MAGNETIC SURVEYS OF ULTRAMAFIC BODIES IN THE VICINITY OF LOWELL, VERMONT

By

VINCENT J. MURPHY AND ANDREW V. LACROIX

WESTON GEOPHYSICAL ENGINEERS, INC.

for the

VERMONT GEOLOGICAL SURVEY

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DEPARTMENT OF WATER RESOURCES

MONTPELIER, VERMONT

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Plate

I. Area Geology and Magnetic Traverses	(In Pocket)
II. Area Geology and Magnetic Contours	(In Pocket)

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Introduction

Asbestos mines in the lower Missisquoi River Valley in north central Vermont supply over 85% of the asbestos produced in the United States. This area is in the vicinity of Lowell, a small village in the northern part of the State (Index Map). The "Centennial Geologic Map of Vermont" under the direction of the Vermont Geological Survey, Charles G. Doll, State Geologist (1961) and "Bedrock Geology and Asbestos Deposits of the Upper Missisquoi Valley and Vicinity, Vermont", W. M. Cady, A. L. Albee, and A. H. Chidester, Bulletin No. 1122-B, United States Geological Survey, 1963, have inspired a revival of interest in the appraisal of promising localities as part of a new economic geology series of the Vermont Geological Survey.

An agreement was entered into between the Vermont Geological Survey and Weston Geophysical Engineers, Inc., to conduct a magnetic survey in specified areas within the ultramafic belt in order to disclose the presence of potential economic deposits of asbestos.

Dr. Charles G. Doll, Vermont State Geologist and Mr. Vincent J. Murphy, Weston Geophysical Engineers, Inc., made several field inspections to establish an economical and effective reconnaissance program. It was decided that a number of magnetic traverses should be conducted over ultramafic bodies indicated in prior geological mapping. On Plate 1 of the accompanying drawings, the magnetic traverses and major geologic features are shown relative to the various roads, county lines, etc. The genetic relationship between asbestos and magnetite as well as the magnetic minerals associated with ultramafic bodies in contrast to the non- or weakly magnetic country rocks makes a magnetic survey the most economical and accurate geophysical method in asbestos exploration.

Although the Lowell region contains many large ultramafic bodies of potential economic importance, which are well documented in geologic literature, there exists no publicly available geophysical data. It is the purpose of this study to integrate geophysical and geological data in order to evaluate zones of probable asbestos mineralization in the region.

Method of Study

The magnetic method of geophysical exploration establishes relative values of the earth's magnetic field within the area of interest. Similar readings resulting in a flat curve of the plotted results are obtained when no concentrations of magnetic minerals are present. Highly anomalous readings are obtained wherever a concentration of magnetic minerals exists. If large magnetic anomalies extend over a wide area, or if they can be traced for great longitudinal distances, a body of possible economic value is indicated.

Besides the magnetite associated with asbestos, chromite is another magnetic mineral found with magnetite. The relative concentrations of magnetite-chromite may vary greatly in an ultramafic body, but there is a quantitive relationship between the amount of magnetite and asbestos; therefore, magnetite serves as an indicator that is readily detectable.

For this study, a magnetic level of approximately 1,500 gammas indicates a smooth magnetic field condition free of anomalies; however, when the values are in the range of 2,000 to 6,000 gammas, an

anomalous condition exists. In this study, the width of an anomaly indicates the approximate width of the buried concentration of magnetic minerals. The magnitude of the anomalies and the sudden transition from level values to highly anomalous values indicate geologic features that are very close to the ground surface.

Location of Magnetic Stations

Magnetic stations were established along roads, trails and other landmarks that facilitated locating them on photo-enlargements of the United States Geological Survey topographic maps. Approximately 1,350 stations were occupied and spaced approximately 200 feet apart, depending upon the presence of cultural features that would interfere with the magnetometer. In some instances, very close spacings were used to determine if anomalous data should be rejected.

Results of the Survey

Sections of the Jay Peak and Irasburg United States Geological Survey Topographic maps were enlarged for use in the field. The traverses are indicated on the enlarged geologic map of Cady, Albee and Chidester (1963), Plate 1, as well as the locations of two or more stations for each traverse. The remaining stations for each traverse can be located readily by use of the plan map data and the spacing of points shown on the magnetic profile for each traverse.

Magnetic station values for each traverse are plotted on the graph sections accompanying this report. Tabulations of these values are also included in this report in the event that a specific need for them arises.

Presentation of Data

Magnetic survey data can be displayed in a similar manner as topographic survey data; that is, by means of profiling and/or contouring. Although profiling is the preferred method for showing the existence and relative magnitude of the anomalies disclosed by this study, contour maps are helpful in showing the trend and extent of the anomalies.

Magnetic profiles and a contour map are therefore included for the area studied. Wherever a large number of stations are occupied and cross-profiles or adjacent profiles exist, the data can be considered as very reliable and approaching the coverage of a highly detailed survey; however, they should be used with discretion in areas where the profiles and contour map are based on only a few or isolated stations.

Correlation With Known Geology

The type and amount of correlation of magnetic survey data with known geology depends primarily on the geographical extent and density of stationing. For studies where magnetic traverses extend for hundreds of miles, definite inferences can be drawn regarding the depths of surface formations and the existence of deeply buried formations. In studies such as this survey, where the area is of a limited extent, the objectives are usually concerned with prospecting for economic minerals. The correlation with geology, therefore, exists in the explanation and evaluation of magnetic anomalies from an economic standpoint and the correlation may be direct or indirect. Direct correlation is based upon pertinent information observed in the field as outcrop or in the literature. Indirect correlation pertains to anomalies that cannot be explained with certainty by surface geology, but does have a logical explanation that can be verified only by exploration drilling.

Specific correlations of data included in this report are concerned with the anomalous magnetic conditions disclosed in the area.

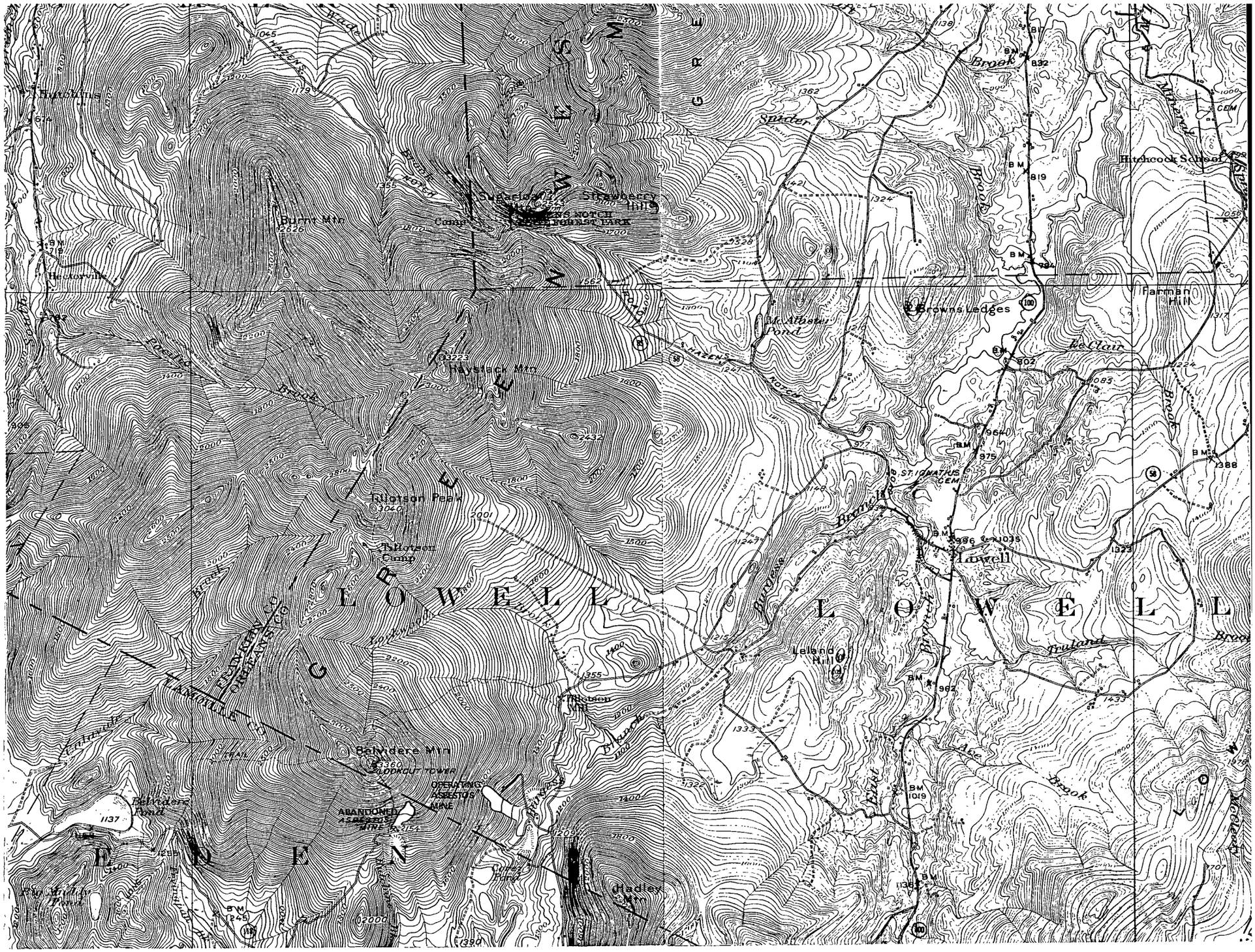
For descriptions of the geology of the area and pertinent references see "Centennial Geologic Map of Vermont", C. G. Doll et al, Compilers and Editors, 1961, and "Bedrock Geology and Asbestos Deposits of the Upper Missisquoi Valley and Vicinity, Vermont", W. M. Cady, A. L. Albee and A. H. Chidester, Bulletin No. 1122-B, U. S. Geological Survey, 1963. Articles pertinent to the asbestos deposits of the area can be found in "Selected Annotated Bibliography of Asbestos Resources in the United States and Canada", R. B. Avery, M. L. Conant and H. F. Weissenborn, Bulletin No. 1019-L, United States Geological Survey, 1958.

Structure and Stratigraphy

Structural interpretations and lithologic descriptions have been taken from the work of Cady, Albee, and Chidester (1963), (Plate I). Only that information pertinent to direct and indirect correlation with magnetic data is cited.

Major structures in the area include the Missisquoi Valley syncline, east of Lowell Village; the area between the Gilmore anticline and Jay Peak syncline which is characterized by a series of transverse synclines, and associated with several of these transverse folds are small ultramafic bodies; a similar relationship holds for the amphibolite and gneiss near Hazen's Notch.

As illustrated in Table I, individual formations are difficult to delineate solely on the basis of magnetic information. The wide range of magnetic values over any one formation is attributable to subtle lithologic facies changes, degree of metamorphism, and deformation, and varying concentrations of weak or strong magnetic minerals, namely, ilmenite, hematite, and magnetite.


Burnt Mtn
Hectorville
Haystack Mtn
Wilgtson Peak
Wilgtson Camp
Belvidere Mtn
LOWELL
Lowell
Lelland Hill
Browns Ledges
Farman Hill
Hitchcock School
Gladley Mtn
Belvidere Pond
Sugarloaf
Strawberry Hill
Camp
Brook
Spider
Brook
Mineral
Brook
Belair
Brook
Truland
Brook
Ace
Brook
Brown
Brook
Pleasant
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Hazens
Notch
Wade
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Notch
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Lightning
Brook
Belvidere
Brook
Brown
Brook
East
Brook
Lookout
Brook
Lookout
Trail
Lookout Tower
Operating Asbestos Mine
Abandoned Asbestos Mine
Franklin Co
Lamoille Co
Franklin Co
Orleans Co
Lamoille Co
Sky Hitch Pond
Lake
Lake
Pond
Pond
Pond
Pond
Pond
Pond
Cemetery
Cemetery
St Ignatius Cem
Cem
Cem

TABLE I

Magnetic values over formations in the area studied:

FORMATIONS	MAGNETIC VALUES	MAGNETIC MINERALS REPORTED
Hazen's Notch	1,400 ± 350 gammas	ilmenite; magnetite
Jay Peak	1,600 ± 50 gammas	2% magnetite
Belvidere Mountain Amphibolite	1,800 ± 300 gammas	abundant magnetite
Ottauquechee	1,600 ± 200 gammas	pyrite – limonite
Stowe	1,400 ± 150 gammas	1% limonite; magnetite
Moretown	1,350 ± 200 gammas	ilmenite, hematite, pyrite

Ultramafic Rocks

Dunite consists almost entirely of olivine with less than 1% finely dispersed chromite-magnetite and when altered to serpentinite it contains, in order of decreasing abundance, olivine, antigorite, chromite, magnetite, chrysotile and minor accessory minerals. The type and degree of alteration gives a highly variable composition of the dunites. There are four types of peridotite in the area, all of which are associated with chrysotile veins related to shear zones. The principal source of commercial asbestos is schistose serpentinite which is a highly fractured rock in which the interstices are filled with chrysotile and magnetite. The ultramafics are commonly zoned and smaller plutons may be completely replaced by calc-silicate, talc-carbonate or carbonate rock. This zonation is related to steatitization which is subsequent to serpentinization but contemporaneous with regional metamorphism. It is unrelated to the extent of prior serpentinization. Steatitization includes the alteration of serpentine and magnetite to talc, magnesite, and magnetite, where the magnetite is decreased in volume and altered in composition. The volume decrease, breakdown, and dissemination of magnetite, significantly decreases the magnetic intensity over partially or wholly altered ultramafic rocks.

Ultramafic bodies north of State Route 58 are extensively altered and on the basis of magnetic evidence alone cannot be distinguished from the country rock by their normal or slightly anomalous magnetic characteristics. Similarly, talc-carbonate and carbonate rock are indistinguishable from the country rock. Chrysotile present in steatitized rock is mainly a relic of prior serpentinization; altered bodies would not contain sufficient chrysotile to be of economic importance.

