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GMAP - Geographic mapping and palaeoreconstruction package

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In this account we describe GMAP, a combined palaeomagnetic data-base, geographic mapping and palaeoreconstruction package. GMAP is written for IBM AT compatible computers and the package contains approximately 1 Mbyte of geographic data, i.e. continental grid data, political boundaries and magnetic anomalies from the Central and Northern Atlantic. Large palaeomagnetic data-bases from Scandinavia, the British Isles and the USSR are also included. In addition selected palaeomagnetic data from Spitsbergen, Central Europe and North America/Greenland are included. The palaeomagnetic data and files containing information on finite rotation poles are used for palaeoreconstructions, but GMAP also allows interactive translation and rotation of continents.

Emneord	Tolkning	
EDB	Paleomagnetisme	
Geofysikk		Brukerdokumentasjon

G M A P

GEOGRAPHIC MAPPING AND PALAEORECONSTRUCTION PACKAGE*

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1. INTRODUCTION

GMAP is a combined palaeomagnetic data-base, geographic mapping and palaeoreconstruction system. The work on GMAP was initiated in 1983 by THT in an attempt to develop a palaeo-reconstruction system for IBM compatible PC/AT computers. GMAP was originally designed as a numerical and graphical tool linked with a relatively primitive data-base system. However, during a working group meeting for the European Geotraverse Project (EGT) in 1986 the data-base system underwent considerable improvement with assisting help from Drs. Gøran Bylund (University of Lund) and S.Å. Elming (University of Luleå).

In 1987 GMAP was considerably expanded and large quantities of geographical data, i.e. continental grid data, political boundaries and magnetic anomalies from the Central and Northern Atlantic were added. The anomaly data were kindly provided by Dr. M. Hellman (Oxford University).

During 1988 and 1989 the palaeomagnetic-data base system was upgraded with the addition of new routines for fitting smooth paths to palaeomagnetic poles. The latter routines are based on the method of Jupp and Kent (1987).

GMAP is written for IBM PC/AT compatible computers run under MS-DOS version 2.0 or higher. GMAP is modular and has been written in several programming languages including TBB 1.1, TBP 4.0, MF 3.2, F77L and HALO88. The source code, a trademark software of THT, is only made available on an extraordinary collaborative basis. Compiled versions and data-bases can be purchased from the authors.

The most recent developments of the GMAP package include sophisticated animation procedures and integration of data such as paleontological, radiometric, typographic, bathymetric, magnetic anomaly and 'gravity' data (Seasat). It should be emphasized that GMAP is being continuously updated and improved, thus the authors would be grateful to receive comments and information on possible 'bugs' in the system.

1.1 HARDWARE REQUIREMENT

Minimum requirement:

- IBM PC/AT compatible computer with minimum 640 Kb RAM
  (1 Mb Ram recommended)
- Mathematical co-processor
  (programs compiled without co-processor only on special request)
- EGA (color) or VGA (color) graphic card
  (Hercules, PS/2 or CGA on special request)
- Hard-disk

Optional:

- HP-GL compatible plotter
  (high quality such as Hewlett Packard or Roland plotters)
- Matrix printer or Laser/Desk Jet printers
- Logitech Mouse (cf. 1.3)

1.2 INSTALLATION

- Create a sub-directory named GMAP on the hard-disk (drive c) by typing:

  C:>**md gmap**

- Copy **all** programs and data-files from the GMAP disks to hard-disk by typing:

  C:>**copy a:*.* c:\gmap**

1.3 LOGITECH MOUSE

If a 'mouse' is used with the GMAP package, the following commands must be added to the autoexec.bat file, or alternatively written to a free-standing batch file which is executed before GMAP is started:

```
mouse                   'activate 'mouse'
menu gmap               'load menu-driver gmap.mnu
                        'note that gmap.mnu must be copied to
                         root-directory
```

Movements of a 'mouse' can be used as an alternative to arrow keys. The three 'mouse' function keys are programmed as follows:

```
Left key : <ENTER>
Mid  key : <PG UP>      'scale increase in graphical modes
Right key: <PG DN>      'scale decrease in graphical modes
```

Note that any type of 'mouse' can be used in the GMAP package, provided that function keys are programmed as described above.

MAIN PROGRAMS

MENUGMAP.EXE - Batch program which controls all other programs

GMAP4.EXE - Graphical reconstruction program

Note that the spline routines (7.15.3) will not work if GMAP4 is run from MENUGMAP (due to memory exhaustion)

DBGMAP.EXE - Palaeomagnetic data-base program

UTILITY-PROGRAMS

GMAPCON.EXE - Manipulation of grid (.con) files (used in GMAP4)

MAP.EXE - Graphical tool-program for selecting geographical area in DBGMAP

ANI.EXE - Create animation files (used in GMAP4)

VGP.EXE - Create VGP files (used in GMAP4)

PJ.BAT - Batch-file controlling spline-support programs

PJA.EXE* - Data preparation splines

PJ11.EXE* - Numerical analysis - Create splines

PJGMAP.EXE - Convert PJ11.EXE splines to GMAP4 format

(*modified from Kent, 1986)

CONFIGURATION PROGRAMS

CONF.EXE - Main configuration program

PCONF.EXE - Screen auto-detect program (called from conf.exe)

***.BGI - Device drivers used in CONF.EXE/PCONF.EXE

DATA FILES

CFG.SYS	- Main system-file created by CONF.EXE (used in both DBGMAP, GMAP4 and GMAPCON)
EGA.SYS	- Driver file for EGA systems
VGA.SYS	- Driver file for VGA systems
CGA.SYS	- Driver file for CGA systems
HER.SYS	- Driver file for HERCULES systems
GMAP.MNU	- Driver file for Logitech Mouse
MOUSE.BAT	- Batch file driver for Logitech Mouse
***.DBD	- Main data-base file (used in DBGMAP)
***.DBI	- Main data-base index file (used in DBGMAP)
***.CON	- Continental grid-files (used in GMAP4 and GMAPCON)
***.VGP	- VGP files (used in GMAP4 and VGP, also produced from DBGMAP)
***.FIN	- Finite Rotation File (Euler-poles) (limited for use in GMAP4)
***.ANI	- Animation files (used in GMAP4 and created by ANI)

1.5 SOME ABBREVIATIONS

VGP	- VIRTUAL GEOMAGNETIC POLE
APW	- APPARENT POLAR WANDER
APWP	- APW PATH
CONTINENT	- A GRID-FILE CONTAINING LATITUDES AND LONGITUDES WHICH COULD BE COASTLINES, MAGNETIC ANOMALIES OR A LINEAMENT
a95	- 95 PERCENT CONFIDENCE CIRCLE ON DIRECTIONS (DEC/INC)
A95	- 95 PERCENT CONFIDENCE CIRCLE ON POLES (VGP)
k	- PRECISION PARAMETER (FISHER, 1953)
dp,dm	- SEMI-AXES OF THE OVAL OF 95 PERCENT CONFIDENCE ABOUT THE POLE
DEC	- DECLINATION
INC	- INCLINATION
GLAT	- GEOGRAPHIC LATITUDE (SAMPLING LATITUDE)
GLON	- GEOGRAPHIC LONGITUDE
PLAT	- POLE LATITUDE (VGP)
PLON	- POLE LONGITUDE (VGP)
NA	- NORTH ATLANTIC
CA	- CENTRAL ATLANTIC
EUR	- EUROPE
AF	- AFRICA
GGF	- GREAT GLEN FAULT (SCOTLAND)
IS	- IAPETUS SUTURE
HBF	- HIGHLAND BOUNDARY FAULT
SUF	- SOUTHERN UPLANDS FAULT
VAR	- VARISCAN
ALP	- ALPINE
CAL	- CALEDONIAN
TZ	- TORNQUIST ZONE
NASZ	- NORTH ATLANTIC SHEAR ZONE
BI	- BRITISH ISLES
SAM	- SOUTH AMERICA
NAM	- NORTH AMERICA

All programs and data-files should be copied to sub-directory \gmap, thus always make directory **c:\gmap** the current directory MENUGMAP controls all programs in the GMAP system and is started by typing **MENUGMAP.**

After start-up the main menu is displayed and the preferred **option** in the menu should be selected by moving the cursor (resp. the 'mouse') to the desired option (box) by means of arrow keys (up/down), and pressing <ENTER> (resp. left function key). The concept of pop-up screen menus is characteristic of most programs in the GMAP package.

The following options are available in MENUGMAP:

OPTION	**EFFECT**
GMAP4	RUN GMAP4 (main reconstruction program) This program must be run from the command-line when calculating smooth polar wander paths.
DBGMAP	RUN DBGMAP (palaeomagnetic data-base)
GMAPCON	RUN GMAPCON (manipulate grid files)
CONF	RUN CONF (configure graphics for screen)
ANI	RUN ANI (create animation files)
IMPGMAP	RUN IMPGMAP (import of external ASCII files) (To be implemented to read Oracle produced files)
VGP	RUN VGP (create VGP files)
LIST CON-VGP FILES	DIRECTORY LISTING
LIST FIN-ANI FILES	DIRECTORY LISTING
LIST PRG-SYS FILES	DIRECTORY LISTING
SYSTEM DUMP	COPY ALL PROGRAMS AND SYSTEM FILES TO FLOPPY DISK -Select target drive A or B
BACKUP ALL FILES	BACKUP ALTERED DATA-FILES TO FLOPPY DISK -Select target drive A or B
RESTORE ALL FILES	RESTORE DATA-FILES TO HARD-DISK -Select source drive A or B
EXIT	EXIT PROGRAM (END SESSION)

DBGMAP is initiated by typing **DBGMAP** <ENTER> or by selecting it from the MENUGMAP menu (see section 2).

During start-up, the program searches for the configuration file CFG.SYS which **must** be on the same directory as DBGMAP (i.e. located on directory \gmap).

The main menu contains the following options:

OPTION	**EFFECT**
READ FILE	DATA-BASE FILES ARE DISPLAYED AND THE REQUIRED FILE IS SELECTED BY MOVING THE CURSOR TO THE FILE FOLLOWED BY <ENTER>.
PATH	CHANGE PATH IF NECESSARY (EXAMPLE c:\test)
NEW FILE	CREATE NEW DATA-BASE FILE
END JOB	EXIT PROGRAM

Options are selected by pressing the keys **R**, **P**, **N** or **E**.

After entering the READ FILE option in the introductory menu, the first data-record in the specified file is displayed, and the following options become available:

OPTION	EFFECT
LIST	LIST RECORDS OR ENTRIES SEQUENTIALLY ON THE SCREEN -Press any key to search through data-base -Interrupt search by pressing **A** (abort) or **R** (reset) **A** - Subsequent use of LIST will resume at next record **R** - Subsequent use of LIST will resume at start -Note that the options FILTER and SORTING depend on LIST -During LIST with option FILTER, LIST can be interrupted by pressing **A** at any stage
SEARCH	SEARCH A RECORD -Search on rock unit -Only one, or a few consecutive characters in the rock unit need be provided If necessary use NEXT or PREVIOUS to select the desired record/entry
NEXT	SHOW NEXT RECORD -not affected by FILTER, but SORT
PREVIOUS	SHOW PREVIOUS RECORD -not affected by FILTER, but SORT
ADD	ADD A NEW RECORD -A 25 character search-key index in DBGMAP combines rock-unit (16), author (3), Dec (3) and Inc(3). Duplicate entries are <u>not</u> allowed. -Option ADD and UPDATE (see later) use the following function-keys: PG UP - Display page 2 PG DN - Display page 1 ARROW DN - Move to next field ARROW UP - Move to previous field RETURN - Move to next field ESC - Escape or End

REMOVE — REMOVE A RECORD

-Verify with **y** (yes) if you want to remove the record /entry which is displayed on the screen from the data-base
-SEARCH/NEXT/PREVIOUS options are used to find the record which is to be removed.

