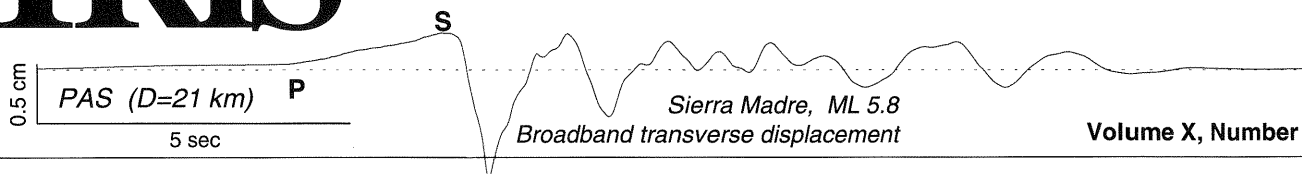


IRIS Newsletter



Volume X, Number 2

From the President

In July, IRIS signed a new Cooperative Agreement with the National Science Foundation for support of the core IRIS programs. Based on a proposal submitted to NSF last year, the new Agreement outlines a five year plan that works toward the goals set forth in the original IRIS program plan presented to NSF in 1984.

The first six years of IRIS have seen the establishment of a new generation of facilities for support of research in seismology, through programs in array studies (PASSCAL), global seismology (GSN), and data management (DMS). The Joint Seismic Program with the Soviet Union applies the facilities developed under the IRIS core programs to topics related to the monitoring of nuclear explosions.

As I start a term as President of IRIS, I look forward to working with the IRIS staff and members of the consortium to consolidate the successes of the early years and to open new directions for IRIS. The challenge during the next few years will be to bring the established facilities into full production, providing researchers with access to data required for an improved understanding of the structure and dynamics of the earth.

I encourage you to let us know your views on how IRIS is developing and where it should be going. There are a variety of avenues open for communication - you can work through the Standing Committees, the Program Managers, members of the Executive Committee, or contact me directly (simpson@iris.edu). •

David Simpson, President

TERRAScope

Hiroo Kanamori and Egill Hauksson, California Institute of Technology

In 1985 the Seismological Laboratory of the California Institute of Technology decided to deploy several modern broadband seismographic stations in southern California. With seed funding from The James Irvine Foundation, the first modern, high quality seismographic station was installed in Pasadena (PAS) at the Kresge Laboratory in November 1987, just after the 1987 Whittier Narrows earthquake. This station is a joint project between Caltech, the University of Southern California, the US Geological Survey, and IRIS. The PAS station consists of a broadband Streckeisen STS-1 seismometer and Quanterra data logger with a 24 bit digitizer and a Kinemetrics FBA-23 strong-motion sensor. PAS is included in the IRIS open system of seismographic stations where anyone can access the data through a telephone dial-up modem.

In 1988, when Caltech received a grant from the L. K. Whittier Foundation, the name TERRAScope was adopted, and development of the new network began. The initial goal for TERRAScope was to install at least a dozen modern broadband (10 Hz to DC) and wide dynamic range (nominally 200 db) seismographic stations with "real-time" data retrieval capability. The PAS station served as a prototype, and various calibrations and tests continue to be done at this station.

Analysis of the new high quality data recorded at PAS from numerous regional earthquakes, including the December 1988 (M=4.9) Pasadena earthquake at an epicentral distance of 3 km, have demonstrated that the high quality broadband data are the cornerstone needed for significant advances in both regional seismology and studies of teleseisms. In particular, the broadband data recorded at

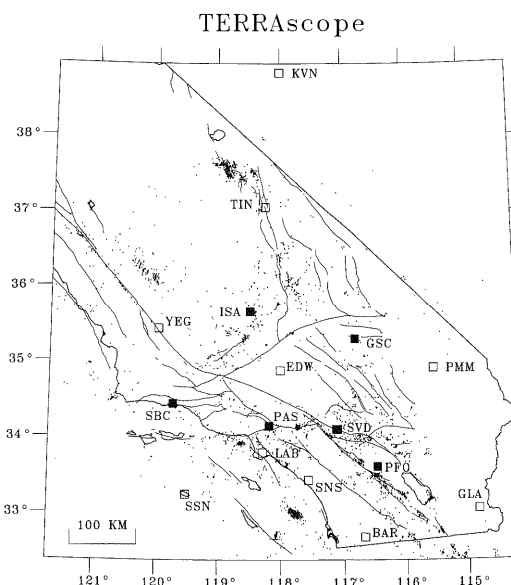


Figure 1. TERRAScope stations. Solid symbols indicate stations in operation as of February 1991. Open symbols indicate approximate locations of TERRAScope stations to be installed during 1991 to 1992.

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PAS from the October 1989 ($M=7.1$) Loma Prieta earthquake were easily available immediately after the event to determine the style of faulting and other seismological parameters of the earthquake. The encouraging results from our analysis of TERRAscope data so far have led us to modify our initial goal from a dozen stations to 20 stations in southern California.

Current Status

As of February 1991, six TERRAscope stations, Pasadena (PAS), Goldstone (GSC), Piñon Flats (PFO), Santa Barbara (SBC), Isabella (ISA) and Seven Oaks Dam (SVD), are in operation (Figure 1). The station PFO is operated jointly with the University of California, San Diego, and the station SVD was installed and operated by the US Geological Survey. The five stations, PAS, GSC, PFO, SBC, and ISA and the data retrieval and analysis system at Caltech comprise the Whittier Advanced Geophysical Observatory, funded by the L. K. Whittier Foundation.

In addition to the permanent stations, TERRAscope includes portable PASS-CAL type recorders with broadband sen-

sors and GPS (Global Positioning Satellite) receivers. The portable seismic instruments enable seismologists to easily reconfigure the network for their own projects, thereby increasing the versatility of TERRAscope.

TERRAscope complements and extends the capabilities of the existing 220 station (300 components) short-period Southern California Seismographic Network (SCSN). The data from TERRAscope will also be included in the SCSN data base used for generating the CIT/USGS southern California earthquake catalog. Because of their real-time capability and location in a populous earthquake-prone area, both networks enable seismologists to provide the public and state officials with timely information about significant earthquakes.

The TERRAscope stations are also included as a subnetwork of the global seismographic network, operated by IRIS, and the US National Seismic Network, operated by the US Geological Survey.

Data Availability

TERRAscope data are recorded in both continuous and event-trigger modes on site. The tape cartridges that contain

continuous data are sent to the IRIS Data Collection Center at Albuquerque and archived at the IRIS Data Management Center. These data are available upon request from the IRIS DMC. The data stored on disk at each station are available through a dial-up modem, which is open to the general user.

For quick and efficient data access, an automatic dial-up data retrieving system called Caltech Gopher (adapted from the IRIS Gopher system) has been implemented. The Caltech Gopher receives mail from NEIC for teleseisms and the Southern California Seismographic Network with origin time, location, and magnitude for regional events. The Gopher retrieves data from all six TERRAscope stations for these events. The data reside in a FTP anonymous account at the Caltech Seismological Laboratory, and are available to users through INTERNET. Usually the data are available within 15 minutes after the occurrence of a regional event and several hours after the occurrence of a teleseism.

