

GPlates Tutorial:

Paleomagnetism

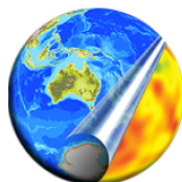
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Earth **BYTE**

Linking observations to kinematic and dynamic models

Working with Paleomagnetic Data in GPlates

INTRODUCTION

The Earth's magnetic field is described by its inclination (angle with respect to the local horizontal plane), declination (angle with respect to the Greenwich meridian) and field-strength. The inclination of the Earth's field varies systematically with latitude (Fig. 1), which is of prime importance for palaeomagnetic reconstructions. At the north magnetic pole the inclination of the field is $+90^\circ$ (straight down), at the Equator the field inclination is zero (horizontal) pointing north and at the south magnetic pole the inclination is -90° (straight up). The magnetic north and south poles currently differ from the geographic north and south poles by 11.5° because the magnetic axis is inclined from the geographic (= rotation) axis. The magnetic axis, however, is slowly rotating/precessing around the geographic axis (known as secular variation), and over a period of a few thousand years it is hypothesised that the averaged magnetic poles correspond reasonably with the geographic poles. This is known as the geocentric axial dipole (GAD) hypothesis.

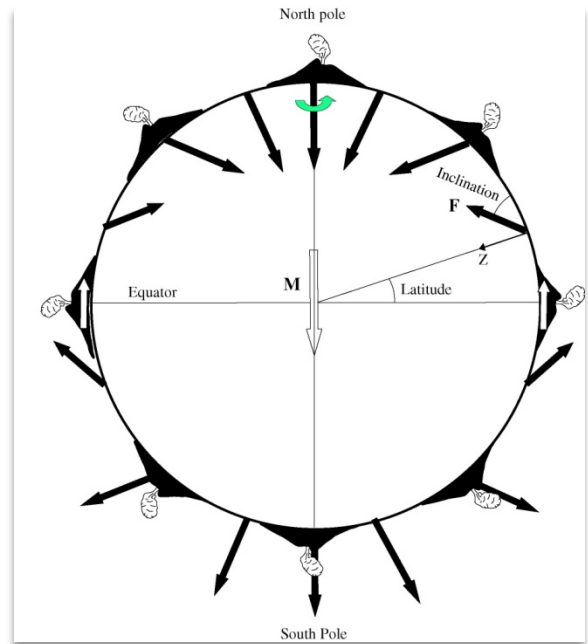


Figure 1. Inclination of the Earth's magnetic field and how it varies with latitude

Based on measurement of the remanent inclination we can calculate the ancient latitude for a continent when the rock formed from the dipole formula $\tan(I) = 2 * \tan(\text{latitude})$. In addition, the remanent declination, which deviates from 0° or 180° (depending of the polarity of the Earth's magnetic field), provides information about the rotation of a continent. The inclination and declination change with the position of the sampled rock on the globe, but the position of the magnetic pole of a geocentric axial dipole is independent of the locality where the rock acquired its magnetisation. Thus, it is practical to calculate pole positions in order to compare results from various sites or to perform plate-tectonic reconstructions.

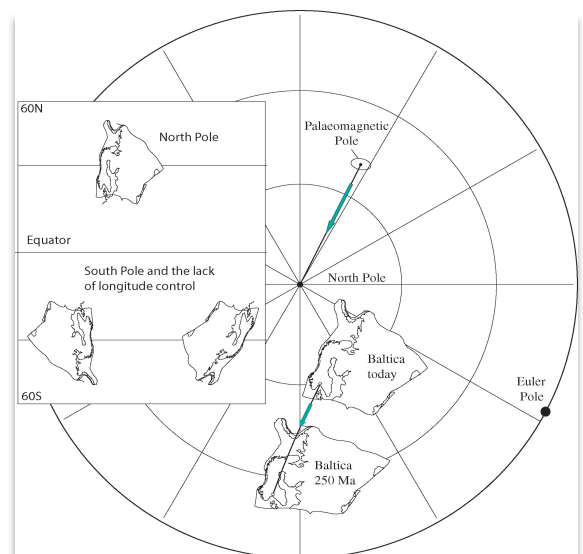


Figure 2. Reconstruction of Baltica with paleomagnetic poles. Inset reconstruction uses the south Paleomagnetic pole

Ideally, as a time average, a palaeomagnetic pole (calculated from declination, inclination and the geographic site location; Box 1 below) for a newly formed rock will correspond with the geographic north or south pole. If a continent moves later, the palaeomagnetic pole must move with the continent. To perform a reconstruction with palaeomagnetic poles we therefore have to calculate the rotation (Euler) pole and angle which will bring the palaeomagnetic pole back to the geographic north or south pole, and then rotate the continent by the same amount. In our example (Fig. 2), a palaeomagnetic pole (latitude= 49.3°N , longitude= 152.3°E), calculated from the situation depicted in the diagram, will position the Baltica palaeo-continent (most of northern Europe eastward to the Urals) at latitudes

between 15-50°N, causing the city of Oslo to have been located at 24°N in the Late Permian. Because the current latitude of Oslo is 60°N, Baltica must have drifted northwards since the Permian.

Palaeomagnetic data can only constrain latitude (based on inclination) and the amount of angular rotation (based on declination). Because the palaeolongitude is unknown, we can position a continent

BOX 1 (after Butler 1992)

A palaeomagnetic pole position (λ_p , ϕ_p) is calculated from a site-mean direction (I_m , D_m) measured at a particular site (λ_s , ϕ_s). The first step is to determine the magnetic colatitude, p , which is the greatcircle distance from site to pole. From the dipole formula:

$$p = \cot^{-1}\left(\frac{\tan I_m}{2}\right) = \tan^{-1}\left(\frac{2}{\tan I_m}\right)$$

Pole latitude is given by:

$$\lambda_p = \sin^{-1}(\sin \lambda_s \cos p + \cos \lambda_s \sin p \cos D_m)$$

The longitudinal difference between pole and site is denoted by β , is positive toward the east, and is given by:

$$\beta = \sin^{-1}\left(\frac{\sin p \sin D_m}{\cos \lambda_p}\right)$$

At this point in the calculation, there are two possibilities for pole longitude. If

$$\cos p \geq \sin \lambda_s \sin \lambda_p$$

then

$$\phi_p = \phi_s + \beta$$

But if

$$\cos p < \sin \lambda_s \sin \lambda_p$$

then

$$\phi_p = \phi_s + 180^\circ - \beta$$

at any longitude we wish subject to other geological constraints. However, this degree of freedom can be minimized by selecting an appropriate reference plate; in other words, if one can determine which plate (or continent) has moved longitudinally the least since the time represented by a reconstruction, then that plate should be used as the reference plate (Burke & Torsvik 2004; Torsvik et al. 2008). Africa is the most ideal candidate to minimize longitude uncertainty, and thus in the GPlates rotation file, all plates are first reconstructed relative to Africa with appropriate plate-circuits and then a global apparent polar wander (APW) path constructed in African co-ordinates are used to position all plates at their correct latitude and best possible longitude.

In addition to longitude, we cannot tell in old rocks whether a palaeomagnetic pole is a South or North pole. In the top inset of Figure 2 we assumed that the pole was a North pole, but if we used a South pole, Baltica would plot in the southern hemisphere but in a geographically inverted orientation (Fig. 2, bottom inset). Hence, there is freedom to select north or south poles when producing reconstructions, placing the continent in an opposite hemisphere and rotated by 180 degrees — this is not a major problem since Mid-Late Palaeozoic times.

