The Steps to Locating the Epicenter of an Earthquake

by Nicky_Arellano on February 8, 2014

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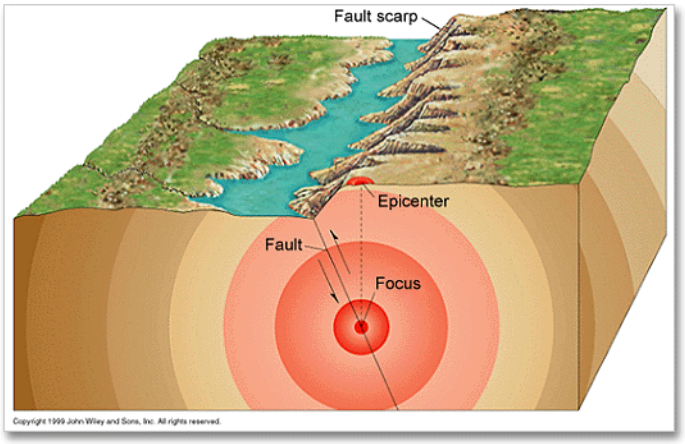
Intro: The Steps to Locating the Epicenter of an Earthquake

This instructable explains the basic steps seismologists undertake to locate the epicenter of an earthquake:

1. Measure the time that elapses between the arrival of the P (primary) wave and the arrival of the S (secondary) wave to the seismic stations.
2. Using the S-P time, determine the epicentral distance of each station to the earthquake using a travel time curve.
3. Use a map and graphical compass to draw arcs of radii equal to the epicentral distances around each station. Where these arcs overlap, you may approximate your epicenter.

This instructable utilizes online government resources and university research institutions such as the US Geological Survey and the University of South Carolina's earthquake database.



Step 1: Choose Your Quake

Go to:

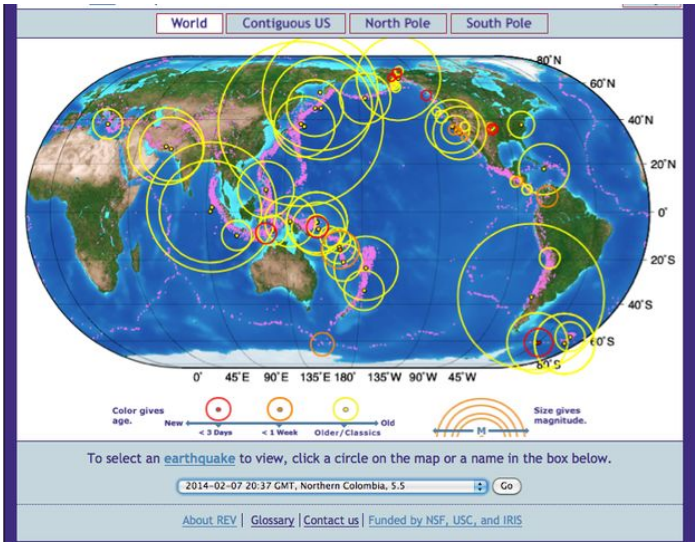
http://rev.seis.sc.edu/earthquakes.html

Select an earthquake to view, and click the go button.

I chose a magnitude 5.5 that occurred in Northern Colombia on February 7th of this year.

You may choose to view an older earthquake.

Picking an earthquake that was less than 20 kilometers in depth will prove helpful later!



Step 2: Intro to Seismograms

You should now be presented with information about the earthquake you chose.

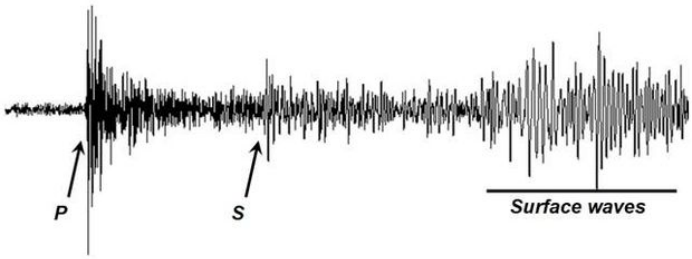
To the right you will also see seismograms.

Before going any further you will need to understand how to read these seismograms. A seismogram is a record written by a seismograph in response to ground motions (US Geological Survey definition).

Seismograms depict the arrival of different earthquake waves to seismograph stations. These waves include both surface waves and body waves. We are concerned with the body waves, primary (compression) and secondary. Primary waves travel with the greatest velocity so they reach the station first, followed by secondary waves, then surface waves.

To determine the arrival of these waves from the seismogram, look for a sharp increase in amplitude and decrease in frequency.