Research in Progress

TERRAscope has already provided key data for rapid determination of earthquake source parameters of many im-

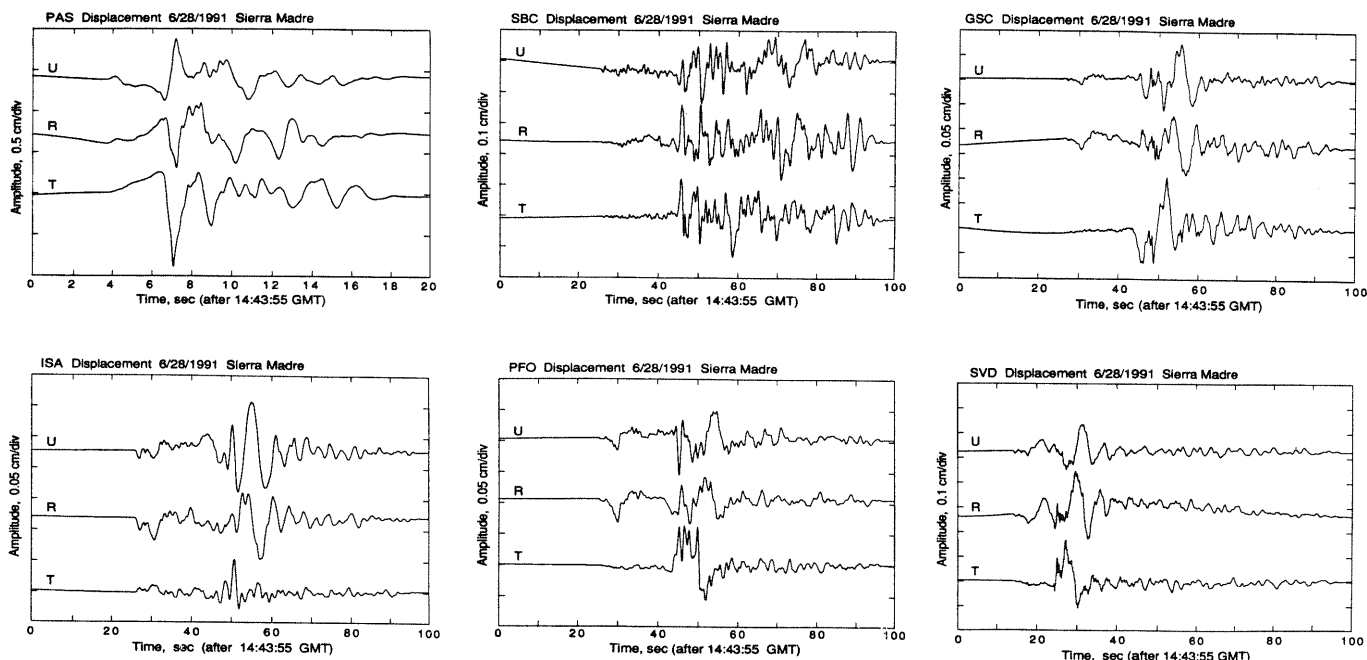


Figure 2. Ground-motion displacements of the 6/28/1991 Sierra Madre earthquake ($M_L=5.8$) recorded at TERRAscope stations.

portant regional and teleseismic earthquakes. For instance, ground motions from the June 28, 1991 Sierra Madre earthquake ($M_L=5.8$) in southern California were recorded on scale at all the TERRAscope stations (Figure 2) and the source parameters such as the magnitude, focal mechanism, and seismic moment were determined within about 1 1/2 hours after the earthquake. This information was provided quickly to the news media, emergency services officials, and some transportation and utility companies, and was effectively used for immediate emergency response and inspection purposes. In addition to providing information about earthquakes, both large and small, TERRAscope provides a great deal of data about the structure and the physics of the Earth's interior. During its very short time of operation, TERRAscope has enabled seismologists to carry out many different projects.

Waveform Inversion. We have analyzed the very broadband data from regional events in southern and eastern California such as the 1990 Upland earthquake, the 1990 Lee Vining earthquake, and the 1991 Sierra Madre earthquake, and determined the rupture process for each event as well as the crustal structure along the respective source receiver paths.

Development of energy-magnitude scale. Taking advantage of the broadband and wide dynamic range of TERRAscope, we have developed a method to estimate the total amount of radiated energy from earthquakes. We plan to use this method as the basis for an energy-magnitude scale.

Inversion of close-in displacement seismograms. The comparison of source spectra from different events, determined from close-in data, provides an important clue to the rupture behavior. We have determined source spectra for several moderate-sized events. The results so far indicate that the rupture behavior varies widely from event to event.

Investigation of non-earthquake events. In August 1989, PAS recorded a seismic wave excited by the high-rise buildings in downtown Los Angeles which were hit by the shock wave caused by the passage of the Space Shuttle Columbia (Figure 3a). This result has an important implication for the

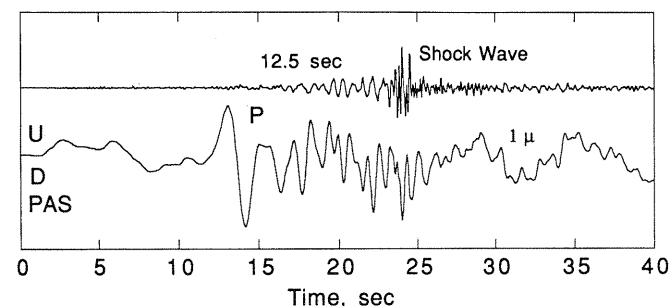


Figure 3a. Acoustic shock wave and seismic wave excited by Space Shuttle Columbia. The seismic wave shown was excited by high-rise buildings in downtown Los Angeles which were hit by the space-shuttle shock wave.

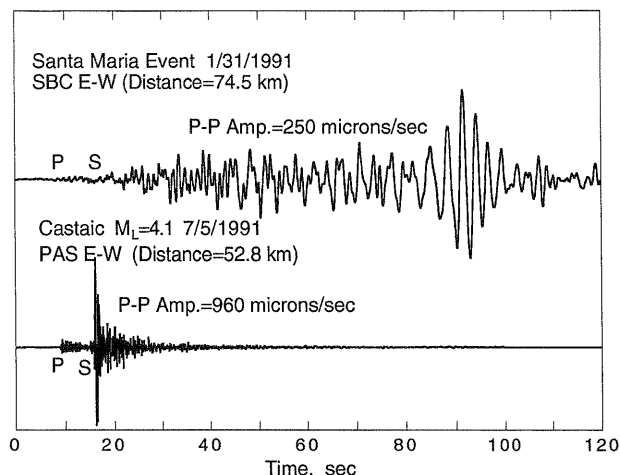


Figure 3b. The waveform excited by an anomalous event near Santa Maria. The bottom trace shows a seismic wave from an ordinary earthquake with about the same magnitude and recorded at a comparable distance.

seismic response of the high-rise buildings in downtown Los Angeles.

Induced seismicity. A very unusual earthquake near Santa Maria, California, was recorded at the SBC station as shown in Figure 3b. After numerous inquiries we found that this event was caused by failure in shallow sediments in an oil field.

Mantle structure beneath southern California. We have measured phase velocities of Love and Rayleigh waves propagating across TERRAscope in southern California. From these data, the upper mantle structures to a depth of 200 km beneath southern California can be determined.

Crustal response functions. Presently, a portable TERRAscope station is deployed in the Los Angeles basin to study the long period response of the basin sediments.

Future Developments

With funds provided by the L. K. Whittier Foundation and the Arco Foundation we plan to deploy ten more stations during 1991 and 1992. Although the actual locations have not been finalized, the following sites are being evaluated: San Nicolas Island, the Los Angeles basin, Barrett, Glamis, Western Mojave, Eastern Mojave, Owens Valley, and the Coast Ranges in California, and Kaiserville, Nevada (Figure 1).

To have the data available for immediate analysis following a major event, we are testing two real-time telemetry systems. One is a satellite telemetry system that is being installed in cooperation with the USNSN. The other is based on data transmission over telephone-lines or radio links and a local real-time data collection system developed by Adebahr Systemtechnik. Although the two systems provide different capabilities, the two systems will complement each other; redundancy is desirable, especially in emergency situations after a large earthquake. •

US/USSR Historical Seismogram Project

*Holly Given, Scripps Institution of Oceanography, UCSD
Don Helmberger, California Institute of Technology*

As part of the Joint Seismic Program, IRIS and the Soviet Academy agreed to exchange analog seismograms recorded within the US and the USSR and explore automatic methods to convert and store the records in digital form.

