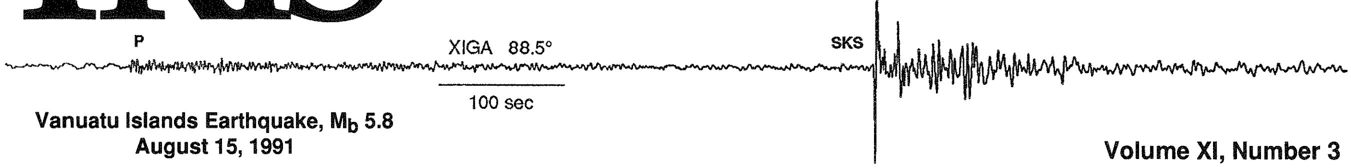
IRIS Newsletter



Vanuatu Islands Earthquake, M_b 5.8
August 15, 1991

Volume XI, Number 3

The Tibetan Plateau Passive-Source Seismic Experiment

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From July 1991 until July 1992, 11 broadband PASSCAL instruments were operated in the Tibetan Plateau during the NSF-funded Tibetan Plateau Passive-Source Seismic Experiment. This project was a cooperative experiment between the University of South Carolina, SUNY-Binghamton, and the Institute of Geophysics of the State Seismological Bureau of China. The fundamental scientific objective of this experiment was to extend our understanding of the deep structure of the Tibetan Plateau through observations of local, regional, and teleseismic events recorded within the Tibetan Plateau. This was the first extensive passive-source experiment attempted within the Tibetan Plateau. It was also the first long-term deployment of the PASSCAL STS-2 broadband sensors. For these reasons, we will describe here both some practical aspects of this deployment and some initial observations.

For logistical reasons, most of the stations were located along the Qinghai-Tibet Highway between Lhasa and Golmud (Figure 1). Six new sites were constructed based on our specifications while the remaining five sites were located at existing permanent stations of the Chinese regional network. All sites were located on bedrock. The five instruments located at permanent sites were slightly noisier than the remote field sites because these sites were located within staffed compounds at the edge of villages. Constructing stations on the Tibetan Plateau represents an extreme test for "non-permanent" broadband installations. The average elevation of the sites we constructed was 4578 meters. Winter temperatures average as low as -19° C at our coldest site with historical minimum temperatures as low as -47° C. In addition, the three northernmost sites we constructed were in areas of permafrost. Based on discussions with the Chinese, we designed insulated wooden vaults to house the equipment. Each site

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U.S. and Chinese seismologists on a service run through Yushu village, eastern Tibetan Plateau in March 1992 (near site USHU as shown in Figure 1). *(Photo - Dan McNamara)*

What's Inside

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consisted of two 1.2 m square subsurface vaults, one for the sensor and one for the PASSCAL recorder and six 36 Amp-hr batteries. The sites were powered by two 30W solar panels provided by PASSCAL. The PASSCAL Instrument Center at Lamont-Doherty Geological Observatory also built simple power distribution boards to provide up to three independent battery banks. Each vault was insulated on the sides with 10cm of styrofoam and on the top with 15cm. The vaults were buried with 20-30cm of soil. The sensor vault was required to be on bedrock. A 80 cm square concrete pad was laid in each sensor vault. This pad was not in contact with the walls of the vault to decouple it from overlying soil movements. The sensor was further insulated with two styrofoam boxes totalling 15 cm of material separated by dead air. These boxes were also used for the sensors on the piers of the permanent stations we occupied. The batteries and PASSCAL instrument were covered by 5 cm foam boxes.

This vault design was successful in that we had no temperature related instrument failures. However, we did have some trouble in the winter and spring with sensor pad movements at the 3 permafrost sites. One site (ERDO) produced noisy records between the winter and spring service runs largely due to pad movement. To compensate for small pad movements and sensor drift, we used the calibration functions of the PASSCAL recorder to automatically recenter the sensor every three days. This was successful except during an unscheduled long (175 day) service gap in the winter when our calibration sequence expired and sensors began to drift at all sites.

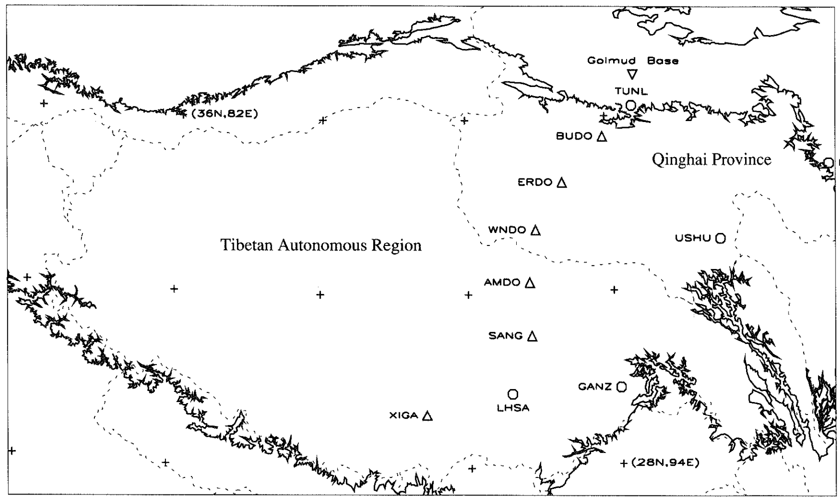
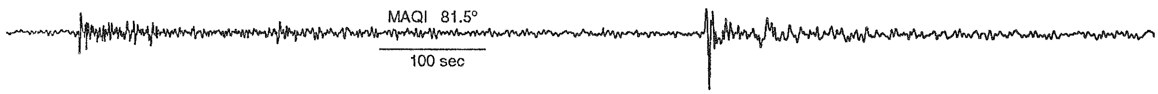


Figure 1. Tibetan Plateau deployment. Triangles represent sites that were constructed especially for this project. Circles are permanent vaults of the Chinese seismic network that were occupied by broadband instruments during this project. Heavy solid line is the 4000 m contour to outline the Tibetan Plateau boundary. Dashed lines are international and provincial boundaries.

Instrumentation for this experiment consisted of 10 Streckeisen STS-2 sensors and 1 Guralp CMG-3ESP sensor (at TUNL) and PASSCAL digital event recorders equipped with 360Mb hard disks. We took 13 complete sets of instrumentation to China. The complete shipment, including field computer and extra supplies totalled 1250 kg in 45 boxes. Installation of the array took 35 days and was completed on August 5, 1991. The first event was recorded July 4, 1991 and the last event was recorded on July 1, 1992. After the initial installation, we undertook 4 service runs (August, September, February, and June). Each service run required 5000 km of driving, 1600 km on the train and took at least 30 days. Data were uploaded to two media (hard disk and exabyte tape) during each service visit. Exabyte tape uploads were occasionally frustrating, but all were accomplished successfully. Uploads to hard disks were uneventful, but on several occasions data were not recoverable due to disk failures. Between the two media, 100% of the recorded data was recovered from the field.

We recorded two data streams: A 40 sample/sec triggered stream and a 1 sample/sec continuous data stream. The 40 sps triggered stream had an LTA of 100 seconds, an STA of 6 second, and a trigger ratio of 3.5. It recorded for 100 seconds pre-trigger and 1500 seconds post-trigger to capture later teleseismic body wave phases. This stream also can adequately record complete regional and teleseismic wavetrains out to distances of about 40 degree (Figure 2). Beyond

This Issue's Bannergram: The seismogram on the cover shows the radial component, broadband velocity record of a deep earthquake from the Vanuatu Islands (Mb=5.8, h=188km) recorded by station XIGA on August 15, 1991 during the Tibetan Plateau Seismic Experiment. On the inside pages, triggers for 8 different stations of the Tibetan Plateau array are displayed. The P- and S-arrivals can be observed in the first 1000 seconds of the radial seismogram shown on the right-hand page. A window around the S-wave arrivals for the same station is blown up on the left-hand page. The distance range from this event to the Tibetan Plateau is 81 to 88 degrees. The S-wavetrain changes from a relatively simple pulse at MAQI (d=81.5 deg) prior to the emergence of SKS, to a complex signal at USHU and GANZ (d=83.4 and 84.4) and finally to a signal with a simple SKS pulse leading and separated from the simple S pulse at distance beyond 86 degrees (TUNL, SANG, AMDO, WNDO, and XIGA). •



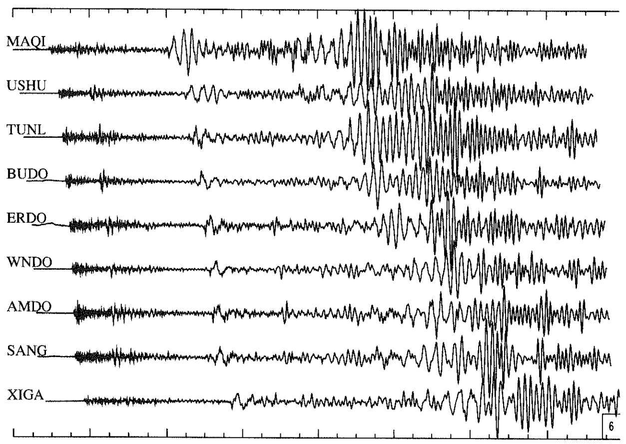


Figure 2. Radial component of the September 3, 1991, Ms=6.4 Honshu earthquake. Distance ranges from 31 to 42 degrees. Large tick marks = 200 secs.

