RVNG
#93010

Cruise Report

R/V Revenge (22' whaler)
May 24, 1993 - May 29,1993
San Pablo Bay , CA

Ocean Bottom Seismometer Operations in San Pablo Bay

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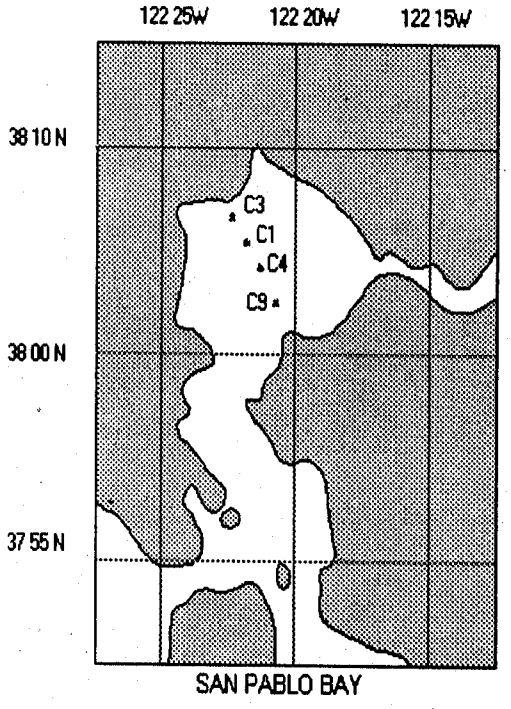
SUMMARY

A seismic refraction study was undertaken by the Seismology Branch in Menlo Park from May 24-29, 1993. The study was primarily a land operation using over 400 recording systems located along two lines orthogonal to one another. Four shallow water OBS's were deployed in San Pablo Bay to extend coverage in the area covered by water.

The objectives were to create a seismic source at various epicenter locations and measure the strength of the energy reflected back to each instrument. This information will then be used to predict which areas will suffer the greatest damage in the event of an actual earthquake at or near one of these epicenters. Two lines were shot, but the OBS's were used only on the second line which was parallel to the Hayward fault. This second line was several hundred kilometers long with recording instruments each kilometer. The OBS's were deployed along a line approximately 6 kilometers long with each OBS located 2 kilometers apart. All OBS's were recovered, although one was initially lost and recovered later. Data was recorded on all four systems.



THE USGS OCEAN BOTTOM SEISMOMETERS

The Ocean Bottom Seismometer (OBS) is a self-contained data-acquisition system that is deployed on the ocean floor to record wide-offset seismic data on a 200 Megabyte hard disk. There are eight OBS's; four are rated for a depth up to 500 meters, and the other four are rated to 5,000 meters. Each OBS is powered using 72 alkaline batteries which will run all of the systems for ten days. The US Geological Survey OBS has been designed as a

continuous recording system set up to acquire signals from one vertical 4.5 Hertz geophone, two horizontal 4.5 Hertz geophones, and one hydrophone. The software controlling the system allows selection of any combination of these four channels to sample at 200 samples/second, providing a record time of 36 hours for all four channels.

