GEOMAGNETIC REPORT - DAVIS AND CASEY, 1994

BY

A.J. GIFFEN

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Geomagnetic Report Davis and Casey

1994

A.J. Giffen

Geomagnetism Section
Geophysical Observatories and Mapping Division, AGSO

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SUMMARY

Casey and Davis are Australian National Antarctic Research Expedition bases on the Antarctic mainland managed by the Australian Antarctic Division. Geomagnetic observations have been made at both bases, in cooperation with the Australian Geological Survey Organisation, since the early 70s to provide information on the secular variation of the magnetic field. The magnetic observations and recording carried out by the ANARE expeditioners during 1994 were processed by AGSO's observer at Mawson. Results indicate the secular variation of the field at Casey was relatively unchanged over the year, while the field at Davis has decreased by some 30 nT in total field strength, and moved westerly by some 8 minutes in declination.

CHAPTER 1. INTRODUCTION

The geomagnetic program at Davis and Casey is conducted in association with the Auroral and Space Physics (ASP) section of the Australian Antarctic Division. The Antarctic Division purchased, installed and now operate EDA FM100 fluxgate magnetometers at both stations to assist upper atmospheric physics investigations. The variometers are not calibrated to observatory standard. However using the digital variation data in association with absolute observations provides much better estimates of monthly field values than relying on absolute observations alone.

In 1994 absolute measurements were nominally performed twice a month at Casey and 4 times a month at Davis in order to calibrate the variometers. At Davis the observer was Pelham Williams (1994 ASP physicist) and at Casey the observer was Miro Dubovinsky (1994 ASP Physicist). Absolute instrument comparisons were performed at Davis in the 1993/94 summer by Adrian Giffen and at Casey in the 1994/95 summer by Suzanne Barr, using AGSO's travelling instrument standards.

The variometer output was logged as 10s data by ASP's LSI11 computers on station, using a routine called LOGIT which is common to several of ASP's experiments. The data are collected in daily files and are periodically telemetered back to the VAX network at the Antarctic Division. These files are then archived some days/weeks later.

The monthly averages derived by AGSO for Davis and Casey, and published in the Australian Geomagnetism Report, are averages of the 5 Quiet Days as determined from Mawson data. Once the Mawson Quiet Days are determined (using K indices), the Casey and Davis digital data are averaged over those 5 days. Software on the VAX can be used to calculate an average of a daily data file; the procedure is outlined in detail in de Deuge 1992.

CHAPTER 2. VARIOMETER EQUIPMENT

The variometer systems at Davis and Casey consist of EDA FM100 fluxgate magnetometers measuring X,Y and Z aligned along geographic north, east and the zenith, respectively. They were bought , installed and operated by Antarctic Division. The analogue output signal is passed through a signal conditioner and A/D converter before being logged as 10s digital data by ASP's LSI11 computer using the LOGIT software. The system is described by two separate equations and sets of parameters so that changes to either the magnetometer or conditioner/converter can be maintained as direct changes to only the relevant parameters. The terminology used in the ASP monthly magnetometer reports is adopted here for ease of reference to the ASP system in future work.

The first equation characterises the signal conditioner and A/D converter and gives the magnetometer output voltage in terms of the logged digital value. It is determined only by the status of the conditioner and converter hardware and the parameters are determined in annual calibrations. For the X component, the first equation is:

$$\mathbf{V_X = (D_X - Off_X) / (205*G_X)}$$

where V_X = the analogue output from the magnetometer, in volts.
D_X = the recorded digital value.
Off_X = the offset value,
ie. the digital value recorded when the magnetometer output is 0V.
G_X = the gain of the signal through the conditioner/converter in digits/volt.

The second equation characterises the magnetometer only; it gives the value of the magnetic field corresponding to a given magnetometer output voltage. For the X component it is:

$$\mathbf{B_X = S_X * V_X + BL_X}$$

where B_X = value of the magnetic field, in nT.
S_X = sensitivity of the magnetometer, in nT/volt.
BL_X = the baseline value in nT,
ie. the value of the field when the magnetometer output is 0V.

Combining these, the equation for the complete system is:

$$\mathbf{B_X = SV_X * D_X + Int_X}$$

where $\mathbf{SV_X}$ $= \mathbf{S_X / (205*G_X)}$.
= the scale value for the complete system, in nT/digit.

and $\mathbf{Int_X}$ $= \mathbf{BL_X - SV_X*Off_X}$.
= the value of the field when the system output is 0 digital units.

