



1  **Earthquakes**


***Earth*, 9th edition, Chapter 11**

2  **Earthquakes: summary in haiku form**


*Built on shaky ground,
Memphis, south of New Madrid -
whole lotta shakin'...*

3  **Key Concepts**

- Earthquake basics.
- "Seismology" and locating earthquakes.
- Measuring the size of earthquakes.
- Destruction resulting from earthquakes.
- Predicting earthquakes.
- Earthquakes and the Plate Tectonics Model.

4  **What is an earthquake?**

- An earthquake is the vibration of Earth produced by the rapid release of energy
 - ☒ Energy released radiates in all directions from its source, the focus
 - ☒ Energy is in the form of waves
 - ☒ Sensitive instruments around the world record the event

5  **Earthquake focus and epicenter**

6  **What is an earthquake?**


- Earthquakes and faults
 - ☒ Movements that produce earthquakes are usually associated with large fractures in Earth's crust called faults
 - ☒ Most of the motion along faults can be explained by the plate tectonics theory

7  **What is an earthquake?**


- Elastic rebound
 - ☒ Mechanism for earthquakes was first explained by H.F. Reid
 - ◆ Rocks on both sides of an existing fault are deformed by tectonic forces
 - ◆ Rocks bend and store elastic energy
 - ◆ Frictional resistance holding the rocks together is overcome

8  **What is an earthquake?**


- Elastic rebound
 - ☒ Earthquake mechanism
 - ◆ Slippage at the weakest point (the *focus*) occurs
 - ◆ Vibrations (earthquakes) occur as the deformed rock "springs back" to its original shape (*elastic rebound*)
 - ☒ Earthquakes most often occur along existing faults whenever the frictional forces on the fault surfaces are overcome

9  **What is an earthquake?**

- Foreshocks and aftershocks
 - ☒ Adjustments that follow a major earth-quake often generate smaller earthquakes called *aftershocks*
 - ☒ Small earthquakes, called *foreshocks*, often precede a major earthquake by days or, in some cases, by as much as several years

10  **San Andreas: An active earthquake zone**















- San Andreas is the most studied fault system in the world
- Displacement occurs along discrete segments 100 to 200 kilometers long
 - ☒ Some portions exhibit slow, gradual displacement known as *fault creep*
 - ☒ Other segments regularly slip producing small earthquakes

11  **San Andreas: An active earthquake zone**

- Displacements along the San Andreas fault

- ☒ Still other segments store elastic energy for hundreds of years before rupturing in great earthquakes
 - ◆ Process described as *stick-slip motion*
 - ◆ Great earthquakes should occur about every 50 to 200 years along these sections
- 12 ☐ ***Displacement produced by the 1906 San Francisco earthquake***
- 13 ☐ ***Seismology***
 - The study of earthquake waves, *seismology*, dates back almost 2000 years to the Chinese
 - *Seismographs*, instruments that record seismic waves
 - ☒ Records the movement of Earth in relation to a stationary mass on a rotating drum or magnetic tape
- 14 ☐ ***Seismologist***

one who studies the shaking of Earth
- 15 ☐ ***Seismograph designed to record vertical ground motion***
- 16 ☐ ***Seismology***
 - *Seismographs*
 - ☒ More than one type of seismograph is needed to record both vertical and horizontal ground motion
 - ☒ Records obtained are called *seismograms*
 - Types of seismic waves
 - ☒ *Surface waves*
 - ◆ Travel along outer part of Earth
- 17 ☐ ***Seismographs***
- 18 ☐ ***A seismogram records wave amplitude vs. time***
- 19 ☐ ***Seismology***
 - Types of seismic waves
 - ☒ *Body waves*
 - ◆ Travel through Earth's interior
 - ◆ Two types based on mode of travel
 - ◆ *Primary (P) waves*
 - Push-pull (compress and expand) motion, changing the volume of the intervening material
 - Travel through solids, liquids, and gases
 - Generally, in any solid material, P waves travel about 1.7 times faster than S waves
- 20 ☐ ***Primary (P) waves***
- 21 ☐ ***Seismology***
 - Types of seismic waves
 - ☒ *Body waves*
 - ◆ *Secondary (S) waves*
 - "Shake" motion at right angles to their direction of travel
 - Travel only through solids
 - Slower velocity than P waves
 - Slightly greater amplitude than P waves
- 22 ☐ ***Secondary (S) waves***
- 23 ☐ ***Earthquake Waves***
- 24 ☐ ***Locating the source of earthquakes***
 - Terms:
 - ☒ *Focus*
 - ◆ the place within Earth where earthquake waves originate
 - ☒ *Epicenter*
 - ◆ location on the surface directly above the focus

