**MAG2D: An Interactive 2 1/2-Dimensional
Magnetic Modeling Program
(User's Guide and Documentation for Rev. 1)**

by
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ABSTRACT

MAG2D is an interactive computer program used for modeling 2 1/2-dimensional magnetic data. A forward algorithm is used to give the theoretical attraction of magnetic intensity at a station due to a perturbing body given by the initial model. The resultant model can then be adjusted for a better fit by a combination of manual adjustment, one-dimensional automatic search, and Marquardt inversion.

MAG2D has an interactive data management system for data manipulation and display built around subroutines to do a forward problem, a one-dimensional direct search and an inversion. These subroutines were originally separate batch-mode programs developed by John H. Snow at the Department of Geology and Geophysics, University of Utah.

This report is a user's guide and documentation for MAG2D. REV1.

INTRODUCTION

MAG2D.REV1 is an interactive program for 2 1/2-dimensional magnetic modeling and is used for the interpretation of magnetic anomalies. Models are composed of two-dimensional polygons with a finite, rather than infinite, strike length. A forward algorithm gives the theoretical attraction of magnetic intensity at a station due to a perturbing body given by the initial model. The model can then be manually adjusted to obtain a better fit, or the program can be employed to do a one-dimensional direct search to automatically adjust the model until a good match is obtained between observed and theoretical curves. The search technique usually requires a large number of computations of the forward problem. After a good match is obtained with manual or automatic searching, an inversion can be done to further improve the model. The search method is restricted by a decreasing-resolution-with-depth problem that is inherent in potential field data. The Marquardt inversion requires a good starting point (low objective function) to be effective.

This program is operational on the University of Utah Research Institute's (UURI) PRIME 400 computer operating under PRIMOS IV, Rev. 17.

MAG2D is a modification of programs MAGSER and MAGINV developed by John Snow while a graduate student at the Department of Geology and Geophysics, University of Utah. MAG2D is essentially an interactive interface built around Snow's programs. The interactive interface was designed to facilitate data manipulation.

This user's guide will document how to use the interactive interface. The necessary input parameters will be described. The user is referred to Appendix III for a description of the mathematics.

GRAV2D.REV2 is a related program for gravity modeling.

USER'S GUIDE

MASTER

The program MAG2D is menu-driven. The user has a variety of available options that allow him to perform the necessary I/O, data manipulation and computation to produce a new model and theoretical magnetic values.

By selecting the appropriate options and responding to the prompts correctly, the user can work his way through the modeling process.

The user enters the program at the operating system level by typing

MAG2D

The program responds by typing the program name and revision number at the terminal. The user then encounters the first options query as follows:

TERMINL- Option:

The user enters the appropriate option number to continue with the program. If the user doesn't know or can't remember the available options and their corresponding option numbers, he can obtain the options list by entering a zero or carriage return, whereupon the program displays the options list to the terminal and again requests an option number.

The options list for TERMINL- is

- 1 HARD COPY 80 COLUMN
- 2 TEKTRONIX 4014
- 3 CRT 80 COLUMN

The user enters the option number corresponding to the type of terminal being used.

Choosing option #2 causes appropriate action for erasing the Tektronix screen when necessary. Choosing options #2 or #3 causes printing to halt after a certain number of lines, so the user can examine the information before it is overwritten or scrolled off the screen. The user causes the printing to continue by typing a carriage return for which the program prompts.

The next option request is for the controlling option list called MASTER.

MASTER-- Option:

The available options under MASTER are

- 1 EXIT FROM SYSTEM
- 2 INPUT NEW DATA
- 3 EDIT DATA
- 4 LIST DATA AND RESULTS
- 5 XGT SEARCH/INVERSION PROGRAM
- 6 FILE MAIN. - SAVE AND RECALL
- 7 PLOT MODELS AND CURVES

The MASTER options are discussed separately in the following sections.

Options are nested, with TERMINL and MASTER at level 1. Lower-level options are indented from the next higher one. Option #1 will always return the user to the next higher options list unless the current options list is for device selection. Option #1 in MASTER causes the program to terminate.

A zero input to the options query will always result in a listing of the options available.

INPUT

The model is defined by specifying a number of polygons in the x-z plane, where x-y-z is a normal right-hand coordinate system with z down, x to the right, and y out of the page. The y dimension is specified by the strike half-length for that polygon. It is this finite length in the y direction that provides the 1/2 dimension for the 2 1/2-dimensional modeling.

Data is enter from the keyboard. Optionally, the station, model and search data can be input from previously created disc files. Keyboard data is entered in free format (list-directed READ). Formats for station, model and search data files are also free format, and data would appear in the file just as if the user were answering the interactive queries from the keyboard. See the sample terminal sessions for an example. When input is from data files, the input queries will still appear on the screen.

Model z-vertices and station elevations are given in distance units relative to a reference line. Elevations are measured relative to this reference line with positive being above the line, negative below. Model z-vertices are measured relative to the line with positive below, negative above. If the elevations are all the same, this can be the reference line with elevations all zero and model vertices equal to the relative distance from the surface. If the stations are at varying elevations, the reference line can be chosen to be MSL (mean sea level). In this case, many of the z-vertices may be negative. The reference line could also be chosen to be the maximum or minimum station elevation.

Distance can be in any units as long as the units are consistent throughout the input data.

The INPUT subroutine displays at the terminal the maximum values allowed for the # of stations, # of polygons, # of

vertices per polygon, and # of search directions. A displayed message notifies the user that he can exit the INPUT function (with no change to the work file) by typing "RETURN TO MASTER" (quotes not included) instead of the WORK FILE HEADER. This is primarily an escape mechanism for inadvertant selection of the INPUT function or in case the input disc files have variables exceeding the maximum allowed (in which case, the results of INPUT are unpredictable but generally unsatisfactory).

The following is a list of queries for input and the corresponding input parameters.

INPUT WORK FILE HEADER (80 CHAR.)

Variable name HEAD(20) is an alphanumeric identifier for the work file up to 80 characters.

DO YOU WANT TO INPUT STATION DATA FROM FILE?

Answer appropriately with "YES" or "NO" (also "Y" or "N").

If answer to previous query was "NO", enter the station data from the keyboard, otherwise

INPUT FILENAME (16 CHAR)

Enter the name of the file (up to 16 characters) from which the station data is to be read.

The next five queries are for station data.

INPUT PROFILE ID.

Variable name PROFID(20) is an alphanumeric identifier for the station data. It will be used as a title for the plot output.

INPUT CODE FOR FIELDS TO BE COMPUTED:

1 = TOTAL

2 = VERTICAL

Variable NOPT is an integer. If a number other than 1 or 2 is entered, the program will request NOPT again.

INPUT STATION NO. OR MATCH PT.

Variable NBASE is an integer referring to the station number or match point where the theoretical magnetic intensity will be set equal to the observed. Match point at zero will calculate absolute residual.

INPUT NO. OF STATIONS

Variable NSTAT is an integer referring to the number of stations. The maximum number of stations is set to 500. If an invalid number is entered (NSTAT < 1 or > 500), the program will request NSTAT again.

INPUT OBS. INTENSITY, DIST., ELEV. FOR n STATIONS

Enter TD(i), XSTAT(i), ZSTAT(i), i=1, NSTAT where

TD(i) is the observed magnetic value at the ith station, XSTAT(i) is the distance of the ith station from the origin (positive to the right). The first station is always the leftmost station of the profile, ZSTAT(i) is the elevation above the reference line of the

ith station (positive up).

This is the end of the station data. The following four queries are answered from the keyboard.

INPUT EARTHS TOTAL MAGNETIC FIELD (GAMMAS)

Enter AMBF in gammas.

INPUT INCLINATION (DEG)

Enter INCL, inclination of the earth's total magnetic field, in degrees. INCL is declared real.

INPUT ANGLE BETWEEN MAG. NORTH & PROFILE AXIS (DEG)

Enter ANG, the angle in degrees between magnetic north and the profile axis, clockwise from magnetic north (Azimuth).

DO YOU WANT TO INPUT MODEL DATA FROM FILE?

Answer appropriately "YES" or "NO".

If answer to previous query is "NO", enter the model data from keyboard, otherwise

INPUT FILENAME (16 CHAR)

enter the filename of the file containing the data for the model.

This is the first query for the model data. (Note that this data set includes some search data.)

INPUT NO. OF POLYGONS

Variable NPOLY is an integer equal to the number of polygons in the model. The maximum number of polygons is set to 15. The maximum number of vertices per polygon is 33. If an invalid number is entered (NPOLY < 1 or > 15), the program will request it again.

FOR POLYGON 1, INPUT:

OF SIDES, SUSCEPT. (CGS), STRIKE HALF-LENGTH, SUSCEPT. SEARCH#

for polygon #1, enter variables NSIDES(1), SUS(1), Y(1), ISUS(1)

where

NSIDES(1) is an integer equal to the number of sides of polygon 1.

SUS(1) is a floating point number equal to the susceptibility of polygon 1.

Y(1) is a floating point number equal to the strike half-length of polygon 1.

ISUS(1) is an integer equal to the search number for the susceptibility of polygon 1 (some number between 1 and the total number of search directions). Enter zero if no search is required on susceptibility.

FOR m VERTICES, INPUT:

HORZ. COORD., VERT. COORD., VERT. SEARCH #, HORZ. SEARCH #
XSTART(1,m), ZSTART(1,m), IVD(1,m), IVX(1,m) for
m=1, NSIDES(1)+1

where

XSTART(1,m) is the horizontal coordinate of the mth vertex of the 1st polygon (positive to the right of the origin).

ZSTART(1,m) is the vertical coordinate of the mth vertex of the 1st polygon (positive downward) measured from the reference line.

IVO(1,m) is the search number for vertical movement on the mth vertex of the 1st polygon.

IVX(1,m) is the search number for the horizontal movement on the mth vertex of the 1st polygon.

Note: The vertices are ordered clockwise around the polygon.

Note: For NSIDES(1)+1 vertices, the last input vertex parameters should be the same as the first input vertex parameters, e.g., a closed polygon. Polygons should have all common vertices along mutual borders. Remember to change the vertices in all polygons with common vertices when editing a shared vertex.

Note: The polygons next to the surface must have their end points extended beyond the boundaries and a trivial thickness, on the order of 10 meters (0.01 km), added just below the surface to add stability to the search and inversion procedures. When adding the extension along the x-direction, do not include a station in the extended area. Stations and model data should be determined without regard to this extension.

Note: The model parameters may be adjusted in any order. For instance, the first search may be a set of vertices (1 or more) which are to be adjusted vertically, then the IVO(L,LL)=1 for all those vertices which are to be moved in the first search. The second search could then be the susceptibility of 1 or more of the polygons, then ISUS(L)=2 for all those polygons, etc.

Note: For inversion, IVO and IVX specify which parameters will be solved for by inversion. Set IVO and/or IVX to zero to exclude, and non-zero to include in inversion.

FOR POLYGON 2, INPUT:

OF SIDES, SUSCEPT. (CGS), STRIKE HALF-LENGTH, SUSCEPT.
SEARCH#

for polygon #2, input variables NSIDES(2), SUS(2),
Y(2), ISUS(2)

where

NSIDES(2) is an integer equal to the number of sides of polygon 2.

SUS(2) is a floating point number equal to the susceptibility of polygon 2.

Y(2) is a floating point number equal to the strike half-length of polygon 2.

ISUS(2) is an integer equal to the search number for the susceptibility of polygon 2 (some number between 1 and the total number of search directions). Enter zero if no search is required on susceptibility.

FOR m VERTICES, INPUT:

HORZ. COORD., VERT. COORD., VERT. SEARCH #, HORZ. SEARCH #
XSTART(2,m), ZSTART(2,m), IVO(2,m), IVX(2,m) for
m=1, NSIDES(2)+1

where

XSTART(2,m) is the horizontal coordinate of the mth vertex of the 2nd polygon (positive to the right of the origin).

ZSTART(2,m) is the vertical coordinate of the mth vertex of the 2nd polygon (positive downward) measured from the reference line.

IVO(2,m) is the search number for vertical movement on the mth vertex of the 2nd polygon.

IVX(2,m) is the search number for the horizontal movement on the mth vertex of the 2nd polygon.

FOR POLYGON N, INPUT:

OF SIDES, SUSCEPT. (CGS), STRIKE HALF-LENGTH, SUSCEPT. SEARCH#

for polygon #N, input variables NSIDES(N), SUS(N), Y(N), ISUS(N)

where

NSIDES(N) is an integer equal to the number of sides of polygon N.

SUS(N) is a floating point number equal to the susceptibility of polygon N.

Y(N) is a floating point number equal to the strike half-length of polygon N.

ISUS(N) is an integer equal to the search number for the susceptibility of polygon N (some number between 1 and the total number of search directions). Enter zero if no search is required on susceptibility.

FOR m VERTICES, INPUT:

HORZ. COORD., VERT. COORD., VERT. SEARCH #, HORZ. SEARCH #
XSTART(N,m), ZSTART(N,m), IVO(N,m), IVX(N,m) for
m=1, NSIDES(N)+1

where

XSTART(N,m) is the horizontal coordinate of the mth vertex of the Nth polygon (positive to the right of the origin).

ZSTART(N,m) is the vertical coordinate of the mth vertex of the Nth polygon (positive downward) measured from the reference line.

IVO(N,m) is the search number for vertical movement on the mth vertex of the Nth polygon

IVX(N,m) is the search number for the horizontal movement

on the mth vertex of the Nth polygon.
 INPUT BACKGROUND SUSCEPT.

Variable SUSBCK is the susceptibility (cgs) of the background (so susceptibility contrasts can be calculated).

This is the end of the model data.

DO YOU WANT TO INPUT SEARCH DATA FROM FILE?

Answer appropriately "YES" or "NO".

If answer to the previous query is "NO", enter the search data from the keyboard, otherwise

INPUT FILENAME (16 CHAR)

enter the name of the file where the search data resides.