FILTER — SET AN ACTIVE FILTER

-Set FILTER to on

-Filter is active in LIST, HCOPY and DumpD options

-All fields can be 'filtered', and input/update in this option is similar to ADD described above.

-Note that min-max values for latitude-longitude can be set by using MAPPER option (3.1).

-Rock-unit, author and title fields allow search in free text

-Filter does not affect SEARCH, NEXT and PREVIOUS

OFF-F — SET FILTER TO OFF
-Re-activated by entering FILTER OPTION

QUIT — QUIT PROGRAM
-**Always** use this option to END the program. For example turning computer off without using EXIT may result in corruption of the data-base

I & D — CALCULATE DECLINATION AND INCLINATION
-Based on geographic latitude, longitude and VGP position

GEOS — CALCULATE GEOGRAPHIC SITE
-Based on VGP pole and declination & inclination (there is an error in this function; to be changed)

VGP — CALCULATE VGP (AND DP/DM)
-Based on declination, inclination (α_{95}) and study location

UPDATE — REWRITE RECORD USING NEW CALCULATED VALUES
-Option used after e.g. after accessing VGP

MAPPER — ACTIVATE A MAP DRAWING PROGRAM FOR AREA SEARCH
-See separate description below (3.1)

HCOPY — HARDCOPY TO LINE-PRINTER
-Always LPT1: (parallel port 1)
-FILTER and SORT affect this option

DUMPD — DUMP NUMERICAL DATA TO A FILE OF VGP FORMAT
-This provides a data-interface with GMAP4
(These files can also be created manually using the program VGP)
-FILTER and SORT affect this option

SORT — SORT RECORDS
-Sorts data in memory
-Sorting can be performed on any single field

3.1 OPERATION OF MAPPER

MAPPER is called from DBGMAP and is a tool for selecting palaeomagnetic data from studies located within a given geographic area. Minimum and maximum latitudes and longitudes are selected.

A map of Europe (CON2.CON) is displayed in Galls projection and the options available are as follows:

OPTION	**EFFECT**
END	EXIT TO DBGMAP
SCALE	SCALE OR MAGNIFICATION (DEFAULT=1) -Scale can also be altered using <PGUP> and <PGDN> keys
ZOOMCENT	ZOOM-CENTER (DEFAULT 0°N - 0°E) -This is the principal option in Mapper -After selecting this option a cross appears on the screen. The cross can be moved around the screen using the cursor arrows. During this operation LATITUDE and LONGITUDE are displayed in the bottom left corner of the screen -Leave option by pressing <ENTER-RETURN> A new map, centered upon the selected cross position (zoom-center) will be displayed. NOTE: This option permits the definition of a square or rectangle which defines the boundary condition for geographical search within the data-bases. To draw a square or a rectangle press **D** after accessing the zoom-center option. Subsequent movements of the cross define MIN-MAX co-ordinates which are displayed during drawing. When boundary conditions have been set, press <ENTER-RETURN> to return to menu. MIN-MAX values of LAT-LONG are now stored for use in DBGMAP. Use option END to return to DBGMAP. After having used this option, note that LAT-LONG are used as FILTER boundary conditions, and when using options LIST, HCOPY and DUMPD only records within the specified geographic area will be listed.
LOAD	CHANGE CONTINENT -CON2 (Europe), CON3 (Africa), CON4 (Greenland/L.S.) CON5 (Australia), CON6 (Antarctica) and finally

CON1 (North and South America) are displayed sequentially when using this option

3.2 DATA FORMAT: DBGMAP

The screen display in DBGMAP is organized into two pages. Toggle between pages using <PG UP> and <PG DN> keys.

PAGE 1:

Variable	Max Ch	Description
Rock unit	40	Name of rock unit, component etc.
Code	15	Tectonic unit or any arbitrary selected code
Country	5	Country - uses international 'car' codes
GLAT	7	Geographic latitude
GLON	7	Geographic longitude
Sites	3	Number of sites (used in statistics)
Samples	4	Number of samples (used in statistics)
Specimen	4	Number of specimens (used in statistics)
Dec	6	Declination
Inc	6	Inclination
a95	4	α_{95}
k	5	Precision parameter (Fisher, 1953)
Pol (n,r,m)	3	Polarity (n=normal, r=reverse & m=mixed)
R/N Ration%	4	Percentage ratio of reverse and normal polarity
Age Range	15	Rock age range
Working age	5	Magnetic age, for example, in splines
PoleLat	7	VGP latitude
PoleLong	7	VGP longitude
dp	4	Semi-axis
dm	4	Semi-axis
Treatment	10	Demagnetization method (a=AF, t=thermal & c=chemical)
BD Grade	3	Briden & Duff (1981) classification (A-D, see Appendix 6)
RV Grade	3	Van Der Voo (1988) classification (1-7, see Appendix 6)

PAGE 2:

Variable	Max Ch	Description
Author	80	Authors
Year	5	Publication year
Title	200	Title of paper
Magazine	80	Magazine
Vol	10	Volume
Page	9	Pages
Age 1	20	Rock age 1
Met	15	Method
Age 2	20	Rock age 2

Met	15	Method
Age 3	20	Rock age 3
Met	15	Method
Field-T	70	Field tests
Field-T	70	Field tests (extension if necessary)
Comment	70	Comment

3.3 CREATING VGP FILES FROM DBGMAP

VGP files (extension .VGP) are created from DBGMAP using option DUMPD. FILTER and SORT are active during creation of VGP files. Numeric data are dumped along with 'working age' which is used in GMAP4 to generate APWP splines. 'Classification' and 'polarity' are also dumped, which determine plotting symbols used in GMAP4 (see later sections).

Grading option (Briden & Duff, 1981 or Van der Voo, 1988) are selected by **b** or **v**, followed by VGP file name. The file will AUTOMATICALLY receive extension '.VGP', and the file contain the following information:

1	CLPOL	Combined string of grading (**b** or **v**) and polarity Controls plotting symbols in GMAP4 Example: an=grade a and normal polarity (n)
2	DEC	Declination
3	INC	Inclination
4	α_{95}	95 percent confidence circle
5	GLAT	Geographic latitude
6	GLON	Geographic longitude
7	PLAT	VGP latitude
8	PLON	VGP longitude
9	dp	Error-oval
10	dm	Error-oval
11	INIT	Initials/code used during plotting in GMAP4 **Working Age is substituted for INIT** Used for calculation of APWP's (7.15.3)

4. DESCRIPTION OF GMAPCON

The GMAP package is supplied with a number of grid files (file extension .CON). Grid files contains digitized coast-lines, magnetic anomalies, terrane boundaries etc. (Appendix 2; Figs. 1 & 2). GMAPCON is supplied to manipulate, merge and modify these grid files. It also allows you to create your own grid files from scratch.

The GMAPCON main menu has the following options:

OPTION	**EFFECT**
FILES CONTINENT	LIST CONTINENT FILES ON CURRENT DIRECTORY
LOAD CONTINENT	LOAD A CONTINENT FILE -NOTE THAT **CONTINENTS** CAN BE MERGED BY TYPING * BEFORE FILENAME (e.g. *NAM)
DRAW CONTINENT	DRAW CONTINENT
TABLE CONTINENT	TABULATE CONTINENT DATA
SAVE CONTINENT	SAVE CINTINENT DATA
INPUT CONTINENT	INPUT CONTINENT DATA FROM THE KEYBOARD
QUIT CONTINENT	QUIT GMAPCON

4.1 DRAW CONTINENT

After loading a CONTINENT grid, a geographic display of the data can be obtained using option DRAW. Data are displayed in Galls projection, and the following sub-options are available:

OPTION	**EFFECT**
END	RETURN TO MAIN MENU
SCALE	SCALING (DEFAULT 1) -Can also use PG-UP and PG-DN for scaling
ZOOMCENT	ZOOM-CENTER (DEFAULT 0°N - 0°E)

-After initiating this option a cross appears on the screen. The cross can be moved around the screen using the cursor arrows. During this operation LATITUDE and LONGITUDE are displayed in the bottom left corner of the screen

-Leave this option by pressing <ENTER-RETURN>. A new map, centered on the cross LAT & LONG (new zoom-center), is displayed.

NOTE:

This option can be used to add data to a grid file. Select mode **D**raw to draw continuous lines across the display which are added to the grid file. **P**oint draws a line between each point where **P** has been pressed. In this manner you can add/merge tectonic lineaments, terrane boundaries etc. to grid files. Remember to SAVE the modified grid under a new file-name in the main menu.

GRID — DISPLAY LONGITUDE-LATITUDE LINES

BLANK — BLANKING OF SCREEN (DEFAULT=ON)
If BLANK is set to **OFF** by pressing **B**, the screen will not be blanked when a new .CON file is loaded, enabling you to draw as many continental files as you wish on the screen. Pressing **B** again would set BLANK **ON** mode again.

CLOAD (*) — LOAD CONTINENT FILE
Typing * followed by filename will merge the file with continent data in memory. Otherwise provide file-name

4.2 TABLE CONTINENT

This option displays a listing of CONTINENT grid data in memory, i.e. latitude and longitude data.

During listing of continental data the following options are available:

OPTION	**EFFECT**
A	ABORT LISTING AND RETURN TO MAIN MENU
D	DELETE ENTRIES TO A SPECIFIC NUMBER IN THE FILE -Deletes point in the file from start to the specified data point number
R	DELETE DATA-POINTS FROM A SPECIFIC NUMBER -Removes point in the file from a specified point to end of data-file

NOTE : HIT ANY OTHER KEY TO PROCEED THROUGH DATA FILE LISTING, SCREEN FULL BY SCREEN FULL

Note that any longitude exceeding 500 will be interpreted as a code to lift pen during screen and hard-copy plotting (GMAP4). Also note that changes in the data are not be stored on disk unless the SAVE CONTINENT option has been performed in the main menu.

4.3 INPUT CONTINENT

Input latitudes and longitudes of linear features. Input is ended by typing **999** in the latitude field.

Latitudes and longitudes must be entered in **DEGREES**
For example 60 degrees and 30 minutes should be entered as 60.5

To instruct plotter to lift pen during drawing, the following entries can be made:

1000,1000 (latitude,longitude)

0,0 (latitude,longitude)

FIGURE 1
Example of plotting of CONTINENT (*.CON) files (Galls Projection). Map is produced from GMAP4. Cf. Appendix 2 for details concerning CONTINENT files.