APW paths represent a convenient way of summarising palaeomagnetic data for a continent or terrane instead of producing palaeogeographic maps at each geological period. APW paths represent the apparent motion of the rotation axis relative to the continent depending on whether one plots the movement of the North or South Pole. APW paths can therefore be constructed as north or south paths. To construct an APW path, a set of palaeomagnetic poles of varying geologic age are presented in a single diagram, and a synthetic path is fitted to the incrementing poles. There are three common methods for generating APW paths, (1) spherical splines, (2), running mean (sliding-time window) and (3) the small circle method. In our tutorial (next section) we include examples of APW paths that are generated with the running mean method averaged over a time-window of 20 Myr.

TUTORIAL FILES

All files are located in separate tutorial folder within the folder *SampleData* and are as follows:

Coastline Features:

101_North_America.shp	(North American craton)
102_Greenland.shp	(Greenland)
302_Balticat.shp	(Baltica)
GondwanaSome.shp	(South America, South Africa)
Arabia.shp	(Arabia)
Iran.shp	(Iran)
SouthChina.shp	(South China)
ELIP_CHINA_260Ma.shp	(Emeishan large igneous province)
SMEANSLOW1.shp	(1% slow contour in SMEAN tomography model)

Palaeomagnetic Mean Poles (GMAP Format; Torsvik & Smethurst 1999; data based on Torsvik et al. 2008a)

Europe2004_RM_Npoles.vgp	(Running mean stable Europe 0-330 Ma)
NorthAmerica2004_RM_Npoles.vgp	(Running mean North America 0-330 Ma)
Gondwana2010_RM_NPoles.vgp	(Running mean Gondwana in Africa frame)
Laurussia2010_RM_NPoles.vgp	(Running mean Laurussia in N. America frame)

Rotation Files (Europe and North America based on palaeomagnetic mean poles given above):

Baltica260PM.rot	(Euler rotation for Baltica at 260 Ma)
Baltica_Europe.rot	(Euler rotations for Baltica/Stable Europe)
North_America.rot	(Euler rotations for Baltica/Stable Europe)
Greenland_vs_NorthAmerica.rot	(Relative fits between Greenland and North America)
Laurussia_PM.rot	(Combined the 3 files above)
Pangea_PM.rot	(Euler rotations for some Pangea elements)
Pangea_A_PM.rot	(Euler for some elements in Pangea A)

TUTORIAL 1: Reconstruct a continent according to a palaeomagnetic pole

This is a typical task for a palaeomagnetist, that after fieldwork and lengthy laboratory work, has finally calculated a mean pole from his/her study and now wants to display the resulting reconstruction of the continent where the samples were derived from.

As an example, you have studied Permian 260 Ma volcanic rocks in the Oslo Rift (part of Baltica) and obtained a palaeomagnetic pole of $\sim 48.1^\circ\text{N}$ and 156.8°E with an error oval $A95=4.3^\circ$.

1. Go to *File* \rightarrow *Open Feature Collection* and select file `\SampleData\ Tutorial_1\302_Balticat.shp`
2. Go to *Paleomagnetism* \rightarrow *Create VGP* (Fig. 3) and type in properties. Type 48.1 and 156.8 for pole latitude and longitude, type 4.3 for A95 etc. (Fig. 4).
3. Click *Next* and then '< Create a new Feature Collection >'. Alternatively you can save your VGP pole to an existing Feature Collection (name of file can later be changed; see Tutorial 3) (Fig. 5).
4. Set *Time* to 260

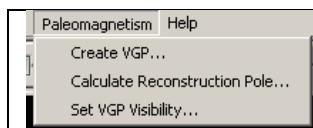


Figure 3. Step 2 – How to create a virtual geomagnetic pole (VGP)

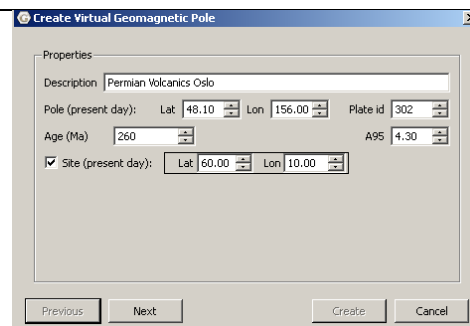


Figure 4. Step 2 – How to enter the values for your virtual geomagnetic pole

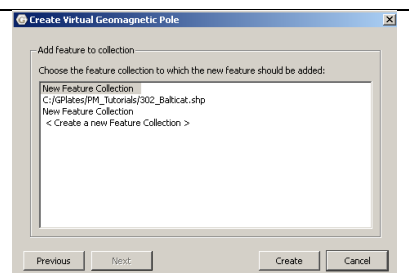


Figure 5. Step 3 - How to turn your VGP into a new feature collection

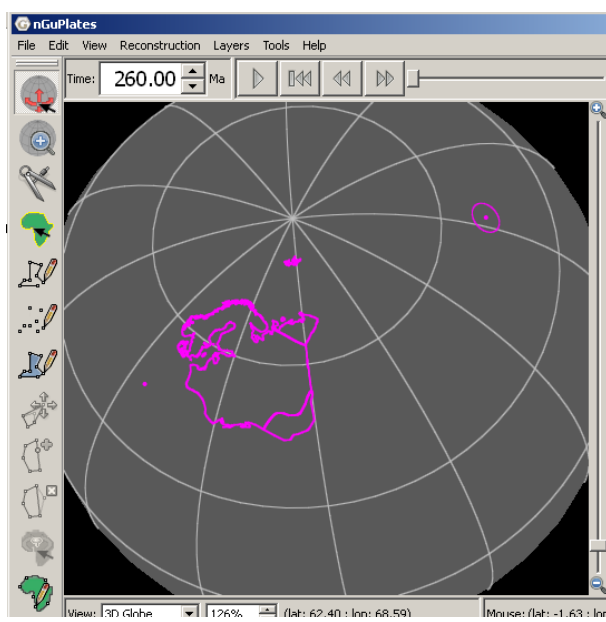


Figure 6. Baltica and its VGP

On the screen you should now see Baltica (302) and the VGP in its current position as we have not done any reconstructions yet (Fig. 6). In order to make a reconstruction we need to calculate the rotation pole (Euler poles) that will bring the VGP to the present-day North Pole (assuming that it is a north pole).

