

Idaho Seismicity: Where and How Often do Earthquakes Occur in Idaho?

Putting Down Roots, p. 2, "Idaho is 'Earthquake Country'"

Idaho State Standards:

Earth Science 1.2.1, 1.2.3, 1.6, 1.8

8th Mathematics 3.5, 4.3, 5.1.1, 5.3.1, 5.3.2, 5.5.1

9th Mathematics 1.1.2, 1.3.1, 2.2, 2.3, 2.4.1, 3.5.1, 4.3, 4.4, 5.1, 5.2, 5.3, 5.5

Objectives:

Students will:

- Describe the pattern of historical seismicity at magnitude 5 or greater in Idaho.
- Describe the pattern of Quaternary faults in Idaho.
- Describe the relationship of seismicity to faults in Idaho.
- Describe the relation of seismicity to Idaho's geologic provinces.
- Define the concept of the recurrence interval for earthquakes.
- State the recurrence intervals in Idaho for earthquakes with magnitudes of at least 5, 6, or 7.

RATIONALE

This exercise is designed to help students understand where and how often earthquakes are likely to occur in Idaho. This activity will require students to analyze data and describe patterns associated with the data.

FOCUS QUESTION(S):

- Is there a pattern to where and why earthquakes occur in Idaho?
- What is the recurrence interval for earthquakes in Idaho with different magnitudes?

TEACHING CLUES AND CUES

Become familiar with the different maps associated with this activity. A current Quaternary fault map of Idaho can be found at the following USGS web site: <http://earthquake.usgs.gov/hazards/qfaults/>. Select the static link on the left side bar of the web page – unless you are good working with Google Maps and want to download the KMZ files. The two Google maps you want to download would be the Holocene to Late Pleistocene (younger than 15,000 years) and Late Quaternary (younger than 130,000 years). This map could be projected. The map is interactive and will display the names of the faults when pointed to. Be aware of the color code used; orange for the Holocene faults and yellow for the Quaternary faults.

You might notice that when plotting location of the earthquakes from Table 1 that some do not fall on or near a named fault. There are many unknown faults in Idaho and it is through earthquakes that these faults are identified and studied further.

You may also want to purchase a classroom set of a poster-sized "Geologic Map of Idaho" from the Idaho Geologic Survey at http://www.idahogeology.org/Products/reverselook.asp?switch=pubs&value=Miscellaneous_Maps. Click on "How to Order" at the top of the page. 4 x 6 postcards of the map are also available for purchase.

The Geologic Map of Idaho is colored and has more faults plotted than the Google maps, because it includes faults older than 130,000 years old. It also has details about rock type and geologic age.

*A new geologic map will be coming out in the fall of 2011. It is not known at this time if there will also be an accompanying poster-sized map printed.

MATERIALS: for teacher

- Teacher Background, pp. 10-11
- Answer Key, pp. 12-14
- *Optional*, Geologic Map of Idaho, Computer with internet capabilities, Projection equipment
- Geologic Time Chart at http://imnh.isu.edu/Exhibits/Online/geo_time/geo_chart.htm

for the students:

- Student worksheet, pp. 3-6
- Maps (Figures 1 & 2), pp. 8-9
- Data table (Table 1), p. 7.

PROCEDURE:

Teacher Preparation

Copy the materials for the students. Decide if the fault map and plotting will be interactive or done on paper. Using available technology, teachers may want to give each student an earthquake latitude and longitude from the list (Table 1) and have them plot its position on the projected map. Teachers may also want students to use a graphing program to plot the data and generate a graph, instead of doing it manually. Both approaches have merit and are dependent on the skills and academic level of the student.

A. Introduction

The general question addressed in this activity concerns where and how often earthquakes occur in Idaho. Using maps and data, the students will explore the answer to this question.

Many earthquakes occur within tectonic plates, instead of at plate boundaries. These intraplate earthquakes are responsible for Idaho's seismicity and are best understood in relation to the geologic and tectonic settings (see the diagrams in Teacher Background, pp. 10-11). In this activity students associate earthquake epicenters with active faults, identify regions of high and low seismic activity, and determine the recurrence intervals for earthquakes of certain magnitudes.

