Using USGS ShakeMaps to Understand Intensity

***Putting Down Roots*, pp. 14 - 18**

Idaho State Standards:

8th/9th Earth Science 1.2.1-.3, 1.3.1-.3, 1.6.2-.7, 1.8, 5.2
8th Mathematics 2.1, 3.1.1, 3.5.1, 4.3, 5.1.1-.3, 5.2.1, 5.3.1-5.3.2, 5.4.1-.4, 5.5.1-.3
9th Mathematics 1.2, 2.3, 2.4.1, 3.2, 3.5, 3.6, 4.3, 4.4, 5.1, 5.2, 5.4, 5.5

Objectives:

Students will be able to:

1. Interpret a ShakeMap from the USGS website http://earthquake.usgs.gov/earthquakes/shakemap
2. Understand the relationship between acceleration of gravity and intensity (ground shaking).

RATIONALE

In this activity, students examine ShakeMaps generated from the USGS website. ShakeMaps allow students to explore other factors besides event size and the distance from the source to the receiver that can affect the intensity (e.g. structures, land composition, etc.).

FOCUS QUESTION(S):

- How hard does the ground shake during an earthquake?
- How is ground shaking quantified?
- How is intensity displayed on a map?

TEACHING CLUES AND CUES

This activity does not require the technology and materials of the previous activity. However, it does allow the students to interpret ShakeMaps and develop an understanding of intensity. It is important that students understand that when an earthquake occurs, the ground shakes and this shaking is measured as acceleration. This acceleration is converted to a value expressed as % of gravity (%g). The greater the %g, the greater the intensity as described on the Modified Mercalli Scale.

ShakeMaps display this change by color variations. It is important to note that earthquake waves do not always propagate outward like ripples on a pond. Variations in surface composition or geologic structural changes affect the amount of shaking the ground will display at the surface during an earthquake. Show the video of the 1995 Kobe, Japan Earthquake (M7.2) to students as an anticipatory hook to the activity. Ask "how hard did the ground shake? How could this be displayed on a map? Can you tell from the video when the ground was moving fast or slow?"

MATERIALS:

for teacher

- Computer and projection equipment to show video and/or ShakeMaps
- Copies of the ShakeMaps that will be used in the activity, pp. 61 - 62
- Teacher answer key, pp. 63 - 64
- Copy of the Modified Mercalli Scale, p. 44
- Download video clip of the 1995 Kobe, Japan Earthquake (M7.2) called "Earthquake in Kobe, Japan" at http://www.youtube.com/watch?v=0plbf5w0sbA

for the students: (work in pairs)

- Copies of the ShakeMaps, pp. 61 - 62
- Student Worksheet, pp. 58 - 60
- Copy of the Modified Mercalli Scale with Acceleration Values, p. 44

PROCEDURE:

Teacher Preparation

1. Make copies as needed for the activity.
2. Access the 1995 Kobe, Japan video.
3. Become familiar with the ShakeMaps in order to answer student questions.
4. Access the ShakeMaps to be displayed.

A. Introduction

When an earthquake occurs, the ground shakes. The soil at the surface responds to that shaking, as does anything on the soil. The video of an office building during the 1995 Kobe, Japan earthquake (M7.2) illustrates how violently the ground can shake. The amount of ground shaking and what happens to structures on the surface is referred to as intensity. It can be measured, usually by visual inspection of the damage. The scale used to determine the intensity is called the Modified Mercalli Scale.

B. Lesson Development

1. Present the video "Earthquake in Kobe, Japan." Ask students to determine when they think the earthquake is shaking the least and the hardest. Show the video a couple of times.
2. Distribute copies of the student worksheet, the ShakeMaps, and the Modified Mercalli Scale with Acceleration Values.
3. Discuss the concept of %acceleration from gravity. Compare the acceleration concept to the Modified Mercalli scale and to the video.
4. Display the Mount Borah ShakeMap from the 1983 earthquake. Discuss the map's features and information.

