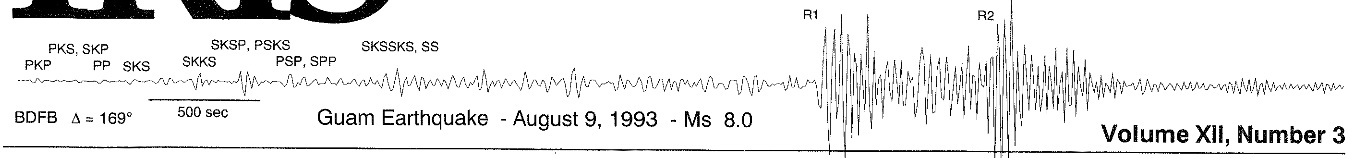
IRIS Newsletter



Guam Earthquake - August 9, 1993 - Ms 8.0

Volume XII, Number 3

Performance Estimates of a Global Network of Open Stations

John P. Claassen, Sandia National Laboratories
John Unger and William Leith, U.S. Geological Survey

Over the past eight years IRIS has played a major role in the installation of a global network of high-quality, digital seismic stations known as the Global Seismographic Network (GSN). The eventual goal of the GSN is to establish broadband stations throughout the world at uniform spacing of approximately 2000 km [1]. The primary purpose of the GSN is a research tool for understanding the structure and dynamics of the earth; however data from the GSN can also play an important role in contributing to the detection and location of earthquakes and explosions.

IRIS and other global networks (CDSN, GEOSCOPE, USNSN, MEDNET, etc.) are coordinating their efforts through an international organization called the Federation of Digital Seismographic Networks (FDSN). The FDSN primarily establishes and coordinates standards for station hardware, station siting, and data formats so as to promote the exchange of high quality data on a global basis.

All of the stations of the FDSN are "open" in the sense that their data are openly and freely available to all interested parties. Many of the stations are also "open" in the more limited technical sense that they can be remotely accessed to retrieve data.

As the U.S. and other countries consider the difficult task of monitoring a comprehensive test ban (CTB), it has been speculated that the data from the open stations might be used to supplement data from other monitoring networks[2]. For example, critically located open stations might be queried for data to improve the location of a "suspicious event," or to provide crucial waveform evidence for confirming whether or not the event was a nuclear test [3]. Open stations could provide convincing third party data to an international debate, without compromising the capabilities of a country's defense monitoring networks. Also, since they are distributed worldwide, they serve as a deterrent to nuclear testing by the practice of a "neighborhood watch"[4].

Thus, it is worthwhile to consider the collective capability of the open global networks for detecting, locating, and classifying seismic events, either earthquakes or explosions. Here, we evaluate the magnitude detection capabilities on the Eurasian and African continents of a set of current and planned open seismic stations. The results presented here are

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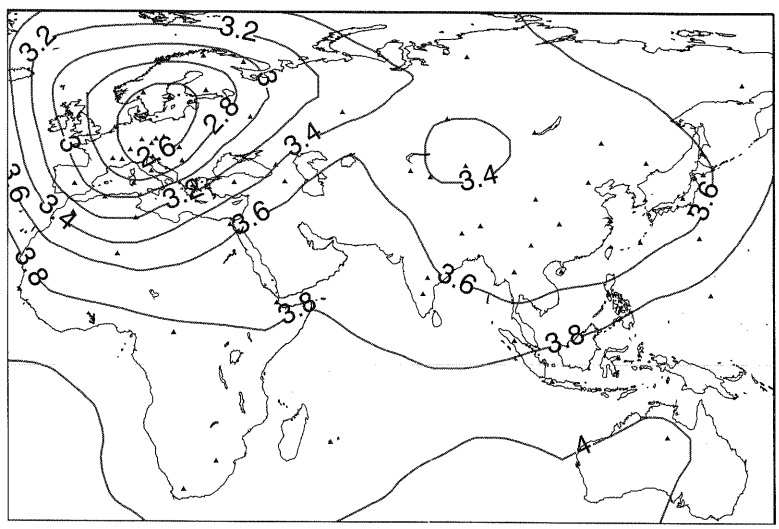

Figure 1. The detection threshold estimate in mb(Lg) units when 79 of the current open stations in Africa, Asia, and Europe are included in the simulation. The threshold was based on a network detection criterion that required at least 4 P arrivals be observed 90% of the time. Station noise spectra were modeled with actual daytime (worst case) values when station data were available and with average daytime values otherwise [12].

What's Inside

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based on more detailed calculations that were originally done independently by the authors and integrated for this article. Copies of the original studies can be obtained directly from the authors. The stations used in these evaluations represent existing, planned, or proposed stations from the FDSN networks, and are not the only ones available for seismic monitoring.

Modeling Network Performance

Several computer programs (e.g., SNAP/D-HF [5] and NetSim [6]) are available to model the performance of seismic networks whose stations are separated at regional distances. These programs are capable of modeling either detection or location performance. When a modeling code is used in different ways we can estimate 1) the event magnitude detectable at a given level of confidence (detection threshold), 2) the event magnitude at which an evader risks being detected (evasion threshold), 3) the network probability of detection at a given source magnitude, 4) the location accuracy, including source depth if desired, at a given source magnitude, and 5) the event magnitude for a required location accuracy (location threshold). Other results, at the discretion and creativity of the user, may also be extracted.

Network modeling requires a substantial database to achieve a simulation outcome. The requirements generally include 1) station noise spectra statistics, 2) coda noise spectral statistics, 3) geology-dependent propagation models for the various regional and teleseismic phases; 4) a worldwide regionalization of the propagational dependencies, 5) a station database including the station coordinates, station detection and location modeling parameters, station data availability, local propagational velocities, and rock density, 6) source models for different geologies, 7) a regionalization of the source geologies, and 8) a knowledge of the frequency at which the secondary arrivals are propagated. Furthermore, as a network becomes mature and station data become available, the station specific parameters become more important to modeling.

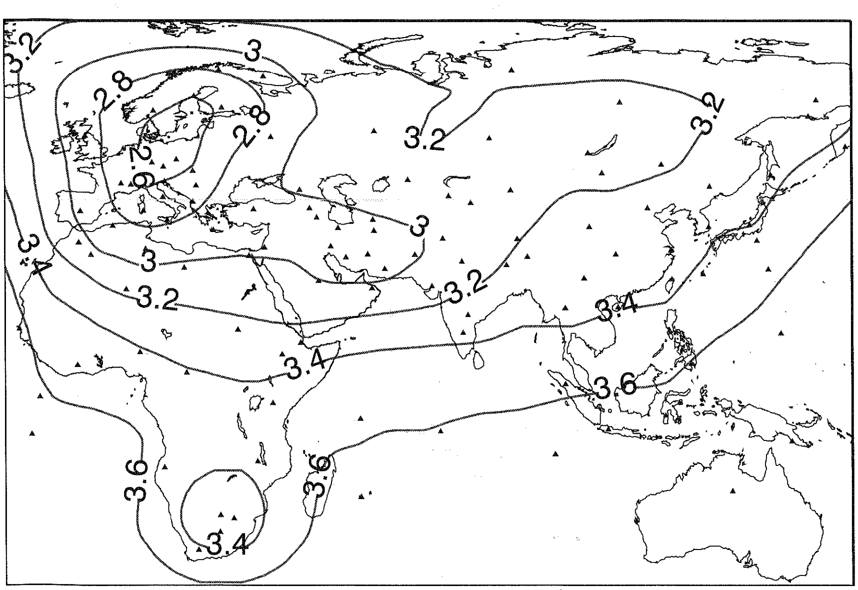

Figure 2. The detection threshold estimate in mb(Lg) values when 128 of existing and future open stations in Africa, Asia, and Europe are included in the simulation. The threshold was based on a network detection criterion that required at least 4 P arrivals be observed 90% of the time. Station noise spectra were modeled with actual daytime (worst case) values when station data were available and with average daytime values otherwise. The actual 4P detection threshold estimate can be lowered by the careful siting of stations or noise reduction (e.g., through boreholes or arrays) at existing or future sites.

Among these, the most influential parameter on detection and location is the seismic background noise at individual stations. A rule of thumb is that every 10 dB change in network noise level results in a 1/2 magnitude change in network sensitivity when detection is restricted to the P arrivals. Mean log noise spectra and the associated log variance to relatively high frequencies are required for proper modeling of the detection of nearby events. When designing and evaluating networks, it is appropriate to use worst case noise levels so that judgements can be made regarding the vulnerability of the network to evasive measures. In the case of coda noise, coda decay models are required to properly assess the signal-to-noise ratios of the secondary arrivals.

