AD-A034 849 SCRIPPS INSTITUTION OF OCEANOGRAPHY SAN DIEGO CALIF --ETC F/G 8/7
SEISMIC REFRACTION STUDIES IN THE SOUTHERN CALIFORNIA BORDERLAN--ETC(U)
JUL 76 G G SHOR, R W RAITT, D D MCGOWAN N00014-75-C-0749

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SCRIPPS INSTITUTION OF OCEANOGRAPHY
SAN DIEGO, CALIFORNIA

15 JULY 1976

MARINE PHYSICAL LABORATORY
of the Scripps Institution of Oceanography
San Diego, California 92132

SEISMIC REFRACTION STUDIES IN THE SOUTHERN CALIFORNIA BORDERLAND, 1949-1974

George G. Shor, Jr., Russell W. Raitt, and Delpha D. McGowan

Sponsored by
Office of Naval Research
N00014-75-C-0749
N00014-75-C-0704
and
National Science Foundation
NSF OCE 75-19387

15 July 1976

SIO REFERENCE 76-13

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER SIO Reference 76-13	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) SEISMIC REFRACTION STUDIES IN THE SOUTHERN CALIFORNIA BORDERLAND, 1949-1974		5. TYPE OF REPORT & PERIOD COVERED Summary
		6. PERFORMING ORG. REPORT NUMBER MPL-U-13/75
7. AUTHOR(s) G.G. Shor, Jr., R.W. Raitt, D.D. McGowan		8. CONTRACT OR GRANT NUMBER(s) ONR N00014-75-C-0749 & 0704 and NSF OCE 75-19387
9. PERFORMING ORGANIZATION NAME AND ADDRESS University of California, San Diego, Marine Physical Laboratory of the Scripps Institution of Oceanography, San Diego, California 92132		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Office of Naval Research, Code 212, Department of the Navy, Arlington, Virginia 22217		12. REPORT DATE 15 July 1976
		13. NUMBER OF PAGES 70 + i
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Document cleared for public release and sale; its distribution is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

seismic refraction, layer solutions, marine geology, crustal structure

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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S/N 0102 LF 014 6601

UNCLASSIFIED

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F. N. SPIESS, DIRECTOR
MARINE PHYSICAL LABORATORY

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ABSTRACT

Seismic refraction observations have been made by the staff of the Marine Physical Laboratory in numerous locations in and near the Southern California Continental Borderland; many of these stations have not been reported previously. Travel-time plots, cruise notes, position data, and layer solutions for fifteen operations in the area (30^{o} to 35^{o} north latitude, from the coast west to 123^{o}west longitude) provide the basic information for studies of crustal structure, and are presented here.

INTRODUCTION

A bit of history

Starting in 1948, a group at the Marine Physical Laboratory of the University of California, under Russell W. Raitt, began developing methods of carrying out seismic refraction measurements at sea, as part of a continuing program of study of the reflection and refraction of underwater sound by the sea floor. The early work concentrated on development of techniques, and by early 1949 had resulted in the acquisition of records that could be interpreted in terms of crustal structure in the Southern California Borderland and, more important, had developed a technique of observation that gave records with a relatively high signal/noise ratio. Reports of progress during this period appeared in the Quarterly Reports of the Marine Physical Laboratory; a summary of the techniques was reported by Raitt (1952) in a volume on "Oceanographic Instrumentation" published by the NAS-NRC.

In 1949-1950 an extensive set of short refraction profiles was carried out near San Diego using various small ships, mostly in preparation for subsequent deep sea operations to be made on Expedition MIDPAC in 1950. Additional local work was done in 1951, 1954, 1955, and 1956, mostly as tests of new equipment in preparation for other deep sea operations; some stations were carried out near the coast as the first stations of long cruises in 1957, 1959, and 1962. In 1965 we made our first studies of anisotropy of the upper mantle on Expedition QUARTET just west of the Southern California Borderland, and in 1967 made an additional set of measurements in the Catalina channel while testing balloon telemetering systems.

The methods of operation, first described by Raitt (1952), were discussed in more detail by Shor (1963); only in cases where the techniques differed from those described in that paper are notes on methods given here.

The navigation on these early cruises left a great deal to be desired. Nearly every ship owned by the Scripps Institution of Oceanography or by the U.S. Navy Electronics Laboratory was used at one time or another, usually for a short time on a single trip. The masters of these ships usually did their best as they saw it; they were, however, accustomed to taking scientists "out to deep water," and most of the other customers did not care particularly about exact positions. There wasn't much to work with, either. Decca or Shoran did not exist in these waters in the 1950's, and the southernmost LORAN station was at Point Arguello. Satellite navigation and Omega were in the future, and the U.S. Coast and Geodetic Survey's precise "EPI" method was available only to their own ships. As a result, navigation was normally by dead reckoning, star- and sun-sights when the weather was clear, and by visual bearings and radar fixes when land was close enough. A frequent last resort (that was surprisingly effective and served as a basis for post-operation checks) was by matching echo-sounder profiles with the extremely accurate bathymetric charts made by Shepard and Emery (primarily from soundings by the U.S. Coast and Geodetic Survey). In 1955 Shor tried to check and reconcile all of the navigational tracks from the early trips, and assembled a summary chart representing a "best estimate" of shooting and receiving positions; the principal criteria used were internal consistency, matches of the navigation of the two ships involved when they were in sight of each other, agreement with range between ships from water-wave travel time, and agreement with known soundings. In some areas this provided relatively tight control (within a mile or two); in areas where the bottom is smooth and the land is far away, the errors can be considerably greater. At this time there is no way of rechecking the work, since many of the original track plots have disappeared.

A portion of the data was published in 1958 in the proceedings of the International Geological Congress at Mexico City (Shor and Raitt, 1958), but many of the travel-time plots were omitted and no tabulated data were given. Figures from some of the quarterly reports have occasionally been used for illustrations in other papers, but again without original data or travel times. We have, therefore, included all available data and solutions in the present manuscript, without regard to previous partial publication.

Interpretation methods

All the records involved were taken as wiggly-line analog records, normally from three hydrophones which were all close to the receiving ship. In most cases recordings were on a photographic oscillograph plus a pen-and-ink (Brush) recorder; on a few trips only the Brush recorder was used. The times of first arrivals were picked by eye, with an allowance of a few hundredths of a second for the "rise time" of the filters. Second arrivals were used wherever they were strong, but due to the wide spacing between shots phase correlation could not be used. After the first few trips (on which the shooting ship stopped, and fired charges electrically), all charges were fired using time fuse, with the ship underway. A correction (the "T_f correction") is therefore made to account for the delay between detonation of the charge and receipt of the firing mark at the shooting ship. All readings have been corrected for this. Shot depth has normally been determined by calculation from the bubble pulse period of the shot.

During most of the period of this work, the standard procedure was to correct the travel times of the refracted arrivals to the equivalent time that would have been recorded if the shot and receiver had been on the sea floor. This involves use of the cosine of the angle of emergence of the refracted ray, and therefore requires identification of the reading as part of a "set" of readings with a particular emergence angle. The correction is fairly large for stations in the basins, and the effect of shifting assignment of a reading from one layer to another (and thereby changing the correction cosine) can be significant. The travel-time plots in general give corrected times for the refracted arrivals. Later data have been corrected only for variations in the depth of the sea floor, and therefore have much smaller corrections.

The most common procedure in interpreting marine seismic refraction travel-time curves in terms of layers of rock or sediments has been that presented by John Ewing (1963), in which the assumption is made that the structure can be approximated by a set of plane layers of constant dip, with no anisotropy and no lateral variation of velocity. In this approach, the effect of topography of the sea floor is usually removed, with a (usually unstated) assumption that all of the topography is either in the sediments or (more usually) all in the basement rock. This approach has been used by us in most of the more recent deep-sea profiles, including some that are given in this manuscript. On the earlier stations in the Southern California Continental Borderland, however, a different interpretational approach was used initially. The interpretation was a variant of Gardner's delay-time method, in which the velocities of the sediment and basement rocks were first determined using all available data, and the arrival times of the waves refracted through the basement were then used to make a cross-section showing sediment thickness along the profile. This approach was most appropriate for use in the Borderland basins, where sediment thickness varied radically within the length of a single profile; it is difficult to use, however, where more than two layers are observed. Delay-time cross-sections are presented wherever they were calculated; on the later stations, and some of the earlier ones that had never been subjected to a delay-time analysis, the standard Ewing "dipping layer" solution, with or without topographic corrections as noted, was used for convenience.

Report format

Each of the field operations reported

here was originally given a cruise name, related in some way to the area of major work. Within the "cruise" or expedition are numbered "runs" or numbered stations: a run is a sequence of shots by the shooting ship for one location of the receiving ship; a station is a single receiving location, and may have one or more runs. Records have been kept by cruise name, date, and run or station number. In this report, accordingly, the data are presented in chronological order for the short cruises using this indexing scheme. For each cruise, there is first presented a summary of the field notes, giving any unusual circumstances about the work and the locations of all shooting and receiving positions. These notes are followed by any layer solutions or delay-time cross-sections determined from the data, and discussions of the results (either those given at the time, or later comments). If the solution required use of data from more than one cruise, the results are given with the last cruise used. Following the discussion are a set of track plots showing the runs, and a set of travel-time plots.

Copies of the original readings, water depths, shot and receiver depths are available in our files, but are not included here.

It should be emphasized that these stations can be interpreted in more than one way, and the "dipping layer" solutions given with many of them represent only the simplest possible interpretation of a single reversed pair without regard to other data. The delay-time solutions represent a somewhat more subjective interpretation (which may be closer to the real structure); the solutions made for the long cross-section up the Catalina Channel (as presented in the 1958 report) involve a great many assumptions and subjective decisions. The reader may prefer to reinterpret these on the basis of other assumptions than those we used.

Because of the manner in which results have been combined for interpretation, an index is provided, showing in what section information can be found for a particular cruise. Some cruises (especially those made in 1948 and early 1949) did not result in data that we considered worth the effort of interpretation; other cruises were made to the portion of the Continental Borderland off Baja California.

In each report, results of layer solutions are given with layers listed as a, b, c.... in arbitrary velocity groupings. All of these station results are repeated in Table I on pages 6 and 7.

Notation

D The travel time of the direct water wave from shot to receiver, travelling through the mixed layer. It is corrected for T_f.

D* Computed travel time of D where it was not actually observed; usually obtained from the travel time of a bottom reflection.

C_o Velocity of sound in the mixed layer.

C_s Sounding velocity (the vertical average velocity in the water).

T_f Firing time correction; from the equation $T_f = \frac{\text{velocity of the ship}}{C_o} t_f$

where t_f is the time from dropping the shot to hearing the explosion.

R_1 Travel time of the first observed refraction arrival; R_2, R_3, etc., are later observed refracted arrivals in order of reading.

S_1 Travel time of the first bottom reflection as recorded at the receiving ship; S_2 etc., are higher order bottom reflections with the subscript indicating the number of bottom bounces.

B_1 Subbottom reflection; B_2, etc. numbered in sequence of depth.

A_1 Equivalent to S_1, except that it is detected at the shooting ship and telemetered by radio (along with the firing mark) to the receiving ship.

F Firing mark.

W Water wave arrivals, unidentified as to D, S_1, etc.; usually in shallow water where the arrivals all merge into one.

* When used with a velocity indicates that the velocity is assumed.

( ) When used with a velocity on a reverse indicates that the enclosed velocity was found on one side only.

Shot Depth The depth below the surface at which the shot explodes. It is given in fathoms.

INDEX

Other SIO seismic refraction cruises off Southern California which are not included in this report are: PATTON I, Coronado Strand, and Catalina Island I, in 1948; local test trips, PATTON II, and San Diego Trough in 1949; Coronado Ridge in 1950, and SAN NICOLAS II, 1953. These are omitted as there are later, better data from the same areas.

Also omitted are some cruises nearby which were farther south, off Baja California which are not within the specified geographical area. They are GUADALUPE ISLAND, Jan., 1949, CEDROS ISLAND I, Mar., 1949; CEDROS ISLAND II, Mar., 1950; CEDROS ISLAND III, July, 1952; and VIZCAINO BAY, Feb., 1956.

Run	Velocity, km/sec								Thickness, km							M depth, km
	Water	a	b	c	d	e	f	g	Water	a	b	c	d	e	f	
PAT III 1&2	1.5*		2.8*			6.41 3.56†		8.15	3.81		0.86			5.46		
Alternative:																
PAT III 1&2	1.5*		2.8*			6.24 3.56†	6.95	8.15	3.81		0.62			2.56	4.53	
SC-SN 4	1.5*	1.70*	3.00		4.80				0.09	0.15	1.13					
SC-SN 5									0.12	0.52	1.21					
SC 1	1.5*		2.6						0.14							
SC 3-4	1.5*		(2.90)		(4.50)	5.79			0.21		1.19		2.45			
SC 5-N									1.89		2.38		0.54?			
SC 6	1.5*		3.20			5.55	(6.70)		1.84		2.06			2.57		
SC 5-S									1.89		2.35					
SC 7	1.5*		2.70			5.55			1.88		2.47					
SC 8									0.74		1.31					
SC 9	1.5*		(2.57)			5.86			0.74		2.22					
SC 10									0.47		0.79					
SC 11	1.5*		(3.10)		5.44				0.48		1.23					
SC 12									0.34		0.34					
SC 14	1.5*		2.8*			5.74			0.52							
SC 2-W									0.20							
SN 2	1.504	(2.46)		4.23		6.09			1.40	1.69		1.01				
SN 3-E									0.09	1.51		3.70				
SN 3-N	1.504	(2.40)		3.68	4.54				0.09	1.03		0.48				
SN 4-S									0.09	0.63		0.86				
SN 4-N	1.504		2.60		4.68	6.38			0.09		1.73		4.44			
SN 5	1.505								1.78		2.48		2.12			
SN 6	1.505		2.80*		4.53		6.64		1.76		2.81		2.67			
SN 1	1.504								1.44		2.24		1.08			
SB I 2(T)	1.499	1.85			4.87	5.86*			0.11	0.86			1.41			
SB II 5(U)	1.494								0.06	0.43			3.03			
Alternative,																
SB I 2(T)	1.499	1.85			4.87		6.73		0.11	0.86			2.38			
SB II 5(U)	1.494								0.06	0.43			2.02			
SB I 3(T)	1.491	1.85*			4.87*	5.86			0.11	0.85			3.10			
SB II 4(S)	1.483								0.95	0.64			1.09			
SB II 3(V)	1.490		2.60	4.31	5.38						0.16	1.66				
SB I 5-NW &	1.499								0.09		0.68	2.85				
SB II 2(P)	1.490															
SB I 5-SE(P)	1.499		2.60	4.17		5.85			0.09		0.50	2.54				
SB II 1-NW(0)	1.485								1.30		1.03	2.26				
SB II 1-SE(0)	1.485	1.82	3.00	3.79		5.85			1.30	0.78	0.28	1.58				
SB I 5-SE(P)	1.499		(2.60)	4.17		5.85	6.70	8.20	0.89		0.50	2.54		3.5		
SB II 1-NW(0)	1.485								1.30		1.03	2.26		2.0		
PAT V 5(near 0)															16.7	

PAT V 1									2.12		0.42		0.43	0.74		
PAT V 2	1.5*		2.58		4.72	5.72	6.66	(8.07)	1.47		1.30		0.89	4.80	5.32	13.8
Average Structure from: PAT IV, Runs 4 and 5, PAT V, Runs 3 and 4.																
	1.5*		2.8*		5.10	6.20	6.79	8.13	1.27		1.05		3.57	3.55	8.14	17.6
Mean structure from CATALINA TEST TRIP																
	1.489	1.75	3.30	4.12					1.12	0.22	0.65					
AR I	1.496	2.15*			5.46		6.52		3.73	0.38			0.57			
AR 1'	1.498	2.15*			5.46		6.52		3.70	0.54			0.42			
AR 2/3(rev)	1.495	2.15*			5.49		6.66	8.16	3.64	0.69			0.67		4.70	9.70
AR 4	1.491	1.66			5.16	6.30,6.11	7.62	8.20	1.76	5.55			12.92		6.16	
AR 5	1.495	1.66		3.65		5.84	7.62	8.20	0.71	1.88		13.75			7.02	
AR 6	1.482	1.66,2.11	3.16		5.11	6.15			0.49	0.62,1.00	2.32		2.36			
FF 5	1.511	2.15*			4.67		6.79	8.44	3.94	0.09			1.73		4.46	10.22
HL 1									3.80	0.42				0.66	5.09	9.98
HL 2	1.49	2.15*				5.78	6.54	7.87	3.90	0.17				0.42	5.17	9.65
HL 3									4.00			0.56		0.97	2.95	
HL 4	1.496			3.54		6.07	6.65	8.20	3.94			0.76		1.33	4.61	
QT BAIRD									3.91	0.26				0.83	4.00	9.00
27 Jan FLIP	1.495	2.15*			5.00		6.69	7.89	4.08	0.21				1.30	4.59	10.18
QT BAIRD									3.97	0.17				1.20	6.34	11.68
30 Jan FLIP	1.496	2.15*			5.19		6.78	8.21	4.00	0.36				0.76	4.51	9.63
ERDC I 1	1.486		2.5*	4.46		5.72	7.27		1.68		1.45	1.04		1.39		
ERDC I 2	1.495	1.65			5.43		6.91, 7.39 3.76†		3.78	0.32			1.32		1.29	

†Shear wave
*An assumed velocity
( ) On a reverse indicates the enclosed velocity was found on one side only

Work in 1949

In 1949, several cruises were carried out in the Continental Borderland; these are PATTON II (5-8 April 1949), PATTON III (23-27 May 1949), SANTA CRUZ- SAN NICOLAS (18-22 July 1949), and PATTON IV (19-23 September 1949). Data from PATTON II were inadequate for layer solutions; data from PATTON III, SANTA CRUZ-SAN NICOLAS, and PATTON IV were combined for solutions. Some data from SANTA CRUZ- SAN NICOLAS were combined with later work for studies of the Catalina Trough.

Large charges were set off by SIO staff near Santa Rosa Island for experiments by Tuve and Tatel of the Carnegie Institution; most of the recording was on shore by Tuve and Tatel, but some shots were recorded at sea along two lines, first down the Catalina Basin, and then across structure from Santa Rosa out to deep water. A travel-time plot is given for the Catalina Basin run only.

PATTON III, 23-27 May 1949 (PAT III) PAOLINA-T shooting (Raff), EPCE(R) 857 receiving (Raitt)

This cruise consisted of runs in two areas. Runs 1 and 2 were in deep water, south and east of San Juan Seamount and west of Patton Escarpment, about 180 nautical miles west of San Diego; they partially reversed each other.

Run 3 was in the flat, central portion of the Santa Cruz Basin, and was not reversed at this time; it was reversed later by SC-SN Run 7.

Shots for this station were fired electrically. The shooting ship stopped to set off the shots.

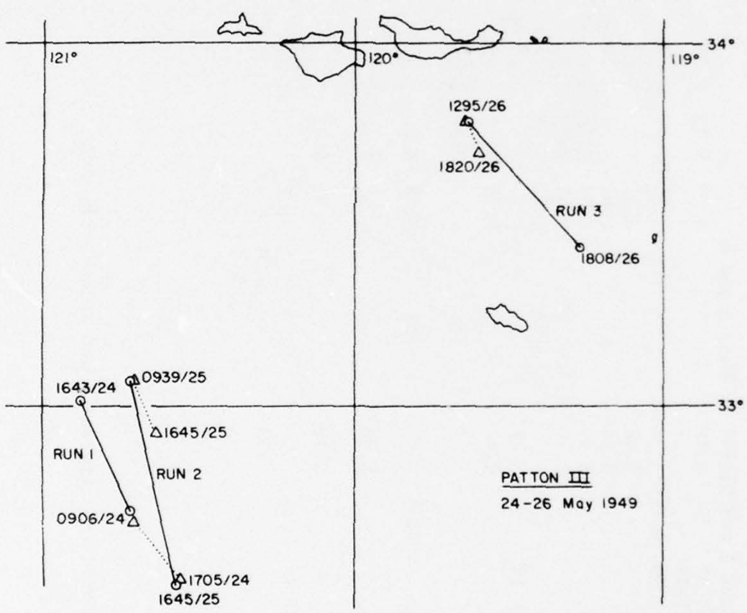


Fig. 1.

24 May

Run 1-West of Patton Escarpment

TIME	COURSE	POSITION
Shooting		
0906	335°T	32°42.5'N, 120°43.2'W
1643	end	33°00.7'N, 120°52.8'W
Receiving		
0906		32°40.8'N, 120°42.3'W
1705		32°30.7'N, 120°33.3'W

25 May

Run 2-West of Patton Escarpment

Shooting		
0939	180°T	33°04.1'N, 120°43.3'W
1645	end	32°29.5'N, 120°34.5'W
Receiving		
0939		33°04.1'N, 120°43.3'W
1645		32°55.2'N, 120°37.7'W

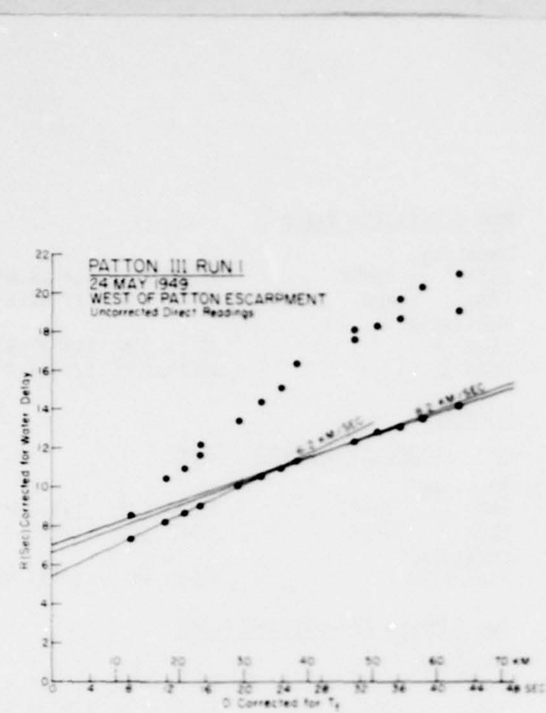


Fig. 2.

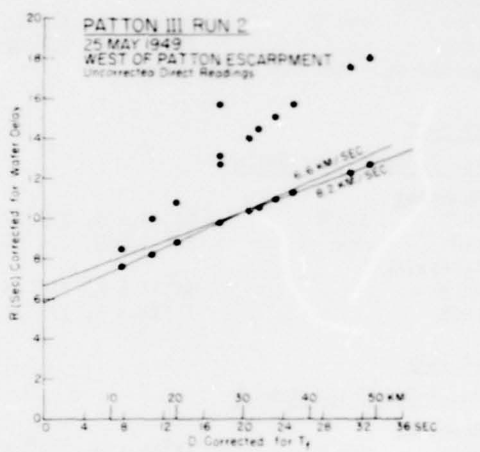


Fig. 3.

26 May

Run 3-Santa Cruz Basin

Shooting

1259	140°T	33°47.0'N, 119°38.2'W
1808	end	33°26.1'N, 119°16.7'W

Receiving

1259	33°47.0'N, 119°38.2'W
1802	33°42.0'N, 119°36.0'W

Results

Runs 1 and 2 are not close enough together to constitute a real reversal; they are, however, close to reciprocal. Run 1 gave velocities of 6.2, 8.2, and 8.7 km/sec; Run 2 gave 6.6 and 8.2 km/sec. Both runs have strong second arrivals, with mean velocity 3.45 km/sec, which are apparently shear waves.

Two alternative solutions have been made. The first solution, which was used in Shor and Raitt (1958), assumes that the 6.2 and 6.8 km/sec apparent velocities are the same layer observed up- and down-dip; on this assumption the mean structure for the station pair would be:

	Velocity, km/sec			
Run	Water	b	e	g
PAT III I and 2	1.5*	2.8*	6.41 3.56 †	8.15

Thickness, km		
Water	b	e
3.81	0.86	5.46

†Shear wave

This solution, although the one involving the fewest assumptions, may not be the best answer. An alternative solution, requiring the assumption that the observed layers with velocity 6.2 and 6.6 km/sec are indeed separate layers, with each masked on one profile, gives a solution with greater resemblance to other later stations in the vicinity. The shear wave observed gives nearly the same depth as the layer with compressional velocity 6.24 in the second solution.

Alternative:

	Velocity, km/sec				
Run	Water	b	e	f	g
PAT III 1 and 2	1.5*	2.8*	6.24 3.56 †	6.95	8.15

Thickness, km			
Water	b	e	f
3.81	0.62	2.56	4.53

†Shear wave

PAT III Run 3 was reversed by SC-SN Run 7, and is included with SANTA CRUZ-SAN NICOLAS.

SANTA CRUZ-SAN NICOLAS, 18-22 July 1949 (SC-SN)
PAOLINA-T shooting (Whitney), E.W. SCRIPPS receiving (Raitt)

This cruise consisted of eight runs in four areas. The first and eighth runs were in the San Diego Trough, Run 1 being largely reversed by Run 8. The second area was the Catalina Basin where Run 2 went from the southern tip of Santa Catalina Island southwest to the northern tip of San Clemente Island across the Catalina Basin. Run 3 began at about the center of Run 2, at right angles to it, and went up the Catalina Basin, to the northwest.

The third area was the Santa Rosa-Cortes Ridge, which goes from Santa Rosa Island to San Nicolas Island. Run 4 began with both ships near Begg Rock slightly northwest of San Nicolas Island. The shooting ship shot out northwest toward Santa Rosa Island. At the end of Run 4, the receiving ship moved to a point near the end of the run and the shooting ship returned to the area of Begg Rock. From here Run 5 was shot over almost the same ground as Run 4, although the shooting ship ended the run by turning in toward the receiving ship. Run 6 was also in this area with the receiving ship staying in the position it had during Run 5, while the shooting ship ran due east across the ridge toward the Santa Cruz Basin.

Run 7 was a split profile in the Santa Cruz Basin. It was shot southeast down the basin and over the saddle between the Santa Cruz Basin and the San Nicolas Basin. SC-SN Run 7 reversed PAT III Run 3.

18 July

Run 1-San Diego Trough

TIME	COURSE	POSITION
Shooting		
1344	314°T	32°51.9'N, 117°44.5'W
1850	end	33°12.6'N, 118°09.9'W
Receiving		
1312		32°51.7'N, 117°44.8'W
1850		32°50.5'N, 117°45.0'W

19 July

Run 2-Catalina Basin

Shooting		
0917	229°T	33°18.4'N, 118°17.4'W
1333	end	33°00.9'N, 118°41.5'W
Receiving		
0917		33°18.4'N, 118°17.4'W
1400		33°18.6'N, 118°16.8'W

Run 3-Catalina Basin

Shooting		
1531	318°T	33°10.9'N, 118°28.0'W
1733	end	33°23.2'N, 118°41.1'W
Receiving		
1525		33°11.2'N, 118°27.8'W
1800		33°11.2'N, 118°24.8'W

20 July

Run 4-Santa Rosa-Cortes Ridge

Shooting		
0820	317°T	33°20.8'N, 119°37.0'W
1102	end	33°32.1'N, 119°49.7'W
Receiving		
0820-1102		33°20.8'N, 119°37.0'W

Run 5-Santa Rosa-Cortes Ridge

Shooting		
1332	317°T	33°20.8'N, 119°37.0'W
1544	265°T	33°29.0'N, 119°46.3'W
1559	end	33°28.9'N, 119°47.7'W
Receiving		
1306		33°31.1'N, 119°48.6'W
1807		33°28.1'N, 119°47.6'W

Run 6-Santa Rosa-Cortes Ridge

Shooting		
1603	090°T	33°29.2'N, 119°47.4'W
1804	end	32°29.3'N, 119 31.6'W

Receiving - see Run 5 above.

21 July

Run 7-Santa Cruz Basin

Shooting		
0925	140°T	33°45.4'N, 119°37.1'W
1503	end	33°12.0'N, 119°02.9'W
Receiving		
0929		33°32.8'N, 119°23.6'W
1508		33°33.3'N, 119°22.2'W

22 July

Run 8-San Diego Trough

Shooting		
0638	134°T	33°07.5'N, 118°03.5'W
0908	end	32°51.5'N, 117°43.8'W
Receiving		
0638		33°07.5'N, 118°03.5'W
0908		33°07.5'N, 118°00.8'W

All positions for this cruise were scaled from a reconciled plot by Shor made in 1955.

Results

Runs 1 and 8 constitute a reversed profile in the San Diego Trough. A delay-time solution made by Raitt at the time is given in Figure 4 as a cross-section. Data from this pair of runs were also used for construction of the Catalina Basin cross-section presented as Figure 7 of Shor and Raitt (1958).

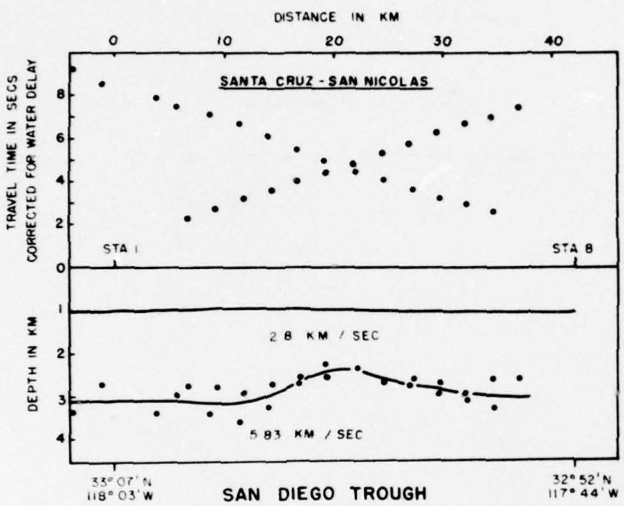


Fig. 4.

Run 2 was also interpreted as a delay-time cross-section, using the same average velocities (2.80 and 5.83 km/sec) as Runs 1 and 8; these results are given in Figure 5. In both of these cases, no refracted arrivals were observed from any layers above the basement. On later stations in the same area, in slightly shallower water (SANTA BARBARA I and II), arrivals were detected from sediments (with velocities lower than the 2.8 km/sec used for the delay-time solutions) and from deeper rocks (consolidated sediments or volcanics) with velocities between 4 and 5 km/sec. The cross-sections were therefore recomputed with an "equivalent layer velocity" of 3.82 km/sec for the presentation in Figures 2 and 7 of Shor and Raitt (1958). This recomputation makes the depth to basement significantly greater.

Run 3 was unreversed at the time; it was reversed later by SB II Run 1-SE. The travel-time plot and solution are included with that cruise.

