A MAGNETIC SURVEY OF SAND CANYON FOR PLACER DEPOSITS, SAN GABRIEL MOUNTAINS CALIFORNIA

By

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CONTENTS

ILLUSTRATIONS and PROFILES

ABSTRACT

A magnetic survey was made in Sand Canyon, which is in the northwestern part of the San Gabriel Mountains, the object being to locate possible placer deposits. The bedrock in this area is an iron rich igneous rock which has been intruded by numerous dikes. The stream gravels consist of large boulders interspersed with highly magnetic sands.

Over 200 stations were involved in the survey in which vertical magnetic intensity was measured using a Schmidt-type vertical magnetometer. Magnetic anomalies found were so large that all instrument corrections were ignored.

Results of the survey show that the magnetic intensity readings are due to both the basement and the gravels, though the gravels have a greater effect. The location of the largest anomalies, thus the most probable placers, is at the eastern end of the area. Downstream from this site the intensity decreases rather uniformly; upstream it decreases very sharply where the canyon narrows suddenly. Geologically, this is the expected picture. It is thought that a fault has been located, which strikes up the canyon, but this has not been confirmed by surface evidence.

Data and profiles of the traverses, and a detailed map of the magnetic intensities of the region are included in this paper.

INTRODUCTION

The purpose of this study is to determine the location of placer deposits with the use of the Schmidt-type vertical magnetometer. Placers consist of stream deposits of various heavy minerals, both magnetic and non-magnetic. If present, gold, platinum, cassiterite, and other heavy non-magnetic minerals will be deposited with the magnetic ones, thus they can be located with a magnetometer.

The measurements were made intermittently between February and May, 1943.

ACKNOWLEDGEMENTS

The writer wished to thank Dr. G. W. Potapenko of the Institute Physics and Geology Departments for his advice and interest in this work. The area and problem chosen resulted from his suggestions.

The Division of Geological Sciences of the Institute kindly furnished a Schmidt-type magnetometer, a field car, and funds to cover the field expenses.

The friendly cooperation of the residents of Sand Canyon is appreciated.

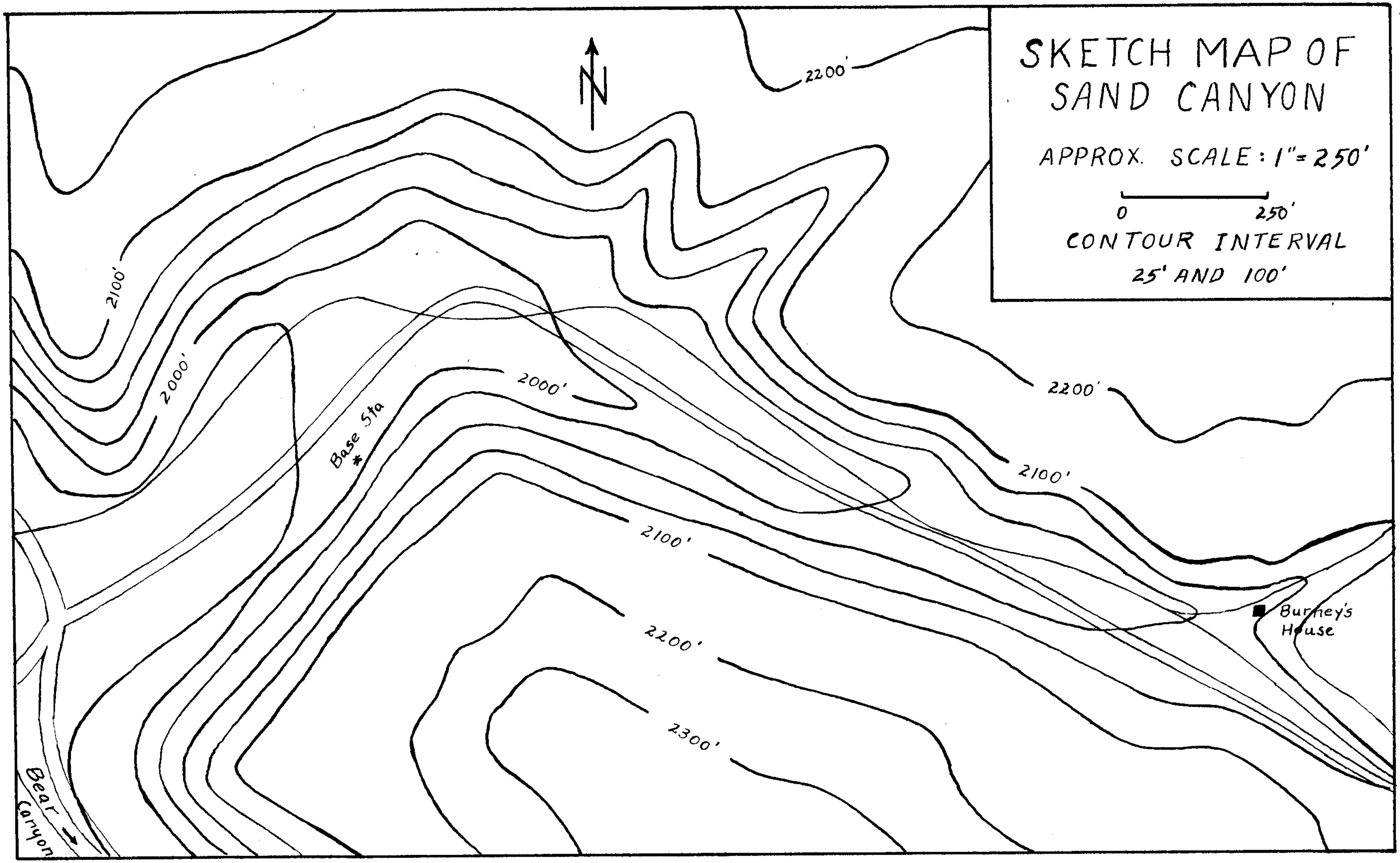

SKETCH MAP OF
SAND CANYON
APPROX. SCALE: 1" = 250'
0
250'
CONTOUR INTERVAL
25' AND 100'
N
2200'
2100'
2000'
2200'
2000'
2100'
2100'
2200'
2300'
Base Sta
Burney's House
Bear Canyon

Fig. 1.

