# Bureau of Mineral Resources, Geology & Geophysics



RECORD

BMR Record 1989/44

**The BMR MAGSAT and 3rd-Order Geomagnetic ORACLE Databases**

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## Introduction

This Record describes the two BMR MAGSAT ORACLE databases (MAGSAT_DATA and MAGSAT_KEY) and the BMR 3rd-Order Geomagnetic ORACLE database (MAG3_DATA). Full details of the processing procedures applied to the data sets prior to their incorporation into the databases are also given.

Procedures for querying the databases are outlined using examples and 2 software demonstrations are included on floppy disc.

## Data holdings

### MAGSAT Dataset

MAGSAT was launched on 2/11/79 into a 350 to 550 km altitude near polar orbit. The orbit was set up in such a way that the plane of the orbit precessed at a sun-synchronous rate and therefore remained approximately normal to the Earth-sun direction. Thus, the satellite effectively flew along the dawn-dusk separator and passed over the Australian region twice a day. The orbit slowly decayed over a 7 month period and MAGSAT ceased transmitting usable data on 19/5/80. It fell from orbit on 14/6/80. Collections of papers on MAGSAT and the data collected have been published in special volumes of *Geophysical Research Letters* (Vol. 9, Number 4, April 1982) and the *Journal of Geophysical Research* (Vol. 90, Number B3, February, 1985).

The data held in the BMR's MAGSAT databases are derived from a subset of the MAGSAT quiet day dataset (World Data Center dataset 142-A07-003). This subset was selected from the "MSDB" study of Johnson et al (1984) and includes data from the equator to 50°S in the longitude range from 82.9° to 180°E and the altitude range 348 to 502 km. As is detailed below, the selected data have been further processed and have been filtered to remove spikes prior to insertion into the MAGSAT databases. The final results in the BMR MAGSAT databases represent 163 passes of the satellite over the Australian region in the period 26/11/79 to 20/4/80. The geographic distribution of the data from these passes is illustrated in Figure 1. Passes in this figure which trend SE-NW are ascending (i.e. dusk) half-orbits, while those trending NE-SW are the descending (i.e. dawn) equivalents.

The MAGSAT data have been separated into 2 ORACLE tables. The first, MAGSAT_DATA contains all the spatial (latitude, longitude, altitude) data together with the measurements of the magnetic field and attitude quality flag values. Also included in this table are calculations of the three components of the magnetic field and their vector sum made by solving the DGRF80 field model at each MAGSAT location. The second table, MAGSAT_KEY, contains the header information from each of the 163 passes. The holdings in this table include maximum and minimum values for latitude, longitude and altitude for each pass of the satellite within the Australian region (as defined above), the number of points in each pass over the region, the value of the external magnetic field at the time the satellite crossed the equator and the values of various flags describing the orbit (see below). Common to both tables is a column called PASSNO which identifies the pass number of the orbit associated with each record.

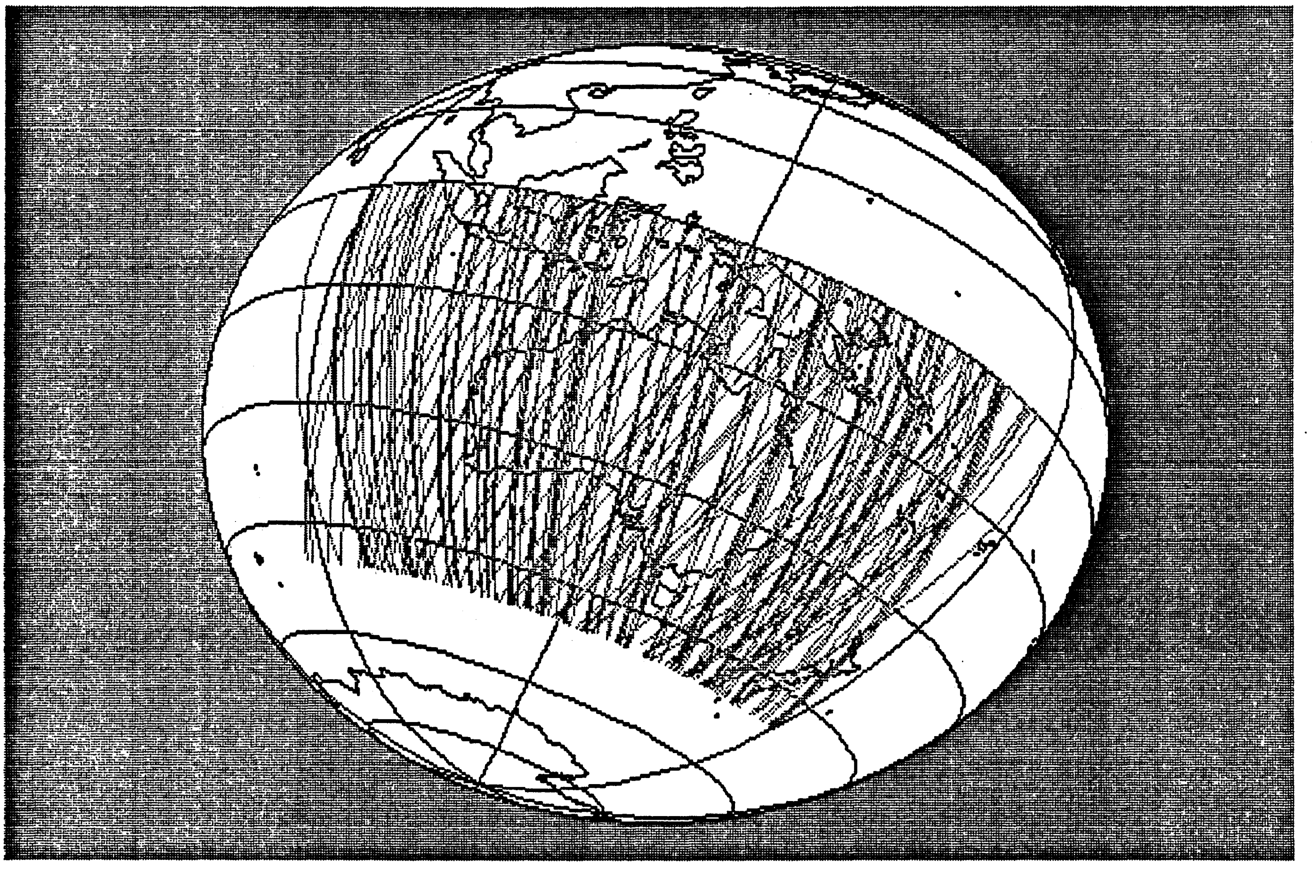


Figure 1

Geographic distribution of MAGSAT data held in the BMR MAGSAT_DATA ORACLE database. The data comprise 163 passes of the satellite over the Australian region (0 to 50$^{\circ}$S and 82.9 to 180$^{\circ}$E).

There are 25014 records in the MAGSAT_DATA table. Each record corresponds to a single location of the satellite. These records are indexed in ORACLE on the LATITUDE and LONGITUDE columns for faster retrievals of spatial data, and on the PASSNO column for faster join operations with the MAGSAT_KEY table. That table contains 163 records (1 record per pass) and is similarly indexed on the PASSNO column.

Error estimates for the MAGSAT data, as given by Langel et al (1981) are as follows.

Magnetic measurements were made with a 3 component fluxgate magnetometer. The measurements of total field were calculated from the vector data because the cesium-vapour scalar instrument failed early in the mission. The vector measurements are thought to be probably good to +/- 3 nT with the Z component probably +/- 1 nT, the X component to +/- 1 nT and the Y component usually good to +/- 2.5 nT.

Satellite position is accurate to within 60 metre radially and 300 metre horizontally. This would have kept the magnetic field error due to position to less than 1 nT. This positional accuracy was retained until the last 2 - 3 weeks of the mission when atmospheric drag effects became significant. The data in the BMR database were not affected in this way since the last pass held in MAGSAT_DATA, viz. pass 2656, dates from 9 weeks before the end of the mission.

Satellite attitude estimates are thought to have a relative rms accuracy of well within 20 arc-seconds in spite of jumps in the estimates caused by switching of processing between different combinations of instruments used to derive the attitude. This switching in the processing has been one of the major problems encountered in the analysis and application of MAGSAT data (Langel et al, 1981).

Time. The accuracy of the data is thought to be +/- 1 millisecond.

### 3rd-Order Dataset

The BMR 3rd-Order Geomagnetic Dataset was collected in the period 10/5/67 to 3/10/75 at ground level from sites within mainland Australia, Tasmania and some close offshore islands (Dooley and McGregor, 1982). Data were collected along roads at regular intervals of approximately 15 km throughout most of the country. In desert areas of central and western Australia, measurements were made on a regular 25 km grid by using helicopter transport. For the majority of sites, measurements were made of three components of the magnetic field. All measurements were made during daylight hours and no corrections have been applied for diurnal variation. The geographic distribution of the dataset is illustrated in Figure 2.

The 3rd-Order Geomagnetic Dataset has been stored in the MAG3_DATA ORACLE database on the BMR Data General MV20000 computer. This database contains 8079 records, each corresponding to an individual 3rd-Order site. Included in this database are the unique station number of each site and the date it was occupied, the site's latitude and longitude and, where known, the site's elevation together with the measured values of the horizontal component of the field (H), the total field (F) and the declination (D). The values of the X, Y and Z components of the field calculated from the 3 observed field components are also included where possible, as are calculations of H,F,D,the inclination (I) and the X, Y and Z components made from secular variation adjusted field models (see below).

The MAG3_DATA ORACLE database has been indexed on the LATITUDE, LONGITUDE, STATION and MDATE (= measurement date) columns for faster retrievals.

