



Report on the Seismic Survey of
P. L. 5609 and 5610,
Livingstone Creek, Yukon Territory

Prepared on Behalf of

Gem Resources Ltd.
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by

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October 19, 1981

<u>TABLE OF CONTENTS</u>		<u>Page</u>
1.0	<u>INTRODUCTION</u>	1
1.1	Terms of Reference	
1.2	Property Description, Location and Access	
1.3	Physiography	
1.4	History of the Livingstone Creek Gold Camp	
1.5	Rationale	
2.0	<u>PLACER LEASE 5609 ("4 Mile Lease")</u>	6
2.1	Geomorphology	
3.0	<u>SEISMIC SURVEY</u>	7
3.1	Description and Results	
4.0	<u>SUMMARY AND CONCLUSIONS</u>	8
	<u>FIGURES</u>	Following Text
	Figure 1 - Property Location Map	
	Figure 2 - Location and Placer Leases 5609 and 5610	
	Figure 3 - Location of Seismic Survey Lines; P.L. 5609	
	Figure 4 - Location of Seismic Survey Lines; P.L. 5610	
	<u>APPENDIX</u>	
	Appendix A - Reconnaissance Seismic Refraction Surveying at Livingstone Creek Placer Lease 5609, Yukon Territory	
	Appendix B - Reconnaissance Seismic Refraction Surveying at Livingstone Creek Placer Lease 5610, Yukon Territory	
	Appendix C - Certificate and Statement of Qualifications	

1.0 INTRODUCTION

1.1 Terms of Reference

Nevin Sadlier-Brown Goodbrand Ltd. and Geo-Compu-Graph Inc. have been retained by Granada Exploration Corporation to conduct an exploration program on two placer mining leases in the Livingstone Creek area of the Yukon Territory. The work was performed on behalf of Gem Resources Ltd. in order to incur sufficient prospecting expenditure to convert the leases to claims. The following is a report on these activities.

The placer leases were visited on June 15, 1981 by Granada Exploration Corporation President Andrew E. Nevin in the presence of Jim Wallace, P.Eng., geological engineer; Stuart Croft, geologist; and Jerry Leverman, President of Gem Resources Ltd., present holder of the placer leases. An exploration program geared towards sub-surface bedrock mapping was developed on the basis of this reconnaissance.

The program consisted of a detailed refraction seismic survey, performed at the recommendation of Jim Wallace, P.Eng., of Atlin, B.C. Geophysical work and interpretation was contracted to Geo-Compu-Graph Inc., whose two-man crew spent ten days in the Livingstone Creek area commencing on August 11, 1981. A two-man geological crew supplied by Nevin Sadlier-Brown Goodbrand Ltd. accompanied the seismic contractor. The geologists staked placer mining claims on the leases concurrent to seismic work and assisted the geophysics crew as required.

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1.2 Property Description, Location and Access

The Livingstone Creek area is located 85 km northeast of Whitehorse, Yukon Territory (Figure 1). Livingstone Creek is a tributary of the South Big Salmon River which eventually joins the Big Salmon River at a point 30 km to the north.

Access during summer months is by way of aircraft. Livingstone airstrip, approximately 90 km by air from Whitehorse, is a well maintained gravel runway and frequently handles DC-3 traffic supplying local placer mining activity. From the airstrip, helicopter support is required for the 8 km flight into the property. A helicopter flight directly from Whitehorse would likely prove to be more efficient for brief visits to the Livingstone Creek area.

A trail has been established to allow ground access into the area for heavy machinery during winter months. However after break-up on the Teslin River and numerous small lakes and swamps enroute, the trail is impassable.

The property consists of two placer leases numbered 5609 and 5610 totalling approximately 8 km (Figure 2). The leases are located on NTS map no. 105-E-8 at latitude 61° 20'N and longitude 134° 15'W. P.L. 5609 is situated on Livingstone Creek and extends approximately 4 miles upstream from the "number one" post located 9.5 km from the confluence with the South Big Salmon River. P.L. 5610 extends for 1 mile upstream from a point 1500 feet (460 m) south of Livingstone Creek on an unnamed tributary feeding from the south. Both leases are in good standing until October 15, 1981.

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1.3 Physiography

Upper Livingstone Creek drains the rolling mountains of the Big Salmon Range of south-central Yukon. Topographic relief is moderate although the valleys are generally broad with a gentle slope. The elevation along creekline on the property ranges from 4000 feet up to 5000 feet although surrounding peaks rise to more than 6000 feet.

The climate is typified by cold winters with short, mild summers. Snow is present until early June over much of the property and year-round on some higher ridges. Summer is brief but temperatures are pleasant and rainfall is infrequent. Snow should be expected before October.

Vegetation consists mostly of sparse islands of stunted coniferous trees within large areas of thick brush. Willow grows abundantly near the creek and knee-high grasses occupy the numerous swampy areas. Thick sphagnum moss blankets the ground and, especially in drier areas, caribou moss is common. White spruce and fir predominate stands of timber which are spotty along the valley floor and more extensive on the adjoining slopes. Thick brush consisting of scrub willow extends well above the local treeline at 4500 feet.

Game is abundant in the area and includes large species such as caribou, moose, wolves and bear as well as a thriving beaver colony. Ptarmigan and several types of songbirds inhabit the underbrush and hawks feed on a variety of small rodents.

1.4 History of Livingstone Creek Gold Camp

Livingstone Gold Camp has been active since the discovery of placer gold on the South Big Salmon River in 1898. Remnants of the mining boom town that was established during the first decade of this century still exist and, indeed, some of the buildings are occupied by present-day placer miners. Production of gold from the camp during the early part of the century was estimated to be more than \$1,000,000. Of the ten gold producing creeks in the camp, Livingstone Creek has proven to be by far the richest.

Most of the Livingstone Creek gold has been mined from pre-glacial gravels deposited in the 1.2 km V-shaped canyon lower on the creek. Rusty coloured gravels derived from local rocks formed the base of unconsolidated gold-bearing material in the canyon. This pay-zone extended upstream from the canyon into a buried channel where gold was removed by driving adits southward from the present stream channel. Hydraulic mining was attempted as a final recovery step on the "buried channel" portion of the deposit but was abandoned after permafrost hampered the already marginal operation (Bostock and Lees, 1938).

Elevated gold prices over the past two years have resulted in renewed exploration and mining activity in the Livingstone camp. Four creeks in the camp were being actively mined during the summer of 1981 with several others showing promise. At Livingstone Creek, a hydraulic monitor was used to strip frozen overburden from a pay-zone located in "the canyon". Although the ground had previously been mined by underground excavations, a significant but undisclosed amount of gold was recovered.

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Livingstone camp placer gold is characteristically coarse; a third of the gold recovered from the Livingstone Creek discovery claim consisted of nuggets weighing more than an ounce. The largest nuggets reported by Bostock and Lees (1938) are 19 oz. and 18½ oz. Paystreaks are generally located on the bedrock surface, in crevices, and within the first 50 cm of pre-glacial gravels immediately overlying the bedrock.

1.5 Rationale

Yukon placer gold has historically been mined from pre-glacial fluvial sediments such as the White Channel gravels. More northerly areas (such as Dawson) escaped glaciation. However, the southern Yukon, including the Livingstone Creek area, was glaciated, and much of the original gold-bearing gravels were stripped.

Livingstone Creek placer gold deposits are located in areas protected from glaciation. The most prominent example occurs on the lower Livingstone where revived placer mining operations have recently recovered a substantial amount of coarse gold. Steep bedrock buttresses form a narrow V-shaped canyon at this point and it is considered that this topography would effectively shield the gravels from glacial erosion. If such a bedrock configuration were present in the upper Livingstone, similar gold deposits could reasonably be expected.

However, because the area is masked by a thick layer of recent fluvial and glacial deposits, a protective buttress of bedrock high is not immediately apparent.

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Bearing these considerations in mind, it was decided a seismic survey be conducted in an attempt to locate a near surface "high velocity" horizon indicative of bedrock. Survey lines were run down stream and across the valley in order to give both longitudinal and cross-sectional profiles. Such a survey would conceivably result in selection of a drill or shaft target in the most geologically favourable location.

2.0 PLACER LEASE 5609 ("4 Mile Lease")

2.1 Geomorphology

The four mile lease is typified by a broad, U-shaped valley profile along its whole length: the stream gradient averages 150 feet/mile (3%) on the lower three miles although this varies locally. In particular, on the lower mile of this lease, the stream gradient exhibits a subtle increase to about 250 feet/mile (5%).

Bench-like meander scars mark the broad valley floor indicating that the valley may have been occupied by a stream considerably larger than at present. Conceivably, a meltwater stream during the most recent glacial retreat could have produced these fluvial features.

Although there is no surface expression of a buried bedrock canyon, Livingstone Valley narrows at two points. Rock bluffs and felsenmeer near the lower end of the lease and approximately two miles up the lease may indicate a steepening of the bedrock subcrop into a V-shaped form. Seismic lines were placed so as to investigate this possibility.

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Surficial deposits in the valley consist largely of glaciofluvial sediments and till. Soil composed of large sub-rounded cobbles in a supporting matrix of coarse sand was noted over most of the valley floor. A blue-grey clayey silt was exposed in the creek bottom on the lower mile of the lease. The frost susceptible material was not frozen at this location, inferring that permafrost may not be present to any great extent. The silt, exposed in a seismic shot-hole, was fully saturated and sloughed into the hole quickly. At a depth of 1.5 m, the bottom of the excavation began to pipe, possibly indicating the presence of an aquifer beneath the silt.

Much of the valley floor is relatively flat and swampy. However, several dry "terraces" were noted on lower parts of the lease. The terraces reflect a marked change in the hydro-geological regime and present an interesting target. The possibility that the terraces represent a buried, high permeability channel or a bedrock high was investigated by the seismic survey.

3.0 SEISMIC SURVEY

3.1 Description and Results

The geophysical survey on the upper Livingstone Creek four mile placer lease consisted of 2 km of detailed refraction seismic work profiling the valley bottom. The survey was performed on the lower mile of the lease, partly along the "baseline" which was re-established for the purpose of staking placer claims (Figure 3).

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Further descriptive details and the results of the seismic survey on P.L. 5609 are presented in Appendix A.

4.0 SUMMARY AND CONCLUSIONS

Livingstone Creek Camp has historically been a strong producer of coarse placer gold. Although the upper Livingstone shows no placer gold production to date, further exploration is justified by elevated gold prices.

Favourable geological conditions for placer gold deposits are felt to exist in the area in the form of a buried bedrock canyon. Such a feature would protect gold-bearing gravels from glacial erosion.

A refraction seismic survey was undertaken in an attempt to detail and bedrock surface beneath the thick mask of glacial and fluvial sediments in the upper Livingstone Valley.

The results of the survey are given in the reports by Geo-Compu-Graph Inc. which is attached as Appendices A and B.

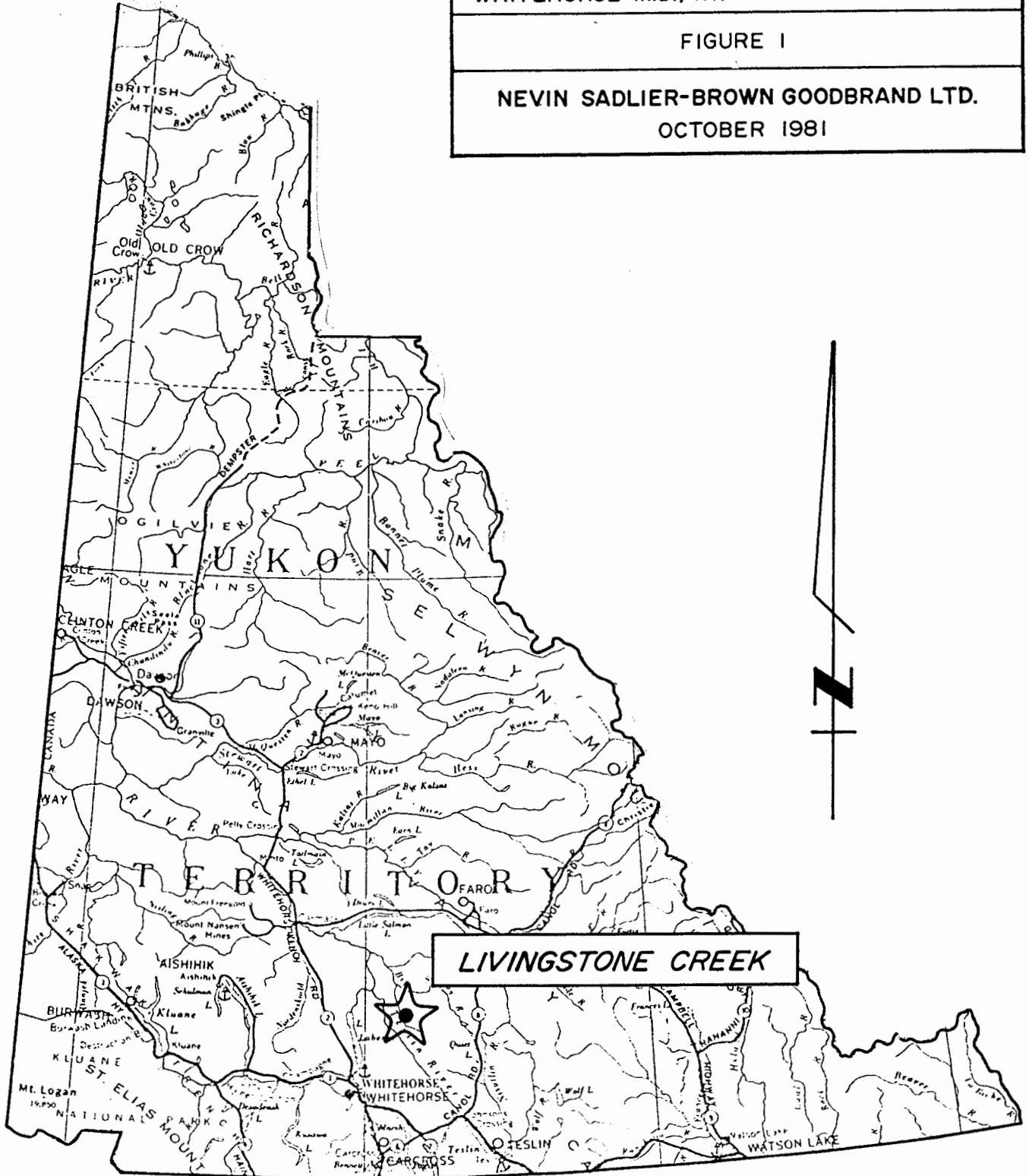
GEM RESOURCES LTD.

