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— HYPERMAG — An Interactive, 2- and 2 1/2-Dimensional Gravity and Magnetic Modeling Program: Version 3.5

by

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Abstract

Hypermag is an interactive, two and two-and-one-half dimensional forward modeling program for gravity and magnetic data (Fig. 1). The 2D calculations are based on the standard Talwani algorithm (Talwani and others, 1959); the 2D gravity equations are from Grant and West (Grant and West, 1965). The 2.5D calculations are from Cady (1980). **Hypermag** is written in FORTRAN 77 and references Calcomp-style graphics routines (i.e., PLOT, PLOTS, SYMBOL) as described in Appendix C. **Hypermag** allows interactive editing of the model bodies on an X-windows screen and can produce PostScript-style plot files compatible with Adobe Illustrator and other plotting programs as well as numerous graphic output devices. **Hypermag** can read models in the ASCII format used by Mike Webring's **Saki** (Webring, 1985) inversion program, so the two programs can be used together. **Hypermag** was originally released in 1983 as Version 1.3 (Saltus and Blakely, 1983).

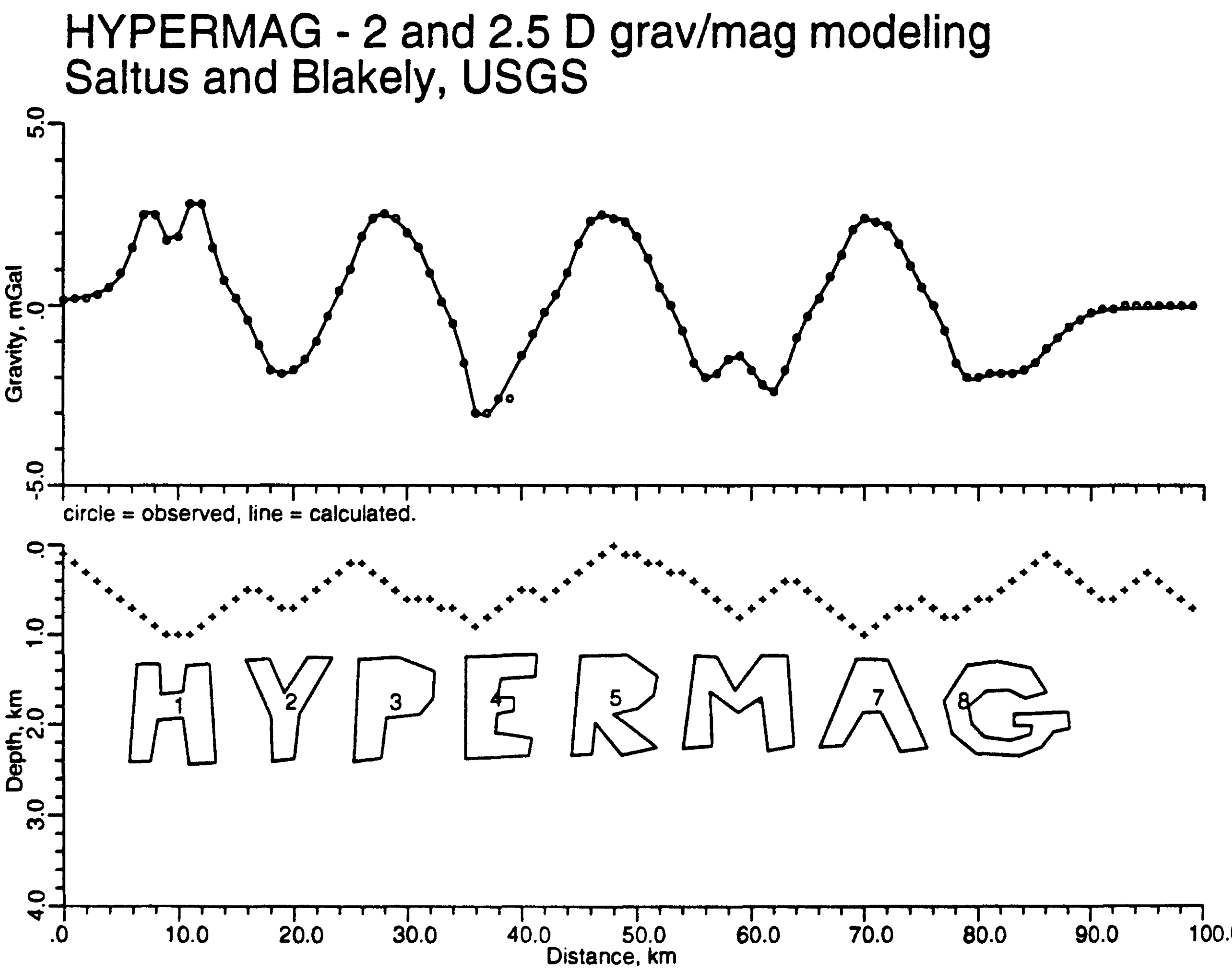

Figure 1: Magnetic anomalies calculated over non-geologic bodies.

Contents

List of Tables

List of Figures

1 Introduction

Gravity and magnetic data can provide useful constraints on crustal structure. Lateral variation in subsurface density causes gravity anomalies; these density variations are often associated with geologic units. Magnetic anomalies are caused by variations in the magnetic properties of the subsurface; these variations are also often associated with geologically significant units or processes. However, unlike density which is dependent on the properties of the whole rock, magnetic properties of Earth materials are caused by magnetic minerals that usually make up only a small fraction of the material. The most common magnetic minerals for crustal rocks fall in the solid solution from magnetite, Fe_3O_4, to ulvospinel, Fe_2TiO_4.

Hypermag allows the user to calculate the gravity and/or magnetic field produced by a two-dimensional subsurface distribution of density and/or magnetization. The two-dimensional (2D) density and/or magnetization distribution is represented by 2D polygons of arbitrary shape, each with a specified density and/or magnetic intensity. In the strictly 2D case, the polygons represent the cross section of bodies that extend infinitely in both directions perpendicular to the plane of the polygons. In the so-called two-and-one-half (2.5D) dimensional case, the bodies have a specified finite extent in and out of the plane (Cady, 1980). The program will accept models with up to 50 bodies, each with up to 50 corners. This limit can easily be extended if necessary.

The calculated gravity and/or magnetic fields can be compared with observed data and the body shapes or physical properties modified to improve the match of observed and calculated fields: this is the trial-and-error approach known as "forward modeling". **Hypermag** can handle profiles with up to 1,000 data points, and this limit can easily be extended if necessary. Given the inherent non-uniqueness of gravity and magnetic modeling (an infinite number of density or magnetization distributions can be constructed to produce the same gravity or magnetic field), some form of assumption always must be made to solve the inverse problem (that is, to determine the distribution of physical properties from the potential field). The forward-modeling approach allows the user to test geological assumptions against the gravity and magnetic data. The purpose of **hypermag** is to make this type of experimentation as easy as possible.

2 Units and sign conventions

Hypermag uses a mixture of cgs and SI units, reflecting common practice. Distances and depths can be in meters, kilometers, feet, kilofeet, miles, or in user-specified units. Depth and distance are represented on an orthogonal coordinate system (Fig. 2). The depth (z) axis is positive down (depths are positive, elevations are negative). The distance (x) axis is positive to the right. The positive y direction, which is important only for 2.5D calculations, is out of the screen (toward the user).

