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RE-EVALUATION OF SEISMIC VELOCITY MEASUREMENTS

HANFORD SITE

FOR

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

Weston Geophysical
CORPORATION

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In-situ velocity data were acquired by Weston Geophysical for proposed Units WNP-1 and WNP-4 during the period of May - June 1974 (WNP-1 and WNP-4 are adjacent to WNP-2). The in-situ velocity measurements were made utilizing the seismic cross-hole technique described in Appendix A to this report. The results of that cross-hole survey including velocity tabulations and time distance plots were presented in Appendix 2L, Amendment 9 of the WNP-1 PSAR, dated August 1974. The result of the in-situ velocity measurements were presented on Table 2L-1 for the WNP-1 plant location and on Table 2L-5 for the WNP-4 plant location. Time distance plots for the cross-hole survey were presented on Figure 2L-5 for WNP-1 and Figure 2L-6 for WNP-4. The boreholes utilized in the cross hole survey are described in Amendment 9 of the WNP-1 PSAR.

In response to concerns expressed by the Nuclear Regulatory Commission, Washington Public Power Supply System requested Weston Geophysical to re-examine the cross hole data and confirm and clarify the existence of lower velocity layers at depth, within the Ringold Formation. At the WNP-1 site, the higher velocity layer between elevations 340 and 188 feet is underlain by a lower velocity layer (see Table 2L-1). At the WNP-4 site the higher velocity layer between elevations 354 and 208 feet is underlain by a lower velocity layer (see Table 2L-5).

In order to demonstrate the existence of a lower velocity layer at depth, original seismic data was reanalyzed for elevations 190 (depth 250) and 160 (depth 280) at the WNP-1 site and elevations 220 (depth 230) and 170 (depth 280) at the WNP-4 site. Time distance plots for these data were presented on Figure 2L-5 and 2L-6 of Amendment 9. The results of the reanalysis are displayed on Figures 1 through 4 which are time distance plots showing actual seismic arrivals for direct and refracted compressional "P" and shear "S" waves. In most instances, enhancement of the original data by arithmetic methods was performed; this was achieved by addition of independent time series generated from repeated shots at the same level.

The direct arrivals of the high velocity "P" and "S" waves at elevation 220 beneath the WNP-1 site are shown on Figure 1. The direct arrivals for the lower velocity "P" and "S" waves at elevation 160 beneath the WNP-1 site are shown on Figure 2. Refracted arrivals from the overlying high velocity layer are also shown on Figure 2. The seismic wave arrivals shown on Figure 2 are redisplayed on Figure 2A to show only the direct arrivals from the low velocity layer. Where applicable, the high gain records have been minimized in the enhancement process in order to reduce the amplitude of the refracted arrivals.

The direct arrivals of the high velocity "P" and "S" waves at elevation 220 beneath the WNP-4 site are shown on Figure 3.

The direct arrivals for the lower velocity "P" and "S" waves at elevation 170 beneath the WNP-4 site are shown on Figure 4. The refracted seismic arrivals from the underlying high velocity layer (at elevation 151) are also shown on Figure 4. The seismic wave arrives shown on Figure 4 are redisplayed on Figure 4A to show only the direct arrivals from the low velocity layer. Where applicable, the high gain records have been minimized in the enhancement process in order to reduce the amplitude of the refracted arrivals.

The velocity values determined from the data reanalysis for each of the four elevations are consistent with the values previously reported in Appendix 2L. This confirms the existence of a lower velocity layer at depth within the Ringold Formation.

