66-58

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 66-58

PROGRESS REPORT ON LOW-LEVEL AEROMAGNETIC PROFILES OVER THE LABRADOR SEA, BAFFIN BAY, AND ACROSS THE NORTH ATLANTIC OCEAN

(Report and 5 figures)

Peter J. Hood, P. Sawatzky, and Margaret E. Bower

Price, $1.00

1967

GEOLOGICAL SURVEY

OF CANADA

CANADA

PAPER 66-58

PROGRESS REPORT ON LOW-LEVEL AEROMAGNETIC PROFILES OVER THE LABRADOR SEA, BAFFIN BAY, AND ACROSS THE NORTH ATLANTIC OCEAN

Peter J. Hood, P. Sawatzky, and Margaret E. Bower

DEPARTMENT OF ENERGY, MINES AND RESOURCES

Available by mail from the Queen's Printer, Ottawa,
from the Geological Survey of Canada,
601 Booth St., Ottawa
and at the following Canadian Government bookshops:

OTTAWA
Daly Building, Corner Mackenzie and Rideau

TORONTO
221 Yonge Street

MONTREAL
Æterna-Vie Building, 1182 St. Catherine St. West

WINNIPEG
Mall Center Bldg., 499 Portage Avenue

VANCOUVER
657 Granville Street

or through your bookseller

A deposit copy of this publication is also available
for reference in public libraries across Canada

Price $1.00 Cat. No. M44-66-58

Price subject to change without notice

ROGER DUHAMEL, F.R.S.C.
Queen's Printer and Controller of Stationery
Ottawa, Canada
1967

CONTENTS

Illustrations

PROGRESS REPORT ON LOW-LEVEL AEROMAGNETIC PROFILES OVER THE LABRADOR SEA, BAFFIN BAY, AND ACROSS THE NORTH ATLANTIC OCEAN

INTRODUCTION

An aeromagnetic survey was carried out during 1966 field season in co-operation with the National Aeronautical Establishment using two high-sensitivity digitally-recording magnetometers installed in NAE's North Star aircraft. One of the magnetometers was installed in the 25-foot tail stinger of the aircraft; the second magnetometer was flown in a bird about 200 feet behind and 90 feet below the aircraft. With this arrangement vertical gradient measurements could be calculated by a subsequent subtraction of the total field digital readings obtained from the two magnetometers. The survey altitude was maintained at 500 feet above the ocean surface as much as weather conditions would allow.

Navigation was by Loran A, Doppler, and by Astro fixes. A rubidium-vapour ground magnetometer was operated during the flights by Howard Knapp; for the Labrador Sea flights the ground station was located at Goose Bay, Labrador; for the Baffin Bay flights it was located at Sondrestrom in western Greenland; and for the profiles over the north Atlantic it was located at Gander, Newfoundland.

Acknowledgments are made to E.A. Godby, C. Foley, and J. Waddell of the National Aeronautical Establishment, and also the RCAF crew of the North Star aircraft, namely F/L N. F. Paul (Captain), F/L G.E. Kelly (Co-pilot), F/L J.G. Kilgour and F/L M. Landry (Navigators), and Sgt C. L. Empey (Flight Engineer), for their essential contributions to the aeromagnetic surveys herein described.

This paper is Canadian Contribution 145 to the International Upper Mantle Project.

LABRADOR SEA

In carrying out an aeromagnetic reconnaissance of the Labrador Sea during 1964 (Godby, Baker, Bower and Hood, 1966) the survey aircraft flew a number of lines from Frobisher Bay on Baffin Island to the coast of Greenland and thence to Goose Bay in Labrador. This procedure left a blank area between the parallel sets of survey lines flown (see Fig. 1). The subsequent compilation of the aeromagnetic data showed that there were two magnetic zones running approximately parallel to the median line of the Labrador Sea in a northwesterly direction. The westerly magnetic zone extended up to the aforementioned blank area, and from the results to the north it was not readily apparent whether the zone died out or perhaps was displaced to one side. The 1966 survey lines were therefore positioned to resolve this problem.