Ultramafics in the vicinity of the Long Trail, those beyond the eastern limit of transverse folding, are inferred to be isolated structural outliers associated with the transverse folds. They are partly or wholly altered and are of small areal extent. Anomaly values associated with altered ultramafics are not high except where abundant magnetite and chromite are observed as in the Haystack Mountain body. Although the traverses did not completely enclose the body, the size limitations indicated by nearby traverses and the geologic setting suggest that this body may not contain an economic asbestos deposit. However, the abundance of chromite warrants further assessment of the body in terms of exploratory drilling for this ore.

The smooth but high anomalies south of Burnt Mountain and the lack of exposure of ultramafic rock suggest a possible buried ultramafic. There is no information from outcrops or lithologic descriptions in the literature that suggests a magnetite-rich lithology in the area. The body is estimated to be at least several hundred feet below the country rock. Whether or not this anomaly is associated with chrysotile or chromite or other mineralization will remain unresolved until drilling records can be correlated with the magnetic data.

The highly anomalous values on Belvidere Mountain cannot be directly correlated to chrysotile deposits since veinlets of magnetite intrude a predominantly talcose schist lithology in the area. The geologic map indicates a large talc-carbonate body on Belvidere Mountain.

Ultramafics east of the boundary marking the limit of transverse folding are extensive, parallel or subparallel, and closely spaced along strike with the axis of the Missisquoi Valley syncline. The larger plutons are altered along their outer margins, but the width of the alteration zone cannot be discerned magnetically. Highly anomalous zones within the plutons indicate likely areas of chrysotile mineralization. While the magnetic data does not conclusively indicate that all or some of the larger bodies are interconnected, they are of a larger areal extent, especially in the region east and west of State Route 100, than the outcrops indicate; however, they appear to be unconnected to the chrysotile-producing ultramafic at Belvidere Mountain. The sharp gradients and highly anomalous values over the eastern ultramafics suggest that they are near-surface bodies covered only by glacial or other overburden deposits.

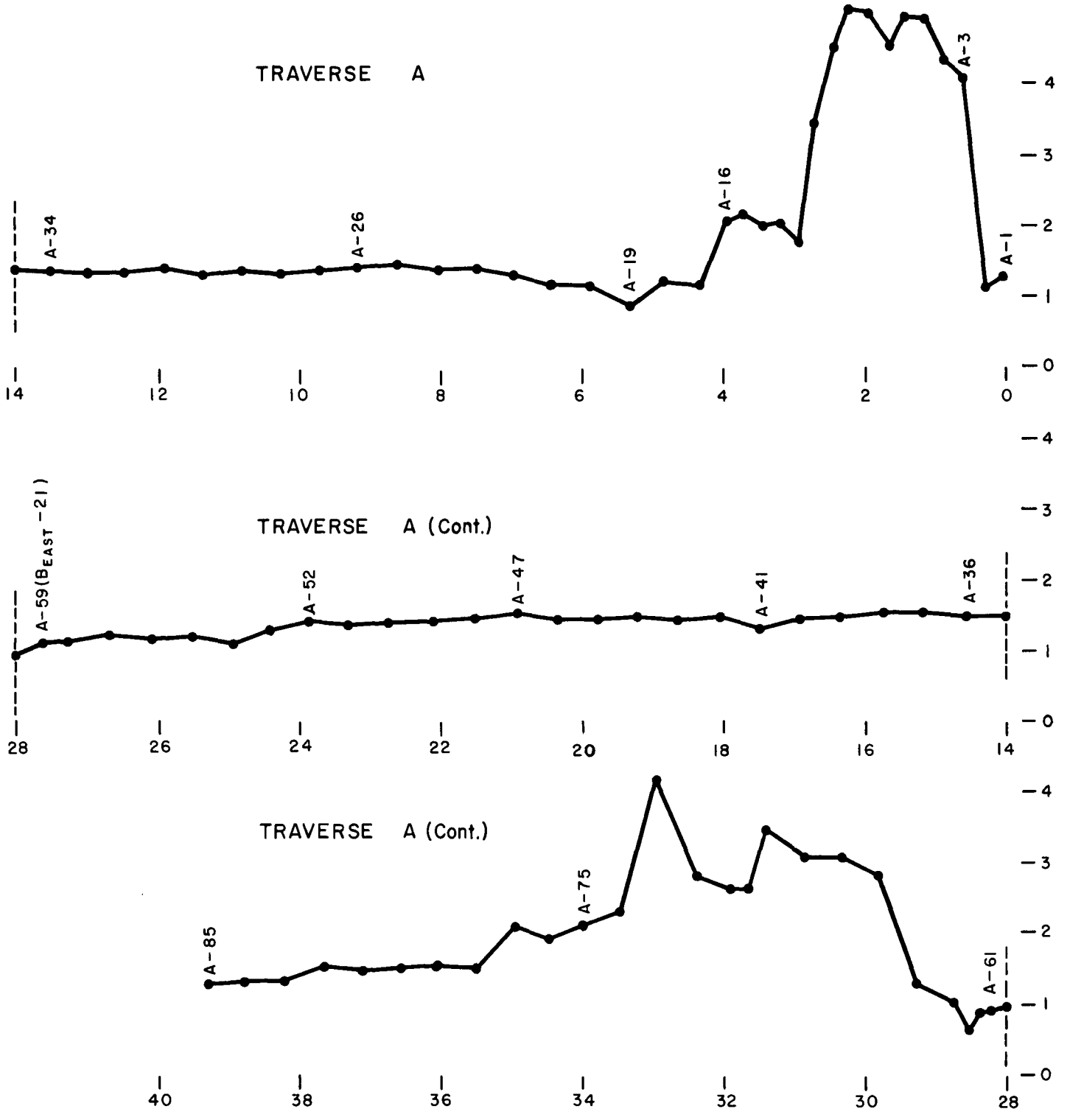
Economic Possibilities

The larger plutons of the eastern belt appear to have significant economic possibility. The anomalous magnetic readings in this area indicate high concentrations of magnetic minerals. The magnetic minerals in most cases indicate zones of chrysotile mineralization.

Recommendations

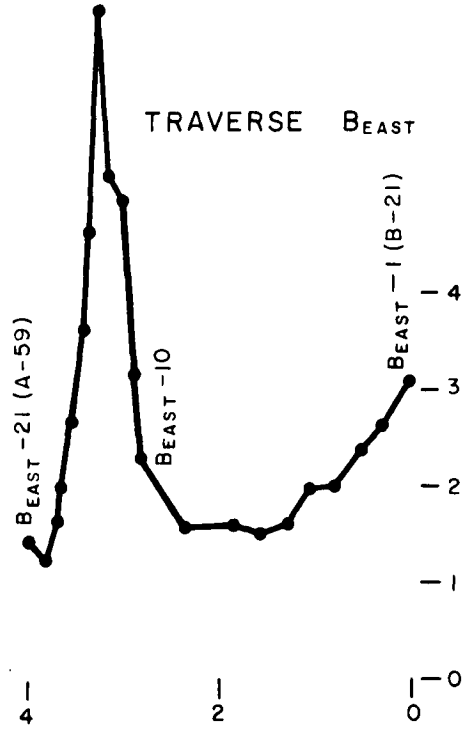
Test drilling in the vincinity of magnetic anomalies in the eastern belt is definitely warranted to determine if mineralization of economic significance is associated with the magnetic anomalies. The suggested positions for drilling are in the vicinity of Stations A 16, B-East 10-21, C 45, and along the anomalous trends north and south of these stations (cf. Plate II).

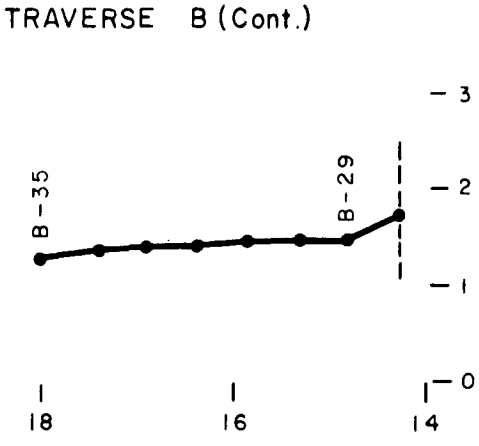
In other locations additional and more detailed magnetic studies may prove helpful, prior to drilling, to more accurately delineate anomalous trends. It is apparent, however, from the results of the present survey that no further magnetic studies will be necessary to disclose the existence and general location of anomalies.

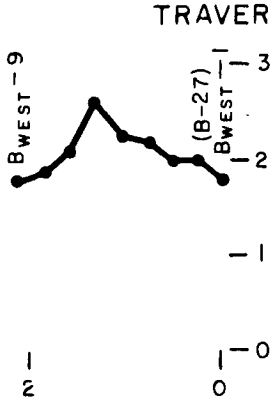


MAGNETIC PROFILE SECTIONS
TRAVERSE A
for
VERMONT GEOLOGICAL SURVEY
by
WESTON GEOPHYSICAL ENGINEERS, INC.

SCALE: VER. 1" = 2000 GAMMAS
HOR 1" = 2000 FEET







MAGNETIC PROFILE SECTIONS
TRAVERSES B, B_{EAST}, B_{WEST}
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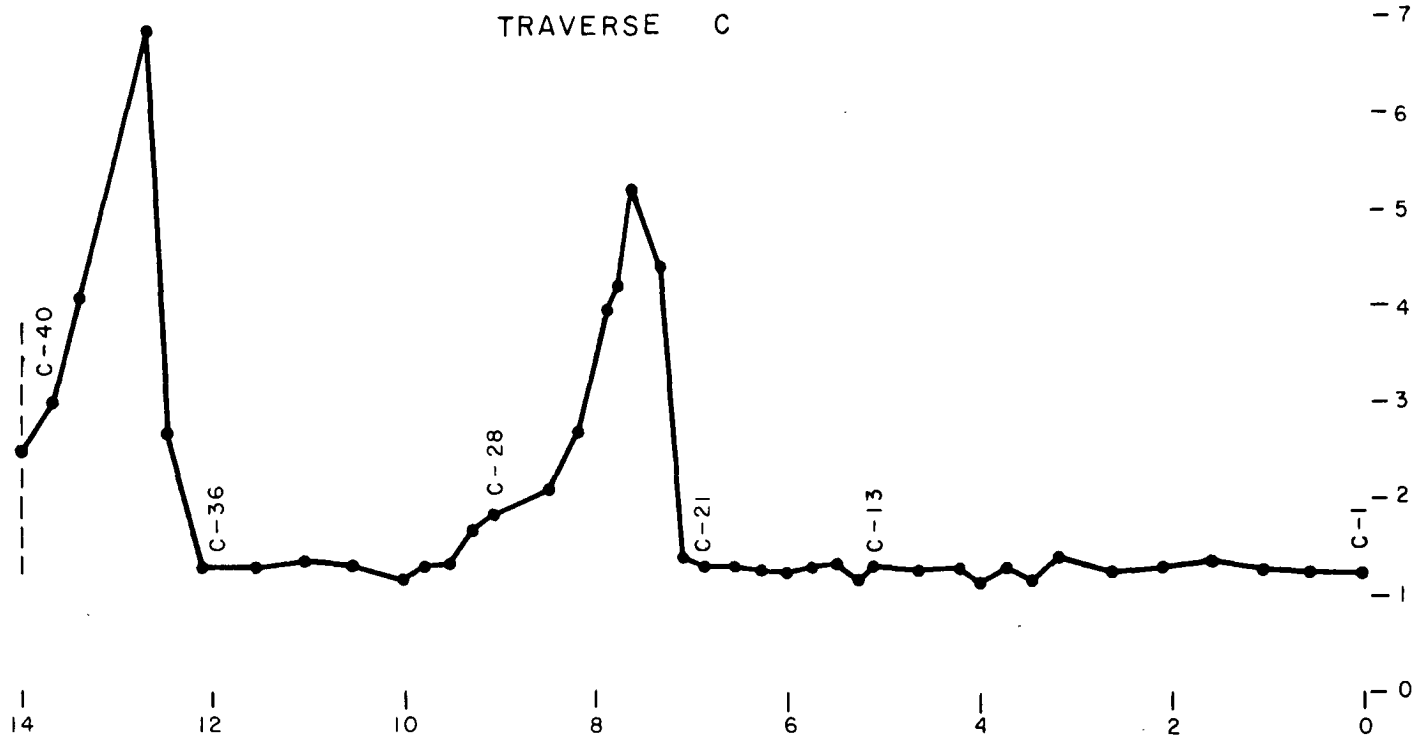

