# 4. IPOD SURVEY AREA AT-6: SEISMIC REFRACTION RESULTS[1]

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## INTRODUCTION

Seismic refraction experiments were carried out at three locations within the IPOD Survey Area AT-6 (Figure 1). The problems involved with working over such rough topography, coupled with repeated instrument difficulties, resulted in a data set of poor quality. We did not satisfactorily achieve our primary aims of detailing the shallow seismic structure beneath the proposed drill site and of determining the regional structure over the survey area.

## EXPERIMENTS

Line 1 was carried out using Select International 73 MHz telemetering sonobuoys and three Lamont ocean bottom seismometers (MacDonald et al., in press). This line was so situated as to permit determination of the gross crustal structure beneath Five Trough (Figure 1; Purdy et al., this volume). By positioning an OBS close to the proposed drill site and using a 2000 in.$^3$ airgun triggered at 3-minute intervals, we hoped to better define the shallow crustal structure. This proved unsuccessful because the airgun signal levels were inadequate, and the low amplitude high frequency content of the airgun pulse made identification of water wave arrivals impossible. Only one of the three OBS deployed yielded interpretable data from the explosive shots.

We used 73-MHz radio sonobuoys for Line 2. As can be seen in Figure 1, instead of maintaining a constant shooting course we adjusted the track so individual shots could, as far as possible, be placed in constant water depths. Thus we hoped to reduce inaccuracies caused by approximate topographic corrections and to avoid structural inhomogeneities associated with the topographic ridges. This proved moderately successful, but was marred by a navigational error which caused one of our shooting runs to trend too far west of the North-South-trending trough in which we had planned to carry out this experiment. We believed that by restricting our experiments to the linear trough, we would increase our chances of encountering laterally homogeneous structures. The detailed bathymetry shown in Figure 1 was not available at the time these experiments were carried out.

The OBS were deployed for Line 3, situated in the westernmost trough of the survey area. The shot sizes used were too small, and again we encountered difficulties in reliably identifying high-frequency water wave arrivals upon which accurate determinations of shot-receiver ranges depend.

## RESULTS

The results of the surface sonobuoy experiments were determined by correcting each seismogram for sediment thickness (assuming a 2.0 km/sec velocity) and bottom topography, using a replacement velocity of 4.7 km/sec and preparing record sections of the seismograms for each sonobuoy. Figure 2 shows an example of such a corrected record section for the sonobuoy placed at the southern end of Line 2. Common features are the well-defined Layer 3 velocities and emergent low-amplitude mantle arrivals. Figure 2 shows a dramatic decrease in transmitted energy at about 30 seconds range, which suggests an underlying thin low-velocity zone. Crustal sections determined from unreversed slope-intercept interpretations of the sonobuoy data for Lines 1 and 2 are shown in Figure 3. Reversed interpretations could not be made; one causative factor was the apparent variations in thickness of Layer 2A, in consequence of which this layer was not recorded as a first arrival at the northern end of Line 1 and the southern end of Line 2.

A thin layer 2A (0.4 to 0.5 km) with velocity of 3.4 to 3.5 km/sec was detected at the southern end of Line 1 and at the north end of Line 2. Layer 2B, with velocities in the range 4.7 to 5.3 km/sec, varied in thickness from 1.3 to 1.7 km. Layer 2 is underlain by Layer 3, which has normal oceanic crustal velocities of 6.4 to 6.9 km/sec and thickness varying between 4.0 and 5.6 km. Mantle velocities of 7.8 to 8.0 km/sec were recorded at all receiver locations.

The quality of the ocean bottom seismometer (OBS) data on Line 1 was disappointing, because the high-frequency water wave was not recorded. The recordings at one site in Five Trough (Figure 1) were adequate, however, to obtain accurate shot-receiver separations. The resulting seismic section was similar to that recorded by the sonobuoys, except that the geometry of the travel paths for the sea-floor receiver allowed better delineation of the shallow velocities (Figure 4). In particular, Layer 2A as a first arrival and Layers 2B and 3 as both first and second arrivals were clearly recorded by the vertical geophone. The only significant difference between the OBS and sonobuoy results in Five Trough was a slightly earlier (0.2 sec) high-frequency, low-amplitude first onset at distances of 25

