UNITED STATES

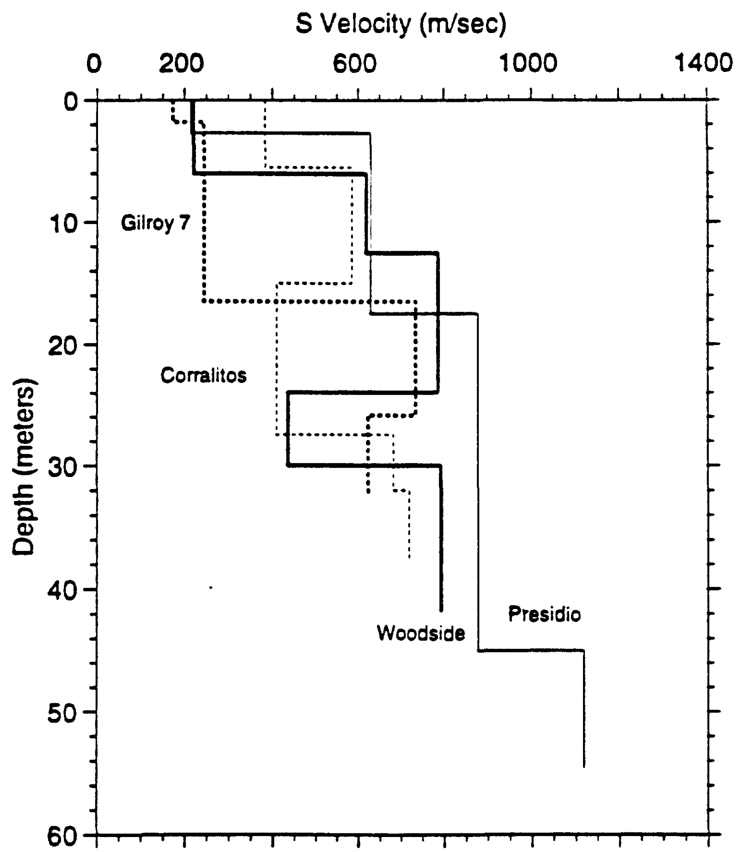
DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

SEISMIC VELOCITIES AND GEOLOGIC LOGS FROM BOREHOLE MEASUREMENTS AT EIGHT STRONG-MOTION STATIONS THAT RECORDED THE 1989 LOMA PRIETA, CALIFORNIA, EARTHQUAKE

by

James F. Gibbs, Thomas E. Fumal, and Thomas J. Powers



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Seismic velocities and geologic logs from borehole measurements at eight strong-motion stations that recorded the 1989 Loma Prieta, California, earthquake

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INTRODUCTION

The Loma Prieta earthquake of October 17, 1989 (1704 PST) was recorded at 131 strong-motion stations located through-out the San Francisco Bay area (Maley et al., 1989, Shakal, et al., 1989). This data set has enormous value for engineering and seismological studies regarding earthquake ground motions. Using shaking-damage to man-made structures from the 1906 San Francisco earthquake, Lawson (1908) recognized that ground motion intensity could be correlated with differences in local site geology. In order to quantify the effect of local geology (e.g., Borcherdt, 1970; Borcherdt and Gibbs, 1976) on ground motions from the 1989 earthquake, detailed geologic and geophysical data are needed. To plan the acquisition of these data a meeting was held on July 6, 1990 at the USGS in Menlo Park, California. Eighteen scientist and engineers representing thirteen institutions attended the meeting to coordinate drilling and data aquisition plans at strong-motion stations.

This is the second of a planned series of four reports (Gibbs et al., 1992) detailing the results of borehole measurements at strong-motion stations recording significant ground motions during the 1989 Loma Prieta earthquake. This report contains the results of the field effort by the USGS for the following eight boreholes located near strong-motion stations operated by the California Division of Mines and Geology. (Figure 1).

1. APEEL #1
2. APEEL #2
3. Corralitos
4. Gilroy #7
5. Oakland 2-Story
6. Palo Alto 2-Story
7. Presidio
8. Woodside Fire Station

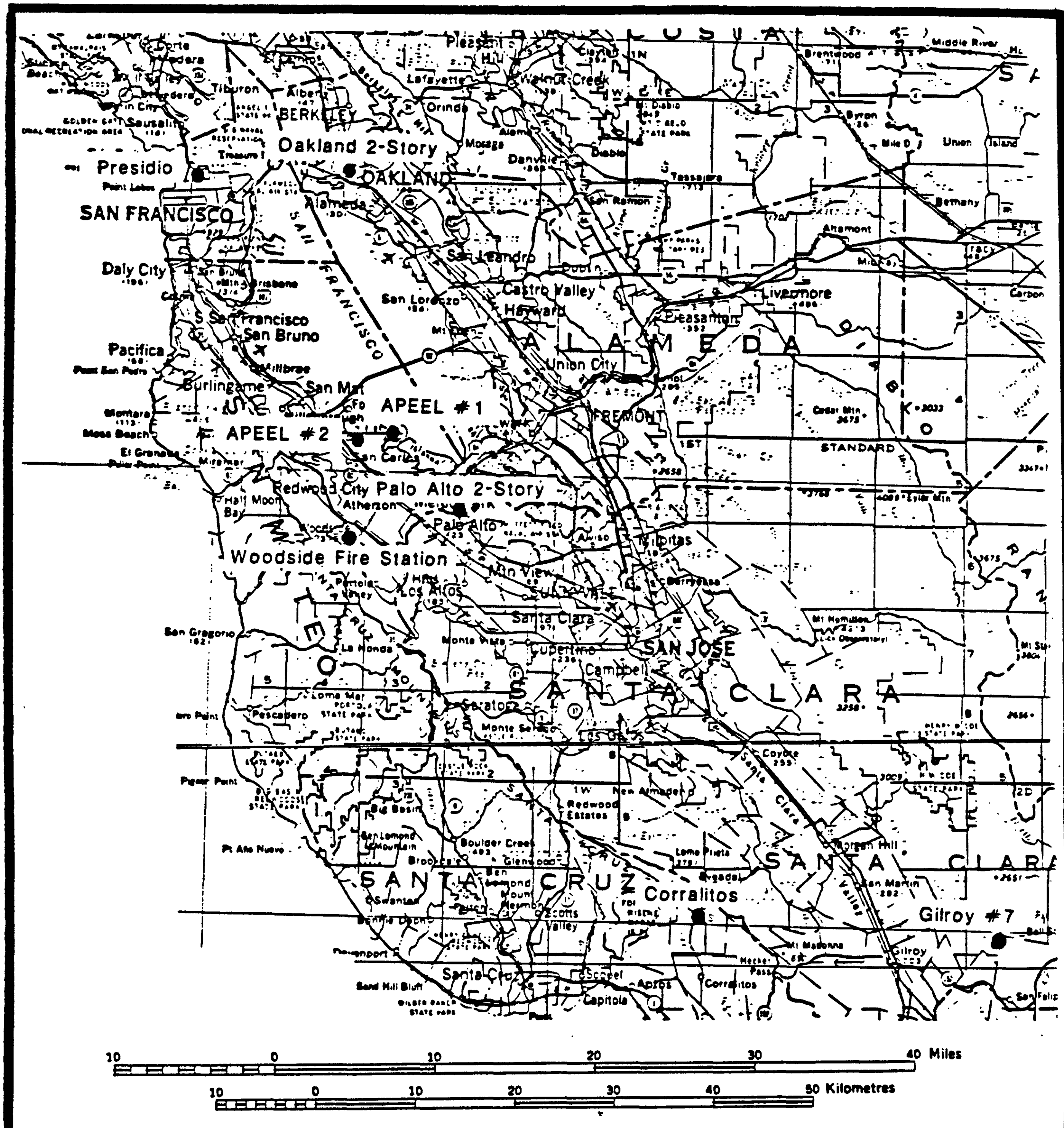

Figure 1. Regional map showing the locations of boreholes (solid circles) included in this report.

FIELD MEASUREMENTS

Drilling and Sampling Procedures

Boreholes were located as close as possible to the strong motion accelerographs usually within 10 meters. In the case of Oakland 2-Story office building site, the borehole was located in Snow Park about 150-200 meters from the instrument location. The Presidio borehole is located approximately 100 meters from the strong-motion instrument.

At each site a hole approximately 6 to 10 inches in diameter was drilled using rotary wash drilling with bentonite mud. For purposes of ecomony, samples were not taken in any of the boreholes except for Oakland 2-Story (Snow Park). At this site seven "Undisturbed" samples were taken inside Shelby tubes (3-inch outside diameter) using a Pitcher barrel. These samples were allowed to drain of free water and sealed with wax plugs and endcaps. These samples were sent to Jonathan Bray at Purdue University for testing. The borings at Woodsite Fire Station and Gilroy #7 were cased 3-inch inside diameter, class 200, polyvinyl-chloride pipe capped at the bottom. APEEL #1 and APEEL #2 were cased with 4-inch pipe and the other sites were cased with 5-inch inside diameter pipe.

The annular space around the casing was tremie grouted by pumping a water-cement-bentonite mixture through a 1-inch steel pipe installed next to the casing. This provides good coupling between the casing and the wall of the borehole, and provides a sanitary seal preventing contamination of ground water. Grouting was done in stages of about 50-60 meters to prevent collapse of the casing. The California Division of Mines and Geology plans to install a strong-motion instrument package at the bottom of each 5-inch hole to supplement surface recordings.

Geologic Logs

Geologic logs are based on descriptions of drill cuttings, samples, reaction of the drill rig, and inspection of nearby outcrops. Sediment samples are described using the field techniques of the Soil Conservation Service (1951). Descriptions include sediment texture, color, and the amount and size of coarse fragments. Texture refers to the relative proportions of clay, silt, and sand particles less than 2 millimeters in diameter. This is determined visually and by feel without using laboratory tests. As such, this system is easier to use in the field than other classification systems. The dominant color of the sediment and prominent mottles are determined from the Munsell soil color charts.

Descriptions of rock samples include rock name, weathering condition, color, grain size, hardness, and fracture spacing. Classifications of rock hardness and fracture spacing are those used by Ellen et al., (1972) in describing hillside materials in San Mateo County, California.

Most information needed for describing relatively well-sorted soils and such properties of rock as lithology, color, and hardness are readily obtained from cuttings. Inspection of samples and nearby outcrops is necessary for determining the nature of poorly-sorted materials and fracture spacing. Reaction of the drill rig is useful in determining approximate sediment texture and in determining degree of fracturing because the rate of penetration in rock is highest for very closely fractured and crushed materials and drilling roughness generally is at a maximum in closely to moderately fractured rock. In-situ consistency of soil is determined largely from standard penetration measurements and rate of drill penetration.

Site Geology

Four sites, APEEL #1, APEEL #2 (Portside Park), Oakland 2-Story (Snow Park) and Palo Alto 2-Story are located near the margin of San Francisco Bay on thick sections of Holocene and Pliestocene estuarine and alluvial sedimentary deposits. These deposits consist largely of fine-grained sediments with occasional thick layers of sand and/or gravelly sand. Two of the boreholes were drilled into the underlying bedrock. At APEEL #1, serpentinite was encountered at 188.5 meters (618 feet) and at APEEL #2, greywacke sandstone of the Franciscan assembladge was encountered at 84.7 meters (278 feet).

The geology at Gilroy #7 consists of 17.4 meters (57 feet) of poorly sorted gravelly clay and sandy clay alluvium overlying hard Tertiary shale and sandstone. Two sites are underlain by bedrock. The Presidio site is underlain by serpentinite. Woodside Fire Station is underlain by firm to hard sandstone and mudstone which may be a part of the Butano sandstone. The strong motion instrument at Corralitos sits on 32 meters (105 feet) landslide deposits consisting of very closely fractured black shale. Major slide planes apparently were encountered at 15 meters (50 feet) and 32 meters (105 feet). The landslide deposits are underlain by sandstone which is probably part of the Purisima formation.

Cracks in the road above the site suggest that the landslide may have moved slightly during the earthquake.

Travel-time Data

Shear waves* were generated at the ground surface by an air-powered horizontal hammer (Liu, et al., 1988) striking anvils attached to the ends of a 2.3-meter-long aluminum channel. The hammer can be driven in both horizontal directions to generate positive and negative shear pulses. The switch that determines zero time is a piezo-electric sensor attached to the shear source. The source is offset from the borehole to prevent the direct arrival from traveling down the grout next to the casing. The source offset is 2 to 5 meters depending on the depth of the borehole. Shallow holes (30 meters or less) are generally offset 2 meters, while boreholes deeper than approximately 100 meters are offset 5 meters. Travel times are corrected (for slant offset) to vertical by the cosine of the angle of ray incidence.

P-waves are made by striking a steel plate with a sledge hammer at the same intervals described above. The recorder is triggered by the sledge hammer making electrical contact with the steel plate.

Measurements are made by lowering a single three-component geophone into the borehole and clamping it to the casing-wall with an electrically actuated lever arm. A second three-component geophone is placed at the surface approximately 30 centimeters from the shear source and is used as a check of the switch triggering the recorder for zero time. Depending on geologic information, measurements are repeated at 2.5 or 5.0 meter intervals. The 2.5 meter spacing is used when the layering of the sediments is thin (under 10 meters) and generally from the surface to 30 meters depth.

The data are recorded on magnetic tape cassettes in digital form on a twelve channel recording system.

DATA INTERPRETATION and PROCESSING

The flow-chart, Figure 2, describes the processing and interpretation proceedures. The magnetic tape cassette contains 18 recorded traces from each depth. These include data

* In this report shear-wave(s) and S-wave are used interchangeably as well as P-wave and compressional-wave.

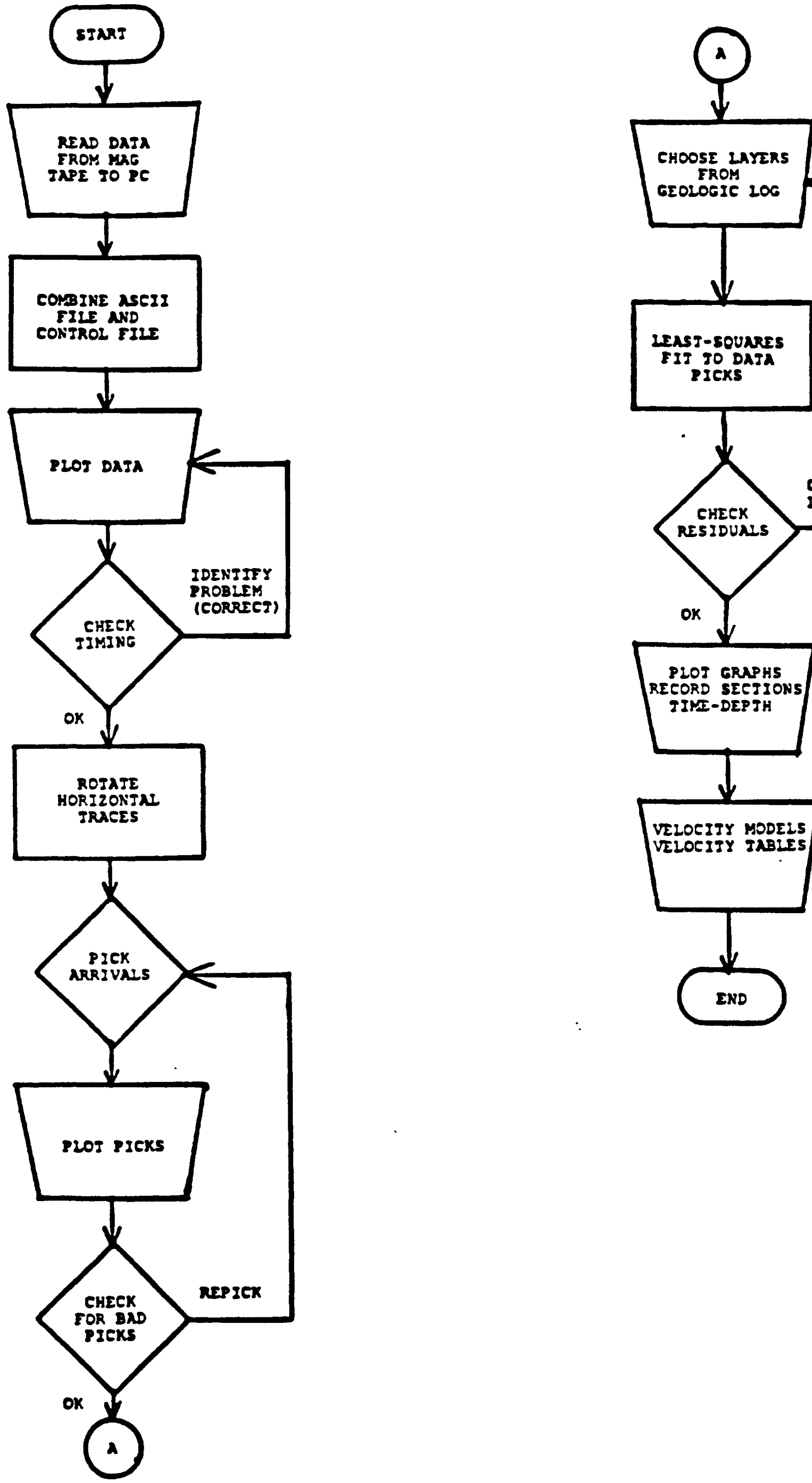

Figure 2. Flow-chart outlining the data processing and interpretation steps.

from the surface three component geophone and the downhole three-component geophone: A total of 6 traces for each source type (positive horizontal, negative horizontal, and vertical). As mentioned previously, the surface geophone is used only to check timing.

The orientation of the downhole geophone cannot be controlled when moving from one depth to the next, so that horizontal components are not generally oriented parallel and perpendicular to the source. This causes slight phase shifts, timing differences and amplitude variations. To minimize these effects, when timing shear-wave arrivals, the horizontal components are combined (rotated) to obtain a single component of motion. The direction of motion is determined by maximizing the integral square amplitude within a time interval containing the shear wave (Boatwright et al., 1986). Rotated traces are plotted on a 20-inch computer monitor and the first shear-wave arrival is timed for each of the horizontal rotated traces. Two arrival times are obtained from picks of positive and negative shear-wave arrivals. Timing of the arrivals is done to one millisecond precision. The two time-picks are not always identical, due to interfering waves obscuring the first shear-arrival, slight phase shifts, or amplitude differences. If the time difference is greater than about 5 milliseconds a mistake in phase correlation (perhaps due to a reversed trace, noise etc.) can be suspected and a repick may be necessary. The two picks are averaged for velocity determinations. On clear traces one-millisecond picking accuracy can be maintained; however, because of lower signal-to-noise ratios and interfering waves in the deeper sections of the boreholes, this accuracy cannot always be achieved. The arrivals are weighted by the inverse of an assigned normalized variance. A normalized standard deviation of 1 was assigned to the accurate picks and values ranging up to 5 were assigned to the others.

For determining the final velocity model there are a number of ways to proceed. In previous reports (e.g., Gibbs et al., 1975) we determined the initial layer boundaries from the travel time plots by eye and then added or subtracted layers based on geologic boundaries consistent with the data. We also required at least three data points in each layer. This requirement limited the velocity determination to layers greater than 7.5 meters in thickness. The problem with this proceedure is that a mismatch (overlap or underlap) of the line segments sometimes occurred at the intersections of the layers, resulting in a discontinuous travel time curve. To address this problem we are now using a least-squares program (Press et al., 1986) that fits the travel time data with line segments hinged at each selected layer boundary from the surface (forced through zero) to the bottom data point. Initial layer boundaries are chosen from the geologic log and are adjusted, if necessary, to reduce residuals and for consistency with the data. The S-wave travel time data are analyzed first; layer boundaries are initially the same for the P-wave model, and are then adjusted, if necessary, by adding a layer for the water table or reducing the number of layers. The velocity plots (e.g., Figure 13) show upper and lower bounds which approximate 68% confidence limits. These bounds are not symmetrical because they are based on the standard deviation of the slope of the least-squares line fit to the travel time plots (the inverse of the velocity).

SUMMARY OF RESULTS

S-wave velocities

Figure 3 summarizes S-wave velocities at four sites; Palo Alto 2-Story, Oakland 2-Story (Snow Park), APEEL #2 and at APEEL #1 to a depth of 120 meters. The S-wave velocities are similar in the upper 50 meters at Palo Alto 2-Story, APEEL #1, and APEEL #2. Oakland 2-Story has somewhat higher velocities due in part to the gravelly layers at 15 and 28 meters. Velocities shown on Figure 3 are similiar to those reported earlier (Gibbs et al., 1992) for San Francisco Airport, Treasure Island, Alameda Naval Air Station, and Oakland Outer Harbor Wharf, typical of mixtures of young clay-loam-sand near the margins of San Francisco Bay. At APEEL #2 bedrock (Franciscan Graywacke) was penetrated in the borehole at 85 meters. Unfortunately, we were unable to interpret a bedrock velocity due to poor transmission of energy across the sedimentary-bedrock boundary.

Figure 4 summarizes S-wave velocities at Gilroy #7, Corralitos, Woodside Fire Station, and at the Presidio. The S-wave velocity below 6 meters are near 600 meters/second at Corralitos, Woodside Fire Station, Presidio and Gilroy #7 at a depth below 16 meters. Lower velocities occur at Corralitos and Woodside Fire Station at 15 and 24 meters respectively. The velocities shown on Figure 4 are generally higher than those of Figure 3 which are closer to the Bay margins.

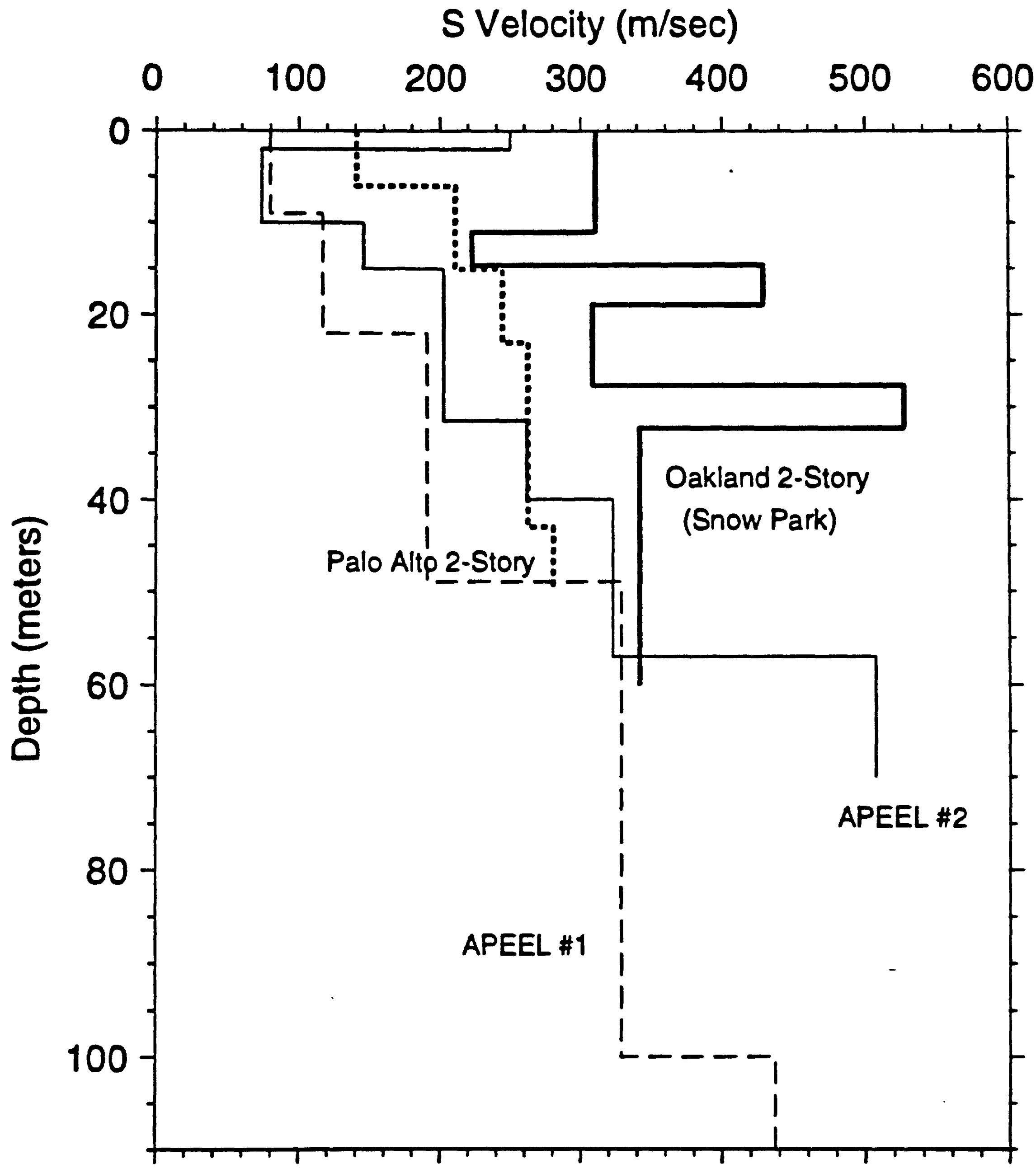

Figure 3. S-wave velocity models superimposed for comparison. The four sites shown are soft fine-grained deposits located close to the margin of San Francisco Bay. The velocities shown here are generally lower than those of Figure 4.

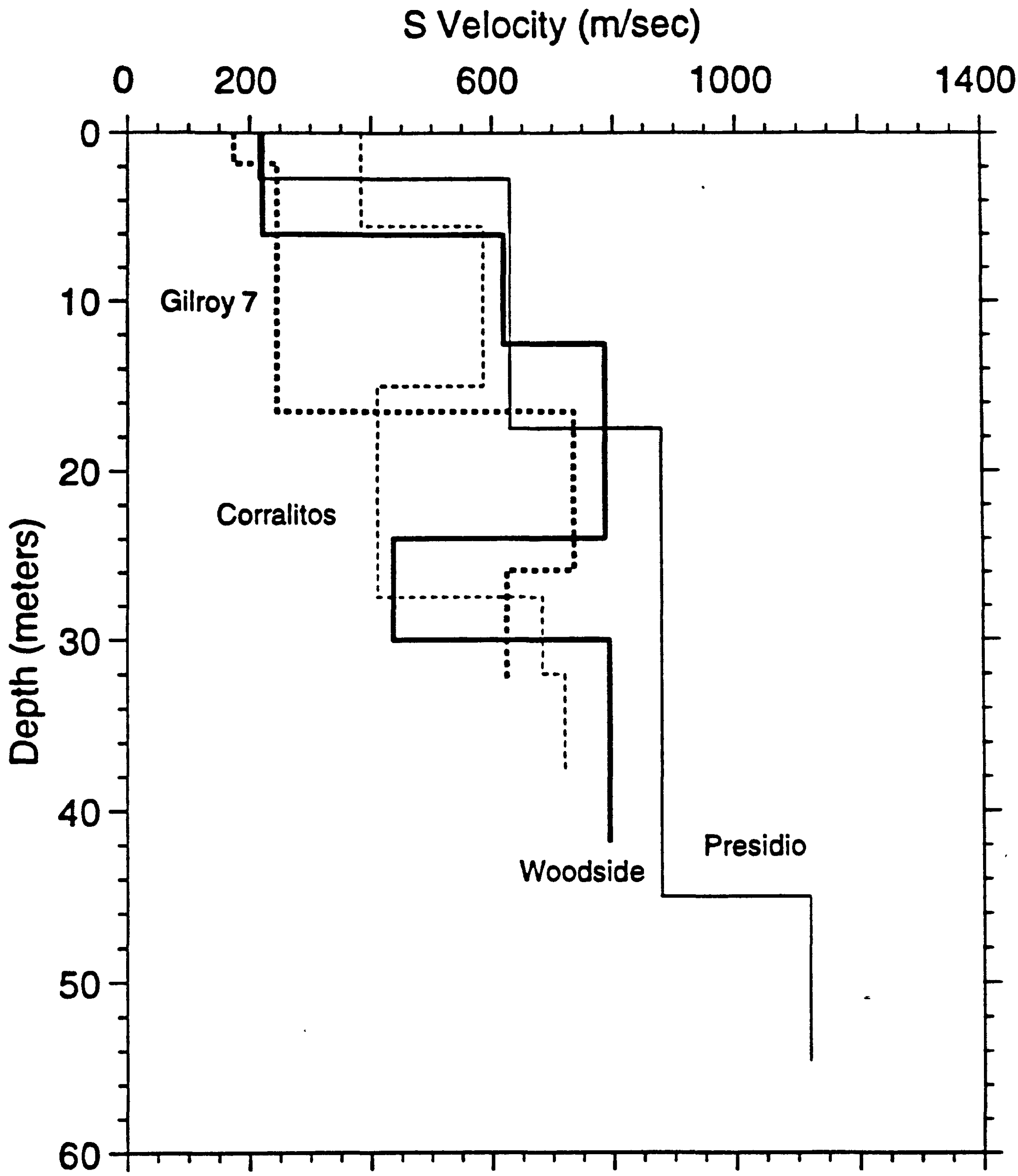

Figure 4. S-wave velocity models superimposed for comparison. The velocities shown here are somewhat higher than those of Figure 3. In general they have thinner sections of fine-grained deposits overlying denser sandstone, shales or Francican bedrock. Corralitos site is a detached landslide block that may have moved during the 1989 Loma Prieta earthquake.

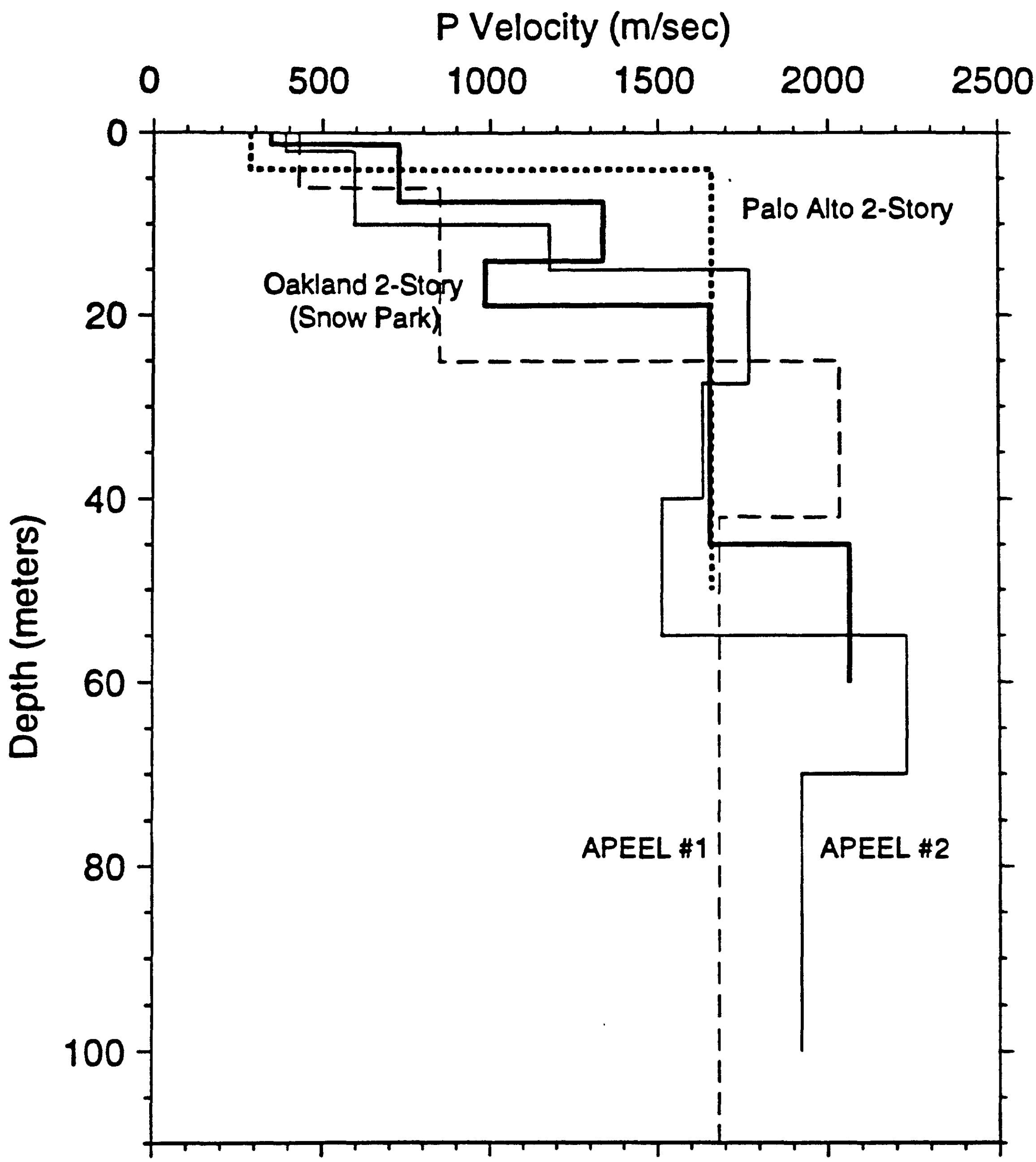

Figure 5. P-wave velocity models superimposed for comparison.

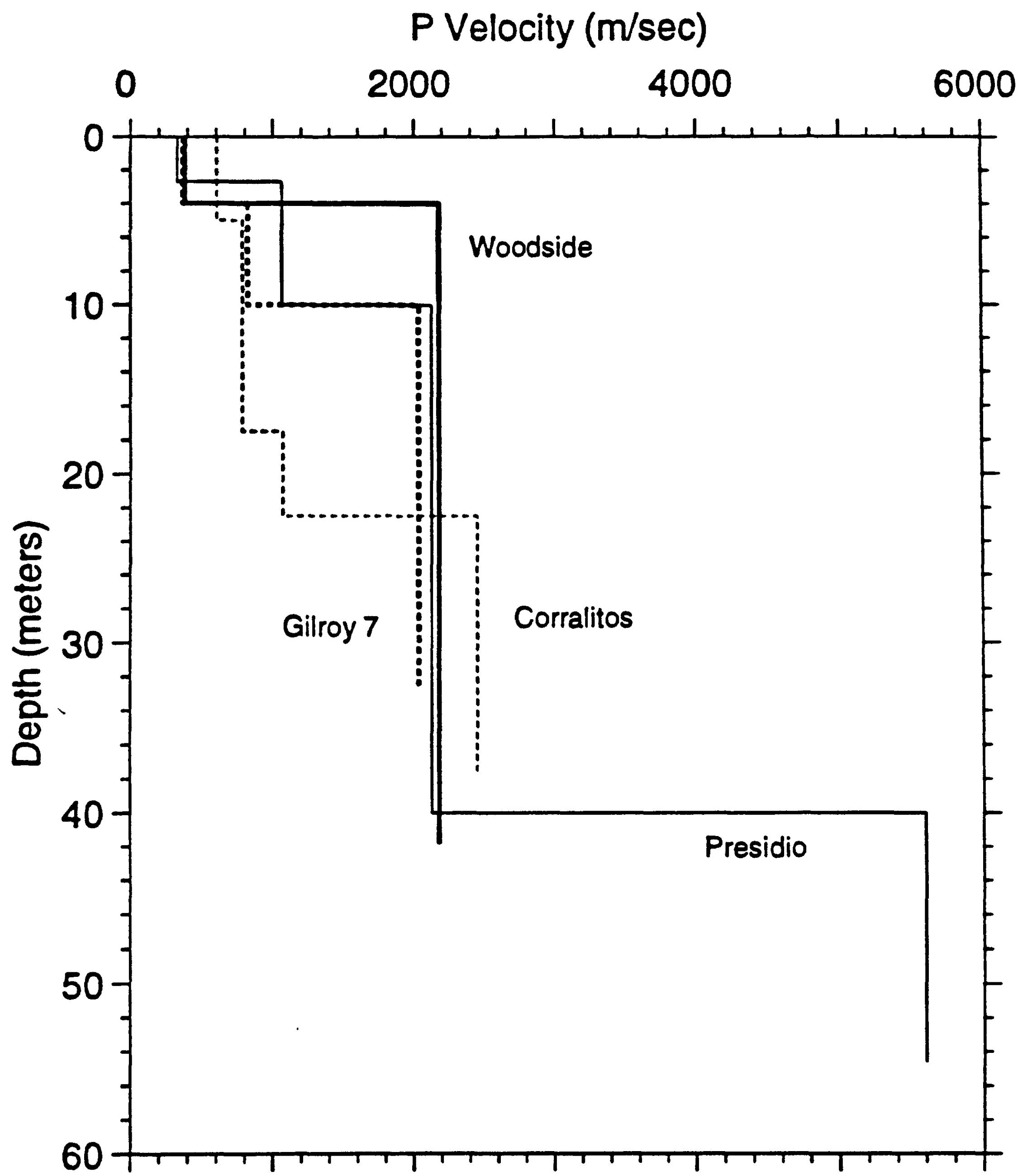

Figure 6. P -wave velocity models superimposed for comparison.

P-wave velocities

Figures 5 and 6 summarizes the P-wave velocities at four sites near the margins of San Francisco Bay and at four sites further inland respectively. There is a poorer correlation between P-wave velocity and lithology than S-wave velocity and lithology because P-wave velocity is strongly affected by degree of saturation. Note that even though saturated, the P-wave velocities measured in the Holocene bay mud are less than the velocity of P-waves in water ($\approx$ 1500 meters/second). The explanation for this may be that the presence of trapped gas (Brandt, 1960) has reduced the P-wave velocity (e.g. air, methane from decaying organic matter).

The appendix lists the detailed results, organized alphabetically by borehole. Figures and tables for each site are arranged in the following order:

1. location map
2. geologic log
3. record sections
4. time-depth graph
5. velocity profiles
6. velocity tables

ACKNOWLEDGMENTS

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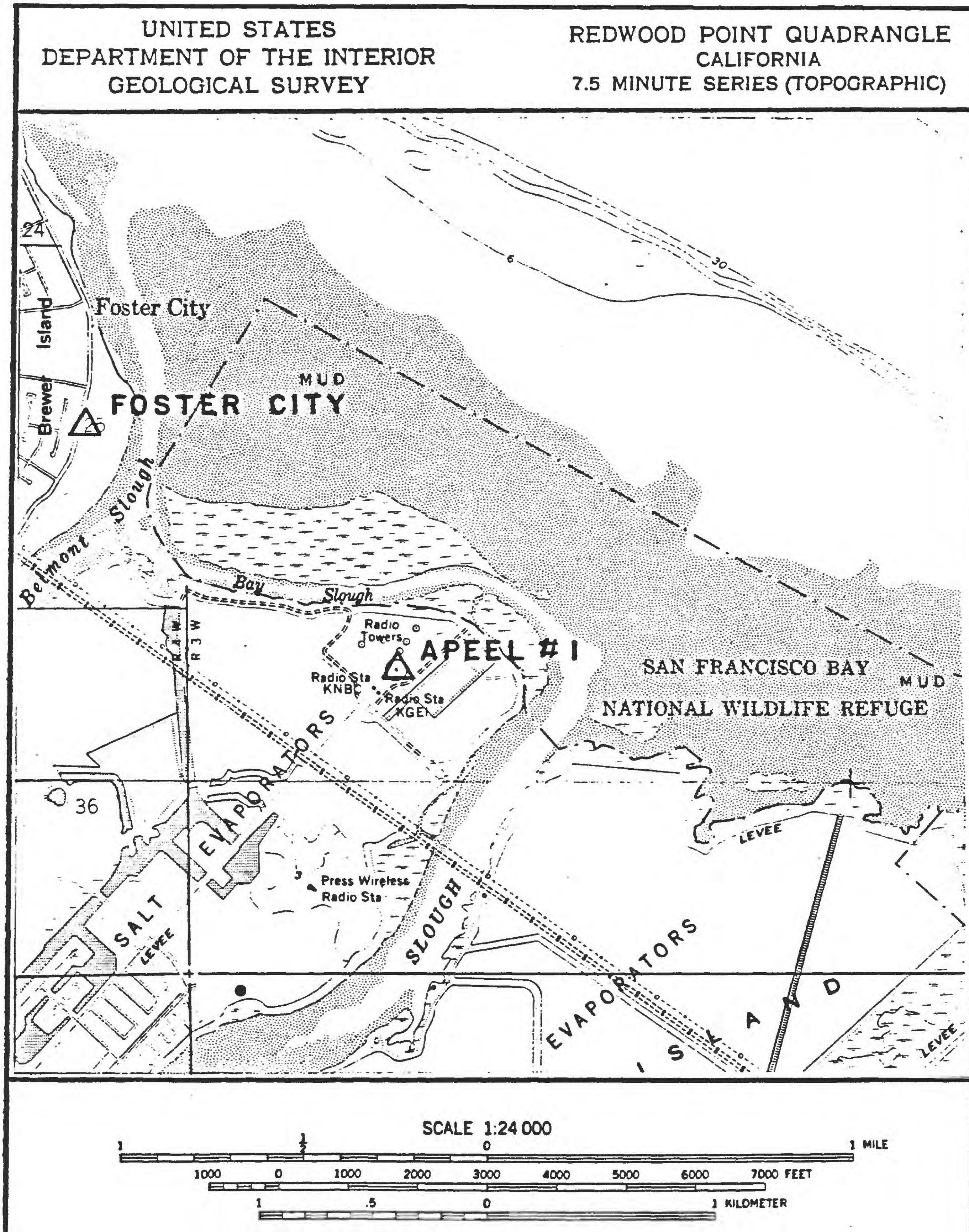


Figure 7. Site location map for the borehole at APEEL #1 and Foster City (not in this report). The borehole at APEEL #1 is located within 30 meters of the strong-motion recorder.

Definitions of terms used for descriptions of sedimentary deposits and bedrock materials

Rock hardness: response to hand and geologic hammer: (Ellen et al., 1972)

hard - hammer bounces off with solid sound
firm - hammer dents with thud, pick point dents or penetrates slightly
soft - pick points penetrates
friable material can be crumbled into individual grains by hand.

Fracture spacing: (Ellen et al., 1972)

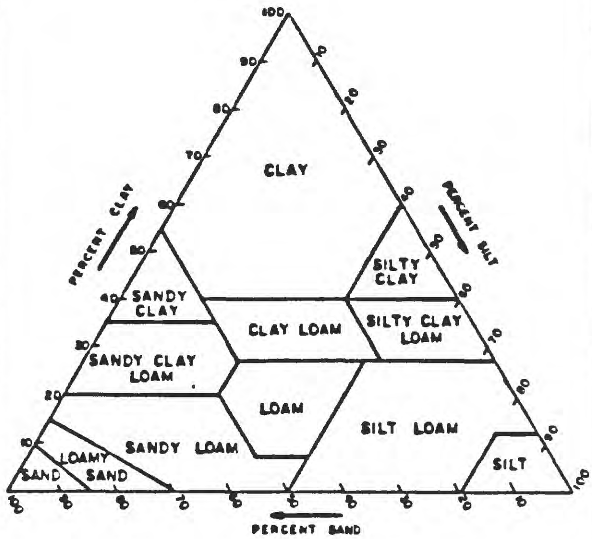
cm	in	fracture spacing
0-1	0-1/2	v. close
1-5	1/2-2	close
5-30	2-12	moderate
30-100	12-36	wide
>100	>36	v. wide

Weathering:
Fresh: no visible signs of weathering
Slight: no visible decomposition of minerals, slight discoloration
Moderate: slight decomposition of minerals and disintegration of rock, deep and thorough discoloration
Deep: extensive decomposition of minerals and complete disintegration of rock but original structure is preserved.

