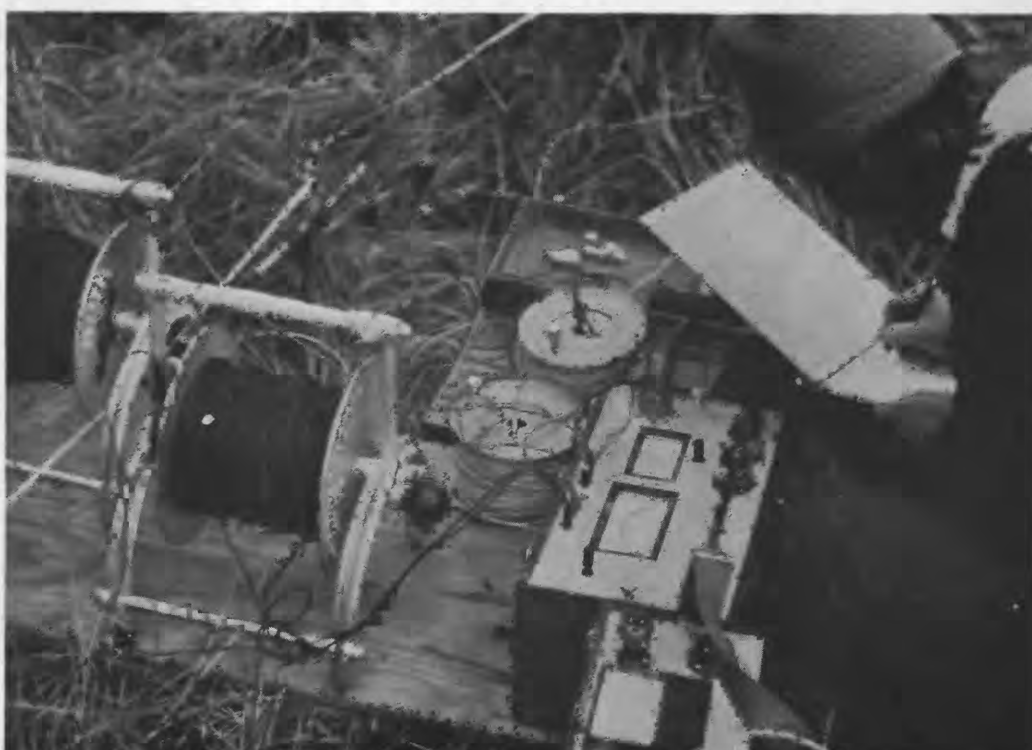
# SURFACE GEOPHYSICAL INVESTIGATION AT TWO CROSS-VALLEY LINES IN THE MIDDLE EAGLE RIVER VALLEY, SEPTEMBER 1979

U.S.GEOLOGICAL SURVEY

OPEN-FILE REPORT 80-2000



Prepared in cooperation with the Municipality of Anchorage

FRONT COVER PHOTOS

Top photo: Middle reach of Eagle River valley looking upstream near Seward Meridian. Typical summer flow from glaciated headwaters (area of snowy peak) on August 23, 1979.

Bottom photo: Donald Schaefer making electrical resistivity reading at the R-2 site on September 14, 1979.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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Anchorage, Alaska
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UNITED STATES DEPARTMENT OF THE INTERIOR

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## CONVERSION TABLE

| Multiply inch-pound units | By | To obtain SI units |
|---|---|---|
| feet (ft) | 0.3048 | meters (m) |
| feet per second (ft/s) | 0.3048 | meters per second (m/s) |
| miles (mi) | 1.609 | kilometers (km) |
| million gallons per day (Mgal/day) | 90.85 | liters per second (L/s) |
| pounds (lb) | 0.4536 | kilograms (kg) |

Contrary to standard geophysical practice, depths and distances are given in inch-pound units instead of metric units to accommodate local report users.

# SURFACE GEOPHYSICAL DATA FOR TWO CROSS-VALLEY LINES IN THE MIDDLE EAGLE RIVER VALLEY, ALASKA

By Larry L. Dearborn and Donald H. Schaefer*

## ABSTRACT

In 1979 the U.S. Geological Survey made electrical resistivity and seismic soundings along two lines crossing the floor of the middle reach of the Eagle River valley northeast of Anchorage. This work was undertaken primarily to determine the approximate depth to bedrock and the gross layering within the overlying unconsolidated sediments. A resistivity sounding was made also at a site about 7 miles downstream in an apparent ancient outlet valley of Eagle River to explore for a buried bedrock channel. No prior subsurface data were available for these areas.

Interpretations of the geophysical data collected indicates that the depth to bedrock below the valley floor along the two lines varies between 350 and 450 feet. Two, and perhaps three, major unconsolidated sedimentary layers are inferred to overlie bedrock, although other possible significant layers may not have been recognizable.

Resistivity data for a site in the apparent ancient outlet valley suggest a local bedrock surface at about 50 feet above sea level. This low altitude relative to that of a bedrock outcrop in the channel of Eagle River a half mile downstream of the sounding lends more credence to the hypothesis of a channel in the buried bedrock that may lead to the Fossil Creek drainage.

## INTRODUCTION

In 1979 the U.S. Geological Survey made electrical resistivity and seismic refraction surveys in the middle reach of the Eagle River valley, 15 mi northeast of Anchorage. The primary objective was to determine the approximate depth to bedrock along two lines crossing the valley floor. In addition, an indication of the number of major sedimentary units and their thicknesses was anticipated. No prior data describing the subsurface geology were available for this part of the valley. Surface geophysical methods were chosen over test drilling because of time, budget, and access restrictions.