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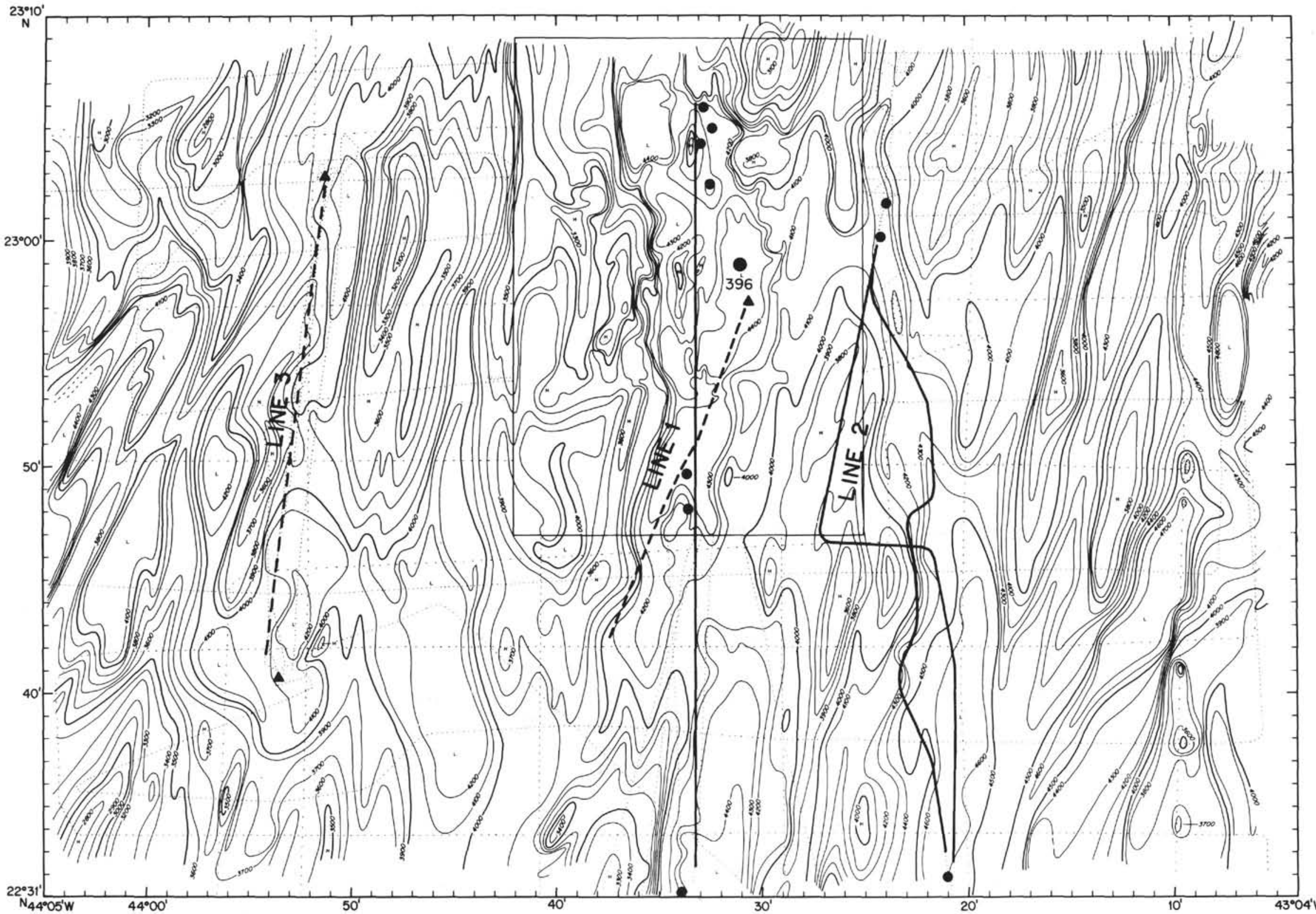


Figure 1. *Locations of seismic refraction experiments. Small black triangles are OBS locations, large black circle is location of drilling Site 396. Small black circles are sonobuoy locations. Solid lines are sonobuoy shooting runs, dashed lines are OBS shooting runs, 100-meter contour interval bathymetry is from Purdyet al., this volume Five Trough trends north-south across the survey area at about longitude 43° 33′ W.*