The signal conditioner and A/D converter parameters are determined by applying a series of input voltages and recording the digital output. Linear regression is performed on a set of voltages covering the full range of digital values and these calibrations are performed annually.

During 1994 the LOGIT system was operated in parallel with a new Antarctic Division logging system called ADAS. Very good comparison results were obtained between the two systems and the ADAS system will be used exclusively from January 1995 onwards.

CHAPTER 3. ABSOLUTE OBSERVATIONS & REDUCTIONS

Absolute magnetic observations were performed approximately twice per month at Casey and 4 times per month at Davis during 1994. The standard instruments were a Declination Inclination Magnetometer (DIM), purchased by the Antarctic Division, and a proton precession magnetometer (PPM), supplied by AGSO, at both stations. Zero instrument corrections in D and I for the DIMs have been adopted in both cases. F corrections from the most recent comparison have been both adopted for each PPM. They are -9.8 nT for G816/1023 at Casey, and +0.6 nT for G816/1025 at Davis. There was a three month period from September to November 1994 during which the physicist at Davis was unable to perform observations for medical reasons. A Quartz Horizontal Magnetometer (QHM) is provided by AGSO at both stations to maintain a backup capability.

Raw magnetic absolute observations were reduced by the ASP personnel on station using ASP software. The ASP reduction procedures are less rigorous than those used by AGSO but are adequate considering that both magnetic stations are not run at observatory standard. Only two sets of digital values are referenced; the X, Y, and Z averages over the entire period of the H and D observations for a QHM, or D and I observations for a DIM, and the X, Y, and Z averages over the entire period of the F observation. AGSO observatories used 1 second variometer data to reduce absolute observations. For an explanation of the absolutes reduction methodology, see ASP's " Fluxgate Magnetometer Annual Report and Calibration Davis 1993" (Parcell).

The 1994 fluxgate annual reports by Williams and Dubovinsky for Davis and Casey, respectively, include graphs of variometer baselines from absolutes and final magnetometer equations covering 1994. For the purposes of this report the magnetometer scale values and A/D offset and gains presented in these reports have been adopted; new baseline values were however determined.

CHAPTER 4. DAVIS

4.1 Davis Absolute Instruments

In late 1992 a DIM was purchased by ASP, compared against the Australian standards at Canberra by AGSO, and has been used as the primary absolute instrument since 1993. The QHM was used as a backup and comparison instrument. Details of the instruments, parameters and corrections for 1994 are given in Table 1.

Table 1. Absolute Instrument Parameters and Corrections for Davis, 1994

DAVIS	
DIM	**E810/2592 (or 2506** - has 2 serial numbers)
Theodolite	**355939**
D correction	0.0' (compared at Davis in Dec 93)
I correction	0.0' (compared at Davis in Dec 93)
QHM	**492** (arrived late 1992)
Circle	QHM circle 73
QHM constant, K	7659 nT
" " k1	42.9 x 10^{-5} °C^{-1}
" " k2	115 x 10^{-10} nT^{-1}
H correction	-8.0 nT (compared at Davis in Dec 1993)
Collimation angle	-8.0'
D correction	0.0' (compared at Davis in Dec 1993)
Thermometer	**N152**
Thermometer correction	+0.05 °C @ 0 °C +0.15 °C @ 10 °C +0.20 °C @ 20 °C
PPM	**G816/1025** (arrived Nov 93)
F correction	0.6 nT (compared at Canberra in Nov 93)
Pier	**C** in absolute hut used for H, D, I, and F
Main azimuth mark	**PP** (erected Dec 1990)
Azimuth of mark	312° 0.8'

4.2 Davis Instrument Comparisons.

Recent comparisons for the Davis instruments are summarised below in Table 2:

Table 2. Instrument Comparisons for Davis

2 .1 Horizontal Field Comparisons - Corrected for H = 16760 nT at Davis

Date	*Primary Instrument A*	*Secondary Instrument B*	*A-B*
10/11/93 & 24/3/94 at CMO	QHMs 460, 461, 462 [1]	QHM 172, circle 508813 [2]	-41.6 ± 1.2 nT
29/10/93 & 6/4/94 at CMO	QHMs 460, 461, 462 [1]	HTM 704, circle 508813	4.2 ± 1.0 nT
5/12/93 at Davis	HTM 704, circle 508813	QHM 492, circle 73	-10.4 ± 0.5 nT
5/12/93 at Davis	HTM 704, circle 508813	DIM 2506	-1.9 ± 1.4 nT

[1] There is an additional correction for QHMs 460, 461 and 462 of -0.00010 * H = -1.68 nT

[2] Only 2 QHM 172 observations were available at Davis as others were lost. HTM 704 results for H are more reliable and will be used for the H comparison.