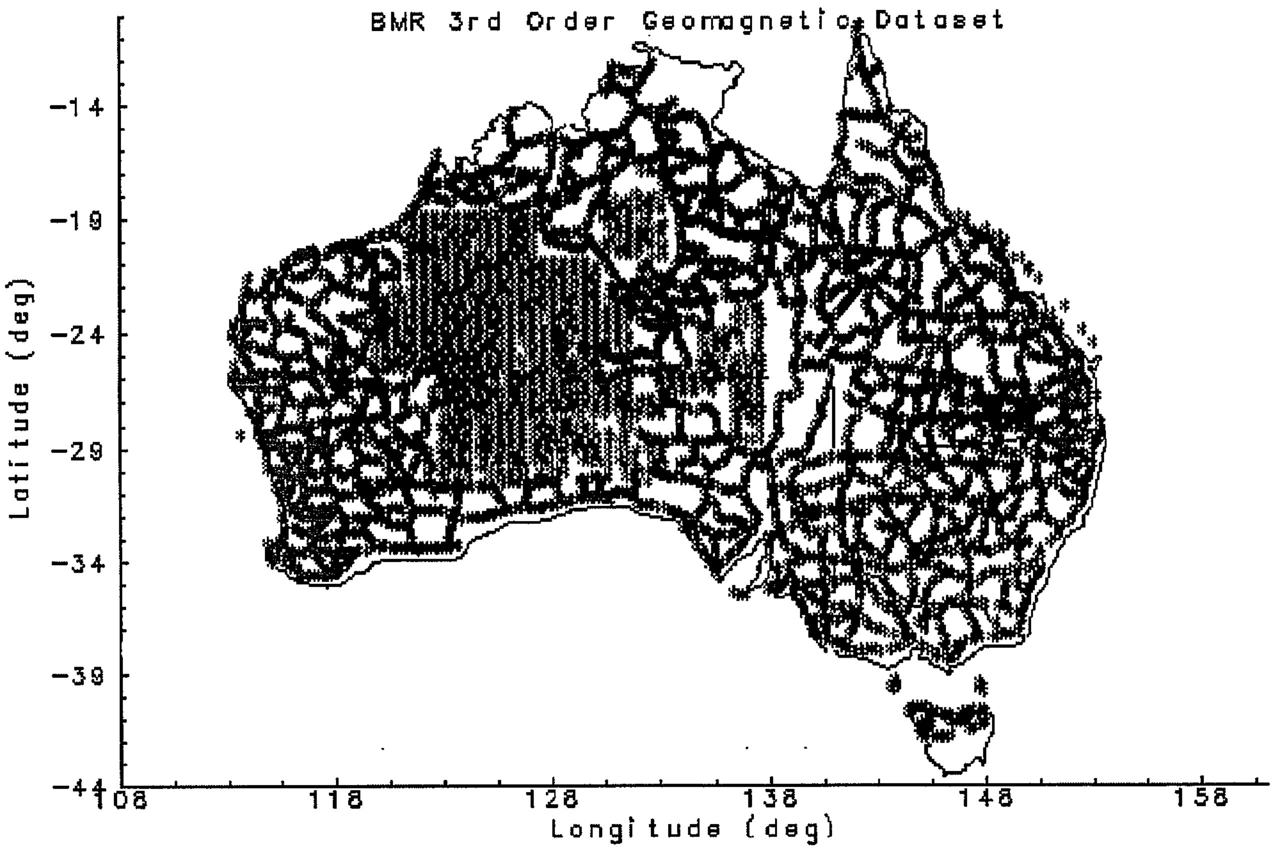



Figure 2a

Geographic distribution of 3rd-Order Geomagnetic data in the BMR MAG3_DATA ORACLE database. Sites at which 3 components of the magnetic field have been recorded.

## Data Processing

### MAGSAT Observations

The MAGSAT data, which were processed and ultimately inserted into the BMR ORACLE databases were provided in a single file by B.D. Johnson. This file is stored on the Data General computer as :ULD:MAG_DIR:MAGSAT:DATA.1. It consists of a sequence of 171 passes of MAGSAT over the Australian region. The magnetic field data in this file are anomaly values (i.e. measured field minus the values predicted by the MGST 4/81 field model). The processing steps that have been followed are illustrated in Appendix 1.

The data from each succeeding pass are broken up into a header section and a data section. The header contains information on the extremes of latitude, longitude, altitude and time of day for the pass within the Australian region. Also included are the number of data points in the pass, the modified Julian day (see Langel et al; 1981, p 22) at the time that the satellite crossed the south pole, the external magnetic field recorded as MAGSAT crossed the equator on the particular pass and values for a number of orbit flags. The data section for each pass consists of a sequence of 10 blocks of data, each of the length specified in the header. These data blocks are: latitude, longitude, altitude, time, attitude processing flag, total field, X, Y, and Z vector field components and distance along the pass in the Australian region (as defined previously). A distance of zero corresponds to the first point of a pass that falls in the region. Latitudes and longitudes are in decimal degrees, altitudes and distances are in km, time is recorded in seconds into the modified Julian day and field data are given in nanoTesla.

A FORTRAN 77 program was written to read the MAGSAT data from the input file and apply corrections and perform a consistency check (see below) before assembling the data into tables. This program is stored on the Data General computer as :ULD:MAG_DIR:MAGSAT: MSDATA.F77.

MSDATA.F77 read the anomaly data from the DATA.1 input file a pass at a time and applied a number of corrections to the field data. Firstly, Disturbance Storm Time (DST) corrections applied in the MSDB study were reversed. Johnson applied DST corrections to the X and Z components of the field by subtracting the relations

DSTX = E . cos(dipole latitude)
DSTZ = E . sin(dipole latitude)
where E = the measured external field as the satellite crossed the equator on a given half orbit.
and dipole latitude is given by 2 tan(inclination)

from the X and Z components of the field. This procedure has subsequently been shown to be incorrect.

To undo these corrections, DSTX and DSTZ were recalculated using the above relations and were then added back to the X and Z components. The original MAGSAT Investigator-B data tapes that Johnson worked with include values for the dipole latitude (and the field predictions from the MGST 4/81 model) at each location in each satellite pass. These data did not however come to BMR in the DATA.1 file so they had to be calculated in program MSDATA.F77 for each point in order to undo the DST corrections.

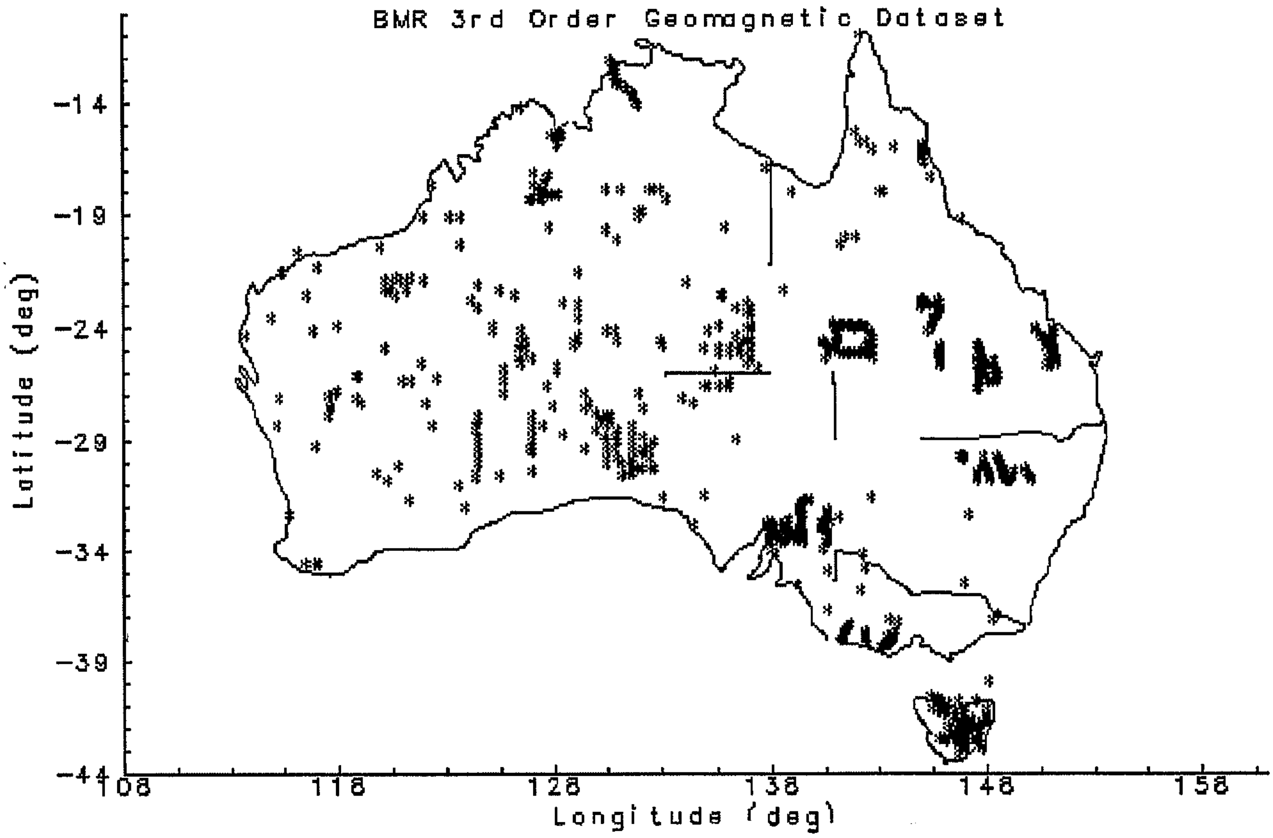



Figure 2b

Geographic distribution of 3rd-Order Geomagnetic data in the BMR MAG3_DATA ORACLE database. Sites at which not all 3 magnetic field components have been measured.

