# GEOL 1102 GEOLOGIC HAZARDS PART I
# Tectonic environments, Earthquakes, Tsunamis

**PART 1 – TECTONIC ENVIRONMENTS**

Complete the chart below and label each of the locations listed on the attached map.

Determine if the location is an active or ancient plate boundary, over a hotspot, or none. Name the type of boundary if applicable. Types of plate boundaries may be: continental rift, mid-ocean ridge, island arc subduction, volcanic arc (continental) subduction, continental collision, transform

If there is an earthquake risk, determine if these are frequent (earthquakes occur every year) or infrequent. Determine if the area has historically common strong earthquakes or mostly weak earthquakes. Then determine if the location is likely to have the threat of tsunamis.

If there is a volcanic risk, determine if pyroclastic eruptions are common, if there are mostly quiet lava flows, or if both styles of eruptions are likely to occur

| LOCATION TO BE LABELED ON MAP | TYPE OF ACTIVE PLATE BOUNDARY, ANCIENT PLATE BOUNDARY, HOTSPOT, or none | EARTHQUAKE RISK: FREQUENT or INFREQUENT; STRONG or WEAK | TSUNAMI RISK (yes or no) | VOLCANIC RISK: PYROCLASTIC or LAVA FLOWS |
|---|---|---|---|---|
| Japan | | | | |
| Himalayas | | | | |
| Aleutians | | | | |
| Iceland | | | | |
| Martinique, Caribbean | | | | |
| San Andreas Fault | | | | |
| Cascades | | | | |
| Andes | | | | |
| Haiti, Caribbean | | | | |
| New Zealand | | | | |
| Indonesia | | | | |
| Hawaii | | | | |
| New Madrid, Missouri | | | | |
| Río Grande Rift | | | | |
| Yellowstone Park, Wyoming | | | | |
| El Paso, TX | | | | |

1. Which of the places listed above are along the Ring of Fire?

2. Which of the places above are at risk for lahars?

3. The strongest earthquake in the continental U.S. was the 1811-1812 New Madrid, Missouri earthquake. We live near an active continental rift, the Río Grande rift, which has many earthquakes every year. What is the difference in the earthquake risk between our area and Missouri?

How does the risk in our area compare to the risk of earthquakes in Seattle, Washington and Portland, Oregon?

**PART 2 – EARTHQUAKE HAZARDS**

Earthquakes are classified using two different scales. The **Richter Scale** is a measure of the energy released during the earthquake. The **Mercalli Scale** is a measure of the amount of damage done by the earthquake. Scientists record responses from many people who experience the earthquake and assign a value from I (1) to XII (12). These numbers are plotted on a map and used to locate the epicenter of the earthquake. This method is based on the idea that the area closest to the epicenter will suffer the most damage.

Below is a chart listing the damage and experiences in different cities during the same earthquake. For each city, use the attached Modified Mercalli Scale and assign local intensity values for this earthquake. Then place the Intensity value next to each city on the map.

| CITY | DAMAGE and OBSERVATIONS | ESTIMATED INTENSITY |
|---|---|---|
| ASHLAND | Hanging lamps swayed | |
| BEAR CREEK | People outdoors did not notice anything | |
| BURNEVILLE | Felt by people sitting at dinner | |
| CEDAR PASS | Families sitting at dinner noticed dishes rattling | |
| DODGE | Dishes, windows, and doors rattled | |
| EMERYVILLE | Not felt | |
| FALLS | Felt by nearly everyone. A few windows were broken | |
| FORKS | Big windows in stores downtown were broken | |
| GRANTS PLAIN | Church bells rang all over town. Plaster walls developed cracks. Candlesticks fell of the mantle. | |
| GREENBURG | Not much damage, but felt by everyone. | |
| HILLSDALE | Some plaster ceilings fell. Many people were scared. | |
| KEMPOE | Felt by some people on upper floors, some windows rattled. | |
| LEEDS | Noticed by many people working late in tall buildings | |