LOCATION

In order to determine the location of a placer deposit with a magnetometer, there must be a detectable change in the magnetic intensity of the deposit. As Sand Canyon, which is in the northwestern part of the San Gabriel Mountains, was known to have highly magnetic gravels, it was chosen as the area to be surveyed.

The part of the canyon in which measurements were made is located in the NE ¼ of Section 1, T 3 N, R 15 W, and the NW ¼ of Section 6, T 3 N, R 14 W. The western end of the area is approximately 500 feet east of the Bear Canyon junction. The eastern end is on Burney's ranch, some 2000 feet up the canyon from the western boundary.

TOPOGRAPHY, VEGETATION, AND CLIMATE

The map in figure 1 is an enlargement of a portion of two U. S. G. S. quadrangles of scale 1:24,000. Because of the extreme enlargement, it is not very accurate.

The canyon walls are steep, being vertical for a hundred feet above the canyon floor in places, and in others, sloping at about thirty degrees. The hillsides are covered with yuccas, sage brush, and other vegetation common to

Fig. 2. The magnetometer as used in the survey.

Fig. 3. View upstream from traverse 3.

semi-arid regions. In the canyon bottom scattered cottonwood, poison oak, live oak, and sycamore trees are found.

The temperature of the region varies from moderate in the winter to extremely hot in the summer. It rains only in the winter and spring, and then usually in the form of cloud bursts. Almost every spring the canyon is completely flooded once or twice. For the remainder of the year the stream is dry. During floods such an enormous amount of water flows down the canyon that most of the gravels in the area are moved en masse. This makes duplication of magnetic readings impossible from year to year, although the general picture of the placer locations will not be altered appreciably.

GENERAL GEOLOGY

Sand Canyon, in the youthful stage of the erosional cycle, is being cut through iron rich igneous rocks. Most of the bed rock in this vicinity is brown in appearance, has a metallic luster, and is very dense in composition. Megascopically the iron appears to be in the form of ilmenite with some magnetite. Intruded into this heavy rock are many granitic dikes which are notably absent of magnetic minerals.

On the Burney Ranch, at the eastern end of the area, a water well has been dug in the stream bed. Bed rock was found to be six feet below the surface. Approximately 350 feet upstream from this point no gravel is in the canyon. In several places 100 to 200 feet downstream from where the gravels terminate, bed rock is exposed in the stream bed. Approximately a mile downstream from the Ranch water wells have struck bed rock at 80 feet. Just east of traverse 3, in the center of the canyon, a shaft is being dug by some of the local people. To date the shaft is 15 feet deep, and bed rock has not been reached. The total thickness of the gravels at the shaft is probably 20 to 30 feet.

THE MAGNETIC SURVEY

Method and Procedure:

The method and the construction of the Schmidt-type vertical magnetometer can be found in any standard text on geophysics.[(1,2,3,4)*] The effects of various geological bodies and topographical features on the magnetometer are avaiable in the same references. (See also references 5, 6, 7, and 9).

Eighteen traverses were run in the area using the pace and compass method. The traverses were staked out at both extremities, e.g. 1-S (south) and 1-N (north) are

* See bibliography

the staked out stations on traverse 1, and similarly, 15-W (west) and 15-E (east) for traverse 15; the intermediate stations were paced from each preceding station. The distance between stations is generally 17 feet, although closer spacing was used where necessary, and somewhat larger spacing where the topographic changes are sharp. Some inaccuracy was encountered in the use of the Brunton compass because of the highly magnetic nature of the country rock. The magnitude of this error is not certain, but is not sufficient to change the mapped locations of the placer deposits appreciably. Neither is the error in pacing important in the final map, for it is less than 3%.

In the first few traverses (1 to 3 inclusive) the magnetic intensities were moderate; therefore, in the first part of the work base station readings were taken regularly in order to determine the diurnal variations and the changes in the constants of the instrument. As the work progressed, however, (see traverses 3 to 18 and figures 13, 14, and 15) the magnetic anomalies became so large that diurnal variations could be ignored. These variations are on the order of 20 gammas, which is less than one scale division. The total magnetic relief in the area is over 250 scale division, with a relief of 50 to 100 divisions in the more important traverses. The effect of temperature on the scale readings was also found to be unimportant, hence no temperature corrections were made. The base station variations were similarly small, and except in the case of traverses 1, 2, and 6, they could be ignored. These particular traverses, however, are of little importance.

The values of magnetic intensity used in this work are given in scale divisions since calibrating instruments were unobtainable. The Schmidt-type vertical magnetometer, as made by the Askania Corporation, generally has a value of 20 to 35 gammas per scale division. Thus the total magnetic relief in the area is probably between 5000 and 9000 gammas. This is approximately 10% of the earth's total magnetic field, and 20% of the earth's vertical field at this latitude.

Causes of Positive Anomalies:

A positive anomaly in the thickest part of a stream channel is indicative of a greater concentration of magnetic minerals in the gravels than in the basement rock. If the basement has a higher magnetic concentration than the gravels, however, a negative anomaly is found in the channel. A change in the thickness of the gravels, or in the magnetic concentration of either the stream deposit or the basement rock will also be expressed by the isanomalic lines. Still another factor influencing the magnetic anomalies is a sudden change in elevation. At the bottom of a cliff there is a comparatively large magnetic concentration "above" the instrument as well as below it.(5) Thus negative anomalies are expected at the foot of a cliff. To summarize, the factors which must be considered in interpreting a magnetic anomaly are:

(a) The relative amount of magnetic minerals in the basement and the gravels.
(b) The change in magnetic concentration in either the gravels or the basement rock.
(c) The relative thickness of the channel gravels.
(d) The topographic relief.