2.2 Declination Comparisons.

Date	*Primary Instrument A*	*Secondary Instrument B*	*A-B*
11/11/93 & 11/4/94 at CMO	Ruska	Dec 505, circle 508813	-0.2' ± 0.4'
3/12/93 &5/12/93 at Davis	Dec 505, circle 508813	DIM 2506	+0.5' ± 0.5'
3/12/93 &5/12/93 at Davis	Dec 505, circle 508813	QHM 492, circle 73	0.0' ± 1.3'

2.3 Total Field Comparisons.

Date	*Primary Instrument A*	*Secondary Instrument B*	*A-B*
12/11/93 at CMO	MNS2.3X	PPM G816/1025	+0.6 ± 0.3 nT

The corrections adopted for 1994 to bring the Davis standard instrument combination of DIM 2506 and PPM G816/1025 into line with the Australian standards are :

D : 0.0' **I : 0.0'** **F : +0.6 nT**

In terms of X, Y and Z these are : **X : 0.0 nT** **Y : -0.2 nT** **Z : -0.6 nT**

4.3 Davis Baselines

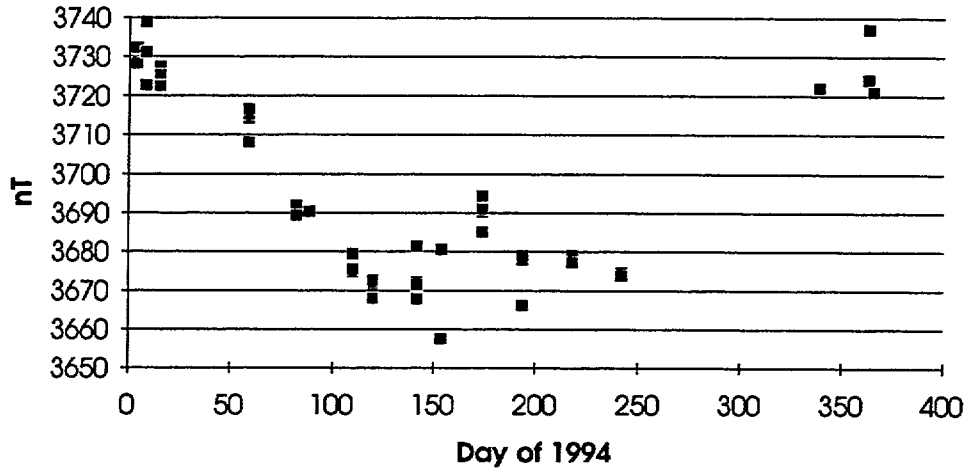
The baseline values quoted in the Davis 1994 Report (Williams) were adopted by ASP for purposes of their research. New baseline values were adopted by AGSO for the requirement of producing quiet day monthly averages. These are given in table 3 without the DIM/PPM correction applied. The baseline observations for the year are given in graphs 1 to 3.