The basic scientific objective for the project has been the acquisition of data for exploration of the structure of the lithosphere. High-quality, broadband data are now being recorded by IRIS/IDA stations in the USSR, but these have been operating for only two years. However, decades of regional data have been recorded by the analog seismographs of the Soviet network, similar in many respects to the WWSSN (World-Wide Standardized Seismographic Network). Thus the analog data contain a much larger number of event-to-station paths to study regional propagation. Figure 1 shows the location of IRIS/IDA stations and the contributing Soviet analog stations.

Initially we have concentrated on an event collection stored on microfilm reels at the Soviet archive in Obninsk which contains data from over 2000 earthquakes worldwide, including 800 events in or near the boundaries of the USSR,

from the 1950's until the present. Thirty earthquakes in tectonic areas were selected and duplicated onto microfilm in the US in an initial exchange. Each earthquake is recorded at approximately 20-30 stations, many at regional distances. In addition to earthquakes included in the microfilm collection, we have requested regional records from several off-test-site nuclear explosions (PNE's). Because they were frequently conducted in aseismic areas of the Soviet Union, the PNE's will be particularly valuable for structural studies. Epicenters of events that have been requested or received are shown in Figure 1.

A system to digitally scan seismograms and convert the bitmap into a time series has been developed under the program and is now in routine use at Caltech. A Houston Instrument LD 4000 scanner, controlled by an AT-compatible PC, forms bitmaps of originals up to 36' wide of any length and sends them to a Sun4 computer. Menu-driven software allows the user to display the bitmap in an X-Windows environment, select the interesting portion of the waveform and digitize with

a single command. Artifacts of paper recording, such as time marks, pen curvature, or overlapping traces, are easily

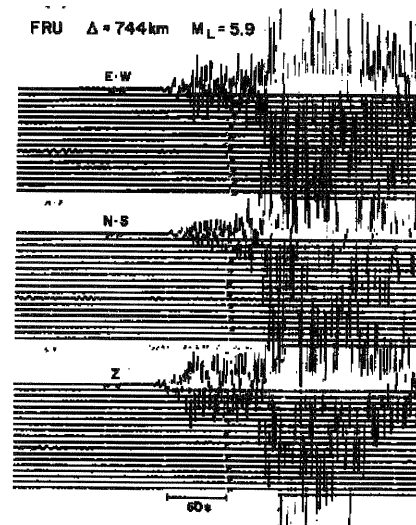


Figure 2a. Print made from microfilmed archive of paper seismogram from a regional earthquake recorded at station FRU (Frunze, near AAK in Figure 1).

corrected. The cost of the scanner, together with its controlling PC, is approximately \$14,000. Figure 2 shows an example of a digitized time series that was obtained from a paper record written at station FRU of an earthquake 750 km away. The digitized time series was low-pass filtered at 1 s and rotated. The separation of P energy onto the vertical and radial components shows that accurate seismological information has been retained from the first 100 s of the record.

Three resources resulting from the historical seismogram project are now available to IRIS researchers. A copy of the event catalog of the Soviet microfilm collection, with a Fortran program to sort the catalog, can be obtained through the IRIS DMC; this catalog contains approximately 2100 earthquakes. For patient individuals, events from the catalog can be ordered directly from the USSR. Copies of microfilm data from 30 selected earthquakes are available

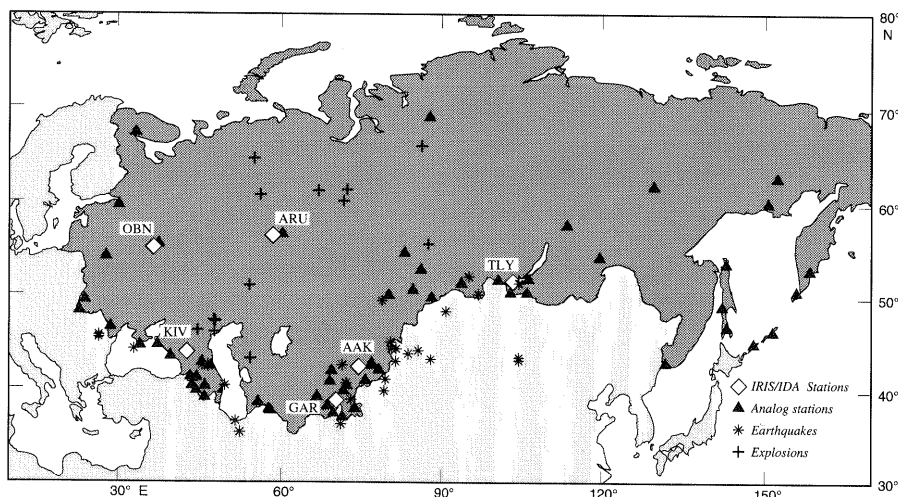


Figure 1. Stations and events for which data are available or have been requested as part of the Historical Seismogram Project.

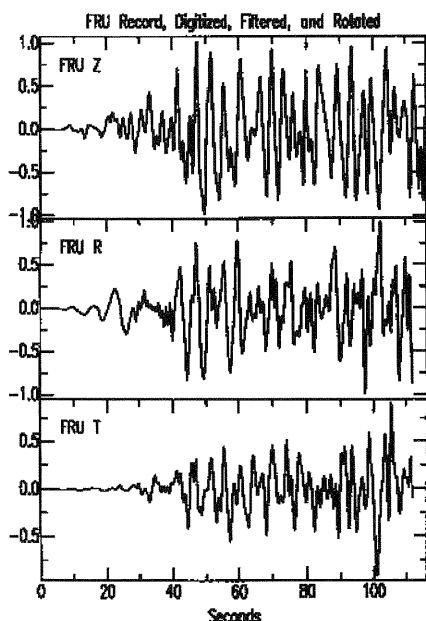


Figure 2b. Digitized time series retrieved from seismogram in Figure 2a after scanning, digitization, filtering, and rotation. (NOTE: The time scale has been expanded approximately 3x from Figure 2a.)

for approximately \$16.00 per event to cover duplication costs. Those interested in these resources should contact Holly Given at UCSD. Information about the prototype automatic digitizing system can be obtained from Don Helmberger at Caltech.

A digitizing system is under development for the IRIS Data Analysis Center in Moscow for use with a wide number of analog data sets in the USSR. We plan on refining the digitizing software into a documented, distributable package to run on Sun workstations. This way, 'original' analog data, in the form of bitmaps, can be distributed to interested users along with the digitizing software. Any ideas regarding the historical seismogram project are welcome and should be directed to IRIS Headquarters or Holly Given at UCSD. •

Report on the FDSN Meeting at IUGG

The Federation of Digital Seismographic Networks conducted its annual meeting in conjunction with the IUGG meeting in Vienna, Austria. The meetings were held on August 15 and August 19 with meetings of several working groups held between the two full meetings. Several items of particular relevance to IRIS members occurred and are highlighted in this brief report.

Networks

The FDSN membership continues to expand global coverage of the Earth with broadband seismographic instrumentation, complementing IRIS's GSN efforts. Australia has installed Guralp seismometers at their Mawson base in Antarctica, and plans a new installation in northwest Australia. France's Project GEOSCOPE will be upgrading its Tahiti, California, and Djibouti Streckeisen sites to VBB response this year. Germany has completed an eight element STS-2 network and plans to install four additional sites in the eastern Germany. Italy's MEDnet has seven operational sites around the Mediterranean, and is working on sites in Antarctica and Nepal. Japan has completed installation of STS-2 seismometers in South Korea, and will complete installations on Sumatra, Indonesia, and in the Philippines by the year's end. As a group, the FDSN endorsed efforts to have the Ocean Drilling Program drill a borehole in the northwest Pacific for a future Ocean Seismic Network site.