Definitive regional propagational models are important inputs for simulating the performance of regional networks. The significance of region dependent models becomes evident when the seismic phase Lg is included in the simulation results. It is known that the quality factor of Lg propagation varies approximately by a factor of 12 on a global basis. It is further known that changes in the quality of Lg propagation can have significant influence on magnitude estimates [7] and therefore on network performance estimates. The quality of regional Pn and Sn phases are thought to vary in accord with the Lg quality factor since the geologic factors which influence Lg propagation are also thought to affect Pn and Sn. An extensive set of frequency dependent propagation models is available for the regional arrivals [8] on the Scandinavian shield. Lg propagation models for frequencies near 1 Hz are available for large areas of the globe [9][10][11]. These models must be properly coupled with the appropriate source model for the distinct geologies.

An investigation of the performance of nuclear monitoring networks requires hypothetical station sets to establish the influence of station density, noise, and other factors as well as current and future global station sets to confirm actual

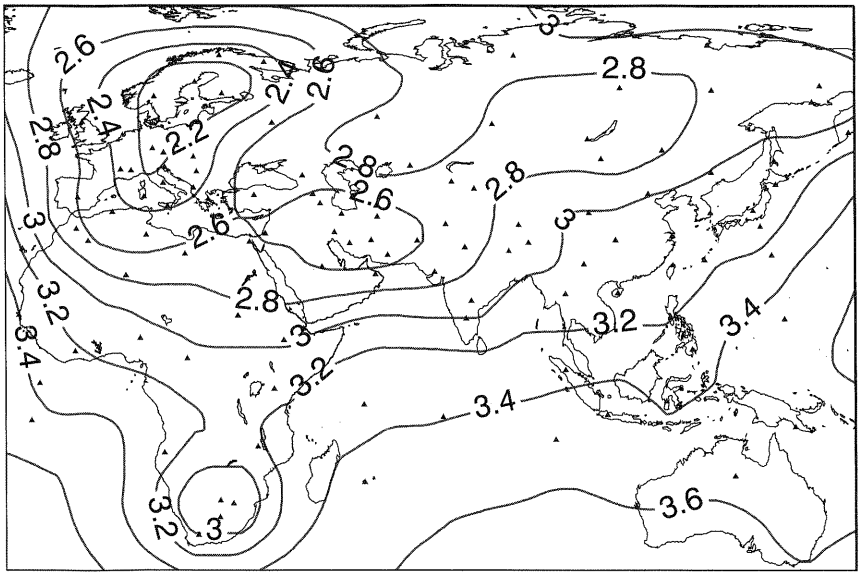

Figure 3. The detection threshold estimate in mb(Lg) values when 128 of the future open stations in Africa, Asia, and Europe are included in the simulation. The threshold was based on a network detection criterion that required at least 4 P or S arrivals be observed 90% of the time with 2 of the 4 arrivals being P arrivals. Station noise spectra were modeled with actual daytime values when station data were available and with average daytime values otherwise. As with the 4P results, the threshold can be lowered by the careful siting of stations or noise reduction.

network designs. The required station information may be acquired from the USGS, IRIS, and the Center for Seismic Studies (CSS/ARPA). The USGS and IRIS maintain a listing of more than 200 existing and 400 planned worldwide, digital broadband seismic stations primarily affiliated with the FDSN. The CSS maintains a listing of stations and station characteristics for those stations which have contributed to the various Group of Scientific Experts Technical Test (GSETT) experiments sponsored by the Conference on Disarmament of the United Nations. The CSS also has an historical database of the global stations and may have data on the stations to be proposed for use in a global verification network.

Some Simulation Results

We have applied the performance simulation codes to collections of stations from the open seismic networks. The evaluations were conducted on a continent by continent basis using up to the number of stations permitted by the simulation codes. Examples of the detection performance levels on the Eurasian and African continents appear in Figures 1, 2, and 3 where the contours are estimates of the detection threshold in mb(Lg) magnitude units. The results in Figures 1 and 2 required that at least 4 P arrivals be detected with 90% confidence (minimum of 4 contributing stations); whereas, the result in Figure 3 required that at least 4 arrivals, either P or S, be observed 90% of the time with at least 2 of the 4 arrivals being P arrivals. The detection thresholds associated with Figure 3 assumed that regional Pn, Pg, Sn, and Lg and teleseismic P, S, and Lg are propagated 100% of the time. The remaining assumptions and conditions contributing to these results are described in the paragraph below and within the figure captions.

The stations employed in these results included the open arrays such as NRAO, GRF, WRA, etc., and the open broadband or short period digital stations from various open networks such as the CDSN, GSN, GEOSCOPE, MEDNET, etc. It was assumed that the stations have their data available 95% of the time. It was reasoned that, if they are to assist as monitoring stations, sufficient spare parts would be made available to bring their reliability to this level (the results will not significantly change if this factor is reduced slightly). The possibility of noise correlation between nearby sites was not considered. The world was divided into four regional propagation classes based on the known or the assumed quality of Lg propagation in each 5 by 5 degree sector of the world. These four regional classes included high Q (low attenuation) regions, medium Q regions, low Q regions, and regions considered to be Lg barriers such as the deep ocean basins. The Pn, Sn and Lg propagational models developed by Sereno [8] for Scandinavia were appropriately scaled to the high Q and low Q regions when the Scandinavian shield was regarded as a medium Q region. It is therefore assumed that the extrapolation of the Scandinavian propagation models and the global regionalization into propagation classes appropriately represent propagation in the remaining parts of the world. All station magnitude biases and variance were considered to be zero.

Discussion and Future Considerations

These performance measures, based on the best data available to us, show that the open networks can make contributions to the global monitoring of fairly small events. The results show that events on the Eurasian and African continents can be detected today down to magnitudes ranging from 2.6 to 3.9 with a typical value of 3.6 using the 4 P detection criterion (See Figure 1). With the stated assumptions, the future global network of open stations will have detection levels ranging between 2.6 and 3.4, with 3.2 being a typical value under the 4 P detection criterion (See Figure 2) and between 2.2 and 3.2 with 2.8 a typical value under the "relaxed" 4 arrival criterion (See Figure 3). We emphasize that the actual detection levels for the network configurations should be better than shown in Figure 2, since not all the stations were or could be included in the simulations. Since the secondary phases are sometimes not propagated or are weakly propagated,

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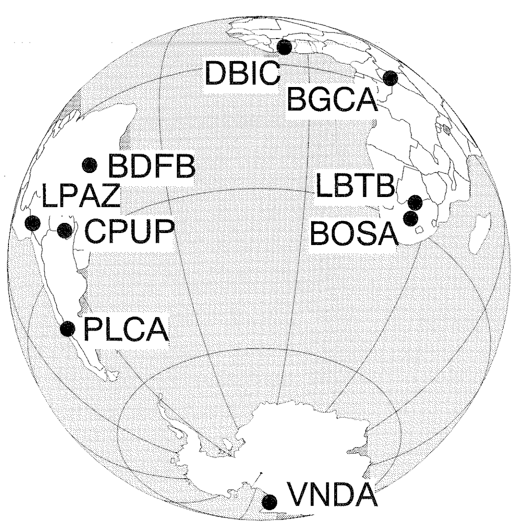
The Global Telemetered Seismograph Network

Charles R. (Bob) Hutt, USGS Albuquerque Seismological Laboratory
Eric A. Bergman, ISOP Coordinator, USGS National Earthquake Information Center

The Global Telemetered Seismograph Network (GTSN) is a cooperative program between the USGS and countries in South America and Africa. The purpose of the program is to obtain and exchange in a timely manner seismological data of high quality and reliability.

The Global Telemetered Seismograph Network (GTSN) is an end result of a long recognized need for more high quality seismic stations in the southern hemisphere. The project began in the late 1970s, with the goal of installing a series of stations which would rapidly read seismograms and report the information to the NEIC (USGS). In 1978, the Air Force and the USGS signed a memorandum of understanding for instrument development and installation. System specifications were developed over the next four years and so-called "Phase I" reporting was initiated, in which existing southern hemisphere stations were used in reporting phases. Between 1983 and 1988 potential sites were visited and studied for noise characteristics. The extraordinary technological advances in digitizer and seismometer design required modification of the concept originally envisioned for a GTSN station, resulting in broadband continuous recording. Since these technical characteristics are similar to those of the design goals for GSN, the GTSN provides an important complement to GSN coverage in the southern hemisphere, filling in a number of gaps in station distribution and allowing IRIS to concentrate on station installations in other critical areas.

The three primary elements of the GTSN are the field system, the communication system, and the data center. The packet-switched telecommunications network (PSN) is not discussed here. The GTSN Data Center (GDC) is located at the USGS's Albuquerque Seismological Laboratory. Currently, field systems are planned for nine sites:



Map showing stations of the GTSN network.