Thus the anomalies are not due exclusively to heavy placer concentrations, but still they do indicate the probable locations of such deposits.

Discussion of the Results:

The most significant traverses in the area are numbers 15, 16, and 17. The canyon narrows abruptly near traverse 15. Upstream of this profile, the magnetic anomalies are strongly negative, whereas immediately downstream the canyon widens and the anomalies are the largest in the entire area. The stream velocity is sharply decreased in this region, and most of the heavy minerals in the stream are deposited en masse. This site contains the main placer deposit in the area. (See map of magnetic anomalies in back of this paper). However, the anomalies here are also greatly influenced by the proximity of the basement rock. Stations 15-W and 16-W are situated in a local, highly magnetic bed rock. The western ends of traverses 15 and 16 are on a thin veneer of gravel; therefore, these anomalies are largely due to the bed rock. Toward the center of the canyon, along these same traverses, bed rock is six to eight feet below the surface, and is not the primary cause for the large anomalies. Figures 14 and 15 show that the magnetic anomalies decrease gradually downstream from this maximum. The sharp decrease in the anomaly upstream results from three factors: less dense bed rock, low magnetic concentrations in the gravels, and the presence of a cliff 20 feet to the east to station 17-8. This latter effect is, however of secondary importance. The traverses downstream from the Burney Ranch indicate that the deposition of magnetic gravels decreased uniformily with distance.

With the exception of traverses 13 and 17 which run longitudenally along the canyon, the profiles indicate high anomalies in the center of the canyon, and lower

Fig. 4. View upstream from traverse 16, showing the narrowing of the canyon.

Fig. 5. Looking Northeast along traverse 6.

anomalies toward the periphery. This is a result of both a decrease in magnetic sand concentration laterally, and the effect of the canyon walls. The latter effect can be illustrated at the north end of traverse 8, which is at the base of a 15 foot cliff of very dense rock. This is expressed by a large negative anomaly in spite of a moderately high magnetic concentration in the gravels. Similar effects are noticable at the north end of traverse 18. The traverses which do not show a steep decrease in readings at the periphery of the canyon were in no case within 10 feet of a vertical slope. Between stations 11 and 12 on traverse 6, 170 feet from the south end of the traverse, the effect of a vertical cliff on the magnetic intensity is clearly illustrated. Here slump from a side ravine has been cut by the stream in the canyon, forming a vertical cliff 12 feet high. (See Fig. 6)

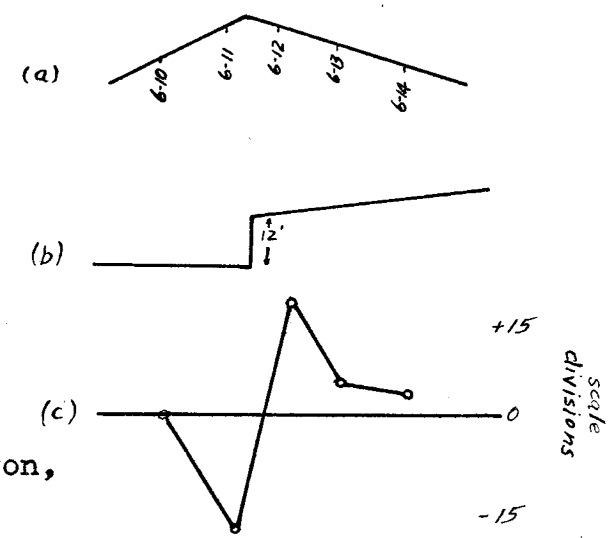


Fig. 6, Showing the effect of a cliff on magnetic intensity.
(a) plan view of trav.,
(b) profile oftraverse,
(c) intensity curve.

The southwestern end of traverse 7 is in gravel having a moderate anomaly. The northeastern end of the traverse is close to a granite dike which is very low in magnetic minerals. The decrease in magnetic intensity in the direction of the dike well illustrates the magnetic effect of the basement rock. However, it should not be concluded that the basement contains a higher concentration of the iron minerals than the gravels. The high anomalies prevalent in the median of the canyon eliminates that possibility. The southern end of traverse 6 is also adjacent to a granite dike, similar to that encountered in traverse 7. The low magnitude of the readings here again illustrates the effect of the basement rock below moderately magnetic gravels. It was thought that these two dikes might be one and the same, and offset by a lateral fault across the canyon. Traverse 13 was run in order to investigate this possibility. However, this traverse shows no more than the presence of the dike.

The effect of the thickness of the gravel on the magnetic anomalies is mainly to smooth out the profiles where the gravel is thicker. Examples of this are in traverses 1 and 2, in which bedrock is the fartherest from the surface. In the upper part of the canyon, particularly traverses 14, 15, 16, 17, and 18, where the gravels are relatively thin, the profiles show large abrupt changes in intensity. Along several traverses, notably 3 and 6,

Fig. 7. Granite Dike at northeast end of traverse 7.

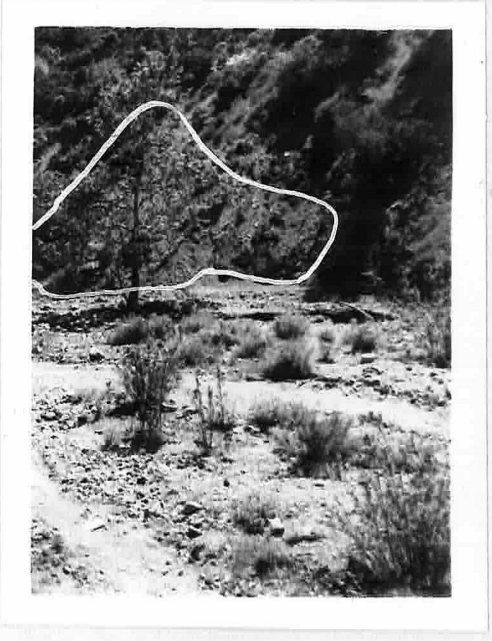


Fig. 8. Looking north on same dike as in Fig. 7.