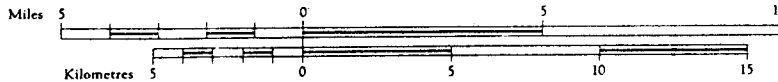
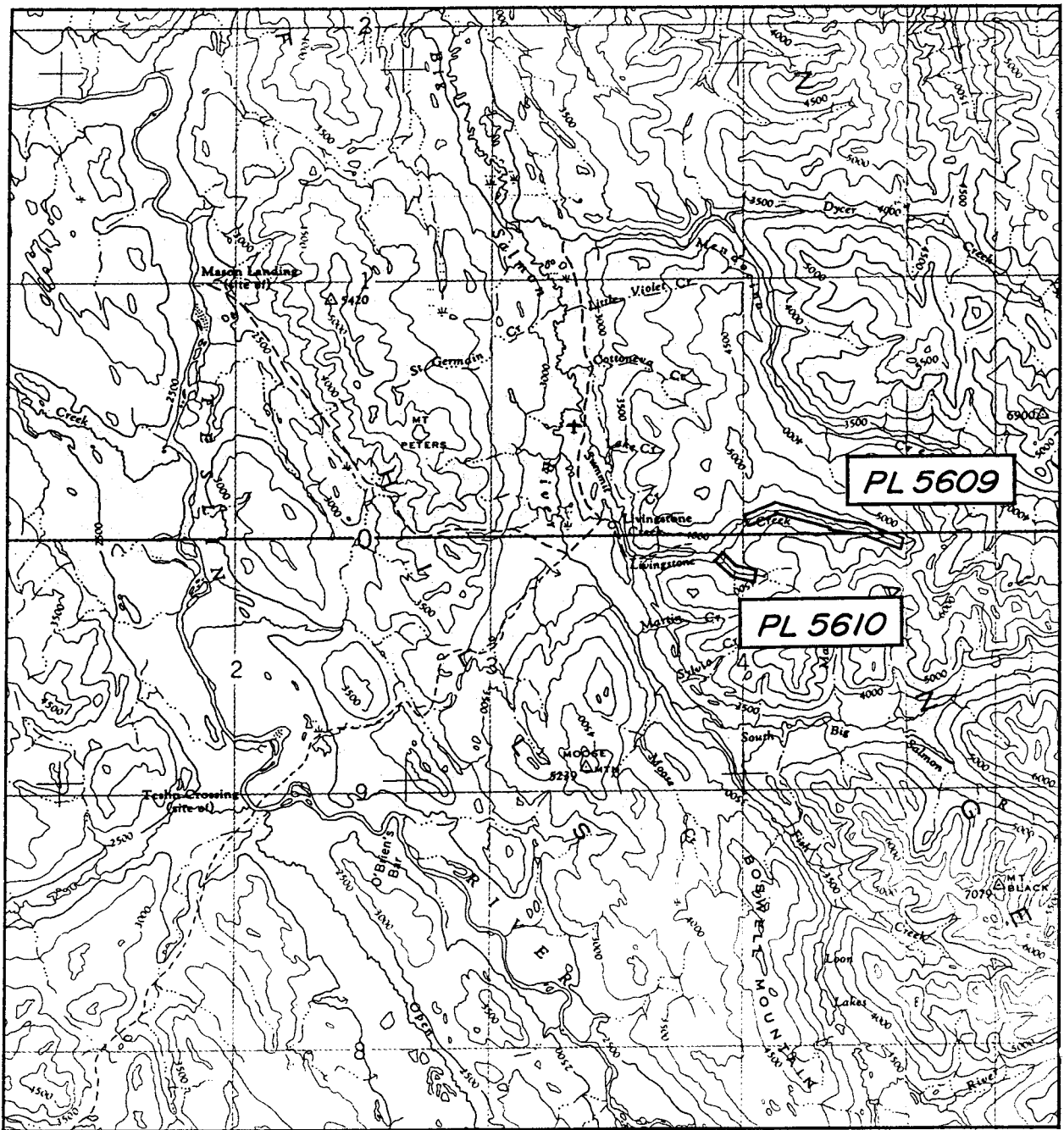
LIVINGSTONE CREEK
LOCATION MAP

WHITEHORSE M.D., Y.T.

FIGURE I

NEVIN SADLIER-BROWN GOODBRAND LTD.
OCTOBER 1981





GEM RESOURCES LTD.	
LIVINGSTONE CREEK LOCATION OF PLACER LEASES 5609 & 5610	
WHITEHORSE M.D., Y.T.	NTS MAP 105 E
FIGURE 2	SCALE 1:250,000
NEVIN SADLIER-BROWN GOODBRAND LTD. OCTOBER 1981	


APPROX. SCALE - METRES

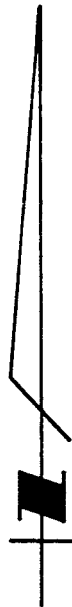


LIVINGSTONE CREEK

PL 5609
(4 MILE)

LEGEND

 SEISMIC TRAVERSE LINE



GEM RESOURCES LTD.

LIVINGSTONE CREEK
LOCATION OF SEISMIC
SURVEY LINES - PL 5609

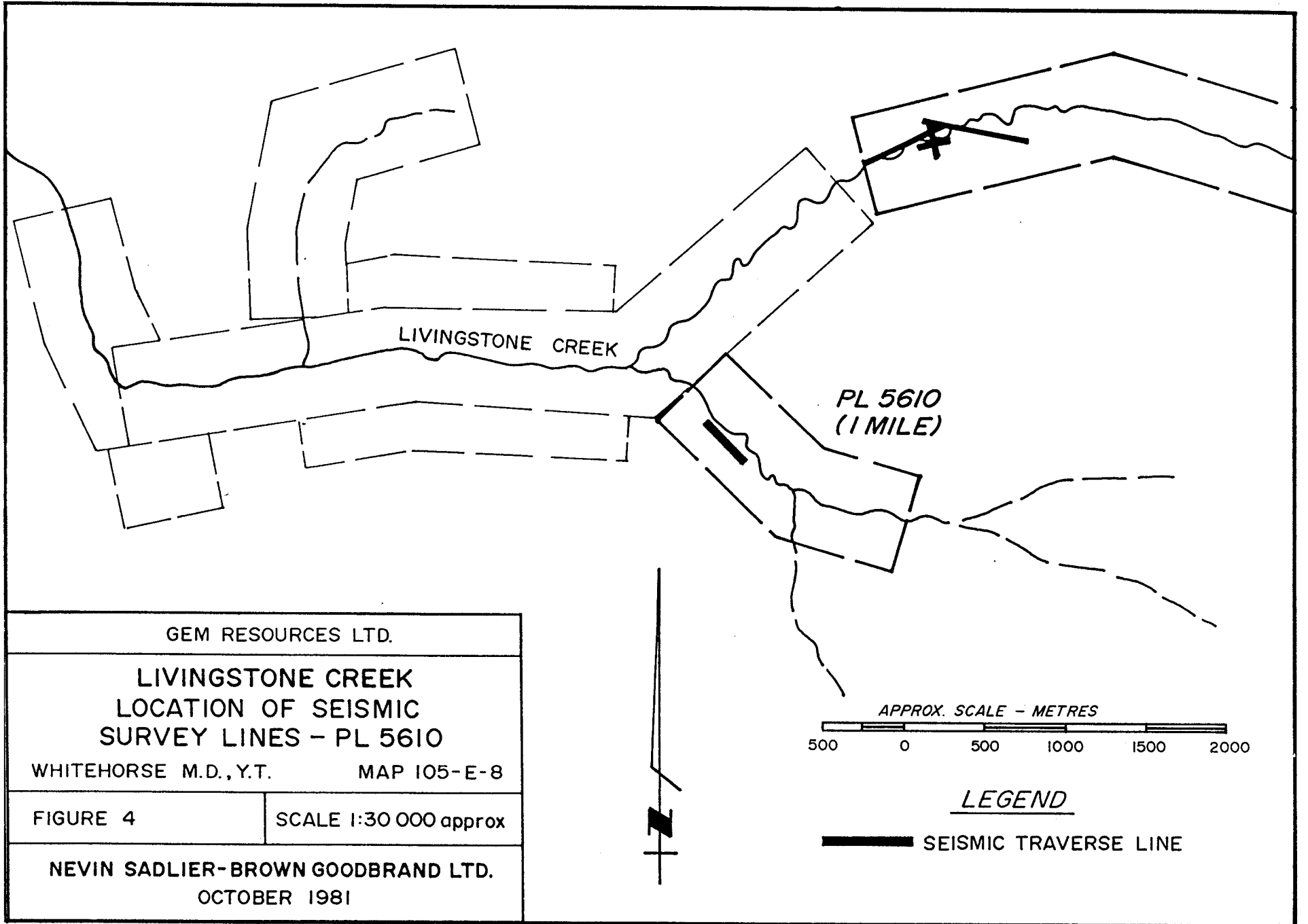
WHITEHORSE M.D., Y.T.

MAP 105-E-8

FIGURE 3

SCALE 1:30 000 approx

NEVIN SADLIER-BROWN GOODBRAND LTD.
OCTOBER 1981



GEM RESOURCES LTD.

**LIVINGSTONE CREEK
LOCATION OF SEISMIC
SURVEY LINES - PL 5610**

WHITEHORSE M.D., Y.T.

MAP 105-E-8

FIGURE 4

SCALE 1:30 000 approx

NEVIN SADLIER-BROWN GOODBRAND LTD.

OCTOBER 1981

Appendix A

Reconnaissance Seismic Refraction Surveying at
Livingstone Creek Placer Lease 5609,
Yukon Territory

**Reconnaissance Seismic Refraction Surveying
at Livingstone Creek
Placer Lease 5609
Yukon Territory**

Submitted to

**Granada Exploration Corporation
Vancouver, British Columbia**

by

**Geo-Compu-Graph, Inc.
Spokane, Washington**

**Principal in Charge of Project
Robert W. Lankston, Ph. D., P.G.**

September 25, 1981

Reconnaissance Seismic Refraction Surveying at Livingstone Creek
Placer Lease 5609
Yukon Territory

Submitted to

Granada Exploration Corporation
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Geo-Compu-Graph, Inc.
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Principal in Charge of Project
Robert W. Lankston, Ph. D., P. G.

September 25, 1981

Statement of Professional Qualifications

The geophysical field operations and data processing described in this report were conducted under my direct supervision. The techniques employed include commonly accepted and state-of-the-art procedures. The following list of credentials will support my competence as a geophysicist.

Education

- 1969 B. S. in Geology, Indiana University
- 1971 M. A. in Geology (geophysics specialization),
Indiana University
- 1975 Ph. D. in Geology (geophysics specialization),
University of Montana

Employment

Employment continuously since 1974 as a professional geophysicist by industrial companies and academic institutions.

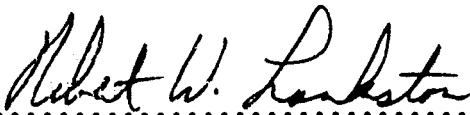
Registration

Certificate # 406, State of Idaho. Washington has no state registration requirements for geoscientists. Idaho registers geologists and geophysicists with one license.

Publications

Numerous publications in professional journals and reports to clients on gravity, magnetic, radiometric, and seismic surveying.

This report is respectfully submitted to Granada Exploration Corporation, September 25, 1981.



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Robert W. Lankston
Vice President
and Manager of the Geophysical
Systems Development Department
Geo-Compu-Graph, Incorporated

Table of Contents

	Page
List of Illustrations	ii
Introduction	1
Geologic Problem	2
Field Methods	2
Data Interpretation Technique	5
Interpretation	11
Conclusions and Recommendations	15
References Cited	17

List of Illustrations

	Page
1. Typical field record	3
2. Shooting geometry indicating geophone and shot point locations	4
3. Sketch map indicating approximate positions of recording locations	6
4. Time distance graph of all data recorded from Locations 4 and 5	7
5. Composited time distance data from Locations 4 and 5	9
6. Velocity analysis graph for composited data from Locations 4 and 5	10
7. Computer generated profile based upon composited data from Locations 4 and 5	12
8. Results of interpretation of data frm Valley Cross Line . .	13
9. Results of interpretation of data from Road Ext Line	14

Reconnaissance Seismic Refraction Surveying at Livingstone Creek Yukon Territory

Introduction

Seismic refraction surveying with portable seismographs has been used for more than 25 years to determine the depth to bedrock under unconsolidated alluvium or colluvium. Seismic refraction surveying has among its strengths relatively low cost for the precision of the subsurface data that are obtained. Depth precisions of less than +/- one meter can often be expected in a properly executed survey.

