BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

Record 1981/59

GEOPHYSICAL AND SURVEYING WORK ALONG THE INGRID CHISTENSEN COAST NEAR DAVIS BASE, ANTARCTICA, 1980/1981 SUMMER

by

J.W. WILLIAMS

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CONTENTS

ABSTRACT

During the 1980-81 summer season in Antarctica, BMR conducted helicopter supported geophysical and mapping surveys along the Ingrid Christensen Coast. Observations were made of ice surface height, ice thickness, gravity and total magnetic field on a 20 km grid over a 140 x 170 km area of Plateau ice. At some sites, ice samples were collected for oxygen isotope analysis. Vertical air photographs in colour were taken of all rock outcrop between the Vestfold Hills and Landing Bluff using 70 mm colour film. Late Proterozoic basaltic dykes in the Vestfold Hills were sampled for palaeomagnetic analysis; 144 samples were collected from 47 sites. This Record documents the basic information gathered during the survey. Interpretation of the data will be reported elsewhere on its completion.

INTRODUCTION

BMR land Antarctic field work during the 1980/1981 summer consisted of geological and geophysical studies along the Ingrid Christensen Coast using Hughes 500C helicopters for transport. This geophysical work extended that carried out by BMR from 1969-1975 in the Prince Charles Mountains, and from 1976-1980 in Enderby, Kemp and McRobertson Lands (Wellman & Tingey, 1977), and by Antarctic Division in Wilkes Land.

REGIONAL GEOPHYSICAL SURVEY

The primary geophysical objective was to extend the gravity coverage of the continent, by measurements on a grid over the ice cap using ice radar to measure ice thickness, particularly to define geophysical anomalies over the contact between Archaean and Late Proterozoic rocks at the Sorsdal Glacier, (see Fig 11), and to investigate the extent of the contact inland. Results are listed in Table 1 and illustrated in Plates 1-3.

Previously, gravity observations had been made as spot readings on nunataks, and on isolated glaciological stations and tractor train routes, with radar measurements of ice thickness. The major difficultly in measuring gravity on a systematic grid were the problems of obtaining positions with only sun shots and dead-reckoning available, and in determining Bouguer corrections using only spot readings of ice thickness in areas of irregular topography. Total force magnetic observations were made to complement the gravity readings. A VLF receiver was tested to investigate the practicability of measuring the conductivity of the basement. At seventeen sites, one-metre deep ice core samples were taken for oxygen isotope analysis by the Antarctic Division Glaciology Section.

Gravity measurements

Two Lacoste and Romberg gravity meters, G101 and G20, were taken to Davis. Before leaving Canberra, both were checked at BMR for reading-line sensitivity and level adjustments, and were taken over the Canberra Calibration line. Melbourne University station 6592.0001 was measured before leaving on the ship "Nella Dan". It was found on arrival at Davis both meters required further reading-line and sensitivity adjustments.

The BMR gravity station 6905.0020 at Davis was located and permanently marked with a gravity-station brass disk and 1.34 m high pole. Station

6905.0021, located on the floor of the gas generation room of the meteorological balloon filling hut, was also marked with a brass disk. Both stations were tied with G101 and G20 to a new gravity base station 8007.0000 at National Mapping's survey point NMS-5. This new station is on a low hill near the helicopter pads. Although it is very exposed, no difficulty was experienced taking readings during this summer season. The new station was the base for all gravity and magnetic work. Only meter G20 was used for further field work.

Gravity station tie results and station locations are listed in Table 2 and Plates 4-9.

At times when it was not possible to work on the ice cap eleven gravity-magnetic stations were read around the Vestfold Hills mostly at trig stations. Some of these sites are at very rugged locations and only selected values have been plotted.

A total of forty-three gravity-magnetic stations were measured on the Plateau ice.

Few problems were encountered in making gravity measurements on the plateau. The snow was a firm base for the meter, and only when on blue ice near the coast or on glaciers did melting-in of the meter dish occur. The gravity meter was powered from 6 Amp-hour lead-acid gell-cell batteries which were changed during the day. The meter went below operating temperature only once (17.1.81) owing to a flat battery.

Observed gravity values are based on a Davis B (6905.0020) value of 982589.7 mGal (Potsdam Datum) (Woollard & Rose, 1963). No corrections were made for gravity meter instrumental drift or tide corrections because these are generally less than 0.2 mGal, had a maximum of 0.6 mGal, and so were negligible compared with terrain and ice thickness corrections. Bouguer and free-air anomalies were calculated assuming a rock density of 2.67 tm^{-3} and an ice density of 0.9 tm^{-3}. Terrain corrected free-air anomalies were calculated by subtracting the Bouguer corrections for a 100 x 100 km area from the Bouguer anomalies calculated at each station.

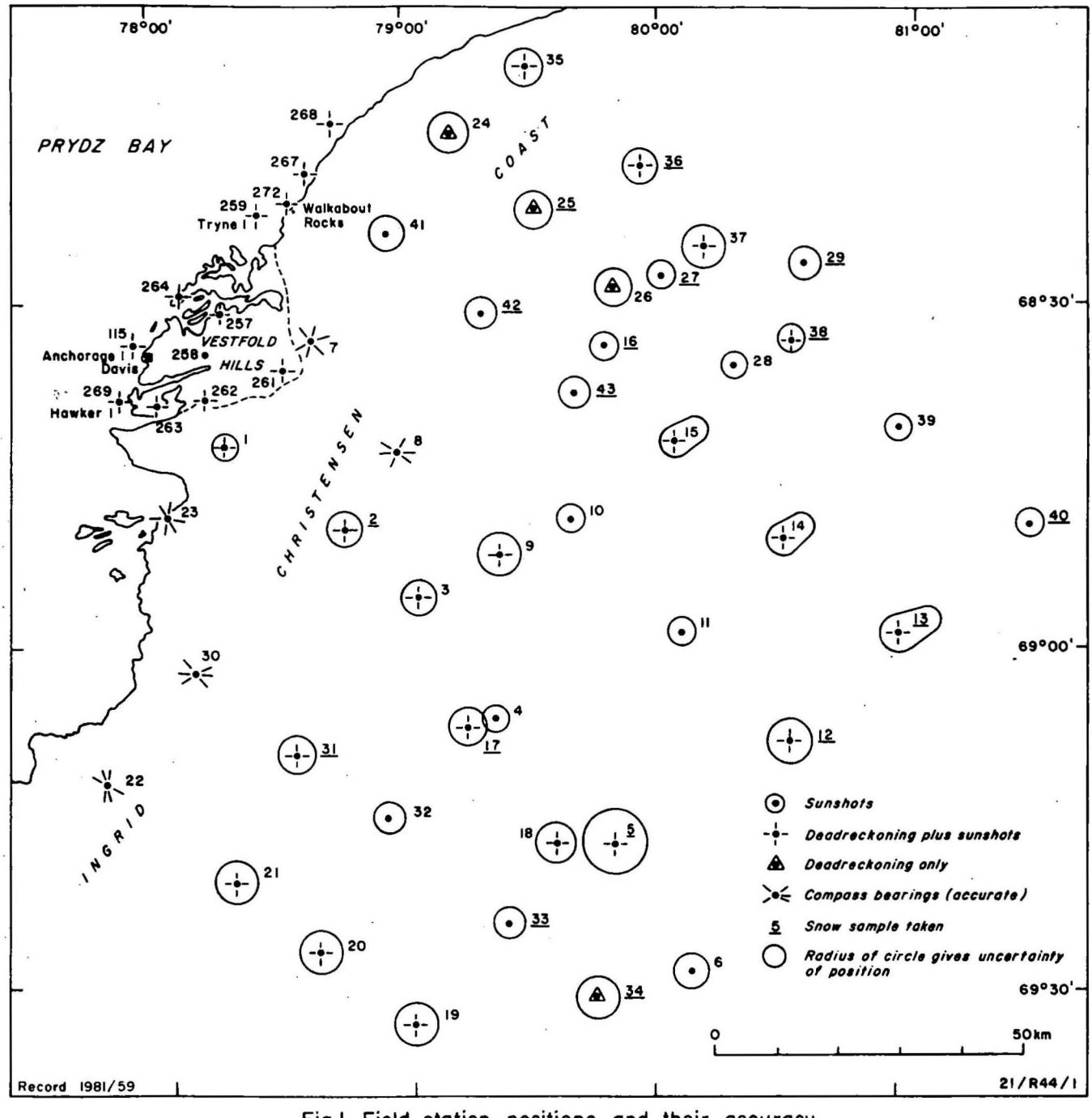
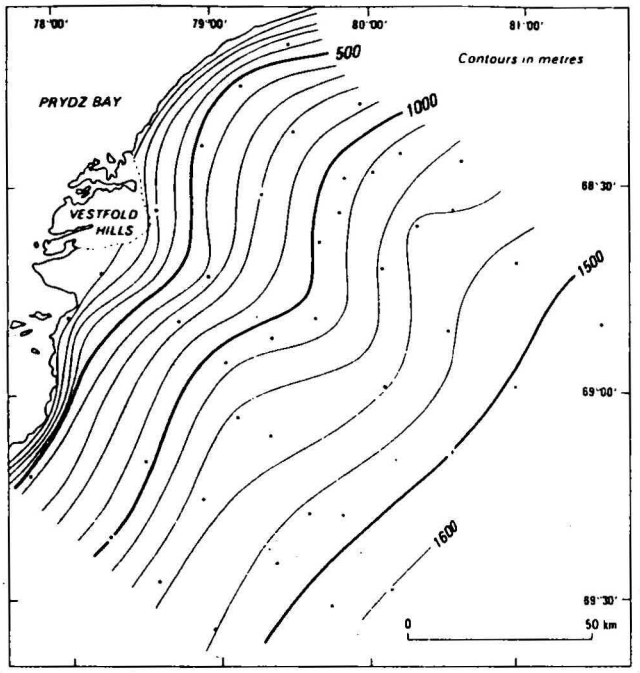
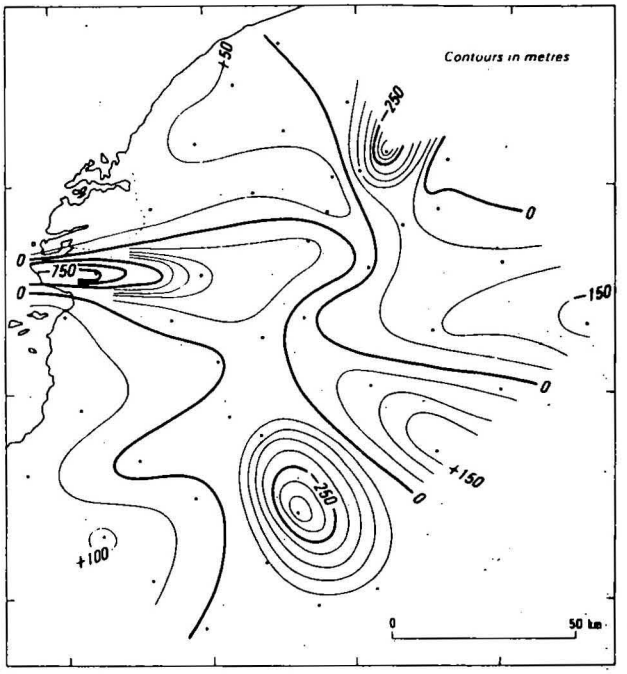


