GPlates: Next Generation Plate Tectonics Reconstruction Software

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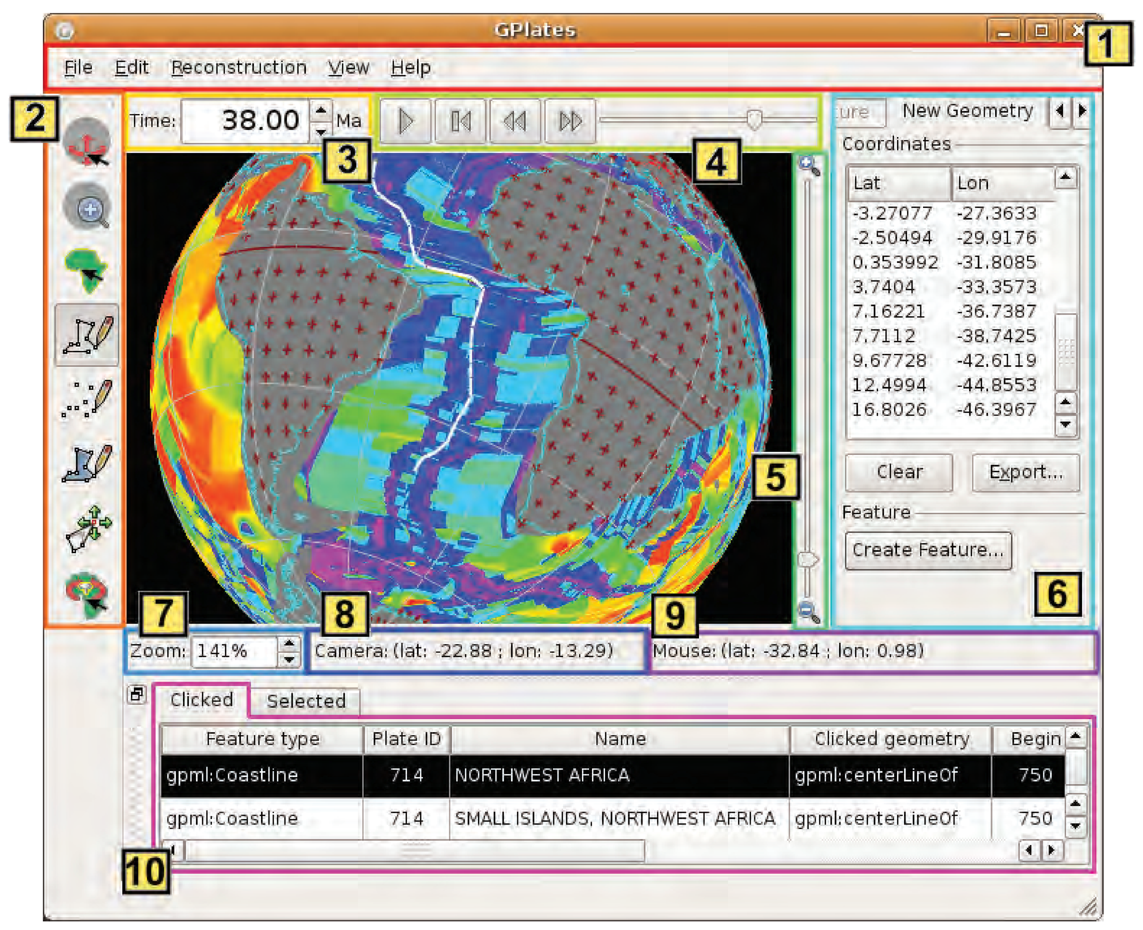
Traditional Interactive Plate Tectonics Reconstruction Tools



GPlates main window user interface elements:

