UNITED STATES
DEPARTMENT OF THE INTERIOR
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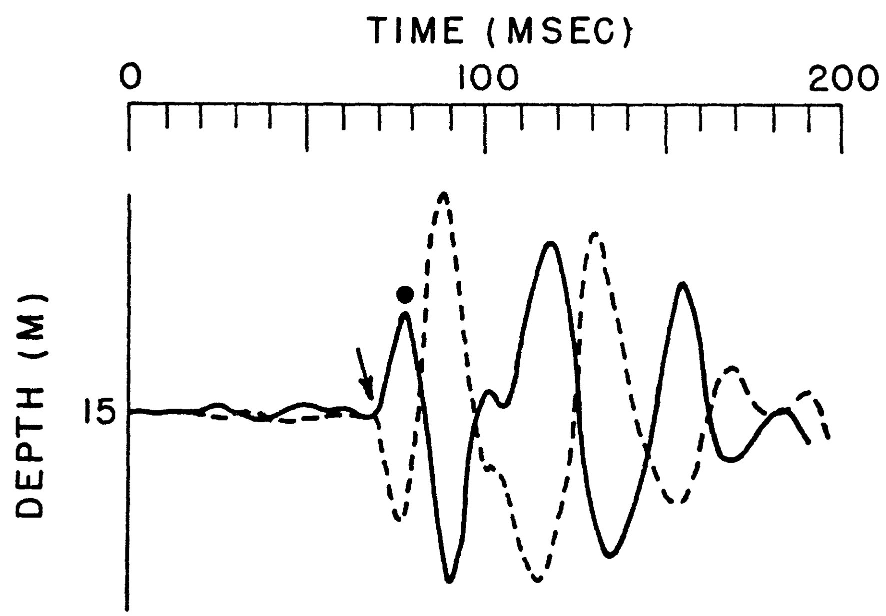
IN – SITU MEASUREMENTS OF SEISMIC VELOCITIES AT TWELVE LOCATIONS IN THE SAN FRANCISCO BAY REGION



U.S. GEOLOGICAL SURVEY
OPEN-FILE REPORT 75-564

Menlo Park, California
1975

UNITED STATES
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National Center for Earthquake Research
345 Middlefield Road
Menlo Park, California 94025

IN-SITU MEASUREMENTS OF SEISMIC VELOCITIES AT TWELVE LOCATIONS IN THE SAN FRANCISCO BAY REGION

by

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This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature.

CONTENTS

INTRODUCTION

Seismic wave velocities (compressional and shear) are important parameters for determining the seismic response characteristics of various geologic units when submitted to strong earthquake ground shaking (Borcherdt, 1970; Joyner, 1975).

Seismic velocities of various units often show a strong correlation with the amounts of damage following large earthquakes and have been used as a basis for certain types of seismic zonation studies (Medvedev, 1965; Gibbs and others, 1975).

Currently a program is in progress to measure seismic velocities in the San Francisco Bay region at an estimated 150 sites. At each site seismic travel times are measured at 2.5-m intervals in drill holes to a depth of 30 m. Geologic logs are determined from drill hole cuttings, undisturbed samples, and penetrometer samples. The data provide a detailed comparison of geologic and seismic characteristics and provide parameters for estimating strong earthquake ground motions quantitatively at each of the sites (Joyner, 1975). A major emphasis of this program is to obtain a detailed comparison of geologic and seismic data on a regional scale for use in seismic zonation. The broad data base available in the San Francisco Bay region suggests using the area as a pilot area for the development of general techniques applicable to other areas.

This paper is a progress report on the data collected and analyzed at the first 12 sites. Shear wave velocities in near-surface geologic materials are of especial interest for engineering seismology and seismic zonation studies, yet in general they are difficult to measure because of contamination by compressional waves. A comparison of various in-situ techniques by Warrick (1974) established the reliability of the method utilizing a "horizontal traction" source for sites underlain by bay mud and alluvium. The data presented in this paper establish the reliability of the method for sites underlain by a variety of different rock units and suggest the feasibility of making the measurements at a much larger number of sites. The data collected from these first 12 holes have provided an opportunity for developing a routine and efficient procedure for collection and reduction of the data. This report presents a detailed description of these procedures and the resulting data.

Gibbs and others (1975) reported preliminary comparisons of the data with the amplification data recorded from nuclear explosions (Gibbs and Borcherdt, 1974), and the intensity data for the 1906 earthquake (Lawson, 1908). These comparisons showed that strong correlations existed between the three data sets. The correlations and the quality of the seismic and geologic data collected to date suggest that extending the measurements to a much larger number of sites should provide a significant new data set from which ground motion predictions for seismic zonation can be made.

SELECTION AND LOCATION OF SITES

Several types of data are available in the San Francisco Bay region which are pertinent to the overall problem of estimating earthquake ground motions for seismic zonation. These are (1) distribution of intensity for the California earthquake of April 18, 1906, (2) ground motion amplifications recorded at 99 sites, and (3) detailed geologic mapping. Sites are selected on the basis of each of these data sets. The present locations of strong motion instrumentation are also considered. Once a site is selected on the basis of these data sets, accessibility of the site is determined and formal permission is obtained from the property owners. A file of access data and sketch maps is being compiled for each site. The locations of the sites are presented on 7 1/2-minute map sheets (see figs. 1-6 for locations of the first 12 sites).

DRILLING AND SAMPLING PROCEDURES

At each site selected, a hole 12.4 cm in diameter was drilled to a depth of 30 m using a "Failing 1500" truck-mounted drill and a rock bit with mud and water circulation. The boring was then cased with 7.6 cm diameter PVC plastic pipe and backfilled with drill cuttings and fine gravel. Casing insured accessibility of the hole and provided a secure clamping surface for the seismic probe.

Samples were taken in each of the holes at depths of approximately 3 m, 7.5 m, 30 m, and at boundaries defined by continuously monitoring the drill cuttings and the drill reaction. The type and number of samples taken at each site were determined by the type of material, the number of significant lithologic boundaries, and variations in weathering. For those holes which penetrated a single rock unit, material variations as a function of depth were due largely to weathering. For these holes the depths of 3, 7.5, and 30 m usually provided samples of deeply weathered, moderately weathered, and fresh rock. Additional samples were taken where unusually thick weathering zones were encountered. Cost and the need for a large number of holes distributed on a regional scale prohibited continuous sampling. In soils, standard penetration measurements were made and undisturbed samples were taken using a "Pitcher" core barrel and a "Shelby" thin tube liner. Undisturbed samples were also taken in soils with large amounts of hard rock fragments and in firm rock. Samples were obtained in hard rock using a core barrel with a diamond core bit.

RECORDING PROCEDURES

Compressional waves are generated at each site by the vertical impact of a sledge hammer on a steel plate. A signal produced by the opening of an impact switch attached to the hammer is recorded for determining origin time.

Shear waves are generated using the horizontal traction source introduced by Kobayashi (1959) and discussed by Warrick (1974). Briefly, the method consists of applying a horizontal impact to a large timber (244 x 30 x 18 cm). The timber is placed on a flattened soil surface and held firmly in place by the front wheels of a truck. A steel pipe extends through the timber and supports a 30 kg hammer to which is attached an impact switch. The specially constructed hammer rolls on bearings and moves a distance of 45 cm along the pipe before impacting the timber. The "horizontal traction" source generates a high proportion of S to P wave energy. The timber is impacted twice, once on each end. The two impacts reverse the polarity of the S waves but not the polarity of the smaller amounts of P wave energy. Comparison of the two signals provides an important tool for identifying the onset of the S wave.

The timber is offset 2.0 m from the hole and a three-component geophone package (natural frequency 14 Hz) is placed within 9 cm of its center. The signals recorded from the surface geophones are used to monitor the input signals and determine the onset time for the generated S waves. The arrangement of timber, steel plate, and surface geophone package is illustrated in figure 7A.

The P waves generated by a vertical impact on the steel plate and the S waves generated by impacting both ends of the timber are recorded separately. This procedure is repeated for each 2.5 m interval in the drill hole. The seismic probe used in the first 12 drill holes consists of three sensors (one vertical and two horizontal) (Mark Product L-10, natural frequency 14 Hz). The three-component package is 5.1 cm in diameter and is locked in position with a sidewall clamp made of spring steel. This package is not easily oriented from the surface, so that one horizontal seismometer is inline and the other transverse. The downhole instrument has been recently replaced with a three-component unit built by Oyo Corp., Tokyo, Japan. The new instrument package has a declinometer and an inflatable diaphragm which easily permits obtaining the desired orientation from the surface. Proper orientation aids in identifying the onset of the S wave.

The signals from the downhole and surface seismometers and the impact switches are recorded on photographic paper and magnetic tape in analog form. The velocity unit-impulse of the recording system is essentially flat from 2 Hz to ab ove 100 Hz. A detailed description of the recording instrumentation is presented by Warrick and others (1961). For this project the recording oscillograph has been modified by adding 500 Hz galvanometers and increasing the paper speed to 46 cm/sec.

REDUCTION OF GEOLOGIC DATA

Description of Samples

Portions of each of the samples have been examined and described in the laboratory. The terms used for the descriptions are summarized on figure 8. The sample descriptions for the first 12 holes are presented in the left-hand columns of figures 9-20.

The soil samples were described using the field techniques of the Soil Conservation Service and those specified for the Unified Soil Classification System. Descriptions include soil texture, color, amount, and size of coarse grains, plasticity, dry and wet consistency, and moisture condition. Texture refers to the relative proportions of clay, silt, and sand particles less than 2 mm in diameter. The dominant color of the soil and prominent mottles were 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 and others (1972) in describing hillside materials in San Mateo County. The weathering classification was modified from that used by Aetron-Blume-Atkinson (1965) in describing Tertiary sedimentary rocks in the foothills of the Santa Cruz Mountains.

Geologic Log

Geologic logs have been compiled for each of the 12 holes using the field log and descriptions of the samples (figures 9-20). The field log was based on the reaction of the drill rig, a continuous record of drill cuttings, preliminary on-site inspection of samples, and inspection of nearby roadcuts and gullies.

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

Density Measurements

Density measurements are required to calculate elastic modulii from measurements of seismic velocity. Densities have been measured from most of the penetrometer, Pitcher tube, and diamond core samples (figs. 9-20). Densities were measured, where possible, by weighing a small piece of the sample and obtaining its volume by the mercury displacement method. A different method was used for very friable materials such as grus or poorly sorted materials which necessitated using a large sample. A slice was sawed from the Shelby tube containing the sample, its height and diameter measured, and the sample extruded for weighing. For the mercury displacement method, measurements were made on three portions of a sample and the average reported.

While the accuracy of the density measurements is generally sufficient for calculation of elastic modulii, a number of the samples used to obtain densities are not too representative of the in-situ material. Materials that were sampled by penetration are compressed in sampling and several of these dried out before density measurements could be made. For these samples, the measured density is probably somewhat higher than the in-situ density. Densities of the hard rock samples were obtained using whole rock fragments from diamond core samples and are maximum densities. Depending on the amount and openness of fractures, these rock densities could be higher than in-situ densities by approximately 0.1-0.2 gm/cc.

REDUCTION OF SEISMIC DATA

Identification of Shear-Wave Onset

To identify the shear-wave arrivals, the signals recorded in the drill hole from the impacts on opposite ends of the timber are superimposed and drafted on a common time base (figs. 21-32). The amplitude scales for the two horizontal signals recorded at each depth in the drill hole are approximately the same, however, the scales vary between depths.

The onset of the S wave arrival (arrows) and the first peak of the S wave arrival (dots) identified for each depth and for each site are indicated on figures 21-32.

It was not possible to control the orientation of the downhole seismometer package; hence the relative amounts of S wave energy recorded on the two horizontal seismometers vary with depth. The S wave arrival is generally most easily identified on the horizontal seismogram with the largest amplitudes (e.g., see fig. 22). Comparison of the signals recorded on the horizontal sensors with that recorded on the vertical sensor shows that the S wave energy generated by the horizontal traction source is at least twice as large as the P wave energy.

On many seismograms some P wave energy prior to the onset of the S wave is apparent. Some P wave energy is generated by the horizontal traction source and some probably results from conversion of S to P at seismic boundaries. In some cases the polarity of this P wave energy is reversed and careful consideration of the entire record section is required to identify the S arrival. In general, the onset of the S wave is easier to identify at sites underlain by the various types of soil than for sites underlain by the more consolidated rock units.

Travel Times and Average Velocities

To determine the travel time for the S wave onset identified from the record sections (figs. 21-32), the following times are measured with respect to a 100 Hz time code signal recorded on the records:

1) $t_1 \equiv$ time of break in signal from impact switch

2) $t_2 \equiv$ onset time of S wave arrival on inline uphole geophone

3) $t_3 \equiv$ onset time of identified S wave arrival on downhole sensors

The time considered to be the origin time for the S wave recorded on the downhole sensor is the onset time of the S arrival on the uphole inline sensor. To reduce the uncertainties in determining this origin time, an average value (t_A) is determined for the set of values, $t_1 - t_2$, measured at each depth. The travel time for the first S arrival is given by

$$t_s \equiv (t_3 - t_1) + t_A .$$

A corrected S wave travel time (t_{s_c}), corresponding to the travel time for a vertical ray path, is computed from $t_{s_c} \equiv t_s + t_c$ where t_c corresponds to a timing correction due to the distance the plank is offset from the center of the hole (usually 2.0 m). Average velocities from the surface are determined by dividing the corrected travel time by the corresponding depth. The travel time for the first S peak is determined similarly. The origin corrections ($|t_1 - t_2|$), the travel times of the first S arrival and the first S peak (t_s), the corrected travel times for the first S arrival and the first S peak (t_{s_c}), and the average corresponding velocities computed at each site are presented in tables 1-12.

The travel times for the P waves generated by a vertical impact on a steel plate are determined similar to those for the S waves, except that the origin time for the P wave is given by the impact switch and no origin correction is necessary. The travel times, the corrected travel times, and the average velocities for the P waves are also presented for the first 12 sites in tables 1-12.

INTERVAL VELOCITIES AND ELASTIC MODULI

Calculation of interval velocities and elastic moduli requires determination of depth intervals over which the velocity is approximately constant within the uncertainty of the travel-time measurements. To determine these depth intervals, the travel-time data (tables 1-12) were plotted as a function of depth (figs. 33-44) and the geologic logs (figs. 9-20) were simplified (figs. 33-44). Depth intervals for velocity determinations have been selected on the basis of distinct changes in slope of the travel-time plots and evidence for lithologic boundaries. For those geologic materials with s velocities greater than 350 m/sec, the intervals were required to contain at least four travel-time measurements to avoid determining a velocity from a travel-time differential due in large part to measurement error. For purposes of a generalized comparison between the different sites, the interval 10-30 m was selected for routine computation of velocity. For site No. 11, North Peak, the velocity in the interval 10-30 metres was not reported because of the abrupt change in travel time occurring at 22.5 metres (fig. 43). It is possible that the S wave picks at 22.5, 25.0, and 26.6 metres are converted phases (P to S), which could explain the early arrival times of the S phases.

Velocities have been calculated for each of the selected intervals (tables 13-24) from the slope of the linear regression line which best fits the travel-time data in a least squares sense (Borcherdt and Healy, 1968, eqs. 3.1-3.5). The equation of the linear-regression line which best fits, in a least-squares sense, a sample of n pairs of time-depth coordinates $\{(x_1,t_1),\ldots,(x_n,t_n)\}$ is

$$t(x) = a + b\ (x - \bar{x})$$

where

$$\bar{x} \equiv \frac{1}{n} \sum_{i=1}^{n} x_i ,$$

the intercept (INCPT) is $a \equiv \frac{1}{n} \sum_{i=1}^{n} t_i$, and

the slope is $b \equiv \sum_{i=1}^{n} w_i t_i$

with $w_i = (x_i - \bar{x})/D$ and $D \equiv \sum_{k=1}^{n}(x_k - \bar{x})^2$.

The desired velocity (VEL) is given by $v = 1/b$. Assuming the standard statistical model (Borcherdt and Healy, 1968), the 68.3 confidence interval (UNC INT) for the velocity is estimated by

$$\left(\frac{1}{b+S_b} , \frac{1}{b-S_b}\right) ,$$

where

$$S_b \equiv \frac{1}{(n-2)D} \sum_{i=1}^{n} (t_i - t(x_i))^2$$

is the standard error of the regression coefficient.

For those depth intervals with measurements of density (ρ), the shear modulus (SHEAR MOD, M) and bulk modules (BULK MOD, K) have been calculated (tables 13-24) using

$$M = \rho\, V_s^{\,2}$$

and

$$K = \rho\, V_p^{\,2} - \frac{4}{3} M \, .$$

Poisson's ratio (σ) has been calculated (tables 13-24) using

$$\sigma = \frac{\left(\frac{V_p}{V_s}\right)^2 - 2}{2\left(\frac{V_p}{V_s}\right)^2 - 2}$$

CONCLUSIONS

The data from the first 12 boreholes have established that reliable velocities for both shear waves and P waves can be determined for all near-surface geologic units in the San Francisco Bay Area. Poor results have been obtained at only one site, "North Peak" (fig. 31), underlain by Montara granite. Repeated measurements at this site (not shown) did not improve the results and suggest that the poor results are probably due to poor coupling of the casing to the sidewalls of the bore hole. The quality of the data collected suggests the feasibility of extending the measurements to a much larger number of sites in order to develop a data base for predicting ground motions on a regional scale for purposes of seismic zonation.

ACKNOWLEDGMENTS

We wish to especially thank Kenneth R. Lajoie for his support of the program, for many helpful discussions of the geology of the San Francisco Bay area and for his help in site selection. T. Leslie Youd has participated in many helpful discussions and provided laboratory personnel and equipment for density measurements. Edward F. Roth has been helpful in collecting the data in the field. We are deeply indebted to Richard E. Warrick, who pioneered the development of most of the S-wave apparatus and techniques used in this project.

REFERENCES

Aetron-Blume-Atkinson, 1965, Geologic site investigation for Stanford Linear Accelerator Center: Report No. ABA-88.

Borcherdt, R. D., 1970, Effects of local geology on ground motion near San Francisco Bay, Bull. Seism. Soc. Am., 60, 29-61.

Borcherdt, R. D., and Healy, J. H., 1968, A method for estimating the uncertainty of seismic velocities measured by refraction techniques, Bull. Seism. Soc. Am.,58, p. 1769-1790.

Brabb, E. E., 1970, Preliminary geologic map of the Central Santa Cruz Mountains, California: U.S. Geological Survey, Bay Region Environment and Resources Planning Study, Basis Data Contribution 6.

Brabb, E. E., and Pampeyan, E. H., 1972, Preliminary geologic map of San Mateo County, California: U.S. Geol. Survey Misc. Field Studies Map MF-328, scale 1:62,500.

Duke, C. M., 1969, Techniques for field measurement of shear wave velocity in soils, in Proceedings of the fourth world conference on earthquake engineering: Santiago, Chile, v. III, p. 39-54.

Ellen, S. D., Wentworth, C. M., Brabb, E. E., and Pampeyan, E. H., 1972, Description of geologic units, San Mateo County, California: Accompanying U.S. Geol. Survey Miscellaneous Field Studies Map, MF-328.

Gibbs, James F., and Borcherdt, Roger D., 1974, Effects of local geology on ground motion in the San Francisco Bay region, California, a continued study, U.S. Geological Survey open-file report No. 74-222.

Gibbs, J. F., Warrick, R. E., Fumal, T. E., Borcherdt, R. D., Lajoie, K. R., and Youd, T. L., 1975, In situ measurements of seismic velocities in the San Francisco Bay region, Abstract presented before the 71st Annual Meeting Cordilleran Section, P406, Ca. State Univ., Los Angeles, California.

Jolly, R. N., 1956, Investigation of shear waves: Geophysics, v. 21, p. 905-938.

Joyner, William B., and Chen, Albert T. F., 1975, Calculation of nonlinear ground response in earthquakes, in press, Bull. Seism. Soc. Am., 65, October 1975.

Kitsunezaki, C., 1971, Field-experimental study of shear waves and the related problems: Geophysics. Inst., Kyoto Univ., p. 103-177.

Kobayaski, N., 1959, A method of determining the underground structure by means of SH waves: Zisin, ser. 2, v. 12, p. 19-24.

Kuto, K., and Shima, E., 1970, Attenuation of shear-waves in soil: Earthquake Research Inst. Bull., Tokyo Univ., v. 48, p. 145-158.

Lawson, A. C. (Chairman), 1908, The California earthquake of April 18, 1906, Report of the State Earthquake Commission, Carnegie Inst. of Washington, Atlas Maps 21 and 22.

Medvedev, S. V., 1965, Engineering Seismology: National Technical Inf. Service, NTIS No. TT65-50011, 260 p.

Mooney, H. M., 1974, Seismic shear waves in engineering: Am. Soc. Civil Engineers Proc., Jour. Geotechnical Eng. Div., v. 100, p. 905-923.

Shima, E., and Ohta, Y., 1967, Experimental study on generation and propagation of S-waves: I. Designing of SH-wave generator and its field tests: Earthquake Research Inst. Bull., Tokyo Univ., v. 45, p. 19-31.

Soil Survey Staff, 1951, Soil Survey Manual: U.S. Department of Agriculture Handbook 18.

Warrick, R. E., Hoover, D. B., Jackson, W. H., Pakiser, L. C., and Roller, J. C., 1961, The specification and testing of a seismic-refraction system for crustal studies: Geophysics, v. 26, p. 820-824.

Warrick, R. E., 1974, Seismic investigation of a San Francisco Bay mud site: Seismol. Soc. America Bull., v. 64, p. 375-385.

White, J. E., Heaps, S. N., and Lawrence, P. L., 1956, Seismic waves from a horizontal force: Geophysics, v. 21, p. 715-723.

FIGURES

TABLES

TABLES

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Tables 1-12. "Travel-times and average velocities", are a summary of the times and corrections. Average velocity is calculated from the surface to each depth.

Tables 13-24."Interval velocities and elastic moduli", are a summary of the calculations for seismic velocities and elastic moduli. At locations where a reasonably good density could not be determined, bulk and shear modulus are not reported.

