IRIS Newsletter

RCC Δ=1.2° 20 sec

Solvay Mine Collapse
M_L 5.2 - February 3, 1995

Volume XV, Number 1

The 1994-5 Colorado Plateau-Great Basin PASSCAL Experiment

by Craig H. Jones, CIRES, Univ. of Colorado, Boulder
on behalf of the Field Team of the CPGB experiment

The expedition's lofty goals were in jeopardy. Equipment had been lost outside of Reno, team members were sick and unable to go into the field, and the team leader had been struck by lightning while setting up equipment. The attempt to form a link between surveys in California and Colorado seemed doomed.

And yet King's U.S. Geological Exploration of the Fortieth Parallel (1867-1872) [Bartlett, 1962] went on to become an example of efficiency sufficient to propel the survey's leader into becoming the first head of the U.S. Geological Survey. I reflected on this as I followed in the expedition's footsteps, courting disaster in the name of science. My risks were considerably smaller, but the snow of the mid-November storm flooding over the hood of my truck seemed foreboding. I lowered the window and learned the reason: the snow was deeper than the floorboards were high. My truck was now acting as a snowplow on the untraveled dirt track in central Utah. Shifting into the lowest gear I had, I moved forward towards one of our seismometers.

Just 8 days previous I had installed this broadband seismometer under clear skies and without any snow at all. It was one of eleven PASSCAL and one UNR portable broadband seismometers deployed and operating across the Colorado Plateau into the eastern Basin and Range (Figure 1). The instruments in Nevada had been deployed by Martha Savage and Serdar Ozalaybey in September, 1994; the instruments I and Anne Sheehan were responsible for were only deployed in late October and November owing to

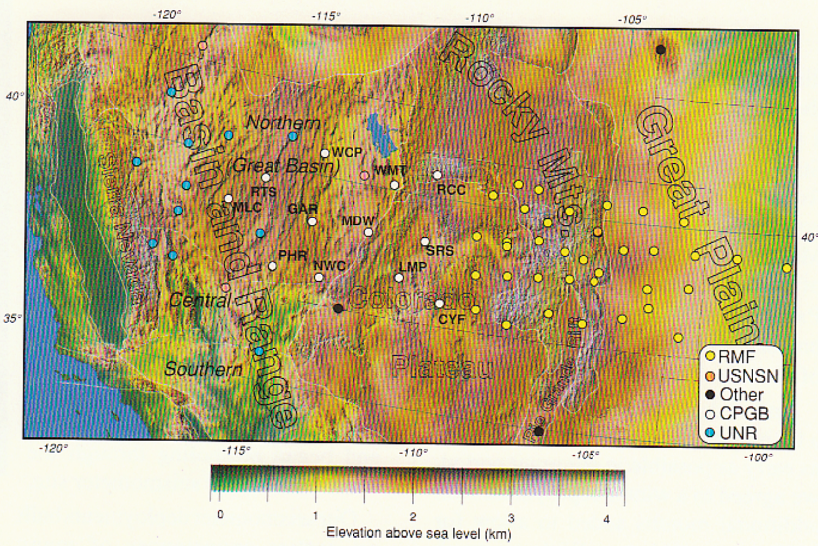

Figure 1. Shaded relief map of the southwestern United States with locations of digital broadband seismic instruments east of California as of 1994.

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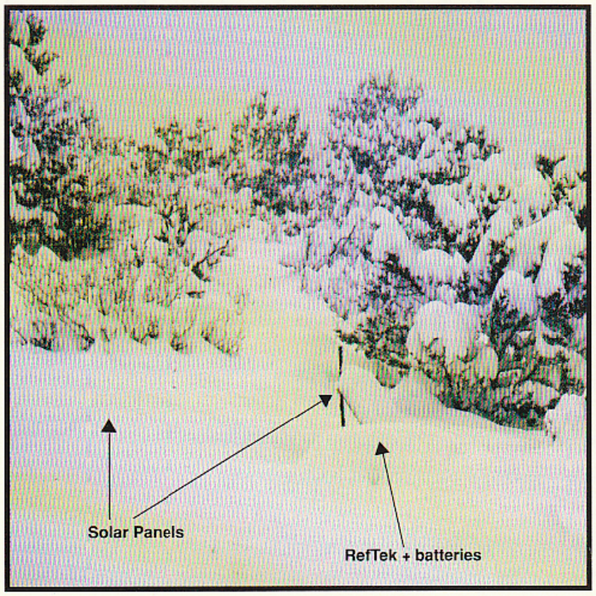

Figure 2a. **Station MDW prior to removal of snow, mid-November 1994.**

paving stone plastered to the soil or rock underneath (Figure 2b). The cover was a water-catcher base from a large pot for houseplants. The CMG-3 ESP inside was cabled to a RefTek -08 DAS with internal GPS clock and two lead-acid car batteries. Two solar panels recharged the system, and a 540 Mb RefTek-housed disk drive recorded the data continuously at 32 bits/sample (compressed) and 25 samples per second. Batteries, sewer pipe, and gray boxes used to protect the DAS and disk were recycled from an earlier experiment in the Sierra Nevada and Death Valley. To avoid long

Figure 2b. Installing station CYF. Typical CPGB installation using sewer pipe for vault is apparent. Colorado University-Boulder undergraduate Noah Hughes is examining the recording equipment.

difficulties in obtaining permits from the BLM. Much as King's survey filled a gap between the original California State Geological Survey and Hayden's Rocky Mountain Survey, our basic goal was to fill a gap between the Rocky Mountain Front broadband deployment of 1991-2 (Lerner-Lam and RMF Field Party, 1993) and the permanent broadband network run by the University of Nevada, Reno in western Nevada.

And, at the moment, that goal seemed a bit of a reach. To get the instruments as early as possible in our grant period, we agreed to a winter deployment with additional months added to allow for equipment problems. With my truck now a snowplow moving slowly up the face of the mountains near Meadow, Utah, it seemed an unwise decision. In fact, the winter of 1994-5 proved one of the snowiest in Utah history. Considering the success of perseverance in the case of King, though, I continued to force the truck up the grade towards a seismometer probably hopelessly smothered in snow. At last, several miles from help should the truck become a snowdrift, I stopped and opened the door, pushing aside several inches of snow higher than the bottom of the door. I gathered my notebook, tools, disk drive, and heavy jacket and began postholing through the snow towards the seismometer site.

Our seismometer deployments built on earlier experiences of many PASSCAL groups. We opted for a simple vault lined with a 13-diameter PVC sewer pipe; the base, dug as near to bedrock as possible, was a cement

This issue's bannergram:

The bannergram on this issue's cover is the broadband, transverse velocity record of a seismic event on February 3, 1995 recorded at station RCC (Rock Creek Corral) of the Colorado Plateau-Great Basin Experiment. The event, related to the collapse of the Solvay Mine near Glen River, Wyoming was of magnitude M_L 5.2 (see Pechmann et al., Seismol. Res. Letts, 66, 25-34).

waits in the snow and cold at a station, we had two swap disks and a stripped-down DAS for motel playback at night to a field DAT drive. We were somewhat pessimistic about the amount of time the equipment would be running during the winter, especially storms.

Approaching the thoroughly buried seismometer, my doubts were heightened (Figure 2c). One solar panel on the ground was totally hidden; only fishing around in the snow allowed me to locate the panel and dig it out. The other, mounted on a wooden frame and fencepost (as were most of our panels) held a nice thick blanket of snow. I dug out the gray box containing the electronics and pulled out the Epsom hand terminal, optimistically hoping for a response from the DAS.

I was shocked to see 11.6 volts from the internal sensor—pretty good for our year-and-a-half old batteries; furthermore, the disk usage and number of events was consistent with the station having remained up throughout the storm. In point of fact, the station had not lost power at all and would remain up through most of the winter. Overall, our stations recorded data more than 95% of the time, and several stations (including one at 2280 m on the south flank of the Uinta Mountains (Figure 2c) recorded continuously over the full duration of the experiment. Such success allowed us to start to make a systematic connection between the Rockies and the western Great Basin using receiver functions, surface waves, and shear-wave splitting techniques.

