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REPORT

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Title:
A software tool to rotate geographic themes on the surface of the sphere (Earth) for ESRI's ArcMAP

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Summary:

Movement of the Earth's plates through geological time can be described in terms of a series of rotations on the sphere (Earth). If we can determine what these rotations have been, we can rotate ancient geological features on the Earth's plates back to their former positions to produce paleogeographic maps.

We present an open source computer program that performs such rotations on the sphere. The program is written for *Microsoft Windows* and runs inside the widely used Geographic Information System (GIS) called *ArcGIS* produced by the *Environmental Systems Research Institute* (*ESRI*: www.esri.com). The rotation function is activated via a push button control in the *ArcMap* program (a component of *ArcGIS*) and can operate on any geographic or geological phenomena represented by points, lines or polygons.

Our rotation program is distributed free of charge together with this report, but a licensed version of ESRI's *ArcGIS* software is required to run it. Anyone installing and using our rotation software does so at his or her own risk. We do not accept responsibility for any loss or corruption of data that might occur through use of the software.

Keywords: Euler rotation	ArcMap	ESRI
Paleogeography	ArcGIS	
Rotation	Visual Basic 6	

CONTENTS

1. INTRODUCTION

Earth's plates are in motion. Over millions of years, plates move over large potions of the Earth to produce continuously evolving paleogeographies. The translation of a plate from one place to another can be described by a rotation on the sphere about an Euler pole (Cox & Hart 1986). An Euler pole is simply the pivot point about which the rotation takes place. It has a geographic position expressed in terms of its latitude and longitude, and a rotation angle associated with it in degrees counter-clockwise.

Construction of a palaeographic map for any given time in Earth history (e.g. Figure 1) requires knowledge of the present positions of the geographic/geological entities to be placed on the map, and the Euler poles that translate the entities back to their former positions on the globe.
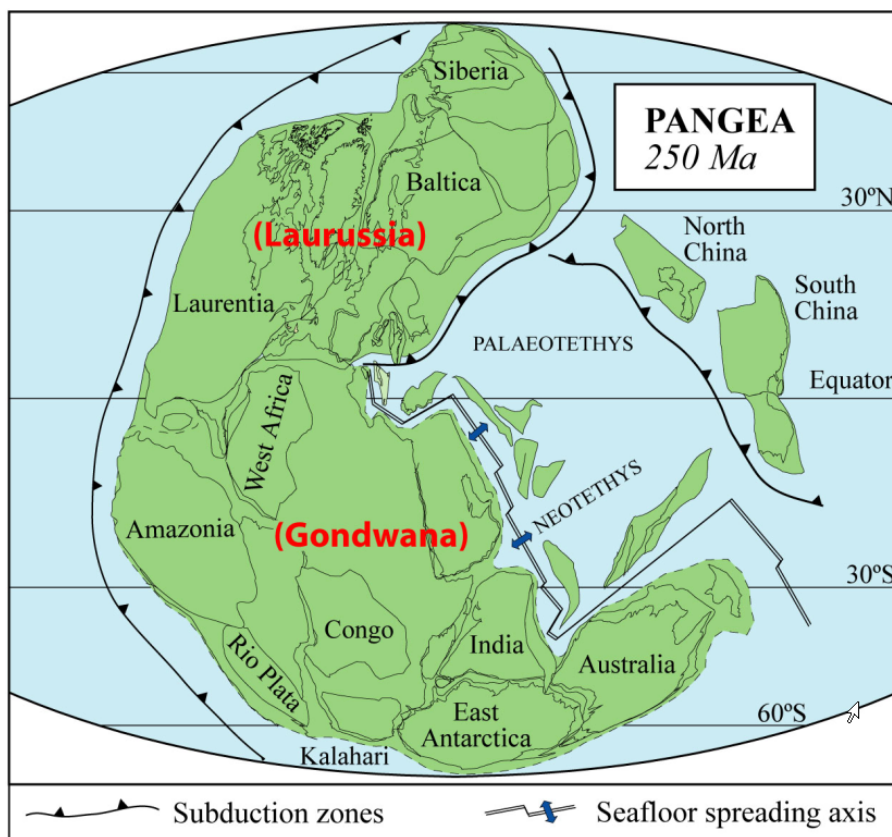

Figure 1. Paleogeographic map showing the former supercontinents Pangea, 250 million years ago (Torsvik, 2003). The present coastlines of the continents that made up Pangea are indicated by the thin solid lines.