A total of ten aeromagnetic profiles were obtained in the Labrador Sea during May and June 1966. The tracks of the 1966 survey lines are shown in Figure 1

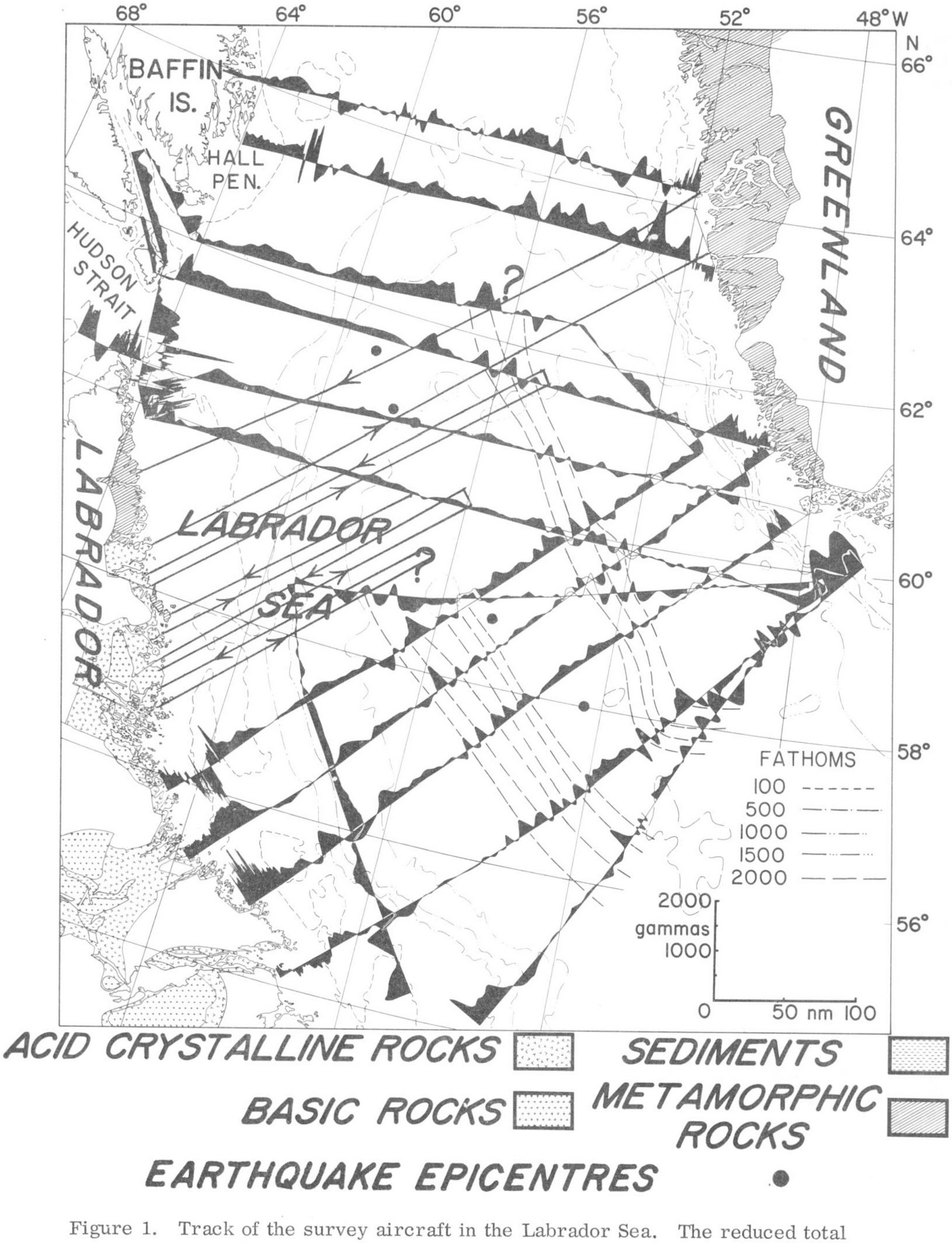

Figure 1. Track of the survey aircraft in the Labrador Sea. The reduced total intensity profiles resulting from the 1963 and 1964 surveys are also shown.

by the heavier solid lines. Included on the figure are the reduced total intensity profiles, which were obtained in previous survey flights during 1963 (Hood and Godby, 1964) and 1964 (Godby, Baker, Bower and Hood, 1966), together with the bathymetry and simplified geology of the continental land masses. Five earthquake epicentres, which are listed in publications of the Dominion Observatory, have also been included on the map. It can be seen that these fall approximately midway between the two magnetic zones.