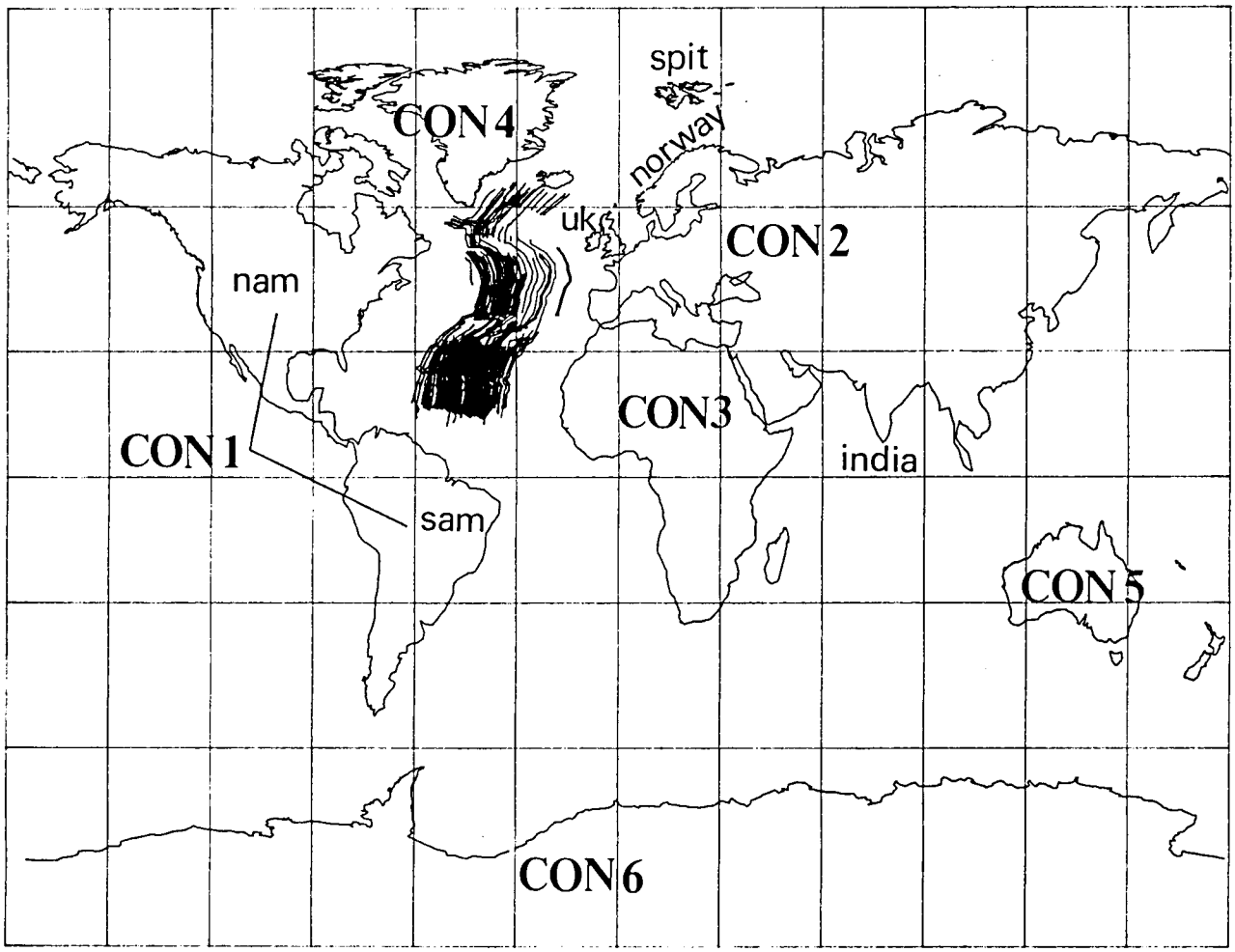
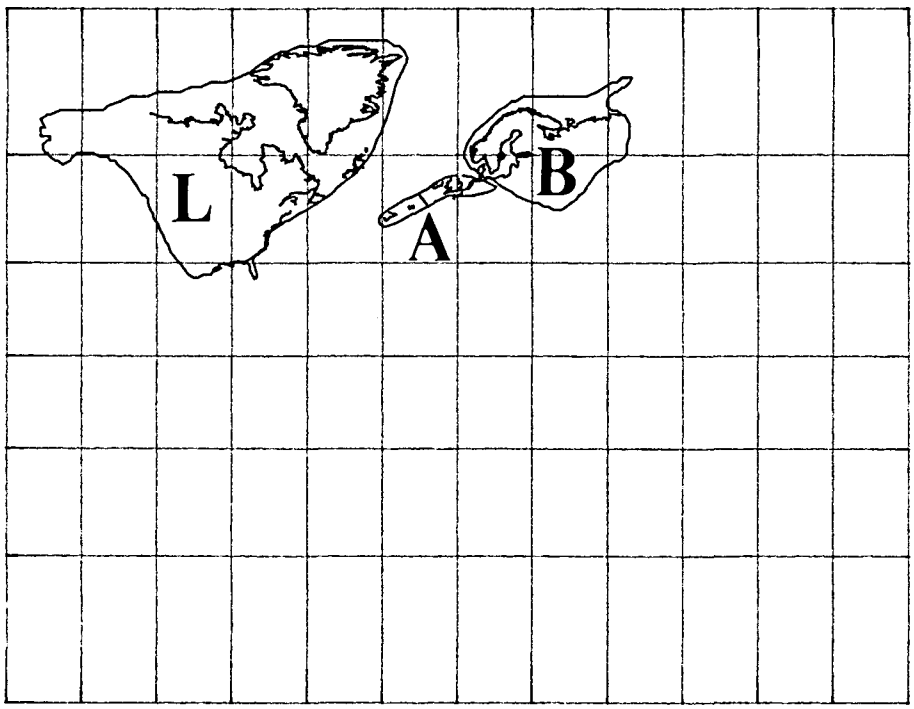


FIGURE 2
Example of terrane CONTINENT files created by GMAPCON. Map is produced using GMAP4. Lettering is as follows: L=Laurentia, B=Baltica, A=Avalonia (cf. Appendix 2).



5. DESCRIPTION OF VGP

VGP creates and edits '.VGP' files, if not created by DBGMAP. The operation of this program is similar to ANI (next section). VGP files, containing data on VGP's, are essentially used in GMAP4, which provides limited editing facilities for these files.

The main menu consist of the following options:

OPTION	**EFFECT**
READ F	READ A VGP FILE
EDIT F	EDIT A VGP FILE -Use PGDN/PGUP to move between pages of VGPs before entering this option -Codes: ARROW DN - Move to next field ARROW UP - Move to previous field RETURN - Move to next field ESC - Escape EDIT mode
NEW F	CREATE A NEW FILE -Codes: As edit
STORE AS	STORE VGP FILE WITH NEW FILE-NAME
KILL D	KILL OR REMOVE DATA-POINT (VGP) -Select VGP data-point number
QUIT	QUIT PROGRAM
PGUP	MOVE ONE SCREEN PAGE FORWARD
PGDN	MOVE ONE SCREEN PAGE BACKWARD

The input-format in VGP is as follows:

1	CLPOL	Combined string of grading and polarity May control hard-copy plotting symbols in GMAP4
2	DEC	Declination
3	INC	Inclination
4	α_{95}	95 percent confidence circle
5	GLAT	Geographic latitude
6	GLON	Geographic longitude
7	PLAT	VGP latitude
8	PLON	VGP longitude
9	dp	Error-oval
10	dm	Error-oval
11	INIT	Initials/code used during plotting in GMAP4 **Working Age is substituted for INIT** Used for APWP calculation (7.15.3)

6. DESCRIPTION OF ANI

This program is used to create animation files for use in GMAP4.

The main menu consist of the following options:

OPTION	**EFFECT**
READ F	READ AN ANI FILE
EDIT F	EDIT ANI FILE -Use PGDN/PGUP to edit the correct page before entering this option -Codes: ARROW DN - Move to next field ARROW UP - Move to previous field RETURN - Move to next field ESC - Escape EDIT mode
NEW F	CREATE A NEW FILE -Codes: As Edit
STORE AS	STORE FILE WITH NEW FILE-NAME
KILL D	KILL OR REMOVE DATA-POINT -Select data-point number
QUIT	QUIT PROGRAM
PGUP	MOVE ONE PAGE FORWARD
PGDN	MOVE ONE PAGE BACKWARD

The input-format in ANI is as follows:

1	CON	Continent (name of .CON file; see appendix 2)
2	LAT	Euler rotation latitude
3	LONG	Euler rotation longitude
4	ANGLE	Euler rotation angle
5	COMMENT	Comment

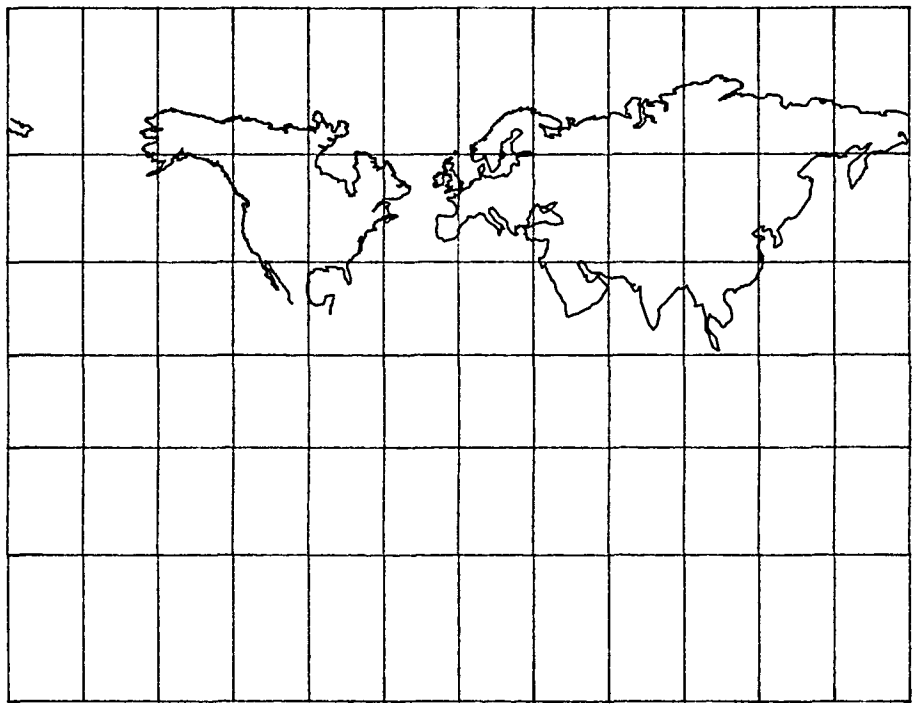
Example:

If you want to display North America in a Bullard et al. fit (1965), and leave Europe **in-situ**, create the following file:

CON	LAT	LONG	ANGLE	COMMENT
nam	87	27	37	NA bullard fit
con2	0	0	0	In-situ Europe

Store the file with file-name TEST (extension .ANI is automatically added to file-name). In GMAP4, using option ANIMATE in GRAPHICAL mode, a map resembling Fig. 3 would be plotted on the screen.

FIGURE 3
Example of plotting an animation files created by program ANI.
Map produced in GMAP4.



7. DESCRIPTION OF GMAP4

GMAP4, like the other programs in the package can be run from MENUGMAP, but if APWP's are to be calculated the program must be run from the command line (as a free-standing program):
In the latter case type GMAP4 at the system prompt.

In accordance with DBGMAP and GMAPCON, the program searches for the configuration file CFG.SYS during start-up.

