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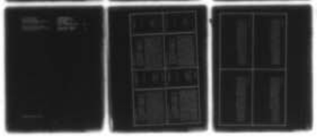

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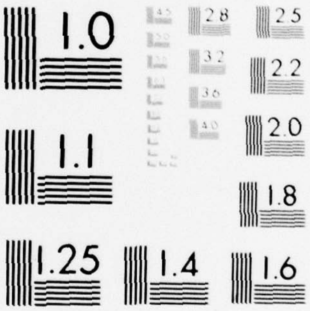
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CRUISE REPORT: MARIANA LEG 10

George G. Shor Jr

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The primary scientific goal of leg 10 of Mariana Expedition was to make a set of measurements in the thick sedimentary section of the Bengal Fan that would make it possible to calculate the attenuation of sound as a function of depth in the sediments. The Bengal Fan was chosen as the location for the study because it contains the thickest section of fan sediments in the ocean, and previous studies by Curray and Raitt have shown that the sedimentary section has few sharp velocity discontinuities. The types of measurements required → over

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Abstract - continued

were of two types: multichannel seismic reflection measurements and "diving wave" studies of waves continuously refracted through the sedimentary column from deep sources to receivers located at the sea floor. Additional observations taken to provide environmental data and to make use of the available ship time on the transit to and from the primary working area including sonobuoy/airgun refraction work, XBT measurements, a few gravity cores at the study area, continuous 12 kHz and 3.5 kHz echo-sounding, magnetometer measurements along all portions of the track of adequate water depth, and gravity measurements in the first portion of the leg. Single-channel airgun measurements were taken along much of the track, and in selected locations were digitized for later playback.

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CRUISE REPORT: MARIANA LEG 10

by

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1 July 1979

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F. N. SPIESS, DIRECTOR
MARINE PHYSICAL LABORATORY

MPL-U-26/79

CRUISE REPORT: MARIANA LEG 10

George G. Shor, Jr.

GOALS AND OBSERVATIONS

The primary scientific goal of leg 10 of Mariana Expedition was to make a set of measurements in the thick sedimentary section of the Bengal Fan that would make it possible to calculate the attenuation of sound as a function of depth in the sediments. The Bengal Fan was chosen as the location for the study because it contains the thickest section of fan sediments in the ocean, and previous studies by Curray and Raitt have shown that the sedimentary section has few sharp velocity discontinuities. The types of measurements required were of two types: multichannel seismic reflection measurements and "diving wave" studies of waves continuously refracted through the sedimentary column from deep sources to receivers located at the sea floor. Additional observations taken to provide environmental data and to make use of the available ship time on the transit to and from the primary working area included sonobuoy/airgun refraction work, XBT measurements, a few gravity cores at the study area, continuous 12 kHz and 3.5 kHz echosounding, magnetometer measurements along all portions of the track of adequate water depth, and gravity measurements in the first portion of the leg. Single-channel airgun measurements were taken along much of the track, and in selected locations were digitized for later playback.

CHRONOLOGY

R/V Thomas Washington arrived in Jakarta, Indonesia, on 11 February 1979 at the completion of a program of reflection profiling and multichannel reflection work in the Molucca and Banda Seas under the leadership of Eli Silver. Oncoming members of the scientific party arrived on February 12 and 13. A conference was held between Indonesian officials and members of both scientific parties at the Bureau of Foreign Cooperation, Ministry of Mines and Energy, on Feb. 13, to solve clearance problems and expedite work. Equipment for the scientific program was received and cleared through customs expeditiously; the ship fueled and received stores and spare parts. A tour of the ship, for personnel of the U.S. Embassy and of the Indonesian Institute of Oceanology, was conducted on the afternoon of the 15th. The ship departed port at 1600 local time on Feb. 16. A complete list of scientific party and crew is given as Appendix I.

No scientific work had been planned for the shallow-water run from Jakarta north to Malacca Strait. The time was therefore spent in setting up and checking out equipment during a pleasant run in excellent weather and calm seas among the islands of the Indonesian archipelago (and among the unlighted boats of the fishing fleet). The track north was east of Bangka and west of Billiton Island, joining the main shipping route just west of Singapore Strait, as shown in Figure 1.

19-21 February

At 0040Z (0740 local time) 19 February, in Malacca Strait, we set an underway scientific watch and started standard underway observations. A 3.5 kHz (bottom-penetrating) echosounder was recorded on a Raytheon UGR recorder; a 12-kHz echosounder was recorded on a Hydro Products GDR recorder. The ship's gravimeter had been kept turned on from the previous cruise leg, but the quality of data from it is dubious. Since the ship never tied up to a pier, there was no opportunity to make a gravity tie at Jakarta. In addition, the automatic digital logging device, which normally logs the gravimeter directly into the shipboard IBM 1800 computer, had been occasionally slipping half-turns of the screw, causing large (but detectable) errors in logged readings. The gravimeter was, however, kept levelled until March 3, when one of the control amplifiers failed; there may therefore be useful relative gravity readings between crossings of previous lines. The 3.5 kHz UGR was operated continuously from here to the end of the cruise; the 12-kHz GDR was operated most of the time, starting at 0255Z/19 February. The

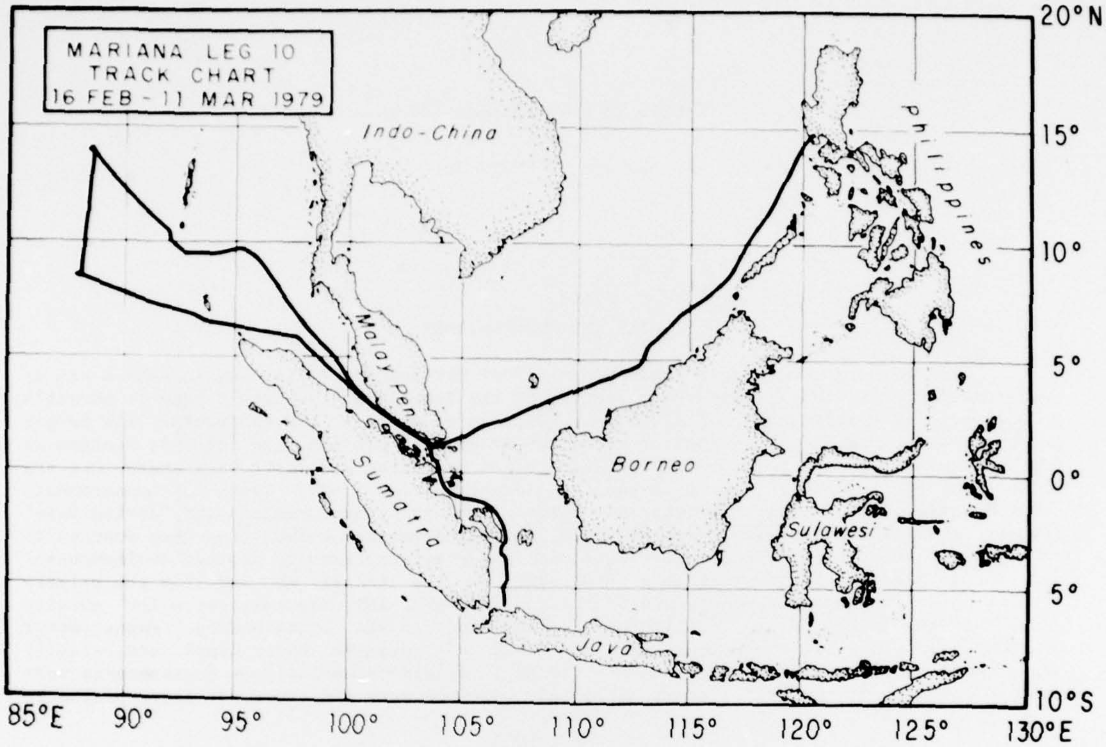

Fig. 1. Cruise track.

magnetometer was streamed at 0603Z/19 Feb., and was operated for most of the remainder of the cruise, the exceptions being some periods of multichannel seismic operations, station time, and time in areas of shallow water.

At 2204Z/19 February, single-channel seismic reflection (airgun) profiling was started. A survey was carried out across the Andaman Sea on a pattern involving a small amount of deviation from the most direct course, concluding at 1940Z/21 Feb., at Ten Degree Channel, between the Andaman and Nicobar island groups. On this survey fifteen sonobuoys were deployed to obtain velocity data; not all of the sonobuoys worked (many were extremely old units). A full list of sonobuoy stations is in Table I.

