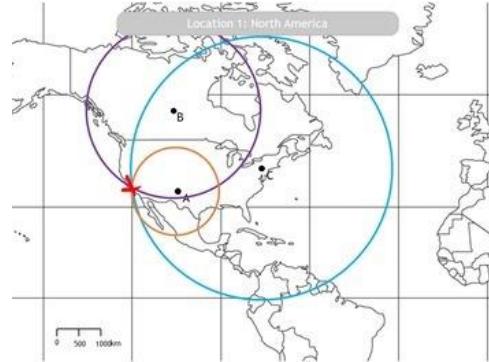# Earthquake Epicenter   Lab #20

Discussion: Geologists who study earthquakes are called seismologists. When an earthquake occurs, seismologists receive data from stations across the country that gives the arrival times of pressure waves (P-waves) and shear waves (S-waves or secondary waves).   Data from at least three stations allows seismologists to determine the exact location of the earthquake epicenter.

Objectives: Use page 7 of the PS/ESRT to determine lag times between P-waves and S-waves, determine distance from a station to the epicenter, determine the location of an epicenter using triangulation, and to determine the time the earthquake occurred.

Purpose: Use lag times to determine the location of the epicenter of an earthquake.

Hypothesis: Because P-waves and S-waves travel at different rates, it is possible to calculate the distance to an earthquake epicenter using lag times. Given distances from three stations, the location of the epicenter can be determined.

Theory: Earthquakes .

Materials: pencil   compass   PS/ESRT (pg 11)

Method:

 Part I

 1. On the table for Earthquake 1, determine the lag time (difference between arrival times of the P-waves and S-waves for each city and record your answer on the table.

 2. Use the chart on your PS/ESRT page 11 to determine the distance to the epicenter from each city and record your answers on the table.

 3. Use the chart on your PS/ESRT page 11 to determine the travel time for both the P-wave and the S-wave and record your answers on the table.

 4. Calculate the time the earthquake occurred and record your answer for each city on your table. The times should be the same within experimental error.

 5. On the map, use your compass to draw circles around each station with a radius equal to the distance to the epicenter. The point where all three circles intersect should be the location of the epicenter.

City	P Arrival	S Arrival	Lag Time	Distance	Time to P	Time to S	Time of Occurrence
			Earthquake 1 – USA				
Houston	12:30:15	12:34:15					
Denver	12:28:35	12:31:22					
Seattle	12:28:15	12:30:40					

4000 kilometers
3000
2000
1000
0

Atlantic Ocean
Pacific Ocean
Gulf of Mexico

THE BAHAMAS

Ontario
Quebec
Montreal
New Brunswick
Fredericton
MAINE
Augusta
NH
VT
Concord
Montpelier
Boston
RI Providence
CT
Hartford
New York City
Trenton
Atlantic City
Albany
NEW YORK
Buffalo
Newark
NJ
Dover
DE
Annapolis
MD
Washington DC
PENNSYLVANIA
Philadelphia
Harrisburg
Pittsburgh
Richmond
VA
Roanoke
Norfolk
Raleigh
Durham
NORTH CAROLINA
Charlotte
Greensboro
Columbia
SOUTH CAROLINA
Charleston
Wilmington
Savannah
Jacksonville
FLORIDA
Orlando
Tampa
St. Petersburg
W. Palm Beach
Miami
Key West

Ottawa
Kingston
L. Ontario
Toronto
L. Erie
Cleveland
OHIO
Columbus
Cincinnati
Sault Ste. Marie
Lake Huron
MICHIGAN
Lansing
Detroit
Lake Michigan
Gary
Ft. Wayne
INDIANA
Indianapolis
Frankfort
Louisville
KENTUCKY
WV
Charleston
Knoxville
Nashville
TENNESSEE
Memphis
Atlanta
GEORGIA
Augusta
Albany
Birmingham
ALABAMA
Montgomery
Tallahassee
Mobile
MISSISSIPPI
Jackson
Greenville

Thunder Bay
Lake Superior
Duluth
MINNESOTA
St. Paul
Minneapolis
WISCONSIN
Madison
Milwaukee
Chicago
ILLINOIS
Springfield
Peoria
IOWA
Davenport
Des Moines
St. Louis
MISSOURI
Springfield
Kansas City
ARKANSAS
Fort Smith
Little Rock
Shreveport
LOUISIANA
Baton Rouge
New Orleans

Lake Winnipeg
Winnipeg
Regina
NORTH DAKOTA
Fargo
Bismarck
SOUTH DAKOTA
Pierre
Rapid City
Sioux Falls
NEBRASKA
Lincoln
Omaha
KANSAS
Topeka
Wichita
OKLAHOMA
Oklahoma City
Tulsa
Dallas
Ft. Worth
TEXAS
Austin
Houston
Wichita Falls
San Angelo
San Antonio
Laredo
Brownsville
Matamoros
Nuevo Laredo

MONTANA
Helena
Billings
Butte
Sheridan
WYOMING
Cheyenne
Boulder
Denver
COLORADO
Pueblo
Amarillo
Santa Fe
Albuquerque
NEW MEXICO
Roswell
El Paso
Monterrey

IDAHO
Boise
Idaho Falls
Salt Lake City
Provo
UTAH
NEVADA
Reno
Las Vegas
ARIZONA
Phoenix
Tucson
Hermosillo
Chihuahua
Culiacan

Victoria
Seattle
Tacoma
Spokane
WASHINGTON
Portland
Salem
Eugene
OREGON
Sacramento
Oakland
San Francisco
Fresno
Bakersfield
CALIFORNIA
Santa Barbara
Los Angeles
Long Beach
San Diego
Mexicali
Mexicali

