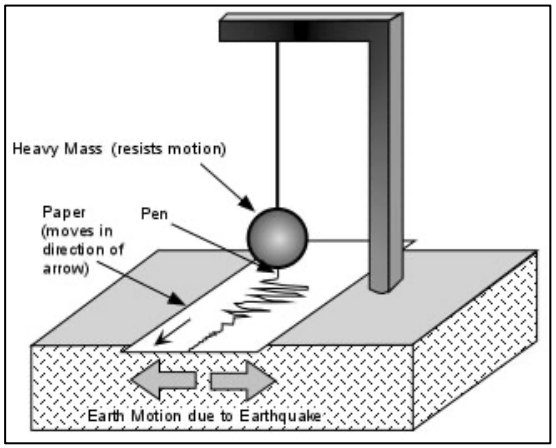
The Morocco earthquake and the Richter scale

Friday evening, September 8th, a powerful 6.8 magnitude earthquake hit Morocco southwest of Marrakech.

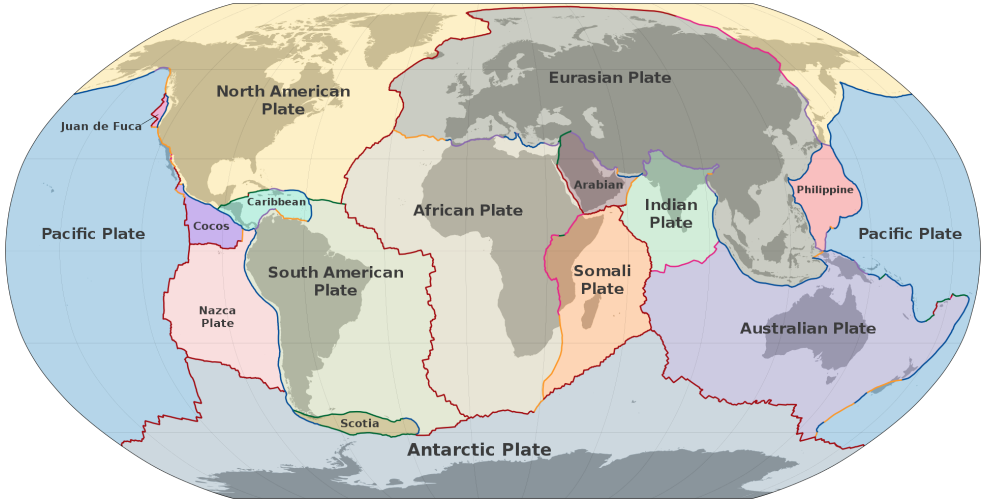
What does a 6.8 magnitude earthquake mean? How powerful was that? What is a seismometer and a seismograph? What is the amplitude of a seismograph reading? Why did the quake happen in Morocco?

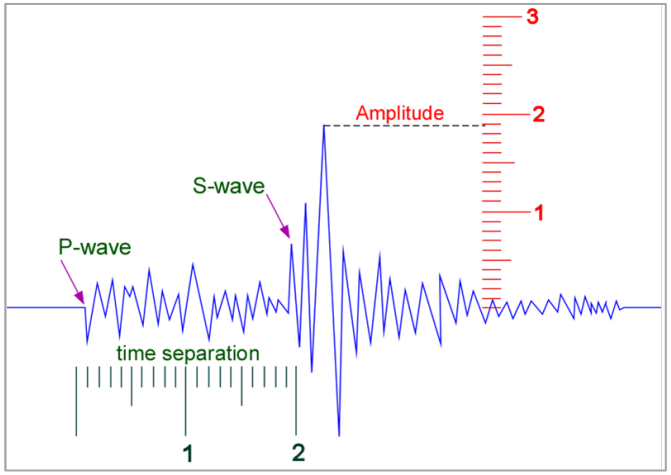
Seismometers, like the simple one pictured on the right, are located all over the world. When an earthquake occurs, readings that register the quake will be compared and the quake's epicenter and magnitude will be determined.

