Chapter 5 Study Guide and Case Studies: Earthquake Seismology

Key Concepts

- A fault is the surface expression of the fault plane. The orientation of the latter is described by the strike and dip. The foot wall is located below the fault plane, while the hanging wall is above it.
- The relative movement between two blocks is described by the slip vector. The slip vector is defined by three angles (the strike, dip and rake) and the displacement or slip.
- Normal earthquakes occur in an extensional stress regime (e.g. at divergent plate boundaries). The hanging wall moves downward.
- Reverse earthquakes occur in a compressional stress regime (e.g. at convergent plate boundaries). The hanging wall moves upward. Earthquakes with shallow dip are thrust events. Very large thrust events are called mega-thrust events. Earthquakes with very shallow dip are shallow thrust events. Blind thrust events occur on thrust faults that are covered by sediments. Thrust earthquakes can cause relatively large ground accelerations.
- Strike-slip earthquakes involve purely horizontal slip and occur in a shear-stress regime (e.g. at transform plate boundaries). The sense of slip (left-lateral or right-lateral) is determined by facing the opposing block and observing its relative movement. The San Andreas Fault (in California) and the North Anatolian Fault (in Turkey) are right-lateral strike-slip boundaries, while the Dead Sea Transform fault (in Jordan and Israel) is a left-lateral strike-slip boundary.
- The size of an earthquake scale with the fault plane. Large earthquakes are therefore more likely to occur on long faults compared to short faults.
- The amount of damage, the shaking and the energy released by an earthquake is described by the Mercalli intensity scale, Richter magnitude scale and moment magnitude scale respectively.
- The number of earthquakes occurring worldwide decreases exponentially with increasing moment magnitude, where each step on the moment magnitude scale is associated with an increase in released energy by a factor 30. Though very large earthquakes are rare, they nevertheless release the bulk of seismic energy every year.
- The recurrence time of an earthquake (time between two earthquakes of the same magnitude) determines its probability. Earthquakes with a long recurrence time have a lower probability to occur within a certain time period than earthquakes with a high probability.
- Asperities are protrusions in an earthquake fault that increase friction and may lock the fault. Stress builds up until the friction is over come and slip occurs. The

slip signifies an earthquake. These processes describe one cycle in the stick-slip model.

- Compressional waves (p-waves) and shear waves (s-waves) are body waves that travel through Earth from an earthquake to seismic stations. They arrive before the Rayleigh waves and Love waves, which are surface waves. The Rayleigh waves cause the most extensive shaking during an earthquake.
- The relative arrival time difference between s-waves and p-waves can be used to determine the epicentral distance of the recording station. The epicenter can be determined through triangulation using seismograms from three stations. Four stations are needed to determine the hypocenter.
- Forensic seismology is a relatively young field that can help discern earthquakes from anthropogenic events such as explosions and mine collapses. Forensic seismology also helps to detect and monitor induced seismicity that occur when fluids are pumped into the ground under high pressure or when large reservoirs change the ambient pore pressure in the rocks beneath.

Key Terms

- fault plane
- nucleation
- fault
- hanging wall
- foot wall
- hypocenter
- epicenter
- rupture area
- source time
- source duration
- strip
- dip
- rake
- slip vector
- displacement
- normal fault
- reverse fault
- thrust fault
- mega-thrust events
- blind thrust fault
- strike-slip fault
- Rose Canyon Fault
- Mercalli intensity scale
- Richter magnitude scale

- moment magnitude scale
- seismic moment
- radiated seismic energy
- seismicity
- recurrence time
- probability
- Parkfield Prediction Experiment
- Asperities
- stick-slip behavior
- stress drop
- aseismic creep
- period
- frequency
- wavelength
- compressional waves
- shear waves
- body waves
- surface waves
- Rayleigh waves
- Love waves
- Seismograph
- Seismometer
- Seismogram
- forensic seismology

Questions for Review

1. What is a fault?

2. Where relative to a fault is the foot wall located?

3. What is the difference between the epicenter and the hypocenter on an earthquake?

4. Which two angles define the orientation of the fault plane?

5. What does the slip vector indicate in an earthquake?

6. Explain the three principal types faults. On which type of plate boundaries do they typically occur?

7. On which faults are large earthquakes more likely to occur, on short or long faults?

8. Describe the three types of earthquake magnitude.

9. Which earthquakes are more likely to occur, small ones or large ones?

10. How much more seismic energy does a magnitude $Mw = 7.0$ earthquake radiate than a $Mw = 6.0$ earthquake?

11. What is the recurrence time of an earthquake of a particular magnitude?

12. Explain the concept of asperities.

13. Describe the steps involved in the stick-slip model.

14. Which seismic wave arrives first at a seismic station?

15. Which seismic wave causes the most severe shaking?

16. How many stations are needed to locate the hypocenter of an earthquake?

17. Describe and discuss an example of forensic seismology.