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Near-surface P- and S-wave velocities from borehle measurements near Lake Hemet, California

by

James F. Gibbs

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Introduction

In situ measurements of shear (S) and compressional (P) waves were made near Lake Hemet, California (Figure 1). Measurements were made inside a borehole to a depth of 100 meters. The borehole was cased with 10-1/4 inch inside diameter 1/4 inch thick steel casing. A three component geophone was lowered into the borehole and held in place by an electrically actuated lever arm for positive clamping to the casing wall. The data are interpreted for velocities of P-and-S waves using conventional methods of travel-time plots and straight line segments. The length of the line segments are determined by eye and each segment is fit to the data points by least squares (Gibbs et al., 1975). The reciprocal of the regression coefficient is used to determine the velocities. P and S velocities as interpreted provide a model of the near-surface layers for studying the effects of alluvium over a bedrock surface. This site geology is common to many areas and a number of important structures are built or proposed on similar near-surface materials.

Recording Proceedure

The shear-wave source used in this study is a air-powered horizontal traction device (Liu et al., 1988) that provides a reversible shear wave pulse (Figure 2). The 3-component geophone shown next to the shear-wave source is used to verify the timing accuracy of the recorder triggers. Although the signals from this geophone are clipped, even at the lowest gain settings, they are valuable for verifing the consistency of recorder turn-on (zero time).

P-waves were generated by striking a steel plate with a sledge hammer. Measurements of both P-and S-waves were made at 5 meter intervals from 100 meter depth to 40 meters and at 2-1/2 meter intervals from 40 meters to the surface. The data were recorded on magnetic tape in digital form by a Nimbus ES-1210F, 12 channel seismograph.

Velocity Model

Velocities interpreted for the S-waves are shown on Figure 3. The velocity of 220 m/s represents the unconsolidated alluvium that is about 20 meters thick. Velocities of 580 m/s and 1310 m/s are probably due to semi-consolidated to consolidated sediments respectively. Figure 4 shows the reversed S-wave recordings with two picks; zero crossing (dots) and trough (filled). Starting at about 25 meters depth (Figure 4) an early phase starts to build in amplitude. These spurious arrivals shown by the dashes and small dots have not been positively identified. Their velocity has been determined to be 1170 m/s and their origin is thought to be due to one of the following possibilities.

1. poor coupling of casing to the formation
2. tube wave in casing

Low gain setting made at the recorder may be attenuating these arrivals from the surface to a depth of approximately 20 meters where they begin to become apparent as mentioned above.

P-wave velocities are shown on Figure 5. Velocity of 400 m/s, from the surface to 5 meters depth, is not well determined constrained by only two measurements and an zero intercept. The velocity of 2030 m/s from 5 to 65 meters and 2460 m/s from 65 to 100 meters are consistant with saturated sediments with a slight increase in consolidation below 65 meters.

Figure 7 shows the model for the upper 100 meters of geologic materials interpreted from the downhole measurements.

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Acknowledgements

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References

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Liu, Hsi-Ping, Warrick, Richard E., Westerlund, Robert E., Fletcher, Jon B., and Maxwell, Gary L.,(1988), An air-powered impulsive shear-wave source with repeatable signals, *Bull. Seismo. Soc. Am., v. 78 p. 355-369.*