| | | |
|---|---|---|
| OAKDALE | Felt only by a few people | |
| PETERSON | Felt by almost everyone. Some plaster ceilings fell down. | |
| RED HILLS | People inside watching television noticed the vibrations. | |
| RIVER GLEN | Felt by almost everybody. | |
| SANDPOINT | Many windows were broken. Some people were scared. | |
| SPLIT ROCK | Poorly built structures were badly damaged. A few drivers noticed their cars moving strangely for a moment. | |
| TRAVIS CITY | Felt by almost everybody. Church bells rang. | |
| TUCKER | Books fell off shelves in the main library. Some windows were broken. | |
| VERNON | Dishes in cupboards rattled. Felt by people indoors. | |
| VICTOR | Most people were alarmed and ran outside. Chimneys were broken. | |
| VISTA | Felt only by people in upper floors of tall buildings. | |
| WELLS | Noticed by people on the third floor. Some windows rattled. | |
| WESTBURY | Some people noticed the vibrations, but thought it was a freight train. | |
| WHEATFIELD | People sitting at the dinner table noticed doors and windows rattling. | |
| YALCO | Many people ran outside. Many windows were broken. | |

Write your estimated intensity next to each city on the attached map.
Using these intensities, you will construct an **Isointensity** (or **isoseismal**) **map**, a contour map showing areas of equal intensity for the earthquake. To do this, you draw lines enclosing areas of the same intensity. The lines drawn are your estimated boundaries between these areas of equal intensity. You will have to estimate where these lines will go in the areas that have no data. Colored pencils may be used to more clearly show these areas.

Isointensity maps are commonly used to determine the epicenters and strengths of historical earthquakes for which there are no measurements of magnitude. Epicenters of most earthquakes are near the areas with the strongest intensity.

After constructing your isointensity map, answer the following questions:

1. What cities were nearest the epicenter? How did you determine this?

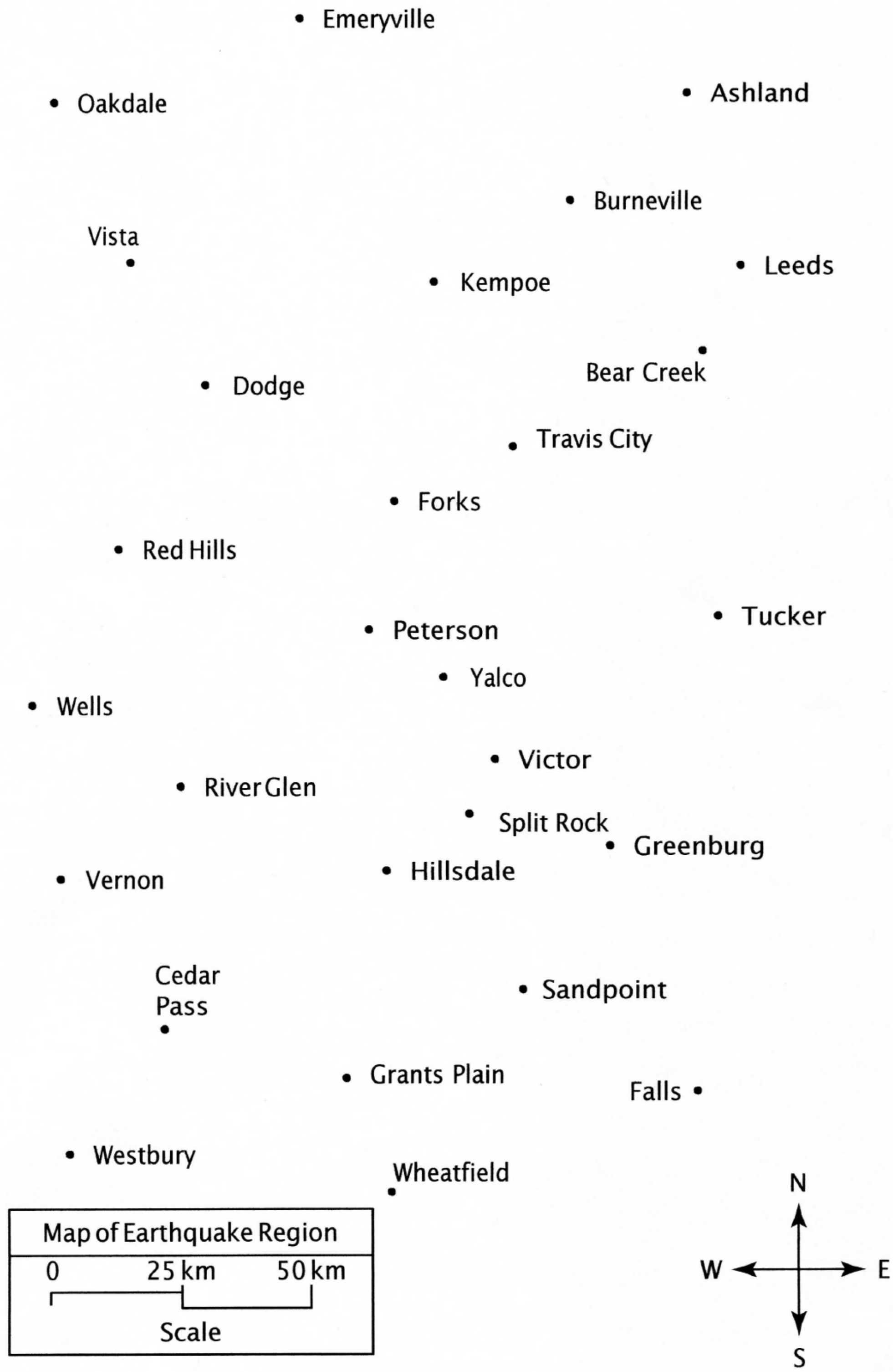
2. Using the scale of the map, determine the approximate width of the zone with an intensity of V.

3. What are possible sources of error when using the intensities of an earthquake to estimate the location of an epicenter?

## MODIFIED MERCALLI SCALE

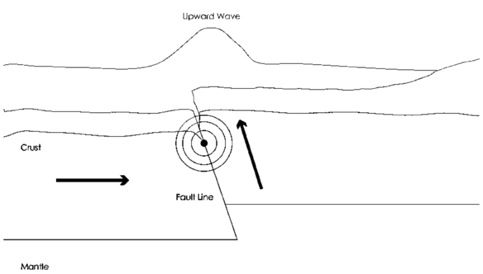
| Intensity | Description of Shaking/Damage |
|---|---|
| I | Not felt except by a very few under especially favorable conditions. |
| II | Felt only by a few persons at rest, especially on upper floors of buildings. |
| III | Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated. |
| IV | Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably. |
| V | Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop. |
| VI | Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. |
| VII | Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. |
| VIII | Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. |
| IX | Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. |
| X | Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. |
| XI | Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. |
| XII | Damage total. Lines of sight and level are distorted. Objects thrown into the air. |

**Figure 1**

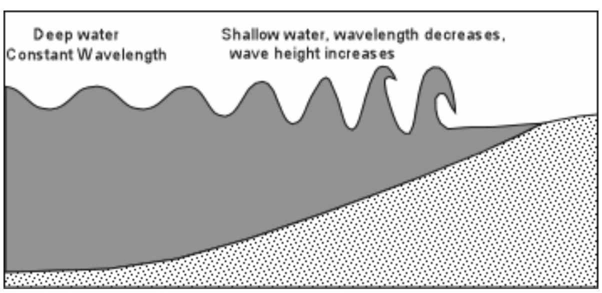

Emeryville
Oakdale
Ashland
Burneville
Vista
Kempoe
Leeds
Bear Creek
Dodge
Travis City
Forks
Red Hills
Tucker
Peterson
Yalco
Wells
Victor
River Glen
Split Rock
Greenburg
Hillsdale
Vernon
Cedar Pass
Sandpoint
Grants Plain
Falls
Westbury
Wheatfield
Map of Earthquake Region
0
25 km
50 km
Scale
N
W
E
S