Data Exchange

The area of data exchange is just beginning to see real activity within the FDSN. This is possible since the FDSN has adopted the SEED format as the only acceptable format for data exchange between members of the FDSN. The IRIS DMC will act as the Federation archive for continuous data and as such will be archiving data from several of the FDSN networks. Data will be available to all IRIS members. A representative from the FDSN will be an observer at IRIS DMS standing committee meetings and will act as the liaison between the IRIS DMS and the FDSN. Specific policies concerning data flow into and out of the FDSN archive at the IRIS DMC will be determined by the FDSN working group on data exchange and the IRIS DMS Standing Committee. We anticipate that routine archiving of data from other FDSN networks will begin during the next year.

Members of the FDSN agreed to participate in a data exchange experiment between members. The goal is to share data from significant earthquakes as soon after an earthquake as possible. Networks that have agreed to participate in this exercise include ORFEUS, MEDnet, GEOSCOPE, IRIS, and POSEIDON. ORFEUS, POSEIDON, and IRIS will use the GOPHER system, MEDnet and GEOSCOPE will use systems developed internally. Data will be transmitted between data centers as SEED data records. IRIS users will be able to access these data through the GOPHER system at the IRIS DMC in the normal manner.

FDSN Station Book

It is the intention of the FDSN to develop a standard format for providing station information. Information for all stations in the FDSN network will be available in this standard format, providing the scientific community with much needed and at present sometimes difficult to obtain information. It is the intention of the IRIS DMS to provide this information for all IRIS GSN stations, even those that may not be official FDSN stations. •

*Tim Ahern, DMS Program Manager
Rhett Butler, GSN Program Manager*

Data Overview & Preliminary Observations

Initial processing of the triggered 100 sps data showed that from February 8 to April 7 we recorded approximately 97 local events, 8 regional events, 19 teleseismic events, and 3 underground nuclear explosions from the Nevada Test Site. Figure 2 shows examples of a local event, a regional event, a teleseismic event, and one of the NTS shots.

The 20 sps data have not yet been fully processed due to the sheer volume (approximately 10 Gbytes). We are presently working to extract signals from teleseismic events recorded on this data stream. This is necessary because the trigger algorithm on the 100 sps data stream did not appear to reliably trigger on teleseismic signals, so that smaller teleseisms may have been missed completely or at best only partially recorded.

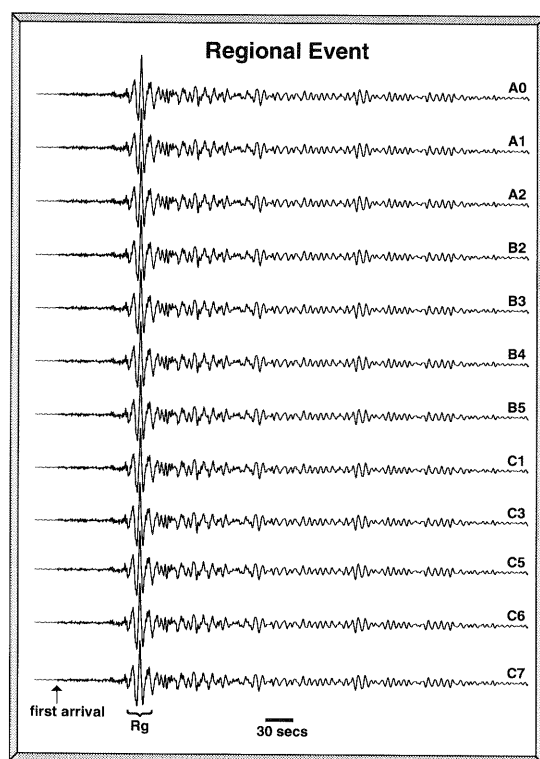


Figure 2b. Regional event (Gulf of California, February 15, 1991) recorded at 100 sps by the Piñon Flat broadband array. The data have been plotted at a constant scale and are arranged according to the first arrival time.

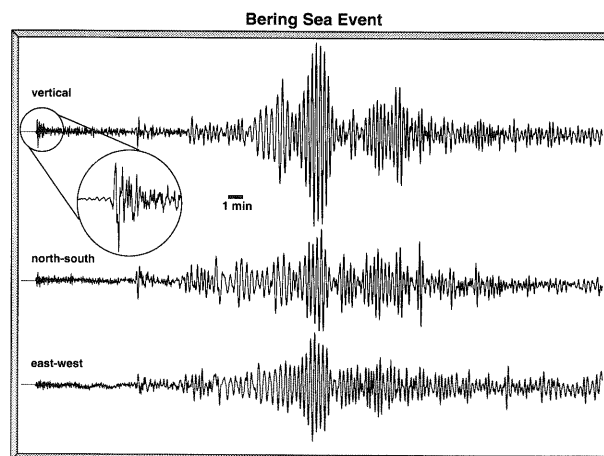


Figure 2c. Sample three-component seismograms for a teleseismic event recorded by the Piñon Flat broadband array. These data are for an event that occurred in the Bering Sea on February 21, 1991.

Initial inspection of data we collected during this experiment suggests three tentative observations that we plan to investigate in the coming months.

1. There is a remarkable variation in the recorded amplitudes of P and S waves from local earthquakes recorded by the array. In some instances the absolute amplitudes of P or S waves can vary by nearly an order of magnitude. Figure 2a shows one example. The S-P time indicates the source is sufficiently far away that the amplitude variations seen cannot be due to the source radiation pattern, yet the amplitude variations are huge. The cause of these amplitude variations is not completely clear, but a preliminary hypothesis is that these are caused by variations in near surface scattering effects. We are working on testing this hypothesis by comparing spectra from different stations and different sources.

2. There is a clear frequency dependence of the coherence of signals as a function of position within the array that can be seen from a simple qualitative inspection of the waveforms. For example, the long period surface waves from the regional event shown in Figure 2b are nearly identical. However, at the other end of the spectrum, the local event seen in Figure 2a, which is rich in high-frequencies, has virtually no two signals that even look alike. An intermediate example is the NTS event seen in Figure 2d. Here the surface waves, with a period of a

This Issue's Bannergram: The seismogram on the cover shows the broadband ground-motion displacement of S wave from the June 28, 1991 Sierra Madre earthquake ($M_L=5.8$) recorded at Pasadena ($D=21$ km). This seismogram does not exhibit oscillatory motions commonly seen in ordinary seismograms. Because of the short distance, and the broadband characteristic of the instrument, the Pasadena station recorded the nearfield displacement and the direct S pulse from the source without much distortion. The width of the S pulse, about 1.1 sec, is very short for an earthquake of this size, indicating that this is a high-stress drop earthquake. The triangular pulse following the direct S pulse is a reflected phase from a shallow structural boundary. •

Hiroo Kanamori, Caltech

few seconds, show systematic changes with station location. The body waves, which are higher frequency, show similar changes, but these occur over much shorter length scales. While these qualitative observations are relatively clear, what is not clear is how these variations depend quantitatively on position and how they scale with wavelength. That is, we should not be surprised that the long-period surface waves in Figure 2b should be coherent since the array spans only a small fraction of a wavelength in this case. On the opposite end, at 40 Hz, this array spans many wavelengths and the huge variations in waveforms are not especially unexpected. How does this transition occur, however? Answering this question has important consequences for understanding what we can and cannot really measure from seismograms, especially at the high-frequency end of the spectrum.