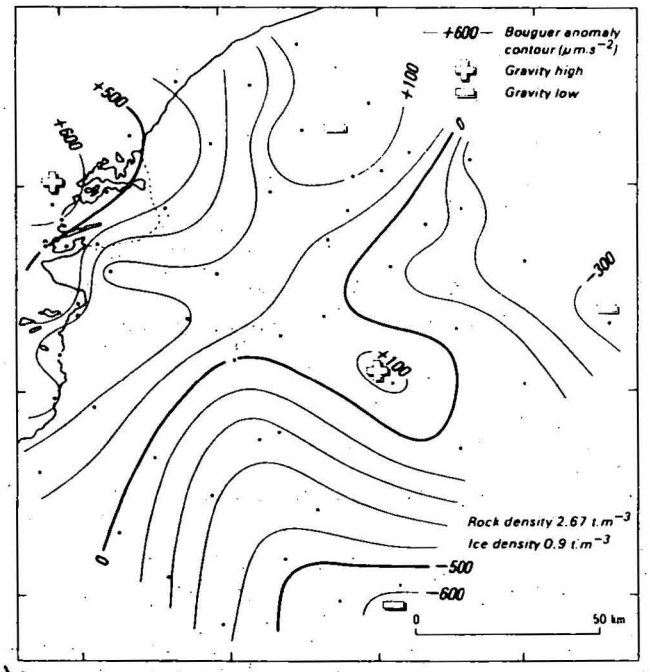
Fig.1 Field station positions and their accuracy



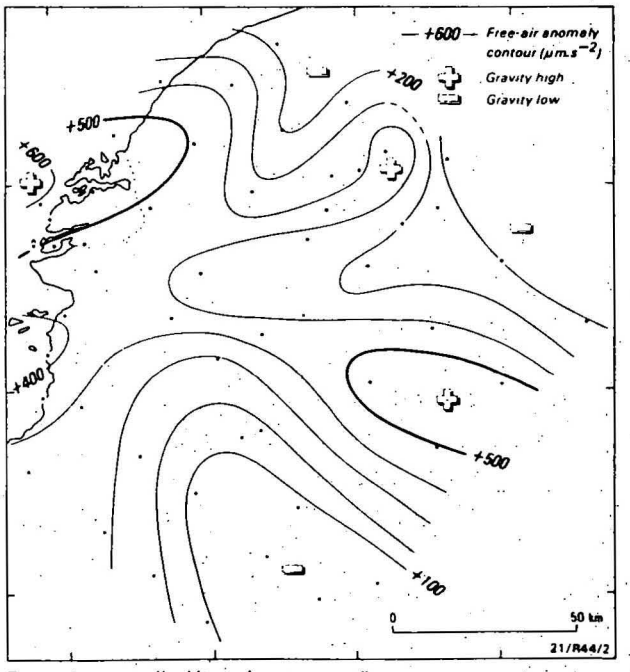
a) Ice altitude



b) Rock altitude



c) Bouguer gravity anomalies



d) Free-air anomalies (terrain corrected)