40 deg, the 1 sps continuous stream is appropriate for recording surface waves. We briefly experimented with a surface-wave trigger, but did not have an opportunity to test it completely and disabled this trigger after the initial installation phase. The only triggering problem we encountered was at LHSA which triggered too frequently due to blasting activities in the area (some due to the new CDSN vault being built nearby!). After the first service run, we recorded LHSA at 5 sps continuous to be sure we recorded adequate teleseismic data.

During the experiment, a total of 573 events listed in the USGS weekly PDEs were recorded by the Tibet network (Figure 3). In addition, we recorded nearly 100 unlocated events at 6 or more stations. We will use the Chinese regional catalogs and sparse network location methods to locate and utilize many of these events. Data were dumped to a Sun field computer located in Golmud and previewed for quality control only and archived. Event identification and final archiving were done at the University of South Carolina. The data will be released to the IRIS DMC in late summer, 1993 in volumes totaling nearly 10 Gb of trace data.

These data are currently being used at the participating institutions for a wide variety of seismic studies ranging from teleseismic surface wave inversion to local earthquake travel-time analysis. We are particularly interested in variations in the upper mantle beneath the Tibetan Plateau that might help differentiate between competing models for plateau development and evolution. In addition to the contribution this data set will make toward understanding this particular problem, this broadband passive seismic profile has the potential to contribute to studies of deep earth structure as well. Variations in deep structure of the core-mantle boundary or the mantle transition zone over 1000 km length scales can only be resolved by experiments of the scale of this deployment. As an example of data suitable for studies of sublithospheric structure, Figure 4 shows broadband PKP waveforms from a single Easter Island event recorded by the Tibetan Plateau experiment. To date, we have over 20 similar events in the 140 to 165 degree distance range that could be used to examine the variability of the core-mantle boundary in the western South Pacific.

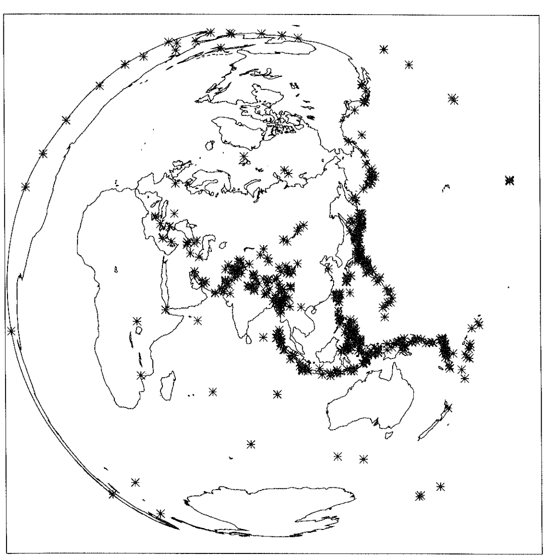


Figure 3. Distribution of the 573 PDE-located events recorded by the Tibetan Plateau network between July 1991 and July 1992.

Acknowledgments:

Many people contributed to the success of this Tibetan Plateau experiment. In addition to the project investigators, Bob Busby (PIC-Lamont), Randy Kuehnel (Carnegie-DTM), Dan McNamara, Sally Owens, Mario Salvador, and Greg Wagner (all USC) journeyed to China during the course of this experiment. We were assisted by numerous Chinese scientists and technicians in the field and in Beijing. The PASSCAL Instrument Center at Lamont deserves special thanks for preparation of the instruments and custom configurations for this deployment and for their response to our needs during the year. •

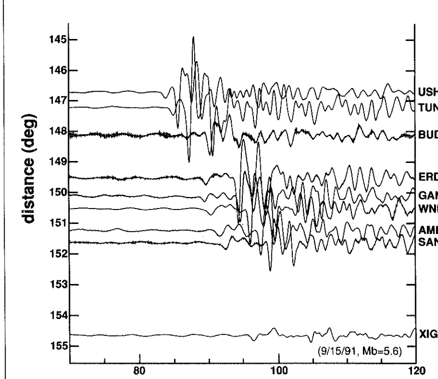


Figure 4. Record section for PKP arrivals from the September 15, 1991, Mb=5.6 Easter Island event. True amplitude variations are displayed.

NEW GSN SITES

NVS, Novosibirsk, Russia
CHTO, Cheng Mai, Thailand
TATO, Taipei, Taiwan
ANTO, Ankara, Turkey

IRIS-SEIS TRAINING

IRIS will hold training sessions for the IRIS-SEIS software extensions to SiereaSEIS at the IRIS Booth during the AGU meeting in San Francisco. Topics will include a review of the IRIS-SEIS processors, import/export of non-SEGY data, data transfer to external software, seismogram flow within SierraSEIS for nonuniform data, and modifying an existing or adding a new processor. Because the sessions will be held on an informal basis, we will focus on those topics of interest to you. An Exabyte drive will be available to read tapes containing your own data. For more information please contact David Okaya (okaya@coda.usc.edu) or Jim Fowler (jim@iris.edu).

CALL FOR PAPERS 1993 ANNUAL MEETING SEISMOLOGICAL SOCIETY OF AMERICA

The 1993 Annual Meeting of the Seismological Society of America will be held April 14-16 in Ixtapa-Zihuatanejo, Mexico. Co-convenors for the meeting are Gerardo Suarez and S.K. Singh, Instituto de Geofisica, UNAM.

Papers reporting original research in seismology and earthquake engineering are invited and should be submitted to:

Program Chair
c/o SSA Headquarters
201 Plaza Professional Building
El Cerrito, CA 94530 USA

Abstracts must be received no later than **January 10, 1993**. Format instructions for submitting abstracts will be mailed to all SSA members in late Fall, 1992. Additional copies of the instructions for submitting abstracts may be obtained from SSA Headquarters at the above address.

Software Exchange Library

At a Special Interest Group meeting at the last IRIS Workshop, the need to formalize a method of exchanging software among seismologists was identified. The IRIS DMS is instituting a Software Exchange Library (SEL) to meet this need. The IRIS DMC will act as the central receiving and distribution point for the SEL. Authors interested in making submissions should fill out a Software Information Form (SIF, see example below). Contributors are encouraged to submit this form electronically. Those who prefer to submit software and forms by mail contact the DMC for blank copies of the SIF.

Most packages that are to be submitted to the IRIS DMC SEL should be transmitted to the DMC as two files. The first is a PROGRAM.README file that includes all information on the SIF and additional information the author wishes to include. The second file should be a PROGRAM.tar file that contains everything necessary to describe, build and run the program. For authors that do not have the ability to produce a tar file, programs can be sent in alternate forms preferably by ftp in binary or ascii format as appropriate. Contact DMC staff for specific details.

A copy of the SIF can be found in the anonymous ftp area of the machine dmc.iris.washington.edu (128.95.166.2). To obtain a copy of this form electronically:

1. ftp dmc.iris.washington.edu
2. login as ftp
3. use your name as password
4. cd pub/programs
5. get soft_info_form.ps *(for a Postscript version of the form)*
6. or get soft_info_form.text *(for a text file version of the form)*
7. quit

The Postscript version is intended for those who wish to submit programs and prefer to fill out a form manually rather than electronically. The Postscript version of the form can be printed directly on a Postscript printer. The text file version can be easily edited to make electronic form submission easier.

