APPENDIX 1

THE PMAG SOFTWARE PACKAGE

1.1. Getting started

After each chapter in the book, there are a number of practical examples for paleomagnetic problems using real data. The programs referred to in the examples are part of the PMAG package of programs. The distribution described here is **pmag1.7**. The most current version of the PMAG package is available by anonymous ftp at:

ftp://sorcerer.ucsd.edu/pub/pmag.

These programs were designed to operate in a UNIX type environment and we include the source code (in Fortran 77) as well as compiled versions for Linux, Solaris, and Mac OS X operating systems. There are also executables (available for pmag1.4 only) provided for running under the MSDOS prompt on a PC. There are many advantages to working in a UNIX environment so we will start with a brief discussion of how to get along in UNIX in general. There are many excellent books on UNIX and the reader is referred to them for a detailed discussion. What follows are the barest essentials for being able to use the programs in this book.

1.1.1. SURVIVAL UNIX

This book assumes that you have an account on a UNIX type machine and know how to log in. If you are using a Macintosh with Mac OS X, just use the terminal window. In this book, what *you* type is printed in boldface. At the end of every line, you must also type a carriage return ("Return" or "Enter" on most computer keyboards). To end input into a program, press the control key and "d" < *control – D* > simulaneously.

After a login message specific to your computer, you will get a command line prompt which varies widely. In this book, we use the symbol "%" as the command line prompt.

1.1.2. THE UNIX FILE STRUCTURE

Fundamental to the UNIX operating system is the concept of directories and files. On windows-based operating systems, directories are depicted as "folders" and moving about is accomplished by clicking on the different icons. In UNIX, the directories have names and are arranged in a hierarchical sequence with the top directory being the "root" directory, known as "/" (see Figure A.1. Within the "/" directory, there are subdirectories (e.g. **usr** and **home**). In any directory, there can also be "files" (e.g. *ex1.1, ex1.2* in the figure). Files can be "readable", "writable" and/or "executable".

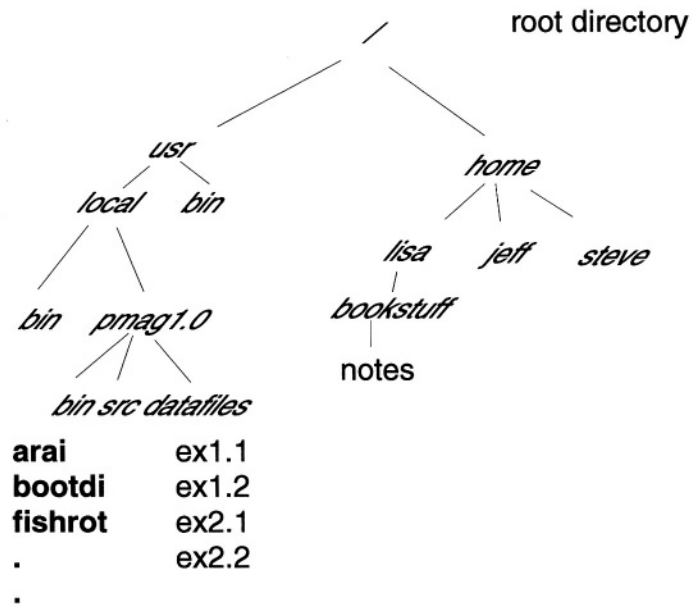

Figure A.1. Part of a UNIX filesystem tree. Directories are shown in italics, ascii files in plain text and executable programs in boldface.

When you log in you enter the computer in your "home" directory. To refer to directories, UNIX relies on what is called a "pathname". Every object has an "absolute" pathname which is valid from anywhere on the computer. The absolute pathname always begins from the root directory **/.** So the absolute pathname to the home directory **lisa** in Figure A.1 is **/home/lisa**. Similarly, the absolute pathname to the directory containing pmag1.7 executables is **/usr/local/pmag1.7/bin**. There is also a "relative" pathname, which is in reference to the current directory. If user "lisa" is sitting in her home directory, the relative pathname for the file **notes** in the directory **bookstuff** would be **bookstuff/notes**. When using relative pathnames, it is useful to remember that **./** refers to the current directory and **../.** refers to the directory "above".

Commands typed at the command line prompt are handled by a program called the "shell". There are many different sorts of shells (e.g. *sh, csh, jsh, ksh, bash, tsh*) that have a different look and feel but they all perform the task of interpreting between the user and the "kernel" which is the actual UNIX operating system. In order to execute a command, the shell needs to know where the command is. There are several "built-in" commands, but most are programs that are either part of the operating system, or something someone wrote (like the ones referred to here). There

are any number of places where programs are kept, so the shell looks in particular places determined by your "path" environment variable. To instruct the shell to look in directories other than the default directories (for example in **/usr/local/pmag1.7/bin**), ask your system administrator to add this directory to your "path". Otherwise, you can always type the absolute pathname for any program (e.g. **/usr/local/pmag1.7/bin/fishrot** to execute the program **fishrot**.

1.1.3. REDIRECTING INPUT AND OUTPUT

Most UNIX programs print output to the screen and read input from the keyboard. This is known as "standard input and output" or "standard I/O" in the following. One of the nicest things about UNIX is the ability to redirect input and output. For example, instead of typing input to a program with the keyboard, it can be read from a file using the symbol <. Output can either be put into a file using the symbol >, appended to the end of a file with >> or used as input to another program with the UNIX pipe facility (|).

1.1.4. WILDCARDS

UNIX has the ability to refer to a number of files and/or directories using "wildcards". The wildcard for a single character is "?" and for any number of characters is "*". For example, to refer to all the files beginning with "ex" in the directory:

/usr/local/pmag1.7/datafiles,

we use:

/usr/local/pmag1.7/datafiles/ex*.

To refer only to those from Chapter 1, we use:

/usr/local/pmag1.7/datafiles/ex1.* .

1.1.5. UNIX COMMANDS

Now we briefly describe essential UNIX commands.

- **awk**

Usage: awk [options] [file(s)] [Standard I/O]

Description: There are whole books on this program. We will use **awk** in a very primitive way to select specific columns from standard input for use as input into another program. For example, if the third and fourth column of file **myfile** is desired as input to program **myprog** type:

% **awk '{print $3, $4 }' myfile | myprog**

- **cat**

Usage: cat [options][file(s)] [Standard I/O]

Description: Con**cat**inates and displays files. It reads from standard input or from the specified file(s) and displays them to standard output.

- **cd**

Usage: cd [directory]
Description: Changes directory from current directory to the one specified.

- **cp**

Usage: cp [file1] [file2]
Description: Copies files or directories.

- **grep**

Usage: grep [options] [expression] [file(s)]
Description: **grep**, like **awk**, is a very versatile (and complicated) program about which one could read an entire book. However, we will use **grep** simply to pick out particular key strings from a file. For example, if a file **myfile** contains lines of data for many samples, and we wish to consider the data for a single sample **mysamp**, lines containing the word **mysamp** can be "grepped" out by:

% **grep "mysamp" myfile**

and listed to the screen, redirected to a file, or piped to a program.

- **join**

Usage: join [options] file1 file2
Description: *file1* and *file2* share a common "join" field, by default the first column. This could for example be a sample name. The output file prints the join field, followed by the rest of the line from **file1**, then the rest of the line in **file2**. Say **file1** has magnetometer output data, with lines of data containing: sample, treatment, *D, I, M* and **file2** has pertinent information such as sample orientation, with lines: sample, azimuth, plunge. We may wish to attach the sample orientation data to the magnetometer output for further processing. **join** allows us to do this by the following:

% **join file1 file2**

- **ls**

Usage: ls [options] [directory name]
Description: Lists the contents of the specified directory. If none specified, lists the current directory.

- **man**

Usage: man [command name]
Description: Prints the on-line documentation for the specified command.

- **mkdir**

Usage: mkdir [directory name]
Description: Makes a directory with the specified name.

- **more**

Usage: more [file name]

Description: Displays the contents of a text file on the terminal, one screenful at a time. To view line by line, type RETURN. To view page by page, use the space bar.

- **mv**

Usage: mv [file1 file2]
Description: Renames *file1* to *file2*. This also works for directory names.

- **paste**

Usage: paste [options] [file1 file2]
Description: "Pastes" lines from *file2* onto the corresponding line in *file1*.

- **pwd**

Usage: pwd
Description: Prints the absolute pathname of the working (or current) directory.

- **rm**

Usage: rm [options] [file(s)]
Description: Deletes the specified file or files.

- **rmdir**

Usage: rmdir [options] [file(s)]
Description: Deletes the specified directories. Note: the directory has to be empty.

- **tee**

Usage: tee [file name]
Description: Makes a copy of the standard input to the specified file, then passes it to standard output.

More detailed descriptions are usually available on-line with the **man** command. For example, to find out more about **cat**, type:
% **man cat**
and read all about it.

1.1.6. TEXT EDITORS

Text editing is a blessing and a curse in most UNIX systems. You either love it or hate it and in the beginning, you will certainly hate it. There are many ways of editing text and the subject is beyond the scope of this book. Almost all UNIX systems have some flavor of **vi** so try reading the man pages for that.

1.2. Getting the programs used in this book

The PMAG software distribution contains the fortran 77 source code, compiled programs for the Solaris, Linux and Mac OS X operating systems as well as executables for MSDOS (only the pmag1.4 distribution for MSDOS).

To run the compiled programs, simply "untar" them using for example the command

%tar xvf macosx.tar

Put the resulting *macosx* directory in your path or move the files in that directory to a directory that is in your path already.

We recommend that you "untar" the file *pmag1.7.tar*. This contains the source code and miscellaneous files for use with the the exercises in this book. Follow these instructions:

1) Place **pmag1.7.tar** in any directory (PARENTDIR) that you have write permission for.

