CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
3550 N. Central Ave, 2nd floor
Phoenix, AZ, 85012
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

REPORT ON
A SEISMIC SURVEY
PAPAGO INDIAN RESERVATION,
ARIZONA, U.S.A.

HUNTING SURVEY CORPORATION LIMITED

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REPORT ON

A SEISMIC SURVEY

PAPAGO INDIAN RESERVATION, ARIZONA, U.S.A.

for

HUNTING GEOPHYSICAL SERVICES, INC.

by

HUNTING SURVEY CORPORATION LIMITED

Toronto, Canada

October, 1962

TABLE OF CONTENTS

FIGURES

INTRODUCTION

Between the 8th. and 22nd. of September, 1962, Hunting Survey Corporation Limited carried out a seismic survey for Hunting Geophysical Services, Inc. in an effort to determine the depth of bedrock in the valley east of the Vekol Mountains in the Papago Indian Reservation, Arizona, United States of America.

This seismic survey was carried out at 1/2-mile intervals along the road from Kohatk to the Reward Mine. The determinations were shot along N40°E - S40°W lines, i.e. approximately perpendicular to the road.

The field work was done using a Model FS-2 portable facsimile seismograph with dynamite as the source of energy. During the period of operation close communication was maintained with the Tucson office of Hunting Geophysical Services, Inc.

The data were interpreted in the Toronto office of Hunting Survey Corporation Limited and the final results are described in this report. The results are presented in the form of tables giving depths and velocities, and also as interpretation sections along the seismic profiles and the Kohatk - Reward Mine road. The actual time/distance curves (replotted from the records) are also provided with this report to allow reinterpretation as more geology becomes available.

The position of shot points have already been plotted accurately on a map supplied by Hunting Geophysical Services, Inc., but a sketch map (Figure 1) showing these locations is included in this report.

GENERAL GEOLOGY

The Valley

Unfortunately, little is known of the geology of the valley which has a cover of alluvium supporting desert vegetation. However, on the west it is bounded by the Vekol Mountain Range, the geology of which is known and it is possible that the same formations occur in the valley beneath the blanket of alluvium.

The Reward Area

Limestone, magnesium limestones and dolomites of Paleozoic age outcrop in this area. This limestone series includes some beds of shale and sandstone, especially towards the bottom. The beds strike northeast and dip about 40 degrees northwest.

The Paleozoic series is overlain unconformably by Cretaceous clastic rocks. These are a thick conglomerate at the top, followed by a porphyry breccia of volcanic origin, which is underlain by sandstones and quartzite with a basal conglomerate. Dikes of quartz porphyry and of felsite cut all the bedded rocks. There is a massive hornblende sill in the upper conglomerate.

Several faults traverse the area, the largest being the Reward Fault, which trends east-west and has a stratigraphic displacement of less than 200 feet.

RECORD QUALITY

The depth determinations are based on the assumption of uniform velocities and planar interfaces between layers. Any departure from this ideal condition will cause a scatter in the points and difficulty in interpretation; therefore every determination should be graded in order to specify the relative accuracy of the determinations.

In this case, the records provided on the whole well defined velocities in the earlier parts of the record. At greater distances from the geophones, the records were sometimes of a more ambiguous nature.

Thus, in the first part of the records, i.e. with the shot location 0-800 feet from the geophone, the amount of scatter was small and the noise level was removed so that the estimated accuracy of the determination is $\pm 10\%$. However, for shot locations 800 feet and more from the geophones, the accuracy is diminished and is estimated at $\pm 20\%$.

DISCUSSION AND INTERPRETATION OF RESULTS

Limitations of the Instrument and Recommendations

The Facsimile Seismograph Model FS-2, though possessing a great many advantages over its predecessors, is still classed as a shallow depth determination instrument. Its depth penetration range, though increased considerably by the use of the coincidence circuit and the method of data presentation, still has its practical limitations.

In this case it was found that the amount of explosives and the rate of laying out the charges over the distance necessary to achieve depths in excess of 400 feet to a large extent outweighed the advantages of low cost and portability.

For this reason mainly, the survey was discontinued and it is thought that if a substantial amount of seismic work is planned in this area a 12-channel instrument may be more economical.

Method of Interpretation

The entire process of refraction seismic interpretation can be illustrated by the simple yet important case of the single horizontal discontinuity shown in Figure 2.

Let the horizontal discontinuity be at a depth d at which the velocity increases abruptly from V_1 to V_2.

Let X denote the horizontal distance between source and receiver, and let T be the time of travel of the distance.

When the detector is located very close to the source in comparison with the depth d, the first waves to reach the detector will travel horizontally in the upper layer at a velocity V_1 and will arrive at times $T_1 = \frac{X}{V_1}$. Therefore the time/distance curve starts out as a straight line through the origin with slope $^1/V_1$.

At a certain distance X_c, a wave that has been refracted along the discontinuity will arrive at the receiver at the same time as the direct one. This will occur when the time gained in travelling the path BC is greater than the time lost in travelling AB and CD. At all distances greater than X_c, the refracted wave constitutes the first arrival.

Thus, its time of travel is given by

$$T_2 = \frac{AB}{V_1} + \frac{BC}{V_2} + \frac{CD}{V_1}$$

But by geometry $AB = CD = \frac{d}{\text{Cos } i}$

and $BC = X = \frac{2d}{\text{Cos } i}$

Also, Snell's Law gives the relationship of the critical angle i_c to the velocities, i.e. $\text{Sin } i_c = \frac{V_1}{V_2}$

Thus by substitution $T_2 = \frac{2d}{V_1 \cos i} + \frac{X}{V_2} - \frac{2d \tan i}{V_2}$

and by trigonometrical simplification gives $T_2 = \frac{X}{V_2} + \frac{2d \cos i}{V_1}$ *

This latter equation shows that beyond the critical distances, the slope of the time/distance curve will be given by $^1/V_2$. Thus the presence of a subsurface discontinuity will be represented by a break in the time/distance curve between the two segments.

Now at the critical distance X_c $T_1 = T_2$ and by substitution for cos i in *, the equation becomes

$$\frac{X_c}{V_1} = \frac{X_x}{V_2} + 2d \cdot \frac{V_2^2 - V_1^2}{V_1 \quad V_2}$$

whence $d = \frac{X_c}{2}\sqrt{\frac{V_2 - V_1}{V_2 + V_1}}$

Certain minor correction factors have to be applied, but need not be considered here. Thus in general the thickness of each layer may be written

$$d_{n-1} = \frac{X_{cn-1}}{2}\sqrt{\frac{V_n - V_{n-1}}{V_n + V_{n-1}}} + \text{Correction}$$

Relation between Velocity and Lithology

A certain degree of material identification can be done by means of the observed seismic velocities. In this survey six classes of velocity were observed.

V_1 : 1,100 - 1,200 ft/sec.

This velocity was observed to depths of 7 to 12 feet on all of the profiles. It is believed to correspond to loose, sandy material forming the dry surface layer of the ground.

V_2 : 2,850 - 4,000 ft/sec.

This layer is absent on Profile 0 which was surveyed near to limestone outcrop but is present in thickness 24 to 38 feet on all other profiles. It corresponds to dry alluvium of a sandy or fine gravelly composition.

V_3 : 4,750 - 5,500 ft/sec.

Most of the velocities in this class are in excess of 5,000 ft/sec. and are believed to be related to compacted gravel or poorly cemented conglomerate. Velocities in this class can be observed in extremely weathered rock in some instances and this possibility is kept in mind in the interpretation of the results. Variations in velocity within this class may be caused by varying degrees of compaction and cementation but also and, in this instance, in more likelihood by the degree of saturation by groundwater. Thus the 4,850 ft/sec. velocity on Profile 4 most probably represents the counterpart of the 5,500 ft/sec. layer lying above the water table.

V_4 : 8,400 - 9,300 ft/sec.

Normally these velocities correspond to cemented gravel or conglomerate, sandstone or shale. However, on this survey it is possible that they represent the weathered equivalents of crystalline limestone and/or intrusive or extrusive rock. Both possibilities are indicated in the interpretations of Profiles 0, 1 and 2.

V_5 : 11,000 ft/sec.

The layer observed with this velocity under location B on Profile 0 is almost certainly limestone. The same is believed to lie at some depth below Profiles 1 and 2. Conglomerate, sandstone and quartzite could all have velocities close to this value.

V_6 : 17,300 - 21,500 ft/sec.

The single layer observed with the 17,300 ft/sec. velocity most probably represents unweathered, acid igneous rock. Other alternatives are metamorphosed sedimentary rock (limestone or quartzite) and basic intrusive or extrusive rock, in all cases mainly unweathered.

The 21,300 - 21,500 ft/sec. velocities again represent unweathered, crystalline rock; but in this case it is improbable that the material is metamorphic and relatively unlikely that it is "basement" in the sense of acid, igneous rock of Precambrian age. The most satisfactory solution geophysically is basic igneous rock in the form of diabase or basalt. However, quartz porphyry, felsite, diorite etc. can have velocities in this range and may provide a more satisfactory geological interpretation.

Interpretation of Profiles

Since there are only five, widely spaced determinations and little or no geological information, the interpretation becomes a matter of choice between several possible solutions. Since this choice has to be made mainly on geological grounds, the following solutions (Figures 3 to 12) may be taken only as geophysical possibilities, presented to enable the reader to make his own final interpretation. The writers have, however, selected one combination of profile solutions as being, to them, more satisfactory than the others, and this is presented in Figures 13 and 14.

Profile 0:

Profile 0 was surveyed twice - first from location A southwest towards a limestone ridge, secondly from location B (located almost on the ridge) northeast towards location A.

The solution of the data from these determinations provides a steeply dipping discontinuity 208 feet northeast of location B. To the southwest of this discontinuity a limestone bedrock is overlain by about 10 feet of loose sand and decomposed rock. To the northeast the alluvium thickens abruptly to 70 feet consisting of 12 feet of loose material and 58 feet of gravel or loose conglomerate. The discontinuity which separates the limestone on the southwest from the gravel on the northeast is most probably a near-vertical fault scarp.

Below the gravel, a layer 93 feet thick occurs, which may be a more tightly compacted and cemented gravel, or a weathered sedimentary rock or, and most probably, a weathered igneous rock. Solution (1) in Figure 3 shows the layer as a weathered equivalent of an underlying acid, igneous rock. Solution (2) in Figure 4 has the 8,400 ft/sec. layer identified as an extrusive lying on the top of the same igneous basement. The latter interpretation was influenced by the observation of an outcrop of volcanic rock on the Reward Mine road between Profiles 1 and 2, (see Figure 1). For this solution to be correct, however, the volcanic rock would have to be so highly weathered as to be unlikely in view of the compact nature of the limestone near location B. Solution (1), with the qualification that the 8,400 ft/sec. layer may in fact be sedimentary, is preferred.

The depth of the limestone layer southwest of the discontinuity is at least 50 feet but below this horizon it may be underlain by igneous or other, higher velocity rock.

Profile 1:

Profile 1 was surveyed in one direction only. Alluvium has a total thickness of 45 feet and the gravel there is either missing or very thin.

Beneath the gravel a layer approximately 115 feet thick occurs with a velocity of 9,300 ft/sec. Solution (1) shows this layer as weathered limestone underlain by massive limestone at a depth of 160 feet. Solution (2) identifies the 9,300 ft/sec. layer with the volcanic rock discussed in Solution (2) of Profile 0.

The presence of limestone, rather than igneous rock, as the lowest layer on this profile is not explained. Actually the limestone layer could be relatively thin and overlie igneous rock of the sort observed on Profile 0. Alternatively, the layer identified as limestone may, in fact, be a partially weathered igneous layer. It is supported by two points only on the time/distance graph.

Profile 2:

The interpretation of this profile shows an abrupt, steeply dipping discontinuity some 960 feet southwest of the geophone location. This appears as a sudden depression in the 9,000 ft/sec. layer which underlies the gravels. Further to the southwest along the profile the gravels must thicken abruptly to a depth of at least 400 feet if underlain by material of approximately 11,000 ft/sec. (greater if the underlying material is of higher velocity).

In Solution (1) the 9,000 ft/sec. layer has been identified as weathered limestone overlying at a depth of 209 feet its unweathered equivalent. The abrupt discontinuity is shown as a fault scarp. The limestone could be underlain at a shallow depth by higher velocity (possibly igneous) material.

Solution (2) is equivalent to Solutions (2) on Profiles 0 and 1 in that it identifies the 9,000 ft/sec. layer as weathered volcanic rock. The flow is shown as being approximately 60 to 90 feet thick but this is pure conjecture.

Profile 3:

The seismic results from this profile satisfy a simple 4-layer case. The overburden consists of 40 feet of alluvium and topsoil plus 382 feet of consolidated gravel. The bedrock consists of hard, crystalline rock with a velocity of 21,500 ft/sec. at a depth of 422 feet. As has been mentioned earlier, this is identified as igneous rock, probably basic.

An alternative solution (Solution (2)) shows a thin limestone layer overlying the igneous rock but undetected seismically because of its intermediate velocity. This layer, with a velocity of 11,000 ft/sec., could have a maximum thickness of 210 feet. The depth to its upper surface would then be 286 feet and the total depth to the igneous rock would be 536 feet. This alternative is conjectural and would have to be supported by other evidence before it became a probability.

Profile 4:

This profile is very similar to Profile 3 and the interpretation is exactly the same. A slight change in the velocity of the gravel layer is detected at a depth of 125 feet. This is tentatively attributed to the change in the degree of moisture content.

Solution (2) again assumes a hidden layer of velocity 11,000 ft/sec. The layer in this case would have a maximum thickness of 141 feet and the total depth to igneous rock would be a maximum of

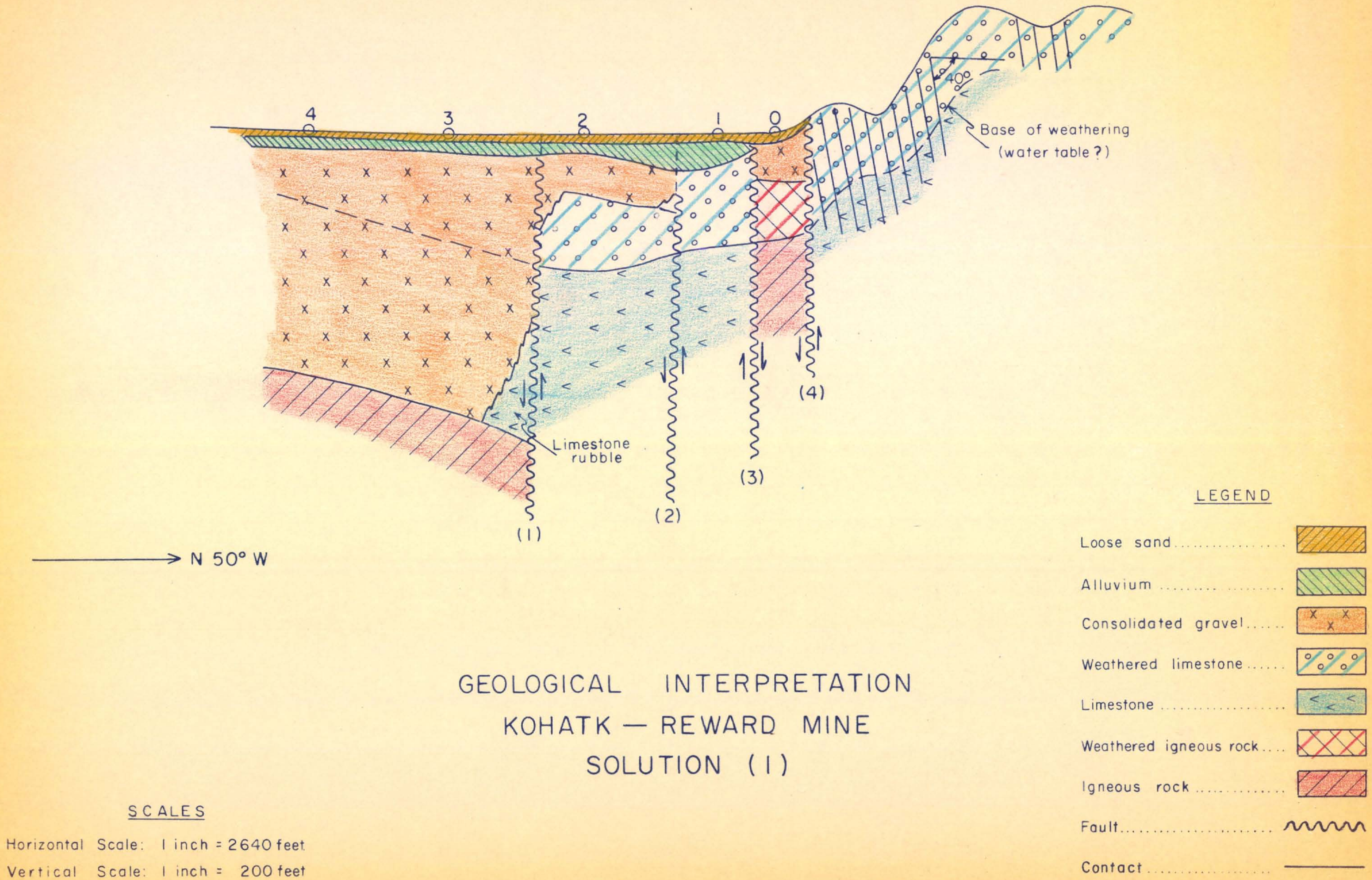
469 feet.