The software presented here is designed to rotate map features from one place to another on the surface of the globe according to user-defined Euler poles. We chose to implement the rotation algorithm within the commercial map-making program *ArcMap*, part of the *ArcGIS* Geographic Information System developed and distributed by the *Environmental Systems Research Institute* (ESRI, www.esri.com). *ArcMap* is a widely used and sophisticated map-making tool. *ArcMap* displays geographic/geological features stored in the widely used *shapefile* format. Functioning as a button control in *ArcMap*, our rotation algorithm reads geographic features from any given shapefile and writes rotated features to a new shapefile. All geographic features in a shapefile are rotated about a single Euler pole. Complete

paleogeographic maps like Figure 1 may be produced by rotating the contents of multiple shapefiles about multiple Euler poles.

2. INSTALLATION OF THE ROTATION SOFTWARE

The rotation software is written in Microsoft Visual Basic 6.0 for the Microsoft Windows operating system and can only be run as a command from within ESRI's map-making program *ArcMap*.

1. ESRI's *ArcGIS* software package (v. 9.0 or higher, including *ArcMap*) must be installed on the computer

2. Our rotation algorithm resides in a single DLL file on a CD accompanying this report

3. Copy the DLL file to a folder on one of the computer's internal disk drives

4. Open *ArcMap*

5. Open the "Customize…" dialog box in the "Tools" menu

6. Click on the "Commands" tab

7. In the lower left corner of the dialog box, choose whether you want the rotation command to be stored in "Normal.mxt" (available in all subsequent maps) or the current map document (available only in the current map)

8. Click the "Add from file…" button

9. Browse to and open the DLL file containing the rotation algorithm (on the computer's internal disk drive)

10. A second dialog box with title "Added Objects…" displaying the word "Projisering" appears. Click the "OK" button. The program returns to the "Customize" dialog box

11. A command with the name "Rotation on the sphere" is added to the "MyCustomTools" category (on the "Commands" tab)

12. Use the mouse to drag and drop the "Rotation on the sphere" command from the dialog box to any of the toolbars displayed in *ArcMap*. A new button with the text "Rotation on the sphere" will be added to that toolbar. One can also drag and drop the command into any of the *ArcMap* menus

13. Close the "Customize" dialog box

The command is now installed.

3. OPERATION OF THE ROTATION SOFTWARE

Requirements

1. The "Rotation on the sphere" command must be installed and appear in *ArcMap* as a button or menu item (see section 2)

2. The geographic/geologic features to be rotated should be stored in ESRI shapefile format, of either POINT, POLYLINE or POLYGON type

3. The co-ordinate system for the shapefile must be *geographic*, datum *WGS-1984* (CGS_WGS_1984)

   * If the shapefile's co-ordinate system is undefined, make sure you know what the correct co-ordinate system is and define it using ESRI's *ArcCatalog*. If that co-ordinate system is not as specified above, use ESRI's *ArcToolbox* to re-project it to CGS_WGS_1984

Performing a rotation

1. Open a map in ArcMap

2. Add at least one shapefile to the map as a layer. The shapefile should conform with the requirements above

3. Activate the command "Rotation on the sphere" (installed as a button or menu item, section 2 above step 12). The dialog box below will appear.
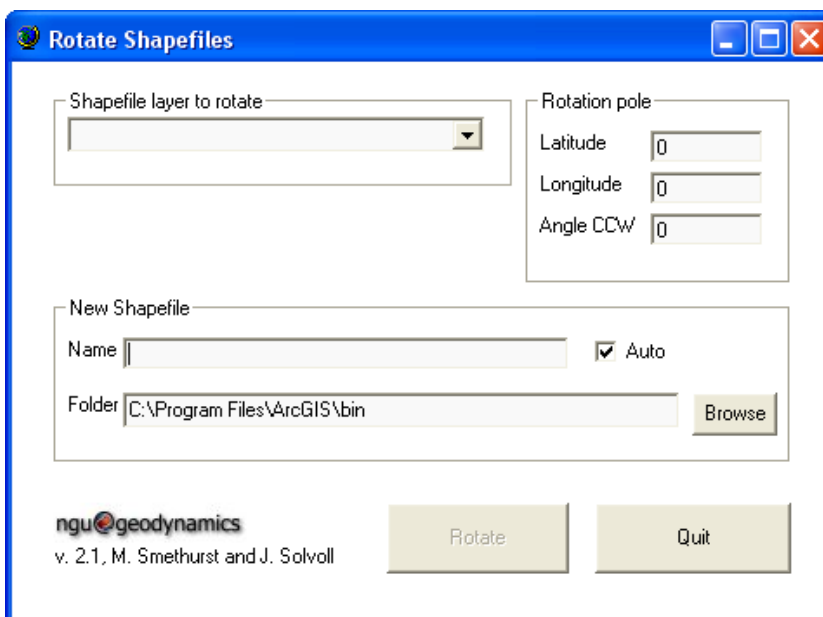
*The command is only active when the map has one or more shapefiles present as layers

4. Fill in the dialog box, including (a) the name of the shapefile to rotate, selected from a drop down list of shapefiles displayed on the open map, (b) the rotation parameters to use ("Rotation pole"), (c) the name for a new shapefile to contain rotated features and (d) the folder to which the new shapefile will be written.