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Fig. 2 a,b,c,d

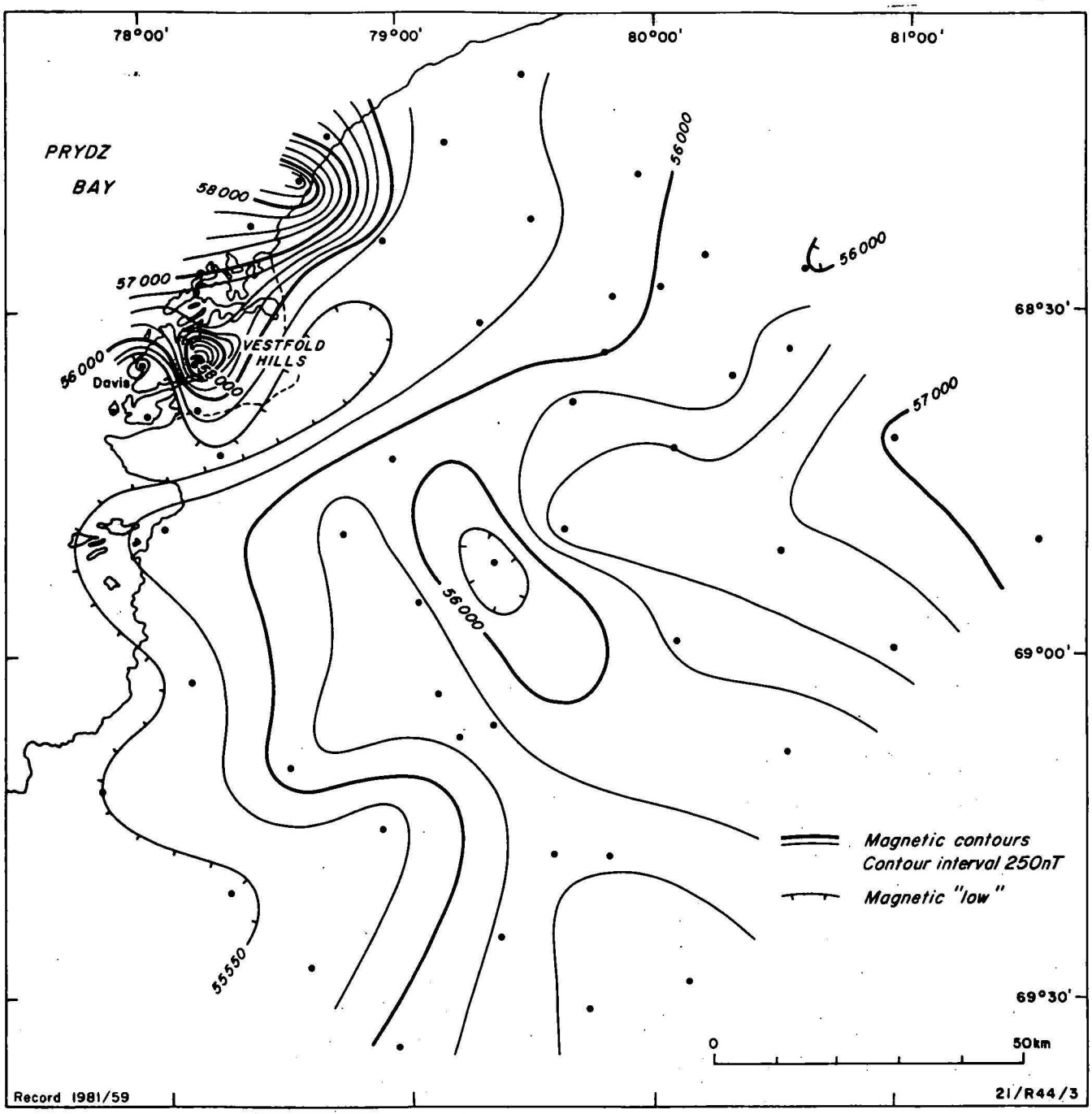
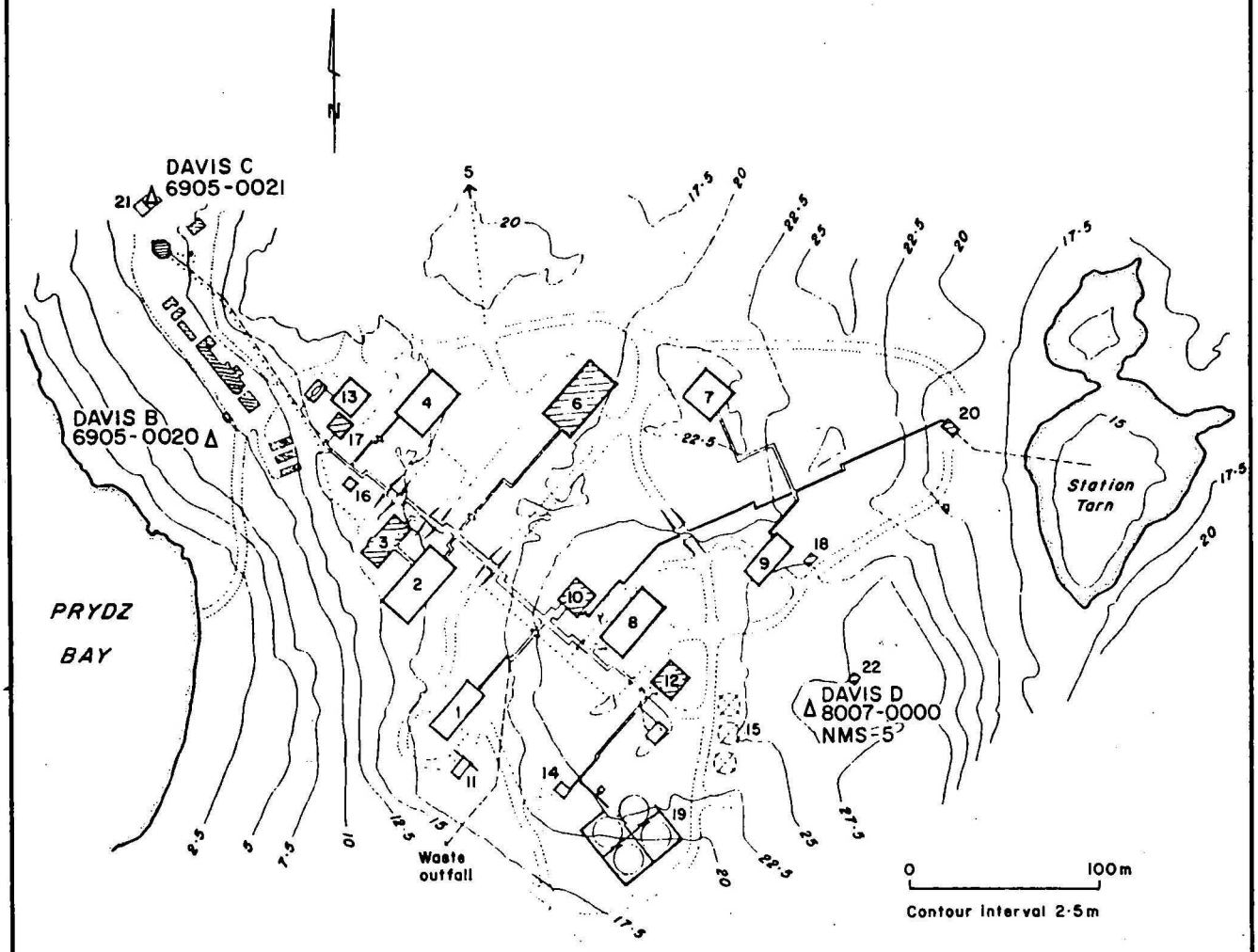


Fig. 3 Total magnetic field

Fig.4



1 Operations building
2 Sleeping / medical quarters
3 Living quarters
4 Store
5 Transmitter building
6 Workshop
7 Vehicle store
8 Recreation building
9 Science laboratory
10 Services building
11 Balloon building
12 Power house no.1
13 Power house no.2
14 Flammable liquids store
15 Helipads
16 Incinerator
17 Existing power house
18 Auroral building
19 Fuel storage
20 Water supply building
21 Balloon filling and gas generation building
22 Magnetometer building
Existing building

NMS-5 68° 34' 46·9512" Lat.
77° 58' 38·4383" Long.

▲ Primary base
△ Secondary base
◎ Excentre

(BASED ON 21/1)

