INSTITUTE FOR GEOPHYSICS
THE UNIVERSITY OF TEXAS AT AUSTIN

Memorandum December 30, 1994

To: Dr. Paul Stoffa, Director

From: Kirk McIntosh

Subject: Request for student training support for Costa Rica OBS Project

1) STATEMENT OF REQUEST:

With this memorandum I request student training salary support and other permissible expenses for Faruq Akbar, Carlos Calderon, and Alison Teagan to participate in our NSF funded project "Investigation of Upper Plate Response to Subducting Plate Morphology and Seamounts as Subduction Zone Asperities: Cooperative German, Costa Rican, and United States Project". These three graduate students are expected to participate in the scientific cruise aboard the R/V *Maurice Ewing* in the area off the Pacific coast of Costa Rica from 27 March to 21 April, 1995. Support is requested for Akbar during the period January through August, 1995, for Calderon during March through August, 1995, and for Teagan for the duration of the cruise only.

2) EXISTING SUPPORT

The NSF grant includes two full years of graduate student salary support plus tuition and fees. This funding is expected to support Akbar who will contribute significantly to the post cruise data processing and interpretation. All travel and computer expenses and research related materials and supplies will be paid by the NSF grant.

3) STUDENT TRAINING ACTIVITIES

The field work will consist of participating in the scientific cruise aboard the R/V *Maurice Ewing*. The specific activities during the cruise will include monitoring navigation equipment, single channel seismic data and gravity data acquisition, and assisting in the deployment and recovery of ocean bottom seismographs. The students may also participate in preliminary data processing and data transfer to tape. After the cruise Akbar and Calderon will work on processing algorithms to create 2D and 3D migrated images from the OBS data set. After the cruise, Teagan expects to do additional work on previously acquired MCS data from the Costa Rica area; this will be complement the work of Akbar and Calderon.

4) DELIVERABLES FROM THE STUDENTS

Shortly after the cruise the students will submit a report describing their training experience. By August 1995 Akbar and Calderon should have developed or modified algorithms to produce migrated images from OBS data. We would like to have a preliminary version of the 3D migration by the end of August. Continued work on the migration techniques and data processing and interpretation of the Costa Rica OBS data will likely be an important part of Akbar's Ph.D. thesis project. Akbar is ultimately expected to describe the results of this work in a manuscript for publication and in his thesis.

INSTITUTE FOR GEOPHYSICS
THE UNIVERSITY OF TEXAS AT AUSTIN

8701 North MoPac Expressway • Austin, Texas 78759-8397 • (512) 471-6156 • Fax: (512) 471-8844
Internet: utig@utig.ig.utexas.edu • Omnet: UTIG.AUSTIN

October 18, 1995

Dr. PaulS. Stoffa
Director, Institute for Geophysics
The University of Texas at Austin

Dear Paul:

As you know, the TICOSECT cruise went very well. The students involved in this cruise, Faruq Akbar, Carlos Calderon, and Alison Teagan, were interested participants and all performed very well at their assigned tasks. It is clear that after years of work in the classroom and lab this cruise opened their eyes to the realities of data acquisition and the broader realm of geophysics.

Alison worked as a watchstander and did preliminary processing of the 2 channel reflection data that we recorded. This cruise provided her an opportunity to learn about OBS operations to supplement her experience with multichannel data acquisition.

Carlos also worked as a watchstander and worked with Alison on the 2 channel data. This was his first cruise, so he learned a great deal about the many facets of data acquisition. Since the cruise Carlos has worked with Faruq to develop a method of creating 3D migrated images from the OBS data. This work is at the leading edge of wide angle seismic data processing technology.

Faruq performed as the designated assistant to Yosio Nakamura and Glen Caglarcan. He was very effective in testing and repairing the OBS instruments prior to the cruise, and he assisted very well in preparing the instruments during the cruise. As a result Faruq has received a very good exposure to geophysical instrumentation. Faruq also was an interested observer in all aspects of the shipboard operations leading to a very positive experience. As noted above, Faruq has worked with Carlos since the cruise to produce images from the OBS data.

During the cruise a variety of UTIG researchers were involved in supervising the students. Gail Christeson was the watch leader whose team included Alison and Carlos. Yosio Nakamura was Faruq's sole supervisor. Tom Shipley and I both helped Alison and Carlos with the 2 channel data.

My summary assessment is that the three students gained very useful experience that they would not have without going on the cruise. For Carlos and Faruq in particular it has given them direct exposure to all aspects of this data set and additional motivation and insight to develop the imaging methods.

Sincerely,

Kirk D. McIntosh

Kirk D. McIntosh
Reasearch Associate

EW9502 Offshore Costa Rica Cruise

A cruise Report by

Faruq E. Akbar

The University of Texas at Austin

Introduction

A seismic experiment was conducted during the month of March-April, 1995 by the UT Institute for Geophysics in collaboration with German and Costa Rican scientists to record seismic signals using a large airgun source, ocean bottom instruments (seismometers and hydrophones), land instruments and shots fired on land to obtain both wide angle and near verticle seismic data. I participated in the marine experiments conducted in offshore Costa Rica on board the RV Maurice Ewing . Ocean-bottom seismometer data were collected along three portions of the Middle America Trench in offshore Costa Rica. The objective of the experiments was to investigate the subduction of the Cocos plate beneath the Caribbean plate. One of the experiments was a survey over a smooth segment of the Cocos plate while another was designed to investigate the seamount dominated segment of the Cocos plate. Yet another experiment involved the investigation of the Cocos ridge subduction and its deformation effects on the Caribbean plate.

In the second experiment, 30 Ocean -bottom instruments (seismometers or hydrophones) were deployed in a gridded pattern within a 35 X 15 sq. km area above the site of the 1990 Cobano earthquake (Mw = 7.0). The data collected in this experiment will be used to image the plate boundary. A 3-D Kirchhoff prestack depth migration technique will be used to fulfil this objective. We expect that the depth migrated image will prove that seamounts on the subducting plate may be nucleation sites for earthquakes or asperities.

