Earthquake activity 3: Introduction to Earthquakes

Description: A teacher-led lesson introducing senior elementary students to earthquakes, including cause, seismic waves, magnitude and intensity, and where they commonly occur. The lesson involves classroom discussion, map analysis and 2 brief demonstrations.

Materials: Overheads: 1. Earthquakes in Canada map; 2. Tectonic Plates map; 3. Seismogram; 4. Magnitude Scale and 5. Modified Mercalli Intensity Scale

Brick, sandpaper, elastic cord

Teacher instructions and notes:

- Preparation: The teacher may want to review information in advance on the following websites.

  Geological Survey of Canada: http://earthquakescanada.nrcan.gc.ca

  Atlas of Canada: Earthquakes [PDF] - included as part of these resources

Introduce the topic by asking a few questions to encourage student participation.

  - Have you ever felt an earthquake? What happened? Where were you when it happened?

- Ask the class the following questions and lead them to the appropriate answer provided below. Class should take notes.

1. **What is an earthquake?** A sudden shaking of the ground.

2. **What happens during an earthquake?**

   The ground trembles or shakes. Depending on the size of the earthquake, people may fall down; buildings or bridges might collapse; it might even create a huge wave in the ocean called a tsunamis. Ensure that they also understand that many events are so small that people do not even notice them, although scientific instruments can still measure them. About 4000 earthquakes per year are located in or near Canada, but only 50-55 are reported as 'felt'. The majority of these felt earthquakes are too small to cause any damage. In the 20th century, about 20 earthquakes have caused significant damage in Canada. (Show overhead 1, the Earthquakes in Canada map)

3. **What causes an earthquake?**

   An earthquake is the result of a sudden release of energy when rocks under stress slide abruptly past one another along a break (fault) in the Earth's crust. Earthquakes are caused by the slow deformation of the outer, brittle portions of "tectonic plates", the earth's outermost layer of crust and upper mantle. (Show overhead 2, the Tectonic Plates map.) Due to the heating and cooling of the rock below these plates, the resulting convection causes the adjacently overlying plates to move, and, under great stress, deform. The rates of plate movements range from about 2 to 12 centimeters per year. Sometimes, tremendous energy can build up within a single plate, or between neighbouring plates. If the accumulated stress exceeds the strength of the rocks making up these brittle zones, the rocks can break suddenly, releasing the stored energy as an earthquake.

   Epicentre: The epicentre is the position on the surface of the Earth directly above the location of the earthquake. The amount of ground shaking generally decreases as you move away from epicentre.

To illustrate the stick-slip action, use the following earthquake simulation demonstration:

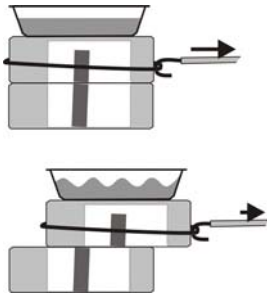
Demonstration 1: Earthquake Simulation Model (courtesy of Earthnet)

Purpose: to demonstrate the sudden rupture of a fault that produces an earthquake

Materials: 2 bricks
string and bungee cord
tray of water
paper and pen and Blu Tak

Procedure:

1. Put two bricks, one on top of the other, on a table.
2. Draw a bar across the paper and cut in half so that the bar is divided in the middle. With Blu Tak, attach one half of the paper on the bottom brick and the other half on the top brick so that the bar appears continuous.
3. Put a tray of water on top of the bricks.
4. Tie string around the top brick.
5. Hook the end of bungee cord onto the string and gently, but persistently, pull the bungee cord until the top brick suddenly slides.
6. At the moment the brick slides, observe the waves that travel through the water. The shock waves travel down the bungee cord in the same way seismic waves travel through the earth after an earthquake.
7. The displaced bar represents a fault that has suddenly moved.



4. **How is the energy transmitted?** As seismic waves. Two important types of seismic waves are the P and S waves.

   P wave: Also called **primary or compressional waves**, P waves carry energy through the Earth as longitudinal waves, moving particles in the same line as the direction of the wave. These waves are the fastest body waves and arrive at seismic recording stations before the S waves, or secondary waves. P waves may be felt by humans as a bang or thump.

