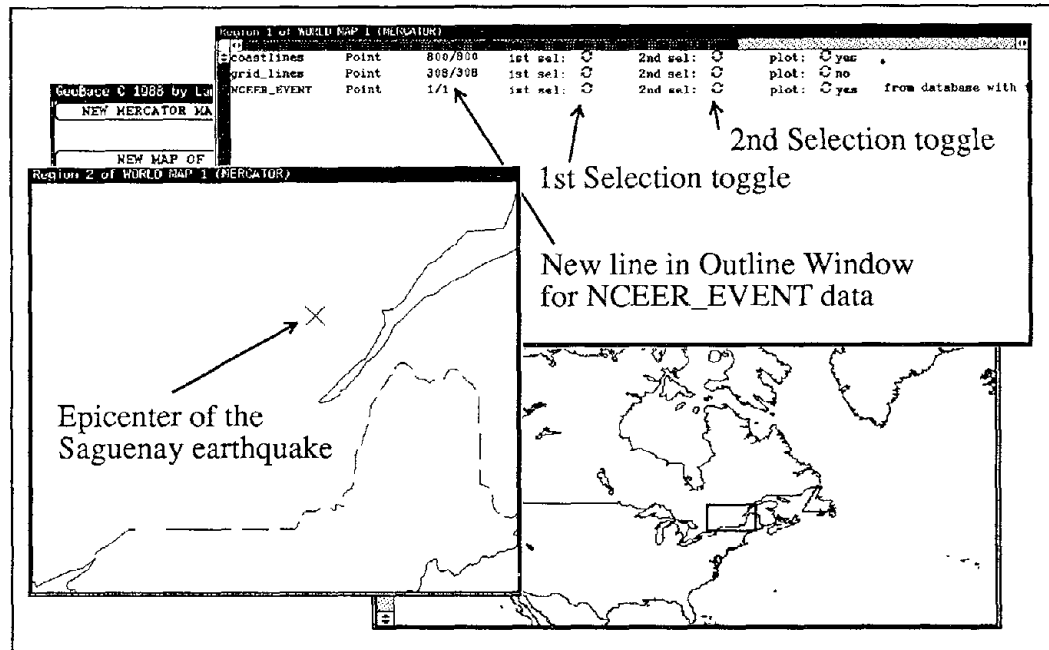


Figure 6-4 Outline and Region of Interest windows with data selected from the NCEER_EVENT table. The position of the primary and secondary selection toggles are indicated.

6.1.5 Examining and Outputting Data

To examine the actual parameters of a line of data point and click on the line's primary selection toggle (Figure 6-4). Doing this causes the toggle to display **yes** and **primary** selects a line of data in the Outline for some future operation (e.g., display of the data's parameters). Then, from the same window, select the menu sub-item **DISPLAY DATA BY SHORT FORMS**, of the menu item **DISPLAY DATA**. This action will result in a Data Display window appearing in the center of the screen (Figure 6-5). The Data Display window shows the values found for each of the fields, one record at a time. The buttons along the top of this window (**NEXT** and **PREVIOUS**) allow paging back and forth between records (a bell will sound when the last record is reached). The button **REGISTER CHANGE** will not function for any of the data base's in this release (i.e., the values in the data base cannot be changed) and the **CANCEL** button exits the window.

To output the parameters to a file, primary select (in the above sense) the NCEER_EVENT line again and this time choose the sub-item **WRITE LINE TO ASCII FILE** of the **I/O** menu item in the Outline window. GeoBase will immediately prompt for the name of the output file. Type in a filename and hit return. A window that allows selection of the output fields will appear; note that all of the fields will be selected at first. Deselect those fields you are not interested in by pointing and clicking on them. When finished, select the **OK** button. The data from the selected fields will

then be written to the file you specified. The data is written in an ASCII format which consists of a two line header that describes the fields and type of the data followed by one line per record of tab separated data.

field	value
event_year	1988
event_month	11
event_day	25
event_hrm	2346
event_second	4.5
event_number	1
event_name	SAGUENAY EARTHQUAKE (90KM NORTH OF QUEBEC, CANADA)
country	CANADA
state	PQ
latitude	48.121
longitude	-71.186
depth	28
location_source	GSC
mag_l	0
mag_l_source	UNKNOWN
mag_s	6
mag_s_source	GSC
mag_b	0
mag_b_source	UNKNOWN
mag_w	0
mag_w_source	UNKNOWN
moment_mantissa	0
moment_exponent	0
moment_source	UNKNOWN
mechanism	UNKNOWN
mechanism_source	UNKNOWN
bin	49609
comments	FELT (V) IN PARTS OF MAINE, VERMONT, NEW HAMPSHIRE, AND NEW YORK.