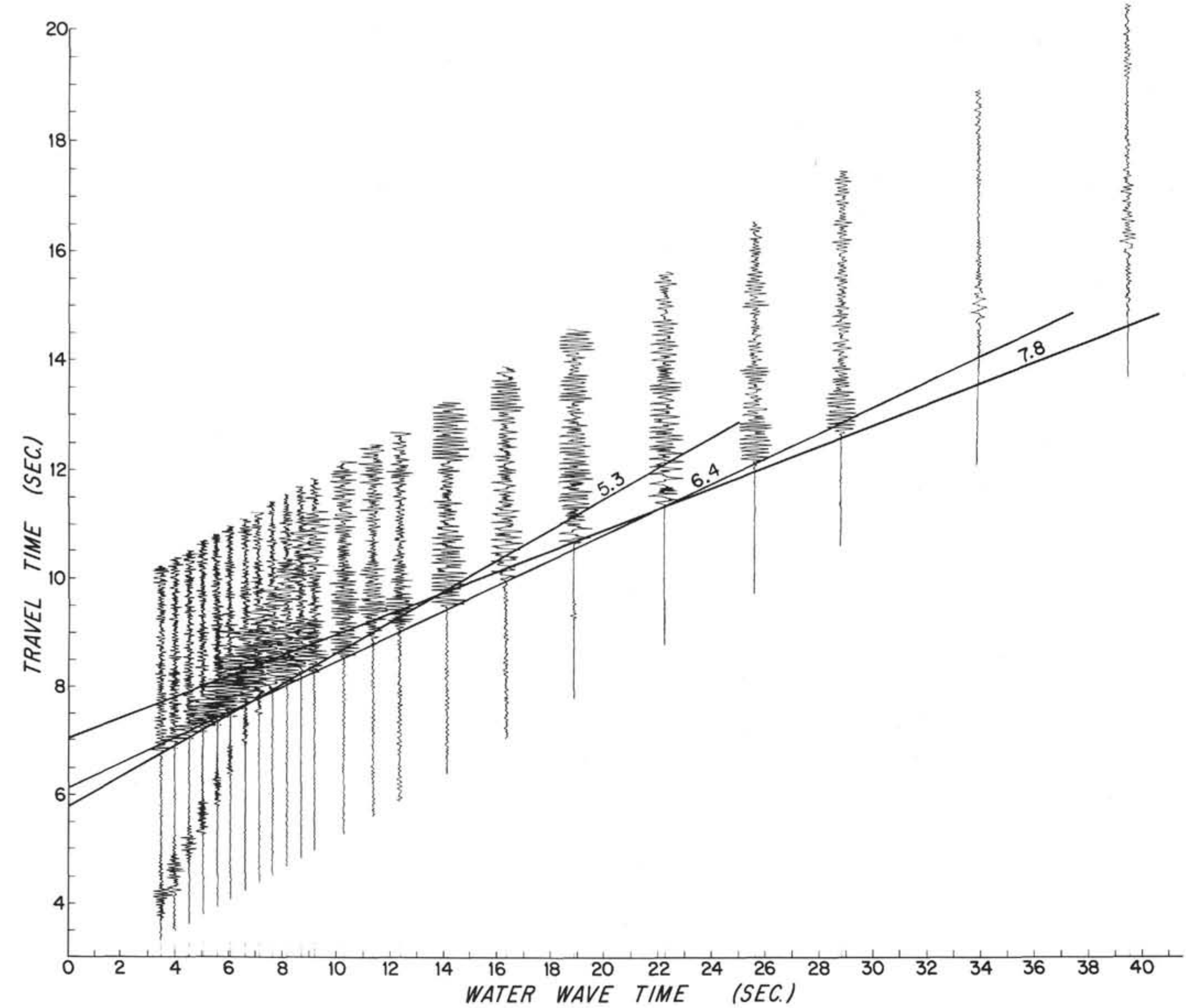


Figure 2. *Corrected composite record section for sonobuoy at southern end of Line 2.*

to 38 km, with a velocity of 8.25 km/sec (see time-distance graph in Figure 4). These events are followed by a much larger amplitude low-frequency event corresponding to the first discernible event on the sonobuoy seismogram. We speculate that the OBS recorded a refracted arrival along a thin high-velocity layer underlain by a lower velocity layer, with a rapid increase in velocity with depth to normal mantle values. Further, because of the low amplitude and high frequency of this event, the energy loss in the water column prevented its detection by the surface sonobuoys. The hydrophone and horizontal-component geophone provided no additional data to aid in this interpretation.