New DST corrections were then applied using the formula of Langel et al (1981), (p. 33) which leads to:

$$DSTX = -[E+\{(a/r)^3\}.I].\ \sin(theta)$$

and

$$DSTZ = +[E-2\{(a/r)^3\}.I].\ \cos(theta)$$

where:

| | | |
|---|---|---|
| E | = | external field for each 1/2 orbit as given in the header for each pass |
| I | = | the resulting induced field as given in the Investigator-B Table of Langel et al (1981). |
| a | = | mean earth radius (6371.2 km) |
| r | = | radial distance to the satellite point |
| theta | = | (90 degrees - dipole latitude) |

The second processing step in program MSDATA.FOR was to put the three component data through a spike removal routine. The scalar field (DMagT = F) data were not treated in this way because they had already been put through a similar routine in the MSDB study.

Most spikes were found to be characterised by large positive exponents and consistent spikes in all 3 components. They were all positive numbers and were single points. In a few cases, spikes were found to occur in a single component only.

Spikes were detected by comparing field data with the preceding and following values in the pass. If the field value being considered was found to be larger or smaller by a factor of 100 than its neighbours then it was considered to be a spike. In these cases, a new field value was interpolated from the values on either side. The original triplet of data and the new interpolated field value were written out to file :ULD:MAG_DIR:MAGSAT:MSDATA. SPIKE_LOG for future reference. In all 864 spikes were detected and removed from 25014 observations.

The values of the 3 components of the field and their scalar sum were then converted back from anomaly to field values by solving the MGST 4/81 field model. These calculations were carried out by subroutine SHSYN2 which is a modification of Barraclough's SFSYN routine. The coefficients for the MGST 4/81 model are listed in Appendix 2.

Finally, a consistency check was run on all the data to check the validity of the processing procedures. This was necessary firstly because spikes were removed from the dataset in 2 separate processes which may have led to inconsistencies (spikes were filtered from the X,Y and Z field components in the present processing while the scalar field data were filtered by some other routine in the MSDB study). Secondly, DST corrections were applied here to only the X and Z field components which could again have produced unacceptable inconsistencies between the X,Y and Z components and DMagT. Lastly, the field model addition warranted checking.

Any MAGSAT sites at which the scalar Field (DMagT) differed from the vector sum of the 3 vector components by more than 1% were excluded from the final output table. Only 347 points failed this test. These points are listed in file :ULD:MAG_DIR:MAGSAT: MSDATA.CONSISTENCY_LOG.

The MAGSAT data output from program MSDATA.FOR is held in file :ULD:MAG_DIR: MAGSAT:MSDATA.OUT. This file consists of 163 tables, one for each pass of the satellite over the Australian region. An example of part of one of these tables is given in Table 1.

The data in Table 1 come from pass 0374 of MAGSAT on modified Julian day 44203 (i.e. 26 November 1979). The satellite entered the Australian region (defined as 0° to 50°S and 82.9° to 180°E) 26735.18 seconds (~7.5 hours) into the modified Julian day. The limiting latitudes, longitudes and altitudes are as given in the header. Of the remaining 9 entries in the header, the ones of greatest interest are: **QAltBot** which indicates in this case (F = logical .FALSE.) that the orbit did not "bottom" over the Australian region. Similarly **QAltTop** indicates that the orbit did not reach a maximum altitude over the region. For passes in which either of these flags = T (i.e. = .TRUE. ) the data from the pass come from a narrow band of altitudes. **External Field** which records the external field for this half orbit at the time the satellite crossed the equator. The other flags are invariant in the BMR data set (further information can be obtained from B.D. Johnson).

## TABLE 1

Record Number 1

Header 0374AP159 Pass Reference 0374 MJDayRef 44203

Number of data points in this pass = 159

Min Time = 26735.18 Max Time = 27511.82

Min latitude = -49.9897 Max latitude = -0.09

Min longitude = 153.36 Max longitude = 164.75

Min altitude = 394.131 Max altitude = 471.842

QCrossSPole Ref = F QAltBot = F QAltTop = F QPrfDel = F

DmagTstrend = 0.0000 DmagTvtrend = 0.0000

External Field = 31.8537 PRFends = 0, 0

| Latitude | Longitude | Altitude | Time | Qual | Dmag(Total) | Dmag(X) | Dmag(Y) | Dmag(Z) | Distance |
|---|---|---|---|---|---|---|---|---|---|
| -4.99896700E+01 | 1.64752460E+02 | 4.71841800E+02 | 2.67351760E+04 | 7068. | 5.02451193E+04 | 1.16719105E+04 | 5.51687892E+03 | -4.85711517E+04 | 0.00000000E-01 |
| -4.96801150E+01 | 1.64642330E+02 | 4.71298830E+02 | 2.67400920E+04 | 7068. | 5.01854224E+04 | 1.18365017E+04 | 5.51075425E+03 | -4.84705023E+04 | 3.53303180E+01 |
| -4.93704530E+01 | 1.64533360E+02 | 4.70755860E+02 | 2.67450080E+04 | 7068. | 5.01228565E+04 | 1.20016992E+04 | 5.50710332E+03 | -4.83657577E+04 | 7.06631470E+01 |
| -4.90606540E+01 | 1.64425450E+02 | 4.70208980E+02 | 2.67499220E+04 | 7067. | 5.00602562E+04 | 1.21695235E+04 | 5.50334087E+03 | -4.82596095E+04 | 1.06002780E+02 |
| -4.87508240E+01 | 1.64318600E+02 | 4.69662110E+02 | 2.67548380E+04 | 2036. | 4.99964860E+04 | 1.23371299E+04 | 5.49950498E+03 | -4.81515980E+04 | 1.41337370E+02 |
| -4.84407650E+01 | 1.64212810E+02 | 4.69119140E+02 | 2.67597540E+04 | 0. | 4.99313629E+04 | 1.24946006E+04 | 5.49892862E+03 | -4.80436666E+04 | 1.76688460E+02 |
| -4.81306760E+01 | 1.64108060E+02 | 4.68572270E+02 | 2.67646680E+04 | 6000. | 4.98651401E+04 | 1.26596561E+04 | 5.49438287E+03 | -4.79323944E+04 | 2.12034560E+02 |
| -4.78203890E+01 | 1.64004270E+02 | 4.68025390E+02 | 2.67695840E+04 | 2036. | 4.97977082E+04 | 1.28295413E+04 | 5.48249408E+03 | -4.78186833E+04 | 2.47394880E+02 |
| -4.75100710E+01 | 1.63901490E+02 | 4.67478520E+02 | 2.67745000E+04 | 2036. | 4.97286647E+04 | 1.29927753E+04 | 5.47567436E+03 | -4.77037294E+04 | 2.82750240E+02 |
| -4.71995700E+01 | 1.63799640E+02 | 4.66935550E+02 | 2.67794160E+04 | 7068. | 4.96593179E+04 | 1.31545608E+04 | 5.47170231E+03 | -4.75877923E+04 | 3.18118260E+02 |
| -4.68890380E+01 | 1.63698750E+02 | 4.66388670E+02 | 2.67843300E+04 | 7068. | 4.95880877E+04 | 1.33186605E+04 | 5.46682335E+03 | -4.74686120E+04 | 3.53481630E+02 |
| -4.65783390E+01 | 1.63598740E+02 | 4.65845700E+02 | 2.67892460E+04 | 1022. | 4.95153956E+04 | 1.34726315E+04 | 5.46858995E+03 | -4.73492501E+04 | 3.88856320E+02 |
| -4.62675780E+01 | 1.63499650E+02 | 4.65298830E+02 | 2.67941620E+04 | 1022. | 4.94422940E+04 | 1.36359394E+04 | 5.46260132E+03 | -4.72269849E+04 | 4.24230040E+02 |
| -4.59566500E+01 | 1.63401410E+02 | 4.64751950E+02 | 2.67990760E+04 | 7068. | 4.93669810E+04 | 1.38007374E+04 | 5.45568364E+03 | -4.71013070E+04 | 4.59615170E+02 |
| -4.56456910E+01 | 1.63304050E+02 | 4.64205080E+02 | 2.68039920E+04 | 2036. | 4.92925490E+04 | 1.39708331E+04 | 5.44635417E+03 | -4.69744585E+04 | 4.94996430E+02 |
| -4.53346250E+01 | 1.63207530E+02 | 4.63662110E+02 | 2.68089080E+04 | 2036. | 4.92150532E+04 | 1.41350480E+04 | 5.44181343E+03 | -4.68447788E+04 | 5.30382140E+02 |
| -4.50233920E+01 | 1.63111800E+02 | 4.63119140E+02 | 2.68138240E+04 | 2036. | 4.91376100E+04 | 1.42913046E+04 | 5.43476707E+03 | -4.67170535E+04 | 5.65779910E+02 |
| -4.47121280E+01 | 1.63016890E+02 | 4.62568360E+02 | 2.68187380E+04 | 2036. | 4.90591418E+04 | 1.44645033E+04 | 5.42788796E+03 | -4.65822564E+04 | 6.01174070E+02 |
| -4.44007720E+01 | 1.62922780E+02 | 4.62029300E+02 | 2.68236540E+04 | 2036. | 4.89786409E+04 | 1.46263300E+04 | 5.41957292E+03 | -4.64481357E+04 | 6.36571410E+02 |
| -4.40892490E+01 | 1.62829390E+02 | 4.61482420E+02 | 2.68285700E+04 | 7068. | 4.88971369E+04 | 1.47847554E+04 | 5.41564312E+03 | -4.63127251E+04 | 6.71981260E+02 |
| -4.37776640E+01 | 1.62736800E+02 | 4.60939450E+02 | 2.68334840E+04 | 1022. | 4.88158681E+04 | 1.49500141E+04 | 5.41088258E+03 | -4.61746649E+04 | 7.07390690E+02 |
| -4.34659880E+01 | 1.62644930E+02 | 4.60392580E+02 | 2.68384000E+04 | 0. | 4.87327898E+04 | 1.51054699E+04 | 5.40302441E+03 | -4.60373772E+04 | 7.42804200E+02 |
| -4.31541750E+01 | 1.62553770E+02 | 4.59849610E+02 | 2.68433160E+04 | 0. | 4.86474945E+04 | 1.52708531E+04 | 5.39618342E+03 | -4.58935461E+04 | 7.78226500E+02 |
| -4.28423310E+01 | 1.62463330E+02 | 4.59306640E+02 | 2.68482320E+04 | 0. | 4.85623410E+04 | 1.54346702E+04 | 5.38994626E+03 | -4.57494456E+04 | 8.13645940E+02 |
| -4.25303190E+01 | 1.62373570E+02 | 4.58763670E+02 | 2.68531480E+04 | 0. | 4.84758189E+04 | 1.55944402E+04 | 5.38264633E+03 | -4.56045054E+04 | 8.49078060E+02 |
| -4.22182920E+01 | 1.62284480E+02 | 4.58220700E+02 | 2.68580640E+04 | 2036. | 4.83875549E+04 | 1.57569841E+04 | 5.37587274E+03 | -4.54558332E+04 | 8.84505800E+02 |
| -4.19060670E+01 | 1.62196060E+02 | 4.57677730E+02 | 2.68629790E+04 | 2036. | 4.82978907E+04 | 1.59140185E+04 | 5.37171342E+03 | -4.53063667E+04 | 9.19949520E+02 |

