U. S. DEPARTMENT OF THE INTERIOR
U. S. GEOLOGICAL SURVEY

Make your own Earth and Tectonic Globes

By

Tau Rho Alpha*, Scott W. Starratt* and Cecily C. Chang*

Open - File Report 93-380-A

Earth globe

Tectonic globe

This report is preliminary and has not been reviewed for conformity with U. S. Geological Survey editorial standards. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U. S. Government.

Although this program has been used by the U. S. Geological Survey, no warranty, expressed or implied, is made by the USGS as to the accuracy and functioning of the program and related program material, nor shall the fact of distribution constitute any such warranty, and no responsibility is assumed by the USGS in connection therewith.

*U. S. Geological Survey
Menlo Park, CA 94025

Description

This report contains instructions and two patterns for making a terrestrial globe and a tectonic globe. The pattern or map projection is designed to be glued onto a used tennis ball. The terrestrial globe is intended to help visualize the location of the continents and oceans. The purpose of the tectonic globe is to help visualize the location of the Earth's plates and types of plate boundaries (e.g., spreading, convergent, and transform). By constructing and examining the globes, students and others will obtain a greater appreciation of why the edges of continents are located where they are, and of the shape and position of the Earth's plates and their boundaries. This exercise will give the students an insight as to how the parts of Earth's surface are put together. Included in this report are the paper patterns (map projections), instructions for assembly, educator's guides, and a simple description of terrestrial and tectonic globes.

Requirements for the diskette version are an Apple Macintosh computer with a hard disk and generic graphics and word-processing software (not supplied). The map projections and graphics are saved in PICT and paint format: the text was saved in Microsoft Word. The paper version of this report has the same map projections, illustrations, and text. Any theme or subject can be added to the terrestrial map projection before or after attaching it to the tennis ball. Global themes as ocean currents, tropical rain forests, population centers, geology, sedimentary basins, and mountain ranges are more easily understood when seen in a global context.

The date of this Open-File Report is 11/2/1993. OF 93-380- A, paper copy, 14p. OF 93-380-B, 3.5-in. Macintosh 1.4 MB high-density diskette.

To order this report, contact: U. S. Geological Survey, Book and Open-File Report Sales, Box 25286 Denver, CO. or call (303) 236 - 4476.

Educator's Guide

Globes

A globe is a world map on the surface of a small sphere that represents the Earth. Of all the world maps, the globe is the easiest to understand because it gives us the most realistic picture of the Earth and has the same attributes as the Earth; round and immense, and impossible to see all at once. Spatial attributes such as distance, direction, shape, and area are preserved as well as the continuity of the all-curved surface. Globes represent the best possible map projection because they include a minimum of distortion and are the ultimate in geographic realism. Globes come in all sizes and are designed for many uses. Most are terrestrial or geographic globes, some are for decoration, without much thought given to geography as we know it, and some are training globes for navigation and general education. Globes that represent the heavens are called celestial globes. Today's globes are constructed of plastic, but, before plastic was available, paper and plaster were used. Early globes used hand-drawn segments of a map projection that were attached to a sphere. These segments, called gores, were tied together near the equator and separated or interrupted toward the poles. As most printing machines cannot print on the all-curved surface of a sphere, the gore method of making globes is still used.

Tennis ball globes

Two globes can be constructed using the enclosed world maps. Each of the world maps is composed of twelve gores that are designed to be attached to a tennis ball. Each gore has a width of 30°, the time it takes the sun to travel two hours over the surface of the Earth. The twelve gores can be cut into four groups of three gores each and glued onto the tennis ball, or the gores can be glued on as a group of twelve. Either way, it is important to have the equator divide the tennis ball into two equal parts and for the equator to be in a straight line. See instructions for the construction of tennis ball globes, pages 9 and 10 in this report.

The Earth globe or terrestrial globe (pertaining to the Earth) is a world map that outlines the continents. This globe can be the base for showing any theme or subject, such as ocean currents, tropical rain forests, mountain ranges, river systems, human population, geology and so on. The second globe is a tectonic globe (tectonic means a structural deformation in the earth's crust) that shows the earth's major tectonic plates. On the tectonic globe, the edges of the plates symbolize divergent (spreading) plate boundaries, convergent plate boundaries, and transform plate boundaries. These two globes allow us to see the whole world and to look at the world from a different angle, giving us a better understanding of the Earth's relationships.