Pre-Cruise activities

Prior to the cruise, I worked with Phil Roper to assemble the Ocean-bottom instruments. This involved inspection of the glass spheres for any damage of their surfaces or any corrosion in the feed-through terminal ports. The resistance of each feed-through wire was checked and was replaced whenever it showed a resistance greater than 1 Ohm . Vacuum port gaskets were inspected for damages and each rubber pad was inspected and replaced if needed. The straight flat cable in each sphere was replaced by a twisted-pair flat cable and the new cable was connected to the hydrophone. Geophone package fluid levels were inspected for any leaks. The output of each geophone was connected to an oscilloscope and the signal observed by lightly tapping on the sphere in the sensitive direction of the geophone and new geophone packages were built and installed the for new glass spheres. 12- or 16- volt battery packs wereconnected to the strobe lights to test them for proper flashing and all faulty strobes were replaced. Thinner, alcohol and acetone were used to carefully clean the mating surface of each glass hemisphere.

My participation also included helping Dr. Yosio Nakamura and Glen Caglarcan in preparing the OBS chassis which includes CPU board, memory board, A/D converter board, SCSI interface, preamplifier/filter, data recorder and power relay board. In the preparation phase, a recording schedule (shot table) was initially created on a Macintosh. All circuit boards were installed inside the card cage in the following order (from top to bottom) : the CPU board, the RAM board, the SCSI board, and the ADC board. One slot between the SCSI board and the ADC board was left open to reduce the possible interference to the ADC board from other boards. All ribbon-cable connections and power cable connections were checked. After checking the necessary battery connections, the instruments were prepared through a communication software on the Macintosh following the step by step procedure provided by Dr. Yosio Nakamura. The same procedure was followed for every OBS and any faulty parts were repaired or replaced. I also participated in building and installing filter blocks (30 Hz low pass) for all OBS's and in building and installing alkaline battery packs, installing 200 Mbyte and 500 Mbyte disk drives, cleaning preamplifier boards in addition to preparing the OBS chassis.

On Board activities

The OBS spheres and chassis along with other equipment arrived in Panama on March 22. These boxes were loaded on the ship and unpacked and a laboratory was set up in the ship. In this laboratory OBS's were assembled and a pre-deployment check list was worked out. For each instrument, the OBS chassis was installed in the bottom glass hemisphere with a rubber pad and secured with screws. All connections were checked and an oscilloscope was set up to observe sensor outputs. Hydrophone preamplifiers were connected and the mating surfaces of each hemisphere were cleaned and dried. Upon connecting the strobe cable, the two glass hemispheres were put together and sealed with a butyl rubber tape and a 2 inch wide vinyl tape. Humid air was purged from the glass sphere with dry-nitrogen and finally two stainless steel straps were tightened on the outer surface of the sphere. The sphere was put in an yellow protective hat and secured with straps. Before the installation , a hydrophone (if necessary) and a release wire were connected.

During the field program, UTIG conducted three experiments. All the OBS's were dropped and recovered by UTIG personnel. In the first experiment , UTIG scientists dropped 10 OBS's between 3/29/12:30:31 and 3/29/19:16:23. The water depths at these deployments varied from 62 m to 4068m. These 10 OBS's were recovered between 3/31/21:23 and 4/3/04:17. In the second experiment, 22 OBS's were dropped. The depths of deployment varied from 83m to 1204m. These depths were considerably less than those for the first series of deployments. The deployments began at 4/5/00:59:51 and finished at 4/5/12:56:30. After 8 days of shooting, the OBS's were recovered between 4/15/09:06 and 4/15/04:42. For the third experiment, 12 OBS's were deployed. The depths of deployment varied from 2216m to 52m. and the deployments were made between 4/16/17:31:30 and 4/17/00:56:58. The recovery began at 4/19/00:07 and ended at 4/20/03:04. The OBS at Station-94 could not be recovered but was later found and returned by local fishermen .

Post cruise activities

Imaging of Costa Rica OBS/H Data

Currently, I am working on a 3-D Kirchhoff depth migration code for imaging the data collected in the second experiment of the Costa Rica cruise. Given the volume of the data and image space, a scheme for very fast travel time calculation in a gridded model was essential. We have used a simplified ray tracing technique to compute travel times that is valid for smooth velocity functions. We use a linear interpolation scheme to construct gridded travel times in depth slices and we can therefore migrate the data on a slice by slice basis. This scheme considerably reduces the computation time and if the data organization is in shot gathers and the data are kept on disk, the computation time can be further reduced by asynchronous I/O that actually hides the traveltime computation time under the time it takes to read the data from the disk to memory. The migration code will be suitable for use on local workstations and on a CRAY at the Center for High Performance Computing (CHPC).

Conclusion

Durin this cruise , I have learned about the mechanical aspects of a seismic experiment. and team work involving assembling, deploying and recovering the instruments. I have also learnt about importance of navigation, scheduling and many other realisties in an experiment. I have learned the importance of good instrumentation in the acquisition of good quality data.

My involvement with the 3-D imaging group has helped me in understanding many real world problems about computation and memory requirements. We have designed the algorithm to use the limited resources available to get the best possible image within a limited time. We expect the code to be suitable for running on both local workstations and on a CRAY.

STF

EW9502 Offshore Costa Rica Cruise

A Cruise Report by

Carlos Calderón-Macías

The University of Texas at Austin

Introduction

During the months of April and May of 1995 we recorded air gun signals generated by the *R/V Maurice Ewing* using ocean bottom seismometers and hydrophones (OBS/H). The data were collected offshore Costa Rica along three portions of the Middle America Trench. In addition to the marine source array used for the experiments, wide aperture seismic data were also collected using land shots. The main goal of the Costa Rica experiment is to study the subduction of the Cocos plate beneath the Caribbean plate. Wide angle data will help to construct a crustal velocity model that later will be used for processing purposes of near vertical OBS/H data. The processing and interpretation of the seismic data include the study of first arrivals using tomographic methods, and also, the use of seismic reflection techniques to enhance the signal to noise ratio.

Three experiments were designed to investigate the response of the Caribbean plate, the upper plate, to different morphological segments of the subducting plate. The area studied in the first experiment corresponds to a smooth segment of the Cocos plate. This survey is expected to image the velocity structure from the trench to beneath the central portion of the Nicoya Peninsula. The second experiment investigates a seamount dominated segment of the subducting plate and corresponds to the location of the 1990 Cobano earthquake. The main interest of this experiment is to test the idea that subducting seamounts act as asperities that serve as earthquake nucleation sites. The last experiment is designed to investigate the Cocos ridge subduction and its deformational effects on the Caribbean plate.

