IRIS Newsletter

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Volume XII, Number 2

RISC High Resolution Crustal Images of the Southern Basin & Range - Salton Trough

David Okaya, University of Southern California and Alan Levander, Rice University

The deployment of a passive multichannel seismic array during a crustal seismic refraction experiment is an effective approach to collect high-quality vertical-to-intermediate offset crustal images. This technique has been applied with great success during the USGS-PACE 1985-1987-1989 and PASSCAL 1986 Basin and Range seismic experiments. These "piggyback" experiments (1) are cost-effective since the source energy is "free"; (2) use high density intermediate-aperture arrays to provide spatial resolutions far superior to the host seismic refraction experiments; (3) recently can provide three-component recording as opposed to the host experiment's vertical component data; (4) can address specific scientific questions not resolvable by the refraction data; and (5) offer close coordination and collaboration between refraction and piggyback investigators during all phases of data collection, analysis, and synthesis.

In collaboration with the USGS, Rice University and the University of Southern California (RISC) conducted a multichannel piggyback experiment during the USGS PACE 1992 refraction experiment in the Colorado River region of southeastern California - southwestern Arizona. This region represents the transition between the Southern Basin & Range and the Salton trough (Figure 1). The piggyback experiment was located in the center of the refraction experiment and involved three distinct sets of instrumentation: two industry-style multichannel recording systems and a full complement of PASSCAL instruments for 1332 recording channels.

Several milestones were reached during the RISC piggyback experiment: the first PASSCAL experiment to utilize all of the then available 3-channel instruments (48 at that time); the largest PASSCAL experiment up to that date in terms of total number of PASSCAL instruments deployed (88), and total number of recording channels (384); the first experiment for the new PASSCAL Instrument Center at Stanford/Menlo Park; the largest three-component piggyback study ever conducted (888 continguous stations at 50 m spacing); and the first to use three-component sensors at 100% of the recording stations (see table).

Scientific Objectives

Major tectonic problems of southeastern California to be addressed by both the host refraction experiment and the RISC piggyback included the structure of the crustal transition between the ~30 km-thick Southern Basin & Range and the <25 km-thick Salton Trough; the process of continental crustal growth as indicated by the emplacement of the late-Mesozoic oceanic supracrustal ("Orocopia") terrane; and the possible lateral continuation of regional extension related to mid-Tertiary metamorphic core complexes which are found

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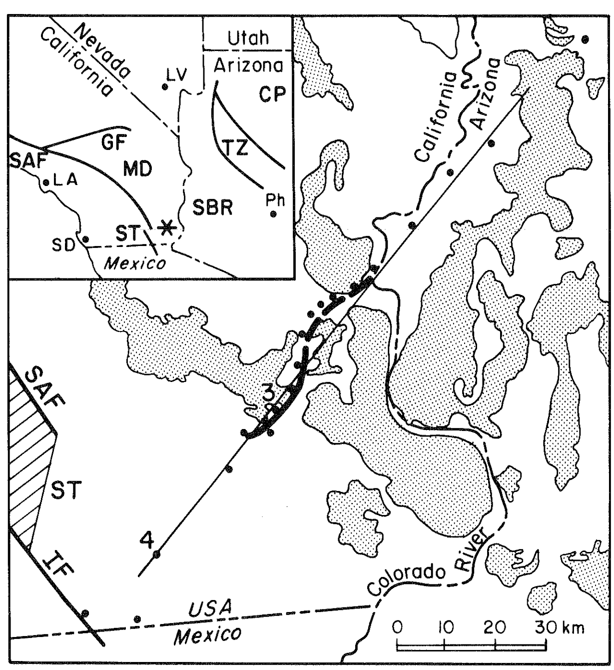

Figure 1. Location of RISC experiment. Left inset: Southwestern U.S. Regional features are Salton Trough (ST), Southern Basin & Range (SBR), Transition Zone (TZ), Colorado Plateau (CP), Mojave Desert (MD), Garlock fault (GF), and San Andreas fault (SAF). Right: Location of USGS and RISC experiments. Bold solid and dashed lines are RISC arrays, thin line is USGS PACE refraction transect. Dots are source points; "3" and "4" are shot point for Figures 2 and 3, respectively. Salton Trough is located to the southwest.

What's Inside

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Seismogram Display

As part of an IRIS educational initiative, Tom Early and Paul Silver (Department of Terrestrial Magnetism, Carnegie Institution of Washington) are developing a seismograph display for a new Earth Science exhibit at the Smithsonian Institution's Museum of Natural History.