Success had its price: we had about 26 Gb of compressed data to manage. A hallmark of the King Survey had been the rapid processing and distribution of results, a procedure inspired by the recriminations directed at King's mentor and former superior Josiah D. Whitney of the California Survey for the slow publication of results from that work. We wanted to push our data through as soon as possible; our goal was to avoid lengthy post-experiment processing. Fortunately, experience from previous experiments combined with the growing maturity of the PASSCAL data processing software made this quite possible.

We used a Sun workstation with about 8 Gb of free disk space; with this setup we could download about 2 months of data from our network at one time—roughly the data from one visit to the field. The station log (a.k.a. "soh" - state-of-health) files were processed for timing glitches and drift; the results from this were used in a modified version of Tom Owens' soh2db TCL script to create a CSS 3.0 schema database. The format of this database and tools developed and maintained by the IRIS JSP center at the University of Colorado permitted us to view the entire two months of data from all stations interactively without manually decompressing the data. In addition, we could search for teleseisms and local events using catalogs converted to the CSS format. Indeed we could (and did) extract full gathers of regional and teleseismic events of interest with a single command; by building this set of event gathers during the experiment, we were able to begin analysis of the data nearly immediately. Total time to create a time-corrected database with event gathers was under a week from the time the field tapes reached the lab. Concurrently, waveforms from US NSN stations in the region were collected from the USGS auto-DMR system and have since been merged into the database.

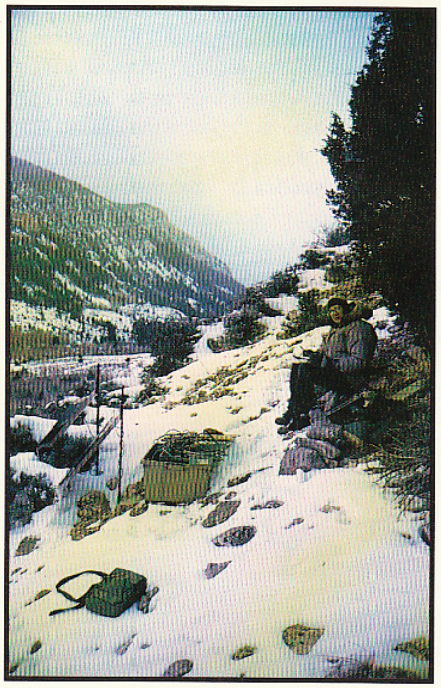

Figure 2c. Anne Sheehan servicing station RCC on the south flank of the Uinta Mountains.

King's Fortieth Parallel Survey was a reconnaissance to provide uniform, if sketchy, information useful to those looking for opportunity along the transcontinental railroad (then under construction). This was one of the first geological studies of the contrast between the Basin Ranges (as they were then called) and the Plateau country to the east. The recognition of basin-range normal faulting and its impact on the physiography of the region came in part from this work; this style of "fault-block" mountains was one of the few fundamental and original contributions to tectonic theory from the southwestern U.S. The fundamental causes of this deformation and the absence of similar deformation immediately to the east remains a topic of controversy, a topic we have sought to explore.

Our survey was conducted to obtain a uniformly collected, if spatially sketchy, view of the relative roles of crust and mantle in the deformation of the Basin and Range and relative absence of deformation in the Colorado Plateau. Are there fundamental differences between these provinces in the crust ? Are there any in the mantle? Is the Colorado Plateau a piece of craton lost in the Cordillera? Or is it merely an accident of history that this region has remained nearly undeformed for more than half a billion years? Is its modern elevation due to some difference in the mantle relative to its neighbors, or is it in the crust? We have begun to address these and other questions through study of receiver functions, shear-wave splitting, and surface waves.

One example of our work is from a preliminary collection of receiver functions over the region (Figure 3). These complement sparse refraction constraints on the depth of the Moho in the region and expand upon earlier work in the Rocky Mountains (Sheehan et al., 1995). Initial analysis suggests a thickness of crust in the Plateau center at the lower end of the refraction estimates (~40 km thick crust) [Jones et al., 1995]. This seems to indicate that the Plateau owes its elevation to the mantle, similar to (though not as extreme as) the Great Basin to the west. The character of Moho changes from a sharp, single discontinuity in eastern Nevada to a double conversion along the Wasatch Front to a lower amplitude conversion in the Colorado Plateau. The *Ps- P* travel-time across the crust is somewhat less than might be anticipated.

Other analyses are well underway. Deeper level receiver functions will be constructed in the near future to investigate variations in the upper mantle discontinuities down to the 660 km discontinuity to complement work from the Rocky Mountain and Snake River Plain experiments (Dueker and Sheehan, ms in prep.). Shear-wave splitting measurements from teleseismic SKS and S phases provide information on the strain patterns in the upper mantle; initial results have already been presented (Savage et al., 1995). Surface wave analysis will provide an important constraint on the shear wave structure of the lithosphere in the same region as the receiver functions; already an analysis combining these techniques has been done within Nevada using the UNR and portable stations from this deployment (Ozalaybey et al., ms in prep.).

While our contributions cannot match the observations of the King Survey for primacy (and our perils cannot match theirs for thrills), our work is part of the first detailed look at this orogen using broadband seismic recordings. We hope our efforts provide data equally seminal to our understanding of the diverse tectonics of the region. Armed with these data, we can look in the coming years to better understand the causative processes that generated the geology first systematically described by King and his contemporaries.

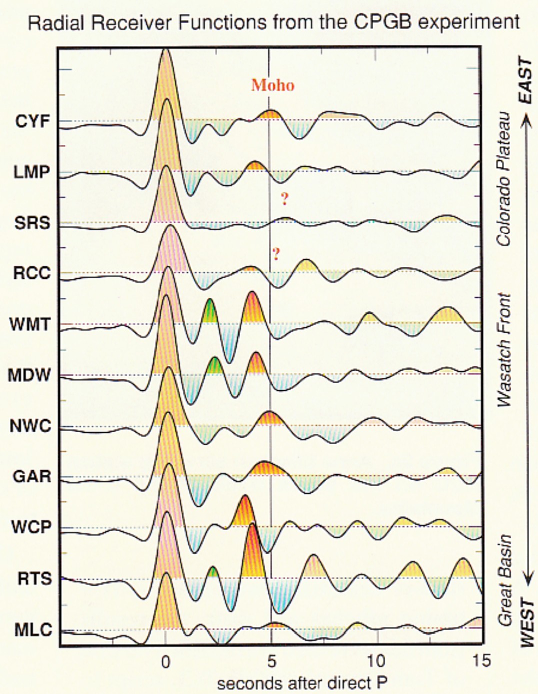

Figure 3. Radial receiver functions stacked over tens of earthquakes at each of the CPGB stations. The probable *Ps* phase from the Moho is in red and a strong intracrustal conversion is in green. Processing and most events are identical across the network.

Acknowledgments. This project was funded by the National Science Foundation Seismology Program. Although CHJ is responsible for this report and any inaccuracies present, there would be nothing to tell were it not for the efforts in the field of M. K. Savage, A. F. Sheehan, L. Trimble, N. Hughes, and especially Serdar Ozalaybey, who kept the Nevada part of the network running. Discussion of some of the early work is possible because of the efforts of those people and K. Dueker and J. Bartsch .

References:

Bartlett, R.A, Great Surveys of the American West, University of Oklahoma Press, 410pp, 1962 (last reprinted 1989)

Jones, C. H., A. F. Sheehan, L. J. Sonder, M. K. Savage, and S. Ozalaybey, Isolating crustal versus mantle sources of isostatic support of the Colorado Plateau, EOS, 76 [suppl. to no. 46], F619, 1995.

Lerner-Lam, and RMF Field Party, PASSCAL meets the Rocky Mountain Front, IRIS newsletter, v. 12, no. 1, 1-3,11, 1993.

Savage, M. K., A. F. Sheehan, J. E. Bartsch, Seismic anisotropy across the Colorado Plateau and surrounding regions, EOS, 76 [suppl. to no. 46], F604, 1995.