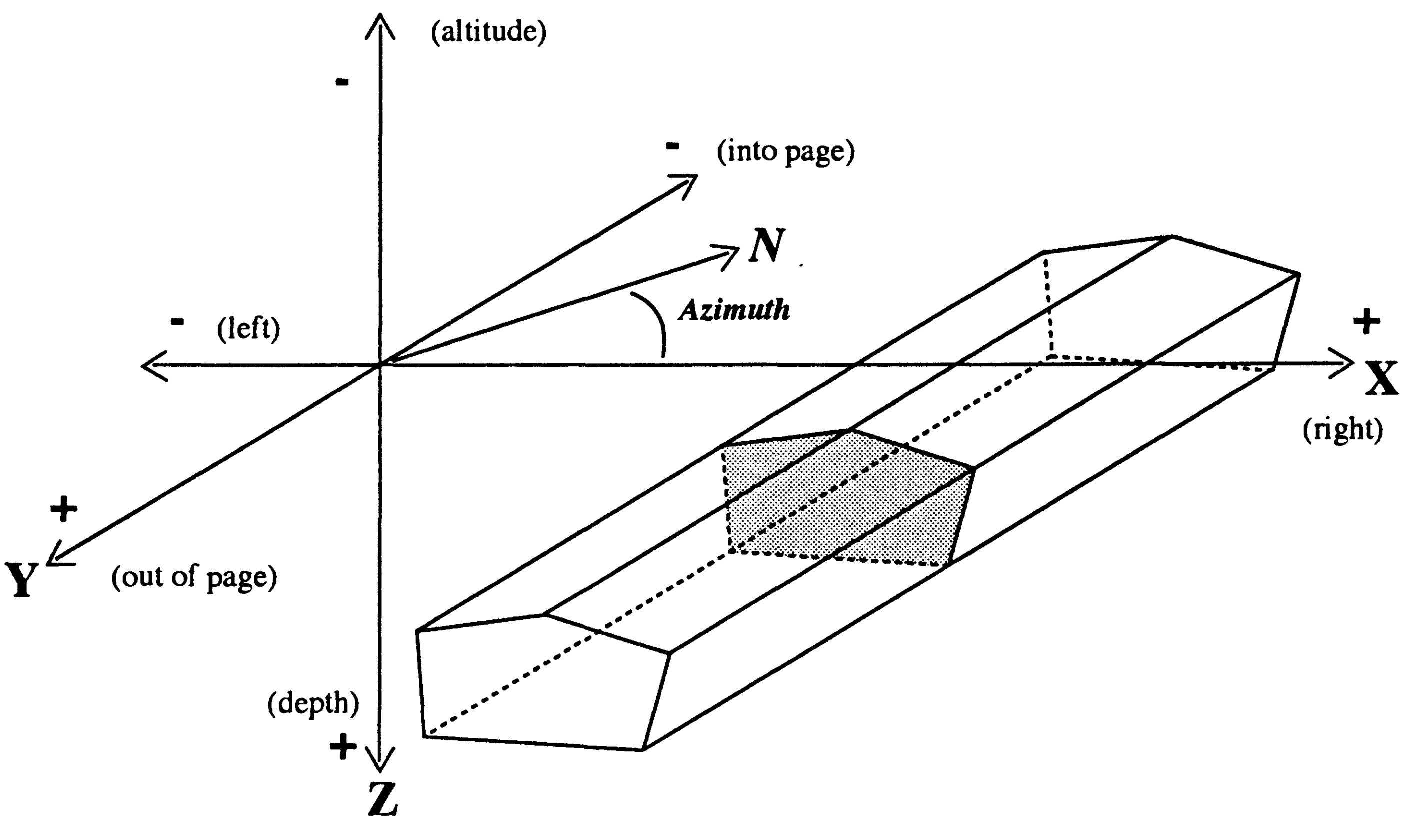

Figure 2: Geometry of a polygonal **hypermag** body.

Azimuth (only important for magnetic models) represents the direction of the profile in degrees with 0 for a south-to-north profile, 90 for a west-to-east profile, etc. Inclination (in degrees) is positive clockwise from north, declination (in degrees) is positive down.

Densities are in g/cm^3 (note that 2.67 g/cm^3 = 2,670 kg/m^3, the proper SI density unit). In practice, density contrast, rather than absolute density, is used. Thus both positive and negative density contrasts make sense. For example, a body representing alluvial valley fill might have a density contrast of -0.7 g/cm^3 relative to a Bouguer reduction density of 2.67 g/cm^3. Gravity anomalies are reported in mGal (1 mGal = 10^{-5} m/s^2). Some typical densities are listed in Table 1 (data from Telford and others, 1976, and Turcotte and Schubert, 1982).

The user has two choices in specifying magnetic body properties: Properties can be expressed either as total magnetization vectors or as a combination of induced and remanent magnetization vectors. In the first case, **hypermag** requires magnetic intensity, declination, and inclination for each body. In the latter case, **hypermag** requires volume susceptibility, remanent inclination, and remanent declination for each body, as well as the inclination, declination, and intensity of the Earth's magnetic field. Magnetizations are required in cgs units of emu/cm^3 (1 emu/cm^3 = 10^3 A/m); susceptibilities, although dimensionless, must also be expressed in cgs units (1 cgs unit = 4π SI unit). Note that program **saki** (Webring, 1985) uses the latter option, i.e., a combination of induced and remanent vectors.

In table 2 we list some magnetic property values (susceptibilities taken from Telford and others, 1976, remanent intensities from Carmichael, 1982). As inspection of the table indicates, magnetic properties can vary by many orders of magnitude for a given rock type. For a good discussion of rock magnetism as it relates to aeromagnetic interpretation, see Reynolds and others (1990).

3 Input/output formats

Hypermag reads and writes the following file types (the generic file name in parenthesis gives the standard file suffixes used by **hypermag** for these file types):

- **Binary model file (*.mod)** - This is a binary file containing all the information needed for a complete **hypermag** model. This includes the body geometries, physical properties, profile location, and observed data. Since this is a binary file it can not be edited directly by the user. It is designed to be modified only by the **hypermag** program in order to prevent the creation of invalid models.

- **Saki namelist file (*.sak)** - This file, along with the next two (*.bod and *.pfl), is part of a complete model for the **saki** program (Webring, 1985). It contains

Table 1: Typical rock densities

Rock type	Density range (g/cm^3)	Average	Reference
Sediments:			
Alluvium	1.9 - 2.0	1.98	1
Gravels	1.7 - 2.4	2.0	1
Sand	1.7 - 2.3	2.0	1
Sedimentary rocks:			
Shale	1.8 - 3.2	2.4	1
Sandstone	1.6 - 2.7	2.35	1
Limestone	2.2 - 2.8	2.55	1
Dolomite	2.3 - 2.9	2.7	1
Igneous rocks:			
Granite	2.5 - 2.81	2.64	1
Granodiorite	2.67 - 2.79	2.73	1
Diorite	2.72 - 2.99	2.85	1
Basalt	2.7 - 3.3	2.99	1
Gabbro	2.7 - 3.5	3.03	1
Peridotite	2.78 - 3.37	3.15	1
Pyroxenite	2.93 - 3.34	3.17	1
Metamorphic rocks:			
Quartzite	2.5 - 2.7	2.6	1
Granulite	2.52 - 2.73	2.65	1
Gneiss	2.59 - 3.0	2.8	1
Amphibolite	2.9 - 3.04	2.96	1
Eclogite	3.2 - 3.54	3.37	1
Peridotite		3.25	2
Dunite		3.25	2

1 = Telford and others, 1976; 2 = Turcotte and Schubert, 1982.

Table 2: Sample magnetic properties

Rock type	Susceptibility range (emu)	Average (emu)	Intensity (emu/cm^3)	Possible remanence (emu/cm^3)
Sedimentary rocks	0 - .004	.00003	.000015	0 - .0001
Metamorphic rocks	0 - .006	.0003	.00015	
Igneous rocks:				
Granite	0 - .004	.0002	.0001	0 - .0008
Dolerite	.0001 - .003	.0014	.0007	
Gabbro	.00008 - .0072	.006	.003	
Basalts	.00002 - .0145	.006	.003	.002 - .03
Diorite	.00005 - .01	.007	.0035	
Peridotite	.0076 - .015	.013	.007	

Intensities are calculated from susceptibilities assuming a normal Earth field of 50,000 nT.

parameters such as azimuth of the profile, magnetic field strength, and the default names of the body and profile files (see Appendix D for list of namelist parameters).

- **Saki-style body file (*.bod)** - This is an ASCII file containing information about the body geometries and physical properties. It is in a free-field format that begins with a list of all the body vertices followed by physical properties and vertex number lists for all bodies in the model. Vertex locations are assumed to be given in kilometers. An example file is given in Appendix D.

- **Saki-style profile file (*.pfl)** - This is an ASCII file containing information about the profile locations and observed anomalies (either gravity or magnetics). It is in a free-field format with columns of x position, z position, and observed anomaly. Position data (both x and z) are assumed to be in kilometers (see Appendix D).

- **Plot parameter file (*.ppm)** - This binary file contains the values of the 46 parameters that control the scaling and appearance of the graphic plots produced by **hypermag** (see Appendix B for description of the plot parameters).

- **Plot file (*.ai)** - This file (an output file only) contains PostScript-like plotting commands. The file may be read directly by many commercial graphics programs including Adobe Illustrator and Micrografx Designer for editing of plots for publication. The file may be converted to PostScript (for plotting) by adding a "dictionary" file to the beginning. The shell script **ai2ps** (distributed with **hypermag**) will perform this conversion.

4 User's guide

DO NOT READ THIS MANUAL! Try the program instead. **Hypermag** is intended to be self-explanatory and interactive. Hopefully you won't have to read any further. The program leads the user through the process of model construction and modification. Default answers are available for most questions; they are given in brackets at the end of a question. The default will be taken if the return key is pressed. When specific responses are expected to a question, the choices are listed in parentheses at the end of the question. When "h" is listed as a possible response, then a brief help message is available at that point. When a list of items is being edited (for example, the 46 plot parameters in the graphic-output subsystem), a negative number indicates that you want to start at that value and then continue to edit subsequent values, a positive number means that you want to edit that value only.