South America

- CPUP: Asuncion, Paraguay
- PLCA: Bariloche, Argentina
- BDFB: Brasilia, Brazil
- LPAZ: LaPaz, Bolivia

Africa

- BGCA: Bangui, Central African Republic
- BOSA: Boshof, South Africa
- DBIC: Dimbroko, Cote d'Ivoire
- LBTB: Lobatse, Botswana

Antarctica

- VNDA: Vanda, Wright Valley, Antarctica

GTSN Field Systems

The field systems consist of three major components: a borehole system, an intra-site communications link, and the station processor. The intra-site communications link transmits data from the sensors to the station processor, which records, processes, and transmits the digital data to the data center. The borehole system can thus be placed in a remote, quiet site while the station processor is placed for convenient access by local seismologists.

The borehole system includes seismometers, wellhead terminals, data acquisition system, power generators, and state of health (SOH) and environmental measurements. Each field site includes two Teledyne Geotech borehole seismometers: a KS-54000 and a GS-21. The model KS-54000 is a broadband, three-component instrument providing output flat to velocity over a frequency range of 0.004-4.2 Hz. It is emplaced at a depth of 100 m. The GS-21 is a passive sensor that acts as a backup to the KS-54000 and provides an output from a vertical component only, flat to velocity in the frequency range 1-8 Hz. The GS-21 is emplaced in a separate borehole (within 6 m of the other borehole) at a depth of 30 m.

The data acquisition system (DA) is manufactured by Quanterra, Inc., and is of the same design as IRIS/USGS/GSN systems. The DA produces four digital streams of 24-bit samples at 20 sps, giving a dynamic range of about 140 dB. Data are compressed and stored in SEED packets. Timing is taken from GPS signals with an accuracy of 10 milliseconds or better. 24-volt DC power is provided from a battery bank which is charged through either solar panels or thermalelectric generators. Time-tagged data packets, along with SOH and environmental data, are passed from the borehole system to the station data processor (DP) through the intra-site communications link, which can be hard wire, optical cable, a radio link (with or without repeaters), or a VSAT link.

The DP is the heart of the GTSN field system. It receives data from the DA and passes it on to the PSN for transmission to the GDC. It also receives commands and controls from the GDC. The DP serves both as a data recorder (normally 2 weeks of data) and as the interface to the DA for host country scientists. The DP is equipped with 8 MB RAM, a 300 MB hard disk, two 150 MB cartridge tape drives, a 14-inch monochrome monitor, and a laser printer. In addition to the DP, the station system includes a field workstation and an uninterruptible power supply. The field workstation is provided to give local seismologists access to the data and the ability to carry out routine reporting and seismological research. Data are transferred from the DP over a LAN running Ethernet. The field workstation is based on a SUN SPARCstation IPC, a medium-performance workstation running UNIX. It is equipped with a 16-inch color monitor, 24 MB of RAM, two 424 MB hard disks, a 150 MB cartridge drive, a CD-ROM reader, and an additional laser printer.

GTSN Data Centers

A GDC will exist at the USGS Albuquerque Seismological Laboratory (ASL) in New Mexico and an alternate GDC will be established elsewhere. Data from all nine field sites will be collected at the GDC over the PSN, recorded on magnetic disk and entered into standard distribution channels for GSN and other seismic data. Data will be forwarded in real time to the NEIC in Golden, Colorado for routine processing and use in NEIC's earthquake location program. Magnetic tape cartridges from the field sites will be sent to the GDC to fill in gaps in the transmitted data streams, for permanent archives, and for distribution on CD-ROMs and other media. All GTSN data will also flow through ASL to the IRIS Data Management Center. They will be merged into the archive and made available to all users in a manner indistinguishable from other stations of the GSN.

Deployment Schedule

Installation of GTSN stations began in January 1993. The South Africa, Brazil and Botswana stations have been installed and are transmitting data in real time to the GDC. The Bolivia station installation was completed in late August, 1993, with connection to the PSN planned for October, 1993. Plans call for the installation of the other five stations by the end of April, 1994.

Conclusion

The GTSN represents significant advances in the acquisition and processing of seismological data from worldwide sites. It builds on the technology developed for the GSN network, and, because the USGS works closely with IRIS in the development of the GSN, the two networks will be geographically complementary. The major advance by the GTSN lies in the real-time telemetry of continuous, broadband digital data from seismic stations on three continents to data centers on a fourth. This will permit increases in the speed, complexity, and reliability of published earthquake parameters. Additionally, when combined with data from the GSN and other sources, it will provide a valuable data base for research. Finally, it will provide seismologists at the individual GTSN sites access to higher quality data and the equipment to process that data. •

(Note: This article is adapted from an article in ISOP Newsletter No. 4, March 1993, by Eric A. Bergman)

IRIS GOPHER System

The IRIS GOPHER system has been enhanced to provide access to some data in near real time from the French GEOSCOPE network. GOPHER is maintained for the IRIS Data Management System by Steve Malone and Sandy Stromme of the University of Washington and they have worked with Danielle Fouassier of GEOSCOPE to successfully integrate data from five GEOSCOPE stations into the GOPHER system. Users can now access data from these selected stations along with data from IRIS stations. The GEOSCOPE stations available for some events include UNM in Mexico City, SSB in Saint Sauveur, France, AGD in Djibouti, RER in La Reunion Island, PPT in Papeete, Tahiti. Station KIP in Hawaii is also accessed by the gopher system. KIP is a joint GEOSCOPE-IRIS station.

Access to another GOPHER system in Japan is also available through the IRIS Electronic Bulletin Board using the "g" option. •

This Issue's Bannergram: The bannergram on the cover is the long period vertical channel (one sample per 1s) from Brazilia (BDFB, one of the new stations of the GTSN) for the magnitude 8 earthquake in the Mariana Islands near Guam on August 8, 1993. The distance is 169 degrees and the record is rich in a variety of core phases, some of which are indicated on the bannergram. •

Bob Hutt, Albuquerque Seismological Lab

Correction: The bar showing the time scale of the last issue's bannergram was incorrectly labeled as one minute instead of one hour. Apologies to the IDA group for this error.

PASSCAL Workshop Notice

There will be a one and a half day workshop in the San Francisco area the weekend before the December AGU. The purpose of this workshop will be to provide a general introduction to PASSCAL equipment, how it works, and how to use it in various experiments.

The workshop will not be geared toward a specific type of experiment, but will be intended as a general introduction. The targeted audience will be those people who have just purchased or are planning to purchase PASSCAL type equipment for their own university or potential PIs who want a better understanding of the instrumentation before they submit their proposals.

Topics to be covered are:

- How do the various digitizers work?
- What are the differences between the 3-channel and 6-channel units?
- Advantages and problems with multiple sample rates.
- How is timing really done?
- Typical problems in the field.
- What parameters are important for a good field site?
- Power problems.
- Problems associated with broad-band sensors.
- Problems associated with reflection/refraction deployments.
- What software support is available from PASSCAL?
- How do you get the data from the field into the field computer?
- How do you handle the data volumes generated in the field?

If you are interested in attending this workshop please contact Jim Fowler at the IRIS office. We will be sending a final schedule and location information to prospective attendees in October. •

IRIS/USGS FDSN Activities

Stuart Sipkin, US Geological Survey, NEIC
Bob Woodward, US Geological Survey ASL,
Luciana Astiz, University of Washington
Kris Skjellerup and Tim Ahern, IRIS Data Management System

FDSN CD-ROM — January - February, 1990

The Federation of Digital Seismographic Networks (FDSN) is an organization whose membership includes representatives from most countries that operate multiple broad band seismographic stations. Its membership is open and presently includes Australia, Canada, China, France, Germany, Great Britain, Italy, Japan, Mexico, Russia, United States (through IRIS and USGS), and a European consortium, ORFEUS. The FDSN cooperates in areas of station siting and data exchange. The Standard for Exchange of Earthquake Data (SEED) format is one of the major developments of the FDSN.

At the 1990 FDSN meeting in Golden, Colorado the IRIS Data Management Center was designated as the FDSN archive for continuous data. Data from most of the FDSN members have now been forwarded to the IRIS DMC for the period of January through March of 1990. IRIS and the USGS are presently cooperating in a project to merge event data from all contributing FDSN members onto a single CD-ROM. The present list of stations that have been designated FDSN stations can be found in the IRIS DMC electronic bulletin board. Use the "u" option in the main menu and then select the "fdsn" option in the sub menu.

The USGS is assembling the list of all earthquakes of magnitude greater than or equal to 5.7, constructing BREQ_FAST files and transmitting them to the IRIS DMC. The DMC will generate a SEED volume for each event complete with hypocenter information. We are starting with the months of January and February, 1990 for the initial FDSN CD-ROM. The DMC will then forward these SEED volumes to the USGS which will be responsible for the organization of the data on the CD-ROM as well as for the production and distribution of the CD-ROM.