Your fortran compiler must be known as "f77" or change the make.all file for the name of your compiler (eg., fort77).

2) Execute the following commands:

%tar xf pmag1.7.tar

%cd pmag1.7/src

3) Type:

%source make.all

Make sure **PARENTDIR/pmag1.7/bin** is in your path (or copy them to a directory that is in your path) and try out the programs as described in the book. The data files mentioned in the excercises can be found in **PARENTDIR/pmag1.7/datafiles** with names is given in the book.

1.3. Other necessary software

Included in this package of programs is a program called **plotxy**, written by Robert L. Parker and Loren Shure. This is freeware and is supplied as is. For a detailed description on how to use it, print out the file:

pmag1.7/src/Plotxy/plotxy.doc.

The program **plotxy** reads commands from standard input and creates a postscript file named by default *mypost.* Finally, you will need to have some sort of Postcript viewer, e.g. **pageview, ghostscript**, **ghostview** or commercial illustration product OR just convert the postscript files to pdf format and view them with Acrobat Reader available for free at this website:

http://www.adobe.com

1.4. Description of programs in excercises

The software described here is updated occasionally. For the description of the program you have, type:

% program_name -h

for a help message.

Here follows are hints for the use of all the programs referred to in the excercises in this book as well as some supplemental programs that are helpful.

The programs described here are part of the package **pmag1.7**. They are designed to take advantage of the power of UNIX in that they all take command line arguments. The common features are:

1) All programs respond with a help message if the [**-h**] switch is used:

% **program_name -h**

2) Programs that produce pictures use the freeware program **plotxy** (see section on getting and installing **plotxy**. PMAG programs output **plotxy** commands which can be piped directly to **plotxy**:

% **program_name | plotxy**

This causes **plotxy** to create a postscript file, by default *mypost* which can be viewed with a postscript viewer such as **pageview**, **ghostscript** or **ghostview**, or it can be printed to a postscript compatible printer. It can also be converted to *pdf* format. The **plotxy** commands generated by the PMAG programs can also be saved to a file and modified as needed:

% **program_name > myfile.com**

A text editor can be used to modify the commands to taste (see **plotxy** documentation **plotxy.doc** in the Plotxy directory:
/usr/local/pmag1.7/Plotxy),
or online at:
http://sorcerer.ucsd.edu/pmag/plotxy.html.

3) Programs read from standard input and write to standard output unless otherwise noted. All input files are expected to be space delimited - not tab or comma delimited. The typical syntax will be:

% **program_name < input_file > output_file**

The output from one program can be piped as input to another program.

Here follows a brief manual for using the programs in the PMAG package. Refer to the examples at the end of each Chapter for further hints about how to use them.

• **arai**

Usage: arai [-sfmd] [min max field] [Standard I/O]
Description: makes an Arai plot from input data.
Example 3.5
Options:
-s sets fit from [min] to [max]
-f sets lab field to [field] (in Tesla)
-m uses .mag file as input
Defaults:
finds "optimum" interval - beware! You may have to "tweak" the [min] and [max] values using the [-s] switch

default laboratory field is 40 μT.
Input options:
1em Default input:
Sample treatment intensity D I
.mag file [-m] option:
Sample treatment CSD intensity D I
treatment steps are coded as follows:
XXX.YY where XXX is the temperature and
YY is as follows:
NRM data: .00
pTRM: .11
pTRM check: .12
Output: plotxy commands.

- **bootams**

Usage: bootams [-pP] [Standard I/O]
Description: calculates bootstrap eigenparameters from input file.
Example: 5.9
Options:
-p option specifies parametric (by sample) bootstrap
-P option specifies parametric (by site) bootstrap
Input: s_1 s_2 s_3 s_4 s_5 s_6 σ
Output: bootstrap error statistics:
τ_1 σ D I η D_η I_η ζ D_ζ I_ζ
τ_2 σ D I η D_η I_η ζ D_ζ I_ζ
τ_3 σ D I η D_η I_η ζ D_ζ I_ζ

- **bootdi**

Usage: bootdi [-pPv] [Standard I/O]
Description: calculates bootstrap statistics for input file.
Example: 4.9
Options:
-p option selects parametric bootstrap
-P works on principal eigenvectors
-v spits out bootstrapped means
Defaults:
simple bootstrap
works on Fisher means
Input: D I [κ N]
Output:
Fisher statistics if Fisherian, otherwise bootstrap ellipses for one or two modes:
Mode $\eta, D_\eta I_\eta \zeta D_\zeta I_\zeta$.
or if -v selected, bootstrapped eigenvectors DI

• **bootstrap**
Usage: bootstrap [-pb] [Nb] [Standard I/O]
Description: Calculates bootstrap statistics from input data.
Example: 4.8
Options:
-p plot a histogram
-b sets number of bootstraps [Nb](< 10000)
Input: single column of numbers
Output:
if no plot, then:
N Nb mean bounds_containing_95%_of_means
if plot, then output is series of plotxy commands
Defaults:
no plot and nb=1000

• **cart_dir**
Usage: cart_dir [Standard I/O]
Description: Converts cartesian data to geomagnetic elements
Example: 1.2
Input: x_1 x_2 x_3
Output: D I magnitude

• **cart_hist**
Usage: cart_hist [-dcbpr][dec inc][file1 file2] [Standard I/O]
Description: Makes histograms of cartesian coordinates of input.
Example: 4.11
Options:
-d compares with direction [dec inc]
-c compares two files [file1 file2]
-b plots confidence bounds
-p specifies parametric bootstrap
-r flips second mode for reversals test
Input: D I $[\kappa$ $N]$
Output is plotxy command file
Defaults:
standard input of single file
no confidence bounds
simple bootstrap
no reversals test

• **curie**
Usage: curie -[lspt] [smooth] [low hi step] [Tmin Tmax] [Standard I/O]
Description: Analyzes Curie temperature data.
Example: 2.2
Options:

-l smooth over [smooth] data points
NB: [smooth] must be an odd number ≥ 3
-s scan range of smoothing intervals
[low] to [hi] using a spacing of [step]
[low],[hi] and [step] must be odd
-p plot option on to generate Plotxy command file
can be piped directly to plotxy and viewed:
curie -p < filename | plotxy; ghostview mypost
printed:
curie -p < filename | plotxy; lpr mypost
or saved to a file for modification:
curie -p < filename > eqarea.com
-t truncates to interval between [Tmin] and [Tmax]
input:
temperature,magnetization

Defaults:
no smoothing
plot option off
uses entire record

- **di_geo**

Usage: di_geo [Standard I/O]
Description: Rotates directions from specimen to geographic coordinates.
Example: 3.2
Input: *D I* azimuth plunge
Output: *D I* (in geographic coordinates)
Notes: the azimuth and plunge are the declination and inclination of the arrow used for reference during the measurements.

- **dir_cart**

Usage: dir_cart [-m] [Standard I/O]
Description: Converts geomagnetic elements to cartesian coordinates.
Example: 1.1
Option: -m read magnitude field
Input: *D I* [magnitude]
Output: x_1 x_2 x_3
Notes: VGP longitude, latitude can be substituted for *D, I.*

- **di_tilt**

Usage: di_tilt [Standard I/O]
Description: rotates directions from geographic to tilt adjusted coordinates.
Example: 3.2
Input: *D I* strike dip
Output: *D I* (in adjusted coordinates)
Notes: convention is that dip is to the "right" of strike.

• **di_vgp**
Usage: di_vgp [Standard I/O]
Description: Transforms declination/inclination to VGP.
Example: 1.5
Input: D I lat.(° N) long.(° E)
Output: Pole_Longitude Pole_Latitude
Notes: convention is positive: North, negative: South and positive: East, negative: West

• **eigs_s**
Usage: eigs_s [Standard I/O]
Description: Converts eigenparameters to .s format.
Example: 5.2
Input:
τ_3 $D_{\mathbf{V}_3}$ $I_{\mathbf{V}_3}$ τ_2 $D_{\mathbf{V}_2}$ $I_{\mathbf{V}_2}$ τ_1 $D_{\mathbf{V}_1}$ $I_{\mathbf{V}_1}$
Output: s_1 s_2 s_3 s_4 s_5 s_6
Notes: τ_1 is the largest eigenvalue and $\mathbf{V}_i$ are the associated eigenvectors.

• **eqarea**
Usage: eqarea [Standard I/O]
Description: Makes an equal area projection of input data.
Example: 1.3
Input: D I
Output: plotxy commands

• **fishdmag**
Usage: fishdmag [-fdm] [beg end ta] [Standard I/O]
Description: Calculates Fisher mean from specified portion of demagnetization data.
Example: 4.3
Options:
-f Fisher mean from [beg] to [end] steps
-d uses .dat file as input
if [ta] = 0 (default), uses geographic (D_g, I_g)
if [ta] = 1 uses tilt adjusted (D_{ta}, I_{ta})
-m uses .mag file as input
where [beg] and [end] are the number of the treatment (i.e. 1st, 2nd, 3rd).
Input options:
Default input:
Sample treatment intensity D I
.mag file [-m] option:
Sample treatment CSD intensity D I
.dat file [-d] option
Sample position treatment CSD intensity D_g I_g D_{ta} I_{ta}
Output: Sample f n beg end α_{95} $\bar{D}$ $\bar{I}$

• **fisher**
Usage: fisher -kns [kappa] [N] [seed] [Standard I/O]
Description: generates set of Fisher distribed data from specified distribution.
Example: 4.1
Options:
-k specifies κ as [kappa]
-n specifies number as [N]
-s specifies random seed (non-zero integer) as [seed]
Defaults:
$\kappa = 30$
N = 100
seed = 1200

• **fishqq**
Usage: fishqq [Standard I/O]
Description: plots Q-Q diagram for input against Fisher distribution.
Example: 4.5
Input: *DI*
Output: plotxy commands

• **fishrot**
Usage: fishrot -kndis [kappa] [N] [dec] [inc] [seed] [Standard I/O]
Description: draws a Fisher distribution with mean of [dec] [inc] and [kappa], [N], using random seed [seed].
Example: 4.4
Options:
-k specifies κ as [kappa]
-n specifies number as [N]
-d specifies *D* as [dec]
-i specifies *I* as [inc]
-s specifies [seed] for random number generator (non-zero)
Defaults:
$\kappa = 30$
N = 100
D = *0*
I = 90

• **foldtest**
Usage: foldtest [-p] [Standard I/O]
Description: Performs bootstrap fold test.
Example: 4.13
Options:
-p option selects parametric bootstrap
Input: *D I* strike dip [κ N]

Output: plotxy commands
Notes: unfolding curve of data is solid line, pseudo samples are dashed histogram is fraction of τ_1 maxima. Also, dip is to the "right" of strike.

