IRIS Newsletter

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Volume X, Number 3

From the President

A Time of Opportunity, Challenge & Change

With the signing of a new Five Year Cooperative Agreement with the National Science Foundation in July of this year, IRIS enters a new and challenging stage in its development. The NSF Agreement defines a base level of funding that will allow IRIS to complete a substantial part of the program that was presented in the original IRIS proposal in 1984. This new Cooperative Agreement is a strong indication of the confidence NSF has in IRIS and is a clear endorsement of the success of the program during its formative years. The new Agreement provides the opportunity to plan effectively for the future development of IRIS and its core programs.

During the first five years of IRIS, the emphasis was on establishing the core programs, setting design goals and identifying new technologies to meet those goals. The success that IRIS has had in establishing a technological base for its programs was one of the major achievements of the first five years. The development of new data loggers and the identification of broadband sensors for both GSN and PASSCAL have been examples of the ability of our community to agree on the technical advances required to open new scientific opportunities and to work with industry to see new instruments developed. The Data Management System has been able to take advantage of rapid developments in computer technology, primarily in mass storage devices, networking and data base software, to establish a system that can handle the large quanti-

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The Year in Review

From the Executive Committee:

This has been a year of many changes for IRIS. Probably the most significant is the renewal of our agreement with NSF. This is a time to look back and see what we have accomplished during the last five years and what lies ahead. The last five years have seen IRIS evolve from a fledgling program, consisting of the amalgamation of two separate initiatives in seismology for new portable- and permanent-station facilities, to a very successful, well integrated program. It has seen these two initially distant branches of seismology not only make progress in their own right, but they have also interacted in such a way as to produce a very new kind of seismology -- a sort of middle ground between 'permanent' and 'portable' seismology -- that may be one of the most promising areas of research for years to come. Boundaries are rapidly coming down. The instrumentation of the GSN and the PASSCAL program are moving toward each other as time goes on.

Another component of IRIS that we can be very proud of is the IRIS Data Management Center. Technology has solved many of the initial problems we had with a data center. The IRIS DMC, long a source of controversy and criticism is now a model for the efficient use of new technology. The concept of a data center -- only a few years ago, imagined as a large room of endless racks of magnetic tapes, and tireless operators -- has been transformed into a robot in a small corner of the University of Washington computer center that quietly grabs 10 Gb cassettes and reads them, responding to a user's request. The program is on track.

Nevertheless, we have not completed our task. The deployment of a 128 station global network of advanced, broadband seismometers, and the deployment of 6000 channels of portable instruments have not yet been achieved. That we still have basically the same goals after several years is a testament to the planning that went into the original proposal, which called for both unprecedented density and coverage of the globe, as well as the possibility of increased density of instruments and the deployment of two-dimensional arrays in portable studies. We must dedicate the next five years of our program to finishing the job of deploying the IRIS facility. This is not only an IRIS goal. It is a goal of the entire seismological community, because everyone gains from its success. This is 'big' science at its best, making it possible for 'small' science in seismology to flourish as never before. This will not be an easy goal to achieve. Funding continues to be tight and we will need to involve our universities as well as others who are interested in the success of seismological research in the United States. But I am convinced that it is within our ability to achieve this goal. •

Paul Silver, Chair, Board of Directors

What's Inside

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ties of data that are produced by the data generating programs.

With the financial security provided by the NSF Cooperative Agreement comes the challenge to rapidly advance beyond the development stage and bring the core programs to full implementation - to reach toward the goals of 128 global stations, 6000 channels of portable recording and a data management system that will make all data rapidly and easily available to interested scientists. This will require some changes in how IRIS is managed and operated. Although we must continue to insure that the IRIS facilities remain state-of-the-art, there will be less emphasis on technical innovation and more on acquisition of equipment, installation of stations and the collection and distribution of data. There must be a determined effort to focus our resources on achieving the goals that have been set and which NSF has now given us the challenge to meet.

The Global Seismographic Network now has design goal data loggers and sensors that are capable of recording, with high fidelity, the complete range of seismic ground motions. These data loggers and broadband seismometers are being installed initially at sites of stations that formed parts of former networks, including WWSSN, IDA, SRO, and DWWSSN. As these sites are upgraded, new stations will be installed that will add truly new observations from regions which have not previously been instrumented. The excitement of new sites is already being seen through the GSN component of the Soviet program. The GSN program has this year begun new work on island sites and with undersea cables that should eventually make possible expansion of the GSN into the least-instrumented part of the globe - the world's oceans.

The Joint Seismic Program, carried out in cooperation with the Soviet Union and the US Geological Survey and funded by the Air Force, brings the facilities of the three core IRIS programs to focus on special questions related to the monitoring of nuclear explosions. Since 1988, when an agreement was signed between IRIS, the USGS and the Academy of Sciences of the USSR, extensive work has been carried out by the IDA/IRIS, USGS and other university groups to establish sites for GSN stations, arrays and data centers in the USSR. The data that are now flowing from these facilities are providing fresh insights into the structure and seismicity of Eurasia and new teleseismic views of the rest of the globenew teleseismic views of the rest of the globe. In all of the projects that have been established in the USSR, efforts have been made to insure that contacts and good working relationships have been established with the local republics and there is optimism that our scientific contacts and working relationships will survive the current political and economic turmoil.

As the core IRIS programs have moved beyond the development stage, there has been increasing interaction between the programs. The JSP is one example of how the various components of IRIS can be brought together to focus on a specific geographical and topical project. IRIS programs are developing a natural interaction in other areas as well, many of which focus on the Data Management System. Many of the data management tasks initially developed for either GSN or PASSCAL are finding application in both programs and common procedures for handling both types of data are now being developed. Stabilization of data formats is also helping to increase interaction, especially in the use of SEED as an exchange format. As it becomes easier to exchange data between projects and institutions, there is also increasing interaction in the development of analysis software. In the past, many of the time series analysis techniques that were applied to seismograms developed independently for different passbands - high frequency exploration and crustal studies, short period body wave seismology and long period surface wave studies. With the broadband emphasis that has come with modern instrumentation, the power of modern computer systems and the exchange of data in common formats, it is becoming apparent how artificial many of the earlier distinctions were.

The ultimate measure of success for IRIS will be in the science that results from the use of data produced by the IRIS facilities. The standardized instruments of the WWSSN and the distribution of seismograms on film chips revolutionized seismology in the 1960's. These enhanced facilities had an enormous impact on research, leading directly to advances as diverse as plate tectonics and improved methods of discrimination between nuclear explosions and earthquakes. In the 1990's, we can find contemporary parallels to the WWSSN throughout IRIS - for example, in the standardized data loggers and broadband seismometers of the GSN and PASSCAL, and the exchange of data in SEED format over the Internet. To the scientists that are the final beneficiaries of the facilities that IRIS is creating, the challenge must be to take these modern resources and apply them with creativity to solving current problems in the Earth sciences and opening new frontiers. •

David Simpson, President

This Issue's Bannergram: The seismogram on the cover shows the vertical component record from Garni, Armenia (epicentral distance = 97.7°) from a magnitude M_S=6.9 earthquake, July 13, 1991, on the Gorda plate off the coast of Oregon. The sample rate is 1 sample per second and the response is flat to displacement between 10 and 100 seconds. The Garni station was installed by the USGS in July 1991 as part of the Joint Seismic Program. Instrumentation includes a 24 bit GSN data logger and STS-1 Streckeisen seismometers. The station is in a tunnel at the Garni Observatory, near Yerevan, operated by the Armenian Academy of Sciences. •

Goran Ekstrom, Harvard University

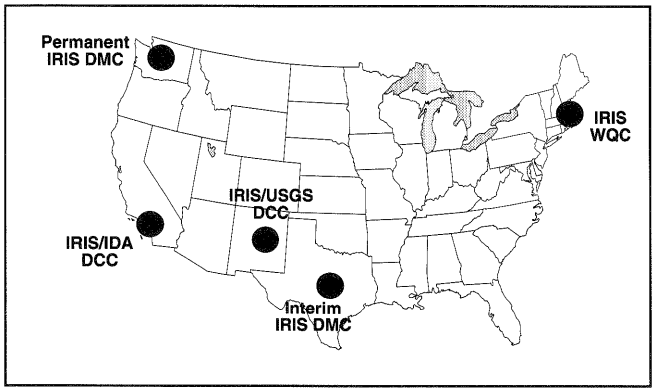
Data Management System

Tim Ahern, Program Manager

The IRIS Data Management System is the primary conduit for data flow within IRIS and to data users. The DMS acts as the archive for all data collected by the GSN and PASSCAL programs. The eventual goal of the DMS is to allow users to make requests for subsets of data, customized to their particular research interests, from the continuous archive on-line at the Data Management Center. In addition to the archiving and distribution of data, the DMS is responsible for working with the network operators to insure that data quality is maintained. The developmental stage for the Data Management Center has included the establishment of formats for data exchange, the design of data base schema and software for data manipulation, and the acquisition of computer and mass storage hardware. Novel means have been designed to provide rapid access to GSN stations for the near-real-time collection of data from significant earthquakes. The recently established facility at the University of Washington provides a permanent home for the DMC. Over the past few years, users have been able to access data using a prototype system. A new data base management system has now been developed and work is underway to transfer all data to the new mass storage device and bring the system up to full operational mode.

The IRIS Data Management System consists of four primary nodes. The IRIS Data Management Center (DMC), located at the University of Washington, acts as the primary archive for all IRIS generated data as well as the distribution point of data to researchers worldwide. The DMS includes two Data Collection Centers (DCCs) that are responsible for primary data quality control and for reformatting data into the SEED format. The IRIS/IDA DCC, located at Scripps Institution of Oceanography, is responsible for data from 13 IRIS/IDA stations. The IRIS/USGS DCC at Albuquerque, New Mexico is operated by the USGS and performs DCC functions on data from the SRO, ASRO, DWWSSN, CDSN, TERRAscope, IRIS University, and IRIS/USGS networks. The IRIS/USGS DCC processes data from 14 IRIS GSN stations as well as five additional TERRAscope stations that meet IRIS GSN specifications. The Waveform Quality Center (WQC) is located at Harvard University. The WQC performs additional quality control on IRIS data, independently from the two DCCs.