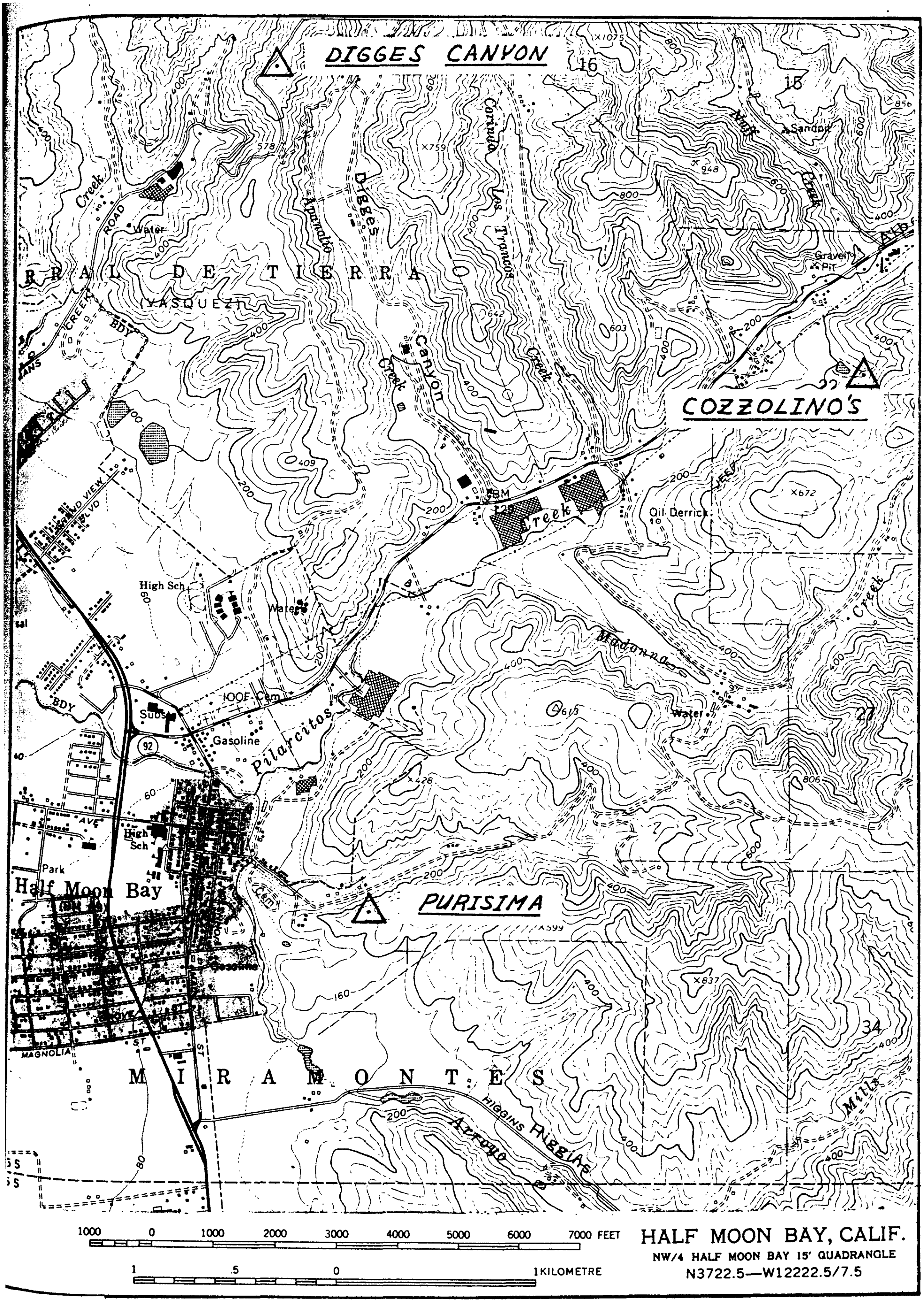

DIGGES CANYON
COZZOLINO'S
PURISIMA
HALF MOON BAY, CALIF.
NW/4 HALF MOON BAY 15' QUADRANGLE
N3722.5—W12222.5/7.5
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETRE
Half Moon Bay
M I R A M O N T E S
Digges Canyon
Madonna Creek
Pilarcitos Creek
Los Tranquitos Creek
Oil Derrick
High Sch
IOOF Cem
Gasoline
Water
Gravel Pit
Arroyo
Higgins
MAGNOLIA

Fig. 1


CUPERTINO, CALIF.
SE/4 PALO ALTO 15' QUADRANGLE
N3715—W12200/7.5
7000 FEET
1 KILOMETER
MARYKNOLL

Fig. 2

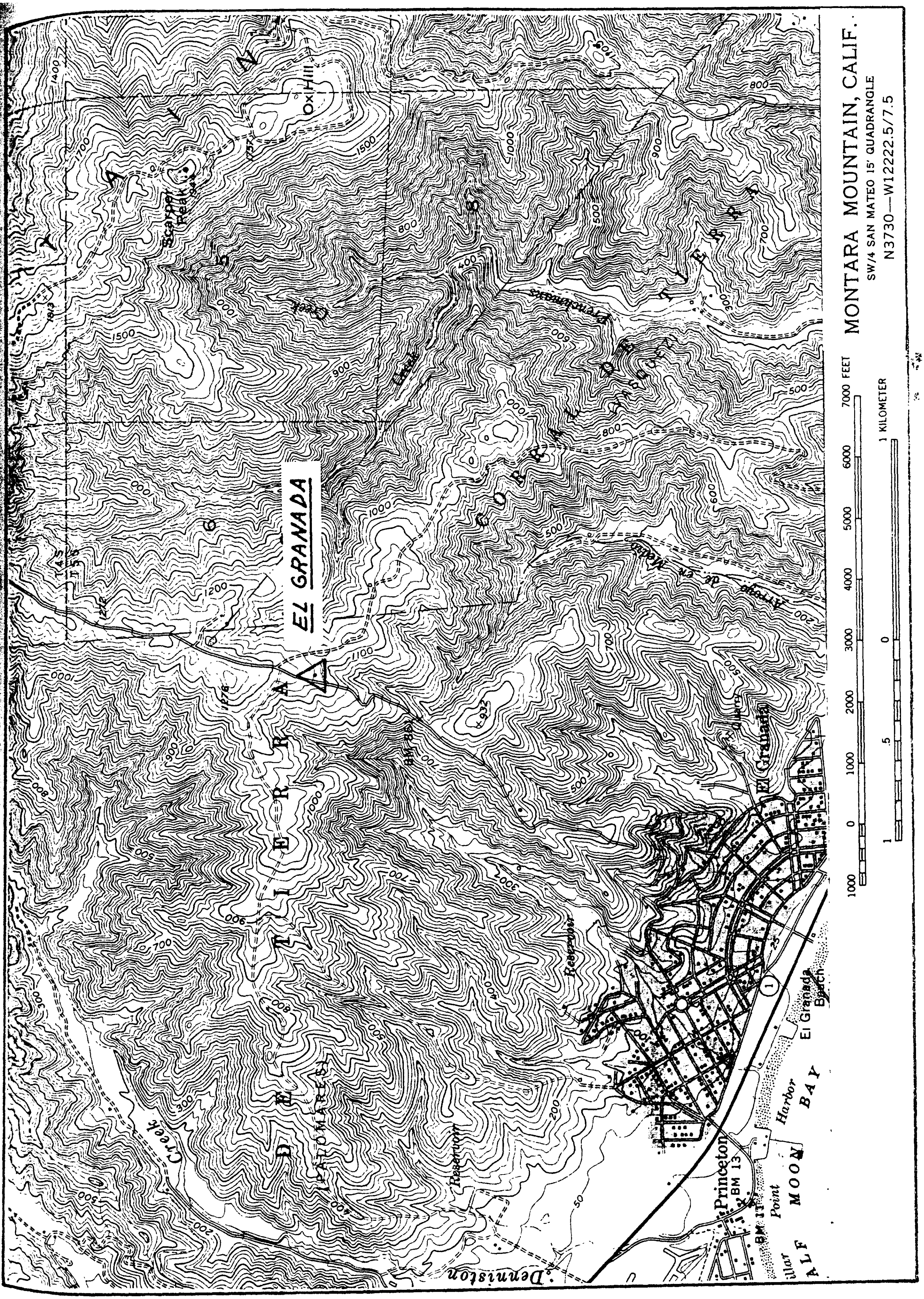
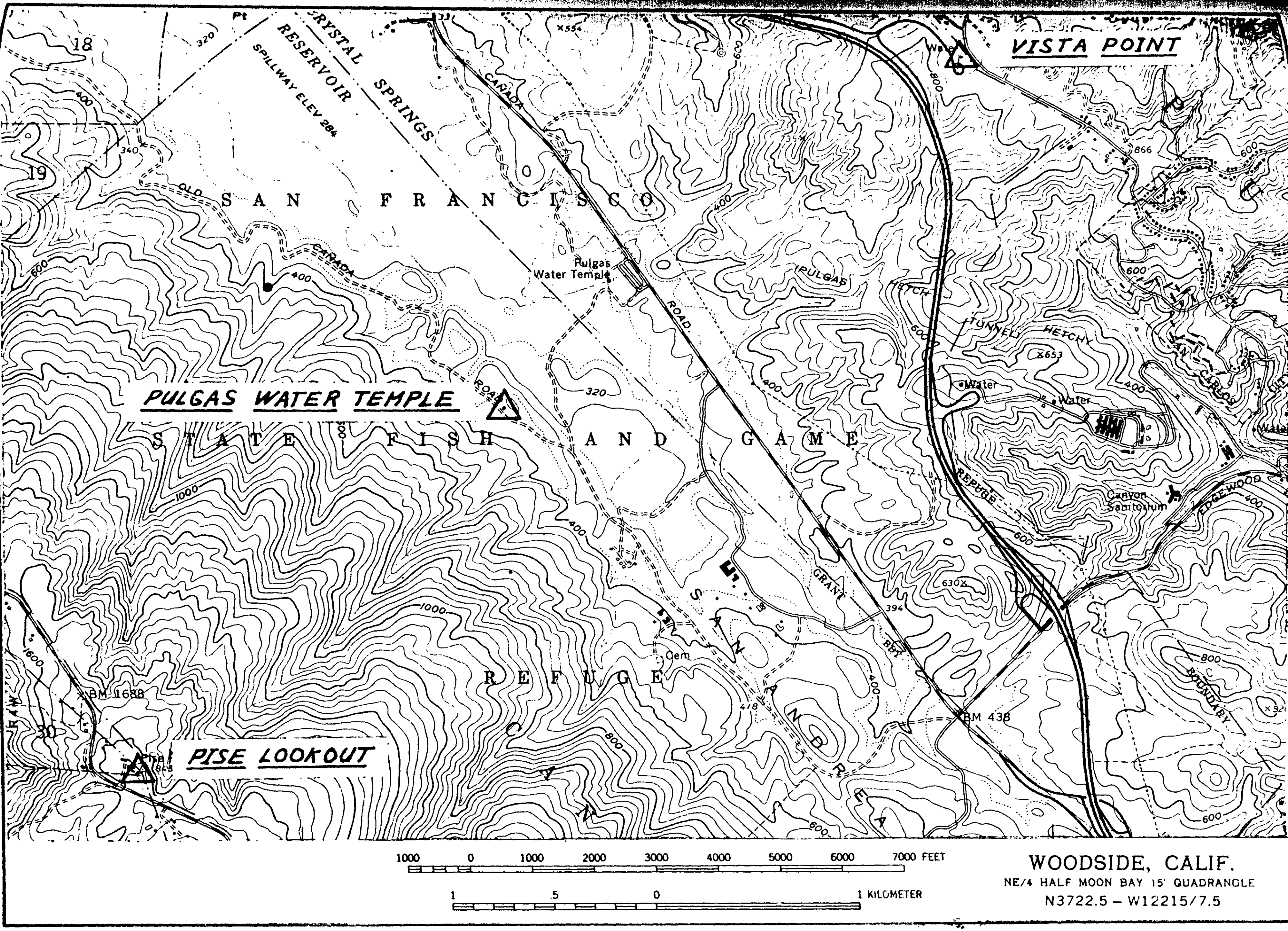

EL GRANADA
MONTARA MOUNTAIN, CALIF.
SW/4 SAN MATEO 15' QUADRANGLE
N3730—W12222.5/7.5
7000 FEET
1 KILOMETER
El Granada
El Granada Beach
Princeton
Harbor
Point
HALF MOON BAY
Denniston
Creek
Reservoir
Scarper Peak
Ox Hill
PALOMARES
TIERRA DE
CORRAL DE TIERRA

Fig. 3

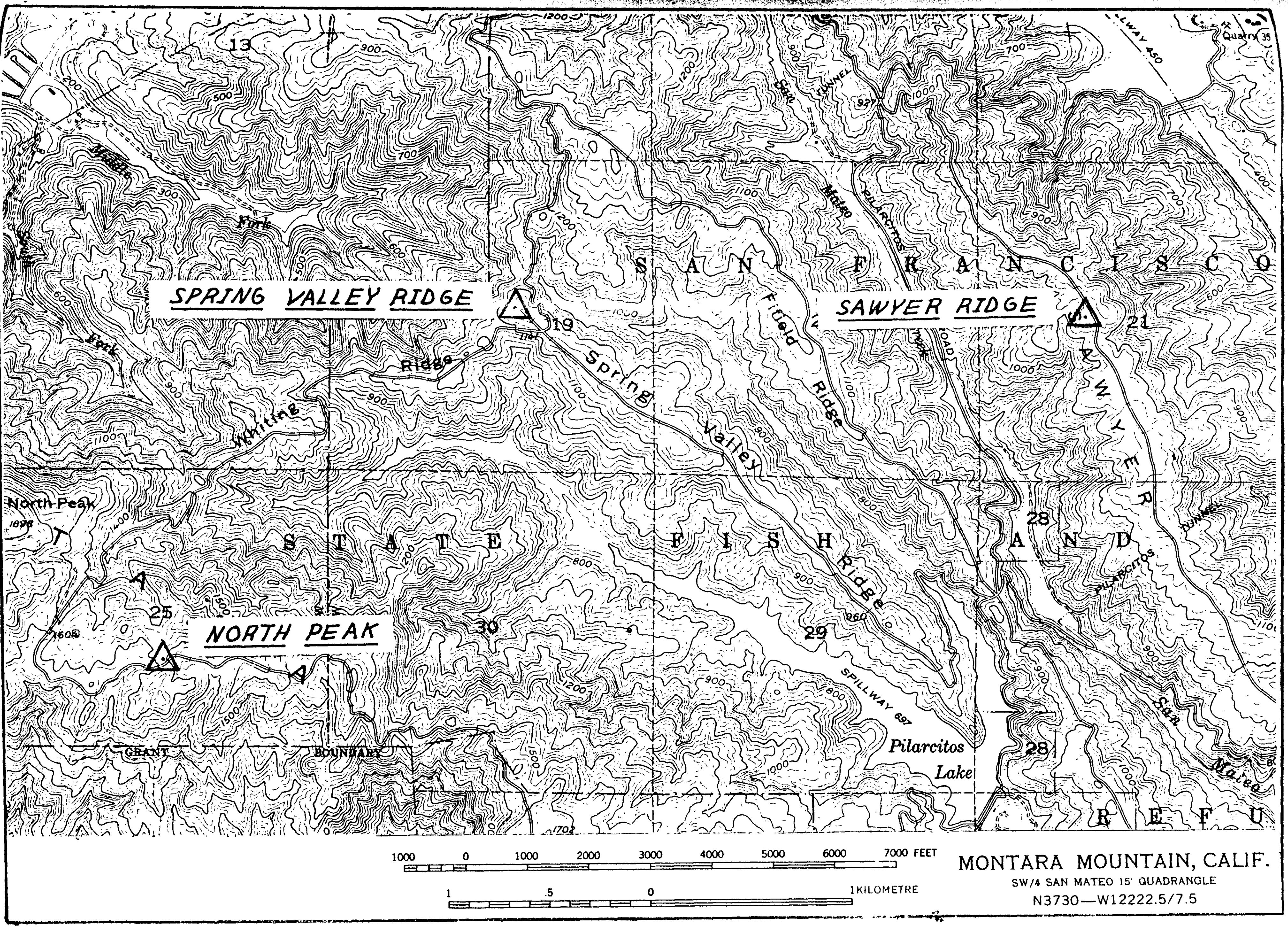

Los Altos Hills
LA PURISIMA CONCEPCION
Mt Helen Childrens Home
Elephant Mountain
Ewing Hill
BLACK MOUNTAIN
Black Mountain
Airway Beacon
Radar Reflector
Spring
Water
PARK
BOUNDARY
MONTE BELLO
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETRE
MINDEGO HILL, CALIF.
SW/4 PALO ALTO 15' QUADRANGLE
N3715—W12207.5/7.5

ig. 4

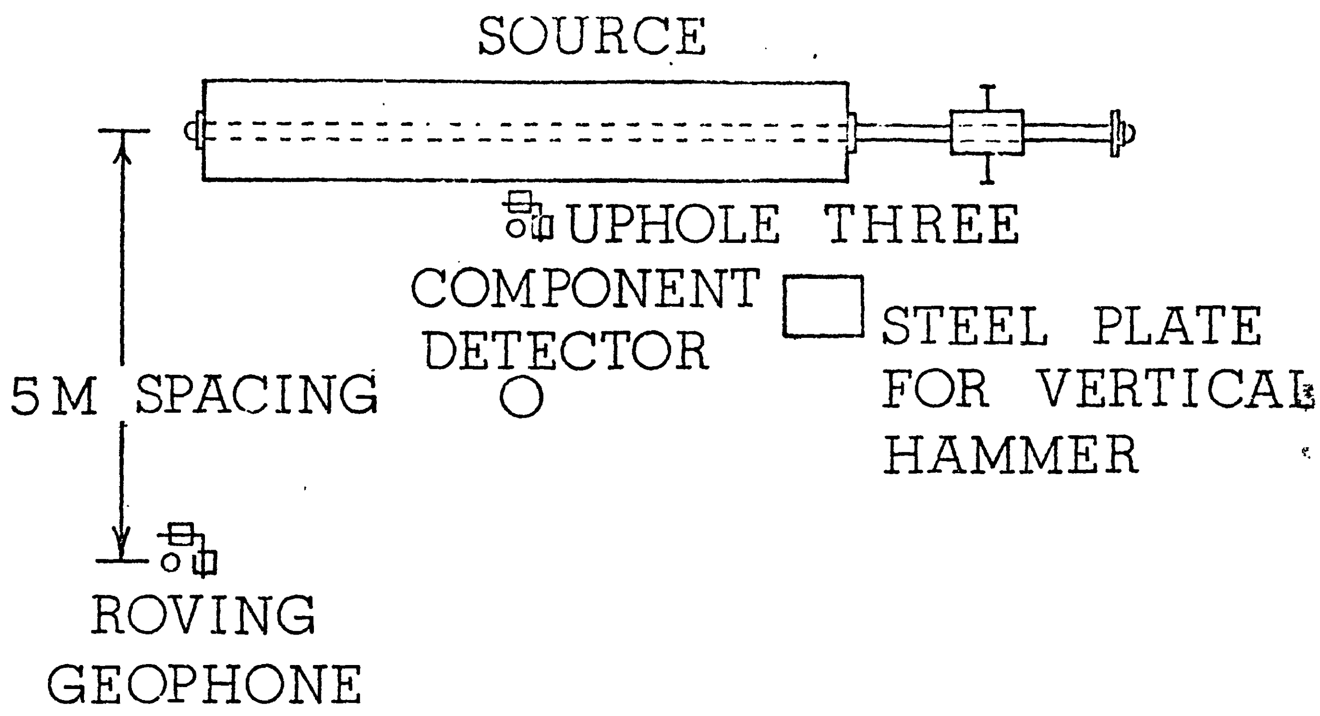
Fig. 5



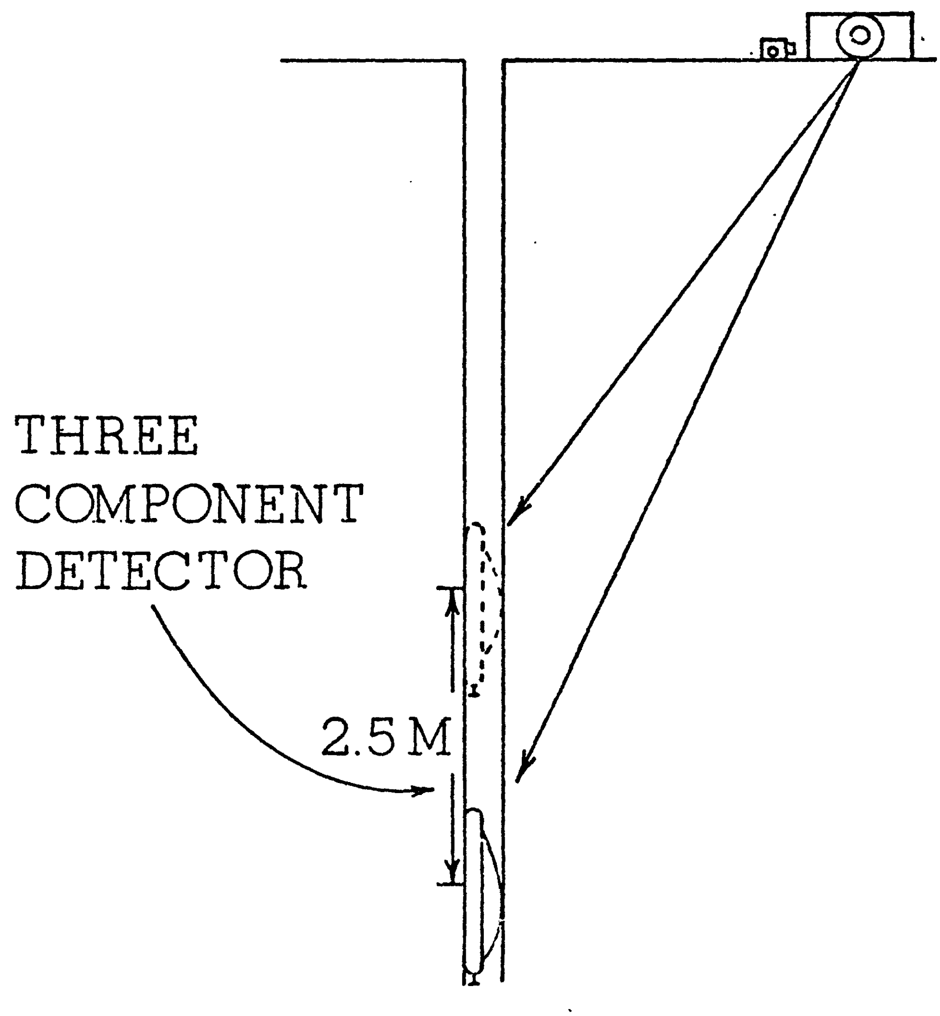
VISTA POINT
PULGAS WATER TEMPLE
PISE LOOKOUT
CRYSTAL SPRINGS RESERVOIR
SPILLWAY ELEV 284
SAN FRANCISCO
STATE FISH AND GAME REFUGE
SAN ANDREA
CAÑADA
ROAD
Pulgas Water Temple
PULGAS
HETCH
TUNNEL
HETCHY
REFUGE
GRANT
BOUNDARY
EDGEWOOD
SAN CARLOS
Canyon Sanitorium
Water
Cem
BM 1688
BM 438
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER
WOODSIDE, CALIF.
NE/4 HALF MOON BAY 15' QUADRANGLE
N3722.5 – W12215/7.5


SPRING VALLEY RIDGE
SAWYER RIDGE
NORTH PEAK
SAN FRANCISCO
STATE FISH AND REFU
SAWYER
Spring Valley Ridge
Fifield Ridge
Whiting Ridge
North Peak
1898
Pilarcitos Lake
SPILLWAY 697
San Mateo
PILARCITOS
TUNNEL
GRANT BOUNDARY
Quarry
13
19
21
25
28
29
30
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETRE
MONTARA MOUNTAIN, CALIF.
SW/4 SAN MATEO 15' QUADRANGLE
N3730—W12222.5/7.5

a)


SOURCE
UPHOLE THREE
COMPONENT
DETECTOR
STEEL PLATE
FOR VERTICAL
HAMMER
5M SPACING
ROVING
THREE
GEOPHONE

b)


THREE
COMPONENT
DETECTOR
2.5M

ELEVATION:	LOCATION.: LAT. LONG.	HOLE NO.:
DATE:	7½' QUAD.	SITE:
		GEOLOGIC MAP UNIT: Brabb (1970) Brabb and Pampeyan (1972) Pampeyan (1965)

SAMPLE DESCRIPTION	DRILLING	DENSITY (gm/cc)	BLOWS/ft.	SAMPLING	GRAPHIC LOG	DEPTH (m)	DESCRIPTION

DRILLING:

Auger

Rotary-wash (mud drilling fluid)

SAMPLING:

Standard penetration sample taken inside a 1⅜" I.D split spoon driven 18" into the soil by a 140 lb. weight falling 30" at the top of the drill rod.

Blow count for last 12" or, if penetration <12", for depth driven as noted. (36; 88/3 in)

California penetration sample taken inside a 2" I.D. split spoon driven into the soil by 425 lb slip jars falling inside the boring. (CA)

Pitcher undisturbed sample take inside a 3" I.D. Shelby thin tube mounted in a Pitcher core barrel. (P)

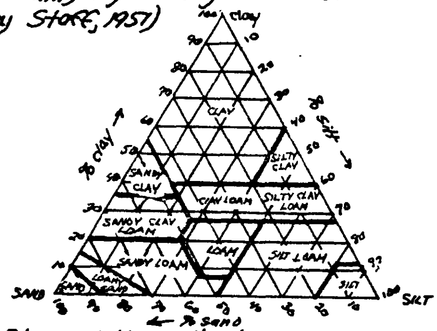
Rock core sample taken inside a NX (2⅛") size core barrel with a diamond bit. (C)

DENSITY:

Results of laboratory tests.

DESCRIPTION:

Texture: the relative proportions of clay, silt, and sand below 2 mm. 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.

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

hard - hammer bounces with solid sound

firm - hammer dents with thud, pick point dents or penetrates slightly

soft - pick point penetrates

friable material can be crumbled into individual grains by hand.

Fracture spacing: (Ellen et. al., 1972)

cm	in.	fracture spacing
0-1	0-½	very close
1-5	½-2	close
6-30	2-12	moderate
30-100	12-36	wide
>100	>36	very wide

Weathering: (Aetron-Blume-Atkinson, 1965)

Fresh: no visible signs of weathering

Slight: no visible decomposition of minerals, slight discoloration

Moderate: slight decomposition of minerals and disintegration of rock, moderate discoloration

Deep: moderate decomposition of minerals, extensive disintegration of rock, deep and thorough discoloration

Decomposed: complete decomposition and disintegration of rock but original structure is preserved

Fig. 8

ELEVATION: 250′ DATE: 8/7/74	LOCATION: LAT. 37°27′36″ LONG. 122°25′07″ 7½′ QUAD.: HALF MOON BAY, CALIF.	HOLE NO.: 1 SITE: PURISIMA GEOLOGIC MAP UNIT: PURISIMA FM. undivided

SAMPLE DESCRIPTION	DRILLING	DENSITY (gm/cc)	BLOWS/ft.	SAMPLING	GRAPHIC LOG	DEPTH (m)	DESCRIPTION
						0	LOAM, v. dk. grey
							SAND, yellowish brown, fine to medium grained, weakly consolidated. Grades to gravelly sand. (SP)
						5	SANDSTONE, dk. yellowish brown, very fine to fine grained, silty; firm but softens upon wetting; moderate fracture; moderately weathered.
SANDSTONE, dk. yellowish brown, very fine to fine grained, firm, fractured at 7.3″, moderately weathered. Softens on wetting and forms a very fine sandy loam. (ML)				CA		10	
						15	SANDSTONE, dk. greenish grey, fresh, very fine grained, silty; firm, moderately fractured. Softens upon wetting though some thin lenses are hard and cemented. Includes beds of siltstone and mudstone.
						20	
						25	
MUDSTONE, dk. greenish grey; firm; fresh; dessicated sample has transverse cracks at ½-1″. Softens upon wetting to a plastic clayey silt. (CL)				CA		30	

COMMENTS: Casing was installed in the top 10m. because of extremely rapid water loss in gravel and fractured sandstone.	LOGGED BY: T. FUMAL

Fig. 9

ELEVATION: 230'	LOCATION: LAT. 37°29'03" LONG. 122°23'19"	HOLE NO.: 2
DATE: 8/16/74	7½' QUAD. HALF MOON BAY, CALIF.	SITE: COZZOLINO'S GEOLOGIC MAP UNIT: ALLUVIUM

SAMPLE DESCRIPTION	DRILLING	DENSITY (gm/cc)	BLOWS/ft.	SAMPLING	GRAPHIC LOG	DEPTH (m)	DESCRIPTION
							Surface: scattered fragments of SANDSTONE, v. fine grained, micaceous.
SILTY CLAY LOAM, v. dk. greyish brown; 10-20% pale brown very coarse sand and fragments of weathered siltstone; soft; wet. (ML)						0	SILTY CLAY LOAM, v. dk. greyish brown 20-30% sand up to very coarse size; soft; wet. Grades to SILT LOAM
						5	GRAVELLY SAND, greenish grey
							SILT LOAM, dk. brown. Wood fragments
LOAMY MEDIUM SAND, dk. olive grey, well-sorted, wet, low dry strength. (SM)			52			10	SAND, greenish grey, medium to coarse, well-sorted. Contains up to 30% subrounded to subangular gravel of v. fine grained green rock and dk. brown shale. (SP)
						15	
SILTSTONE, dk. greyish brown, firm, moist, high dry strength, moderate fracture, micaceous. Softens upon wetting to form a plastic, slightly sticky silt loam.			108			20	SILTSTONE, brown, micaceous, firm, moderately fractured. Cuttings are a plastic, slightly sticky silt. Top ½m. is lt. brown and softer.
						25	SILTSTONE, brown, micaceous, quite firm, moderately fractured. Cuttings are a plastic slightly sticky silt. Firmer than above.
SILTSTONE, dk. greyish brown, quite firm, slightly moist, high dry strength, moderate fracture, micaceous. Softens upon wetting to form a plastic silt loam.				P			

LOGGED BY: T. Fumal

ELEVATION: 420' DATE: 9/23/74	LOCATION: LAT. 37° 19' 50" LONG. 122° 04' 57" 7½' QUAD.: CUPERTINO, CALIF.	HOLE NO.: 3 SITE: MARYKNOLL GEOLOGIC MAP UNIT: SANTA CLARA FM.