The FDSN CD-ROMs will contain *very broad band, mid period, long period and short period data*. The windowing algorithm will remain the same as that used for the most recent NEIC Event CD-ROMs. *Very long period* (1 sample per ten seconds) and *ultra long period* (1 sample per 100 seconds) will be available from the IRIS DMC in the normal fashion. Longer term plans at the DMC also call for production of VLP and ULP data sets that will be available through the FARM area of the anonymous ftp on the machine "dmc.iris.washington.edu". At present, data from the following FDSN networks have been received and archived at the IRIS DMC;

CDSN	Chinese Digital Seismic Network
CNSN	Canadian National Seismic Network
GEOSCOPE	the French Global Seismic Network
GRSN	German Regional Seismic Network
IRIS/IDA	IRIS/IDA portion of the IRIS GSN
IRIS/USGS	IRIS/USGS portion of the IRIS GSN
MEDNET	Italian network in the Mediterranean region
POSEIDON	Japanese network in the western Pacific

Production of the CD-ROM is on schedule for completion by the 1994 IASPEI meeting next January. Seismologists worldwide can look forward to receiving event data from several FDSN members on a single distribution medium.

FDSN Station Noise Study

In conjunction with the creation of the FDSN CDROM, Luciana Astiz, an IRIS supported Post Doc. at the University of Washington, has undertaken a project to analyze the noise characteristics at all stations in the FDSN network. Luciana is using a robust method of noise determination published in "On the robust estimation of power spectra, coherences, and transfer functions" by A.D. Chave, D. J. Thomson, and M.E. Ander in the Journal of Geophysical Research, vol. 92, 633-648, 1987. The processing automatically rejects sporadic local seismic and instrumental noise (like spikes, calibration signals, etc.) resulting in good background noise estimates. The method involves the estimation of power spectra in moving windows for time periods of three months. Separate estimations of background noise for the four quarters of each year will be performed.

As pointed out by Bob North of the Geological Survey of Canada, having the noise estimation done by one person at a central site such as the FDSN archive in Seattle, helps insure that an unbiased, truly representative measure of station noise characteristics can be obtained. The IRIS DMC was selected as the location of this study due to the fact that it is the FDSN archive and has ready access to all FDSN data.

The results of Luciana's noise estimation study will be published in the FDSN Station Book.

FDSN Station Book

John Hoffman, formerly of the USGS Albuquerque Seismic Laboratory, has completed an ASL station book that documents key aspects of all seismic stations for which ASL has responsibility. This new book replaces the familiar Blue Book, "Directory of World Digital Seismic Stations, Report SE-32, August 1982", that many of you are familiar with. Since the FDSN represents many more stations than are included in the ASL station book, a project has begun to fully document all stations operated by FDSN members. Each FDSN member was responsible for supplying the information to the IRIS DMC by August 15, 1993. Kris Skjellerup, of the IRIS DMC, is coordinating this project and will be responsible for the final production of the FDSN Station Book.

At the last FDSN meeting at the IRIS DMC, a definition of the layout of station descriptions was identified. Information that will be included in the station book includes; station name, station director, address and telephone, parent organization, network affiliation and contact, whether the station is open, address to obtain digital data and/or event information, station coordinates and elevation, geological description, and vault conditions. A station history will be included that documents the instrumentation deployed at each site for various times. Plots of seismic background noise and color pictures will also be included if available.

The FDSN Station Book is scheduled for initial distribution at the IASPEI meeting in January, 1994. •

Continued from page 3

the average performance of the future networks may be somewhere between the levels of Figure 2 and 3.

The "relaxed" 4-arrival simulations results of Figure 3 suggest that some of the regional arrivals will have sufficiently high signal-to-noise ratios to permit event discrimination even while detecting at these low network thresholds. These results indicate that some of the regional phases might be available for the characterization of "suspicious" events as regional discriminants become available. This observation and the improved location capability that comes with the use of additional stations emphasize the importance of the open stations.

The careful siting of the future stations and the re-location of existing stations into low noise environments can further improve the performance of the open networks. Monitoring to lower levels, potential political barriers to installing certain stations, or the withdrawal of certain "open" station data may all require that the open networks be augmented with low noise stations or array stations which are dedicated to monitoring a comprehensive test ban. With these additional provisions, monitoring may be extended into critical or inadequately covered areas and provide overall reduced thresholds. Further, if the open stations are to participate in near real-time monitoring, their data transmission capability must also be upgraded. •

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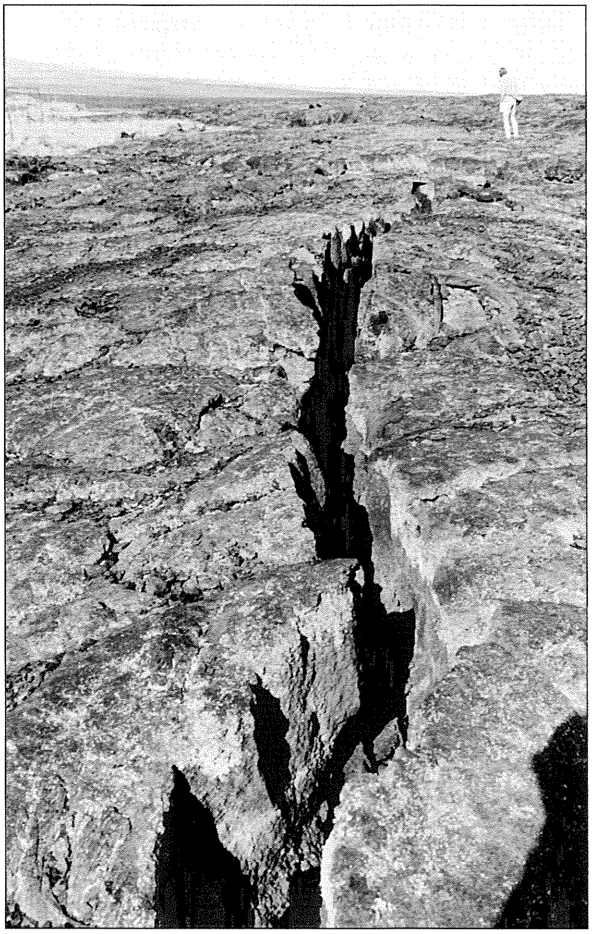
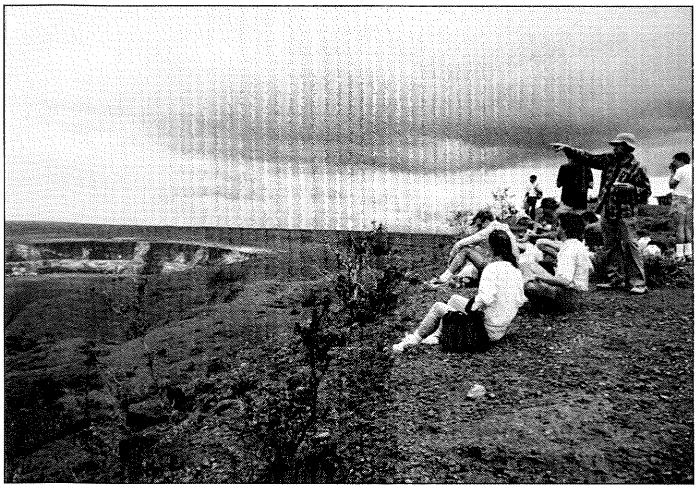
Fifth Annual IRIS Workshop Field Trip to Hawaii Volcano Park

The Fifth Annual IRIS Workshop in Waikoloa, Hawaii proved to be a great success in both attendance and discussion. Over 200 participants were involved in 3 days of meetings, discussions, and field trips.

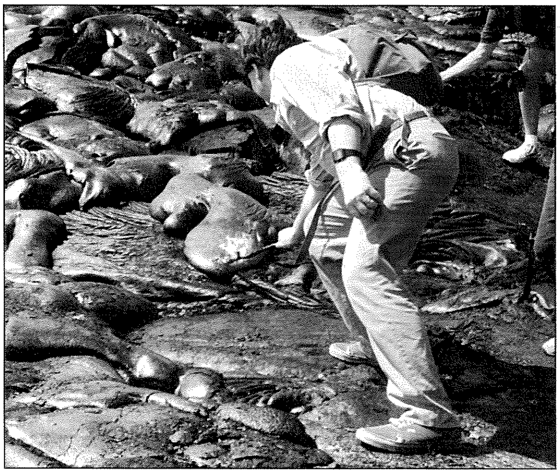
One of the highlights was the field trip to Hawaii Volcano National Park. Groups travelled by bus and/or helicopter to the USGS Hawaii Volcano Observatory (HVO) (located on the rim of the caldera of Kilauea volcano) and to the site of fresh lava flows crossing the highway and entering the ocean in a spectacular steam cloud southeast of Kilauea. The staff of HVO gave tours of the museum and research facility and Jack Lockwood, David Clague, Paul Okubo, and Arnold Okamura of HVO and Carl Johnson of the University of Hawaii, Hilo accompanied the tours and provided excellent commentary on the geology and natural history of the island. •





Jack Lockwood of HVO describes the structure and evolution of Kilauea's caldera.

K. Sue Schoch, David Simpson, and Peter Zimmerman compare notes at HVO.



IRIS Board of Directors Chairman, Jeffrey Park, tests the temperature of fresh molten lava.