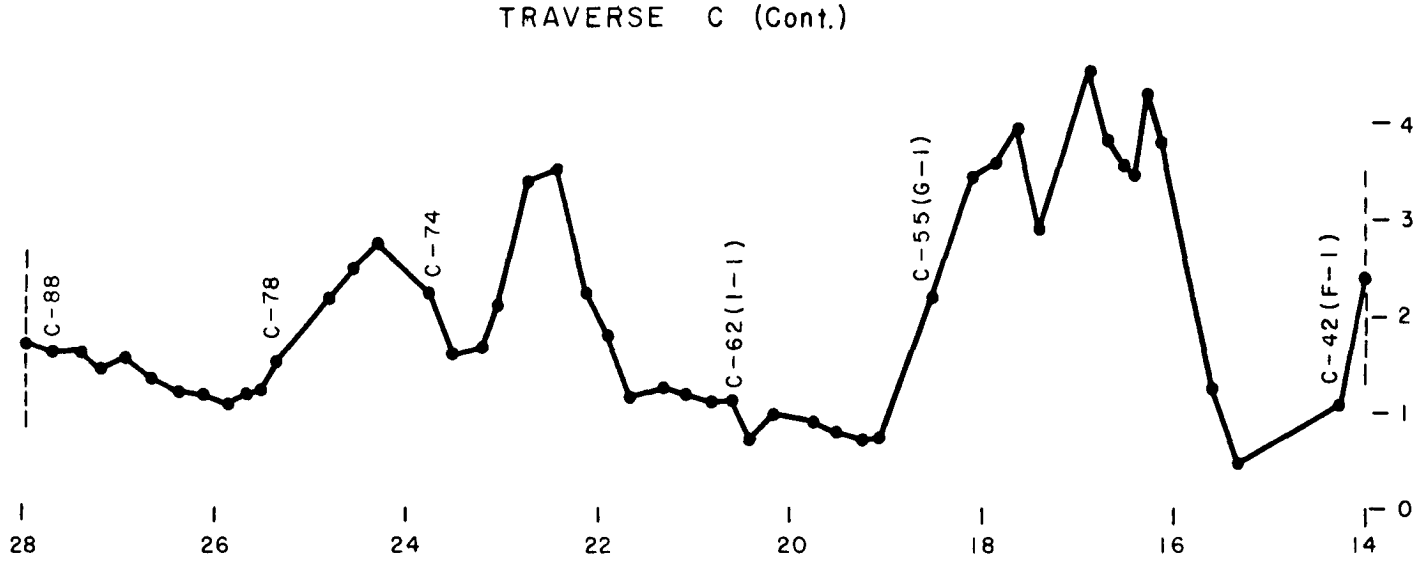

MAGNETIC PROFILE SECTIONS
TRAVERSE C
for
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SCALE: VER. 1"=2000 GAMMAS
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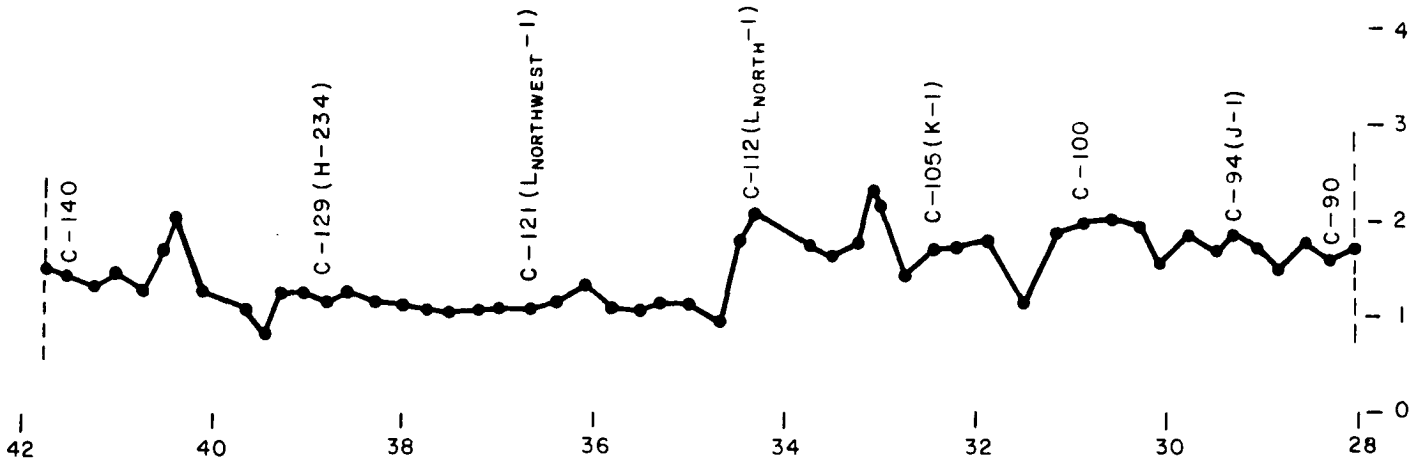
TRAVERSE C (Cont.)



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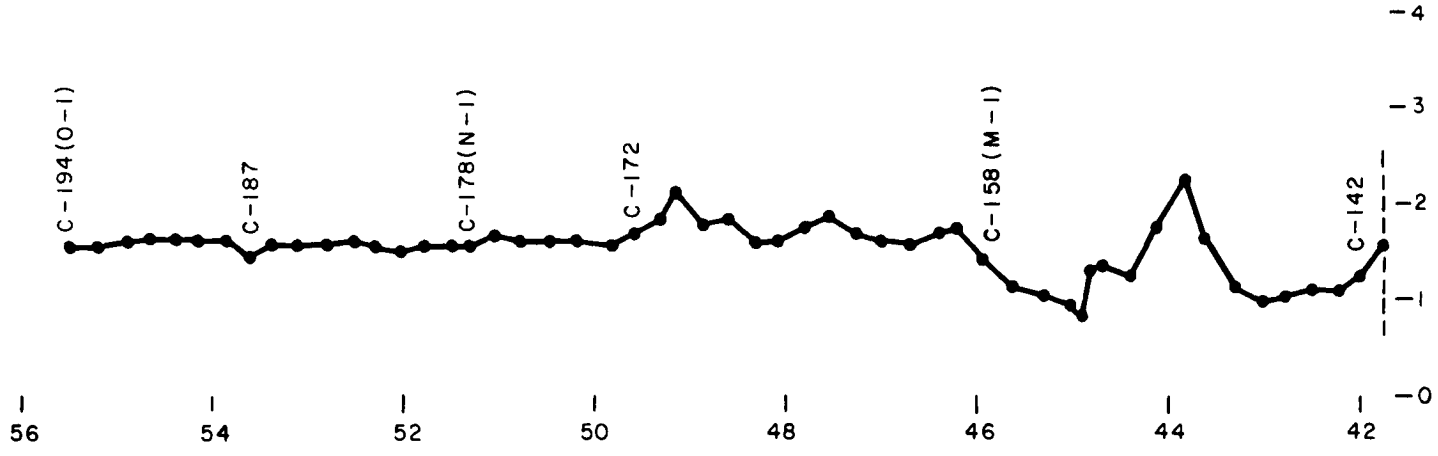

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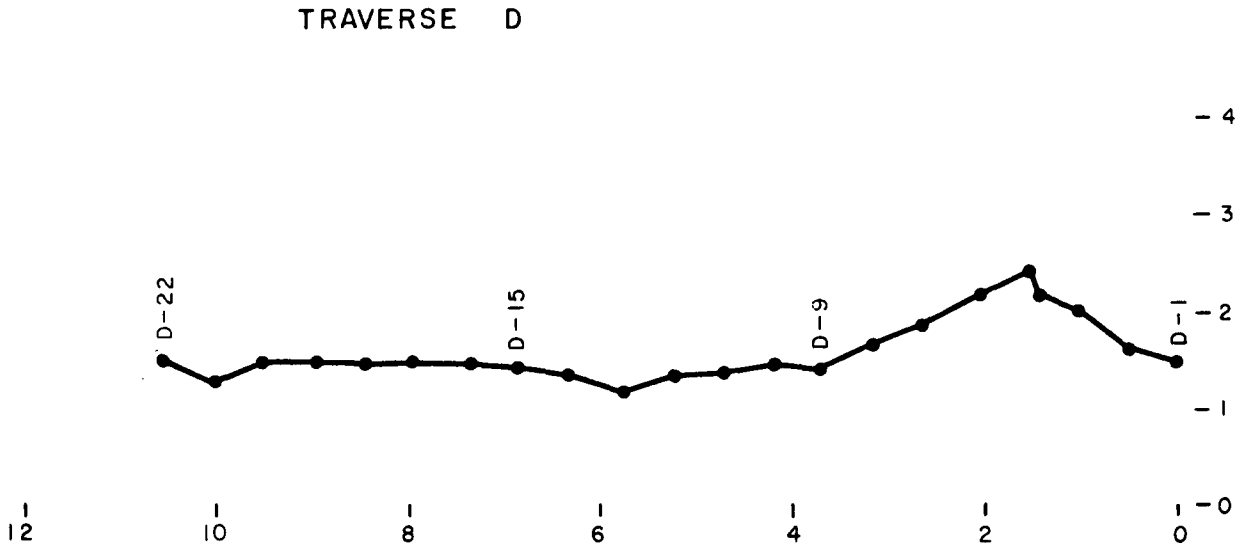

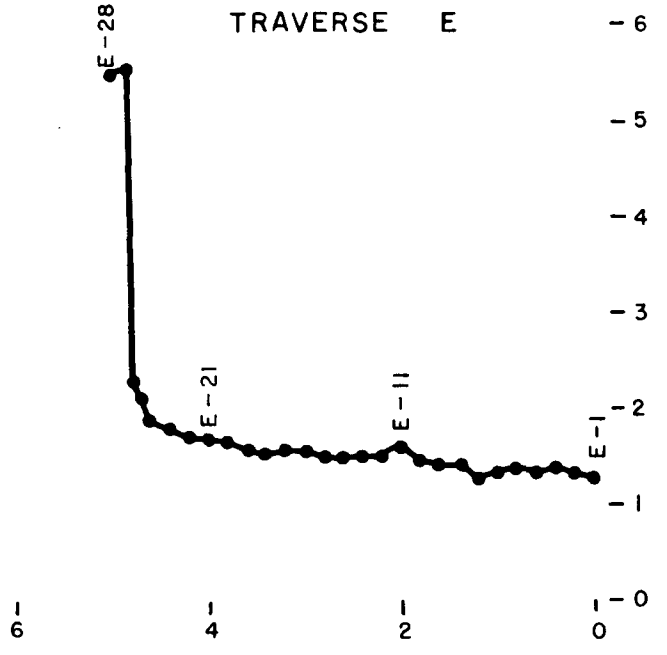

MAGNETIC PROFILE SECTIONS
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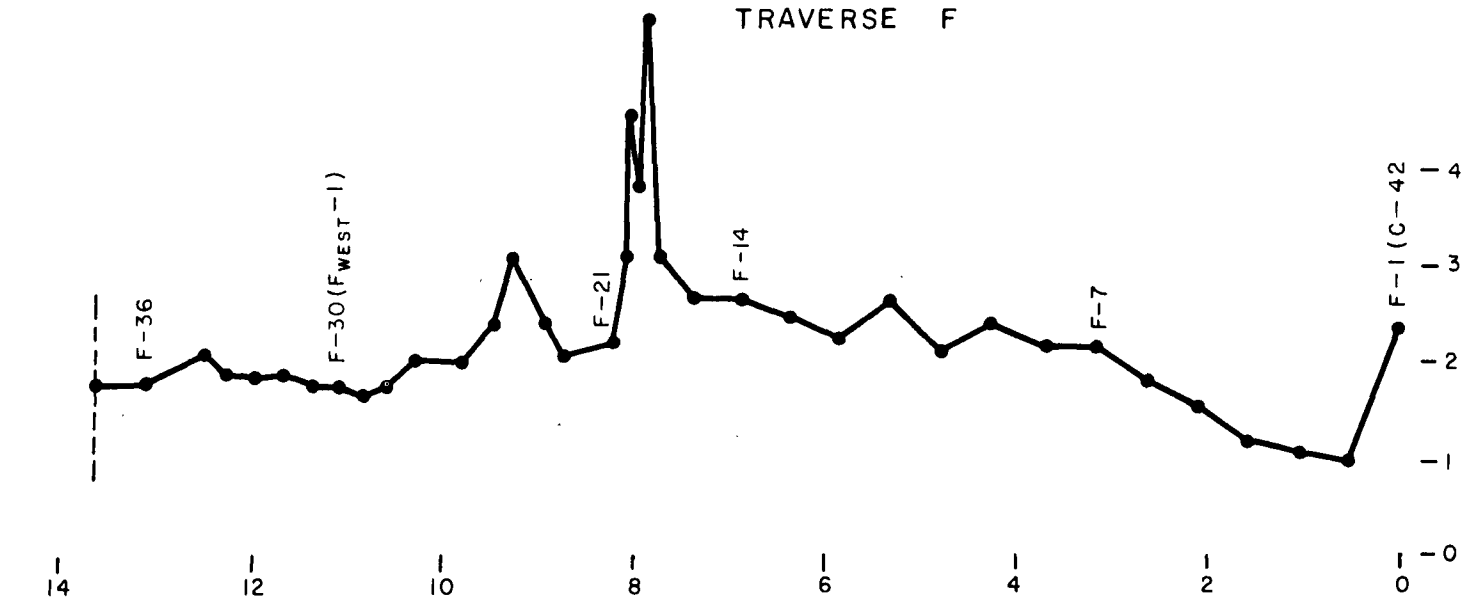