The middle reach of the Eagle River valley is straight with steep, glaciated side-walls that form a U-shaped bedrock trough. Stream alluvium, fine-grained lacustrine deposits, and glacial till are believed to comprise the unconsolidated sediments underlying the valley floor. In this reach Eagle River and a major

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tributary meander on a flat, broad valley bottom that is swampy in places. A shallow water table is probable and is further suggested by seepage into small tributary channels incised into the valley floor.

## COLLECTION OF DATA

Six vertical electric resistivity soundings and four seismic refraction soundings were made along two exploration lines traversing the floor of the valley between the mainstem of Eagle River and the major tributary (fig. 1). These lines were selected because they were paths that presented the least brush clearing in an area targeted for exploratory drilling for ground water.

In addition, a resistivity sounding was taken at site R-7 along the edge of a narrow valley draining into Eagle River about 6,000 ft east of the Hiland Drive overpass (fig. 2). This site is of interest because geomorphic features of the general area suggest that a buried bedrock channel may leave the present stream course on the south side of the valley. If so, a considerable volume of ground water might be moving out of the main valley upstream of the Geological Survey's gaging station. Such a possibility was implied by Bateman (1980) as a result of reconnaissance geologic mapping in 1948. On his plate 3, the oblique aerial photograph clearly shows the "by-passing" valley.

A Gish-Rooney* direct-current electrical resistivity unit was used to make resistivity soundings. The Schlumberger array method was employed. Variable current electrode spacing ranged from 15 to 750 ft (4.6 to 229 m), and a maximum draw of 270 volts was used. All resistivity arrays at sites shown in figure 1 were oriented cross valley, whereas the site near the Hiland Drive overpass required an array orientation parallel to the valley axis. The investigation areas are believed to be well away from any potential source of electrical interference.

Seismic refraction soundings were made with a Bison* six-channel, signal-enhancement, recording seismograph. Energy waves in the earth were produced by detonating 1 to 2 1/4 lbs of 75-percent Atlas* power primer per shot at measured distances ranging from 750 to 1500 ft from the instrument.

At each sounding site six geophones were set at successive 50-ft spacings away from the zero point in the opposite direction of the shot. Because the charges were buried in moist, clayey soil, strong energy signals were received by the geophones. Energy pulses detected by the geophones were entered automatically into electronic storage of the seismograph. Measurements of the arrival times, made internally by the seismograph, were visually displayed on command and later were printed on the strip charts as a permanent record.

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*The use of brand names in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