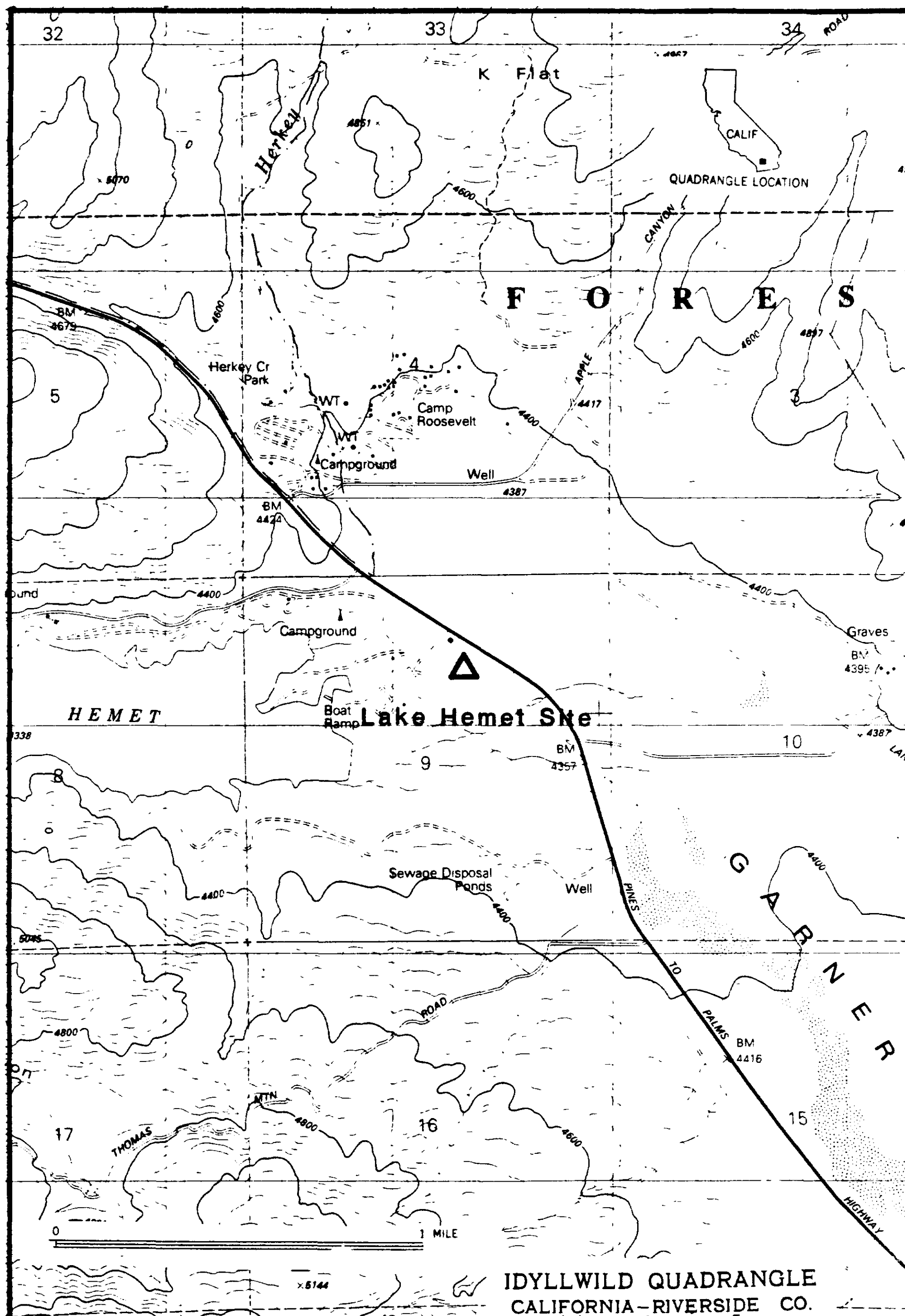

Figure 1–Map showing location of borehole (triangle near center of map).

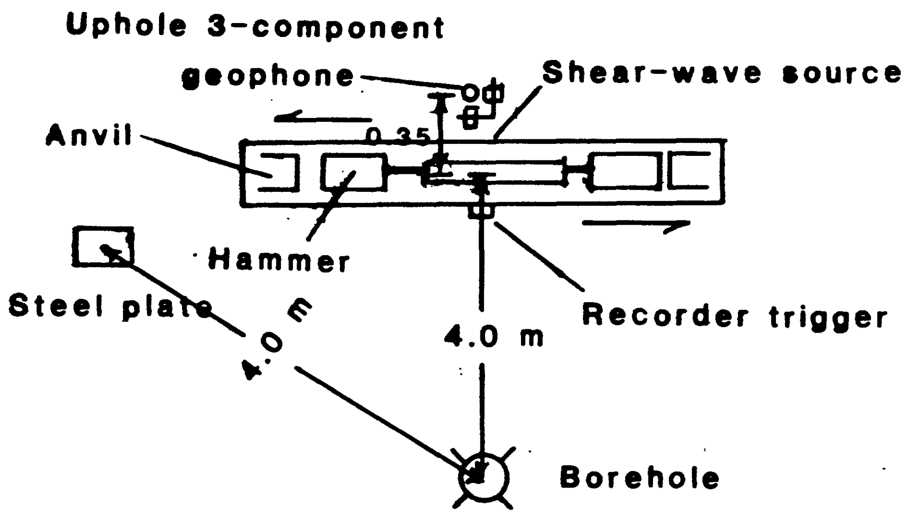

Figure 2–Schematic of shear-wave source, field setup and relative position of P-and S-wave sources to borehole.

