Paleomagnetic Dating and Plotting Software (PDAPS) Guide

LAST UPDATED: January 16, 2015

Introduction

Welcome to this guide that will outline the functions available in the PDAPS Software Package. This software was designed in MATLAB 2009 and has been updated to run in MATLAB 2013b. Other versions of MATLAB should be compatible with this software although they have not been tested as of this date.

A standalone version (does not require MATLAB) is also available for download.

This software package will allow you to date paleomagnetic data based on paleopoles or magnetic directions and will allow the use to plot the results on a variety of projections. For details on the theory behind the dating techniques used in the programs we refer you to the publication:

Hnatyshin, D., Kravchinsky, V. A., 2014. Paleomagnetic dating: methods, matlab software, example. Tectonophysics. http://dx.doi.org/10.1016/j.tecto.2014.05.013

Any use of this program for plotting and age dating purposes must reference the above publication:

Thank You

Table of Contents

Getting Started

Download the software package from http://www.ualberta.ca/~vadim/software.htm

(1) How to install the stand-alone program for dating:

Double click PDAPS_V12_pkg.exe, follow instructions to install the MATLAB Compiler and paleomagnetic dating software.

For more information about the MCR and the MCR Installer, see Distribution to End Users in the MATLAB Compiler documentation in the MathWorks Documentation Center: http://www.mathworks.com/products/compiler/mcr/index.html

NOTE: You will need administrator rights to run MCRInstaller.

(2) Files to Deploy and Package

Files to package for Standalone

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-PDAPS_V12.exe

-MCRInstaller.exe

-if end users are unable to download the MCR using the above link, include it when building your component by clicking the "Add MCR" link in the Deployment Tool

-This readme file

(3) Definitions

For information on deployment terminology, go to http://www.mathworks.com/help. Select MATLAB Compiler > Getting Started > About Application Deployment > Application Deployment Terms in the MathWorks Documentation Center.

How to use the program for dating (Short Version)

1) Choose mode (APWP or Secular Variation)
2) Input paleopole or direction data
3) Click "Accept"
4) Load reference curve using "Load Curve" button
5) Click "Open Age Calculator Button"
6) New window opens (AgeGUI)
7) Choose method (Angular or Rotation)
8) Choose appropriate constraints
9) Click Calculate
10) Plot data if desired
11) Export data if desired

Below is a more in depth explanation of what is required to properly use this software and what features are available

Required Inputs

There are two modes available, APWP mode and SV mode. Each mode requires specific inputs to properly date poles or directions.

Paleopole Inputs (Figure 1):

Select APWP mode

The following information is required to be inputted into the interface shown in Figure 1

For each paleopole you are required to input its latitude, longitude, dm (Semi-major axis of confidence ellipse), dp (semi-minor axis of confidence ellipse). The site latitude and site longitude is also required.

You can add additional columns to input additional poles using the “Add Pole” button

You can delete any pole by highlighting a cell for that pole and clicking the “Delete Pole” button.

Once all the poles are inputted click the “Accept” button. The poles should be now available in the popup menu in the Paleopole Plotting panel.

Direction Inputs (Figure 2):

Select Secular Variation mode

The following information is required to be inputted into the interface shown in Figure 2

For each direction you are required to input its inclination, declination, dm (Semi-major axis of confidence ellipse), dp (Semi-minor axis of confidence ellipse).

You can add additional columns to input additional directions using the “Add Direction” button

You can delete any pole by highlighting a cell for that pole and clicking the “Delete Direction” button.

Once all the directions are inputted click the “Accept” button. The directions should be now available in the popup menu in the Paleopole Plotting panel.