5. Allow students to work independently to answer the questions on the worksheet.

C. Conclusion

Help students to understand that the magnitude of the earthquake does not change, but the intensity does. Intensity is a measure of the amount of ground shaking which may result in damage to structures on the surface during an earthquake. Intensity decreases or increases based on magnitude, distance, soil type, and subsoil geology. Intensity can be measured as a value of % of gravity. Under normal conditions, the value of surface acceleration, at rest, has a value of 0%g. During an earthquake, the land can accelerate (move) in reference to normal conditions. The greater the %g, the more the ground is moving and may be compared to damage noted on the Modified Mercalli scale.

Additional Activities / Labs

Use the following link to access other activities about intensity. http://www.teachingboxes.org/earthquakes/lessons/lesson5_activity2.jsp

This link is to the DLESE teaching box site. In the left margin there are more activities to access. Further instructions and resources accompany Lesson 5: A whole Lot of Shakin' Goin' On! Please note that these lessons focus on California and the Oakland/ San Francisco Area.

DYFI (Did You Feel It?)

You may want to introduce your students to the USGS site "Did You Feel It?" http://earthquake.usgs.gov/earthquakes/dyfi/

There is also a link from the IGS (Idaho Geological Survey) site that connects you to the USGS dyfi page http://www.idahogeology.org/ > Geologic Hazards> earthquakes> Did You Feel It?

Student worksheet

Using USGS ShakeMaps to Understand Intensity

Name_____ **Date**_____

Intensity is a qualitative measure of the strength of ground shaking at a particular site. The Modified Mercalli Intensity Scale is the scale currently used in the United States (see p. 15 of *Putting Down Roots in Earthquake Country: Your Handbook for Earthquakes in Idaho*). Each earthquake large enough to be felt will have a range of intensities. Usually—but not always—the highest intensities are measured near the earthquake's epicenter, while lower intensities occur farther away.

Roman numerals are used to describe intensities in order to distinguish them from magnitudes. For example, the magnitude of the Borah Peak earthquake was 6.9. The intensities ranged from IX (violent) close to the epicenter, to V (moderated) at a distance of about 126 miles (203 Km) southwest in Caldwell, Idaho, and a III (weak) in Teton, Idaho, also at a distance of 126 miles (203 Km), but southeast of the epicenter (USGS).

An instrument used to measure ground shaking is called an accelerometer. This instrument can quantify the amount of shaking or ground motion during an earthquake. This value is a measurement expressed as % of gravity (%g). Normal gravity is zero and any value greater than zero indicates the amount of acceleration. When you step on the accelerator in a car or apply the brakes, the car moves faster or slower. When the car's movement changes from one speed to another, it is accelerating (faster) or decelerating (slower). This change from one speed, or velocity, to another is called acceleration. During an earthquake when the ground is shaking, it also experiences acceleration. The **peak acceleration** is the largest acceleration recorded by a particular station during an earthquake. (USGS)

The USGS ShakeMaps for the 1983 Borah Peak earthquake (Map 1) and the 1985 Michoacan, Mexico earthquake display the intensities recorded during these earthquakes in the surrounding area. Use the map and *Putting Down Roots* to answer the following questions.

1. What information does this map show us?

2. Even though it is not described on the map, what do you think the star represents?

3. Relative to the earthquake, name and describe the location where the strongest shaking took place?

4. What does an accelerometer measure? Why would this measurement be important for earthquake mitigation?

5. What was the highest and lowest probable range of acceleration for the 1983 Borah Peak earthquake? What about the Mercalli value?

6. How would you expect shaking to vary in the region around the earthquake?

7. Where would you expect to find the most damage from an earthquake? Why?

8. If you did not have an accelerometer to measure the shaking in an earthquake, how else could you describe and quantify the shaking at different distances from an earthquake?

9. Based on acceleration estimates, what sort of damage was likely to have occurred?

10. Compare and contrast this map to the map shown on p. 15 of *Putting Down Roots in Earthquake Country*. How are they alike and how are they different?