The display consists of three windows on a Sun workstation: three component seismograms; a world map showing the location of the event and station; and a cross section of the earth with ray paths of the major seismic phases. The expected arrival times for these phases are marked on the seismograms. Waveform and event data for recent events are automatically received from the GOPHER system at the IRIS DMC.

The display is based in form on a similar system developed by Terry Wallace at the University of Arizona. The programs SAC and MAP (see article on page 7) are used for plotting. In addition to its primary application in a museum environment, the display makes an excellent teaching tool for "record reading" in seismology.

The Smithsonian display will also include a display of global seismicity based on the SEISMIC program developed by Allan Jones of SUNY, Binghamton. SEISMIC currently runs on PC computers and can be obtained directly from Alan Jones, or through the Software Exchange Library (SEL) at the IRIS DMC.

A copy of the seismogram display program and related documentation also can be obtained through SEL — use the "p" (Program) option on the Bulletin Board at the IRIS DMC for directions on how to retrieve SEL software. SAC and MAP are required to run the program and IRIS members can also obtain copies through the DMC.

Try it - you'll like it! Comments or suggestions for improvement would be welcome. •

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near the Colorado Plateau to the north.

The objectives of the RISC piggyback were both geological and seismological. The primary geological focus was to obtain near-to-vertical incident, high-resolution, low-fold reflection profiles. From previous exploration industry seismic profiles, reflectors were known to exist at all crustal levels. Imaging targets for the RISC piggyback were thus: the (three-component) seismic signature of the upper-crustal Orocopia schist terrane; the identification of middle crustal strong-amplitude discrete reflections as observed in the industry data; the characterization of known lower crustal reflectivity; and a vertical incident image of the Moho.

The RISC piggyback was also designed to address seismological problems relating to the reflectivity of crustal rocks. Petrophysical measurements of a sample from the intensely foliated Orocopia schist indicate >20% P wave anisotropy. Three-component seismometers were deployed in order to identify the seismic response to this anisotropic behavior. The array was designed to measure the statistical properties of the propagating wavefields when scattered by reflectors; for example, the coherence of signal when scattered from presumably discontinuous reflectors as measured by source-receiver offset variance.

Field Operations

The basic RISC piggyback array was composed of 444 three-component stations (1332 recording channels) every 50 m for a total length of 22 km. For comparison, the host refraction array was 390 single component stations with an average 330 m spacing for an array length of 132 km. The PASSCAL instruments were deployed as a 6.4 km segment (128 three-component stations) with CHEVRON industry strings of 4 Hz three-component sensors. Recorded data were written to disk and downloaded at the base motel in Blythe, California.

The ARCO GUS multichannel recording system composed the bulk of the array. Originally designed for 3-D seismic reflection acquisition, this system was stretched to its maximum 2-D capability in order to obtain 276 three-component stations (13.8 km). Seismic signals from the 10 Hz three-component strings were field demultiplexed (42 MB records) and written to magnetic tape. The CHEVRON DFS-V conventional cable recording system used 40 three-component stations to cover 2 km distance. Sensors were the same as those used on the PASSCAL instruments.

Recent Piggyback Studies in the Western United States

	Refraction Experiment				
	PACE85	PASSCAL86	PACE87	PACE89	PACE92
Piggyback Experiment:	UCSB	PASSCAL working grp	Stanford/ USC	Stanford/ U of Ariz	RISC
#Channels:	48	200-300	568	1700	1332
Vert stations:	48	200-300	448	650	—
3Comp stations:	—	—	40	350	444
Station spacing:	100 m	50-100 m	50 m	50 m	50 m
Total aperture:	4.8 km	20 km	24.4 km	45 km	44.4 km (2 x 22.2 km)
Array note:		array used 3 times		3 comp in 1-5 km arrays	array 2 times, end-to-end
Equipment*:	UCSB	CGG,UCSB, Wyo	Arco,Chev, UCSB	Arco,SGR, Wyo	Arco,Chev, Reftek Srs,Jrs

* Equipment Type:

UCSB = UCSB DFS-IV   Chev = CHEVRON DFS-V
Arco = ARCO GUS 8000   CGG = CGG SERCEL 348
Wyo = Univ. Wyoming DFS-IV   SGR = Stanford & Amoco SGRs