This is the first query for the search data.

INPUT # ITERATIONS FOR INVERSION

Variable MAXIT is an integer equal to the maximum number of iterations of the inversion.

INPUT TOTAL # OF VERTEX SEARCH DIRECTIONS

Variable IORD is an integer equal to the total number of vertex search directions, both horizontal and vertical. This must also be specified non-zero when doing inversion. The maximum number of search directions is 30.

INPUT TOTAL # OF SUSCEPTIBILITY SEARCH DIRS.

Variable ISS is an integer equal to the total number of susceptibility search directions.

Note: If both IORD and ISS are zero, only the forward problem will be computed.

If $IORD+ISS > 0$, the next query will appear,

INPUT TOLERANCE, STEP SIZE FOR n SEARCH DIRECTIONS

variables XLIM(n), DELX(n) $n=1, IORD+ISS$
 where

XLIM(n) is the tolerance for the nth search. This specifies to what degree of accuracy the positioning of the parameter should be found, given in distance units for vertex search and in cgs for susceptibility search. A typical value might be 5 percent of depth. DELX(n) is the step size for the nth search direction (in same units as XLIM). A typical value might be 10 percent of depth.

The search proceeds as follows.

The objective function is evaluated. All parameters for that search are adjusted by DELX and the function is reevaluated. If the objective function value improves, the step size is doubled for the next step. If there is no improvement, the step direction is reversed and the function reevaluated. The search then proceeds as long as function improvement is found. If a minimum cannot

be found, the parameter will be reset at its initial position for the next search. If a vertex is adjusted past its horizontal limits, the vertex will be set at the limit and excluded from the search. These variables are used only by the automatic searching subroutine, not the inversion.

INPUT ADD. AMOUNT OF HORIZ. MOVEMENT (XMOR)

Enter XMOR, additional amount of horizontal movement allowed for the vertices of the model. Enter 0 if not needed. The program automatically sets the limits of horizontal movement as the vertex before and the vertex after that part of the model which is to be adjusted. When either limit is reached the vertex will be deleted from search and fixed at that limit.

INPUT ADD. AMOUNT OF DATA WINDOW (XMORE)

Enter XMORE, amount of data window used for restricted sum of squares objective function. Enter 0 if not needed. XMORE may be useful for shallow and narrow features. (See Appendix III for a discussion of the data window.)

This is the end of the search data.

INPUT HOR. SCALE, VER. SCALE(CURVES), VER. SCALE(MODEL)

variables HSCALE, VSCALE, VBOD are floating point numbers used for scaling the plots, where

HSCALE is the horizontal scale in units per inch for both the observed and computed curve plot and the model plot. VSCALE is the vertical scale of the plot for the observed and computed anomalies in gammas/inch. VBOD is the vertical scale of the model plot in units per inch.

Note: The maximum vertical scale for the curve plot can be determined from the observed anomaly. The maximum vertical scale for the model should be larger than the expected maximum depth of the vertices of the model. These scale factors can be overridden during plotting if they are not suitable. But, they can only be permanently changed in the data file through the editing routines.

After the user enters the last variable, the program returns to the MASTER options.

EDIT

MAG2D has an internal editor to provide limited editing capability under program control. Below is a list of EDIT options. Selecting EDIT options 4, 5 or 6 results in another level of option requests, such as ESTAT--- for editing station data. The user returns to the higher level options list by responding with 1 to the option request. All of the enter parameters can be edited through this internal editor.

EDIT---- Option:

- 1 RETURN TO MASTER OPTIONS
- 2 EDIT WORK FILE HEADER
- 3 EDIT AMBF, INCL, AZIMUTH
- 4 EDIT STATION DATA
- 5 EDIT MODEL DATA
- 6 EDIT SEARCH/INVERSN DATA
- 7 EDIT PLOT DATA

ESTAT--- Option:

- 1 RETURN TO EDIT OPTIONS
- 2 EDIT PROFILE ID.
- 3 EDIT FIELDS CALCULATED
- 4 EDIT STATION #/MATCH PT.
- 5 EDIT NO. OF STATIONS
- 6 EDIT DISTANCES
- 7 EDIT ELEVATIONS
- 8 EDIT OBS. INTENSITY VALUE

EMODEL-- Option:

- 1 RETURN TO EDIT OPTIONS
- 2 EDIT NO. OF POLYGON
- 3 EDIT # OF SIDES OF POLY.
- 4 EDIT SUSCEPTIBILITIES
- 5 EDIT STRIKE HALF LENGTH
- 6 EDIT HOR. COORDINATES
- 7 EDIT VERT. COORDINATES

ESEARCH- Option:

- 1 RETURN TO EDIT OPTIONS
- 2 EDIT # OF ITERATIONS
- 3 EDIT # OF VERTEX SEARCH DIR.
- 4 EDIT # OF SUSCEPT SEARCH DIR
- 5 EDIT SUSCEPT SEARCH #S
- 6 EDIT VERT. SEARCH #S(VERTEX)
- 7 EDIT HORZ. SEARCH #S(VERTEX)
- 8 EDIT TOLERANCES FOR SEARCH
- 9 EDIT STEP SIZES FOR SEARCH
- 0 EDIT XMOR, XMORE

The work file is updated only after selecting the EDIT option #1, RETURN TO MASTER. Any abnormal exit from the EDIT routine will result in a loss of the editing.

The editor works by allowing the user to input a new value

(in free format from the keyboard). If changing arrays, the user specifies the index (indices of 2-D arrays) and then enters the new array element. For 2-D arrays the user must specify whether he is changing an element of an array, adding a new element, or deleting an old one. He can enter the action desired (i.e., "ADD") or only the first letter of the action (i.e., "A" for add). He can add and delete prior to changing the value specifying the length of the array, but should take care to remember to also edit the variable storing the length. For example, if the user adds a new vertex in a polygon, he should also change the number of sides of that polygon. The printing routines will reflect the value that is currently stored in the variable containing the array length. If the index specified is less than zero (negative), the entire array is then entered, one element at a time. For 2-D arrays, enter the first index (or both indices) as negative in order to enter the entire array. An element is added after the one specified by the index. If one wants to add before element (N,1), add an element equal to (N,1) after (N,1) and then change the value of (N,1) to the value of the added element.

LIST

The list options are given below.

LIST---- Option:

- 1 RETURN TO MASTER
- 2 LIST HEADER, AMBF, INCL, AZMTH
- 3 LIST STATION DATA
- 4 LIST MODEL DATA
- 5 LIST SEARCH DATA
- 6 LIST PLOT DATA
- 7 LIST ENTIRE FILE CONTENTS
- 8 SEND WORK FILE TO PRINTER

All output is in 80 column format. Options 2 thru 7 print at the terminal. Option 8 prints the entire work file contents at the on-site printer. If the terminal type (from the TERMINL- options list) is not "hard copy", paging will be done so that the user can examine the printed information before it is scrolled off the screen. Typing a "carriage return" will cause the printing to continue. Option # 3 requests a starting and ending index for printing the station array so that only a portion can be printed. A starting and ending index of 0,0 will result in the entire array being printed. The keyboard characters CTRL-S and CTRL-Q will also stop and start output to the terminal without loss of information. CTRL-S stops output and is entered by hitting the "CTRL" key and the "S" key simultaneously. CTRL-Q restarts the output and is entered like CTRL-S.

EXECUTE

This option causes execution of Snow's programs. The forward problem, the 1D direct search, or the inversion can be done depending on the input parameters stored in the work file and the options selected. The output (calculated magnetic value and new model) is written to the work file upon completion of the forward problem. The output from the direct search or inversion is stored only if the user answers the following query with a "YES".

DO YOU WANT TO SAVE THESE RESULTS?

The execute options are given below.

XGT----- Option:

- 1 RETURN TO MASTER
- 2 XGT SEARCH/FORWARD
- 3 XGT INVERSION

The forward problem only is done by selecting option #2 with IORD and ISS both equal to zero.

Upon entering the search/inversion subroutines, the user can select certain output options. They produce plotter and printer output without executing MASTER options #4 and #7. The user is queried as to whether he wants output produced during the execution of the forward/search/inversion subroutine. This output may be helpful if the user wants to see how things are changing or to save time if he knows he wants to see the results immediately.

If the user responds with "No", no output will appear during execution except for the printing of the value of the sum of squares and the number of iterations left. If the user responds with "Yes", the following two option lists appear so the user can direct the output to the appropriate device.

PRT. DEV- Option:

- 1 TERMINAL
- 2 PRINTER

used to determine where the print will appear.

DEVICE-- Option:

- 1 TEKTRONIX GRAPHICS PLOT
- 2 STATOS PLOT
- 3 PRINTER (DEFAULTS TO #2)
- 4 ZETA PEN PLOT

5 UGCC CALCOMP PLOT

used to determine where the plotting will appear.

Note: Any STATUS, ZETA, or CalComp plot will only be stored as a file of plot vectors until the proper PRIMOS command is given once the user has terminated MAG2D. PRINTER plots are not currently available so this option defaults to option #2.

Printed output will consist of an abbreviated form of LIST options #7 or #8 (LIST options 2,3,4). Plot output will be the same as is generated under the PLOT function.

After each iteration, the objective function will be printed. To reduce the amount of output, the user is queried by

DO YOU WANT OUTPUT THIS ITER. ?

after each iteration. Typically the user will only look at model results for iterations with surprising objective function values.

When finished with the search or inversion, the user can either save the new model and calculated magnetic values or retain the starting model by answering appropriately to the query about saving the results. The results are always saved if just a forward calculation is done, in which case, the user is not queried about saving the results.

FILE MAINTENANCE

This option allows the user to save his work files on a merge file (a catalog of files). This option contains utilities for manipulating the merge file. The merge file should be initialized (with FMAIN- option #7) before attempting to copy the first work file.

The available File Maintenance options are

FMAIN--- Option:

- 1 RETURN TO MASTER PROGRAM
- 2 LIST MERGED FILE DIRECTORY
- 3 SAVE WORK FILE ON MERGED FILE
- 4 RESTORE WORK FILE FROM MERGED FILE
- 5 DELETE AND PACK MERGED FILE
- 6 SYSTEM PACK AND MERGE FILE
- 7 INITIALIZE MERGE FILE
- 8 SEND MERGE FILE CONTENTS TO PRINTER

Option #5 deletes and packs the merge file but does not reduce the physical size of the file. Option # 6 reduces the

size of the file, thereby saving disc space. Option #8 allows the user to print selected subfiles. These are selected by entering "Y" (print) or "N" (don't print) under the appropriate subfile #s. The print format is the same as for LIST options 2,3,4,5, and 6 with all station data being printed.

PLOT

The plot option produces a plot of the calculated and observed magnetic values and a plot of the model. Sample plots are included in the terminal sessions.

The plot options are

```
PLOT---- Option:
      1  RETURN TO MASTER OPTIONS
      2  PLOT CURRENT MODEL
      3  PLOT MULTIPLE SAVED MODELS
```

Option #2 plots the model and magnetic values in the work file. Option # 3 produces plots from the specified subfiles in the merge file.

The PLOT option produces a device selection option request to determine which plotting device is to be used. The device selection is the same as the one used in EXECUTE, called DEVICE-.

STATOS, ZETA and CalComp plots are generated but not plotted until the user terminates MAG2D (by selecting MASTER- option #1) and types the proper PRIMOS command.

Currently, the program asks if the user wants an additional scaling factor for the magnetic intensity values on the plot. This scale factor was added so that the output would be in the same units as that published in AERO SERVICE's "Magnetic Fields and Gradients over Vertical Prisms and Dipping Sheets". This publication was used to verify results from MAG2D. The curve values in the publication are in gammas/120 rather than gammas.

The program requests the units of distance (4 characters) for labels on the plot axes.

The PLOT function allows the user to control the size of the plots. The program displays the maximum and minimum values for each of the three axes used by the PLOT subroutines. The scale factor (the spacing on the axis) is also displayed (input variables HSCALE, VSCALE, and VBOD). The program then asks for the beginning value of the axis (a new minimum for the x-axis and a new maximum for the y-axes) so the user can

control the numbers printed at the 1-inch tick marks. The user is also given the option of temporarily changing the scale factors for this plot. This change of scale factors is not written to the work or merge file. To make a permanent change of scale factors would require using the EDIT function.

The user can have symbols plotted at each station location on both observed and calculated curves by responding with the appropriate answer to the query.

The user can plot a sub-portion of the magnetic curves on the magnetic intensity plot. The full range of both axes is used to determine the size of the plot. The full model is also plotted.

Corner tick marks are plotted to define the plot area.

DIRECT-ACCESS FILE STRUCTURE

This program uses two direct-access files for data storage. These direct-access files have fixed-length records. The record length is defined in the \$INSERT file as PARAMETER IWTH.

DEFILE is the subroutine that defines the direct-access file.

MAG2D-WORK is the name of the direct-access file that contains the current model parameters and the calculated magnetic values. Most options work on data from this file and store results into this file. The two exceptions are MASTER Option #6 (File Maintenance) which provides a number of utilities that access the second direct-access file called MAG2D-MERGE, and the PLOT Option #3 which plots models and curves from selected files stored on the merge file.

MAG2D-MERGE is essentially a catalog of different work files. MAG2D-WORK can be stored in the merge file. The work files in the merge file can be moved back into MAG2D-WORK for manipulation with the program options.

The direct-access work file has 500 words per record and is 11 records long. The variables that are written to the work file are stored in COMMON blocks defined in the \$INSERT file. An entire record is written to the work file with a single write statement by specifying the beginning variable in the COMMON block associated with that record irregardless of mixed type within the COMMON block. The COMMON blocks are filled out with dummy arrays to insure correct record length.

See Appendix I for details on PRIME's direct-access I/O.

SYSTEM IMPLEMENTATION

The PRIME 400 is a virtual memory machine. No attempt was made to optimize paging for this program.