The following options are included in the main menu:

OPTION	**EFFECT**
LOAD CONTINENT (or VGP)	LOAD A CONTINENTAL OR VGP DATA FILE
SAVE CONTINENT (or VGP)	SAVE A CONTINENTAL OR VGP DATA FILE
ROTATE CONTINENT (or VGP)	ROTATE A SET OF CONTINENTAL OR VGP DATA ACCORDING TO EULER-DATA SETTING
HCOPY CONTINENT (or VGP)	HARDCOPY OF CONTINENT OR VGP DATA TO HP-GL COMPATIBLE PLOTTER
GRAPHIC DISPLAY	GRAPHIC DISPLAY OF CONTINENTAL/VGP DATA
MODE	SWITCHES BETWEEN CONTINENT AND VGP MODE
DIRECTORY READ	DISPLAY CONTENTS OF CURRENT DIRECTORY-READ FILE
EULER ROTATIONS	PERFORM MANUAL EULER ROTATION
SYSTEM CONFIGURATION	CONFIGURE PLOTTING DEVICE AND SCREEN
ACTIVE DRIVE	SELECT ACTIVE DISK DRIVE
NET PROJECTION	SELECT NET-TYPE TO DISPLAY DATA
SELECT PATH	SELECT ACTIVE FILE PATH
SET EULER DATA	SET EULER DATA USED IN 'ROTATIONS'
CALCULATE EULER DATA	CALCULATE AN EULER POLE
HCOPY NET	HARDCOPY NET-GRID
TABLE	TABULATE VGP DATA
QUIT	END GMAP4

Top row of screen shows the current CONTINENT FILE, VGP FILE, NET TYPE (projection) and current EULER DATA.

7.1 LOAD CONTINENT (or VGP)

A CONTINENT or VGP file-name (see 7.6) is demanded when performing this operation (Appendix 2; Figs. 1 & 2). Note that a new CONTINENT file can be merged with an existing CONTINENT file, in memory, by entering *FILENAME. These combined data can later be saved to a disk-file using option SAVE CONTINENT in the main menu. Note, however, that the maximum number of paired grid points is 3500.

7.2 SAVE CONTINENT (or VGP)

The purpose of this routine is to save modified CONTINENT and VGP data to disk. New continental data cannot be created by GMAP4. However, merged CONTINENT files or rotated CONTINENT data can be saved under a new file name. This is useful for constructing ancient terrains or storing palaeogeographic maps.

7.3 ROTATE CONTINENT (or VGP)

Define euler-data before entering this option, either manually (or read .FIN files) using option SET EULER DATA in main-menu (7.12), or using sub-option VROT (7.15.2) in the TABLE option (calculates euler data from VGP data).

Note that the grid-data in memory are changed during rotation, thus to perform a rotation on the original data-set, the continent file must be re-loaded. Compound rotations can be performed using 'SET EULER DATA' and 'ROTATE CONTINENT (or VGP)' repeatedly.

Example of compound rotation:

Problem : You wish to position North America during the Devonian according to palaeomagnetic data from Scotland (i.e. palaeomagnetic data in European co-ordinates).

(1) Select continent MODE

(2) LOAD North America (file=NAM)
(If you now use option GRAPHICAL DISPLAY, a map like fig. 4A will be shown on the screen)

(3) Set Euler data to account for the opening of the North Atlantic (e.g. use a Bullard et al. (1965) fit: ca. 87(latitude),27(longitude),37(euler-angle).

(3) Select option ROTATE CONTINENT
The data will then be adjusted for the Mesozoic/Cenozoic opening of the North Atlantic
(If you then use option GRAPHICAL DISPLAY, a map like fig. 4B appears on the screen.

(4) Select MODE VGP

(5) Load palaeomagnetic spline-data from Scotland, e.g. file **nor1500A** (supplied with the GMAP package)

(6) Select option TABLE in main menu.

Select sub-option VROT

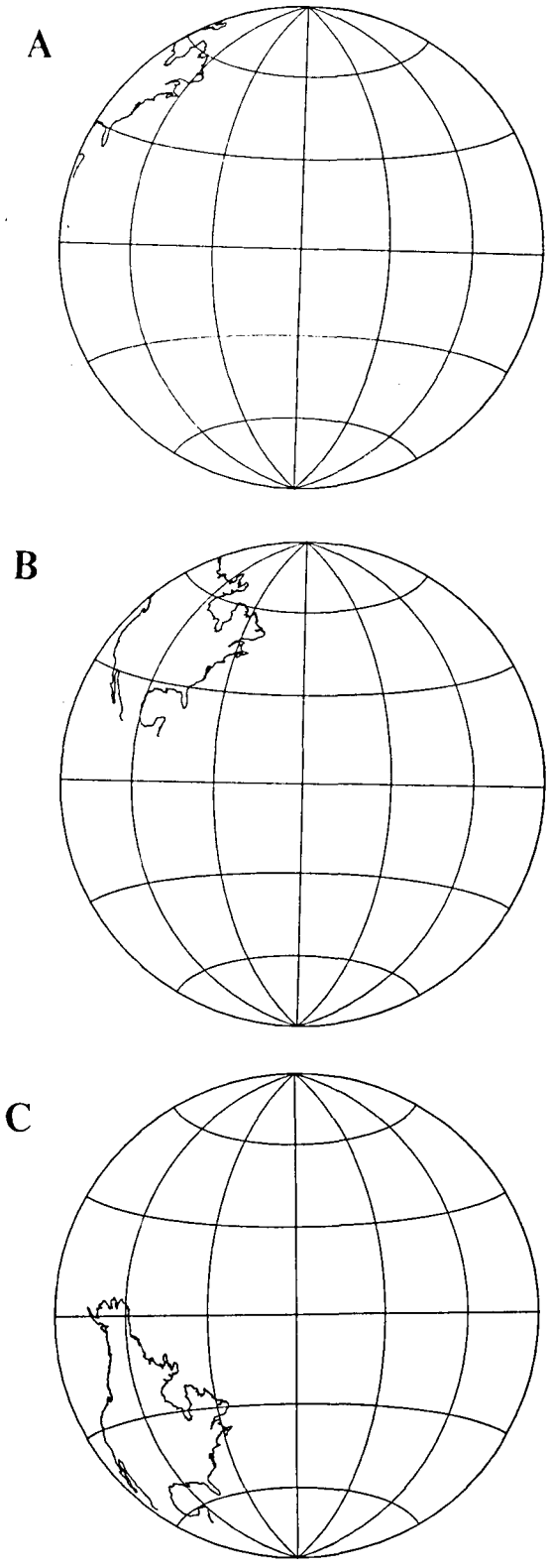
Select reference pole (e.g. pole 5 corresponding to an age of 370 Ma; see code initials).

Answer with **n** for south forcing.

Continental data, already corrected for N. Atlantic opening will now be rotated by an amount which brings the reference VGP to the North pole.

North America will then be displayed on the screen in a Devonian (370 Ma) configuration in "European" coordinates (Fig. 4C).

FIGURE 4
Example of compound rotation. In (A) North-America (CONTINENT File=NAM; Appendix 2) is plotted in 'in-situ' co-ordinates. In (B) NAM is corrected for Mesozoic/Cenozoic opening of the North Atlantic using a Bullard et al. (1965) fit (ca. 87,27,37). Finally, NAM is positioned according to pole **5** in VGP file NI2000A (Appendix 1). Schmidth equal are projection. Cf. text for details.



7.4 HCOPY CONTINENT (or VGP)

Make a hardcopy of CONTINENT (or VGP) on a HP-GL compatible plotter. Hardcopy provides a one to one copy of the screen, but with the full resolution power of the plotter.

Intent to output must be confirmed before plotting starts.

7.5 GRAPHICAL DISPLAY

In this option a CONTINENT (or VGP) file is displayed using the pre-defined projection. Galls projection is used by default. Use option SELECT NET-PROJECTION to alter projection type.
The plot is centered on 'zoom-center', by default zoom-center is 0,0 (LAT,LONG) and scale is set to 1. Blanking is **ON** by default.

The following options are available:

OPTION	**EFFECT**
MENU	RETURN TO MAIN MENU
TRANSLATE	INTERACTIVE TRANSLATION AND/OR ROTATION OF CONTINENT -After entering this option a cross is displayed on the screen, and the cross can be moved around the screen using the cursor arrows. Translate CONTINENT: -Move cross to a desired LAT-LONG of CONTINENT Type 1 (or PG UP) to select LAT-LONG (point 1) Move cross to a new LAT-LONG position Type 2 (or PG DN) to select LAT-LONG (point 2) -Leave option by pressing <ENTER-RETURN>. A new plot showing a translation from point 1 to point 2 will now be displayed Rotate CONTINENT: -Move cross to a desired EULER ROTATION POLE Type **r** to select option ROTATE Type EULER ROTATION angle CONTINENT will now be rotated according to EULER data -Leave option by pressing <ENTER>
SCALE	SELECT SCALE CENTERED AROUND ZOOM-CENTER -Type any scale value -Note that PGUP/GGDN can be used for scaling
ZOOMCENT	DEFINE ZOOM-CENTER -After entering this option a cross is displayed on

	the screen, and the cross can be moved around the screen using the cursor arrows. During this operation LATITUDE and LONGITUDE are displayed in the bottom left corner of the screen -Leave option is by pressing <ENTER-RETURN>. A new plot, centered on the new zoom-center, is displayed
HCOPY	HARDCOPY OF **CONTINENT** TO PLOTTER
WORLD	DISPLAY OF MAJOR CONTINENT FILES
RESET	RESET DISPLAY ACCORDING TO DEFAULT VALUES
GRID	SET AUTOMATIC DRAWING OF NET TO ON/OFF
BLANK	CHANGE BETWEEN BLANK **ON** AND BLANK **OFF** -BLANK **ON** is default, and to preserve picture during successively loading of continents this must be set to BLANK **OFF**
CONLOAD(*)	CONTINENTAL LOAD -Set BLANK **OFF** to display continents together
VGPLOAD	VGP LOAD
OGLOB	SETTING OF GLOBE-CENTER AND TIP/TILT -Default is 0 0 0° (Latitude Longitude Tilt) (see Fig. 7A-C) -Any values can be used, but note that zoom-center is **NOT** changed to fit the new image -Latitude and Tip/Tilt does not affect Galls Projection
ANIMATE	ANIMATION OF PLATE-MOVEMENTS -Select ANIMATION file created with ANI -Select **s** (screen) or **h** (hard-copy plotter) output
IMAGE	SELECTS IMAGE PLANES -Under development -Toggle between image plane 0 and 1

7.6 MODE

Switches between CONTINENT and VGP mode. Note that a CONTINENT (resp. VGP) file is still preserved in the memory after e.g. changing mode to VGP (resp. CONTINENT).

7.7 READ DIRECTORY

List '.VGP' or '.CON' files on the current drive
Select file using the arrow keys followed by <ENTER>.

7.8 EULER ROTATIONS

This utility routine performs euler-rotations based on data defined in option SET EULER-DATA. Latitude and Longitude of a point is requested, and the latitude and longitude in rotated co-ordinates are displayed.

End input by typing **999** in the latitude field.