Geological Interpretation, Kohatk-Reward Mine

For various reasons, including its unnaturally high velocity, the identification of the 9,000 ft/sec. layer on Profiles 0, 1 and 2 seems unlikely. The volcanic outcrop on the Kohatk-Reward Mine road may be of very recent origin and produce little or no seismic effects.

To produce a consistent interpretation of the results it becomes necessary to introduce a series of step faults as shown in Figures 13 and 14. In Solution (1) four faults are introduced, three with downward movement and one with upward movement to the south. In Solution (2) all three faults have downward movement to the south. The main difference between the two solutions is that in Solution (1) the igneous material is clearly younger than the limestone. In Solution (2) the igneous rock may be younger or older but there is a distinct possibility that it is older and therefore probably Precambrian.

The faulting is interpreted as being post Gila in age though some slumping of the limestone beds has been allowed during the faulting process. The strike of the faults is not known but it is inferred as being approximately east-west. Fault No. 1 may be closer to Determination No. 2 than shown and, in fact, cross Profile 2 at the position shown in Figures 7 and 8. Similarly, Fault No. 3 could account for the sudden discontinuity on Profile 0.

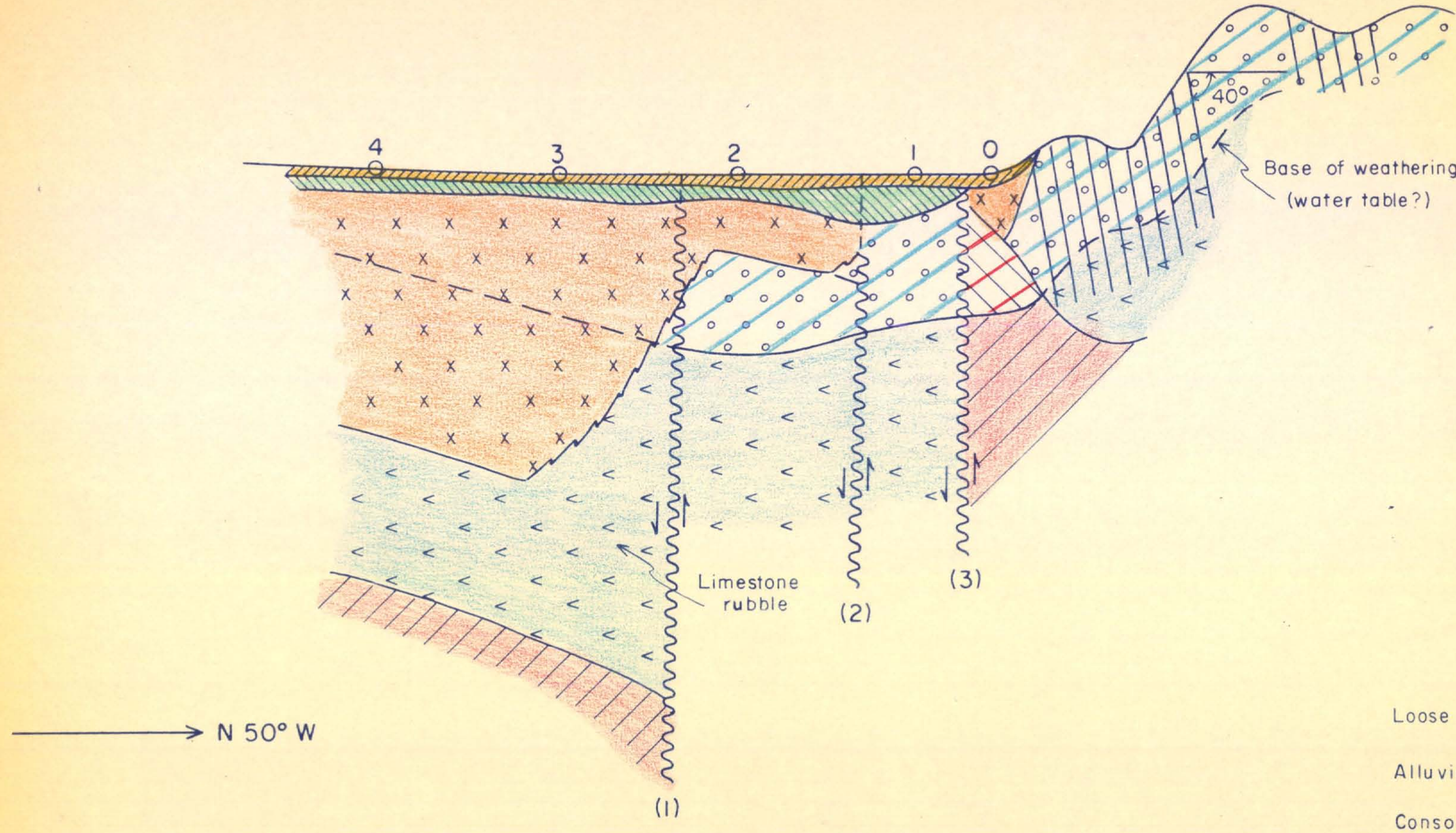


GEOLOGICAL INTERPRETATION

KOHATK — REWARD MINE

SOLUTION (1)

FIGURE 13.



GEOLOGICAL INTERPRETATION
KOHATK — REWARD MINE
SOLUTION (2)

LEGEND

Loose sand ....
Alluvium ....
Consolidated gravel ......
Weathered limestone ......
Limestone ....
Weathered igneous rock ....
Igneous rock ....
Fault ....
Contact ....

SCALES

Horizontal Scale: 1 inch = 2640 feet
Vertical Scale: 1 inch = 200 feet

FIGURE 14.

The latter is somewhat difficult to reconcile with Solution (2) (Figure 14) and in this case it may be that the discontinuity on Profile 0 is associated with a fault entirely different strike.

It has been noticed that the change in velocity from approximately 9,000 ft/sec. to either 11,000 ft/sec. or (in the case of Profile 0) 17,300 ft/sec. appears at approximately the same depth beneath Determinations 0, 1 and 2. Since this change has been tentatively associated with the base of the weathered layer, it has been extrapolated diagrammatically into the Vekol Mountains on the one side and towards Kohatk on the other, linking up with the velocity change beneath Determination 4 which may be the present water table.

SUMMARY AND CONCLUSIONS

As a result of five seismic determinations some knowledge has been gained of the geology to a distance of 4 miles southeast of the Reward Mine. This knowledge is limited to the location of the first massive, crystalline sub-stratum underlying each seismic determination. The unique identification of the sub-strata is not possible seismically.

By the rather lengthy process of trial and error, solutions have been obtained which are consistent with the seismic results and appear to be more or less reasonable geologically. The more likely of these solutions have been presented in this report. It is emphasized that these are not the only possible solutions. Some of the ambiguities could be removed by further seismic work but the final interpretation would nevertheless be imperfect owing to the inability of the seismic method to handle such problems as velocity inversions, "hidden" layers and highly irregular interfaces.

The seismic work was carried out in order to determine the feasibility of magnetometer survey in the area between the Reward Mine and Kohatk. It is concluded from this work that for at least 4 miles southeast of the Reward Mine igneous rock occurs close enough to the surface that variations in magnetite content of the type being sought would most probably be detectable. However, in order to maximize this probability, the survey should be carried out with as high an accuracy as possible, certainly to ±10 gammas or better.

HUNTING SURVEY CORPORATION LIMITED

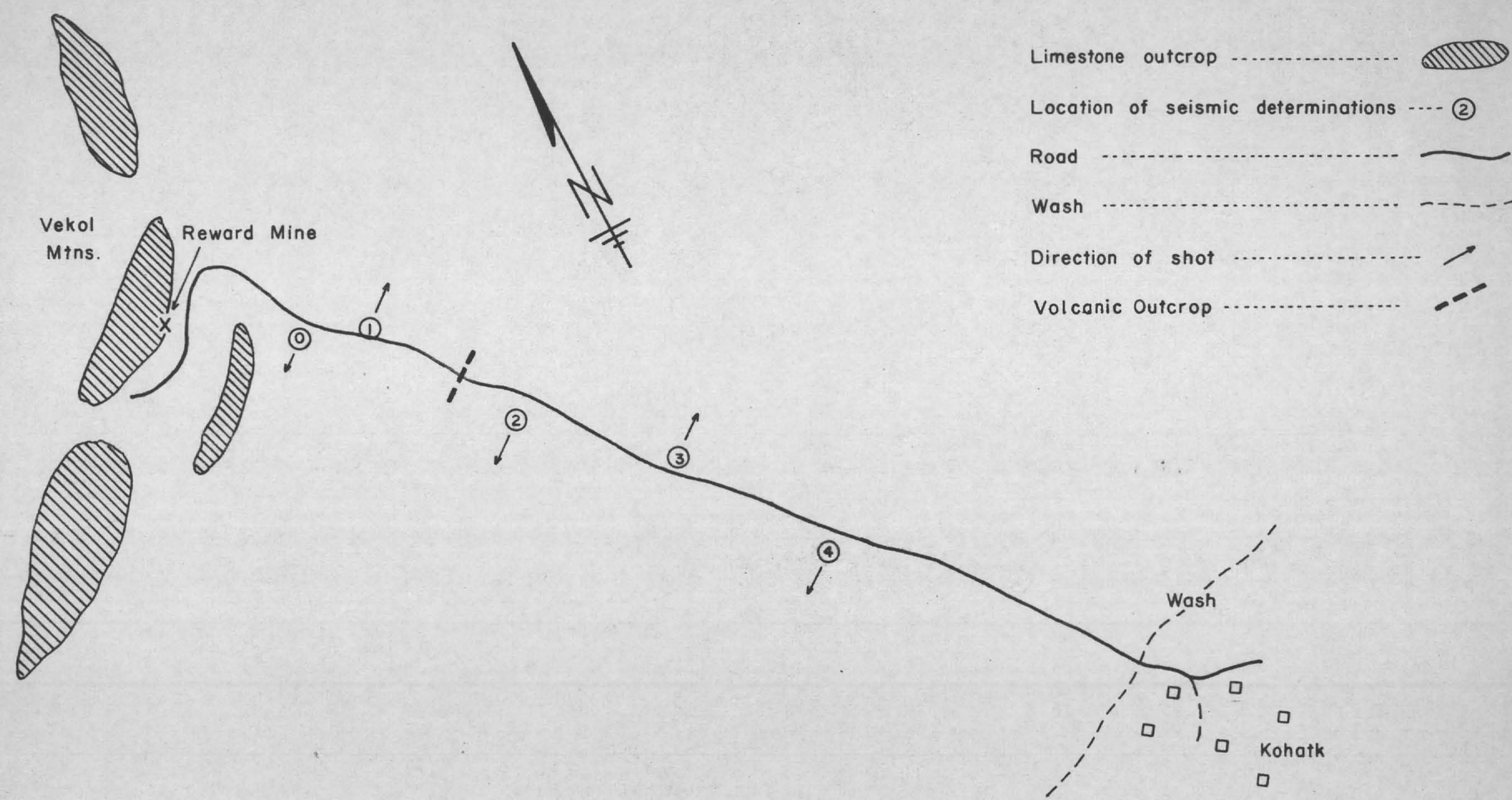
Peter E. Walcott,
Project Geophysicist.

Norman R. Paterson,
Chief Geophysicist.

TABLE OF SEISMIC RESULTS

Location	V_1	d_1	V_2	d_2	V_3	d_3	V_4	d_4	V_5	d_5	V_6	D	Direction of Profile
0 A	1,150	12	-	-	5,500	58	8,400	93	-	-	17,300	163	S40°W
B	-	-	-	-	-	-	-	-	11,000	-	-	-	N40°E
1	1,150	7	2,850	38	-	-	9,300	115	11,100	-	-	160	N40°E
2	1,200	11	4,000	25	5,200	60	9,000	115	11,100	?	-	209	S40°W
3	1,200	12	3,500	28	5,500	382	-	-	-	-	21,500	422	N40°E
	"	"	"	"	5,500	286*	-	-	11,000	210*	21,500	536*	"
4	1,100	10	3,000	24	(4,750 (5,500	85) 257)	-	-	-	-	21,300	376	S40°W
	"	"	"	"	(4,750 (5,500	85) 193*)	-	-	11,000	141*	21,300	469*	"

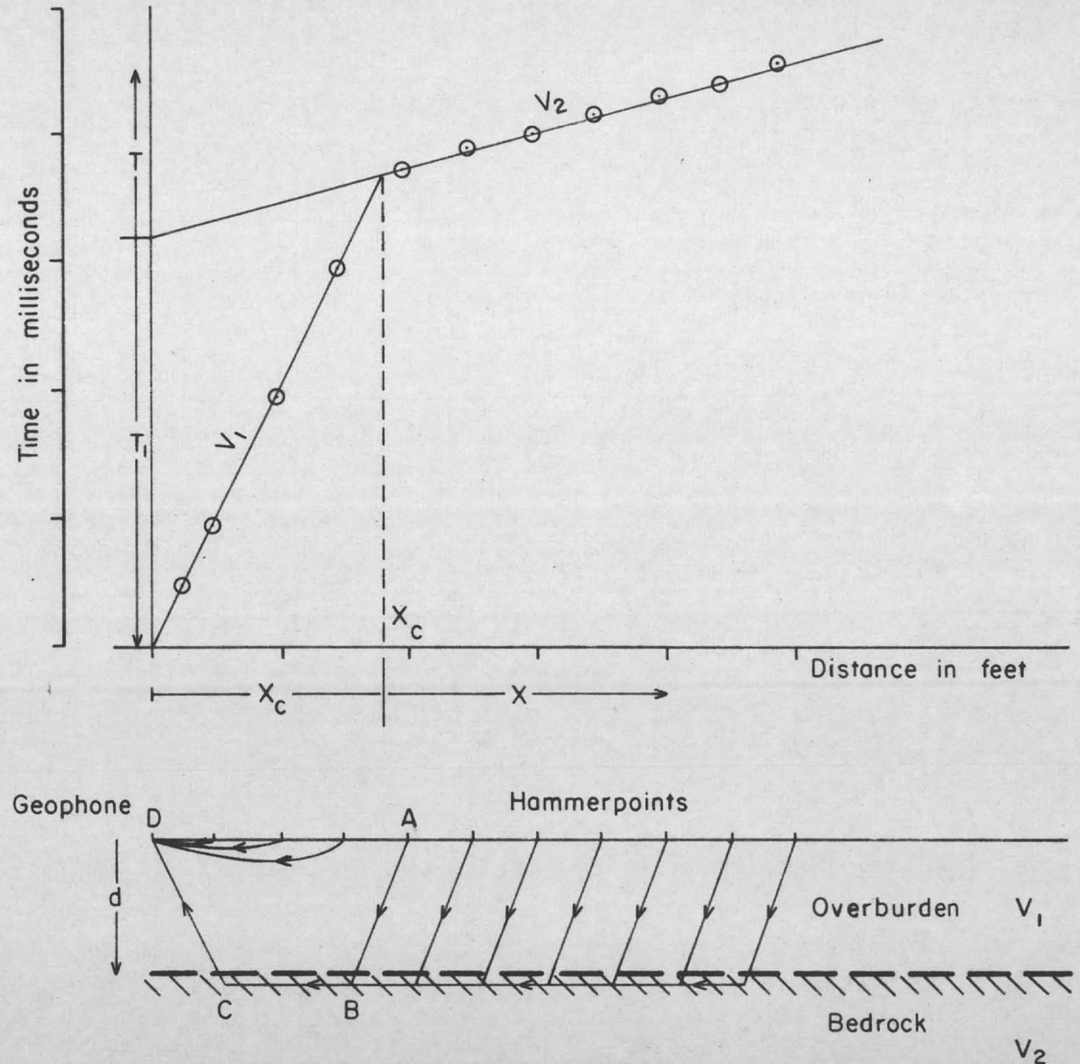
*Assuming "hidden-layer" of 11,000 ft/sec.