Relative density of sand and consistency of clay is correlated with penetration resistance: (Terzaghi and Peck, 1948)

blows/ft.	relative density	blows/ft.	consistency
0-4	v. loose	<2	v. soft
4-10	loose	2-4	soft
10-30	medium	4-8	medium
30-50	dense	8-15	stiff
>50	v. dense	15-30	v. stiff
		>30	hard

Texture: the relative proportions of clay, silt, and sand below 2mm. Proportions of larger particles are indicated by modifiers of textural class names. Determination is made in the field mainly by feeling the moist soil (Soil Survey, Staff, 1951).



Color: Standard Munsell color names are given for the dominant color of the moist soil and for prominent mottles.

Types of samples

SP - Standard Penetration 1 + 3/8 in in ID sampler)
S - Thin-wall push sampler
O - Osterberg fixed-piston sampler
P - Pitcher Barrel sampler
CH - California Penetration (2 in ID sampler)
DC - Diamond Core

Figure 8. Explanation of geologic logs.

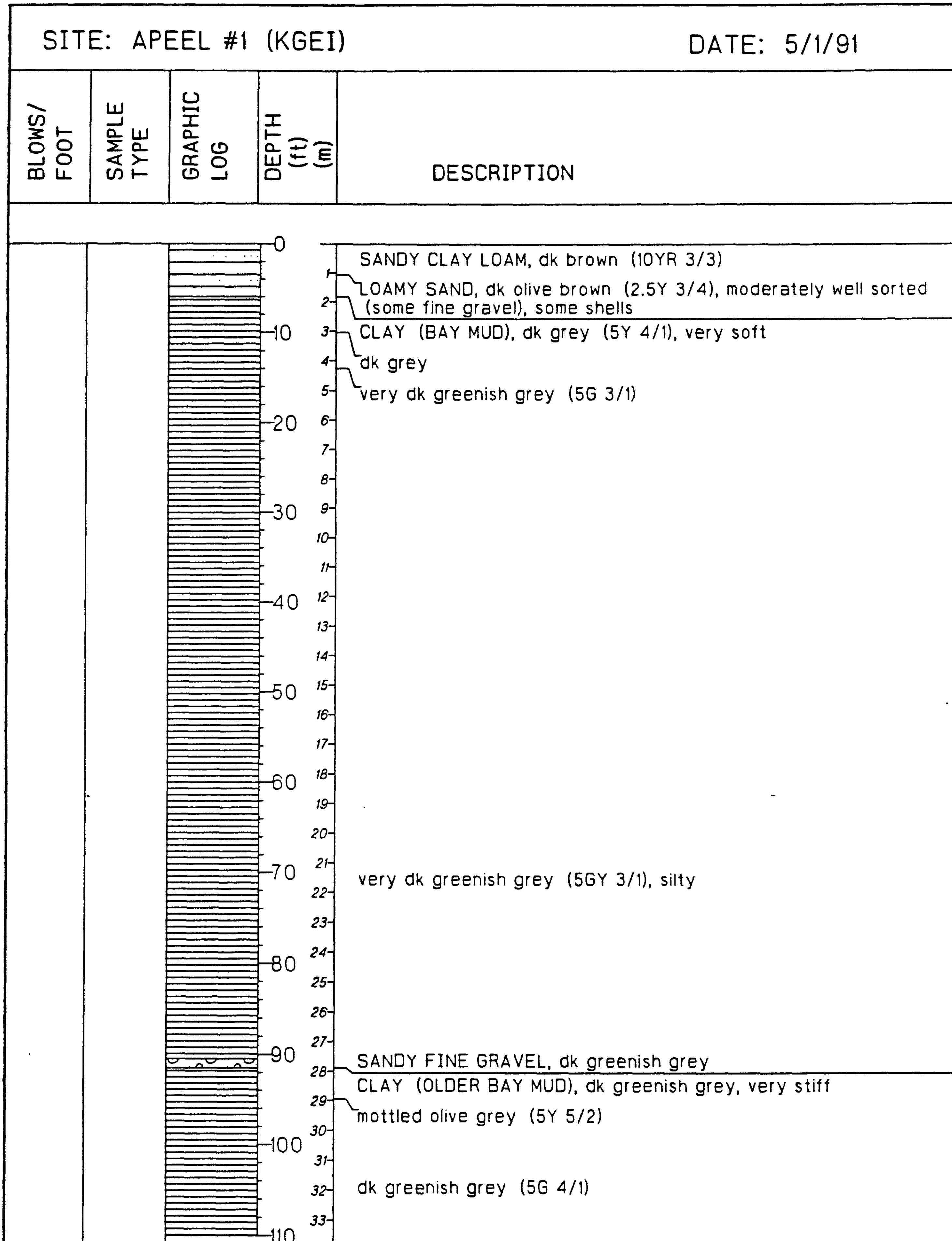
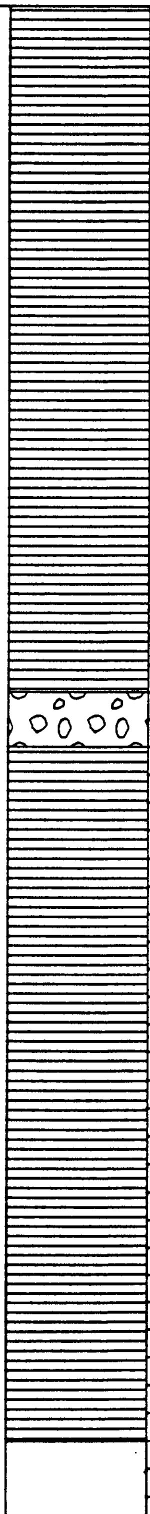


Figure 9. Geologic log for APEEL #1 borehole.

SITE: APEEL #1 (KGEI) DATE: 5/1/91



BLOWS/ FOOT	SAMPLE TYPE	DEPTH (ft)	DEPTH (m)	DESCRIPTION
		110		
			34	
			35	
			36	
		120		
			37	
			38	
			39	
		130	40	very dk greenish grey (5G 3/1), silty, soft
			41	
			42	
		140		
			43	
			44	dk greenish grey (5G 4/1), very stiff
			45	
		150	46	very dk greenish grey (5G 3/1), soft
			47	
			48	
		160	49	FINE GRAVEL AND SHELLS
			50	CLAY, dk greenish grey, very stiff
			51	
		170	52	softer
			53	
			54	stiffer
		180	55	
			56	
			57	very stiff
		190	58	softer
			59	
			60	
		200	61	
			62	
			63	
		210	64	
			65	
			66	SAND, fine to coarse grained
		220	67	

Figure 9. (Continued).

SITE: APEEL #1 (KGEI) DATE: 5/1/91

BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft) (m)	DESCRIPTION
			220	
			250 (76)	GRAVELLY SAND
				SAND, fine to coarse grained (moderately well sorted)
			(87)	CLAY, dk greenish grey, stiff
			300 (91)	CLAY LOAM, olive (5Y 5/4)
			310 (95)	brownish yellow (10YR 6/6) to yellowish brown (10YR 5/4)
			330	

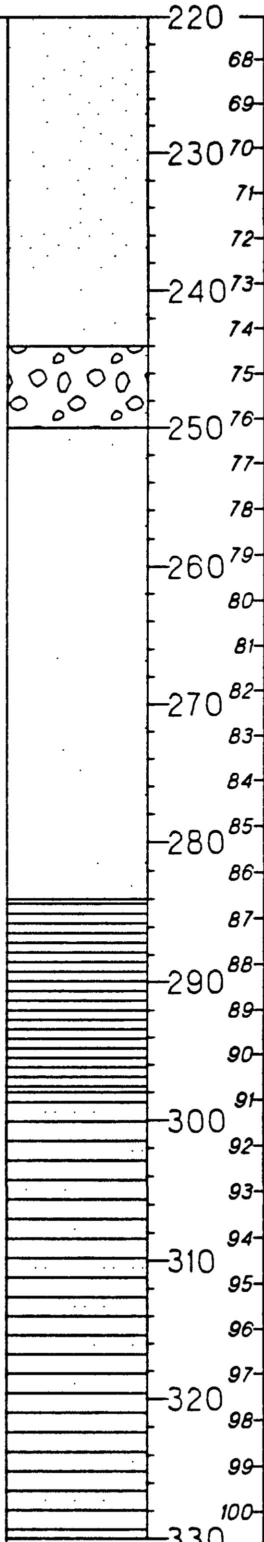


Figure 9. (Continued).

SITE: APEEL #1 (KGEI) DATE: 5/1/91

BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft) (m)	DESCRIPTION
			330 / 101 – 350 / 107	GRAVELLY SAND, dk greyish brown
			111	CLAY, dk greenish grey, very stiff
			118	GRAVELLY SAND
			390 / 119	CLAY, olive grey (5Y 4/2), very stiff
			420 / 128	olive (5Y 5/3)

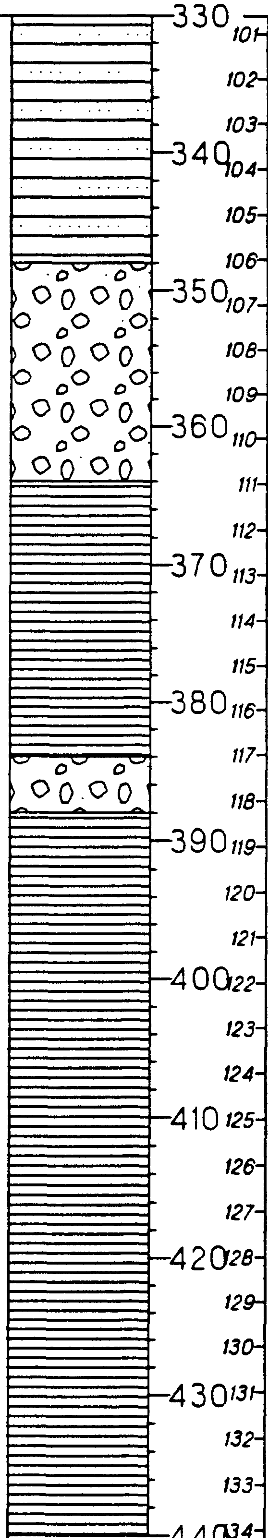
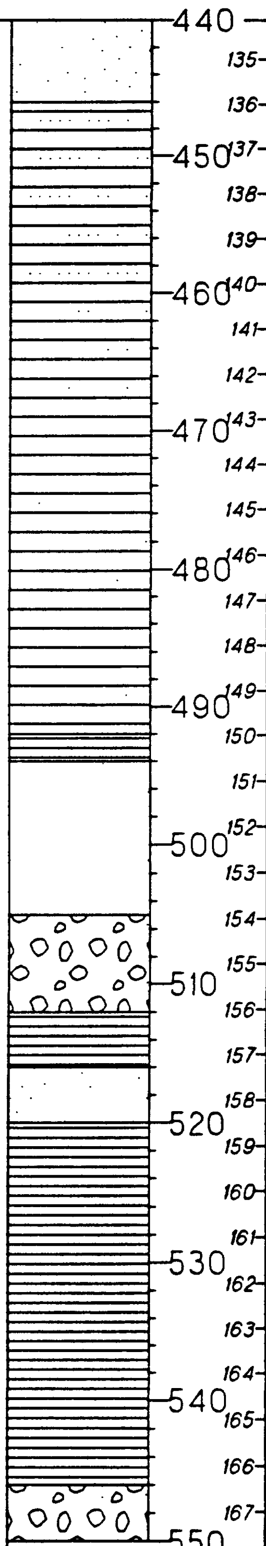


Figure 9. (Continued).

SITE: APEEL #1 (KGEI) DATE: 5/1/91

BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft) (m)	DESCRIPTION



SAND, some gravel, dense

CLAY LOAM, lt olive brown (2.5Y 5/4), very stiff

olive brown (2.5Y 4/4), sandy

CLAY, very stiff

SAND, yellowish brown (10YR 5/4), very dense

GRAVELLY SAND, poorly sorted

CLAY, very stiff

SAND, some gravel, dense

CLAY, very stiff

dk greenish grey, firm

GRAVELLY SAND, dk yellowish brown (10YR 5/4), poorly sorted

Figure 9. (Continued).

SITE: APEEL #1 (KGEI) DATE: 5/1/91

BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft)	DEPTH (m)	DESCRIPTION
			550	168	stiffer
				169	yellowish brown
				170	
			560	171	
				172	
				173	
			570	174	
				175	
				176	
			580	177	
				178	
				179	
			590	180	SAND, poorly sorted
				181	
				182	
			600	183	
				184	
				185	
			610	186	SANDY LOAM, lt olive brown (2.5Y 5/6), some dk brown fine gravel
				187	
				188	
			620	189	SERPENTINITE (FRANCISCAN FORMATION), pale green (5G 6/2) to greyish green (5G 5/2)
				190	
				191	
			630	192	
				193	
				194	
			640	195	sheared, hard
				196	
				197	
			650	198	
				199	harder
				200	
			660	201	

Figure 9. (Continued).

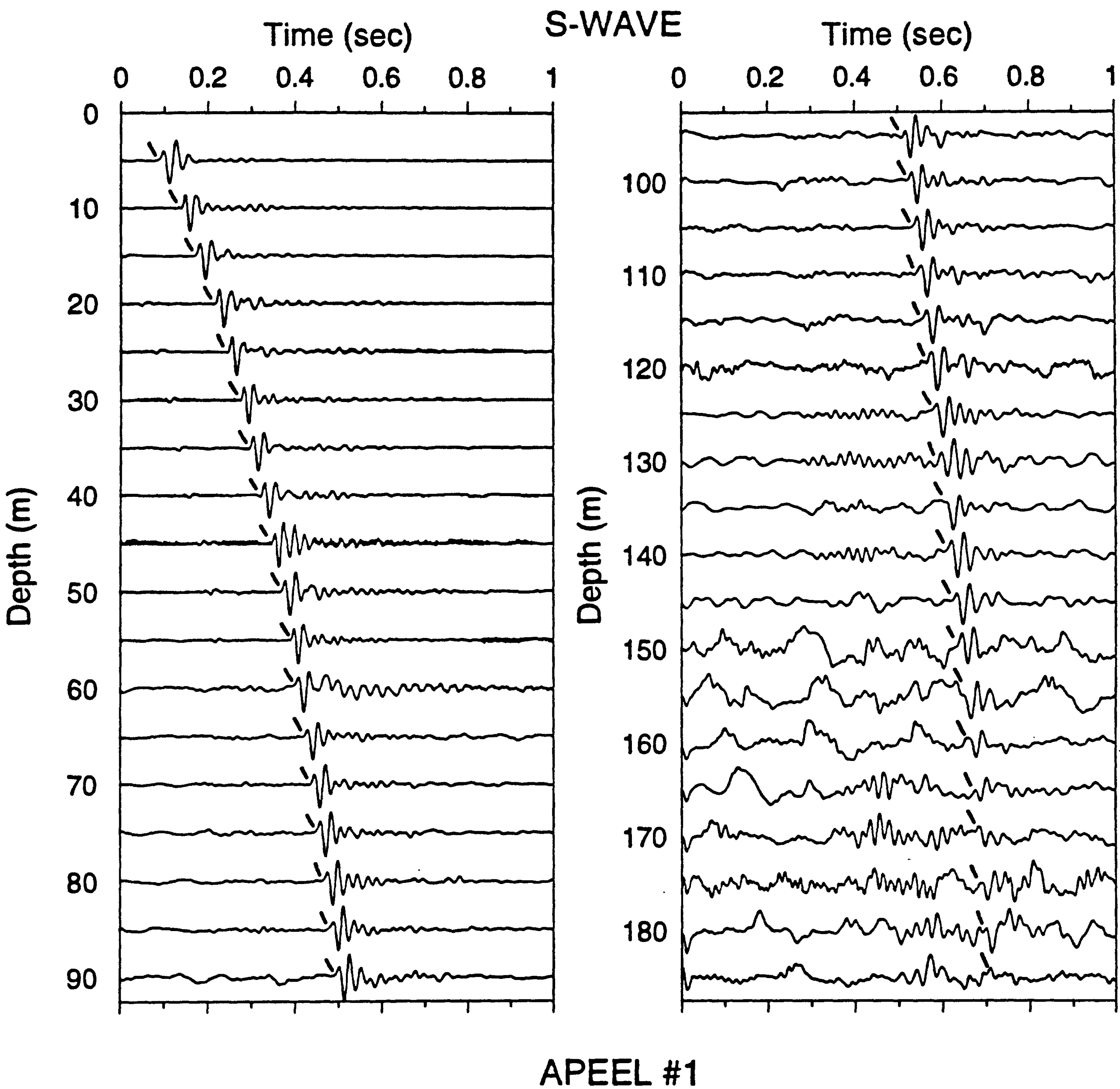


Figure 10. Record section showing the "Away" horizontal components. Records have been 50 Hz low-pass filtered. Because of better signal-to-noise ratios, the shear arrivals (shown by the accent marks) were picked from these components only. The "Toward" records are shown on the next figure.

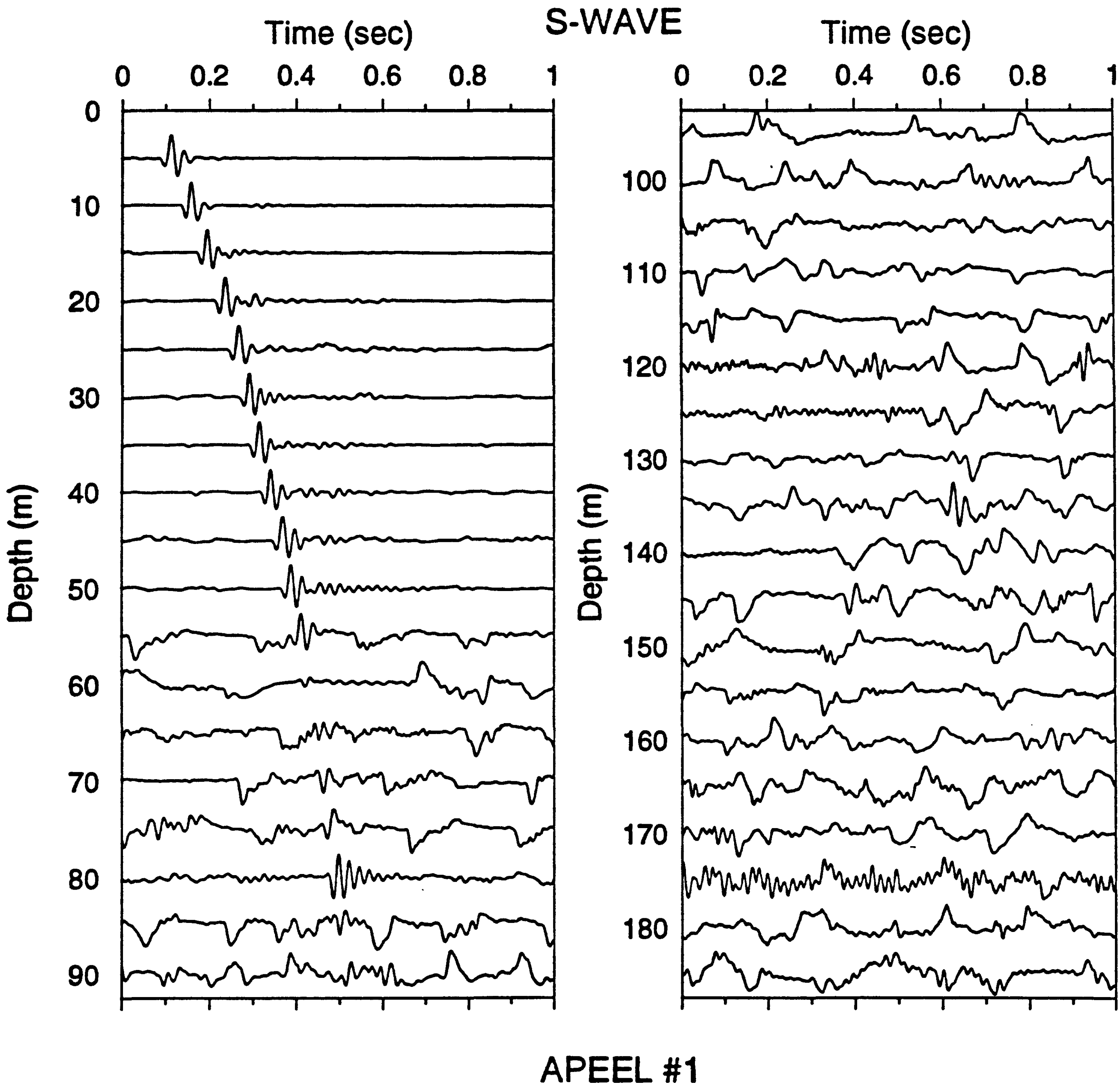


Figure 10. (Continued). Record section showing the "Toward" components. The noise level is higher on these records compared to the "Away" components. Because of the noise the shear arrivals were not pickable from the deeper traces and velocities were determined using the "Away" components only.

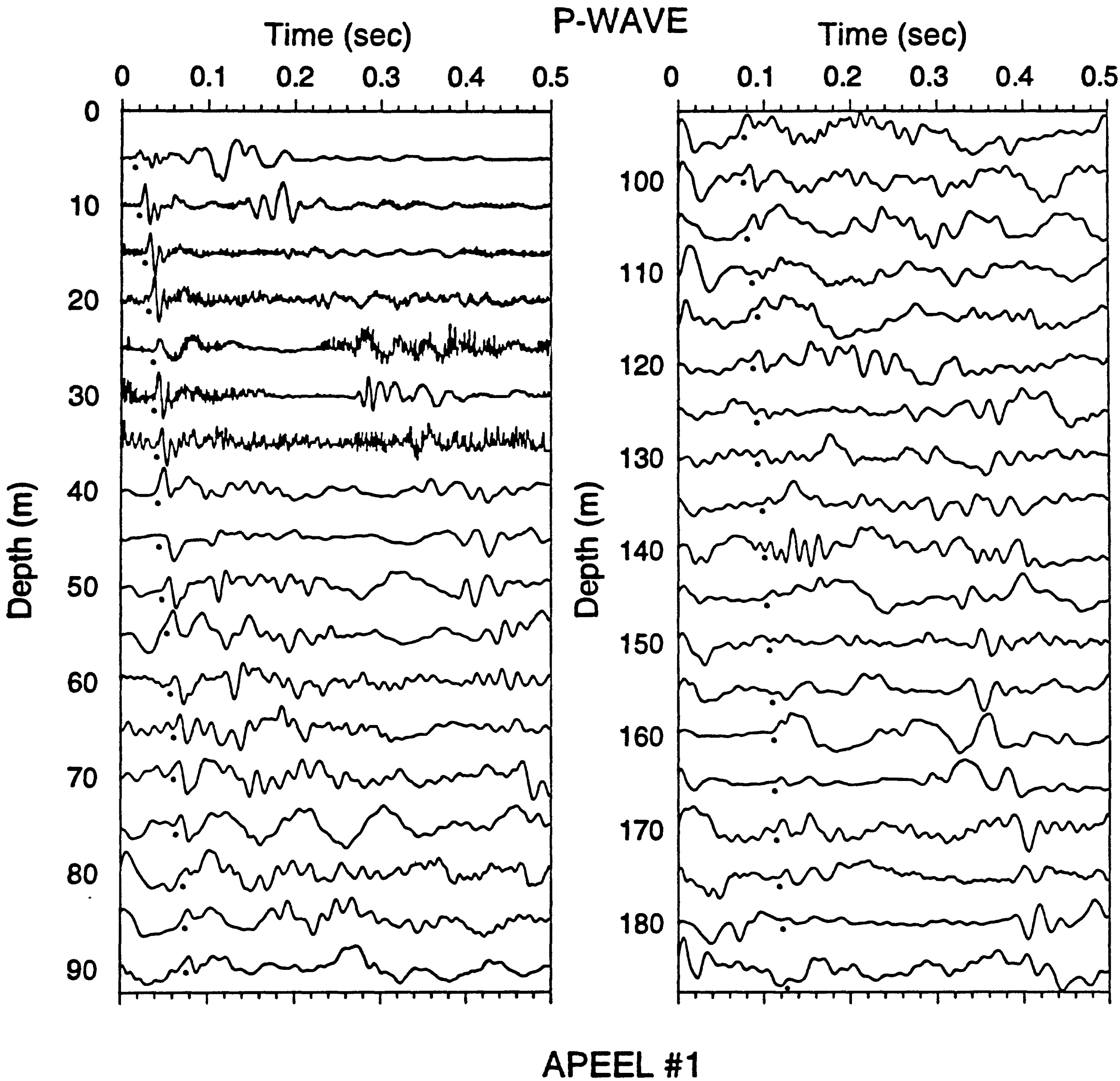


Figure 11. Vertical component record section. P-wave arrivals are shown by the solid circles.

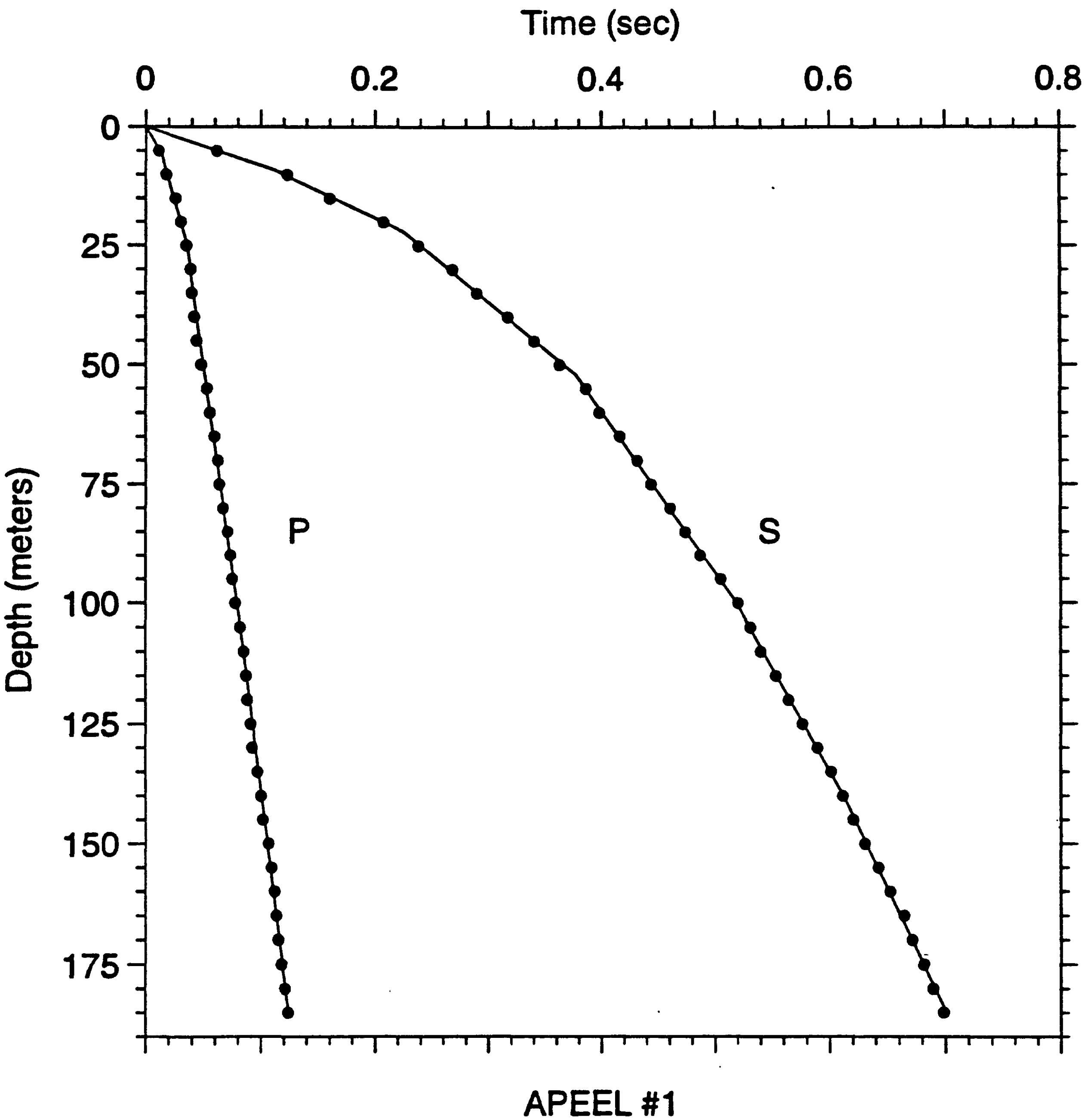


Figure 12. Time-depth graph of P-wave and S-wave picks. Line segments show the hinged-least-squares fit to the data points.

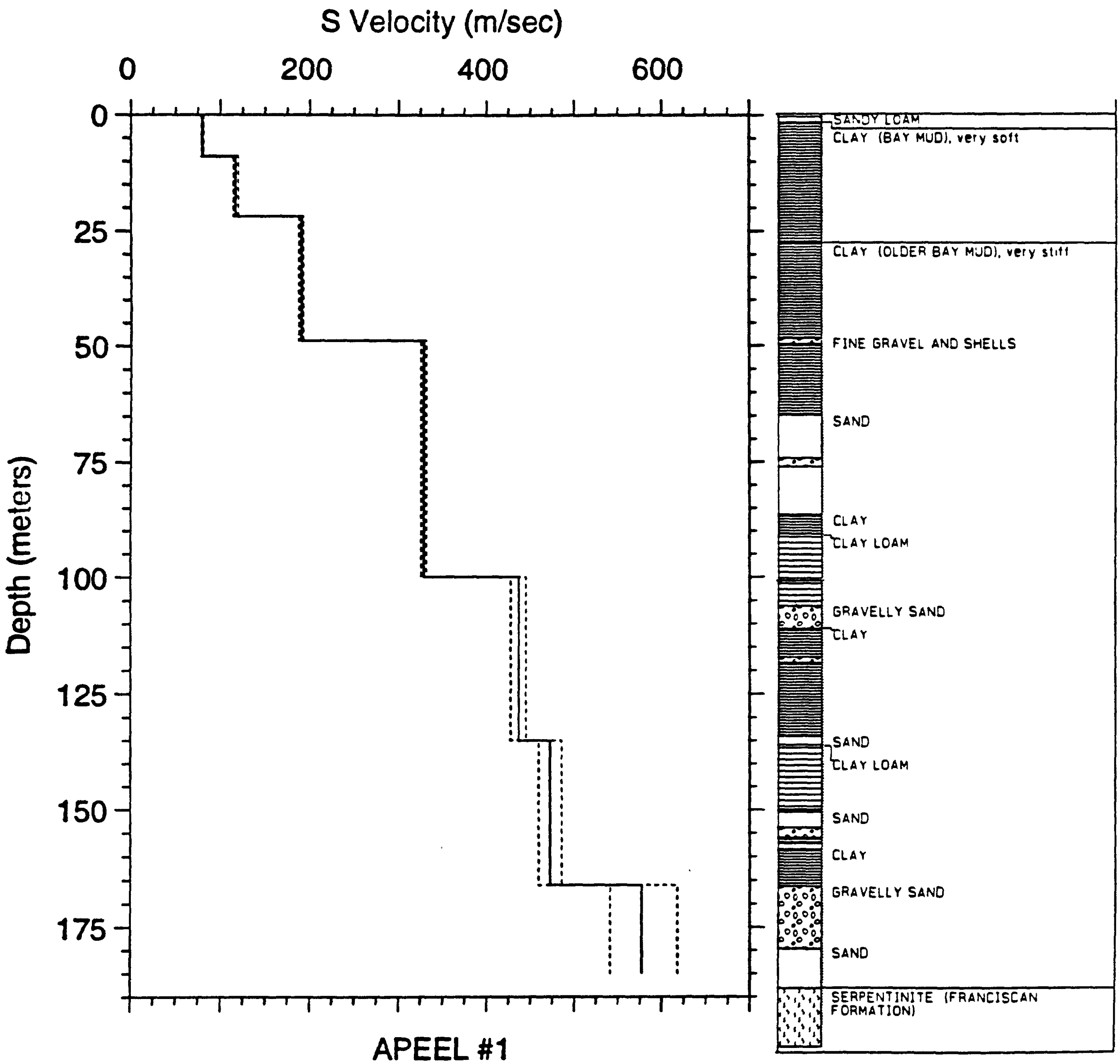


Figure 13. S-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

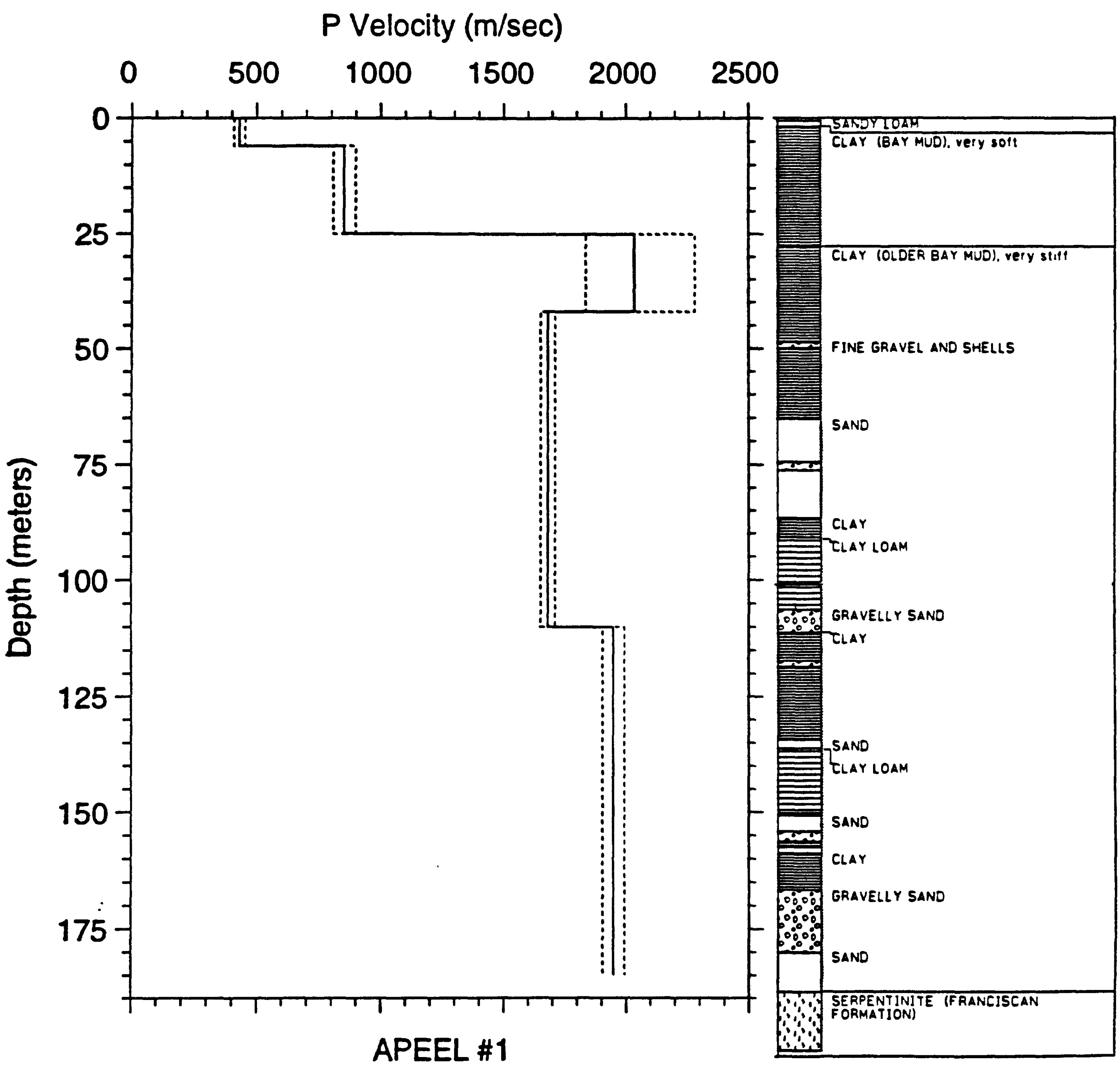


Figure 14. P-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

TABLE 1. S-wave arrival times and velocity summaries for APEEL #1.

d(m)	d(ft)	t(sec)	sig	rsdl/sig
5.0	16.4	.0615	1	-1.0
10.0	32.8	.1234	1	2.3
15.0	49.2	.1603	1	-3.4
20.0	65.6	.2076	1	1.4
25.0	82.0	.2383	1	-.7
30.0	98.4	.2683	1	3.0
35.0	114.8	.2901	1	-1.4
40.0	131.2	.3175	1	-.2
45.0	147.6	.3409	1	-3.1
50.0	164.0	.3632	1	-4.8
55.0	180.4	.3864	1	3.2
60.0	196.9	.3986	1	.2
65.0	213.3	.4168	1	3.2
70.0	229.7	.4319	1	3.1
75.0	246.1	.4440	1	.0
80.0	262.5	.4611	1	1.9
85.0	278.9	.4742	1	-.1
90.0	295.3	.4872	1	-2.3
95.0	311.7	.5053	1	.6
100.0	328.1	.5203	1	.4
105.0	344.5	.5314	1	.0
110.0	360.9	.5404	1	-2.4
115.0	377.3	.5535	1	-.8
120.0	393.7	.5645	1	-1.2
125.0	410.1	.5765	1	-.7
130.0	426.5	.5896	1	1.0
135.0	442.9	.6016	1	1.5
140.0	459.3	.6116	1	.9
145.0	475.7	.6206	1	-.6
150.0	492.1	.6306	1	-1.2
155.0	508.5	.6427	1	.3
160.0	524.9	.6527	1	-.3
165.0	541.3	.6647	1	1.2
170.0	557.7	.6717	1	-.9
175.0	574.1	.6817	1	.5
180.0	590.6	.6897	1	-.2
185.0	607.0	.6987	1	.1

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	80	79	81	262	258	266
9.0	29.5	.113	80	79	81	262	258	266
22.0	72.2	.223	117	115	120	385	377	394
49.0	160.8	.365	191	188	193	625	617	633
100.0	328.1	.520	329	326	332	1080	1069	1091
135.0	442.9	.600	437	428	445	1433	1406	1460
166.0	544.6	.666	473	460	486	1551	1511	1594
185.0	607.0	.699	577	541	618	1893	1775	2027

Explanation:
- d(m) = depth in meters
- d(ft) = depth in feet
- t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
- sig = sigma, standard deviation normalized to the standard deviation of best picks
- rsdl/sig = least-squares residual divided by sigma
- dtb(m) = depth to bottom of layer in meters
- dtb(ft) = depth to bottom of layer in feet
- ttb(s) = arrival time in seconds to bottom of layer
- v(m/s) = velocity in meters per second
- vl(m/s) = lower limit of velocity in meters per second *
- vu(m/s) = upper limit of velocity in meters per second
- v(ft/s) = velocity in feet per second
- vl(ft/s) = lower limit of velocity in feet per second
- vu(ft/s) = upper limit of velocity in feet per second

* see text for explanation of velocity limits

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TABLE 2. P-wave arrival times and velocity summaries for APEEL #1.

d(m)	d(ft)	t(sec)	sig	rsdl/sig
5.0	16.4	.0113	1	-.3
10.0	32.8	.0179	1	-.8
15.0	49.2	.0261	1	1.6
20.0	65.6	.0306	1	.2
25.0	82.0	.0353	2	-.5
30.0	98.4	.0390	1	.2
35.0	114.8	.0401	1	-1.1
40.0	131.2	.0422	1	-1.5
45.0	147.6	.0442	4	-.6
50.0	164.0	.0483	1	-1.1
55.0	180.4	.0533	1	.9
60.0	196.9	.0558	1	.4
65.0	213.3	.0598	1	1.5
70.0	229.7	.0628	1	1.5
75.0	246.1	.0639	1	-.4
80.0	262.5	.0674	1	.1
85.0	278.9	.0714	1	1.2
90.0	295.3	.0739	1	.7
95.0	311.7	.0754	1	-.8
100.0	328.1	.0779	1	-1.3
105.0	344.5	.0824	1	.3
110.0	360.9	.0854	1	.3
115.0	377.3	.0874	4	-.1
120.0	393.7	.0884	2	-.9
125.0	410.1	.0914	2	-.7
130.0	426.5	.0929	2	-1.2
135.0	442.9	.0974	2	-.3
140.0	459.3	.1004	4	.0
145.0	475.7	.1019	2	-.6
150.0	492.1	.1069	4	.3
155.0	508.5	.1099	2	.8
160.0	524.9	.1124	3	.5
165.0	541.3	.1139	2	.3
170.0	557.7	.1155	2	-.2
175.0	574.1	.1185	1	.0
180.0	590.6	.1215	3	.1
185.0	607.0	.1240	4	.1

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	430	409	453	1411	1343	1486
6.0	19.7	.014	430	409	453	1411	1343	1486
25.0	82.0	.036	850	808	897	2789	2652	2942
42.0	137.8	.045	2034	1835	2281	6672	6019	7484
110.0	360.9	.085	1681	1652	1710	5514	5419	5611
185.0	607.0	.124	1947	1904	1993	6389	6247	6538

Explanation:
- d(m) = depth in meters
- d(ft) = depth in feet
- t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
- sig = sigma, standard deviation normalized to the standard deviation of best picks
- rsdl/sig = least-squares residual divided by sigma
- dtb(m) = depth to bottom of layer in meters
- dtb(ft) = depth to bottom of layer in feet
- ttb(s) = arrival time in seconds to bottom of layer
- v(m/s) = velocity in meters per second
- vl(m/s) = lower limit of velocity in meters per second *
- vu(m/s) = upper limit of velocity in meters per second
- v(ft/s) = velocity in feet per second
- vl(ft/s) = lower limit of velocity in feet per second
- vu(ft/s) = upper limit of velocity in feet per second

* see text for explanation of velocity limits

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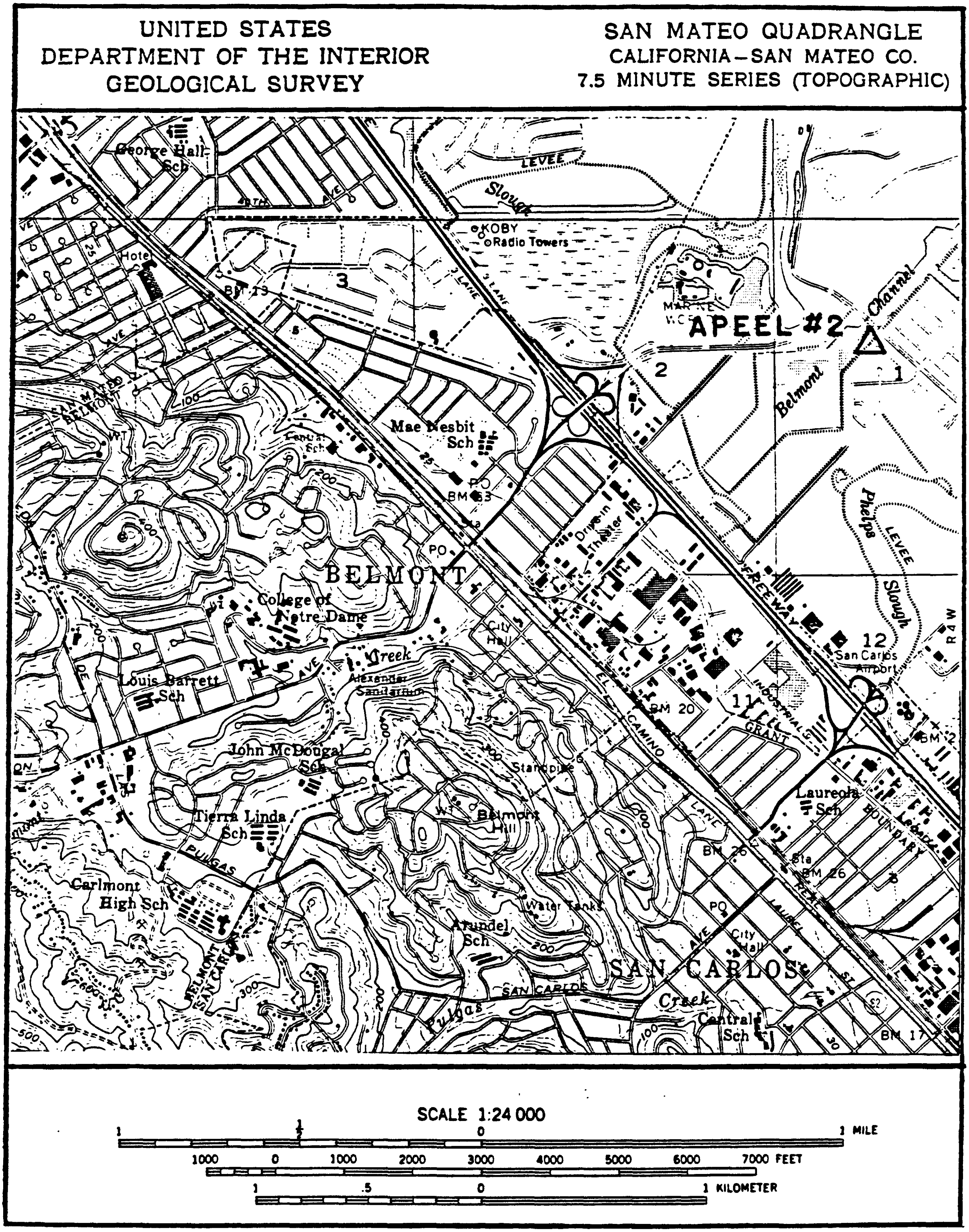


Figure 15. Site location map for APEEL #2 (Portside Park).

