

GIS-based Reconstruction of Pangaea with Recent Progresses in Plate Tectonics

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I. Introduction

- There have been many debates about the existence and features of the supercontinent Pangaea since Alfred Wegener suggested the continental drift hypothesis. Now, the question about its existence was clearly solved.
 - Wegener's proposed Pangaea matches well with the supercontinent reconstructed by modern scientists in the late 1960s based on concrete evidence and sophisticated scientific paradigms such as plate tectonics.

- Nonetheless, despite a wealth of geological data and the development of related areas of scientific enquiry, the precise shape of Pangaea before the supercontinent broke up and drifted apart has remained uncertain.
 - The Pangaeian supercontinent proposed by Wegener is a huge rounded to oval landmass. Several other shapes for Pangaea are now recognized by the geological community.

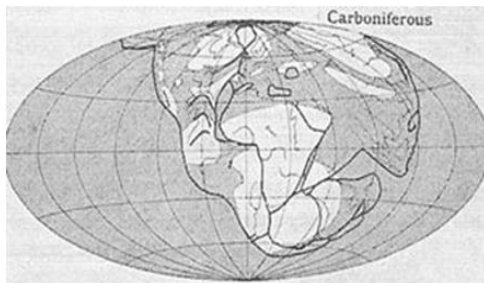
- In this study, the shape of the Pangaeian supercontinent was reconstructed incorporating recent advances in plate tectonics using a sophisticated geographical information system (GIS) mapping technique.
 - To better visualize of the shape of the supercontinent, Pangaea was reconstructed using an equidistant map projection where the central point of Pangaea was placed in the center of the map.

- Pangaea as reconstructed in this manner appears almost circular in shape with two large inland seas, unlike in previous reconstructions.

II. The Shape of Pangaea in Previous Studies

1. Types of the Shape of Pangaea in Previous Studies

- The exact shape of Pangaea still remains unresolved.
 - Pangaea has been historically reconstructed as either oval in shape with elongation in a north-south direction, or C-shaped owing to an incursion by the sea from the east.
 - Recent proposals have included ring or circular shapes.
- Oval shape



Wegener(1915)



Darrel Hess(2011)

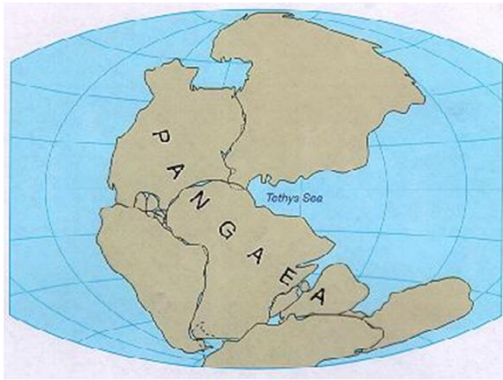
- C shape



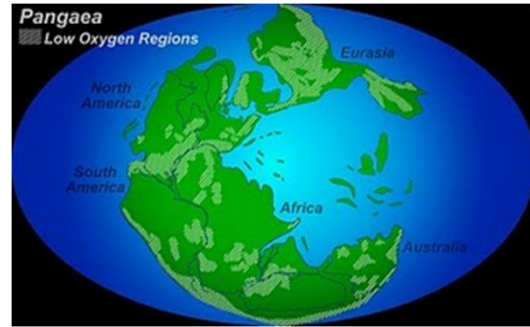
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<http://cy.wikipedia.org/wiki/Pangaea>

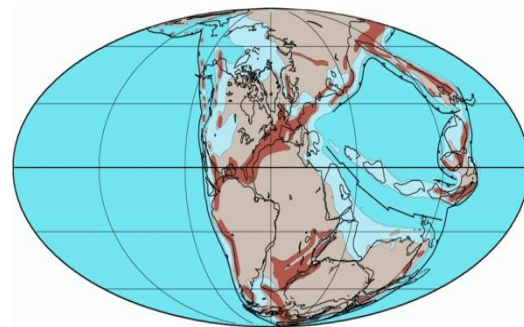
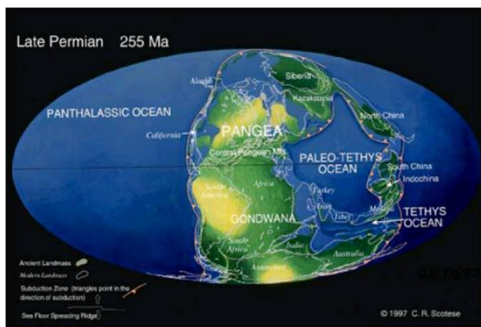