Scale: 2 inches = 1 mile

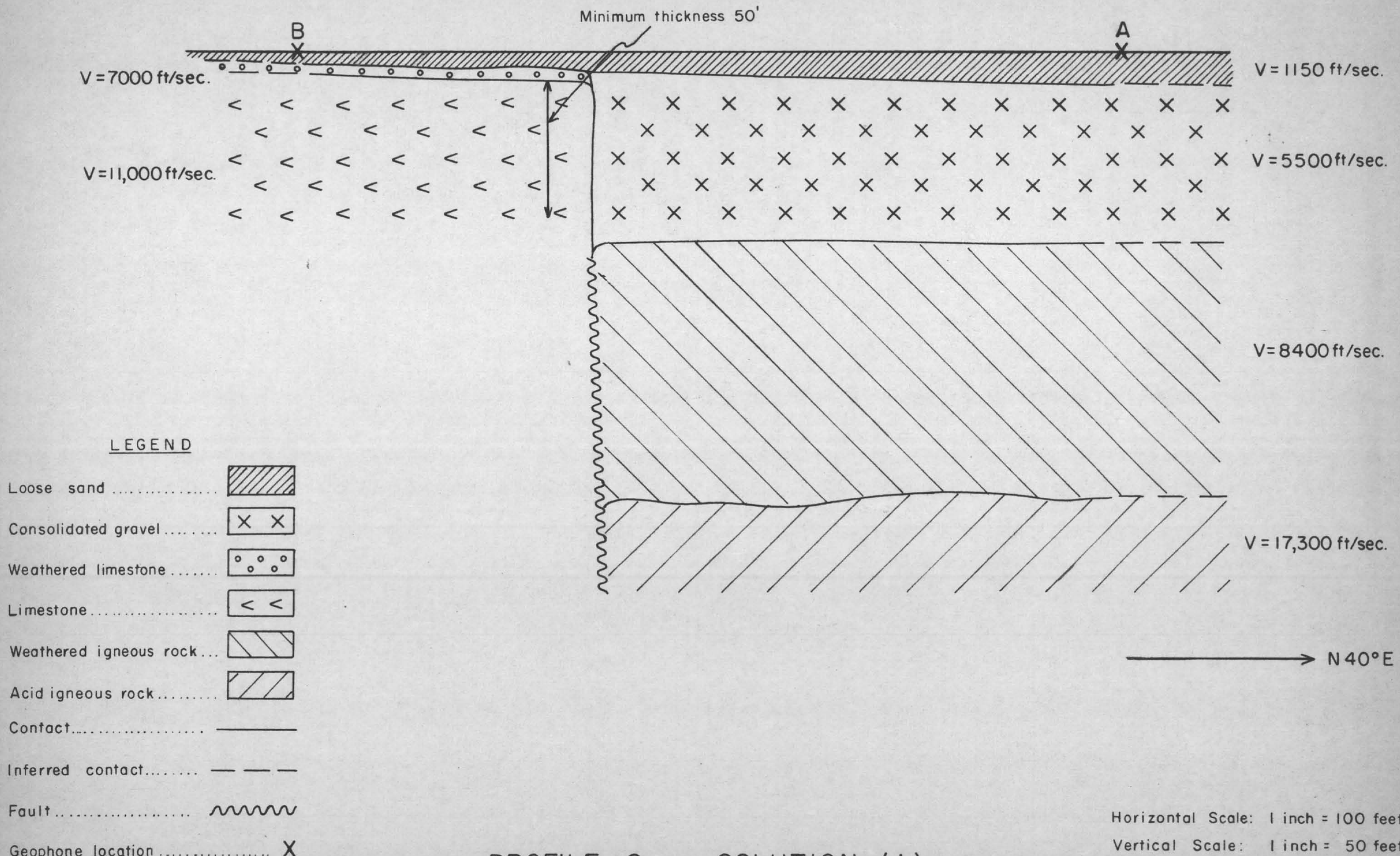
SKETCH MAP OF AREA SHOWING LOCATIONS OF SEISMIC DETERMINATIONS

FIGURE 1.



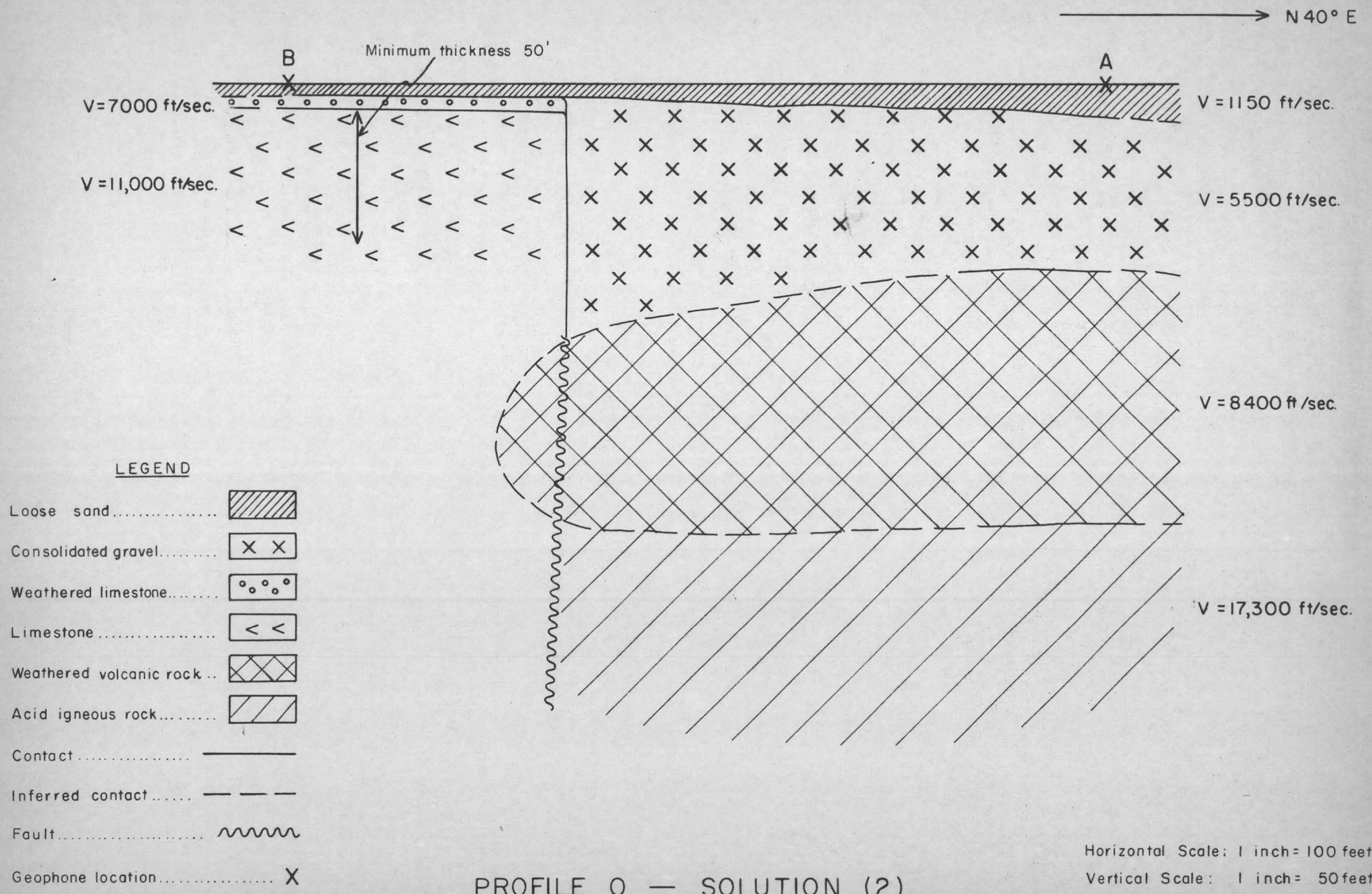
Time in milliseconds
T
T1
V1
V2
Xc
Distance in feet
Xc
X
Geophone
D
A
Hammerpoints
d
Overburden
V1
C
B
Bedrock
V2

FIGURE 2.



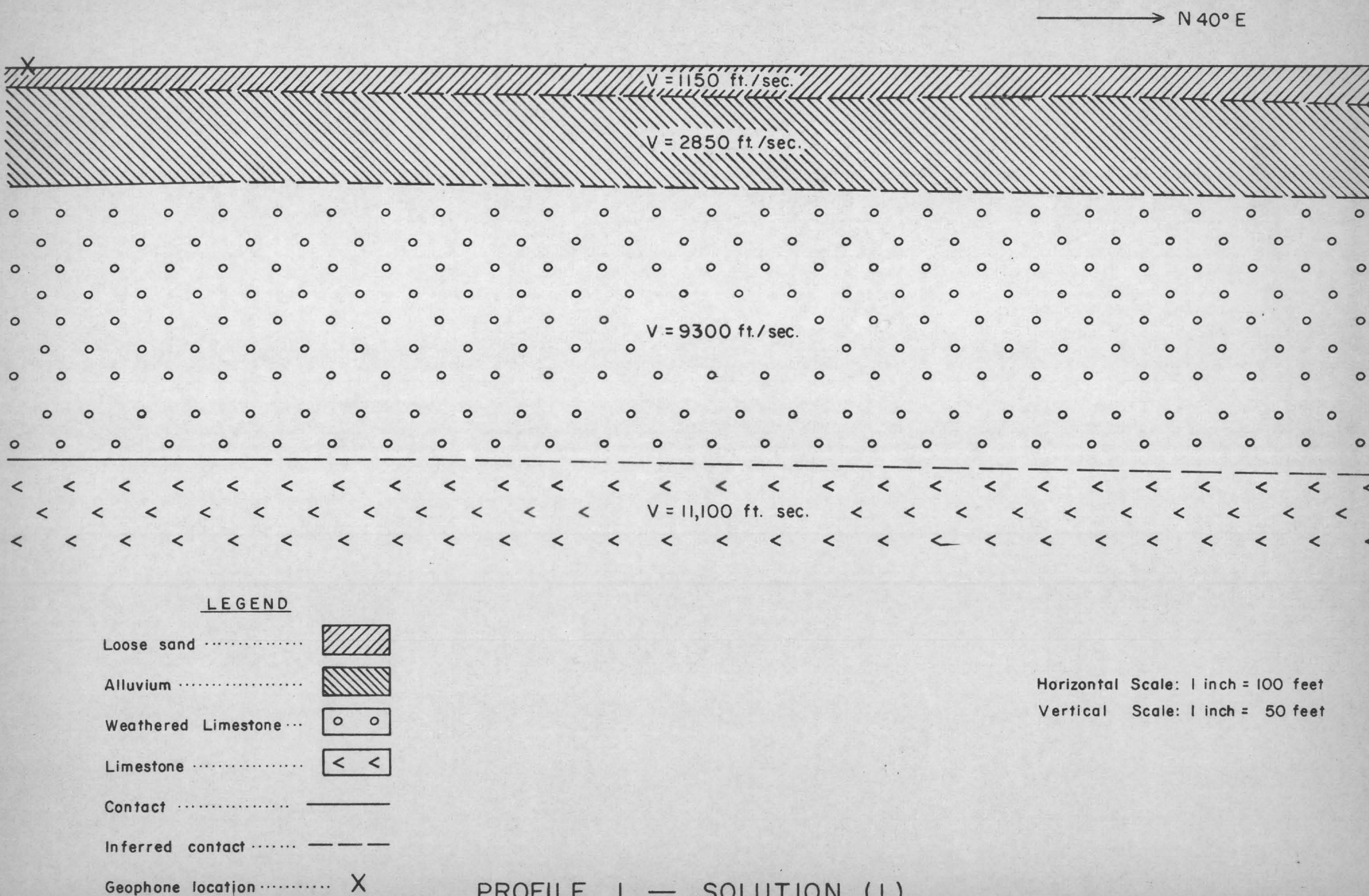
PROFILE O — SOLUTION (1)

FIGURE 3.



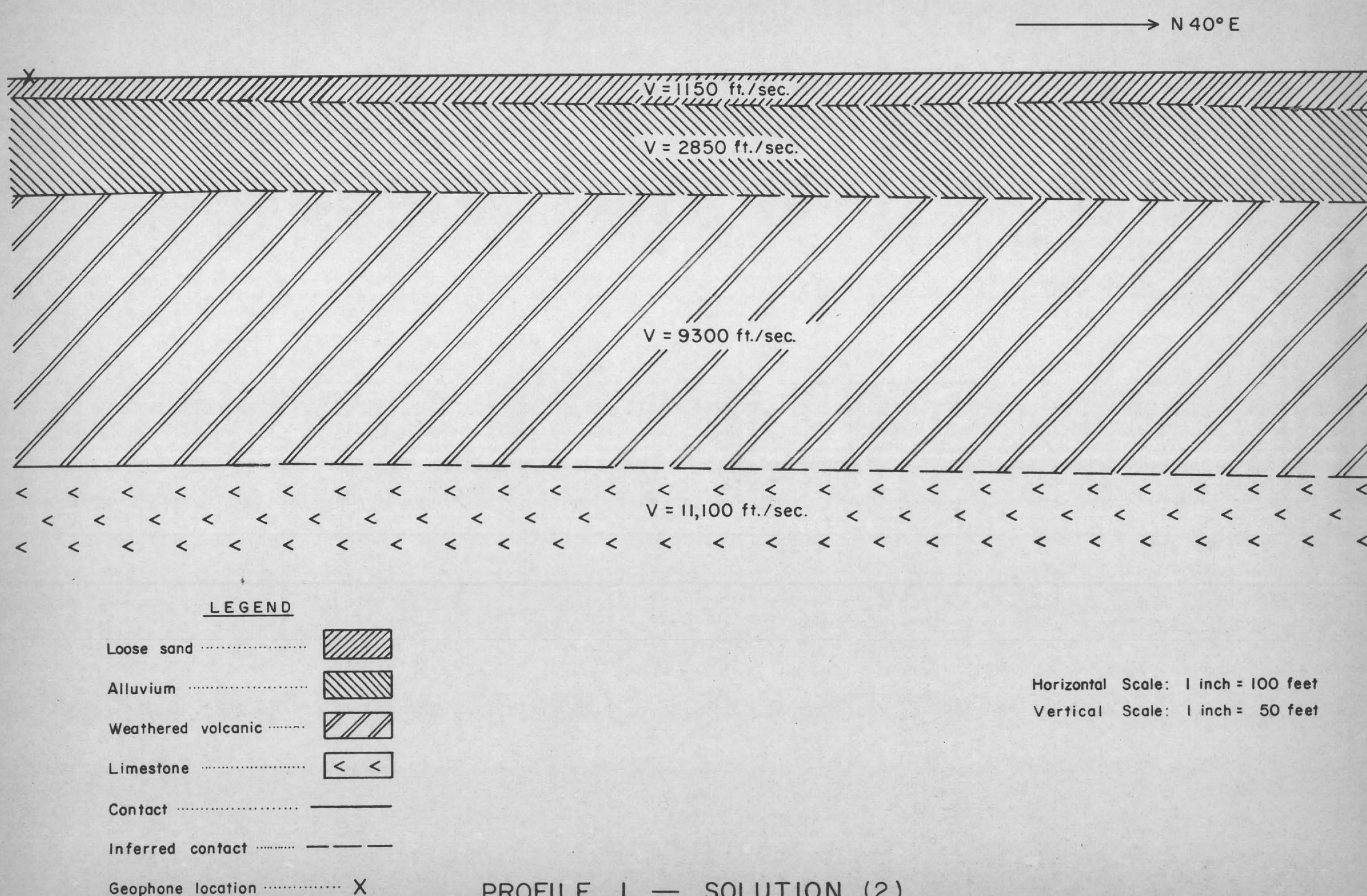
PROFILE O — SOLUTION (2)

FIGURE 4.



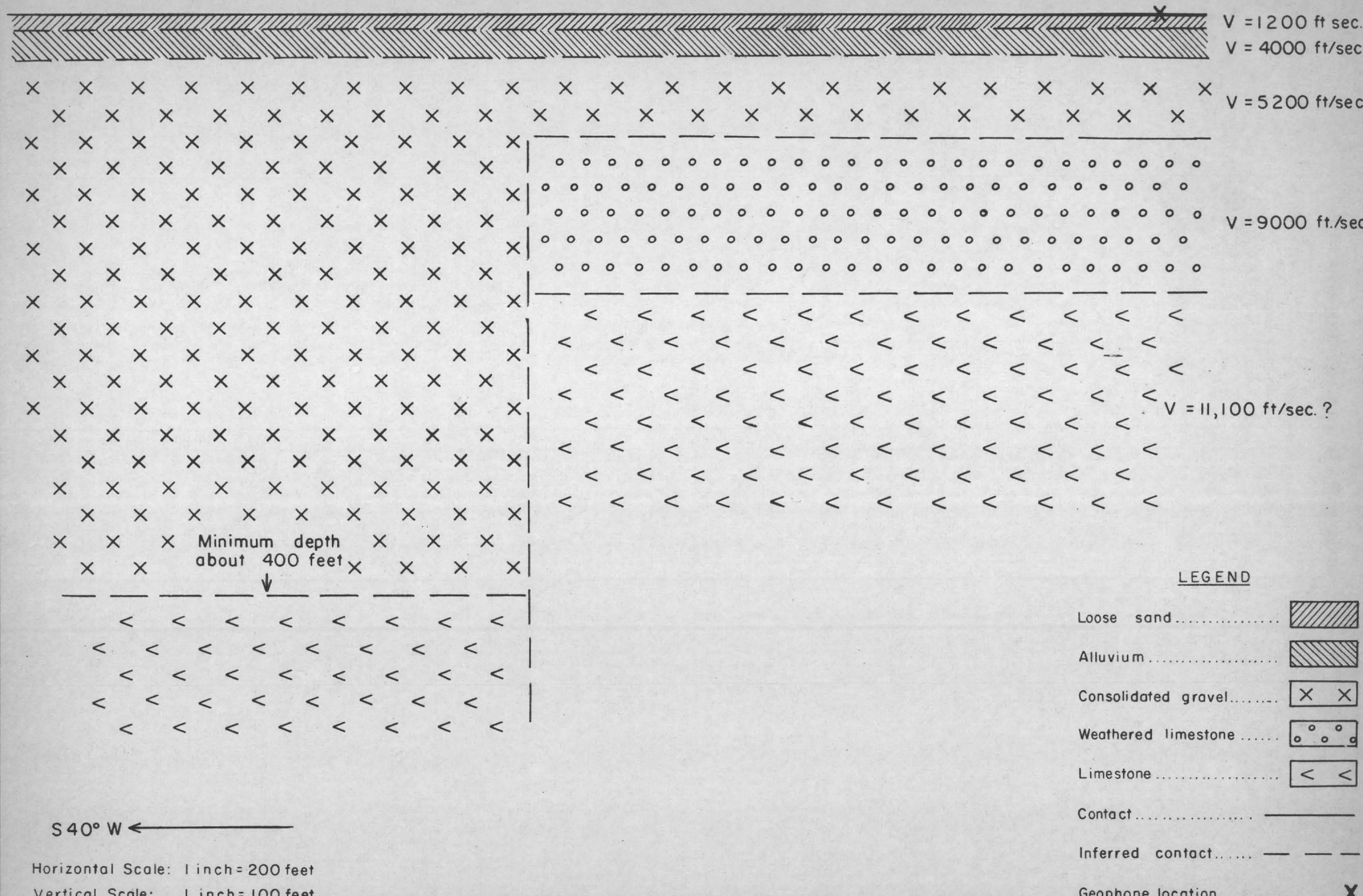
PROFILE I — SOLUTION (1)

FIGURE 5.