SAMPLE DESCRIPTION

(Columns: DRILLING, DENSITY (gm/cc), BLOWS/ft., SAMPLING, GRAPHIC LOG, DEPTH (m))

Sample description	Density	Blows/ft.
FINE SANDY CLAY LOAM, strong brown, sticky, plastic, moderate dry strength, small % of coarse, subangular sand and gravel (CL)	1.86	
FINE SANDY CLAY LOAM, dk. brown with common fine black mottles, sticky, plastic, moderate dry strength. (CL)		29
FINE SANDY LOAM, strong brown, slightly plastic, grading to VERY COARSE LOAMY SAND, with subrounded gravel to 1" of brown sandstone and red basalt. (SM)		84
CLAY LOAM, dk. brown with common fine black mottles, plastic, sticky, moderate dry strength. (CL)		36
COARSE LOAMY SAND, strong brown, subrounded to subangular, small % of brown sandstone gravel. (SM)		97
VERY COARSE SANDY CLAY LOAM, dk. yellowish brown, sticky, plastic, moist, moderate dry strength, 60-70% sand, some gravel to 1". (SC)	2.05	
SILTY CLAY, brown, sticky, plastic, high dry strength, 15-20% subrounded to angular sand and gravel to ½". (CL)		103
VERY COARSE LOAMY SAND, strong brown, subrounded to subangular, non plastic, low dry strength, small % of gravel to 1". (SM)		74
VERY COARSE LOAMY SAND, strong brown, subrounded to subangular, non plastic, low dry strength, small % of gravel to 1". (SM)		100/3"
NO SAMPLE - probably drove lg. gravel down through silty clay.		74
SILTY CLAY, brown, sticky, plastic, high dry strength, small % of gravel in lower part (CL)		93
GRAVELLY CLAY, yellowish red with common, fine, white and black mottles, moist, plastic, 25-30% gravel. (CL)		
SILTY CLAY, yellowish red with common fine black mottles, 15% sand and gravel. (CL)		69

DESCRIPTION

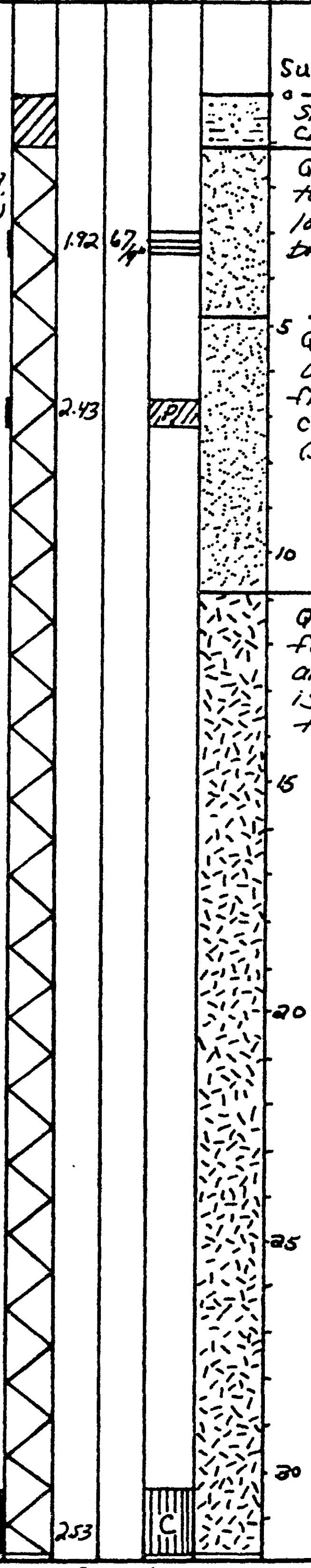
Depth (m)	Description
	Surface: scattered chert cobbles with some sandstone gravel.
0	SANDY CLAY LOAM, brown, plastic. Includes layers of coarse sand and gravel. (CL)
5	VERY COARSE LOAMY SAND and GRAVEL, brown, non plastic. Includes layers of SANDY LOAM. (SM)
10	CLAY LOAM, brown, plastic. (CL)
	COARSE LOAMY SAND. (SM)
	SILTY CLAY, brown. (CL)
	VERY COARSE SANDY CLAY LOAM. (SC)
15	SILTY CLAY, brown, small % of sand and gravel. (CL)
20	VERY COARSE LOAMY SAND, brown. Includes thin layers of gravel and silty clay. (SM)
25	SILTY CLAY, brown to yellowish red, plastic. Includes layers containing up to 30% gravel. (CL)
30	

LOGGED BY: T. Fumal

Fig. 11

ELEVATION: 1155' DATE: 9/30/74	LOCATION: LAT. 37°31'23" LONG. 122°27'17" 7½' QUAD.: MONTARA MOUNTAIN, CALIF.	HOLE NO.: 4 SITE: EL GRANADA GEOLOGIC MAP UNIT: GRANITIC ROCKS

SAMPLE DESCRIPTION	DRILLING	DENSITY (gm/cc)	BLOWS/ft	SAMPLING	GRAPHIC LOG	DEPTH (m)	DESCRIPTION



Description:

Surface: coarse SAND

0 — SANDY LOAM, v. dk. grey (SM) grading to SANDY CLAY LOAM, yellowish brown. (SC)

QUARTZ DIORITE GRUS, decomposed to deeply weathered; coarse sandy loam to loamy sand moist; soft; brown; dry in place. (SM)

5 — QUARTZ DIORITE GRUS, moderately weathered; partly oxidized; easily friable though firm in place; gravelly coarse sand to coarse loamy sand. (SM-SP)

10 — QUARTZ DIORITE, hard, 30-40% ferromagnesian minerals, mostly altered to chlorite; plagioclase is partly saussuritized; close to moderate fracture.

Sample description:

QUARTZ DIORITE GRUS, deeply weathered, soft and friable with difficulty, loamy sand moist; brown with common fine white and dk. brown mottles; dry in place. (SM) [1.92 gm/cc; 67/4"]

QUARTZ DIORITE GRUS, moderately weathered; soft and easily friable to gravelly coarse sand; dk. olive grey remolded; moist in place. (SM) [2.43 gm/cc; P]

QUARTZ DIORITE, hard 30-40% ferromagnesian minerals, mostly altered to chlorite; plagioclase is partly saussuritized, especially along major fractures; close to moderate fracture:
0-3' fractured 1½"-3"
3-5' fractured <1" [2.53 gm/cc; C]

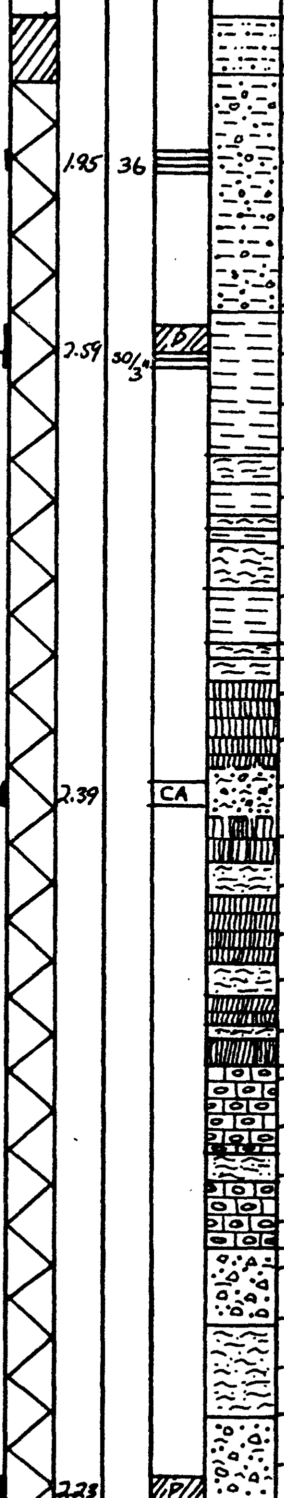
COMMENTS: Drilling began to become more difficult at about 9.7 m. The core-drilled same was stuck in the core barrel because of fracturing and was difficult to remove.

LOGGED BY: T. Fumal

Fig. 12

ELEVATION: 2655'	LOCATION: LAT. 37°19'7" LONG. 122° 09'20"	HOLE NO.: 5
DATE: 10/7/74	7½' QUAD. MINDEGO HILL, CALIF.	SITE: BLACK MOUNTAIN GEOLOGIC MAP UNIT: FRANCISCAN GREENSTONE

SAMPLE DESCRIPTION	DENSITY (gm/cc)	BLOWS/ft	SAMPLING	DEPTH (m)	DESCRIPTION
					Surface: subangular cobbles of greenstone, and some quartz and limestone.
				0	LOAM, dk. brown; some rock fragments (ML)
SANDY CLAY LOAM, brown, sticky, slightly plastic; 10% fine gravel of dk. grey brown shale, basalt(?) and sandstone(?) (SC)	1.95	36			SANDY CLAY LOAM, brown, sticky, slightly plastic; 10-15% fine gravel of shale, basalt(?) and sandstone(?) (SC)
SHALE and SANDSTONE, moderately weathered; shale is hard, black, fractured <½" with parallel parting <¼"; sandstone is hard, brownish grey, medium grained and fractured at 1"; fractured surfaces commonly coated olive brown.				5	
SHALE, moderately weathered, hard, black; fractured <½" with parallel parting <¼"; fracture surfaces coated olive brown.	2.59	50/3"	P		SHALE and SANDSTONE, moderately to slightly weathered; hard, very close to close fracture; dk. brownish grey to black. Includes some seams of grey clay gouge.
				10	
					red clay
				15	BASALT, red, amygdaloidal, hard, close to very close fracture.
LOAMY COARSE SAND, mottled black, dk. green, and dusky red; some subangular gravel up to 1½" of dusky red amygdaloidal basalt. Sheared rock. (SC)	2.39		CA		SHEARED ROCK, LOAMY COARSE SAND
					BASALT, dk. green, massive, hard close to very close fracture. Includes seams of clay gouge.
				20	
					LIMESTONE and CHERT, grey and black, hard, close to very close fracture. Includes seams of clay gouge.
				25	
					SHEARED ROCK, mostly dk. grey v. coarse loamy sand with some angular to subrounded fragments of grey limestone, black chert, red basalt and greenstone. Includes seams of clay gouge.
SANDY CLAY LOAM, v. dk. grey with common, fine, lt. grey, calcareous mottles; sticky, plastic; some subrounded fragments to 2" of greenstone and dusky red basalt. Sheared rock. (SC)	2.23		P	30	



COMMENTS: Easy drilling was encountered throughout the hole because of highly fractured condition of the rock.

LOGGED BY: T. Fumal

Fig. 12

ELEVATION: 740' DATE: 10/8/74	LOCATION: LAT. 37°29'53" LONG. 122°25'28" 7½' QUAD: HALF MOON BAY, CALIF.	HOLE NO: 6 SITE: DIGGES CANYON GEOLOGIC MAP UNIT: GRANITIC ROCKS

SAMPLE DESCRIPTION	DENSITY (gm/cc)	BLOWS/ft.	SAMPLING	DEPTH (m)	DESCRIPTION
					Surface: coarse gravel of quartz and feldspar, angular.
				0	SANDY LOAM, v. dk. gray grading to brown. (SM)
QUARTZ DIORITE GRUS, decomposed, soft and friable with difficulty, sandy clay loam moist; yellowish brown; moderate dry strength. Biotite is major ferro-magnesian mineral and is deeply oxidized, much feldspar is decomposed, original rock texture is preserved. (SC)	1.91	36			QUARTZ DIORITE GRUS, soft and friable with difficulty; coarse sandy loam grading to coarse loamy sand (SM); yellowish brown; dry in place.
				5	
QUARTZ DIORITE GRUS, decomposed, soft and friable, coarse sand moist; dry in place; olive brown remolded; low dry strength. Includes GRANITE PEGMATITE vein, deeply weathered. (SP)	1.97		P		
QUARTZ DIORITE GRUS, decomposed, soft and friable; loamy coarse sand (SM) with some sandy clay loam (SC) moist; moderate dry strength; dk. yellowish brown.		54			
				10	
					GRANITE PEGMATITE, fresh, hard
					QUARTZ DIORITE GRUS, moderately to deeply weathered; firm and friable with difficulty; medium grained; white with common brown and black mottles.
				soft 15	QUARTZ DIORITE GRUS, deeply weathered; soft and easily friable to gravelly coarse sand (GP), speckled very pale brown, brown, and black. Includes decomposed zones which are coarse sandy loam (SM) moist. Dry in place.
QUARTZ DIORITE GRUS, deeply weathered, soft and easily friable to gravelly coarse sand; speckled very pale brown, brown, and black; dk. olive brown remolded; Biotite is moderately altered; some feldspar is soft, most is fractured to sand size. (SP)	2.13		CA		
				soft	
				20	Soft
				25	
					Soft
				30	
QUARTZ DIORITE GRUS, deeply weathered, soft and easily friable to gravelly coarse sand (GP) and loamy coarse sand (SM); speckled v. pale brown, brown, and black. Biotite has brown weathering rinds; some feldspar is soft, most is hard but fractured to coarse sand; dry in place.	2.19		P		

LOGGED BY: T. Fumal

ELEVATION: 1840' DATE: 11/5/74	LOCATION: LAT. 37°27'41" LONG. 122°20'33" 7½' QUAD.: WOODSIDE, CALIF.	HOLE NO.: 7 SITE: PISE LOOKOUT GEOLOGIC MAP UNIT: BUTANO SANDSTONE

SAMPLE DESCRIPTION | DRILLING | DENSITY (gm/cc) | BLOWS/FT | SAMPLING | GRAPHIC LOG | DEPTH (m) | DESCRIPTION

Surface: subangular cobbles of SANDSTONE, yellowish grey, coarse grained, hard.

0 — SANDY LOAM, black to yellow brown. (SM)

SANDSTONE, deeply weathered; mostly gravelly fine sandy loam with some layers of firm, closely fractured, yellowish brown sandstone.

Sample (blows/ft 63): GRAVELLY FINE SANDY LOAM, dark yellowish brown; 25% angular gravel size fragments of brown sandstone. (SM)

6

Sample (density 2.26; blows/ft 50/4"; sampling P): LOAMY FINE SAND, dk. grey; moist; low dry strength, non plastic. (SM)

SANDSTONE, dk. grey; medium grained; arkosic; hard to firm; fractured at <1".

SANDSTONE, dk. grey; medium to fine grained; arkosic; most is hard to firm but some beds are soft though dense. Includes a small amount of hard black siltstone.

10

soft

soft

15

soft

soft

soft

20

25

soft

30

Sample (sampling C): NO SAMPLE RECOVERED

COMMENTS: Began to loose water at 4.5m. Cemented sandstone below 8.5m was relatively hard drilling.

LOGGED BY: T. Fumal

Fig. 15

ELEVATION: 355'

DATE: 11/6/74

LOCATION: LAT. 37°28'39"
LONG. 122°19'19"

7½' QUAD.
WOODSIDE, CALIF.

HOLE NO.: 8

SITE: PULGAS WATER TEMPLE

GEOLOGIC MAP UNIT: SLOPE WASH/SANTA CLARA FM.

SAMPLE DESCRIPTION	DRILLING	DENSITY (gm/cc)	BLOWS/ft.	SAMPLING	GRAPHIC LOG	DEPTH (m)	DESCRIPTION
							Surface: subangular to subrounded cobbles of SANDSTONE, reddish brown; fine grained.
SANDY CLAY LOAM, brown; 20% hard, fine subrounded gravel; common subangular fragments up to 1" of dk. brown, lt. yellowish brown, lt. grey and reddish brown medium to fine grained sandstone and dk brown siltstone, most of which is soft. (SC)		1.97	81			0	SANDY LOAM, yellowish brown; some subangular; soft; fragments of reddish and yellowish brown fine sandstone. (SM)
VERY COARSE LOAMY SAND, dk olive brown; moist; sticky; low dry strength; some fine gravel and occasional subrounded cobbles of dk brown sandstone and siltstone; poorly sorted. (SC-SP)		2.13	76	P		5	SANDY CLAY LOAM, brown; some subangular, soft, fragments of fine sandstone and hard subrounded gravel (SC) grading to: VERY COARSE LOAMY SAND, dk. brown; some fine, hard gravel and lg. soft fragments of red, yellow, brown and grey sandstone (SM) grading to: GRAVELLY COARSE SAND (SP)
GRAVELLY COARSE SAND, dk yellowish brown; subangular to subrounded; <15% fines. Bottom 6" is mostly gravel and cobble sized fragments of firm greyish brown sandstone and dk brown siltstone. (SP)						10	LOAMY GRAVEL, mostly subangular to subrounded black siltstone and brown fine sandstone gravel with loam matrix.
						15	FINE SILTY SAND, dk grey; some dk. grey siltstone gravel
							FINE SILTY SAND, yellowish brown; some fine brown sandstone gravel.
						20	LOAMY GRAVEL, mostly subangular to subrounded fine brown sandstone gravel in brown sandy clay loam matrix.
						25	
LOAMY GRAVEL, olive brown; moist; 60-70% coarse subangular gravel and cobbles up to 2" of firm olive brown fine sandstone and soft, dk. greyish brown siltstone. Matrix is ½ fine sand and ½ silt and clay. (GM-GC)		2.32		P		30	

COMMENTS: Drilling became more difficult at 19.7m.

LOGGED BY: T. Fumal

Fig. 16

ELEVATION: 1150' DATE: 11/11/74	LOCATION: LAT. 37°34'15" LONG. 122°26'53" 7½' QUAD. MONTARA MOUNTAIN, CALIF.	HOLE NO.: 9. SITE: SPRING VALLEY RIDGE GEOLOGIC MAP UNIT: FRANCISCAN SANDSTONE

SAMPLE DESCRIPTION	DENSITY (gm/cc)	BLOWS/ft.	SAMPLING	DEPTH (m)	DESCRIPTION
					Surface: Littered with angular gravel to cobble size frags. of sandstone & limestone.
				0	SANDY LOAM, dk. brown to lt. yellowish brown. Some gravel. (SM)
SHALY LOAM, lt. brown, yellowish brown and lt. grey mottled; shale fragments are soft and easily friable. Deeply weathered shale - bedding preserved. (SM-GM)	1.93	64		5	SHALE, deeply weathered; mostly gravelly loam; dk. olive brown, lg. % of gravel sized fragments of greyish brown shale with some fine brown sandstone. (SM-GM)
SANDY CLAY, mostly streaks of black and dk. grey with some greyish green, white and yellow mottles; sticky; plastic; high dry strength; moist; low % of hard, subangular, gravel size fragments of limestone. clay gouge. (CL)	2.45		P	10	SHEARED ROCK, black; mostly black siltstone fractured to less than ½" with sandy clay matrix. Includes layers that are mostly clay gouge.
					SILTSTONE, black; hard; closely fractured.
				15	SHEARED ROCK, black; mostly black siltstone fractured at <½" with sandy clay matrix. Includes layers which are mostly clay gouge.
				20 25	SILTSTONE, black; hard; closely fractured.
SANDSTONE (Greywacke), v. dk. bluish grey; hard; fine to medium grained; 2"x1" max. size, mostly fractured at <1."	2.63		C	30	SANDSTONE and SILTSTONE, v. dk. bluish grey; hard; fine to medium grained; closely fractured.

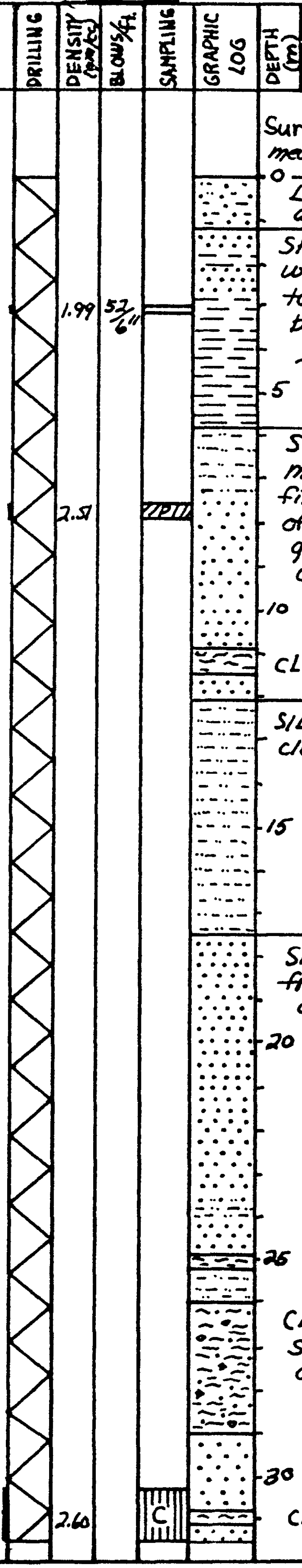
COMMENTS: Drilling was hard from 10.9 to 13.6m. and very hard below 19.4m.

LOGGED BY: T. Fumal

Fig. 17

ELEVATION: 880' DATE: 11/8/74	LOCATION: LAT. 37° 29' 36" LONG. 122° 17' 48" 7½ QUAD.: WOODSIDE, CALIF.	HOLE NO.: 10 SITE: VISTA POINT GEOLOGIC MAP UNIT: FRANCISCAN SANDSTONE

SAMPLE DESCRIPTION | DRILLING | DENSITY (gm/cc) | BLOWS/ft. | SAMPLING | GRAPHIC LOG | DEPTH (m) | **DESCRIPTION**



Sample description:

VERY SHALY LOAM, dk. brown; angular shale fragments are mostly easily friable. (GC)

SANDSTONE, olive; fine grained; moist; firm; closely fractured, 1½"x2" maximum, most is <1"; dk brown coatings on fractured surfaces. Moderately weathered.

SANDSTONE (Greywacke), dk greenish grey; medium grained, hard; top is fractured at 1½-2½", bottom <1½", middle was gouge and washed out. Two major sets of fractures:
1) inclined 45°, coated with black shaly material (bedding?)
2) inclined 75°, mostly calcite healed and slickensided.

Description:

Surface: cobbles of SANDSTONE, brown, medium grained, firm to hard.

0

LOAM, dk. brown, grading to CLAY LOAM, dk. reddish brown.

SHALE and SANDSTONE, deeply weathered. Mostly gravel sized, soft to firm, angular fragments of brownish grey shale with some yellowish brown sandstone.

5

SANDSTONE and SILTSTONE, moderately to slightly weathered; firm to hard angular fragments of fine grained greyish brown to dk. grey sandstone and black siltstone; closely fractured with common yellowish brown coatings on fracture surfaces.

10

CLAY GOUGE

SILTSTONE, fresh; black; hard, close to moderate fracture.

15

SANDSTONE (greywacke), dk. grey; fresh; hard; medium to fine grained; closely fractured. Includes some beds of hard, black siltstone and seams of clay gouge.

20

25 CLAY GOUGE

CLAY GOUGE, grey; plastic; sticky; soft; sandy clay with fragments of black siltstone.

30

CLAY GOUGE

COMMENTS: Drilling became very hard at 12.1 m.

LOGGED BY: T. Fumal

Fig. 18

ELEVATION: 1605'

DATE: 11/12/74

LOCATION: LAT. 37° 33' 19"
LONG. 122° 28' 03"

7½' QUAD:
MONTARA MOUNTAIN, CALIF.

