

# Activity— Foam Faults



This simple demonstration shows how tectonic plates move under compression and extension and helps students visualize the forces that shape our landscape. By watching the formation of mountains and valleys students gain an understanding of the motion of rock layers during normal, reverse and block faulting.

There are fancier blocks available for \$64–\$200 on the Internet, but this activity can be effectively done with simple home-made models.

## Science Standards (NGSS; pg. 287)

- Motion and Stability—Forces and Interactions: MS-PS2-2
- Energy: MS-PS3-5
- Earth’s Place in the Universe: MS-ESS1-4, HS-ESS1-5
- Earth’s Systems: HS-ESS2-1, MS-ESS2-2, HS-ESS2-2, MS-ESS2-3

## Additional Resources on this DVD & Internet relevant to Foam Faults

**VIDEOS**—in the folder on this DVD

 **VIDEOS\_Earthquake & Tsunami > DEMO\_Fault Models\_Butler.mov**

(or on the Internet: [http://www.iris.edu/hq/programs/education\\_and\\_outreach/videos#F](http://www.iris.edu/hq/programs/education_and_outreach/videos#F))

**ANIMATIONS**—are in the folder:  **2. ANIMATIONS\_Earthquake & Tsunami >  Faults**  
with a background document called: **0. EarthquakeFaults\_Background.pdf**

### INTERNET LINKS

Animations of faults, description of the processes, and other links are on the IRIS education site:  
[http://www.iris.edu/hq/programs/education\\_and\\_outreach/animations](http://www.iris.edu/hq/programs/education_and_outreach/animations)

# Teaching About Plate Tectonics and Faulting Using Foam Models

Activity modified from [L.W. Braille, Purdue University](#), by Chris Hedeem, Oregon City High School, OR

## Objective

Demonstrate plate tectonic principles, plate boundary interactions and the geometry and relative motions of faulting of geologic layers using 3-D foam models. The foam models aid in visualization and understanding of plate motions and faulting because the models are three-dimensional, concrete rather than abstract descriptions or diagrams, can be manipulated by the instructor and the students, and the models can show the motions of the plates and faults through time in addition to the three-dimensional configuration of the plates or layers. The fault and plate boundary models shown here illustrate relatively simple motions and geologic structures. Although these models are accurate representations of real Earth faulting and plate tectonic structures and motions, the spherical shape of the Earth and the complexity of geological features caused by varying rock types and rock properties and geological development over many millions or hundreds of millions of years, result in significant complexity and variability of actual fault systems and plate tectonic boundaries.

## Materials

Pre-made foam block models

**OR.....**

- Foam (open cell, foam mattress type) "blocks" shown in Figure 1A
- Felt pens (permanent marker, red and black)
- Manila folders or thin poster board
- Rubber cement
- Closed cell foam ("sleeping bag pads," camping equipment) as shown in Figures 3 and 5
- Pins
- Open cell foam as shown in Figure 3A
- Styrofoam core poster board, 0.6 cm (1/4 in) thick, as shown in Figure 3B
- Razor blade knife
- Metric ruler

## Procedures:

Prepare foam block models as shown in Figure 1A. Cardboard (cut from manila folders or thin poster board) attached to both faces of the fault plane allows the blocks to slip easily along the fault as forces are applied to the blocks.

