BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

Record 1982/10

Third-order Magnetic Survey of Yorke Peninsula SA February 1982

by

A.J. McEwin

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SUMMARY

Third-order magnetic measurements of horizontal intensity, total intensity and declination were made at twenty-eight stations on Yorke Peninsula, in February 1981. This completes the coverage of South Australia and is a continuation of the third-order magnetic survey to chart features of the regional magnetic field having dimensions of 50-100 kilometres within Australia.

1. INTRODUCTION

In 1967 the third-order magnetic survey of Australia was begun (van der Linden, 1970). The object is to chart features of the regional magnetic field having dimensions of 50-100 km. It is a once only evaluation of the morphology of the regional field, the station spacing being nominally 15 km along roads, to average about 35 km overall.

A third-order station is defined by map coordinates and the magnetic field is measured only once with an accuracy of 20 nT. On this scale diurnal variations represent minor noise on the internal field signal and can be ignored. See Appendix 1 for BMR classifications of magnetic surveys.

Previous third-order road surveys in 1968, 1970, 1972 had covered most of the easily accessible areas in South Australia. Remote desert areas were covered by helicopter during 1975. This left Yorke Peninsula as the only area in South Australia not covered.

This record describes the third-order road survey of Yorke Peninsula in which twenty-eight stations (Figure 1) were occupied during 22-24 February 1982 by A. McEwin and J. Vahala.

2. OPERATIONS

Topographic maps at 1:250 000 were prepared before the survey, and station positions were plotted at intervals of 15 km along selected roads within the area. Stations were then deleted from this excess number, and the position of others was adjusted so that the average station interval was 20 km and they could be occupied with minimal travelling (Figure 1). This spacing is less than the overall average of 35 km for previous surveys.

Pre-survey instrument comparisons were carried out (Table 1) and the following instruments were used during the survey: Quartz Horizontal Magnetometer (QHM) serial number 306 (with QHM 288 carried

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as a backup) for the measurement of horizontal intensity (H), Austral Proton Precession Magnetometers (PPM) serial numbers 3-524 and 3-525 for total intensity (F), and Wild Compass Theodolite serial number T093794 for sunshots, from which declination (D) was derived. A list of observing equipment is included in Appendix 2.

A Datsun 200B station wagon was used for transport. The survey party of A.J. McEwin and J. Vahala left Canberra on 19 February and finished on 24 February; 28 stations were occupied in spite of cloudy conditions during the first two days. The survey returned to Canberra on 27 February.

At station 14 PPM3-524 became difficult to tune so PPM3-525 was used for the remainder of the survey.

The observing procedure followed closely that described in van der Linden (1970) but with minor differences. Each instrument was read by only one observer as has been the practice in more recent third-order surveys, one observer reading the QHM and Wild theodolite, the other pencilling and reading the PPM. Only the torsion positions of the QHM were recorded. A chronometer (stopwatch) correction was obtained at every station by reference to the time service of VNG, Lyndhurst, Victoria.

The Wild-Roelofs solar prism attachment was used for the sun-shots but with four individual sightings, two with vertical circle left and two with vertical circle right.

When the altitude of the sun was too great for direct sighting an objective pentaprism was attached to the Wild-Roelofs solar prism, In this arrangement four sightings were made, two facing the sun and two over the shoulder, to remove any error due to collimation with respect to the vertical axis of the telescope. Owing to the arrangement for attaching the Wild-Roelofs prism and the objective pentaprism, all sun shots with this combination can be made only with the vertical circle left. Errors introduced by this restriction are minor and can be ignored in third-order survey work.

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3. RESULTS

Other than a brief check of observations on the first day results were computed after the survey party returned to Canberra.

The map coordinates (to one tenth of a minute) and the elevation were entered on the observation forms and the results calculated using a Hewlett Packard 65 programmable hand calculator.

H was calculated using the program in Appendix 3. To check for errors in D, the sunshots were plotted on graph paper with time as the abscissa and the magnetic bearing of the sun as the ordinate. For the direct sightings a straight line was obtained and for the objective pentaprism sights two parallel lines.

The declination and Greenwich hour angle of the sun were extracted from the Nautical Almanac and together with UT (to one tenth of a second), latitude and longitude of the station (to one tenth of a minute) were entered into the program (Appendix 4) to give the true bearing of the sun for each of the four sightings at each station. D was obtained by subtracting this value from the magnetic bearing of the sun (as observed in the field). The four values of D for each station were then averaged. Details of the 28 stations occupied and the observed values of H, D and F are listed in Table 2. Corrected values of D are also listed; the correction adjusts compass-theodolite values to the Canberra Magnetic Observatory preliminary D standard (Ruska.4813 - 0.3').