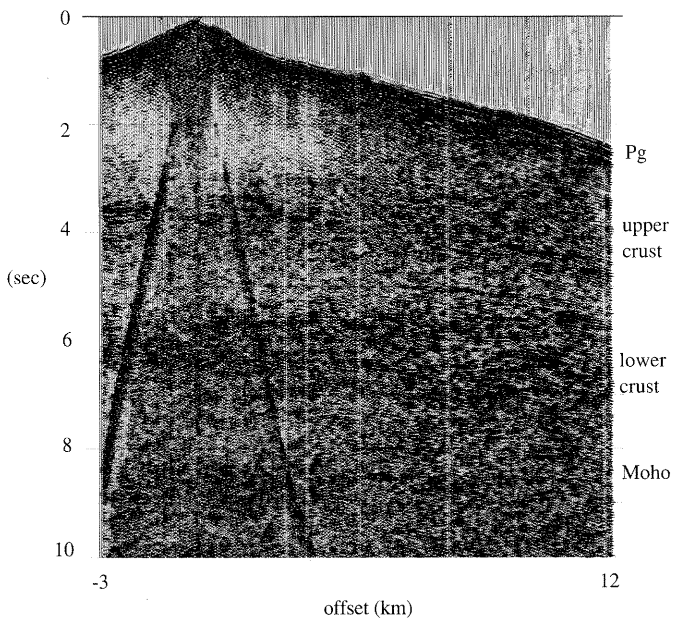


Figure 2. Portion of a 44-km wide shot gather. Offsets are -3 to +12 km. A 10-35 Hz filter is applied. Strong crustal reflectivity is present through much of the approximately 30 km crust.

Because the experiment sources were divided into two groups and collected on different nights, the RISC piggyback array was redeployed in order to make an effective 888 station, 44 km three-component array. The USGS sources ranged between 300-4000 lbs and created source-receiver offsets of 0-100 km. In order to provide full vertical incidence imaging, the RISC project contributed several additional shots. Of the 22 source locations, five were used for both deployments, in order to construct common shot gathers of significant aperture (33% of the host refraction array).

Data Merging and Preliminary Observations

After transcription, demultiplexing and conversion to common format, the combined data produced twenty-seven 444-trace shot gathers for each component, representing a three-component data set of 2.88 Gbytes of seismic data. Co-location of stations of the three recording systems allowed for direct comparison of seismogram waveforms and the construction of transfer functions.

The crustal image in Figure 2 reveals reflective zones in the middle of the upper crust and in the lower crust, with a less-prominent Moho at 9 sec. Clarity (coherence) in the overall reflectivity increases with offset as predicted by scattering theory. The complexity in the lower crustal reflections suggests strong geologic dips or out-of-plane/scattering propagation behavior.

The character of Pg and PmP phases are exhibited in Figure 3 for offset distances of 53-80 km. The vertical component section possesses coherent arrivals for both phases at all offsets. Note the second-order lateral variability of each phase. The in-line horizontal component section has weak events which are identifiable due to the close station spacing (e.g., phase lateral continuity). Not shown is the transverse horizontal component which has little recognizable energy.

The RISC piggyback data set represents seismic imaging of transitional continental crust using vertical-incidence to wide angle (100+ km) source propagation. The availability of large numbers of recording channels allowed for the construction of a wide-aperture array which could record the full wavefield at high spatial resolution. These data can produce a low-fold vertical incidence profile at nominal experimental costs. This and earlier piggyback experiments have greatly benefited from the participation of industry groups whose seismic equipment in most cases provided the majority of the recording capacity. Current economic trends make future industry participation more difficult, increasing the importance of a large pool of portable PASSCAL instruments. •

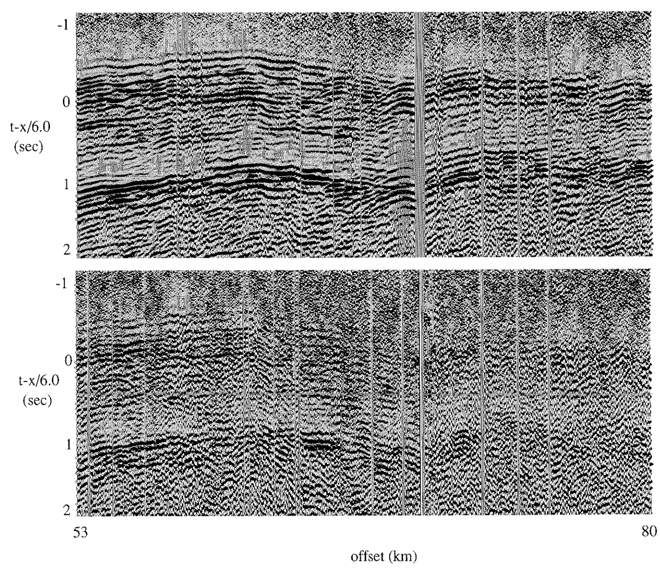


Figure 3. Vertical (top) and in-line horizontal (bottom) components for 53-80 km offset (Pg and PmP phases). Time scale is reduced travel time using a velocity of 6.0 km/s. The presence of PmP at low far-offsets suggests thin transitional crust between the Salton Trough and Basin & Range. Lateral variation within each phase is observable due to the high spatial resolution.