Great-Circle Indicator

You can use the great-circle indicator to measure both latitude and longitude. To find the latitude of your city align the great-circle indicator for latitude over both poles and your city. Use the indicator like a ruler to find the degree of latitude directly over your city. To find the longitude of your city, hold the great-circle indicator on the equator. Where a meridian, a north-south line, from your city intersects the great-circle indicator is the longitude for your city. Longitude is read in degrees east or west of the Greenwich (prime) meridian.

The theory of plate tectonics

Seashells more than 50 million years old have been found near the summit of Mount Everest, the highest point on Earth (29,028 ft ; 8840 m). Oil (the remains of one-celled marine plants and animals) is found deep beneath the Earth's surface from Texas to central Canada, hundreds of miles from the nearest ocean. How can this be? The Theory of Plate Tectonics provides the answer. But, let's go back to the beginning.......

More than 2000 years ago Aristotle wondered aloud about the discovery of marine animals on the mountains of ancient Greece. The people laughed.

In the 15th century, Leonardo da Vinci wrote that above the plains of Italy where birds now fly, fish once swam. The people laughed.

In the early 1600's Sir Francis Bacon commented on the similarity between the shape of the western shoreline of Africa and the eastern shoreline of South America. The people laughed.

In 1912, meteorologist Alfred Wegener published his Theory of Continental Drift. Earth scientists in Europe and North America laughed. Earth scientists in South America said, "Hmm, why not?"

Wegener based his Theory of Continental Drift on several observations. These included 1) the fit of continental margins, 2) matching mountain chains in North America (Appalachians north through Nova Scotia and Newfoundland) and Europe (British Isles north into Norway), 3) the presence of similar 250-million-year-old fossil leaves and reptiles in South America, Australia, Antarctica, India, and Madagascar, and 4) sediments deposited by glaciers more than 250 million years ago on Africa, South America, India, Australia, and Madagascar. The one critical question that Wegener was unable to answer was, "what made the continents drift?"

It was not until the mid-1960's that the Theory of Plate Tectonics was generally accepted (some scientists are still not convinced).

More recently, supporting evidence has come from the magnetic history of the Earth, the topography of the ocean basins, radioactive dating of rocks, and the location of earthquakes and volcanic eruptions. The last piece of the puzzle was the proposal of convection cells as the means by which the plates moved. The two theories have been joined into a underlying model of crustal development called plate tectonics.

The Earth's surface is divided into more than twelve rigid crustal plates, each plate is 70 to 100 km thick (43 to 65 miles). The Tectonic Globe of this report is too small to show the names of all the plates, so only the larger plates are named. These plates are moved around by forces (heat) from within the earth. The crust under the ocean is as thin as 3 mi (5 km) thick; continental crust is as much as 45 mi (72 km) thick. Average plate movement is about 2 in (5 cm) a year, or about the diameter of the tennis-ball globe.

There are three different type of plate boundaries: 1) **Divergent plate boundaries**-- at divergent (spreading) plate boundaries, the two plates are moving away from each other. As the plates move apart, the space between them is immediately filled with magma rising from below forming new oceanic crust. Since the plates do not move apart uniformly, fracture zones are sometimes formed. Fracture zones usually form along ocean ridges where sea-floor spreading is taking place (for example, the Atlantic and Indian Oceans). 2) **Convergent plate boundaries**-- At these boundaries, where two plates come together, or converge, one plate usually slides under the other plate (this process is called subduction). The Tectonic Globe marks this type of plate edge with triangles. For example when a continental plate (South American plate) and an oceanic plate (Pacific plate) converge, the denser oceanic plate is subducted under the less dense continental plate. When two oceanic plates converge, as in the western Pacific Ocean, the faster plate is subducted under the slower one. When two continental plates collide (Eurasian and Indian plates), a mountain range (Himalayas, in this example) is formed. 3) **Transform plate boundaries**--At this type of boundary, the two plates slide past each other to facilitate the motion of curved "plates" on a spherical surface. Crust is neither destroyed or produced at this boundary. Crustal plates shear laterally past each other producing many earthquakes. Part of the eastern boundary of the Pacific Plate is a long transform fault system. The San Andreas fault system in California is the most famous of the many faults which form a transform plate boundary between the Pacific and North American plates.

The idea of continental drift and its successor, plate tectonics, has been discussed for hundreds of years. But the recent proposal of convection cells as the mechanism for plate movement made the theory of Plate Tectonics complete.