A preliminary examination of the 1966 aeromagnetic profiles indicates that the western magnetic zone does extend in a northwesterly direction towards Hudson Strait. The individual anomalies tend to coalesce so that the zone is much narrower in the vicinity of Hudson Strait.

Some interesting results were also obtained over the Labrador continental shelf. It can readily be seen from the aeromagnetic profiles on Figure 1 that there is a marked change in the character of the aeromagnetic profile some tens of miles from the coastline. The anomalies are relatively sharp close in to shore and then quite abruptly the wavelength of the anomalies increases and the amplitude decreases. The change occurs about 20 nautical miles offshore opposite Cape Kakkiviak in the northern part of the Labrador shelf, and about 40 nautical miles from the coast in the vicinity of Hamilton Inlet. This change is undoubtedly due to a sudden increase in the depth to the crystalline basement. There also appears to be some correlation between the location of the change and a deep longitudinal depression in the continental shelf, which runs parallel to the coastline (Holtedahl, 1958). It seems likely that the western scarp of the depression marks the edge of the Precambrian basement. Preliminary depth determinations on the profiles indicate that the thickness of sediment in the outer Labrador shelf probably exceeds 20,000 feet over a wide area.

BAFFIN BAY

Figure 2 shows the 1966 survey lines in the southern Baffin Bay and Davis Strait areas. Also included on the map is the simplified geology of the surrounding land masses, the bathymetry, total field contours, earthquake epicentres, and the reduced aeromagnetic profiles published in the literature. The profiles immediately to the south of Davis Strait were obtained in 1964 (Godby, Baker, Bower, and Hood, 1966); most of the profiles shown in the northern half of the map were obtained by the Geophysical and Polar Research Centre of the University of Wisconsin (Ostenso, 1962). Two of the profiles in the vicinity of Devon Island were obtained by the Geological Survey of Canada during the aeromagnetic reconnaissance survey of the Arctic Islands in 1955(Gregory, Bower, and Morley, 1961).

One of the more interesting geological features of the area is the flat-lying Tertiary lava, which outcrops at Cape Dyer on the Cumberland Peninsula of Baffin Island and on the opposite coast of west Greenland in the vicinity of Disco Island (see Fig. 3). The occurrence of these basaltic lavas has a special significance in the light of Wegener's hypothesis that continental drift has occurred between Canada and Greenland. One of the aeromagnetic lines was therefore chosen to run between the

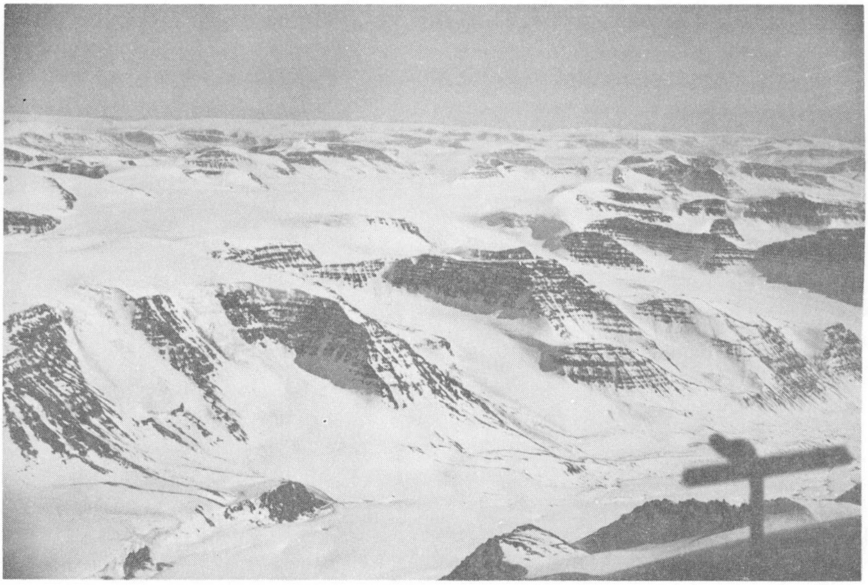

Figure 3. Flat-lying Tertiary lava flows on Disco Island, west Greenland.