MAG2D uses 1344K (21 segments) words of memory (16 bits/word). Most floating-point and integer numbers are 32 bits. Most system subroutines require short integer arguments (INTEGER*2). PRIME FORTRAN has two functions, INTL and INTS, that convert short integers to long (INTEGER*4) and long integers to short. Some variables in the program are double precision (REAL*8) to increase the accuracy of repeated calculations. A machine with a larger word size than 32 may adequately use single precision.

The large size of the program is primarily a function of the maximum limits of the number of stations and model size. The \$INSERT file contains some very large COMMON blocks, MAGWK and MAGWW, that are dependent on the following PARAMETER variables

IWITH =	NS = 500	- # of stations, also width of direct- access file records
	NSDIR = 50	- # of search directions
	NP = 15	- # of polygons in model
	NV = 33	- # of vertices per polygon

These COMMON blocks store intermediate results for the inversion and search subroutines.

The amount of storage required by this program can be reduced considerably by decreasing the four PARAMETER variables mentioned above. They need only be changed in the \$INSERT file. (See \$INSERT and PARAMETER statement descriptions in Appendix I.) Changing the width of the direct-access file records will make previously created direct-access files unusable. The \$INSERT file contains some notes on changing these PARAMETER variables. The entire code in the \$INSERT file could be substituted for the \$INSERT MAG2D.COM statements throughout the program if no equivalent mechanism exists at the site installing the program.

The program makes use of direct-access files. See the previous section and Appendix I for more details.

The ENCODE/DECODE statements are used in the program to read and write data between memory locations. Appendix I describes ENCODE/DECODE statements.

All subroutines are compiled using PRIME FORTRAN's -BIG option to allow large arrays to span segment boundaries (1 segment=64K words). Long integer is the default on ESL's FOR

compiler.

MAG2D makes use of a device-independent plotting software package resident on the system for plotting on various graphic devices. This software library, UUPLT, is available from UURI/ESL. It uses Tektronix PLOT10 software to interface to the resident Tektronix 4014 graphics terminal. PLOT10 is available from Tektronix. It uses Varian Graphic's DATAPLOT III software to interface to the resident Varian STATOS electrostatic plotter. Nicolet-Zeta software is used to interface to the ZETA pen plotter. MAG2D generates plot files that can be read by the University of Utah Computer Center's (UU/CC) CalComp plotting system. The CalComp plot files are written to magnetic tape and transferred to UU/CC for actual plotting.

The plotting subroutines in MAG2D are very modular and could easily be replaced to conform to the plotting capabilities of another installation or be removed entirely.

The program uses five logical units for I/O.

- LU 1 - terminal read/write
- LU 8 - assigned to the work file
- LU 9 - assigned to the merge file
- LU 11 - assigned to temporary print files
- LU 13 - assigned to input files, if used

Logical unit numbers are converted to PRIME unit numbers for use by system subroutines by subtracting 4.

MAG2D makes use of some system subroutines. See Appendix II for a list and description. Integer arguments for system subroutines are short integer unless otherwise stated. An equivalent system routine is probably available at any site. PRIME manual SUBROUTINES, P/N MAN3251-001 contains more detail if needed.

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The original program source code that was published in John Snow's M.S. thesis has been modified, expanded, and integrated into a modeling system by Carleen Nutter at the Earth Science Laboratory Division, University of Utah Research Institute.

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John H. Snow has given the Earth Science Laboratory Division permission to publish Appendix I (pages 129 through 142) of his M.S. thesis which appears in this report as Appendix III. This Appendix explains the methodology of the program and we are grateful for John's permission to include it in this user's guide.

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APPENDIX I

PRIME FORTRAN EXTENSIONS

The following extensions are a part of PRIME's FORTRAN IV library. Additional information on the use of these extensions can be found in the PRIME system manual titled "The FORTRAN Programmers Guide", PDR3057, dated November 1977. PRIME Computer Inc. has given permission to reproduce the descriptions that follow.

CODING statements

For the 3 coding statements, the following variable descriptions apply.

c	Number of ASCII characters to be transferred.
f	Format statement label.
a	Array name.
sn	The statement number to which control is transferred if a FORMAT/DATA mismatch occurs.
list	I/O list of elements (same as in READ or WRITE statement)

Formatted DECODE statement

DECODE(c, f, a[, ERR=sn]) list

Converts the first c characters in the array a from ASCII data into the I/O list elements according to the specified format f. If the optional error branch is inserted, a FORMAT/DATA mismatch will cause a transfer to the statement labelled sn.

List-directed DECODE statement

DECODE(c, *, a[, ERR=sn]) list

Allows the user to input/decode data from free-format input devices such as the user terminal. The requirements on input

and delimiters are the same as for the list-directed READ statement.

ENCODE statement

ENCODE(c,f,a) list

Converts the elements of the I/O list into ASCII data according to format f and stores the first c characters of the resultant string into array a.

List Directed READ statement

READ(u,*[,END=a][,ERR=b]) list

Where u is the FORTRAN read unit and * is the symbol indicating that this is a free-format read. A and b are the statement numbers to which control is passed if an end-of-file or a read error is encountered.

List-directed READ frees the programmer from including format statements for READs from free-format devices such as the user terminal. The input data is converted according to the data type of items in the I/O list. Additionally, this feature provides a method to indicate in the input data that an item in the I/O list is to remain unchanged by the READ statement.

Delimiters: Values in list-directed input are separated by a blank, comma, or slash. A slash or comma may be preceded and followed by any number of blanks. An end of record is treated as a blank. A slash terminates a READ and leaves the remaining items in the I/O list unchanged. Two adjacent commas with no intervening characters except blanks will leave the corresponding item in the I/O list unchanged. A list-directed READ will read any number of records until a slash is encountered or until all items in the I/O list have been satisfied.

Numerical Input: If an item in the I/O list is a long or short integer variable or array element, the corresponding input field must contain a string of decimal digits optionally preceded by a + or - sign, as in

-357 100514 +12387

If a real or double-precision item is in the I/O list, the corresponding input field must contain a string of decimal digits with an optionally embedded decimal point. An exponent field may follow either an E or D format, as in

51 -27.68 7.65E-14 863D2
 .503 +265.

The input field corresponding to a complex item must contain two real numbers (as described above) separated by a comma and enclosed in parentheses, as in

(1E2, -2.) (5.67E-6, 8.09)

Character String Input: A variable or array of any type can be set equal to a character string using list-directed READ. A character string must be enclosed in single quotation marks in the input data. Within a character string, a quotation mark is represented by two consecutive single quotation marks. A character string, regardless of length, matches a single item in the I/O list whether it is a variable, array element, or whole array (represented by including the unsubscripted array name in the I/O list). If the character string is shorter than the list item, the rightmost characters of the list item are blank-filled. If the character string is longer than the list item, the rightmost characters of the character string are ignored.

Direct-access READ and WRITE statements

The FORTRAN compiler and run-time library support direct-access READ and WRITE statements. READ and WRITE statements may contain a record number to randomly access file records. With sequential access, record n-1 must be read or written before record n. The syntax implemented is compatible with both IBM FORTRAN and the new ANSI standard FORTRAN.

Usage: Special action is required by the user when creating and opening files to be used for direct access I/O. Files used for direct access I/O should be DAM files (direct-access I/O statements may be used with SAM files but execution time will be longer). If the file is formatted, the ATTDEV

subroutine must be called so that fixed length records are written (the ATTDEV subroutine is also used to set the record length). DAM files are created by opening a new file using the K\$NDAM subkey in either a SRCH\$\$ or TSRC\$\$ call (see Reference Guide, PRIMOS Subroutines for details).

The ATTDEV subroutine may be used to alter the mapping of FORTRAN units to file system units. The records of a direct-access formatted file must be fixed length. This is done by setting the second argument of ATTDEV to 8. The records of an unformatted file are fixed length by default.

A program that creates a direct-access file cannot write record n before record $n-1$ has been written. A separate program should be used. Once the file has been created, it can be read or written in random order.

After a direct-access I/O statement, the file is positioned as the record following the one just transferred. If the direct-access file is then accessed sequentially, using other forms of the READ or WRITE statement, it is not necessary to include the record number. This enhances performance by eliminating the positioning call.

IBM compatibility: The READ and WRITE statements are identical to IBM FORTRAN. The DEFINE FILE and FIND statements of IBM FORTRAN are not supported. The record size in the DEFINE FILE statement must appear in the ATTDEV call. The record size in the DEFINE FILE statement is measured in bytes or 32-bit words rather than 16-bit words required by ATTDEV. If the U specified is used in the DEFINE FILE statement, the record size of the DEFINE FILE statement should be doubled for the ATTDEV call; otherwise the record size should be halved.

The ATTDEV call requires INTEGER*2 arguments. If the INTL option is used during compilation, constants used as arguments in the ATTDEV calls must be converted to INTEGER*2 by the INTS function (e.g., INTS(8)).

There is no equivalent of the DEFINE FILE associated variable in Prime's implementation of direct-access files. In IBM FORTRAN, the value of the associated variable is the number of the record that follows the record just transferred.

Direct-access READ statements

READ(u'r[,f][,ERR=b]) list	IBM format
READ(u[,f],REC=r[,ERR=b]) list	ANSI format

- u A long or short integer constant or variable whose value is the FORTRAN unit number.
- r The long or short integer expression whose value is the record number to be accessed.
- f The statement number of the format specified (optional).
- b The statement number to which control is transferred if a device or format error is encountered during transfer (optional).

The apostrophe (') is required in the IBM form of direct-access READ and WRITE statements.

The END=specifier is not allowed in the direct-access READ statement. This restriction is consistent with both IBM FORTRAN and the new ANSI standard FORTRAN.

Direct-access WRITE statements

WRITE(u'r[,f][,ERR=b]) list	IBM format
WRITE(u[,f],REC=r[,ERR=b]) list	ANSI format

Parameters are the same as those described for the READ statement.

NOBIG / BIG

-BIG (a parameter on the compilation statement)

BIG treats all dummy arrays as arrays that span segment boundaries. BIG forces the 64V mode and thus cannot be used in the 32R or 64R modes. If a dummy argument array may become associated with an array spanning a segment boundary

(through a subroutine call or function reference), the compiler must be made aware of this by including `BIG` in the parameter list. The code generated will work whether or not the array actually spans segment boundaries.

PARAMETER statement

`PARAMETER(V1=C1,...,Vn=Cn)`

The `Vs` are variables (arrays are not allowed) and the `Cs` are constants or constant expressions of the same mode as the corresponding variables. The operands in the constant expressions may be constants or previously defined parameters. Allowed operations include `+`, `-`, `*`, and `/` on `INTEGER*2`, `REAL*8`, and `REAL*4` operands. `INTEGER*2 XOR`, `OR`, `AND`, `MOD`, shift, and truncate function references are also allowed. An error message, `ILL. CONSTANT EXPR.`, is generated if these restrictions are violated. The variable names must be typed explicitly prior to the `PARAMETER` statement or default-typed implicitly. All other uses of the `PARAMETER` names must follow the `PARAMETER` statement. `PARAMETER` names may be used wherever a constant would be used (including `DATA` and `DIMENSION` statements) except in `FORMAT` statements. Since the parameters are named constants, `PARAMETER` names may not be used in `COMMON` or `EQUIVALENCE` statements.

Enclosing the parameter list in parentheses is required by the FORTRAN 77 standard. Prime's FORTRAN will accept a `PARAMETER` statement with or without the parentheses.

\$INSERT statement

`$INSERT insert-file`

Insert into the program, at compilation time, the file whose pathname is `insert-file`. The `$INSERT` command should not be nested; do not include a `$INSERT` command in a file which will be inserted into a program by a `$INSERT` command.

`$INSERT` is used for:

- Insertion of `COMMON` specification into programs.
- Commonly used one-line functions.

- Data initialization statements.
- Parameter definitions, especially for the file management system, applications library, MIDAS, etc.

APPENDIX II

PRIME SYSTEM ROUTINES

The following material is taken from PRIME system manual PRIMOS SUBROUTINES REFERENCE GUIDE PDR 3621, dated March 1979, reproduced here with the permission of PRIME Computer, Inc.

This section is intended to describe the function of PRIME system routines used by MAG2D. A non-PRIME site will have to substitute equivalent routines suitable to its operating environment. If the user requires more detail on system routines, he is directed to the appropriate PRIME manuals.

UURI/ESL's device-independent plotting software, UUPLT, is not documented in this publication but is available as a separate document from ESL.

ATCH\$\$

ATCH\$\$ attaches to a UFD and, optionally, makes it the home UFD. In attaching to a directory, the subroutine **ATCH\$\$** specifies where to look for the directory. **ATCH\$\$** specifies a User File Directory (UFD) in the Master File Directory (MFD) on a particular logical disk, a sub-directory in the current UFD, or the home UFD as the target-directory of the **ATCH\$\$** operation.

CALL ATCH\$\$ (ufdnam, namlen, ldisk, passwd, key, code)

ufdnam The name of the UFD to be attached. If key=0 and ufdnam is the key K\$HOME, the home UFD is attached. If the reference subkey is K\$IMFD or K\$ICUR, ufdnam is either a Hollerith expression or the name of a three-word array that specifies a ufdname to attach to.

namlen The length in characters (1-32) of ufdnam. If ufdnam=K\$HOME, namlen is disregarded.

ldisk The number of the logical disk to be searched for ufdnam when key=K\$IMFD. The parameter, ldisk, must be a logical disk that is started up. Other values are:

K\$ALLD Search all started-up logical devices in logical device order, and attach to the UFD in which ufdnam appears in the MFD of the lowest-numbered logical device.