It proved impossible to determine a reasonable travel-time interpretation for Line 3. The time-distance graph for vertical geophone arrivals (Figure 5) shows poorly defined velocities (except the 4.36 km/sec velocity) and large scatter of the travel times about the least-squares-fitted lines. Although the reverse points for the 7.26 and 7.45 km/sec lines match quite well, the shallow structures at the two ends of the line are apparently completely dissimilar. At the southern end of the line (OBS 1), a masked layer probably exists between the 4.36 and 7.26 km/sec velocities. At the northern end some lower velocity unobserved layer must exist above the 6.12 km/sec layer to bring the solution into agreement with the known water depth. No coherent second arrivals could be reliably identified to help in resolving these difficulties. We judged that any reasonable structural solution would require so many assumptions as to make its validity questionable. A qualitative solution would be that at the southern end we have a thicker 2A/2B layer and 2C/3A layers so thin as not to be observed as first arrivals. To the north, the 2C/3A layer (6.12 km/sec apparent velocity) is significantly thickened at the expense of the shallow 2A/2B layer. Figure 6 adds further qualitative support for the existence of a significant inhomogeneity

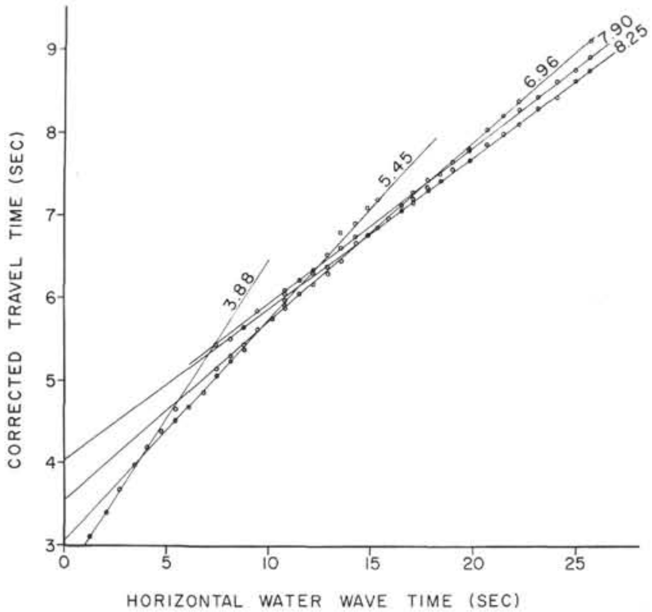


Figure 3. *Crustal sections from unreversed slope-intercept solutions of Lines 1 and 2. The speculative 8.25 km/sec layer within Layer 3 at the southern end of Line 1 is based on the OBS data alone, and is discussed in the text.*

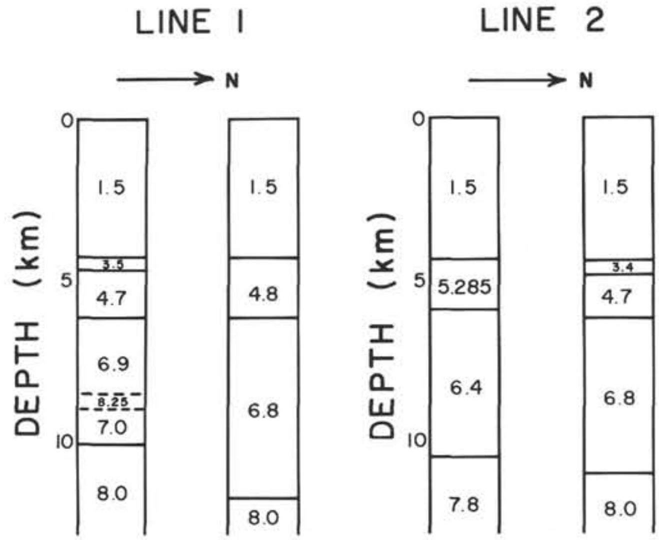


Figure 4. *Time-distance graph for OBS arrivals on Line 1. Segments are annotated, with velocities in km/sec.*