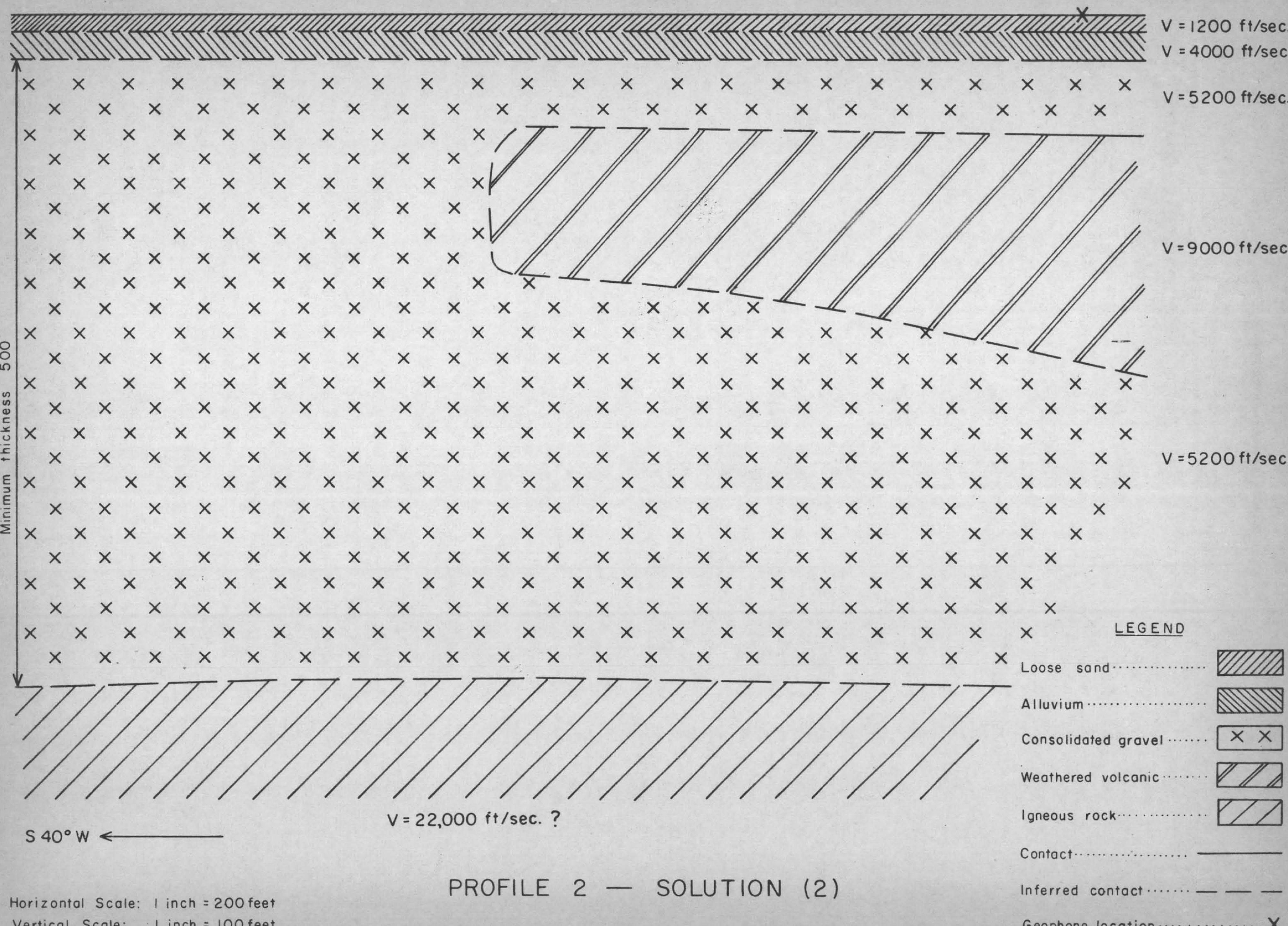
PROFILE 1 — SOLUTION (2)

FIGURE 6.



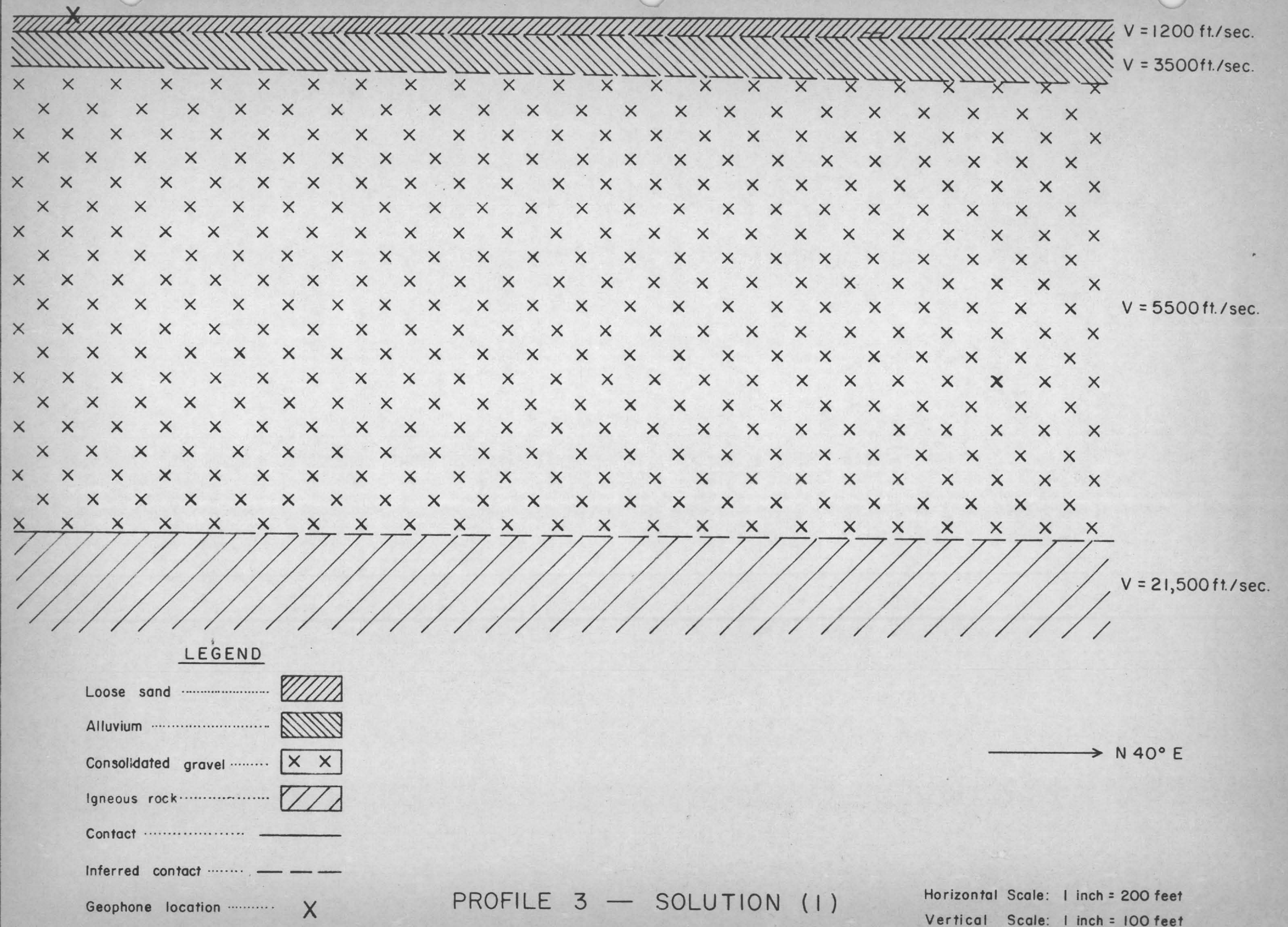
PROFILE 2 — SOLUTION (1)

FIGURE 7.



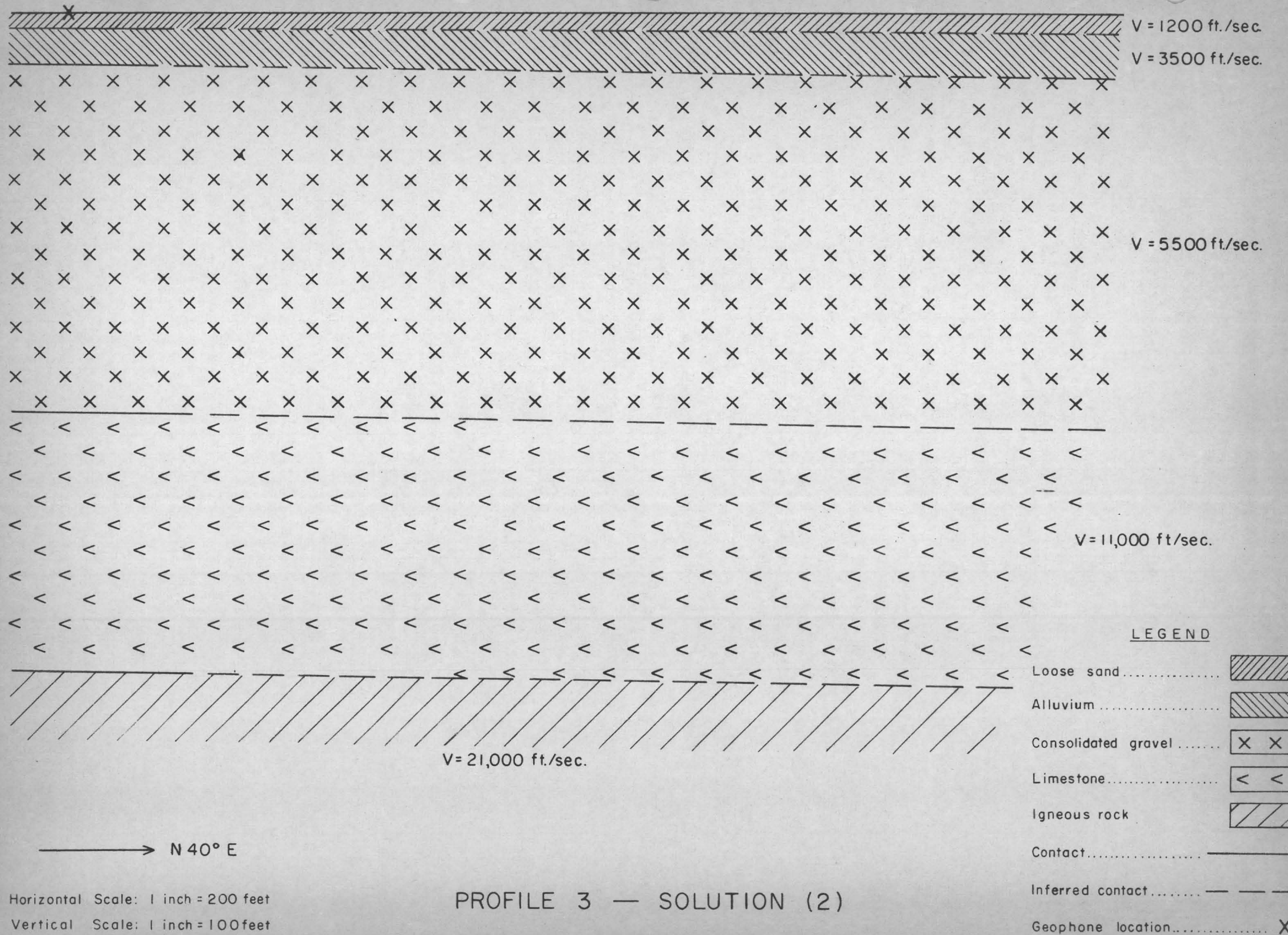
PROFILE 2 — SOLUTION (2)

FIGURE 8.



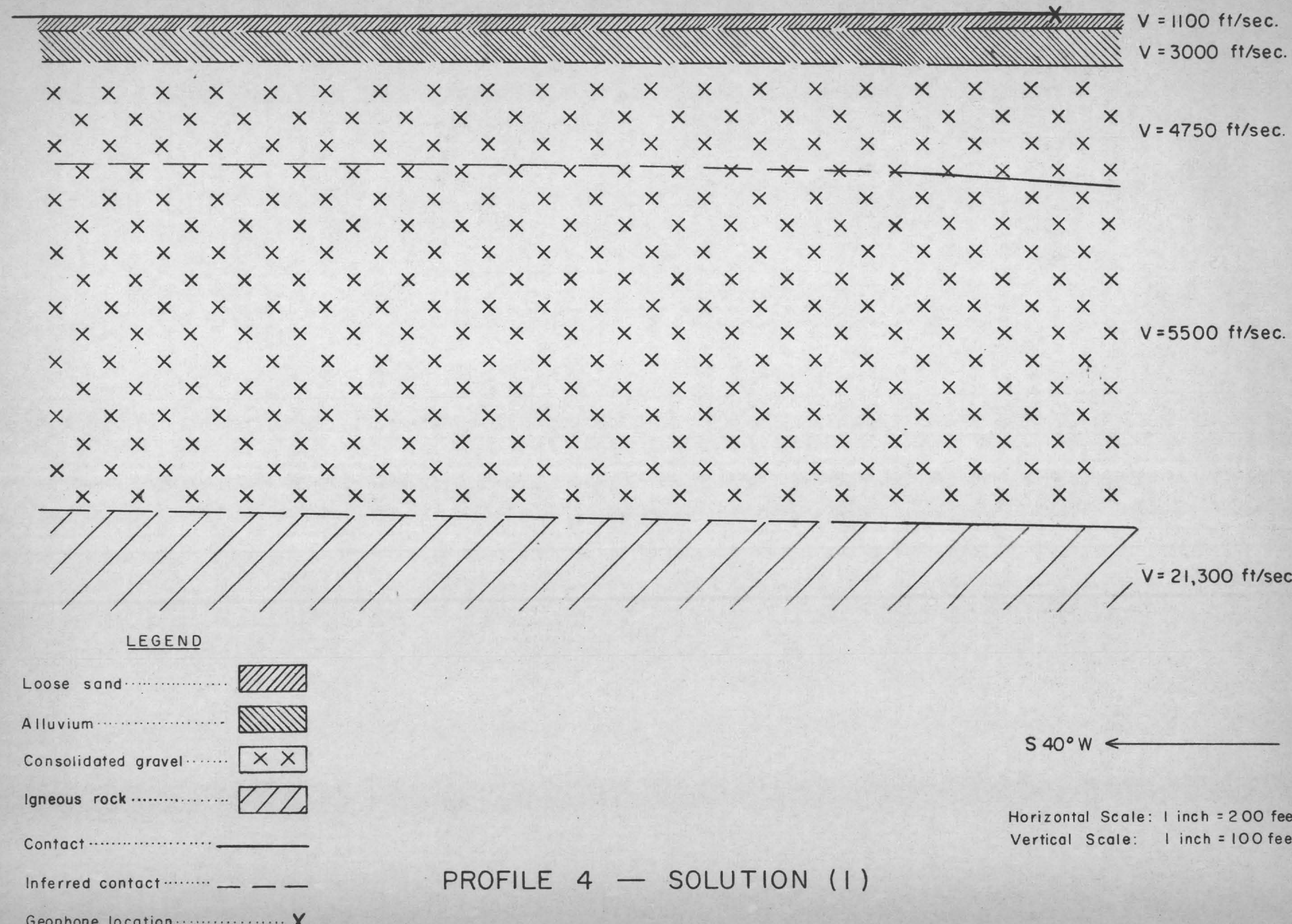
PROFILE 3 — SOLUTION (1)

FIGURE 9.