Definitions of terms used for descriptions of sedimentary deposits and bedrock materials

Rock hardness: response to hand and geologic hammer: (Ellen et al., 1972)

hard - hammer bounces off with solid sound
firm - hammer dents with thud, pick point dents or penetrates slightly
soft - pick points penetrates
friable material can be crumbled into individual grains by hand.

Fracture spacing: (Ellen et al., 1972)

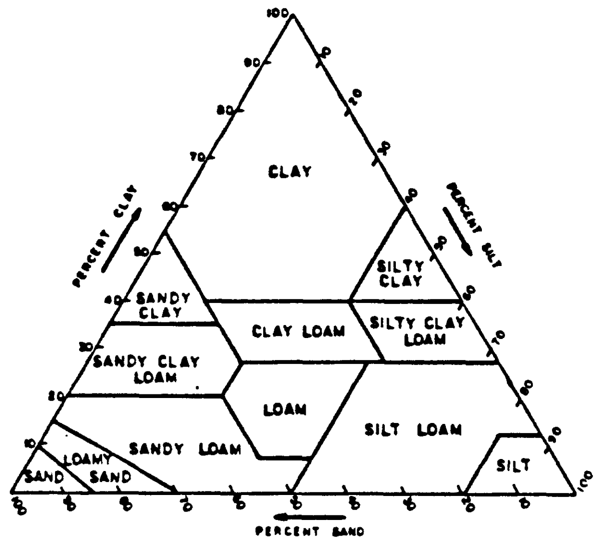
cm	in	fracture spacing
0-1	0-1/2	v. close
1-5	1/2-2	close
5-30	2-12	moderate
30-100	12-36	wide
>100	>36	v. wide

Weathering:
Fresh: no visible signs of weathering
Slight: no visible decomposition of minerals, slight discoloration
Moderate: slight decomposition of minerals and disintegration of rock, deep and thorough discoloration
Deep: extensive decomposition of minerals and complete disintegration of rock but original structure is preserved.

Relative density of sand and consistency of clay is correlated with penetration resistance: (Terzaghi and Peck, 1948)

blows/ft.	relative density	blows/ft.	consistency
0-4	v. loose	<2	v. soft
4-10	loose	2-4	soft
10-30	medium	4-8	medium
30-50	dense	8-15	stiff
>50	v. dense	15-30	v. stiff
		>30	hard

Texture: the relative proportions of clay, silt, and sand below 2mm. Proportions of larger particles are indicated by modifiers of textural class names. Determination is made in the field mainly by feeling the moist soil (Soil Survey, Staff, 1951).



Color: Standard Munsell color names are given for the dominant color of the moist soil and for prominent mottles.

Types of samples

SP - Standard Penetration 1+3/8 in in ID sampler)
S - Thin-wall push sampler
O - Osterberg fixed-piston sampler
P - Pitcher Barrel sampler
CH - California Penetration (2 in ID sampler)
DC - Diamond Core

Figure 16. Explanation of geologic log for APEEL #2 (Portside Park).

SITE: APEEL #2 (PORTSIDE PARK) DATE: 4/24/91

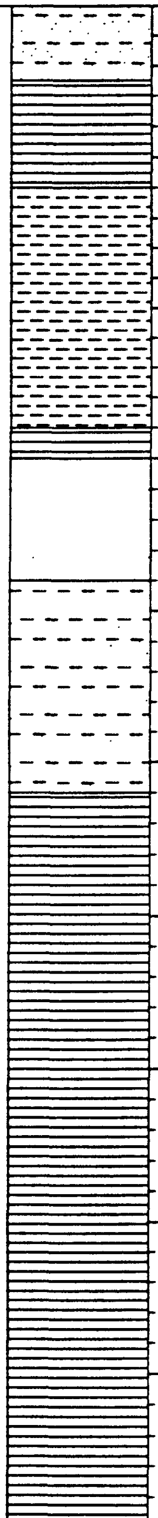
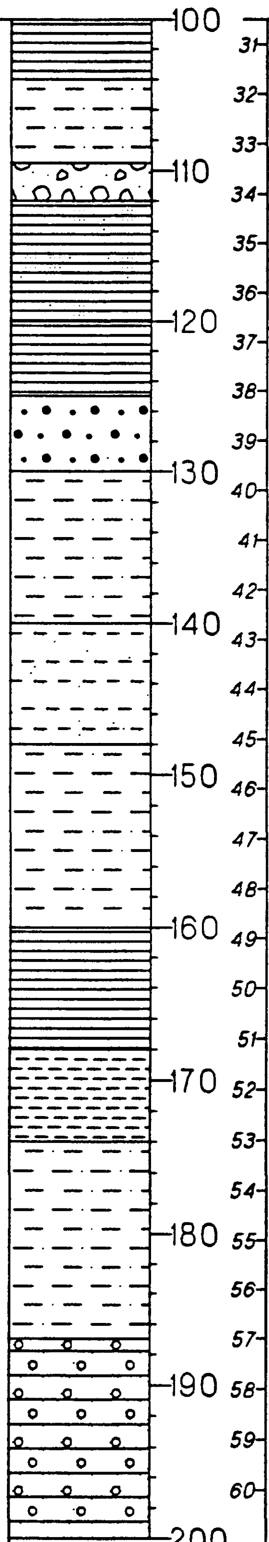
BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft) (m)	DESCRIPTION
			0–100 ft; 1–30 m	VERY GRAVELLY, CLAY LOAM (fill), dk brown (7SYR 3/4) CLAY, very dark greenish grey (5GY 3/1), very soft (HOLOCENE ESTUARINE DEPOSITS) CLAY, dark greenish grey (5GY 4/1), very soft ORGANIC-RICH CLAY, dk greenish-grey (5GY 4/1), soft SAND, dark greenish grey, very fine to fine grained SANDY CLAY, light olive brown (2.5Y 5/4), stiff (LATE PLEISTOCENE ALLUVIUM AND ESTUARINE DEPOSITS) stiffer CLAY, olive (5Y 4/3) to olive grey (5Y 4/2), stiff olive grey olive grey mottled olive greenish grey (5G 5/1), stiff

Figure 17. Geologic log for APEEL #2.

SITE: APEEL #2 (PORTSIDE PARK) DATE: 4/24/91

BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft) (m)	DESCRIPTION



CLAY TO CLAY LOAM, brown (10YR 5/3)

FINE GRAVELLY SAND

FINE SANDY CLAY LOAM, dark yellowish brown (10YR 4/4), stiff

grading to

CLAY, greenish grey (5GY 4/1)

FINE GRAVELLY SAND, mixed greenish grey, dark brown, and olive brown

CLAY LOAM, dark greyish brown (2.5Y 4/2)

CLAY LOAM, dark greyish brown (2.5Y 4/2) to olive brown (2.5Y 4/4), poorly sorted (some fine gravel), very stiff

CLAY LOAM, olive brown (2.5Y 4/4), poorly sorted

CLAY, dark yellowish brown (10YR 4/4)

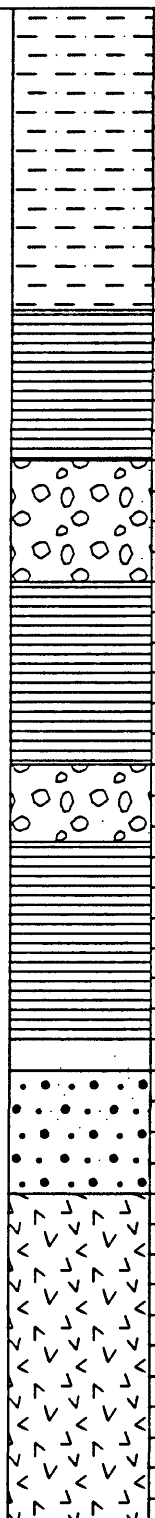
CLAY, dark yellowish brown (10YR 4/6)

CLAY LOAM, strong brown (7.5YR 4/6)

GRAVEL, dark brown, poorly sorted

Figure 17. (Continued).

SITE: APEEL #2 (PORTSIDE PARK) DATE: 4/24/91



BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft)	DEPTH (m)	DESCRIPTION
			200	61	CLAY LOAM, dark brown (7.5YR 4/4)
				62	
				63	
			210	64	
				65	
				66	
			220	67	CLAY, very stiff
				68	
				69	
			230	70	SANDY GRAVEL, brown
				71	
				72	
			240	73	CLAY, very stiff
				74	
				75	
			250	76	SANDY GRAVEL, very dense
				77	
				78	SANDY CLAY LOAM, very dense, some gravel lenses
			260	79	
				80	
				81	
				82	SAND
			270	83	GRAVELLY SAND, yellowish brown (10YR 5/6)
				84	
			280	85	GREYWACKE, greenish grey (5G 5/1), very closely fractured
				86	
				87	
			290	88	dk greenish grey (5G 5/1), very hard
				89	
				90	
				91	
			300		

Figure 17. (Continued).

SITE: APEEL #2 (PORTSIDE PARK) DATE: 4/24/91

BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft) (m)	DESCRIPTION

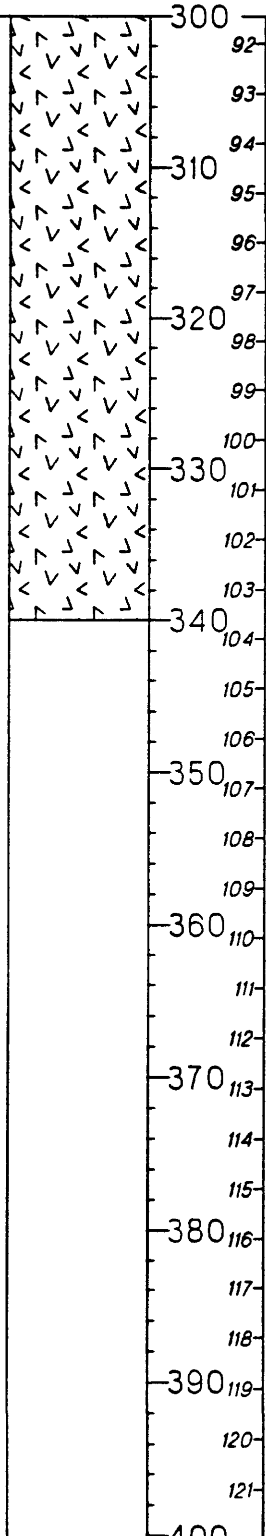


Figure 17. (Continued).

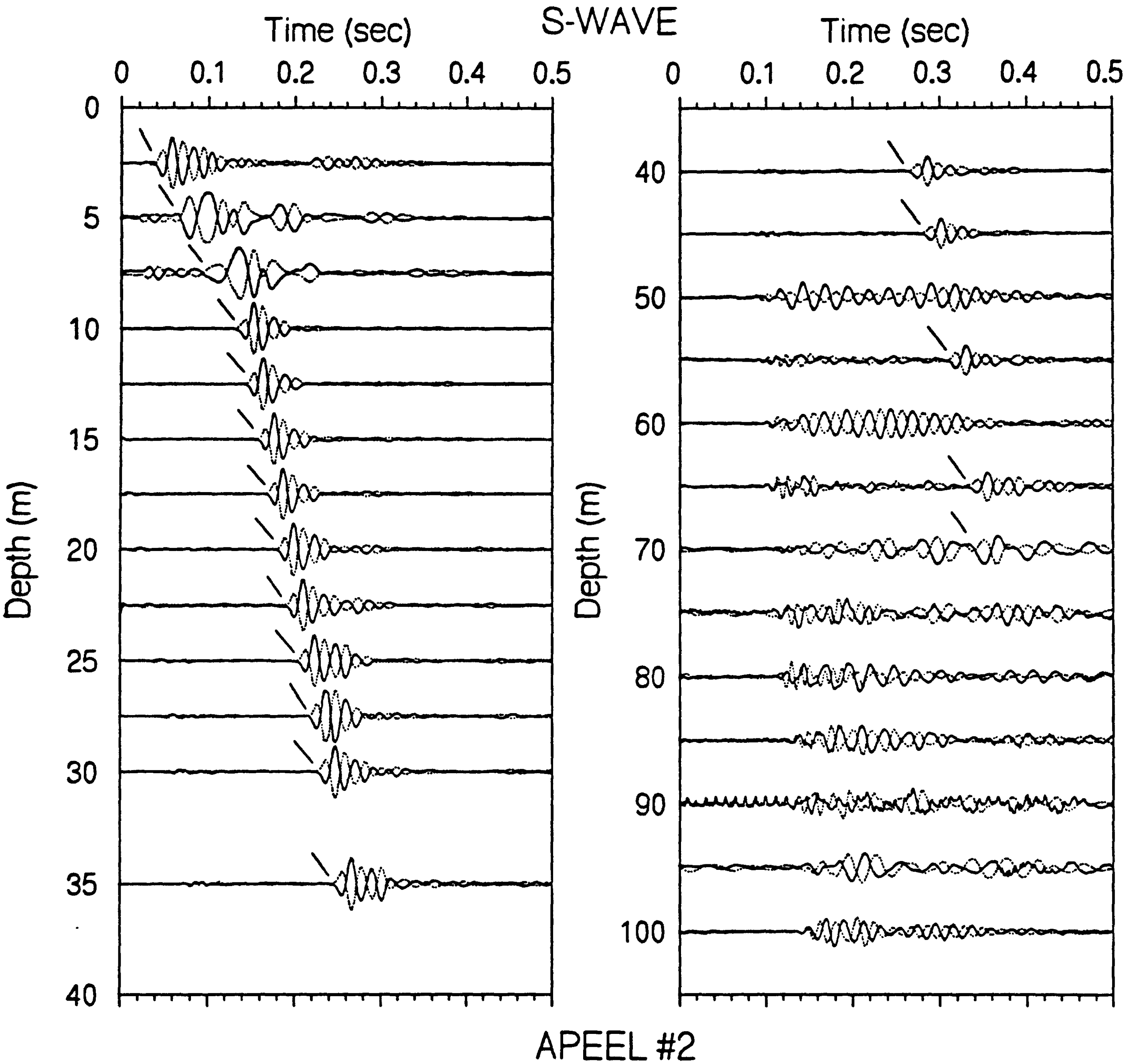


Figure 18. Horizontal-component record section from impacts in opposite horizontal directions superimposed for identification of shear arrivals. S-wave arrivals are shown by the accent marks. An early arriving wave-train starts to build in amplitude at about 50 meters and continues to the bottom of the borehole. Interference to S-wave arrivals below 70 meters made picks too uncertain for velocity determinations .

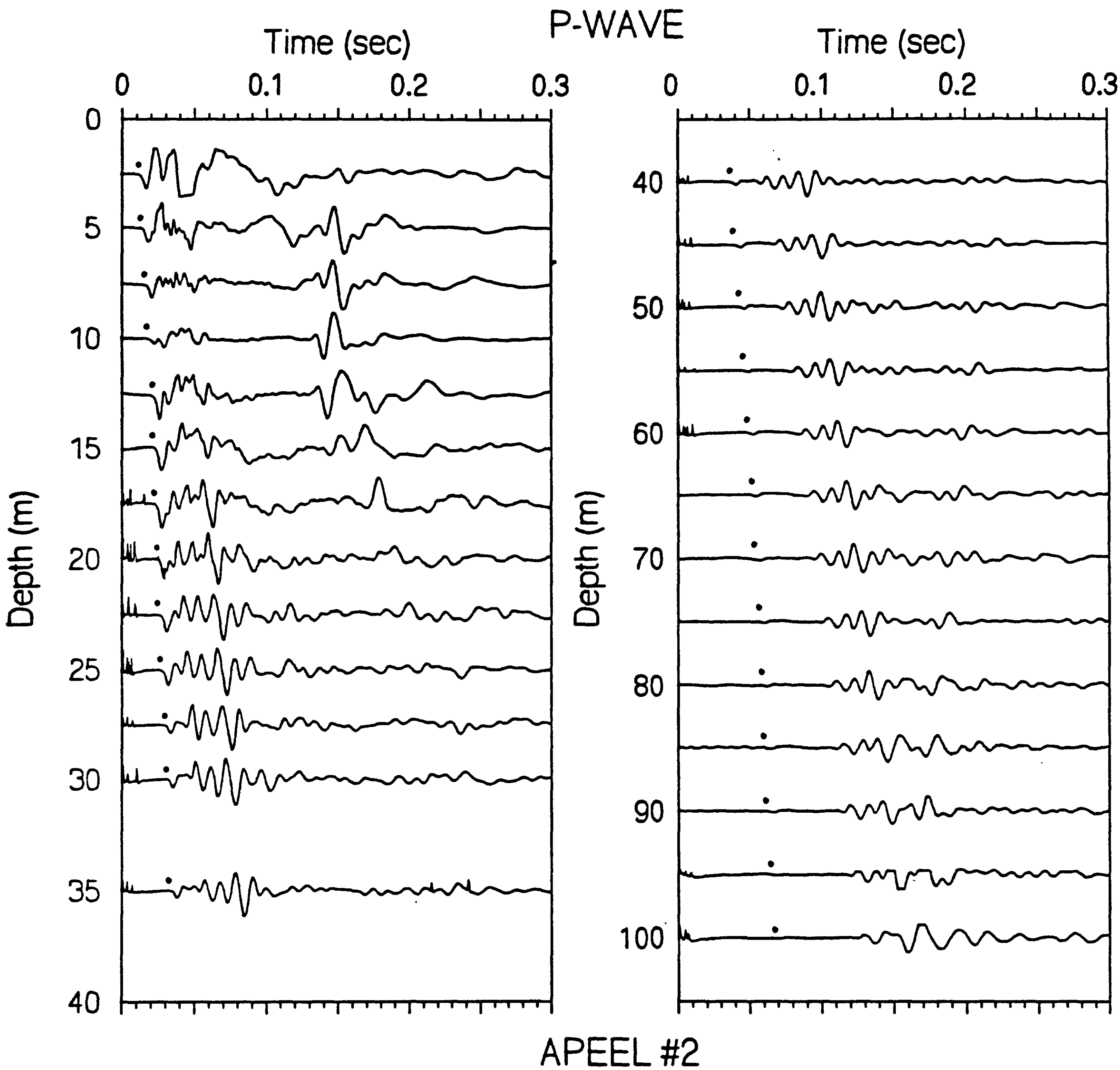


Figure 19. Vertical-component record section. P-waves are shown by the solid circles.

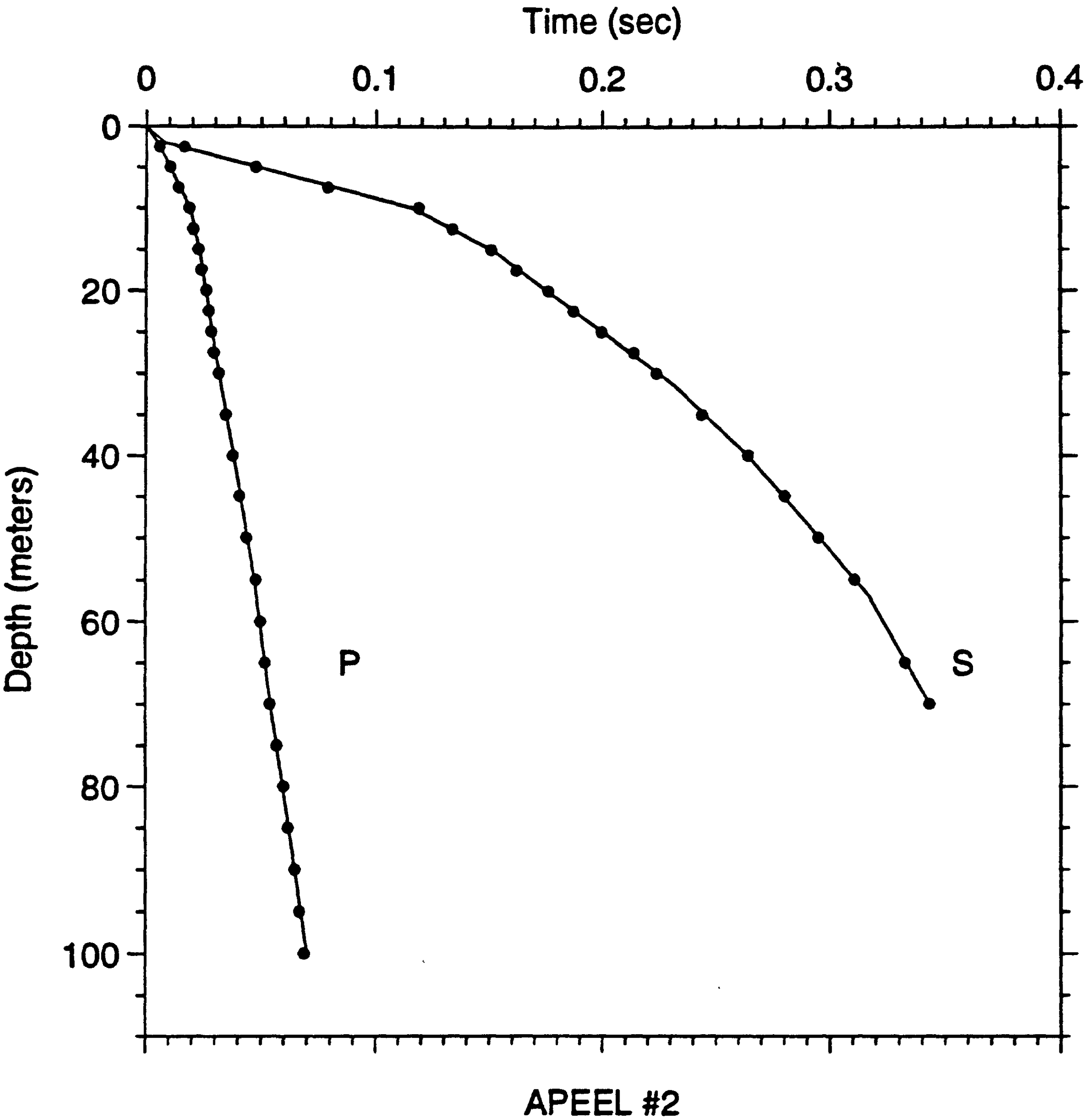


Figure 20. Time-depth graph of P-wave and S-wave picks. Line segments show the hinged-least-squares fit to the data points.

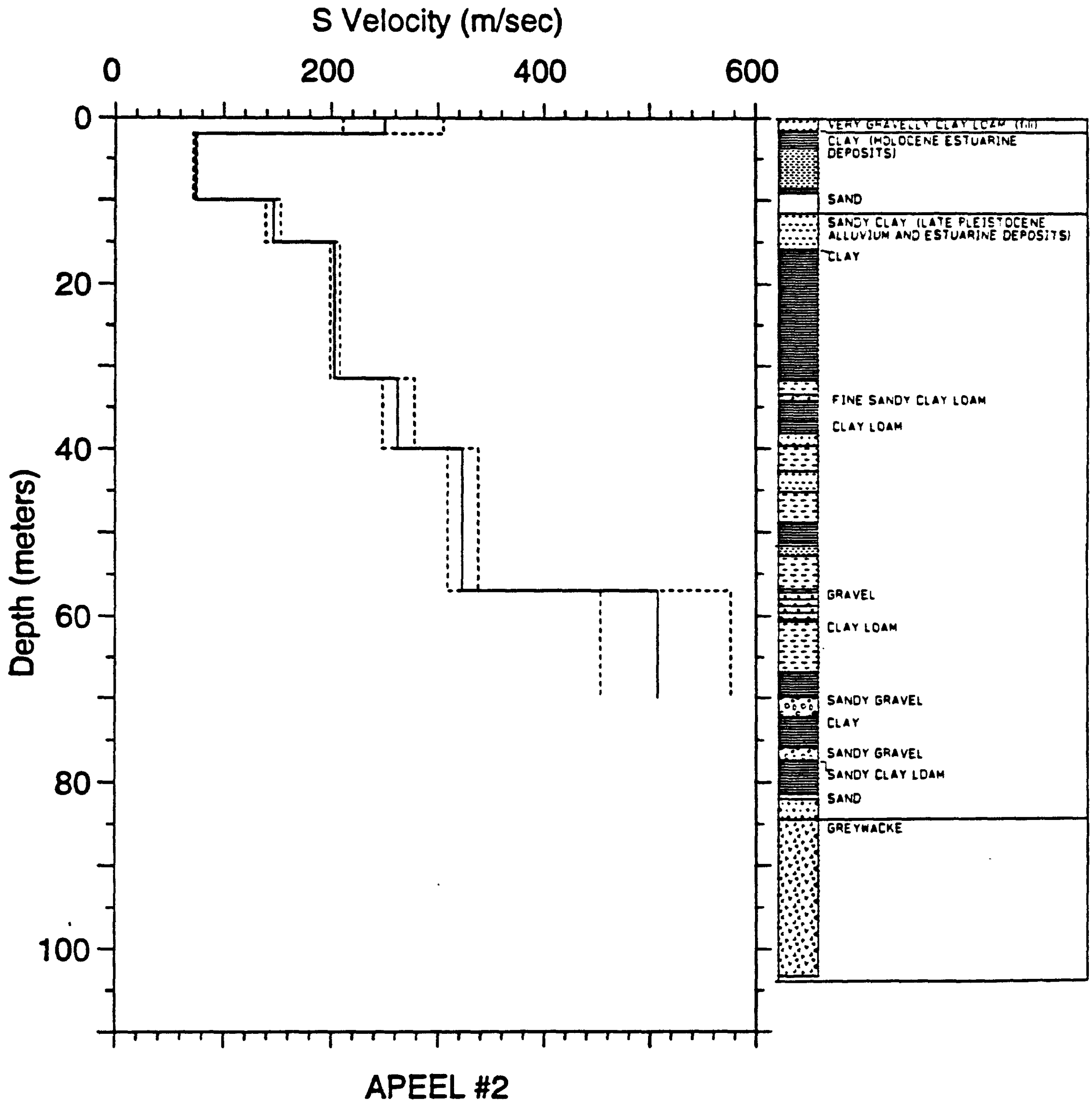


Figure 21. S-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

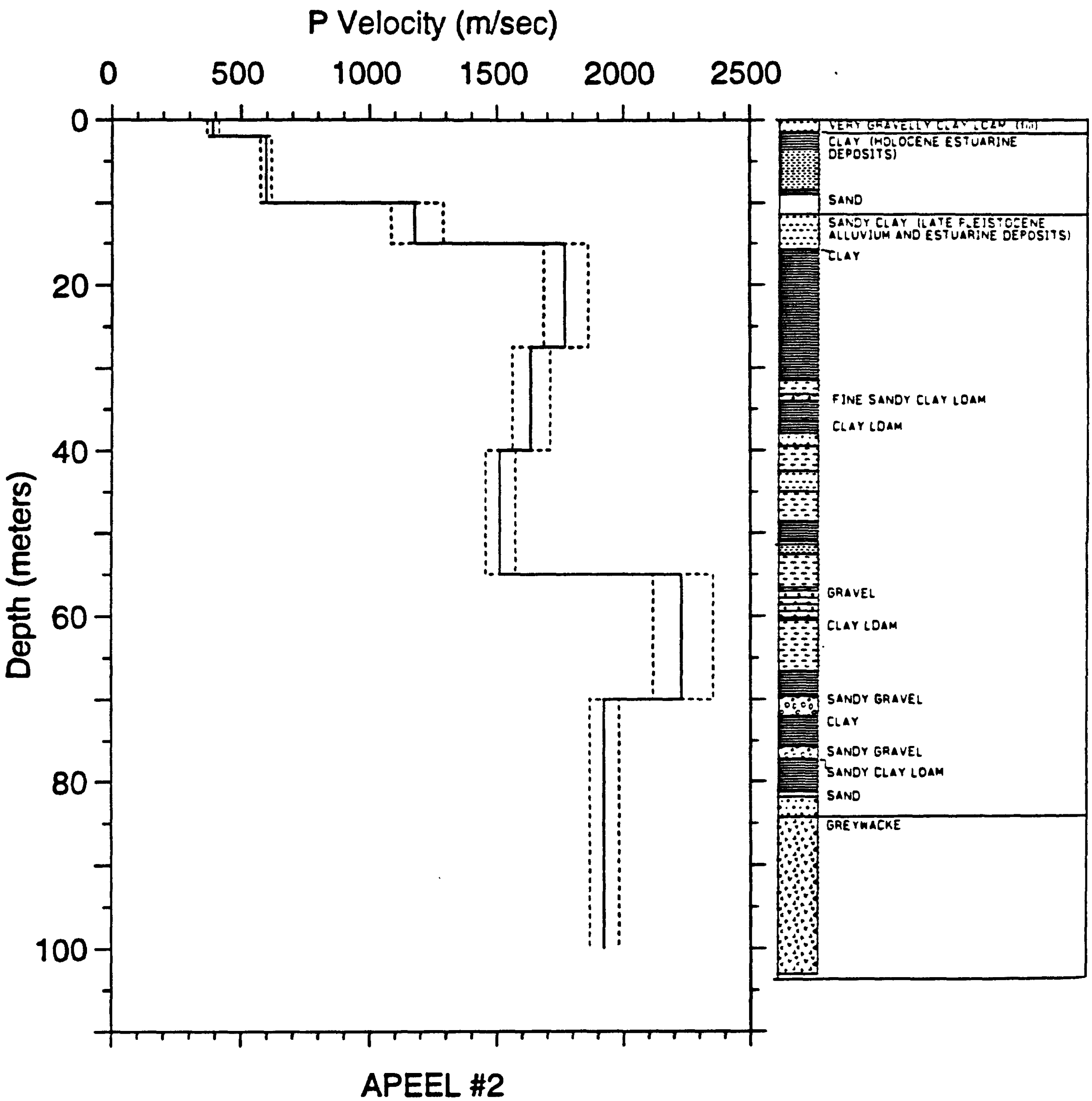


Figure 22. P-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope of the line segments (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

TABLE 3. S-wave arrival times and velocity summaries for APEEL #2.

d(m)	d(ft)	t(sec)	sig	rsdl/sig
2.5	8.2	.0166	1	1.8
5.0	16.4	.0477	1	-1.0
7.5	24.6	.0790	1	-3.5
10.0	32.8	.1190	1	2.6
12.5	41.0	.1337	1	.1
15.0	49.2	.1508	1	.1
17.5	57.4	.1620	1	-1.0
20.0	65.6	.1761	1	.8
22.5	73.8	.1874	1	-.2
25.0	82.0	.1996	1	-.3
27.5	90.2	.2140	1	1.8
30.0	98.4	.2239	1	-.6
35.0	114.8	.2440	1	-1.2
40.0	131.2	.2644	1	.1
45.0	147.6	.2803	1	.5
50.0	164.0	.2950	2	-.1
55.0	180.4	.3107	1	.0
65.0	213.3	.3325	1	-.2
70.0	229.7	.3431	2	.3

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	250	211	305	819	694	999
2.0	6.6	.008	250	211	305	819	694	999
10.0	32.8	.116	74	72	75	242	237	247
15.0	49.2	.151	146	139	153	478	455	503
31.5	103.3	.232	203	199	208	667	653	683
40.0	131.2	.264	262	248	278	860	814	911
57.0	187.0	.317	323	309	338	1059	1013	1109
70.0	229.7	.343	507	453	576	1664	1487	1889

Explanation:
- d(m) = depth in meters
- d(ft) = depth in feet
- t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
- sig = sigma, standard deviation normalized to the standard deviation of best picks
- rsdl/sig = least-squares residual divided by sigma
- dtb(m) = depth to bottom of layer in meters
- dtb(ft) = depth to bottom of layer in feet
- ttb(s) = arrival time in seconds to bottom of layer
- v(m/s) = velocity in meters per second
- vl(m/s) = lower limit of velocity in meters per second *
- vu(m/s) = upper limit of velocity in meters per second
- v(ft/s) = velocity in feet per second
- vl(ft/s) = lower limit of velocity in feet per second
- vu(ft/s) = upper limit of velocity in feet per second

* see text for explanation of velocity limits

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TABLE 4. P-wave arrival times and velocity summaries for APEEL#2.

d(m)	d(ft)	t(sec)	sig	rsdl/sig
2.5	8.2	.0058	1	-.2
5.0	16.4	.0106	1	.4
7.5	24.6	.0141	1	-.3
10.0	32.8	.0188	1	.2
12.5	41.0	.0204	1	-.3
15.0	49.2	.0228	1	.0
17.5	57.4	.0240	1	-.2
20.0	65.6	.0262	1	.5
22.5	73.8	.0273	1	.2
25.0	82.0	.0284	1	-.1
27.5	90.2	.0295	1	-.4
30.0	98.4	.0316	1	.2
35.0	114.8	.0346	1	.1
40.0	131.2	.0377	1	.1
45.0	147.6	.0407	1	-.2
50.0	164.0	.0438	1	-.4
55.0	180.4	.0478	1	.3
60.0	196.9	.0498	1	.1
65.0	213.3	.0518	1	-.2
70.0	229.7	.0539	1	-.3
75.0	246.1	.0569	1	.1
80.0	262.5	.0599	1	.5
85.0	278.9	.0619	1	-.1
90.0	295.3	.0649	1	.3
95.0	311.7	.0669	2	-.2
100.0	328.1	.0689	2	-.5

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	389	367	413	1276	1205	1356
2.0	6.6	.005	389	367	413	1276	1205	1356
10.0	32.8	.019	595	575	616	1951	1887	2021
15.0	49.2	.023	1177	1084	1289	3863	3555	4229
27.5	90.2	.030	1769	1686	1861	5804	5530	6107
40.0	131.2	.038	1633	1561	1711	5356	5121	5614
55.0	180.4	.047	1511	1455	1572	4958	4773	5159
70.0	229.7	.054	2228	2116	2353	7310	6941	7719
100.0	328.1	.070	1922	1865	1982	6306	6119	6504

Explanation:
- d(m) = depth in meters
- d(ft) = depth in feet
- t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
- sig = sigma, standard deviation normalized to the standard deviation of best picks
- rsdl/sig = least-squares residual divided by sigma
- dtb(m) = depth to bottom of layer in meters
- dtb(ft) = depth to bottom of layer in feet
- ttb(s) = arrival time in seconds to bottom of layer
- v(m/s) = velocity in meters per second
- vl(m/s) = lower limit of velocity in meters per second *
- vu(m/s) = upper limit of velocity in meters per second
- v(ft/s) = velocity in feet per second
- vl(ft/s) = lower limit of velocity in feet per second
- vu(ft/s) = upper limit of velocity in feet per second

* see text for explanation of velocity limits

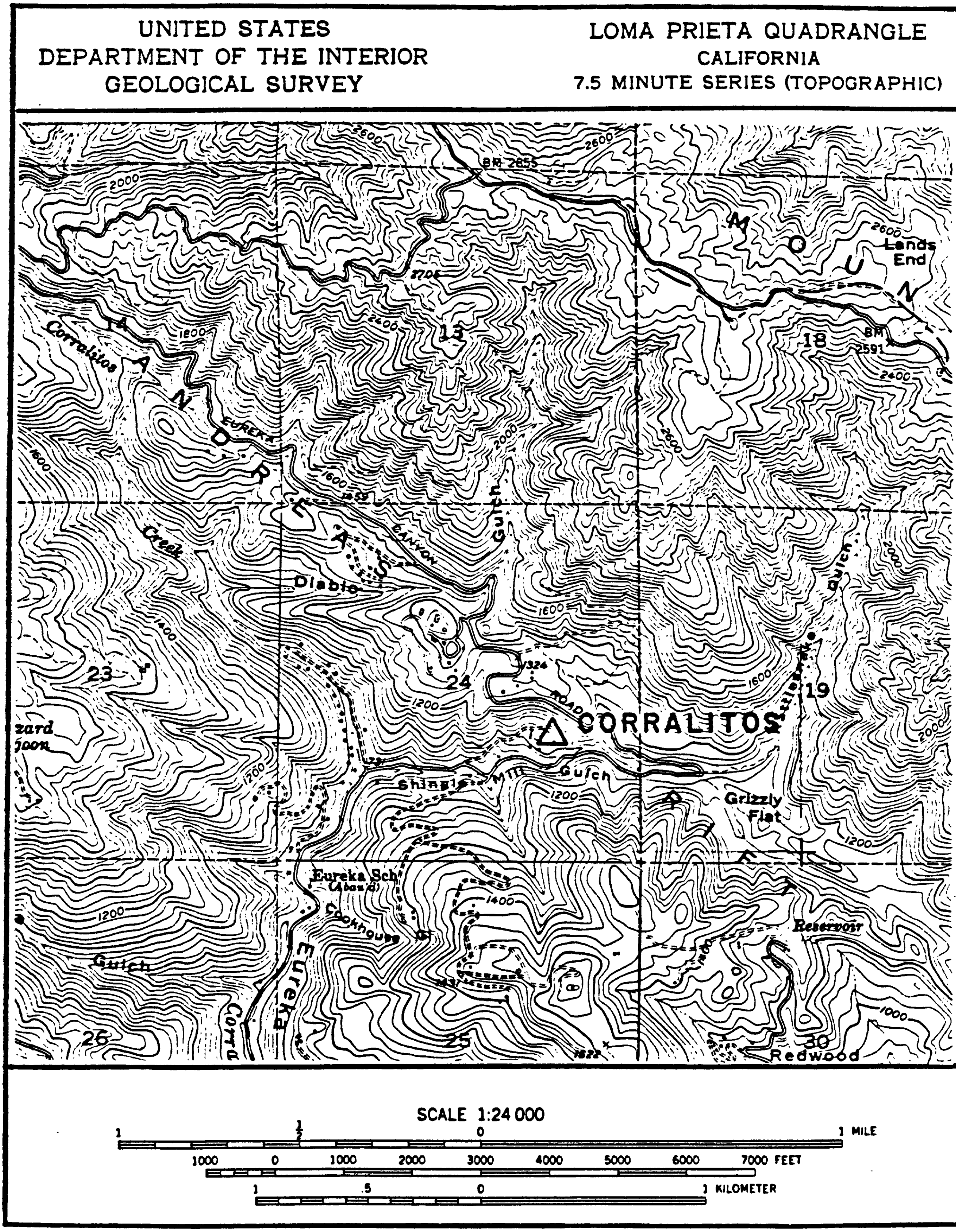


Figure 23. Location map for Corralitos borehole. The borehole is located within 10 meters of the strong-motion accelerograph.

Definitions of terms used for descriptions of sedimentary deposits and bedrock materials

Rock hardness: response to hand and geologic hammer: (Ellen et al., 1972)

hard - hammer bounces off with solid sound
firm - hammer dents with thud, pick point dents or penetrates slightly
soft - pick points penetrates
friable material can be crumbled into individual grains by hand.

Fracture spacing: (Ellen et al., 1972)

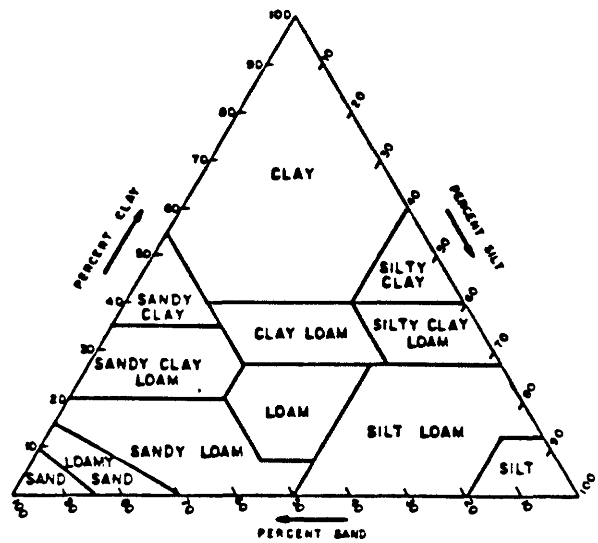
cm	in	fracture spacing
0-1	0-1/2	v. close
1-5	1/2-2	close
5-30	2-12	moderate
30-100	12-36	wide
>100	>36	v. wide

Weathering:
Fresh: no visible signs of weathering
Slight: no visible decomposition of minerals, slight discoloration
Moderate: slight decomposition of minerals and disintegration of rock, deep and thorough discoloration
Deep: extensive decomposition of minerals and complete disintegration of rock but original structure is preserved.