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4. References

THE NAUTICAL ALMANAC 1982 - Her Majesty's Stationery Office, London, 1981.

VAN DER LINDEN, J., 1970 - Third-order Regional Magnetic Survey, Queensland 1967. Bureau of Mineral Resources, Australia, Record 1970/56 (unpublished).

APPENDIX 1

BMR Classification Of Regional Magnetic Stations
(1979 version)

First-order station

A first-order station is a place at which the vector magnetic field has been recorded with 'Absolute' control continuously for 2 to 4 days, at an accuracy of 5 nT or better in the absence of magnetic disturbance, and which is permanently marked and located so that re-occupation within 3 to 5 years will be possible.

(The object is to calibrate the recordings so that at least two nights' records at undisturbed levels are obtained to provide accurate secular variation data).

Second-order station

A second-order station is a place at which the vector field has been measured frequently throughout the day to an accuracy of 5 nT or better, and which is permanently marked so that re-occupation in the future may be possible.

(The object is to obtain sufficient data to account approximately for the diurnal variation when estimating the station value; abbreviated measurements at half-hourly intervals over 6 to 8 hours centred on (local) noon, and four complete measurements comprise a second-order observation).

Third-order station

A third-order station is a place at which the vector field has been measured once with an accuracy of about 20 nT and which is located only by means of a map.

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(The object is to chart features of the regional field having dimensions of 50-100 km; on this scale diurnal variations represent minor noise on the internal field signal and can be ignored).

Notes:

(a) The third-order survey is a once-only evaluation of the morphology of the regional field; station spacing is nominally 15 km along roads and tracks, and averages about 35 km overall.

(b) Second-order surveys and measurements are now made only in emergency e.g. when first-order recording cannot be obtained.

(c) The accuracies refer to low and mid-latitude stations. In high latitudes the accuracies may be lowered in accordance with the general level of disturbance.

APPENDIX 2

Observing Equipment

Declination

- Wild Compass theodolite T093794
- Wild-Roelofs solar prism
- Objective pentaprism
- Tripod
- Micronta L.C.D. digital stopwatch
  - backup : Hever split-second 60 minute stopwatch

Total intensity

- Austral PPM3-524
  - backup : Austral PPM3-525

Horizontal Intensity

- QHM306
  - backup QHM288
- QHM Circle 46 (+cork and damping magnet)
- Askania tripod
- QHM telescope
- Brass screwdriver

Time signal receiver

- Radio-Realistic DX-40

Observation forms

APPENDIX 3

HP-65 QHM Program - Card 1

Temperature + Ø

(P. Gidley)

KEY ENTRY	CODE SHOWN	COMMENTS	KEY ENTRY	CODE SHOWN	COMMENTS	REGISTERS
f PRGM	00	Clear	STO	33		R_1 Corrected
LBL	23		+	61		Temp
A	11		5	05		
R/S	84	Enter four	R/S	84		R_2 Ø
+	61	Temperatures	STO	33		
R/S	84		+	61		
+	61		4	04		
R/S	84		RCL 3	34 03	Mean - Degrees	
+	61		2	02		
4	04	Mean Temperature	+	81		
+	81		STO 3	33 03		
R/S	84	Add Temperature	RCL 5	34 05	Mean - Minutes	
+	61	Correction	2	02		
STO 1	33 01	Store	4	04		
RTN	24	End	0	00		
LBL	23		+	81	Decimal	
B	12		RCL 3	34 03	Degress Mean	
STO 2	33 02		+	61		
R/S	84		STO 3	33 03		
STO 3	3303	Enter +, -, -, +	RCL 2	34 02		
R/S	84		2	02	Mean + Degrees	
STO	33	Degrees	+	81		
+	61		STO 2	33 02		
3	03	STO + SUM in	RCL 4	34 04	Mean + Minutes	
R/S	84	Register 2	2	02		
STO	33	STO _ SUM in	4	04		
+	61	Register 3	0	00		
2	02		+	81		
g R↑	35 09	Change register to °	RCL 2	34 02	Decimal	
R/S	84		+	61	Degrees Mean	
STO 4	33 04	Add + Minutes	STO 2	33 02		
R/S	84	to Register 4	RCL 3	34 03		
STO 5	33 05		g X≤Y	35 22	Test if - Mean	
R/S	84	Add - Minutes	GTO	22	is + Mean	
STO	33	to Register 5	3	03		
+	61		g X⇄Y	35 07	Interchange	
5	05		3	03		
R/S	84		6	06	Add 360°	
STO	33		0	00		
+	61	Enter Data	+	61		
4	04	down columns	LBL	23		
R/S	84	of QHM Form	3	03		
STO	33		-	51	Take - From +	
+	61		g	35	to give 2Ø	
4	04		ABS	06		
R/S	84		2	02	Give Ø	
STO	33		+	81		
+	61		STO 2	33 02	STO 2	
5	05		RTN	24		
R/S	84					