Part II

<table>
<tr><th colspan="8">Earthquake 2 – Africa</th></tr>
<tr><th>City</th><th>P Arrival</th><th>S Arrival</th><th>Lag Time</th><th>Distance</th><th>Time to P</th><th>Time to S</th><th>Time of Occurrence</th></tr>
<tr><td>Station A</td><td>6:24:00</td><td>6:28:40</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Station B</td><td>6:25:50</td><td>6:32:00</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Station C</td><td>6:23:45</td><td>6:28:10</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
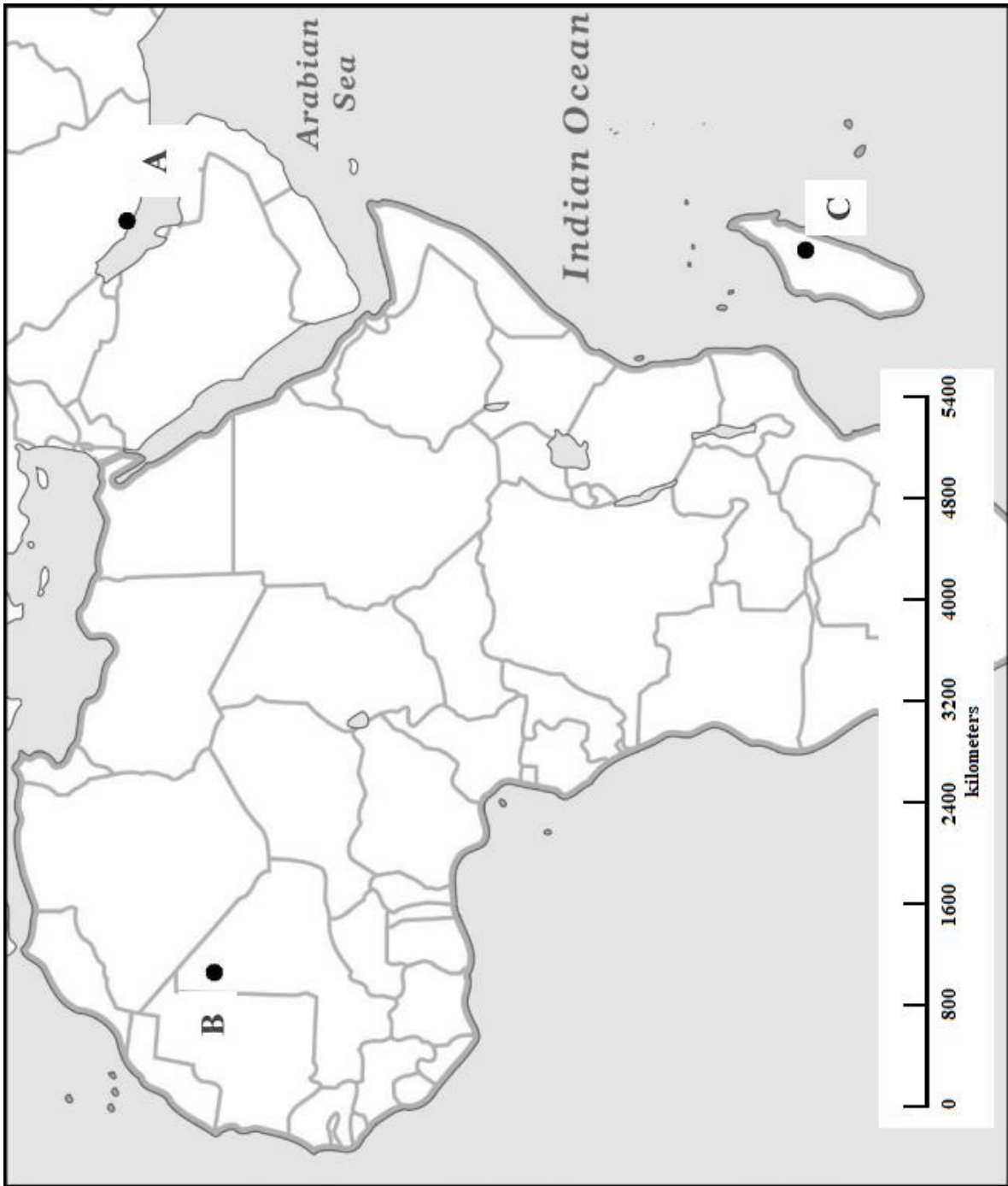
Conclusions:

1. Add a P or an S next to each word or phrase to identify it as a P-wave or an S-wave.

   arrives 1st _____   shear _____   push-pull _____   primary _____

   arrives 2nd _____   secondary _____   compression _____

   travels through solid, liquid, or gas _____   travels through solid only _____

   particles move at right angles to the direction the wave is moving _____

2. Describe the difference between a focus and an epicenter of an earthquake.

   _____

   _____

Questions 3 through 6 refer to Earthquake 1

3. What is the approximate location of the epicenter of the earthquake (what cities are nearby)?

   _____

4. Using the scale, determine how far, in kilometers, the epicenter is from the closest city.

   _____

5. Which city (Houston, Denver, or Seattle) had the fastest P-wave travel time? _____

   Which of these cities was closest to the epicenter? _____

   Describe the relationship between distance to the epicenter and P-wave travel time.

   _____

6. List the three cities in order of the first to detect the earthquake to last to detect the earthquake.

   _____

   _____

   _____

7. Explain why it is necessary to know the distance from at least three stations to detect the location of an epicenter.

   _____

   _____

8. What happens to the lag time between S-waves and P-waves as the distance to the epicenter increases?

   _____

   _____