Seismic refraction surveying was undertaken in the upper reaches of the Livingstone Creek drainage approximately 60 miles northeast of Whitehorse in The Yukon Territory. The refraction survey was conducted in an effort to map the configuration of the bedrock in the valley. Field operations commenced August 11, 1981 and were completed August 21, 1981.

The present report outlines the general considerations of the design of the Livingstone Creek survey, field operations, and the results of interpretation of a portion of the data collected. Interpretation of the records not mentioned in this report is continuing. It is not anticipated, however, that the results of the interpretation of the remaining records will be significantly different from the results herein reported.

Geologic Problem

Gold is believed to exist in the placer deposits at Livingstone Creek which is situated approximately 60 miles northeast of Whitehorse in The Yukon Territory. In this particular drainage, the gold is believed to reside in alluvial deposits that were not eroded by glacial action. Such remnant deposits are believed to rest on the down stream side of "paleo-waterfalls". The paleo-waterfalls would have been bedrock buttresses over which the glaciers would have ridden. Any alluvial deposits on the down stream side of the waterfalls would have been protected by the bedrock high and thus the gold bearing strata would not have been removed by the glacial action. Depending upon the actual configuration of the bedrock, gold bearing gravels might have been spared glacial erosion at locations other than downstream from the bedrock buttress.

Seismic refraction surveying was undertaken in the upper reaches of Livingstone Creek in an effort to determine the thickness of unconsolidated deposits and to discover any paleo-waterfalls.

Field Methods

The seismic refraction surveying that was conducted in the Livingstone Creek Valley incorporated an EG&G geoMetrics ES-1210F seismograph. This is a twelve channel, signal enhancement instrument. A twelve channel system allows the earth vibrations at twelve discrete locations to be recorded simultaneously. The signal enhancement feature of the system was not employed because explosives were used as an energy source. Figure 1 is a typical seismogram recorded during the Livingstone Creek Project. The first break refraction arrivals are of the highest quality.

The objective of the refraction survey was to map bedrock which was believed to be at depths as great as 30 meters below the surface. The design of seismic refraction surveys is discussed in detail in many geophysics textbooks (e. g., Telford, et al., 1976). The survey in the Livingstone Creek Valley incorporated five shots per set-up of the twelve channel seismic system (Fig. 2). The twelve channel seismograph cable was extended such that the distance between the successive geophones was 10 meters. This gave a total spread of 110 meters. The total distance between a shot placed five meters off of the end of the geophone cable and the twelfth geophone was 115 meters. The expected depth of penetration of the signals that could be recorded with this shooting geometry would be approximately 35 meters. This geometry, therefore, would satisfy the need to penetrate to a target depth of 30 meters. The multiplicity of data obtained by recording five shots per geophone spread reduces ambiguity in defining the number of refracting horizons during the interpretation phase of the project.

The multiplicity of data requires that a computer assist in the

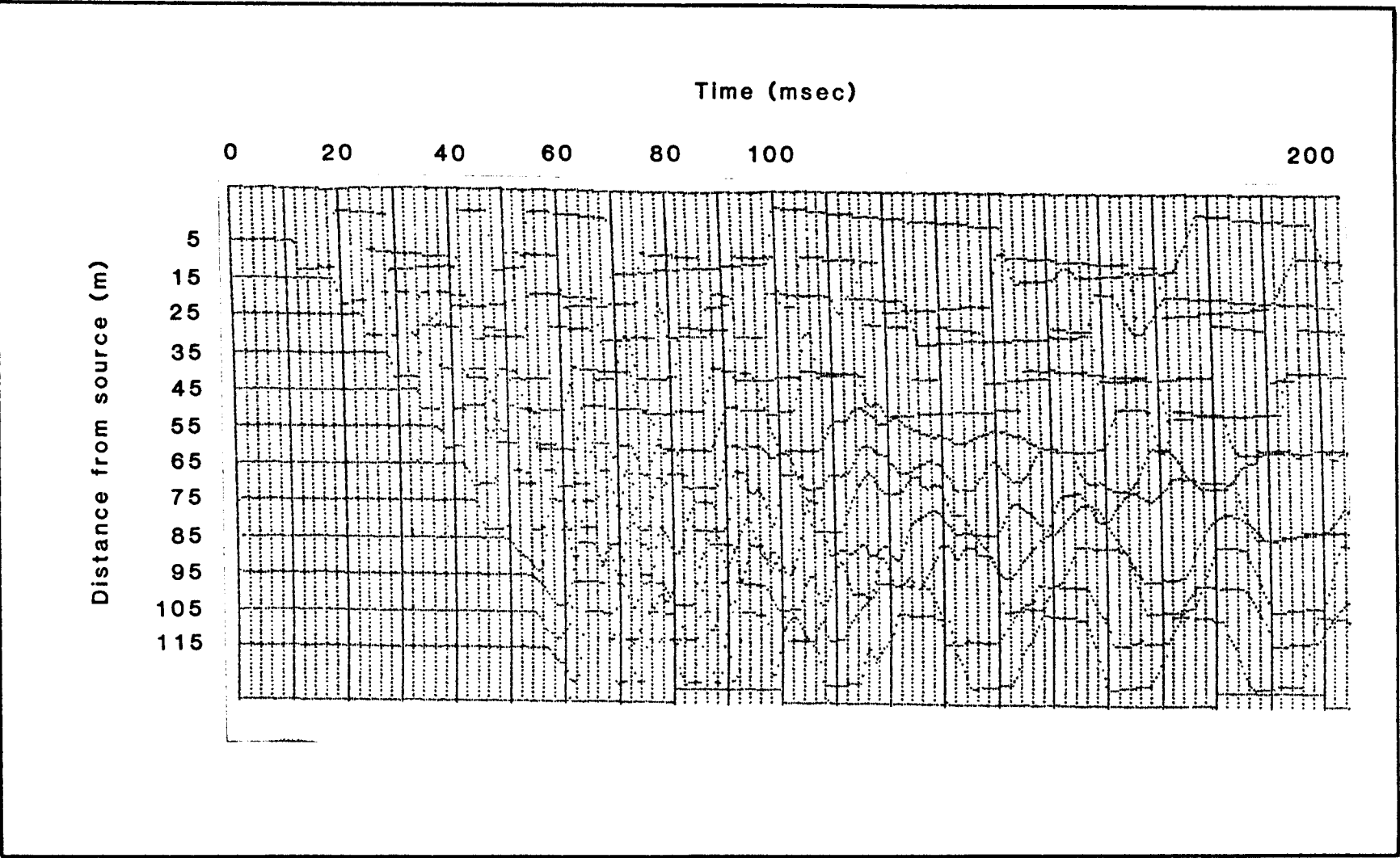


Figure 1. Typical field record. Record is from Location 19, forward shot, 5 meters between source and geophone 1.

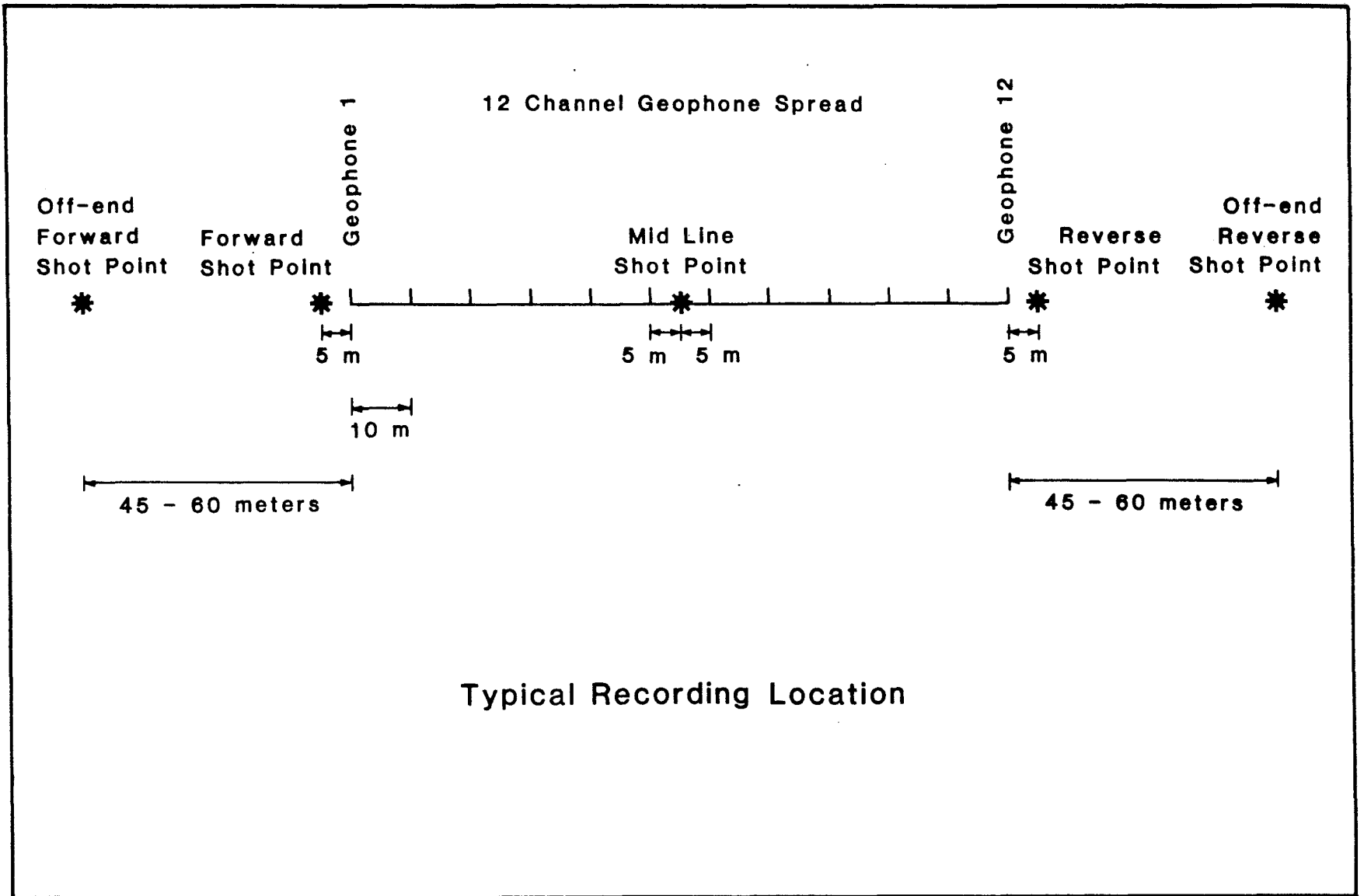


Figure 2. Shooting geometry indicating geophone and shot point locations.

interpretation of the data. Therefore, only minimal consideration was given to the data in the field. In the field, each record (e. g., Fig. 1) was inspected to determine that first breaks were obvious. Identifying first breaks was not a problem because the explosive signal sources provided sufficient energy to give good first breaks in almost every instance. Time versus distance graphs were made for selected field records. However, this was primarily a quality control effort and was not intended to yield geologic results. Manual plotting of a portion of the refraction data is time consuming and unless all of the shots for each geophone spread are plotted, erroneous thoughts can be generated with respect to the velocity of refracting horizons and the apparent dip and depth of the horizons.

Figure 3 is a sketch map indicating the approximate positions of the locations of geophone spreads. Each spread comprises twelve geophones, 10 meters apart. Figure 3 identifies the approximate position of geophone 1 in each spread. The profiles that are presented later in this report present the lateral positions of the geophones more precisely than Figure 3.

Data Interpretation Technique

The seismic refraction data collected in the upper reaches of the Livingstone Creek Valley were interpreted with the aid of a microcomputer executing programs which belong to The GREMLIN™ Package. The GREMLIN™ Package is a set of programs that employs a technique known as the generalized reciprocal method of interpreting seismic refraction data (Palmer, 1980). This technique requires that sufficient data be recorded in the field to detail each refracting horizon. Depending upon the actual geology encountered, this requirement should have been met by the field recording procedure discussed above.

The GREMLIN™ Programs perform two basic functions. The first function is to allow the determination of the seismic velocity of each refracting horizon. The second function is to present a profile of the subsurface. The software can handle considerable complexity in the geology along each refraction line. As many as six different horizons can be evaluated. In these six horizons, as many as 10 lateral velocity variations can be taken into account. The present study did not encounter any situations that were this complex.