Figure 4. An aerial view of the new volcanic island of Surtsey, August 28th, 1966.

basaltic lavas forming Disco Island and those outcropping near Cape Dyer; the rest of the lines were positioned approximately parallel to this important line. It was hoped that the characteristic magnetic pattern observed over the Mid-Atlantic Ridge might possibly be observed in this area also, but unfortunately this does not appear to be the case. A preliminary examination of the aeromagnetic data shows that there is no obvious correlation between the lines except in isolated places. Because of the shallowness of the water and the presence of basic rocks having a high intensity of magnetization, the reduced profiles are much sharper and are generally more complicated than those obtained to the south in the Labrador Sea. Thus the easterly magnetic zone does not appear to extend into Baffin Bay. However, the earthquake epicentres in the northern half of Baffin Bay seem to fall in a linear belt, so possibly there may be a concomitant magnetic pattern in that area paralleling the linear belt.

NORTH ATLANTIC OCEAN

The track of the profiles obtained across the North Atlantic Ocean during August 1966 is shown in Figure 5. Also included on the figure is the simplified geology of the adjacent land areas, the bathymetry, the total intensity magnetic contours, and a number of airborne and shipborne magnetic profiles obtained by the U.S. Naval Oceanographic Office (Avery, 1963), Lamont Geological Observatory (Heirtzler, Le Pichon, and Baron, 1966), and those resulting from previous co-operative airborne surveys carried out by the Geological Survey of Canada and the National Aeronautical Establishment (Hood and Godby, 1965; Godby, Baker, Bower, and Hood, 1966). The total intensity scale used by each agency in publishing the profiles has been given adjacent the appropriate profile. The crest of the Mid-Atlantic Ridge has been indicated by a thick dashed line.

The two profiles across the continental shelf northeast of Newfoundland indicated that the underlying sedimentary section is at least 20,000 feet thick. An interesting sequence of magnetic anomalies was recorded to the south of those occurring in the Labrador Sea and indicates that the two zones continue to the south. Between Iceland and the southern tip of Greenland, a number of distinct anomalies were recorded, which appeared to be correlatable between the lines. It would be interesting to ascertain the extent of the symmetry in the magnetic anomalies about the crest of the Mid-Atlantic Ridge. The width of the known symmetry is indicated on the profiles to the southwest of Iceland, which were obtained as a result of a co-operative aeromagnetic project between the U.S. Naval Oceanographic Office and Lamont Geological Observatory (Heirtzler, Le Pichon, and Baron, 1966). The symmetrical anomalies have been labelled 1, 2, 3, 4, 5, B, and C, and their strike closely parallels the crest of the ridge. It is therefore planned to fly several lines from the southeast coast of Greenland at right angles to the Mid-Atlantic Ridge towards Ireland to establish the total width of the symmetry about the crest of the Mid-Atlantic Ridge in this area.

Four lines were also flown across the Denmark Strait between Iceland and eastern Greenland. There appeared to be reasonably good correlation between the two westerly lines, but not much correspondence was noted on the two easterly profiles. This is probably due to their proximity to the crest of the Mid-Atlantic Ridge, as indicated by the line of epicentres on Figure 5, which the most easterly track intersected at a fairly oblique angle. The opportunity was taken at the end of this particular sortie of flying over the new volcanic island of Surtsey, which erupted on November 14, 1963. The island is located about 20 miles south of Iceland (Fig. 4). The lava phase began in April 1964 and the main volcanic vent is still active. The red hot molten lava could be seen bubbling up at the lip of the vent and running down the hillside into the sea. A distinct magnetic anomaly approximately 350 gammas in amplitude was recorded as the survey aircraft flew a traverse immediately south of the island at a height of 500 feet.

The aeromagnetic profiles obtained between Iceland and Scotland had higher-frequency anomalies than those observed on the profiles to the southwest of Iceland. This is probably due to the shallower depth of water between Scotland and Iceland.

REFERENCES

Avery, O. E.
1963: Geomagnetic and bathymetric profiles across the north Atlantic Ocean; U.S. Naval Oceanographic Off., Tech. Rept. 161, 74 pp.

