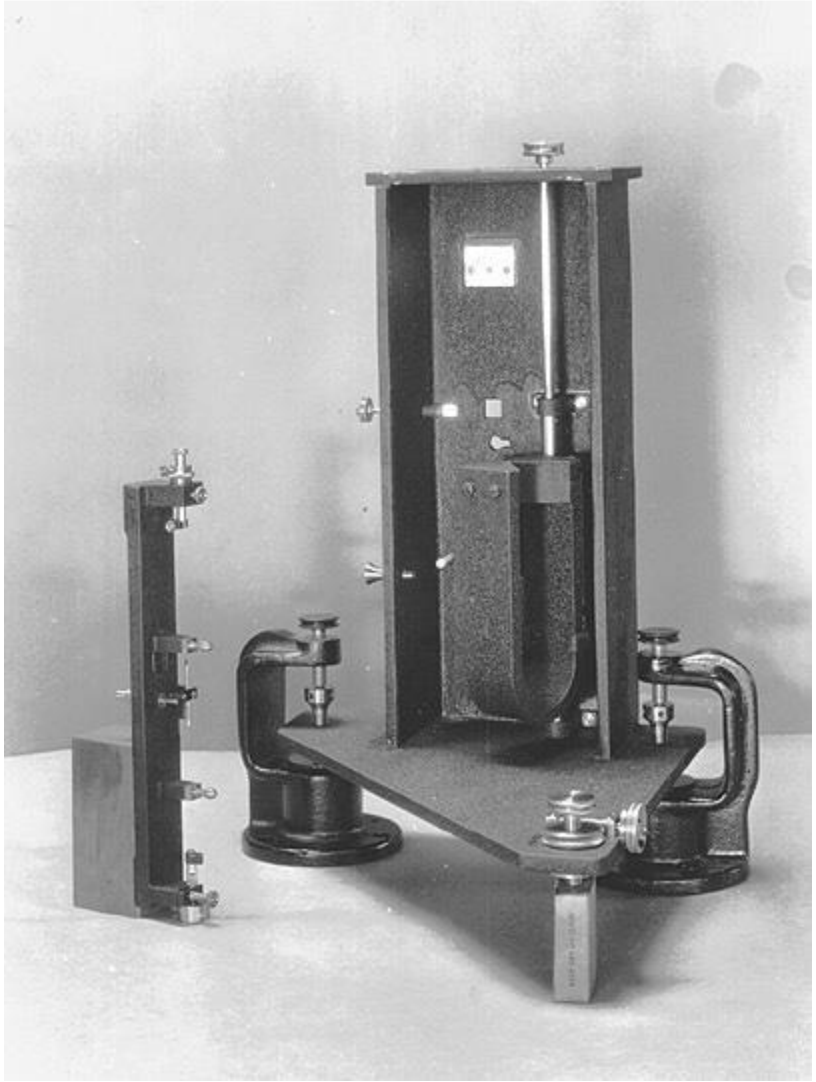
INTEGRATED EARTH SCIENCE

- LAB 15
- EARTHQUAKES

- Dr. Gregg Wilkerson and Larry Drennen



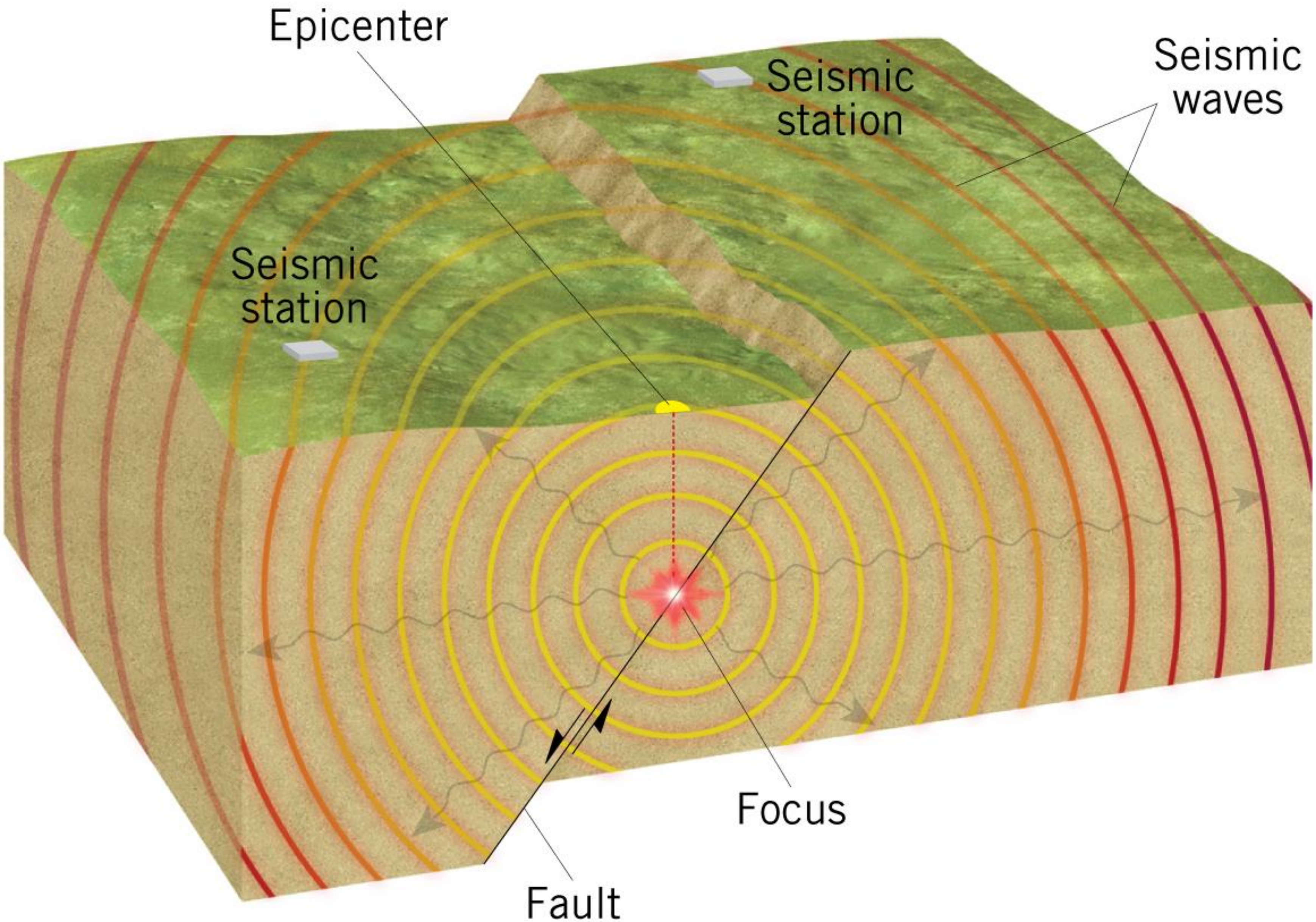
LABORATORY SIXTEEN

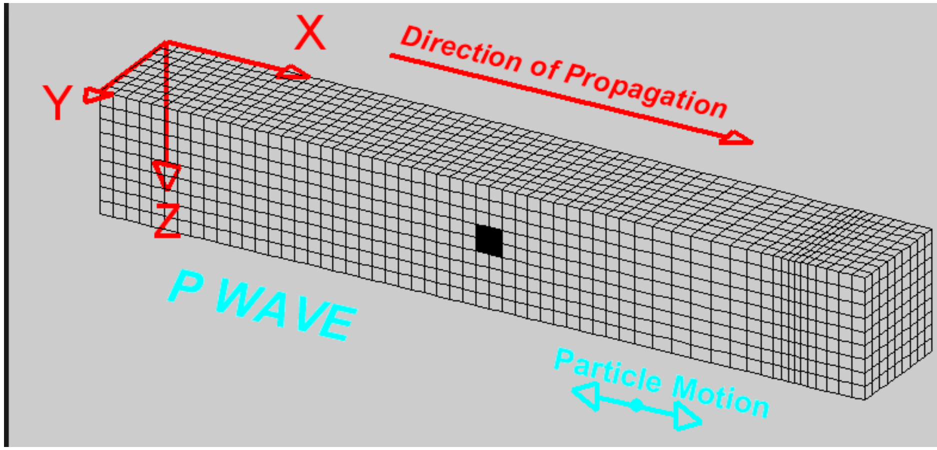
Earthquake Hazards and Human Risks
Activities 16.3, 16.4

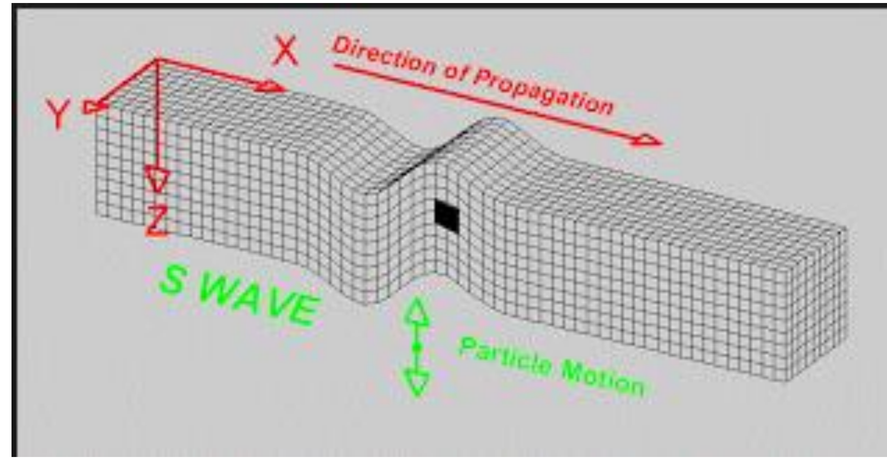
BIG IDEAS: Earthquakes are natural vibrations that originate below Earth's surface. An earthquake in the upper crust occurs when energy that had been stored in elastically deforming rock is quickly released and moves outward from the earthquake source area in the form of seismic waves. Most earthquakes recorded by seismographs are too small to be felt or cause damage, but damage associated with the largest earthquakes is often catastrophic when they occur at shallow depths near populated
areas. Vertical displacement of a fault under water during an earthquake can generate a tsunami that can cause great destruction far beyond the area shaken by the earthquake. Information collected by networks of seismographs not only tells us about the location
of the earthquake source but also provides a wealth of data about Earth's interior. Geoscientists provide information to engineers, architects, builders, public planners, politicians, and society in general that can help us to avoid the most dangerous effects
of earthquakes.