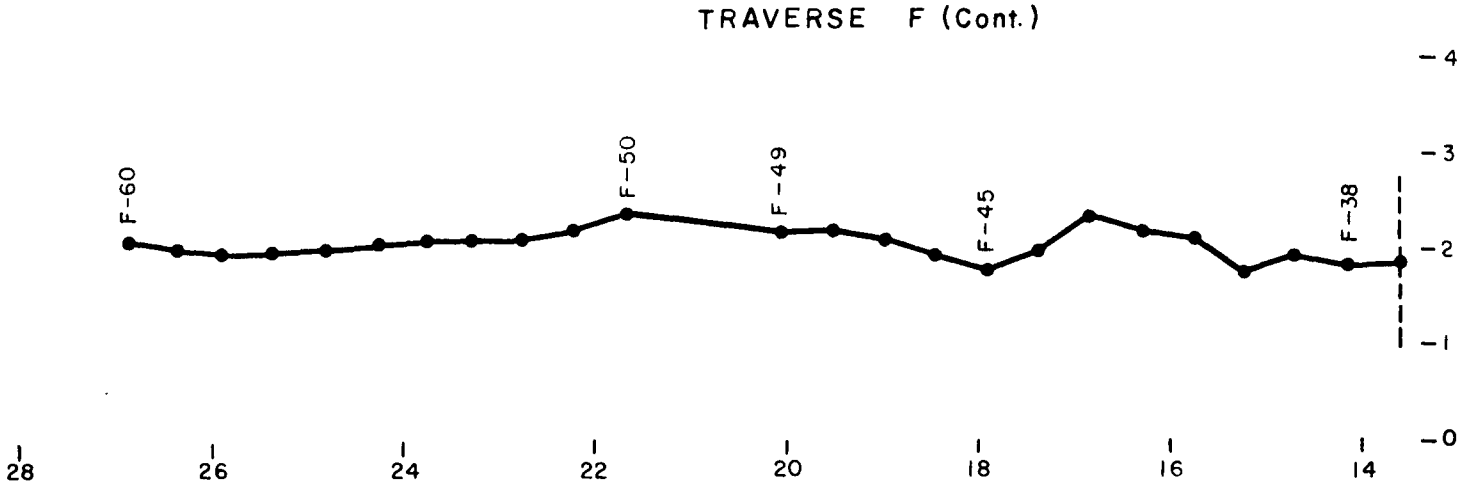

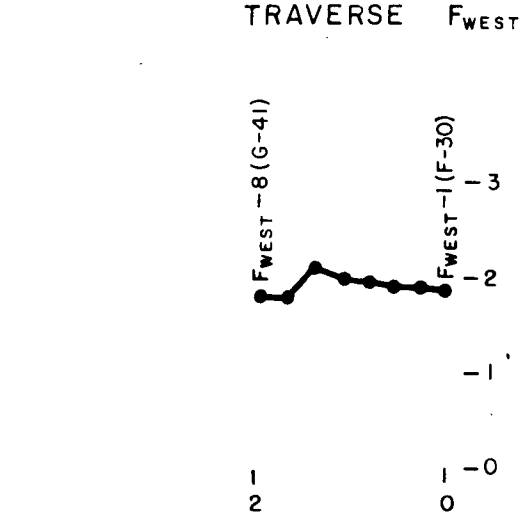

MAGNETIC PROFILE SECTIONS
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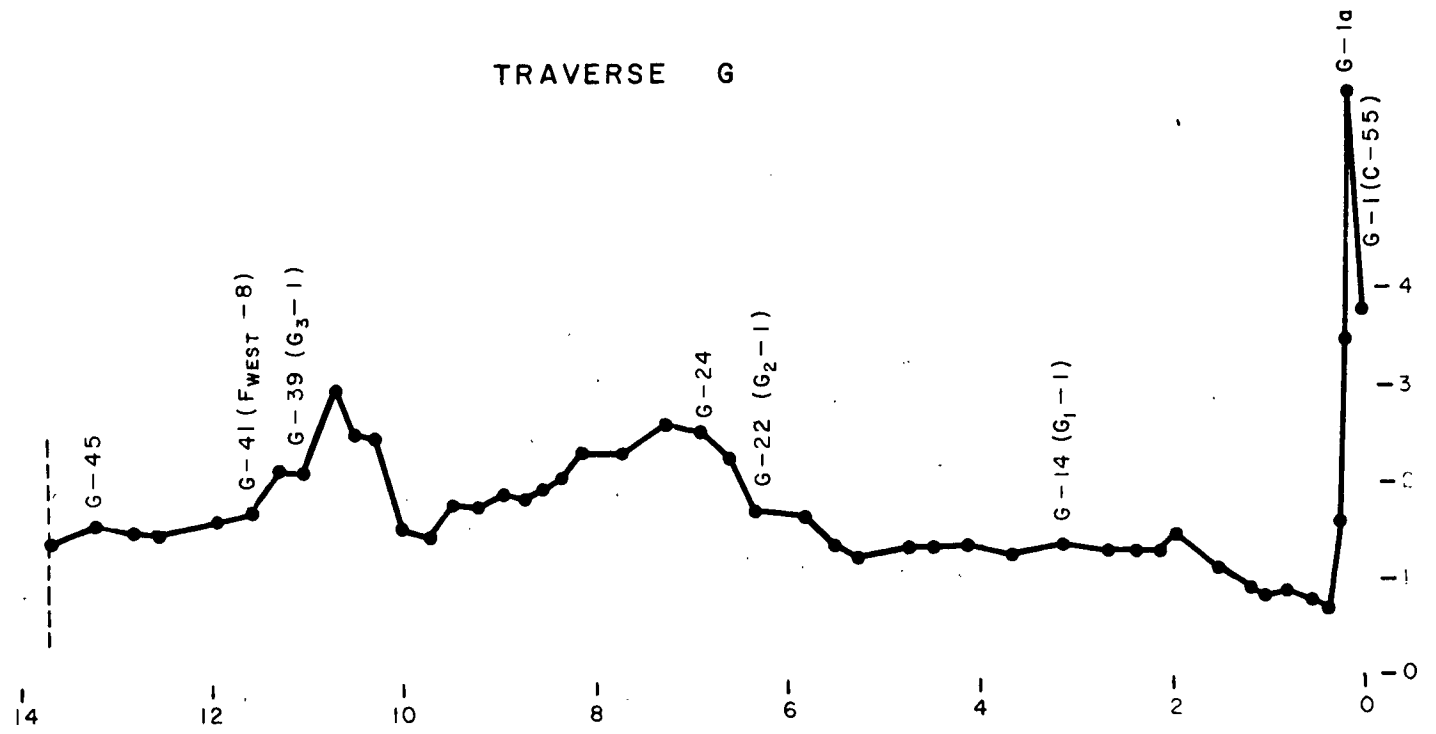

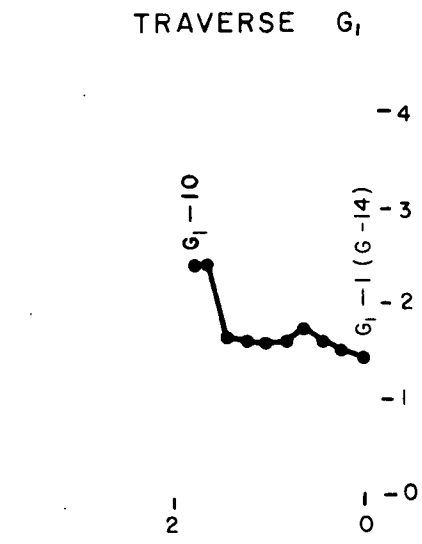

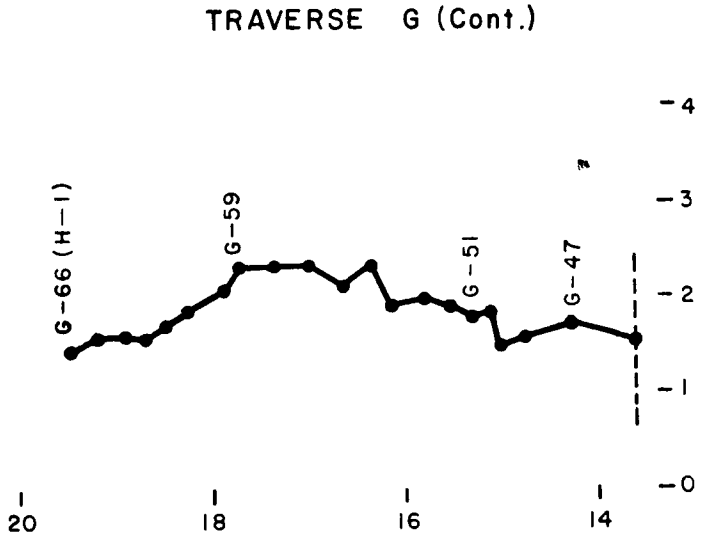

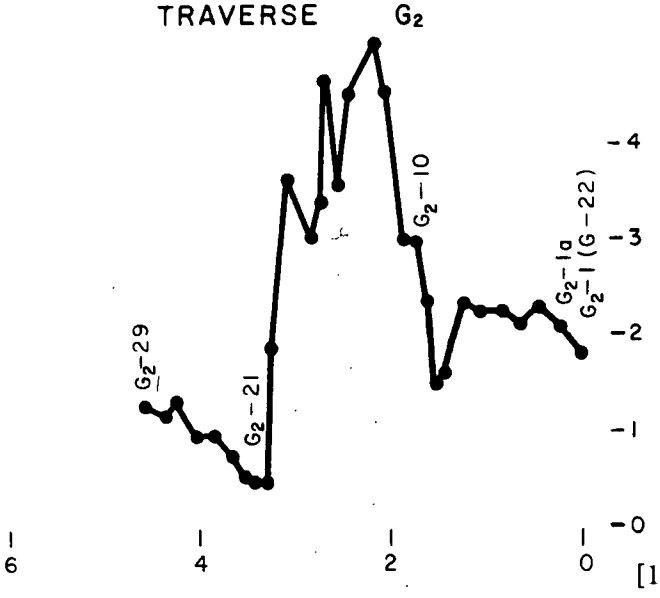

MAGNETIC PROFILE SECTIONS
TRAVERSES G, G_1, G_2
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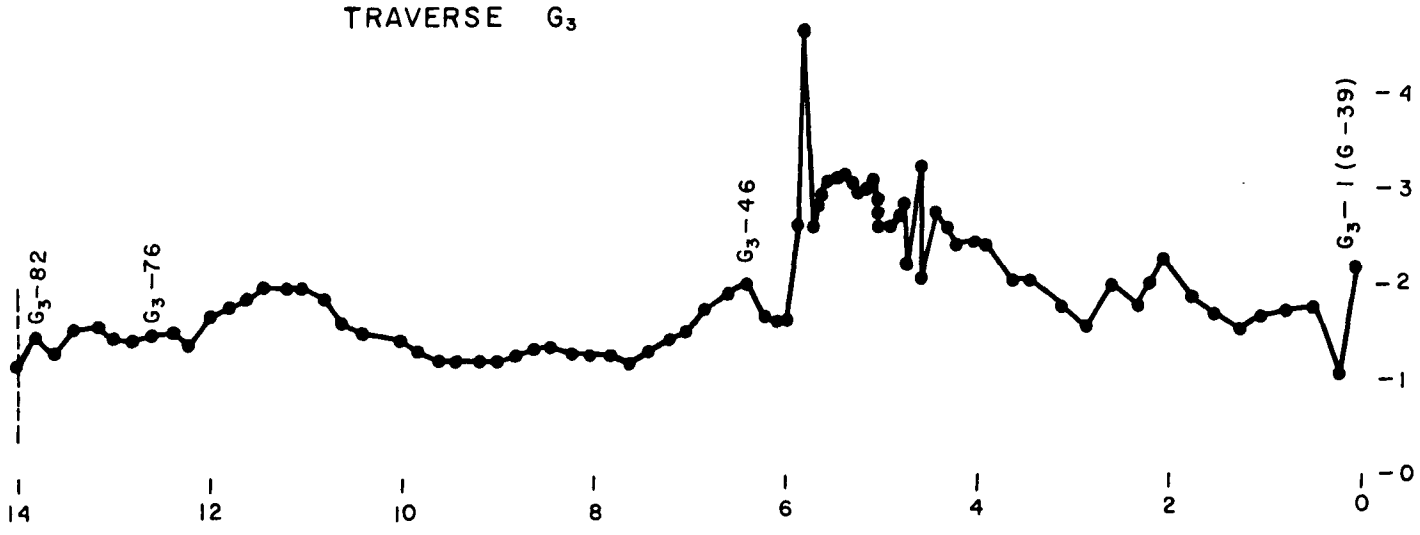

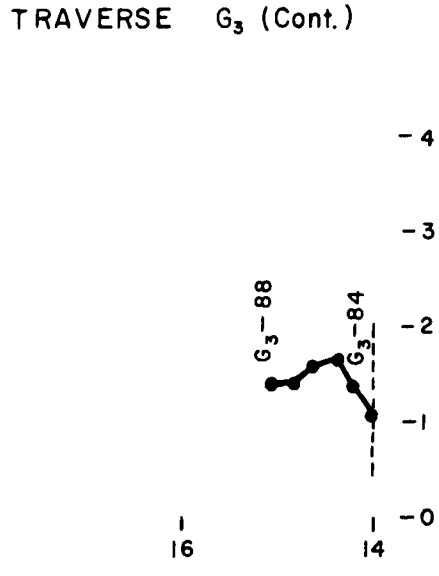

MAGNETIC PROFILE SECTIONS
TRAVERSE G_3
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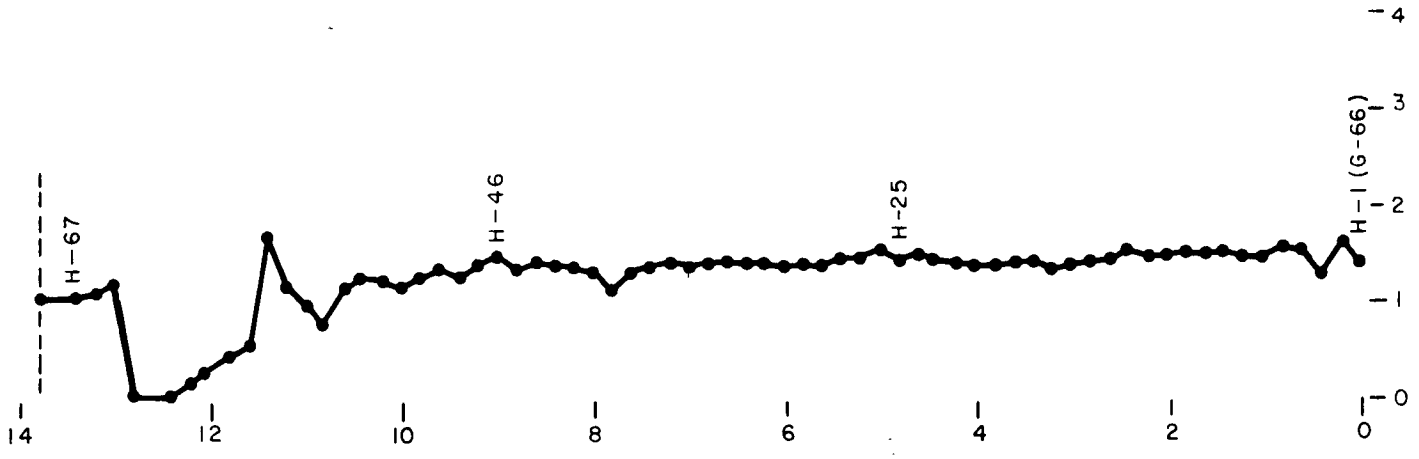
TRAVERSE H



