Plate Reconstructions

Authors: Samantha Ross¹, Grace Shephard¹, Kara Matthews¹, Jo Whittaker¹ & Dietmar Muller¹

¹EarthByte Research Group, School of Geosciences, The University of Sydney, Australia

Plate Reconstructions

Aim Included files Background to Plate Rotation Models Background to Plate Rotation Models Plate ID Finite Rotations Total Reconstruction Poles Anchored Plate ID The Rotation Hierarchy Content of a rotation file Exercise 1 - Plate Hierarchy Exercise 2 - Reconstructing Data on the Globe Exercise 3 - Applying Rotations Exercise 4 - Modifying Rotations Exercise 5 - Exporting reconstructed geometries References

Aim

This is a condensed version of the tutorials designed to introduce the user to creating plate reconstructions with GPlates

Included files

<u>Click here</u> to download the data bundle for this tutorial.

The tutorial dataset (9.2-Plate_Reconstructions.zip) includes the following files:

Global Coastlines:

Seton_etal_ESR2012_Coastlines_2012.1_Polygon.gpmlz

Global Rotation File: Seton_etal_ESR2012_2012.1.rot

Australia Antarctica Rotation File: AusAnt_ExampleRotation.rot

Rotation File: Global_EarthByte_GPlates_Rotation_AusAnt_Example.rot

Australia - Antarctica Fracture Zones: AusAnt_FZs.gpml

List of Plate IDs for Seton et al (2012) Plate model: Seton_etal_ESR2012_PlateIDs.pdf

Background to Plate Rotation Models

If you do not have a background in plate motions, we recommend that you read Cox and Hart (1986). Below are some definitions used in this tutorial (see <u>GPlates User Manual</u> for further details):

Plate ID

A Plate ID assigns a feature to a plate or tectonic element that has moved relatively to other plates for some period during its geological history. A Plate ID is a non-negative integer number. Tectonic elements can include anything from large plates to island arcs and relatively small blocks or terranes in regions experiencing complex deformation. In GPlates we also assign separate Plate ID's to pieces of oceanic crust that were transferred from one plate to another by a ridge jump or propagation. Even though such pieces of crust were always part of one plate or another, we need to assign it a separate plate ID to model this process. The fixed reference frame of the Earth's spin axis is assigned Plate ID 0, whereas sections of the Earth's mantle that appear to have moved relatively coherently to other portions of the mantle can be assigned Plate IDs as well.

Finite Rotations

Euler's Displacement Theorem specifies that any displacement on the

surface of the globe can be modelled as a rotation about some axis. This combination of axis and angle is called a finite rotation and can be expressed as a latitude, longitude and angle of rotation. Finite rotations are used by GPlates as the elementary building blocks of plate motion.

Total Reconstruction Poles

Total Reconstruction Poles tie finite rotations to plate motion. A total reconstruction pole is a finite rotation which "reconstructs" a plate from its present day position to its position at some point in time in the past. It is expressed as the combination of a "fixed" Plate ID, a "moving" Plate ID, a point in time and a finite rotation.

Reconstructions are defined in a relative fashion; A single total reconstruction pole defines the motion of one plate id (the "moving" Plate ID) relative to another (the "fixed" Plate ID) at a specific moment in geological time. A sequence of total reconstruction poles is needed in order to fully model the motion of one particular plate across the surface of the globe throughout time.

Anchored Plate ID

A sequence of total reconstruction poles is used to model the motion of a single plate across the surface of the globe. Total reconstruction poles describe the relative motion between plates, but ultimately this motion has to be traced back to a single Plate ID which is considered "anchored". GPlates calls this the Anchored Plate ID. Generally, this Plate ID corresponds to an absolute reference frame, such as a hotspot, paleomagnetic, or mantle reference frame. The convention is to assign the anchored Plate ID to 000, but GPlates allows any Plate ID to be used as the anchored Plate ID.

The Rotation Hierarchy

To create the model of global plate rotations that is used in GPlates, total reconstruction poles are arranged to form a hierarchy, or tree-like structure. At the top of the hierarchy is the anchored Plate ID. Successive Plate IDs are further down the chain and linked by total reconstruction poles. To calculate the absolute rotation of a Plate ID of a feature with a given Plate ID (relative to the fixed reference defined by the anchored plate ID, at a given time), GPlates starts at that point in the hierarchy and works its way up to the top - to the root of the tree.

For example, in the GPlates-compatible 2008 EarthByte Global Rotation

Model, the South American plate (also known by the abbreviation "SAM", with plate ID 201) moves relative to the African plate ("AFR", 701), as does the Antarctic plate ("ANT", 802), while the Australian plate ("AUS", 801) moves relative to the Antarctic plate. This is illustrated in Figure 1.





Content of a rotation file

Figure 2 is a section from a rotation file. The basic content is the same in other file formats e.g. GPML.

Column 1: "Moving" Plate ID e.g. 652

Column 2: Time e.g. 0.0 (Ma)

Columns 3, 4, 5: Rotation poles. The first two are the coordinates of the pole of rotation (latitude, longitude), the third is the angle of rotation.

Column 6: Conjugate or "fixed" Plate ID (Rotations relative to this plate) e.g. 609

Column 7: Abbreviation of Plate and Conjugate Plate and name, and sometimes the relevant reference e.g. WPV-NPS West Parece Vela Basin – North Philippine Sea.

There are usually multiple entries for the same Plate ID, but with different times and rotation poles and, sometimes, different conjugate plates, to capture the rotation history of a given plate relative to neighboring, or conjugate plates. Which plate is assigned as a given plate's conjugate depends on the user. Generally this choice is determined by where most of the constraints for reconstructing the relative motion history are, and this can be time-dependent.