User Instructions

1 Enter first Temperature
Press A

2-4 Enter Temperatures
Press R/S each time

5 Enter Temp Corr^n (with sign)
Press R/S

6 Enter First Degrees + Reading
Press B

7-9 Enter Degress Reading -,-,+
Press R/S each time

10 Enter 1st Minutes + Reading
Press R/S

11-16 Continue entering '+' & '-'
Minutes down QHM form colums -
pressing R/S each time

17 Last minutes entry (+) and R/S
gives Ø

APPENDIX 3

HP-65 QHM Program - Card 2

QHM 306

(P. Gidley)

KEY ENTRY	CODE SHOWN	COMMENTS	KEY ENTRY	CODE SHOWN	COMMENTS	REGISTERS
f PRGM	00 00		X	71		
LBL	23		X	71	c_2 H cos ø	
A	11		STO 7	33 07		
LBL	23		f	31		
1	01		TF 2	81	Test if 4	
.	83		GTO	22	or 2	
0	00		3	03		
0	00	c_1	LBL	23		
0	00		4	04		
1	01		RCL 5	34 05	c - log sin ø +	
					c_1t - c_2 H cos ø	
4	07		-	51		
6	08		g	35		
STO 3	33 03		ABS	06		
3	04		STO 6	33 06		
0	00	c_2	f^{-1}	32		
EEX	43		LOG	08		
1	10		ENTER	41		
0	00		f	31		
CHS	42		TF 1	61		
STO 4	33 04		GTO	22		
ENTER	41		2	02		
4	04		RTN	24		
.	83		LBL	23		
2	02	c	B	12		
			f	31		
3	09		SF1	51		
1	02					
9	09		f	31		
1	03		SF2	71		
ENTER	41		GTO	22		
RCL 2	34 02		1	01		
f	31		LBL	23		
SIN	04		3	03		
f	31	log sin ø	RCL 07	34 07		
LOG	08		2	02		
-	51		X	81		
ENTER	41		GTO	22		
RCL 3	34 03		4	04		
ENTER	41		LBL	23		
RCL 1	34 01		2	02		
X	71		RCL 6	34 06		
+	61	c - log sin ø + c_1t	ENTER	41		
STO 5	33 05		2	02		
f^{-1}	32		f	31		
LOG	08		LOG	08		
ENTER	41		+	61		
RCL 2	34 02		f^{-1}	32		
f	31		LOG	08		
COS	05		ENTER	41		
ENTER	41		RTN	24		
RCL 4	34 04					

HP-65 User Instructions

1 After running 1st card enter 2nd card then press either :

A if 2

B if 4

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APPENDIX 4

Observations of the sun for Azimuth: BMR procedure

(P.M. McGregor)

The fundamental celestial spherical triangle is defined by the three points:

Z - the zenith, fixed by the plumb-bob

P - the (south) celestial pole

S - the sun's centre

The angle Z is the angle between the NS meridian plane and the vertical plane containing the sun i.e. it gives the true bearing of the sun. Therefore the triangle SPZ has to be solved to give Z.

We know, or can find out:

$ZP = 90 - \phi$ where ϕ = latitude

$SP = 90 - d$ where d = sun's declination

t = sun's local hour angle

The last two are obtained from the Nautical Almanac (NA) for the UT date and time of the sun shot. The NA shows (d) as Dec, N (North) or S (South); in order to make the side PS greater than 90° (winter) or less than 90° (summer) we use this convention for the sign of (d):

Dec North, d Negative

The angle (t) is the angular distance of the sun from the meridian (morning shot), or the angular distance of the sun after the meridian (afternoon shot) i.e. it is the time to or from meridian transit, which is called the local hour angle (LHA).

