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GEOMAGNETIC ACTIVITIES AT DAVIS, MAWSON AND CASEY, ANTARCTICA

- 1985/86 SUMMER

by

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SUMMARY

The author spent most of the 1985/86 summer at Davis. An EDA FM-100C fluxgate magnetometer was installed to measure magnetic variations at Davis for the Antarctic Division, Department of Science. Magnetic stations C, D and E were occupied and station differences were derived through EDA baselines. The magnetic absolute hut site was found to be in jeopardy from the rebuilding program.

Five third order magnetic stations spread between Davis and the Amery Ice Shelf were reoccupied using the Larsemann Hills as a base, and some reconnaisance geology was also undertaken in the area.

Mawson and Casey were visited briefly to check the instruments, solve any problems and assess their operations.

1. INTRODUCTION

The author arrived at Davis on the MV Icebird on 12 December 1985. The purpose of the visit was to assist in the installation of an EDA fluxgate magnetometer. The oportunity was taken to use the magnetometer as a variometer to help determine accurate station differences between magnetic stations C (the absolute pier), D, and a new station, E. The author departed Davis for Mawson on the MV Nella Dan on 26 January 1986.

After familiarization at Mawson and solving some operational problems the author departed on the MV Nella Dan on 01 February 1986.

The author arrived back at Davis on 03 February to prepare for the regional magnetic survey which had become feasible since the repair of the second helicopter. The author arrived at the Larsemann Hills on the MV Nella Dan on 04 February, reoccupied five third order magnetic stations between Davis and the Amery Ice Shelf with the Davis 1986 physicist, Russell McLoughlin, and investigated the regional geology, then departed by helicopter on 09 February. It was intended to occupy the remaining regional magnetic station en route to Davis, but this was not possible due to winds exceeding 25 knots. The author departed Davis for Australia on the MV Nella Dan on 09 February 1986.

The Nella Dan called into Casey on 14 February. The observer, OIC Barry Martin, was pleased to have the equipment serviced and his observations checked. The author arrived at Princes Warf, Hobart on 22 February 1986.

2. DAVIS

Installation of EDA FM-100C fluxgate magnetometer

BMR assistance was requested by the Antarctic Division, Department of Science, to install an EDA fluxgate magnetometer, model FM-100C. With the assistance of Alistair Urie, an Upper Atmosphere Physics engineer with the Antarctic Division, analogue recording commenced at Davis on 4 January 1986; digital recording with a 10 second sample rate is due to commence later in the year.

The site chosen for the sensor is approximately 26 metres from the absolute hut pier (Figure 1). The cables, tested to -40 C, were run in polypipe to the UAP laboratory where the electronics are housed. The sensors are oriented geographically to record X, Y and Z. The X and Y orientations were determined by comparing simultaneous absolute X and Y outputs with the declination measured in the Davis absolute hut. The orientation is accurate to 0.25 degree. The EDA calibration constants determined at the Canberra Magnetic Observatory (CMO) on 4 November 1985 are summarized in Table 1, and the method is outlined in Appendix 1. The EDA is configured to record

X-up = mod(X)-up
Y-up = mod(Y)-up
Z-up = mod(Z)-up

It should be noted that Y and Z are both always negative at Davis. The sensor is thermostatically heated to 20 °C +/- 0.5 °C, which was the ambient temperature during the calibration tests.

Magnetic station comparisons

The history of Davis magnetic stations is discussed in Gaull (in prep.). It was not possible to find the exact locations of stations A and B; the present absolute pier represents station C; station D is well clear of Davis station, being 270 metres SSW of the proposed waste treatment building location, but occupies the proposed site of the aerial farm! A new first order station, station E, was created on the north side of Davis on the first hill inland from the transmitter hut. Figure 2 gives the station description.

The following site selection criteria were used:

- a greater than 100 metre clearance from any present or proposed buildings, service lines, etc
- more than 50 metres from any road
- site must be drift free all year
- line of sight to Anchorage Island Cross

- low gradients of local total magnetic field

- site suitable for a future absolute hut

- site must be situated on bedrock, or a slab of rock which will not be moved by repeated freezing/thawing of the surrounding soil.

Differences between stations C, D and E were determined using a QHM for H and D and a PPM for F and baselines through the EDA analogue output with a chart speed of 10 cm/hour. Table 2 lists the pre-survey QHM comparison results. Table 3 lists mean values +/- one standard deviation of the 11, 7 and 8 sets of observations at stations C, D and E respectively.

