Sumatra Earthquake and Tsunami: December 26th, 2004

The tragic loss of life due to the 9.0 magnitude earthquake and ensuing tsunami is shocking and almost unbelievable. As the daily death rate soars to higher and higher levels and people struggle to help those most in need we mark the most devastating natural disaster to hit the world in over 100 years. In times like these we are humbled by the awesome power of the nature of our planet. Hopefully, by learning from this tragedy we will be spurred to implement systems that help prevent this type of overwhelming loss.

"If we intend to live on this planet...we truly need to understand how it works."
Thomas McGuire, Earth Science Educator & Author

Introduction: This laboratory investigates the waves of destruction caused by the Sumatra earthquake December 26th, 2004. You will be given actual seismographs from three different seismic stations, all which recorded the massive 9.0 magnitude earthquake on December 26th, 2004. You will need to compare the arrival times of the P and S waves on each seismograph to determine the relative distances to the epicenter. Only when you have those three distances can you pinpoint the epicenter of the earthquake. Once you have found the epicenter you can draw the waves of the tsunami as they radiated out from the center of the quake. From those determinations, you will be able to predict how much time people had before the impending tsunami crashed on their shore.

Materials:
- 3 seismograms from the same earthquake
- Safe drawing compass
- P- and S-wave travel time curve (reference tables page 11)
- Map for plotting the earthquake epicenter
- Scrap paper

Procedure Part 1: Finding the Epicenter

1. Read the time of the P and S waves at each station and place that information in DATA TABLE 1. Read each arrival time to the nearest second. Note: The first vertical line marks the P-wave arrival and the second vertical line marks the S-wave arrival time.
2. Devise a way to determine the amount of time that elapsed between the arrival of the P and S waves at each station. One way is to subtract the P-wave arrival time from the S-wave arrival time, though there is a more direct way to get that information off the seismogram. Double check and record your results in DATA TABLE 1.
3. Use your P and S wave travel-time curves (E.S.R.T) to find the distance that each station is from the epicenter and record that distance in your data table.
4. On MAP #1, use the map scale and your safety compass to draw circles around each station of a radius equal to the epicenter distances that you just found using your reference tables.
5. The intersection of the 3 circles marks the epicenter of the ‘quake. Label it on your map.
Seismographs for Part 1

IC.LSA (Tibet, China): Latitude: 29.7 N, Longitude: 91.15 E

KMBO Latitude: 1.13 S, Longitude: 37.25 E

GUMO - Guam, Mariana Islands Latitude: 13.59 N, Longitude: 144.87 E
DATA TABLE 1:

<table>
<thead>
<tr>
<th>Seismograph Station</th>
<th>P-wave Arrival</th>
<th>S-wave Arrival</th>
<th>Time Difference (S – P)</th>
<th>Epicenter Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC.LSA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KMBO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GUMO</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Part 1 Questions: (Use your Earth Science Reference Tables)

1. Which Seismic Station is located farthest from the epicenter? ____________________
   How could you have figured which was the most distant viewing ONLY the seismograms?
   _____________________________________________________________________________
   _____________________________________________________________________________

2. The quake occurred very nearly on a tectonic plate boundary.
   Refer to the tectonic map in the ESRT to answer the following questions:
   a. Between what 2 tectonic plates did this ‘quake occur?
      ____________________ and ____________________
   b. How are the plates moving relative to each other in the area of the ‘quake?
      __________________________________________________________________________
   c. What type of plate boundary is this boundary?
      ____________________

3. What is the origin time of the earthquake for the following?
   *Subtract the time it takes the P-wave to travel the epicenter distance from the time that
   station felt the P-wave. You will need to use your reference tables to find this answer.

   Show your work here!

   IC.LSA: ________________  KMBO: ________________  GUMO: _________________

4. How do earthquakes destroy? This earthquake sent off many waves of disaster.
   Name and describe at least three of these devastating “waves”.
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
Procedure Part 2: Narrowing down the Epicenter!

Now that you have an idea where the earthquake originated you will use three closer seismograph stations that will allow you to more accurately pinpoint the location of the epicenter.

