

# Introduction to the Kinematics Tool

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## Aim

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This tutorial is designed to introduce the user to the features of the Kinematics Tool and teach the user how to compare absolute and relative plate kinematics.

## Included Files

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**Click here** to download to download the data bundle for this tutorial.

The tutorial dataset (2.8-Kinematics\_Tool.zip) includes the following files:

Rotation file: Seton\_etal\_ESR2012\_2012.1.rot

Coastline file: Seton\_etal\_ESR2012\_Coastlines\_2012.1\_Polyline.gpmlz

## Background

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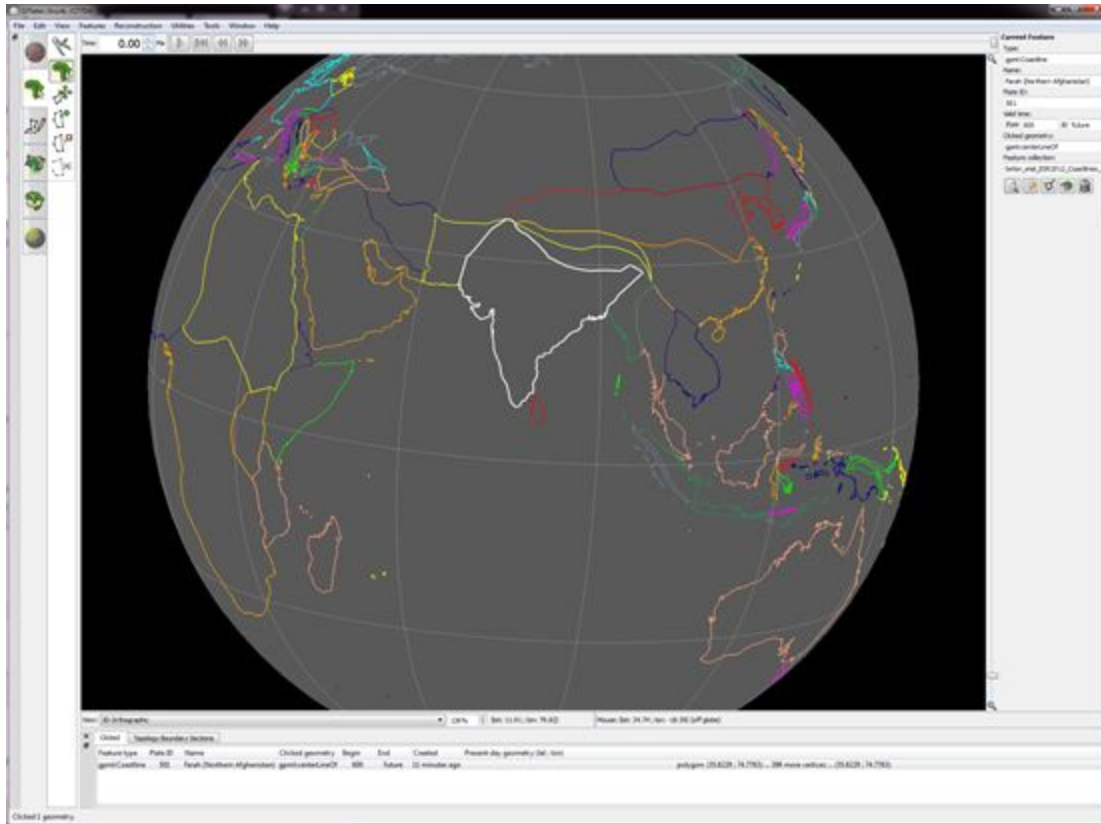
Kinematics describes the motion of objects and in a GPlates context, we can look at the kinematics of various features to understand their magnitude and direction of motion over time. In GPlates, the Kinematics Tool renders 2D plots of velocity (and velocity-related quantities) over time.

## Exercise 1 - Using the Kinematics Tool

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*Introduction to the features of the Kinematics Tool and learn how to export data*

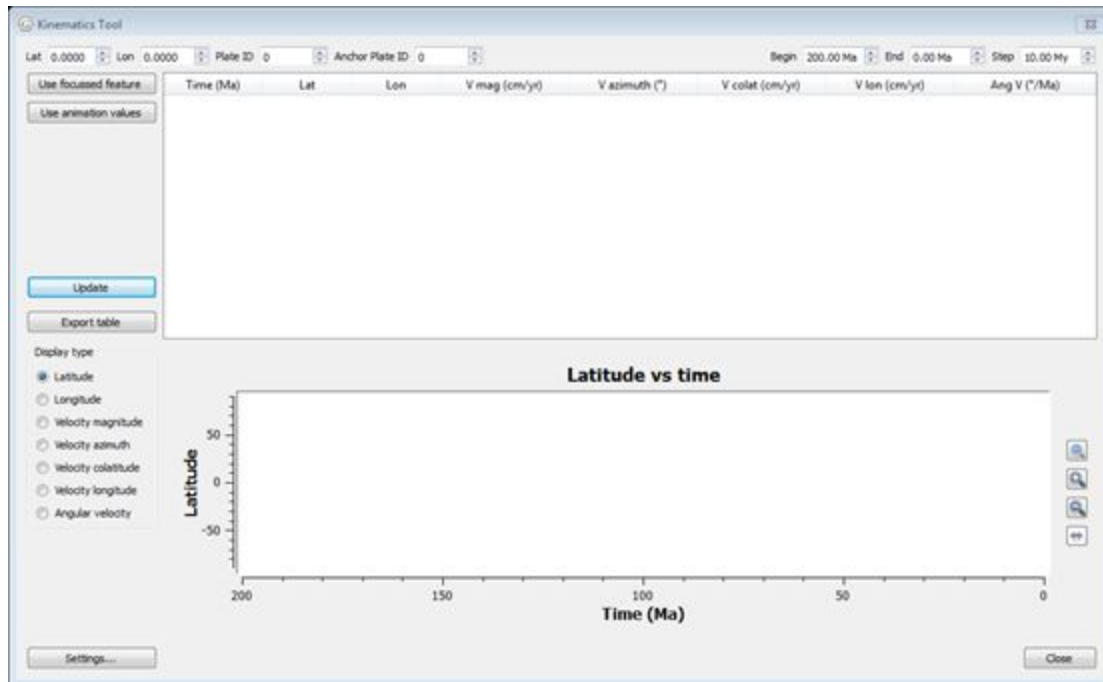
1. Open GPlates and load the following files using Open Feature Collection.
  - Seton\_etal\_ESR2012\_2012.1.rot
  - Seton\_etal\_ESR2012\_Coastlines\_2012.1\_Polyline.gpmlz
2. Rotate the globe so that it is centred on **India** and select it using the Feature Inspection tool (Figure 1)



**Figure 1:** View of India (Step 2)

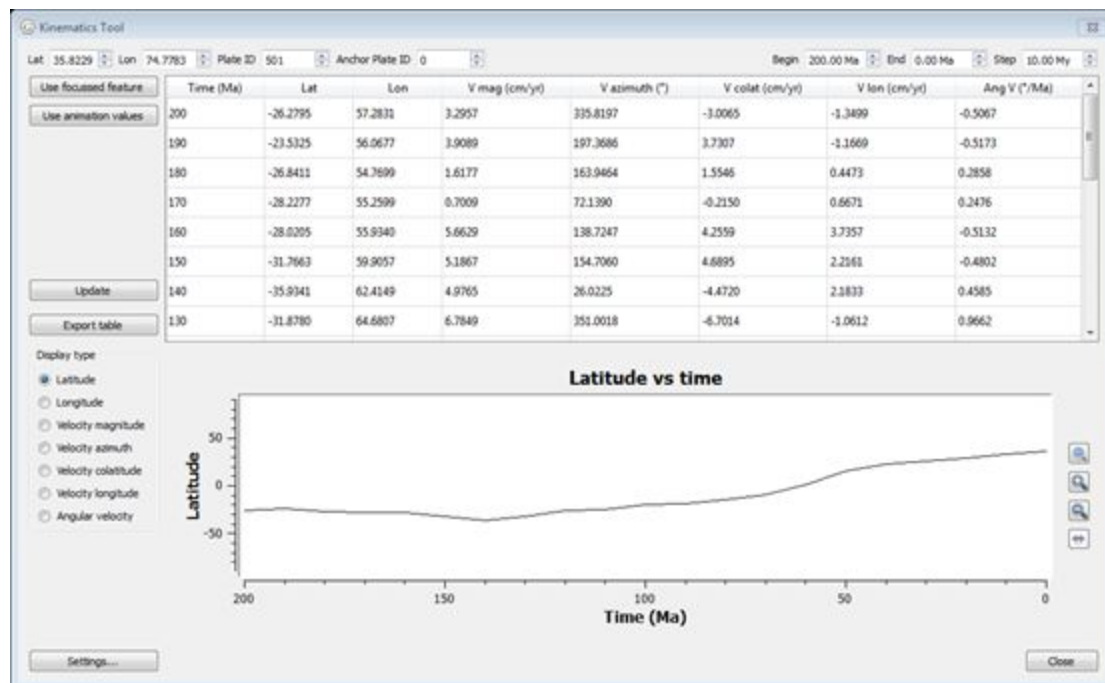
3. Utilities > Open Kinematics Tool... (or Ctrl+Shift+K)

A new window will open (Figure 2), however you will notice that it is blank (Figure 2)



**Figure 2:** Kinematics Tool Window

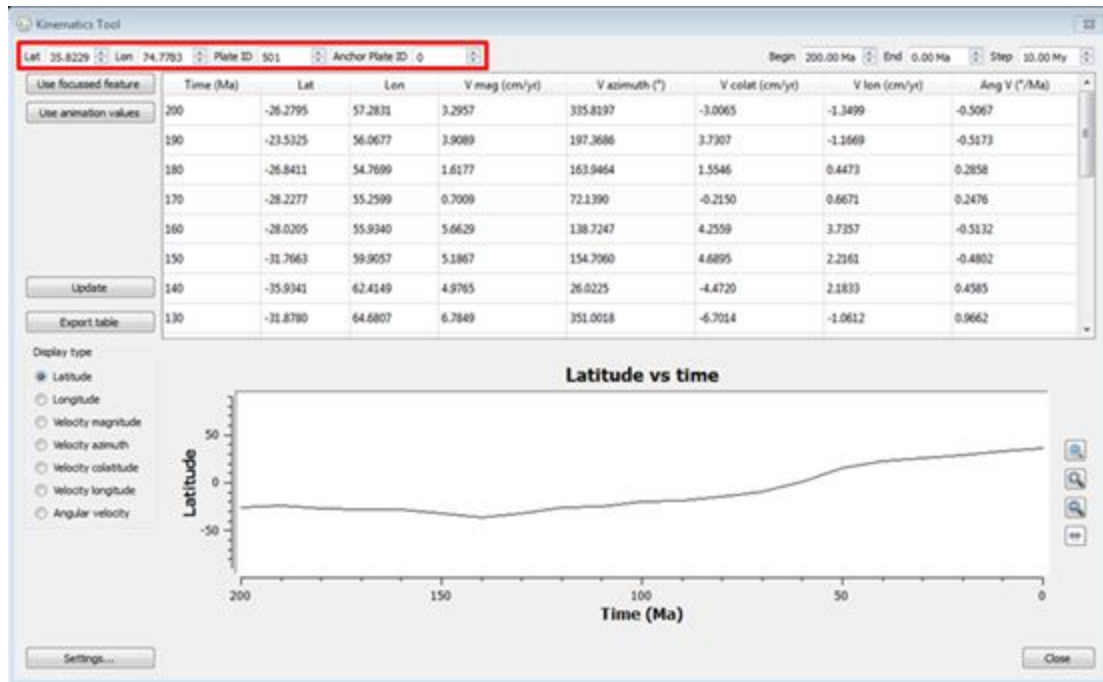
4. Click the 'Use focussed feature' button in the top left corner of the box. Data should now appear in the window that corresponds to the focussed feature (Figure 3).



**Figure 3:** Kinematics Tool describing the motions of the Indian Craton (Plate ID 501)

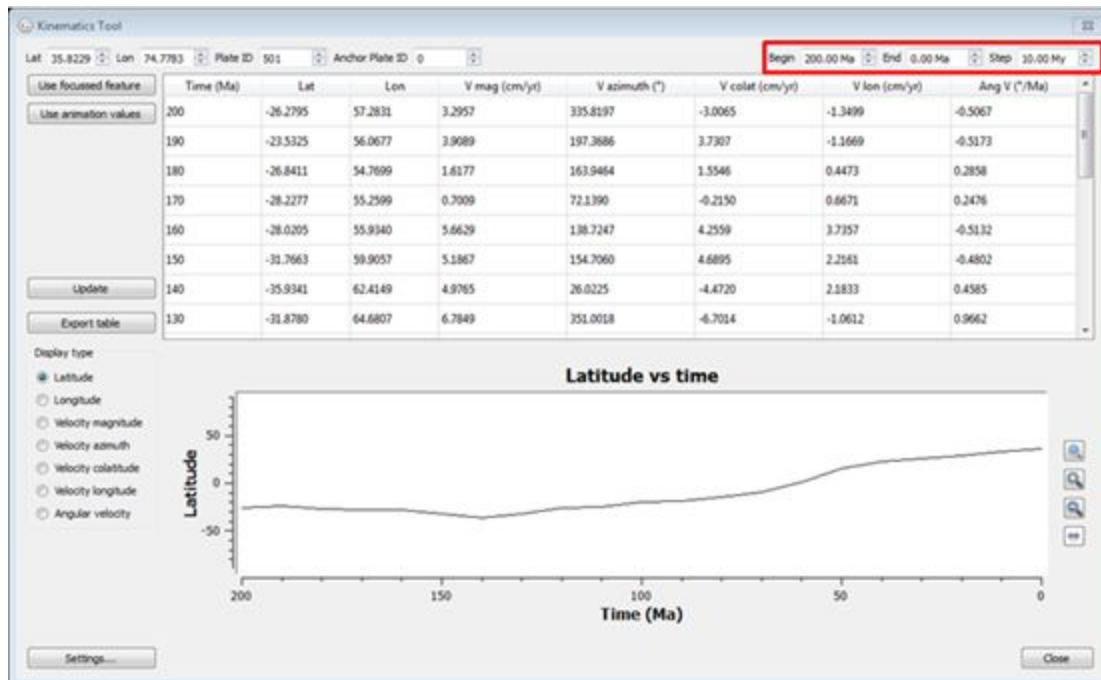
Note that this tool specifies the Latitude, Longitude and Plate ID of a point on the feature in focus (Figure 4). In this example, we note that the point we are calculating kinematics for has a Plate ID of 501, which corresponds to the Indian craton. Note that the Anchor Plate ID is set at 0. This means that we are calculating the absolute motion of this point. If we want to compute relative motion, we need to specify the plate we want to calculate relative motion with respect to (we will do this in Exercise 2).

If there is a specific point you wish to calculate kinematics for, you can manually type in the Latitude, Longitude and corresponding Plate ID into these fields and click Update. This is an alternate method of specifying the point you wish to calculate kinematics for, rather than using the focussed feature method.



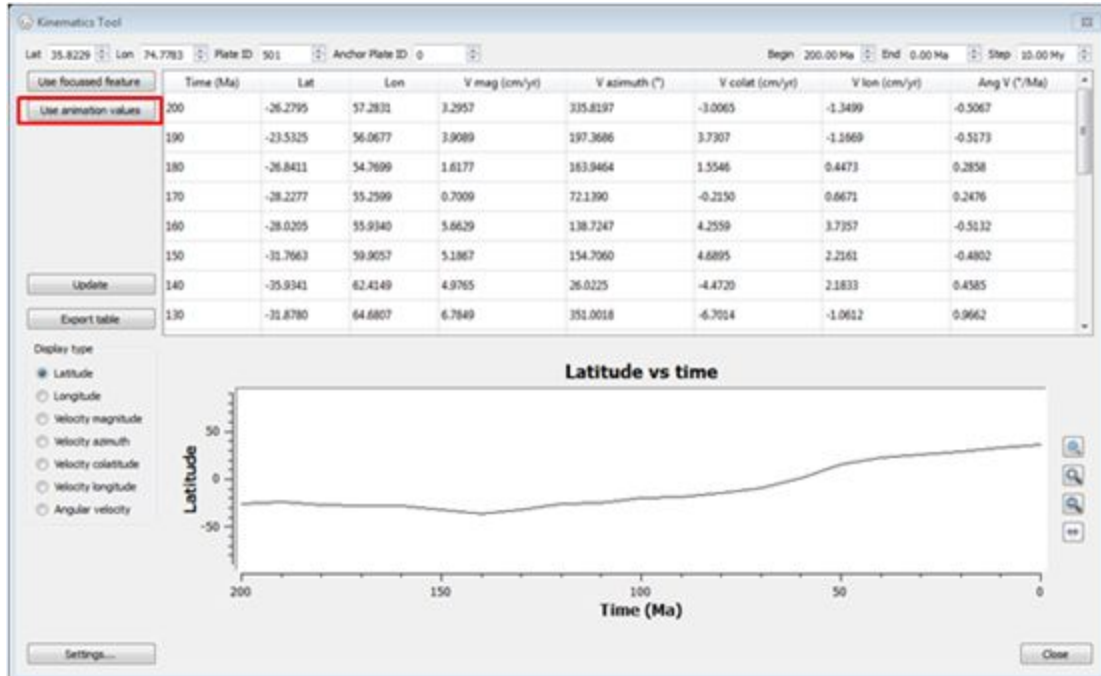
**Figure 4:** Kinematics Tool highlighting Latitude, Longitude and Plate ID specifications

The table in the top half of this window describes a variety of parameters over a specified time period with specific time steps, as defined in the top right corner of the window (Figure 5). In this example, kinematics have been calculated between 200-0 Ma in steps of 10 My.



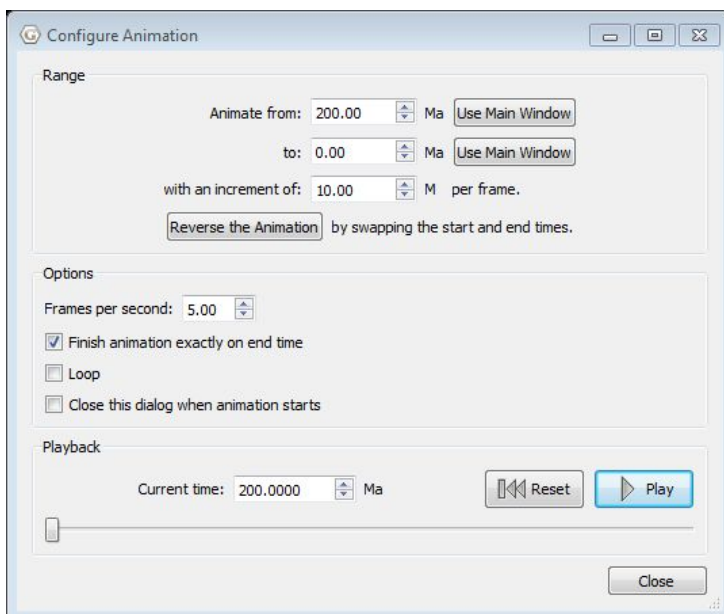
**Figure 5:** Kinematics Window highlighting calculation specifications

The Begin, End and Step fields can also be determined by how your animation is configured. To calculate kinematics for the same time period and timesteps as the animation, click the 'Use animation values' option (Figure 6). Unless you have already specified values, GPlates will use the default Begin, End and Step values.



**Figure 6:** Kinematics Tool window highlighting the 'Use animation values' button

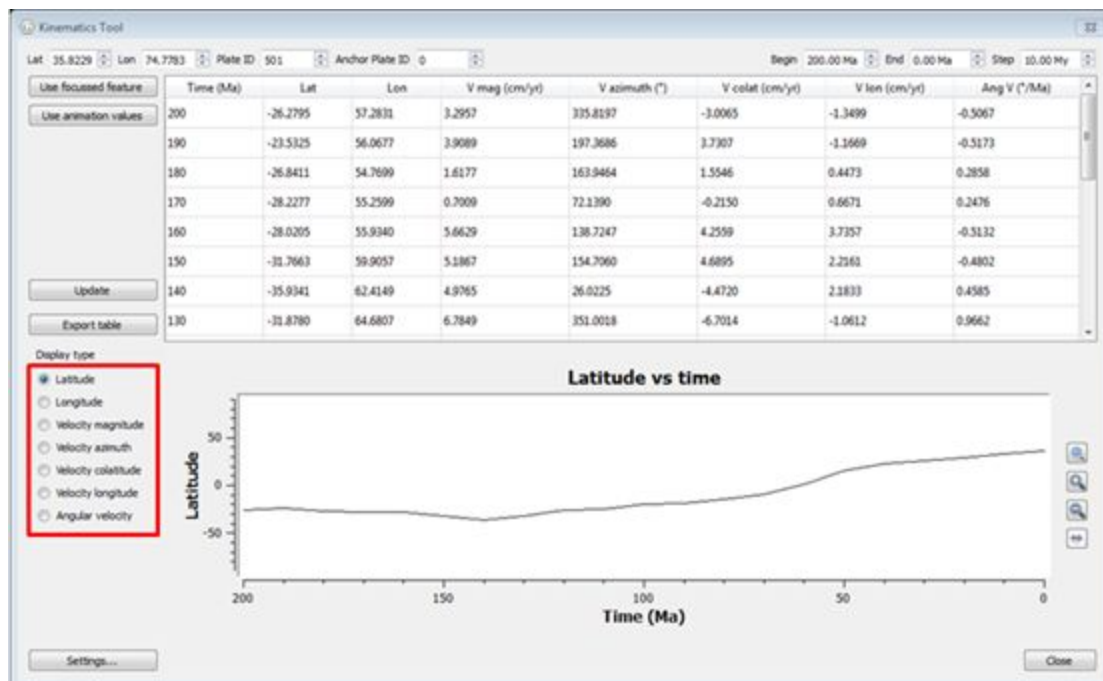
If you want to configure the animation values, go Reconstruction > Configure Animation... and specify values here (Figure 7).



**Figure 7:** Configure Animation window



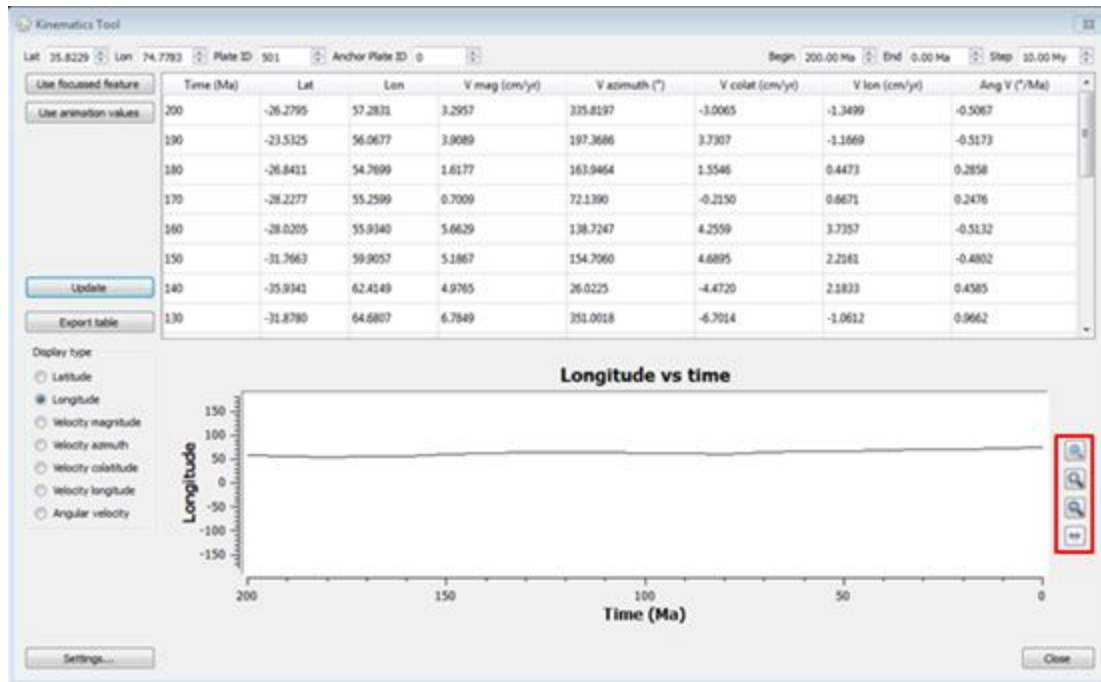
The data in this table is displayed as a graph in the bottom half of the window, however only one variable is displayed at a time. To change the variable that is displayed, we can use the buttons to the left of the graph (Figure 8). At the moment, we can see how latitude has changed from 200-0 Ma.



**Figure 8:** Kinematics Tool with Display panel highlighted

5. Change the graph so that it displays Longitude vs time.

The y-axis of the graph (Longitude) shows all values, which compresses the graph a little and makes it difficult to detect changes in motion. We can use the tools to the right of the graph (Figure 9) to zoom in and out to see more detailed longitudinal changes.



**Figure 9:** Kinematics Tool with view controls highlighted

The 4 controls can be used to change the way the graph is presented as follows:



Autoscale y-axis: automatically scales to the extent of the y-axis - useful for detecting minor changes in motion.



Stretch y-axis: zooming in



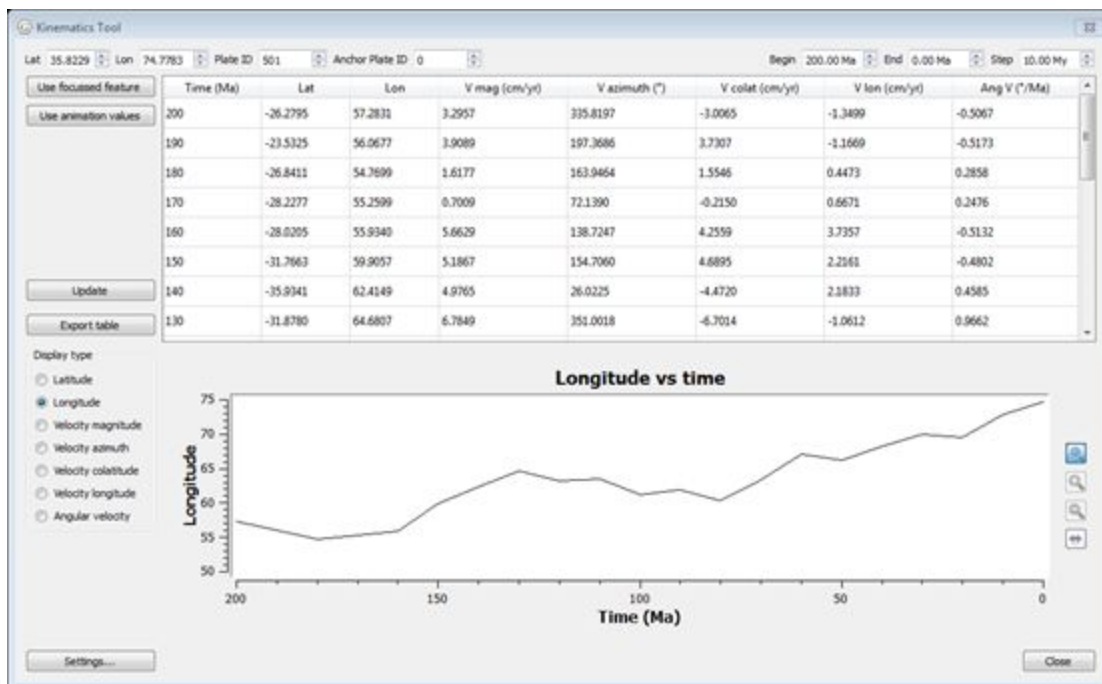
Compress y-axis: zooming out



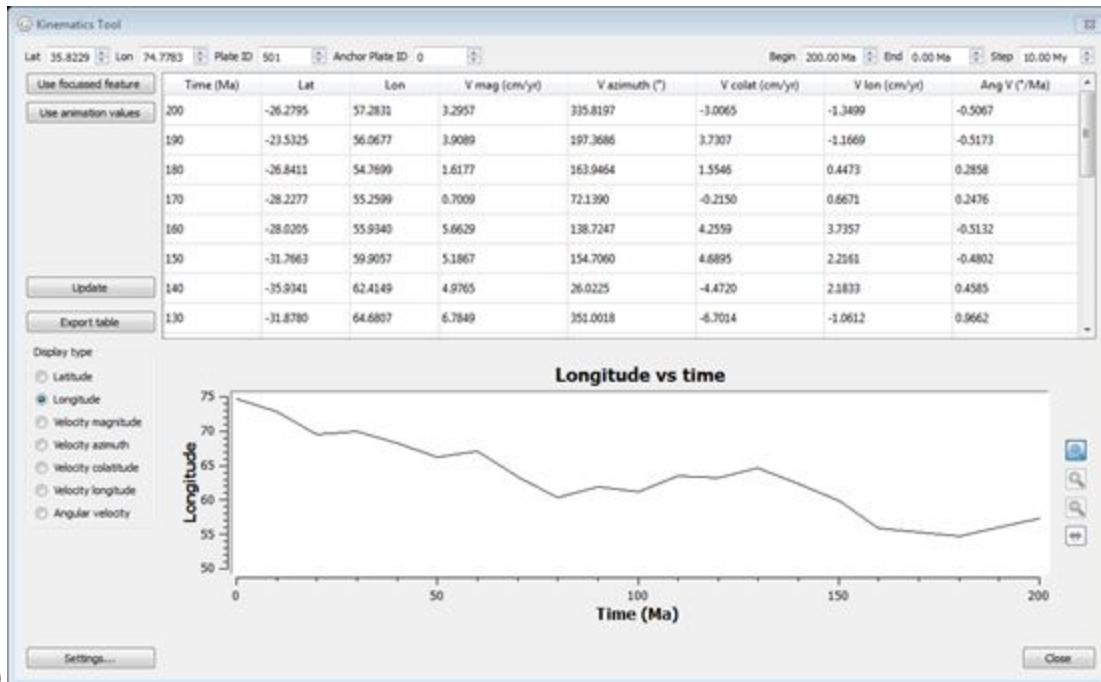
Flip horizontal axis: flips time axis (x-axis) - useful to see motion backwards from present day or motion forwards from the specified time.

6. Have a play around with these tools to see how they change the presentation of the graph so it is easier to see how the longitude changed over time (Figure 10).

Note: when you have finished using the 'Autoscale y-axis' tool, you must deselect it to make the other tools available



a)

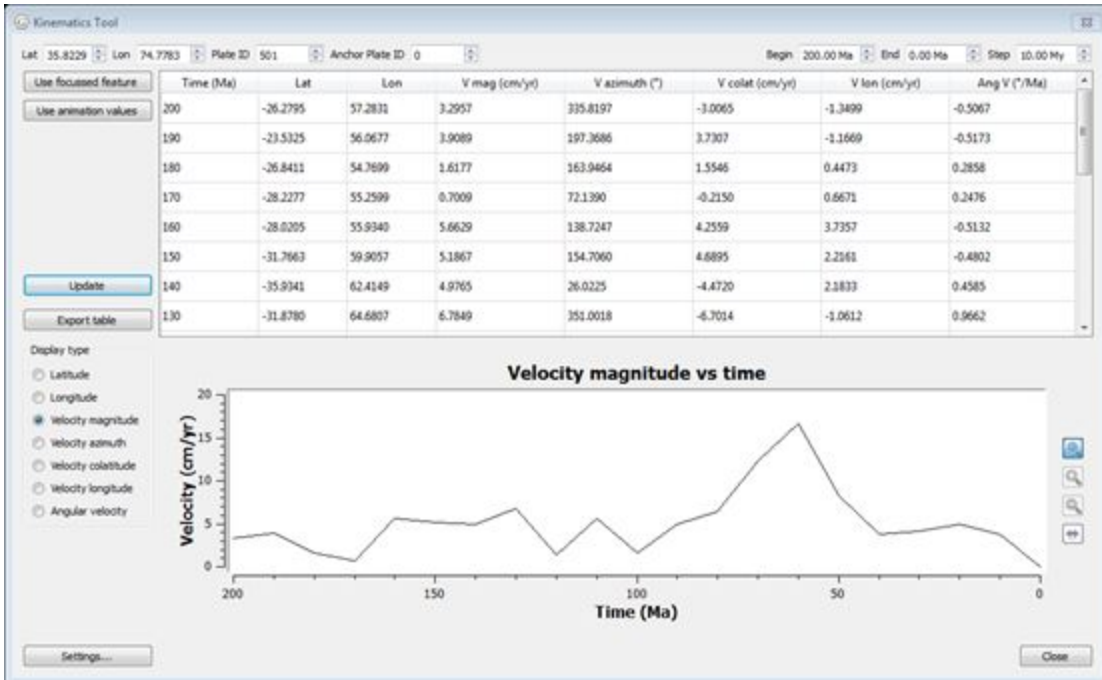


b)

**Figure 10:** Longitude vs time with: **a)** 'Autoscale y-axis' **b)** 'Autoscale y-axis' and 'Flip horizontal axis'

7. Change the graph so that it displays Velocity magnitude vs time (Figure 11).

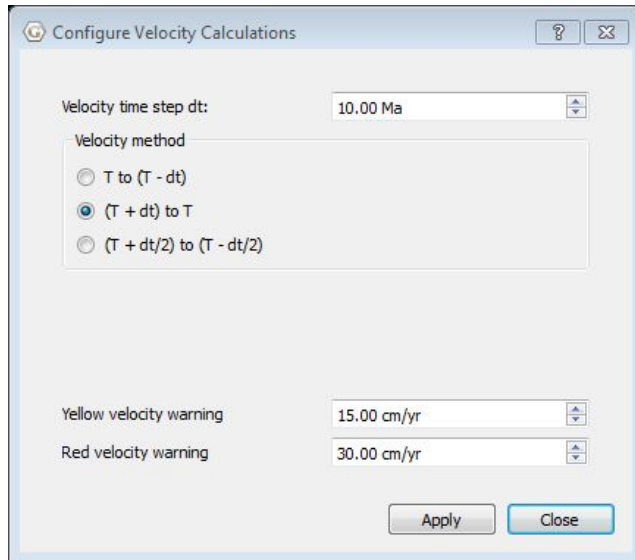
See that at 0 Ma (present day), it says that the velocity is 0 cm/yr (Figure 9). This implies that the point we are looking at is stationary, yet we know that this is not true.



**Figure 11:** Kinematic Tool

8. To fix this, click 'Settings' in the bottom left corner, which will open up a new window. Choose the second velocity option "( $T + dt$ ) to  $T$ " and change the Yellow velocity warning to 15cm/yr (Figure 12).

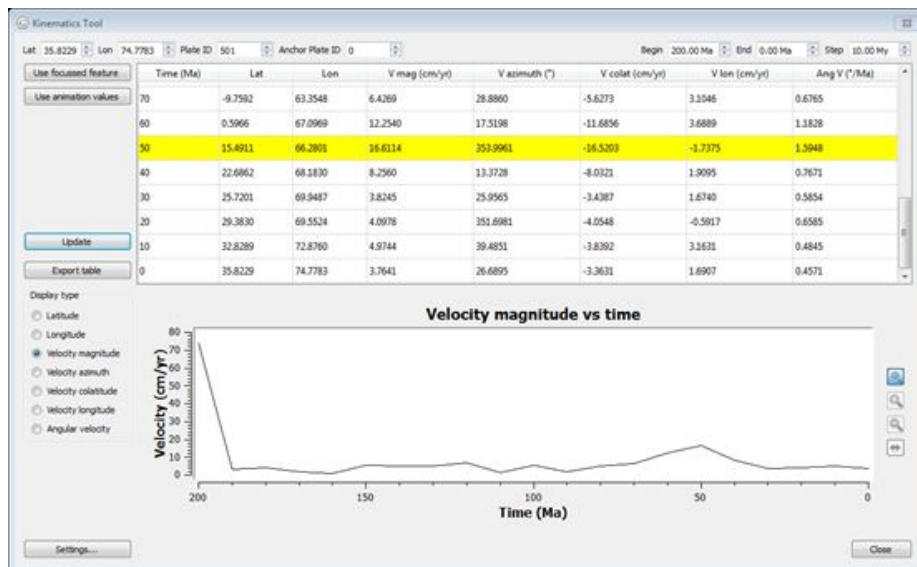
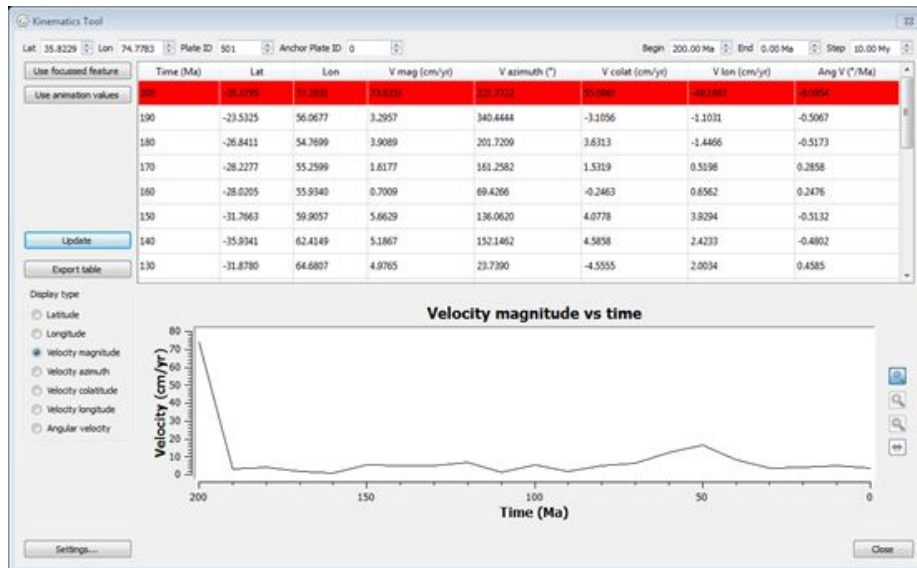
This will highlight the row of any timestep that has a velocity greater than 15cm/yr in yellow. Similarly, the row of any timestep with a velocity greater than 30cm/yr will be highlighted in red. These velocity warnings can be changed to any values you choose and are particularly useful to determine when plate motion reaches and/or exceeds a particular velocity threshold.



**Figure 12:** Configure Velocity Calculations (Step 8)

9. Click 'Apply', then 'Close' and click 'Update' in the main Kinematic Tool window.

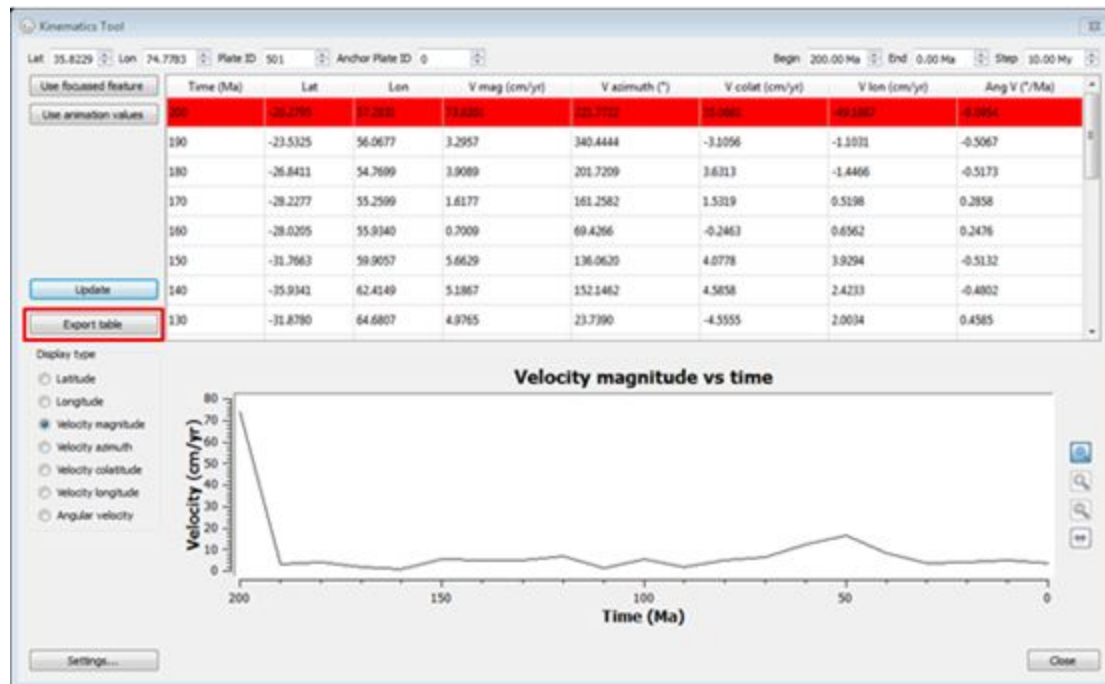
Notice that now we have one of the rows highlighted in red (200 Ma). Are there any rows highlighted in yellow? Hint: scroll down in the table or use the graph to help you (Figure 13).



**Figure 13:** Kinematics tool after velocity has been updated **a)** Velocity warning for 200 Ma when velocity was greater than 30cm/yr **b)** Velocity warning for 50 Ma when velocity was greater than 15cm/yr

The values calculated in the table can be saved and exported for later use as a csv file.

10. In the main kinematic Tool window, click 'Export Table' (Figure 14). Navigate to where you would like to save your file and click 'Save'.



**Figure 14:** Kinematics Tool showing 'Export table' option (Step 10).

Exporting these values can be useful if you wish to plot the motion of different points on the same graph. GPlates only allows you to plot the motion of one point at a time, however if you export this data to another program (eg. Excel), you can then plot the kinematics of multiple points eg. to compare the motion of a single point in different reconstruction models.

## Exercise 2 - Looking at relative and absolute motion

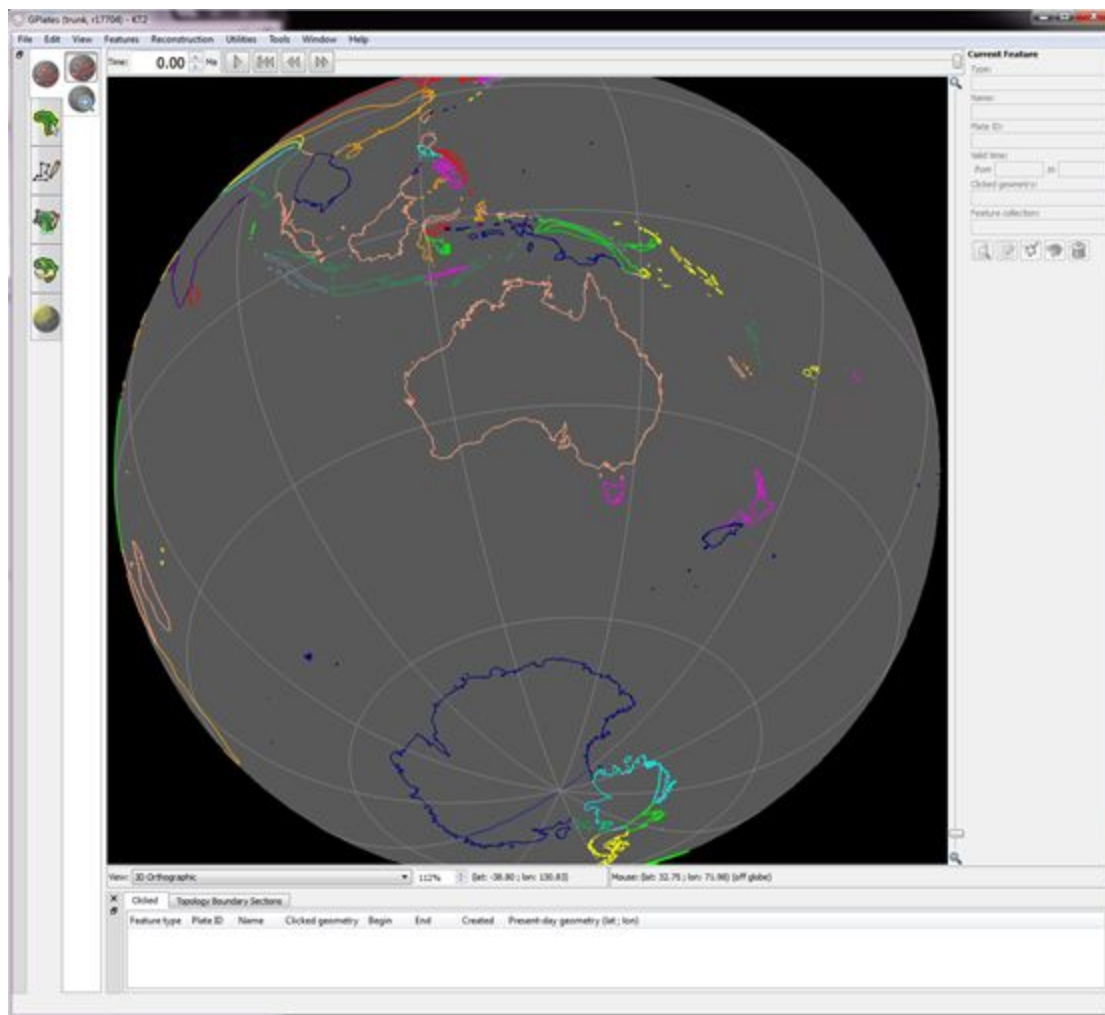
*Compare the absolute kinematics of Australia with its kinematics relative to Antarctica.*

In Exercise 1, we looked at the absolute motion of a point over time. We can also use the Kinematics Tool to investigate the motion of a point relative to another plate. This can be useful to determine when different plates are moving as one and when they start to move independently.



In this exercise, we will investigate both the absolute motion of Australia over the past 200 Ma and also its motion relative to the Antarctic plate.

1. Make sure the rotation and coastlines files are loaded in GPlates
  - Seton\_etal\_ESR2012\_2012.1.rot
  - Seton\_etal\_ESR2012\_Coastlines\_2012.1\_Polyline.gpmlz
2. Rotate the globe so that Australia and Antarctica are in view (Figure 15)



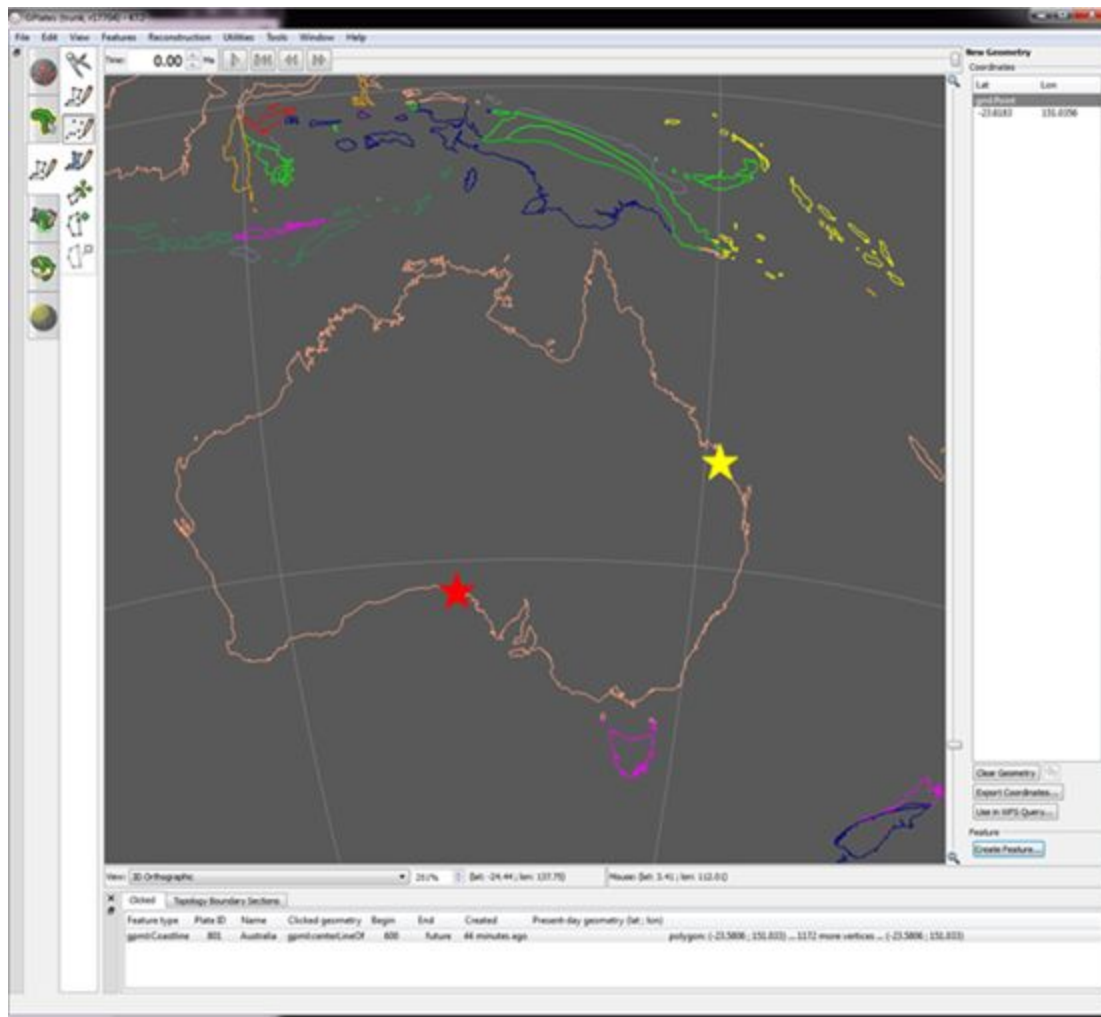
**Figure 15:** View of Australia and Antarctica (Step 2)

3. Using the Feature Inspection Tool, select Australia

4. Utilities > Open Kinematics Tool... (or Ctrl+Shift+K)

5. Select 'Use focussed feature'. Notice that this option gives us a point on the eastern edge of the Australian continent (Figure 16)

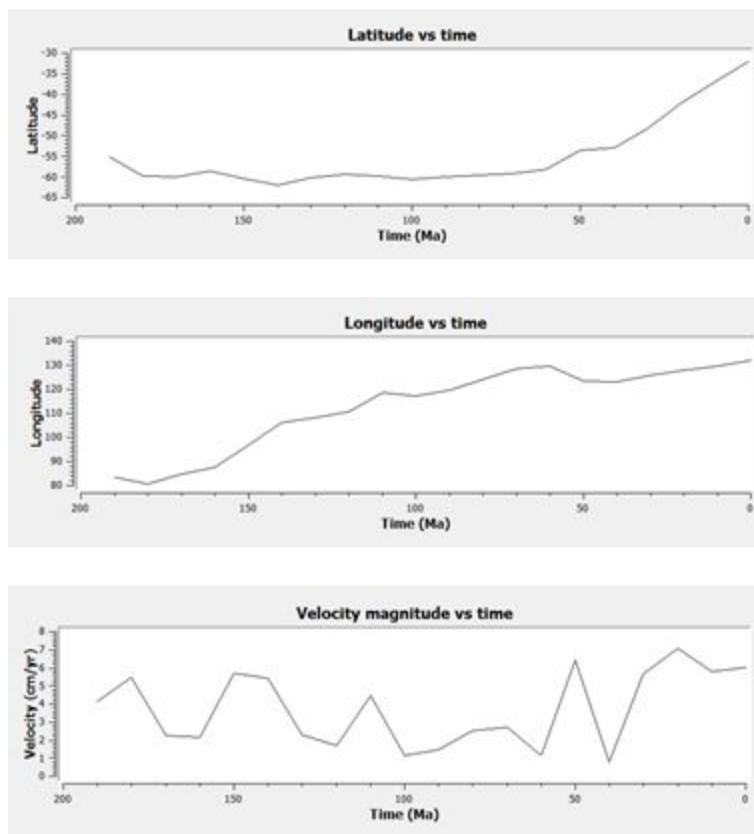
Since we will be looking at the motion of Australia relative to Antarctica, we want to choose a point closer to Antarctica, ideally somewhere along the southern coast (Figure 16).

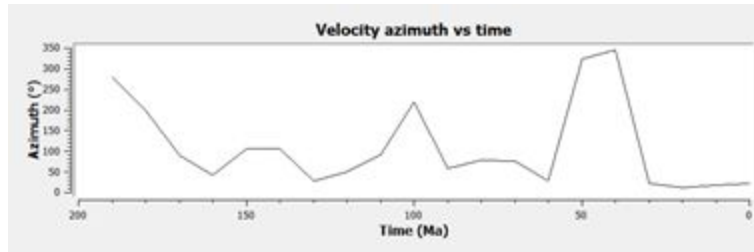


**Figure 16:** Automatically selected point for kinematic calculations in yellow, manually selected point in red

6. Manually change the Latitude and Longitude in the top left corner of the Kinematics Tool window to -32.0295, 132.1987. Make sure the Plate ID is 801 (Australian Plate) and the Anchored Plate ID is 0. We will also change the Begin and End times to 190 Ma and 0 Ma respectively. We keep 10 My timesteps. Then press 'Update'.

7. Change the display of the graph and look at the absolute Latitude, Longitude, Velocity Magnitude and Velocity Azimuth of Australia over time (Figure 17)



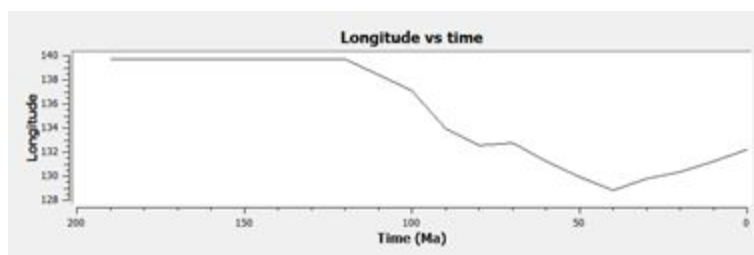
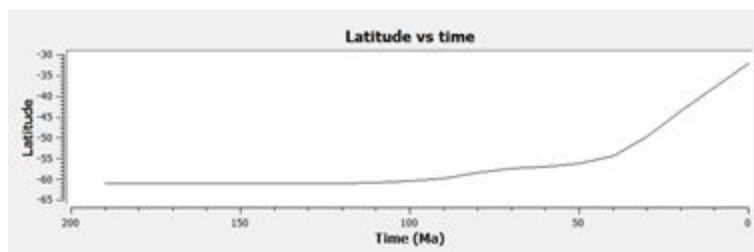


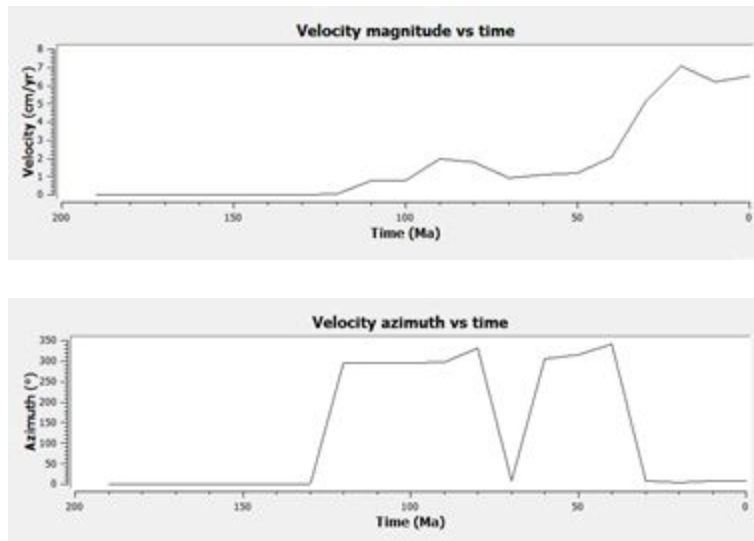
**Figure 17:** Absolute kinematics for a point on the southern Australian coastline

We now want to compute the motion of this same point relative to Antarctica

8. In the Kinematics Tool window, specify the Anchor Plate ID as 802 (Antarctica) and click 'Update'

9. Change the display of the graph and look at the absolute Latitude, Longitude, Velocity Magnitude and Velocity Azimuth of Australia over time (Figure 18).





**Figure 18:** Kinematics for a point on the southern Australian coastline, relative to the Antarctic plate.

Notice that for a period between 190-130 Ma, the four parameters we are looking at do not change. This indicates that there is no relative motion between Australia and Antarctica at this time, but this does not mean that the point is stationary. Rather, this indicates that Australia and Antarctica were moving as one during this period, and when the graphs begin to show changes in these parameters, Australia and Antarctica are starting to move independently.

If we were to look at the absolute motion of a corresponding point in Antarctica, we would expect identical kinematics during 190-130 Ma, as indicated by the lack of relative motion. We can also check this by playing the animation in the main GPlates window.

Note: Be careful when comparing graphs if you have used the 'Autoscale y-axis' tool - some changes will be magnified so they appear greater than they are. The y-axis extents of different graphs may also differ and become a problem when comparing Latitude and Longitude.