Sheehan, A. F., G. A. Abers, C. H. Jones, and A. Lerner-Lam, Crustal thickness variations across the Colorado Rocky Mountains from teleseismic receiver functions, J. Geophys. Res., 100, 20,391-20,404, 1995. •

PEPP Participants Selected

The Princeton Earth Physics Project (PEPP) continues to grow. Led by Guust Nolet and Bob Phinney from Princeton University, PEPP is supported by the Education and Human Resources Program at NSF to develop classroom teaching material and establish a national network of high school seismographs. IRIS is helping to coordinate PEPP activities through the selection of member institutions to act as regional centers for teacher training and support. In 1995, two workshops for teachers were held at the University of Arizona and Oregon State University. This year workshops will be held at New Mexico Tech, University of Alaska, Colorado School of Mines, Georgia Tech, Indiana University, Purdue University and Boston College. Final testing of seismometers and data acquisition systems is now underway. With the completion of the workshops this summer, almost 150 schools are expected to be PEPP participants. More information on PEPP can be obtained by contacting Lauri Wanat (wanat@geo.princeton.edu) or on the PEPP WWW home page (http://lasker.princeton.edu/pepp.shtml). •

Bill Best
January 5, 1996

William Jennings Best, who served as Chief of the Geophysics Division and as Program Manager for Seismology at the Air Force Office of Scientific Research, passed away on January 5, 1996. Both as an Air Force officer and later as a civilian, Bill dedicated his career to furthering the application of seismology to nuclear test monitoring. During his twenty years as Program Manager for Seismology at AFOSR, Bill was responsible for management of external research under the Defense Research Projects Agency (DARPA) Project VELA Uniform. The primary focus of the VELA program was the development of seismological methods for monitoring nuclear explosions, providing the basis for the importance of seismology in monitoring nuclear test ban treaties today. The fundamental research supported by AFOSR also had far-reaching impact throughout the Earth sciences. The revolutionary ideas of plate tectonics were in large measure founded on data, techniques and fundamental new discoveries supported by AFOSR under Bill's leadership in the 1960's and 1970's.

Highly respected by the research community for his management abilities and scientific insight, Bill took special efforts to encourage the work of young scientists. Many of today's leading seismologists began their careers working on DARPA and AFOSR projects managed by him.

Colonel Best was awarded the US Air Force Commendation Medal in 1964 and the US Government Outstanding Civilian Service Award in 1984. He was made an Honorary Member of the Seismological Society of America in 1984. In 1993 he was presented with the American Geophysical Union's Edward A. Flinn III Medal "for unselfish cooperation in research".

Contributions in Bill's memory can be made to a special fund established in his name at the American Geophysical Union.•

Execom News

The IRIS-2000 proposal continues to make its way through the NSF review process. This spring the Executive Committee was presented with a summary of external reviews which were very enthusiastic. This is a testament to the success of the first decade of IRIS which has changed the way seismology is done. The next step in the proposal review process is a review within NSF and, finally, at the National Science Board. One of the highlights of the review process has been the strength of the "Science Section" of the proposal. We would once again like to thank all those who contributed to this document.

The IRIS consortium has grown to 87 institutions; members have a major commitment to research in seismology. We are exploring ways in which IRIS can also have "educational members" for those institutions, such as liberal arts colleges, that use IRIS mainly for educational purposes rather than research purposes.

Perhaps the biggest challenge to the IRIS membership in the next few years is to respond to the major shifts in federal policy towards funding university research in seismology. Traditionally, the university community has received research funding from three federal agencies: NSF, Department of Defense and the USGS (Department of Interior). Although NSF funding seems relatively secure, Department of Defense and USGS funding for external grants programs is highly uncertain. There will be a special session at the 1996 IRIS workshop to discuss the future of federal support for seismology. •

Terry Wallace,
Chair, IRIS Executive Committee

The Council of the National Seismic System and a Composite Earthquake Catalog for the United States

Steve Malone, University of Washington
Dave Oppenheimer, US Geological Survey, Menlo Park
Lind Gee and Doug Neuhauser, University of California, Berkeley

The Council of the National Seismic System (CNSS) is a consortium of seismograph network operators in the United States whose purpose is to coordinate policy for an effective National Seismic System. The integration of the US regional and the national seismograph networks to provide comprehensive seismic data for research, education, and public information is the primary goal of the CNSS. Virtually all operators of seismograph stations in the U.S. funded by public sources are currently members of the CNSS. A more detailed description of the CNSS - its history, purpose, and current activities - can be found in Arabasz and Malone (1995). IRIS became a member of the Council during the past year because of the mutual interest of both organizations for improving the quantity and quality of seismic data available to the research community. A sampling of current CNSS projects of interest to the IRIS community include:

• CNSS networks are being actively encouraged and assisted in making their waveform data available to the research community in a standard manner through one of the major seismic data centers including the IRIS DMC. IRIS has helped generate a SEED writer for CUSP data as well as University of Washington format data.

• CNSS supports real-time data exchange projects among network operators, such as the USGS EARTHWORM project. This system is currently running in some fashion at five different regional networks. (Johnson et. al., 1995).

• CNSS is working to establish performance goals and standards for member networks to improve the uniformity and quality of data. This includes both standards for seismograph equipment and calibration as well as reporting of recorded earthquakes.

• CNSS is sponsoring the exchange and merging of network information and data of interest to seismic network operators including an inventory of operating stations and their catalogs, the latter of which is the main topic of this report.

A great deal of progress is currently

Catalog Code	Network Name (area)	Date Started	Finger_quake address	# events	Color on map
AK	Univ Alaska (Alaska)	>5/94	quake@giseis.alaska.edu	4,536	red
BK	Univ Cal Berkeley (CA)	7/94	quake@quake.geo.berkeley.edu	2,660	orange
BSU	Boise State Univ. (Idaho)	3/95	quake@sisyphus.idbsu.edu	140	light-orange
CN	Canadian National Seis. Net	1/95	quake@seismo.emr.ca	782	light-green
CI	Cal Tech (Southern Cal)	>5/94	quake@scec.gps.caltech.edu	1,257	grey-blue
HV	USGS Hawaii Volcano Obs	<5/94	quake@tako.wr.usgs.gov	1,521	magenta
LEO	Lamont Earth Obs (New York)	9/94	quake@ldeo.columbia.edu	57	dark-blue
MBM	Montana Bureau of Mines	1/95	quake@mbmgsun.mtech.edu	337	dark-green
NC	USGS, Menlo Park (CA)	5/94	quake@quake.wr.usgs.gov	2,024	orange
NN	Univ Nevada Reno (NV)	>5/94	quake@seismo.unr.edu	1,129	green
SLU	St. Louis University (central US)	>5/94	quake@quake.eas.slu.edu	34	red
UBR	U.S. Bureau of Rec (2 dam sites)	2/95	quake@info.seismo.usbr.gov	169	purple
US	National Seis Net (NEIC)	>5/94	quake@gldfs.cr.usgs.gov	702	cyan
UU	Univ Utah (Utah-Yellowstone)	>5/94	quake@eqinfo.seis.utah.edu	2,310	pink
UW	Univ Washington (WA-OR)	>5/94	quake@geophys.washington.edu	242	red
VT	Virginia Tech (Virginia area)	6/94	quake@vtso.geol.vt.edu	9	pink

Table 1. List of networks providing recent catalogs via the "finger_quake" mechanism. Number of events reported thus far and map color refer to Figure 2.