   S wave: Also called **secondary or shear waves**, S waves carry energy through the Earth in very complex patterns of transverse (crosswise) waves. These waves move more slowly than P waves, but in an earthquake they are usually bigger.

   A very good animation of earthquake waves can be viewed at
   http://web.ics.purdue.edu/~braile/edumod/waves/WaveDemo.htm

   To illustrate seismic waves use the following wave demonstration:

Demonstration 2: Seismic Waves

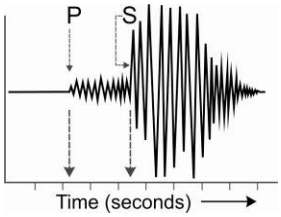
Purpose: to demonstrate the passage of P and S waves through a solid and a liquid.

Procedure:

1. Have about 10 students stand in a line, shoulder to shoulder, with linked elbows. The linked elbows represent the solidity of rock.
2. The first person in line leans into the person next to them, pushing against their shoulder, and then straightens back up. Again, the movement or wave is transferred to each person in the line. This is the compressional or **P wave**.
3. The first person at one end of the line leans forward by bending at the waist, and then straightens up again. Because their arms are linked, each person in the line does the same movement, and the wave passes along the line of people. This is the shear or **S wave**.
4. Have the students remain shoulder to shoulder, but do not link elbows. (This represents liquid conditions.) Repeat the two movements. Result: P waves can transmit through water : S waves can not.

5. How are Earthquakes measured?

During an earthquake, vibrations initiated by fracturing of the Earth's crust radiate outward from the point of fracture. Direct compressional waves (**P-waves**) are faster moving and shear waves (**S-waves**) are slower. Each type appears as a unique signature on a **seismograph**, a very sensitive instrument used to record and measure earthquakes. The visual record produced is called a "seismogram". (Show overhead 3, the Seismogram)



Earthquakes can be measured two ways: **Magnitude** and **Intensity.** Magnitude of an earthquake is determined based on measuring the ground motion with instruments (seismographs), whereas the intensity of an earthquake is determined based on observations of earthquake effects on building structures and human perceptions. (Show overheads 4 and 5 - Magnitude Scale and Modified Mercalli Scale)

- **Magnitude** is a unique number representing the size of an earthquake and **measures the amount of fault movement at the source** of the earthquake. Magnitude is measured from <1 (recorded but not felt) to 9 or even greater (seriously damaging). This is a logarithmic scale and each value is 10 times greater than the preceding number on the scale. Magnitude is calculated based on arrival times and amplitude of earthquake waves recorded by a seismograph. The largest earthquake ever recorded was a magnitude 9.5 in Chile in 1960. Canada's largest recorded earthquake (magnitude 8.1) occurred along the Queen Charlotte Fault in BC in 1949.
- **Intensity** is a **measure of local shaking** and therefore differs from place to place. The strength of shaking generally decreases with distance from the source, but also is influenced by local geologic conditions. For example, thick deposits of soft soils will experience much greater shaking than will hard bedrock. Intensity is measured on the **Modified Mercalli Scale** – a numeric scale from I to XII, which is based on people's descriptions of what was felt and the amount of damage incurred in their location during the earthquake. For any earthquake, there is only one magnitude but as many intensities as there are communities reporting effects.

6. Where do earthquakes occur? Show overhead 2, the Tectonic Plates map.

Earthquakes occur all over the world; however, most occur on active faults that define the major tectonic plates of the earth. Ninety percent of the world's earthquakes occur along these plate boundaries. The "Ring of Fire" circling the Pacific Ocean, and including Canada's west coast, is one of the most active earthquake and volcanic areas in the world.