This Issue's Bannergram: The seismogram on the cover is the radial, very long-period component from IRIS/IDA station Lovozero, Russia (LVZ) for the M=7.5 Indonesian earthquake of December 12, 1992. As well as being rich in body wave phases, this record shows long-period surface waves that have encircled the Earth multiple times: R1 is the direct Rayleigh wave along the forward direction; R2 traveled along the reverse arc; R3 traveled the foward direction with an additional trip around the Earth. X phases denote surface wave overtone packets which travel with group velocities between Love and Rayleigh waves.

Installation of IRIS/IDA Stations at Lovozero and Norilsk, Russia

Todd Johnson, University of California, San Diego

One of the aspects of installing seismic stations in Russia you can count on is that the trip always starts off about the same— until you reach Moscow. In November 1992, a 21 hour marathon of flights and waiting in airports had me leaving San Diego one day and arriving in Moscow the next afternoon. Winter had already arrived in Russia, which became all too apparent as I stepped off the airplane at Sheremetevo airport. I was greeted by a steel gray sky and a biting wind that managed to penetrate my southern California winter clothing. Temperature, 0°C. Little did I realize that this was warm compared to the temperature I would experience at the two sites I would visit during the next month.

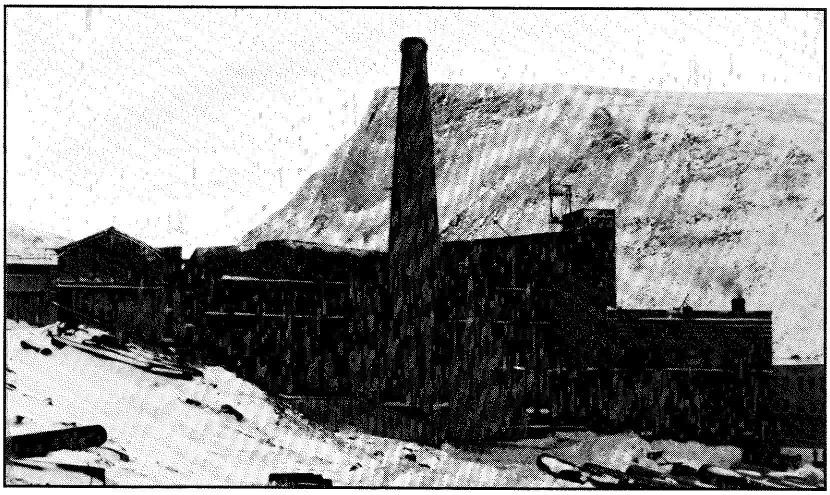
The IRIS/IDA station Lovozero is located on the Kola Penninsula near Revda, a small community of about 10,000 people that is located about 2 1/2 hours drive southeast of Murmansk. Due to the winter weather and the capricious nature of jet fuel suppliers, our travel to the Lovozero station was by rail - transport that appears to run despite the weather or the political situation. We had reservations for a compartment in a sleeper car on the midnight Arctic Express.

Snow began to fall as we approached the train station in Moscow shortly before midnight, an obvious omen of what was to come. Struggling through the snow and slush with all our equipment and a footlocker full of food, we were able to find our car with the help of our Russian colleague, Slava Bereza. Our compartment consisted of four padded benches arranged two to a side, one above the other. The upper bunks were hinged allowing them to be secured up and out of the way when not in use. Despite the compactness of our accomodations (6 x 5 x 8 feet), it was clean, cozy and had a remarkable amount of storage space. Each sleeper car had its own conductor who was responsible for taking the tickets, making sure that passengers did not over sleep their stop and keeping the water hot for those wanting to make tea. He was also in charge of heating which meant stoking the coal stove located at the front of each car. This was to be our home for the next 32 hours as the train carried us the 1300 miles to our destination above the Arctic Circle.