21-24 February

At 2000Z/21 February (0200 22 February local time), the streamer for the multichannel seismic reflection system was deployed, on the Andaman-Nicobar Ridge, southwest of Little Andaman Island. One neuston tow was taken during deployment. On the previous cruise leg, 5 sections of the multichannel streamer had become inoperative. The streamer, which was originally built for Exxon as an experimental unit, is oddly configured. Unlike most 24-channel streamers, not all of the active sections are of equal length; dead sections are provided that make it possible, however, to come close to a standard uniform spacing. As presently configured, it has 22 active sections that are 300 feet between centers; the remaining two active sections, numbers 2 and 4 from the shipboard end, are located respectively half way between channels 1 and 3, and between 3 and 5. The sections that were out of operation were numbers 1, 3, 12, 13 and 14; the last 3 put a rather large gap in the spacing. Repairs or changes can only be made when the streamer is being launched or recovered, so no repairs could be made in port. During the launching of the streamer for multichannel run #1, therefore, we took the time to remove sections 12, 13 and 14, and to put in the one spare section. However, when the work was completed and the streamer out, we found that the trouble had merely moved down the line -- the sections that now occupied those same physical positions were not returning signals, indicating that the

TABLE I

Sonobuoy Runs

Buoy#	GMT Time /	Date	Latitude	Longitude	Comments
1	2322	19/2/79	6°00.7'N,	98°26.4'E	
2	0055	20/2/79	6°14.8'N,	98°14.3'E	Better signal than #1
3	0154	20/2/79	6°23.8'N,	98°06.8'E	
4	0918	20/2/79	7°29.9'N,	97°18.8'E	
5	1053	20/2/79	7°43.3'N,	97°08.1'E	No signal
6	1100	20/2/79	7°44.3'N,	97°07.3'E	Noisy
7	1305	20/2/79	8°02.6'N,	96°53.8'E	Noisy
8	1405	20/2/79	8°12.0'N,	96°46.9'E	No data
9	1408	20/2/79	8°12.5'N,	96°46.6'E	
10	2357	20/2/79	9°37.8'N,	96°31.9'E	
11	0113	21/2/79	9°41.0'N,	95°17.5'E	
12	0533	21/2/79	9°44.6'N,	94°26.8'E	
13	1424	21/2/79	9°36.3'N,	92°42.6'E	
14	1552	21/2/79	9°46.5'N,	92°28.6'E	Died about 1615Z
15	1627	21/2/79	9°50.3'N,	92°23.0'E	
16	1952	21/2/79	10°14.4'N,	91°55.1'E	Microseismicity study
17	0935	22/2/79	10°48.1'N,	91°30.2'E	Faded rapidly, lost signal approximately 0955Z
18	1003	22/2/79	10°49.9'N,	91°28.0'E	Good
19	1559	22/2/79	11°15.7'N,	91°00.4'E	
20	1726	22/2/79	11°22.2'N,	90°52.7'E	Excellent
21	2141	22/2/79	11°41.6'N,	90°32.3'E	Lost, clipped by tail buoy
22	2206	22/2/79	11°43.6'N,	90°30.5'E	Not digitized
23	0952	23/2/79	12°38.5'N,	89°41.0'E	
24	1337	23/2/79	12°57.3'N,	89°26.3'E	Lost, clipped by tail buoy
25	1352	23/2/79	12°58.5'N,	89°25.3'E	Lost, clipped by tail buoy
26	1414	23/2/79	13°00.1'N,	89°23.8'E	Excellent
27	0212	26/2/79	13°55.1'N,	88°33.3'E	Poor buoy, noisy, no useful data
28	0349	26/2/79	14°06.3'N,	88°33.3'E	
29	0808	26/2/79	13°50.7'N,	88°43.7'E	
30	2048	26/2/79	13°52.0'N,	88°34.1'E	Ranging for seismic station #2
31	2048	26/2/79	13°52.0'N,	88°34.1'E	Ranging for seismic station #2
32	2019	28/2/79	8°30.2'N,	88°05.4'E	
33	2151	28/2/79	8°26.6'N,	88°15.4'E	Lost, clipped by tail buoy
34	2202	28/2/79	8°25.9'N,	88°17.2'E	
35	0009	1/3/79	8°20.5'N,	88°30.8'E	Bad
36	0023	1/3/79	8°19.9'N,	88°32.3'E	
37	0210	1/3/79	8°15.1'N,	88°44.5'E	Excellent
38	0430	1/3/79	8°08.6'N,	88°59.8'E	Lost at approximately 0553Z
39	0755	1/3/79	7°59.3'N,	89°21.2'E	Lost, clipped by tail buoy
40	0810	1/3/79	7°58.6'N,	89°22.8'E	Lost, clipped by tail buoy
41	0831	1/3/79	7°57.7'N,	89°25.1'E	Bad
42	0844	1/3/79	7°57.1'N,	89°26.6'E	
43	1606	1/3/79	7°42.1'N,	90°11.0'E	
44	0030	2/3/79	7°15.4'N,	91°32.3'E	
45	0317	2/3/79	7°09.0'N,	92°02.4'E	Weak
46	0337	2/3/79	7°08.3'N,	92°06.0'E	Noisy
47	0815	3/3/79	6°05.3'N,	96°23.7'E	Pretty Good
48	0942	3/3/79	6°03.2'N,	96°33.1'E	Weak
49	1027	3/3/79	6°02.2'N,	96°37.9'E	Good
50	1923	3/3/79	5°56.5'N,	97°39.3'E	Excellent
51	0744	8/3/79	6°26.5'N,	114°04.7'E	
52	1002	8/3/79	6°37.3'N,	114°16.0'E	
53	1003	8/3/79	6°37.3'N,	114°16.0'E	
54	1112	8/3/79	6°43.4'N,	114°21.6'E	Bad
55	1237	8/3/79	6°51.0'N,	114°27.8'E	
56	1240	8/3/79	6°51.4'N,	114°28.2'E	

trouble was due to broken leads somewhere between that point and the ship. Lacking the necessary time to pull the streamer back in and rework it, we carried out Line #1 with only 17 active sections working. The streamer was finally out and the system operating at 0222Z/22 February.

Ship speed and firing rate were adjusted several times to get proper synchronization for common-depth-point processing. Initially, we tried for 6.0 knot speed over the ground, operating at 6.4 knots (indicated) to allow for drift. We eventually settled on an indicated (Doppler log) speed of 6.9 knots to make good 6.2 knots, with a firing repetition rate of 14.6 seconds. Three airguns were used: 40, 120 and 300 cubic inches. The run was carried out (see Figure 1) from the Andaman-Nicobar Ridge, across the Sunda Trench and the north end of the (buried) Ninety-East Ridge, out onto the Bengal Fan. The crest of the Ninety-East Ridge was at one second (two-way travel time) of subbottom depth (Fig. 2).

Sonobuoys no. 17 through 26 were launched during the multichannel run. On this run, as on some later runs, some sonobuoys were caught by the Condep depressors ("birds") or the tail buoy of the multichannel streamer, and therefore did not get far enough behind the ship to produce useful data. Very good sonobuoy records were obtained in the cases where sufficient range was obtained.

The reflection monitor records showed many areas in which old filled channels were visible; on the 3.5 kHz records modern channels were frequent and obvious.

At the end of the run we took the necessary time to recheck the streamer carefully to find the location of the broken leads; they were found in one of the stretch sections at the front end of the streamer. The bad stretch section was removed and moved to the tail