In particular, the setup for the second experiment in which a total of 30 instruments were deployed in a grid pattern, is a very challenging part of the project that has never been tested before. The data acquired within the grid will be processed with a 3-D pre-stack migration method that will make use of the redundancy of the data. We expect that the final subsurface image obtained from the velocity model produced by tomographic methods and from the pre-stack algorithm, will be paramount in the relocation of earthquake hypocenters. Figure 1 shows the location of the experiments, and Figure 2 shows the details of the source-receiver geometry for Experiment II.

Field Activities

Two different ocean bottom seismometers were used for the experiments. The University of Texas, Institute for Geophysics (UTIG) instruments carry three geophones and one hydrophone and can record up to 500 megabytes of data. The UTIG instruments are deployed with a disposable anchor frame, and are released from the frame at a preprogrammed time. To make the retrieval of the instruments easier, we usually made the recoveries at night. Radio beacons and flashing strobes accommodated inside the capsule, aid in the intrument recovery. The second type of instrument, provided by the German group (Geomar), use a hydrophone as the only sensor. The release system of the Geomar instruments, different to the UTIG instruments, uses an acoustic signal produced from the ship through a transponder. In all three experiments, both types of instruments were deployed for the data acquisition. Some of the instruments were refurbished for re-deployment during transit between experiments.

A powerful marine source array with 20 air guns with a total capacity of 11,400 cubic inches, were fired as often as 50 meters (19 seconds during Experiment II at 5.1 knots). Wide aperture data were also acquired by firing land explosives. The data were recorded using 5 milliseconds of sampling rate. A very precise navigation for shot locations in real time was required throughout all the experiment. This was achieved with a differential GPS system.

In all three experiments reflection as well as refraction data were recorded by the OBS/H instruments. Experiments I and III had a similar shot-receiver geometry: A long dip line intersected by 3 shorter strike lines (Figure 1). The setting for Experiment II consisted of 30 instruments deployed in a rectangular area with 37 dip lines of 35 km distance each, and 5 strike lines of 37 km distance each (Figure 2). The separation distance between dip lines was 0.250 km, and between strike lines was 5 km. The horizontal distance between instruments is 5 km along dip lines, and 1 km along strike lines. A single dip line consists of approximately 700 shots. Considering all shot lines, each instrument recorded approximately 26,800 shots inside the rectangular box. We spent 7 days of shooting in this area for a total distance covered by the ship of 1,340 km inside the box.

The accuracy of measurements for shot and receiver locations was crucial due to the resolution of this experiment. In few occasions the ship had to change the direction during the shooting of a line to avoid getting too close to shrimpers. For this reason, at the end of the survey small portions of lines were reshot. An outstanding fact from this experiment was that 29 instruments recorded the complete experiment, and one 3/4 of the experiment before it was dragged and captured by a shrimper.

I participated in the third scheduled watch-standing team. Our job during this period was to make sure things worked properly in the seismic laboratory. We reported in short periods of time navigation information such as geographical coordinates, speed of the ship, water depth, occasionally ship turns, and the starting and termination of a shooting line. Our busiest time occurred during the deployment and recovery of the instruments. In particular, there is a lot of expectancy during the recovery of the instruments. The time at which an instrument appears on the surface is calculated based on the water depth, and in general, Geomar instruments were easier to predict due mainly to their system of release. Once an instrument is visible, it can take from 10 to 30 minutes of maneuvering before the instrument is on deck.

Once an instruments is captured, the data stored in the hard disk of the OBS/H instrument are transferred to exabyte tapes. The data are preprocessed in the field using the OBS-Tool which outputs the data in the SEG-Y format. The data are saved with a reduction velocity of 8 km/s, plus 0.5 seconds of constant time shift. The time corrections that result from this transformation are recorded in the SEG-Y data headers.

As part of my activities, I participated in the processing of two seismic channels that were also collected for all the experiments. The streamer used for the experiments had a total length of approximately 310 meters, with the recording channels around 200 m of horizontal distance to the source array. We applied basic processing steps for near vertical incidence data: Frequency filtering, seismic deconvolution, stacking, and constant velocity migration. During the trip, we were able to organize and transform all the reflection data from 3480 magnetic tapes written in SEG-D format to exabyte tapes using the SEG-Y format. The transformation, data organization and processing were done using the Sioseis software. We were able to process all the data acquired during the first experiment. We made an initial interpretation of the shallow structure. We identified normal faulting in shallow sediments, and the top of the downgoing slab from the trench to the shelf edge. The main objective of acquiring reflection data during the trip was to help in the interpretation of shallow events in the OBS/H data.

Processing of Costa Rica OBS-Data : Area II

After the Costa Rica cruise, I have been involved in the processing and interpretation of the OBS/H data acquired in Area 2. I have worked with preselected UTIG OBS instruments in order to improve the signal to noise ratio in the data. One of the objectives of the preprocessing is also to help identify reflecting events previous to applying a 3-D prestack migration process.

I tested different processing methods using the pressure component for two OBS's to remove the direct wave arrival: trace mix and filtering in the frequency wavenumber or

FK domain. All processing tests were performed using the Geovectour software. Figure 3 shows a pressure component for one OBS. Figures 4a and 4b show a comparison of results when using trace mix and FK filtering. Both processes are successful in removing the energy related to the direct wave, but FK gives clearly better results. Nevertheless, FK filtering introduces artifacts for offline shots in which shallow events have a similar moveout than the direct wave. A bandpass filter followed by a simple 3-trace mix could serve as the preprocessing of the data previous to the application of a 3-D migration process.