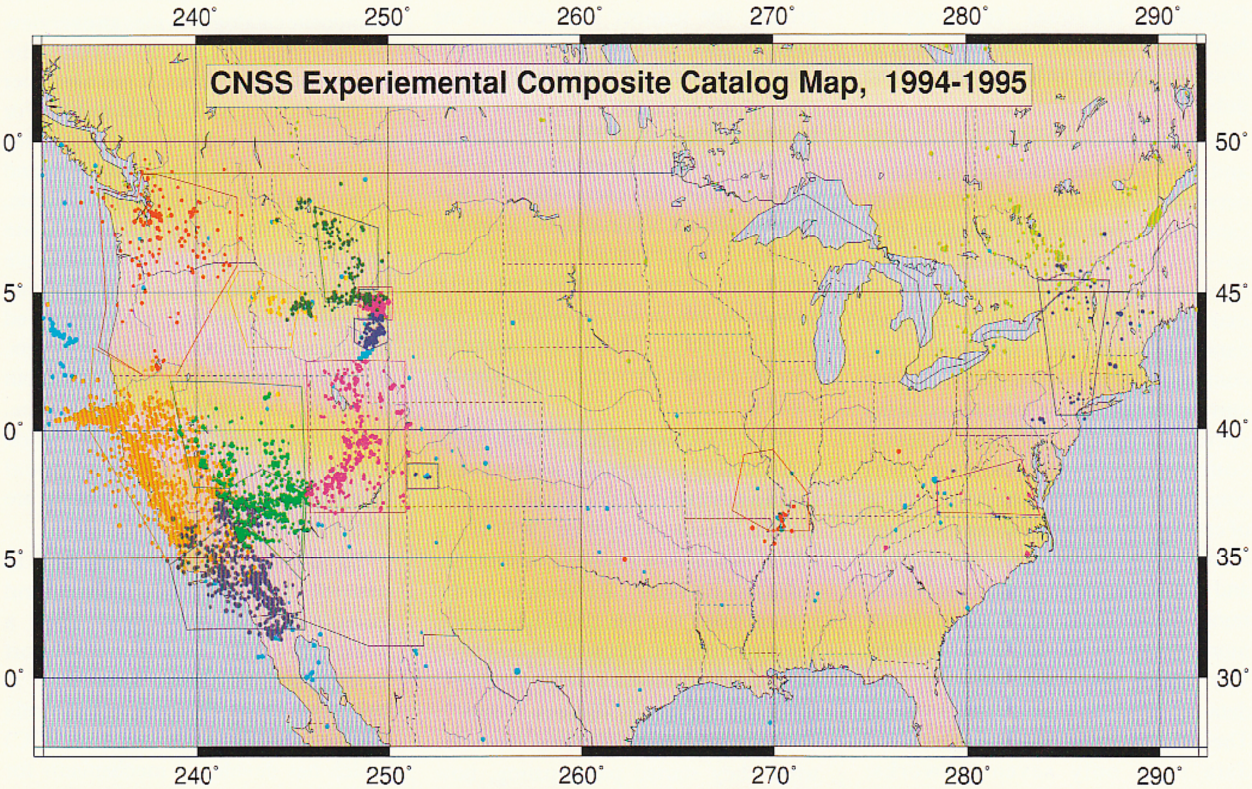

Figure 1. Mainland U.S. map of the experimental CNSS composite catalog for May, 1994 through Dec. 1995 with reported earthquakes color coded by network as given in Table 1.

being made to generate a composite earthquake catalog based on data from CNSS member networks. The motivation of the current effort arises from a successful program to conveniently provide catalog type data to the public from all seismic networks with near real-time recording and processing capability. Starting in 1989 the Pacific Northwest Seismograph Network began providing a short catalog of recent earthquakes via the Internet using the "finger" TCP/IP service. A computer account called "quake" was set up on the main departmental machine with a ".plan" file containing the catalog. Doing "finger quake@geophys.washington.edu" from anywhere on the Internet produces a listing of the catalog. The login procedure and email handling for the account were modified so that anyone logging in or sending email to the account gets the same catalog as well. More recently an interface from the World-Wide-Web to this same catalog has been developed.

After the "finger quake" system was presented to network operators at an early CNSS meeting they were encouraged to provide a similar catalog for their regions. By mid 1993 several regional networks were participating, and in 1994 the US National Seismograph Network started providing their catalog of global as well as US locations using this mechanism. At a CNSS working group meeting in late 1994 the previous defacto format for the 'finger quake' catalogs was modified slightly and endorsed as the standard. An example of the 'finger quake' catalog

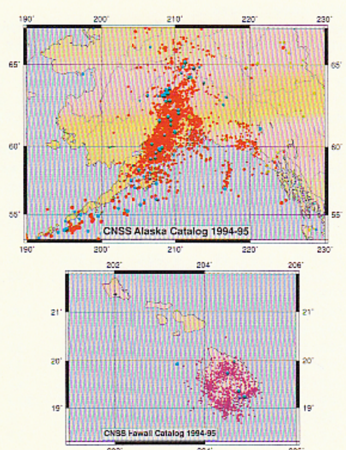

Figure 2. Alaska, and Hawaii maps of the experimental CNSS composite catalog for May, 1994 through December 1995 with reported earthquakes color coded by network as given in Table 1.

from the NEIC produced on Feb 15, 1996, is shown in Table 2. By the end of 1995, 15 networks in the US plus the Canadian National Seismograph Network were using this technique to provide current information to the public.

With the standardization of the format and the participation of multiple networks, it became possible to combine catalogs to look at larger regions than covered by a single network. Indeed, there were reports of school classes extracting several different network catalogs using this technique and combining them to make maps showing current seismicity for large areas. In the spring of 1994 an experimental composite CNSS catalog was constructed by automating the extraction of catalogs from all networks providing them via the 'finger quake' mechanism and combining them in such a way as to remove duplicate entries when two or more networks reported the same event. The catalog was truncated to include data for only the previous two weeks. The early version of this catalog included data from only seven networks; however, these were the networks with the highest levels of seismicity and so provided considerable numbers of events. As more networks joined the project, the number of events in the catalog grew only slightly. However, the coverage of the seismically active areas of the US improved significantly. In the spring of 1994 the catalog averaged about 320 events for a two week period. By early 1996 it was running almost 500 events for a similar period. A master catalog of all events since the spring of 1994 has been generated but is not provided to the general public. There are currently almost 18,000 events in this master catalog.

The CNSS "experimental" composite U.S. catalog is currently updated four times a day and is available to the public via the World-Wide-Web (WWW) at URL:"http://www.geophys.washington .edu/cnss.cat.html". References in the catalog point to several different maps generated from it. Maps generated from the combined master catalog for 1994-1995 are shown in Figures 1 and 2. Table 1 gives the participating networks, when they started participating, how many events of theirs are in the combined catalog and the color code used for epicenters plotted in the maps.

Although this experimental CNSS composite catalog provides an overview of current seismicity from the participating networks, it has a number of deficiencies which limit its use. For example, the current technique for merging the individual catalogs and removing duplicate events is very crude, often resulting in a more accurate solution being replaced by a less reliable one. Furthermore, there is no easy way to update the catalog with improved solutions or to remove spurious events. Finally, the amount of information about an event is limited to origin time, location, and magnitude. No information about quality of solution, focal mechanism, or other parameters are contained in this catalog.