11. If distance is a factor that affects intensity, why isn't the shaking around an area consistent and spherical? (Refer to the map on p. 15)

12. According to the map, list the states that felt the earthquake with a Mercalli intensity of III.

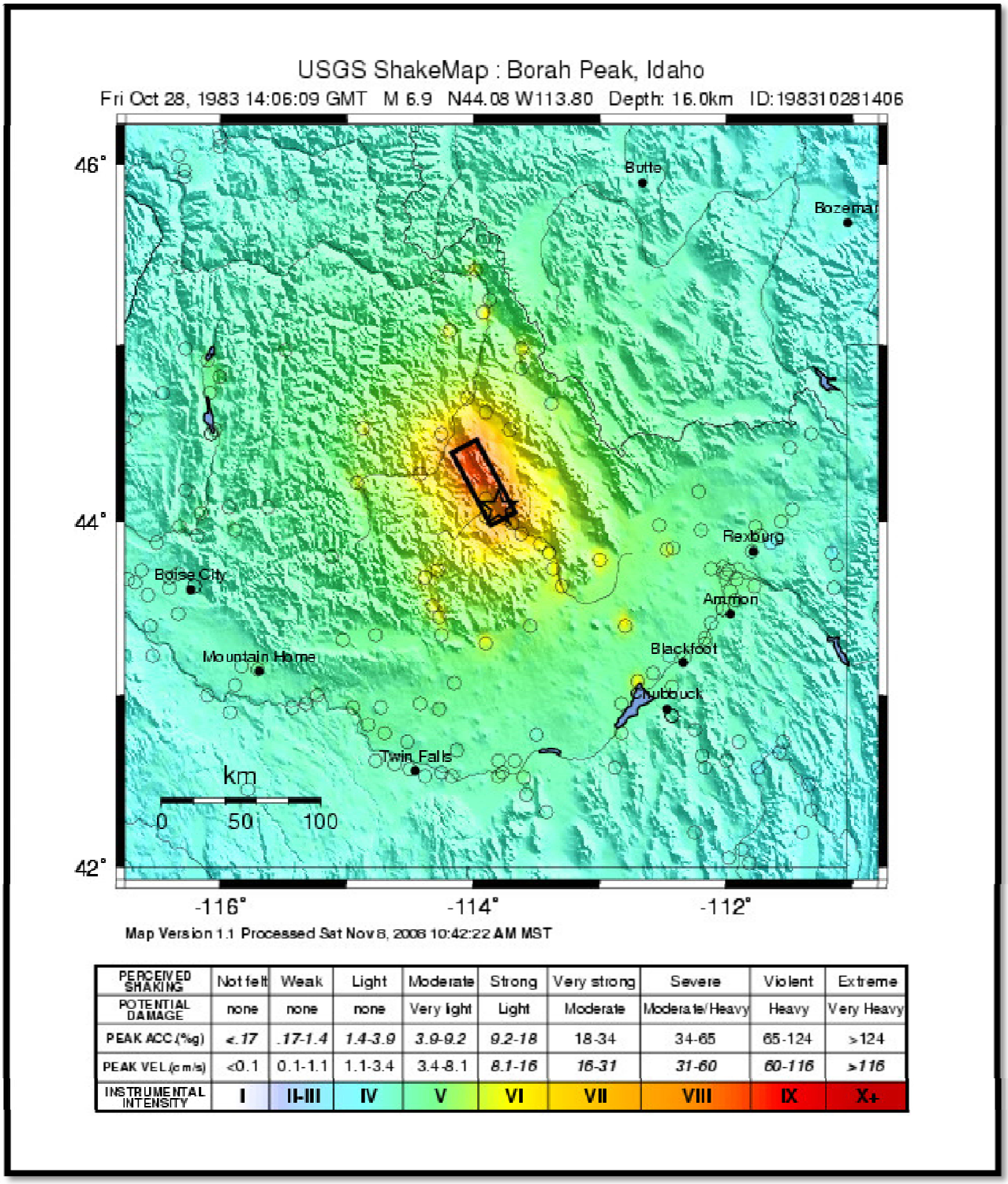
13. Based on the information found on p. 15 of *Putting Down Roots*, what is the largest expected earthquake that could happen in Idaho? Why?

14. How does the topography of Idaho amplify or reduce intensity (shaking) of an earthquake? (See p. 14)

15. How can intensity maps like the ShakeMaps help scientists and engineers reduce the damage from earthquakes?

16. **BONUS:** Look at the ShakeMap for the 1985 Mexico earthquake (Map 2). Notice the two yellow dots (Mexico City) toward the right side of the map. (a) Using the scale on the map, determine the distance from the epicenter to Mexico City. (b) What reason can you give for this area having such strong shaking at such a distance from the epicenter of the earthquake? Cite your reference sources.