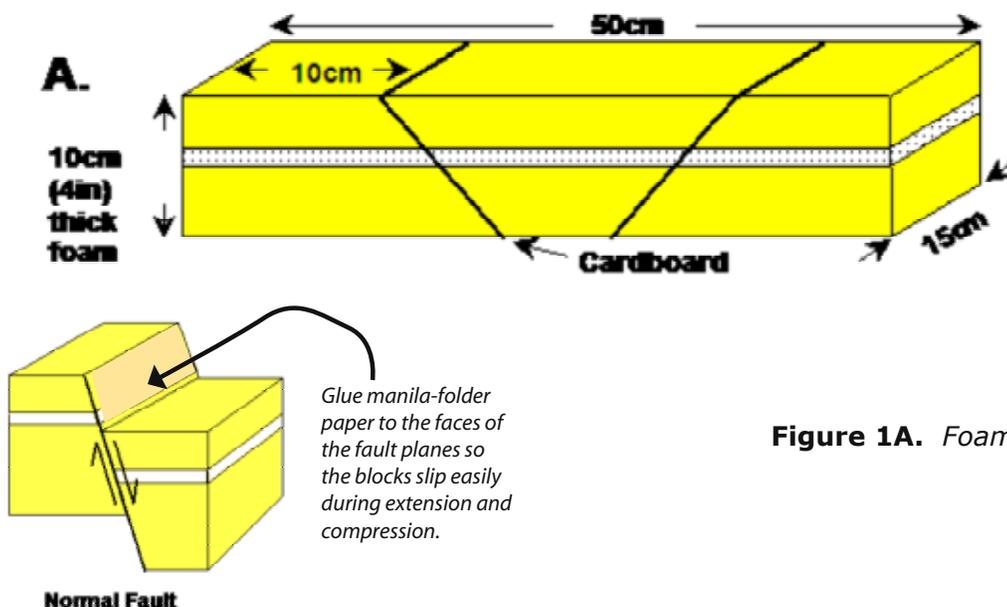


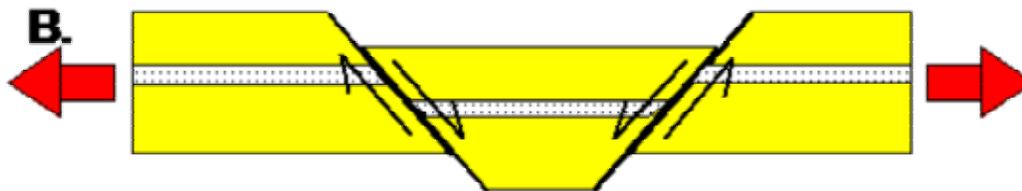
Figure 1A. Foam block model

# Types of Faulting and Plate Boundaries

## 1) Normal Faulting (Extension)

Use the block models to demonstrate **normal faulting** as the two outer blocks are moved **apart** as shown in Figure 1B. This procedure is best performed by holding the blocks “in the air” in front of you, supporting the model by the two outer blocks, rather than on a table. Note that as the two outer blocks are moved apart, the inner block drops downward or “subsides.” This relationship between extensional motion of geologic layers and downdropped fault blocks (graben or rift valley if the downdropped block is bounded on both sides by normal faults, as in this block model) produces normal faulting. It also represents the extensional motion and resultant rift development associated with divergent plate boundaries (Table 1).

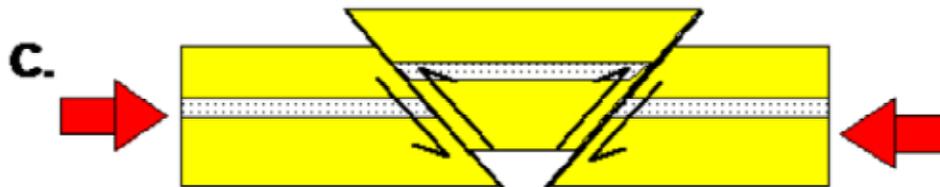
Examples of divergent plate boundaries, where extensional faulting is prominent, are the mid-ocean ridge system in which a narrow rift or graben (downdropped fault block) is commonly observed along the highest part of the ridge and the East African Rift in which extension has been occurring in the continental lithosphere for about 30 million years and the resulting rift system of normal faults is beginning to break apart the continent. In a plate-tectonic-related, but not plate boundary environment, the Basin and Range area of the Western United States displays a prominent topographic signature of extensional faulting with many adjacent downdropped fault blocks or grabens and the topographic “high” areas between the grabens are called horsts



**Figure 1B.** Normal faulting using the foam model. Red arrows represent extension. Half-arrows along faults show direction of relative motion along the fault plane.

