GEOL 309 Laboratory Activity: **Euler Poles**

Name ________________________________

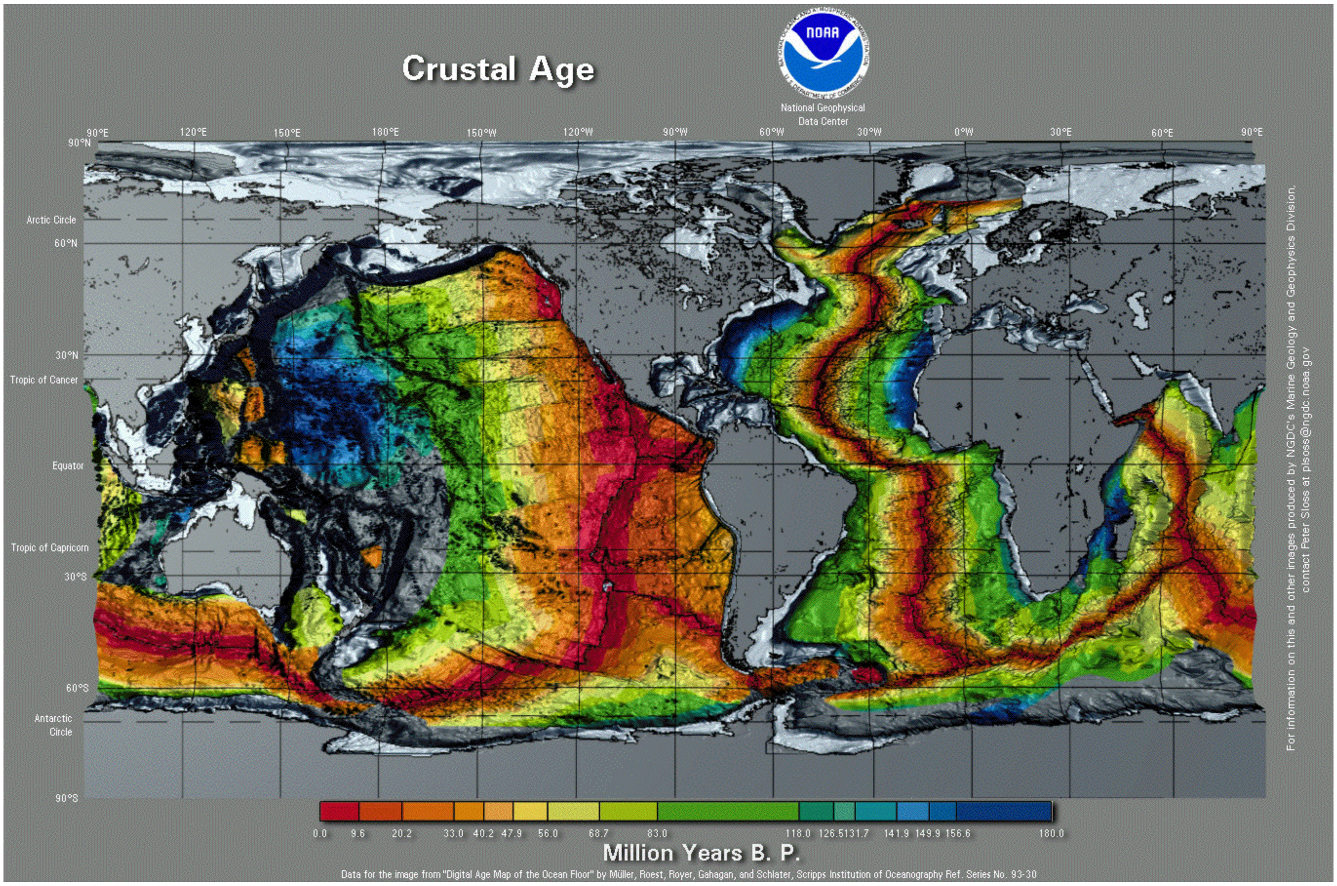
Instructions:

- Follow the directions given.
- Take a picture (with your phone) of your work showing final pole locations on the globe. Print pictures and turn in with your lab.