Figure 6-5 Data Display window for the NCEER_EVENT table. The record displayed contains parameters about the Saguenay Quebec earthquake; for many of the fields data are missing.

GeoBase also allows you to output a hard-copy of the ROI map. This is done by choosing the **SAVE POSTSCRIPT VERSION OF MAP TO FILE** item from the pull-right menu of I/O. You will be prompted for the name of a file to output the map to. The file will be created upon entering a filename and hitting Return. It can be printed on any printer that supports PostScript format. One of the benefits to generating a hard-copy is that the XOR plotting option is not used (e.g. all data points will be plotted).

6.1.6 Getting Data from Subtables

Once retrieving, examining, and outputting data from a geographic region of interest using GeoBase is understood, these same operations can be tried on a different table for this region, such as the ENAM_SM_STATIONS table. Once data can easily be retrieved from a single table, you will probably want to perform queries that cross tables (i.e., use the relationships shown in figure 2-1). The steps to do this are outlined below.

Continuing with the example, let's retrieve parameters of time-series with horizontal accelerations that are related to the Saguenay earthquake. Primary select the NCEER_EVENT line and then choose, from the Outline window's menu, the DATABASE item's sub-item **GET SUBTABLE**. A Subtable Selection window will appear in the center of the desktop; it will contain a list of data base subtables (NCEER_TRACE and NCEER_RECORD) that are related to the one that was a primary selection. If the table selected had no subtables, a message to that effect would be displayed. To select a subtable from the Subtable Selection window, point and click on its name.

A **check mark** will appear in the box next to its name; it is toggled on and off by repeated clicks. Choose the NCEER_TRACE subtable and then select the button **OK** to continue (CANCEL will quit the subtable selection process). Another small window will appear in the center of the screen; it asks the question: "**Keep data outside of region?**" This window provides the option to include or ignore data in the subtable's that are outside of the region of interest by selecting one of two buttons, **KEEP** or **THROW AWAY**. After an option is chosen (choose **KEEP**), a Query window for each selected subtable will appear.

Since the NCEER_TRACE subtable was chosen, only its Query window appears. In the Query window, you can perform a query on the records of the subtable. In response to the previous Query window, you entered TRUE to get all of the records associated with a table. Now, however, only those records that have horizontal orientation and are measurements of acceleration are wanted. To select this data, type in the following logical test:

```
cmp("ACC", type_of_trace) && orientation <= 360
```

cmp, the first operator of this query, is a string function that returns TRUE if its two arguments (strings and/or fieldnames) are equal; the other string operator available is substr(x,y) which returns TRUE if x is a sub-string of y. In this instance, the first argument to cmp is a constant string ("ACC") and the second is a fieldname (type_of_trace). The second operator in the query (&&) is a logical AND operation; other logical operators are || (OR), <, <=, >, >=, == (EQUAL), and != (NOT EQUAL). The last operation in this query is another logical test and is equivalent to TRUE if the orientation of a trace in the table is less than or equal to 360 (horizontal as defined in Section 2.1.4).

After the query is typed, hit the Return key. If the query was typed in correctly, the Query window will disappear; otherwise it will flash and beep indicating that a mistake was made (i.e., the Query window performs error checking). After the Query window vanishes, there will be a pause of a few seconds as the data are being retrieved from Lamont. Once the data has been obtained (stored in memory on the workstation), a new line for NCEER_TRACE will appear in the Outline window (Figure 6-6). In this example, there are 22 records in the trace table that are related to the Saguenay earthquake and that meet the requirements of the query. The data are also plotted in the ROI window. By default, each table has associated with it a plotting symbol and size; for the NCEER_TRACE data the symbol is a directional arrow that corresponds to the orientation (Figure 6-6).

If the data in the ROI are clustered close together, as they are here, a zooming option in GeoBase may be used to shrink the field of view. To be able to zoom in, select the **ZOOM IN** sub-item from the **CURSOR ACTION** item of the ROI menu. This will change the ROI cursor's shape from a cross-hair to a capital **Z**. To zoom in on a region in the ROI window, hold down the *left mouse button* and position the square, that immediately appears upon depressing the button, over the desired area. Upon releasing the button only those data within the square will be expanded to the size of the ROI window. The result of two 'zooms' on the data surrounding the St. Lawrence Seaway is shown in Figure 6-7. Following the above instructions, try and duplicate the results of these zooms. Once 'zoomed', the ROI window may be unzoomed by choosing the **UNZOOM** item of the same menu. For now do not unzoom.