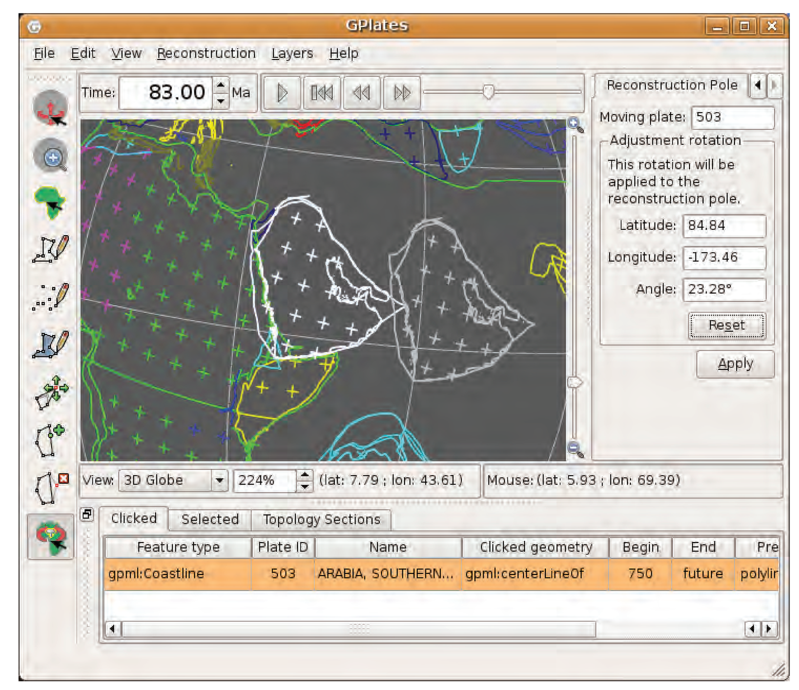
1 Menu Bar - This region of the Main Window contains the titles of the drop down menus.
2 Tool Palette - A collection of tools which are used to interact with the globe and geological features.
3 Time Controls - A collection of user-interface controls for precise control of the reconstruction time.
4 Animation Controls - A collection of tools to manipulate the animation of reconstructions.
5 Zoom Slider - A mouse-controlled slider which controls the zoom level of the Globe View camera.
6 Task Panel - Task-specific information and controls which correspond to the currently-activated tool.
7 Zoom Control - A user-interface control for precise manipulation of the Globe View camera zoom.
8 Camera Coordinate - An information field which indicates the current globe position of the Globe View.
9 Mouse Coordinate - An information field which indicates the current globe position of the mouse pointer.
10 Clicked Geometry Table - Displays a summary of each geometry or feature touched by mouse click.

GPlates has most of the traditional plate tectonics reconstruction tools:
- Reconstruction of geo-physical features via Euler Poles
- Digitization and Editing of feature geometries
- Interactive Euler Pole manipulation

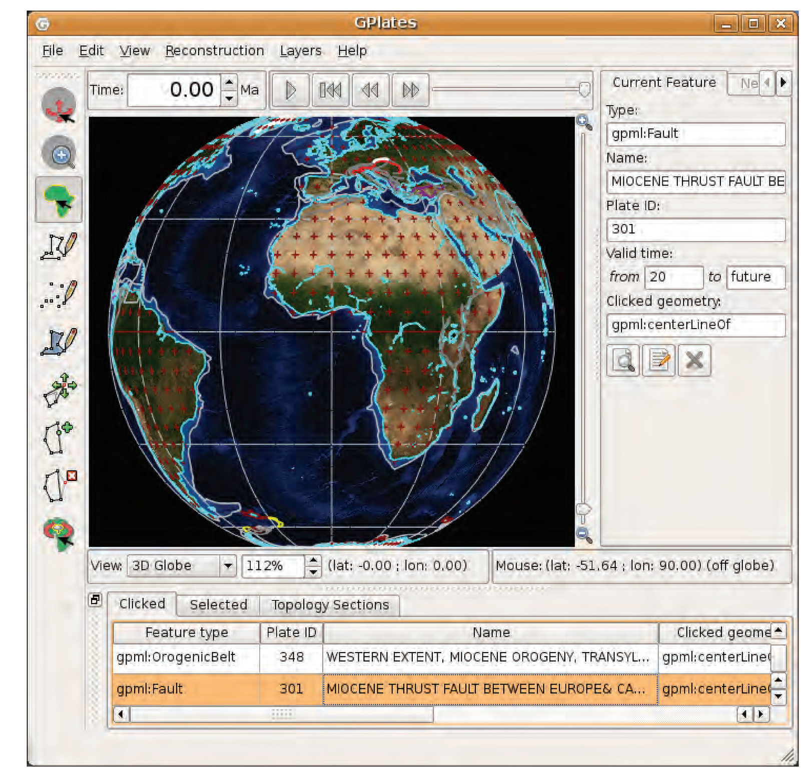
GPlates is open source, cross platform: Linux, Mac, Windows.
Written in C++ with Standard Template Library (STL).
We use Qt for GUI and OpenGL for low level drawing (fast!)

The native file format is GPML, an open source data interchange format that builds upon the Open Geospatial Consortium's primitive data types defined in GML. GPML / XML is (mostly) human readable plain text.