Hypermag is organized in a tree-structure (Fig. 3). To get from a subsystem back to a higher level, you can enter "q" or "//". Each of the main subsystems is discussed in the sections that follow.

4.1 Command recording and playback

Hypermag recognizes several special characters that control command recording and playback (Table 3). Multiple commands may be entered on a single line if they are separated by semi-colons. For example, the command:

```
c;m;;t;;
```

if entered at the Hyper-command level, would cause the mag calculations to be performed, a table of results to be printed, and control to return to the Hyper-command level.

Commands may be read in from a file by typing `<filename` where "filename" is the name of a file containing **hypermag** commands. **Hypermag** will read subsequent commands from that file until it reaches the end of the file. Any characters enclosed in number signs (# like this #) in the file are comments and are ignored by **hypermag**.

Commands may be recorded in a file. The `>filename` command directs **hypermag** to open a file with the name "filename" and echo subsequent dialog to that file. Questions asked by **hypermag** are enclosed in number signs in the recording file. Recording continues until >< is entered.

Since the questions are delimited by number signs in the recording file, these files can be read subsequently as command files. For example, to create a command to calculate and produce a printer plot of your model you can turn on recording with `>calcplot`, enter

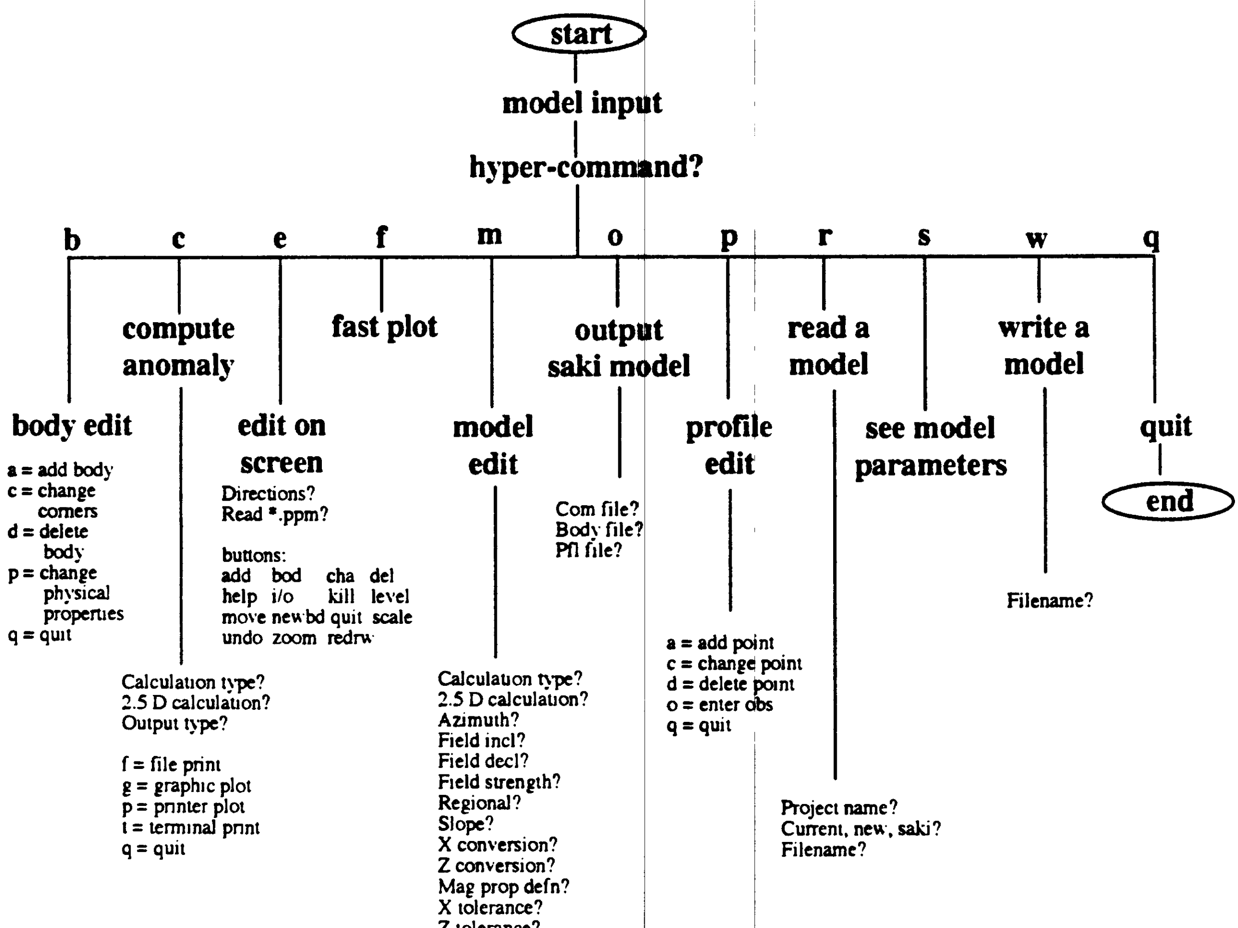

Figure 3: **Hypermag** tree structure.

Table 3: **Hypermag** special commands

Characters	Meaning
//	Exit from a subsystem (move up in the command tree)
;	Command delimiter for multiple commands on one line
#	Following text is a comment (until the next #)
`<filename`	Read commands from the filename given
`>filename`	Write commands to the filename given
><	Stop command recording
>*	Echo commands at the terminal
><*	Turn off command echoing

the commands to calculate and plot, then close the file with ><. Then typing `<calcplot` will re-execute those same commands.

Questions and responses may be echoed at the terminal by entering > *. This is useful when multiple commands are given on one line, or commands are being read in from a file and you want to know what they are. To turn off this command echoing, enter >< *.

4.2 Start-up (model input)

When **hypermag** is started a welcome banner containing the program version number (3.5 as of this writing) is printed. The user is then asked for the information needed to read in an existing model or construct a new model.

Question: `One-word project name (used for default file names)?`

Response: A descriptive project name of not more than 80 characters (shorter is better). This name is used to construct default filenames for the various input and output files used by **hypermag**.

Question: `Current, new, or saki model (c/n/s) [C]?`

Response: Indicate whether you want to: read in an existing **hypermag** model from a binary model file ("c"), answer questions to create a new model ("n"), or read in an existing **saki** model from ASCII files ("s").

4.2.1 Creating a new model

If you answer "n" to the previous question, you will be asked the following questions to create a new gravity or magnetic model:

Question: `Gravity or magnetics (g/m) [M]?`

Response: Answer "g" to select gravity calculations or "m" to select magnetic calculations.

Question (Mag only): `Intensity or susceptibililty and remanence (i/s) [I]?`

Response: Indicate whether you want to enter magnetic body properties in terms of intensity "i" or in terms of susceptibility and remanence "s" (See manual section 2 and Table 2 for more on the difference between these two systems).

Question (Mag only):
`Azimuth of the profile (0= S to N, 90= W to E, etc.) [90.00000]?`

Response: Enter the angle between the profile and true north. The angle is measured in degrees, clockwise from north (Fig. 2).

Question (Mag only): `Inclination of the regional field (deg)?`

Response: Enter the angle, in degrees, of the Earth's magnetic field below horizontal. Positive is down, therefore inclinations in the northern hemisphere are positive.

Question: `Declination of the regional field (deg)?`

Response: Enter the angle, in degrees, that the Earth's magnetic field makes with respect to true north at the surface. Clockwise is positive. For example, in the western conterminous U.S. declinations range from about +10 to +20.

Question (Mag only): `Earth field strength (nT) [50000.00000]?`

Response: Enter the strength of the Earth's field in the region of the profile, in nT. **Note:** this value only affects calculations when magnetic properties are given as susceptibility and remanence, not magnetic properties given as intensity.

Question: `Number of points in the profile?`

Response: Enter the number of calculation points that make up the profile. In most cases when observed gravity or magnetic anomalies are to be used it is better to just enter a few "dummy" points here. These temporary points can then be replaced later by reading in a *.pfl file using the read-model subsystem (see section 4.11).

Question: `Horizontal (x-axis) units [2]?`

Response: Enter a code number (1-6) indicating the units of measure along the x (and y) axis. The codes are: 1-meters, 2-kilometers, 3-feet, 4-kilofeet, 5-miles, 6-other. If your choose 6 (other), you will prompted for a conversion factor to km. **Hypermag** does internal calculations in km and **saki** requires distances to be in km. For these two reasons it is generally preferable to use km if possible.

Question: `Vertical (z-axis) units [2]?`

Response: Enter a code number (1-6) indicating what units of measure to use along the z (depth) axis. See previous question for discussion of codes.