5. Go to *Paleomagnetism* \rightarrow *Calculate Reconstruction Pole* (Fig. 3) and type VGP latitude and longitude (48.1 and 156.8), Plate Id. (302) and age (260)(Fig. 7).
6. Select “North Pole” and click on *Calculate*

This should result in a reconstruction pole of

latitude=0 (will always be zero), longitude = 66.8 and angle = 41.9. In future GPlates versions this rotation pole can be directly inserted into a rotation file by clicking *Insert pole in rotation model*, but for now we must do this manually using a text editor (e.g. Wordpad). In this tutorial we have already prepared a rotation file (Fig. 8), and this file should be loaded as follows:

7. Go to *File* → *Open Feature Collection* and select the file
 \SampleData\ Tutorial_1\Baltica260PM.rot

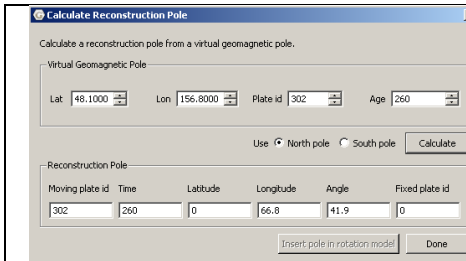


Figure 7. Step 5 – How to calculate reconstruction poles for your VGP

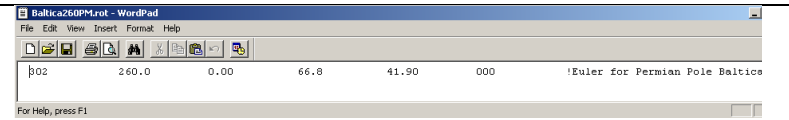


Figure 8. Prepared rotation file using reconstructed pole.

After loading the rotation files Baltica will be reconstructed to its Permian position and the pole will coincide with the present north pole (Fig. 9).

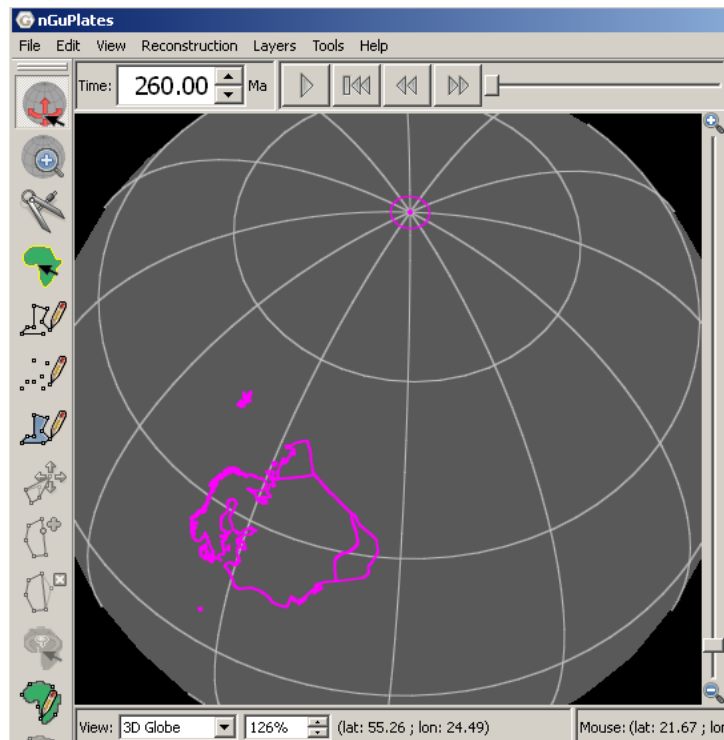


Figure 9. Baltica reconstructed to its Permian position, with its pole now coinciding with the present day north pole.

TUTORIAL 2: Reconstruct multiple continents with palaeomagnetic poles

1. Go to *File* → *Open Feature Collection* and select all files at \SampleData\Tutorial_2 as shown in Figure 10.

In this example we load three plates: North America (Plate Id.=101), Greenland (Plate Id.=102) and Baltica (Plate Id.=302) that all are Arc-GIS shape files (.shp). In addition we have opened APW paths for North America (file=NorthAmerica2004_RM_Npoles.vgp) and Baltica (file=Europe2004_RM_Npoles.vgp). These are running mean APW paths (20 Myr window) based on raw palaeomagnetic poles listed in Torsvik et al. (2008) with A95 confidence circles. Based on these APW paths we have already calculated Euler poles from these APW paths and built a rotation file (Laurussia.rot). The rotation file is the *'engine'* in GPlates and special attention is therefore required:

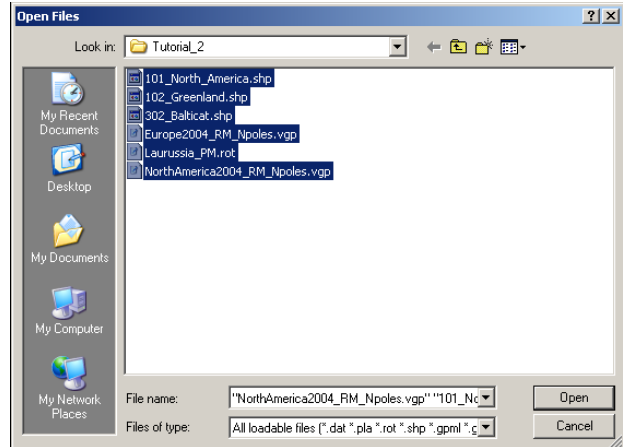


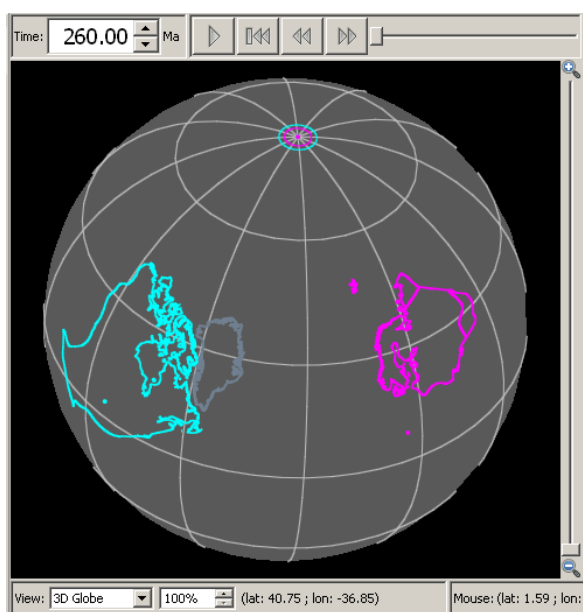
Figure 10. Step 1 – How to load multiple features into GPlates.

GPlates is delivered with a default rotation file but you can build your own using a standard text editor (e.g. WordPad). A rotation file follows the standard 'PLATES' format and contains 7 columns: Column 1 is Plate Identity (3 digit number), column 2 = time of reconstruction, column 3 = Euler latitude (always 0 when calculated from a palaeomagnetic pole), column 4 = Euler Longitude, column 5 = Euler angle, column 6 = rotation relative to plate XXX (000 is relative spin-axis and used for palaeomagnetic poles), column 7 is a comment and always started with an exclamation mark (see BOX 2).