B. Lesson Development

1. Tell students that they will use data to understand where and how often earthquakes are likely to occur in Idaho. They will be using a list of earthquakes with a Richter magnitude of 5 or greater that have occurred in or near Idaho since 1884.
2. Students will describe the patterns associated with earthquakes and the location of faults and geologic provinces of Idaho.
3. Have students look at the two maps. Instruct them to identify the latitude and longitude markings on Figure 1. Figure 1 is a map of faults in Idaho that show evidence of displacement (movement) in the last 15,000 years. Note that if you use the Google map component, you may display other faults that are younger than 130,000 years to mirror the fault map that students have). Students will need to have an understanding of geologic time with reference to Periods and epochs as well as age range values. Reference http://imnh.isu.edu/Exhibits/Online/geo_time/geo_chart.htm for a visual of a geologic time chart. The second map (Figure 2) shows the geologic provinces of Idaho.
4. Using the data table (Table 1), maps (Figs. 1 & 2), and the graph on the student worksheet, answer the questions as they apply to location and recurrence interval. Graph your data and frequency of occurrence.
5. Utilizing the components of this activity, write a summary report explaining where, why, and how often earthquakes are likely to occur in Idaho. Support your report with data from the activity as evidence.

C. Conclusion

Help students to synthesize the information from the activity. Encourage them to use data from the activity to support their written conclusion (using computational values and names for geologic provinces or faults, etc).

Adaptations and Extensions

If teachers or students use the Google Maps KMZ files they may want to add the faults from 1.6Ma

USGS (United States Geological Survey)
<http://earthquake.usgs.gov/earthquakes/>

The USGS website includes interactive maps of the latest earthquakes nationally and worldwide. In addition, the website links to two different formats, a live feed (Atom XML) that monitors earthquakes and the Google Earth KML format, that would be useful in the classroom. An application available at <https://geohazards.usgs.gov/eqprob/2009/index.php> allows students and teachers to look at Probability Mapping for Earthquakes. The necessary zip codes for Idaho can be found at http://www.555us.com/555ID/555id_zipcodes.htm.

Another mapping option found at the USGS site is the Interactive or Static Fault Maps at <http://earthquake.usgs.gov/hazards/qfaults/usmap.php>. Visit the Earthquakes Hazards Program website at <http://earthquake.usgs.gov/hazards/> for additional maps and tools through the "Online Seismic Hazard Analysis Tools."

Student worksheet

Where Do Earthquakes Occur in Idaho?

Name _____ Class _____ Date _____

1. Using the latitude and longitude values provided in Table 1, place a dot on the fault map (Figure 1) for each of the listed earthquakes and write the earthquakes magnitude next to each dot.

2. Using Figure 1, answer the following questions.

a. How many earthquakes occur on or very near a fault? _____

b. How many earthquakes occur in area lacking faults? _____

3. Write the number of earthquakes plotted on the map for each of the following regions:

a. North of 45 degrees north latitude _____

b. Between 44 degrees and 45 degrees north latitude _____

c. In southwestern Idaho _____

d. In southeastern Idaho and northern Utah _____

e. In western Montana and western Wyoming _____

4. Refer to the Idaho Geologic Provinces map (Figure 2) to answer the following questions.

a. Which geologic provinces show the greatest seismicity in the last 110 years?

b. Which geologic provinces show the least seismicity in the last 110 years?