Relative density of sand and consistency of clay is correlated with penetration resistance: (Terzaghi and Peck, 1948)

blows/ft.	relative density	blows/ft.	consistency
0-4	v. loose	<2	v. soft
4-10	loose	2-4	soft
10-30	medium	4-8	medium
30-50	dense	8-15	stiff
>50	v. dense	15-30	v. stiff
		>30	hard

Texture: the relative proportions of clay, silt, and sand below 2mm. Proportions of larger particles are indicated by modifiers of textural class names. Determination is made in the field mainly by feeling the moist soil (Soil Survey, Staff, 1951).



Color: Standard Munsell color names are given for the dominant color of the moist soil and for prominent mottles.

Types of samples

SP - Standard Penetration 1 + 3/8 in-in ID sampler)
S - Thin-wall push sampler
O - Osterberg fixed-piston sampler
P - Pitcher Barrel sampler
CH - California Penetration (2 in ID sampler)
DC - Diamond Core

Figure 24. Explanation of geologic log.

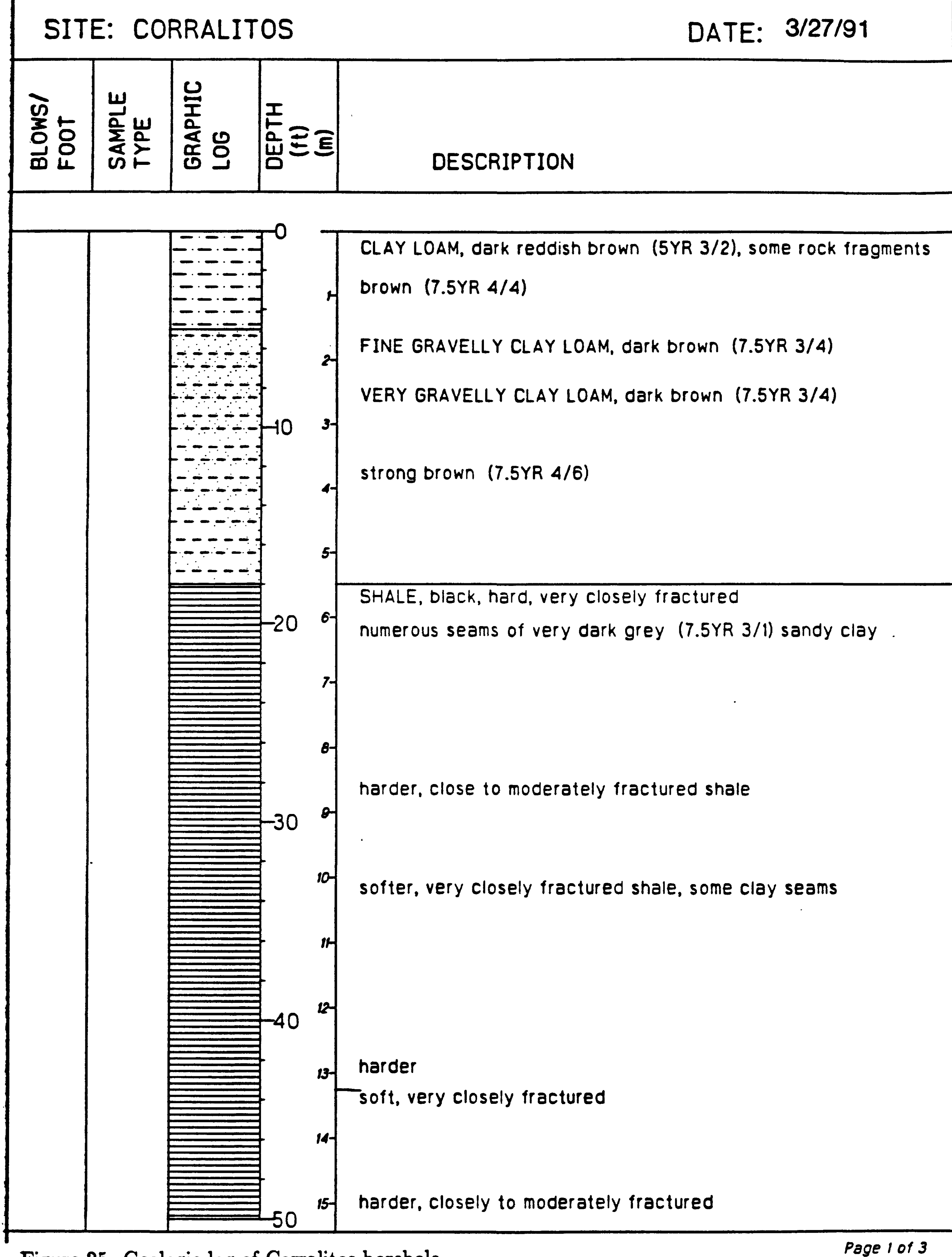


Figure 25. Geologic log of Corralitos borehole.

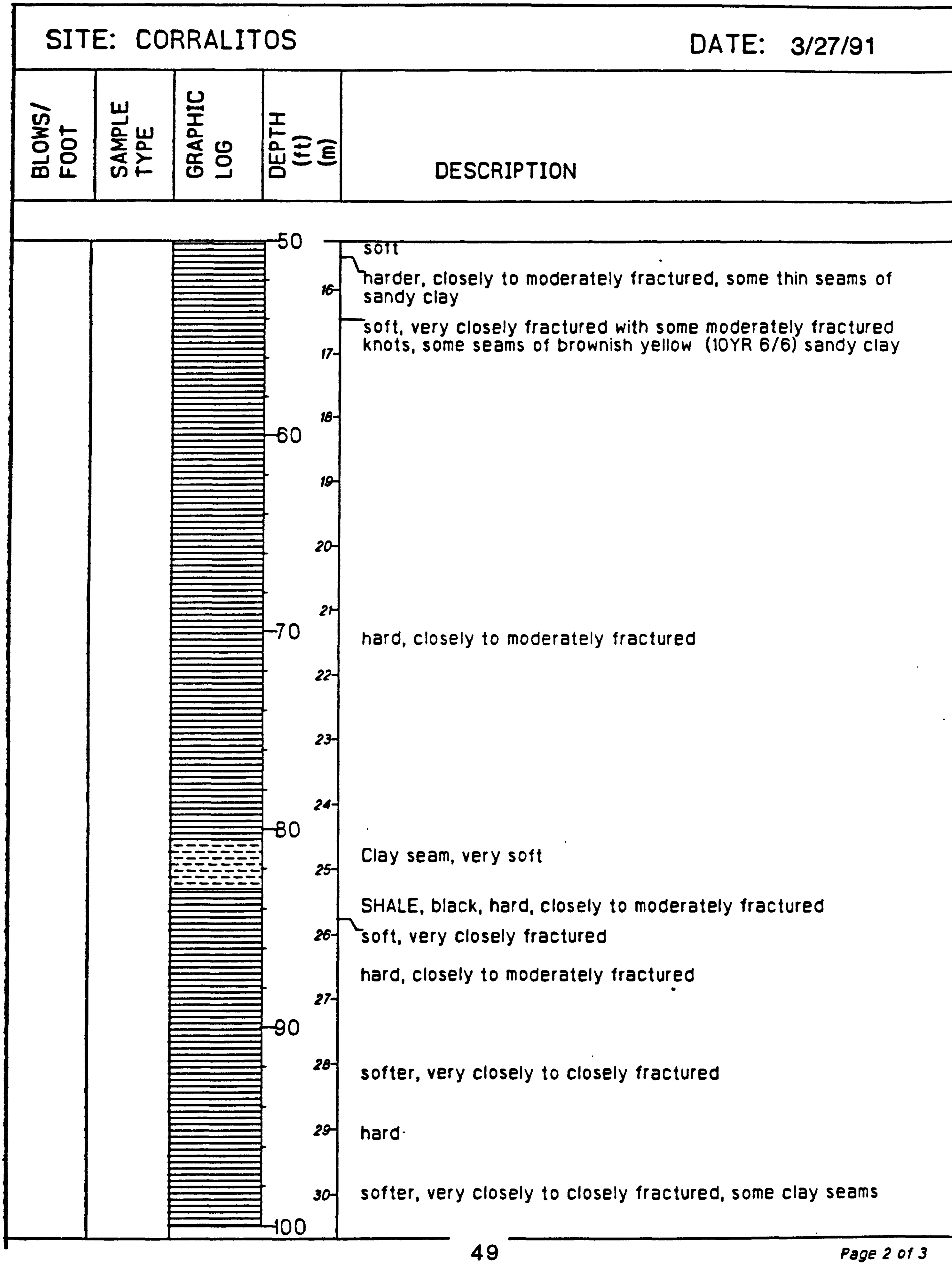


Figure 25. (Continued).

SITE: CORRALITOS DATE: 3/27/91

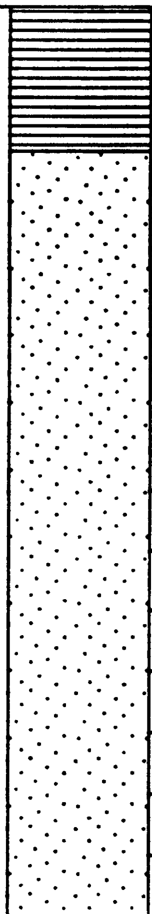
BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft) (m)	DESCRIPTION
			100	
			31	hard, closely to moderately fractured
				softer, very closely to closely fractured
			32	SANDSTONE, grey, fine-grained, very hard, moderately fractured
			33	
			110	
			34	
			35	
			36	
			120	
			37	
			38	
			39	
			130	
			40	
			41	
			42	
			140	
			43	
			44	
			45	
			150	

Figure 25. (Continued).

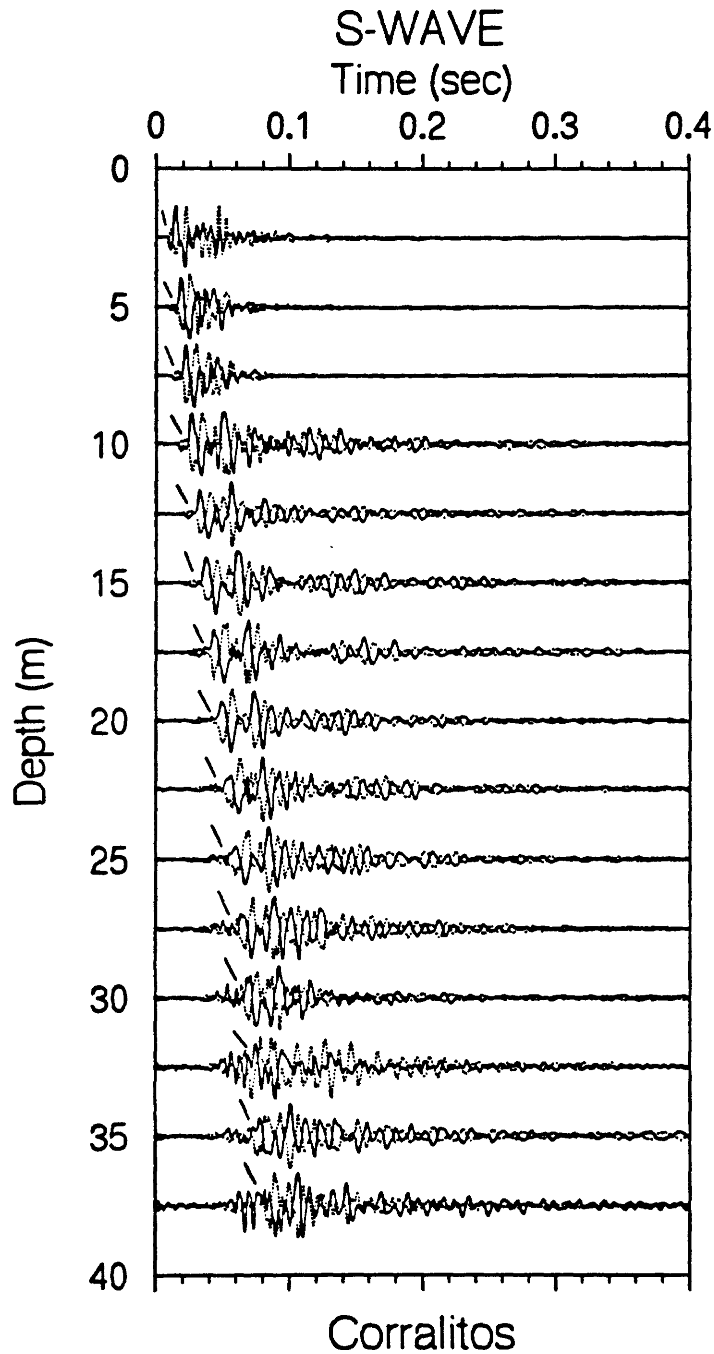


Figure 26. Horizontal-component record section from impacts in opposite horizontal directions superimposed for identification of shear arrivals. S-wave arrivals are shown by the accent marks.

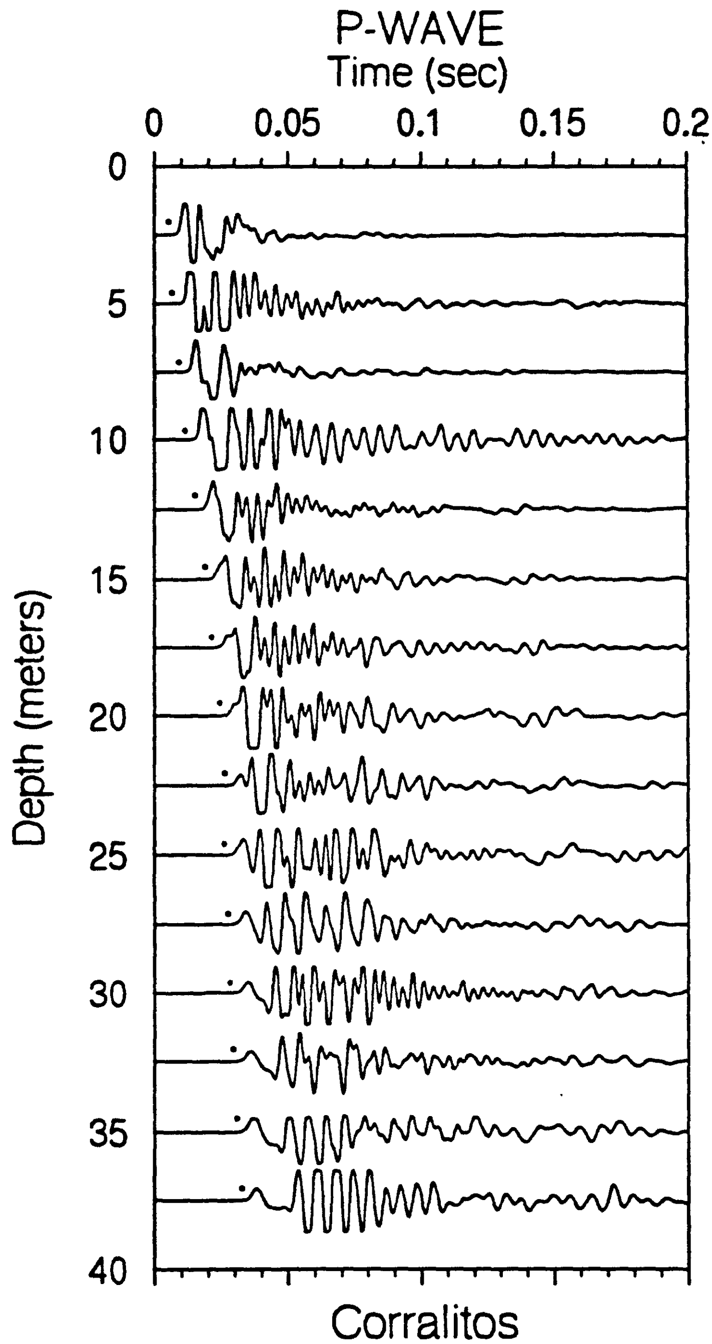


Figure 27. P-wave record section. Approximate location of the picks are shown by the dots.

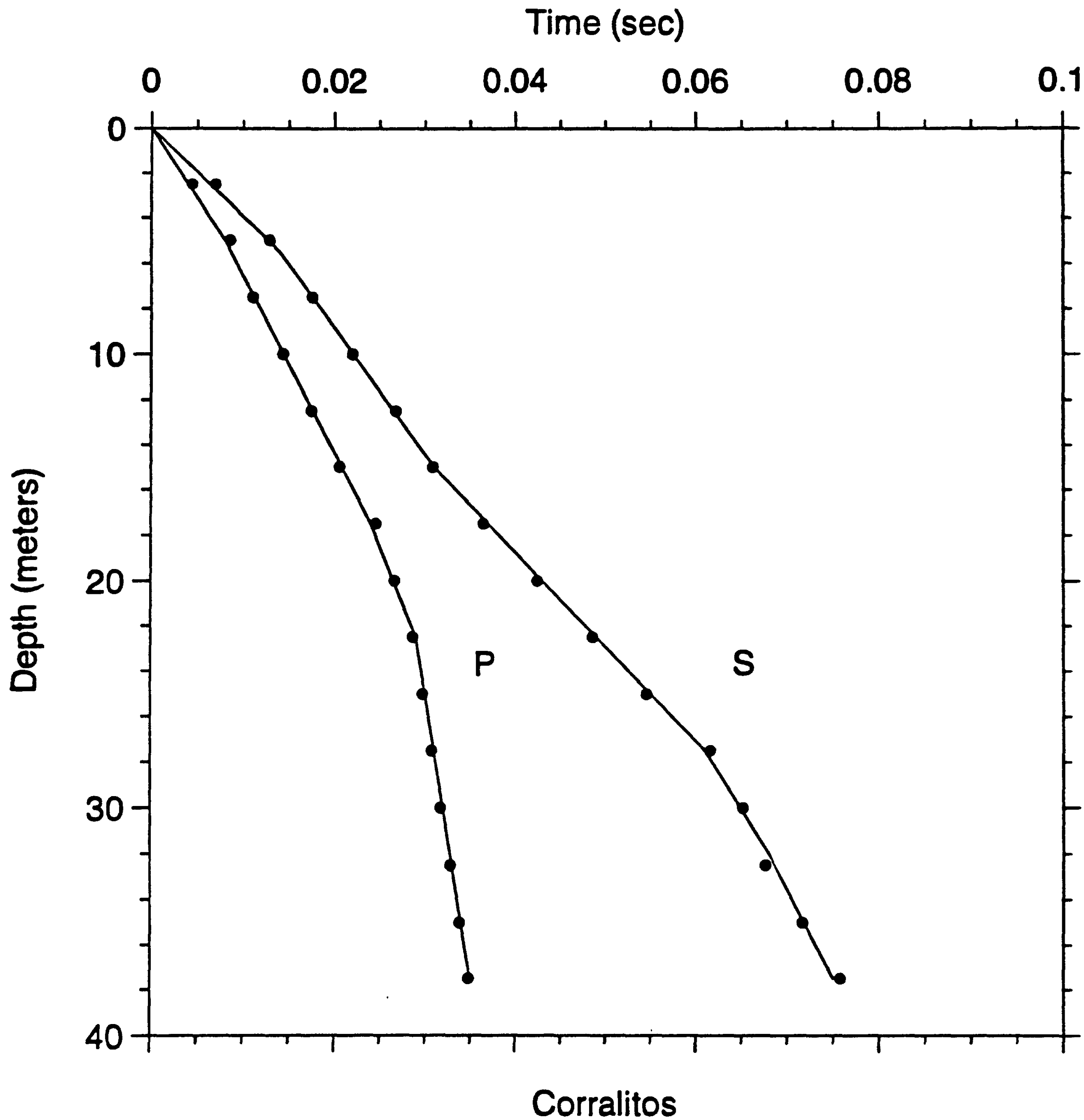


Figure 28. Time-depth graph of P-wave and S-wave picks. Line segments show the hing-least-squares fit to the data.

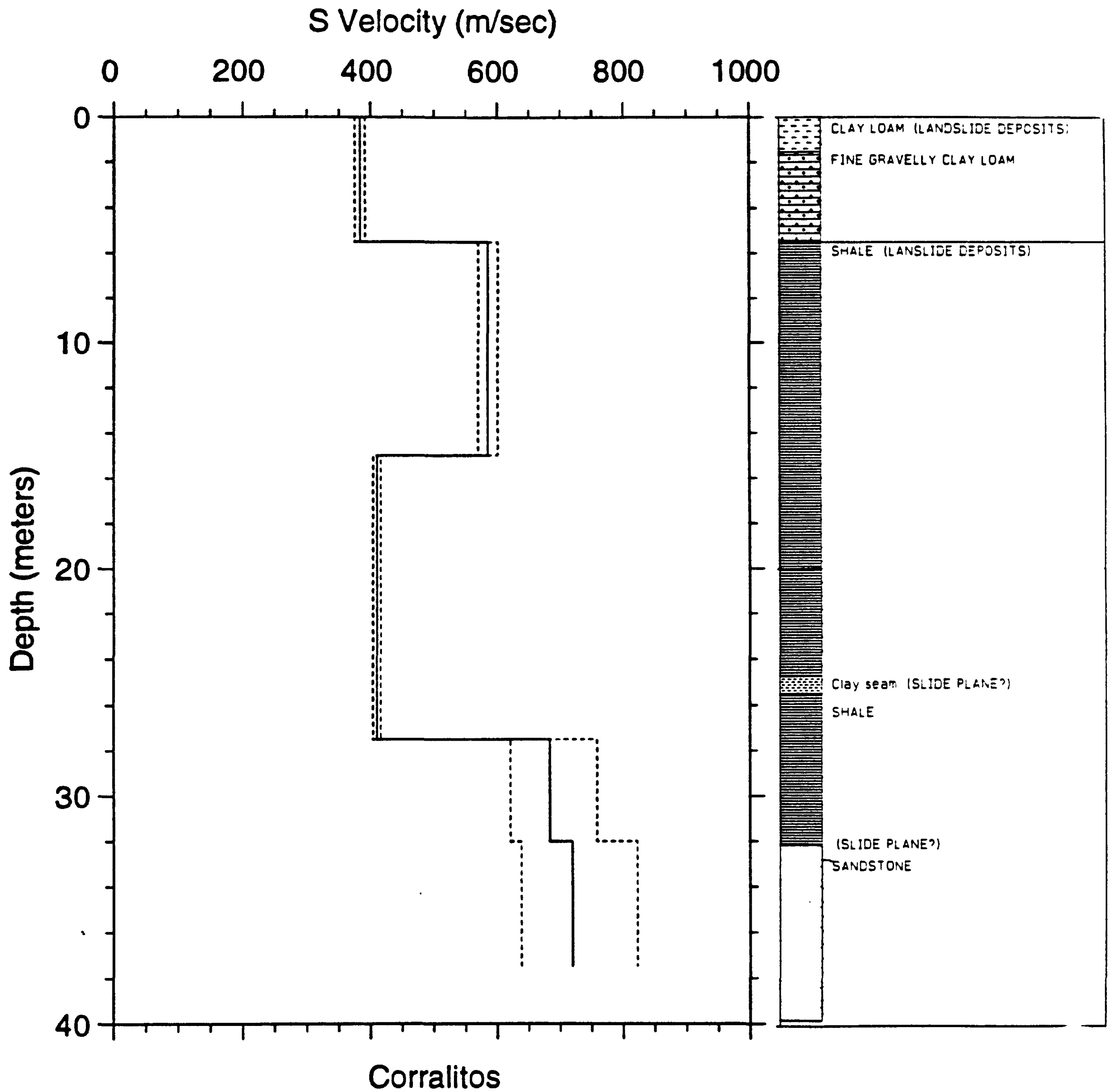


Figure 29. S-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

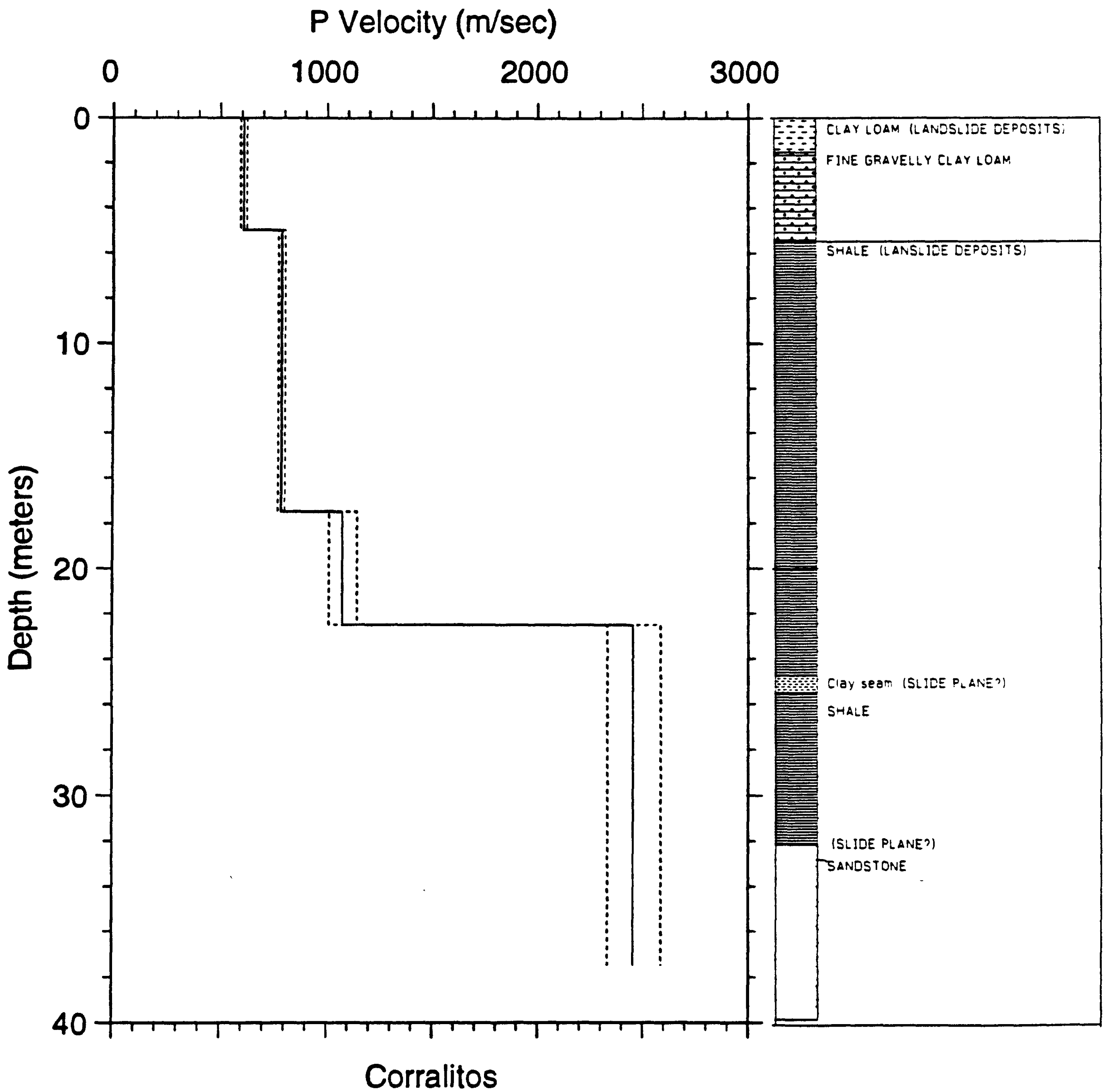


Figure 30. P-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

TABLE 5. S-wave arrival times and velocity summaries for Corralitos.

d(m)	d(ft)	t(sec)	sig	rsdl/sig
2.5	8.2	.0070	1	.5
5.0	16.4	.0129	1	-.2
7.5	24.6	.0176	1	-.2
10.0	32.8	.0220	1	-.1
12.5	41.0	.0268	1	.5
15.0	49.2	.0309	1	.3
17.5	57.4	.0365	1	-.2
20.0	65.6	.0425	1	-.3
22.5	73.8	.0486	1	-.3
25.0	82.0	.0546	1	-.4
27.5	90.2	.0616	1	.5
30.0	98.4	.0652	1	.4
32.5	106.6	.0677	2	-.3
35.0	114.8	.0717	1	-.2
37.5	123.0	.0758	2	.2

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	383	375	391	1256	1230	1282
5.5	18.0	.014	383	375	391	1256	1230	1282
15.0	49.2	.031	585	570	601	1919	1869	1972
27.5	90.2	.061	410	404	416	1345	1326	1364
32.0	105.0	.068	683	621	758	2240	2037	2488
37.5	123.0	.075	719	638	822	2358	2094	2698

Explanation:

d(m) = depth in meters
d(ft) = depth in feet
t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
sig = sigma, standard deviation normalized to the standard deviation of best picks
rsdl/sig = least-squares residual divided by sigma
dtb(m) = depth to bottom of layer in meters
dtb(ft) = depth to bottom of layer in feet
ttb(s) = arrival time in seconds to bottom of layer
v(m/s) = velocity in meters per second
vl(m/s) = lower limit of velocity in meters per second *
vu(m/s) = upper limit of velocity in meters per second
v(ft/s) = velocity in feet per second
vl(ft/s) = lower limit of velocity in feet per second
vu(ft/s) = upper limit of velocity in feet per second
* see text for explanation of velocity limits

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TABLE 6. P-wave arrival times and velocity summaries for Corralitos.

d(m)	d(ft)	t(sec)	sig	rsdl/sig
2.5	8.2	.0045	1	.4
5.0	16.4	.0086	1	.4
7.5	24.6	.0111	1	-.3
10.0	32.8	.0144	1	-.2
12.5	41.0	.0175	1	-.3
15.0	49.2	.0206	1	-.4
17.5	57.4	.0246	1	.5
20.0	65.6	.0267	1	.2
22.5	73.8	.0287	1	-.1
25.0	82.0	.0298	1	.0
27.5	90.2	.0308	1	.0
30.0	98.4	.0318	1	.0
32.5	106.6	.0329	1	.0
35.0	114.8	.0339	1	.0
37.5	123.0	.0349	1	.0

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	607	593	622	1991	1945	2039
5.0	16.4	.008	607	593	622	1991	1945	2039
17.5	57.4	.024	787	771	803	2580	2530	2633
22.5	73.8	.029	1074	1012	1143	3523	3321	3751
37.5	123.0	.035	2453	2333	2586	8047	7654	8483

Explanation:
- d(m) = depth in meters
- d(ft) = depth in feet
- t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
- sig = sigma, standard deviation normalized to the standard deviation of best picks
- rsdl/sig = least-squares residual divided by sigma
- dtb(m) = depth to bottom of layer in meters
- dtb(ft) = depth to bottom of layer in feet
- ttb(s) = arrival time in seconds to bottom of layer
- v(m/s) = velocity in meters per second
- vl(m/s) = lower limit of velocity in meters per second *
- vu(m/s) = upper limit of velocity in meters per second
- v(ft/s) = velocity in feet per second
- vl(ft/s) = lower limit of velocity in feet per second
- vu(ft/s) = upper limit of velocity in feet per second

* see text for explanation of velocity limits

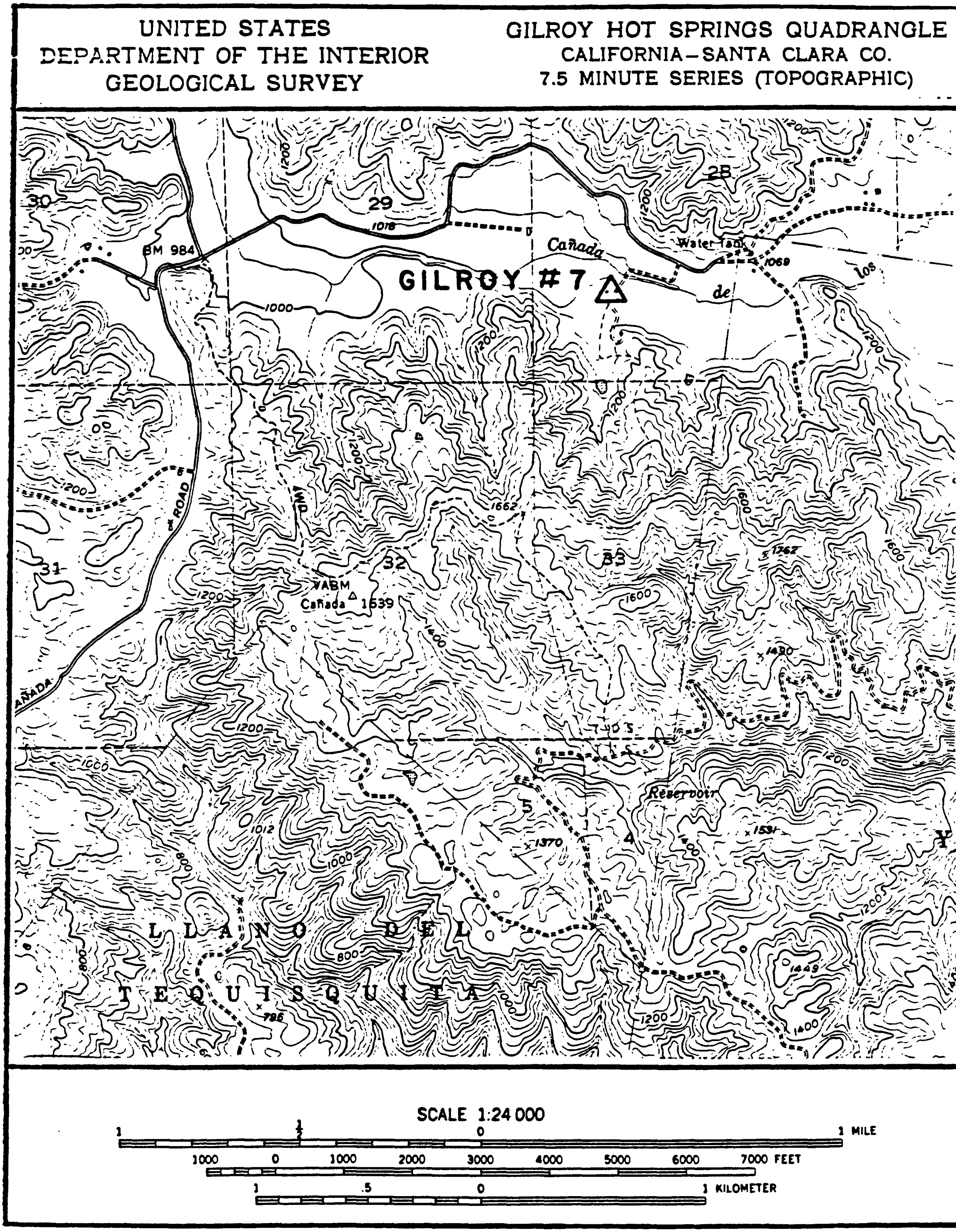


Figure 31. Location map for Gilroy #7 borehole. The strong-motion accelerograph is located within 10 meters of the borehole.

Definitions of terms used for descriptions of sedimentary deposits and bedrock materials

Rock hardness: response to hand and geologic hammer: (Ellen et al., 1972)

hard - hammer bounces off with solid sound
firm - hammer dents with thud, pick point dents or penetrates slightly
soft - pick points penetrates
friable material can be crumbled into individual grains by hand.

Fracture spacing: (Ellen et al., 1972)

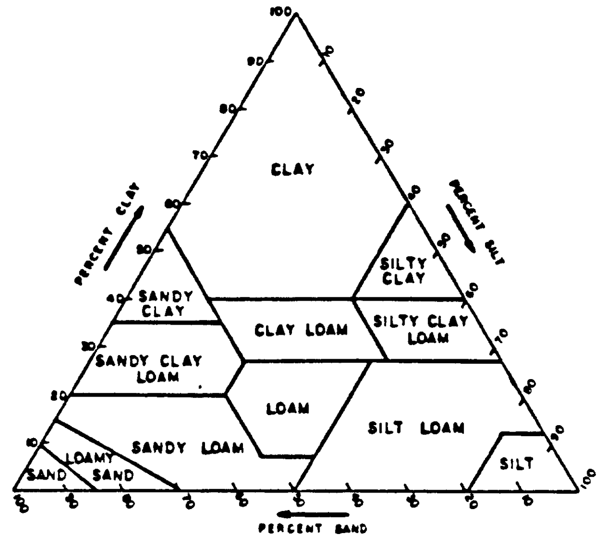
cm	in	fracture spacing
0-1	0-1/2	v. close
1-5	1/2-2	close
5-30	2-12	moderate
30-100	12-36	wide
>100	>36	v. wide

Weathering:
Fresh: no visible signs of weathering
Slight: no visible decomposition of minerals, slight discoloration
Moderate: slight decomposition of minerals and disintegration of rock, deep and thorough discoloration
Deep: extensive decomposition of minerals and complete disintegration of rock but original structure is preserved.

Relative density of sand and consistency of clay is correlated with penetration resistance: (Terzaghi and Peck, 1948)

blows/ft.	relative density	blows/ft.	consistency
0-4	v. loose	<2	v. soft
4-10	loose	2-4	soft
10-30	medium	4-8	medium
30-50	dense	8-15	stiff
>50	v. dense	15-30	v. stiff
		>30	hard

Texture: the relative proportions of clay, silt, and sand below 2mm. Proportions of larger particles are indicated by modifiers of textural class names. Determination is made in the field mainly by feeling the moist soil (Soil Survey, Staff, 1951).



Color: Standard Munsell color names are given for the dominant color of the moist soil and for prominent mottles.

Types of samples

SP - Standard Penetration 1+3/8 in in ID sampler)
S - Thin-wall push sampler
O - Osterberg fixed-piston sampler
P - Pitcher Barrel sampler
CH - California Penetration (2 in ID sampler)
DC - Diamond Core

Figure 32. Explanation of geologic log.

SITE: GILROY 7 - MANTELLI RANCH DATE: 4/1/91

BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft)	DEPTH (m)	DESCRIPTION
			0		CLAY LOAM, very dark greyish brown (10YR 3/2)
				1	
				2	GRAVELLY SANDY CLAY LOAM, dark brown (7.5YR 3/2), very poorly sorted, sandstone pebbles to 3 cm
			10	3	
				4	GRAVELLY CLAY LOAM, dark brown (7.5YR 3/2), 10-20% gravel (mostly sandstone, some shale), very stiff
				5	sandier
			20	6	
				7	
					SANDY CLAY LOAM, dark brown (7.5YR 3/4), sand to very coarse
				8	
				9	GRAVELLY CLAY LOAM very poorly sorted, 10-15% fine gravel (mostly shale
			30		
				10	SANDY CLAY LOAM, dark brown, very poorly sorted, some gravel, very stiff
				11	
				12	
			40		
					CLAY LOAM, dark brown (10YR 3/3)
				13	
				14	
				15	GRAVELLY SANDY LOAM
			50		

Figure 33. Geologic log of Gilroy #7 borehole.

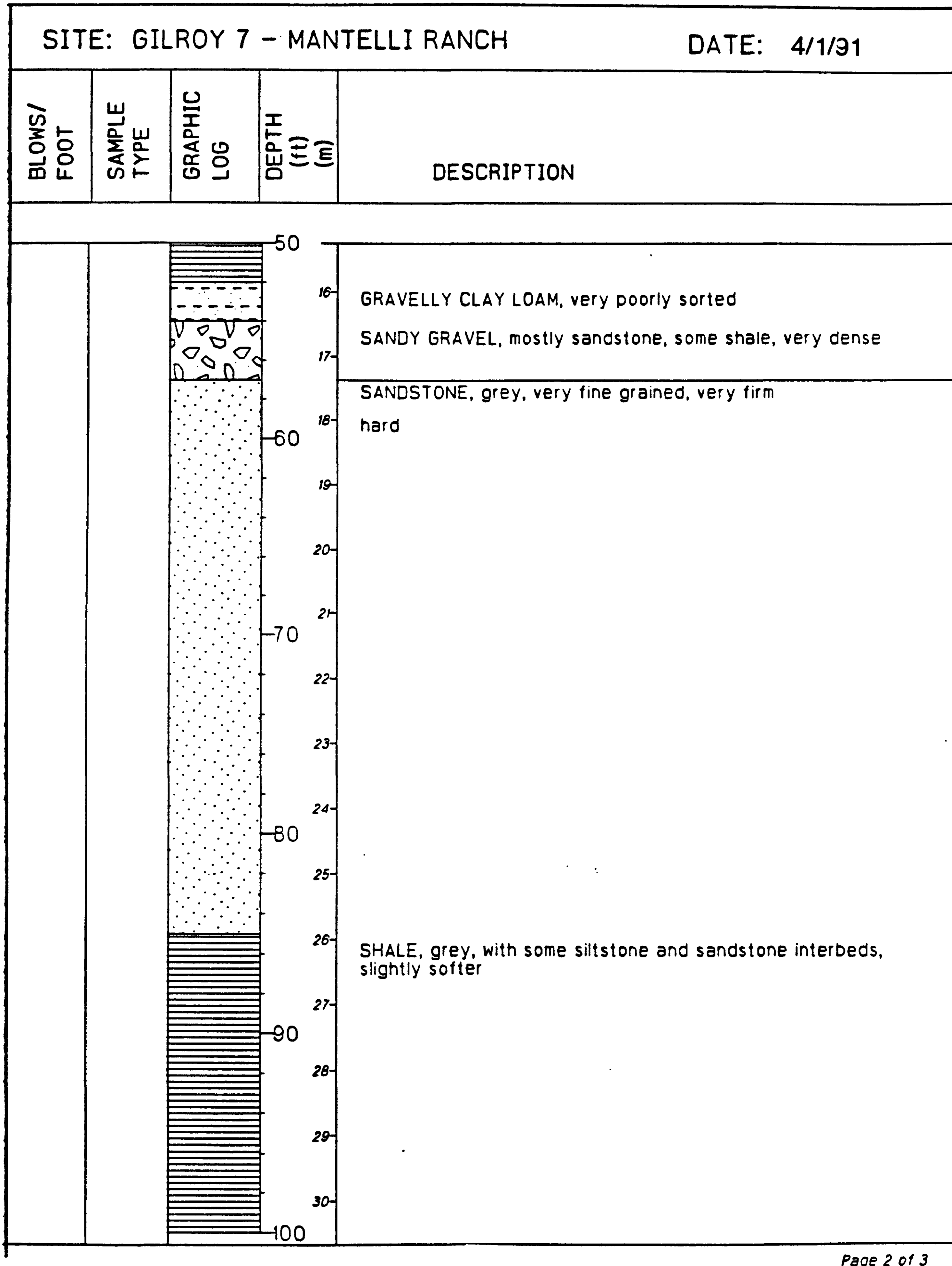


Figure 33 (Continued).