- Epicenter is located using the difference in velocities of P and S waves
- 25  **Locating the source of earthquakes**
 - Locating the epicenter of an earthquake
 - ☒ Three station recordings are needed to locate an epicenter
 - ☒ Each station determines the time interval between the arrival of the first P wave and the first S wave at their location
 - ☒ A travel-time graph is used to determine each station's distance to the epicenter
- 26  **A travel-time graph is used to find the distance to the epicenter**
- 27  **Locating the source of earthquakes**
 - Locating the epicenter of an earthquake
 - ☒ A circle with a radius equal to the distance to the epicenter is drawn around each station
 - ☒ The point where all three circles intersect is the earthquake epicenter
- 28  **Epicenter is located using three or more seismographs**
- 29  **Locating the source of earthquakes**
 - Earthquake belts
 - ☒ About 95 percent of the energy released by earthquakes originates in a few relatively narrow zones that wind around the globe
 - ☒ Major earthquake zones include:
 - the Circum-Pacific belt
 - Mediterranean Sea region to the Himalayan complex
 - the oceanic ridge system
- 30  **Distribution of magnitude 5 or greater earthquakes, 1980 - 1990**
- 31  **Locating the source of earthquakes**
 - Earthquake depths
 - ☒ Earthquakes originate at depths ranging from 5 to nearly 700 kilometers
 - ☒ Earthquake foci arbitrarily classified as:
 - *shallow* (surface to 70 kilometers)
 - *intermediate* (between 70 and 300 kilometers)
 - *deep* (over 300 kilometers)
- 32  **Locating the source of earthquakes**
 - Earthquake depths
 - ☒ Definite patterns exist
 - Shallow focus occur along the oceanic ridge system
 - Almost all deep-focus earthquakes occur in the circum-Pacific belt, particularly in regions situated landward of deep-ocean trenches
- 33  **Relationship of earthquake depth to subduction zones**
- 34  **Measuring the size of earthquakes**
 - Two measurements that describe the size of an earthquake are:
 - ☒ *Intensity*
 - a measure of the degree of earthquake shaking at a given locale based on the amount of damage
 - ☒ *Magnitude*
 - estimates the amount of energy released at the source of the earthquake
- 35  **Santa Clara County Richter Scale**
- 36  **Measuring the size of earthquakes**
 - Intensity scales:
 - ☒ *Modified Mercalli Intensity Scale*
 - was developed using California buildings as its standard
 - ☒ The drawback of intensity scales is that destruction may not be a true measure of the earthquakes actual severity
- 37 
- 38  **Measuring the size of earthquakes**

- Magnitude scales
 - ☒ *Richter magnitude*
 - ◆ concept introduced by Charles Richter in 1935
 - ☒ *Richter scale*
 - ◆ Based on the amplitude of the largest seismic wave recorded
 - ◆ Accounts for the decrease in wave amplitude with increased distance
- 39 ***Measuring the size of earthquakes***
- Magnitude scales
 - ☒ *Richter scale*
 - ◆ Largest magnitude recorded on a Wood-Anderson seismograph was 8.9
 - ◆ Magnitudes less than 2.0 are not felt by humans
 - ◆ Each unit of Richter magnitude increase corresponds to a tenfold increase in wave amplitude and a 32-fold energy increase
- 40 ***Richter Scale of Earthquake Magnitude***
- 41 ***Measuring the size of earthquakes***
- Magnitude scales
 - ☒ *Other magnitude scales*
 - ◆ Several "Richter-like" magnitude scales have been developed
 - ◆ Moment magnitude was developed because none of the "Richter-like" magnitude scales adequately estimates the size of very large earthquakes
 - ◆ Derived from the amount of displacement that occurs along a fault
- 42 ***Earthquake destruction***
- Amount of structural damage attributable to earthquake vibrations depends on:
 - ☒ Intensity and duration of the vibrations
 - ☒ Nature of the material upon which the structure rests
 - ☒ Design of the structure
- 43 ***Earthquake destruction***
- Destruction from seismic vibrations
 - ☒ Ground shaking
 - ◆ Regions within 20 to 50 kilometers of the epicenter will experience about the same intensity of ground shaking
 - ◆ However, destruction varies considerably mainly due to the nature of the ground on which the structures are built
- 44 ***Damage caused by the 1964 Anchorage, Alaska earthquake***
- 45 ***Earthquake destruction***
- Destruction from seismic vibrations
 - ☒ Liquefaction of the ground
 - ◆ Unconsolidated materials saturated with water turn into a mobile fluid
 - ☒ Seiches
 - ◆ The rhythmic sloshing of water in lakes, reservoirs, and enclosed basins
 - ◆ Waves can weaken reservoir walls and cause destruction
- 46 ***Earthquake destruction***
- Destruction from seismic vibrations
 - ☒ Landslides
 - ◆ Hebgen Lake quake, 1959, M 7.5
 - ◆ Landslide buried Forest Service Campground, killing 26 campers
 - ◆ Quake Lake created by landslide
 - ◆
- 47 ***Damage caused by the 1959 Hebgen Lake, Montana earthquake***
- 48 ***Damage caused by the 1959 Hebgen Lake, Montana earthquake***
- 49 ***Damage caused by the 1959 Hebgen Lake, Montana earthquake***
- 50 ***Damage caused by the 1959 Hebgen Lake, Montana earthquake***