Longitudes and latitudes in the table are in decimal degrees, altitudes and distances along the orbit are in kilometres and the 4 magnetic field values are in nT. The data in the Qual column contain information on the quality of the satellite attitude data. This attitude data is important in determining the vector components of the magnetic field relative to the NEV (North, East, Vertical) system. Langel et al (1981) report that the attitude data is stored in a 5-digit word **abcde** on the MAGSAT Investigator-B tapes.

Where **a** = a character indicating the level of smoothing of the final attitude data.
= 0 for no smoothing
= 1 for linear smoothing
= 2 for non-linear smoothing

**b** = a character representing the residual about the fit of the attitude solution.
= 0,1,2 and 3 if the residual is <= 20 arcseconds
= 4,5,6 and 7 if >= 20 arcsec.

**c** = pitch gyro and ATS (attitude position sensor) flag.
= 0 (best case) indicates an observed gyro point and an observed ATS point.
= 8 (worst case) indicates gyro point invalid and default ATS point used.

**d** = method of final attitude computation
= 0 for using 2 star cameras + sun sensor
= 1 for using star camera (SC) 1 and 2
= 2 for using SC1 and sun sensor
= 3 for using SC2 " " "
= 4,5,6 worse cases
= 7 not computed

**e** = Pattern matching character (see Langel et al; 1981, p. 28)
= 0 SC1 and SC2 valid(V) & identified(I)
= 1 SC1 V and I, SC2 V not I
= 2 SC1 V and I, SC2 not valid
= 3 SC1 V not I, SC2 V and I
= 4 SC1 V not I, SC2 V not I
= 5,6,7 etc
= 8 SC1 not V, SC2 not V

The attitude quality data in Table 1 and in the MAGSAT_DATA ORACLE database are at most 4 digit numbers. It would appear that the "a" character is not included (perhaps because it is everywhere zero for these data) and that we have "bcde" only.
A preliminary search on the database for quality factors < 3999 (i.e. b <= 3 and residuals about the fit to the attitude solution of less than 20 arcseconds) returned 15217 records out of the total of 25014.

All the data in file :ULD:MAG_DIR:MAGSAT:MSDATA.OUT have been imported into the 2 ORACLE databases, MAGSAT_DATA and MAGSAT_KEY. This data import was carried out with program :ULD:MAG_DIR:MAGSAT:LOADMSDATA2.SQR written using Structured Query Report Writer (SQR). This program reads the MSDATA.OUT file and inserts the data into the 2 databases.

### MAGSAT Calculations

As outlined above, the MAGSAT_DATA database also contains calculations at each location of the 3 components of the magnetic field and of the total field made using the DGRF80 model. These calculations were made on an IBM PC-AT compatible computer using FORTRAN 77 program DGRF80.FOR. Source code for this program is included on the floppy disc at the back of this Record.

In order to use this program to generate the field estimates, SQR program QSAT.SQR (discussed below) was run on the MAGSAT databases on the Data General computer with a WHERE condition of LATITUDE < 0 (i.e. all the data were selected). The resulting QSAT output file then provided the location of each point in the MAGSAT dataset (longitude, latitude, altitude) for DGRF80.

These procedures produced a file, DGRF80.OUT, which contained the location of each MAGSAT observation and estimates of the field values from DGRF80. This file was inserted into a temporary ORACLE database, TEMP_MAG by SQR program LOAD_TEMP.SQR. The final step in the procedure was to join the TEMP_MAG and MAGSAT_OBS databases using the longitude and latitude columns which had been indexed for this purpose. The resulting database was then named MAGSAT_DATA.

Comparisons between the MAGSAT observations and the total field values calculated by CAL_DGRF.FOR are presented in Figures 3 and 4. These histograms of the observed data minus the calculations demonstrate that the calculations and the measurements do, for the most part, agree very closely. For example, in 97.1% of cases the absolute residual is <40 nT (note: this figure of 40 nT is only ~0.08% of the average total field value). The full details for these histograms are given on the floppy disc in files \MAGSAT\ 20BINS.HST and 100BINS.HST.

### 3rd-Order Observations

The 3rd-Order data that were processed and inserted into the MAG3_DATA ORACLE database came from file :UDD:AJM:TEMP:MHV_DIR:T3570B on the Data General MV20000. This file was headed WORLDAT DMRXOA L1 C&199SBT::O 12/04/83 13.16.53. /VER 3.0/ and contained data from 8079 localities in mainland Australia, Tasmania and some near shore islands. At 7708 of these localities, 3 component magnetic data (H,F and D) were available. At the bulk of the remaining sites, only F was measured.

These data were processed by following the scheme outlined in Appendix 1. FORTRAN program \3RD-ORDR\3RD.FOR (listed in the floppy disc appendix) was run on an IBM compatible PC-AT computer with a downloaded copy of T3570B and produced the output file 3RD.DATA. Program 3RD.FOR resolved conflicts in 621 records between the station number prefix (i.e. the year) and the year entry in the date columns. In some cases either the station prefix or the year entry was blank. In others, one of the entries had a value outside the 1967 - 1975 period of the survey. Details of the modified records are given in file \3RD-