Fig. 9. Looking northeast along traverse 4.

the effect of changes in elevation on the magnetic anomalies can be seen. Except in traverse 3, this effect was found to be of minor importance when the elevation change was not abrupt. In traverse 3 a gradual increase in elevation up to 40 feet is encountered. Such a change in the thickness of the gravels is of course of importance in the interpretation of the anomalies. In the other traverses the changes in elevation are on a much smaller scale.

Upon inspection of the profiles, particularly 5, 8, 10, 14, and 18, it will be observed that between the maximum intensity, and the minimum at the northern end of the traverses, there is a slight rising jog in a decreasing or negative slope. Plotted on the map, these jogs lie approximately on a straight line. It will also be noticed that in nearly every traverse east of number 5, the northern end of the traverses have a much lower intensity than the southern. This fact, in addition to the lining up of the jogs just mentioned, strongly suggests a fault. However, no evidence for faulting is found west of traverse 4 and east of traverse 18. Such a fault can readily be corroborated, without resorting to other methods such as geological mapping or gravity measurements, by taking magnetic readings at the same stations in subsequent

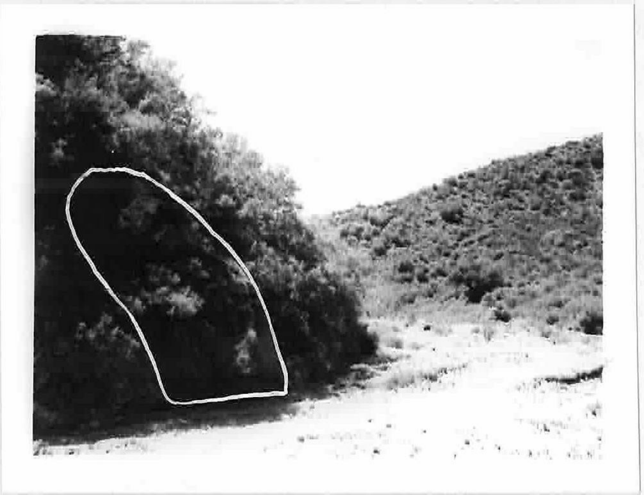


Fig. 10. Looking southeast on granite dike at southern end of traverse 6.

Fig. 11. Looking northeast along traverse 3.

years after floods have disturbed the present position of the gravels. If similar jogs are then found at the same locations, there can remain little doubt of the presence of a fault.

Attempts were made to determine the depth of the gravels by means of taking readings at a given station at two different elevations. (2,9) No definite results were obtained. This was expected as the technique for determining the depth of a body is applicable only to localized bodies and not to long horizontal layers. These measurements thus confirm the view that the gravels are in the form of a horizontal sheet and not a definitely circumscribed area. Another factor that would complicate determinations of such depth measurements, even if the magnetic concentrations were in the form of localized ore bodies, is the influence of the canyon walls on the intensity.

The stream in Sand Canyon is probably depositing as much material now as at any time in the past. This is suggested by the presence of large gravel boulders over the entire canyon bottom. The canyon is narrow, particularly east of traverse 6. Thus, through its whole history, the stream has flowed in its present channel, with the main deposition of the heavy minerals taking place approximately in the center of the canyon.

Probable Error:

The error involved in pacing is small, within 3% of the distance traversed. This is an insignificant factor as the placers do not have well defined boundaries.

Variations in magnetic intensities due to temperature changes were found to be less than 0.3 scale divisions per degree centigrade. A change in temperature of 10 degrees involves a variation of only 3 divisions. Ignoring this effect results in a probable uncertainty of 2% of the average magnetic relief.

Base station variations are within ±2 divisions. In the more important traverses this involves a probable error which is less than 2%.

Another small source of error is in the balance of the quartz bearings in the magnetometer. Inspection of the bearings showed them to be slightly chipped. However, the effect of this is negligible, for readings could be duplicated within ±0.1 divisions, or 0.2% of the average relief.

The effect of diurnal variations has been shown to be less than one scale division; hence these variations were ignored.

Topographic changes are small in the area except in traverses 3 and 6. (See tables of magnetic readings)

This effect is much smaller than the unknown factor of the changes in the thicknesses of the stream gravels.

The uncertainty in the use of the Brunton compass is not known. The compass was read to 0.5 degrees, but the local magnetization may have an appreciably larger effect. This possible source of error will be expressed only in the staking of the traverses and not in the instrument readings. The instrument can be oriented off the normal to the magnetic meridian by as much as 10 degrees with negligible effect on the readings.(2)

The probable error in the measurements of the vertical magnetic intensity is less than 1.5% of the total magnetic anomaly, and less than 4% of the average magnetic relief. Ignorance of such factors as the magnetic effect of the basement, the canyon wall, and the depth and variation in the depth of the gravels is a much larger source of error than that involved in the measurements.