🔐 D:\Jar	mes\GPlates Tu	torial Updates\Data Bu	undle Updates\2.1-Plate_Reconstructions\Seton_etal_ESR2012_2012.1.rot - Notepad++	- • ×
File Ed	it Search Vi	ew Encoding Lan	guage Settings Macro Run Plugins Window ?	X
		۵۵ 🖌 🖌 🗅	🕽 🗲 🏙 🍇 🔍 👒 🗓 😳 🎫 1 📳 🕢 🔍 🔍 💷 🕑 🔤 🔤 🤯 🌾	
E Setor	_etal_ESR2012	_2012.1.rot		
1388	652 0.0	0.0 0.0	0.0 673 ! FAI-NSM Flores/Alor Islands-North Sumatra	*
1389	652 9.8	-8.08 130.54	1.0 673 ! FAI-NSM Lee & Lawver 1995	
1390	652 57.3	-8.08 130.54	1.0 673 ! FAI-NSM	
1391	653 0.0	0.0 0.0	0.0 608 ! NWC-SPS Northwest Caroline Sea-South Philippine Sea	
1392	653 15.0	9.87 132.0	-25.0 608 ! NWC-SPS Open Ayu Trough Gaina & Muller 2007	
1393	653 25.0	9.87 132.0	-25.0 608 ! NWC-SPS Gaina & Muller 2007	
1394	653 35.0	9.45 135.84	-13.98 608 ! NWC-SPS Gaina & Muller 2007	
1395	653 55.0	9.45 135.84	-13.98 608 ! NWC-SPS Gaina & Muller 2007	
1396	654 0.0	0.0 0.0	0.0 655 ! WCS1-WCS2 Western Caroline Sea 1-Western Caroline Sea 2	
1397	654 28.3	0.0 0.0	0.0 655 ! WCS1-WCS2 an9ro Gaina & Muller 2007	
1398	654 28.7	0.0 0.0	0.15 655 ! WCS1-WCS2 anlory Gaina & Muller 2007	
1399	654 29.4	-6.58 -0.42	1.67 655 ! WCS1-WCS2 anloro Gaina & Muller 2007	
1400	654 29.4	2.7 92.02	3.4 653 ! WCS1-NWC Western Caroline Sea 1-Northwest Caroline Sea an12 crossover	
1401	654 33.1	2.7 92.02	3.4 653 ! WCS1-WCS2 an12 Gaina & Muller 2007	
1402	655 0.0	0.0 0.0	0.0 692 ! WCS2-WCS3 Western Caroline Sea 2-Western Caroline Sea 3 an8ro cross-over	
1403	655 26.0	0.0 0.0	0.0 692 ! WCS2-WCS3 an8ro Gaina & Muller 2007	
1404	655 26.6	0.0 0.0	0.06 692 ! WCS2-WCS3 an8ro Gaina & Muller 2007	
1405	655 27.0	0.0 0.0	1.13 692 ! WCS2-WCS3 an8ro Gaina & Muller 2007	
1406	655 28.0	0.0 0.0	1.33 692 ! WCS2-WCS3 an9ry Gaina & Muller 2007	
1407	655 28.3	0.0 0.0	2.03 692 ! WCS2-WCS3 an9ro Gaina & Muller 2007	
1408	655 28.3	5.96 117.5	3.86 653 ! WCS2-NWC Western Caroline Sea 2-Northwest Caroline Sea Gaina & Muller 2007	
1409	655 29.4	5.96 117.5	3.86 653 ! WCS2-NWC	
1410	656 0.0	0.0 0.0	0.0 608 ! WAY-SPS Western Ayu Trench-South Philippine Sea	
1411	656 35.0	0.0 0.0	0.0 608 ! WAY-SPS	
1412	658 0.0	0.0 0.0	0.0 613 ! SCH-SCH South China Sea-South South China Sea	
1413	658 258.0	0.0 0.0	0.0 613 ! SCH-SCH Briais et al 1993	
1414	659 0.0	0.0 0.0	0.0 611 ! ESB-WSB East Shikoku Basin-West Shikoku Basin	
1415	659 15.0	0.0 0.0	0.0 611 ! ESB-WSB Sdrolias et.al 2004	-
•		<u> </u>	1 00 (11) BOD DO DI 1 1	E F
Normal te	ext file		length:351367 lines:4791 Ln:646 Col:9 Sel:0 UNIX ANSI	INS

Figure 2: Sample of a rotation file.

Exercise 1 - Plate Hierarchy

Here we will see what the plate hierarchy looks like in GPlates.

- 1. Open GPlates
- 2. File > Open Feature Collection... > Open the following files:
 - Coastlines: Seton_etal_ESR2012_Coastlines_2012.1_Polygon.gpmlz
 - Rotation: Seton_etal_ESR2012_2012.1.rot

3. Click and drag the globe to rotate it such that it is centred on the South Atlantic (Figure 3). You will see that all the plates are coloured according to their Plate ID.



Figure 3: Coastlines of the world, globe centred on the South Atlantic

We will now view the plate hierarchy of the files loaded

4. Reconstruction > View Total Reconstruction Poles (Figure 4) > Reconstruction Tree (third tab, Figure 5).

	K	Time:	44	Reconstruct to Time	Ctrl+T		Current Featu Type:	ire
E.			NN.	Step Backward One Frame	Chile I	Q	gpml:Coastline	-
	52		PP	Step Forward One Frame	Ctri+1	i Es	Name:	
0	(LAS			Reset Animation			Africa	
JA	2 and			Play Animation			Plate ID:	
-	14			Configure Animation			701	
	100						Valid time:	
N	1			Specify Anchored Plate ID	Ctrl+D		from 600	to future
۳ a	10			View Total Reconstruction Poles	Ctrl+P		Clicked geomet	ry:
			-				gpml:centerLin	eOf
8-97	-1		6	Export		•	Feature collecti	on:
mar 1	38		1		1		Seton etal ES	R2012 Coastline

Figure 4: Navigating to View Total Reconstruction Poles from the Main Menu.

wing total i	truction Tree La	poles generated at 0	12.1 Ma, with anchored plate ID	•	
lelative Ro	otations Eq	uivalent Rotations rel. Anchored Plat	e Reconstruction Tree	Plate Circuits to Anchore	ed Plate
tree-like r	representation	of the hierarchy of relative rotations	at the current reconstruc	tion time.	
Plate ID	Fixed Plate ID	Rotation rel. fixed (parent) p	olate	Equivalent rotation rel. and	chored plate
▶ 1 3	0	(indeterminate pole) (indeterminate pole)	angle: 0.00 angle: 0.00	(indeterminate pole) (indeterminate pole)	angle: 0.00 angle: 0.00

Figure 5: The plate hierarchy is found under the Reconstruction Tree tab in the Total Reconstruction Poles window (third tab).

You will see that the highest entry id is Plate ID 1 (001 - Atlantic-Indian hotspots) which is fixed to 0 (000 - Earth's spin axis).

5. Click the small triangle to the left of the '1', this will reveal the next highest plate in the plate hierarchy - Plate 701 (Africa) (Figure 6).

ow Reconstr	ruction Tr	ee Layer:	Seton_etal_ESR2012_	2012.1		•		
wing total re	econstruc	tion poles g	enerated at 0	Ma, with anchore	d plate ID	0		
Relative Rot	ations	Equivalent	t Rotations rel. Anchored I	Plate Reconstru	ction Tree	Plate Circuits to Anchored	Plate	
A tree-like re	epresenta	ation of the h	nierarchy of relative rotation	ons at the current r	econstructio	on time.		
Plate ID	Fixed	Plate ID	Rotation rel. fixed (par	ent) plate		Equivalent rotation rel. an	chored plate	
⊿ 1	0		(indeterminate pole)	angle: 0.	00	(indeterminate pole)	angle: 0.00	
Þ 701	L 1		(indeterminate pole)	angle: 0.	00	(indeterminate pole)	angle: 0.00	
Expand Al	I Co	ollapse All						Close

Figure 6: Expanding Plate ID 1, you reveal the next highest plate in the plate hierarchy.

6. Now expand the tree even further by clicking the small triangle next to Plate ID 701 (which plate is this?). You will see that plates 201, 307 503, 507 etc move relative to 701, which in turn moves relative to 001, which in turn is fixed to 000 (Figure 7).

ving total recon	struction poles gen	erated at 0 Ma,	with anchored plate ID	0		
elative Rotatio	ns Equivalent R	otations rel. Anchored Plate	Reconstruction Tree	Plate Circuits to Anchored Plate		
tree-like repres	sentation of the hie	rarchy of relative rotations at	the current reconstructio	n time.		
Plate ID	Fixed Plate ID	Rotation rel. fixed (paren	t) plate	Equivalent rotation rel. ancho	ored plate	*
⊿ 1	0	(indeterminate pole)	angle: 0.00	(indeterminate pole)	angle: 0.00	
⊿ 701	1	(indeterminate pole)	angle: 0.00	(indeterminate pole)	angle: 0.00	-
▷ 201	701	(indeterminate pole)	angle: 0.00	(indeterminate pole)	angle: 0.00	-
⊳ 307	701	(indeterminate pole)	angle: 0.00	(indeterminate pole)	angle: 0.00	
503	3 701	(indeterminate pole)	angle: 0.00	(indeterminate pole)	angle: 0.00	
507	701	(indeterminate pole)	angle: 0.00	(indeterminate pole)	angle: 0.00	
508	3 701	(indeterminate pole)	angle: 0.00	(indeterminate pole)	angle: 0.00	
509	701	(indeterminate pole)	angle: 0.00	(indeterminate pole)	angle: 0.00	
519	701	(indeterminate pole)	angle: 0.00	(indeterminate pole)	angle: 0.00	
⊳ 531	701	(indeterminate pole)	angle: 0.00	(indeterminate pole)	angle: 0.00	
▷ 702	2 701	(indeterminate pole)	angle: 0.00	(indeterminate pole)	angle: 0.00	
Þ 709	701	(indeterminate pole)	angle: 0.00	(indeterminate pole)	angle: 0.00	
710	701	(indeterminate pole)	angle: 0.00	(indeterminate pole)	angle: 0.00	-
717	701	(indekomaineko nele)	0.00	(in determinate male)		
Expand All	Collapse All					

Figure 7: The plate hierarchy tree for our loaded files.