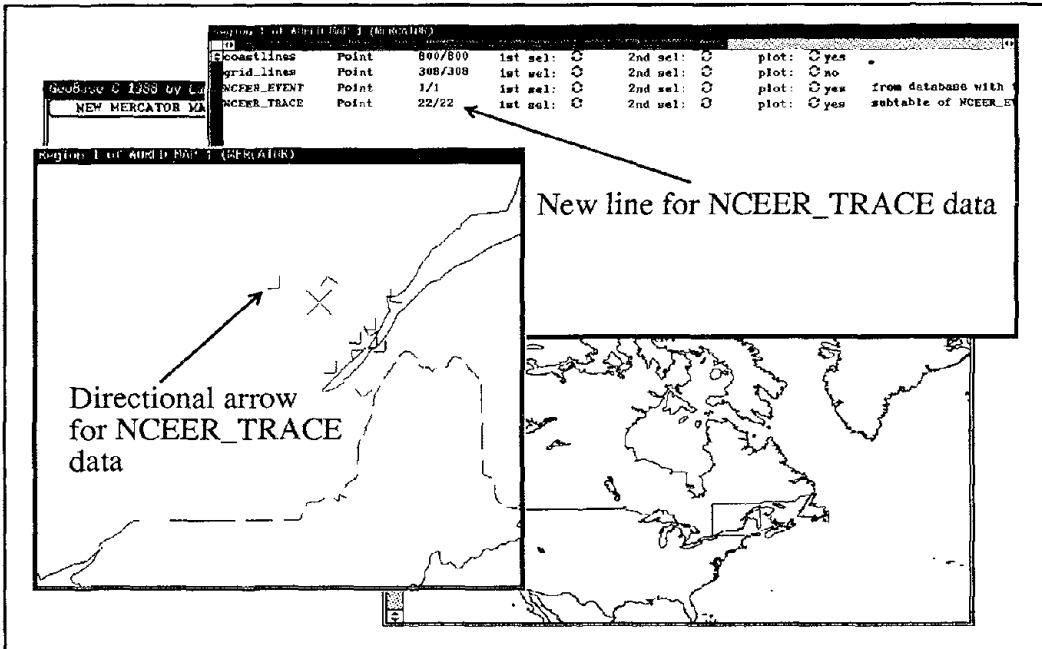


Figure 6-6 The Outline window displays a new line for the NCEER_TRACE data retrieved as a sub-table of NCEER_EVENT. The trace data are plotted as directional arrows in the ROI window. There exists one arrow for each of the 22 traces; 2 arrows are present at each location (site).

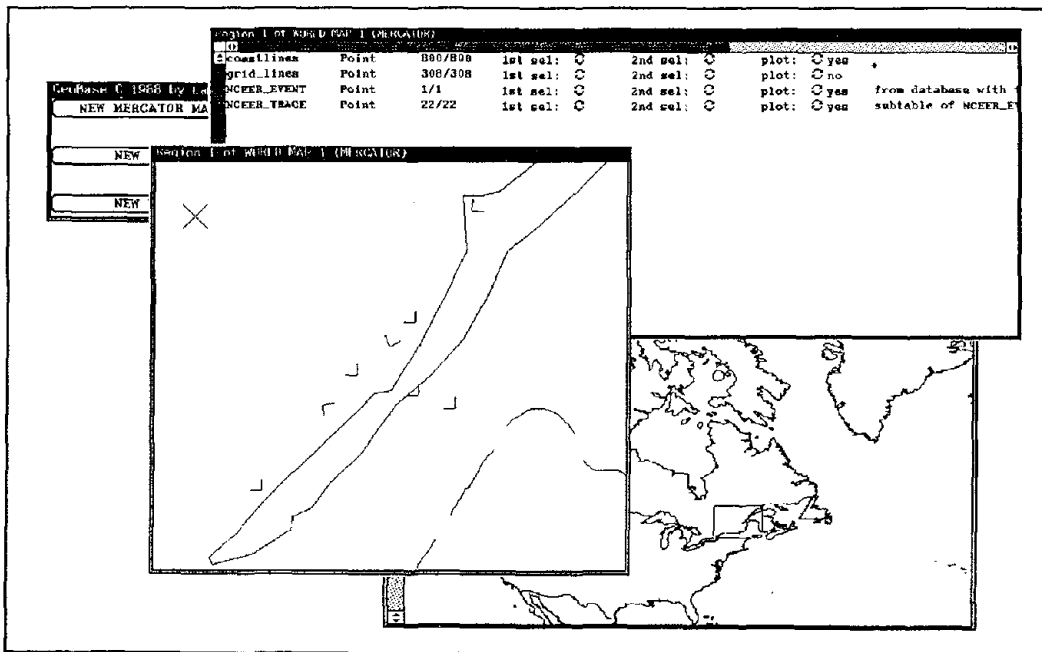


Figure 6-7 Close up of NCEER_TRACE data along the St. Lawrence Seaway as obtained from the ZOOM IN cursor action. Notice that the poor resolution of the coastline map at this scale actually places one station in the water.