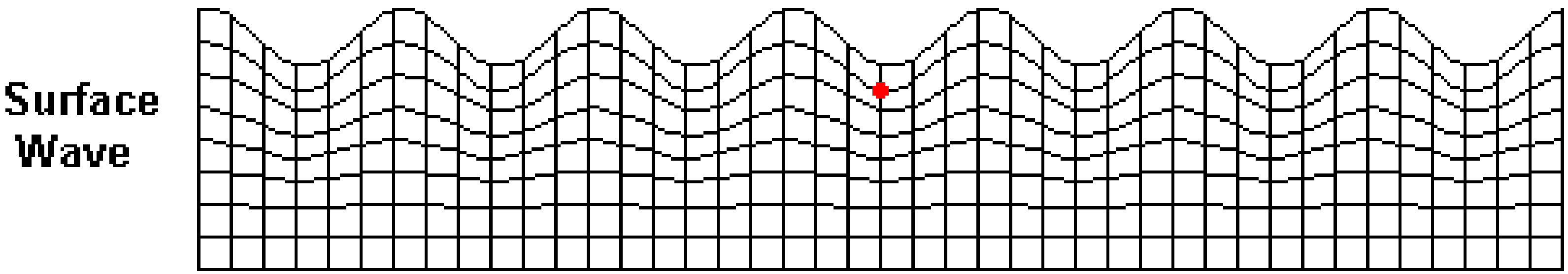
THINK ABOUT IT (Key Questions):

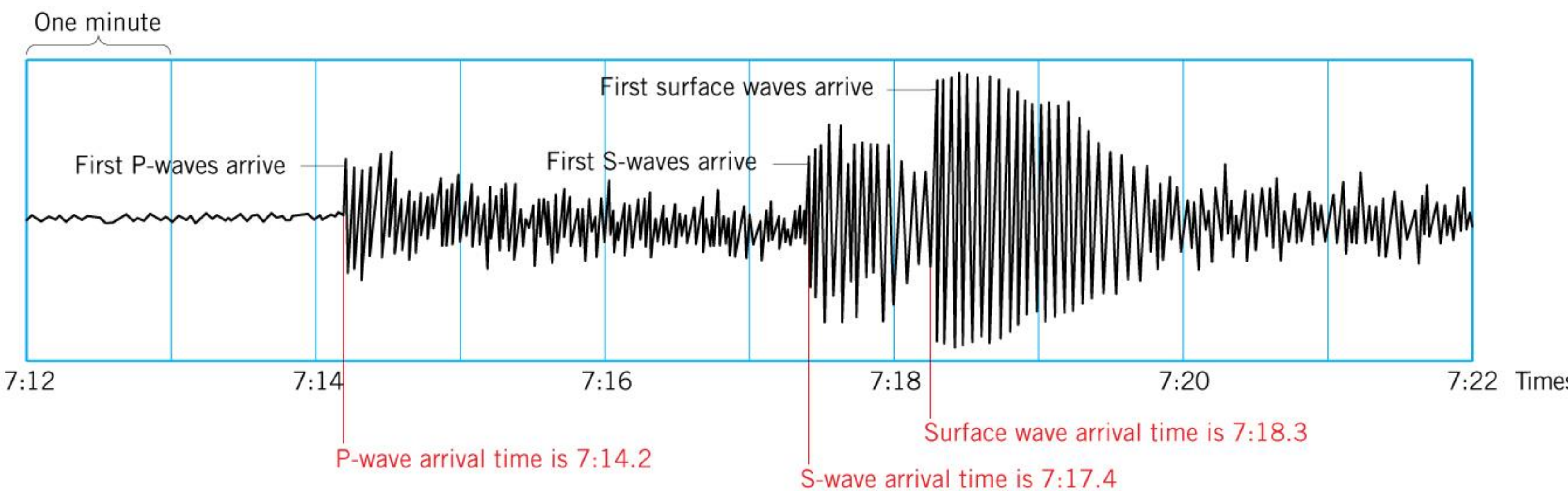
- How do bedrock and sediment behave during earthquakes, and how does this affect human-made structures? (Activity 16.1)
- How can information about seismic waves be used to locate the epicenter of an earthquake? (Activities 16.2 & 16.3)
- How do geologists use landscape features and focal mechanism studies to analyze fault motions? (Activities 16.4 & 16.5)