7. Click Expand All, and you can see how all the plates in the Coastline file move at the reconstructed time, i.e. which plates they move relative to.

Changing something high in the rotation tree will affect the absolute rotations of all lower plates (relative motions will remain the same). You can always check the conjugate plate by looking at the information of a particular plate, or checking the reconstruction tree as above.

For more detailed information about plate hierarchy, see <u>Tutorial 2.1</u> or the <u>GPlates User Manual</u>

Exercise 2 - Reconstructing Data on the Globe

Now that you have some understanding of how a plate hierarchy works, it is a good idea to spend some time actually reconstructing the coastline data. We will now employ the rotation file to reconstruct our coastlines back to 100 Ma, The easiest way to reconstruct data is by using the Time (Figure 8) and Animation tools (Figure 9).



Figure 8: The Time tools enable you to jump to a certain time.



Figure 9: The Animation tools in the Main Window enable you to reconstruct data back and forth through time.

1. In the Time Controls box (Figure 8) type 100 Ma > Enter. Rotate the globe and have a look at where the continents were 100 Ma (Figure 10).



Figure 10: View of the coastlines at 100 Ma. Note that in the Time Controls box (top left) the time says 100.00 Ma.

An alternative way to reconstruct your data is by using the Animation controls. You can simply click and manually move the time slider (notice that in Figure 10, the slider is no longer at the far right but is a third of the way along) or you may jump to a certain time and then "play" an animation of the feature data reconstructing.

2. Make sure that you are still at 100 Ma (or jump to any time in the past) >

press the play button in the Animation Controls and watch the coastlines rotate back to their present-day positions. To animate the entire

time period you have rotations for, first use the Reset button to take you back to the oldest time you have rotations for and then press play.

You may also watch animations of your data by using the Configure Animation option from the Reconstruction menu (Figure 11).



Figure 11: Animations can be manually configures from the Reconstruction menu.

The Animate window provides you additional control over your animation (Figure 12). For example, you can specify whether you want to watch a reconstruction run backwards or forwards through time by clicking the Reverse the Animation button.

Range					
	Animate from:	200.00	🖨 Ma	Use Main Window	
	to:	0.00	🚔 Ma	Use Main Window	
	with an increment of:	1.00	♥ M	per frame.	
	Reverse the Animatio	by swa	pping the s	start and end times.	
Options					
Frames per s	econd: 5.00 ≑				
Finish ani	mation exactly on end time				
Loop					
Close this	dialog when animation star	ts			
 Loop Close this Playback 	s dialog when animation star	ts			
Close this Playback	s dialog when animation star Current time: 100.0000	ts	a	Reset	Play

Figure 12: The Animate window allows you to specify details about your animations.

GPlates also enables you to change the anchored plate so that you can reconstruct data keeping different plates fixed.

3. Reconstruction > Specify Anchored Plate ID... > 201 > OK (Figure 13).

Anchoreur	hate ID	
Plate ID:	D	×
	Fill from Current Feature, 🛛 🥱 Reset	

Figure 13: Nominating which plate to keep fixed.

Now that we have fixed the South American plate, change the animation time to 100 Ma and see how this influences the plate motions.

4. Once you have finished experimenting, set your anchored plate back to 000 (the spin axis – default).

For more detailed information about reconstructing data, see $\underline{\text{Tutorial 2.1}}$ or the $\underline{\text{GPlates User Manual}}$

Exercise 3 - Applying Rotations

When creating tectonic reconstructions, it is more likely that you will want to change or apply a rotation to a feature back in time, rather than changing anything at the present-day. Using a simple example, we will learn how to apply a rotation.

Australia started to move away from Antarctica ~83 Ma. According to Tikku and Cande (1999), Australia moved in a northward direction relative to a fixed Antarctica. You will implement this rotation in the provided rotation file, AusAnt_ExampleRotation.rot. For simplicity, this file contains rotations for Australia and Antarctica only.

1. Open AusAnt_ExampleRotation.rot in a text editor so you can see what it looks like (Figure 14):

- a. Plate ID 000 = Spin axis
- b. Plate ID 001 = Atlantic hotspots
- c. Plate ID 701 = Africa
- d. Plate ID 801 = Australia
- e. PlateID 850 = Tasmania
- f. Plate ID 802 = Antarctica

2 D:\	James\2	3-Changii	ng_Rotatio	ns_Data\2.3	-Cha	nging_R	otations_Dat	a\AusAnt_	ExampleR	otation.rot -	Notepad++			
File	Edit S	earch Vie	w Encod	ding Lang	uage	Settin	gs Macro	Run Pl	lugins W	indow ?				Х
	88				Þ	C	8 kg 🔍	3		1 🗐 🖉			5	
E Se	ton_etal_	ESR2012_	2012.1.rot	📄 AusAnt	_Exam	pleRotati	on.rot							
1	001	0.0	0.0	0.0		0.0	000 !AI	IS-HOT	Present	day Atl	antic-Indian	hotspots	fixed to	000
2	001	600.0	0.0	0.0		0.0	000 !AI	IS-HOT						
3	701	0.0	0.0	0.0	0.0	001	!AFR-AHS	Africa	a-India	n/Atlant	ic Hotspots			
4	701	600.0	0.0	0.0	0.0	001	!AFR-AH	5						
5	801	0.0	0.0	0.0	0.0	802	!AUS-AN	Austr	alia-Ar	tarctica				
6	801	600.0	0.0	0.0	0.0	802	!AUS-AN	C						
7	802	0.0	0.0	0.0	0.0	701	ANT-AF	Antar	ctica-A	frica				
8	802	600.0	0.0	0.0	0.0	701	!ANT-AF	2						
9	850	0.0	0.0	0.0	0.0	801	!TSM-AU	5 Tasma	nia-Aus	tralia				
10	850	600.0	0.0	0.0	0.0	801	!TSM-AU	5						
•								III						+
Norma	al text file		length :	597 lines	: 10		Ln : 1	Col:1 S	iel : 0		UNIX	ANSI		INS

Figure 14: The contents of our example rotation file.

You will notice that Australia moves relative to Antarctica, Antarctica moves relative to Africa, Africa moves relative to the hotspot reference frame which is fixed to the spin axis.

- 2. If you are proceeding from Exercise 2, File > Manage Feature Collections...
 - Eject the global rotation file (Seton_etal_ESR2012_2012.1.rot)
 - Click Open File... > Select AusAnt_ExampleRotation.rot

(If you are coming directly to this tutorial, open the coastlines file as well as the AusAnt_ExampleRotation.rot file by File > Open Feature Collection...)