BOX 2 GPlates rotation file (example Laurussia.rot)

Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7
101	0.00	0.00	0.0	0.0	000	!PM GLOBAL Torsvik et al. 2008
101	10.00	0.00	306.05	4.90	000	!PM GLOBAL Torsvik et al. 2008
101	20.00	0.00	58.38	5.78	000	!PM GLOBAL Torsvik et al. 2008
101	30.00	0.00	73.95	7.03	000	!PM GLOBAL Torsvik et al. 2008
101	40.00	0.00	73.51	7.12	000	!PM GLOBAL Torsvik et al. 2008
101	50.00	0.00	72.21	8.70	000	!PM GLOBAL Torsvik et al. 2008
101	60.00	0.00	81.65	12.01	000	!PM GLOBAL Torsvik et al. 2008
101	70.00	0.00	100.43	13.49	000	!PM GLOBAL Torsvik et al. 2008
etc.						
102	0	0	0	0	101	!GRN-NAM
102	33.058	0	0	0	101	!LABRADOR SFS STOPS
102	47.906	62.8	260.9	-2.8	101	!GRN-NAM AN21
102	53.347	40.64	243.07	-3.615	101	!GRN-NAM AN24
102	55.904	20.3	221.8	-3	101	!GRN-NAM AN25
102	68.737	52.86	223.6	-6.28	101	!GRN-NAM AN31
etc...						
302	0.00	0.00	0.0	0.0	000	!Europe_Baltica Torsvik et al. 2008
302	10.00	0.00	15.11	4.78	000	!Europe_Baltica Torsvik et al. 2008
302	20.00	0.00	22.19	8.03	000	!Europe_Baltica Torsvik et al. 2008
302	30.00	0.00	62.60	9.70	000	!Europe_Baltica Torsvik et al. 2008
302	40.00	0.00	80.36	7.89	000	!Europe_Baltica Torsvik et al. 2008
302	50.00	0.00	74.75	13.37	000	!Europe_Baltica Torsvik et al. 2008
302	60.00	0.00	75.16	13.92	000	!Europe_Baltica Torsvik et al. 2008
etc.						

In our example file we have generated Euler poles for two plates, namely North America (101) and Baltica (302) based on palaeomagnetic poles. In addition we have included relative fits between Greenland and North America (Gaina 2002, unpublished; listed in Torsvik et al. 2008a); column 6 in the rotation file therefore contains the value 101 to tell the system that the Euler poles are Greenland (102 in column 1) relative North America (101 in column 6). This rotation file goes back to 330 Myr; you can type any reconstruction age ≤ 320 and GPlates will interpolate to any age from the original file.



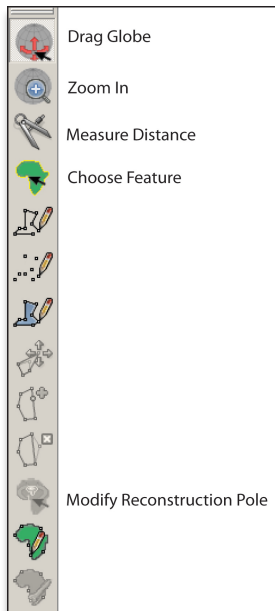
2. Type 260 in the 'Time' window and <RETURN>

A picture as in Figure 11 should now appear with North America and Baltica reconstructed and the poles should coincide with the North pole. The poles are shown within a time window of ± 5 Myr and will only coincide with the North pole when they are reconstructed to the exact age. Press the 'play' button (animation controls, above globe) to see how this works.

Figure 11. North America and Baltica reconstructed at 260 Ma.

TUTORIAL 3: Interactively modify a reconstruction: Updating the rotation file

- 1 Go to *File* → *Open Feature Collection* and select all files at \SampleData\Tutorial_3 (same data as used in Tutorial 2).
- 2 Type 260 in the 'Time' window and <RETURN>



The result of this procedure is already described above but we will now modify the relative position between Baltica and North America/Greenland. These plates were part of Pangea at this time and Baltica was located next to Greenland. However, since Baltica and North America were reconstructed with palaeomagnetic poles, their true longitude is undetermined, and we must correct this to produce a 'sensible' reconstruction.

- 3 Select 'Choose Feature' (Fig. 12) and click on Baltica.
- 4 Select 'Modify Reconstruction Pole'
- 5 Click on 'Constrain Latitude' in the dialog box to the right (Note: Since palaeomagnetic poles ideally should give you the correct latitude this tool makes sure that you can only move the continent in longitude; otherwise you can move the plate freely and rotate by pressing 'Shift' when you drag the plate. If you have two poles with error circles you can statistically move and rotate as long as error circles overlap).

Figure 12. Step 3 – How to choose a feature

- 6 Drag the plate until you are happy with the new fit between Greenland and Baltica (Fig. 13) and click 'Apply'.
- 7 'Apply reconstruction Pole adjustment' dialog will now appear (Fig. 14) and click 'OK' if you are happy with your choice.
- 8 Your new reconstruction (Euler) pole at 260 Ma is now stored only in memory: For permanent storage (Figs. 15 & 16) go to 'Manage Feature Collection' and save Laurussia_PM.rot (advised to make your own filename). How to manually manipulate longitudinal positions

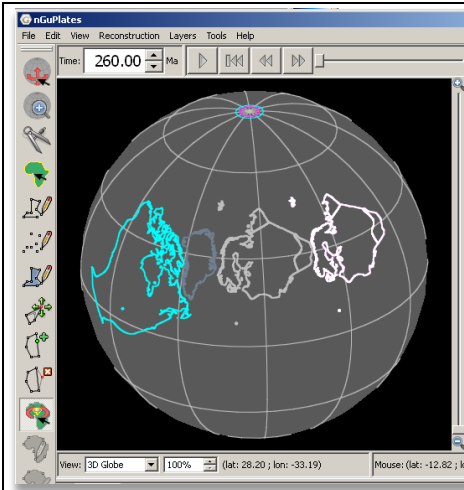


Figure 13. Step 6 – How to manually manipulate longitudinal positions

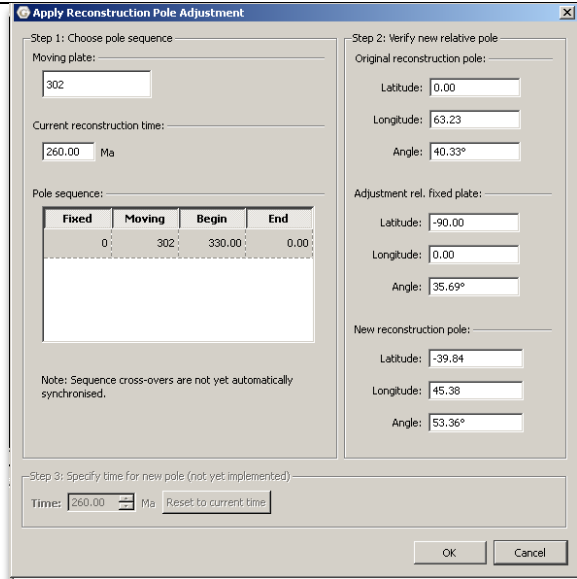


Figure 14. Step 7 – How to apply a new reconstruction pole adjustment

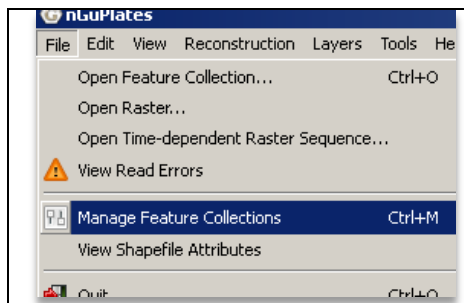


Figure 15. Step 8 – How to open the manage feature collections function to save new features

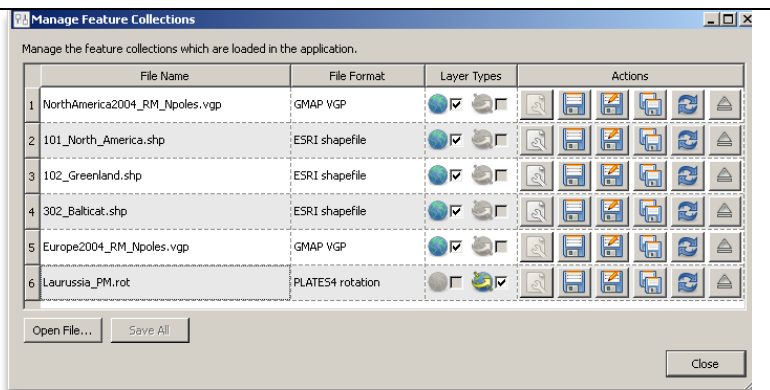


Figure 16. Step 8 – How to permanently save your new rotation files

TUTORIAL 4: Reconstructing 'Laurussia' from a combined APW path

1. Go to *File* → *Open Feature Collection* and select all files at \SampleData\Tutorial_4 (Fig. 17).
2. Type 260 in the 'Time' window and <RETURN> and Laurentia (North America, Greenland) and Baltica will be reconstructed (Fig. 18).