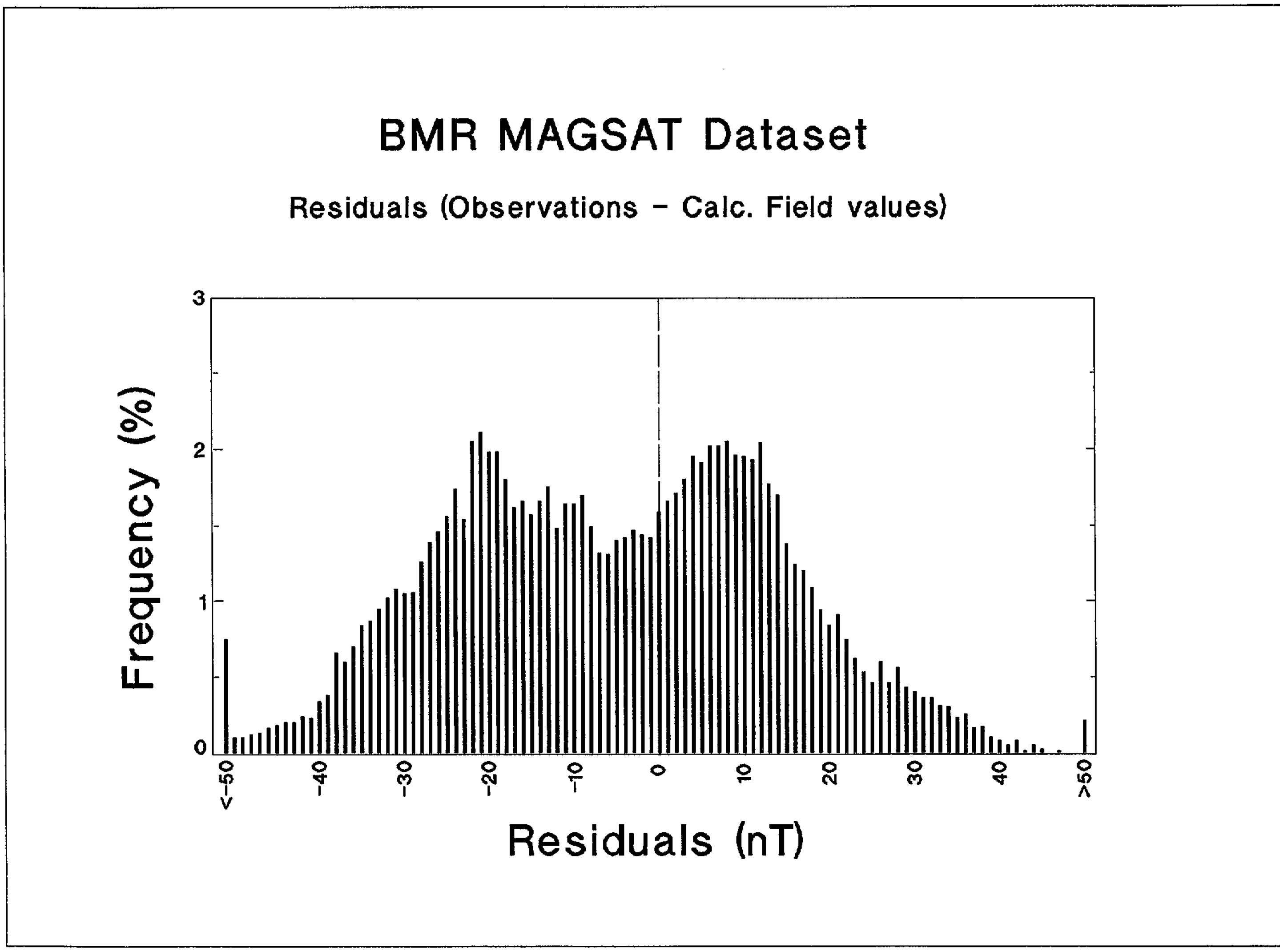
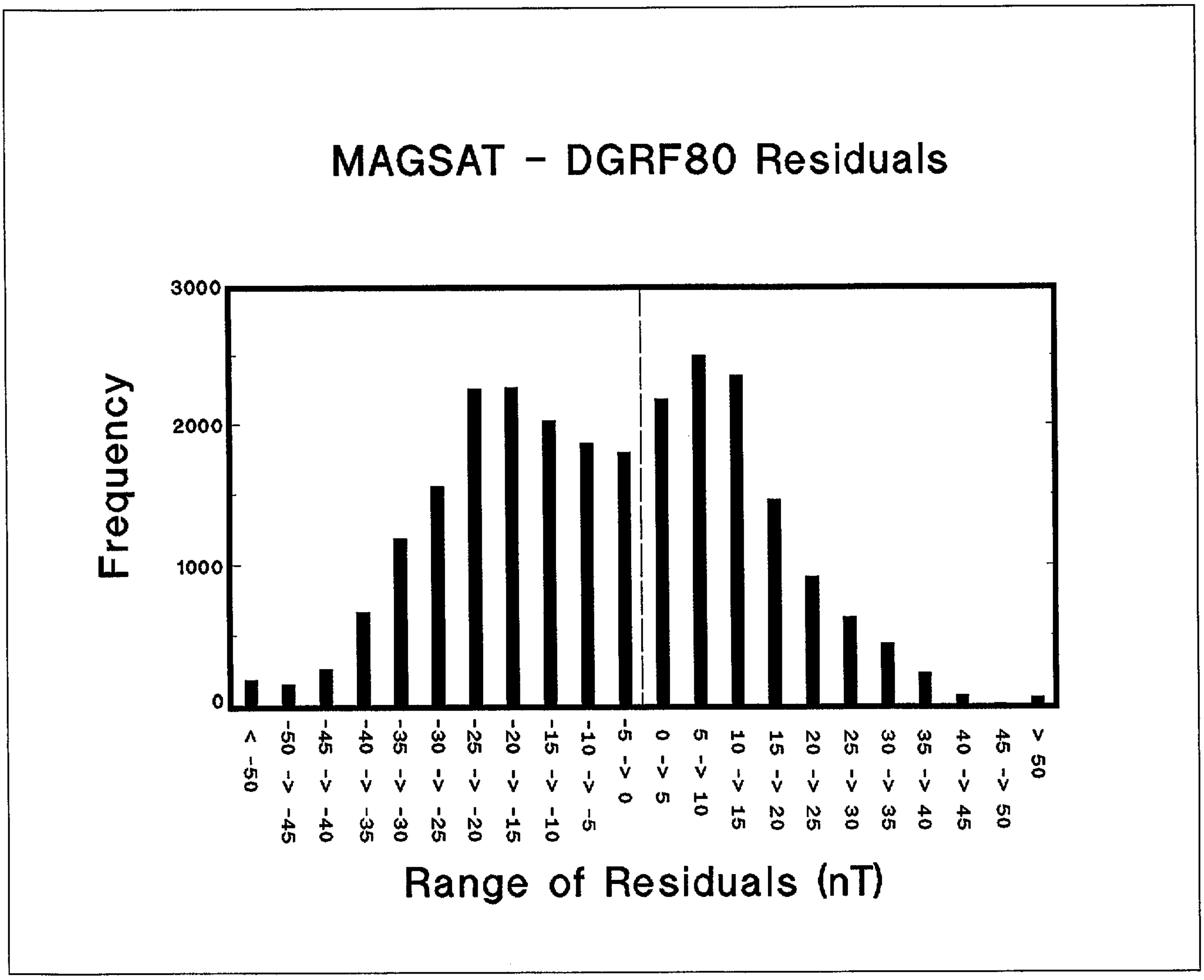



Figure 3

Histogram of the residuals between the observed MAGSAT data and the estimates of the total magnetic field calculated by program DGRF80.FOR (see text).




<u>Figure 4</u>

Another histogram of residuals between MAGSAT observations and calculated field values from DGRF80.FOR. The residuals have been sorted into 22 histogram bins.

ORDR\3RD_ERROR.LOG in the floppy disc appendix.

Program 3RD.FOR also converted the longitudes, latitudes and declinations into decimal degrees and, where H, F and D were all not null, it calculated the X, Y and Z components of the field. Finally, all entries in the input data table which were blank, were replaced by the character string "NULL" so that ORACLE would not allocate space for these entries in the MAG3_DATA database.

### 3rd-Order Calculations

The X, Y, Z, H, F, D and I components of the magnetic field at each 3rd-order site were computed from appropriate DGRF field models by program \3RD-ORDR\IGRF-2.FOR on an IBM compatible PC-AT computer (see the floppy disc appendix for a listing of the source code). Inputs to the program for each site were provided in file 3RD.LAT which was produced by editing 3RD.DATA. The edited file contained the date of occupancy, the latitude and longitude and, where available, the elevation of each site. For those sites at which no elevation data were recorded, an elevation of 200 metre was used for the calculations. This value roughly approximates the average Australian elevation. The approximation is likely to be only a small source of error as indicated in Table 2. The output table of field calculations (3RD_CALS.) was joined to the 3RD_DATA. file with an editor and the resulting file was stored on the Data General computer as :ULD:MAG_DIR: 3RD_ORDR.D:3RD_ALL. Finally, the results in 3RD.ALL were loaded into the MAG3_DATA ORACLE database (created by SQL routine MAKE.TABLE) by running program 3RD.SQR.

Comparisons between the observed F values and those calculated by IGRF-2.FOR are presented in the form of a histogram in Figure 5. As the figure demonstrates, there is good agreement between the calculations and the observations in the majority of cases. For example, as is documented in \3RD-ORDR\100BINS.HST in the floppy disc appendix, 81.7% of the 3rd-order sites have absolute residuals of <250 nT (i.e. <0.5% of the average observed F).

**Table 2**
**Calculations of the Effect of Elevation on 3 Geomagnetic Components**
IGRF 1985, Location: 43°S, 133°E

| Elevation (metre) | F (nT) | D (°) | I (°) |
|---|---|---|---|
| 3000 | 63708 | 4.9100 | -74.7795 |
| 2000 | 740 | .9112 | .7709 |
| 1500 | 756 | .9118 | .7711 |
| 1000 | 733 | .9124 | .7713 |
| 800 | 779 | .9126 | .7713 |
| 600 | 785 | .9129 | .7714 |
| 400 | 792 | .9131 | .7715 |
| 200 | 798 | .9133 | .7715 |
| 100 | 801 | .9134 | .7716 |

Calculations courtesy of C.E. Barton

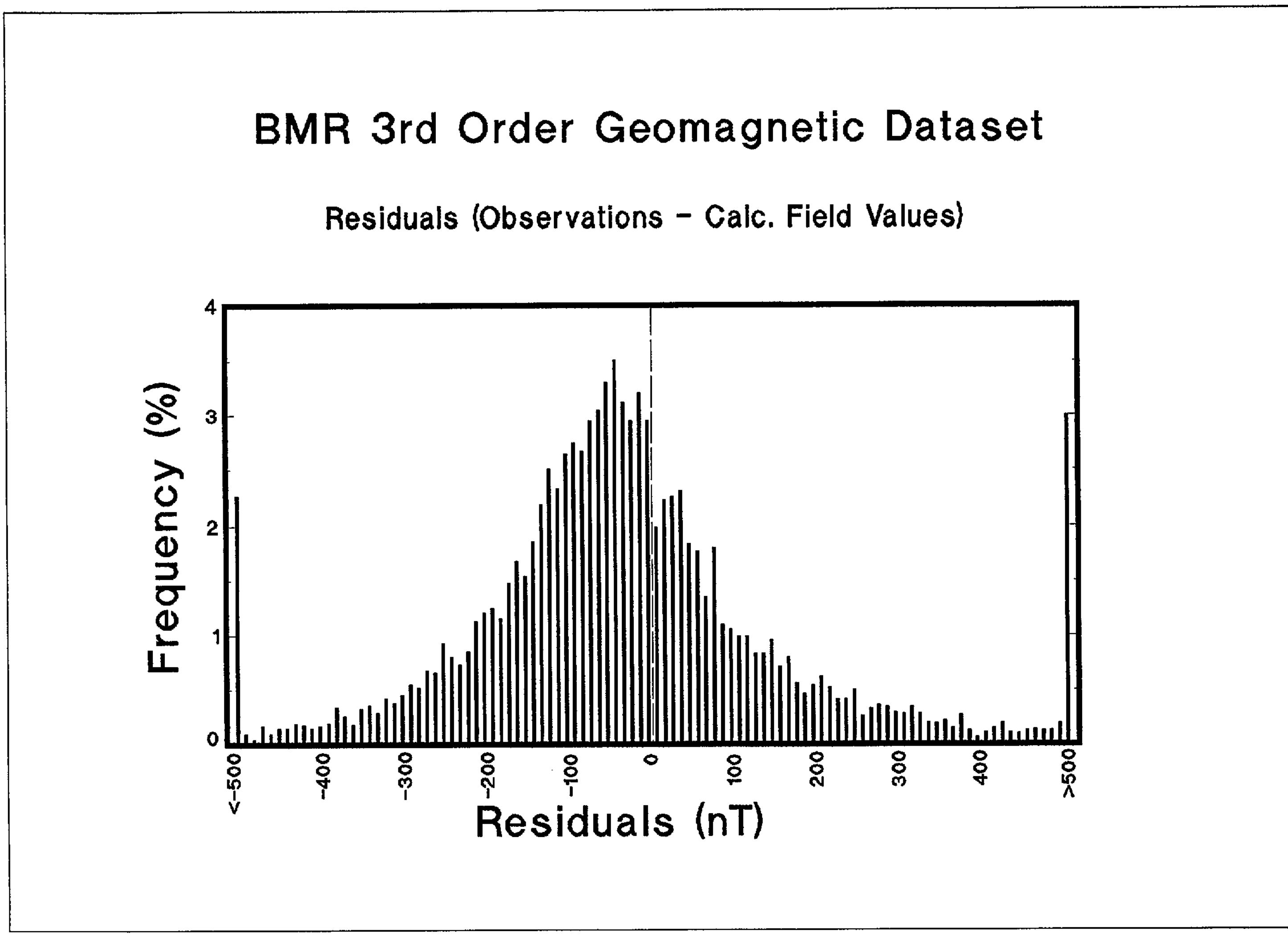



Figure 5

Histogram of the residuals between the observed 3rd-Order Geomagnetic data and the estimates of total magnetic field calculated by program IGRF-2.FOR (see text).