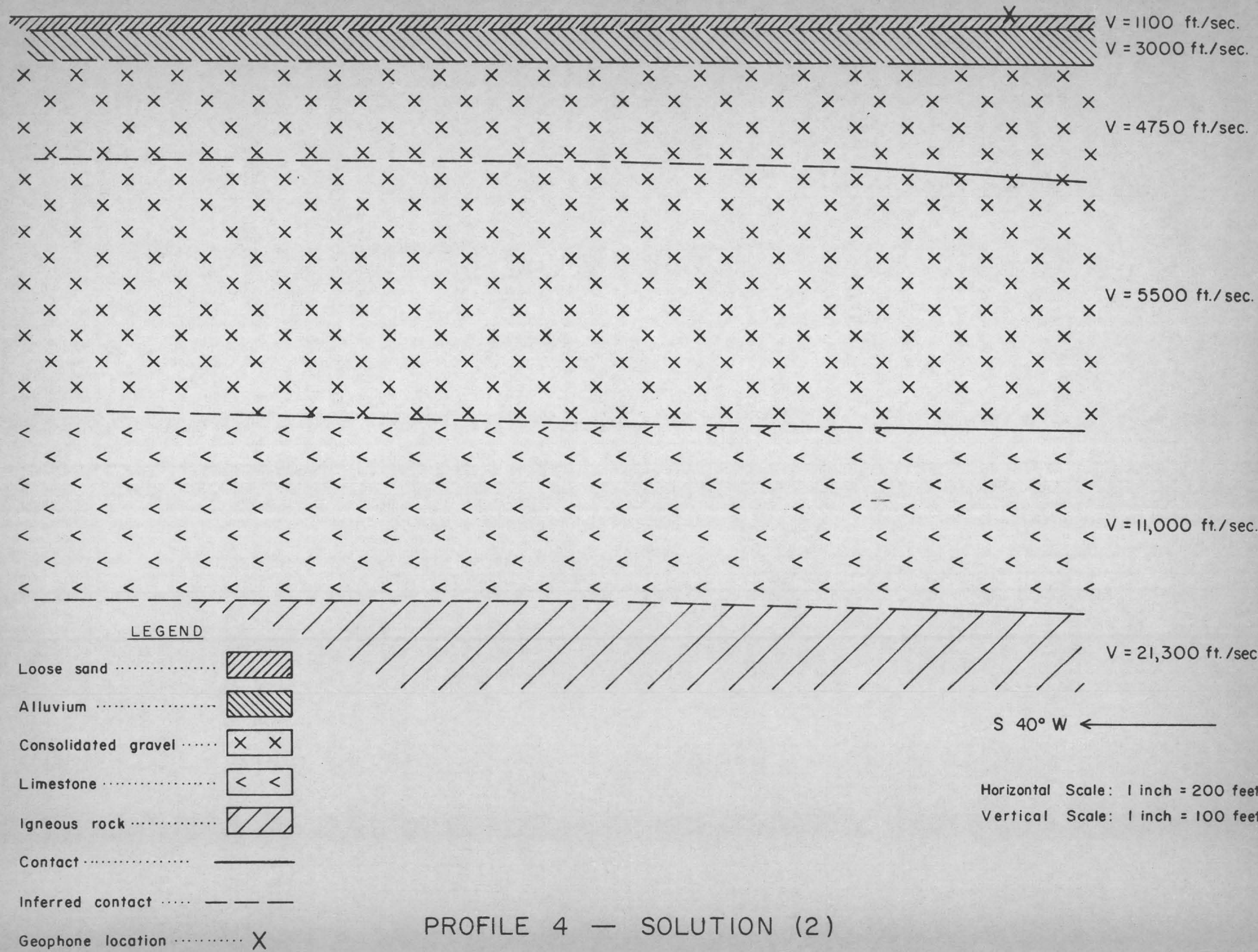
PROFILE 3 — SOLUTION (2)

FIGURE 10.



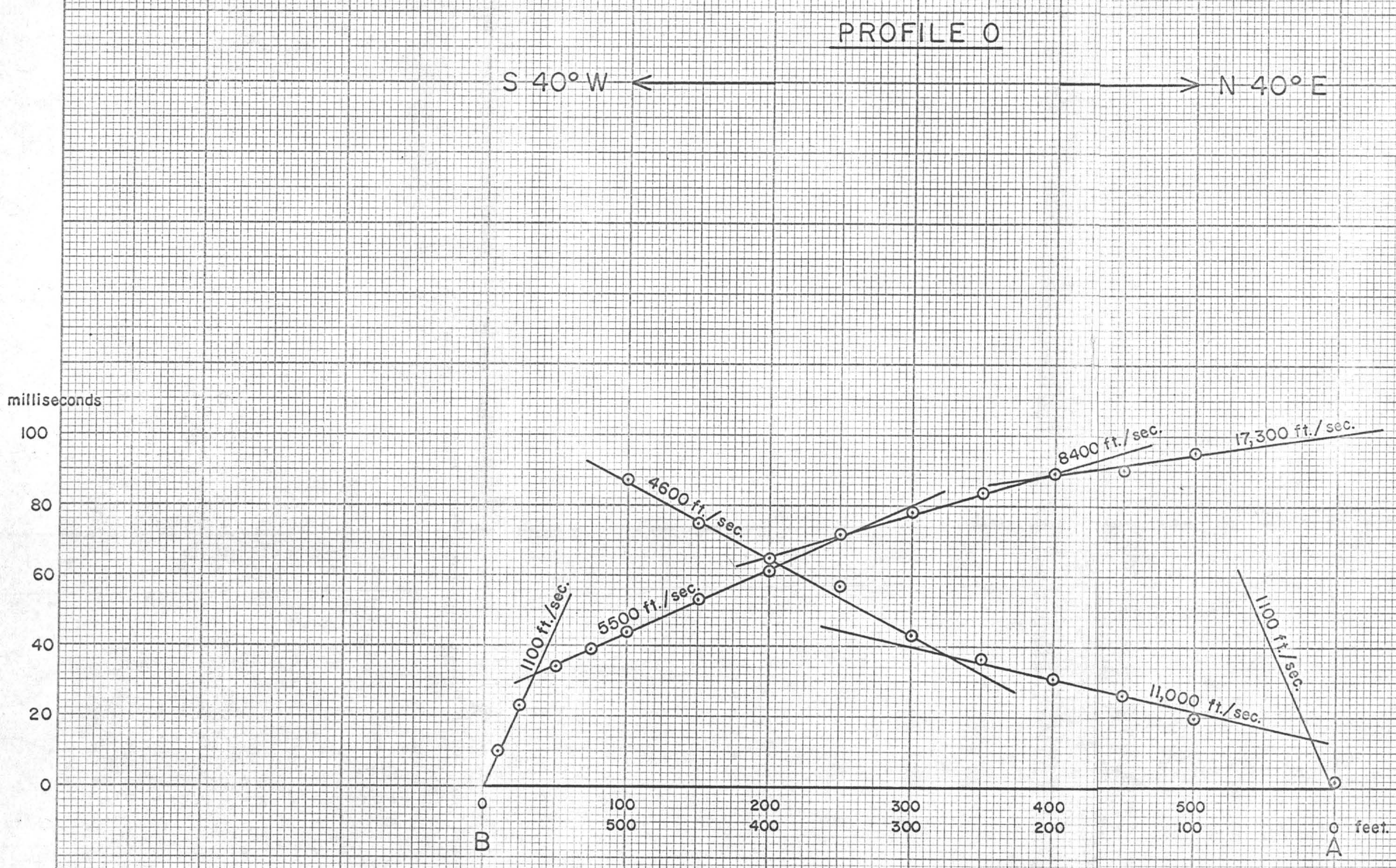
PROFILE 4 — SOLUTION (1)

FIGURE 11.

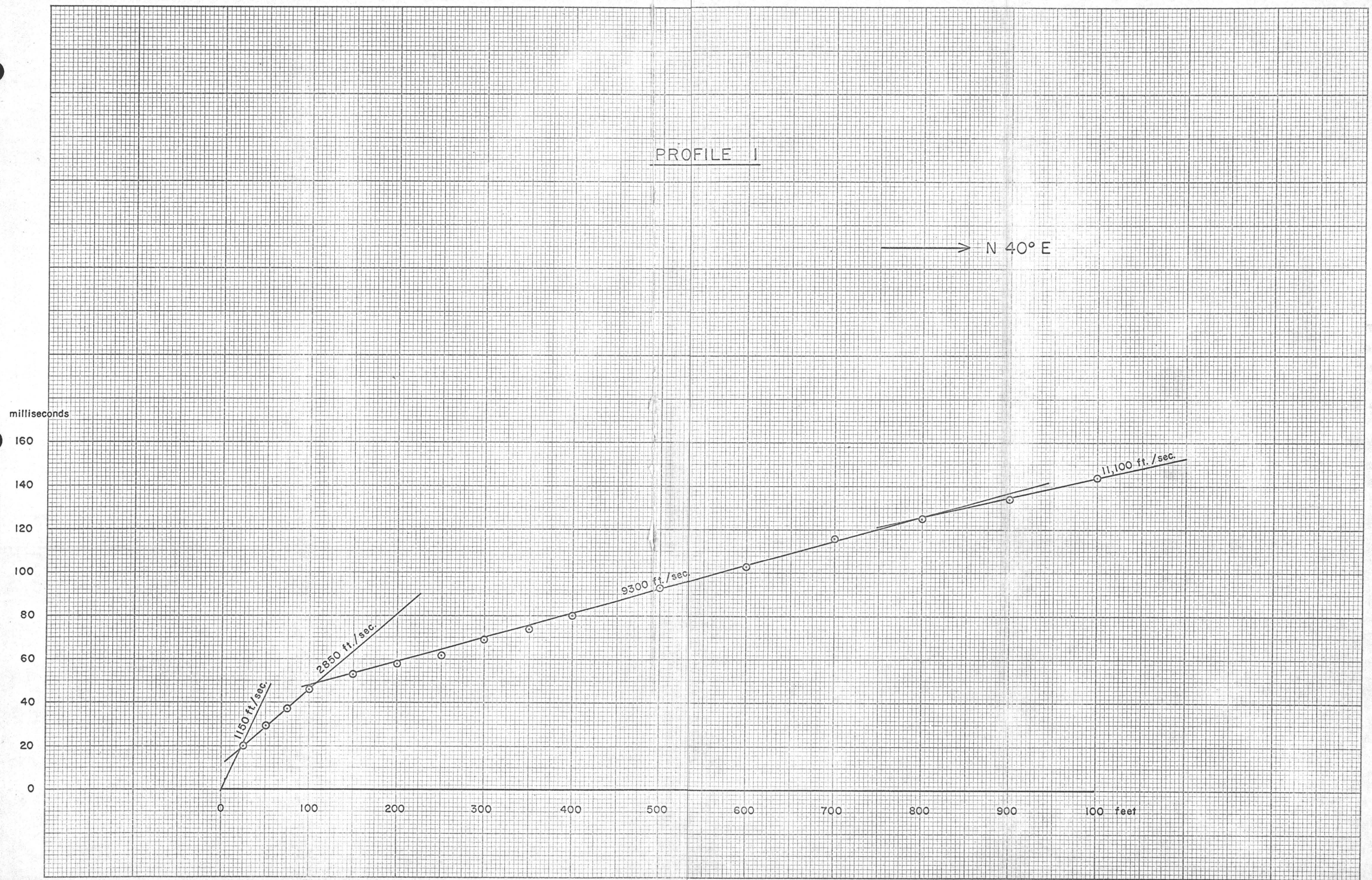


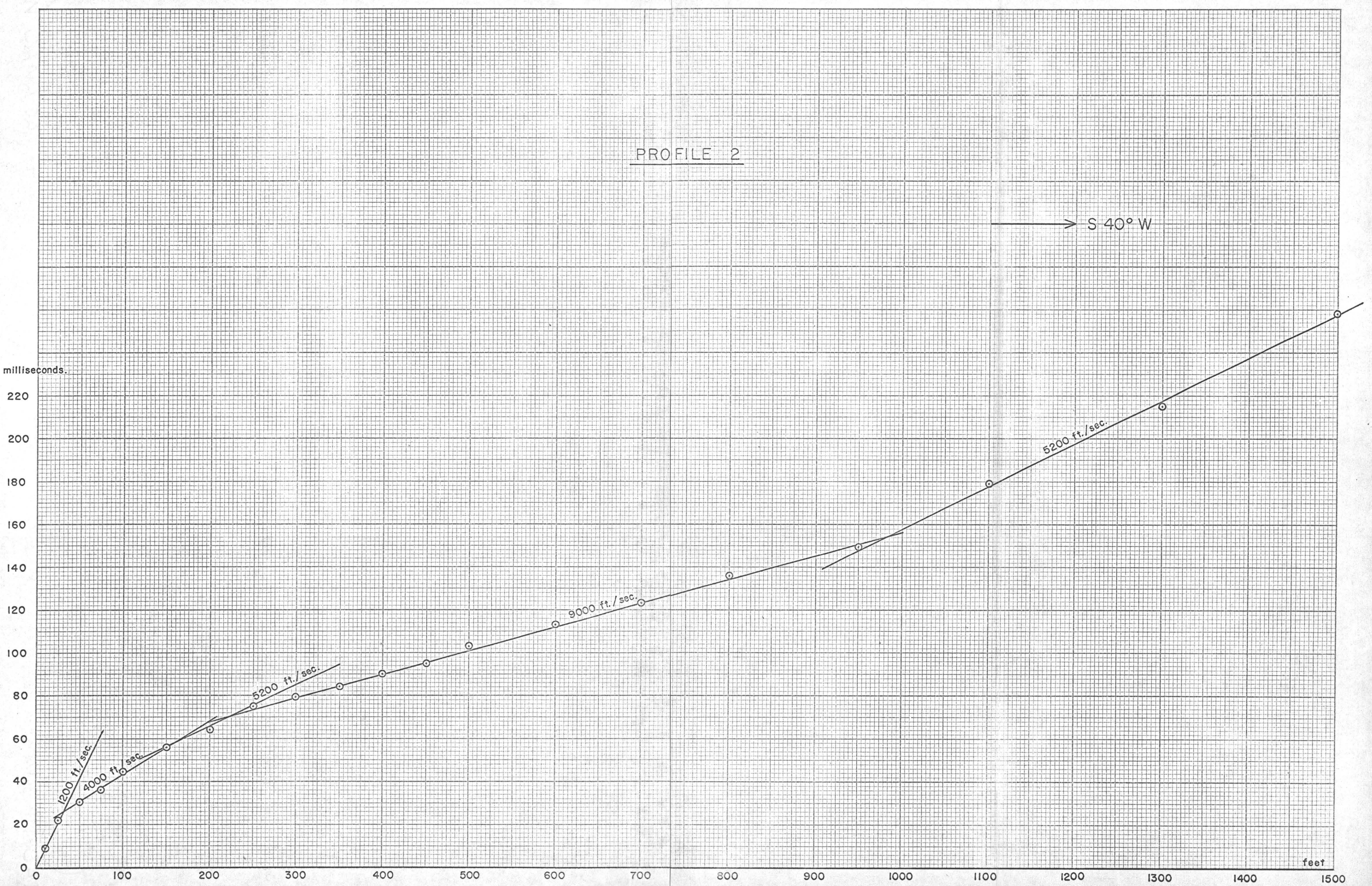
PROFILE 4 — SOLUTION (2)

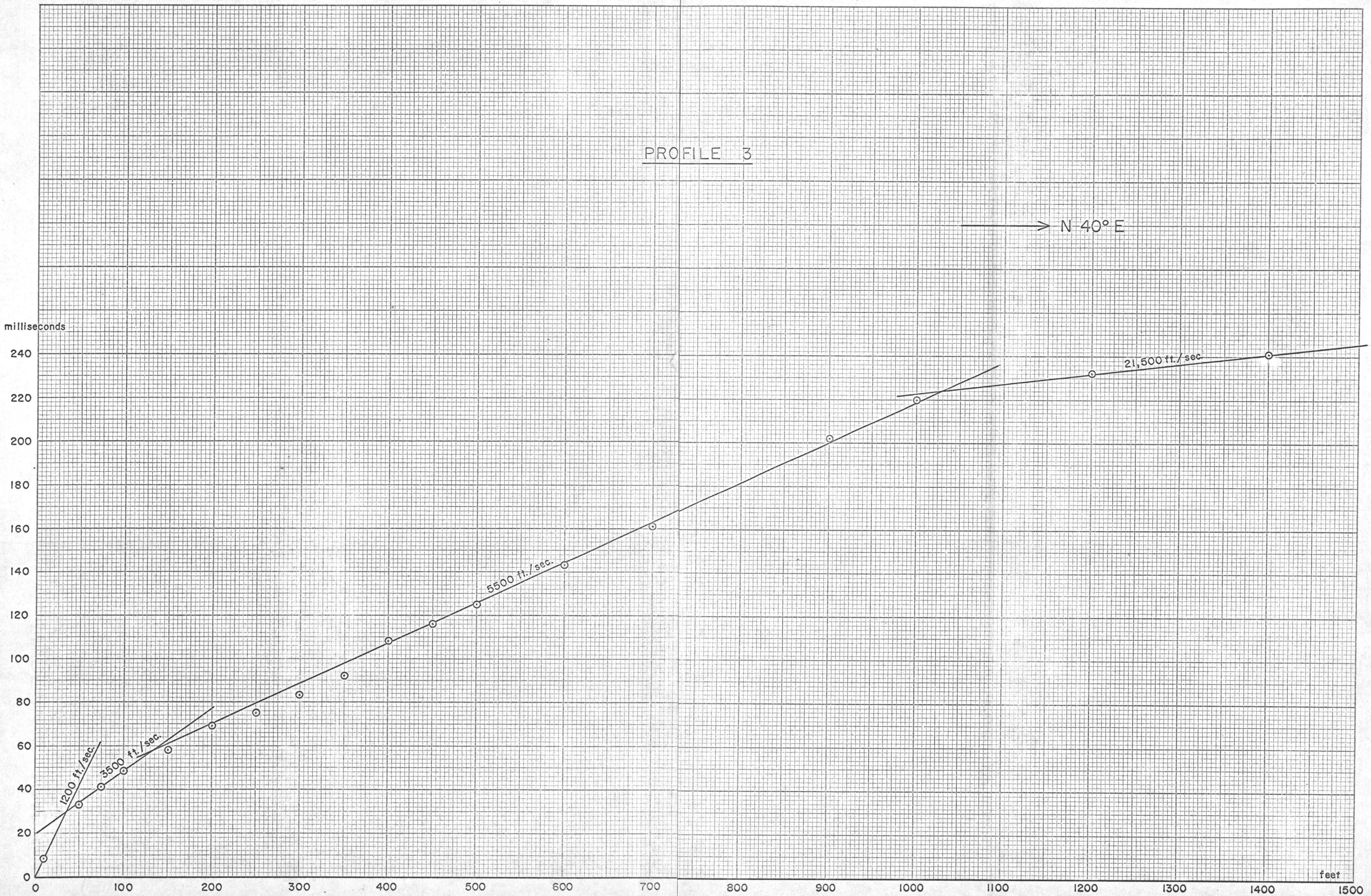
FIGURE 12.