IRIS DMS Nodes



The Data Management Center

In response to a Request for Proposals, Steve Malone and Ken Creager, from the University of Washington, submitted the successful proposal to serve as the permanent host of the IRIS DMC. Steve Malone brings his extensive computer and regional network expertise to the IRIS DMC. Steve will continue to enhance the GOPHER system. Steve's interest in regional network problems may also be pursued in conjunction with the IRIS DMC. Ken Creager has an ambitious program that will produce an important data set of relative phase travel times. In the process of acquiring this data set, he and data analyst Rick Benson will also be providing additional quality control of data at the IRIS DMC.

The IRIS Data Base Management System (DBMS) developed by Sue Schoch is seeing increasing use by researchers around the world. Since its release in March, a total of 60 different users have accessed the system and some of those have used the SPROUT system to generate data requests. The DBMS is presently populated with all 1990 waveform and event data, but only a limited number of phase associations have been made. There are adequate data to test the system but the database is not fully populated. As the IRIS DMC relocates to its permanent home in Seattle, the IRIS DBMS will be fully populated and available for use in the second quarter of next year.

The DMC has acquired a Metrum RSS 600 mass storage system that is capable of storing more than 6 terabytes of data. Initial tests of the system indicate that it will be able to service user requests for data very efficiently. The RSS 600 stores tape on VHS size tapes using the familiar helical scan technology. Each tape holds more than 10 gigabytes of data and the RSS 600 holds 600 tapes. It is anticipated that this system will become fully operational by the second quarter of 1992.

Waveform Quality Center

The IRIS DMS includes a Waveform Quality Center (WQC) at Harvard University. Goran Ekström, Mikhail Salganik, and Bob Woodward routinely review large quantities of digital

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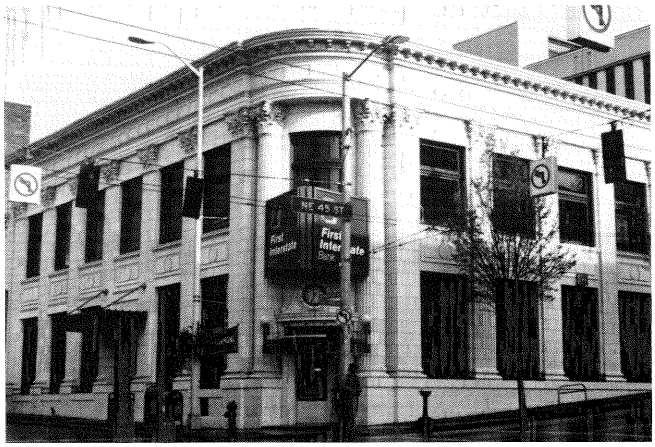


New location of the Data Manangement System offices in Seattle, Washington. *(photo - Becky Woffard)*

data in the production of the Centroid Moment Tensor (CMT) catalog. This process makes it possible to identify existing data problems. By incorporating the activity at Harvard into the DMS, the quality of IRIS data will be improved. The WQC has detected and reported quality problems such as incorrect station locations, polarity reversals, incorrect gains, and timing problems. Methods of reporting these problems are still evolving. All verified problem reports are kept within the "User Comments" option on the IRIS Electronic Bulletin Board.

The WQC also forwards all CMT solutions electronically to the IRIS DMC. These will eventually be incorporated into the IRIS DBMS, but for the present time are simply available on the Electronic Bulletin Board.

IRIS/IDA Data Collection Center

The IRIS/IDA DCC in San Diego is responsible for quality control and reformatting of data from all IRIS/IDA stations worldwide. Presently, this includes six stations in the Soviet Union and seven stations elsewhere.

During the past year, Shane Ingate has been hired as the Director of the IRIS/IDA DCC and has worked to establish high standards at the DCC. Since his arrival, the IRIS/IDA DCC has installed a new SEED writer, verified the correctness of all IRIS/IDA response information, and reestablished the data flow between the IRIS/IDA DCC and the IRIS DMC.

IRIS/USGS Data Collection Center

The IRIS/USGS DCC is operated by the Albuquerque Seismic Laboratory of the USGS. Under the direction of Bob Hutt, ASL personnel perform quality control and reformatting on data from 14 IRIS/USGS GSN stations, as well as many other GDSN stations.

This year the IRIS DMS performed upgrades of the SONY Aquidnex WORM jukebox at the IRIS/USGS DCC to a 330

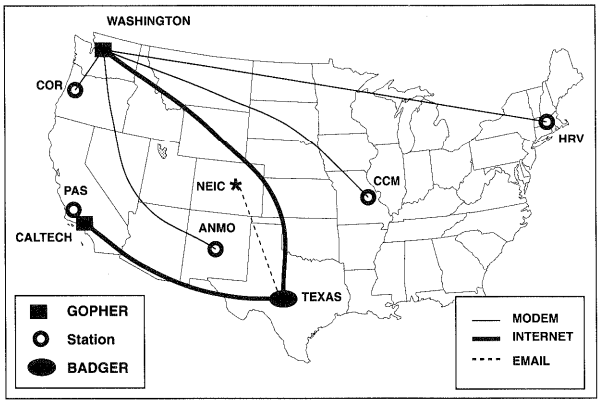
GOPHER/BADGER Enhancements

GOPHER, which has been widely used by researchers to quickly access recent earthquake data, has been extensively modified by Steve Malone. GOPHER presently accesses 12 stations by modem and the system has been enhanced to distribute the load of accessing the data to several centers around the world.

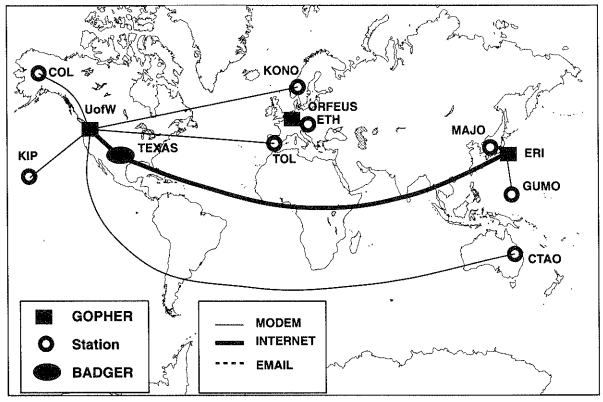
The system now runs under the control of a centralized BADGER system at the IRIS DMC. BADGER determines which of several geographically distributed GOPHER systems should access a given station. BADGER sends an electronic command to these GOPHER systems. The remote GOPHER system then accesses specific IRIS GSN stations, recovering data based upon event-station distances and event magnitudes. The data are then returned to the central BADGER system by Internet. Users can access these data in the normal manner and not be concerned with the complexity of the data retrieval system.

GOPHER systems are presently installed at the Interim DMC in Austin, Texas, the Permanent DMC in Seattle, Washington, the Earthquake Research Institute (ERI) in Tokyo, Japan, and at Caltech. A Gopher system has also been installed at ORFEUS in Utrecht, The Netherlands where testing is currently taking place. •

Domestic Badger System



International Badger System



gigabyte capacity. The DMS has also upgraded much of the computer hardware used at ASL.

A significant improvement at the IRIS/USGS DCC this year was the removal of the 60 day delay in data flow to the IRIS DMC. At present, the IRIS/USGS DCC forwards all quality controlled data to the DMC each week. IRIS generally has data archived for many stations within two weeks of the recording. A principal goal of the IRIS DMS is to make data available to the research community in a more timely manner.

Next Year Within the IRIS DMS

The direction that the IRIS DMS takes is largely controlled by input from the IRIS user community. Much of this input is channeled to IRIS staff through the IRIS DMS Standing Committee. We encourage you to contact representatives from the standing committee to make your wishes known. Members of the IRIS DMSSC are listed on page 10 of this Newsletter.

Additional Data Sets to be Archived:

Agreements have been made with various data centers to archive additional data at the DMC. In addition to all IRIS GSN and PASSCAL data, the IRIS DMS will also add the following data over the next year.

- 1972 - 1980 HGLP, RSTN, and SRO data stored at ASL
- 1980 - 1987 GDSN data from ASL
- IDA Gravimeter data from Scripps Institution of Oceanography
- multiple years of data from stations within the FDSN network

With the exception of the IDA Gravimeter data, all of the above data will be available in SEED format making the task of format conversion simpler for the end user.

Improved USER Interface to the IRIS DBMS

Although the present SPROUT system provides extremely powerful mechanisms for making queries of the DBMS, it requires knowledge of Structured Query Language. To simplify the user interface, Sue Schoch is presently developing the new XTRACT system that will allow most queries to be made in a point and click manner. This system will run under the X Window environment.

Inclusion of Event Information on SEED Distribution Volumes

The SPROUT system allows users to request data based on earthquake events as specified by the NEIC or ISC. Presently, the IRIS DMS does not distribute this event information on the same volumes as the waveform data. During the next year, the IRIS DBMS, the IRIS SEED writer, and the RDSEED SEED reading program will be modified so that information about events will also be included with the waveform data. This will allow the requestor of the data to be able to relate waveforms to events if so desired. Both hypocenter and phase information will be included.

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From the DMS Standing Committee:

Early this year, IRIS began a process which culminated in the selection of the University of Washington as the host institution for the IRIS Data Management Center (DMC). Among other tasks, it is anticipated that University of Washington investigators, in close cooperation with members of the research community, will be developing enhancements to the data services now available through the DMC. The present Interim System located at the University of Texas Institute of Geophysics (UTIG) will continue to operate until the DMC in Seattle becomes fully operational early next year. We are especially appreciative to the UTIG staff for their services during the past three years as hosts to the IRIS DMC during its startup and development phase.

A major acquisition by the DMS program this year has been a mass storage system from Metrum Information Storage. This VHS helical scan storage system can keep 6 terabytes of data on-line and will be able to retrieve seismic data at a rate of a station-channel-day every two seconds. Several months of continued testing are required before this system becomes operational, but it is clear that this device will more than meet the needs of DMC users over the foreseeable future.

Despite this substantial progress, significant challenges remain. The timeliness and integrity of the data must be maintained, thus problems of data flow and quality need to be promptly addressed. Close coordination with the PASSCAL and JSP programs over the coming year is needed to keep pace with major developments in these programs. As a data archive for the Federation of Digital Broadband Seismograph Networks (FDSN), the DMS needs to work closely with FDSN members in the areas of data exchange and access. Finally, on the horizon are issues of distributed data archives and the archiving of data from regional networks and arrays.

