Real World Globes – Exploring the Ancient World of Pangaea

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Purpose:
- To practice plotting coordinates on a map and extrapolating fossil distributions
- To illustrate the lines of evidence that lead to the ‘discovery’ of Pangea
- To perform basic unit conversions and velocity calculations given measured distances and times
- To demonstrate some of the lines of evidence that the scientific community used to establish the validity of Pangaea in the first place

Target Audience:
- High school science students
- Undergraduate students in an entry-level geology course

Materials:
- Dual Pangea Globe™ (Jurassic and Cretaceous)
- 2 Clear 18” hemispheres
- Spherical Ruler or Vinyl tape measure
- Dry-erase markers and a calculator

Introduction:

On the scale of a human lifetime, continents seem immense and immobile. While the continents certainly are huge, the don’t actually stay in one place. The movements of these plates have led to many collisions and separations throughout earth’s history. From about 335 million years ago until about 175 million years ago all of earth’s major continents were joined into a supercontinent called Pangaea (“Pan” means “all/entire/whole” and “Gaia” means “earth/land” in Ancient Greek).

For hundreds of years, scholars had noted how certain continents (in particular South America and Africa) looked like they might fit together nicely, but most people credit German meteorologist Alfred Wegener with synthesizing previous ideas into the “theory of continental drift” and the proposal of the supercontinent Pangaea in a paper published in 1912. The geology world was, to put it mildly, really upset with this theory, coming from a ‘meteorologist’ of all people! “What force was moving the continents around?!” they cried and “Where’s the evidence?!” they wailed for nearly 50 years before enough new data had been collected that the theory started to make more sense than the old models and become generally accepted by the scientific community. These ideas are then taught to you in the classroom as our current best explanation of the way earth works.

Trying to imagine all the continents smashed together can seem a bit daunting, it certainly seemed that way to scientists when the theory was first proposed, so we’re going to work through some activities that follow the same lines of evidence and thought experiments that scientists themselves went through to convince themselves that continental drift actually does occur. In this lesson, you’ll take on the role of paleontologist, prospector, and predictor as we map out some puzzles from earth’s deep past.

Activity 1 – Mapping fossil finds:

It's 1913 and you've just returned home from several months of globe-trotting field work collecting fossils for your museum. Your department is up in arms over a new theory proposing that all the continents used to be one giant landmass. You only care about the data, so you set to work unpacking your fossils, and plotting where you found them on this theoretical supercontinent.

1 – Assemble the Jurassic half of the Dual Pangaea Globe™ and cover it with the 18" clear hemisphere. (The Triassic half should also work for this exercise if either the Jurassic or Cretaceous is unavailable.)

Figure 1: An artist's rendition of what *Mesosaurus* may have looked like in life.

2 – The first batch of fossils we're going to plot are some *Mesosaurus*, which were a group of small aquatic reptiles that were one of the first groups to return to life in the water after animals had evolved to live on land. (Don't confuse them with the much larger *Mososaurus* that didn't evolve until much later.) Based on the small size of the animals, and the types of rocks you found them in, you're pretty sure they lived in fresh water or near the coast, not out at sea.

2a – The first *Mesosaur* you found was from a deposit near the town of Tatuí, outside São Paulo, Brazil. Using a modern-day map, locate this spot in the Jurassic and mark it on the Jurassic globe.

2b – The second *Mesosaurus* you found was from a deposit near the city of Keetmanshoop, Namibia. Using a modern-day map, locate this spot in the Jurassic and mark it on the Jurassic globe.

3 – The second batch of fossils are a type of fern called *Glossopteris*. As part of your expedition to Brazil, you checked out a few coal mines, which are often a great source for plant fossils. You have some fossils from a mine just outside the town of Faxinal, in the State of Paraná, Brazil. Mark the spot on your globe.

3a – A collaborator friend of yours has been working with coal miners in India. They've identified some specimens as *Glossopteris* and have sent them to you for confirmation. You agree with their identification, so using a map find the town of Parsora, India, and mark it as a site for Glossopteris fossils.