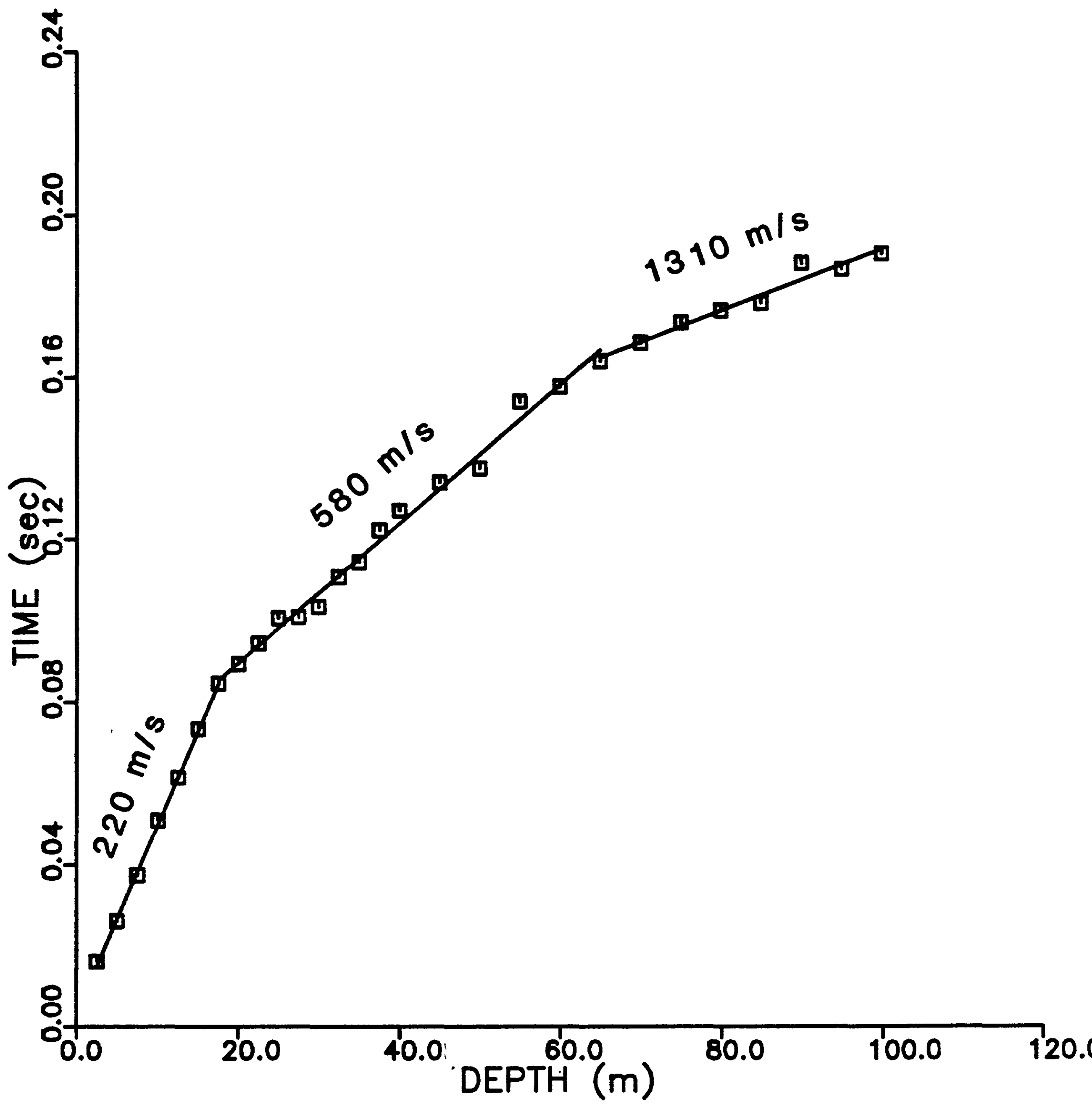

Figure 3–Travel-time graph of S-wave picks showing the fit to the data points with velocities indicated above line segments.