SITE: GILROY 7 - MANTELLI RANCH DATE: 4/1/91

BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft) (m)	DESCRIPTION

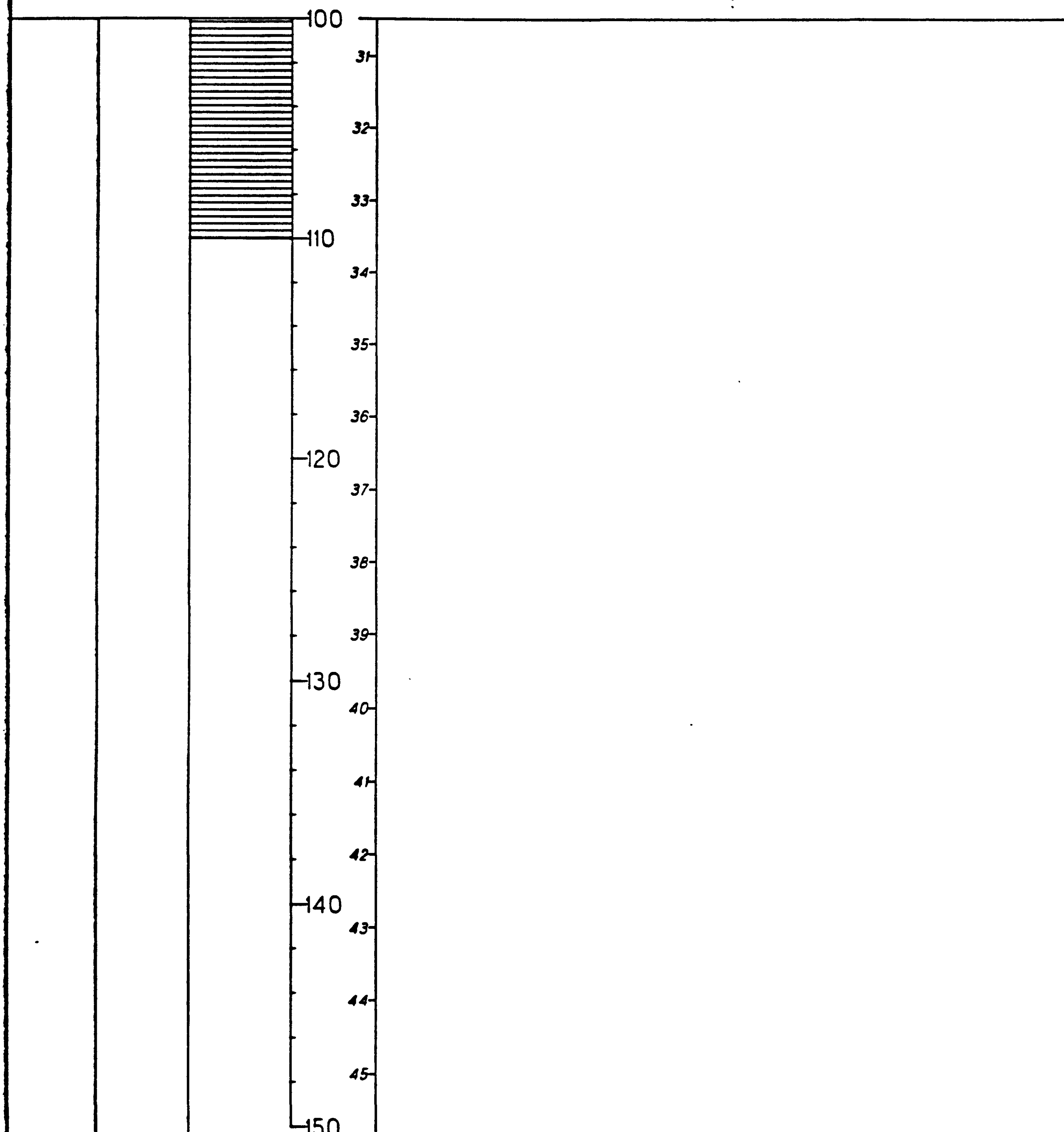


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Figure 33 (Continued).

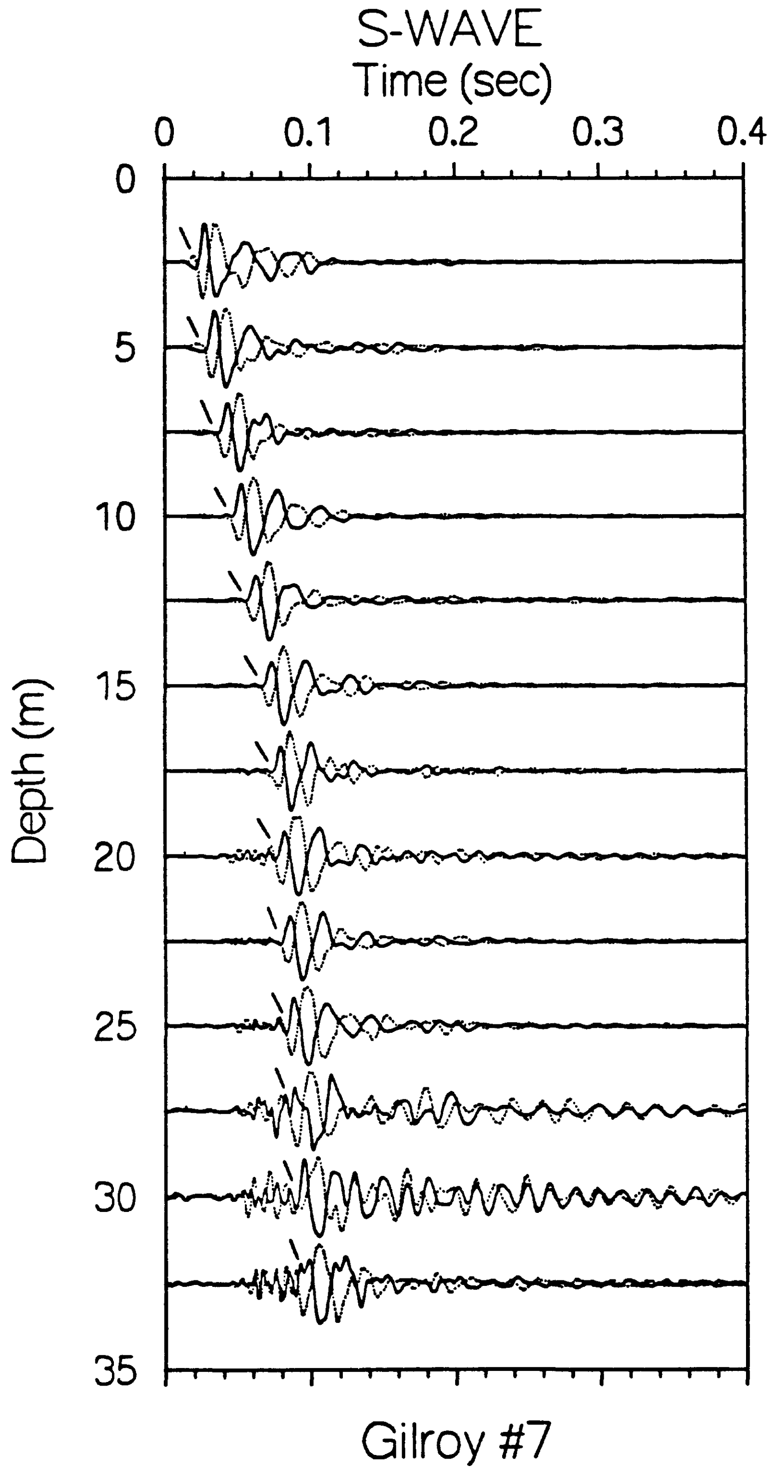


Figure 34. Horizontal-component record section from impacts in opposite horizontal directions superimposed for identification of shear arrivals. S-wave arrivals are shown by the accent marks.

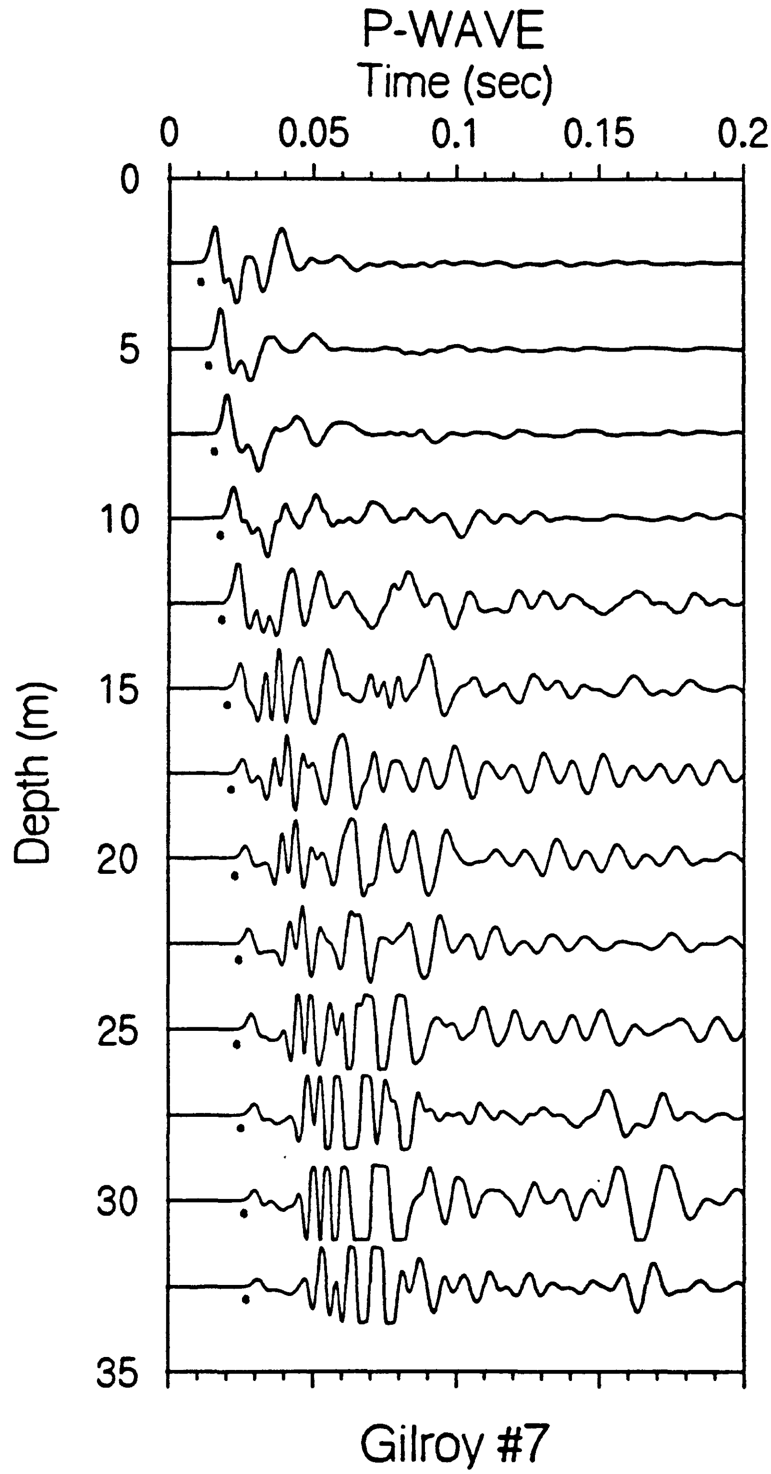


Figure 35. Vertical-component record section. P-wave arrivals are shown by the solid circles.

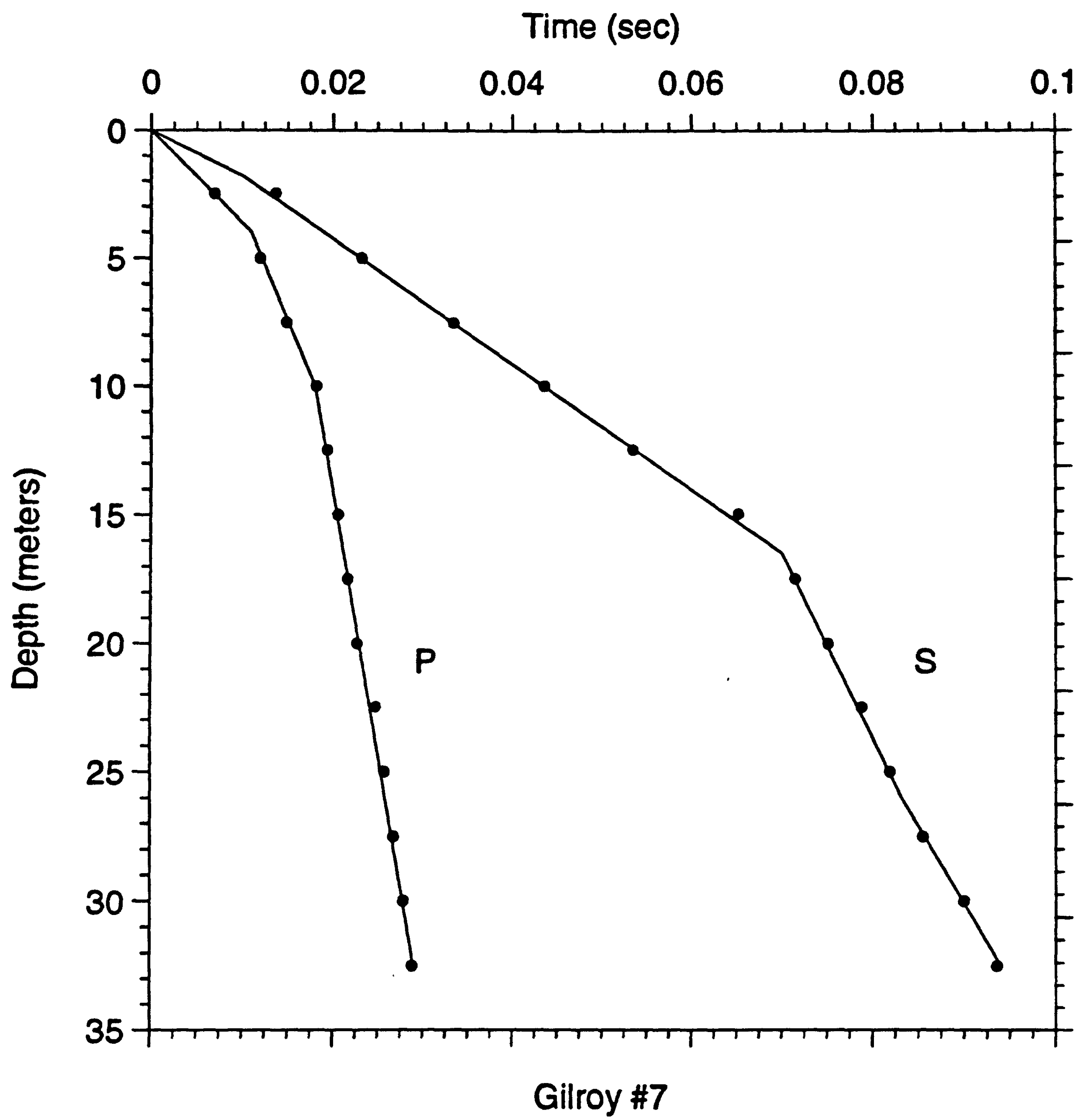
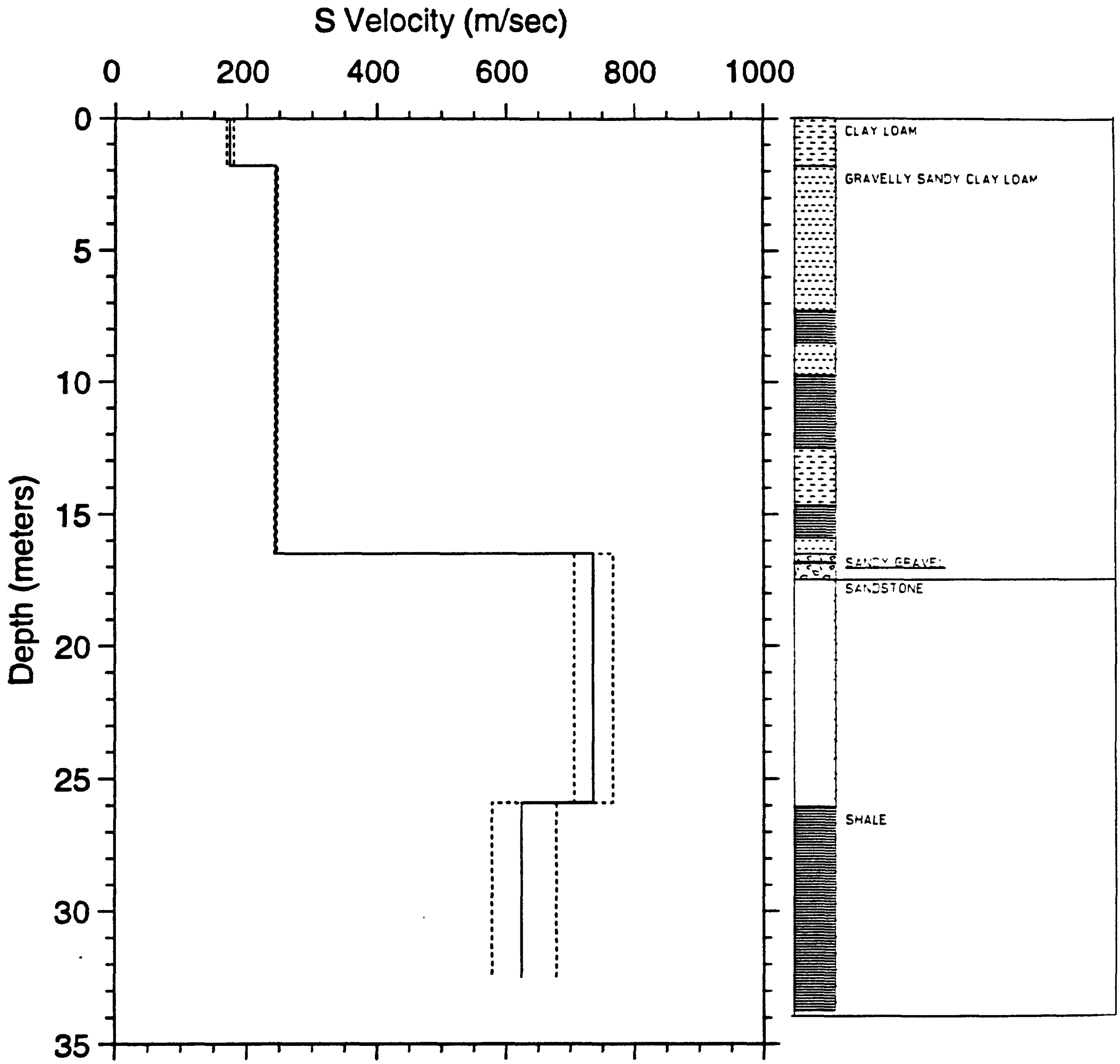


Figure 36. Time-depth graph of P-wave and S-wave picks. Line segments show the hinged-least-squares fit to the data points.



Gilroy #7

Figure 37. S-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

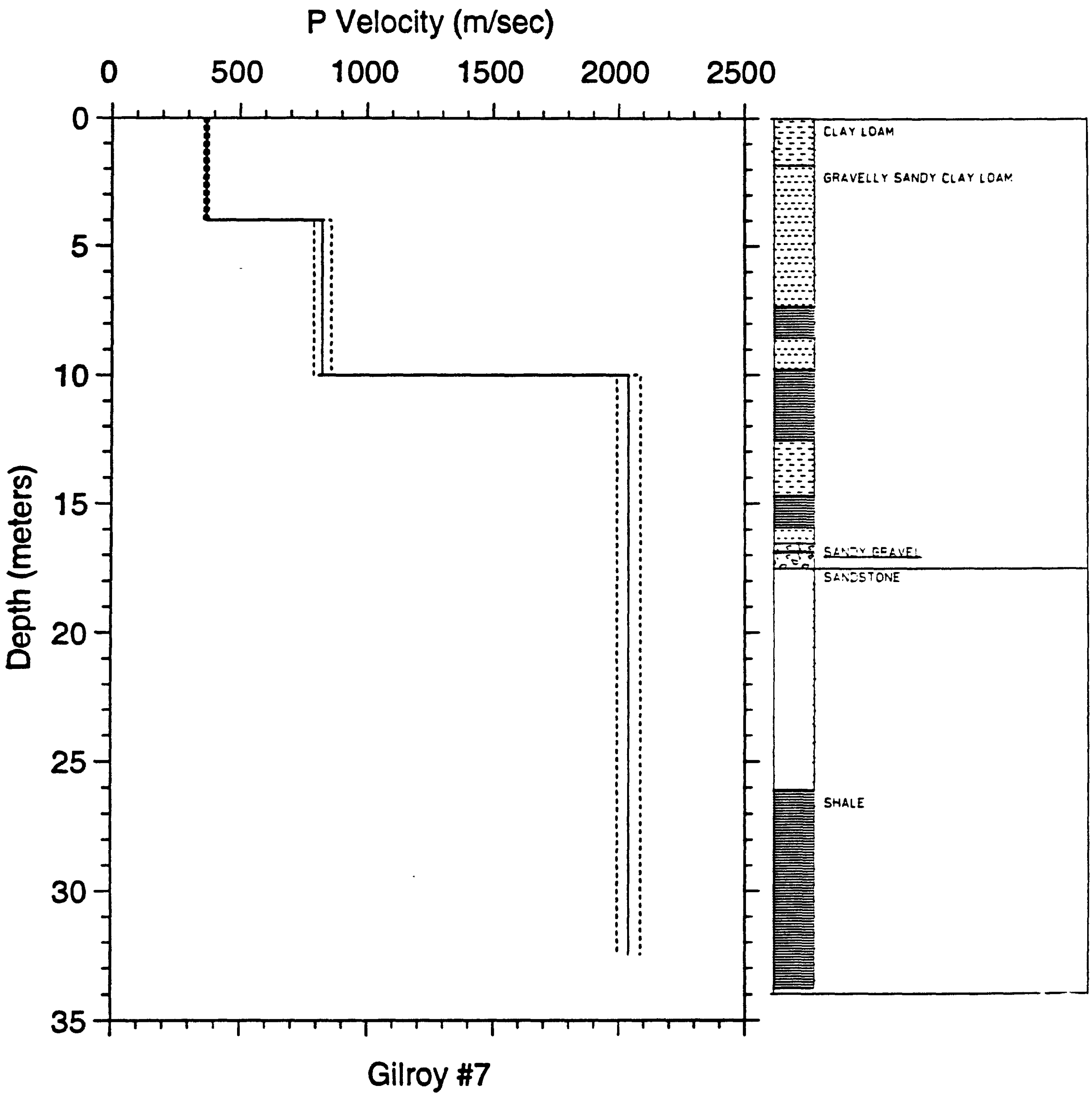


Figure 38. P-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

TABLE 7. S-wave arrival times and velocity summaries for Gilroy #7 (USGS).

d(m)	d(ft)	t(sec)	sig	rsdl/sig
2.5	8.2	.0137	1	.5
5.0	16.4	.0232	1	-.2
7.5	24.6	.0334	1	-.2
10.0	32.8	.0436	1	-.2
12.5	41.0	.0535	1	-.6
15.0	49.2	.0652	1	.9
17.5	57.4	.0715	1	-.3
20.0	65.6	.0751	1	-.1
22.5	73.8	.0788	1	.2
25.0	82.0	.0819	1	-.1
27.5	90.2	.0855	2	-.2
30.0	98.4	.0900	2	.2
32.5	106.6	.0936	2	-.1

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	174	169	180	571	553	590
1.8	5.9	.010	174	169	180	571	553	590
16.5	54.1	.070	245	243	247	803	796	810
25.9	85.0	.083	735	706	766	2410	2315	2514
32.5	106.6	.094	624	578	678	2049	1897	2226

Explanation:

d(m) = depth in meters
d(ft) = depth in feet
t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
sig = sigma, standard deviation normalized to the standard deviation of best picks
rsdl/sig = least-squares residual divided by sigma
dtb(m) = depth to bottom of layer in meters
dtb(ft) = depth to bottom of layer in feet
ttb(s) = arrival time in seconds to bottom of layer
v(m/s) = velocity in meters per second
vl(m/s) = lower limit of velocity in meters per second *
vu(m/s) = upper limit of velocity in meters per second
v(ft/s) = velocity in feet per second
vl(ft/s) = lower limit of velocity in feet per second
vu(ft/s) = upper limit of velocity in feet per second

* see text for explanation of velocity limits

TABLE 8. P-wave arrival times and velocity summaries for Gilroy #7 (USGS).

d(m)	d(ft)	t(sec)	sig	rsdl/sig
2.5	8.2	.0070	1	.2
5.0	16.4	.0120	1	-.1
7.5	24.6	.0149	1	-.2
10.0	32.8	.0182	1	.1
12.5	41.0	.0194	1	.0
15.0	49.2	.0206	1	.0
17.5	57.4	.0217	1	-.1
20.0	65.6	.0227	1	-.4
22.5	73.8	.0248	1	.5
25.0	82.0	.0258	1	.3
27.5	90.2	.0268	1	.1
30.0	98.4	.0279	1	-.1
32.5	106.6	.0289	1	-.3

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	369	361	377	1210	1184	1237
4.0	13.1	.011	369	361	377	1210	1184	1237
10.0	32.8	.018	822	789	857	2696	2589	2813
32.5	106.6	.029	2038	1993	2086	6687	6538	6844

Explanation:

d(m) = depth in meters
d(ft) = depth in feet
t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
sig = sigma, standard deviation normalized to the standard deviation of best picks
rsdl/sig = least-squares residual divided by sigma
dtb(m) = depth to bottom of layer in meters
dtb(ft) = depth to bottom of layer in feet
ttb(s) = arrival time in seconds to bottom of layer
v(m/s) = velocity in meters per second
vl(m/s) = lower limit of velocity in meters per second *
vu(m/s) = upper limit of velocity in meters per second
v(ft/s) = velocity in feet per second
vl(ft/s) = lower limit of velocity in feet per second
vu(ft/s) = upper limit of velocity in feet per second
* see text for explanation of velocity limits

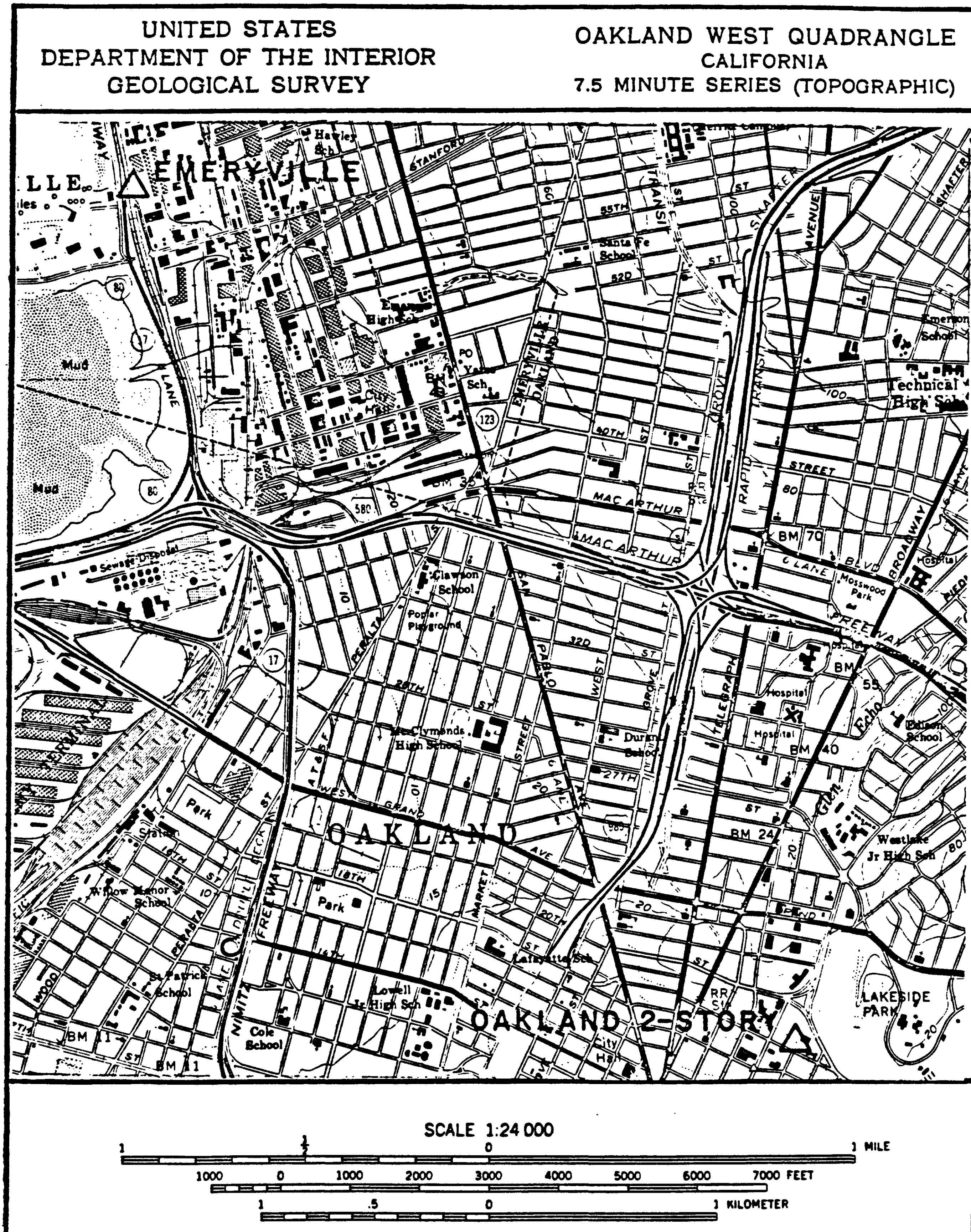


Figure 39. Site location map for Oakland 2-Story (Snow Park) and Emeryville (not in this report). The strong-motion accelerograph is located approximately 150 to 200 meters from the borehole.

Definitions of terms used for descriptions of sedimentary deposits and bedrock materials

Rock hardness: response to hand and geologic hammer: (Ellen et al., 1972)

hard - hammer bounces off with solid sound
firm - hammer dents with thud, pick point dents or penetrates slightly
soft - pick points penetrates
friable material can be crumbled into individual grains by hand.

Fracture spacing: (Ellen et al., 1972)

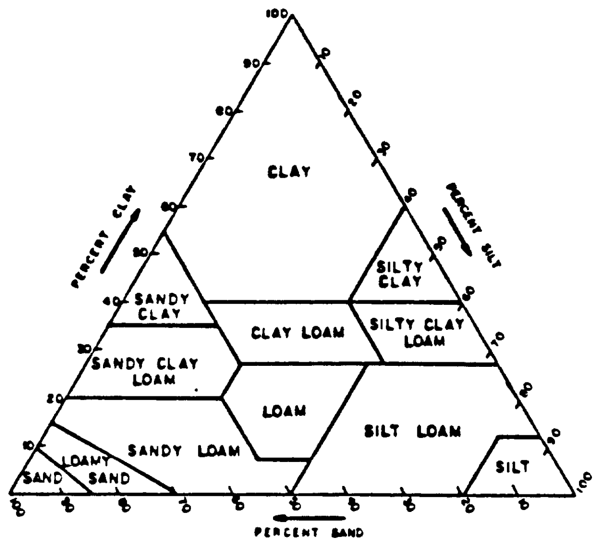
cm	in	fracture spacing
0-1	0-1/2	v. close
1-5	1/2-2	close
5-30	2-12	moderate
30-100	12-36	wide
>100	>36	v. wide

Weathering:
Fresh: no visible signs of weathering
Slight: no visible decomposition of minerals, slight discoloration
Moderate: slight decomposition of minerals and disintegration of rock, deep and thorough discoloration
Deep: extensive decomposition of minerals and complete disintegration of rock but original structure is preserved.

Relative density of sand and consistency of clay is correlated with penetration resistance: (Terzaghi and Peck, 1948)

blows/ft.	relative density	blows/ft.	consistency
0-4	v. loose	<2	v. soft
4-10	loose	2-4	soft
10-30	medium	4-8	medium
30-50	dense	8-15	stiff
>50	v. dense	15-30	v. stiff
		>30	hard

Texture: the relative proportions of clay, silt, and sand below 2mm. Proportions of larger particles are indicated by modifiers of textural class names. Determination is made in the field mainly by feeling the moist soil (Soil Survey, Staff, 1951).



Color: Standard Munsell color names are given for the dominant color of the moist soil and for prominent mottles.

Types of samples

SP - Standard Penetration 1+3/8 in in ID sampler)
S - Thin-wall push sampler
O - Osterberg fixed-piston sampler
P - Pitcher Barrel sampler
CH - California Penetration (2 in ID sampler)
DC - Diamond Core

Figure 40. Explanation of geologic logs.

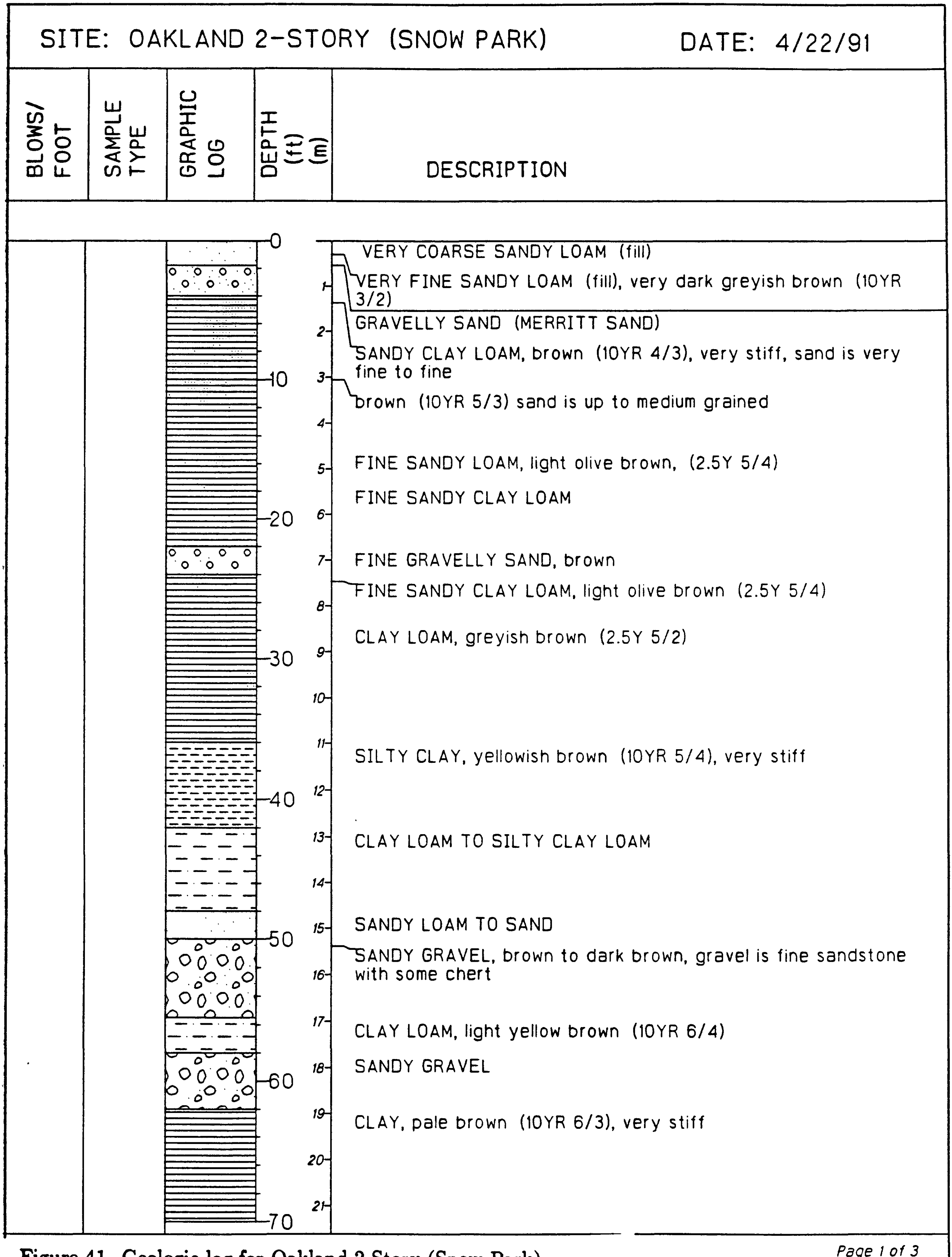
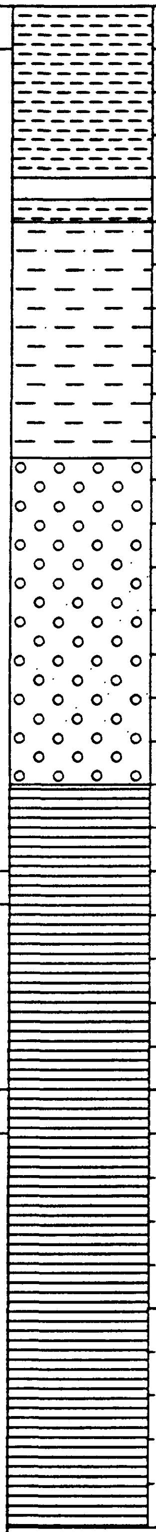


Figure 41. Geologic log for Oakland 2-Story (Snow Park).

SITE: OAKLAND 2-STORY (SNOW PARK) DATE: 4/22/91



BLOWS/ FOOT	SAMPLE TYPE	DEPTH (ft)	DEPTH (m)	DESCRIPTION
	P	70		CLAY, brown (10YR 5/3), very stiff
			22	
			23	
			24	SAND, fine to coarse
		80		CLAY
			25	SILTY CLAY LOAM, olive grey (5Y 5/2)
			26	
			27	
		90		
			28	FINE GRAVELLY SAND, gravel is fine brown sandstone with some chert
			29	
			30	
		100		
			31	
			32	
				CLAY, olive grey, stiff (PLEISTOCENE ESTUARINE DEPOSITS)
			33	very dark greenish grey (5GY 3/1 to 5G 3/1)
	P	110		
			34	dark greenish grey (5G 4/1)
			35	dark greenish grey (5GY 4/1)
			36	
	P	120		
			37	
			38	
			39	softer
		130		
			40	SILTY CLAY, dark greenish grey (5GY 4/1), medium stiff
			41	
			42	
		140		

Figure 41. (Continued).

SITE: OAKLAND 2-STORY (SNOW PARK) DATE: 4/22/91

BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft)	DEPTH (m)	DESCRIPTION
	P		140	43	
				44	SILT LOAM
					SAND
				45	SILT LOAM
			150	46	SILTY CLAY LOAM, dark greenish grey (5G 4/1)
				47	
				48	CLAY, dark greenish grey (5GY 4/1), very stiff, some small carbonate (?) nodules
	P		160	49	
				50	
				51	SANDY CLAY LOAM, brown (10YR 4/3) to yellowish brown (10YR 5/4)
			170	52	VERY COARSE SAND
				53	CLAY TO CLAY LOAM, dark greenish grey (5GY 4/1), very stiff
				54	
	P		180	55	CLAY
				56	
				57	
			190	58	
				59	
				60	
	P		200	61	olive grey (5Y 5/2)
				62	
				63	
			210	64	

Figure 41. (Continued).

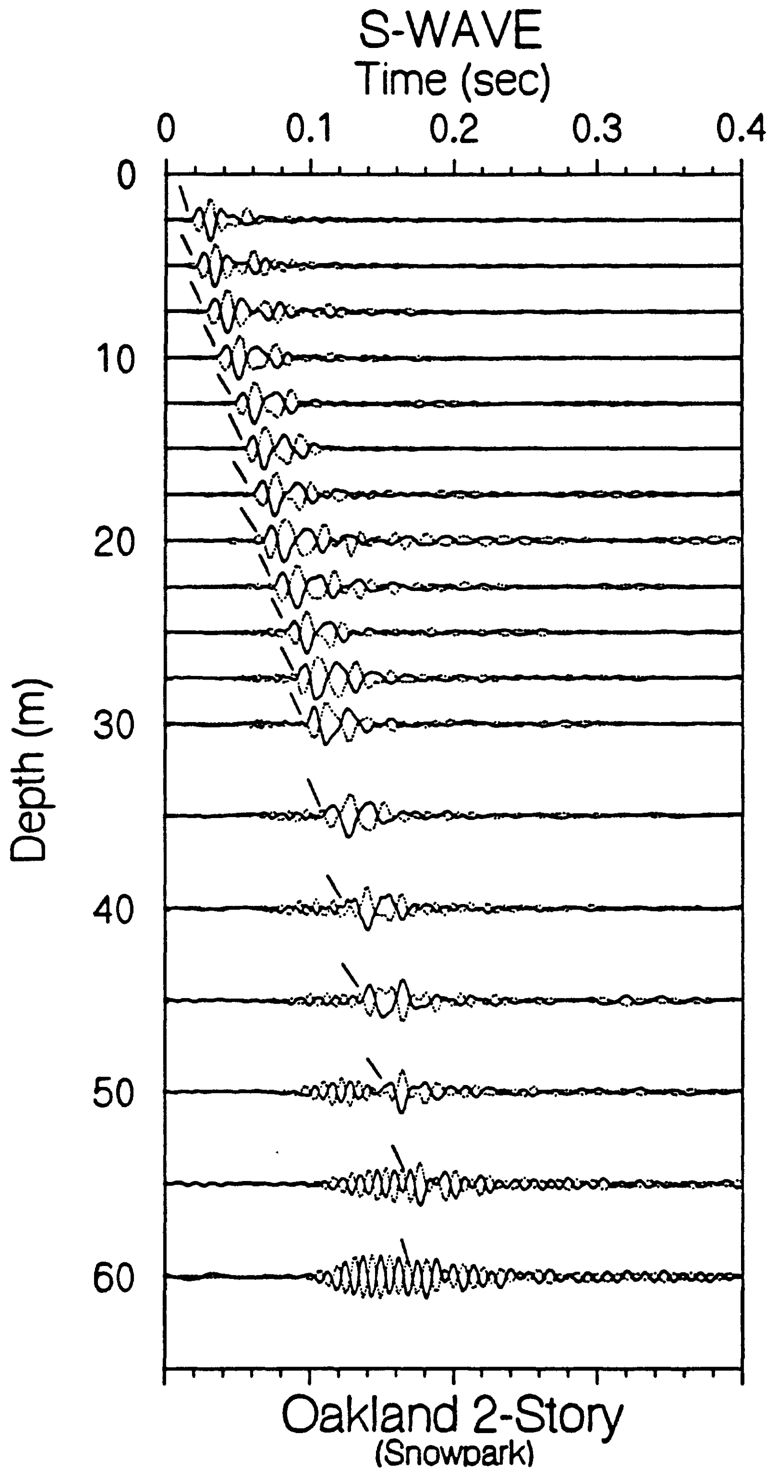


Figure 42. Horizontal-component record section from impacts in opposite horizontal directions superimposed for identification of shear arrivals. S-wave arrivals are shown by the accent marks.