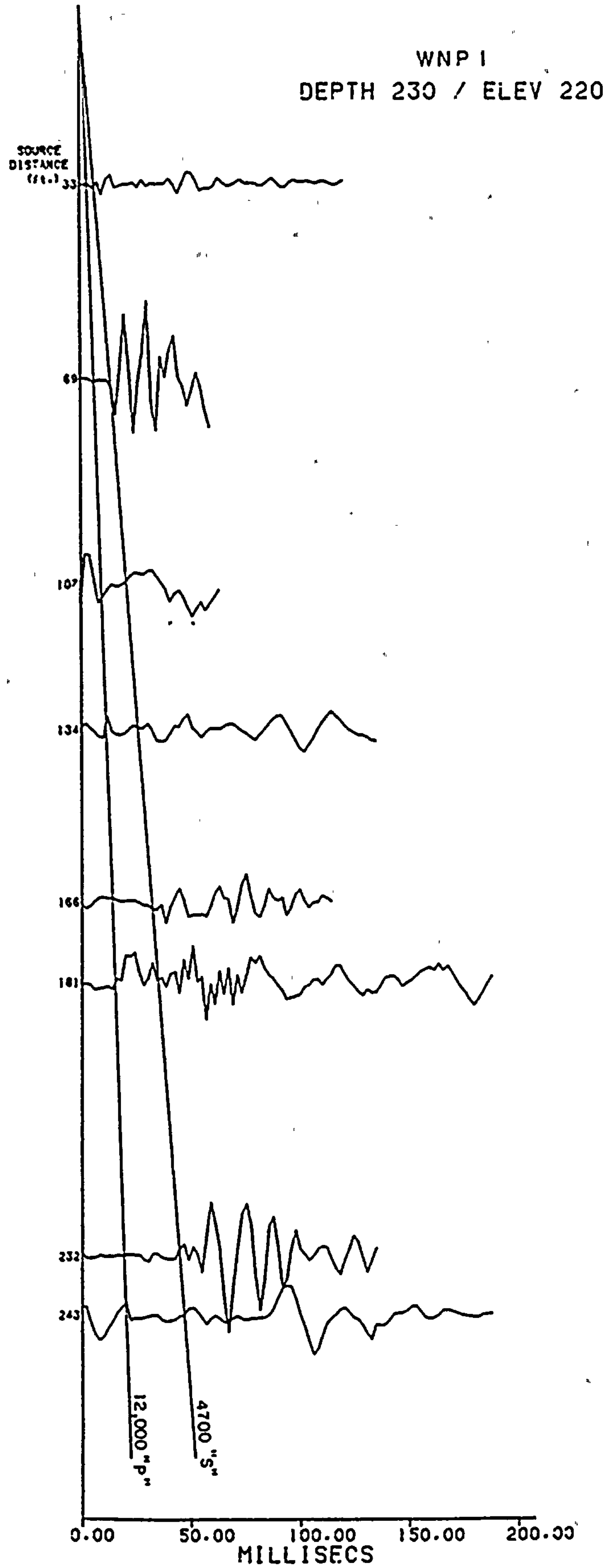

FIGURE I

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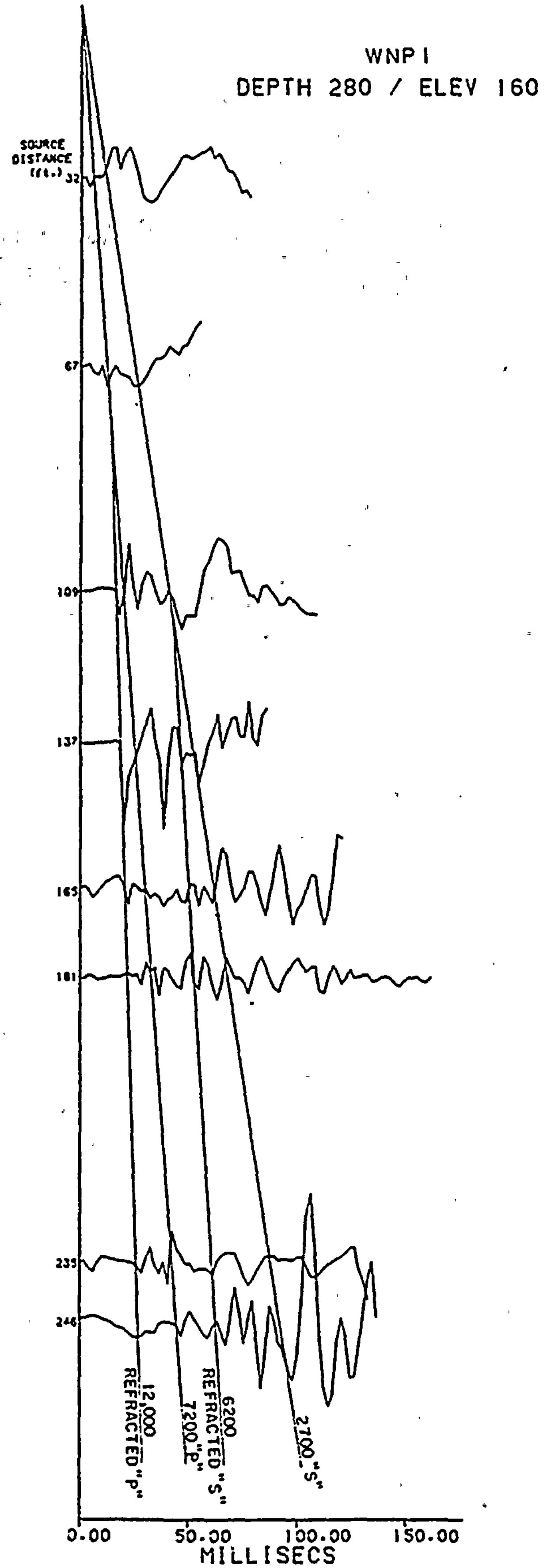