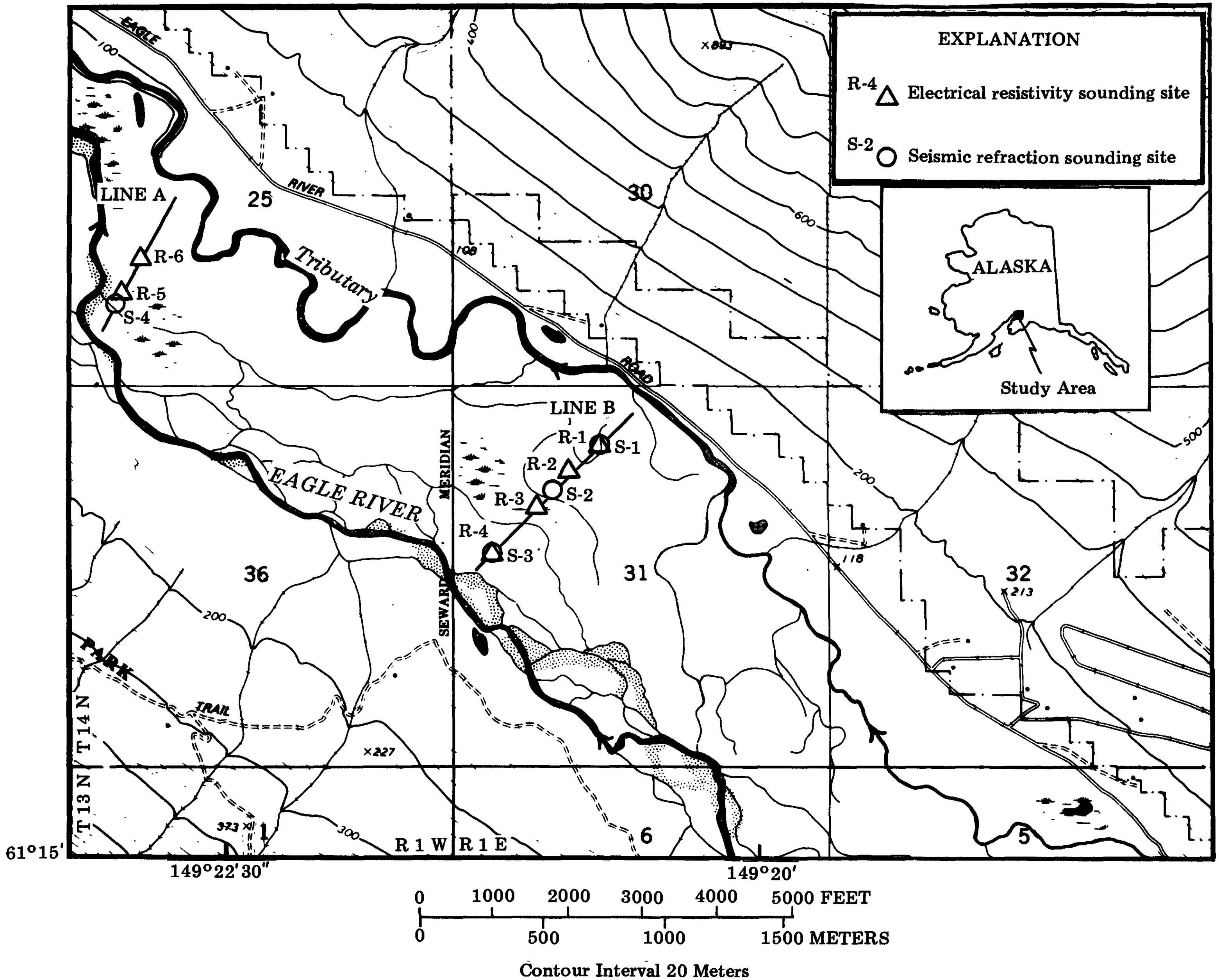


Figure 1.--Location of Eagle River valley study area and geophysical sounding sites.

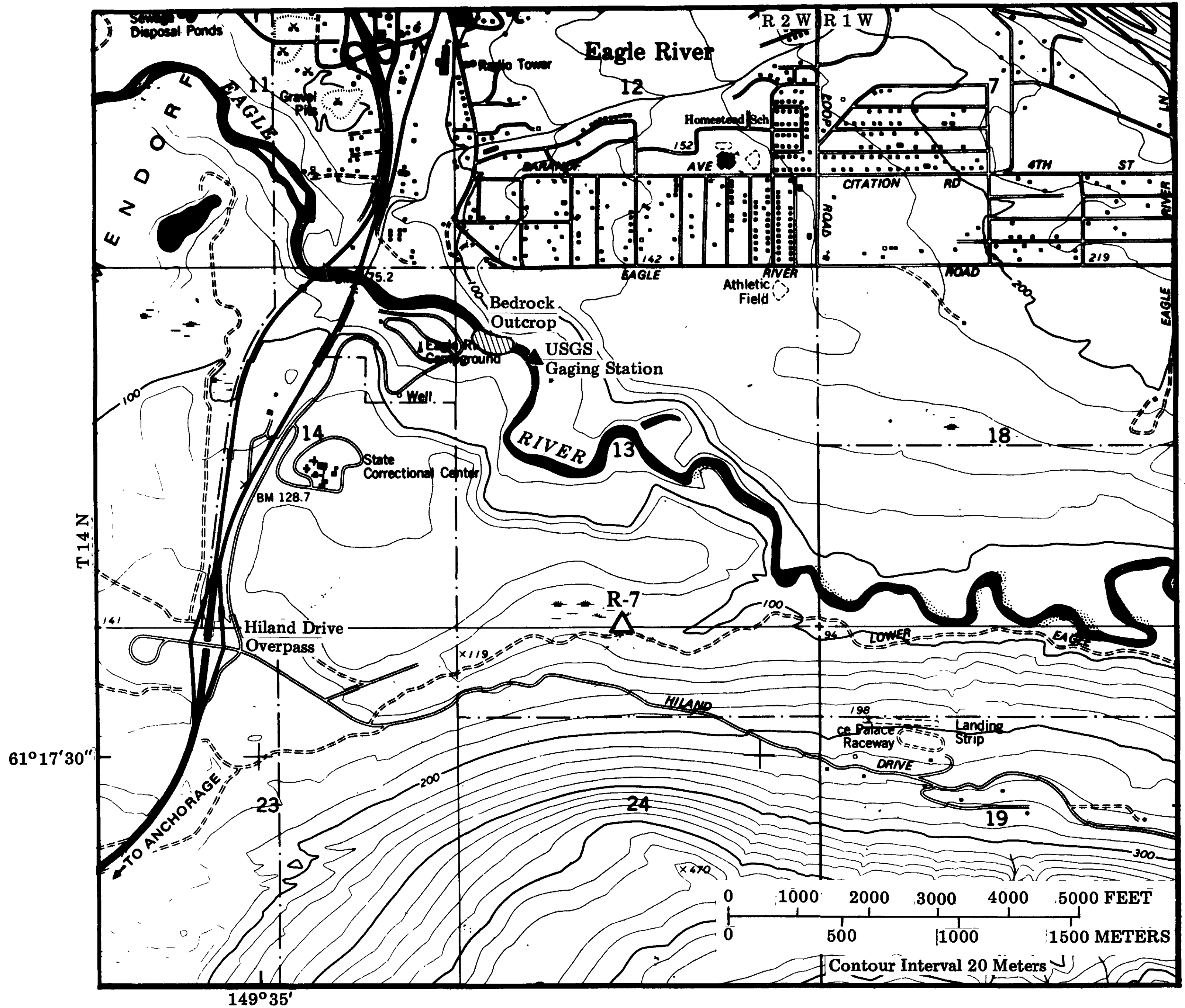


Figure 2.--Location of resistivity sounding site R - 7 in Eagle River valley.

## ANALYSIS OF ELECTRICAL RESISTIVITY SOUNDING DATA

The field sounding curves for line B, line A, and R-7 are shown in figures 3, 4, and 5, respectively. Apparent resistivity ($\rho_a$) of the composite of geologic materials conducting applied current, expressed as ohm-meters, was calculated from the field data using the standard equation (Zohdy, 1974a):

$$\rho_a = \pi \frac{(AB/2)^2 - (MN/2)^2}{MN} \frac{V}{I} \qquad \text{(Eq. 1)}$$

where, V = voltage drop between the two inner electrodes (in millivolts),
I = measured electric current flowing between the two outer electrodes (in milliamperes),
AB/2 = distance from midpoint to either equidistant current (outer) electrode (in meters), and
MN = distance between the two potential (inner) electrodes (in meters).