Figure 1

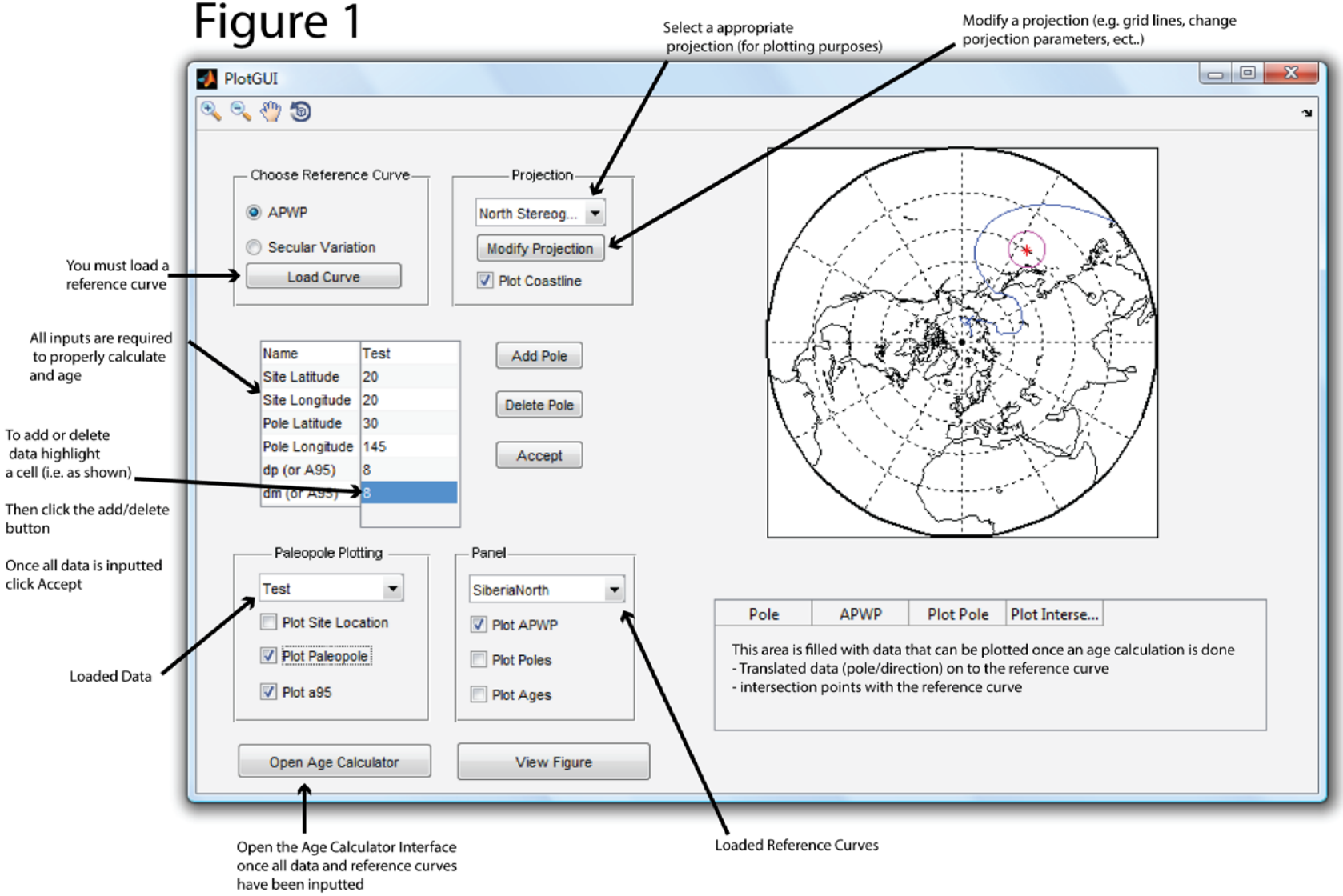
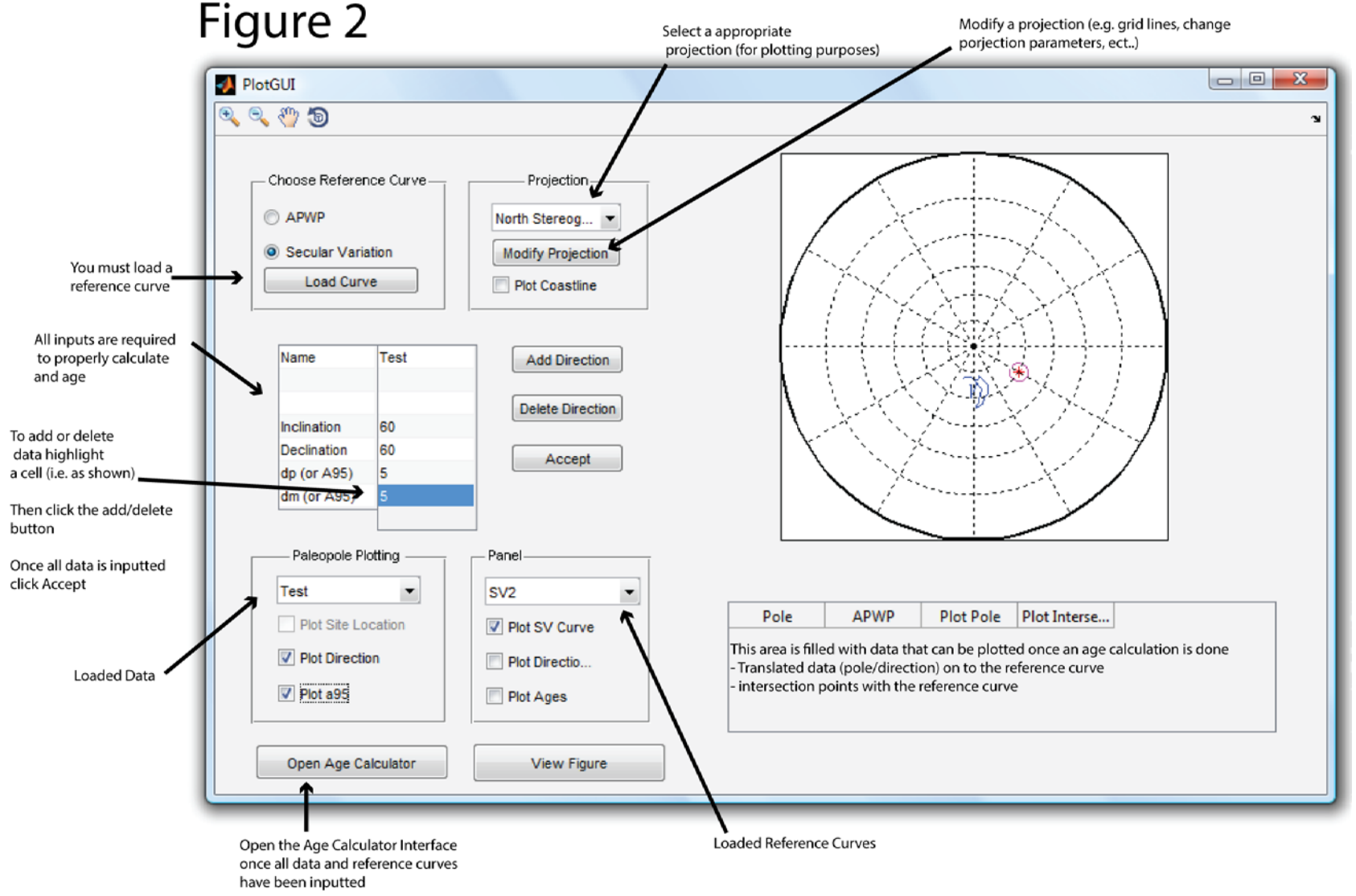

Select a appropriate projection (for plotting purposes)
Modify a projection (e.g. grid lines, change porjection parameters, ect..)
PlotGUI
Choose Reference Curve
APWP
Secular Variation
Load Curve
Projection
North Stereog...
Modify Projection
Plot Coastline
You must load a reference curve
All inputs are required to properly calculate and age
Name
Test
Site Latitude
20
Site Longitude
20
Pole Latitude
30
Pole Longitude
145
dp (or A95)
8
dm (or A95)
8
Add Pole
Delete Pole
Accept
To add or delete data highlight a cell (i.e. as shown)
Then click the add/delete button
Once all data is inputted click Accept
Paleopole Plotting
Test
Plot Site Location
Plot Paleopole
Plot a95
Loaded Data
Panel
SiberiaNorth
Plot APWP
Plot Poles
Plot Ages
Pole
APWP
Plot Pole
Plot Interse...
This area is filled with data that can be plotted once an age calculation is done
- Translated data (pole/direction) on to the reference curve
- intersection points with the reference curve
Open Age Calculator
View Figure
Open the Age Calculator Interface once all data and reference curves have been inputted
Loaded Reference Curves