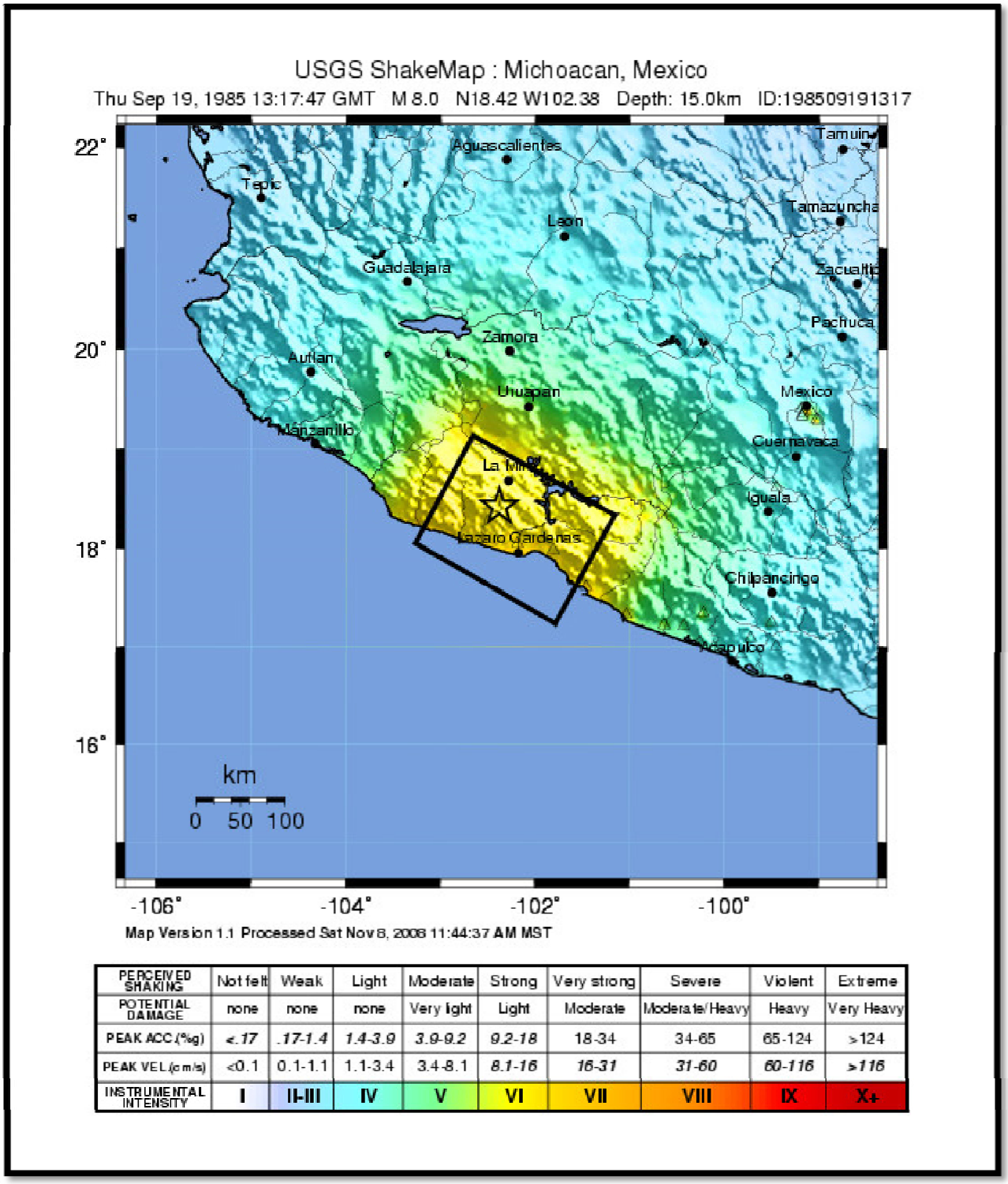
Map 1



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

USGS image

Map 2



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

USGS image

ANSWER KEY to Student Worksheet
(Using USGS ShakeMaps)

1. What information does this map show us?
   The map tells us the strength of the ground shaking at each location shown on the map.

