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CHIEF SCIENTISTS' CRUISE REPORT

Ocean Bottom Instrument Package Measurements, Bottom Sampling, and Subbottom Profiling: Northeastern Gulf of Alaska

CRUISE II, LEG II, RP-4-SU-79B

INTRODUCTION

General

The U.S. Geological Survey (Office of Earthquake Studies) in Menlo Park, California, presently maintains a land based network of seismic stations in southeastern Alaska. Earthquakes occurring beneath the continental shelf and slope are subject to location errors because of their distance from these land stations. Although observed seismic activity has apparently decreased since 1974, it is possible that small earthquakes are continuing to occur offshore in this structurally complex region. The potential for larger earthquakes also requires more detailed evaluation. Detection and analysis of these seismic events could significantly contribute to our understanding of the transition zone between the Fairweather Fault and the Aleutian Trench. Accurate spatial and temporal data on these earthquakes would also permit a more accurate assessment of the seismic hazards to man-made structures in the northeast Gulf of Alaska (NEGOA).

An array of ocean bottom seismometers (OBS) would allow accurate location and magnitude information to be collected for these offshore seismic events. Accordingly, the U.S. Geological Survey (Atlantic-Gulf Branch of Marine Geology, Woods Hole) built five ocean bottom instrument packages (OBIP) to gather data on the natural seismicity in the NEGOA area during the period July to September 1979.

These fully digital data acquisition systems provide two data channels (vertical and horizontal seismometers) with 120 db dynamic range. Inputs go to a seven track digital storage recorder with a capacity of 4×10^8 bits; a sampling frequency of 125 Hz gives a continuous recording lifetime of 18 hours. Time is recorded once per second as days/hours/minutes/seconds from the start-up time which is referenced to a master clock and WWV.

The OBIP may be programmed to turn on at specific time windows for seismic refraction operations, or it may be set to operate in the event detection mode for long term seismicity studies. In the latter case, recording begins only upon detection of an event and continues until the signal falls below the preset threshold levels for 15 seconds. This insures complete detection of the total seismic event with minimum tape usage.

The OBIP is housed in a 20-inch aluminum pressure sphere having a depth rating of 1000 meters. The sphere contains the tape recorder, geophone sensors, battery packs, acoustic release receiver, and associated electronics. Recovery aids fastened to the outside of the sphere consist of a radio beacon and flashing strobe. Total weight of the instrument package is 100 pounds. The sphere is attached to a 260-pound concrete mushroom anchor designed for optimum acoustic coupling in mud and silt bottoms. A metal ring with three protruding legs (embedment spikes) is attached to the anchor to improve coupling in hard sand or gravel. The instrument package is held to the anchor by an acoustic release bolt and an elastomeric spring with a preload of 400 pounds. For recovery, a coded acoustic command is used to release the sphere from the anchor. The instrument package is then located on the surface by visual recognition and a radio direction finder tuned to the OBIP's beacon.

Participating Scientists

The scientific party on the 19-27 July cruise of SURVEYOR consisted of:

Mr. Bruce Ambuter	USGS, Woods Hole
Mr. Ray Davis	USGS, Woods Hole
Dr. Mark Holmes	USGS, Seattle
Mr. Joe Edwards	USGS, Menlo Park

PROJECT OBJECTIVES

The general objectives of the program are: 1) to detect and locate earthquake activity in the NEGOA, 2) to obtain measurements of seafloor accelerations accompanying both strong and weak earthquakes, and 3) to demonstrate and evaluate the effectiveness of the USGS OBIPs when used in the seismic refraction mode.

The offshore OBIP array was designed to complement the land station network operated by the U.S. Geological Survey. Magnitude and acceleration data on offshore earthquakes in the NEGOA are essential for deriving meaningful criteria for the design, maintenance, and operation of all man-made structures cited on the continental shelf.