Materials:

- Real World Globe – 8 piece assembly (with ring base)
- Clear hemisphere overlay (from Real World Globes)
- Large white rings (like a Saturn ring) with degree tics for globe (from Real World Globes)
- Interior work board (use white back or front with distance scale)
- Long pole – wooden round rod (length > diameter of globe ~3-4 ft) – get at Home Depot
- Sticky overhead sheets (stick on one side) 8.5” x 11”
- Push pins
- Large straws (to go over push pins)
- Dry erase markers & erasers
- Protractor

Euler Poles: Flat Earth Method



1a. Determine the Euler Pole of rotation between the Pacific plate and the Antarctic plate on the flat map above using the East Pacific Rise spreading center near Latitude 60 S and between Longitudes 120 W – 180 W. Use the map given. Can the transform faults here help you find the Euler pole graphically (see class lecture to help you) ? Try it! (Show your work. Take a picture and turn in with this lab. Give the final Euler pole in Lat, Long. Discuss the error in the pole position you obtained and give an error estimate – For example 10 degrees +/- 1.5 degree.).

Note: The map above is a Mercator project. What does that mean ? The only true latitude line with accurate distance is at the equator (Latitude = 0). The Earth (spherical globe) is stretched out with each latitude away from the pole (both north and south). The north and south poles are stretched out the most!

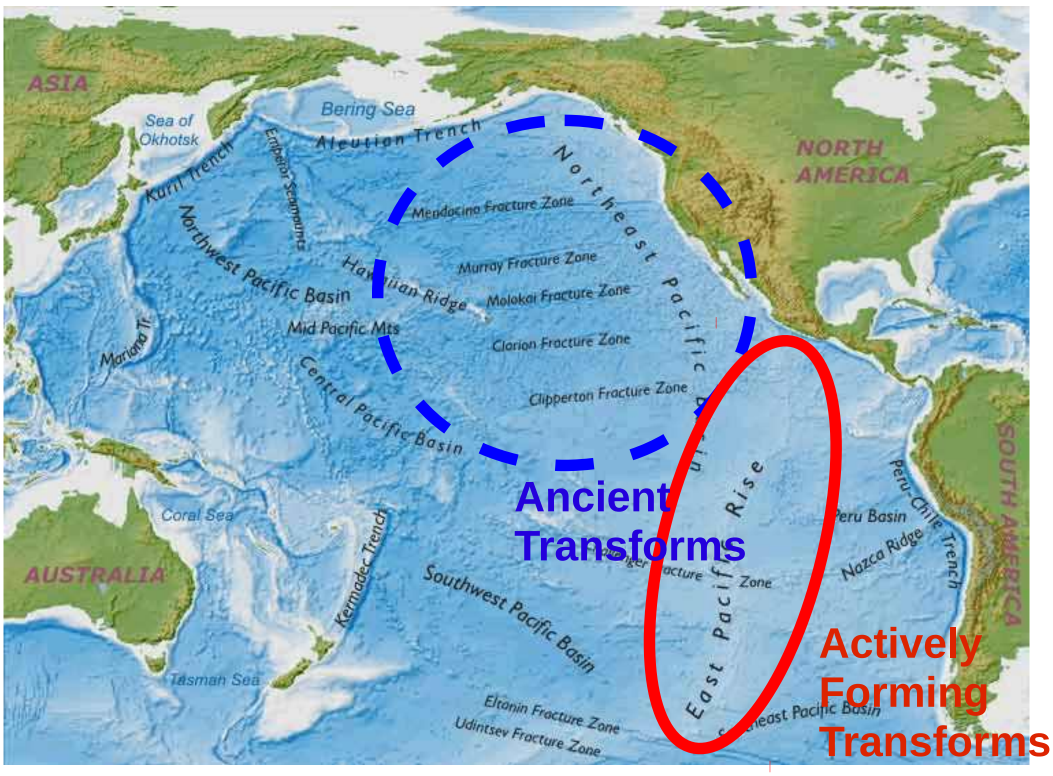
Euler Poles: Spherical Earth Method

(*Orient yourself on the globe*: Assemble your globe on the ring base given. Your globe Latitude and Longitude lines are all spaced 5 degrees apart. The Greenwich meridian where Longitude = 0 goes through Greenwich England and is the divide of 2 of your globe pieces. Yes – you can write on it – and erase! Use a dry erase marker.)