• **gauss**
Usage: gauss -msni [mean] [sigma] [N] [seed] [Standard I/O]
Description: draws a set of Gaussian distributed data from specified distribution.
Example: 4.6
Options:
-m sets the mean to [mean]
-s sets the standard deviation to [sigma]
-n sets the number of points to [N]
-i sets integer random seed to [seed]
Defaults:
[mean] is 1
[sigma] is .5
[N] is 100

• **gofish**
Usage: gofish [Standard I/O]
Description: calculates Fisher statistics from input file.
Example: 4.2
Input: $D\ I$
Output: $\bar{D}\ \bar{I}\ N\ R\ k\ \alpha_{95}$

• **goprinc**
Usage: goprinc [Standard I/O]
Description: calculates principal component from input data.
Example: 4.2
Input: $D\ I$
Output: $D\ I\ N\ \tau_1$

• **gtcirc**
Usage gtcirc [-gdm] [beg end ta] [Standard I/O]
Description: calculates best-fit plane through specified input data.
Example: 3.3
Options:
-g best-fit great circle (plane) from [beg] to [end] steps
[beg] and [end] are the numbers of the treatment step.
For example the kNRM step is [1], the second step is [2], etc.
-d uses .dat file as input
if [ta] = 0 (default), uses geographic (D_g, I_g)
if [ta] = 1 uses tilt adjusted (D_{ta}, I_{ta})
-m uses .mag file as input
Input options:

Default input:
Sample treatment intensity *D I*
.mag file [-m] option:
Sample treatment CSD intensity *D I*
.dat file [-d] option
Sample position treatment CSD intensity D_g I_g D_{ta} I_{ta} Output:
Sample g N beg end MAD *D I*
where *D* and *I* are for the pole to the best-fit plane
and [beg] and [end] are the numbers of the treatment step.

- **histplot**

Usage: histplot [-lb] [bin] [Standard I/O]
Description: creates a histogram of input data.
Example: 4.6
Options:
-l plots the distributions of logs
-b sets bin size to [bin]
Input: single column of data
Output: Plotxy commands
Defaults:
not logs
auto binning

- **hystcrunch**

Usage: hystcrunch -[mpatl] [trunc_deg] [label] [Standard I/O]
Description: plots hysteresis loop data and massages them.
Example: 2.3
Options:
-m Micromag data file
-p do not plot
-a do not adjust slope
-t truncate to trunc_deg harmonics
-1 label plot with label
Defaults:
- xy data file
- retain 99 terms of FFT
- adjust for high field slope
- no plot label
- generate plotxy commands

- **igrf**

Usage: igrf [Standard I/O]
Description: calculates reference field vector at specified location and time uses appropriate IGRF or DGRF for date > 1945.
Example: 1.4

Input: year altitude latitude longitude
where year is decimal year, altitude is in kilometers, latitude is in ° N and longitude is in ° E.
Output: D I B (nT)

- **incfish**

Usage: incfish [Standard I/O]
Description: calculates an estimated inclination, assuming a Fisher distribution, for data with only inclinations. Uses the method of McFadden and Reid [1982].
Example: 4.4
Input: inclinations
Output: < I >, upper and lower bounds, N, estimated κ and α_{95}.

- **jackstrat**

Usage: jackstrat Standard I/O
Description: calculates magnetostratigraphic jackknife parameter J.
Example: 6.1
Input: VGP latitudes or inclinations in stratigraphic order
Output: plotxy commands

- **k15_hext**

Usage: k15_hext [-tga] [Standard I/O]
Description: calculates Hext statistics from 15 measurements uses Jelinek's 15 measurement scheme.
Examples: 5.5 & 5.6 .
Options:
-a average whole file
-g geographic coordinates
-t geographic tilt coordinates
Default: average by sample
Input: 1 line with sample name, [azimuth, plunge, strike, dip] followed by 3 rows of 5 measurements for each specimen in the following order (see Chapter 5):
K_1 K_2 K_3 K_4 K_5
K_6 K_7 K_8 K_9 K_{10}
K_{11} K_{12} K_{13} K_{14} K_{15}
Output: Hext statistics
[if individual samples, id and bulk chi]
F F_{12} F_{23}
τ_1 D I ϵ_{12} D I ϵ_{13} D I
τ_2 D I ϵ_{12} D I ϵ_{13} D I
τ_3 D I ϵ_{12} D I ϵ_{13} D I

- **k15_s**

Usage: k15_s [-gt] [Standard I/O]

Description: calculates $\bar{\mathbf{s}}$ from 15 measurements scheme (K_i) (see Chapter 5).
Example: 5.4
Options:
-g geographic rotation
-t geographic AND tectonic rotation
Input: (see k15_hext)
Output: $\bar{s}_1$ $\bar{s}_2$ $\bar{s}_3$ $\bar{s}_4$ $\bar{s}_5$ $\bar{s}_6$ σ

- **lnp**

Usage: lnp [-f] [infile] [Standard I/O]
Description: calculates Fisher mean from combined directed lines and great circles using the method of McFadden and McElhinny [1988].
NB: this program has changed somewhat since the first distribution!
Example: 4.3
Options:
-f calculates mean from data in [infile], one site at a time
Input: output file from **pca, gtcirc, fishdmag** programs, i.e.
Sample [fpg] n beg end α_{95} MAD *D I*
sample name convention: ABC123D[1]
where ABC is a study designator of letters (any length)
123 is the site number (any length)
D is a (single) letter for each separately oriented sample
[1] is an optional (single digit) specimen number
Default: assumes whole file is one site.
Output:
site *NL NG*$\kappa\alpha_{95}$ *D I*
where *NL is* the number of directed lines
where *NG* is the number of great circles

- **mag_dat**

Usage: mag_dat -n nfofile [Standard I/O]
Description: Converts magnetometer data file to format with geographic and tilt adjusted coordinates. Also pastes in stratigraphic position data. Uses **.nfo** files made by **mk_nfo.**
Example: 6.4
Input:
magnetometer data (.mag file format):
sample [optional specimen number] treatment CSD intensity *D I*
(.nfofile format):
Sample position [cpsdu] NBaz NBpl LABaz LABpl NBstr strike dip
Output:
(.dat file foramt)
Sample position treatment CSD intensity D_g I_g D_{ta} I_{ta}

where D_g and I_g are D,I in geographic coordinates and D_{ta} and I_{ta} are D, I in tilt adjusted coordinates.

- **mk_nfo**

Usage: mk_nfo [-HbBDstfk] [strike dip][magdec][lat. long. delta T] [cpsdu] [az_add az_mult pl_add pl_mult] [basename] [keyboard input]

Description: Makes an information file(s) for conversion of data into geographic, tectonic and stratigraphic references.

Example: 6.3

Options:

-H stratigraphic position data
-b structural strike/dip for each sample
-B structural for entire suite read as [strike dip]
-D add [magdec] to all declination/strike info
-s sun compass data using [lat. long. dT]
lat/long of study area
and dT is time difference from GMT
-t type of conversion from
notebook azimuth (= NBaz)/ notebook plunge (= NBpl) to
lab azimuth (= LABaz)/ lab plunge (= LABpl)
[c]ube:
NBaz/NBpl are strike and dip on face perpendicular
to face with lab arrow
LABaz=NBaz-90, LABpl=NBpl-90
[p]omeroy orientation device:
NBaz/NBpl are direction of drill and angle from vertical
LABaz=NBaz, LABpl=-NBpl
[s]trike/dip:
NBaz/NBpl are strike and dip on face with lab arrow
LABaz=NBaz+90, LABpl=NBpl
[d]rill direction/dip:
NBaz/NBpl are direction of drill (az/pl) in plane perpendicular
to face with lab arrow
LABaz=NBaz, LABpl=NBpl-90
[u]ser defined conversion
input [az_add az_mult pl_add pl_mult] to
specify affine for NBaz/NBpl to LABaz/LABpl
e.g. for [p] above, az_add=0, az_mult=1
pl_add=-90, az_mult=-1
-f output file specified as [basename]
ouput file will be appended to basename.nfo and if
sun compass data calculated, basename.snfo
-k input from keyboard with prompts

<cntl-D>. to quit.
Input:
Sample NBaz NBpl [position] [strike dip] [yyyymmdd hhmm shadow]
Output:
Sample position type NBaz NBpl LABaz LABpl NBstr strike dip
Defaults:
read/write from Standard I/O
input only: sample, NBaz,NBpl
no declination adjustment
LABaz=NBaz; LABpl=NBpl

