

The UNIVERSITY of WISCONSIN

Geophysical & Polar Research Center

DEPARTMENT OF GEOLOGY

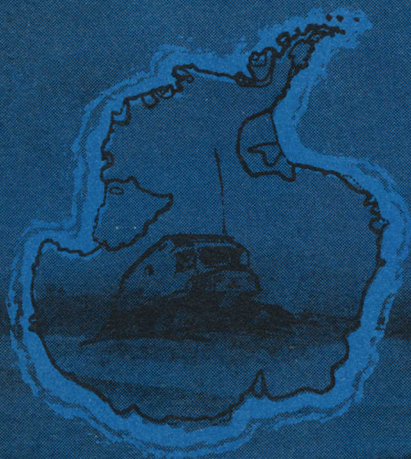
Research
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AEROMAGNETIC RECONNAISSANCE
OF ANTARCTICA
BETWEEN BYRD AND WILKES STATIONS

by

Ned A. Ostenso and Edward C. Thiel

RESEARCH REPORT NO. 64-6 - July 1964



6021 South Highland Road
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Ned A. Ostenso and Edward C. Thiel*

The University of Wisconsin
Geophysical and Polar Research Center
6021 South Highland Road
Madison, Wisconsin 53705

*Deceased



TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	1
RESIDUAL MAGNETIC PROFILES	3
QUANTITATIVE INTERPRETATION	6
REGIONAL TOTAL MAGNETIC FIELD	7
ACKNOWLEDGEMENTS	10
REFERENCES	11
APPENDIX	
Flight T-1	13
Flight T-2	15
Flight T-3	18
Flight T-4	20
Flight T-5	21
Flight T-6	23
Flight T-7	25
Flight T-8	27
Flight T-9	29
Flight T-10	31

ILLUSTRATIONS

Figure 1	2
Figure 2	5
Figure 3	8
Figure 4	9
Table 1	4

INTRODUCTION

During the three austral field seasons from 1958 to 1961, 13,000 km of airborne magnetics were flown in the sector of Antarctica between the 85th West meridian and Wilkes Station (66°15'S, 110°31'E). This survey, consisting of 12 flights, was flown in U. S. Navy Air Development Squadron-6 aircraft instrumented with a Varian nuclear precession magnetometer which recorded the absolute value of the earth's total field (F). Two of the flights, those east of Byrd Station (79°59'S, 120°01'W), have been previously reported by Behrendt and Wold (1963) in conjunction with other flights in this area. The remainder are shown in Figure 1 and include, (T-1) Little America to Byrd Station, (T-2) the 1959 Byrd Station traverse reconnaissance flight, (T-3) Edsel Ford Range reconnaissance flight, (T-4) Little America to McMurdo Station, (T-5) McMurdo to Wilkes Station, (T-6) Wilkes to McMurdo Station, (T-7) McMurdo to Byrd Station, (T-8) McMurdo to the South Pole Station, (T-9) McMurdo to Little Rockford to Byrd Station and, (T-10) Ross Ice Shelf reconnaissance flight.

All but two tracks were flown in a R4D (DC-3) aircraft with the magnetometer sensing head towed at the end of a 30 m cable. The flights between McMurdo and Wilkes Station were flown in a P2V (Neptune) aircraft with the sensing head mounted in a non-magnetic fiberglass extension of the fuselage. On all flights tight circles were flown over areas of zero magnetic gradient to confirm adequate isolation from the aircraft's magnetic field.

The elevation of the aircraft during flight was determined by aneroid altimeter with an estimated accuracy of ± 200 m. On November 9, 1961, Thiel was killed in an airplane crash while on an aeromagnetic flight between McMurdo, Mirny and Wilkes Stations. In addition to the tragic loss of life, some valuable data were lost, including notes on the elevation of the flights between McMurdo and Wilkes Station and McMurdo and Byrd Station.

Navigation was dependent upon dead-reckoning, augmented by sun lines of position. Uncertainties in horizontal position control may be as great as 50 km.

The Varian magnetometer was designed to cycle approximately every 0.7 sec. Thus, at the normal flying speed of 280 km/hr, a magnetic observation was made every 55 m. The readout of the magnetometer was in analog form and in practice the analog record was picked only four times a minute or approximately every kilometer of horizontal distance traveled. These data were then fed into the CDC 1604 computer at the University of Wisconsin Computing Center which computed F from the precession frequency and downward continuations to depths of 5, 6, 8 and 10 km below flight level using the formula of Henderson (Ostenso, 1962).