Absolute hut site and the rebuilding program

The present absolute hut site was chosen in 1980/81 summer by the Mawson 1980 winterer, B. Gaull. It is an excellent site for observations except

1. The present Upper Atmosphere Physics building is only 70 metres from the absolute hut.
2. The replacement building, proposed for summer 1986/87, is only 60 metres away.
3. The fuel farm, proposed also for summer 1987/88, is only 50 metres away.

The possibility of (2) and (3) above being erected on different sites was dicussed with Antarctic Division and Department of Housing and Construction representatives. All were satisfied that this could be achieved with a minimum of extra cost, time and inconvenience except Dr Gary Burns, who is in charge of the Upper Atmosphere Physics program. His objections, and the DHC responses are

Objection:
The road between the Fire Tender Shelter and the Power House should not go between the UAP building and the remote sensing equipment, ie. not over the instrument cables. A 100 metre clearance around the magnetic hut would put the UAP building on the opposite side of this road.

DHC response:
Suitable ducting and other cable protection could easily be built at minimal cost.

Objection:
All-sky cameras mounted in the roof of the UAP hut must be above other station lights to prevent interference with these experiments. The current proposed site is approximately 2 metres higher than the alternative sites.

DHC response:
The UAP building is modular and could be raised on pillars. The extra cost would be small and this would provide an additional storage area.

Objection:
The new UAP building is required as soon as possible and any delay in its

construction is unacceptable.

DHC response:
The specifications of the building would not change with the site and footings modifications; thus there would be no delay.

Regional magnetic survey

The author camped at the Larsemann Hills while occupying the third order regional magnetic stations. The camp consisted of 3 polar pyramid tents, 1 Apple hut, 2 Jet Ranger helicopters and 10 other expeditioners.

Five of the six magnetic stations between Davis and the Amery Ice Shelf were visited on 5 and 6 February 1986. The Davis instruments, QHM 494(1403) used at 4-pi, QHM circle 73 and PPM E770/194 were used with a collapsable BMZ tripod. BMZ 115 was taken as a spare but not needed. The magnetic field and weather were both kind: Mawson recorded a K maximum of 3 for both 5 and 6 February during the observations; a K9 storm occurred on 8 February. The weather was overcast with 5-15 knot winds; observing with a QHM in over 15 knots would not be possible.

Station descriptions are presented in Gaull (in prep.). The Russian hut at Landing Bluff had been moved down onto the seaice adjacent to a large landing strip, where there were also fuel drums, sea containers, helicopter parts and a skidoo. The hut had been recently occupied. An immaculate Russian star and sickle symbol had been made with quartz rubble near the magnetic station.

Results from the survey are presented in Table 4. Gaull's azimuths were used; there was no oportunity to check them.

3. MAWSON

The seaice had not broken out of the bay when voyages 5 (MV Nella Dan) and 6 (MV Icebird) arrived at Davis on 21 January. Mawson passengers and as much of their gear as possible were transferred to the Nella Dan; the Icebird was sent back to Hobart for an early start to her next voyage.

Rod Hutchinson, the incoming Mawson winter geophysicist, and only 2 boxes of BMR reorders, equipment and personal gear were transferred at this time. The problem was caused by BMR using sturdy timber boxes that were packed towards the bottom of the hold, which could not reasonably be repacked without wharf facilities. It is recommended that in future most reorders be sent in sturdy cardboard boxes which would then be packed in cage pallets for transport and handling. The remaining 10 boxes arrived on a shuttle run 3 days later as the auther left for Davis and the Larsemann Hills.

Rod and the author were shown around the base by Peta Kelsey, the outgoing geophysicist. The following arose from the author's visit:

1. PEM's
The PEM output was configured to be numerically correct, ie. X-up = mod(X)-up, Y-up = mod(Y)-down, Z-up = mod(Z)-down. Y and Z are always negative at Mawson. As the Z PEM baseline determinations displayed an unacceptably large scatter the method of HDF to XYZ baseline calculations was reviewed and a standard adopted. The scatter was greatly reduced.

Rod and Peta installed a new PEM circuit board. Unfortunately the new photodiodes and temperature sensors were in the ten boxes still to come. There were no complications with the installation.

2. Comparisons
Peta commenced QHM and declinometer comparisons recording 10 second samples on the Edas, rather than delaying further PEM modifications by waiting for suitable magnetic quiet days.