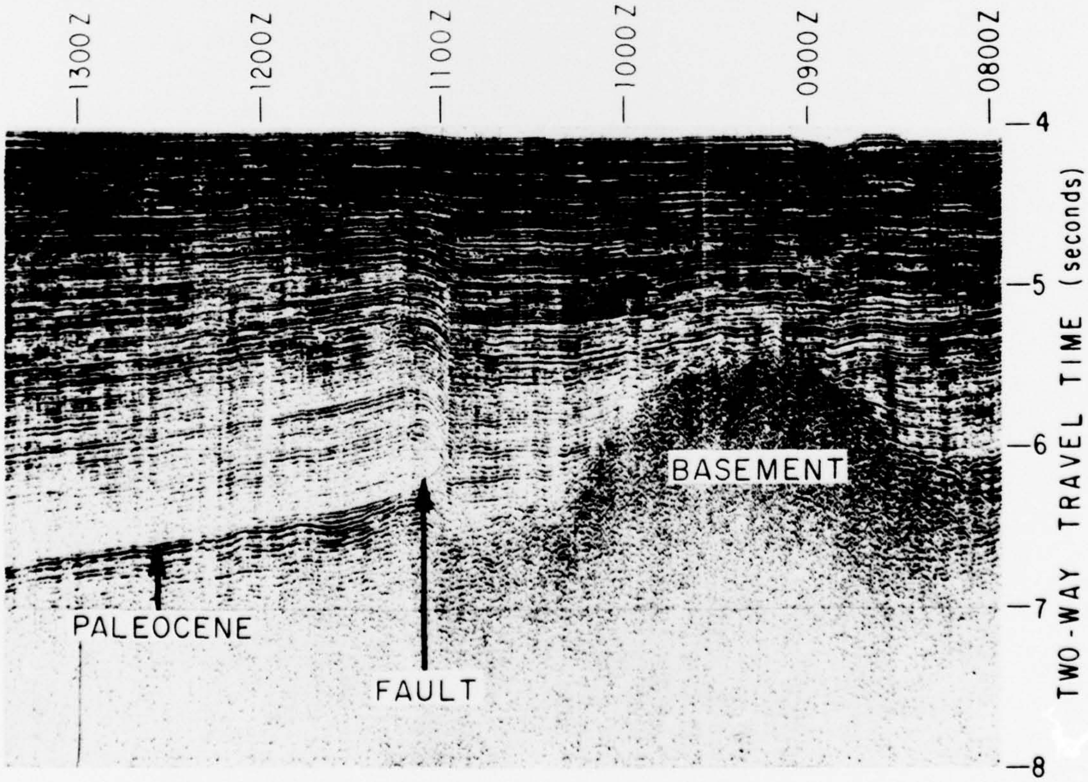

Fig. 2. Monitor (single-channel) record taken during multichannel seismic reflection run 10-1, from the Andaman Ridge to the Bengal Fan. This section covers a section on the west side of the Ninety-East Ridge. Note the buried ridge, the diffraction patterns from a major fault in the sediments, evidence of old distributary channels of the Bengal Fan, and reflections from one major discontinuity (identified by Curray as the top of the Paleocene) near the bottom of the record.

end of the streamer; on the next deployment a good stretch section from the tail of the streamer was inserted in its place. Neuston tow no. 2 was attempted at 1246Z/24 during this work; the net was lost.

The multichannel streamer was aboard at 1434Z/24 February. The single-channel streamer was deployed, and a very short survey made to make sure there was no significant subbottom topography in the zone south of the multi- channel line where the sediment attenuation station was to be carried out; a short run southeast, followed by a run north to the multichannel line was sufficient. All underway gear was aboard at 1948Z/24 February.

24-25 February: Station Work

The station position was chosen on negative evidence: there was no evidence from the monitor records of the multichannel reflection line or the brief single-channel reflection survey that there was any significant structure within the sedimentary section, that any strong reflectors were present within the first 4 seconds of the sediments, that there were any basement hills protruding up into the section, or any distributary channels of the fan system at the surface. There had been some concern in advance about the sediment thickness, since the isopach map by Curray had shown a small area of thinned sediments close to the station site; if it were more extensive than he had interpreted, it would have made the station site unsuitable. We found no evidence for any thinning (or basement hills, which would cause it), and suspect that the buried hill or ridge in question is either nonexistant or small. The station location was therefore placed on the multichannel reflection line at 14°00'N, 88°30'E.

A moored buoy (unit Donna) was set at 2240Z/24, with 10,000 feet of mooring line in 1597 fathoms of water. The satellite position at launch was 13°56.14'N, 088°32.63'E. A second buoy, unit Jo, was set at 0036Z/25, with 10,000 feet of mooring line in 1598 fathoms, at 13°55.00'N, 088°33.03'E (bracketed by two satellite fixes 36 minutes apart). "Launch" positions are probably good to a few tenths of a mile or better, but the actual equilibrium position assumed by each buoy may be farther off of the designated position.

The moored buoys have been in use at MPL for several years. Since they have been built from items "on hand", with modifications almost every year, they have never been adequately documented; a brief description is therefore attached as Appendix II.

A recording system was set up to use the 3.5 kHz echosounder signal, transmitted from a hull-mounted transducer, detected acoustically at the buoy, and telemetered back to the ship, as a ranging system for dropping shots. Unfortunately, buoy Donna had a very weak radio transmitter that did not carry the few miles needed; buoy Jo started out with a strong signal, but during the run the audio modulation became very weak despite a strong carrier.

Ship drift was fairly steady at 0.8 knots to the south; we therefore planned to deploy the instruments and shots with the ship lying to, drifting away from the buoys. The plan was to set three free-fall "Sea Floor Hydrophones" at 250-meter spacing, and then drop deep charges every 250 meters starting 1000 meters beyond the third instrument. (A description of the SFH units is included as Appendix II). A fourth instrument was aboard, but still had some original construction bugs in it, which have not yet been found and corrected. The audio signal from buoy Jo abruptly became weak and noisy, just as SFH 1 was being dropped; SFH 1 was dropped at 0330Z/25 on an extrapolation of the drift rate, at an estimated range of 800 meters from buoy Jo. We returned to a location near the buoy again, picked up the acoustic ranging signal, and drifted off to drop SFH2 at 0459Z/25 at 1.2 km. We then returned to the buoy, brought it aboard to check it and replaced the hydrophone and drop cable, which improved the audio signal. Unfortunately, the buoy mooring line broke while the buoy was on deck, so that we could not deploy at the same location. SFH 3 was launched at 0816Z, and then buoy Jo was set on a new mooring, which placed the buoy south of its original position.

Shots were dropped as the ship drifted south from the buoy. First, a 1/2-lb shot was fired both as a warning and an equipment test; then 16 large deep shots and one more small shallow ranging shot were fired, for a total of 18 shots. Two of the deep shots were apparently duds; five more were either partial detonations or only SUS charge detonations. Each of the deep charges fired on this run consisted of 4 boxes of M034 8-lb TNT demolition blocks, a total of 256 lb of TNT, banded and wired together, with a SUS Mk 94 Mod 0 tied, taped (and on the later shots also wired) to the top of the boxes. Five of the shots were fired with 8000 foot SUS, 11 with 6000-foot SUS. The 8000-foot shots took 30 to 32 minutes to sink to detonating depth; five of the 6000-foot shots took 23 to 25 minutes to sink, as expected; 2 were duds, 2 took 31-32 minutes and detonated at 8000 feet, one took 18 minutes, and one 13 minutes; the scatter was rather surprising compared with earlier experience.

TABLE II

Gravity Cores

Core No.	Time/Date	Latitude	Longitude	Length	Description
16	1830Z/25	13-51.3N	88-33.3E	35 cm	Hard grey clay
17	2050Z/25	13-52.7N	88-33.5E	140 cm	Top 67 cm brown unconsolidated calcareous ooze. Bottom 71 cm sticky grey clay.
18	0022Z/26	13-55.0N	88-32.7E	20 cm	Top is brown unconsolidated ooze. Bottom is very dark grey clay.

In each case, except for the earliest detonation, the shot and several surface and bottom reflections were recorded on the ship both from a shallow hydrophone trailed behind the ship (0.2 to 0.4 miles from a point directly above the shot) and from the hydrophone at buoy Jo, providing the necessary data to make it possible to calculate shot depth and origin time.

The shooting run was relatively short (from 0944Z to 1413Z) because the SFH turn-on, turn-off, and release times had been preset before the delay to service the moored buoy.

At release time, SFH1 did not surface. SFH2 came up on time, and was recovered at 1602Z/25; SFH3 was recovered at 1631Z. While waiting for SFH1 to return on its magnesium-link backup release, we took 3 gravity cores at the approximate locations of the SFH drops; these are gravity cores CG-16, CG-17, and CG-18 (preliminary descriptions given in Table II). The radio signal from SFH1 was heard (indicating that it had surfaced) while core 17 was being taken. As soon as the core was aboard, we maneuvered to pick up SFH1, recovering it at 2230Z, 19 hours after it was dropped.

After the third core was aboard, airguns were streamed to start airgun refraction runs to the moored buoys and to sonobuoys. The first run was made on course 000° from the moored buoys, recording signals from buoy Jo and from sonobuoy 27, which was dropped next to buoy Donna. The run was made at 8.5 knots, to about 14 miles distance. We then reversed course, dropped sonobuoy 28, and steamed back to the moored buoys. The next run was made on course 090 from buoy Jo, this time at 4 knots out to a distance of about 9 miles, at which point course was reversed again and another sonobuoy (29) dropped for a reverse run back in. Strong refracted signals were received, with the best records from the moored buoy (Fig. 3); refracted arrivals show curvature indicating the presence of strong velocity gradients.

During the airgun/sonobuoy runs, the seafloor hydrophones were checked and data tapes were removed and checked with a "quick-look" program which uses one instrument as a playback to put the contents on the screen of a Tektronix 4051 terminal. The resolution of this technique, which uses only a single gain setting, is limited, but it appeared that SFH1 and SFH2 had taken records of all shots fired. SFH3 had not recorded properly. The tape had only two events in it: a third event was stored in the digital memory, and was later extracted and put on the tape cassette. A voltage regulator in the Tandberg tape deck had failed, prior to the recording of the third event. Subsequently -- after completion of the entire station work, when full playbacks were made of all data through the ship's IBM 1800 computer, it was found that unit SFH1 had a peculiar arrangement of surface and bottom reflections on it, indicating that it had never reached the seafloor, but had either sunk very slowly or had reached an equilibrium depth in the water. Because of problems with the original gel-cell rechargeable batteries in the units, lithium battery packs (which are considerably lighter) had been put in instead; one small glass float had been removed to compensate for this, but apparently the compensation had not been adequate. This unit, therefore, being above the seafloor, had received reflected arrivals but no refracted arrivals. Shot times, depths, and ranges from both shooting runs are listed in Table III.