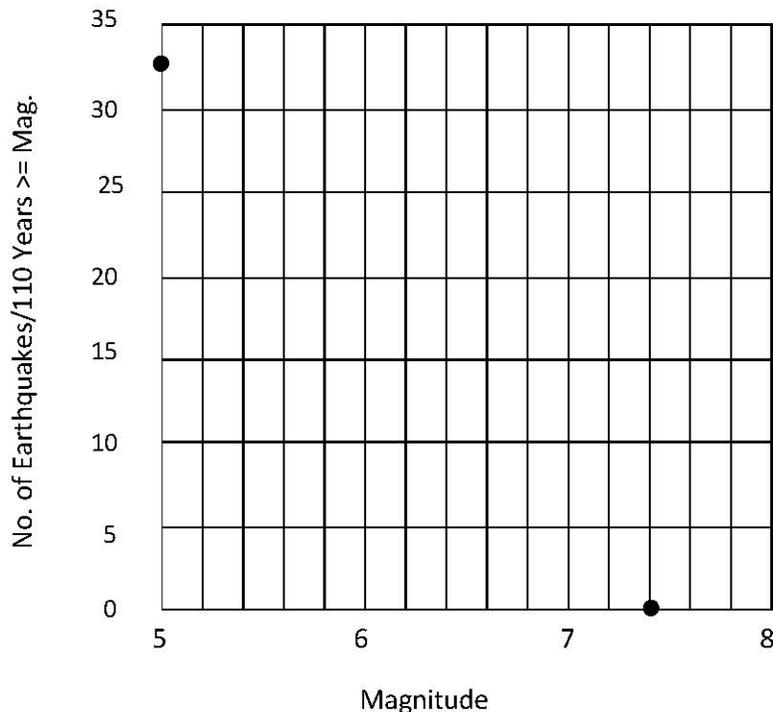
How Often are Earthquakes Likely to Occur in Idaho

1. Next, determine when an earthquake of magnitude 5 or greater is likely to occur in Idaho. Using the data from Table 1, complete the table below by entering in the second column the number of earthquakes having the magnitude listed or greater. The first two and last values have already been entered.

<u>Magnitude</u>	<u>Earthquakes</u>	<u>Magnitude</u>	<u>Earthquakes</u>
5.0	33	6.4	
5.2	27	6.6	
5.4		6.8	
5.6		7.0	
5.8		7.2	
6.0		7.4	0
6.2			

2. Now plot these pairs of values as points of the graph below. The first and last points have already been plotted.

Number of Earthquakes vs. Magnitude



WHY SHOULD I CARE?

3. Draw a smooth curve that passes through the plotted points or passes very close to them (instead of connecting the points with short, straight line segments).

4. Looking at the graph, how many earthquakes occurred between 1884 and 1994 with a magnitude of 5 or greater?

Answer _____ earthquakes

5. Now divide 110 years by the number of earthquakes having a magnitude greater than 5 to find how often an earthquake above magnitude 5 is likely to occur in Idaho. This is called the recurrence interval.

Answer _____ years

6. Repeat steps 4 and 5 to find the recurrence interval for an earthquake of magnitude 6 or greater.

Answer _____ years

7. Repeat steps 4 and 5 to find the recurrence interval for an earthquake of magnitude 7 or greater.

Answer _____ years

8. If the last earthquake with a magnitude of 5 or greater was in 1994, what does the above data say about the probability of a 5.0, 6.0 or 7.0 earthquake occurring?

9. Seismologists at the Idaho Geological Survey have identified the following years in which there was an earthquake with a magnitude of 6 or larger: 1905, 1916, 1934, 1944, 1945, 1959, 1975, 1983, and 1994. Calculate the average (mean) recurrence interval based on this data. How does this average compare to what you calculated above? Are we due or past due for another major shaking event in Idaho?

10. The Idaho Bureau of Homeland Security is responsible for public safety through hazard mitigation activities (any sustained action taken to reduce or eliminate the long term risk to human life and property) of risk from a hazard event.

Seven major risks or hazards that affect Idahoans are: Flooding, Wildfire, Earthquakes, Dam/Levee failure, Severe Weather, Hazardous Materials, and Landslides. Rank these hazards from most (1) funds needed for mitigation to the least (7)? Why did you rank the hazard of earthquakes as you did?

11. Write a summary report that utilizes the components of this activity to explain where, why, and how often earthquakes are likely to occur in Idaho. Support your report with data from the activity as evidence.

Table 1. Historical record of Idaho Earthquakes with magnitudes of 5 or greater.