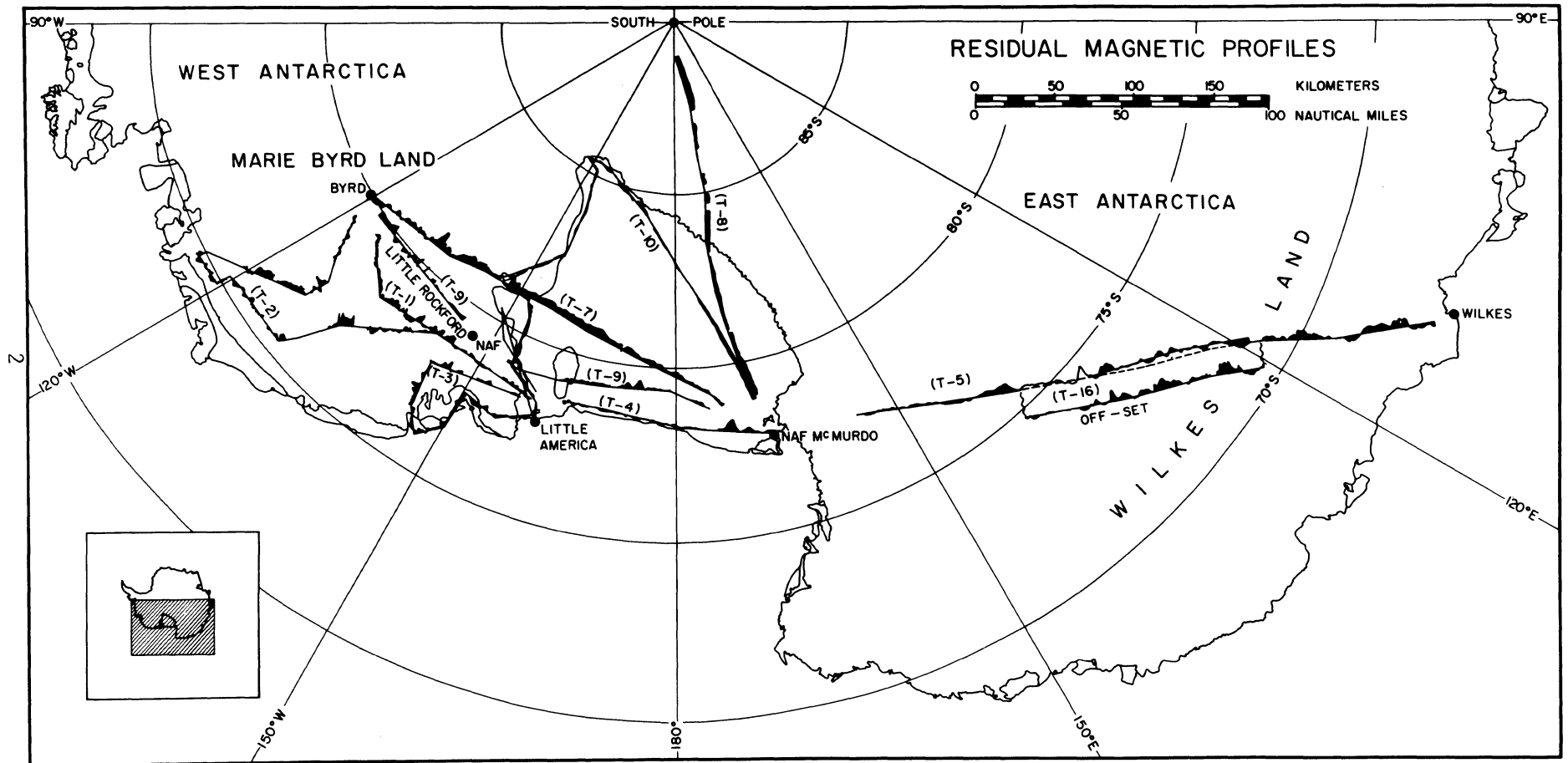


Figure 1

No corrections were made for temporal changes in the earth's magnetic field as attempts to correlate such changes over great distances from the Antarctic magnetic observatories might introduce more ambiguities than it would eliminate. Pudovkin (1956) has shown that in subpolar regions magnetic variations differ significantly at points only 200-300 km apart. However, a "degree of credence" for the anomalies along any profile can be obtained if the intensity of magnetic disturbance of the region being surveyed is known for the time of the survey. The K-indices that are available from Antarctic observatories for the flight intervals are listed in Table 1. From these it is possible to obtain a qualitative estimate of temporal disturbances which might be expected on each magnetic profile. Fortunately, none of the flights were made during periods of magnetic storms; the highest K-index during any flight was 5, the average being 3. In addition, the observatory magnetograms were checked and no correlation could be found between temporal magnetic disturbances and significant anomalies. All of the survey flights were adjusted to mean values of F of 64,870 γ at Little America, 60,700 γ at Byrd Station, 65,600 γ at McMurdo, 65,710 γ at Wilkes Station, and 59,250 γ at the Pole Station.

The regional magnetic field was removed from the observed aeromagnetic profiles by use of stiff splines so that a smooth line, giving the best overall fit to the observed data, could be drawn through a profile. The resulting residual magnetic profiles along the various flight lines are shown in Figure 1.

RESIDUAL MAGNETIC PROFILES

Bentley and Ostenso (1961) and Behrendt and Wold (1963) have discussed the division of West Antarctica by the Byrd Subglacial Basin into what appear to be separate geologic provinces. North and west of the basin is a region of young volcanic mountains, whereas, to the south and east of the basin a more extensive area comprised mainly of sediments and metasediments (see schematic geologic base map in Fig. 2). The above investigators discussed the difference in magnetic character between these two provinces; the latter province exhibiting a smoother residual field than the former. The region of West Antarctica covered by the aeromagnetic survey reported here consists solely of the young volcanics and, as shown in Figure 1, has the characteristic intense residual magnetic field of such an environment. Similar magnetic profiles were obtained over East Antarctica on the flights between McMurdo and Wilkes Station. This portion of the continent is believed to be a Precambrian shield, bordered on its eastern margin by thick sedimentary series (Ross and Beacon Series) which have been uplifted and faulted forming a mountain system along the southwestern margin of the Ross Ice Shelf and extending to the Weddell Sea (Anderson, 1962).

In contrast to these regions of West and East Antarctica, the Ross Ice Shelf is marked by relative magnetic quiescence, suggesting underlying material of low magnetic susceptibility. It is interesting to note on the McMurdo to Pole flight that no anomaly is associated with the postulated fault zone along the northeastern flank of the Queen Maud Range.

Table 1

<u>Flight</u>	<u>Date</u>	<u>Flight Interval/U.T.</u>	<u>K-Indices</u>		
			<u>Time/U.T.</u>	<u>South Pole</u>	<u>Byrd</u>
Little America to Byrd (T-1)	6-7 Dec. 1958	2309-0230	21-24	3	3
			00-03	3	4
Byrd Station Traverse Recon (T-2)	21 Dec. 1958	1124-1802	09-12	5	4
			12-15	4	3
			15-18	4	2
Edsel Ford Range Recon (T-3)	23-24 Dec. 1958	2323-0355	21-24	3	3
			00-03	4	3
			03-06	4	4
Little America to McMurdo (T-4)	3 Jan. 1959	0017-0247	00-03	2	3
McMurdo to Wilkes (T-5)	2-3 Dec. 1959	2115-0050	21-24		3
			00-03		4
Wilkes to McMurdo (T-6)	3 Dec. 1959	0521-0908	03-06		4
			06-09		4
			09-12		5
McMurdo to Byrd (T-7)	13 Dec. 1959	0317-0740	03-06		3
			06-09		2
McMurdo to Pole (T-8)	6-7 Jan. 1960	2335-0430	21-24		2
			00-03		1
			03-06		2
McMurdo to Little Rockford to Byrd (T-9)	15 Jan. 1960	0619-0915 1156-1325	06-09		3
			09-12		3
			12-15		4
Ross Ice Shelf Recon (T-10)	22 Oct. 1961	0136-0935	00-03	2	2
			03-06	1	3
			06-09	2	3
			09-12	3	3