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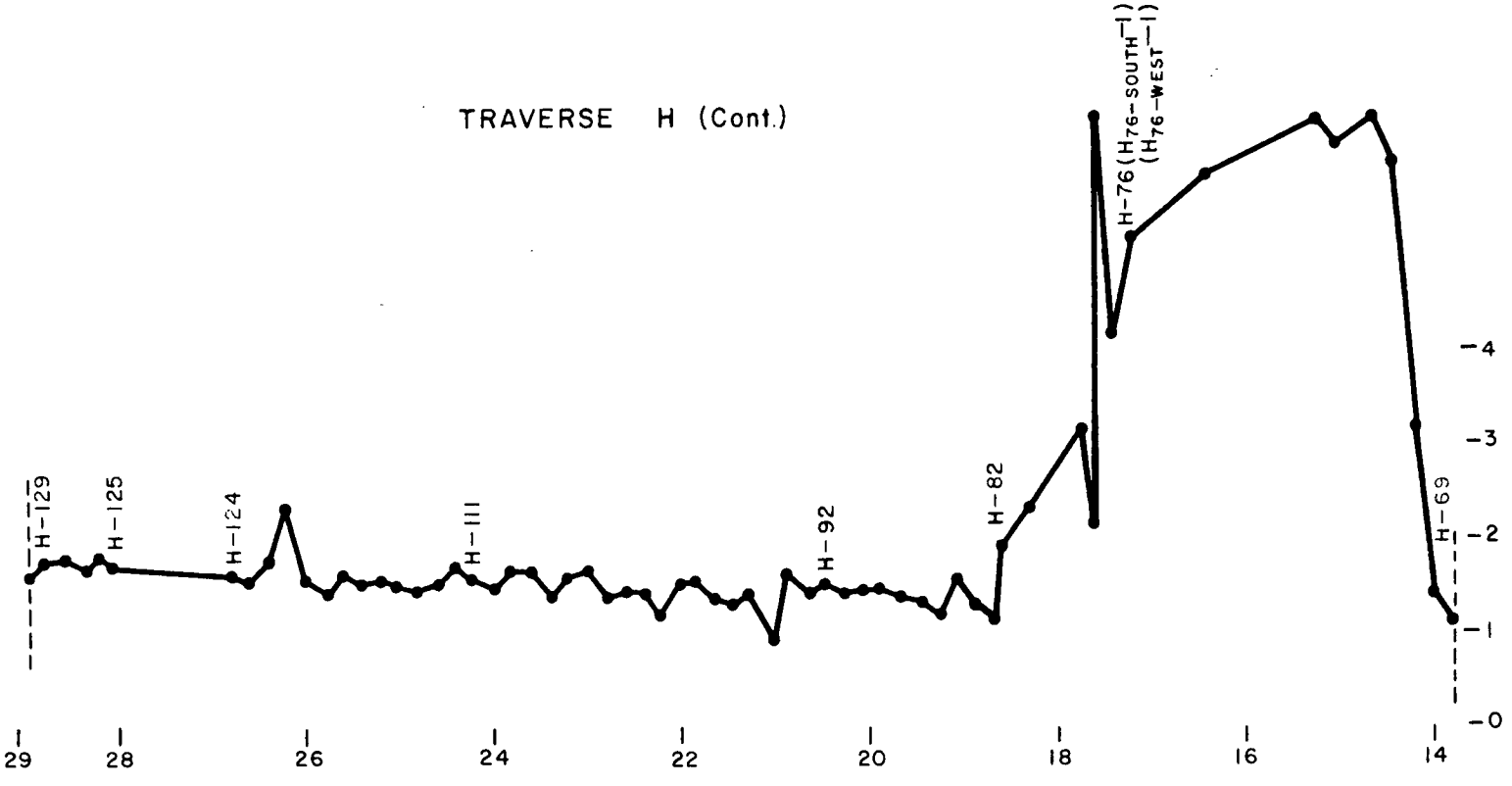

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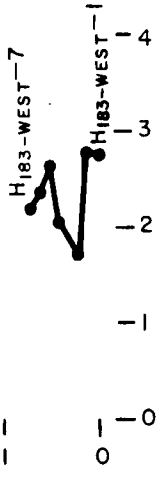

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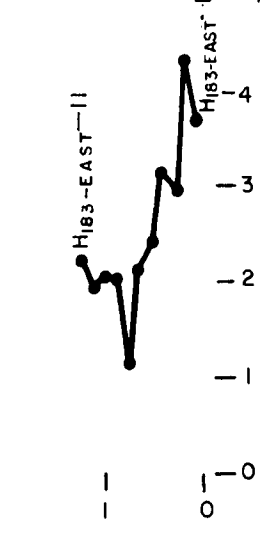

MAGNETIC PROFILE SECTIONS
TRAVERSES H, $H_{183\text{-}EAST}$, $H_{183\text{-}WEST}$
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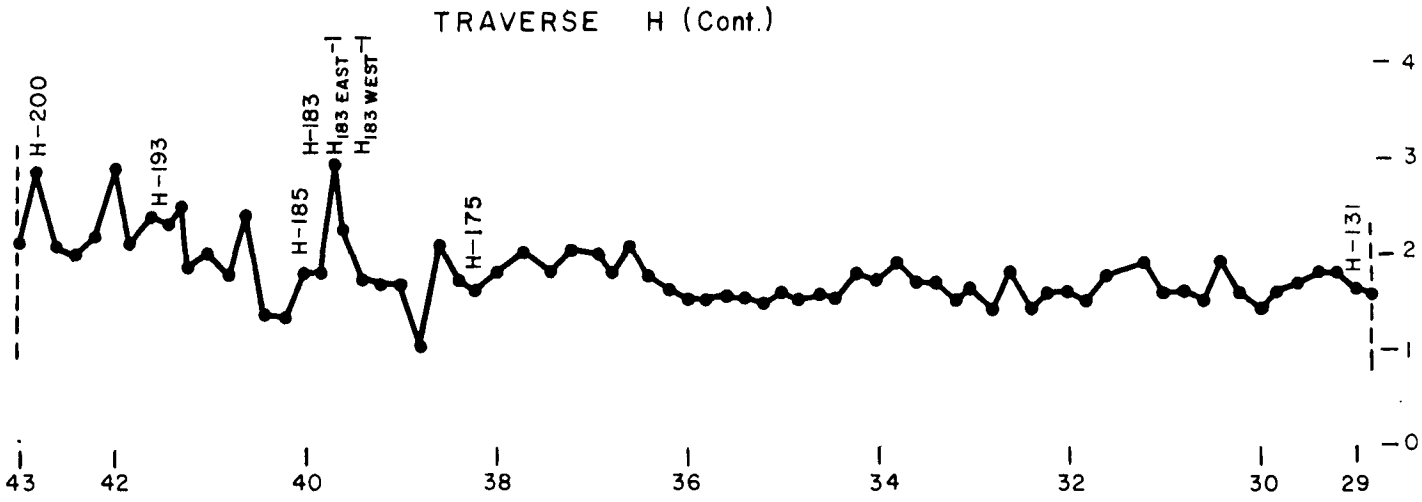
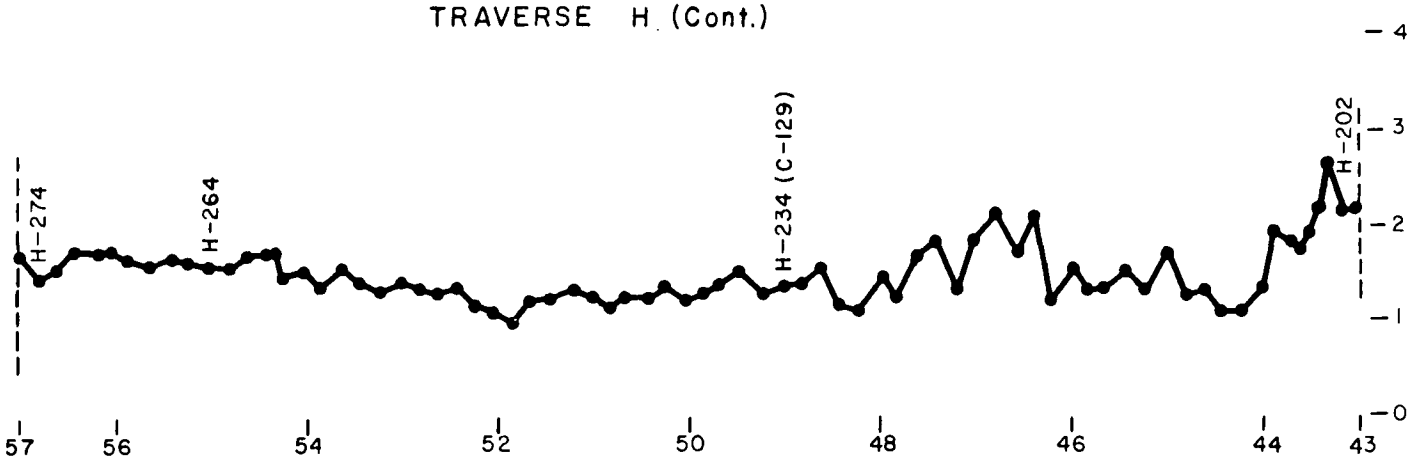
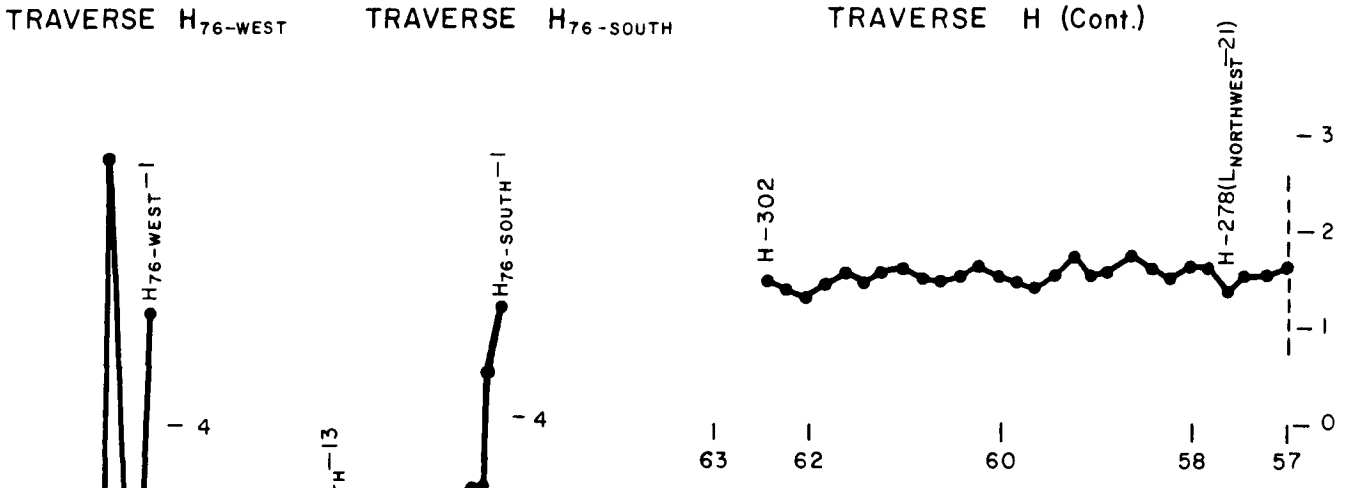
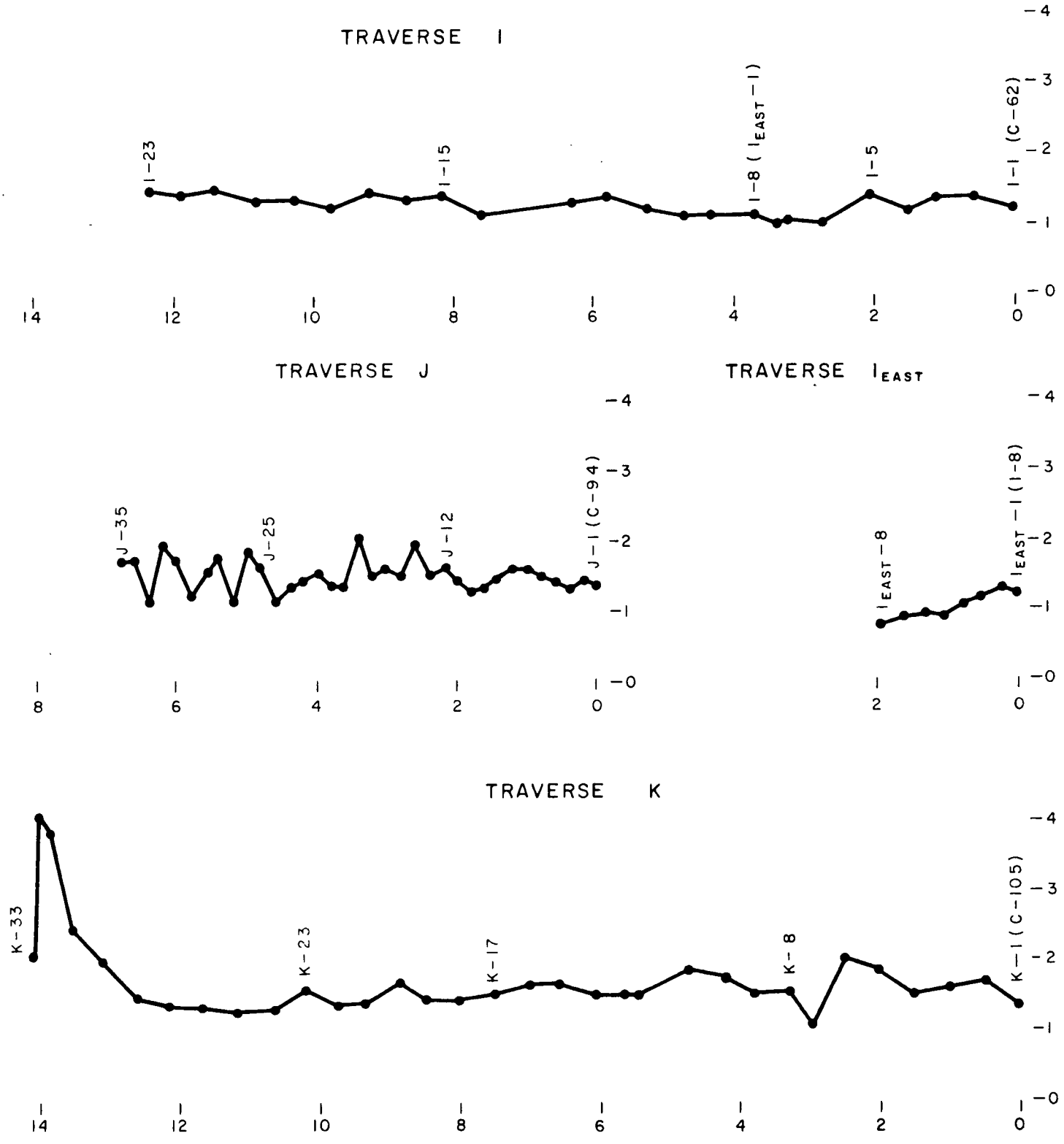