Seismic refraction measurements at sea, normally made using free-floating sonobuoys, are necessary to determine the compressional velocity structure of the rock strata beneath the sea floor. These data in turn are vital for accurate interpretation of seismic reflection data obtained in the course of environmental hazard and resource assessment studies on the continental margins. Use of ocean bottom seismometers to collect refraction data would permit the use of arrays which would not be subject to drift during the experiment. Improvement in signal/noise ratio and raypath geometry should also be expected. An evaluation of the OBIPs for use in this mode was therefore an important part of this program.

SUMMARY OF OPERATIONS AND RESULTS

Preliminary Noise Tests

The first phase of the study commenced on 20 July 1979 with the launching of two OBIPs to measure ambient noise levels in the area of final array deployment. One unit was placed in shallow water (157 m) and one in deep water 256 m). Previous investigators working in different geographic areas encountered what they interpreted to be high levels of biologically generated noise on the continental shelf (depths less than 200 m). The results of our noise tests were encouraging, showing low ambient noise levels at both sites; at least two seismic events were detected during the nine-hour recording period. All subsequent OBIP deployments had system gains based on the results of these initial deployments.

Seismic Refraction Experiment

The seismic refraction program consisted of two reversed refraction lines 50-km long, with an OBIP located 10 km in from the ends of each line. The refraction lines were located near previously obtained multi-channel seismic reflection lines. The sound source for the refraction experiment consisted of two 466 cubic inch air guns operated at 2000 psi. Firing rates were once every 32 seconds on one line and every 28 seconds on the other; ship speed was 5.5 knots and fixes were taken every 5 minutes.

The first refraction line had to be repeated due to a minor instrument malfunction. It was also discovered that time synchronization between the OBIPs and the master clock had been lost. The reason for this was discovered shortly after commencement of the next refraction line. Interference from SURVEYOR's radio transmitter was causing misfiring of the air guns and loss of time sync. These problems were completely eliminated by maintaining strict radio silence during all future OBIP deployments. Preliminary examination of some of the refraction data displayed on a wiggle trace recorder showed low noise levels and strong refracted and reflected arrivals. Complete playback of the data on a seismic section recorder and detailed velocity analyses will be made after the cruise.

Deployment and Recovery Operations

All deployment and recovery operations went very smoothly. It took no more than 10 minutes to assemble and deploy each OBIP using the small davit on the starboard side of the main deck. Recovery was accomplished using either the 21 foot Boston Whaler or the larger motor rescue launch. Calm seas and SURVEYOR's excellent navigation combined to make recoveries rapid and routine. The RDF system did not work as well as expected, giving accurate bearing information only when the OBIP was on the ship's starboard bow.

OBIP Site Surveys

Concurrently with the noise tests and refraction work, detailed surveys were conducted at each OBIP site prior to actual deployment. These site surveys consisted of obtaining 3.5 kHz bathymetry and subbottom profiling information, as well as a Shipek grab sample. All of the OBIP sites but one are underlain by silty clays of low to medium stiffness. The lone exception was situated on sandy gravel. Additional 3.5 kHz data were obtained throughout the survey area along 450 km of track in order to map the distribution of major sediment types and to determine the thickness of unconsolidated sediment. The site survey work resulted in relocation of two of the proposed sites at the edge of the continental shelf. One of these sites was on a steep slope, the other in an area of apparently active slumping. Alternate sites were chosen in areas where bottom slope and sediment type were favorable for OBIP deployment.

Seismicity Study

The last phase of the operation was the deployment of five OBIPs on 25 and 26 July for the long term seismicity study. Seismic event threshold levels were set at 18 db on four of the instruments and 12 db on the fifth. All OBIPs were timed to begin recording at 0550 GMT on 27 July. It is anticipated that at least 300 earthquakes will be recorded during the planned 2-month operating period.

FUTURE OPERATIONS

September 4-14, 1979: Recover all five OBIPs.

Summer 1980: A proposal has been submitted to NOAA (OCSEAP) for additional OBIP work in the NEGOA. This would entail deployment of at least six instruments and the shooting of two reversed air gun refraction lines.