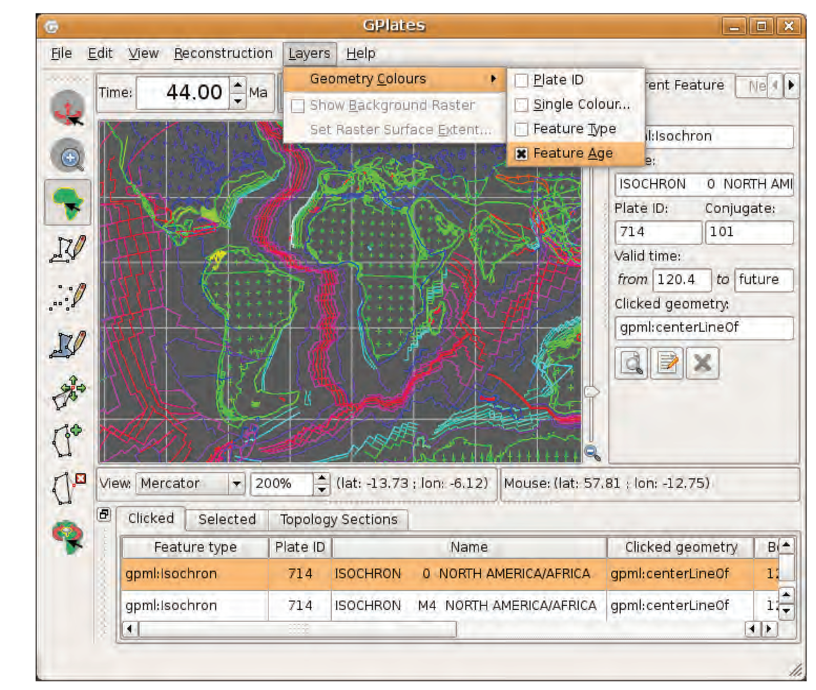
We use the Geospatial Data Abstraction Library (GDAL/OGR) reader for other formats (Shapefiles, raster images, etc.)