To address these problems and to provide a much more robust and complete method of generating a composite CNSS catalog, a new effort is currently underway. This effort is being assisted by the Northern California Earthquake Data Center (NCEDC) which has developed mechanisms for maintaining an automatically updated earthquake catalog and whose needs include the merging of the parametric data from the Northern California Seismic Network (NCSN), operated by the USGS in Menlo Park and the Berkeley Digital Seismograph Network operated by UC Berkeley. The NCEDC has developed a technique for submitting parameter data to a merging procedure using a new and comprehensive data format. The submission technique and format have been reviewed and tested by several CNSS operators for completeness and ease of use. Sample conversion codes from several different storage formats used by different network operators have been written and tested. These samples along with detailed submission instructions and a UNIX shell script are available to help others adapt their data to a composite catalog.

```
Login name: quake
Plan: The following near-real-time Earthquake Bulletin is provided by the National
Earthquake Information Service (NEIS) of the U. S. Geological Survey as part of a
cooperative project of the Council of the National Seismic System.  For a description of
the earthquake parameters listed below, the availability of additional information, and
our publication criteria, please finger qk_info@gldfs.cr.usgs.gov.
Updated as of Thu Feb 15 17:34:02 MST 1996.

DATE-(UTC)-TIME      LAT     LON       DEP   MAG   Q   COMMENTS
yy/mm/dd hh:mm:ss    deg.    deg.      km
96/02/08 22:11:36   0.57N   26.08W    10.0  4.8Mb  B   CENTRAL MID-ATLANTIC RIDGE
96/02/08 22:27:57  38.29N   21.18E    10.0  4.6Mb  A   GREECE
96/02/09 00:18:02  38.25N   21.05E    33.0  4.6Mb  A   GREECE
96/02/09 12:14:11  34.38N  116.46W     5.0  3.7Ml  A   SOUTHERN CALIFORNIA
96/02/09 17:33:49   5.86S  146.50E    33.0  5.8Ms  A   E NEW GUINEA REG., P.N.G.
96/02/11 09:28:49  45.37N  150.46E    33.0  5.1Mb  B   KURIL ISLANDS
96/02/11 09:46:37  60.19N  153.20W   150.0  3.5Md  A   SOUTHERN ALASKA
96/02/11 13:04:05  59.73N  153.04W   100.0  4.0Md  B   SOUTHERN ALASKA
96/02/11 23:51:01  52.14N  159.97E    33.0  4.8Mb  B   OFF EAST COAST OF KAMCHATKA
96/02/12 01:59:02  62.13N  148.78W    33.0  3.6Ml  A   CENTRAL ALASKA
96/02/12 02:58:52  45.16N  150.15E    33.0  5.3Mb  B   KURIL ISLANDS
96/02/12 09:08:12  11.05S  118.64E    33.0  5.8Ms  C   SOUTH OF SUMBAWA, INDONESIA
96/02/14 05:57:21  59.83N  153.45W   123.3  4.3Mb  A   SOUTHERN ALASKA
96/02/14 18:29:01  38.00N   81.62W     0.0  3.9Lg  A   WEST VIRGINIA
96/02/14 20:31:05  45.29N  150.37E    33.0  5.9Mb  A   KURIL ISLANDS
96/02/14 21:26:55  29.28N  140.37E   133.1  5.9Mb  B   SOUTH OF HONSHU, JAPAN
96/02/15 00:45:52  51.37N  179.79W    33.0  5.5Mb  A   ANDREANOF ISL, ALEUTIAN IS.
96/02/15 19:35:57  20.29S   68.46W   137.6  4.4Mb  B   CHILE-BOLIVIA BORDER REGION
96/02/15 20:16:12  37.62N  118.86W     5.0  3.7Ml  A   CALIFORNIA-NEVADA BORDER REG
96/02/15 22:46:27  40.34N  126.57W    10.0  3.6Mb  A   OFF COAST OF N CALIFORNIA
96/02/15 23:56:22  34.35N  118.69W    10.0  2.8Ml  A   SOUTHERN CALIFORNIA
```

Table 2. Sample output from executing the command: 'finger quake@gldfs.cr.usgs.gov'

The new data format addresses several issues not well handled by existing formats including a way to have the source of the data (i.e., the originating seismic network) carried with the data entry. The format is quite comprehensive, including fields for most parameters found in existing formats. While exhaustive, its use does not require any but a few basic fields to have entries. Thus, networks which compute only a few parameters (or only choose to distribute such) can use the format as well as those who compute and distribute many parameters.

The NCEDC is developing a sorting/merging procedure which will generate a composite catalog of authoritative entries. Under this scheme, each network submits its event catalog in monthly increments using the CNSS comprehensive format to the NCEDC. Scripts at the NCEDC will merge the monthly network contributions into chronological order. A technique is being developed to identify duplicate events based on similar origin time, location, and magnitude. Assuming no individual network will report more than one solution for a given earthquake, duplicates will arise only when two different networks report on the same earthquake. In these cases only an authoritative solution will be retained in the composite catalog. A network's solution is considered authoritative within a boundary which encompasses its stations and is negotiated with adjacent networks to be non-overlapping. The US National Network is authoritative for any earthquake not falling within a local network's region.

Figure 3 shows the current stations and preliminary areas of coverage for west coast CNSS networks (where the boundaries are the most complicated). Adjustments to the details of the area boundaries may yet be made as the development of this catalog matures. This methodology is designed so that any earthquake located by any network (within or outside its region) will be reported, but only one and, presumably, the best version of the location will be retained. Tuning of the duplicate removal technique, particularly for events near network boundaries, will be needed to maximize the accuracy of the composite catalog. Catalogs will be updated and stored at the NCEDC by complete months. So, if a network discovers an error in their catalog from several months or even years ago, they simply resubmit the corrected catalog for the whole month containing the corrections and the composite catalog will be updated accordingly.

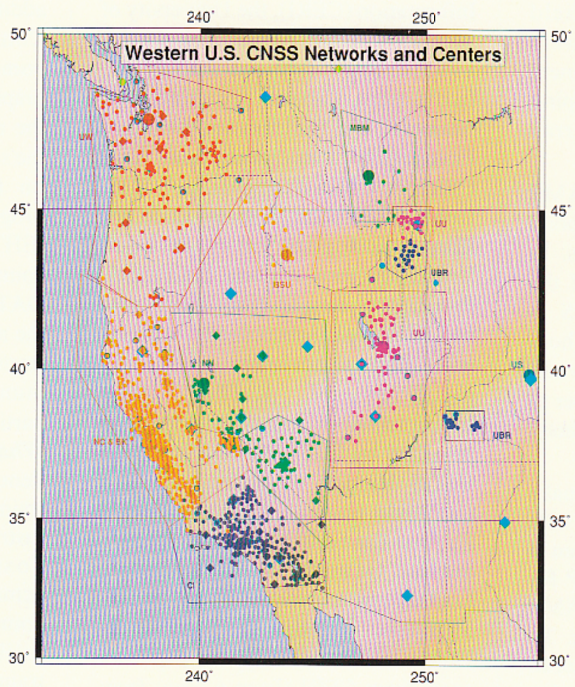

Figure 3. Mainland U.S. west coast CNSS seismograph stations with tentative network boundaries color coded by network as given in Table 1.

While the NCEDC will be the maintainer of the authoritative CNSS composite catalog, arrangements with them can be made to obtain a copy of it on one's own machine. The NCEDC will provide a search engine to make subsets from the catalog. Epicenter maps for predefined areas and time periods will be provided and routinely updated there as well. Software for providing catalogs and maps for specialized areas or event selections with standardized looks can also be made available to any network contributing to the catalog.

Details for submission to the catalog, the data formats, the descriptions of the regional network authoritative boundaries, and other general information may be found on the Web at URL: http://quake.geo.berkeley.edu/cnss/cnss.cat.html

The hope is that the CNSS composite catalog will be a useful source of earthquake data for both the public and the research community. If this system proves useful, the plan is to expand it to include seismological information other than just hypocentral parameters.

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Arabasz, W., S. Malone, 1995, Council of the National Seismic System (CNSS) - Background and Update, "Seis. Res. Let." v66 p29-30 (also in IRIS-2000 proposal)

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PASSCAL Training Goes Big in Memphis

Joan Gomberg, U.S. Geological Survey, Memphis
Paul Bodin, Center for Earthquake Research and Information, Univ. of Memphis
Sid Hellman and Gennady Pratusevich, PASSCAL Instrument Center, LDEO

'If you can't bring the central U.S. to the Lamont PASSCAL Instrument Center, bring the Instrument Center to Memphis'. Following this philosophy, 21 practicing or aspiring field seismologists and geologists were trained to use PASSCAL equipment recently as part of the developing Central U.S. (CUS) Rapid Array Mobilization Program (RAMP).

IRIS has established the RAMP facility as part of PASSCAL to respond immediately to record aftershocks. In cooperation with the Council of the National Seismic System, IRIS is encouraging regional groups to hold training sessions to train operators and prepare mobilization plans in order to most efficiently respond in aftershock studies.

Last year a consortium of earthquake researchers in the CUS, together with the IRIS PASSCAL program, began to develop and implement a RAMP for the central U.S. A final CUS RAMP document is now nearly complete. To make the RAMP document useful, likely participants need to be trained to use PASSCAL's digital data acquisition systems (DASs). Thus, a new type of PASSCAL training workshop was born. In this article we summarize the results of, and the lessons learned from this new on-site group training workshop.