Runs 4 and 5 constitute a reversed pair on the Santa Rosa-Cortes Ridge. The reverse distance is approximately 18.9 seconds (28.35 km). A solution has been made by the

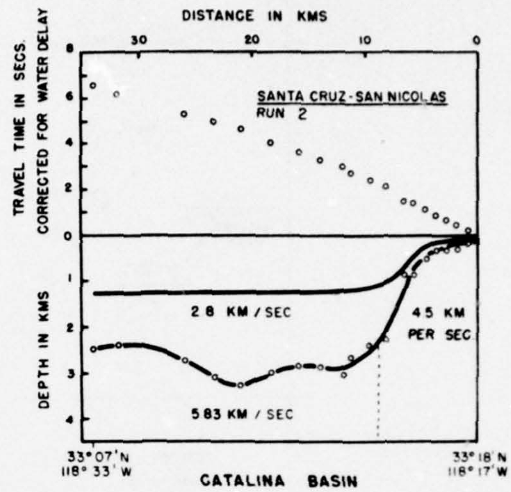


Fig. 5.

plane layer approximation, as follows:

Observed arrivals on the two runs are shown in Figures 8 and 9, with lines fitted to the actual observations. The reverse points of these lines do not agree well, so lines were fitted for a common reverse point (by eye) with the following equations:

SC-SN Run 4	SC-SN Run 5
0.00 + x/1.70*	0.00 + x/1.70*
0.15 + x/2.95	0.50 + x/3.05
0.75 + x/4.60	1.20 + x/5.00

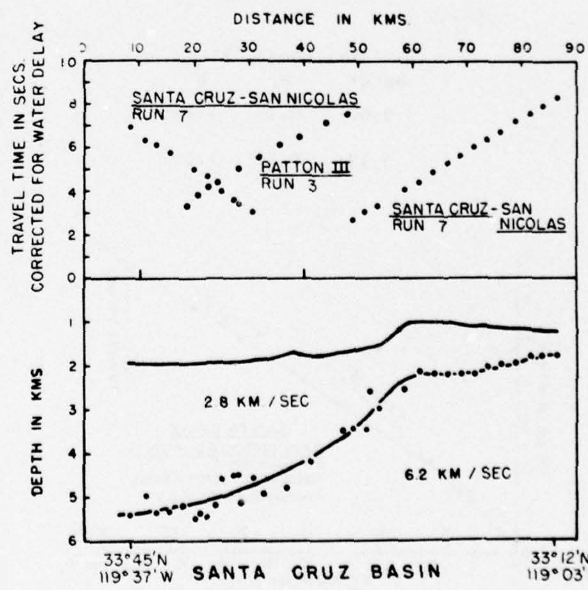


Fig. 6.

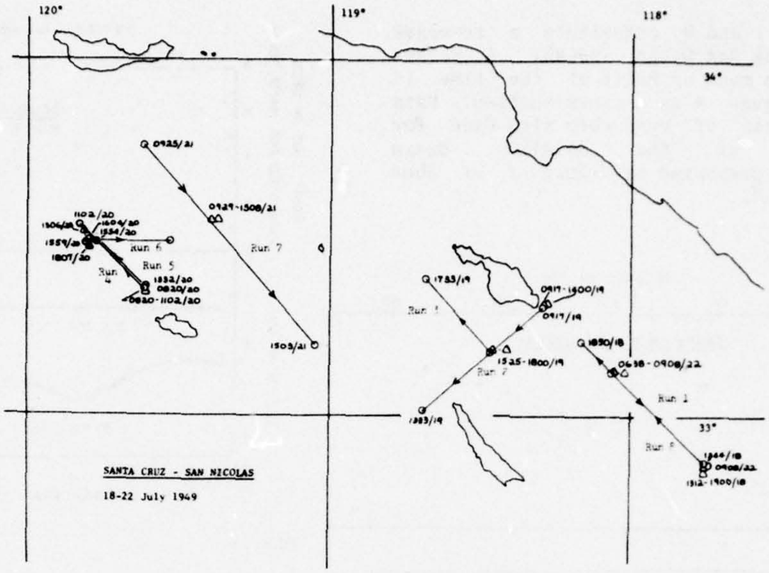


Fig. 7.

The velocity of 1.70 km/sec was introduced because the observed arrivals give a positive intercept time. The highest velocity that could have been present but unobserved as a first arrival is 1.70. The solution on this basis is:

Run	Water	Velocity, km/sec a	b	d
SC-SN 4 SC-SN 5	1.5*	1.70*	3.00	4.80

Thickness, km Water	a	b
0.09	0.15	1.13
0.12	0.52	1.21

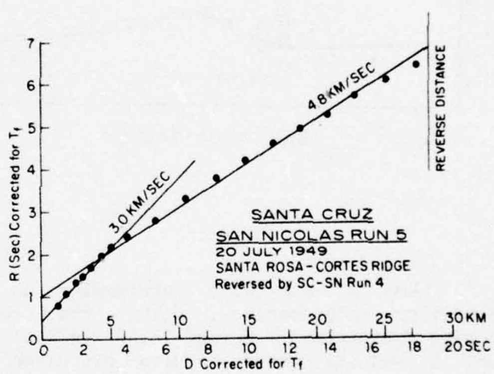


Fig. 9.

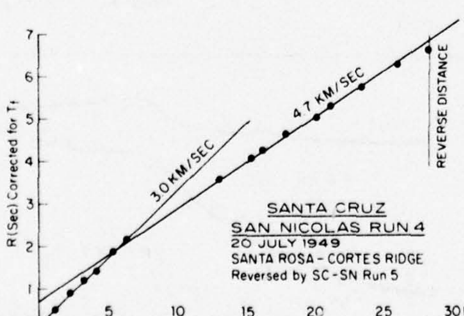


Fig. 8.

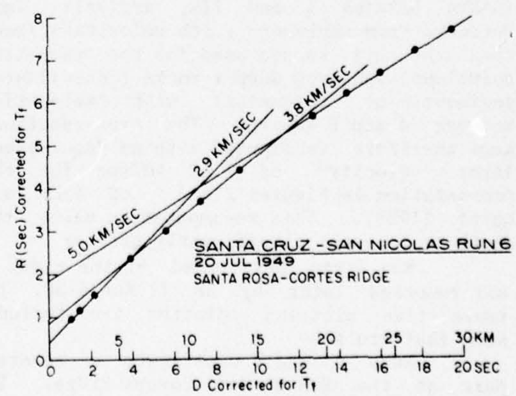


Fig. 10.

Run 6 has the same receiving point as Run 5. If the basement velocity is the same, the data indicate that there is an increase in thickness of the sedimentary layers of at least 0.55 km along the run east of the receiver.

SC-SN Run 7 reverses PAT III Run 3. They were combined for a delay-time solution, using velocities of 2.8 and 6.2 km/sec, and are illustrated in Figure 6. This solution was published as Figure 5 by Shor and Raitt (1958).

THE LARGE EXPLOSIONS OF AUGUST, 1949, August 6, 18-19, and 23-24.

These were a series of large shots for H. E. Tatel and M. A. Tuve of the Carnegie Institute under the sponsorship of the Office of Naval Research and with the cooperation of California Institute of Technology and Scripps Institution of Oceanography.

6 August, The Corona Quarry Blast

This was a single shot of 156,000 lbs. of "Nitramon" fired at a Minnesota Mining and Manufacturing Company quarry near Corona, California, 33°50.81'N, 117° 30.36'W. It was recorded by the California Institute of Technology seismograph network and at one SIO sea station by the PAOLINA-T (Raitt) off Point Loma at 32°42.02'N, 117°18.83'W.

18-19 and 23-24 August, The Santa Rosa Explosions

PAOLINA-T shooting, E. W. SCRIPPS receiving (Raitt), 18-19 August, EPCE(R) 855 (Raitt) receiving, 23-24 August.

These were shot by SIO in conjunction with the Corona Quarry blast and were recorded on land by Tuve. As it was a Navy project, they sent out an ordnance expert who fired the shots from the PAOLINA-T. There were a total of six 1200-lb. shots and six 2400-lb. shots fired in shallow water in a protected area in Becher's Bay, Santa Rosa Island. Shot number 10, 24 August, was supposed to be fired in deeper water. It was originally placed on a slope and rolled to about 400 fms depth. All shots were TNT and were fired electrically.

The shots were recorded at sea at a total of thirteen stations, the most distant being 105 nautical miles from the firing point.

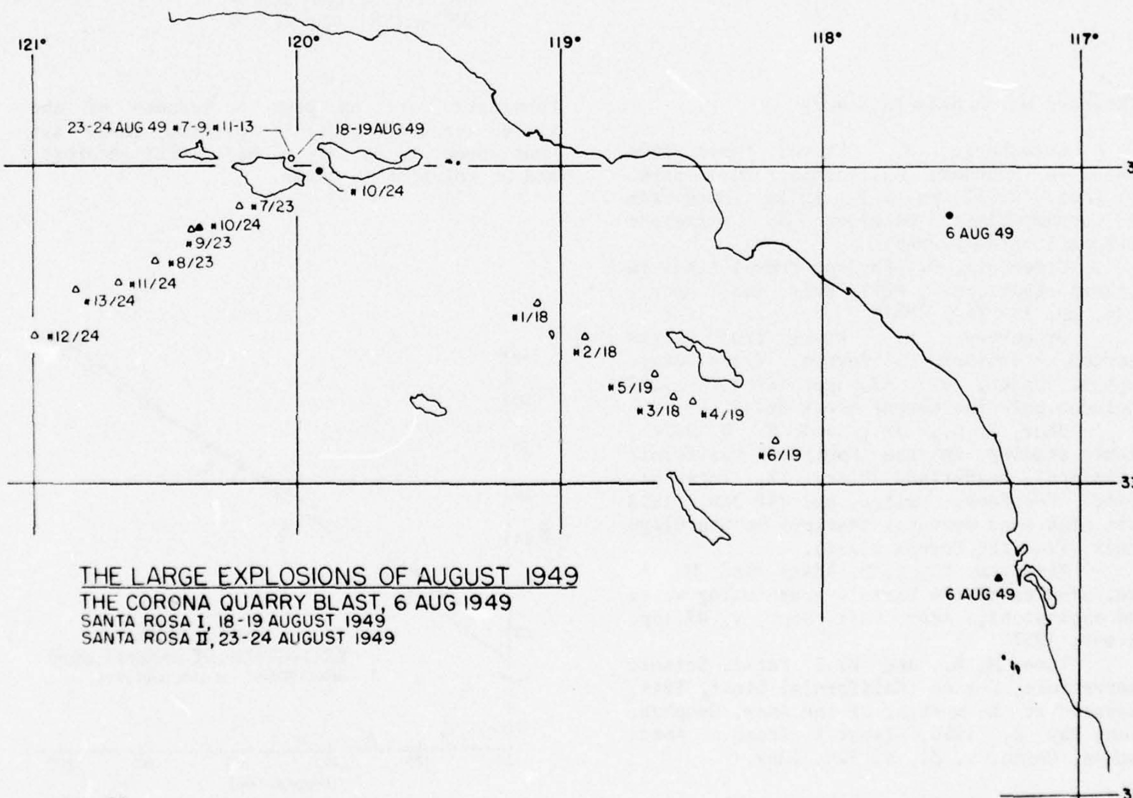


Fig. 11.

<u>18-19 August</u>	Shooting positions, Becher's Bay, Santa Rosa Island	
8/18	Shots 1 and 2	34°01.33'N, 120°01.34'W
8/18	3	34°01.42'N, 120°01.28'W
8/19	4,5,6	34°01.28'N, 120°01.34'W
	Receiving positions, Catalina Basin	
8/18	1	33°33.6'N, 119°04.6'W
8/18	2	33°27.3'N, 118°53.9'W
8/18	3	33°16.1'N, 118°33.8'W
8/19	4	33°15.6'N, 118°28.8'W
8/19	5	33°20.4'N, 118°38.1'W
8/19	6	33°07.7'N, 118°10.5'W
<u>23-24 August</u>,	Shooting positions, Becher's Bay, Santa Rosa Island and the Santa Cruz Channel	
8/23-24	Shots 7,8,9 12,13	34°01.4'N, 120°01.3'W
8/24	10	33°59.2'N, 119°54.5'W
8/24	11	34°01.4'N, 120°00.9'W
	Receiving positions, on a line southwest of Santa Rosa Island, the farthest being in deep water beyond Patton Escarpment.	
8/23	Shot 7	33°52.2'N, 120°17.8'W
8/23	8	33°42.2'N, 120°32.0'W
8/23	9	33°48.0'N, 120°23.8'W
8/24	10	33°48.1'N, 120°22.0'W
8/24	11	33°37.5'N, 120°40.4'W
8/24	12	33°27.8'N, 120°59.6'W
8/24	13	33°36.6'N, 120°50.0'W

References which used this work:

Gutenberg, B., Travel times from blasts in Southern California, Bull. Seis. Soc. Amer., v. 41, pp. 5-12, 1951a. (Data from the Corona blast recorded at permanent earthquake seismographs).

Gutenberg, B., Revised travel times in Southern California, Bull. Seis. Soc. Amer., v. 41, pp. 143-163, 1951b.

Gutenberg, B., Waves from blasts recorded in Southern California, Trans. Amer. Geophys. Union, v. 33, pp. 427-431, 1952 (includes only the Corona blast data).

Shor, G. G., Jr., and R. W. Raitt, Seismic studies in the Southern California Continental Borderland, Proc. XX, Internat. Geolog. Congress, Mexico, pp. 243-259, 1958 (data from land portable stations in San Diego County, from the Corona blast).

Tatel, H. E., L. H. Adams, and M. A. Tuve, Studies of the Earth's crust using waves from explosions, Amer. Phil. Soc., v. 97, pp. 658-669, 1953.

Tuve, M. A., and H. E. Tatel, Seismic observations, Corona (California) blast, 1949, presented at the meeting of the Amer. Geophys. Union, May 2, 1950, (abst.) Trans. Amer. Geophys. Union, v. 31, p. 324, 1959.

A travel-time plot for shots 1-6, 18-19 August, is given in Fig. 12, and the tabulated data on page 15. Because of the varied structure along the profile, these are considered to be only of historical interest, and no solution is given.

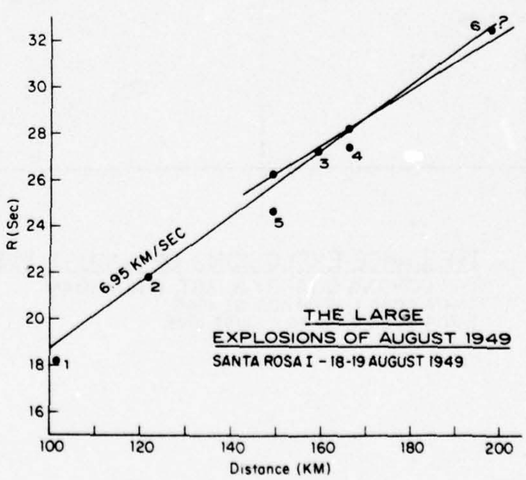


Fig. 12.

SANTA ROSA I SHOTS - 18-19 August 1949

Shot Number	1	2	3	4	5	6
Shot Position						
Latitude	34°01.33'N	34°01.33'N	34°01.42'N	34°01.28'N	34°01.28'N	34°01.28'N
Longitude	120°01.34'W	120°01.34'W	120°01.28'W	120°01.34'W	120°01.34'W	120°01.34'W
Water Depth (fm)	12	12	12	12	12	12
Shot Depth (fm)	12	12	12	12	12	12
Recording Position						
Latitude	33°33.6'N	33°27.3'N	33°16.1'N	33°15.6'N	33°20.4'N	33°07.7'N
Longitude	119°04.6'W	118°53.9'W	118°33.8'W	118°28.8'W	118°38.1'W	118°10.5'W
Water Depth (fm)	60	670	710	660	680	580
Hydrophone Depth (fm)	33	33	33	33	33	33
Computed Δ (fm)	101.48	121.69	159.11	166.15	149.21	198.06
Firing Time F	0959:59.62	1200:00.00	1700:00.54	1000:00.56	1200:00.49	1530:00.49
R_1 - F	18.2	21.8	27.3	27.5	24.7	32.7?
R_2 - F				28.3	26.3	

PATTON IV, 19-23 September 1949 (PAT IV)

EPCE(R) 855 shooting (Gibson), SALUDA receiving (Raitt)

This cruise consisted of five runs, the first three west of Patton Escarpment in the same area as PAT III Runs 1 and 2. The last two runs were on top of Patton Ridge.

Run 1 was a split profile, roughly north-south, Runs 2 and 3 combine to make up a split. Run 4 was a split with several course changes. For Run 5, the receiving ship moved to the end of Run 4 and the shooting ship reversed course and ran a reverse of the outgoing southern leg of Run 4.

20 September

Run 1-West of Patton Escarpment

TIME	COURSE	POSITION
Shooting		
1300	150°T	32°55.8'N, 120°30.1'W
1412	180°T	32°46.8'N, 120°24.1'W
1414	200°T	32°46.4'N, 120°24.1'W
1429	195°T	32°43.2'N, 120°25.6'W
1443	190°T	32°40.7'N, 120°26.3'W
1459	165°T	32°38.4'N, 120°26.8'W
		abeam of SALUDA
1725	end	32°16.4'N, 120°25.2'W
Receiving		
0745		32°35.6'N, 120°30.0'W
2000		32°37.9'N, 120°27.6'W

During this period the SALUDA lay to with steadying sail while receiving.

21 September

Run 2-West of Patton Escarpment

Shooting		
1025	345°T	32°11.5'N, 120°14.0'W
1345	end	32°35.4'N, 120°22.2'W
Receiving		
0750		32°11.5'N, 120°14.0'W
1400		32°08.5'N, 120°09.0'W

Run 3-West of Patton Escarpment

Shooting		
1625	165°T	32°08.8'N, 120°12.9'W
1925	end	31°41.7'N, 120°06.0'W
Receiving		
1630		32°08.8'N, 120°12.9'W
2200		32°05.9'N, 120°08.4'W

22 September

Run 4-Top of Patton Ridge

Shooting		
0929	139°	33°10.0'N, 120°21.0'W
0958	160°	33°01.5'N, 120°15.0'W
1010-1015	abeam	
1138	138°	32°54.0'N, 120°14.0'W
1203	end	32°45.0'N, 120°06.0'W
Receiving		
0900		33°01.9'N, 120°12.5'W
1200		32°59.5'N, 120°13.7'W

Run 5-Top of Patton Ridge

Shooting		
1531	322°	32°42.0'N, 120°04.0'W
1815	end	33°01.6'N, 120°20.1'W
Receiving		
1541		32°42.0'N, 120°04.0'W abeam EPCE(R)
1840		32°40.7'N, 120°01.2'W

On the following pages is reproduced the material printed in the original Quarterly Reports of the Marine Physical Laboratory, covering work on cruises PATTON II, PATTON III, SANTA CRUZ-SAN NICOLAS, and PATTON IV. Cross-sections following the reports give the delay-time solutions for the PATTON IV runs, with accompanying travel-time plots. Data from Runs 4 and 5 were also used later with the data from cruise PATTON V for a solution with deeper arrivals.

PATTON II and PATTON III

Extract from MPL Quarterly Reports, 1 April to 30 June 1949, by R. W. Raitt:

Previous studies of the transmission of refracted waves through the sea bottom (see MPL Quarterly Reports, 1 October to 31 December 1948, and 1 January to 21 March 1949) made use of a motor whaleboat for firing the source bombs. Experience of several cruises demonstrated that this technique was practicable only when restricted to areas near islands or other land points where lee from wind and waves provided sufficient protection for whaleboat operation. Only a small percentage of the time did weather conditions permit operating in the deep ocean beyond the continental slope off California and Lower California.

Consequently the use of the PAOLINA T, a former purse seiner, now part of the Scripps Institution of Oceanography fleet, was obtained to serve as a source boat. Two cruises were made with the EPCE(R) 857 and the PAOLINA T to two areas: (1) an area of about 2050 fathoms depth beyond the continental slope and about 180 nautical miles west of San Diego; (2) the Santa Cruz Basin, an area of about 100 fathoms depth south of Santa Cruz Island.

On the first cruise, instrumental troubles hindered the work and the bottom refracted wave was not observed at distances greater than about 16 km.

Four profiles, two in each area, were recorded. In the deep water area beyond the continental slope the average velocity of the first arriving bottom wave was about 6.5 km/sec with an intercept time of 5.5 sec. In the Santa Cruz Basin the velocity was about 6.2 km/sec with an intercept of 4.5 sec.

On the second cruise, the equipment performed much better and first arrivals of the bottom wave were observed up to distances of 57 km, using 50 pounds of TNT as source. In the deep water area the short-range sections of the two profiles recorded showed an average velocity of first arrivals of about 6.5 km/sec and intercept time of about 5.5 sec in agreement with the previous results in this area. At distances greater than 30 km, an increase in velocity to a value of about 8 km/sec was observed on both profiles. Although the two profiles were recorded in opposite directions over approximately the same region, complete reversed control was not attained. Hence, further work is required before the effect can be established with certainty. If real, it indicates that a velocity of the order of 8 km/sec is reached at a depth of the order of 5 km beneath the ocean floor in this area.

In the Santa Cruz Basin, a 30-km profile through the flat central portion gave a velocity of first arrival of 6.9 km/sec with an intercept of 4.7 sec. A reversed profile was not recorded.

The strong second arrival observed in deep water southeast of Guadalupe Island (see MPL Quarterly Report, 1 January to 31 March 1949) was observed in the southern portion of the deep water area 180 miles west of San Diego. In the northern portion and in the Santa Cruz Basin it was either missing or too weak to be identified with certainty. The reason for this is not known.

PATTON III, SANTA CRUZ-SAN NICOLAS and PATTON IV

Extract from MPL Quarterly Reports, 1 October to 31 December 1949, by R. W. Raitt:

Analysis of the records of the waves refracted through the ocean bottom (see MPL Quarterly Report, 1 July to 30 September, 1949) has yielded estimates of the depth of the hard-rock basement underlying the sedimentary rocks for a number of locations extending from San Diego to deep water west of the continental slope.

Examples of the results of this analysis are depicted in Figure 1 [Fig. 13 in this paper]. In each example the upper portion represents the observed travel time of the [refracted] wave, corrected for the delay introduced by the water column at the source and receiver. In the lower portion, two interfaces are drawn. The upper one is the bottom surface obtained from fathometer records of the source ship. The lower one is the basement calculated from the observed travel time data using 2.8 km/sec for the wave velocity of the material between the bottom surface and the basement. This velocity is actually observed only at the three closest points to Station 1 in Figure 1(b) [Fig. 14 in this paper]. Failure to observe the wave propagated through the bottom sediment at the *other profiles may not be a serious weakness. If the material deposited above the surface depicted as basement is similar to the sediment found in formations in Southern California, it is unlikely that its velocity differs from 2.8 km/sec by more than 40%. An error of this magnitude would not change the general form of the calculated basement surface significantly.*

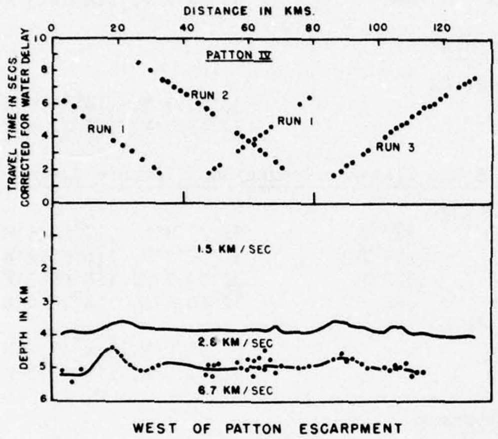


Fig. 13

All three of the profiles shown run from northwest at the left to southeast at the right. Figure 1(a) [Fig. 13 in this paper] runs parallel to the continental slope about 5 to 10 miles west of the foot of the slope and about 175 miles west of San Diego. Figure 1(b) [Fig 14 in this paper] runs along a ridge at the top of and parallel to the continental

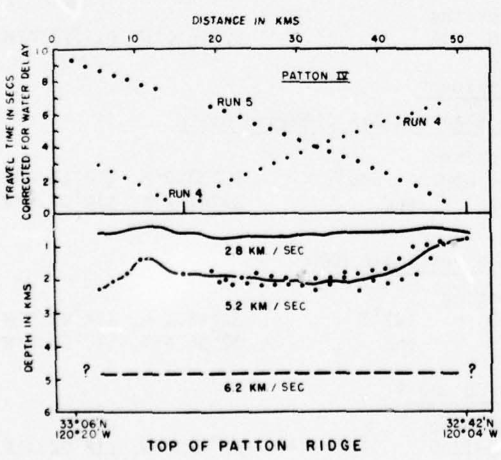


Fig. 14.

slope. Figure 1(c) [Fig. 6 in this paper] runs across the Santa Cruz Basin and through the saddle between Santa Barbara Island and San Nicolas Island.

These three profiles illustrate features which are also characteristic of other profiles not shown:

(1) Within the continental borderland area between the coast and the continental slope, the sedimentary formation is much thicker in the basins than on the ridges. Hence the topographic relief of the basement is greater than that of the exposed sea bottom.

(2) Within the continental borderland the wave velocity is lower on top of the ridges than in basins.

(3) Within the Pacific Ocean basin immediately west of the continental slope the sedimentary thickness is significantly less than within the basins of the continental borderland.

(4) The basement velocity of 6.7 km/sec observed west of the continental slope is greater than any observed within the continental borderland.

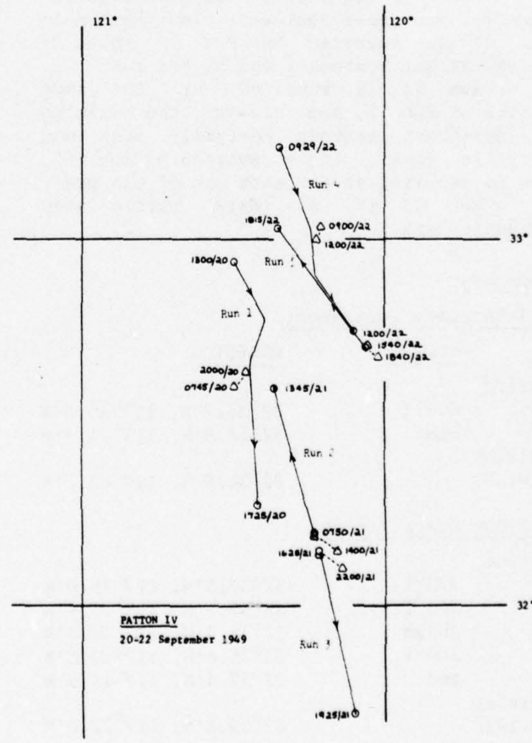


Fig. 15.

SAN CLEMENTE ISLAND, 6-10 February 1950 (SC)
EPCE(R) 855 shooting (Gibson), SALUDA receiving (Raitt)

This cruise consisted of 14 runs, arranged in a zigzag pattern between San Diego and the south end of San Clemente Island, as follows:

Run 1 is a short split southeast to northwest along the Coronado Escarpment.

Run 2 crosses the San Diego Trough from the Coronado Escarpment westward to Thirtymile Bank. It is reversed by Run 14.

Run 3 was received in shallow water at the south end of San Clemente Island, and goes down slope southeast into the San Clemente Basin. Run 4, received at the same location, continues Run 3.

Run 5 is split southeast to northwest in the San Clemente Basin. The north side reverses Runs 3-4; the south side continues down the San Clemente Basin along the same azimuth, and is reversed by Run 6.

Run 7 is received at the southwest end of the run in the same location as Run 5, and crosses the San Clemente Basin to the northeast to Fortymile Bank. It is reversed by Run 8, which is received at the northeast end of the run.

Run 9 is received at the same location as Run 8, and goes southeast along Fortymile Bank. It is reversed by Run 10 which is received at the southeast end of the run.

Run 11 is received at the same location as Run 10, and crosses the basin to the northeast between Fortymile Bank and Thirtymile Bank. It is reversed by Run 12, which is received at the east end of the run.

Run 13 is a small circle atop Thirtymile Bank.

6 February

Run 1-Coronado Escarpment

TIME	COURSE	POSITION
Shooting		
1250	327°T	32°33.7'N, 117°20.8'W
1350	end	32°38.4'N, 117°25.3'W
Receiving		
1215-1407		32°36.8'N, 117°23.7'W

Run 2-San Diego Trough

Shooting		
1545	270°T	32°37.5'N, 117°19.0'W
1555	200°T	32°37.2'N, 117°21.5'W
1602	abeam	32°35.8'N, 117°22.0'W
1608	260°T	32°35.6'N, 117°23.8'W
1750	end	32°37.4'N, 117°44.9'W
Receiving		
1445-1930		32°35.8'N, 117°22.0'W

7 February

Run 3 San Clemente Island-San Clemente Basin

Shooting		
0840	132°T	32°44.6'N, 118°23.7'W
0950	end	32°34.3'N, 118°13.0'W

Run 4 San Clemente Island-San Clemente Basin

Shooting		
1025	118°T	32°33.3'N, 118°11.8'W
1115	end	32°28.5'N, 118°01.3'W

Runs 3-4

Receiving		
0700		32°45.3'N, 118°24.0'W
1128		32°43.7'N, 118°23.6'W

Run 5 San Clemente Island-San Clemente Basin

Shooting		
1435	307°T	32°27.9'N, 117°58.6'W
1539	295°T	32°32.8'N, 118°06.2'W
1555	315°T	32°34.1'N, 118°09.7'W
1730	end	32°46.8'N, 118°23.0'W
Receiving		
1328		32°35.7'N, 118°11.8'W
1730		32°32.9'N, 118°08.9'W

8 February

Run 6 San Clemente Island-San Clemente Basin

Shooting		
0850	312°T	32°26.5'N, 118°00.5'W
1026	end	32°40.6'N, 118°15.4'W
Receiving		
0850-1026		32°28.3'N, 118°02.7'W

Run 7 Across San Clemente Basin

Shooting		
1510	039°T	32°34.6'N, 118°13.1'W
1625	end	32°45.9'N, 118°02.6'W
Receiving		
1510-1625		32°36.1'N, 118°11.4'W

9 February

Run 8 Across San Clemente Basin

Shooting		
0850	approx. 040°T	32°33.9'N, 118°13.0'W
1015	end	32°47.2'N, 118°00.6'W

Run 9 Fortymile Bank

Shooting		
1050	142°T	32°46.2'N, 118°02.7'W
1200	end	32°35.6'N, 117°53.5'W

Runs 8 and 9

Receiving		
0850-1200		32°45.6'N, 118°02.4'W

Run 10 Fortymile Bank

Shooting		
1425	139°T	32°45.6'N, 118°04.8'W
1520	121°T	32°36.9'N, 117°55.9'W
1540	end	32°34.8'N, 117°52.5'W

Run 11 Fortymile Bank-Thirtymile Bank

Shooting		
1610	057°T	32°35.3'N, 117°52.5'W
1655	end	32°40.2'N, 117°43.5'W

Runs 10 and 11

Receiving	
1357	32°35.1'N, 117°54.0'W
1655	32°35.3'N, 117°51.7'W

10 February

Run 12 Fortymile Bank-Thirtymile Bank

Shooting		
0751	075°T	32°36.5'N, 117°56.3'W
0803	085°T	32°37.6'N, 117°53.2'W
0846	020°T	32°38.4'N, 117°43.8'W

Run 13 Top of Thirtymile Bank

Shooting		
0850	090°T	32°39.1'N, 117°43.4'W
0854	342°T	32°39.0'N, 117°42.4'W
0904	000°T	32°41.1'N, 117°43.3'W
0909	320°T	32°42.1'N, 117°43.3'W
0916	270°T	32°43.2'N, 117°44.4'W
0924	162°T	32°43.2'N, 117°46.5'W
0933	125°T	32°41.5'N, 117°45.8'W
1000	end	32°38.9'N, 117°41.5'W

Run 14 San Diego Trough

Shooting		
1030	090°T	32°39.5'N, 117°44.1'W
1200	end	32°39.3'N, 117°23.3'W

Runs 12, 13, and 14

Receiving	
0730	32°38.7'N, 117°43.6'W
1044	32°39.2'N, 117°42.6'W
1200	32°40.0'N, 117°42.7'W

All positions given are taken from reconstructed track charts of the cruise made by G. G. Shor, Jr., 1955.