3. Rotate the globe so that it is centred on Australia. Now reconstruct backwards through time. You will notice that the features fixed in their present-day locations (this is because they have no relative rotations). The only thing that changes is that features will disappear if you reconstruct to before their 'appear time'.

It is generally believed that Australia moved northwards, relative to a fixed Antarctica, between \sim 83 Ma and the present (Tikku and Cande, 1999). We will implement this rotation.

5. Centre your globe so that Australia and the coastline of Antarctica nearest Australia are in view (Figure 15).



Figure 15: View of Australia and Antarctica.

6. As we want to implement a rotation at 83 Ma, jump to this time using the Time controls.

to select Australia (click somewhere 7. Use the Choose Feature tool on the coastline - it should go white once selected) and then click Modify

Reconstruction Pole





8. Drag Australia in a southward direction so that it approximately lines up with Antarctica (Figure 16).

If at first you are not happy with the new location of Australia, just click and drag again as appropriate. The feature can also be rotated about its axis by holding down SHIFT and dragging.

Note: the globe can still be re-oriented whilst holding down the Command (Mac)/Control(PC) key while in the "Modify Reconstruction Pole" mode. Information regarding the reconstruction pole is displayed in the task panel to the right. This includes the Plate ID of the feature you are moving and the new rotation pole that will be applied if this location is confirmed by pressing Apply.



Figure 16: Australia has been dragged southward at 83 Ma to line up with Antarctica.

9. Once the feature attains the desired position and orientation, click Apply (right of the globe). This will open up Apply Reconstruction Pole Adjustment window, where you can review the details of your implemented rotation (Figure 17).

step 1: Choose	pole sequence	e		Step 2: Verify	new relative pole
Moving plate:		-7		Original recor	nstruction pole:
801				Latitude:	
Current recons	struction time:			Longitude:	
Pole sequence				Angle:	0.00°
Fixed	Moving	Begin	End	Adjustment r	el. fixed plate:
802	801	600.00	0.00	Latitude:	-0.79
				Longitude:	-141.93
				Angle:	30.40°
				New reconstr	ruction pole:
				Latitude:	0.79
				Longitude:	38.07
Note: Sequenc synchronised.	e cross-overs a	are not yet au	tomatically	Angle:	-30.40°
Step 3: Specify Time: 83.00	time for new p	o <mark>ole (not yet ir</mark> eset to curren	n plem<mark>ented)</mark> t time		
	comment				
Step 4: Provide					
Step 4: Provide					

Figure 17: Apply Reconstruction Pole Adjustment window, where you can review the details of your rotation implementation.

9. In this window you can verify the new relative pole and details (Figure 17). Click OK (this will implement your rotation)

You will notice that Australia is now positioned adjacent to Antarctica at 83 Ma (Figure 18).



Figure 18: Australia is now positioned adjacent to Antarctica at 83 Ma. It is south of its present-day position.

Now you need to save your rotation file.

10. File > Manage Feature Collections > save a copy of the rotation file with a new name (this is so you can compare it to the old rotation file)

11. Remove the old rotation file (by clicking the eject button) and load this new rotation file by clicking Open File and navigating to the directory where it is saved > Open.

12. Use the Animation slider to reconstruct from 83 Ma to the present. You will see Australia move in a northward direction relative to Antarctica!

13. However there is one more thing we need to do. If you jump to 600 Ma for example and animate back to 0 Ma, you will notice that Australia starts in its present day coordinates, moves southward to its 83 Ma position and then

moves northwards again. This is because the location of Australia at 600 Ma is the same as present-day in our rotation file (Figure 19). We need to alter the rotation file so that there are not rotations between 600 Ma and 83 Ma.

🗾 D:\	James\2	.3-Chang	ing_Rotatio	ons_Data\2.	3-Chang	ing_Ro	tations_Data	\AusAnt_ExampleRotationAustralia.rot - Notepad++	
File	Edit S	earch V	iew Enco	ding Lan	guage	Setting	s Macro	Run Plugins Window ?	Х
	98	B		4 G B	90	2 88	b <u>a</u> ≪ (* 🖪 🖼 🏣 🏾 🏣 💽 🗉 🗉 🕨 🔛 😹	ABC
🔚 Sel	ton_etal_	ESR2012	_2012.1.rot	📔 AusAni	_Example	Rotatio	n.rot 📄 Au	sAnt_ExampleRotationAustralia.rot	
1	001	0.0	0.0	0.0	0.0	000	AHS-HOT	Present day Atlantic-Indian hotspots fix	ed to 000
2	001	600.0	0.0	0.0	0.0	000	!AHS-HOT	r	
3	701	0.0	0.0	0.0	0.0	001	AFR-AHS	Africa-Indian/Atlantic Hotspots	
4	701	600.0	0.0	0.0	0.0	001	!AFR-AHS	3	
5	801	0.0	0.0	0.0	0.0	802	!AUS-ANT	Australia-Antarctica	
6	801	83.0	0.79	38.07	-30.4	80	2 !Calcul	lated interactively by GPlates	
7	801	600.0	0.0	0.0	0.0	802	! AUS-ANT		
8	802	0.0	0.0	0.0	0.0	701	!ANT-AFR	Antarctica-Africa	
9	802	600.0	0.0	0.0	0.0	701	!ANT-AFF	R	
10	850	0.0	0.0	0.0	0.0	801	! TSM-AUS	Tasmania-Australia	
11	850	600.0	0.0	0.0	0.0	801	!TSM-AUS	5	
12									
								m	•
Norma	l text file		length	677 lines	:12		Ln:5 0	Col:1 Sel:189 Dos\Windows ANSI	INS

Figure 19: A rotation has been added for Australia at 83 Ma. However notice that the latitude and longitude of Australia at 600 Ma is the same as present-day.

14. Open the new rotation file in a text editor. And make the 600 Ma rotation data (lat., long., rotation angle) for Plate ID 801 the same as the 83 Ma rotation (ie duplicate the data) (Figure 20). This will result in no rotation between Australia and Antarctica until the period 83 Ma – 0 Ma.

2 *D:\	James\/	2.3-Chang	jing_Rotati	ons_Data\/	2.3-Chan	ging_R	otations_Data	a\AusA	nt_ExampleRotationAustr	alia.rot - Notepad++			3
File I	Edit Se	earch Vi	ew Enco	ding Lan	guage	Setting	gs Macro	Run	Plugins Window ?				Х
) 🤉 (2 #	b 10 10 10 10 10 10 10 10 10 10 10 10 10	3	3 🖪 🎫 🤋 🗐 🖉		🔤 🛛 😓 🌾		
🔚 Set	on_etal_	ESR2012_	2012.1.rot	🔚 AusAn	t_Example	Rotatio	on.rot 📔 Au	sAnt_Ex	ampleRotationAustralia.rot				
1	001	0.0	0.0	0.0	0.0	000	!AHS-HOT	Pres	ent day Atlantic-	Indian hotspo	ts fixed t	000 0:	
2	001	600.0	0.0	0.0	0.0	000	AHS-HO	r					
3	701	0.0	0.0	0.0	0.0	001	!AFR-AHS	Afri	ca-Indian/Atlanti	c Hotspots			
4	701	600.0	0.0	0.0	0.0	001	!AFR-AHS	5					
5	801	0.0	0.0	0.0	0.0	802	!AUS-ANT	Aust	ralia-Antarctica				
6	801	83.0	0.79	38.07	-30.4	1 80	2 !Calcul	lated	interactively by	GPlates			_
7	801	600.0	0.79	38.0)7 -3(0.4	802 !AUS-	ANT					
8	802	0.0	0.0	0.0	0.0	701	!ANT-AFR	Anta	rctica-Africa				
9	802	600.0	0.0	0.0	0.0	701	!ANT-AFE	5					
10	850	0.0	0.0	0.0	0.0	801	!TSM-AUS	Tasm	ania-Australia				
11	850	600.0	0.0	0.0	0.0	801	!TSM-AUS	5					
12													
-													
								III					•
Normal	text file		length :	680 line	s:12		Ln:7 (ol : 33	Sel:0	Dos\Windows	ANSI	INS	14

Figure 20: Modified rotation file, note that the 600 Ma and 83 Ma rotations for Plate ID 801 are the same.