Godby, E. A., Baker, R. C., Bower, M. E., and Hood, P. J.
1966: Aeromagnetic reconnaissance of the Labrador Sea; J. Geophys. Res., vol. 71, pp. 511-517.

Gregory, A. F., Bower, M. E., and Morley, L. W.
1961: Geological interpretation of aerial magnetic and radiometric profiles, Arctic Archipelago, Northwest Territories; Geol. Surv. Can., Bull. 73, 148 pp.

Heirtzler, J. R., Le Pichon, X., and Baron, J. G.
1966: Magnetic anomalies over the Reykjanes Ridge; Deep-Sea Res., vol. 13, pp. 427-443.

Holtedahl, H.
1958: Some remarks on geomorphology of continental shelves off Norway, Labrador, and southeast Alaska; J. Geol., vol. 66, pp. 461-471.

Hood, P. J., and Godby, E. A.
1964: Magnetic anomalies over the Mid-Labrador Sea Ridge; Nature, vol. 202, p. 1099.

1965: Magnetic profile across the Grand Banks and Flemish Cap off Newfoundland; Can. J. Earth Sci., vol. 2, pp. 85-92.

Ostenso, N. A.
1962: Geophysical investigations of the Arctic Ocean basin; Geophys. and Polar Res. Centre, U. of Wisconsin, Res. Dept. 62-4, 124 pp.

APPENDIX

The following table, which was compiled by K. H. Owens, lists the earthquake epicentres that appear in Figure 5. The five columns are as follows:

1. The number given to a particular epicentre on Figure 5.

2. Day, month, and year on which the earthquake occurred.

3. Latitude of the epicentre in degrees and decimals of a degree.

4. Longitude of the epicentre in degrees and decimals of a degree.

5. Magnitude of the earthquake on the Richter scale for those listed by Sykes (1965), by Gutenberg and Richter (1949), and by the Seismological Society of America (1963). The epicentres listed under the Coast and Geodetic Survey use the modified Mercalli intensity scale of 1931. The symbol d was used by Gutenberg and Richter to designate earthquakes having magnitudes in the range 5.3 to 5.9.

6. References:

G & R – Gutenberg, B. and Richter, C. F. (1949), Seismicity of the Earth, Princeton Univ. Press, 273 pp.

ISS (Year) – Annual publication of the International Seismological Society of Great Britain.

SSA – Seismological Society of America, vol. 53, p. 1094 (1963).

Sykes – Sykes, L. R. (1965). The seismicity of the Arctic, Seismological Soc. Amer., vol. 55, pp. 519-536.

US (Year) – United States Earthquakes, Year, US Coast and Geodetic Survey, Washington, D. C.

Earthquake Epicentres in the
North Atlantic Ocean appearing on Figure 5

(compiled by K. H. Owens)

No.	Date	Lat.	Long.	Mag.	Ref.
1	Jan. 15/55	64.04	22.19	5.1	Sykes
2	Feb. 4/55	70.46	15.08		".
3	Feb. 6/55	70.9	14.04	5. 2	"
4	Feb. 6/55	70.75	14.45	5.8	"
5	Feb. 27/55	66.12	16.25	4.4	"
6	Feb. 27/55	66.08	16.51	4.2	"
7	Apr. 1/55	63.97	21.27	5.2	"
8	May 19/55	66.34	17.33	4.9	"
9	June 1/56	63.96	21.88	4.7	"
10	June 10/56	64.12	18.03	4.7	"
11	Oct. 29/56	66.46	19.02	4.5	"
12	Oct. 29/56	66.46	17.73	4.6	"
13	Oct. 29/56	66.59	17.09	4.3	"
14	Oct. 30/56	66.48	17.73	4.9	"
15	Nov. 25/56	59.64	30.01	4.4	"
16	July 9/57	68.10	18.69	4.2	"
17	July 9/57	68.18	18.61	4.3	"
18	July 10/57	68.33	19.05	4.3	"
19	Dec. 9/57	64.72	18.05	4.5	"
20	Dec. 27/57	58.24	32.34	4.3	"
21	Feb. 4/58	57.95	52.41	3.7	"
22	Feb. 16/58	67.61	18.84	4.5	"
23	Mar. 30/58	72.08	14.17		"
24	May 19/58	63.79	19.22	4.0	"
25	June 18/58	68.82	16.50	5.2	"
26	June 18/58	68.93	16.34	4.7	"
27	June 18/58	69.05	16.87	3.6	"
28	June 18/58	68.85	16.59	4.8	"
29	June 18/58	68.89	17.37	4.2	"
30	Sept. 27/58	66.07	18.08	4.6	"
31	Dec. 6/58	66.42	18.75	3.9	"
32	Dec. 6/58	66.42	18.27	4.7	"
33	Dec. 6/58	66.40	18.12	4.6	"
34	Feb. 2/59	64.56	17.24	4.0	"
35	May 15/59	68.00	19.81	3.7	"
36	June 25/59	61.59	27.16	4.2	"
37	June 25/59	61.76	27.29	5.5	"
38	June 25/59	61.86	27.03	4.1	"
39	June 28/59	63.97	19.32	4.7	"
40	July 8/59	70.57	19.51	4.5	"