WHAT'S IN IT FOR ME?

The consequences of plate movement are evident in our daily lives. The movement of plates is responsible for present-day earthquake and volcanic activity. Knowledge of past plate location and movement helps in the search for oil and minerals.

Glossary

The following glossary will help you get acquainted with some of the terms associated with earth globes.

Geology: the study of the planet Earth.

Globe: a body having the form of a sphere that has a map of the Earth attached to it.

Gore: a lune-shaped piece of paper that conforms to a spherical base.

Great circle: the shortest distance between any two points on the globe. Lune: a crescent-shaped figure on a plane or sphere.

Plate tectonics: A widely accepted theory that the Earth's crust is composed of a dozen or more rigid slabs or plates that move slowly relative to one another.

Plate: a large mobile segment of the Earth's crust.

Sphere: an object bounded by a uniformly all curved surface, all points on which are equidistant from the center.

Tectonic: The cause and result of structural deformation of the Earth's crust.

Terrestrial globe: an earth globe.

Up: Which way is up?
On the earth "up" means away from the center of the earth and "down" means toward the center of the earth. That's why people in the southern hemisphere can stand "up" with their feet pointing "down" to the center of the earth.

Questions

In what direction does the earth rotate?

In what direction does the day travel?

What is the circumference of the earth?

List the names of the plates.

What kinds of boundaries does each plate have?

In which oceans are the ocean ridges found?

Can you find a spreading center that isn't at the bottom of an ocean? (Hint: it's in a cold place at a high latitude.)

Along which boundaries is oceanic crust formed?

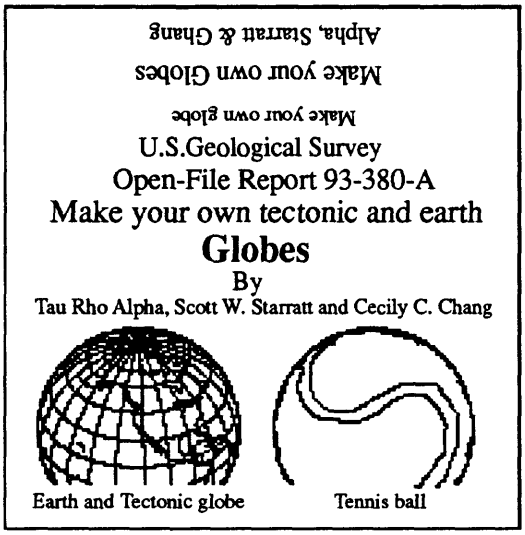
Along which boundaries is oceanic crust destroyed?

Why is the theory of plate tectonics important to the people who live in the state of California?

Millions of years from now, will Los Angeles be a suburb of San Francisco or San Diego?.