HOLE NO.: 11

SITE: NORTH PEAK

GEOLOGIC MAP UNIT: GRANITIC ROCKS

SAMPLE DESCRIPTION	DRILLING	DENSITY (gm/cc)	BLOWS/ft.	SAMPLING	GRAPHIC LOG	DEPTH (m)	DESCRIPTION
							Surface: v. coarse SAND. Outcrops nearby.
						0	SANDY LOAM, dk. brown. (SM)
QUARTZ DIORITE GRUS, deeply weathered; soft and easily friable; coarse grained; loamy medium sand moist; biotite is somewhat more abundant than hornblende and is deeply oxidized; substantial feldspar is decomposed. (SM)		2.06	50/4"				QUARTZ DIORITE GRUS, deeply weathered; soft and easily friable though top has some cementation by clay and iron oxides; coarse grained; loamy medium sand to coarse sand moist; 30% biotite and some hornblende, deeply oxidized; feldspar is hard but highly fractured, substantial is decomposed. (SM-SP)
						5	
QUARTZ DIORITE GRUS, deeply weathered; coarse grained; coarse sand moist; speckled bright reddish yellow, white and v. dk. brown; biotite deeply oxidized; most feldspar is hard but highly fractured; moist in place. (SM-SP)		2.30		P			
						10	
						15	
						20	
							QUARTZ DIORITE GRUS, slight to moderately weathered; most is easily friable, some is hard and fractured closely; biotite is moderately oxidized; feldspar is mostly hard but highly fractured.
						25	
QUARTZ DIORITE GRUS, slight to moderately weathered; most is easily friable to coarse sand, some hard spots; biotite is moderately oxidized; feldspar is hard but fractured to coarse sand or finer; major fractures at 1". 8" recovered		2.37		C		30	

LOGGED BY: T. Fumal

Fig. 19

ELEVATION: 1135'	LOCATION: LAT. 37° 34' 16" LONG. 122° 25' 01"	HOLE NO: 12
DATE: 11/13/74	7½' QUAD: MONTARA MOUNTAIN, CALIF.	SITE: SAWYER RIDGE GEOLOGIC MAP UNIT: FRANCISCAN SANDSTONE

SAMPLE DESCRIPTION	DENSITY (gm/cc)	BLOWS/ft	SAMPLING	DEPTH (m)	DESCRIPTION
					Surface: angular fragments of SANDSTONE yellowish brown, hard. Outcrops near by.
				0	LOAMY SAND, dk. brown. (SM)
FINE SANDY LOAM, yellowish brown, soft and easily friable (SM); and CLAYEY SILT, lt. grey to white; sticky; plastic; moderate dry strength (CL).	2.02	88/1½		5	SANDSTONE, and SILTSTONE, deeply to moderately weathered. Mostly yellowish brown sandy loam and silty clay. Includes zones with a high % of firm to hard angular fragments of lt. grey sandstone and dk grey siltstone with yellowish brown coatings.
LOAMY GRAVEL, dk. olive brown, 60-70% hard, angular fragments of dk. greyish brown siltstone; matrix is ½ coarse angular sand, ½ fines. (GM-GP)	2.50		P		SANDSTONE, moderately to deeply weathered; dk. olive brown, 30% sand
				10	SILTSTONE, slightly weathered; black; close to very close fracture; 10-30% clay; some weathering stains.
				15 20 25	SANDSTONE and SILTSTONE, fresh; hard; close to moderate fracture. Sandstone is lt. grey, coarse to medium grained, arkosic. Black siltstone comprises < 30%.
SANDSTONE, lt. grey; hard; coarse grained, arkosic; massive; 3½" max. core length, mostly fractured < 1½".	2.41		C	30	

COMMENTS: Drilling was very hard below 11.5 m.

LOGGED BY: T. Fumal

Fig. 20

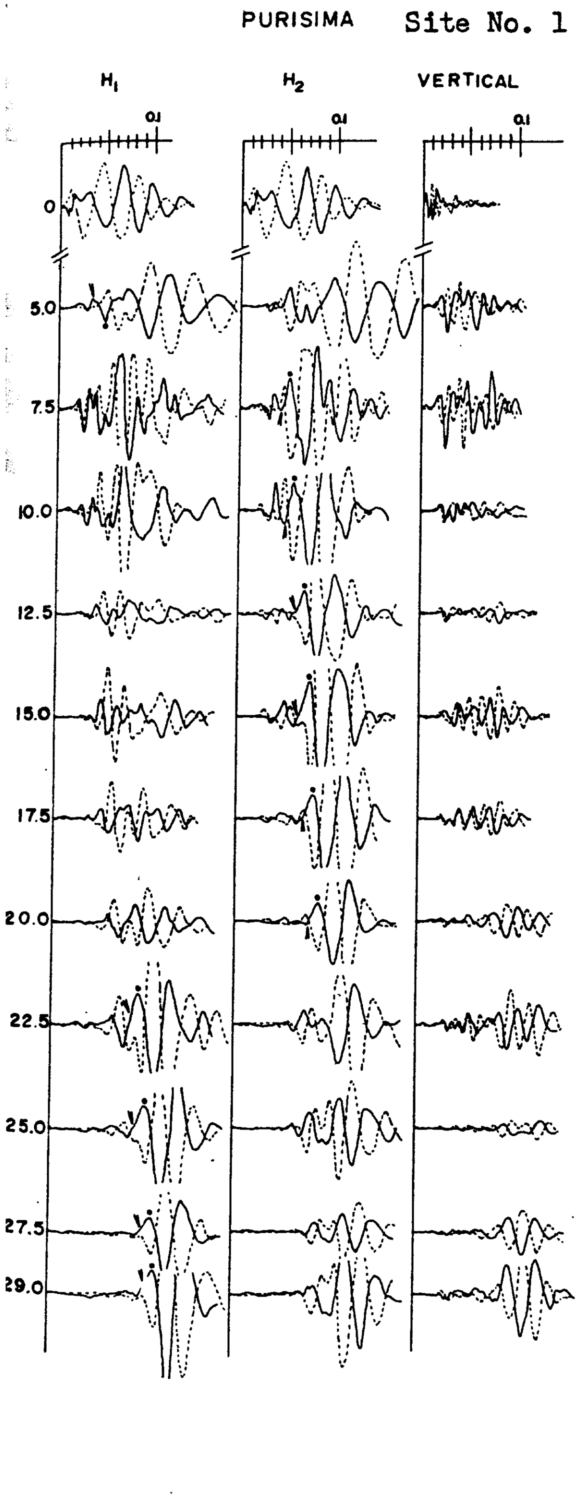

PURISIMA Site No. 1
H1
H2
VERTICAL
0.1
0
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
29.0

Fig. 21

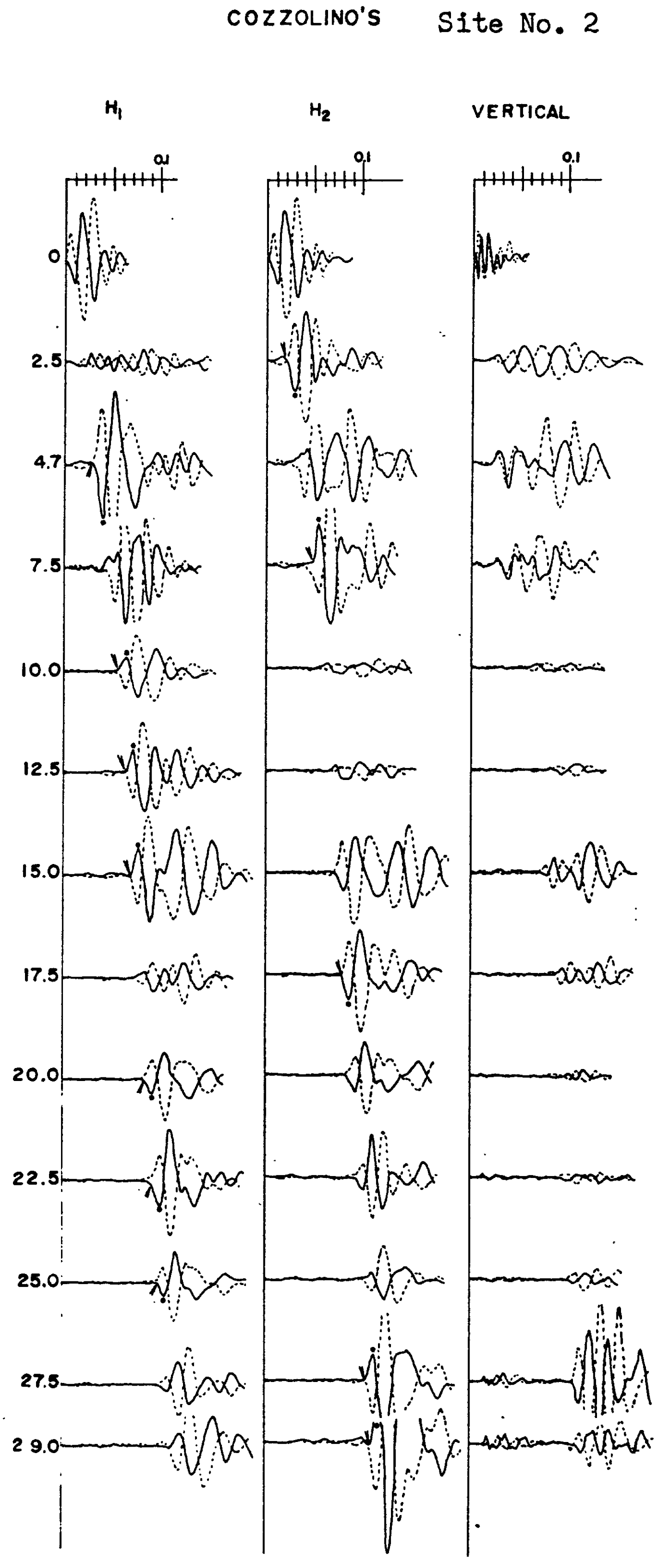

COZZOLINO'S Site No. 2
H1
H2
VERTICAL
0.1
0
2.5
4.7
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
29.0

Fig. 22

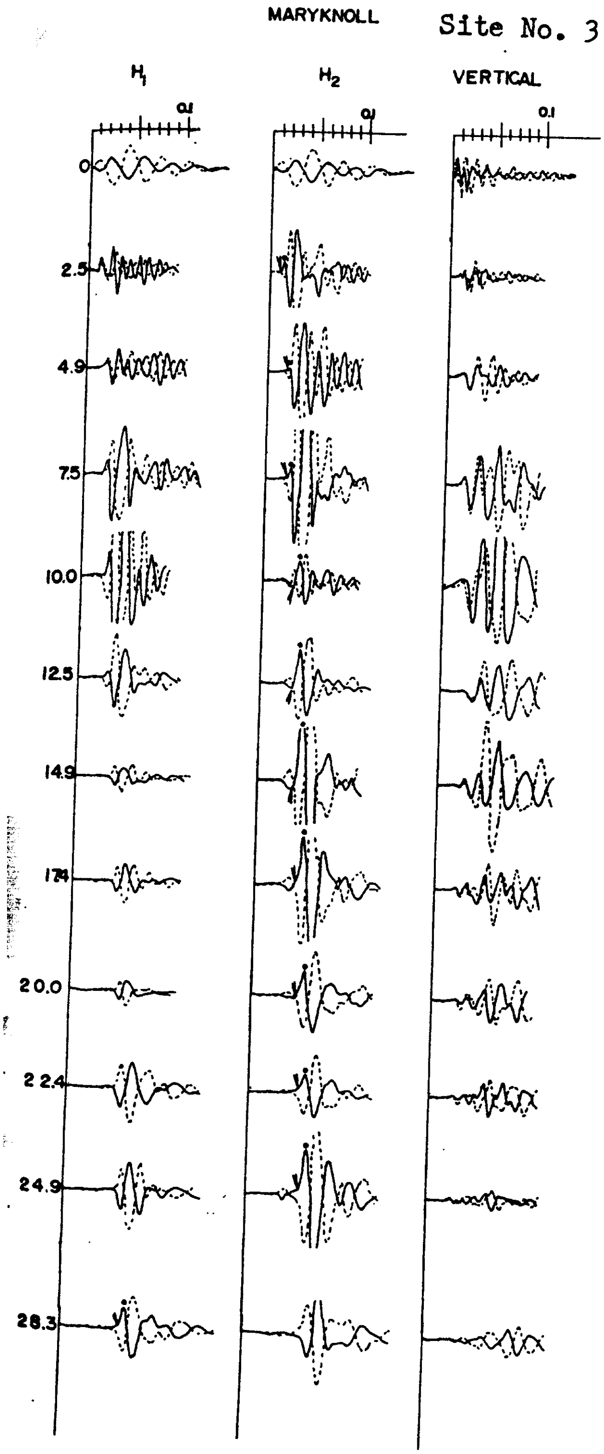

MARYKNOLL
Site No. 3
H1
H2
VERTICAL
0.1
0.1
0.1
0
2.5
4.9
7.5
10.0
12.5
14.9
17.4
20.0
22.4
24.9
28.3

Fig. 23

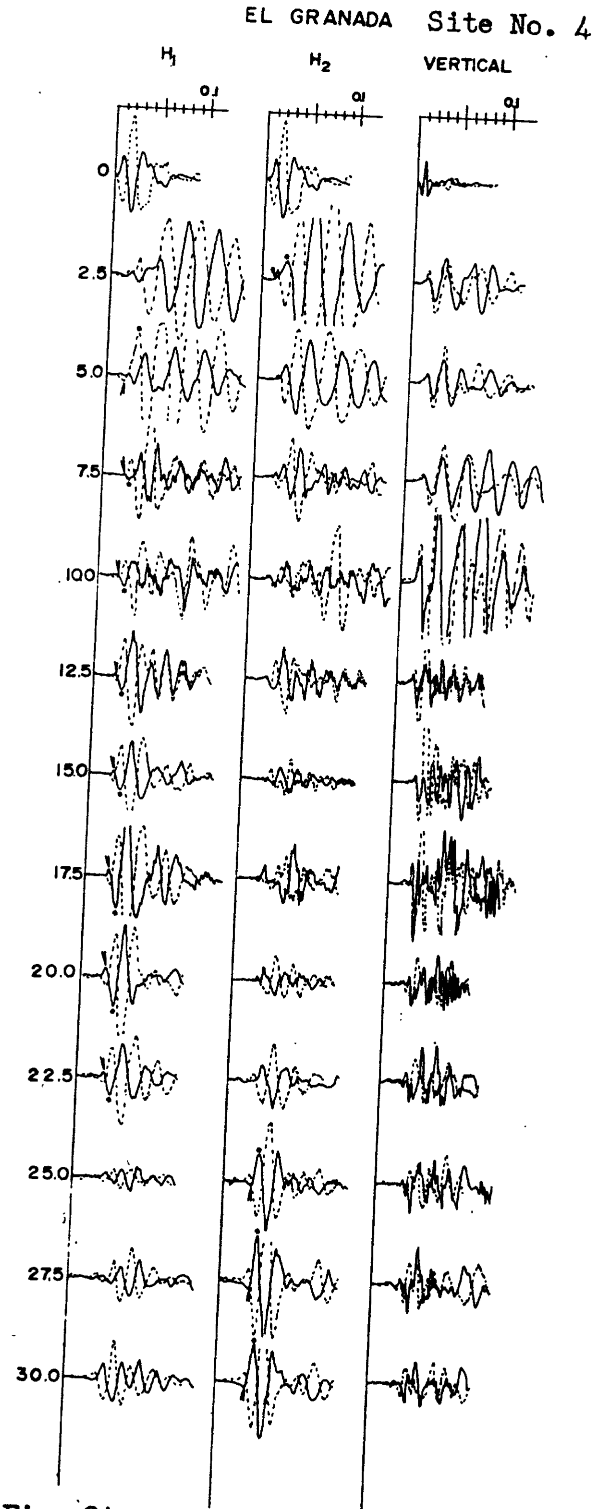

EL GRANADA
Site No. 4
H1
H2
VERTICAL
0.1
0.1
0.1
0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0

Fig. 24

BLACK MOUNTAIN Site No. 5

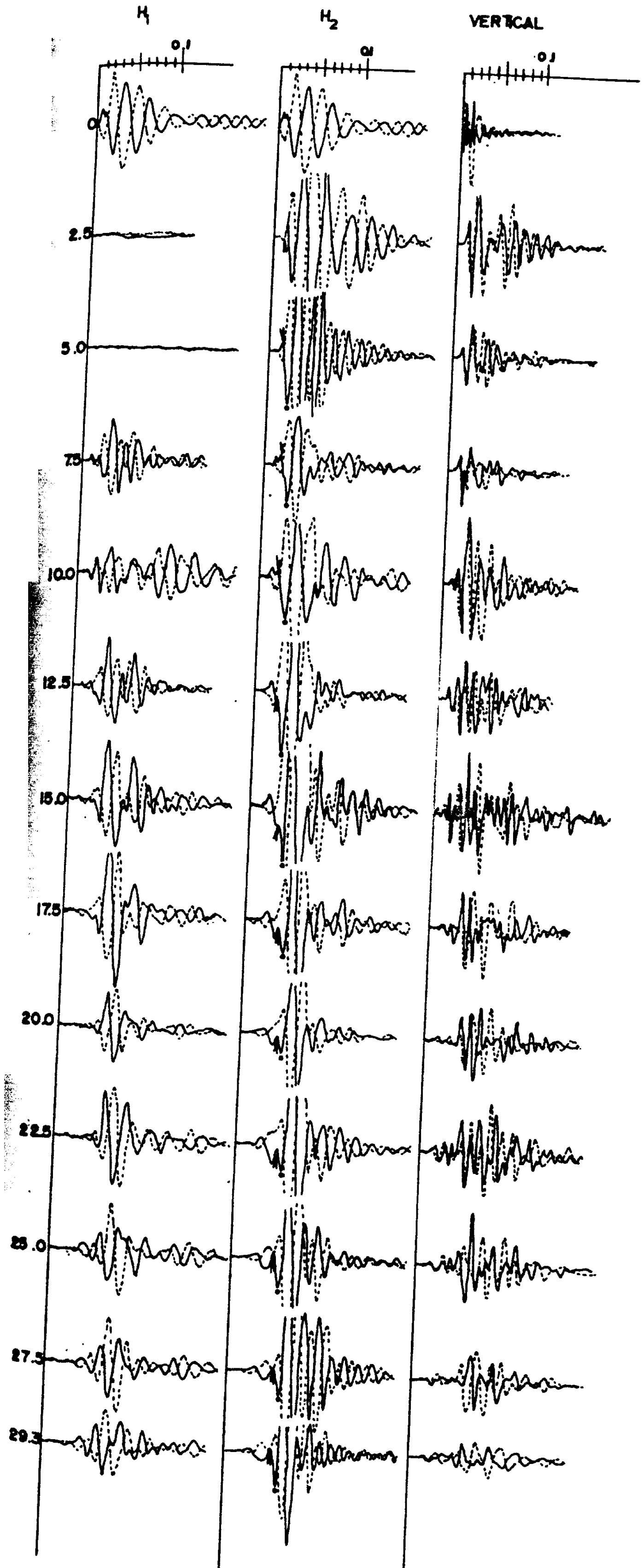


Fig. 25

DIGGES CANYON Site No. 6

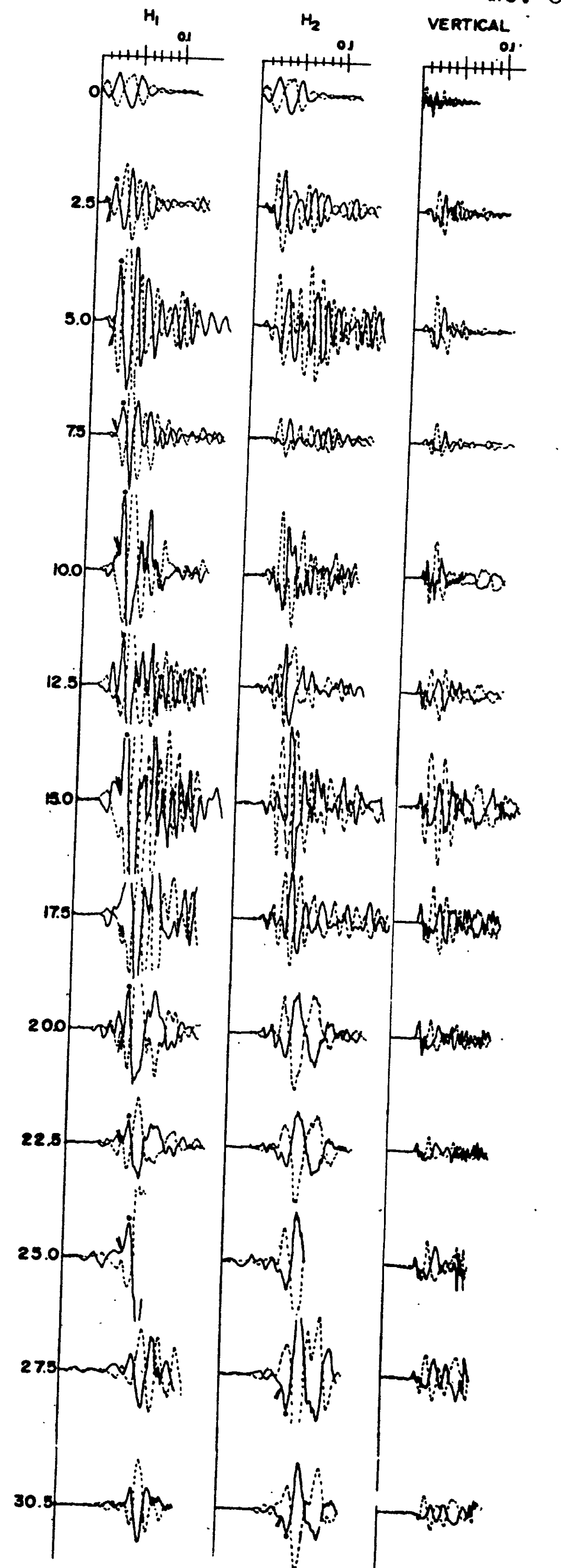
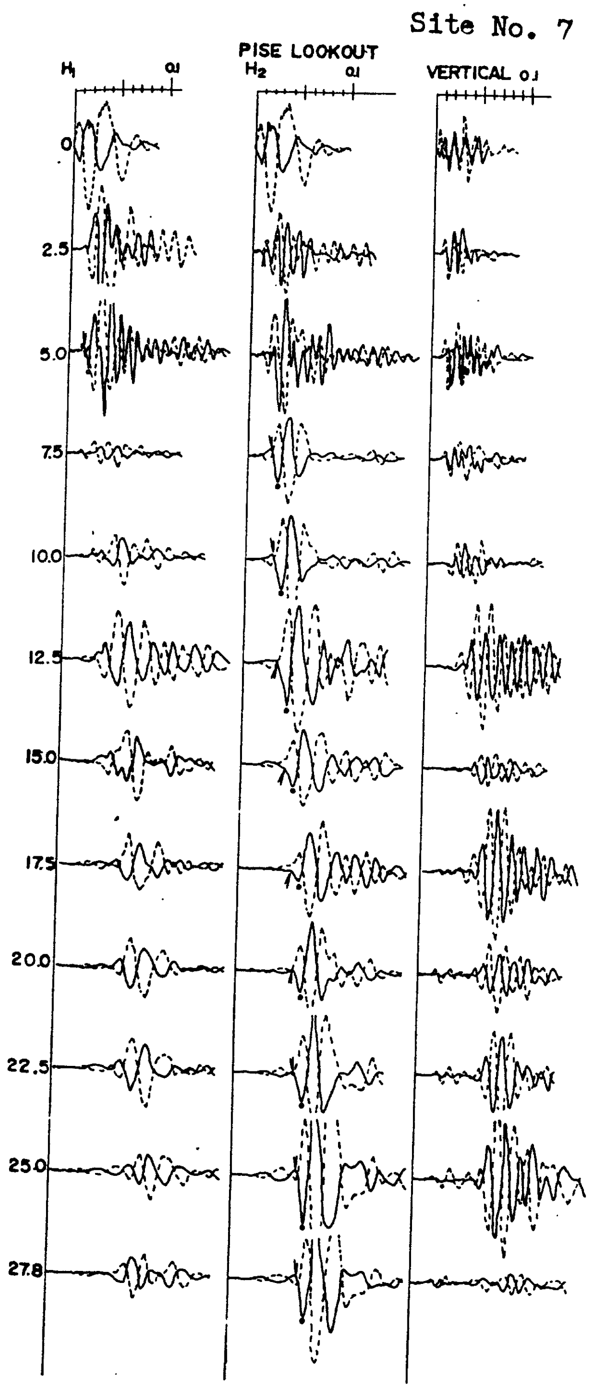
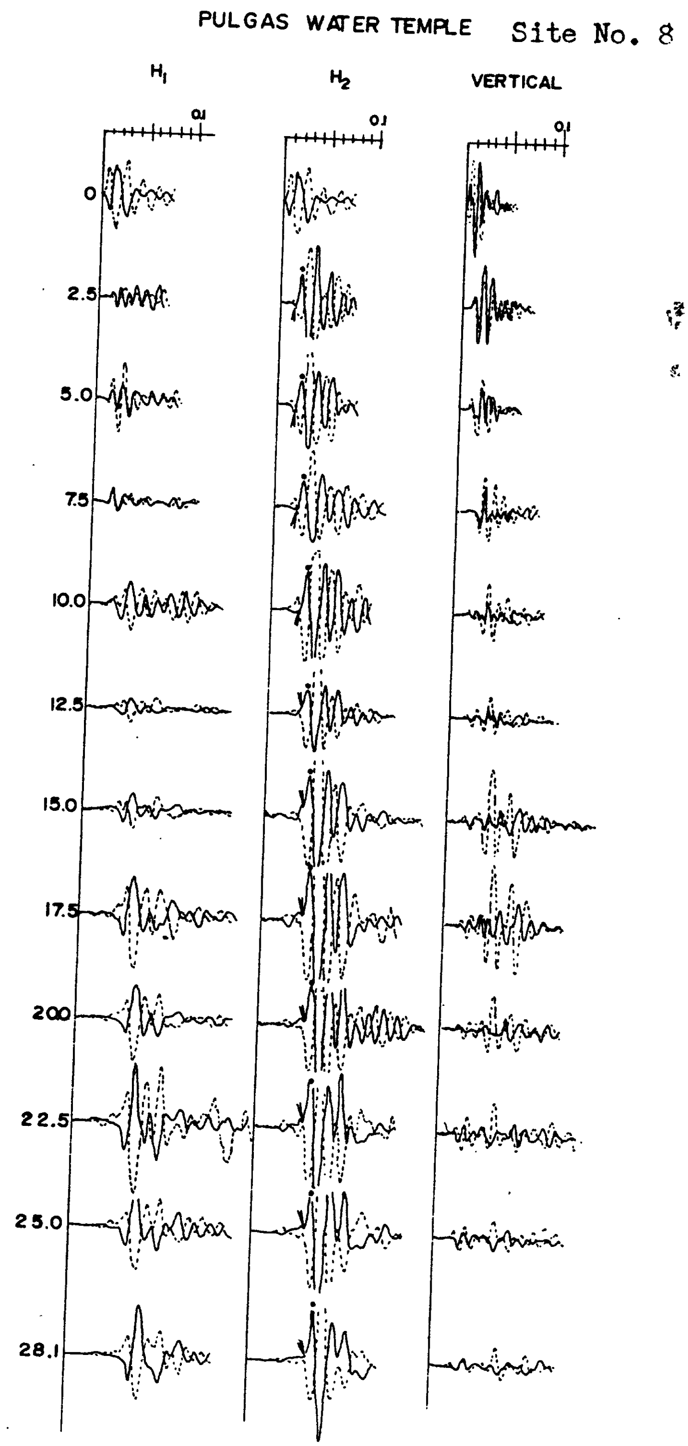