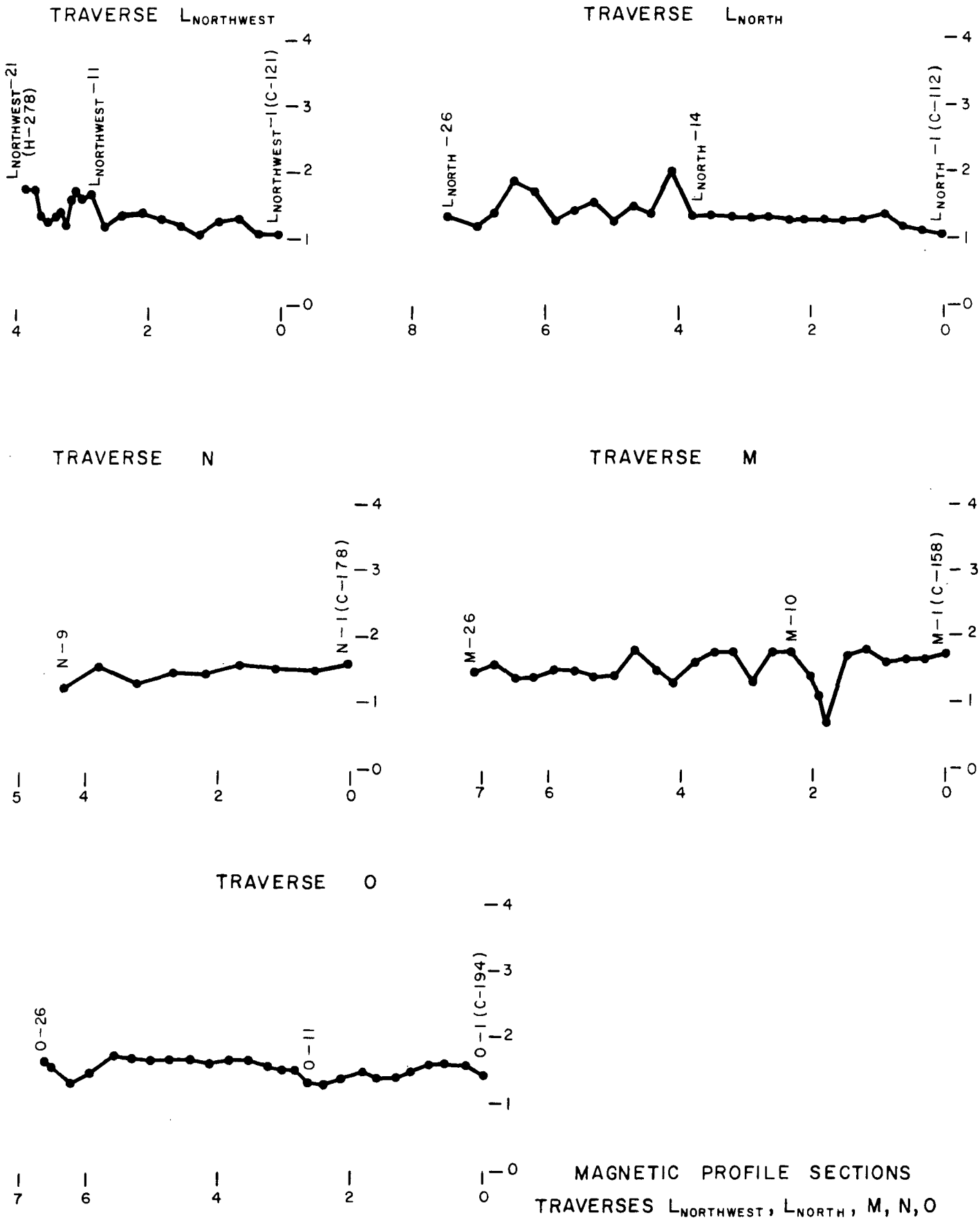


MAGNETIC PROFILE SECTIONS
TRAVERSES H, $H_{76\text{-WEST}}$, $H_{76\text{-SOUTH}}$
for
VERMONT GEOLOGICAL SURVEY
by
WESTON GEOPHYSICAL ENGINEERS, INC.

SCALE VER 1"=2000 GAMMAS
HOR 1"=2000 FEET

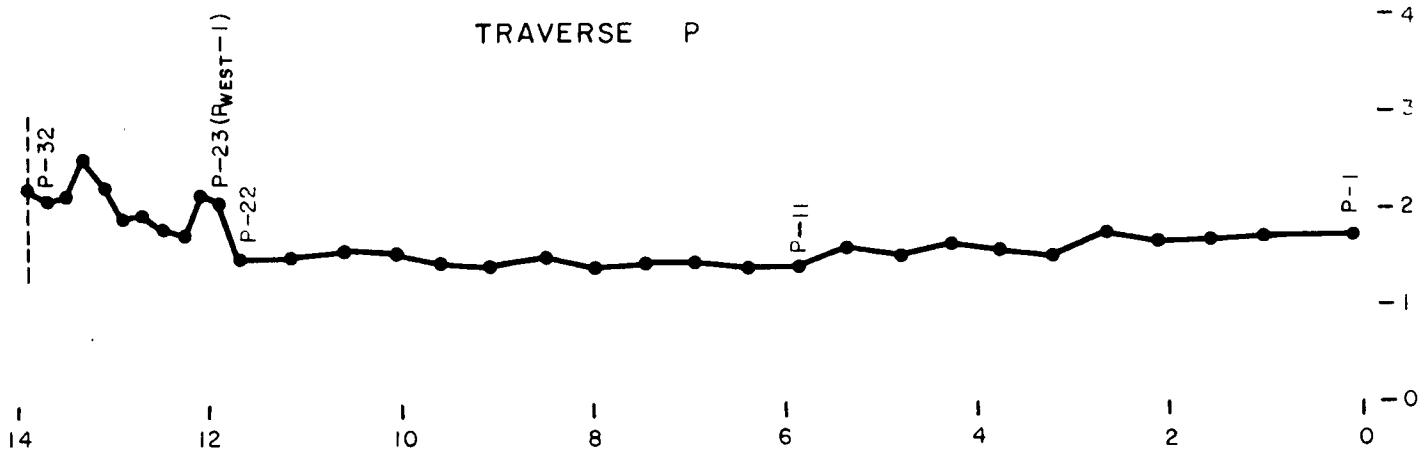


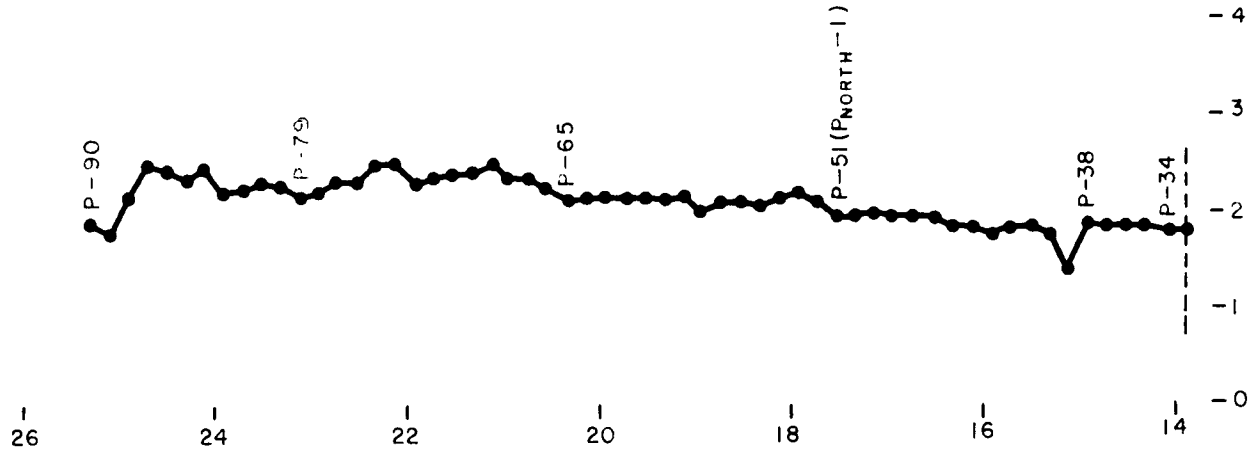
MAGNETIC PROFILE SECTIONS
TRAVERSES I, I_{EAST}, J, K
for
VERMONT GEOLOGICAL SURVEY
by
WESTON GEOPHYSICAL ENGINEERS, INC.
SCALE: VER. 1"=2000 GAMMAS
HOR. 1"=2000 FEET

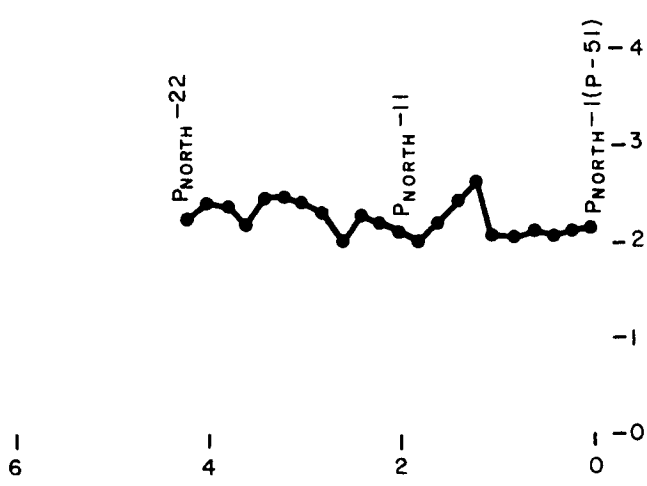


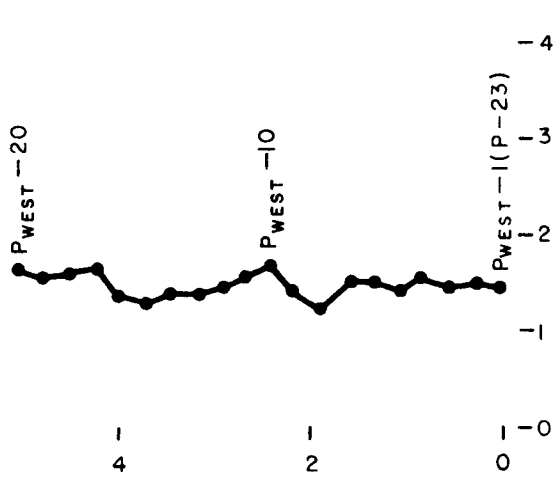
MAGNETIC PROFILE SECTIONS
TRAVERSES $L_{NORTHWEST}$, L_{NORTH}, M, N, O
for
VERMONT GEOLOGICAL SURVEY
by
WESTON GEOPHYSICAL ENGINEERS, INC.

SCALE: VER. 1" = 2000 GAMMAS
HOR. 1" = 2000 FEET









MAGNETIC PROFILE SECTIONS
TRAVERSES P, P_{NORTH}, P_{WEST}
for
VERMONT GEOLOGICAL SURVEY
by
WESTON GEOPHYSICAL ENGINEERS, INC.