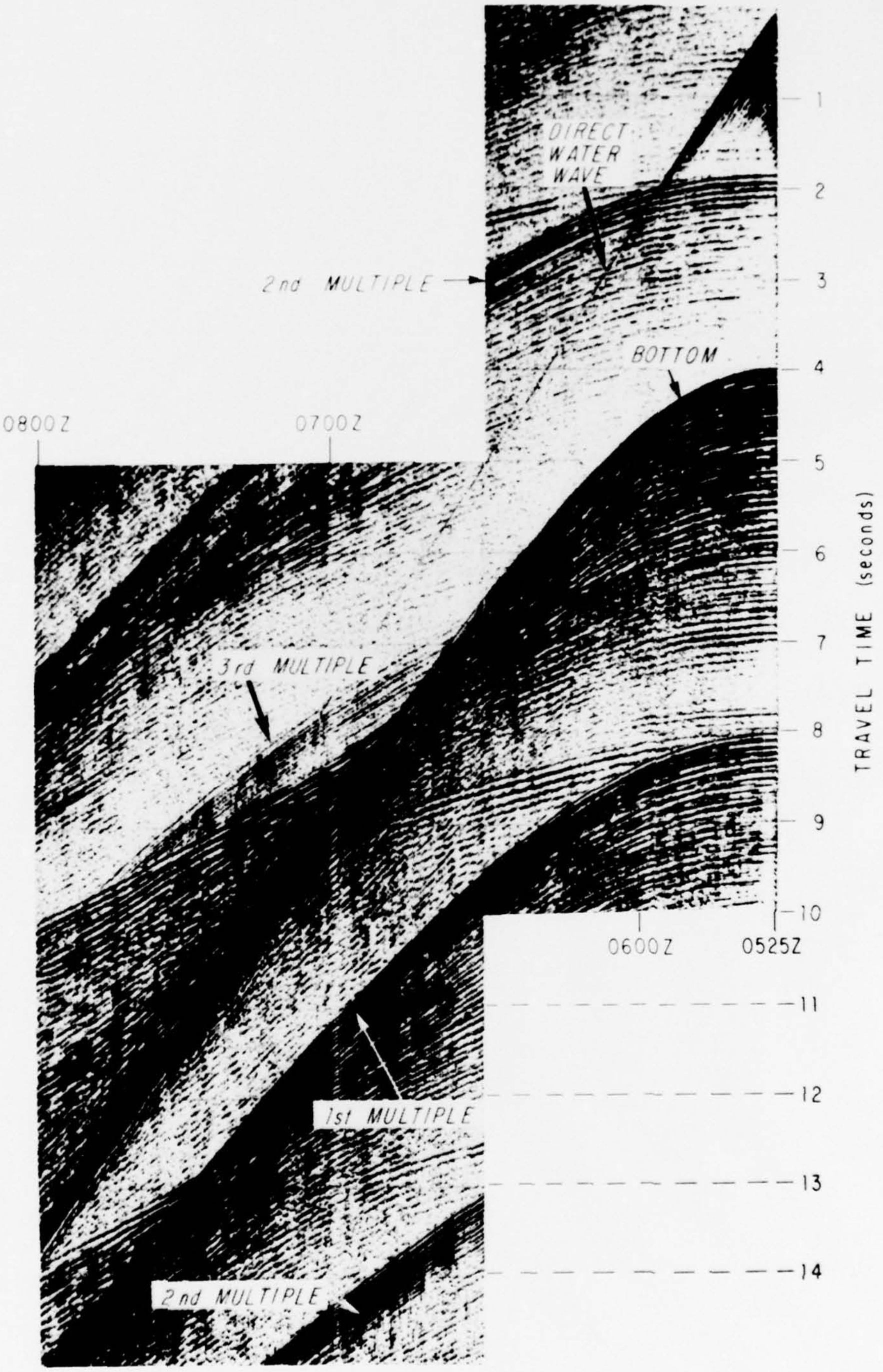

Fig. 3. Wide-angle reflection and refraction record from moored telemetering buoy at station site. Airguns were used as a sound source; ship speed was 4 knots.

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Table III

Shot Data

Shot	Time, UT		Shot Depth, km		Explosive		Range, km		Comments
No.	Drop	Detonation	Nominal	Actual	Weight	Type	SFH2	SFH3	
25 Feb 1979									
001	0959:50	1029:58	2.44	2.43	256(116)	TNT	4.67	-	Partial detonation
002	1011:01	1041:10	2.44	2.45	256(116)	TNT	4.88		
003	1020:14	1051:11	1.83	2.45	256(116)	TNT	5.15		
004	1031:32	1056:05	1.83	1.80	256(116)	TNT	5.42		
005	1040:30	1112:20	2.44	2.40	256(116)	TNT	5.53		
006	1053:02		2.44		256(116)	TNT			Dud
007	1100:02		1.83		256(116)	TNT			Partial detonation
008	1120:30	1151:59	2.44	2.45	256(116)	TNT	6.38		
009	1130:30	1202:36	1.83	2.38	256(116)	TNT	6.62		
010	1150:36		1.83		256(116)	TNT			SUS only
011	1211:35	1235:06	1.83	1.80	256(116)	TNT	7.50		
012	1229:20	1253:11	1.83	1.74	256(116)	TNT	7.88		
013	1249:33		1.83		256(116)	TNT			Dud
015	1310:03	1333:32	1.83	1.82	256(116)	TNT	8.63		
016	1330:01		1.83		256(116)	TNT			Partial detonation
017	1349:10	1413:01	1.83	1.78	256(116)	TNT	9.48		
26 Feb 1979									
101	1524:00		2.44		256(116)	TNT			Partial detonation
102	1533:00	1554:22	1.83	1.75	240(109)	HBX	1.54	1.33	
103	1541:00	1614:57	2.44	2.45	256(116)	TNT	1.82	1.59	
104	1549:00	1621:01	2.44	2.47	256(116)	TNT	2.09	1.84	
105	1558:00	1619:05	1.83	1.80	240(109)	HBX	2.33	2.11	
106	1607:05	1628:14	1.83	1.83	240(109)	HBX	2.59	2.37	
107	1618:00	1650:30	2.44	2.49	256(116)	TNT	2.95	2.75	
108	1627:08	1658:45	2.44	2.49	256(116)	TNT	3.25	3.04	
109	1638:00	1711:00	2.44	2.44	256(116)	TNT	3.62	3.38	
110	1647:00	1708:40	1.83	1.79	240(109)	HBX	3.84	3.62	
111	1703:00	1725:59	1.83	1.75	256(116)	TNT	4.36	4.15	
112	1718:03	1738:57	1.83	1.81	240(109)	HBX	4.79	4.56	
113	1738:40		1.83		240(109)	HBX			Partial detonation
114	1748:04		1.83		256(116)	TNT			Partial detonation
115	1803:03	1826:06	1.83	1.95	240(109)	HBX	6.15	5.91	
116	1818:02		1.83		256(116)	TNT			Partial detonation
117	1833:08	1855:57	1.83	1.89	240(109)	HBX	7.14	6.89	
118	1848:04	1911:45	1.83	1.79	256(116)	TNT	7.72	7.46	
119	1903:05	1927:11	1.83	1.01	240(109)	HBX	8.20	7.97	
120	1918:07	1943:38	1.83	1.99	256(116)	TNT	8.75	8.53	
121	2106:00		2.44		240(116)	HBX			Partial detonation
122	2122:01	2143:06	1.83	1.83	240(109)	HBX	4.78	4.56	
123	2125:05	2145:15	1.83	1.84	240(109)	HBX	5.24	5.01	
124	2144:02	2204:20	1.83	1.72	240(109)	HBX	7.90	7.64	

Note: detonation times are as recorded on SFH2, and are not corrected for clock drift.

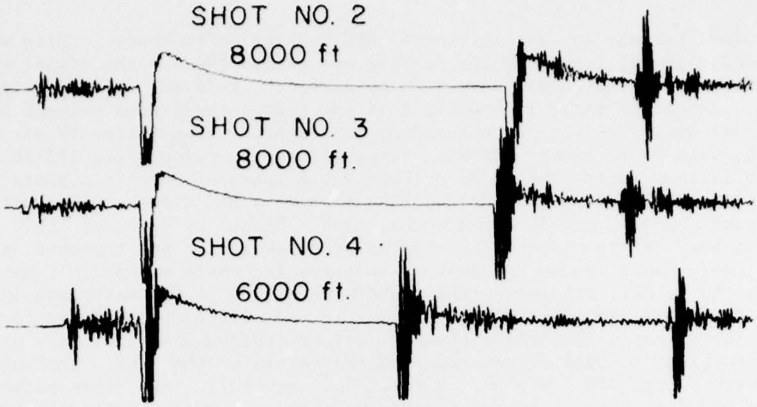

Fig. 4. Individual record from Seafloor Hydrophone system #2, run #1. Dominant frequency of 52 Hz in the refracted waves is as predicted from the bubble-pulse equation.