3. BMZ
The neutral division on the BMZ was very difficult to see. The optics were adjusted and the BMZ worked well.

4. Wombat (the BMR/IPS science building)
This building was due to be moved closer to the old station, which would have required rerouting or extending the data cables. The plan was shelved. The building is in good condition and serves our purposes well, although it is not yet connected to the station services, eg. running water.

5. Ionospheric Prediction Service
This is the last year the IPS will have a representative at Mawson. It will leave the BMR geophysicist as the sole occupant of Wombat - UAP and Cosray have separate buildings. As the BMR tasks are becoming less time consuming with digital and visual equipment, and the IPS work will require only a small time commitment, BMR should approach IPS to take over the chart changes and preliminary data reductions.

6. RTA
A box of disused equipment was packed for RTA.

4. CASEY

The author spent 10 am to 5 pm, 14 February 1986 at Casey while carrying out the following

- The QHM telescope was adjusted; it had been giving double images.
- The BMZ had been moved while unclamped; the magnet was repositioned and clamped.
- The PPM setting was checked.
- The observer, Barry Martin, was given a refresher course on the operation of all instruments, with most time spent on the BMZ. He was enthusiastic but lacked the confidence a scientific background would have provided.
- A computer program to calculate H and D from QHM observations, written by the glaciologist, was checked.
- A hand calculation of a recent observation was left as a backup for the computer program.
- One set of observations was carried out.
- The equipment and literature available to the observer were noted.
- It was requested that the steel framed heater in use in the absolute hut be replaced by the non-magnetic heater sent on voyage 2.

The absolute hut is in good condition but for the application of a few coats of paint. This has been requested.

ACKNOWLEDGEMENTS

Many thanks go to the following for their willing assistance

- Alistair Urie for his diligence and a quality job on the EDA installation;
- Russell McLoughlin for his assistance with the regional magnetic observations and with locating the site for magnetic station E;
- Reg Sheriden and Eric McGibbon, Division of National Mapping, for installing a permanent marker at station E, surveying its position and providing an azimuth to Anchorage Island Cross;
- the helicopter crew, Graham Scandrett, Bruce Cameron and Kireon Meakin, for providing excellent service, especially around the Larsemann Hills;
- DHC for their assistance with the concreting for the EDA sensor; and
- the Antarctic Division for providing all logistic support.

REFERENCES

Gaull, B.A., in prep., Geomagnetic observations at Davis, Antarctica - 1980/81 summer, *BMR Record*.

Tingey, R.J., 1981, Geological investigations in Antarctica 1968-69: The Prydz Bay - Amery Ice Shelf - Prince Charles Mountains area, *BMR Record 1981/34*.

APPENDIX 1 - Calibration of EDA FM-100C fluxgate magnetometer for Davis

The first test undertaken was for magnetic contamination. The EDA sensor and housing were brought close to a QHM hanging in the zero-torsion position. This produced no deflection of the QHM magnet.

The remaining tests used the PVM coils in the absolute hut at CMO. The coils were aligned with the ambient geomagnetic field, in the zero-degree position. The X, Y or Z sensor under test was centred in the relevant coil; that is, the sensor head was repositioned for the calibration of each sensor. The positioning involved elevating the sensor head, levelling it with the levelling bubbles and, for X and Y, rotating it to the appropriate direction. For example, to orient the X-sensor in the H-coil of the PVM, the Y-channel on the EDA electronics was monitored. The orientation was correct when current fed into the H-coil had no effect on the Y-sensor.

The coil constants for the PVM are H: 153.5 nT/mA, Z: 153.4 nT/mA.

Determination of the rear cal pot settings (divisions)

A scale value of approximately 200.0 nT/volt was sought for the relative chart output for each channel. Rear cal pot setting (div), PVM current (mA), and relative chart output (volts) with normal, reverse and zero currents were recorded. Once determined the rear cal pot setting was not changed.

Determination of EDA relative and absolute outputs (nT/volt)

With the rear cal pot at this setting a range of currents were sent through the PVM coil and the relative chart output was recorded. This provided an accurate calibration of the EDA relative output.

The FM-100C is designed as an absolute instrument, so also has absolute chart output terminals. These should in future be calibrated at this stage. The absolute output was instead determined at Davis using the scale values of the calibration coil in the sensor housing and the voltage produced by various scale value currents. The offset was determined by measuring the voltage from the sensor with the sensor power disconnected.