Year	N. Latitude	W. Longitude	Magnitude
1884	42.00	111.30	6.3
1905	42.90	114.50	5.3
1916	43.70	116.20	5.3
1917	43.00	111.30	5.3
1928	42.10	115.20	5.2
1934	41.50	112.50	6.6
1934	41.80	113.00	5.5
1944	44.50	115.50	6.0
1944	44.25	115.04	6.1
1945	44.70	115.40	6.0
1947	44.75	111.75	6.3
1959	44.83	111.08	7.3
1959	44.90	111.63	6.0
1962	41.80	111.80	5.7
1963	44.30	114.70	5.1
1964	44.80	111.60	5.8
1965	44.90	112.70	5.0
1974	44.56	111.09	5.1
1975	42.06	112.54	6.2
1975	44.75	110.61	6.1
1975	44.80	110.70	5.1
1976	44.80	110.80	5.0
1977	44.85	111.50	5.2
1983	44.05	113.85	6.9
1983	44.23	114.10	5.8
1983	44.10	113.90	5.4
1984	44.40	114.10	5.6
1984	44.50	114.00	5.3
1991	44.50	114.25	5.2
1993	44.40	114.80	5.1
1994	42.70	111.15	5.8
1994	42.70	111.02	5.2
1994	42.56	111.03	5.2