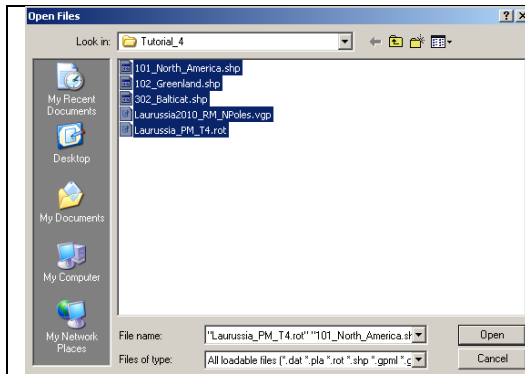


Figure 17. Step 1 – How to load feature collections

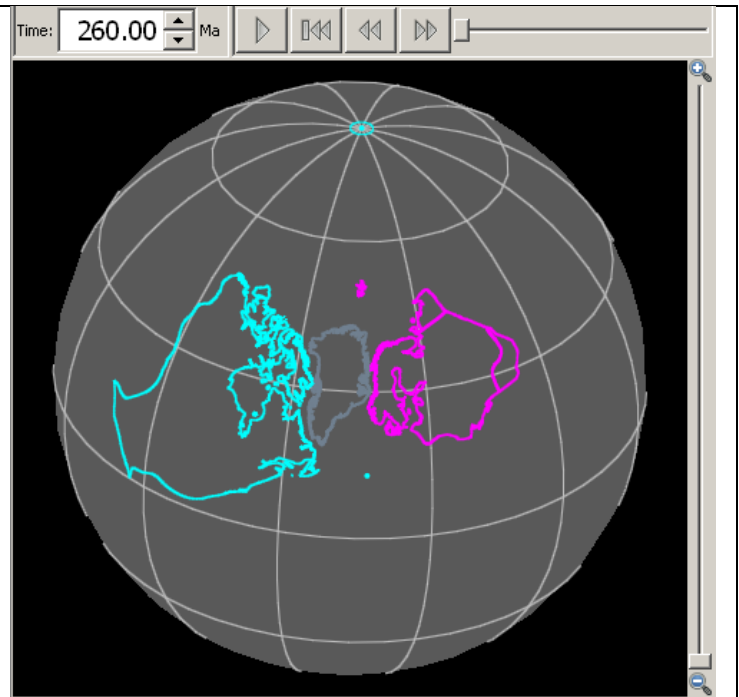


Figure 18. Step 2 – Reconstruction of North America, Baltica and Greenland

This tutorial essentially teaches you to get used to building rotation files that consist of palaeomagnetic data to position continents in latitude, orientation and relative plate circuits. The rotation file was built from a global apparent polar wander (APW) path in North American coordinates (File = Laurussia2010_RM_NPoles.vgp). We then calculated rotation (Euler) poles for each mean pole in 10 Myr intervals (Fig.19), and thus the first lines in the rotation file consist of North America (101) relative 000, which is the spin axis. The rotations can be used back to 320 Myr (i.e. when Pangea formed). After the North America rotations, follows relative plate motions between Greenland and North America (accounting for Labrador Sea/Baffin bay opening in the Late Cretaceous and Tertiary. Finally, the relative position of Baltica (now part of Europe, 302) is given vs. North America (101).

Familiarize yourself by typing different reconstruction times between 320 Ma and Today (Fig. 20). Also use the play animation functions and see how the reconstruction varies with time. Mean VGPs are shown at their true age ± 5 Myr by default (this can be changed in 'Paleomagnetism' menu). They should coincide with the north pole when the reconstruction time is exactly the same as the VGP age.