## 2) Reverse (Thrust) Faulting (Compression)

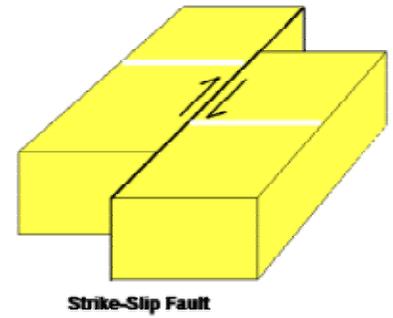
To demonstrate compressional motion and resulting **reverse** (also called thrust) faults hold the foam block models as described above and then move the two outer blocks **together** as in Figure 1C. The inner block will be thrust upwards producing reverse faults and an uplifted block. In a plate tectonic setting, such compressional motion is associated with convergent plate boundaries (Table 1) where two lithospheric plates are moving together or colliding (see also section 3 below). Not surprisingly, these convergent zones are associated with mountain ranges (Himalayas, Alps, Andes, etc.).



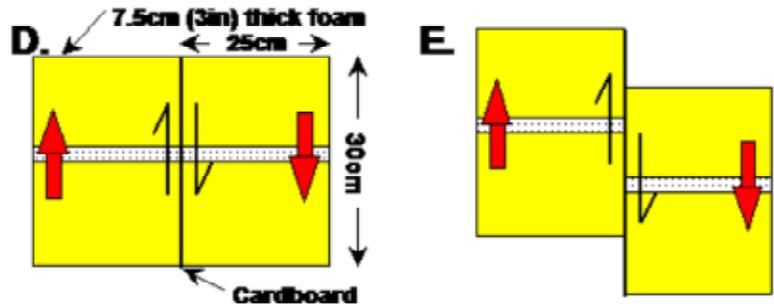
**Figure 1C.** Reverse faulting using the foam model. Red arrows represent compression. Half-arrows along faults show direction of relative motion along the fault plane.

### 3) Strike-slip or Horizontal slip fault motion (Shear)

Note: This does not require the building of a second model as suggested here. This motion can be modeled by looking at the top of the foam block model used above. Coloring in a feature to be offset such as a road or river shows the lateral offset of strike-slip faulting.



To demonstrate horizontal slip or strike-slip fault motion, prepare foam blocks as shown in Figure 1D. Moving the blocks horizontally on a tabletop, as shown in Figure 1E, demonstrates strike-slip or horizontal slip fault motion. This motion along a plate boundary is also called **transform** (Table 1). The San Andreas Fault zone is a system of strike-slip faults that form the transform plate boundary at the western edge of the North American Plate. Transform faults also occur as oceanic fracture zones between segments of the mid-ocean ridge spreading zones



**Figure 1D and 1E.** Strike-slip faulting using the foam model. Red arrows represent shearing. Half-arrows along faults show direction of relative motion along the fault plane.