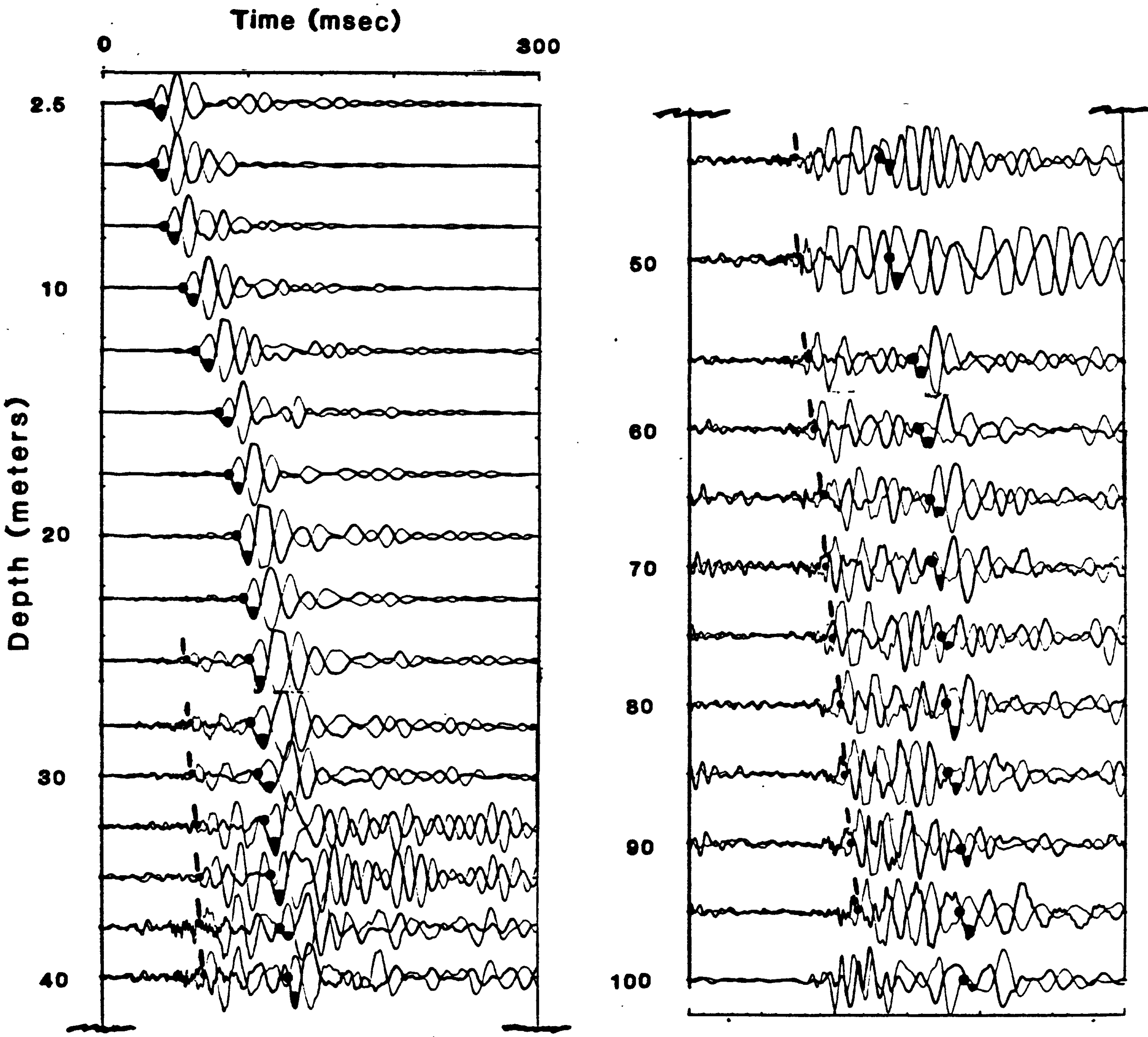

Figure 4–Record section showing reversed traces superimposed with S-wave picks, zero-crossings (dots) and first trough (filled). Dashes and small dots between 25 and 95 meters show early arrival not postively identified.