Figure 2


Select a appropriate projection (for plotting purposes)
Modify a projection (e.g. grid lines, change porjection parameters, ect..)
PlotGUI
Choose Reference Curve
APWP
Secular Variation
Load Curve
Projection
North Stereog...
Modify Projection
Plot Coastline
You must load a reference curve
All inputs are required to properly calculate and age
To add or delete data highlight a cell (i.e. as shown)
Then click the add/delete button
Once all data is inputted click Accept
Name
Test
Inclination
60
Declination
60
dp (or A95)
5
dm (or A95)
5
Add Direction
Delete Direction
Accept
Paleopole Plotting
Test
Plot Site Location
Plot Direction
Plot a95
Panel
SV2
Plot SV Curve
Plot Directio...
Plot Ages
Pole
APWP
Plot Pole
Plot Interse...
This area is filled with data that can be plotted once an age calculation is done
- Translated data (pole/direction) on to the reference curve
- intersection points with the reference curve
Loaded Data
Open Age Calculator
View Figure
Open the Age Calculator Interface once all data and reference curves have been inputted
Loaded Reference Curves

Reference Curves

All reference curves are required to fit a specific Microsoft excel template (see Figure 3a example) in order to be read properly by the software.

The loaded reference curve is constructed using the points that define the curve's latitude/longitude (APWP mode) or inclination/declination (SV Mode).

To use a curve for dating purposes each data point must also have an associated age.

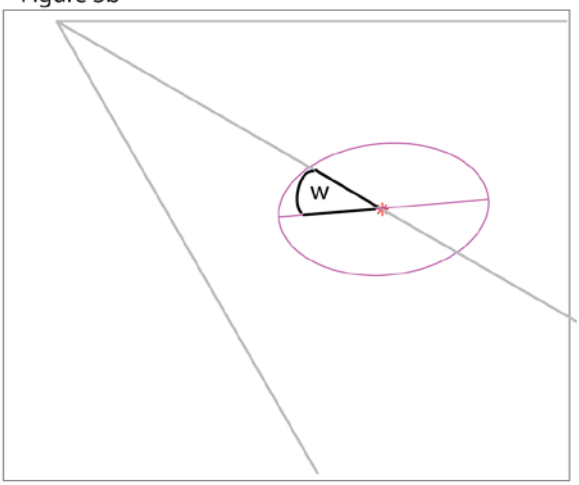
If the curve has errors associated then additional inputs are required (dp, dm, offset) where:

dm = Semi-major axis of the confidence ellipse
dp = Semi-minor axis of the confidence ellipse
offset = if dm ≠ dp then this is the angle between dm and the meridian that passes through the center of the confidence ellipse (Figure 3b)

Figure 3a

	A	B	C	D	E	F
1	Age	Plat/Inc	Plong/Dec	dp or A95	dm or A95	offset or omega
2	0	83.7	110.3	0	0	0
3	10	80.2	151.1	0	0	0
4	20	78	156.9	0	0	0
5	30	78.9	160.6	0	0	0
6	40	79.2	166.6	0	0	0
7	50	78.9	169.8	0	0	0
8	60	77.7	164.1	0	0	0
9	70	74.7	158.3	0	0	0
10	80	73.5	156.7	0	0	0
11	90	74.2	159	0	0	0
12	100	77.6	163.2	0	0	0
13	110	79.7	168.2	0	0	0
14	120	78.7	179	0	0	0
15	130	77.4	-177.6	0	0	0
16	140	75.3	-178.3	0	0	0
17	150	75.7	162.3	0	0	0
18	160	72.9	138	0	0	0
19	170	67.7	117.8	0	0	0
20	180	68.5	107.4	0	0	0

Figure 3b



A) Required inputs are required for reference curve construction, Column A - Age for each data point, Column B - Latitude or Inclination, Column C - Longitude or Declination, D = semi-minor axis for data point error ellipse (dp) E = semi-major axis for data point error ellipse (dm), F = angle between dm and meridian passing through data point)

B) Diagram showing offset angle w for a confidence ellipse. This angle should be inputted into column F if required

Age Calculation

In the PlotGUI interface click the "Open Age Calculator Button" to load the AgeGUI interface (Figure 4).

Once AgeGUI is open select the desired dating method.

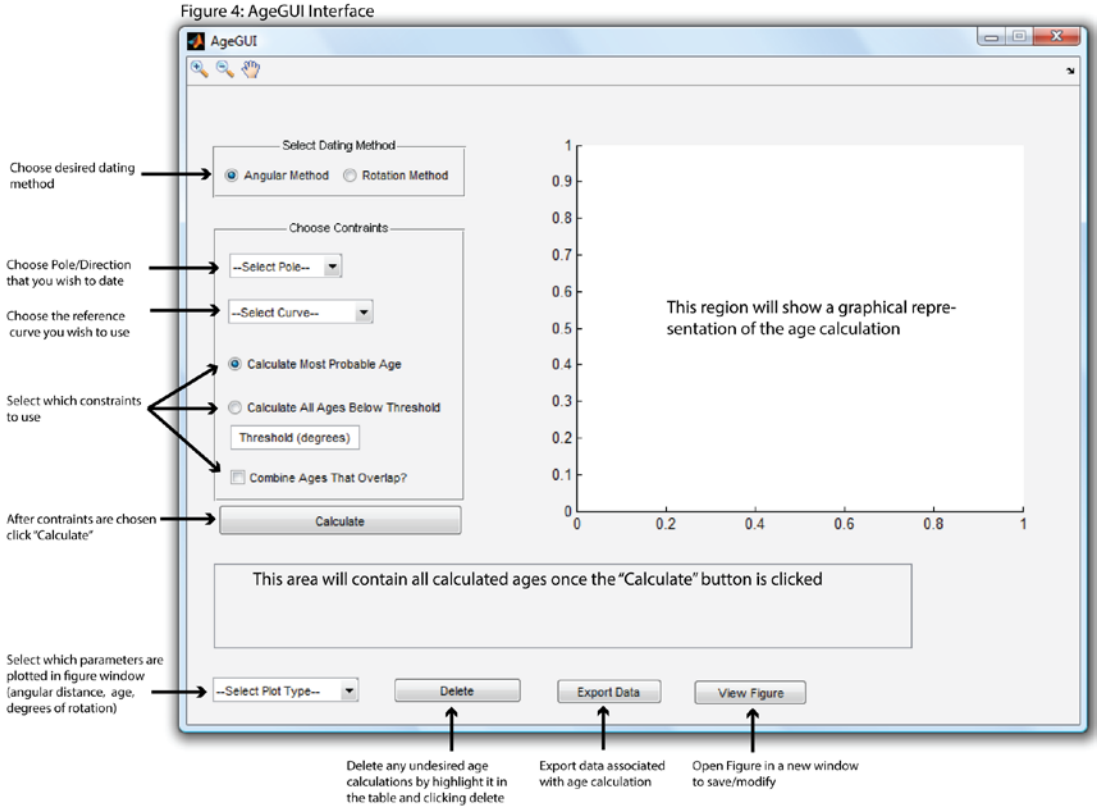
NOTES

* The example given here is using APWP with the parameters shown in Figure 1

*Note that rotation mode is disabled in SV mode

*Switching between methods clears any previously calculated data!