Euler Pole Manipulation Tool



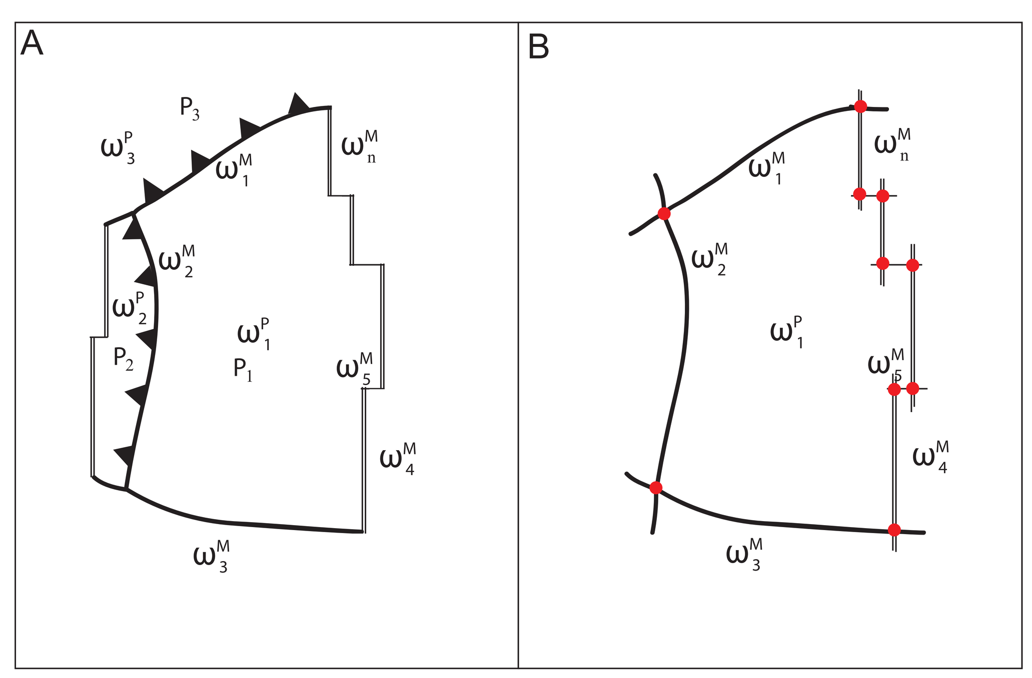
Background raster images for reference



Visualization controls on feature data

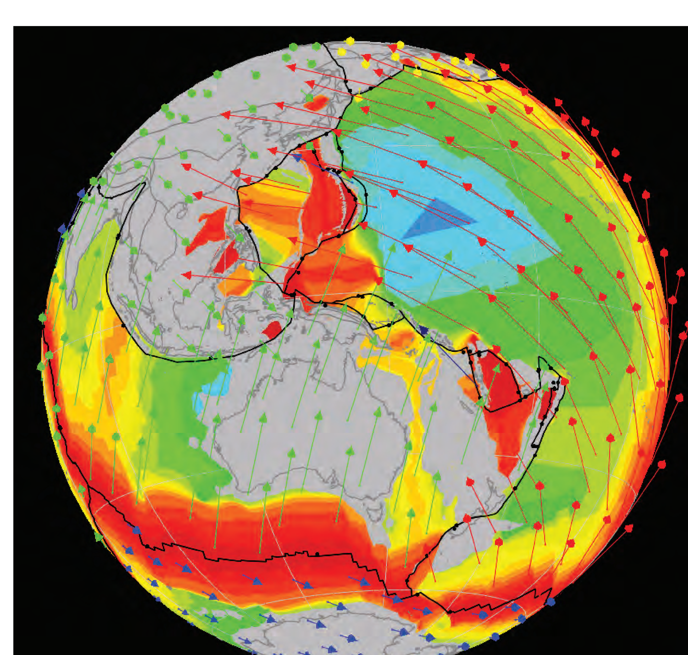
Global Plate Model: Continuously Closing Plate Polygons

An idealized tectonic plate showing component margin line data features. Each line feature has its own euler pole and rotates according to the rules of plate tectonics (A). The user selects line features to create a plate polygon. GPlates automatically calculates the intersection points (red dots in B) to form the complete plate boundary. Upon each reconstruction all data rotates independently, and GPlates automatically recomputes the new closed plate boundary.

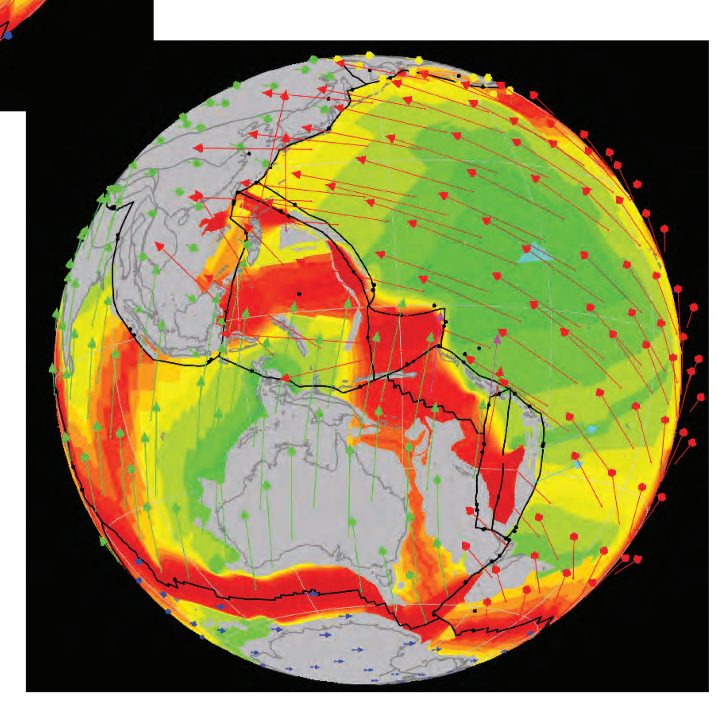


Global Closed Plate Polygon Model:

Using the CCP algorithms, we created global reconstructions with continuously closing plates from 140 Ma to the present. There are 45 'plates' but with 485 'logical plate polygons'. These polygons are closures that were manually created with GPlates and embody the rules of continuous closure. The life span of a polygon is between 1 Myr and ~40 Myr. The Australian and Pacific plates are the most complex with 53 and 49 closures, respectively, and with polygons lasting on average ~3 Myr. The global average lifetime of a CCP is >5Myr. The reconstruction is available dynamically as a GPML file, which can be read in, manipulated, and output in other formats with GPlates. The data are also available as 140 sets of static polygons.



Global plate model showing the western Pacific at 0Ma (left), and 24 Ma (below)