We left the train at Olenegorsk and were met by Ravil Gegoriovich Rahimov, the officer in charge of safety procedures at the Rudnyk Karnasurt mine. The 45 minute drive to Revda carried us through gently rolling hills with forests of stunted fir and pine covered with a thick blanket of snow. There were no traffic lights on the way to Revda and vehicles on the roads were mostly trucks and buses. People were bundled up against the cold and appeared to be hurrying everywhere, no doubt because of the temperature, -27°C.

The seismic station is installed in the Rudnyk Karnasurt mine that produces ore containing rare earth metals. The region is known as Lovozero, named for a lake some 20 km from the city. The mine consists of five levels that are 248, 312, 324, 350 and 430 meters above sea level. The IRIS/IDA instrument room is located on level 430, about 200 m below the surface. Excavation work is occurring on this level, 1.5 km from where the sensors are located.

The mine tunnels are lighted in some areas and not in others, making for an eerie 15 minute walk to the instrument room. The tunnels are wide enough for one of the mine's electric trains as well as a narrow catwalk for foot traffic. It was a rather unnerving experience the first time I found myself in one of these tunnels with a train. Initially, the faint noise blended in with the background of the mine, but as the unknown sound



IRIS/IDA station LVZ (Lovozero): Administration Building, Rudnyk Karnasurt mine.

Three new IRIS/IDA stations began operation in 1992 in Russia: Novosibirsk (NVS) in central Siberia, Lovozero (LVZ) ,on the Kola Peninsula, and Norilsk (NRIL) in northern Siberia. LVZ and NRIL lie north of the Arctic Circle and are sited in large working mines where the Institute of Physics of the Earth of the Russian Academy of Sciences has maintained geophysical instruments for years. This is a compilation of trip reports written by Todd Johnson, IDA Senior Electronics Technician, during the LVZ and NRIL installation trips in November and December 1992. After Mr. Johnson's return from Russia, he spent Christmas vacation in Hawaii before once again crossing the Arctic Circle for a maintenance trip to the IRIS/IDA station at Alert, Canada, in January 1993. - Holly Given, Executive Director, Project IDA.

Auxiliary recording unit at IRIS/IDA station NRIL (Norilsk).

grew in intensity so did my anxiety level. Suddenly, the Safety Officer turned around and pointed to a depression in the wall of the tunnel beside the catwalk. I didn't need to understand Russian to determine what he meant! I hurriedly squeezed into the shallow opening and pressed my back to the wall as the train with its overflowing ore carts went speeding by.

The instrument room is 100 meters down a side tunnel that is closed off from the main tunnel by a padlocked steel door. The passageway to the instrument room is through a succession of rooms that contain varying amounts of debris, transformers (for 220 V), a strain meter and the recording equipment for a tilt meter. The air in this side tunnel is filled with mist. With only the illumination of our miner's lamps to light the way it was like walking through a heavy fog.

Seismographic equipment at IRIS/IDA stations LVZ and NRIL is nearly identical. Streckeisen STS-1 broadband seismometers provide continuous data streams and Teledyne Geotech GS-13's provide triggered, short-period data streams. The data acquisition (DA) unit is also located with the sensors in the instrument room. This is a Refraction Technology model 97-08 which contains analog signal conditioning, analog-to-digital conversion, digital signal processing and the communications hardware needed to transmit the data to the auxiliary recording (AR) unit in the recording room. The DA unit records three high-gain and three low-gain broadband channels from the STS-1's (sampled at 20 sps), three STS-1 mass position channels (sampled at 0.1 sps), three high-gain and three low-gain short-period triggered channels from the GS-13's (sampled at 200 sps) and a temperature channel for diagnostic purposes. VLP streams (0.1 sps) are created from the broadband STS-1 channels by digital signal processing. The DA and AR units are connected via a multiconductor uplink cable.

At LVZ, the pier is 3 x 1m and rises 23 cm above the floor with 1 meter extending below the surface. The instrument room is dry and free of the fog that fills the main tunnels. Temperature in the instrument room was measured at 3.1°C. The distance between the sensors and the recording room in the administration building of the mine is about 1.2 Km. The recording room contains power conditioning equipment, the AR unit, OMEGA clock, main 60 V DC power supply for the vault equipment, with a 24 hour battery back-up in the event of power outages. The AR unit is a Refraction Technology model 94-02 that receives data packets from the DA unit and controls the write transfer to the recording medium — a Sony DAT recorder model SDT-1000 with a 1 Gigabyte capacity. The AR unit also monitors the main supply voltage and the recording room temperature.