The objective of the 3D OBS experiment is to obtain an image of the top of the subducting slab, and to confirm whether there is a seamount acting as an asperity beneath the Cobano epicenter. Due to the size of the data acquired in this experiment, and the size of the image volume, it is important to design a 3-D pre-stack migration algorithm that will process the data in a reasonable amount of time making the best possible use of the available computer resources that we have at hand. We have been working towards this aim, to produce a code that will perform the migration algorithm based on a local network of workstations at UTIG, and a Cray Y-MP from the Center for High Performance Computing (CHPC). The migration algorithm that we are developing is a 3-D Kirchhoff based scheme. Travel-times are generated using a simplified and very fast 3-D ray tracing method which considers small lateral velocity variations. Figure 5 explains the principles behind the 3-D pre-stack migration Kirchhoff based scheme. The velocity model that will be used for the pre-stack migration will be obtained from tomographic inversion and interpretation of the of 2-D lines that conform the grid, and from previous works.

Summary

As part of the research party in the Costa Rica cruise, I have had the opportunity to learn about the design, adcquisition, processing and interpretation of wide angle as well as near vertical incidence data. The Costa Rica cruise was a complete experience in terms of acquisition of seismic data since it involved a lot of synchronous work in real time between recording instruments and onboard operations. We were also able to do some preprocessing and organization of the data using the computer resources from the seismic lab of the *R/V Maurice Ewing*. We produced a seismic section based on the two seismic channels that we collected that helped to locate the OBS/H instruments for an initial data interpretation.

The processing and interpretation of OBS data is a new experience for me. We have been applying different processing algorithms in order to enhance the signal to noise ratio of the data. We have been studying ways in which we can simplify the 3-D problem of Experiment II in order to better identify reflecting events. We are looking also for ways in wich we can perform the 3D pre-stack migration algorithm in a reasonable amount of time. We have advanced a code that will run on workstations as well as on a Cray super computer that optimizes memory and computation time.

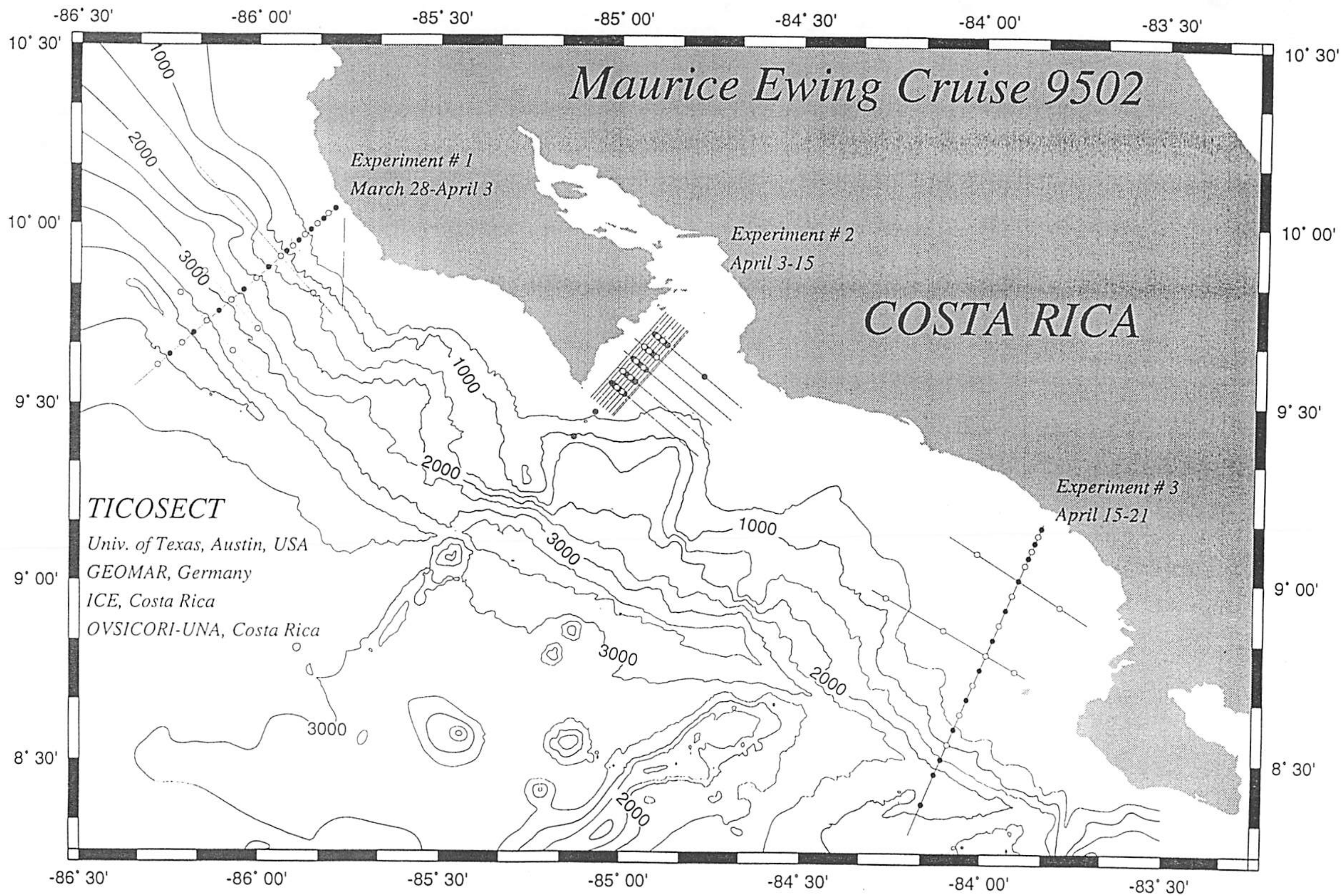

Figure 1. EW9502 offshore Costa Rica cruise. Test location sites and bathymetry of the area.