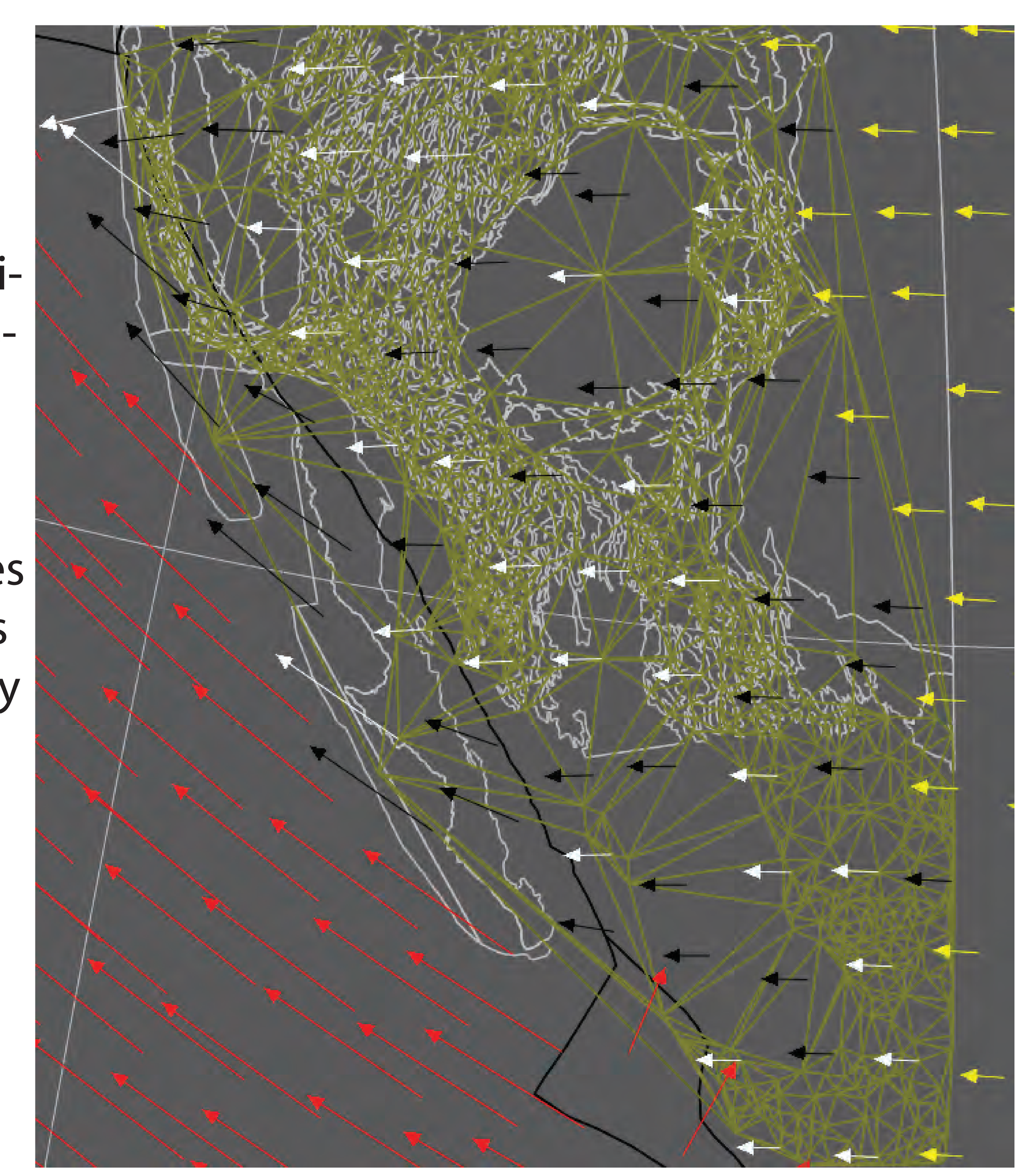
The figures shows the Global Plate Polygons outlined in black; Present day Coastlines, and line features in gray. Velocity vectors are computed by plate, and colored by individual Plate ID's (PAC=red; AUS=green, ANT=blue, etc.). The background image is a sea floor age map, with continents masked out in grey.

Plate Deformation: Triangulation Networks

Our current research focuses on plate deformation. The objective is to model intra-plate deformation with a hierarchical combination of the global plate polygons, rigid blocks, and zones of plate deformation. We have introduced another topology type using Delaunay Triangulations to incorporate specific measurements of displacement and strain within constrained regional areas into the larger global model.

Upon each reconstruction each element in the topology network moves according to its own Euler Pole. The triangulation is re-computed from these new positions. The triangulation is then used to interpolate velocity values for any arbitrary point in the network's domain. Velocity at arbitrary points outside the network are computed from the containing plate polygon. In this way we build up a hierarchy of control and constraints over crust motions

The figure shows displacement data from: "An Animated Tectonic Reconstruction of Southwestern North America Since 36Ma" [McQuarrie & Wernicke, Geosphere, 2005]. Approximately 1000 individual polygons representing the Basin and Range elements were incorporated (white). Each centroid of the block has measured or inferred displacement values from 0Ma to 36Ma. The white arrows show these displacements as velocity vectors.



The light yellow network shows the triangulation at this age (0Ma). The black arrows show interpolated velocity values within the network. The red and gold arrows show velocity from the PAC & COC, and