K\$CURR Search the MFD of the disk currently

attached.

passwd

A three-word array containing one of the passwords of ufdnam. Passwd can be specified as 0 if attaching to the home UFD. If the reference subkey is K\$IMFD or K\$ICUR, passwd is either a Hollerith expression (1 to 6 characters) or the name of a three-word array that specifies one of the passwords of ufdnam. If passwd is blank, it is specified as three words, each containing two blank characters.

key

Composed of two subkeys that are combined additively, a REFERENCE subkey and a SETHOME subkey. The REFERENCE subkey values are as follows:

K\$IMFD Attach to ufd in MFD on ldisk.

K\$ICUR Attach to ufdnam in current UFD (ufdnam is a subdirectory).

The SETHOME subkey, K\$SETH, may be added to the REFERENCE subkey, e.g., K\$IMFD+K\$SETH, which will set the current UFD to the home UFD after attaching. If the REFERENCE subkey is K\$ICUR, or if ufdnam is 0, ldisk is ignored, and ldisk is usually specified as 0.

code

An integer variable set to the return code.

To access files, the file system must be attached to some UFD. This implies that the file system has been supplied with the proper file directory name and either the owner or nonowner password, and the file system has found and saved the name and location of the file directory. The nonowner password may be given only under PRIMOS and PRIMOS III.

A BAD PASSWD error condition does not return to the user's

program. PRIMOS command level is entered, and the user is not attached to any UFD. Other errors leave the attach point unchanged.

ATTDEV

ATTDEV attaches specified devices by initializing both LUTBL, associating logical-device to physical device, and PUTBL, associating the logical-device to a specific unit or file of the device.

CALL ATTDEV(logical-device, physical-device, unit, buffer-size)

logical-device	The device-independent logical I/O unit for WRASC, RDASC, WRBIN, RDBIN, and FORTRAN READ and WRITE statements.
physical-device	The position in the device-type tables.
unit	The unit for multi-unit devices (e.g., for disk, file unit number).
buffer-size	The record size associated with the logical unit. Must be as large as maximum record size.

For the given logical-device, set the physical-device, unit, and buffer-size in the LUTBL, PUTBL, and RSTBL so that the logical unit has a current mapping.

Errors

If device is incorrect, ATTDEV returns the message: ATTDEV BAD UNIT (unit-number).

CLOS\$A

CLOS\$A is a logical function that closes the file open on unit. If the operation is successful, the function is **.TRUE.** and if unsuccessful, the function is **.FALSE.**

LOG = **CLOS\$A**(unit)

CALL CLOS\$A(unit)

unit File unit.

unit is **INTEGER*2**.

CNAM\$\$

CNAM\$\$ changes the name of a file in the current UFD.

CALL CNAM\$\$(oldnam, oldlen, newnam, newlen, code)

oldnam	The name of the file to be changes.
oldlen	The length in characters of oldnam.
newnam	The new name of the file.
newlen	The length in characters of newnam. code An integer variable set to the return code.

The user must be the owner of the UFD of the file to change the name. **CNAM\$\$** does not change the last modified date-time of the file or any of the other attributes of the file. However, the last modified date-time of the UFD in which the file resides is changed. **CNAM\$\$** may cause the position of the file in the UFD to change with respect to the other files if the new name is longer than the old name. It is illegal to change the name of the MFD, BOOT, BADSPT. A NO

RIGHT error message is generated if this is attempted.

ERRPR\$

ERRPR\$ interprets a return code and, if non-zero, prints a standard message associated with the error return code, code, followed by optional user text.

CALL ERRPR\$(key,code,text,txtlen,filnam,namlen)

key

An integer specifying the action to take subsequent to printing the message. Possible values are:

K\$NRTN Exit to the system, never return to the calling program.

K\$SRTN Exit to the system, return to the calling program following an 'S' command.

K\$IRTN Return immediately to the calling program.

code

An integer variable containing the return code from the routine that generated the error. If code is 0, ERRPR\$ always returns immediately to the calling program and prints nothing.

text

A message to be printed following the standard error message. Text is omitted by specifying both text and txtlen as 0.

txtlen

The length in characters of text.

filnam The name of the program or subsystem detecting or reporting the error. Filnam is omitted by specifying both filnam and namlen as 0.

namlen The length in characters of filnam.

EXIT

The EXIT subroutine provides a way to return from a user program to PRIMOS; it prints 'OK,' (or 'OK:') at the terminal and PRIMOS awaits a user command.

CALL EXIT

The user may open or close files or switch directories, and restart a FORTRAN program at the next statement by typing 'S' (i.e., START).

EXST%A

EXST%A is a logical function which returns .TRUE. if the file exists and .FALSE. if the file does not exist or if an error was encountered.

LOG = EXST%A(name,namlen)

name File name (may be a treename).

namlen Length of name in characters. (Mode is INTEGER*2, but the type of name doesn't matter.)

SLEEP\$

SLEEP\$ suspends execution of a user process.

CALL SLEEP\$(interval)

interval	A variable in milliseconds for which execution is to be suspended (INTEGER*4).
-----------------	--

Execution of the user process is suspended for the specified interval. An interval $<$ or $=$ to 0 will result in an effective no-op. A QUIT and START from the user terminal will cause immediate return from the SLEEP\$ call.

SPOOL\$

A user program can insert a file into the spool file directory by calling the SPOOL\$ subroutine from the applications program. This subroutine SPOOL\$ is in the SPOOL\$ library (R-mode) and VSP00\$ library (V-mode).

CALL SPOOL\$(key, name, namlen, info, buffer, buflen, code)

key	1 - copy named file into queue. 2 - open file on unit info(2) for writing.
name	File to be copied (key=1). Name to appear on banner (key=2).
namlen	Length of name, in characters (1-32).
info	Information array, 12 elements, as follows: 1 temp file unit 1 (may range from 1-62, Rev. 16 and above).

- 2 temp file unit 2 (may range from 1-62, Rev. 16 and above).
- 3 print option word (see below).
- 4-6 form type (6 ASCII characters).
- 7 plot raster scan size (plot only). This represents #words/raster scan.
- 8-10 spool filename (returned).
- 11 deferred print time (valid only if defer bit specified in option word).
- 12 file size, returned if key 1.

buffer

Scratch buffer - this is used to set up control info and to copy the file to the spool queue (key=1) - it must be at least 40 words long. Copy time is inversely proportional to buffer size. Nominal size is between 300-2000 words.

buflen

Length of buffer.

code

Return code (non-zero if file system error).

SRCH\$\$

SRCH\$\$ is used to open a file, close a file, delete a file, or check on the existence of a file.

CALL SRCH\$(action+ref+newfil, filnam, namlen, funit, type, code)

action

A subkey indicating the action to be performed. Possible values are:

K\$READ Open filnam for reading on funit.

K\$WRIT Open filnam for writing on funit.

K\$RDWR Open filnam for reading and writing on funit.

K\$CLOS Close file by filnam or by funit.

K\$DELE Delete file filnam.

K\$EXST Check on existence of filnam.

ref

A subkey modifying the action subkey as follows:

K\$IUFD Search for filnam in the current UFD (this is the default).

K\$ISEG Perform the action specified by action on the file that is a segment directory entry in the directory open on file unit filnam.

K\$CACC Change the access mode of the file already open on funit to action. (K\$READ, K\$WRIT, K\$RDWR only).

K\$GETU Open filnam on an unused file-unit selected by PRIMOS. The unit number is returned in funit. When this key is used, SRCH\$\$ supplies a unit number not currently in use.

newfil

A subkey indicating the type of file to create if filnam does not exist. Possible values are:

K\$NSAM New threaded (SAM)
file (this is the
default).

K\$NDAM New directed (DAM)
file.

K\$NSGS New threaded (SAM)
segment directory.

K\$NSGD New directed (DAM)
segment directory.

It is not possible to
generate a new UFD with
SRCH\$\$; use CREA\$\$
instead.

filnam

Name of the file to be opened
(2 characters per word).
K\$CURR can be used to open the
current UFD (ACTION keys
K\$READ, K\$WRIT, or K\$RDWR
only). If ref is K\$ISEG,
filnam is a file unit from 1 to
62 (1 to 15 under PRIMOS II) on
which a segment directory is
already open.

namlen

The length in characters (1-32)
of filnam.

funit

The number (1-15 under PRIMOS
II) of the file unit to be
opened or closed, or returned
argument with K\$GETU key.

type

An integer variable that is set
to the type of the file opened.
Type is set only on calls that
open a file -- it is unmodified
for other calls. Possible
values of type are:

- 0 SAM file.
- 1 DAM file.
- 2 SAM segment directory.
- 3 DAM segment directory.
- 4 UFD.

code

An integer variable set to the
return code.

SRCH\$\$ is a complex subroutine that has multiple uses. The most common use is to open and close files.

TIMDAT

TIMDAT returns the date, time, CPU time, and disk I/O time used since LOGIN, the user's unique number on the system, and his login UFD name in an array as follows:

CALL TIMDAT(array,num)

array

(1)	Two ASCII characters representing month.
Example: 11
(2)	Two ASCII characters representing day.
Example: 30
(3)	Two ASCII characters representing year.
Example: 75
(4)	Integer time in minutes since midnight.
(5)	Integer time in seconds.
(6)	Integer time in ticks.
(7)	Integer CPU time used in seconds.
(8)	Integer CPU time used in ticks (standard is 330 ticks/second).
(9)	Integer disk I/O time used in seconds.
(see note)
(10)	Integer disk I/O time used in ticks. (see note)
(11)	Integer number of ticks per second.
(12)	User number.
(13-15)	Six-character login name, left-justified.
Example: MSMITH

num

Num words of array
are set. This
routine does not
return any useful
information under
PRIMOS II.

Note: Disk I/O time is from start of seek to end of transfer, including both explicit file I/O and paging operations. CPU time used in controlling the transfer is counted under CPU time, array(7) and array(8).

TNOU

TNOU outputs count characters to the user terminal followed by the LINE FEED, CARRIAGE RETURN. Buffer is expected to contain 2 characters per word.

CALL TNOU(buffer, count)

TNOUA

TNOUA outputs count characters to the user terminal but is not followed by the LINE FEED, CARRIAGE RETURN.

CALL TNOUA(buffer, count)

TSRC\$\$

TSRC\$\$ is used to open a file, close a file, delete a file, or check on the existence of a file, anywhere in the PRIMOS file structure.

CALL TSRC\$(action+newfil, treename, funit, chrpos, type, code)

action

A subkey indicating the action to be performed. Possible values are:

K\$READ Open treename for reading on funit.

K\$WRIT Open treename for writing on funit.

K\$RDWT Open treename for reading and writing on funit.

K\$CLOS Close treename.

K\$DELE Delete file treename.

K\$EXST Check on existence of treename.

newfil

A subkey indicating the type of file to create if treename does not exist. Possible values are:

K\$NSAM New threaded (SAM) file (this is the default).

K\$NDAM New directed (DAM) file.

K\$NSGS New threaded (SAM) segment directory.

K\$NSGD New directed (DAM) segment directory.

treename

A specification of any file in any directory or subdirectory stored in any array treename packed two characters per word.

funit

The number (1-62) of the file unit to be opened or deleted. funit is closed before any action is attempted.

chrpos

A two element integer array setup as follows:

chrpos(1) On entry, set to contain the first character in the array that is part of the treename, the count starting at 0. On exit, it will be pointing one past the last character that was part of the treename. A comma, new line, or carriage return will terminate the name, as will end of array. In case of error, chrpos(1) points one past the treename component that caused the error. Chrpos(1) is always modified by this subroutine, therefore, it must be set up before each call.

chrpos(2) The number of characters in the treename array.

type

An integer variable that is set to the type of the file opened. type is set only on calls that open a file -- it is unmodified for other calls. Possible values of type are:

- 0 SAM file.
- 1 DAM file.
- 2 SAM segment directory.
- 3 DAM segment directory.
- 4 UFD.

code

An integer variable set to the return code. If no errors, code is 0.

TSRC\$\$ always closes the specified file unit then attaches to the user's home UFD before attempting any action. If the user's home UFD differs from his current UFD before calling TSRC\$\$, he will find himself attached to his home UFD

following the call.

UNIT\$A

UNIT\$A is a logical function which returns .TRUE. if the unit is open and .FALSE. if the unit is not open.

LOG = UNIT\$A(unit)

unit

PRIMOS file unit (mode is
INTEGER*2).

APPENDIX III
DESCRIPTION OF NONLINEAR OPTIMIZATION METHOD
by
John H. Snow

REFERENCE

Snow, J. H., 1978, Study of structural and tectonic patterns in south-central Utah as interpreted from gravity and aeromagnetic data, M.S. thesis, University of Utah.

Methods, such as those given by Talwani and others (1959) for 2-dimensional gravity modeling or by Shuey and Pasquale (1973) for 2-1/2-dimensional magnetic modeling, are commonly used for the interpretation of gravity and magnetic anomalies. Such methods simulate observed data by employing a forward algorithm which will give the theoretical attraction of gravity or magnetic intensity at some point (station) due to a perturbing body of polygonal cross section and of uniform density or magnetization. A theoretical anomaly is computed from some initial model, specified by the vertices $(x(i), z(i))$ of the polygon, a density or magnetic susceptibility contrast, and a strike length (either finite or infinite), and compared with the observed anomaly. The model is then adjusted, either manually or by an optimization or automatic procedure, until a good match is obtained between observed and theoretical curves.

Automatic modeling of gravity or magnetic data is a necessarily complicated problem for several reasons. 1) The forward problem is in general nonlinear and therefore usually requires a nonlinear optimization method to find a set of reasonable models (unless a good initial guess is available). 2) The number of parameters is usually large. For instance, if one were trying to find an optimum position, both horizontally and vertically for all the vertices of an eight-sided polygon (a relatively simple model), one would need to solve for sixteen parameters. 3) The non-uniqueness of potential field data can lead into an infinite number of "good fit" solutions, most of which are geologically unreasonable. 4) The model at best is only a much simplified approximation to the true subsurface structure.