A summary of the meeting and its program will be published in EOS.

Deep Scientific Drilling in the San Andreas Fault Zone

Stephen Hickman, U.S. Geological Survey, Menlo Park, California
Mark Zoback, Stanford University
William Ellsworth, U.S. Geological Survey, Menlo Park, California
Leland Younker, Lawrence Livermore National Laboratory

For the past year and a half we have been coordinating the efforts of an international team of scientists proposing to continuously core inclined holes through the San Andreas fault zone at depths up to 10 km to provide fundamental constraints on the structure, composition, mechanical behavior and physical state of an active, major plate-boundary fault. By doing this it would be possible to: 1) conduct extensive laboratory measurements on the composition, physical properties and deformational behavior of exhumed gouges and pore fluids; 2) directly measure pore pressure, stress and fluid permeability within the fault zone; 3) study the P- and S-wave seismic velocity, intrinsic attenuation and anisotropy of the fault zone and gouge materials; and 4) utilize the hole for long-term fault-zone monitoring. In this article, we will briefly describe the scientific objectives, experimental strategy and site-selection process for the San Andreas drilling project.

Key Scientific Objectives and Experimental Design

In December of 1992 we conducted a workshop on the San Andreas fault zone drilling project at Asilomar, California. The purpose of this workshop, which was attended by 113 scientists and engineers from seven different countries, was to facilitate a broad-based scientific discussion of the issues that could be addressed by deep drilling in the San Andreas fault, identify potential drilling sites and identify technological developments required to make this drilling possible. There are a number of well-recognized questions about the San Andreas and other plate-boundary faults that were discussed at the Asilomar workshop. These questions include: 1) Why are plate-boundary faults like the San Andreas so much weaker than the rest of the Earth's crust?; 2) How do mineralogy and deformation mechanisms within the fault zone change with depth, temperature and country-rock geology?; 3) What processes lead to the localization of slip and strain rate?; 4) How does the width and character of the active slip zone vary with depth?; 5) How is energy partitioned within the fault zone between seismic radiation, frictional dissipation, grain size reduction and chemical reactions?; 6) What are the origin and composition of fault zone fluids?; 7) What are the fluid pressures within and adjacent to the fault zone?; 8) What are the nature and extent of fluid migration during a seismic cycle?; 9) What are the permeabilities of fault-zone materials and country rock?; 10) What types of water-rock interaction occur at different structural levels and how do these effect fault-zone rheology?; 11) Why are some segments of the fault creeping and some locked?; 12) What determines the maximum depth of seismic activity?; 13) What factors control the nucleation, propagation, arrest and recurrence of earthquake ruptures?; 14) How does stress vary in the vicinity of the fault zone?; 15) How is the fault zone loaded at different crustal

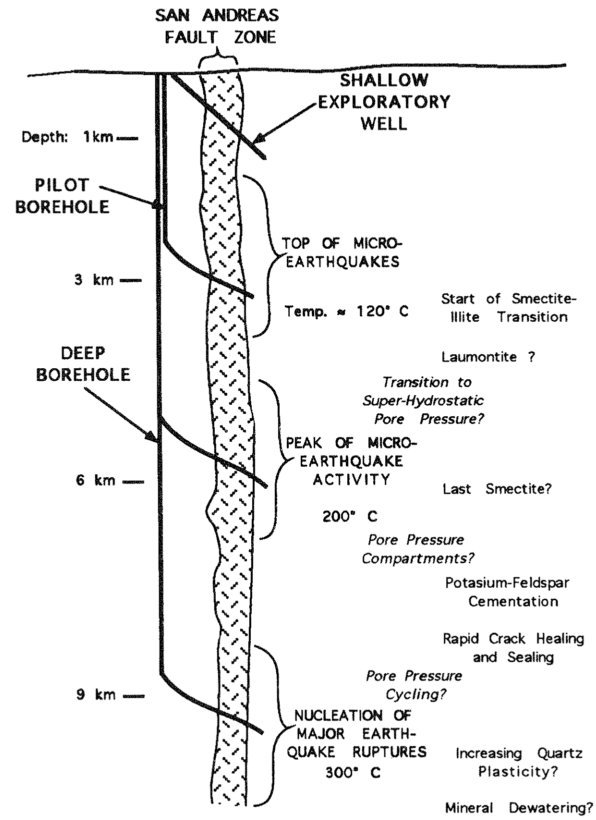


Figure 1: Schematic of proposed fault-zone drilling project. An inclined, shallow exploratory core hole would be drilled at 4 sites as part of the site characterization process and would penetrate the fault zone at a depth of about 1 km. Once the best location for the deep hole is selected, a 3-km-deep pilot hole and a 10-km-deep main hole would be cited at a distance of about 300 to 500 m from the surface trace of the San Andreas fault and deviated (whip-stocked) to intersect the fault zone at depths of about 3, 6 and 9 km. Use of two separate boreholes for deep drilling would allow for cross-hole tomography and ongoing experimentation in the pilot hole while the deeper hole was being drilled. Also shown are the approximate temperatures and mineral stability fields, deformation regimes and hydrologic phenomena hypothesized at depth along the San Andreas fault.

Continued on page 10

Continued from page 9

levels?; 16) How are stress and strain transferred along or between faults over different time-scales?; 17) Can the frequency-magnitude relationship for earthquakes be extrapolated to very small magnitudes?; and 18) What is the origin of low-velocity/high-electrical-conductivity zones in the fault zone? Many of these questions have gone unanswered due to our fundamental ignorance of the physical and chemical processes operating on the San Andreas and other faults at depth.

To help answer these and other questions, we propose drilling vertical holes adjacent to the San Andreas fault at one site that would be deviated (whip-stocked) through the fault at depths of about 3, 6 and 9 km (Figure 1). Whip-stocked portions of the borehole would be cored to provide complete cross sections of the fault for mineralogical and microstructural characterization and laboratory experiments. Geophysical logging tools and cross-hole tomographic techniques would also be used to characterize variations in physical properties within and adjacent to the fault zone. Because of likely hole stability problems within the fault zone, we plan to conduct as many of the downhole experiments as possible after casing is cemented into the hole. In particular, we anticipate that fluid pressure, fluid sampling, permeability measurements and hydraulic fracturing tests within the fault zone may have to be conducted through perforations in the cemented casing. Upon completion of drilling, seismometers and other instruments will be emplaced in the hole for long-term monitoring of earthquake locations and source parameters, seismic wave propagation, electromagnetic radiation, fluid pressure, fluid chemistry, temperature and deformation.

We propose to conduct the San Andreas Fault Zone drilling project in five stages. The first stage (1993-94) involves the initiation of detailed geophysical and geological site characterization studies in four potential drilling areas (see below). The second stage (1994-1996) involves continued site characterization, shallow exploratory drilling at each of the four sites (see Figure 1) and initial technology development. The second and subsequent stages can only be carried out if we are successful in obtaining new funding for this project. The third stage (1996-97) involves drilling a pilot corehole at the deep drilling site to penetrate the fault at a depth of about 3 km. The fourth stage (starting around 1997 and lasting for about five years) involves drilling the deep borehole. The fifth stage involves utilizing the borehole for long-term fault zone monitoring. The third, fourth and fifth stages would most likely occur in the context of an International Continental Drilling Program currently under consideration by a number of countries, with financial, technical and scientific participation by as many international partners as possible. Even in the context of such an international program, however, obtaining sufficient U.S. funding to conduct a project of this scope is a major concern. We have been working to develop a U.S. funding strategy that involves both the Federal government and private industry. An important aspect of this strategy is to obtain new money for fundamental science as well as for drilling and technology development.

Site Selection Process

We recognize, at the outset, that it will not be possible to answer all of the above-mentioned questions about the fault at a single site. Thus, the process of selecting one site for the deep drill hole will necessarily involve making choices about which of these fundamental questions we may be able to answer with this project. Discussions at the Asilomar workshop brought out a number of characteristics that the ideal deep drilling site would possess, including: 1) geometrically simple, well-defined fault zone; 2) clearly defined record of recent slip: either as great earthquakes, smaller events or creep; 3) simple geologic setting, preferably with crystalline basement on at least one side of the fault; 4) enough instrumentally located seismicity to allow for location of the fault at depth; 5) hydrologic environment dominated by fault-related processes; 6) moderate-to-high heat flow (to bring the seismic-aseismic transition within the depth range of drilling technology); and 7) relevance to earthquake hazard reduction. The final site for the deep hole will be selected on the basis of the scientific merits of the site, the technical difficulty anticipated in achieving the scientific goals and environmental considerations.