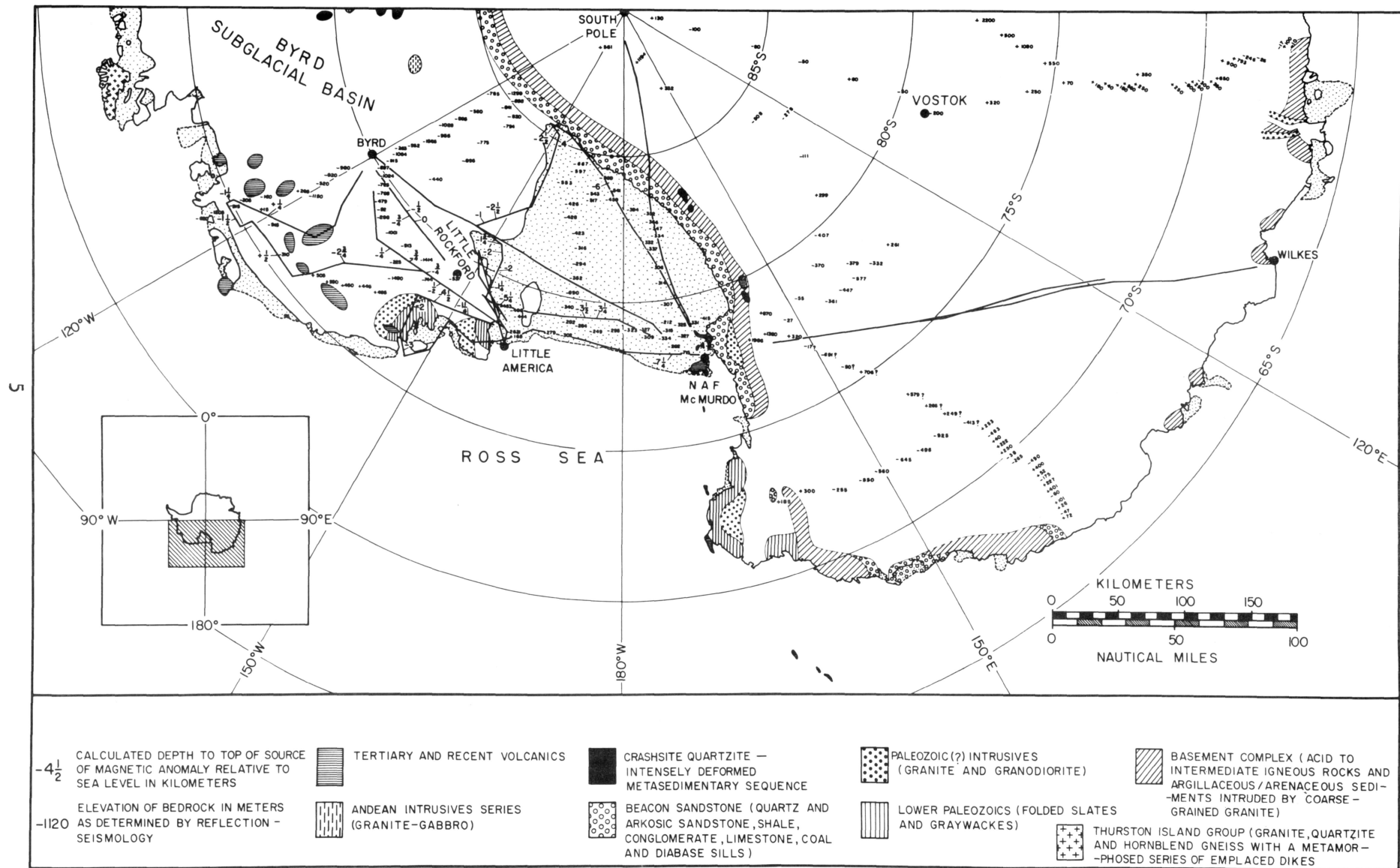


Figure 2

QUANTITATIVE INTERPRETATION

In an attempt to determine the origin of the magnetic anomalies, Peters' (1949) half-slope method was used to compute depths to sources of selected anomalies. Only the anomalies shown by the computed downward continuations to be uncontaminated by adjoining anomalies were used in these calculations. In practice only a small percentage of the total number of recorded anomalies were sufficiently symmetrical and "pure" to be usable for quantitative consideration. Recent evaluations of practical applications of Peters' method have been discussed by Sanker-Narayan (1961), Ostenso (1962) and Behrendt and Wold (1963). Suffice it to say here that any likely deviation from the conditions assumed by the method will result in too great a computed depth to the source of an anomaly. Thus, all computations can be considered as giving the maximum, probable depth to the origin of an anomaly. Furthermore, no great reliance should be given to any single calculation, however, a group of depth estimates from a number of determinations is significant.

The depths, relative to sea level, to the origin of the magnetic anomalies suitable for such calculations are shown in Figure 2 on a schematic geologic base map (after Bentley, 1960). The elevations of the subglacial rock surface determined from seismic soundings are also shown.

The depth calculations in West Antarctica that are near seismic soundings are in close agreement with the rock surface elevations determined by the reflection measurements. In fact, considering the mountainous character of this region, they agree surprisingly well. Thus, it appears that the sources of the magnetic anomalies occur at the rock surface, as might be expected in such a volcanic region. In this portion of West Antarctica aeromagnetic surveys would be an expeditious way to obtain a qualitative picture of sub-ice topography and maximum possible ice thickness.

Geological investigations have shown that young volcanic intrusions are found along the western periphery of the Ross Ice Shelf wherever rock is exposed. These volcanics are known to have high magnetic susceptibility (Robinson, in press) in contrast to the low susceptibility (0.14 to 10.15×10^{-4} c.g.s. units) reported by Bull and Irving (1960) for the igneous country rock of South Victoria Land. The general quiescence of the magnetic profiles over the Ross Ice Shelf reflects the paucity of volcanic activity in this area in marked contrast to its environs. However, twelve anomalies were suitable for depth computations (Fig. 2). The bulk of these are located along the eastern margin of the ice shelf and give an average depth of $1 \frac{3}{4}$ km. From seismic soundings, Crary (1961) reports that the ice shelf may be underlain by the Beacon series. Only at Little America V was the refraction profile long enough to penetrate this formation (P wave velocity 4.24 km/sec) and to establish its thickness at 647 m. The Beacon series is underlain here, at a depth of 2815 m below sea level, by material with a compressional wave velocity of 6.39 km/sec and is overlain by a 1325 m thick sedimentary column with a P wave velocity of 2.40 km/sec. The upper surface of the 4.24 km/sec layer is at an elevation of -1933 m. Thus it is reasonable to conclude that the sources of these anomalies are

high susceptibility volcanics at or near the top of the Beacon(?) series; similar to the volcanic relationship in the series adjacent to the ice shelf. Bennett (in preparation) suggests that the source of similar magnetic anomalies may be the top of the 6.39 km/sec layer.

The remaining anomalies, which gave a considerable scatter of greater depths (i.e. $3\frac{1}{4}$, $3\frac{1}{2}$, 4, $5\frac{1}{4}$, 6, and $7\frac{1}{4}$ km) most probably are but indicative of inherent difficulties in quantitative interpretation of magnetic data over thin lava flows. One of the assumptions used in Peters' method is that the anomalous mass extends to infinite depth. As the length of the mass in the vertical direction becomes small relative to the depth of burial to the top surface of the mass, a greater than real depth is obtained by this method of calculation.

Because the flight elevations on the McMurdo-Wilkes Station tracks are unknown, any attempt at computing the depth to anomaly sources would be meaningless. Flight elevations could have varied from 3500 m to 6500 m.

REGIONAL TOTAL MAGNETIC FIELD

A map of the regional total magnetic field (F) is shown in Figure 3 for the portion of West Antarctica where there is sufficient data to permit contouring. The aeromagnetic flight tracks, from which the data for constructing this map were obtained, are shown as dotted lines. Isogonic lines from H. O. 1703 S (adjusted to 1958) are shown as dashed contours. The interval for both sets of contours is .01 oersted (1000γ). Observed regional gradients were determined by fitting a stiff spline through the observed aeromagnetic profile. All flights are tied to the mean value of F at the magnetic observatories as described earlier. The estimated accuracy of the observed regional total field at any point is $\pm 200\gamma$.

As can be seen in Figure 3 there is appreciable divergence between the observed field and the calculated field from H. O. 1703 S. Such divergence is hardly surprising considering the limited data upon which the 1955 U. S. Hydrographic Office chart was based. Rather, it is remarkable that the fields are even similar, which speaks well for the system of extrapolation used in constructing the Hydrographic Office (now U. S. Navy Oceanographic Office) charts. The observed field shows a generally higher value but lesser gradient than the computed field, although the contour orientations are very similar.

In 1962 the Soviet investigator, Shlyakhtina, published a total field map for all of Antarctica and surrounding oceans (an enlarged portion of this map is shown in Fig. 4). This map was based upon all magnetic observatory data available as a result of the IGY program plus the following ship data:

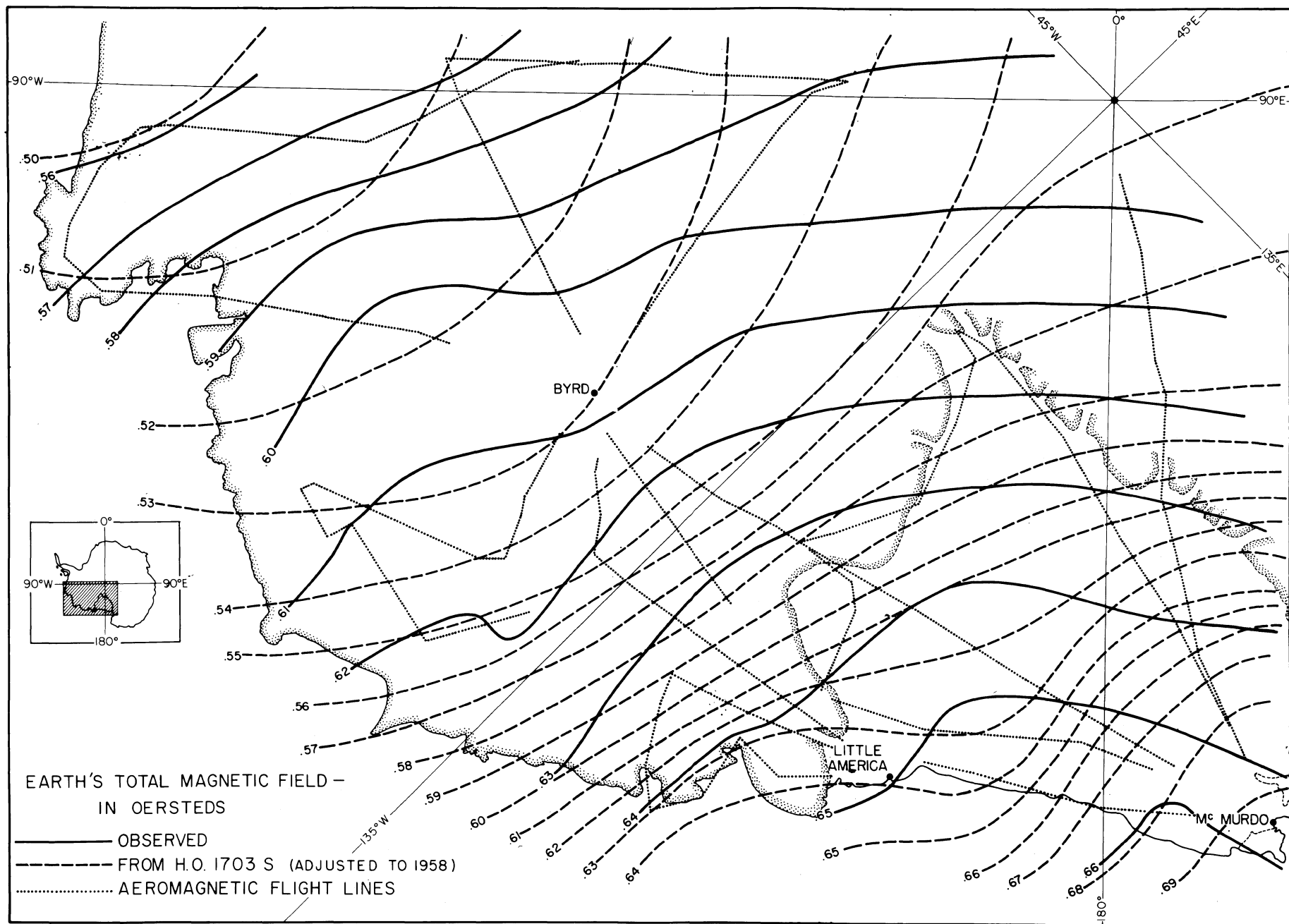


Figure 3

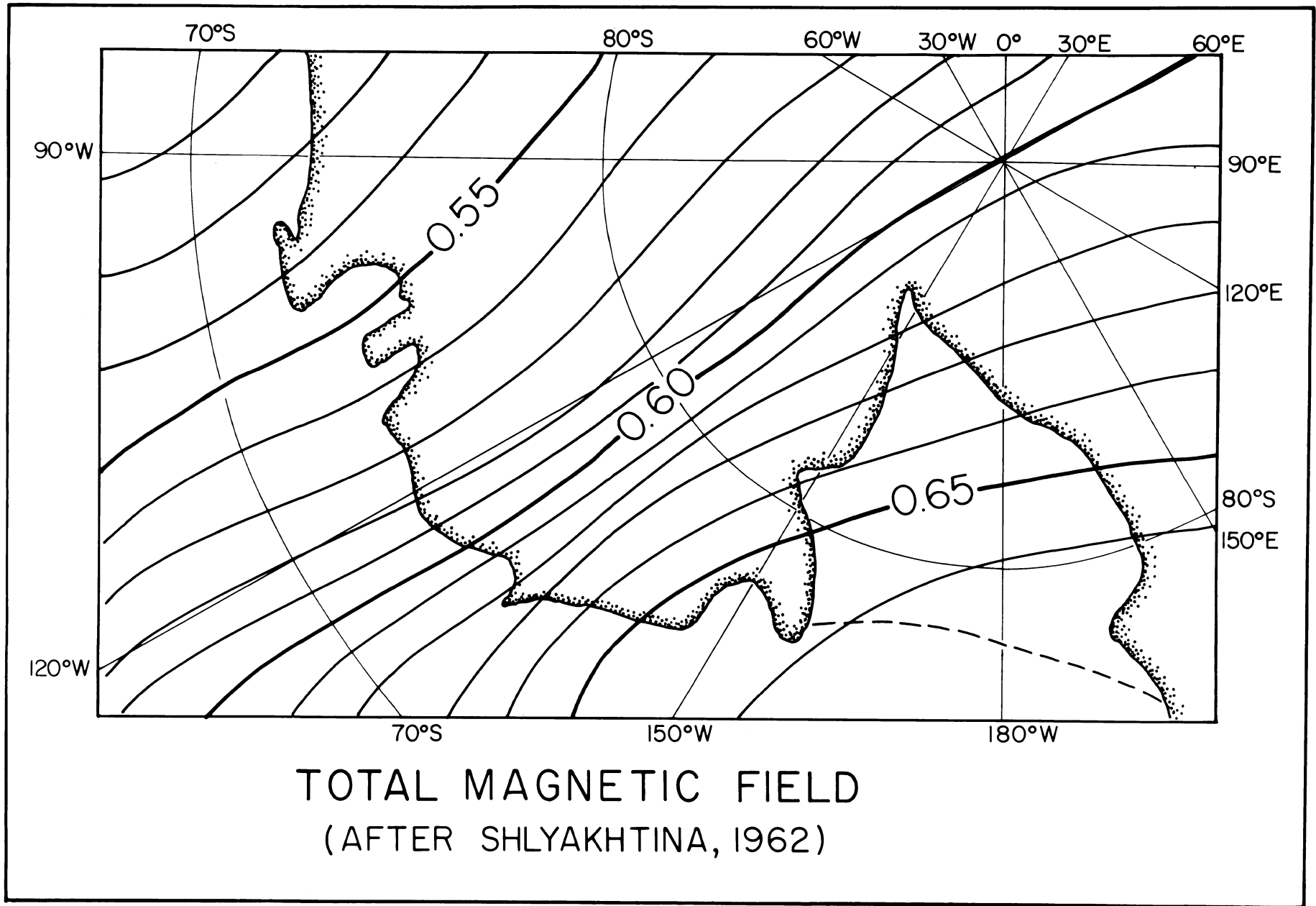


Figure 4

Ship	Country	Period	Sector
Ob	U.S.S.R.	1957-58	Pacific sector
Zarya	U.S.S.R.	1959-61	trans-global, between lat. 4°50'S.
Vema	U.S.A.	1959-60	30 - 60°S. latitude
Endeavor	New Zealand	1958-60	between New Zealand and Antarctica
Soya	Japan	1958	between South Africa and Antarctica

As should be expected, the Soviet chart is in close agreement with the total field observed from this aeromagnetic study. However, the airborne data show a less steep field gradient than indicated on Shlyakhtina's map.