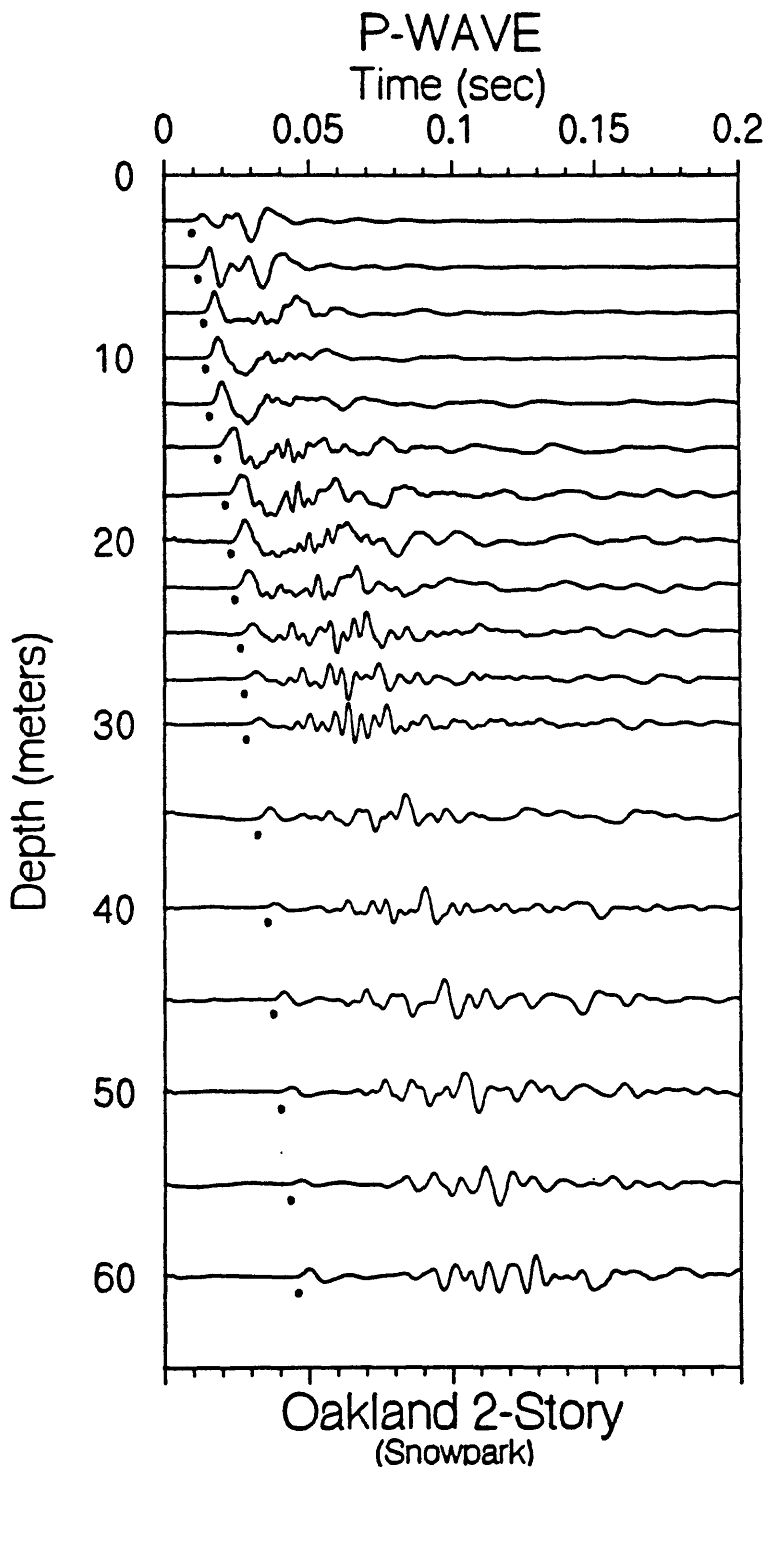


Figure 43. Vertical-component record section. P-wave arrivals are shown by the solid circles.

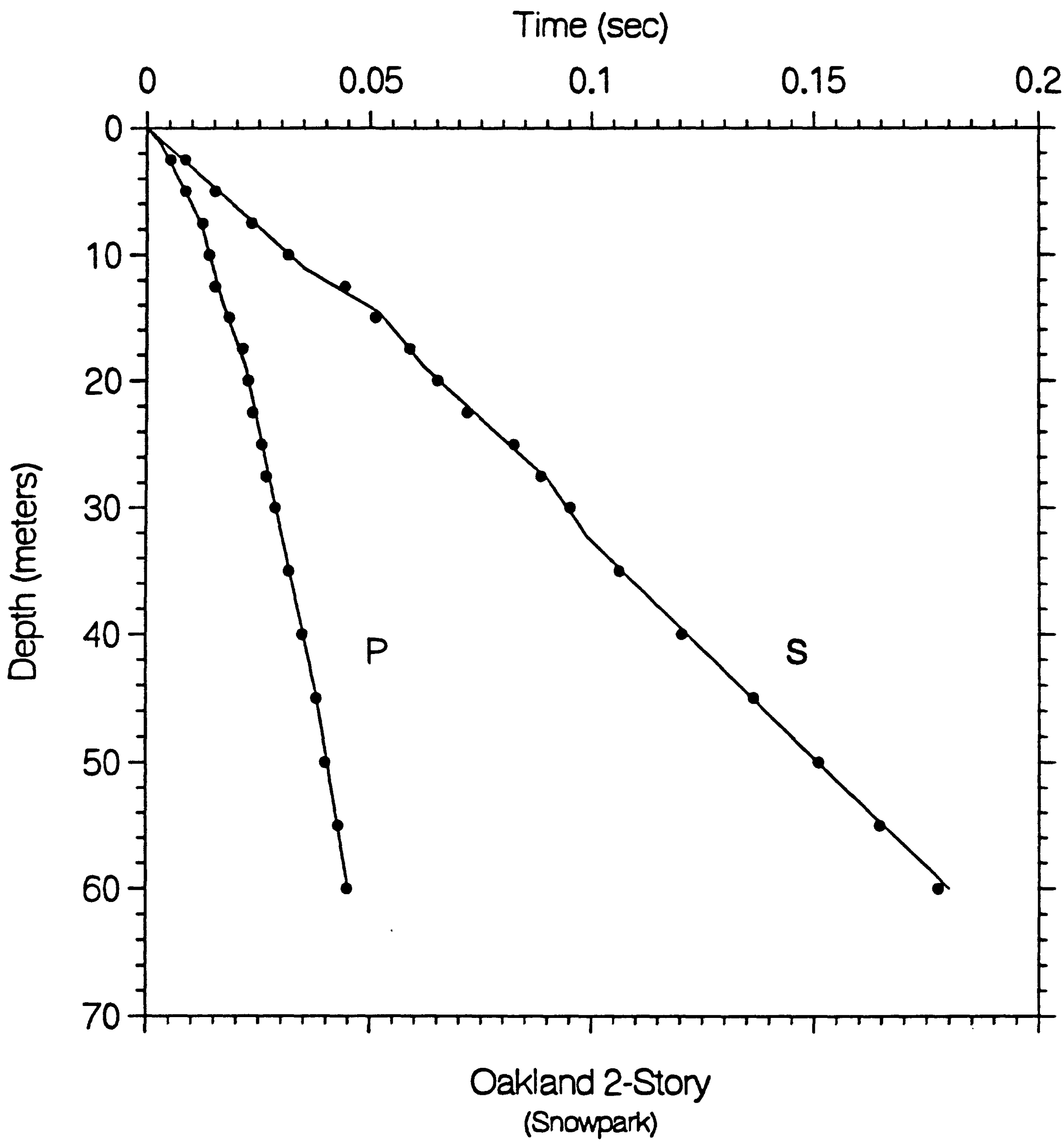


Figure 44. Time-depth graph of P-wave and S-wave picks. Line segments show the hinged-least-squares fit to the data points.

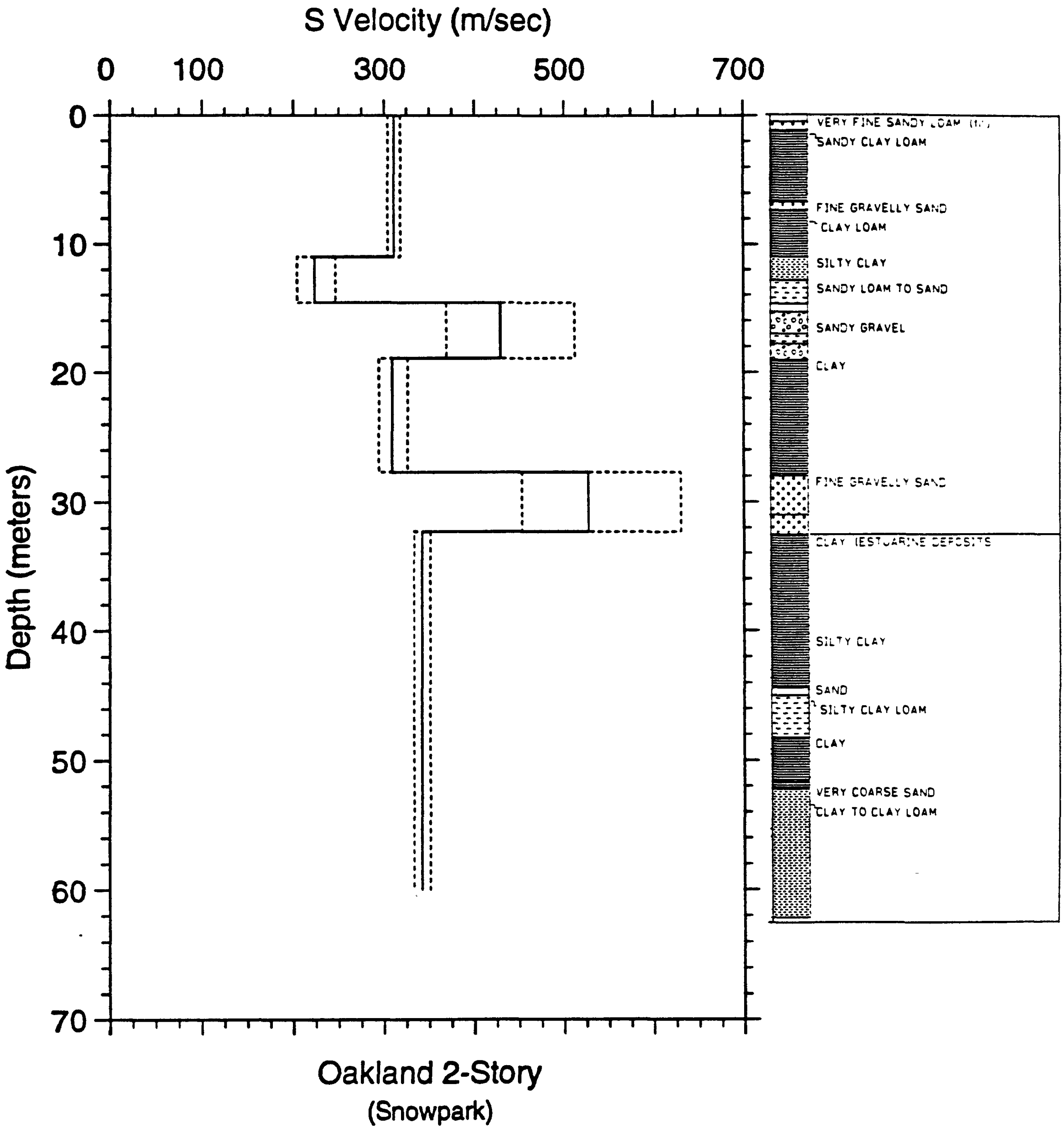


Figure 45. S-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

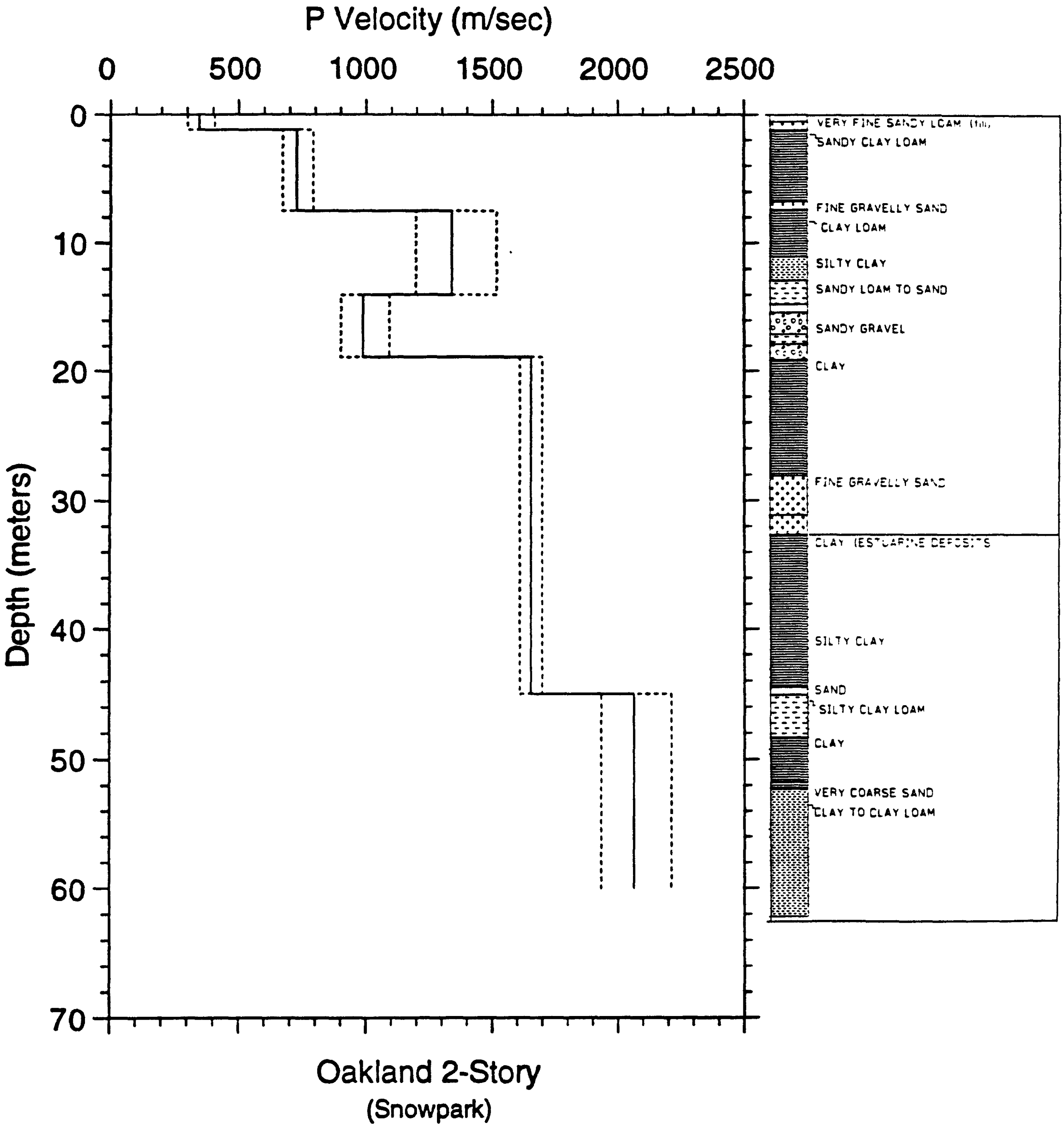


Figure 46. P-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

TABLE 9. S-wave arrival times and velocity summaries for Oakland 2-Story (Snow Park).

d(m)	d(ft)	t(sec)	sig	rsdl/sig
2.5	8.2	.0085	1	.5
5.0	16.4	.0152	1	-.9
7.5	24.6	.0234	1	-.7
10.0	32.8	.0316	1	-.6
12.5	41.0	.0443	1	2.2
15.0	49.2	.0512	1	-1.2
17.5	57.4	.0589	1	.6
20.0	65.6	.0652	1	.1
22.5	73.8	.0719	1	-1.3
25.0	82.0	.0825	1	1.2
27.5	90.2	.0886	1	-.8
30.0	98.4	.0952	1	.8
35.0	114.8	.1063	1	-.3
40.0	131.2	.1204	1	-.9
45.0	147.6	.1365	1	.6
50.0	164.0	.1510	1	.5
55.0	180.4	.1646	2	-.3
60.0	196.9	.1776	3	-.7

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	311	304	318	1020	997	1045
11.0	36.1	.035	311	304	318	1020	997	1045
14.6	47.9	.052	223	204	246	732	670	807
18.9	62.0	.062	429	369	512	1407	1210	1680
27.7	90.9	.090	309	294	326	1014	963	1070
32.3	106.0	.099	527	453	630	1730	1488	2068
60.0	196.9	.180	342	333	351	1122	1094	1152

Explanation:
- d(m) = depth in meters
- d(ft) = depth in feet
- t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
- sig = sigma, standard deviation normalized to the standard deviation of best picks
- rsdl/sig = least-squares residual divided by sigma
- dtb(m) = depth to bottom of layer in meters
- dtb(ft) = depth to bottom of layer in feet
- ttb(s) = arrival time in seconds to bottom of layer
- v(m/s) = velocity in meters per second
- vl(m/s) = lower limit of velocity in meters per second *
- vu(m/s) = upper limit of velocity in meters per second
- v(ft/s) = velocity in feet per second
- vl(ft/s) = lower limit of velocity in feet per second
- vu(ft/s) = upper limit of velocity in feet per second

* see text for explanation of velocity limits

TABLE 10. P-wave arrival times and velocity summaries for Oakland 2-Story (Snow Park).

d(m)	d(ft)	t(sec)	sig	rsdl/sig
2.5	8.2	.0053	1	.0
5.0	16.4	.0086	1	-.1
7.5	24.6	.0124	1	.3
10.0	32.8	.0139	1	-.1
12.5	41.0	.0152	1	-.7
15.0	49.2	.0184	1	.4
17.5	57.4	.0214	1	.9
20.0	65.6	.0226	1	.0
22.5	73.8	.0236	1	-.5
25.0	82.0	.0257	1	.0
27.5	90.2	.0267	1	-.5
30.0	98.4	.0287	1	.0
35.0	114.8	.0318	1	.1
40.0	131.2	.0348	1	.1
45.0	147.6	.0379	1	.2
50.0	164.0	.0399	1	-.3
55.0	180.4	.0429	1	.3
60.0	196.9	.0449	1	-.1

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	346	302	406	1137	991	1333
1.2	3.9	.003	346	302	406	1137	991	1333
7.5	24.6	.012	727	672	791	2384	2204	2596
14.0	45.9	.017	1338	1197	1516	4388	3926	4973
18.9	62.0	.022	986	900	1091	3236	2954	3579
45.0	147.6	.038	1654	1610	1699	5425	5284	5575
60.0	196.9	.045	2063	1933	2212	6769	6343	7256

Explanation:
d(m) = depth in meters
d(ft) = depth in feet
t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
sig = sigma, standard deviation normalized to the standard deviation of best picks
rsdl/sig = least-squares residual divided by sigma
dtb(m) = depth to bottom of layer in meters
dtb(ft) = depth to bottom of layer in feet
ttb(s) = arrival time in seconds to bottom of layer
v(m/s) = velocity in meters per second
vl(m/s) = lower limit of velocity in meters per second *
vu(m/s) = upper limit of velocity in meters per second
v(ft/s) = velocity in feet per second
vl(ft/s) = lower limit of velocity in feet per second
vu(ft/s) = upper limit of velocity in feet per second
* see text for explanation of velocity limits

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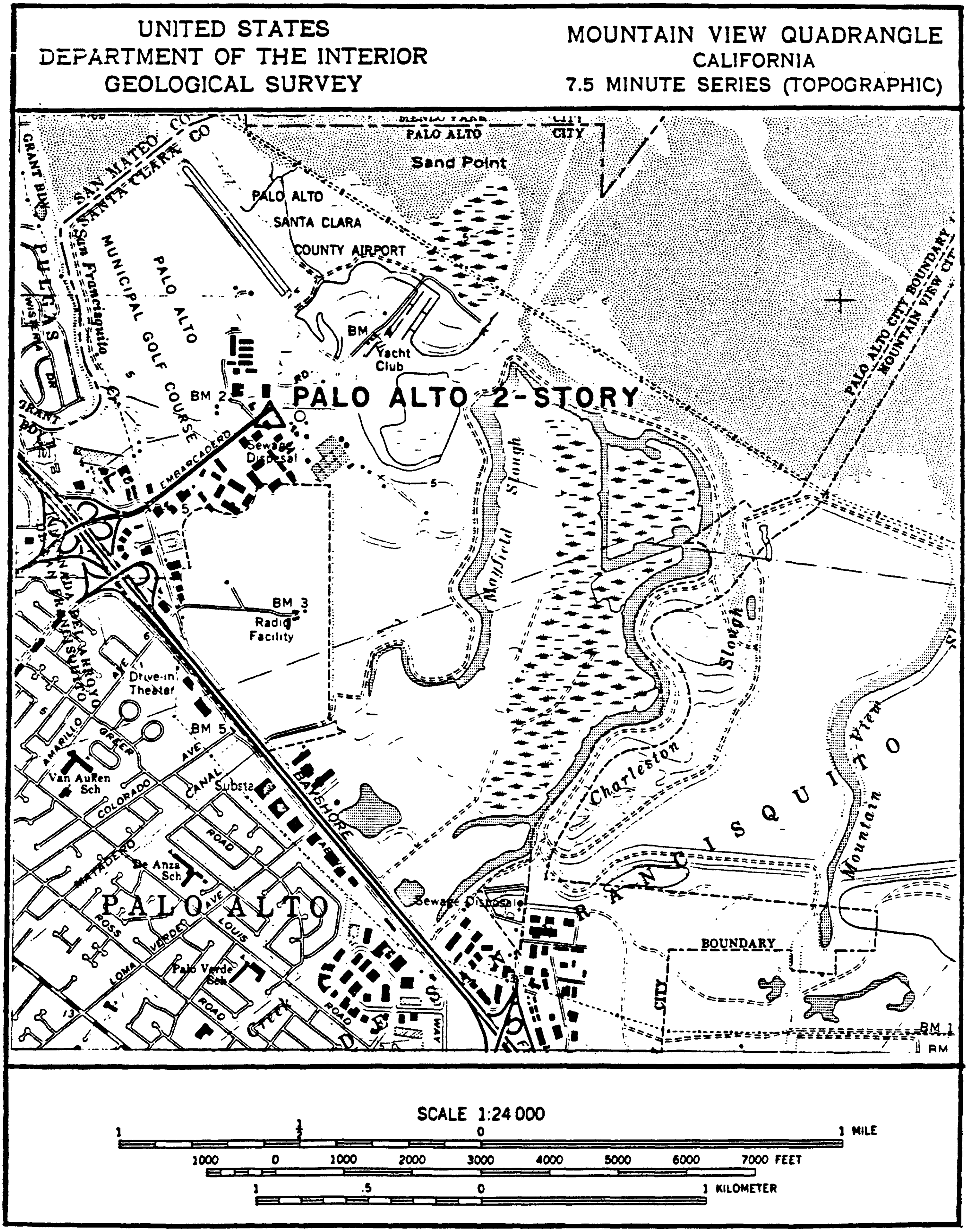


Figure 47. Location map for Palo Alto 2-Story. The borehole is located within 30 meters of the strong-motion recorder.

Definitions of terms used for descriptions of sedimentary deposits and bedrock materials

Rock hardness: response to hand and geologic hammer: (Ellen et al., 1972)

hard - hammer bounces off with solid sound
firm - hammer dents with thud, pick point dents or penetrates slightly
soft - pick points penetrates
friable material can be crumbled into individual grains by hand.

Fracture spacing: (Ellen et al., 1972)

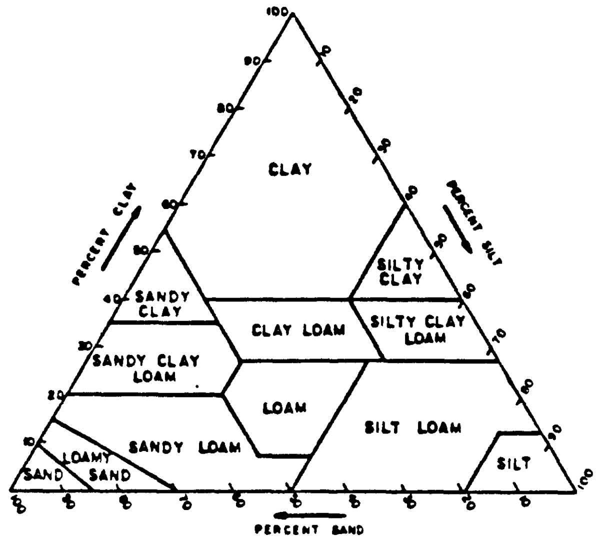
cm	in	fracture spacing
0-1	0-1/2	v. close
1-5	1/2-2	close
5-30	2-12	moderate
30-100	12-36	wide
>100	>36	v. wide

Weathering:
Fresh: no visible signs of weathering
Slight: no visible decomposition of minerals, slight discoloration
Moderate: slight decomposition of minerals and disintegration of rock, deep and thorough discoloration
Deep: extensive decomposition of minerals and complete disintegration of rock but original structure is preserved.

Relative density of sand and consistency of clay is correlated with penetration resistance: (Terzaghi and Peck, 1948)

blows/ft.	relative density	blows/ft.	consistency
0-4	v. loose	<2	v. soft
4-10	loose	2-4	soft
10-30	medium	4-8	medium
30-50	dense	8-15	stiff
>50	v. dense	15-30	v. stiff
		>30	hard

Texture: the relative proportions of clay, silt, and sand below 2mm. Proportions of larger particles are indicated by modifiers of textural class names. Determination is made in the field mainly by feeling the moist soil (Soil Survey, Staff, 1951).



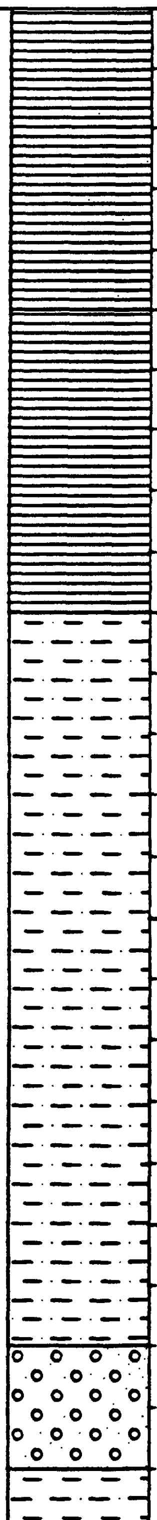
Color: Standard Munsell color names are given for the dominant color of the moist soil and for prominent mottles.

Types of samples

SP - Standard Penetration 1 + 3/8 in in ID sampler)
S - Thin-wall push sampler
O - Osterberg fixed-piston sampler
P - Pitcher Barrel sampler
CH - California Penetration (2 in ID sampler)
DC - Diamond Core

Figure 48. Explanation of geologic log.

SITE: PALO ALTO 2-STORY OFFICE BLDG DATE: 5/15/91



BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft) (m)	DESCRIPTION
			0	CLAY LOAM TO SANDY CLAY LOAM (fill), very dark greyish brown (10YR 3/2), very poorly sorted
			1	
			2	
			3 / 10	CLAY, very dark greenish grey (5GY 3/1), soft
			4	
			5	greenish grey (5GY 5/1), stiffer
			6 / 20	SILTY CLAY LOAM TO SILTY CLAY, olive (5Y 4/3), stiff to very stiff
			7	
			8	
			9 / 30	
			10	some carbonate nodules
			11	some fine sandy lenses
			12 / 40	SANDY CLAY LOAM, dark olive brown (2.5Y 3/4), poorly sorted
			13	FINE GRAVELLY SAND
			14	
			15 / 50	CLAY LOAM, dark olive brown (2.5Y 3/4)

Figure 49. Geologic log for Palo Alto 2-Story.

Page 1 of 4

SITE: PALO ALTO 2-STORY OFFICE BLDG DATE: 5/15/91

BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft) (m)	DESCRIPTION
			50	
			16	
			17	
			18	
			60	
			19	
			20	
			21	
			70	SAND
			22	
			23	SILTY CLAY, olive with grey mottling, stiff
			24	
			80	olive grey (5Y 5/2), very stiff
			25	
			26	
			27	
			90	SILTY CLAY LOAM, olive
			28	
			29	
			30	
			100	

Figure 49. (Continued).

SITE: PALO ALTO 2-STORY OFFICE BLDG DATE: 5/15/91

BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft)	DEPTH (m)	DESCRIPTION
			100		
				31	
				32	CLAY, mottled olive grey (5Y 5/2) and greenish grey (5GY 5/1), slightly less stiff
				33	
			110		
				34	
				35	
				36	
			120		
				37	
				38	
				39	
			130		SILTY CLAY, olive grey
				40	
				41	
				42	
			140		SAND, fine to medium-grained
				43	
				44	
				45	
			150		

Figure 49. (Continued).

SITE: PALO ALTO 2-STORY OFFICE BLDG DATE: 5/15/91

BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft) (m)	DESCRIPTION
			150 / 46	
			47	CLAY, stiff
			48	
			160 / 49	
			50	
			51	
			170 / 52	
			53	
			54	
			180 / 55	
			56	
			57	
			190 / 58	
			59	
			60	
			200	

Figure 49. (Continued).

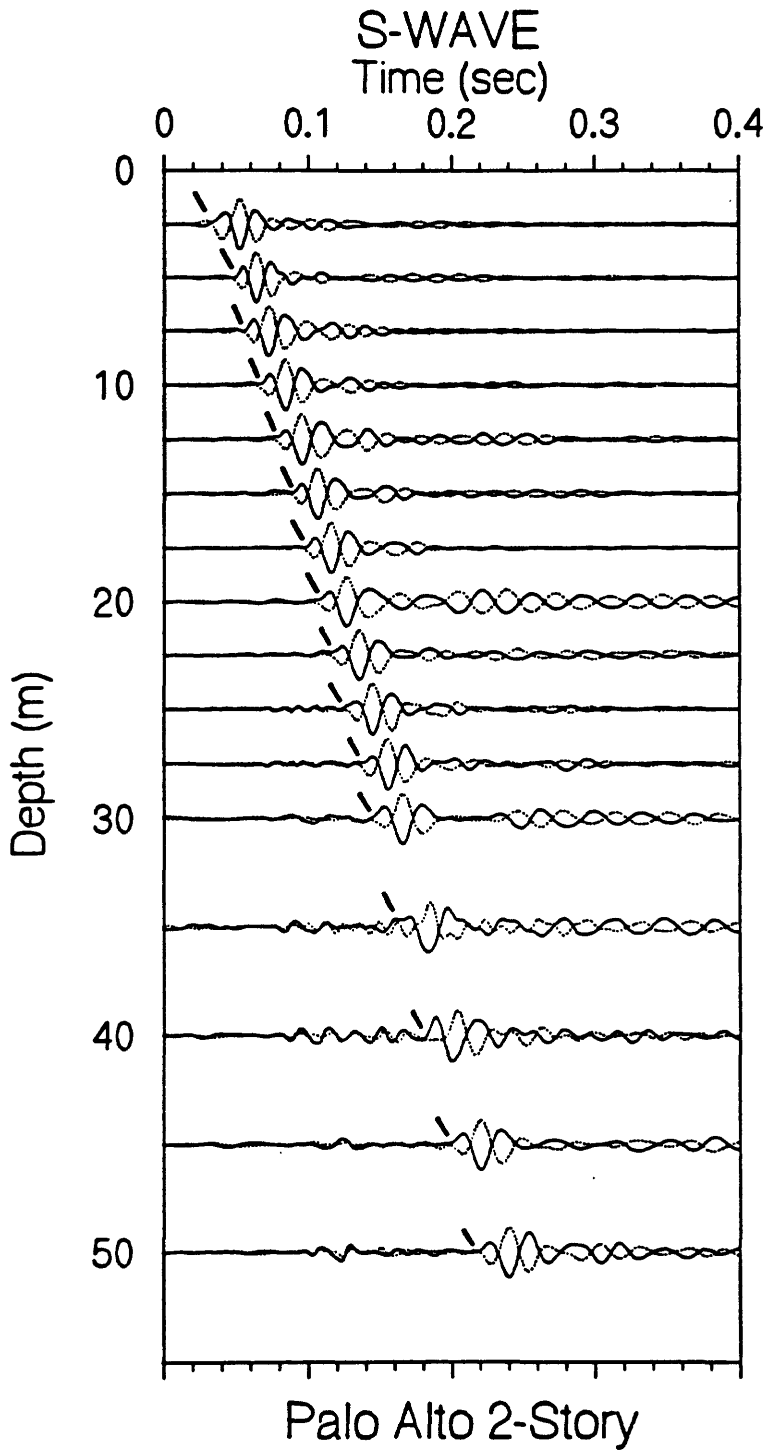


Figure 50. Horizontal-component record section from impacts in opposite horizontal directions superimposed for identification of shear arrivals. S-wave arrivals are shown by the accent marks.

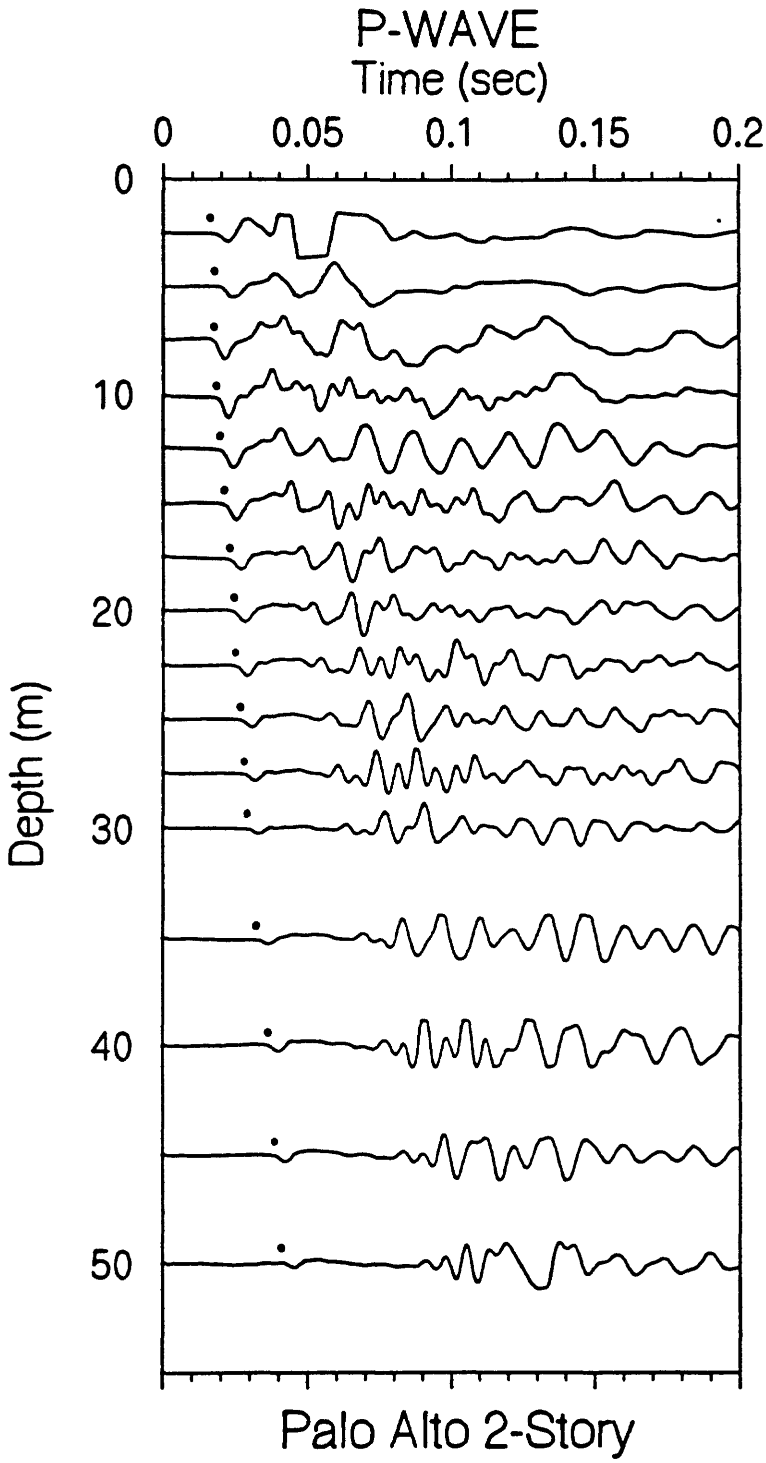


Figure 51. Vertical-component record section. P-wave arrivals are shown by the solid circles.

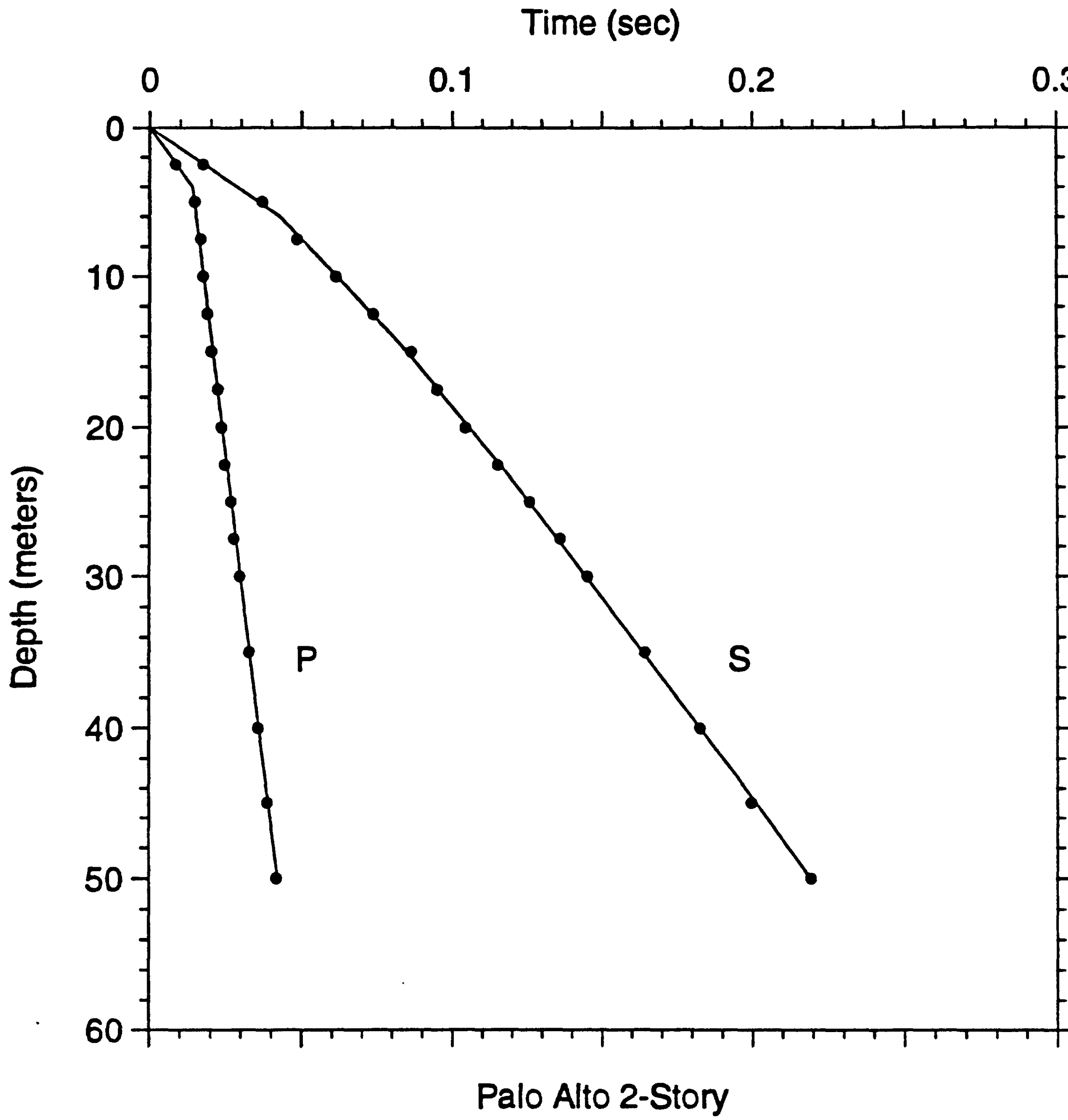


Figure 52. Time-depth graph of P-wave and S-wave picks. Line segments show the hinged-least-squares fit to the data points.