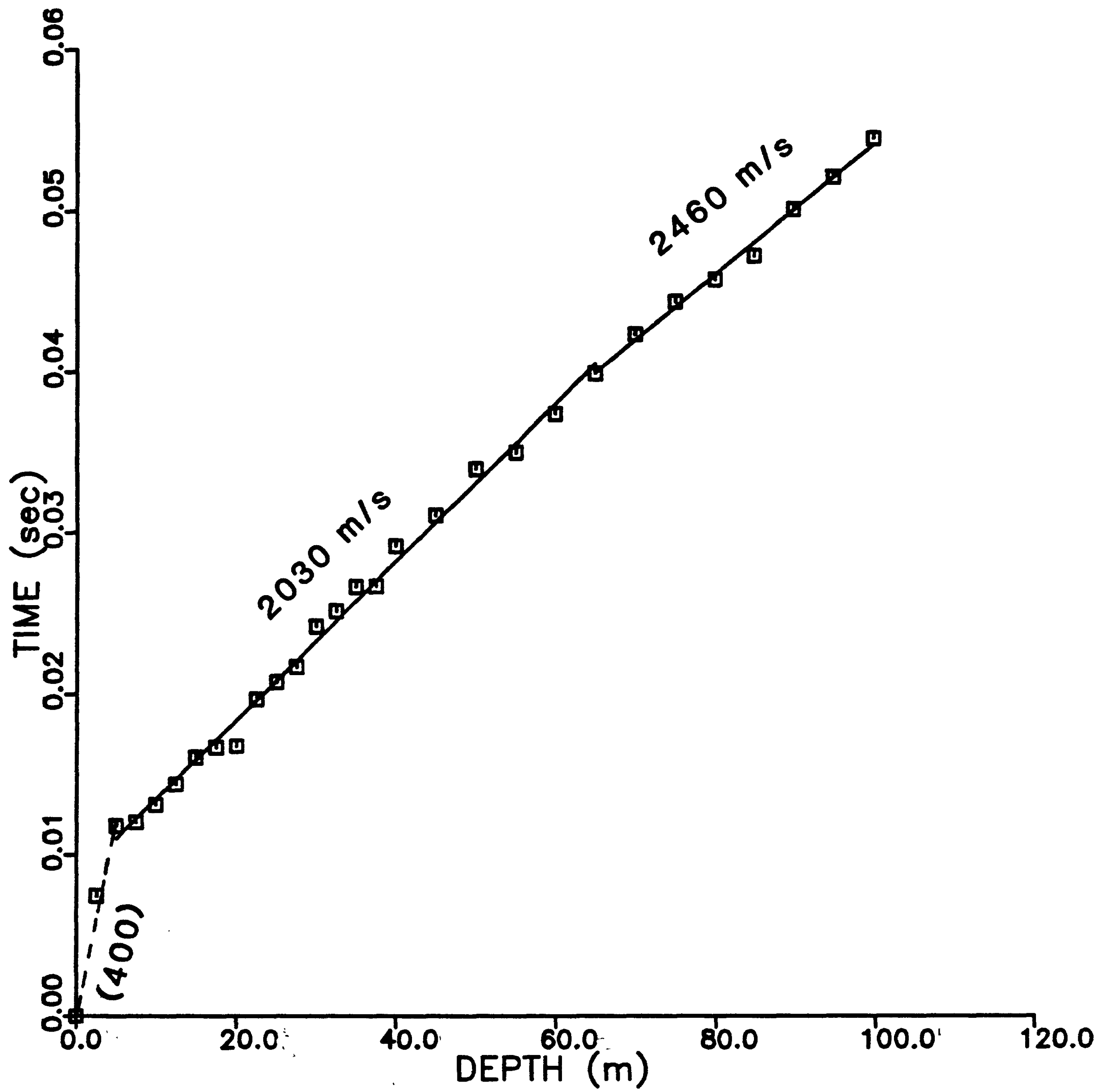

Figure 5–Travel-time graph of P-wave picks showing fit to data points with velocities near line segments. The velocity of 400 meters-per-second is not well determined constrained by only two data points and a zero intercept.