ACKNOWLEDGEMENTS

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LITTLE AMERICA TO BYRD. FLIGHT T-1, 6-7 DECEMBER 1958

<u>Time GMT</u>	<u>Total Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight Elevation/m</u>	<u>Time GMT</u>	<u>Total Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight Elevation/m</u>
1109	64216	78°21'	159°25'	490		63154			1524
1110	64181 64146 64119 64110 64093 64067 64049 64058 64058					1240	62888 62943 62808 62733 62750 62808 62825 62918 62792 62699		
1115	64067 64049 64058 64058			490	1245	62724 62599 62553 62499 62449 62458 62466 62532 62976 62909			1790
1120	64067 64049 64040 64067 64075 64084	78°27'	157°40'	490	1250	62724 62599 62553 62499 62449 62458 62466 62532 62976 62909			1790
1125	64067 64058 64058 64023					1255	62817 62682 62292 62102 62184 62078 62160 62086 62102 62184		
1130	63979 64102 64040 63953 63918 63918			490 910	1300	62817 62682 62292 62102 62184 62078 62160 62086 62102 62184			1790
1135	64014 63935 63815 63824			490 910	1305	62817 62682 62292 62102 62184 62078 62160 62086 62102 62184			1790
1140	63832 63867 63850 63789 63711			910	1310	62086 62160 62342 62657 62649 62383 62168 62111 62375 62433			1790
1145	63677 63685 63677 63642 63616			870	1315	62383 62350 62483 62491 62333 62242 62391 62358 62201 62094			1980
1150	63642 63594 63564 63556 63547 63573			870	1320	62383 62350 62483 62491 62333 62242 62391 62358 62201 62094			1980
1155	63556 63452 63401 63384			870	1324 1325	62242 62391 62358 62201 62094			1980
1200	63350 63333 63325 63299 63299 63274 63274 63282 63308 63342			870 1220	1330	62119 61882 62013 62192 62119 62086 62004 61914 61923 61898			1980 2130
1205	63274 63274 63282 63308 63342			870 1220	1334 1335	62086 62004 61914 61923 61898	78°25'	132°30'	
1210	63393 63410 63418 63401 63384 63345			1220	1340	61939 61947 61988 61996 61955 61914 61898 61914 61923			2130
1215	63299 63256 63248 63197			1520	1345	61914 61898 61898 61914 61923			2130
1220	63154 63103 63027 62993 62968 62968			1520	1350	61947 61841 61791 61799 61783 61718 61710 61726 61726 61702			2130
1225	62985 62993 63112 63461			1520 1524	1355	61645 61508 61371 61323 61323 61395 61419 61387 61347 61468			2130
1230	63359 63461 63427 63316 63163 63120			1520 1524	1400	61645 61508 61371 61323 61323 61395 61419 61387 61347 61468			2130
1235	62976 62842 62918 63239	78°43'	143°20'		1405	61645 61508 61371 61323 61323 61395 61419 61387 61347 61468			

LITTLE AMERICA TO BYRD. FLIGHT T-1, 6-7 DECEMBER 1958 (con't)

<u>Time</u> <u>GMT</u>	<u>Total</u> <u>Intensity/f</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight</u> <u>Elevation/m</u>
1410	61492 61484 61476 61443 61451 61484			2130
1415	61379 61419 61435 61395			2440
1420	61291 61230 61235 61283 61331 61371	79°17'	126°00'	2440
1425	61291 61299 61227	79°25'	125°40'	
1428	61196	79°25'	124°55'	2400

BYRD STATION TRAVERSE RECON. FLIGHT T-2, 21 DECEMBER 1958

<u>Time GMT</u>	<u>Total Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight Elevation/m</u>	<u>Time GMT</u>	<u>Total Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight Elevation/m</u>
1124	60564	79°16'	121°00'	2134		61080			
1125	60666 60690 60682 60603 60557				1255	60980 61063 60988 60678 61233	76°49'	126°15'	2622
1130	60518 60533 60541 60479				1300	61080 61089 61072 61114			2744
1135	60479 60572 60611			2134	1305	61097 61089 61063			2744 2896
1137	60635 60627 60627	79°07'	121°45'			61029 60980 60997			
1140	60683 60740 60756 60772				1310	61021 60913 60930 60963			
1145	60804 60732 60667 60619 60546 60571			2134	1315	60963 60946 60888 60812 60770 60720			2896
1150	60742 60907 60980 60890				1320	60686 60643 60600 60557			
1155	60783 60865 60948 60964 60997 61106			2134	1325	60514 60495 60520 60537 60520 60528			2896
1200	61004 60921 60871 60888			2140	1330	60537 60528 60479 60413			2774
1205	60938 61029 61148 61276 61276 61208			2140	1335	60388 60388 60388 60413 60413 60281			2774 2561
1210	61046 61233 61232 61231	78°05'	124°40'		1340	60215 60215 60182 60158			
1215	61230 61229 61227 61226 61225 61224			2140	1345	60158 60149 60190 60396 60322 60248			2561 2439
1220	61223 61222 61221 61220				1350	60198 60149 60158 60166			
1225	61219 61218 61217 61215 61214 61213			2140 2286	1355	60141 60094 60070 60045 60021 59996			2439
1230	61212 61211 61210 61209				1400	59972 59947 59922 59898			2430
1235	61208 61207 61206 61204 61203 61202			2286	1405	59873 59849 59824 59800 59775 59751			2430
1240	61201 61200				1410	59726 59701			
1242	61199 61123	77°28'	126°30'	2440		59677 59652			
1245	61352 61165 61216 60989 60762 61012			2440	1415	59628 59603 59579 59554 59523 59453			2430
1250	61327 61089 60997 61063			2622	1420	59453 59501 59453			
					1423	59389	75°04'	116°00'	

BYRD STATION TRAVERSE RECON. FLIGHT T-2, 21 DECEMBER 1958 (con't)

<u>Time GMT</u>	<u>Total Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight Elevation/m</u>	<u>Time GMT</u>	<u>Total Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight Elevation/m</u>
1425	59365 59405 59421 59437 59606 59783			2430	1555	61072 61174 61242 61225 61327 61395			2317
1430	59767				1600	61480 61472 61437 61352			2439
1431	59694 59767 59734	74°49'	116°00'						
1435	59638 59509 59389 59381 59397 59453			2430	1605	61369 61575 61773 61781 61843 61825	75°24'	128°35'	2439
1440	59630 59791 59962 59864				1610	61829 61832 61836 61838			
1445	59831 59823 59929 59929 60092 60133			2430	1620	61842 61845 61849 61852 61856 61859	75°54'	129°45'	2439
1450	60207 60306 60133 59994				1625	61863 61866 61870 61873			
1455	60019 60076 60043 60019 60076 60149			2430	1630	61877 61880 61884 61887 61891 61894			2439 2957
1500	60248 60347				1635	61898 61901 61905 61908			
1502	60380 60413	74°53'	119°30'						
1505	60446 60471 60471 60479 60537 60580			2430	1640	61912 61915 61919 61956 62200 62026			2957
1510	60555 60529 60504				1645	61973 62078 62139 62173			
1513	60479	75°19'	119°30'						
1515	60453 60415 60405 60322 60264 60347			2430 2439	1650	62156 62376 62802 62802 62650 62500	77°01'	131°45'	2957 2896
1520	60421 60653 60770 60754				1655	62606 62561 62535 62526			
1525	60720 60545 60471 60570 60661 60871	75°24'	122°00'	2439	1700	62526 62802 62760 62718 62675 62633			2896
1530	61029 60988 60921 60787			2440	1705	62591 62549 62507 62465			
1535	60812 60804 60804 60862 60921 60904			2440	1710	62423 62381 62339 62296 62455 62147			2896
1540	60896 60913 60896 60938				1715	62156 62156 62235 62296			2682
1545	61097 61163 61153 61143 61134 61124			2440	1720	62385 62526 62464 62402 62358 62385			2682
1550	61114 61105 61046 61055			2317	1725	62420 62500 62570 62623			