7.9 SYSTEM CONFIGURATION

This option controls plotter/screen operations, and the following parameters can be changed:

PAPER SIZE (A4 OR A3) **4 OR 3**
(Default=4)

ACTIVE PEN **1 TO 8**
(Default=1)

DRAWING SPEED **1 TO 80**
(Default=25)

PLOTTER COMMUNICATION **LPT1-2: or COM1-2:**
(Default=LPT1:)

SELECT CONTINENT RESOLUTION **1 in every 1, to**
(Default=1) **1 in every 10**

SAVE CHANGES TO DISK
Creates a new 'CFG.SYS' file.
Only PAPER SIZE, ACTIVE PEN, DRAWING SPEED and PLOTTER COMMUNICATION can be permanently changed (see section 8).

MAIN MENU
Return to Main Menu GMAP4

PLOT STUDY LOCATION **(y or n)**

If **y** (yes) is selected, geographic latitude/longitude (GLAT/GLON) are plotted instead of VGP pole data (Fig. 5A). This is useful when producing a map of sampling locations. Thus, first plot a map covering all sampling locations (e.g. UK in Fig. 5A), then load a VGP file and select **y** for this option. The use of this option is exemplified in Fig. 5A & B.

SELECT RELIABILITY **(a-d or 1-7)**

VGP data can be filtered with this option. Leave blank for no filtering. Type **a**, for example, to only plot **a-GRADE** poles (Briden and Duff, 1981). Similarly **7** will only plot poles graded 7 in Van der Voo's classification scheme. You can also build a combine string, for example **abc** would plot all **a**, **b** and **c-GRADE** poles. Accordingly, **a7** would plot all **a-GRADE** poles and grade **7** poles of Van der Voo (1988).
(Default=blank)

DROP SYMBOL **(y/n)**

n (reps. y):draw (reps. not draw) point/symbol at pole position.
(Default=n - not affecting screen display)

DROP AGE **(y/n)**

n (reps. y):print (reps. not print) 'init' string (age) by pole position.
(Default=n - not affecting screen display)

PROMPT FOR POLE AGE **(y/n)**

During plotting each pole age or ('init' string) is displayed and you can decide wether to plot the pole or not. Useful when plotting detailed APW paths (splines; see 7.15.3).
(Default=n - not affecting screen display)

INCLUDE REMANENCE DECLINATION **(y/n)**

If you are plotting location rather than poles, this option allows you to plot 'in-situ' declination vectors.
(Default=n - not affecting screen display)

DRAW LINES BETWEEN POLES **(y/n)**

Option **y** (yes) will draw a line between VGP data. Useful when dealing with APW paths (splines).
(Default=n - not affecting screen display)

PLOT A95 **(y/n)**

If VGP data represent mean poles you can choose to draw an A95 around each pole by typing **y** (yes).
(Default=n)

PLOT TRUE CONFIDENCE OVALS **(y/n)**

y (yes) produce error ovals for each pole.

Note that this routine requires α_{95}, declination/inclination and geographic longitude/latitude to produce error ovals (Fig. 5). Therefore, these parameters **MUST** be in the VGP data-file if confidence oval are required.

FORCE COMMON PLOT-SYMBOL **(n, 1-6)**
(Default=n - not affecting screen display)

In this option you can overrule the normal plotting symbol routine and select a common plotting symbol for all poles (1-6).

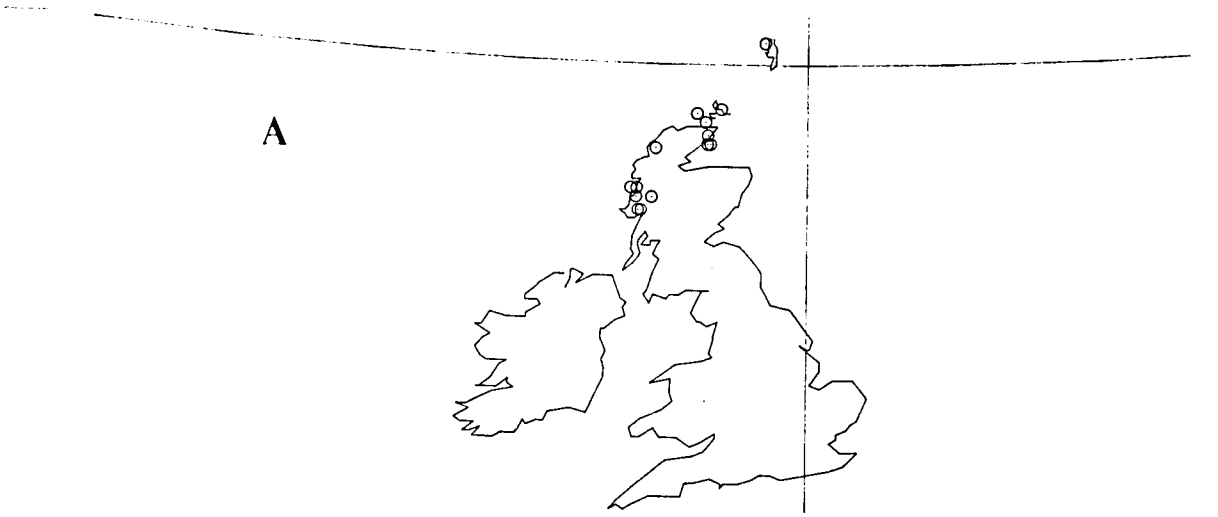
Plotting symbols are as follows:

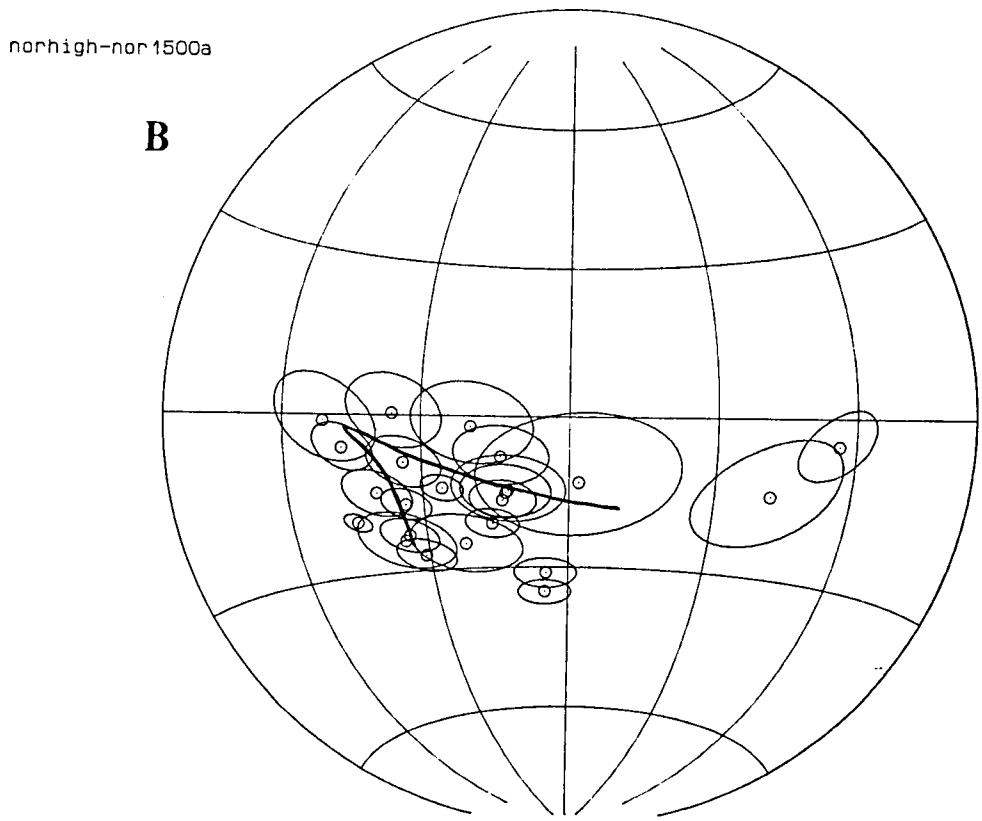
Symbol-Code	Symbol	Briden & Duff (1981) Grading	Polarity
1	open square	A	N
2	closed square	A	R
	(half - closed)	A	M
3	open triangle	B	N
4	closed triangle	B	R
	(half - closed)	B	M
5	open circle	C	N
6	closed circle	C	R
	(half - closed)	C	M

any value +

Grading and polarity usually control symbol-code (1-6). An average pole calculated via STAT option in TABLE VGP (and saved to file), however, would be plotted as + (mean pole). If grading and polarity is undefined then symbol 5 (open circle) is used by default. This option is presently updated to include Van der Voo (1988) grading.

FIGURE 5
(A) Plot of study-locations (form VGP file=norhigh) shown along with CONTINENT file UK (high scale).
(B) Corresponding VGP poles plotted with true error confidences, along with an example of fitting a smooth path to VGP data (smooth path VGP file=ni2000A; Appendix 1).





7.10 NET PROJECTION

Select net projection and define grid-spacing. Grid spacing can be any **integer** value, and the following net-types have been implemented in GMAP4:

W	**(WULF NET, EQUAL ANGLE PROJECTION)**	(Fig. 6A)
S	**(SCHMIDT NET, EQUAL AREA PROJECTION)**	(Fig. 7A-C)
O	**(ORTHOGONAL PROJECTION)**	(Fig. 8B)
K	**(KAVRAISKII NET)**	(Fig. 6B)
G	**(GALLS PROJECTION)**	(Fig. 8A)
	-Default net-type with 30^{o} grid-spacing	

FIGURE 6
Examples of Wulf (equal angle) projection (A), and Kavraiskii projection (B).

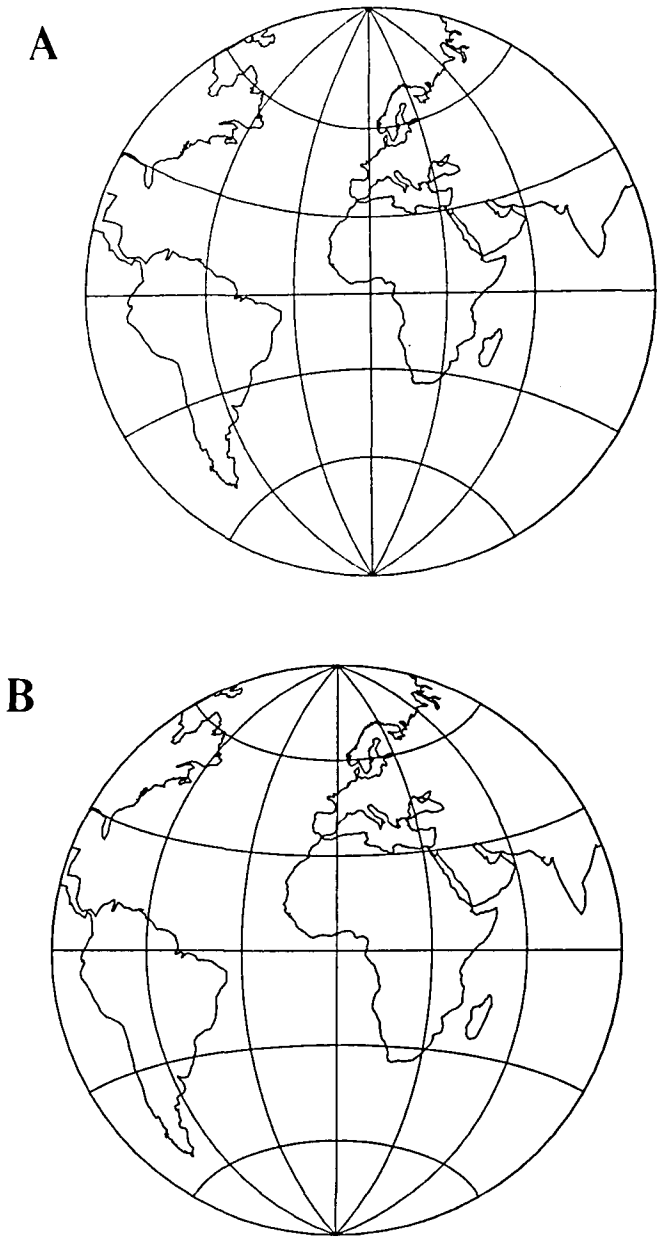


FIGURE 7
Examples of Schmidt (equal are) projections (most common projection). In (A) projection center is 0 (latitude), 0 (longitude) and tip is set to 0. In (B) projection center is 45,45 45. In (C) latitude is set to 90, whereas longitude and tip are both set to 0.