Davis gravity control stations

21/R44/4

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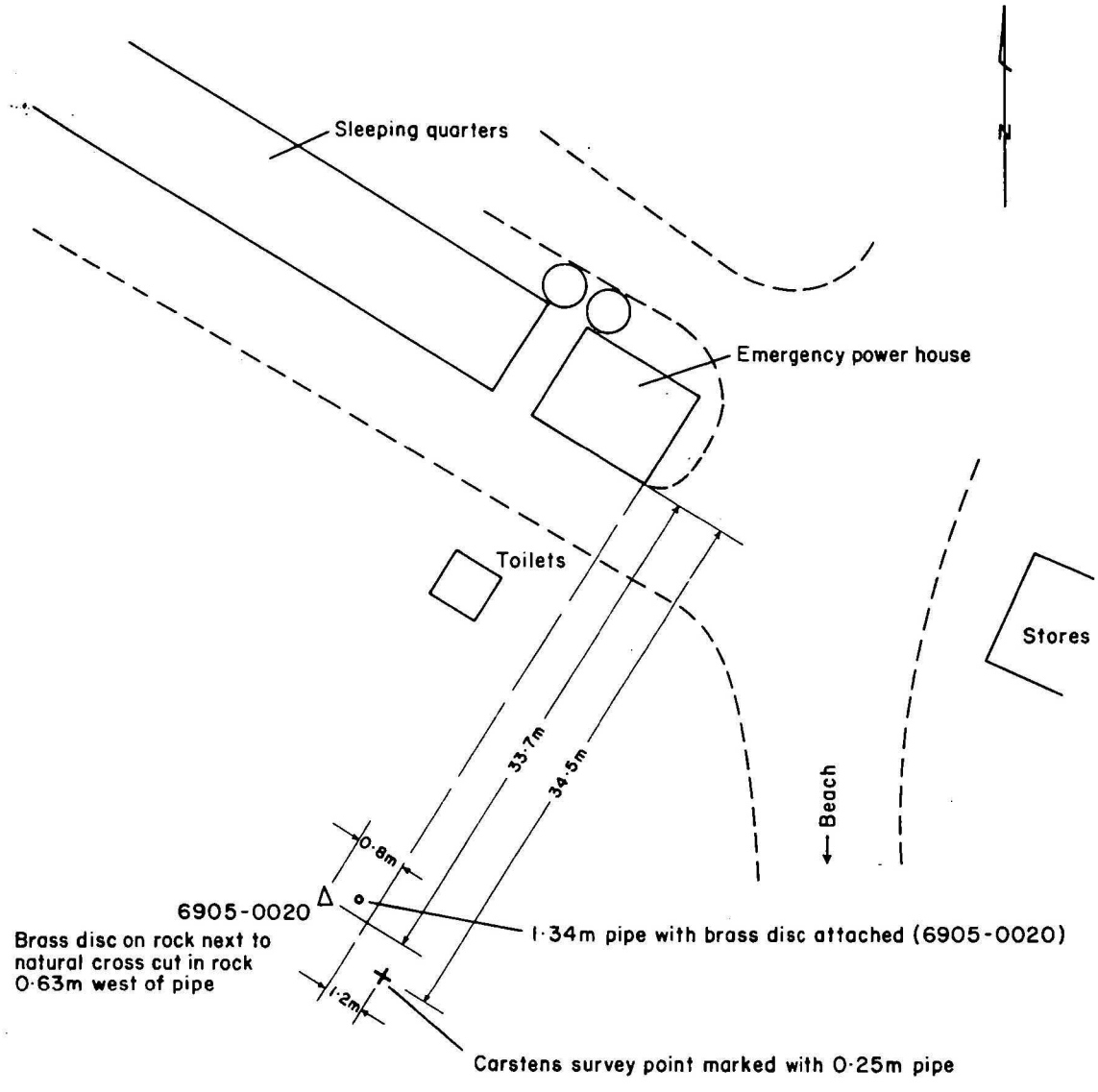
Fig. 5



▲ Primary base
△ Secondary base
⊙ Excentre

Davis (B) 6905-0020

Record 1981/59
(BASED ON 21/1)

21/R44/5

GRAVITY STATIONS
AUSTRALIAN NATIONAL GRAVITY NETWORK

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

NATMAP and BMR gravity site 6905 - 0020

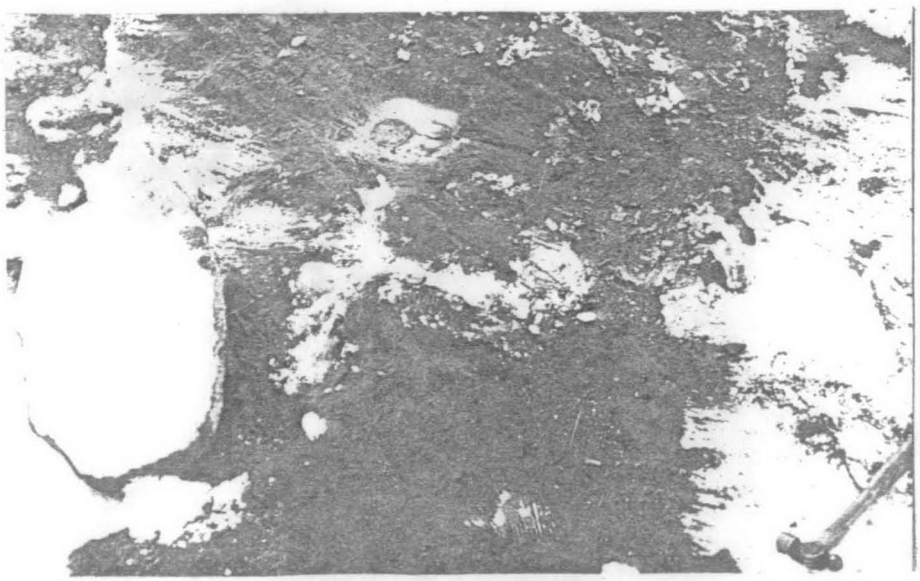
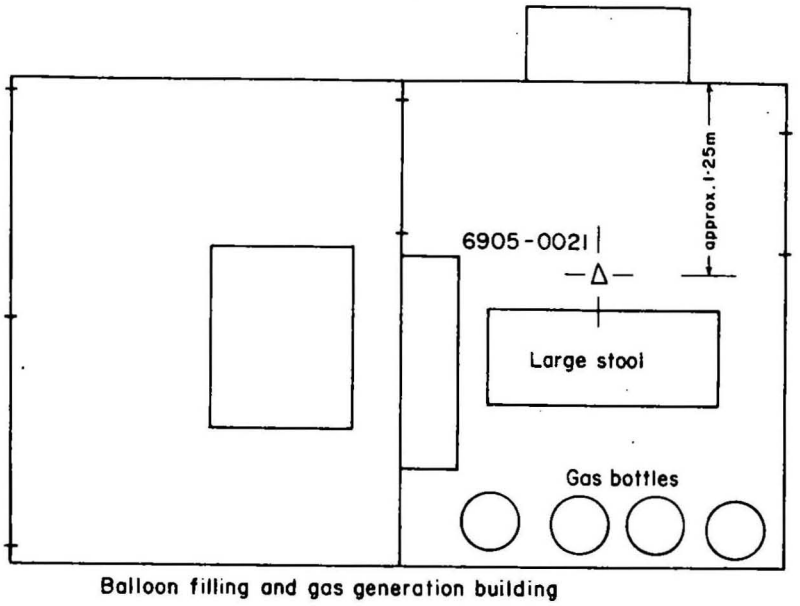


Fig.6 Davis 6905 - 0020 (B)

Fig. 7



Balloon filling and gas generation building

▲ Primary base
Δ Secondary base
⊖ Excentre

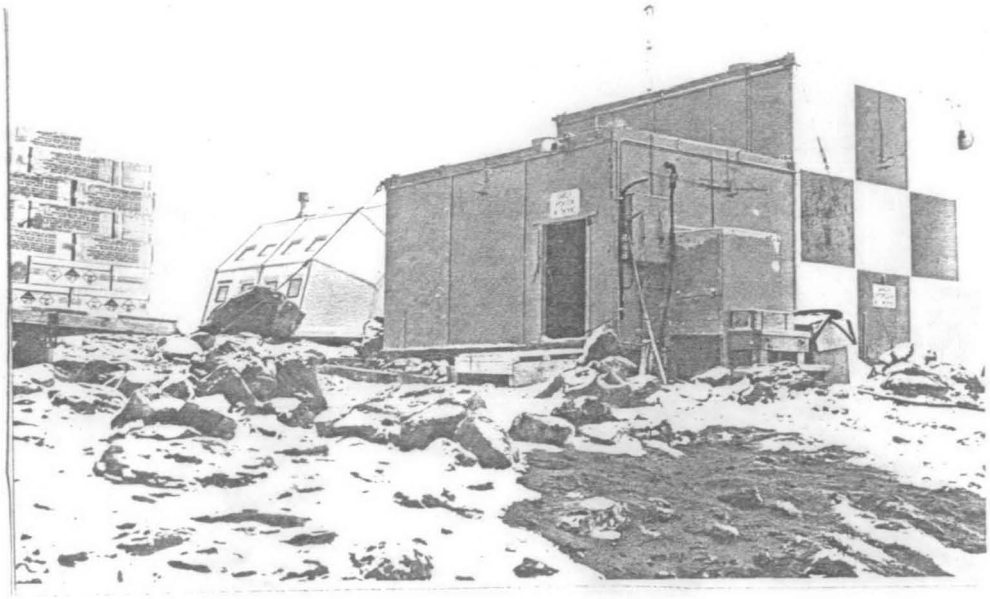
Davis (C) 6905-0021

Record 1981/59
(BASED ON 21/1)