Optimization techniques utilize an objective function such as

$$(1) \quad SSR(\bar{\theta}) = \sum_{i=1}^{NSTAT} (O_i - C_i)^2$$

where $SSR(\bar{\theta})$ is the sum of the differences between the

observed anomaly $O(i)$ and computed anomaly $C(i)$ squared. Given an initial model, the optimization procedure searches through a p -dimensional parameter space for a minimum of the objective function $SSR(\bar{\theta})$ by some type of iterative adjustment of the model parameters ($\bar{\theta}$). The behavior of the objective function in parameter space is complicated by the fact that the parameter space may contain many local minima which represent "good fit" solutions but are not realistic (Al-Chalabi, 1971).

The problem then is to find the minima which represent geologically reasonable models and to eliminate those minima which represent unreasonable models (many of which can give a solution within the tolerance of the data).

The simplest type of nonlinear optimization technique is just a manual adjustment of the model parameters until a good fit between observed and theoretical anomalies is obtained (usually referred to as the forward problem). The interpreter essentially eliminates unrealistic models by assuming an initial guess which is reasonable (either based on additional geologic and/or geophysical information, and/or an intuitive feel), and modifies that guess to fit the observed data.

Automated optimization methods such as a search technique do much the same thing. An initial guess is made and the objective function is evaluated. One or more of the parameters is then adjusted by either a systematic or random process and the objective function is re-evaluated. This usually requires a large number of computations of the forward problem. When a minimum is found the model is tested by some criteria to see if it is reasonable. By repeatedly evaluating different minima in the parameter space, a region which defines acceptable models can be found.

Other optimization methods, such as derivative methods, start from an initial point in parameter space and find the direction of steepest descent, (or direction toward a minima), of the objective function. The function can be linearized by representing it by a Taylor series expansion, and parameter corrections can then be calculated using linear inversion techniques. This process is repeated until a "good fit" solution is obtained. These methods require a starting point near an acceptable minimum to locate a reasonable model.

Al-Chalabi (1971) points out that a search method should be employed in the early stages of optimization to locate acceptable minimum and then an appropriate gradient method can be used to converge to the solution. The method presented here utilizes this two-phase approach, i.e., a 1-dimensional direct search to find an approximate solution, and a linearization method which further minimizes the

objective function (equation 1).

PHASE 1: 1-Dimensional Direct Search

A one-dimensional search technique was chosen for the phase 1 part of the optimization to minimize the number of forward problem computations and therefore reduce the computer costs. This method utilizes a 1-dimensional search algorithm (Kuester and Mize, 1973) which minimizes the objective function

$$(2) \quad SSR(\bar{\theta}) = \sum_{i=n_1}^{n_2} (O_i - C_i(\bar{\theta}))^2$$

where $n(1)$ and $n(2)$ define a data window, the width of which depends on the type of parameter (θ) being used (the data window will be discussed in more detail in a later section).

The forward algorithms for 2-dimensional and 2-1/2-dimensional gravity and 2-1/2-dimensional magnetic modeling as given by Talwani and others (1959), Cady (1977), and Shuey and Pasquale (1973) can be expressed as

$$(3) \quad C_i = \sum_{j=1}^{NPOLY} \phi_j \sum_{k=1}^{NSIDES(j)} Z_{ijk}(x_k, z_k)$$

where $\phi(j)$ represents either the density or susceptibility contrast of the j th polygon, and $Z_{ijk}(x(k), z(k))$ represents the analytic expression for the integral over one side of the j th polygon with respect to the i th station. The total theoretical anomaly at the i th station is the sum of the integrals over all sides of all the polygons in the model.

Equation 2 can then be expressed as

$$(4) \quad SSR(\bar{\theta}) = \sum_{i=n_1}^{n_2} \left(O_i - \sum_{j=1}^{NPOLY} \phi_j \sum_{n=1}^{NSIDES(j)} Z_{ijk} \right)^2$$

In the 1-dimensional search, a single parameter (either densities, susceptibilities, or certain vertices of the model) is incremented by a step size in some user-specified direction and the remaining parameters held fixed. Note that parameter, as used here, refers to some part of the model.

This may be a single vertex of a set, or a single density or susceptibility contrast or a set. The objective function is evaluated at each step until a minimum is found or the search goes beyond the desired range of search. When only the density or susceptibility is varied, equation 4 reduces to

$$(5) \quad SSR(\bar{\theta}) = \sum_{i=1}^{NSTAT} (O_i - (A_i + \sum_{j=1}^k \phi_j B_{ij}))^2$$

where $SSR(\bar{\theta})$ is the sum over all stations (NSTAT), and depends only on the density or susceptibility contrast $\phi(j)$. $A(i)$ represents the contribution of those polygons, which do not change, and $B(ij)$ represents the contribution of the sum of the integrals around those k polygons whose densities or susceptibilities change.

When a vertex or set of vertices is varied, equation 3 becomes

$$(6) \quad SSR(\bar{\theta}) = \sum_{n_1}^{n_2} (O_i - (A_i + \sum_{j=1}^m \phi_j \sum_{k=1}^1 Z_{ijk}))^2$$

where the objective function depends on those 1 integrals of the m polygons which change. $A(i)$ is the contribution of that part of the model which remains fixed and the remaining contribution is from the parts of the model which change and need to be recalculated at each step. Equations 5 and 6 were used to further reduce the computation time required for the search.

The Search Method

The search procedure used is a slight modification of an algorithm by Coggins (Kuester and Mize, 1973). The method finds an unconstrained minimum of a single parameter, nonlinear objective function, where the objective function is assumed to be unimodal (note: The program actually finds a maximum, which is just the negative of a minimum). The algorithm works as follows:

An initial starting point is chosen and the objective function evaluated. The parameter is then incremented by the step size DELX and the objective function re-evaluated. If function improvement is obtained, the step size is doubled for the next function evaluation. If improvement is not obtained the step direction is reversed.

When a minimum is found, the procedure will yield the last three values of the objective function which straddle the minimum. A quadratic equation is then curve-fitted to these

points. The derivative of the quadratic equation is then taken with respect to the parameter and set equal to zero. This equation can then be solved for the optimum parameter location.

Constraints were added to the search algorithm which stop the search when the step size exceeds 20 times its initial value to avoid unrealistic results when a minimum could not be found.

The Data Window

Because more than one minimum could be found along a given search direction (i.e., multimodal), the objective function $SSR(\theta)$ uses a restricted sum of squares defined by a data window of varying width. The width of the data window is based on the type of parameter under consideration.

When density or susceptibility is being varied, the entire data set is used for the objective function. The reasoning here is that in general this search direction will be unimodal due to the fact that if density or susceptibility are changed, only the amplitude of the anomaly is changed. For example, for a single polygon with fixed shape and some true density, the objective function has a single minimum at the true density. That is, for an anomaly calculated using the true model vertices but a density contrast higher or lower than the true density contrast, the anomaly will be larger or smaller than the true anomaly and the difference between them increased.

This is, however, not necessarily the case when the density is held fixed and the vertices of the polygon are adjusted. Al-Chalabi (1971) shows several good examples of gravity and magnetic models which have approximately the same density or susceptibility contrasts and give very similar anomalies, but have very dissimilar shapes.

When the entire data space is used to adjust, say, the depth of a single vertex, that vertex may be pushed to extreme positions. This occurs because, while moving the vertex only a reasonable amount may improve the fit in the vicinity of the vertex, an extreme move could create large residuals in the vicinity of the vertex but may give a lower total residual sum of squares for the overall data set. Therefore, when vertices are adjusted, only those stations which lie in the vicinity of the vertices are used.

The actual data window employed here is either twice the depth of the deepest vertex of that part of the model being adjusted, or the maximum and minimum horizontal coordinates of the vertices which come before and after that part of the model being changed, whichever provides the larger window. For example, if a single vertex $(x(i), z(i))$ were to be moved,

the maximum width of the data window would be either $|x(i+1) - x(i-1)|$ or $2 \cdot X \cdot z(i)$, whichever gives the larger window.

Model Constraints

Constraints were also placed on how much any search parameter in the model could be adjusted. As mentioned earlier, no parameter can be adjusted further than 20 times the initial step size for that search direction. Further constraints were placed on the vertice search directions. For horizontal adjustment in gravity modeling, no vertices can be moved past the fixed vertices before or after (in a clockwise sense) those vertices which are being moved. This then will allow only for vertical or lower angle faults to be adjusted, unless the entire fault plane is being moved. Magnetic modeling is the same except the user has the option to specify how much more to allow the vertices to move. Once a vertex has been moved past its limit, that vertex is fixed at the limit and deleted from further search.

Vertical adjustment was limited only in that no vertices were allowed to move above the surface, but they are not deleted from search.

PHASE 2: Marquardt Inversion

Once an approximate minimum is found, a derivative or linearization method can be used to adjust all the parameters simultaneously to obtain a final model.

The forward problem is linearized by expanding it into a Taylor series and neglecting higher order terms. From equation 3 we obtain

$$(7) \quad C_i^T = C_i^0 + \sum_{m=1}^M \frac{\partial C_j^0}{\partial \theta_m} \Delta \theta_m = \dots\dots\dots$$

where C_i^T is the theoretical anomaly, C_i^0 the initial estimate of C_i , the $\theta(m)$ are the parameters of the model, and the $\Delta \theta(m)$ the parameter corrections which, when added to the parameters of the initial model, will give a better approximation to the theoretical anomaly C_i . If we then substitute the observed anomaly $O(i)$ for the theoretical anomaly C_i , expand the function about the initial guess, and rearrange terms, equation 7 becomes

$$(8) \quad G_i = (O_i - C_i^0) = \sum_{m=1}^M \frac{\partial C_j^0}{\partial \theta_m} \Delta \theta_m$$

This then will give NSTAT (number of stations) equations in M (number of parameters) unknowns which can be solved using matrix inversion techniques.

Equation 8 can be represented in matrix notation as

$$(9) \quad \Delta \bar{G} = A \Delta \bar{\theta}$$

(the bar indicates a vector). The vector $\bar{G}$ is a residual vector of length NSTAT and $\Delta \bar{\theta}$ is a parameter correction vector of length M. A is an NSTAT X M Jacobian matrix given by

$$A = \begin{vmatrix} \frac{\partial C_1}{\partial \theta_1} & \dots & \dots & \frac{\partial C_1}{\partial \theta_m} \\ \vdots & \ddots & \vdots & \vdots \\ \frac{\partial C_{\text{NSTAT}}}{\partial \theta_1} & \dots & \dots & \frac{\partial C_{\text{NSTAT}}}{\partial \theta_m} \end{vmatrix}$$

The elements of the matrix A are partial derivatives of the computed field $C(i)$ at each station i , with respect to a particular parameter $\theta(m)$ (either susceptibility or density contrasts, and horizontal and vertical positions of the vertices). The derivative with respect to either density or magnetization is obtained directly from equation 3 simply by replacing $\phi(j)$ with 1, or

$$(10) \quad \frac{\partial C_i}{\partial \phi_j} = \sum_{k=1}^{\text{NSIDE}(j)} Z_{ijk}$$

The derivative of $C(i)$ with respect to a vertex is obtained numerically as follows:

$$(11) \quad \frac{\partial C_i}{\partial x_{jk}} = \frac{C_i(x_{jk} + \Delta x) - C_i(x_{jk})}{\Delta x}$$

for horizontal derivatives, and

$$(12) \quad \frac{\partial C_i}{\partial z_{jk}} = \frac{C_i(z_{jk} + \Delta x) - C_i(z_{jk})}{\Delta x}$$

for vertical derivatives. Δx is a small increment in either the x (horizontal) and z (vertical) directions (a step of 0.1 was used for the gravity irregardless of the units of distance used, such as kilometers or kilofeet). For the magnetics, a step of 10 percent of the depth of the vertex was used. This was simply to avoid computer underflows when working with units such as meters (i.e., at a depth of 1000 meters moving a vertice in any direction by 0.1, would give a very small change in the magnetic field measured at the surface). Either way, the parameter corrections are virtually the same.

Equation 9 can then be solved by finding a general linear inverse to the Jacobian matrix A. Lanczos (1961) has shown that the matrix A can be decomposed into

$$(13) \quad A = U\Lambda V^T$$

(where the T indicates transpose), by the principles of eigenvector decomposition. The columns of U are M eigenvectors of length NSTAT associated with the columns of A, and the rows of V^T are M eigenvectors of length M associated with the rows of A. Λ is an M X M diagonal matrix containing the eigenvalues ($\lambda(i)$) associated with the matrix A. The inverse of A can then be easily obtained from

$$(14) \quad A^{-1} = V\Lambda^{-1}U^T$$

that is, by inverting the diagonal elements of Λ and pre-multiplying by V and post-multiplying by U^T .

Using the generalized inverse and solving for the parameter corrections $\Delta\bar{\theta}$, we obtain

$$(15) \quad \Delta\bar{\theta} = A^{-1}\Delta\bar{G}$$

A more convenient form of equation 15, in terms of regression analysis, is obtained from equation 9 by premultiplying both sides of the equation by A^T and then solving for the

parameter corrections,

$$(16) \quad \Delta \bar{\theta} = (A^T A)^{-1} A^T \Delta \bar{G}$$

In terms of the eigenvector decomposition this can be written as

$$(17) \quad \Delta \bar{\theta} = V \frac{1}{\Lambda} U^T \Delta \bar{G}$$

For small eigenvalues of the matrix A, the inverse can give rise to large changes in the parameters. This may drive the parameters outside the range of the linearization, (i.e., outside the range of the local minimum). A more stable form is given by the Marquardt step (Shuey, 1977), as

$$(18) \quad \Delta \bar{\theta} = (A^T A + (SSQ)I)^{-1} A^T \Delta \bar{G}$$

I is the identity matrix and SSQ is the estimate of the variance determined from the last value of the objective function $SSR(\bar{\theta})$ as

$$(19) \quad SSQ = SSR(\bar{\theta}) / (NSTAT - M)$$

Therefore, using the Marquardt step equation 17 becomes

$$(20) \quad \Delta \bar{\theta} = V \frac{\Lambda}{\Lambda^2 + (SSQ)I} U^T \Delta \bar{G}$$

The Linearization and Linear Regression Analysis

Once the model has been linearized, the usual statistical formulae of regression theory can be applied. Any statistical results derived from the linearization, however, are only valid to the extent that the linearization provides a good approximation to a realistic geologic model. That is, some models can be found which give good statistical results, but must be discounted because they are not geologically reasonable.