The relative output is used during normal recording; the absolute output was used during installation to orient the sensors:

$$\text{Declination} = \arctan(Y/X)$$

So for X and Y absolute outputs,

$$\text{Declination} = \frac{(\text{Y volts} \times \text{Y abs scale value}) + \text{Y abs offset}}{(\text{X volts} \times \text{X abs scale value}) + \text{X abs offset}}$$

Determination of calibration coil scale values (nT/mA)

The effect of current applied to the calibration coil in the sensor head was determined by measuring the relative output voltage (previously calibrated),

with various PVM coil currents giving a range of background field strengths.

Calibration of baseline pots (nT/div)

The baseline pot on the front pannel of the EDA electronics was set to null the meter, then a current was applied to the PVM coil and the pot was adjusted to renull the meter. The associated changes in pot reading (divisions) and PVM coil current were noted.

The calibrations were carried out at 20 °C.

APPENDIX 2 - A reconnaisance of the Larsemann Hills geology

Eight sites in the Larsemann Hills were visited by helicopter on 6-7 February 1986 as part of the Larsemann Hills summer science program.

The Larsemann Hills are predominantly banded gneiss (described in detail in Tingey, 1981), with a conformable alkali granite in the eastern-most peninsula. The approximate mineral composition of the granite, from a hand specimen analysis, is orthoclase (pink) 50%, quartz 40%, biotite 10%, and a trace of plagioclase.

An approximately vertical cleavage striking 255° true (330° magnetic) occurs throughout the hills. Two sets of joints were identified:

(i) in the eastern and central Larsemann Hills joints dip approximately vertically and strike 355° true (70° magnetic);

(ii) in the western Larsemann Hills joints dip approximately vertically and strike 115° true (190° magnetic).

Overlapping features indicate that the joints post-date the cleavage.

Table 1 - Davis EDA FM-100C fluxgate magnetometer calibration summary (4/11/86)

Constant	X	Y	Z
calibration coil (nT/mA)	206.0	185.2	-106.2
relative output (nT/V)	200.0	200.5	200.3
absolute output (nT/V)	9682	9794	9470
absolute output offset (nT)	0	-9.8	37.9
baseline potentiometer (nT/div)	48.08	48.46	22.06
rear cal pot setting (div)	5.63	5.32	7.24

Note that in January 1986 a front cal pot setting of 10.0 divisions gave a calibration current of 3.202 mA.

Table 2 - QHM 494 comparison results

Date	Place	Instrument A	Instrument B	A - B (nT)	A - B (nT/23700)
5/9/85	CMO	QHM 461	QHM 494	-15.7 +/- 2.0	-0.00066H

Table 3 - Davis magnetic station C, D and E preliminary baseline values and station differences (January 1986)

Instruments	preliminary corrections applied
H QHM 494(1403)	-8 nT
D QHM 494(1403)	collimation angle = +3.5 minutes; alpha calculated separately for each observation
F PPM E770/194	-2 nT

STATION C (absolute pier)

X = 3794 +/- 10 nT
Y = -16133 +/- 7 nT
Z = -52063 +/- 4 nT

STATION D (first order station south of Davis)

X = 3812 +/- 18 nT
Y = -16176 +/- 2 nT
Z = -52374 +/- 2 nT

STATION E (First order station north of Davis)

X = 3592 +/- 13 nT
Y = -16158 +/- 7 nT
Z = -52322 +/- 2 nT

STATION DIFFERENCES

C - D	C - E
X = -18 nT	X = +202 nT
Y = +43 nT	Y = +25 nT
Z = +311 nT	Z = +259 nT

Table 4 - Davis to Amery Ice Shelf regional magnetic results

Instruments	Preliminary corrections applied
H QHM 494(1403)	-8 nT
D QHM 494(1403)	collimation angle = +3.5 minutes; alpha calculated separately for each observation
F PPM E770/194	-2 nT