Results

These runs were all relatively short, and therefore give information primarily about sediment thickness and basement velocity. The structure in the area is too steep and too complex, however, to permit preparation of a sediment isopach map from this small a data set. Plane-layer solutions have been made for SC Runs 3 through 12, as reversed pairs. The data were corrected for total water delay (as shown in the accompanying travel-time plots), and then were fitted by eye with velocity lines for common reverse times; the standard plane-layer solution was then computed. These should be considered only first approximations, and if better information on basement velocity and sediment velocity were available, the lines should be recomputed as delay-time sections. Run 1 did not reach basement, and therefore gives only an estimate of sediment velocity; Runs 2 and 14 (a reversed pair) cross topography that is much too rough for a plane-layer solution. An estimate of total thickness of sediments in the San Diego Trough was obtained from Runs 2 and 14, along with an estimate of basement velocity (based on time differences); this is shown along with the calculated solutions from the other stations on the cross-section in Figure 16.

General conclusions drawn from these data were: a) The velocity in the sediments on the banks is relatively high (2.5 to 3.2 km/sec) and there is relatively little unconsolidated sediment either on the banks or beneath the basin south of San Clemente Island. b) Material with velocity between 4 and 5 km/sec was not detected except on the south flank of San Clemente Island; it is found on stations from other cruises under a number of the ridges to the north and northwest of here. c) The basement velocity is fairly uniform in this area. d) The sediment thickness is extremely variable.

	Velocity, km/sec					Thickness, km			
Run	Water	b	d	e	f	Water	b	d	e
SC 1	1.5*	2.6				0.14			
SC 3/4						0.21	1.19	2.45	
	1.5*	(2.90)	(4.50)	5.79					
SC 5-N						1.89	2.38	0.54?	
SC 6						1.84	2.06		2.57
	1.5*	3.20		5.55	(6.70)				
SC 5-S						1.89	2.35		
SC 7						1.88	2.47		
	1.5*	2.70		5.55					
SC 8						0.74	1.31		

	Velocity, km/sec					Thickness, km			
Run	Water	b	d	e	f	Water	b	d	e
SC 9						0.74	2.22		
	1.5*	(2.57)		5.86					
SC 10						0.47	0.79		
SC 11						0.48	1.23		
	1.5*	(3.10)	5.44						
SC 12						0.34	0.34		
SC 14						0.52			
	1.5*	2.8*		5.74					
SC 2-W						0.20			

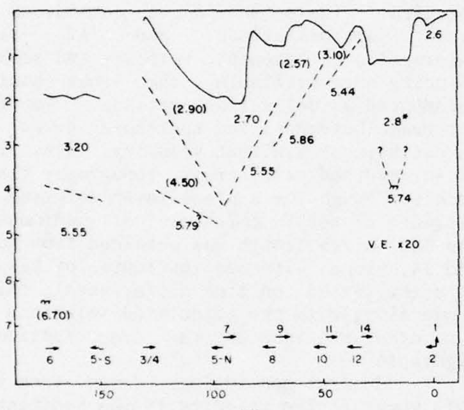


Fig. 16. Structural section from the Coronado Escarpment, on the right, through the San Diego Trough and San Clemente Basin to San Clemente Island. From the San Clemente Island runs, 1950.

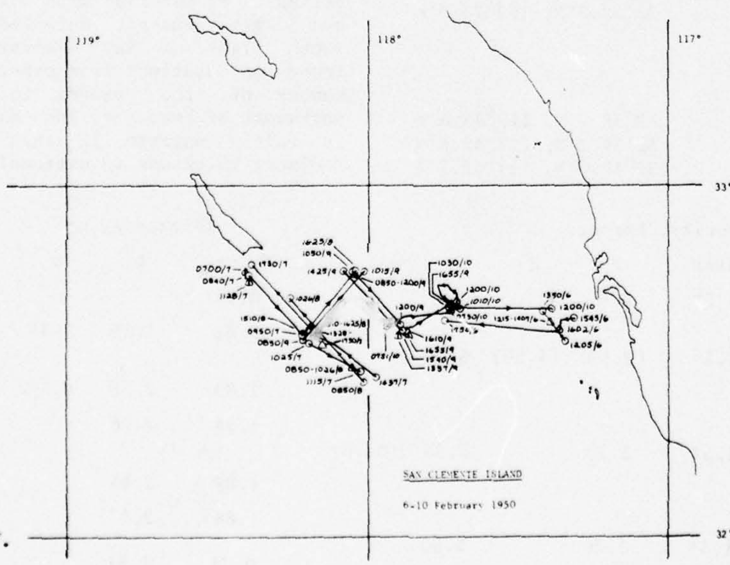


Fig. 17.

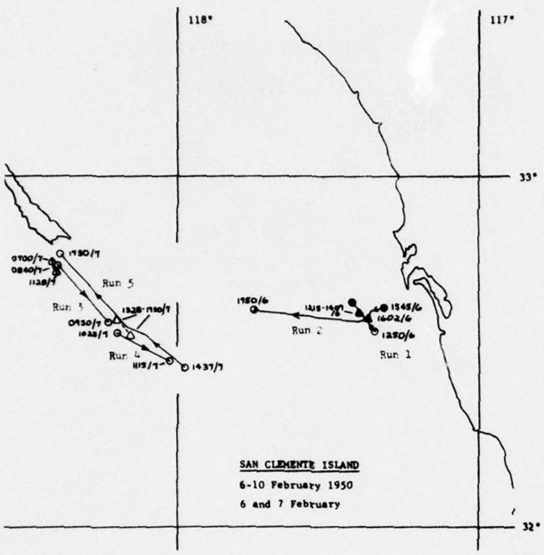


Fig. 18

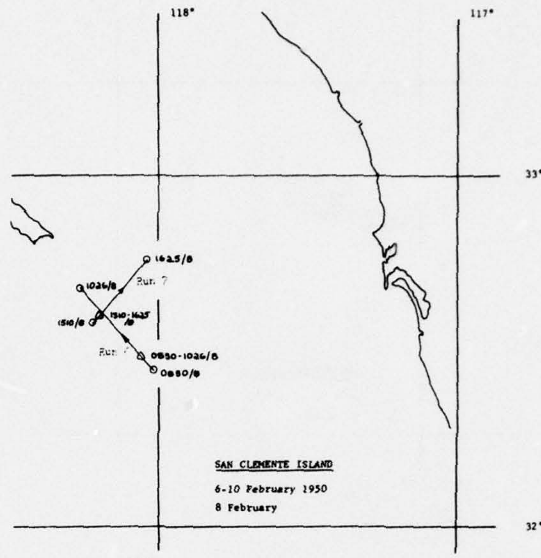


Fig. 19.

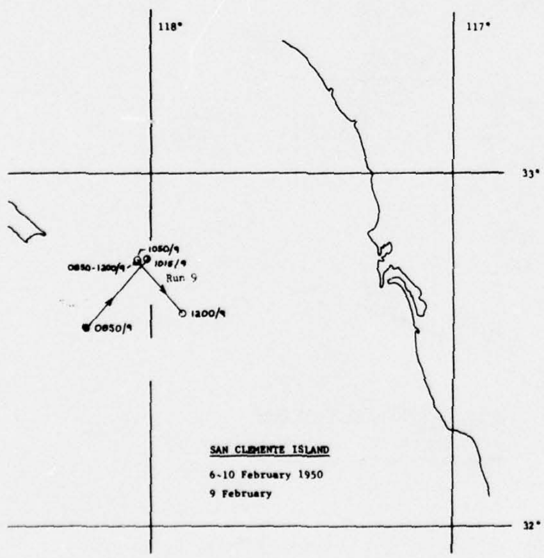


Fig. 20.

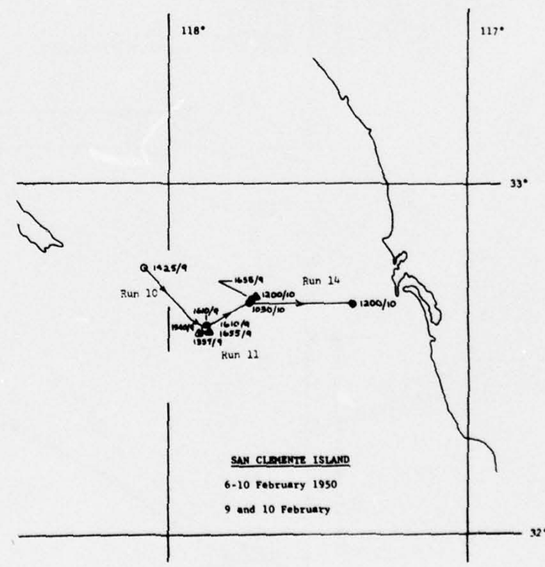


Fig. 21.

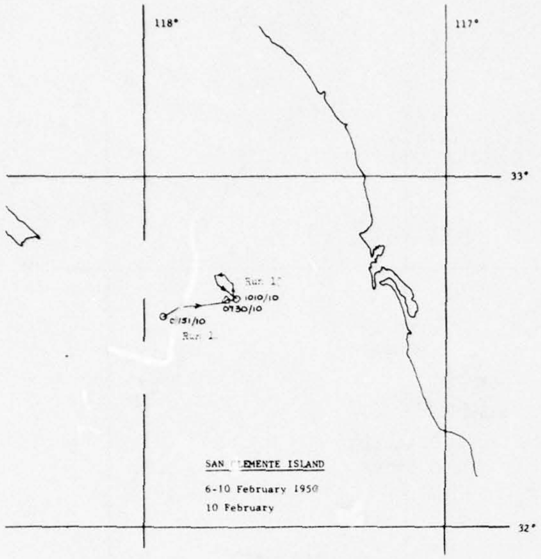
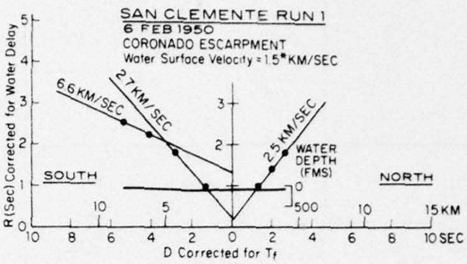


Fig. 22.



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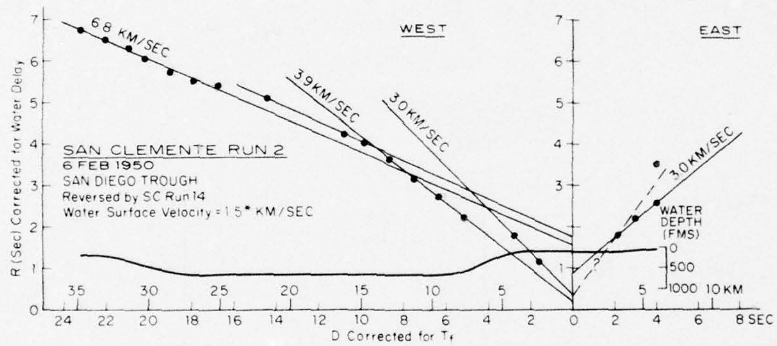


Fig. 24.

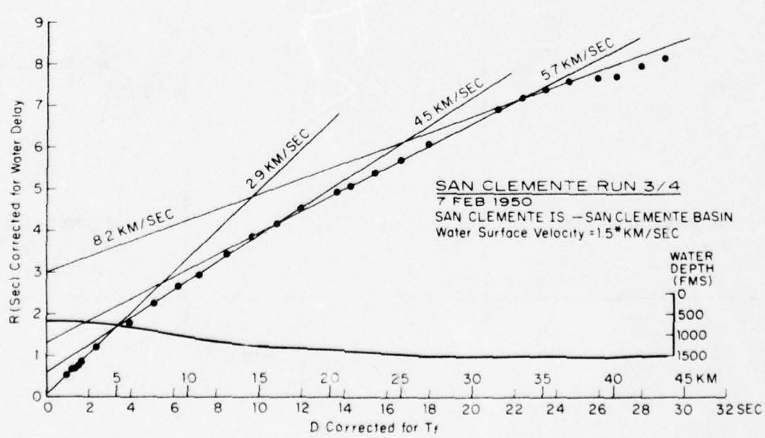


Fig. 25.

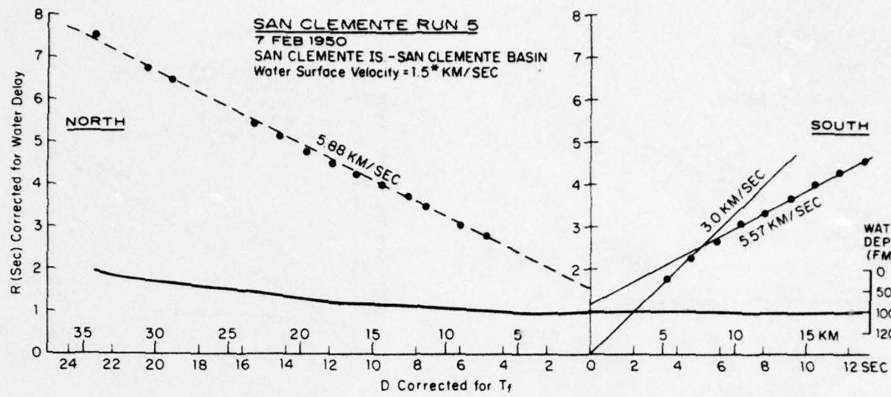


Fig. 26.

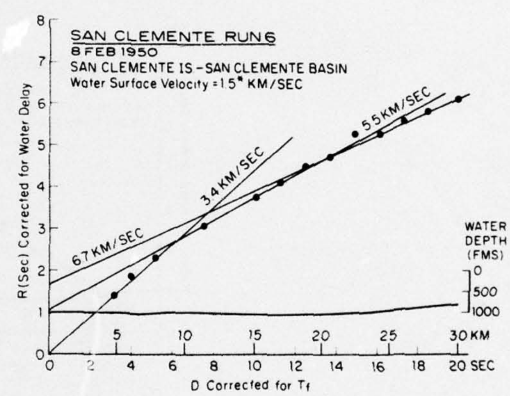


Fig. 27.

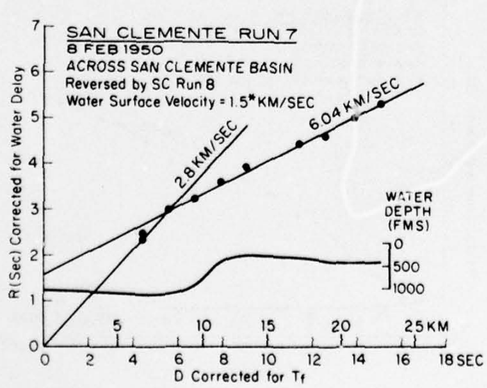


Fig. 28.

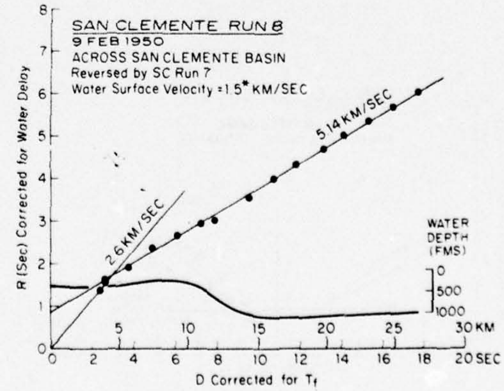


Fig. 29.

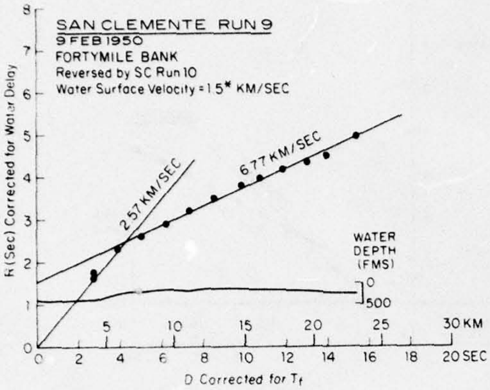


Fig. 30.

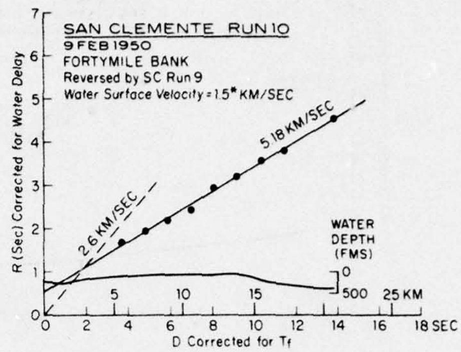


Fig. 31.

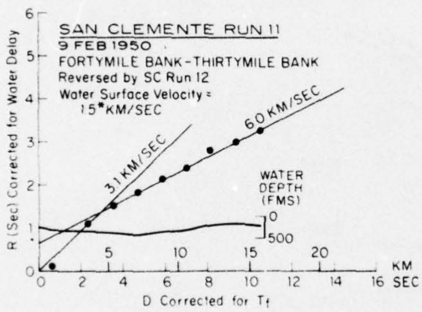


Fig. 32.

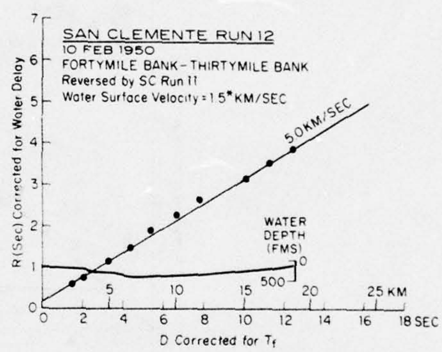


Fig. 33.

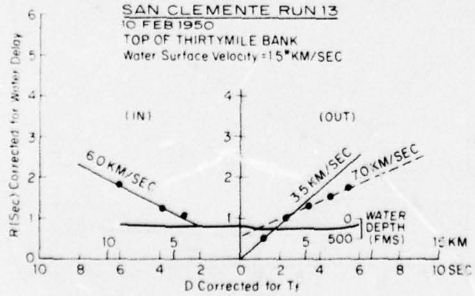


Fig. 34.

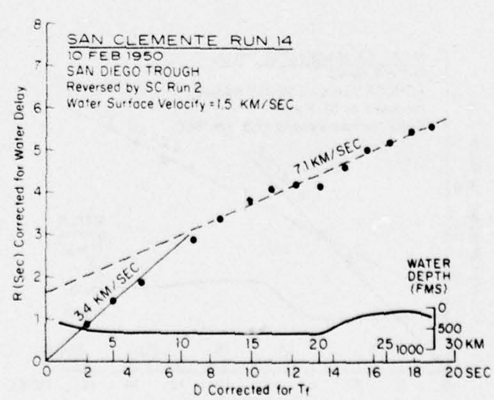


Fig. 35.

SAN NICOLAS ISLAND I, 27-29 November 1951 (SN)
EPCE (R) 857 shooting (Gibson), E. W. SCRIPPS receiving (Raitt)

This cruise was in the area between San Nicolas Island, San Clemente Island and Tanner Bank and consisted of seven runs which form a rough quadrilateral from Tanner Bank to the San Nicolas Basin. The longest runs are in the San Nicolas Basin.

Run 1 was a single profile which went from the northwest end of the San Nicolas Basin (Able) through Baker and on to the southeast, ending near Charlie at the receiver. These designations, Able, Baker, Charlie, etc., were used only during the cruise and do not refer to any permanent bathymetric features. Run 1 was reversed by Run 6, a single profile received at Able and Run 7, a split, received at Baker, paralleled Runs 1 and 6 down the San Nicolas Basin.

Run 2 was a single profile received at Charlie which started at Charlie in the San Nicolas Basin, went west up the slope of Tanner Bank to Dog, changed course there and went along the top of Tanner Bank to just southeast of Easy. The first section of Run 2 was reversed by the first section of Run 3, a split, received at Dog. The second sections of Runs 2 and 3 are parallel and outgoing and are reversed by the first section of Run 4 which was a split received at Easy.

Run 4 went from Dog on Tanner Bank along the top of the bank to Easy, turned and went downslope to Able in the San Nicolas Basin. Its second section was reversed by Run 5, which went from Easy to Able.

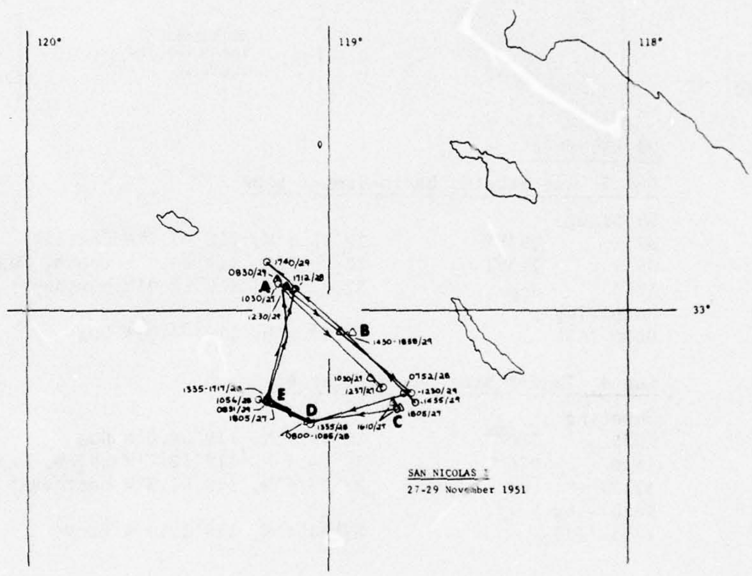


Fig. 36.

27 November

Run 1 San Nicolas Basin

TIME	COURSE	POSITION
Shooting		
1030	138° T	33° 04.6'N, 119° 10.2'W Able
1237	end	32° 46.4'N, 118° 49.4'W
Receiving		
1030		32° 48.0'N, 118° 51.6'W northwest of Charlie
1237		32° 46.3'N, 118° 49.4'W

Run 2 San Nicolas Basin-Tanner Bank

TIME	COURSE	POSITION
Shooting		
1610	258°T	32°43.9'N, 118°46.4'W Charlie
1732	293°T	32°40.7'N, 119°04.0'W Dog
1805	end	32°43.5'N, 119°11.4'W southeast of Easy
Receiving		
1610		32°43.6'N, 118°46.8'W Charlie
1805		32°43.1'N, 118°45.5'W Charlie

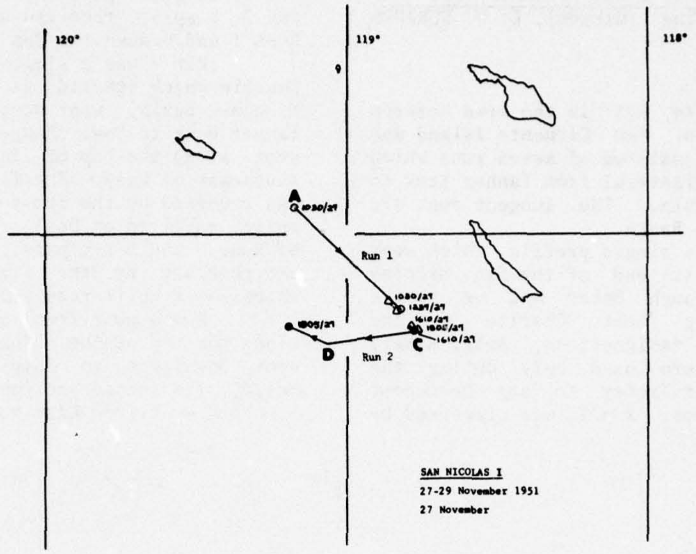


Fig. 37.

28 November

Run 3 San Nicolas Basin-Tanner Bank

Shooting		
0752	253°T	32°45.6'N, 118°44.7'W Charlie
0937	293°T	32°40.7'N, 119°04.0'W abeam, Dog
1056	end	32°44.3'N, 119°14.0'W northwest of Easy
Receiving		
0800-1055		32°40.5'N, 119°03.9'W Dog

Run 4 Tanner Bank-San Nicolas Basin

Shooting		
1335	300°T	32°40.7'N, 119°04.0'W Dog
1510	016°T	32°44.9'N, 119°12.7'W abeam, Easy
1712	end	33°03.6'N, 119°07.3'W southeast of Able
Receiving		
1335-1717		32°44.7'N, 119°12.0'W Easy

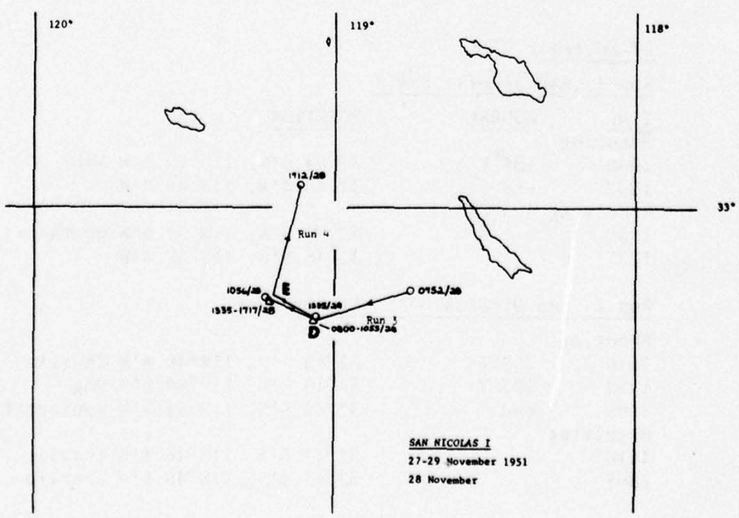


Fig. 38.

29 November

Run 5 Tanner Bank-San Nicolas Basin

Shooting		
0831	016°T	32°44.0'N, 119°12.5'W Easy
0934	356°T	32°55.3'N, 119°08.7'W
1011	end	33°04.3'N, 119°09.6'W Able

Run 6 San Nicolas Basin

Shooting		
1015	131°T	33°04.3'N, 119°09.6'W Able
1230	end	32°45.2'N, 118°43.5'W northeast of Charlie

Runs 5 and 6

Receiving		
0830		33°04.8'N, 119°10.6'W Able
1230		33°03.7'N, 119°08.7'W Able

Run 7 San Nicolas Basin

Shooting		
1435	316°T	32°43.8'N, 118°42.6'W northeast of Charlie
1611	310°T	32°56.0'N, 118°56.8'W Baker
1740	end	33°07.9'N, 119°12.8'W southeast of Able
Receiving		
1403		32°56.1'N, 118°57.8'W Baker
1838		32°55.9'N, 118°55.4'W Baker

All positions given are from reconstructed track charts made by G.G. Shor, Jr., 1955.

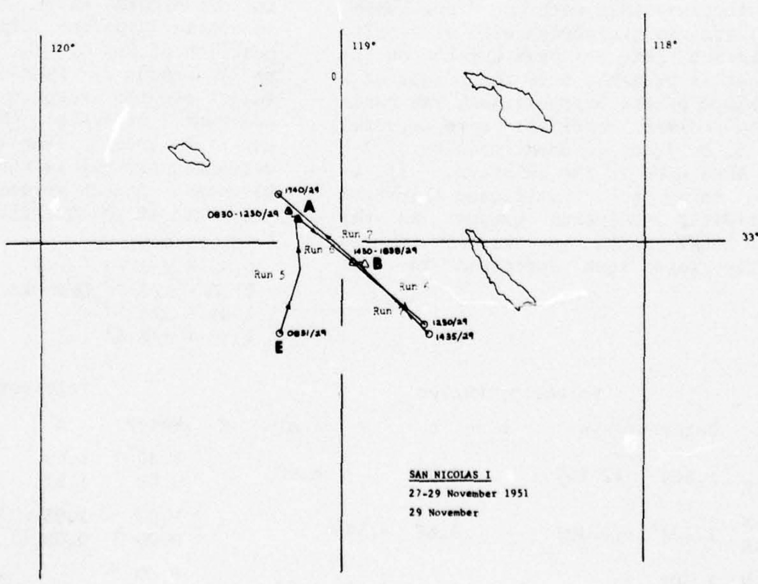


Fig. 39

SAN NICOLAS ISLAND I

Extract from MPL Quarterly Report, 1 October to 31 December 1951, by R.W. Raitt:

A five-day cruise was made to the area included between San Nicolas Island, San Clemente Island, and Tanner Bank, using USNEL'S USS EPCE(R)-857 to fire TNT bombs and SIO's M/V E. W. SCRIPPS as receiving ship. Combined reflection and refraction studies were made of San Nicolas Basin-Tanner Bank region. Rough preliminary study of the travel-time data indicate the presence of four velocity layers of 2, 3, 4.5, and 6 km/sec, respectively.

Results

SN Run 1 and SN Run 6, a reversed pair, were presented as Figure 6 of Shor and Raitt (1958); the other stations have not been reported previously.

Travel times for all seven runs are given in the pages that follow. As presented, they have been corrected for water delay, but not for topography. The velocities marked on the travel-time plots are the least-square fits to the corrected data. For purposes of computation, lines were fitted by eye to the same data with the requirement that the reverse times must agree. The line equations used in the solutions are given below. The layer solutions are plane-layer solutions by the method given by Ewing (1963).

SN Run 1 and SN Run 6 are a reversed pair. SN Run 7 is a split profile between the two, and therefore reverses Run 1 and Run 6 again. If the reversals with Run 7 are used, an extra layer is introduced with a velocity near 6.2 km/sec; this has been omitted on the basis that it is probably only the effect of a change of slope of the basement near the basin margins. No sediment arrivals were detected on Runs 1, 6, or 7; an assumed velocity of 2.8 km/sec has been used in the solution. If, as is probable, there is a significant thickness of unconsolidated sediments present in the basin, the total depth to basement may be significantly less than indicated in this solution.

SN Run 1	SN Run 6
0.00 + x/2.80*	0.00 + x/2.80*
1.26 + x/4.47	1.58 + x/4.60
1.80 + x/6.19	2.68 + x/7.19

SN Run 2 and Run 3-East form another reversed pair. On these lines a set of three points on Run 3-E gives a sediment velocity of 2.46 km/sec; this has been used in the solution. A small amount of unconsolidated sediment may be present at the receiving position of Run 3-E.

SN Run 2	SN Run 3-East
-	0.15 + x/2.46
1.12 + x/4.27	1.00 + x/4.20
1.60 + x/5.62	2.38 + x/6.72

SN Run 3-North and Run 4-South are a reversed pair on top of Tanner Bank. Arrivals at short range from the receiving position of Run 4-S indicate the possible presence of high-velocity material locally near the receiving point; as a result it has been necessary to take the sediment velocity only from Run 3-N for this station. If such high-velocity material is present (probably a volcanic dike) at the station, the value given for sediment thickness at Run 4-S is best considered to be an extrapolation of the value along the line, not as a value at the receiving point.