Our highest priority remains the effective dissemination of data to research seismologists. This enables them to concentrate primarily on the analysis and interpretation of data rather than the assembly of useable data sets, the latter task being a principal responsibility of the IRIS DMS. To achieve this objective the Standing Committee welcomes all advice, comments, or criticism from the user community. •

E.R. Engdahl, Chair, DMS Standing Committee

Federation of Digital Broadband Seismographic Networks

The goal of installing and operating 128 geographically distributed permanent GSN stations cannot be accomplished using IRIS resources alone. The Federation of Digital Broadband Seismographic Networks (FDSN) is an international organization that brings together countries that operate broadband stations worldwide. In addition to IRIS and the USGS, members include France (GEOSCOPE), Italy (MEDNET), Japan (POSEIDON), Canada (CNSN), European Foundation (ORFEUS), Great Britain, Germany, Australia, Soviet Union, and China (CDSN). The FDSN membership has worked closely in the development of the SEED format to facilitate data exchange between members.

At the last FDSN meeting in Vienna, the IRIS DMC was designated as the FDSN archive for continuous data. As such, continuous data from all stations within the FDSN Network will be archived at the IRIS DMC. This will enable IRIS researchers to access data from all FDSN stations through the IRIS DMC. The IRIS DMC will also service requests for data from all FDSN data centers and, where appropriate, individual researchers in FDSN countries. By including all FDSN data at the IRIS DMC, the task of acquiring data will be simplified for all seismologists. IRIS welcomes the opportunity to assist the FDSN in its goal of data exchange. •

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Porting of the IRIS DBMS to Research Centers

The IRIS DBMS uses the db_Vista software. One of the original reasons for using this system was that executable versions of the DBMS could be distributed royalty free. It is anticipated that 1992 will see the first port of the DBMS outside the IRIS DMC. Utilities exist that process incoming SEED data volumes and Hypocenter Data Files (HDF) to update the DBMS. Since users receive data from the IRIS DMS in SEED format, the porting of the DBMS will allow users to manage requested data at their home institution. Universities interested in testing this concept should contact the IRIS DMS staff. It should be possible for individual researchers to transfer portions of the IRIS archive to their local systems, use the IRIS DBMS to manage the data, and actually be able to produce SEED volumes for their own research purposes.

PASSCAL Data Collection Centers

Deployments of PASSCAL instruments have already exceeded the capability of most IRIS researchers to manage the large quantity of data at their home institutions. The need to have large amounts of buffer space available to perform sorting operations on large data sets has prompted the IRIS DMS and PASSCAL programs to investigate using the Metrum RSS 600 mass storage system for this purpose. The DMC will study the feasibility of using the Metrum RSS 600 mass storage system to assist in the processing of data from PASSCAL field experiments. The IRIS DMC will also install complete PASSCAL field computer software at the DMC this year. Assuming that the test is successful, the IRIS DMS plans to make certain DMC resources available for both visiting scientists and PIs of PASSCAL field experiments.

Distributed Data Centers

The IRIS archive will be the primary archive for all IRIS data and for additional selected data sets. Nevertheless, the need to provide interfaces to other data centers clearly exists. During 1992, the IRIS DMS will investigate access to other distributed archives. Concepts such as the Lamont View Server, standardization of data request protocols, and other distributed data management concepts will be investigated and implemented if appropriate. •

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PASSCAL

Jim Fowler, Program Manager

The Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL) provides portable instrumentation and support facilities for temporary deployments in studies of seismic sources and earth structure. Data loggers developed to PASSCAL specifications form the core of the program. These data loggers are extremely flexible in their ability to respond to a variety of deployment schemes - mobile arrays for recording of planned explosions; temporary deployments for aftershock studies; longer term deployments for observations of teleseismic events. The initial design and testing stage has now ended. Over 150 instruments are available and individual experiments involving up to 40 PASSCAL instruments have been supported. As the program moves towards acquisition of the eventual goal of 6000 channels, the current emphasis is on supporting field experiments; maintaining equipment; implementing improvements in hardware; and developing software for the efficient collection and initial processing of data.

This has been the second year of significant growth for the PASSCAL program. Although funding delays meant that we did not start taking delivery of new instruments until late in the year, the field support efforts continued to grow at a rapid pace. The number of experiments and the number of instruments in the field almost doubled compared to those supported in 1990. A second instrument center operated by Stanford and the USGS has been opened in Menlo Park and will be ready to support field experiments by January 1992. Thirty portable broadband sensors have been ordered, and their delivery in 1992 will triple our ability to support broadband experiments.

Field Support

The PASSCAL program provides a full range of field support for Principal Investigators through the PASSCAL Instrument Center at Lamont-Doherty Geological Observatory. During 1991 the center at Lamont supported 27 different field experiments, including seven outside the US. Figure 1 shows the growth of the field support program over the last three years. This chart shows the total number of instrument-months spent in the field each year compared to the total number of instrument-months available. Also shown is the number of experiments supported. Usage has grown from approximately 200 instrument-months in the field in 1989 to almost 1000 in 1991. Figure 2 is a chart of the instrument use by month during 1991. This chart show that the PASSCAL program has become a very effective resource for the research community. The instruments are being utilized in the field essentially all of the available time. This usage is much higher than can usually be supported by any single institution. Table 2 lists the field programs that used PASSCAL instruments during 1991.

A second instrument center has been opened in response to a growing demand for field support. At the end of 1990, PASSCAL issued a request for proposals to institutions interested in housing a new instrument center. Following evaluation of the proposals and visits to several potential sites, the selection committee chose the Stanford/USGS site. The PASSCAL Instrument Center - Stanford/USGS is a joint effort between Stanford and the USGS and will be located at the Geological Survey facility in Menlo Park. The center officially opened in October 1991 and started receiving the first complement of instruments soon thereafter. The center should be in full operation by the end of the year. The first instruments delivered to the new center were the first 50 production units of the new three-channel recorder. Both the Lamont and Stanford/USGS centers will provide training and support for all types of field experiments.

Table I shows the instrumentation available as of the end of 1991. In addition to the 50 new three-channel instruments purchased this year we have also purchased 12 new six-channel instruments and received delivery of 10 broadband sensors.

In addition to the support of the standard PASSCAL instruments, PASSCAL continued to provide support to the Seismic Group Recorder (SGR) Facility at Stanford. This facility provides access to about 200 single channel SGRs for recording reflection/refraction data. These instruments have been

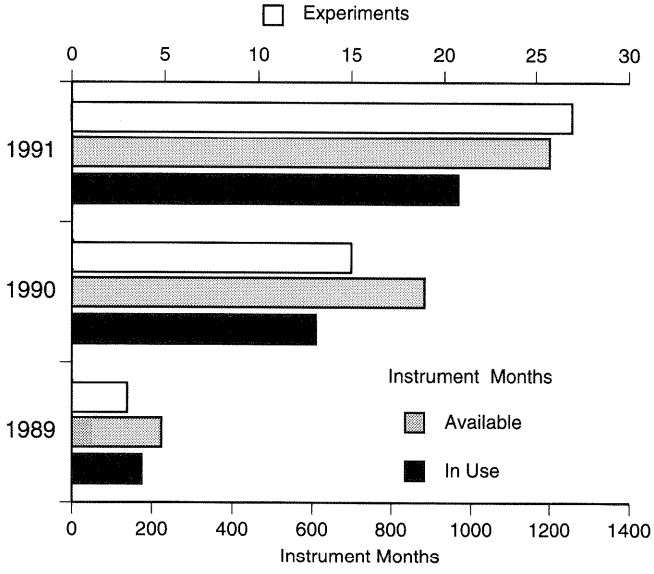

Figure 1. Growth in the PASSCAL Program from 1989-1991.

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used on several experiments in the last few years and they provide additional high quality digital recording channels which will be very useful until the PASSCAL instrument pool is completed.

As part of our effort to provide support to field projects, the Instrument Center continues to hold training programs for field crews and sends technical personnel to the field for large experiments. During the last year the Instrument Center trained 21 people and furnished over 100 days of in-field support to experiments.

The PASSCAL Users Guide was distributed to potential PASSCAL users this summer. This guide is intended to provide the Principal Investigators with information necessary to plan and execute experiment using PASSCAL instruments. It outlines the capability of the equipment and specifies the responsibilities of the Principal Investigator and those of PASSCAL. Additional copies of this document are available from IRIS Headquarters.

Instrumentation

Instrumentation work during 1991 mainly involved testing of the new three-channel recorder and broadband sensors. The prototype three-channel recorders were delivered toward the end of 1990. These units were tested and evaluated during the first half of 1991. When new funding became available in July, fifty productions units were ordered. The three-channel instrument uses many of the same boards as the six-channel unit and uses the same set-up and down-load devices. The three-channel unit is designed principally for reflection/refraction surveys, and this accounts for most of the differences. The three-channel unit utilizes a 16-bit A/D, recording both a high gain and low gain version of the signal. This gives the system the necessary dynamic range to record large explosions at near offsets. An internal 200 Mbyte disk is used for data recording. The three-channel instrument does not have an OMEGA timing receiver as standard equipment, but the addition of an external timing receiver can allow the unit to be used in long-term deployments. The major disadvantage of the three-channel unit is that it is possible to use only one sample rate at a time, whereas the six-channel units can simultaneously record multiple sample rates.

PASSCAL Instrumentation December 1991		
Recording Equipment	6-channel recorders	101
	3-channel recorders	55
	Disk Units	144
	EXABYTE Recorders	14
Sensors	Mark Products L-22 2 Hz	100
	Mark Products L-4 1 Hz	5
	Mark Products 8 Hz string	120
	Geotech S-13 1 Hz set of 3	10
	Streckeisen STS-2	11
	Guralp CMG-3ESP	5
	Guralp CMG-3T	1
	Kinemetrics WR-1	1
Field Computers	SUN 3/160	2
	SUN 3/50	3
	SUN SPARCstation 1+	2
	SUN SPARCstation IPC	4
	SUN SPARCstation IPX	2
Miscellaneous	3-channel cables (250 m)	100
	Trimble GPS Receivers	2
	Kinemetrics GOES Receiver	1
	Nanometrics Portable Clock	4
	30 Watt solar panels	33

Table 1. Inventory of PASSCAL equipment at the end of 1991.