Figure 4: AgeGUI Interface



How to read the output table

The following data will be found in the data table.

Angular Mode

Pole - The name of the pole that was chosen to date

APWP - The selected reference curve used for the calculation

Age - The age associated with the pole that was translated to the reference curve

Plus - The upper bound error on the age

Minus - The lower bound error on the age

Angular Distance - The distance (in degrees) between the original pole (as defined in PlotGUI) and the translated pole (i.e. the pole that was translated on to the reference curve).

Plot - Plot the results in the graph

Rotation Mode

Pole - The name of the pole that was chosen to date

APWP - The selected reference curve used for the calculation

Age - The age associated with pole that was translated to the reference curve

Plus - The upper bound error on the age

Minus - The lower bound error on the age

Angular Distance - The distance between the pole (that was rotated along the small circle through a specific rotation) and the APWP.

Rotation - The clockwise rotation required to obtain the calculated age

Plot - Plot the results in the graph

Using Angular Method - Most Probable Age (Figure 5)

This method will translate your pole (or direction) to the closes point on the reference curve.

Once you select your pole, reference curve, and the "Calculate Most Probable Age" radio button, click the “Calculate” button. The results will be reported in the table at the bottom of the interface.

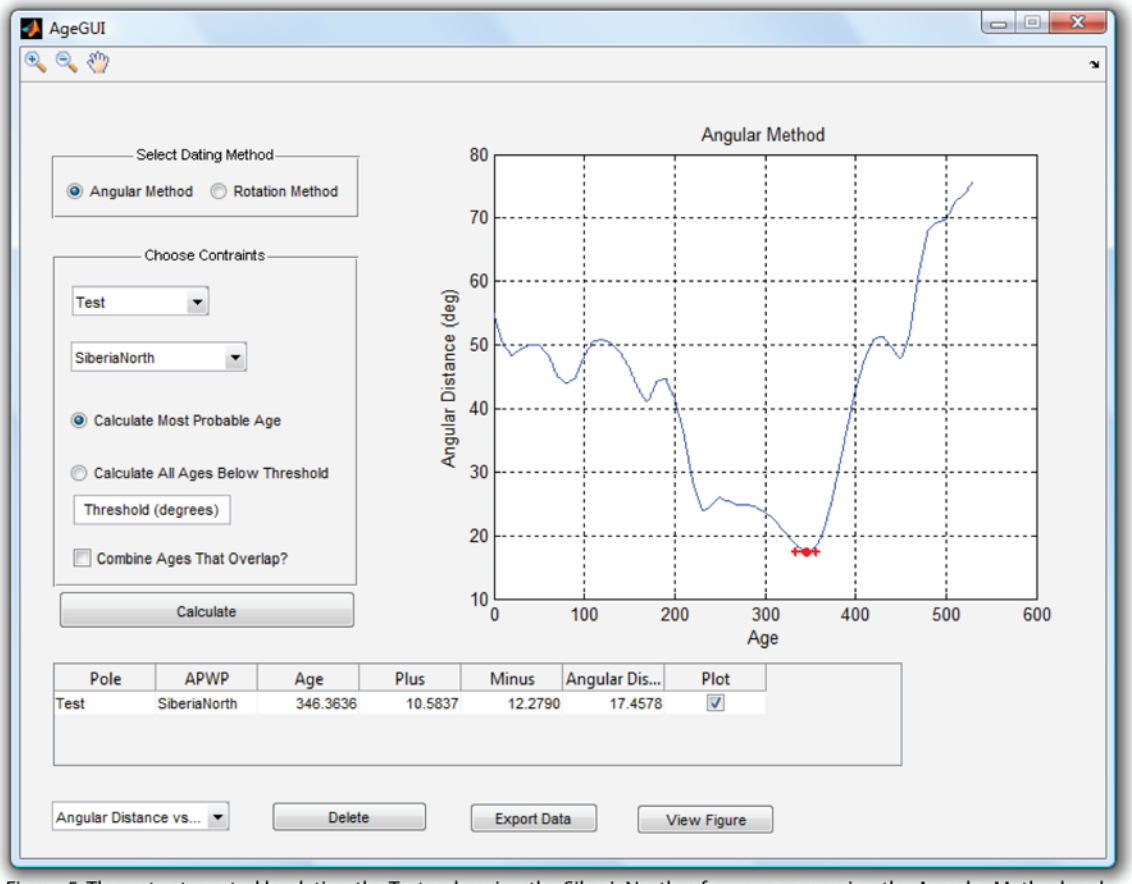


Figure 5: The output created by dating the Test pole using the SiberiaNorth reference curve using the Angular Method and choosing to find the most probable age. The calculated age is $346.4^{+10.6}_{-12.3}$ after a translation of 17.5 degrees.

Using Angular Method - Calculate All Ages Below Threshold (Figure 6)

To determine other potential ages that a pole may have you can choose to find all ages (i.e. minima) below a certain threshold.

To do this select the "Calculate All Ages Below Threshold" button and input the desired threshold (in degrees) into the textbox and click "Calculate".

Example:

Using the parameters from Figure 1 we may choose to find all ages below an angular distance of 30 degrees (Figure 6). In this case four ages were determined to potentially exist within the threshold of 30 degrees.