SN Run 3-North	SN Run 4-South
0.08 + x/2.40	-
0.65 + x/3.79	0.40 + x/3.58
0.88 + x/4.65	0.72 + x/4.44

SN Run 4-N and Run 5 are a reversed pair from Tanner Bank down to the center of the San Nicolas Basin. High-velocity material is again apparent close to the receiving position of Run 4. The mean velocity out to 6 km is about 2.7 km/sec, and that has been taken as the accepted value. Run 5 has no sediment arrivals; the sediment velocity cannot be greater than 2.5 km/sec if the first refracted arrival is through the sediment or basement. A mean velocity of 2.6 km/sec has been used in the solution.

SN Run 4-North	SN Run 5
0.00 + x/2.70	0.00 + x/2.50*
0.30 + x/3.04 (not used)	-
1.05 + x/4.77	1.50 + x/4.60
2.45 + x/6.64	2.28 + x/6.15

Run	Velocity, km/sec							Thickness, km				
	Water	a	b	c	d	e	f	Water	a	b	c	d
SN 2 SN 3-E	1.504	(2.46)		4.23		6.09		1.40 0.09	1.69 1.51		1.01 3.70	
SN 3-N SN 4-S	1.504	(2.40)		3.68	4.54			0.09 0.09	1.03 0.63		0.48 0.86	
SN 4-N SN 5	1.504 1.505		2.60		4.68	6.38		0.09 1.78		1.73 2.48		4.44 2.12
SN 6 SN 1	1.505 1.504		2.80*		4.53		6.64	1.76 1.44		2.81 2.24		2.67 1.08

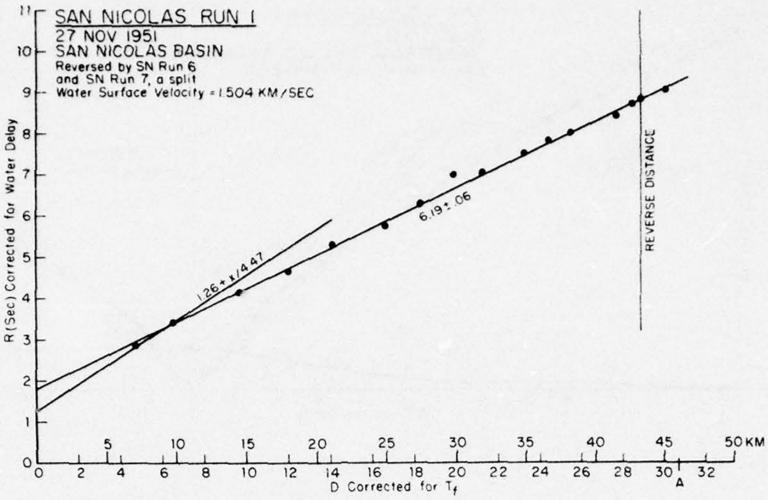


Fig. 40.

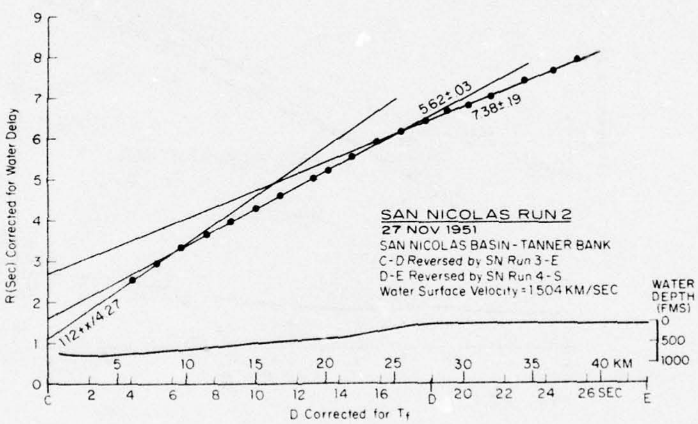


Fig. 41.

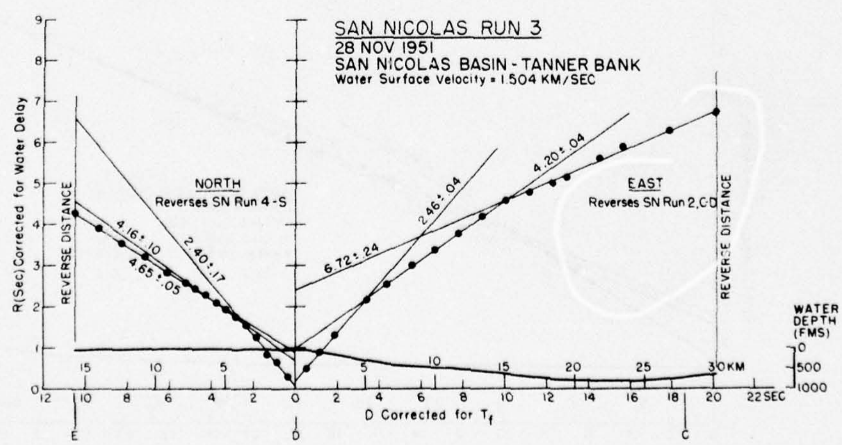
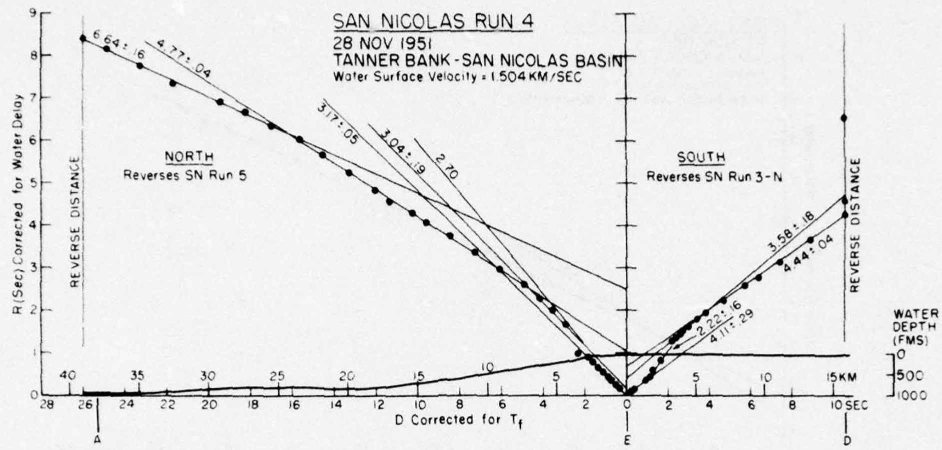


Fig. 42.



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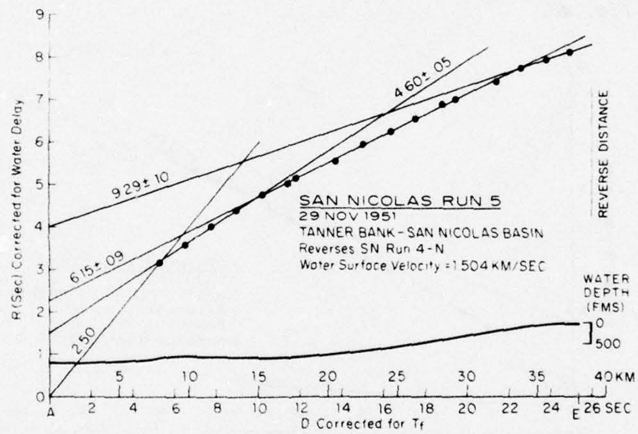

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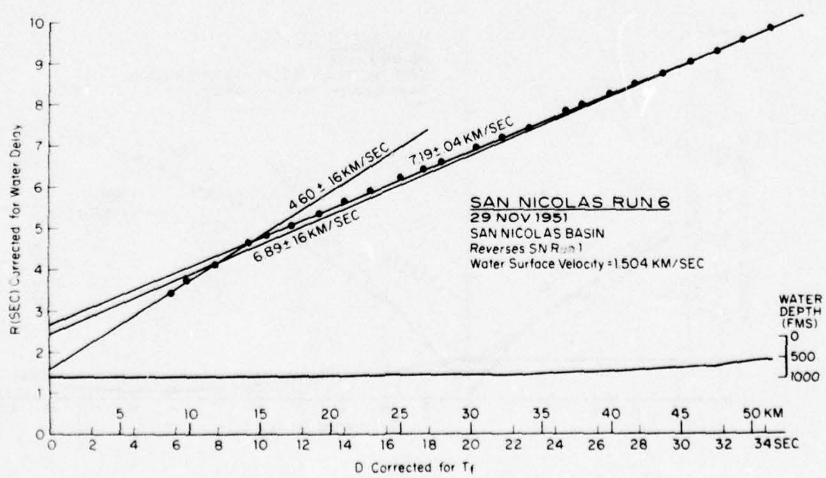

Fig. 45.

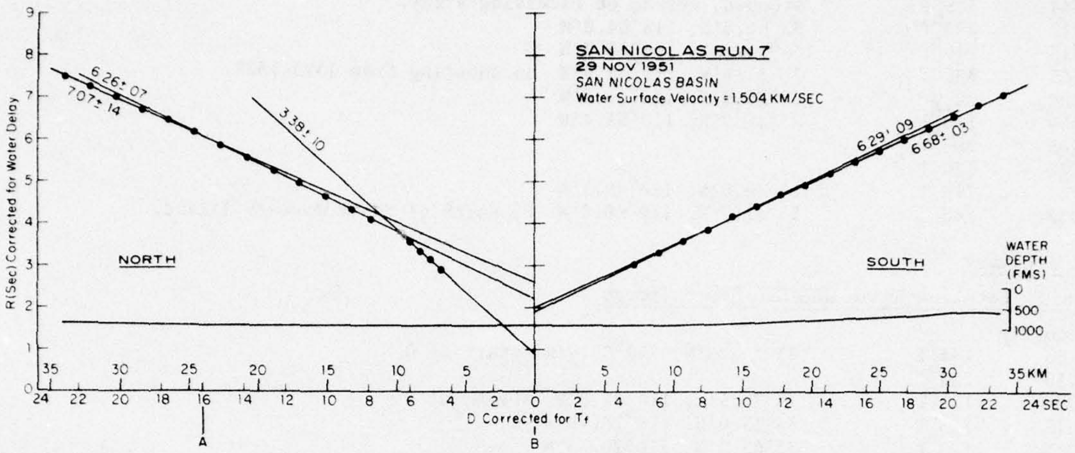

Fig. 46.

SANTA BARBARA I, 23-25 February 1954 (SB I)
HORIZON shooting (Gibson), CREST receiving (Raitt)

The runs on this cruise and on SANTA BARBARA II, 26-28 May 1954, were in the San Diego area, across the San Diego Trough and up the Catalina Basin and onto the bank northwest of Santa Barbara Island.

The first three runs of SANTA BARBARA I were all short ones, near Point Loma. Run 1 was a single run from W (off Point Loma) to T to the northwest where the receiver was anchored for Runs 1, 2, and 3. Run 2 was a single side going north from T to U, and Run 3 was an outgoing run to the northwest from T to S.

Run 4 was a single run which began at S where Run 3 ended and continued up the Catalina Basin ending just north of Santa Barbara Island at P. Run 5 began slightly northwest of Santa Barbara Island, at Q, went past the receiving ship at P and down the Catalina Basin and across the San Diego Trough reversing Runs 3 and 4 and ending at T.

23 February

Run 1 Point Loma area

TIME	COURSE	POSITION
Shooting		
1304	294°T	32°41.4'N, 117°16.9'W W
1354	end	32°43.0'N, 117°19.7'W T

Run 2 Point Loma area

Shooting		
1426	000°T	32°41.7'N, 117°20.0'W south of T
1501	000°T	32°45.4'N, 117°20.7'W
1543	end	32°51.2'N, 117°20.6'W U

The ship records in the station book don't show any course change, but the reconstructed plot does. According to the ship's log, the HORIZON steered 000° throughout Run 2. The reconstructed plot, based in large part on numerous visual fixes on land, shows the course made good as 353° for the first part of the run, then 000°. This is probably due to current, and indicates how inaccurate the navigation of other runs farther from land may be.

Run 3 Point Loma area

Shooting		
1641	303°T	32°42.0'N, 117°19.1'W
1807	end	32°48.7'N, 117°31.8'W southeast of S

Runs 1, 2, 3, and 4 T, Point Loma area

Receiving	
1304-1807	32°42.0'N, 117°19.1'W

Five miles, 300°T from Point Loma Light

24 February

Run 4 San Diego Trough and Catalina Basin

Shooting			
0730	305°T	32°48.7'N, 117°31.8'W	same position as last shot of Run 3.
0844-0919	305°T	stopped, worked on receiving array.	
1112	293°T	33°06.8'N, 118°04.8'W	
1315	240°T	33°18.4'N, 118°33.3'W	
1325	300°T	33°17.6'N, 118°35.6'W	no shooting from 1315-1325.
1600	stop	33°25.0'N, 118°51.4'W	
1656 u/w	120°T	33°25.0'N, 118°51.4'W	
1705	300°T		
1726	120°T		
1733	295°T	33°26.0'N, 118°49.5'W	
1833	end	33°31.0'N, 119°00.8'W	P, north of Santa Barbara Island.

25 February

Run 5 Catalina Basin and San Diego Trough

Shooting			
0703	134°T	33°33.25'N, 119°05.4'W	start at Q
0730	149°T		
0737	120°T	33°30.5'N, 119°01.0'W	abeam, at P
1019	113°T	33°15.0'N, 118°28.45'W	
1225	123°T	33°05.2'N, 118°20.35'W	
1526	120°T?	32°45.6'N, 117°27.2'W	
1612	end	32°41.2'N, 117°18.6'W	end at T

Receiving	
0700	33°30.7'N, 119°01.0'W
1630	33°30.4'N, 119°01.0'W

From the track chart available there appears to have been a course change of about 3° at 1526 although this is not mentioned in the notes in the station book.

When Run 5 began the CREST was anchored in 46 fms off Santa Barbara Island. At 1245 the anchor wire parted and they drifted off into water of 60 fms depth. At 1322 they moved to a new shallow anchorage. The HORIZON stopped at 1320 and waited for them to get into the new position which is the one listed above for 1630.

The original track charts for this cruise and SANTA BARBARA II have disappeared. It is possible that they may have been thrown away. The positions given for these two cruises have been gleaned from sketches and notes and are thought to be reasonably accurate but may not be exact.

All records for SANTA BARBARA I were taken on the pen-and-ink recorder only. Travel times for SANTA BARBARA I are plotted together with those from SANTA BARBARA II, PATTON V, and SANTA CRUZ-SAN NICOLAS runs in the same area.

SANTA BARBARA I

Extract from MPL Quarterly Reports, 1 January to 31 March 1954 by R.W. Raitt and George G. Shor:

During the period 23 to 25 February 1954 a reversed refraction profile was recorded between Point Loma and Santa Barbara Island .... Shots were received on R/V CREST at anchor at two receiving positions: (A) [T on Fig. 47] five miles northwest of Point Loma; (B) [P on Fig. 47] two miles northeast of Santa Barbara Island. Both positions were in flat areas just inside the break in slope to deep water. Shots were fired from R/V HORIZON.

Bottom refracted waves were recorded simultaneously on a two-channel pen oscillograph, one with a single hydrophone, and the other with three hydrophones streamed in tandem 50 feet apart and connected in parallel. Very calm conditions prevailed and noise levels on both channels were low. (See current report on "Low Frequency Background Noise.") There was little, if any, better signal-to-noise ratio on the multiple hydrophone as compared with the single one, and there were times when the multiple was significantly worse, possibly because the drift was so slight that the multiple units tended to tangle with one another.

In spite of the low noise conditions the low intensity of bottom refracted waves made the results rather spotty beyond about 50 nautical miles range. Although observable refracted intensity was received out to the total distance of about 100 miles between A [T on Fig. 47] and B [P on Fig. 47], the beginnings of the more distant shots were indistinct and unreliable. The travel-time distance plots resemble typical continental observations, hence were strikingly different from the deep sea data west of the continental slope. Velocities as high as about 6.6 km/sec were reached. There was no evidence for subcrustal velocities of the order of 8

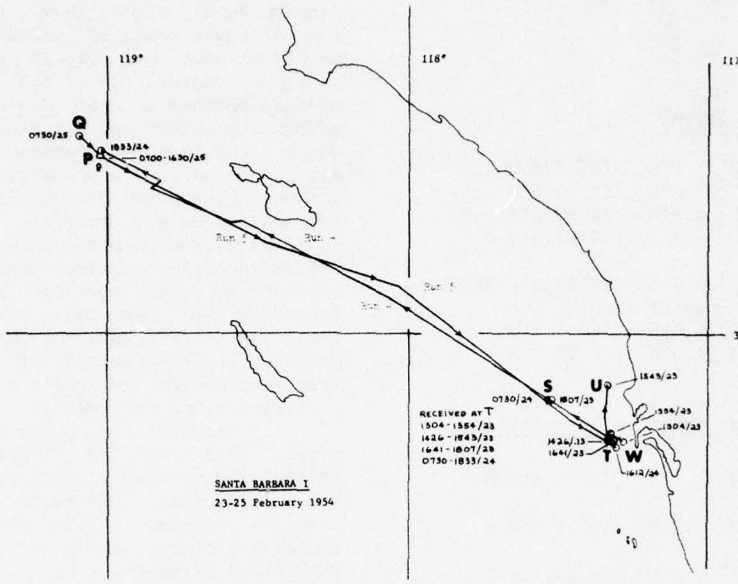

Fig. 47.

km/sec, either because the crust is too thick or because refracted waves were too weak to detect as a first arrival. Analysis of the data is not yet completed.

While CREST was at receiving position B [P on Fig. 47] at Santa Barbara Island, two 300-lb depth charges were fired from R/V E. W. SCRIPPS at a distance of about 90 miles by a group from the U. S. Navy Electronics Laboratory under the supervision of John N. Shellabarger and Joseph F. King. Very strong bottom refracted signals were received from these shots, much better than from the 80-lb demolition charges fired on the seismic run. In order to test the reality of this effect with similar shots by the USNEL group and to make further noise comparisons with single and multiple hydrophones, a second trip to Santa Barbara Island was made on 18 March 1953. The R/V E. W. SCRIPPS served as a receiving vessel. Bottom refracted waves from three 300-lb depth charges were received at positions northeast of Santa Barbara Island. Their strength was less than those of 25 February, and appeared reasonable relative to the demolition charges at a comparable range.

When we were working up the data from this cruise, it became obvious immediately that the shallow structure was so variable along the line that we would have to reverse the short runs and add more short profiles along the length of the long ones in order to get any sort of reliable solution. It also appeared that there might be some weak mantle arrivals on the long runs, but if so these had faded out quickly at greater range. We accordingly went back to the same area on two succeeding trips -- SANTA BARBARA II, and PATTON V--to do additional runs. The solutions to the SB I runs, therefore, follow the reports of SB II. PAT V Run 5 served to confirm that the interpretation of the mantle depth on the SB I runs was indeed correct.

<u>SANTA BARBARA II, 25-28 May 1954 (SB II)</u> E. W. SCRIPPS shooting (North), SALUDA receiving (Shor)

Run 1 was a split profile in the Catalina Basin shot from N, in the center of the channel, northwest to O, near the northwest end of Catalina Island, where it was received. From there the run went on to P near Santa Barbara Island. The incoming run, SB II Run 1-SE (N to O) reverses SANTA CRUZ-SAN NICOLAS Run 3. The outgoing run, SB II Run 1-NW (O to P) is a quasi-reversal of the short range portion of SB I Run 5-SE. For the next run, SB II Run 2, the receiving ship reoccupied P, near Santa Barbara Island, and the shooting ship started at Q, where SB I Run 5-NW had begun. The shooting ship then made a run northwest to R, extending the old run: SB II Run 2 is therefore an extension of SB I Run 5-NW. The receiving ship then moved to V, between R and Q, and the shooting ship shot SB II Run 3 from V to Q to P, reversing the combination of SB I Run 5-NW and SB II Run 2.

Both ships then returned to the Point Loma area and reversed two of the shallow water runs of SB I, as follows: SB II Run 4 reverses SB I Run 3; SB II Run 5 reverses SB I Run 2.

26 May
Run 1 Catalina Basin

TIME	COURSE	POSITION
Shooting		
0735	318°T	$33^{\circ}11.7'$N, $118^{\circ}28.8'$W N
0907	340°T	$33^{\circ}21.0'$N, $118^{\circ}38.8'$W
0953	291°T	$33^{\circ}24.0'$N, $118^{\circ}40.2'$W ~ O
1238	end	$33^{\circ}31.4'$N, $119^{\circ}01.0'$W P
Receiving		
0735		$33^{\circ}26.3'$N, $118^{\circ}38.9'$W Drifting on station
		$33^{\circ}25.6'$N, $118^{\circ}40.4'$W
1238		$33^{\circ}24.5'$N, $118^{\circ}40.7'$W

27 May
Run 2 Northwest of Santa Barbara Island

Shooting		
0923	325°T	$33^{\circ}35.7'$N, $119^{\circ}06.4'$W Q
0927	322°T	
1105	end	$33^{\circ}46.2'$N, $119^{\circ}16.3'$W R
Receiving		
0923-1105		$33^{\circ}30.8'$N, $119^{\circ}01.2'$W P

Run 3 Northwest of Santa Barbara Island

Shooting		
1410	143°T	$33^{\circ}41.0'$N, $119^{\circ}12.0'$W V
1554	131°T	$33^{\circ}34.1'$N, $119^{\circ}05.8'$W Q
1622	end	$33^{\circ}31.1'$N, $119^{\circ}01.5'$W P
Receiving		
1410		$33^{\circ}41.0'$N, $119^{\circ}12.0'$W V
1640		$33^{\circ}41.8'$N, $119^{\circ}12.0'$W V

28 May
Run 4 Point Loma area

Shooting		
0642	121°T	$32^{\circ}51.5'$N, $117^{\circ}37.2'$W S
0902	end	$32^{\circ}42.5'$N, $117^{\circ}19.7'$W T
Receiving		
0642-0902		$32^{\circ}51.5'$N, $117^{\circ}37.2'$W S

Run 5 Point Loma area

Shooting		
1242	174°T	$32^{\circ}51.6'$N, $117^{\circ}19.6'$W ~ U
1347	end	$32^{\circ}42.0'$N, $117^{\circ}18.5'$W ~ T
Receiving		
1242-1347		$32^{\circ}51.7'$N, $117^{\circ}19.7'$W U

Travel times for SANTA BARBARA II are plotted together with those from SANTA BARBARA I, PATTON V, and SANTA CRUZ-SAN NICOLAS runs in the same area, see Fig. 52.

Extract from MPL Quarterly Reports, 1 April to 30 June 1954, by R. W. Raitt and G. G. Shor:

Seismic refraction measurements in the southern California embayment were continued in the current quarter. During 25 to 28 May five refraction profiles were recorded between Pt. Loma and the Santa Barbara Channel Islands along the line of the long profile shot 23 to 25 February. (See MPL Quarterly Report, 1 January to 31 March 1954, SIO Ref. 54-18). Four of these profiles provided reversals to profiles shot one way in February and in previous years; the fifth was a reversed profile northwest from Santa Barbara Island across a platform approximately 100 fathoms in depth. The same 3-hydrophone tandem streamer was used as in February, recording two channels singly and the entire group of three in parallel on a third trace. Conditions were again calm, and no new conclusions about the effectiveness of mixing could be drawn. Two more 300-lb depth charges fired by personnel from USNEL were recorded. These shots were fired at 1000 feet, at which depth some destructive interference of the bubble-pulse frequency can be expected; as a result bottom refracted waves were weak.

Charges fired in the February and May trips were recorded surprisingly well on shore-based permanent seismograph stations of the California Institute of Technology network. The most distant shot recorded was a 10-lb TNT charge fired 97 miles from the station at Barrett Reservoir.

Results
1) Lines near Point Loma

Because of the variability of sediment thickness along the profile from Point Loma to Santa Barbara Island, individual station solutions can give radically different results from those adjoining them when solved by the usual plane-layer approximation. On the other hand, information on the velocities within the sedimentary section was generally missing on the deep-water lines. In order to make any consistent interpretation of the long profile down the San Diego Trough and Catalina Basin, therefore, it was necessary to go over the stations with a variety of assumptions, to try to get a "best estimate" of velocities and thicknesses of the shallow layers. This analysis should be re-done on the basis of newer additional information, and will therefore not be repeated in full here. Results on the lines near Point Loma have been given in some detail as an example of the approach used. The cross-section derived from these analyses was published by Shor and Raitt (1958); it is presented in slightly modified form following this discussion (Fig. 48).

Lines on the shelf off Point Loma provide the most information on the shallow sediments. Unfortunately, the shooting run of SB II Run 5 was not over exactly the same track as SB I Run 2 (due to inexcusably bad navigation), and the reverse times do not agree. There is also undoubtedly change in structure both along and transverse to the shooting runs.

Lines SB I Run 1, SB I Run 2 and SB II Run 5 were solved together to get velocities for the shallowest material. For the first layer, observed arrivals were:

SB I Run 1	0.25 + x/2.29
SB I Run 2	0.21 + x/2.06
SB II Run 5	0.04 + x/1.87

obviously with some undetected sediments of lower velocity at the sea floor. To get a working number, arrivals from these three runs were combined for the first layer. A zero intercept time was assumed, and a velocity of 1.85 km/sec obtained; this was used for solutions on all runs near Point Loma. Additional sediment arrivals were obtained on lines SB I Run 3 and SB II Run 4 (on the continental slope), with velocities of 1.76 and 1.72 respectively; these data were not used since second-order errors in the water-delay corrections can cause large errors in the determination of low velocities on steep slopes. The material with velocity 1.85 km/sec probably represents an average velocity within the unconsolidated surficial sediments of the shelf, and may correspond to the "post-orogenic sediments" of Moore (GSA Special Paper 107). Deeper sediments with an unreversed velocity of 2.65 km/sec may be present (at a depth of about 120 meters) near U, the receiving position for SB II Run 5, and possibly elsewhere on the shelf. This corresponds closely with the velocity found for the pre-orogenic sediments on the banks of the Borderland. If such a layer is present beneath the Point Loma shelf, it would increase calculated sediment thickness by not more than 0.12 km.

For a second-layer velocity (volcanics or older sediments, probably the Cretaceous that outcrops on Point Loma) data were used from lines SB I Run 2 and SB II Run 5 (the reversed pair between T and U) for solutions both on these lines and on the lines between S and T on the continental slope. In determining the mean velocity, agreement of reverse times was not required; the mean velocity is 4.87 km/sec. This velocity was used on lines between S and T because there is an apparent large thickening of the low-velocity sediments on these lines near the base of the slope; this distorts the travel-time curves, makes the second-layer apparent velocities too low and the third-layer apparent velocities too high.

Third-layer velocities on SB I Run 2 and SB II Run 5 are inconsistent with those on SB I Run 3 and SB II Run 4. A velocity for the third layer was obtained for the latter two runs by use of a time-difference plot, in which the difference of refracted arrival time was plotted against difference of water-wave arrival time for pairs of shots with approximately the same subsurface position but received at opposite ends of the profile. This gave a value of 5.86 km/sec for e and a difference of intercept times of 0.58 seconds for the two ends of the line. From these values, plus the reverse time, intercept times could be obtained for the runs between S and T; these values were used in the solution for the reversed pair between S and T. If, however, one accepts both the third-layer velocity from ST and the intercept time at T, and then tries to derive a matching set of apparent velocities and intercepts for the runs between T and U, one finds inconsistencies with the observed data. One may accept the intercept time at T but not the true velocity, or the velocity but not the intercept time. Solutions have been computed both ways: using a velocity of 5.86 km/sec, fitted to the observed data, or using an

Run	Velocity, km/sec					Thickness, km		
	Water	a	d	e	f	Water	a	d
SB I 2(T)	1.499					0.11	0.86	1.41
		1.85	4.87	5.86*				
SB II 5(U)	1.494					0.06	0.43	3.03
Alternative,								
SB I 2(T)	1.499					0.11	0.86	2.38
		1.85	4.87		6.73			
SB II 5(U)	1.494					0.06	0.43	2.02

The interpretation for the runs between S and T, lines SB I Run 3 and SB II Run 4, is:

Run	Water	a	d	e	Water	a	d
SB I 3(T)	1.491				0.11	0.85	3.10
		1.85*	4.87*	5.86			
SB II 4(S)	1.483				0.95	0.64	1.09

intercept time of about 1.58 sec at T and obtaining the velocity (6.73 km/sec) by fitting to the data. The former approach implicitly assumes that there is a steep slope to the basement near point T; the latter implies a near-vertical boundary (probably a fault along the escarpment) separating an upthrust section of the high-velocity basement from the usual low-velocity material. Both interpretations could well be correct.

2) Lines near Santa Barbara Island

The three short reversed profiles near Santa Barbara Island give problems similar to the Point Loma set; adjacent profiles do not match, and the necessary dependence on first arrivals for interpretation leaves doubt about continuity of layers. Considerable juggling of delay-times was used to make the cross-section given by Shor and Raitt (1958); a less complex interpretation is given here.

Runs between P and V form a reversed pair: SB I Run 5-NW was extended by SB II Run 2, and partially reversed by SB II Run 3. The runs were in shallow water, from the platform of Santa Barbara Island across a saddle to the shallow bank to the northwest.

Sediment arrivals were detected on only a few close-in shots on these runs. A sediment velocity was derived by using arrivals from the closest shots on runs SB I Run 5-SE, SB I Run 5-NW, and SB II Run 3 combined; the mean velocity is 2.60 km/sec, with little indication of the presence of any low-velocity sediment above the layer producing the refracted arrivals. This is consistent with previous observations on Tanner Bank, Thirtymile Bank, Fortymile Bank, and elsewhere. This velocity was used in interpretation of both the reversed profile between P and V, and also the adjacent one between P and O. The observed travel times between P and V (from lines fitted by eye for common reverse times, with a reverse distance of 26.2 km) were as follows:

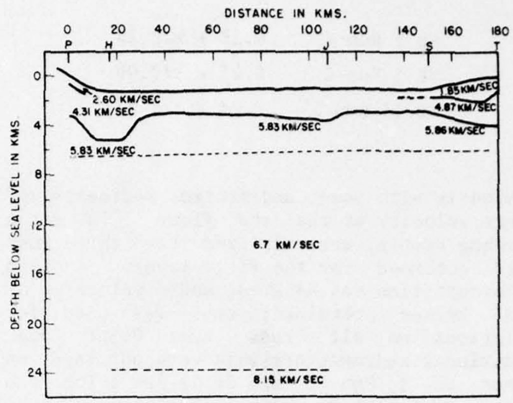

Fig. 48.

This does not match very well with adjacent pairs, and there is the possiblity that the velocity of 5.38 is an artifact, caused by averaging two different velocities of materials making up the two shallow banks (with a near-vertical discontinuity between).