Fig. 26



Site No. 7
PISE LOOKOUT
H1
0.1
H2
0.1
VERTICAL 0.1
0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.8

Fig. 27



PULGAS WATER TEMPLE
Site No. 8
H1
H2
VERTICAL
0.1
0.1
0.1
0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
28.1

Fig. 28

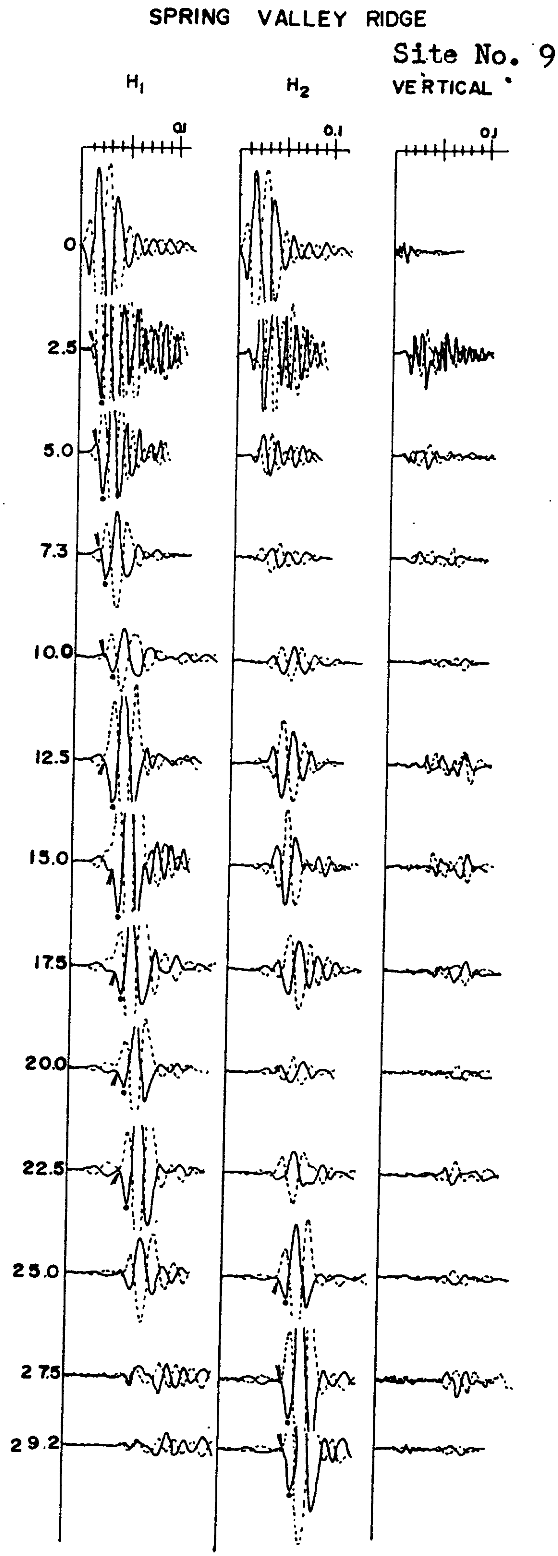

SPRING VALLEY RIDGE
Site No. 9
H1
H2
VERTICAL
0.1
0
2.5
5.0
7.3
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
29.2

Fig. 29

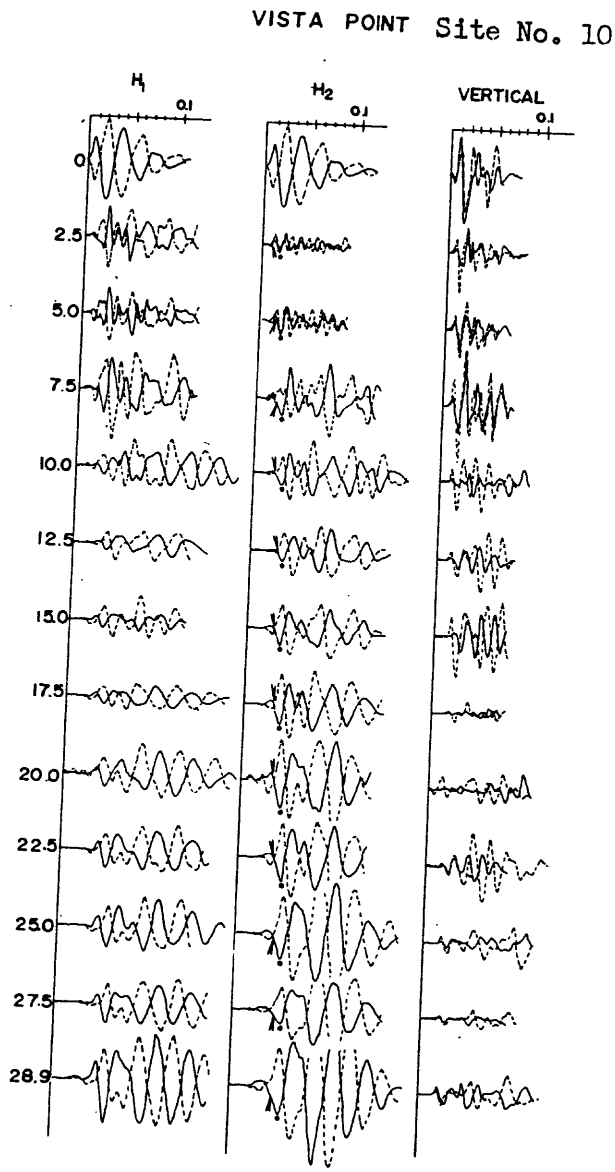
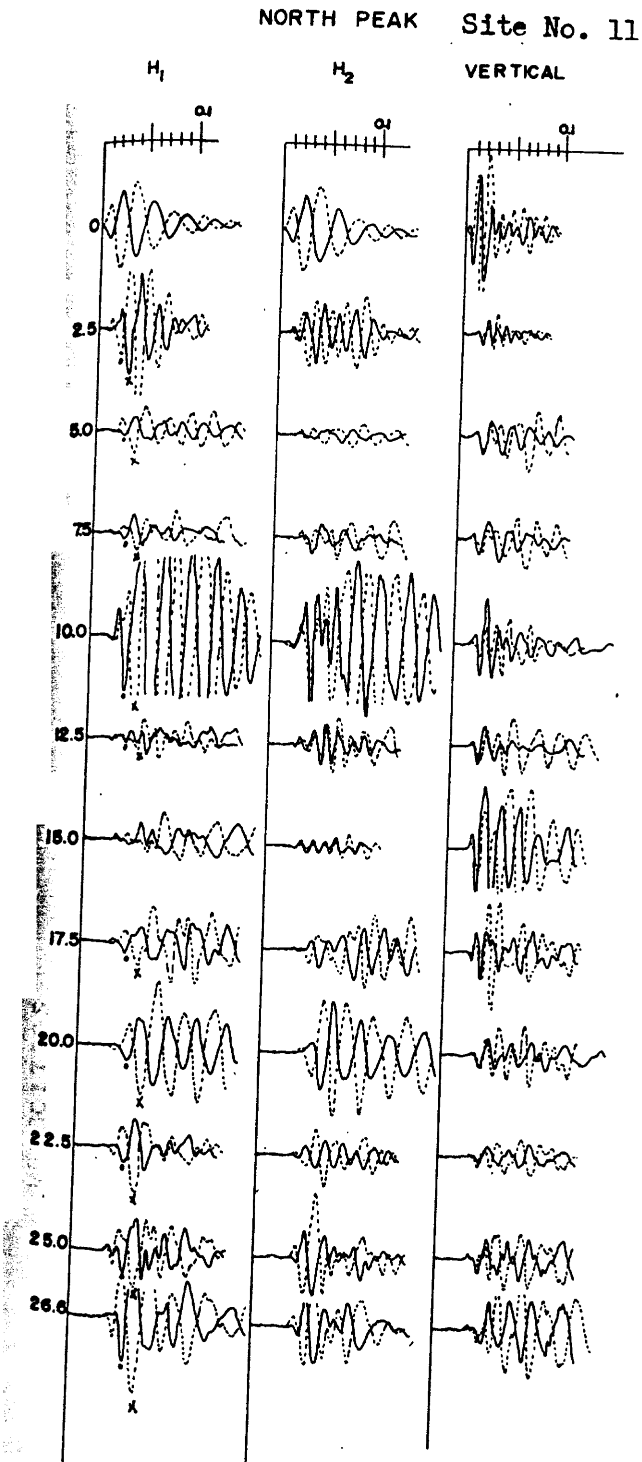
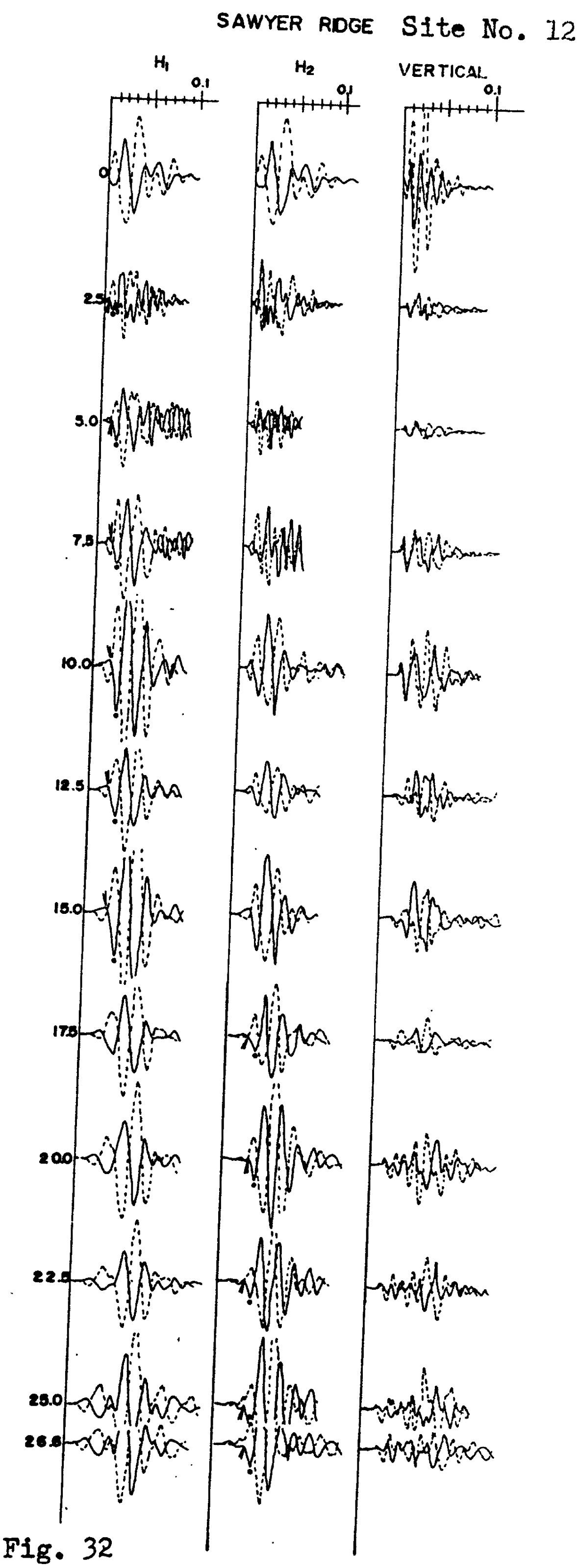

VISTA POINT Site No. 10
H1
H2
VERTICAL
0.1
0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
28.9

Fig. 30



NORTH PEAK
Site No. 11
H1
H2
VERTICAL
0.1
0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
26.6

Fig. 31



SAWYER RIDGE
Site No. 12
H1
H2
VERTICAL
0.1
0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
26.6

Fig. 32

TRAVEL-TIMES AND AVERAGE VELOCITIES

SITE NO. 1 PURISIMA
PLANK DIST= 2.0 PLATE DIST= 2.4 DATE LOGGED 8-20-74
AVE ORIGIN CORR= 0.002

DEPTH (M)	ORIGIN CORR (S)	FIRST S ARRIVAL (S)	CORR S TIME (S)	AVE VEL S WAVE (M/S)
5.0	0.002	0.038	0.035	141
7.5	0.002	0.043	0.042	180
10.0	0.002	0.050	0.049	203
12.5	0.002	0.059	0.058	214
15.0	0.002	0.064	0.063	236
17.5	0.002	0.071	0.071	248
20.0	0.002	0.077	0.077	261
22.5	0.002	0.083	0.083	272
25.0	0.002	0.087	0.087	288
27.5	0.002	0.094	0.094	293
29.0	0.002	0.100	0.100	290

DEPTH (M)	FIRST S PEAK (S)	CORR S PEAK (S)	P TIME (S)	CORR P TIME (S)	AVE VEL P WAVE (M/S)
5.0	0.047	0.044	0.012	0.011	462
7.5	0.051	0.049	0.014	0.013	562
10.0	0.056	0.055	0.016	0.016	642
12.5	0.067	0.066	0.019	0.019	669
15.0	0.072	0.071	0.020	0.020	759
17.5	0.079	0.078	0.022	0.022	802
20.0	0.086	0.086	0.023	0.023	875
22.5	0.090	0.090	0.024	0.024	942
25.0	0.095	0.095	0.026	0.026	965
27.5	0.102	0.102	0.027	0.027	1020
29.0	0.107	0.107	0.028	0.028	1040

TRAVEL-TIMES AND AVERAGE VELOCITIES

SITE NO. 2 COZZOLINOS
PLANK DIST= 2.0 PLATE DIST= 2.5

DATE LOGGED 8-21-74
AVE ORIGIN CORR= 0.009

DEPTH (M)	ORIGIN CORR (S)	FIRST S ARRIVAL (S)	CORR S TIME (S)	AVE VEL S WAVE (M/S)
2.5	0.009	0.020	0.016	156
4.7	0.008	0.032	0.030	157
7.5	0.010	0.048	0.047	160
10.0	0.009	0.057	0.056	177
12.5	0.008	0.063	0.063	199
15.0	0.009	0.070	0.070	214
17.5	0.008	0.078	0.078	224
20.0	0.008	0.086	0.086	232
22.5	0.009	0.094	0.094	239
25.0	0.009	0.099	0.099	252
27.5	0.006	0.105	0.105	261
29.0	0.008	0.108	0.108	268

DEPTH (M)	FIRST S PEAK (S)	CORR S PEAK (S)	P TIME (S)	CORR P TIME (S)	AVE VEL P WAVE (M/S)
2.5	0.029	0.023	0.008	0.006	441
4.7	0.039	0.036	0.008	0.007	665
7.5	0.056	0.055	0.009	0.009	878
10.0	0.064	0.063	0.011	0.011	937
12.5	0.071	0.071	0.013	0.013	980
15.0	0.078	0.078	0.013	0.013	1170
17.5	0.086	0.086	0.015	0.015	1180
20.0	0.094	0.094	0.016	0.016	1260
22.5	0.101	0.101	0.017	0.017	1330
25.0	0.106	0.106	0.018	0.018	1400
27.5	0.113	0.113	0.019	0.019	1450
29.0	0.116	0.116	0.020	0.020	1460

TRAVEL-TIMES AND AVERAGE VELOCITIES

SITE NO. 3 MARYKNOLL
PLANK DIST= 2.0 PLATE DIST= 2.0 DATE LOGGED 9-25-74
AVE ORIGIN CORR= 0.002

DEPTH (M)	ORIGIN CORR (S)	FIRST S ARRIVAL (S)	CORR S TIME (S)	AVE VEL S WAVE (M/S)
2.5	0.001	0.013	0.010	242
4.9	0.001	0.020	0.019	262
7.5	0.001	0.024	0.023	320
10.0	0.002	0.031	0.031	327
12.5	0.001	0.035	0.035	359
14.9	0.002	0.038	0.038	393
17.4	0.003	0.042	0.042	415
20.0	0.002	0.047	0.047	426
22.4	0.002	0.051	0.051	439
24.9	0.002	0.054	0.054	461
28.3	0.003	0.059	0.059	479

DEPTH (M)	FIRST S PEAK (S)	CORR S PEAK (S)	P TIME (S)	CORR P TIME (S)	AVE VEL P WAVE (M/S)
2.5	0.019	0.015	0.008	0.006	400
4.9	0.026	0.024	0.011	0.010	481
7.5	0.030	0.029	0.013	0.013	597
10.0	0.038	0.037	0.015	0.015	679
12.5	0.041	0.041	0.017	0.017	744
14.9	0.046	0.046	0.019	0.019	791
17.4	0.050	0.050	0.021	0.021	834
20.0	0.054	0.054	0.022	0.022	913
22.4	0.058	0.058	0.023	0.023	977
24.9	0.061	0.061	0.024	0.024	1040
28.3	0.067	0.067	0.026	0.026	1090

TABLE 4

TRAVEL-TIMES AND AVERAGE VELOCITIES

SITE NO. 4 EL GRANADA
PLANK CIST= 2.0 PLATE DIST= 2.4

DATE LOGGED 11-26-74
AVE ORIGIN CORR= 0.007

CEPTH (M)	ORIGIN CCRR (S)	FIRST S ARRIVAL (S)	CORR S TIME (S)	AVE VEL S WAVE (M/S)
2.5	0.006	0.016	0.013	195
5.0	0.006	0.019	0.018	277
7.5	0.007	0.022	0.022	346
10.0	0.007	0.023	0.023	435
12.5	0.006	0.024	0.024	518
15.0	0.006	0.026	0.026	572
17.5	0.009	0.028	0.028	619
20.0	0.008	0.C29	0.029	683
22.5	0.005	0.030	0.030	742
25.0	0.0C6	0.032	0.032	773
27.5	0.007	0.C33	0.033	825
30.0	0.006	0.035	0.035	848

CEPTH (M)	FIRST S PEAK (S)	CORR S PEAK (S)	P TIME (S)	CORR P TIME (S)	AVE VEL P WAVE (M/S)
2.5	0.025	0.020	0.015	0.011	231
5.0	0.028	0.026	0.C16	0.014	346
7.5	0.028	0.027	0.C18	0.017	437
10.0	0.030	0.030	0.C19	0.018	541
12.5	0.031	0.031	0.C2C	0.020	636
15.0	0.033	0.033	0.020	0.020	759
17.5	0.035	0.035	0.021	0.021	841
20.0	0.037	0.037	0.C22	0.022	915
22.5	0.037	0.037	0.022	0.022	1030
25.0	0.04C	C.040	0.023	0.023	1090
27.5	0.041	0.041	0.023	0.023	1200
30.0	0.042	0.042	0.024	0.024	1250

TABLE 5

TRAVEL-TIMES AND AVERAGE VELOCITIES

SITE NO. 5 BLACK MOUNTAIN DATE LOGGED 10-10-74
PLANK DIST= 2.0 PLATE DIST= 2.9 AVE ORIGIN CORR= 0.004

DEPTH (M)	ORIGIN CORR (S)	FIRST S ARRIVAL (S)	CORR S TIME (S)	AVE VEL S WAVE (M/S)
2.5	0.006	0.015	0.012	215
5.0	0.005	0.019	0.017	285
7.5	0.004	0.021	0.020	372
10.0	0.005	0.025	0.024	410
12.5	0.005	0.028	0.027	454
15.0	0.003	0.032	0.032	475
17.5	0.003	0.036	0.036	491
20.0	0.004	0.044	0.044	458
22.5	0.004	0.047	0.047	482
25.0	0.004	0.051	0.051	493
27.5	0.004	0.064	0.054	512
29.3	0.003	0.055	0.055	535

DEPTH (M)	FIRST S PEAK (S)	CORR S PEAK (S)	P TIME (S)	CORR P TIME (S)	AVE VEL P WAVE (M/S)
2.5	0.024	0.019	0.011	0.007	348
5.0	0.026	0.024	0.012	0.010	481
7.5	0.028	0.027	0.011	0.010	731
10.0	0.034	0.033	0.012	0.012	867
12.5	0.037	0.036	0.013	0.013	987
15.0	0.041	0.040	0.014	0.014	1090
17.5	0.045	0.045	0.016	0.016	1110
20.0	0.050	0.050	0.017	0.017	1190
22.5	0.053	0.053	0.018	0.018	1260
25.0	0.056	0.056	0.018	0.018	1400
27.5	0.059	0.059	0.019	0.019	1460
29.3	0.060	0.060	0.019	0.019	1550

TRAVEL-TIMES AND AVERAGE VELOCITIES

SITE NO. 6 DIGGES CANYON
PLANK DIST= 2.0 PLATE DIST= 2.0
DATE LOGGED 10-11-74
AVE ORIGIN CORR= 0.002

DEPTH (M)	ORIGIN CORR (S)	FIRST S ARRIVAL (S)	CORR S TIME (S)	AVE VEL S WAVE (M/S)
2.5	0.002	0.019	0.015	167
5.0	0.002	0.025	0.023	214
7.5	0.002	0.035	0.034	221
10.0	0.002	0.041	0.040	248
12.5	0.002	0.046	0.046	274
15.0	0.001	0.050	0.050	302
17.5	0.002	0.058	0.058	303
20.0	0.001	0.061	0.061	329
22.5	0.003	0.065	0.065	347
25.0	0.002	0.069	0.069	363
27.5	0.002	0.074	0.074	372
30.5	0.002	0.077	0.077	396

DEPTH (M)	FIRST S PEAK (S)	CORR S PEAK (S)	P TIME (S)	CORR P TIME (S)	AVE VEL P WAVE (M/S)
2.5	0.024	0.019	0.010	0.008	320
5.0	0.031	0.029	0.012	0.011	448
7.5	0.039	0.038	0.016	0.015	485
10.0	0.045	0.044	0.018	0.018	566
12.5	0.051	0.050	0.021	0.021	602
15.0	0.056	0.056	0.023	0.023	657
17.5	0.065	0.065	0.026	0.026	677
20.0	0.067	0.067	0.028	0.028	717
22.5	0.072	0.072	0.030	0.030	752
25.0	0.076	0.076	0.033	0.033	759
27.5	0.080	0.080	0.035	0.035	787
30.5	0.C84	0.084	0.037	0.037	826

TRAVEL-TIMES AND AVERAGE VELOCITIES

SITE NO. 7 PISE LOCKOUT DATE LOGGED 11-25-74
PLANK DIST= 2.0 PLATE DIST= 2.0 AVE ORIGIN CORR= 0.006

DEPTH (M)	ORIGIN CORR (S)	FIRST S ARRIVAL (S)	CORR S TIME (S)	AVE VEL S WAVE (M/S)
2.5	0.006	0.015	0.012	212
5.0	0.005	0.018	0.017	297
7.5	0.006	0.025	0.024	309
10.0	0.007	0.032	0.031	317
12.5	0.005	0.037	0.037	341
15.0	0.006	0.046	0.046	328
17.5	0.006	0.054	0.054	325
20.0	0.007	0.058	0.058	346
22.5	0.005	0.062	0.062	363
25.0	0.005	0.066	0.066	379
27.8	0.007	0.071	0.071	392