To actually submit a program, the author must first electronically transmit the readme and tar files to the DMC by doing the following:

1. ftp dmc.iris.washington.edu
2. login as ftp
3. use your name as password
4. cd pub/dropoff
5. binary
6. put PROGRAM.tar
7. put PROGRAM.README
8. quit

Second, send email to *comments@iris.washington.edu* indicating that you wish to add the program to the IRIS SEL. The programs will be tested by University of Washington staff and IRIS DMC staff and when appropriate, added to the inventory in SEL. •

Tim Ahern, DMS Program Manager

SOFTWARE INFORMATION FORM

Contributor Name: Allen Nance **Institution:** IRIS DMC
Email address: allen@iris.washington.edu **Program Name:** rdseed
Version Number: 3.22 **Distribution Date:** July 16, 1992
Description: (1 line): RDSEED processes information on SEED volumes

Details: RDSEED takes data volumes in Standard for Exchange for Earthquake Data (SEED) format and converts time series data into SAC, AH or CSS format. Auxiliary files containing response information can also be generated.

Associated Programs: (Complete Program Name, Version Number and Description as needed for each associated program, if any) SAC - 10.6D - Seismic Analysis Code
AH - Lamont Doherty Ad Hoc analysis program

Computer and OS: SUN3 and Sparc , SUN OS 4.1.1 and higher

Special Hardware or Other Software Needed:

Distribution Contains:

MANDATORY
Statically Linked Executable - Enter Name(s): rdseed
UNIX Style Manual Page: yes

DESIRABLE (Answer Yes or No)
Detailed Reference Manual: No
Tutorial Code or script: yes
Makefile: yes
Tutorial Text: yes
Source Code: yes
Special or extra libraries: None

IRIS's Joint Seismic Program Center (JSPC) Opens

Michael H. Ritzwoller and Danny Harvey, University of Colorado

The Joint Seismic Program (JSP) is a cooperative seismological program between scientists in the United States and in the Commonwealth of Independent States (CIS). The U.S. is represented by IRIS and the USGS, and the CIS is represented by a wide array of scientific agencies including the Institute of Physics of the Earth of the Russian Academy of Sciences, the Institute of the Dynamics of Geospheres, the Organized Methodological Expedition, the Institute of Marine Geology and Geophysics of Yuzhno-Sakhalinsk, the Yakutian Institute of Geological Sciences, and the Academies of Sciences of Kirghizstan, Armenia, and Kazakhstan. IRIS is the manager of the JSP. The focus of the JSP is to provide data to improve the understanding of seismic wave propagation to facilitate an improved capacity to monitor the testing and spread of nuclear weapons. In addition, the JSP provides data to support basic research aimed at improving the understanding of earthquake hazards as well as the structure and dynamics of the Earth.

The Joint Seismic Program Center

The Joint Seismic Program Center at the University of Colorado, Boulder was recently established by IRIS to facilitate the scientific goals of the Joint Seismic Program. In order to accomplish this broadly stated mission, the JSPC undertakes two general tasks. The first is the compilation and development of 'information products' (described immediately below) which are distributed to the seismological community through the IRIS Data Management System (DMS). This is the task to which the majority of effort at the JSPC is devoted. The second task is the establishment of a cooperating scientists program to allow the research community to be involved in the specification of JSPC goals and priorities. A new e-mail newsletter, JSPNews, which is described below is designed to play an important role in this latter task. The JSPC is directed by the authors.

JSPC Information Products

A loose definition of 'information product' is a self-contained set of both processed and unprocessed waveform data and parameter data in an integrated package along with software and documentation. Such a product is designed to give the user data which are 'research ready'; that is, data that have been carefully quality checked and to which much of the 'vanilla processing' has been applied to reduce duplication of effort. In addition, data management and certain data processing capabilities are supplied.

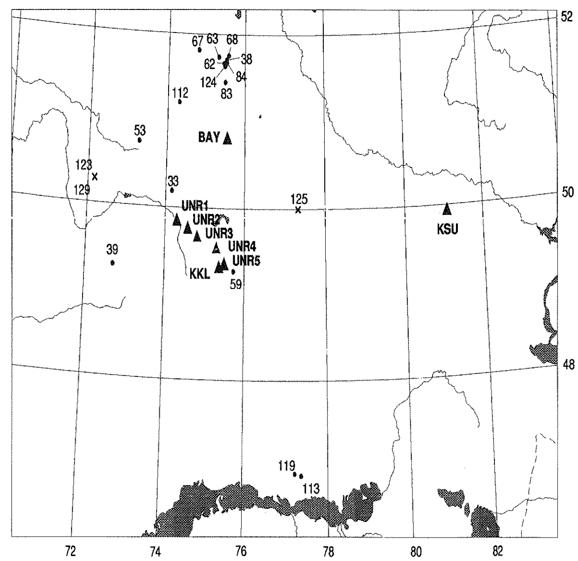


Figure 1. Locations of NRDC stations and local associated events. Triangles denote stations, x's denote the three large chemical explosions, and dots correspond to local mine/quarry blasts. The numbers correspond to the "orid" values in the origin relation.

The idea of an 'information' versus a 'data' product comes from the notion that 'data become information only when they have been properly checked and organized'. The JSPC will concentrate on making information products that closely pertain to areas of research relevant to the JSP. In particular, emphasis will be placed on the use of data from all of the JSP facilities, including data from the: GSN, Caucasus Network, Kirghiz Network, Garni Dense Array, JSP Small Aperture Array Experiments, and pertinent historical data such as Soviet Deep Seismic Sounding (DSS) data. However, due to the underlying similarities between all areas of seismological research involving the use of large volumes of waveform and parameter data, the relevance of the JSPC information products to areas of seismology outside of the JSP should be direct.

Perhaps the best way to clarify what is meant by a JSPC information product is by example, and the NRDC information product is discussed in the next subsection. We include first a general description here and note that the types of information contained in a typical JSPC information product include:

- raw waveform data from as many sources as possible,
- identification of data clips glitches, gaps, and other problems along with processed versions of the data in which these problems have been marked or corrected,
- verified instrument gains and responses,
- detailed receiver/channel characteristics,
- verified phase arrival times, amplitudes, and polarizations,
- event associations and locations,
- detailed source parameters,
- enhanced waveforms (beams) for array studies,
- F-K estimates for array data,
- structural models and travel time functions used in event locations,
- pertinent references in the published literature,

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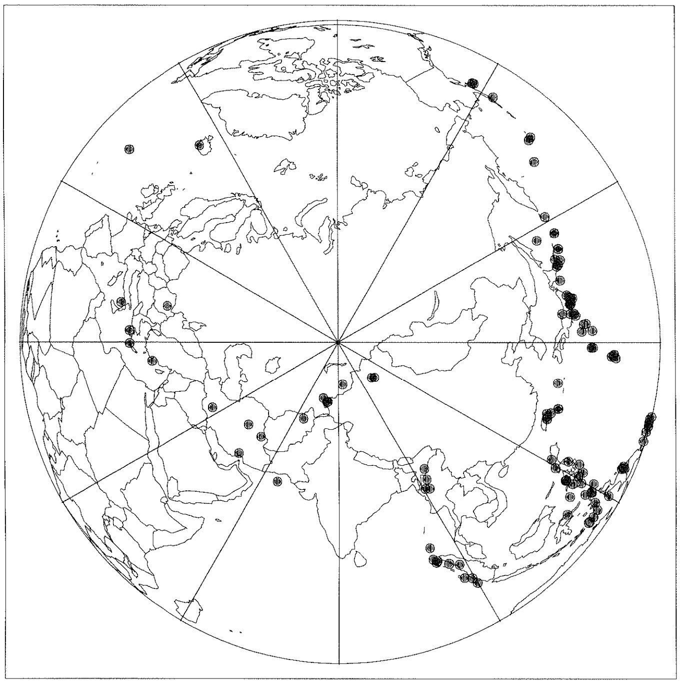

Figure 2. Orthographic projection centered on the station at Bayanaul, Kazakhstan (BAY) with the locations of recorded teleseisms plotted so that azimuths can be determined.

• notes relating to reliability,
• and sources of information.

All errors found in GSN or PASSCAL data are reported to the IRIS Data Management Center (DMC) so that corrective actions can be taken.