15. Load your modified rotation file into GPlates and animate forward in time from say 150 Ma. You will notice that Australia stays attached to Antarctica until 83 Ma.

For more detailed information about rotation features, see <u>Tutorial 2.1</u>, or about applying rotations, see <u>Tutorial 2.2</u> or the <u>GPlates User Manual</u>

Exercise 4 - Modifying Rotations

In this exercise we will learn how to modify an existing rotation file. Keeping with the theme of Australia and Antarctica we will implement a new rotation for Australia at 83 Ma. Whittaker et al. (2007) proposed that 83 Ma Australia was located further eastwards with respect to Antarctica than previously thought (e.g. Tikku and Cande, 1999). They suggest that from ~83 Ma to 50 Ma Australia moved northwest relative to a fixed Antarctica, before then commencing northward motion between 50 Ma and the present.

1. Eject all existing rotation files from GPlates but keep the Seton_etal_ESR2012_Coastlines_2012.1_Polygon.gpmlz file loaded. File >

Manage Feature Collections > click the eject symbol

corresponding to

all loaded rotation files. Keep the Manage Feature Collections window open.

2. Open File > select the rotation file for this exercise Global EarthByte GPlates Rotation AusAnt Example.rot > Open

The rotation file we have just loaded is significantly more complicated than that of the last exercise. Reconstruct the globe back through time and you will see that all the plates move. If you open this rotation file in a text editor you can see how much longer and more detailed it is compared to the last exercise.

3. Use the Time Controls to jump to 83 Ma.

We will use the fracture zones to help us constrain the position of Australia 83 Ma.

4. File > Manage Feature Collections > Open File > select AusAnt_FZs.gpml from the data bundle > Open

Following Whittaker et al. (2007) we will align the Antarctic fracture zone with the most westerly Australian fracture zone, whereby shifting Australia east relative to a fixed Antarctica.

5. Use the Choose Feature button to select the Australian fracture zone

> click Modify Reconstruction Pole > drag the fracture zone eastward so that it is connected to the Antarctic fracture zone (Figure 21) > click Apply (right of globe) > you can then click OK in the Apply Reconstruction Pole Adjustment window once you have reviewed the details of your new reconstruction and are satisfied.



Figure 21: Australia shifted east using the Modify Reconstruction Pole tool.

When you return to the globe you will notice that Australia is located further east than when you started (Figure 22). We now need to save this data.



Figure 22: Australia shifted further east 83 Ma.

6. File > Manage Feature Collections > save your Global_EarthByte_GPlates_Rotations_AusAnt_Example.rot file with a new

name so that you preserve the old rotation file.

Now use the Time controls to watch Australia's motion from 83 Ma to present-day and you will see that there is northwest motion of Australia relative to a fixed Antarctica between 83 Ma and \sim 50 Ma. Then Australia commences northward motion.

7. Open your modified rotation file and the original rotation file using a text editor and scroll down to the entries for Plate ID 801, compare the two rotation files, you will see that they have different entries now for 83 Ma (Figure 23).

