SHAKE, RATTLE AND ROLL:
STUDYING THE EFFECTS OF AN EARTHQUAKE

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Level: Grades 5 - 8

Anticipated Learning Outcomes

- Students will learn what happens during an earthquake. (Unless they have actually experienced an earthquake, most students don't have a good understanding of what happens in an earthquake. Some may even believe that entire buildings are "swallowed up" by the earth and that the area of total devastation is very extensive. This activity will provide students with direct information about the nature and extent of earthquake damage.)
- Students will learn how one can measure the effects of an earthquake. (Not all scientific data are obtained from measurements with instruments. In this exercise students will use newspaper accounts of people's experiences in an earthquake to conduct a scientific study of earthquake effects.)
- Students will gain experience making scientific estimates. (Scientists often have insufficient information to make fully informed decisions. This activity exposes students to the idea that science commonly involves estimates and judgements.)
- Students will be introduced to the concept of generalizing their results. (In this exercise, data from a few locations will be used to draw a map of the effects of an earthquake over an entire region. This procedure presents an opportunity to discuss the importance and limitations of generalizations in science.)

Background

Prior knowledge about earthquakes is not necessary. The activity is designed to take advantage of the interest in earthquakes that is generated by a strong earthquake somewhere in the United States or even elsewhere in the world. The activity could also be done with newspaper clippings from an older, earlier earthquake.

Materials

- A current newspaper article with brief accounts of people's experiences during a recent earthquake. (Typically after a major earthquake in the United States, newspapers carry one or two-line accounts of the effects of the earthquake in various places. Often these
accounts are direct quotes from individuals. An article with ten or twelve accounts should be sufficient.)

- Copies of the Modified Mercalli Intensity Scale. (Provided with this activity.)
- An automobile club map of the area affected by the earthquake.
- Wide-tipped magic marker

**Procedures**

1. Pass out copies of the Modified Mercalli Intensity Scale. The scale contains brief descriptions of what people might have felt in an earthquake and what might have happened to buildings and natural features. The different levels of the scale are designated with Roman numerals, and they correspond to groups of effects that are produced by about the same amount of shaking.

2. Read aloud each account of a personal experience in the earthquake and have the students assign a Modified Mercalli intensity level to it. Scientists who study earthquakes base the intensity level on the most severe effect experienced by a given individual, and this is usually the effect reported in the newspapers. Only one effect is needed to determine the intensity level; in an actual earthquake, very few individuals experience more than one or two of the effects listed for a particular intensity level.

3. Discuss problem cases with the class. In some cases, the account may be so vague that the intensity level cannot be determined. In others, the account may not be specific enough for students to decide which of two adjacent levels is the more appropriate. Classroom discussion should focus on why there are problems and what additional information would be needed to make a better determination. It is not necessary to reach a consensus about each account. Some accounts might be given a dual assignment, such as VII/VIII.

4. Ask the students to find the location of each account on the map and mark it with a large Roman numeral corresponding to the intensity level.

5. With the advice of the students, draw lines which separate regions that experienced different intensity levels. Do not be afraid to draw the lines across regions that have little or no data. Use dashed lines where the uncertainty is large. Classroom discussion of the problems in drawing the lines is an opportunity to introduce the idea of uncertainty and inference in science.

6. Have the class discuss what the map tells them about the effects of the earthquake. Topics for discussion could include the size of the affected area, the relative levels of damage, and precautions that people could have taken to protect themselves and their property.

**Results and Discussion**

1. The lines on the map are called isoseismals (from iso meaning "same" and seismal meaning "shaking"). The resulting map is called an isoseismal map. The isoseismals for a particular earthquake usually form a bull's eye pattern around the region of most intense damage. The bull's eye is usually distorted, and the isoseismals seldom form concentric circles. On a regional scale, the intensity can be strongly influenced by geologic features, such as mountains and valleys. On a local scale, the underlying rock, the water content of the ground, and the type of construction can also be important.
2. Isoseismal maps are important tools for studying earthquakes because they provide a rapid estimate of the nature and distribution of the shaking. After a moderate or strong earthquake in the United States, information about the intensity is gathered by the United States Geological Survey using a postcard questionnaire that is distributed to selected federal, state and municipal employees. The questionnaire focuses on the effects that are specifically used in determining the Modified Mercalli intensity.