The coordinates for the station were measured at 67° 53.87'N, 34° 39.08'E. IRIS/IDA station LVZ became operational on December 4, 1992 (day 339).

Norilsk

We returned to Moscow on the 6th of December and were scheduled to fly out of Vnukovo airport to Norilsk on the 7th but were told by airport authorities that the weather had closed the Norilsk airport. People were stacked up like cordwood at Vnukovo airport waiting for flights to resume. It wasn't until 11 AM on the 8th that we got word that the Norilsk airport had reopened.

The plane finally left the ground at 2 PM on the 8th. We were off to Norilsk, 69°N, one of three cities above the Arctic Circle with over 100,000 population. On American maps this area of Russia is referred to as the Central Siberian Uplands and is most well known, to Russians, for the many Gulags there. Being December, I knew it was going to be cold but the icy blast that greeted me as I got off the plane in Norilsk was still a shock to the system. The temperature was -32°C with a 9 m/sec (20 mph) wind! It was dark when we arrived and except for a couple of hours of twilight during midday, would remain that way for the duration of our stay.

The seismic station is located at the Rudnyk Komsomolski mine in the town of Talnakh, 15 km NE of Norilsk. Our contact was Sergei Pavlovich Odarchenco, the chief mine safety engineer for the Combinant. It took two days to make contact with him and find the shipment of seismic equipment that we had sent ahead, as well as coordinate transportation of this equipment to the mine.

One of the more difficult aspects of this installation was access to the mine. Blasting went on every day between 7 and 8 AM and 3 to 6 PM. No one was allowed in the mine during this time and for an hour afterwards, while the fumes from the explosions were ventilated. We were always accompanied by the safety officer who worked a regular shift which left us, most of the time, working between 7 PM and midnight. Our entrance and exit to the mine was via the emergency elevator located in

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New GSN Sites

The IRIS/ASL-MEDNET site TBT, Taburiente, Canary Islands was completed on March 29. The installation is the collaborative effort of IRIS/ASL, Italy's MEDNET, and the Spain's Insituto Geografico Nacional.

IRIS/IDA completed at the end of April the installation of a new GSN station ABKT, Alibek, Turkmenistan.

The first Global Telemetered Seismic Network (GTSN) station BOSA was completed at Boshof, South Africa. The GTSN is being installed by the USGS and the Air Force with equipment which meets IRIS GSN design goals. Data from BOSA and future GTSN sites will be available-through the IRIS Data Management System. •

PASSCAL Software Update

The latest version of firmware from Refraction Technology for PASSCAL type instruments requires new software for conversion of the data from field format to processing format. The latest version of PASSCAL software is now available to handle these modifications. PASSCAL release 1.5 is now available through anonymous ftp from lamont.ldgo. columbia.edu. In addition to the changes necessitated by the change in firmware, this release has several new programs and updates and improvements to many of the other program.

We are currently field testing a new database system for processing and quality control of field data. This software along with associated utility programs will be available sometime in late fall.•

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the ventilation shaft. The procedure to enter the mine was as follows: strip to your underwear, put on the official miner's uniform, including wrapping your feet in "partinkas" (rags) and stuffing them into rubber boots, walk outside and 100 meters to the ventilation shaft, go through an air lock, climb into the open-sided cage that they call an elevator and drop 400 m straight down. The first time down you don't know what to expect and so it's both exhilarating and exciting. The adrenlin is pumping and the senses are working overtime just to separate all the input. The ears are being assaulted by the wind which is not quite severe enough to mask a sound similar to water falling on rock, like a waterfall. The lamps on our helmets soon revealed the noise source: water pouring down the sides of the ventilation shaft. Further on, the air being pulled up the shaft by the ventilation fans pulled the water away from the walls and up as well. Soon it was raining upwards. The temperature in the ventilation shaft was close to 10°C without the wind, but there was always wind here with water pouring down. The uplink cable connecting the data acquisition unit in the instrument room with the auxiliary recording unit on the surface is located in the shaft. David Chavez had remarked in his site report what a inhospitable place the ventilation shaft was, but you can't fully grasp this until you have experienced "the ride to Hell"!!

The IRIS/IDA instrument room is located 492 m below the surface (413 m below sea level) and about 250 m from the foot of the ventilation shaft. A 35m side tunnel leading to the instrument room passes through two large steel doors, both of which are generally kept locked, and ends in a 10 x 5 x 7 m chamber. Three piers have been constructed here, one that completely spans the back wall of the chamber (about 5 m), and two towards the center of the chamber with a space of about 1 m separating them.