FIGURE 2

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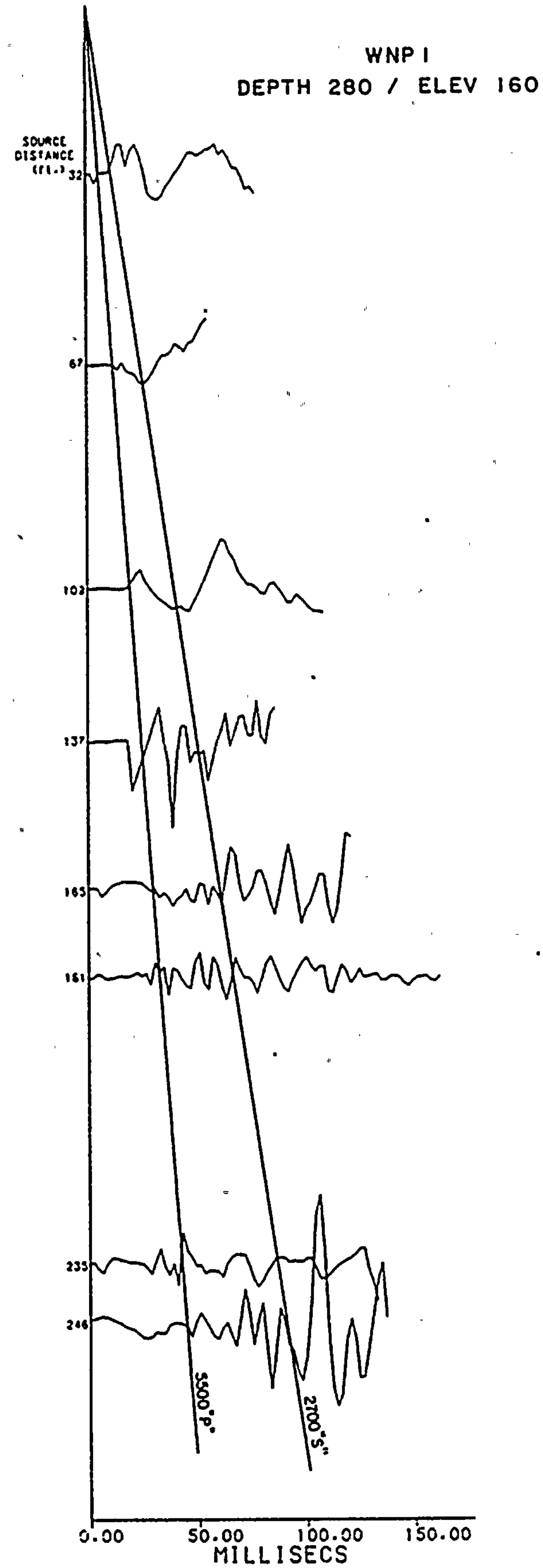