DEPTH (M)	FIRST S PEAK (S)	CORR S PEAK (S)	P TIME (S)	CORR P TIME (S)	AVE VEL P WAVE (M/S)
2.5	0.020	0.016	0.014	0.011	228
5.0	0.024	0.022	0.014	0.013	384
7.5	0.031	0.030	0.015	0.014	517
10.0	0.039	0.038	0.016	0.016	637
12.5	0.045	0.045	0.017	0.017	744
15.0	0.054	0.054	0.019	0.019	796
17.5	0.062	0.062	0.021	0.021	838
20.0	0.066	0.066	0.022	0.022	913
22.5	0.071	0.071	0.023	0.023	982
25.0	0.075	0.075	0.024	0.024	1040
27.8	0.080	0.080	0.025	0.025	1110

TRAVEL-TIMES AND AVERAGE VELCCITIES

SITE NO. 8 PULGAS WATER TEMPLE DATE LOGGED 11-20-74
PLANK DIST= 2.0 PLATE DIST= 2.0 AVE ORIGIN CORR= 0.003

DEPTH (M)	ORIGIN CCRR (S)	FIRST S ARRIVAL (S)	CORR S TIME (S)	AVE VEL S WAVE (M/S)
2.5	0.003	0.016	0.012	203
5.0	0.CC3	0.020	0.018	272
7.5	0.CC4	0.C25	0.024	313
10.0	0.C02	0.031	0.030	331
12.5	C.CC2	0.C35	0.034	364
15.0	0.003	0.040	0.039	380
17.5	0.CC3	0.044	0.043	402
20.0	0.CC3	0.050	0.049	4C4
22.5	0.005	0.053	0.053	428
25.0	C.CC4	0.C58	0.058	434
28.1	0.004	0.C63	0.063	449

DEPTH (M)	FIRST S PEAK (S)	CORR S PEAK (S)	P TIME (S)	CORR P TIME (S)	AVE VEL P WAVE (M/S)
2.5	0.023	0.018	0.013	0.010	246
5.0	0.025	0.023	0.C13	0.012	414
7.5	0.03C	0.029	0.C14	0.014	554
10.0	0.037	0.036	0.015	0.015	679
12.5	C.04C	0.039	0.C17	0.017	744
15.0	0.046	0.045	C.C18	0.018	840
17.5	0.C51	0.050	0.019	0.019	927
20.0	0.056	0.055	C.02C	0.020	1000
22.5	C.060	0.059	0.022	0.022	1030
25.0	0.063	0.063	0.023	0.023	1090
28.1	0.069	0.C69	0.C24	0.024	1170

TRAVEL-TIMES AND AVERAGE VELCCITIES

SITE NC. 9 SPRING VALLEY RIDGE DATE LOGGED 11-15-74
PLANK DIST= 2.0 PLATE DIST= 2.0 AVE ORIGIN CORR= 0.005

DEPTH (M)	CRIGIN CCRR (S)	FIRST S ARRIVAL (S)	CORR S TIME (S)	AVE VEL S WAVE (M/S)
2.5	0.005	0.014	0.011	225
5.0	0.006	0.018	0.017	296
7.3	0.005	0.021	0.020	357
10.0	0.004	0.026	0.026	389
12.5	0.005	0.032	0.032	393
15.0	0.006	0.040	0.040	376
17.5	0.004	0.045	0.045	389
20.0	0.004	0.049	0.049	408
22.5	0.005	0.055	0.055	409
25.0	0.005	0.059	0.059	423
27.5	0.004	0.065	0.065	423
29.2	0.005	0.067	0.067	435

DEPTH (M)	FIRST S PEAK (S)	CORR S PEAK (S)	P TIME (S)	CORR P TIME (S)	AVE VEL P WAVE (M/S)
2.5	0.021	0.017	0.010	0.008	320
5.0	0.025	0.023	0.011	0.010	489
7.3	0.029	0.028	0.012	0.012	630
10.0	0.034	0.034	0.013	0.013	784
12.5	0.041	0.041	0.014	0.014	904
15.0	0.048	0.048	0.015	0.015	1010
17.5	0.052	0.052	0.016	0.016	1100
20.0	0.056	0.056	0.018	0.018	1120
22.5	0.063	0.063	0.019	0.019	1190
25.0	0.068	0.068	0.019	0.019	1320
27.5	0.072	0.072	0.020	0.020	1380
29.2	0.075	0.075	0.021	0.021	1390

TRAVEL-TIMES AND AVERAGE VELOCITIES

SITE NC. 10 VISTA POINT
PLANK DIST= 2.0 PLATE DIST= 2.0 DATE LOGGED 11-22-74
AVE ORIGIN CORR= 0.005

DEPTH (M)	ORIGIN CORR (S)	FIRST S ARRIVAL (S)	CORR S TIME (S)	AVE VEL S WAVE (M/S)
2.5	0.006	0.014	0.011	222
5.0	0.004	0.020	0.019	263
7.5	0.005	0.022	0.022	346
10.0	0.004	0.024	0.024	417
12.5	0.004	0.029	0.029	430
15.0	0.004	0.031	0.031	481
17.5	0.005	0.032	0.032	543
20.0	0.005	0.034	0.034	584
22.5	0.005	0.037	0.037	603
25.0	0.003	0.041	0.041	605
27.5	0.005	0.045	0.045	607
28.9	0.005	0.046	0.046	624

DEPTH (M)	FIRST S PEAK (S)	CORR S PEAK (S)	P TIME (S)	CORR P TIME (S)	AVE VEL P WAVE (M/S)
2.5	0.020	0.016	0.007	0.005	457
5.0	0.024	0.023	0.009	0.008	598
7.5	0.029	0.028	0.010	0.010	776
10.0	0.030	0.030	0.013	0.013	784
12.5	0.036	0.036	0.014	0.014	904
15.0	0.036	0.036	0.014	0.014	1080
17.5	0.039	0.039	0.015	0.015	1170
20.0	0.042	0.042	0.015	0.015	1340
22.5	0.047	0.047	0.016	0.016	1410
25.0	0.051	0.051	0.017	0.017	1480
27.5	0.054	0.054	0.018	0.018	1530
28.9	0.C55	0.055	0.019	0.019	1520

TABLE 11

TRAVEL-TIMES ANC AVERAGE VELOCITIES

SITE NO. 11 NORTH PEAK DATE LOGGED 1 1-18-74
PLANK DIST= 2.0 PLATE DIST= 2.0 AVE ORIGIN CORR 0.006

DEPTH (M)	ORIGIN CCRR (S)	FIRST S ARRIVAL (S)	CORR S TIME (S)	AVE VEL S WAVE (M/S)
2.5	0.007	0.026	0.020	123
5.0	0.006	0.030	0.028	179
7.5	0.006	0.C34	0.033	228
10.0	0.006	0.039	0.038	261
12.5	0.C06	0.042	0.041	301
17.5	0.006	0.047	0.047	374
20.0	0.005	0.053	0.053	379
22.5	0.C06	0.C54	0.054	418
25.0	0.006	0.C57	0.057	439
26.6	0.CC6	0.058	0.058	459

DEPTH (M)	FIRST S PEAK (S)	CORR S PEAK (S)	P TIME (S)	CORR P TIME (S)	AVE VEL P WAVE (M/S)
2.5	0.036	0.028	0.015	0.012	213
5.0	0.042	0.039	0.018	0.017	299
7.5	0.047	0.045	0.020	0.019	388
10.0	0.051	0.050	0.022	0.022	463
12.5	0.054	0.053	C.C23	0.023	550
15.0			0.025	0.025	605
17.5	0.06C	0.060	0.026	0.026	677
20.0	0.067	0.067	0.C3C	0.030	669
22.5	0.064	0.064	0.036	0.036	627
25.0	0.067	0.067	0.C37	0.037	677
26.6	0.068	0.068	0.C38	0.038	701

TABLE 12

TRAVEL-TIMES AND AVERAGE VELOCITIES

SITE NO. 12 SAWYER RIDGE DATE LOGGED 11-19-74
PLANK DIST= 2.0 PLATE DIST= 2.0 AVE ORIGIN CORR= 0.006

DEPTH (M)	ORIGIN CORR (S)	FIRST S ARRIVAL (S)	CORR S TIME (S)	AVE VEL S WAVE (M/S)
2.5	0.CC6	0.007	0.005	482
5.0	0.006	0.011	0.010	5C6
7.5	0.007	0.014	0.013	569
1C.0	0.CC6	0.C16	0.015	652
12.5	0.006	0.C21	0.020	613
15.0	0.007	0.025	0.024	614
17.5	0.CC5	0.C29	0.028	615
20.0	0.005	0.C32	0.031	635
22.5	0.008	0.037	0.036	616
25.0	0.CC7	0.C39	0.039	649
26.6	0.007	0.040	0.040	672

DEPTH (M)	FIRST S PEAK (S)	CORR S PEAK (S)	P TIME (S)	CORR P TIME (S)	AVE VEL P WAVE (M/S)
2.5	0.010	0.008	0.0C5	0.004	640
5.0	0.015	0.014	C.0C9	0.008	598
7.5	0.02C	0.019	0.C11	0.011	7C5
10.0	0.C22	0.021	0.012	0.012	849
12.5	0.C27	0.026	0.C13	0.013	973
15.0	0.031	0.030	0.C13	0.013	1160
17.5	0.C35	0.034	0.014	0.014	1260
20.0	0.038	0.037	0.C14	0.014	1440
22.5	0.042	0.041	0.016	0.016	1410
25.0	0.044	0.043	C.C16	0.016	1570
26.6	0.046	0.046	0.C17	0.017	1570

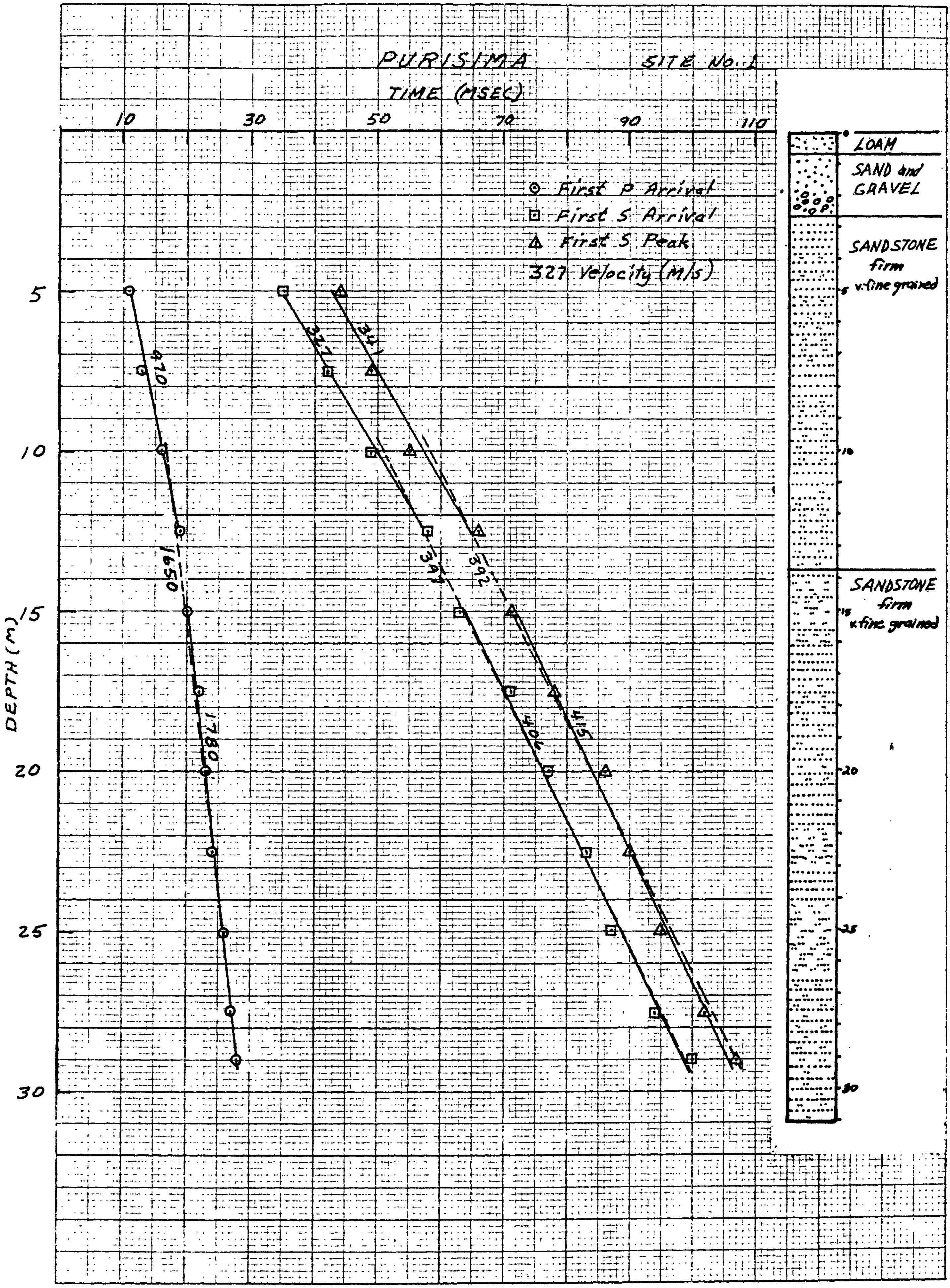

PURISIMA
SITE No. 1
TIME (MSEC)
10
30
50
70
90
110
DEPTH (M)
5
10
15
20
25
30
First P Arrival
First S Arrival
First S Peak
327 Velocity (m/s)
970
1650
1780
327
341
347
392
406
415
LOAM
SAND and GRAVEL
SANDSTONE firm v. fine grained
SANDSTONE firm v. fine grained

Fig. 33

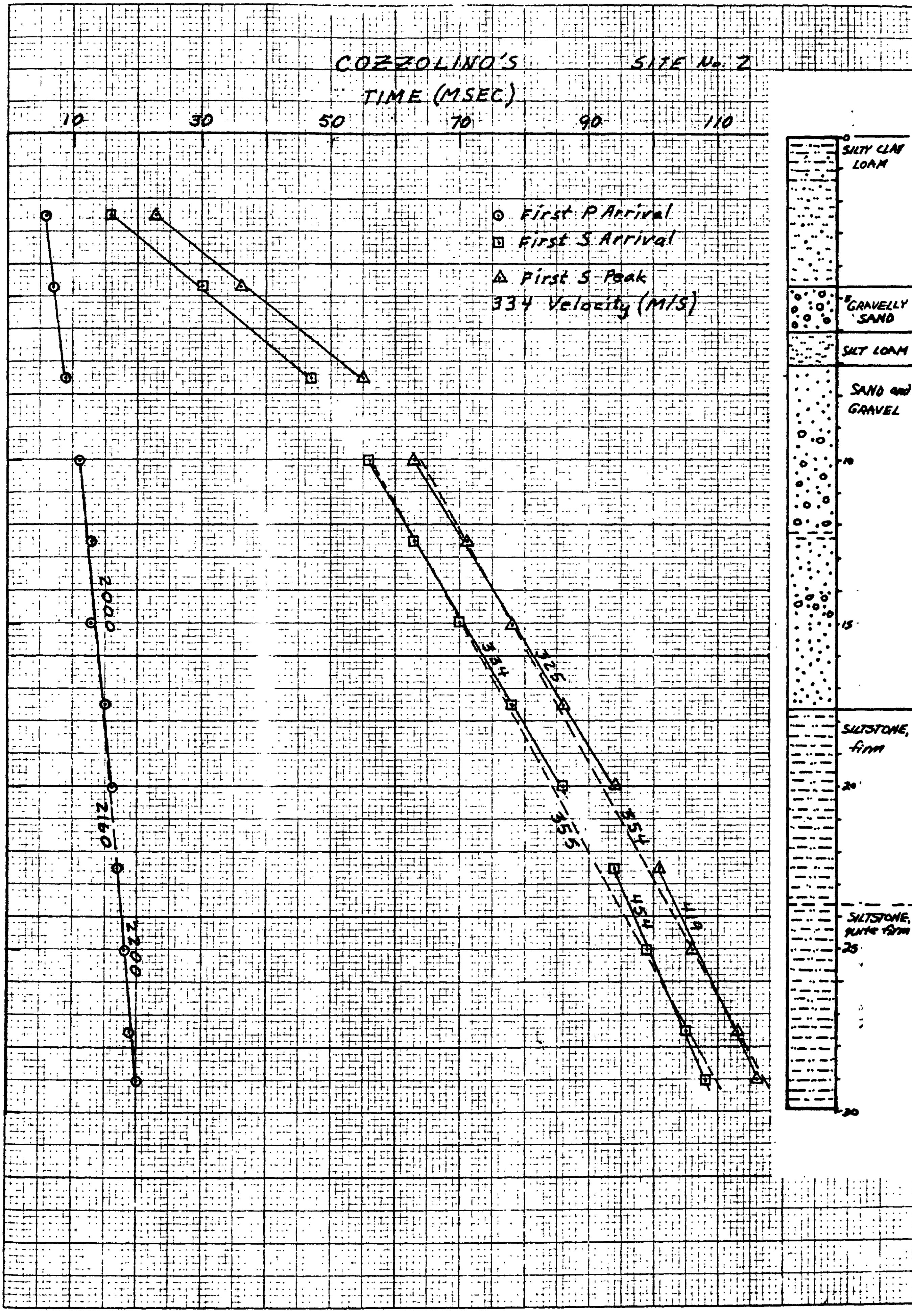

COZZOLINO'S SITE No. 2
TIME (MSEC)
10 30 50 70 90 110
DEPTH (M)
5 10 15 20 25 30
First P Arrival
First S Arrival
First S Peak
334 Velocity (M/S)
2000
2160
2200
334
326
355
354
454
419
SILTY CLAY LOAM
GRAVELLY SAND
SILT LOAM
SAND and GRAVEL
SILTSTONE, firm
SILTSTONE, quite firm

Fig. 34

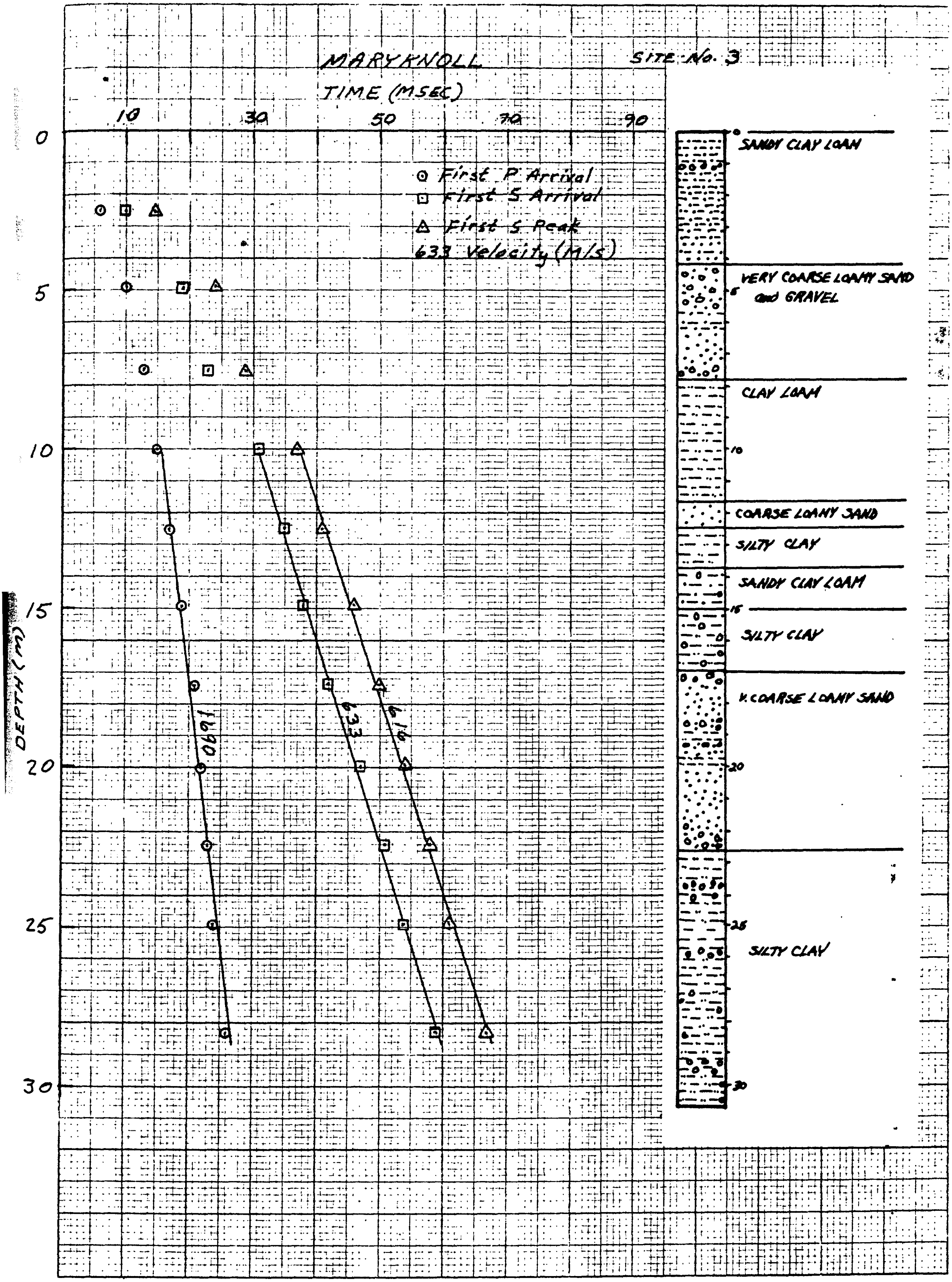

MARYKNOLL
SITE No. 3
TIME (MSEC)
10
30
50
70
90
0
5
10
15
20
25
30
DEPTH (m)
First P Arrival
First S Arrival
First S Peak
633 Velocity (M/s)
1690
633
616
SANDY CLAY LOAM
VERY COARSE LOAMY SAND and GRAVEL
CLAY LOAM
COARSE LOAMY SAND
SILTY CLAY
SANDY CLAY LOAM
SILTY CLAY
V. COARSE LOAMY SAND
SILTY CLAY

Fig. 35

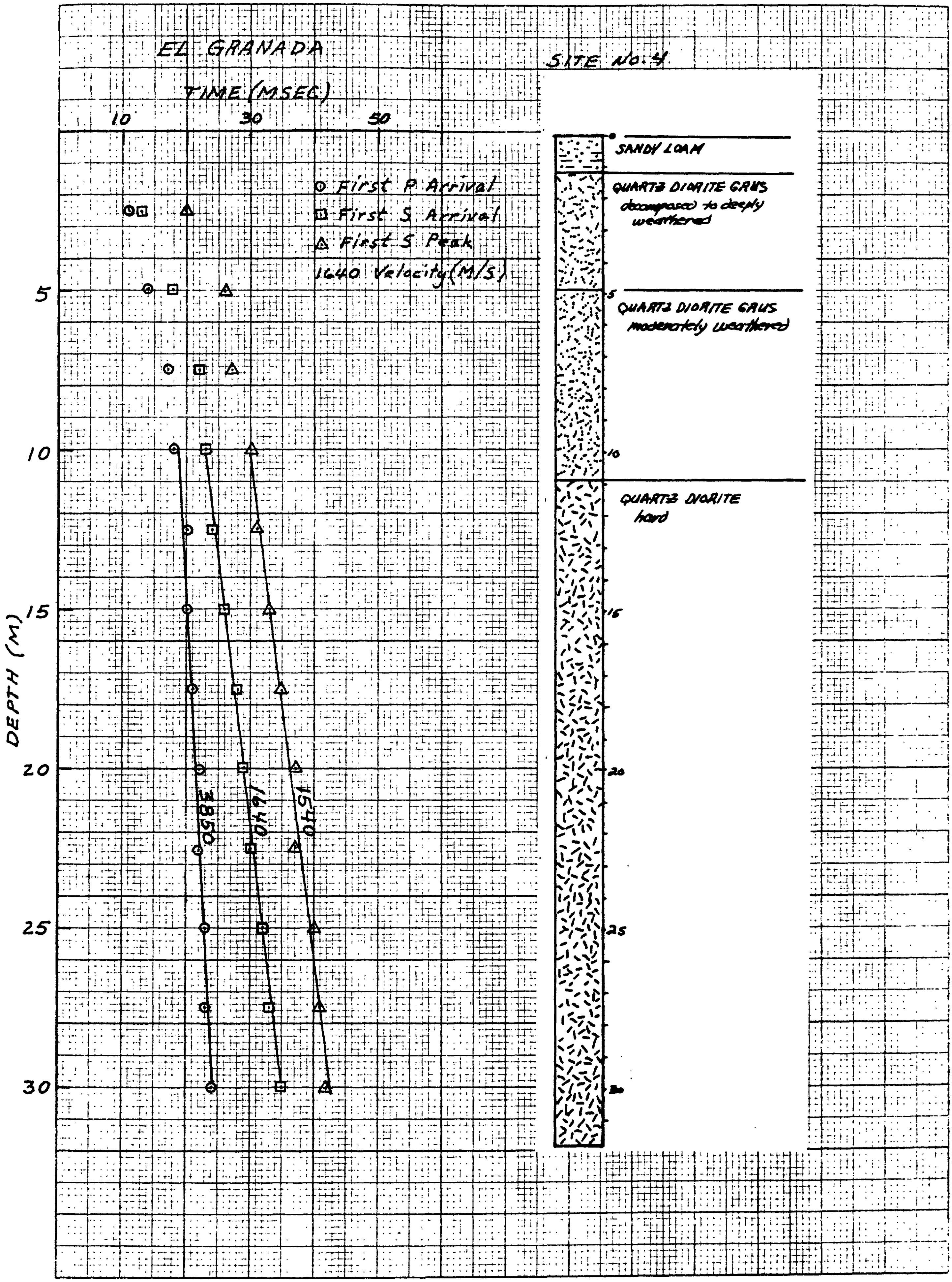

EL GRANADA
SITE No. 4
TIME (MSEC)
10
30
50
First P Arrival
First S Arrival
First S Peak
1640 Velocity (M/S)
DEPTH (M)
5
10
15
20
25
30
3850
1640
1540
SANDY LOAM
QUARTZ DIORITE GRUS
decomposed to deeply weathered
QUARTZ DIORITE GRUS
moderately weathered
QUARTZ DIORITE
hard