SB I Run 5-SE, recorded at P, extends down the Catalina Basin and across the San Diego Trough all of the way to Point Loma (T). The portion of this line closest to P is nearly reversed by run SB II Run 1-NW and has been worked with it for shallow structure. Because of the steep slope from the island platform to the Catalina Basin, the travel-time plot is extremely irregular; because the two runs do not coincide exactly, it was not possible to remove the structural effects and determine the velocity by means of a time-difference plot. The pair of runs is therefore of considerably reduced value. A plane-layer solution has been made, without

SB II Run 3 (V)		SB I Run 5-NW and SB II Run 2 (P)
	mean 0.00 +	x/2.60
0.10 + x/4.20		0.42 + x/4.43
0.57 + x/5.10		1.25 + x/5.86

A solution by the plane-layer approximation gives:

Run	Velocity, km/sec				Thickness, km		
	Water	b	c	d	Water	b	c
SB II 3(V)	1.490					0.16	1.66
		2.60	4.31	5.38			
SB I 5-NW and SB II 2(P)	1.499 1.490				0.09	0.68	2.85

Run	Velocity, km/sec				Thickness, km		
	Water	b	c	e	Water	b	c
SB I 5-SE(P)	1.499				0.09	0.50	2.54
		2.60	4.17	5.85			
SB II 1-NW(O)	1.485				1.30	1.03	2.26

requiring matching of reverse times; the irregularity of the travel-time plots means that the fits of lines to the data points are rather subjective.

Higher velocities were obtained on the farther shots of SB I Run 5-SE; these were reversed by SB I Run 4 to get a solution on the deeper layers.

3) Lines in the Catalina Channel and San Diego Trough

SB II Run 1-SE reversed the older run SC-SN Run 3. The original run had a relatively small number of shots, and it was not possible to follow second arrivals. It was interpreted as a two-layer delay-time section, with assumed velocities of 2.8 and 5.83 km/sec obtained from other reversed profiles. The original interpretation is shown with the travel-time plot (Fig. 49). The new line, SB II Run 1-SE, had a much closer shot spacing, and shows essentially the same basement velocity (5.85 km/sec) but has usable second arrivals giving velocities of 1.82 km/sec, 3.00 km/sec, and possibly 3.79 km/sec. The mean velocity for the sedimentary section, as derived from the layer solution, comes out very close to 2.8 km/sec, so that the original cross-section can be considered valid.

A solution was computed for SB II Run 1-SE with unreversed velocities, as follows:

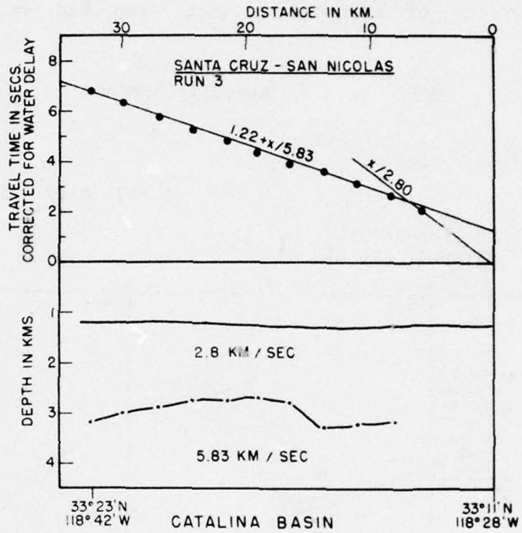

Fig. 49.

Run	Velocity, km/sec					Thickness, km			
	Water	a	b	c	e	Water	a	b	c
SB II 1-SE(O)	1.485	1.82	3.00	3.79	5.85	1.30	0.78	0.28	1.58

This comes out with a total depth to basement that is shallower than the value at O for the reversed pair from P to O, but deeper than the computed value at O for SC-SN Run 3. Since line SC-SN Run 2 across the Catalina Basin shows a great deal of variation in sediment depth, this mismatch is not surprising.

The long profiles between points T and P show consistent arrivals with velocity near 6.7 km/sec: arrivals with equation 1.85 + x/6.65 on run SB I Run 4 recorded at T, and 1.90 + x/6.69 on SB I Run 5-SE recorded at P; in both cases the shots were in the Catalina Basin. Both profiles also have some indication of arrivals with velocity near 8.2 km/sec over a short interval in the Catalina Channel. This was verified by later reshooting on PAT V Run 5 across the San Diego Trough, which, recorded both at H in the Catalina Basin and at the Barrett seismograph station ashore, gave arrivals with velocities 6.75 and 7.95 km/sec at Barrett, and 8.20 km/sec at H. A mean velocity of 6.70 km/sec has been used for the upper layer (the high-velocity crust), and 8.20 km/sec for the lower layer (the mantle).

Using observed layering at P and O,

the mean thickness of the high-velocity crust was calculated; since the velocity was not reversed at these two points, the assumption had to be made that it was at equal depth under both to prepare a cross-section. The mean thickness was 2.7 km; if the top of the high-velocity crust is at constant depth below sea level, its thickness would be 3.5 km at P and 2.0 km at O.

Adding information from line PAT V Run 5 to the computation, and assuming constant structure under the Catalina Basin for purposes of computation (not too bad an assumption, in view of the fact that the apparent velocities on both high- velocity crust and mantle show no dip effects), one obtains a thickness for the high-velocity crust of 16.7 km, and a mean depth below sea level to the Mohorovicic discontinuity of 23.3 km.

These numbers are slightly different from those given in Shor and Raitt (1958); they have been recomputed from the same original data with slightly different assumptions.

Run	Velocity, km/sec						Thickness, km				
	Water	b	c	e	f	g	Water	b	c	e	f
SB I 5-SE(P)	1.499						0.89	0.50	2.54	3.5	
		(2.60)	4.17	5.85	6.70	8.20					
SB II-1-NW(O)	1.485						1.30	1.03	2.26	2.0	
PAT V-5(near O)											16.7

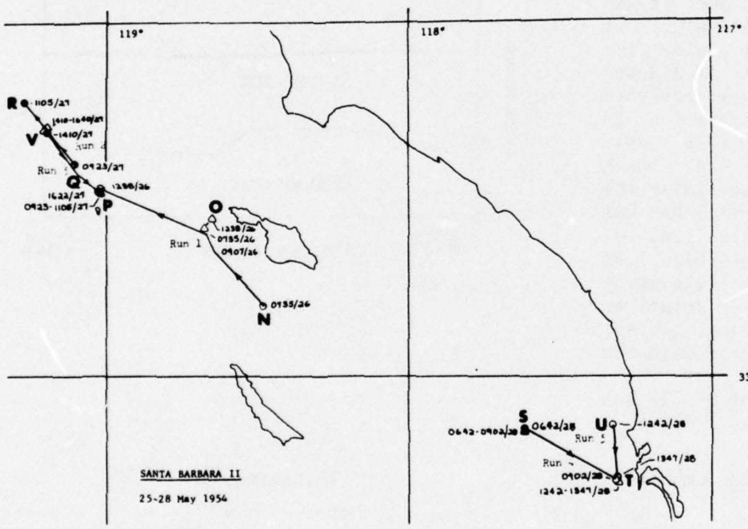

Fig. 50.

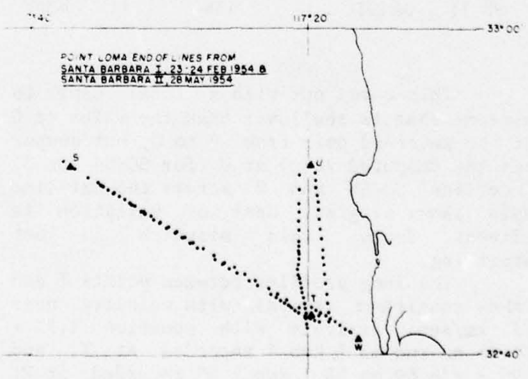

Fig. 51.

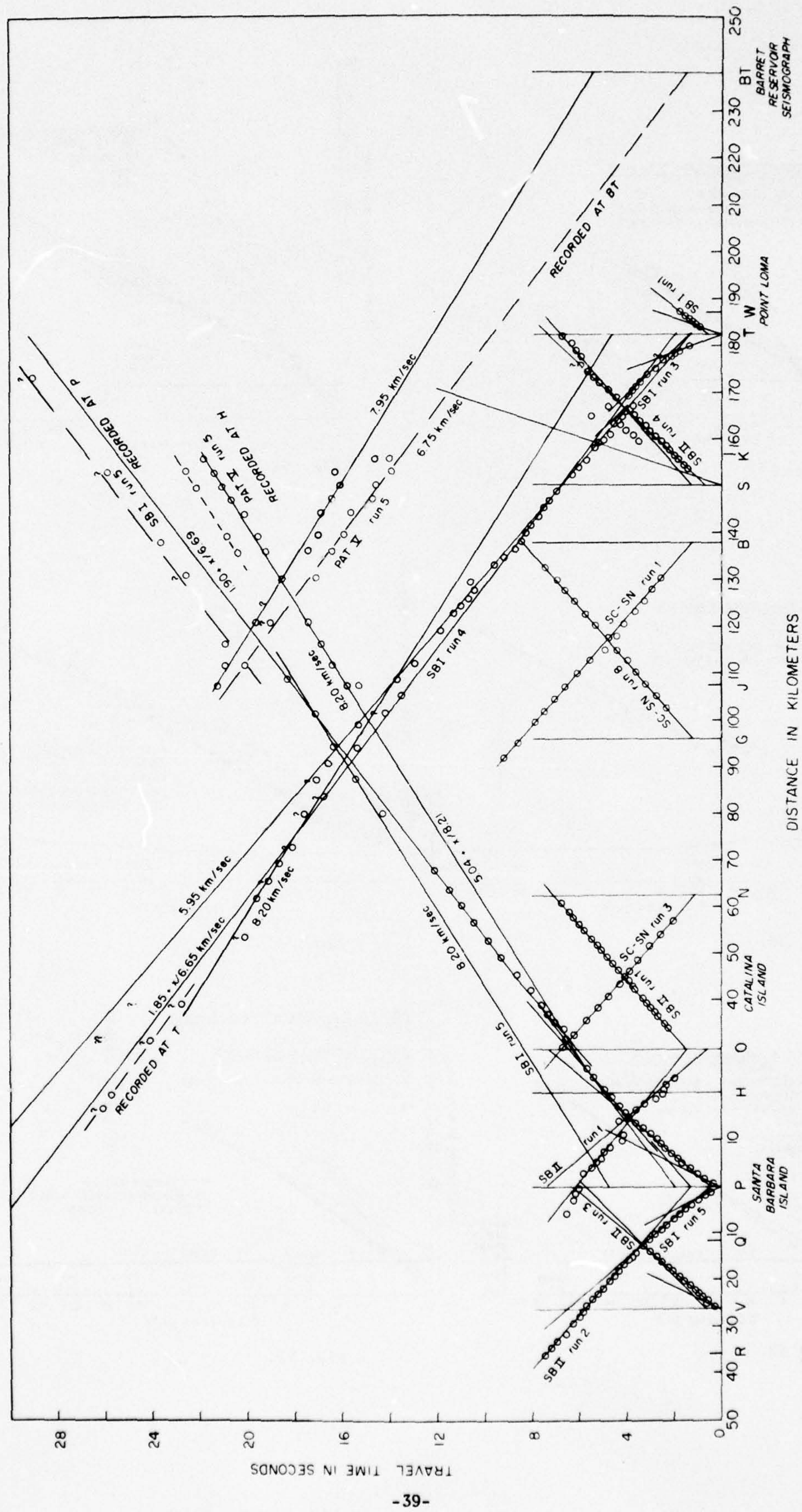
DISTANCE IN KILOMETERS
TRAVEL TIME IN SECONDS
BT
BARRET RESERVOR SEISMOGRAPH
T W
POINT LOMA
SANTA BARBARA ISLAND
CATALINA ISLAND
RECORDED AT BT
RECORDED AT P
RECORDED AT H
RECORDED AT T
7.95 km/sec
6.75 km/sec
5.95 km/sec
8.20 km/sec
1.85 + x/6.65 km/sec
1.90 + x/6.69
5.04 + x/8.21
SBI run 5
SBI run 4
SBI run 3
SBI run 1
SBII run 4
SBII run 3
SBII run 2
SBII run 1
PAT V run 5
SC-SN run 1
SC-SN run B
SC-SN run 3

Fig. 52.

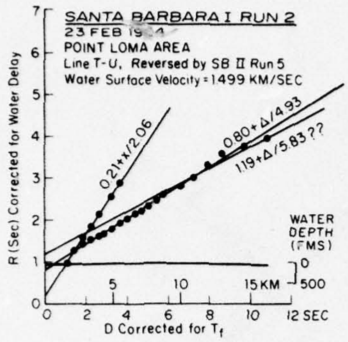

Fig. 53.

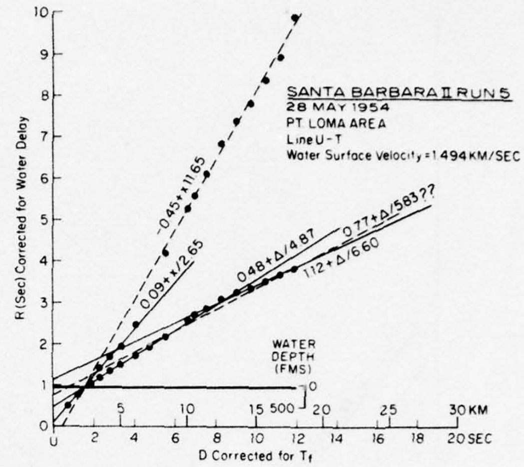

Fig. 54.

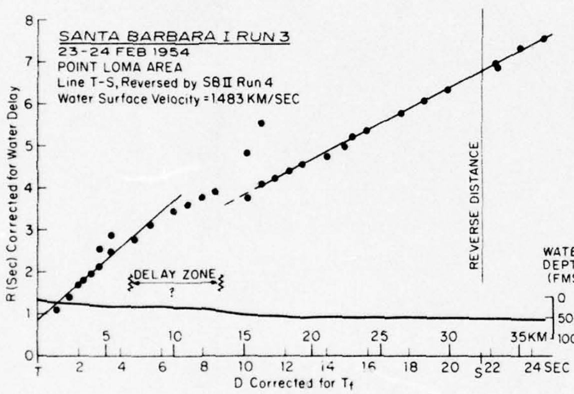

Fig. 55.

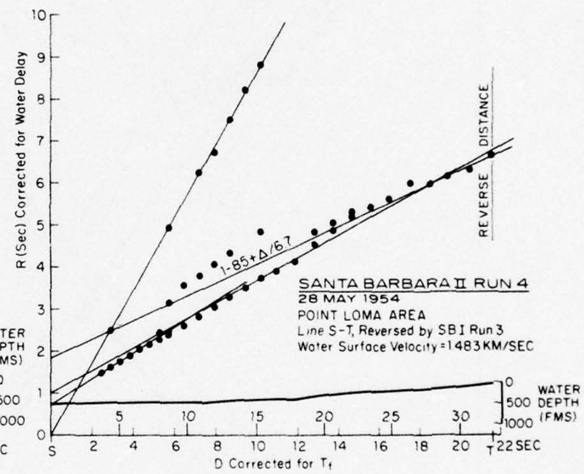

Fig. 56.

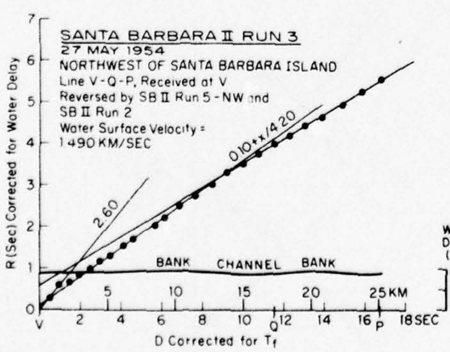

Fig. 57.

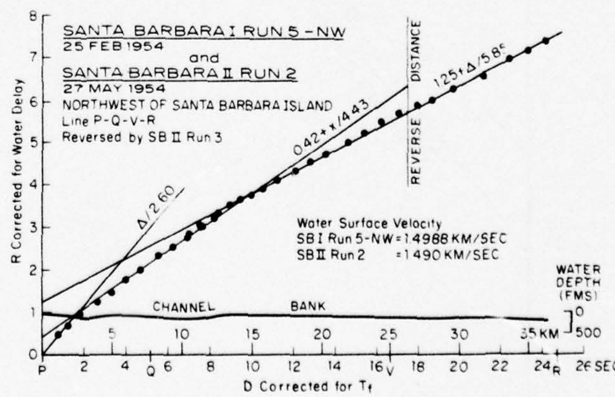

Fig. 58.

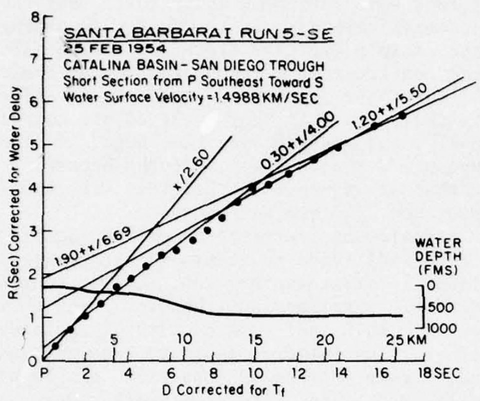

Fig. 59.

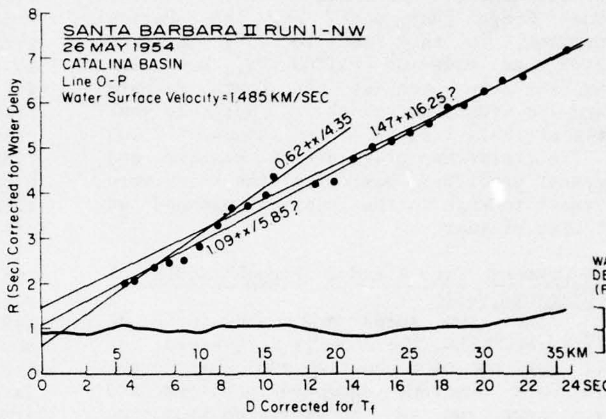

Fig. 60.

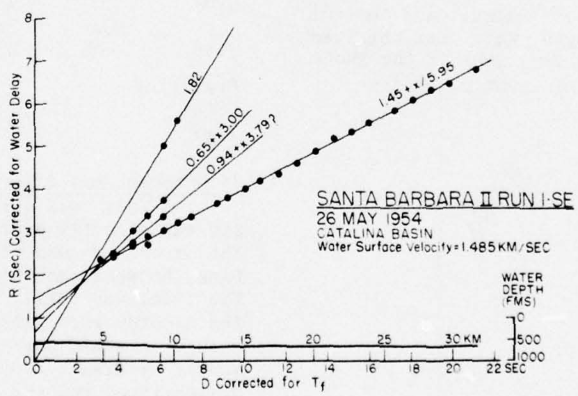

Fig. 61.

PATTON V, 19-25 October, 1955 (PAT V) T-441 shooting (North), PAOLINA-T receiving (Shor)

This cruise consisted of runs in three widely separated areas, all intended to add to previous work and to try to determine the depth to mantle under the borderland. Runs 1 and 2 extended south from the previous San Clemente Island work, along a narrow 1000-fathom trough parallel to the coast of Baja California. Runs 3 and 4 were along the Patton Ridge just east of the Patton Escarpment, in the same locality as the shorter runs made on PATTON IV. Run 5 was along the same area as the Santa Barbara Island long runs, to check the possible weak mantle arrivals from SB I Run 4 and SB I Run 5. The cruise was plagued with weather and equipment problems; basically the ships were too small to work in the locations planned at that time of year.

19-20 October Runs 1 and 2 Trough south of San Clemente Basin

The two ships proceeded to B at 31°12'N, 117°57'N. The PAOLINA-T received; the T-441 set out on a shooting run due north. There were numerous equipment problems, and only a short run was accomplished from time 1538 to 1800. The PAOLINA-T then moved north to A overnight, at approximately 31° 12'N, 117°57.5'W. The T-441 shot an incoming run north from time 0709 to 1518. The navigational data were poor originally, and little remains in the files other than a rough sketch. The echo-sounder on the T-441 did not work in this depth of water, and bottom reflections from the shots were not obtained by the shooting ship on very many of the shots.

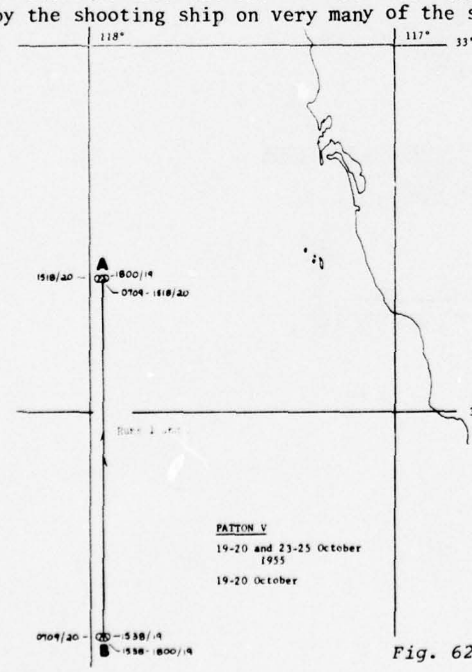

Fig. 62.

23 October Run 3 Patton Ridge

The intention was to make a long reversed profile on Patton Ridge, with the center of the reversal beneath the earlier stations. The weather was bad, and the T-441 had considerable difficulties. The ships therefore lay to at San Nicolas Island waiting for the weather to improve. They finally went to a position at the northern end of the ridge, and tried a run. During the run, the T-441 took some extremely heavy rolls, and the gyro compass came out of its mount. According to the ship's log they stayed on course 152° for the entire run; a reconstruction of their track from their soundings and the existing charts indicates that they drifted off course radically, and started over the edge of the escarpment. When the water depths became so great that it was obvious that they were badly off position, the run was ended.

Following termination of the shooting run, the T-441 tried to return to the original position to start another run. This course was directly into the sea, however, and they obviously could not make it. Instead, therefore, they headed east to San Nicolas Island, came north in the lee of Point Arguello, and then with the weather down to the planned starting point. The PAOLINA-T went with the weather southeast to the receiving position for Run 4.

TIME	COURSE	POSITION
Shooting		
0904	152°?	33°44.8'N, 120°43.5'W D
	c/c	33°13.5'N, 120°30.0'W C
1549	end	32°43.5'N, 120°20.0'W E
Receiving		
0904		33°44.8'N, 120°43.5'W
1549		33°38.0'N, 120°41.0'W

24 October Run 4 Patton Ridge

This was a partial reversal of Run 3, and was directly over PATTON IV Runs 4 and 5. The receiver was 70 km away on a separated bank, between Northeast Bank and Long Basin. The T-441 was still having difficulties, and the records were noisy, so that as soon as enough data had been obtained to reverse the mantle arrivals from Run 3, the station was discontinued and the ships headed for shelter.

Following the run, both ships were supposed to head for the north point of San Clemente Island, and spend the night in the lee of the island; the PAOLINA-T indeed did so. The T-441, however, was unable to use their gyro compass because of earlier damage, and only discovered in the middle of the night that they had a 20° error in their magnetic compass (caused by the proximity of the magnet in a Brush recorder, which had been stowed beneath the compass). As a result, they rounded the north end of Catalina Island instead, and spent the night at Avalon.

Shooting

0706	152° ?	33°04.5'N, 120°18.0'W	
0906	139°	32°48.1'N, 120°08.7'W	
1005	end	32°40.0'N, 120°01.2'W	

Receiving

0706	32°08.8'N, 119°33.2'W
1005	32°08.5'N, 119°30.5'W

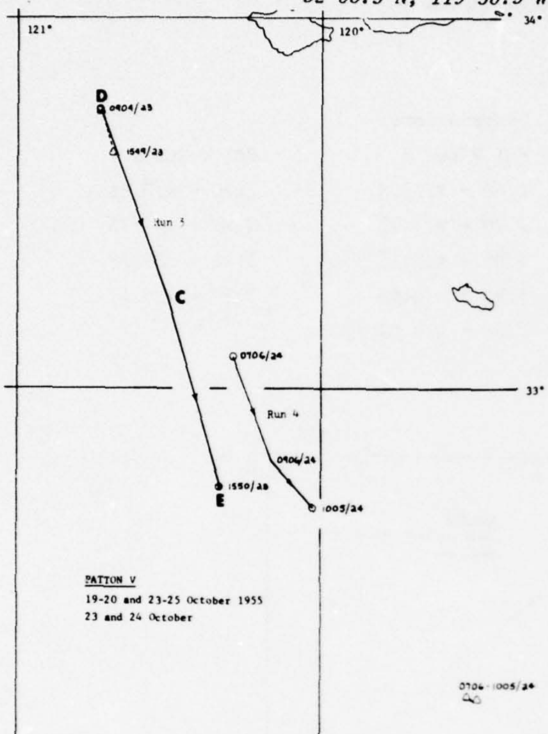

Fig. 63.

25 October Run 5 San Diego Trough

This run was shot to check mantle arrivals from the previous runs in the San Diego Trough. Since some of the earlier shots had appeared on the records of earthquake seismographs operated by California Institute of Technology at Barrett and Palomar, this run was intended to see if we could get usable records on their stations. The PAOLINA-T received with hydrophones in the north end of the Catalina Basin, and the T-441 dropped large shots along a line connecting the PAOLINA-T position to the Barrett seismograph. The run is therefore not exactly colinear with the earlier SANTA BARBARA I runs. The records at Barrett were indeed good enough to use, and received mantle arrivals.

Shooting

0845	122°T	33°03.0'N, 118°00.0'W	J
1105	128°T	32°53.0'N, 117°35.0'W	
1126	end	32°51.2'N, 117°32.0'W	K

Receiving

0845	33°25.3'N, 118°51.5'W	H
1125	33°23.5'N, 118°51.0'W	

Data from Run 5 are plotted together with the Santa Barbara Island runs that they supplement and were discussed with those runs.

Excerpt from Shor and Raitt, 1958:
PATTON RIDGE

At the top of the Patton Escarpment is a continuous ridge at a depth of approximately one kilometer below sea level. This ridge is unnamed on the charts; it is here referred to as the Patton Ridge. Four stations were occupied. Two of them were on the shallowest portion of the ridge, and had reversal on the shallowest crustal layers only. The other two stations were subsequently occupied in such a manner that the reversal was on the arrivals from the deepest part of the crust and the mantle, and the zone of reversal was close to the position of the earlier short lines. Data from the short lines give the section of Fig. 4 [of Shor and Raitt, 1958]; here velocities could be accurately determined from time-difference plots in the zone of reversal.

The longer lines shot on the later trip were slightly west of the short lines, in 1.2 km of water. Shallow layer velocities observed were the same as those obtained on the short lines. Deep crustal and mantle arrivals with apparent velocities indicating pronounced dip to the north were obtained in the zone of reversal. The dip is probably related to a sharp bend in the Patton Escarpment near the point where the deep arrivals were obtained. Layering has been computed for a short zone at the north end of the line of shooting where maximum control was available. It is migrated along the contours and plotted as the western Patton Ridge point in Fig. 2 [of Shor and Raitt (1958)]. The depth to the Mohorovicic discontinuity of 17½ km below sea level given for this point does not prevail over the entire line of shooting; there is some evidence for a minimum depth between 14 and 15½ km below sea level at the edge of the escarpment near the bend.

Results

Stations PAT V Run 1 and PAT V Run 2 have never been worked up for publication, primarily because of sad deficiencies in the "auxiliary data". The echo-sounders on the two ships did not work very well in deep water, so that water delay corrections were difficult. Usually when we don't have echo-sounder data, we use the bottom reflections (A_1 and A_2 if available) from the shooting ship records of the shot marks, and obtain a depth of adequate accuracy for correction. In this case, we were receiving the shot marks through the echo-sounder transducer of the T-441, and while it gave passably usable indications of the shot time, it rarely received the bottom echo. In addition, the navigation was only marginal because of overcast. The alleged distance between the two receiving points is one degree of latitude (60 nautical miles; 111 km), but the direct waterwave time from the most distant shot on Run 2, which should be at the reverse point, is 90 seconds (about 135 km). They were lost.

The travel-time plots for Runs 1 and 2 are given in Fig. 65. They have been corrected for firing delay, but not for water delay or topography because of the absence of these essential data. The following layer solution is derived from the uncorrected plots, with lines for Run 2 fitted to the observed data, and lines for Run 1 fitted to the reverse times of Run 1 on the assumption that the reverse distance is 135 km. They do not do any gross violence to the observations; the set of extremely thin crustal layers computed for the receiving point of Run 1 are not, however, ones that should be given any great confidence. The solution for the receiving station of Run 2 is remarkably similar to the adjacent receiving point of SAN CLEMENTE Run 6.

Observations:

PAT V Run 2	PAT V Run 1
1.60 + x/2.58	2.30 + x/2.61
2.70 + x/4.72	2.95 + x/4.76
3.00 + x/5.72	3.20 + x/5.77
3.90 + x/6.66	3.30 + x/6.47
5.30 + x/8.07 ??	

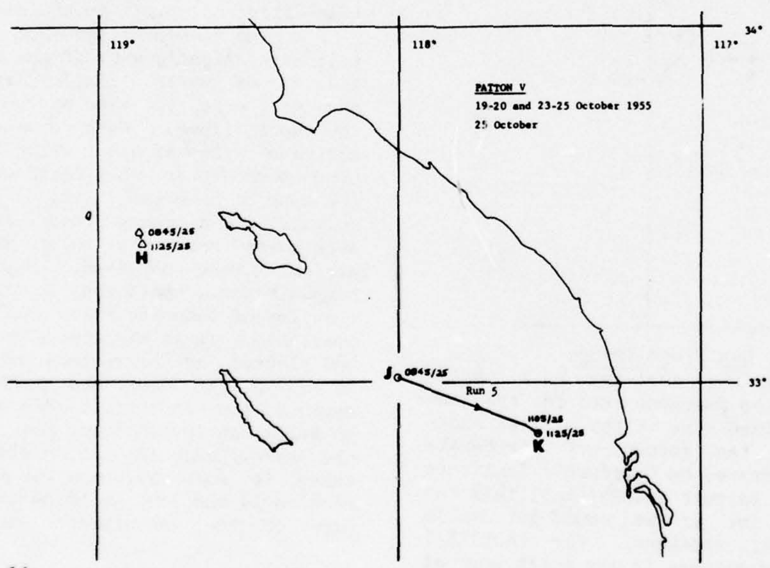

Fig. 64.

Flat-layer solution:

Run	Velocity, km/sec Water	b	d	e	f	g	Thickness, km Water	b	d	e	f	M depth, km
PAT V 1	1.5*	2.58	4.72	5.72	6.66	(8.07)	2.12	0.42	0.43	0.74		
PAT V 2							1.47	1.30	0.89	4.80	5.32	13.8

Average Structure from: PATTON IV, Runs 4 and 5 and PATTON V, Runs 3 and 4.