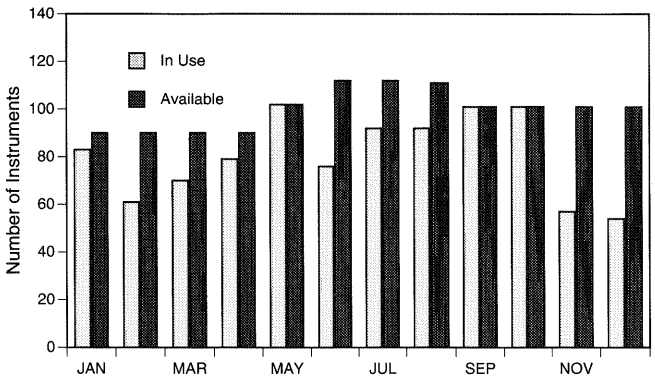


Figure 2. PASSCAL instrument use in 1991.

Tests were conducted on broad-band sensors both on a pier and in temporary field installations. These tests revealed that it is possible to get coherent energy in field installations down to periods on the order of 100 seconds. These studies also showed that the interface between the PASSCAL recorder and the broad-band sensor requires some modifications to give optimal noise performance. Several possible modifications are now being examined. Based on the positive results of the studies, orders were placed for 30 portable broad-band sensors to augment the 17 currently on hand.

Continued signal reception problems with the current OMEGA clock have led to a re-examination of timing for the PASSCAL instrument. PASSCAL has issued a contract to the University of Wisconsin to look at an alternative design for an OMEGA clock. This work is proceeding well, and it is expected that prototyping of various components will be complete by the end of 1991. Other timing systems are also being evaluated. A prototype GPS clock is currently under test at the instrument center. It is expected that within the next year there will be several options for improved timing and a decision will be made on which one to adopt.

PASSCAL Instrument Use - 1991

Texas A&M		**U.C. Los Angeles**	
High Frequency	35	**Wisconsin**	
USGS		*Lake Baikal*	10
Geysers	15	**U.C. Santa Cruz**	
Iceland	30	*Loma Prieta*	10
Stanford		**U.C. San Diego**	
Antarctica	30	*Heard Island*	6
Oregon State		**Utah**	
Texas, El Paso		*Yellowstone I & II*	5
Cascade Range	30	**U.C. San Diego**	
Stanford		**Indiana**	
San Fransisco	30	**S. Carolina**	
USGS		*Pinon II (BB sensors)*	15
Redoubt Volcano	20	**Wisconsin**	
USGS		*Mississippi Embayment*	5
Lithoprobe		**LBL**	
Newfoundland	15	*Parkfield*	5
SUNY Binghamton		**Utah**	
S. Carloina		*Salt Lake Valley*	5
Tibet	13	**New Mexico Tech**	
Columbia - L-DGO		**New Mexico State**	
Georgia/Ossetia	4	*Rio Grande Rift*	4
Rocky Mtn Front	10	**Princeton**	
U. S.C.		*Student Camp*	3
San Andreas	12	**Cal Tech**	
S. Carolina		*Yellowstone*	2
Bad Creek Reservoir	10	**Nevada, Reno**	
Memphis State		*Sierra Foothills*	1
New Madrid	10		

Table 2. This table lists institutions that used PASSCAL equpiment in experiments during 1991. The number of instruments used is shown. Many of these were cooperative experiments involving more than one institution. In these cases, the institution repsonsible for operation of the PASSCAL instruments is listed.

Field Computers

The SUN 3 computers are gradually being upgraded to color SUN SPARCstations. The older machines are not being lost to the program, but are being used as training and laboratory machines while the newer models are being sent to the field. The newer machines offer a significant increase in speed and the color monitors make it possible to take advantage of some of the newer data presentation techniques being developed by both universities and commercial vendors.

In addition to the hardware changes, we have initiated development of a new software environment for the field computers. This new environment will improve data transfer to the field computer and provide facilities to carry out initial quality control checks and optimize data acquisition. The field computer will then be able to generate output tapes in various formats compatible with the user's home computer or with the IRIS Data Management System.

The PASSCAL program in cooperation with the Data Management System has continued the operation of the SierraSEIS Maintenance Center at Lawrence Berkeley Laboratories. This center has produced an add-on (IRISSEIS) to the basic package, which contains specialized routines to facilitate processing of nonstandard reflection and refraction data. The center also acts as a clearing

Continued on page 10

From the PASSCAL Standing Committee:

The growth of the PASSCAL facility has continued in 1991 with the establishment of a second instrument center equipped with a complement of 50 new 3-channel PASSCAL "juniors". The Stanford/USGS Instrument Center will specialize in servicing primarily reflection/refraction seismic experiments, wheras the Lamont Instrument Center, which will continue for another three years, will specialize in servicing earthquake/broadband studies.

The success of PASSCAL as a facility serving a broad spectrum of the IRIS community is demonstrated by the nearly 100% field use of the instruments during some months, and the very respectable usage (approximately 80%) averaged over the year. In all, 27 experiments, using from 1 to 35 instruments each, and extending from 3 weeks to 1 year in duration, were serviced. This hectic pace has kept the IRIS/PASSCAL personnel at Lamont very busy and shows no sign of abating in 1992. Moreover, 1992 will bring a three fold increase in the number of instruments to be fielded in a single experiment, which will certainly require adjustments of field procedures and software.

In spite of the large increase in the number of PASSCAL instruments over the past two years, we are still far short of the PASSCAL goal of high-resolution 3-dimensional imaging of the crust and lithosphere. The next several years will require growth of the facility on all fronts.

To publicize PASSCAL policies and procedures and to assist investigators in designing experiments using PASSCAL instruments, a comprehensive PASSCAL Users' Guide was distributed to the community in the late summer. The Standing Committee welcomes comments and criticisms from the PASSCAL community. •

Anne Trehu, Chair, PASSCAL Standing Committee

Continued from page 9

house so that routines developed at other institutions can be added to the package. Personnel at the center have also been testing the pre-release version of the next major SierraSEIS release.

Plans for 1992

The schedule for instrument use in 1992 represents another large increase in field support. During the year we plan to support two or more large field experiments with almost 100 instruments each. This is more than double the largest number of instruments we have supported to date on a single experiment. As the experiments get larger the quantity of data collected will put a severe strain on the field computer systems. A high priority will be put on software development to improve the data management tasks during an experiment, and to make it possible to produce a reasonable data product while in the field. •

IRIS Governance

IRIS has grown from an initial group of 22 charter members in 1984 to a current membership of 77. Institutions welcomed to membership in the Consortium during 1991 were Lehigh, Duke, and Syracuse Universities and The University of Oklahoma. Each member institutions is represented on the Board of Directors. The Executive Committee acts in matters of policy on behalf of the Board of Directors. Management is provided by the Corporate Office through the President and Program Managers. Oversight of the IRIS programs comes from Standing Committees.

Listed below are the members who served on IRIS committees in 1991. One of the greatest strengths of IRIS is the broad representation of the US seismological community reflected in the committee membership. To those who end their term on committees this year, we express our sincere appreciation for the guidance they have provided and the part they have played in shaping the future of IRIS. •

IRIS Committees - 1991

Executive Committee

Paul Silver, Chair	Carnegie Institution of Washington
Jeffrey Park, Vice Chair	Yale University
Sue McGeary, Secretary	University of Delaware
Gary Pavlis	Indiana University
John Orcutt	University of California, San Diego
George Thompson	Stanford University
Terry Wallace	University of Arizona
Doug Wiens	Washington University, St. Louis

Global Seismographic Network

Don Forsyth, Chair	Brown University
Jonathan Berger *(observer)*	University of California, San Diego
Greg Beroza	Stanford University
John Filson *(ex officio)*	US Geological Survey, Reston
Stephen Grand	University of Texas, Austin
Heidi Houston	University of California, Santa Cruz
C.R. Hutt *(observer)*	US Geological Survey, ASL
Charles Langston	Pennsylvania State University
Hiroo Kanamori	California Institute of Technology
Barbara Romanowicz	University of California, Berkeley
Stuart Sipkin	US Geological Survey, Golden

Program for Array Studies

Anne Trehu, Chair	Oregon State University
Larry Braile	Purdue University
Tom Brocher	US Geological Survey, Menlo Park
Diane Doser	University of Texas, El Paso
David Okaya	University of California, Berkeley
Thomas Owens	University of South Carolina
Robert Smith	University of Utah
Brian Stump	Southern Methodist University
Frank Vernon	University of California, San Diego

Data Management System

Robert Engdahl, Chair	US Geological Survey
Shelton Alexander	Pennsylvania State University
Goran Ekstrom	Harvard University
Clifford Frohlich	University of Texas, Austin
C.R. Hutt *(observer)*	US Geological Survey, ASL
Shane Ingate *(observer)*	University of California, San Diego
Peter Malin	Duke University
Stephen Malone	University of Washington
John Nabelek	Oregon State University
Toshiro Tanimoto	California Institute of Technology
Francis Wu	SUNY, Binghamton

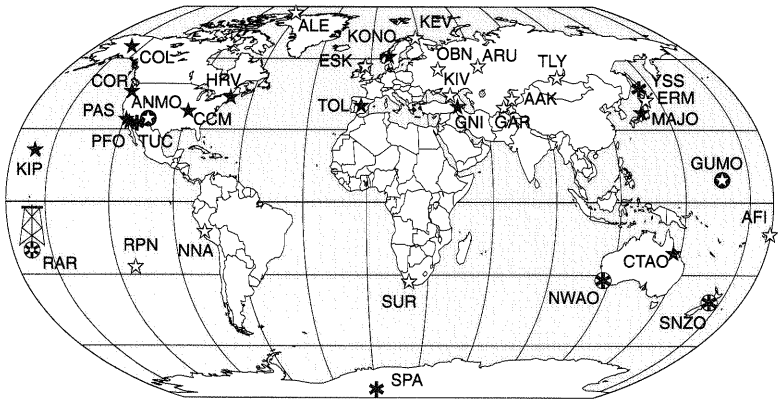
US/USSR Joint Seismic Program

Stewart Smith, Chair	University of Washington
Charles Archambeau	University of Colorado, Boulder
Jonathan Berger	University of California, San Diego
Goran Ekstrom	Harvard University
John Filson	US Geological Survey, Reston
Charles Langston	Pennsylvania State
Arthur Lerner-Lam	Columbia University
Jeffrey Park	Yale University
Robert Phinney	Princeton University
Paul Richards	Columbia University
Brian Stump	Southern Methodist University
Terry Wallace	University of Arizona

Global Seismographic Network

Rhett Butler, Program Manager

The IRIS Global Seismographic Network is the focused effort of the United Sates academic seismological community to provide a state-of-the-art, broadband, digital network of seismic instrumentation for research on the three-dimensional structure of the Earth and the study of earthquakes and other seismic sources. The goals of the GSN are two-fold: globally-distributed, uniform coverage with approximately 128 (2^7) stations, and real-time telemetry of the data to the IRIS Data Management Center. The GSN is a partnership between IRIS and the US Geological Survey, cooperating under a Memorandum of Understanding. IRIS GSN global siting plans are coordinated with other international networks through the Federation of Digital Seismic Network, of which IRIS is a founding member. Beginning in late 1986 with the installation of the first broadband seismometers, the GSN has seen steady progress toward its long-term goals, and already serves as a fundamental resource in the study of earthquake dynamics and tomographic analyses of the elastic and anelastic structure of the Earth.