Image from Purdue University, Copyright 2008 L. Braile



Step 3: Choose a Station

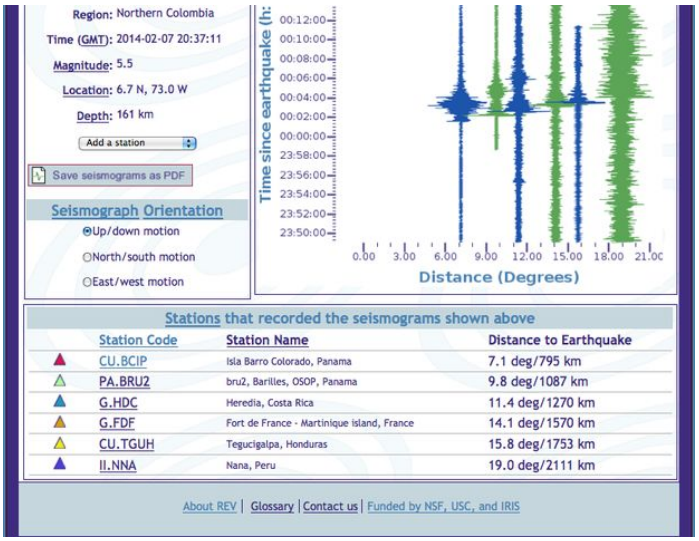
When choosing arrival times, you must be as accurate as possible. Look for pattern changes; when the lines get "taller" and closer together than they previously were, there's a good chance a new seismic phase has arrived. Remember: the P wave will arrive first, followed by the S wave and surface waves.

While learning how to do this is an important skill to acquire for budding geologists, the University of South Carolina, funded by the National Science Foundation, IRIS Education, and Outreach Program, has provided the public with a feature that overlays the arrivals on the seismograms. All we have to do is determine the difference between the arrival of the P waves and S waves.

To do this, scroll to the bottom of the webpage for your chosen earthquake, beneath the earthquake info and seismograms to view the list of stations that recorded the shown seismograms.

To determine the location of the epicenter, you will need to choose at least three stations.

Begin by choosing the station that was closest in distance to the earthquake (see the furthest column to the right). Click on the code for that station.



Step 4: S - P Lag

The webpage should look like the previous, except now the seismogram displays the records from only one station rather than six stations (which were color coded). Scroll to the bottom of the page and change zoom from "Default" to "Around S Wave."

Try on your own to locate the S wave arrival. Then, check "overlay estimated P wave/ S wave arrival times." Red flags will appear over the arrival times of the S waves.

Look at the horizontal time scale (h:min:s) and estimate the time of arrival for the S wave.

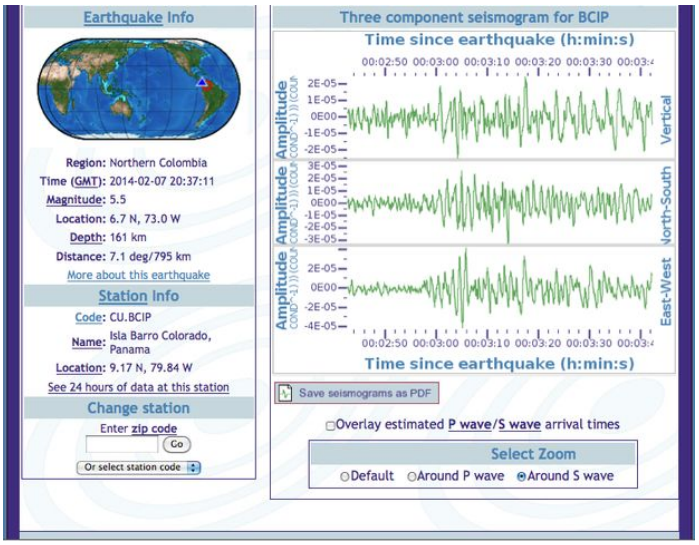
Record it, then do the same for the P wave ("Zoom Around P Wave" and estimate its arrival).

*I estimate 3 minutes 3 seconds (00:03:03) for my S wave at station BCIP and 1 minute 41 seconds for the P wave (00:01:41).

Subtract the P wave arrival time from the S wave arrival time to find the S-P lag time. Remember to convert minutes to seconds.

*My S-P is 82 seconds (183-101).

Go back to the previous webpage and select a different station. Try to pick one that is a bit further from the earthquake. Repeat Step 4. Then, do this process one more time to have a total of three S-P times from three different stations.



Step 5: Intro to Travel Time Graphs

The S - P times you have found will correlate to epicentral distances in kilometers or miles.

To find those epicentral distances, seismologists construct travel time curves, which plot distance versus time. The curves vary based on earthquake depth because the velocities of the waves vary with depth and material (rock type). Since Earth is a sphere, "Great Circle Distance" is usually calculated using the latitudes and longitudes of different stations and this equation:

Cos (D) = (Sin a Sin b) + (Cos a Cos b Cos |c|)

http://people.hofstra.edu/geotrans/eng/ch1en/conc1...