D:\Ja	mes\2.3	-Changi	ng_Rotation	s_Data\2.3-Cl	hanging_Rot	ations_	Data\Global_EarthByte_Gl	Plates_Rotations_AusAnt_Exam	oleCopy.rot - N	
File Ed	lit Sei	arch Vie	ew Encodi	ng Langua	ge Settings	Mac	ro Run Plugins Wir	ndow ?		Х
			6	001) C #	^b 8	🤹 😪 🖪 🛃 🎫	🛚 💽 💽 ا 💽 📰	🖬 🗟 🏷	
E Seto	n_etal_E	SR2012_	2012.1.rot	AusAnt_Ex	ample Rotation	.rot	Global_EarthByte_GPlate	s_Rotations_AusAnt_ExampleCopy	r.rot	
1519	801	10.9	13.1	36.1 -6	5.55 802	AU:	S-ANT Royer & Cha	ng 1991		*
1520	801	20.1	15.4	32.7 -11	L.97 802	AU:	S-ANT Royer & Cha	ng 1991		
1521	801	33.1	13.8	33.4 -20	0.41 802	! AU:	S-ANT Royer & Cha	ng 1991		
1522	801	40.1	17.1	30.6 -23	8.68 802	! AU:	S-ANT An18 Muller	et.al 1997		
1523	801	43.8	15.7	30.0 -24	1.59 802	! AU:	S-ANT An20 Muller	et.al 1997		
1524	801	53.3	13.5	32.2 -25	5.44 802	! AU	S-ANT An21 Muller	et.al 1997		
1525	801	83.0	-5.55	34.19 -	-28.69 8	02 !	Calculated intera	ctively by GPlates		and the second sec
1526	801	99.0	-5.92	41.22 -	-28.61 8	02 !	AUS-ANT EarthByte	Group 2002		
1527	801	120.4	11.1 -	137.17	29.65 8	02 !	AUS-ANT MO EarthB	yteGroup 2002		
1528	801	600.0	11.1 -	137.17	29.65 8	02 !	AUS-ANT			
1529	802	0.0	0.0	0.0	0.0 701	! ANT	-AFR Antarctica-A	frica		40.25
1530	802	0 0	82 -	40 4 1	53 701	17.M	T-ARD AN 5 Dover	5 Chang 1001		-
					10					
Normal t	ext file		length : 1	64973 lines	: 2259	Ln :	1 Col:1 Sel:0	Dos\Windows	ANSI	INS
	mes\2:	-Changi	ng Rotation	s Data\23-Cl	hanging Rot	ations	Data\Global FarthByte Gl	Plates Rotations AusAnt Evam	ale rot - Noten	
D:\Ja	mes\2.3	-Changi	ng_Rotation	s_Data\2.3-Cl	hanging_Rot	ations_	Data\Global_EarthByte_Gl	Plates_Rotations_AusAnt_Exam	ole.rot - Notep 🗖	
D:\Ja File Ec	mes\2.3 lit Sei	3-Changi arch Vi	ng_Rotation	s_Data\2.3-Cl	hanging_Rot ge Settings	ations_	Data\Global_EarthByte_Gl cro Run Plugins Wir	Plates_Rotations_AusAnt_Exam	ole.rot - Notep	X X
D:\Ja File Ed	mes\2.3 lit Sei	3-Changi arch Vie	ng_Rotation: ew Encodii	s_Data\2.3-Cl ng Langua C	hanging_Rot ge Settings	ations_ Mac	Data\Global_EarthByte_Gl cro Run Plugins Wir 🤏 👒 🍱 🖼 🚍	Plates_Rotations_AusAnt_Exam ndow ? ¶ 📳 🕡 💿 📄 🕨 😥	ole.rot - Notep 👝	X E
D:\Ja File Ed	mes\2.3 lit Sei) 📄 I al_Earth	9-Changi arch Vie Pa 🔒 🕻 Byte_GPla	ng_Rotation ew Encodi Call &	s_Data\2.3-Cl ng Langua D In ; s_AusAnt_Exa	hanging_Rot ge Settings C (# mple.rot)	ations_ Mac	Data\Global_EarthByte_Gl rro Run Plugins Wir 🤏 😪 🎧 🔂 🚍	Plates_Rotations_AusAnt_Exam ndow ? ¶ 🗐 🕢 📄 🕨 😥	ole.rot - Notep 👝	X X
D:\Ja File Ec	mes\2.3 lit Sea Dial_Earth 801	B-Changi arch Vie Byte_GPla 33.1	ng_Rotation: ew Encodi i de diates_Rotation: 13.80	s_Data\2.3-Cl ng Langua C T I I I s_AusAnt_Exa 33.40	hanging_Rot ge Settings d d m ple.rot -20.41	ations_ Mac bal	Data\Global_EarthByte_Gl ro Run Plugins Wir R R R R R E	Plates_Rotations_AusAnt_Exam ndow ? ¶ 🗐 🗊 📄 🖿 🕨 Chang 1991	ole.rot - Notep 👝	X x
D:\Ja File Ec Glob	mes\2.3 lit Sea lit Sea lit Sea lit Sea lit Sea al_Earth 801 801	B-Changi arch Vie Byte_GPla 33.1 40.1	ng_Rotation: w Encodi lo lo lo ates_Rotation: 13.80 17.1	s_Data\2.3-Cl ng Langua I III III III s_AusAnt_Exa 33.40 30.6	hanging_Rot ge Settings C C B mple.rot -20.41 -23.68	ations_ Mac 202 802 802	Data\Global_EarthByte_Gl ro Run Plugins Wir R R R R R E !AUS-ANT Royer & !AUS-ANT Royer &	Plates_Rotations_AusAnt_Exam ndow ? ¶ 🗐 🕢 🔲 🕨 🕪 Chang 1991 iller et.al 1997	ole.rot - Notep 👝	X A
D:\Ja File Ec Glob	mes\2.3 lit Sea al_Earth 801 801 801	B-Changi arch Vir Byte_GPla 33.1 40.1 43.8	ng_Rotation: ew Encodi ates_Rotation: 13.80 17.1 15.7	s_Data\2.3-Cl ng Langua ing langua s_AusAnt_Exa 33.40 30.6 30.0	hanging_Rot ge Settings C # mple.rot -20.41 -23.68 -24.59	ations_ Mac ba 802 802 802	Data\Global_EarthByte_Gl ro Run Plugins Wir R R R R R E !AUS-ANT Royer & !AUS-ANT An18 Mu !AUS-ANT An18 Mu	Plates_Rotations_AusAnt_Exam ndow ? ¶	ole.rot - Notep 👝	X
D:\Ja File Ec Glob 1521 1522 1523 1524	mes\2.3 lit Sea al_Earth 801 801 801 801	B-Changi arch Vie Byte_GPla 33.1 40.1 43.8 53.3	ng_Rotation: w Encodi ates_Rotation: 13.80 17.1 15.7 13.5	s_Data\2.3-Cl ng Langua () () () () s_AusAnt_Exa 33.40 30.6 30.0 32.2	mple.rot -20.41 -23.68 -24.59 -25.44	ations_ Mac bal 802 802 802 802 802	Data\Global_EarthByte_Gl ro Run Plugins Wir R R R R R E !AUS-ANT Royer & !AUS-ANT An18 Mu !AUS-ANT An20 Mu !AUS-ANT An21 Mu	Plates_Rotations_AusAnt_Exam ndow ? ¶ I I I I I I I I I I I I I I I I I I I	ole.rot - Notep 👝	
D:\Ja File Ed Glob 1521 1522 1523 1524 1525	mes\2.3 lit Sec al_Earth 801 801 801 801 801	P-Changi arch Vid Byte_GPla 33.1 40.1 43.8 53.3 83.0	ng_Rotation: w Encodi ates_Rotation: 13.80 17.1 15.7 13.5 2.05	s_Data\2.3-Cl ng Langua () () () () s_AusAnt_Exa 33.40 30.6 30.0 32.2 40.79	mple.rot -20.41 -23.68 -24.59 -25.44 -27.12	ations_ Mac bal 802 802 802 802 802 802 802	Data\Global_EarthByte_Gl TO RUN Plugins Wir Compared to the second sec	Plates_Rotations_AusAnt_Exam ndow ? ¶	ole.rot - Notep 👝	
D:\Ja File Ed Glob 1521 1522 1523 1524 1525 1526	mes\2.3 lit Sec al_Earth 801 801 801 801 801 801 801	B-Changi arch Vir Byte_GPla 33.1 40.1 43.8 53.3 83.0 99.0	ng_Rotation: w Encodi ates_Rotation: 13.80 17.1 15.7 13.5 2.05 -5.92	s_Data\2.3-Cl ng Langua () () () () () s_AusAnt_Exa 33.40 30.6 30.0 32.2 40.79 41.22	hanging_Rot ge Settings C # mple.rot -20.41 -23.68 -24.59 -25.44 -27.12 -28.61 -28.61	ations_ Mac bal 802 802 802 802 802 802 802 802 802	Data\Global_EarthByte_Gl TO RUN Plugins Wir Comparison of the second s	Plates_Rotations_AusAnt_Exam ndow ? ¶	ole.rot - Notep 👝	