<http://geology.com/pangea.htm>



www.readingworkbook.blogspot.com/201...ell.html

□ Ring shape



<http://www.ucmp.berkeley.edu/history/wegener.html>

□ circle shape



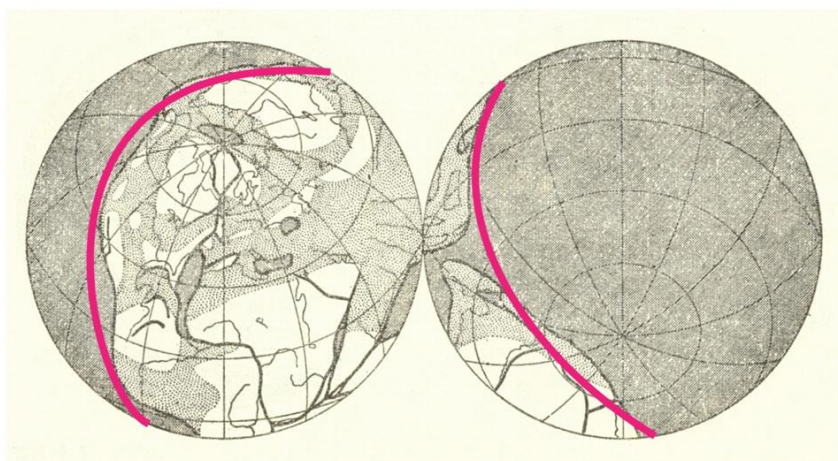
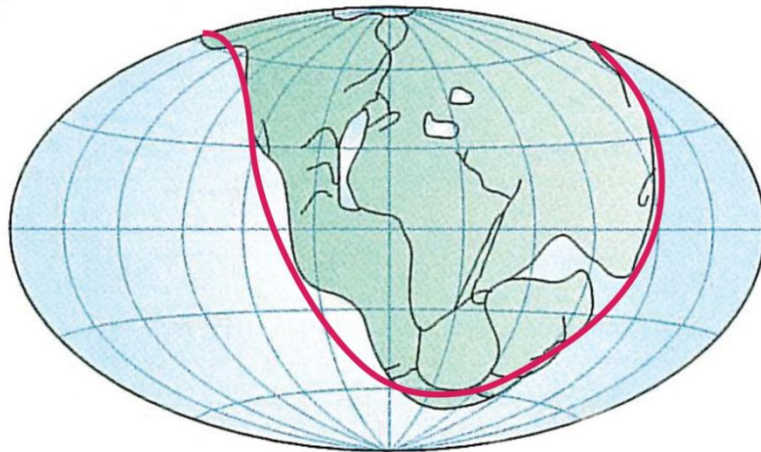
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2. Problems and Limitations of Previous Studies

- The uncertainty of the shape and location of southeast Eurasia and Alaska.
 - The shapes and locations of southeast Eurasia and Alaska within Pangaea still remain to be settled.
- Distortion of the shape of Pangaea resulting from map projections.
 - For example, Pangaea as drawn by Alfred Wegener may be more circular than oval if it is displayed using an equidistant map projection.
 - The red lines on the figures below are sets of points which are equidistant from the central point of Pangaea (the Sinai Peninsula).