Conclusions:

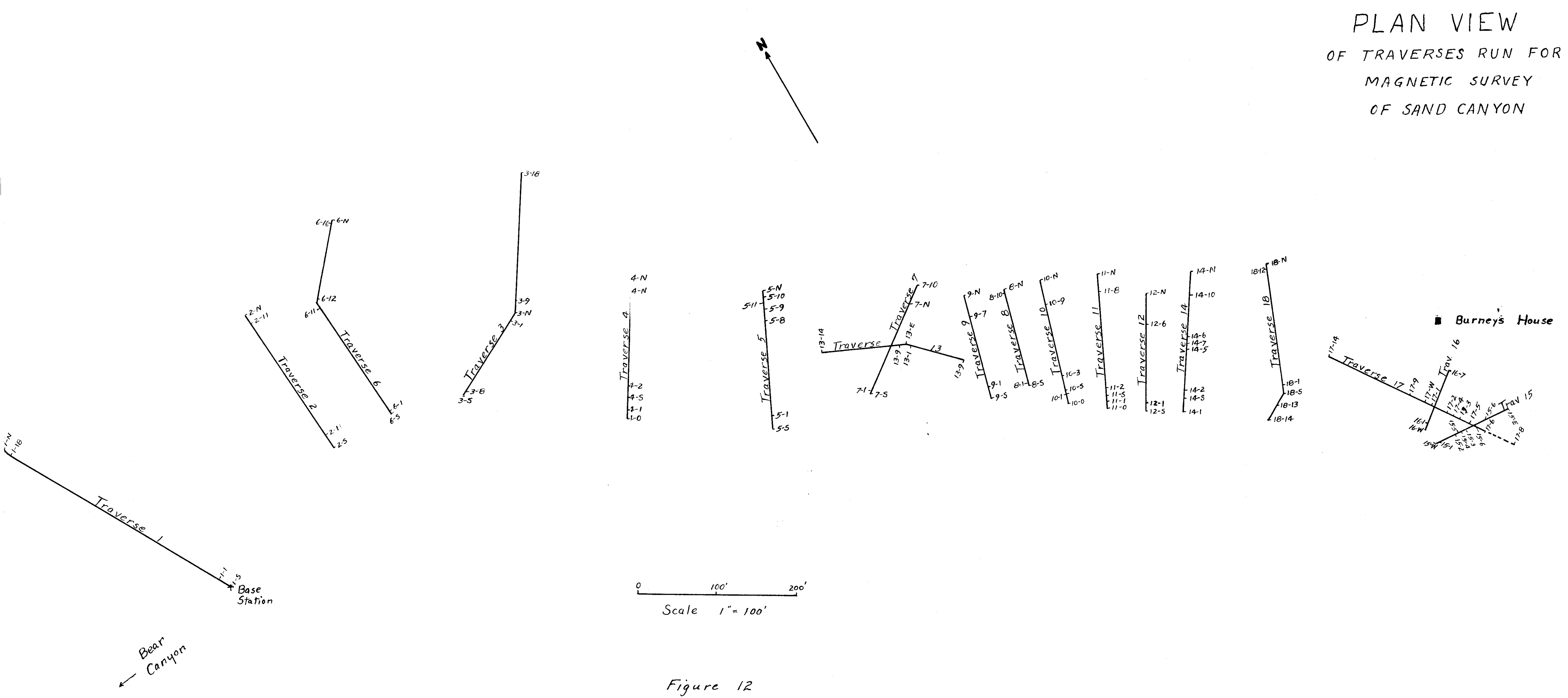
The large anomalies found are due to the presence of magnetic minerals in both the basement and the gravels, but the latter has the greater effect. The relative effect of the basement and the gravel on the anomaly is not known definitely. This indicates that the percentage of magnetic minerals in the gravels may lie within a wide range.

The effect of the canyon wall on the readings is not known precisely, but it is a minimum in the center of the canyon where the largest anomalies occur.

The magnetic measurements show that the main placer deposit is located just south of Burney's house. Geologically this is the expected site for placers to be found, because at this point the canyon widens and the stream slope decreases appreciably.

A fault probably runs longitudinally up the canyon. Many of the canyons in the San Gabriel Mountains are located along fractured lines;* therefore, such a fault is an expected rather than an unexpected feature.

* From personal communication with Dr. J. P. Buwalda of the Division of Geological Sciences, California Institute of Technology.



PLAN VIEW
OF TRAVERSES RUN FOR
MAGNETIC SURVEY
OF SAND CANYON
N
Traverse 1
Base Station
Bear Canyon
Traverse 2
Traverse 3
Traverse 4
Traverse 5
Traverse 6
Traverse 7
Traverse 8
Traverse 9
Traverse 10
Traverse 11
Traverse 12
Traverse 13
Traverse 14
Trav 15
Trav 16
Traverse 17
Traverse 18
Burney's House
Scale 1" = 100'
0
100'
200'