	Water	b	d	e	f	g	Water	b	d	e	f	M depth, km
	1.5*	2.8*	5.10	6.20	6.79	8.13	1.27	1.05	3.57	3.55	8.14	17.6

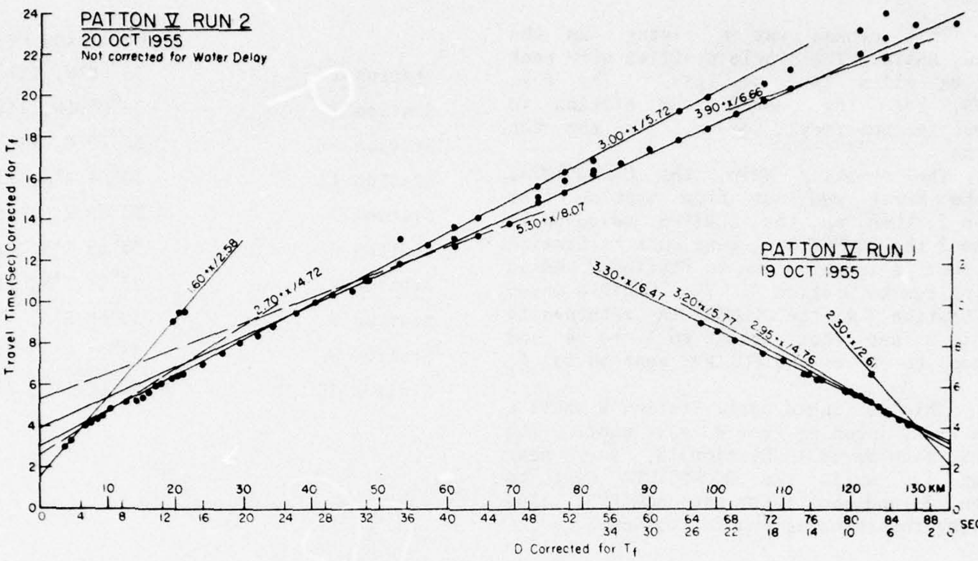
PATTON V RUN 2
20 OCT 1955
Not corrected for Water Delay
PATTON V RUN 1
19 OCT 1955
Travel Time (Sec) Corrected for T_f
D Corrected for T_f
130 KM
SEC
.60+x/2.58
2.79+x/4.72
5.30+x/8.07
3.00+x/5.72
3.90+x/6.66
3.30+x/6.47
3.20+x/5.77
2.95+x/4.76
2.30+x/2.61

Fig. 65.

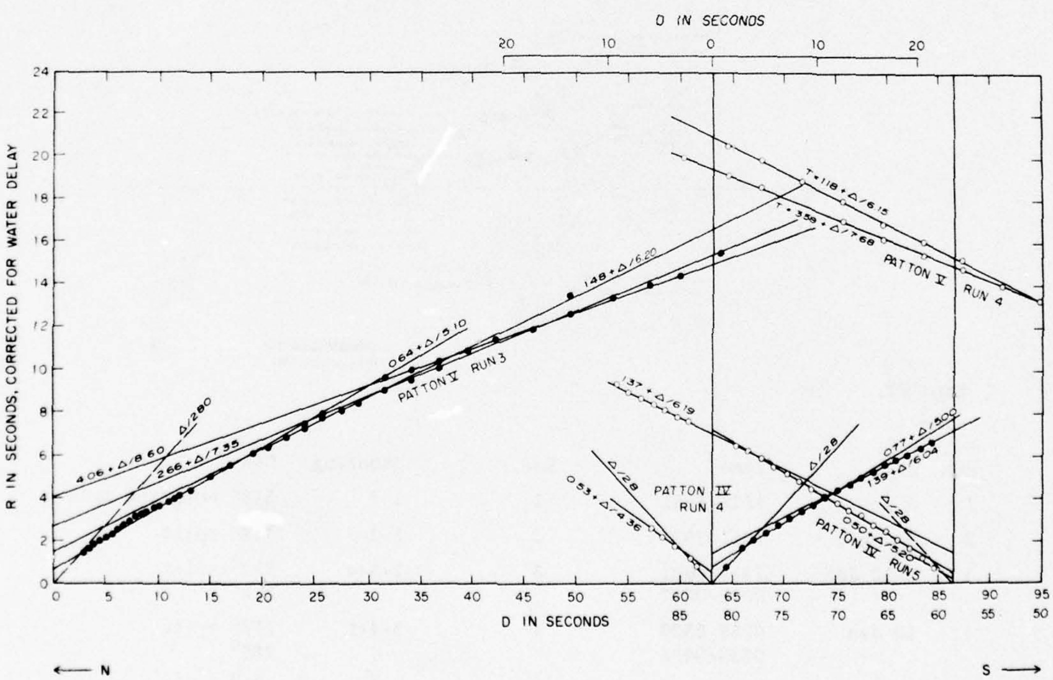
D IN SECONDS
R IN SECONDS, CORRECTED FOR WATER DELAY
D IN SECONDS
PATTON V RUN 3
PATTON V RUN 4
PATTON IV RUN 4
PATTON IV RUN 5
T=1.18+Δ/6.15
T=3.58+Δ/7.68
1.48+Δ/6.20
0.64+Δ/5.10
4.06+Δ/8.60
2.66+Δ/7.35
Δ/2.80
1.37+Δ/6.19
0.53+Δ/4.36
Δ/2.8
0.77+Δ/5.00
1.39+Δ/6.04
0.50+Δ/5.20
← N
S →

Fig. 66.

Catalina Test Trip, 9-11 January 1967 (CTT)
OCONOSTOTA Shooting (Francis), E.B. SCRIPPS Receiving (Shor)

This cruise was a zigzag up the Catalina Basin. The single profiles were each about 8½ miles long or less. The E.B. SCRIPPS, receiving, moved from station to station in numerical order, for the ten stations.

The shooting ship, the OCONOSTOTA, shot the first run out from Station 1 to Station 2, then as the SCRIPPS moved up to Station 2 the OCONOSTOTA went back to Station 1 and shot an incoming run to Station 2 and an outgoing run to Station 3. The SCRIPPS moved on to Station 3 as the OCONOSTOTA returned to Station 2 and shot from 2 to 3 to 4 and returned to 3 as the SCRIPPS went on to 4, etc.

This continued until Station 9 where a single run, incoming from 8 was shot. The SCRIPPS then moved to Station 10, very near Station 1, while the OCONOSTOTA went to Station 3 and shot in to the SCRIPPS, thus reversing the incoming run to Station 3.

	Receiving Position
Station 1	33°00'N, 117°55'W
Station 2	33°05.5N, 118°01'W
Station 3	33°10'N, 118°07'W
Station 4	33°04.4'N, 118°12.2'W
Station 5	33°06.2'N, 118°20.5'W
Station 6	33°13.1'N, 118°18.2'W
Station 7	33°13.7'N, 118°26.9'W
Station 8	33°06.5'N, 118°32.2'W
Station 9	33°11.1'N, 118°40.3'W
Station 10	33°00.2'N, 117°55.5'W

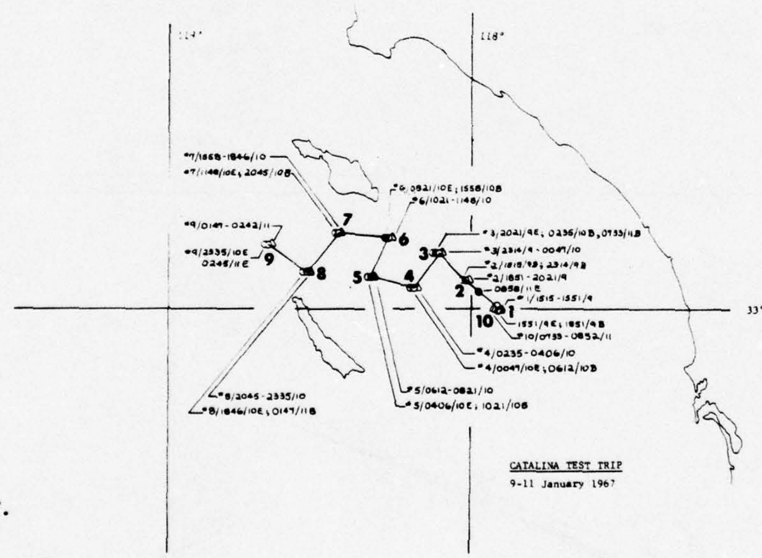

Fig. 67.

Run	Date	Time	Rec.	Shooting	Cse
1	9 Jan	1515-1551	1	1-2	318° outgoing side
2	9 Jan	1851-2021	2	1-2-3	318° split
3	9-10 Jan	2314-0002 0005-0047	3	2-3-4	313° split 217°
4	10 Jan	0235-0329 0335-0406	4	3-4-5	217° split 285°
5	10 Jan	0612-0654 0736-0821	5	4-5-6	285° split 028°
6	10 Jan	1021-1100 1103-1148	6	5-6-7	017° split 270° (?)

Run	Date	Time	Rec.	Shooting	Cse.	Type of run
7	10 Jan.	1558-1712 1736-1846	7	6-7-8	270° 224°	split
8	10 Jan.	2045-2144 2200-2335	8	7-8-9	219° 303°	split
9	11 Jan.	0147-0242	9	8-9	298°	incoming, side
10	11 Jan.	0733-0852	10	3 towards 10	134°	incoming, side

Between Runs 6 and 7 both ships went in to Avalon on Santa Catalina Island and exchanged some of the scientific party.

Position for the end of Run 10 (time 0858) is 33°03'N, 117°58.8'N, between Stations 2 and 10.

Notes from the cruise indicate that after coming abeam of the E. B. SCRIPPS at Station 6 the OCONOSTOTA continued on cse 017° T for the rest of the run. However, judging by earlier and later patterns for this cruise, noted water depths and the course given to get to Avalon, it seems probable to assume that they went from Station 6 to Station 7 but neglected to note the course change. The distance from Station 6 to Station 7 agrees closely with the direct water wave time of the last shot and the depth at Station 7 with the depth at the last shot. If the ship had followed cse 017° the water depth at the time of the last shot would have been much shallower than the depth given.

Results:

The Catalina Test Trip lines were all relatively short; this was in part an attempt to avoid the effects of roughness in the basement topography, which had made it impossible to apply plane-layer methods to previous profiles in the basin. It was found, however, that even with these short profiles and closely spaced shots, the scatter in the basement arrivals was so severe that the plane-layer approach gives widely varying values for the basement velocity and depth from adjacent stations. The data will, therefore, be reexamined using time-difference methods for determination of velocity, and delay-time computation for construction of a sediment isopach map. This latter project has not been completed.

Data on sediment velocities from these runs were much better than on any previous runs in the Catalina Basin. Second arrivals from the unconsolidated (post-orogenic?) sediments were clear on most of the records, and gave relatively consistent values on all runs. Refracted arrivals from the older, deeper sediments came in as first arrivals on some lines, and as second arrivals on many; they could, however, be confused with the scattered arrivals from the basement in some

Run	Velocity, km/sec				Thickness, km		
	Water	a	b	c	Water	a	b
CTT#10	1.489	1.86	--	--	0.99	--	--
CTT#1	1.489	1.91	--	--	1.00	--	--
CTT#2-SE	1.489	1.87	--	3.58	0.99	--	0.79
CTT#2-NW	1.489	--	3.40	--	1.03	0.22	--
CTT#3-SE	1.489	1.82	3.21	--	1.03	0.22	--
CTT#3-SW	1.489	1.59	--	--	1.03	--	--
CTT#4-NE	1.489	--	--	--	1.12	--	--
CTT#4-NW	1.489	1.70	--	--	1.12	--	--
CTT#5-SE	1.489	1.70	--	--	1.15	--	--
CTT#5-NE	1.489	1.71	--	--	1.15	--	--
CTT#6-SW	1.489	1.77	--	--	1.14	--	--
CTT#6-W	1.489	1.66	--	--	1.14	--	--
CTT#7-E	1.489	--	--	3.70	1.21	--	0.30
CTT#7-SW	1.489	1.69	--	--	1.21	--	--
CTT#8-NE	1.489	1.63	--	4.48	1.25	--	0.63
CTT#8-NW	1.489	--	--	4.47	1.25	--	0.74
CTT#9	1.489	1.90	--	4.38	1.31	--	0.80
Mean		1.75	3.30	4.12	1.12	0.22	0.65

cases, so that the velocity determinations on the deeper sediments are not as reliable as for the post-orogenic sediments. There is some indication of an increase in the velocity of the deeper sediments as one moves northwest up the basin; this is in agreement with earlier measurements. The preceding list gives sediment velocities determined from the CTT runs, with the stations listed from southeast to northwest. Where a value is not given for the velocity, there were insufficient data to make a determination. Values for the thickness of the first sediment layer are only given where there was a determination of velocity for a deeper sediment layer, to avoid "lumping" all of the sediment delay time to basement with the first layer.

Travel-time plots on the following pages are in different format from those for the earlier trips. Observed travel time (without water-delay correction) is plotted in "reduced time" format, with x/7.0 subtracted. This would make a 7.0 km/sec line horizontal on the plot.

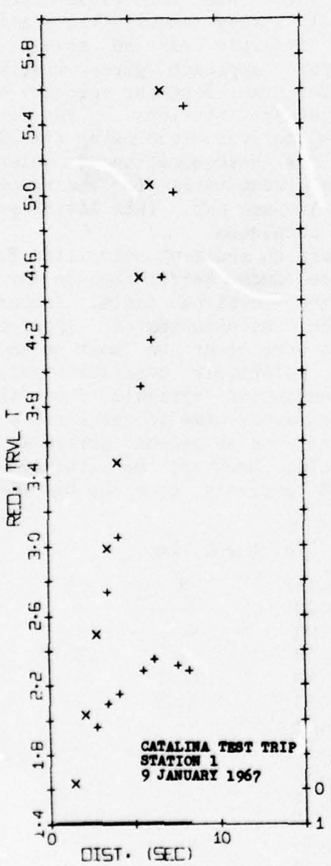

Fig. 68.

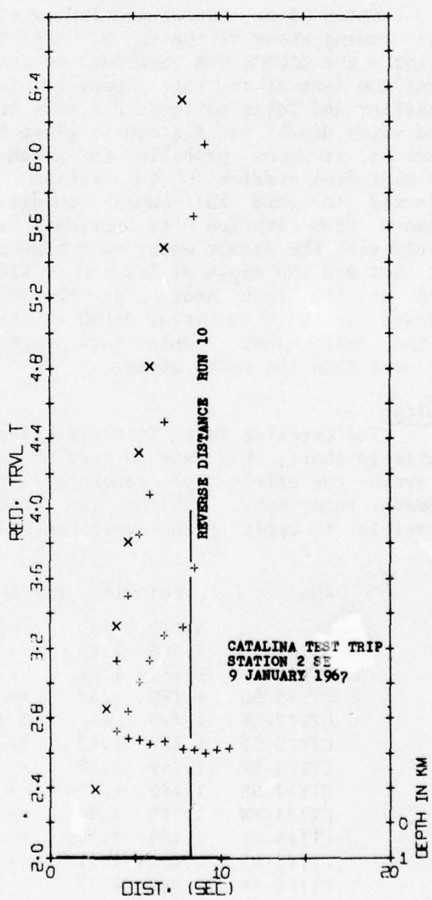

Fig. 69.

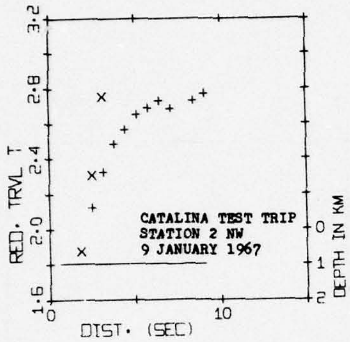

Fig. 70.

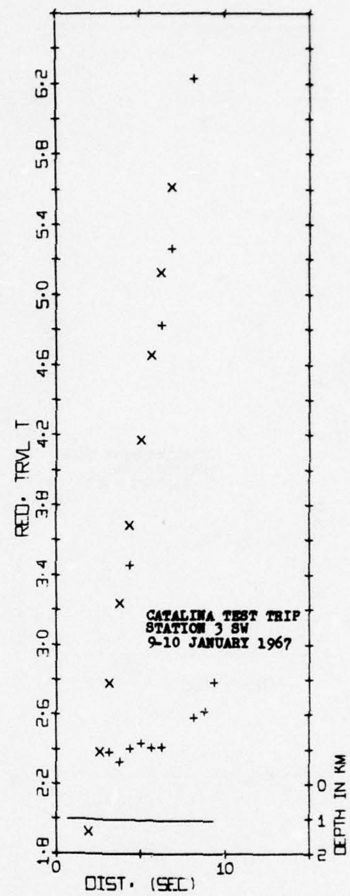

Fig. 72.

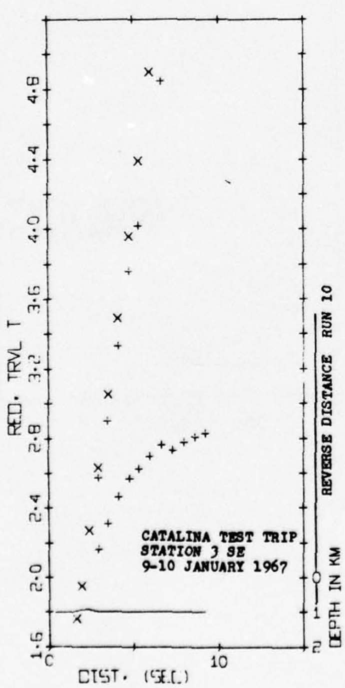

Fig. 71.

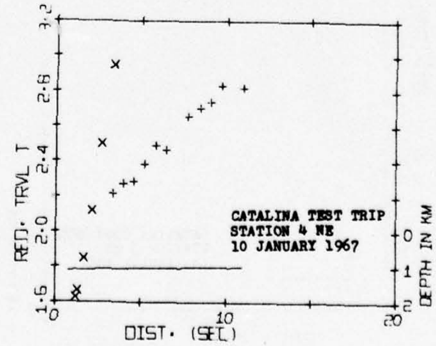

Fig. 73.

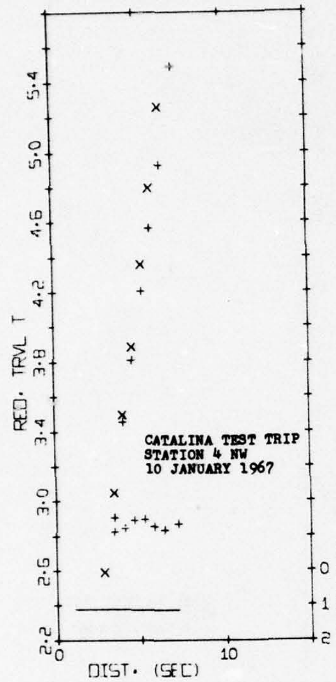

Fig. 74.

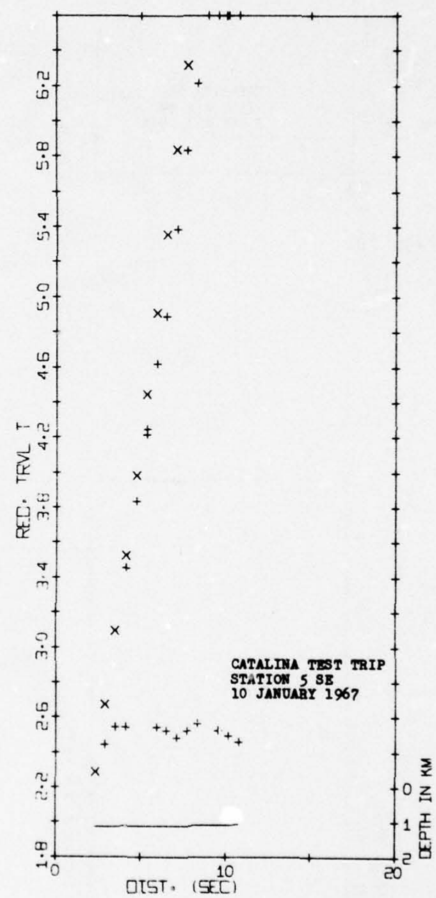

Fig. 75.

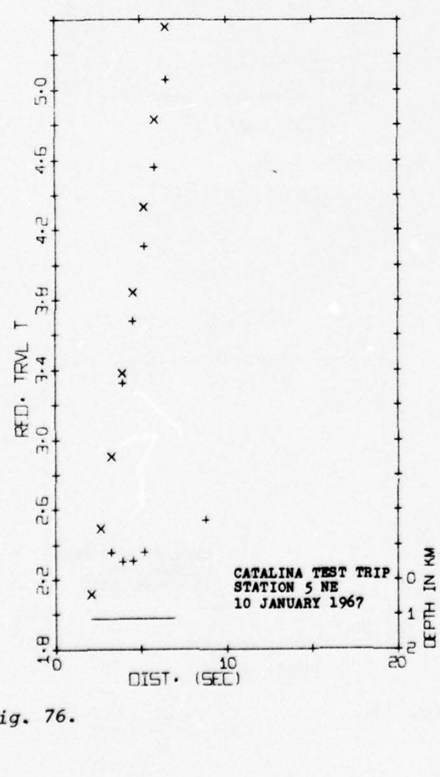

Fig. 76.

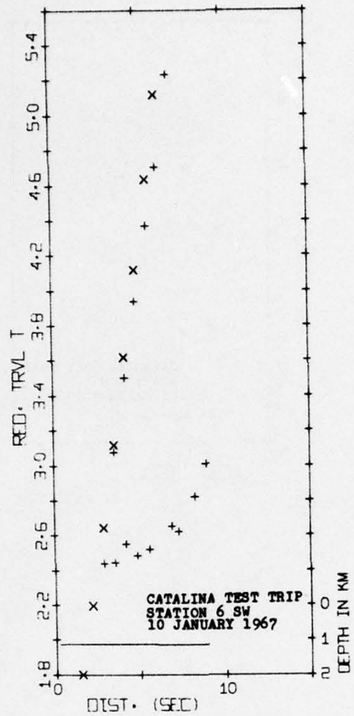

Fig. 77.

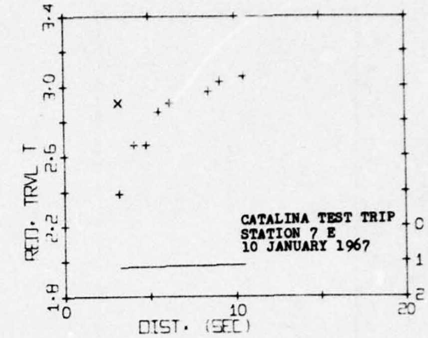

Fig. 79.

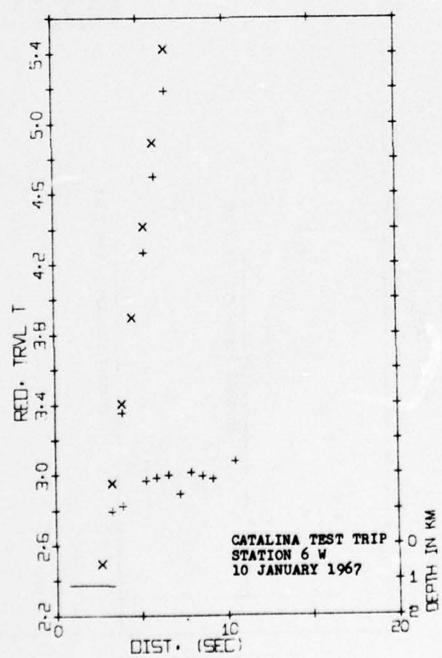

Fig. 78.

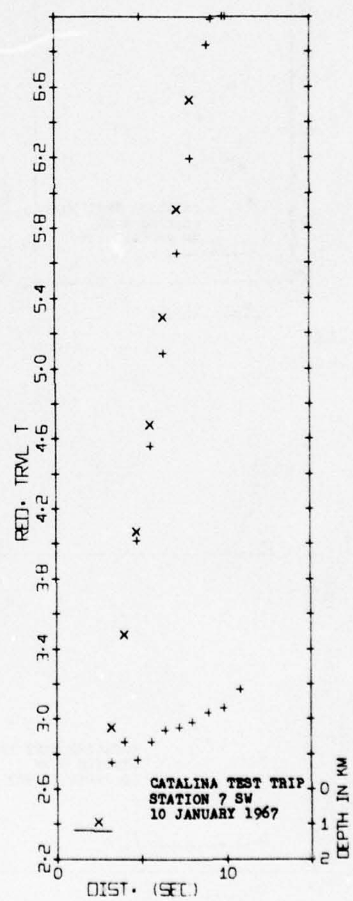

Fig. 80.

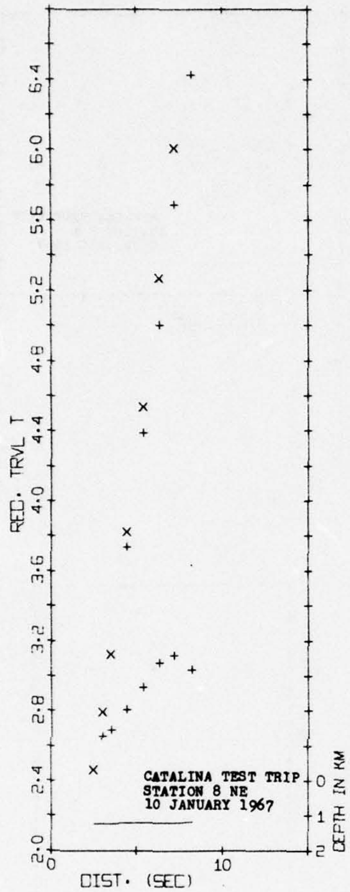

Fig. 81.

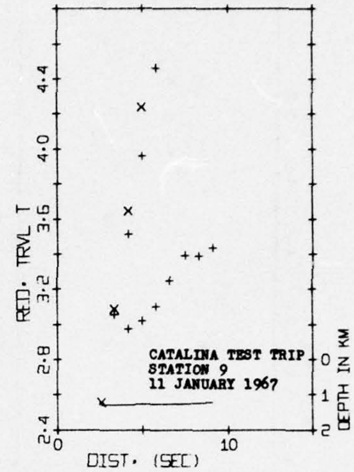

Fig. 83.

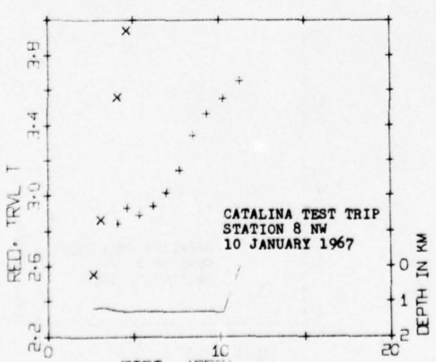

Fig. 82.

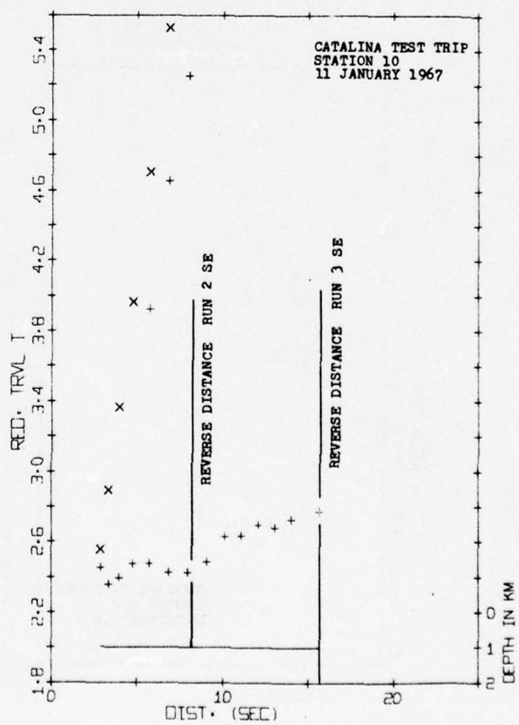

Fig. 84.

ARGUELLO, Stations 1 and 1', 15 and 16 March 1957
HORIZON shooting (Krause), BAIRD receiving (Raitt)

AR 1. This was a north-south split about 12 miles total length, south of San Juan Seamount at the foot of Patton Escarpment. There were so many duds on the outgoing run the shooting ship reversed course and went over it again.

15 March West of Patton Escarpment

Run 1

TIME	COURSE	POSITIONS
Shooting		
1602	008°	32°22.4'N, 120°44.6'W
1627	010°	32°25.9'N, 120°44.1'W
1635	015°	32°26.7'N, 120°43.9'W
1655	abeam	32°28.7'N, 120°43.5'W
1807	reverse cse 195°	32°33.5'N, 120°42.0'W
1828	end	32°30.8'N, 120°42.8'W
Receiving		
1312		32°30.0'N, 120°44.2'W
1835		32°28.1'N, 120°43.2'W

Results

Run	Velocity, km/sec			
	Water	a	d	f
AR 1	1.496	*2.15	5.46	6.52

Thickness, km		
Water	a	d
3.73	0.38	0.57

* indicates an assumed velocity, sounding velocity was 1.4939 km/sec.

AR 1'. This station consisted of three fairly short runs with the receiver in the same position for all three. It was just to the east of AR 1, south of San Juan Seamount and at the foot of Patton Escarpment. The first run was from south to north with three course reversals, the second was from north to south and the third was from west to east.

16 March West of Patton Escarpment

Run 1

TIME	COURSE	POSITION
Shooting		
0834	345°	32°15.3'N, 120°27.8'W
1101	abeam	32°28.7'N, 120°32.2'W
1202		32°34.1'N, 120°34.6'W
1257		32°36.3'N, 120°35.6'W
1310	end	32°36.9'N, 120°35.8'W

Run 2

Shooting		
1310	160°	32°36.9'N, 120°35.8'W
1333		32°34.1'N, 120°35.5'W
1424	180	32°26.6'N, 120°33.8'W
1433	abeam	32°25.0'N, 120°33.9'W
1438		32°24.0'N, 120°33.9'W
1530	end	32°17.5'N, 120°33.7'W

Run 3

Shooting		
1616	070°	32°21.4'N, 120°41.8'W
1655	085°	32°21.7'N, 120°35.9'W
1716	abeam	32°21.6'N, 120°34.5'W
1817	end	32°21.6'N, 120°21.6'W

Runs 1, 2, 3

Receiving	
0720	32°30.9'N, 120°34.1'W
1211	32°27.9'N, 120°33.9'W
1716	32°21.6'N, 120°34.4'W
1850	32°19.1'N, 120°34.6'W

Results

Run	Velocity, km/sec			
	Water	a	d	f
AR 1'	1.498	*2.15	5.46	6.52

Thickness, km		
Water	a	d
3.70	0.54	0.42

* indicates an assumed velocity, sounding velocity was 1.4941 km/sec.

Positions for all ARGUELLO stations are from plots by D. Newhouse, Feb. 1975.

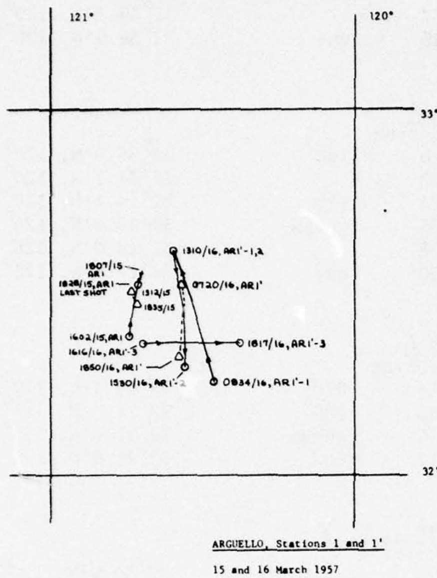

Fig. 85.