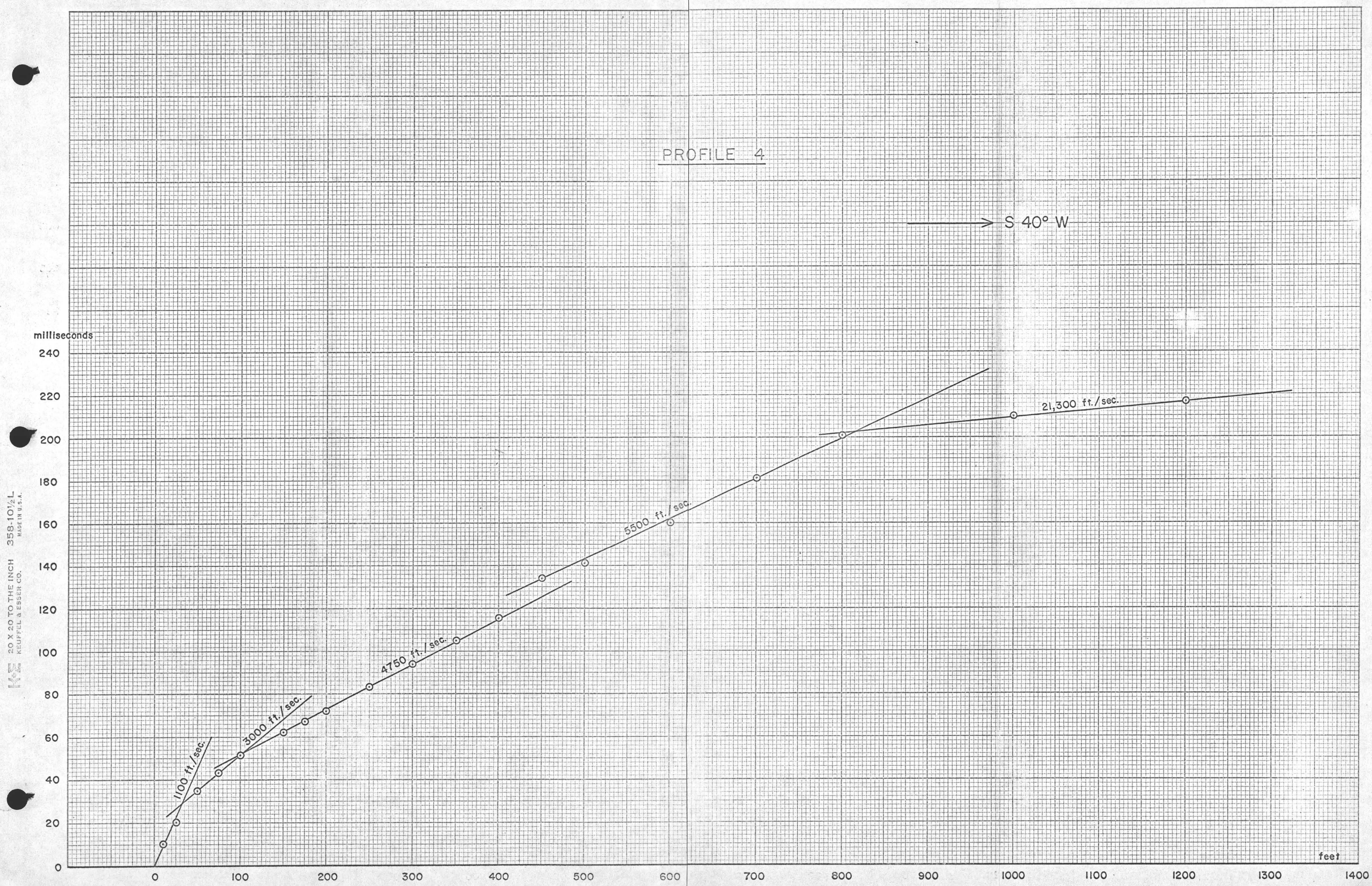


PROFILE O
S 40° W
N 40° E
milliseconds
100
80
60
40
20
0
0
100
200
300
400
500
500
400
300
200
100
0 feet.
B
A
1100 ft./sec.
5500 ft./sec.
4600 ft./sec.
8400 ft./sec.
17,300 ft./sec.
11,000 ft./sec.
1100 ft./sec.


PROFILE I
N 40° E
milliseconds
160
140
120
100
80
60
40
20
0
0
100
200
300
400
500
600
700
800
900
100 feet
1150 ft./sec.
2850 ft./sec.
9300 ft./sec.
11,100 ft./sec.


PROFILE 2
S 40° W
milliseconds.
220
200
180
160
140
120
100
80
60
40
20
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
feet
1200 ft./sec.
4000 ft./sec.
5200 ft./sec.
9000 ft./sec.
5200 ft./sec.


PROFILE 3
N 40° E
milliseconds
240
220
200
180
160
140
120
100
80
60
40
20
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
feet
1200 ft./sec.
3500 ft./sec.
5500 ft./sec.
21,500 ft./sec


PROFILE 4
S 40° W
milliseconds
240
220
200
180
160
140
120
100
80
60
40
20
0
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
feet
1100 ft./sec.
3000 ft./sec.
4750 ft./sec.
5500 ft./sec.
21,300 ft./sec.
20 X 20 TO THE INCH
KEUFFEL & ESSER CO.
358-10½L
MADE IN U.S.A.

HEINRICHS

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TUCSON, ARIZONA

STEBBINS MINERAL SURVEYS INCORPORATED

GEOLOGIC REPORT SUPPORTING LEASE APPLICATION IN VEKOL & QUIJOTOA AREAS PAPAGO INDIAN RESERVATION ARIZONA

BY
STEBBINS MINERAL SURVEYS INCORPORATED
OLD GREENWICH, CONNECTICUT
JULY, 1964

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SUMMARY OF THE PAPAGO EXPLORATION PROGRAM

The Reservation comprises 4,335 square miles (2,774,000 acres). Between September 20 and November 14, 1961 all outcrop was photographed simultaneously in color and black and white as stereo pairs of aerial photography in a scale of 1:10,000 (1 inch equals 833 feet). The outcrop areas approximate 40 per cent of the Reservation.

From November 20, 1961 to August 9, 1962 a geologic study of the aerial photography combined with field investigations was completed. During this period areas of no economic geologic interest were defined and relinquished, as specified by the permit, and areas warranting additional investigation were selected and assigned priorities. This mapping was compiled as 15-minute quadrangles at a scale of 1 inch equals two miles made from enlargements of the Arizona Bureau of Mines County Geologic Maps published at a scale of 1:375,000.

The remainder of the program (August, 1961 to October, 1963) comprised detailed geologic mapping, geochemical sampling, airborne and ground geophysics, and the drilling of one diamond drill hole. A total of 1499 geochemical samples were collected from which 3095 analyses were reported. Two miles of shallow seismic profiles were obtained, approximately 1,700 line miles of aeromagnetic survey were completed, 37 line miles of ground magnetic survey, and 65.4 line miles of induced polarization survey. The one diamond drill hole was drilled to a depth of 168 feet through 85 feet of alluvium.

Two geologic reports have been submitted to the Department of Interior (August, 1962 and February, 1963), in each case at the time land was relinquished as required by the permit.

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Index.