In linear regression theory, the statistical model can be represented as

$$\bar{Y} = X\bar{\beta} + \bar{\epsilon}$$

where $\bar{Y}$ is a vector of observations of length N , X is an $N \times M$ system matrix, $\bar{\beta}$ is a vector of the expected model parameters of length M , and $\bar{\epsilon}$ is a vector of length N which represents the observation error.

When no bias is present in the model, the estimate of β given by

$$b = (X^T X)^{-1} X^T Y$$

minimizes the sum of squares of the error ($\bar{\epsilon}^T \bar{\epsilon}$) between observed and theoretical data, and has minimum variance among all unbiased estimators of β . However, when bias is present, i.e., the model is not the true model (always the case with gravity and magnetic modeling), the estimate

$$b = (X^T X + \sigma^2)^{-1} X^T Y$$

has minimum variance plus (bias)² among all linear estimators (Shuey, 1977). σ^2 is the variance about the regression based on P degrees of freedom where

$$P = (\text{number of observations} - \text{number of parameters})$$

The variance is estimated by the sample variance SSQ given by equation 19.

The variance-covariance matrix of the parameters, in terms of the Marquardt inversion (equation 20), can be expressed as

$$(21) \quad \text{COV}(b) = \sum_{i=1}^m \frac{\sigma^2}{\lambda^2 + \sigma^2} v_i v_i^T$$

The variance-covariance matrix provides estimates for the variance or scatter of the parameters about their expected values. Parameter standard deviations are obtained from the square root of the diagonal terms of the variance-covariance. The parameter standard deviations represent a confidence region for which parameter values can be expected to be found for a given standard deviation in the data (SSQ).

The parameter correlation matrix can be obtained from the covariance matrix as

$$(22) \quad \text{COR}_{ij}(b) = \frac{\text{COV}_{ij}(\bar{b})}{\sqrt{\text{COV}_{ii}(\bar{b})} \sqrt{\text{COV}_{jj}(\bar{b})}}$$

The correlation matrix gives an indication of how independent each of the parameter solutions is with respect to the other parameters. For example, suppose one were modeling an anomaly over a single graben structure. The same anomaly could be obtained either by decreasing the density contrast and increasing the depth of the graben, or increasing the density contrast and decreasing the depth. These parameters would have a high negative correlation (where correlation ranges from -1 to 1, -1 indicates high negative correlation, 0 indicates no correlation, and 1 indicates high positive correlation).

APPENDIX IV

SAMPLE TERMINAL SESSION #1

The model in this terminal session was taken from Snow (1978). This example is an extremely noisy ground magnetic profile taken over two volcanic plugs. The result of the search shows that the susceptibility contributed most to the solution of the search. However, the inversion contributed very little in terms of model improvement, probably because of the high ground noise.

The input data were estimated from the information in Snow (1979), but may not have been the exact input data Snow used, because he did not list all his input parameters.

OK, DATE

Tuesday, March 31, 1981 3:37 PM

OK, TIME

0'00 0'01 0'00

OK, SLIST STATN-DATA

SNOW-FORWARD-INITIAL GUESS

1

14

58

736. 57, 13. 60, 0. 0

757. 14, 64. 60, 0. 0

380. 00, 119. 00, 0. 0

633. 71, 166. 60, 0. 0

644. 00, 214. 20, 0. 0

613. 14, 265. 20, 0. 0

671. 43, 316. 20, 0. 0

688. 57, 367. 20, 0. 0

609. 71, 462. 40, 0. 0

626. 86, 486. 20, 0. 0

568. 57, 530. 40, 0. 0

644. 00, 567. 80, 0. 0

702. 29, 612. 00, 0. 0

705. 71, 612. 00, 0. 0

688. 57, 635. 80, 0. 0

657. 71, 659. 60, 0. 0

661. 14, 659. 60, 0. 0

702. 29, 686. 80, 0. 0

1161. 71, 703. 80, 0. 0

678. 29, 731. 00, 0. 0

616. 57, 771. 80, 0. 0

589. 14, 802. 40, 0. 0

599. 43, 833. 00, 0. 0

572. 00, 890. 80, 0. 0

572. 00, 931. 60, 0. 0

537. 71, 986. 00, 0. 0

273. 71, 1009. 80, 0. 0

349. 14, 1020. 00, 0. 0

-21. 14, 1037. 00, 0. 0

493. 14, 1047. 20, 0. 0

496. 57, 1047. 20, 0. 0

493. 14, 1047. 20, 0. 0

664. 57, 1060. 80, 0. 0

770. 86, 1081. 20, 0. 0

647. 43, 1105. 00, 0. 0

630. 29, 1132. 20, 0. 0

712. 57, 1156. 00, 0. 0

599. 43, 1179. 80, 0. 0

1017. 71, 1203. 60, 0. 0

1021. 14, 1203. 60, 0. 0

935. 43, 1230. 80, 0. 0

938. 86, 1230. 80, 0. 0

647. 43, 1275. 00, 0. 0

788. 00, 1305. 60, 0. 0
825. 71, 1329. 40, 0. 0
815. 43, 1353. 20, 0. 0
853. 14, 1380. 40, 0. 0
1021. 14, 1404. 20, 0. 0
877. 14, 1411. 00, 0. 0
880. 57, 1431. 40, 0. 0
911. 43, 1451. 80, 0. 0
836. 00, 1479. 00, 0. 0
729. 71, 1506. 20, 0. 0
668. 00, 1530. 00, 0. 0
633. 71, 1553. 80, 0. 0
633. 71, 1553. 80, 0. 0
692. 00, 1659. 20, 0. 0
664. 57, 1703. 40, 0. 0

OK, SLIST MODEL-DATA

2
4, 0. 001, 150. , 3
550. , 10. , 7, 5
700. , 10. , 7, 6
700. , 1000. , 1, 6
550. , 1000. , 1, 5
550. , 10. , 7, 5
4, . 001, 300. , 4
1100. , 10. , 8, 9
1400. , 10. , 8, 10
1400. , 1000. , 2, 10
1100. , 1000. , 2, 9
1100. , 10. , 8, 9
0. 0

OK, SLIST SEARCH-DATA

2
8
2
50. , 100.
50. , 100.
28. , 55.
35. , 70.
55. , 110.
70. , 140.
0.
0.

OK, MAG2D

** [MAG2D. REV1] **

TERMINL- Option: 0

- 1 HARD COPY 80 COLUMN
- 2 TEKTRONIX 4014
- 3 CRT 80 COLUMN

TERMINL- Option: 3

MASTER-- Option: 0

- 1 EXIT FROM SYSTEM
- 2 INPUT NEW DATA
- 3 EDIT DATA
- 4 LIST DATA AND RESULTS
- 5 XGT SEARCH/INVERSION PROGRAM
- 6 FILE MAIN. - SAVE AND RECALL
- 7 PLOT MODELS AND CURVES

MASTER-- Option: 2

MAXIMUM NO. OF STATIONS = 500
 MAXIMUM NO. OF POLYGONS = 15
 MAXIMUM NO. OF VERTICES/POLYGON = 33
 MAXIMUM NO. OF SEARCH DIRECTIONS = 50

TYPE "RETURN TO MASTER" TO EXIT INPUT FUNCTION
 INPUT WORK FILE HEADER (80 CHAR.)

SNOWS MODEL

DO YOU WANT TO INPUT STATION DATA FROM FILE?

YES

INPUT FILENAME (16 CHAR)

STATN-DATA

INPUT PROFILE ID.

INPUT CODE FOR FIELDS: 1 = TOTAL FIELD COMPUTED

2 = VERTICAL FIELD COMPUTED

INPUT STATION NO. OR MATCH PT.

INPUT NO. OF STATIONS

INPUT OBS. INTENSITY, DIST., ELEV. FOR 58 STATIONS

INPUT EARTHS TOTAL MAGNETIC FIELD (GAMMAS)

53000.

INPUT INCLINATION (DEG)

64.

INPUT ANGLE BETWEEN MAG. NORTH & PROFILE AXIS (DEG)

105.

DO YOU WANT TO INPUT MODEL DATA FROM FILE?

YES

INPUT FILENAME (16 CHAR)

MODEL-DATA

INPUT NO. OF POLYGONS

FOR POLYGON 1, INPUT:

OF SIDES, SUSCEPT. (CGS), STRIKE HALF-LENGTH, SUSCEPT. SEARCH

FOR 5 VERTICES, INPUT:

HORZ. COORD., VERT. COORD., VERT. SEARCH #, HORZ. SEARCH #

FOR POLYGON 2, INPUT:

OF SIDES, SUSCEPT. (CGS), STRIKE HALF-LENGTH, SUSCEPT. SEARCH

FOR 5 VERTICES, INPUT:

HORZ. COORD., VERT. COORD., VERT. SEARCH #, HORZ. SEARCH #

INPUT BACKGROUND SUSCEPT.

DO YOU WANT TO INPUT SEARCH DATA FROM FILE?

YES

INPUT FILENAME (16 CHAR)

SEARCH-DATA

INPUT # ITERATIONS FOR INVERSION

INPUT TOTAL # OF VERTEX SEARCH DIRECTIONS

INPUT TOTAL # OF SUSCEPTIBILITY SEARCH DIRS.

INPUT TOLERANCE, STEP SIZE FOR 10 SEARCH DIRECTIONS

INPUT ADD. AMOUNT OF HORZ. MOVEMENT (XMOR)

INPUT ADD. AMOUNT OF DATA WINDOW (XMORE)

INPUT HOR. SCALE, VER. SCALE (CURVES), VER. SCALE (MODEL)

340., 340., 340.

MASTER-- Option: 4

LIST---- Option: 0

- 1 RETURN TO MASTER
- 2 LIST HEADER, AMBF, INCL, AZMTH
- 3 LIST STATION DATA
- 4 LIST MODEL DATA
- 5 LIST SEARCH DATA
- 6 LIST PLOT DATA
- 7 LIST ENTIRE FILE CONTENTS
- 8 SEND WORK FILE TO PRINTER

LIST---- Option: 2

WORK FILE HEADER: SNOWS MODEL

EARTH'S TOTAL MAG. FIELD IN GAUSS = 53000.000

INCLINATION IN DEG. OF EARTH'S TOTAL MAG. FIELD = 64.0000

ANGLE IN DEG. BETWEEN MAG. N AND PROFILE AXIS = 105.0000

THE TOTAL SUM OF SQUARES IS 0.000

LIST---- Option: 3

* STATION DATA *

PROFID: SNOW-FORWARD-INITIAL GUESS

TOTAL FIELD IS COMPUTED

STATION # OR MATCH PT IS 14

THE TOTAL SUM OF SQUARES IS 0.000

INPUT RANGE OF STATIONS TO BE PRINTED

AS START INDEX, END INDEX

0,0 WILL PRINT ALL

1,23

TYPE <CR> TO CONTINUE

STATION	DISTANCE TO STATION	ELEVATION	COMPUTED INTENSITY	OBSERVED INTENSITY	DIFFEREN OBS-COM
1	13.600	0.000	0.000	736.570	0.000
2	64.600	0.000	0.000	757.140	0.000
3	119.000	0.000	0.000	380.000	0.000
4	166.600	0.000	0.000	633.710	0.000
5	214.200	0.000	0.000	644.000	0.000

6	265.200	0.000	0.000	613.140	0.000
7	316.200	0.000	0.000	671.430	0.000
8	367.200	0.000	0.000	688.570	0.000
9	462.400	0.000	0.000	609.710	0.000
10	486.200	0.000	0.000	626.860	0.000
11	530.400	0.000	0.000	568.570	0.000
12	567.800	0.000	0.000	644.000	0.000
13	612.000	0.000	0.000	702.290	0.000
14	612.000	0.000	0.000	705.710	0.000
15	635.800	0.000	0.000	688.570	0.000
16	659.600	0.000	0.000	657.710	0.000
17	659.600	0.000	0.000	661.140	0.000
18	686.800	0.000	0.000	702.290	0.000
TYPE <CR> TO CONTINUE					
19	703.800	0.000	0.000	1161.710	0.000
20	731.000	0.000	0.000	678.290	0.000
21	771.800	0.000	0.000	616.570	0.000
22	802.400	0.000	0.000	589.140	0.000
23	833.000	0.000	0.000	599.430	0.000

LIST---- Option: 4

* MODEL DATA *

BACKGROUND SUSCEPTIBILITY = 0.00000
 POLYGON NO. 1 SUSCEPTIBILITY = 0.00100
 STRIKE HALF LENGTH = 150.00000
 SEARCH NO. = 3

X VERTICE	Z VERTICE	VERT. SEARCH NO.	HOR. SEARCH NO.
550.000	10.000	7	5
700.000	10.000	7	6
700.000	1000.000	1	6
550.000	1000.000	1	5
550.000	10.000	7	5

TYPE <CR> TO CONTINUE
 POLYGON NO. 2

SUSCEPTIBILITY = 0.00100
 STRIKE HALF LENGTH = 300.00000
 SEARCH NO. = 4

X VERTICE	Z VERTICE	VERT. SEARCH NO.	HOR. SEARCH NO.
1100.000	10.000	8	9
1400.000	10.000	8	10
1400.000	1000.000	2	10
1100.000	1000.000	2	9
1100.000	10.000	8	9

TYPE <CR> TO CONTINUE

LIST---- Option: 5

* SEARCH DATA *

NO. OF ITERATIONS FOR INVERSION IS 2
 TOTAL NO. OF VERTEX SEARCH DIRECTIONS IS 8
 TOTAL NO. OF SUSCEPT. CONTRAST SEARCH DIRECTIONS IS 2
 TYPE <CR> TO CONTINUE

TOLERANCE STEP SIZE
 1 50.00000 100.00000

2	50.00000	100.00000
3	0.00005	0.00010
4	0.00005	0.00010
5	28.00000	55.00000
6	35.00000	70.00000
7	0.50000	1.00000
8	0.50000	1.00000
9	55.00000	110.00000
10	70.00000	140.00000

LIST---- Option: 6

* PLOT DATA *

HORIZONTAL SCALE (UNITS/INCH) = 340.00000

VERTICAL SCALE FOR CURVES (GAMMAS/INCH) = 340.00000

VERTICAL SCALE FOR MODEL (UNITS/INCH) = 340.00000

LIST---- Option: 1

MASTER-- Option: 5

XGT----- Option: 0

- 1 RETURN TO MASTER
- 2 XGT SEARCH/FORWARD
- 3 XGT INVERSION

XGT----- Option: 2

THE TOTAL SUM OF SQUARES (SSR) = 2204604.000

10 SEARCHES LEFT

DO YOU WANT OUTPUT DURING ITERATIONS?