The floor of the side tunnel as well as the instrument room was very muddy, with water seeping down the back wall of the chamber and onto the rear pier. The two piers in the center of the chamber were relatively dry and were used for the IRIS/IDA instrumentation: the Streckeisen STS-1's and feedback electronics on one and Teledyne Geotech GS-13's on the other. Temperatue in the vault was measured at 12.6°C and the humidity appeared very high. The vault coordinates for NRIL are 69° 30.30' N, 88° 26.48'E. The station became operational on 15 December 1992 (day 350).

Returning to the surface via the ventilation shaft was, in some respects, worse than the trip down. The elevator remained at the bottom of the shaft during our stay in the mine and with all the water coming down became quite water logged by the time we were finished. During the ascent, the water not pulled up by the ventilation fans fell relentlessly, beating against your helmet and running down the back of your neck. By the time the elevator stopped at the top, you were soaked. Through the airlock and out the door, we began our trek back through the snow to the main building. The first breath outside in the -35°C cold froze the nostrils together and we found ourselfs blinking our eyes faster and faster because the water on our eye lashes was freezing, causing them to stick together. It became more and more difficult to move because our clothing had become sheets of ice. It was with a shiver and a sigh of relief that we entered the warmth of the main building. These were the harsh realities that were very apparent working here in the Siberian North. •

Acknowledgements: There are a number of people at Scripps Institution of Oceanography and in the former Soviet Union who were directly or indirectly responsible for the successful installation of these stations, including: Jonathan Berger (Principal Investigator); Holly Given (Executive Director); Christian Winther (Project Engineer); Anthony Wei (Development Engineer); and David Holcomb (Electronic Technician). The installation team, David Chavez and myself, would have had a much more difficult time if it were not for our Russian scientific colleagues, especially Natasha Zaharchenko and Volodya Mishatkin. Their experience dealing with Russian bureaucracy, their negotiation skills and assistance in bridging the language barrier were indispensable.

SAC and MAP

Eileen Vergino, Lawrence Livermore National Laboratory
Arthur Snoke, Virginia Polytechnic Institute and State University

SAC (Seismic Analysis Code) and MAP (A cartographic program for the display of seismic data) are two components of a larger software processing package that was developed at Lawrence Livermore National Laboratory (LLNL) and funded primarily by the Treaty Verification Program to assist in the processing, analysis, and display of seismic data. In addition to the popularity of the package as a whole, several other analysis packages use the SAC data format and/or the SAC plotting package. Due to budgetary constraints, SAC is being maintained primarily for LLNL researchers and to correct reported bugs. Other efforts in SAC are currently dictated by the needs of LLNL personnel and not the general community. A new version of SAC (SAC2000) is planned that will have the full complement of programming support, upgrades, updates and documentation. This article is written to answer questions regarding the present and future status of SAC/MAP.

The History of SAC

SAC has evolved from its initial configuration as a collection of signal processing packages that Joe Tull of LLNL tied together with a common data format and common plotting package. The feeling at LLNL has been that the primary strength of SAC is that it was written essentially by seismologists and geophysicists, in close collaboration with a programmer, which ultimately led to the development of a product of high utility to the users. One of the requirements was that SAC and MAP have: extensive user documentation; FORTRAN code readily available for verification and modification by the users; and a set, documented procedure for quality assurance. SAC was also initially written to be portable, since, at the time it was written, LLNL researchers were doing data processing on the CDC 7600, the Cray 1, various Primes, and even a few VAX's. Currently SAC is only supported at LLNL under the SUN UNIX environment (OS 4.1.x), although SAC (version 10.6d) has been successfully ported to the IBM RISC architecture. The version for VAX VMS (using decwindows for the graphics) is no longer available or supported. SAC has been successfully ported to SUN OS Solaris 2.1 with some minor modifications. Information is available from LLNL on the necessary changes.

Present Status of SAC

LLNL has made an effort to make SAC and MAP available to the general seismic community through IRIS and distributes the code and documentation using programmatic funds. Upon receiving the code from LLNL, users are asked to sign a letter of agreement to provide user feedback to LLNL and to forward all additional requests for SAC/MAP to LLNL. Users have the option of receiving the code via FTP (the preferred distribution method) or on a variety of media. The current contact person at LLNL is Eileen Vergino (phone (510) 422-3907, fax (510) 423-4077, or e-mail verginoes@llnl.gov). SAC and all documentation are also available upon request from the IRIS DMC. The IRIS DMC has distributed approximately 70 copies of SAC/MAP to IRIS users over the past four years.