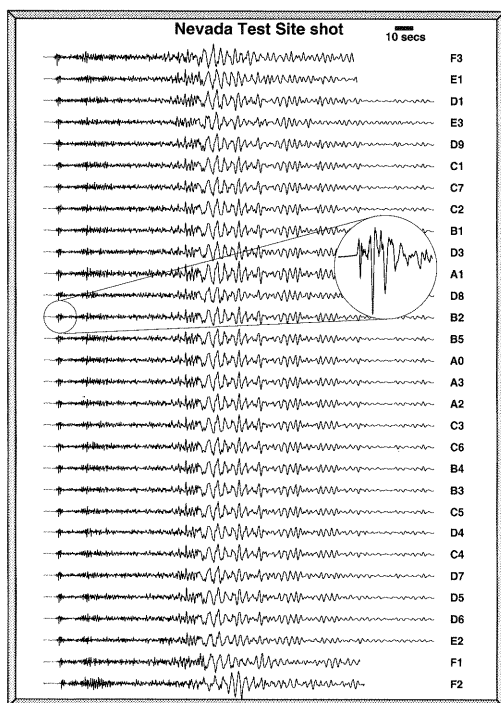


Figure 2d. Vertical component, 100 sps seismograms from the NTS shot of April 4, 1991, recorded by the Piñon Flat broadband array. These data are arranged and scaled as in other parts of this figure. Some stations are truncated after 160 s of recording because they were running as independent instruments instead of via telemetry. Note the enormous difference in the waveforms of station F2 relative to other stations in the array. F2 is on the opposite side of the San Jacinto Fault (Figure 1) from the other stations in the array.

3. Noise records from the array show well-matched micro-seism signals across the entire array on all the vertical components. However, the horizontal components contain significant long-period noise. This long-period noise has two characteristics that we have noticed: (1) it is completely incoherent spatially; and (2) the actual noise level varies significantly with time. These observations indicate that this long-period noise

is due to tilting of the sensors, but that the tilts are highly variable spatially. One consequence of this observations is that arrays of broadband sensors could be used to enhance signals with periods beyond about 20 seconds since the noise at those frequencies has little spatial coherence.

Acknowledgements:

A large number of people helped make this experiment a success. First of all, the entire community must recognize the accomplishments of the technical group at IGPP headed by Frank Vernon and made up of the following individuals: Glenn Offield, James Battie, Phil Porter, and Adam Edelman. They developed and engineered the telemetry system used in the experiment, and made it work. During the experiment, in addition to the authors of this article, the following people were involved in the field work: Paul Anderson, Michael Ham-burger, Chung Horn Lin, Dan McNamara, Rob Mellors, Steve Roecker, and Bing Jun Zheng. Finally, the following Soviet scientific and technical staff helped in the execution of this experiment: Vitali Bragen, Sergei Daragon, Peter Kasik, Ivan Kitov, Genedei Kolhelhev, Misha Krakov, Oleg Kuznetkov, Muchtar Sarkboyov, and Vasili Velikov. •

GSN Update

In September, IRIS GSN began drilling a borehole on Rarotonga under contract with the DSIR group in New Zealand. The installation of a 24-bit IRIS GSN data logger and KS36000i borehole seismometer by the USGS is planned for the fourth quarter of the year.

NOTICE: PASSCAL Equipment Available for Semi-Permanent Loan

During the first two years of the PASSCAL program we acquired several different types of portable seismic recording equipment for test and evaluation. We will be willing to accept proposals from IRIS member institutions for use of the equipment. Available equipment includes:

- 1-Teledyne Geotech PDAS 100
- 5-Sprengnether DR-2000
- 5-EDA PRS-4
- 1-Terra Technology IDS 3602

Any institution which has similar equipment, or has programs where some or all of the equipment can be used, should contact Jim Fowler at the IRIS Headquarters for a copy of the Request for Proposal.

Joint US/USSR Survey of Georgian/ Ossetian Earthquake Aftershock Sequence

*Art Lerner-Lam, Geoff Abers, and David Lentricchia, Lamont-Doherty Geological Observatory
Natalia Zakharchenko and Vladimir Mishatkin, OME, Institute of the Physics of the Earth, Moscow*

The Joint Seismic Program took an unexpected turn this past Spring when US seismologists were invited by Institute of the Physics of the Earth Director Strakhov to survey the epicentral region of the April 29, 1991 $M_S=7.2$ Georgian/Ossetian earthquake. Responding to an offer of assistance from the USGS and IRIS, Strakhov issued the invitation for a joint study of geological and seismological phenomena to a group comprising USGS and Lamont seismologists and specialists in neotectonics and landslide morphology. This earthquake was the largest event to have occurred in the Greater Caucasus in the past 700 years and was widely felt throughout the rugged southern flank. Initial reports of widespread damage and significant loss of life underscored the urgency of a geological and geophysical survey, particularly with respect to landslide potential and aftershock locations.

The Greater Caucasus are the result of the north directed closure of the Tethys and its associated marginal basin. Continental collision first started in the early to middle Pliocene (5 to 3.5 m.y.b.p.), when the Arabian plate first made contact with the Russian platform. To the north, uplifted Jurassic to middle Miocene platform sediments of the southern Russian Platform form a front range sequence overlying a Paleozoic granitoid core which where exposed forms a high and rugged massif. On the south, the Cretaceous sequence overthrusts more recent sediments along a highly segmented boundary thrust system. In the central Greater Caucasus, this main boundary thrust lies just north of Tbilisi, Georgia, and strikes WNW-ESE. The segment just northwest of Tbilisi presumably ruptured during the April 29 event. Thus, in addition to its implications for seismic hazard, this earthquake offers a fundamental look at the kinematics associated with the very early stages of continent-continent collision. Moreover, this earthquake was one

of the largest shallow thrusts to occur recently in a continental collisional setting.

The epicenter of the main shock was approximately 180 km from the IRIS/GSN station at Kislovodsk, on the northern flanks of the Caucasus in the Russian Republic. Kislovodsk also serves as the central station for the joint IRIS/Soviet array program being carried out under the auspices of the Joint Seismic Program by Lamont-Doherty Geological Observatory and the Seismic Monitoring (OME) group of the Institute of Physics of the Earth, based in Obninsk. The array currently includes seven telemetered stations within 60 km of Kislovodsk, digitally recorded with both Soviet and US equipment, and six portable PASSCAL instruments which are being used to extend the observations beyond the range of the telemetered network. During a field trip in April, 1991, a team from Lamont-Doherty visited the Kislovodsk area to install the US telemetry network and move some of the portable stations which had been installed in August 1990. Four US telemetry stations were installed, which with the Soviet telemetry network provided a seven station network near Kislovodsk. Two new portable stations, with broadband Guralp CMG3-ESP seismometers, were installed during late April at DOM and ZE1 and plans were made to install a third station at NUT. Collectively, these stations are known as the KMV Net. The ZE1 station is less than 50 km from the epicenter of the April 29 earthquake (Figure 1). The Lamont team returned to New York on April 27.

Immediately following the earthquake on April 29, plans were initiated to allow the US team to return to the epicentral area for aftershock studies. With considerable logistic support from USGS officials in Reston, David Chavez and the staff of the IRIS/UCSD Data Center in Obninsk and the PASSCAL Instrument Center at Lamont, personnel from Lamont and the USGS left New York on May 7 and the Lamont group flew to Kislovodsk on May 8. Meanwhile, the OME group from Obninsk had begun efforts to install additional PASSCAL equipment near the epicentral area. The NUT station was installed on April 30. Two portable instruments were installed by the OME group south of ZE1 on May 3 and 6. Political unrest in the epicentral area made access by westerners impossible until May 9. After an eight-hour drive by truck from Kislovodsk, the Lamont group arrived in ZE1 on May 10 and set up a PASSCAL field laboratory (a local area network linking two Suns, a PC, and 2 GBytes of disk storage) at the OME outpost there. Between May 10 and 15, four additional stations were installed in the immediate epicentral area, south of the Russian-Georgian border in South Ossetia.

The Russian-Georgian border in this area follows the spine

RDSEED Version 3.1

RDSEED version 3.1 is now available for use. Users may obtain a copy through anonymous ftp from [irisdmc.ig.utexas.edu](ftp://irisdmc.ig.utexas.edu) or they may request the program (on any media) by leaving a note in the electronic bulletin board.