Question: `Are the points evenly spaced and constant elevation (y/n) [N]?`

Response: Answer "Y" if you want to calculate gravity or magnetic values along a level surface with a regular spacing. If you choose "Y", you will be prompted for the spacing between points, the elevation of the points, and the x and z coordinates of the first point. If you answer "N", you will be prompted for the x and z positions (remember that z is positive down so elevations are negative) of each profile point.

Question: `Do you wish to enter observed anomalies (y/n) [N]?`

Response: If you answer "Y", you will be prompted for an observed gravity or magnetic value for each profile point.

Question: `Susceptibility [.00000]?`

Response: Enter the physical properties of the body. At this point, depending on what type of model (gravity or magnetic) and physical property definition (for magnetic models) you have chosen, you will be prompted for either: 1. susceptibility, remanent intensity, remanent inclination, and remanent declination, or 2. magnetic intensity, inclination, and declination, or 3. density.

Question: `Number of corners?`

Response: Give the number of corners for the body (minimum of 3, maximum of 50). You will then be asked for the x and z coordinates of the corners. **Enter the corners in clockwise order.** If you are planning to create the bodies interactively using the screen-edit subsystem, then just specify one simple 3-corner body and modify it once you get to screen editing.

Question: `Another body (y/n) [N]?`

Response: Enter "Y" if you want to specify the physical parameters and geometry of another body. If you answer "N", the model is complete.

Question: `Save model (y/n) [Y]?`

Response: Choose "Y" to write your newly-created model into a binary **hypermag** model file. This is recommended, particularly if you have expended the effort to create a complicated model by hand. If the program should quit unexpectedly (i.e., crash) you will be able to recover by reading in the model from the file.

4.2.2 Example of start up and new model creation

```
*****   WELCOME TO HYPERMAG - version 3.3 (3/10/93) *****
One-word project name (used for default file names)?beispiel
Current, new, or saki model (c/n/s) [C]?n
Gravity or magnetics (g/m) [M]?m
Choose magnetic property convention:
Intensity or susceptibililty and remanence (i/s) [I]?s
Azimuth of the profile (0= S to N, 90= W to E, etc.) [90.00000]?
Inclination of the regional field (deg)?61
Declination of the regional field (deg)?16
Earth field strength (nT) [50000.00000]?
Number of points in the profile?100
Unit codes: 1-meters, 2-kilometers, 3-feet, 4-kilofeet,
5-miles, 6-other
Horizontal (x-axis) units [2]?
Vertical (z-axis) units [2]?
Are the points evenly spaced and constant elevation (y/n) [N]?y
Spacing between points?1
The x coordinate of the first profile point?0
The z coordinate of the first profile point?0
Do you wish to enter observed anomalies (y/n) [N]?n
Body number:  1
Susceptibility [.00000]?.01
Remanent intensity [.00000]?.01
Remanent inclination [61.00000]?
Remanent declination [16.00000]?
Number of corners?3
Type the x and z coordinates of each corner...
Corner   1
x coordinate?50
z coordinate?1
Corner   2
x coordinate?75
```

```
z coordinate?1
Corner   3
x coordinate?60
z coordinate?2
Another body (y/n) [N]?n
This model is ready
Save model (y/n) [Y]?y
Name of model file to write to [beispiel.mod]?
Hyper-command (type H for help)?
```

4.3 Hyper-command level

After a valid model has been entered, **hypermag** presents the following options (see Fig. 3):

```
Hyper-command (type H for help)?h
Enter one of the following:
    B = edit bodies
    C = calculate computed anomaly
    E = edit the model using an X-windows screen
    F = fast re-calculation and plot.
    M = edit model parameters
    O = output generic model files (for program saki, etc.)
    P = edit profile
    R = read in a new model
    S = see model parameters
    W = write model to a file
    Q = quit hypermag
```

The **hypermag** subsystem corresponding to each of these options is discussed briefly in the following sections.

4.4 Body editing - "B" command

The body-edit subsystem allows the user to manually edit body geometries or physical properties (these functions are also performed by the screen-edit subsystem). Within this subsystem you may add a body, delete a body, or modify an existing body.

4.4.1 Example of body-edit subsystem

```
Body command (a/c/d/h/q/p) [H]?h
```

```
Body commands:
    A = add new body
    C = change body corners
    D = delete body
    P = change body parameters
    Q = quit the body area
Body command (a/c/d/h/q/p) [Q]?a
Body number:  2
Susceptibility [.00000]?.001
Remanent intensity [.00000]?
Remanent inclination [61.00000]?
Remanent declination [16.00000]?
Number of corners?3
Type the x and z coordinates of each corner...
Corner   1
x coordinate?80
z coordinate?1
Corner   2
x coordinate?90
z coordinate?1
Corner   3
x coordinate?85
z coordinate?2
Body command (a/c/d/h/q/p) [Q]?c
Change body # [-1]?2
Add, change, or delete corners (a/c/d/q) [C]?c
Change corner # [-1]?
Corner # 1 x coord=    80.000, z coord=     1.000
New X coordinate [80.000]?82
New Z coordinate [1.000]?
Change corner # [-2]?
Corner # 2 x coord=    90.000, z coord=     1.000
New X coordinate [90.000]?
New Z coordinate [1.000]?
Change corner # [-3]?
Corner # 3 x coord=    85.000, z coord=     2.000
New X coordinate [85.000]?
New Z coordinate [2.000]?
Change corner # [0]?//
Add, change, or delete corners (a/c/d/q) [C]?//
```

```
Change body # [0]?//
Body command (a/c/d/h/q/p) [Q]?//
Hyper-command?
```

4.5 Calculate anomaly - "C" command

The calculate subsystem allows the user to modify the type of calculation performed and then choose from a menu of output options including the graphic plot that allows modification of the plotting parameters. An automatic calculation is always performed before a model is plotted (such as in the fast-plot and screen-edit subsystems).

Question: `Calculation type (g=grav, m=mag) [M]?`

Response: Specify either "g" or "m" to switch between gravity or magnetic calculations. See the model-edit subsystem for another place to make this same switch.

Question: `2.5 Dimensional calculation (y/n) [N]?`

Response: A yes answer will select 2.5 dimensional calculations (bodies can have limited extent in the y axis direction). The positive and negative Y extent of the body can be specified in the parameter section of the change-body subsystem. Note that a body need not be symmetric about the Y axis; in fact, a body can lie entirely to one side of the profile, if desired. Positive Y is toward the viewer and negative is into the screen (see Fig. 2). The calculations are made by the GRAV and MAG subroutines of John Cady (1980).

Question: `Output type (f/h/g/p/q/t) [F]?`

Response: Choose the output mode for the calculated results. The most common choice is "g" for graphic plot (described in Appendix B). Other choices are: f = print results in a file, g = graphic plot, p = printer plot, t = print at terminal, q = quit output section.

4.6 Edit on screen - "E" command

The screen-edit subsystem allows the user to interact with the model on a terminal screen. This subsystem allows most modeling operations to be done simply by pointing and clicking with the mouse.

Question: `Do you want directions (n/y) [N]?`

Response: If you answer yes, **hypermag** prints a brief summary of the "button" definitions on the edit screen (Fig. 4).

Question: `Read in plot parameter file (y/n) [N]?`

Response: Answer "y" if you have previously created a plot parameter file (see Appendix B) to customize the appearance of the model on the screen. You will then be asked for the name of the plot parameter file.

At this point your model will be plotted on the screen (Fig. 4 is a simple example). Position your X windows so that you can see both the plot and the dialog window. Be sure to check the dialog window as you are screen editing, it will contain important feedback. For some operations (such as changing body physical properties) you must type responses to questions in that window.

To select a command in screen edit mode, position the cursor over the command on the right side of the screen and click the first button. Look at the dialog in the other window, it will indicate which command is active and give you instructions. For commands that require graphic input (add, bod, cha, del, kill, move, newbd, zoom), then click on the appropriate position of the body you are editing. For some of the commands (i/o, level, bod, newbd) you must type answers to questions posed in the dialog window. Some other commands (scale, redrw, undo) operate immediately with no further input. Each of the commands is described in a bit more detail below:

<u>Corner commands:</u>

add - Add corners to existing bodies. Click on a body side at a point where you want a new corner.

cha - Change the position of existing corners. Click on the corner to be moved, then click on its new position. If a corner is shared by more than one body, you must give the new location for each body, one at a time (the dialog window will indicate which body is being changed). If you want to leave a corner in the same spot, click in the "quit" button when the new position of that corner is requested.

del - Delete a corner. Click on the corner to be deleted.