## Structures of the Databases

### MAGSAT_DATA

The MAGSAT_DATA database consists of 25014 rows and 17 columns. The names of these columns are:
PASSNO LATITUDE LONGITUDE ALTITUDE TIME QUALITY DMagT DMagX DMagY DMagZ DISTANCE FIELDX FIELDY FIELDZ F F_RESIDUAL

The LATITUDE, LONGITUDE, PASSNO and F_RESIDUAL columns have been indexed for faster retrievals in ORACLE using non-compressed indexing. All columns in the database are of type NUMBER. The database has been stored in ORACLE Partition B on the Data General MV20000.

### MAGSAT_KEY

The MAGSAT_KEY database contains 163 rows and 22 columns. The names of the columns are:
PASSNO HEADER MJDayRef LENGTH MINTINE MAXTIME MINLAT MAXLAT MINLONG MAXLONG MINALT MAXALT ORBIT QSPOLE QALTBOT QALTTOP QPRFDEL DMAGTSTREND DMAGTVTREND EXTFLD PRFEND1 PRFEND2

All columns in the database are of type NUMBER except for the following which are type CHARACTER: HEADER (length 9) and ORBIT, QSPOLE, QALTBOT, QALTTOP and QPRFDEL (length 1). The PASSNO column has been indexed for speedier JOIN operations with the MAGSAT_DATA database. The faster non-compressed indexing mode has been used. The database is stored in Partition B of ORACLE on the Data General computer.

### MAG3_DATA

The MAG3_DATA database consists of 8079 rows and 17 columns. The names of these columns are:
STATION LATITUDE LONGITUDE MDATE H F D ELEVATION FIELDX FIELDY FIELDZ Calc_H Calc_F Calc_D Calc_I Calc_FIELDX Calc_FIELDY Calc_FIELDZ F_RESIDUAL

All columns in the database are of type NUMBER with the exception of MDATE which is of type DATE. The LATITUDE, LONGITUDE, STATION and F_RESIDUAL columns have been indexed for faster retrievals in ORACLE using non-compressed indexing. This database is also stored in ORACLE Partition B on the MV20000.

## Querying of the Databases and Sample Outputs

### MAGSAT -- QSAT.SQR

The MAGSAT_DATA and MAGSAT_KEY databases can be accessed on the Data General MV20000 by authorised users using standard ORACLE command syntax. This is not however a very "user-friendly" way of accessing the databases because it requires the user to be quite familiar with SQL and SQLPLUS. A considerable amount of time typically needs to be spent before a user becomes completely conversant with the syntax of these database languages.

For this reason a program has been written using the Structured Query Report writer (SQR) on the Data General MV20000. This program, QSAT.SQR, provides a query interface to the ORACLE MAGSAT databases without requiring the user to be familiar with ORACLE syntax.

The cornerstone of ORACLE queries is the SELECT statement. This statement takes the general form:

```
SELECT [Column Names]
FROM [Database Name]
WHERE [some condition is true];
```

QSAT.SQR builds a SELECT statement like this for the user by iteratively soliciting the components of the WHERE clause. The user is informed of the total number of points selected from the database at each step in the development of the WHERE clause and when the final WHERE has been built, the results of the query are written out to a file in the user's current directory.

Because the MAGSAT data are held in 2 ORACLE databases, it is sometimes necessary to JOIN the 2 databases before a query can be executed. However, since the JOIN involves many records, there is a considerable penalty in performance. For this reason, QSAT.SQR has been written in such a way that the JOIN is only made for those queries which require data from the MAGSAT_KEY database. For what are expected to be the bulk of the queries made on the MAGSAT data, only the MAGSAT_DATA database will be needed.

The operation of QSAT.SQR is demonstrated in detail by a tutorial included in the floppy disc appendix. To run this demonstration: log on to the disc with a PC and type DEMOS QSAT.

This demonstration displays a series of screens captured from a PC workstation during a typical QSAT.SQR session on the Data General computer. The demonstration takes the user through the steps involved in the running of QSAT.SQR and presents the results of a typical simple query (i.e. one which does not involve the MAGSAT_KEY database).

QSAT.SQR can be run on the Data General computer by typing :ULD:MAG_DIR: MAGSAT:QSAT and entering the username GEOMAG followed by the correct access password for the MAGSAT databases.

QSAT.SQR outputs a data file called QSAT.LIS in the user's current directory on the Data General MV20000. This file may be TYPE'd or inspected with an editor such as SLATE or SED.

Alternatively, it may be screen plotted on a PC workstation after downloading from the Data General by running program MAPIT in conjunction with the METAWNDO graphics toolkit. This program, by virtue of METAWNDO's support for a very wide range of screen devices, will run on most PC's with graphics cards. Figure 2 is an example of such a plot.

Table 3 is an example of the kind of output generated in file QSAT.LIS by a simple query on the MAGSAT_DATA database. For brevity, only the first few lines of output are included in this Table.

### 3rd-Order -- Q3RD.SQR

Data queries can also be made on the MAG3_DATA database through an SQR program. The Q3RD.SQR program provides a similar interface to the 3rd-order dataset as that provided by QSAT.SQR for the MAGSAT data. Again a WHERE clause is constructed iteratively and an output file is generated in the user's current directory on the Data General MV20000.

The use of this program is also demonstrated in the floppy disc appendix. To run this demonstration: log on to the disc with a PC and type DEMOS Q3RD. This demonstration illustrates a typical data query on the MAG3_DATA database by presenting screens captured from a PC workstation during a Q3RD.SQR session on the Data General computer.

Q3RD.SQR can be run on the Data General computer by typing :ULD:MAG_DIR: 3RD_ORDR.D:Q3RD and entering the username GEOMAG followed by the correct access password for the MAG3_DATA database.

Q3RD.SQR outputs a data file called Q3RD.LIS in the user's current directory on the Data General MV20000. This file may be TYPE'd or inspected with an editor such as SLATE or SED. Alternatively, it may be screen plotted on a PC workstation after downloading from the Data General by running program MAPIT in conjunction with the METAWNDO graphics toolkit.

Table 4 is an example of the kind of output generated in file Q3RD.LIS by a simple query on the MAG3_DATA database. For brevity again, only the first few lines of output are included in this Table.

## Summary

Two databases of MAGSAT data and one of 3rd-order geomagnetic data have been established in ORACLE on the Data General MV20000 computer. The sources of these datasets and the processing steps followed prior to insertion of the data into the databases have been described.

Procedures for the rapid querying of the databases by non-specialist ORACLE users have been established using the Structured Query Report writer (SQR). The programs which provide these interfaces have been demonstrated through software tutorials. Typical outputs of queries made using these SQR programs have been presented.

**Table 3**

## Data Extract
## From the BMR MAGSAT quiet-day dataset for the Australian Region
## Data extracted using program QSAT.SQR version of 1 May 1989

Data query used was: where magsat_data.passno = magsat_key.passno and
Orbit = 'A' and ExtFld < 20 and latitude between -30 and -20 and quality < 3999

| Pass | Latitude | Longitude | Altitude | DmagT | DmagX | DMagY | DMagZ |
|---|---|---|---|---|---|---|---|
| 420 | -20.3484 | 161.1565 | 406.9043 | 39641.5172 | 26159.1638 | 5096.6609 | -29375.3909 |
| 420 | -20.6669 | 161.2204 | 407.3301 | 39792.3250 | 26042.2606 | 5112.1178 | -29678.6970 |
| 420 | -20.9854 | 161.2844 | 407.7598 | 39941.6085 | 25924.1573 | 5126.2109 | -29978.4957 |
| 420 | -21.3038 | 161.3485 | 408.1895 | 40091.1399 | 25805.7002 | 5139.2109 | -30276.3559 |
| 420 | -21.6222 | 161.4129 | 408.6191 | 40240.6118 | 25684.2625 | 5153.8425 | -30573.7235 |
| 420 | -22.8951 | 161.6723 | 410.3652 | 40831.5390 | 25186.0444 | 5209.7547 | -30865.9549 |
| 420 | -23.2132 | 161.7376 | 410.8066 | 40976.2798 | 25057.2777 | 5223.0756 | -31739.1182 |
| 420 | -23.5313 | 161.8032 | 411.2481 | 41122.1196 | 24927.9021 | 5236.5737 | -32023.8880 |
| 420 | -23.8492 | 161.8689 | 411.6856 | 41267.4509 | 24799.4606 | 5248.5580 | -32308.1474 |
| 420 | -24.1672 | 161.9349 | 412.1348 | 41411.9458 | 24668.3655 | 5260.6851 | -32588.9126 |
| 420 | -24.4850 | 162.0011 | 412.5801 | 41554.9080 | 24540.3368 | 5271.4151 | -32868.3157 |
| 420 | -25.1206 | 162.1342 | 413.4746 | 41841.6227 | 24263.2822 | 5301.6941 | -33141.5230 |
| 420 | -25.4383 | 162.2011 | 413.9277 | 41983.1640 | 24129.3800 | 5312.8286 | -33696.3693 |
| 420 | -25.7560 | 162.2682 | 414.3770 | 42124.5869 | 23991.6437 | 5326.2952 | -33965.5055 |
| 420 | -26.0735 | 162.3355 | 414.8301 | 42264.4878 | 23856.0759 | 5338.4112 | -34234.7947 |
| 420 | -26.7085 | 162.4710 | 415.7441 | 42543.2659 | 23578.9363 | 5363.6157 | -34498.8789 |
| 420 | -27.0259 | 162.5392 | 416.2012 | 42681.8642 | 23439.6649 | 5373.3008 | -35023.7331 |
| 420 | -27.6606 | 162.6762 | 417.1231 | 42957.4279 | 23160.8248 | 5397.0186 | -35283.1850 |
| 590 | -20.5274 | 147.2040 | 375.0723 | 42029.1568 | 26442.1440 | 3648.5457 | -35794.0546 |
| 590 | -21.1702 | 147.3328 | 375.2832 | 42360.1104 | 26187.6626 | 3672.3631 | -32505.0358 |
| 590 | -21.4917 | 147.3975 | 375.3926 | 42525.4509 | 26054.0450 | 3683.7924 | -33131.2552 |
| 590 | -21.8130 | 147.4624 | 375.5059 | 42690.2162 | 25919.0216 | 3695.1040 | -33445.3265 |
| 590 | -22.1344 | 147.5274 | 375.6191 | 42854.0489 | 25787.0815 | 3711.3988 | -33757.1342 |
| 590 | -22.4557 | 147.5927 | 375.7363 | 43018.0791 | 25650.2053 | 3723.4806 | -34062.2498 |
| 590 | -22.7770 | 147.6582 | 375.8535 | 43181.0380 | 25514.1935 | 3732.7075 | -34369.3169 |