Each information product will be distributed by the DMC. Information product availability is summarized under the assembled data products section of the DMC's bulletin board and ordering is done through the bulletin board's note writing facility, as described below. Each information product is shipped from the DMC, usually as a Exabyte tape together with paper copies of four manuals: (1) a Technical Reference Manual describing that particular product, (2) an Installation/Tutorial Manual, (3) a Software Manual covering JSPC-created software, and (4) a data base Schema Reference Manual describing the data base used in archiving the parameter data. The contents of the tape include data, software, documentation (including postscript versions of the aforementioned manuals), and demos designed to allow users to incorporate the data quickly into research efforts. Data formats of the raw data are chosen to be similar to, if not identical to, the format in which the data are received at the JSPC. Frequently, this will be in short integer form, but in any event it will be a format well known to the user community. Processed data are uniformly included as SAC files within the Center for Seismic Studies (CSS) v. 3.0 relational data base management schema. Small modifications to the CSS rdbms have been made and are documented in the JSPC data base Schema Reference Manual. All raw data (and soon processed data as well) are also available separately in SEED volumes. All parameter data are included within CSS v. 3.0 shema. Programs for viewing and for reformatting the data are included in each information product, as are programmatic libraries in both FORTRAN and C to access all information. The availability of data in the CSS schema and in both SAC and SEED formats with JSPC-developed subroutine access to both tabular and waveform data insures multitiered data access. The CSS v. 3.0 relational data base schema has been chosen for the processed waveform data and for the parameter data since it is well documented and relatively widely used within the JSP community. It is a heterogeneous schema in which all parameter data are stored as ASCII flat files and waveform data are stored as binary files in a variety of formats. The JSPC chooses to keep waveform data in SAC files and, in coordination with the DMC, will attempt to provide reformatting programs to SEGY, AH, SEED and other common archival and transmittal formats.

A shell script is provided in each product to subset and install the data. The script installs any combination of the documentation, the software, the parameter tables, and/or selected (by day, time, channel, station) processed and/or raw waveform data. It audits the amount of data selected for installation.

NRDC Information Product

In 1986, a group of U.S. scientists approached the Natural Resources Defense Council (NRDC), a nonprofit environmental organization, to initiate contact with the Soviet government in order to install three temporary seismic stations around the nuclear test site in Kazakhstan. These stations, the locations of which are shown in Figure 1, comprise surface and borehole three-component high frequency instruments (1-50 Hz) recorded at 250 sps at two gain levels totaling on average 15 channels. They triggered on regional (Figure 1) and teleseismic (Figure 2) earthquakes, as well as on local quarry blasts (Figure 1) over 77 days from March 19 to August 5, 1987. Event triggering resulted in over 20,000 individual waveform segments totaling approximately 600 million samples. In original form (16-bit integer) the waveform data occupies about 1.2 Gbytes. The experiment ended in the recording of three large chemical explosions, two of 10 tons and the other of 20 tons, on September 2 and 3, 1987. On these two days, five additional stations were situated near the test site at Semipalatinsk by researchers from the University of Nevada, Reno. Figure 3 shows samples of waveform data from a variety of seismic sources.

The NRDC data are very high quality

and, due to the proximity to Semipalatinsk in Eastern Kazakhstan, are located in a region of the world still poorly instrumented by Western seismologists. Even preliminary analysis of these data are revealing new information (see the NRDC Information Product Technical Reference Manual for a reference list) and some surprises as evidenced by the observed azimuth anomalies from events in the Western Pacific shown here in Figure 4, which we speculate may be caused by slab-channeling of the earliest P-wave arrivals.

The NRDC program represents the logical precedessor of the JSP and these data collected in Kazakhstan provide the earliest detailed look at the seismic characteristics of Central Asia by Western scientists. Consequently, the NRDC data are a natural first information product for the JSPC. Figure 5 shows the UNIX directory structure of the NRDC information product now available from the DMC. The structure of future products will be similar. There are three main directories: /data, /doc, and /sw. The /data directory is broken into three main subdirectories: /raw, /proc, and /tables. The subdirectories /raw and /proc contain the compressed raw and processed data, respectively. The raw data have been selected, processed, merged into the CSS v. 3.0 schema, converted to SAC and are stored in /proc. The compressed raw and processed data occupy approximately 450 and 480 Mbytes, respectively. The subdirectory /tables contains parameter information about instrument sites and channels, sensor information and instrument responses, event information (locations, times, moment tensors, etc.), picks and so forth in the following CSS 3.0 tables:nrdc.affiliation, nrdc.arrival, nrdc.assoc, nrdc.centryd, nrdc.instrument, nrdc.moment, nrdc.network, nrdc.origin, nrdc.sensor, nrdc.site,nrdc.sitechan, nrdc.sregion. Instrument responses are contained in subdirectory nrdc.resp and velocity models and travel time curves are found in subdirectory nrdc.vmodel. As described below, the parameter data and a subset of processed waveform data can be obtained via the JSPC's and the DMC's anonymous ftp facilities.

The /doc directory contains the four manuals in postscript files (tech_report.ps, install_tutorial.ps, software.ps, schema.ps) and an installation example. The /sw directory contains all the JSPC-created software. All documents and software can also be obtained via anonymous ftp from the JSPC and the DMC in the way described below.

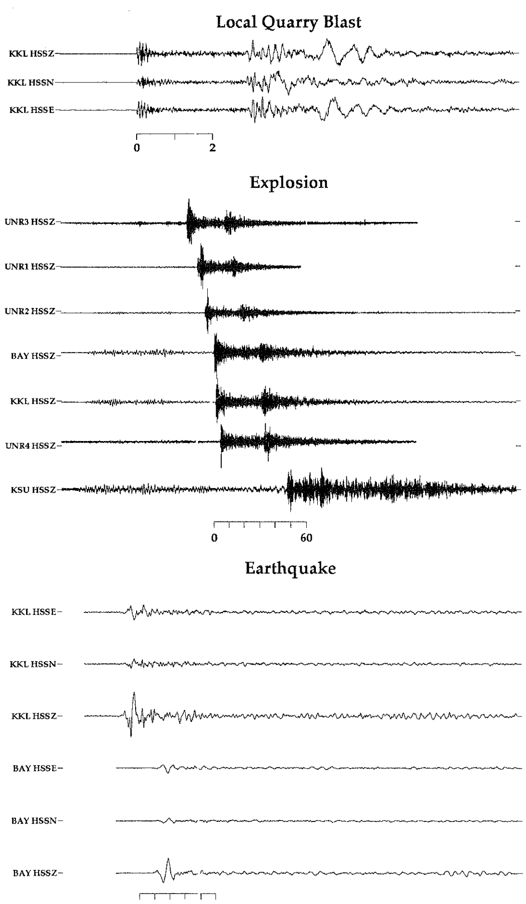

Figure 3. Plots of a subset of the NRDC data. TOP: A local quarry blast near origin #59. MIDDLE: A 10 ton chemical explosion, origin #129. BOTTOM: A teleseism located in the Banda Sea, origin #40.

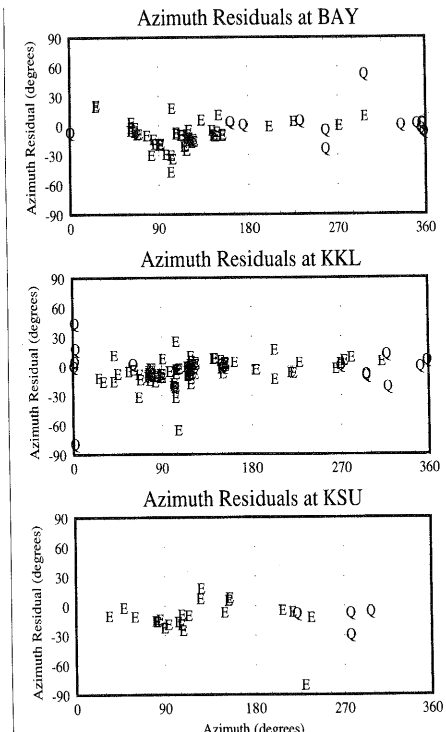

Figure 4. Azimuth residual, defined as the difference between the measured and predicted azimuth to source, plotted as a function of the source azimuth. E's represent earthquakes and Q's quarry blasts or explosions. Comparison with Figure 2 shows that events in the West and Southwest Pacific manifest a considerable azimuth anomaly.

Planned Information Products

The following two information products, in addition to the NRDC product, are scheduled for release in 1992.

Kirghizstan/Caucasus Network Unified Event Bulletin: An event bulletin comprising locations of local and regional events determined from the early operation of the Kirghizstan (September, 1991 through December, 1991) Network is planned for an approximate release date of November 15, 1992. In addition, it is hoped that an information product containing the triggered waveform data from these networks can also be completed at this time.

Large Nuclear Test Information Product: Another product is projected for release around December 15, 1992 including the Joint Verification Experiment (JVE) data and data for the large Chinese nuclear test in May, 1992.