<u>Body commands:</u>

bod - Change the physical properties (density and/or magnetic properties) of the chosen body. Click on a corner of the body to modify. If the point you select is shared by more than one body, you will be requested for new physical properties of all bodies sharing the corner. Move the cursor to the dialog window and type new physical property values as you are prompted for them.

kill - Deletes an entire body. Click on one corner of the body that is to be deleted.

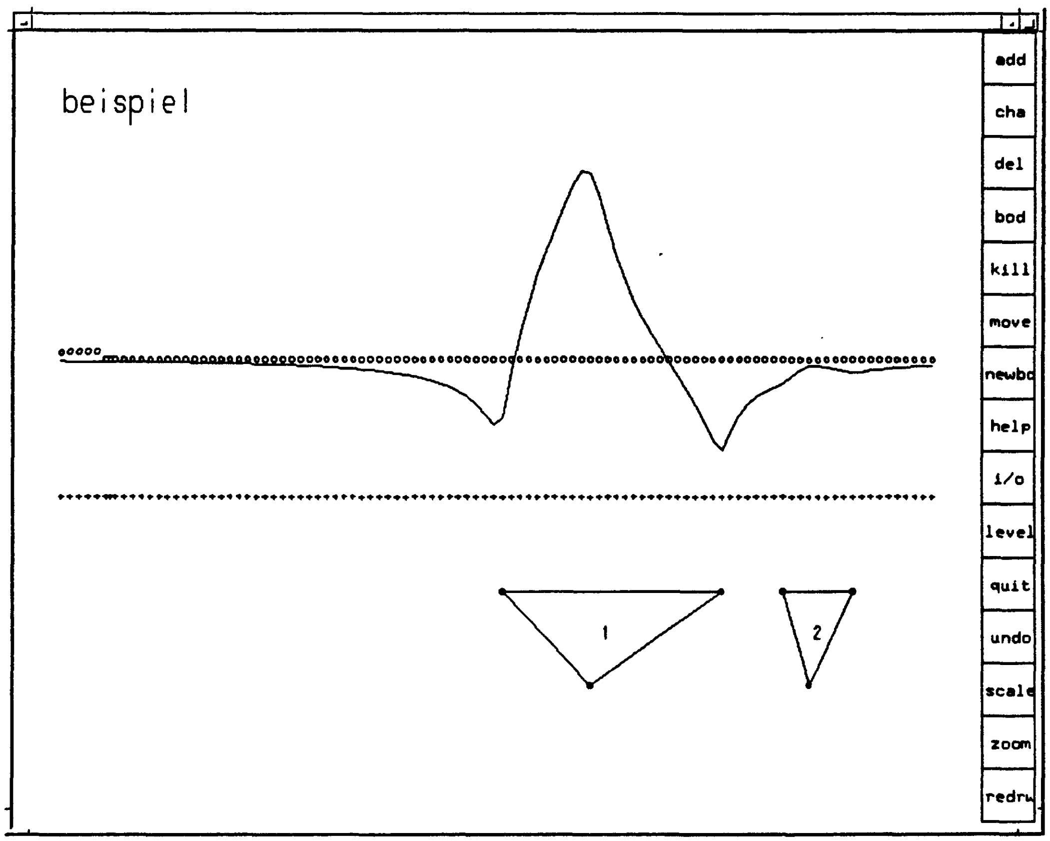

Figure 4: **Hypermag** screen edit display.

move - Move a body. Click on one corner of the body to be moved, then click on the new location for that corner.

newbd - Create a new body. Click on the new corners in clockwise order. When you are finished, click on the "quit" button (you do not need to make the last and first corners agree, **hypermag** will close the polygon). Then enter the physical property for the body in response to the prompt in the dialog window.

<u>View commands:</u>

redrw - Redraw the screen. This button was added to get around a bug on Sun computers. Sometimes the screen is not drawn completely - especially the first time the graphic window is opened. If this happens just click in the lower right corner of the graphics screen to redraw the model.

scale - Re-scale the plot. This is the "unzoom" command to restore the entire model to the screen. It is also useful if changes in bodies make the calculated field plot outside the original plot boundaries.

zoom - Magnify a portion of the model. Click on the spot to zoom in on. Each click will zoom by a factor of 2. There is no limit to the number of zooms you can do (except the resolution of real numbers on your computer). To get back to the original view of the entire model, use the "scale" button.

<u>Miscellaneous commands:</u>

help - Prints a summary of button meanings in the dialog window.

i/o - Allows you to save the current model to a file. The filename is requested in the dialog window.

level - Set a datum level or remove a linear trend. **Hypermag** will report (in the dialog window) the average difference between the calculated and observed values and the best-fitting linear trend to the observed data. Enter the datum shift or shift and trend in response to the prompts in the dialog window.

quit - Exit from the screen edit mode and return to the `Hyper-command?` level.

undo - Undo the last operation. If you didn't mean to do the last thing you tried, maybe this will save you.

4.7 Fast plot - "F" command

The fast-plot subsystem does a forward calculation using the current model and makes a plot on the screen using the current plot parameters.

4.8 Model edit - "M" command

The model-edit subsystem allows the user to edit global parameters that apply to the model as a whole such as the azimuth of the profile and the direction and magnitude of the Earth's magnetic field. Here is a listing of the questions asked in this subsystem:

```
Hyper-command?m
Calculation type (g=grav, m=mag) [M]?
2.5 Dimensional calculation (y/n) [N]?
Azimuth (degrees) [90.0000]?
Field inclination (degrees) [61.0000]?
Field declination (degrees) [16.0000]?
Note: field strength only affects magnetization of bodies
      defined with susceptibility and remanence.  It has
      no effect on magnetizations defined by intensity.
Field strength [50000.0000]?
Initial regional value [.0000]?
Regional slope [.0000]?
X axis conversion to KM [1.0000]?
Z axis conversion to KM [1.0000]?
Magnetic property definition (i=intensity, s=susceptibility) [S]?
Body point location tolerance in X direction [.1980]?
Body point location tolerance in Z direction [.0100]?
Hyper-command?
```

The first six values are described in the section of the manual on new model input (section 4.2.1).

The initial value and regional slope are parameters that allow you to make a datum shift or remove a linear trend from the observed anomaly values. The "level" button in the screen-edit subsystem also allows you to change these values.

The x and z axis unit conversion factors should normally not be changed, but are presented here in case some special problem arises.

Magnetic property definition can be switched in this subsystem. **Hypermag** can calculate intensity from susceptibility and remanence but not vice versa.

The two body point location tolerance variables are used in the conversion of **hypermag** models to **saki** models. These tolerances define the distances within which two corners are regarded to be coincident. If **saki** models are created with corners that are close but not coincident, then these tolerances should be increased. The tolerances are in the same units as x and z locations.

4.9 Output ASCII model files - "O" command

The output subsystem produces a set of ASCII output files that are compatible with the **saki** modeling program (Webring, 1985). Since these files are in ASCII format they may be edited directly by the user (in contrast with the binary model file created by the write-model subsystem). See Appendix D for a complete description of the **saki** file formats.

4.10 Profile edit - "P" command

The profile-edit subsystem allows the user to manually edit the position and/or observed field value of the profile points. If new points are added, **hypermag** inserts them in the proper position in the profile. Here is an example:

```
Hyper-command?p
Profile command (a/c/d/h/o/q) [H]?h
Profile commands:
    A = add point to profile
    C = change point on profile
    D = delete point from profile
    O = enter observed anomalies
    Q = quit profile area
Profile command (a/c/d/h/o/q) [Q]?a
X coordinate (// to finish) [.0000]?5.5
Z coordinate [.0000]?
X coordinate (// to finish) [5.5000]?//
Profile command (a/c/d/h/o/q) [A]?c
Change point # (-1 for all, 0 for done) [-1]?
Profile point:    1
X coordinate [.0000]?
Z coordinate [.0000]?
Profile point:    2
X coordinate [1.0000]?
Z coordinate [.0000]?
Profile point:    3
X coordinate [2.0000]?//
Change point # (-1 for all, 0 for done) [-3]?//
Profile command (a/c/d/h/o/q) [Q]?o
    1 x=         .0000 y=          .0000
Observed value [.0000]?25
    2 x=        1.0000 y=          .0000
Observed value [.0000]?30
```

```
    3 x=         2.0000 y=          .0000
Observed value [.0000]?30
    4 x=         3.0000 y=          .0000
Observed value [.0000]?31
    5 x=         4.0000 y=          .0000
Observed value [.0000]?32
    6 x=         5.0000 y=          .0000
Observed value [.0000]?//
Profile command (a/c/d/h/o/q) [Q]?d
Delete point # (// to end) [-1]?5
X=         4.0000 Y=          .0000 Obs=          32.0000
Delete (y/n) [N]?n
Profile command (a/c/d/h/o/q) [Q]?
Hyper-command?
```

4.11 Read in model files - "R" command

The read-model subsystem allows the user to input all or part of a new model. If a **hypermag**-format binary model file is input it replaces the current model. The ASCII **saki**-format models consist of three parts (namelist control file - *.sak, body definition - *.bod, and profile definition - *.pfl) which can be selectively input. For example, a new profile may be input by specifying only a *.pfl file and the existing bodies will be unchanged. This way the user can use the same body file for both a magnetic and gravity profile.