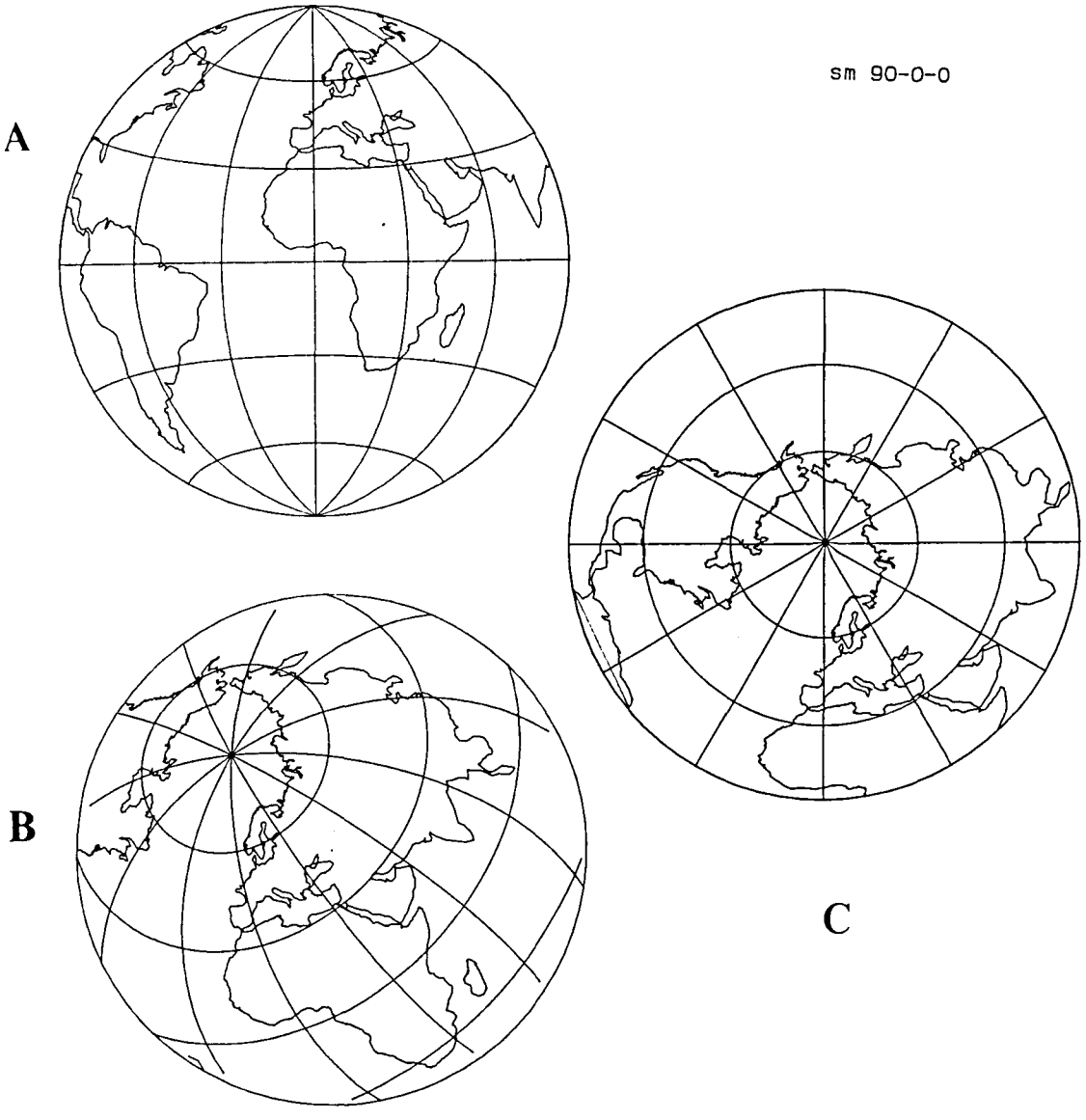
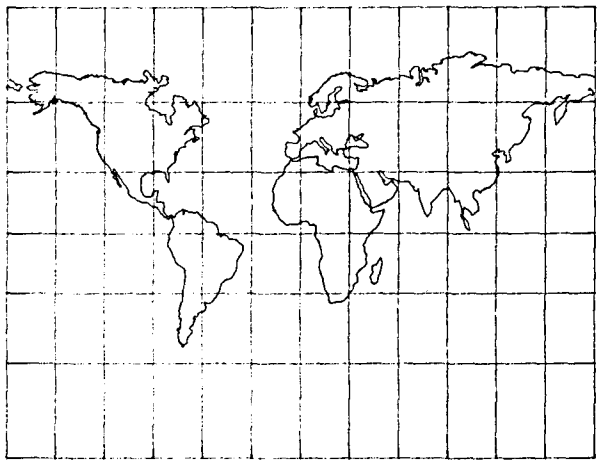
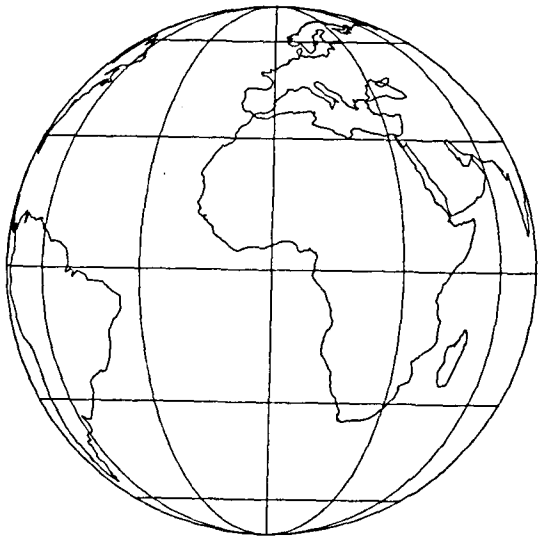


FIGURE 8
Examples of Galls projection (A) and orthogonal projection.

A



B



7.11 SELECT PATH

Selection of active path

Example - c:\gmap (drive **c** and sub-directory **gmap**)

7.12 SET EULER DATA

This option sets euler data which are subsequently used for rotation of CONTINENT or VGP data with 'ROTATE CONTINENT' (7.3).

Apart from automatic calculation of euler-data (option TABLE VGP, VROT, 7.15.2), there are two methods of defining euler-data in this option: manual input or file input (*.FIN files).

MANUAL

Select **m** (manual) and input euler-data in the following format:

latitude,longitude,euler rotation angle

Example: 87,27,37 (ca. Bullard et al. (1965) fit)

READ EULER-DATA FROM FILE

Select **f** (file), and choose desired file-name from the directory listing.

Euler-data will be listed on the screen, and the required euler-data can be selected by **y** (yes) at the correct data-line.

7.13 CALCULATE EULER-DATA

This utility routine calculates a rotation pole and angle of rotation, given **two** points (poles) on the sphere.

Input-data are typed in **latitude and longitude.**
Result is displayed in latitude, longitude and euler-angle.

End input by typing **999** in the latitude field for pole A

7.14 HCOPY NET

Hardcopy selected net-projection on HP-GL plotter.
Hardcopy must be confirmed by **y** before plotting starts.

7.15 TABLE

This is an important option in GMAP4, and this option handles all palaeo-reconstructions based on palaeomagnetic data.

Upon entering this mode (if a VGP file is present or loaded), the following information is displayed:

1-	Nr.	Number in file. Used to identify a data-line
2-	CLPOL	Combined string of classification/grading and polarity This string is important and controls plotting symbols (see section **2.6.2**)
3-	DEC	Declination
4-	INC	Inclination
5-	a95	95 percent confidence circle
6-	GLAT	Geographic latitude
7-	GLON	Geographic longitude
8-	PLAT	VGP latitude
9-	PLON	VGP longitude
10-	dp	error-oval
11-	dm	error-oval
12-	INIT	Initials/working age (printed during HCOPY)

If data exceed one full screen page, use <PGUP> or <PGDN>. Options are listed at the bottom of the screen. These options are selected by pressing the first character in the name of the option.

The options are as follows:

OPTION	**EFFECT**
QUIT	RETURN TO MAIN MENU
EDIT	EDIT A DATA-LINE -Select VGP record. Ppress <RETURN> at data fields which at pole is OK. -Note that data can be appended by typing a VGP number which is greater than the maximum size of the data list. End adding by typing **999** in 'CLPOL' entry. -Note that thorough editing is done in VGP

REF	CALCULATE AMOUNT OF ROTATION AND FLATTENING -Select REFERENCE POLE and **A**95 (see 7.15.1)
CPOL	REVERSE ALL VGP POLARITIES IN FILE -Only in memory
STAT	CALCULATE AN **A**95 ON POLES IN DATA-FILE -After calculation you are asked to save the mean pole, and FILE-NAME is requested. Mean-poles will be merged/appended to this file, thus enabling construction of a file of mean poles.
D&I	CALCULATE DECLINATION AND INCLINATION -Based on pole and geographic locality
BREF	CALCULATE PALAEOLATITUDE -Select REFERENCE locality (latitude, longitude)
KILL	KILL OR REMOVE A VGP -Select data number (VGP) to kill
VROT	PERFORM AN EULER-ROTATION BASED ON A GIVEN VGP -Pole is selected from data-list -Select **n** to rotate VGP to the North Pole, and **y** to rotate VGP to South Pole The two options produce maps which are 'inverted' relative to each other -If a continent is not present in memory, a continent file name is demanded
HCOPY	COPY TABLE TO PRINTER -Normally the data-list will be printed -After using REF option, however, rotation, flattening and errors will be printed -After using BREF, palaeo-latitudes will be printed
UPDA	SAVE/UPDATE VGP DATA TO DISK FILE (As SAVE option in main menu)
ASPL	A SMOOTH (APW) PATH TO THE VGP DATA
POLE	CALCULATE POLE -Based on declination, inclination and geographic locality

7.15.1 REF

This option is important if we are dealing with possible displaced and rotated terrains.

- A reference pole and A95 is required

Based on this reference pole the remanence declination difference between the reference pole and the tabulated data are calculated. This gives an estimate of the rotation. Similarly, difference in inclination is calculated, which provides an estimate of latitudinal movement, or flattening.

When using the HCOPY option after performing this calculation, a detailed listing of estimated rotation and flattening together with the associated errors will be printed.