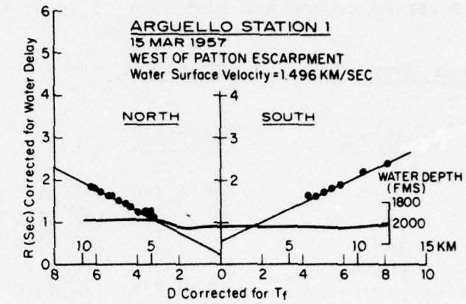

Fig. 86.

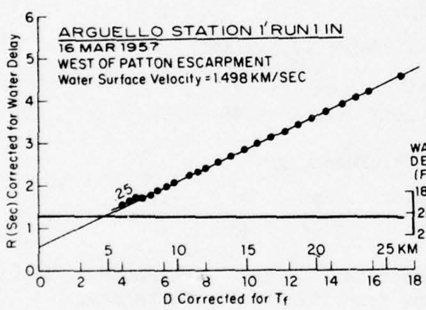

Fig. 87.

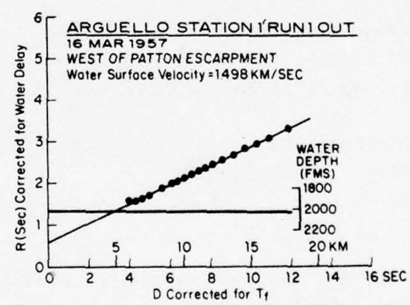

Fig. 88.

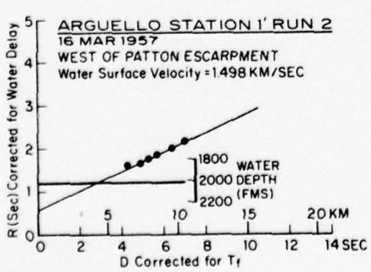

Fig. 89.

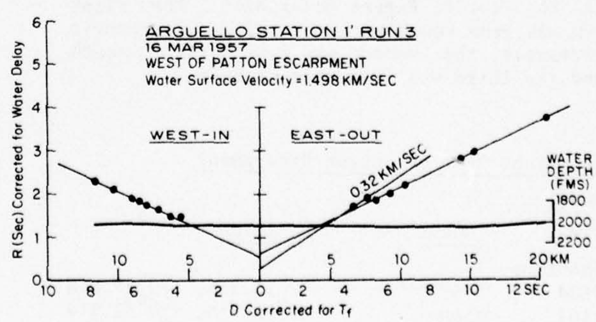

Fig. 90.

ARGUELLO, Stations 2 and 3, 17 and 18 March 1957 HORIZON shooting (Krause), BAIRD receiving (Raitt)

These two stations form a reversed profile with an azimuth of 154° in deep water, from 1900-2125 fms, off Pt. Arguello. AR 2, going from southeast to northwest, had so many duds and 'cap only's' that the shooting ship had to reverse and do part of the run over. On AR 3, three separate shooting runs were made passing the receiving ship.

AR 2

17 March Off Pt. Arguello

TIME	COURSE	POSITION
Shooting		
0813	340°	33°27.9'N, 121°33.4'W
1000	311°	33°47.7'N, 121°40.7'W
1018	320°	33°48.9'N, 121°43.0'W
1021-1023 stop to fix firing circuit		
1037 abeam	345°	33°51.4'N, 121°44.2'W
1121	153°	33°55.9'N, 121°47.0'W
reverse course to run through cross over again		
1140	333°	33°55.1'N, 121°47.2'W
1525	end	34°38.0'N, 122°07.7'W
Receiving		
0625		33°43.1'N, 121°44.9'W
1215		33°55.6'N, 121°43.0'W
1842		34°05.3'N, 121°42.2'W

AR 3

18 March Off Pt. Arguello

TIME	COURSE	POSITION
Shooting		
0845	160°	35°05.8'N, 122°36.0'W
0915		35°03.5'N, 122°35.3'W
1037		34°53.7'N, 122°30.7'W
1103	185°	34°49.6'N, 122°30.7'W
1114	200°	34°47.8'N, 122°30.8'W
1120 abeam	150°	34°47.0'N, 122°31.3'W
		34°45.2'N, 122°30.0'W
1150 reverse	330°	34°43.6'N, 122°29.0'W
1221 abeam	000°	34°47.2'N, 122°33.1'W
1242	190°	34°50.3'N, 122°33.1'W
1344-1351		34 42.3'N, 122°31.0'W
1733 end		35°06.6'N, 122°06.0'W
Receiving		
0640		34°45.0'N, 122°20.4'W
1211		34°47.3'N, 122°32.5'W
1900		34°47.4'N, 122°38.3'W

Positions for all ARGUELLO stations are from plots by D. Newhouse, Feb. 1975. In the case of AR 3, positions for the numerous course reversals near the receiving ship were not determined as they were all close in time and would not show well on a small-scale chart. It should be possible to find the positions by converting the direct water-wave time of the shots to distance.

Results

For AR 2 and AR 3 as a reversed profile:

Velocity, km/sec

Water	a	d	f	g
1.495	*2.15	5.49	6.66	8.16

Thickness, km; M depth, km

Water	a	d	f	M depth, km
3.64	0.69	0.67	4.70	9.70

*indicates assumed velocity, the sounding velocities were 1.4946 and 1.4939 km/sec.

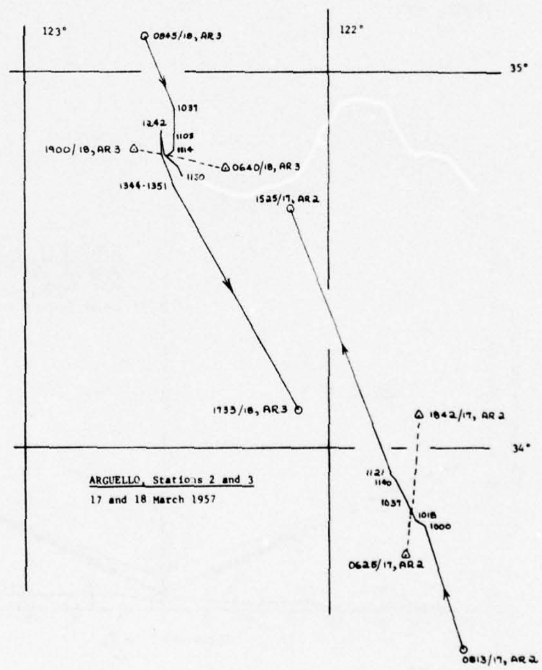

Fig. 91.

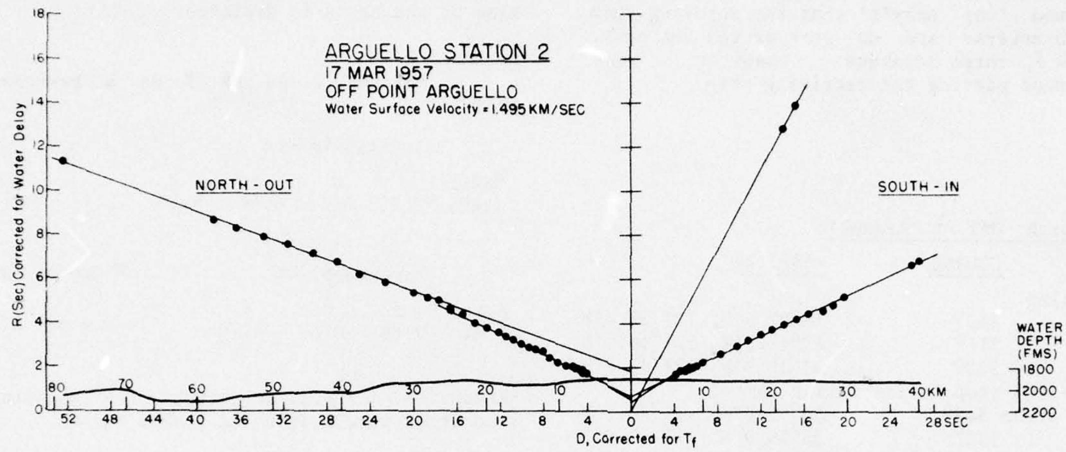
ARGUELLO STATION 2
17 MAR 1957
OFF POINT ARGUELLO
Water Surface Velocity = 1.495 KM/SEC
NORTH - OUT
SOUTH - IN
R(Sec) Corrected for Water Delay
D, Corrected for T_f
WATER DEPTH (FMS)
KM
SEC

Fig. 92.

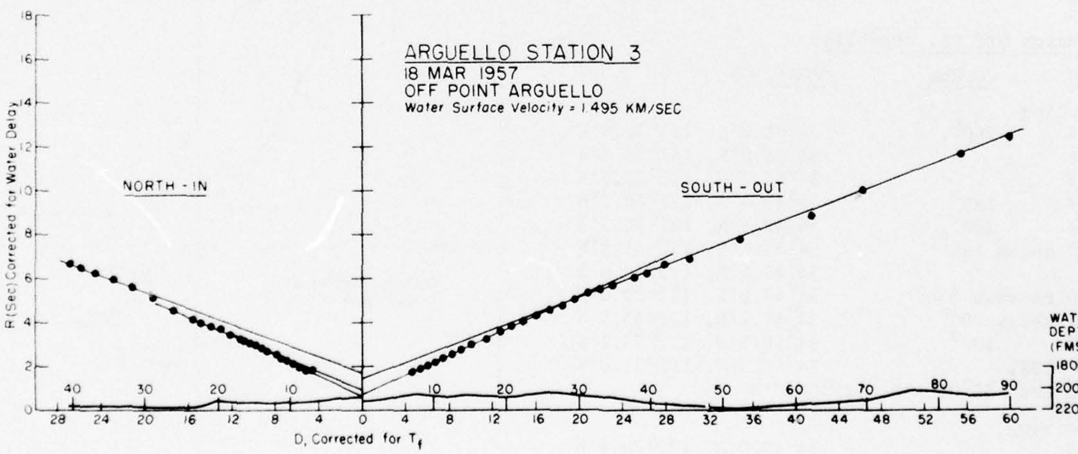
ARGUELLO STATION 3
18 MAR 1957
OFF POINT ARGUELLO
Water Surface Velocity = 1.495 KM/SEC
NORTH - IN
SOUTH - OUT
R(Sec) Corrected for Water Delay
D, Corrected for T_f
WATER DEPTH (FMS)

Fig. 93.

ARGUELLO, Stations 4 and 5, 19 and 29 March 1957 HORIZON shooting (Krause), BAIRD receiving (Raitt)

AR 4 and AR 5 are a reversed pair with an azimuth of 157° on the continental shelf off Pt. Arguello. AR 4 goes from northwest to southeast and AR 5 from southeast to northwest.

Positions for all ARGUELLO stations are from plots by D. Newhouse, Feb. 1975.

Results

Ar 4 and AR 5 were worked up separately and delay times were then used to work up the full profile, see the cross-section Fig. 94.

AR 4

19 March Off Pt. Arguello

TIME	COURSE	POSITION
Shooting		
0907	172°	35°36.2'N, 121°31.3'W
1010	125°	35°24.0'N, 121°29.4'W
1050	abeam 154°	35°19.5'N, 121°22.0'W
1800	end	34°00.7'N, 120°35.0'W
Receiving		
0652		35°20.9'N, 121°23.5'W
1213		35°19.0'N, 121°22.0'W
		35°10.3'N, 121°12.6'W
1845		35°09.3'N, 121°11.6'W

AR 5

29 March Off Pt. Arguello

TIME	COURSE	POSITION
Shooting		
0727	336°	33°56.8'N, 120°35.7'W
0843	333°	34°10.3'N, 120°43.1'W
0850	340°	34°11.7'N, 120°43.5'W
0903	abeam	34°13.8'N, 120°44.7'W
1025	335°	34°29.0'N, 120°51.0'W
1616	end	35°22.4'N, 121°21.6'W
Receiving		
0637		34°15.0'N, 120°44.8'W
1030		34°13.5'N, 120°43.5'W
1616		34°10.6'N, 120°39.4'W

Run	Velocity, km/sec							Thickness, km				
	Water	a	c	d	e	f	g	Water	a	c	d	e
AR 4	1.491	1.66		5.16	6.30,6.11	7.62	8.20	1.76	5.55		12.92	6.16
AR 5	1.495	1.66	3.65		5.84	7.62	8.20	0.71	1.88	13.75		7.02

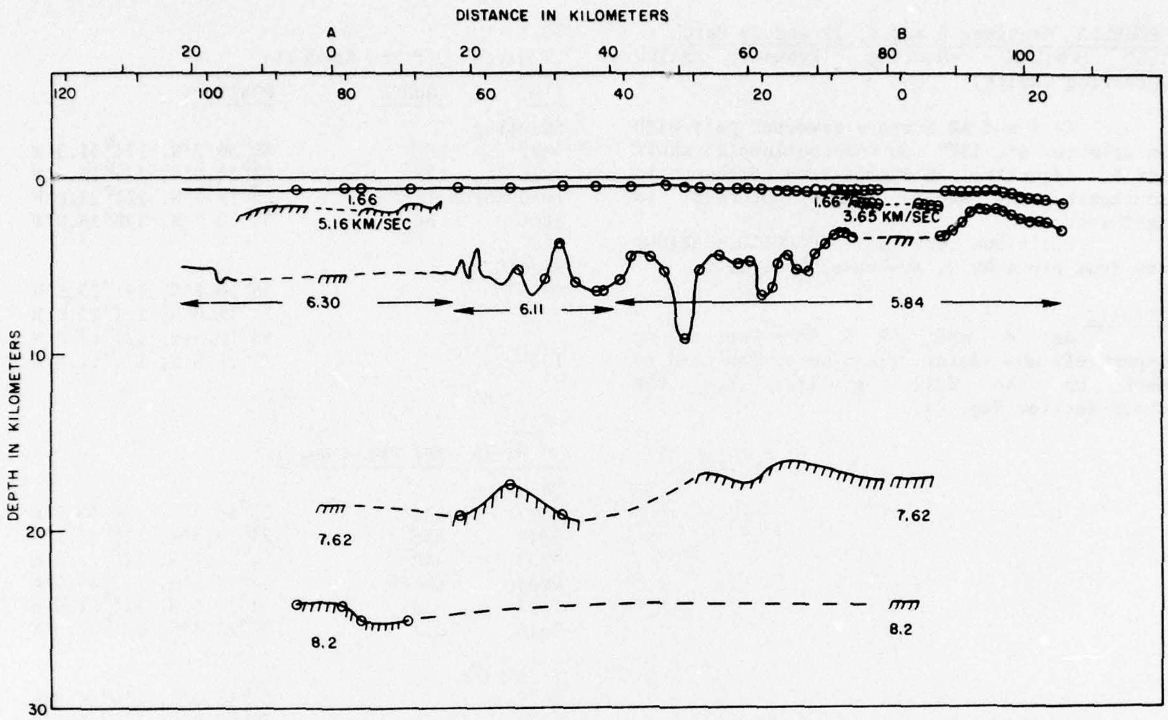

Fig. 94. Structural section, ARGUELLO, Stations 4 and 5, 19 and 20 March 1957

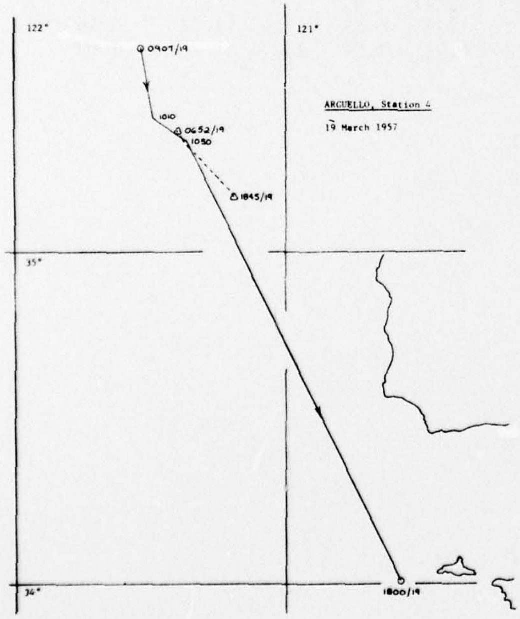

Fig. 95.

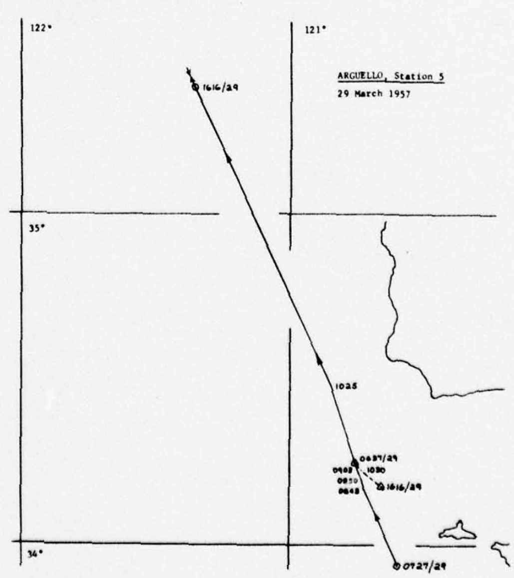

Fig. 96.

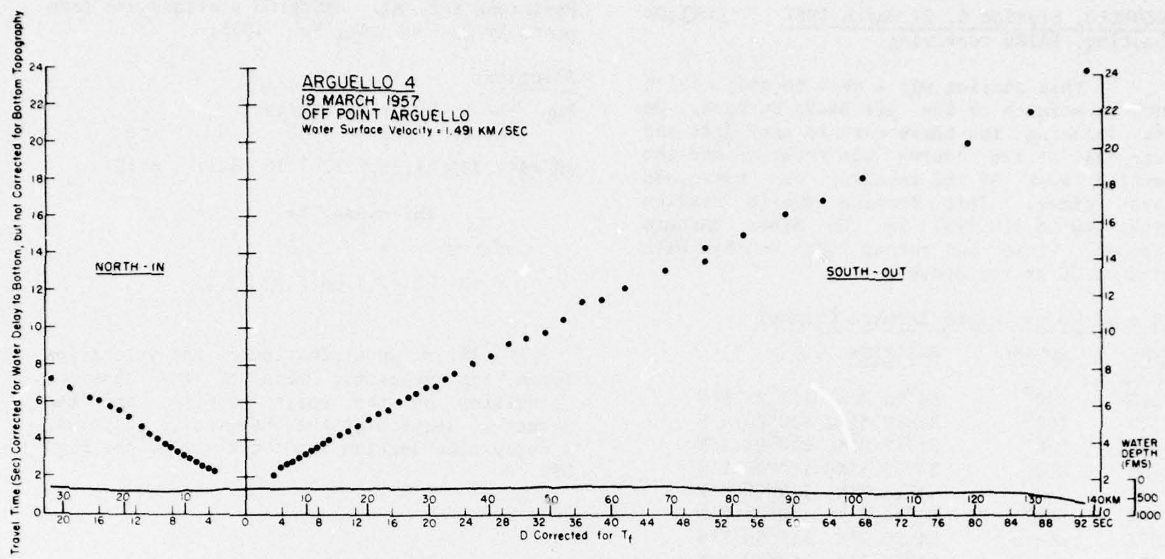
ARGUELLO 4
19 MARCH 1957
OFF POINT ARGUELLO
Water Surface Velocity = 1.491 KM/SEC
NORTH - IN
SOUTH - OUT
WATER DEPTH (FMS)
D Corrected for T_f
Travel Time (Sec) Corrected for Water Delay to Bottom, but not Corrected for Bottom Topography

Fig. 97.

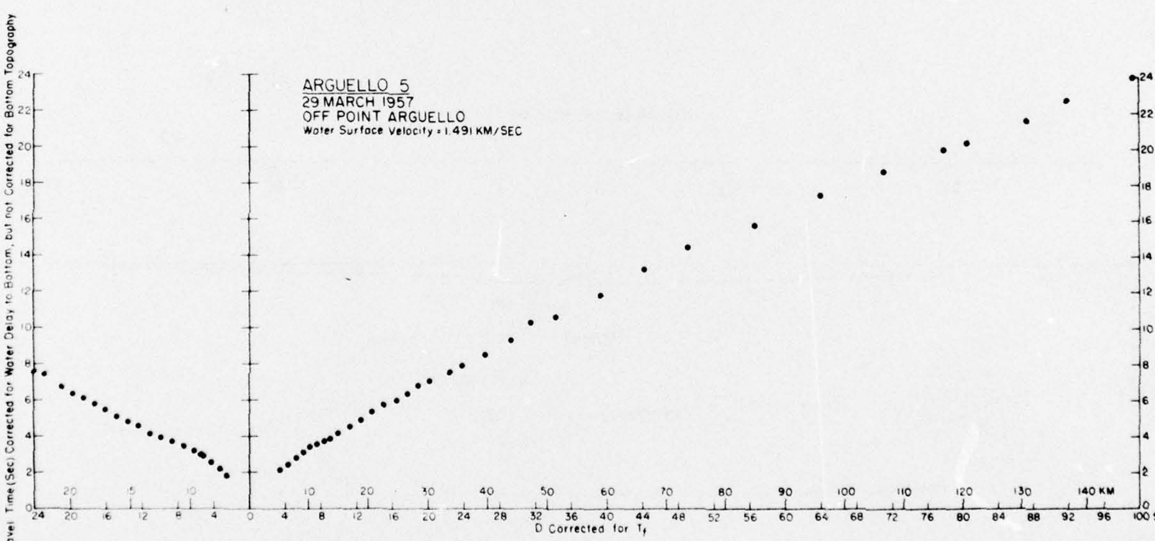
ARGUELLO 5
29 MARCH 1957
OFF POINT ARGUELLO
Water Surface Velocity = 1.491 KM/SEC
D Corrected for T_f
Travel Time (Sec) Corrected for Water Delay to Bottom, but not Corrected for Bottom Topography

Fig. 98.

ARGUELLO, Station 6, 21 March 1957 HORIZON shooting, BAIRD receiving

This station was a west to east split with an azimuth of 104° off Santa Barbara. On the incoming run there were so many duds and 'cap only's' the course was reversed and the section west of the receiver was traversed three times. This station was in shallow water (40 to 310 fms) in the Santa Barbara Channel. There was rather rough weather with wind of 20 kts or above.

AR 6 21 March Santa Barbara Channel

TIME	COURSE	POSITION
Shooting		
1313	099°	34°20.2'N, 120°23.5'W
1327	100°	34°19.6'N, 120°20.9'W
1444	070°	34°17.0'N, 120°04.1'W
1459	060°	34°17.7'N, 120°00.8'W
1515	240°	34°18.7'N, 119°58.5'W
1542	060°	34°16.8'N, 120°02.3'W
1621	abeam	34°20.2'N, 119°55.5'W
1814	end	34°16.7'N, 119°32.0'W
Receiving		
1305		34°19.1'N, 119°58.5'W
1600		34°19.9'N, 119°55.8'W
1814		34°20.3'N, 119°54.2'W

Positions for all ARGUELLO stations are from plots by D. Newhouse, Feb. 1975.

Solution:

Run	Velocity, km/sec				
	Water	a	b	d	e
AR #6	1.482	1.66,2.11	3.16	5.11	6.15

Thickness, km

Water	a	b	d
0.49	0.62,1.00	2.32	2.36

After determination of the velocities (from the geometric mean of the observed velocities on the split profile) and the structure section at the observation position, a delay-time section was constructed, see Fig. 99.

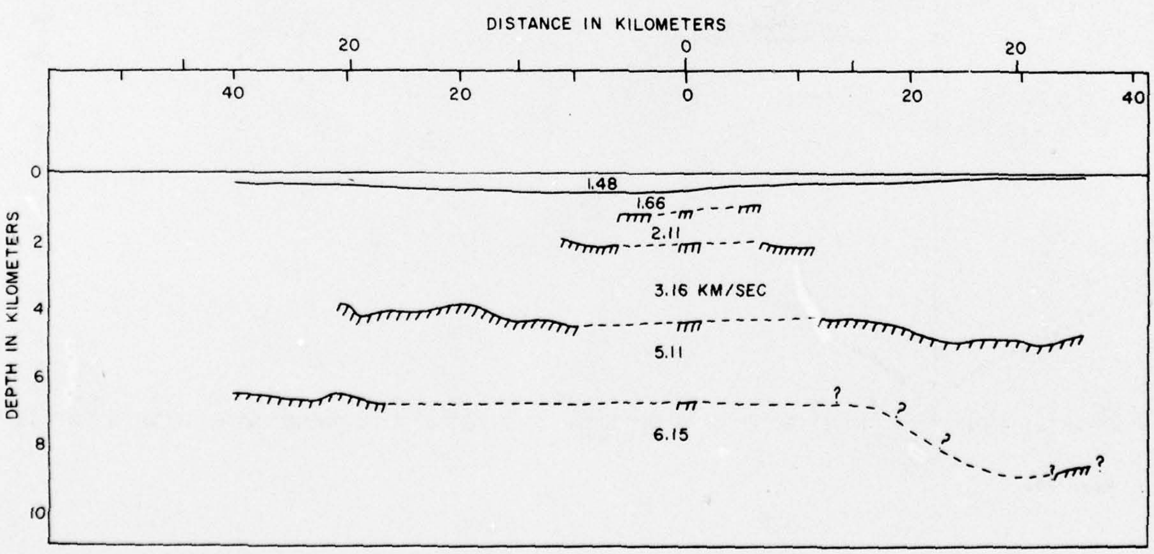

Fig. 99. Structural section, ARGUELLO, Station 6, 21 March 1957

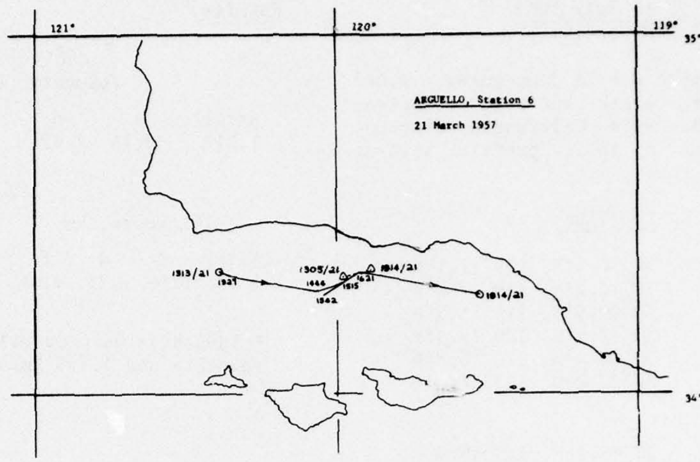

Fig. 100.

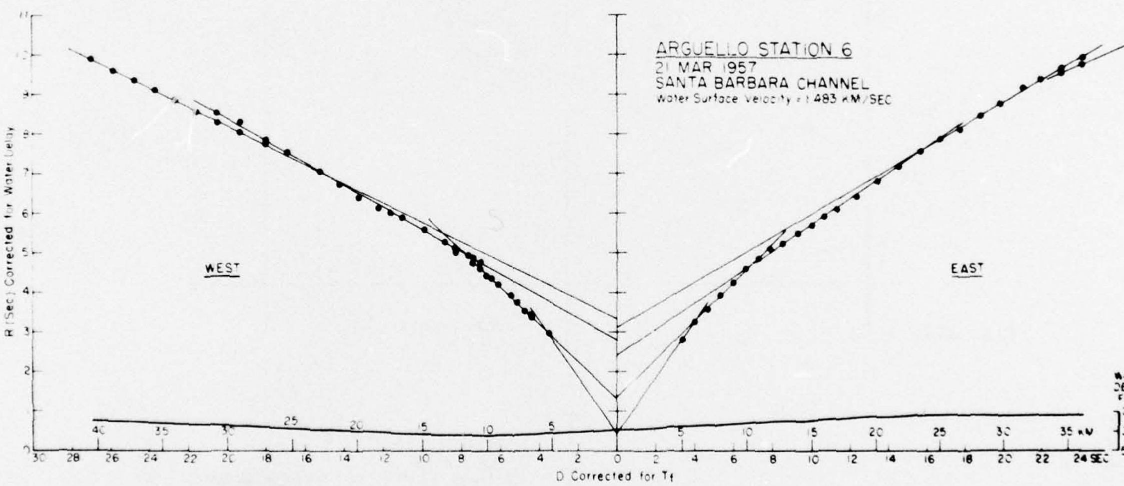

Fig. 101.

FANFARE, Station 5, 13 July 1959
SMITH shooting, BAIRD receiving

This station was in deep water, 2,000 - 2,100 fathoms, south and west of Patton Escarpment in the Baja California Seamount Province. It was a split profile with an azimuth of 065°.

TIME	COURSE	POSITION
Shooting		
1019	245°T	30°59.5'N, 119°12.1'W
1352	215°T	30°46.2'N, 119°47.0'W
1443	245°T	30°40.0'N, 119°51.5'W
1720		30°28.3'N, 120°18.2'W
1740		30°29.1'N, 120°18.8'W
1905	end	30°23.2'N, 120°32.4'W
Receiving		
0920		30°45.4'N, 119°49.0'W
1205		30°43.0'N, 119°50.3'W(LAN)
1927		30°40.0'N, 119°52.5'W

Results

Velocity, km/sec

Water	a	d	f	g
1.511	*2.15	4.67	6.79	8.44

Thickness, km / M depth, km

Water	a	d	f	M depth
3.94	0.09	1.73	4.46	10.22

* indicates assumed velocity, the sounding velocity was 1.495 km/sec

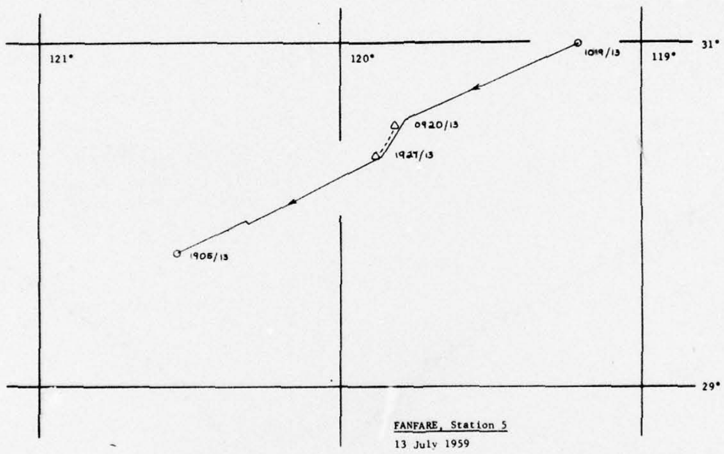

Fig. 102.