Current Sites	Installations Scheduled through 3/92
★ STS-1 vault seismometer	✱ STS-1 vault installation +24-bit data logger
✪ KS36000i borehole seismometer +24-bit data logger •dial-up access (Except GNI)	✱ SRO site upgrade with KS36000i +24-bit data logger
☆ STS-1 vault seismometer + 16-bit dual-gain data logger or DWWSSN (AFI. KEV)	New borehole has been drilled, both STS-1 and KS36000i +24-bit data logger

There are now twenty-seven stations in the IRIS Global Seismographic Network. During the past year five existing GDSN stations were upgraded with 24-bit GSN data loggers and very broadband borehole and vault seismometers. One new site was established and installed in Armenia. Beginning IRIS's efforts to improve oceanic coverage, new boreholes were drilled on the island Raratonga and in the ocean bottom 200 km SE of Oahu, and re-engineering work began on the Guam–Japan oceanic cable. A field team is now in Australia installing NWAO, and a new installation at the South Pole should be complete by the end of the year.

IRIS/USGS

Through November of this year IRIS-2 data loggers have been installed on existing Streckeisen sensors at COL, College, Alaska; CTAO, Charters Towers, Australia; and at TOL, Toledo, Spain. IRIS-2 data loggers and broadband seismom-

Continued on page 12

Continued from page 11

eters have been installed at GUMO, Guam; KONO, Kongsberg, Norway; and GNI, Garni, Armenia. The existing Guam SRO borehole sensor has been upgraded with a Geotech KS36000i, and Streckeisen STS-1 sensors were installed at the KONO site, which is a deep mine, and in a tunnel in Garni. Supplemental sensors were also installed at several sites: strong-motion Kinemetrics FBA-23 sensors at COL, GUMO, and CTAO; high-frequency Geotech GS-13 seismometers at GNI.

The drilling of a new borehole has been completed on Rarotonga in the Cook Islands by the DSIR group from New Zealand. Streckeisen STS-1 seismometers will temporarily be installed at RAR along with a borehole KS36000i sensor in January to test the relative merits of vault versus borehole siting on small islands. A new seismic vault at the South Pole has been completed and SPA is ready for the installation of an IRIS-2 data logger and Streckeisen seismometers. Daily telemetry of seismic events from SPA has been arranged via an ATS satellite circuit available through NSF. A seismic vault is being constructed this austral summer for a new site at Palmer Station off of the Antarctic peninsula. Installation and upgrade of SPA, South Pole; NWAO, Narrogin, Australia; RAR, Rarotonga; SNZO, Wellington, New Zealand; and YSS, Yuzhno Sakhalinsk, Russia are planned to be completed by the end of the first quarter of 1992. Installations in 1992 following these mentioned will focus upon completing the upgrade of existing SRO sites.

IRIS/University

The installation of the new University of Arizona site near Tucson should take place in the next few months. The GSN Standing Committee has selected the proposals of two additional universities for participation in the IRIS University Network: Penn State University for its KS36000i borehole site, SSP, at Standing Stone, PA; and UC Berkeley for its Streckeisen STS-1 site, CMB, at Columbia College, CA. Each of these sites will also be part of the US National Seismic Network.

Kazuya Fujita of Michigan State University in conjunction with the University of Alaska successfully completed a noise

From the GSN Standing Committee:

The Global Seismographic Network made considerable progress this year thanks to the efforts of the Network Operators, the US Geological Survey Albuquerque Seismo Lab and the UC San Diego IRIS/IDA group, led by Bob Hutt and Jon Berger, respectively, and the GSN Program Manager, Rhett Butler. Routine installation of GSN design-goal data loggers has been under way for a year now, providing high dynamic range (24-bit) recording and telephone dial-up access to the data at some stations. A problem with writing SEED data has now been overcome, so data is again flowing to the Data Management Center from all stations.

New Streckeisen STS-1 seismometers have been installed in Norway and at a new site in Armenia. The GSN program to upgrade the existing SRO network with the broadband-modified Geotech KS36000i borehole seismometers continued at Guam and in Narrogin, Australia. Most of the DWWSSN sites, where IRIS initially installed only broadband sensors several years ago, now have design-goal data loggers as well. The coming year will still see many upgrades of existing digital stations, but efforts are now turning toward new site preparation and installation.

The installation of a new University Network site in cooperation with the University of Arizona near Tucson is now ready, and the GSN Standing Committee accepted proposals from Penn State and UC Berkeley for participation this coming year. A new 120m borehole was drilled on the island of Rarotonga, which will serve as the testbed site for borehole versus vault noise comparisons at island sites. Our future efforts toward ocean-bottom siting have progressed through efforts toward undersea telephone cable reuse and the successful drilling of a seafloor borehole south of the Hawaiian Islands.

IRIS's effort to secure a five-year funding authorization from NSF has been successful — congratulations and thanks are in order for all involved. The GSN program has benefited enormously from the broad and active support of the seismological and Earth sciences communities. For the GSN program to succeed in its far-reaching goals, this community support must not abate. On behalf of the Standing Committee, I urge you to continue your active and vocal support for the GSN. Acknowledge IRIS when you write papers and give talks — word of mouth is the best advertisement.

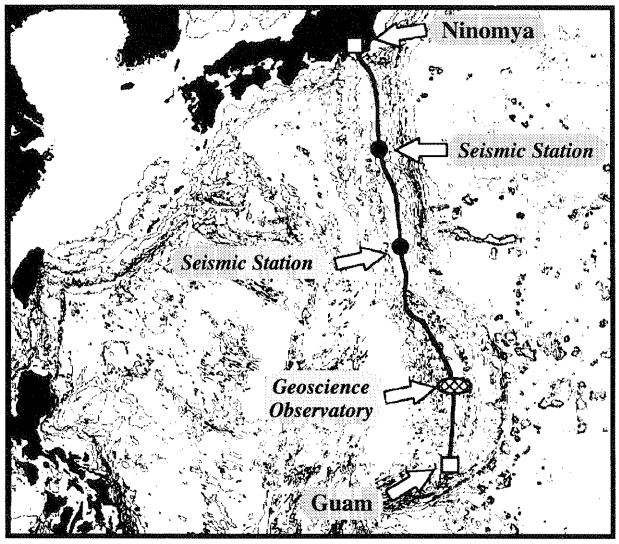
Many of the most difficult new sites are ahead of us. We have seen the dramatic improvements resulting from new instrumentation. It will be even more exciting for the science to experience the improvement in global coverage from new siting efforts. Keep up your support. •

Don Forsyth, Chair, GSN Standing Committee

survey of a proposed YAK Yakutsk site working with the Yakut Geological Survey. Permission has been obtained from the Russians for a Yakutsk site. The existing site is somewhat noisy. Dr. Fujita will work with the USGS team toward establishing a permanent GSN site at or near the existing YAK site.

IRIS/IDA

Software revisions to the IRIS-3 data logger have been completed and tested. A prototype 24-bit system using a Hewlett-Packard digitizer is under test. These new units will have three 24-bit channels and up to sixteen DSP channels. A



The route of TPC-1 between Guam and Ninomiya, Japan, is shown with planned locations for instrumentation sites.

trip to ALE Alert to upgrade software and to move the data acquisition system from the unheated vault to a nearby heated area has been indefinitely postponed due the recent crash of a Canadian military transport plane.

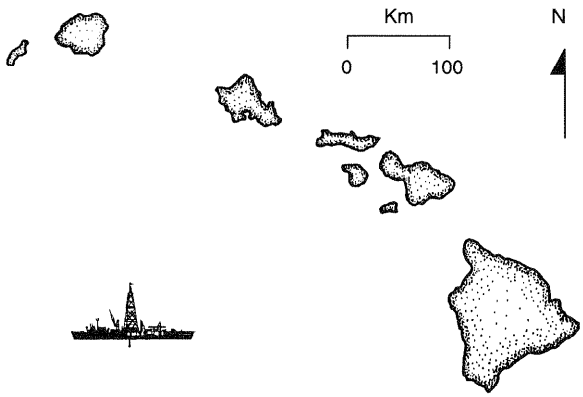
Installation of a new site at FFC, Flin Flon, Canada is currently scheduled for sometime in spring of 1992, awaiting completion of site preparations by the Canadians. A site survey of Ascension Island was conducted in January. A new tunnel vault is being constructed for KIV, Kislovodsk, Russia; upon completion the seismometers will be moved from their present location in the basement of a building. Site development activities are underway at Novosibirsk, Norilsk, Lovozero, and Ashkabad in the (former) Soviet Union. The installation of a GSN station in cooperation with the Soviets at their Novolazarevskaya base in Antarctica has been delayed until the 1992 season. Further details on IRIS/IDA sites in the USSR are discussed in the following section on the Joint Seismic Program.

IRIS OCEAN CABLE

The transfer of Trans Pacific Cable–1 (Guam-Japan section) from AT&T, KDD, and Hawaiian Telephone to the Earthquake Research Institute (ERI) of the University of Tokyo and IRIS took place effective November 1, 1990. A non-profit corporation — IRIS Ocean Cable, Incorporated — was formed by IRIS to receive ownership of AT&T and Hawaiian Telephone's share of the cable. AT&T agreed to continue to power the cable for one year at the request of IRIS and AT&T Bell Labs, in order to provide sufficient time for the re-termination engineering of the cable. IRIS has received funding from NSF for the Guam cable facility. The re-termination engineering of the IRIS/ERI Guam–Japan Cable is tentatively scheduled for November at the Guam cable Station, and is coordinated with Japanese efforts at Ninomiya near Tokyo.

Ocean Seismic Network

The Ocean Drilling Program successfully emplaced a cased borehole with a re-entry cone into the oceanic crust 200 km southwest of Oahu in March. The drillhole, OSN-1, will be used for pilot R&D experiments toward eventual deployment of seismic stations in the ocean. •



The location of the OSN-1 borehole is indicated by the drilling ship southwest of Oahu.