- **pca**

Usage: pca [-pmd] [beg end] [ta] [Standard I/O]
Description: Calculates best-fit line through specified input data.
Example: 3.3
Options:
-p PCA from [beg] to [end] steps
[beg] and [end] are the numbers of the treatment step.
For example the NRM step is [1], the second step is [2], etc.
-d uses .dat file as input
if [ta] = 0 (default), uses geographic (D_g, I_g)
if [ta] = 1 uses tilt adjusted (D_{ta}, I_{ta})
-m uses .mag file as input
Input options:
Default input:
Sample treatment intensity D I
.mag file [-m] option:
Sample treatment CSD intensity D I
.dat file [-d] option
Sample position treatment CSD intensity D_g I_g D_{ta} I_{ta}
Output:
Sample p N beg end MAD D I
where D and I are for the principal component

- **plotams**

Usage: plotams [-BpPvxjn] [name] [Standard I/O]
Description: Plots AMS data from s data
Example: 5.10
Options:
-B do not plot simple bootstrap ellipses
-p plot parametric (sample) bootstrap ellipses
-P plot parametric (site) bootstrap ellipses
-v plot bootstrap eigenvectors - not ellipses
-x plot Hext [1963] ellipses

-j plot Jelinek [1978] ellipses
-n use [name] as plot label
Default: plot only the simple bootstrap
Input: s_1 s_2 s_3 s_4 s_5 s_6 [σ]
Output: plotxy commands

• **plotdi**

Usage: plotdi [-pPv] [Standard I/O]
Description: Makes equal area plot of input data, with uncertainties.
Example: 4.10
Options:
-p parametric bootstrap
-P works on principal eigenvector
-v plots bootstrapped eigenvectors
Defaults:
simple bootstrap
works on Fisher means
plots estimated 95% conf. ellipses
Input: D I [k N]
Output: plotxy commands

• **plotdike**

Usage: plotdike [-BpPvn] [name] [Standard I/O]
Description: Makes a plot of ams data for dike margins. Designed for estimating flow directions.
Example 6.5
-B DONT plot simple bootstrap ellipses
-p plot parametric (sample) ellipses
-P plot parametric (site) ellipses
-v plot bootstrap eigenvectors
-n use [name] as plot label
Input:
-one or both files called:
e.s and w.s containing:
$s1$ s_2 s_3 s_4 s_5 s_6 [σ] for the nominal east and west margins respectively
- a file called dike.dd containing one or more measurements of the dip direction and dip of the dike
-optional files:
struct.dat: contains first and second tectonic corrections as strike and dips
lin.di: contains dec,inc of lineation data
Output: plotxy commands and a file:
fort.20 is summary file

Default: plot only the simple bootstrap confidence ellipses

• **plotdmag**

Usage: plotdmag [-pgfrmd] [beg end] [D] [ta] [Standard I/O]
Description: Makes orthogonal and equal area projections of input demagnetization data.
Example: 3.3
Options:
-p PCA from [beg] to [end] steps
-g gtcirc from [beg] to [end] steps
-f fisher mean from [beg] to [end] steps
-r plot horizontal axis = [D] degrees
-m uses .mag file format
-d uses .dat file format
Defaults:
North on horizontal ([D] = 0)
no PCA, gtcircle, or fisher calculations
Input options:
Default input:
Sample treatment intensity D I
.mag file [-m] option:
Sample treatment CSD intensity D I
.dat file [-d] option
Sample position, treatment CSD intensity D_g I_g D_{ta} I_{ta}
Output: plotxy commands
Notes: select either p, f OR g

• **pseudot**

Usage: pseudot [-sm] [min] [ta] [Standard I/O]
Description: Analyses pseudo-Thellier data
Example 3.6
Input options:
-s sets the minimum field to [min]
-m sets input file to .mag format
Input options:
Default input:
Sample tr int dec inc
.mag file option
Sample tr csd int dec inc
treatment steps are coded as follows:
XXX.XY where XXX.X is the AF level and
Y is as follows:
NRM data: 0
ARM: 1

Output: plotxy command file

- **qqplot**

Usage: qqplot [Standard I/O]
Description: Plots data against Normal Quantile
Example: 4.7
Input: single column of data
Output: plotxy commands
Notes: On the plot, there are these parameters:
N: the number of data points
mean: the Gaussian mean
σ: the standard deviation
D: the Kolmogorov-Smirnov D-statistic
D_c: the critical value given N at 95% confidence
(if $D > D_c$, distribution is not Gaussian at 95% confidence)

- **s_eigs**

Usage: s_eigs [Standard I/O]
Description: Converts s format data to eigenparameters.
Example: 5.1
Input: $s_1\ s_2\ s_3\ s_4\ s_5\ s_6$
Output:
$\tau_1\ D_{\mathbf{V}_1}\ I_{\mathbf{V}_1}\ \tau_2\ D_{\mathbf{V}_2}\ I_{\mathbf{V}_2}\ \tau_3\ D_{\mathbf{V}_3}\ I_{\mathbf{V}_3}$
Notes: $D_{\mathbf{V}}$, $I_{\mathbf{V}}$ are the directions of the eigenvectors corresponding to the eigenvalues, τ and τ_1 is the largest eigenvalue.

- **s-flinn**

Usage: s_flinn [-pl] [Standard I/O]
Description: Plots Flinn diagram of input s data.
Example: 5.13
Options:
-p parametric bootstrap
-1 plots L' versus F'
Input: $s_1\ s_2\ s_3\ s_4\ s_5\ s_6\ [\sigma]$
Output: plotxy commands

- **s_geo**

Usage: s_geo [Standard I/O]
Description: Rotates s data to geographic coordinates
Example: 5.3
Input: $s_1\ s_2\ s_3\ s_4\ s_5\ s_6$ azimuth plunge
Output: $s_1\ s_2\ s_3\ s_4\ s_5\ s_6$ rotated to geograpphic coordinates

- **s_hext**

Usage: s_hext [Standard I/O]
Description: Calculates Hext statistics from input s data.
Example: 5.7

Input: $s_1\ s_2\ s_3\ s_4\ s_5\ s_6$
Output: Hext statistics
$F\ F_{12}\ F_{23}\ \sigma$
$\tau_1\ D\ I\ \epsilon_{12}\ D\ I\ \epsilon_{13}\ D\ I$
$\tau_2\ D\ I\ \epsilon_{21}\ D\ I\ \epsilon_{23}\ D\ I$
$\tau_3\ D\ I\ \epsilon_{32}\ D\ I\ \epsilon_{31}\ D\ I$

- **s_hist**

Usage: s_hist (-cbpP123t][file1 file2] [standard I/O]
Description: Plots histograms of bootstrapped eigenparameters of s data.
Example: 5.11
Options:
-c compares [file1] and [file2]
-b plot 95% confidence bounds
-p sample parametric bootstrap
-P Site parametric bootstrap
-1 plots principal eigenvector
-2 plots major eigenvector
-3 plots minor eigenvector
-t plots eigenvalues
Defaults:
simple bootstrap
all eigenparameters
no confidence limits
Input: $s_1\ s_2\ s_3\ s_4\ s_5\ s_6\ [\sigma]$
Output: plotxy command for histograms of eigenvalues and eigenvectors of bootstrap samples

- **s_jel78**

Usage: s_jel78 [Standard I/O]
Description: Calculates Jelinek (1978) statistics from s data.
Example: 5.8
Input: $s_1\ s_2\ s_3\ s_4\ s_5\ s_6$
Output: Jelinek statistics
$\tau_1\ D\ I\ \epsilon_{12}\ D\ I\ \epsilon_{13}\ D\ I$
$\tau_2\ D\ I\ \epsilon_{21}\ D\ I\ \epsilon_{23}\ D\ I$
$\tau_3\ D\ I\ \epsilon_{32}\ D\ I\ \epsilon_{31}\ D\ I$

- **s_pt**

Usage: s_pt [-p] [Standard I/O]
Description: Makes a Jelinek plot of input s data.
Example: 5.13
Options: -p parametric bootstrap
Input: $s_1\ s_2\ s_3\ s_4\ s_5\ s_6\ [\sigma]$
Output: plotxy commands for P' versus T diagram

- **s_tern**

Usage: s_tern [-p] [Standard I/O]
Description: Makes a Ternary projection of input s data.
Example: See Chapter 5
Options: -p parametric bootstrap
Input: s_1 s_2 s_3 s_4 s_5 s_6 $[\sigma]$
Output: plotxy command file of ternary diagram
Notes: triangles are data, dots are bootstrapped means

- **s_tilt**

Usage: s_tilt [Standard I/O]
Description: Rotates s data into tilt adjusted coordinates
Example: 5.3
Input: s_1 s_2 s_3 s_4 s_5 s_6 strike dip
Output: s_1 s_2 s_3 s_4 s_5 s_6 [in tilt adjusted coordinates]

- **splint**

Usage: splint [-i] [interval] [Standard I/O]
Description: Calculates spline interpolation of input.
Option: -i uses interpolation interval [interval]
Default: [interval] = 1
Input: x y data with monotonic increasing x
Output: interpolated x,y

- **stats**

Usage: stats [standard I/O]
Description: Salculates Gauss statistics for input data
Example: 4.6
Input: single column of numbers
Output: N mean sum σ (%) stderr 95%conf.
Notes: σ is the standard deviation % is σ as percentage of the mean stderr is the standard error and 95% conf.$= 1.96\sigma/\sqrt{N}$

- **sundec**

Usage: sundec [-u] [delta T] [Standard I/O]
Description: Calculates declination from sun compass measurements.
Example: 3.1
Options: -u sets the time difference [delta T] in hours from universal time (e.g. -5 for EST)
Input: latitude longitude year month day hours minutes shadow_angle
Output: *D*
Notes: positive: North, East; negative: South, West

- **vgp_di**

Usage: vgp_di [Standard I/O]
Description: Transforms VGP to equivalent *D, I*
Example: 1.6

Input: pole_latitude longitude site_latitude longitude.
Output: *D I*
Notes: convention is positive: North, negative: South and positive: East, negative: West

- **vspec**

Usage: vspec [Standard I/O]
Description: Calculates a vector average for multiple measurements of a single specimen at a single treatment step.
Example: 6.2
Input:
(.mag file format - see mag_dat)
Sample treatment CSD intensity *D I*
Output:
Sample treatment CSD/R* intensity $\bar{D}$ $\bar{I}$
Unique specimen/treatment data are simply copied.
R* is the vector resultant (including intensity) over the sum of all intensities and ranges from 0 to 1.