- 51 *Damage caused by the 1959 Hebgen Lake, Montana earthquake*
- 52 *Mid-continent Earthquakes:
Life NOT on the Edge*
- 53 *Earthquake Hazards in the U.S.*
- 54 *Now, for the exception...*

- 55 *Reelfoot Rift Zone
Seismicity:*

locations of earthquakes since 1974

source: USGS

- 56 *Way back in 1811 and 1812...*
- 57
- 58 *New Madrid in 1774*
- 59 *New Madrid in 1810*
- 60
- 61 *Waves on the Mississippi*
- 62 *Destruction on Land*
- 63 *Mercalli
vs.
Richter*
- 64 *Fault Structure*
- 65 *1811 – 1812 estimated magnitudes*
- 66 *1811 – 1812 estimated magnitudes*
- 67 *Intensity Map for 1811 - 1812*
- 68 *Relative Earthquake
Energy Transfer:*
- 69 *Oh no! A quiz!*

What's round on the ends and "high" in the middle?

- 70 *Answer:*
- 71 *t*
- 72 *t*
- 73 *1811 – 1812 estimated magnitudes*
- 74 *Reelfoot Lake: cypress trees*
- 75 *Reelfoot Lake*
- 76 *Reelfoot Lake*
- 77 *Memphis in the Crosshairs*

The King:

Jan. 8, 1935 – Aug. 16, 1977

- 78 *Memphis*
- 79 *AutoZone HQ, Memphis*
- 80 *The Sterick Building, Memphis*

Completed in 1930, repainted in 1960's, vacant since 1980's

- 81 *The St. Louis Arch
Completed in 1965, brought down in 20??*
- 82 *Earthquake Survival Kit
do you know where yours is?*

83  ***It could happen tomorrow...***

84  ***Earthquake destruction***

- *Tsunamis, or seismic sea waves*

- ☒ Destructive waves that are often inappropriately called “tidal waves”

- ☒ Result from vertical displacement along a fault located on the ocean floor or a large undersea landslide triggered by an earthquake

85  ***Earthquake destruction***

- *Tsunamis, or seismic sea waves*

- ☒ In the open ocean height is usually less than 1 meter

- ☒ In shallower coastal waters the water piles up to heights that occasionally exceed 30 meters

- ☒ Can be very destructive

- *Landslides and ground subsidence*

86  ***Formation of a tsunami***

87  ***Can earthquakes be predicted?***

- *Short-range predictions*

- ☒ Goal is to provide a warning of the location and magnitude of a large earthquake within a narrow time frame

- ☒ Research has concentrated on monitoring possible precursors

- ◆ phenomena that precede a forthcoming earthquake such as measuring uplift, subsidence, and strain in the rocks


88  ***Can earthquakes be predicted?***

- *Short-range predictions*

- ☒ Currently, no reliable method exists for making short-range earthquake predictions

- *Long-range forecasts*

- ☒ Give the probability of a certain magnitude earthquake occurring on a time scale of 30 to 100 years, or more

89  ***Can earthquakes be predicted?***

- *Long-range forecasts*


- ☒ Based on the premise that earthquakes are repetitive or cyclical

- ◆ Using historical records or paleoseismology

- ☒ Are important because they provide information used to

- ◆ Develop the Uniform Building Code

- ◆ Assist in land-use planning

90  ***End of Chapter***