N

THE TOTAL SUM OF SQUARES (SSR) = 2204604.000

9 SEARCHES LEFT

THE TOTAL SUM OF SQUARES (SSR) = 2204604.000

8 SEARCHES LEFT

THE TOTAL SUM OF SQUARES (SSR) = 1434330.250

7 SEARCHES LEFT

THE TOTAL SUM OF SQUARES (SSR) = 1434330.250

6 SEARCHES LEFT

XSTART = 550.000 DELETED FROM SEARCH

THE TOTAL SUM OF SQUARES (SSR) = 1434330.250

5 SEARCHES LEFT

XSTART = 700.000 DELETED FROM SEARCH

THE TOTAL SUM OF SQUARES (SSR) = 1434330.250

4 SEARCHES LEFT

THE TOTAL SUM OF SQUARES (SSR) = 1434330.250

3 SEARCHES LEFT

THE TOTAL SUM OF SQUARES (SSR) = 1434330.250

2 SEARCHES LEFT

XSTART = 1100.000 DELETED FROM SEARCH

THE TOTAL SUM OF SQUARES (SSR) = 1434330.250
 1 SEARCHES LEFT
 XSTART = 1400.000 DELETED FROM SEARCH
 THE TOTAL SUM OF SQUARES (SSR) = 1434330.250
 0 SEARCHES LEFT
 DO YOU WANT TO SAVE THESE RESULTS?
 Y

XQT----- Option: 1

MASTER-- Option: 4

LIST---- Option: 4

* MODEL DATA *

BACKGROUND SUSCEPTIBILITY = 0.00000
 POLYGON NO. 1 SUSCEPTIBILITY = 0.00040
 STRIKE HALF LENGTH = 150.00000
 SEARCH NO. = 3

X VERTICE	Z VERTICE	VERT. SEARCH NO.	HOR. SEARCH NO.
550.000	10.000	7	0
700.000	10.000	7	0
700.000	1000.000	1	0
550.000	1000.000	1	0
550.000	10.000	7	0

TYPE <CR> TO CONTINUE
 POLYGON NO. 2

SUSCEPTIBILITY = 0.00100
 STRIKE HALF LENGTH = 300.00000
 SEARCH NO. = 4

X VERTICE	Z VERTICE	VERT. SEARCH NO.	HOR. SEARCH NO.
1100.000	10.000	8	0
1400.000	10.000	8	0
1400.000	1000.000	2	0
1100.000	1000.000	2	0
1100.000	10.000	8	0

TYPE <CR> TO CONTINUE

LIST---- Option: 1

MASTER-- Option: 7

PLOT---- Option: 0

- 1 RETURN TO MASTER OPTIONS
- 2 PLOT CURRENT MODEL
- 3 PLOT MULTIPLE SAVED MODELS

PLOT---- Option: 2

CURRENT MODEL PLOT

DEVICE-- Option: 0

- 1 TEKTRONIX GRAPHICS PLOT
- 2 STATOS PLOT
- 3 PRINTER (DEFAULTS TO #2)
- 4 ZETA PEN PLOT
- 5 UUCS CALCOMP PLOT

DEVICE-- Option: 2

DO YOU WANT ADD. SCALING ON Y-CURVE AXIS?

N

X-AXIS EXTENT IS FROM 13.60 TO 1703.40

WITH SPACING BETWEEN TICK MARKS = 340.

INPUT STARTING VALUE FOR X-AXIS

0.

DO YOU WANT TO CHANGE X-AXIS SPACING? N

CURVE Y-AXIS EXTENT IS FROM 1161.71 TO -21.14

WITH SPACING BETWEEN TICK MARKS = 340.

INPUT STARTING VALUE FOR CURVE Y-AXIS

1200.

DO YOU WANT TO CHANGE CURVE Y-AXIS SPACING? N

MODEL Y-AXIS EXTENT IS FROM 0.00 TO -1000.00

WITH SPACING BETWEEN TICK MARKS = 340.

INPUT STARTING VALUE FOR MODEL Y-AXIS

0.

DO YOU WANT TO CHANGE MODEL Y-AXIS SPACING? N

INPUT UNITS OF DISTANCE (4 CHAR.)

DO YOU WANT SYMBOLS?

N

DO YOU WANT TO GRAPH SUBSECTION? (Y,N)

N

Statos Plot - Number of Vectors = 1739

PLOT---- Option: 1

MASTER-- Option: 0

- 1 EXIT FROM SYSTEM
- 2 INPUT NEW DATA
- 3 EDIT DATA
- 4 LIST DATA AND RESULTS
- 5 XGT SEARCH/INVERSION PROGRAM
- 6 FILE MAIN. - SAVE AND RECALL
- 7 PLOT MODELS AND CURVES

MASTER-- Option: 3

EDIT---- Option: 0

- 1 RETURN TO MASTER OPTIONS
- 2 EDIT WORK FILE HEADER
- 3 EDIT AMBF, INCL, AZIMUTH
- 4 EDIT STATION DATA
- 5 EDIT MODEL DATA
- 6 EDIT SEARCH/INVERSN DATA
- 7 EDIT PLOT DATA

EDIT---- Option: 6

ESEARCH- Option: 0

- 1 RETURN TO EDIT OPTIONS
- 2 EDIT # OF ITERATIONS
- 3 EDIT # OF VERTEX SEARCH DIR.
- 4 EDIT # OF SUSCEPT SEARCH DIR
- 5 EDIT SUSCEPT. SEARCH #S
- 6 EDIT VERT. SEARCH #S(VERTEX)
- 7 EDIT HORZ. SEARCH #S(VERTEX)
- 8 EDIT TOLERANCES FOR SEARCH
- 9 EDIT STEP SIZES FOR SEARCH
- 10 EDIT XMOR, XMORE

ESEARCH- Option: 3

CHANGE-# VERTX SEARCH DIR. S
 OLD= 8 NEW=
 16

ESEARCH- Option: 5

CHANGE-SUSCEPT. SEARCH #S
 3 4
 CHANGE, ADD, DELETE OR RETURN?C
 PARAMETER # (I)=-1
 # 1 OLD = 3 NEW =
 1
 # 2 OLD = 4 NEW =
 2
 1 2
 CHANGE, ADD, DELETE OR RETURN?R

ESEARCH- Option: 6

CHANGE-VERT. SEARCH #S
 7 7 1 1 7
 8 8 2 2 8
 CHANGE, ADD, DELETE OR RETURN?C
 PARAMETER # (I, J)=-1, 1
 # 1 1 OLD = 7 NEW =
 3
 # 1 2 OLD = 7 NEW =
 5

#	1	3	OLD =	1	NEW =
7					
#	1	4	OLD =	1	NEW =
9					
#	1	5	OLD =	7	NEW =
3					
#	2	1	OLD =	8	NEW =
11					
#	2	2	OLD =	8	NEW =
13					
#	2	3	OLD =	2	NEW =
15					
#	2	4	OLD =	2	NEW =
17					
#	2	5	OLD =	8	NEW =
11					

	3	5	7	9	3
	11	13	15	17	11

CHANGE, ADD, DELETE OR RETURN?R

ESEARCH- Option: 7

CHANGE-HORZ. SEARCH #S

0	0	0	0	0
0	0	0	0	0

CHANGE, ADD, DELETE OR RETURN?C

PARAMETER # (I, J)=-1, 1

#	1	1	OLD =	0	NEW =
4					
#	1	2	OLD =	0	NEW =
6					
#	1	3	OLD =	0	NEW =
8					
#	1	4	OLD =	0	NEW =
10					
#	1	5	OLD =	0	NEW =
4					
#	2	1	OLD =	0	NEW =
12					
#	2	2	OLD =	0	NEW =
14					
#	2	3	OLD =	0	NEW =
16					
#	2	4	OLD =	0	NEW =
18					
#	2	5	OLD =	0	NEW =
12					

	4	6	8	10	4
	12	14	16	18	12

CHANGE, ADD, DELETE OR RETURN?R

ESEARCH- Option: 1

EDIT---- Option: 1

MASTER-- Option: 5

XGT----- Option: 3

DO YOU WANT OUTPUT DURING INTERATIONS?

N

THE TOTAL SUM OF SQUARES IS 1434330.250

2 ITERATIONS LEFT

THE TOTAL SUM OF SQUARES IS 1434831.500

1 ITERATIONS LEFT

THE TOTAL SUM OF SQUARES IS 1454303.000

0 ITERATIONS LEFT

DO YOU WANT TO SAVE THESE RESULTS?

N

XGT----- Option: 1

MASTER-- Option: 1

OK, SPLOT

P_S.MAG2D ON STATOS QUEUE AS PLS001

OK, TIME

0'11 3'02 0'03

OK, COMO -END

POLYGON SUSCEPT.	
1	0.00040
2	0.00100
BCRD	0.000

SNOW-FORWARD-INITIAL GUESS

APPENDIX V

SAMPLE TERMINAL SESSION #2

This model was used to check against the curves published in Aero Service's "Magnetic Fields and Gradients over Vertical Prisms and Dipping Sheets".

Only a forward problem was done and the observed magnetic intensity was entered as zero to obtain a theoretical curve. The objective function value, therefore, has no meaning.

OK, DATE

Tuesday, March 31, 1981 3:49 PM

OK, TIME

0'12 3'04 0'06

OK, SLIST STATION-DATA

MODEL F3 - P 179-180

1

37

81

0.,0.,0.

0.,.25,0.

0.,.5,0.

0.,.75,0.

0.,1.,0.

0.,1.25,0.

0.,1.5,0.

0.,1.75,0.

0.,2.,0.

0.,2.25,0.

0.,2.5,0.

0.,2.75,0.

0.,3.,0.

0.,3.25,0.

0.,3.5,0.

0.,3.75,0.

0.,4.,0.

0.,4.25,0.

0.,4.5,0.

0.,4.75,0.

0.,5.,0.

0.,5.25,0.

0.,5.5,0.

0.,5.75,0.

0.,6.,0.

0.,6.25,0.

0.,6.5,0.

0.,6.75,0.

0.,7.,0.

0.,7.25,0.

0.,7.5,0.

0.,7.75,0.

0.,8.,0.

0.,8.25,0.

0.,8.5,0.

0.,8.75,0.

0.,9.,0.

0.,9.25,0.

0.,9.5,0.

0.,9.75,0.

0.,10.,0.

0.,10.25,0.

0.,10.5,0.

0., 10. 75, 0.
0., 11., 0.
0., 11. 25, 0.
0., 11. 5, 0.
0., 11. 75, 0.
0., 12., 0.
0., 12. 25, 0.
0., 12. 5, 0.
0., 12. 75, 0.
0., 13., 0.
0., 13. 25, 0.
0., 13. 5, 0.
0., 13. 75, 0.
0., 14., 0.
0., 14. 25, 0.
0., 14. 5, 0.
0., 14. 75, 0.
0., 15., 0.
0., 15. 25, 0.
0., 15. 5, 0.
0., 15. 75, 0.
0., 16., 0.
0., 16. 25, 0.
0., 16. 5, 0.
0., 16. 75, 0.
0., 17., 0.
0., 17. 25, 0.
0., 17. 5, 0.
0., 17. 75, 0.
0., 18., 0.
0., 18. 25, 0.
0., 18. 5, 0.
0., 18. 75, 0.
0., 19., 0.
0., 19. 25, 0.
0., 19. 5, 0.
0., 19. 75, 0.
0., 20., 0.

OK, MAG2D
** [MAG2D. REV1] **

TERMINL- Option: 3

MASTER-- Option: 2

MAXIMUM NO. OF STATIONS	=	500
MAXIMUM NO. OF POLYGONS	=	15
MAXIMUM NO. OF VERTICES/POLYGON	=	33
MAXIMUM NO. OF SEARCH DIRECTIONS	=	50

TYPE "RETURN TO MASTER" TO EXIT INPUT FUNCTION

INPUT WORK FILE HEADER (80 CHAR.)
RETURN TO MASTER

RETURN TO MASTER - WORK FILE NOT CHANGED

MASTER-- Option: 2

MAXIMUM NO. OF STATIONS = 500
MAXIMUM NO. OF POLYGONS = 15
MAXIMUM NO. OF VERTICES/POLYGON = 33
MAXIMUM NO. OF SEARCH DIRECTIONS = 50

TYPE "RETURN TO MASTER" TO EXIT INPUT FUNCTION
INPUT WORK FILE HEADER (80 CHAR.)

TEST OF MAG2D

DO YOU WANT TO INPUT STATION DATA FROM FILE?

Y

INPUT FILENAME (16 CHAR)

STATION-DATA

INPUT PROFILE ID.