Examples of individual record playbacks (at high gain) are shown in Fig. 4. A record section, with rough water delay correction and only rough correction for charge size and instrument sensitivity, is Fig. 5.

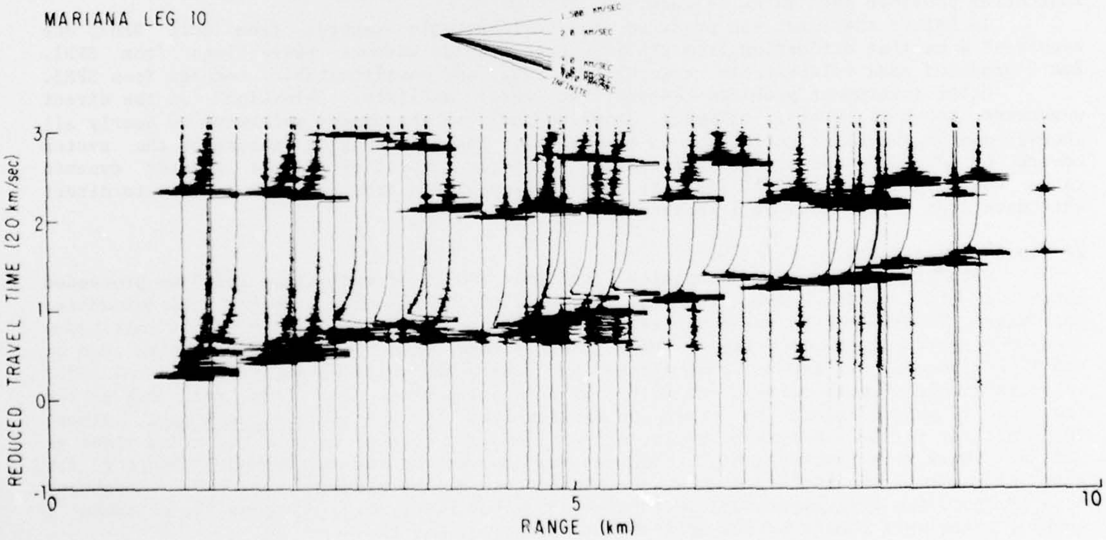

Fig. 5. Rough record section, combined data from runs 1 and 2, all instruments. Shots at depths of 6000 feet and 8000 feet, in waterdepth of 9600 feet. Approximate corrections have been made for variations in shot depth. Gain settings have not been compensated fully for calibration of the hydrophones or for partial detonations of shots.

26-27 February

We returned to buoy Jo, got all three SFH working units ready. Units were dropped in quick succession trying for 300 meter spacing by using the 3.5 kHz signal relayed back from Jo. Before the instrument turn-on time came, the relayed 3.5-kHz signal became extremely weak. After the fact, it appears that the hydrophone preamp voltage had dropped, so that the signal wasn't getting to the radio, although the transmitter RF was strong. We shot the line, with very weak 3.5-kHz ranging signal, using a few 1/2-lb charges for ranging for the farther shots. Again we drifted (at a speed of about 0.8 knots) during the shot "run". Using combinations of 6000 and 8000 foot Mk94 Mod 0 SUS charges with 240 lb of M791 HBX haversack changes, or 256 lb (4 boxes, each 8 blocks of 8 lb) of TNT. The 256-lb TNT worked well; the 240-lb haversack charges were awkward to put together, and somewhat loose. There were some duds and gaps in shot spacing where we couldn't get the 240-lb charges made up in time; otherwise the shots were at 300 to 600 meter spacing. At 8 km range from the furthest SFH, we returned to buoy Jo and drifted south again for four final shots, to fill in the gaps. The final shot was not recorded on the shotbreak streamer.

Upon returning to buoy Jo, we awaited the return of the SFHs. Instruments II and III came up uneventfully; SFH I did not surface on schedule. We then picked up buoy I (Donna), and returned to buoy II to await the release of SFH1 by its 24-hour magnesium link. Finally, at 1800 (local) 27 Feb., we picked up buoy II (Jo), and spliced the anchor line to the hydrowinch to try to pull it in to see if SFH was caught on the line. The polypropylene line broke where the pennant connection jammed in the hydrosheave. Since there was no sign of SFH1; we abandoned it 26 hours after deployment time, and headed south to 8-30N 88-00E to start the next multichannel line.

Both SFH2 and SFH3 apparently recorded all shots, including 1/2-lb ranging shots. Our quick-look program was set up to use SFH1 as the playback unit, with some built-in modifications that were not in the other instruments, so any look at the records had to wait for modification of one of the other instruments.

When playback was completed, first with the quick-look program and then with full playback on the IBM 1800, it was found that units SFH2 and SFH3 both had complete record sets, but that the records on unit 3 were approximately 30 db down in signal level; due to the large dynamic range of the recording system they were recoverable. A post-deployment calibration indicated that the recording electronics were normal, but the internal resistance of the hydrophone had dropped from more than 125 Megohm, to about 125,000 ohms, indicating possible salt water leakage.

In brief: the first run produced good, calibratable records from unit SFH2; one record of a partial defonation from SFH3; several records without refractions from SFH1. Run 2 produced good calibratable records from SFH2, and uncalibratable records from SFH3.

Other instrument problems encountered were: amplifier "blocking" on the direct waterwave on most shots; clipping (overloading) on the direct waterwave on nearly all shots, and on the first reflection on some shots. The gain-ranging feature of the system covers 60 db, and the actual digitization 72 db for a total of 132 db; greater dynamic range would be needed if full fidelity were to be achieved from background noise to direct waterwave from large shots at 1 km range.

27 February - 3 March

With all station work completed (and only 240 lb of explosives left) we proceeded south, at full ship speed, running airguns, single-channel streamer, magnetometer, gravimeter, 3.5-kHz UGR on gated programs for bottom return and 12-kHz GDR on continuous sweep for scattering layer returns. Many "long finned echoes" (large fish?) were seen on the 12-kHz record. At 1600Z/28, we stopped to launch the multichannel streamer. At 1935Z we started multichannel seismic reflection line #2. The track led from well out on the fan, at a point chosen to cross an earlier line by the Glomar Challenger, almost perpendicular to the Ninety-East Ridge, and was designed to come up onto the ridge slope as far as there were fan sediments. Basement was apparent on the multichannel monitor for much of the run; the sediments here are thinner than at the station position. Sonobuoys were dropped for airgun/sonobuoy refraction along the line, no. 32 through 42; of these 6 worked, three were caught by the multichannel streamer, and two were bad.

At the end of the run, the basement came up smoothly toward the break in slope of the seafloor; a blanket of relatively transparent (pelagic) sediments covered the ridge itself at this crossing. We got underway as soon as the multichannel streamer was aboard. The airguns were repaired and then the ship slowed to stream the single-channel system, with a short gap in reflection coverage. The single-channel records were digitized on the PDP8 computer, along with sonobuoys as they were dropped. Four more sonobuoys (43 to 46) were used during the single-channel run across the Ninety-East Ridge, the Nicobar Fan, and the north end of the Sunda Trench.

3 March - 5 March

Our track came up the trench slope to a point just south of Great Nicobar Island, then to a point just north of the north tip of Sumatra, entering the North Sumatra Basin. As we crossed the approximate offshore extension of the Great Sumatran Fault, we found a deep narrow graben, partially filled with sediments. At 0114Z/3 March, we stopped and put out the multichannel streamer again for MCS line 3, and started the run at 0324Z. The attempted operating speed was 7 knots, with repetition rate on the airguns set to 13.0 seconds to match. During the run, the indicated speed on the Doppler Log fluctuated frequently, going down to as low as 6 knots, and up to 8. The bridge reported the existence of lines of discoloration in the water ("tide rips,") although exact times were not logged. The 12-kHz echosounder, which was being operated on continuous sweep to see the scattering layers, had visible shallow discrete scattering layers 40 to 60 fathoms below the surface; in places (especially between times 0330Z and 0900Z), fluctuations in depth to one or more of these layers was visible with an amplitude (peak-to-peak) of 10 to 15 fathoms, and a wavelength of 0.5 to 0.8 miles (4 to 7 minutes of ship travel) (Fig. 6).