FIGURE 2A

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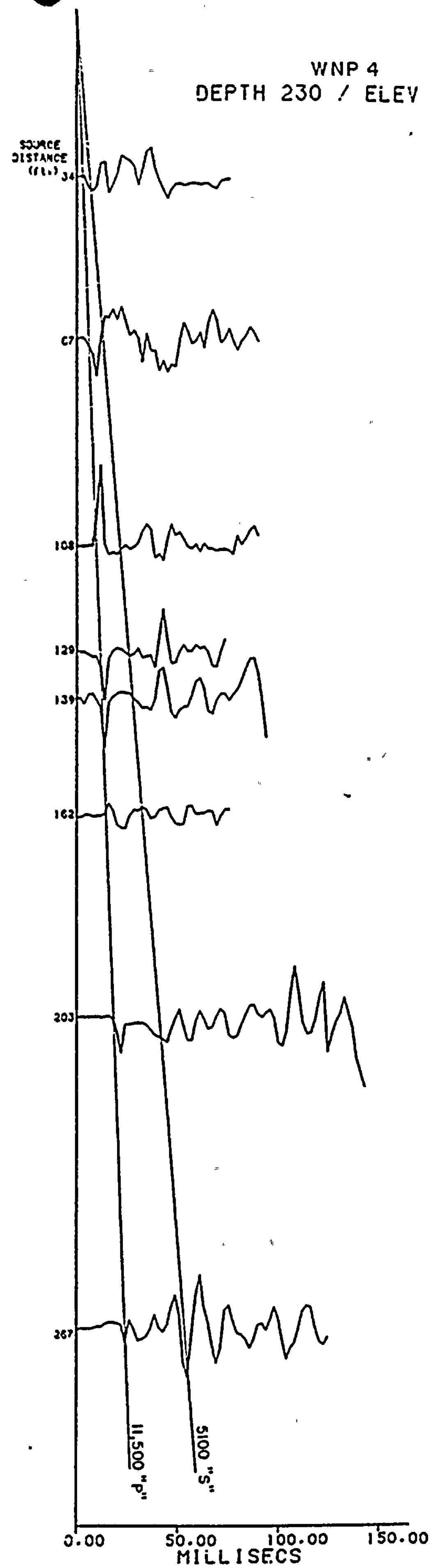