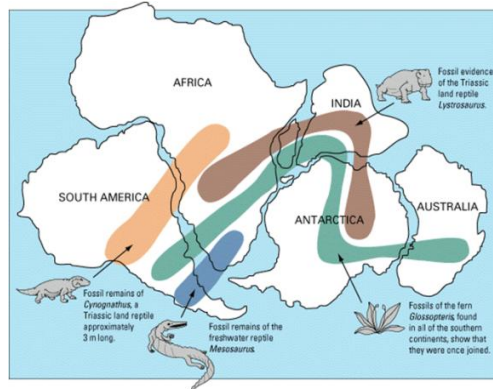


Wegener(1915)

III. GIS-based Reconstruction of Pangaea

1. Facts to be Confirmed with the Results of Recent Research

- The shapes and locations of the continents in Gondwana.
 - The distributions of animals and plants show the fit of the Gondwanan continents.



E. A. Keller(2008)

- The distribution of glaciers in Gondwana shows the fit of the Gondwanan continents.



E. A. Keller(2008)

- The fit of the Gondwanan continents, prior to the breakup of Pangaea.

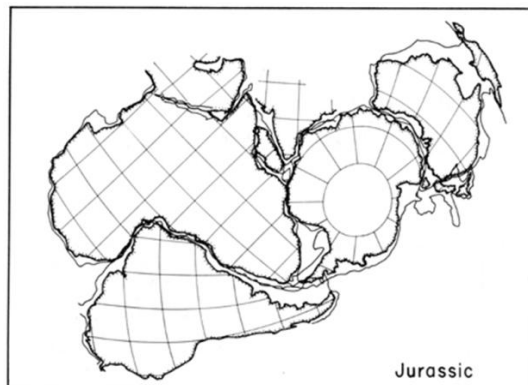


FIGURE 1. Fit of the Gondwana continents during the Jurassic, prior to breakup (after Smith & Hallam, 1970).

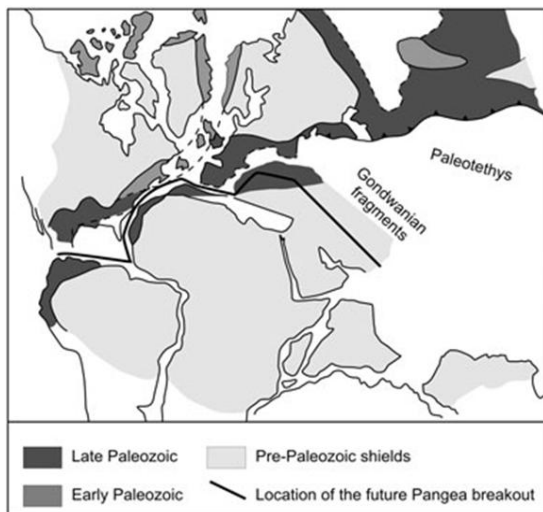
Smith and Hallam(1970)

- The shapes and locations of North America and Greenland.
 - A large mountain range shows the locations of North America and Greenland in Pangaea.



Darrel Hess (2011)

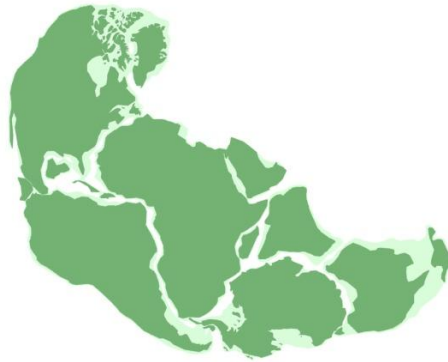
- Reconstruction of Pangaea showing the Paleozoic orogenic belts.



Smith & Briden(1977)

2. Recent Research Results Displayed Using an Equidistant Map Projection

- The results of recent research plotted on an equidistant projection map.
 - This map was constructed using GIS techniques incorporating recent advances in the study of plate tectonics.
 - The map includes Gondwana, North America, and Greenland, the locations and shapes of which were confirmed generally with the recent research results on the Pangaea.