D:\Ja File Ec G Glob 1521 1522 1523 1524 1525 1526 1527	mes\2.3 lit Sec al_Earth 801 801 801 801 801 801 801 801	Byte_GPla Byte_GPla 33.1 40.1 43.8 53.3 83.0 99.0 120.4	ng_Rotation: w Encodi ates_Rotation: 13.80 17.1 15.7 13.5 2.05 -5.92 11.10	s_Data\2.3-Cl ng Langua () () () () () s_AusAnt_Exa 33.40 30.6 30.0 32.2 40.79 41.22 -137.17	hanging_Rot ge Settings C # mple.rot -20.41 -23.68 -24.59 -25.44 -27.12 -28.61 29.65	ations_ Mac bal 802 802 802 802 802 802 802 802 802 802	Data\Global_EarthByte_Gl ro Run Plugins Wir Carl Carl Carl Carl Carl !AUS-ANT Royer & !AUS-ANT An18 Mu !AUS-ANT An20 Mu !AUS-ANT An21 Mu !AUS-ANT An21 Mu !AUS-ANT S4 Tik !AUS-ANT EarthBy !AUS-ANT M0 Eart	Plates_Rotations_AusAnt_Exam ndow ? ¶	ole.rot - Notep 👝	
D:\Ja File Ec Gold 1521 1522 1523 1524 1525 1526 1527 1528	mes\2.3 lit Sec al_Earth 801 801 801 801 801 801 801 801 801	Byte_GPla Byte_GPla 33.1 40.1 43.8 53.3 83.0 99.0 120.4 600.0	ng_Rotation: w Encodi ates_Rotation: 13.80 17.1 15.7 13.5 2.05 -5.92 11.10 11.10	s_Data\2.3-Cl ng Languay	hanging_Rot ge Settings D C # mple.rot -20.41 -23.68 -24.59 -25.44 -27.12 -28.61 29.65 29.65	ations_ Mac 202 802 802 802 802 802 802 802 802 802	Data\Global_EarthByte_Gl ro Run Plugins Wir R R G G G E !AUS-ANT Royer & !AUS-ANT An18 Mu !AUS-ANT An20 Mu !AUS-ANT An21 Mu !AUS-ANT An21 Mu !AUS-ANT 34 Tik !AUS-ANT BarthBy !AUS-ANT MO Eart !AUS-ANT	Plates_Rotations_AusAnt_Exam ndow ? ¶	ole.rot - Notep 🗖	
D:\Ja File Er Glob 1521 1522 1523 1524 1525 1526 1527 1528 1529	mes\2.3 iit Ser al_Earth 801 801 801 801 801 801 801 801	Byte_GPla Byte_GPla 33.1 40.1 43.8 53.3 83.0 99.0 120.4 600.0 0.0	ng_Rotation: w Encodi ates_Rotation: 13.80 17.1 15.7 13.5 2.05 -5.92 11.10 0.0	s_Data\2.3-Cl ng Languay	hanging_Rot ge Settings C # -20.41 -23.68 -24.59 -25.44 -27.12 -28.61 29.65 29.65 0.0	ations_ Mac base 802 802 802 802 802 802 802 802 802 802	Data\Global_EarthByte_Gl ro Run Plugins Wir Carl Carl Carl Carl Carl Carl Carl Carl	Plates_Rotations_AusAnt_Exam ndow ? ¶	ole.rot - Notep 🗖	
D:\Ja File Er Glob 1521 1522 1523 1524 1525 1526 1527 1528 1529 1530	mes\2.3 iit Sec al_Earth 801 801 801 801 801 801 801 801	Byte_GPla 33.1 40.1 43.8 53.3 83.0 99.0 120.4 600.0 0.0 9.9	ng_Rotation: w Encodi ates_Rotation: 13.80 17.1 15.7 13.5 2.05 -5.92 11.10 0.0 8.2	s_Data\2.3-Cl ng Languay	hanging_Rot ge Settings C # -20.41 -23.68 -24.59 -25.44 -27.12 -28.61 29.65 29.65 0.0 1.53	ations_ Mac 802 802 802 802 802 802 802 802 802 802	Data\Global_EarthByte_Gl ro Run Plugins Wir Carl Carl Carl Carl Carl Carl Carl Carl	Plates_Rotations_AusAnt_Exam ndow ? ¶	ole.rot - Notep 👝	
D:\Ja File Er Glob 1521 1522 1523 1524 1525 1526 1527 1528 1529 1530 1531	mes\2.3 iit Sec al_Earth 801 801 801 801 801 801 801 801	Byte_GPla Byte_GPla 33.1 40.1 43.8 53.3 83.0 99.0 120.4 600.0 0.0 9.9 20.2	ng_Rotation: w Encodi ates_Rotation: 13.80 17.1 15.7 13.5 2.05 -5.92 11.10 11.10 0.0 8.2 10.7	s_Data\2.3-Cl ng Languay S_AusAnt_Exa 33.40 30.6 30.0 32.2 40.79 41.22 -137.17 -137.17 0.0 -49.4 -47.9	hanging_Rot ge Settings C # -20.41 -23.68 -24.59 -25.44 -27.12 -28.61 29.65 29.65 29.65 0.0 1.53 2.78	ations_ Mac 802 802 802 802 802 802 802 802 802 802	Data\Global_EarthByte_Gl ro Run Plugins Wir Carl Carl Carl Carl Carl Carl Carl Carl	Plates_Rotations_AusAnt_Exam ndow ? Plates_Rotations_AusAnt_Exam ndow ? Plates_Rotations_AusAnt_Exam Chang 1991 ller et.al 1997 ller et.al 1997 ller et.al 1997 iter et	ole.rot - Notep 👝	
D:\Ja File Er Glob 1521 1522 1523 1524 1525 1526 1527 1528 1529 1530 1531 1532	mes\2.3 jit Sea al_Earth 801 801 801 801 801 801 801 801	Byte_GPla Byte_GPla 33.1 40.1 43.8 53.3 83.0 99.0 120.4 600.0 0.0 9.9 20.2 33.2	ng_Rotation: w Encodi ates_Rotation: 13.80 17.1 15.7 13.5 2.05 -5.92 11.10 11.10 0.0 8.2 10.7 12.0	s_Data\2.3-Cl ng Languay s_AusAnt_Exa 33.40 30.6 30.0 32.2 40.79 41.22 -137.17 -137.17 0.0 -49.4 -47.9 -48.4	hanging_Rot ge Settings C # -20.41 -23.68 -24.59 -25.44 -27.12 -28.61 29.65 29.65 29.65 0.0 1.53 2.78 5.46	ations_ Mac 2802 802 802 802 802 802 802 802 802 80	Data\Global_EarthByte_Gl ro Run Plugins Wir Carl Carl Carl Carl Carl Carl Carl Carl	Plates_Rotations_AusAnt_Exam ndow ? Plates_Rotations_AusAnt_Exam ndow ? Plates_Rotations_AusAnt_Exam Chang 1991 liler et.al 1997 liler et.al 1997 liler et.al 1997 liler et.al 1997 iter et.al 1997 ite	ole.rot - Notep 👝	
D:\Ja File Er Glob 1521 1522 1523 1524 1525 1526 1527 1528 1529 1530 1531 1532 4	mes\2.2 iii Sec al_Earth 801 801 801 801 801 801 801 801	Byte_GPk Byte_GPk 33.1 40.1 43.8 53.3 83.0 99.0 120.4 600.0 0.0 9.9 20.2 33.2	ng_Rotation: w Encodi ates_Rotation: 13.80 17.1 15.7 13.5 2.05 -5.92 11.10 11.10 0.0 8.2 10.7 12.0	s_Data\2.3-Cl ng Languar S_AusAnt_Exa 33.40 30.6 30.0 32.2 40.79 41.22 -137.17 -137.17 0.0 -49.4 -47.9 -48.4	hanging_Rot ge Settings CC # -20.41 -23.68 -24.59 -25.44 -27.12 -28.61 29.65 29.65 29.65 0.0 1.53 2.78 5.46 IIII	ations_ Mac 802 802 802 802 802 802 802 802 802 802	Data\Global_EarthByte_Gl ro Run Plugins Wir Carl Carl Carl Carl Carl Carl Carl Carl	Plates_Rotations_AusAnt_Exam ndow ? ¶	ole.rot - Notep 👝	