SHIP'S EQUIPMENT: COMMENTS AND RECOMMENDATIONS

3.5 kHz Bathymetry/Subbottom Profiling System

Although good records were obtained during most of the survey, the system had several minor problems which limited power output to less than 2 kilowatts much of the time.

Air Compressors

The steam driven Worthington compressors worked very well during the seismic refraction phase of the cruise. We estimate that both compressors could provide enough air to fire a 1000 cubic inch air gun at a rate of 3 shots per minute. For future air-gun operations a relief (pop-off) valve could be added to the system so that the compressors do not have to cycle on and off.

Science Van and Radio Interference

The large van located amidships on the boat deck provided excellent laboratory facilities for the OBIP operations. The ship's carpenter further improved the space by adding some additional shelves and retaining strips. The only problem encountered with respect to the van was lack of adequate grounding and shielding. The nature of the OBIP electronics made them especially susceptible to RF interference. Vans used in the future should have a metal framework so that they can be properly grounded to sea water. Additional RF shielding would be highly desirable, including line filters for the van's power. Proper precautions along these lines would probably obviate the necessity for radio silence when sensitive electronic systems are being used.

Air Guns, Streamer, and Seismic Amplifiers

Considering the SURVEYOR's compressor capabilities, we recommend that NOAA consider adding other components to provide geology/geophysics users with a complete seismic reflection system. A single channel hydrophone streamer and seismic amplifier are needed, as well as an air gun sound source or sources with capacities ranging from 40-120 cubic inches. One of the UGRs presently on board could be used as a seismic recorder, although the addition of a third recorder would permit simultaneous acquisition of 3.5 kHz, narrow beam 12 kHz, and air gun reflection data. Several of these items were purchased by PMEL/PMC in 1973; perhaps they could be located and installed in SURVEYOR.

Sonobuoy Refraction System

Seismic refraction data are necessary for accurate interpretation and analysis of reflection profiles. We recommend the addition of a two channel sonobuoy receiver with associated high and low frequency receiving antennae. A 1000 cubic inch air gun would be desirable for use as a refraction sound source.

Navigation System

The navigation, shiphandling, and plotting of navigational and bathymetric data were superb. The ability of the ship's survey group to provide both preplot and postplot charts significantly lessened the workload of the scientific party and greatly facilitated the OBIP site survey work. The accuracy of navigation during OBIP launch and recovery operations left nothing to be desired.

ACKNOWLEDGEMENTS

We would like to express our sincere thanks to Capt. Williams, the officers, and crew of SURVEYOR for making our stay on board so enjoyable and successful. Everyone seemed genuinely interested in assisting us in every way possible, and we are looking forward to the opportunity of another cruise aboard SURVEYOR.

APPENDIX

The following operations and data collections were accomplished on the cruise:

OBIP Deployments	13
OBIP Recoveries	8
Seismic refraction (3 lines)	165 km
Bathymetry/subbottom profiling	580 km
XBT launches	12
Bottom samples (Shipek)	8

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NOAA Ship SURVEYOR S132
RP-4-SU-79B (OCSEAP)
Cruise II Leg II

9 sheets, Marine Observation & Station Abstract Tex
9 sheets, Deck Weather Observation Tex
6 volumes, Bathymetry & Refraction Records Tex ✓
15 sheets, Mylar Smooth Plot (Bathymetry & Refraction Trackline Tube ✓ 2 Short
Scales 1:50000, 1:60000 & 1:500000)
5 fanfold, UGR Fathogram
1 fanfold, XBT Trace
1 Chart 16760, Smooth Plot , Leg II Tube ✓
8 bags, Shipek grab Bottom Samples (Will be picked up in Seattle)

XBT records will be transformed into water velocity vs. depth curves and then sent along.
Fathograms will be sent as soon as I can get through them to check the annotations

FROM: (Signature)
Bruce I. Williams
Cdr. Bruce I. Williams, NOAA, Commanding Officer

Return receipted copy to:

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Mark L. Holmes
U.S. GEOLOGICAL SURVEY.
SEATTLE, WASH.
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