The first stage in processing the refraction data with The GREMLIN™ Package is to measure the first break arrival times for each of the twelve traces on each of the five records for each recording location. This task is aided by the computer. Each record, in turn, is placed on a sensitized digitizer surface. The operator touches a stylus to the first break position on each trace of the record. The computer automatically scales the touched point on the sensitized surface to arrival time in milliseconds. Moreover, the arrival time and offset distance are stored on disk, a table of offset distances and arrival times is printed, and a time distance graph is plotted (Fig. 4). All of

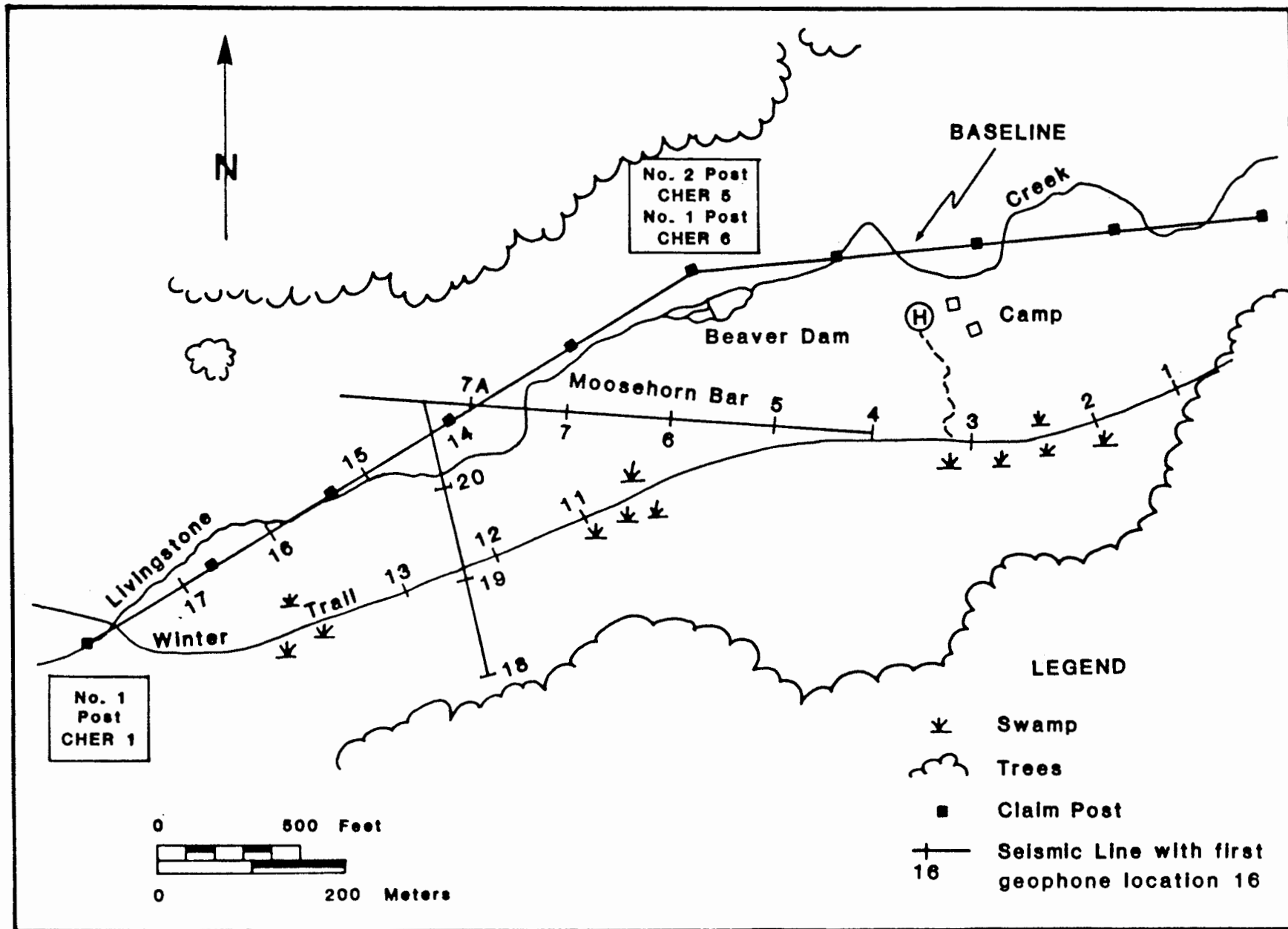


Figure 3. Sketch map indicating positions of recording locations.

TIME DISTANCE GRAPH

LINE NAME....ROAD EXT

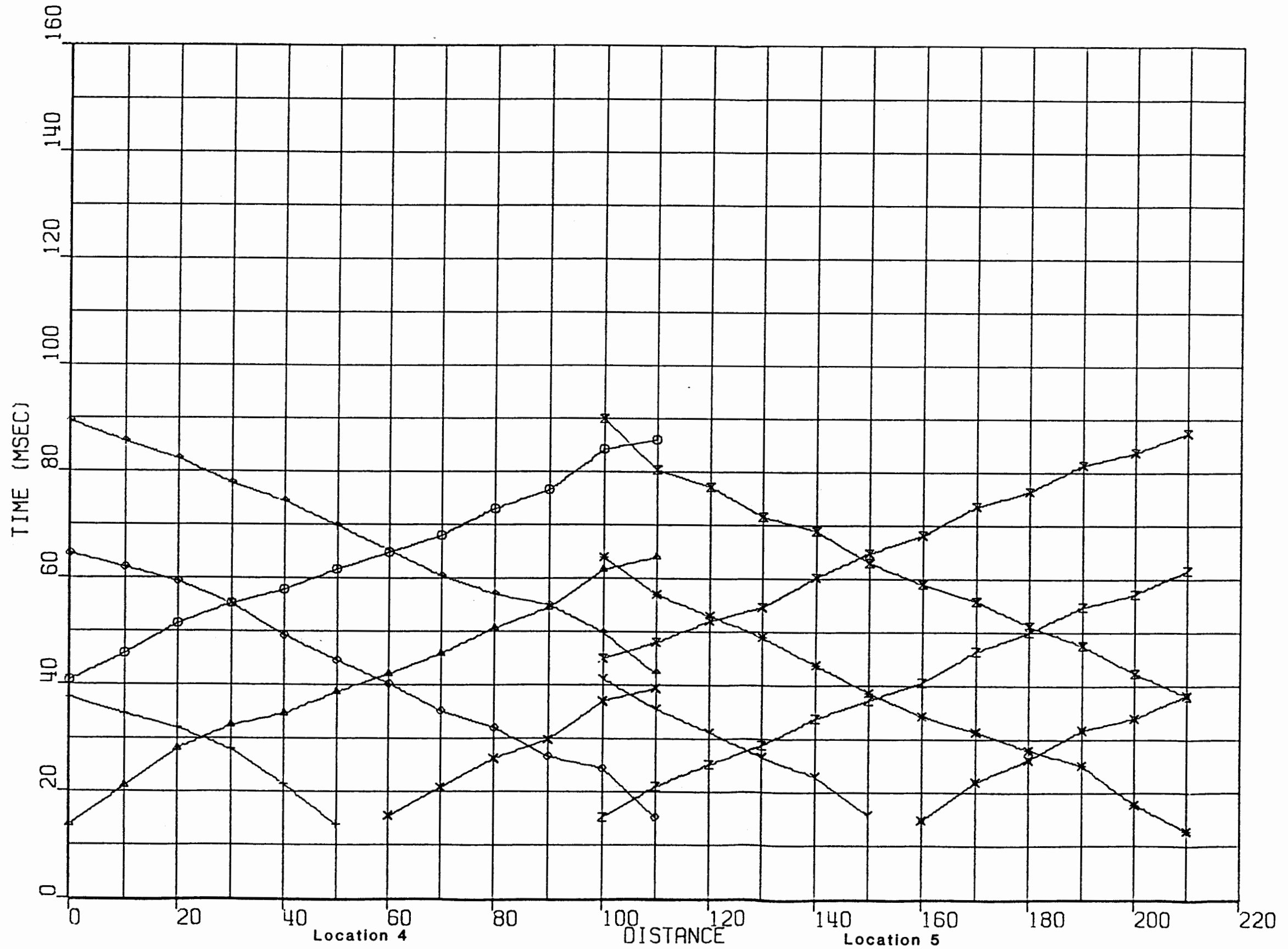


Figure 4. Time distance graph of all data recorded from Locations 4 and 5.

this occurs almost simultaneously as far as the operator is concerned. The five records from one shooting location can be timed in this manner in approximately fifteen minutes. Manually timing, tabulating, and plotting a similar amount of data would require 30 to 60 minutes.

The second stage in the interpretation is to determine from the time distance graph how many refractors are being mapped by the refracted signals. This task is made easier by the multiplicity of data. For example, in Figure 4, the interpreter notes that the three curves representing reverse shots are nearly parallel. This indicates that all of the signals giving rise to first breaks are returning to the surface from the same horizon in the subsurface. The change in slope of the curves at 20 meters might be mistakenly interpreted as indicating a deeper refracting horizon having a higher velocity if only one of the curves had been recorded. In order for the change in slope to indicate a deeper, faster refracting horizon, the change in slope would have occurred at different lateral positions on the three reverse curves respectively. Therefore, in this instance, the interpreter can state that only one refracting horizon is being mapped.

Because of the overlap in coverage between Location 4 and Location 5 (Fig. 4), the interpreter is able to further state that the horizon that is observed across Location 4 continues across Location 5. The interpreter, thus far, has only made a qualitative statement about the number of refractors and their lateral extent. The next step is to quantify the velocity of the material overlying the refracting horizon and the velocity of the refracting horizon itself. Because the arrivals from Locations 4 and 5 have been determined to be from the same horizon, the arrival time data from the forward and reverse shots, respectively, of the two locations can be composited in a technique known as "phantoming" (Redpath, 1973). The composited arrival time data are then presented on a time distance graph (Fig. 5).

The time distance graph is studied to make sure that no errors were made in entering the composited data into the computer. The next stage is the analysis of the refractor velocity. The computer generates the refractor velocity functions following the equations presented by Palmer (1980). Figure 6 is the velocity analysis graph. The nature of the points plotted for the XY equal 10 case are determined by the interpreter to best define the velocity of the refracting horizon. The inverse of the slope of the line through these points gives the refractor velocity, in this case 2400 meters per second.

The velocity of the material overlying the refracting horizon is not defined as well as that of the refracting horizon. However, in this case, the velocity has a minimum value of 400 meters per second. For interpretation purposes, a velocity of 1000 meters per second is used for this upper layer. Using this velocity in the analysis procedure will give greater depths than using 400 meters per second. However, 1000 meters per second is probably a more realistic value for moist (not saturated) alluvium.

The final stage in the computer assisted data interpretation is the

TIME DISTANCE GRAPH
 LINE NAME...ROAD EXT.PAIR 1

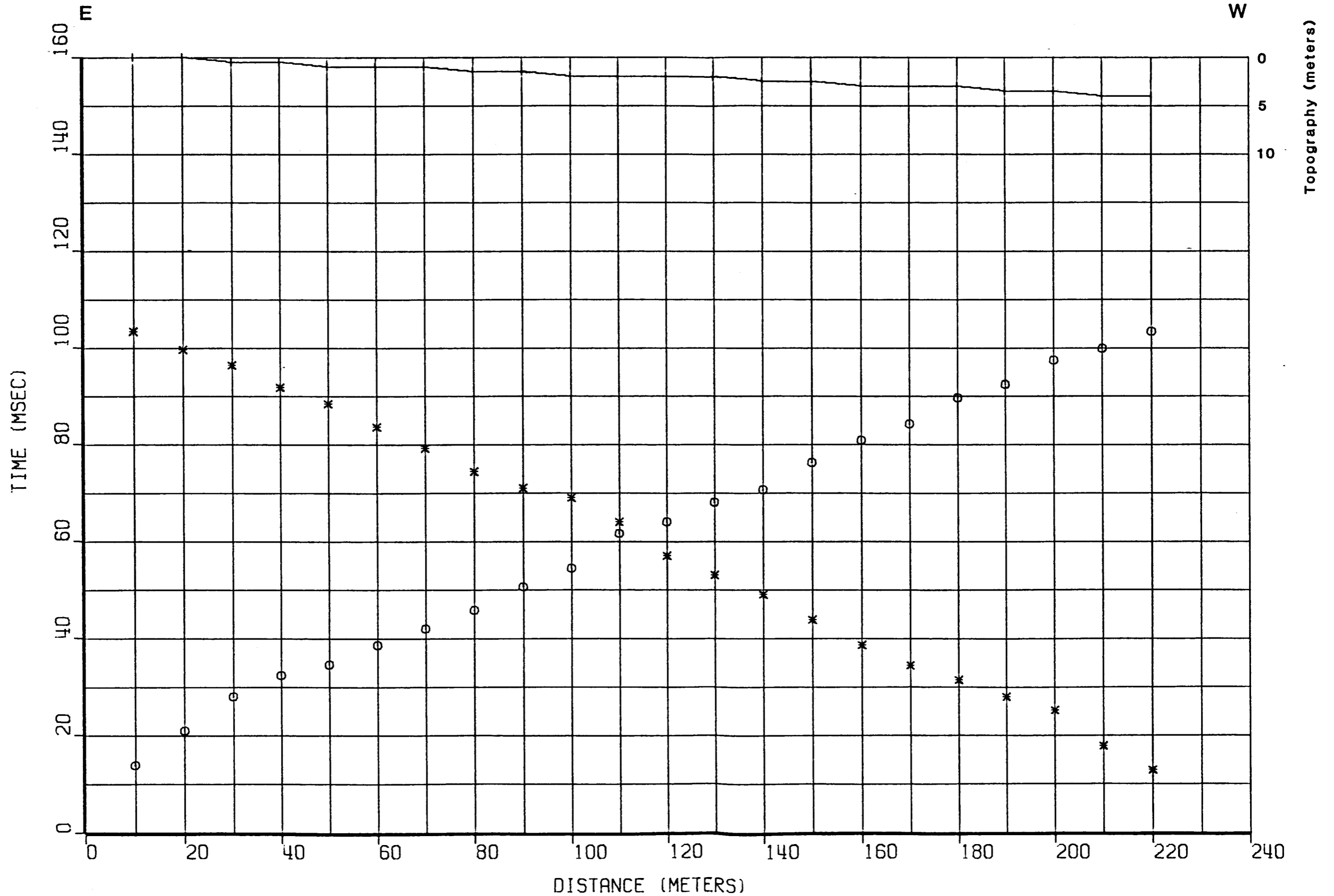


Figure 5. Compositied time distance data from Locations 4 and 5.