   The dialog box below is filled out to rotate the present coastline of Greenland in shapefile *GreenlandLL.SHP* through 12.8 degrees counter-clockwise about an Euler pole at Lat. 31.2/Long. 133.9 and write it to *c:\temp\Greenl250.SHP*
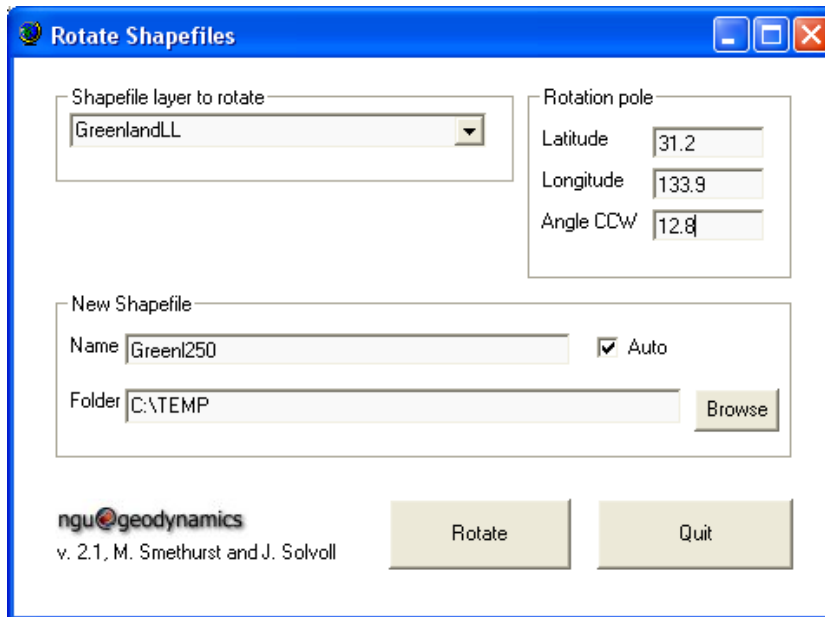

5. Press "Rotate" (above) to carry out the specified rotation. The example above rotates Greenland to the position it had with respect to Europe 250 million years ago (see Mosar et. al. 2002).