DATE	U.T.	H(nT)	U.T.	D (° W)	U.T.	F(nT)
1. LANDING BLUFF - observer W.Welsh						
05 02 86	0535	17328	0535	73.93	0517	53740
	0553	17372	0553	73.96	0602	53693
	0613	17348	0613	73.90	0605	53694
	0627	17359	0627	73.92	0637	53686
mean		17352		73.93		53703
2. MT CAROLINE MIKKELSEN - observer R. McLoughlin						
05/02/86	0900	15920	0900	81.94	0820	56291
	0920	15915	0920	81.88	0936	56306
	0951	15929	0951	81.94	0939	56303
	1016	15909	1016	81.80	1030	56314
mean		15918		81.89		56304
3. DODD ISLAND - observer W. Welsh						
05/02/86	1206	17049	1206	77.45	1155	54394
	1217	17054	1217	77.42	1225	54387
	1234	17055	1234	77.38	1227	54389
	1245	17089	1245	77.39	1254	54402
mean		17062		77.41		54393
4. BLUNDELL PEAK - observer R. McLoughlin						
06/02/86	0346	17123	0346	73.92	0325	54490
	0410	17089	0410	74.05	0422	54477
	0438	17063	0438	74.11	0423	54481
	0456	17032	0456	74.12	0507	54448
mean		17077		74.05		54474
5. HOVDE ISLAND - observer W. Welsh						
06/02/86	0849	16801	0849	76.62	0832	54382
	0908	16808	0908	76.63	0917	54387
	0930	16808	0930	76.64	0920	54389
	0946	16821	0946	76.71	0956	54406
mean		16810		76.65		54391

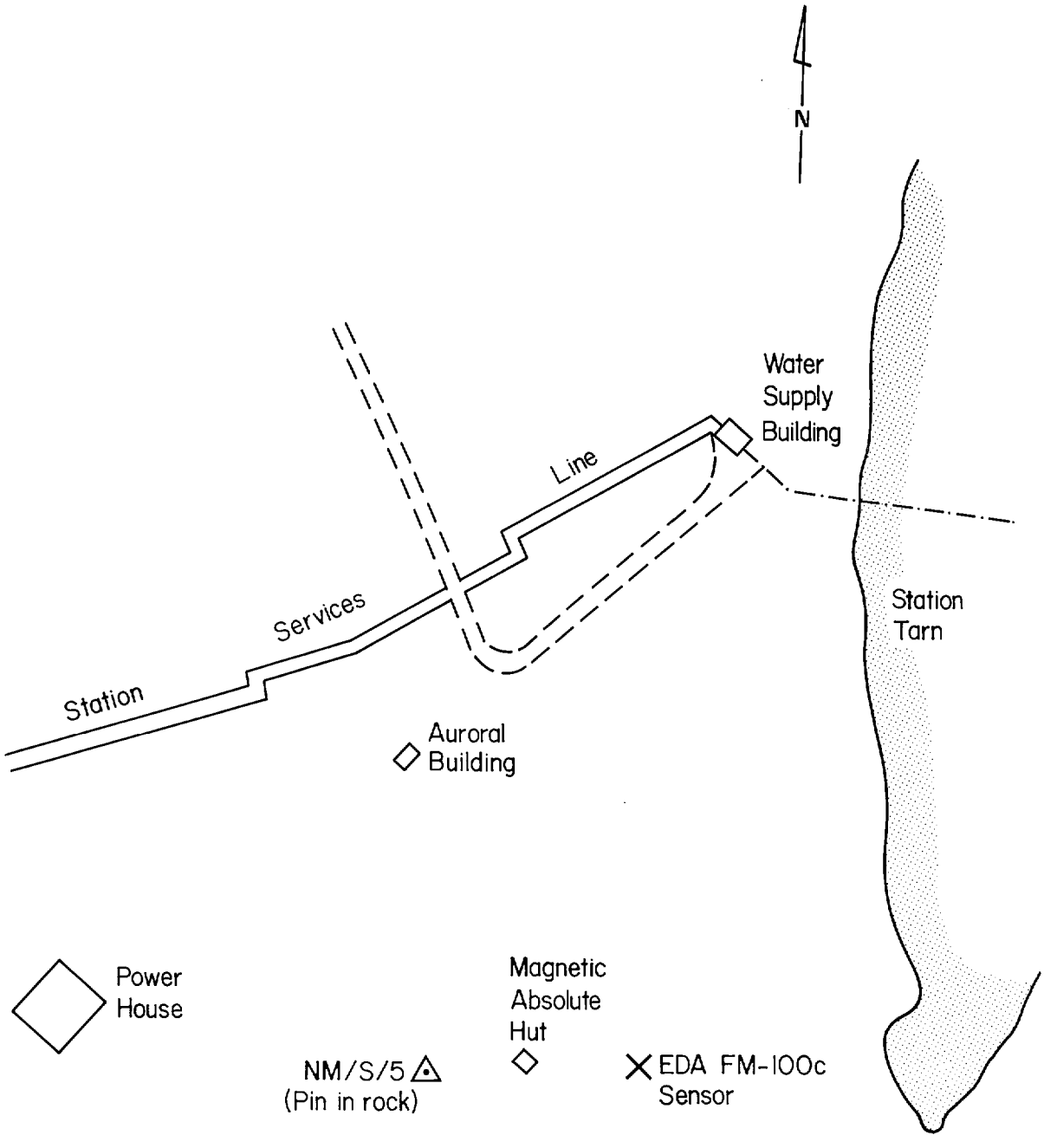

Figure 1: Location of Davis EDA FM-100c fluxgate magnetometer sensor.