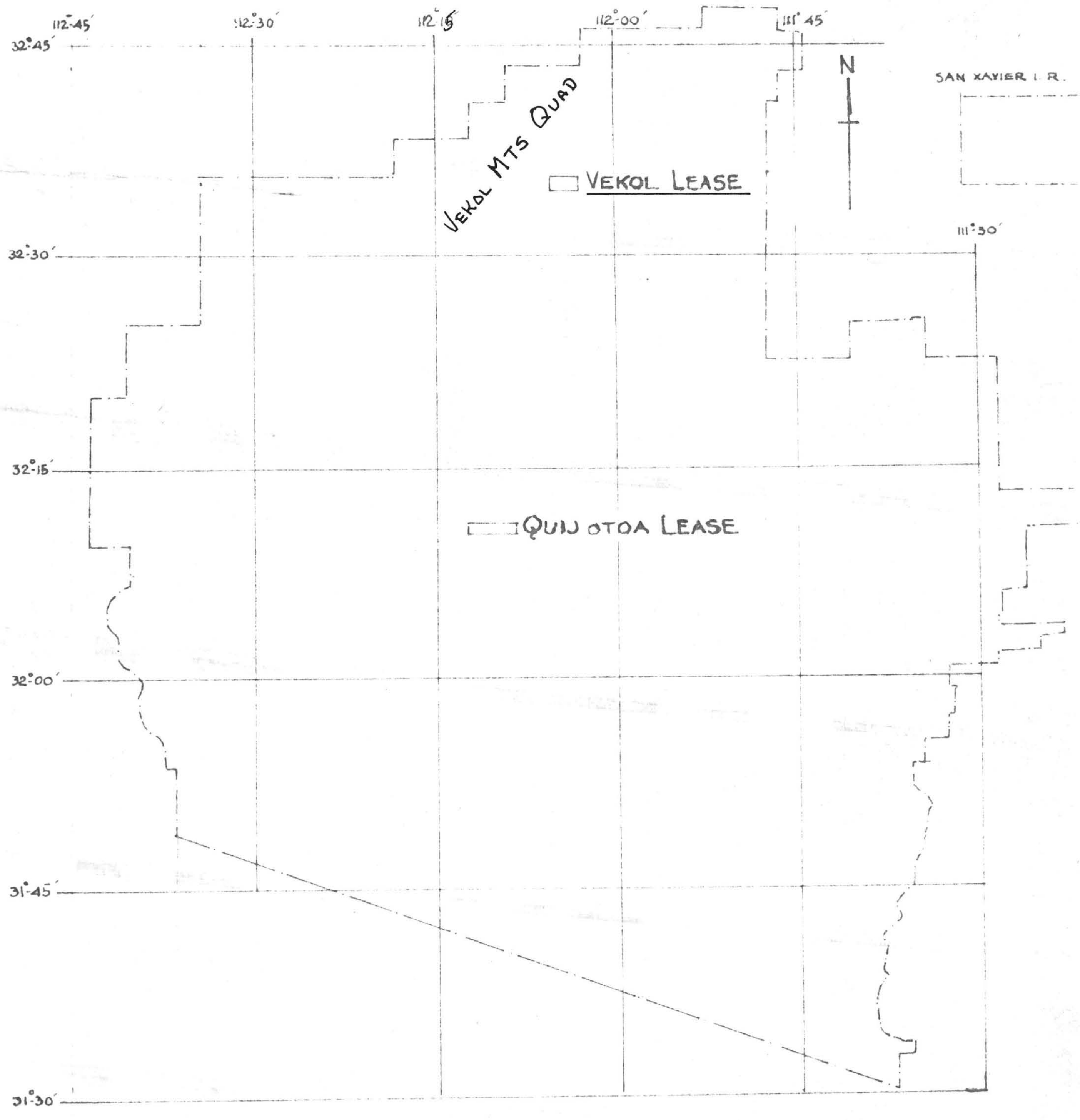
Map # 1

LOCATION MAP
STATE OF ARIZONA
SHOWING
PAPAGO INDIAN RESERVATION

Scale of Miles

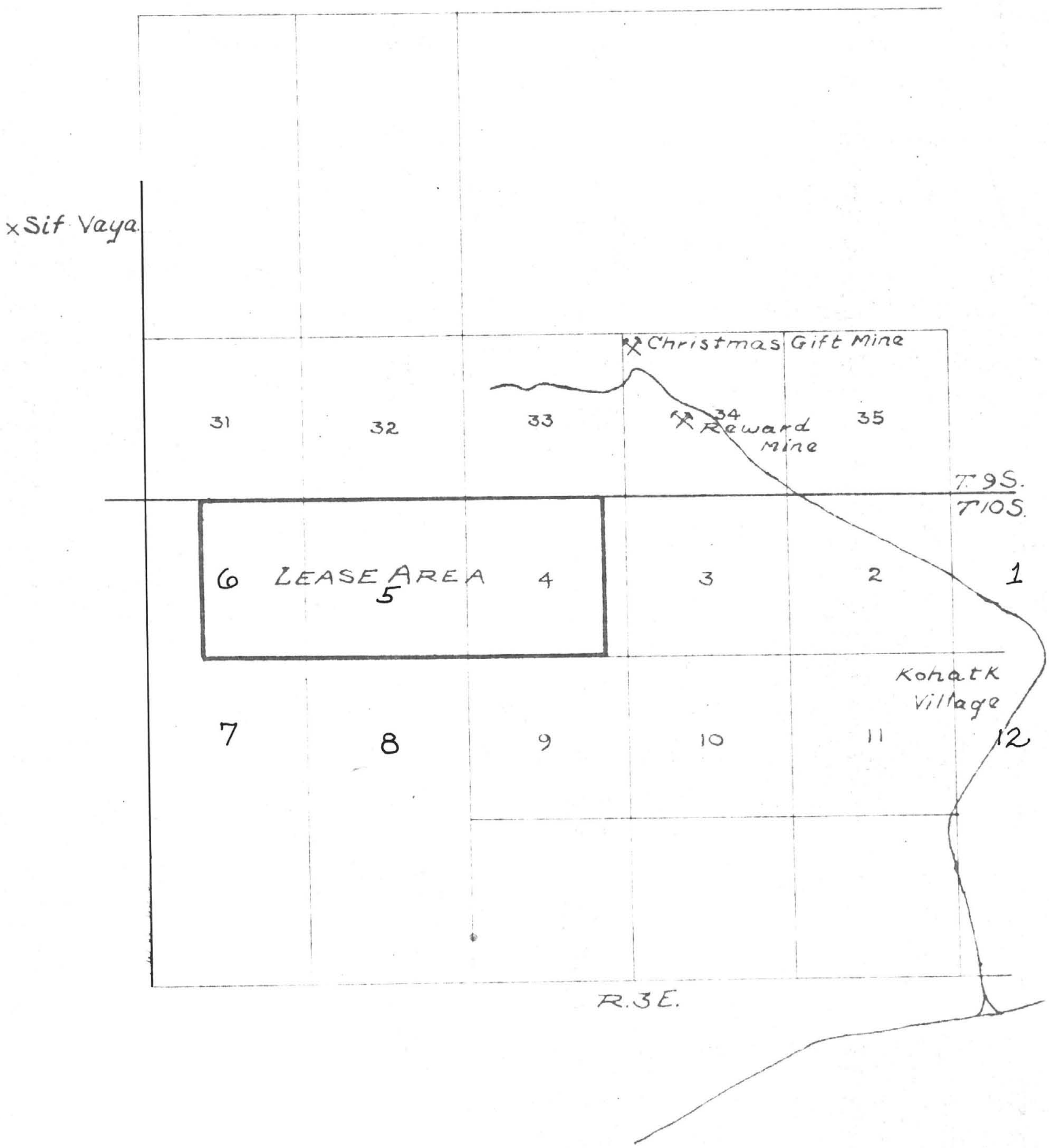
0 25 50 75 100 125 150 175 200

Map # 2



LOCATION MAP
PAPAGO INDIAN RESERVATION
ARIZONA
SHOWING LEASE AREAS

SCALE 1" = 12 MILES



LOCATION MAP

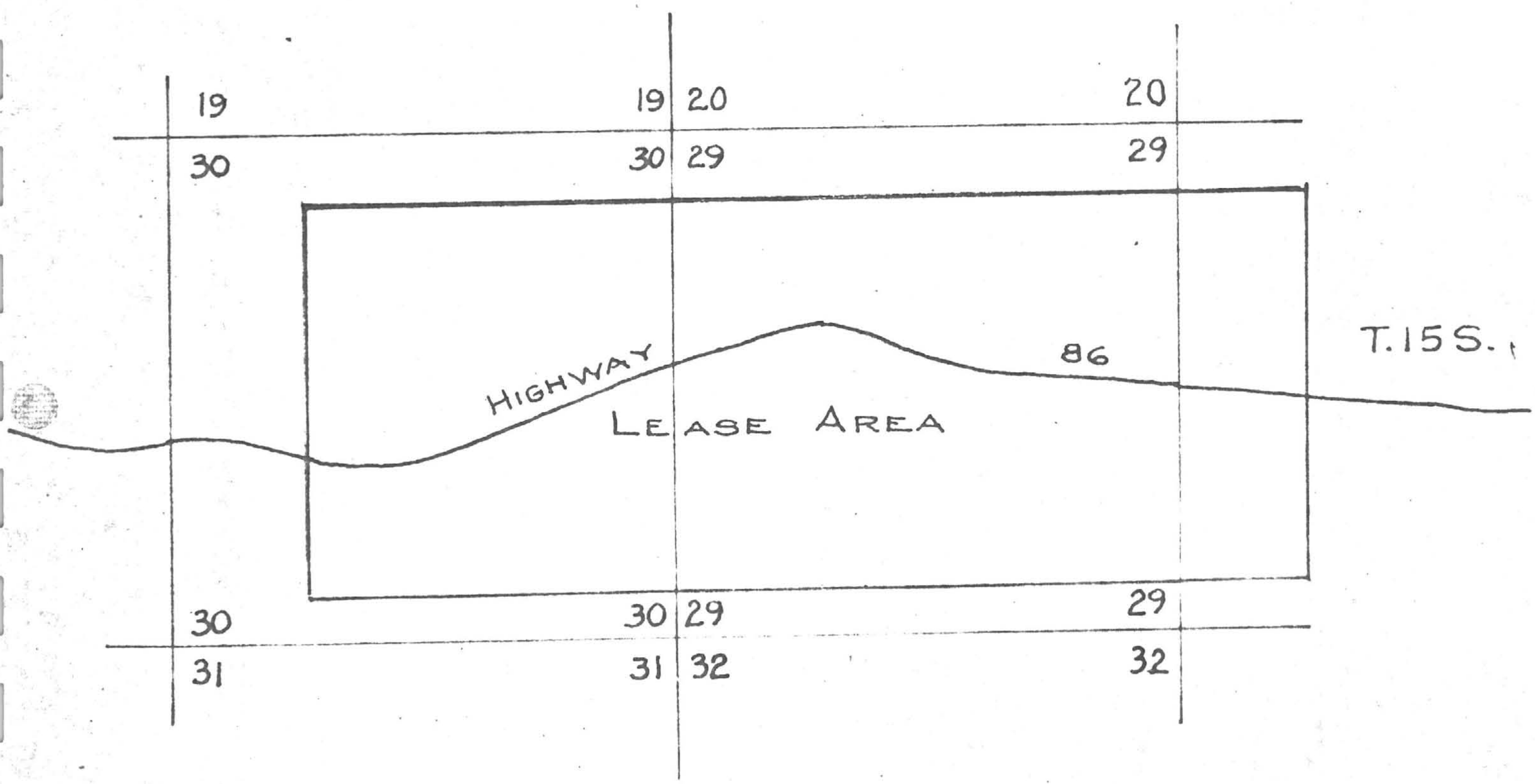
VEKOL LEASE AREA

VEKOL MOUNTAIN QUAD

PINAL COUNTY, ARIZONA

SCALE 1:62,500

Map # 4



R. 2 E.

LOCATION MAP
QUIJOTOA 4N.W. QUADRANGLE
PIMA COUNTY, ARIZONA
SHOWING QUIJOTOA LEASE AREA
SCALE 1" = 2000'

VEKOL MOUNTAINS

Location

This range lies in the north of the Papago Indian Reservation and in the southeast corner of Pinal County in Ts. 9 & 10 S. Rs. 2 & 3 E.

Access

The Vekol Mountains are reached from the town of Casa Grande, Pinal County, south seventeen miles on paved road to a turn off to the west to Kohakt village. The Vekol range lies three miles to the west of the village. A number of old unimproved roads give access to the mines in the area.

Topography

The Vekol range runs northwest and is six miles long. The main range is about two miles wide but a group of hills lie to the northeast separated from the main range by a basin 1½ miles wide in which is the abandoned village of Sif Vaya.

The mountains rise to a maximum elevation of 4000 feet. They are bounded on the east by the Santa Rosa Valley, a gravel filled basin ten miles wide with an average elevation of 1700 feet. The Vekol valley lies to the west of the range.

The area of possible economic interest is southwest of the Reward Mine.

Climate

The climate is arid with annual rainfall under ten inches per annum. Winters are cool and summers hot.

Vegetation consists of Cactus and other desert plants.

Geology

The southern end of the Vekol Mountains near the Reward Mine is composed of Paleozoic sediments, mostly limestone, ranging in age from Cambrian to Pennsylvanian. These are covered by Cretaceous Conglomerate and Tertiary Volcanics. A small stock of Quartz Monzonite Porphyry intrudes the sediments about one mile to the west of the Reward Mine.

Mineralization

Production of 400,000 lbs. of copper is recorded from the Reward Mine.

The ore occurs as small replacement bodies in the Escabrosa (Mississipian) limestone. The mineralization is controlled by faults.

To the south of the Reward, on the same ridge are several prospect pits, shafts and adits which were sunk on similar small deposits. However, the sulphide at the south end of the ridge is predominantly sphalerite which is associated with massive magnetite.

Work Carried out by Stebbins Mineral Surveys

About three man months were spent on the geological and geochemical survey of this area.

The Vekol Mountain area was mapped by M.A. Kaufman on the scale of the aerial photography, approximately 1:10,000. A portion of the map is included with this report.

Two possibilities for further mineralization were considered to exist.

a. Copper or Zinc replacement bodies in limestone associated with magnetite, beneath gravel.

b. "Porphyry" type copper mineralization.

The following work was undertaken to test these possibilities.

(1) A total intensity magnetic survey was carried out using a Varian Nuclear Precession Magnetometer Model V-4910 mounted in a Bell 47G - 3B helicopter flying at a constant ground clearance of 150 feet with the "bird" at 50 feet ground clearance, along flight lines spaced 1000' apart. A portion of the magnetic contour map compiled from the results of this survey is included as overlay #1 to the geologic map.

A magnetic high was seen to extend from the southwest end of the Reward ridge for about 3000 feet to the southwest.

(2) A ground magnetic survey was carried out over this anomaly using a Jalander fluxgate instrument. Readings were taken at 100 foot spacing on lines running N30ºW, 200 feet apart. Magnetic contours from the results of this survey are shown as overlay #2 to the geologic map.

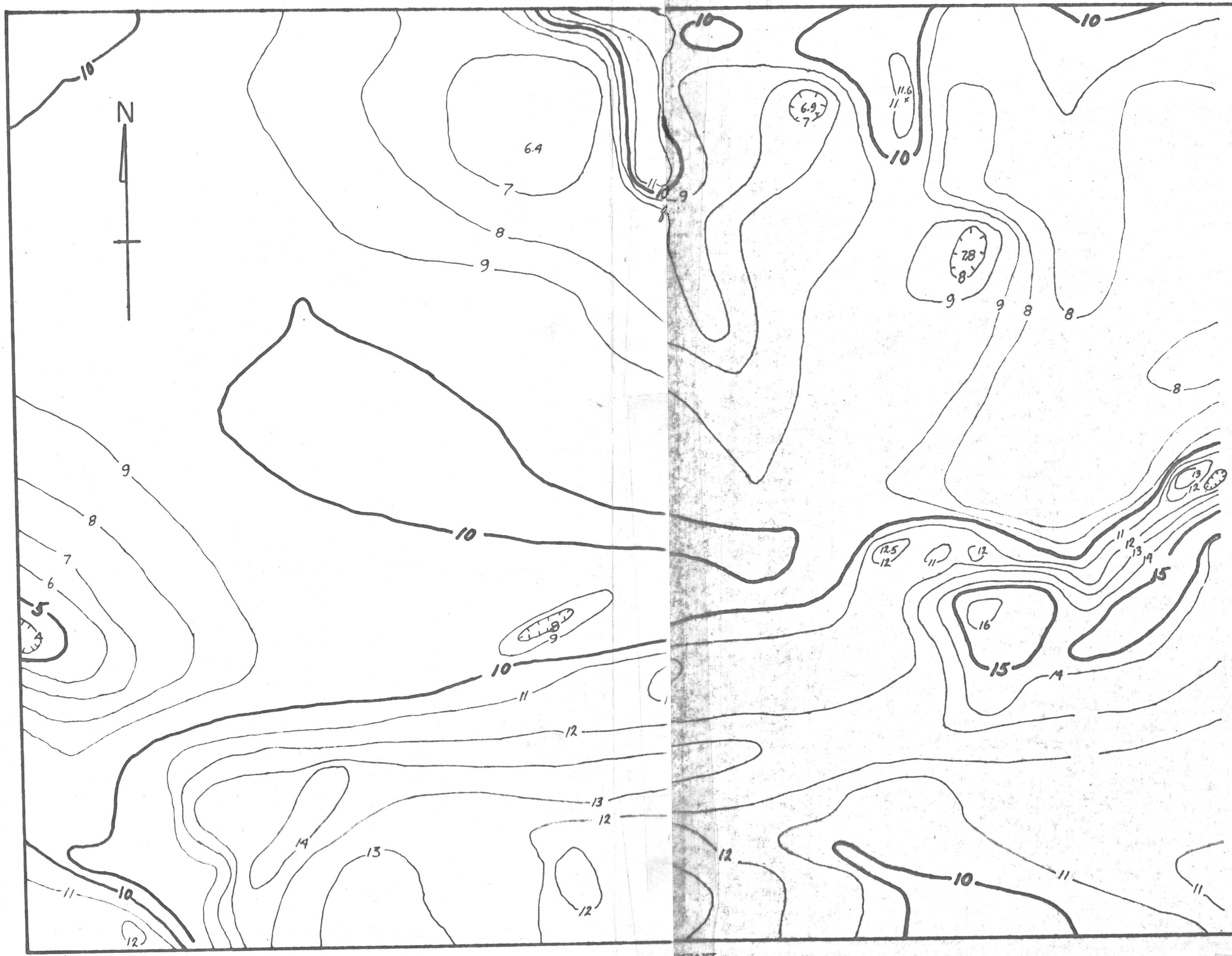
Zones of magnetite occur both in the Paleozoic limestone and in the underlying Cambrian quartzite. An interpretation of the magnetic data by R.W. Whipple, Geophysical Consultant to Stebbins Mineral Surveys Inc. suggested that the anomalies were caused by further zones of magnetite in sediments beneath from 50 feet to 250 feet of gravel cover.

(3) To test for sulphide possibly associated with the zones of magnetite, an induced polarization survey was carried out over the area and extended to the west to cover the contact of the sediments with granite in which were recorded scattered anomalous geochemical values in copper from 300 up to 1200 ppm. (See overlay #3 showing geochemical sample locations and values).

A Seigel Associates 7.5 kilowatt pulse type induced polarization unit, rated at 5 amps and 5,000 volts was used with three electrode array configuration at 250, 500 and 1,000 feet electrode spacing. A plan of the chargeability and resistivity profiles is included as overlay #4 to the geologic map.

Interpretation

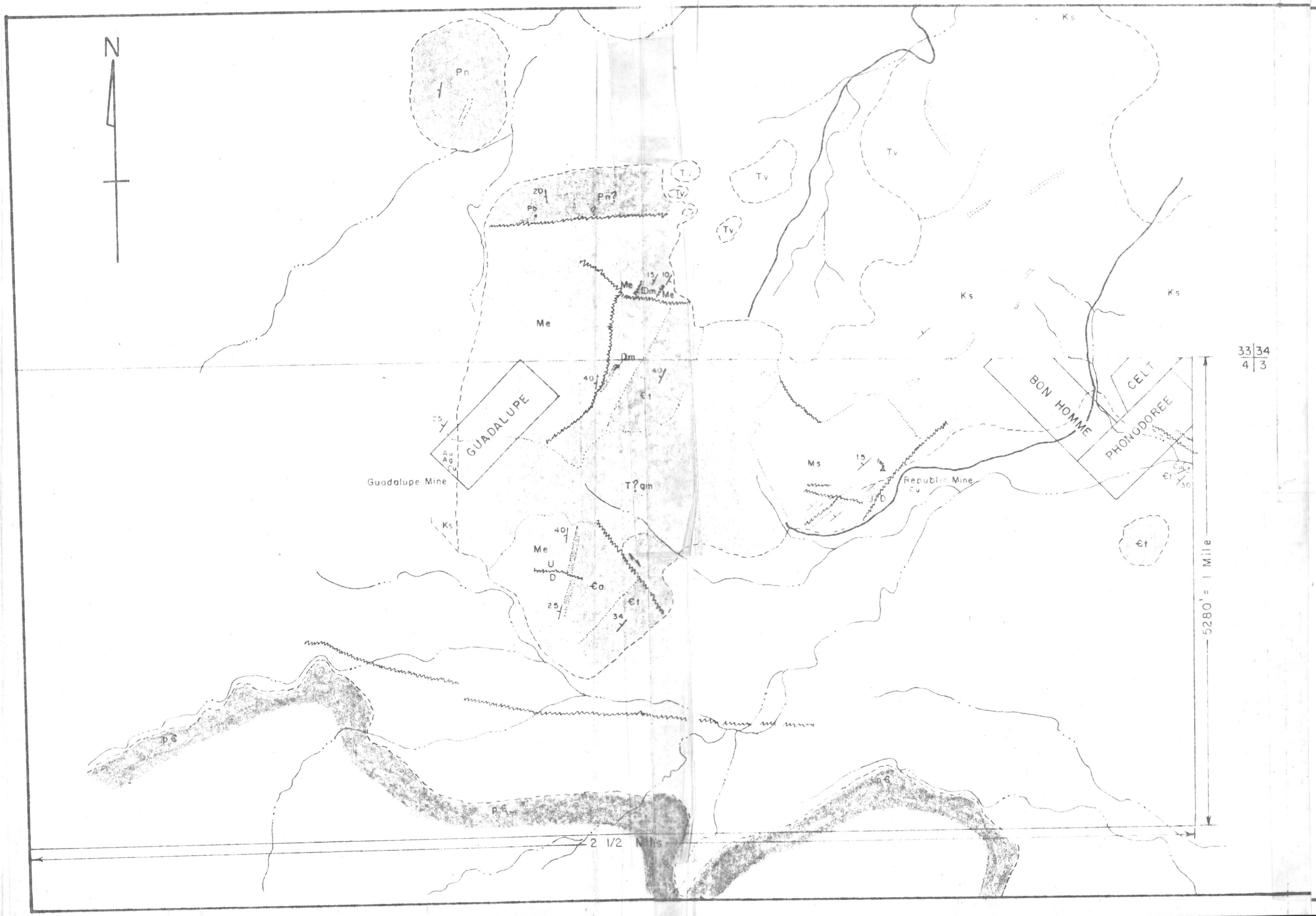
Four major anomalous zones and three minor are shown on the plan of profiles. An interpretation by Dr. H.O. Seigel is included with this report. (appendix #1).



OVERLAY FOR
GEOLOGIC MAP VEKOL MOUNTAINS

SHOWING AEROMAGNETIC SURVEY

CONTOURS INTERVAL 100 (APPROX.)
SCALE 1" = 1000' (APPROX.)