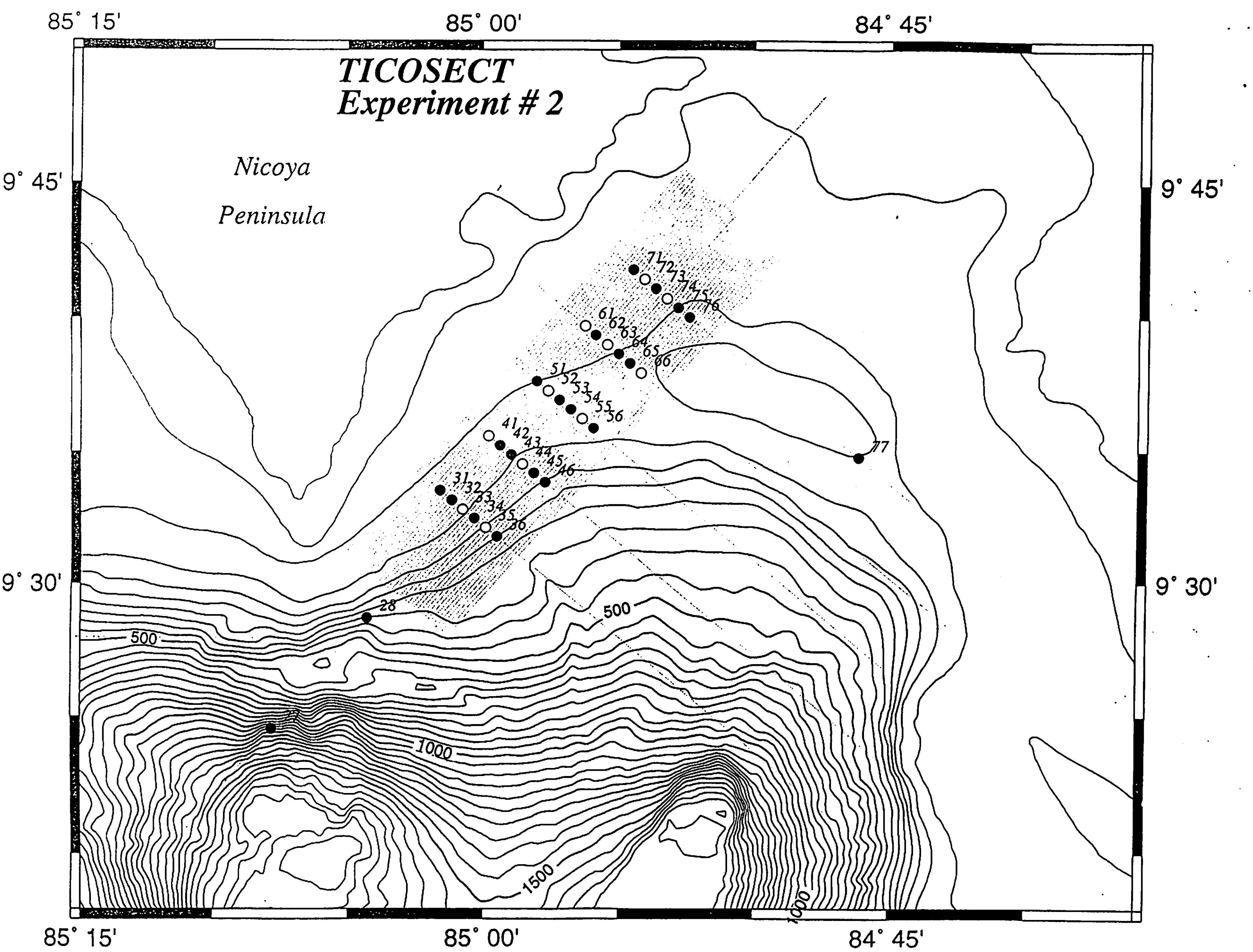

Figure 2. Source-receiver geometry for Experiment II. A total of 33 OBS instruments deployed in the area recorded 42 seismic lines of shooting.