The resulting curves were then digitized at regular intervals, and the corresponding apparent resistivities were used as input to a resistivity-interpretation computer program (modified after Zohdy, 1974b). This program, which requires metric distance units, computes a subsurface model of probable layer thicknesses and estimates resistivities of each geoelectric layer that the model recognizes. The resulting thicknesses given for the sounding sites are not derived from unique solutions, but they represent the best geologic fit to the field data.

## ANALYSIS OF SEISMIC REFRACTION SOUNDING DATA

Initial arrival times of compressional waves resulting from a shot blast at a six-geophone array can be used to calculate the depths to geologic interfaces where an abrupt change in wave velocity occurs. The travel times of the generated energy waves are plotted against distances between a shot and the receiving geophone (fig. 6). Two or three straight lines can be drawn through each set of data plots. The slope of each straight-line segment is the reciprocal of the wave velocity of a single seismically homogenous layer. Successively deeper layers are represented by distinctly sloped segments that plot further from the origin of the graph.

Due to suspected geologic complications, only the velocity differences between bedrock (about 12,500 ft/s) and the immediately overlying material (4,100 to 7,000 ft/s) were considered substantial enough to derive reliable depths to an interface. The small velocity differences at shallower depths indicated on the S-3 and S-4 plot (fig. 6) may be meaningful, although attempts to derive interface depths that agree with the resistivity results were unsuccessful.

The depths to bedrock ($Z_b$) were calculated from the seismic data plots using the equation (Bison Instruments Inc., 1971, p. 22):

$$Z_b = \frac{X_c}{2} \sqrt{\frac{V_b - V_o}{V_b + V_o}} \qquad \text{(Eq. 2)}$$

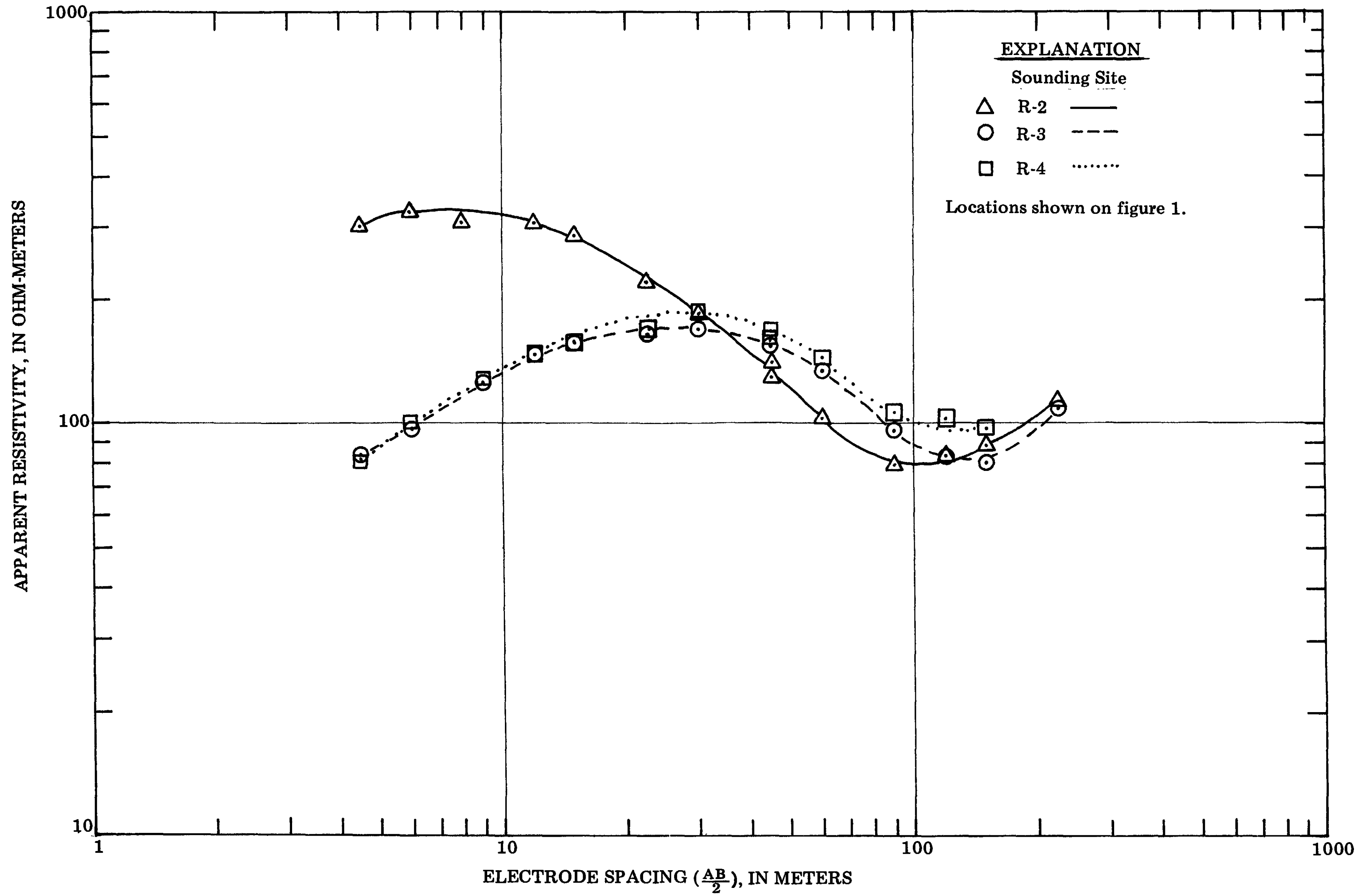


Figure 3.--Resistivity field curves for exploration line B.