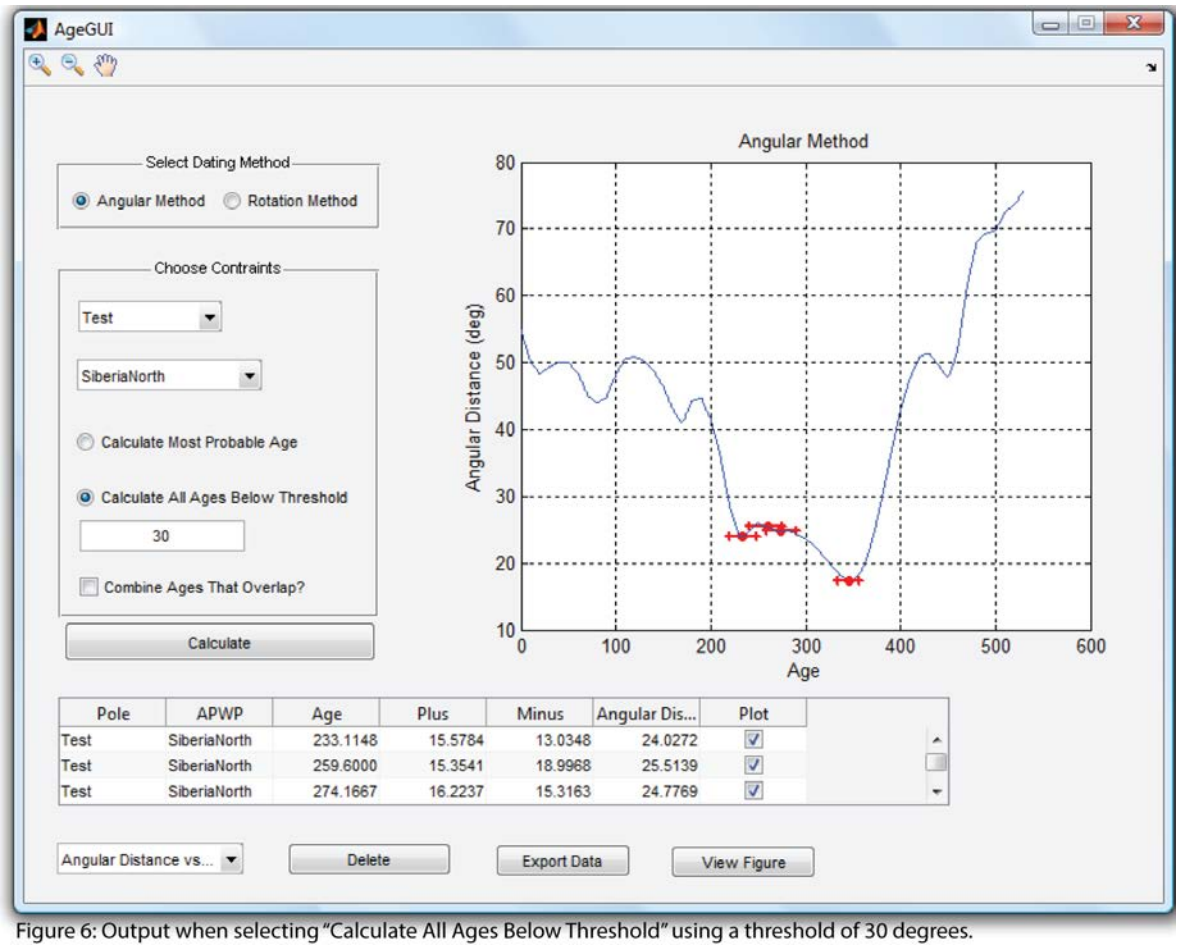


Figure 6: Output when selecting "Calculate All Ages Below Threshold" using a threshold of 30 degrees.

Using Angular Method - Combining Ages (Figure 7)

In some cases when multiple ages are calculated the error bars will overlap. In these cases they may not be statically different enough from each other to warrant separating them into separate ages. Therefore it may useful to combine the error bars when overlap between ages occurs.

Example:

Consider the case show in Figure 6 where there are two distinct clusters of ages. By selecting the "Combine Ages That Overlap?" checkbox and then clicking the "Calculate" button we will merge any error bars that overlap (Figure 7).