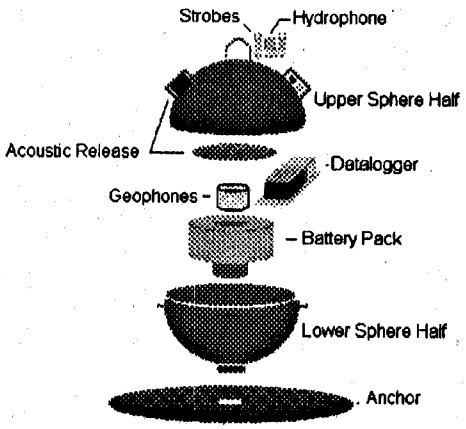


Figure 6. Major Components of the OBS

Each acquisition of data into the memory buffer is 1,015,808 bytes. The time and data pointer for that acquisition are placed into a header that gets recorded with each memory buffer of data. The OBS's record data continuously with these time-of-day marks in the data as the only reference to external events. To provide the highest possible accuracy time is recorded to the nearest millisecond. Each OBS uses an oven-controlled oscillator as a stable clock reference for which the drift in time can be as little as 0.5 milliseconds/day. This accuracy requires several days of careful calibration and the use of a rubidium (Rb) standard as a reference for the oscillators. All eight OBS data loggers are continuously powered using a 24 volt DC power supply to keep the oscillators at a constant temperature. Prior to each deployment, the frequency of each oscillator is checked, and if necessary, recalibrated. The time-of-day is set via software in each logger using the minute pulse of the GPS satellite clock as a starting trigger. When locked on a satellite, the time is accurate to within 100 nanoseconds, and the Rb standard can be used to maintain an accurate time when satellite coverage is not adequate. The offset from GPS time is determined by comparing the second pulse of the data logger with the second pulse of the GPS clock. After each deployment, the offset is measured again to determine the total drift.

The data loggers in each OBS use a 200 Megabyte hard disk to store the acquired data. The data must be transferred to another storage media each time an OBS is retrieved. A 386 PC with a 2.2 gigabyte hard disk and an exabyte tape drive is used to archive the data. Data is downloaded from the data logger onto the hard disk of the PC. The quality of the data is checked using two programs. One program reads, displays, and checks the header information of each data record. This program will report any errors found. The second program graphically displays the sensor data for all four channels. Once all of the OBS's have been downloaded, the data files are written to exabyte tape in TAR format for permanent storage.

Deployment and recovery operations are simple operations designed to work on a variety of different vessels. The OBS's are programmed, sealed, and

stored on deck prior to deployment. At the deployment location, the release is tested a final time, and the OBS is then attached to its anchor. The preferred method of deployment uses a winch to lift the OBS and anchor and an A-frame to move the assembly outboard of the ship. The OBS is then lowered to the water surface where a simple rope loop and metal pin is used to release the OBS into the water to free fall to the bottom. An acoustic release is used to free the OBS from its anchor. Once released, the OBS rises to the surface at a rate of 1 meter/second. At the surface, two externally mounted strobes will flash to aid in spotting the floating OBS. The OBS is attached to the lifting line using a snap hook mounted on a pole, and once the OBS is lifted back aboard, the release is recocked to turn off the strobes. The deep water OBS and anchor weigh 320 lbs. in air, so the requirements for lifting are not much. A block and tackle are often used when no winch is available. The shallow water OBS and anchor only weigh 250 lbs. in air enabling small boat operations such as this cruise.

NARRATIVE

Predeployment

All of the OBS equipment was shipped via truck on May 14,1993 to the Menlo Park complex. The equipment arrived on May 25, 1993 to the USGS warehouse facility. All field personnel arrived on May 24. No arrangements had yet been made for transportation, work space, or post-cruise shipping of the equipment. We made arrangements with Steve Wallace who was kind enough to provide us a place to setup our gear at MARFAC even though there was no advance notice and they had limited space available. He also undertook the responsibility of ensuring that the equipment was shipped back to us. The afternoon of the 25th was spent moving the OBS equipment from the USGS warehouse in Menlo Park to MARFAC in Redwood City. We inspected the boat with Steve Wolf and outlined an itinerary and method for deploying the OBS's. May 26th was spent unpacking and setting up the OBS's. The only problem with any of the equipment was that the Magellan GPS receiver would not acquire a position, so we borrowed a Trimble handheld unit from the Menlo Park office. All systems were programmed and ready by nightfall.

Deployment

On the morning of the 27th we went to San Rafael to begin deployment operations. All of the equipment was loaded into the back of a rental van, and the boat was towed by a government pickup truck. Personnel included Steve Wolf, Don Reed, VeeAnn Cross, and Greg Miller. Only two OBS's could be safely loaded into the boat at one time, so OBS C-1 and OBS C-3 were loaded for deployment. Because of our