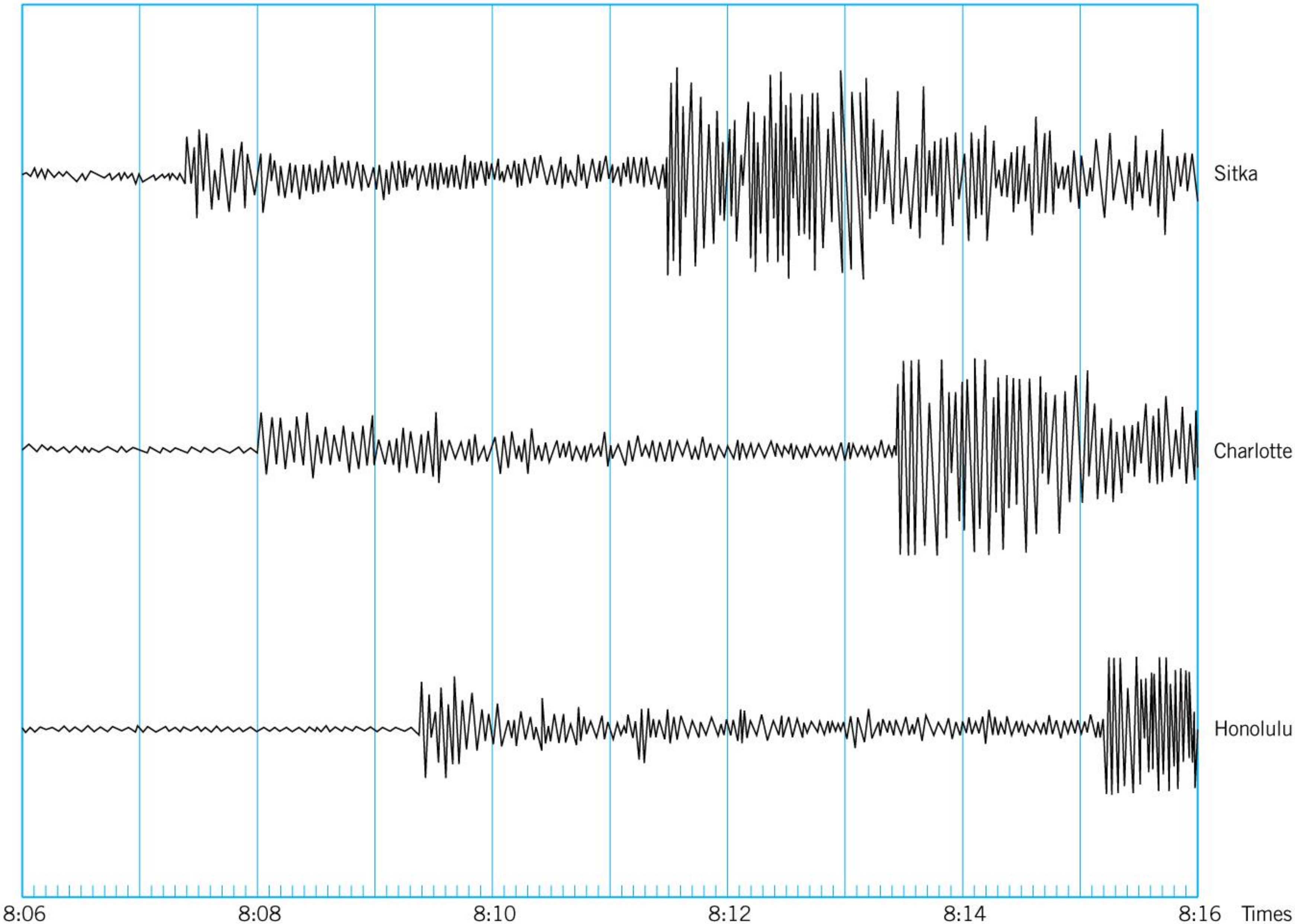

Epicenter
Seismic station
Seismic waves
Seismic station
Focus
Fault

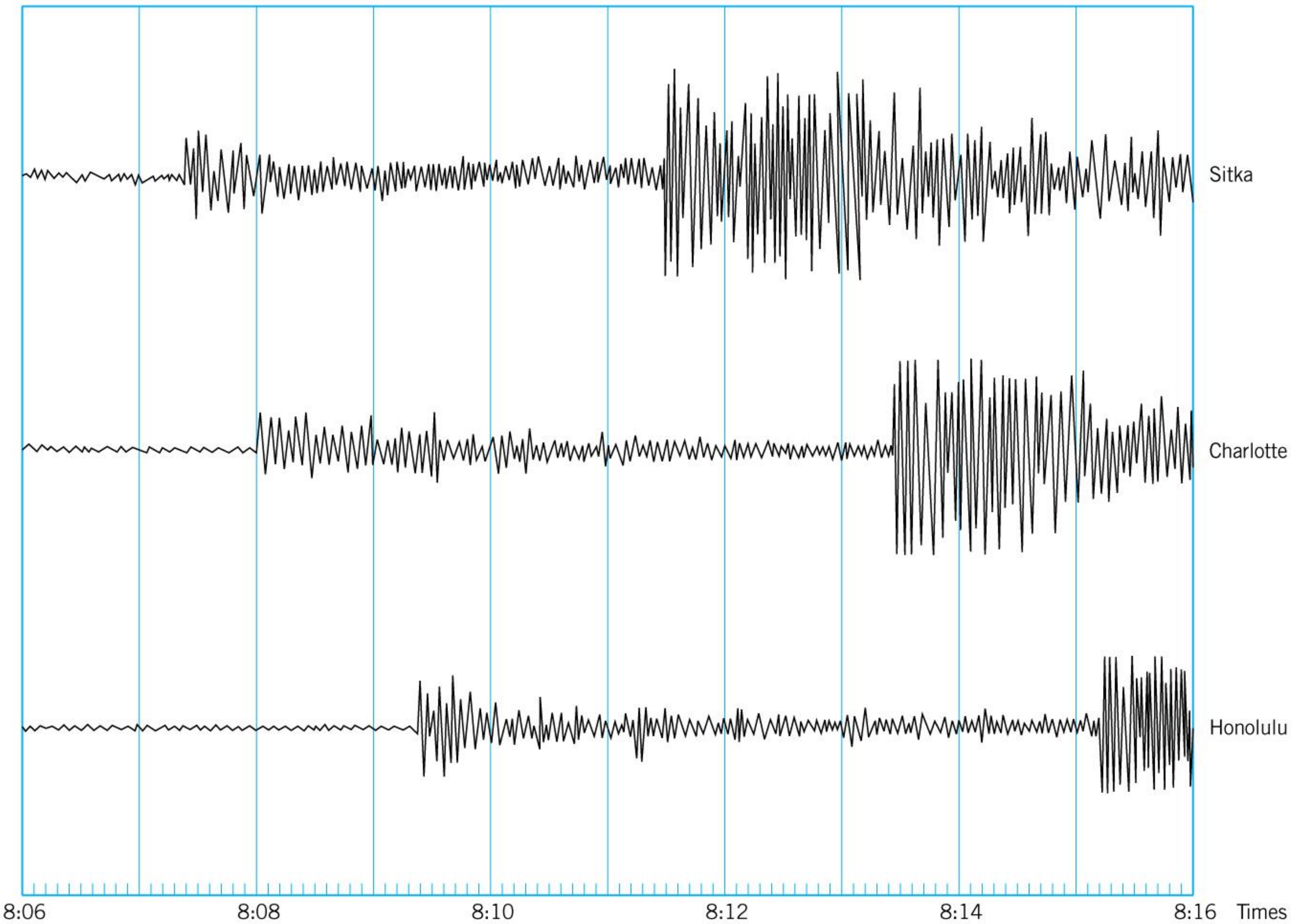

X
Y
Z
Direction of Propagation
P WAVE
Particle Motion


X
Y
Z
Direction of Propagation
S WAVE
Particle Motion


Surface Wave


One minute
First surface waves arrive
First P-waves arrive
First S-waves arrive
7:12
7:14
7:16
7:18
7:20
7:22
Times
Surface wave arrival time is 7:18.3
P-wave arrival time is 7:14.2
S-wave arrival time is 7:17.4