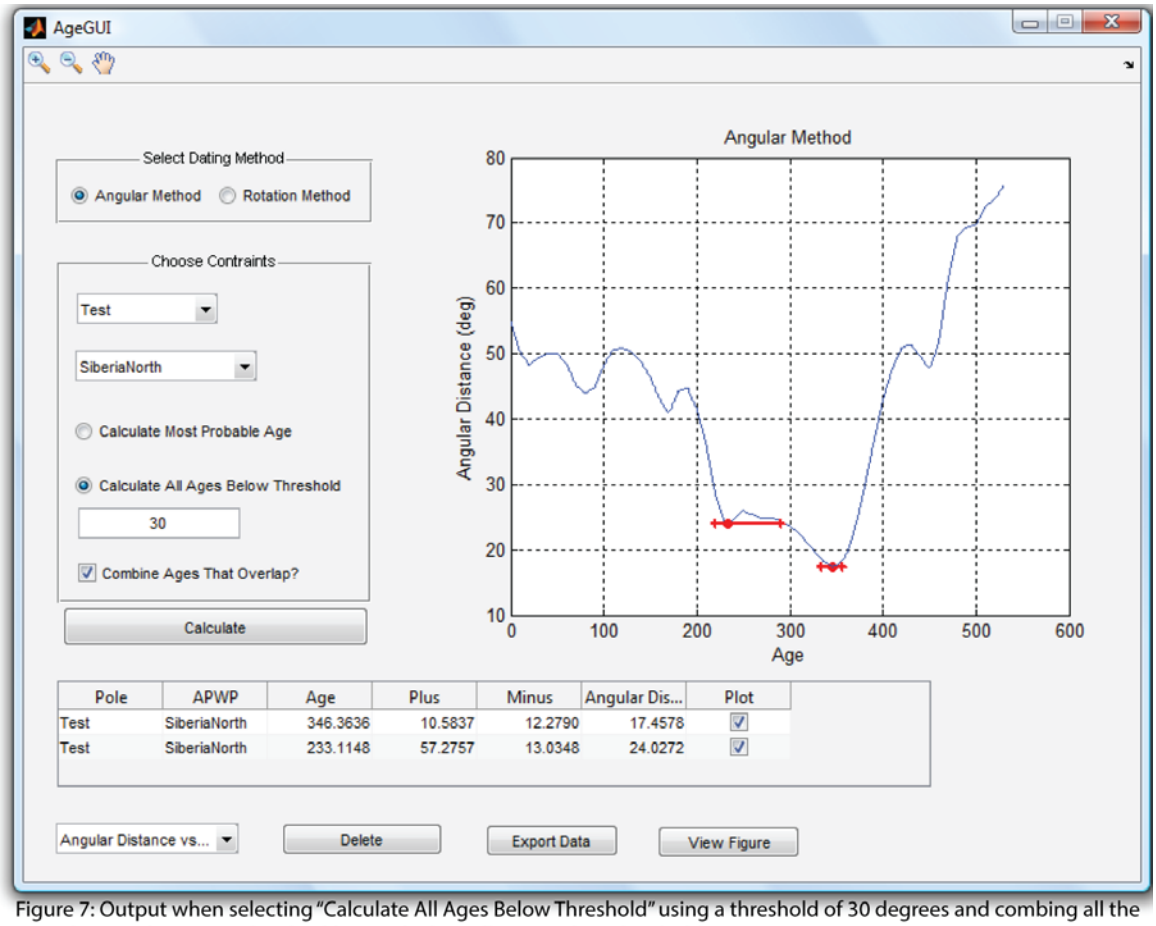


Figure 7: Output when selecting "Calculate All Ages Below Threshold" using a threshold of 30 degrees and combing all the ages that overlap (using the checkbox "Calculate All Ages Below Threshold".

Using Rotation Method - Most Probable Age (Figure 8)

***Note this mode is disabled in SV mode.**

This method will translate your pole along a small circle centered on the site location and it will calculate how close the small circle comes to the APWP. An interaction occurs

when the angular distance between the small circle and the APWP goes to zero. There may be multiple intersections and therefore multiple ages will be calculated

Once you select your pole, reference curve, and the "Calculate Most Probable Age" button, click “Calculate”. The results will be reported in the table at the bottom of the interface.

Example:
Using Rotation Mode on the data from Figure 1 will result in three calculated ages. These three ages represent intersections (angular distance ~0) between the small circle and the APWP.

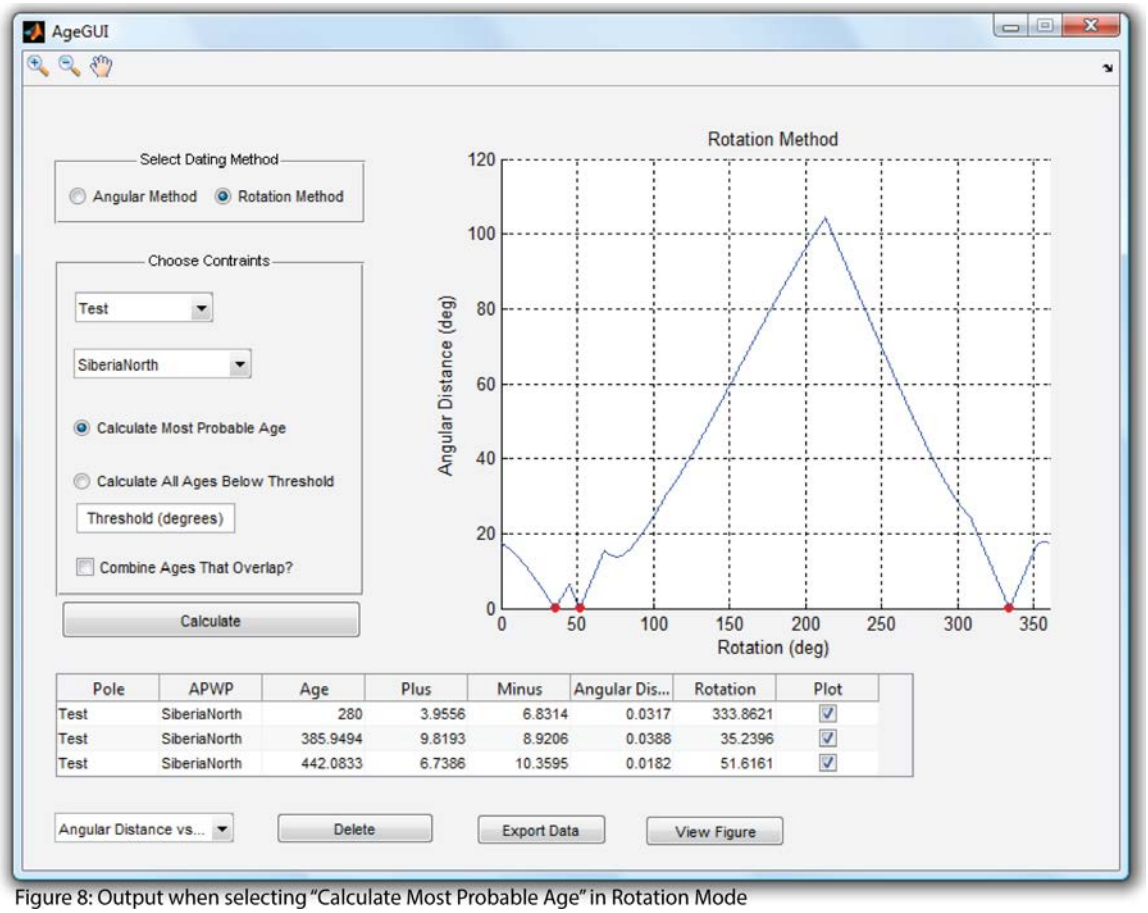


Figure 8: Output when selecting “Calculate Most Probable Age” in Rotation Mode

Using Rotation Method - Calculate All Ages Below Threshold (Figure 9)

To determine other potential ages that a pole may have you can select to find all ages (i.e. minima) below a certain threshold.

To do this select the "Calculate All Ages Below Button" and input the desired threshold (in degrees) in the textbox below and click "Calculate".

Example:
Using the parameters from Figure 1 we may choose to find all ages below an angular distance of thirty degrees (Figure 9). In this case four ages were determined to potentially exist within the threshold of 30 degrees. Three of these ages are intersections between the small circle and the APWP (as in Figure 8). One additional age is found at a rotation of 76^{o} that lays 13.8^{o} from the APWP. This location on the small circle is translated to the APWP (using the Angular Method) to determine its age.