FIGURE 3
Weston Geophysical

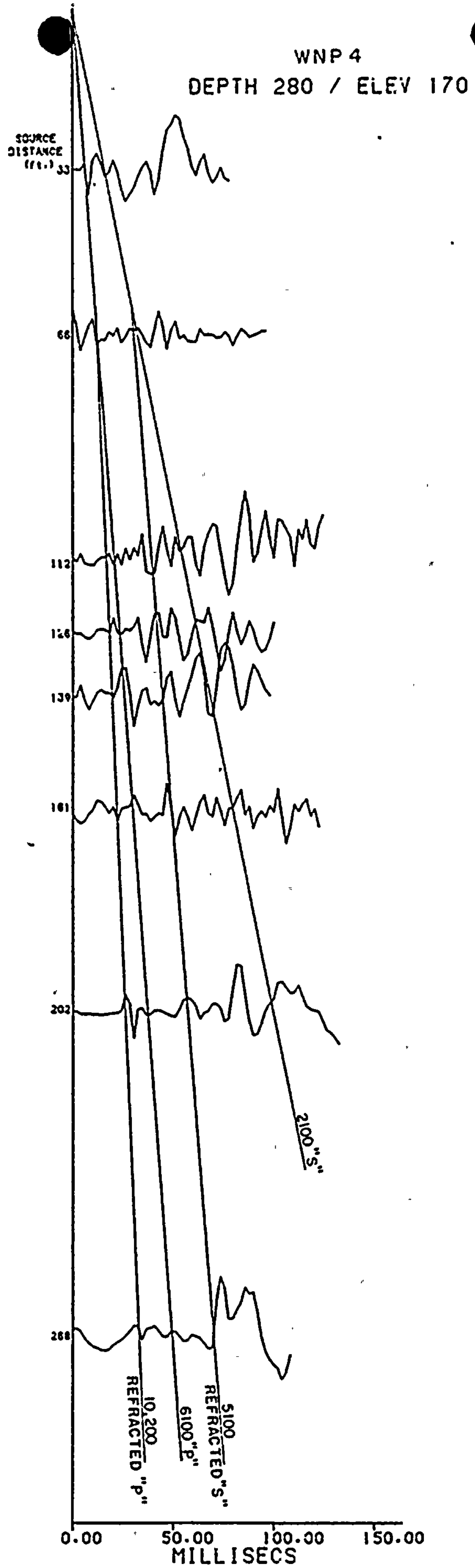

FIGURE 4

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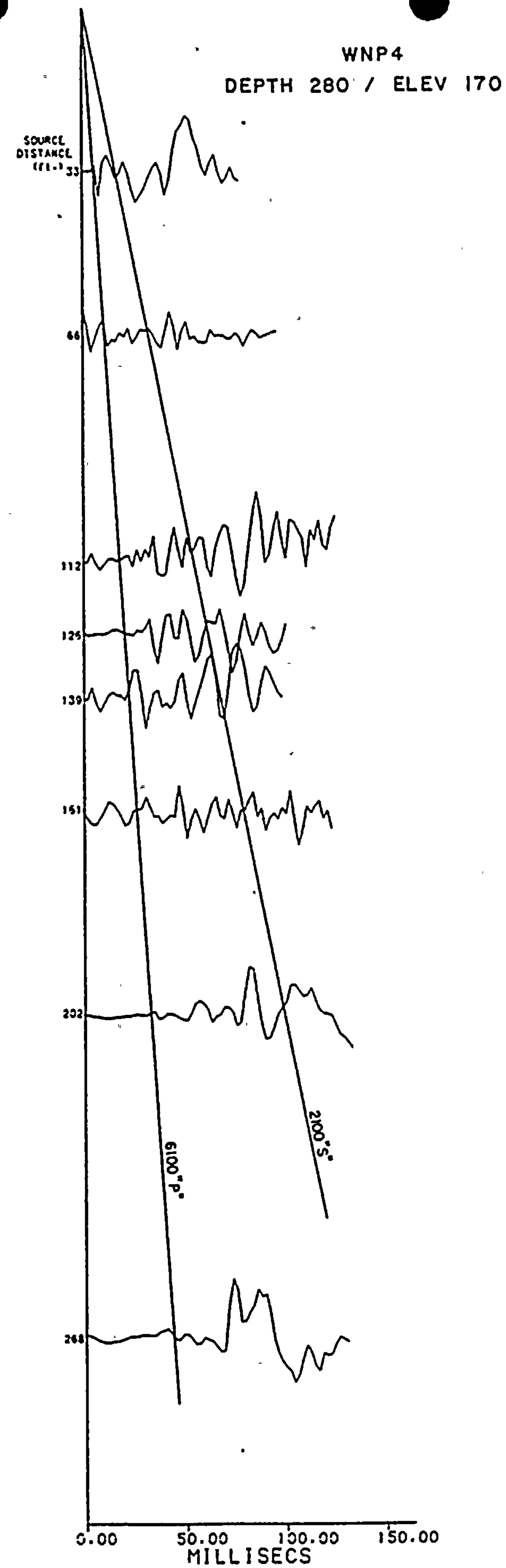

FIGURE 4A
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APPENDIX A

IN-SITU VELOCITY MEASUREMENTS
CROSS-HOLE PROCEDURE

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IN-SITU VELOCITY MEASUREMENTS
CROSS-HOLE PROCEDURE

In-situ measurements of compressional "P" and shear "S" wave velocities of subsurface materials are obtained by the cross-hole techniques. Measurements are made using geophones containing three orthogonal elements, one vertical and two horizontal. Seismic energy is generated in one hole and detected by the geophones in four other holes with the seismic energy source and geophones at the same elevation level (Figure A-1). The borings are spaced apart at varying distances so that interchanging the seismic energy source and detectors yields different combinations of shot to detector distances, adding data points for velocity control. Borings which are proposed or existing for other disciplines may be included in the cross-hole array to minimize drilling effort. Field recordings are obtained using a 12-trace seismograph system; multiple recordings are obtained at each level. Both high and low gain recordings are made to obtain the "P" and "S" arrivals. The seismic signal is passed through an amplifier which amplifies and filters the signal and is recorded on an oscillograph with a two millisecond timing system. Recordings are normally made at 10-foot intervals by simultaneously raising or lowering the source and detectors. Seismic energy is generated by small explosive charges or a borehole airgun.

INTERPRETATION

Data obtained from cross-hole tests are the times required for both "P" compressinal and "S" shear waves to travel from the source to each of the component geophones. The "P" wave is readily identified as the first arrival time to the detector. The arrival of the "S" wave is less apparent. Traces from all three components of each geophone must be examined in the area where high amplitude lower frequency wave forms characteristic of "S" wave arrivals occur. "S" wave arrivals may appear as a distortion in the wave form with a phase shift (reversed polarity) or without a phase shift.

For an accurate determination of the velocities, all distances between the source and the geophones must be corrected for drift or misalignment of boreholes. This is normally accomplished by a borehole verticality survey.