3. The Modified Mercalli intensity should not be confused with the Richter magnitude. The magnitude is a measure of the energy released in an earthquake; the intensity is a measure of the amount of shaking that occurred at a particular place. The Richter magnitude is determined from the reading on a seismometer at a certain distance from the earthquake. An earthquake has only one Richter magnitude, but it has many different the Modified Mercalli intensity levels. These levels will vary from barely perceptible far from the earthquake to some upper limit of damage and destruction close to the location of the fault rupture that produced the earthquake.

4. One advantage of studying earthquake intensities is that isoseismal maps can be constructed for earthquakes that happened many years ago. Like the newspaper accounts in this exercise, an individual's account of what he or she experienced in an earthquake usually focuses on the most severe effect. Using newspaper reports, letters, and diaries, seismologists and historians have been able to draw isoseismal maps for earthquakes that occurred as far back as the early nineteenth century in California and the middle of the eighteenth century in the eastern part of the United States.

5. The isoseismal maps from older earthquakes are particularly useful in determining the seismic risk in any given area. A basic principle in assessing seismic risk is that the maximum Modified Mercalli intensity that an area has experienced in the past is at least the minimum intensity that it could experience in the future. By superimposing isoseismal maps from many different earthquakes, it is possible to develop a seismic risk map for a state or region. Such maps can be used for determining insurance rates, developing building codes, and providing individuals with an estimate of the actual seismic risk which they face at home or at work.

Examples

Here are some newspaper accounts of what people experienced in a recent earthquake in southern California along with possible assignments of the Modified Mercalli intensity level.

- "I felt it a little bit," said a worker on the 55th floor of a 62-story building. "Since there was no wind today, I assumed it was an earthquake." II
- The windows shook and the building creaked and a plant in front of me moved," said B.K. III
- The quake was felt as a mild rumble, swaying chandeliers and skyscrapers. IV
- A listener to a radio station said he had been awakened by the quake. IV
- In the newspaper building, one window shattered and a heavy light fixture crashed to the floor of the composing room. V
- "The whole house shook and it didn't feel like it was ever going to stop," said S.G. "The bed was jiggling and the ceiling lights were swaying." V
• M.W. said she "felt a very strong jolt" that knocked a large picture off the wall, "slammed it to the floor and broke the glass." VI
• Residents reported that dishes and books were shaken off shelves. VI
• "A lot of people were just pouring out of my apartment complex into the parking lot, said J.W. "There was a little bit of panic, and a little bit of hysteria." VII
• R.M. said that her refrigerator and stove were heaved into the middle of the kitchen and that cupboards ripped loose from the walls. VII
Modified Mercalli Intensity Scale


I Not felt by people, except under specially favorable circumstances. However, dizziness or nausea may be experienced. Sometimes birds and animals are uneasy or disturbed. Trees, structures, liquids, bodies of water may sway gently, and doors may swing very slowly.

II Felt indoors by a few people, especially on upper floors of multistory buildings, and by sensitive or nervous persons. As in Grade I, birds and animals are disturbed, and trees, structures, liquids and bodies of water may sway. Hanging objects swing, especially if they are delicately suspended.

III Felt indoors by several people, usually as a rapid vibration that may not be recognized as an earthquake at first. Vibration is similar to that due to passing of a light, or lightly loaded trucks, or heavy trucks some distance away. Duration may be estimated in some cases. Movements may be appreciable on upper levels of tall structures. Standing motor cars may rock slightly.

IV Felt indoors by many, outdoors by few. Awakens a few individuals, particularly light sleepers, but frightens no one except those apprehensive from previous experience. Vibration like that due to passing of heavy, or heavily loaded trucks. Sensation like a heavy body striking building, or the falling of heavy objects inside. Dishes, windows and doors rattle; glassware and crockery clink and clash. Walls and house frame creak especially if intensity is in the upper range of this grade. Hanging objects often swing. Liquids in open vessels are disturbed slightly. Stationary automobiles rock noticeably.

V Felt indoors by practically everyone, outdoors by most people. Direction can often be estimated by those outdoors. Awakens many, or most sleepers. Frightens a few people, with slight excitement; some persons run outdoors. Buildings tremble throughout. Dishes and glassware break to some extent. Windows crack in some cases, but not generally. Vases and small or unstable objects overturn in many instances, and a few fall. Hanging objects and doors swing generally or considerably. Pictures knock against walls, or swing out of place. Doors and shutters open or close abruptly. Pendulum clocks stop, or run fast or slow. Small objects move, and furnishings may shift to a slight extent. Small amounts of liquids spill from well-filled open containers. Trees and bushes shake slightly.