VELOCITY ANALYSIS GRAPH

LINE NAME....ROAD EXT.PAIR 1

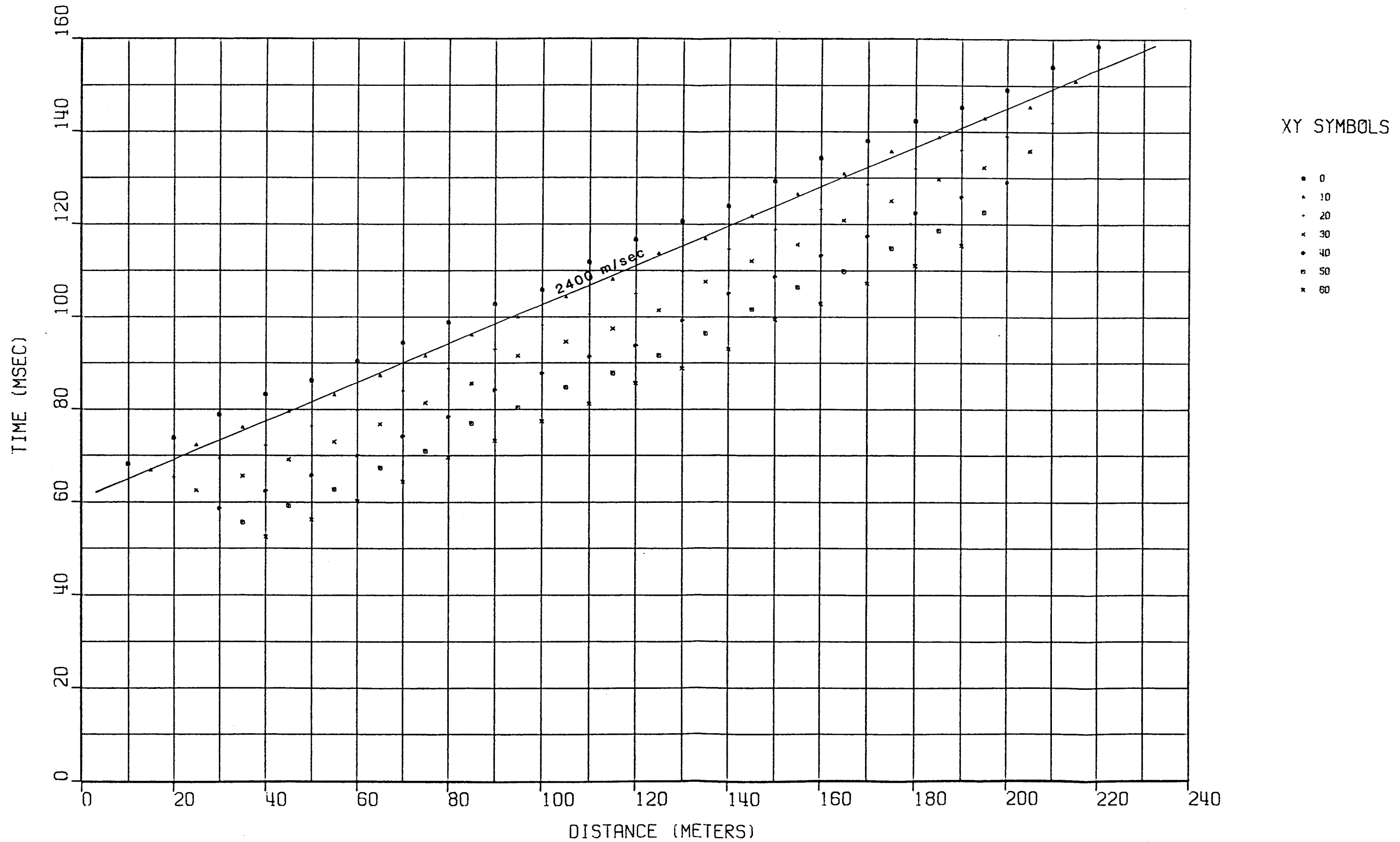


Figure 6. Velocity analysis graph for composited data from Locations 4 and 5.

generation of the cross section of the earth based upon the refraction arrivals (Fig. 7). The cross section presents the surface topography, and arcs that represent the possible position of the refracting horizon below each geophone. The refracting surface is the smooth curve that connects tangent lines between the arcs. In the present example, only one refracting horizon is indicated by the refraction data. If more than one layer rested over the refracting horizon, these would each have been interpreted in the general manner described in this section. The final plot would have all of the horizons plotted.

(GREMLIN is a trademark of Geo-Compu-Graph, Inc.)

Interpretation

Two lines have been interpreted using the computer assisted interpretation technique described above. These lines are named Valley Cross (valley cross section) and Road Ext (road extension). The recording Locations are 18, 19, and 20 and Locations 4, 5, 6, 7, and 7A, respectively (Fig. 3)

Both lines indicate but one refracting horizon with a velocity of 2400 meters per second. This velocity is too slow for competent bedrock although fractured bedrock could exhibit such a slow velocity. The velocity is higher than that normally considered for water saturated alluvium. The velocity is also too slow for permafrost. Data were collected on Placer Lease 5610 approximately one mile southwest of the presently described survey at an area of known permafrost. The velocity recorded there was 2800 meters per second.

The refracting horizon with the velocity of 2400 meters per second is interpreted to be a compacted clay horizon. This could be water lain clay or it could be glacial till. A blue-black clay was exposed at one shot location after explosion of the dynamite. This shot point is at distance 265 on the Valley Cross line (Fig 8). The depth of the refractor at this location is approximately one meter.

Figures 8 and 9 present the interpretations of Valley Cross and Road Ext lines, respectively. The time distance graphs do not give any indication of deeper refracting horizons. The data were recorded such that horizons at depths as great as 50 meters would be detected. Two conclusions can be drawn from the failure to detect a faster (i. e., bedrock) refractor. Either the bedrock is greater than 50 meters below the surface or a fundamental requirement of refraction surveying, i. e., that each succeeding deeper horizon have a greater velocity than the horizon overlying it, is not being met by the geology. A relatively thin layer of higher velocity clay overlying lower velocity sand and gravel would virtually preclude detection of the bedrock.

Fortuitously, the record from the long offset forward shot from Location 7 exhibited a set of waveforms that could be reflection signals.

DEPTH SECTION

LINE NAME....ROAD EXT.PAIR 1

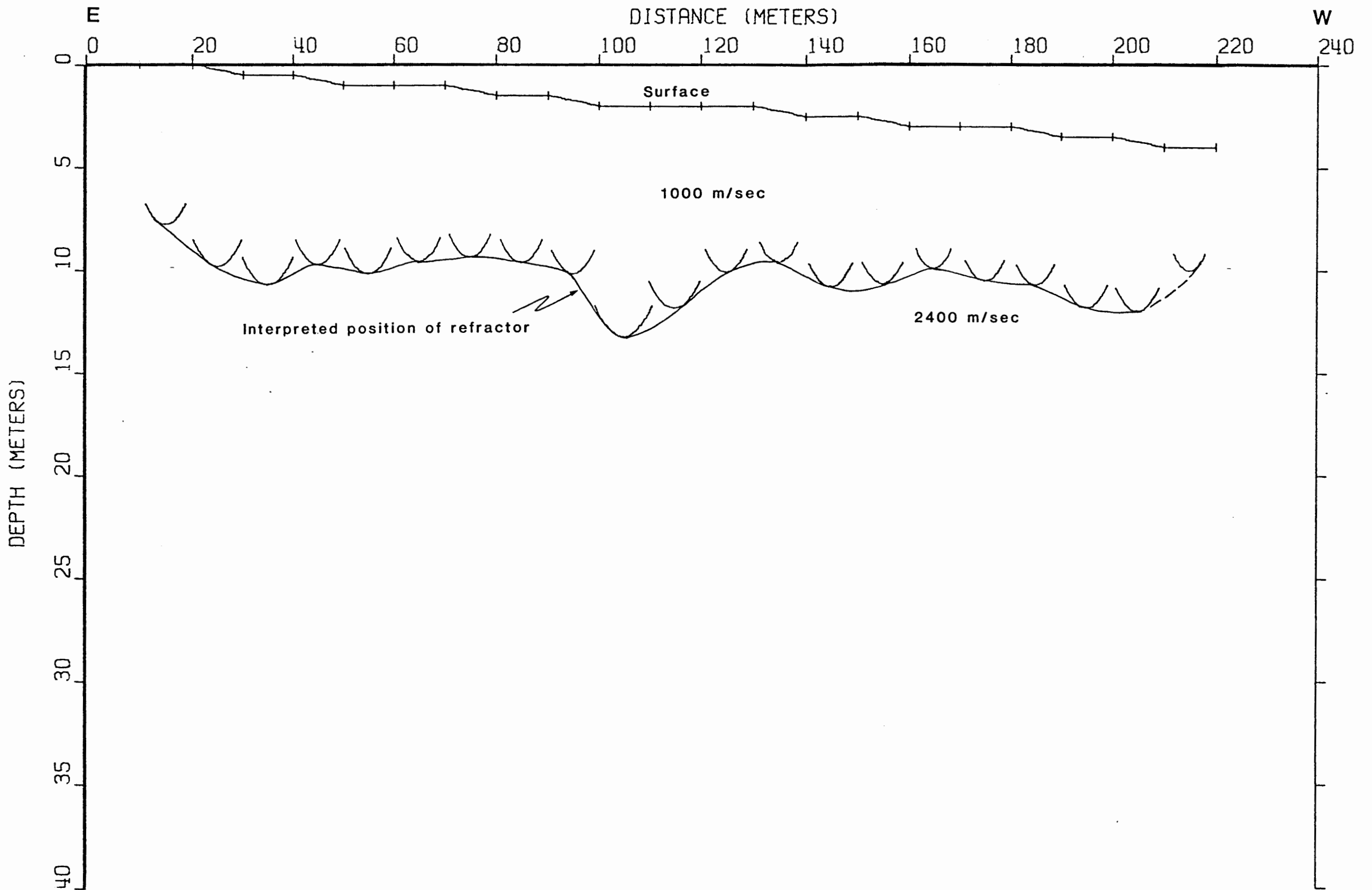


Figure 7. Computer generated profile based upon composited data from Locations 4 and 5.

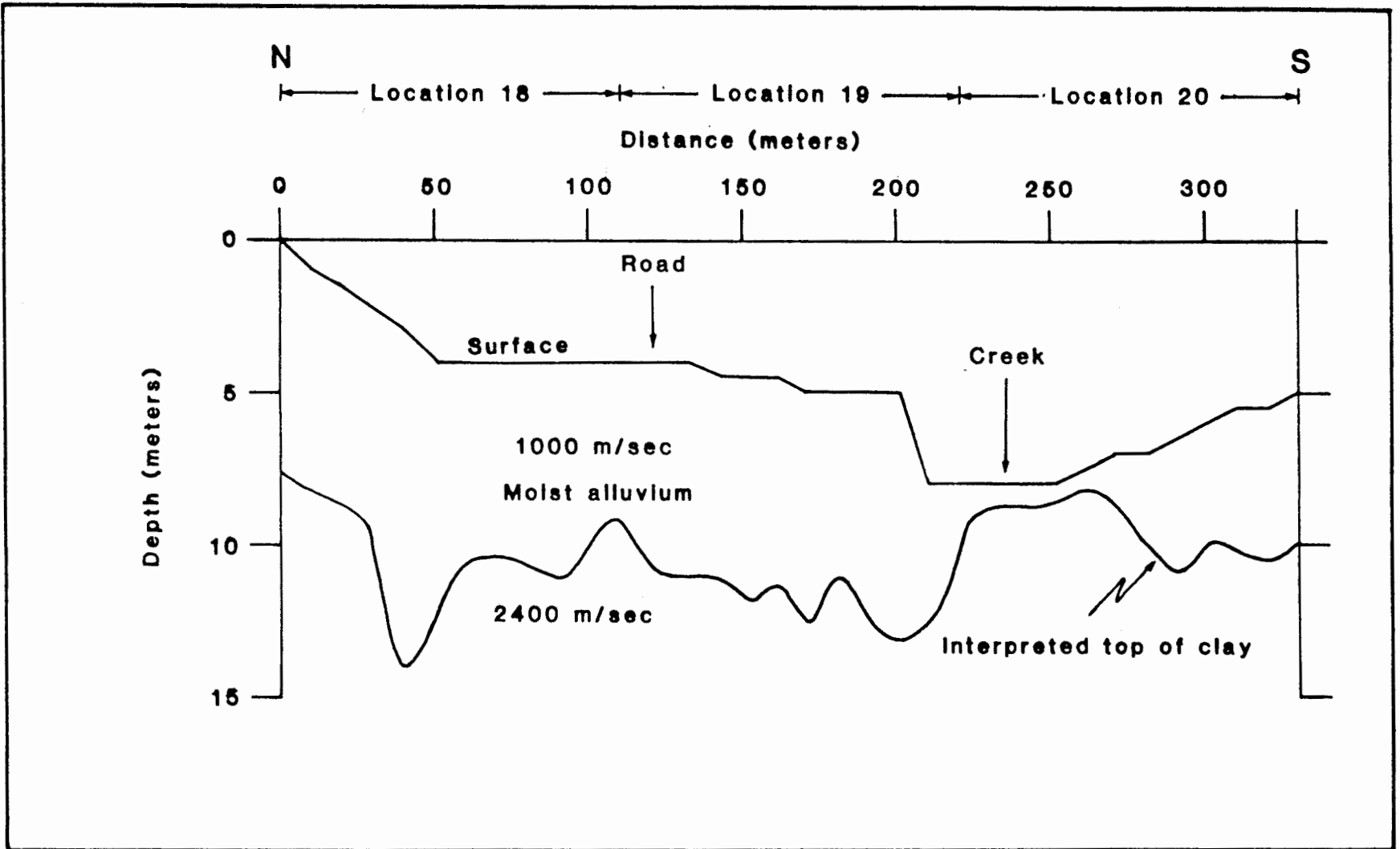


Figure 8. Results of Interpretation of data from Valley Cross Line.