21/R44/6

GRAVITY STATIONS
AUSTRALIAN NATIONAL GRAVITY NETWORK

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics



Balloon filling and gas generation room

Gravity station 6905 - 0021 on gas generation room floor

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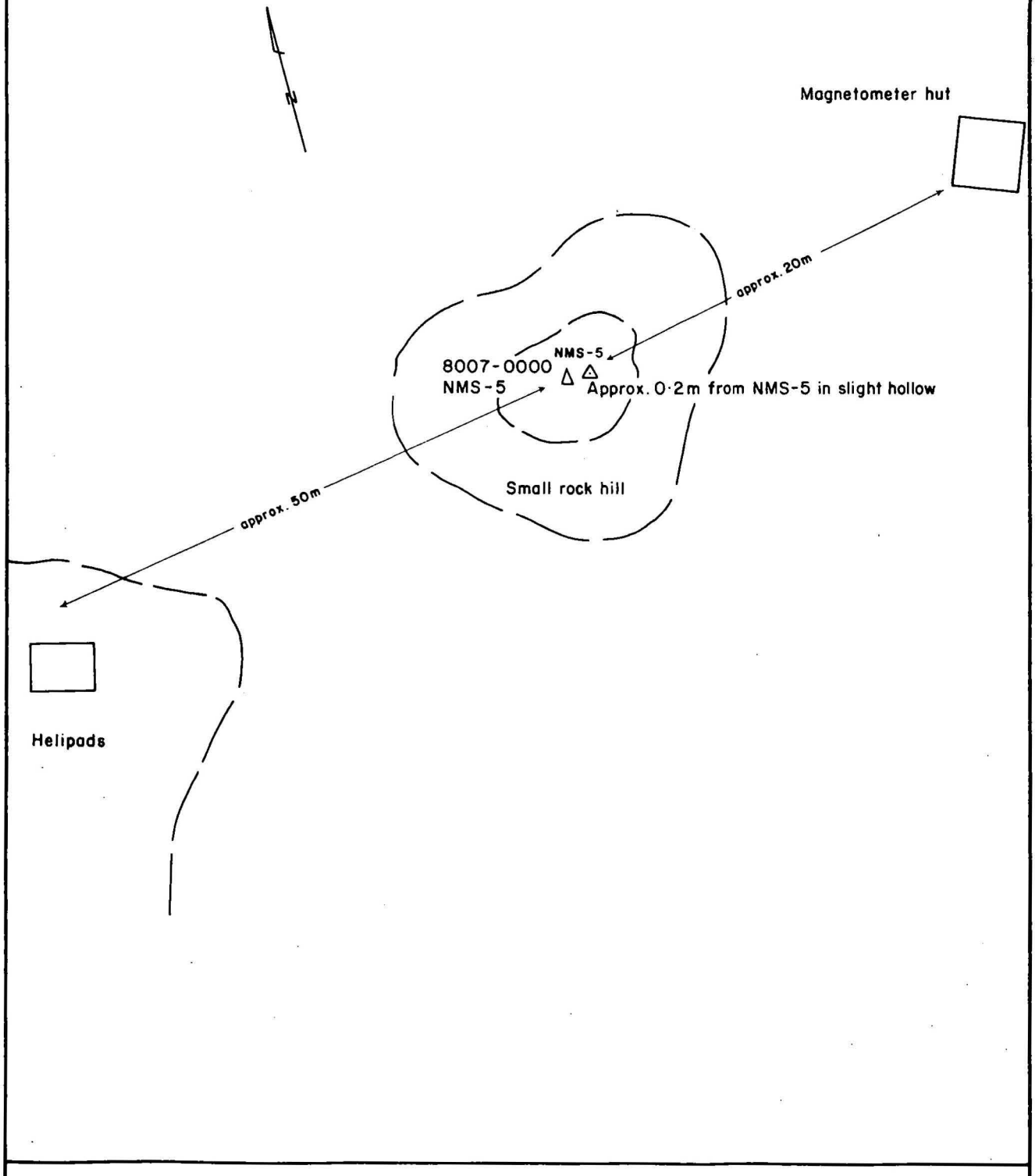
21/R44/13

Fig. 8 Davis 6905 - 0021 (C)

Fig. 9



▲ Primary base
△ Secondary base
◎ Excentre

Davis (D) 8007-0000

Record 1981/59

21/R44/7

(BASED ON 21/1)

GRAVITY STATIONS
AUSTRALIAN NATIONAL GRAVITY NETWORK

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

Magnetic measurements

A Geometrics 816 proton-precession magnetometer was used for total field measurements. A three-component fluxgate-magnetometer base-station monitor operated at Davis. A mean base total field (F) of 55238nT was derived from the H and Z values for the times of the field readings. Field values were corrected for diurnal variation assuming a value of 55238nT as the mean field for the base station. The diurnal variation measured at the base station monitor had a range of 34 to 167nT. For two of the eleven days on which field work was conducted on the ice plateau, the G816 field instrument readings appeared to be low by a constant amount of 13838nT, due to an electronic failure. The values have been corrected for this discrepancy.

Ice-radar measurements

Gravity measurements on the ice plateau cannot be interpreted without ice-depth measurements. Hence, ice depth was recorded at each site using an ANARE Mk V ice radar. It was intended that continuous soundings be made between stations, but owing to Department of Transport restrictions concerning the fitting of aerials to the helicopter, this was not possible. Wooden stands were therefore made so that the antennae could be positioned on the ice on either side of the helicopter after landing.

It was originally intended to use the helicopter battery power supply, but the power drain was found to be too great. Hence two 12 V lead-acid batteries, that were originally intended to supply the gravity meters, were used. Two BMR Tectronics Type 321 CRO's displayed the echo pulse. Radar measurements were made using a motor driven camera on the Z-scan (intensity modulated) CRO intended for continuous recording in flight. The camera failed on several occasions and some Z-scan was lost. The echo-time delay was also read visually and recorded at each site from the A-scan CRO. The brilliance for Z-scan recording was very sensitive to vibration and a better system of recording Z, and perhaps also A-scan, is desirable.

Except for an electronic failure at the input stage to the receiver at the beginning of the survey, and a tendency on two occasions for the 2us timing marks to disappear, the ice radar worked reliably. Station 8007.0005 was the only

site where no recognisable return could be detected.

Plate No 10a shows the ice-radar antennae set-up on the ice cap.

Navigation

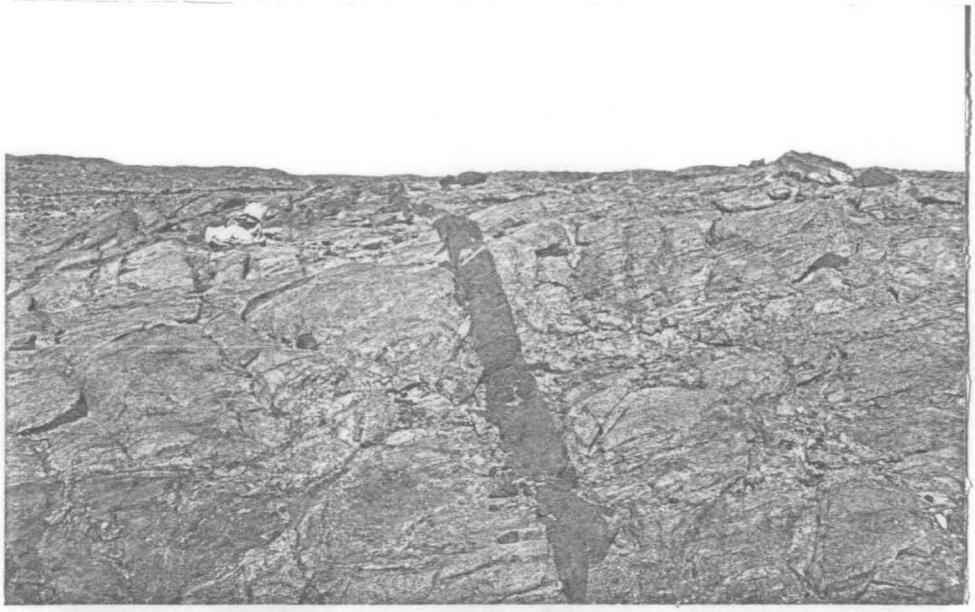
Positioning of ice-plateau stations was by dead reckoning, sun shots, and, where possible, compass bearings from known features. Navigation was difficult, and at times inaccurate and frequently there were no terrain features that could be identified on ERTS photographs. One method used for positioning survey stations on the ice cap was to take two fixes of the sun with a theodolite (the moon was not seen during the survey period) and, by using position lines, calculate an intercept from readings taken approximately 60 minutes apart.