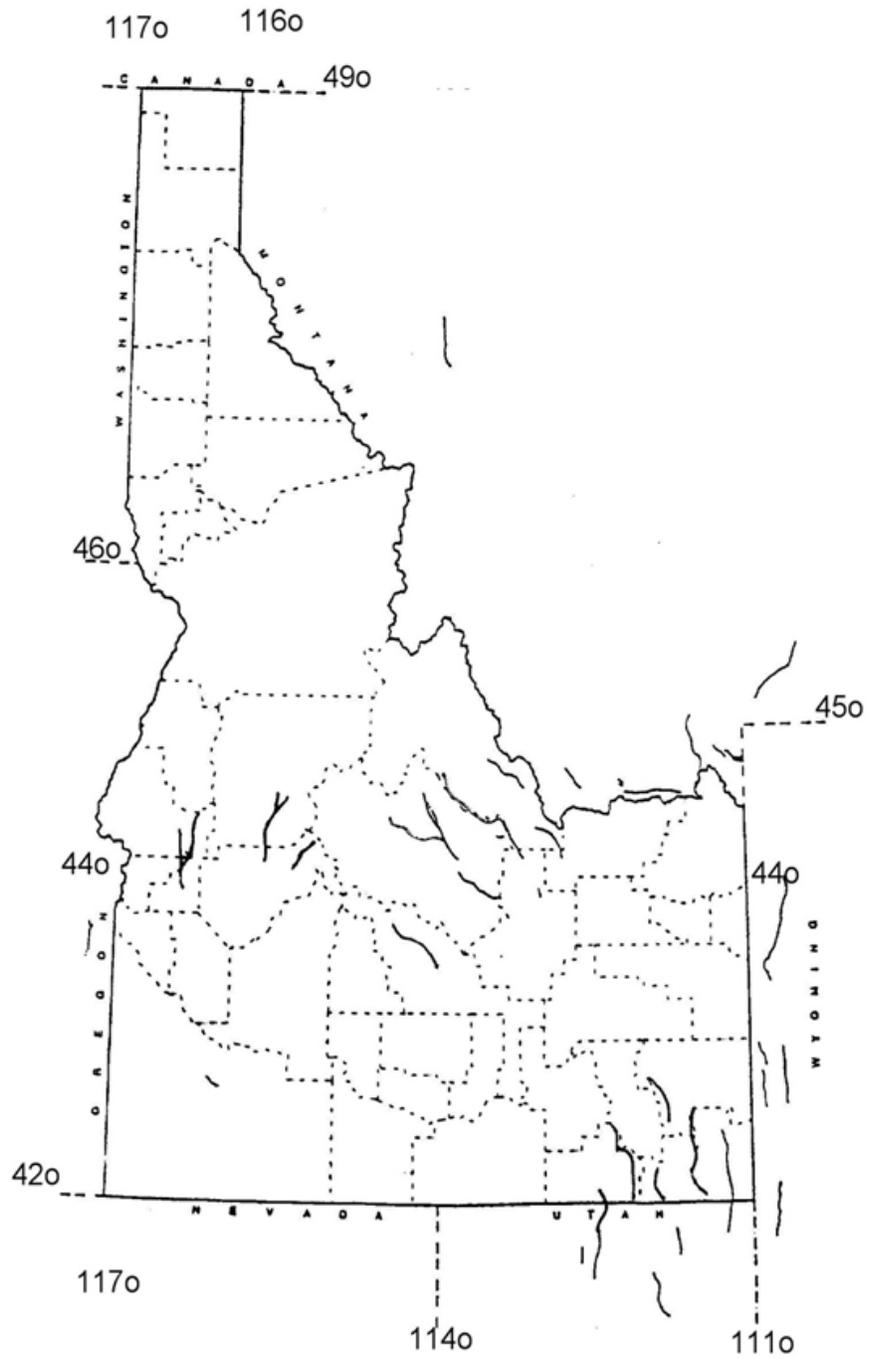


Figure 1. Neotectonic fault map of Idaho (after Hilt, A.P., Breckenridge, R.M., and Sprenke, K.F., 1994, Preliminary Neotectonic Map of Idaho, Idaho Geological Survey, Technical Report 94-1) and worksheet for plotting locations of earthquakes

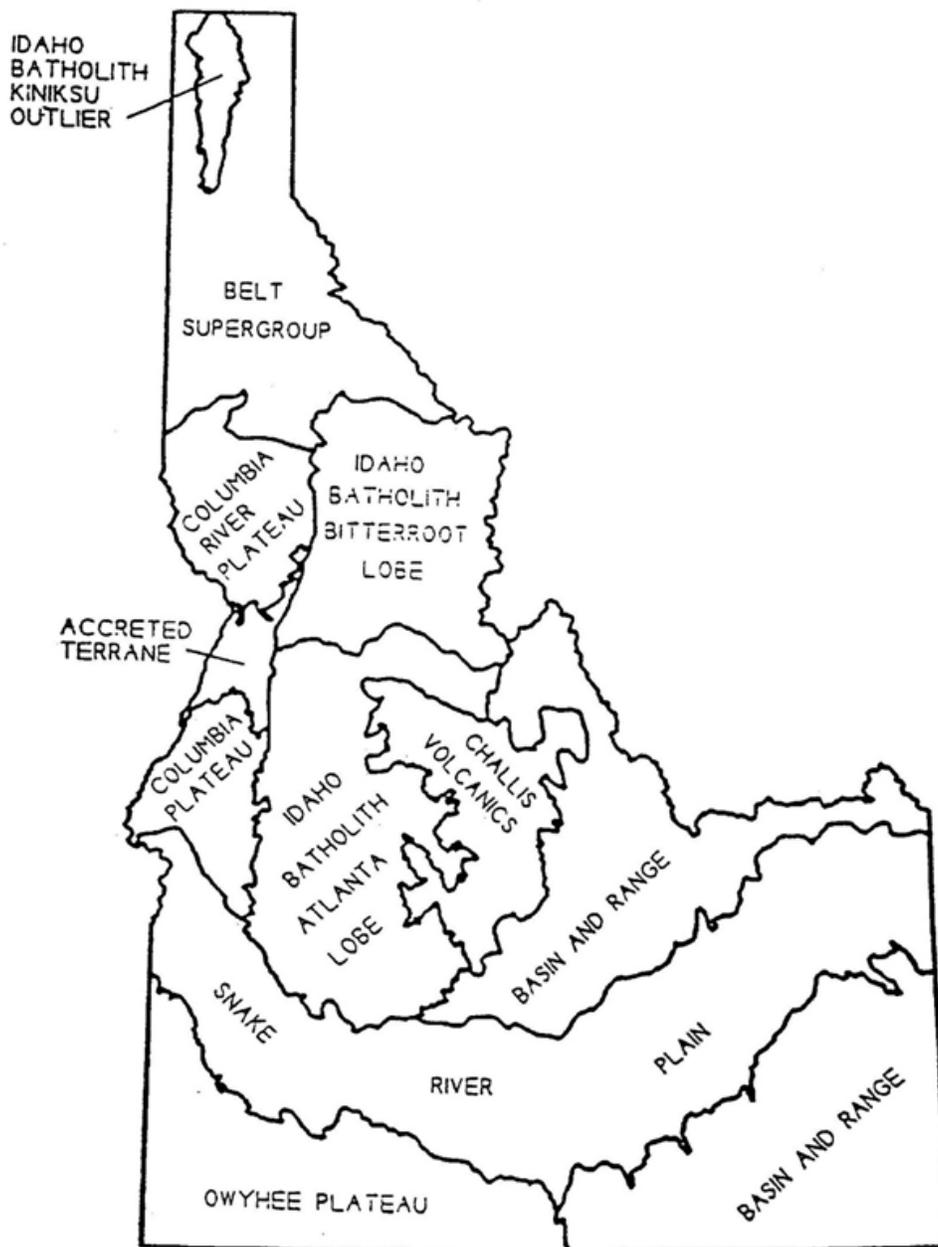


Figure 2. Geologic provinces of Idaho.