2b. Now use your 3D globe to re-calculate the same *Euler pole* for the Pacific and Antarctic plates on a sphere. Use the same section of the EPR spreading center near Latitude 60 S. Assemble your globe and use the large white ring to draw great circles (with a dry erase marker) perpendicular to the transform faults. Find the location where they intersect.

Do you get the same Euler pole position ? What is the difference between the 2 results ? You may need to use the big white ring to measure degrees if it is along a Great circle that does not coincide with normal longitude lines on the Earth. Which method do you think is more accurate ? Why ? Please explain your reasoning. (Give the new pole position lat and lon obtained from the globe. Give the difference between each pole in degrees)

3a. Can the pole position of 2 plates change with time ? Determine the *ancient* Euler pole position of the Pacific plate relative to the ancient Farallon plate (now observed in pieces as the Juan de Fuca, Cocos, and Nazca plates). Use the ancient transforms within the dashed blue circle (shown below). Draw great circles perpendicular to the transforms on the globe.



3b. Now determine the *current* Euler pole position for the Pacific relative to the Cocos or Nazca plate today. Use the transforms actively forming today (inside the solid red ellipse) shown above. Give the current Euler pole in Lat,Long.

3c. How much has the Euler pole changed between these 2 plates (Give answer in degrees)? Can you suggest a reason for this change in the Euler pole ? (hint: look at other features on the Pacific seafloor. Does any other feature show a change in direction this large ?) Please explain your own words.

Relative Linear Velocity

4. Find the *relative linear velocity* between the African and North American plate at the point given for the African plate. **Use the Table** below to find the NUVEL-1A angular velocities, $\boldsymbol{\omega}$, **(c**olumn 4) and Euler pole location (columns 2-3) for these 2 plates.

Step 4.1: Find and plot the point **X1** on the African Plate of your globe:

Latitude: 30.0 N
Longitude: 5.0 E

Extra credit: What country are you in (or nearest)?

Step 4.2: Find and put a pin in the Euler pole position for these 2 plates. (you can put a straw over the pin to help you visualize this as a Euler pole).

Step 4.3.) Open one element of your globe and turn the interior work board so that both point **X1** and the Euler pole are in the same plane.

b.) Draw the Euler pole on the work board that goes through the center of the Earth and both exit and entry surfaces of the Earth (using a dry erase marker) .

c.) Draw a line from point **X** to the center of the Earth

d.) Find $\boldsymbol{\theta}$ from the diagram you have drawn.
(Give you answer here in degrees. Use the white ring if needed).

e.) Now draw a line perpendicular to the Euler pole which meets point **X1**. (Draw a "right-angle" symbol to show this forms a 90^{o} angle with the Euler pole.

Take a picture of your Euler pole diagram (with phone...) and print out with final lab to show your work.

Step 4.4. Use the equation discussed in lecture to calculate the linear velocity, **V**, using the values you have obtained. Remember: to convert $\boldsymbol{\omega}$ to radians first (radians - $\boldsymbol{\omega}$***(**π/180). (Give your answer in units of cm/yr. Show your work.)

Table 2.1: **NOTE** the order or magnitude for $\boldsymbol{\omega}$ (angular velocity) in column 4 is 10^{-7}

Table 2.1 *Rotation vectors for the present-day relative motion between some pairs of plates: NUVEL-1A*

Plates	Positive-pole position Latitude	Positive-pole position Longitude	Angular velocity (10^{-7} deg yr^{-1})
Africa–Antarctica	5.6°N	39.2°W	1.3
Africa–Eurasia	21.0°N	20.6°W	1.2
Africa–North America	78.8°N	38.3°E	2.4
Africa–South America	62.5°N	39.4°W	3.1
Australia–Antarctica	13.2°N	38.2°E	6.5
Australia–Eurasia	15.1°N	40.5°E	6.9
Pacific–Antarctica	64.3°S	96.0°E	8.7
South America–Antarctica	86.4°S	139.3°E	2.6
Arabia–Eurasia	24.6°N	13.7°E	5.0
India–Eurasia	24.4°N	17.7°E	5.1
India–Africa	23.6°N	28.5°E	4.1
Eurasia–North America	62.4°N	135.8°E	2.1
Eurasia–Pacific	61.1°N	85.8°W	8.6
Pacific–Australia	60.1°S	178.3°W	10.7
North America–Pacific	48.7°N	78.2°W	7.5
Cocos–North America	27.9°N	120.7°W	13.6
Nazca–Pacific	55.6°N	90.1°W	13.6
Nazca–South America	56.0°N	94.0°W	7.2

Note: The first plate moves anticlockwise with respect to the second plate as shown.
Source: After DeMets *et al.* (1990; 1994).

5a. Now find the linear relative velocity for 2 more points on the same African plate. Repeat the steps above (in #3) to find the linear relative velocity for these 2 points.

Point **X2**

Latitude: 15.0 N
Longitude: 5.0 E

Extra credit: What country are you in (or nearest) ?

Give the relative velocity, V, for point **X2**. (Show your work. Give answer in units of cm/yr)

5b. Find the linear velocity for point **X3.**

Latitude: 10.0 S
Longitude: 5.0 E

Extra credit: What country are you in (or nearest) ?

Give the relative velocity, V, for point **X3**. (Show your work. Give answer in units of cm/yr)

5c. Are the linear velocities for V_1, V_2, & V_3 the same ? Why or why not ? Are these points all on the same plate ? Please explain your answer. Use a sketch or graph if needed to explain. Take a picture of your final work board and include with lab.

6a. Now consider the *angular velocity* of the African plate (using **ω** from the NUVEL-1A Table) 30 million years from now.

Step 6a.1 Outline the North American plate on the globe with a dry erase marker.

Step 6a.2. Take a sticky mylar sheet (from box given). DO NOT peel yet. Place mylar on globe over African plate and outline the African plate on the mylar. (Do as much of African plate as you can – it's a big plate!).

Step 6a.3. Place the clear hemisphere cap (given to you) on top of the globe. Place a push pin at the Euler pole location (see Table above) for Africa-North America. Place a straw over the pin to visualize this as a "pole".

Step 6a.4. Stick on the African plate mylar to the clear plastic hemisphere in the correct location

Step 6a.5. Now rotate the clear hemisphere (in CCW direction – right hand rule)

Use this to answer the questions below.

Can you estimate where the point **X2** will be in 30 Million years ? Use the angular velocity (see Table above) to calculate how many degrees the African will rotate in this time. Now rotate the African plate this degree. Give the Lat/Lon of the new location.

6b. Look at the plate boundaries surrounding the African plate. After 30 million years of plate motion around its Euler pole, can you predict any changes in the plate boundaries surrounding the African plate ? Explain changes to all plate boundaries that are effected. Sketch diagrams to show each plate boundary and changes which will occur between today and 30 My in the future.

6c. After 30 million years of plate motion what will happen to the Atlantic ocean ? Will the effect be the same in the north Atlantic and the south Atlantic ? Please explain the reasoning behind your answer. Draw a sketch to illustrate your explanation.

6d. After 30 million years of plate motion what will happen to the Red Sea rift ? Draw a before and after sketch) showing the changing plate boundaries and explain your answer in your own words.

6e. Discuss and describe changes in any other plate boundary that is relevant.