Major new features of RDSEED version 3.1 are as follows:

- support of AH format on output
- use of time span indices for faster access to SEED data on CDROMs
- improved polarity correction capability
- support for reading GEOSCOPE multiplexed data on CD-ROMs

of the Greater Caucasus and the region known as Ossetia straddles that border. Ossetia is rugged and mountainous with small farming villages scattered throughout. The main population centers are built along river flood plains. Most of the construction is unreinforced masonry, with many of the back-country dwellings little more than grouted piles of boulders. Most of the damage in the larger villages was apparently the result of sediment amplification, while in the mountains, slope failure and weak construction were contributing factors. Near the epicenter, a huge landslide obliterated an entire village. Factories, hospitals, schools and five-to-ten story high-rise apartment blocks suffered substantial damage and many were rendered unusable. Several tens of thousands were left homeless, and many communities were cut off by landslides along the main roads. Emergency services were being provided by local civil defense groups and the Soviet Army and transportation was possible only by off-road vehicles or by helicopter. Working in this difficult and dangerous environment, OME personnel were able to establish contacts with local authorities, install some stations, and make it possible for the Lamont team to continue the field work. More stations were installed, a station visiting schedule was established, and data collection was begun. Although the Soviet Army graciously offered the use of a helicopter, weather conditions only once allowed its use and most of the field work was accomplished using OME trucks and jeeps. Despite the personal suffering of much of the population and the demands on emergency services, the Ossetians lived up to their reputation for hospitality in a manner which is unparalleled in our experience.

Network analysis software from Lamont was installed on the field lab computers and the team began to locate hypocenters within two days of arrival. The stations were triggering on up to 200 events a day, taxing the capabilities of the field computers but giving us several hundred well-associated events

to work with. Many of the S-P times were less than one or two seconds. These preliminary locations were used to guide some of the later instrument deployments. Even though most of the stations locked to the Omega time signal, a portable clock was used to supply a time standard at every data pickup. Station locations were obtained with navigation-quality GPS.

Three of the portable stations were removed on May 22, when the Lamont team left. Arrangements were made to have the OME group continue to operate the three stations left in the immediate epicentral area, plus ZEI and a new fourth station in the epicentral area. Figure 1 shows the station locations. The array was dismantled and equipment returned to Kislovodsk by mid-August.

Preliminary locations determined in the field using data from the PASSCAL stations in the epicentral area are shown in Figure 1. The aftershocks delineate a rupture zone about 100 km long extending in an WNW-ESE direction, roughly strike-parallel to the Harvard CMT solution. Depths in the eastern section of the zone are reasonably well determined in these preliminary locations and range from near surface to more than 11 km. The rupture zone straddles the border between Ossetia and Georgia, which was closed because of civil unrest, making deployments around the entire zone by any one group virtually impossible. The PASSCAL array covers the southeastern end of the aftershock zone. A team organized through the Institute of Physics of the Earth in Moscow, with participants and instrumentation from the USGS (Golden and Menlo Park), France (IPG-Strasbourg), and England (Cambridge), left Moscow on May 8 to attempt to reach the western part of the

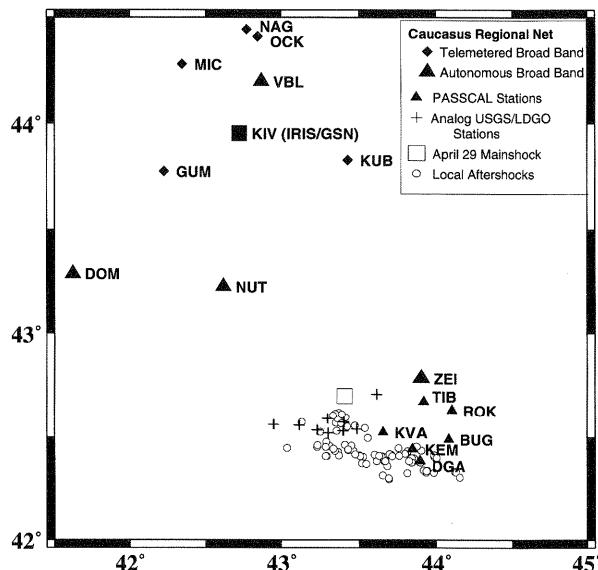


Figure 1. Stations of the Caucasus Regional Network and temporary stations used in the aftershock study of the Georgian/Ossetian earthquake.

epicentral area from the Georgian side. The Lamont-Doherty group was invited to join this team, but chose instead to remain north of the Georgian-Russian border to insure that the equipment already installed was functioning properly and to approach the epicentral region through a vehicular tunnel from Ossetia. Deployment plans were discussed with USGS participants and arrangements were made to provide additional instruments (MEQ-800s) and a common time base for the deployment, but the political unrest between Georgia and Ossetia made it impossible to make contact or communicate with that group while in the field (attempts by the local KGB radio crew notwithstanding). However, we now have station coordinates for the combined USGS/IPG/Cambridge deployments and coverage of the epicentral zone by the merged arrays appears to be excellent.

Preliminary discussions have taken place among the groups to merge these data sets. Data from the IRIS supported deployments will be made available through the DMC.

Post Doc at the IRIS DMC

The Geophysics Program at the University of Washington invites applications for a postdoctoral research associate in seismology. The successful candidate will be expected to pursue seismological interests that can benefit by the extensive IRIS waveform data base and to interact with the IRIS staff during their development of data access software.

This is a one-year, non-tenure appointment, starting winter 1992. Extension for a second year is possible.

For more information contact Ken Creager, Geophysics Program AK-50, University of Washington, Seattle, WA 98195.

Opportunity in the USSR!

The University of California, San Diego has a temporary position open as Director of the Data Collection and Operations Center in Obninsk, USSR. This facility is operated as part of the IRIS JSP in cooperation with the Institute of Physics of the Earth (IPE). The director's primary tasks are to operate and maintain the center's computer system, oversee routine data processing, undertake some program development, and coordinate activities of visiting US personnel. Requirements include familiarity with UNIX, Sun computers, networking, and a basic fluency in Russian. Knowledge of seismology and seismological instrumentation is highly desired. The assignment will be for a minimum of one year. An apartment, car, living allowance, and travel expenses for periodic travel to the US are included. Contact Jon Berger at IGPP for more information.

IRIS Opens Data Analysis Center in Moscow

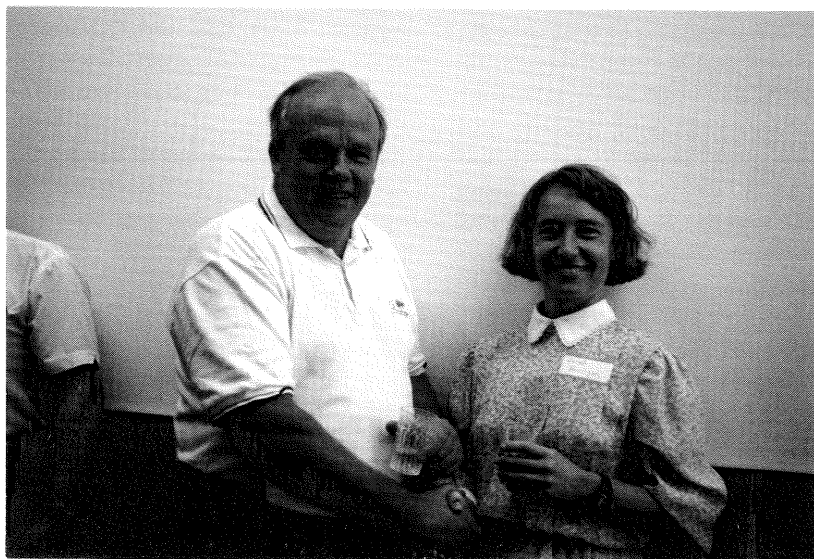
On August 2, 1991 IRIS opened a Data Analysis Center in Moscow under the US/USSR Joint Seismic Program (see Newsletter Special Supplement). The Center will serve as the Soviet center to archive and analyze data from the US/USSR Joint Seismic Program, and will be connected to the IRIS Data Management System through a direct computer-to-computer link.