1. Judging from the picture on the right of a simple seismometer, how do you suppose it is able to register a quake. Please describe how you think this simple machine functions.



2. This a picture of Earth's most significant tectonic plates. Why do you think that we are showing you this picture in this activity?





3. In the seismograph on the left, the amplitude of the graph is marked. What is the value of the amplitude of this shake?

The Richter Magnitude of an earthquake is the base-10 logarithm of that amplitude.

Logarithms are related to exponents. Base-10 logarithms are the exponent required to bring 10 to a certain number.

For instance; $10^0 = 1$
$10^1 = 10$
$10^2 = 100$
$10^{1.9} = 79.43$

The exponents 0, 1, 2, and 1.9 are the base-10 logarithms of 1, 10, 100, and 79.43.

4. What would you expect the seismogram of this 6.8 recent earthquake to look like?

Clearly there are other measurements shown on this seismograph.

5. What more do you see and wonder about in this image?

Seismologists use a **Richter Magnitude** scale to express the seismic energy released by an earthquake. The chart below demonstrates Richter magnitude numbers and the explosive equivalent of energy that the magnitude represents.

Let's take a look at the seismic wave energy yielded by our two examples of recent activity and compare those to earthquakes and other phenomena. For this we'll use a larger unit of energy, the seismic energy yield of quantities of the explosive TNT:

Richter Magnitude	TNT for Seismic Energy Yield	Example (Approximate)
2.0	1 ton	Large Quarry or Mine Blast
2.5	4.6 tons	
3.0	29 tons	
3.5	73 tons	
4.0	1,000 tons	Small nuclear weapon
4.5	5,100 tons	Average tornado (total energy)
5.0	32,000 tons	
5.5	80,000 tons	Little Skull Mtn., NV Quake, 1992
6.0	1 million tons	Double Spring Flat, NV Quake, 1994
6.5	5 million tons	Northridge, CA Quake, 1994
7.0	32 million tons	Hyogo-Ken Nanbu, Japan Quake, 1995; Largest thermonuclear weapon
7.5	160 million tons	Landers, CA Quake, 1992
8.0	1 billion tons	San Francisco, CA Quake, 1906
8.5	5 billion tons	Anchorage, AK Quake, 1964
9.0	32 billion tons	Chilean Quake, 1960
10.0	1 trillion tons	(San-Andreas's type fault circling Earth)

6. Look at the table. What do you see? What do you think? What does it make you wonder?

7. How would you describe the change in destructiveness as you move up in Richter magnitude? Is the relationship between magnitude and energy yield roughly proportional? Linear? Something else? Discuss your reasoning.

Let's find the multiplicative difference between each Richter magnitude.

8. Use the table to answer the following questions:
   a. How many times greater is a 3.0 magnitude quake than a 2.0-magnitude quake?
   b. How many times greater is a 4.0 magnitude quake than a 3.0-magnitude quake?

c. How many times greater is a 5.0 magnitude quake than a 4.0-magnitude quake?

d. How many times greater is a 6.0 magnitude quake than a 5.0-magnitude quake?

e. How many times greater is a 7.0 magnitude quake than a 6.0-magnitude quake?

f. How many times greater is an 8.0 magnitude quake than a 7.0-magnitude quake?

g. How many times greater is a 9.0 magnitude quake than an 8.0-magnitude quake?