As the sun's azimuth changed by about 15° between readings, the position lines intersected at this small angle (90° is ideal). Consequently small displacements of the position lines parallel to themselves due to errors in measuring the sun's altitude produced large displacements of the intersection points, which represent large errors in position. Navigational calculations were made at Davis each night. An H.P. 67 programmable calculator, with programs developed by J.A. Major (BMR), was used to calculate the sun's altitude and azimuth from an assumed position, using the declination and G.H.A. (Greenwich Hour Angle) from the Nautical Almanac. A course error of 10° apparent on the first two days proved to be a compass error in one of the helicopters. Subsequent flights were navigated from the other helicopter. The dead-reckoning positions allowed for course corrections using the wind speed and direction measured at each site. Simple drift measurements were taken in flight, and flights were timed by stopwatch. At some sites the dead-reckoned position was much more accurate than the sun-shot position. The two methods of navigation complemented each other; both were used in selecting the adopted site positions. For those stations near the coast preference was given to dead-reckoning navigation using identified coastal features. Plate 1 gives an indication of the station position accuracies.

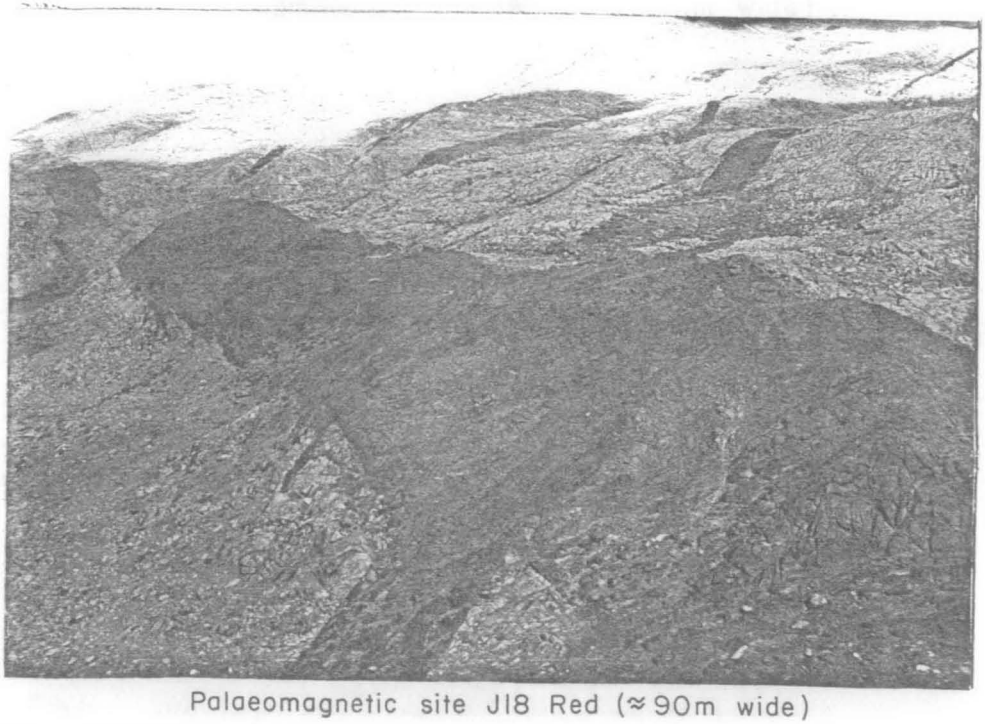
Barometric measurements

Atlitude measurements at ice plateau gravity stations were made using two BMR Mechanism microbarometers (D113 and D162). Barometric control at the

Ice Radar antennas being set up on icecap



Palaeomagnetic site 147 (≈ 200 mm wide)



Palaeomagnetic site J18 Red (≈ 90m wide)

Fig.10 Typical palaeomagnetic sample locations

base station was provided by the Davis staff of the Bureau of Meteorology. Temperatures were recorded from the helicopter's thermometer. Field readings were corrected for diurnal pressure changes using 3-hourly readings at Davis base. Altitude precision is probably similar to earlier surveys of this type (s.d. = 10 m; Wellman and Tingey, 1977). There were no control stations on the ice cap, so the higher altitudes may have a systematic error.

Basement Conductivity

A Ronka EM 16 VLF receiver for audio-signal phase and dip measurements was tested to investigate basement conductivity. Although Northwest Cape could be received, the very low audio output of the receiver was masked, under field conditions, by the high wind noise which made it impossible to accurately null the instrument. Consequently it was not used for the survey.

PALAEOMAGNETIC SAMPLING

In the Vestfold Hills there are numerous basaltic dykes of several ages. The Archaean country rock was not deformed during the extensive Antarctic metamorphism about 600 m.y. ago. Some dykes give a late Proterozoic Rb/Sr whole rock age of 1075 $\pm$ 10 m.y. Stable palaeomagnetic results have been found for the few dykes investigated so far (Embleton & Arriens, 1973). The objective of the 1980-81 work was to sample dykes used previously, or planned to be used, for geochemical or geochronological analysis.

Forty-seven palaeomagnetic sites in basaltic dykes were sampled in the Vestfold Hills. Twenty-nine sites were pre-selected from Dr K. Collerson's 1973 sampling, and 8 sites were in areas where he sampled during 1980-81. Seven sites were selected where Dr J. Sheraton conducted geochemical sampling during 1980-81, and three sites were selected to complete a rough west-to-east traverse from Davis to the ice cap. Approximately 144 samples were sent to Canberra for palaeomagnetic measurements. Traversing was by helicopter and walking. Sites were located on air photographs and on a 1: 50 000 map of the Vestfold Hills. This program was hindered by many days of heavy cloud and snow falls when samples could not be oriented using the sun compass.

Plates 10b and c show two palaeomagnetic sample locations and Plate 11 is a map for all palaeomagnetic sample locations.

PHOTOGRAPHY AND SURVEYING

Previous photography in the area was by Lars Christensen's expedition during 1936-1937, Operation Highjump in 1947, ANARE's photography in 1959, photography by a Soviet expedition of Rauer Islands about 1970, and Division of National Mapping's 70 mm vertical photography of the Vestfold Hills in 1979. The main objective of this season's work was vertical photography of all rock outcrops between the Vestfold Hills and the Amery Ice Shelf. The photographs will be used in present and future geological work along the coast.

Vertical Photography

Rock outcrops between the Sorsdal Glacier and the Amery Ice Shelf were photographed from 3050 m (10 000 ft) on 70 mm Kodak Aero Colour Type 2445 film. Photograph overlap is generally about 60-70%. The photographs with flight-line map and frame numbers, are now held by Division of National Mapping. Plate No. 12 shows preliminary flight lines for the 1980-81 field survey.

At the request of National Mapping coloured air photographs were taken of Davis base from 460 m (1500 ft) and photographs of National Mapping points NMS-5, Anchorage Island, Hawker Island, M4, M5, M6 were taken at 250-460-915 m (750-1500 and 3000 ft).

Four areas of the Vestfold Hills (Walkabout Rocks/Wyatt Earp Islands, Trynne Island, Varkhneye Lake, and Chelnok Lake including the Garbage dump area) were photographed from 3050 m (10 000 ft) for Antarctic Division. An attempt was made to take 70 mm black and white photographs of all the penguin rookeries for the FIBEX penguin census. However, bad weather permitted photography of only about 50% of these rookeries.

Two 70 mm black and white vertical photographic runs over Davis base were made at 460 m for Department of Housing and Construction, and miscellaneous oblique photographs were taken during the same runs.