During the opening ceremonies in Moscow, Dr. Sarah Horrigan presented to Academician Evgenii Velikhov, Vice-President of the USSR Academy of Sciences, a letter from Congressman Ed Markey. The letter expressed Congressman Markey's satisfaction with the program and presented the following challenge:

"The US/USSR Joint Seismic Program has been of great interest to the US Congress because of the importance of the research both to earthquake hazards and to the monitoring of underground nuclear explosions....While this program has made contributions in both of these areas, we expect this program to become even more important in the future. As you know, the Non-Proliferation Treaty, to which both of our countries are signatories, will conclude in 1995. Many of us in Congress expect that, unless substantial progress has been made toward a Comprehensive Test Ban Treaty by that time, nuclear testing will be a major topic of discussion at the United Nations during the renewal conference, as it has been at each of the five-year review conferences. 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. 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 Moscow Center will be used by members of the USSR Academy of Sciences, and all other institutions involved in the US/USSR Joint Seismic Program, including the International Institute of Earthquake Prediction and the Institute of the Dynamics of the Geospheres. •

Gregory van der Vink, JSP Coordinator



At the opening of the Moscow Data Analysis Center, Congressional staff member Dr. Sarah Horrigan (representing Congressman Ed Markey) confers with Evengii Velikhov, Vice-President of the USSR Academy of Sciences. (photo - Caroline Phinney)

**IRIS Workshop
Santa Fe New Mexico
April 12-14 1992**

The Fourth Annual IRIS Workshop will be held in conjunction with the Seismological Society of American (SSA) meeting in Santa Fe, New Mexico April 12-14, 1992.

The IRIS part of the meeting will start on Sunday, the 12th, and continue through noon on Tuesday, the 14th, with committee meetings, special interest discussion groups, demonstrations, and scientific sessions. Tuesday afternoon there will be a joint scientific session with SSA on "Eurasian Seismic Studies". The SSA program will continue through Thursday, including joint SSA/IRIS poster sessions.

Doug Wiens (doug@wuearth2.wustl.edu) is Program Chairman for the IRIS Workshop, assisted by Terry Wallace. The SSA Meeting is being organized by Jim Ni (jni@atlas.nmsu.edu). Please get in touch with any of the organizers or with David Simpson (simpson@iris.edu) if you have suggestions for discussion topics or other ideas for the Workshop program.

The scientific sessions during the IRIS Workshop will follow a format similar to last year, with invited talks on major issues related to IRIS programs.

To avoid conflicts in scheduling, anyone wishing to organize a working group or discussion during the Workshop should contact the organizers as soon as possible. Some of the topics already suggested for discussion include: planning for major PASSCAL field projects; software development; education; instrumentation; and regional networks. Demonstrations and training courses related to the use of PASSCAL and DMS facilities are also planned.

An announcement will be mailed later in the year with program details and information on travel assistance.

Stanford to Join Lamont as Hosts for PASSCAL Instrument Centers

Stanford University will act as host institution for the second PASSCAL Instrument Center (PIC). The Stanford PIC will be a joint effort between Stanford and the US Geological Survey in Menlo Park. Principal Investigators will be Professors Simon Klemperer and George Thompson of Stanford and Dr. Walter Mooney of the USGS.

The new PIC will initially be housed in space at the USGS facility, 345 Middlefield Road, in Menlo Park. Professor Klemperer will serve as manager of the PIC, and will be assisted by personnel from the USGS and Stanford. The contract with Stanford to operate the center will be for three years and is renewable.

The PASSCAL program procures and provides a standard line of high performance portable digital seismic recording systems for array deployments designed to study the structure of the earth's interior and the dynamics of earthquake or explosion sources. The PIC serves as an engineering support, maintenance, training, and distribution depot for the PASSCAL equipment, including dataloggers, several kinds of sensors, timing, cabling, and storage systems. In addition, the PASSCAL field computers used by investigators for rapid playback and quality control of field data are supported by the PIC. The new PIC at Stanford/USGS will house the first major complement of the new three-channel dataloggers, intended for crustal imaging programs which use dynamite or airgun sources.

The first PIC opened at Lamont-Doherty Geological Observatory in 1989. It now has 102 six-channel PASSCAL dataloggers and associated sensors along with appropriate support equipment. The Lamont PIC has supported 34 field programs conducted by 31 separate research institutions since its inception. In addition to the training and field support, the Lamont PIC has been engaged in a continuing engineering support program to improve the performance of the recording system and a software support effort to provide a complete quality control processing system for the field computers.

The Principal Investigator for the Lamont effort is Doug Johnson. The technical and field support tasks have been accomplished by Larry Shengold, Bob Busby, Tom Jackson, and David Lentricchia, while the major software developments have been provided by Richard Boaz, and Catherine Susch. These personnel have made the center at Lamont a success, and a new three year contract has been awarded to Lamont to continue operation of the center.

The two PICs will operate in close cooperation with one another. It is envisioned that both centers will house both types of instruments and will be able to support all types of experiments. However, the center at Stanford will initially specialize in active source experiments with the three-channel instruments while the Lamont center will principally support the experiments utilizing the six-channel instruments. •

Jim Fowler, PASSCAL Program Manager

PASSCAL Users Guide Available

A PASSCAL Users Guide is now available. If you did not receive a copy of this document in the mail you can request a copy through the IRIS Headquarters. The guide is designed for Principal Investigators who are planning proposals which require the use of PASSCAL equipment. The manual contains information on what to expect from PASSCAL at each phase of an experiment, how to interact with PASSCAL (formally and informally), technical information about PASSCAL equipment, and copies of official PASSCAL policies related to instrument use.

E-Mail Address List

The e-mail address list, previously published in the IRIS Newsletter, continues to be maintained and updated by Rick Williams and is available through the IRIS DMC. Using the Bulletin Board facility you can search for specific addresses (telnet or login to irisdmc.ig.utexas.edu or 128.83.149.25; `userid = bulletin`; `password = board`; select option *e* from the Main Menu).

A variety of other services are available through the Bulletin Board, including news items, descriptions of data holdings and access to data, software, and manuals.

To get a copy of the most recent version of the e-mail list, use `ftp` to rockytop.gg.utk.edu (`ftp 128.169.201.150`). Login as `userftp` or `anonymous` using your surname as the password. The file is in the *dist* subdirectory, and is named *email.list*.

If you want your name added to the list or changes to your current listing, **please send a message to Rick Williams** (rick@tanasi.gg.utk.edu).

Our thanks to Rick for keeping this important resource maintained.

GUAM CABLE

In October, IRIS will begin engineering the Guam re-termination of the Trans-Pacific Cable-1 running from Guam to Japan. The Margus Company, an enterprise of former AT&T Cable engineers, has been contracted to do the work. The engineering work will be closely coordinated with Japanese efforts at the Ni-nomiya termination near Tokyo.

University of Washington Selected to Host Permanent IRIS Data Management Center

In response to a Request for Proposals issued in January of this year, IRIS has selected the University of Washington, with Co-Principal Investigators Ken Creager and Steve Malone, to host the IRIS Data Management Center for at least the next five years. Several new development tasks will be undertaken by the University of Washington personnel. Ken Creager's activities will include enhancements to the user interface to the DMC archive and RDSEED. A system will be developed to routinely pick relative phase arrival times at IRIS and FDSN stations using cross correlation techniques. Rick Benson, a seismic analyst, will perform the phase picking and check the quality of the waveform data and resulting parametric estimates. In addition to a valuable data set of phase arrival times, this procedure will provide timely quality control of IRIS and FDSN data. Cooperative work with members of the research community to implement state-of-the-art phase picking algorithms is encouraged. Please contact Ken Creager if you wish to participate in this development.