**PART 3 – TSUNAMI HAZARDS**

Tsunamis are shallow water ocean waves that are caused by some sort of disturbance that displaces the ocean floor, and therefore the ocean water. While the most common cause of tsunamis is a strong (usually greater than magnitude 6.5) submarine earthquake, large landslides, volcanic eruptions, and even meteorite impacts can also cause enough ocean water to be displaced to form tsunamis.




There is a direct relationship between the length of a wave, the height of a wave, and the water depth. The diagram below shows how as waves approach shallow water, the wavelength shortens and the wave height increases. The wave period (the time necessary for successive waves to pass a given point) and the total energy of the wave, however, remains constant. In the deep water of the open ocean the wavelength of a tsunami is over 100 kilometers and the wave height may be less than one meter. The velocity of the wave also depends on the water depth, with wave speeds decreasing as the water depth decreases. In the open ocean tsunami speeds will be over one hundred kilometers per hour,




1. From your answers in chart for Part 1, where do you think most tsunamis occur. In the Atlantic or Pacific Ocean? Why?

2. The strongest earthquake ever recorded was the 1960 Chilean earthquake with a magnitude of 9.5. From Part 1, what is the type of plate boundary associated with this earthquake?

3. The 1960 Chilean earthquake occurred at 19:11 UMT on May 22. The tsunami generated by this enormous submarine quake traveled throughout the entire Pacific Ocean basin. At 10:00 UMT on May 23, the tsunami reached Hawaii with waves over 10 meters, killing 61 people and injuring almost 300 near Hilo. How long did the tsunami travel before it reached Hawaii?

4. Using either the maps in your lab or the internet to determine the approximate distance between Chile and Hawaii in kilometers.

5. What was the speed (in km per hour) of the 1960 tsunami from Chile to Hawaii?

6. The 1960 Chilean tsunami reached Japan at 17:00 UMT on May 23 with heights of over 5 meters, killing 185 people. How long did the tsunami travel before it reached Japan?

7. Using either the maps in your lab or the internet and determine the approximate distance between Chile and Japan in kilometers, and then calculate the speed (in km per hour) of the 1960 tsunami from Chile to Japan.

8. How much did the tsunami speed change as the distance increased? Why?

Since the wavelength begins to change as water depth decreases, the speed of a tsunami will change as it approaches shallow water. In shallow water, wave speeds can be calculated by the formula:

$$\text{speed} = \sqrt{g \times d}$$

where g = the acceleration of gravity ; 9.8 meters/second$^2$ and d = water depth in meters.

9. In the 1964 Alaskan earthquake (magnitude 9.2) a tsunami travelled across the Aleutian Basin, with an average water depth of 3000 meters. Calculate the tsunami speed as it traveled across the Aleutian Basin in meters per second.

Convert the tsunami speed above to kilometers per hour.

10. Adak Island in the Aleutians is about 1500 km away from the epicenter of the 1964 earthquake near Valdez, Alaska. How long did it take the tsunami to reach Adak?

11. The 2004 Indian Ocean tsunami caused by the Sumatra-Andaman earthquake (magnitude 9.2) killed over 35,000 people in Sri Lanka 1600 km away on the other side of the Bay of Bengal. Average water depth in the Bay of Bengal is about 4000 meters. How fast did the tsunami travel through the Bay of Bengal? Convert your answer to kilometers per hour.

12. Near Sri Lanka, the water depths are only about 500 meters. Calculate the speed in km per hour of the tsunami as it approached Sri Lanka, then convert this speed to miles per hour (1 km = 0.62 miles). Do you think people were able to outrun the tsunami?