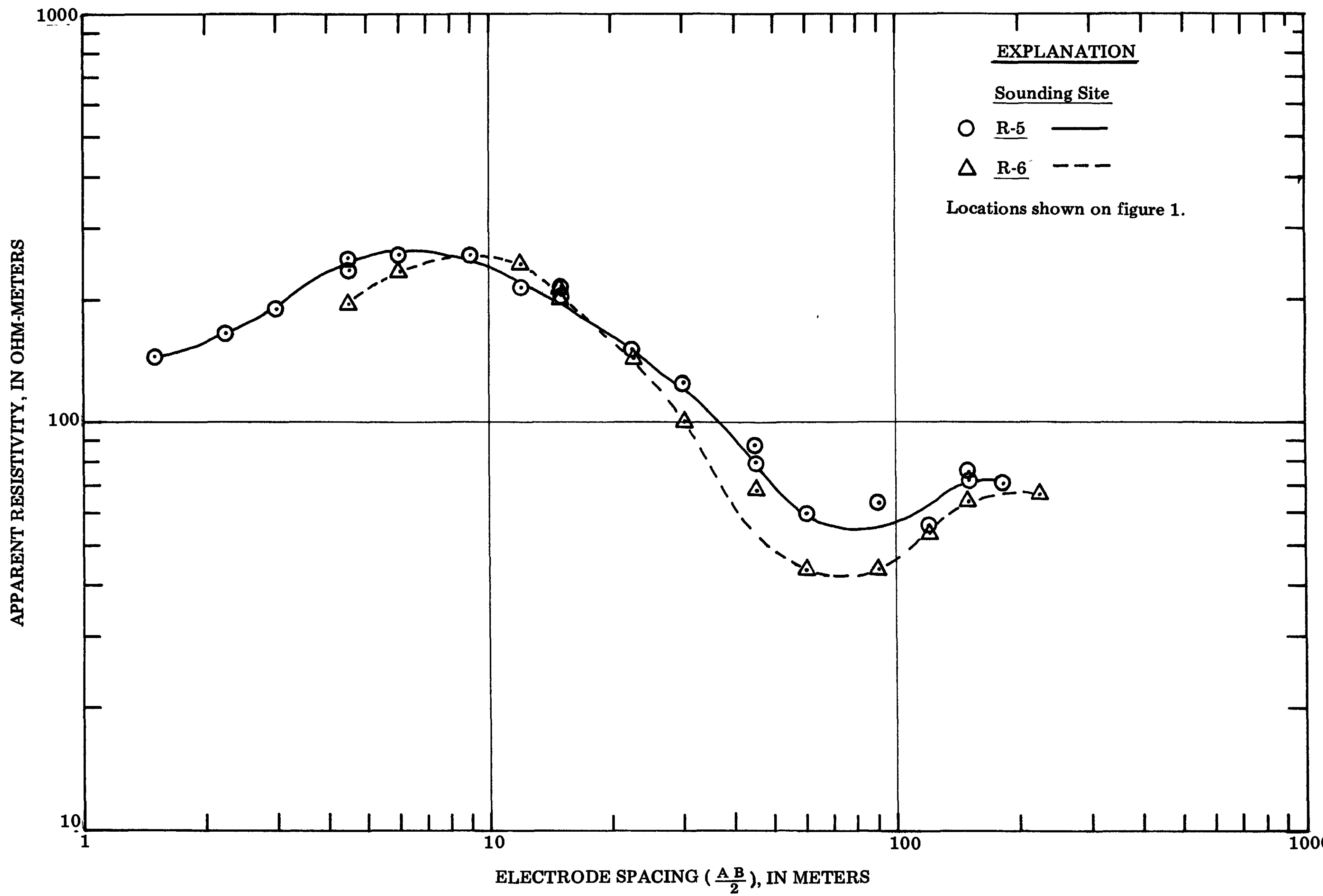


Figure 4.--Resistivity field curves for exploration line A.