Figure 12

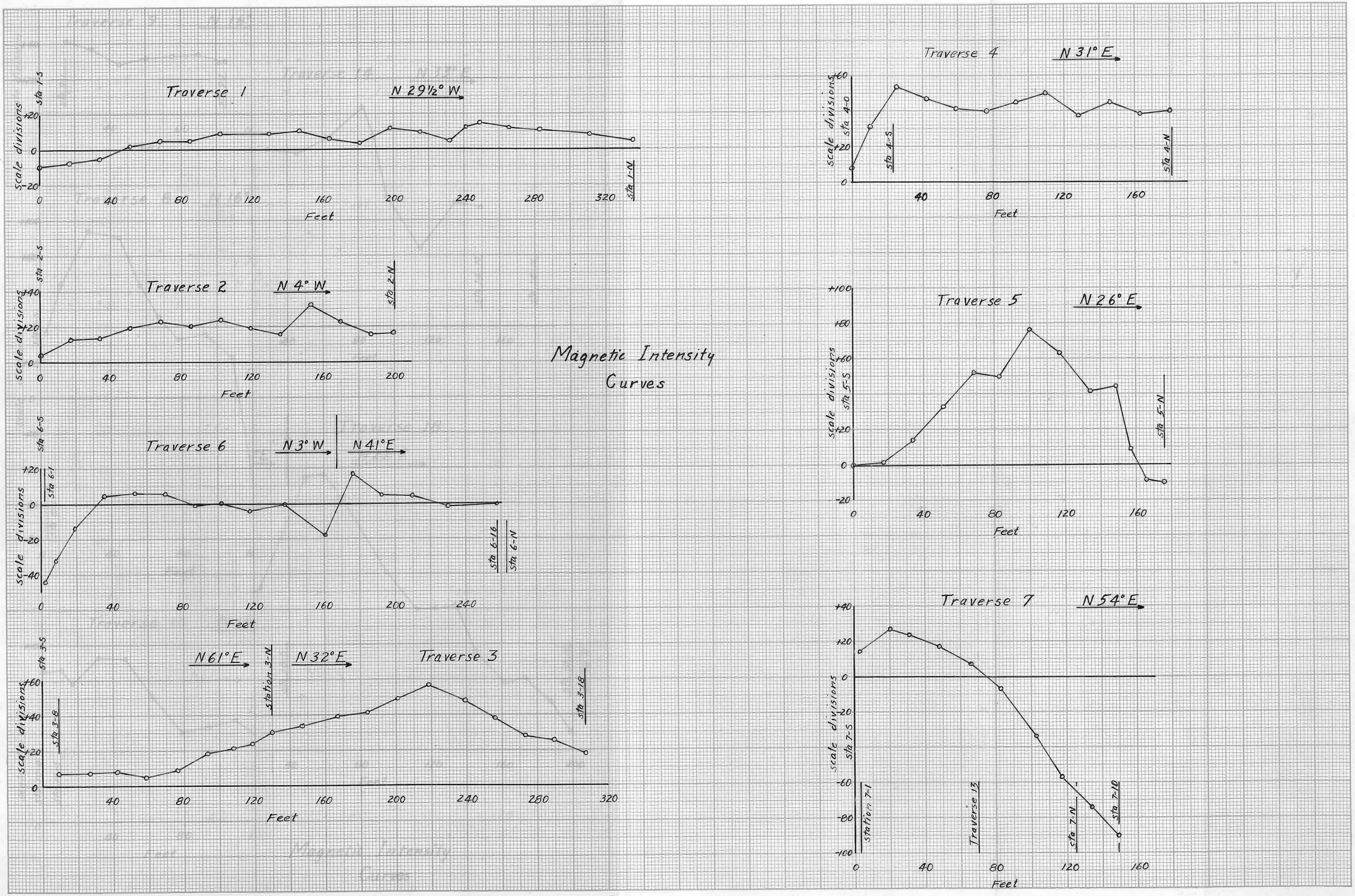

Magnetic Intensity Curves
Traverse 1
N 29½° W
sta 1-S
sta 1-N
Traverse 2
N 4° W
sta 2-S
sta 2-N
Traverse 6
N 3° W
N 41° E
sta 6-S
sta 6-1
sta 6-16
sta 6-N
Traverse 3
N 61° E
N 32° E
sta 3-S
sta 3-8
station 3-N
sta 3-18
Traverse 4
N 31° E
sta 4-0
sta 4-S
sta 4-N
Traverse 5
N 26° E
sta 5-S
sta 5-N
Traverse 7
N 54° E
sta 7-S
station 7-1
Traverse 13
sta 7-N
sta 7-10
scale divisions
Feet