along the north-south-trending trough in which this experiment was carried out. OBS 2, at the northern end of the line, shows strong arrivals on the vertical geophone and very little energy on the horizontal geophone. From a shot of twice the magnitude at the same range, OBS 1 (at the southern end) shows weaker vertical geophone arrivals, but strong horizontal geophone arrivals. The clear second arrivals visible on this horizontal geophone trace could not be correlated through surrounding seismograms. It must be noted that the amplitude difference of the horizontal geophone arrivals is of questionable significance because the geophone orientation is not known. The small (0.1 sec) delay of the horizontal first arrival, relative to the vertical, may be a result of P to S conversion at the base of a thin sediment layer underlying OBS 1. This "delay" could not be adequately or consistently identified on other seismograms, so no reliable conclusions can be drawn.

## ACKNOWLEDGMENTS

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MacDonald, W. G., Hubbard, A. C., Bookbinder, R. B., and McCamy, K., in press. Design and shipboard operation of a multipurpose ocean bottom seismograph, *Mar. Geophys. Res.*

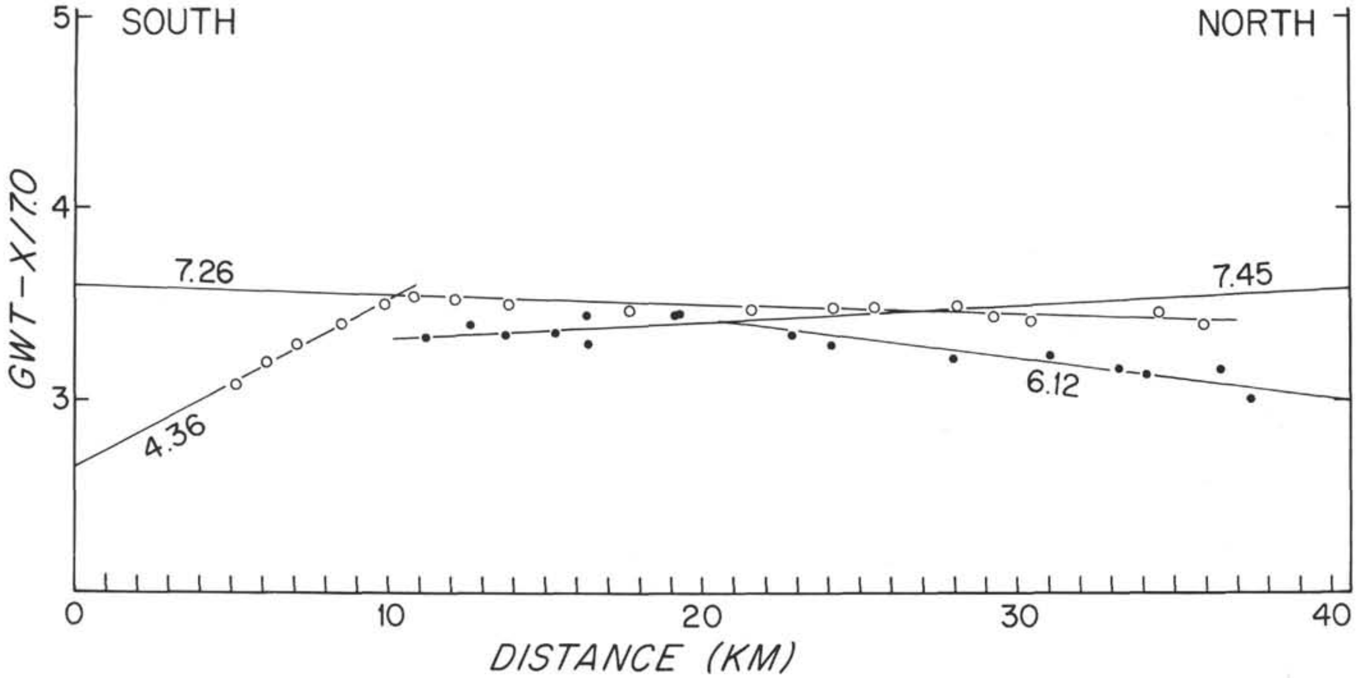


Figure 5. *Time-distance graph for Line 3. Open circles denote arrivals on southern OBS and solid circles denote arrivals on northern OBS. Least-squares-fitted lines segments are annotated, with velocities in km/sec.*