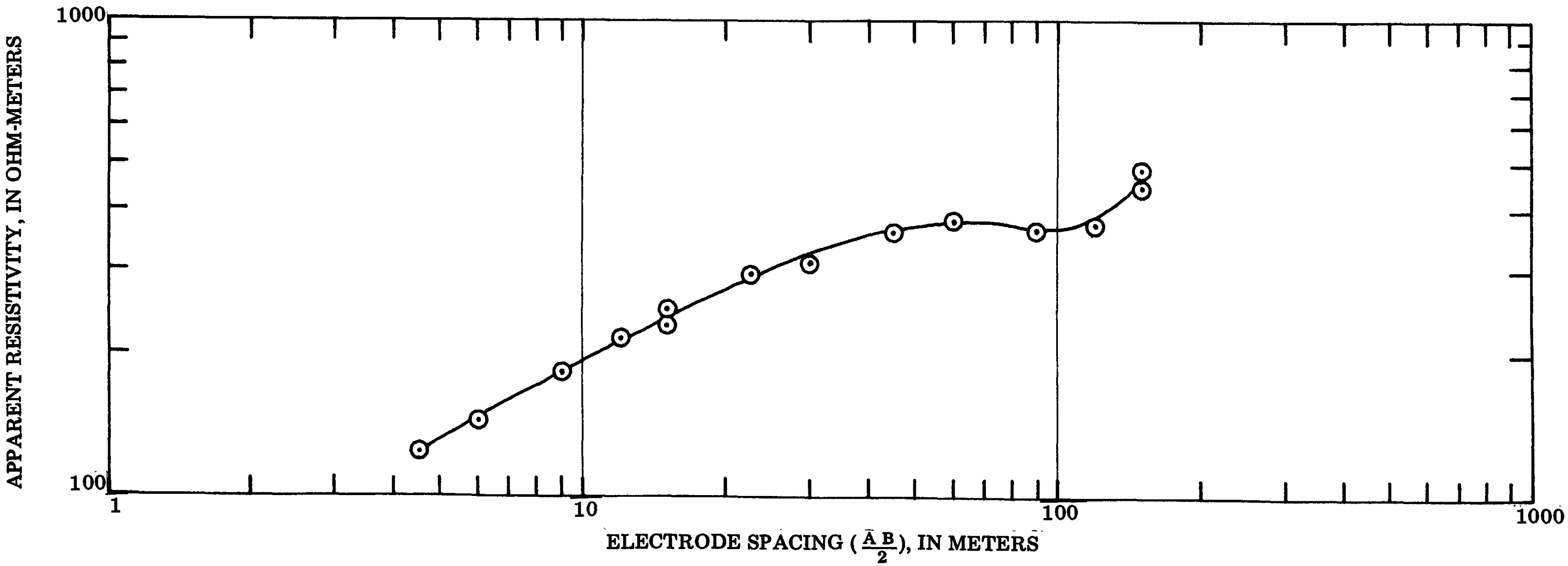


Figure 5.--Resistivity field curve for sounding site R-7 (location shown on figure 2).

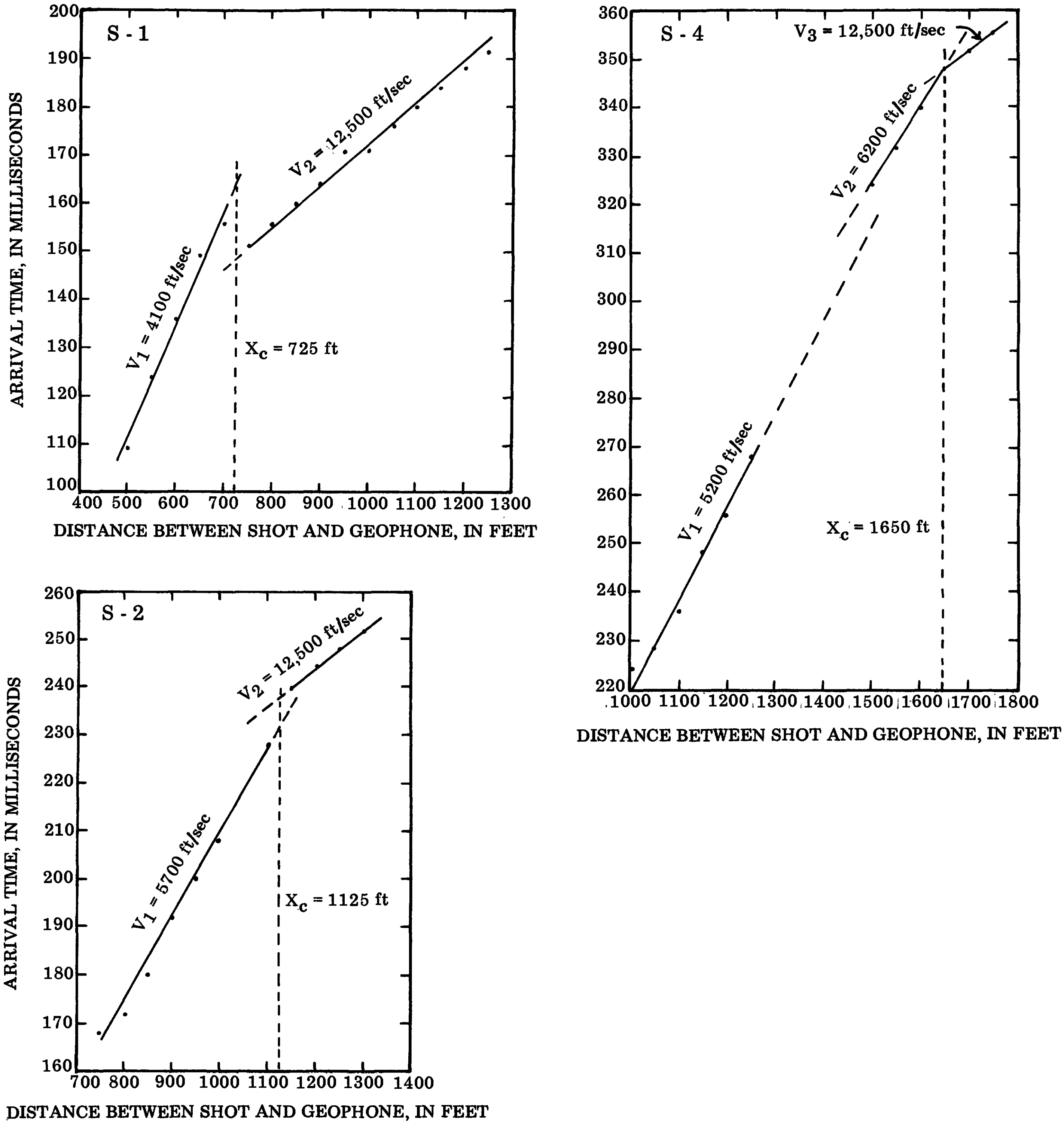


Figure 6.--Seismic travel-time plots for test sites along exploration lines A and B. S = Seismic test site (locations shown on figure 1).