7. Where do most of the earthquakes happen in Canada?

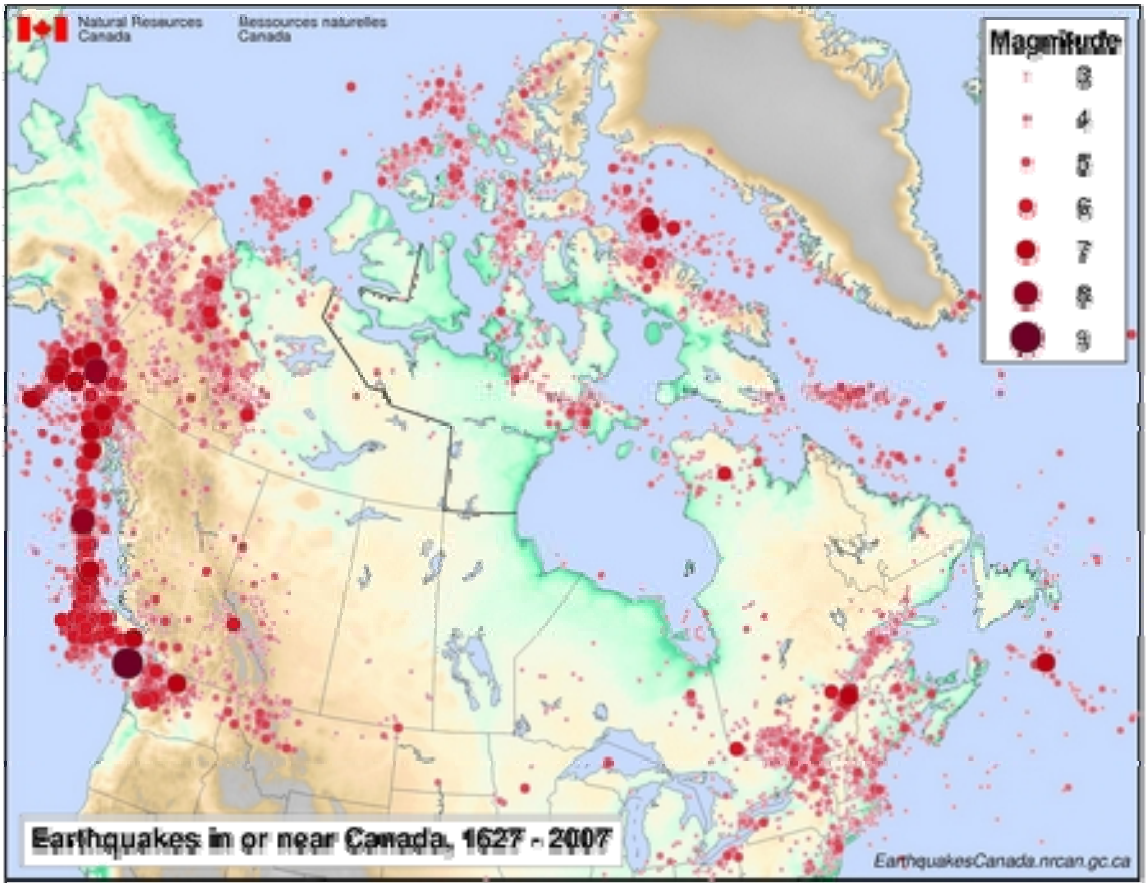
Using the Earthquakes in Canada map, have students identify hazard regions where earthquakes are common.

- Earthquakes along Canada's west coast occur at or near the margins of slowly moving tectonic plates.
- In Eastern earthquakes are not at the edge of a tectonic plate. They are in regions of crustal weakness. The slow movement of the North American Plate away from the Mid-Atlantic Ridge may activate old zones of weakness and faults such as the St. Lawrence Valley.
- In the Arctic, earthquakes also seem to be associated with older geological features, but may also be related to stresses produced as the land continues to rise following melting of the heavy ice sheets from the last continental glaciation.

Although some regions may have earthquakes, human risk is slight if few people live there. Ask the students which regions of Canada have significant risk associated with this hazard. (*southern Cordillera and St. Lawrence Lowlands*)