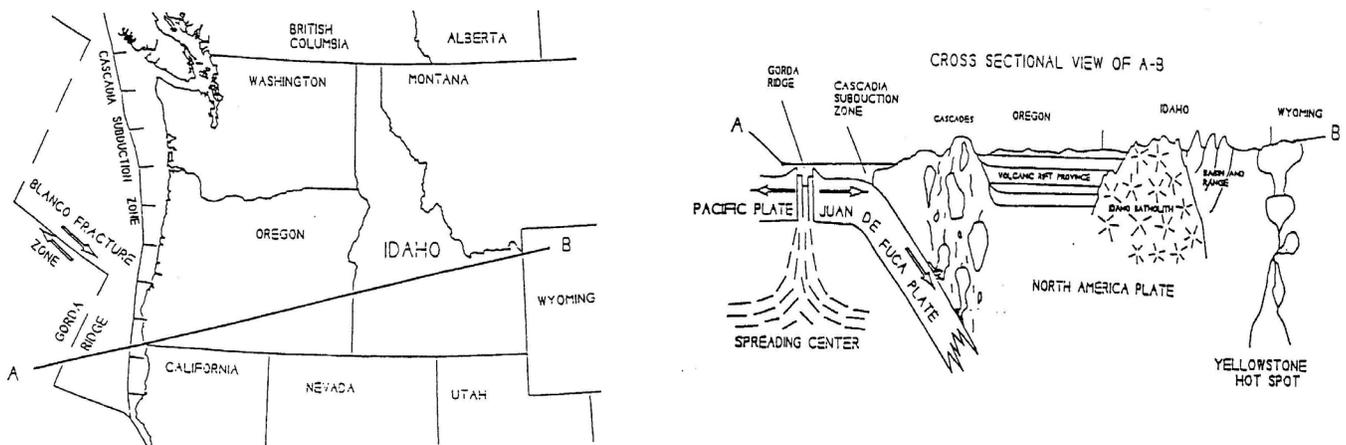
Teacher Background

INTRODUCTION

The general question addressed in this activity is “Where and how often do earthquakes occur in Idaho?” Using maps, and data the students will explore the answer to this question.

IDAHO SEISMICITY

Many earthquakes occur within tectonic plates instead of at plate boundaries. These intraplate earthquakes are responsible for Idaho’s seismicity and are best understood in relation to the geologic and tectonic settings as shown below.



Idaho’s relationship to tectonic plates of the Northwest (after Hilt, A.P., Breckenridge, R.M., and Sprenke, K.F., 1994, Preliminary Neotectonic Map of Idaho, Idaho Geological Survey, Technical Report 94-1). The cross section shows some of the causes of regional uplift and faulting in Idaho.

An exercise designed to help students understand where and how often earthquakes occur in Idaho is included in the activity, *Idaho Seismicity*. In this activity, students associate earthquake epicenters with active faults, identify regions of high and low seismic activity, and determine the recurrence intervals for earthquakes of certain magnitudes.

The activity should be accompanied or preceded by additional teaching media that presents the following concepts and principles.