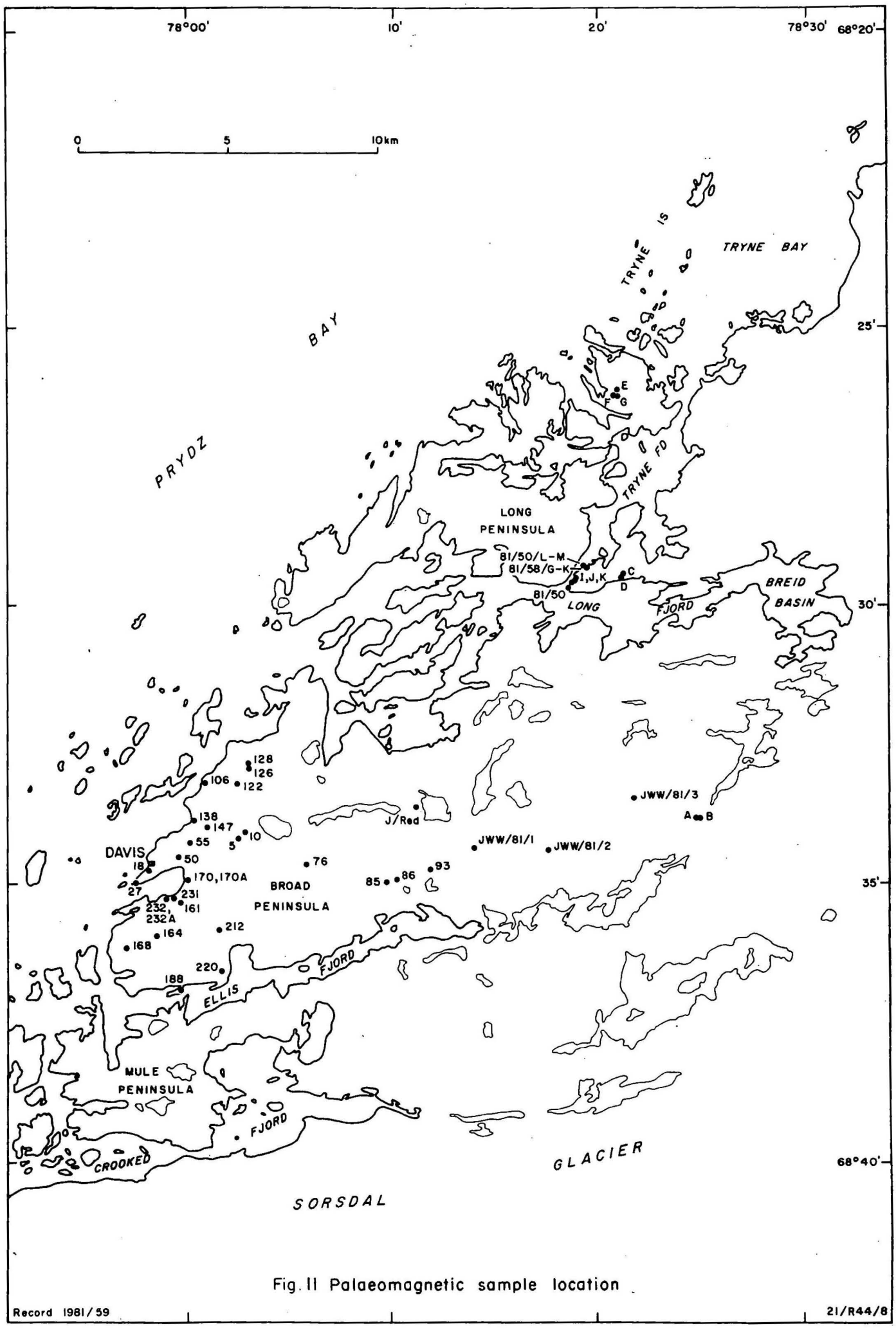
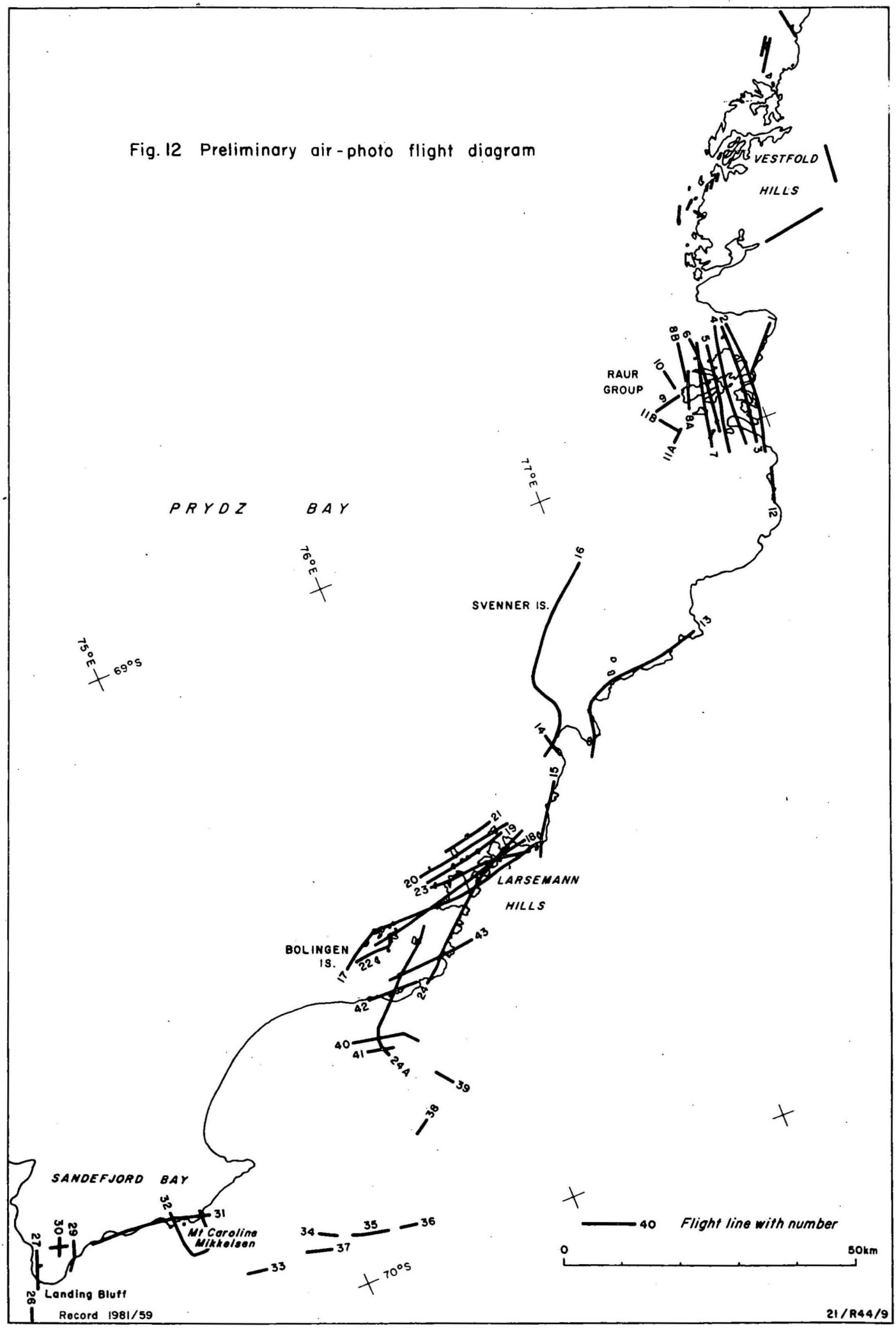


Fig. 11 Palaeomagnetic sample location

Fig. 12 Preliminary air-photo flight diagram



A Hasselblad 70 mm (2 ¼" square) camera, complete with two 70 exposure cartridges and camera mounting bracket were borrowed from Division of National Mapping for the Photography. Coverage of the Larsmann Hills and Svarthausen Ntk areas was interrupted on many occasions when the camera failed owing to what appeared to be the film cartridges sticking, causing small areas to be missed.

Miscellaneous Surveying

National Mapping requested that D. Carsten's survey point at Davis gravity station 6905.0020 be located. The most likely position was marked with a small pipe 0.25 m high and levelled to station NMW/S/4 with a builders level. The distance was measured from the National Mapping control point NMW/S/5 to the water's edge. Results are listed in Tables 3a and b.