Velocity is the direct distance divided by the travel time. A plot of seismic wave arrival times vs. source to detector distance is shown on Figure A-1. It should be noted that the velocity lines draw in through the individual arrival times tie to time zero at the energy source indicating that seismic waves have propagated through the same velocity layer.

If a nearby higher velocity layer exists the wave will refract and travel along that layer. At some distance from the source the least time path from source to detector will become the refracted wave path rather than the direct wave path as shown on Figure A-2. The velocities for each layer are shown

on the time distance plot. It should be noted that the velocity lines through the layer in which the source is located tie into time zero; however, the velocity lines for the refracted arrivals tie in at a time related to the distance of the refracting layer above or below the source. In such instances, calculations based on Snell's law may be used to arrive at a distance above or below the source for the adjacent zones of higher velocity material.

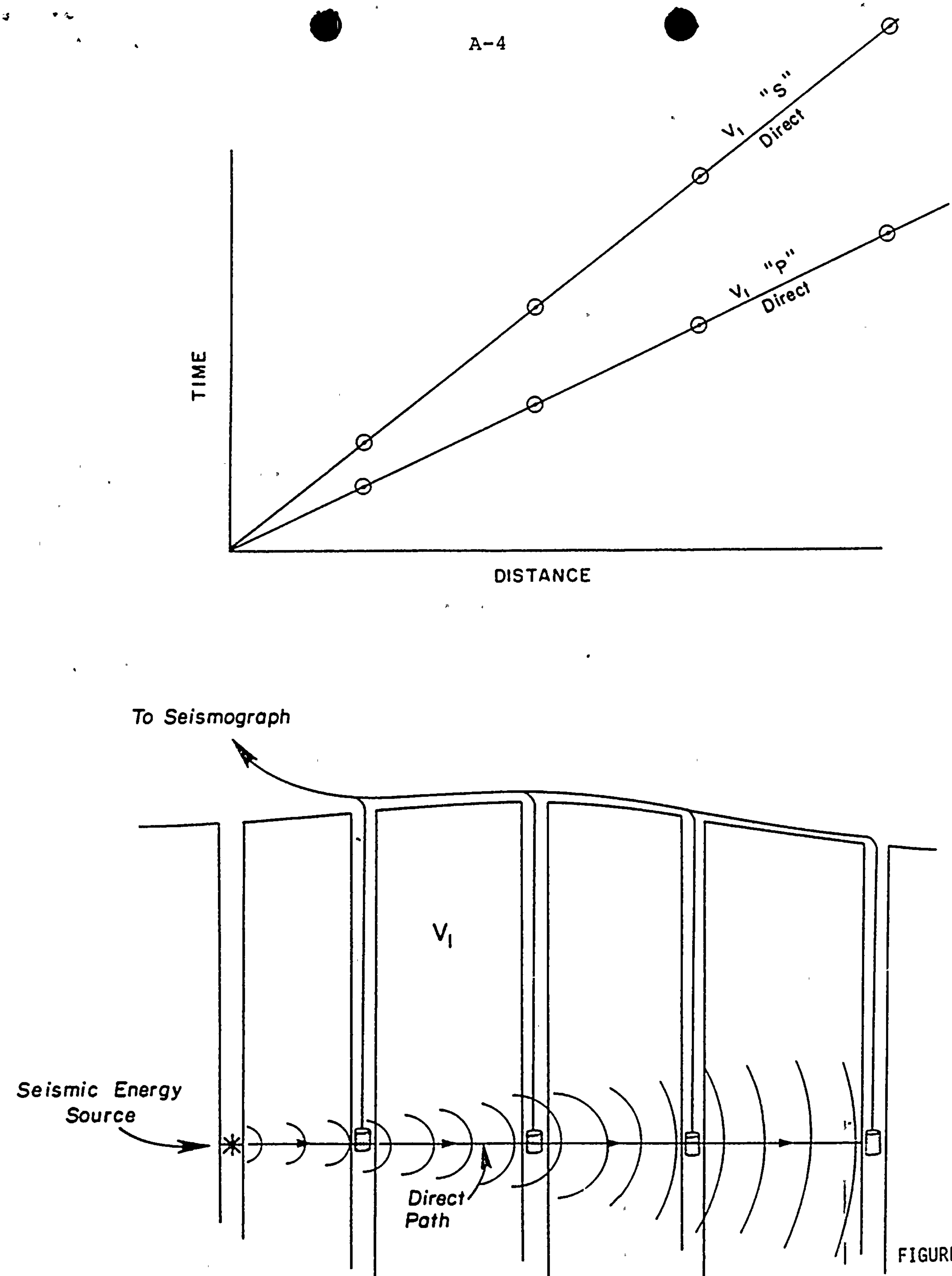

FIGURE A-1

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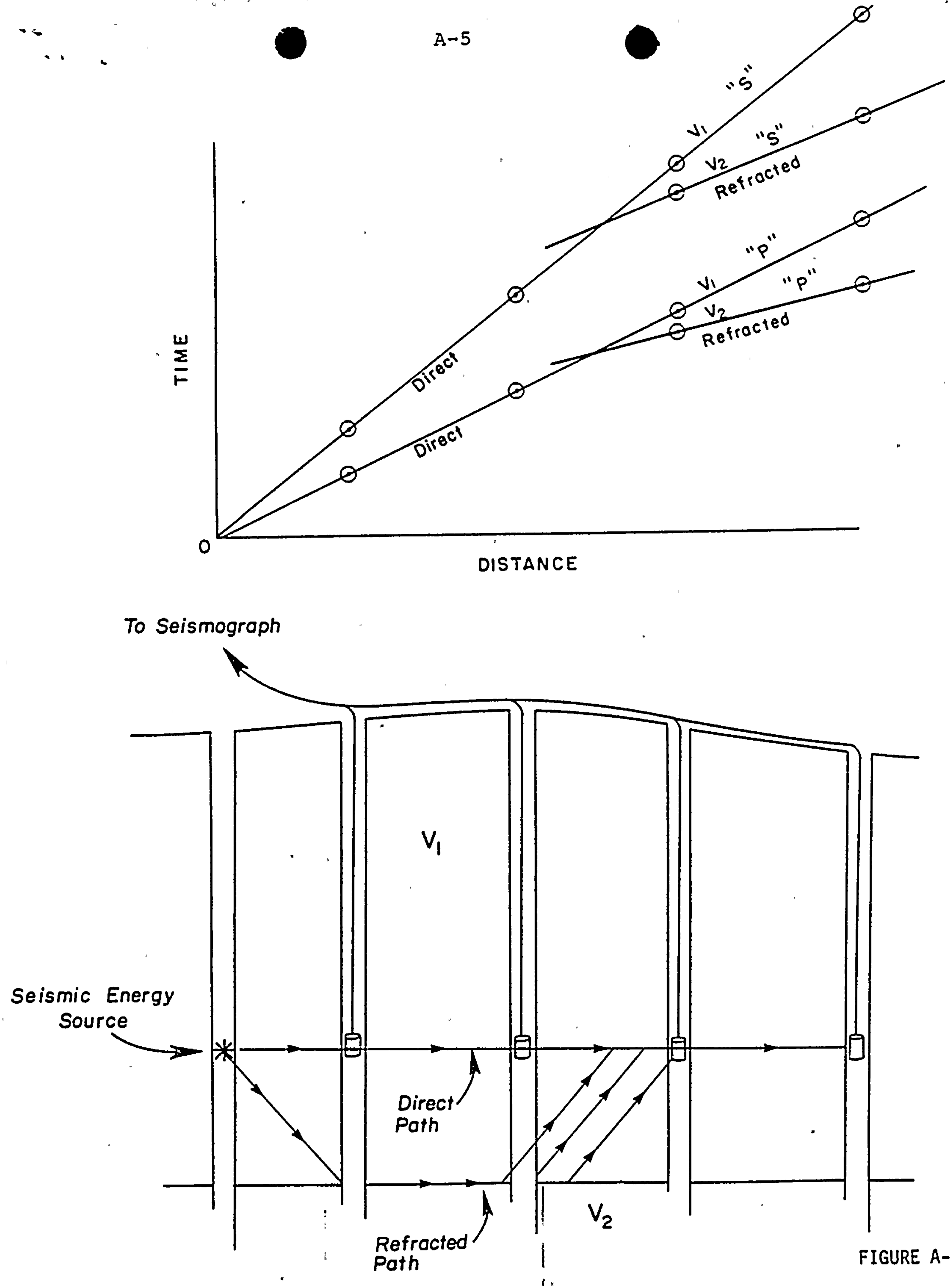

FIGURE A-2

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