A. Geologic provinces of Idaho

1. Belt rocks of northern Idaho
2. Accreted terranes of west central Idaho
3. Columbia River basalts of west central Idaho
4. Idaho batholiths of central Idaho
 - a. Bitterroot lobe-north
 - b. Atlanta lobe-south
5. Owyhee Plateau of southwestern Idaho
6. Snake River Plain of southern Idaho
7. Basin and Range province of southeastern Idaho
8. Challis Volcanics of east central Idaho

B. Intermountain Seismic Belts (*Putting Down Roots in Earthquake Country*, pp. 8-13)

1. Yellowstone Tectonic parabola
2. Intermountain seismic belt (southeastern Idaho)
3. Central Idaho Seismic Zone
4. Western Idaho seismic Zone
5. Lewis and Clark Zone

C. Yellowstone Caldera and Hot Spot

D. Extensional tectonics

1. Possible sources of vertical stress
 - a. Mantle plumes
 - b. Idaho batholiths isostatic adjustment
2. Resulting strain
 - a. Normal Faulting
 - b. Reverse Faulting

E. Mathematical skills: plotting x-y coordinates

ANSWER KEY to Idaho Seismicity**WHERE DO EARTHQUAKES OCCUR IN IDAHO?**

1. See Figure 3
2. a. 21 (± 3 depending on what students idea of "very close" means)
b. 12 (± 3 depending on what students idea of "very close" means)
3. a. North of 45 degrees 0
b. 44 to 45 degrees 21
c. SW Idaho (114 to 117 degrees) 12
d. SE Idaho & Utah (111 to 114 degrees) 21
e. Montana & Wyoming 7
4. Greatest: Atlanta batholiths, Challis Volcanics, Basin & Range
Least: Bitterroot batholiths, Columbia River Plateau, Accreted Terrane, Belt Supergroup, Kaniksu Outlier

HOW OFTEN ARE EARTHQUAKES LIKELY TO OCCUR IN IDAHO?

1. 33, 27, 18, 16, 14, 11, 6, 3, 3, 2, 1, 1, 0
2. See Figure 4
3. See Figure 4
4. 33
5. $110 \div 33$ earthquakes = 3.3 years per 5.0 earthquakes
6. 10
 $110 \div 11$ earthquakes = 10 years per 6.0 earthquakes
7. 1
 $110 \div 1$ earthquakes = 110 years per 7.0 earthquakes

Figure 4.

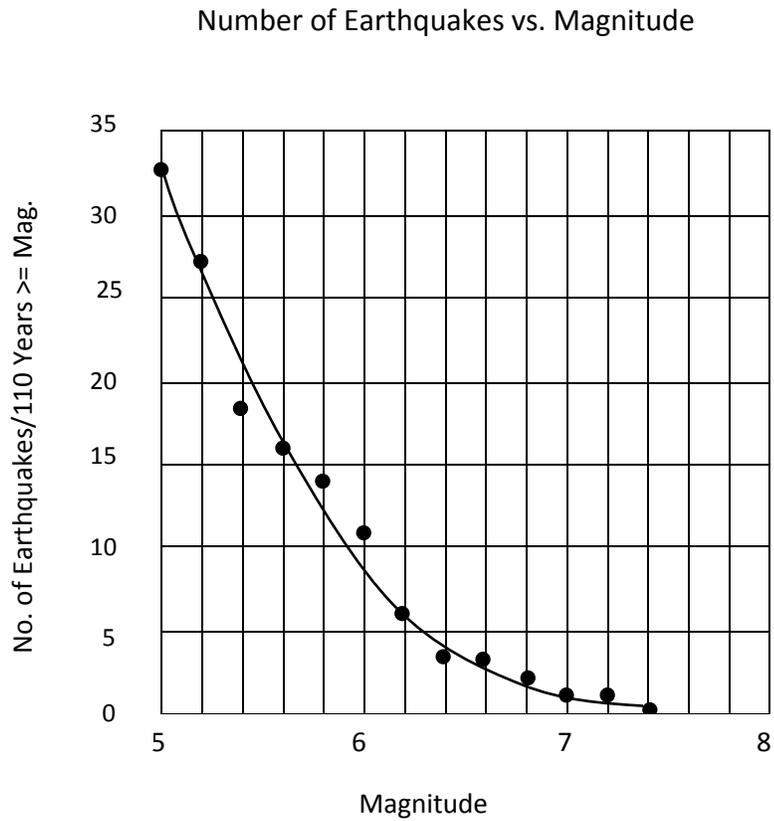


Figure 4. Solution to *Idaho Seismicity, How Often are Earthquakes Likely to Occur in Idaho*, problem numbers 2 and 3.