7.15.2 VROT

This is the most important routine in reconstructions based on palaeomagnetic data. When selecting this option, the code number of the pole you want to use for the reconstruction is requested.

In GMAP4, the euler-pole and rotation angle which is required to rotate the selected VGP to the NORTH POLE is calculated. The method is ambiguous in terms of palaeo-reconstruction, and the VGP may equally well be rotated to the SOUTH POLE. This results in a continental reconstruction which is 180 degrees opposite in longitude (optional) and the continent being 'inverted'.

During program-execution you have an option to decide wether you want to force VGP to SOUTH POLE according to which polarity you assign the VGP (default=n).

BACKROUND

To aid the definition of APW trends within tectonic units and to compare trends between tectonic units there is a natural tendency to find a smooth path that fits the data. Path fitting also has the advantage of provisional data extrapolation and filtering/removal of outliers.

A number of numerical methods for fitting smooth paths to palaeomagnetic poles have been offered in the literature (Gould, 1969; Parker and Denham, 1979; Thompson and Clark, 1981, 1982; Clark and Thompson, 1984; Jupp and Kent, 1987). In GMAP we have used the method of Jupp and Kent (1987) because most of the previous methods can produce distortion if the data are spread over a large portion of the sphere and further the fitted path is not invariant under changes in the co-ordinate system. The method aims to fit 'spherical smoothed splines' to a given data-set on the sphere with known ages.

The method of Jupp and Kent (1987) allows the use of various levels of smoothing and weighting of individual data points. In GMAP4 the data are weighted according to their a_{95}, but we have also implemented a procedure allowing **GRADE A POLES** (Briden & Duff, 1981) or **GRADE 7POLES** (Van der Voo, 1988) to be assigned an artificially low a95 (1 degree) to anchor the path. Smoothing methods have certain limitations especially in cases of abrupt trend changes in the path. In such instances it is necessary to use low smoothing parameters.

In GMAP4 the smooth paths can consist of up to 200 points. No errors are given along the fitted path (these will be added in a later version).

OPERATION

- Load a VGP file, and enter option TABLE in main menu

- Select option ASPL in TABLE

- State wether you want the fitted path to be anchored by key poles, i.e. all GRADE A (resp. GRADE 7) poles will be assigned a95=1 during calculation of the fitted path

  Type **y** (yes) or **n** (no)

- Set (1) **SMOOTHING PARAMETER** (typically 1 - 1000000)
  A high value results in extreme smoothing.
  Cf. example values given in Appendix 1

  (2) **PATH RESOLUTION IN DEGREES** (typically 3-5^{o})

  (3) **PRECISION IN DEGREES** (typically 3-5^{o})

- Type VGP file-name for the fitted path

- Leave TABLE option using QUIT

- Load fitted path using LOAD VGP option in main menu

- Select option DRAW VGP to display the path

7.16 QUIT

End GMAP4

8. DESCRIPTION OF CONF

This is a utility program to generate a system configuration file named CFG.SYS which is read by most programs in the GMAP package during start-up. CFG.SYS is supplied on the enclosed disk. In addition files named EGA.SYS, VGA.SYS, CGA.SYS and HER.SYS are supplied. These files can be renamed to CFG.SYS using SAVE option in CONF.

The main menu consist of the following options:

OPTION	**EFFECT**
AUTO-DETECT	DETECT THE GRAPHIC CARD WHICH IS PRESENT
SCREEN TEST	TEST CIRCLE DRAWING ON THE SCREEN -adjust aspect to obtain a circle
SAVE CFG.SYS	SAVE CFG.SYS FILE TO DISK
READ CFG.SYS	READ DEFAULT CFG.SYS FILE FROM DISK
EDIT CFG.SYS	EDIT CFG.SYS FILE IN MEMORY
LOAD EGA.SYS	LOAD EGA GRAPHIC DRIVER
LOAD CGA.SYS	LOAD CGA GRAPHIC DRIVER
LOAD VGA.SYS	LOAD VGA GRAPHIC DRIVER
LOAD HER.SYS	LOAD HERCULES GRAPHIC DRIVER
PATH	SELECT CURRENT PATH
QUIT	END CONF

8.1 AUTO-DETECT

This option tests for the installed graphic card, and returns graphic card type, aspect (X:Y ratio) and the number of colors available.

8.2 SCREEN TEST

The aspect (X:Y ratio) may often be fine-tuned for various screens, and this is a graphical routine to image a circle correctly. Adjust aspect until a true circle is obtained on the screen.

You may also experiment by changing the ENVIRONMENT and MONCAL variable to obtain a correct circle.

8.3 EDIT CFG.SYS

All variables in the configuration file can be manually edited.

CFG.SYS contains the following information:

VARIABLE	**EXAMPLE**	
GRAPHIC CARD TYPE	EGA	
GRAPHIC MODE	9 (EGAHi)	
SCALE (USED IN GRAPHICS)	.8299999833106995	
ENVIRONMENT	.8799999952316284	
NUMBER OF COLORS	15	
ASPECT	0.73	
PLOTTER PORT	lpt1:	
DEFAULT PEN	3	
DEFAULT PLOTTING FORMAT	4 (4=A4, 3=A3)	
DEFAULT PEN SPEED	25	
DEFAULT PRINTER	lpt1:	(ALWAYS IN GMAP)
NOT USED	dat	
MONITOR CALIBRATION	1	

In EDIT option press <ENTER> if variable is correct. Note that a change of GRAPHIC CARD TYPE would produce new graphic variables, and you have to re-enter EDIT mode to change other variables.

GRAPHIC CARD TYPE must be entered in UPPER CASE CHARACTERS and the following options are valid:

EGA	'(640x350 pixels)
CGA	'(640x200 pixels)
VGA	'(640x480 pixels)
MCGA	'(640x480 pixels)
HER	'(720x400 pixels)

Cited References:

Briden, J.C. and Duff, B.A., 1981. Pre-Carboniferous palaeomagnetism of Europe North of the Alpine orogenic belt. In M.W. McElhinny & D.A. Valencio (Eds.) Palaeoreconstruction of the Continents, AGU Geodynamic series, Volume 2, p. 137-149.

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Fisher, R.A. Dispersion on a sphere. Proc. R. Soc. Lond. Ser A., **217**, 295-305.

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Thompson, R. & Clark, 1981. Fitted polar wander paths. Phys. Earth Planet. Inter., **27**, 1-7.

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Torsvik, T.H., Smethurst, M.A., Briden, J.C. and Sturt, B.A, 1990a. A review of Palaeozoic palaeomagnetic data from Europe and their palaeogeographical implications. In W.S. McKerrow & C.R. Scotese (eds.) Palaeogeography and Biogeography, Geological Society Memoir, No. 12, pp. .

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General References:

Cox, A. & Hart, R.B., 1986. Plate tectonics: How it works. Blackwell Scientific Publications, Oxford, 382 pp.

Duncan, A.C., 1981. A review of Cartesian co-ordinate construction from a sphere, for generation of two dimensional geological net projections. Computers & Geosciences, **7**, 1, 367-385

Lee, B. & Crain, I., 1976. CONTPLOT: A program to draft continental reconstructions. Computers & Geosciences, **1**, 279-308.

APPENDIX 1 - SUPPLIED FILES

DBGMAP FILES:

UK.DBD UK.DBI	Palaeozoic palaeomagnetic data from Britain
EUROPE.DBD EUROPE.DBI	Palaeozoic data from Europe
SPIT.DBD SPIT.DBI	Palaeozoic data from Spitsbergen
RUSSIA.DBD RUSSIA.DBI	Palaeozoic data USSR
BALTIC.DBD BALTIC.DBI	All reported Archean to Recent palaeomagnetic data from Scandinavia
NAMERICA.DBD NAMERICA.DBI	Key Palaeozoic poles from North America

GMAP4 VGP FILES

These numerical vgp-files are created from DBGMAP with option DUMPD using the files listed above. Most of these files are produced by filtering on code.

Filename	Area	Code-argument
norhigh .vgp	- north of GGF	
midland .vgp	- north of IS, but south of GGF	
southb .vgp	- south of IS	
armorica.vgp	- armorica	
ceurope .vgp	- other European data	
spit .vgp	- spitsbergen	
baltica .vgp	- baltica	
rus .vgp	- russian platform	
ur .vgp	- urals	
sib .vgp	- siberia	
niap .vgp	- north of IS	
rawpx .vgp	- revised VGP file data for Baltica	
sørøy .vgp	- revised alternative VGP file data for Baltica	
nam .vgp	- North America (European co-ordinates)	

SPLINE VGP-FILES

These spline-files are created from GMAP4 using the VGP-files listed above (cf. Torsvik et al., 1990a & b).

		PARAMETERS SETTING			
Name		LAMDA	ANGACC	ANGDIV	GRAD
nor1500A	- north of GGF	1500	5	5	YES
mid2000A	- north of IS -south of GGF	2000	5	5	YES
ni2000A	- north of IS	2000	5	5	YES
siapc	- south of IS	100	3	3	
armb	- armorica	1000	1	1	
bal2000A	- baltica	2000	5	5	YES
spit100	- spitsbergen	100	5	5	
rplata	- russian plate	23395	1	1	
sibc	- siberian platform	100	5	5	
pathx	- Baltica	100	5	5	
pathy	- Baltica	100	5	5	
nam100a	- North America	100	5	5	YES

Explantion of parameters:

LAMDA = SMOOTHING PARAMETER
ANGACC= PATH RESOLUTION IN DEGREES
ANGDIV= PRECISION IN DEGRESS
GRAD = GRADED (A POLES ASSIGNED a95=1)

APPENDIX 2 - CONTINENTAL FILES

All continental files (extension .CON) are ordinary sequential Aschii files. These files can be manipulated/edited in GMAPCON.