Included with the distribution is a report detailing all aspects of the package including the installation procedures and a detailed user's manual. The user's manual and all documentation are available in hard copy, Postscript files, and TeX format files. The latter two versions are available by anonymous ftp through LLNL or the IRIS DMC.

Prior to April 1993, the versions available for distribution were 10.6d for SAC and 4.0a for MAP. As of May, 1993 versions 10.6f of SAC and 5.0a of MAP are available. Those who are familiar with SAC will find the following description (from Mandy Goldner of LLNL) of the upgrade of version 10.6f from 10.6d of interest.

> "In addition to several bug fixes, this version [10.6f] has the capability of operating on a subset of signals in memory instead of all signals which has been the mode in the past. We compare it to the file folders on the Macintosh. SAC allows you to copy, delete, group, name, and read files into these file folders (or data set as we call them). This is probably the best version we've had because Bill [Tapley] discovered several hidden problems when he ported it to the IBM which has a much more stringent compiler. ... I have recently added several new commands to the signal stacking subprocess module that facilitates plotting travel time curves over the signals. So far I've added the iasp91 model and a way for users to include their own travel time curves. This version also has a reduced travel time plot based on a velocity or a particular wave. It also plots error bars and alpha labels on graphs. ... Version 5.0a of MAP contains contouring, focal mechanisms and scalebars."

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IRIS Newsletter
1616 N. Fort Myer Drive, Suite 1050
Arlington, VA 22209-3019
Phone 703-524-6222 • FAX 703-527-7256
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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 (simpson@iris.edu)
Production Editor: Denise Dillman Crump (denise@iris.edu)

CALENDAR

JUNE

10-14 **Fifth Annual IRIS Workshop**
Waikoloa, Hawaii

SEPTEMBER

8-10 **PL/AFOSR/ARPA Seismic Research Symposium**
Vail, Colorado

OCTOBER

1-4 **National Survey for Seismic Protection International Conference**
Yerevan, Armenia

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

New Members

IRIS welcomes the University of Bristol, Bristol, England and the University of Cambridge, Cambridge, England as a new foreign affiliates. George Helffrick will be the representative liason on the Board of Directors for Bristol and Keith Priestley for Cambridge. •

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Future Plans for SAC

Plans are underway at LLNL to develop a new data analysis tool (SAC2000) which will build upon the expertise gained with the data analysis capabilities in SAC. SAC2000 will incorporate a new, more flexible data structure (i.e. an improved method for handling large, diverse data sets); a simpler, more flexible and user-friendly method for describing data manipulation and analysis functions; and modern visualization tools. The current version of SAC has a flat, inflexible data structure, primitive syntax, and largely non-interactive graphics. The new data structure will allow the user to handle not only data as objects, but measurements, commands, and macros as well. Filters will be included to convert existing data sets to be compatible with the new structure.

The new visual, graphical user interface, interchangeable with a command line interface will provide the user with the capability for:

- data organization including listing, selecting, scanning, editing, manipulating, and deletion of data objects;
- trace review, including the ability for cutting, windowing, overlaying, combining, augmenting, and rearranging data objects;
- and an improved graphical output

The command line interpreter will provide the capability for:

- subroutines and in-line function definition, including the ability to pass results directly from one command to another;
- macro and off-line batch processing;
- the capability for the capture of keyboard and mouse commands;
- and history and audit trail capability

Finally, SAC2000 will take advantage of the advances available in computer graphics and enhancement and provide improved graphical output, including:

- better Postscript compatibility with line styles and shading, and Postscript fonts;
- more complete export capability to software where post-editing can be done

The ultimate goal is to not just maintain or replace existing capabilities, but to seek innovation and new capability. The development schedule for SAC2000 is as follows: initial planning and design, summer 1993; testing of the new tool within LLNL, summer 1994; evaluation by users outside of LLNL and completion of documentation, early 1995. SAC200 will include the full complement of support including bug fixes, upgrades, and documentation. At present, the only platform being considered for SAC2000 is the SUN Workstation running SUN OS.

LLNL is fully committed to supporting the current version of SAC, in a minimal fashion, until the new tool is fully operational. While no new improvements are planned for the current version of SAC, effort will be made to fix reported bugs. •

the IRIS CONSORTIUM
1616 N. Fort Myer Drive
Suite 1050
Arlington, VA 22209

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