Acknowledgments

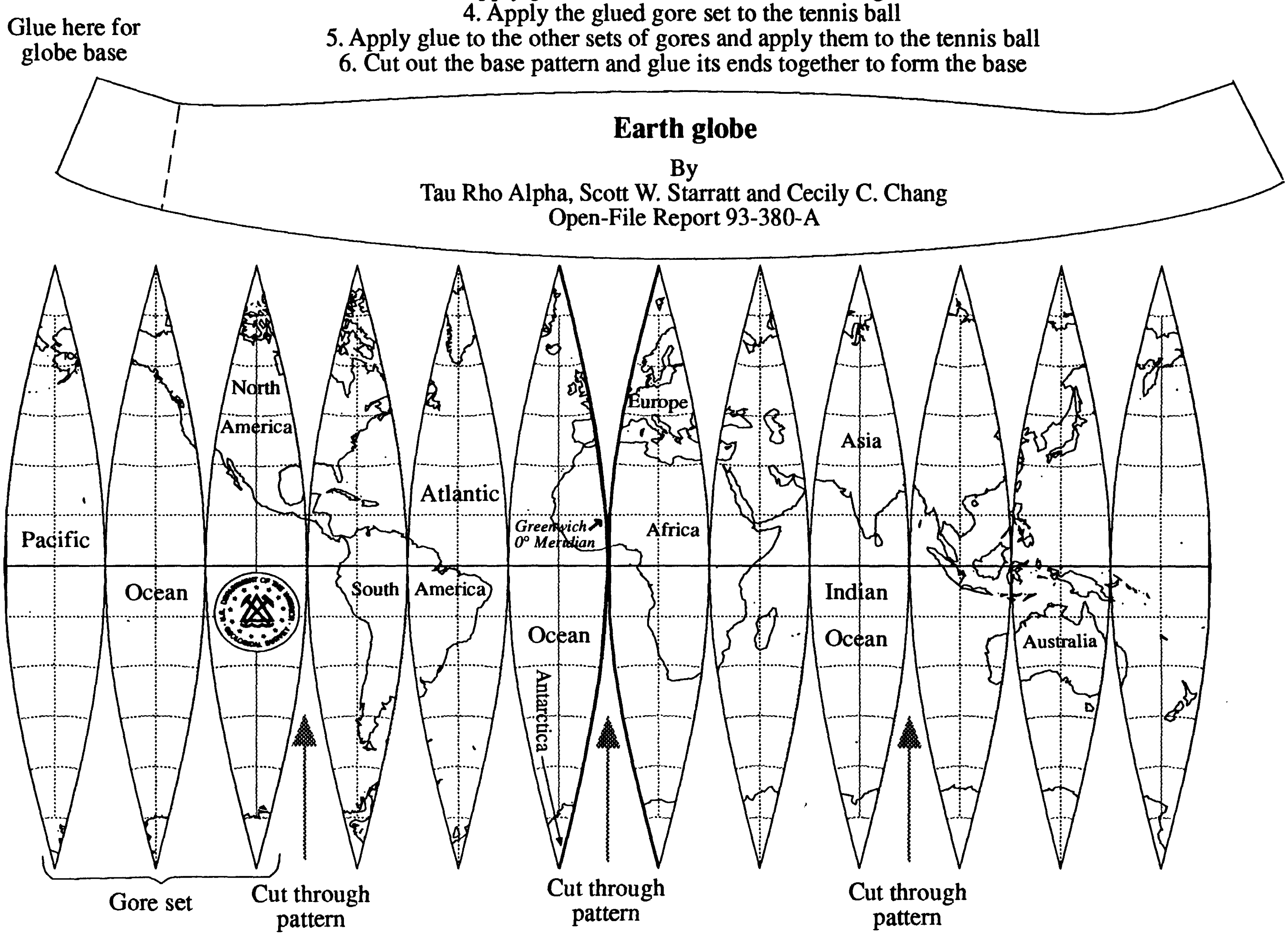
A project of this kind is a journey into the unknown–no one knows what the outcome will be. There is no guarantee that the pattern will work, nor that all of the different software used to compile such a publication will provide satisfactory solutions. Without Daan Strebe's map-projection software, **Geocart** (distributed in the U.S.A. by Terra Data Inc., Bramblebush, Croton-on-Hudson, N. Y., 10520), this report could not have been completed. The patterns for the globes are similar to a map projection called Rectangular Polyconic that was invented by Strebe. Many people, mostly teachers, provided help and encouragement in development of the globes. Although there is not enough space here to list them individually, their support is gratefully acknowledged. This report was enhanced by the excellent reviews by Wilma Kious, John Galloway, and Jim Pinkerton.



Label for diskette

Instructions for constructing a tennis ball globe

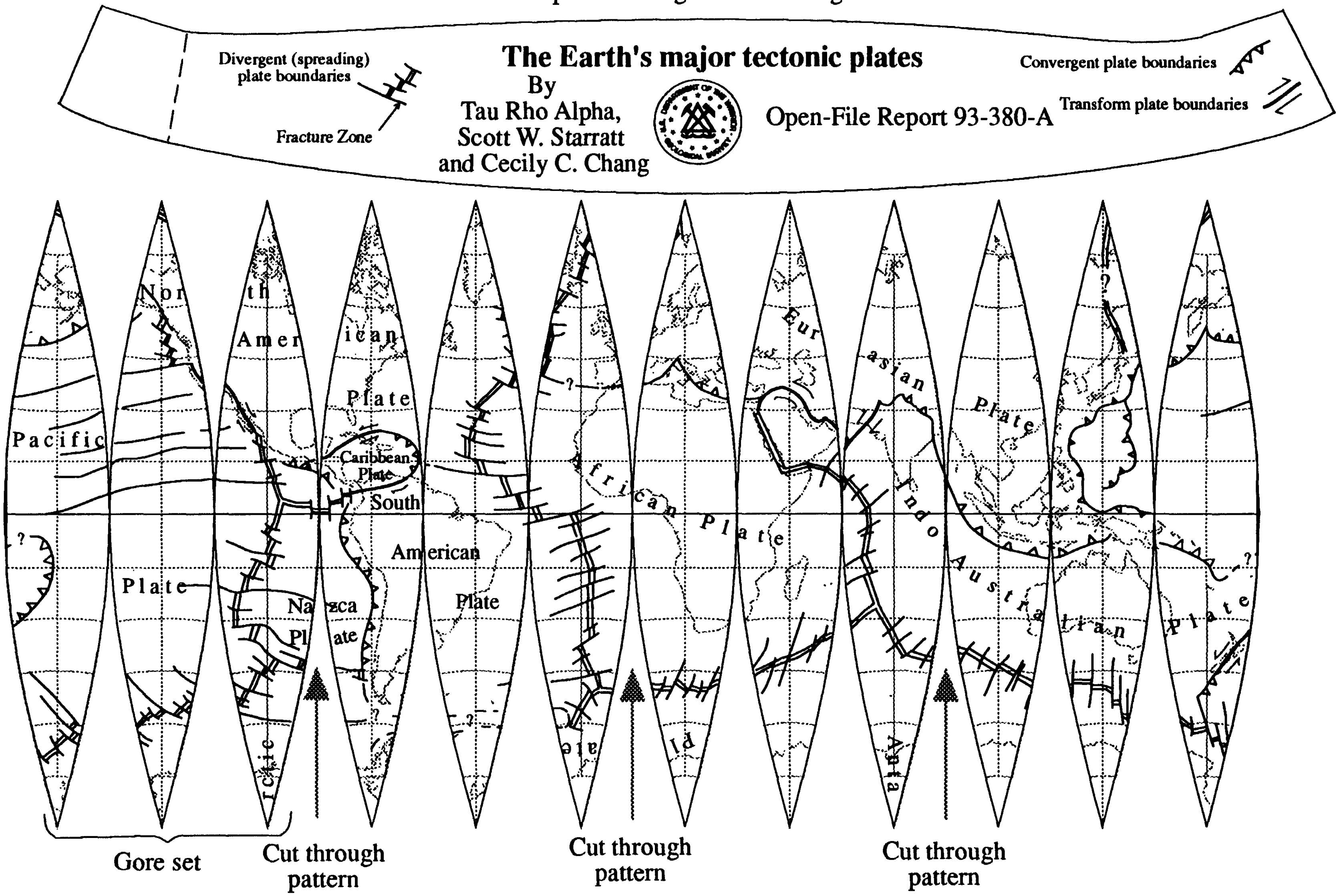
1. Cut out the pattern of the map projection
2. Cut the map projection into four groups of gores (three gores each)
3. Apply glue to the back side of first set of gores
4. Apply the glued gore set to the tennis ball
5. Apply glue to the other sets of gores and apply them to the tennis ball
6. Cut out the base pattern and glue its ends together to form the base



Instructions for constructing a tennis ball globe

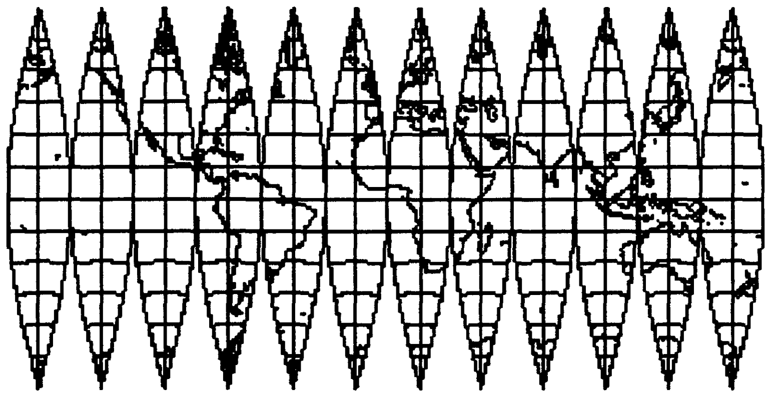
1. Cut out the pattern of the map projection
2. Cut the map projection into four groups of gores (three gores each)
3. Apply glue to the back side of first set of gores
4. Apply the glued gore set to the tennis ball
5. Apply glue to the other sets of gores and apply them to the tennis ball
6. Cut out the base pattern and glue its ends together to form the base