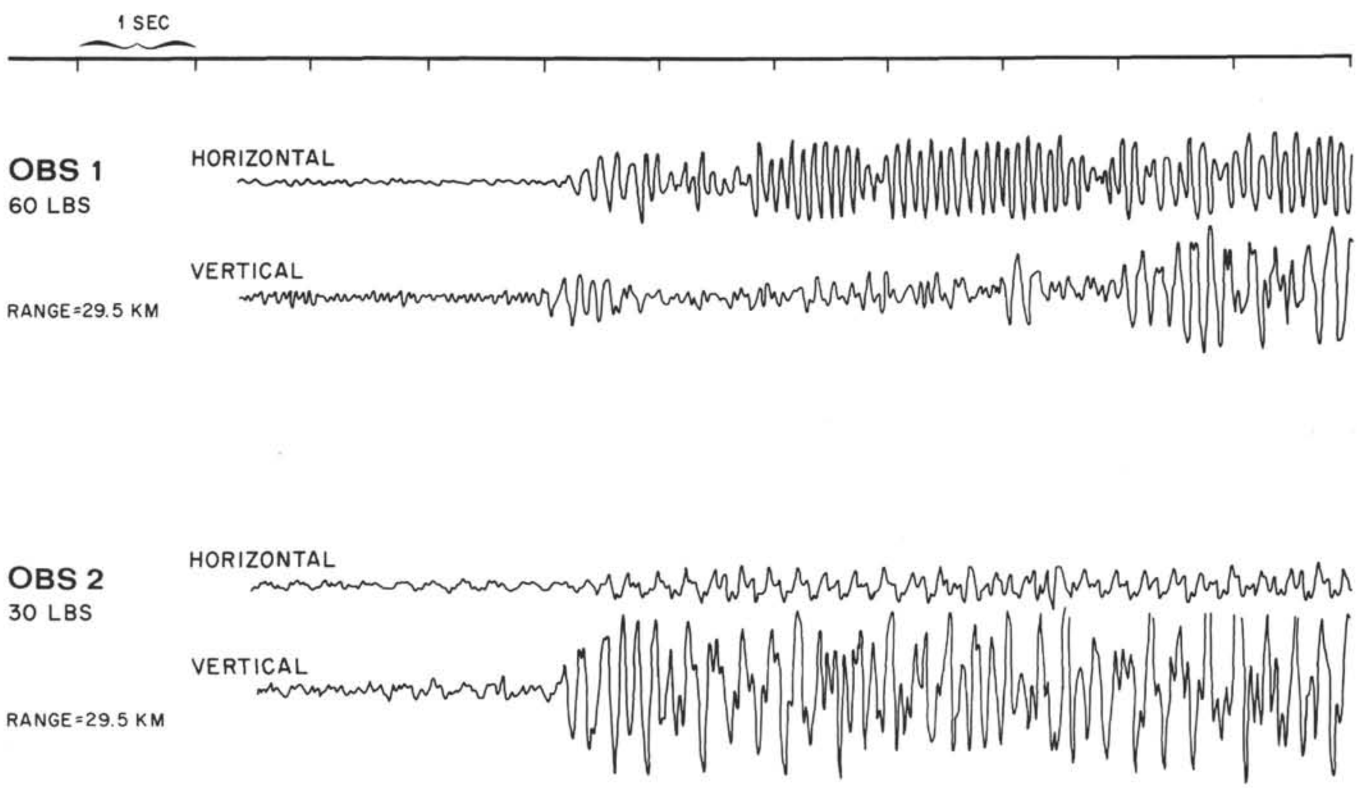


Figure 6. *Sample seismograms from Line 3. OBS 1 is at the southern end of the line. Compared with OBS 1, OBS 2 shows greater vertical geophone amplitude and lower horizontal geophone amplitude for a shot of half the magnitude at the same range.*