Starting with 18 potential drilling areas identified at Asilomar, we held two meetings at the U.S. Geological Survey in Menlo Park, California, with the Site Selection Committee and resident experts. At the first meeting we reduced the initial list of fault segments to the seven shown in Figure 2. At a second meeting of the Site Selection Committee, teams of volunteers made brief presentations on the pro's and con's of each of these sites. Four of these segments were then selected for further study: 1) the Mojave segment of the San Andreas between Leona Valley and Big Pine; 2) the Carrizo Plain between Highways 58 and 33/166; 3) the San Francisco Peninsula between Los Altos and Daly City; and 4) the Northern Gabilan Range between the Cienega winery and Melendy Ranch. Although Parkfield was highly ranked by many, we are not recommending further site characterization studies at Parkfield at this time because a great deal is already known about fault-zone structure at Parkfield. Also, many people were concerned that if the expected M~6 earthquake did occur at Parkfield in the next few years, it would place us at the very beginning of the seismic cycle when it would be hard to distinguish post-seismic transients from long-term conditions in the fault zone. Nevertheless, because fault-zone studies are already occurring in the Parkfield area (as well as along the Hayward fault and the San Bernadino segments of the San Andreas to a lesser degree), we will have the option of considering all seven areas in selecting the site for deep drilling.

Our goal in site characterization studies over the next 2-3

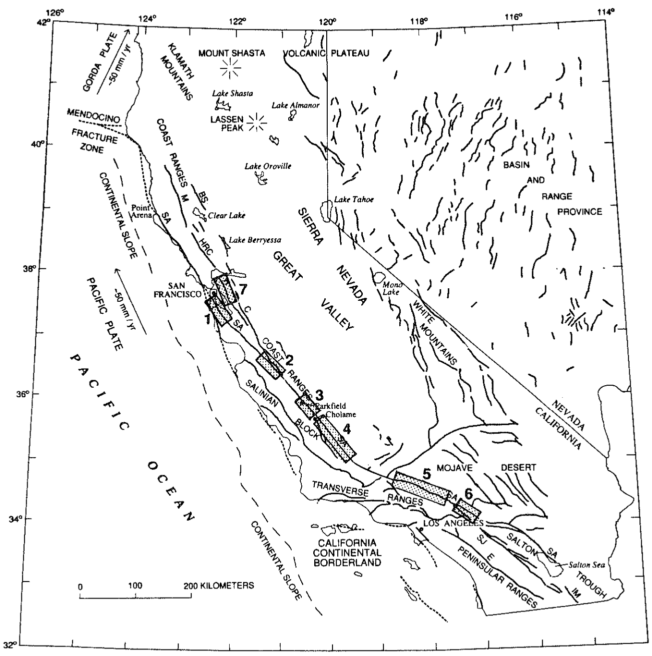


Figure 2: Mapped Holocene faults in California and Nevada. Shaded rectangles show approximate boundaries for segments of the San Andreas and Hayward faults which are being considered for the 10-km-deep San Andreas fault zone hole. These segments are: 1, San Francisco Peninsula; 2, Northern Gabilan Range; 3, Parkfield; 4, Carrizo Plain; 5, Mojave Dessert; 6, San Bernadino; and 7, Hayward fault. Major faults comprising the San Andreas fault system are labeled as follows: SA, San Andreas; M, Maacama; BS, Bartlett Springs; HRC, Healdsburg-Rodgers Creek; H, Hayward; C, Calaveras; SJ, San Jacinto; E, Elsinore. Arrows and numbers indicate relative motions of Pacific and Gorda plates with respect to the North American plate (after Hill et al, 1990).

years is to build a suite of comparative models of the geology, crustal structure, geophysical environment, hydrology, seismotectonics and fault-movement history at each of the 4 candidate sites. These investigations will be conducted by individual investigators, each of whom will contribute their results to a common data base. Through this process, we will deepen and extend our knowledge of the fault as a whole, whether or not the proposed 10-km-deep hole is ever drilled. Collectively, these studies will have a major impact on models of how this fault works, as well as for more general models of how earthquakes occur. They will also form a critical framework for applying the knowledge gained in the deep San Andreas hole to other segments of the fault and other tectonic environments.

We envision that deployment of PASSCAL instruments or other high-quality 3-component portable seismic instrumentation could play an important role in site characterization for the San Andreas drilling project in a number of ways. First, these instruments could be critical to the delineation of fault geometry at depth along "locked" sections of the San Andreas fault (i.e. the San Francisco Peninsula, Carrizo Plain, and Mojave segments) where existing network coverage maybe too sparse to detect and locate small-magnitude earthquakes along the principal branch of the San Andreas. Second, portable 3-component seismic arrays deployed along the surface trace of the fault would be very useful in determining the velocity structure, width and seismic anisotropy of the fault zone using arrivals from local and/or teleseismic events. Finally, PASSCAL-type instrumentation could be used to acquire vertical-to-intermediate offset reflection data during conventional seismic refraction profiles proposed across the fault. These "piggyback" experiments, which would be similar to studies already conducted using PASSCAL instruments in the southern Basin and Range and elsewhere (e.g. Okaya and Levander, 1993), would greatly enhance the spatial resolution for crustal structure immediately adjacent to the San Andreas fault, providing improved estimates of fault-zone width and location at depth.

To date, more than 250 collaborators from about a dozen countries have expressed an interest in participating in this project. During the past few months, we have been coordinating proposals by individual investigators for site characterization studies. In June and July of 1993, about 25 proposals were submitted to the U.S. Geological Survey, the National Science Foundation and the U.S. Department of Energy to conduct preliminary geological, seismological, potential field, hydrological and borehole geophysical investigations along these four segments. Any investigators not yet involved in this project who wish to participate in the site characterization studies should contact Bill Ellsworth (telephone 415-329-4784; fax 415-329-5163; e-mail: ellsworth@andreas.wr.usgs.gov). Individuals wishing to be involved in drilling-related science or technology development should contact Steve Hickman (telephone 415-329-4807; fax 415 329-5163; e-mail:hickman@thepub.wr.usgs.gov); Mark Zoback (telephone 415-725-9295; fax 415-725-7344; e-mail: zoback@pangea.stanford.edu); or Lee Younker (telephone 510-422-6472; fax 510-422-4918). •

References:

Hill, D. P., J. P. Eaton, and L. M. Jones, Seismicity,1980-86, in R. E. Wallace (ed.), The San Andreas fault system, California, *U.S. Geol. Surv. Prof. Paper 1515*,115-151, 1990.

Okaya, D., and A. Levander, RISC high resolution crustal images of the Southern Basin & Range - Salton Trough, *IRIS Newsletter, v.XII, No. 2*, 1-3, 1993.

IRIS/ASL GSN Station Installation at Palmer Station, Antarctica

Leo Sandoval and Gary Holcomb, Albuquerque Seismological Laboratory

The IRIS siting plan designates Palmer Station, Antarctica as the location of a station to fill in the large geographical gap between South Pole Station and Southern South America. This station was installed in March, 1993. This report highlights significant events occurring during the installation.

A one week site survey visit to Palmer Station in December, 1990 provided valuable information for use in preparing for this installation. The primary objective of the survey was to evaluate whether this site should be equipped with borehole or surface sensors. An evaluation of probable borehole costs at this remote site and anticipated data quality improvement with a borehole indicated that this site should initially be a surface installation. If the first two or three years' data prove to be unbearably noisy, a borehole upgrade may be in order. In addition, the survey identified potential radio frequency (rf) interference as a serious factor which had to be considered in the design of the equipment for deployment at Palmer. The anticipated seismic sensor deployment site was directly beneath a large rhombic transmitting antenna, which is used for two way communication with other Antarctic stations throughout the year.

Therefore, the design of the equipment packaging was dominated by the need to reduce the potential rf interference from this antenna as much as possible. Provisions were made to install the STS-1 sensors in Faraday cages constructed with brass window screen and to enclose all cables between the sensor electronics and the a-d converter in flexible metallic shielding. All remote end electronics including the Quanterra Q680 and the data processor were housed in special rf shielded equipment racks. All of the equipment was assembled and dry run for three weeks at the Albuquerque Seismological Laboratory prior to packing and shipment to Port Hueneme, California where it entered the National Science Foundation's (NSF) United States Antarctic Program shipping channels for forwarding to Palmer Station.

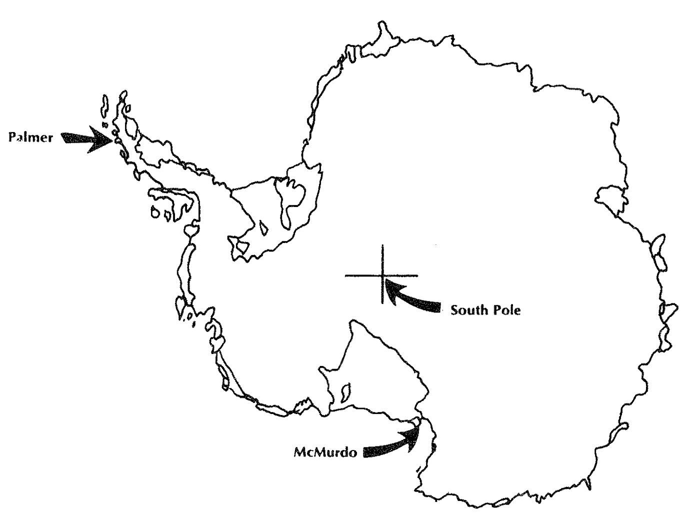


Figure 1. Locations of permanent United States Antarctic Program stations.