inexperience with the navigation system, we were only capable of logging information, not using it for positioning the boat to the site. We went to the first site near channel marker '6' and deployed OBS C-1 at 18:46 UTC (11:46 local) just outside the channel in 3 meters of water. Data file 8 on the navigation system recorded our position. Unfortunately, the antennae was not connected so nothing useful was recorded. We then moved to channel marker '10'. OBS C-3 was deployed just inside the channel in 3 meters of water at 19:04 UTC. Deployment within the channel was necessary because water depth outside the channel is < 1 meter. Data file 9 on the navigation system recorded our position. We returned to the marina to load OBS C-4 and OBS C-9 into the boat. At 21:11 UTC the boat was positioned just south of Buoy '7'. The seas were rough, so there was additional movement southward before the OBS C-9 was deployed. Data file 11 on the navigation system recorded our position. The final site had no references nearby, so the boat was positioned visually on a point half way (approximately) between marker '7' and marker '6' on a line with the channel markers and Pinole Point. Data file 12 on the navigation system recorded our position at 21:36 UTC. There were no problems in deploying the OBS's from a whaler. Mounting the anchors was difficult as the anchor had to be balanced on the rail of the boat while the OBS was being attached. This meant that three people plus the OBS were on one side of the boat (not a very desirable position in a whaler).

Recovery

The whaler was left at the marina over night. The morning of May 28th we began to recover the OBS's. Personnel on this day included Steve Wolf, VeeAnn Cross, and Greg Miller. At 18:30 UTC the boat was positioned just south of Buoy '7' to recover OBS C-9. Data file 13 on the navigation system recorded our position. A release command was sent and the OBS responded with a confirmation of release. The seas were very rough, and after an hour of searching, OBS C-9 could not be located. At 19:15 UTC we moved into position to retrieve OBS C-1. Data file 14 on the navigation system recorded our position. The release command was sent and OBS C-1 acknowledged the release and surfaced very near the boat. The OBS was retrieved by simply grabbing it and hauling into the boat by hand. The program was shut down with indications that the OBS had successfully recorded 92 tracks of data. At 21:35 UTC the boat was positioned at the location of OBS C-3. Data file 15 on the navigation system recorded our position. The release command was sent and OBS C-3 acknowledged the release surfacing near the boat. The program was shut down, and indications were that the OBS had successfully recorded 92 tracks of data. At 21:50 UTC the boat was in position to retrieve OBS C-4. Data file 16 on the navigation system recorded our position. The release command was sent and OBS C-3 acknowledged the release.

After several minutes of searching, the OBS was sighted about .5 miles north of our position. The program was shut down, and indications were that the OBS had successfully recorded 92 tracks of data. A search pattern was then attempted to find OBS C-9, but without success. The US Coast Guard was alerted, and our search called off at 23:45 UTC. The boat was pulled out of the water, and all personnel returned to Redwood City. May 29th was spent downloading the data from all OBS's and packing up the equipment. All OBS's worked properly, and no problems were encountered while packing up the equipment. Arrangements were made to have the equipment shipped back to Woods Hole on June 3.

The Lost OBS

OBS C-9 was sighted several times on the night of May 28th winding its way in and out of San Pablo Bay via the ship channel. On the afternoon of May 29th, a tug boat operator picked up the OBS and called on June 2. The OBS was returned and had worked without problems.

CONCLUSIONS AND RECOMMENDATIONS

The OBS's worked well in this operation. There were no mechanical or electronic problems. The remote communications capability with the OBS on deck (which is new as of this operation) worked well. In small boat work such as this, the small spheres were a blessing and in fact the work could not have been done with the large spheres. Using a whaler as a deployment and recovery vehicle is marginal. The davit, which held the OBS 40 inches above the rail and 20 inches out, was essential in deploying the OBS's. Work needs to be done on developing navigational and power systems that can work effectively on small boats, particularly since the majority of recent deployment have been small boat operations.

The assistance provided by MARFAC in Redwood City (especially Steve Wallace and Steve Wolf) was invaluable. They bent over backwards to provide us with lab space, transportation (a truck to retrieve our equipment from shipping and receiving), and shipping with virtually no notice. It was probably the only facility that could provide the accessibility that we needed for weekend hours. In the future, all arrangements for OBS operations should be arranged with MARFAC being involved early in the discussions. If that had been done for this operation, renting a cargo van probably wouldn't have been necessary.