US/USSR Joint Seismic Program

Gregory van der Vink, Program Coordinator

The US/USSR Joint Seismic Program (JSP) is going through a period of dramatic change due both to the disintegration of the Soviet Union and to shifting US national security priorities (*See Box: "Impact of Changes in the USSR" and essay "The Future of the JSP"*). In 1992, the JSP will expand beyond the borders of the Soviet Union and will involve scientists from over seven Soviet research organizations, ten US universities, and the US Geological Survey.

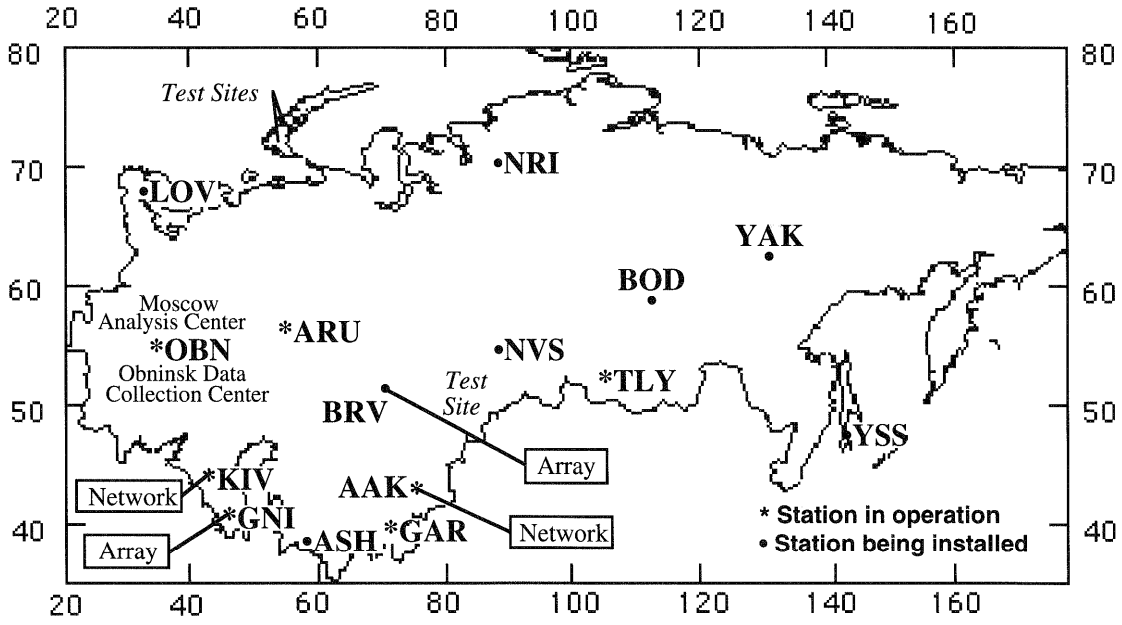
The JSP continues to function as the common intersection of different interest groups. As such, the program is not geographically defined, but rather it exists to achieve the objectives of its various supporting groups. As a consequence, the program operates through many forums:

- the funding is provided by members of Congress who are interested in developing a framework to verify further restrictions on underground nuclear testing and the proliferation of nuclear weapons;
- the Air Force administers the program for the contribution of research to their task of monitoring existing treaties that limit underground nuclear explosions;
- the program is carried out under Area IX of the Agreement on Cooperation in the Field of Environmental Protection because of the application to the mitigation of earthquake hazards; and,
- IRIS manages the program because of the direct contribution to the expansion and achievement of the IRIS program goals.

The work of the JSP is relevant to such policy issues as the monitoring of underground nuclear explosions and the mitigation of earthquake hazards. It is largely for this reason that Congress has provided supplemental funding to the Air Force for the support of the JSP and declared the program to be an item of special Congressional interest. The relevance of the work is viewed by IRIS as both a strength of the program and as an opportunity for its member institutions to contribute objective technical information on important issues of public concern. IRIS, however, assumes no position on policy issues. All data from the program are available by request, without restriction, on an international basis.

Program Status

Under the JSP, high performance seismic stations, seismic networks, and portable arrays of seismic instruments are being installed in the Soviet Union and areas of interest for non-proliferation. In addition to these data collection facilities, IRIS has established the associated data management, scientific collaboration and exchanges necessary to incorporate Soviet data and Soviet seismology into the international community.

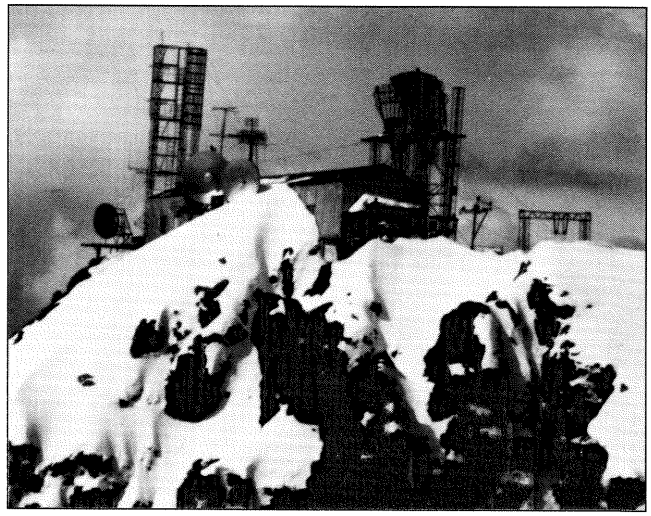


GSN Stations

Under the Joint Seismic Program, the following seven broad-band IRIS stations in the USSR are now routinely sending data back to the United States: Garm (GAR), Kislovodsk (KIS), Arti (ARU), Obninsk (OBN), Talaya (TLY), Ala-Archa (AAK), and Garni (GNI). Permission has been obtained for eight additional stations; and plans for 1992 include the installation of Novosibirsk (NVS), Lovozero (LOV), Ashkabad (ASH), Norilsk (NRI), Yuzhno-Sakhalinsk (YSS), and Borovoye (BRV) by UCSD and the US Geological Survey. It is expected that when the network is completed, IRIS and the USGS will operate 20 stations in the USSR.

In cooperation with personnel from the Soviet Academy of Sciences, a new IRIS station will be installed in Antarctica during the austral summer of 1992-3. The tentative location for the site is *Novolasarevskaya* (70.46S, 11.50E), a Soviet research station run by the Meteorological Agency of the USSR Academy of Sciences. Additional sites outside of the Soviet Union, in areas of interest for for the monitoring of non-proliferation, are being proposed for 1992.

Due to the difficulties in accessing Soviet stations and facilitating repairs, telemetry is important for both timely data collection and state-of-health maintenance. Plans call for the additional installation of dedicated telephone circuits (land-lines) and perhaps satellite links to transmit data from the individual Soviet stations to the Data Collection Center in Obninsk. Collected data are already being sent via satellite from the Obninsk Data Center to the Data Collection Center in San Diego.



Western repeater for the ten-station telemetered network in the northern Tien Shan mountains of Kirghizia, USSR. *(photo - Frank Vernon)*

Networks and Arrays

In addition to permanent broad-band stations in the USSR, IRIS has installed regional networks and small aperture arrays. This work was initiated at the request of the Soviet Union in 1989 for modern telemetered networks in Armenia and Kirghizia, two areas of greatest earthquake hazard in the USSR. Under this initiative, a telemetered regional network has been installed in Kirghizia. A second regional network has been located on the northern edge of the Caucasus. The US Geological Survey is operating an array in and around a tunnel in Armenia. Plans for 1992 call for the re-location of the small aperture array from Pinyon Flat, California to the Borovoye

Continued on page 16

Background of the JSP

The Soviet Union, comprising a large percentage of the Earth's land area, has long been inaccessible to US seismologists. As a result, global seismographic coverage has been limited and the Eurasian structures have been largely unexplored. The 1984 plan for the IRIS/USGS global seismic network did not include stations within the Soviet Union. Original requests by IRIS to the Soviet Union to locate seismic stations within their country had been turned down and almost all Soviet seismic data was considered classified by the Soviet government.

In 1987, however, the Natural Resources Defense Council (a not-for-profit environmental organization) was permitted to place temporary seismic stations around the Soviet test site in Kazakhstan. The temporary stations were part of an experiment to demonstrate the feasibility of seismically monitoring treaties that limit the testing of nuclear weapons. Sensing the impact of *glasnost* and a change in Soviet policy, IRIS approached the Soviet Academy of Sciences and proposed a joint program. Soviet permission and US funding for the program were obtained by April 1988. The first deployment of IRIS instruments in the USSR occurred at the end of the summer in 1988.

The Joint Seismic Program has been strongly supported by members of Congress interested in contributing seismic data to the technical debate over verification of arms control agreements that would further limit the underground testing of nuclear weapons and the proliferation of nuclear weapons to non-nuclear countries. In 1988-90, the program was funded by Congress through an addition to the nuclear monitoring program budget of the Defense Advanced Research Projects Agency. For FY91, Congress transferred the funding authority to the Air Force Office of Scientific Research and, at the same time, declared the program to be a special Congressional interest item. In FY 92 funding was again provided to the Air Force by the Congress. Funding for the program is transmitted through the National Science Foundation, which administers it under the terms of the Cooperative Agreement with IRIS. Consequently, the program falls under the NSF authorization, although funds are not provided out of the NSF budget. •

Benefits of Cooperation

As described earlier, the JSP program is an intersection of interests, and as such, it benefits from cooperation. For example, the instruments being installed in the Soviet Union were developed through the university research community with support from the National Science Foundation, the Cecile and Ida Green Foundation, and the US Geological Survey. The US side of the installation is funded through the Air Force, and the Soviet site preparation and station maintenance is provided by various organizations within the Soviet research community. In the Caucasus, both US and Soviet seismic stations have been telemetered together to form a network. While the US provides computer support through work developed by various US universities, the Soviet Union supplies logistical support and maintains the network.

With the National Science Foundation, Air Force, US Geological Survey, Cecile and Ida Green Foundation, and various USSR research organizations all contributing, the JSP is able to provide tremendous cost-savings to each of its individual sponsoring agencies. In addition, the involvement of over 10 universities, the US Geological Survey, and the Air Force Geophysics Laboratory provides a broad range of expertise. •

Continued from page 15

Geophysical Observatory in Kazakhstan.