Where was it and who participated? The workshop was held at the Center for Earthquake Research and Information (CERI), the University of Memphis, from September 19-21, 1995. The Lamont-PASSCAL Instrument Center provided two 'trainers', Sid Hellman and Gennady Pratusevich. Participants came from CERI, the USGS-Memphis, the USGS-Golden, Southeast Missouri State, the Illinois Geological Survey, St. Louis University, and Auburn University. Participants ranged from those who had never seen a seismometer, to others who had experience collecting gigabytes of RefTek data. Instrumentation and computers were provided by IRIS-PASSCAL and the USGS Branch of Earthquake and Landslide Hazards (now the Central Region Earthquake Hazards Team). Sid and Gennady led the workshop. Logistics were arranged by the USGS-Memphis. Funding for PASSCAL-IRIS's travel and shipping expenses came from CERI (from a grant from Union Pacific Railroad) with a supplement from the USGS and IRIS. IRIS provided Sid and Gennady.

What did we use? Six teams of 4-5 participants each shared six complete PASSCAL systems (Table 1) in a RAMP configuration. Sid provided a PASSCAL Sparcstation for the training, and the instrument center provided three notebook PCs. In addition to containing the Field Setup Controller (FSC) software (for communicating with the seismographs), the PCs were equipped with the new Linux operating system and the same processing software that runs on the Sparcstation. Specially programmed Epson hand terminals (EHT-10 or 30) also provided means of communicating with the DASs. A DAT-tape drive facilitated lessons in the all-important task of copying data from disk to tape. One IRIS-PASSCAL manual was provided per two participants.

What did we do? In addition to the new venue, the workshop was the first training with the objective of providing instruction for a RAMP experiment. To simulate an aftershock situation, an actual field deployment away from the comforts and security of the CERI facilities augmented the classroom training. The schedule of events was:

<u>Monday afternoon</u>: Equipment unpacking, set up, and testing happened in the CERI conference center.

<u>Tuesday morning</u>: Sid presented an overview of the IRIS-PASSCAL manual.

Table 1 - PASSCAL RAMP Seismographic System
6-channel, Refraction Technology, Inc. (RefTek) 72A-06 or 72A-07 Data Acquisition Systems
3-component Mark Product L-22 or L-28 velocity sensors
RefTek 72A-05 SCSI disk, 190 Mb to 1.2 Gb
RefTek 111 GPS receiver
RefTek 72A-04 Auxiliary Power System, or car battery
Cables (seismometer, GPS, SCSI, serial, battery)

Tuesday afternoon: Each team practiced setting up and communicating with their systems using both PCs and hand-held terminals.

Wednesday morning: Sid instructed on the wonders of the PASSCAL software suite, and the field applications that run under Linux (Figure 1).

Wednesday afternoon: All equipment was repacked. We drove 30 miles north to the Meeman Biological reserve with high hopes for recording an earthquake (Figure 2). The teams deployed five stations in a micro-array configuration.

Thursday morning: We returned to the Biological reserve, and retrieved the equipment.

Thursday afternoon: Sid instructed us on procedures for data copying, previewing, and field archiving. Each team attempted to follow these procedures for the data recorded at their station (which even included a local earthquake).

What lessons were learned? A post-workshop poll of the participants gave the workshop very positive marks. Most indicated that it provided them with sufficient training be able to deploy and retrieve PASSCAL data successfully. However, the problems associated with retrieving large volumes of data from numerous instruments while only having access to one or two workstations became evident. More computing facilities would have enabled faster archiving, conversion and playback of data. Nonetheless, the reality of data retrieval during an actual RAMP deployment was effectively simulated. For training purposes, teams of four people sharing a single system functioned adequately, but probably should be no larger.

Finally, we close with some recommendations taken from workshop participants' notes.

(1) *Before going in the field*, be sure you have a partner who knows what they are doing and has everything you need. (2) *Once in the field*, perform a voodoo ceremony to clear the site of ticks, thorns, and poison ivy. (3) *When leaving a site, do NOT* trip on wires, drive over instruments, leave your partner behind, remove flora from local ecosystem (appropriating chiggers from site is acceptable). (4) *When servicing or shutting down a site*, blame all problems/mistakes on someone else. (5) Finally, lots of Memphis barbecue really helps a workshop, but success certainly doesn't depend on it. •

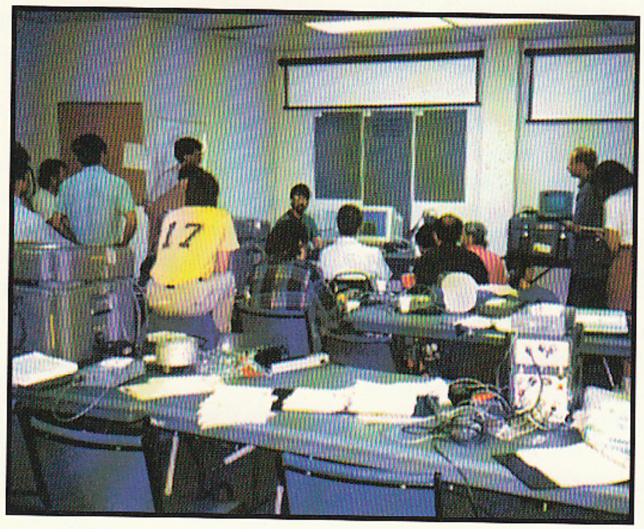

Figure 1. Participants being instructed in the wonders of PASSCAL software during the classroom portion of the training.

Figure 2. Workshop participants at Meeman Biological Reserve, just north of Memphis, receiving instruction from Sid Hellman and Gennady Pratusevich (left two persons) of the LDEO IRIS-PASSCAL Instrument Center.

A Novel Approach to Automatic Monitoring of Regional Seismic Events

Gennady A. Ryzhikov, Marina S. Biryulina, and Eystein S. Husebye,
University of Bergen

Summary

Improved event detection and location capability of regional networks can be achieved by developing and incorporating new concepts for seismic data analysis. Our strategy for automatic event location is tied to transforming high-frequency data to energetic wavelet envelopes (EW-transform) and is anchored in the theory of pulse propagation in a randomly stratified medium with waveguides. Testing the new method on mining events from southern Norway, our epicenter determinations were far better than those derived by the analyst (bulletins). In Germany, our scheme could handle very weak events for which interactive analysis failed. With this method it is possible to reduce the data volume for on-line transmission, by *in situ* (i.e. at the recording site) re-sampling of records from a digitizing frequency 40 - 80 Hz to 2 Hz. Our automatic location scheme is 'robust' in the sense that no crustal information is needed for its realization, once the network has been trained through the development of proper EW travel time curves.

Event location and detection

The conventional approach to the problem of seismic event detection and subsequent location is a four-step process:

(1) signal detection,

(2) phase identification (P, S, etc),

(3) phase association (matching phases from many stations), and

(4) event location using 'phase association' parameters.

This approach is not attractive for automated location analysis; a four-step process is rather clumsy, and for poor to moderate signal-to-noise ratio the first three tasks are error-prone. We find that by using the energetic wavelet envelope transform (EW-transform) of records, we can merge the above four tasks into one; that is reformulate the problem as a joint *event* location/detection problem. The steps involved are: EW-association → event pre-location →EW-identification → event detection. These steps in our real-time event localization algorithm are described below.

In-situ seismic record analysis.

The raw vertical-component high-frequency records are pre-filtered in the band 2-4 Hz and/or 5-10 Hz, where the signal-to-noise ratio is optimum for local/regional events, and then subjected to the *EW* -transform as illustrated in Figures 1 and 2.