Appendix 2

TERMS, ACRONYMS AND CONSTANTS

Symbol	Term and Definitions
	Paleomagnetic acronyms and terms
τ	Relaxation time: Section 2.6.1; equation 2.18
θ_m	Magnetic co-latitude: Section 1.3.3; equation 1.14
$[a_m]$	Magnetic activity: Section 3.10.2
APWP	Apparent polar wander path: Section 6.3
AF	Alternating field demagnetization: Section 3.5
ARM	Anhysteretic remanent magnetization: Section 2.6.4
CRM	Chemical remanent magnetization: Section 2.6.5
D	Declination: Section 1.3.1; equation 1.6
DGRF	Definitive geomagnetic reference field: Section 1.3.3
DRM	Detrital remanent magnetization: Section 2.6.6
GAD	Geocentric axial dipole: Section 1.3
GPTS	Geomagnetic polarity time scale: Section 1.4.2; Section 6.1
IGRF	International geomagnetic reference field: Section 1.3.3
IRM	Isothermal remanent magnetization: Section 2.4.1
M_{eq}	Equilibrium magnetization: Section 2.6.2
MD	Multi-domain: Section 2.5
NRM	Natural remanent magnetization: Section 2.6.7
pARM	Partial anhysteretic remanence: Section 2.6.4
pDRM	Post-depositional detrital remanent magnetization: Section 2.6.6
PSD	Pseudo-single domain: Section 2.5
PSV	Paleosecular variation of the geomagnetic field: Section 1.4.1
pTRM	Partial thermal remanence: Section 2.6.3
sIRM	Saturation IRM: See M_r
SD	Single domain: Section 2.5
SP	Superparamagnetic: Section 2.6.1
SV	Secular variation: Section 1.4.1
TRM	Thermal remanent magnetization: Section 2.6.3
VADM	Virtual axial dipole moment: Section 1.3.5
VDM	Virtual dipole moment: Section 1.3.5; equation 1.19
VDS	Vector difference sum: Section 3.7
VGP	Virtual geomagnetic pole: Section 1.3.4
VRM	Viscous remanent magnetization: Section 2.6.2
	Miscellaneous terms
GHA	Greenwich hour angle: Section 3.1
SQUID	Superconducting quantum interference device: Section 3.4
UT	Universal time (Greenwich mean time): Section 3.1

	Physical Parameters and Constants
α	Co-inclination: Section 4.5
χ	Magnetic susceptibility: The slope relating induced magnetization to an applied field: Section 1.1
χ_b	Bulk magnetic susceptibility: Section 5.3; equation 5.23
χ_d	Diamagnetic susceptibility: Section 2.1.1
χ_f	Ferromagnetic susceptibility: Section 2.2; equation 2.11
χ_p	Paramagnetic susceptibility: Section 2.1.2; equation 2.9
ΔM curve	Curve defined by subtracting the ascending from the descending curves in a hysteresis loop: Section 2.4.1
λ, ϕ	Latitude, Longitude
μ_o	Permeability of free space: $(4\pi \times 10^{-7}\ \mathrm{Hm}^{-1})$: Section 1.1.3
θ	Co-latitude: Section 1.3
Θ	Curie temperature. Section 2.2
a_{ij}	Direction cosines: Section 3.2
a	The radius of the Earth $(6.371 \times 10^6\ \mathrm{m})$: Section 1.3.3
AMS	Anisotropy of magnetic susceptibility: Section 5.1
$\mathbf{B}$	Magnetic induction: Section 1.1.2
C	Frequency factor $(10^{-10}\ \mathrm{s}^{-1})$: Section 2.6.1
D	Declination: Section 1.3.1
g_m^l, h_m^l	Gauss coefficients: Section 1.3.3
$\mathbf{H}$	Magnetic field: Section 1.1.1
H_{cr}	Coercivity of remanence; field required to reduce saturation IRM to zero: Section 2.4.1
H_c	Coercivity; the magnetic field required to change the magnetic moment of a particle from one easy axis to another: Section 2.4
H_s	Saturating field; field required to impart M_s: Section 2.4.1
I	Inclination: Section 1.3.1; equation 1.6
k	Boltzmann's constant $(1.381 \times 10^{-23}\ \mathrm{JK}^{-1})$: Section 2.1.1
K_i	AMS measurement: Section 5.1
K_u	Constant of uniaxial anisotropy energy: Section 2.4
$\mathbf{m}$	Magnetic moment: Section 1.1.3
$\mathbf{m}_b$	Bohr magneton $(9.27 \times 10^{-24}\ \mathrm{Am}^2)$: Section 2.0
$\mathbf{M}$	Magnetization: Section 1.1.3
M_r	Saturation remanence (also sIRM): Section 2.4.1
M_s	Saturation magnetization; the magnetization measured in the presence of a saturating field: Section 2.4.1
P_l^m	Schmidt polynomials: Section 1.3.3
$\mathbf{s}$	Six elements of χ_{ij}; $s_1 = \chi_{11}, s_2 = \chi_{22}, s_3 = \chi_{33}, s_4 = \chi_{12}, s_5 = \chi_{23}, s_6 = \chi_{13}$: Section 5.1; equation 5.4
T	Absolute temperature (in kelvin)
T_b	Blocking temperature: Section 2.6.3
v	Volume
v_b	Blocking volume: Section 2.6.5

	Statistical parameters
α_{95}	Circle of 95% confidence (Fisher): Section 4.1, equation 4.4
δ	Residual errors for AMS measurements: Section 5.2,equation 5.20
ϵ_{ij}	Semi-angles of Hext uncertainty ellipses: Section 5.3; equation 5.21
κ	Fisher precision parameter: Section 4.1
η, ζ	Semi-angles of bootstrap uncertainty ellipses: Section 4.10; equation 4.16
$\tau, \mathbf{V}$	Eigenvalues and eigenvectors of tensors
k	Estimate of κ: Section 4.1
CSD	Circular standard deviation (Fisher): Section 4.1
dm	Uncertainty in the meridian (longitude) of a paleomagnetic pole: Section 4.1; equation 4.5
dp	Uncertainty in the parallel (latitude) of a paleomagnetic pole: Section 4.1; equation 4.5
F, F_{12}, F_{23}	Significance tests for anisotropy (Hext): Section 5.3; equation 5.22
J	Magnetostratigraphic jackknife parameter: Section 6.1.1
LPA	Linear Perturbation Analysis: Section 5.2
MAD	Maximum angular deviation of principal eigenvector (Kirschvink): Section 3.8.2; equation 3.9
MAD_{plane}	MAD of the pole to a best-fit plane (Kirschvink): Section 3.8.2; Equation 3.10
M_u, M_e	Significance tests for uniform and exponential distributions: Section 4.6
N	Number of samples, specimens or sites
n_f	Number of degrees of freedom
R	Resultant vector length (Fisher): Section 4.2
R_o	Critical value of R for non-random distribution (Watson): Section 4.2; equation 4.6
S_o	Residual sum of squares of errors (Hext): Section 5.2; equation 5.14
T	Orientation tensor: Section 3.8.1; equation 3.6

REFERENCES

Abramowitz, M. and I. Stegun, *Handbook of Mathematical Functions,* National Bureau of Standards, New York, 1970.

Aharoni, A., *Introduction to the Theory of Ferromagnetism,* Oxford University Press, 1996.

Anson, G. L. and K. P. Kodama, Compaction-induced inclination shallowing of the post-depositional remanent magnetization in a synthetic sediment, *Geophys. J. R. astr. Soc., 88,* 673–692, 1987.

Backus, G., R. Parker, and C. Constable, *Foundations of Geomagnetism,* Cambridge University Press, 1996.

Balsley, J. and A. Buddington, Magnetic susceptibility anisotropy and fabric of some Adirondack granites and orthogneisses, *Amer. J. Sci., 258A,* 6–20, 1960.

Banerjee, S. K., New grain size limits for paleomagnetic stability in hematite, *Nature Phys. Sci., 232,* 15–16, 1971.

Banerjee, S. K., J. King, and J. Marvin, A rapid method for magnetic granulometry with applications to environmental studies, *Geophys. Res. Lett., 8,* 333–336, 1981.

Bard, E., B. Hamelin, R. G. Fairbanks, and A. Zindler, Calibration of the ^{14}C timescale over the past 30,000 years using mass spectrometric U-Th ages from Barbados corals, *Nature, 345,* 405–410, 1990.

Barton, C., *International Geomagnetic Reference Field, 1995 revision,* EOS, Trans. AGU., 1996.

Barton, C. E. and M. W. McElhinny, Detrital remanent magnetization in five slowly redeposited long cores of sediment, *Geophys. Res. Lett., 6,* 229–232, 1979.

Behrensmeyer, A. K. and L. Tauxe, Isochronous fluvial systems in Miocene deposits of northern Pakistan, *Sedimentology, 29,* 331–352, 1982.

Bingham, C., *Distributions on the sphere and on the projective plane,* Ph.D. Thesis, Yale University, 1964.

Blakely, R., *Potential Theory in Gravity and Magnetic Applications,* Cambridge University Press, 1995.

Borradaile, G. J., Magnetic susceptibility, petrofabrics and strain, *Tectonophysics, 156,* 1–20, 1988.