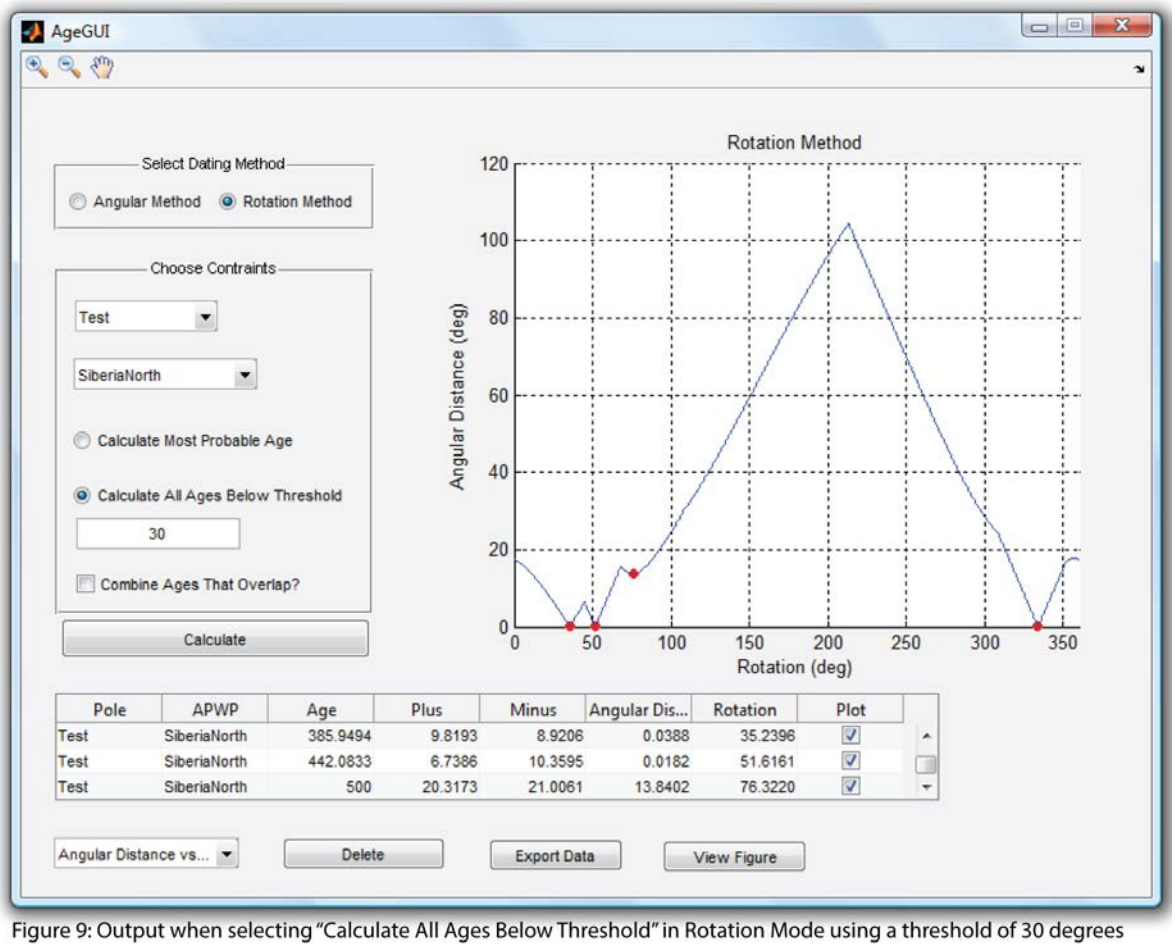


Figure 9: Output when selecting "Calculate All Ages Below Threshold" in Rotation Mode using a threshold of 30 degrees

Using Rotation Method - Combining Ages

Please See: Using Angular Method - Combining Ages (Figure 7)

Plotting Options

Plotting Data

In PlotGUI you have the option to plot the following data:

Prior to any age calculation:

- Any poles/direction inputted into the table
- Any reference curves loaded

After age calculations:

- The translated poles/directions associated with the calculated age(s)
- The intersection between the translated poles/directions and the reference curves
- If Rotation Mode was chosen, the small circle used for the age calculation can be plotted

Example:

Using the parameters from Figure 1, and choosing “Calculate Most Probable Age” with the Angular Method allows you to plot the translated pole and its intersection points (Figure 10).