Projected information products for

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1993 include: continued release of the Kirghizstan/Caucasus Network Unified Event Bulletin and triggered waveforms from these networks, a long-period (approximately 2 Hz sampling rate) information product from the continuous channels of these two networks so that regional and teleseismic surface waves can be studied, a Eurasian Tomography data product containing data from significant earthquakes in and around Eurasian for seismic structural studies, and, perhaps, release of some DSS data received from Russia.

Status reports on each of these products will be found in subsequent issues of JSPNews. Announcement of their availability will appear in JSPCNews and on the DMC bulletin board. Suggestions for future products should be addressed to editor@jspc.colorado.edu.

Receiving JSPC Information Products

Each completed JSPC information product can be obtained from the DMC at the University of Washington through the DMC's Bulletin Board. To connect to the Bulletin Board telnet or rlogin as follows: **rlogin dmc.iris.washington.edu-l bulletin** using a password of **board**. The DMC's internet address is 128.95.166.2. A listing of JSPC-created information products available through the DMC can be found by using the Main Menu Option *a*, for ASSEMBLED data sets, with the submenu option *j*, for JSPC. An order is placed through the Main Menu note writing facility using Main Menu option *n*. Ordered in this way, an Exabyte tar tape and the four paper manuals described above will be mailed from the DMC to the orderer. If a SEED volume of the data is also required, please specify as such in the ordering note left with the *n* facility.

A copy of all documents, man pages, JSPC-created software, parameter data including raw and processed data wfdisc files, and a subset of the processed data are available through both the JSPC's and the DMC's anonymous ftp facilities. Thus, the complete directory structure shown in Figure 5 is available via ftp except for the waveform data. For the NRDC information product, only processed data from day 1987141 are available via ftp. To connect to the JSPC's or the DMC's ftp facility type: **ftp jspc.colorado.edu** with username anonymous and a password of your e-mail address or **ftp dmc.iris.washington.edu** with username **anonymous** and a password of your lastname. The NRDC information product is located in /pub/products/jspc/nrdc at the DMC. At the JSPC, the software is broken out and is located in /pub/sw and the NRDC specific information is located in /pub/info_products/nrdc. The JSPC's internet address is 128.138.142.43.

Potential users are invited to peruse the contents of the ftp facility at the JSPC. Of potential future interest is the directory /pub/seismograms that mainly contains ASCII or postscript files of seismograms considered interesting for some reason or another. For example, there is directory called /seismograms/chinese_test, containing a number of seismograms in ASCII

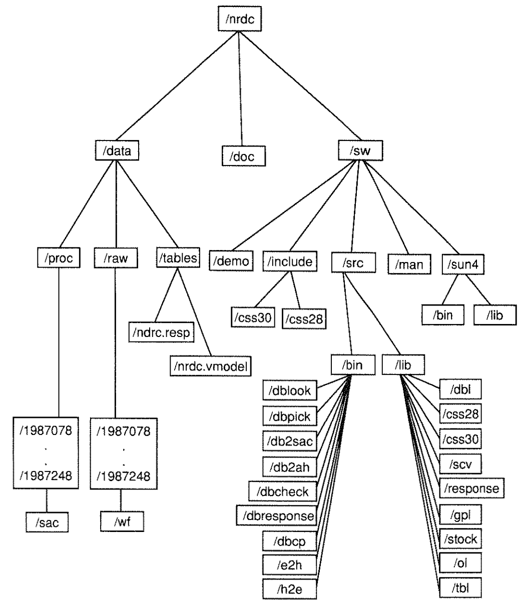

Figure 5. NRDC information product distribution directory tree.

from the Chinese nuclear test on May 21, 1992 recorded at OBN and seismograms from an earthquake on the Russian-Mongolian border also recorded at OBN. Postscript versions of the figures in this article are contained in /seismograms/iris_newsletter. A README file in each directory should explain the contents of that and, perhaps, the interest of the seismograms. Any problems or questions should be addressed to problems@jspc.colorado.edu.

User Feedback and JSPNews

The success of the JSPC depends strongly on user feedback. To facilitate and motivate user input, the JSPC is distributing a new e-mail newsletter called JSPNews which contains information relevant to the Joint Seismic Program. It is intended that JSPNews will provide a mechanism for two-way communication between the JSPC and its clients as well as a forum for the interchange of ideas and information between members of the JSP community. Each issue will contain a status report of JSPC information products and announcements of new products as they are developed. In addition, subscribers are encouraged to contribute information in the form of short articles, and to publicize research opportunities, positions available, reports from significant meetings, upcoming scientific conferences and so forth. Contributions should be sent to editor@jspc.colorado.edu. To add, remove, or change your e-mail address for JSPNews contact postman@jspc.colorado.edu. Include your full name, post office address, phone number, and e-mail address. Old issues of JSPNews are available in the JSPC anonymous ftp in /pub/JSPNews. •

International Seismological Observing Period

Eric Bergman and E. R. Engdahl, U.S. Geological Survey, Golden, Colorado

The International Seismological Observing Period (ISOP) is to be a specific time interval designated for enhanced international cooperation in the collection and dissemination of observatory measurements from the global seismographic network. The concept of the ISOP was first proposed in the mid-1980's by T. H. Jordan. At the 1989 IASPEI General Assembly a Steering Committee was formed, consisting of J. Berrocal (Brazil), D. Denham (Australia), D. J. Doornbos (Norway), E. R. Engdahl (U.S.A., Chair), and N. V. Kondorskaya (Russia). The ISOP Office was established at the NEIC in Golden, Colorado in 1990, under the direction of E. R. Engdahl and E. A. Bergman (Coordinator). The project is sponsored by IASPEI, SEDI and ICL.

The general scientific goal of ISOP is to collect a high quality, globally-distributed set of body-wave seismic data for high-resolution studies of deep Earth structure. Specific goals include improved models of the Earth's average radial velocity structure, better resolution of the detailed structure and lateral extent of major internal discontinuities and associated boundary layers, and the identification of short-wavelength structures in the Earth's mantle and core.

Secondary phase data are essential for further progress on many of these scientific problems. For example, denser, more precise sets of primary and later phase arrival-time and amplitude data can significantly improve three-dimensional tomographic images of subduction zones and deep Earth structure, and can also aid in the identification of small-scale structural anomalies for the planning of intensive special-purpose studies. Current measurement and reporting practices largely ignore the abundant information on secondary phases on many seismograms (Figure 1).

The strategy of the ISOP project is to designate earthquakes for intensified analysis aimed at extracting as much information as possible on secondary phases. Earthquakes will be chosen, at the rate of about one per day, so as to sample the Earth as evenly as possible. Simulated ISOP experiments have shown that a three-year observing program will adequately sample the Earth's major seismic zones. Current plans call for the observing period to begin in early 1994.

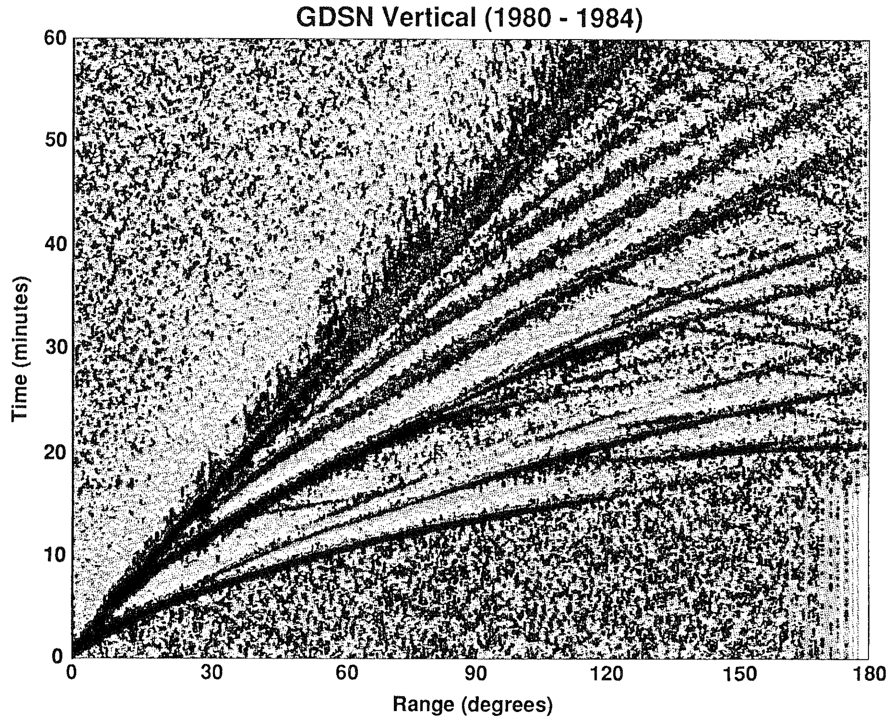

Figure 1. Stacked image of long-period GDSN vertical component data for the years 1980–84. Amplitudes are normalized by an AGC algorithm. Absolute amplitude and polarity information are lost in this procedure. The wavefield is clearly rich in secondary phase data, even though some phases (e.g., PcP) are better-imaged at shorter periods. *(Courtesy of P. Shearer)*

Selection of ISOP events will take place at the NEIC; notification to participating stations will take place through various publication channels operated by the NEIC, including the QED and PDE (Figure 2). Any seismic station, regardless of instrumentation, can participate in the ISOP, but stations with high-quality digital systems will be able to take advantage of advanced processing techniques to improve their ability to read secondary phases. Readings will be transmitted in the standard manner to the NEIC or ISC, where they will be processed in the normal manner. ISOP data will ultimately be published in the Bulletin of the ISC, but a variety of other forms of publication are being planned as well. For example, combined packages of waveform and other data on ISOP events may be issued on CD-ROM.