LEGEND

Tv	TERTIARY VOLCANICS (ANDESITE TO BASALT) AND RELATED INTRUSIVES.
an	ANDESITE PORPHYRY FELDSPAR-HORNBLEND PORPHYRY IN FINE GRAINED MATRIX. INCLUDES SEDIMENTARY AND INTRUSIVE ROCK COMPLEX.
T mq	FINE GRAINED ACIDIC INTRUSIVE (QUARTZ PORPHYRY TO QUARTZ MONZONITE). (PROBABLY TERTIARY).
gr	COARSE GRAINED PORPHYRITIC GRANITE (WITH ORTHOCLASE PHENOCRYSTS) (AGE UNKNOWN).
Ks	CRETACEOUS - CONGLOMEATE, SILTSTONE AND QUARTZITE. RED EXCEPT BASAL UNIT. INCLUDING AGGLOMERATE UNITS.
Pn	PENNSYLVANIAN LIGHT GRAY FOSSILIFEROUS NACO LIMESTONE.
Me	MISSISSIPPIAN DARK GRAY ESCABROSA LIMESTONE.
Dm	DEVONIAN TAN MARTIN LIMESTONE.
€a	CAMBRIAN CHIEFLY BROWN CLASTIC SEDIMENTS (ABRIGO TYPE LIMESTONE OCCURS ON TOP OF SECTION).
€t	CAMBRIAN PURE WHITE TO TAN FINE GRAINED QUARTZITE (TROY TYPE).
pЄ	PRECAMBRIAN (ARCHEAN) HIGHLY CONTORTED "PINAL" TYPE METAMORPHICS. CHIEFY QUARTZ MUSCOVITE GNEISS.

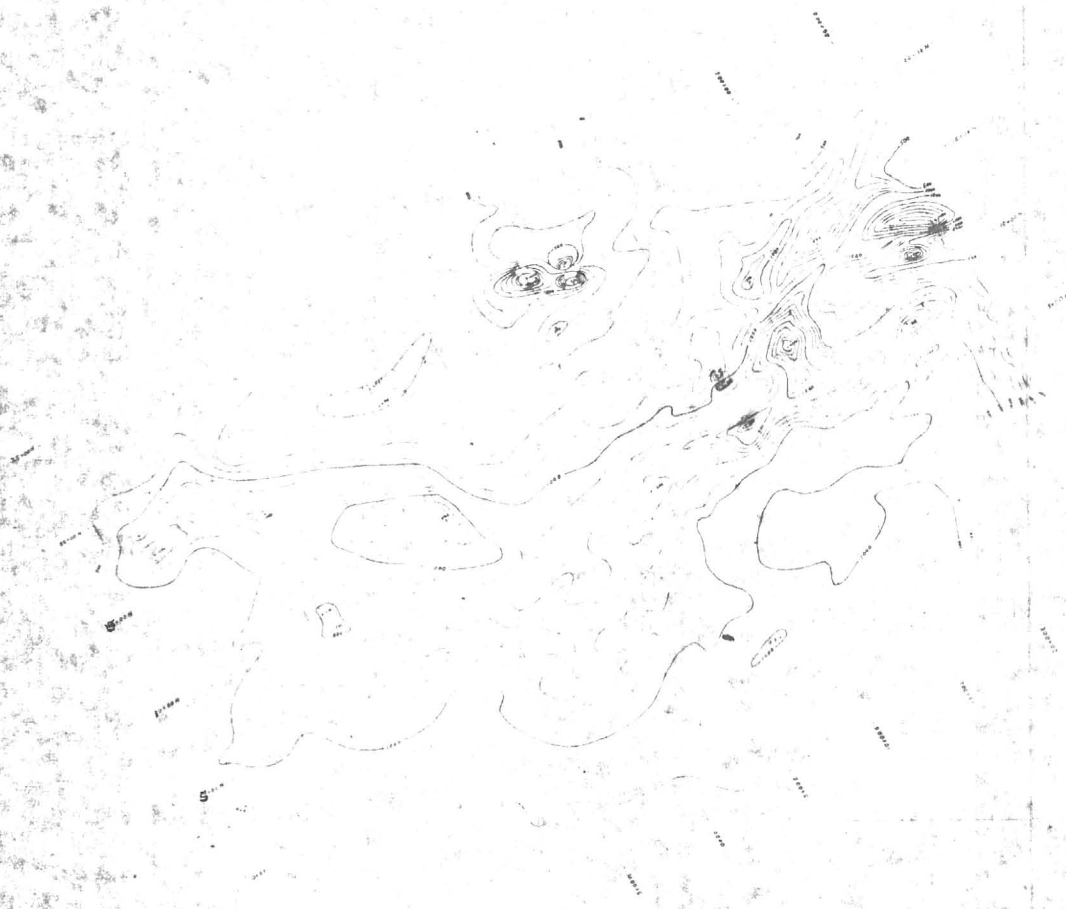
FAULT ZONE
OUTCROP BOUNDARY
MAGNETITE OCCURRENCE
MINERALIZATION OR ALTERATION
CONTACTS
ROADS
SCHISTOSITY
STRIKE AND DIP OF BEDS

GEOLOGIC MAP OF PART OF VEKOL MOUNTAINS

PAPAGO INDIAN RESERVATION, ARIZONA

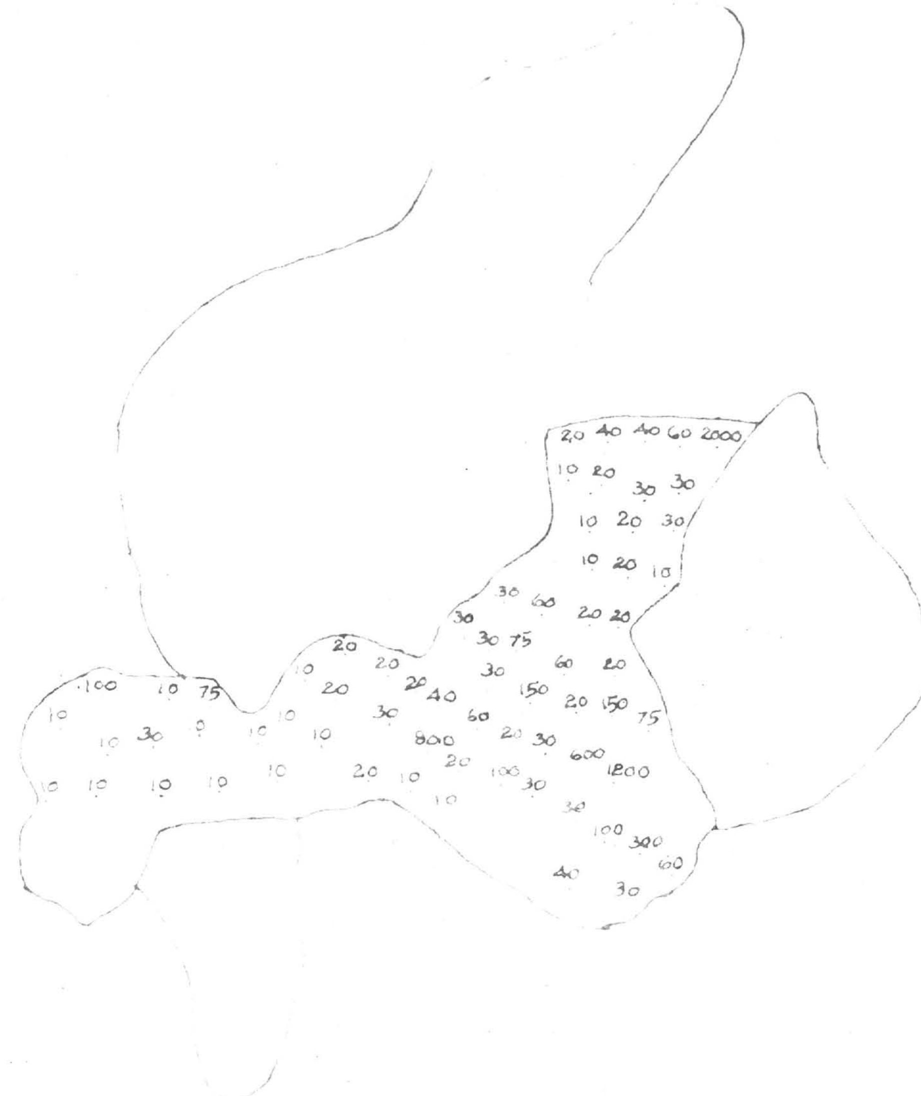
SCALE 1" = 1000' APPROX.

Overlay #2



OVERLAY FOR
GEOLOGIC MAP
VEKOL MOUNTAINS
SHOWING GROUND MAGNETIC
SURVEY CONTOURS
CONTOUR INTERVAL 100 γ
SCALE 1" = 1000'

Overlay #3



VEKOL MOUNTAINS

OVERLAY TO GEOLOGICAL MAP
ROCKCHIP GEOCHEMICAL S RVEY
COPPER PARTS PER MILLION,
SCALE 1:1000'

Overlay #4

Overlay For Geologic Map
VEKOL MOUNTAINS
Showing I.P. Profiles

Legend

Chargeability	Resistivity	Spacing	Array
O——————O	——————O	250′	3
O- - - - - -O	- - - - -O	500′	3

Chargeability >6.0 Millesecond
a = 250′
a = 500′

Scales

Chargeability ½ Inch = 5.0 Millisecond
Resistivity ½ Inch = 500 Ω Meters
Plan 1 Inch = 1,000′

A number of possibilities exist. Depths to sulphide as determined by Seigel are greater than the depths to magnetite as estimated by Whipple. It is possible that the magnetite zones occur in the Paleozoic rocks overlying sulphide mineralization in Precambrian Pinal schist.

The pattern of the induced polarization anomalies may indicate a steeply dipping tabular body of sulphide whose sub outcrop is repeated by faulting. Whipples interpretation of the magnetic results shows a series of NE - SW faults.

The series of anomalies is not fully explored to the west.

Application for Lease

Application is made for a lease in accordance with the terms of the Mineral Prospecting Permit No. 14-20-0450-3736.

The boundary of the lease area, a rectangle 2¼ miles east-west by one mile north-south, runs as follows:

From S.E. corner of Sec. 33 T 9 S. R 3 E., 1/8 mile west to the northeast corner of the lease area.

From northeast corner of the lease area 2¼ miles west to the northwest corner of the lease area.

From northwest corner of the lease area 1 mile south to the southwest corner of the lease area.

From the southwest corner of the lease area 2¼ miles east to the southeast corner of the lease area.

From the southeast corner of the lease area north 1 mile to the northeast corner of the lease area (starting point).

This area is shown of the geologic map.

From this area are withdrawn the following valid mineral claims which have prior rights:

	Sq. ft.
All of Guadalupe	900,000
Part of Bon Homme	737,950
Part of Phonodoree	882,000
Part of Phenomenon	55,400
Part of Celt	243,750

Total 2,819,100 sq.ft. = 64.71 acres

Total area	1600.00	acres
Less Claims	64.71	
Net area of lease	1535.29	acres

The claims are plotted on the geologic map, but their location is not accurately known so the area is subject to survey and the figure for the net area of the lease is subject to correction.

QUIJOTOA AREA

Location

Three miles west of Covered Wells Trading Post, which is 49 miles east of Ajo on Highway 86 between Tucson and Ajo. The area lies in T 15 S. R 2 E. Pima County, Arizona.

Access

The area lies astride highway 86. A number of old unimproved mine roads give access to the Quijotoa and Brownell Mountains.

Topography

The area is in a group of low hills between the Quijotoa Mountains to the south and the Brownell and Sierra Blanca Mountains to the north. The elevation is about 2500 feet and local relief is about 300 feet.

Climate

Climate and vegetation are similar to those of the Vekol Mountains.

Geology

The Quijotoa Mountains consist of a complex of acid igneous intrusives. At the north end of the range, on either side of highway 86, the rock is a fine grained quartz porphyry which is considered to be intrusive. Within an area of about one square mile a number of brecciated and iron stained zones occur. In places fine grained tourmaline forms the matrix of the breccia. The similarity of this rock to that from a copper bearing breccia pipe at Cananea, Sonora, Mexico, first drew attention to the area. The quartz porphyry in the vicinity of the breccia zones is altered, fractured and stained with limonite and hematite. The breccia zones and the areas of alteration are shown of the geologic map of Quijotoa area.

Mineralization

There is no record of mineral production from the immediate area, but copper and silver have both been produced in small quantities in the Quijotoa and Brownell Mountains.

Work Carried out by Stebbins Mineral Surveys Inc.

About three man months were spent on geological mapping. An area of about 50 square miles in the Brownell Mountains and the northern part of the Quijotoa range was mapped on a scale of 1" : 1000' by K. Droste. Alteration in the area of the breccia zones was mapped in detail by M.A. Kaufman.

A portion of the geologic map showing alteration zones is included with this report, Geological Map of Quijotoa Area.

The possibility of disseminated copper mineralization in the quartz porphyry and in the breccia zones was considered worth testing.

Geochemistry

Some rock chip samples from areas of outcrop were assayed by hot extraction method for traces of copper and molybdenum. One small area was slightly anomalous in molybdenum (five times back ground). Copper values were uniformly near back ground. Values are shown on the overlay to the geologic map.

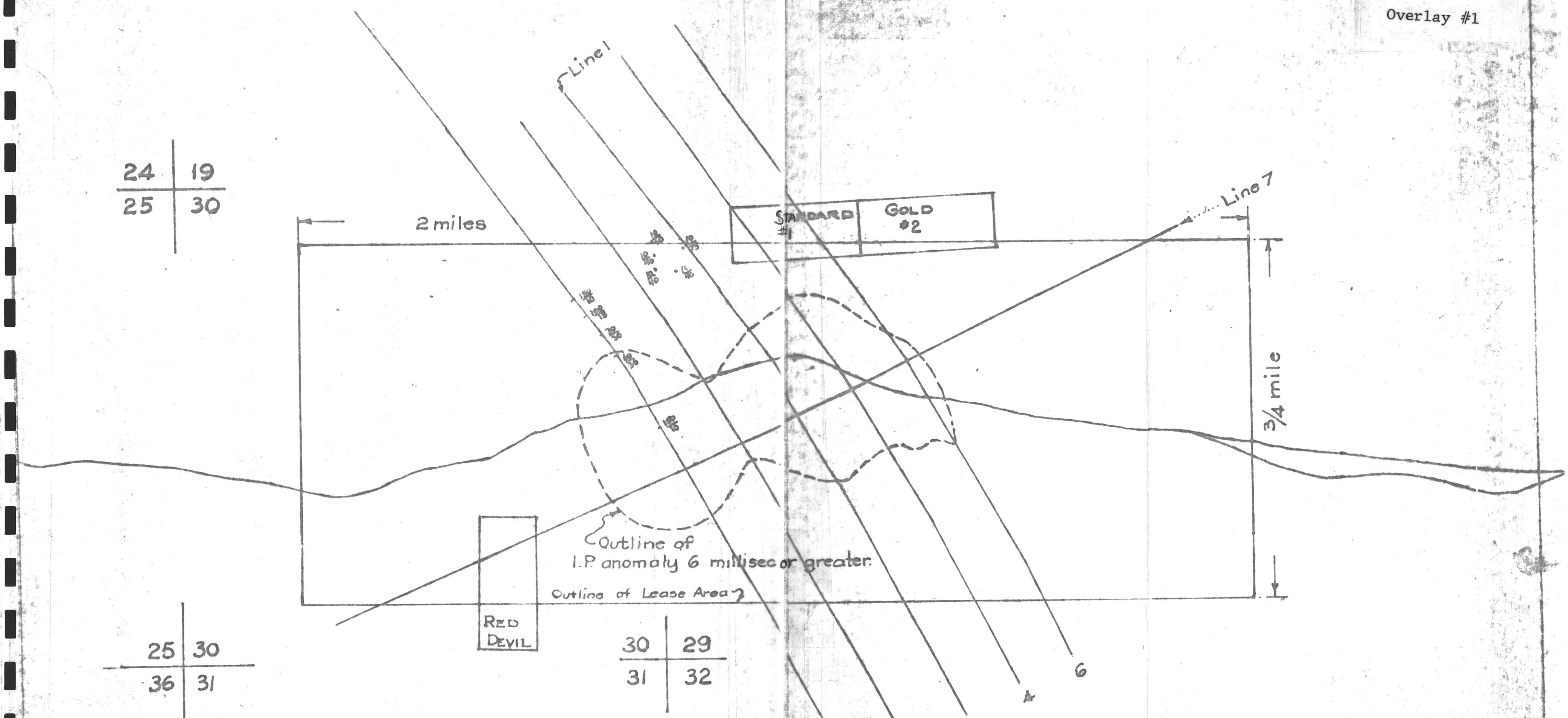
Geophysics

An induced polarization survey with a Hunting 2.5 kilowatt pulse type unit, using the three electrode array configuration at 250 feet and 500 feet spacing was carried out over the area.

An anomaly was recorded in an area 3000 feet east-west by 2000 feet north-south roughly where alteration in the quartz porphyry is strongest. The anomaly is still "open" to the east and west.

Chargeability varies from 6.6 milliseconds to 14 milliseconds against a background of about 2 milliseconds. Resistivity remained constant at 180-300 ohm-meters.

Overlay #1



OVERLAY FOR GEOLOGIC MAP-QUIJOTOA AREA
SHOWING I.P. SURVEY & GEOCHEMISTRY RESULTS
Scale 1" = 1000'

$\frac{10}{60}$ PARTS PER MILLION COPPER / PARTS PER MILLION MOLYBDENUM