Access to Palmer Station is through Chile in South America, rather than through New Zealand which is the typical access point for all of the remaining United States Antarctic Research Stations. Approximately twenty four hours of continuous travel from Albuquerque put the installation team (Leo Sandoval and Gary Holcomb) at the southern end of Chile in the town of Punta Arenas. This small port city is located on the Strait of Magellan near the southern tip of South America (across the Strait from the old WWSSN station at Sombrero). The first item of business in Punta Arenas was to check the status of our cargo. Unfortunately, it was already safely stored away out of sight in the hold of the ship. We were assured by NSF contractor Antarctic Support Associates (ASA) personnel that all the cargo had arrived in Punta Arenas and that all was well, but without the luxury of personal visual confirmation that it was indeed all present, we were left with an uneasy feeling.

Punta Arenas is the home port for the NSF chartered research ship Polar Duke. The Polar Duke is a 67 meter ice-strengthened vessel which provides the primary mode of transportation from Punta Arenas to Palmer Station; all access to Palmer is by sea because there is no air strip at the station. From Punta Arenas, the Duke sailed northeast along the Strait to the open Atlantic, thence southeast along the coast of Tierra Del Fuego, past Cape Horne and into the Drake Passage by the end of the first day. The Drake Passage contains some of the roughest open ocean in the world. For landlubbers from the desert southwest, this rough water, combined with a 67 meter ship, creates one of the wildest experiences one can imagine -a full day and a half of continuous roller coaster ride with meals thrown in on the go. At times, the ship was forced to slow to 4-5 knots to ease the pounding we were experiencing. Many of the people on board disappeared into their bunks during the crossing only to emerge when the ship reached the relatively calm waters surrounding Deception and Low Islands. Here we enjoyed a four hour break for deep sea fishing (in freezing drizzle with a net) during which many different slimy creatures were hauled up from the bottom to be used as raw material for one of the environmental research projects being conducted at Palmer Station. Then we were treated to the spectacular day-long voyage on glass smooth water among the glacier covered mountainous islands along the edge of the Antarctic Peninsula, through the Neumayer Channel, and finally to Palmer Station.

Palmer Station is a small year-round United States Antarctic Program station located on a small rocky peninsula on the southwest corner of Anvers Island (station coordinates are 64º 46' south, 64º 03' west). The land area available for the station is quite limited by the sea surrounding the peninsula and the fact that the land end of the peninsula is blocked off by a large piedmont glacier which covers most of the island. The station consists of a small cluster of buildings located immediately on shore. The winter population of about ten people swells to around forty in the summer. The summer population of wild life is much higher with large penguin rookeries occupying several of the nearby islands in the bay and numerous seals lounging about the station itself. Marine biology is the primary research activity at Palmer. There are also active programs in upper atmospheric physics and air pollution studies.

Preparation for the installation began immediately after our two PM arrival with a quick survey of the status of site. ASA personnel were in the final phases of erecting a prefabricated steel shelter over a preexisting concrete pier to house the seismometers. Only the roof and door remained to be finished and electrical service was being installed. Incredibly, only an hour or so after docking, our ship cargo began arriving by forklift at our instrumentation building. Before nightfall we had all seventeen crates of equipment on site. Unpacking commenced at once. The data processor was unpacked, mounted in its rack and running in the data recording building (building T-5 at Palmer) before we turned in. Since the Duke was to remain tied up at the dock for nine days, and since lodging space onshore was in limited supply, we were privileged to be berthed and dine onboard ship. This was a delight because of the hospitality of the Norwegian crew and the excellent food we were served throughout the voyage.

Since the seismometer shelter was not quite finished, we decided to assemble and test the data acquisition system in the recording building also. The next item of business was to install the direct burial optical fiber data transmission cable between the sensor shelter and the recording building. This was accomplished on a miserably windy day in intermittent cold rain and freezing drizzle. Yes, it does rain in the summer in parts of Antarctica; remember that Palmer is only 64 degrees south. Three days after our arrival, the seismometer shelter was sufficiently finished that we were able to begin installation of the vault equipment. The preassembled and pretested data acquisition rack was transported from the data recording building to the seismometer shelter with a four wheel drive "multi jointed go anywhere over any terrain" forklift. Watching this machine lurch and scramble over the boulder strewn route to the remote shelter with $40,000 worth of electronic instrumentation tightly strapped to the forks was a traumatic experience. Luckily the equipment made the trip unscathed. Installation of the seismometer and remote electronic equipment went very smoothly from that point on and the station was up and running five days after arrival at Palmer.

Figure 2. Palmer Station with the new IRIS seismometer vault in the foreground, and the grounded iceberg in the background.

Much of the credit for this rapid installation should be given to the excellent cooperation and assistance of ASA personnel at Palmer. Their prompt and flexible response to our needs was a valuable asset. They were a pleasure to work with.

Tests conducted over the following days in conjunction with the Palmer communication center indicated that the efforts to shield the installation from RF had been successful. No evidence of interference could be found even at the highest transmission power levels, which are used rather infrequently.

Several weeks before our arrival, a tabular iceberg with a beautiful arch carved by the sea had cruised into the bay and ran aground a short distance from the Palmer dock. Since its arrival, this iceberg had been the focus of station gambling activities with many differing opinions on when the arch would collapse. One night about one o'clock in the morning, while we were all were safely tucked away in our bunks onboard ship, the arch collapsed and the whole berg turned completely upside down. This created quite a disturbance in the bay and aboard ship because the vessel suddenly rolled over at an alarming angle and began rocking violently. The rocking slowly subsided only to be immediately followed by the start of the ships main engines and the roar of the bow thrusters which lasted for fifteen minutes or so. Of course the newly awakened guests had no idea what was going on, but the next morning we learned of the berg's demise and that three of nine mooring lines had been snapped by the ship's initial roll. The bow thrusters had been needed to hold the ship tightly to the dock while new lines were secured ashore.

All that remained to complete a highly successful installation was to recross the dreaded Drake Passage - Ugh. •

RUMBLE

K. Sue Schoch, IRIS Data Management Center

RUMBLE (Requests Users Make By Listing Events) is a new method of accessing data archived in the IRIS Data Management System. It is very similar to the way data are requested using breq_fast files. Unlike breq_fast, which accepts requests for specific time segments, RUMBLE is event oriented, i.e. requests for waveform data are made relative to the expected arrival times from events in an earthquake catalog. At present, this catalog is the USGS monthly Preliminary Determination of Epicenters (PDE). Requests can be made for data from a particular event, or from events that satisfy user specified criteria on magnitude, location, size.

To initiate a request via RUMBLE, you create a text file on your machine and mail it to a special account named rumble@dmc.iris.washington.edu.

Data can be returned to you through a number of options, including Electronic (ftp), Exabyte and other forms of magnetic media (see the breq_fast or RUMBLE manuals on the IRIS Bulletin Board for details).

Below is a definition of all allowable lines in the RUMBLE request file. Information which may vary is shown in bold typeface.

.NAME **Sue Schoch**
.ADDR **1408 NE 45th Street**
.CITY **Seattle, WA 98105**
.PHONE **(206) 547-0393**
.EMAIL **sue@iris.washington.edu**
.MEDIUM **Electronic**
.END

one or more EVENT lines REQUIRED
: EVENT between **92 01 05 01 00 0.0** and **92 02 15 10 00 0.0**
or : EVENT **92 01 05 10 45 27.0**

one and only one TIME_WINDOW line REQUIRED
: TIME_WINDOW EVENT **00 05 00** before **00 10 00** after
or : TIME_WINDOW PHASE **00 05 00** before **P 00 10 00** after **S**

one and only one LAT line allowed
: LAT between **-30** and **20**
or : LAT **10**

one and only one LON line allowed
: LON between **-100** and **150**
or : LON **100**

one and only one MAG line allowed
: MAG > **5.5** *valid operators >, <, =, >=, <=*
or : MAG_TYPE = **MB**

Any of the following can also be included, but there must be only one of each:

: DEPTH > **400** *valid operators >, <, =, >=, <=*
: REGION **32**
: SEISMIC_REGION **1**
: DISTANCE between **30** and **50**
: AZIMUTH between **50** and **70**
: BACK_AZIMUTH between **10** and **50**
: MPLAT between **0** and **180**
: MPLON between **-180** and **180**
: DISTANCE between **0** and **400**
: STATIONS **ANMO HRV TUC**
: CHANNELS **VHZ BH? L??** *wildcard character is ?*

Most of those parameters should be obvious (except maybe MPLAT and MPLON, which refer to mid point of the source receiver path; and REGION and SEISMIC_REGION, which are Flinn-Engdahl region numbers). Details can be found in the SPROUT manual, available from the DMC or through the Bulletin Board.