Table 3. Davis adopted baseline values for 1994

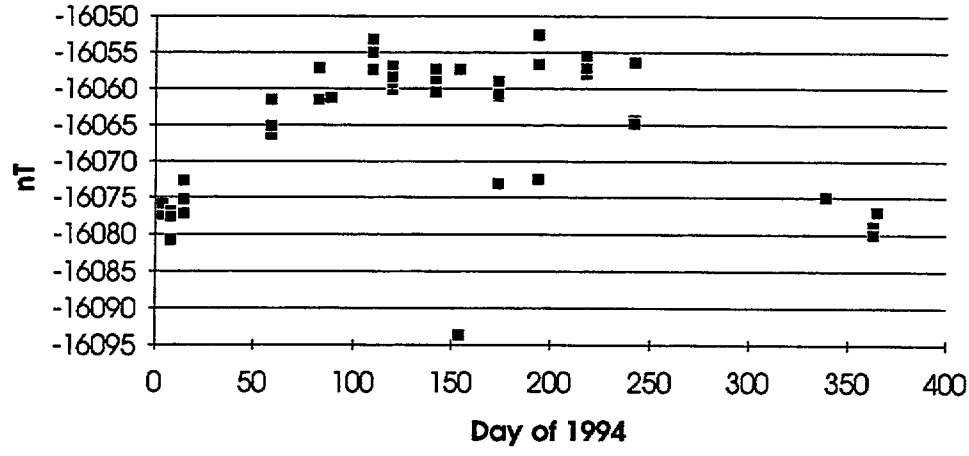
Component	*Period (1994)*	*Days of 1994*	*Baseline*
X	1 Jan - 28 Feb	1 - 59	BL_X= 3730 - 0.271*(DOY-1)
X	1 Mar- 29 Apr	60 - 119	BL_X= 3714 - 0.717*(DOY-60)
X	30 Apr - 23 Jun	120 - 174	BL_X= 3671 + 0.327*(DOY-120)
X	24 Jun - 30 Aug	175 - 242	BL_X= 3689 - 0.221*(DOY-175)
X	31 Aug - 31 Dec	243 - 365	BL_X= 3674 + 0.472*(DOY-243)
Y	1 Jan - 24 Feb	1 - 91	BL_Y= -16078 + 0.231*(DOY-1)
Y	25 Feb - 26 May	92 - 248	BL_Y= -16057
Y	27 May - 31 Dec	249- 365	BL_Y= -16057- 0.197*(DOY-249)
Z	1 Jan - 5 Sep	1 - 248	BL_Z= -52170 - 0.040*(DOY-1)
Z	6 Sep - 31 Dec	249 - 365	BL_Z= -52180 +0.103*(DOY-249)

where : DOY = Day of year 1994. 1 January is day 1.

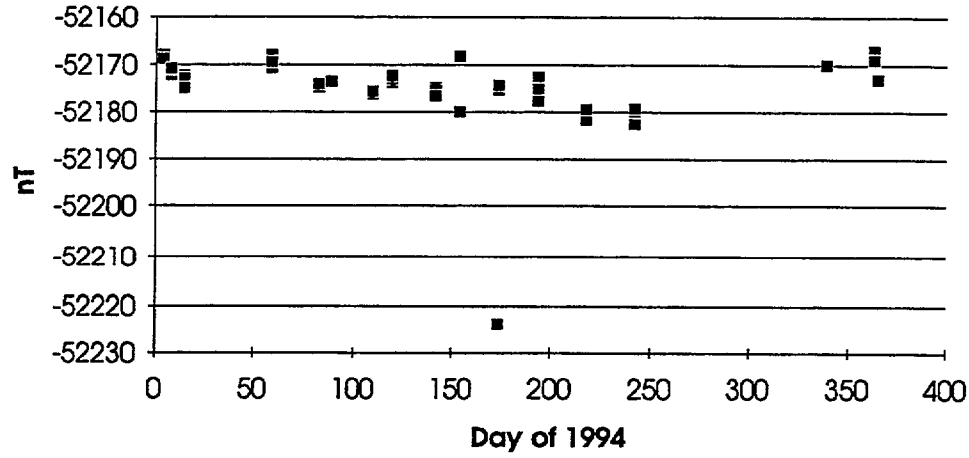
Graph 1 Davis X Baseline Observations



Graph 2 Davis Y Baseline Observations



Graph 3 Davis Z Baseline Observations



CHAPTER 5. CASEY

5.1 Casey Absolute Instruments

In late 1992 a DIM was purchased by ASP, compared against the Australian standards at Canberra by AGSO, and has been used as the primary absolute instrument since 1993. The QHM was used as a backup and comparison instrument. Details of the instruments, parameters and corrections for 1994 are given in Table 4.

Table 4. Absolute Instrument Parameters and Corrections for Casey, 1994

CASEY		
DIM Theodolite D correction I correction	**E810/2591** **356514** 0.0' (compared at CMO [1] Aug 92) 0.0' (compared at CMO [1] Aug 92)	
QHM Circle QHM constant, K " " k1 " " k2 H correction Collimation angle D correction **Thermometer** Thermometer correction	**493** (arrived early 1992) QHM circle 94 7624 nT 41.2x 10^{-5} °C^{-1} 140 x 10^{-10} nT^{-1} -3 nT (compared at CMO [1] in Sep 1992). 70.8' -10.3' (compared at CMO [1] in Sep 1992). **1084** -0.05 °C @-20 °C -0.10 °C @-10 °C -0.05 °C @ 0 °C -0.05 °C @ 10 °C 0.00 °C @ 20 °C	
PPM F correction	**G816/1023** -9.8 nT (compared at Casey in Nov 94)	
Pier Pier difference	**A** in mag obs hut for H & D. -423 nT in F. (maghut - magapple)	pier in **magapple** for F.
Main azimuth mark Azimuth of mark	**G11** 307° 41.03'	

[1] CMO is the Canberra Magnetic Observatory

5.2 Casey Instrument Comparisons

Recent comparisons for the Casey instruments are summarised below in Table 5.