Routine Processing of Digital Data

When they were newly deployed and few in number it was acceptable for high-quality digital stations to be considered "special", best-suited for advanced research projects, and therefore exempt from participating in the traditional activities of global seismology,

continued on page 10

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such as measuring phase arrival times and amplitudes, locating earthquakes, and assigning magnitudes. One can imagine that it will eventually be possible to carry on these tasks using full-waveform analysis of digital data alone. The importance of phase arrival time and amplitude measurements will not cease at that time, however; they will remain an important data set for research. Unfortunately, most digital data are not now used and are unlikely, under current practices, to be used for basic measurements of phase arrival times and magnitudes.

Accurate measurements of secondary phases are notoriously difficult from records made with narrow-band analog instruments, especially if only a vertical short-period component is available. Interactive processing of three-component digital data offers a number of advantages. When a rough estimate of the hypocenter is available (as it normally is for larger events), synthetic seismograms can be quickly computed for comparison with recorded waveforms (Figure 3). Such comparisons can be very instructive in making a correct interpretation of the observed phases, especially when theoretical travel times from a model such as iasp91 can be easily overlaid on the traces. Amplitude measurements made from standardized instrument responses derived from broad-band records can ensure continuity and homogeneity of magnitude data bases, a goal of critical importance for studies of seismic hazard. Polarization analysis is invaluable in separating closely spaced phases with different polarizations. Accurate measurement of some phases, such as PP and PK_{Pab}, can only be made if the trace has been Hilbert transformed (Figure 4). The consistency and reliability of reported data can be improved by automated formatting of messages for transmittal to international agencies.

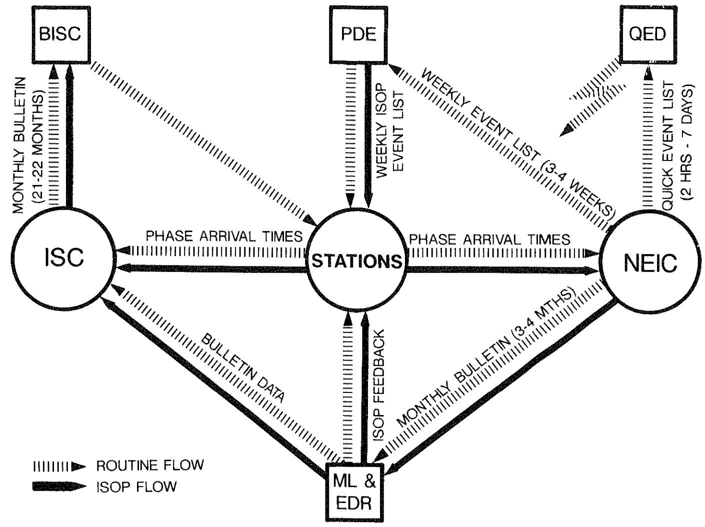

Figure 2. Data flow for the ISOP observing program. Notification of event designation to stations comes from NEIC through the QED, PDE, and Monthly Bulletins. Data are sent to NEIC or ISC. The IRIS DMC will provide additional data archival services.

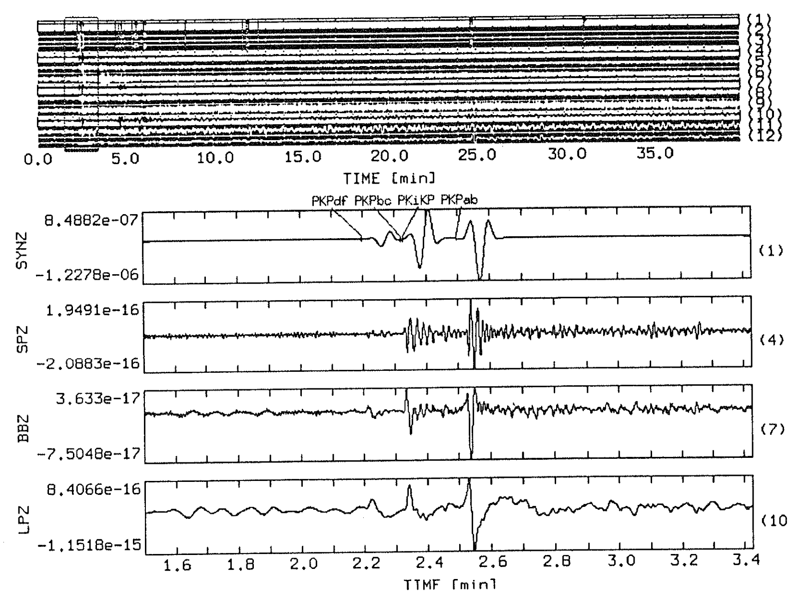

Figure 3. A portion of the screen display from the prototype of the ISOP software for interactive analysis of seismograms. The upper part shows full time series for 12 traces, 3 components each for a synthetic seismogram and three standardized instrument responses: WWSSN short period, Kirnos BB, and WWSSN long period. The lower part displays the vertical components only for the time segment indicated by the box over the full traces. Phase arrival times calculated from the iasp91 model are labeled on the synthetic. The zeroth-order ray-synthetic seismograms can be calculated on a PC quickly enough to be useful for routine analysis. *(Courtesy of F. Scherbaum and A. Plesinger)*

ISOP Software

In March 1991, ISOP convened a workshop in Denver attended by representatives of IRIS (D. Simpson, R. Butler, and T. Ahern), the USGS, major digital seismic networks, companies involved in digital seismic instrumentation, and seismologists who have been active in the field of interactive analysis of digital data. This group developed a set of design goals for software to assist the observatory seismologist in making efficient, consistent, and thorough analysis of digitally-recorded data, regardless of the particular instrumentation in use, in support of the ISOP observing program on secondary phases. Although a number of software packages were displayed, many of which possessed features considered desirable for the purpose, none was judged to be fully satisfactory. A decision was made within the ISOP project to proceed with development of such a package, using as a basis the PITSA software developed by F. Scherbaum and J. Johnson.

Within the IRIS community, UNIX workstations have become a standard tool for seismological analysis. IBM-compatible PCs are much more widely available in observatory settings worldwide, however, and the goals of ISOP require that the analysis software support this hardware. The ISOP software is being written so that it is largely hardware-independent, requiring only a different graphic front-end to function on a different platform. Initially, the ISOP software will support UNIX workstations and PCs.

IRIS Participation

IRIS already has several points of contact with the ISOP project, and discussions are underway to identify other ways in which IRIS members can participate.

GSN stations are natural "seeds" for the growth of seismology in many countries. However, simply installing a station does not guarantee a local flowering of seismological activity. Participation in the ISOP project can help ensure that GSN stations are well-maintained and fully utilized by the host institution. ISOP also functions as a scouting service for the GSN, identifying sites and institutions which are particularly well-qualified and eager to operate a station.

Discussions are underway with the IRIS DMC to develop special archives for ISOP data which can be readily accessed by all interested scientists as soon as possible after the data are processed at the NEIC. The DMC will maintain an electronic bulletin board for the ISOP project and provide a message broadcasting service. The DMC is also developing automated procedures for making some kinds of measurements on secondary phases which can supplement the data reported by stations participating in the ISOP observing program.

Development of the workstation version of the ISOP software is being supported by the IRIS DMS program to provide an advanced field-analysis capability for PASSCAL as well as providing the ability to read SEED format directly. Because they are normally deployed in regions where there are few permanent seismic stations, PASSCAL instruments and other high-quality mobile seismic systems, including the latest-generation OBSs and arrays like PANDA and NARS, can contribute data of exceptional value to the ISOP program. Plans for such participation are underway with representatives of the various programs.