If you are interested in obtaining data about sites which recorded these traces, the NCEER_SITE table must be accessed separately. This is because the trace table contains no information about site characteristics. Furthermore, the NCEER_SITE table is not a sub-table of NCEER_TRACE. Observe what happens when you try to access the subtables of NCEER_TRACE; do this the same way you accessed NCEER_TRACE as a subtable of NCEER_EVENT. A prompt with the notice that no subtables exist for this data base will appear. This is because NCEER_TRACE is a subtable of NCEER_SITE. Thus, it becomes clear that there are three ways to use the subtable option provided with GeoBase and the relationships in the NCEER data base: (1) to obtain trace and record data related to specific events; (2) to obtain trace and record data related to specific sites; and (3) to obtain trace information related to specific records. As was seen, with the current version of GeoBase at least, there is no way to traverse a table from the child to the parent (i.e., from child table to parent). This will be rectified in future versions.

6.1.7 Changing Plot Symbol Characteristics

So far, only two out of the seven plotting symbols available to GeoBase have been shown: the **CROSS** used for the epicenters of NCEER_EVENT data and the **DIRECTIONAL ARROW** used for the orientation of NCEER_TRACE data. Both of these symbols are the defaults specified for the NCEER Data Base. GeoBase allows you to change the plot symbol's size and shape for each line of data. In this section, the method for changing plotting symbol characteristics is introduced. To make the example interesting, get all of the data for this zoomed region from the NCEER_SITE table (choose GET DATA FROM DATABASE, select NCEER_SITE button, etc.).

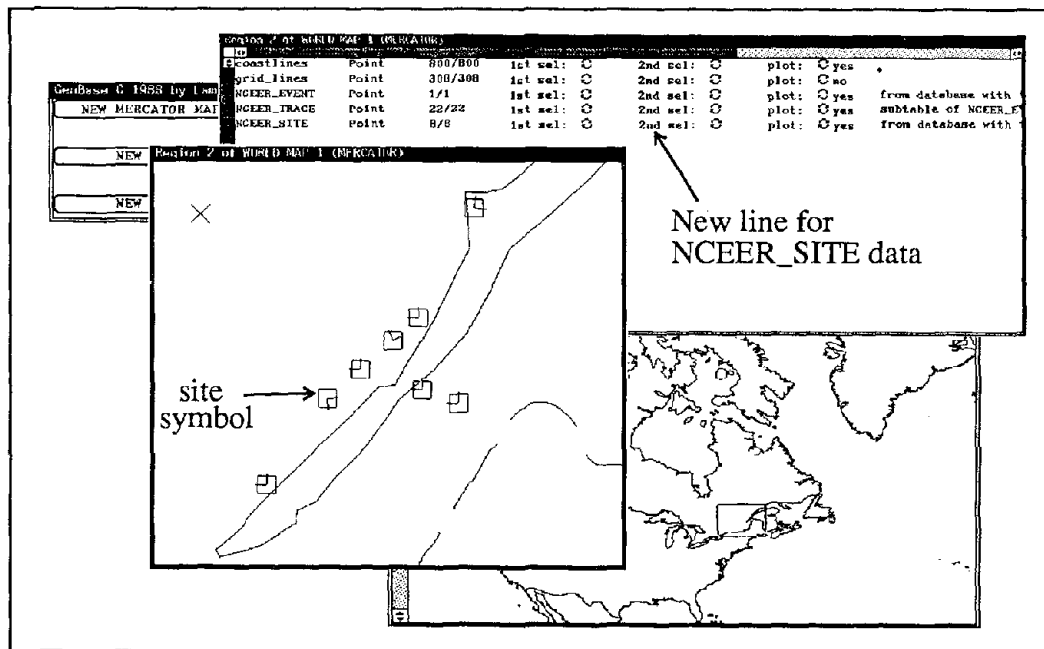


Figure 6-8 Outline and ROI map, for the zoomed region, with data plotted from the NCEER_SITE, NCEER_TRACE, and NCEER_EVENT tables.