**Table 4**

**Data Extract**
**From the BMR 3rd Order Geomagnetic Database**
**Data extracted using program Q3RD.SQR version of 18 August 1989**
Data query used was: where mdate < '1-APR-69' and elevation is not null
and F_residual between -100 and +100

| Stat ion | Latitude | Longitude | Date | FieldX | FieldY | FieldZ | Total Field |
|---|---|---|---|---|---|---|---|
| 670001 | -28.0383 | 152.9433 | 10-MAY-67 | 28334.860 | 5166.347 | 46364.200 | 54582 |
| 670004 | -28.3983 | 152.6433 | 11-MAY-67 | 28183.960 | 5444.382 | 46660.480 | 54783 |
| 670010 | -28.2000 | 151.6033 | 11-MAY-67 | 28323.140 | 5130.166 | 46615.310 | 54786 |
| 670013 | -28.4083 | 151.1667 | 12-MAY-67 | 28144.420 | 4987.948 | 46893.480 | 54918 |
| 670014 | -28.4450 | 150.9883 | 12-MAY-67 | 28019.210 | 4932.140 | 47046.770 | 54980 |
| 670015 | -28.5417 | 150.8583 | 12-MAY-67 | 28044.650 | 5046.029 | 47076.810 | 55029 |
| 670020 | -28.4700 | 150.0450 | 12-MAY-67 | 28048.450 | 4979.355 | 47247.540 | 55171 |
| 670026 | -28.3717 | 149.0967 | 13-MAY-67 | 28036.150 | 4691.643 | 47405.570 | 55275 |
| 670027 | -28.3567 | 148.9400 | 13-MAY-67 | 28062.420 | 4637.317 | 47468.830 | 55338 |
| 670028 | -28.2833 | 148.7883 | 13-MAY-67 | 28172.870 | 4487.350 | 47318.570 | 55253 |
| 670030 | -28.0450 | 148.5950 | 13-MAY-67 | 28379.380 | 4351.105 | 47055.540 | 55123 |
| 670032 | -27.9683 | 148.2983 | 14-MAY-67 | 28430.610 | 4553.845 | 46952.630 | 55078 |
| 670033 | -27.9617 | 148.1083 | 14-MAY-67 | 28398.380 | 4658.896 | 47093.130 | 55190 |
| 670035 | -27.9783 | 147.7783 | 15-MAY-67 | 28295.470 | 4422.520 | 47097.050 | 55121 |
| 670036 | -28.0033 | 147.6133 | 15-MAY-67 | 28251.890 | 4390.455 | 47126.210 | 55121 |
| 670037 | -28.0300 | 147.4367 | 15-MAY-67 | 28208.550 | 4350.111 | 47213.170 | 55170 |
| 670040 | -27.9850 | 146.9350 | 15-MAY-67 | 28187.330 | 4472.839 | 47264.610 | 55213 |
| 670041 | -27.9950 | 146.7733 | 15-MAY-67 | 28122.820 | 4470.990 | 47384.890 | 55283 |
| 670042 | -27.9967 | 146.6067 | 15-MAY-67 | 28151.940 | 4349.766 | 47388.210 | 55291 |
| 670043 | -28.0033 | 146.4417 | 15-MAY-67 | 28193.880 | 4280.703 | 47465.250 | 55373 |
| 670044 | -28.0017 | 146.2783 | 15-MAY-67 | 28261.760 | 4333.071 | 47500.660 | 55442 |
| 670046 | -28.0300 | 145.9617 | 15-MAY-67 | 28163.680 | 4117.003 | 47636.330 | 55492 |
| 670047 | -28.0667 | 145.7950 | 16-MAY-67 | 28108.460 | 4058.838 | 47558.640 | 55393 |
| 670048 | -28.0800 | 145.6300 | 16-MAY-67 | 28204.610 | 4022.480 | 47634.170 | 55504 |
| 670049 | -28.0900 | 145.4500 | 16-MAY-67 | 28123.110 | 4111.073 | 47622.380 | 55459 |

## References

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Langel R., J. Berbert, T. Jennings and R. Horner (1981). *MAGSAT Data Processing: A Report for Investigators*, NASA Technical Memorandum 82160, Goddard Space Flight Center, Greenbelt, Maryland.