Fig. 36

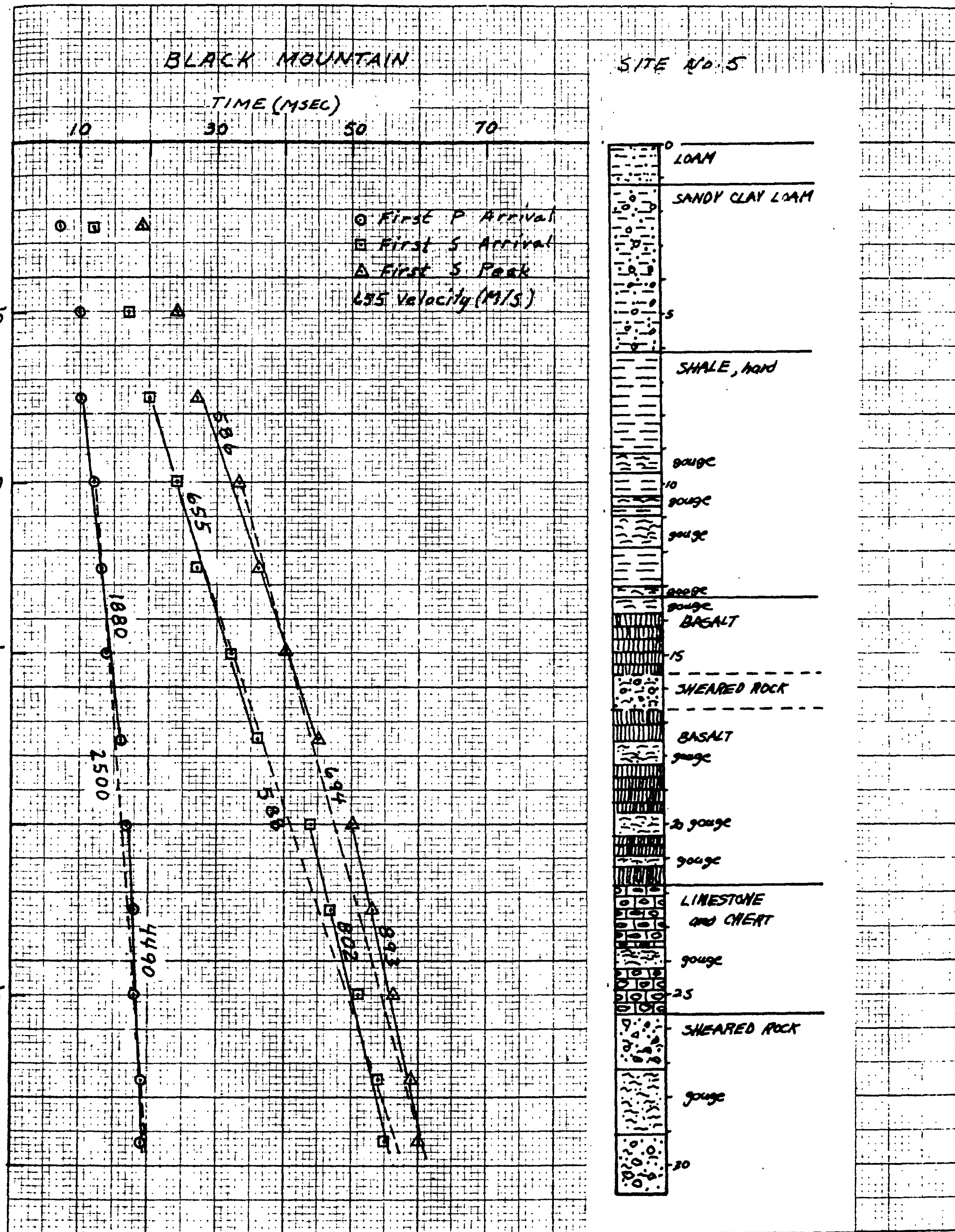

BLACK MOUNTAIN
SITE No. 5
TIME (MSEC)
10
30
50
70
DEPTH (M)
5
10
15
20
25
30
First P Arrival
First S Arrival
First S Peak
655 Velocity (M/S)
586
655
1880
2500
4490
588
694
802
843
LOAM
SANDY CLAY LOAM
SHALE, hard
gouge
gouge
gouge
gouge
gouge
BASALT
SHEARED ROCK
BASALT
gouge
gouge
gouge
LIMESTONE
and CHERT
gouge
SHEARED ROCK
gouge

Fig. 37

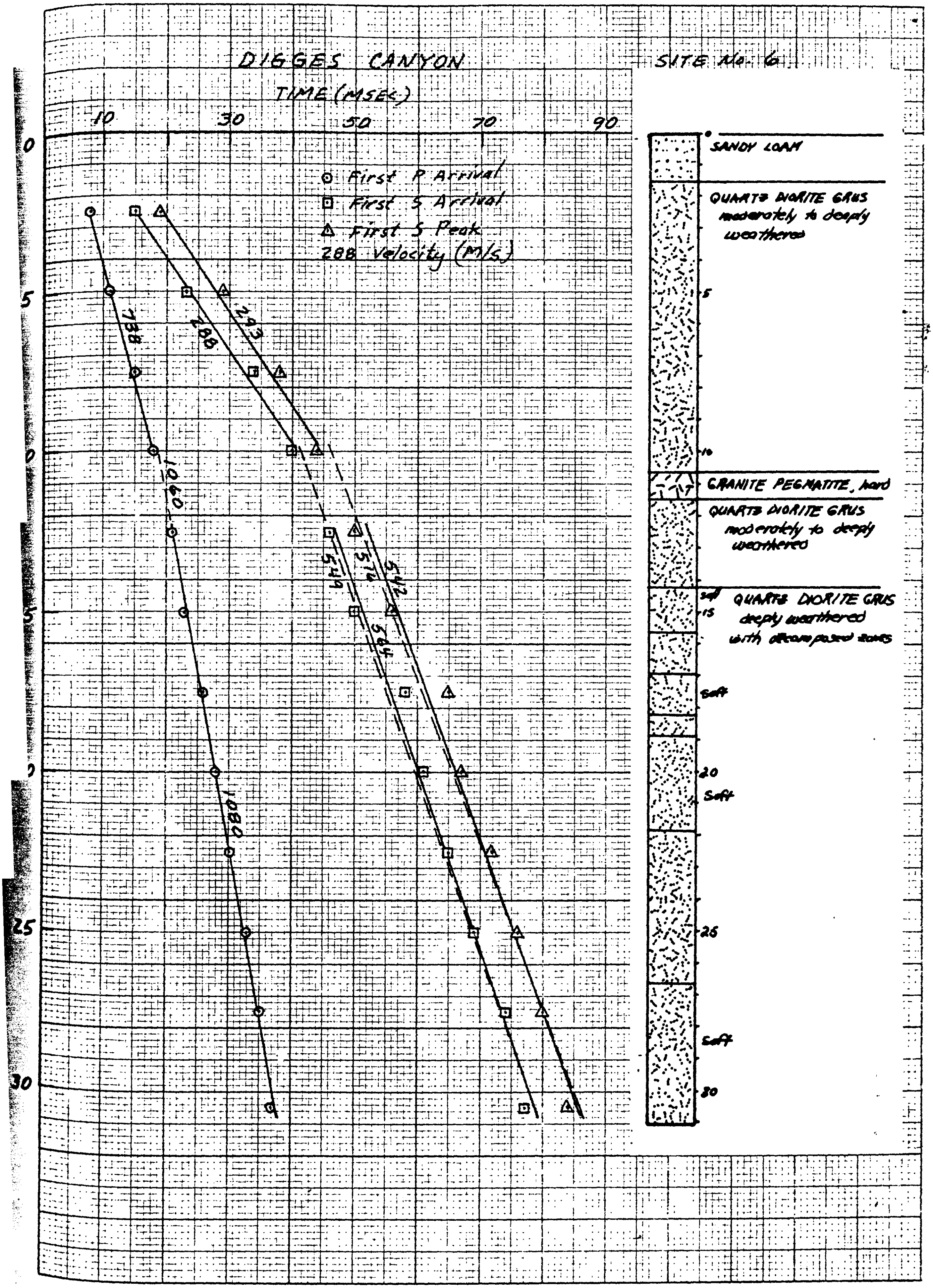
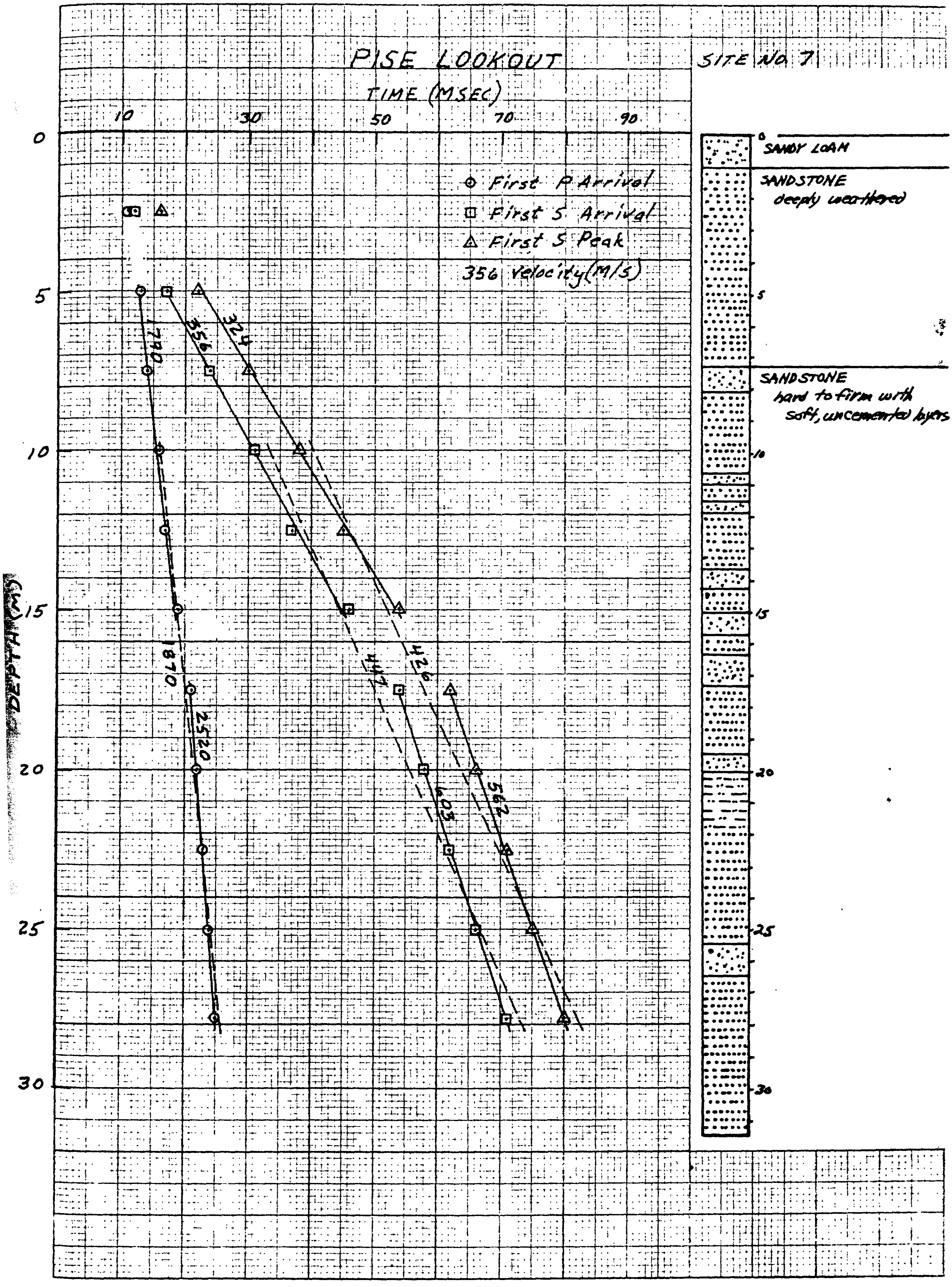
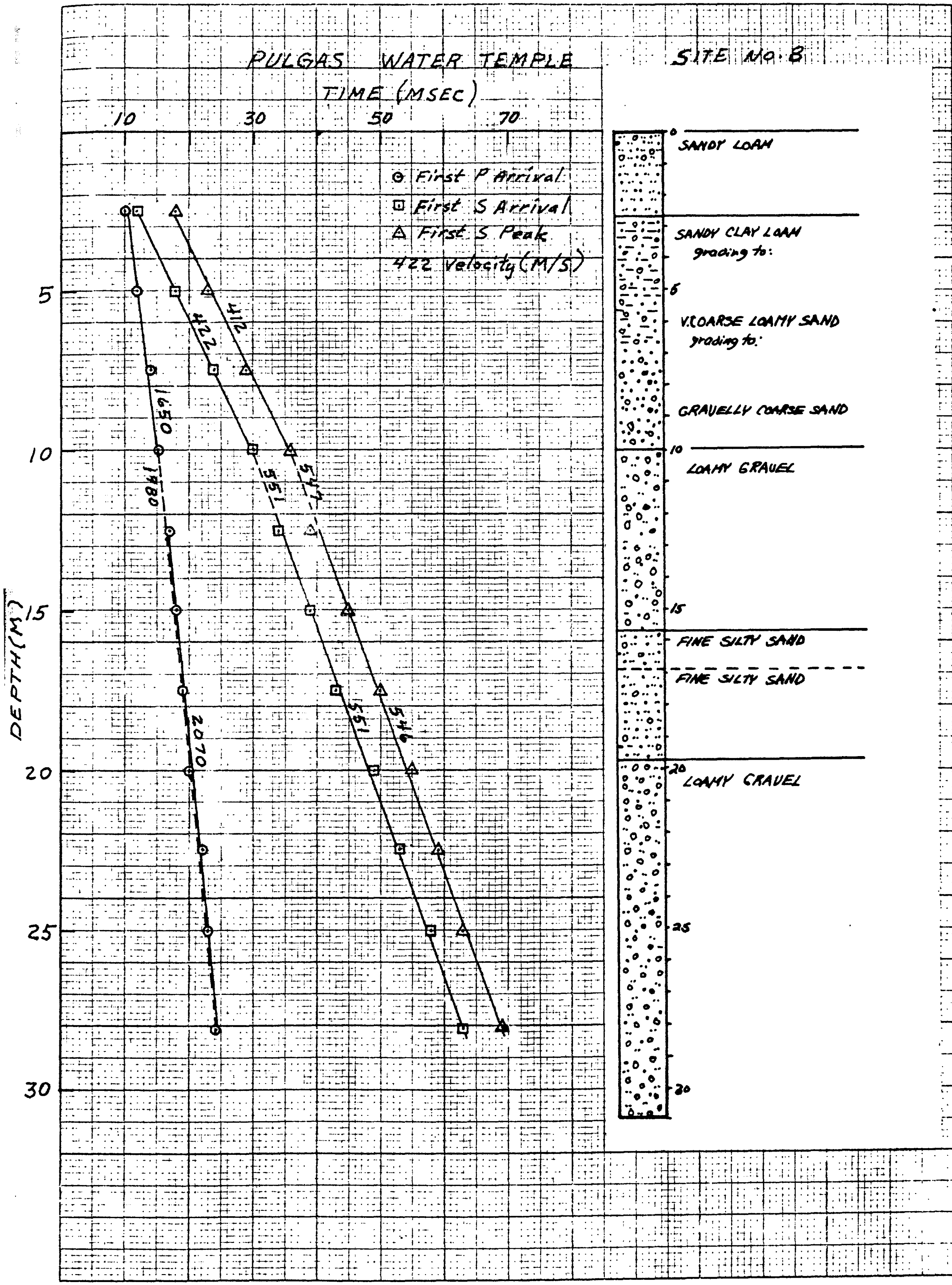

DIGGES CANYON
SITE No. 6
TIME (MSEC)
10
30
50
70
90
0
5
25
30
First P Arrival
First S Arrival
First S Peak
288 Velocity (M/S)
738
288
293
1060
549
514
542
564
1080
SANDY LOAM
QUARTZ DIORITE GRUS moderately to deeply weathered
GRANITE PEGMATITE, hard
QUARTZ DIORITE GRUS moderately to deeply weathered
QUARTZ DIORITE GRUS deeply weathered with decomposed zones
Soft
20
Soft
25
Soft
30

Fig. 38



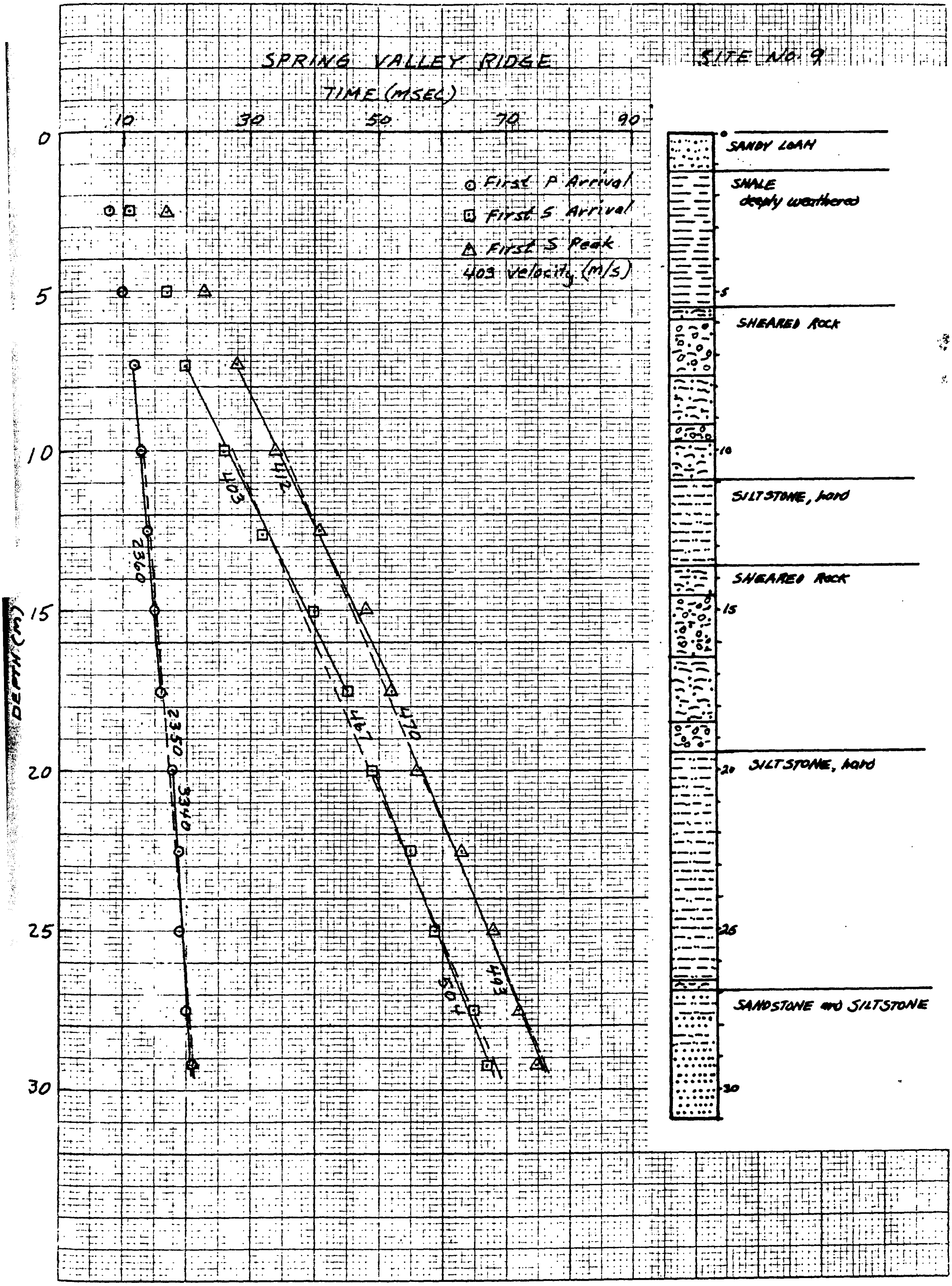
PISE LOOKOUT
SITE No. 7
TIME (MSEC)
10
30
50
70
90
DEPTH (M)
0
5
10
15
20
25
30
First P Arrival
First S Arrival
First S Peak
356 Velocity (M/S)
1790
356
324
1870
447
426
2520
603
562
SANDY LOAM
SANDSTONE
deeply weathered
SANDSTONE
hard to firm with
soft, uncemented layers

Fig. 39



PULGAS WATER TEMPLE
SITE No. B
TIME (MSEC)
10
30
50
70
First P Arrival
First S Arrival
First S Peak
422 Velocity (M/S)
DEPTH (M)
5
10
15
20
25
30
1650
1980
2070
422
551
551
412
547
546
SANDY LOAM
SANDY CLAY LOAM grading to:
V. COARSE LOAMY SAND grading to:
GRAVELLY COARSE SAND
LOAMY GRAVEL
FINE SILTY SAND
FINE SILTY SAND
LOAMY GRAVEL

Fig. 40



SPRING VALLEY RIDGE
SITE No. 9
TIME (MSEC)
10
30
50
70
90
DEPTH (m)
0
5
10
15
20
25
30
First P Arrival
First S Arrival
First S Peak
403 velocity (m/s)
2360
2350
3340
403
412
447
470
504
493
SANDY LOAM
SHALE deeply weathered
SHEARED ROCK
SILTSTONE, hard
SHEARED ROCK
SILTSTONE, hard
SANDSTONE and SILTSTONE