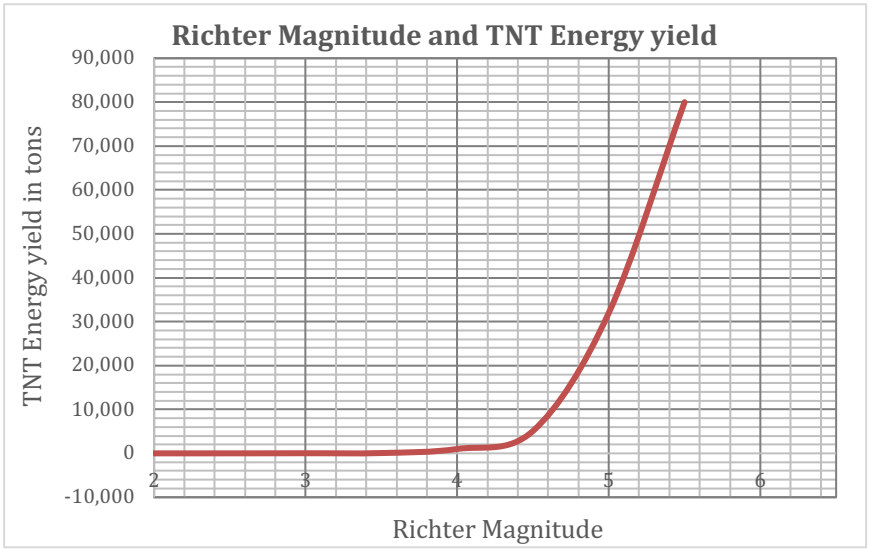
h. How many times greater is a 10.0 magnitude quake than a 9.0-magnitude quake?

9. Look back at your answers from problem six. What pattern do you notice? About how much more powerful is an earthquake when we move up one unit on the Richter scale? How about when you move up two units on the scale?

10. How powerful do you think a 12.0 magnitude quake would be?

11. Do you think a more powerful earthquake necessarily translates to a more destructive earthquake? For example, will a 6.0 earthquake always cause more damage than a 5.0 earthquake?

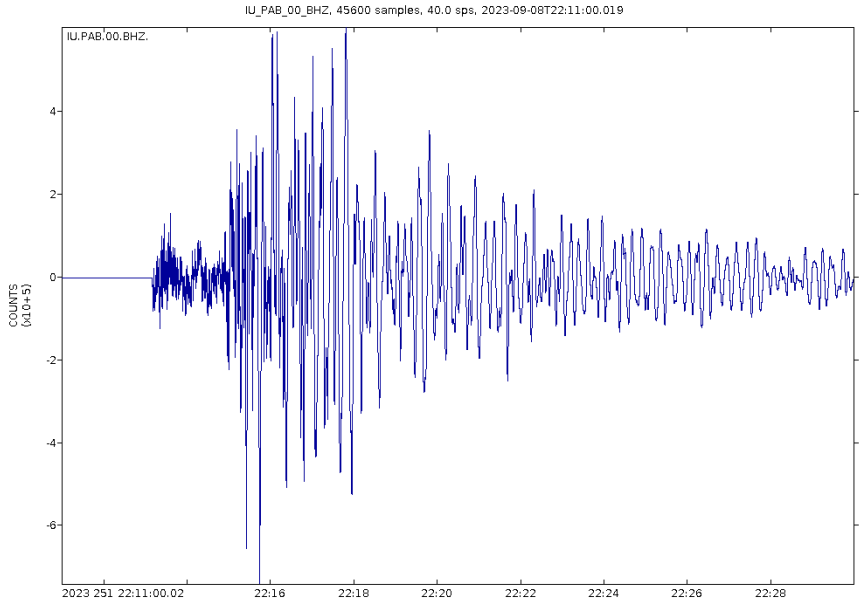
12. The graph below shows the energy yield for Richter magnitudes from 2.0 to about 5.0. Notice that the graph is not linear. Follow the curve to find the energy yields from a 4.3 magnitude earthquake. Do the same for a 4.7 magnitude earthquake.



13. If you had to create a create a graph showing the relationship between Richter magnitude and energy yield what scales would you use for your graph? Take some time to discuss this in small groups or as a class. What are the difficulties of graphing all of this data on one graph?

This is the seismograph of Morocco's recent earthquake.

14. Draw on this image where you think the p and s waves begin.



Sources: [1]https://www.usgs.gov/natural-hazards/earthquake-hazards/science/earthquake-magnitude-energy-release-and-shaking-intensity?qt-science_center_objects=0 - qt-science_center_objects
https://www.usgs.gov/programs/earthquake-hazards/science-earthquakes
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