Sitka
Charlotte
Honolulu
8:06
8:08
8:10
8:12
8:14
8:16
Times



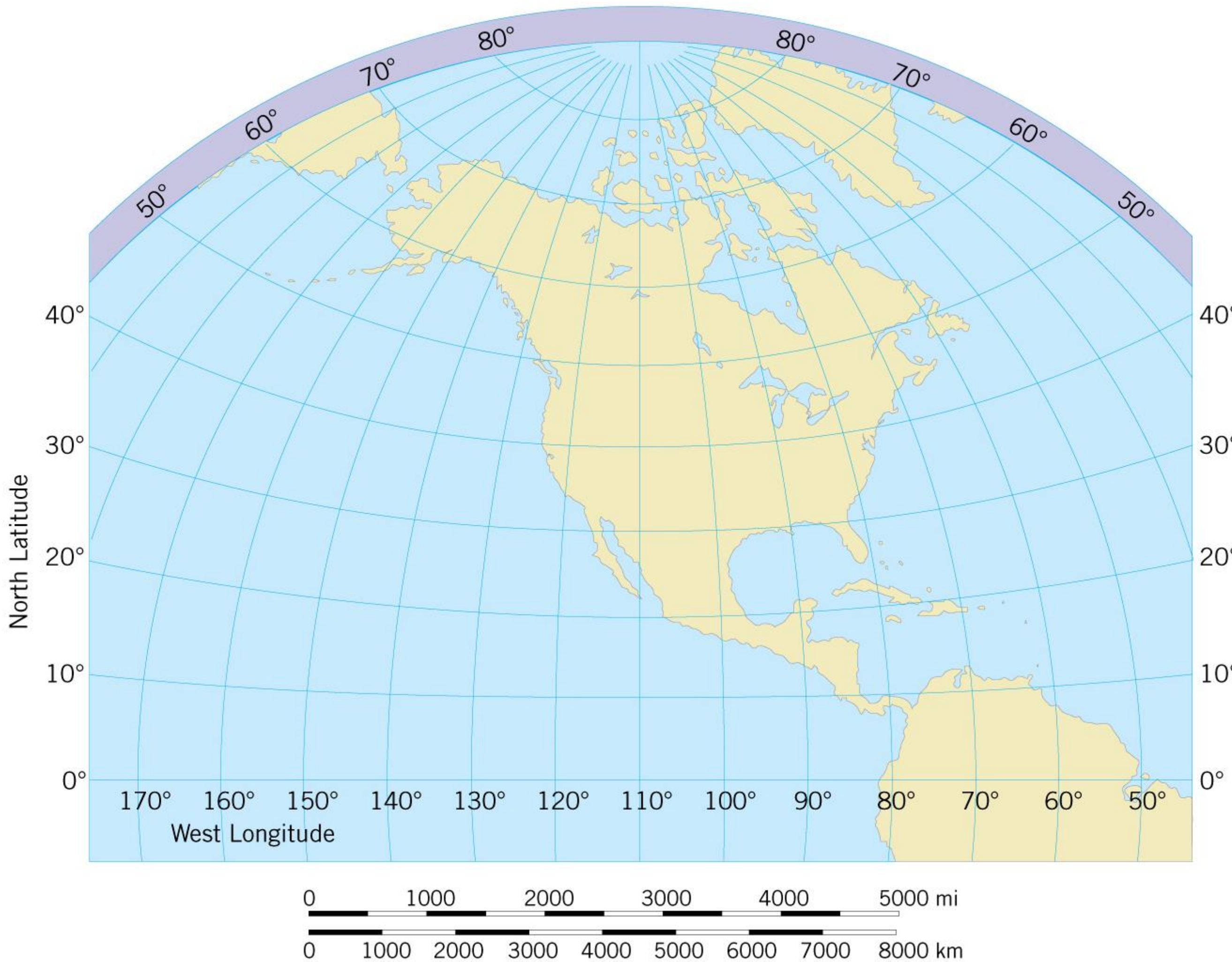
ACTIVITY 16.3: Locate the Epicenter of an Earthquake

16.3A

	First P arrival	First S arrival	S-minus-P time interval
Sitka, AK	8:07.4	8:11.5	4.1 minutes
Charlotte, NC	8:08.0	8:13.4	5.4 minutes
Honolulu, HI	8:09.4	8:15.2	5.8 minutes

16.3B Approximate epicentral distances are as follows:

Sitka ~2650 km Charlotte ~3800 km Honolulu ~4200 km

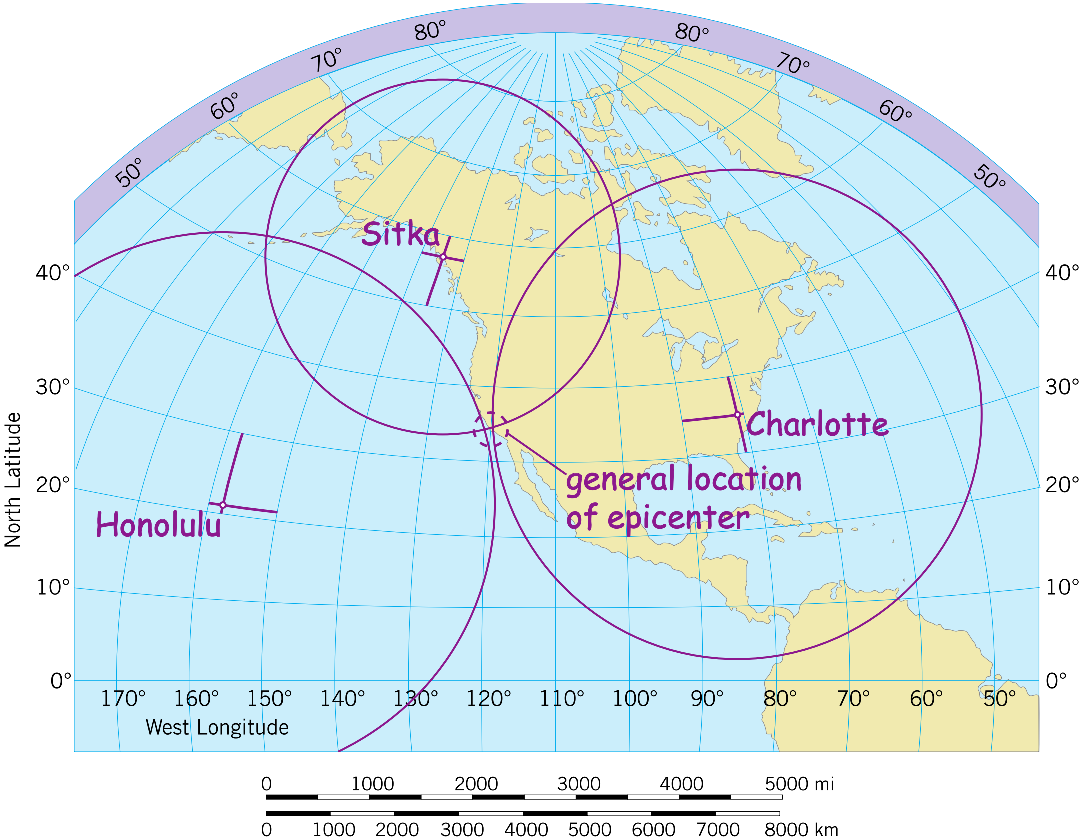


The kilometer bar scale printed on Figure A16.3.2 is ~67.5 mm long, and represents 8000 km on the ground in the map area. We can solve for the radii of the three circles using proportions as follows:

radius from Sitka = (67.5 mm * 2650 km)/8000 km = ~22.4 mm

radius from Charlotte = (67.5 mm * 3800 km)/8000 km = ~32.1 mm

radius from Honolulu = (67.5 mm * 4200 km)/8000 km = ~35.4 mm



16.3C 1. Refer to the annotated version of Figure A16.3.2 above.

2. *Very* approximate epicenter: N latitude ~34°, W longitude ~120°

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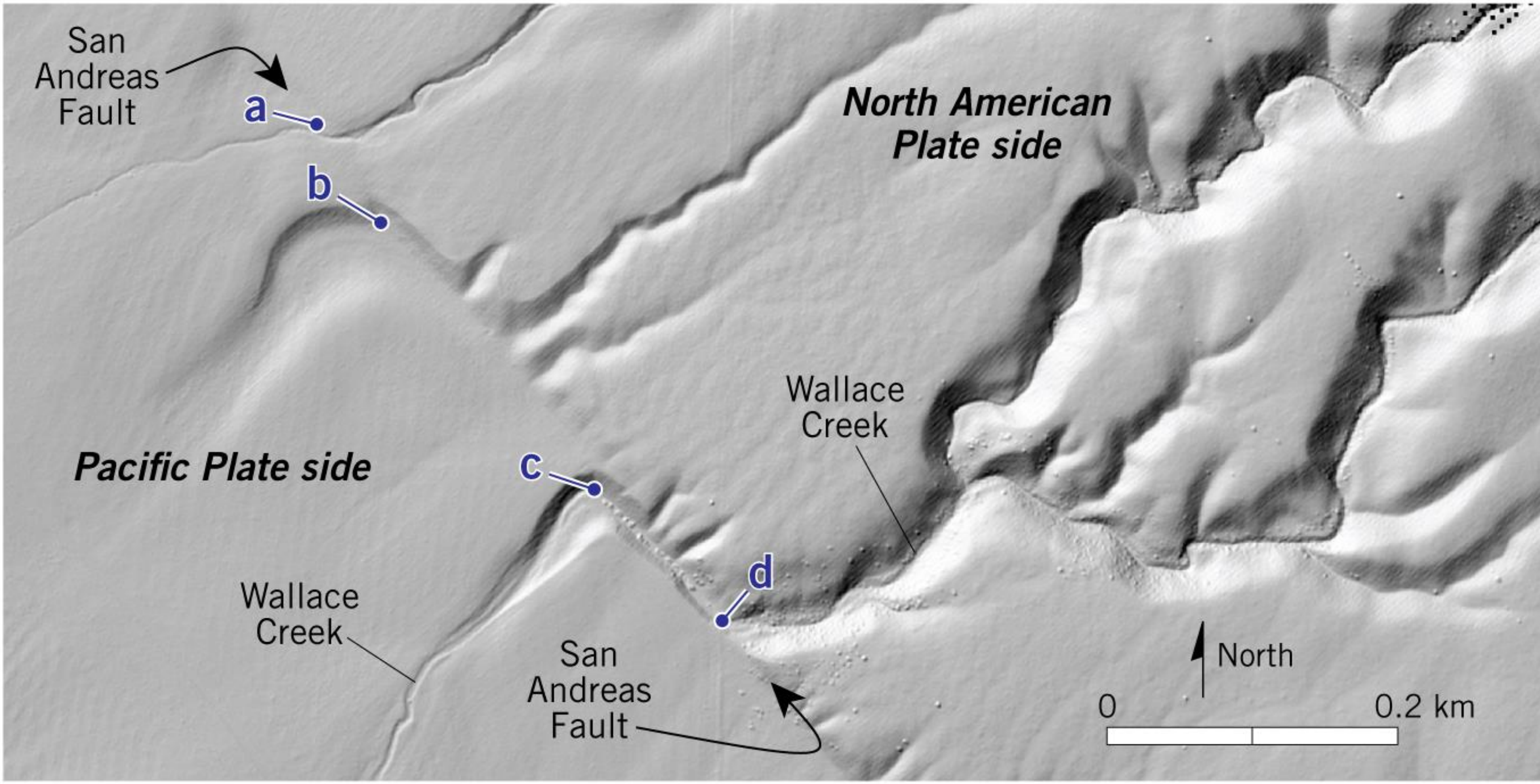
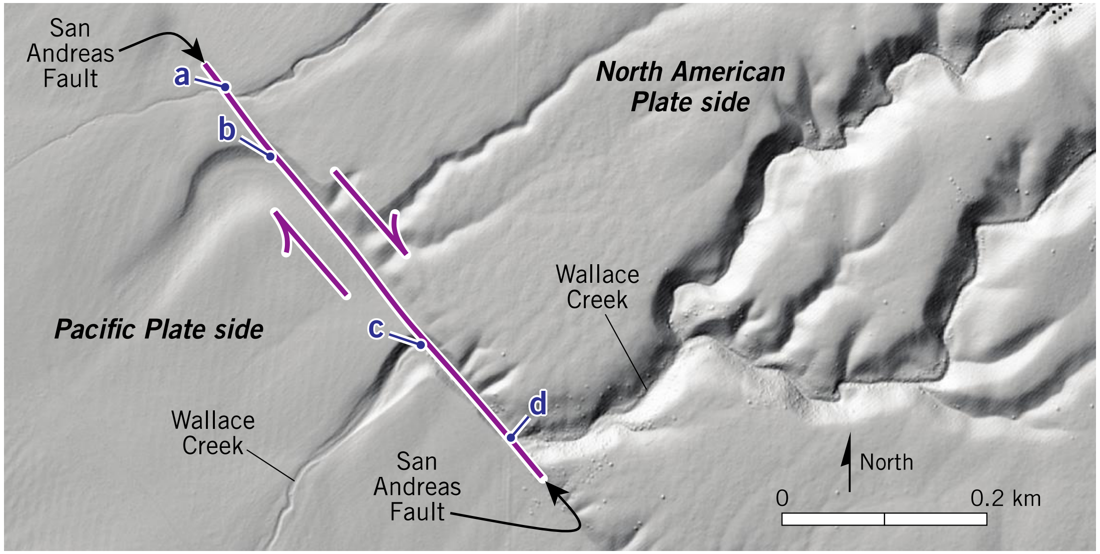
When students determine the epicenter of this earthquake, their arcs might intersect in a triangle rather than a point. The estimated location of the epicenter would be the center of the triangle. For some students, the arcs might not intersect both of the other arcs. In this case, the estimated epicenter would be where the three arcs would intersect if the radius of each was increased by just a little bit so that they intersected. The data provided indicate an epicenter located very approximately around 34° N, 120° W.