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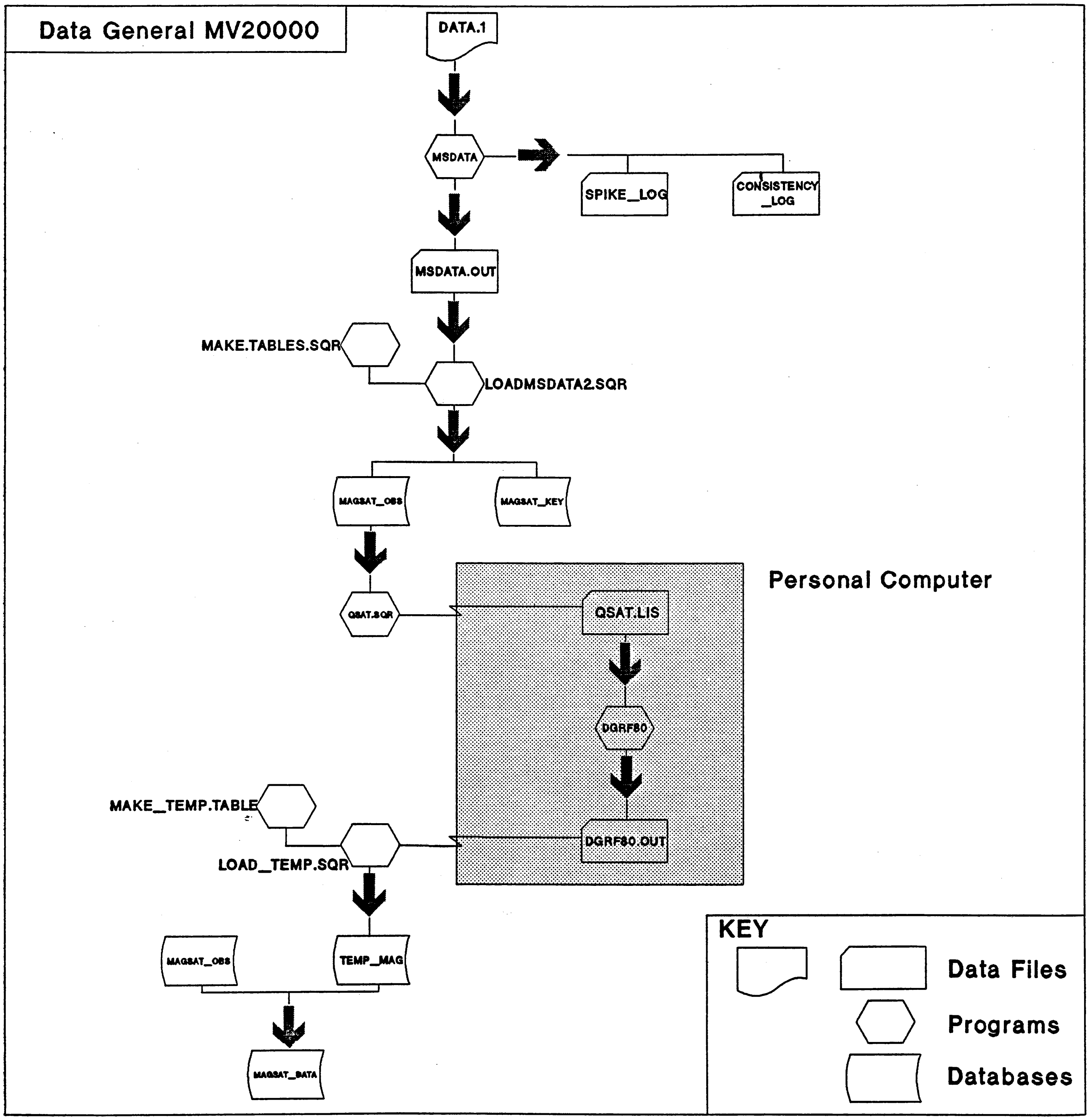
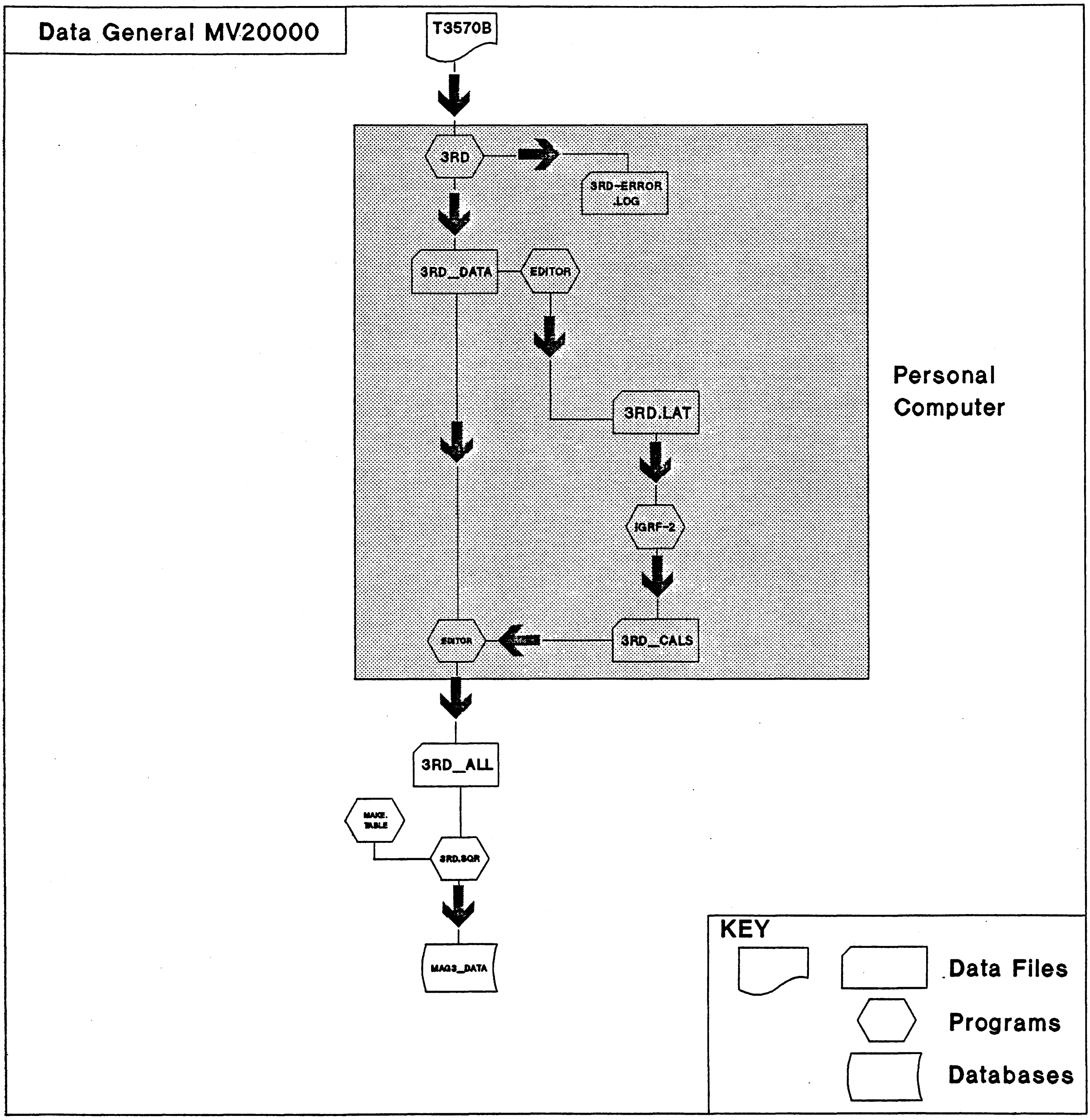
Essential help was provided from staff in Geoscience Computing and Database Branch during the course of this project. Dave Johnson provided the MAGSAT dataset and more importantly, the crucial experience and advice on its processing. Tony Boston, with his expertise in ORACLE and SQR, was also of great assistance.
I also wish to acknowledge the assistance of several staff in Geomagnetism Section, Division of Geophysics , particularly Charles Barton, Phil McFadden and Andrew McEwin.

# APPENDIX 1
# PROCESSING SCHEME FOR MAGSAT DATABASES



## APPENDIX 1 (Continued)

### PROCESSING SCHEME FOR 3RD-ORDER DATABASE



**Appendix 2**
**Table of Coefficients for the MGST 4/81 Field Model**

SHC_MGST (4/81 - 1) coeffs used by Johnson for MSDB anomaly data in X,Y & Z
1980.0

| | | | | | |
|---|---|---|---|---|---|
| -29987.4000 | 0.0 | -1956.6600 | 5604.6000 | -1996.2500 | 0.0 |
| 3027.4700 | -2129.3500 | 1663.5100 | -199.5380 | 1279.7800 | 0.0 |
| -2180.9600 | -334.3280 | 1251.4800 | 271.1530 | 832.6880 | -252.1600 |
| 937.6950 | 0.0 | 782.5540 | 212.0730 | 396.9690 | -256.7500 |
| -419.5190 | 52.2635 | 198.1010 | -297.9320 | -217.1460 | 0.0 |
| 357.8880 | 45.8936 | 261.2161 | 149.9210 | -74.3759 | -150.5120 |
| -161.9630 | -77.7928 | -47.7669 | 92.3732 | 48.5202 | 0.0 |
| 65.0260 | -14.6295 | 41.9786 | 93.1565 | -192.1000 | 71.0004 |
| 3.4479 | -43.0348 | 13.8406 | -2.1000 | -107.5920 | 17.3804 |
| 72.0881 | 0.0 | -59.1756 | -82.6712 | 1.6851 | -27.1635 |
| 20.7827 | -5.2576 | -12.2068 | 16.0015 | 0.4589 | 17.8601 |
| 10.2424 | -22.9516 | -2.0440 | -10.0028 | 18.5027 | 0.0 |
| 6.7180 | 7.1663 | -0.2224 | -17.5402 | -10.9832 | 3.7765 |
| -7.2255 | -22.1662 | 4.4361 | 9.0807 | 2.5194 | 16.1905 |
| 6.0924 | -13.3311 | -0.7953 | -14.8611 | 5.3658 | 0.0 |
| 10.4237 | -20.9565 | 1.4015 | 15.4832 | -12.1722 | 8.7292 |
| 9.4666 | -5.0770 | -3.5123 | -6.8231 | -1.0148 | 8.9425 |
| 6.8629 | 9.7115 | 1.4235 | -5.6699 | -4.9588 | 2.2038 |
| -3.2005 | 0.0 | -3.8158 | 1.2020 | 2.4102 | 0.3740 |
| -5.6489 | 2.9286 | -1.8386 | 5.8115 | 4.5390 | -4.2946 |
| 3.3065 | -0.1615 | 0.6702 | -1.2889 | 2.2606 | 3.0986 |
| 3.0480 | -0.2038 | -0.5355 | -6.3757 | 2.4607 | 0.0 |
| -1.3286 | 0.8352 | -1.8108 | 1.9880 | 2.4251 | -1.5165 |
| 0.1636 | -3.2010 | -0.8577 | 0.4420 | -0.3623 | -0.2882 |
| 1.3624 | -2.3326 | 1.5073 | -0.2371 | -0.6185 | -1.4691 |
| 1.8933 | -1.8966 | 3.4709 | 1.1203 | -1.7403 | 0.0 |
| 0.0508 | 0.4838 | -0.2592 | 0.6381 | -0.1101 | 2.3578 |
| 0.7578 | -1.3924 | 0.5927 | 0.3802 | -0.4967 | 0.1595 |
| -0.2294 | -0.2287 | 0.3136 | 0.1281 | -0.6368 | -0.0427 |
| -0.1405 | -1.2912 | 0.8124 | 0.4636 | 0.0221 | 0.8789 |
| -0.0553 | 0.0 | -0.3744 | -0.3332 | 0.4393 | 0.2688 |
| -0.5120 | 1.3166 | -0.1548 | -0.2319 | 0.9147 | -0.5096 |
| -0.4817 | -0.1245 | 0.1629 | 0.9306 | -0.8723 | 0.2064 |
| 0.2056 | 0.9744 | -0.1174 | 0.1600 | 0.3076 | -0.1404 |
| -0.4995 | -0.3430 | 0.4846 | -0.9249 | | |

**Appendix 2** (Continued)
**Table of Coefficients for the MGST 4/81 Field Model**
**Secular Variation Coefficients**

SV-MGST(4/81 - 1)

| | | | | | |
|---|---|---|---|---|---|
| 14.1443 | -23.3289 | -11.5808 | 0.0 | 24.2670 | 0.0 |
| 1.1068 | -11.7041 | 11.6413 | -20.3421 | -6.1531 | 0.0 |
| -6.2654 | 4.0504 | -2.3586 | 1.4991 | -2.6353 | -8.6918 |
| -1.1505 | 0.0 | 2.2571 | -0.9730 | -6.1304 | -2.2003 |
| 0.2624 | 4.9619 | -7.3546 | -4.9235 | 0.7381 | 0.0 |
| -1.3683 | 1.7185 | 0.8192 | 0.6335 | -3.6889 | -1.3293 |
| 1.8522 | 2.9164 | -0.4809 | 0.6970 | 1.7015 | 0.0 |
| 2.3799 | -1.5498 | 1.0258 | -3.3001 | -0.2131 | -0.4147 |
| 0.5975 | 1.0068 | 0.3363 | 1.2481 | -1.3949 | 4.5539 |
| 1.3474 | 0.0 | -2.4253 | -2.2604 | 0.6883 | 0.8954 |
| -0.3423 | 0.3084 | -1.0092 | 0.5518 | -1.4889 | -1.2125 |
| 1.0496 | -0.1881 | 0.0320 | 1.3946 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | | |