Constructing a Plate Model From Scratch

Authors: Simon Williams[1]
[1] EarthByte Research Group, School of Geosciences, University of Sydney, Australia

Aim

This tutorial is designed to describe the process of creating a plate model in GPlates. The model of Rodinia assembly and breakup presented by Li et. al. (2008) is used an example - you will learn how to build a rotation file from scratch, both from published poles of rotation values and by generating additional poles of rotation using the tools in GPlates. You'll also create a new set of plate polygons. The tutorial builds on skills described in many of the earlier tutorials, including those for 'Changing Rotations' and 'Creating Features'.

Included Files

Click here to download the data bundle for this tutorial.

In this data bundle you should have:

Directory "Tutorial13_ExerciseFiles"

- RodiniaBlocks_for_Tutorial.shp
- RodiniaRotationTable.doc
- Rodinia_Tutorial_Rotation_Tables.xls
- Rodinia_Tutorial_ExportFromExcelSheet3.rot

Directory "Tutorial13_CompletedRodiniaModel"

- Rodinia_Tutorial_CompleteRotationFile.rot
- RodiniaBlocks_WithPlateIDColumnAndIDs.shp
- Rodinia_LIPS_and_Dykes_intersected.shp
- USGS_PorphoryCopper_intersected
- USGS_SedimentHosted_ZnPb_intersected.shp
- USGS_SedimentHostedCopper_intersected.shp

This tutorial dataset is compatible with GPlates 1.5.

Exercise 1 – Creating the rotation file

Previous tutorials have described the rotation file. Here is a brief recap of how the rotation file is organized;

Column 1: “Moving” Plate ID e.g. 611

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)

Column 7: Abbreviation of Plate and Conjugate Plate and name

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.

Global_EarthByte_GPlates_Rotation_20091015.rot

```
611   0.0    0.0     0.0     0.0   609 !WPV-NPS West Parece Vela Basin-North Philippine Sea
611  78.9    0.0     0.0     0.0   609 !WPV-NPS bounds Phil Plate
612   0.0    0.0     0.0     0.0   602 !NCS-SCH Northside South China Sea-South China Platform
612 600.0    0.0     0.0     0.0   602 !NCS-SCH
613   0.0    0.0     0.0     0.0   612 !SCS-NCS Southside South China Sea-Northside South China Sea
613  15.0    0.0     0.0     0.0   612 !SCS-NCS spreading stopped Briais et.al 1993
613  16.8   -3.00   93.60    0.70  612 !SCS-NCS A5C Briais et.al 1993
613  17.6    5.00  105.50    3.70  612 !SCS-NCS A5D Briais et.al 1993
613  18.9   -1.40   88.70    2.40  612 !SCS-NCS A5E Briais et.al 1993
613  20.1    0.10   83.30    2.80  612 !SCS-NSC A6 Briais et.al 1993
613  21.3    0.10   81.30    3.50  612 !SCS-NSC A6A Briais et.al 1993
613  23.1   -1.10   75.90    3.90  612 !SCS-NSC A6B Briais et.al 1993
613  25.2    7.00   87.80    7.50  612 !SCS-NSC A7 Briais et.al 1993
613  26.6    9.30   91.20   10.30  612 !SCS-NSC A8 Briais et.al 1993
613  28.0    8.20   87.40   10.30  612 !SCS-NSC A9 Briais et.al 1993
613  28.6    7.90   85.70   10.80  612 !SCS-NSC A10 Briais et.al 1993
613  30.1    7.90   85.70   11.10  612 !SCS-NSC A11 Briais et.al 1993
```

Figure 1: Plate Rotation File

For this exercise, we are going to build a completely new rotation file describing Rodinia assembly and dispersal, based on the poles of rotation given by Li et al (2008). Appendix 3 of this paper contains the poles of rotation for each cratonic block at a series of times between 1100Ma and 530Ma. Below is a screenshot of the first page in this document.

Appendix III. Rotation parameters for selected time slices during the assembly and break-up of Rodinia and the assembly of Gondwanaland (rotation parameters are relative to the present-day location of each continent).

Craton/block/terrane	Euler Pole (°N)	Euler Pole (°E)	Angle of Rotation (°)
1100 Ma			
Amazonia	24.22	-150.53	-168.79
Australia	55.88	165.81	-90.75
Baltica	53.57	-162.69	146.1
Cathasia	27.93	40.01	38.79
Central Svalbard	64.4	-148.77	152.54
Chortis	84.18	63.99	-141.04
Chukotka	53.97	-159.79	118.91
Congo	12.30	64.20	83.57
Dronning Maud Land	39.92	-120.43	-177.34
Eastern Svalbard	61.97	-142.88	147.14
Greenland	61.54	-161.03	168.41
India	50.47	151.38	-97.38
Kalahari	-12.00	56.39	172.40
Kara	63.26	-140.63	127.94
Laurentia	64.47	-167.30	-175.54
Mawson	37.81	170.15	-103.79
New Siberian Islands	59.06	-155.22	112.46
North Alaska	55.60	-156.35	104.76
North China	32.65	173.72	-142.91
Oaxacia	2.33	-159.9	166.41
Pampean terrane	14.92	-138.32	-173.14
Parana	28.74	46.63	89.64
Rayner	11.30	155.75	-159.90
Rio de La Plata	15.30	-140.24	-172.95
Rockall	66.07	-160.89	161.83
Sao Francisco	16.69	28.86	98.74
Siberia	11.81	164.13	-53.49
Sri Lanka	57.53	130.57	-107.93
Tarim	44.73	62.90	166.60
West Africa	15.31	-125.13	-177.78
Western Svalbard	66.82	-156.71	159.44
Yantzy	38.14	78.17	72.61
1050 Ma			
Amazonia	8.66	-154.88	-140.33
Australia	28.39	147.02	-96.91
Baltica	34.94	-166.56	160.14
Cathasia	48.51	-66.27	31.62
Central Svalbard	44.21	-162.56	166.74
Chortis	66.06	132.91	-140.90
Chukotka	30.95	-158.74	136.50
Congo	0.23	63.75	65.90
Dronning Maud Land	18.17	-126.65	-127.32
Eastern Svalbard	42.52	-157.19	164.24
Greenland	40.84	-172.15	179.36

1

Figure 2: A screenshot of appendix 3 in Li et. al. (2008) showing the poles of rotations for each cratonic block between 1100 Ma and 530 Ma

This table contains all the information we need to make reconstructions at each of the times given (and GPlates will interpolate the positions of each block for all the times in between). However, we need to modify and rearrange the data into a format that GPlates can understand. In rotation files, each plate has it's own unique integer ID number, and all the finite rotations for each plate are grouped together in chronological order (rather than grouping by age, as in the table shown above).

First, you can open the word document '*RodiniaRotationTable.doc*' then cut and paste the contents of the table into a spreadsheet application (Excel, Numbers, Google Docs). Alternatively, you can load the file '*Rodinia_Tutorial_Rotation_Tables.xls'* and look at the first sheet. Either way, you are now ready to carry out the steps listed below.

We need to perform the following operations:

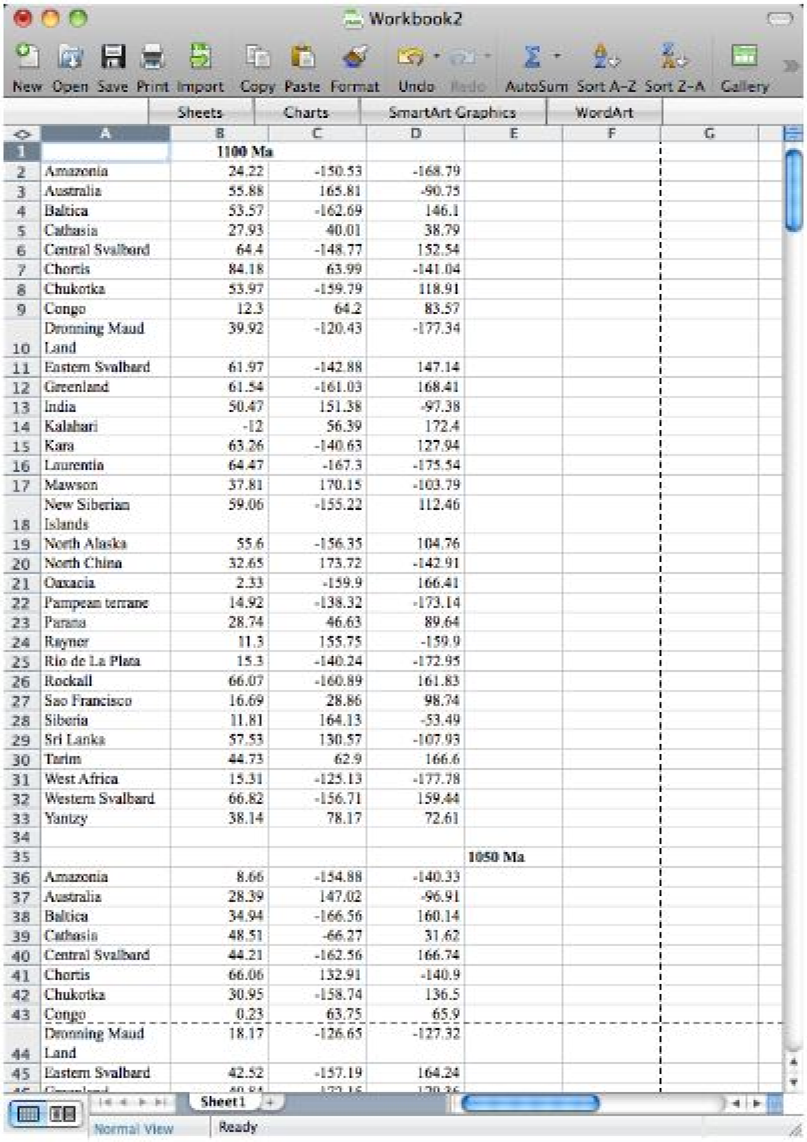
1. Add a new column for the 'Time' of each rotation. Set this value to 1100 for the rows of finite rotations at 1100Ma, 1050 for the rows corresponding to 1050Ma, etc down to 530Ma at the bottom of the table.

2. Look at the part of the table that contains the rotations for 600Ma. You'll see that their are two sets of rotations for this time, reflecting two alternative reconstruction scenarios (the 'Low-Latitude Option' and 'High-Latitude Option', referring to different possible latitudes for Laurentia at this time). To compare these two models, we can make two rotation files containing the two alternative sets of 600Ma poles of rotation. For the moment, keep the 'High-Latitude Option' poles and delete the rows containing the 'Low-Latitude Option'.

3. Also Delete all the spare rows in the table without any rotations.

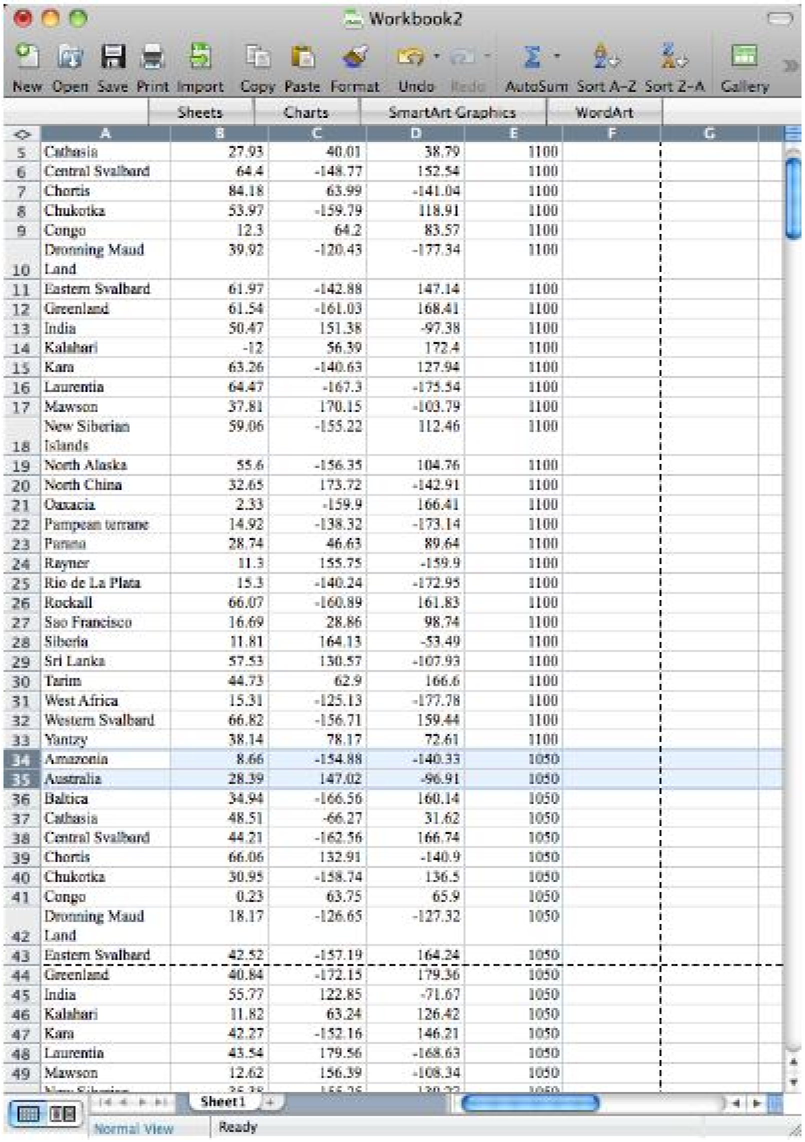
4. Sort the table based on the 'Name' column into alphabetical order, so that all the rotations for Amazonia are grouped together, followed by all the rotations for Australia, etc. (be sure to sort **all** columns, not just the column containing the names)

Illustration of steps 1-4: Load table into spreadsheet, remove unnecessary rows, sort all columns on the column containing the plate names.



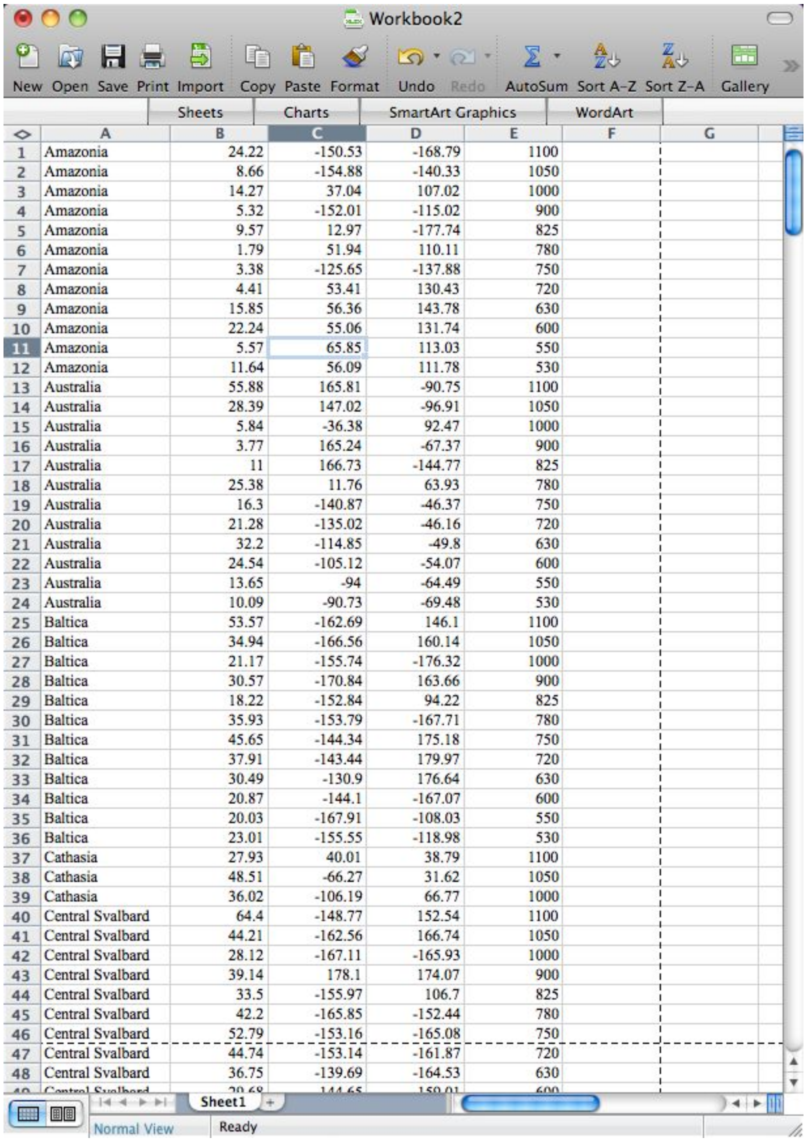
	A	B	C	D	E	F	G
1		1100 Ma					
2	Amazonia	24.22	-150.53	-168.79			
3	Australia	55.88	165.81	-90.75			
4	Baltica	53.57	-162.69	146.1			
5	Cathasia	27.93	40.01	38.79			
6	Central Svalbard	64.4	-148.77	152.54			
7	Chortis	84.18	63.99	-141.04			
8	Chukotka	53.97	-159.79	118.91			
9	Congo	12.3	64.2	83.57			
10	Dronning Maud Land	39.92	-120.43	-177.34			
11	Eastern Svalbard	61.97	-142.88	147.14			
12	Greenland	61.54	-161.03	168.41			
13	India	50.47	151.38	-97.38			
14	Kalahari	-12	56.39	172.4			
15	Kara	63.26	-140.63	127.94			
16	Laurentia	64.47	-167.3	-175.54			
17	Mawson	37.81	170.15	-103.79			
18	New Siberian Islands	59.06	-155.22	112.46			
19	North Alaska	55.6	-156.35	104.76			
20	North China	32.65	173.72	-142.91			
21	Oaxacia	2.33	-159.9	166.41			
22	Pampean terrane	14.92	-138.32	-173.14			
23	Parana	28.74	46.63	89.64			
24	Rayner	11.3	155.75	-159.9			
25	Rio de La Plata	15.3	-140.24	-172.95			
26	Rockall	66.07	-160.89	161.83			
27	Sao Francisco	16.69	28.86	98.74			
28	Siberia	11.81	164.13	-53.49			
29	Sri Lanka	57.53	130.57	-107.93			
30	Tarim	44.73	62.9	166.6			
31	West Africa	15.31	-125.13	-177.78			
32	Western Svalbard	66.82	-156.71	159.44			
33	Yantzy	38.14	78.17	72.61			
34							
35					1050 Ma		
36	Amazonia	8.66	-154.88	-140.33			
37	Australia	28.39	147.02	-96.91			
38	Baltica	34.94	-166.56	160.14			
39	Cathasia	48.51	-66.27	31.62			
40	Central Svalbard	44.21	-162.56	166.74			
41	Chortis	66.06	132.91	-140.9			
42	Chukotka	30.95	-158.74	136.5			
43	Congo	0.23	63.75	65.9			
44	Dronning Maud Land	18.17	-126.65	-127.32			
45	Eastern Svalbard	42.52	-157.19	164.24			

Figure 3: The '*RodiniaRotationTable.doc*' in Excel



	A	B	C	D	E	F	G
5	Cathasia	27.93	40.01	38.79	1100		
6	Central Svalbard	64.4	-148.77	152.54	1100		
7	Chortis	84.18	63.99	-141.04	1100		
8	Chukotka	53.97	-159.79	118.91	1100		
9	Congo	12.3	64.2	83.57	1100		
10	Dronning Maud Land	39.92	-120.43	-177.34	1100		
11	Eastern Svalbard	61.97	-142.88	147.14	1100		
12	Greenland	61.54	-161.03	168.41	1100		
13	India	50.47	151.38	-97.38	1100		
14	Kalahari	-12	56.39	172.4	1100		
15	Kara	63.26	-140.63	127.94	1100		
16	Laurentia	64.47	-167.3	-175.54	1100		
17	Mawson	37.81	170.15	-103.79	1100		
18	New Siberian Islands	59.06	-155.22	112.46	1100		
19	North Alaska	55.6	-156.35	104.76	1100		
20	North China	32.65	173.72	-142.91	1100		
21	Oaxacia	2.33	-159.9	166.41	1100		
22	Pampean terrane	14.92	-138.32	-173.14	1100		
23	Parana	28.74	46.63	89.64	1100		
24	Rayner	11.3	155.75	-159.9	1100		
25	Rio de La Plata	15.3	-140.24	-172.95	1100		
26	Rockall	66.07	-160.89	161.83	1100		
27	Sao Francisco	16.69	28.86	98.74	1100		
28	Siberia	11.81	164.13	-53.49	1100		
29	Sri Lanka	57.53	130.57	-107.93	1100		
30	Tarim	44.73	62.9	166.6	1100		
31	West Africa	15.31	-125.13	-177.78	1100		
32	Western Svalbard	66.82	-156.71	159.44	1100		
33	Yantzy	38.14	78.17	72.61	1100		
34	Amazonia	8.66	-154.88	-140.33	1050		
35	Australia	28.39	147.02	-96.91	1050		
36	Baltica	34.94	-166.56	160.14	1050		
37	Cathasia	48.51	-66.27	31.62	1050		
38	Central Svalbard	44.21	-162.56	166.74	1050		
39	Chortis	66.06	132.91	-140.9	1050		
40	Chukotka	30.95	-158.74	136.5	1050		
41	Congo	0.23	63.75	65.9	1050		
42	Dronning Maud Land	18.17	-126.65	-127.32	1050		
43	Eastern Svalbard	42.52	-157.19	164.24	1050		
44	Greenland	40.84	-172.15	179.36	1050		
45	India	55.77	122.85	-71.67	1050		
46	Kalahari	11.82	63.24	126.42	1050		
47	Kara	42.27	-152.16	146.21	1050		
48	Laurentia	43.54	179.56	-168.63	1050		
49	Mawson	12.62	156.39	-108.34	1050		

Figure 4: The '*RodiniaRotationTable.doc'* with assigned timeframe of each rotation



	A	B	C	D	E	F	G
1	Amazonia	24.22	-150.53	-168.79	1100		
2	Amazonia	8.66	-154.88	-140.33	1050		
3	Amazonia	14.27	37.04	107.02	1000		
4	Amazonia	5.32	-152.01	-115.02	900		
5	Amazonia	9.57	12.97	-177.74	825		
6	Amazonia	1.79	51.94	110.11	780		
7	Amazonia	3.38	-125.65	-137.88	750		
8	Amazonia	4.41	53.41	130.43	720		
9	Amazonia	15.85	56.36	143.78	630		
10	Amazonia	22.24	55.06	131.74	600		
11	Amazonia	5.57	65.85	113.03	550		
12	Amazonia	11.64	56.09	111.78	530		
13	Australia	55.88	165.81	-90.75	1100		
14	Australia	28.39	147.02	-96.91	1050		
15	Australia	5.84	-36.38	92.47	1000		
16	Australia	3.77	165.24	-67.37	900		
17	Australia	11	166.73	-144.77	825		
18	Australia	25.38	11.76	63.93	780		
19	Australia	16.3	-140.87	-46.37	750		
20	Australia	21.28	-135.02	-46.16	720		
21	Australia	32.2	-114.85	-49.8	630		
22	Australia	24.54	-105.12	-54.07	600		
23	Australia	13.65	-94	-64.49	550		
24	Australia	10.09	-90.73	-69.48	530		
25	Baltica	53.57	-162.69	146.1	1100		
26	Baltica	34.94	-166.56	160.14	1050		
27	Baltica	21.17	-155.74	-176.32	1000		
28	Baltica	30.57	-170.84	163.66	900		
29	Baltica	18.22	-152.84	94.22	825		
30	Baltica	35.93	-153.79	-167.71	780		
31	Baltica	45.65	-144.34	175.18	750		
32	Baltica	37.91	-143.44	179.97	720		
33	Baltica	30.49	-130.9	176.64	630		
34	Baltica	20.87	-144.1	-167.07	600		
35	Baltica	20.03	-167.91	-108.03	550		
36	Baltica	23.01	-155.55	-118.98	530		
37	Cathasia	27.93	40.01	38.79	1100		
38	Cathasia	48.51	-66.27	31.62	1050		
39	Cathasia	36.02	-106.19	66.77	1000		
40	Central Svalbard	64.4	-148.77	152.54	1100		
41	Central Svalbard	44.21	-162.56	166.74	1050		
42	Central Svalbard	28.12	-167.11	-165.93	1000		
43	Central Svalbard	39.14	178.1	174.07	900		
44	Central Svalbard	33.5	-155.97	106.7	825		
45	Central Svalbard	42.2	-165.85	-152.44	780		
46	Central Svalbard	52.79	-153.16	-165.08	750		
47	Central Svalbard	44.74	-153.14	-161.87	720		
48	Central Svalbard	36.75	-139.69	-164.53	630		

Figure 5: The '*RodiniaRotationTable.doc'* with sorted names in alphabetical order

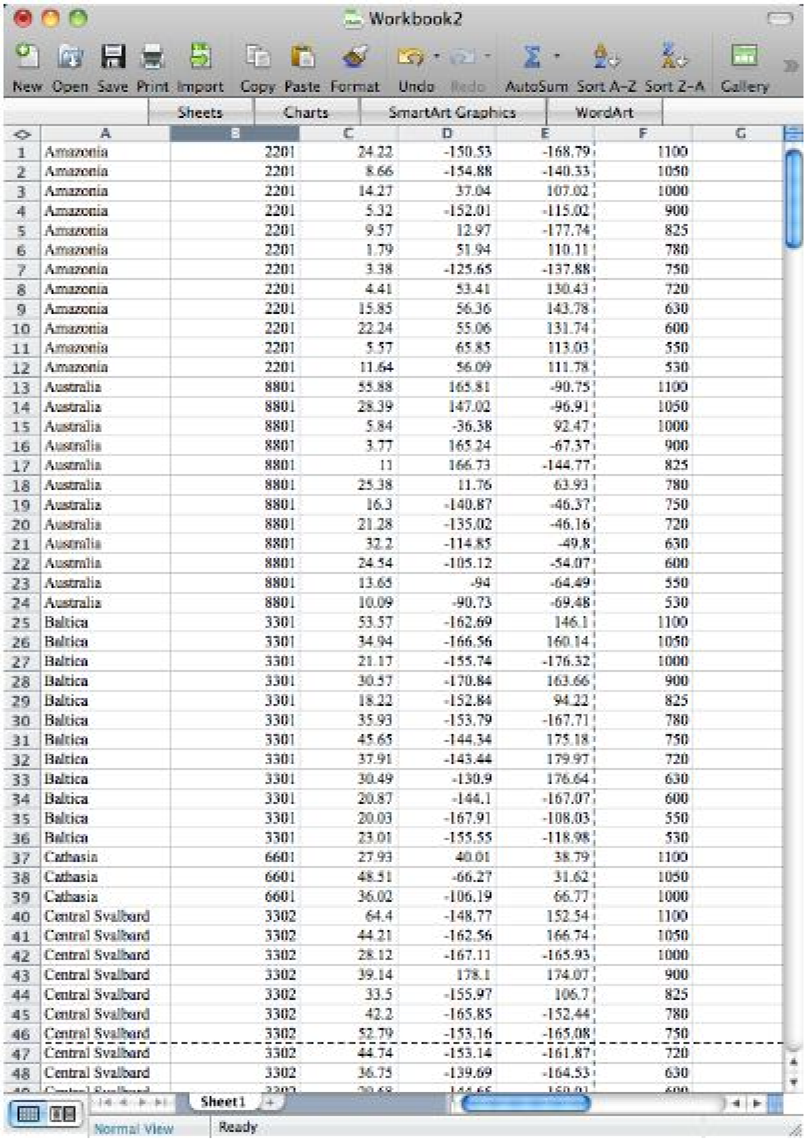
5. Create a new column for the moving plate code for each rotation. You need to decide on an integer value to use as a unique ID for each plate. Any integer should work, but it is suggested that the numbers chosen follow some general conventions that have become established within the plate modelling community - plates that form part of present day North America begin with a 1, South America 2, Europe 3, Eastern Eurasia 4, India-Central Asia 5, East Asia 6, Africa 7, Australia-Antarctica 8, and Pacific 9. So in this case, we could give Amazonia the code 2201, the Sao Francisco craton 2202, and so on until each plate has its own unique ID number.

6. Once you've decided on the plate codes, make sure that each line in the 'Moving Plate' column contains the appropriate integer ID value.

7. You also need to add a column for the 'Fixed Plate'. For this particular model, all the rotations are given relative to the present-day location of the plate (rather than relative to another plate). In this case, we assign 0 to be the value in the Fixed Plate column.

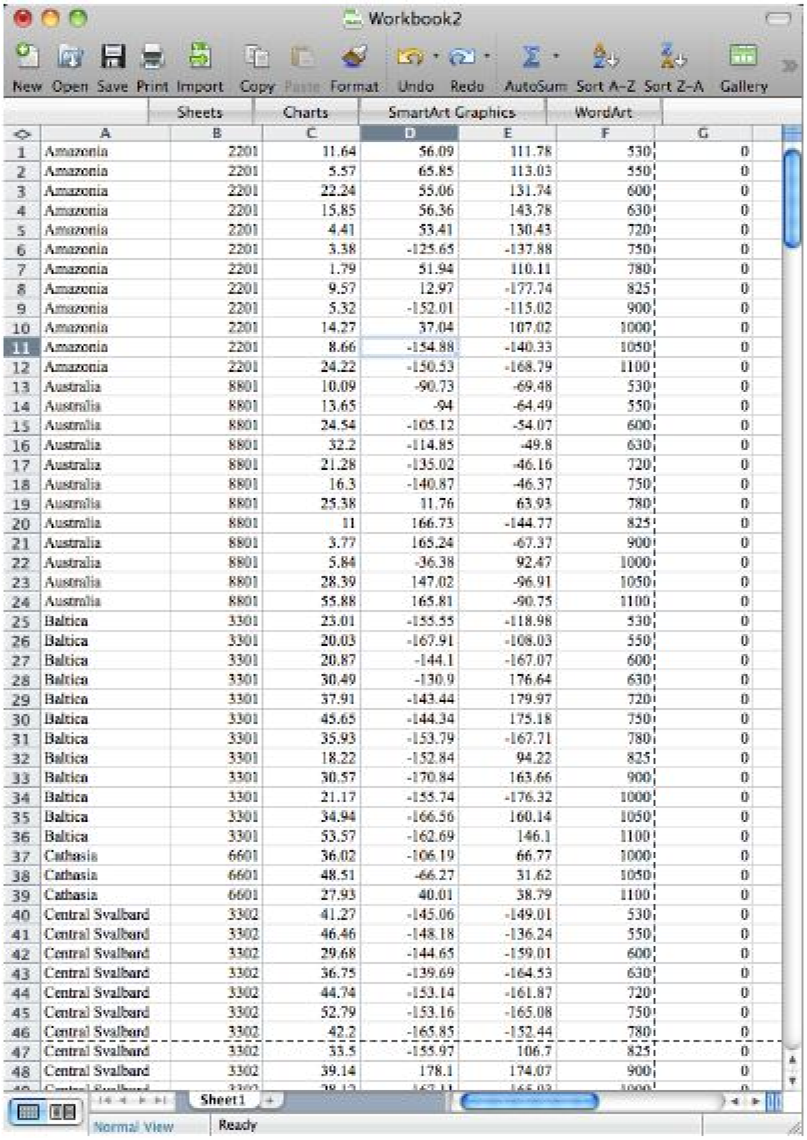
8. For each plate, we need to add an entry that defines the pole of rotation for the present day (t=0). In each case, this row is just a series of zeros for the pole latitude, longitude and angle.

Illustration of steps 5-8: Insert unique integer plate codes for each plate, add a column for the 'fixed' plate containing all zeros, add in rotations for time=0.



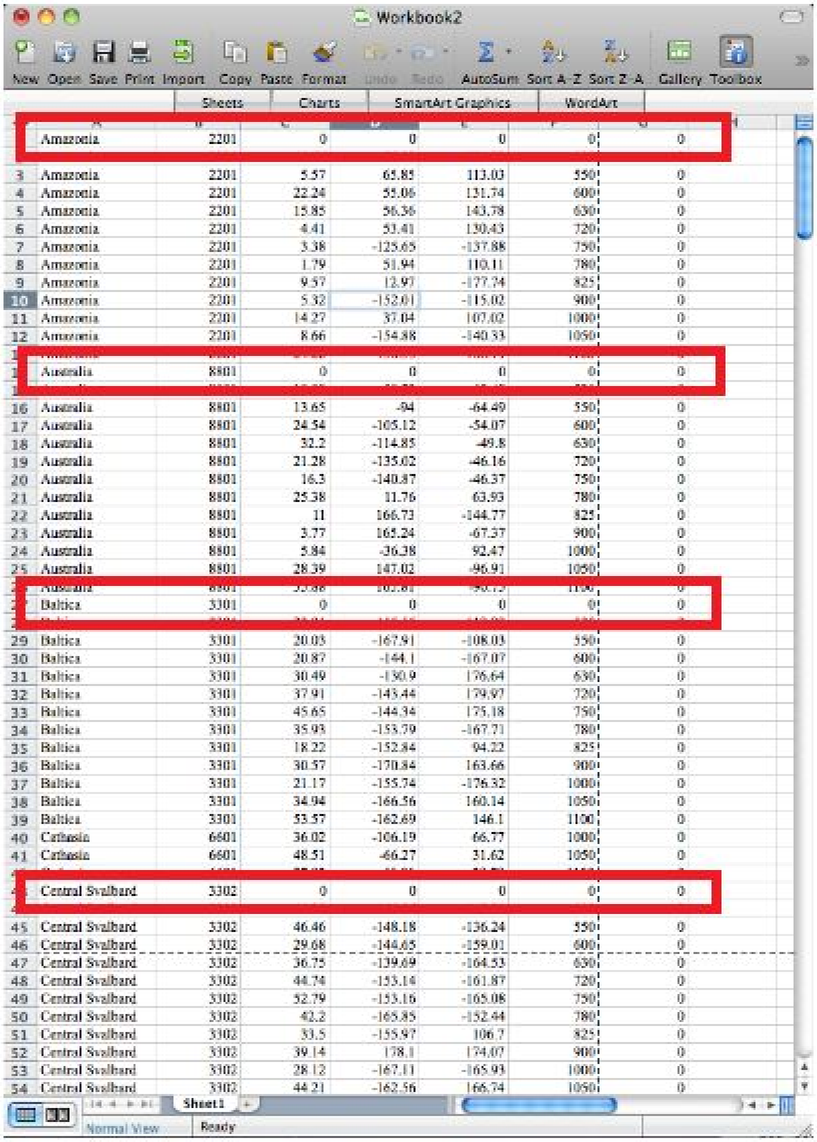
	A	B	C	D	E	F	G
1	Amazonia	2201	24.22	-150.53	-168.79	1100	
2	Amazonia	2201	8.66	-154.88	-140.33	1050	
3	Amazonia	2201	14.27	37.04	107.02	1000	
4	Amazonia	2201	5.32	-152.01	-115.02	900	
5	Amazonia	2201	9.57	12.97	-177.74	825	
6	Amazonia	2201	1.79	51.94	110.11	780	
7	Amazonia	2201	3.38	-125.65	-137.88	750	
8	Amazonia	2201	4.41	53.41	130.43	720	
9	Amazonia	2201	15.85	56.36	143.78	630	
10	Amazonia	2201	22.24	55.06	131.74	600	
11	Amazonia	2201	5.57	65.85	113.03	550	
12	Amazonia	2201	11.64	56.09	111.78	530	
13	Australia	8801	55.88	165.81	-90.75	1100	
14	Australia	8801	28.39	147.02	-96.91	1050	
15	Australia	8801	5.84	-36.38	92.47	1000	
16	Australia	8801	3.77	165.24	-67.37	900	
17	Australia	8801	11	166.73	-144.77	825	
18	Australia	8801	25.38	11.76	63.93	780	
19	Australia	8801	16.3	-140.87	-46.37	750	
20	Australia	8801	21.28	-135.02	-46.16	720	
21	Australia	8801	32.2	-114.85	-49.8	630	
22	Australia	8801	24.54	-105.12	-54.07	600	
23	Australia	8801	13.65	-94	-64.49	550	
24	Australia	8801	10.09	-90.73	-69.48	530	
25	Baltica	3301	53.57	-162.69	146.1	1100	
26	Baltica	3301	34.94	-166.56	160.14	1050	
27	Baltica	3301	21.17	-155.74	-176.32	1000	
28	Baltica	3301	30.57	-170.84	163.66	900	
29	Baltica	3301	18.22	-152.84	94.22	825	
30	Baltica	3301	35.93	-153.79	-167.71	780	
31	Baltica	3301	45.65	-144.34	175.18	750	
32	Baltica	3301	37.91	-143.44	179.97	720	
33	Baltica	3301	30.49	-130.9	176.64	630	
34	Baltica	3301	20.87	-144.1	-167.07	600	
35	Baltica	3301	20.03	-167.91	-108.03	550	
36	Baltica	3301	23.01	-155.55	-118.98	530	
37	Cathasia	6601	27.93	40.01	38.79	1100	
38	Cathasia	6601	48.51	-66.27	31.62	1050	
39	Cathasia	6601	36.02	-106.19	66.77	1000	
40	Central Svalbard	3302	64.4	-148.77	152.54	1100	
41	Central Svalbard	3302	44.21	-162.56	166.74	1050	
42	Central Svalbard	3302	28.12	-167.11	-165.93	1000	
43	Central Svalbard	3302	39.14	178.1	174.07	900	
44	Central Svalbard	3302	33.5	-155.97	106.7	825	
45	Central Svalbard	3302	42.2	-165.85	-152.44	780	
46	Central Svalbard	3302	52.79	-153.16	-165.08	750	
47	Central Svalbard	3302	44.74	-153.14	-161.87	720	
48	Central Svalbard	3302	36.75	-139.69	-164.53	630	

Figure 6: Column 'B' represents the plate ID codes for each rotation



	A	B	C	D	E	F	G
1	Amazonia	2201	11.64	56.09	111.78	530	0
2	Amazonia	2201	5.57	65.85	113.03	550	0
3	Amazonia	2201	22.24	55.06	131.74	600	0
4	Amazonia	2201	15.85	56.36	143.78	630	0
5	Amazonia	2201	4.41	53.41	130.43	720	0
6	Amazonia	2201	3.38	-125.65	-137.88	750	0
7	Amazonia	2201	1.79	51.94	110.11	780	0
8	Amazonia	2201	9.57	12.97	-177.74	825	0
9	Amazonia	2201	5.32	-152.01	-115.02	900	0
10	Amazonia	2201	14.27	37.04	107.02	1000	0
11	Amazonia	2201	8.66	-154.88	-140.33	1050	0
12	Amazonia	2201	24.22	-150.53	-168.79	1100	0
13	Australia	8801	10.09	-90.73	-69.48	530	0
14	Australia	8801	13.65	-94	-64.49	550	0
15	Australia	8801	24.54	-105.12	-54.07	600	0
16	Australia	8801	32.2	-114.85	-49.8	630	0
17	Australia	8801	21.28	-135.02	-46.16	720	0
18	Australia	8801	16.3	-140.87	-46.37	750	0
19	Australia	8801	25.38	11.76	63.93	780	0
20	Australia	8801	11	166.73	-144.77	825	0
21	Australia	8801	3.77	165.24	-67.37	900	0
22	Australia	8801	5.84	-36.38	92.47	1000	0
23	Australia	8801	28.39	147.02	-96.91	1050	0
24	Australia	8801	55.88	165.81	-90.75	1100	0
25	Baltica	3301	23.01	-155.55	-118.98	530	0
26	Baltica	3301	20.03	-167.91	-108.03	550	0
27	Baltica	3301	20.87	-144.1	-167.07	600	0
28	Baltica	3301	30.49	-130.9	176.64	630	0
29	Baltica	3301	37.91	-143.44	179.97	720	0
30	Baltica	3301	45.65	-144.34	175.18	750	0
31	Baltica	3301	35.93	-153.79	-167.71	780	0
32	Baltica	3301	18.22	-152.84	94.22	825	0
33	Baltica	3301	30.57	-170.84	163.66	900	0
34	Baltica	3301	21.17	-155.74	-176.32	1000	0
35	Baltica	3301	34.94	-166.56	160.14	1050	0
36	Baltica	3301	53.57	-162.69	146.1	1100	0
37	Cathasia	6601	36.02	-106.19	66.77	1000	0
38	Cathasia	6601	48.51	-66.27	31.62	1050	0
39	Cathasia	6601	27.93	40.01	38.79	1100	0
40	Central Svalbard	3302	41.27	-145.06	-149.01	530	0
41	Central Svalbard	3302	46.46	-148.18	-136.24	550	0
42	Central Svalbard	3302	29.68	-144.65	-159.01	600	0
43	Central Svalbard	3302	36.75	-139.69	-164.53	630	0
44	Central Svalbard	3302	44.74	-153.14	-161.87	720	0
45	Central Svalbard	3302	52.79	-153.16	-165.08	750	0
46	Central Svalbard	3302	42.2	-165.85	-152.44	780	0
47	Central Svalbard	3302	33.5	-155.97	106.7	825	0
48	Central Svalbard	3302	39.14	178.1	174.07	900	0

Figure 7: The ‘Fixed Plate’ identity is represented by column ‘G’



	A	B	C	D	E	F	G
	Amazonia	2201	0	0	0	0	0
3	Amazonia	2201	5.57	65.85	113.03	550	0
4	Amazonia	2201	22.24	55.06	131.74	600	0
5	Amazonia	2201	15.85	56.36	143.78	630	0
6	Amazonia	2201	4.41	53.41	130.43	720	0
7	Amazonia	2201	3.38	-125.65	-137.88	750	0
8	Amazonia	2201	1.79	51.94	110.11	780	0
9	Amazonia	2201	9.57	12.97	-177.74	825	0
10	Amazonia	2201	5.32	-152.01	-115.02	900	0
11	Amazonia	2201	14.27	37.04	107.02	1000	0
12	Amazonia	2201	8.66	-154.88	-140.33	1050	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Australia	8801	0	0	0	0	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	Australia	8801	13.65	-94	-64.49	550	0
17	Australia	8801	24.54	-105.12	-54.07	600	0
18	Australia	8801	32.2	-114.85	-49.8	630	0
19	Australia	8801	21.28	-135.02	-46.16	720	0
20	Australia	8801	16.3	-140.87	-46.37	750	0
21	Australia	8801	25.38	11.76	63.93	780	0
22	Australia	8801	11	166.73	-144.77	825	0
23	Australia	8801	3.77	165.24	-67.37	900	0
24	Australia	8801	5.84	-36.38	92.47	1000	0
25	Australia	8801	28.39	147.02	-96.91	1050	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Baltica	3301	0	0	0	0	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	Baltica	3301	20.03	-167.91	-108.03	550	0
30	Baltica	3301	20.87	-144.1	-167.07	600	0
31	Baltica	3301	30.49	-130.9	176.64	630	0
32	Baltica	3301	37.91	-143.44	179.97	720	0
33	Baltica	3301	45.65	-144.34	175.18	750	0
34	Baltica	3301	35.93	-153.79	-167.71	780	0
35	Baltica	3301	18.22	-152.84	94.22	825	0
36	Baltica	3301	30.57	-170.84	163.66	900	0
37	Baltica	3301	21.17	-155.74	-176.32	1000	0
38	Baltica	3301	34.94	-166.56	160.14	1050	0
39	Baltica	3301	53.57	-162.69	146.1	1100	0
40	Cathasia	6601	36.02	-106.19	66.77	1000	0
41	Cathasia	6601	48.51	-66.27	31.62	1050	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Central Svalbard	3302	0	0	0	0	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
45	Central Svalbard	3302	46.46	-148.18	-136.24	550	0
46	Central Svalbard	3302	29.68	-144.65	-159.01	600	0
47	Central Svalbard	3302	36.75	-139.69	-164.53	630	0
48	Central Svalbard	3302	44.74	-153.14	-161.87	720	0
49	Central Svalbard	3302	52.79	-153.16	-165.08	750	0
50	Central Svalbard	3302	42.2	-165.85	-152.44	780	0
51	Central Svalbard	3302	33.5	-155.97	106.7	825	0
52	Central Svalbard	3302	39.14	178.1	174.07	900	0
53	Central Svalbard	3302	28.12	-167.11	-165.93	1000	0
54	Central Svalbard	3302	44.21	-162.56	166.74	1050	0

Figure 8: The zeroes define the poles of the rotation for present day.

The second sheet in the spreadsheet provided shows the results of the process outlined above

One final wrinkle with the Rodinia example is when plates have finite rotation poles greater than 180 degrees. If you simply use the rotations given in the Li et al table directly into GPlates, the reconstructions at the time prescribed in the table will look fine - however, the interpolated poles defining the positions of the plates between these times may give strange results. This is a problem that is more likely to occur in models going a long way back in time (e.g. this Rodinia model), since there is greater potential for blocks to have rotated large amounts relative to their original position. To avoid this problem, we can add 360 degrees to the rotation angle for each time where the rotation pole results in an unnecessarily circuitous path from one finite rotation pole time to the next. To see the effect of this process, look at the third sheet in the provided spreadsheet and compare it to the second one.

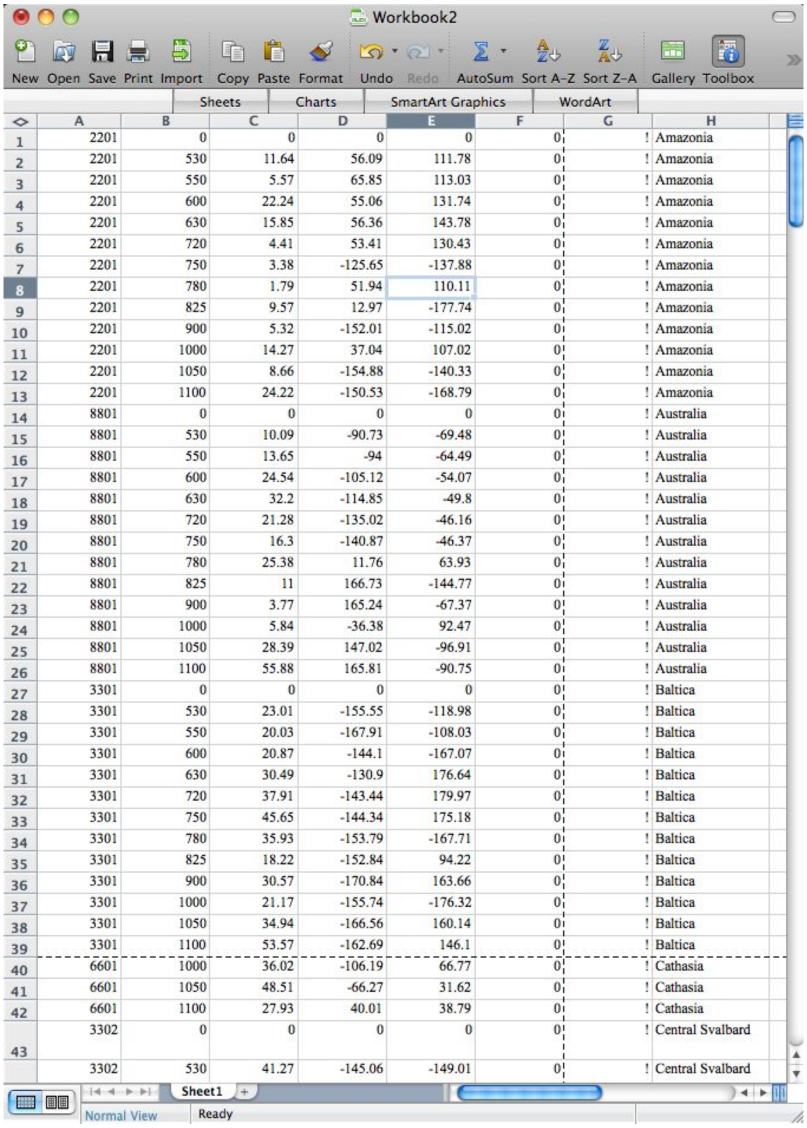
The table now contains all the information necessary for it to work in GPlates. The final step is to export the data into an ascii '*.rot' file, the standard format for rotation tables used in GPlates.

To export to .rot format, follow these steps:

1. Rearrange the columns so that they appear in the standard order; Moving Plate,Time,Pole Lat, Pole Lon, Pole Angle, Fixed Plate, Comment. The comment needs to be preceded by a exclamation mark (!), so we can insert a column of !'s before the plate name column to use these as the comments.

2. export to a tab delimited text file, give it the file extension *.rot so that GPlates will recognise it as a rotation table

(IMPORTANT NOTE: mac users may experience an issue where a rotation file that appears perfectly fine will not load properly into GPlates (no error message is returned, but the rotation table is empty). A possible cause is that the rotation file has 'Mac OS style' line endings. Try opening the file in a text editor (e.g. textmate), go to 'Save As...' then specify Windows format line endings. The new file should load ok.



	A	B	C	D	E	F	G	H
1	2201	0	0	0	0	0	!	Amazonia
2	2201	530	11.64	56.09	111.78	0	!	Amazonia
3	2201	550	5.57	65.85	113.03	0	!	Amazonia
4	2201	600	22.24	55.06	131.74	0	!	Amazonia
5	2201	630	15.85	56.36	143.78	0	!	Amazonia
6	2201	720	4.41	53.41	130.43	0	!	Amazonia
7	2201	750	3.38	-125.65	-137.88	0	!	Amazonia
8	2201	780	1.79	51.94	110.11	0	!	Amazonia
9	2201	825	9.57	12.97	-177.74	0	!	Amazonia
10	2201	900	5.32	-152.01	-115.02	0	!	Amazonia
11	2201	1000	14.27	37.04	107.02	0	!	Amazonia
12	2201	1050	8.66	-154.88	-140.33	0	!	Amazonia
13	2201	1100	24.22	-150.53	-168.79	0	!	Amazonia
14	8801	0	0	0	0	0	!	Australia
15	8801	530	10.09	-90.73	-69.48	0	!	Australia
16	8801	550	13.65	-94	-64.49	0	!	Australia
17	8801	600	24.54	-105.12	-54.07	0	!	Australia
18	8801	630	32.2	-114.85	-49.8	0	!	Australia
19	8801	720	21.28	-135.02	-46.16	0	!	Australia
20	8801	750	16.3	-140.87	-46.37	0	!	Australia
21	8801	780	25.38	11.76	63.93	0	!	Australia
22	8801	825	11	166.73	-144.77	0	!	Australia
23	8801	900	3.77	165.24	-67.37	0	!	Australia
24	8801	1000	5.84	-36.38	92.47	0	!	Australia
25	8801	1050	28.39	147.02	-96.91	0	!	Australia
26	8801	1100	55.88	165.81	-90.75	0	!	Australia
27	3301	0	0	0	0	0	!	Baltica
28	3301	530	23.01	-155.55	-118.98	0	!	Baltica
29	3301	550	20.03	-167.91	-108.03	0	!	Baltica
30	3301	600	20.87	-144.1	-167.07	0	!	Baltica
31	3301	630	30.49	-130.9	176.64	0	!	Baltica
32	3301	720	37.91	-143.44	179.97	0	!	Baltica
33	3301	750	45.65	-144.34	175.18	0	!	Baltica
34	3301	780	35.93	-153.79	-167.71	0	!	Baltica
35	3301	825	18.22	-152.84	94.22	0	!	Baltica
36	3301	900	30.57	-170.84	163.66	0	!	Baltica
37	3301	1000	21.17	-155.74	-176.32	0	!	Baltica
38	3301	1050	34.94	-166.56	160.14	0	!	Baltica
39	3301	1100	53.57	-162.69	146.1	0	!	Baltica
40	6601	1000	36.02	-106.19	66.77	0	!	Cathasia
41	6601	1050	48.51	-66.27	31.62	0	!	Cathasia
42	6601	1100	27.93	40.01	38.79	0	!	Cathasia
43	3302	0	0	0	0	0	!	Central Svalbard
	3302	530	41.27	-145.06	-149.01	0	!	Central Svalbard

Figure 9: Illustration of the rotation table with the columns in the correct order to be exported to an ascii rotation table

Exercise 2 – Creating plate polygons

Now that we have a rotation model, we need to create some vector data sets that allow us to visualize the plate motions.

The file '*RodiniaBlocks.shp*' is a shapefile containing the block outlines used to create the Geodynamic Map of Rodinia project (the shapefile is derived from a larger set of GIS data available online here: http://www.tsrc.uwa.edu.au/440project/rodiniamaps)

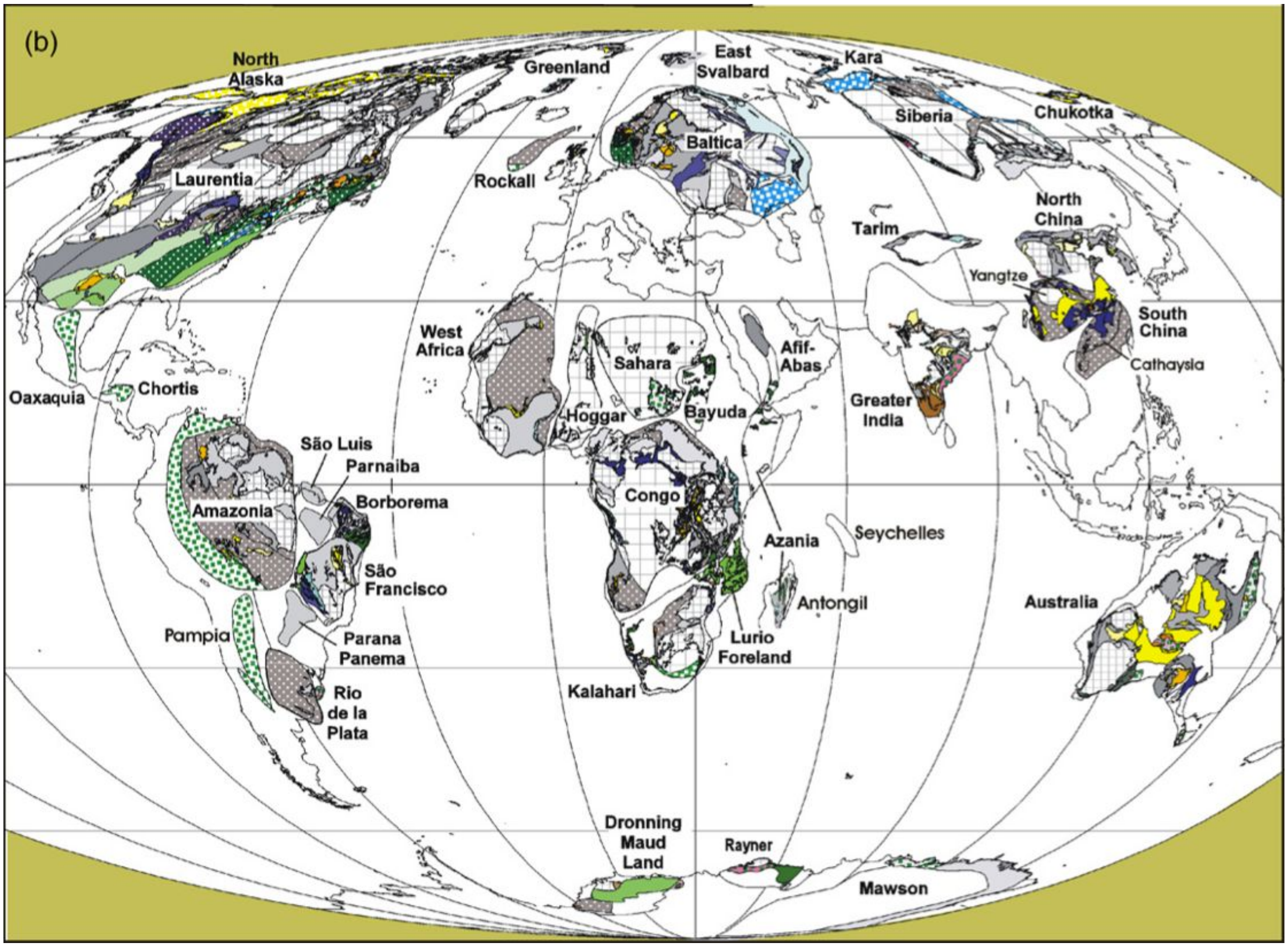


Figure 10: A representation of the Roginia model block names

To get started with the Rodinia model, do the following;

1. Open GPlates
2. Load the rotation file you have created - go to 'File --> Open Feature Collection...' , then select the .rot file. Alternatively, if you don't want to go to the trouble of creating the rotation file yourself, you can use the already rotation file '*Rodinia_Tutorial_ExportFromExcelSheet3.rot*'
3. Using the same file load dialogue, also load the shape file '*RodiniaBlocks_ForTutorial.shp*'.

In the 'rectangular' projection, the data should look like this;

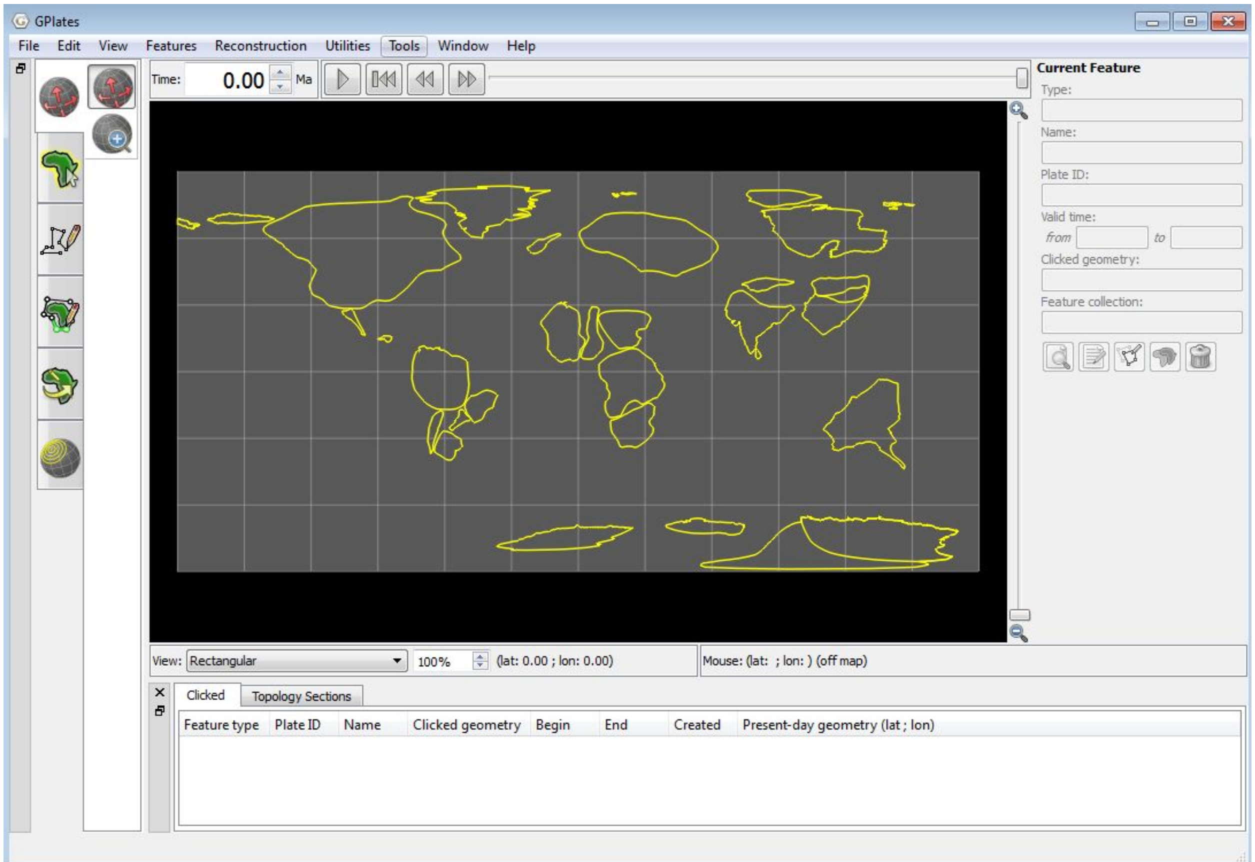


Figure 11: Rodinia blocks in the 'rectangular' projection

The Rodinia model contains rotation poles for time between 1100 Ma and 530 Ma. Change the reconstruction time to one of these times by typing it into the 'Time' panel in the top left of the GPlates window.

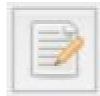
Notice that nothing appears to have happened.

This is because the polygon do not have plate codes assigned. (Note that by default, the plates are displayed with colours matched to Plate ID. At the moments all the plates have an ID of zero, hence they are all yellow. If you look at the table of reconstruction poles ('Reconstruction --> View Total Reconstruction Poles...') you will see that the rotation table is populated with values for each plate as defined by the .rot file. Since the polygons in the shapefile don't have the corresponding Plate IDs defined, GPlates doesn't know where to move each one.

So we need to define the Plate ID for each polygon:

1. Select the 'Choose Feature' icon  from the Tool Palette

2. Click on one of the plates.

3. Click on the ‘Edit Feature’ icon  in the Current Feature Panel to the right of the main view.

4. Select the gpml:reconstructionPlateId property, then in the dialogue box at the bottom of the panel, enter the value of the Plate ID for the plate that you selected. For example, below the 'West Africa' plate is selected. We assigned this plate to have an ID of 7703, so we assign the same value to the polygon.