Glue here for globe base

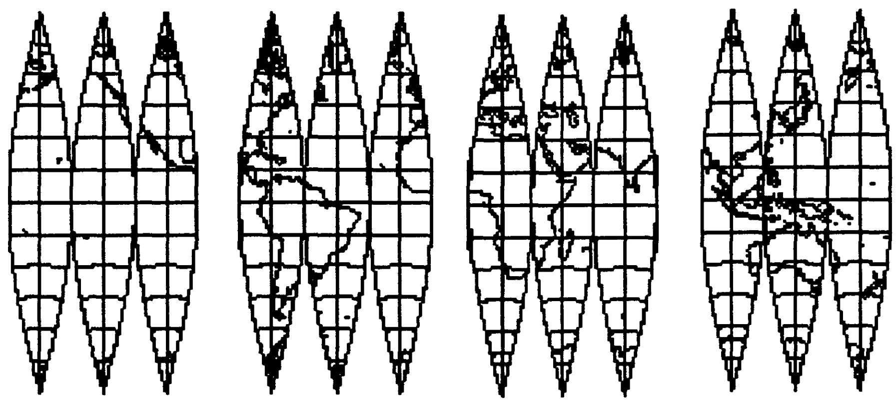


How to construct the tennis ball globes.

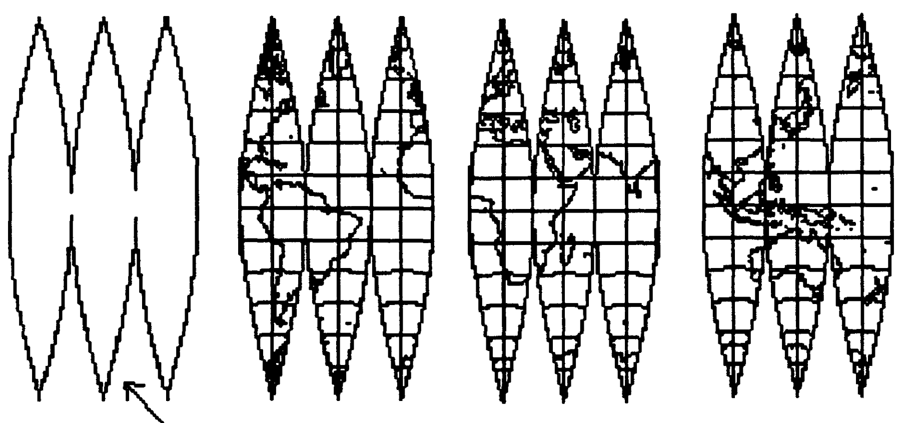
(Page one of two)



Step 1. Cut out pattern of the map projection.



Step 2. Cut the map projection into four groups of gores
(three gores each)

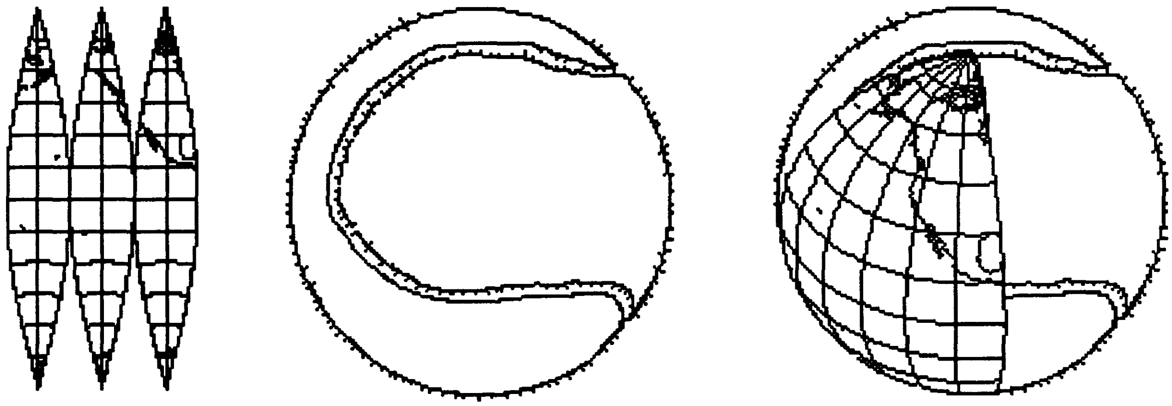


Back side of first set of gores.