The multichannel line showed detailed structure of the North Sumatra Basin, including numerous small faults, the buried Mergue Ridge, and possible diapirs; correlatable reflections could be followed up the continental slope, where the line was concluded at 5°56'N, 97°47'E.

At this point the multichannel streamer was pulled in, and all underway equipment secured except the 3.5 kHz echosounder and the magnetometer, for passage through Malacca Strait. The magnetometer was pulled at 1323Z/4, when the water became too shoal.

Fig. 6. Fluctuations in depth of shallow scatterers on the 12 kHz GDR echosounder record in the North Sumatra Basin. Scale lines are at 20 fm spacing; ship speed is 7 knots. These fluctuations were accompanied by 1 knot variations in the speed readings of the ships Doppler log, with no change in engine rpm.

5 March - 11 March

After we left Singapore Strait, the 12-kHz echosounder was turned back on, on 100 fathom sweep, for shallow bottom penetration. The 3.5-kHz was put on a 200 fathom sweep, and adjusted for best definition of shallow layers. Numerous filled stream channels were found (Fig. 7); in some locations one could identify as many as 3 stages of erosion and resedimentation within the first 40 fathoms below the sea floor. The magnetometer was streamed again after we passed Natuna Besar Island and the water deepened slightly. Airguns were streamed again at the southwest end of Palawan Trough, for the run down into the trough and along the trough axis, at 2039Z/7. We used an old streamer because explosives use was planned to supplement airguns on sonobuoy runs. The records were poor; checking disclosed that the 300 cubic inch gun had cracked, and that there was a broken lead in the streamer. While these were being repaired, we crossed over an uncharted ridge, 780 fathoms at shoalest point, crossing the axis of the Palawan Trough, separating a sedimented area with a depth of about 1400 fathoms to the southwest from an area with a depth of about 1500 fathoms to the northeast; the shoalest point was at 06°16'N, 113°53'E. Sonobuoy 51 was launched at 0744Z/8, and the airgun run from it was first recorded on PSR, then we changed to shots for sources for station 10-3. Sonobuoys 52 and 53 were launched at 1002Z and 1003Z; a basement hill just penetrating through the sediments was crossed

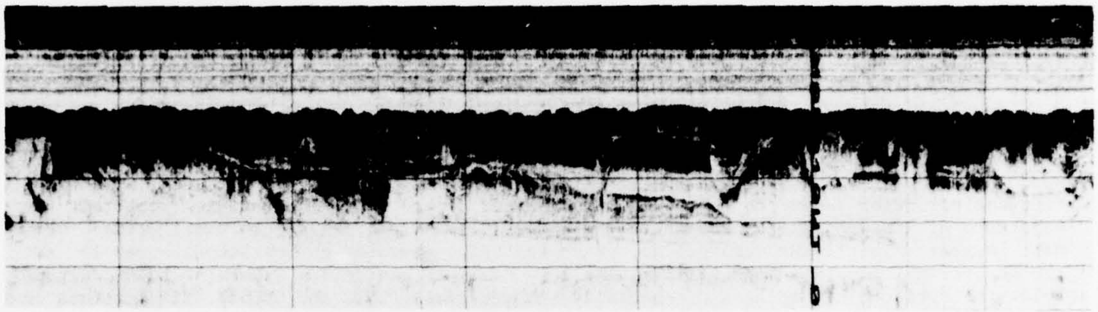

Fig. 7. Shallow subbottom topography on the Sunda Shelf, east of Natuna Island, as shown on the 3.5 kHz echosounder. Note repeated cutting and filling of channels. Scale line spacing is 10 fm; vertical lines are at approximately one mile intervals.

immediately after launch. Airgun/shot run 10-4 was shot from these 2 buoys. Buoy 54 failed. Buoys 55 and 56 were launched at 1237Z and 1240Z, and airgun/shot run 10-5 made from them, concluding at 1421Z with all explosives expended. At 1456Z airgun operations were secured and we found yet another cracked airgun. Underway 3.5-kHz and 12-kHz echosounding and magnetometer operations continued until 1600Z (2400 local) 10 March, when they were secured preparatory to entering Subic Bay.

Acknowledgements

The primary program, on attenuation of sound in thick sediments, was sponsored by the Naval Ocean Research and Development Activity (NORDA), contract no. N00014-75- C-0749. The Office of Naval Research provided the necessary surplus explosives and sonobuoys, and supported the earlier environmental studies by Curray et al. that provided the needed data base. The cruise as originally planned was to have been a 10-day loop out of Phuket, Thailand; ship time funded by NORDA was therefore sufficient to cover only this part of the track. Subsequent cancellation of programs intended for the Thomas Washington preceding and following this work required rather longer runs: from Jakarta to the working area, and to Subic Bay, Philippine Republic, following completion of the main work. Ship time for these transit runs was provided by the University of California through ship operation funds of the Scripps Institution of Oceanography. Similarly, the cost of operating the multichannel seismic reflection system over this longer time period required some subsidy which came from Scripps Industrial Associates funds of the Scripps Institution. We thank the crew and the scientific party of the Thomas Washington, for their help.

Appendix I-A
Scientific Party Aboard R/V Thomas Washington
MARIANA Leg 10 16 Feb. - 11 March, 1979

NAME	JOB TITLE	DUTIES
George G. Shor, Jr.	Prof. of Marine Geophysics	Chief Scientist; Shooter; watchstander; XBTs
J. Lynn Abbott	Prin. Devel. Engineer	In charge, shipboard computer and multichannel seismic recording system
Arthur Burkhalter	Devel. Engineer	Shipboard computer & multichannel seismic recording system
Perry Crampton	Senior Devel. Engineer	In charge: airgun reflection system & multichannel seismic wetware
Frank Hubenka	Pr. Electronics Tech	Airgun single-channel reflection system & multichannel seismic wetware; echosounder
Ronald Comer	Marine Tech	Resident Marine Tech; coring; underway data handling; stowage & rigging; forms & reports
Martin Benson	Asst. Devel. Engineer	Seafloor hydrophone system; refraction construction & maintenance
Paul O'Neill	Staff Research Assoc. II	Seafloor hydrophone system; refraction construction & maintenance
Randall Jacobson	Research Assistant	Graduate student; attenuation program; refraction recording; underway watchstander; sonobuoy program
Robert Kieckhefer	Research Assistant	Graduate student; recording/telemetering moored buoys & sonobuoy program, shooter, underway watchstander
Delpha McGowan	Staff Research Assoc. II	Refraction recording; underway watchstander
Elizabeth Shor	Senior Writer	Volunteer watchstander; biological sampling

Shor

Appendix I-B
Ship's Crew Aboard R/V Thomas Washington
MARIANA Leg 10, 16 Feb.-11 March, 1979

NAME	JOB TITLE	DUTIES
Curtis Johnson	Captain	Master
Albert Pelz	First Mate	First mate; 04-08 watch
Alvin Gettler	Second Mate	Second mate; 00-04 watch
David Kendall	Third Mate	Third mate; 08-12 watch
Larkin (Whitey) Garner	Boatswain	Dayman; maintenance & rigging
Lambert (Bambu) Halsema	AB Seaman	Seaman 0-4 watch
Samuel Devlin	AB Seaman	Seaman, 04-08 watch
Theodore Falagan	AB Seaman	Seaman, 08-12 watch
Julio Catudio	Cook	Cook
Alejandro Velasco	Cook	Cook
Donald Lingle	Radio Officer	Radio operator
Craig Hodgert	Chief Engineer	Chief engineer; in charge
Anastacio (Tony) Dy	First Engineer	First engineer; 04-08 watch & aux. maintenance
Michael Dorthalina	Third Engineer	Acting second engineer; 0-4 watch & oil king
Bryan Dunlop	Oiler	Acting third engineer; 8-12 watch
Robert Shahl	Oiler	Oiler, 0-4 watch
Ronald Ellis	Oiler	Oiler, 4-8 watch
Terry Hoopes	O-in-C, float. inst. platf.	Acting oiler, 8-12 watch
Walter Hallfarth	Ships Electrician	Electrician, 4-8 watch

Appendix II

MPL Seismic Refraction Recording/Telemetering Moored Buoys

The SRRT buoys were built to provide a simple, easily deployed and relatively inexpensive moored buoy for single-ship seismic refraction work, and replaced the relatively awkward "balloon telemetry" system used earlier. A good quiet hydrophone provides much better signal/noise ratio than standard sonobuoys. Mooring reduces ambiguities in data interpretation in areas of rough topography or rapidly changing structure. Telemetry in the 80 MHz band provides real-time data to permit adjustments of shot size over the length of most seismic refraction runs, and internal tape recording provides a backup in cases where radio range is inadequate or radio interference wipes out telemetry.