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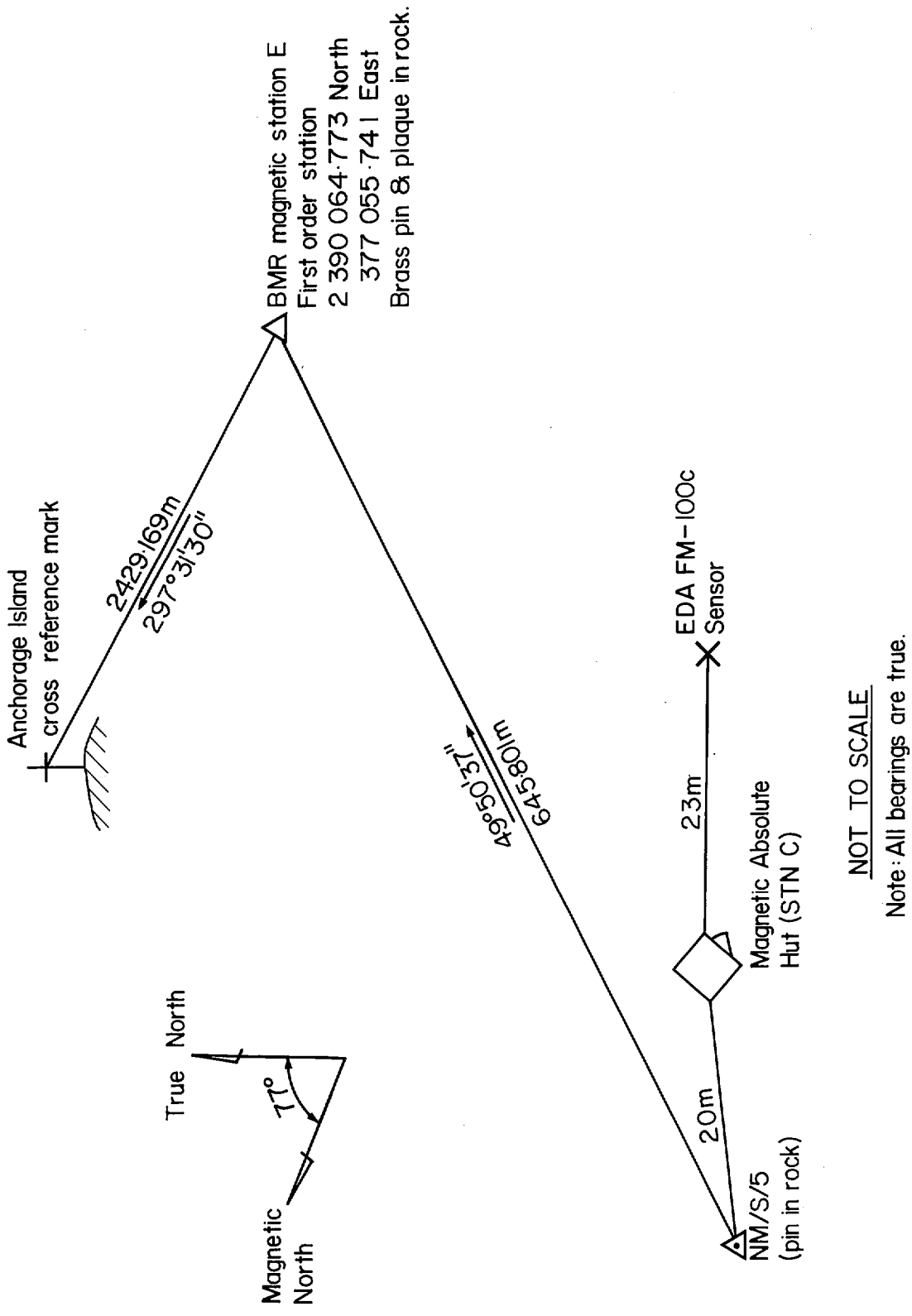

Figure 2: Station description-magnetic station E, Davis, Antarctica.