BYRD STATION TRAVERSE RECON. FLIGHT T-2, 21 DECEMBER 1958 (con't)

<u>Time</u> <u>GMT</u>	<u>Total</u> <u>Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight</u> <u>Elevation/m</u>
1730	62606 62544 62517 62597 62614 62544			2682
1735	62508 62659 62793 62945			
1740	62954 62811 62909 63007 62900 62793			2682 2286
1745	62811 62829 62838 62882			
1750	62954 62963 62981 63016 63088 63088			2286
1755	62981 62998 63106 63260			2073
1800	63469 63515 63351			2073 1829
1802	63125	78°44'	142°10'	

EDSEL FORD RANGE RECON. FLIGHT T-3, 23-24 DECEMBER 1958

<u>Time GMT</u>	<u>Total Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight Elevation/m</u>	<u>Time GMT</u>	<u>Total Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight Elevation/m</u>
1200	64016 64007 64025 64034 64061	78°17'	157°18'	1520	1320	63087 63130 63069 63001 62966			1830
1205	64061 64043 64016 63972 63954				1325	62949 62949 62966 63035 63026			
1210	63945 63909 63909 63866 63831			1520	1330	63035 63026 63035 63122 63217			1830
1215	63813 63804 63795 63787 63778				1335	63322 63322 63278 63252 63243			
1220	63760 63751 63751 63734 63742			1520	1340	63304 63330 63348 63374 63269			1830
1215	63760 63822 63892 63787 63734				1345 1346	63382 63513 63540 63557 63504	76°31'	145°15'	1890
1220	63681 63663 63646 63628 63637			1520	1350	63452 63417 63400 63391 63400			1890
1225	63601 63584 63584 63581 63572				1355	63426 63382 63391 63417 63443			
1230	63563 63554 63545 63535 63526	78°10'	150°05'	1520	1400	63531 63698 63795 63787 63804			1890
1235	63517 63508 63498 63489 63478				1405	63839 63822 63831 63848 63875	75°56'	147°20'	1620
1240	63452 63400 63356 63304 63278			1830	1410	64025 63945 63884 63884 63778			1220
1245	63235 63182 63130 63400 63690				1415	63663 63681 63822 63981 64016			1310
1250	63654 63426 63295 63330 63443			1830	1420	64007 63927 63935 63934 63932			1310
1255	63417 63174 63139 63165 63148				1425	63931 63930 63929 63927 63979			
1300	63104 63104 63113 63078 62923			1830	1430 1431	64084 64128 64146 64067 63962	76°34'	150°00'	1310
1305	62923 62913				1435	63867 63824 63841 63858 63850			
1307	62902 62891 62880	77°56'	142°55'						
1310	62869 62872 62932 62906 62872			1830	1440	63824 63798 63772 63746 63737			1310
1315	62881 62898 62906 62992 63104				1445	63720 63711 63703 63694 63703			1220

EDSEL FORD RANGE RECON. FLIGHT T-3, 23-24 DECEMBER 1958 (con't)

<u>Time</u> <u>GMT</u>	<u>Total</u> <u>Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight</u> <u>Elevation/m</u>
1450	63711 63720 63746 63746 63754	77°46'	150°10'	1220
1455	63720 63694 63651 63616 63599			
1500	63590 63599 63625 63642 63668			1310
1505	63694 63720 63772 63979 64163			
1510	64216 64040 63893 63893 63927			1400
1515	63953 63988 64032 64084 64146			
1520	64207			1400
1521	64040 64023 64075 64137	77°29'	155°10'	
1525	64172 64172 64172 64163 64181			
1530	64084 64023 64023 64049 64032			1520
1535	64049 64067 64102 64110 64110			
1540	64110			1520
1541	64128 64146 64163 64181	77°52'	159°00'	
1545	64207 64259 64356 64445 64480			1460
1450	64471 64462 64445 64418 64409			1460
1555	-----	78°07'	160°47'	

MCMURDO TO WILKES. FLIGHT T-5, 2-3 DECEMBER 1959

<u>Time GMT</u>	<u>Total Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/E</u>	<u>Flight Elevation/m</u>	<u>Time GMT</u>	<u>Total Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/E</u>	<u>Flight Elevation/m</u>
2115	66591 66485 66505 66600 66371	75°24'	136°30'	unknown	2245	66457 66495 66485 66600 66843			unknown
2120	66332 66361 66457 66533 66533				2250	66867 66731 66594 66515 66561	72°00'	121°34'	
2125	66524 66562 66562 66572 66591			unknown	2255	66512 66502 66434 66395 66482			unknown
2130	66591 66572 66581 66639 66765				2300	66346 66619 66887 66531 66492			
2135	66771 66677 66584 66495 66457			unknown	2305	66561 66619 66414 66006 66015			unknown
2140	66457 66466 66476 66452 66380				2310	66035 65996 65948 65929 66015			
2145	66342 66265 66217 66237 66237			unknown	2315	66121 66150 66189 66209 66336			unknown
2150	66342 66438 66514 66610 66736				2320	66414 66346 66404 66424 66355	70°50'	118°32'	
2155	66629 66524 66409 66332 66304			unknown	2325	66414 66424 66434 66385 66258			unknown
2200	66409 66418 66901 67056 66736				2330	66219 66267 66277 66258 66346			
2205	66610 66562 66600 66687 66775			unknown	2335	66355 66258 66102 65938 66006			unknown
2210	66736 66716 66629 66466 66380				2340	66404 66385 66238 66434 66718			
2215	66390 66380 66438 66658 66775			unknown	2345	66649 66609 66659 66659 66580			unknown
2220	66697 66658 66707 66668 66572	73°16'	126°30'		2350	66443 66404 66395 66375 66404			
2225	66639 66852 66726 66950 67105			unknown	2355	66346 66316 66287 66238 66180			unknown
2230	66988 66775 66716 66697 66746				2400	66141 66170 66130 66150 66130			
2235	66668 66572 66284 66132 66170			unknown	0005	66091 66022 66015 66064 66095	68°58'	115°35'	unknown
2240	66351 66533 66581 66457 66428				0010	66040 65882 65743 65799 65780			

MCMURDO TO WILKES. FLIGHT T-5, 2-3 DECEMBER 1959 (con't)

<u>Time</u> <u>GMT</u>	<u>Total</u> <u>Intensity/r</u>	<u>Latitude/S</u>	<u>Longitude/E</u>	<u>Flight</u> <u>Elevation/m</u>
0015	65808 65891 65993 66198 66329			unknown
0020	66441 66460 66404 66319 66319			
0025	66348 66470 66432 66338 66319			unknown
0030	66113 66113 66237 66514 66380			
0035	66524 66418 66476 66284 65820			unknown
0040	65725 65716 65706 65905 65678			
0045	65641 65952 65858 65801 65650			unknown
0050	65706	66°39'	111°34'	