The results of this selection are shown in figure 6-8 above. From this figure it can be seen that there are eight sites located in this zoomed region and the default symbol for the NCEER_SITE data is a square. The squares convey a site's geographic position. Let's correct this so that the symbol presents additional information, such as an annotated value. This is done by primary selecting its line in the Outline and choosing the appropriate pull right menu from the **SYMBOL CHARACTERISTICS** menu item. For now, choose the menu item **SET ALL ATTRIBUTES**. A prompt with a window to set the data's plot mode (ignore this option) and the symbol shape appears. Move the cursor over the **SYMBOL SHAPE:** item and hold down the right mouse button; a menu of symbol shapes will appear. Choose the symbol shape **annotation** as with any other menu-item. Now select the **OK** button. Another window will appear in the center of the desktop. Although this window looks identical to the Query window, its purpose is different. It provides the ability to specify the pixel size or value (in the case of an annotation) of the data's plotting symbol. The pixel size may either be a constant value (20) or some function of the fields ($\exp(\text{mag}_s/3) + 5$). The value in the window is now 20. It represents the default size of the squares. Delete this value, type in the fieldname structure, and hit Return. The plotting symbol of the NCEER_SITE data will change from a square to the string contained in the structure field (Figure 6-9). Next, use the same procedure to scale the NCEER_EVENT symbol size by the surface wave magnitude; do not change the symbol shape but enter mag_s instead of the default value.

6.1.8 Manipulating Data in the Outline

Once data has been selected from the data base it may be broken down into subsets for output or display purposes. There are two ways this may be done in GeoBase: either by performing a logical test on the data; or by 'painting', with the cursor, the symbols plotted in the ROI window. To perform the former, primary select the line of data to be split and choose the **PUT SOME OF SELECTED LINE'S DATA IN A SUBSET** item (which actually chooses the menu sub-sub-item **BY LOGICAL TEST ON EACH RECORD**) of the **REARRANGE OUTLINE** item from the Outline window's menu. Then a prompt appears with a Query window to enter a logical test that will be used to generate the subset. For now, select the **CANCEL** button. If a query had been entered, upon its completion a child line, indented from the parent, would have appeared in the Outline. A child line represents the subset of data based on a logical test. The quantity of data records that went into generating the subset will be decremented from the quantity in the parent and a comment describing the query will be placed on the child's line.

To split a line of data into a subset by painting: (1) select the **SELECT SUBREGION BY BRUSHING** sub-item of the **CURSOR ACTION** item from the ROI window's menu (this changes the ROI cursor's shape to a paint brush); (2) **paint** (point and click the cursor in the ROI window) over the data of interest; (3) primary select the data of interest from the Outline window; and (4) choose the **BY WHETHER THE DATA HAVE BEEN BRUSH-SELECTED** sub-sub-item of the sub-item **PUT SOME OF SELECTED LINE'S DATA IN A SUBSET** of the **REARRANGE OUTLINE** option of the Outline window. This produces the same results in the Outline window as the logical test except that only data that were painted are extracted. Perform this operation on the NCEER_TRACE data that corresponds to the site which has the annotated label "UNDERGROUND SEISMIC VAULT". The result of such an operation generates a new line in the Outline window as shown in Figure 6-9 below. To clear a brush selection, select the item **CLEAR** from the ROI window's menu.