The NA tabulates values of GHA (values at the UT hour in the body of the NA, interpolation tables for minutes and seconds at the back); GHA is the angle westwards from the Greenwich meridian to the sun's meridian. The LHA is calculated from the longitude of the observation point via:

$t = \pm(\text{GHA} + \text{east long} - 360^\circ)$

It will range from about $+60^\circ$ (8 am) to -60° (4 pm); we need only its magnitude.

The equation for the derivation of Z in terms of the two sides PS and PZ and the angle t is:

$\cot Z = (\cot(90 - d)\sin(90-\phi) - \cos(90-\phi)\cos t)/\sin t$

which reduces to:

$\cot Z = (\tan d \cos \phi - \sin \phi \cos t)/\sin t$.

The only convention to remember is that for the sign of (d) - (North-Negative). A program has been written for the HP-65 pocket calculator based on this equation and convention (see attachment). It requires the entry of: latitude, longitude, UT, GHA at hour of UT, declination. The answer will be expressed as a positive or negative angle. If the answer is Negative the sun's bearing is counted from the North; if the answer is positive the bearing is from the south.

It is unwise and unnecessary to try to give rules which define which quadrant the sun lies in, and which will cover all situations. Instead a diagramatic plan view should be drawn showing the computed sun's bearing, the circle readings of the sun and reference mark(s), and the derived azimuth of the reference mark. It is re-iterated that the adopted sign convention fixes the datums for the bearing; which side of the meridian it lies is of course fixed by whether the sun-shot was made in the local morning of afternoon.

Note: beware of daylight saving adjustments when deriving local noon.

HP-65 PROGRAM

Observation of the sun for Azimuth

(G.R. Small)

KEY ENTRY	CODE SHOWN	COMMENTS	KEY ENTRY	CODE SHOWN	REGISTERS
LBL	23	Program A lat. long.	STO 2	33 02	
A	11		RCL 6	34 06	
DSP	21	- enter latitude and	1	01	
6	06	longitude as	5	05	
f^{-1}	32	DEC,MIN SEC convert	x	71	
→DMS	03	to decimal degrees	RCL 5	34 05	
STO 8	33 08		+	61	R_3 declination
R/S	84		RCL 7	34 07	increment
f^{-1}	32		+	61	
→DMS	03		3	03	R_4 Sun's declin^n
STO 7	33 07		6	06	
RTN	24		0	00	
LBL	23	Program B	-	51	R_5 GHA
B	12		g	35	
f^{-1}	32	- enter UT HR.MIN SEC	ABS	06	
→DMS	03	(tenths) convert to	STO 1	33 01	R_6 UT
f^{-1}	32	decimal hours	RCL 2	34 02	fractional
INT	83		f	31	part only
STO 6	33 06		TAN	06	R_7 Longitude
RTN	24		RCL 8	34 08	
LBL	23	Program C	f	31	
C	13		COS	05	R_8 Latitude
f^{-1}	32	- enter GHA DEG.MIN SEC	x	71	
→DMS	03	convert to decimal	↑	41	
STO 5	33 05	degrees	RCL 8	34 08	
RTN	24		f	31	
LBL	23	Program D	SIN	04	
D	14		RCL 1	34 01	
f^{-1}	32	- enter sun's	f	31	
		declination			
→DMS	03	DEC.MIN SEC convert	COS	05	
STO 4	33 04	to decimal degree	x	71	
R/S	84		-	51	
6	06	- enter declination	RCL 1	34 01	
0	00	increment	f	31	
+	81		SIN	04	
STO 3	33 03		+	81	
RTN	24		g	35	
LBL	23	Program E	1/x	04	
E	15		f^{-1}	32	
RCL 3	34 03	- compute Azimuth	TAN	06	
RCL 6	34 06		f	31	
x	71		→DMS	03	
RCL 4	34 04		RTN	24	
+	61				

User Instructions

1 Enter latitude in DEG.MIN SEC
- Press A (South positive)

2 Enter longitude in DEG.MIN SEC
- Press R/S

3 Enter UT HR.MIN SEC TENTH
- Press B

4 Enter GHA of hour (UT) from Almanac
DEG.MIN SEC
- Press C

5 Enter Sun declination of hour (UT) of
observation from Almanac
DEG.MIN SEC
SOUTH POSITIVE -
- Press D
Enter increment d from Almanac for declination
SOUTH-POSITIVE
- Press R/S

6 Calculate Azimuth - Press E
answer in DEG.MIN SEC

TABLE 1.