WILKES TO MCMURDO, FLIGHT T-6, 3 DECEMBER 1959

<u>Time GMT</u>	<u>Total Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/E</u>	<u>Flight Elevation/m</u>	<u>Time GMT</u>	<u>Total Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/E</u>	<u>Flight Elevation/m</u>
0521	53937 53795 53795 53777	71°06'	118°44'	unknown		53924 54050 54069 54057			unknown
0525	53764 53733 53709 53709 53727 53795				0655	54139 54292 54485 54549 54420 54286			
0530					0700				
	53851 53900 53931 53925			unknown		54031 53936 53936 53917			unknown
0535	53944 53950 53974 54037 54080				0705	53949 53987 54012 54038 54063 54127			
0540					0710		74°42'	133°00'	
	54080 54137 54143 54118			unknown		54171 54197 54235 54203			unknown
0545	54074 53906 53888 53888 53919 53968				0715	54190 54197 54203 54197 54203 54209			
0550					0720				
	54068 54093 54093 54087			unknown		54222 54216 54203 54197			unknown
0555	54049 53999 54005 54030 54037 54005				0725	54197 54209 54203 54197 54216 54203			
0600		72°40'	123°00'		0730				
	54005 54068 54112 54180			unknown		54152 54108 54089 54063			unknown
0605	54243 54093 53999 53917 53955 54127				0735	54057 54089 54133 54254 54343 54388			
0610					0740				
	54229 54216 54152 54076			unknown		54362 54336 54317 54273			unknown
0615	53974 53936 53892 53854 53835 53873				0745	54229 54203 54184 54203 54197 54197			
0620					0750				
	53968 54095 54089 54012			unknown		54178 54139 54108 54089			unknown
0625	53980 53987 53980 53987 53974 53961				0755	54063 54044 54038 54025 53980 53924			
0630					0800				
	53980 53968 53999 54038			unknown		53917 53999 53974 53924			unknown
0635	54031 54018 53999 54018 54095 54197				0805	53911 53911 53911 53924 53924 53936			
0640					0810				
	54248 54292 54323 54222			unknown		53930 53924 53924 53936			unknown
0645	54209 54273 54190 54082 53924 53879				0815	53961 53999 54006 54018 54044 54050			
0650					0820				

WILKES TO MCMURDO, FLIGHT T-6, 3 DECEMBER 1959 (con't)

<u>Time</u> <u>GMT</u>	<u>Total</u> <u>Intensity/y</u>	<u>Latitude/S</u>	<u>Longitude/E</u>	<u>Flight</u> <u>Elevation/m</u>
	54025			unknown
	54076			
	54057			
0825	54025			
	54038			
	54038			
	54050			
	54101			
0830	54063	76°56'	147°45'	
	54044			
	54050			unknown
	54044			
	54057			
0835	54018			
	53999			
	53993			
	54025			
0840	54025			
	54018			
	54018			
	53999			unknown
	54025			
	54063			
0845	54095			
	54108			
	54063			
	54076			
	54050			
0850	54050			
	54082			
	54069			unknown
	54076			
	54057			
0855	54031			
	54006			
	54006			
	53999			
	53987			
0900	53987			
	53980			
	53993			unknown
	53999			
	54018			
0905	54012			
	54012			
	54012			
0908	54006	77°31'	155°10'	
	53999			

MCMURDO TO BYRD. FLIGHT T-7, 13 DECEMBER 1959

<u>Time</u> <u>GMT</u>	<u>Total</u> <u>Intensity/r</u>	<u>Latitude/S</u>	<u>Longitude/E</u>	<u>Flight</u> <u>Elevation/m</u>	<u>Time</u> <u>GMT</u>	<u>Total</u> <u>Intensity/r</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight</u> <u>Elevation/m</u>
1517	65505 65505 65478	78°52'	175°00'	unknown		63875 63875 63858			unknown
1520	65442 65423 65414 65414				1720	63850 63832 63824 63806			
1525	65396 65360 65332				1725	63780 63772 63772			
	65305 65296 65269			unknown		63789 63780 63772			unknown
1600	65241 65232 65223 65223	79°11'	175°15'		1730	63711 63634 63590 63564			
1605	65205 65196 65169				1735	63547 63530 63513			
	65142 65115 65097			unknown		63513 63530 63547			unknown
1610	65079 65052 65043 65052				1740	63573 63608 63599 63547	81°01'	156°15'	
1615	65016 64971 64935				1745	63495 63444 63393			
	64962 64953 64971			unknown		63342 63316 63291			unknown
1620	64962 64971 65115 64935				1750	63308 63325 63299 63248			
1625	64872 64818 64782				1755	63205 63171 63188			
	64755 64738 64738			unknown		63163 63129 63103			unknown
1630	64764 64809 64800 64747				1800	63061 63027 63018 63095	81°00'	150°00'	
1635	64702 64684 64702				1805	63205 63120 62960			
	64693 64631 64587			unknown		62934 62985 63265			unknown
1640	64596 64551 64498 64471	80°09'	175°15'W		1810	63044 63350 63342 63018			
1645	64445 64445 64454				1815	62876 62800 62741			
	64454 64498 64498			unknown		62691 62733 62876			unknown
1650	64462 64471 64347 64303				1820	62758 62657 62640 62607			
1655	64224 64207 64172				1825	62574 62591 62591			
	64146 64119 64119			unknown		62566 62582 62607			unknown
1700	64154 64189 64216 64259				1830	62607 62615 62615 62582	80°59'	142°05'	
1705	64233 64154 64110				1835	62557 62499 62591			
	64093 64067 64014			unknown		62699 62574 62449			unknown
1710	63935 63901 63893 63909	80°48'	163°10'W		1840	62400 62408 62267 62160			
1715	63927 63944 63893				1845	62078 61980 61923	80°40'	135°50'	

MCMURDO TO BYRD. FLIGHT T-7, 13 DECEMBER 1959 (con't)

<u>Time</u> <u>GMT</u>	<u>Total</u> <u>Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight</u> <u>Elevation/m</u>
	61898			unknown
	62029			
	62160			
1850	62062			
	61906			
	62201			
	62053			
	62375			
1855	62741			
	62716			
	62127			unknown
	61816			
	61759			
1900	61791			
	61540			
	61411			
	61395			
	61694			
1905	61637			
	61726			
	61637			unknown
	61476			
	61387			
1910	61484			
	61613			
	61645			
	61726			
	61670			
1915	61573	80°20'	127°00'	
	61557			
	61573			unknown
	61581			
	61419			
1920	61204			
	61148			
	61188			
	61283			
1925	61435			
	61411			
	61108			
	61044			unknown
	61084			
	61204			
1930	61196			
	61204			
	61148			
	60706			
	60737			
1935	60650			
	60557			
	60479			unknown
	60487			
	60549			
1940	60619	80°00'	120°00'	

MCMURDO TO POLE. FLIGHT T-8, 6-7 JANUARY 1960

<u>Time GMT</u>	<u>Total Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/E</u>	<u>Flight Elevation/m</u>	<u>Time GMT</u>	<u>Total Intensity/γ</u>	<u>Latitude/S</u>	<u>Longitude/E</u>	<u>Flight Elevation/m</u>
2335	65374 65355 65346 65346 65346	78°59'	167°47'	unknown	0105	64174 64155 64137 64119 64101			unknown
2340	65327 65317 65317 65308 65298				0110	64092 64073 64064 64046 64019	82°07'	171°22'	
2345	65298 65289 65270 65260 65251			unknown	0115	64000 63982 63964 63936 63918			unknown
2350	65241 65241 65241 65232 65232				0120	63900 63901 63892 63892 63874			
2355	65232 65222 65204 65194 65185			unknown	0125	63865 63856 63847 63838 63820			unknown
0000	65166 65166 65147 65119 65091				0130	63802 63775 63739 63703 63676			
0005	65072 65044 65007 64988 64979			unknown	0135	63658 63631 63613 63604 63595			unknown
0010	64960 64950 64932 64913 64894	80°10'	169°35'		0140	63568 63568 63550 63541 63514	83°05'	172°00'	
0015	64875 64847 64819 64810 64810			unknown	0145	63496 63487 63477 63465 63452			unknown
0020	64800 64782 64782 64782 64782				0150	63443 63416 63389 63363 63327			
0025	64782 64791 64782 64782 64736			unknown	0155	63309 63283 63256 63230 63212	83°37'	171°58'	unknown
0030	64662 64625 64620 64616 64597				0200	63185 63167 63150 63123 63105			
0035	64578 64569 64541 64532 64514			unknown	0205	63088 63052 63035 63017 63000			unknown
0040	64504 64514 64495 64467 64440	81°12'	170°32'		0210	62991 62965 62938 62930 62912			
0045	64421 64412 64393 64384 64366			unknown	0215	62903 62895 62895 62886 62868			unknown
0050	64356 64338 64338 64329 64311				0220	62851 62842 62825 62807 62790			
0055	64292 64274 64265 64256 64238			unknown	0225	62772 62755 62731 62706 62681			unknown
0100	64228 64219 64210 64192 64183				0230	62657 62632 62607 62583 62558			