Only lines beginning with a period (.) or a colon (:) are processed in the request file. Other lines are treated as comment lines. There must be one and only one TIME_WINDOW line. The EVENT and TIME_WINDOW lines, along with the name and address information, are the only required lines. Unless you are requesting data from a specific event, it makes sense to add additional constraints to your request. Also, each RUMBLE request can only include events in one year. To make a multi-year request, just change the event times and submit the request multiple times.

Several criteria lines need further explanation. First, an EVENT line must be present or the request will be rejected. You may either request data for individual events by giving a specific time:

: EVENT 92 01 05 10 45 27.0

or request all events within a time period such as 1:00 am Jan 5, 1992 through 10:00 am Feb 15, 1992:

: EVENT between 92 01 05 01 00 0.0 and 92 02 15 10 00 0.0

The format for the time specification is year, month, day, hour, minute, second. The seconds field may include a fraction of a second. You may include more than one specific event in your request (i.e. the following are valid):

: EVENT 92 01 05 10 45 27.0
: EVENT 92 1 1 01 11 49
: EVENT 92 1 1 03 32 06
: EVENT 92 1 1 05 35 01
: EVENT 92 1 1 05 38 44
: EVENT 92 1 1 05 54 44

But you may not intermingle specific events with a time range for events (i.e. the following is invalid):

: EVENT 92 01 05 10 45 27.0
: EVENT 92 1 1 01 11 49
: EVENT between 92 01 05 01 00 0.0 and 92 02 15 10 00 0.0

And you may not include more that one event time range; only one event time range may be present in a request (i.e. the following is invalid):

: EVENT between 92 01 05 01 00 0.0 and 92 02 15 10 00 0.0
: EVENT between 92 05 01 00 00 0.0 and 92 07 01 00 00 0.0

Second, only one line starting with the keyword TIME_WINDOW may be present in the request file and this line too must be present for the request to be processed. The time window of the data requested can be relative to either the time of the event or the time of phases arriving at stations. Use the keyword EVENT to signify the time window is relative to the event time. For example to request a time window that is 5 minutes before the time of the event to 10 minutes after the time of the event, use the following line:

: TIME_WINDOW EVENT 00 05 00 before 00 10 00 after

Use the keyword PHASE to signify the time window is relative to the phase arrival time. For example, to request a time window that is 5 minutes before the first arriving P phase to 10 minutes after the last arriving S wave, use the following line:

: TIME_WINDOW PHASE 00 05 00 before P 00 10 00 after S

This will select a time period 5 minutes before the earliest P wave that arrives at a station and will extend to 10 minutes after the latest arriving S phase at a station. The current list of phases that the database contains are P, Pdiff, PKPdf, S, Sdiff, SKS, and SKIKS. The list of phases to be stored in the database is currently being revised and will eventually be propagated through all the databases. When this list is finalized, it will be published in the IRIS bulletin board.

Currently, all times must be specified relative to the expected times of the first arriving P or last arriving S phases. You can specify both start and end times relative to one type of phase (either P or S). For example if you want data only relative to P phases you can use this command:

: TIME_WINDOW PHASE 00 05 00 before P 00 10 00 after P

This will give you data from 5 minutes before the first arriving P phase to 10 minutes after the last arriving P phase.

Only the operators listed in the full example above are allowed. For example, you cannot use the commands:

: LAT > 30	INVALID
: DEPTH between 400 and 500	INVALID

Also, in any expression that contains the "between" keyword, the smaller number must be entered first followed by the larger number. This is especially true in situations where the numbers may be negative such as in latitude and longitude specifications.

If you find, after using of constraint lines in a RUMBLE a bit, that other operators or constraints would be useful, please give us suggestions by sending email to sprout@iris.washington.edu.

Below is an example of constraint lines in a RUMBLE request. The requester wants data for all events from an area in south Asia in 1991 that have a magnitude greater than 6.0 where the distance between the event origin and the stations BJI, KMI, LZH, KIP, and PAS is between 30 and 100 degrees inclusive. Only data for broad band channels are requested. The time period for the data should be 2 minutes before the first arriving P wave and continue through 2 minutes after the last arriving S wave.

: EVENT between 91 00 00 00 00 0.0 and 91 12 31 23 59 9.9999
: TIME_WINDOW PHASE 00 02 00 before P 00 02 00 after S
: MAG >= 6.0
: DISTANCE between 30 and 100
: LAT between -10 and 50
: LON between -110 and -40
: STATIONS BJI KMI LZH KIP PAS
: CHANNELS BH?

Once the RUMBLE request file has been created on your home machine, you will send the request to rumble@dmc.iris.washington.edu. If you have questions about RUMBLE, please send email to sprout@iris.washington.edu or call the IRIS Data Management Center at (206) 547-0393.•

New GSN Sites

IRIS/ASL has installed a new GSN site at SJG, San Juan, Puerto Rico. An IRIS-2 data acquisition system was installed by the ASL team at KEV, Kevo, Finland, completing the upgrade of the DWWSSN station where IRIS STS-1 seismometers had been deployed in 1987.

Three Global Telemetered Seismic Network (GTSN) stations were completed at BDFB, Brasilia, Brazil; LBTB, Lobatse, Botswana; and LPAZ, La Paz, Bolivia. The GTSN is being installed by the USGS with equipment which meets IRIS GSN design goals. Data from all GTSN sites will be available from the IRIS Data Management System. •

the IRIS CONSORTIUM

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The Incorporated Research Institutions for Seismology (IRIS) is a consortium of over 75 research institutions with major commitments to research in seismology and related fields. IRIS operates a facilities program in observational seismology and data management sponsored by the National Science Foundation. Major funding for IRIS programs is provided by the National Science Foundation through its Division of Earth Sciences and the Air Force Office of Scientific Research.

The IRIS Newsletter welcomes contributed articles. Articles should be less than 1000 words and four figures. Please send articles or requests for details on submission of articles to the address listed above. Electronic submission is encouraged.

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CALENDAR

OCTOBER

1-2	Execom Meeting, IRIS Headquarters Washington, DC
1-4	NSSP International Conference, Yerevan, Armenia
20-21	DMS Meeting, Albuquerque, New Mexico

JANUARY

10-21	IASPEI Meeting, Wellington, New Zealand

DECEMBER

7	Board of Directors Meeting, San Francisco, California

APRIL 1994

5-7	SSA Meeting, Pasadena, California
7-10	Sixth Annual IRIS Workshop, Glendale, California

New Member

IRIS welcomes the Australian National University as a new foreign affiliate. Brian Kennett will be the representative liaison to the Board of Directors. •

Sixth Annual IRIS Workshop
Glendale, California

The Sixth Annual IRIS Workshop will be held from April 7-10 at the Red Lion Hotel in Glendale, California following the SSA Meeting in Pasadena on April 5-7. The IRIS Workshop will start with a reception on Thursday night (April 7) and run through Sunday afternoon (April 10). Planning for the workshop program has begun. Please contact Liz McDowell by email (liz@iris.edu) if you have suggestions for topics for science sessions, SIG's, posters or demonstrations. Volunteers to assist in working on the program committee would be welcome.

For those of you attending the SSA meeting beforehand, the Red Lion is approximately 10-15 minutes from the Pasadena Convention Center. Taxi service from Pasadena or shuttle service from Los Angeles International Airport to the hotel is roughly $15. Complimentary shuttle service is available from Burbank Airport (located 7 miles away) to the Red Lion.

The Red Lion offers excellent meeting facilities as well as friendly and efficient staffing. Nearby extra-curricular activities for family members include tours of Universal and NBC Studios and Disneyland. The hotel will extend the $80/night meeting rate both three days before and after the workshop. •

U.S. Seismic Networks to Form National Seismic System

Following an organizational meeting sponsored by the USGS in February, nine institutions to date have signed a charter establishing a Council of the National Seismic System—a union of national, regional, and local seismic networks. The Council's purpose is to promote cooperation and coordination among U.S. institutions and agencies engaged in the sustained operation of seismic networks (both seismographic and strong-motion). Voting membership is restricted to U.S. institutions, but all individuals and groups engaged in relevant efforts are welcome and encouraged to participate. Working groups are now being formed to advance and coordinate: (1) rapid post-earthquake distribution of information; (2) data archiving and exchange; (3) joint development of software and hardware; (4) integration of strong-motion and network seismology; (5) meeting user needs relating to the NSS; and (6) rapid emergency distribution of portable seismographs. For more details, contact John Filson, USGS (tel. 703-648-6785; jfilson@rsg1.er.usgs.gov) or Walter Arabasz, University of Utah (tel. 801-581-6274; arabasz@uuss.seis.utah.edu). •

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