Kirghiz Telemetered Network: A ten-station telemetered network has been installed in the Bishkek (formerly Frunze) area of Kirghizia at the request of the Soviet Union. The network will provide the Soviet Union with data for earthquake predication and hazard studies in one of their most earthquake prone areas. Each station records high and low gain, three component, broadband seismic data along with six low sample rate ancillary channels. Data are transmitted from each station back to the central receiving point at Chumysh. Two repeater locations relay data from the three stations located south of the Kirghiz range. A data collection and maintenance facility is located at the central station.

Caucasus Regional Network: The Caucasus Regional Network was designed for two purposes 1) to record seismic signals from artificial and natural sources in the active continental collision zone between the Arabian and Eurasian plates, and 2) to provide a portable seismic array capability for technical programs and scientific experiments conducted under the auspices of the Joint Seismic Program. The Network consists of six broadband stations telemetered around Kislovodsk: four of which are US stations, two of which are Soviet stations. Three additional stations operate autonomously along the Georgian/Russian border. A tenth station is located in Bakuriani, Georgia; however, political unrest in that area has

From the JSP Committee:

As many of you know, the Joint Seismic Program was reorganized this past year and now has an oversight committee similar in some respects to the standing committees for the other IRIS programs. The establishment of this committee, as well as a number of other administrative steps taken, have as their objective to improve the coordination of JSP activities with the other elements of IRIS, to explicitly recognize the special role that IRIS has taken on in the nuclear treaty verification arena, and to broaden the base of support within IRIS for the JSP.

In the earliest days of this program, IRIS was able to move rapidly to establish new stations and cooperative projects within the USSR as political change there made that a possibility for the first time. An intense Congressional interest in treaty verification issues provided the necessary funds. As a result, today there are seven IRIS stations operating in the USSR, four array experiments under way, and plans for the installation of an additional five stations during the coming year. Data flowing from these new stations located in previously inaccessible regions has revolutionized the way in which research on nuclear monitoring can be carried out, and has opened up many new opportunities for basic research on earthquakes hazards and earth structure.

The momentous changes taking place in the USSR have created much confusion, but they have also created remarkable new opportunities. One of the new opportunities that results from political change and the resulting shift in arms control objectives is an increased emphasis on the issue of non-proliferation. The spread of nuclear weapons to non-nuclear states is viewed as an increasingly important problem, and one on which the US and USSR can work jointly. The JSP forms a natural framework for this work to proceed, and the expansion of JSP supported stations outside the boundaries of the US and USSR fits well with IRIS objectives in establishing a global network. Last year, agreement was reached to install an IRIS station at the Soviet research facility in Antarctica, and this year several new locations are being proposed, including Mongolia, Kenya, India, Chile, Ascension Island, and Nigeria. One of our challenge for the future is to direct the evolution of the JSP so that it can provide crucial data for policy makers as they approach the renegotiation of the Nuclear Non-Proliferation Treaty in 1995. •

Stewart Smith, Chair, JSP Committee

Impact of Change

Both the move towards independence by the Soviet republics and the failed coup have had an impact of the Joint Seismic Program. The independence of the republics has decreased Moscow's influence. The failed coup has weakened the more conservative elements of the government, shifting the stance of the central government towards increased liberalism.

At each facility that has been established under the JSP, effort has been made to involve the local seismological community. As a result, participation in the program has expanded beyond Moscow's USSR Academy of Sciences to include the Armenian Academy of Sciences, the Academy of Sciences of Kazakhstan, the Academy of Sciences of Kirghizia, the Georgian Academy of Sciences, Institute of Marine Geology and Geophysics, Yuzhno-Sckhalinski, and the Yakutsk Science Center. As the republics become more autonomous, they are exercising independence in making decisions on facilities within their republics rather than having to coordinate work through Moscow.

Obtaining permission from the Soviet government to install seismic stations in new locations within the Soviet Union has been both difficult and time consuming due to requirements imposed by the Soviet Ministry of Defense. Several of our proposals to install seismic stations were turned down or postponed prior to the coup. In the wake of the failed coup, however, permission for some of these same sites has been readily obtained.

While the changes in the Soviet Union have created much confusion, they have also created tremendous opportunity. On balance, the JSP seems to have benefited from the goals of the reform, namely, less bureaucracy and more freedom. Although we must constantly adapt the program to the changes that are occurring, we look forward to greater opportunity within the Soviet Union. •

American and Soviet scientists inspect a seismometer installation while recording aftershocks of the April 29, 1991 Greater Caucasus earthquake (M_S=7.2), Bugiata, Southern Ossetia. *(photo - Geoff Abers)*

made the site inaccessible for almost a year. The operation of the seismic stations in both the configuration of a regional network and as portable instruments, allows for comprehensive approach to broad-scale studies of the seismicity, tectonics, and structure of the Caucasus.

Garni Dense Array: During June-July 1990 a dense seismic array was installed in and around a 200 meter tunnel at the Garni Observatory near Yerevan, Armenia by the USGS. The array consists of 10 sites with 3-component 1.0 Hz seismometers at each site. Because the tunnel at Garni is sunk into the side of a steep hill, array sites could be established on the hill directly above those in the tunnel, forming a three-dimensional geometry. A six element network with larger aperture will be installed in the Spring of 1992. The purpose of this larger network is to study the source of local seismicity detected on the dense array.

Borovoye Small Aperture Array: A portable 25-element three-component high wavenumber array was deployed in the United States last year for testing and development. The small array provides unique capabilities for the detailed study of Earth structure and very low magnitude seismicity. In the spring of 1992, the array will be moved to the geophysical observatory in Borovoye. The array may also be used in Kirghizia to record chemical explosions during the construction of the Kambarata dams and the hydroelectric power plant on the river Narin.

Data Facilities

The Data Collection Center in Obninsk is the collection point for all data from stations within the Soviet Union. The data are transmitted by satellite to the IRIS DCC in San Diego and archived in the IRIS Data Management System (DMS) in Seattle, Washington. Data from the program are available through direct access to the IRIS DMS. The Joint Seismic Program Center, located in Boulder Colorado, produces data products for distribution through the IRIS DMS. The data products are developed from JSP facilities and are specifically tailored for verification research, particularly the identification of low-yield seismic events. To supplement the data that are now being recorded by the IRIS/IDA stations within the USSR, older, analog data from Soviet archives are being obtained and digitized under the JSP's Historical Seismogram Project.

In 1991 IRIS opened a Data Analysis Center in Moscow. The Center provides a location for the training of Soviet scientists and the development of program software. The Moscow Data Analysis Center also serves as the Soviet archive for data from the Joint Seismic Program. •

The Future of the Joint Seismic Program

For years, much of the debate over the capability of seismology to monitor limits on nuclear testing was due to the lack of data from within the USSR. Although extrapolations were made about the performance of hypothetical seismic networks within the USSR, the basic premises of these extrapolations — the amount of low-level seismicity, seismic noise, and the efficiency of regional wave propagation within the Eurasian land mass — were unknown. During the 1987 Senate deliberations on the ratification of the Threshold Test Ban Treaty, for example, the lack of data from within the Soviet Union made it difficult to assess the uncertainties associated with the seismic monitoring of the 150 kiloton limit of the treaty. As described to the US Senate Committee on Armed Services in 1987 by the Assistant Secretary of Defense (Atomic Energy):

"...despite the optimistic predictions and efforts of seismologists over the years, they have no empirical data, no hard data on which to base their estimations of yields of Soviet nuclear detonations; they only have estimates built on extrapolations from tests and geological media far from the Soviet Union."

The ability of the Joint Seismic Program to contribute data directly to seismic verification research, along with usefulness of the work to earthquake hazard mitigation, is largely what has prompted members of Congress to support the program and designate the JSP an item of special Congressional interest. At the most recent conference on seismic verification research, over a dozen talks referenced JSP data, demonstrating the extent to which the JSP deployment of seismic stations, regional networks, and portable arrays is already contributing to our assessments of monitoring capabilities. The success of the JSP program has been recognized not only within the seismological community, but also within the United States Congress, as indicated by the following statement made by Senator Samuel Nunn, Chairman of the Senate Armed Services Committee, during a floor colloquy with Senator Kennedy:

"I want to take this opportunity to advise the Senator from Massachusetts that I share his strong support for the [US/USSR Joint Seismic] Program administered by the Incorporated Research Institutions for Seismology. The IRIS Program has added significantly to our knowledge of the seismic characteristics of the Soviet Union and hence to our abilities for monitoring compliance with limitations on nuclear testing." - *Congressional Record for legislative day August 3, 1990.*

Recently, political circumstances have changed, resulting in a shift of national security priorities and arms control objectives. The Soviet Union is moving towards a more democratic form of government and many of the republics are pressuring Moscow for independence. The nuclear testing site in Kazakhstan has been closed and the USSR has begun a one-year testing moratorium. With the Ukraine, Belorussia and Kazakhstan declaring independence, the development of future Soviet weapons is now less of a concern than Moscow's ability to account for its current nuclear stockpile. The discovery by United Nations officials of an advanced nuclear weapons development program within Iraq has further heightened concerns over the spread of nuclear weapons to previously non-nuclear states. Discussions of additional restrictions on nuclear testing among the nuclear states will most likely increase as the 25 year term of the Non-Proliferation Treaty (NPT) comes up for extension in 1995, and several non-nuclear states view further restrictions in nuclear testing as a *sine qua non* for preserving the NPT regime.

Given both the dramatic changes in the USSR, and the possible spread of nuclear weapons, concern over US/Soviet competition on the development of new generations of nuclear weapons (sometimes referred to as "vertical proliferation") has decreased relative to concerns over the spread of nuclear weapons to non-nuclear states (termed "horizontal proliferation"). As a result, the role of seismic monitoring to the maintenance of the non-proliferation regime must be both developed and assessed. The expanded importance of the JSP to non-proliferation was noted by the House Armed Services Committee during the authorization of funds for the program in the 1992 Defense Bill as follows:

> This program has made and continues to make important contributions to increase our capability to monitor nuclear testing treaties and the proliferation of nuclear weapons.
>
> - *1992 Defense Authorization Act, House Armed Services Committee*

During the opening of the Moscow Data Analysis Center in August, 1991, Congressman Markey sent a letter to Academician Velikhov, proposing the following goals and timetable for the Joint Seismic Program.