CON1	North, Central & South America
CON2	Baltica, Russia, Asia, Europe
CON3	Africa & Madagascar
CON4	Greenland & Arctic Canada
CON5	Australia & New Zealand
CON6	Antarctica
SPIT	Spitsbergen
UK	England, Scotland, Ireland, Orkney & Shetland
NEWF	Newfoundland
ICELAND	Iceland
NAM	North America
SAM	South America
NORWAY	Norway
EUROPE	Europe
GREENL	Greenland
INDIA	India
ICON1	Islands & lakes associated with CON1 (CON2)
ICON2	Islands associated with CON2 (including JAPAN)
IBERIA	Iberian peninsula
INDO	Indonesia & Islands
CASIA	Coast line ASIA & RUSSIA
PSAM	Political boundaries for South America (SAM)
PCON2	Political boundaries for Europe (CON2)
PCON3	Political boundaries for Africa (CON3)
PASIA	Political boundaries for ASIA

TERRAINS

LAURENTIA	North America & Greenland, W. Newfoundland, N. England/Ireland (Bullard et al. (1965) fit). (North-American co-ordinates)
AVALONIA	S. England, E. Newfoundland and Maritime Provinces
ARMORICA	NW Europe, S. England & Avalon platform
ARMORICB	Alternative to ARMORICA
BALTICA	Fennoscandian and Russian Platforms
EURAMERICA	LAURENTIA, BALTICA & ARMORICA (European co-ordinates)

MAGNETIC ANOMALIES

Files have same format as *.CON files (same extension)

North Atlantic:

NAAXIS	Axis
ENAOLIVE	East
WNAOLIVE	West
WNA	West
WNASHARI	West
NA	(fracture zones/transform faults)

Central Atlantic:

CAAXIS	Axis
ECA	East
WCA	West
CA	(fracture zones/transform faults)

Labrador Sea:

LABOLIVE

LINEAMENTS (to be implemented)

Files in same format as *.CON files (same extension)

GGF	Great Glen Fault
HBF	Highland Boundary Fault
SUF	Southern Upland Fault
IS	Iapetus Suture
NASZ	North Atlantic Shear Zone
TL	Tornquist Zone
VAR	Variscan/Hercynian Front
CAL	Caledonian Front
ALP	Alpine Front
BSE	Baltic Shield Elements

FINITE ROTATION POLES CENTRAL ATLANTIC

HELMAN AND CANDE (1986 UNPUBLISHED) NA/AF

FILE=CAHELMAN.FIN

LAT	LONG	ANG	ANOM
77.073	-20.735	29.616	34
78.300	-18.350	27.165	33R
81.570	-8.140	23.696	33
81.570	-9.150	22.870	32
81.272	-5.839	22.095	31
81.272	-5.839	21.435	30
81.272	-5.839	21.050	29
81.272	-5.839	20.610	28
80.600	-0.500	19.900	27
80.600	-0.500	18.790	26
80.600	-0.500	18.180	25
77.775	0.359	16.910	24
77.775	0.359	16.365	23
76.429	3.641	15.579	22
76.429	3.641	14.593	21
75.38	1.682	13.345	20
75.358	1.682	12.880	19
74.399	-4.060	12.345	18
74.399	-4.060	11.755	17
74.399	-4.060	11.185	16
74.399	-4.060	10.805	15
74.399	-4.060	10.151	13
74.399	-4.060	9.685	12
74.399	-4.060	9.245	11
74.399	-4.060	8.925	10
74.399	-4.060	8.465	9
80.061	36.369	7.275	8
80.061	36.369	6.925	7
80.061	36.369	6.575	6C
80.061	36.369	6.225	6B
80.061	36.369	5.775	6A
80.061	36.369	5.222	6
80.061	36.369	4.925	5E
80.061	36.369	4.650	5D
80.061	36.369	4.150	5C
79.497	55.547	3.400	5B
79.497	55.547	2.980	5A
79.497	55.547	2.285	5
79.497	55.547	1.951	4A
79.497	55.547	1.767	4
79.497	55.547	1.394	3A
79.497	55.547	1.001	3
79.497	55.547	0.590	2A
79.497	55.547	0.380	2

PITMAN AND TALWANI (1972) NA/AF

LAT	LONG	ANG	ANOM
71.0	-10.0	24.0	33
75.0	15.0	17.0	25
77.0	15.0	13.9	21
79.0	13.0	9.75	13
69.7	-33.4	3.6	5

FILE=CAPITMAN.FIN

KLITGORD AND SCHOUTEN (1986) NA/AF

LAT	LONG	ANG	ANOM
76.55	-20.73	29.60	34
78.30	-18.35	27.06	33R
80.76	-11.76	23.91	33
81.35	-9.15	22.87	32
83.86	1.28	20.86	30
80.60	-0.50	18.07	25
74.51	-4.83	15.32	21
76.41	7.12	9.81	13
79.57	37.84	5.29	6
79.08	77.95	2.41	5

FILE=CASCHOUT.FIN

OLIVET ET AL. (1984) NA/AF

LAT	LONG	ANG	ANOM
72.9	26.1	33.9	34
78.2	-16.5	26.7	33
79.4	3.2	17.0	24
78.0	11.5	9.5	13

FILE=CAOLIVET.FIN

FINITE ROTATION POLES NORTH-ATLANTIC

HELMAN AND CANDE (1986 UNPUBLISHED) NA/EUR

FILE=NAHELMAN.FIN

LAT	LONG	ANG	ANOM
75.00	152.50	21.200	34
71.50	152.50	19.690	33R
69.50	152.00	18.100	33
68.10	152.00	17.350	32
68.10	153.50	16.900	31
66.80	152.50	16.540	30
66.80	152.50	16.220	29
66.80	152.50	15.900	28
66.80	152.50	15.450	27
66.00	148.75	14.120	26
66.00	148.75	13.640	25
61.10	144.90	12.040	24
55.70	144.90	11.210	23
55.70	144.90	10.640	22
55.70	143.25	9.810	21
62.50	141.50	9.290	20
62.50	141.50	8.990	19
62.50	141.50	8.390	18
62.50	138.50	7.830	17
62.50	138.50	7.680	16
62.50	138.50	7.550	15
62.50	138.50	7.300	13
62.50	138.50	6.825	12
62.50	138.50	6.610	11
62.50	138.50	6.340	10
62.50	138.50	6.040	9
66.85	135.46	5.965	8
66.85	135.46	5.855	7
66.85	135.46	5.335	6B
66.85	135.46	5.055	6A
66.85	135.46	4.545	6
66.85	135.46	4.345	5D
66.85	135.46	4.010	5C
66.85	135.46	3.170	5B
68.00	137.00	3.005	5A
68.00	137.00	2.410	5
68.00	137.00	2.090	4A
68.00	137.00	1.740	4
68.00	137.00	1.400	3A
68.00	137.00	0.980	3
68.00	137.00	0.620	2A
68.00	137.00	0.410	2

OLIVET ET AL. (1984) NA/EUR

FILE=NAOLIVET.FIN

LAT	LONG	ANG	ANOM
81.6	150.3	23.8	34
69.5	147.0	19.3	33
61.1	143.0	12.3	24
57.6	141.5	10.1	21
68.1	138.2	7.8	13

PITMAN AND TALWANI (1972) NA/EUR
(NOTE 33 IS NEW ANOMALY IDENTITY FOR 31)

FILE=NAPITMAN.FIN

LAT	LONG	ANG	ANOM
77.00	160.00	20.50	33
63.00	157.00	14.00	25
56.00	144.00	9.90	21
65.00	133.00	7.45	13
68.00	137.00	2.40	5

SRIVASTAVA AND TAPSCOTT (1986) NA/EUR

FILE=NASHARI.FIN

LAT	LONG	ANG	ANOM
76.23	148.80	21.83	34
74.52	147.69	20.30	33
70.66	145.91	17.59	31
69.82	145.61	17.10	30
63.25	143.89	14.15	25
62.28	140.37	12.68	24
67.12	137.28	10.94	21
68.00	129.90	7.78	13
68.00	138.20	4.75	6
68.00	137.00	2.50	5

SRIVASTAVA AND TAPSCOTT (1986) NA/PRP

FILE=PRPSHARI.FIN

LAT	LONG	ANG	ANOM
72.82	152.76	20.60	34
70.78	151.77	19.11	33
66.14	150.12	16.48	31
65.12	149.84	16.01	30
57.15	148.19	13.22	25
55.51	145.54	11.76	24
62.55	142.01	10.25	21
68.00	129.90	7.78	13
68.00	138.20	4.75	6
68.00	137.00	2.50	5

APPENDIX 4 - SPLINES USED IN THE MANUAL

APWPs in 10 million year intervals (Torsvik et al., 1990a).

	lat	long	lat	long	lat	long	lat	long	lat	long
Age	N Britain		S Britain		Armorica		Baltica*		Spitsbergen	
260	-42	343					-42	344		
270	-42	342					-42	348		
280	-41	341	-46	342			-41	351	-36	322
290	-39	340	-48	345			-38	352	-35	323
300	-35	337	-48	347	-33	328	-37	351	-34	325
310	-31	333	-45	346	-31	328	-34	347	-32	326
320	-28	332	-38	341	-28	327	-31	342	-30	328
330	-24	330	-32	335	-26	327	-27	337	-28	328
340	-18	328	-25	327	-23	328	-23	333	-27	328
350	-14	327	-20	322	-20	330	-19	331	-25	328
360	-9	326	-12	315	-17	331	-16	333	-22	328
370	-5	325	-8	313	-12	333	-14	337	-20	326
380	-2	324	-3	312	-8	336	-14	339	-16	325
390	+1	322	+1	315	-4	337	-14	341	-13	324
400	0	320	+2	322	0	339	-16	342	-9	323
410	-3	320	+3	334	+6	341	-18	344	-5	322
420	-8	325	+2	348	+10	343	-19	346		
430	-12	335	0	359	+15	345	-21	348		
440	-15	352	-2	006	+20	346	-23	350		
450	-16	004	-3	007	+25	346				
460	-16	019	-3	003	+29	346				
470	-15	036			+33	345				
480					+36	345				
490					+39	344				

*This path should be substituted by 'pathx' or 'pathy' (Torsvik et al., 1990b)

APPENDIX 5 - SOME DATA-FILE FORMATS AND DIMENSIONS

*.CON FILES (used in GMAP4 and GMAPCON)

Sequential ASCII file
Maximum number of grid-points=3500

These files contain latitudes and longitudes in free real/integer format.

Example:

```
-39.37,33.7
-38.95,33.62
-40.48,31.88
-40.57,31.79
-41.53,30.86
-41.74,30.72
-41.81,30.58
-41.87,30.47
-41.95,30.28
-42.69,29.73
-42.99,29.45
-42.99,29.34
-43.68,28.42
-43.87,28.04
-44.16,27.54
-44.27,27.37
-44.32,27.19
-44.41,26.88
```

*.VGP FILES (used in GMAP4 and VGP)

Sequential ASCII file
Maximum number of entries=200

Contain VGP data in free format. See section 2.7 for file-data information.

Example:

```
dm                          First Pole (class/polarity)
191
21
24
60.5
10.4
18
179
13.3
25.3
1
ar                          Second Pole
226
-30
11.5
54.2
15.3
38
134
7
11
2
```

CFG.SYS FILE (used in most programs)

Sequential ASCII file (CONF)

This file contain vital system and configuration options and the format (free) is as follows:

Variable	Use
EGA	graphic card type
9 (EGAHi)	graphic mode
.8299999833106995	scale (graphics)
.8799999952316284	environment variable (graphics)
15	number of colors
0.73	screen aspect (vital in graphics)
lpt1:	default plotter port
3	default plotter pen
4	default plotting format 4=A4, 3=A3
25	default pen speed
lpt1:	default printer port
dat	not used in GMAP

Briden and Duff (1981):

This reliability classification scheme grades poles from A (high) to D (low):

1 Established by complete demagnetization of NRM using any combination of thermal, AF or chemical demagnetization, either that NRM is a single stable component or, if multi-component, that separate components have been distinguished → **NO** D POLE
2 Tectonic correction unambiguous
3 Results (experimental) fully documented

↓ **YES**

1 Sufficiently large samples (> 6 sites)
2 Moderate to high precision (k>10)
3 Rock unit age known within a period
4 Author assigns full reliability to pole → **NO** C POLE

↓ **YES**

Age of magnetization established → **NO** B POLE

↓ **YES**

A CLASS KEY POLE for calibration of APW path - realizing that ambiguity of the 'polarity option' may remain

Van der Voo (1988):

This scheme grades poles from 1 (low) to 7 (high):

1 Well determined age
2 Sufficient number of samples (>25) and high precision (k>10, α_{95}<16)
3 Demagnetization results published in details
4 Positive field tests (fold-, cgl- or contact tests)
5 Tectonic coherence with block and sufficient structural control
6 Presence of antipodal results
7 Lack of similarity with poles from younger times