Box, G. and J. Hunter, Multi-factor experimental designs for exploring response surfaces, *Ann. Math. Statist., 28,* 195–241, 1957.

Briden, J. C. and M. A. Ward, Analysis of magnetic inclination in bore cores, *Pure Appl. Geophys., 63,* 133–152, 1966.

Bullard, E., J. Everett, and A. Smith, A symposium on continential drift - IV. The fit of the continents around the Atlantic, *Phil. Trans. Roy. Soc., 258,* 41–51, 1965.

Butler, R. F., *Paleomagnetism,* Blackwell Scientific Publications, 1992.

Cande, S. and D. Kent, Revised calibration of the geomagnetic polarity timescale for the late Cretaceous and Cenozoic, *J. Geophys. Res., 100,* 6093–6095, 1995.

Cande, S. C., and D. V. Kent, A new geomagnetic polarity time scale for the late Cretaceous and Cenozoic, *J. Geophys. Res., 97,* 13917–13951, 1992.

Cañon-Tapia, E., E. Herrero-Bervera, and G. Walker, Flow directions and paleomagnetic study of rocks from the Azufre volcano, Argentina, *J. Geomag. Geoelectr., 46,* 143–159, 1994.

Chapman, S. and J. Bartels, *Geomagnetism,* Oxford University Press, London, 1940.

Chikazumi, S. and S. Charap, *Physics of Magnetism,* Krieger, Melbourne, 1986.

Clement, B. M. and D. V. Kent, A detailed record of the lower Jaramillo polarity transition from a southern hemisphere, deep-sea sediment core, *J. Geophys. Res., 89,* 1049–1058, 1984.

Coe, R. S., The determination of paleointensities of the Earth's magnetic field with emphasis on mechanisms which could cause non-ideal behavior in Thellier's method, *J. Geomag. Geoelectr., 19,* 157–178, 1967a.

Coe, R. S., Paleointensities of the Earth's magnetic field determined from Tertiary and

Quaternary rocks, *J. Geophys. Res., 72,* 3247–5281, 1967b.
Coe, R. S., S. Grommé, and E. A. Mankinen, Geomagnetic paleointensities from radiocarbon-dated lava flows on Hawaii and the question of the Pacific nondipole low, *J. Geophys. Res., 83,* 1740–1756, 1978.
Collinson, D. W., *Methods in Rock Magnetism and Paleomagnetism,* Chapman and Hall, 1983.
Constable, C. and L. Tauxe, The bootstrap for magnetic susceptibility tensors, *J. Geophys. Res., 95,* 8383–8395, 1990.
Constable, C. and L. Tauxe, Towards absolute calibration of sedimentary paleointensity records, *Earth Planet. Sci. Lett., 143,* 269–274, 1996.
Constable, C., L. Tauxe, and R. Parker, Analysis of 11 Myr of geomagnetic intensity variation, in press, 1998.
Day, R., M. D. Puller, and V. A. Schmidt, Hysteresis properties of titanomagnetites: grain size and composition dependence, *Phys. Earth Planet. Int., 13,* 260–266, 1977.
Dekkers, M. J., Magnetic properties of natural pyrrhotite. II. High and low temperature behaviors of Jrs and TRM as a function of grain size, *Phys. Earth Planet. Inter., 57,* 266–283, 1989a.
Dekkers, M. J., Magnetic properties of natural goethite I. Grain size dependence of some low and high field related rock magnetic parameters measured at room temperature, *Geophys. J., 97,* 323–340, 1989b.
Dekkers, M. J., J.-L. Mattei, G. Fillion, and P. Rochette, Grain-size dependence of the magnetic behavior of pyrrhotite during its low temperature transition at 34 K., *Geophys. Res. Lett., 16,* 855–858, 1989.
Dunlop, D., Developments in rock magnetism, *Rep. Prog. Phys., 53,* 707–792, 1990.
Dunlop, D., Magnetism in rocks, *J. Geophys. Res., 100,* 2161–2174, 1995.
Dunlop, D. and . Ö. Özdemir, *Rock Magnetism: Fundamentals and Frontiers,* Cambridge University Press, 1997.
Dunlop, D. and S. Xu., Theory of partial thermoremanent magnetization in multidomain grains, 1. Repeated identical barriers to wall motion (single microcoercivity), *J. Geophys. Res., 99,* 9005–9023, 1994.
Efron, B., *The Jackknife, the Bootstrap and Other Resampling Plans,* SIAM (Regional Conf. Ser. in App. Math.), 1982.
Ellwood, B. B., F. Hrouda, and J.-J. Wagner, Symposia on magnetic fabrics: Introductory comments, *Phys. Earth Planet. Inter., 51,* 249–252, 1988.
Elsasser, W. M., E. P. Ney, and J. R. Wenkker, Cosmic ray intensity and geomagnetism, *Nature, 178,* 1226, 1956.
Fisher, N. I. and P. Hall, New statistical methods for directional data 1. bootstrap comparison of mean directions and the fold test in palaeomagnetism, *Geophys. J. Int., 101,* 305–313, 1990.
Fisher, N. I., T. Lewis, and B. J. J. Embleton, *Statistical Analysis of Spherical Data,* Cambridge University Press, 1987.
Fisher, R. A., Dispersion on a sphere, *Proc. Roy. Soc. London, Ser. A, 217,* 295-305, 1953.
Flinn, D., On folding during three-dimensional progressive deformation, *Geol. Soc. London Quart. Jour., 118,* 385–433, 1962.
Frank, M., B. Schwarz, S. Baumann, P. Kuhik, M. Suter, and M. A, A 200 kyr record of cosmogenic radionuclide production rate and geomagnetic field intensity from ^{10}Be in globally stacked deep-sea sediments, *Earth Planet. Sci. Lett., 144.* 121–129, 1996.
Fuller, M., *Methods of Experimental Physics,* vol. 24, A, chap. Experimental methods in rock magnetism and paleomagnetism, pp. 303–465, Academic Press, 1987.
Gee, J. and D. Kent, Magnetic hysteresis in young mid-ocean ridge basalts: dominant cubic anisotropy?, *Geophys. Res. Lett, 22,* 551–554, 1995.
Gilder, S. A., R. S. Coe, H. Wu, G. Kuang, X. Zhao, Q. Wu, and X. Tang, Cretaceous and Tertiary paleomagnetic results from southeast China and their tectonic implications,

Earth Planet. Sci. Lett., 117, 637–652, 1993.
Glen, W., *The Road to Jaramillo,* Stanford University Press, 1982.
Graham, J., The stability and significance of magnetism in sedimentary rocks, *J. Geophys. Res., 54,* 131–167, 1949.
Granar, L., Magnetic measurements on Swedish varved sediments, *Arkiv. for Geo., 3,* 1–40, 1958.
Grommé, C. S., T. L. Wright, and D. L. Peak, Magnetic properties and oxidation of iron-titanium oxide minerals in Alae and Makaopulhi lava lakes, Hawaii, *J. Geophys. Res., 74,* 5277–5293, 1969.
Guyodo, Y., and J.-P. Valet, Relative variations in geomagnetic intensity from sedimentary records: the past 200,000 years, *Earth Planet. Sci. Lett., 143,* 23–36, 1996.
Haigh, G., The process of magnetization by chemical change, *Phil. Mag., 3,* 267–286, 1958.
Hargraves, R. B., Distribution anisotropy: the cause of AMS in igneous rocks?, *Geophys. Res. Lett., 18,* 2193–2196, 1991.
Harland, W., R. Armstrong, A. V. Cox, L. E. Craig, A. G. Smith, D. G. H. W. B. Smith, and A. R. L., *A Geologic Time Scale,* Cambridge University Press, 1989.
Hartl, P., and L. Tauxe, A precursor to the Matuyama/Brunhes transition-field instability as recorded in pelagic sediments, *Earth Planet. Sci. Lett., 138,* 121–135, 1996.
Hartl, P., L. Tauxe, and C. Constable, Early Oligocene geomagnetic field behavior from DSDP Site 522, *J. Geophys. Res., 98,* 19649–19665, 1993.
Hext, G., The estimation of second-order tensors, with related tests and designs, *Biometrika, 50,* 353–357, 1963.
Hilgen, F. J., Astronomical calibration of Gauss to Matuyama sapropels in the Mediterranean and implication for the geomagnetic polarity time scale, *Earth Planet. Sci. Lett., 104,* 226–244, 1991.
Hoffman, K. A. and R. Day, Separation of multi-component NRM: a general method, *Earth Planet. Sci. Lett., 40,* 433–438, 1978.
Housen, B., B. van der Pluijm, and E. Essene, Plastic behavior of magnetite and high strains obtained from magnetic fabrics in the Parry Sound shear zone, Ontario Grenville Province, *J. Struct. Geol, 17,* 265–278, 1995.
Ising, G., On the magnetic properties of varved clay, *Arkiv. For. Mate., Astr., Och Fys., 29,* 1–37, 1942.
Jackson, M., W. Gruber, J. Marvin, and S. K. Banerjee, Partial anhysteretic remanence and its anisotropy: applications and grainsize-dependence, *Geophys. Res. Lett., 15,* 440–443, 1988.
Jackson, M., J. P. Craddock, M. Ballard, R. van der Voo, and C. McCabe, Anhysteretic remanent magnetic anisotropy and calcite strains in Devonian carbonates from the Appalachian Plateau, New York, *Tectonphysics, 161,* 43–53, 1989.
Jackson, M., H.-U. Worm, and S. K. Banerjee, Fourier analysis of digital hysteresis data: rock magnetic applications, *Phys. Earth Planet. Int., 65,* 78–87, 1990.
Jelinek, V., The statistical theory of measuring anisotropy of magnetic susceptibility of rocks and its application, Brno, Geophysika,1–88, 1976.
Jelinek, V., Statistical processing of anisotropy of magnetic susceptibility measured on groups of specimens, *Studia Geophys. et geol., 22,* 50–62, 1978.
Jelinek, V., Characterization of the magnetic fabric of rocks, *Tectophys., 79,* T63–T67, 1981.
Jiles, D., *Introduction to Magnetism and Magnetic Materials,* Chapman and Hall, 1991.
Joffe, I. and R. Heuberger, Hysteresis properties of cubic single-domain ferromagnetic particles, *Phil. Mag., 314,* 1051–1059, 1974.
Johnson, C. and C. Constable, Paleosecular variation recorded by lava flows over the past five million years, *Phil. Trans. Roy. Soc. Lond, Series A - Math. Phys., Eng. Sci., 354,* 89–141, 1996.
Juárez, M., L. Tauxe, J. Gee, and T. Pick, The intensity of the Earth's magnetic field over the past 160 million years, Nature, 394, 878–881, 1998.