16.3D The San Andreas Fault is the closest well-known major fault to the epicenter.



	Distance (m)	Displacement time (yr)	Displacement rate (m/yr)
a to *b*		13,000 – 10,000 = ______	
b to *c*		10,000 – 3,700 = ______	
c to *d*		3,700	
a to *d*		13,000	

ACTIVITY 16.4: San Andreas Fault Analysis at Wallace Creek



16.4A1. Refer to the annotated version of Figure A16.4.1 above.

2. Student answers will vary. Stream drainages change their shape or appear to end (i.e., appear to be truncated) along the fault. In some places, the stream channel follows the fault trace for a short distance before resuming its typical direction. There appears to be a topographic step along the fault, with high ground to the NE and lower ground to the SW.

3. If you stand on the southwest side of the fault in the image above, then the northeast side of the fault seems to have moved Wallace Creek to the right. Thus, the San Andreas Fault is a right-lateral fault.

16.4B1. Approximately 29 mm on the map reflects a distance of 0.2 km or 200 m on the ground in the field area.

2. The fractional scale is 1: ~6897
200,000 mm/29 mm = ~6896.55

3. *a* to *b* is ___~11___ mm on the map or ___~75,862___ mm in the field.
b to *c* is ___~34___ mm on the map or ___~234,483___ mm in the field.
c to *d* is ___~18___ mm on the map or ___~124,138___ mm in the field.
a to *d* is ___~63___ mm on the map or ___~434,483___ mm in the field.

Fractional scale 1: ~6897
So 11 mm * 6897 = 7,862 mm

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a to *d* is ___~63___ mm on the map or __~434,483__ mm in the field.

	Distance (m)	Displacement time (yr)	Displacement rate (m/yr)
a to *b*	75.9	13,000 – 10,000 = 3000	0.0253
b to *c*	234.5	10,000 – 3,700 = 6300	0.0372
c to *d*	124.1	3,700	0.0336
a to *d*	434.5	13,000	0.0334

4. Refer to the annotated version of Figure A16.4.2 above.

16.4C (0.0334 m/yr) ÷ (0.051 m/yr) = ~0.6549, so slip along the San Andreas Fault at Wallace Creek has accommodated about 65% of the total displacement of the Pacific Plate relative to the North American Plate at that location during the past 13,000 years.

16.4D Reflect & Discuss There are several reasonable responses to the question of where the rest of the motion between the Pacific and North American Plates occurs, including the following:

- Perhaps the rest of the motion is accommodated on other faults and fault systems. We could refer to the Quaternary Fault and Fold Database of the United States to find information about faults along this broad plate-boundary zone that have been active during the Holocene.
- Perhaps the rest of the motion is accommodated through elastic strain and non-fault deformation, such as folding, uplift, subsidence, etc. We could look at GPS velocity data using online resources from NASA and UNAVCO, including the GPS Velocity Viewer and velocity records from the many individual GPS sites throughout the western US.

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