<Figure 1> Gondwana, North America, and Greenland on an equidistant projection map

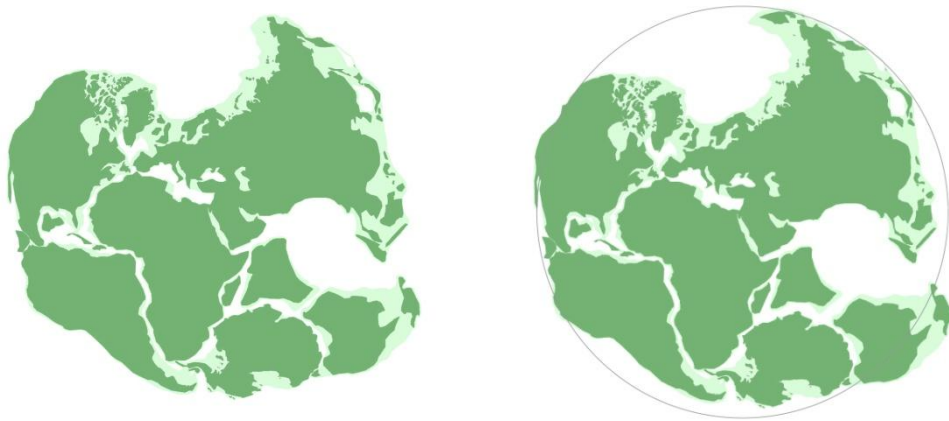
- It looks like a half-circle.



<Figure 2> Gondwana, North America, and Greenland within Pangaea with a best-fit circumscribing circle

3. Merging of the Eurasian Continent with Gondwana and North America

- This figure shows the circular shape that results from merging the Eurasian continent with Gondwana and North America.
- The shoreline of Pangaea is smoothly curved, and irregularities found in modern shorelines are not apparent.



<Figure 3> Merging of the Eurasian continent with Gondwana and North America

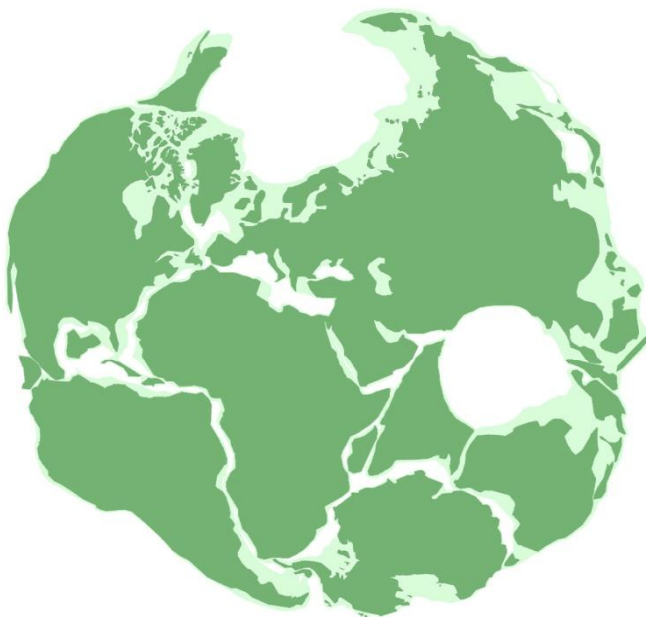
4. Shape of Pangaea after Partial Modification of India, Alaska, and Oceania

- After confirming that Pangaea was approximately round in shape, we partially adjusted the locations and forms of the continents to match the circular frame. (See red lines in <Figure 4>.)
- Main adjustment points.
 - The shape of the northern Indian subcontinent: The Himalayan mountain range that forms the boundary between India and Asia is arc-shaped. When India collided into Asia, the northwest part of India seems to have broken away.
 - The location of Alaska: Part of Alaska belonged to the Asian continent, whereas the remainder of Alaska had a different source.
 - The location of Oceania: Although the location of Oceania in Pangaea is shifted slightly in the northwest direction, it seems to agree well with recent research results.