IRIS has championed the use of advanced telecommunications technology for exchange of seismological data in near-real time. This is of tremendous interest in countries with a seismic hazards problem. Rapid access to digital data from stations in other countries, and the capability to process such data quickly are perhaps the most often-expressed need of seismological services worldwide. IRIS's efforts to share its expertise in this field have been greatly appreciated and contribute substantially to the practice of observational seismology.

IRIS could be involved in establishing standards and protocols for digital seismology. Because its membership is composed of academic institutions, it is natural also that IRIS take a lead role in developing training programs for young seismologists and those who are new to digital seismology.

Conclusions

ISOP seeks to reach across boundaries between traditional analog, parameter-based seismological methods and recently developed methods based on digital technology. The interests of seismology as a global observational science are best served by a tolerant, inclusive, attitude which recognizes the distinctive contributions of a variety of approaches within the existing infrastructure of global seismology. At the same time seismology must constantly adapt to new technologies and the changing organizational principles necessary to exploit them. This philosophy has been shaped by members of the IRIS community who have been active in the ISOP project from the beginning. Through participation in ISOP, IRIS members have a singular opportunity to play a role in guiding seismology through a period of extraordinary change and promise.

For further information on the ISOP project, contact Eric Bergman, USGS, Box 25046, Mail Stop 967, Denver Federal Center, Denver, CO 80225; phone 303-273-8421; fax 303-273-8450; email bergman@gldfs.cr.usgs.gov. •

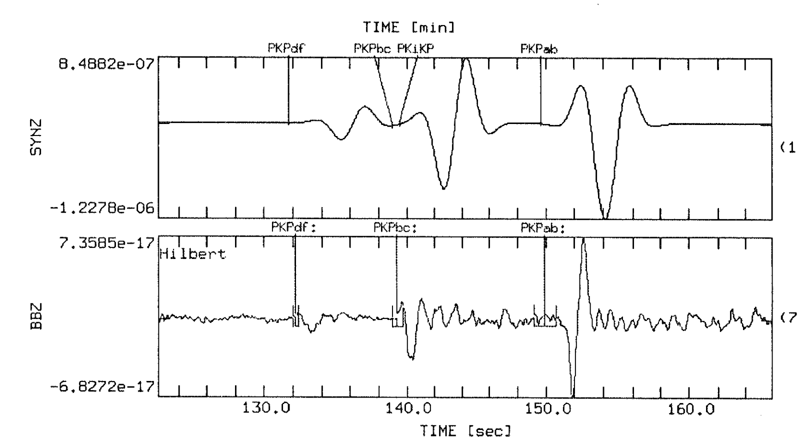

Figure 4. Same screen display as Figure 3 (minus the full traces at the top), showing the synthetic and the Hilbert-transformed BB traces. Arrival times for the three PKP branches were picked from the original record, but the PKP_{ab} phase has experienced a phase shift during propagation and should be picked from a trace which has been Hilbert-transformed. The PKP_{ab} arrival time picked from the original BB trace is clearly too early. *(Courtesy of F. Scherbaum and A. Plesinger)*

Initial Results from Project ALOHA

Clifford Thurber and Clifford Munson, University of Wisconsin-Madison
Yingping Li, State University of New York at Stony Brook (currently at MIT)
William Prothero, Jr., University of California, Santa Barbara

In the fall of 1990 through spring of 1991, we carried out a passive seismic field experiment on Hawaii to image the major discontinuities in structure beneath Hawaii. Our primary aim was to test the hypothesis that major earthquakes occur along a subhorizontal buried sediment layer (BSL) at the interface between the volcanic pile and the underlying ocean crust. Our research efforts are directed towards profiling the BSL, the Moho, and the near-surface structure using converted and reflected seismic waves from local earthquakes. Microearthquakes occur from the near-surface down to a depth of 60 km beneath Hawaii, with a concentration of flank events at a depth range of 5 to 14 km. Such well distributed microearthquakes are excellent natural sources for imaging the interfaces within the crust using reflected and converted waves. They also provide shear waves for the investigation of possible anisotropy. The large earthquakes occurring around the Pacific 'rim of fire' provide the potential for studying the large scale structure beneath Hawaii with the receiver function or array analysis methods.

The array deployment phase of Project ALOHA was initiated in July 1990 with the installation of 5 UCSB recorders and 16 PASSCAL instruments on the southeast flank of Mauna Loa volcano. The UCSB teleseismic array was deployed in the Kaoiki area with a spacing of approximately 1 km (Figure 1). The PASSCAL instruments were deployed primarily in the form of 4 to 7 station arrays of three-component seismometers, with array apertures on the order of 5 km or less. We installed four PASSCAL arrays on the southeast flank of Mauna Loa volcano and one PASSCAL array on the south flank of Kilauea volcano (Figure 1). We first set up two PASSCAL arrays in the Kaoiki area (BP and AN) and one array in the Hilea area (WG) for 1 to 3 months, and then moved one array to the south flank of Kilauea (SF) and placed another array in the Hilea area (PG), the epicentral area of the 1868 Kau great earthquake. The PASSCAL instruments were deployed over areas of active local seismicity in order to produce 'vertical earthquake profiling' of structure. The 'local' portion of the experiment using PASSCAL instruments ended December 12, 1990, but the 'teleseismic' portion of the project remained in operation until July 1, 1991.

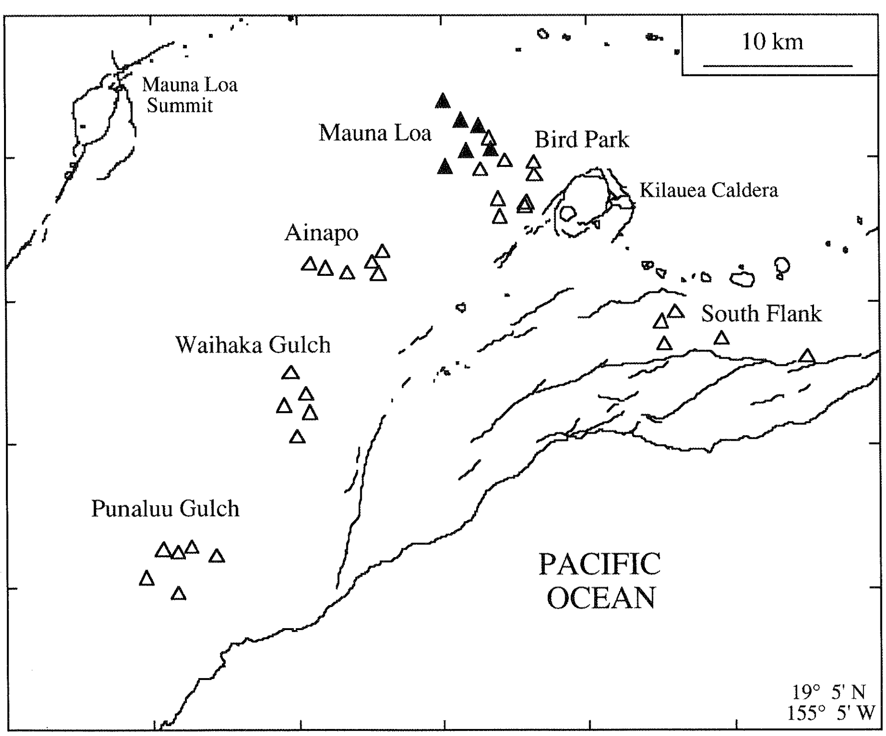

Figure 1. Seismic array deployments in Southern Hawaii by project ALOHA. Open triangles are PASSCAL units and solid triangles are UCSB teleseismic recorders.

During our experiment, portable broadband Guralp CMG-3ESP sensors and RefTek instruments were set up for the first time on the Island of Hawaii. We investigated the broadband ambient seismic noise for eight sites on the Big Island to explore whether the island might provide a good site for a GSN permanent station. The instruments operated continuously for one day to one month with a sample rate of 10 or 20 sps. Compared to the GSN/Geoscope station KIP (Kipapa) on Oahu, noise is generally lower on the Big Island by 5 to 10 db. The exception is at longer periods (> 10 seconds), where our surface deployment of the sensor caused increased noise levels.