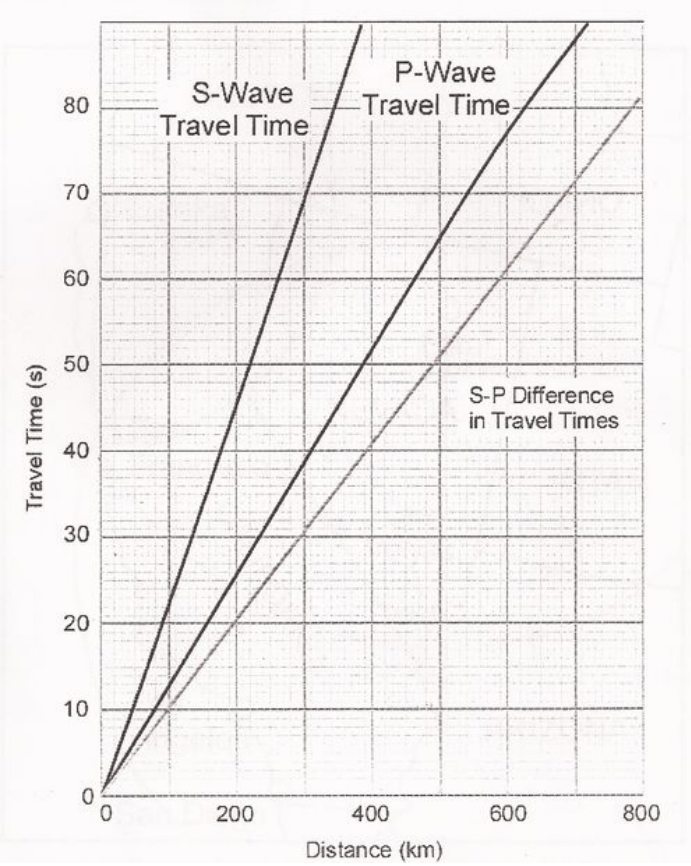
Thus, constructing and reading travel time graphs is more complicated than it seems. **For the purpose of this instructable you will estimate epicentral distances using a travel time graph for earthquakes with shallow depths (<20 kilometers).**

If you are really interested in learning about travel time graphs, there are many online educational sources, including:

http://web.ics.purdue.edu/~braile/edumod/constvel/...

Now, see the above travel time graph. You may print it if you like, but it is not absolutely necessary.

Chances are, at least one if not two of your stations were less than 800 km from the earthquake (see "Distance to Earthquake" column underneath earthquake info and seismograms). **For the stations that are less than 800 km in distance to the earthquake, plot the S-P time(s) you found (in seconds) on the "S-P Difference in Travel Times" curve and find what distance this correlates to (see x axis).** Since you are not using a computer program make your best estimation. Now, check that this/these distance(s) match the "Distance to Earthquake" numbers given in deg/km on the webpage for your earthquake.



Step 6: Print Your Map

Now that you have been introduced to travel time graphs and understand that they are constructed and used to find wave velocity or epicentral distance, note for each of your three stations the "Distance to Earthquake" in kilometers.

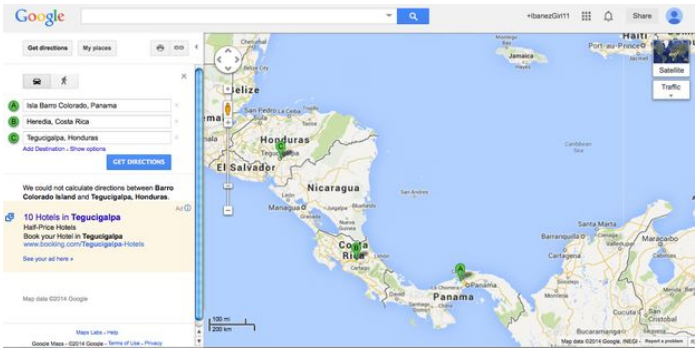
Open in a new tab or window Google Maps. Insert your "Station Name"s (locations) into the boxes labeled A, B, and C, and click "Get Directions." You should see balloons marking the locations of your stations. You should also see a scale in the bottom corner of your map in miles and kilometers. Click on the printer icon in the left corner of the webpage. A new window should open with your map and a scale.