3b – Finally, you notice another set of *Glossopteris* fossil in a drawer in the museum (Fun fact: You'd be amazed how often 'new' fossils are found because someone forgot about them in a drawer). These specimens say they're from Bacchus Marsh in southern Australia. Mark this final spot on your map.

Figure 2: An artist's reconstructions of what Glossopteris sp. may have looked like in life.

4 – Last up are *Lystrosaurus*, a small, strange, terrestrial (lived on land), herbivorous (ate plants) reptile. The first specimen you have in your collection is from Burgersdorp, South Africa. You know what to do.

Figure 3: An artists' rendition of what *Lystrosaurus georgi* may have looked like in life.

4b – In modern times, Madagascar has a very odd assortment of plants and animals. In the past, it was clearly home to one of your *Lystrosaurus* fossils too. The one you have is from outside the city of Betroka, mark the city on your map.

4c – Finally, on one of you more intrepid expeditions, you were able to collect some samples from Antarctica, and upon examination, you're amazed to find yet another *Lystrosaurus*. Checking your field notes (because it's <u>essential</u> to take detailed field notes), you wrote down that these rocks came from Graphite Peak, and you mark that on your globe.

Question Set #1:

1) Given what you know about *Mesosaurs* biology and habitat (review the activity above if you can't remember), do the places where you've found the fossils <u>support or hurt</u> Wegener's hypothesized supercontinent? Explain your reasoning.

2) Given the spacing of the fossils you plotted, where on other continents might you go prospect to find additional *Glossopteris* and *Lystrosaurus* fossils? (<u>Hint:</u> Think about the continents in between where you've already found these specimens and try to "fill in the gaps".)

Don't erase the mark's you've made on the globe so far, you'll need them for Activity 2.

Activity 2 – The speed of the spread

In his paper, Wegener proposed a continental drift speed of 250 centimeters per year (cm/yr). Your colleagues have argued that without a mechanism to drive the drifting, this number is way too high. You decide to see for yourself. Since this section involves some math, there's questions as we go along instead of a question set at the end.

1 – Assemble the Cretaceous half on the opposite side of the Jurassic on the dual Pangaea globe.

2 – As best as you're able to, mark where your Jurassic fossil finds would be in the Cretaceous.

3 – Using a spherical ruler or flexible tape measure, and using your fossil finds as reference points, measure how far apart your fossils were in the Jurassic. You can use the suggested fossil localities below, or choose your own.

Mesosaurus (Brazil – Namibia):

Glossopteris (Brazil – India):

4 – Make the same measurements in the Cretaceous. Again, use the suggested species or pick your own.

Mesosaurus (Brazil – Namibia):

Glossopteris (Brazil – India):

5 – Using unit conversions and the scale bar on the globe, calculate how many kilometers apart the fossils have moved.

6 – Using Wegener's proposed speed of 250 cm/yr, calculate how many years the continents would have been drifting apart. Think about whether or not this answer seems reasonable to you. (Hint: the circumference of the earth around the equator is ~40,000 km.)

7 – A colleague has suggested that the difference between these two globes is probably closer to 50 million years. Using the distances you've measured, calculate the speed of the spreading if the continents have moved that distance ins 50,000,000 years. Think about whether or not this seems like a better answer than what you calculated in question 6.

8 – For the sake of argument, let's assume that South America is the only continent that's moving. Using the Cretaceous side of the globe and Wegener's proposed speed, measure the distance from a point on South America to where you think it might collide with another continent (make sure to write down which one), and then calculate how many years until that collision happens. If the Cretaceous map is 140 million years old, should there have been a collision by now?

Concluding thoughts:

It's now time to attend a faculty meeting discussing this new and exciting concept of Pangaea. Given what you've plotted and calculated above, are you going to support Wegner's ideas to the rest of the faculty? Are some things he said correct while others need refinement? Write 3 or 4 sentences explaining your position on this controversial topic using the ideas you've thought about above.