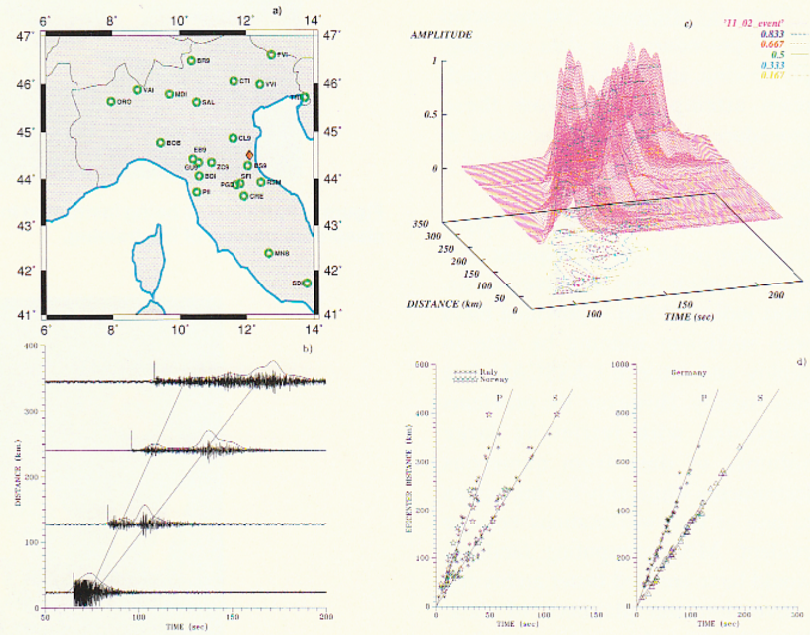

Figure 1. Example of energetic wavelet processing of data from stations (green circles) of the Italian network for an event of 26.02.1995 (red rhombus).

b) Original waveform records and EW-envelopes. First arrivals are marked with flags.

c) The entire set of relevant dimensionless envelopes, ordered with respect to epicenter distances. Amplitude isolines are drawn below. Note the linear spreading of EW, which is typical of diffusion processes.

d) P- and S-energetic wavelet travel time curves for Italian, Norwegian and German networks. The P- and S-EW maxima are automatically identified and picked at the event post-location stage. The dispersion of maxima for the German network was essentially reduced after a brief period of "network training". The corresponding EW-velocities are 6.3 km/s and 3.5 km/s for Italy/Norway and 5.9 km/s and 3.4 km/s for Germany.

The theoretical basis of the EW-transform is that pulse propagation in a randomly stratified medium should create an energy wave train with diffusion in space and time, and therefore the energy distribution recorded by a station can be interpreted as a random realization of a diffusion process in the time domain. Two main wavefield intensity components occur in the vicinity of the free surface, namely *primary energetic wavelets*, or P-EW, and *secondary-*, or S-EW, which exhibit distinct group velocities which are quite different from P_n, S_n or L_g phase velocities. It is important to note that these velocities are nearly independent of local crustal structure, focal depths and source mechanisms (Figure 1), as expected from theory. The validity of this EW-transform was tested on real data from Germany, Italy and Norway and the results are presented in Figure 1d. Similar phenomena would exist in a deterministic isotropic stratified medium with waveguides. [Kennett, *1983*]. It is sufficient to transmit just EW-transformed traces to the network hub for subsequent event location and detection analysis.

Event location

We pose the problem as a linear inversion of EW- forms with respect to an artificial energetic source image; i.e. an arbitrary space/time distribution of point-like incoherent sources. An infinite set of distributions exists that can fit the observed data quite well, but there should be just one that approximates an impulse emitted at a proper time/space location.

Note, that a *network area* is defined by a minimum of 4-5 network stations which are located at distances from the source of less than 1000 km - in our tests we used grid size 10 x 10 deg^2 in latitude/longitude and gridding units 20 km and 1 sec in space/time.

An essential step in network training is estimation of P- and S-EW velocities, or a part of self-learning of networks. This involves joint inversion of EW-forms from N events with respect to 3 x N parameters (epicenter coordinates, origin times) plus proper P- and S-EW velocities, from which travel time curves are constructed.

The steps involved in the location procedure are:

Normalized migration : each network station is considered to be a source which in reversed time 'emits' all samples of the corresponding EW-record into the network area with appropriate P- and S-EW velocities. [Note, to avoid errors during estimation of a 'true' amplitude, all EW-records are normalized with respect to the corresponding maxima.] This procedure provides us with a source image in the network monitoring area at each 0.5 - 1.0 sec (depends on a digitizing frequency of EW-records). The normalized migration applied here is similar to that described by Biryulina and Ryzhikov. [Ryzhikov and Biryulina, 1995]

Source image dimensionless measure: We extract the best source image 'snapshot', namely the one most focused in space. This requires the introduction of the Entropy of source Image Contrast (*EnIC*) [Biryulina and Ryzhikov, 1995] The corresponding time is associated with the event origin time, while the spatial coordinate of the source image maximum indicates the event location.

Proper detection involves estimation of a few parameters such as 'sharpness' of a source image, self-consistency of P- and S-EW identification, signal-to-noise ratios for both P- and S-EWs and magnitude. In a post-event location/detection stage we may introduce finer gridding for more refined epicenter location. Moreover, the EW-transforms also provide us with estimates of peak P- and S- signal amplitudes within the 'raw' trace filtered passband(s) and hence a mean

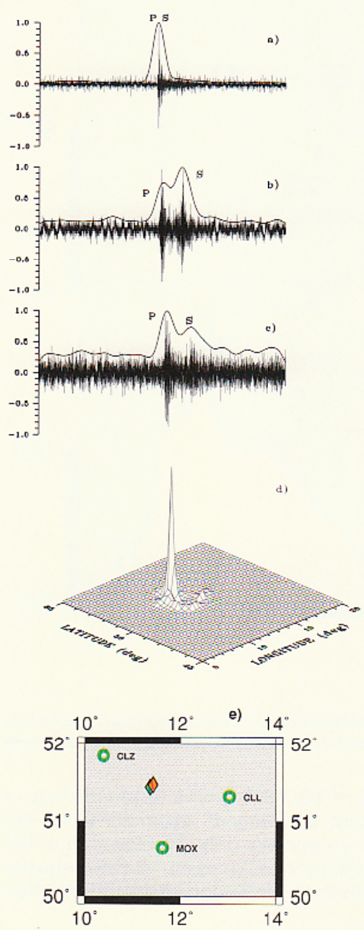

Figure 2. Location of a weak (M_L ~1.2) mining event from the Harz area, Germany. The "raw" records, prefiltered in the band 5-10 Hz, and the corresponding envelopes clearly indicate the better signal-to-noise ratio for EWs than for Pg - and Sn/Lg - phases. The best source image "snapshot", extracted automatically with time-scanning of EnIC is shown in d). The three stations used from the German network (CLZ, 87 km; MOX, 94 km and CLL, 116 km), are shown in e) with bulletin and our location marked by green and red rhombuses respectively. Differential epicenter parameters are 0.01° N and 0.02° E.

for event magnitude estimation (Mendi and Husebye, 1994). These parameters are also widely used in seismic event classification studies.

The above type of automatically extracted seismic record parameters are well-suited for advanced network training. This can address problems such as more refined EW-velocity estimates, event magnitudes, event classification parameters and relative contributions of individual stations in a network. Since our automatic event location scheme works with P- and S-wavelet maxima, the detectability of weak events is excellent as demonstrated in Figure 2. Despite the low-frequency nature of the EW-wavelets, the event location accuracy is also very good as shown in Figure 3.

Concluding remarks.

Here we have used the expression "location in real time", since the time involved in processing is small compared to the travel time from source to receiver. In our case, it takes about 4 minutes for signal to reach the most remote station, while the location/detection algorithm takes only a few seconds of computer time to analyze 5-minute record segments from 10 stations. Our processing scheme has been tested on weak events (Germany and Norway - e.g. Figure 2 and 3), interfering events (Germany), but not on a continuous data stream from a network. The reason for this is that for the networks we have used only segments with known/presumed signal presence are retained in permanent storage, therefore it was rather difficult to simulate continuous data stream. Nevertheless we are confident that our scheme will analyze continuous data stream in the same efficient manner as for segmented data. In this contribution we have also described and demonstrated a strategy for the training of regional seismic networks. The approach appears to be flexible and nearly invariant with respect to a crustal structure and thus should be easy transportable to any network even in adverse tectonic regions.