Juárez, T., M. Osete, G. Melendez, C. Langereis, and J. Zijderveld, Jurassic magnetostratigraphy of the Aguilon and Tosos sections (Iberian range, Spain) and evidence of a low-temperature Cretaceous overprint, *Phy. Earth Planet. Inter., 85,* 195–211, 1994.

Kamerling, M. J., and B. P. Luyendyk, Tectonic rotations of the Santa Monica mountains region, Western Transverse Ranges, California, suggested by paleomagnetic vectors, *Geol. Soc. Amer. Bull, 90, Pt. 1,* 331–337, 1979.

Kent, D. V., Post-depostitional remanent magnetization in deep-sea sediment, *Nature, 246,* 32–34, 1973.

Kent, J. T., The Fisher-Bingham distribution on the sphere, *J.R.Statist. Soc. B., 44,* 71–80, 1982.

King, J. W., S. K. Banerjee, and J. Marvin, A new rock magnetic approach to selecting sediments for geomagnetic paleointensity studies: Application to paleointensity for the last 4000 years, *J. Geophys. Res., 88,* 5911–5921, 1983.

King, R. F., The remanent magnetism of artificially deposited sediments, *Mon. Nat. Roy. astr. Soc., Geophys. Suppl., 7,* 115–134, 1955.

Kirschvink, J. L., The least-squares line and plane and the analysis of paleomagnetic data, *Geophys. J. Roy. Astron. Soc., 62,* 699-718, 1980.

Knight, M. and G. Walker, Magma flow directions in dikes of the Koolau Complex, Oahu, determined from magnetic fabric studies, *J. Geophys. Res., 93,* 4301–4319, 1988.

Kok, Y., and L. Tauxe, Saw-toothed pattern of relative paleointensity records and cumulative viscous remanence, *Earth Planet. Sci. Lett., 137,* 95–99, 1996a.

Kok, Y., and L. Tauxe, Saw-toothed pattern of sedimentary paleointensity records explained by cumulative viscous remanence, *Earth Planet. Sci. Lett., 144,* E9–B14, 1996b.

Kono, M., Statistics of paleomagnetic inclination data, *J. Geophys. Res., 85,* 3878–3882, 1980.

Lovlie, R., and T. Torsvik, Magnetic remanence and fabric properties of laboratory deposited hematite-bearing red sandstone, *Geophys. Res. Lett., 11,* 229–232, 1984.

Lowrie, W., Identification of ferromagnetic minerals in a rock by coercivity and unblocking temperature properties, *Geophys. Res. Lett., 17,* 159–162, 1990.

Lowrie, W., W. Alvarez, g. Napoleone, K. Perch-Nielsen, I. Premoli-Silva, and M. Toumarkine, Paleogene magnetic stratigraphy in Umbrian pelagic carbonate rocks: The Contessa sections, Gubbio, *Geol. Soc. Amer. Bull., 93,* 414–432, 1982.

Lu, G., and C. McCabe, Magnetic fabric determined from ARM and IRM anisotropies in Paleozoic carbonates, southern Appalachian Basin, *Geophys. Res. Lett., 20,* 1099–1102, 1993.

Lu, R., S. K. Banerjee, and J. Marvin, Effects of clay mineralogy and the electrical conductivity of water on the acquisition of depositional remanent magnetization in sediments, *J. Geophys. Res., 95,* 4531–4538, 1990.

Lund, S., J. Liddicoat, T. K. Lajoie, and T. Henyey, Paleomagnetic evidence for long-term (10^4 year) memory and periodic behavior in the Earth's core dynamo process, *Geophys. Res. Lett., 15,* 1101–1104., 1988.

McCabe, C., R. van der Voo, C. R. Peacor, C. R. Scotese, and R. Freeman, Diagenetic magnetite carries ancient yet secondary remanence in some paleozoic carbonates, *Geology, 11,* 221–223, 1983.

McElhinny, M., *Paleomagnetism and Plate Tectonics,* Cambridge University Press, 1973.

McElhinny, M. W., Statistical significance of the fold test in paleomagnetism, *Geophys. J. R. astro. Soc., 8,* 338–340, 1964.

McFadden, P. L., A new fold test for paleomagnetic studies, *Geophys. J. Int., 103,* 163–169, 1990.

McFadden, P. L., and D. L. Jones, The fold test in paleomagnetism, *Geophys. J. R. astr. Soc., 67,* 53–58, 1981.

McFadden, P. L., and F. J. Lowes, The discrimination of mean directions drawn from Fisher distributions, *Geophys J. R. astr. Soc., 67,* 19–33, 1981.

McFadden, P. L., and M. W. McElhinny, The combined analysis of remagnetization circles and direct observations in paleomagnetism, *Earth Planet. Sci. Lett., 87,* 161–172, 1988.

McFadden, P.L., and A. Reid, Analysis of paleomagnetic inclination data, *Geophys. J.R. Astr. Soc., 69,* 307–319, 1982.

Merrill, R., M. McElhinny, and P. McFadden, *The magnetic field of the Earth: Paleomagnetism, the Core, and the Deep Mantle,* Academic Press, 1996.

Moskowitz, M., B, Methods for estimating Curie temperatures of titanomaghemites from experimenal Js-T data, *Earth Planet. Sci. Lett., 52,* 84–88, 1981.

Nagata, T., *Rock Magnetism,* Maruzen, Tokyo, 2nd edn., 1961.

Nagata, T., Y. Arai, and K. Momose, Secular variation of the geomagnetic total force during the last 5000 years, *J. Geophys. Res., 68,* 5277–5282, 1963.

Néel, L., Théorie du trainage magnétique des ferromagneétiques en grains fines avec applications aux terres cuites, *Ann. Geophys., 5,* 99–136, 1949.

Néel, L., Some theoretical aspects of rock magnetism, *Adv. Phys., 4,* 191–243, 1955.

Nye, J., *Physical Properties of Crystals,* Clarendon Press, Oxford, 1957.

Opdyke, N., and J. Channell, *Magnetic Stratigraphy,* Academic Press, 1996.

Opdyke, N., and K. Henry, A test of the dipole hypothesis, *Earth Planet. Sci. Lett., 6,* 139–151, 1969.

O'Reilly, W., *Rock and Mineral Magnetism,* Blackie, 1984.

Owens, W., Mathematical model studies on factors affecting the magnetic anisotropy of deformed rocks, *Tectonophys., 24,* 115–131., 1974.

Özdemir, Ö., and S. K. Banerjee, High temperature stability of maghemite (γ-Fe_2O_3), *Geophys. Res. Lett, 11,* 161–164, 1984.

Özdemir, Ö., D. Dunlop, and B. Moskowitz, The effect of oxidation of the Verwey transition in magnetite, *Geophys. Res. Lett., 20,* 1671–1674, 1993.

Pick, T., and L. Tauxe, Characteristics of magnetite in submarine basaltic glass, *Geophys. J. Int., 119,* 116–128, 1994.

Pick, T. S., and L. Tauxe, Geomagnetic palaeointensities during the Cretaceous Normal Superchron measured using submarine basaltic glass, *Nature, 366,* 238–242, 1993.

Press, W. H., B. P. Flannery, S. Teukolsky, and W. T. Vetterling, *Numerical Recipes: the Art of Scientific Computing,* Cambridge University Press, 1986.

Prévot, M., M. A. Mankinen, C. S. Grommé, and R. S. Coe, How the geomagnetic field vector reverses polarity, *Nature, 316,* 230–234, 1985.

Prévot, M., M. E. M. Derder, M. McWilliams, and J. Thompson, Intensity of the Earth's magnetic field: evidence for a Mesozoic Dipole Low, *Earth Planet. Sci. Lett., 97,* 129–139, 1990.

Ramsay, J., *Folding and fracturing of rocks,* McGraw-Hill Book Co., New York, 1967.

Rees, A., The use of anisotropy of magnetic susceptibility in the estimation of sedimentary fabric, *Sedimentology, 4,* 257–271, 1965.

Rees, A. I., and W. A. Woodall, The magnetic fabric of some laboratory deposited sediments, *Earth Planet. Sci. Lett., 25,* 121–130, 1975.

Roberts, A., Magnetic properties of sedimentary greigite (Fe_3S_4), *Earth Planet. Sci. Lett., 134,* 227–236, 1995.

Roberts, A., Y. Cui, and K. Verosub, Wasp-waisted hysteresis loops: Mineral magnetic characteristics and discrimination of components in mixed magnetic systems, *J. Geophys. Res., 100,* 17909–17924, 1995.

Rochette, P., G. Fillion, J.-L. Mattei, and M. J. Dekkers, Magnetic transition at 30–34 kelvin in pyrrhotite: Insight into a widespread occurrence of this mineral in rocks, *Earth Planet. Sci. Lett., 98,* 319–328, 1990.