4.12 See model parameters - "S" command

This subsystem prints a list of all the model parameters.

4.13 Write binary model file - "W" command

This subsystem creates a **hypermag**-format binary file containing all the parameters that describe a model. You must use either this command or the "O" command to save your model if you indend to reinvoke the model later. The "Q" command also invokes the "W" command to give you one last chance to save your model before leaving the program.

4.14 Quit hypermag - "Q" command

As it's name implies, this command allows the user to exit **hypermag**. The "Q" command also invokes the "W" command to give you one last chance to save your model before leaving the program.

5 Errors and Recovery

For the magnetic case, the following error message could be produced:

```
Error from ribbon2... i = <profile pt>, j = <body #>, ier = <1 or 2>
```

This indicates that a problem was encountered in calculating the magnetic effect of body j and profile point i. If ier = 1, two body corners were too close together to yield a valid calculation (probably indicates duplicate corners). The program will assume that the two corners are supposed to be a single corner and will continue. If ier = 2, the field point i is too close to, or inside of, body j. In this case the calculation continues but could produce an incorrect result.

In the gravity case, if a profile point is positioned exactly on a body side or corner it is moved 0.1 meter away before calculation. If the point is inside the body, the equations still apply, so no error is signaled.

In both the magnetic and gravity case one of the following warnings will appear if body corners seem to be ordered in a counter-clockwise direction:

```
*****************************************************
*** WARNING - this body appears counter-clockwise.*
*** If so, it will yield inverse anomalies.       *
*****************************************************

*** WARNING - body number 1 appears to have corners in counter-clockwise order.
```

The algorithm to evaluate the order of body corners is not perfect, so it is possible for bodies with complicated geometry to produce this warning even if they are correct.

To prevent loss of significant model modifications it is a good idea to save the current model often. One never knows when a stray cosmic ray might cause the computer to crash.

6 For Additional Information

Simpson and Jachens (1989) give an excellent treatment of gravity modeling methods. Blakely and Connard (1989) treat magnetic modeling methods. Won and Bevis (1987) published a set of FORTRAN subroutines to do the 2-dimensional forward calculation for gravity and magnetic data. The results of calculations with their subroutines were compared with **hypermag** calculations and no discrepancies were observed. Program **saki** (Webring, 1985) performs inversion for free parameters (may be density, magnetization, or body corners). Northwest Geophysical Associates, Inc. (Corvallis Oregon), markets a gravity and magnetics modeling program called **GM-SYS** for the IBM PC. A program called **Grav2D** for the Apple Macintosh is available from Steve Hurst at Duke University.

7 References

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8 Appendix A - Hypermag installation notes

Hypermag is written in ANSI77 FORTRAN. It has been tested on HP, Sun, and Data General unix workstations. To run **hypermag** you need a computer with an ANSI77 FORTRAN compiler, a C compiler, and the X-windows library (MIT X11 vers. 5 or later). To edit the plot files produced by **hypermag** you need a graphics program that understands Adobe Illustrator input format (e.g. Adobe Illustrator for Macintosh or Micrografx Designer for PC). To make hardcopy of the **hypermag** plots you need a PostScript printer, or conversion software that accepts PostScript.

The **hypermag** source code is available over internet from Saltus. Send mail to: **saltus@musette.cr.usgs.gov** to request the source code. A file containing a unix archive (made with the `ar` command) will be mailed to you. To unpack the file: save the mail message to a file, edit the file to remove text before the !<arch> line, use the unix command `ar x filename` (where `filename` is the name of the edited mail message) to extract all the files from the archive. The archive will include at least the following files:

README-HYPERMA - Information on the latest release and installation instructions.

hypersource.f - FORTRAN source code.

hypercom.f - FORTRAN include file containing common block definitions.

PostScript.inc - FORTRAN include file with PostScript definitions.

xdevice.c - C code for X-window driver.

xdevice.bit - Auxiliary file for X-window driver.

xdevice.h - Include file for X-window driver.

PostScriptHead - File header for conversion of Adobe Illustrator PostScript dialect to standard postscript.

ai2ps - Shell script to convert Adobe Illustrator PostScript to standard PostScript.

hypermag.1 - Unix manual page for **hypermag**.

makefile - A simple makefile for building **hypermag**. This file must be edited for your system. You will need to check the syntax of the FORTRAN compiler command, the names of directories, and the location of X-window subroutine libraries.

9 Appendix B - Graphic-plot subsystem and parameters

The graphic-plot subsystem (part of the calculate-anomaly subsystem) allows the user to customize the graphic model display. A total of 46 plot parameters control the appearance of the plots. Default values are assigned to each of the parameters based on the details of the current model. These defaults will be appropriate in many cases, but may be modified and optionally written-to or read-from a file. A plot may be produced on the screen or an Adobe Illustrator plot file may be created for subsequent editing or plotting.

9.1 Plot parameters

The following 46 plot parameters control the appearance of a **hypermag** plot (see Fig. 5). **Hypermag** constructs default values based on your model. The plotting page is measured in inches.

Some parameters affect other parameters. For example, if vertical exaggeration (#30) is changed, it requires a change in the height of body plot area (#4) as well as the total plot height (#2). **Hypermag** attempts to keep the parameters consistent by checking them each time the `Plot command?` prompt is reached and altering them as necessary. Precedence is given to the last value changed. If you really want, say, vertical exaggeration (#30) to have a certain value, then set that parameter last to be sure it won't be reset as a result of some other changes you make.

1. Total plot width (inches) - This width is the sum of the left margin (#14), width of the body area (#5), and the right margin (#45). If it is changed it can cause a proportional change in those parameters.

2. Total plot height - This height is the sum of the bottom margin (#13), height of the body plot area (#4), center margin (#15), height of the anomaly area (#6), and the top margin (#44). If this parameter is changed it can cause a proportional change in those parameters.

4. Height of body plot area - This size can affect vertical exaggeration (#30). If it is set to 0, no body plot area will appear.