INPUT CODE FOR FIELDS: 1 = TOTAL FIELD COMPUTED
2 = VERTICAL FIELD COMPUTED

INPUT STATION NO. OR MATCH PT.

INPUT NO. OF STATIONS

INPUT OBS. INTENSITY, DIST., ELEV. FOR 81 STATIONS

INPUT EARTHS TOTAL MAGNETIC FIELD (GAMMAS)

60000.

INPUT INCLINATION (DEG)

30.

INPUT ANGLE BETWEEN MAG. NORTH & PROFILE AXIS (DEG)

0.

DO YOU WANT TO INPUT MODEL DATA FROM FILE?

N

INPUT NO. OF POLYGONS

1

FOR POLYGON 1, INPUT:

OF SIDES, SUSCEPT. (CGS), STRIKE HALF-LENGTH, SUSCEPT. SEARCH #
4., .002, 4., 0

FOR 5 VERTICES, INPUT:

HORZ. COORD., VERT. COORD., VERT. SEARCH #, HORZ. SEARCH #

6., 1., 0, 0

14., 1., 0, 0

14., 8., 0, 0

6., 8., 0, 0

6., 1., 0, 0

INPUT BACKGROUND SUSCEPT.

0.

DO YOU WANT TO INPUT SEARCH DATA FROM FILE?

N

INPUT # ITERATIONS FOR INVERSION

0

INPUT TOTAL # OF VERTEX SEARCH DIRECTIONS

0

INPUT TOTAL # OF SUSCEPTIBILITY SEARCH DIRS.
 0
 INPUT ADD. AMOUNT OF HORZ. MOVEMENT (XMOR)
 0.
 INPUT ADD. AMOUNT OF DATA WINDOW (XMORE)
 0.
 INPUT HOR. SCALE, VER. SCALE (CURVES), VER. SCALE (MODEL)
 4., 50., 10.

MASTER-- Option: 5

XGT----- Option: 2

THE TOTAL SUM OF SQUARES (SSR) = 2542222.500
 0 SEARCHES LEFT
 DO YOU WANT OUTPUT DURING ITERATIONS?
 N

XGT----- Option: 1

MASTER-- Option: 4

LIST----- Option: 2

WORK FILE HEADER: TEST OF MAG2D
 EARTH'S TOTAL MAG. FIELD IN GAUSS = 60000.000
 INCLINATION IN DEG. OF EARTH'S TOTAL MAG. FIELD = 30.0000
 ANGLE IN DEG. BETWEEN MAG. N AND PROFILE AXIS = 0.0000
 THE TOTAL SUM OF SQUARES IS 2542222.500

LIST----- Option: 3

* STATION DATA *
 PROFID: MODEL F3 - P 179-180
 TOTAL FIELD IS COMPUTED
 STATION # OR MATCH PT IS 37
 THE TOTAL SUM OF SQUARES IS 2542222.500
 INPUT RANGE OF STATIONS TO BE PRINTED
 AS START INDEX, END INDEX
 0,0 WILL PRINT ALL

0,0

TYPE <CR> TO CONTINUE

STATION	DISTANCE TO STATION	ELEVATION	COMPUTED INTENSITY	OBSERVED INTENSITY	DIFFEREN OBS-COM
1	0.000	0.000	81.338	0.000	-81.338
2	0.250	0.000	86.688	0.000	-86.688
3	0.500	0.000	92.474	0.000	-92.474
4	0.750	0.000	98.736	0.000	-98.736
5	1.000	0.000	105.518	0.000	-105.518
6	1.250	0.000	112.866	0.000	-112.866
7	1.500	0.000	120.831	0.000	-120.831

8	1.750	0.000	129.468	0.000	-129.468
9	2.000	0.000	138.834	0.000	-138.834
10	2.250	0.000	148.992	0.000	-148.992
11	2.500	0.000	160.005	0.000	-160.005
12	2.750	0.000	171.936	0.000	-171.936
13	3.000	0.000	184.849	0.000	-184.849
14	3.250	0.000	198.795	0.000	-198.795
15	3.500	0.000	213.814	0.000	-213.814
16	3.750	0.000	229.913	0.000	-229.913
17	4.000	0.000	247.040	0.000	-247.040
18	4.250	0.000	265.045	0.000	-265.045
TYPE <CR> TO CONTINUE					
19	4.500	0.000	283.597	0.000	-283.597
20	4.750	0.000	302.046	0.000	-302.046
21	5.000	0.000	319.200	0.000	-319.200
22	5.250	0.000	332.993	0.000	-332.993
23	5.500	0.000	340.214	0.000	-340.214
24	5.750	0.000	336.872	0.000	-336.872
25	6.000	0.000	320.110	0.000	-320.110
26	6.250	0.000	290.996	0.000	-290.996
27	6.500	0.000	254.614	0.000	-254.614
28	6.750	0.000	216.660	0.000	-216.660
29	7.000	0.000	180.769	0.000	-180.769
30	7.250	0.000	148.402	0.000	-148.402
31	7.500	0.000	119.739	0.000	-119.739
32	7.750	0.000	94.416	0.000	-94.416
33	8.000	0.000	71.902	0.000	-71.902
34	8.250	0.000	51.658	0.000	-51.658
35	8.500	0.000	33.198	0.000	-33.198
36	8.750	0.000	16.099	0.000	-16.099
37	9.000	0.000	0.000	0.000	0.000
38	9.250	0.000	-15.411	0.000	15.411
TYPE <CR> TO CONTINUE					
39	9.500	0.000	-30.402	0.000	30.402
40	9.750	0.000	-45.208	0.000	45.208
41	10.000	0.000	-60.037	0.000	60.037
42	10.250	0.000	-75.076	0.000	75.076
43	10.500	0.000	-90.493	0.000	90.493
44	10.750	0.000	-106.442	0.000	106.442
45	11.000	0.000	-123.060	0.000	123.060
46	11.250	0.000	-140.466	0.000	140.466
47	11.500	0.000	-158.755	0.000	158.755
48	11.750	0.000	-177.981	0.000	177.981
49	12.000	0.000	-198.140	0.000	198.140
50	12.250	0.000	-219.118	0.000	219.118
51	12.500	0.000	-240.621	0.000	240.621
52	12.750	0.000	-262.030	0.000	262.030
53	13.000	0.000	-282.184	0.000	282.184
54	13.250	0.000	-299.046	0.000	299.046
55	13.500	0.000	-309.432	0.000	309.432
56	13.750	0.000	-309.377	0.000	309.377
57	14.000	0.000	-296.051	0.000	296.051
58	14.250	0.000	-270.549	0.000	270.549
TYPE <CR> TO CONTINUE					

59	14.500	0.000	-237.981	0.000	237.981
60	14.750	0.000	-204.071	0.000	204.071
61	15.000	0.000	-172.482	0.000	172.482
62	15.250	0.000	-144.705	0.000	144.705
63	15.500	0.000	-120.954	0.000	120.954
64	15.750	0.000	-100.897	0.000	100.897
65	16.000	0.000	-84.037	0.000	84.037
66	16.250	0.000	-69.877	0.000	69.877
67	16.500	0.000	-57.971	0.000	57.971
68	16.750	0.000	-47.941	0.000	47.941
69	17.000	0.000	-39.474	0.000	39.474
70	17.250	0.000	-32.309	0.000	32.309
71	17.500	0.000	-26.236	0.000	26.236
72	17.750	0.000	-21.077	0.000	21.077
73	18.000	0.000	-16.690	0.000	16.690
74	18.250	0.000	-12.953	0.000	12.953
75	18.500	0.000	-9.768	0.000	9.768
76	18.750	0.000	-7.052	0.000	7.052
77	19.000	0.000	-4.734	0.000	4.734
78	19.250	0.000	-2.758	0.000	2.758
TYPE <CR> TO CONTINUE					
79	19.500	0.000	-1.073	0.000	1.073
80	19.750	0.000	0.361	0.000	-0.361
81	20.000	0.000	1.581	0.000	-1.581

LIST---- Option: 4

* MODEL DATA *

BACKGROUND SUSCEPTIBILITY = 0.00000

POLYGON NO. 1 SUSCEPTIBILITY = 0.00200

STRIKE HALF LENGTH = 4.00000

SEARCH NO. = 0

X VERTICE	Z VERTICE	VERT. SEARCH NO.	HDR. SEARCH NO.
6.000	1.000	0	0
14.000	1.000	0	0
14.000	8.000	0	0
6.000	8.000	0	0
6.000	1.000	0	0

TYPE <CR> TO CONTINUE

LIST---- Option: 5

* SEARCH DATA *

NO. OF ITERATIONS FOR INVERSION IS 0

TOTAL NO. OF VERTEX SEARCH DIRECTIONS IS 0

TOTAL NO. OF SUSCEPT. CONTRAST SEARCH DIRECTIONS IS 0

LIST---- Option: 6

* PLOT DATA *

HORIZONTAL SCALE (UNITS/INCH) = 4.00000

VERTICAL SCALE FOR CURVES (GAMMAS/INCH) = 50.00000

VERTICAL SCALE FOR MODEL (UNITS/INCH) = 10.00000

LIST---- Option: 1

MASTER-- Option: 7

PLOT---- Option: 2

CURRENT MODEL PLOT

DEVICE-- Option: 2

DO YOU WANT ADD. SCALING ON Y-CURVE AXIS?

N

X-AXIS EXTENT IS FROM 0.00 TO 20.00

WITH SPACING BETWEEN TICK MARKS = 4.00

INPUT STARTING VALUE FOR X-AXIS

0.

DO YOU WANT TO CHANGE X-AXIS SPACING? N

CURVE Y-AXIS EXTENT IS FROM 340.21 TO -309.43

WITH SPACING BETWEEN TICK MARKS = 50.0

INPUT STARTING VALUE FOR CURVE Y-AXIS

350.

DO YOU WANT TO CHANGE CURVE Y-AXIS SPACING? Y

NEW CURVE Y-AXIS SPACING =

150.

MODEL Y-AXIS EXTENT IS FROM 0.00 TO -8.00

WITH SPACING BETWEEN TICK MARKS = 10.0

INPUT STARTING VALUE FOR MODEL Y-AXIS

0.

DO YOU WANT TO CHANGE MODEL Y-AXIS SPACING? Y

NEW MODEL Y-AXIS SPACING =

5.

INPUT UNITS OF DISTANCE (4 CHAR.)

DO YOU WANT SYMBOLS?

N

DO YOU WANT TO GRAPH SUBSECTION? (Y,N)

N

Status Plot - Number of Vectors = 1522

PLOT---- Option: 2

CURRENT MODEL PLOT

DEVICE-- Option: 2

DO YOU WANT ADD. SCALING ON Y-CURVE AXIS?

Y

INPUT ADD. SCALING FACTOR

120.

X-AXIS EXTENT IS FROM 0.00 TO 20.00

WITH SPACING BETWEEN TICK MARKS = 4.00

INPUT STARTING VALUE FOR X-AXIS

0.
DO YOU WANT TO CHANGE X-AXIS SPACING? N
CURVE Y-AXIS EXTENT IS FROM 2.84 TO -2.58
WITH SPACING BETWEEN TICK MARKS = 50.0
INPUT STARTING VALUE FOR CURVE Y-AXIS

3.
DO YOU WANT TO CHANGE CURVE Y-AXIS SPACING? Y
NEW CURVE Y-AXIS SPACING =

1.5
MODEL Y-AXIS EXTENT IS FROM 0.00 TO -8.00
WITH SPACING BETWEEN TICK MARKS = 10.0
INPUT STARTING VALUE FOR MODEL Y-AXIS

0.
DO YOU WANT TO CHANGE MODEL Y-AXIS SPACING? Y
NEW MODEL Y-AXIS SPACING =

5.
INPUT UNITS OF DISTANCE (4 CHAR.)

DO YOU WANT SYMBOLS?

N

DO YOU WANT TO GRAPH SUBSECTION? (Y,N)

N

Status Plot - Number of Vectors = 1463

PLOT---- Option: 1

MASTER-- Option: 4

LIST---- Option: 6

* PLOT DATA *

HORIZONTAL SCALE (UNITS/INCH) = 4.00000
VERTICAL SCALE FOR CURVES (GAMMAS/INCH) = 50.00000
VERTICAL SCALE FOR MODEL (UNITS/INCH) = 10.00000

LIST---- Option: 1

MASTER-- Option: 6

FILE MAINTENANCE

FMAIN--- Option: 0

- 1 RETURN TO MASTER PROGRAM
- 2 LIST MERGED FILE DIRECTORY
- 3 SAVE WORK FILE ON MERGED FILE
- 4 RESTORE WORK FILE FROM MERGED FILE
- 5 DELETE AND PACK MERGED FILE
- 6 SYSTEM PACK MERGE FILE
- 7 INITIALIZE MERGE FILE
- 8 SEND MERGE FILE CONTENTS TO PRINTER

FMAIN--- Option: 7

INITIALIZE MERGE FILE (VERIFY Y OR N)?Y
FILE IDENTIFIER (60A)= MODELS FOR MAG2D

FMAIN--- Option: 2

MODELS FOR MAG2D
MERGE FILE IS EMPTY

FMAIN--- Option: 3

SAVE WORK FILE
WORK FILE SAVED AS SUBFILE# 1

FMAIN--- Option: 2

MODELS FOR MAG2D
*SUBFILE# 1
TEST OF MAG2D
MODEL F3 - P 179-180

FMAIN--- Option: 1

MASTER-- Option: 1

OK, SPLOT
P_S. MAG2D ON STATUS QUEUE AS PLS001

OK, TIME
0'19 3'36 0'16
OK, COMO -END

POLYGON SUSCEPT.	
1	0.00200
BCRD	0.000

MODEL F3 - P 179-180

SSR=2542222.50

POLYGON SUSCEPT.	
1	0.00200
BCRD	0.000

MODEL F3 P 179-180