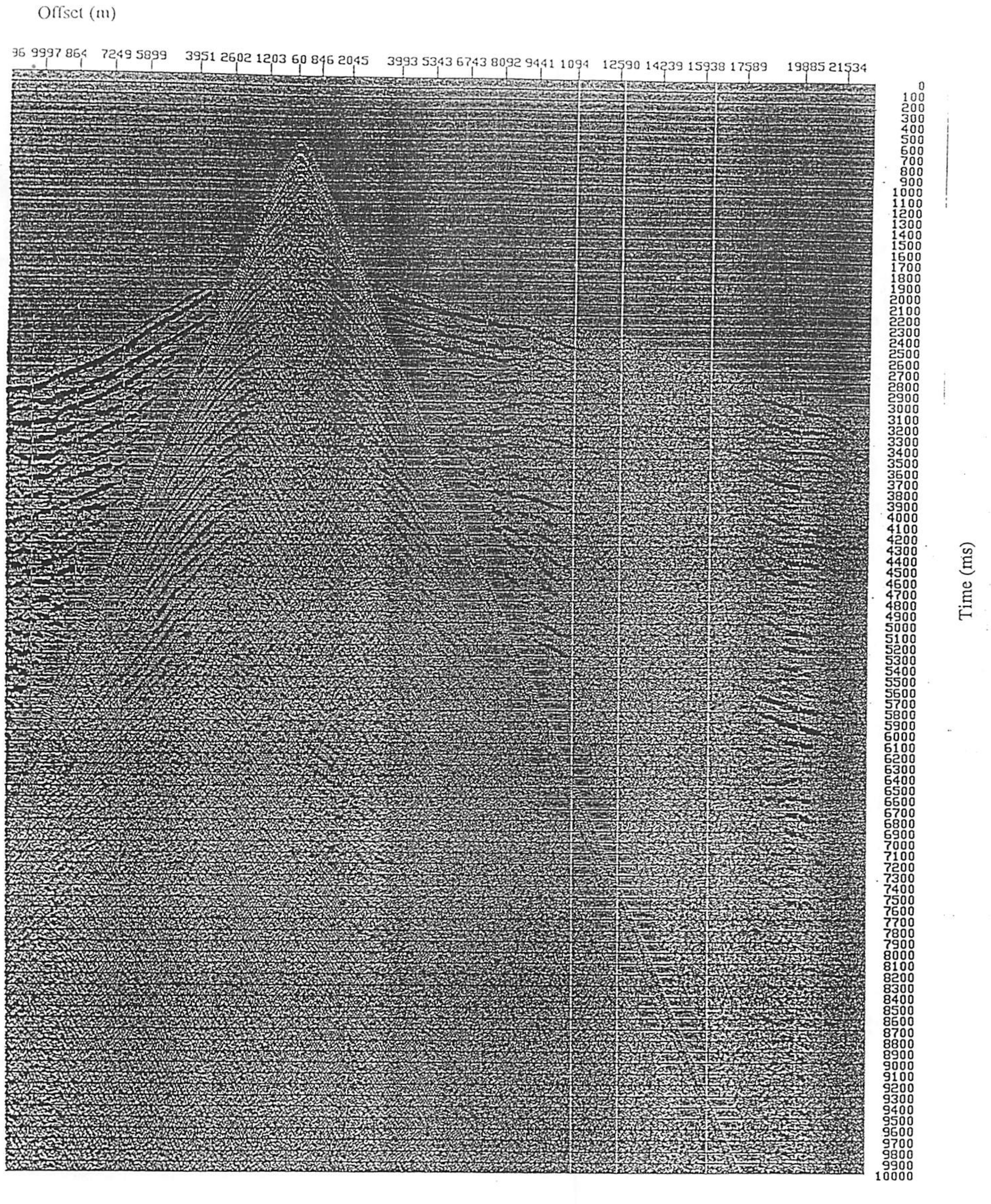

Figure 3. Pressure component receiver gather for OBS 46 and line 229.

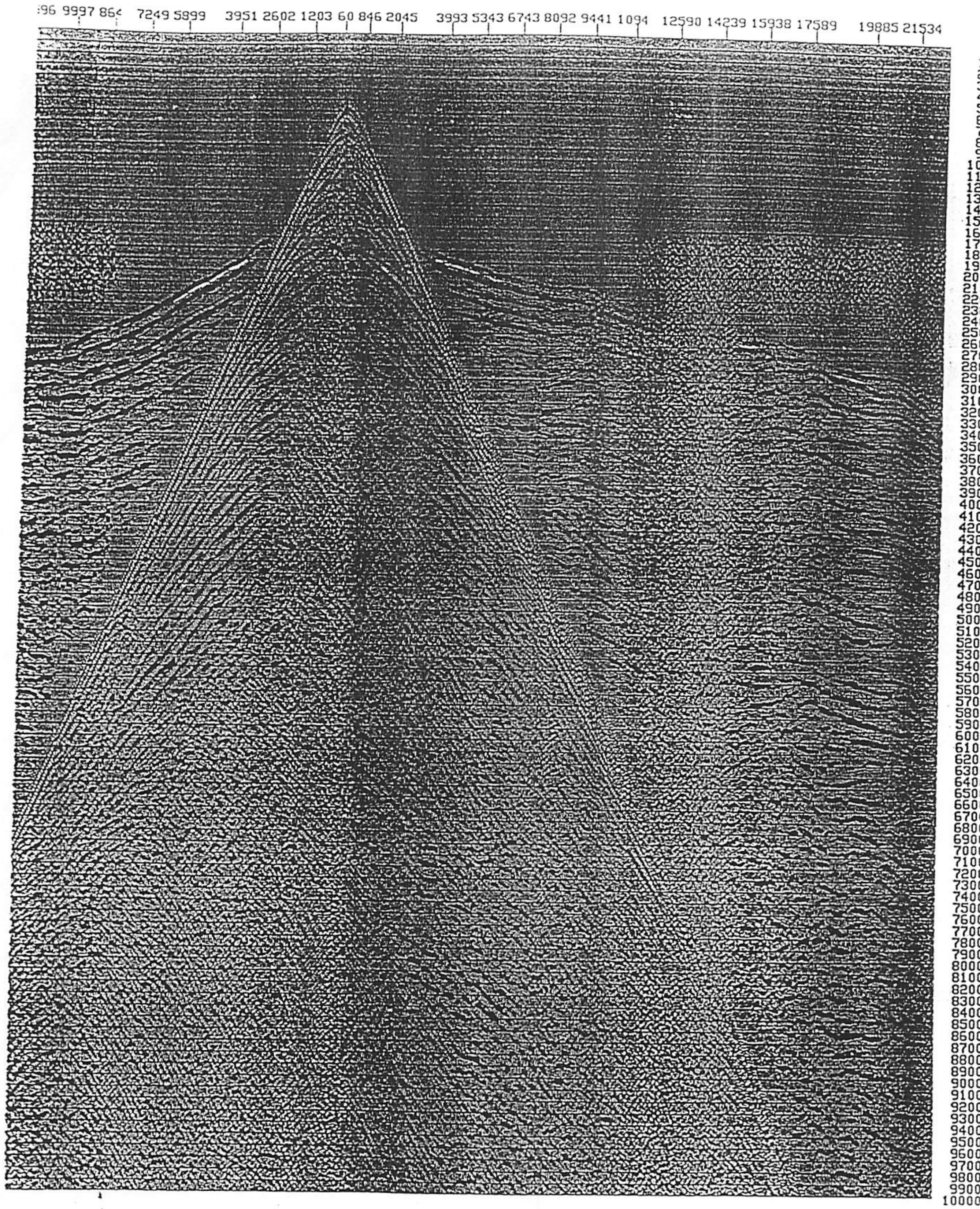

Figure 4a. OBS 46 line 229. A bandpass filter and three-trace weighted mix have been applied to the data to remove the direct wave arrival.

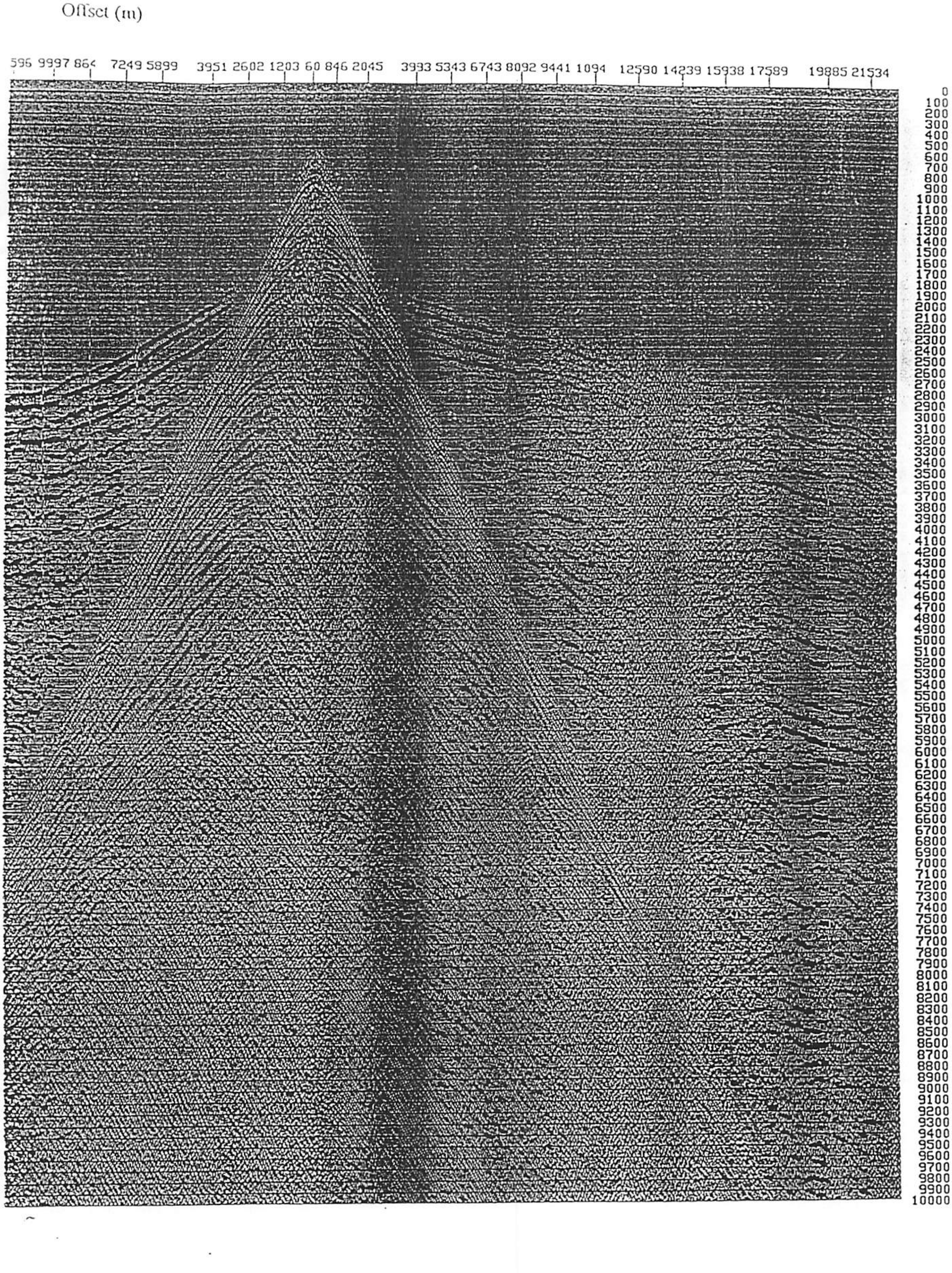

Figure 4b. OBS 46 line 229. A F-K filter has been applied to the data to remove the direct wave.

3-D Migration for single shot and single receiver

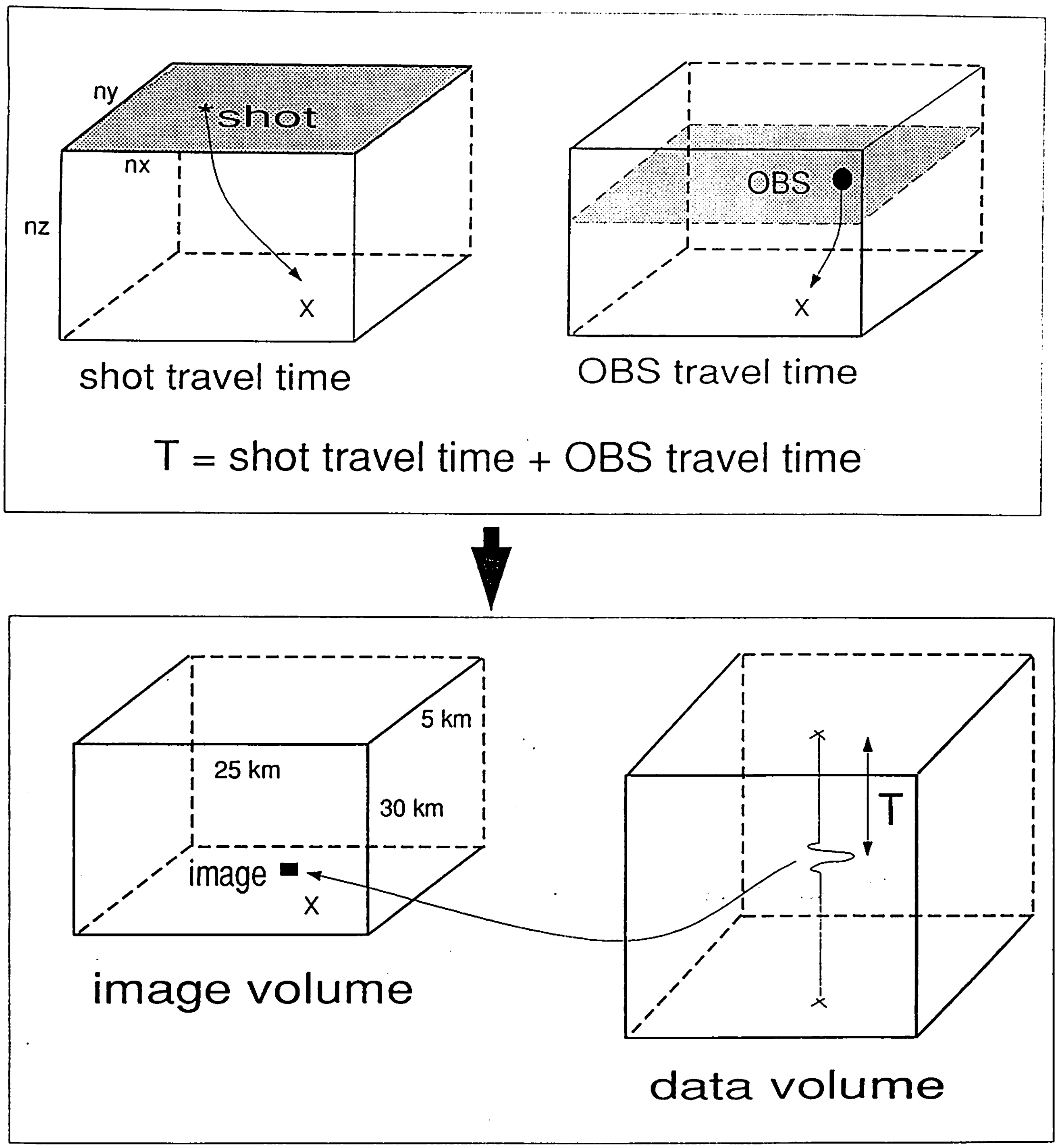

Figure 5. Principles of the 3-D prestack migration algorithm. A shot and receiver traveltime cube is constructed in order to produce a depth image volume.

Student Cruise Report: EW9502 Offshore Costa Rica

Alison Teagan

6/21/95

Introduction

In March and April of 1995, I participated in a research cruise offshore Costa Rica onboard the *RV Maurice Ewing*. The Pacific margin off Costa Rica consists of a 575 km section of the Middle America Trench. It is a convergent margin, where the Cocos plate is subducting under Central America at a rate of about 9 cm/yr. The purpose of the cruise was to investigate the upper plate response to subduction. The study area was designed to cover three subducting crust segments: the smooth segment, the seamount-dominated segment and the Cocos Ridge segment. Ocean bottom instruments were used to record refraction data in three separate experiments.

Method

The Ewing carries 20 air guns, which we used for our seismic source. Its maximum capacity is over 8000 cubic inches. We collected two channels of seismic data in each of the three locations. The streamer used was approximately 300 meters in length. However, the main aspect of the survey was the use of University of Texas ocean bottom seismometers (OBSs) and German ocean bottom hydrophones (OBHs). The OBSs record pressure and ground displacement, while the OBHs record only pressure data.

Objectives

The overall goal of the survey was to investigate the upper plate response to the three different types of subducting crust. The main focus was on the seamount-dominated segment of crust. One of our experiments was located above the site of the 1990 Cobano earthquake (Mw=7.0). It has been suggested that a subducting seamount caused the earthquake and we were investigating this theory. For this experiment, over thirty ocean bottom instruments were deployed in a three-dimensional grid above the earthquake site. We then shot 37 dip lines and 5 strike lines over the instruments. The dip lines were spaced 250 m apart so that 3-D processing could be performed on the data.

Watch-standing

I acted as a watch-stander during the cruise. Each day was divided into three 8-hour shifts, with three watch-standers in the main science lab during each shift. Our primary function was to make sure things were running smoothly and to help out when needed. We were busiest during instrument deployment and recovery. I worked the midnight to 8 AM shift, so I was involved with the recoveries.

The Texas instruments were deployed off the back deck of the ship. The instrument, attached to its anchor, was hoisted off the deck and maneuvered over the water and dropped. The bridge, the back deck and the science lab remained in constant contact so that the instruments were deployed at the correct locations. The locations and times were recorded in the science lab. Each instrument was programmed to release from its anchor and float toward the surface at a predetermined time. The time of its appearance on the surface could then be calculated based on water depth. The Texas instruments were equipped with strobe lights and radio beacons to identify them once they reached the surface. They were programmed to come up at night because the strobe was easier to see at night.

The German instruments were deployed off the waist deck of the ship. The instrument was lowered into the water, where a final test of its release transducer was performed. The German scientists on the ship were able to "talk" to the instrument. Instead of programming the instruments to "pop up" at a certain time, the German scientists released their instruments using sound transmissions. The German instruments were also equipped with strobes and radio beacons. They were not necessarily released at night because they had large orange flags attached to them that made them easier to see during daylight hours.

The German scientists took care of their instruments, so as a watch-stander I was primarily involved with recovering the Texas instruments. The first step in the recovery was for the ship to approach the position at which the instrument was deployed. Then, we listened for the radio beacon that indicated that the instrument was on the surface. Next, we looked for the strobe. Once the strobe was in sight, the ship maneuvered toward the instrument and attempted to approach within several feet at a very slow speed. A person with a large net on a long pole was positioned at the waist deck to scoop up the instrument as it passed. The net was then hooked onto a rope connected to a pulley and the instrument was hoisted aboard. Then the OBS specialists went to work, examining the instrument and recovering the data it collected.

One of the most impressive aspects of this process was maneuvering the ship alongside the instrument. The ship is over 200 feet long and its steering controls are somewhat sluggish at low speeds. The OBSs were only several feet in diameter and were carried along by the waves. Yet the ship approached the instruments successfully on the first attempt most of the time.

Onboard Processing

When we were not deploying or recovering instruments, I worked on the seismic reflection data that we collected. We collected two channels, with offsets less than 200 meters. The cruise consisted of three experiments. Two of the experiments consisted of several strike and dip lines.

The 3-D experiment consisted of 37 dip lines and 5 strike lines. Data were continuously recorded, not only on lines, but during transits and turns as well. The data were recorded on 3480 magnetic tapes. Each tape contains approximately 1000 shot points. Our first step was to identify the beginning and end of each line on the tapes according to GMT times recorded in the log book. Then, we extracted the lines and stored them on an exabyte tape. This was a long process, but it was completed before the cruise was over.

While we were extracting the lines, we looked at some of the data. Much of it was recorded in shallow water and the source produced a significant amount of noise. Deconvolution, stacking of the two channels, filtering and migration processes were applied to the data in order to improve the image. We hoped to come up with a processing sequence while onboard, so that the data could be processed quickly when we returned home.

Conclusions

I learned a great deal about the recording of seismic data during this trip. Since I was involved in extracting the seismic lines from the magnetic tapes, it was important for me to understand how the recording system performed. I have worked mainly with the processing aspect of seismic reflection data, so learning more about the acquisition process was very useful. By viewing the data immediately after it was recorded, I discovered that quality control is an important part of seismic data surveys. Many of the lines contained small gaps that must be correlated with navigation information and shot times. This was the first time I looked at shallow water seismic data and I observed the strong ringing from the seafloor. We experimented with deconvolution to remove this effect.

I also learned about refraction data. I looked at the plots of data from individual instruments and learned to identify the direct arrival, the head waves and the reflections. Understanding the concept of refraction gives me a fuller understanding of the overall seismic exploration method.