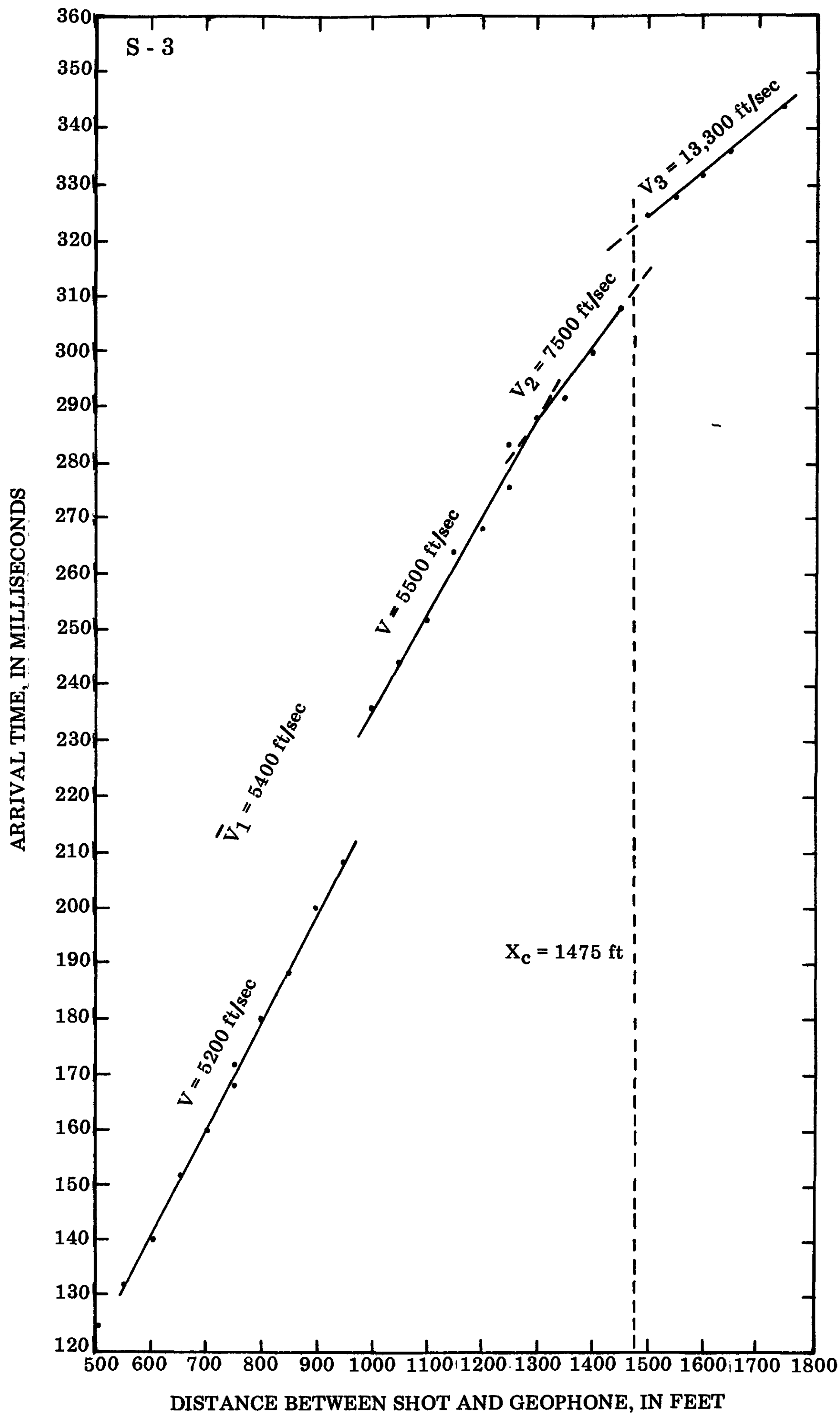


Figure 6.--Seismic travel-time plots for test sites along exploration lines A and B--*Continued*
S = Seismic test site (locations shown on figure 1).

where, $X_c$ = distance corresponding to the intersection of the bedrock-velocity segment and the overlying sediment-velocity segment (in ft),

$V_b$ = seismic velocity calculated for bedrock (in ft/s), and

$V_o$ = seismic velocity calculated for the adjacent overlying sediment (in ft/s).

## RESULTS OF INTERPRETATIONS

The results of interpretations of electrical resistivity and seismic refraction soundings are summarized in table 1. Depth-to-bedrock figures should be viewed as estimates in that the geophysical techniques used are based on contrasts between geophysical properties of conceptualized geologic layers, the analysis of which requires some simplifying assumptions. Therefore, these techniques do not necessarily measure absolute depths to geologic interfaces.

Computer reduction of the resistivity data indicates three major layers possessing substantially different resistivities: layer I, greater than 100 ohm-meters; layer II, less than 100 ohm-meters; and bedrock, greater than 1,000 ohm-meters. The presence of another layer (III) immediately overlying bedrock along the southwest side of the valley is suggested by increased resistivities below 270, 210, and 285 ft at sites R-4, R-5, and R-6 respectively.