Figure 13

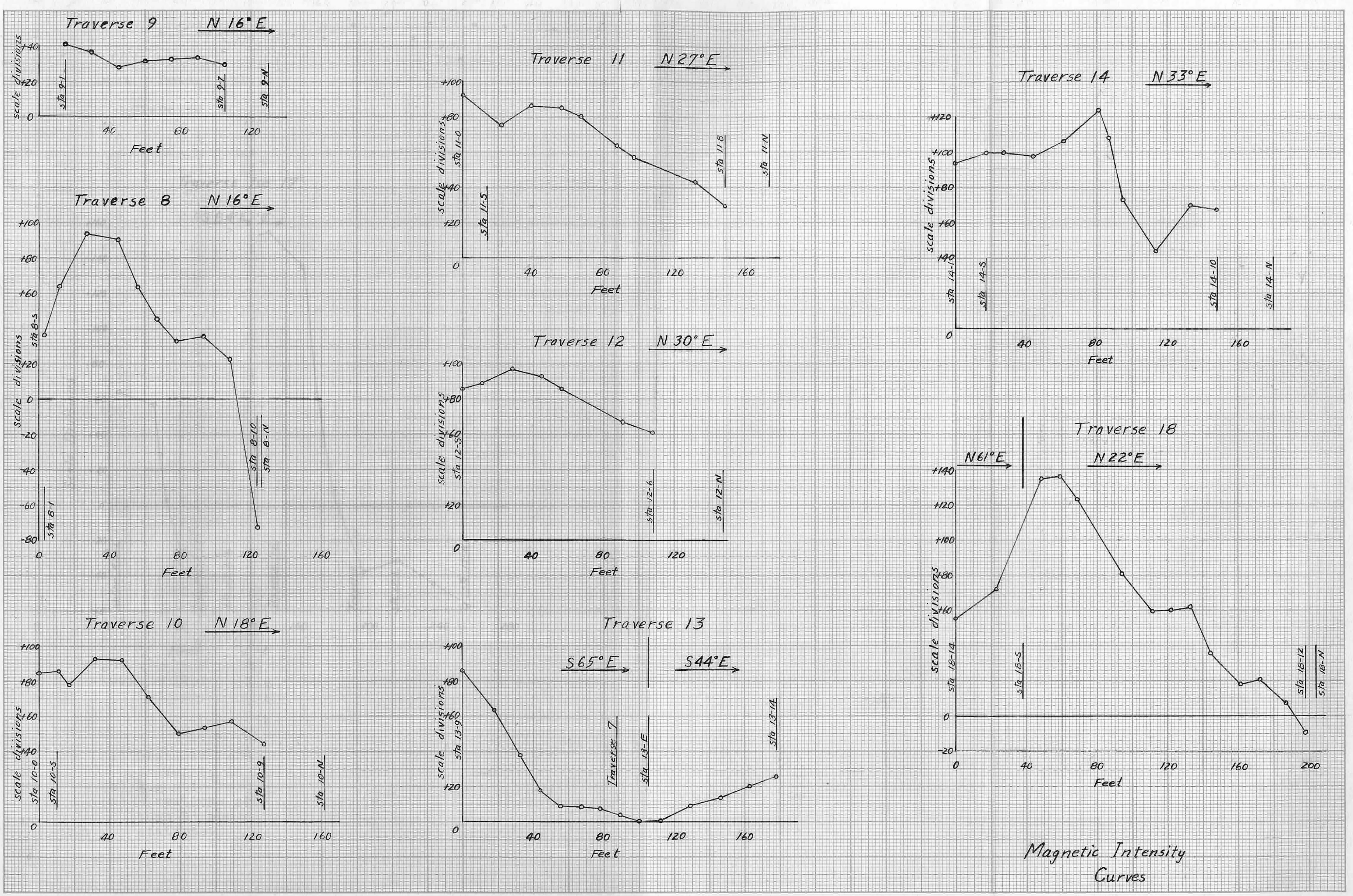

Traverse 9
N 16° E
sta 9-1
sta 9-7
sta 9-N
Traverse 8
N 16° E
sta 8-5
sta 8-1
sta 8-10
sta 8-N
Traverse 10
N 18° E
sta 10-0
sta 10-5
sta 10-9
sta 10-N
Traverse 11
N 27° E
sta 11-0
sta 11-5
sta 11-8
sta 11-N
Traverse 12
N 30° E
sta 12-5
sta 12-6
sta 12-N
Traverse 13
S 65° E
S 44° E
sta 13-9
Traverse 7
sta 13-E
sta 13-14
Traverse 14
N 33° E
sta 14-1
sta 14-5
sta 14-10
sta 14-N
Traverse 18
N 61° E
N 22° E
sta 18-14
sta 18-5
sta 18-12
sta 18-N
scale divisions
Feet
Magnetic Intensity Curves

Figure 14.

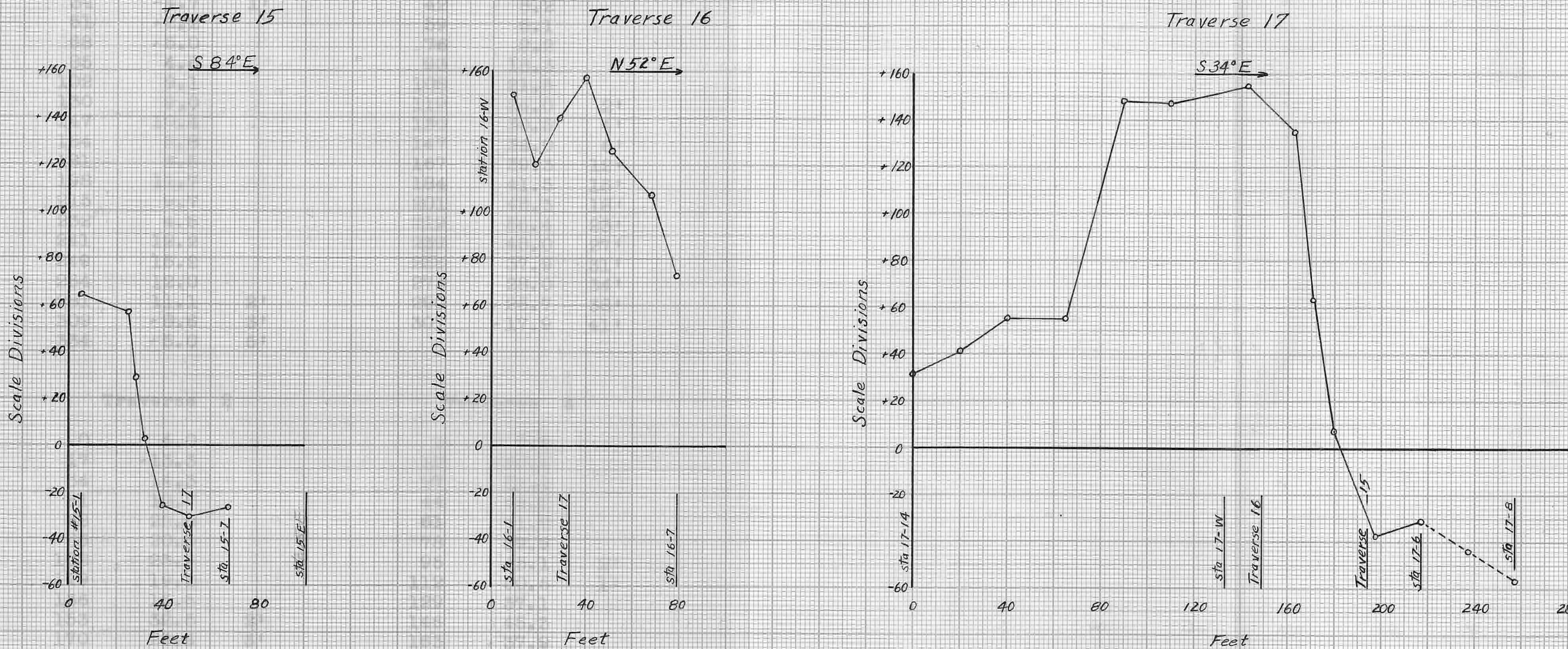


Figure 15

Magnetic Intensity Curves.