   Rotation parameters specified under "Rotation pole" are added to the new shapefile's attribute table as a text string as shown in the picture below. Parameters for every subsequent rotation applied to a shapefile are appended to the text string so that a record of all rotations applied to geographic/geological features is maintained.
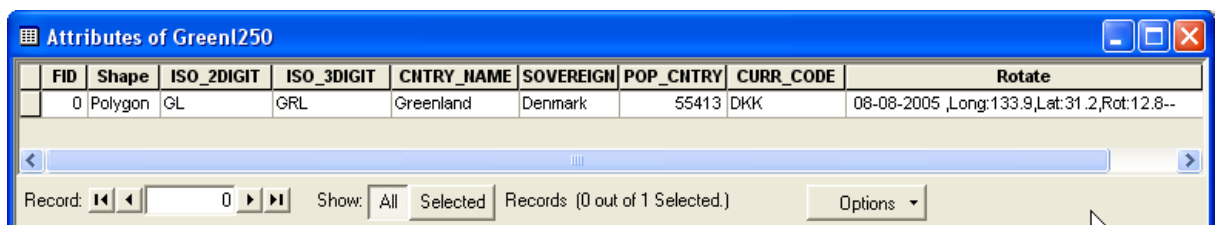
   In the example above, the coastline of Greenland was rotated from its present position to its position relative to Europe 250 million years ago, before the opening of the North Atlantic Ocean. Greenland is shown in these and in intermediate positions in Figure 2.
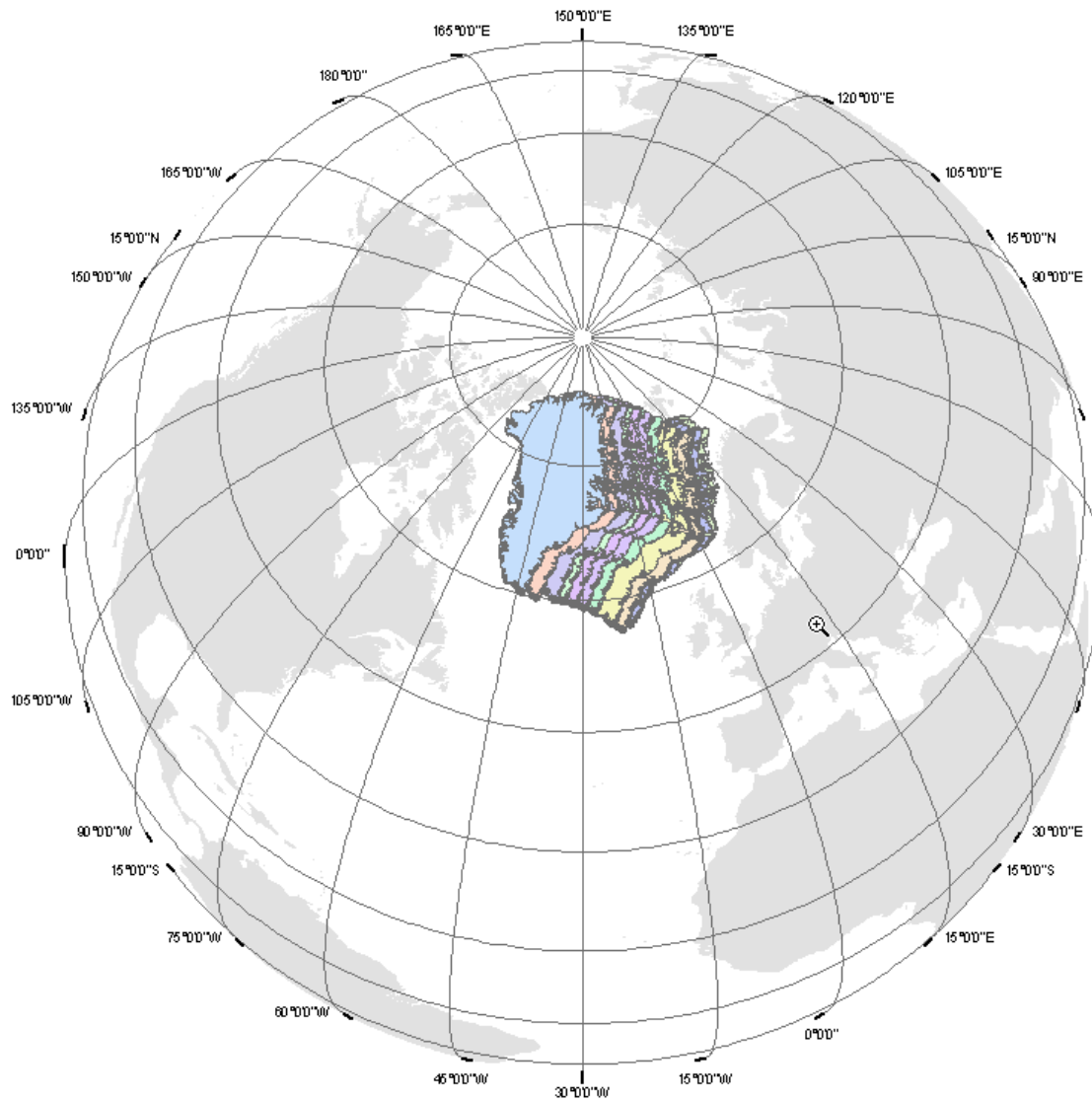
Figure 2. Former positions of Greenland with respect to Europe. The top outline of Greenland (blue) is the present position of the continent. The outlines of Greenland beneath it are successively older positions for Greenland ending with the 250 My position against the Atlantic coast of Norway.

4. SOFTWARE DISTRIBUTION

This software is distributed in the form of a single dynamic link library (DLL) file. This file can be installed and used together with ESRI's *ArcMap* software as described in sections 2 and 3 of this report. The file is accompanied by this report and a Visual Basic 6.0 project containing source code. A licence for ESRI's Object Developer Toolkit is required to compile the source code.

> Anyone installing and using our rotation software does so at his or her own risk. We do not accept responsibility for any loss or corruption of data that might occur through use of the software.

5. REFERENCES

Cox, A. & Hart, R.B. 1986: Plate Tectonics: How It Works. Blackwell Science Ltd., Oxford, UK. 392p.

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