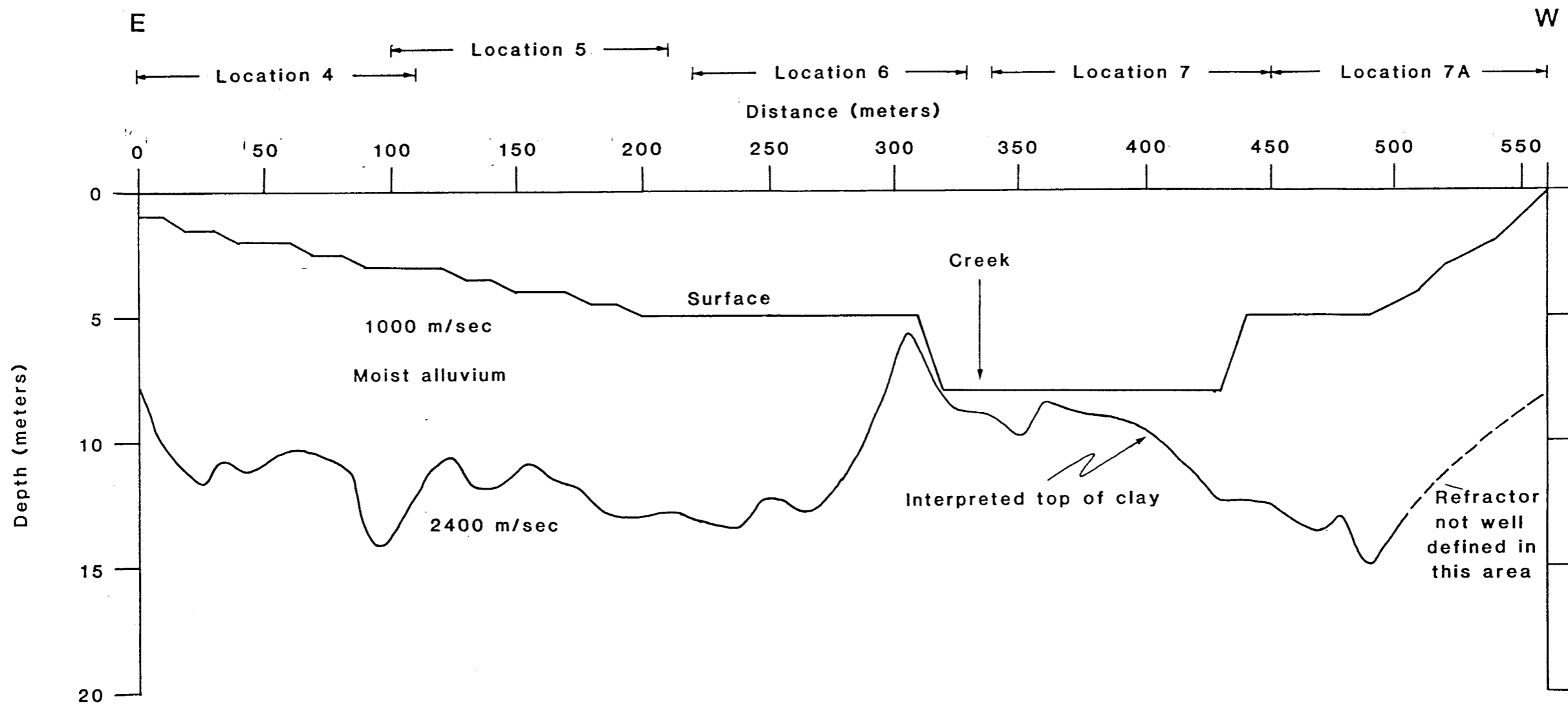


Figure 9. Results of interpretation of data from Road Ext Line.

Because the survey was not designed to record reflections, the signals are not as clear as would be desired. However, by interpreting the set of waveforms as if they were reflection arrivals, a depth of 56 meters is calculated. The average velocity of the section overlying the reflecting horizon is calculated to be 2085 meters per second. These figures pose an interesting situation. If the velocity of the near surface clay is 2400 meters per second, and the average velocity of the entire section is 2085 meters per second, the suggestion that the clay is a thin layer and is underlain by slower material, perhaps sand and gravel, is somewhat substantiated.

Data recorded at Locations 11, 12, and 13 had more attention given to identification of reflection signals. Signals do occur on the records from these locations that may be reflections. A detailed evaluation of these signals has not been completed. However, at Location 11, a reflecting horizon may exist at a depth of 43 meters. The average velocity to this horizon is approximately 1275 meters per second. This velocity is significantly slower than the average velocity determined from Location 7. However, average velocity can only be used in a general way in comparing results from one site to another.

Conclusions and Recommendations

The results of the interpretation of two intersecting refraction lines indicate that an extensive clay horizon underlies much of the lower one mile of the four mile long lease in Livingstone Creek Valley. Preliminary inspection of signals that appear to be reflections on selected records suggest that bedrock may be forty to fifty meters below the surface in this area.

Because the existence of a paleo-waterfall in this area is at present speculation, gravity surveying would be recommended for locating the approximate position of any such waterfall structures. The seismic methods are high precision techniques. Once a feature of interest is located, the seismic methods would allow it to be defined in detail. However, the seismic methods are slow when applied to locating the feature of interest in the first place.

Gravity surveying, on the other hand, has reduced depth and position resolving power, but it is more efficient in an environment where gross bedrock changes under alluvium or till must be located. If further work in Livingstone Creek aimed at locating bedrock highs in the subsurface is planned, consideration should be given to the gravity method.

Future seismic work in the Livingstone Creek drainage should incorporate faster evaluation of the data whether refraction or reflection. A microcomputer based processing system could be set up at the field camp with proper attention to power needs and shelter from the elements. Alternatively, at least for refraction surveying, a processing center could be established at Whitehorse. The first break data could be transmitted by radio to the processing center with the results returned

the next day. Such turnaround would have alerted the field party in the present study to consider switching from refraction to reflection surveying or abandonment of the area being studied in order to try a new area.

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Appendix B

Reconnaissance Refraction Seismic Surveying at
Livingstone Creek Placer Lease 5610,
Yukon Territory

**Reconnaissance Seismic Refraction Surveying
at Livingstone Creek
Placer Lease 5610
Yukon Territory**

Submitted to

**Granada Exploration Corporation
Vancouver, British Columbia**

by

**Geo-Compu-Graph, Inc.
Spokane, Washington**

**Principal in Charge of Project
Robert W. Lankston, Ph. D., P. G.**

September 25, 1981

Reconnaissance Seismic Refraction Surveying at Livingstone Creek
Placer Lease 5610
Yukon Territory

Submitted to

Granada Exploration Corporation
Vancouver, British Columbia

by

Geo-Compu-Graph, Inc.
Spokane, Washington

Principal in Charge of Project
Robert W. Lankston, Ph. D., P. G.

September 25, 1981

Statement of Professional Qualifications

The geophysical field operations and data processing described in this report were conducted under my direct supervision. The techniques employed include commonly accepted and state-of-the-art procedures. The following list of credentials will support my competence as a geophysicist.

Education

- 1969 B. S. in Geology, Indiana University
- 1971 M. A. in Geology (geophysics specialization),
Indiana University
- 1975 Ph. D. in Geology (geophysics specialization),
University of Montana

Employment

Employment continuously since 1974 as a professional geophysicist by industrial companies and academic institutions.

Registration

Certificate # 406, State of Idaho. Washington has no state registration requirements for geoscientists. Idaho registers geologists and geophysicists with one license.

Publications

Numerous publications in professional journals and reports to clients on gravity, magnetic, radiometric, and seismic surveying.

This report is respectfully submitted to Granada Exploration Corporation, September 25, 1981.


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Robert W. Lankston
Vice President
and Manager of the Geophysical
Systems Development Department
Geo-Compu-Graph, Incorporated

Table of Contents

	Page
List of Illustrations	ii
Introduction	1
Geologic Problem	2
Field Methods	2
Data Interpretation Technique	5
Interpretation	10
Conclusions and Recommendations	10
References Cited	12

List of Illustrations

	Page
1. Typical field record	3
2. Shooting geometry indicating geophone and shot point locations	4
3. Time distance graph of all data recorded from Locations 8 and 9	6
4. Time distance data from Location 8	8
6. Velocity analysis graph for time distance data from Location 8	9

Reconnaissance Seismic Refraction Surveying at Livingstone Creek Yukon Territory

Introduction

Seismic refraction surveying with portable seismographs has been used for more than 25 years to determine the depth to bedrock under unconsolidated alluvium or colluvium. Seismic refraction surveying has among its strengths relatively low cost for the precision of the subsurface data that are obtained. Depth precisions of less than +/- one meter can often be expected in a properly executed survey.

Seismic refraction surveying was undertaken in the upper reaches of the Livingstone Creek drainage approximately 60 miles northeast of Whitehorse in The Yukon Territory. The refraction survey was conducted in an effort to map the configuration of the bedrock in the valley. Field operations on Placer Lease 5610 were conducted on August 16, 1981.

The present report outlines the general considerations of the design of the Livingstone Creek survey, field operations, and the results of the interpretation of the data collected.

Geologic Problem

Gold is believed to exist in the placer deposits at Livingstone Creek which is situated approximately 60 miles northeast of Whitehorse in The Yukon Territory. In this particular drainage, the gold is believed to reside in alluvial deposits that were not eroded by glacial action. Such remnant deposits are believed to rest on the down stream side of "paleo-waterfalls". The paleo-waterfalls would have been bedrock buttresses over which the glaciers would have ridden. Any alluvial deposits on the down stream side of the waterfalls would have been protected by the bedrock high and thus the gold bearing strata would not have been removed by the glacial action. Depending upon the actual configuration of the bedrock, gold bearing gravels might have been spared glacial erosion at locations other than downstream from the bedrock buttress.

Seismic refraction surveying was undertaken in the upper reaches of Livingstone Creek in an effort to determine the thickness of unconsolidated deposits and to discover any paleo-waterfalls.

Field Methods

The seismic refraction surveying that was conducted in the Livingstone Creek Valley incorporated an EG&G geoMetrics ES-1210F seismograph. This is a twelve channel, signal enhancement instrument. A twelve channel system allows the earth vibrations at twelve discrete locations to be recorded simultaneously. The signal enhancement feature of the system was not employed because explosives were used as an energy source. Figure 1 is a typical seismogram recorded during the Livingstone Creek Project. The first break refraction arrivals are of the highest quality.

The objective of the refraction survey was to map bedrock which was believed to be at depths as great as 30 meters below the surface. The design of seismic refraction surveys is discussed in detail in many geophysics textbooks (e. g., Telford, et al., 1976). The survey in the Livingstone Creek Valley incorporated five shots per set-up of the twelve channel seismic system (Fig. 2). The twelve channel seismograph cable was extended such that the distance between the successive geophones was 10 meters. This gave a total spread of 110 meters. The total distance between a shot placed five meters off of the end of the geophone cable and the twelfth geophone was 115 meters. The expected depth of penetration of the signals that could be recorded with this shooting geometry would be approximately 35 meters. This geometry, therefore, would satisfy the need to penetrate to a target depth of 30 meters. The multiplicity of data obtained by recording five shots per geophone spread reduces ambiguity in defining the number of refracting horizons during the interpretation phase of the project.