VI Felt by everyone, indoors and outdoors. Awakens all sleepers. Frightens many people; general excitement, and some persons run outdoors. Persons move unsteadily. Trees and bushes shake slightly to moderately. Liquids are set in strong motion. Small bells in churches and schools ring. Poorly built buildings may be damaged. Plaster falls in small amounts. Other plaster cracks somewhat. Many dishes
and glasses, and a few windows, break. Knick-knacks, books and pictures fall. Furniture overtops in many instances. Heavy furnishings move.

VII  **Frightens everyone. General alarm, and everyone runs outdoors.**
People find it difficult to stand. Persons driving cars notice shaking. Trees and bushes shake moderately to strongly. Waves form on ponds, lakes and streams. Water is muddied. Gravel or sand stream banks cave in. Large church bells ring. Suspended objects quiver. Damage is negligible in buildings of good design and construction; slight to moderate in well-built ordinary buildings; considerable in poorly built or badly designed buildings, adobe houses, old walls (especially where laid up without mortar), spires, etc. Plaster and some stucco fall. Many windows and some furniture break. Loosened brickwork and tiles shake down. Weak chimneys break at the roofline. Cornices fall from towers and high buildings. Bricks and stones are dislodged. Heavy furniture overturns. Concrete irrigation ditches are considerably damaged.

VIII  **General fright, and alarm approaches panic**
Persons driving cars are disturbed. Trees shake strongly, and branches and trunks break off (especially palm trees). Sand and mud erupts in small amounts. Flow of springs and wells is temporarily and sometimes permanently changed. Dry wells renew flow. Temperature of spring and well waters varies. Damage slight in brick structures built especially to withstand earthquakes; considerable in ordinary substantial buildings, with some partial collapse; heavy in some wooden houses, with some tumbling down. Panel walls break away in frame structures. Decayed pilings break off. Walls fall. Solid stone walls crack and break seriously. Wet ground and steep slopes crack to some extent. Chimneys, columns, monuments and factory stacks and towers twist and fall. Very heavy furniture moves conspicuously or overturns.

IX  **Panic is general**
Ground cracks conspicuously. Damage is considerable in masonry structures built especially to withstand earthquakes; great in other masonry buildings--some collapse in large part. Some wood frame houses built especially to withstand earthquakes are thrown out of plumb, others are shifted wholly off foundations. Reservoirs are seriously damaged, and underground pipes sometimes break.

X  **Panic is general**
Ground, especially when loose and wet, cracks up to widths of several inches; fissures up to a yard in width run parallel to canal and stream banks. Landsliding is considerable from river banks and steep coasts. Sand and mud shifts horizontally on beaches and flat land. Water level changes in wells. Water is thrown on banks of canals, lakes, rivers, etc. Dams, dikes, embankments are seriously damaged. Well-built wooden structures and bridges are severely damaged, and some collapse. Dangerous cracks develop in excellent brick walls. Most masonry and frame structures, and their foundations, are destroyed. Railroad rails bend slightly. Pipe lines buried in earth tear apart or are crushed endwise. Open cracks and broad wavy folds open in cement pavements and asphalt road surfaces.

XI  **Panic is general**
Disturbances in ground are many and widespread, varying with the ground material.
Broad fissures, earth slumps, and land slips develop in soft, wet ground. Water charged with sand and mud is ejected in large amounts. Sea waves of significant magnitude may develop. Damage is severe to wood frame structures, especially near shock centers; great to dams, dikes and embankments, even at long distances. Few if any masonry structures remain standing. Supporting piers or pillars of large, well-built bridges are wrecked. Wooden bridges that "give" are less affected. Railroad rails bend greatly, and some thrust endwise. Pipe lines buried in earth are put completely out of service.

XII  Panic is general

Damage is total, and practically all works of construction are damaged greatly or destroyed. Disturbances in the ground are great and varied, and numerous shearing cracks develop. Landslides, rock falls, and slumps in river banks are numerous and extensive. Large rock masses are wrenched loose and torn off. Fault slips develop in firm rock, and horizontal and vertical offset displacements are notable. Water channels, both surface and underground, are disturbed and modified greatly. Lakes are dammed, new waterfalls are produced, rivers are deflected, etc. Surface waves are seen on ground surfaces. Lines of sight and level are distorted. Objects are thrown upward into the air.