Overhead 1

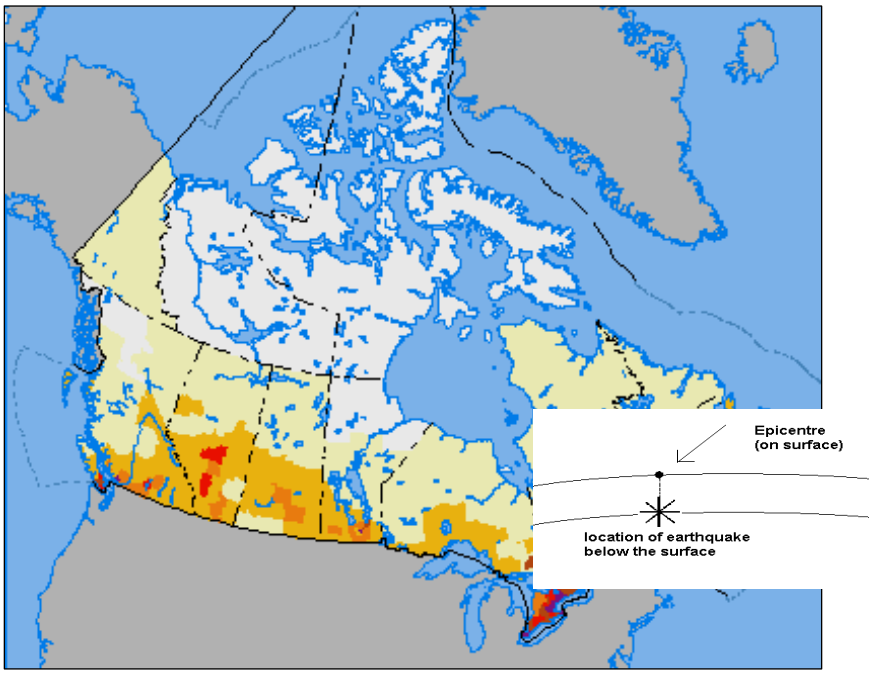
Earthquakes in Canada

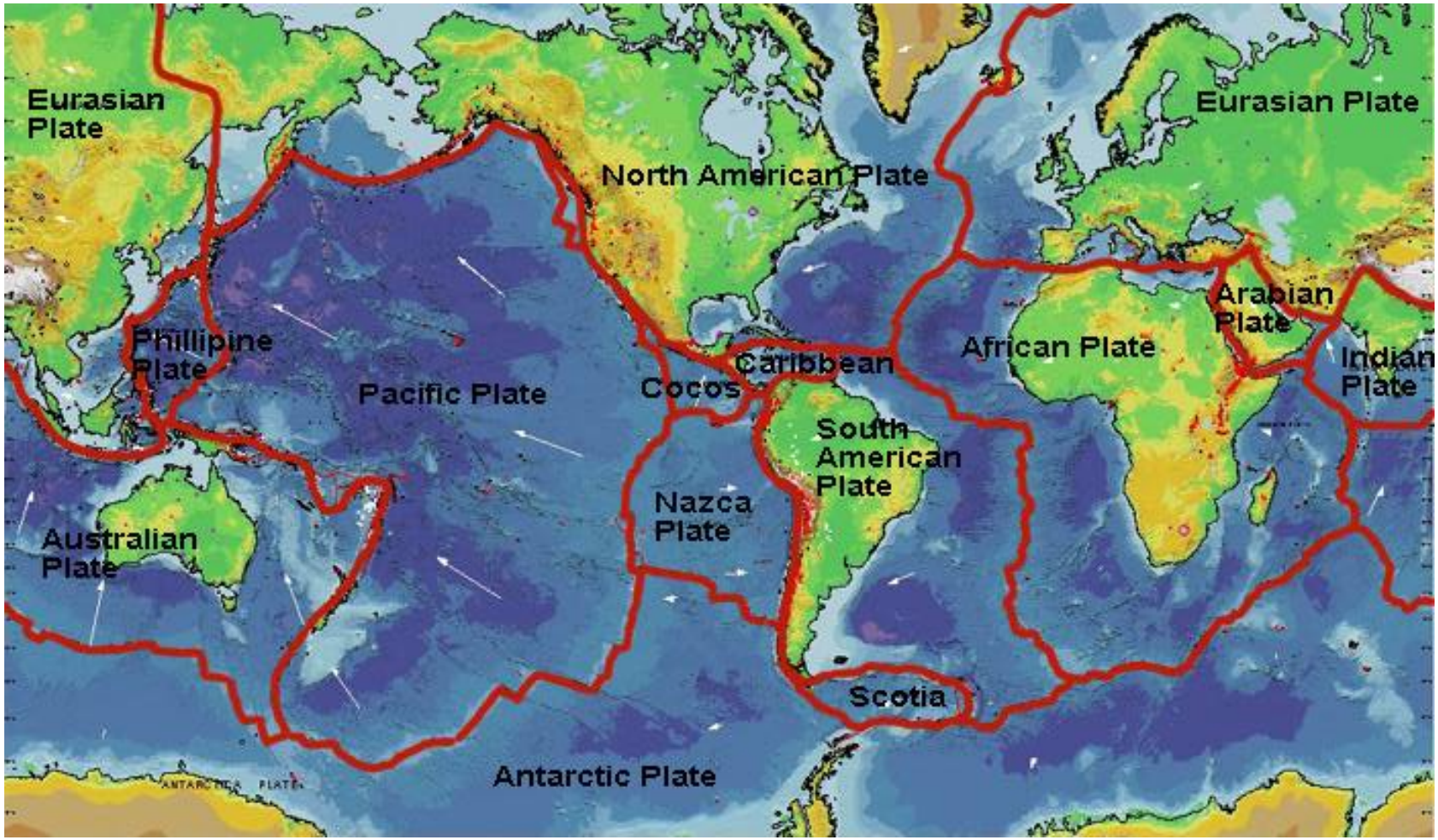


Population Density

by Census Division (persons / km^2)