ACKNOWLEDGEMENTS

I would like to express my appreciation to NATMAP for the loan of the Hasselblad camera and theodolite and the assistance given by ANARE for the loan of their ice radar and making the work possible. Thanks also to the BMR and Davis personnel whose help was willingly given, and to Vic Barkell and Bill Winefield, pilots for Vowell Helicopters who contributed greatly to the success of the ice plateau work.

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Table 1 **Principal data for gravity and magnetic stations.**

Station Number	Lat. (°S)	Long (°E)	Meter altitude (m)	Observed gravity (μms^{-2})	Rock altitude (m)	Free air anomaly (μms^{-2})	Bouguer anomaly (μms^{-2})	Bouguer correction 100x100 km area (μms^{-2})	Terrain corrected free air (μms^{-2})	Total magnetic field (nT)
6905.0020	68.56	77.96	8.0	9825897.0	8.0	621.1	612.2	20	590	
8007.0000	68.58	77.97	28.7	9825854.3	28.7	628.2	596.1	20	580	55238
8007.0001	68.72	78.28	96.9	9824737.4	-807.3	-364.0	197.7	-90	300	55407
8007.0002	68.83	78.78	786.3	9823557.6	-16.5	516.7	232.7	-220	450	56305
8007.0003	68.92	79.08	1086.5	9822573.4	13.4	404.3	-15.0	-300	280	56339
8007.0004	69.12	79.37	1245.5	9821993.0	-64.3	193.8	-227.8	-400	170	56298
8007.0005	69.18	79.51	1464.7	9821052.8	-	-105.9	-	-500	-	56458
8007.0006	69.48	80.17	1608.2	9820804.0	5.8	09.3	-592.3	-560	-30	56663
8007.0007	68.57	78.65	273.4	9825032.9	95.6	568.0	394.2	-90	480	55305
8007.0008	68.72	78.79	604.2	9823944.9	-114.1	309.0	166.0	-210	380	56197
8007.0009	68.88	79.38	1022.6	9822789.5	-33.7	447.4	87.1	-330	420	55556
8007.0010	68.82	79.67	1034.2	9822718.9	28.7	449.1	38.2	-350	390	56591
8007.0011	68.98	80.12	1284.1	9822247.0	75.8	651.4	111.4	-450	560	56327
8007.0012	69.15	80.57	1502.1	9821699.5	193.9	674.2	-35.4	-530	480	56058
8007.0013	68.98	81.00	1513.7	9821456.6	18.1	569.5	-14.2	-540	530	56541
8007.0014	68.85	80.57	1382.7	9821629.1	-96.1	416.5	-33.2	-460	430	56657
8007.0015	68.70	80.08	1216.9	9822012.0	8.6	379.2	-85.7	-360	270	56504
8007.0016	68.58	79.82	1038.5	9822697.4	66.8	587.5	146.8	-280	430	55199
8007.0017	69.12	79.25	1231.3	9822024.1	-19.3	181.1	-268.5	-380	110	56328
8007.0018	69.30	79.62	1413.2	9821242.3	-386.7	-147.2	-393.1	-480	90	56483
8007.0019	69.58	78.98	1398.5	9821745.5	-12.7	144.4	-373.0	-480	110	56093
8007.0020	69.45	78.60	1285.8	9822236.6	60.6	364.7	-164.6	-410	240	55583
8007.0021	69.35	78.27	1001.8	9823134.7	114.6	445.8	-16.5	-330	310	55461
8007.0022	69.20	77.85	582.2	9824333.8	75.2	439.7	164.6	-190	350	55496
8007.0023	68.82	78.05	58.4	9825685.8	58.4	404.7	339.4	-80	410	55835
8007.0024	68.10	79.20	524.0	9823904.8	42.4	504.4	275.6	-90	370	55557
8007.0025	68.37	79.53	839.9	9822953.6	37.2	360.2	16.2	-180	200	55677
8007.0026	68.48	79.85	1086.0	9822476.5	80.5	574.7	105.9	-260	370	55949
8007.0027	68.47	80.03	1146.1	9822165.1	-113.0	454.9	106.9	-280	390	56108
8007.0028	68.60	80.33	1311.8	9821651.5	-65.6	372.6	-73.0	-360	290	56117
8007.0029	68.45	80.62	1249.6	9821694.0	66.6	315.5	-204.6	-350	150	56051
8007.0030	69.05	78.15	613.2	9824187.5	80.9	479.2	188.2	-180	370	55570
8007.0031	69.15	78.55	943.5	9823034.7	-28.3	285.5	-49.0	-310	260	56206
8007.0032	69.25	78.93	1270.5	9821998.5	19.9	198.5	-294.9	-380	90	55593
8007.0033	69.42	79.42	1439.9	9821439.8	-38.9	61.2	-452.4	-480	30	56341
8007.0034	69.52	79.77	1573.5	9820770.0	(618.7)	-255.6	(-1306.8)	-530	(-780)	56576
8007.0035	68.17	79.48	360.3	9824156.3	-3.1	207.1	73.6	-100	170	55719
8007.0036	68.30	79.95	848.8	9822848.0	-13.1	325.5	15.4	-220	240	55901
8807.0037	68.42	80.22	1124.0	9822069.6	-388.6	322.1	186.5	-290	480	56175
8007.0038	68.57	80.47	1279.3	9821710.5	-22.0	349.9	-115.8	-390	270	56363
8007.0039	68.68	80.98	1433.2	9821159.9	-79.4	206.8	-274.3	-470	200	57012
8007.0040	68.83	81.53	1566.3	9820739.5	-182.9	105.7	-348.9	-560	210	57205
8007.0041	68.40	78.93	533.4	9824183.0	34.9	625.2	398.4	-90	490	55564
8007.0042	68.53	79.32	796.8	9823297.0	53.2	471.9	132.2	-200	330	55718
8807.0043	68.63	79.70	1023.6	9822625.6	-49.6	439.1	90.2	-280	370	56296
8007.0269	68.63	77.83	39.3	9825792.2	39.3	568.1	524.2	10	510	55151
8007.0263	68.65	78.00	72.2	9825659.8	72.2	525.0	444.3	-20	460	55089
8807.0262	68.65	78.22	82.1	9825549.8	82.1	445.5	353.8	-50	400	55864
8007.0257	68.50	78.27	127.8	9825557.1	127.8	686.0	543.1	-10	550	56781
8007.0268	68.23	78.73	22.4	9825407.3	22.4	378.0	352.9	0	350	56374
8007.0259	68.37	78.42	29.6	9825661.6	29.6	567.6	534.6	10	520	57445
8007.0261	68.51	78.50	158.0	9825402.2	158.0	618.1	441.5	-30	470	56331
8807.0272	68.36	78.55	40.9	9825596.3	40.9	543.4	497.6	0	500	58140
8807.0258	68.47	78.41	137.3	9825460.3	137.3	637.0	483.5	0	480	58367
8007.0264	68.50	78.10	73.7	9825768.4	73.7	730.3	647.9	0	650	55537
8007.0115	68.56	77.93	52.1	9825808.1	52.1	666.5	608.2	0	610	55902
8007.0267	68.31	78.64	15.9	9825550.8	15.9	451.7	434.0	0	430	58706

Table 2

DAVIS GRAVITY STATION TIE RESULTS

STATION	BMR STATION NUMBERS A	B	NUMBER OR METERS	GRAVITY DIFFERENCE (A-B) ums^{-2}	n	standard devation ums^{-2}	standard error of mean
Davis B-C	6905.0020	6905.0021	2	10.87	17	.11	.03
Davis C-D	6905.0021	8007.0000	2	31.92	16	.11	.03

Table 3

a) GRAVITY STATION 6905.0020 to NMB/S/4 LEVELLING

FROM	TO	FALL
NATMAP survey (D. Carstens)	NMV/S/4	4,824 m
Point marked with 0.25 m pipe.	Natural cross in rock.	0.205 m
	Depression by cross.	0.329 m
	(Taken to be 6905.0020)	

b) NATMAP SURVEY POINT NMV/S/5

Was 10 metres from the seawater's edge @ 0400 GMT on 07-01-81.