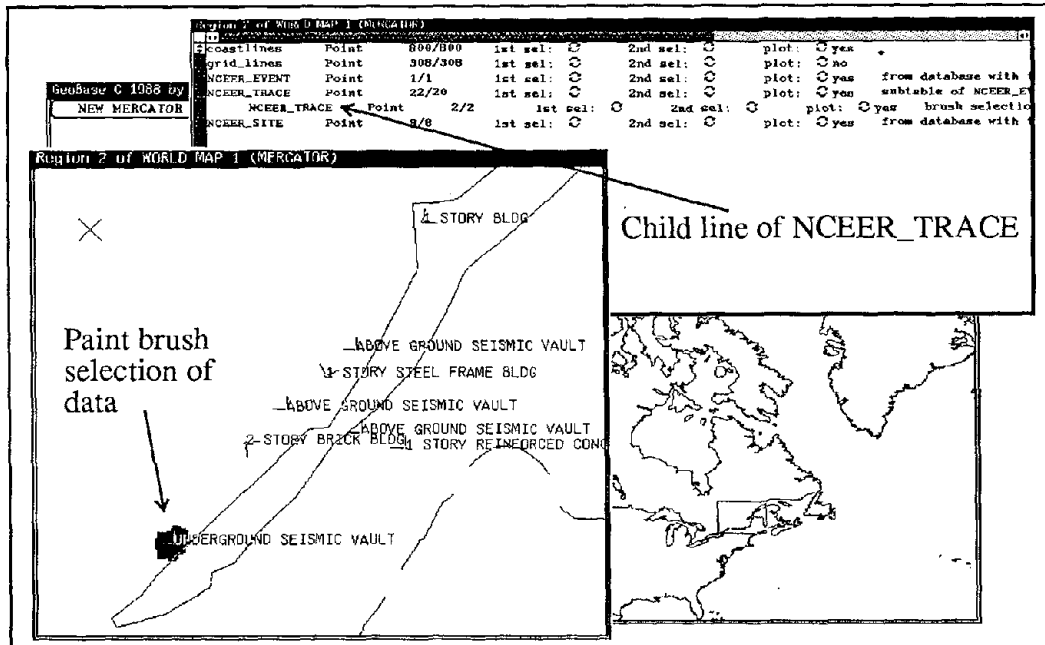


Figure 6-9 ROI window shows change in plot symbol shape for NCEER_SITE data from square to annotated value of 'structure' field. The Outline window displays the subset of NCEER_TRACE based on a 'brush' selection.

6.1.9 Outputting Time-Series Data

Now that parameters from the NCEER_TRACE, NCEER_SITE, and NCEER_EVENT tables have been obtained, as a final example, let's obtain actual time-series data described by two of the sixteen traces shown in figure 6-8. In particular, time-series from the subset of two traces that were created in the previous step by paint selection. To do this, primary-select the line that contains the subset of NCEER_TRACE and choose the sub-item **COPY AH TIMESERIES TO FILE** of the I/O item from the Outline window's menu. A window will prompt for the name of a output file. Enter the name **sag.ah** and hit Return. Since the time-series are not actually stored in the data base (Section 2.1.4), only their UNIX filenames are, GeoBase needs to be told which field contains the time-series data. Therefore, a prompt of an additional window, one that requests the name of the field which contains the filename, will appear. Since the filename will be a string, this window provides a list of all the fields that are of type string. Point and click on the field named **filename**; note that a check mark will appear in the box beside the field. Now select the **OK** button. If the files are accessible (i.e. the system administrator mounted the disk properly and the Internet is functioning) they will be catenated (AH time-series may be bunched together in one file) into the file named **sag.ah**. However, if there is a problem accessing the files, a prompt with the message stating that some (usually meaning all) of the files could not be read and were skipped. Check the directory where GeoBase was executed and make sure that the **sag.ah** file exists.

The AH file is in a special binary format, and while GeoBase does provide the ability to display point data, it does not display time-series data. There are other programs supplied with this software package, however, that do operate on the AH files. Proceed to the next section to learn how to manipulate (split apart and convert to ASCII format) and examine the sag.ah file.

6.1.10 Exiting GeoBase

To exit GeoBase, choose the **Quit** sub-item of the **FRAME** item from the menu of the Control window.

SECTION 7

TIME-SERIES DATA FORMAT

7.1 The AH Format

This section briefly describes Lamont's binary AH (Ad Hoc) format, how to examine data in the AH format, and how to convert it to ASCII format. Much of the details of the AH format, and its accompanying analysis package, are described in the ah.man document supplied with this software (see Section 5.3), so only a brief summary of it is given below.

The AH format was designed to efficiently store seismic waveform data in a self-contained manner. Programs that operate on data in AH format may work in a stand-alone manner (i.e., no data base look-ups for parameters are necessary). AH data files may contain any number of header and data block pairs, all in the binary XDR (external data representation) format. Thus, a single AH file may hold many time-series. AH header blocks are fixed in length and completely describe the variable length data blocks that follow them (see Appendix A of the ah.man document for a specification of the AH header). They also provide place holders for information about the causative event and the recording station. Although these headers are limited to a few necessary items, in comparison with the number of fields in the data base, they are still enough to describe strong-motion data.

Strong-motion waveforms in the NCEER data base are stored in AH format one time-series, of either acceleration, velocity, or displacement, per file. A mapping from the fields of the NCEER data base to the AH headers is provided in Appendix B. Each AH file is stored on-line on a 600 megabyte hard-disk and is indexed through the field named filename in the trace table. The time-series data are accessible through GeoBase and may be manipulated and displayed using the set of four AH routines provided. A larger body of software that operates on the AH format exists at Lamont (see Appendix B of the ah.man document for a description of a few of the programs available in this package). This software package may be obtained from Lamont by sending a request to Mr. Ken Howard at the address listed in Section 4.2 or via electronic-mail at ken@lamont.lidgo.columbia.edu.

7.1.1 Displaying Time-Series in AH Format

There are two highly interactive mouse-driven plotting utilities, sgp and ql, provided with this software package that may be used to quickly display and print out the AH time-series accessed through GeoBase. Each of these utilities is well documented in the manuals provided (see Section 5.3 for the ql.man and sgp.man manual pages).