- < 0.1
- 0.1 - 0.9
- 1 - 4.9
- 5 - 19.9
- 20 - 49.9
- 50 - 150
- > 150





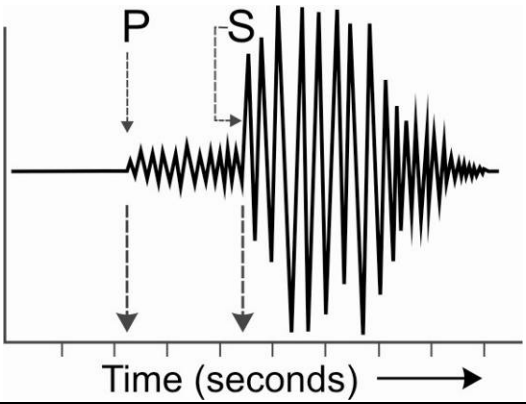
Tectonic Plates

Courtesy of the USGS

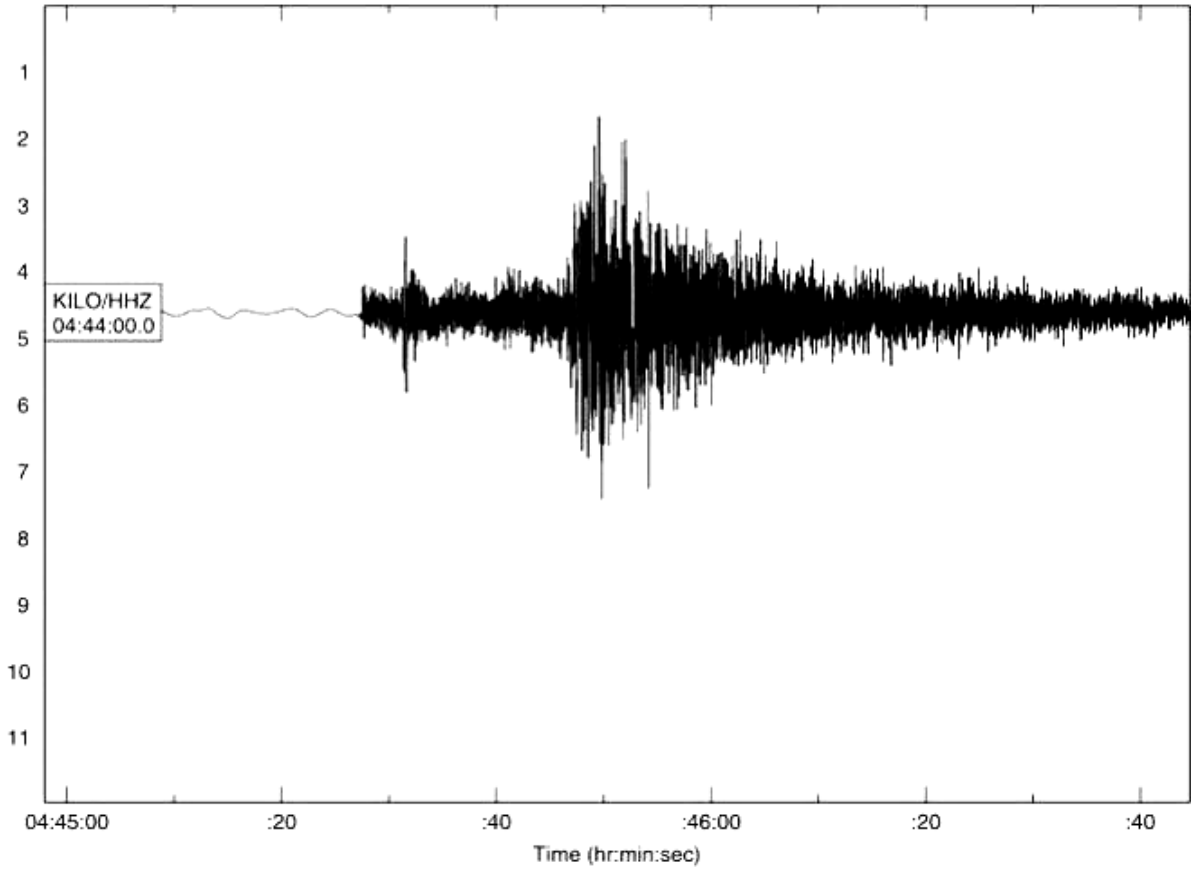
Overhead 3

Seismogram

Diagram showing arrival of the P waves and S waves



Actual seismogram of the arrival of seismic waves at station KILO on Dec. 7, 2006. Magnitude 4.2 earthquake.



Overhead 4

Magnitude Scale

- A unique number representing the size of an earthquake.
- Magnitude is the measure of the amount of energy released by the earthquake.

Magnitude	Earthquake Effects
Under 3	Generally not felt, but recorded.
3 - 5	Often felt, but rarely causes damage.
5 - 6	At most slight damage to well-designed buildings. Can cause significant damage to poorly constructed buildings over small regions.
6 - 7	Can be destructive in areas up to about 100 kilometres across where people live.
7 - 8	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred kilometres across.

Intensity is a measure of local shaking based on ‘felt’ and damage reports

Intensity: Modified Mercalli Scale

Scale	Earthquake Effects
I	People do not feel any Earth movement.
II	A few people might notice movement if they are at rest and/or on the upper floors of tall buildings.
III	Many people indoors feel movement. Hanging objects swing back and forth. People outdoors might not realize that an earthquake is occurring.
IV	Most people indoors feel movement. Hanging objects swing. Dishes, windows, and doors rattle. The earthquake feels like a heavy truck hitting the walls. A few people outdoors may feel movement. Parked cars rock.
