

Counting Quakes: Frequency, Magnitude and a 30-Year Forecast

Learning target: I can calculate how often earthquakes of different magnitudes happen, compare their energy on a logarithmic scale, and use the record of past quakes to write a forecast that gives a chance, not a date.

Data and graphing

About 50 min

Individual

MS-ESS3-2 · assesses

data analysis

independent practice

writing

Name

Date

Period

Directions

The Redrock Fault Zone and the town of Millbrook are invented for this sheet, and both Redrock datasets are teaching datasets with realistic but simulated numbers. The world table in Part A is real. Show every calculation with units, round to two decimal places unless a question says otherwise, and use a ruler for the graph. Remember the rule for magnitude: each step of one whole number means about 32 times more energy released.

You will need: This worksheet, Pencil, Ruler, Calculator

Part A: How often, and how strong?

Seismometers have recorded every earthquake of magnitude 3 or larger along the Redrock Fault Zone for 50 years (1976 to 2025). The town of Millbrook sits 10 km from the fault. The table counts the quakes in each magnitude group.

Earthquakes recorded on the Redrock Fault Zone, 1976-2025 (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Magnitude group	Number of quakes in 50 years
3.0 to 3.9	1240
4.0 to 4.9	118
5.0 to 5.9	13
6.0 to 6.9	2
7.0 or larger	0

Simulated data for teaching. The counts follow the real pattern of roughly ten times fewer quakes for each step up in magnitude, but no real fault is described.

Real reference: earthquakes worldwide in an average year

Magnitude group	Average number per year worldwide
8.0 or larger	1
7.0 to 7.9	15
6.0 to 6.9	134
5.0 to 5.9	1319

U.S. Geological Survey, Earthquake Facts and Statistics: average number of earthquakes per year worldwide (magnitude 7 and larger based on observations since 1900; magnitude 5 to 6.9 based on observations since 1990).

1. Calculate the frequency of each Redrock magnitude group. Write one full calculation under the table. 3 pts

Quakes per year (count ÷ 50)	About one every ___ years (50 ÷ count)
Magnitude 4.0 to 4.9	
Magnitude 5.0 to 5.9	
Magnitude 6.0 to 6.9	

2. Divide each Redrock count by the count in the next group up (1,240 ÷ 118, then 118 ÷ 13, then 13 ÷ 2). Round to one decimal place. Then do the same for the world table, starting with 1,319 ÷ 134. In one sentence, describe the pattern the two tables share. 3 pts

3. (a) How many times more energy does one magnitude 6 quake release than one magnitude 4 quake? Show the multiplication. (b) Treat each quake in a group as if it were exactly 5.0 or exactly 6.0. Did the 2 magnitude 6 quakes or the 13 magnitude 5 quakes release more energy in total? About how many times more? Show your work. 3 pts

4. Use your answers to q2 and q3. Which magnitude group shakes Millbrook most often, and which group releases most of the fault's energy? Why does the answer matter for planning? 2 pts

Part B: Reading the trench

Fifty years of seismometer records contain no magnitude 7 quakes, so geologists dug a trench across the Redrock Fault. In the trench wall, soil layers that were torn and offset show eight large earthquakes (about magnitude 7 or larger). Dating plant remains in the layers gives the approximate year of each one.

Large earthquakes found in the Redrock Fault trench (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