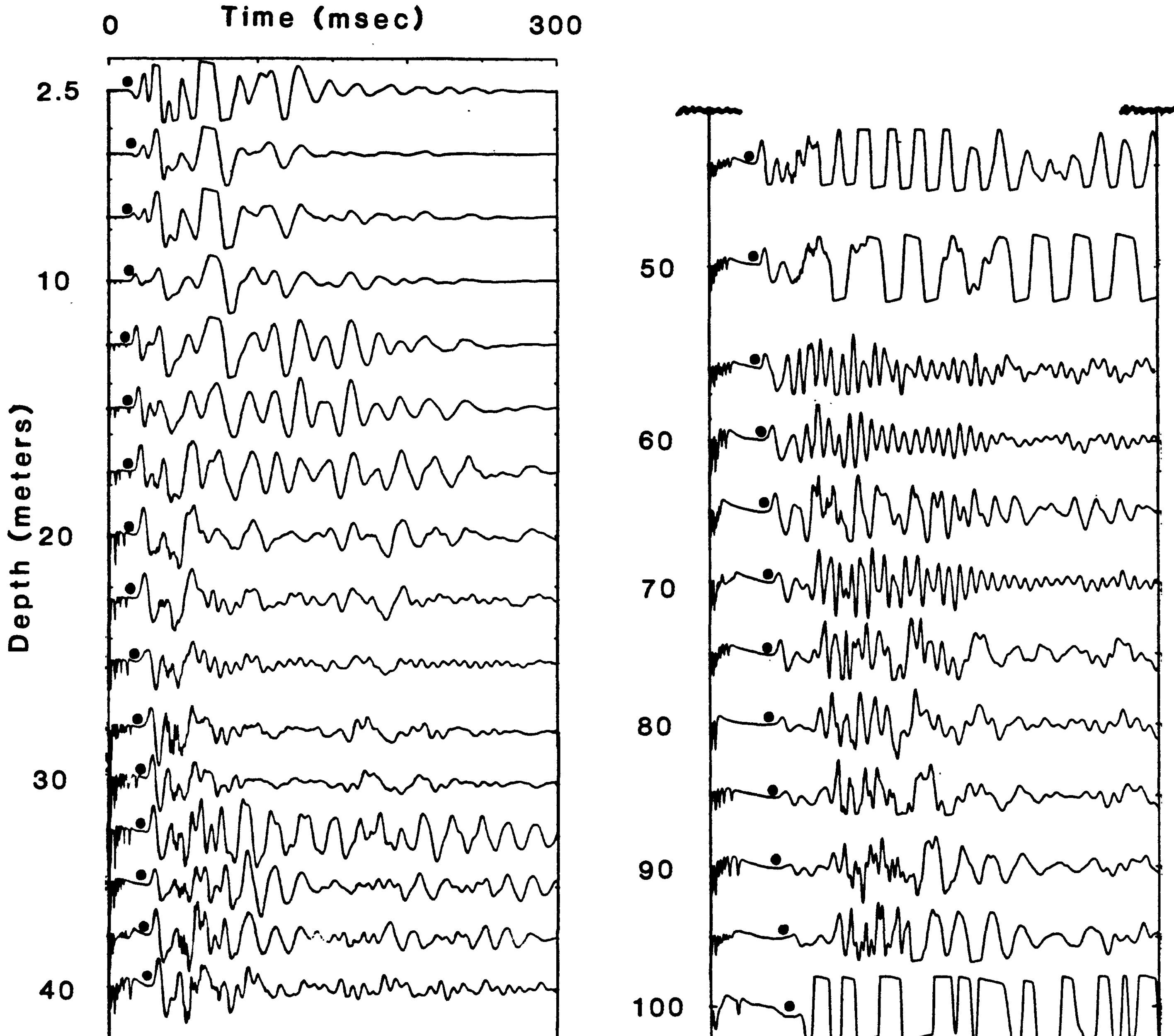

Figure 6–Recond section showing P-wave data and picks (small dots). Electrical noise, generated by hammer swing, can be seen near ordinate.