MAGNETOMETER COMPARISONS

Canberra Magnetic Observatory

Date	Inst A	Inst B	Difference A - B	No.
QHM (Simultaneous)				
11-2-82	462	288	-25.5 ± 1.2nT -0.00108H	2
	462	306	-13.4 ± 2.7nT -0.00057H	2
3-3-82	460	288	-25.1 ± 1.4nT -0.00105H	6
4-3-82	462	306	-20.7 ± 0.8nT -0.00087H	4
	461	288	-29.4 ± 0.7nT -0.00123H	4
5-3-82	461	288	-29.3 ± 1.2nT -0.00123H	6
Wild TO 93794 (through baselines)			Correction to D	
3-2-83	Ruska 4813	TO93794	42.8'	
4-3-82	Ruska	TO93794	39.2'	
			Mean 41.0'	
Proton Precession Magnetometers (through baselines)				
22-12-81	MNS 2/3	Austral 524	-2.1nT	
11-2-82 (Simultaneous)	Austral 524	Austral 525	0nT	
9-3-82	MNS 2/3	Austral 524	-3.1nT	
	MNS 2/3	Austral 525	-3.8nT	

Instrument A is the Observatory standard magnetometer

Instrument B is the field magnetometer

Preliminary D standard = Ruska 4813 - 0.3'

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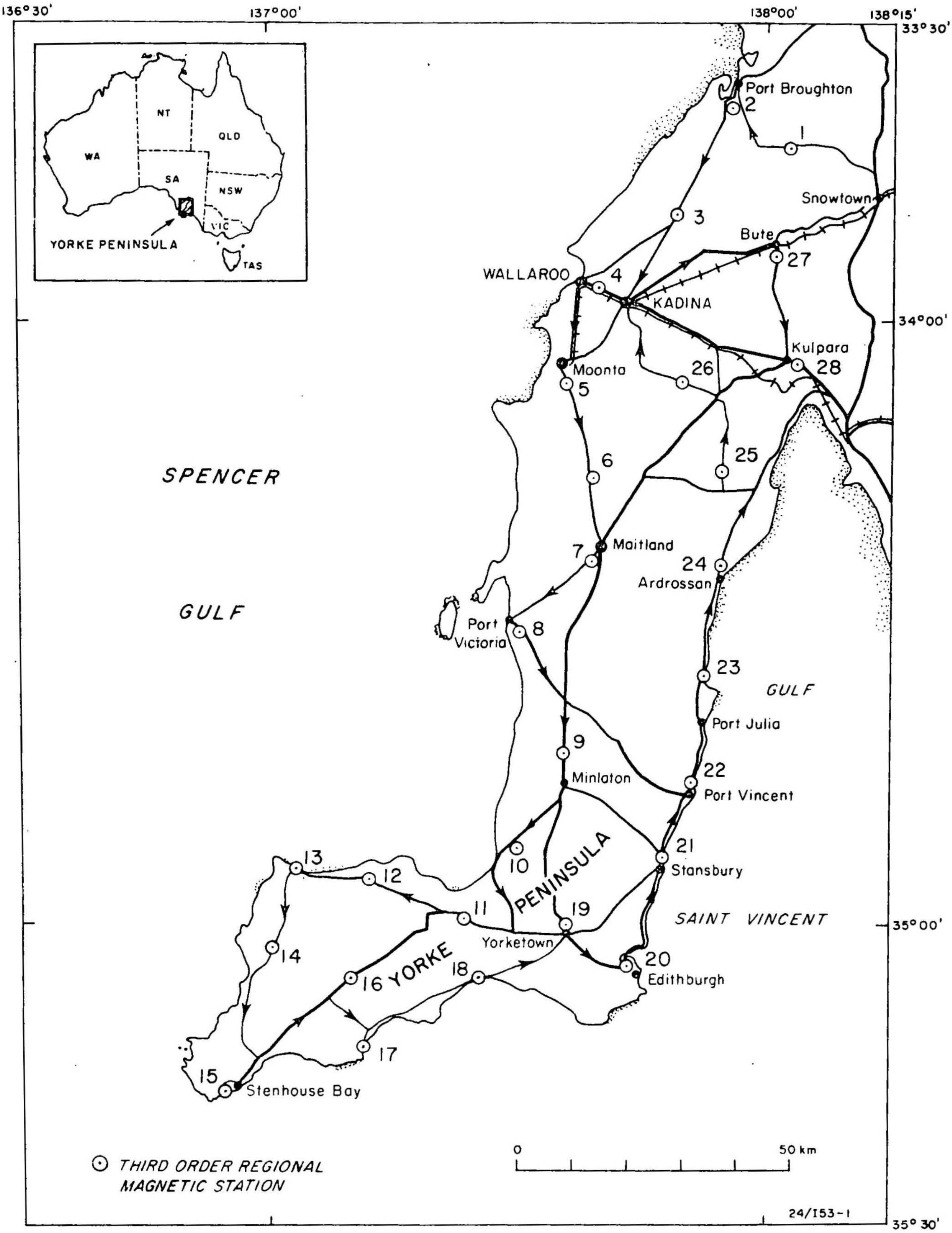
TABLE 2.