The single resistivity sounding made at site R-7 to investigate the possible presence of a buried, ancient, bedrock channel suggests that the bedrock surface at this point may be about 300 ft below land surface. Layering within the unconsolidated sediments at this site was not discernable from the sounding data. The computer solution of depth to bedrock may be questionable in that the tail of the field curve appears to reflect lateral interference in the generated electrical field. However, if this figure is not seriously in error, the altitude of bedrock here is about 50 ft above NGVD (sea level of 1929). Approximately a half mile downvalley from the sounding, bedrock is exposed in the channel of Eagle River at an altitude of about 240 ft. (See figure 2.) The buried-channel hypothesis offers a reasonable explanation for the considerably lower bedrock altitude in the upstream tributary valley.

Seismic travel-time plots clearly reflect the sediment-bedrock interface by velocity increases of 5,000 to 8,000 ft/s. Faint indications of a shallower interface are present for soundings along the mainstem of Eagle River, but the depth to this interface, if it actually exists, could not be determined. The lack of definition by the data of other probable interfaces between contrasting materials is not surprising. Seismic refraction soundings commonly cannot produce data which delineate the existence of a low-velocity layer underlying a layer having medium or high velocity. Therefore, recognition of a typical clay sandwiched between alluvium or till and bedrock generally is not possible with this technique. Also, if there is substantial topographic relief of the buried bedrock surface, arrival times from shallower interfaces will be distorted or disguised.

Fairly good agreement of depths to interfaces resulted from resistivity and seismic soundings taken adjacent to each other. One notable exception in table 1 is the R-5/S-4 locality. No explanation for a disagreement of about 100 ft is readily acceptable. However, the R-5 sounding may not have penetrated to bedrock; thus, bedrock actually could be about 500 ft below the surface and deeper than at the other sites.

Table 1.--Calculated depths to probable lithologic interfaces determined from geophysical soundings

| Sounding site** | | Depth to major interface (in ft below land surface)* | | |
|---|---|---|---|---|
| | | layers I/II | layers II/III*** | top of bedrock |
| line B | S-1 | -- | -- | 260 |
| | R-2 | 50 | -- | 440*** |
| | S-2 | -- | -- | 345 |
| | R-3 | 90 | -- | 390 |
| | S-3 | -- | -- | 390 |
| | R-4 | 90 | 270*** | 375*** |
| line A | S-4 | -- | -- | 480 |
| | R-5 | 40 | 210*** | 360 |
| | R-6 | -- | 285*** | 380 |
| near Hiland Drive | R-7 | -- | -- | 310*** |

* rounded to the nearest 5 ft
** analysis indicated data for R-1 are not interpretable
*** tentative indentification--data interpretation not conclusive

## SUGGESTED ADDITIONAL INVESTIGATIONS

The work described in this report appears to have served well as a means of supplying basic subsurface information in a small segment of the Eagle River valley. Geophysical sounding data for the valley-bottom, alluvial reach that extends 3 mi upstream and downstream of the survey lines used in this study probably would be equally beneficial. Identification and correlation of actual geologic units should be readily feasible when test drilling in the report area occurs. This, in turn, will enhance the direct usefulness of future resistivity and seismic soundings in adjacent reaches of the valley. Future investigators also should consider employing a resistivity technique known as horizontal profiling (Zohdy, 1974a).

Another worthwhile venture in evaluating the ground-water potential of the Eagle River valley would be test drilling in the vicinity of the site R-7. Confirmation of the depth to bedrock here, where a buried bedrock channel is suspected, is needed, as is an estimate of any substantial ground-water movement away from or into the main valley. Further use of resistivity or seismic techniques probably will not yield reliable results in this area as the terrain is either too swampy or hilly.

## SUMMARY

Interpretation of electrical resistivity and seismic refraction data collected in one area of the middle reach of the Eagle River valley indicates that at most points along the exploration lines the depth to bedrock below the valley floor varies between 350 to 450 ft. Two, and perhaps three, major unconsolidated sedimentary layers are inferred to overlie bedrock. Other significant layers may exist that are not recognizable from the sounding data.

A resistivity sounding made in a small tributary valley about 6,000 ft east of the Hiland Drive overpass indicates that here the bedrock surface is about 50 ft above sea level. This low altitude relative to that of bedrock exposed in the channel of Eagle River downstream suggests that a buried, ancient, bedrock canyon may leave the present course and lead to the head of the Fossil Creek drainage 2 mi to the west.

NOTE ADDED AFTER DIRECTOR'S APPROVAL: Four test wells were drilled along line B (fig. 1) in September 1980. At test well 2, approximately midway on line B, drilling was suspended at 634 feet; bedrock had not been reached. Information from the other test wells also suggested that bedrock could be at significantly greater depth than reported herein. In January 1981 two or more of these test wells are scheduled to be deepened. A final report will provide revised depth values for line B.

## REFERENCES CITED


Bateman, A.F., Jr., 1980, Unevaluated reconnaissance report (December 1948) on geology of lower Eagle River valley, Alaska: U.S. Geological Survey Open-File Report 80-275, 16 p.

Bison Instruments Incorporated, 1971, Instruction manual--Bison instruments signal enhancement seismograph model 1570B: Bison Instruments Incorporated, Minneapolis, Minn., 34 p.

Zohdy, A.A.R., 1974a, Application of surface geophysics to ground-water investigations: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 2, Chapter D1, 116 p.

______ 1974b, A computer program for the automatic interpretation of Schlumberger sounding curves over horizontally stratified media: National Technical Information Service (NTIS) PB-232 703/AS, 25 p.