Figure 23: New (top) and old (bottom) rotation files showing entries for Plate ID 801. Entries for 83 Ma have changed.

Note: to better appreciate the change in motion of Australia relative to a fixed Antarctica you can specify Antarctica as the 'anchored plate' rather than the spin axis (default). Reconstruction > Specify Anchored Plate ID > enter 802. Now when you reconstruct the globe you can really notice that Australia moves in a northwest direction between 83 Ma and ~50 Ma.

Things to consider:

The cursor provides longitude and latitude locations to help with re-orienting. This is particularly useful when trying to replicate work from other literature.

Check the existing rotation file for the time increments for the plates. By

reconstructing at these times will avoid jumps between two time steps. For example if the existing rotation file has rotations at 10 Ma and 20 Ma, by creating a new rotation at 16 Ma will only change the rotation between 10 Ma and 16 Ma. Between 16 Ma and 20 Ma the plate may jump erratically according to the old pole of rotation, unless you change it or an older timestep.

For more detailed information about changing rotations or other reconstruction options that are rotation-related, see <u>Tutorial 2.2</u> or the <u>GPlates User Manual</u>

Exercise 5 - Exporting reconstructed geometries

GPlates allows you to export reconstructed geometries, either for a single snapshot or a sequence of snapshots. This functionality allows you to extract palaeo-coordinates for feature data that you have reconstructed back through time using a rotation model. Reconstructed geometries can be exported as a file containing longitudes and latitudes (i.e. in the GMT format, *.xy) or in the shapefile format to be used in GIS software.

To illustrate this procedure we will export reconstructed geometries for our coastlines.

1. Reconstruction > Export...

The Export Animation window is where you specify what type of data you are exporting and for which period of time (Figure 24). We will export our coastline geometries for the time period 50 Ma – 0 Ma, with an increment of 5 Myr.

nine realige					
	Animate from:	sb 0000 Ma		Lice Main Window Time	
	Animate from:	5p.0000 Ma	Y		
al.	to	0.0000 Ma	Y		
with	an increment of	1.0000 My	*	per frame.	
E	Reverse the Anin	nation by swa	oping th	e start and end times.	
Export Data					
At each time step, GPlates wil	create the follo	wing files:			
Data Format		-		Filename	
1					
Add Export	nove) 🗊 Edit.				
Add Export = Ren	nove) 🗊 Edit.				
♣ Add Export	nove Edit.	 ents			
Add Export 📼 Ren Farget directory: C:\Users\j	nove) 📝 Edit. iega4792\Docum	 ents			
Add Export = Ren Farget directory: C:\Users\j Animation Options	nove) 📝 Edit. iega4792\Docum	 ents			
수 Add Export 으 Ren Farget directory: C:\Users\j	nove Edit. ega4792\Docum	 ents			
Add Export Ren Farget directory: C:\Users\j Animation Options Finish exactly on end time	nove Edit. iega4792\Docum	ents			
Add Export Ren Farget directory: C:\Users\j Animation Options	nove Edit. iega4792\Docum	ents			
Add Export Ren Farget directory: C:\Users\ Animation Options Finish exactly on end time Export Progress	nove Edit. iega4792\Docum	ents			
Add Export Ren Farget directory: C:\Users\ Animation Options Finish exactly on end time Export Progress	nove Edit. iega4792\Docum	ents			
Add Export Ren Target directory: C:\Users\j Animation Options Finish exactly on end time Export Progress Ready for export.	nove Edit. iega4792\Docum			Begin Export	Abort Expor
Add Export Ren Target directory: C:\Users\j Animation Options Finish exactly on end time Export Progress Ready for export.	nove Edit. iega4792\Docum	 ents		Begin Export	Abort Expor

Figure 24: The Export Animation window.

2. Next we must select which files we want GPlates to create. Add Export > select the Reconstructed Geometries option from the top box > choose the GMT (*.xy) format > Select Export to multiple files> OK (Figure 25)

I. Choose Data Type to Export	3. Configure Export Options
Reconstructed Geometries Projected Geometries (and Rasters) Image (screenshot) Colour Raster Numerical Raster Scalar Coverages Deformation Velocities Resolved Topologies (General) Resolved Topologies (CitcomS specific) Relative Total Rotation Equivalent Total Rotation Relative Stage Rotation Equivalent Stage Rotation Flowlines Motion Paths Co-registration data Net Rotations	Pile Options Export to a single file Export to multiple files (one per input file/layer) Separate output directory per input file/layer
	4. Specify Output Filenames Template: reconstructed_%0.284a A filename template uses printf-like format strings to specify where the changing per-frame
	values should appear in the filename. Sin frame number, in the range [3, N] Siu frame index, in the range [0, (N-1)] Sif reconstruction time of frame Sid reconstruction time of frame (rounded to integer) Sid reconstruction if and
Export reconstructed geometries.	%R default reconstruction tree layer name %D date format "www-MM-dd"
. Choose Output File Format	%T time format "hh-mm-ss"
GMT (*.xy)	
Shapefiles (*.shp) OGR-GMT (*.gmt)	The precision of %if and padding of %id may be customised using printf conversion specifiers (for example, "%i0.2" or "%i02d"). %in and %iu will be padded automatically to the width of the hichest value.

Figure 25: The Add Export window allows you to select which data you want to export, and in which format.

3. Now ensure that you have selected a target directory where your files will be created. When you are satisfied with all the criteria click Begin Animation (bottom) (Figure 26).

Time Range Anima					
Anima					
	te from:	50.0000 Ma	*	Use Main Window Time	
	to	0.0000 Ma	*	Use Main Window Time	
with an incre	ement of	1.0000 My	*	per frame.	
Reverse	the Anim	nation by swappi	ng the	e start and end times.	
Export Data					
At each time step, GPlates will create	the follo	wing files:		20	
Data Fo	rmat			Filename	
Reconstructed Geometries GMT	(*.xy)	reconstructed_9	%0.2f	Ma.xy	
Add Export Remove	Edit.)			
Add Export Remove	Edit.] ients			
Add Export Remove	Edit.	ents			
Add Export Remove Target directory: C:\Users\jega479 Animation Options Finish exactly on end time.	Edit.				
Add Export Remove Target directory: C:\Users\jega479 Animation Options Finish exactly on end time. Export Progress	Edit.) ents			
Add Export Remove Target directory: C:\Users\jega479 Animation Options Finish exactly on end time. Export Progress Ready to export	Edit.) eents		Begin Exp	ort) 🐼 Abort Expor

Figure 26. Once all the Export Animation fields have been filled hit Begin Export.

4. Go to the target directory where your files have been sent.

You will notice that GPlates has named the files according to the time the

data is for and the number the file is in the sequence of files. The first file is named reconstructed_0.00Ma.xy, the second file is reconstructed_1.00Ma.xy etc.

5. Open one of the files and have a look at the output.

These data can now be plotted using GMT, for example. This GPlates function allows for quick and easy extraction of palaeo-coordinates for use outside of GPlates.

Note: GPlates will extract the reconstructed geometries of all feature data actively being displayed on the Globe. Therefore, turn off the data you do not wish to export the reconstructed geometries for. For example, if you also had the EarthByte Continent-Ocean Boundaries displayed on the globe but you did not wish to extract their reconstructed geometries, then you would go to File > Manage Feature Collections > and either Eject the unwanted files or in the "Layers" window (separate from the main GPlates window) uncheck the eye button, then follow the procedure above.

For more detailed information about exporting reconstructions, see <u>Tutorial</u> <u>2.1</u> or the <u>GPlates User Manual</u>

References

Hall, R. 2002. Cenozoic geological and plate tectonic evolution of SE Asia and the SW Pacific: computer-based reconstructions, models and animations. Journal of Asian Earth Sciences, 20; 353 - 431.

Lee, T.Y., and Lawver, L.A. 1995. Cenozoic plate reconstructions of Southeast Asia. Tectonophysics. 251; 85 - 138.

Replumaz, A. and Tapponnier, P. 2003. Reconstruction of the deformed collision zone between India and Asia by backward motion of lithospheric blocks. Journal of Geophysical Research. 108; 2285.

Tikku, A. A., and S. C. Cande. 1999. The oldest magnetic anomalies in the Australian-Antarctic Basin: Are they isochrons? Journal of Geophysical Research. 104(B1); 661–677.

Whittaker, J.M., Müller, R.D., Leitchenkov, G., Stagg, H., Sdrolias, M., Gaina, C., and Goncharov, A. 2007. Major Australian- Antarctic Plate Reorganisation at Hawaiian-Emperor Bend Time. Science. 318; 83 - 86.