MAGNETIC READINGS ALONG TRAVERSES

Traverse 1

(a(Dist	(b) Read.	(c) El.
0	-9.5	6'
17	-6.8	4'
34	-4.7	1'
51	+2.2	
68	+5.0	
85	4.6	
102	9.1	
130	9,0	
147	10.4	
164	5.8	
181	3.5	
198	11.7	
215	9.7	
232	4.6	
241	12.2	
249	15.2	
264	12.0	
281	11.1	2'
309	+8.6	3'
334	+5.0	6'

Traverse 2

Dist	Read.	El.
0	+ 4.0	
17	+13.3	
34	14.3	
51	19.7	
68	22.8	
85	20.5	
102	23.9	
119	19.2	
136	16.5	
153	32.5	2'
170	23.6	3'
187	+15.6	4'
199	+16.3	5'

Traverse 3

Dist.	Read.	El.
9	+ 7.2	
27	+ 7.5	
42	8.2	
59	5.1	
76	9.2	
93	18.3	
108	21.5	
119	24.0	2'
130	30.5	4'
147	34.0	6'
167	39.3	12'
184	41.5	15'
201	48.3	18'
219	56.4	23'
239	48.0	27'
256	37.9	31'
273	28.0	34'
290	+25.7	38'
307	+17.9	41'

Traverse 4

Dist.	Read.	El.
0	+ 7.6	
10	+30.9	
27	53.4	
44	46.8	
61	41.0	
78	39.9	
95	45.1	2'
112	50.5	1'
129	37.1	
146	45.3	
163	+ 37.9	
180	+ 39.6	2'

(a) Distance from the southern or western end of traverse, in feet.
(b) Magnetic readings in scale divisions.
(c) Elevations above stream (recorded only if more than 3' above stream, or a relief over 2' between stations.).

MAGNETIC READINGS ALONG TRAVERSES (CONT.)

Traverse 5

Dist.	Read.	El.
0	- 1.2	2'
17	+ 1.0	
34	+13.9	
51	32.7	
68	52.4	
83	49.9	
100	78.1	
117	63.2	
134	40.8	
149	+44.0	
157	+ 9.0	
166	- 9.1	
176	-10.2	5'

Traverse 6

Dist.	Read.	El.
2	-43.5	
8	-32.5	
19	-14.2	
36	+ 4.4	
53	+ 5.9	
70	+ 5.3	
87	- 1.2	
102	+ 0.5	
118	- 4.0	
138	- 0.4	
161	-18.2	
176	+16.6	12'
193	+ 4.7	14'
210	+ 3.8	17'
230	- 2.0	20'
258	- 1.6	25'

Traverse 7

Dist.	Read.	El.
3	+14.4	
20	+27.2	
31	+23.8	
48	+17.4	
66	+ 6.8	
83	- 6.8	
103	-33.5	
117	-57.2	
134	-74.4	
149	-90.1	

Traverse 8

Dist.	Read.	El.
3	+ 36.2	2'
12	+ 63.8	2'
27	94.2	
45	90.3	
56	63.4	
67	45.9	
78	33.2	
93	+ 35.5	
108	+ 22.9	
124	-73.3	

Traverse 9

Dist.	Read.	El.
15	+41.1	3'
30	+36.9	2'
45	28.4	
60	31.5	
75	32.3	
90	+33.0	2'
105	+29.1	

MAGNETIC READINGS ALONG TRAVERSES (CONT.)

Traverse 10

Dist.	Read.	El.
0	+84.7	8'
11	+85.8	5'
17	78.0	3'
32	92.8	3'
47	92.3	3'
62	71.3	2'
78	50.4	
93	54.0	
108	+57.4	4'
126	+44.5	4'

Traverse 11

Dist.	Read.	El.
0	+91.8	6'
22	+75.3	6'
39	86.3	6'
56	85.0	5'
67	80.3	5'
87	63.3	1'
97	56.6	
132	+43.0	
149	+29.4	

Traverse 12

Dist.	Read.	El.
0	+85.9	9'
11	+88.8	8'
28	97.2	6'
45	93.3	6'
56	86.0	6'
91	+67.4	2'
108	+61.3	

Traverse 13

Dist.	Read.	El.
0	+84.5	
18	+64.0	
33	38.0	
44	17.6	
55	8.9	
67	8.5	
78	7.6	
89	4.1	
100	0.2	
113	0.4	
130	8.8	
147	13.8	
164	+20.5	
178	+26.0	

Traverse 14

Dist.	Read.	El.
0	+ 94.6	10'
17	+100.0	7'
27	100.1	6'
43	97.6	6'
61	106.0	5'
81	124.2	4'
88	108.0	3'
96	73.1	2'
114	44.0	
134	+ 70.1	2'
149	+ 67.4	2'

MAGNETIC READINGS ALONG TRAVERSES (CONT.)

Traverse 15

Dist.	Read.	El.
5	+ 63.9	
25	+ 57.2	
29	+ 28.7	
32	+ 2.5	
40	- 24.2	
51	- 31.4	
68	- 27.4	

Traverse 16

Dist.	Read.	El.
9	+ 150.0	
18	+ 119.7	
29	140.6	
40	157.8	
51	126.2	
68	+ 107.4	
79	+ 73.6	

Traverse 17

Dist.	Read.	El.
0	+ 31.5	
20	+ 40.4	
40	55.0	
65	55.1	
90	147.7	
110	146.9	
143	155.2	
163	134.9	
171	+ 63.5	
180	+ 6.9	
197	- 38.1	
217	- 30.1	
237	< - 43.0	
257	<<-43.0	

Traverse 18

Dist.	Read.	El.
o	+ 55.5	9'
23	+ 72.2	9'
48	135.4	8'
59	136.5	8'
69	123.4	8'
94	80.8	7'
111	59.6	4'
122	60.7	2'
133	62.4	2'
144	35.5	1'
161	17.7	1'
172	+ 20.5	3'
187	+ 7.6	1'
198	- 9.1	4'

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