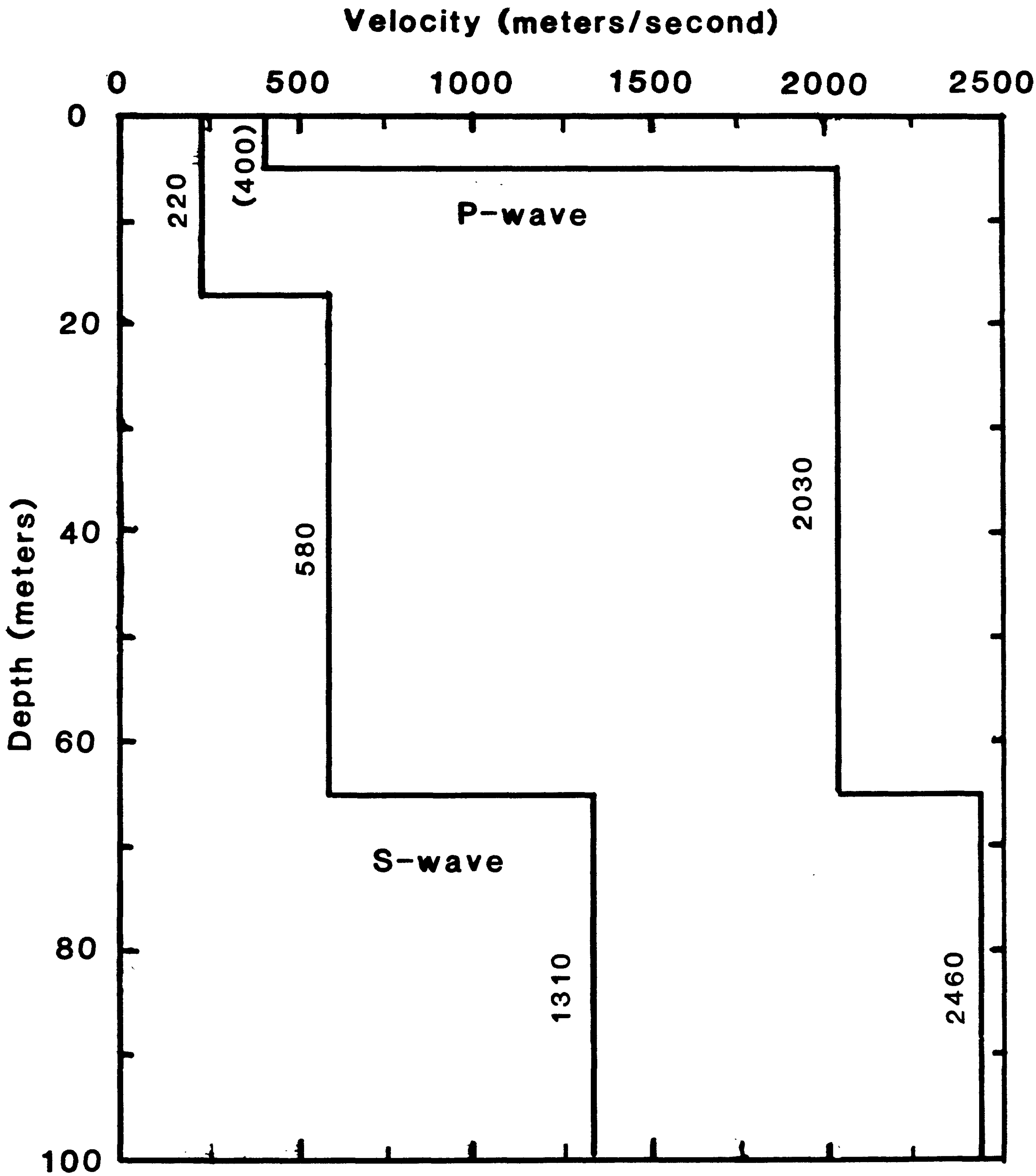

Figure 7–Velocity model of upper 100 meters of geologic material interpreted from downhole measurements.