The PASSCAL arrays recorded about one thousand identified local earthquakes, but only moderate numbers of teleseismic events. The availability of an event catalog from the Hawaiian Volcano Observatory's real-time event location system allowed us to readily identify the overwhelming majority of local events recorded by the arrays. The magnitudes of local earthquakes range

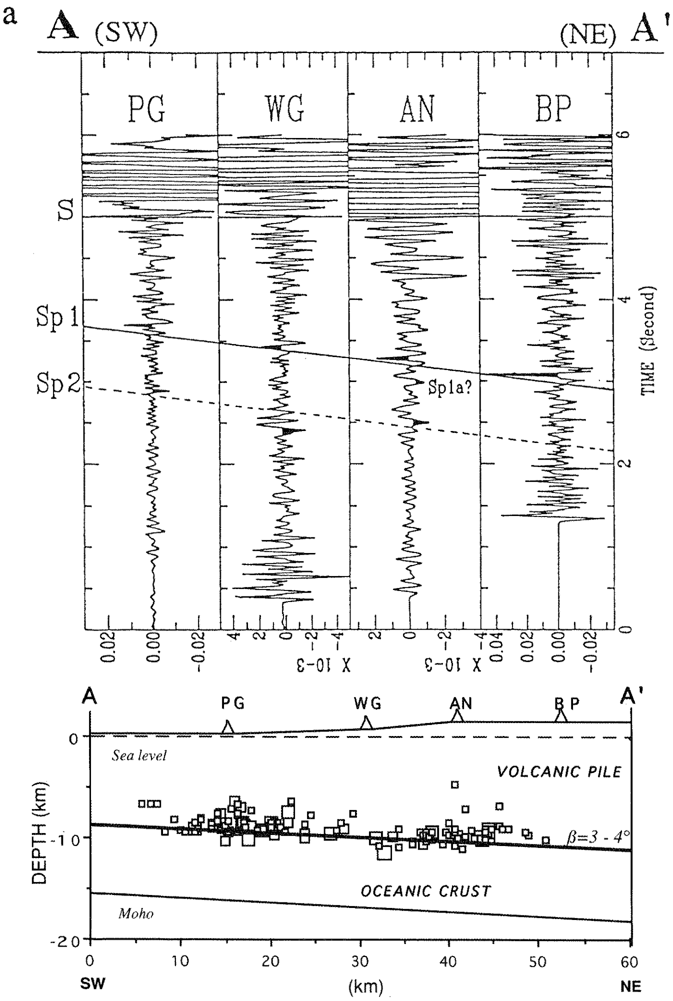

Figure 2. (a) SW to NE seismic record section constructed with data from four arrays (triangles in b). (b) Comparison of the mapped discontinuities with locations of low-angle thrust faulting earthquakes. The bold and dash lines dipping slightly towards the northeast indicate the volcano-crust interface and the Moho. The earthquakes shown here are from results of Endo [1985] and Bryan and Johnson [1991].

from 0.5 to 4.8. The three-component waveform data of these local earthquakes constitute the primary database for subsequent study.

The ultimate goal of these analyses is the production of maps for (1) the structure of near-surface layers, (2) the volcano-ocean crust interface depth and thickness of the BSL, and (3) Moho depth. A detailed model of the near-surface structure can provide information regarding the degree to which the seismograms are affected by local site effects, and may provide information on site response. If site effects are strong, we use a deconvolution technique to remove the reverberations caused by the near-surface layers, thus improving signal to noise ratio for reflections off the BSL. Map (2) can be compared to the depth distribution of low angle thrust events beneath the Kaoiki and Hilea areas. Our initial results for HVO's station AIN [Thurber et al., 1989] indicate that the two coincide there, implying that the volcano-ocean crust interface indeed serves as the detachment fault plane for these earthquakes. Map (3) can be compared to existing models of lithosphere flexure and oceanic crust thickening/thinning [Watts et al., 1985; Thurber and Gripp, 1988; Watts and ten Brink, 1989].

Our first completed results are from the analysis of S to P and P to S converted seismic waves from deep local earthquakes, used to image the volcano-ocean crust interface and the Moho boundary beneath southern Hawaii. Preliminary results of this study have been published [Li et al., 1992]. We applied array techniques to enhance the converted waves and interpret the array observations of conversions in terms of time differences, polarities, amplitudes, particle motion plots, and frequency content. Effects of focal mechanisms of the earthquakes on the observability of the converted seismic waves were also investigated. A profile of crustal discontinuities obtained from S to P converted waves was constructed and compared with the depth distribution of low angle thrust earthquakes, previous results from refraction profiles, and flexure models (Figure 2). The volcano-ocean crust interface ranges in depth from 8.5 to 12 km beneath the southeast flank of Mauna Loa, consistent with depth distribution of the thrust events; whereas the Moho ranges in depth from 15 to 18 km beneath the flank, in conflict with the flexure models. Both interfaces are dipping 3° to 4° towards northeast along our southwest-northeast profile. The observed polarity reversals of the volcano-ocean crust interface conversions compared to the Moho conversions strongly supports the existence of a low velocity BSL at the volcano-ocean crust interface. The thickness of the BSL is estimated to be approximately 1 km.

We have also analyed reverberations in near-surface layers.

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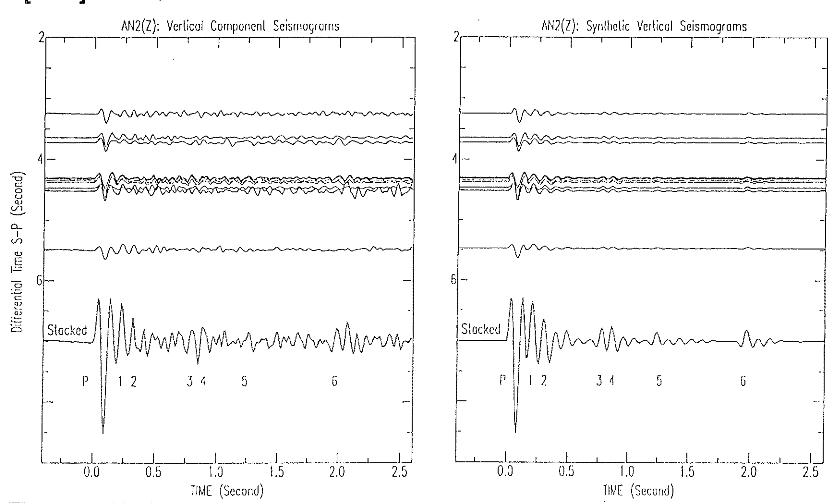

Figure 3. Modeling of near-surface P wave velocity structure with multiple reflections (marked with numbers) on the vertical component seismograms of deep earthquakes recorded at station AN2. Data (left) and synthetic seismograms (right). The bottom seismograms are stacked traces.

CALENDAR

DECEMBER

4-6 FDSN Meeting DMC, Seattle, Washington

7-11 AGU, San Francisco, California

8 Annual IRIS BOD Meeting, San Francisco, California

APRIL 1993

14-16 SSA, Ixtapa, Mexico

MAY 1993

3-5 National Earthquake Conference, Memphis, Tennessee

24-28 AGU, Baltimore, Maryland

JUNE 1993

10-14 Fifth Annual IRIS Workshop, Waikoloa, Hawaii

The calendar is a regular feature of the Newsletter. Please submit dates of interest to IRIS members, including meetings and field programs.

Hawaii Chosen as Site for 1993 Workshop

The Fifth Annual IRIS Workshop will be held from June 10-14 at the Royal Waikoloan Resort on the Big Island of Hawaii. Located just 20 minutes from Kona Airport on the North Shore, the hotel offers excellent facilities, and should prove to be an exciting and enjoyable spot for our meeting. Non-stop air service to Kona is available from San Francisco, and substantial discounts on air fares are possible with early booking. Details on air and hotel reservations will be provided in early 1993.

Included in our plans is a one-day field trip to Hawaii Volcano Observatory (HVO), located on the rim of Kilauea Volcano, where we will tour the USGS research facility. Current volcanic activity is best observed via helicopter or hike

Volcano National Park. *(Photo - Hawaii Visitors Bureau)*

from HVO. If enough interest is indicated, we may offer as options both helicopter tours (at your own expense) and guided hikes. If you are interested in a helicopter tour, please contact us via email (liz@iris.edu) as soon as possible. We should be able to negotiate a competitive rate for a group of this size. Those interested in a guided hike are also encouraged to contact us.

For those of you who would like to bring your families, the hotel will extend the $80 meeting rate both three days before and after the workshop. The Royal Waikoloan has its own white sand beach and is located on Anaehoomalu Bay, which is ideal for snorkeling and swimming. Other on-site or nearby activities include horseback riding, golf, tennis, and boating. See you in Hawaii! •

Liz McDowell, Corporate Office

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