No.	Date	Lat.	Long.	Mag.	Ref.
41	Aug. 11/59	71.17	13.66		Sykes
42	Aug. 11/59	71.16	13.41	4.2	"
43	Aug. 11/59	71.29	13.36	4.2	"
44	Aug. 11/59	71.36	13.15	4.2	"
45	Aug. 11/59	71.33	13.15	4.6	"
46	Aug. 12/59	71.21	13.40	4.2	"
47	Dec. 8/59	66.95	18.78	4.8	"
48	Feb. 21/60	64.59	17.09	4.3	"
49	Mar. 30/60	69.07	17.05	4.2	"
50	Mar. 30/60	68.71	17.90		"
51	June 22/60	68.17	18.27	3.7	"
52	June 22/60	68.16	18.53	4.1	"
53	May 14/61	67.66	18.64	4.3	"
54	May 14/61	67.65	18.56	4.8	"
55	Nov. 3/61	62.53	26.24	4.1	"
56	Mar.7/62	61.9	26.6	4.2	"
57	Mar.7/62	62.1	26.5	4.2	"
58	June 12/62	67.9	12.3	4.2	"
59	June 12/62	65.0	16.7	4.4	"
60	Jan. 15/63	68.9	17.1	5.0	"
61	Jan. 15/63	69.0	16.6	5.0	"
62	Mar. 28/63	66.3	19.6	6.8	"
63	Mar. 28/63	66.3	20.2	5.0	"
64	Mar. 28/63	66.4	19.6	4.7	"
65	Mar. 28/63	66.6	20.0	4.5	"
66	Apr. 7/63	70.3	13.6		"
67	Apr. 27/63	66.7	19.2	4.6	"
68	June 28/63	67.2	18.7		"
69	June 28/63	67.5	18.7	4.2	"
70	Sept. 3/63	62.8	25.2	4.3	"
71	Oct. 15/63	67.2	18.4	5.6	"
71A	Dec. 26/63	69.3	16.5	4.6	"
71B	Jan. 8/64	69.3	15.0		"
72	Feb. 26/64	64.5	10.8		"
73	Jan. 27/32	51.5	29.5	6.0	G & R
74	Feb. 28/33	51.5	30.0	d	"
75	June 18/41	52.0	34.5	6.25	"
76	July 6/27	53.0	34.0	d	"
77	July 31/33	53.0	35.0	d	"
78	Sept. 30/23	54.0	32.0	6.5	"
79	Nov. 28/23	54.0	37.0	d	"
80	Mar. 22/24	55.0	34.5	d	"
81	Apr. 4/30	55.0	34.5	d	"
82	Sept. 21/39	55.5	34.5	d	"
83	Sept. 6/31	55.5	35.0	d	"