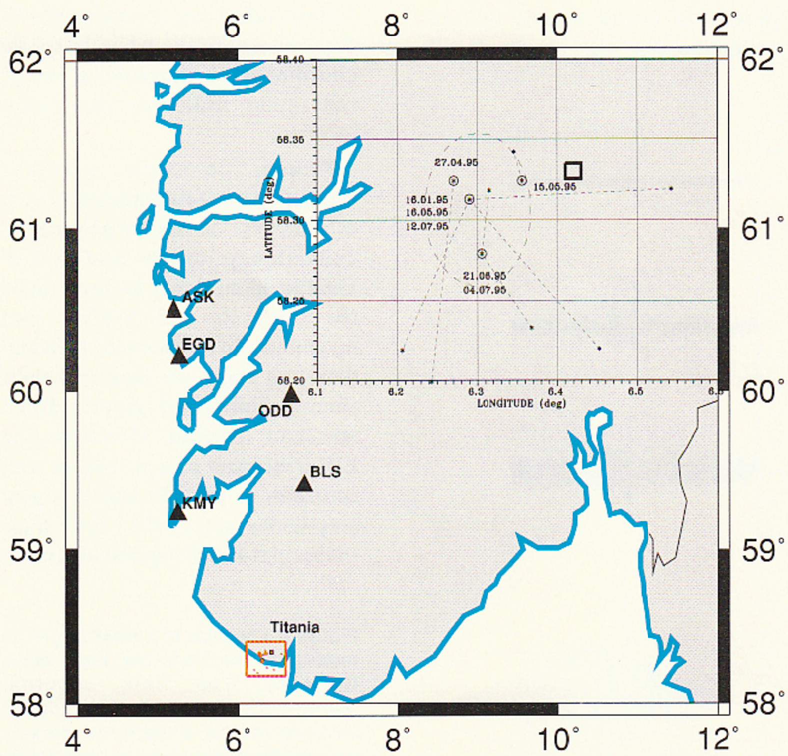

Figure 3. Automatic location of seven seismic events in the Titania mine on the south coast of Norway (red box below). The stations used, part of the Norwegian Seismograph Network, are marked by triangles.

The upper right corner shows a zoom display of the mining area (grid unit here is approximately 5 km). Our solutions are shown by "ringed" asterisks while the corresponding bulletin solutions are marked by asterisks only. The location of the mine itself is indicated by a box. The axes of confidence ellipses are ~3 times shorter for the automatic scheme than for the analyst solutions. No a priori crustal information is used in our analysis.

The research reported here was supported by the US Air Force Office of Scientific Research, AFOSR Grant # F49620-94-1-0278.

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Ryzhikov, G.A., and M.S. Biryulina, 1995, 3D nonlinear inversion by entropy of image contrast optimization, *Nonlinear Processes in Geophysics*, vol. 2, no. 3/4, pp 228-240. •

IRIS Home Page

The IRIS Home Page is best viewed on Netscape. Viewers can access the home page through URL: http://www.iris.edu to obtain information on membership, committee members, and IRIS publications, including an on-line version of the latest Newsletter. Selected articles from Section II, Scientific Contributions, of the IRIS-2000 proposal to the National Science Foundation are also being added. The PASSCAL section has copies of the latest instrument schedules, instrument request forms as well as information and manuals for PASSCAL equipment. The DMS connection allows direct access to the DMC for information on data available and on-line data. •

IRIS Employee News

We congratulate Tim Ahern, DMS Program Manager, and his wife, Rowena, on the birth of their son, David Keith Ahern, born in February.

We would also like to congratulate Denise Dillman Crump, former IRIS Newsletter Production Editor, and her husband, Brian, on the birth of their son, Daniel Robert Emanuel Crump, born this past December.

Gregory van der Vink chaired a session on the Comprehensive Test Ban Treaty at the AAAS Annual Meeting, and was appointed to the Selection Committee for the AAAS Science, Engineering and Diplomacy Fellowship Program.

David Simpson was a member of the U.S. delegation of the U.S.-Russian Science and Technology Committee as part of the Gore Chernomyrdin Commission Meetings in January. •

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

IRIS Newsletter
1616 N. Fort Myer Drive, Suite 1050 • Arlington, VA 22209-3109
Phone 703-524-6222 • FAX 703-527-7256
Telex AC:23, TLX:74004571, ANS:IRISUC

The Incorporated Research Institutions for Seismology (IRIS) is a consortium of over 80 research institutions with major commitments to research in seismology and related fields. IRIS operates a facilities program in observational seismology and data management sponsored by the National Science Foundation. Major funding for IRIS programs is provided by the National Science Foundation through its Division of Earth Sciences and the Air Force Office of Scientific Research.

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

Executive Editor: David Simpson (simpson@iris.edu)
Production Editor: Anne DeLaBarre Miller (anne@iris.edu)

New PASSCAL Datasets Available

Reflection/Refraction Experiment in Southwest Washington

PASSCAL Data Set 96-003: Tom Brocher, Anne Trehu, and Kate Miller; USGS, Oregon State University, and University of Texas, El Paso

Rocky Mountain Front Experiment

PASSCAL Data Set 96-002: Art Lerner-Lam, Lamont-Doherty Earth Observatory

Onshore/Offshore Experiment in the Bering-Chukchi Sea, Western Alaska and Eastern Siberia

PASSCAL Data Set 96-001: Tom Brocher, Richard Allen, David Stone, Lorraine Wolf, and Brian Galloway; USGS, University of Durham, University of Alaska, Auburn, and Stanford

Jemez Tomography Experiment at Valles Caldera, NM

PASSCAL Data Set 95-004: Cliff Thurber, Bill Lutter, and Lee Steck; University of Wisconsin and Lawrence Livermore National Laboratory

For more information please refer to the IRIS DMC electronic bulletin board (telnet iris.washington.edu userid = bulletin password = board) or World Wide Web server (http://www.iris.washington.edu/datasource.html) •

GSN Update

Two new GSN sites have been installed since the last Newsletter.

The IRIS/USGS team has completed a new vault site at KMBO, Kilima Mbogo, Kenya in central Africa and a new borehole site at PTGA, Pitinga, Brazil in the Amazon basin. The KMBO site is a cooperative joint station with the German GEOFOrschungsNetz (GEOFON) and replaces the temporary station NAI, Nairobi.

Equipment upgrades were installed at TSUM, Tsumeb, Namibia and LSZ, Lusaka, Zambia (IRIS/USGS), at SUR, Sutherland, South Africa (IRIS/IDA), and at PAS, Pasadena, California (Terrascope/IRIS). •

Calendar

1996

May 6-10	XXI General Assembly European Geophysical Society FDSN Meeting The Hague
June 19-22	IRIS Workshop Blaine, Washington
Sept. 9-14	XXV General Assembly European Seismological Commission Reykjavik, Iceland
Sept. 16-20	7th International Symposium on Deep Seismic Profiling of the Continents Stanford University, CA

New Members

IRIS welcomes two new foreign affiliates: Observatorio Nacional, Brazil; Jorge Luis de Souza, Representative, and Centro de Investigacion Cientifica y de Education superior de Ensenada, Mexico, Cecilio J. Rebollar, Representative •

1996 Annual IRIS Workshop

June 19-23, 1996 • The Inn at Semi-ah-moo, Blaine, Washington

Registration and travel information forms are now available for the Eighth Annual IRIS Workshop. If you have not received them, please contact Anne or Susan at the IRIS office. All participants are required to register. The registration deadline is **April 15th.**

The workshop will begin with registration on Wednesday evening and end with checkout Sunday noon. Three optional field trips will be offered. The IRIS Data Management Center is also offering a Short Course on June 18th and 19th. Those who wish to register for the Short Course may do so through the World Wide Web at URL http://www.iris.washington.edu/FORMS/dbms.shortcourse.html. Invited talks will review recent scientific projects using IRIS resources, and address a number of technical and strategic challenges that the seismological community will face in the next decade. One focus of this year's program will be experiments along the western margin of North America.

Among the topics for discussion at Scientific Sessions and SIGS (Special Interest Groups) will be:

Pacific Northwest Tectonics	High Resolution Imaging
CTBT Monitoring	Western North American Margin
Seismology, Funding and Public Policy	Regional Networks
Education and Outreach	Hot Scientific Issues

Talks at the scientific sessions will be *by invitation only.*

All participants are encouraged to bring posters. Poster displays will be grouped around the topics of the scientific sessions , but posters on any IRIS-related subject are welcome. One page abstracts for posters MUST be submitted to the IRIS Office by **May 1** -- faxes will not be accepted.

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

General questions may be directed to Anne DeLaBarre Miller (anne@iris.edu) or Susan Strain (susan@iris.edu) at IRIS (703/524-6222). •

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