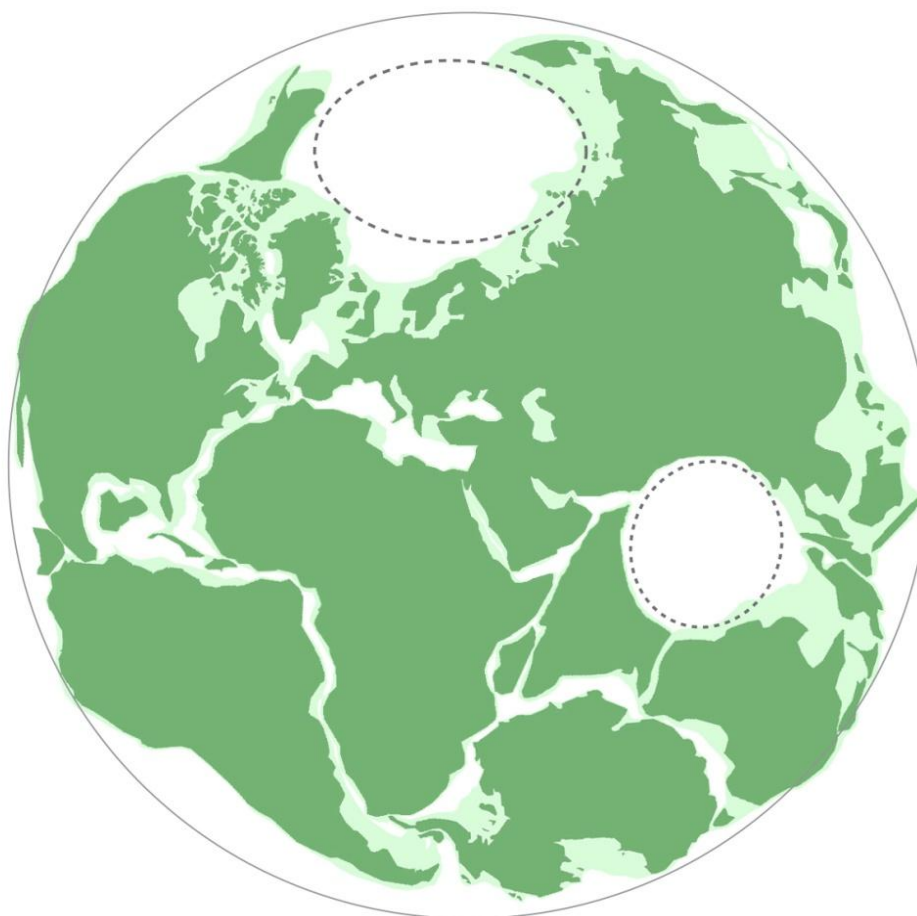
<Figure 4> Partial modification of India, Alaska, and Oceania

- The shape of Pangaea after partial adjustment.
 - In this adjusted version, the continents fit into each other well and Pangaea is geometrically circular in form.



<Figure 5> Shape of Pangaea after partial adjustment

- The radius of the circle that circumscribes Pangaea is about 9,000 km.
- Pangaea is a giant circular continent with two large inland seas (or lakes): a large inland sea (the Tethys Sea) near the north Indian Ocean and an even larger inland sea near the Arctic Ocean.
- Although the two inland seas may appear oval <Figure 6>, they are actually circular. If displayed using an equidistant map projection from the central points of each of the inland seas, they should appear circular.



<Figure 6> Round Pangaea with two circular inland seas

IV. Conclusion

- This research suggests that Pangaea might have existed in a circular shape until it started to break up into separate parts.
 - The radius of the circle that circumscribed Pangaea was about 9,000 km.
 - Comparing Pangaea to present geography revealed that Pangaea's geometric center falls somewhere within the modern Sinai Peninsula.

- A notable feature of Pangaea as reconstructed in this study is the two circular inland seas.
 - One corresponds to the Tethys Sea. The other corresponds to the present Arctic Ocean and is several times larger than the Tethys.
 - From a geological viewpoint these inland seas appear to be oceanic crust contained inside continental crust, and it is likely that they were connected to the Panthalassa Ocean by the sea. During the Permian period, about half of the Pangaeon continent was under water.

- This study shows that Pangaea was likely circular. However, the result may provide much more important information than merely revealing a beautiful geometric configuration.
 - One hypothesis is that the circular shape of Pangaea with two circular inland seas might have resulted from large-scale melting of the earth's crust, as no other geological process would likely produce this arrangement.
 - The large-scale melting of the earth's crust seems to have taken place at the close of the Paleozoic, during the Permian. The greatest mass extinction events on the planet occurred during that time.

Reference

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