SCALE: VER. 1" = 2000 GAMMAS
HOR. 1" = 2000 FEET

TRAVERSES A, B

STATION	GAMMAS	STATION	GAMMAS
A- 1	1280	A- 41	1300
2	1140	42	1500
A- 3	4080	43	1430
4	4340	44	1520
5	4930	45	1470
6	4950	46	1480
7	4560	A- 47	1500
8	4990	48	1450
9	5120	49	1460
10	4540	50	1410
11	3470	51	1410
12	1790	A- 52	1470
13	2030	53	1310
14	1990	54	1090
A- 15	2220	55	1210
16	2100	56	1190
17	1170	57	1260
18	1230	58	1140
A- 19	900	59	1100
20	1260	60	950
21	1260	61	850
22	1340	62	850
23	1380	63	650
24	1380	64	1050
25	1380	65	1300
A- 26	1480	66	2870
27	1430	67	3190
28	1410	68	3200
29	1340	69	3480
30	1410	70	2680
31	1360	71	2610
32	1450	72	2830
33	1430	73	4180
A- 34	1430	74	2300
A- 35	1420	A- 75	2080
36	1430	76	1890
37	1510	77	2130
38	1480	78	1500
39	1450	79	1570
40	1450	80	1570

TRAVERSES A, B East, B West

STATION	GAMMAS
A - 81	1500
82	1550
83	1360
84	1380
A - 85	1310
B - 1	1490
2	1410
3	1400
4	1630
5	1560
6	1080
7	1000
8	930
9	760
10	810
11	860
B - 12	1440
13	1490
14	3570
15	6080
16	6090
17	5590
18	5230
19	5060
20	5930
21	3080
B - 22	3080
23	2260
24	2140
25	1900
26	1990
27	1800
28	1730
29	1510
30	1510
31	1510
32	1460
33	1440
34	1410
B - 35	1320

STATION	GAMMAS
B_E - 1	3120
2	2630
3	2390
4	2010
5	1980
6	1670
7	1500
8	1600
9	1600
10	2300
11	3190
12	5000
13	5260
14	6990
15	4700
16	3670
17	2710
18	1980
19	1640
20	1250
21	1450
B_W - 1	1800
2	2000
3	2000
4	2190
5	2240
6	2600
7	2090
8	1920
9	1780

TRAVERSE C

STATION	GAMMAS	STATION	GAMMAS
C- 1	1250	C- 41	2435
2	1250	42	1100
3	1250	43	450
4	1400	44	1200
5	1300	45	3855
6	1350	46	4315
7	1400	47	3510
8	1150	48	3615
9	1300	49	3760
10	1150	50	4555
11	1300	51	2960
12	1300	52	3930
C- 13	1300	53	3615
14	1150	54	3445
15	1350	C- 55	2210
16	1300	56	695
17	1250	57	695
18	1250	58	790
19	1300	59	900
20	1300	60	1000
C- 21	1400	61	700
22	4385	C- 62	1180
23	5205	63	1150
24	4200	64	1220
25	3975	65	1250
26	2675	66	1130
27	2095	67	1790
C- 28	1800	68	2235
29	1700	69	3560
30	1335	70	3405
31	1300	71	2110
32	1150	72	1630
33	1300	73	1600
34	1375	C- 74	2235
35	1250	75	2740
C- 36	1325	76	2480
37	2650	77	2210
38	6840	C- 78	1560
39	4050	79	1200
40	3870	80	1200

TRAVERSE C continued

STATION	GAMMAS	STATION	GAMMAS
C-81	1030	C-121	1080
82	1220	122	1100
83	1200	123	1080
84	1355	124	1055
85	1560	125	1055
86	1460	126	1105
87	1610	127	1150
88	1610	128	1250
89	1705	129	1175
90	1560	130	1225
91	1760	131	1260
92	1490	132	790
93	1705	133	1090
C-94	1890	134	1225
95	1635	135	2030
96	1800	136	1705
97	1585	137	1280
98	1945	138	1965
99	2020	139	1370
100	1970	140	1450
101	1900	C-141	1560
102	1125	142	1270
103	1800	143	1130
104	1730	144	1150
105	1695	145	1040
106	1415	146	1605
107	2140	147	1130
108	2310	148	1680
109	1730	149	2290
110	1680	150	1780
111	1730	151	1250
112	2045	152	1370
113	1080	153	1345
114	960	154	820
115	1150	155	1455
116	1150	156	1560
117	1055	157	1610
118	1080	C-158	1430
119	1320	159	1755
120	1150	160	1705

TRAVERSE C continued

STATION	GAMMAS
C-161	1610
162	1620
163	1705
164	1875
165	1780
166	1630
167	1610
168	1850
169	1705
170	2130
171	1850
C-172	1705
173	1585
174	1620
175	1610
176	1625
177	1680
C-178	1560
179	1540
180	1640
181	1515
182	1550
183	1610
184	1585
185	1560
186	1600
C-187	1465
188	1620
189	1635
190	1660
191	1660
192	1610
193	1560
194	1570

TRAVERSES D, E

STATION	GAMMAS
D- 1	1500
2	1770
3	2050
4	2220
5	2460
6	2240
7	1930
8	1720
D- 9	1450
10	1500
11	1430
12	1360
13	1230
14	1400
D-15	1450
16	1480
17	1500
18	1520
19	1550
20	1500
21	1330
D-22	1570
E- 1	1300
2	1370
3	1420
4	1370
5	1420
6	1350
7	1320
8	1470
9	1470
10	1490
E-11	1630
12	1560
13	1540
14	1560
15	1560
16	1610
17	1610
18	1540
E-19	1610
20	1690
21	1690
22	1750
23	1830
24	1880
25	2140
26	2280
27	5540
E-28	5510

TRAVERSE F, F West

STATION	GAMMAS	STATION	GAMMAS
F- 1	2400	41	2080
2	1020	42	2230
3	1120	43	2370
4	1220	44	2010
5	1600	F- 45	1820
6	1850	46	1940
F- 7	2200	47	2080
8	2200	48	2220
9	2450	F- 49	2220
10	2150	F- 50	2370
11	2700	51	2270
12	2280	52	2160
13	2540	53	2100
F- 14	2680	54	2130
15	2680	55	2080
16	3170	56	1980
17	5600	57	1980
18	3900	58	1980
19	4600	59	2050
20	3170	F- 60	2150
F- 21	2250		
22	2100	F_W- 1	1870
23	2450	2	1910
24	3150	3	1940
25	2450	4	1940
26	2050	5	2010
27	2050	6	2100
28	1800	7	1800
29	1720	8	1800
F- 30	1800		
31	1800		
32	1940		
33	1890		
34	1940		
35	2090		
36	1850		
37	1870		
38	1850		
F- 39	1920		
40	1770		

TRAVERSE G, G_1

STATION	GAMMAS	STATION	GAMMAS
G- 1	3780	G-40	2300
1a	6030	41	1870
2	3490	42	1800
3	1600	43	1650
4	750	44	1650
5	800	45	1700
6	900	46	1600
7	850	47	1760
8	900	48	1610
9	1160	49	1490
10	1550	50	1870
11	1350	51	1810
12	1380	52	1900
13	1350	53	2040
G-14	1420	54	1940
15	1320	55	2370
16	1400	56	2190
17	1400	57	2320
18	1400	58	2310
19	1300	59	2310
20	1470	60	2110
21	1700	61	1870
G-22	1900	62	1700
23	2330	63	1550
24	2600	64	1550
25	2630	65	1650
26	2410	G-66	1460
27	2950		
28	2160	G_1- 1	1420
G-29	2040	2	1445
30	1980	3	1605
31	1970	4	1750
32	1890	5	1625
33	1845	6	1625
34	1640	7	1605
35	1580	8	1655
36	2570	9	2450
37	2630	10	2450
38	3120		
G-39	2270		

TRAVERSE G_2, G_3

STATION	GAMMAS	STATION	GAMMAS
G_2 - 1	1800	G_3 - 1	2270
1a	2040	1a	1050
2	2300	2	1750
3	2090	3	1700
4	2260	4	1650
5	2230	5	1550
6	2370	6	1700
7	1600	7	1965
8	1510	8	2275
9	2370	9	2060
10	2980	10	1815
11	2980	11	2015
12	4620	12	1555
13	5030	13	1770
14	4540	14	2030
15	3580	15	2035
16	4690	16	2425
17	3410	17	2520
18	3050	18	2425
19	3700	19	2620
20	1900	20	2740
21	500	21	2090
22	500	22	3295
23	570	23	2220
24	730	24	2860
25	980	25	2740
26	1010	26	2665
27	1340	27	2640
28	1200	28	2620
G_2-29	1310	29	2785
		30	2980
		31	3125
		32	2980
		33	2955
		34	3125
		35	3195
		36	3125
		37	3125
		38	2980
		G_3-39	2905

TRAVERSE G_3

STATION	GAMMAS	STATION	GAMMAS
G_3-40	2640	G_3-80	1570
41	4660	81	1370
42	2640	82	1485
43	1510	83	1150
44	1510	84	1440
45	1730	85	1645
46	1985	86	1585
47	1875	87	1465
48	1730	G_3-88	1465
49	1490		
50	1390		
51	1320		
52	1220		
53	1320		
54	1295		
55	1320		
56	1370		
57	1320		
58	1245		
59	1175		
60	1200		
61	1225		
62	1225		
63	1320		
64	1415		
65	1500		
66	1600		
67	1850		
68	1945		
69	1945		
70	1970		
71	1840		
72	1730		
73	1655		
74	1370		
75	1490		
76	1465		
77	1465		
78	1475		
G_3-79	1595		

TRAVERSE H

STATION	GAMMAS	STATION	GAMMAS
H- 1	1445	41	1375
2	1665	42	1400
3	1300	43	1445
4	1545	44	1445
5	1590	45	1400
6	1495	H-46	1520
7	1495	47	1420
8	1520	48	1300
9	1520	49	1400
10	1520	50	1325
11	1520	51	1205
12	1495	52	1275
13	1545	53	1325
14	1495	54	1205
15	1470	55	820
16	1420	H-56	1000
17	1420	57	1225
18	1445	58	1725
19	1450	59	600
20	1420	60	480
21	1420	61	300
22	1445	62	200
23	1495	63	100
24	1520	64	100
H-25	1470	65	1225
26	1570	66	1135
27	1495	67	1100
28	1520	68	1100
29	1420	69	1400
30	1420	70	3185
31	1420	71	6025
32	1470	72	6485
33	1445	73	6185
34	1470	74	6440
35	1470	75	5880
36	1420	H-76	5210
37	1445		
38	1400		
39	1350		
40	1180		

TRAVERSE H76 South, H76 West, H continued

STATION	GAMMAS	STATION	GAMMAS
$H76_S$-1	5210	H- 77	4195
2	4500	78	6510
3	3300	79	2195
4	3300	80	3135
5	3230	81	2340
6	3100	82	1965
7	3100	83	1155
8	2800	84	1325
9	2820	85	1590
10	2625	86	1200
11	2460	87	1350
12	2370	88	1420
13	2170	89	1495
		90	1495
		91	1470
$H76_W$-1	5210	H- 92	1565
2	2820	93	1495
3	9900	94	1665
4	6845	95	940
5	1545	96	1445
6	990	97	1300
7	915	98	1375
8	1035	99	1565
9	230	100	1520
		101	1180
		102	1425
		103	1425
		104	1375
		105	1690
		106	1615
		107	1400
		108	1590
		109	1590
		110	1495
		111	1565
		112	1690
		113	1520
		114	1445
		H-115	1520

TRAVERSE H continued

STATION	GAMMAS
H-116	1545
117	1520
118	1590
119	1425
120	1590
121	2365
122	1785
123	1565
H-124	1640
125	1730
126	1870
127	1775
128	1870
129	1825
130	1630
131	1680
132	1850
133	1850
134	1730
135	1630
136	1440
137	1600
138	1950
139	1560
140	1630
141	1605
142	1970
143	1830
144	1585
145	1680
146	1605
147	1500
148	1825
149	1415
150	1640
151	1510
152	1730
153	1750
154	1920
H-155	1750

STATION	GAMMAS
H-156	1895
157	1550
158	1630
159	1580
160	1605
161	1500
162	1535
163	1585
164	1535
165	1560
166	1655
167	1800
168	2160
169	1870
170	2015
171	2015
172	1850
173	2040
174	1865
H-175	1680
176	1775
177	2110
178	1010
179	1730
180	1730
181	1775
182	2330
H-183	3000

TRAVERSE H183 East, H183 West, H continued

STATION	GAMMAS	STATION	GAMMAS
$H183_E$-1	3680	H-184	1800
2	4310	185	1800
3	2980	186	1390
4	3170	187	1415
5	2400	188	2480
6	2140	189	1825
7	1140	190	2045
8	2040	191	1980
9	2060	192	2525
10	1990	193	2380
11	2230	194	2425
		195	2185
		196	2910
$H183_W$-1	2790	197	2255
2	1730	198	2015
3	1070	199	2160
4	2040	H-200	2910
5	2670	201	2185
6	2380	202	2135
7	2210	203	2645
		204	2235
		205	1420
		206	1750
		207	1825
		208	1920
		209	1365
		210	1100
		211	1100
		212	1320
		213	1270
		214	1705
		215	1320
		216	1510
		217	1340
		218	1365
		219	1535
		220	1220
		221	2090
		222	1705
		H-223	2150

TRAVERSE H continued

STATION	GAMMAS	STATION	GAMMAS
H-224	1855	H-264	1555
225	1280	265	1555
226	1830	266	1640
227	1710	267	1615
228	1250	268	1595
229	1445	269	1675
230	1120	270	1775
231	1155	271	1750
232	1615	272	1750
233	1420	273	1580
234	1395	274	1435
235	1290	275	1690
236	1510	276	1580
237	1410	277	1530
238	1290	278	1390
239	1220	279	1605
240	1340	280	1630
241	1260	281	1555
H- 242	1260	282	1630
243	1170	283	1775
244	1270	284	1605
245	1340	285	1530
246	1250	286	1750
247	1210	287	1530
248	1030	288	1460
249	1100	289	1510
250	1145	290	1530
251	1365	291	1630
252	1290	292	1530
253	1365	293	1510
254	1410	294	1530
255	1365	295	1605
256	1410	296	1580
257	1570	297	1485
258	1365	298	1580
259	1520	299	1485
260	1460	300	1340
261	1725	301	1410
262	1725	H-302	1520
H-263	1615		

TRAVERSE I, I East

STATION	GAMMAS
I- 1	1180
2	1475
3	1415
4	1245
5	1465
6	1055
7	1125
8	1150
9	1150
10	1175
11	1270
12	1465
13	1345
14	1150
15	1400
16	1400
17	1440
18	1270
19	1345
20	1340
21	1490
22	1465
I- 23	1510
I_E- 1	1250
2	1300
3	1200
4	1130
5	960
6	960
7	910
I_E- 8	820

TRAVERSE J

STATION	GAMMAS
J- 1	1470
2	1500
3	1350
4	1490
5	1640
6	1660
7	1660
8	1490
9	1350
10	1350
11	1520
J- 12	1710
13	1570
14	2000
15	1570
16	1660
17	1570
18	2100
19	1420
20	1380
21	1540
22	1470
23	1350
24	1130
J- 25	1640
26	1840
27	1180
28	1810
29	1610
30	1210
31	1740
32	1970
33	1640
34	1740
J- 35	1760