2. Even though it is not described on the map, what do you think the star represents?
   The star represents where the earthquake occurred. This location is called the epicenter.

3. Relative to the earthquake, name and describe the location where the strongest shaking took place?
   The strongest shaking occurred close to the epicenter of the earthquake in the valley to the north of Mount Borah (the star).

4. What does an accelerometer measure? Why would this measurement be important in earthquake mitigation?
   An accelerometer measures the amount of ground shaking or movement. It can tell how strong land movement was and how it would have affected structures on the land.

5. What was the highest and lowest probable range of acceleration for the 1983 Borah Peak earthquake? What about the Mercalli value? (Mercalli value and Peak Acc. %g)
   Greatest: PA (%g) 65-124, IX
   Lowest: PA (%g) 0.17-1.4, III

6. How would you expect shaking to vary in the region around the earthquake?
   The amount of shaking will vary according to the distance and the type of ground material through which the earthquake waves travel.

7. Where would you expect to find the most damage from an earthquake? Why?
   The most damage would occur in the area closest to the epicenter and in areas where the ground motion (acceleration) was the highest. This could be in areas of thick soft soils for tall buildings and in areas of thin stiff soil for short buildings (1-2 stories). The more the land moves, the more likely structures on them will be affected.

8. If you did not have an accelerometer to measure the shaking in an earthquake, how else could you describe and quantify the shaking at different distances from an earthquake?
   Data could be collected by interviewing people about what they felt and saw during the earthquake.

9. Based on acceleration estimates, what sort of damage was likely to have occurred?
   According to the ShakeMap and the map on p. 15 of *Putting Down Roots* the earthquake would have been felt by all in Idaho. The damage would range from partial collapse of buildings, broken windows, chimney collapse, buildings shifted off foundations, underground pipes broken, and cracks in walls and in the ground.

10. Compare and contrast this ShakeMap to the map shown on p. 15, *Putting Down Roots in Earthquake Country*. How are they alike and how are they different?
Same color scheme, same area of Idaho shown. Smaller area shown on the ShakeMap, more information given on the ShakeMap, legend is attached to ShakeMap.

11. If distance is a factor that affects intensity, why isn't the shaking around an area consistent and spherical? (Look at the map on p. 15)
Soil type and thickness, as well as the presence of mountains and valleys, change the way that earthquake waves travel. If the land had the same density and structure, then it would be spherical and consistent.

12. According to the map, list the states that felt the earthquake with a Mercalli intensity of at least III.
The states are: Washington, Oregon, Nevada, Utah, Colorado, and Montana.

13. Based on the information found on p. 15 of *Putting Down Roots*, what is the largest expected earthquake that could happen in Idaho? Why?
Because of the type of faults and geology that exist in the state, a magnitude 7.5 is the largest that could be expected in Idaho.

14. How does the topography of Idaho amplify or reduce intensity (shaking) of an earthquake?
The type of soil determines how the seismic wave will behave. Soft soils (thick or thin) allow the ground motion to be amplified (increased). These are the types of soils that are found in the valleys of the Basin and Range Province of Idaho and the Snake River Plain. Most of Idaho is mountainous; therefore, the earthquake waves would not be amplified or generated.

15. How can intensity maps like the ShakeMaps help scientists and engineers reduce the damage from earthquakes?
Understanding how much the ground shakes during earthquakes of a particular magnitude in different regions helps engineers decide what kind of construction is appropriate for the different regions and areas in a region (depending on geology).

16. **BONUS:** Look at the ShakeMap for the 1985 Mexico earthquake (Map 2). Notice the two yellow dots (Mexico City) toward the right side of the map. (a) Using the scale on the map, determine the distance from the epicenter to Mexico City. (b) What reason can you give for this area having such strong shaking at such a distance from the epicenter of the earthquake? Cite your reference sources.
This ShakeMap is of the 1985 Mexico City earthquake. The epicenter was on the Pacific coast in the state of Michoacán, Mexico, a distance of ~350 km from Mexico City. The quake magnitude was 8.0. Mexico City was built on top of old lakebed sediments. This type of ground material amplified the ground shaking, causing buildings to collapse. Casualty estimates are from 10,000 to 40,000. Faulty construction practices were also cited as a reason for the large amount of damages and casualties.