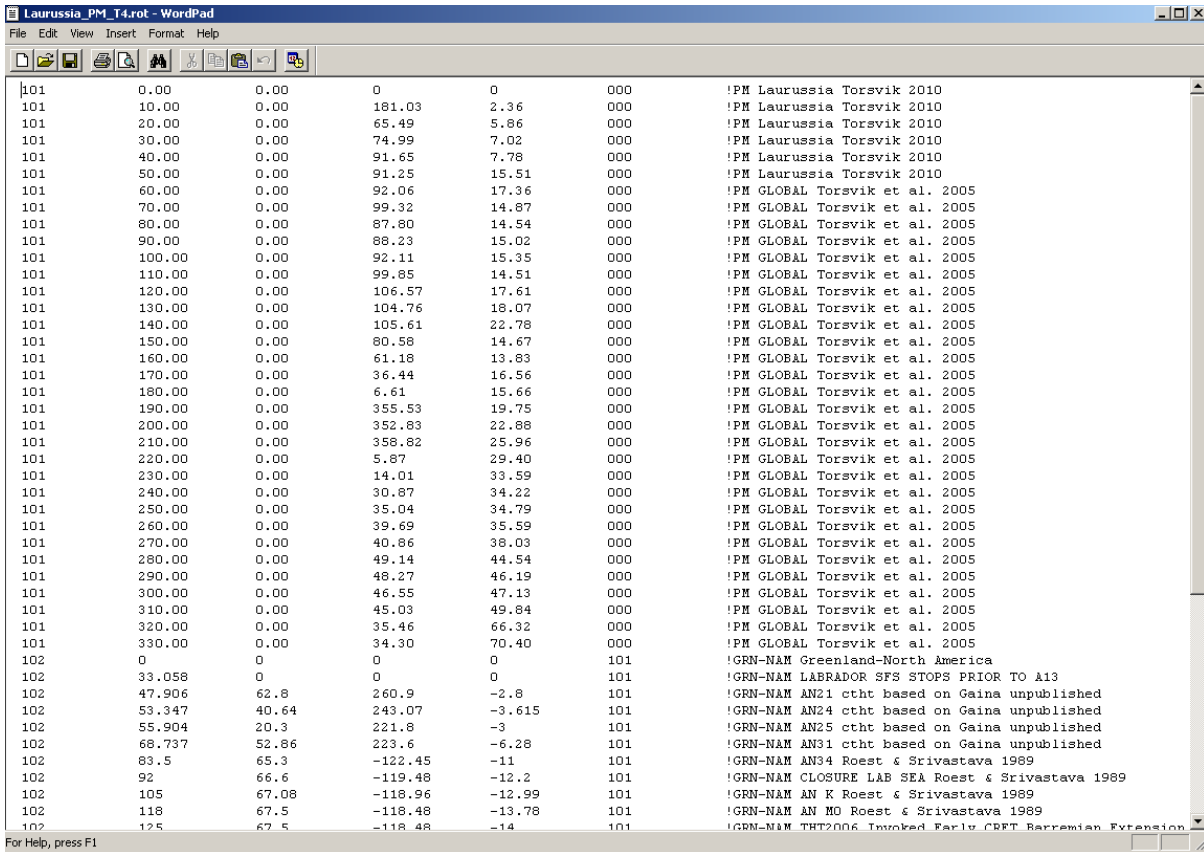


Figure 19. Rotation file

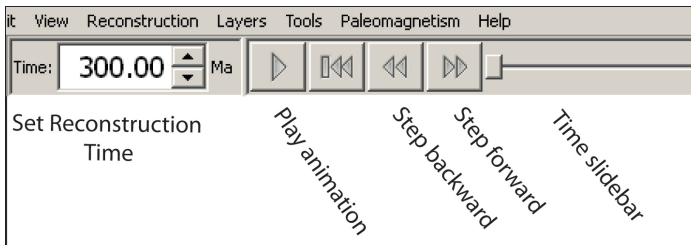


Figure 20. How to manipulate animation reconstruction time

TUTORIAL 5: The making of Pangea

1. Go to *File* → *Open Feature Collection* and select all files at \SampleData\Tutorial_5 (Fig. 21).
2. Type 260 in the 'Time' window and <RETURN> and parts of Laurussia (North America, Greenland, Baltica) and parts of Gondwana (Africa, South America) will be reconstructed (Fig. 22). Laurussia and Gondwana constituted the major parts of Pangea at this time but obviously our reconstruction does not look like the Pangea supercontinent when reconstructed from Laurussia (Laurussia2010_RM_NPoles.vgp) and Gondwana (Gondwana2010_RM_NPoles.vgp) — so what is wrong?

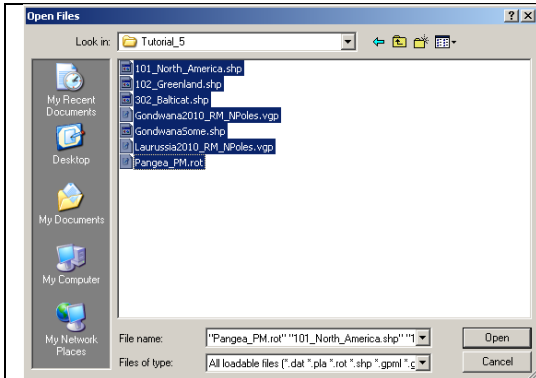


Figure 21. Step 1 – How to open tutorial 5's feature collection

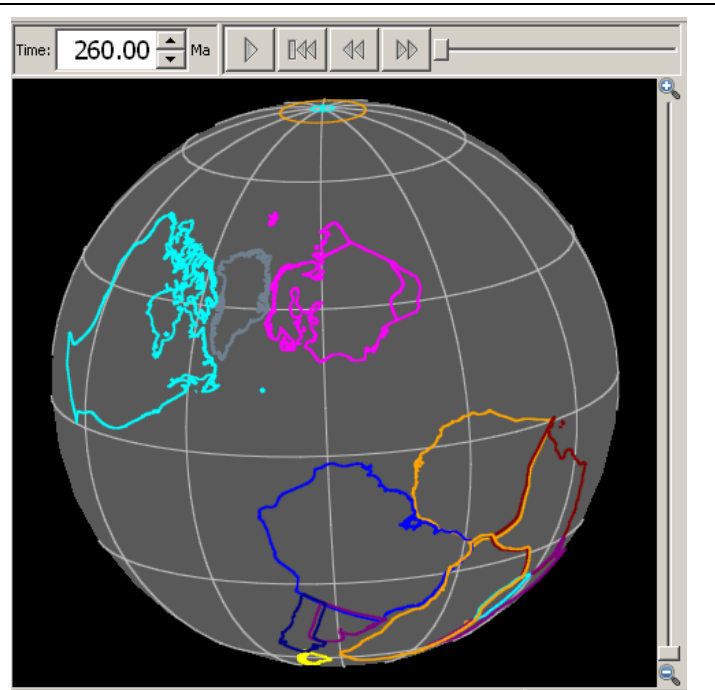


Figure 22. Step 2 – Reconstruction at 260 Ma. What is wrong with this picture?

The rotation file used in this exercise is Euler poles calculated from mean APW paths for Laurussia (in North American co-ordinates - 101) and Gondwana (in South Africa co-ordinates - 701) along with relative plate circuits to connect the various plates in this example. Since longitude is not constrained by palaeomagnetic data, Gondwana (South Pangea) and Laurussia (North Pangea) will not be in their correct relative longitude so we must move one of them sideways (E-W) to make a proper Pangea reconstruction.

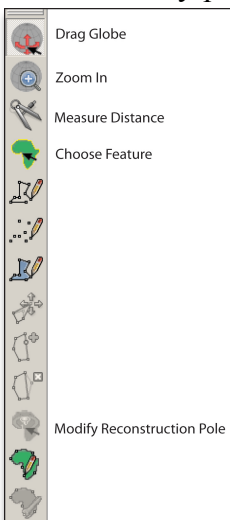


Figure 23. How to choose features

We have already described how to do this in Tutorial 3 but here follows the procedure:

- Select 'Choose Feature' (Fig. 23) and click on South Africa (this is the plate that the palaeomagnetic data in the rotation file relate to).
- Select 'Modify Reconstruction Pole'
- Click on 'Constrain Latitude' in the dialog box to the right
- Drag South Africa until you are happy with the new fit between Laurussia and Gondwana (Fig. 24) and click 'Apply'.
- 'Apply reconstruction Pole adjustment' dialog will now appear and click 'OK' if you are happy with your choice.

- Your new reconstruction Euler pole at 260 Ma is now stored only in memory: For permanent storage go to 'Manage Feature Collection' and save Pangea_PM.rot (advised to make your own filename).

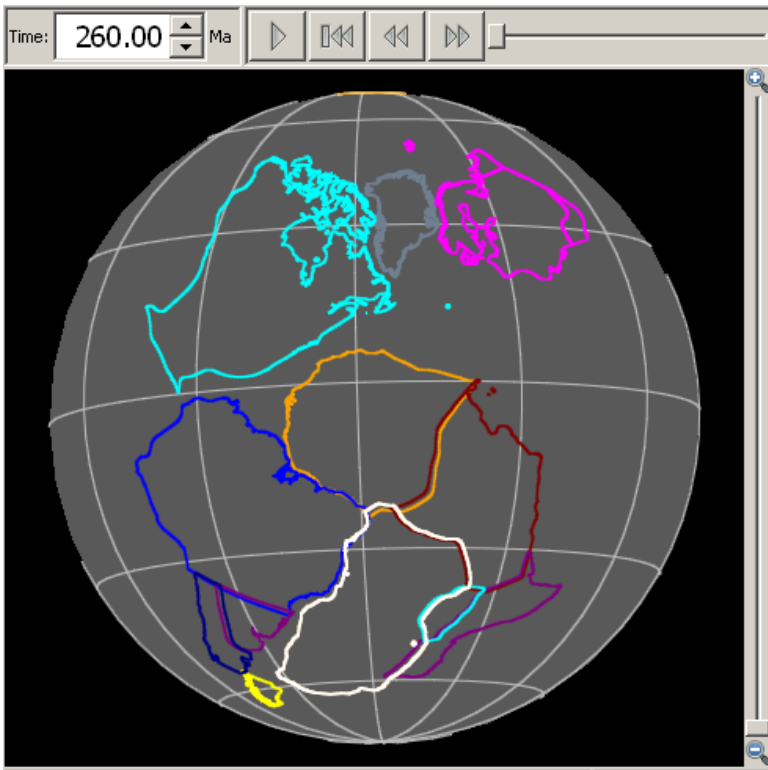


Figure 24. How to longitudinally adjust Gondwana.