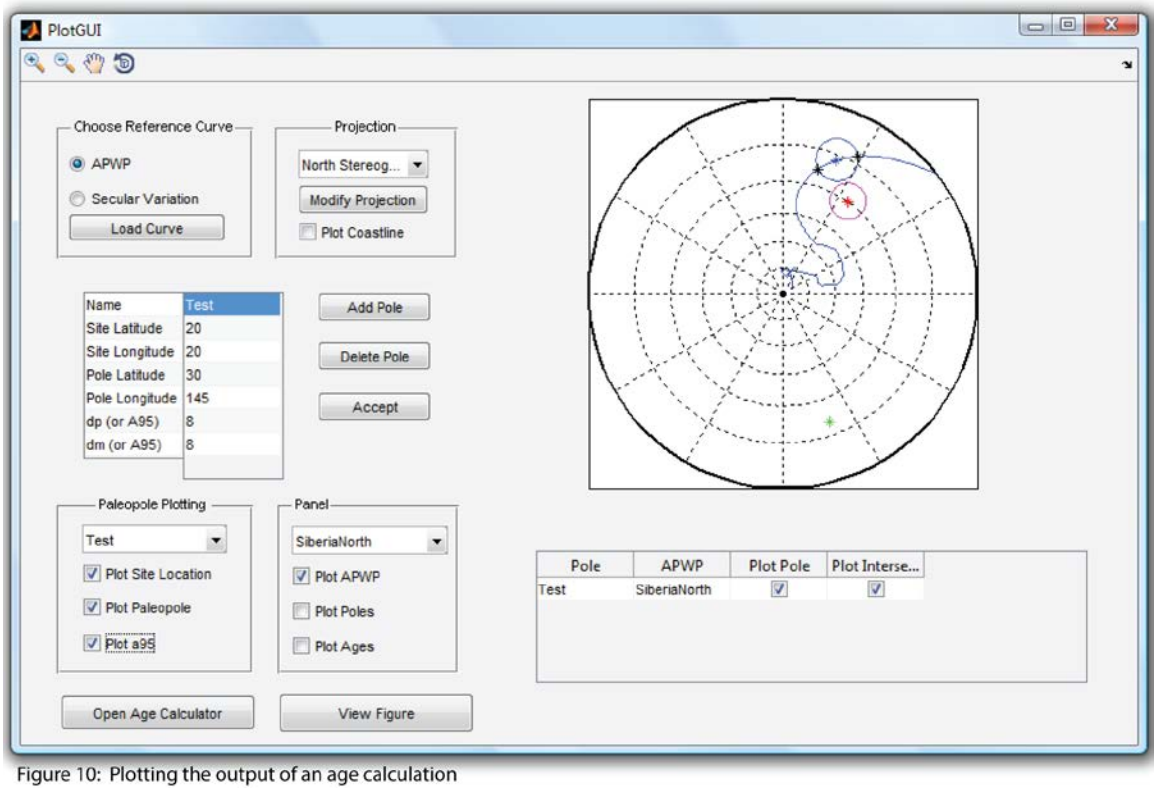


Figure 10: Plotting the output of an age calculation

Changing/Modifying Projections:

It is possible to change the shown projection used in PlotGUI using options in the "Projection" panel.

There are 3 default projections loaded into the software.

1) North Stereographic Projection - A stereographic projection centered on the North Pole
2) South Stereographic Projection - A stereographic projection centered on the South Pole
3) Equal Area Projection - Equal Area Azimuthal (Lambert) Projection

All of these can be modified by clicking on the "Modify Projection" button which brings up a projection control menu that allows you to change various aspects of the projection (Figure 11)

Alternatively selecting "Custom Projection" from the popup menu opens up the projection control menu that allows you to select a custom projection (Figure 11).

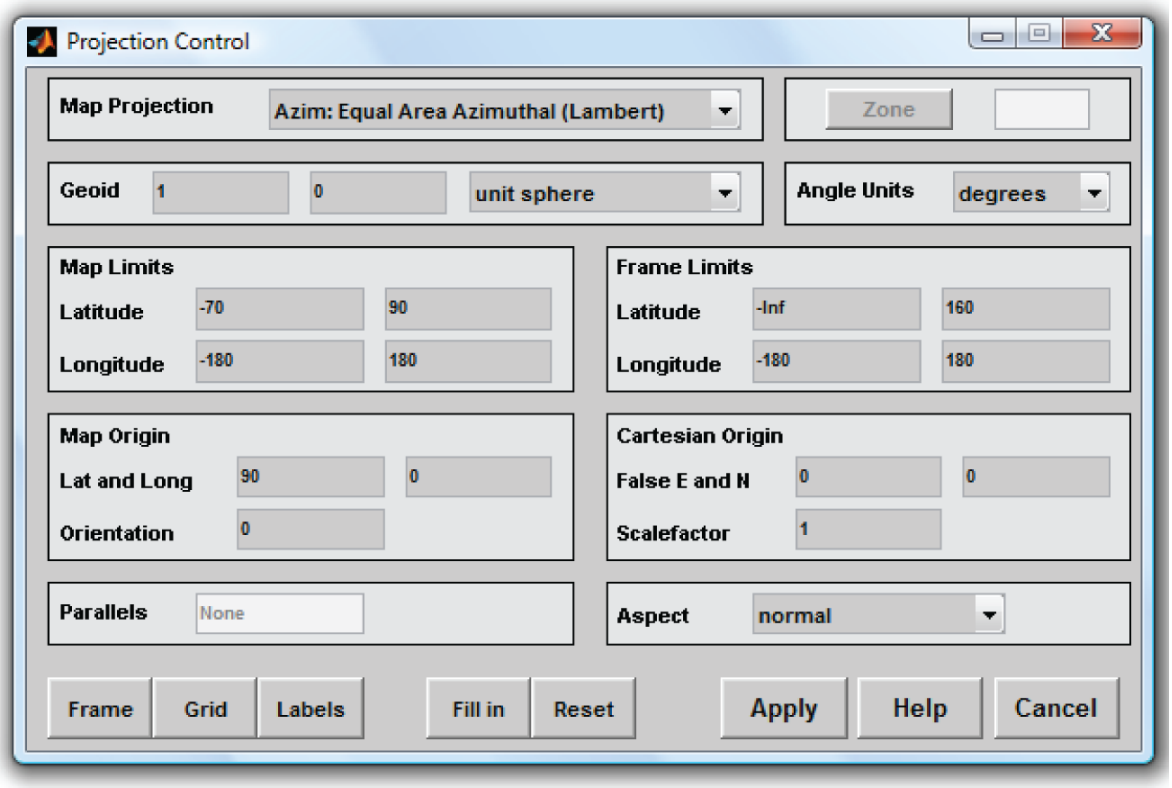


Figure 11: Menu for changing and modifying projection

Saving Figures/Data

Figures

To save a figure in PlotGUI or AgeGUI click on their respective "View Figure" buttons. This opens the figure up in a separate window where the figure can be modified or saved into a variety of formats (e.g. jpg, tif, eps, ect...)

Data

In AgeGUI clicking the "Export Data" button will allow you to export the following data into an excel file.

- Original input data (sheet name = input data)
    - Site Location
    - Inputted poles/directions

- Data Associated with age calculation (sheet name = age data)
    - Pole/Direction name
    - Reference curve used
    - Age of the pole/direction
    - Plus/Minus error of the pole/direction
    - Angular distance between pole/direction and reference curve
    - Clockwise rotation required for age calculation (Rotation Mode only)
    - Translated pole/direction coordinates
    - The coordinates of the intersections used to calculated the upper/lower bound error calculations

- Interpolated reference curve coordinates (sheet name = reference curve)

Known Bugs/Issues

- When selecting "Combine Ages That Overlap?" not all calculated poles/directions will be available to plot in PlotGUI. If these pole locations are required uncheck the "Combine Ages That Overlap?" checkbox and run the calculation, all poles will then be available to plot.

* NOTE: This will delete the any previous calculation done with "Combine Ages That Overlap?" check on. You may wish to export your data prior to recalculating data with "Combine Ages That Overlap?" unchecked.

It is possible that future MATLAB versions will become incompatible with this software due to changes in a functions code. These issues will be addressed as they are brought up.