Table 5. Instrument Comparisons for Casey

5.1 Horizontal Field Comparisons - Corrected for H = 9600 nT at Casey

Date	*Primary Instrument A*	*Secondary Instrument B*	*A-B*
25/9/91 at CMO	CMO Baselines.	QHM 493, circle 73	-3 ±1 nT

5.2 Declination Comparisons

Date	*Primary Instrument A*	*Secondary Instrument B*	*A-B*
25/9/91 at CMO	CMO Baselines.	QHM 493, circle 73	+80.8' ± 0.1'
20/8/92 at CMO	CMO Baselines.	DIM 810/2591	0.0' ± 0.5'

5.3 Total Field Comparisons

Date	*Primary Instrument A*	*Secondary Instrument B*	*A-B*
31/08/94 at CMO	MNS 2.3X	PPM E770/210	+1.2 ± 0.3 nT
30/10/94 at Casey	PPM E770/210	PPM G816/1023	-11.1 ± 3.5 nT
01/11/94 at Casey	PPM E770/210	PPM G816/1023	-10.5 ± 1.1 nT
23/05/95 at CMO	MNS 2.3X	PPM E770/210	+0.8 ± 0.2 nT

The corrections adopted for 1994 to bring the Casey standard instrument combination of DIM 2591 and PPM G816/1023 into line with the Australian standards are :

D : 0.0' I : 0.0' F : -9.8 nT

In terms of X, Y and Z these are : **X : +0.1 nT Y : +1.5 nT Z : +9.7 nT**

In addition to the DIM/PPM instrument correction there is also a pier difference which must be applied to all DIM/PPM readings to correct for the different height between DIM and QHM observations. The determination of this pier difference in January 1995 gave inconclusive results and hence the results from January 1994 (Symons and Dubovinsky) will be used. The corrections must be applied to all DIM/PPM observations to make them equivalent to observations at the height of a QHM, which until 1993 was the standard instrument at Casey. The corrections are :

D : +15.1' I : +0.2' F : +45.0 nT

In terms of X, Y and Z these are : **X : +42.0 nT Y : -11.5 nT Z : -44.0 nT**

The above instrument correction and pier difference have been applied to the mean field values presented in this report.

5.3 Casey Baselines

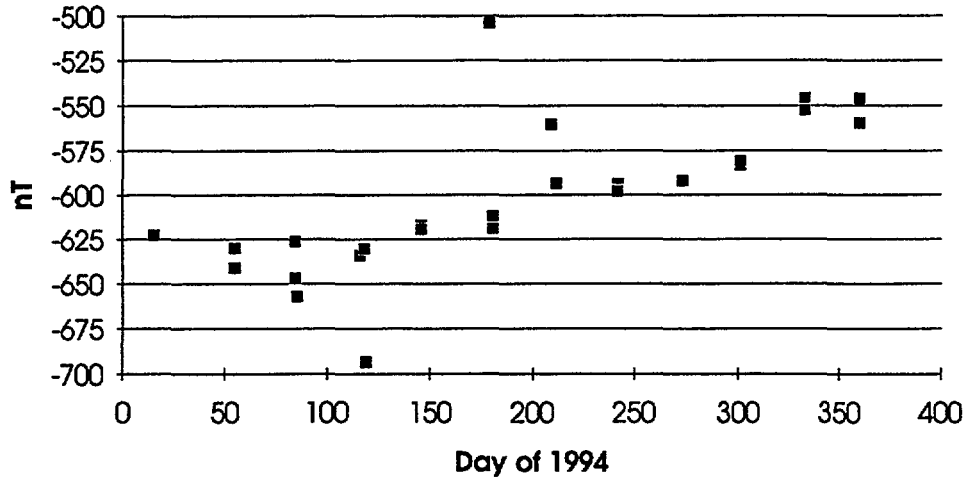
The baseline values quoted in the Casey 1994 Report (Dubovinsky) were adopted by ASP for purposes of their research. New baseline values were adopted by AGSO for the requirement of producing quiet day monthly averages. These are given in table 6 with the pier difference applied but not the DIM/PPM instrument correction. The baseline observations for the year are given in graphs 7 to 9.