We were also fortunate that the marina we used, Loch Lomond Marina, did not charge us to launch the boat, nor did they charge us for the slip where we left the boat overnight. Therefore our only expenses for the deployment/recovery operation was fuel.

APPENDIX 1
Operations Team

Rufus Catchings	- Chief Scientist
VeeAnn Cross	- USGS Woods Hole
Greg Miller	- USGS Woods Hole
Don Reed	- San Jose State
Steve Wolf	- USGS Redwood City

APPENDIX 2
OBS Deployment Locations

OBS ID	LOCATION AT DEPLOYMENT	LOCATION AT RECOVERY	WATER DEPTH (M)	TIME OF DEPLOYMENT	TIME OF RECOVERY
C-1	38.07121 N	122.42522 W	3	18:46 UTC	19:15 UTC
C-3	38.08878 N	122. 44038 W	3	19:04 UTC	21:35 UTC
C-4	38.05775 N	122.41088 W	4	21:36 UTC	21:50 UTC
C-9	30.02363 N	122.38413 W	9	21:11 UTC	18:30 UTC

APPENDIX 3
Shot information

SHOT NO.	LATITUDE	LONGITUDE	ELEV. (M)	TIME (UTC)	CHARGE SIZE (lbs)	AREA
4	37° 12.296' N	121° 38.678' E	201	148 07:00	2,000	O'Connell Ranch
15	36° 58.031' N	121° 27.150' E	44	148 07:02	200	Soda lake
3	37° 36.460' N	121° 57.899' E	411	148 07:04	2,000	Niles Canyon
8	38° 10.065' N	122° 27.100' E	2	148 07:08	200	Sears Point
5	36° 47.561' N	121° 17.626' E	299	148 07:10	4,000	Tobias Ranch
1	38° 25.404' N	122° 37.747' E	280	148 07:12	4,000	Annadel State Park
2	37° 51.892' N	122° 11.295' E	244	148 08:00	600	Orinda
13	37° 18.980' N	121° 42.135' E	463	148 09:00	200	Grant Rch Cty Park
14	37° 05.855' N	121° 32.714' E	253	148 09:02	200	Coyote Reservoir
12	37° 29.044' N	121° 51.178' E	622	148 09:04	200	Weller Road
10	37° 46.793' N	122° 06.972' E	198	148 09:06	300	Upper San Leandro Reservoir
9	38° 00.225' N	122° 21.868' E	21	148 09:08	300	Pinole Point

APPENDIX 4
OBS Specifications

US GEOLOGICAL SURVEY SHALLOW WATER OBS (500M)

Dimensions (meters):	Width	Height
in laboratory	0.60 (24")	0.89 (35")
at launch (including external sensors, if applicable)	1.02 (40")	0.89 (35")
Weight in air (kgs):		
on deployment	75 (202 lbs.)	
on recovery	54 (145 lbs.)	
Anchor configuration:	Flat metal plate 1.02 meters (40") in diameter	
Temperature limits (^{o}C):		
operational	- 5 to 40 ^{o}C	
storage	-20 to 50 ^{o}C (unpowered)	
Sensors:		
type(s)	4.5 Hz L15B geophones, OAS E-2S hydrophone	
configuration	geophones are gimbled,3 axis	
Clock:		
type	Hardware with 1 millisec resolution	
stability	1 x 10^{-8}/month (Oven Controlled) 1 x 10^{-7}/month (TXCO)	
Recording system:		
analog or digital	Digital	
sample rate(s)	5 and 10 milliseconds (200 and 100 samples/sec)	
number of channels	4	
dynamic range	72 dB (AD converter) + 30 dB (1-step gain range)	
recording modes	Continuous	
Data format:	Binary with header information for each 1 Megabyte of data. Data is converted to SEGY after retrieval.	
Relocation aides:	2 Strobes, acoustic Transponder	
Release method:	acoustic	
Maximum deployment length:	36 and 74 hours of record time, battery life using Alkaline batteries is 10 days.	
Typical turnaround time:	8 hours for all instruments	
Number of OBS available:	4	
References:	None	