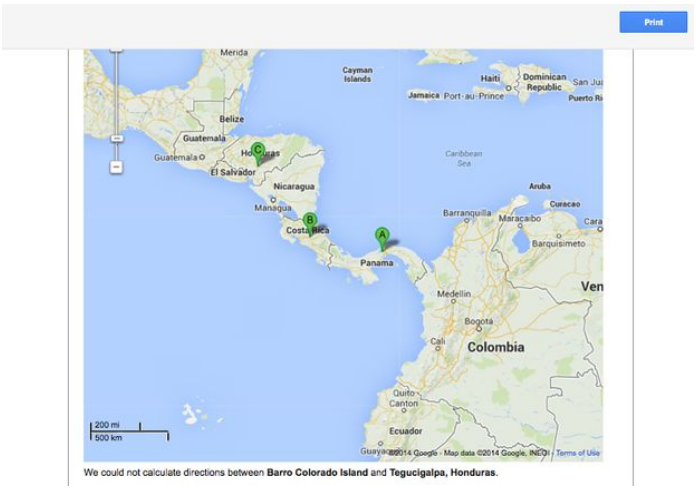
Rather than print it straight from Google you will need to use a screen capture program to save and print the map, otherwise it will be printed from Google maps without a scale.

If you are using a Macintosh, hold down command, shift, 4 to take a screen shot of your map with the scale.

If you are using a PC, press the Windows logo key +PrtScn or press Alt+Print Screen by holding down the Alt key and then pressing the Print Screen key. You may be able to use the Snipping Tool:

http://windows.microsoft.com/en-us/windows/use-sni...





Step 7: Epicentral Distances

Take your printed map, ruler, compass, and your stations' "Distance to Earthquake" in kilometers.

Measure the scale on your map with your ruler in centimeters, and use that to convert your distances in kilometers to centimeters.

Example: 500 km= 2.8 cm, 795 km= 4.45 cm

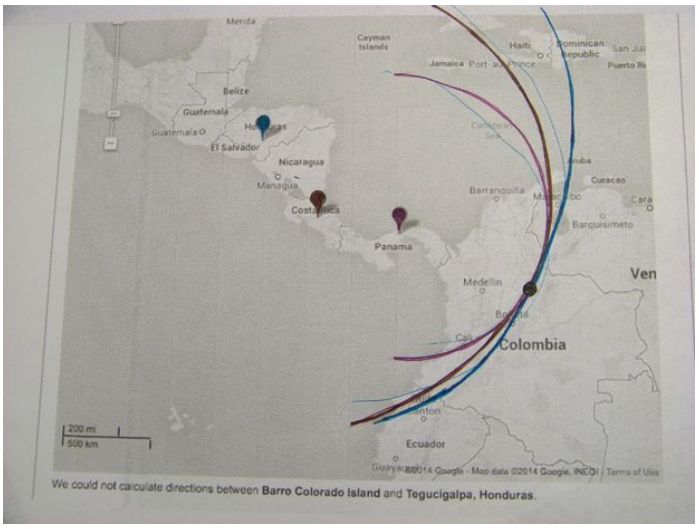
I would then measure out 4.45 cm on my compass and place one end of it on the balloon for the station that was 795 km from the earthquake and draw a circle that is 4.45 cm in radius around it (the center of your circle is your station).

Do the same for your other two stations (scale your other stations' distances from kilometers to centimeters and draw circles around them equal in radii to the distances in centimeters). Then you should have three circles on your map surrounding your stations.

The point where your circles overlap is the approximate epicenter of the earthquake.

I color coded my arcs by station. The **thick** purple, red, and blue lines represent their epicentral distances.

The epicenter of the 5.5 earthquake that struck on February 7th occurred in Northern Colombia near Bogota, a few kilometers east of Aratoca.



Step 8: Check Your Work

You can check your approximation by going to:

http://earthquake.usgs.gov/earthquakes/map/

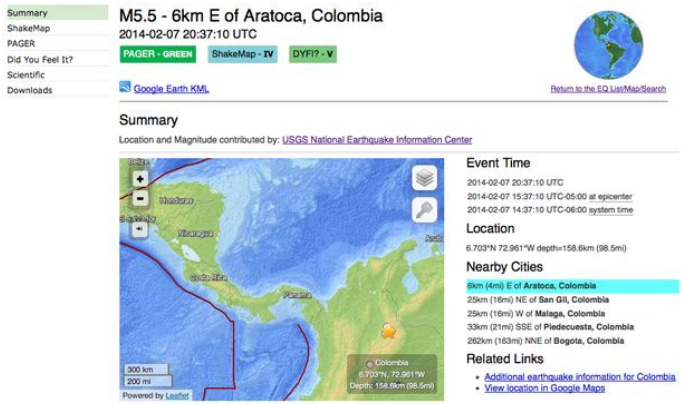
Click on the options wheel in the right hand corner.

Then you can search for your particular earthquake by day and/or magnitude.

USGS will also give you a tectonic summary for the region if you are interested!

Now you know the major steps of earthquake epicenter determination:

- S wave arrival - P wave arrival
- Travel time curve
- Epicentral distances on map



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