TUTORIAL 6: The Plume Generation Zone method

Burke & Torsvik (2004) and Torsvik et al. (2006, 2008b) showed that the centers of most large igneous provinces (LIPs) of the past 300 Myr, when restored to their eruption sites, lie radially above one or other of two narrow belts centered on the 1% slow shear wave velocity contour of the SMEAN model of Becker & Boschi (2002) at the core-mantle-boundary (CMB). We can use the remarkable correlation between LIPs and CMB heterogeneities to estimate the longitudes for LIPs that erupted on plates that were not part of Pangea. As an example, the China blocks were unconnected to Pangea in late Permian times and have thus no longitudinal constraint. However, the 258 Ma Emeishan LIP in South China has excellent palaeomagnetic data that position it at 4°N. If this LIP erupted above the ~1% slow contour, there are five possible longitudinal locations where the 4°N line of latitude intersects or touches the 1% slow contour. Pangea covered the African large low shear velocity province (LLSVP) options, leaving only the two options related to the Pacific LLSVP.

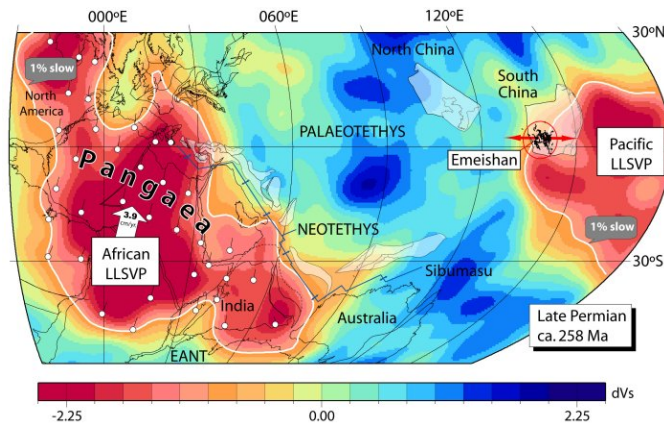


Figure 25. In late Permian times Pangea was centered above the African LLSVP (SMEAN model). Pangea did not include N and S China, which were located within the Palaeotethys Ocean. Because S China was not part of Pangea its longitudinal relation to South Africa is unknown and palaeomagnetic data allow it to be placed anywhere in palaeolongitude. However, if the 258 Ma Emeishan LIP was erupted from a plume derived from the 1% slow shear wave velocity contour in the lowermost mantle of one or other of the Earth's two major large low shear velocity provinces (LLSVP's), the most probable position would be along the western edge of the Pacific LLSVP (see Torsvik et al. 2008b)

A reconstruction with Emeishan erupting above the western margin of the Pacific LLSVP at 140°E (Fig. 25), is in fact the only likely position because the alternative that Emeishan erupted above the eastern margin of the Pacific LLSVP would yield unrealistically high plate convergence rates between Eurasia and South China (25-30 cm/yr) between the Late Permian and the Jurassic.

We will now show how this can all be done in GPlates.

1. Go to *File* → *Open Feature Collection* and select all files at \SampleData\Tutorial_6 (Fig. 26).
2. Type 258 in the 'Time' window (the age of the Emeishan LIP) and press <RETURN>, and parts of Laurussia (North America, Greenland, Baltica) and parts of Gondwana (Africa, South America, Arabia, Iran) will be reconstructed (Fig. 27).

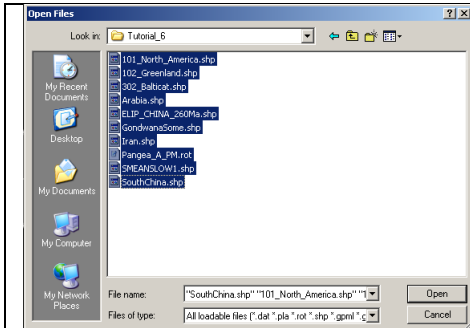


Figure 26. Step 1 - How to open tutorial 6's feature collection

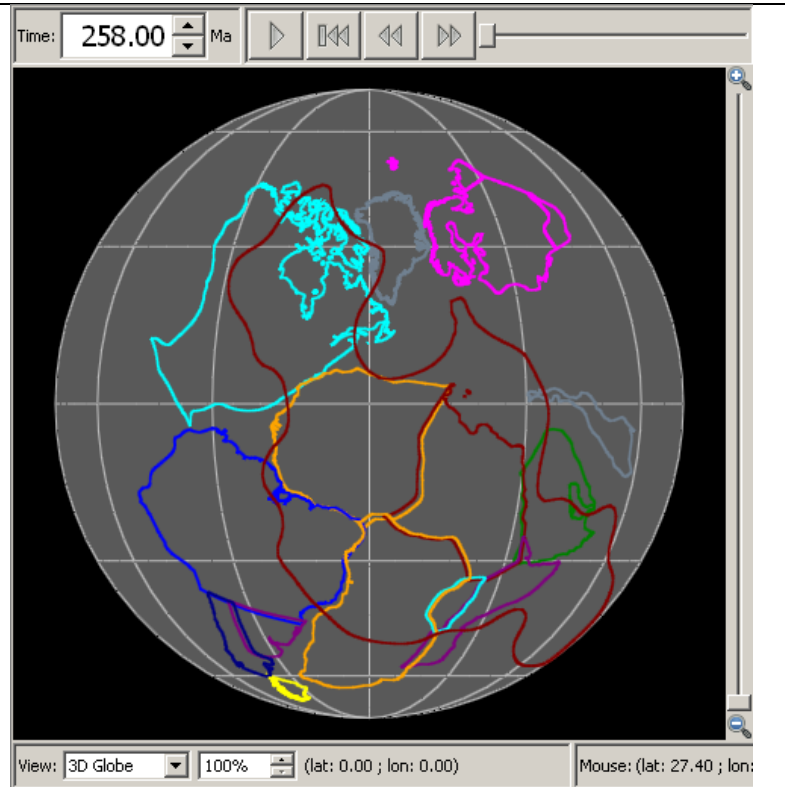


Figure 27. Step 2 – Reconstruction of Pangea with the Emeishan LIP and SMEAN contour files loaded.

The rotation file (only working between 300 and 250 Myr) is constructed in such a way that we now see a Pangea A reconstruction (many pieces not shown) with South China sitting at some distance away from Pangea in the Palaeotethys. All plates are relative to South Africa (701) except South China (602) which is based on its own palaeomagnetic data. The RED line is the 1% slow contour in the SMEAN model (this line is related to 0 i.e. the spin-axis and will thus not move at any time).