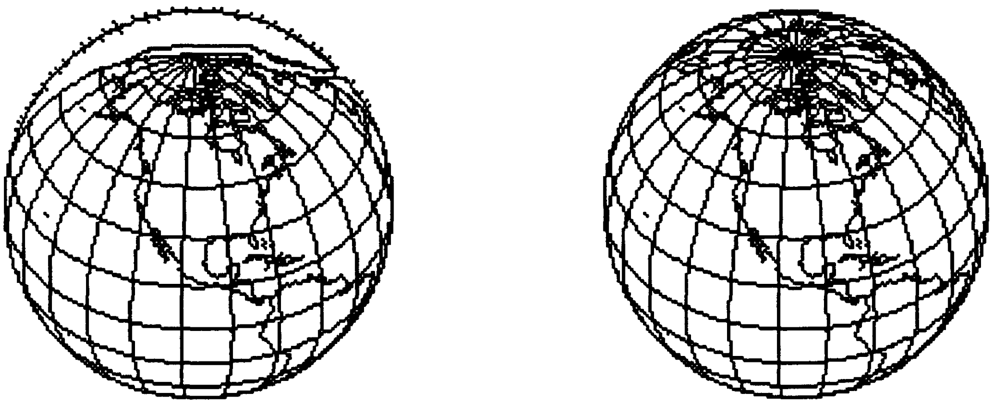
Step 3. Apply glue to the back side of first set of gores.

How to construct the tennis ball globes.

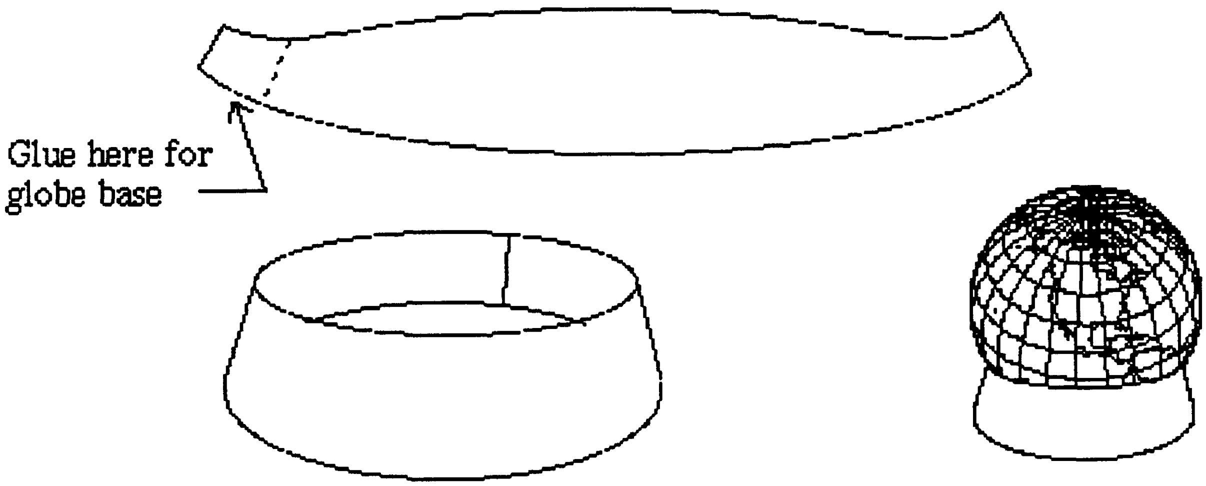
(Page two of two)



Step 4. Apply the glued gore set to the tennis ball.