The major components are: an expendable anchor weight, a light-weight (and cheap) expendable mooring line, a surface instrument case/float, a hydrophone on a decoupled suspension, a hydrophone surface buoy, crystal clock, audio amplifier, slow-speed cassette tape deck, radio transmitter, marker flag, and two flashing lights (one on the hydrophone float, one on the instrument float).

The anchor weight is normally 50 to 100 pounds of scrap anchor chain, to which the mooring line is tied.

The mooring line is 1/4-inch hollow-core braided polypropylene line. It comes in 1000-foot reels, and is end-spliced quickly while the anchor is falling (units are always set "anchor first"). Moorings are abandoned. In deep water, the length of the mooring line is usually 10% more than the depth of water, unless the mooring slacks before that much is paid out.

The instrument case, itself positively buoyant (unless flooded), is a 4-foot section of 8-inch PVC sewer pipe, with one pipe collar glued on the outside, and another slip-on collar clamped on with set screws, a flat PVC bottom glued and screwed to the bottom, and a top plate sealed with an O-ring and trunk latches. It is fastened through the center of a square foam float which has plywood top and bottom boards. There are four penetrations at the top of the instrument case: a plug for the hydrophone, a ground terminal for a seawater ground, an antenna socket, and a shorting plug to turn on transmitter power. On older versions, the transmitter case itself protrudes through the top, rather than an antenna plug.

The hydrophone is a Brush Electronics A-58C unit (made in the 1950s), on a decoupled suspension of the type developed by Raitt. It is on a 50-foot leader neutrally balanced with alternating floats and weights, and a 100-foot drop cable, from a "string of beads" float that acts as a flexible spare buoy; a 100-foot surface cable leads to the instrument buoy. A recovery line (a section of 3/8-inch hollow-core polypropylene) is taped lightly to the surface cable.

The internal time base is a crystal clock, which is set to WWV before launching, and produces a 100 Hz time code that gives hours, minutes, and seconds in "reverse BCD" once per second.

There is an impedance-matching preamplifier in the hydrophone case, powered from the instrument buoy, and another filter/amplifier in the buoy, which amplifies the signal for the recorder.

The radio transmitter is the transmitter section from a Select International 80 MHz sonobuoy. The recorder is a Katsujima 4-track slow-speed AM cassette recorder, of the type used in the ocean bottom seismographs designed by Asada. It records at 0.8 mm/sec (slowed down by a factor of 60 from normal speed of 1 7/8 ips). The 4 tracks have on them a low-frequency high-gain signal, a low-frequency low-gain signal, a high-frequency rectified signal, and the BCD time code: the time code is modulated on the 100 Hz carrier.

The instrument is powered by three battery systems: a set of dry cells for the clock, another set of dry cells for the recorder and amplifier, and either rechargeable gel-cells or disposable lithium cells for the transmitter and hydrophone preamp. This combination caused problems on the present cruise, since excessive current drain by the transmitter could drop the voltage to the hydrophone preamplifier and eliminate the seismic signal even when there was still adequate RF output from the radio; in the future the power sources will be separated.

Playback of the signals was formerly done by playing back at normal speed (60 times recording speed) on a TEAC four-track tape deck, re-recording on a PI FM tape recorder, and then playing back the PI tape at lower speed, approximately 4 times recording speed. In the future we plan to transcribe tapes by playing them into a PDP8 digitization system at high speed, with the digitization controlled by the (speeded up) 100 Hz timing signal.

These buoys were originally built by Bruce Rosendahl and Paul O'Neill, supported by an NSF grant for refraction studies of the Canton Trough. They have since been modified and operated by Bob Kieckhefer, who has completely redesigned the instrument package (with Dale Bibee) and written the software for digitization.

Appendix III

Paul O'Neill

The MPL Sea Floor Hydrophone System

The system was built at the Marine Physical Laboratory, to meet a set of requirements that differ significantly from most OBS and OBH. The controlling requirements were that the units have high dynamic range, good fidelity, and stable calibration, so that the units could be used for amplitude measurements for attenuation studies. Because attenuation usually increases with frequency, and relatively low values of attenuation may be expected in areas of interest, the response must extend to higher frequencies than normally used in earthquake or seismic refraction recording. In order to obtain diving wave data, with the events as first arrivals on the record uncontaminated by events from the same source that have travelled other paths, it is necessary to use not only on-bottom recorders, but also sources at great depth in the water (as close to bottom as possible). Unless one were to lower the sources (shots) on a wire and detonate them electrically, which is slow and somewhat hazardous, the shots must free-fall for a considerable (and variable) time; it is therefore necessary to use event-triggered recording, rather than time-window recording. Other requirements initially set were that the unit use a pressure signal rather than displacement or velocity and be a short distance above the seafloor, in order to avoid noise from trapped shearwaves in the upper part of the sediment section, and that the tape deck not operate during the time that the signal was actually arriving, in order to avoid noise coupled from the mechanical tape drive back into the sensor.

The resultant package fitting these requirements is a digitally-recording, gain-ranging system with microprocessor control, which records the signal from an omni-directional pressure-compensated hydrophone.

Input Stages

The hydrophone is a pressure-compensated ceramic unit with an internal pressure-relief chamber oil-filled and connected through a small orifice to an external oil reservoir that is connected to sea pressure by a flexible diaphragm. The hydrophone is mounted on the cap of the main pressure case. Hydrophone output signals go to a FET preamplifier, the output of which goes both to a 500-1000 Hz bandpass filter and to an anti-alias filter. The bandpass filter is used to ensure that only water-wave signals operate the event-detector circuits. The output of the bandpass filter goes to an analog event-detector, which compares the short-term (0.1 second) average to the long-term (10 second) average, and sends out a spike to the clock circuit when the short-term average is 10 dB above the long-term.

The anti-aliasing filter is a plug-in unit, which must be changed for any change in the digitization rate. Available filters are 20, 40, 80 and 200 Hz, for use with 50, 100, 200, and 500 Hz digitization rates.

The signal from the anti-aliasing filters goes to the gain-ranging amplifiers. Five non-inverting amplifiers, each with a voltage gain of 4 give a possible maximum gain of 1024 (about 60 dB) before the signal is digitized. When a sample is to be taken, the unamplified signal is compared with a reference voltage that is 1/4 of the full-scale voltage of the analog-to-digital converters. A very strong signal will exceed the reference voltage, and be digitized as is. If the signal is smaller than the reference voltage, the output of the first amplifier will be compared with the reference. This continues until one of the amplifier outputs is found that exceeds the reference level, or until the output of the last amplifier is reached. This gain-ranging scheme adds 60 dB to the dynamic range of the instrument. On Mariana 10 the system normally operated at full gain between shots, with a small noise signal present.

Digital Circuitry

The SFH digital circuitry consists of the CPU (central processing unit), the memory, and I/O (input/output) devices listed below:

ADC (analog-to-digital converter)	INPUT
CLOCK	INPUT
TAPE DECK	INPUT + OUTPUT
RS232 COMMUNICATIONS INTERFACE	INPUT + OUTPUT
POWER REGULATORS	OUTPUT
DATA BUS BUFFERS	OUTPUT

All circuits except those associated with the tape deck are built with COSMOS integrated circuits for low power consumption.

The CPU is built around the RCA COSMAC 1802 microprocessor and is patterned after the CPU circuit of the RCA COSMAC EVALUATION KIT. The COSMAC 1802 is an 8-bit device, operating on one 8-bit byte of information at a time. A crystal oscillator clocks the microprocessor through its states and provides timing signals for the clock and ADC. 1024 bytes of ROM (read-only memory) on the CPU board are used for program storage. The data-taking program and a utility program reside here. A 32-byte RAM (random access memory) stores deployment parameters and event information (time of event, event number, etc.). An 8-bit data bus carries information between the CPU, memory, ADC, clock and tape deck.

Memory

The data memory of the SFH is 8192 bytes of COSMOS RAM on a single board. There is space in the system for three more RAM boards, which could be installed for longer record lengths, multi-hydrophone recording, or maintaining long record lengths with faster digitizing rates.

Clock

The clock circuit is driven by the CPU oscillator. It keeps track of seconds and milliseconds in registers that can be read by the CPU. Every minute the registers reset to zero and signal the CPU that a minute has elapsed. The CPU then keeps track of minutes and hours when an appropriate program is running. A switch-selectable sampling frequency of 50 Hz, 100 Hz, 200 Hz, or 500 Hz is generated by the clock and sent to the ADC to initiate the gain-ranging and digital conversion sequences. The clock latches the seconds-to-milliseconds count when the event detector output goes "true" and signals the CPU that an event has occurred.

The ADC converts the output of the gain ranging amplifier to a 12-bit number. A 3-bit number specifying which stage of the gain-range amplifier is being digitized is tacked on to these 12-bits. The CPU reads 2 bytes from the ADC for every sample and stores them in 2 memory locations. Hence the 8192 byte memory board holds 4096 data samples. The 12-bit converter and gain ranging amplifier gives the SFH a dynamic range of 132 dB. The total record storage is 82, 41, 20.5, or 8.2 seconds depending on the digitization rate.