3. Turn the Globe so that South China will appear in the centre and you can see the margin of the Pacific LLSVP in red. The Emeishan LIP related volcanics are shown as numerous blue polygons (see black arrow in Fig. 28).
4. Select 'Choose Feature' (Fig. 23) and click on South China.
5. Select 'Modify Reconstruction Pole'
6. Click on 'Constrain Latitude' in the dialog box to the right
7. Drag South China until you are happy that the Emeishan LIP is centered around the 1% slow SMEAN contour (red line in Fig. 29) and click 'Apply'.
8. 'Apply reconstruction Pole adjustment' dialog will now appear and click 'OK' if you are happy with your choice.

- Your new reconstruction Euler pole at 258 Ma is now stored only in memory: For permanent storage go to 'Manage Feature Collection' and save Pangea_A_PM.rot (you are advised to make your own filename).

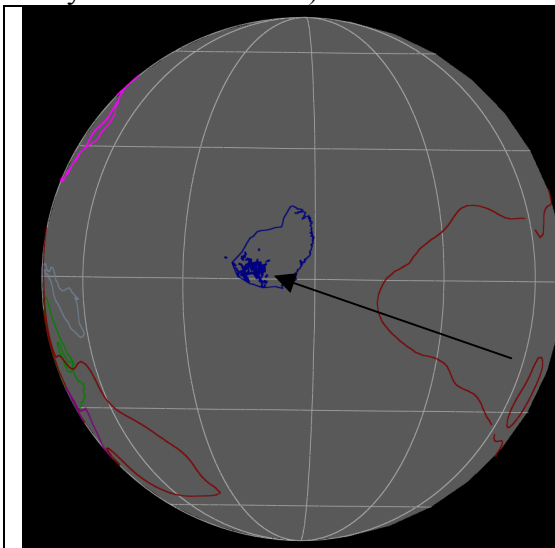


Figure 28. Step 3 – Readjusting the globe to center it on South China

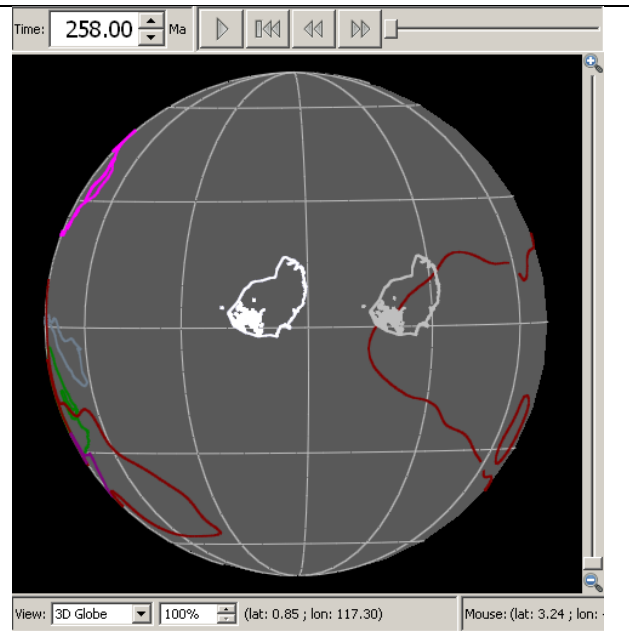


Figure 29. Step 7 – How to longitudinally adjust South China so it lines up with the SMEAN contour

GPlates also handles raster graphics and we can therefore show the SMEAN model at 2800 km depth together with our shape features:

- Go to *File* → *Open Raster* and select tomo-2800.jpg at \SampleData\Tutorial_6 (Fig. 30).

The SMEAN model should now appear (Fig. 31); the two LLSVPs appear as red (hot but dense) and blue regions denote the fastest velocities (slabs?) in the deep mantle.

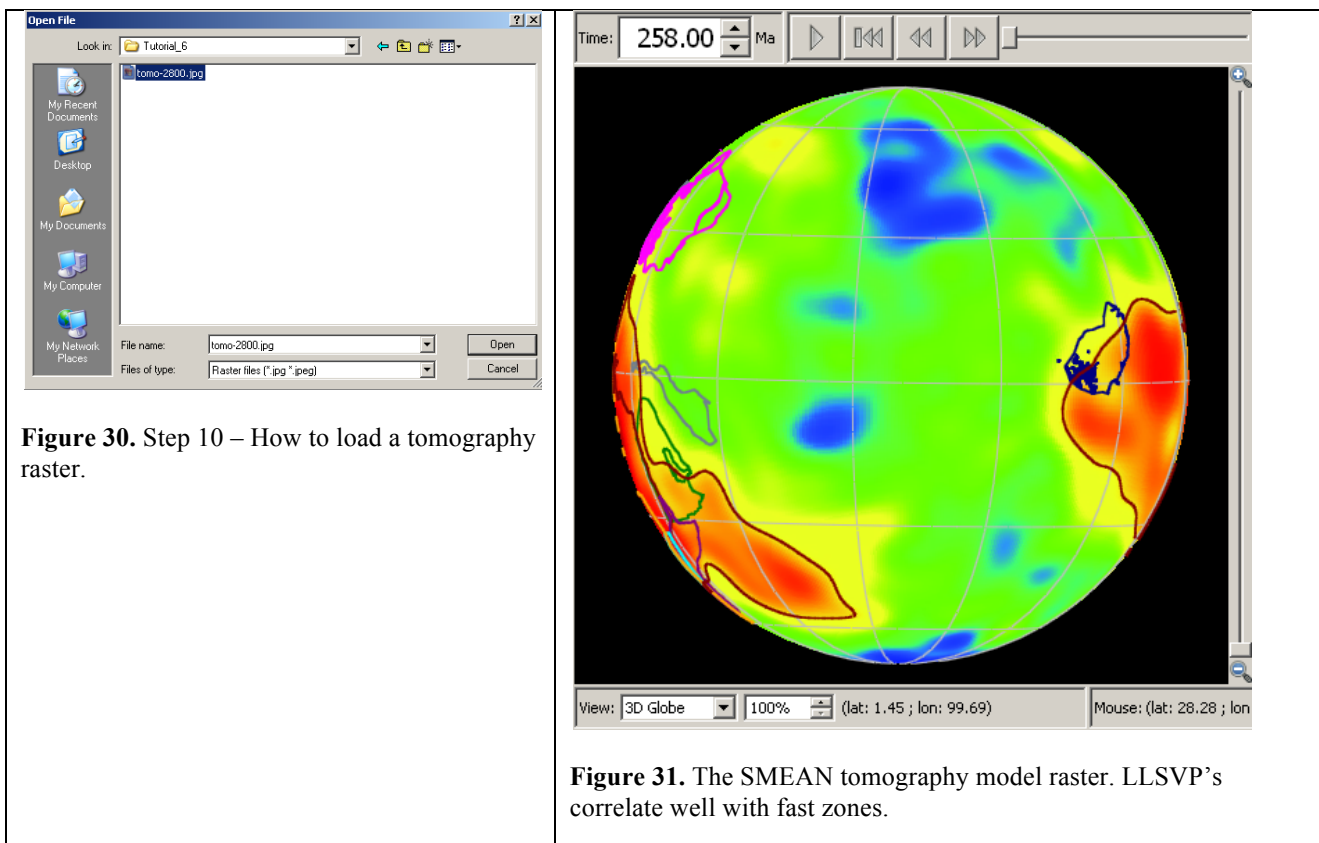


Figure 30. Step 10 – How to load a tomography raster.

Figure 31. The SMEAN tomography model raster. LLSVP's correlate well with fast zones.

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