Table 6. Adopted baseline values for Casey, 1994

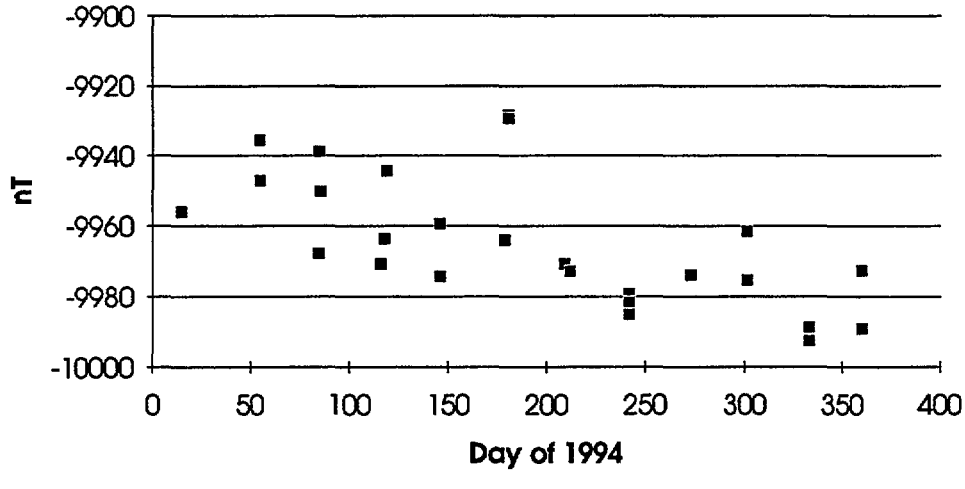
Component	*Period (1994)*	*Days of 1994*	*Baseline*
X	1 Jan - 26 Mar	1 - 85	BL_X= -618 - 0.224*(DOY-1)
X	27 Mar- 28 Oct	86 - 301	BL_X= -637 + 0.255*(DOY-86)
X	29 Oct - 29 Nov	302 - 333	BL_X= -582 + 1.000*(DOY-302)
X	30 Nov - 31 Dec	334 - 365	BL_X= -550
Y	1 Jan - 24 Feb	1 - 55	BL_Y= -9960 + 0.382*(DOY-1)
Y	25 Feb - 26 May	56 - 146	BL_Y= -9939 - 0.308*(DOY-56)
Y	27 May - 31 Dec	147- 365	BL_Y= -9967 - 0.050*(DOY-147
Z	1 Jan - 31 Dec	1 - 365	BL_Z= -64112

where : DOY = Day of year 1994. 1 January is day 1.

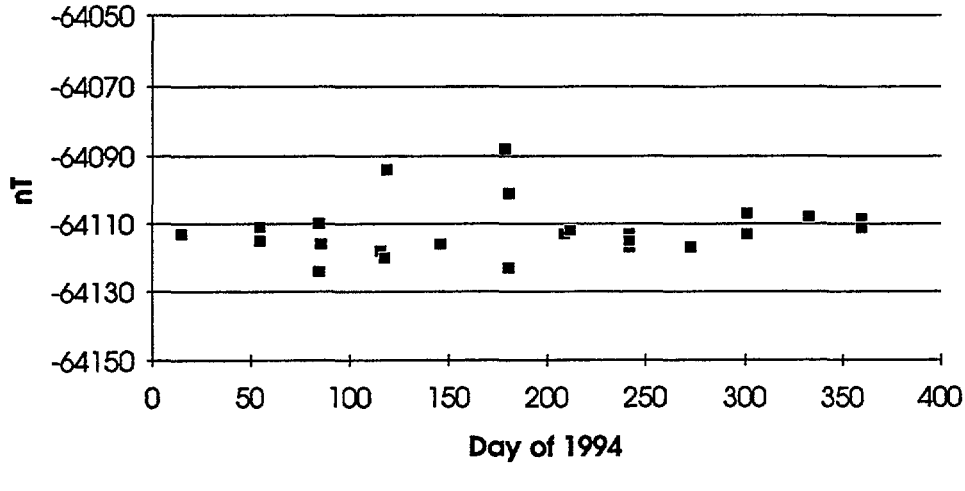
Graph 4 Casey X Baseline Observations



Graph 5 Casey Y Baseline Observations



Graph 6 Casey Z Baseline Observations



CHAPTER 6. MONTHLY QUIET DAY AVERAGES

The quiet day averages for Davis and Casey are derived for the 5 days which have been determined as quiet days from the Mawson data. This assumes that the level of magnetic activity varies in the same way at all three stations; which may not always be true. Apart from determining K indices for every day at all three stations, which is considered unfeasible, this is an acceptable approximation to make.