> It is our hope that during the United Nations discussions, we will be able to use the accomplishments of the US/USSR Joint Seismic Program as an example of what can be done when the scientific communities of different nations work together on problems of verification. It is in this context, and during the occasion of the opening of the Moscow Data

Center, that I propose we set our future goals. I propose that we work together to complete by 1993 the installation of seismic stations within the USSR. I further propose that we continue to expand outside the boundaries of the US and USSR and install stations in areas of concern for nonproliferation, specifically the middle east and southern hemisphere. The installation of these stations through the US/USSR Joint Seismic Program, combined with the Global Seismic Network stations, will enable us to complete a global network by 1995.

- Letter from Congressman Edward Markey to Academician Velikhov, July 24, 1991

The JSP program anticipated this expansion of focus a year ago and began discussions with the Soviet Union regarding the installation of seismic stations in areas of concern for non-proliferation, particularly, the southern hemisphere. Last year, an agreement was reached to install an IRIS station at the Soviet research facility in Antarctica. This year several new locations are being proposed. In addition, several sites in the USSR are being reviewed for their utility in recording seismic events in other countries. For example, the USSR station in Borovoye, Kazakhstan detected a small seismic event outside the Soviet Union that had a surface to body wave ratio characteristic of an underground nuclear explosion in the sub-kiloton range. Although further analysis indicated that the event was not an explosion, it demonstrated the use of high-performance seismic stations within the Eurasian platform. The remarkable changes that have occurred over the last two years have created both new needs and new opportunities. With the foundation that has already been built, the JSP is in a unique position to take advantage of these opportunities and to meet new challenges. •

Gregory van der Vink

the IRIS CONSORTIUM

The IRIS Newsletter is published quarterly by The IRIS Consortium. Please address your letters or inquires to:

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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 through Phillips Laboratory.

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.

Executive Editor: David Simpson
Production Editor: Denise Dillman-Crump

Fourth Annual IRIS Workshop

The fourth Annual IRIS workshop will be held April 12 - 14, 1992 in Santa Fe, New Mexico preceding the Annual SSA meeting. An announcement and registration form are included with this issue of the Newsletter. Additional copies can be obtained from the IRIS office. The Workshop is being organized by Doug Wiens and Terry Wallace.

Following the format that has evolved from earlier Workshops, the program will consist of invited talks, demonstrations, and Special Interest Groups (SIGS).

All presentations during the IRIS Workshop will be invited. The SSA meeting will provide the opportunity for interested participants in the IRIS workshop to present talks or posters. Abstracts should be submitted directly to SSA for their January 15 deadline. Symposia at the SSA that will be of particular interest to IRIS members include: Seismotectonics of the Basin and Range; Structure and Deformation of Continental Rifts; New Madrid Seismic Zone; Array Seismology; and Coda Waves.

A popular and successful part of past IRIS Workshops has been informal discussions groups or SIGS (Special Interest Groups). This year SIGS are already being planned on RAMP (Rapid Array Mobilization Program for aftershock studies), Education, and Software. If you are interested in one of these topics, or would like to suggest or lead another SIG, please contact the organizers. Suggestions will be accepted until February 15, 1992. A list of all SIGS will be included in a circular to be sent to registered participants early in March.

Continued on page 20

CALENDAR

JANUARY

9-10 **Berkeley Workshop -- "Frontiers of Broad Band Seismology"**

APRIL

12-14 **4th Annual IRIS Workshop, Santa Fe, NM**

14-16 **SSA, Santa Fe, NM**

MAY

11-15 **Spring AGU, Montreal, Canada**

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

ANNOUNCEMENTS

New Members

• IRIS welcomes two new members to the corsortium. Syracuse University will be represented on the Board of Directors by Douglas Nelson and by Roger Young for The University of Oklahoma.

Continued from page 19

Scientific sessions will be held at the IRIS Workshop on the following topics:

Aftershock studies - The new generation of portable instruments allows rapid deployment of 3-component broadband seismographs soon after large earthquakes.

- What is the scientific value of recording aftershocks?
- What are the logistical problems and how can they be overcome?

Deep earth structure - Broadband instruments and regional arrays can provide much improved resolution of the structure of the lower mantle, core and core-mantle boundary.

- How can seismology help to answer basic questions from mineral physics about the structure and composition of the mantle and core?
- What techniques provide the best resolution for deep earth structure?

Real time seismology - Many GSN stations are now accessible via telephone dial-up and data can be retrieved directly, allowing rapid determination of source parameters.

- What are the advantages of real-time seismology?
- How well and quickly can we reliably characterize earthquake sources?

Imaging the Crust and Upper Mantle - The PASSCAL instrumentation program has made it possible to image the details of the crust and mantle velocity structure on an unprecidented scale.

- What is the relationship of upper mantle structure and surface topography?
- What can velocity structure tell us about tectonics?

Eurasian Crustal Structure and Seismicity (a joint symposium with SSA) - Data from new stations in China and the USSR are becoming available.

- What have we learned from these data about Eurasian seismotectonics?
- How do the Eurasian stations contribute to our understanding of verification issues?

If you have suggestions or comments on the Workshop or program, please contact the origanizers (Doug Wiens - doug@wuearth1.wustl.edu or Terry Wallace - terry@rupture.ucsc.edu) or David Simpson at IRIS (simpson@iris.edu).

Participation in the Workshop is not limited to IRIS members and all those interested are welcome to attend. **Completed registration forms must be received at IRIS by February 15, 1992.**

the
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the IRIS CONSORTIUM

Fourth Annual IRIS Workshop
April 12-14, 1992 Santa Fe, New Mexico

REGISTRATION FORM

DEADLINE: FEBRUARY 15, 1992

Please complete this form and return it to: IRIS, 1616 N. Fort Myer Drive, Suite 1440, Arlington, VA 22209

First Name _____ Last Name _____

Institution _____

Address _____

City _____ State _____ Zip Code _____

Phone Number _____ Fax Number _____

Please check the days you plan to attend the workshop: ☐ Sunday ☐ Monday ☐ Tuesday

Please check one:

☐ Institutional Representative* ☐ Student or Post Doc Applicant * ☐ IRIS Committee Member ☐ Self Supporting

*IRIS Board Member Endorsement _____ **

***If you are applying for a student/post-doc travel scholarship or are to be your Institutional Representative, please have your representative on the IRIS Board of Directors endorse above. The limited number of student scholarships (one per institution, twenty total) will be awarded based on date of receipt.**

****BOD member please note - only one person from each IRIS institution will be eligible to receive accommodation support - if a committee member from your institution will be attending the Workshop, no additional support can be provided.**

If you are attending the SSA meeting or are "self supporting", you MUST provide credit card information:

☐ MC ☐ Visa ☐ American Express

_____ Card Number _____ Expiration Date

Do you want to have IRIS extend your hotel reservation for the SSA meeting? Yes No

Date of departure: April 15 16 17 AM PM

If attending the SSA meeting, you MUST complete an SSA Registration Form. Forms are available through SSA (415) 525-5477.

Are you willing to share a room? Yes No

Have you made arrangements to room with another Workshop participant? Yes No

_____ **(Name)**

Select your choice of hotel from the list of participating facilities. NOTE: Rooms are assigned on a first come, first served basis.

☐ **La Fonda Hotel** single $80.00 double $80.00	☐ **Inn at Loretto** single $80.00 double $90.00 triple $100.00	☐ **Hilton of Santa Fe** single $80.00 double $80.00	☐ **Hotel St. Francis** single $65.00* double $65.00* single $75.00 double $90.00
☐ **No Preference**			*For Government Employees ONLY

CHECK ONE BELOW:	ARRIVAL	DEPARTURE
☐ Single (one bed) ☐ Double (two beds) ☐ Triple (three beds)	Date AM PM	Date AM PM

Fourth Annual IRIS Workshop
April 12-14, 1992
Santa Fe, New Mexico

The Fourth Annual IRIS Workshop will be held at the La Fonda Hotel in Santa Fe, New Mexico Sunday, April 12 through Tuesday, April 14, 1992. The 87th Annual Meeting of the Seismological Society of America will be held nearby, at the Sweeney Convention Center, immediately after the Workshop.

An ice breaker will be held on Saturday evening. Scientific sessions will be held all day Sunday and Monday, and on Tuesday morning. A joint session with SSA will be held on Tuesday afternoon. Discussion Groups and Workshops will be held in the evenings.

Program

The Workshop will consist of invited talks, demonstrations and Special Interest Groups (SIGS). Scientific sessions will be held on the following topics:

- Aftershock Studies
- Deep Earth Structure
- Real Time Seismology
- Imaging the Crust and Upper Mantle
- Eurasian Crustal Structure and Seismicity (joint with SSA)

All presentations during the Workshop will be invited. IRIS members are encouraged to submit abstracts directly to SSA for papers or posters to be presented during the SSA meeting. The deadline for submission of abstracts to SSA for inclusion in the SSA program is January 15.

There will be facilities available at the SSA meeting for late posters on IRIS experiments. Abstracts describing these posters can be submitted to IRIS up to March 1. These abstracts will be copied for distribution at the Workshop, but will not be published in the SSA program.

Accommodations and Travel Arrangements

To help defray costs, IRIS will provide lunches for **ALL** participants Sunday and Monday and will pay for hotel rooms (Saturday through Tuesday nights) for **ONE** participant from each member institution that does not have a member serving on an IRIS Standing Committee.

For IRIS Standing Committee members and invited speakers, full travel will be supported. In addition, twenty scholarships, covering both travel and hotel rooms during the Workshop, will be provided for students or post docs from member institutions (limit of one per institution, first come, first served - apply using registration form). Those receiving student/post-doc scholarships will be requested to share double rooms.

IRIS will handle hotel reservations for all participants, but will cover costs only for those mentioned above. If indicated on the registration form, IRIS will extend hotel reservations to include the SSA meeting. Travel arrangements will be the responsibility of individual participants; however, IRIS supported participants **must** make their arrangements through W.I.T. Travel (800) 999-6613. All other participants are welcome to use W.I.T. Travel. Participants should plan to arrive on Saturday evening. IRIS supported participants will be sent ground transportation information at a later date.

If you are planning to attend the SSA Meeting following the Workshop, you must submit an SSA registration form directly to SSA. All abstracts for the SSA meeting should be submitted directly to SSA.

Participation in the Workshop is **not** limited to IRIS members and all those interested are welcome to attend, subject to availability of accommodations.

If you have comments or suggestions on the **program,** please contact the organizers via email:

Doug Wiens
doug@wuearth1.wustl.edu

Terry Wallace
terry@rupture.ucsc.edu

For general information on the Workshop, please contact the IRIS office (703) 524-6222.