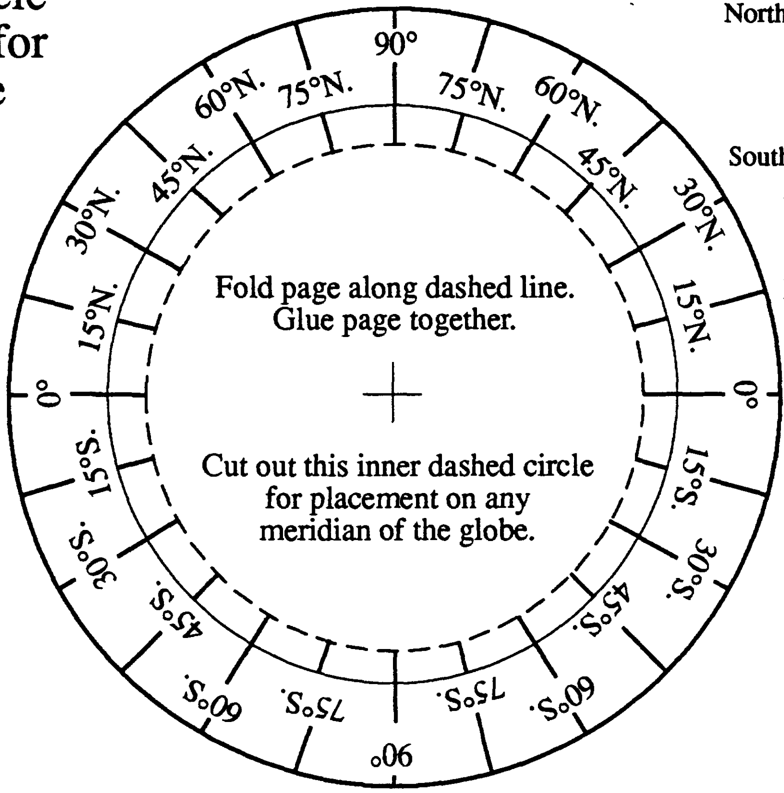
Step 5. Apply glue to the other sets of gores and apply them to the tennis ball.

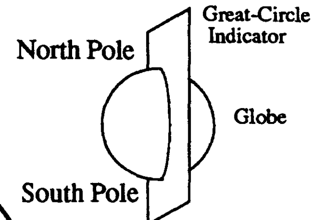


Step 6. Cut out the base pattern and glue its ends together to form the base.

Great-Circle Indicator for Latitude

Scale indicates degrees of latitude from the equator.



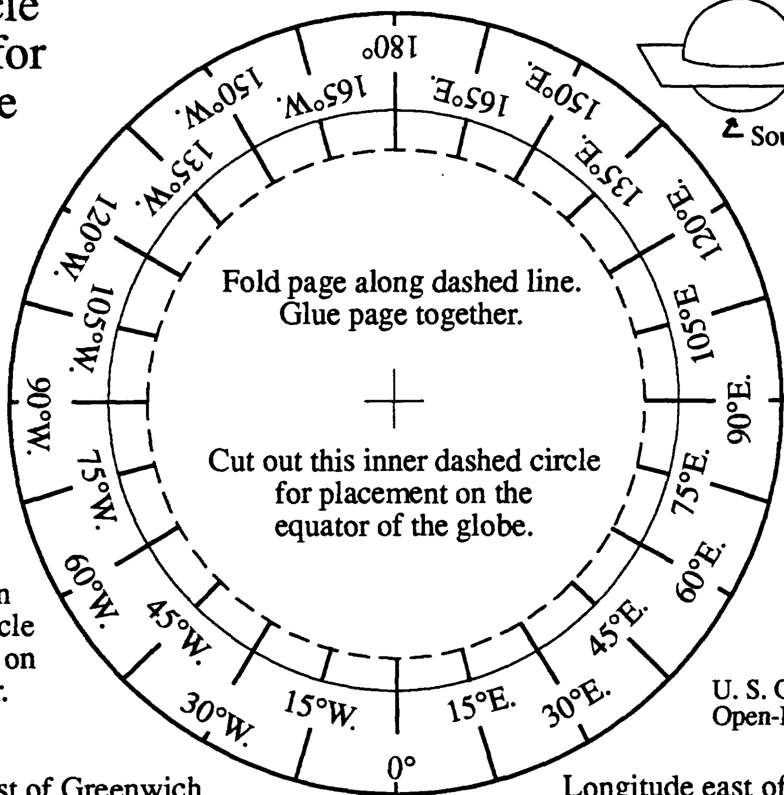


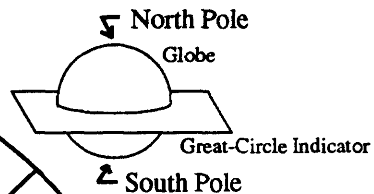
To use this side of the Great-Circle Indicator, hold vertical and align on any meridian.

---- Fold so printed side is out. ----

Great-Circle Indicator for Longitude

Scale indicates degrees of longitude at the equator.





To use this side of the Great-Circle Indicator, hold horizontal and align on equator.

Western Hemisphere

Eastern Hemisphere

Position Great-circle Indicator on equator.

Longitude west of Greenwich

Greenwich

Longitude east of Greenwich

U. S. Geological Survey
Open-File Report 93-380-A