The multiplicity of data requires that a computer assist in the

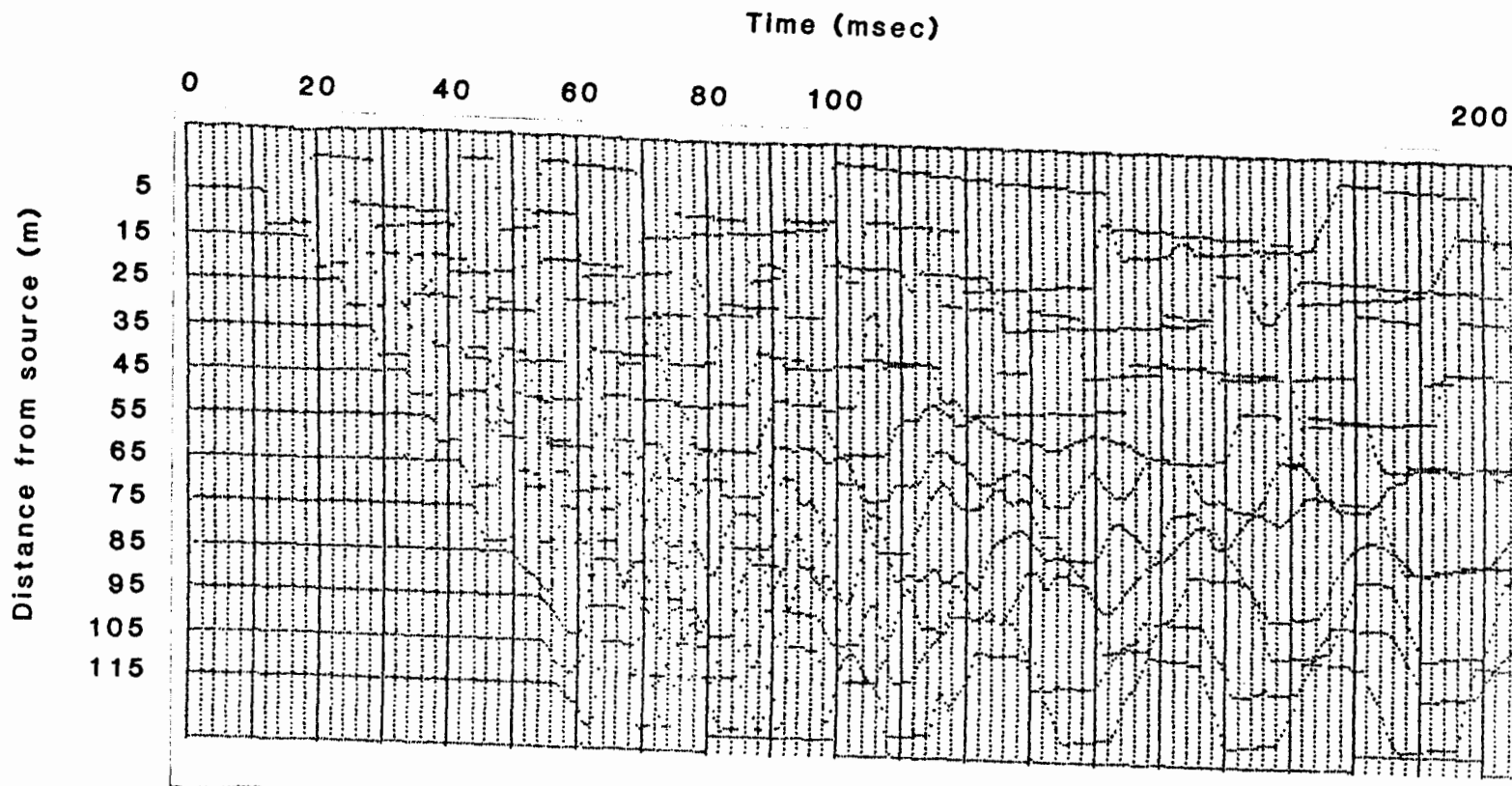


Figure 1. Typical field record. Record is from Location 19, forward shot, 5 meters between source and geophone 1.

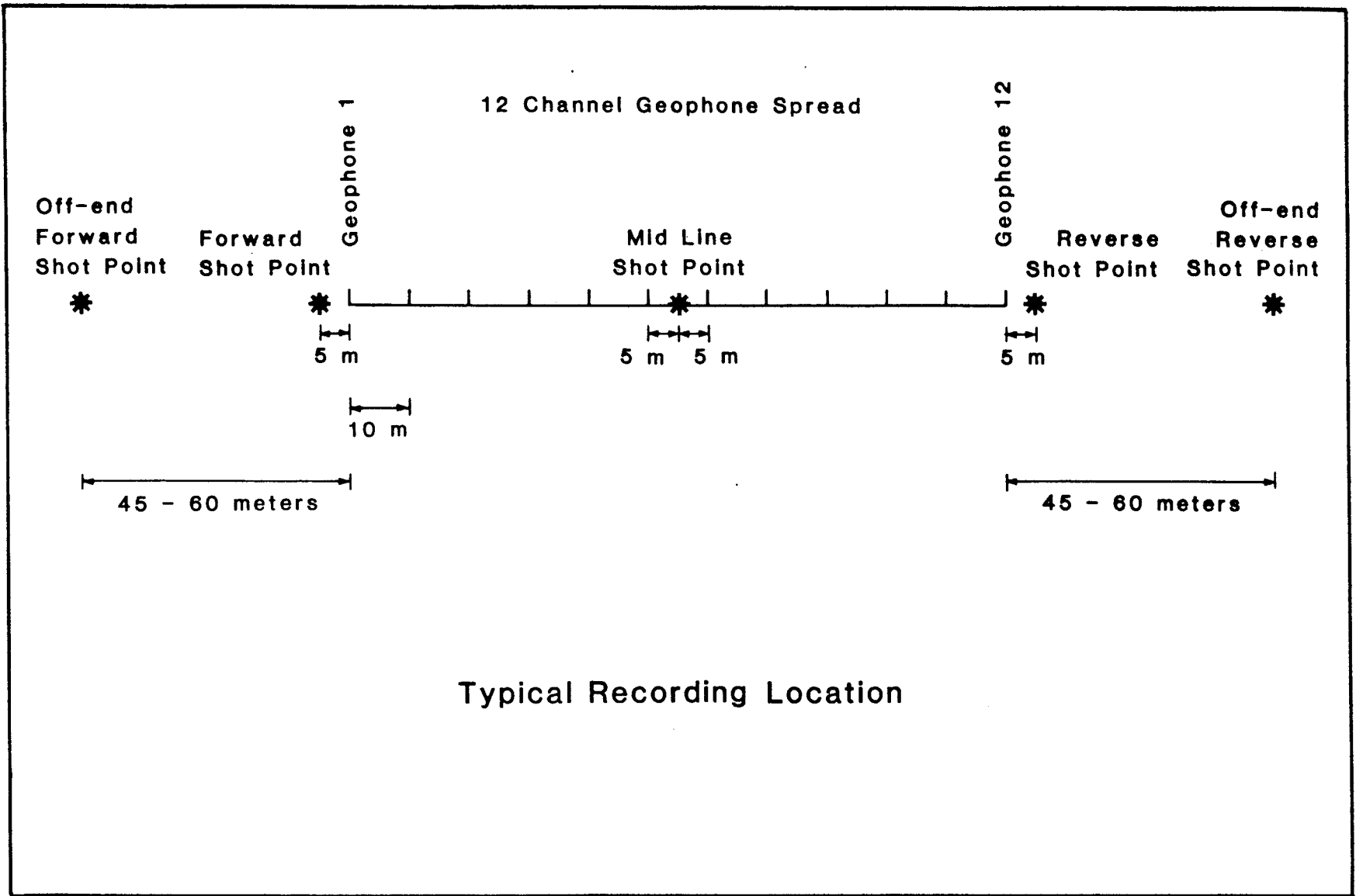


Figure 2. Shooting geometry indicating geophone and shot point locations.

interpretation of the data. Therefore, only minimal consideration was given to the data in the field. In the field, each record (e. g., Fig. 1) was inspected to determine that first breaks were obvious. Identifying first breaks was not a problem because the explosive signal sources provided sufficient energy to give good first breaks in almost every instance. Time versus distance graphs were made for selected field records. However, this was primarily a quality control effort and was not intended to yield geologic results. Manual plotting of the refraction data is time consuming and unless all of the shots for each geophone spread are plotted, erroneous thoughts can be generated with respect to the velocity of refracting horizons and the apparent dip and depth of the horizons.

Refraction data were collected at three locations on Placer Lease 5610. The locations are colinear with each other and were arranged such that the last two geophone positions of one location were coincident with the first two geophone positions of the next location. This line of three locations was on the claim line and was situated on a northeast facing slope.

Data Interpretation Technique

The seismic refraction data collected in the upper reaches of the Livingstone Creek Valley were interpreted with the aid of a microcomputer executing programs which belong to The GREMLIN™ Package. The GREMLIN™ Package is a set of programs that employs a technique known as the generalized reciprocal method of interpreting seismic refraction data (Palmer, 1980). This technique requires that sufficient data be recorded in the field to detail each refracting horizon. Depending upon the actual geology encountered, this requirement should have been met by the field recording procedure discussed above.

The GREMLIN™ Programs perform two basic functions. The first function is to allow the determination of the seismic velocity of each refracting horizon. The second function is to present a profile of the subsurface. The software can handle considerable complexity in the geology along each refraction line. As many as six different horizons can be evaluated. In these six horizons, as many as 10 lateral velocity variations can be taken into account. The present study did not encounter any situations that were this complex.

The first stage in processing the refraction data with The GREMLIN™ Package is to measure the first break arrival times for each of the twelve traces on each of the five records for each recording location. This task is aided by the computer. Each record, in turn, is placed on a sensitized digitizer surface. The operator touches a stylus to the first break position on each trace of the record. The computer automatically scales the touched point on the sensitized surface to arrival time in milliseconds. Moreover, the arrival time and offset distance are stored on disk, a table of offset distances and arrival times is printed, and a time distance graph is plotted (Fig. 3). All of

TIME DISTANCE GRAPH

LINE NAME....AREA 2

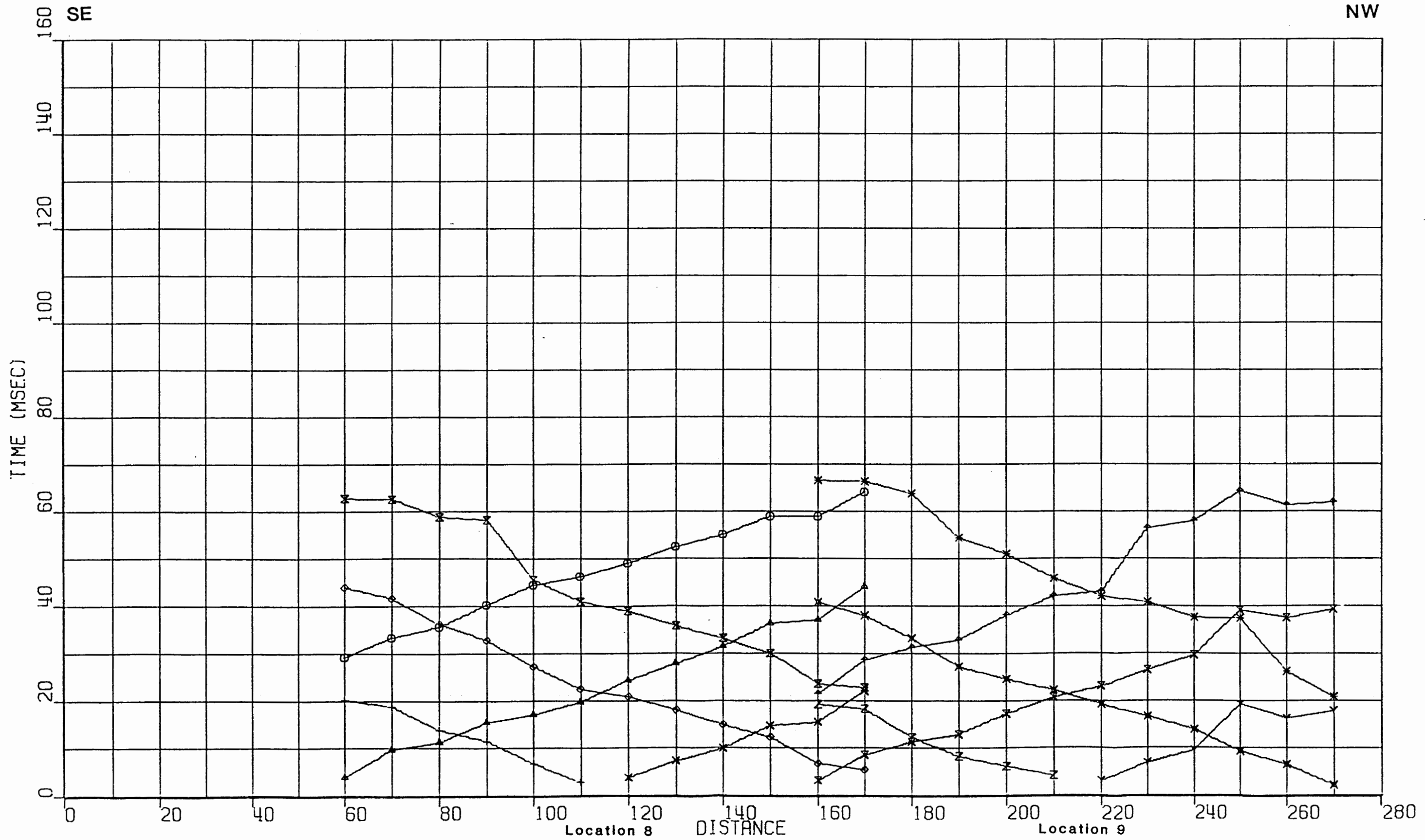


Figure 3. Time distance graph of all data recorded from Locations 8 and 9.

this occurs almost simultaneously as far as the operator is concerned. The five records from one shooting location can be timed in this manner in approximately fifteen minutes. Manually timing, tabulating, and plotting a similar amount of data would require 30 to 60 minutes.

The second stage in the interpretation is to determine from the time distance graph how many refractors are being mapped by the refracted signals. This task is made easier by the multiplicity of data. For example, in Figure 3, the interpreter notes that the three curves representing forward shots for Location 8 are nearly parallel. This indicates that all of the signals giving rise to first breaks are returning to the surface from the same horizon in the subsurface. The same statement can be made about the patterns of the reverse shots arrival times. In this case, therefore, the refraction data give evidence for only one refracting horizon in the subsurface.

Because of the overlap in coverage between Location 8 and Location 9 (Fig. 3), the interpreter is able to further state that the horizon that is observed across Location 8 continues across Location 9. The interpreter, thus far, has only made a qualitative statement about the number of refractors and their lateral extent. The next step is to quantify the velocity of the material overlying the refracting horizon and the velocity of the refracting horizon itself. Figure 4 is the time distance plot of the forward and reverse pair of arrival times from Location 8 that will be used for analysis.