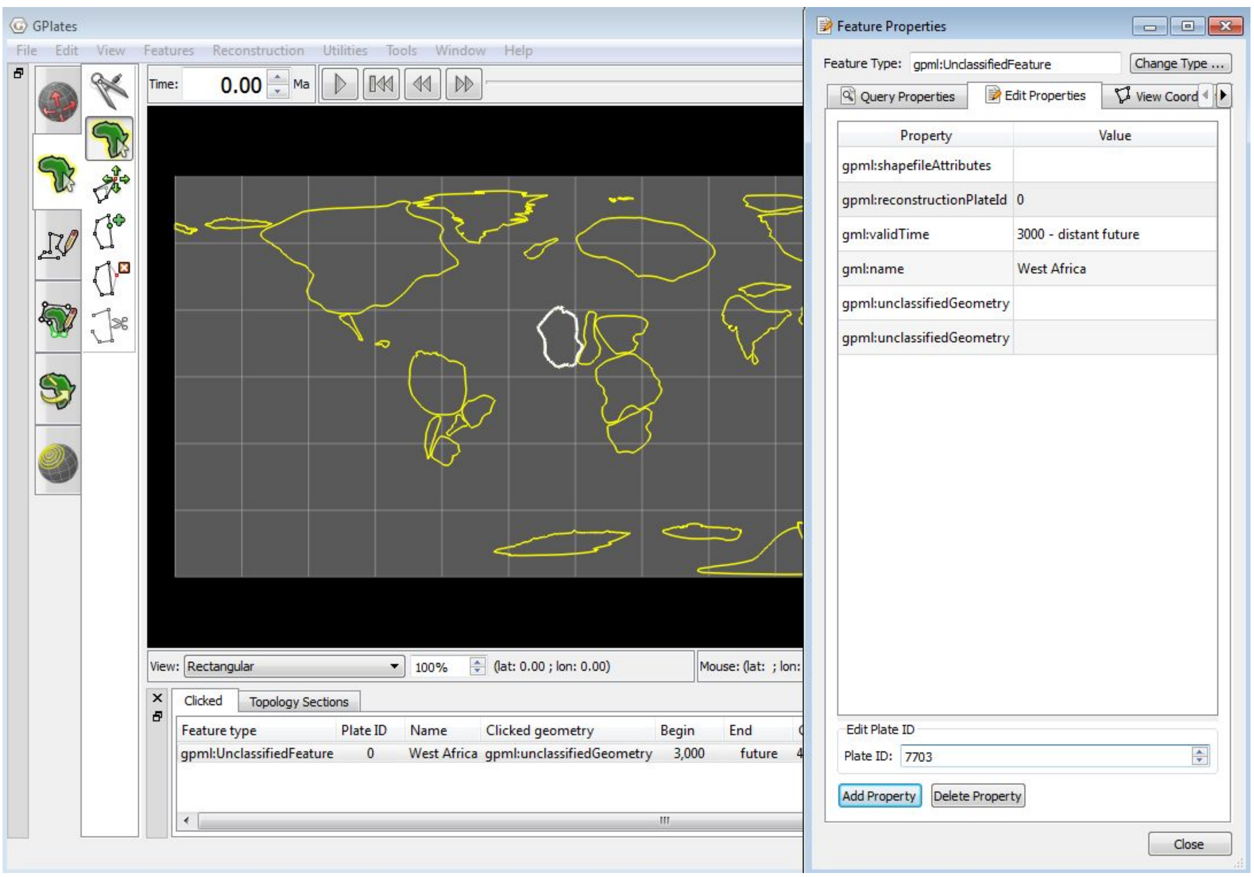


Figure 12: Assigning a plate ID to West Africa

5. Close the Feature Properties dialogue box. You'll see that the polygon for which you just assigned a plate ID has now moved to its reconstructed position at the current reconstruction time.

6. Repeat this process for some of the other plates, assigning the

appropriate plate ID for each one.

At this point, it is worth noting a few things:

i. the polygons you have edited have moved (based on the values in the rotation table) and changed colour (because by default the polygons are coloured by Plate ID - in the beginning all the Plate IDs were zero, hence all the polygons were yellow).

ii. a red disk icon has appeared in the bottom right of the main GPlates window. This indicates that changes have been made to features in GPlates, but that these changes have not been saved. To save changes at any point, go the 'Manage Feature Collections' dialogue (File --> Manage Feature Collections...'). Features with unsaved modifications are highlighted in red.

Illustration of Rodinia model after three of the polygons (West Africa, Australia and Laurentia) have been assigned Plate IDs. The modified plate polygons have changed colour and moved to the correct location at 530 Ma. The red icon in the lower left corner indicates that features have unsaved changes.

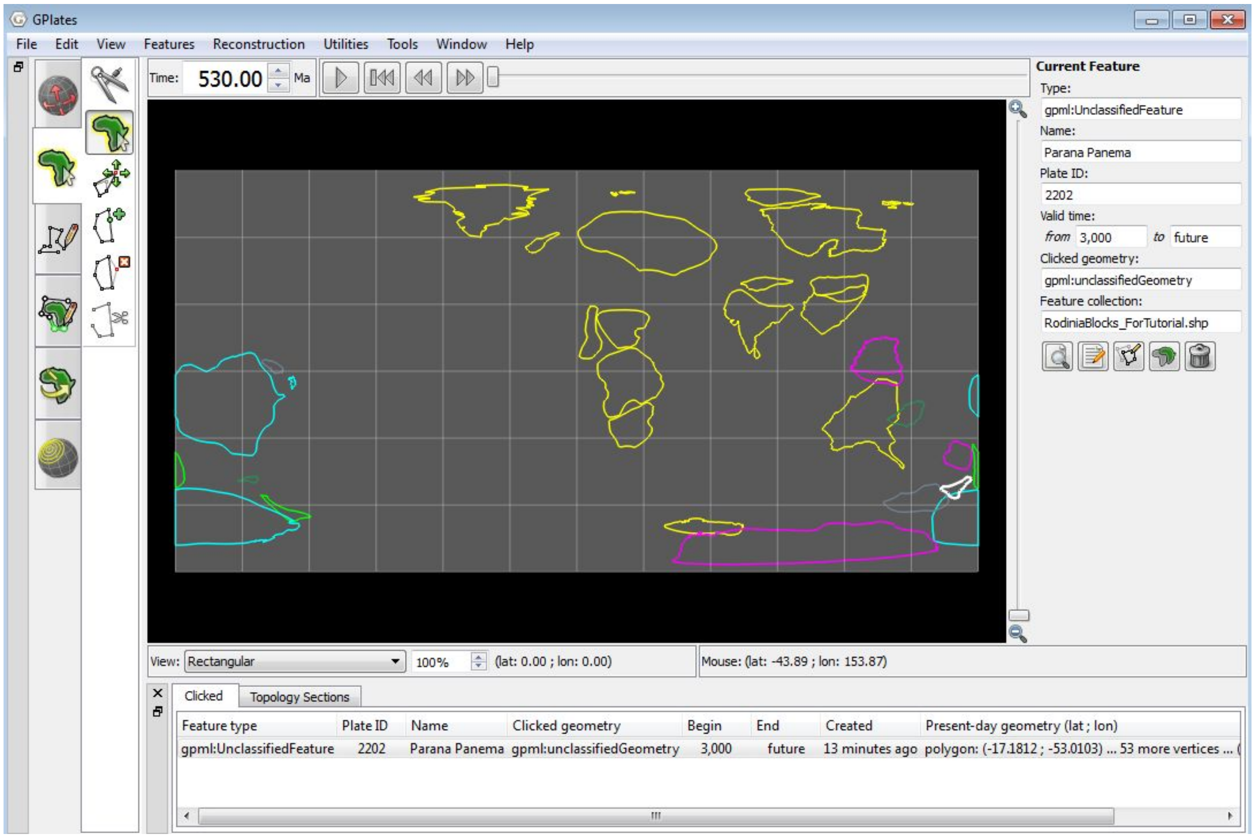


Figure 13: Assigning plate IDs

Now, continue assigning Plate IDs until all the plates for which there are rotations in the rotation table created earlier. Once this process is completed, the reconstruction for 530 Ma should look like this:

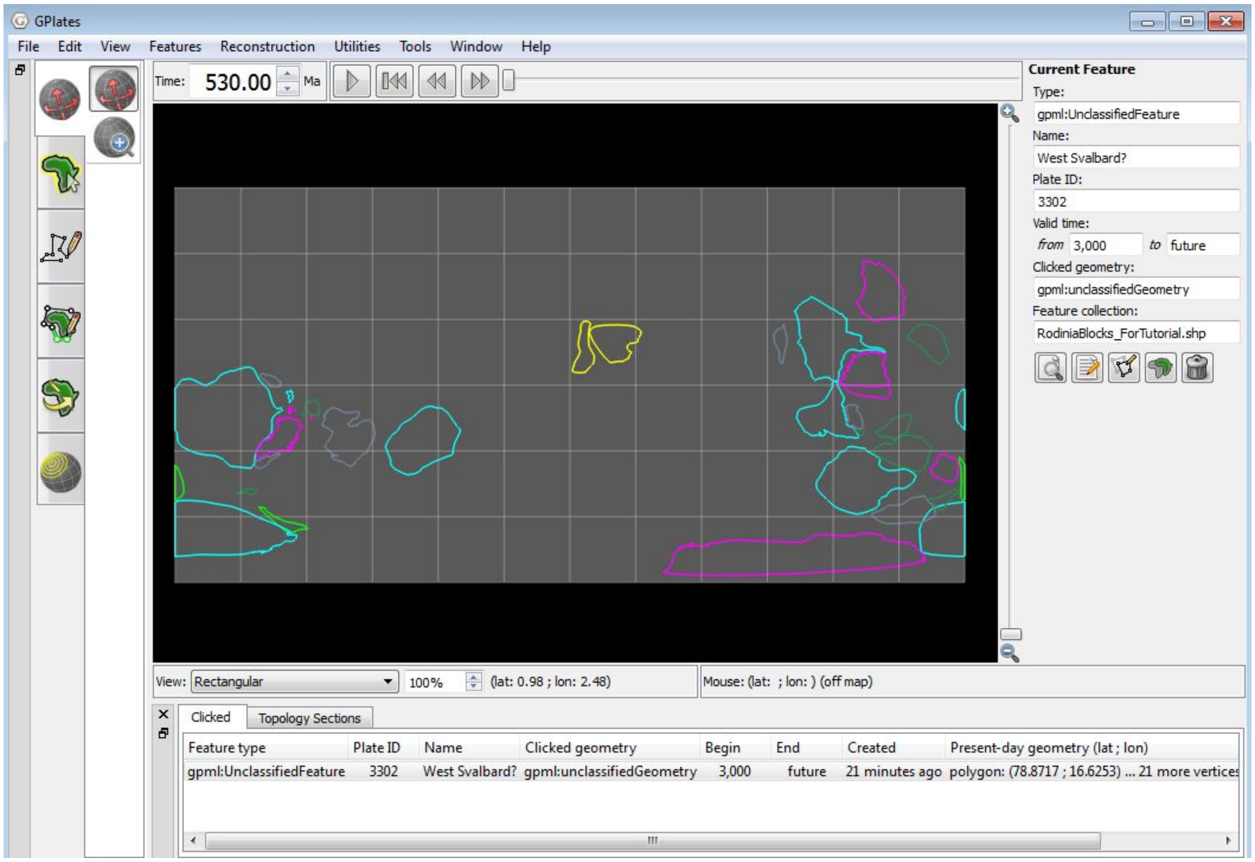


Figure 14: Rodinia with all plate IDs assigned

At this point, we have defined the Rodinia reconstruction model to the full extent allowed by the data provided by Li et al (2008).

