Locate the Quake

Use seismic readings to find an epicenter and estimate magnitude.

ESS.2B.5 "Use mathematical representations to interpret seismic graphs to triangulate the location of an earthquake's epicenter and magnitude and to correlate the frequency and magnitude of an earthquake."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the rule for finding distance from arrival times, circle the magnitude calibration, and number the steps needed to locate an epicenter using three stations.

Three Stations, One Earthquake

1. After an earthquake, a seismograph records two arrivals: fast P waves and slower S waves. The gap between their arrival times helps estimate how far a station is from the epicenter. For this simplified record, multiply the S minus P gap in seconds by 8 km per second. A 2-second gap would indicate a distance of 16 km.

2. Three stations recorded the same earthquake. Their positions use a flat coordinate grid measured in kilometers. Each station's calculated distance defines a circle centered on that station. The epicenter lies where all three circles meet. Two circles may cross at two points, so the third reading helps identify one location. Use the table's arrival times to find the distances.

SEISMIC READINGS FROM ONE EARTHQUAKE

Station	Position (km)	P arrival (s)	S arrival (s)	Peak height (mm)
A	(0, 0)	12	18.25	10
B	(60, 0)	20	26.25	10
C	(30, 80)	30	35	12

3. The peak height of a trace also helps estimate magnitude, but distance affects that height. At 50 km, this simplified calibration assigns magnitude 4 to a 1 mm peak. Each tenfold increase in peak height adds one magnitude unit. In one hypothetical region over a decade, the counts were 1,000 magnitude 4 quakes, 100 magnitude 5 quakes, and 10 magnitude 6 quakes.

2 ANSWER WITH EVIDENCE

Use the passage

1. Calculate the S minus P gap and epicenter distance for each station.

2. What are the epicenter's coordinates? Check your answer against all three station distances.

3. Use station A's peak height and the 50 km calibration to estimate the earthquake's magnitude. Show the peak-height factor.

4. In the hypothetical decade, how many times as frequent were magnitude 4 quakes as magnitude 6 quakes?

3 YOUR TURN

Your own words

Design a different earthquake: choose an epicenter and three station coordinates so each station lies directly north, south, east, or west of it, then give each station's distance and predicted S minus P gap. Put one station 50 km away, choose a peak height of 1, 10, or 100 mm there, find the magnitude, and compare its decade count with another magnitude's count from the passage.

ANSWER KEY

Locate the Quake

HIGH SCHOOL · ESS.2B.5

PART 1 · READ AND MARK

Underline the rule for finding distance from arrival times, circle the magnitude calibration, and number the steps needed to locate an epicenter using three stations. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Calculate the S minus P gap and epicenter distance for each station.	**A: 6.25 s, 50 km. B: 6.25 s, 50 km. C: 5 s, 40 km.**
2	What are the epicenter's coordinates? Check your answer against all three station distances.	**(30, 40) km. It is 50 km from A, 50 km from B, and 40 km from C.**
3	Use station A's peak height and the 50 km calibration to estimate the earthquake's magnitude. Show the peak-height factor.	**Station A's 10 mm peak is 10 times the 1 mm reference peak, so the estimated magnitude is 5.**
4	In the hypothetical decade, how many times as frequent were magnitude 4 quakes as magnitude 6 quakes?	**1,000 ÷ 10 = 100, so magnitude 4 quakes were 100 times as frequent.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

My epicenter is (20, 30) km. Station A at (20, 0) is 30 km away, so its S minus P gap is 3.75 s. Station B at (60, 30) is 40 km away, so its gap is 5 s. Station C at (20, 80) is 50 km away, so its gap is 6.25 s. I choose a 100 mm peak at C. That is 100 times the 1 mm reference peak, giving magnitude 6. The hypothetical decade had 10 magnitude 6 quakes and 100 magnitude 5 quakes, so magnitude 6 quakes were one-tenth as frequent.

For the epicenter, accept a coordinate only if its distances from all three stations match the calculated distances. For Your Turn, check each coordinate distance, divide each distance by 8 to verify its arrival-time gap, and apply the calibration only to the station 50 km away.