Tape Deck

The digitized data is recorded on a TANDBERG TDC-3000 digital tape deck. This is a 4-track, 30 ips, 1600 bpi, phase encoded deck recording on SCOTCH DC-300A tape cartridges. It was chosen for its high data density and physical size, which would fit (barely) into a 6-1/2 inch cylinder.

Read/write, control and servo electronics are all on printed circuit boards supplied by TANDBERG. These circuits make extensive use of TTL integrated circuits and hence are intrinsically power-hungry compared with the COSMOS circuitry used elsewhere in the SFH. The TANDBERG formatter and interface printed circuit boards would not fit in a 6-1/2 inch cylinder. These TANDBERG circuits were copied on wire wrap boards by MPL; again using TTL ic's to avoid a lengthy redesign in COSMOS. Power is supplied to the deck, deck electronics and formatter only when it is being used.

The CPU cannot supply data to the tape deck fast enough at 30 ips, so the deck was slowed to 15 ips. At this speed it takes 4 seconds to record the 8192 bytes stored in the data memory and the 32 bytes of log information on the CPU board. One tape will hold 260 of these records.

Tape Deck Power

The TANDBERG electronics required + 10V and ±20V. A regulator which can be turned on and off by the CPU supplies these voltages.

Data Bus Buffers

The COSMOS circuitry of the SFH has virtually zero power drain when it is in a static (DC) state. AC power drain resulting from stray capacitances being charged and discharged while the circuits are switching states is the major power drain.

The 8-bit data bus and most timing signals are driven by buffers that can be turned on and off by the CPU. They are arranged such that when off only the CPU and clock are active, with the memory and all other I/O devices in a static state. The SFH is launched in this "NOT ACTIVE" mode and returns to it after shooting ends to conserve power. Between pre-programmed turn-on and turn-off times the buffers are turned on and the instrument is "ACTIVE".

RS232 Communications Interface

The bit-serial communications interface enables the CPU to communicate with data terminal equipment in the "outside world". The RS-232 interface, in conjunction with the utility program stored on the CPU board, enable the user to deposit numbers in the SFH's memory, to examine the contents of the memory, and to start execution of a program residing in memory.

Power Supply

Power is supplied by eight 7.5 amp-hour, rechargeable GEL CELL batteries wired as a ± 24V supply. A 5V regulator and a ± 15V regulator are on continuously supplying the COSMOS digital circuitry and analog circuitry, respectively. The ON/OFF regulator described above powers the tape deck. Thirty-six hour deployments are possible with this power pack. Use of lithium cells has been tried, and can either increase deployment time or decrease instrument weight, or both. It also increases the cost per deployment.

Hardware

The pressure case is a 60-inch aluminum tube of 6-1/2 inch inside diameter and 3/4 inch wall thickness. The top pressure cap has a single feed-thru for mounting the hydrophone. The bottom pressure cap has a small pressure case bolted to it containing the time-release electronics.

The time release is the burn-wire system developed by Boegeman and Pavlicek and used extensively by MPL for transponder deployments. It is totally independent of the SFH. At a preset time it drops the 2 m of polypropylene line that tethers the SFH to its anchor (120 lb of scrap iron).

Flotation and recovery aids have been borrowed from the Data Collection and Processing Group of SIO, and are the standard recovery system of the DCPG current meters with the addition of extra flotation to accomodate the heavier instrument package. The "backbone" of this system is a length of nylon line. A mast/flag/radio/flasher/flotation assembly is secured to the top of the line. Glass spheres of sufficient buoyancy are attached to the midpoint. The SFH is interfaced to this system by merely bending the bottom of the line to the bail on the top of the SFH.

Operation

The SFH is pre-programmed for a deployment with a TEKTRONIX 4051 GRAPHICS TERMINAL. This terminal has a communications interface option which connects to the SFH's RS-232 interface. Using the utility program the "lag", or 32-bytes of RAM on the CPU board, are loaded with launch parameters. These include: the current time of day, station ID, SFH ID, hydrophone ID, direct-wave delay (see below) and "ACTIVE" and "NOT ACTIVE" times (turn-on and turn-off times). The utility program is then used to initiate execution of the data-taking program, DATA 1. The 4051 is disconnected. The SFH is sealed in its pressure case. After securing anchor line and recovery line it is ready to launch.

DATA 1 initially does nothing but keep track of the time of day and compare it with the turn-on time. Turn-on time is chosen such that the SFH will have reached the bottom, to avoid false triggers from noise during descent. When turn-on time is reached the data-bus buffers are turned on, activating the SFH, and DATA 1 begins digitizing the hydrophone signal and waiting for an event. When the direct-wave from a shot triggers the event-detector, the clock latches the current seconds and milliseconds and signals the CPU. The CPU reads the seconds and milliseconds and stores them along with its count of hours and minutes in the log. Event #, Tape File # and Tape Track # are also added to the log. Digitizing continues after the trigger for a time specified by the "direct-wave delay". When the direct-wave delay has elapsed digitizing stops, the tape deck is turned on and the log and data memory are dumped to tape. During tape dumping an error routine monitors tape operation. If the read-after-write circuit detects an error the record is repeated. If the end of the tape is reached, the tape is rewound and recording is continued on the next track. When all data are recorded the tape deck is turned off, digitizing resumes and the CPU waits for the clock to signal another event.

It should be noted that the tape deck is never on while data is being digitized. This avoids the common problem in recording instruments of acoustic and electrical noise from the tape recorder showing up in the data. However because of this record length is strictly limited by memory size. Other similar instruments have used memory only for pre-trigger data and then record post-trigger data in real-time on the tape deck. In the SFH all data is first stored in memory, then recorded. This scheme and the "direct-wave delay" provides great flexibility. The water wave that triggered the SFH can be at the beginning of the record, at the end of the record, or anywhere in between.

When turn-off time is reached the data-bus buffers are turned off and DATA 1 no longer looks for events. It continues its time of day count only. When recovered the SFH is reconnected to the 4051 terminal, execution of DATA 1 is stopped and the utility program is run. The log and internal CPU registers are examined. An inspection of these numbers gives a good indication of the success of the deployment and if there was a failure can point to the cause.

Software

Four major programs exist for the SFH's.

The utility program and the DATA 1 have been described.

QLOOK is a quick data playback program which reads the SFH tape data on the SFH tape deck back into the SFH memory where it started from. It then truncates the samples, and draws an analog record of the memory contents on the 4051 GRAPHICS TERMINAL. Hence, the SFH can function as its own playback system. Records drawn by QLOOK have very limited dynamic range and cannot be used to reduce the data. They do give a quick picture of the quality and character of the data.

XCRIBE1 similarily reads SFH data back into SFH memory. It then sends the unaltered samples out the RS232 interface. The Shipboard Computer Group of SIO has developed software for their sea-going IBM 1800 computers that receives this data over the 1800's RS 232 interface and generates 9-track magnetic tapes. These tapes are in the same format as those generated by the PDP8/E computer commonly used at MPL to digitize seismic refraction and reflection stations. Other 1800 software exists for plotting record sections from these tapes.

Credits

William Whitney did the basic design of the SFH system. Paul O'Neill carried out detailed design, constructions, and much of the software development. Randall Jacobson wrote the DATA 1 software. Development of the sytem was supported by a contract from NORDA.

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CRUISE REPORT: MARIANA LEG 10 by George G. Shor Jr., University of California, San Diego, Marine Physical Laboratory of the Scripps Institution of Oceanography, La Jolla, California 92093. <u>SIO Reference 79-8</u>, <u>1 July 1979</u>.

The primary scientific goal of leg 10 of Mariana Expedition was to make a set of measurements in the thick sedimentary section of the Bengal Fan that would make it possible to calculate the attenuation of sound as a function of depth in the sediments. The Bengal Fan was chosen as the location for the study because it contains the thickest section of fan sediments in the ocean, and previous studies by Curray and Raitt have shown that the sedimentary section has few sharp velocity discontinuities. The types of measurements required were of two types: multichannel seismic reflection measurements and "diving wave" studies of waves continuously refracted through the sedimentary column from deep sources to receivers located at the sea floor.

IIIa. Seismic Refraction
and Reflection

George G. Shor, Jr.

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Additional observations taken to provide environmental data and to make use of the available ship time on the transit to and from the primary working area including sonobuoy/airgun refraction work, XBT measurements, a few gravity cores at the study area, continuous 12 kHz and 3.5 kHz echo-sounding, magnetometer measurements along all portions of the track of adequate water depth, and gravity measurements in the first portion of the leg. Single-channel airgun measurements were taken along much of the track, and in selected locations were digitized for later playback.

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