TRAVERSE K

STATION	GAMMAS
K- 1	1410
2	1700
3	1600
4	1520
5	1880
6	2010
7	1670
8	1540
9	1540
10	1780
11	1890
12	1510
13	1510
14	1530
15	1640
16	1660
17	1560
18	1450
19	1420
20	1650
21	1540
22	1350
23	1560
24	1250
25	1290
26	1330
27	1340
28	1480
29	2000
30	2460
31	3810
32	4030
K- 33	2040

TRAVERSE L North, L Northwest

STATION	GAMMAS
L_N - 1	1100
2	1200
3	1250
4	1450
5	1350
6	1350
7	1350
8	1350
9	1350
10	1400
11	1400
12	1410
13	1410
14	1410
15	2110
16	1460
17	1555
18	1360
19	1645
20	1480
21	1335
22	1795
23	1940
24	1505
25	1290
L_N-26	1455

STATION	GAMMAS
L_{NW}- 1	1090
2	1090
3	1360
4	1280
5	1120
6	1265
7	1360
8	1455
9	1380
10	1230
11	1770
12	1670
13	1770
14	1650
15	1230
16	1455
17	1420
18	1330
19	1410
20	1815
21	1820

TRAVERSES M, N

STATION	GAMMAS
M- 1	1700
2	1650
3	1650
4	1600
5	1800
6	1700
7	650
8	1100
9	1400
10	1750
11	1750
12	1300
13	1750
14	1750
15	1600
16	1300
17	1450
18	1750
19	1400
20	1350
21	1450
22	1450
23	1400
24	1350
25	1550
M-26	1450

STATION	GAMMAS
N- 1	1600
2	1500
3	1550
4	1600
5	1500
6	1500
7	1350
8	1600
N- 9	1300

TRAVERSES O, P

STATION	GAMMAS	STATION	GAMMAS
O- 1	1450	P- 15	1460
2	1630	16	1530
3	1635	17	1460
4	1580	18	1480
5	1600	19	1580
6	1460	20	1590
7	1460	21	1530
8	1530	22	1530
9	1460	23	2160
10	1360	24	2210
11	1360	25	1820
12	1550	26	1850
13	1550	27	2020
14	1600	28	1870
15	1700	29	2280
16	1700	30	2550
17	1650	31	2180
18	1700	P- 32	2160
19	1700	33	2230
20	1700	34	1870
21	1700	35	1920
22	1750	36	1920
23	1500	37	1920
24	1350	38	1920
25	1600	39	1440
O-26	1650	40	1800
P- 1	1730	41	1920
2	1770	42	1920
3	1720	43	1850
4	1720	44	1890
5	1800	45	1890
6	1530	46	1970
7	1600	47	1990
8	1720	48	2020
9	1620	49	2040
10	1650	50	1990
11	1430	51	2020
12	1460	52	2160
13	1480	53	2230
P-14	1480	P- 54	2210

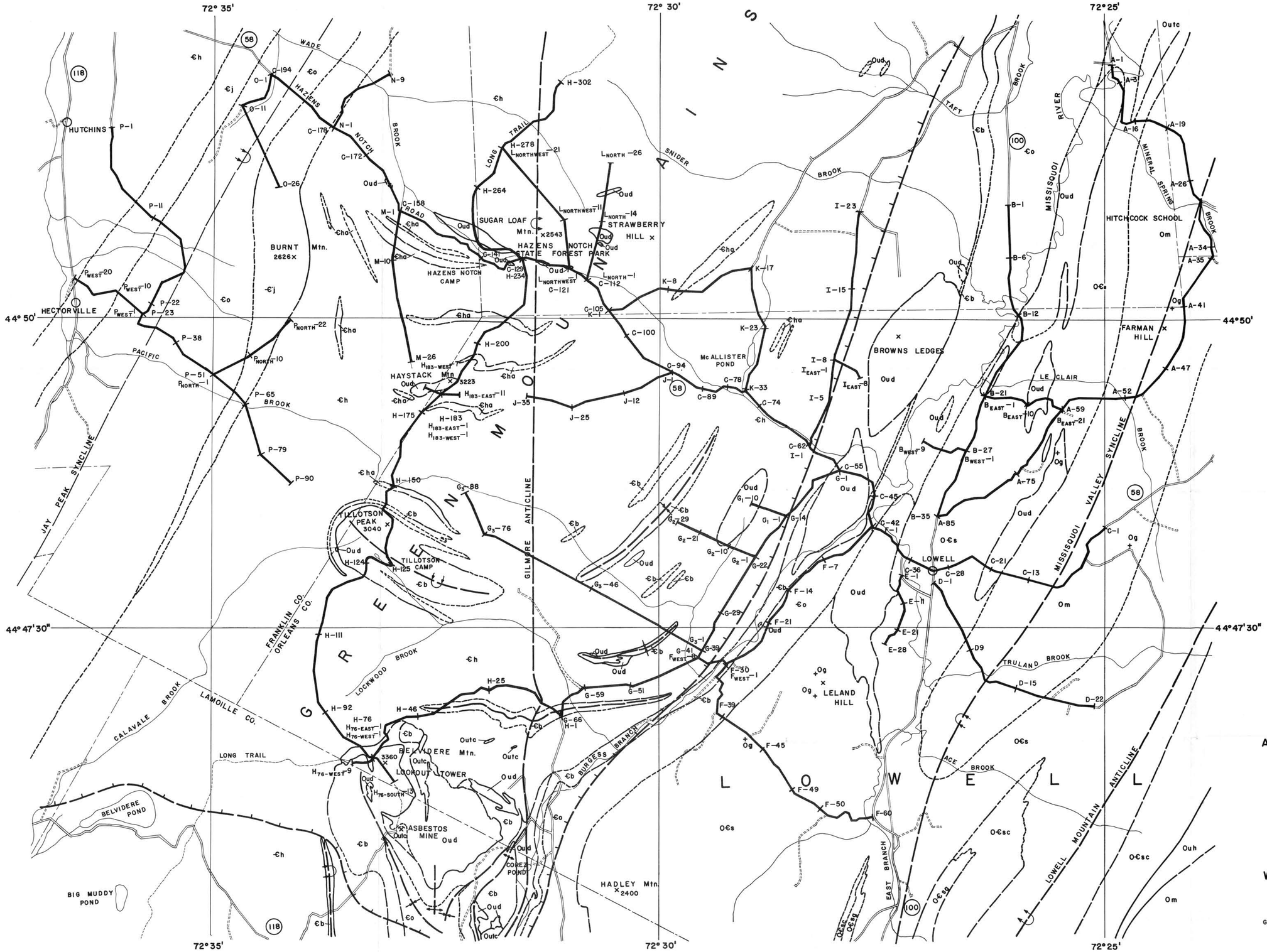
TRAVERSE P

STATION	GAMMAS
P- 55	2110
56	2160
57	2160
58	2040
59	2230
60	2210
61	2190
62	2180
63	2210
64	2210
65	2210
66	2300
67	2400
68	2420
69	2570
70	2470
71	2430
72	2420
73	2380
74	2540
75	2540
76	2330
77	2370
78	2230
79	2180
80	2380
81	2330
82	2280
83	2260
84	2490
85	2380
86	2520
87	2570
88	2220
89	1800
P- 90	1940

TRAVERSE P North, P West

STATION	GAMMAS
P_N - 1	2180
2	2155
3	2105
4	2180
5	2105
6	2130
7	2685
8	2465
9	2200
10	2080
11	2130
12	2250
13	2325
14	2035
15	2325
16	2445
17	2490
18	2515
19	2200
20	2395
21	2445
P_N-22	2325

STATION	GAMMAS
P_W - 1	1480
2	1530
3	1480
4	1580
5	1455
6	1555
7	1530
8	1290
9	1455
10	1770
11	1625
12	1480
13	1460
14	1435
15	1360
16	1460
17	1700
18	1650
19	1605
P_W-20	1750



EXPLANATION

Og+ — METAGABBRO

Oud | Outc | Ouc — ULTRAMAFIC ROCKS
- Oud: DUNITE, PERIDOTITE, AND SERPENTINITE
- Outc: TALC – CARBONATE ROCK AND STEATITE
- Ouc: CARBONATE ROCK

Omc | Om — MORETOWN FORMATION

Ouh — UMBRELLA HILL FORMATION

Ocsg | Ocs | Ocsc — STOWE FORMATION

€o — OTTAUQUECHEE FORMATION

€b — BELVIDERE MOUNTAIN AMPHIBOLITE

€j — JAY PEAK FORMATION

€h | €hg | €hp — HAZENS NOTCH FORMATION

ORDOVICIAN

CAMBRIAN

CAMBRIAN(?)

HORNBLENDE ISOGRAD

CONTACT

NORMAL — OVERTURNED

ANTICLINE

NORMAL — OVERTURNED

SYNCLINE

A-1 — A-4 MAGNETIC TRAVERSE

AREA GEOLOGY and MAGNETIC TRAVERSES

LOWELL AREA, VERMONT

for

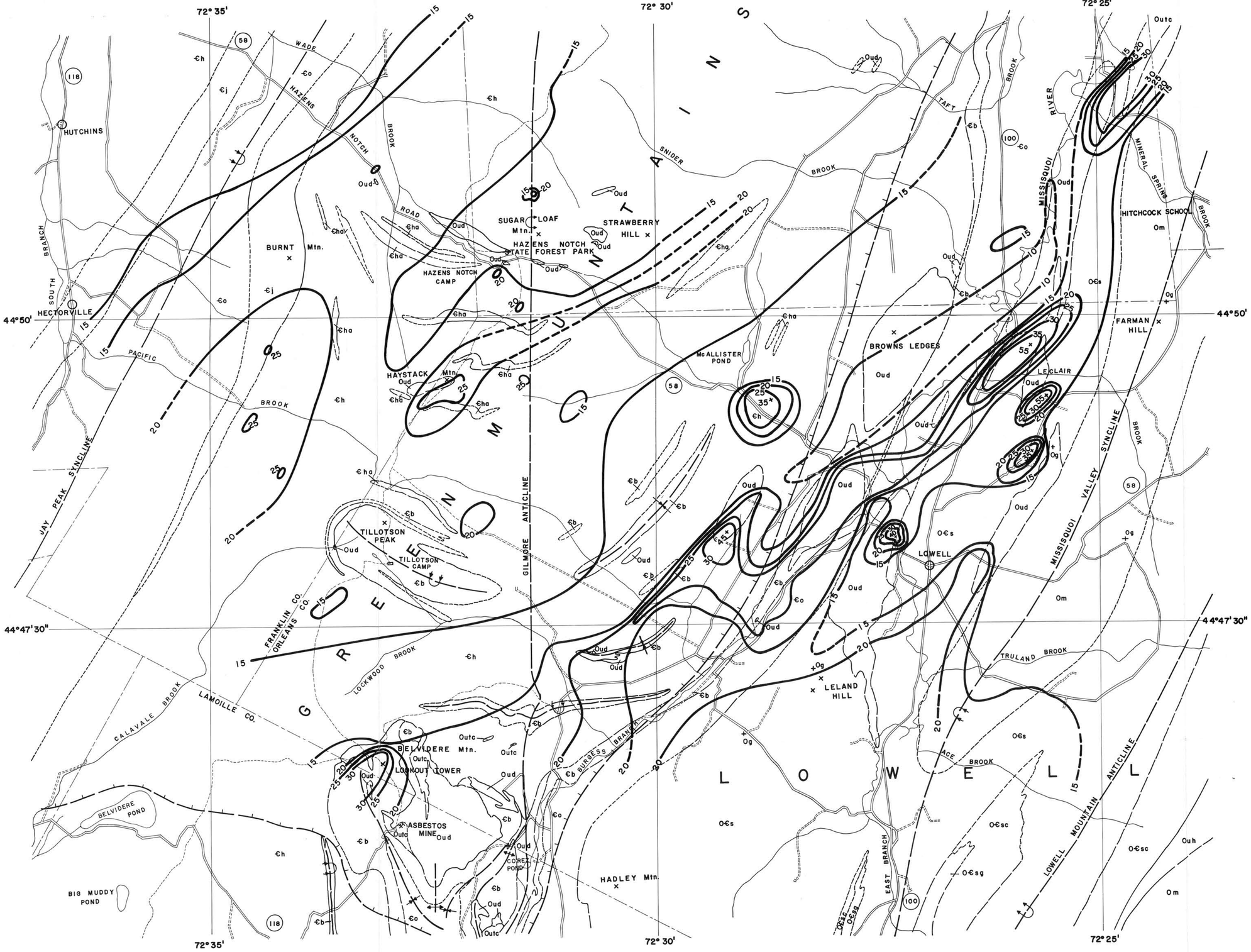
VERMONT GEOLOGICAL SURVEY

by

WESTON GEOPHYSICAL ENGINEERS, INC.

SCALE: HOR. 1" = 2000 FEET

GEOLOGY FROM: BULL. 1122-B PLATE I (CADY, ALBEE, and CHIDESTER) CENTENNIAL GEOLOGIC MAP OF VERMONT (CHARLES G. DOLL, STATE GEOLOGIST)



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€h €hg €ha — HAZENS NOTCH FORMATION

ORDOVICIAN

CAMBRIAN

CAMBRIAN(?)

HORNBLENDE ISOGRAD

CONTACT — NORMAL, OVERTURNED

ANTICLINE — NORMAL, OVERTURNED

SYNCLINE

25 — MAGNETIC CONTOUR

VALUES ARE IN 100'S OF GAMMAS
e.g. 25 = 2500 γ

AREA GEOLOGY and MAGNETIC CONTOURS

LOWELL AREA, VERMONT

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VERMONT GEOLOGICAL SURVEY

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GEOLOGY FROM: BULL 1122-B PLATE I (CADY, ALBEE, and CHIDESTER) CENTENNIAL GEOLOGIC MAP OF VERMONT (CHARLES G. DOLL, STATE GEOLOGIST)

Plate II