Steve Malone will continue his involvement with the very successful GOPHER/BADGER nearly-real-time data retrieval system. There are currently more than 250 requests per month for data through GOPHER. The principal improvements will be the expansion of the GOPHER system to several international locations, including Japan and Europe. These multiple GOPHER nodes will make it possible for a local GOPHER system to interrogate a station, collect data and then transfer them over the Internet back to the IRIS DMC, making the data easily and rapidly accessible to all seismologists. It is hoped that GOPHER will also be expanded to be able to recover waveform data from Group of Scientific Experts (GSE) stations that utilize the Data Request Manager (DRM) protocol.

An important feature of the University of Washington program will be the organization of IRIS training courses to be held in conjunction with other seismological functions. Topics may include: use of full response information from broadband seismographic stations; reading and writing SEED volumes; user interfaces to the IRIS DMC; and synthetic seismogram techniques. These training courses may be held at AGU meetings, IRIS Workshops or at regional locations around the country. Members of the research community that have additional ideas for workshops should contact Dr. Malone, Dr. Creager, or IRIS DMC staff.

The IRIS DMC program at the University of Washington will also support a Post Doctoral Associate position for research related to data management issues. A brief description of this position, to begin in early 1992, is on page 12 of the Newsletter, a full advertisement will appear in EOS.

The operational side of the Data Management Center will continue to be managed and operated by IRIS staff under the direction of Tim Ahern, Program Manager for Data Management Systems. Sue Schoch, Senior Database Programmer, and Becky Wofford, Systems Administrator will continue to play an important role in the Data Management Center. DMC staff will include a programmer and two new operators. The operational portion of the DMC will be located in space immediately adjacent to the University of Washington Super Computer Center and the Northwest Net node for access to the NSFnet. DMC connection to the NSFnet will be via a high speed data connection and it is anticipated that the NSFnet connection at the University of Washington will reach T3 (45 Megabits/s) speeds before the end of 1991.

One of the major activities at the DMC in Seattle will be the integration of a recently acquired 6 Terabyte (6,000,000,000,000 byte) mass storage system from Metrum Information Storage. This VHS helical scan storage system is able to retrieve seismic data at a rate of a station-channel-day every two seconds. This should reduce by an order

of magnitude the time it takes to recover data files in response to data requests from users. Several months of continued testing are required before this system becomes operational.

In order to insure minimal disruption in service to the user community, the present Interim System located at the University of Texas Institute for Geophysics (UTIG) will continue to operate until the the Permanent Data Management Center becomes operational in Seattle early in 1992. The new mailing address for the DMC is given on the last page of the Newsletter. Any changes in procedure for communication with the DMC will be announced through the IRIS DMC Bulletin Board and published in the next Newsletter. In the meantime, users should continue to make requests for data and other services as before.

The University of Texas Institute for Geophysics is commended for the important role that they have played in the development of the Interim IRIS DMC. Special thanks go to Mark Wiederspahn and Fumiko Tajima for their active participation in the DMC activities at UTIG over the past several years.♦

Tim Ahern, DMS Program Manager

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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 70 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.

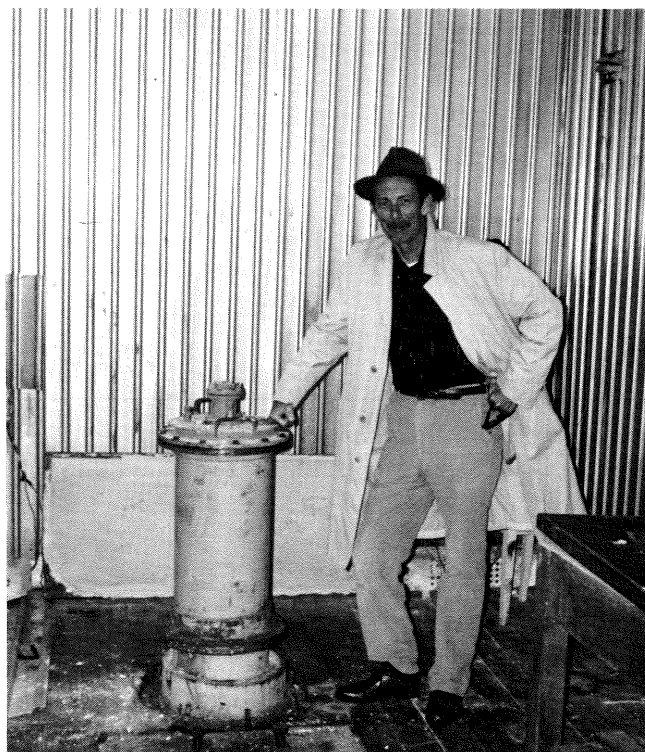
Executive Editor: David Simpson
Production Editor: Denise Dillman-Crump

US/USSR Joint Working Group Meeting Borovoye, Kazakhstan

The US/USSR Joint Seismic Program held a Joint Working Group Meeting at the Borovoye Geophysical Observatory in Kazakhstan, USSR on August 6 & 7. The Borovoye Observatory includes the longest operating digital seismic station in the USSR. The seismic station at the observatory is used both to estimate the yields of USSR underground nuclear explosions, and to monitor US underground nuclear explosions in Nevada. The seismic station, located on a granite outcrop, is highly sensitive to seismic signals from the Nevada Test Site, and can detect and identify US nuclear explosions as low as 2-5 kilotons.

The Joint Working Group Meetings are used to assess the current status of the US/USSR Joint Seismic Program and to develop plans for the following year. Copies of the minutes from the Joint Working Group Meeting in Borovoye are available by request from IRIS Headquarters. A description of the monitoring capabilities of the Borovoye Observatory will be published in the winter edition of the joint US-Soviet journal **Science & Global Security**.♦

Gregory van der Vink, JSP Coordinator



Charles Archambeau, a member of the US side of the Joint Working Group, stands next to one of the test boreholes at the Borovoye Observatory in Kazakhstan, USSR. (photo - Gregory van der Vink)

CALENDAR

OCTOBER

14-16 Eastern Section SSA Annual Meeting,
Memphis, TN

16-17 IRIS EXECOM, Seattle, WA

NOVEMBER

10-14 SEG, Houston, TX

DECEMBER

8 JSP Meeting, San Francisco, CA

9-13 AGU Meeting, San Francisco, CA

10 IRIS Board of Directors Meeting,
San Francisco, CA

12 DMS Meeting, San Francisco, CA

12 GSN Meeting, San Francisco, CA

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

NSF Proposal

- Copies of the 1990 IRIS Proposal to the National Science Foundation are available by contacting Denise Dillman-Crump at IRIS Headquarters (703)524-6222 or denise@iris.edu.

New Members

- IRIS welcomes two new members to the consortium. Lehigh University will be represented on the Board of Directors by Anne Meltzer and Duke University by Peter Malin.

Newsletter Update

- The December issue of the Newsletter will be an annual review of IRIS programs. We plan for the following issue to coincide with the Workshop in April. Contributed articles, announcements, and news items should be received at IRIS before the end of January.

New Address for IRIS DMC

- The new address for the IRIS Data Management Center is 1408 NE 45th Street, Second Floor, Seattle, WA, 98105, (206)547-0393.

Data Rescue Project

- Please contact Bob Phinney (bob@weasel.princeton.edu) if you are interested in an effort to convert the old project VELA earthquake data into modern digital form. These data include analog tapes for the 40-station LRSM network and the Geneva arrays; and digital tapes for the LASA, ALPA, and similar large aperture arrays. The bulk of these data will be lost for research unless the old tapes are copied to modern media soon.

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