The time distance graph is studied to make sure that no errors were made in entering the data into the computer. The next stage is the analysis of the refractor velocity. The computer generates the refractor velocity functions following the equations presented by Palmer (1980). Figure 5 is the velocity analysis graph. The nature of the points plotted for the XY equal 0 case are determined by the interpreter to best define the velocity of the refracting horizon. The inverse of the slope of the line through these points gives the refractor velocity, in this case 2800 meters per second.

The velocity of the material overlying the refracting horizon is not defined as well as that of the refracting horizon. However, in this case, the velocity has a minimum value of 400 meters per second. For interpretation purposes, a velocity of 1000 meters per second is used for this upper layer. Using this velocity in the analysis procedure will give greater depths than using 400 meters per second. However, 1000 meters per second is probably a more realistic value for moist (not saturated) alluvium.

The final stage in the computer assisted data interpretation is the generation of the cross section of the earth based upon the refraction arrivals. The data from Location 8 are such that the computer plotted interpretation section is meaningless. The most likely reason for this is that the velocity of the material at the surface changes laterally. The surface materials have velocities that vary widely from the assumed velocity of 1000 meters per second. The travel time data allow the refractor velocity to be determined essentially continuously along the

TIME DISTANCE GRAPH

LINE NAME....AREA 2.PAIR 1

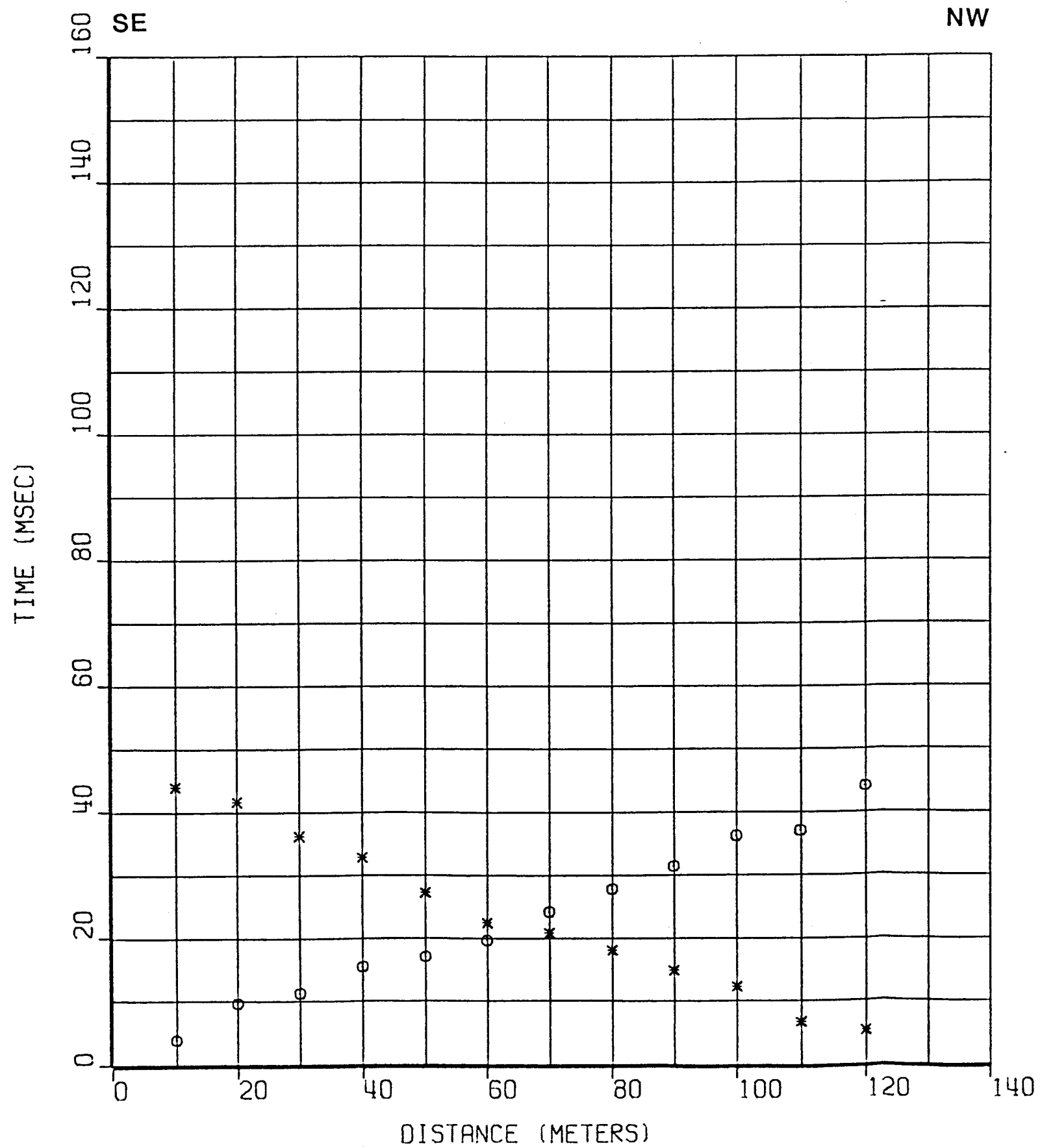


Figure 4. Time distance data from Location 8.

VELOCITY ANALYSIS GRAPH

LINE NAME.....AREA 2.PAIR 1

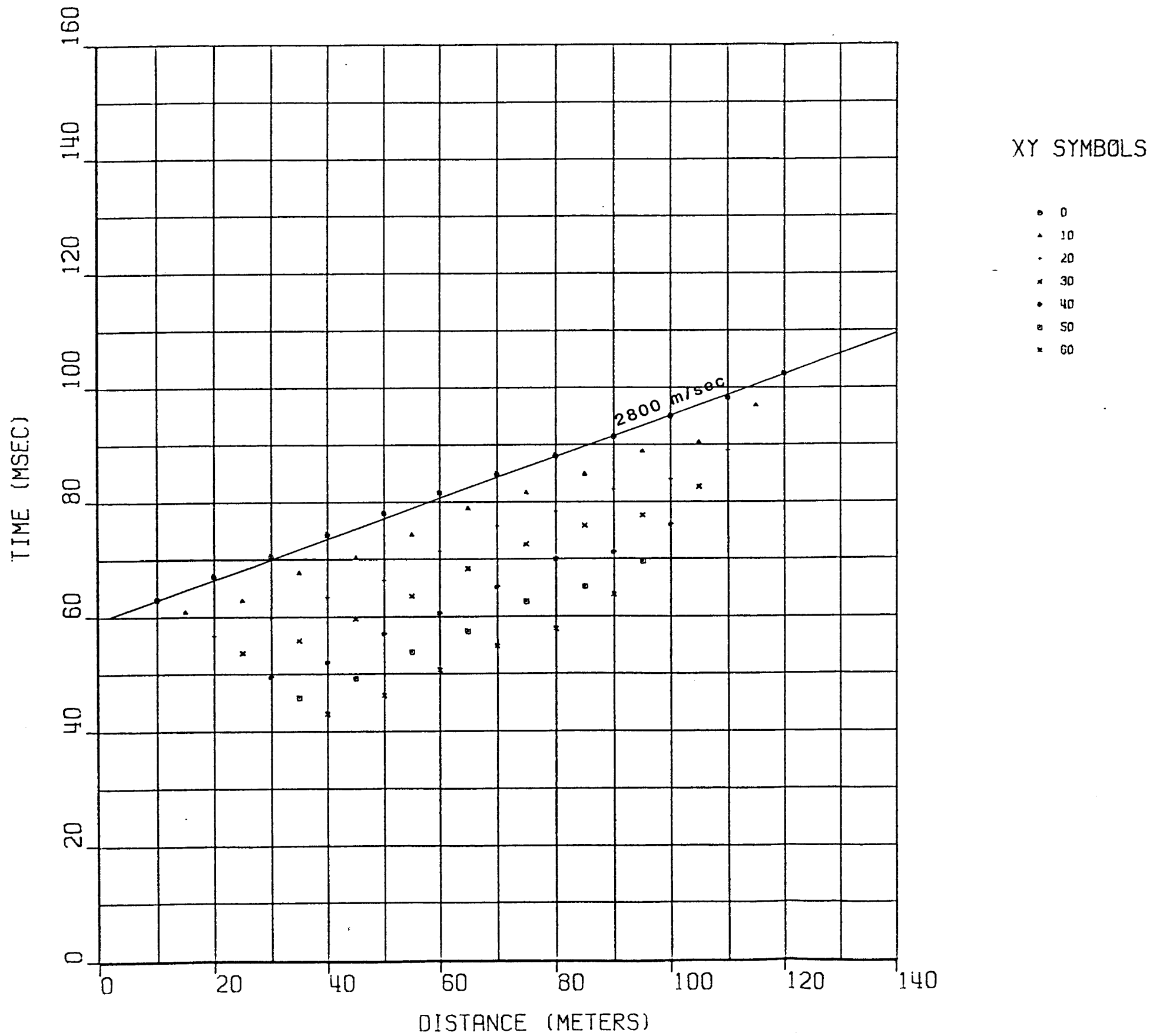


Figure 5. Velocity analysis graph for time distance data from Location 8.

line. However, the surface velocities are known only at a few points. In this case, it is likely that the refracting horizon may actually intersect the surface.

(GREMLIN is a trademark of Geo-Compu-Graph, Inc.)

Interpretation

The travel time data from the three locations surveyed on Placer Lease 5610 were interpreted with the aid of the computer. Locations 9 and 10 indicated a slightly higher refractor velocity than Location 8. The refractor velocity is calculated to be 3000 meters per second. No cross section of this line is presented. The 2800 to 3000 meters per second material is very close to the surface (probably no more than two meters at its greatest depth) and may actually extend to the surface at some points. The refracting horizon showed great irregularity, a symptom that surface velocity changes were occurring. The refraction data do not allow these changes to be recognized or taken into account.

The 2800 to 3000 meters per second material is interpreted to be frozen ground. Velocities in this range are typical of permafrost. Frozen ground was exposed in one shot hole after the dynamite was exploded and digging the shot holes was difficult at every shot point. The entire line is interpreted to be underlain by permafrost. No statement can be made about the thickness of the frozen ground. If the alluvium were frozen to bedrock, the velocity contrast between the frozen ground and the bedrock would be expected to be observable. However, no bedrock velocities were observed along this line.

Therefore, either the bedrock is more than 50 meters below the surface, the maximum depth from which refraction signals could be expected to be recorded, or the frozen ground is underlain by unfrozen alluvium that has a lower seismic velocity. The latter case is known as the velocity inversion problem and is unresolvable with refraction data alone.

Conclusions and Recommendations

Except for determining the velocity of frozen ground, the data collected on Placer Lease 5610 yield nothing toward the identification of bedrock buttresses. Permafrost is not a continuous phenomenon. Therefore, refraction surveying at other sites on this lease might meet with better results. Particularly, surveying on a south or southwest facing slope might find the permafrost absent.

Gravity surveying might be considered for general location of the bedrock buttresses or paleo-waterfalls. Gravity surveying is a much more efficient and cost effective reconnaissance tool. The seismic methods tend to be most efficient and economical when used to detail a

structure as opposed to locate it. Gravity surveying would be expected to yield data based upon the bedrock versus alluvium density contrast. The density contrast would not be appreciably affected by permafrost.

Geophysical testing on Placer Lease 5610 should not be abandoned because of the poor results of the present survey. Geophysical methods offer the most economical means for obtaining physical data about the subsurface.

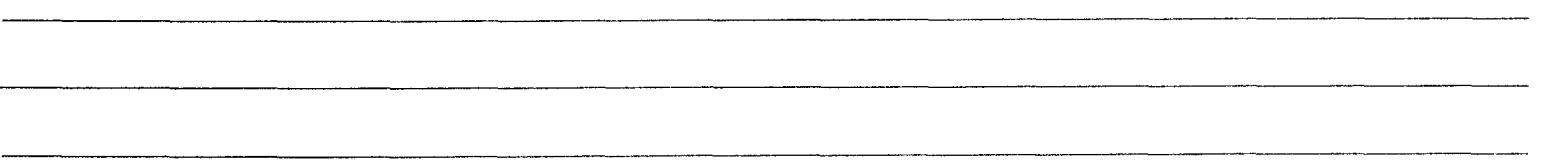
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Telford, W. M., Geldart, L. P., Sheriff, R. E., and Keys, D. A., 1976, Applied geophysics: Cambridge Univ. Press, New York, 860 p.

Appendix C

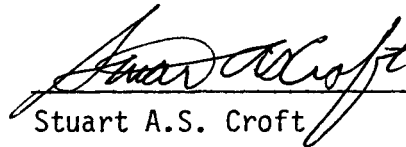
Certificate and Statement of Qualifications



CERTIFICATE AND STATEMENT OF QUALIFICATIONS

I, Stuart A.S. Croft hereby certify that:

1. My residence address is 1340 Inglewood Avenue,
West Vancouver, B.C. V7T 1Y9
2. I am a consulting geologist with the firm of
Nevin Sadlier-Brown Goodbrand Ltd. with offices
at 401-134 Abbott Street, Vancouver, B.C. V6B 2K4
3. I was educated at the University of British
Columbia in geological engineering and have
been practicing my profession since June, 1981
4. I have examined the upper Livingstone Creek placer
leases (P.L. 5609 and 5610) and supervised the
exploration program conducted August 1981.


Stuart A.S. Croft