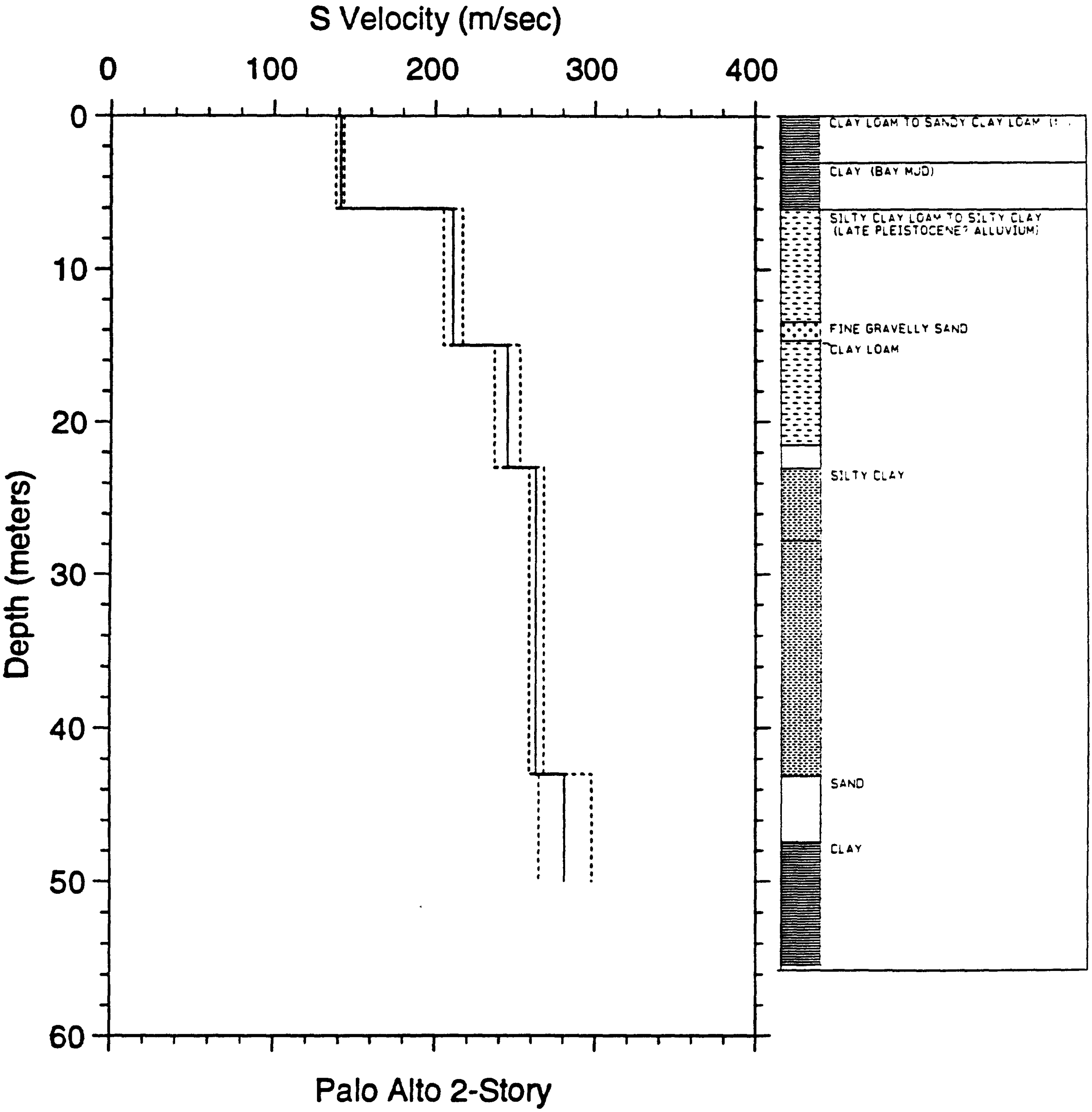


Figure 53. S-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

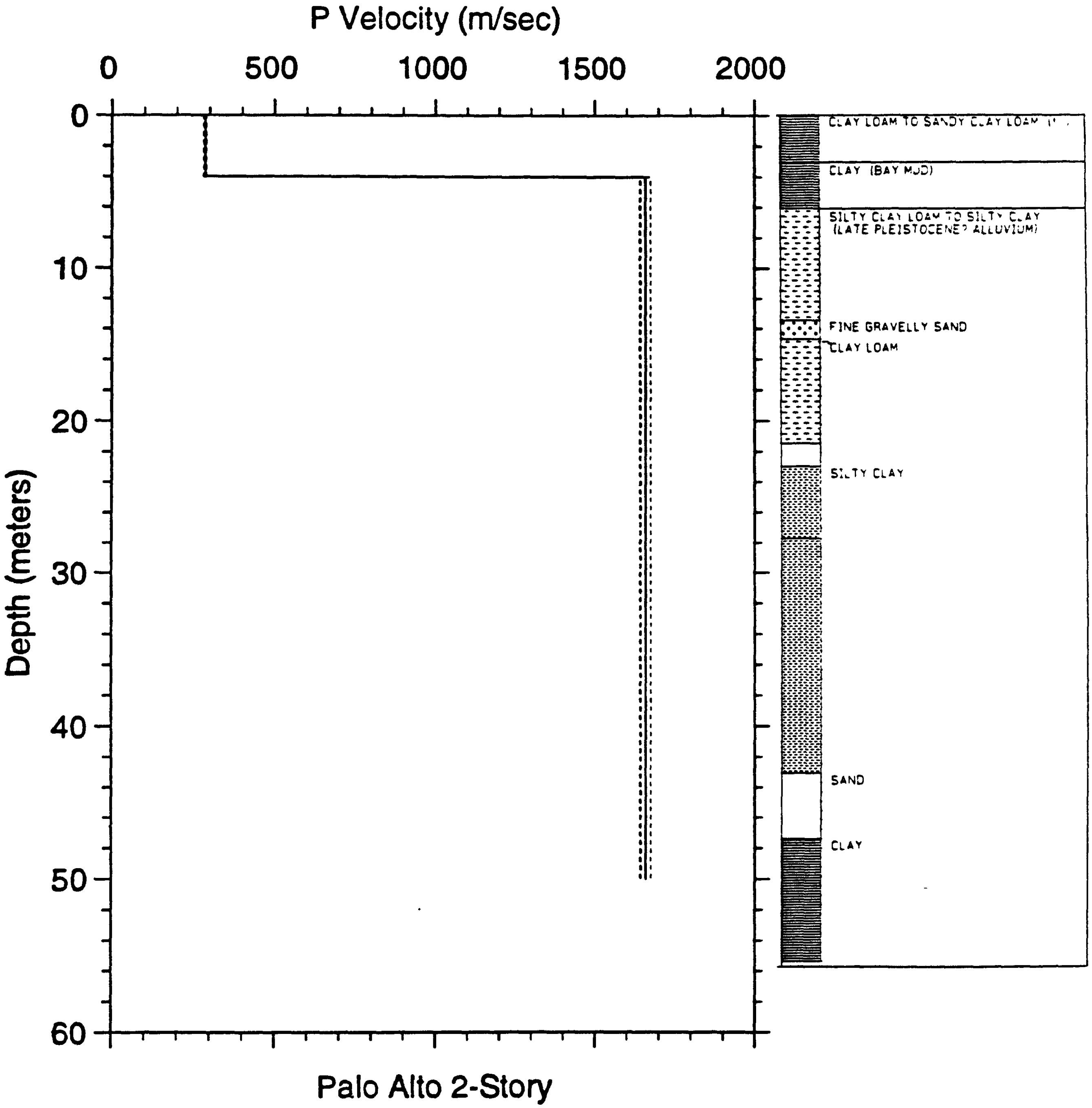


Figure 54. P-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

TABLE 11. S-wave arrival times and velocity summaries for Palo Alto 2-Story.

d(m)	d(ft)	t(sec)	sig	rsdl/sig
2.5	8.2	.0175	1	-.3
5.0	16.4	.0371	1	1.5
7.5	24.6	.0485	1	-1.3
10.0	32.8	.0613	1	-.3
12.5	41.0	.0738	1	.3
15.0	49.2	.0864	1	1.1
17.5	57.4	.0950	1	-.5
20.0	65.6	.1044	1	-1.4
22.5	73.8	.1152	1	-.8
25.0	82.0	.1259	1	.3
27.5	90.2	.1361	1	1.0
30.0	98.4	.1452	1	.6
35.0	114.8	.1644	1	.8
40.0	131.2	.1826	1	.0
45.0	147.6	.1997	1	-1.4
50.0	164.0	.2193	1	.4

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	141	138	143	461	453	470
6.0	19.7	.043	141	138	143	461	453	470
15.0	49.2	.085	211	205	217	692	673	713
23.0	75.5	.118	245	237	253	803	778	830
43.0	141.1	.194	263	259	268	864	850	878
50.0	164.0	.219	281	265	298	920	870	977

Explanation:
- d(m) = depth in meters
- d(ft) = depth in feet
- t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
- sig = sigma, standard deviation normalized to the standard deviation of best picks
- rsdl/sig = least-squares residual divided by sigma
- dtb(m) = depth to bottom of layer in meters
- dtb(ft) = depth to bottom of layer in feet
- ttb(s) = arrival time in seconds to bottom of layer
- v(m/s) = velocity in meters per second
- vl(m/s) = lower limit of velocity in meters per second *
- vu(m/s) = upper limit of velocity in meters per second
- v(ft/s) = velocity in feet per second
- vl(ft/s) = lower limit of velocity in feet per second
- vu(ft/s) = upper limit of velocity in feet per second

* see text for explanation of velocity limits

TABLE 12. P-wave arrival times and velocity summaries for Palo Alto 2-Story.

d(m)	d(ft)	t(sec)	sig	rsdl/sig
2.5	8.2	.0085	1	-.2
5.0	16.4	.0148	1	.2
7.5	24.6	.0168	1	.7
10.0	32.8	.0176	1	.0
12.5	41.0	.0190	1	-.1
15.0	49.2	.0203	1	-.3
17.5	57.4	.0224	1	.3
20.0	65.6	.0235	1	-.1
22.5	73.8	.0246	1	-.5
25.0	82.0	.0267	1	.0
27.5	90.2	.0277	1	-.5
30.0	98.4	.0297	1	.0
35.0	114.8	.0328	1	.1
40.0	131.2	.0358	1	.1
45.0	147.6	.0388	1	.1
50.0	164.0	.0419	1	.2

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	286	283	289	938	928	947
4.0	13.1	.014	286	283	289	938	928	947
50:0	164.0	.042	1659	1643	1675	5443	5390	5497

Explanation:
- d(m) = depth in meters
- d(ft) = depth in feet
- t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
- sig = sigma, standard deviation normalized to the standard deviation of best picks
- rsdl/sig = least-squares residual divided by sigma
- dtb(m) = depth to bottom of layer in meters
- dtb(ft) = depth to bottom of layer in feet
- ttb(s) = arrival time in seconds to bottom of layer
- v(m/s) = velocity in meters per second
- vl(m/s) = lower limit of velocity in meters per second *
- vu(m/s) = upper limit of velocity in meters per second
- v(ft/s) = velocity in feet per second
- vl(ft/s) = lower limit of velocity in feet per second
- vu(ft/s) = upper limit of velocity in feet per second

* see text for explanation of velocity limits

Figure 55. Site location map for Presidio borehole. The borehole is located within 75 meters of the strong-motion recorder.

Rock hardness: response to hand and geologic hammer: (Ellen et al., 1972)

hard - hammer bounces off with solid sound
firm - hammer dents with thud, pick point dents or penetrates slightly
soft - pick points penetrates
friable material can be crumbled into individual grains by hand.

Fracture spacing: (Ellen et al., 1972)

cm	in	fracture spacing
0-1	0-1/2	v. close
1-5	1/2-2	close
5-30	2-12	moderate
30-100	12-36	wide
>100	>36	v. wide

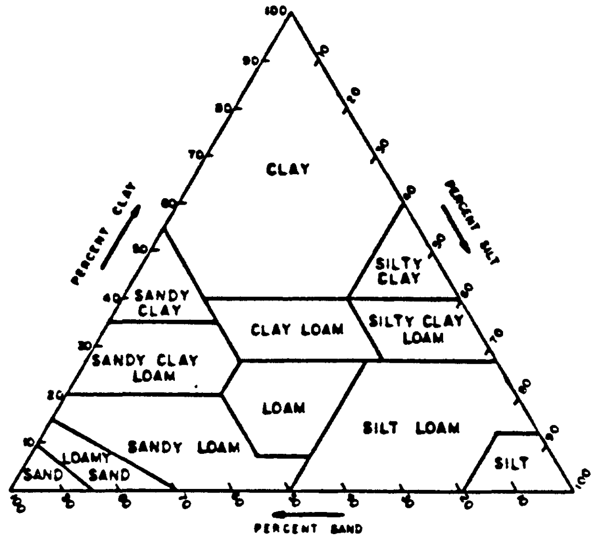
Weathering:

Fresh: no visible signs of weathering
Slight: no visible decomposition of minerals, slight discoloration
Moderate: slight decomposition of minerals and disintegration of rock, deep and thorough discoloration
Deep: extensive decomposition of minerals and complete disintegration of rock but original structure is preserved.

Relative density of sand and consistency of clay is correlated with penetration resistance: (Terzaghi and Peck, 1948)

blows/ft.	relative density	blows/ft.	consistency
0-4	v. loose	<2	v. soft
4-10	loose	2-4	soft
10-30	medium	4-8	medium
30-50	dense	8-15	stiff
>50	v. dense	15-30	v. stiff
		>30	hard

Texture: the relative proportions of clay, silt, and sand below 2mm. Proportions of larger particles are indicated by modifiers of textural class names. Determination is made in the field mainly by feeling the moist soil (Soil Survey, Staff, 1951).



Color: Standard Munsell color names are given for the dominant color of the moist soil and for prominent mottles.

Types of samples

SP - Standard Penetration 1+3/8 in in ID sampler)
S - Thin-wall push sampler
O - Osterberg fixed-piston sampler
P - Pitcher Barrel sampler
CH - California Penetration (2 in ID sampler)
DC - Diamond Core

Figure 56. Explanation of geologic log.

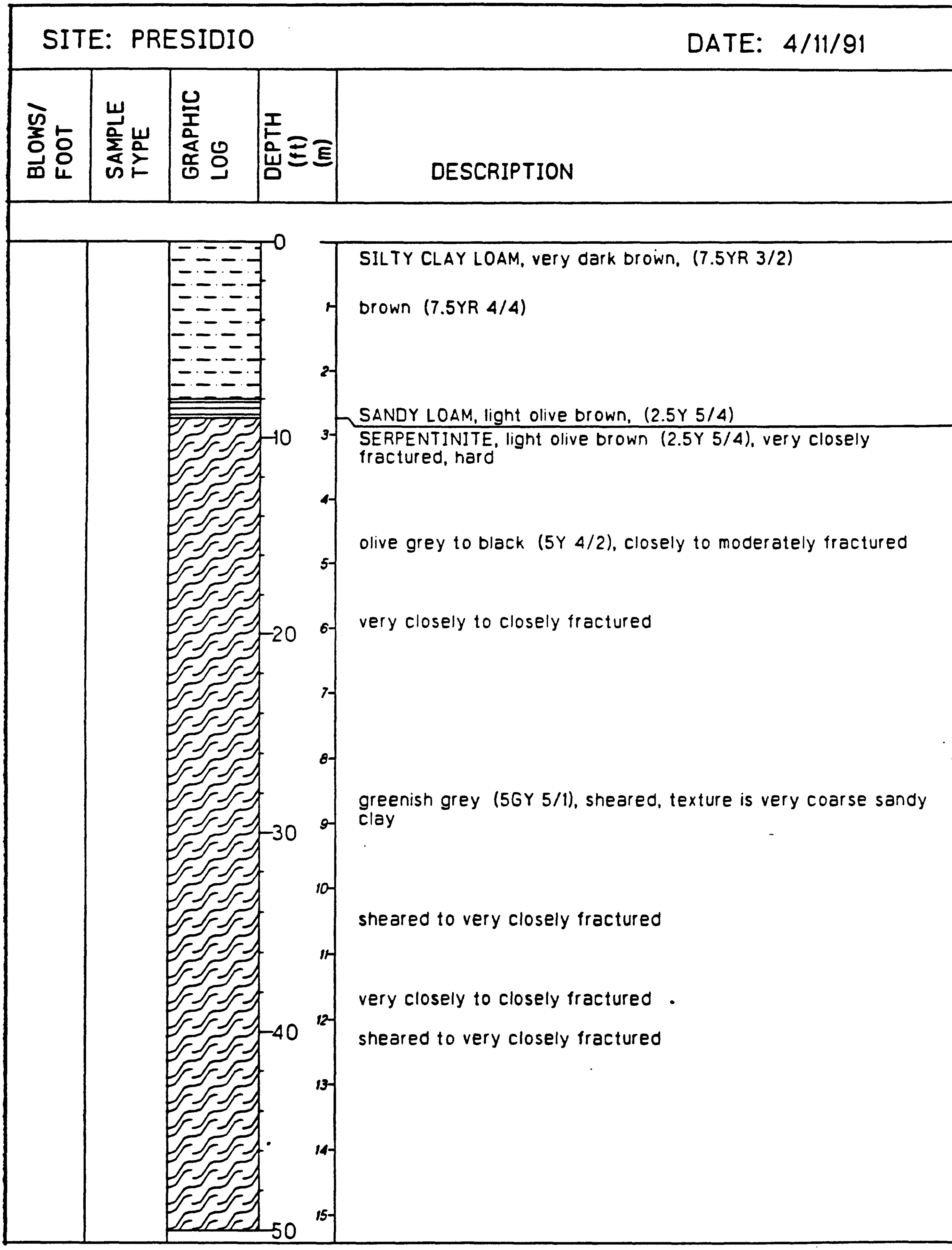


Figure 57. Geologic log for the Presidio borehole.

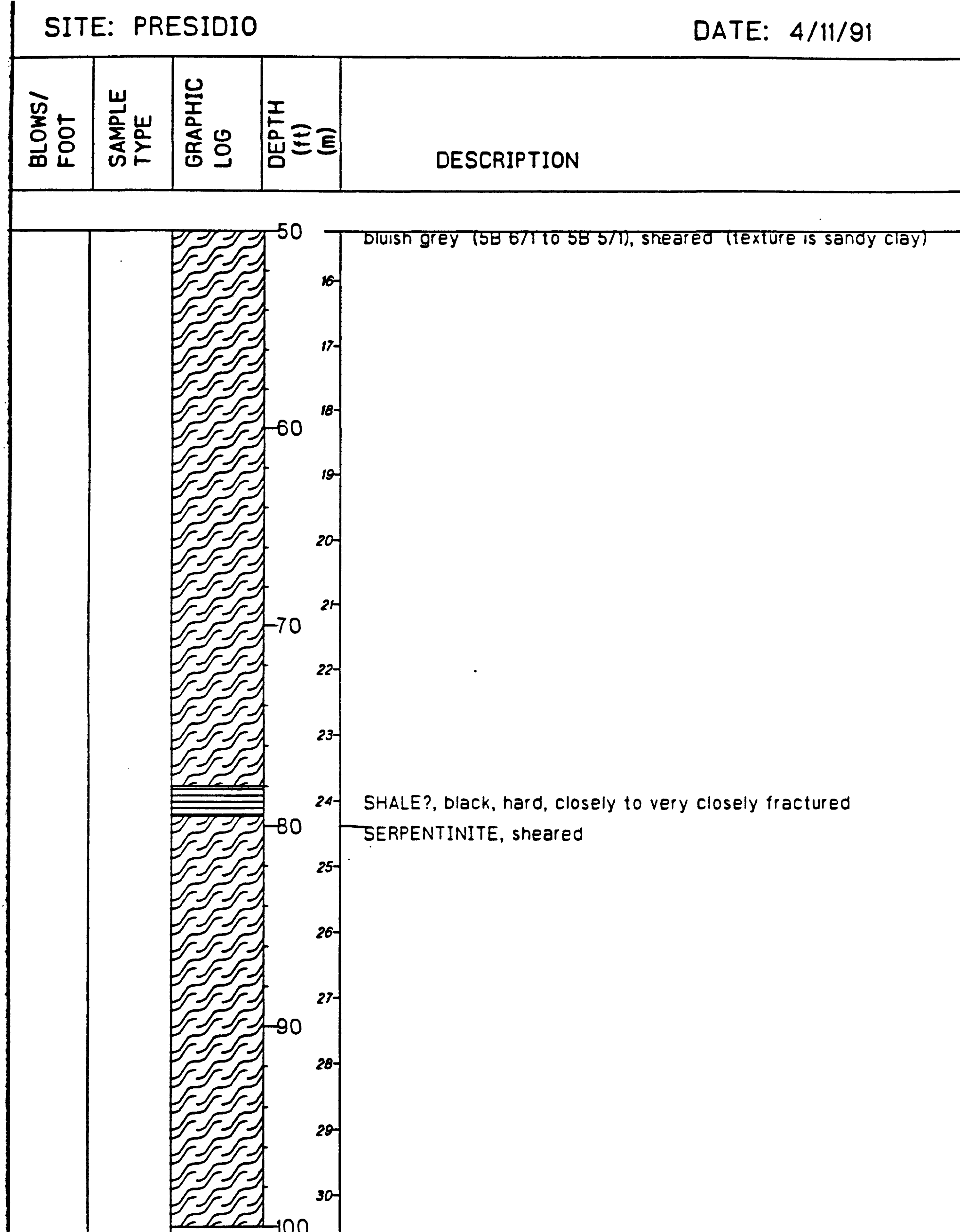
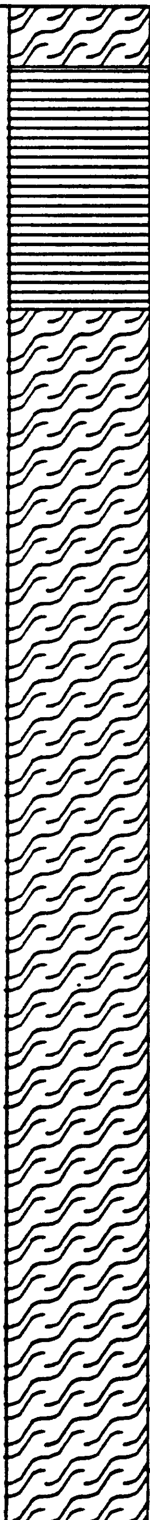


Figure 57. (Continued).

SITE: PRESIDIO

DATE: 4/11/91

BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft)	DEPTH (m)	DESCRIPTION
			100		
				31	SHALE, black, hard
				32	
				33	
			110		SERPENTINITE, sheared (texture is sandy clay)
				34	
				35	
				36	
			120		
				37	
				38	rocky
					very firm, sheared (texture is sandy clay)
				39	
			130		
				40	
				41	
				42	rocky
			140		
				43	very firm, sheared
				44	
				45	rocky
			150		very firm, sheared

Page 3 of 4

Figure 57. (Continued).

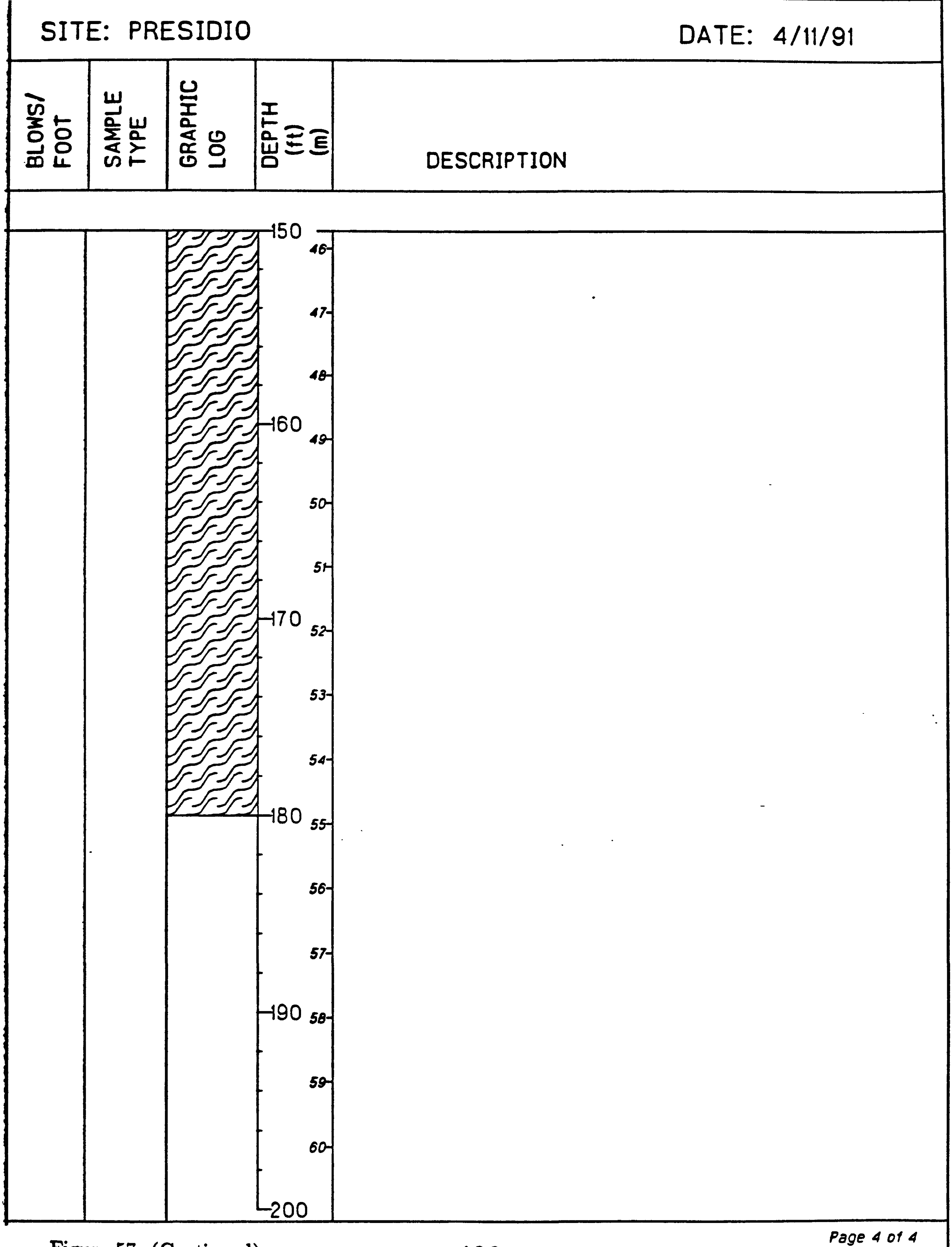


Figure 57. (Continued).

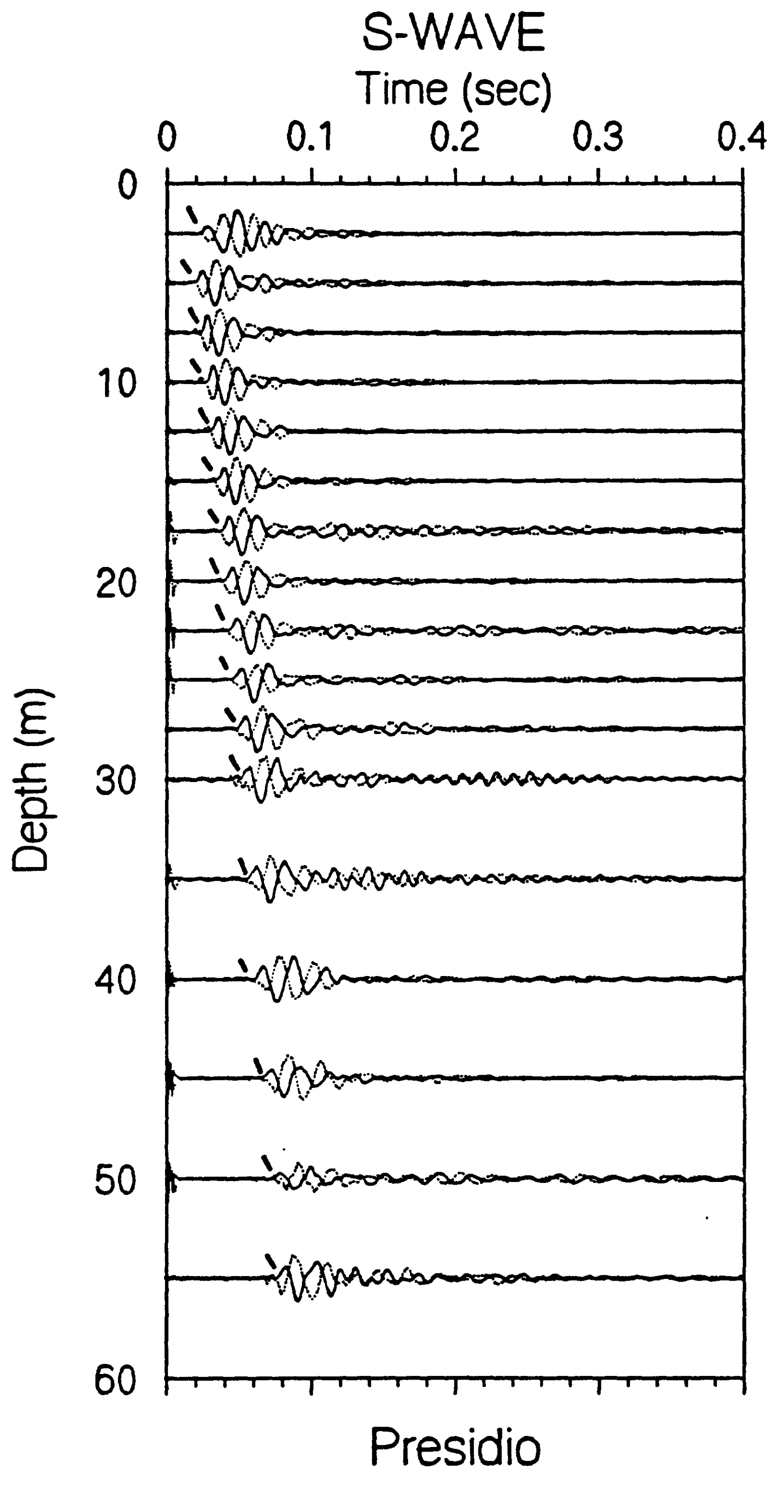


Figure 58. Horizontal-component record section from impacts in opposite horizontal directions superimposed for identification of shear arrivals. S-wave arrivals are shown by the accent marks.

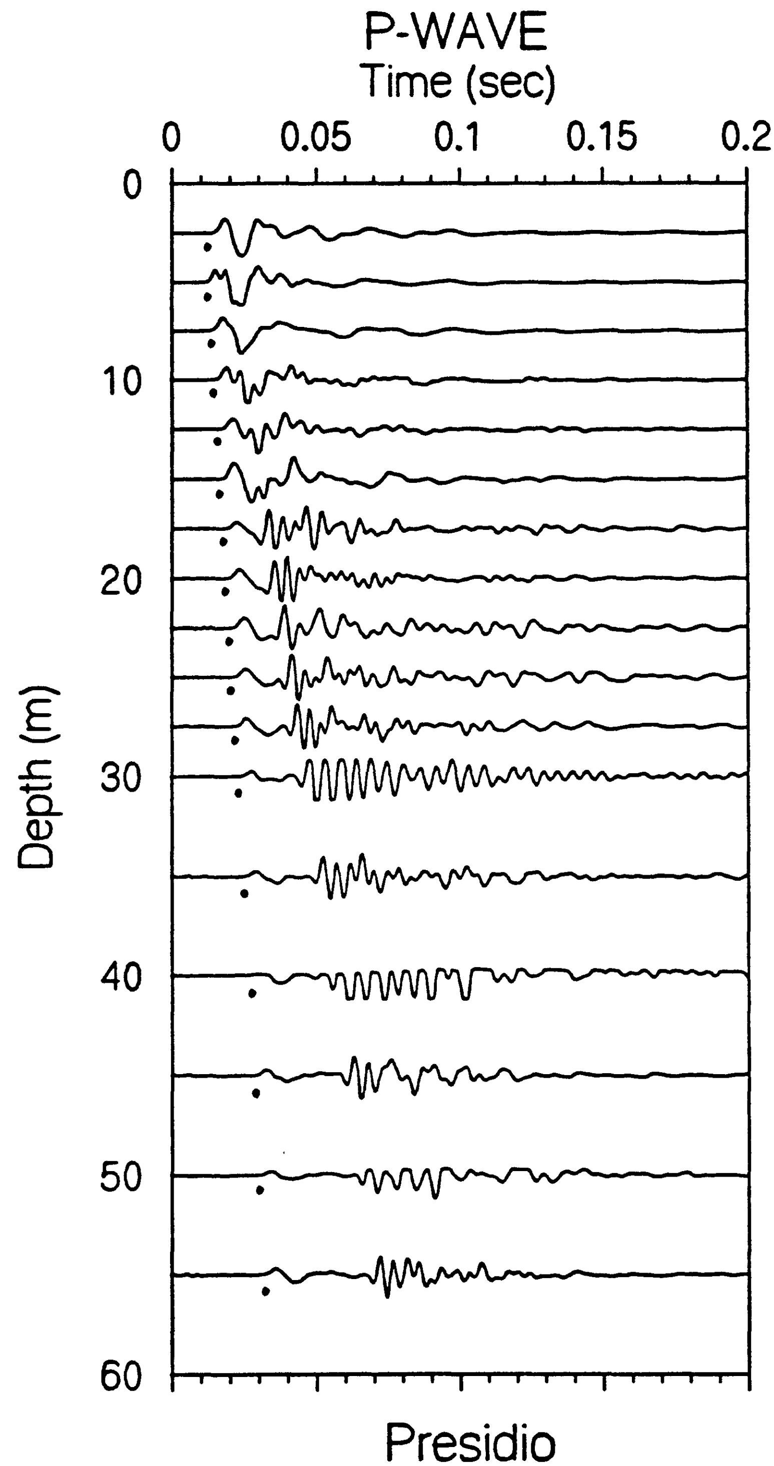


Figure 59. Vertical-component record section. P-wave arrivals are shown by the solid circles.

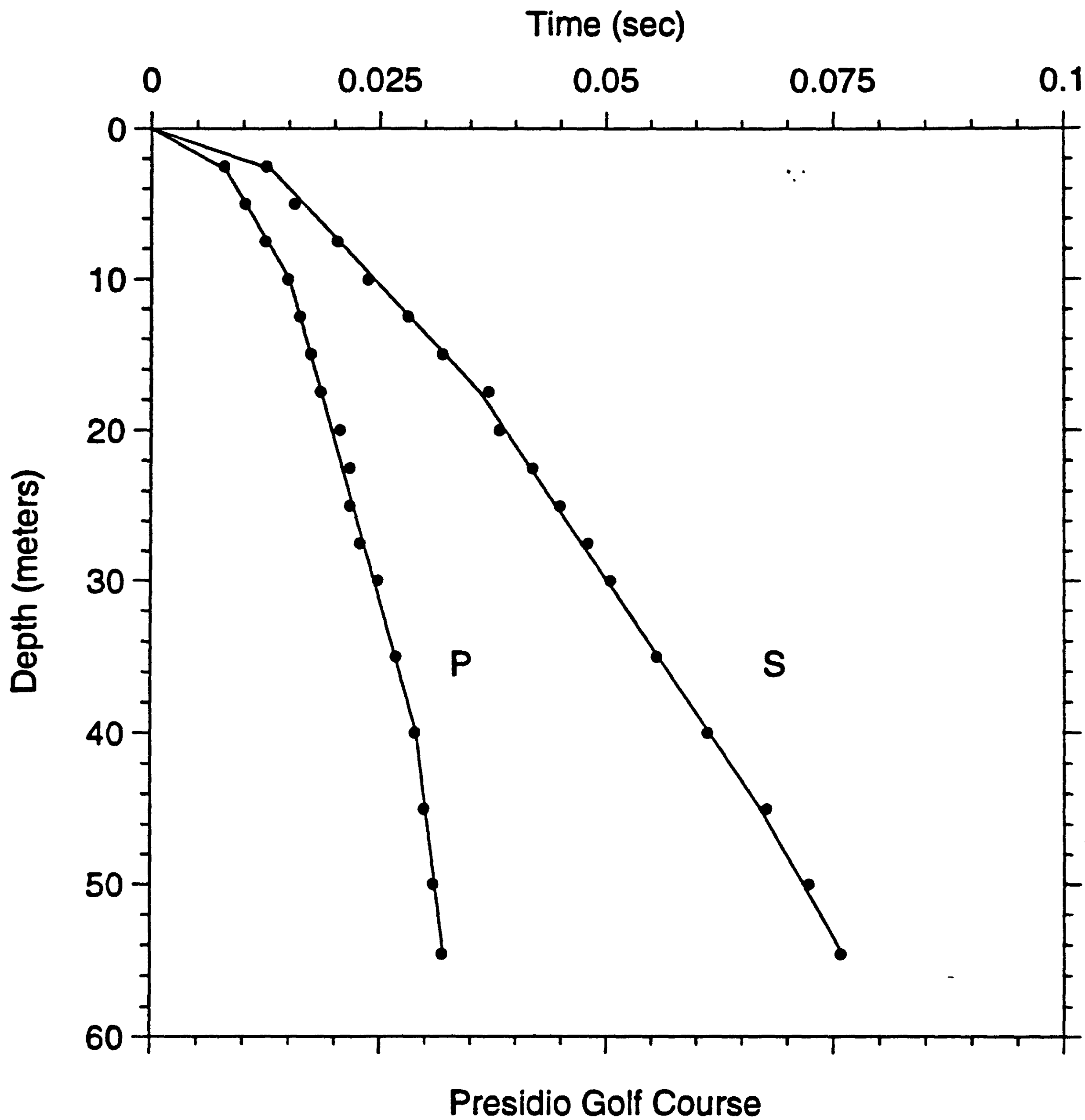


Figure 60. Time-depth graph of P-wave and S-wave picks. Line segments show the hinged-least-squares fit to the data points.

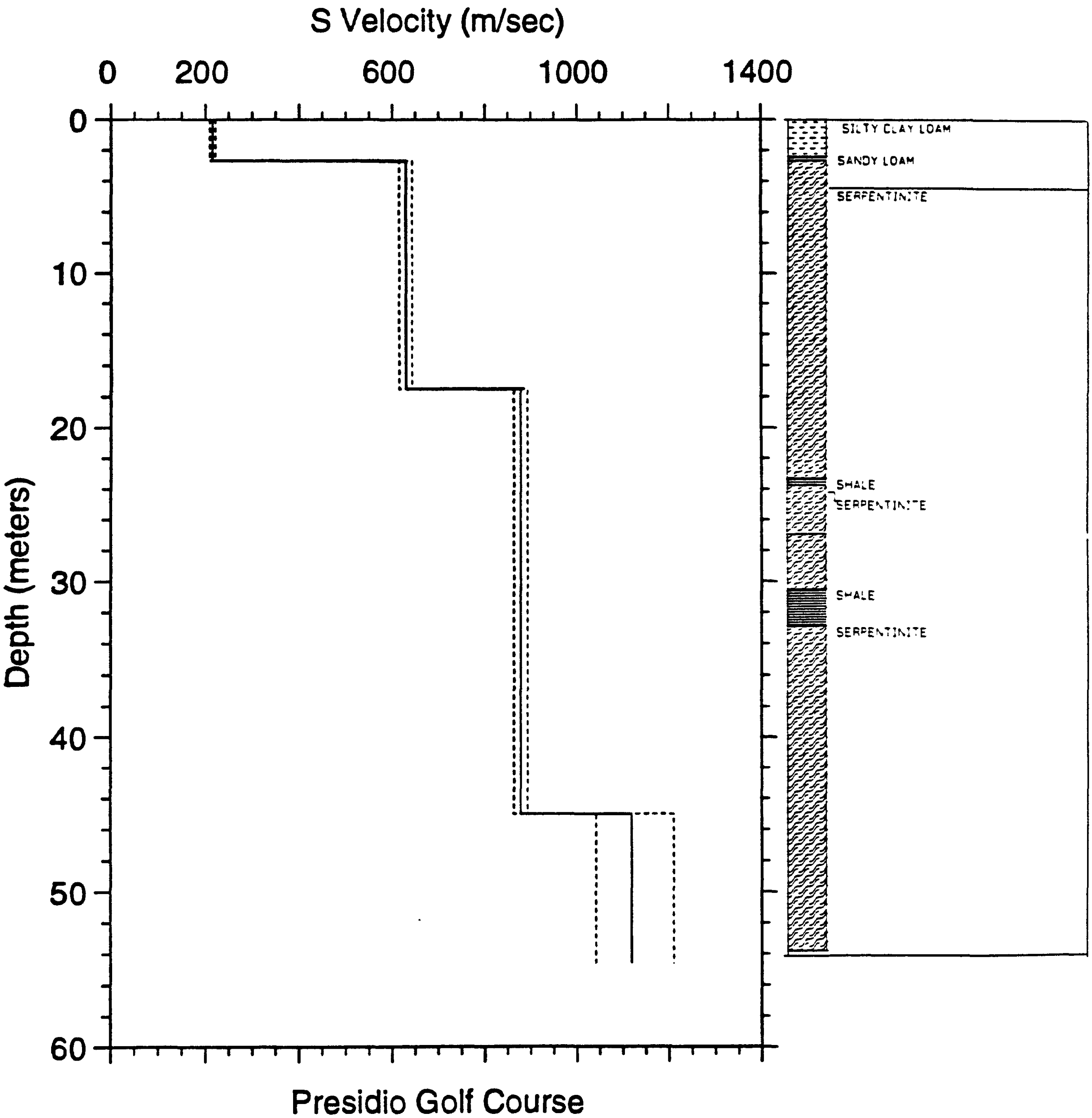


Figure 61. S-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

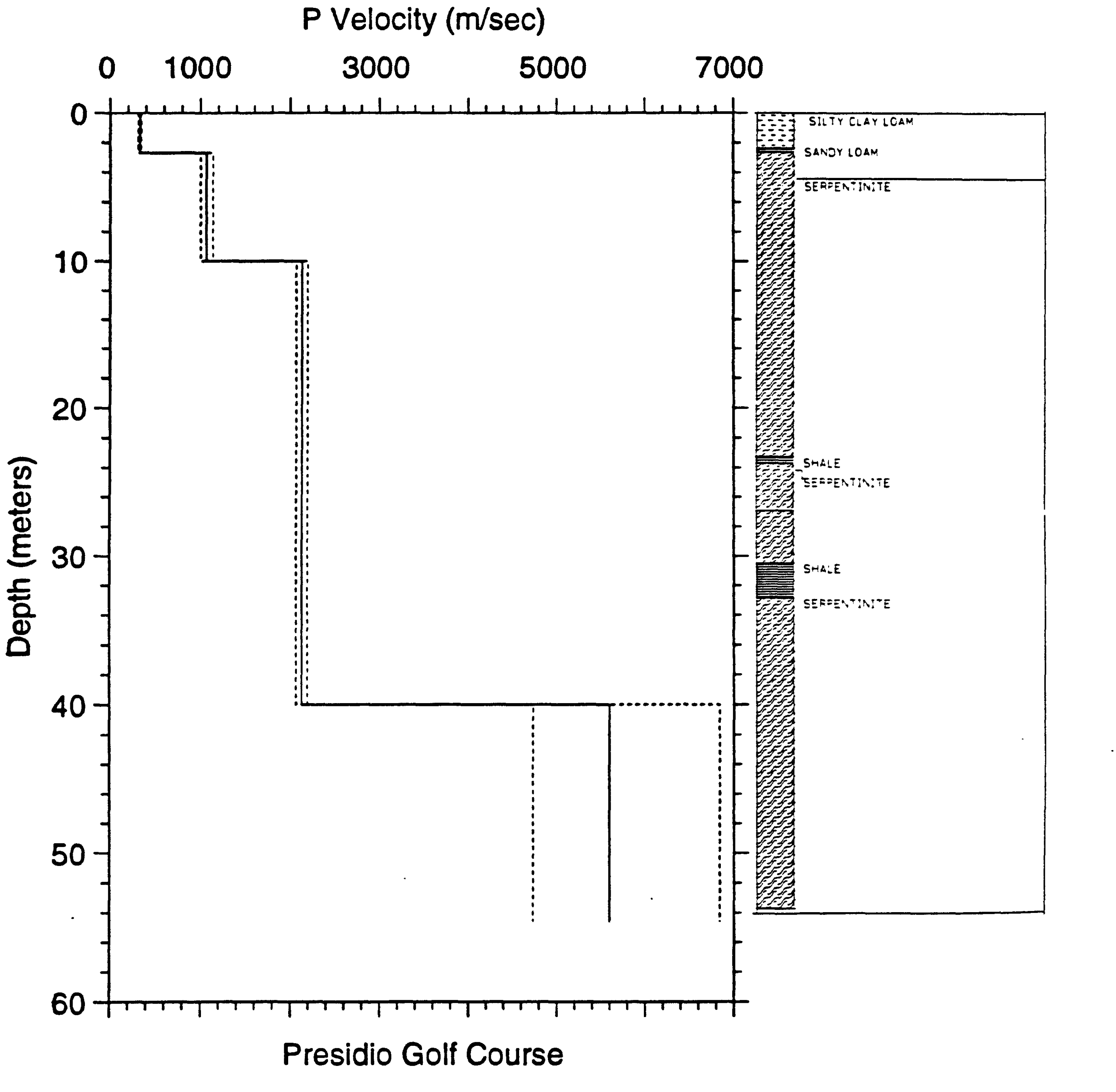


Figure 62. P-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

TABLE 13. S-wave arrival times and velocity summaries for Presidio Golf Course.