Tables 7 and 8 below give the 1994 monthly quiet day averages for Davis and Casey using:

- variometer data provided by ASP
- scale, offset and gain values given by Dubovinsky and Williams
- baseline values given in tables 3 and 6.
- instrument corrections determined by AGSO.

Table 7. Casey 1994 Monthly 5 Quiet Day Averages

	X (nT)	*Y (nT)*	*Z (nT)*	*F (nT)*	*H (nT)*	*D (deg)* [1]	*I (deg)*
Jan	-385	-9624	-63817	64540	9632	-92.291	-81.417
Feb	-386	-9612	-63818	64539	9619	-92.302	-81.428
Mar	-378	-9625	-63840	64563	9632	-92.247	-81.420
Apr	-391	-9616	-63847	64569	9624	-92.330	-81.428
May	-392	-9610	-63852	64572	9618	-92.337	-81.434
Jun	-392	-9626	-63833	64556	9634	-92.330	-81.418
Jul	-387	-9619	-63823	64545	9627	-92.301	-81.422
Aug	-387	-9617	-63819	64541	9625	-92.307	-81.424
Sep	-383	-9624	-63808	64531	9632	-92.281	-81.416
Oct	-358	-9634	-63805	64529	9641	-92.130	-81.408
Nov	-379	-9628	-63812	64536	9635	-92.256	-81.414
Dec	-389	-9620	-63817	64539	9628	-92.313	-81.421
Annual	**-384**	**-9621**	**-63824**	**64547**	**9629**	**-92.285**	**-81.421**

[1] Monthly quiet day averages for D given in Rada (1994) must be multiplied by -1 to give the correct D.

Table 8. Davis 1994 Monthly 5 Quiet Day Averages

	X (nT)	*Y (nT)*	*Z (nT)*	*F (nT)*	*H (nT)*	*D (deg)*	*I (deg)*
Jan	3529	-16365	-51800	54438	16742	-77.832	-72.089
Feb	3521	-16379	-51808	54449	16753	-77.868	-72.080
Mar	3513	-16388	-51830	54473	16761	-77.900	-72.080
Apr	3500	-16397	-51818	54463	16767	-77.953	-72.070
May	3507	-16392	-51814	54459	16763	-77.925	-72.072
Jun	3504	-16400	-51806	54452	16770	-77.939	-72.063
Jul	3515	-16407	-51797	54447	16779	-77.909	-72.051
Aug	3504	-16407	-51794	54443	16777	-77.945	-72.052
Sep [2]	3500	-16410	-51791	54441	16779	-77.960	-72.049
Oct [2]	-	-	-51799	-	-	-	-
Nov [2]	3501	-16392	-51779	54424	16761	-77.942	-72.063
Dec	3495	-16383	-51765	54408	16752	-77.957	-72.068
Annual	**3508**	**-16393**	**-51800**	**54445**	**16764**	**-77.921**	**-72.067**

[2] X and Y data unavailable from approximately 12 UTC 19 September 1994 to 12 UTC 18 November 1994. X, Y, F, H, D and I averages for September and November are based on 2 and 3 quiet days, respectively.

CHAPTER 7. REFERENCES

deDeuge, M., 1991. Mawson Geophysical Observatory Annual Report, 1991
Bureau of Mineral Resources, Record 1992/57

Rada, A., 1994. Geomagnetic Report 1993, Davis and Casey
AGSO Record 1994/29

The following references are internal publications of the Auroral and Space Physics Section of the Australian Antarctic Division:

Dubovinsky, M., 1995. Fluxgate Magnetometer Annual Report and Calibration Casey 1994

Parcell, S., 1994. Fluxgate Magnetometer Annual Report and Calibration Davis 1993

Symons, L. and Dubovinsky, M., 1994. Casey magnetometer calibration January 1994

Williams, P., 1995 Fluxgate Magnetometer Annual Report and Calibration Davis 1994