V	Almost everyone feels movement. Sleeping people are awakened. Doors swing open or close. Dishes are broken. Pictures on the wall move. Small objects move or are turned over. Trees might shake. Liquids might spill out of open containers.
VI	Everyone feels movement. People have trouble walking. Objects fall from shelves. Pictures fall off walls. Furniture moves. Plaster in walls might crack. Trees and bushes shake. Damage is slight in poorly built buildings. No structural damage.
VII	People have difficulty standing. Drivers feel their cars shaking. Some furniture breaks. Loose bricks fall from buildings. Damage is slight to moderate in well-built buildings; considerable in poorly built buildings.
VIII	Drivers have trouble steering. Houses that are not bolted down might shift on their foundations. Tall structures such as towers and chimneys might twist and fall. Well-built buildings suffer slight damage. Poorly built structures suffer severe damage. Tree branches break. Hillsides might crack if the ground is wet. Water levels in wells might change.
IX	Well-built buildings suffer considerable damage. Houses that are not bolted down move off their foundations. Some underground pipes are broken. The ground cracks. Reservoirs suffer serious damage.
X	Most buildings and their foundations are destroyed. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, lakes. The ground cracks in large areas. Railroad tracks are bent slightly.
XI	Most buildings collapse. Some bridges are destroyed. Large cracks appear in the ground. Underground pipelines are destroyed. Railroad tracks are badly bent.
XII	Almost everything is destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move.