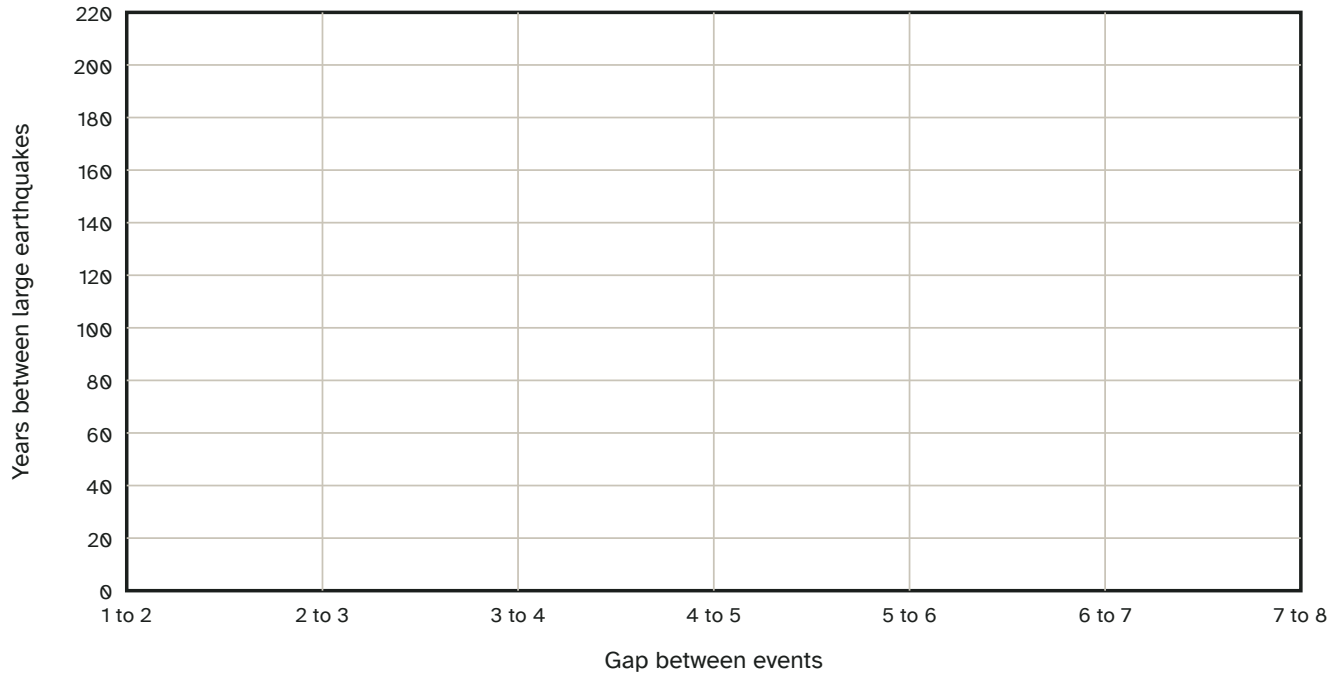
Event	Approximate year
1	1030
2	1160
3	1220
4	1390
5	1480
6	1680
7	1750
8	1870

Simulated data for teaching. Each date is uncertain by about 20 years, as real trench dates are.

5. Subtract to find the number of years between each pair of large earthquakes. 3 pts

Years between the two events
Event 1 to 2
Event 2 to 3
Event 3 to 4
Event 4 to 5
Event 5 to 6
Event 6 to 7
Event 7 to 8

Years between large Redrock earthquakes



6. Find the average (mean) gap between large earthquakes, the shortest gap and the longest gap. 3 pts
Show how you found the average.

7. How many years have passed since event 8, counting to 2026? In how many of the seven past gaps did the next large quake come **sooner** than that? 2 pts

8. A Millbrook resident says: 'The average gap is 120 years and it has been 156, so the fault is 36 years overdue. The big one will hit this year.' Use your graph to explain what is reasonable and what is not reasonable about this statement. 3 pts

9. Assume the rates stay the same. (a) Using Part A, how many magnitude 6 quakes would you expect in the next 30 years? (b) Using the average gap from q6, what fraction of an average gap is 30 years? Use it to estimate the chance of a large (magnitude 7 or larger) quake in the next 30 years as 'about 1 in ____'.

10. Write a three- to five-sentence forecast for the Millbrook town council. Include: where the hazard comes from, the sizes of quakes to expect, how likely they are over the next 30 years (use your numbers), and one thing the data **cannot** tell the council. End with one mitigation the town should fund and the number from this sheet that justifies it.

Three calculation patterns

Frequency: $\text{count} \div \text{number of years} = \text{events per year}$. Recurrence: $\text{number of years} \div \text{count} = \text{about one every } ___ \text{ years}$. Energy: for each whole-number step up in magnitude, multiply by 32 (two steps: $32 \times 32 = 1,024$, about 1,000). Average gap: add all seven gaps, then divide by 7. For q8, look at how tall and how short your bars are compared with the dashed average line.

How much do the error bars matter?

Each trench date could be off by about 20 years in either direction. Pick the shortest gap (events 2 to 3). What are the smallest and largest that gap could really be if each date is 20 years off in opposite directions? Do the same for the longest gap. Write a paragraph explaining whether this uncertainty changes the main conclusion that large Redrock quakes do not arrive on a regular schedule, and why scientists still report forecasts as probabilities.