1. Label the following Countries on MAP 2: (Use your textbook if needed)
   India, Somalia, Thailand, Sri Lanka, Somalia, Sumatra (Indonesia), Myanmar
2. Follow the procedures in Part 1 to find the epicenter on Map 2.
   *You will need to use the seismographs: PALK, DGAR, and COCO (page 6).

DATA TABLE 2:

<table>
<thead>
<tr>
<th>Seismograph Station</th>
<th>P-wave Arrival</th>
<th>S-wave Arrival</th>
<th>Time Difference (S – P)</th>
<th>Epicenter Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>PALK</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DGAR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COCO</td>
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</tbody>
</table>

Part 2 Questions:

5. Why do you need at least three seismic stations to find the epicenter of the quake?
   ________________________________________________________________________
   ________________________________________________________________________

6. Does your KMBO epicenter distance circle go through your found epicenter on map #2? Prove it. ________________________________________________________________
   ________________________________________________________________________
   ________________________________________________________________________

Procedure Part 3: Drawing Tsunami Waves

Information: In the open ocean, tsunami waves travel at speeds of 600 kilometers per hour, but their wave heights are usually only a few inches, and the wavelengths over 100 km long (!), so they are often unnoticed as they pass beneath ships at sea. As they approach shallow water near the coast however, tsunami waves slow down, but their wavelength shorten and heights may increase to many meters. [http://vulcan.wr.usgs.gov/Glossary/Tsunami/description_tsunami.html](http://vulcan.wr.usgs.gov/Glossary/Tsunami/description_tsunami.html)

1. Assuming the tsunami travels 600 kilometers per hour in the open ocean draw and label circles around the epicenter showing the distance the tsunami has traveled.
   *Draw the distance the tsunami traveled in 1 hour, 2 hours, 3 hours, and 4 hours.
   *You should have four labeled circles surrounding your epicenter representing the position of the leading edge of the tsunami as it traveled through the ocean hours after the earthquake happened.
   *Note: use a different colored pen pencil to draw your tsunami circles.

2. Use your maps, reference tables, or other references to answer questions #7 – 10.
Seismographs for Part 2
http://ida.ucsd.edu/IDANetwork/index.html

**PALK**, Pallekele, Sri Lanka: Coordinates: (7.3° N, 80.7° E)
http://ida.ucsd.edu/Stations/palk/index.html
http://ida.ucsd.edu/public/II/PALK/palk.html

**DGAR**, Diego Garcia, British Indian Ocean Territory: Coordinates: (7.4° S, 72.5° E)
http://ida.ucsd.edu/Stations/dgar/index.html
http://ida.ucsd.edu/public/II/DGAR/dgar.html

**COCO**, Cocos (Keeling) Islands, Australia: Coordinates: (12.2° S, 96.8° E)
http://ida.ucsd.edu/Stations/coco/index.html
http://ida.ucsd.edu/public/II/COCO/coco.html
Analysis and Conclusion Questions

7. Investigate the number of people killed by the tsunami in the following countries:

- India ____________________________
- Indonesia ________________________
- Myanmar _________________________
- Somalia __________________________
- Sri Lanka _________________________
- Thailand __________________________

Current Total number casualties ________________________ Date ____________

Source of information: (You may attach articles of interest to your laboratory)
____________________________________________________________________________
____________________________________________________________________________

8. Using MAP 2 and the tsunami circles that you drew, estimate the amount of time that these countries had before the tsunami crashed on their shore.

- India ____________________________
- Indonesia ________________________
- Myanmar _________________________
- Somalia __________________________
- Sri Lanka _________________________
- Thailand __________________________

9. Based on the videos you watched how much time do you believe you would need to get to a place of safety and escape the wrath of the tsunami?
____________________________________________________________________________

Where would you go? Why? ______________________________________________
____________________________________________________________________________

10. Tsunamis are likely to occur when large earthquakes occur on the seafloor, as happens in the Pacific Ocean. Investigate and briefly describe the warning system that exists in the Pacific Ocean. Why do you think no such system exists in the Indian Ocean? (*Cite your sources or attach originals.)

Summary of your findings:
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________