MCMURDO TO LITTLE ROCKFORD TO BYRD. FLIGHT T-9, 15 JANUARY 1960

<u>Time GMT</u>	<u>Total Intensity/r</u>	<u>Latitude/S</u>	<u>Longitude/E</u>	<u>Flight Elevation/m</u>	<u>Time GMT</u>	<u>Total Intensity/r</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight Elevation/m</u>
0619	65455	78°49'	174°40'	750					
0620	65446 65427 65427 65418 65427				0750	64773 64773 64764 64737 64719 64691			750
0625	65455 65483 65483 65474				0755	64709 64700 64700 64709			
0630	65446 65427 65390 65371 65343 65325			750	0800	64700 64664 64655 64655 64646 64646			750
0635	65306 65251 65196 65142				0805	64637 64627 64618 64608			
0640	65087 65032 64977 64922 64867 64812			750	0810	64601 64637 64592 64528 64501 64474			750
0645	64757 64703 64648 64593				0815	64465 64456 64419 64374	79°09'	164°00'	
0650	64510 64456			750	0820	64374 64347 64347 64356 64338 64338			750
0651	64456 64620 64784 64948	79°23'	179°00'W			64374 64347 64356 64338 64338			
0655	65112 65112 65122 65103				0825	64374 64347 64356 64347			
0700	65103 65067 65067 65057 65057 65048			750	0830	64429 64401 64320 64249 64204 64168			750
0705	65021 65001 64995 64990				0835	64150 64168 64150 64159			
0710	64984 64984 65067 65085 65334 65399			750	0840	64158 64157 64156 64154 64153 64152			750
0715	65427 65278 65067 64956				0845	64151 64141 64124 64088			
0720	64938 64956 64993 65085 65177 65195			750	0850	64061 64034 64016 64025 64052 64124			750
0725	65103 65002 64929 64929				0855	64204 64329 64320 64231			
0730	64931 64901 64872 64842 64828 64846			750	0900	64186 64150 64141 64115 64097 64088			750
0735	64846 64837 64825 64816				0905	64088 64070 64061 64097	79°01'	155°25'	
0740	64807 64798 64789 64782 64782 64782			750	0910	64097 64124 64132 64132 64141 64079			750
0745	64782 64773 64764 64773	79°20'	169°18'W		0915 1156	64034 Down at Little Rockford Station from 0915 to 1156 63010 62968	79°06' 79°27'	153°15' 144°12'	1750

MCMURDO TO LITTLE ROCKFORD TO BYRD. FLIGHT T-9, 15 JANUARY 1960 (con't)

<u>Time</u> <u>GMT</u>	<u>Total</u> <u>Intensity/r</u>	<u>Latitude/S</u>	<u>Longitude/W</u>	<u>Flight</u> <u>Elevation/m</u>
	62918			1750
1200	62859	79°30'	143°15'	
	62817			
	62775			
	62750			
	62724			
1205	62699			
	62682			
	62657			
	62640			
	62599			1750
1210	62549			
	62506			
	62464			
	62421			
	62400			
1215	62408			
	62400			
	62391			
	62350			
	62325			1750
1220	62325			
	62317			
	62300			
	62292			
	62283			
1225	62283			
	62259			
	62240			
	62283			
	62300			1750
1230	62292			
	62119			
	62070			
	62062			
	62037			
1235	62021			
	61996			
	61955			
	62358			
	62234			1750
1240	62097			
	61960			
	61891			
	61816			
	61799			
1245	61972	79°48'	133°10'	
	62366			
	61914			
	61670			
	61833			1750
1250	62004			
	62127			1500
	61791			
	61508			
	61500			
1255	61573			
	61702			
	61540			
	61492			
	61387			1500
1300	61276	79°53'	129°45'	
	61313			
	61349			
	61386			
	61275			
1305	61036			
	60989			
	61132			
	61180			
	61251			1500
1310	61307			
	61359			
	61469			
	61613			
	61726			
1315	61637			
	61565			
	61387			
	61267			
	61211			1500
1320	61132			
	61180			
	61219			
	61235			
	61283			
1325	61259	79°51'	123°50'	
	61243			

ROSS ICE SHELF RECON. FLIGHT T-10, 22 OCTOBER 1961 (con't)

Time GMT	Total Intensity/r	Latitude/S	Longitude/W	Flight Elevation/m	Time GMT	Total Intensity/r	Latitude/S	Longitude/W	Flight Elevation/m
	63078			2440		61931			2440
0440	63061					61890			
	63061				0610	61857			
0441	63061	80°29'	153°50'			61824			
	63027				0612	61767	84°05'	154°20'	
	63027					61742			
0445	63018				0615	61742			
	62993					61734			
	63035					61718			
	63018					61710			
	63120			2440		61694			2440
0450	63129				0620	61678			
	62892					61637			
	62783					61605			
	62817					61581			
0454	62850	80°54'	152°05'			61573			
0455	62792				0625	61573			
	62968					61581			
	62918					61605			
	62691					61613			
	62516			2440		61613			2440
0500	62441				0630	61573			
	62441					61500			
	62474					61460			
	62582					61451			
	62549					61435			
0505	62549	81°00'	145°15'		0635	61395	85°10'	152°05'	
	62557					61363			
	62699					61331			
	62825					61291			
	62624			2440		61275			2440
0510	62383				0640	61243			
	62350					61211			
	62342					61188			
	62358					61164			
0515	62383				0645	61148			
	62408					61196			
	62433					61196			
	62458					61180			
	62466			2440	0647	61156	85°22'	146°20'	2440
0520	62425					61172			
	62375					61204			
	62358				0650	61243			
	62358					61283			
	62342					61331			
0525	62342				0655	61387			
	62342					61419			
	62358				0656	61435	85°25'	151°30'	
	62375					61460			
	62383			2440		61500			2440
0530	62408				0700	61540	85°20'	156°40'	
	62408					61557			
	62441					61605			
	62483					61678			
	62508					61750			
0535	62491				0705	61783			
	62499					61775			
	62508					61767			
	62508					61767			
	62474			2440		61775			2440
0540	62458				0710	61775			
0541	62474	82°35'	154°40'			61742			
	62466					61718			
	62458					61734			
	62449					61759			
0545	62449				0715	61816			
	62416					61865			
	62350					61939			
	62308					62021			
	62292			2440		62094			2440
0550	62283				0720	62143			
	62283					62143			
	62275					62152			
	62292					62194			
	62300					62264			
0555	62308				0725	62353			
	62308					62423			
	62308					62494			
	62283					62565			
	62259			2440		62582			2440
0600	62225				0730	62591			
	62160					62591			
	62119					62599			
	62094					62649			
	62078					62674			
0605	62062				0733	62674	84°21'	172°10'	
	62029					62691			
	62004				0735	62674			
	61980					62649			