5. Width of body plot area - This size can affect the body area scale (#31) and the vertical exaggeration (#30).

6. Height of anomaly area - This size affects the anomaly scale (#32).

7. Left limit of profile (data units) - This is the lower limit of the plots.

8. Right limit of profile - This is the upper limit of the plots.

Hypermag Plot Parameters

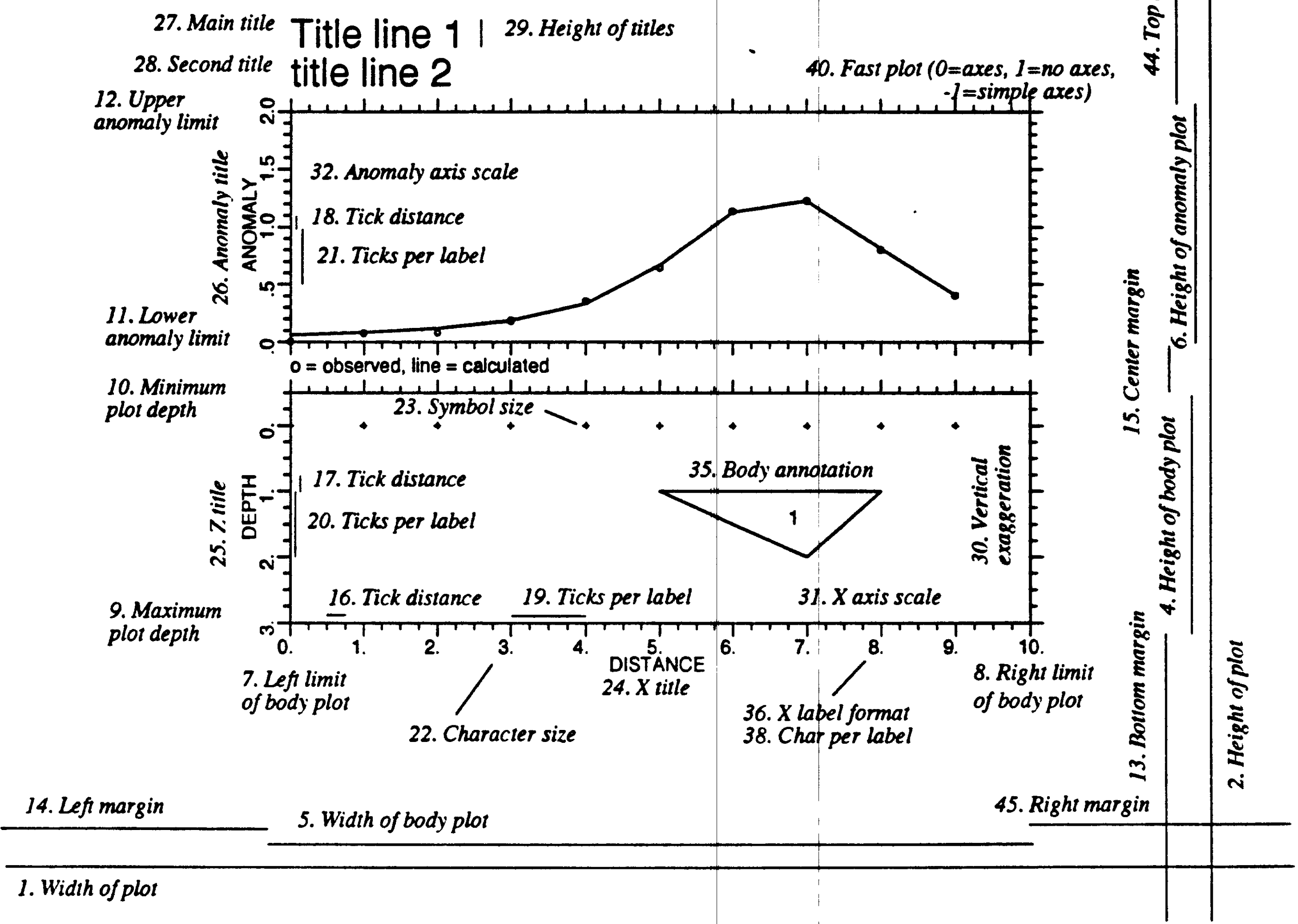

Figure 5: **Hypermag** plot parameters.

9. Maximum depth of body plot area - Bottom limit (greatest value, remember z is positive down) of the body plot. This value can affect vertical exaggeration (#30).

10. Minimum depth of body plot area - Top limit (lowest value, z positive down) of the body plot. Change can affect vertical exaggeration (#30).

11. Lower limit of anomaly plot area - Bottom value of anomaly area. Change can affect height or scale of the plot.

12. Upper limit of anomaly plot area - Top value of anomaly plot. Change can affect height or scale of the plot.

13. Bottom margin - The distance from the lower edge of the body plot to the bottom of the page. Change can affect the total height of the plot.

14. Left margin - The distance from the left edge of the plot areas to the left edge of the page. Change will affect the total width of the plot.

15. Center margin - The distance between the bottom of the anomaly plot and the top of the body plot. Change will affect the height of the plot.

16. Tick mark interval on the X axis - The spacing (data units) between tick marks on the x axes of both the body and anomaly plots.

17. Tick mark interval on the Z axis - The spacing (data units) between tick marks on the z axis of the body plot.

18. Tick mark interval on the Anomaly axis - The spacing (data units) between tick marks on the anomaly axis of the anomaly plot.

19. Tick marks between each label, X axis - Label interval on x axis.

20. Tick marks between each label, Z axis - Label interval on z axis.

21. Tick marks between each label, Anomaly axis - Label interval on the anomaly axis.

22. Height of characters in plot annotation - Height (in inches) of all letters and numbers on the plot except the titles.

23. Height of symbols on profile plot - The size (inches) of the plus signs marking profile locations on the body plot.

24. X axis title - Up to 80 characters for x axis annotation.

25. Z axis title - Up to 80 characters for z axis annotation.

26. Anomaly axis title - Up to 80 characters for anomaly axis annotation.

27. Main title - Up to 80 characters to plot at the top of the page.

28. Second title - Second line of title information, up to 80 characters.

29. Character height for main and second title - Height (inches) of main and second titles.

30. Vertical exaggeration - The ratio of vertical to horizontal scale in the body plot. Change can affect the height of the body plot area and the total plot.

31. Body plot scale (in units/inch) - The scale in units/inch of the horizontal body axis.

32. Anomaly scale (gammas/inch) - The scale in (mGal or nT)/inch of the anomaly plot.

33. Plot file name - Not currently used.

34. Body units (0=none, 1=m, 2=km, 3=ft, 4=kf) - Not currently used.

35. Body annotation (0=none, 1=body #s) - Controls labeling of bodies. Add 10 for body corner circles. Add 20 for body corner numbers.

36. Fortran format for body axis labels - A FORTRAN "f" (or "e") format for body axis labels.

37. Fortran format for anomaly axis labels - A FORTRAN "f" (or "e") format for anomaly axis labels.

38. Number of characters in body axis labels - The number of characters in the FORTRAN format of parameter #36.

39. Number of characters in anomaly axis labels - The number of characters in the FORTRAN format of parameter #37.

40. Fast plot (1=yes, 0=no, -1=simple axis plot) - Indicated whether axes are to be plotted (0) or not (1). A simple axis plot (axes on left and bottom only) is selected with -1.

41. Reverse X axis (0=no, 1=yes) - The direction of the X axis. Normally 0 in **hypermag**.

42. Reverse Z axis (0=no, 1=yes) - The normal direction of the Z axis. Normally 1 in **hypermag**.

43. Size of body corner numbers - Size (inches) of body corner number (if selected). Body corner numbers are selected if plot parameter #35 is greater than or equal to 20.

44. Top margin - Size of the top margin. Change can affect total plot height.
45. Right margin - Size of the right margin. Change can affect total plot width.
46. Tic mark direction (0=out, -1=in) - Direction of tic marks on plots. The default is zero for tic marks pointing out of the plot.

10 Appendix C - Plotting subroutines

Hypermag uses standard "Calcomp" plotting calls for graphical output. In the current release these calls are translated into X-windows for screen display or to Adobe Illustrator PostScript for plot file creation.

To add another output device as an option, the following standard plotting calls would have to be emulated:

PLOTS - Initializes plot. Call PLOTS(idum,idum,idum), where idum is an integer (value not important to **hypermag**).

PLOT - Moves, draws, and changes origin. Call PLOT(x,y,ipen), where x and y are plot location (in inches in **hypermag**) and ipen is a code as follows: 2 = draw, 3 = move (pen up), 999 = end of plot. A negative value for ipen means reset the origin to the given x, y point.

SYMBOL - Writes labels or symbols on the plot. Call SYMBOL(x,y,height,text,angle,nchar), where x and y are position (in inches), height is character height (inches), text (character variable) is the text (or, in the case of symbol, a coded integer value), angle is in degrees, and nchar is the number of characters in text. If nchar = -1, then move to x,y with pen up and plot symbol. If nchar < -1, then move to x,y with pen down and plot symbol. A simple character set line generator is included in the distribution of **hypermag** (it is used in the X-windows display), so it is not strictly necessary to implement this function if a new device is being added to hypermag.

NUMBER - Writes numeric labels on a plot. Call NUMBER(x,y,height,fpn,angle,ndec), where x,y are position (in inches in **hypermag**), height is character height in inches, fpn is a real number, angle is the angle in degrees, and ndec is the number of decimal places to include in the numeric label. This function is implemented in terms of SYMBOL calls in **hypermag**, so it is not strictly necessary to implement it to add a new device.

11 Appendix D - Format of Saki-style files

The following description of the **saki** input files is modified from a help file by M. Webring (written communication, 1993):

A complete **saki** model consists of three files: a profile (data) file (*.pfl), a model file (*.bod), and a command file (*.sak). The profile file is an ascii gravity and/or mag file containing less than 400 records (**saki** limitation) combined, where x,z are km positive to the right along the profile and down respectively. The magnetic data axis is oriented x positive north unless modified by the "azmuth" parameter (in the command file). The model file describes the model as a cross-section through a 2D prism ensemble. The command file contains global parameters such as profile azimuth and Earth's field strength.

When moving models between **saki** and **hypermag** it is important to keep in mind several differences between the programs. **Saki** is, in general, more restrictive of model geometry. See the **saki** model file description for more details. Another difference is that **saki** is generally used in a "floating datum" mode (see the iave and jave parameters described in the **saki** command file section), whereas **hypermag** requires that the user explicitly define the datum (this can be done in either the screen-edit or model-edit subsystems).

11.1 Saki profile file (*.pfl)

This file contains three numbers per line in a free-field format. Each record is x (kilometer), z (km), gravity (mGal) or magnetic (nT) value. The depth axis (Z) is positive down. A total of 400 gravity and magnetic observations are permitted by the **saki** program. **Hypermag** can read up to 1,000 profile points.