Sgp (seismogram plotter), the more sophisticated of the two utilities, is a tool for displaying, magnifying, and plotting up to three AH time-series at one time. It operates in the suntools environment and is invoked by typing sgp followed by the name of the AH file. Although it operates on only three time-series at one time, many more may be read in and then paged through using the mouse. Sgp's primary feature is its ability to invoke other AH programs in order to filter

and Fourier transform the data and then quickly display the results. This allows the user to more efficiently process waveform data by providing the ability to perform time-series processing in a graphics environment. Sgp provides the user with capability to output the plots of time-series to a printer through the use of PostScript format.

The second utility, ql (quick look), is a tool for displaying and plotting more than one time-series at a time. It provides exactly what its name implies, a capability for quick examination of time-series. It too provides the capability for hard copy output in PostScript format. ql also operates in the suntools environment and is invoked by typing the following:

```
example% ql -f sag.ah -x
```

where sag.ah is the name of the file that contains the AH data obtained from the tutorial in the previous section.

7.1.2 Converting AH Time-Series to ASCII Format

Because this package's primary focus is to provide access to the data base and not provide a means with which to perform time-series analysis, it was decided that only two conversion programs from Lamont's AH analysis package would be included. The two programs, ahuncat and ah2nceer, allow for breaking out individual AH time-series from a file and converting them to ASCII format, respectively.

Since AH files may contain many time-series, and they are in binary format, there must be a means to separate them into individual files. This is done through the ahuncat program. It is provided with the package because GeoBase bundles all of the time-series from a query into a single file. Ahuncat requires two parameters on the command line: a prefix to be used in naming the files and the name of the AH file passed through standard input. For example, the following command sequence:

```
example% ahuncat prefix < sag.ah
```

will generate the two AH files prefix.00001.00001 and prefix.00001.00002. The ASCII conversion program ah2nceer operates on AH files by reading from standard input and writing to standard output. For instance, to convert the two binary AH files into ASCII format you would use the ah2nceer program in the following manner:

```
example% ah2nceer < prefix.00001.00001> ascii.1
```

```
example% ah2nceer < prefix.00001.00002> ascii.2
```

The format of the two ASCII files, ascii.1 and ascii.2, is described in Appendix C. Ah2nceer is not limited to AH files that have only one time-series per file (i.e., it can operate directly on the sag.ah file).

SECTION 8

REFERENCES

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2. Row, L.W., "An Earthquake Strong-Motion Data Catalog for Personal Computers: SMCAT, User Manual (Release 1.0), National Geophysical Data Center Report, Boulder, Colorado, 1989, pp. 47.
3. Naumoski, N., "McMaster University Seismological Executive Database System: MUSE", Earthquake Engineering Research Group, Department of Civil Engineering and Engineering Mechanics Publication, McMaster University, 1988, pp. 5.
4. Converse, A., "User's guide to ESM: A Database for Strong-Motion Information", United States Geological Survey Open-File Report 87-160, 1987.
5. Comer, D., "Internetworking with TCP/IP: Principles, Protocols, and Architecture", Prentice Hall, Englewood Cliffs, NJ, 1988, pp. 382.
6. "Strong Motion Earthquake Accelerograms Index Volume", Earthquake Engineering Research Laboratory, California Institute of Technology, Report No. EERL 76-02, 1976, pp. 72.

APPENDIX A

Agency/Source Codes

ACOE	Army Corps of Engineers Waterways Experiment Station PO Box 631 Vicksburg, Mississippi 39180
BRK	University of California at Berkley Seismology Laboratory Berkley, California 94720
CDMG	California Division of Mines and Geology Strong-Motion Instrumentation Program 630 Bercut Drive Sacramento, California 95814
CIT	California Institute of Technology Structural Dynamics Laboratory Pasadena, California 91125
EMR/GSC	Department of Energy, Mines, and Resources of Canada Geological Survey of Canada Ottawa, Ontario K1A 0Y3
HARVARD	Harvard University Department of Earth and Planetary Science Cambridge, Massachusetts 02138
ISC	International Seismological Center Thatcham, Newbury, RG13 4NS Berkshire, United Kingdom
LDGO	Lamont-Doherty Geological Observatory Seismology Department Route 9W Palisades, New York 10964
LSA	LS Associates 7107 Lafayette Street San Jose, California 95050
LAWP	Los Angeles Department of Water and Power Los Angeles, California 90054
MCMASTER	McMaster University Department of Civil Engineering and Engineering Mechanics Hamilton, Ontario Canada L8S 4L7