RESULTS - THIRD-ORDER SURVEY YORKE PENNINSULA FEB 82

					Observed			Corrected
Stn	Date 1982	Time (UTC)	Lat (S) ° '	Long (E) ° '	H nT	F nT	D ° '	D ° '
1	Feb 21	2320	33 42.7	138 02.2	24204	59563	7 11.7	7 52.7
2	Feb 22	0007	33 38.5	137 55.1	24280	60833	7 33.3	8 14.3
3		0045	33 50.3	137 49.0	23588	61366	7 14.9	7 55.9
4		0131	33 56.4	137 39.3	24351	60681	6 7.5	6 48.5
5		0514	34 05.8	137 36.0	23819	60808	6 22.9	7 03.9
6		2211	34 15.2	137 38.8	24144	61415	9 0.8	9 41.8
7		2257	34 23.7	137 39.5	23031	60171	7 26.7	8 07.7
8		2358	34 31.3	137 30.7	22647	59872	5 52.2	6 33.2
9	Feb 23	0049	34 43.0	137 35.7	23192	60615	6 55.4	7 36.4
10		0127	34 52.2	137 30.2	22595	60355	6 44.5	7 25.5
11		0200	34 59.6	137 23.8	22065	60289	5 28.9	6 09.9
12		0240	34 55.6	137 12.1	22238	59631	4 7.8	4 48.8
13		0306	34 54.6	137 03.3	22601	59368	5 52.4	6 33.4
14		0336	35 02.8	137 00.8	22883	59742	6 4.3	6 45.3
15		0423	35 17.0	136 54.1	22490	59875	6 1.0	6 42.0
16		0514	35 05.4	137 09.9	22574	59532	5 8.5	5 49.5
17		0550	35 12.7	137 11.4	22612	59931	5 59.3	6 40.3
18		0622	35 05.6	137 25.9	22541	59914	5 46.4	6 27.4
19		0650	35 00.6	137 36.2	22601	59899	6 40.5	7 21.5
20		2202	35 04.6	137 43.4	22689	59975	5 37.4	6 18.4
21		2247	34 53.8	137 47.8	22973	60829	5 13.0	5 54.0
22		2326	34 46.6	137 51.3	23142	60208	4 39.4	5 20.4
23		2354	34 35.3	137 52.6	23088	59944	4 5.1	4 46.1
24	Feb 24	0036	34 24.4	137 54.9	23093	60527	5 17.5	5 58.5
25		0110	34 14.5	137 55.0	23596	59421	7 37.7	8 18.7
26		0141	34 05.8	137 49.2	23443	59460	8 18.2	8 59.2
27		0303	33 52.6	138 00.7	23998	60362	5 00.7	5 41.7
28		0335	34 03.9	138 02.9	23769	59836	4 56.8	5 37.8



136°30'
137°00'
138°00'
138°15'
33°30'
34°00'
35°00'
35°30'
NT
QLD
WA
SA
NSW
VIC
TAS
YORKE PENINSULA
Port Broughton
Snowtown
Bute
WALLAROO
KADINA
Kulpara
Moonta
Maitland
Ardrossan
Port Victoria
Port Julia
Minlaton
Port Vincent
Stansbury
Yorketown
Edithburgh
Stenhouse Bay
SPENCER
GULF
GULF
SAINT VINCENT
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PENINSULA
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THIRD ORDER REGIONAL MAGNETIC STATION
0
50 km
24/I53-1