11.1.1 Example profile file

In this simple example, the profile consists of ten points at elevations ranging from zero to one kilometer (remember, z is positive down), and x positions from minus ten to one hundred kilometers. The observed data varies from minus fifty to plus fifty.

```
-10.0   0.   25.
  0.0  -0.25 40.
 20.0  -0.3  45.
 50.0  -0.31 50.
 55.0  -0.35 40.
 60.0  -0.45 30.
 70.0  -0.55 10.
 80.0  -0.7   0.
 90.0  -0.8 -10.
100.0  -1.0 -50.
```

11.2 Saki model file (*.bod)

The model file describes the geometry and physical properties of the polygonal bodies. For **saki** the model is limited to 50 prisms with 200 vertices total; **hypermag** is limited to 50 prisms, each with a maximum of 50 corners.

In general, because **saki** performs inversions, it is more restrictive of body geometry than **hypermag**, a purely forward-modeling program. If you intend to create bodies with **hypermag** for later use with **saki**, care must be taken to keep the body geometries acceptable. One danger is that corners of adjacent bodies in **hypermag** may be close, but not exactly coincident. If this occurs, the **saki** model may not indicate that these corners are shared by adjacent bodies. When a **saki**-style model is created by **hypermag** "close" corners are assumed to be equal. Two parameters accessed in the model-edit subsystem control the definition of "close" for this purpose. It may be necessary to adjust these parameters to ensure valid **saki** model creation.

There are two parts to the model file: (1) the vertex array defining x,z locations for body corners (2) prism specifications, each with two sections - a physical property record and a lookup list specifying which vertices make up the body.

```
      example (2 adjacent squares)

   x= -1   0   1   2   3   4

   z=0         1---2---3
               |   |   |
   z=1         4---5---6

      contents of the model file:

1.,0.  2., 0  3, 0      (1,0 is vertex 1; 2,0 is vertex 2; etc)
1. 1.  2. 1.  3. 1.
>>body specifications
-.2 2.e-3  20 -20  1e-5 60 18 <<phys_prop 1
1 2 5 4 <<body1
.2  3.e-3  20 -20  1e-5 -120 18 <<phys_prop 2
2 3 6 5 <<body2
```

The '<<' are any non-alpha numeric character and used as delimiters, note that they are present at the end of the vertex and lookup lists. At the end of the physical property line they are optional. Blanks or commas are necessary to separate numbers from each other and from the delimiters, the program counts entries in each list.

In the example there are 6 prism vertices arranged in x,z pairs and typed in free field with any number per line. The program (**saki**) will try to reject models that have void areas and overlapping prisms. A prism with a density of zero is legal to link sections of the model.

After the vertex list are the prism definitions:

```
line 1  density  in gm/cc
        susceptibility in cgs
        prism lengths in km (right Cartesian coordinates i.e. 20, -20),
                The first number is the near side and the second the far side.
                The default value is the same as parameter 'plenth'.
                These lengths can be different and will move the prism
                off axis for gravity calculations.
        remanent magnetization in emu/cc, inclination in degrees, declination
                in degrees    ( 1 A/m = 1e-3 emu/cc ).
                The total magnetization used in the forward calculation is a
                vector sum of the induced and remanent magnetization or Ji+Jr
                Ji = susc * earth field strength in nTesla
                Jr = remanent * 1.e5

line 2  vertex indices, example for prism 1: 1 2 5 4 (clockwise order,
                don't repeat the first index).  After the delimiter is an
                optional 36 character identifier, if it's blank the program
                will just number the bodies.

>> there must be 7 numbers present on line number one.
>> (for a 2d gravity model enter -.2 0. 0. 0. 0. 0. 0.)
```

11.2.1 Example of saki model file

```
  50.000  1.000   75.000  1.000   60.000  2.000   82.000  1.000   90.000  1.000
  85.000  2.000
>>>*bodies*<<<
.000E+00  .100E-01  .000E+00  .000E+00  .100E-01  .610E+02  .160E+02 <*1*>
   1   2   3 <*1*>
.000E+00  .100E-02  .000E+00  .000E+00  .000E+00  .610E+02  .160E+02 <*2*>
   4   5   6 <*2*>
```

11.3 Saki command file (*.sak)

This file is a FORTRAN "namelist" file for setting global parameters in the **saki** program. The FORTRAN namelist has the identifier "parms" (see example). **Hypermag** is only affected by a few of these parameters, the rest are included for compatibility.

The command file is optional for both **saki** and **hypermag**. In both cases, enter a carriage return and the program will prompt for the names of the input model, gravity, and/or magnetic files; the other parameters have defaults.

11.3.1 Saki namelist parameters used by hypermag

bfile model filename. The default is blank and program will prompt for it.

gfile gravity data file (optional).

hfile magnetic data file (optional).

efield Earth's field strength (default = 50000 nTesla).

einc Earth's field inclination in degrees, positive down from horizontal (default= 90).

edec Earth's field declination in degrees clockwise from north (default= 0).

azmuth profile orientation, degrees clockwise from north (default=0).

11.3.2 Saki namelist parameters ignored by hypermag

ifmtg input format for gfile, specify 3 floating fields for x,z,and gravity. An example is ifmtg="(3f10.3)", the default is free-field.

ifmth input format for hfile, specify 3 floating fields for x,z,and magnetic values. An example is ifmtm="(3f10.3)", the default is free-field.

compon the calculated magnetic component. Set to x, y, z, or t (default) where t is total field. Example: compon='z'.

iave and jave (for grv and mag) automatic dc average removal from the calculated field where the average is the difference between the calculated and the observed functions. Set not equal to zero to activate, each time the forward calculation is performed the level is printed as a reminder. (default iave=1, jave=1) In effect a floating datum level is used and attention given to local anomalies rather than regional ones. This is the recommended mode of operation unless you have reason to believe your regional removal is perfect.

plenth prism length in km measured from the profile to the end of the prism (total length is 2*plenth). Plenth will be overwritten by the individual prism lengths entered from the model file if at least one is nonzero. Default for gravity is a 2-d calculation. The magnetic calculation is always 2.5d where plenth will default to 1,000km as an approximation to 2d.

iparsh (default=0) enables partial derivative plots in the inversion section. This parameter allows a person to look at the column vectors going into the linear system so that relative weighting of gravity and magnetic fields may be examined visually (although the program doesn't allow manual fine tuning).

11.3.3 Saki plotting parameters (ignored by hypermag)

There is an extensive set of defaults for proportioning areas for the graphs and cross-sectional view. Normally each plot defaults to a set fraction of the available plot area. When a scaling factor causes a view to exceed the plotter size the window is cut down to maintain the specified scaling. (Note: in the following, viewport refers to the plotter and window refers to data). Any combination of scaling and defaults may be specified.

iplotr default=1 (tektronix), 5=HP-7580 series, 6=Versatec electrostatic The Versatec plotter has a default size of 72 x 20 inches.

vex vertical exaggeration used when plotting the model. (default=1).

xscale model and graph horizontal scale in km/in.

zscale model vertical scale in km/inch. The default is set to xscale so an easy way to get a desired vertical exaggeration is to leave zscale blank and set 'vex'.

gscale gravity scaling in mGal/inch.

hscale magnetic scaling in nTesla/inch.

xlimit, ylimit in inches, is an alternate way of sizing the plot. These two parameters replace the physical plotting device size from which default scaling parameters are calculated. Scale and limit parameters should be mixed only with due care. Also note that internal switching of plotters causes scales and limits to be overridden with new values.

The following assigned window parameters are useful when graphs are to be overlain, these will be overridden in case of viewport conflicts. Defaults are the min and max in the data.

xxx assigned x minimum, maximum window coordinates.

zzz model depth window.

ggg, hhh gravity and mag windows.

The next 3 parameters are switches (0=off 1=on) that can also be accessed at runtime in the 'setup' function.

istatn (default 1) plots station locations on the cross-section.

numbod (default 1) numbers the bodies.

labelv (default 0) labels the vertices.

title1 56 character label plotted top center.

title2 below title1.

title3 below title2.

titlx (20 char. default='kilometers') plotted under the graph.

titlz default='depth km', plotted to the left of the model.

titlg default='mGal', plotted to the left of the graph.

titlh default='nTesla', plotted to the left of the graph.

sizea axis label size (default=.08).

sizet axis title size for titlx,z,g,h (default=.1).

sizel title1 size (default=.15).

adelx horizontal axis ticking interval in kilometers (default about 50 ticks).

adelz model vertical axis (default about 15 ticks).

adelg gravity ticking interval in mgal (default about 20 ticks).

adelh magnetic in nTesla (20 ticks).

lintx,z,g,h (default=5) axis labeling intervals.

11.3.4 Example saki command file

```
&parms
mfile='beispiel.bod'
gfile='beispiel.pfl'
efield=     .50000E+05, einc=     .61000E+02, edec=     .16000E+02,
azmuth=     .90000E+02
&
```