MWD	Metropolitan Water District PO Box 54153 Los Angeles, California 90054
NGDC	National Geophysical Data Center National Oceanic and Atmospheric Administration 325 Broadway Boulder, Colorado 80303
PDE	Preliminary Determination of Epicenters National Earthquake Information Center United States Geological Survey Box 25046 Denver, Colorado 80025
SLU	Saint Louis University Department of Earth and Atmospheric Sciences 221 North Grand Boulevard Saint Louis, Missouri 63103
USGS	United States Geological Survey 345 Middlefield Road Menlo Park, California 94025
USNAVY	United States Navy Naval Civil Engineering Laboratory Port Hueneme, California 93043
VA	Veteran's Administration Washington, D.C.
WPRS	United States Water and Power Service Denver Federal Center Code 231 Denver, Colorado 80225

APPENDIX B

AH Header Field to Data Base Field Mapping

<u>Data Base Table:</u>	<u>Data BaseField:</u>	<u>AH Header Field:</u>
*	part_of_site_id	head.station.code
trace	orientation	head.station.chan
trace	type_of_trace	head.station.stype
site	site_latitude	head.station.slat
site	site_longitude	head.station.slon
site	elevation	head.station.elev
event	latitude	head.event.lat
event	longitude	head.event.lon
event	depth	head.event.dep
event	year	head.event.ot.yr
event	month	head.event.ot.mo
event	day	head.event.ot.day
event	hrmn	head.event.ot.hr, head.event.ot.mn
event	second	head.event.ot.sec
event	event_name	head.event.ecomment
trace	type_of_data	head.record.type
trace	number_of_points	head.record.ndata
trace	time_step	head.record.delta
trace	peak_value	head.record.maxamp
record	record_year	head.record.abstime.yr
record	record_month	head.record.abstime.mo
record	record_day	head.record.abstime.day
record	record_hrmn	head.record.abstime.hr, head.record.abstime.mn
record	record_second	head.record.abstime.sec
record	comment	head.record.rcomment
site	site_id	head.record.log

APPENDIX C

NCEER's ASCII Format for Strong-Motion Data

The NCEER strong-motion ASCII format was designed to accept strong-motion time-series data stored in AH format. It was created to provide a medium for the exchange of time-series between sites where the XDR binary format of AH is not yet available. This ASCII format is generated by using the ah2nceer program. Each ASCII time-series in this format is composed of a 22 line header, each line of which is variable length, followed by any number of lines of data. The header contains three parts, event, site, and record/trace, which have fixed fields to accept parameters from the AH header. The fields in each part are filled using the mapping described in APPENDIX B. Two key fields, *data format* and *number of points* in the record/trace portion of each header describe the format and number of data that follow it.

An example of a file in the NCEER strong-motion ASCII format is provided below:

```
NCEER ASCII STRONG-MOTION DATA FORMAT
EVENT PARAMETERS:
  DATE:  year=1988 month=11 day=25
  TIME:  hour|minute (24hr)=2346 second= 4.500 time code=UTC
  LOCATION:  latitude= 48.12100 longitude= -71.18600 depth (km)= 28.0
  NAME:  Saguenay earthquake
SITE PARAMETERS:
  LOCATION:  latitude= 47.54960 longitude= -70.32730 elevation (m)= 0.0
  SITE ID:  Site - 20 - , Les Eboulements, PQ
  CODE:  20
RECORD/TRACE PARAMETERS:
  START DATE:  year= 0 month= 0 day= 0
  START TIME:  hour|minute (24hr)=0000 second= 0.000 time code=UTC
  EPICENTRAL DISTANCE:  distance (km)= 90.4 azimuth (deg)=N315.0
  SPECS:  sampling rate (sec)=0.005
          number of points= 4134
          units=CM/SEC/SEC
          type of data=ACCELERATION
          data format=10F8.2 INTERPOLATED
  COMPONENT OF MOTION:  azimuth=N270 (HORIZONTAL)
  COMMENT:  direction of motion. relative to ground
DATA:
  -1.67  -4.10  -4.59  -5.66  -0.02  4.04  5.16  3.78  1.14  0.50
  -6.33 -10.18 -2.46  7.50  9.25  1.19 -5.34 -2.04 -1.97 -5.62
  -2.24  1.07  3.35  0.94 -1.56 -1.93 -4.71 -2.10  4.81  4.27
  -5.78 -3.14  4.76 -2.10 -5.54  3.22  1.72 -13.88 -10.32  7.11
  .
  .
  .
NCEER ASCII STRONG-MOTION DATA FORMAT
EVENT PARAMETERS:
  more parameters...
DATA:
  more data...
```


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- NCEER-87-0003 "Experimentation Using the Earthquake Simulation Facilities at University at Buffalo," by A.M. Reinhorn and R.L. Ketter, to be published.
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