Fig. 41

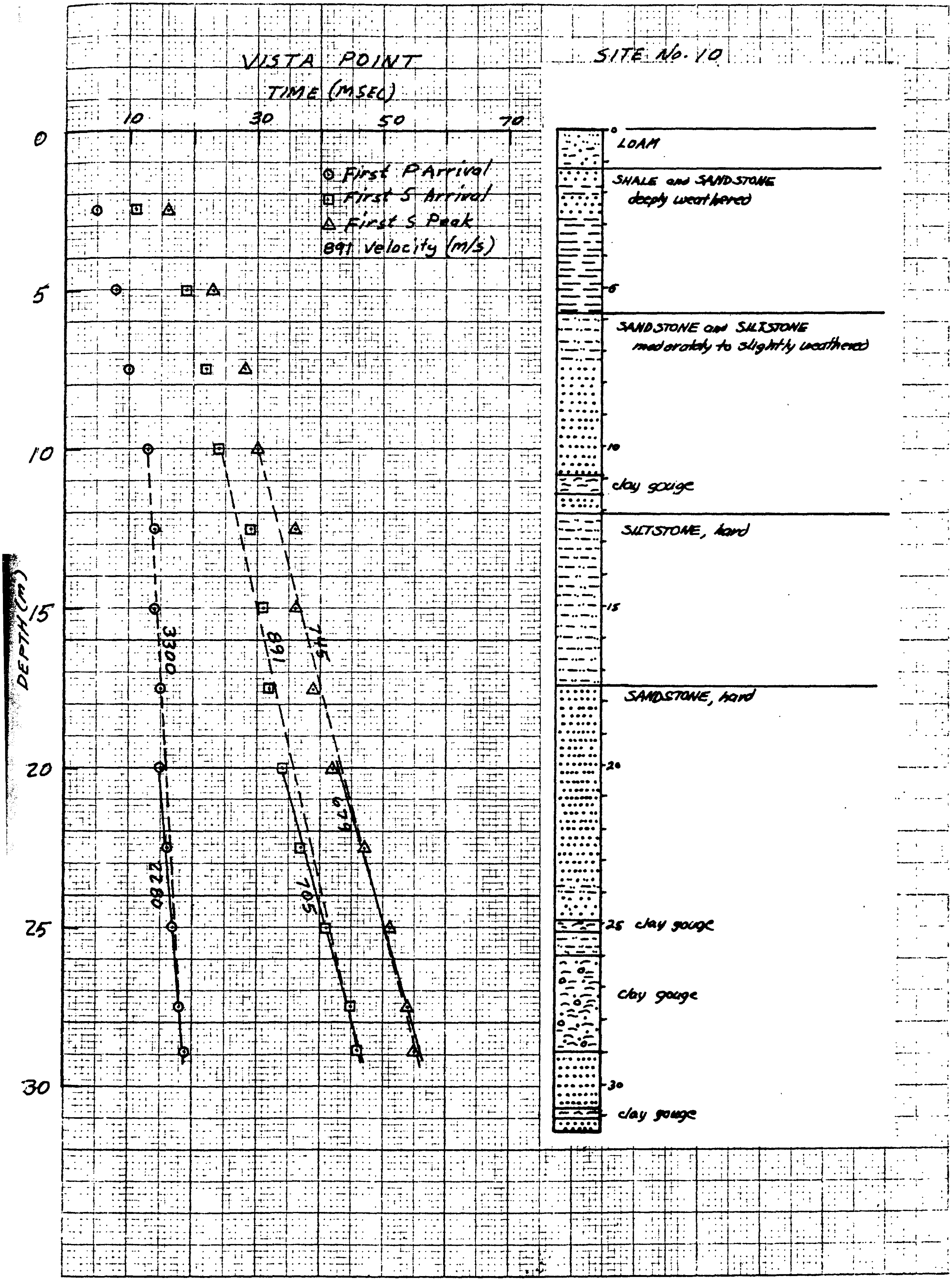
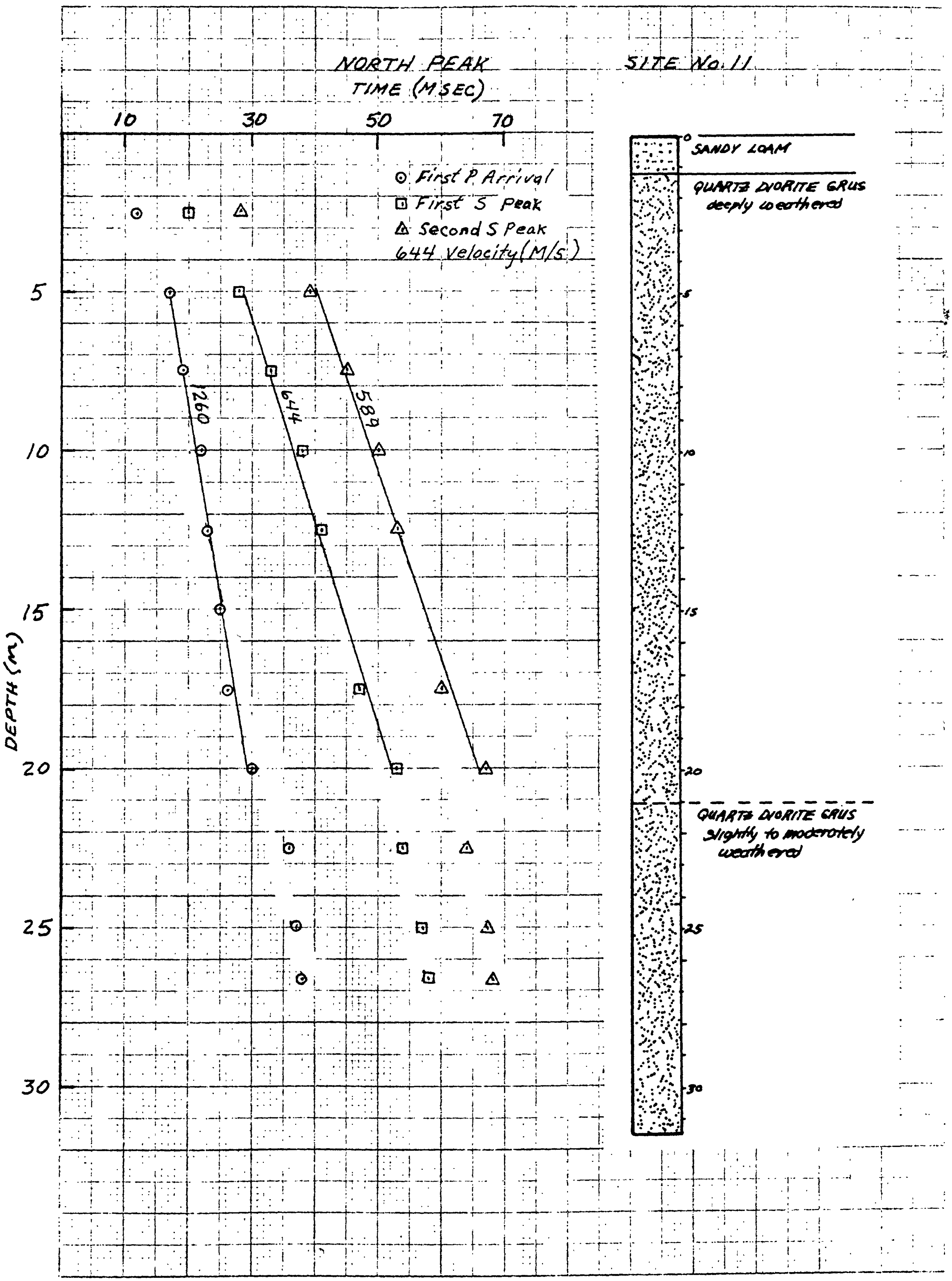
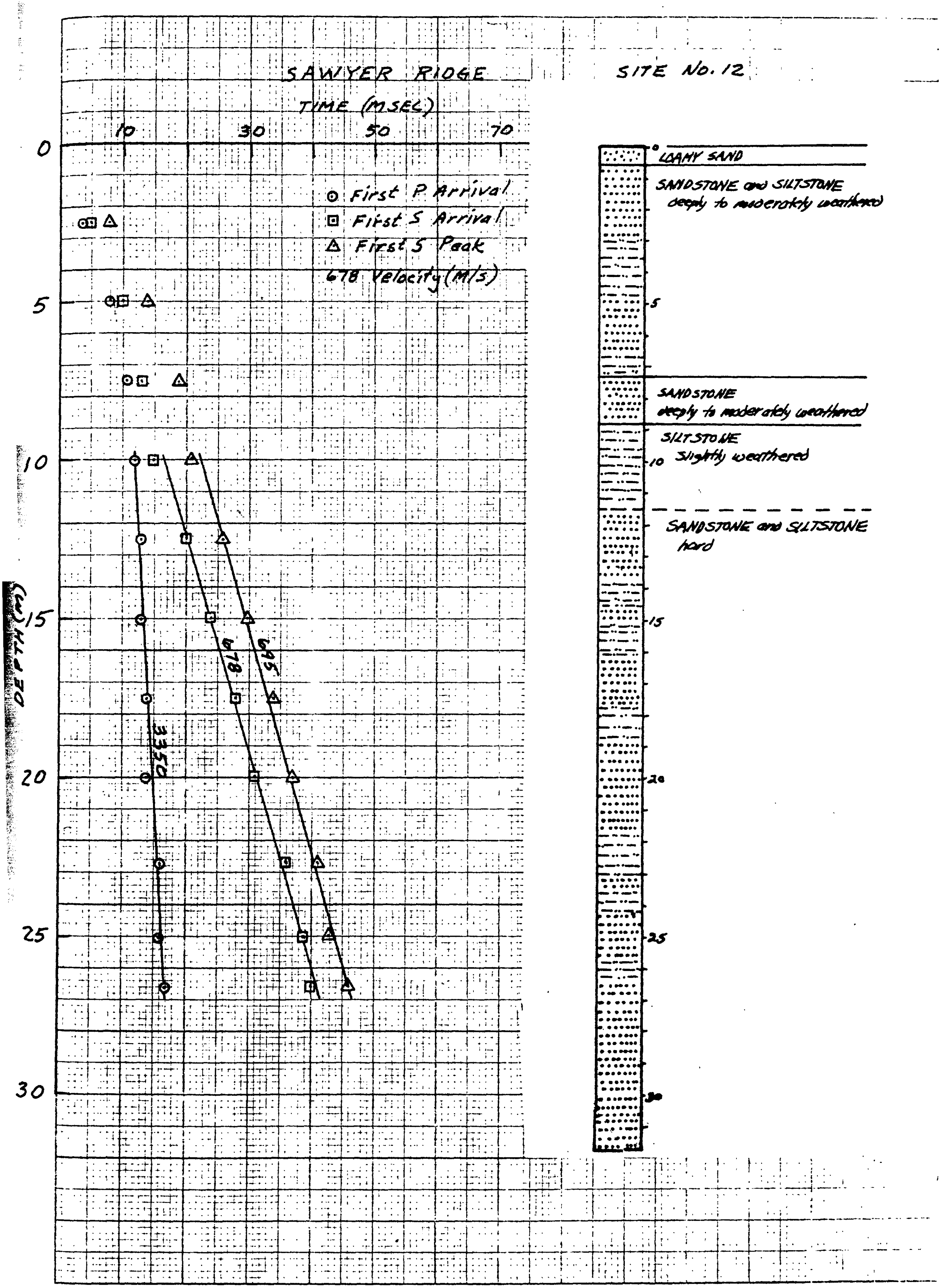

VISTA POINT
SITE No. 10
TIME (MSEC)
10
30
50
70
0
5
10
15
20
25
30
DEPTH (m)
First P Arrival
First S Arrival
First S Peak
891 Velocity (m/s)
3300
2280
891
745
705
679
LOAM
SHALE and SANDSTONE deeply weathered
SANDSTONE and SILTSTONE moderately to slightly weathered
clay gouge
SILTSTONE, hard
SANDSTONE, hard
clay gouge
clay gouge
clay gouge

Fig. 42



NORTH PEAK
SITE No. 11
TIME (MSEC)
10
30
50
70
First P Arrival
First S Peak
Second S Peak
644 Velocity (M/S)
1260
644
589
DEPTH (M)
5
10
15
20
25
30
SANDY LOAM
QUARTZ DIORITE GRUS deeply weathered
QUARTZ DIORITE GRUS slightly to moderately weathered

Fig. 43



SAWYER RIDGE
SITE No. 12
TIME (MSEC)
10
30
50
70
DEPTH (m)
0
5
10
15
20
25
30
First P Arrival
First S Arrival
First S Peak
678 Velocity (M/s)
3350
678
695
LOAMY SAND
SANDSTONE and SILTSTONE deeply to moderately weathered
SANDSTONE deeply to moderately weathered
SILTSTONE slightly weathered
SANDSTONE and SILTSTONE hard

Fig. 44

TABLE 13

INTERVAL VELOCITIES AND ELASTIC MODULI

SITE NO. 1 PURISIMA

DEPTH INT (M)	NO MEAS	FIRST S ARRIVAL INCPT (S)	FIRST S ARRIVAL VEL (M/S)	FIRST S ARRIVAL UNC INT (M/S)	FIRST S PEAK INCPT (S)	FIRST S PEAK VEL (M/S)	FIRST S PEAK UNC INT (M/S)
5.0-12.5	4	0.019	327	(308, 348)	0.028	341	(301, 393)
15.0-29.0	7	0.027	406	(391, 421)	0.036	415	(400, 431)
10.0-29.0	9	0.026	397	(386, 408)	0.033	392	(378, 407)

DEPTH INT (M)	NO MEAS	FIRST P ARRIVAL INCPT (S)	FIRST P ARRIVAL VEL (M/S)	FIRST P ARRIVAL UNC INT (M/S)	DEPTH (M)	DENSITY (G/CC)	SHEAR MOD (BARS)	BULK MOD (BARS)	POISSONS RATIO
5.0-12.5	4	0.006	970	(926,1020)					0.436
15.0-29.0	7	0.012	1780	(1710,1850)					0.472
10.0-29.0	9	0.011	1650	(1570,1730)					0.469

TABLE 14

INTERVAL VELOCITIES AND ELASTIC MODULI

SITE NO. 2 COZZOLINOS

DEPTH INT (M)	NO MEAS	FIRST S ARRIVAL INCPT (S)	FIRST S ARRIVAL VEL (M/S)	FIRST S ARRIVAL UNC INT (M/S)	FIRST S PEAK INCPT (S)	FIRST S PEAK VEL (M/S)	FIRST S PEAK UNC INT (M/S)
2.5- 7.5	3	0.001	162	(160, 164)	0.007	158	(155, 161)
10.0-20.0	5	0.026	334	(325, 345)	0.032	325	(319, 330)
22.5-29.0	4	0.044	454	(442, 460)	0.047	419	(399, 440)
10.0-29.0	9	0.028	355	(346, 365)	0.036	354	(346, 362)

DEPTH INT (M)	NO MEAS	FIRST P ARRIVAL INCPT (S)	FIRST P ARRIVAL VEL (M/S)	FIRST P ARRIVAL UNC INT (M/S)	DEPTH (M)	DENSITY (G/CC)	SHEAR MOD (BARS)	BULK MOD (BARS)	POISSONS RATIO
2.5- 7.5	3	0.004	1740	(1650,1840)					0.496
10.0-20.0	5	0.006	2000	(1770,2290)					0.486
22.5-29.0	4	0.007	2200	(2050,2390)					0.478
10.0-29.0	9	0.006	2160	(2070,2250)					0.486

TABLE 15

INTERVAL VELOCITIES AND ELASTIC MODULI

SITE NO. 3 MARYKNOLL

DEPTH INT (M)	NO MEAS	FIRST S ARRIVAL INCPT (S)	FIRST S ARRIVAL VEL (M/S)	FIRST S ARRIVAL UNC INT (M/S)	FIRST S PEAK INCPT (S)	FIRST S PEAK VEL (M/S)	FIRST S PEAK UNC INT (M/S)
10.0-28.3	8	0.015	633	(621, 646)	0.021	616	(604, 628)

DEPTH INT (M)	NO MEAS	FIRST P ARRIVAL INCPT (S)	FIRST P ARRIVAL VEL (M/S)	FIRST P ARRIVAL UNC INT (M/S)	DEPTH (M)	DENSITY (G/CC)	SHEAR MOD (BARS)	BULK MOD (BARS)	POISSONS RATIO
10.0-28.3	8	0.010	1690	(1590,1810)	14.5	2.05	8230	47700	0.418

TABLE 16

INTERVAL VELOCITIES AND ELASTIC MODULI

SITE NO. 4 EL GRANADA

DEPTH INT (M)	NO MEAS	FIRST S ARRIVAL INCPT (S)	FIRST S ARRIVAL VEL (M/S)	FIRST S ARRIVAL UNC INT (M/S)	FIRST S PEAK INCPT (S)	FIRST S PEAK VEL (M/S)	FIRST S PEAK UNC INT (M/S)
10.0-30.0	9	0.017	1640	(1590,1690)	0.023	1540	(1470,1620)

DEPTH INT (M)	NO MEAS	FIRST P ARRIVAL INCPT (S)	FIRST P ARRIVAL VEL (M/S)	FIRST P ARRIVAL UNC INT (M/S)	DEPTH (M)	DENSITY (G/CC)	SHEAR MOD (BARS)	BULK MOD (BARS)	POISSONS RATIO
10.0-30.0	9	0.016	3850	(3620,4110)	28.0	2.53	68000	284000	0.389

TABLE 17

INTERVAL VELOCITIES AND ELASTIC MODULI

SITE NO. 5 BLACK MOUNTAIN

DEPTH INT (M)	NO MEAS	FIRST S ARRIVAL INCPT (S)	FIRST S ARRIVAL VEL (M/S)	FIRST S ARRIVAL UNC INT (M/S)	FIRST S PEAK INCPT (S)	FIRST S PEAK VEL (M/S)	FIRST S PEAK UNC INT (M/S)
7.5-17.5	5	0.009	655	(639, 671)	0.015	586	(552, 626)
20.0-29.3	5	0.019	802	(749, 862)	0.027	893	(847, 944)
10.0-29.3	9	0.007	588	(561, 619)	0.019	694	(669, 722)

DEPTH INT (M)	NO MEAS	FIRST P ARRIVAL INCPT (S)	FIRST P ARRIVAL VEL (M/S)	FIRST P ARRIVAL UNC INT (M/S)	DEPTH (M)	DENSITY (G/CC)	SHEAR MOD (BARS)	BULK MOD (BARS)	POISSONS RATIO
7.5-17.5	5	0.006	1880	(1750,2030)	15.2	2.39	10300	71100	0.431
20.0-29.3	5	0.013	4490	(3830,5440)	29.3	2.23	14400	431000	0.484
10.0-29.3	9	0.008	2500	(2300,2740)	15.2	2.39	8290	139000	0.471
10.0-29.3	9	0.008	2500	(2300,2740)	29.3	2.23	7740	129000	0.471

TABLE 18

INTERVAL VELOCITIES AND ELASTIC MODULI

SITE NO. 6 DIGGES CANYON

DEPTH INT (M)	NO MEAS	FIRST S ARRIVAL INCPT (S)	FIRST S ARRIVAL VEL (M/S)	FIRST S ARRIVAL UNC INT (M/S)	FIRST S PEAK INCPT (S)	FIRST S PEAK VEL (M/S)	FIRST S PEAK UNC INT (M/S)
2.5-10.0	4	0.006	288	(270, 307)	0.011	293	(275, 315)
12.5-30.5	8	0.025	564	(538, 593)	0.029	542	(512, 576)
10.0-30.5	9	0.023	549	(527, 572)	0.027	516	(491, 544)

DEPTH INT (M)	NO MEAS	FIRST P ARRIVAL INCPT (S)	FIRST P ARRIVAL VEL (M/S)	FIRST P ARRIVAL UNC INT (M/S)	DEPTH (M)	DENSITY (G/CC)	SHEAR MOD (BARS)	BULK MOD (BARS)	POISSONS RATIO
2.5-10.0	4	0.005	738	(681, 806)	3.3	1.91	1590	8310	0.410
2.5-10.0	4	0.005	738	(681, 806)	8.2	1.97	1640	8570	0.410
12.5-30.5	8	0.009	1080	(1060,1110)	15.2	2.13	6800	16000	0.314
12.5-30.5	8	0.009	1080	(1060,1110)	28.0	2.19	6990	16400	0.314
10.0-30.5	9	0.009	1060	(1030,1080)	15.2	2.13	6420	15300	0.316
10.0-30.5	9	0.009	1060	(1030,1080)	28.0	2.19	6600	15700	0.316

TABLE 19

INTERVAL VELOCITIES AND ELASTIC MODULI

SITE NO. 7 PISE LOOKOUT

DEPTH INT (M)	NO MEAS	FIRST S ARRIVAL INCPT (S)	FIRST S ARRIVAL VEL (M/S)	FIRST S ARRIVAL UNC INT (M/S)	FIRST S PEAK INCPT (S)	FIRST S PEAK VEL (M/S)	FIRST S PEAK UNC INT (M/S)
5.0-15.0	5	0.003	356	(341, 372)	0.007	324	(315, 334)
17.5-27.8	5	0.025	603	(595, 611)	0.031	562	(553, 573)
10.0-27.8	8	0.011	447	(419, 478)	0.017	426	(401, 454)

DEPTH INT (M)	NO MEAS	FIRST P ARRIVAL INCPT (S)	FIRST P ARRIVAL VEL (M/S)	FIRST P ARRIVAL UNC INT (M/S)	DEPTH (M)	DENSITY (G/CC)	SHEAR MOD (BARS)	BULK MOD (BARS)	POISSONS RATIO
5.0-15.0	5	0.010	1790	(1680,1910)	8.2	2.26	2870	68600	0.479
17.5-27.8	5	0.014	2520	(2480,2560)					0.470
10.0-27.8	8	0.011	1870	(1760,1990)					0.470

TABLE 20

INTERVAL VELOCITIES AND ELASTIC MODULI

SITE NO. 8 PULGAS WATER TEMPLE

		FIRST S ARRIVAL			FIRST S PEAK		
DEPTH INT (M)	NO MEAS	INCPT (S)	VEL (M/S)	UNC INT (M/S)	INCPT (S)	VEL (M/S)	UNC INT (M/S)
2.5-10.0	4	0.006	422	(416, 429)	0.011	412	(391, 437)
12.5-28.1	7	0.012	551	(537, 566)	0.018	546	(525, 569)
10.0-28.1	8	0.012	551	(540, 562)	0.018	547	(530, 564)

		FIRST P ARRIVAL			DEPTH	DENSITY	SHEAR MOD	BULK MOD	POISSONS RATIO
DEPTH INT (M)	NO MEAS	INCPT (S)	VEL (M/S)	UNC INT (M/S)	(M)	(G/CC)	(BARS)	(BARS)	
2.5-10.0	4	0.009	1650	(1530,1790)	3.5	1.97	3520	49100	0.465
2.5-10.0	4	0.009	1650	(1530,1790)	8.2	2.13	3810	53100	0.465
12.5-28.1	7	0.011	2070	(1980,2180)	28.0	2.32	7060	90400	0.462
10.0-28.1	8	0.010	1980	(1890,2070)	28.0	2.32	7050	81200	0.458

TABLE 21

INTERVAL VELOCITIES AND ELASTIC MODULI

SITE NO. 9 SPRING VALLEY RIDGE

DEPTH INT (M)	NO MEAS	FIRST S ARRIVAL INCPT (S)	FIRST S ARRIVAL VEL (M/S)	FIRST S ARRIVAL UNC INT (M/S)	FIRST S PEAK INCPT (S)	FIRST S PEAK VEL (M/S)	FIRST S PEAK UNC INT (M/S)
7.3-17.5	5	0.002	403	(384, 423)	0.010	412	(392, 434)
20.0-29.2	5	0.010	504	(480, 530)	0.016	493	(461, 528)
10.0-29.2	9	0.006	467	(452, 483)	0.014	470	(456, 485)

DEPTH INT (M)	NO MEAS	FIRST P ARRIVAL INCPT (S)	FIRST P ARRIVAL VEL (M/S)	FIRST P ARRIVAL UNC INT (M/S)	DEPTH (M)	DENSITY (G/CC)	SHEAR MOD (BARS)	BULK MOD (BARS)	POISSONS RATIO
7.3-17.5	5	0.008	2360	(2340,2380)	8.2	2.45	3980	131000	0.485
20.0-29.2	5	0.012	3340	(2860,4010)	28.0	2.63	6680	285000	0.488
10.0-29.2	9	0.009	2350	(2230,2490)	28.0	2.63	5750	138000	0.479

TABLE 22

INTERVAL VELOCITIES AND ELASTIC MODULI

SITE NO. 10 VISTA POINT

DEPTH INT (M)	NO MEAS	FIRST S ARRIVAL INCPT (S)	FIRST S ARRIVAL VEL (M/S)	FIRST S ARRIVAL UNC INT (M/S)	FIRST S PEAK INCPT (S)	FIRST S PEAK VEL (M/S)	FIRST S PEAK UNC INT (M/S)
20.0-28.9	5	0.006	705	(674, 738)	0.014	679	(626, 742)
10.0-28.9	9	0.013	891	(842, 946)	0.017	745	(710, 784)

DEPTH INT (M)	NO MEAS	FIRST P ARRIVAL INCPT (S)	FIRST P ARRIVAL VEL (M/S)	FIRST P ARRIVAL UNC INT (M/S)	DEPTH (M)	DENSITY (G/CC)	SHEAR MOD (BARS)	BULK MOD (BARS)	POISSONS RATIO
20.0-28.9	5	0.006	2280	(2170,2420)	28.0	2.60	12900	118000	0.447
10.0-28.9	9	0.010	3300	(3060,3590)	28.0	2.60	20700	256000	0.461

TABLE 23

INTERVAL VELOCITIES AND ELASTIC MODULI
SITE NO. 11 NORTH PEAK

DEPTH INT (M)	NO MEAS	FIRST S ARRIVAL INCPT (S)	FIRST S ARRIVAL VEL (M/S)	FIRST S ARRIVAL UNC INT (M/S)	FIRST S PEAK INCPT (S)	FIRST S PEAK VEL (M/S)	FIRST S PEAK UNC INT (M/S)
5.0-20.0	6	0.021	644	(603, 691)	0.032	589	(553, 631)

DEPTH INT (M)	NO MEAS	FIRST P ARRIVAL INCPT (S)	FIRST P ARRIVAL VEL (M/S)	FIRST P ARRIVAL UNC INT (M/S)	DEPTH (M)	DENSITY (G/CC)	SHEAR MOD (BARS)	BULK MOD (BARS)	POISSONS RATIO
5.0-20.0	7	0.013	1260	(1180,1350)	8.2	2.30	9710	23500	0.318

TABLE 24

INTERVAL VELCCITIES AND ELASTIC MCDULI

SITE No. 12 SAWYER RIDGE

DEPTH INT (M)	NO MEAS	FIRST S ARRIVAL INCPT (S)	VEL (M/S)	UNC INT (M/S)	FIRST S PEAK INCPT (S)	VEL (M/S)	UNC INT (M/S)
10.0-26.6	8	0.002	678	(647, 711)	0.008	695	(666, 726)

DEPTH INT (M)	NO MEAS	FIRST P ARRIVAL INCPT (S)	VEL (M/S)	UNC INT (M/S)	DEPTH (M)	DENSITY (G/CC)	SHEAR MOD (BARS)	BULK MOD (BARS)	POISSONS RATIO
10.0-26.6	8	0.009	3350	(3060,3700)	26.6	2.44	11200	259000	0.479