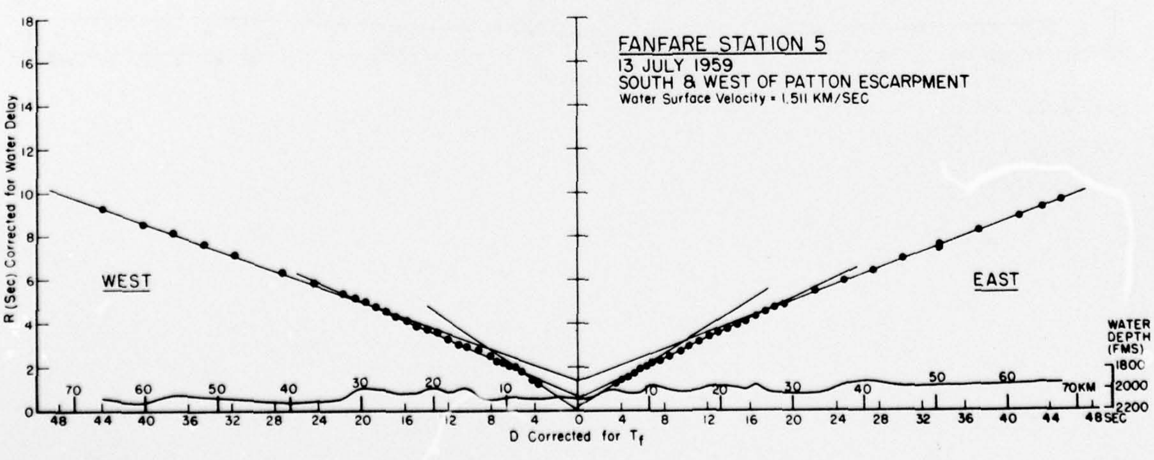

Fig. 103.

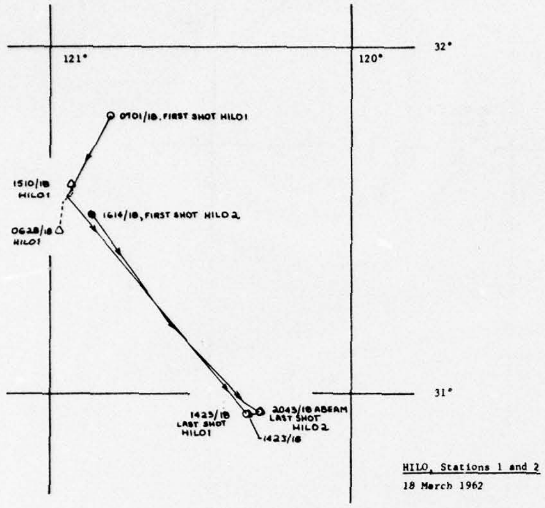

Fig. 104.

<u>HILO, Station 1 and 2, 18 March 1962</u> SMITH <u>shooting and receiving (Pollard), STRANGER</u> shooting and receiving (Shor)

These two stations form a reversed pair at the foot of Patton Escarpment. Data from them were used with that from HILO 3 and 4, FANFARE 5 and QUARTET Expedition for the first anisotropy work at SIO.

For Station 1 the SMITH shot a split and then stopped and became the receiver, while the STRANGER shot toward them over the same ground as the outgoing leg of Run 1 for Run 2. Azimuth for these stations was 142°.

<u>HILO 1</u>

<u>TIME</u>	<u>COURSE</u>	<u>POSITION</u>
Shooting	<u>SMITH</u>	
0710	208°T	31°48.0'N, 120°48.1'W
0850	145°T	31°33.8'N, 120°56.5'W abeam
1423	end	30°56.0'N, 120°21.0'W
Receiving	STRANGER	
0628		31°27.8'N, 120°58.5'W
0751		31°33.2'N, 120°57.5'W
0850		31°33.8'N, 120°56.5'W
1200		31°34.2'N, 120°56.0'W
1510		31°36.1'N, 120°56.0'W

<u>HILO 2</u>

<u>Shooting</u>	<u>STRANGER</u>	
1614	145°T	31°30.9'N, 120°51.9'W
1841	(137°T)	31°21.8'N, 120°37.0'W
2032	130°T	30°58.3'N, 120°21.4'W
2043	end	30°56.5'N, 120°17.5'W abeam
Receiving SMITH		
1425		30°56.0'N, 120°20.5'W
2043		30°56.5'N, 120°17.5'W abeam

<u>Results</u>

Run	Water	Velocity, km/sec a	e	f	g
HL 1 HL 2	1.49	*2.15	5.78	6.54	7.87

		Thickness, km			M depth, km
HL 1	3.80	0.42	0.66	5.09	9.98
HL 2	3.90	0.17	0.42	5.17	9.65

An arrival with apparent velocity 3.93 km/sec is observed on HL-2, with an intercept such that the most appropriate interpretation is that it is a shear wave through Layer 3, the crust. However, the combination of velocities would give a Poisson's ratio of 0.21 for the crustal rocks. It is possible that the crust compressional velocity determined here is too low; if Poisson's ratio were 0.25, and the shear velocity correct, the compressional velocity would be 6.81, a more normal number. One would obtain about this velocity if one used only the first arrivals for the crustal layer on HL-1 and HL-2, and omitted the extensive second arrivals on the outer part of the runs; this may indicate that these other arrivals are either Moho reflections or refracted arrivals from a masked layer, rather than crustal refractions.

<u>HILO, Stations 3 and 4, 19 March 1962</u> STRANGER <u>shooting and receiving (Shor), SMITH</u> shooting and receiving (Pollard)

These two stations form a reversed pair southwest of HILO Stations 1 and 2 in the Baja California Seamount Province, seaward of Patton Escarpment.

For Station 3 the SMITH shot while the STRANGER received. When the SMITH reached the end of the line it became the receiver and the STRANGER shot Run 4 toward the SMITH over the same ground as Run 3. The azimuth for these stations was 145°.

<u>HILO 3</u>

<u>TIME</u>	<u>COURSE</u>	<u>POSITION</u>
Shooting	<u>SMITH</u>	
1500	325°T	29°38.5'N, 121°34.5'W
1903	end	30°04.0'N, 121°54.0'W
Receiving	STRANGER	
1214		29°40.5'N, 121°36.0'W
1942		29°37.7'N, 121°33.7'W

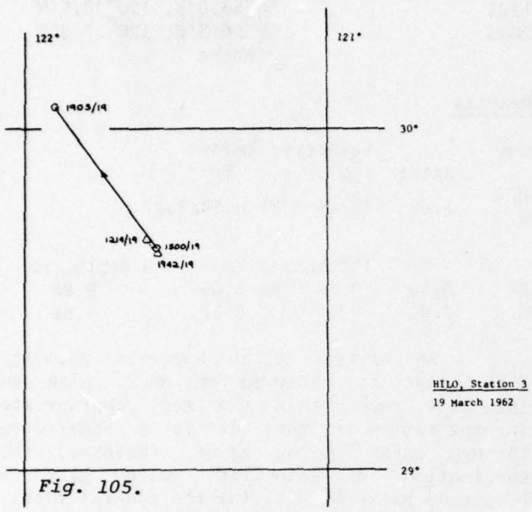

Fig. 105.

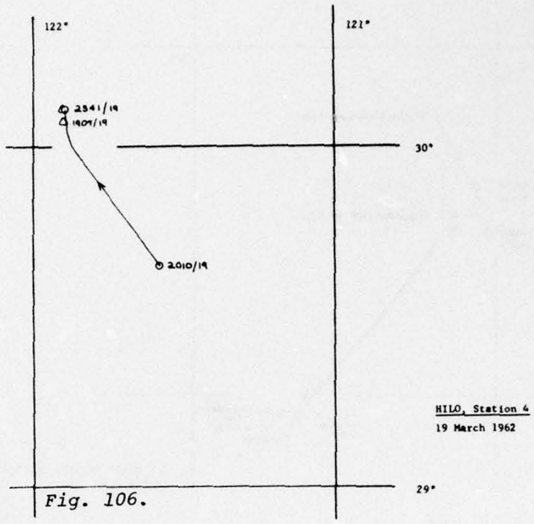

Fig. 106.

HILO 4

Shooting STRANGER

2010	325°T	29°38.9'N, 121°35.0'W
2300	345°T	30°00.0'N, 121°52.4'W
2315	350°T	30°02.3'N, 121°53.4'W
2341	end	30°06.6'N, 121°53.9'W abeam

Receiving SMITH

1907	30°04.6'N, 121°54.0'W
2341	30°06.6'N, 121°53.9'W abeam

Results

Run	Water	c	e	f	g
	Velocity, km/sec				
HL 3	1.496	3.54	6.07	6.65	8.20
HL 4					

Run	Water	c	e	f	M depth
	Thickness, km				
HL 3	4.00	0.56	0.97	2.95	8.48
HL 4	3.94	0.76	1.33	4.61	10.64

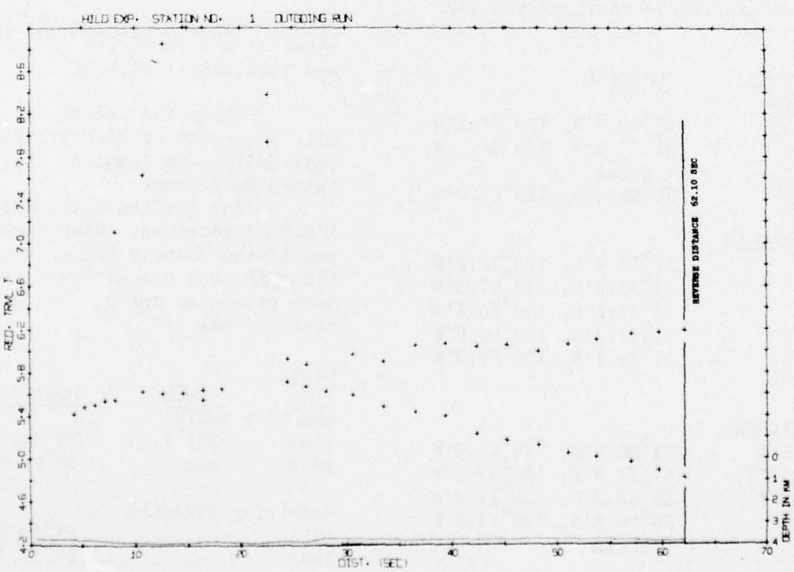

Fig. 107.

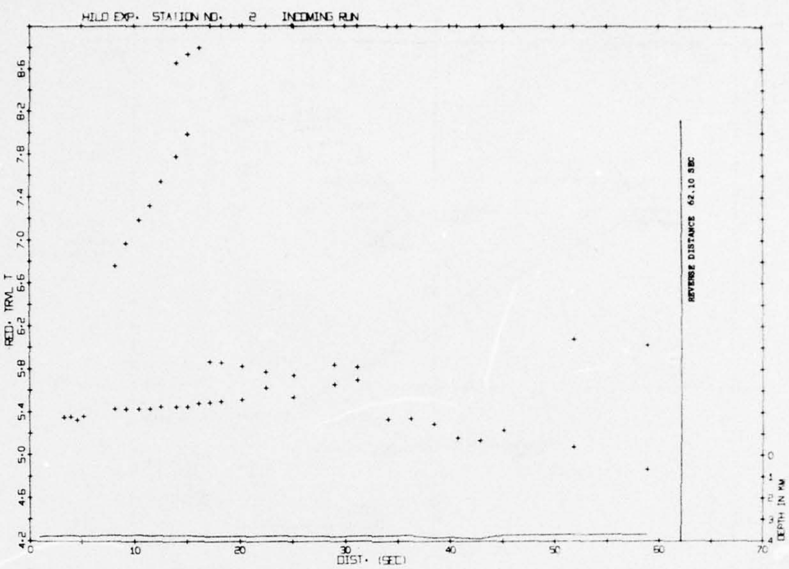

Fig. 108.

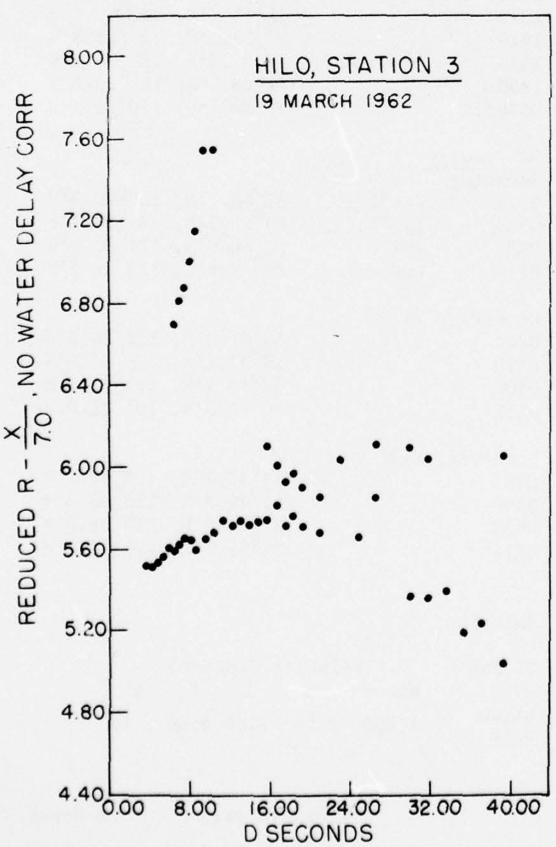

Fig. 109.

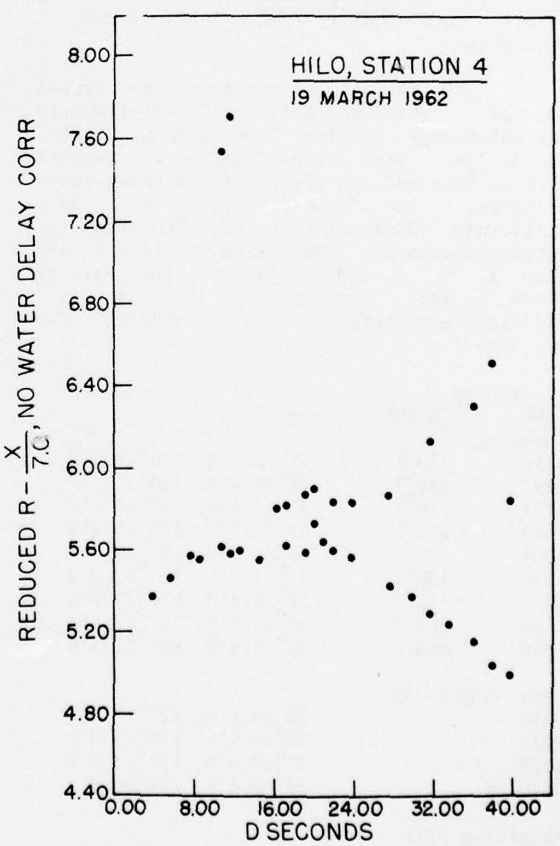

Fig. 110.

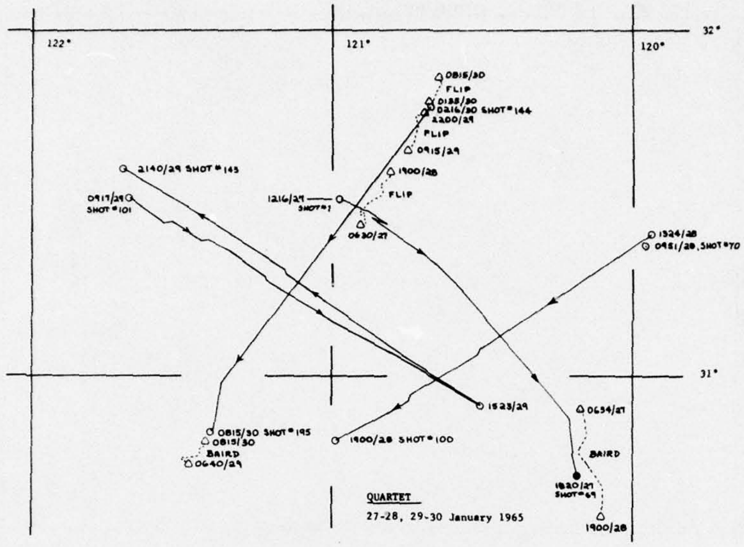

Fig. 111.

<u>QUARTET, 27-30 January 1965</u> HORIZON shooting (Shor), FLIP (Raitt) and BAIRD (Francis) receiving

This was the first anisotropy cruise for SIO. While the data were used primarily for anisotropy studies, the runs of 27 Jan. and 30 Jan. were also treated as regular reverse runs and run through the dipping layer solution. The cruise was in the Baja California Seamount Province southwest of Patton Escarpment. See also FANFARE 5, and HILO 1, 2, 3, and 4. Azimuth for January 27-28 = 142°, for January 29-30 = 032°. Digitized navigation data are available for all runs.

<u>27 January</u>

TIME	COURSE	POSITION
Shooting		
1216	180°T	31°30.8'N, 120°58.0'W
1231	120°T	31°29.4'N, 120°55.3'W
1234	110°T	31°29.1'N, 120°54.5'W
1240	130°T	31°28.7'N, 120°53.2'W
1304	310°T	31°25.9'N, 120°49.0'W
1320	130°T	31°27.6'N, 120°52.0'W
1429	135°T	31°19.4'N, 120°39.2'W
1730	168°T	30°52.5'N, 120°12.8'W
1820	end	30°42.6'N, 120°11.3'W
Receiving BAIRD		
0634		30°54.1'N, 120°10.4'W
1219		30°49.6'N, 120°09.0'W
1759		30°47.0'N, 120°11.2'W
0640/28		30°40.6'N, 120°06.0'W
Receiving FLIP		
0630		31°25.9'N, 120°54.3'W
0730		31°26.6'N, 120°53.5'W
1030		31°27.0'N, 120°54.1'W
1216		31°27.7'N, 120°53.8'W
1440		31°28.0'N, 120°53.8'W
1515		31°27.4'N, 120°54.1'W
1800		31°26.9'N, 120°54.8'W
0630/28		31°29.7'N, 120°52.8'W

<u>30 January</u>

Shooting		
0216	214°T	31°46.7'N, 120°40.3'W
0733	193°T	30°58.5'N, 121°22.1'W
0806	205°T	30°50.6'N, 121°23.9'W
0815	end	30°49.8'N, 121°24.3'W
Receiving BAIRD		
0200		30°47.2'N, 121°26.3'W
0319		30°47.8'N, 121°25.6'W
0500		30°48.1'N, 121°25.3'W
0815		30°48.3'N, 121°25.0'W
Receiving FLIP		
0135		31°47.1'N, 120°40.0'W
0430		31°49.3'N, 120°39.0'W
0630		31°51.0'N, 120°38.0'W
0815		31°51.8'N, 120°38.2'W

Solution:

27 Jan	Velocity (km/sec)				
	Water	a	d	f	g
BAIRD FLIP	1.495	2.15*	5.00	6.69	7.89

	Thickness (km)				M depth
BAIRD	3.91	0.26	0.83	4.00	9.00
FLIP	4.08	0.21	1.30	4.59	10.18

30 Jan	Velocity (km/sec)				
	Water	b	e	f	g
BAIRD FLIP	1.496	2.15*	5.19	6.78	8.21

	Thickness (km)				M depth
BAIRD	3.97	0.17	1.20	6.34	11.68
FLIP	4.00	0.36	0.76	4.51	9.63

Data from this cruise and the FANFARE and HILO stations mentioned above were used in:

Raitt, R.W., G.G. Shor, Jr., T.J.G. Francis and G.B. Morris, Anisotropy of the Pacific Upper Mantle, Jour. Geophys. Res., v. 74, no. 12, pp. 3095-3109, 1969.

Raitt, R.W., Anisotropy of the Upper Mantle, *Geophysical* Monograph No. 13, The Earth's Crust and Upper Mantle, AGU, 1969.

Raitt, R.W., G.G. Shor, Jr., G.B. Morris and H.K. Kirk, Mantle anisotropy in the Pacific Ocean, Tectonophysics, v. 12, pp. 173-186, 1971.

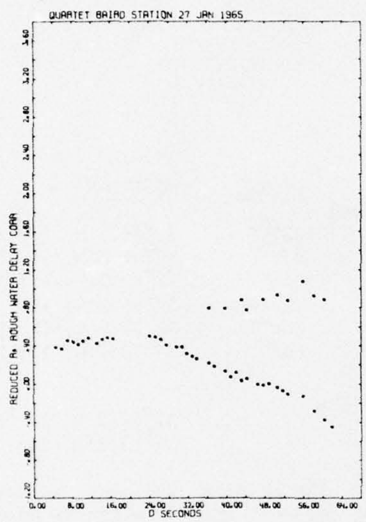

Fig. 112.

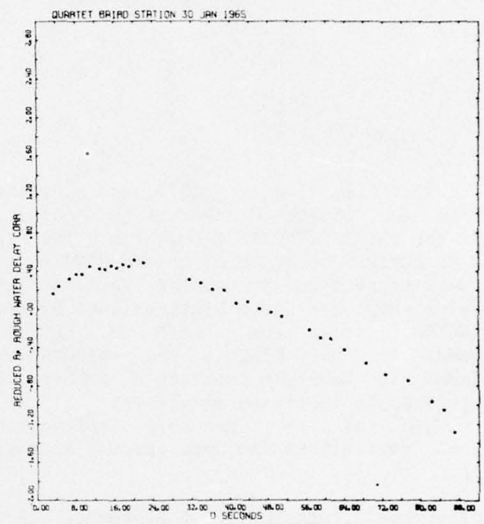

Fig. 114.

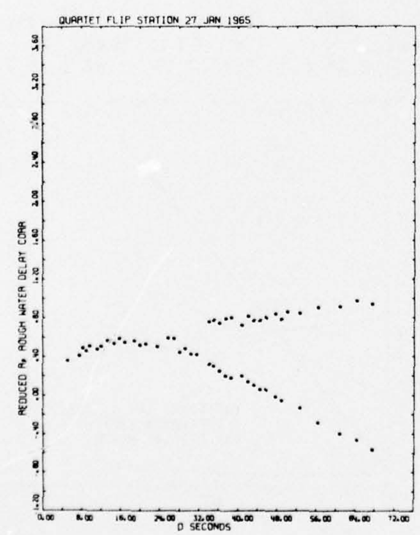

Fig. 113.

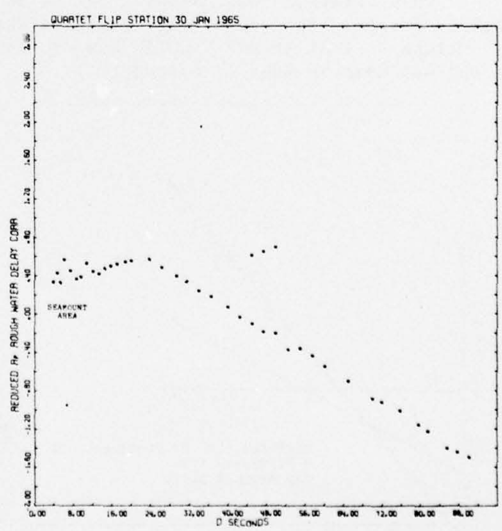

Fig. 115.

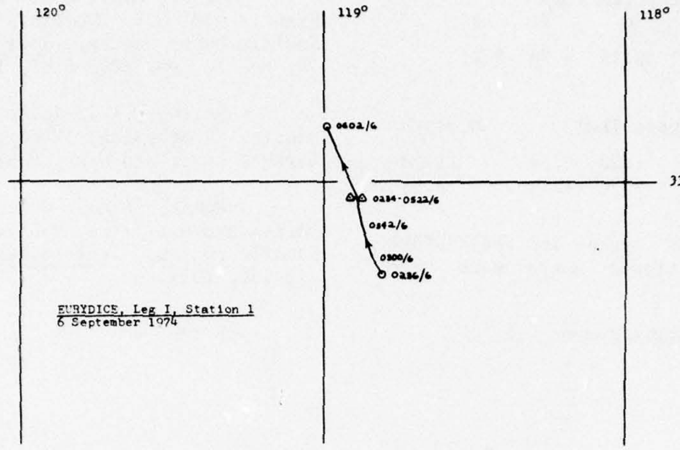

Fig. 116.

EURYDICE, Leg 1 (1974) was a cruise leg from San Diego, California to Honolulu, Hawaii for the R/V THOMAS WASHINGTON. The R/V ELLEN B. SCRIPPS accompanied the WASHINGTON to just west of Patton Escarpment and acted as receiving ship for three stations shot by the WASHINGTON. After the ELLEN B. SCRIPPS returned to San Diego, the WASHINGTON continued to Honolulu shooting a number of seismic runs to receiving *sonobuoys*.

Two of the two-ship refraction stations were within the area covered in this report.

EURYDICE, Leg 1, Station 1, 6 September 1974 (ERDC) T. WASHINGTON shooting (Shor), ELLEN B. SCRIPPS receiving (Whitney)

This station was a split in the San Nicolas Basin. The receiving position was very close to that of SAN NICOLAS Run 7 and the run was near SN Runs 1, 6, and 7.

TIME	COURSE	POSITION
Shooting		
0236	327°T	32°44.2'N, 118°48.9'W
0300	337°T	32°47.3'N, 118°50.5'W
0342	344°T	32°52.7'N, 118°52.4'W
0412	abeam	32°56.6'N, 118°53.2'W
0420	336°T	32°57.9'N, 118°53.4'W
0602	end	33°09.7'N, 118°59.8'W
Receiving		
0234		32°57.2'N, 118°54.7'W
0522		32°57.1'N, 118°52.9'W

The assumed sediment velocity of 2.5 km/sec used on this station is an average of SAN NICOLAS Runs 2, 3, 4 and 5.

Results

Velocity, km/sec					Thickness, km			
Water	b	c	e	f	Water	b	c	e
1.486	2.5*	4.46	5.72	7.27	1.68	1.45	1.04	1.39

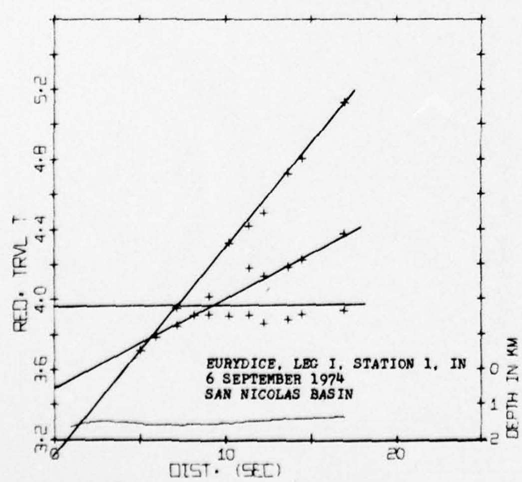

Fig. 117.

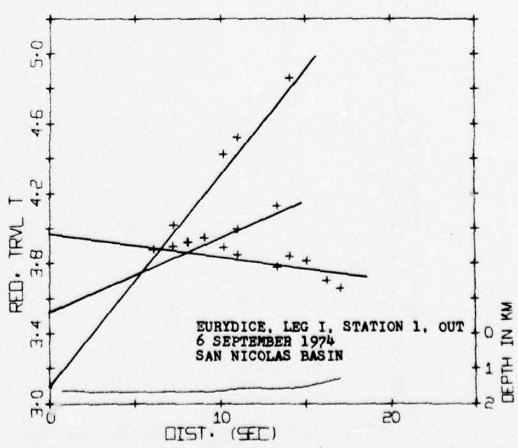

Fig. 118.

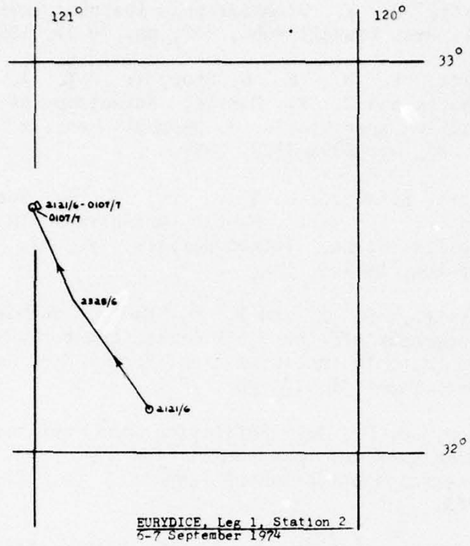

Fig. 119.

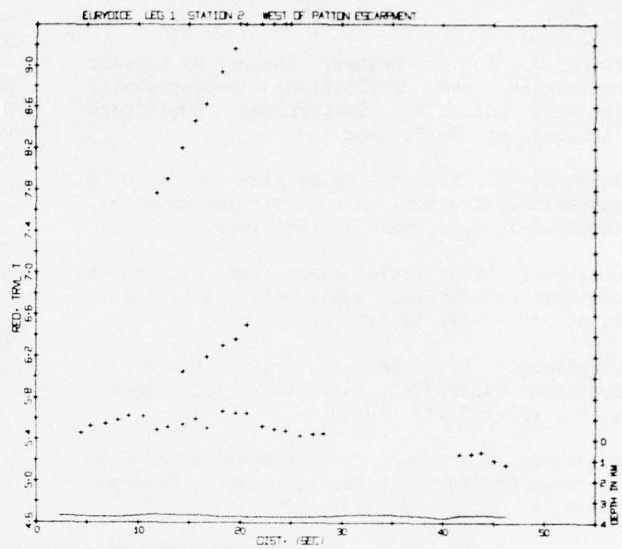

Fig. 120.

EURYDICE, Leg 1, Station 2, 6-7 September 1974 (ERDC) T. WASHINGTON shooting (Shor), ELLEN B. SCRIPPS receiving (Whitney)

This was a single incoming run west of *Patton Escarpment* and AR 1. Thirty- pound shots were fired on 5, 6 and 7 minute intervals, then one pound shots at close range.

TIME	COURSE	POSITION
Shooting		
2121	330°T	32°06.6'N, 120°38.8'W
2328	339°T	32°23.2'N, 120°52.8'W
0107	end	32°37.7'N, 121°00.7'W
Receiving		
0107	end	32°37.7'N, 121°00.7'W

This station was on a small abyssal plain near the foot of the scarp. The run passed over a small basement hill with much *thinner sediments than* the rest of the run so the layer solution was worked without data from shots 41 through 50, which were in the hill area. The sediment velocity of 1.653 km/sec was derived from Hamilton's equation (Hamilton, 1974, Fig. 12) for a reflection time of 0.195 sec. This represents the average velocity for a function $V = 1.4881 + 1.0597\ Z$.

A shear wave was observed at this station with a calculated velocity of 3.76 km/sec and an intercept of 5.59 sec. This is approximately the time at which one would expect a shear arrival from the layer with 6.91 km/sec compressional velocity.

Results

Velocity, km/sec					Thickness, km			
Water	a	d	f	f'	Water	a	d	f
1.495	1.65	5.43	6.91	7.39	3.78	0.32	1.32	1.29
			3.76†					

†Shear wave

Acknowledgments

Nearly all of the work discussed in this report was supported by contracts with the United States Navy, to the Marine Physical Laboratory of the Scripps Institution of Oceanography. The early work was supported by a contract from the Bureau of Ships; the later work by various contracts from the Office of Naval Research, then code 466. The Navy also furnished most of the explosives used, from surplus stocks. Work on Expedition QUARTET was supported by a grant from the National Science Foundation Division of Environmental Sciences; work on Expedition HILO was supported by the National Science Foundation Mohole Project.

As noted in the introduction, nearly every ship operated by the Scripps Institution or the Navy Electronics Laboratory in the late 1940's and 1950's participated in this work. Our thanks go to the captains and crews of the U.S.S. EPCE(R) 855 (Rexburg) and EPCE(R) 857 (Marysville), the USS SALUDA, the Scripps vessels E. W. SCRIPPS, CREST, HORIZON, SPENCER F. BAIRD, STRANGER, HUGH M. SMITH, PAOLINA-T, T-441, ELLEN B. SCRIPPS, OCONOSTOTA, and FLIP, and to the many members of the scientific parties over the years.

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