Scheidegger, A. E., On the statistics of the orientation of bedding planes, grain axes, and similar sedimentological data, *U.S. Geo. Surv. Prof. Pap., 525–C,* 164–167, 1965.

Schneider, D. A. and D. V. Kent, Testing models of the Tertiary paleomagnetic field, *Earth Planet. Sci. Lett., 101,* 260–271, 1990.

Shackleton, N. J., A. Berger, and W. R. Peltier, An alternative astronomical calibration of the lower Pleistocene timescale based on ODP site 677, *Trans. Roy. Soc. Edinburgh: Earth Sciences, 81,* 251–261, 1990.

Shimizu, Y., Magnetic viscosity of magnetite, *J. Geomag. Geoelec., 11,* 125–138, 1960.

Snowball, I. and R. Thompson, A stable chemical remanence in Holocene sediments, *J. Geophys. Res., 95,* 4471–4479, 1990.

Spender, M., J. Coey, and A. Morrish, The magnetic properties and Mössbauer spectra of synthetic samples of Fe_3S_4, *Can. J. Phys., 50,* 2313–2326, 1972.

Stacey, F., G. Joplin, and J. Lindsay, Magnetic anisotropy and fabric of some foliated rocks from S.E. Australia, *Geophysica Pur. Appl., 47,* 30–40, 1960.

Stacey, F. D. and S. K. Banerjee, *The Physical Principles of Rock Magnetism,* Elsevier, 1974.

Staudigel, H., J. Gee, L. Tauxe, and R. J. Varga, Shallow intrusive directions of sheeted dikes in the Troodos Ophiolite: anisotropy of magnetic susceptibility and structural data, *Geology, 20,* 841–844, 1992.

Stokking, L. and L. Tauxe, Properties of chemical remanence in synthetic hematite: Testing theoretical predictions, *J. Geophys. Res., 95,* 12639–12652, 1990.

Stoner, E. and W. P. Wohlfarth, A mechanism of magnetic hysteresis in heterogeneous alloys, *Phil. Trans. Roy. Soc. Lond., A240,* 599–642, 1948.

Tanaka, H., M. Kono, and H. Uchimura, Some global features of paleointensity in geological time, *Geophys. J. Int., 120,* 97–102, 1995.

Tarduno, J., Superparamgnetism and reduction diagenesis in pelagic sediments: Enhancement or depletion?, *J. Geophys. Res. Lett., 22,* 1337–1340, 1995.

Tarling, D. and F. Hrouda, *The Magnetic Anisotropy of Rocks,* Chapman and Hall, London, 1993.

Tauxe, L., Sedimentary records of relative paleointensity of the geomagnetic field: Theory and practice, *Rev. Geophys., 31,* 319–354, 1993,

Tauxe, L. and Y. Gallet, A jackknife for magnetostratigraphy, *J. Geophys. Res. Lett., 18,* 1783–1786, 1991.

Tauxe, L. and P. Hartl, 11 million years of Oliogocene geomagnetic field behaviour, *Geophys. J. Int., 128,* 217–229, 1996.

Tauxe, L. and D. V. Kent, Properties of a detrital remanence carried by hematite from study of modern river deposits and laboratory redepostion experiments, *Geophys. J. Roy. astr. Soc., 77,* 543–561, 1984.

Tauxe, L. and G. Watson, The fold test: an eigen analysis approach, *Earth Planet. Sci. Lett., 122,* 331–341, 1994.

Tauxe, L., P. Tucker, N. Petersen, and J. LaBrecque, The magnetostratigraphy of Leg 73 sediments, *Palaeogeogr. Palaeoclimat. Palaeoecol., 42,* 65–90, 1983.

Tauxe, L., C. Constable, L. Stokking, and C. Badgley, The use of anisotropy to determine the origin of characteristic remanence in the Siwalik red beds of northern Pakistan, *J. Geophys. Res., 95,* 4391–4404, 1990.

Tauxe, L., N. Kylstra, and C. Constable, Bootstrap statistics for paleomagnetic data, *J. Geophys. Res., 96,* 11723–11740, 1991.

Tauxe, L., T. Pick, and Y. Kok, Relative paleointensity in sediments: a pseudo-Thellier approach, *Geophys. Res. Lett., 22,* 2885–2888, 1995.

Tauxe, L., T. Herbert, N. Shackleton, and Y. Kok, Astronomical calibration of the Matuyama Brunhes boundary: consequences for magnetic remanence acquisition in marine carbonates and the Asian loess sequences, *Earth Planet. Sci. Lett., 140,* 133–146, 1996a.

Tauxe, L., T. Mullender, and T. Pick, Potbellies, wasp-waists, and superparamagnetism in magnetic hysteresis, *J. Geophys. Res., 101,* 571–583, 1996b.

Tauxe, L., J. Gee, and H. Staudigel, Flow directions in dikes from AMS data: The bootstrap way, J. Geophys. Res., 103, 17,775–17,790, 1998.

Thellier, E., and O. Thellier, Sur l'intensité du champ magnétique terrestre dans le passé historique et géologique, *Ann. Geophys., 15,* 285–378, 1959.

van der Voo, R., Paleomagnetism of North America - a brief review, *Paleoreconstruction of the Continents, Geodynamic Series Amer. Geophys. Union, Geol. Soc. Amer., 2,* 159–176, 1981, McElhinny, M.W. and Valencio, D.A. (eds.).

van der Voo, R., Phanerozoic paleomagnetic poles from Europe and North-America and comparisons with continental reconstructions, *Rev. of Geophysics, 28,* 167–206, 1990.

van der Voo, R., *Paleomagnetism of the Atlantic, Tethys and Iapetus Oceans,* Cambridge University Press, 1993.

Wasilewski, P. J., Magnetic hysteresis in natural materials, *Earth Planet. Sci. Lett., 20,* 67–72, 1973.

Watson, G. and R. Enkin, The fold test in paleomagnetism as a parameter estimation problem, *J. Geophys. Res. Lett., 20,* 2135–2137, 1993.

Watson, G. S., A test for randomness, *Mon. Not. Roy. Astr. Soc., 7,* 160–161, 1956.

Wegener, A., *Die Entstehung der Kontinente,* Dover, 1915.

Woodcock, N., Specification of fabric shapes using an eigenvalue method, *Geol. Soc. Amer. Bull., 88,* 1231–1236, 1977.

Worm, H.-U., D. Clark, and M. Dekkers, Magnetic susceptibility of pyrrhotite: Grain size, field and frequency dependence, *Geophys. J. Int., 114,* 127–137, 1993.

Xu, S. and D. Dunlop, Theory of partial thermoremanent magnetization in multidomain grains 2. Effect of microcoercivity distribution and comparison with experiment, *J. Geophys. Res., 99,* 9025–9033, 1995.

Zijderveld, J., A.C. Demagnetization of rocks: Analysis of results, in *Methods in Paleomagnetism,* edited by D. Collinson, K. Creer, and S. Runcorn, pp. 254–286, Elsevier, New York, 1967.

INDEX

MODERN APPROACHES IN GEOPHYSICS

1. E.I. Galperin: *Vertical Seismic Profiling and Its Exploration Potential.* 1985 ISBN 90-277-1450-9
2. E.I. Galperin, I.L. Nersesov and R.M. Galperina: *Borehole Seismology.* 1986 ISBN 90-277-1967-5
3. Jean-Pierre Cordier: *Velocities in Reflection Seismology.* 1985 ISBN 90-277-2024-X
4. Gregg Parkes and Les Hatton: *The Marine Seismic Source.* 1986 ISBN 90-277-2228-5
5. Guust Nolet (ed.): *Seismic Tomography.* 1987 Hb: ISBN 90-277-2521-7; Pb: ISBN 90-277-2583-7
6. N.J. Vlaar, G. Nolet, M.J.R. Wortel and S.A.P.L. Cloetingh (eds.): *Mathematical Geophysics.* 1988 ISBN 90-277-2620-5
7. J. Bonnin, M. Cara, A. Cisternas and R. Fantechi (eds.): *Seismic Hazard in Mediterranean Regions.* 1988 ISBN 90-277-2779-1
8. Paul L. Stoffa (ed.): *Tau-p: A Plane Wave Approach to the Analysis of Seismic Data.* 1989 ISBN 0-7923-0038-6
9. V.I. Keilis-Borok (ed.): *Seismic Surface Waves in a Laterally Inhomogeneous Earth.* 1989 ISBN 0-7923-0044-0
10. V. Babuska and M. Cara: *Seismic Anisotropy in the Earth.* 1991 ISBN 0-7923-1321-6
11. A.I. Shemenda: *Subduction.* Insights from Physical Modeling. 1994 ISBN 0-7923-3042-0
12. O. Diachok, A. Caiti, P. Gerstoft and H. Schmidt (eds.): *Full Field Inversion Methods in Ocean and Seismo-Acoustics.* 1995 ISBN 0-7923-3459-0
13. M. Kelbert and I. Sazonov: *Pulses and Other Wave Processes in Fluids.* An Asymptotical Approach to Initial Problems. 1996 ISBN 0-7923-3928-2
14. B.E. Khesin, V.V. Alexeyev and L.V. Eppelbaum: *Interpretation of Geophysical Fields in Complicated Environments.* 1996 ISBN 0-7923-3964-9
15. F. Scherbaum: *Of Poles and Zeros.* Fundamentals of Digital Seismology. 1996 Hb: ISBN 0-7923-4012-4; Pb: ISBN 0-7923-4013-2
16. J. Koyama: *The Complex Faulting Process ofEarthquakes.* 1997 ISBN 0-7923-4499-5
17. L. Tauxe: *Paleomagnetic Principles and Practice.* 1998 ISBN 0-7923-5258-0

KLUWER ACADEMIC PUBLISHERS – DORDRECHT / BOSTON / LONDON