No.	Date	Lat.	Long.	Mag.	Ref.
84	Dec. 12/24	56.0	33.0	d	G & R
85	July 4/29	56.0	33.0	d	"
86	Nov. 10/34	56.0	33.5	d	"
87	Mar. 3/29	56.0	35.0	d	"
88	July 4/29	56.0	35.5	d	"
89	Dec. 15/33	56.5	34.0	6.0	"
90	Aug. 23/21	57.0	34.0	d	"
91	Apr. 14/32	58.0	31.5	d	"
92	Mar. 25/36	58.25	32.0	d	"
93	June 16/41	59.0	32.0	d	"
94	June 30/21	61.5	33.0	d	"
95	Dec. 15/29	63.0	36.0	d	"
96	May 6/12	64.0	20.0	7.0	"
97	July 23/29	64.0	23.0	6.25	"
98	June 10/33	64.0	23.0	6.0	"
99	Sept. 4/24	64.5	23.0	d	"
100	July 31/27	65.5	19.0	d	"
101	June 2/34	66.0	18.25	6.25	"
102	Nov. 18/29	44.0	56.0	7.2	"
103	Feb. 25/54	52.5	34.0		US 1954
104	Aug. 20/54	70.5	15.0		"
105	Aug. 20/54	71.0	14.0		"
106	Aug. 21/54	71.0	13.5		"
107	Aug. 21/54	71.0	14.5		"
108	Aug. 21/54	70.5	14.0		"
	Aug. 22/54	70.5	14.0		"
	Aug. 23/54	70.5	14.0		"
109	Aug. 21/54	71.0	14.0		"
	Aug. 22/54	71.0	14.0		"
	Oct. 16/54	71.0	14.0		"
110	Aug. 27/54	70.5	14.5		"
111	Dec. 19/50	54.0	35.0		US 1952
112	Aug. 28/49	54.0	34.0		US 1950
113	Jan. 18/45	57.0	34.0		US 1947
114	Aug. 23/54	71.0	15.0		US 1954
115	Oct. 19/54	57.5	32.5		"
116	May 15/38	58.0	34.0		US 1939
117	Nov. 25/38	52.0	35.0		"
118	Sept. 21/39	54.0	35.0		"
119	Sept. 21/39	55.0	34.0		"
120	Dec. 25/39	52.0	32.0		"
121	June 16/41	55.3	35.0		ISS 1941
122	June 18/41	52.0	34.0		"
123	Aug. 9/41	61.5	30.0		"
124	May 15/42	61.5	30.0		ISS 1942

No.	Date	Lat.	Long.	Mag.	Ref.
125	Mar. 29/47	64.0	20.0		ISS 1947
126	June 19/48	53.1	35.1		ISS 1948
127	July 3/48	64.0	20.0		ISS 1948
128	Mar. 3/51	53.1	35.1		ISS 1951
129	Dec. 4/51	54.5	35.2		ISS 1951
130	Mar. 8/52	69.5	16.0		ISS 1952
	Mar. 9/52	69.5	16.0		"
	Mar. 12/52	69.5	16.0		"
131	May 16/52	63.9	22.7		"
132	June 6/53	56.0	35.0		ISS 1953
133	Mar. 28/55	53.0	35.0		US 1955
134	Aug. 17/56	54.5	36.0		US 1956
135	June 11/56	52.0	31.5		"
136	Aug. 17/56	54.0	35.0		"
137	Jan. 5/57	52.5	35.0		US 1957
138	Dec. 31/57	58.0	32.0		"
139	July 27/58	55.0	34.5		US 1958
140	Jan. 18/59	57.5	35.0		US 1959
141	Mar. 28/60	58.0	32.5		US 1960
142	Mar. 30/60	69.0	17.0		"
143	Oct. 6/60	58.4	31.6		"
144	Oct. 10/60	58.3	31.9	4.5 - 4.75	"
145	Oct. 14/60	55.7	35.2		"
146	Oct. 15/60	55.8	35.6		"
147	Feb. 13/62	54.3	35.2		US 1962
148	Mar. 28/63	66.3	19.6	6.5 - 7.25	SSA
149	Sept. 2/62	71.2	12.7		US 1962
150	Feb. 27/61	71.9	10.6		US 1961
151	May 9/54	71.0	12.0		US 1954
152	Aug. 23/21	67.0	18.0	6.25	G & R
153	Jan. 22/10	67.5	17.0	7.1	"
154	Nov. 28/25	69.0	18.0	d	"
155	Oct. 10/23	72.0	10.0	6.5	"
156	Dec. 25/39	51.25	32.5	d	"
157	Feb. 15/44	51.0	32.0		US 1945
158	Mar. 2/60	52.0	30.0		US 1960
159	Apr. 25/33	71.0	19.0	d	G & R
160	July 16/27	71.0	17.0	d	"
161	Oct. 10/24	71.0	16.0	d	"