d(m)	d(ft)	t(sec)	sig	rsdl/sig
2.5	8.2	.0125	1	.9
5.0	16.4	.0156	1	-.6
7.5	24.6	.0203	1	.1
10.0	32.8	.0237	1	-.5
12.5	41.0	.0281	1	-.1
15.0	49.2	.0319	1	-.2
17.5	57.4	.0370	1	.9
20.0	65.6	.0382	1	-.8
22.5	73.8	.0419	1	.1
25.0	82.0	.0449	1	.2
27.5	90.2	.0480	1	.5
30.0	98.4	.0505	1	.1
35.0	114.8	.0556	1	-.4
40.0	131.2	.0612	1	-.5
45.0	147.6	.0677	1	.3
50.0	164.0	.0723	1	.4
54.6	179.1	.0758	1	-.2

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	215	209	221	704	684	725
2.7	8.9	.013	215	209	221	704	684	725
17.5	57.4	.036	629	615	642	2062	2019	2108
45.0	147.6	.067	878	864	893	2882	2836	2930
54.6	179.1	.076	1119	1041	1210	3671	3414	3969

Explanation:

d(m) = depth in meters
d(ft) = depth in feet
t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
sig = sigma, standard deviation normalized to the standard deviation of best picks
rsdl/sig = least-squares residual divided by sigma
dtb(m) = depth to bottom of layer in meters
dtb(ft) = depth to bottom of layer in feet
ttb(s) = arrival time in seconds to bottom of layer
v(m/s) = velocity in meters per second
vl(m/s) = lower limit of velocity in meters per second *
vu(m/s) = upper limit of velocity in meters per second
v(ft/s) = velocity in feet per second
vl(ft/s) = lower limit of velocity in feet per second
vu(ft/s) = upper limit of velocity in feet per second

* see text for explanation of velocity limits

TABLE 14. P-wave arrival times and velocity summaries for Presidio Golf Course.

d(m)	d(ft)	t(sec)	sig	rsdl/sig
2.5	8.2	.0079	1	.3
5.0	16.4	.0102	1	-.2
7.5	24.6	.0124	1	-.3
10.0	32.8	.0149	1	-.2
12.5	41.0	.0162	1	-.1
15.0	49.2	.0174	1	.0
17.5	57.4	.0185	1	-.1
20.0	65.6	.0206	1	.8
22.5	73.8	.0217	1	.7
25.0	82.0	.0217	1	-.4
27.5	90.2	.0228	1	-.5
30.0	98.4	.0248	1	.3
35.0	114.8	.0268	1	.0
40.0	131.2	.0289	2	-.1
45.0	147.6	.0299	1	-.2
50.0	164.0	.0309	1	-.1
54.6	179.1	.0319	1	.1

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	328	315	342	1075	1032	1122
2.7	8.9	.008	328	315	342	1075	1032	1122
10.0	32.8	.015	1066	1003	1137	3497	3290	3732
40.0	131.2	.029	2128	2068	2193	6983	6783	7194
54.6	179.1	.032	5596	4735	6839	18358	15534	22439

Explanation:

d(m) = depth in meters
d(ft) = depth in feet
t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
sig = sigma, standard deviation normalized to the standard deviation of best picks
rsdl/sig = least-squares residual divided by sigma
dtb(m) = depth to bottom of layer in meters
dtb(ft) = depth to bottom of layer in feet
ttb(s) = arrival time in seconds to bottom of layer
v(m/s) = velocity in meters per second
vl(m/s) = lower limit of velocity in meters per second *
vu(m/s) = upper limit of velocity in meters per second
v(ft/s) = velocity in feet per second
vl(ft/s) = lower limit of velocity in feet per second
vu(ft/s) = upper limit of velocity in feet per second
* see text for explanation of velocity limits

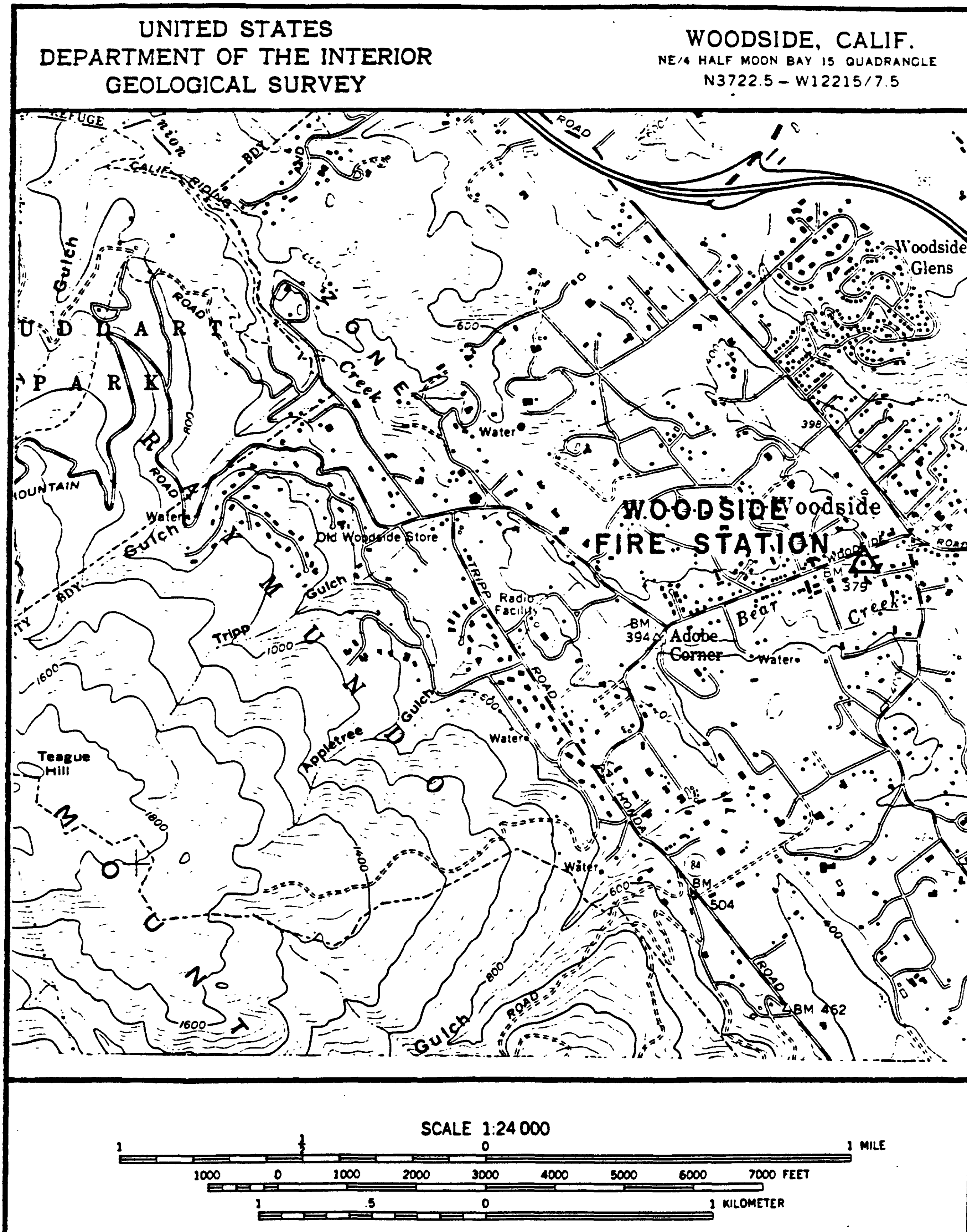


Figure 63. Site location map for Woodside Fire Station. The borehole is located within 20 meters of the strong-motion recorder.

Rock hardness: response to hand and geologic hammer: (Ellen et al., 1972)

hard - hammer bounces off with solid sound
firm - hammer dents with thud, pick point dents or penetrates slightly
soft - pick points penetrates
friable material can be crumbled into individual grains by hand.

Fracture spacing: (Ellen et al., 1972)

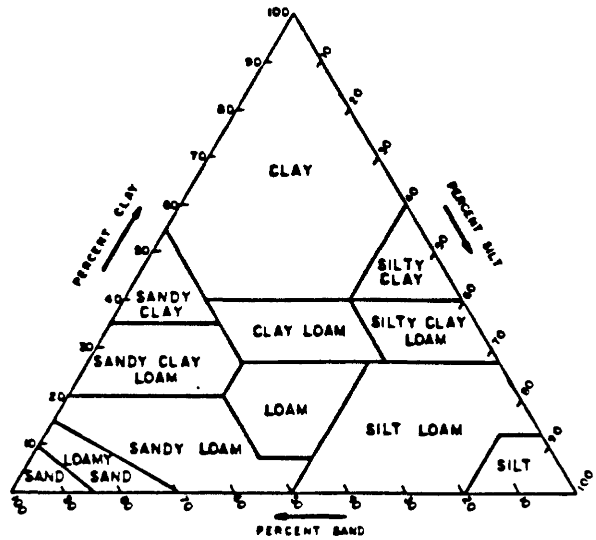
cm	in	fracture spacing
0-1	0-1/2	v. close
1-5	1/2-2	close
5-30	2-12	moderate
30-100	12-36	wide
>100	>36	v. wide

Weathering:
Fresh: no visible signs of weathering
Slight: no visible decomposition of minerals, slight discoloration
Moderate: slight decomposition of minerals and disintegration of rock, deep and thorough discoloration
Deep: extensive decomposition of minerals and complete disintegration of rock but original structure is preserved.

Relative density of sand and consistency of clay is correlated with penetration resistance: (Terzaghi and Peck, 1948)

blows/ft.	relative density	blows/ft.	consistency
0-4	v. loose	<2	v. soft
4-10	loose	2-4	soft
10-30	medium	4-8	medium
30-50	dense	8-15	stiff
>50	v. dense	15-30	v. stiff
		>30	hard

Texture: the relative proportions of clay, silt, and sand below 2mm. Proportions of larger particles are indicated by modifiers of textural class names. Determination is made in the field mainly by feeling the moist soil (Soil Survey, Staff, 1951).



Color: Standard Munsell color names are given for the dominant color of the moist soil and for prominent mottles.

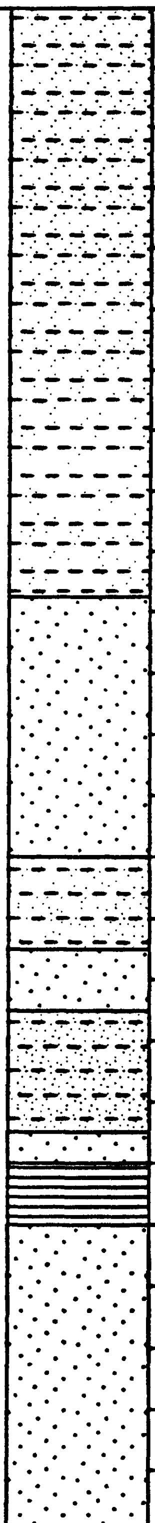
Types of samples

SP - Standard Penetration 1+3/8 in in ID sampler)
S - Thin-wall push sampler
O - Osterberg fixed-piston sampler
P - Pitcher Barrel sampler
CH - California Penetration (2 in ID sampler)
DC - Diamond Core

Figure 64. Explanation of geologic log.

SITE: WOODSIDE FIRE STATION DATE: 4/4/91

BLOWS/ FOOT	SAMPLE TYPE	GRAPHIC LOG	DEPTH (ft) (m)	DESCRIPTION



Depth (ft): 0, 10, 20, 30, 40, 50
Depth (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

FINE SANDY CLAY, dark yellowish brown (10YR 4/4 to 7.5 R 4/4)

yellowish brown (10YR 5/6)

SANDSTONE, light yellowish brown (10YR 6/4), fine-grained, soft

firmer

olive (5Y 5/3)

gray (5Y 5/1), very firm

thin interbeds of very dark grey mudstone

SANDSTONE, grey (5Y 5/1 to N 5/), fine-grained

interbeds of firm dark grey mudstone

very firm to hard

SANDSTONE, grey, fine-grained, hard

MUDSTONE, dark grey, firm

SANDSTONE, light grey, fine-grained, very firm

Figure 65. Geologic log for Woodside Fire Station borehole.

Page 1 of 3

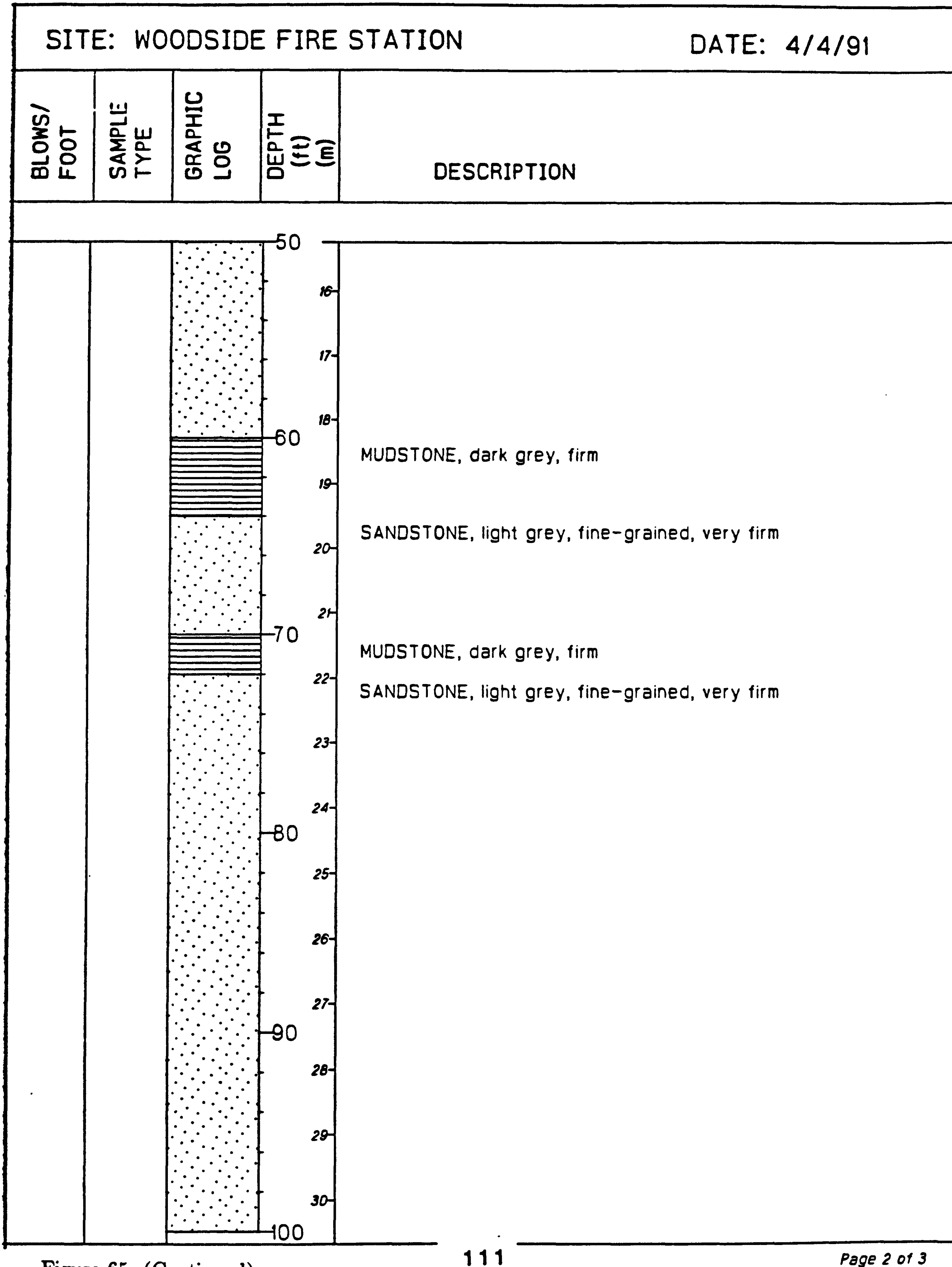


Figure 65. (Continued).

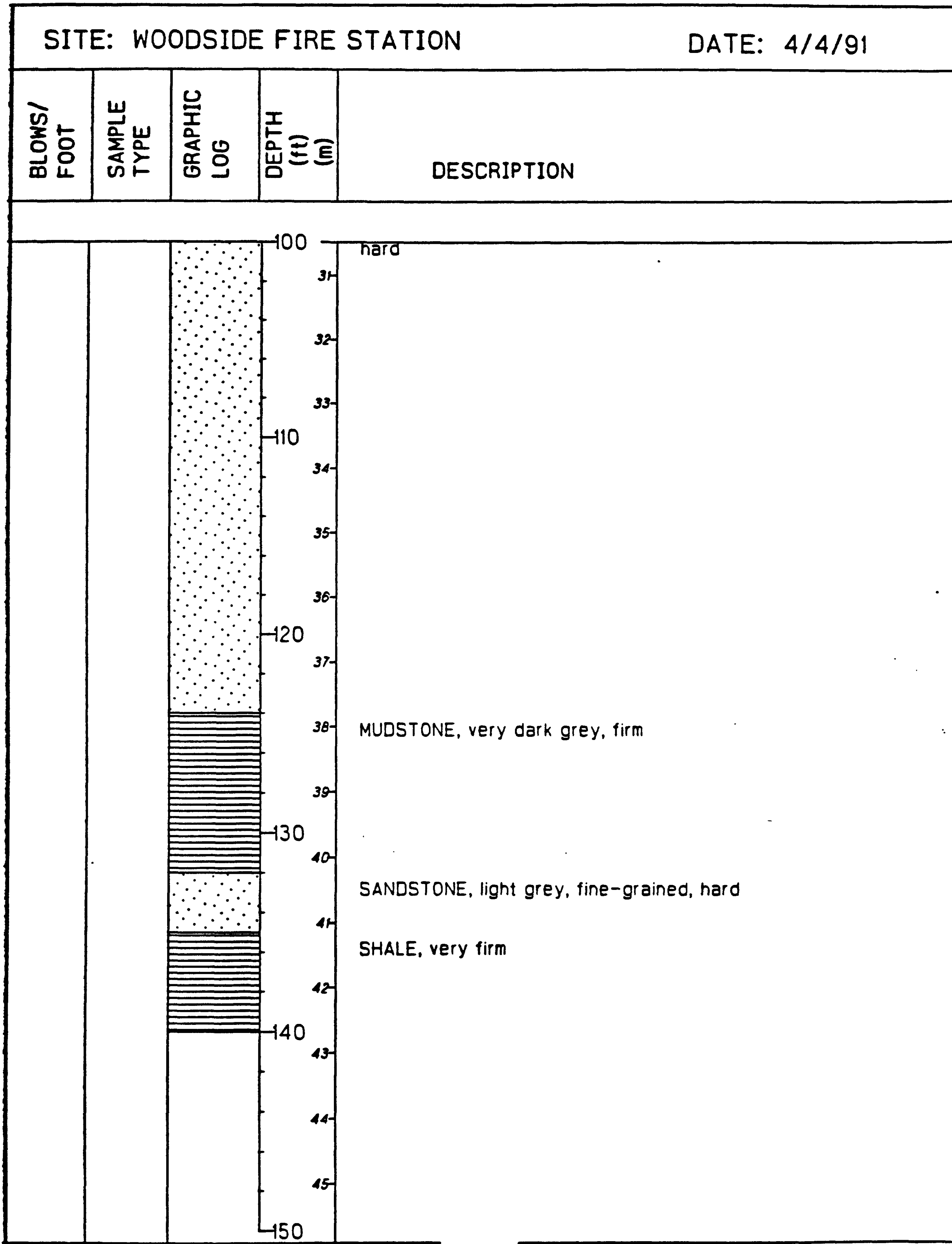


Figure 65. (Continued).

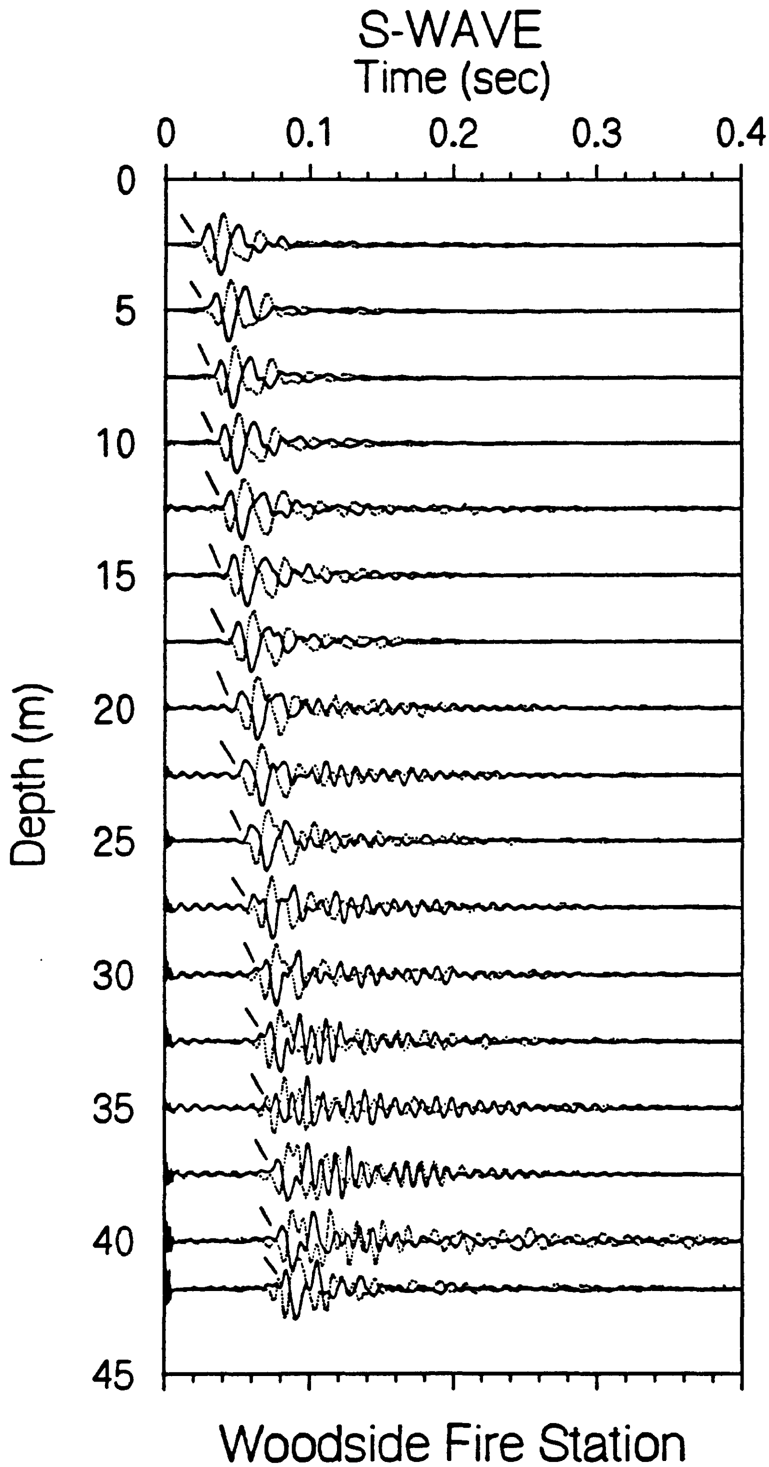


Figure 66. Horizontal-component record section from impacts in opposite horizontal directions superimposed for identification of shear arrivals. S-wave arrivals are shown by the accent marks.

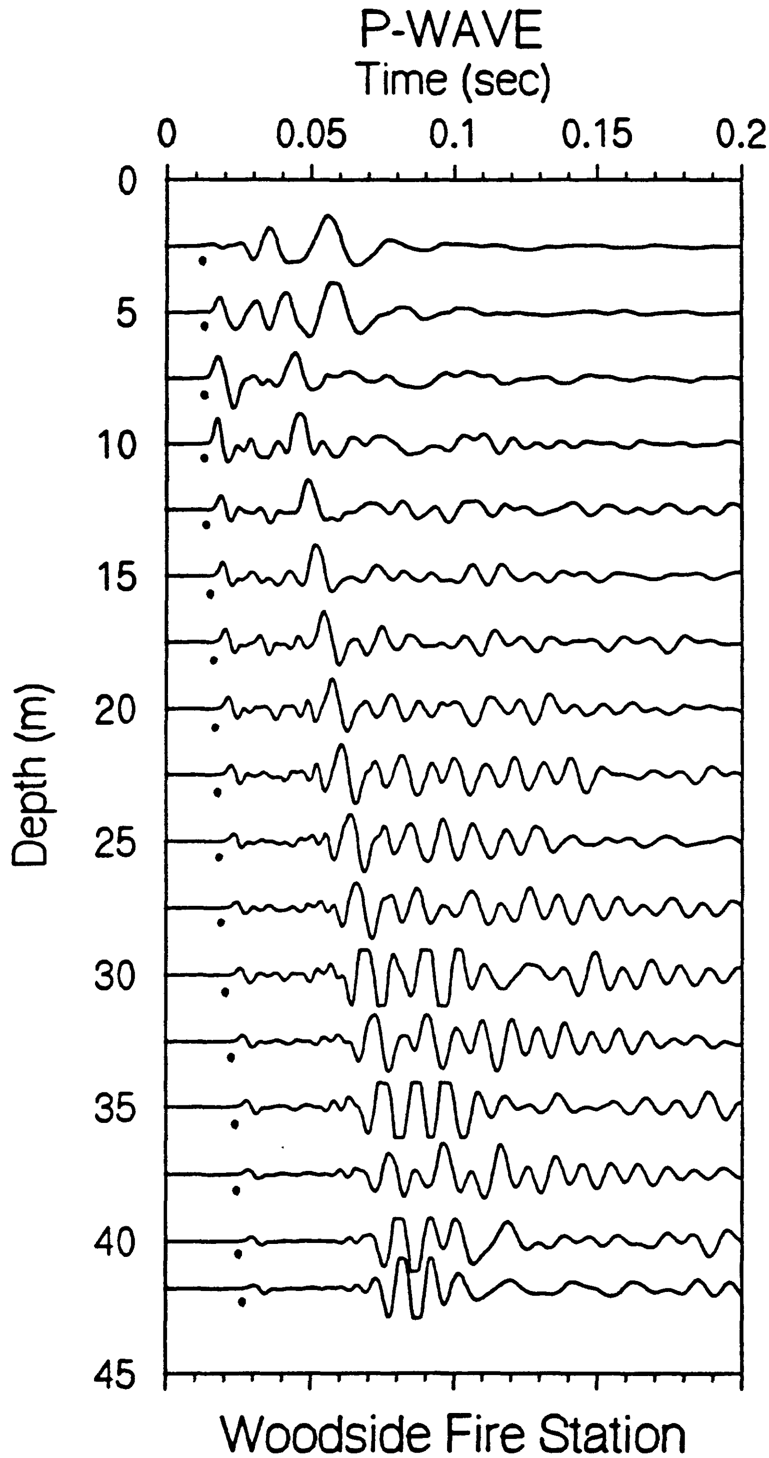


Figure 67. Vertical-component record section. P-wave arrivals are shown by the solid circles.

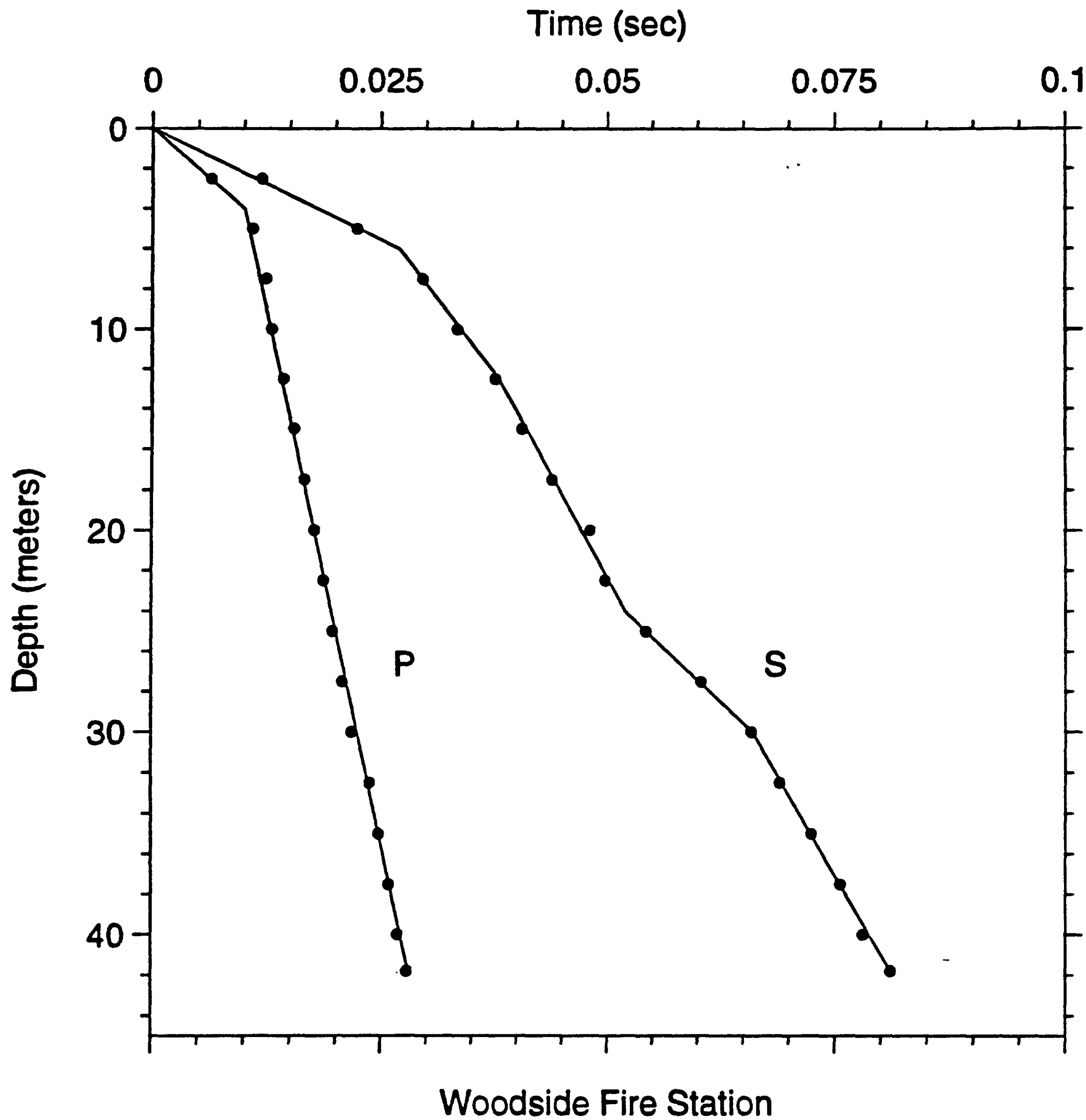


Figure 68. Time-depth graph of P-wave and S-wave picks. Line segments show the hinged-least-squares fit to the data points.

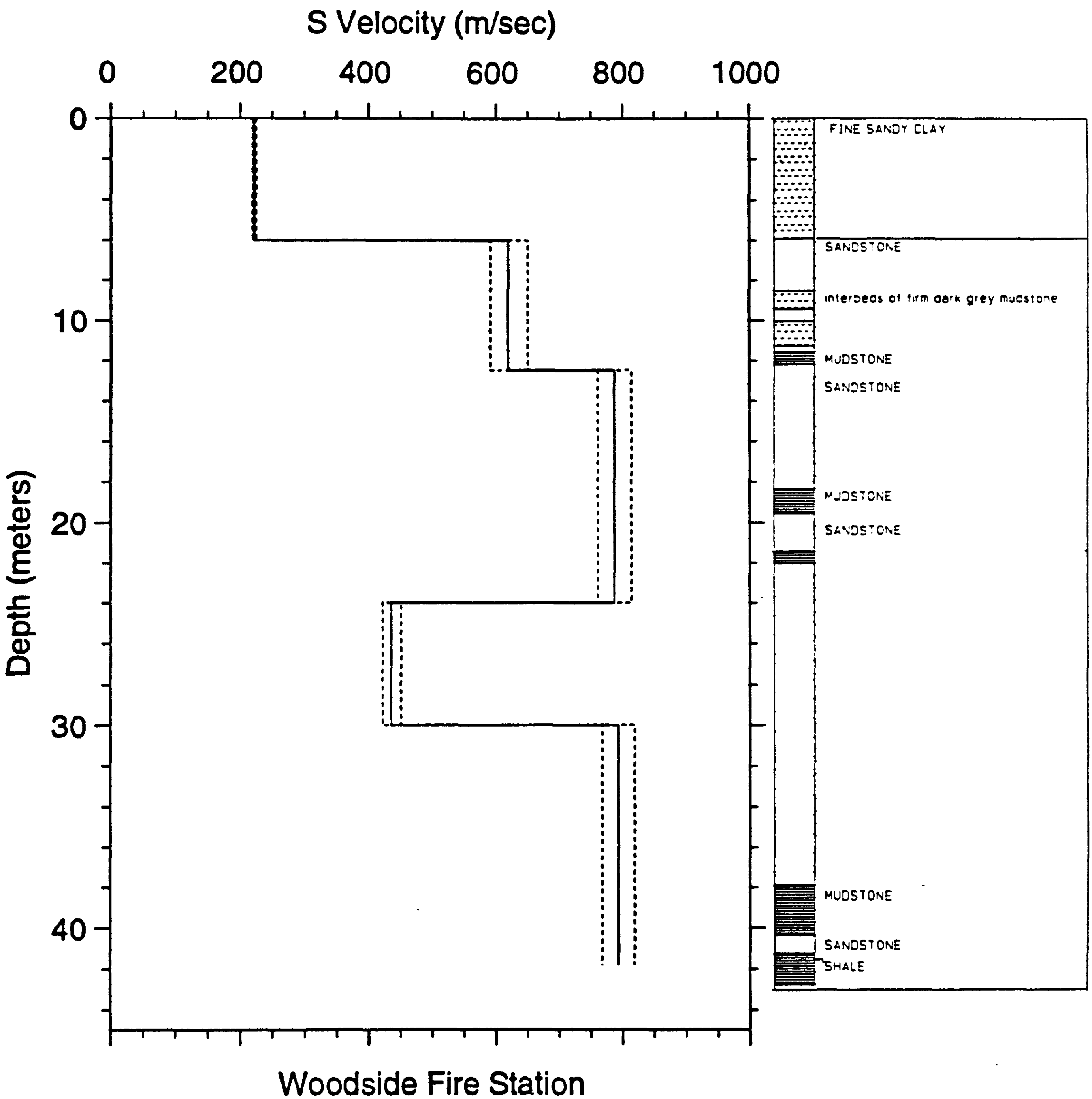


Figure 69. S-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

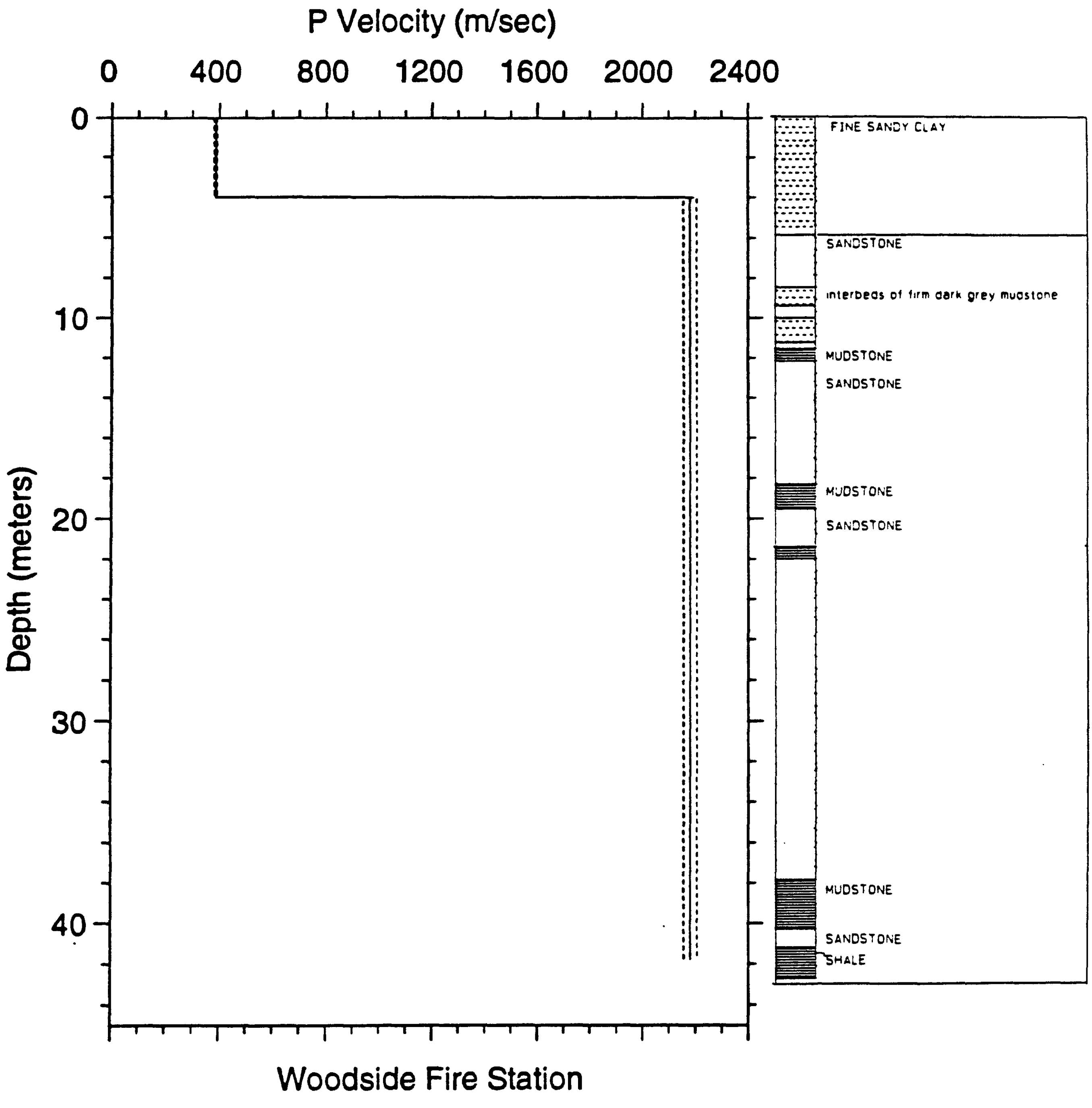


Figure 70. P-wave velocity profiles with dashed lines representing plus and minus one standard deviation. The statistics are done on the slope (reciprocal velocity) so that some of the limits will not appear symmetrical. Simplified geologic log is shown for correlation with velocities.

TABLE 15. S-wave arrival times and velocity summaries for Woodside Fire Station.

d(m)	d(ft)	t(sec)	sig	rsdl/sig
2.5	8.2	.0119	1	.6
5.0	16.4	.0223	1	-.3
7.5	24.6	.0296	1	.1
10.0	32.8	.0334	1	-.2
12.5	41.0	.0376	1	.0
15.0	49.2	.0406	1	-.2
17.5	57.4	.0439	1	-.1
20.0	65.6	.0481	1	1.0
22.5	73.8	.0498	1	-.5
25.0	82.0	.0543	1	-.2
27.5	90.2	.0604	1	.2
30.0	98.4	.0659	1	-.1
32.5	106.6	.0690	1	-.1
35.0	114.8	.0725	1	.2
37.5	123.0	.0756	1	.2
40.0	131.2	.0781	1	-.5
41.8	137.1	.0811	1	.2

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	221	219	224	726	717	736
6.0	19.7	.027	221	219	224	726	717	736
12.5	41.0	.038	619	591	650	2032	1940	2133
24.0	78.7	.052	787	761	814	2581	2498	2669
30.0	98.4	.066	436	422	451	1432	1386	1481
41.8	137.1	.081	793	768	819	2600	2520	2686

Explanation:
d(m) = depth in meters
d(ft) = depth in feet
t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
sig = sigma, standard deviation normalized to the standard deviation of best picks
rsdl/sig = least-squares residual divided by sigma
dtb(m) = depth to bottom of layer in meters
dtb(ft) = depth to bottom of layer in feet
ttb(s) = arrival time in seconds to bottom of layer
v(m/s) = velocity in meters per second
vl(m/s) = lower limit of velocity in meters per second *
vu(m/s) = upper limit of velocity in meters per second
v(ft/s) = velocity in feet per second
vl(ft/s) = lower limit of velocity in feet per second
vu(ft/s) = upper limit of velocity in feet per second
* see text for explanation of velocity limits

TABLE 16. P-wave arrival times and velocity summaries for Woodside Fire Station.

d(m)	d(ft)	t(sec)	sig	rsdl/sig
2.5	8.2	.0064	1	-.1
5.0	16.4	.0109	1	.1
7.5	24.6	.0124	1	.4
10.0	32.8	.0130	1	-.1
12.5	41.0	.0143	1	.0
15.0	49.2	.0155	1	.1
17.5	57.4	.0166	1	.0
20.0	65.6	.0177	1	.0
22.5	73.8	.0187	1	-.2
25.0	82.0	.0197	1	-.3
27.5	90.2	.0208	1	-.4
30.0	98.4	.0218	1	-.5
32.5	106.6	.0238	1	.4
35.0	114.8	.0248	1	.2
37.5	123.0	.0259	1	.2
40.0	131.2	.0269	1	.0
41.8	137.1	.0279	1	.2

dtb(m)	dtb(ft)	ttb(s)	v(m/s)	vl(m/s)	vu(m/s)	v(ft/s)	vl(ft/s)	vu(ft/s)
.0	.0	.000	386	381	390	1265	1251	1279
4.0	13.1	.010	386	381	390	1265	1251	1279
41.8	137.1	.028	2180	2155	2205	7152	7071	7235

Explanation:
- d(m) = depth in meters
- d(ft) = depth in feet
- t(sec) = arrival time in seconds (S-wave arrival times are the average of picks from traces obtained from hammer blows differing in direction by 180°)
- sig = sigma, standard deviation normalized to the standard deviation of best picks
- rsdl/sig = least-squares residual divided by sigma
- dtb(m) = depth to bottom of layer in meters
- dtb(ft) = depth to bottom of layer in feet
- ttb(s) = arrival time in seconds to bottom of layer
- v(m/s) = velocity in meters per second
- vl(m/s) = lower limit of velocity in meters per second *
- vu(m/s) = upper limit of velocity in meters per second
- v(ft/s) = velocity in feet per second
- vl(ft/s) = lower limit of velocity in feet per second
- vu(ft/s) = upper limit of velocity in feet per second

* see text for explanation of velocity limits