Additional Exercise 1: Adding rotations for additional blocks

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You'll notice that, following the process above, there are two blocks that haven't moved - the Hoggar and Sahara Blocks. These weren't listed in the table of rotations of Li et al (2008). So, we need to come up with an alternative method to derive poles of rotation for these blocks. To help in this process, we can look at figures and animations that show the location of these blocks within reconstruction for certain times. For example, in the figure below from Li et al (2008) we can see the approximate location of Sahara, as well as Arabia and Nubia (for which you haven't been provided block outlines).

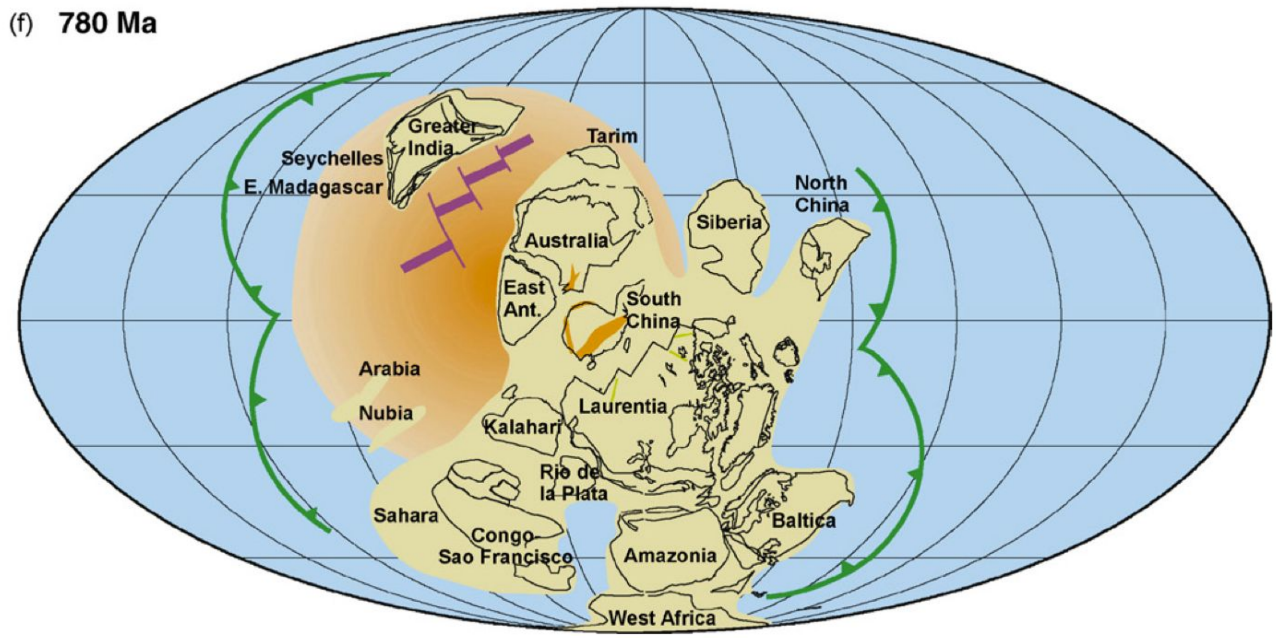

Figure 15: Rodinia reconstruction at 780 Ma, from Li et al (2008)

GPlates tutorial #6 (Data Mining) includes an introduction to the concept of the reverse engineering plate reconstructions from images in papers. You can use this approach to extend the Rodinia model by defining rotations for the Hoggar and Sahara Blocks. You can also define extra blocks by digitizing new geometries, and define rotations for these blocks as well.

Additional Exercise 2: Rotating Data within the Rodinia Model

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The directory "Tutorial13_CompletedRodiniaModel" in the data bundle contains a completed version of the Rodinia model following the steps outlined above. So if you want to skip carrying out all the steps described above, simply unload all the existing data from GPlates, then load in the

shapefiles and rotation file in the directory.
The file '*RodiniaModel_CompleteRotationFile.rot'* contains a completed rotation table (with rotations included for Sahara and Hoggar).
The file '*RodiniaBlocks_WithPlateIDColumnAndIDs.shp'* contains the cratonic block polygons with all plate codes assigned to match the rotation table.

The Rodinia reconstruction model give us an opportunity to reconstruct data back to 1100 Ma, much further back in time than many other global plate models. A few sample data sets have been provided - these are:

- Point data from the USGS containing mineral deposits locations of different types (encoded with formation age)
    - '*USGS_PorphoryCopper_intersected*'
    - '*USGS_SedimentHosted_ZnPb_intersected.shp*'
    - '*USGS_SedimentHostedCopper_intersected.shp*'

- Line data from Li et al showing the interpreted extent of LIPs and Dykes that formed during the Proterozoic
    - '*Rodinia_LIPS_and_Dykes_intersected.shp'*

Load each of these datasets into GPlates and try reconstructing them using the Rodinia model, as illustrated below.

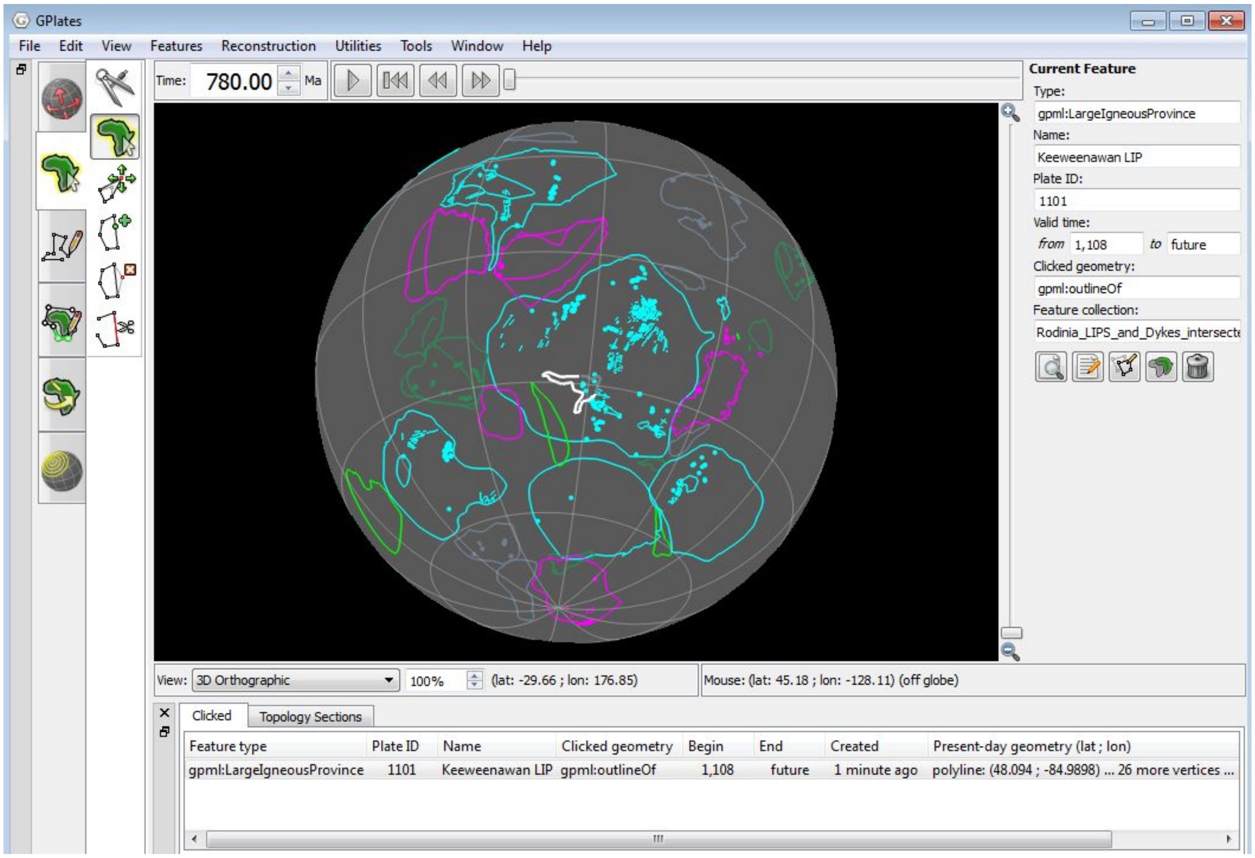

Figure 16: All data sets loaded into GPlates

References

Z.X. Li, S.V. Bogdanova, A.S. Collins, A. Davidson, B. De Waele, R.E. Ernst, I.C.W. Fitzsimons, R.A. Fuck, D.P. Gladkochub, J. Jacobs, K.E. Karlstrom, S. Lu, L.M. Natapov, V. Pease, S.A. Pisarevsky, K. Thrane, V. Vernikovsky, Assembly, configuration, and break-up history of Rodinia: A synthesis, Precambrian Research, Volume 160, Issues 1-2, Testing the Rodinia Hypothesis: Records in its Building Blocks, 5 January 2008, Pages 179-210, ISSN 0301-9268, DOI: 10.1016/j.precamres.2007.04.021.