Flowlines and Motion Paths

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Aim

This tutorial is designed to teach the user how and when to use the flowline and motion path features in GPlates.

Included Files

Click here to download the data bundle for this tutorial.

For this part of the tutorial you will need the associated data bundle, which

includes the following files:

Rotation Model File:
Seton_etal_ESR2012_2012.1.rot

Coastline File:
Seton_etal_ESR2012_Coastlines_2012.1_Polyline.gpmlz

Continent-Ocean Boundary (COB) File:
Seton_etal_ESR2012_ContinentOceanBoundaries_2012.1.gpmlzl

Spreading Ridge File:
Seton_etal_ESR2012_Ridges_2012.1.gpmlz

Hotspot File: HS_triangles.dat

Hawaiian-Emperor Seamount Chain File: HawaiianEmperorChain.gpml

Fracture Zone File: Fracture_Zones_SEPacific.gpml

This tutorial dataset is compatible with GPlates 1.5.

Background

Flowlines

Flowlines are half stage rotations that are calculated by GPlates based on the rotation file you are using. They are used to track plate motion away from spreading ridges. Features like fracture zones are real-world examples of flowlines.

Motion Paths

Motions paths show the absolute motion of a feature in GPlates based on the rotation file you are using. They can be used to track the absolute motion of any feature, but are particularly useful for features like hotspots, as you can compare the motion path produced by your rotation file to the actual hotspot track.

Exercise 1A – Creating and Using Flowlines

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1. Open GPlates

2. File > Open Feature Collection…(Figure 1) > select the Rotation Model File, the Coastline File, the COB File, and the Spreading Ridge File from the data bundle for this tutorial:
(Seton_etal_ESR2012_2012.1.rot,
Seton_etal_ESR2012_Coastlines_2012.1_Polyline.gpmlz,
Seton_etal_ESR2012_ContinentOceanBoundaries_2012.1.gpmlz,
Seton_etal_ESR2012_Ridges_2012.1.gpmlz)

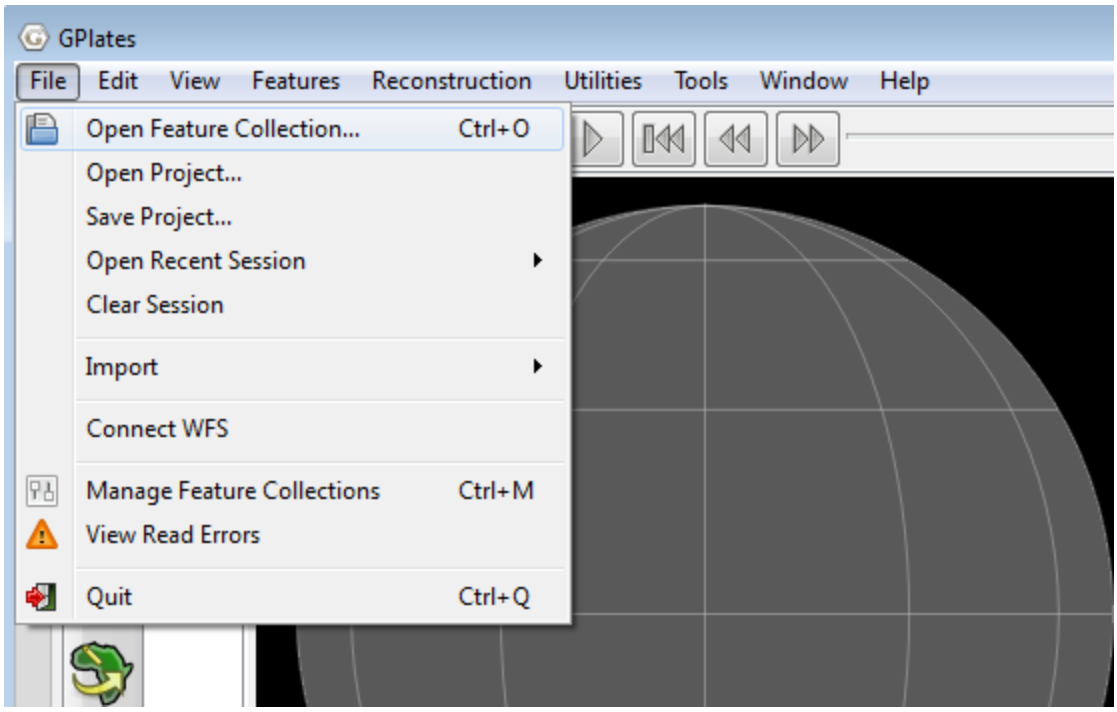

Figure 1. Step 2 - How to open a feature collection from menu bar.

3. Rotate the globe so that the spreading ridge between South America and Africa is centred on your screen (Figure 2).

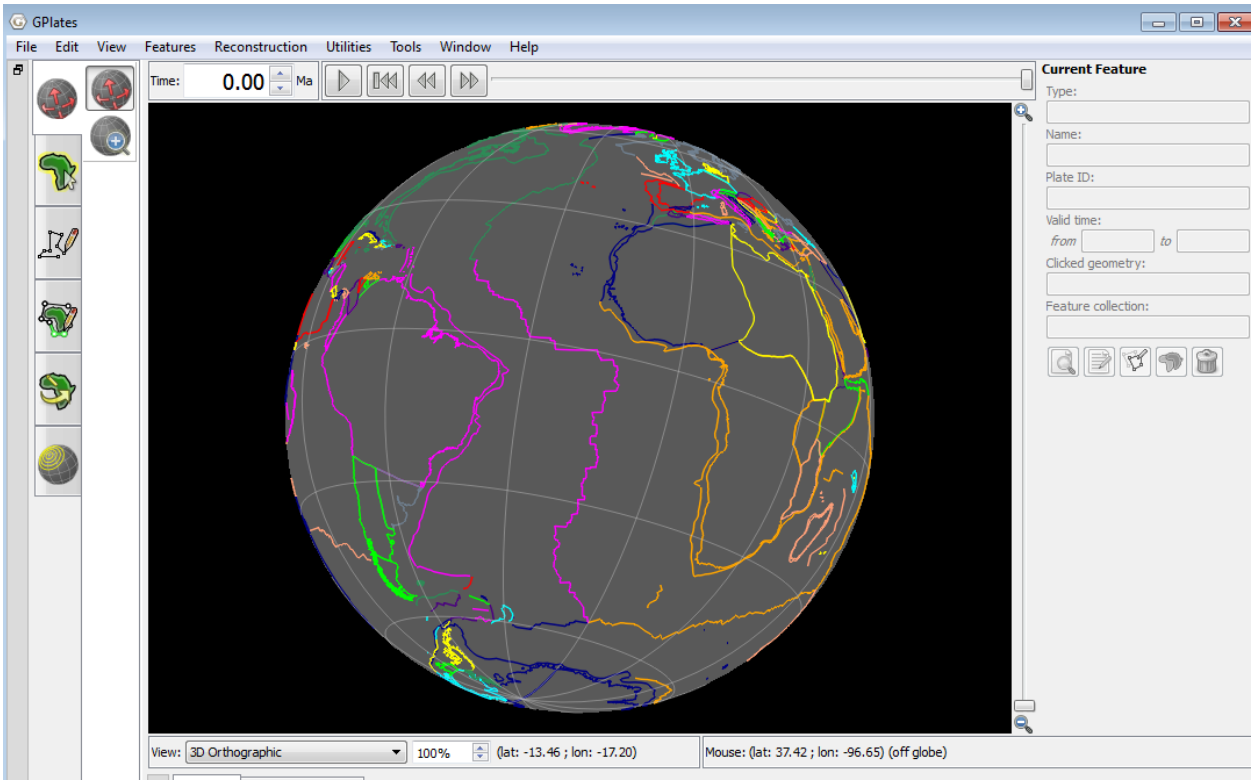

Figure 2. View of spreading ridge between South America and Africa

4. Select the *Digitisation* workflow tab and the *Digitise New Multi-point Geometry tool*  from its submenu. Use this to create a point located on the spreading ridge. Then click on the Create Feature button on the right side of the globe (Figure 3).

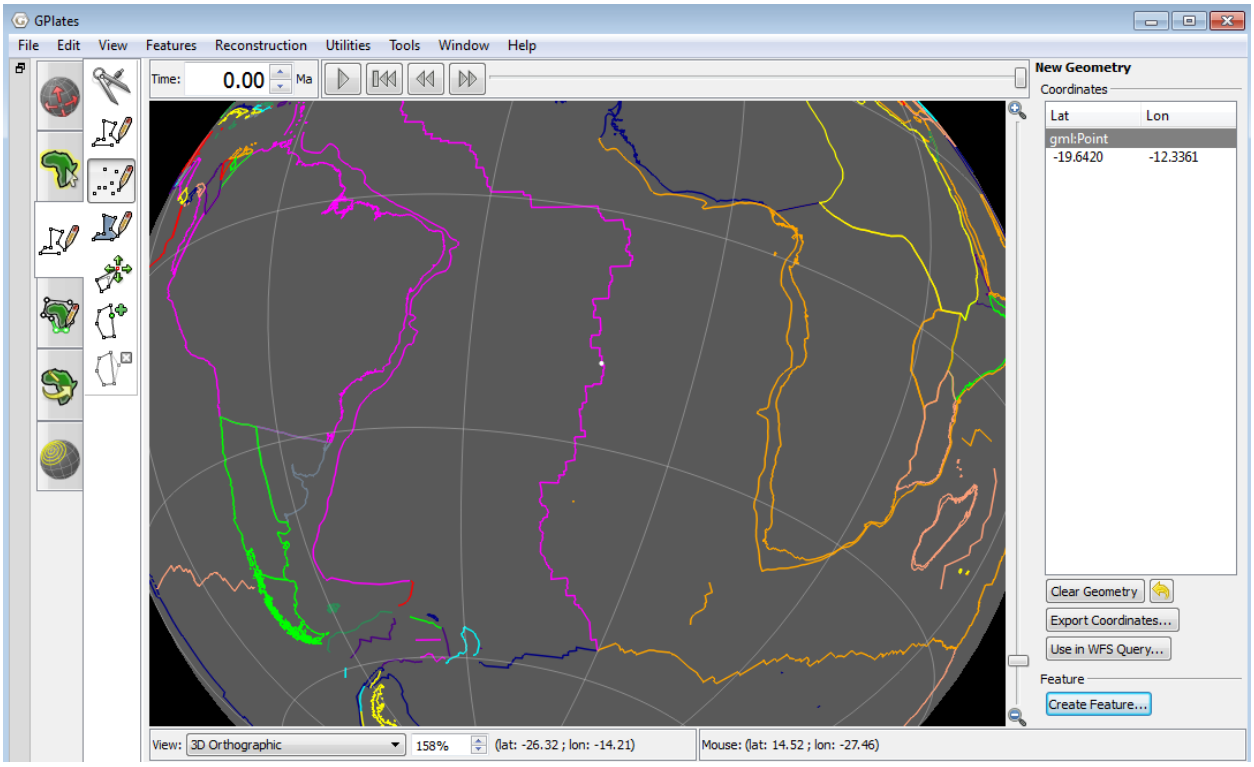

Figure 3. Digitised point on the spreading ridge with the Digitisation workflow tab expanded

This will open up the Create Feature menu.

5. Choose your "Feature Type" to be "gpml:Flowline" (Figure 4) from the list and click Next.

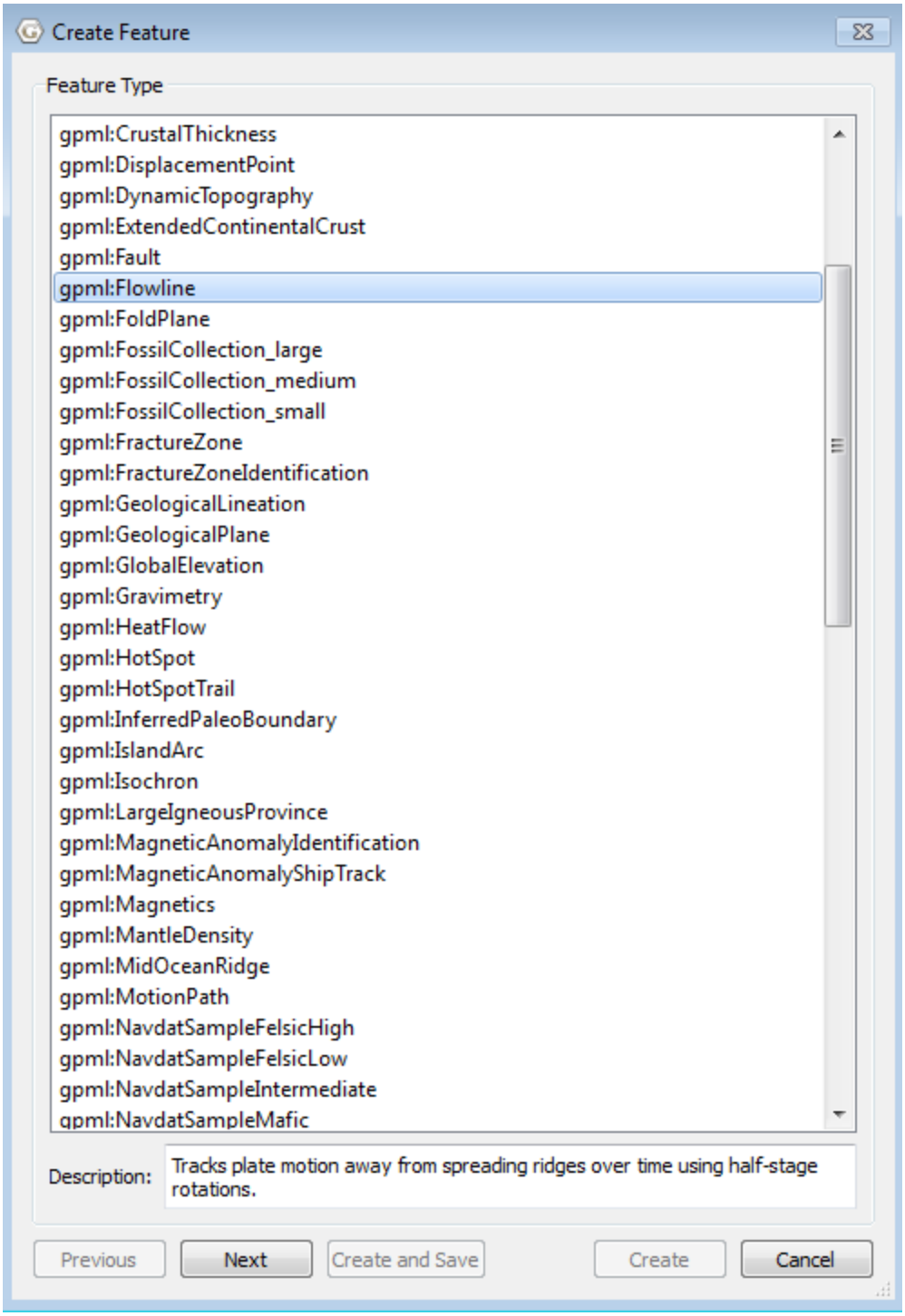

Figure 4. Create Feature menu with gpml:Flowline highlighted

6. In this window you can fill in the properties of your point. Leave the 'Interpret provided geometries' option as *Spreading centre(s)*. Under Common Properties, fill in the following fields (Figure 5):

Left Plate ID: 201 (South America)
Right Plate ID: 701 (Africa)
Begin (time of appearance): 120 Ma
End (time of disappearance): 0 Ma
Name: 201-701 flowline

Click Next

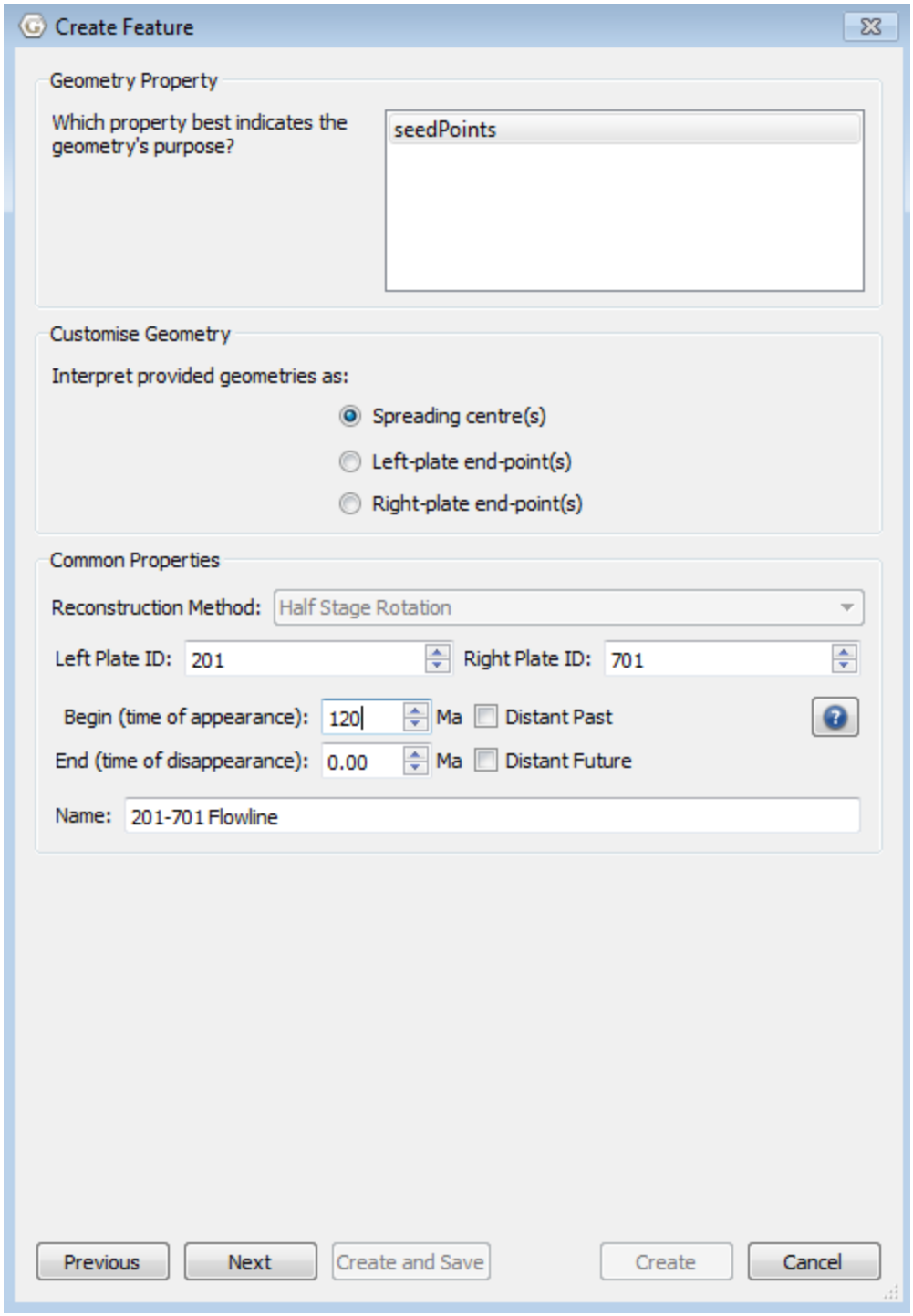

Figure 5. Create Feature menu - flowline properties

7. A new menu will appear. Select *gpml:times* and press '+Add'. This will bring up a new window where we can add our flowline increment times.

Under *Insert multiple times* fill

From: 120 Ma
To: 0 Ma
in steps of: 10 My

Press the Insert button under *Insert multiple times*. This should populate the Times section from 0 to 120 in increments of 10 (Figure 6). Press OK to return to the previous window.

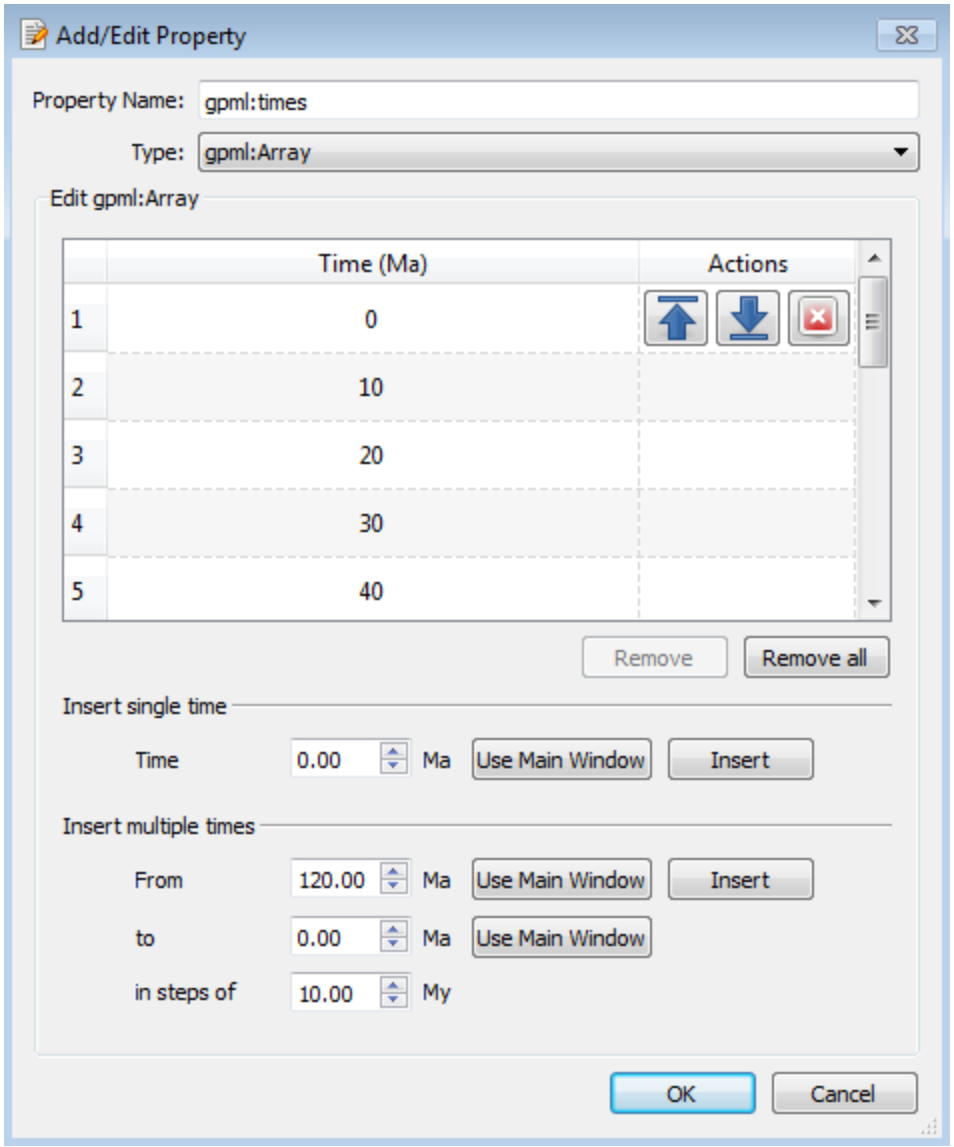

Figure 6. Create Feature menu - geometry and reconstruction times

8. Review the properties of the flowline in *Existing properties.*
These should be:
gml:name - 201-701 Flowline
gml:validTime - 120 - 0

gpml:reconstructionMethod - HalfStageRotation
gpml:leftPlate - 201
gpml:rightPlate - 701
gpml:times - this will appear blank, however if you select ‘Edit’, the previous array will appear and can be modified if necessary.

Select Next.

9. Choose <Create a new feature collection> then click Create.

10. A coloured flowline (in GPlates 1.5; grey in versions previous to 1.3) with arrows indicating direction of plate motion at that time appears, with a yellow point indicating the position of the spreading ridge (Figure 7). You can reconstruct this flowline through time; enter 120 in the time dialog box, and then use the slider or the arrows to move forward through time to see the flowline as it is created.

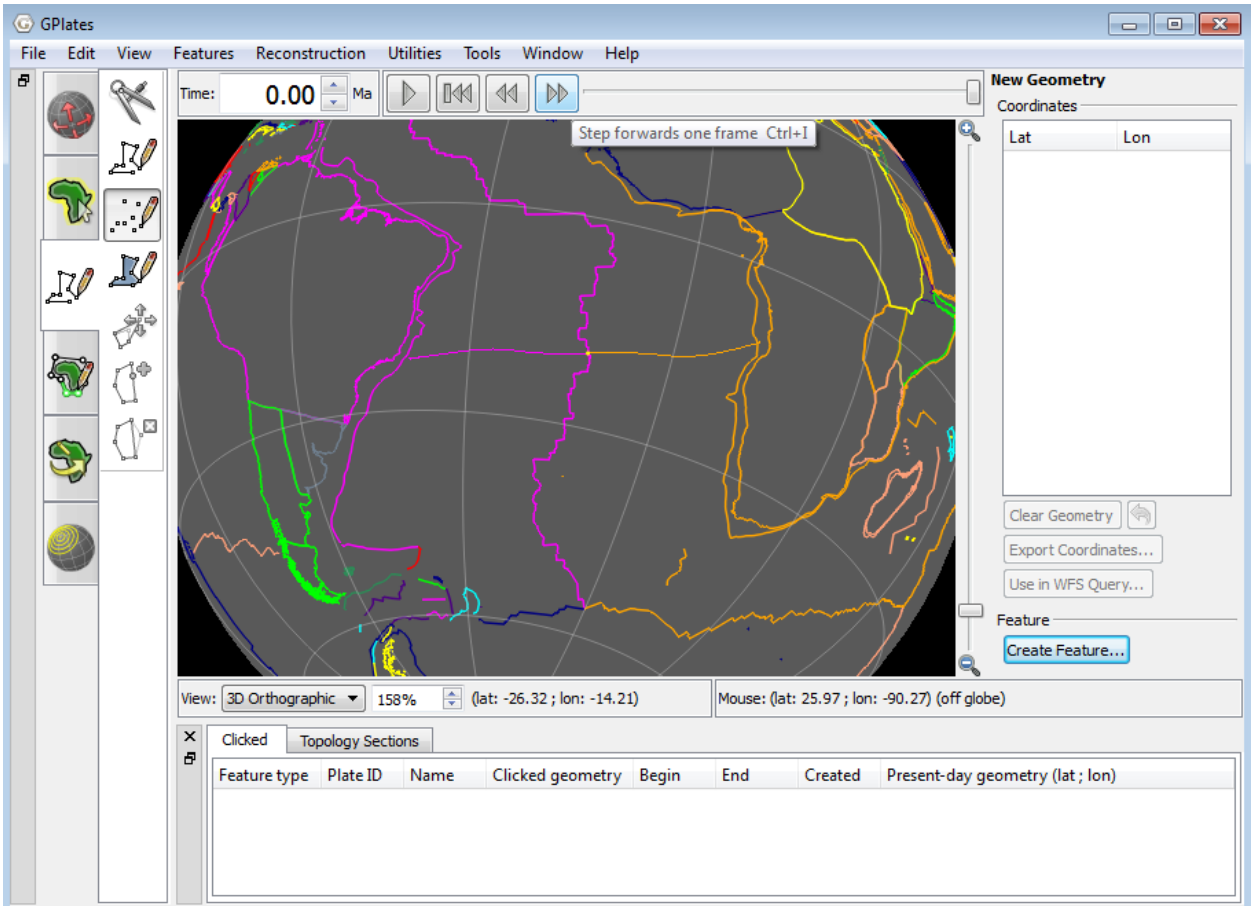

Figure 7. Flowline between South America and Africa

11. If you are satisfied with your flowline, don’t forget to save it!

Note: You can also create flowlines using continent-ocean boundaries (COBs) instead of the spreading ridge. To do this, in Step 4 instead of digitising a point on the spreading ridge, choose a point on a COB. Continue with steps 5 and 6 as above, then for Step 7 under "Interpret provided geometries as:" choose either "Left-plate end-points(s)" or "Right-plate end-points" depending on which plate you have placed your point. Follow the rest of the directions as above.

Note: You can create multiple flowlines at the same time, provided all of the points have the same geometry, ie. they must all be points on a spreading centre, or all on the left plate, or all on the right plate.

Exercise 1B - Creating a flowline at a reconstructed time

Sometimes it is useful to create flowlines that do not originate from present-day spreading centres (i.e. MORs), for example, to follow the motion of a fracture zone. In this exercise, we will create a flowline ensuring a seedpoint coincides with the end of a fracture zone, so we can easily compare the motion described by the flowline and fracture zone (Note: fracture zones are real-world cases of flowlines that incorporates all the complexities of seafloor spreading, including spreading asymmetry, which may not be captured in plate motion models.)

1. If not already open, open GPlates

2. Go to File > Open Feature Collection (as in Exercise 1A), and select the following files:
    - Global_EarthByte_GPlates_Coastlines_20101209.gpml
    - Global_EarthByte_GPlates_PresentDay_Ridges_20100927.gpml
    - Global_EarthByte_GPlates_Rotation_20100927.rot
    - Fracture_Zones_SEPacific.gpml

3. Rotate the globe so that the East Pacific Rise (EPR) is centred on your screen (Figure 8).

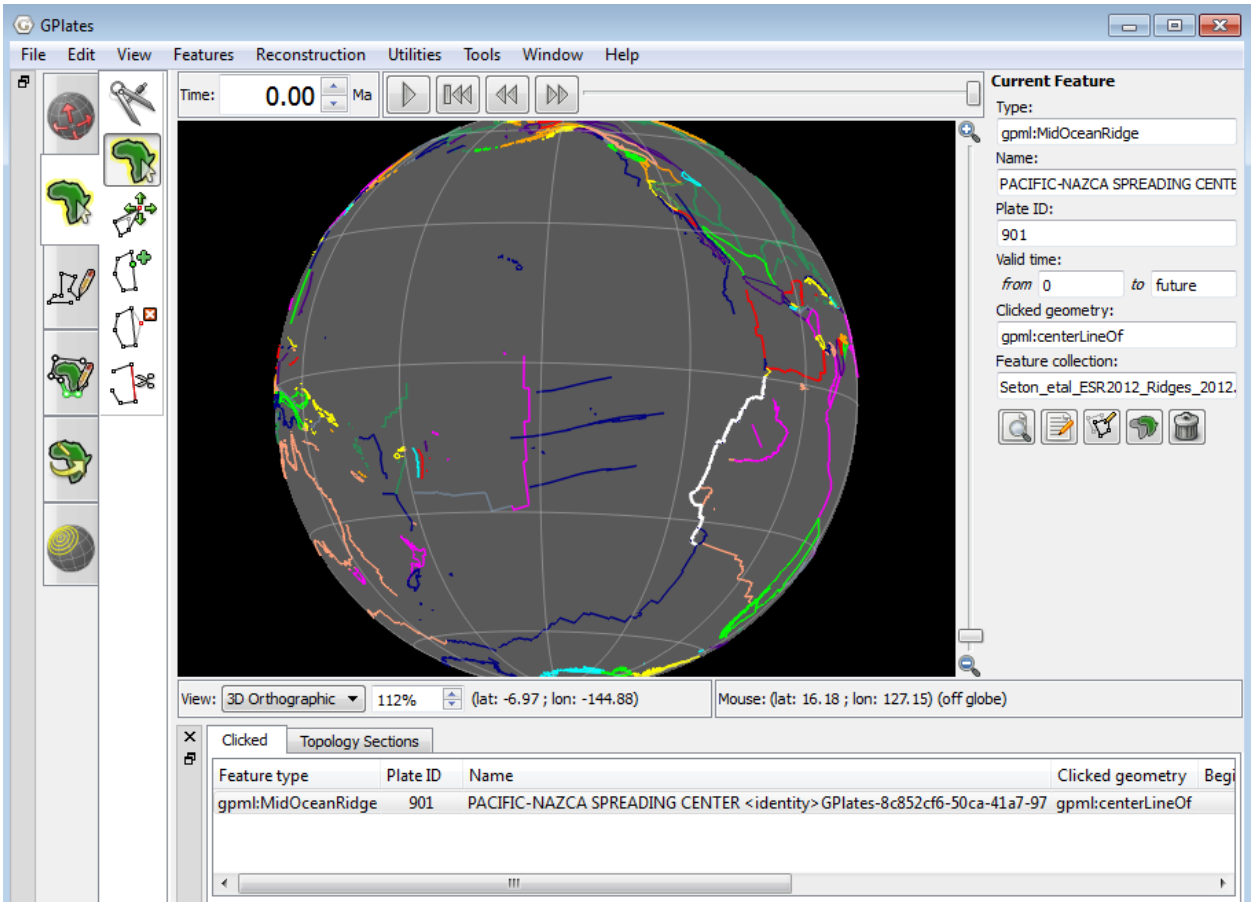

Figure 8. View of the Pacific-Nazca (EPR) spreading system at present day

4. Reconstruct back in time using the time slider at the top (Figure 9). In this case we will reconstruct to 20.1 Ma, since the oldest segment of the fracture zones in question (on the Pacific Plate) are associated with this age.

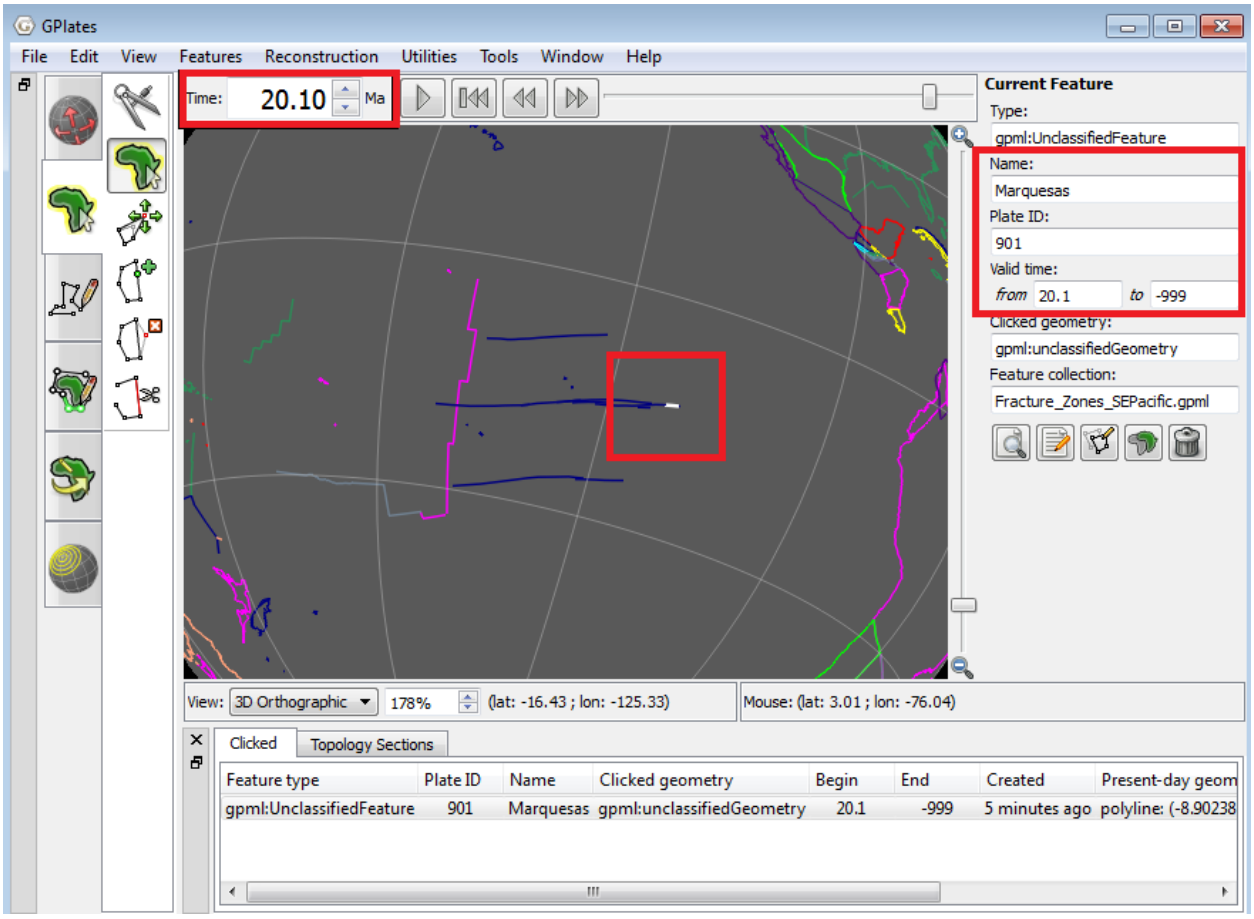

Figure 9. View of the Eastern Pacific reconstructed at 20.1 Ma and the Marquesas FZ, where we will create our seed point.

5. Select the *Digitisation* workflow tab and the *Digitise New Multi-point Geometry* tool from its submenu. Use this to create a feature **on the youngest edge** of the fracture zone, then click on the *Create Feature* bottom on the lower right side of the globe (Figure 10). This will open up the Create Feature menu.

Note: **We are still working at a reconstructed time in GPlates.**

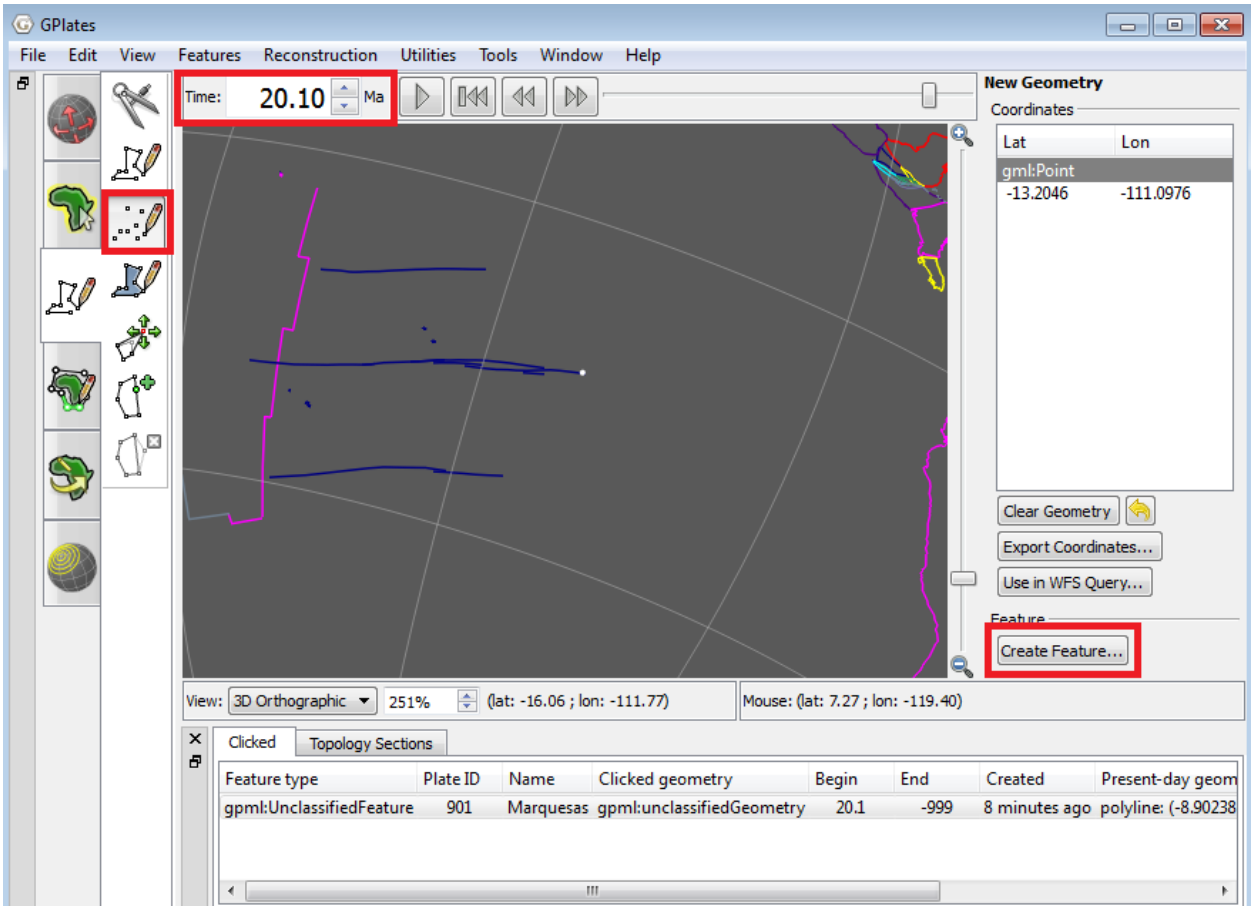

Figure 10. Digitised seed-point on the fracture zone end at 20.1 Ma

6. From the Create Feature menu, choose your feature type to be *gpml: Flowline* from the list (Figure 11). Click Next.

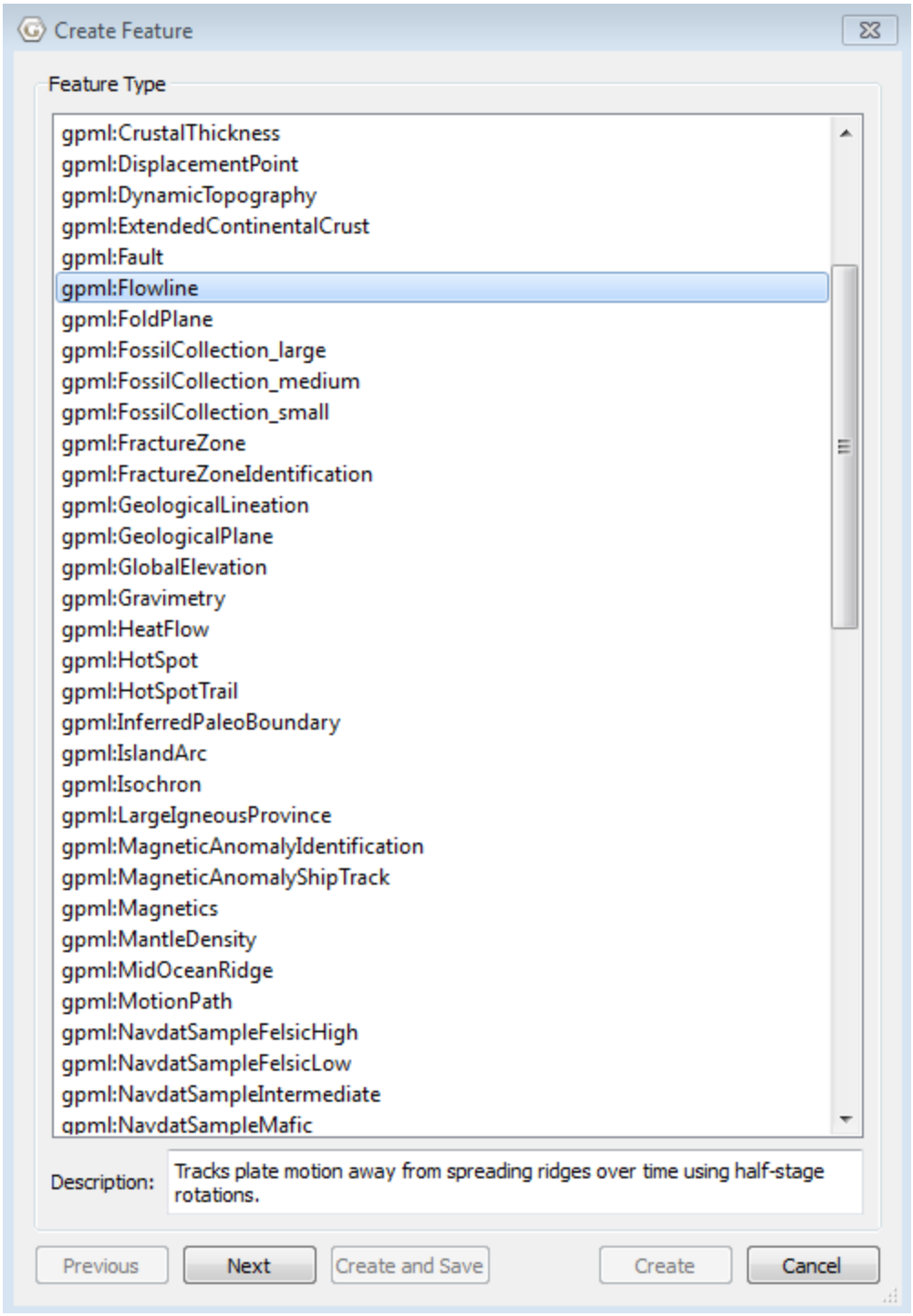

Figure 11. Create feature menu with flowline feature type highlighted

7. Leave the 'Interpret provided geometries' option as *Spreading centre(s).* Under Common Properties, fill in the following fields (Figure 12):

Left Plate ID: 901
Right Plate ID: 911

Begin (time of appearance): 85 Ma
End (time of disappearance): 20.1 Ma
Name: 901-911 flowline

Click Next. Note that the end time (time of disappearance) is the same as our current reconstruction time.

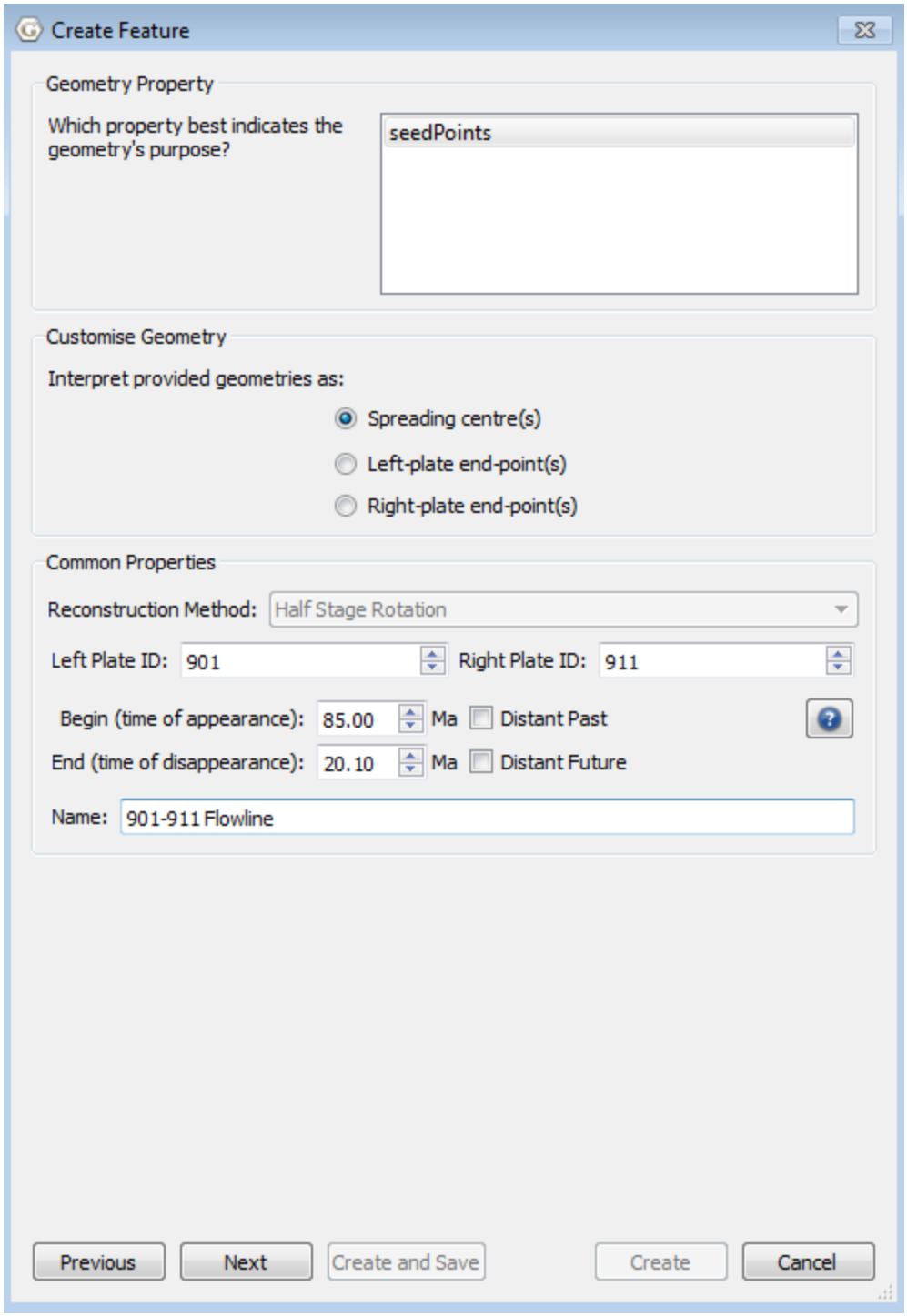

Figure 12. Create flowline feature menu, with common properties filled out

8. A new menu will appear – highlight *gpml:times* and select 'Add'. This will bring up a new window where we can add our flowline increment times (Note: If *gpml:times* does not appear under *Available Properties*, look under *Existing Properties* in the lower half of the window. Highlight it, and click *Edit*).

Under *Insert Multiple Times*, fill
From: 85.00 Ma
To: 0 Ma
in steps of: 5.00 My

Press Insert – this will populate the Times section from 0 to 85 Ma in increments of 5 Myr (Figure 13). Press OK to return to the previous window. **Note**: The flowline time increments is created until **0 Ma**, even though we are creating the flowline at some time in the past. This is needed for proper stage pole interpretation.

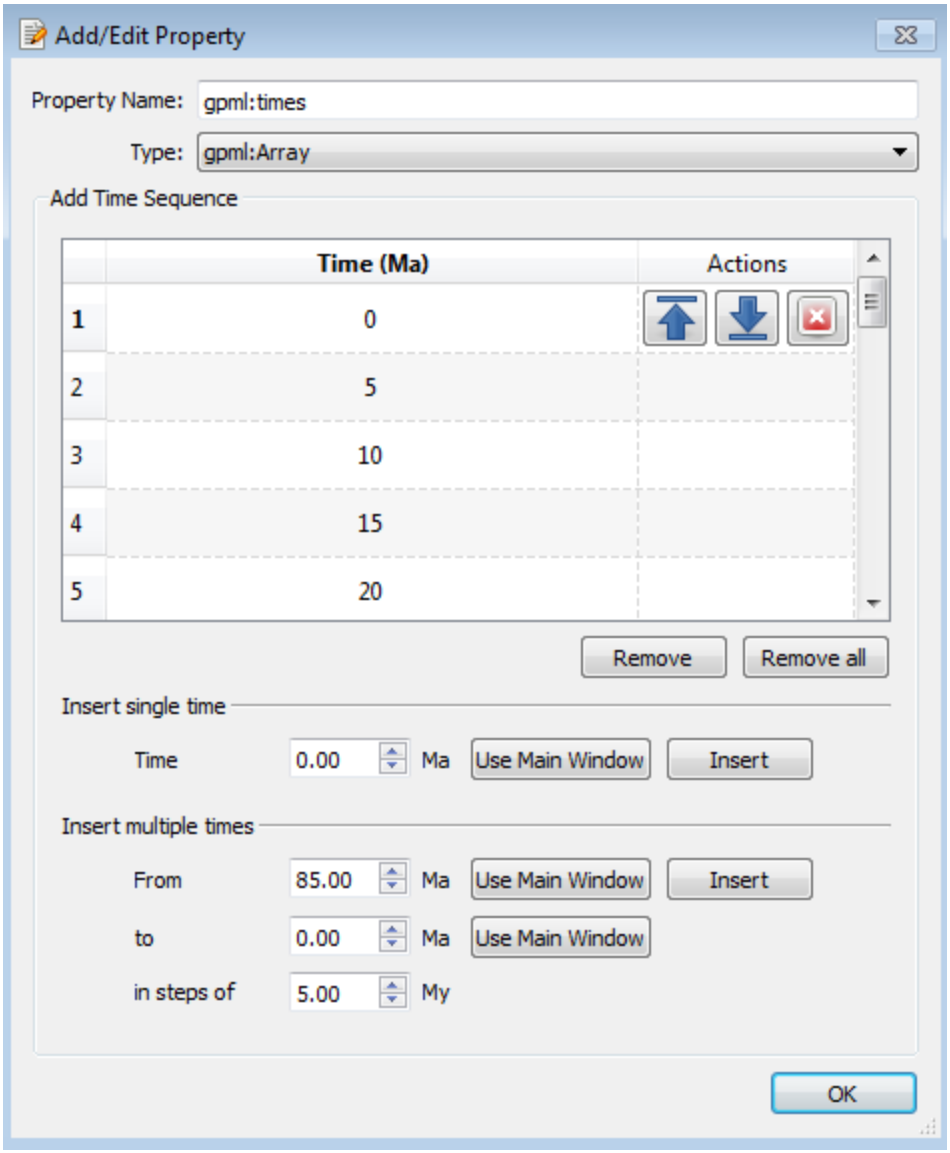

Figure 13. Flowline times array menu, with multiple times (5 myr increments) inserted.

9. Review the properties of the flowline in *Existing Properties*:
These should be:
gml:name - 901-911 flowline
gml:validTime - 85 – 20.1
gpml:reconstructionMethod – HalfStageRotationVersion2
gpml:leftPlate - 901
gpml:rightPlate - 911
gpml:times - this will be blank, however if you select 'Edit', the array will popup and can be edited if needed.
Select Next.

10. Choose a feature collection for the new flowline – in this case we will

select
< Create a new feature collection >
Press Create

11. Your flowline will appear coloured (based on Plate ID), and will have a seedpoint (yellow point) at the edge of the fracture zone (Figure 14). We can reconstruct this flowline through time, from 85 Ma to 20.1 Ma, however this flowline will not appear at present day (0 Ma) since it was not included in its *Valid Time* properties assigned in Step 7.

By creating the flowline in this manner, we can easily compare the motions of the fracture zones (real-world flowlines) and our modelled flowlines, and see where refinements to our plate motions can be made.

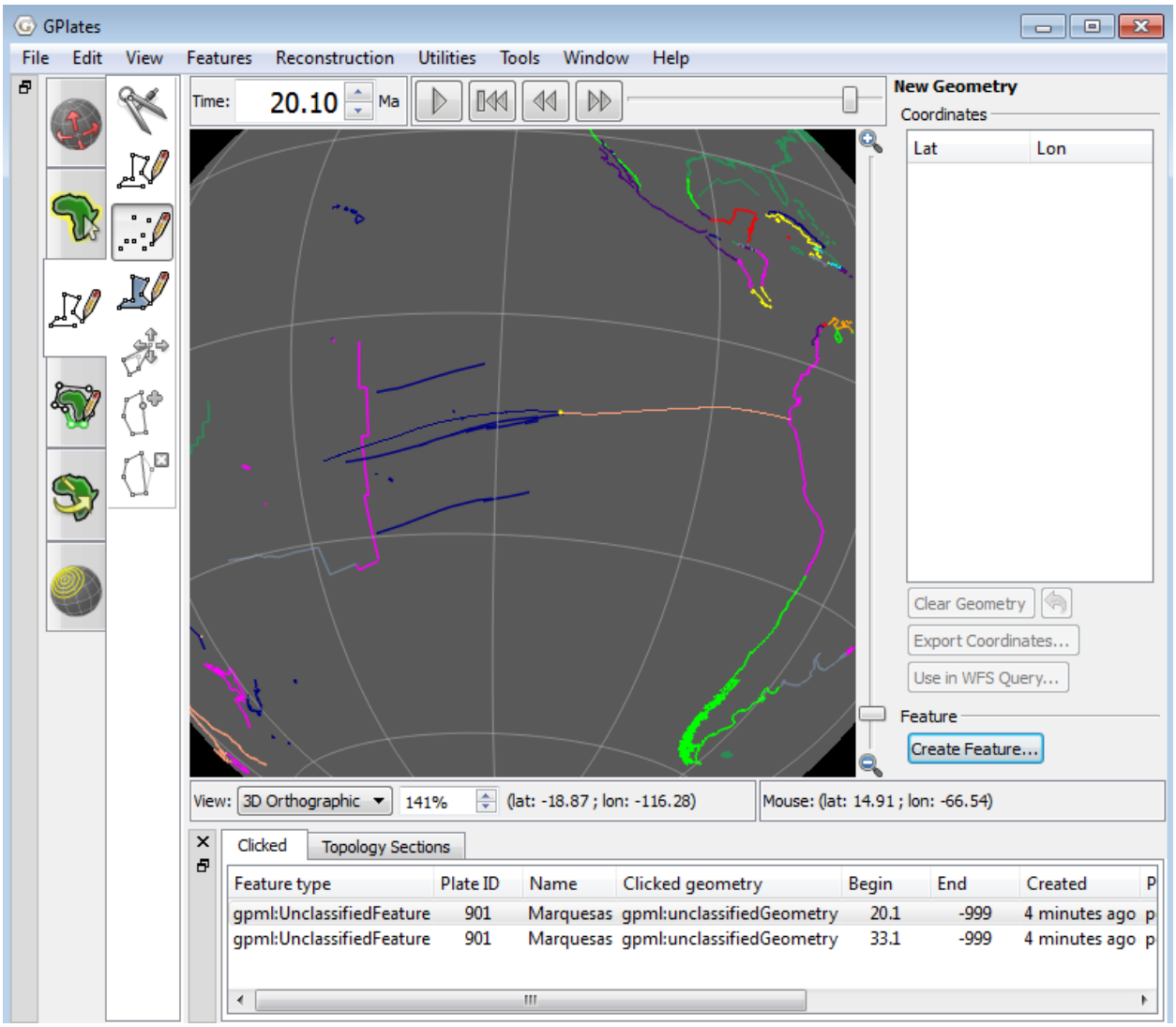

Figure 14. 911-901 (NAZ-PAC) flowline at 20.1 Ma

Exercise 2 – Creating and Using Motion Paths

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1. If not done already, open GPlates.

2. File > Open Feature Collection as done in Exercise 1 above, and select the Rotation Model File, the Coastline File, the Hotspot File, and the Hawaiian-Emperor Seamount Chain File from the data bundle for this tutorial (Global_EarthByte_GPlates_Rotation_20100927.rot, Global_EarthByte_GPlates_Coastlines_20101209.gpml, HS_triangles.dat, HawaiianEmperorChain.gpml).

3. Rotate the globe so that the Hawaiian-Emperor seamount chain in the Pacific Ocean is centred on your screen (Figure 15). There should be a triangle indicating a hotspot at the end of the Hawaiian Island chain.

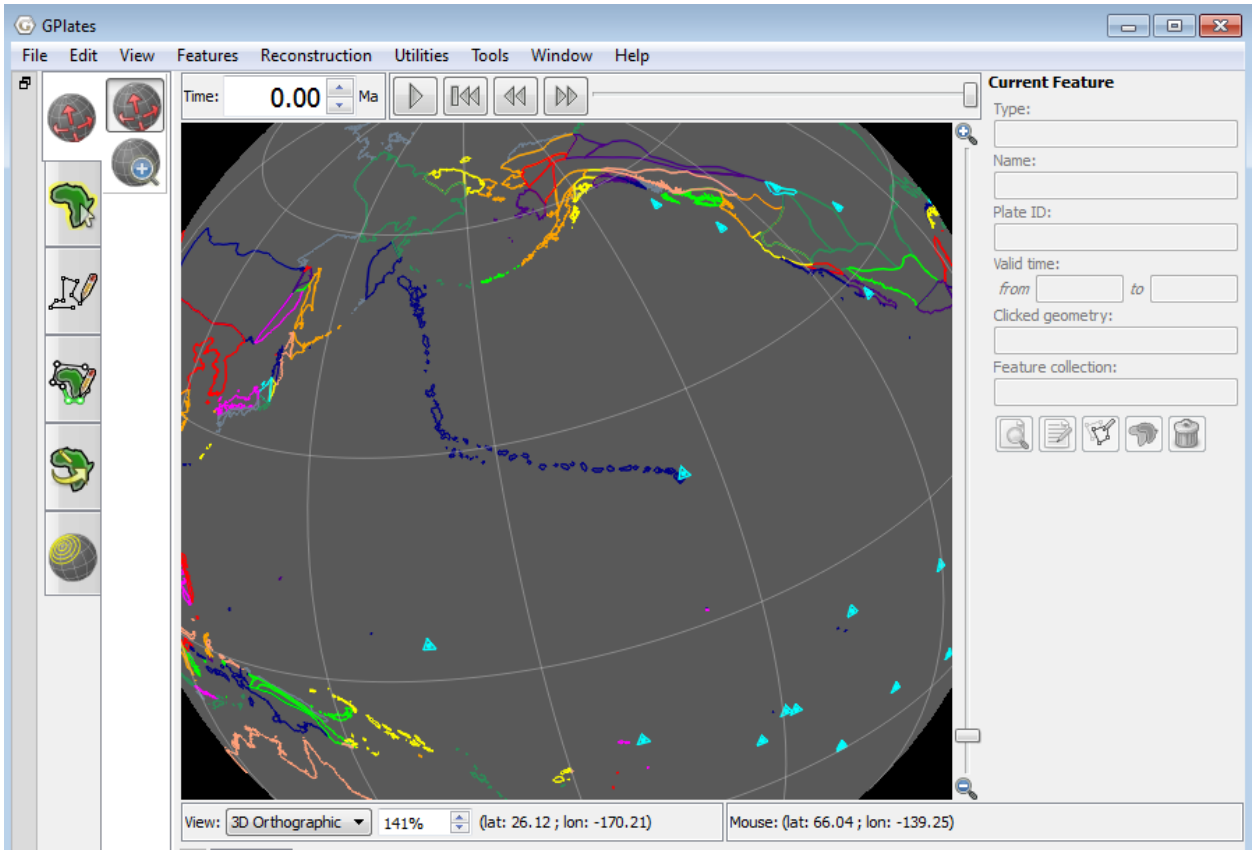

Figure 15. View of Hawaiian-Emperor seamount chain and present day hotspots (blue triangles)

4. Select your Digitise New Multi-point Geometry tool  and use it to create a point located on the Hawaiian hotspot triangle. Then click on the Create Feature button on the right side of the globe (Figure 16).

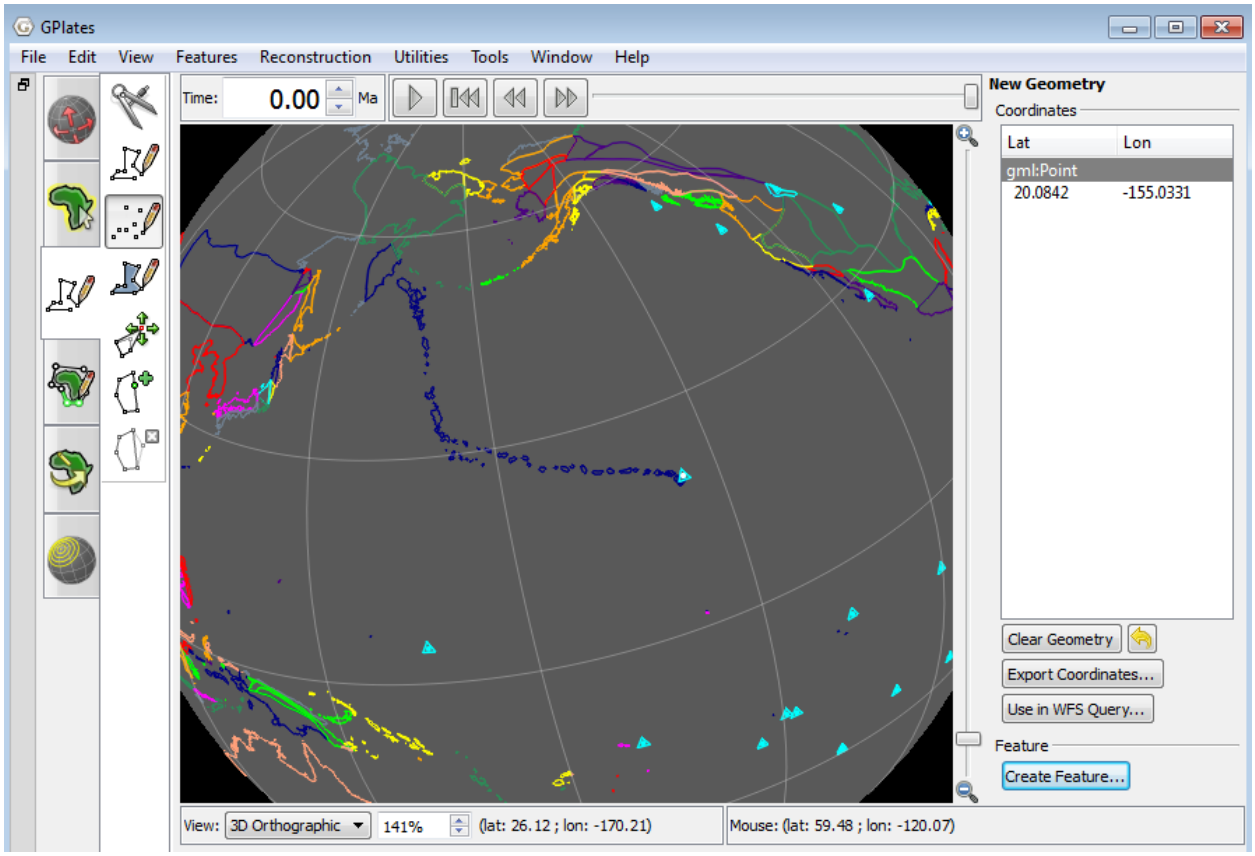

Figure 16. View of digitised geometry on Hawaiian hotspot and New Geometry sidebar

This will open up the Create Feature menu (Figure 17).

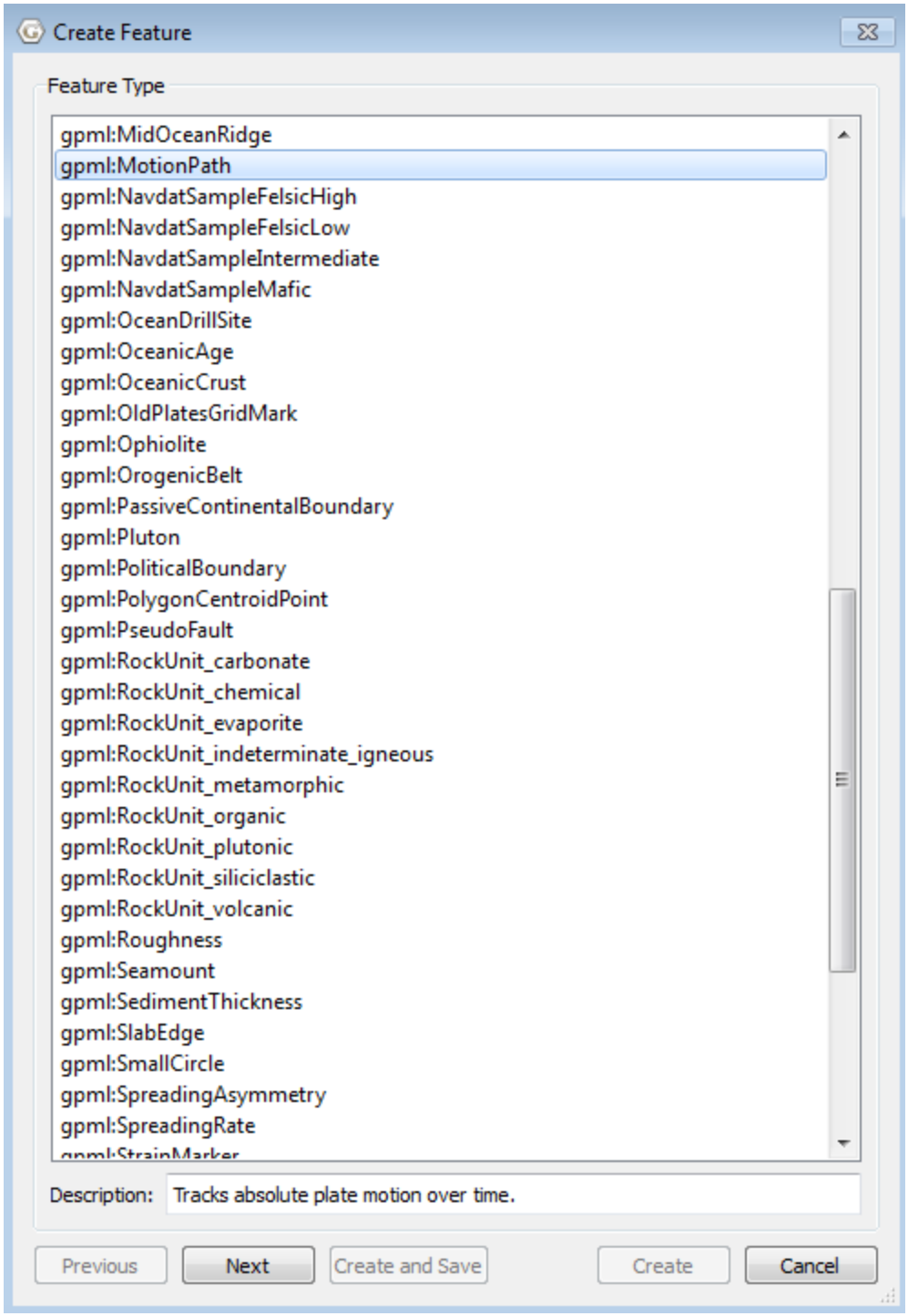

Figure 17. Create Feature menu

5. Choose your "Feature Type" to be "gpml:MotionPath" from the list and click Next.

6. In this window you fill in the properties of your point. In the “Plate ID:” field put “2” (Pacific Hotspot plate ID), for “Begin (time of appearance):” put “80”, for “End (time of disappearance):” check the “Distant Future” box, and under “Name:” put “Hawaiian Emperor Hotspot Path:” in the “Relative Plate Id” field enter the ID of the plate you wish to calculate motion relative to, in this case “901” (Pacific) (Figure 18). Then click Next.

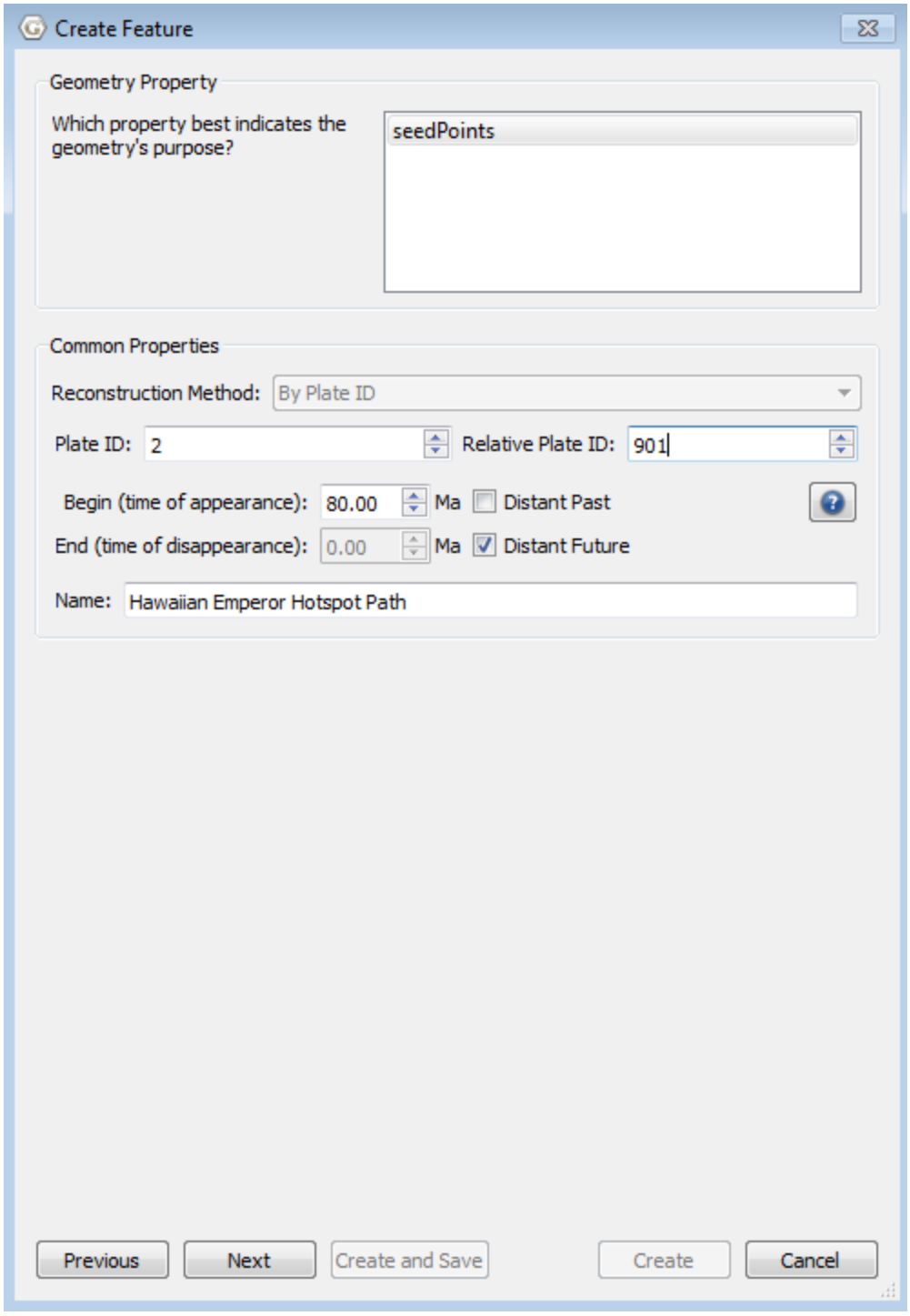

Figure 18. Create Feature menu - motion path properties

7. Click on the property *gpml:times* and click "add". Under the "Insert multiple times" section put a "From" time of "80" Ma, a "to" time of "0" Ma, and an "in steps of" time of "5" my, then click on the "Insert" button in this

section. This should populate the chart in this window (Figure 19). Cick "OK", then "Next".

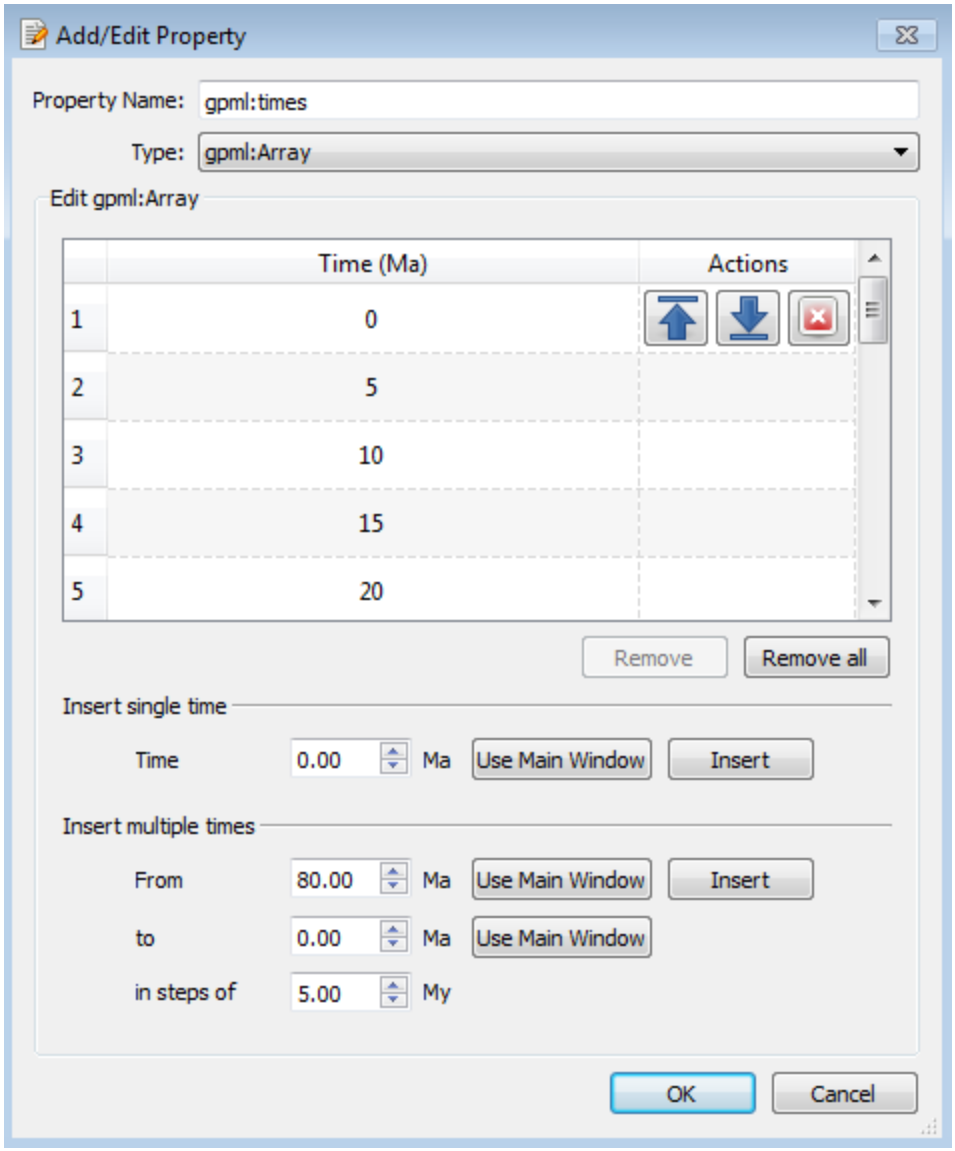

Figure 19. Create Feature menu - relative plate id and reconstruction times

8. Choose <Create a new feature collection> then click Create.

9. A line showing the motion path of the hotspot relative to the Pacific plate should appear. Note how it follows the Hawaiian-Emperor seamount chain (Figure 20). As with flowlines you can reconstruct this motion path through time; enter 80 in the time dialog box, and then use the slider or the arrows

to move forward through time to see the motion path as it is created.

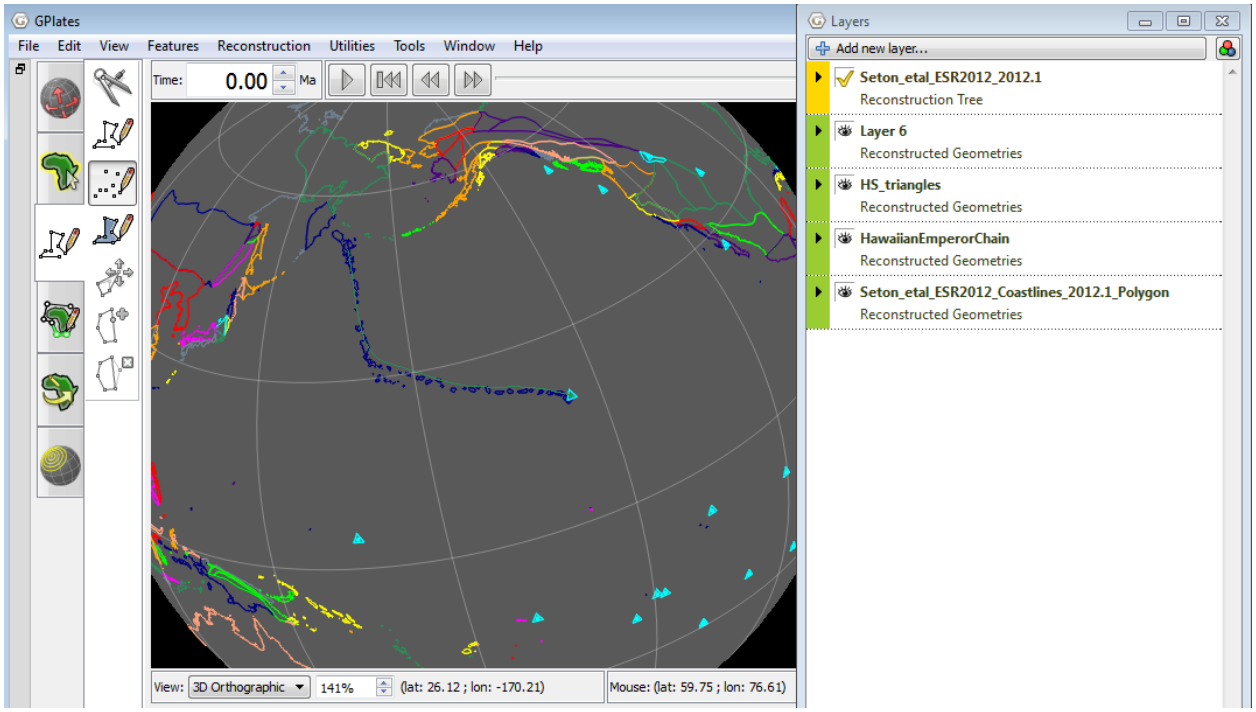

Figure 20. Motion path of the Hawaiian hotspot along the Hawaiian-Emperor seamount chain

10. If you are satisfied with your motion path, don't forget to save it!

Note: You can create multiple motion paths at the same time, provided all of the points have the same plate ids and relative plate ids.