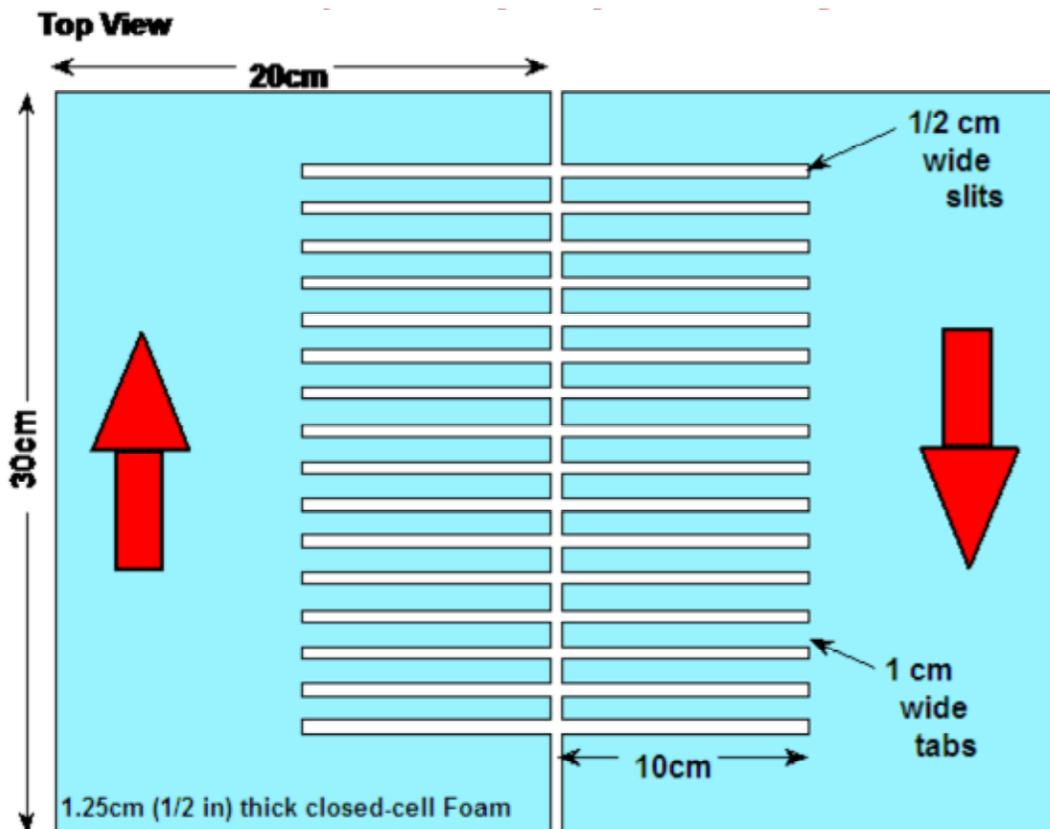
**Table 1: Faults, Plate Boundaries and Relative Motions**

Relative Motion of Layers or Plates	Fault Names	Plate Boundary Descriptions	Related Tectonic and Geologic Features
Extension	Normal	Divergent (extensional, moving apart, spreading, construction - because new lithosphere is generated in the extended zone)	Rifts, grabens, sometimes volcanism, regional uplift but local downdropped fault blocks, shallow earthquakes
Compression	Reverse or Thrust	Convergent (compressional, collision, subduction, moving together, destructive - because one plate is often thrust into the mantle beneath the other plate)	Folded mountain ranges, uplift, reverse faults, volcanic arcs (usually andesitic composite volcanoes), deep ocean trenches, shallow and deep earthquakes in subducted slab
Translation or horizontal slip	Strike-slip	Transform (horizontal slip, translation)	Linear topographic features, offset stream channels, lakes in eroded fault zone, pull-apart basins and local uplifts along fault bends or "steps" between offset fault segments, oceanic fracture zones, offsets of mid-ocean ridges

## Transform or Strike-Slip Plate Boundaries and Elastic Rebound

Use a razor-blade knife to make the foam “plate” models shown in Figure 2. The foam is 1.25 cm (1/2”) thick closed-cell foam often used for “sleeping pads” for camping. It is available at camping supply stores and Wal-Mart and Target. The foam pieces can be used on a tabletop or on an overhead projector (the slits cut in the foam allow the 10 cm long tabs which bend to be seen projected onto a screen). By continuously sliding the two plates past each other with the “tab” edges touching (Figure 5), the foam pieces represent lithospheric plates and the “zone” where the plates touch is a strike-slip (transform) fault. Note that as the plates move slowly with respect to each other (just as Earth’s lithospheric plates move at speeds of centimeters per year), the area of the plates adjacent to the fault (the tabs) becomes progressively bent (deformed), storing elastic energy. As the process

continues, some parts of the fault zone will “slip” releasing some of the stored elastic energy. This slip occurs when the stored elastic energy (bending of the tabs) results in a force along the fault which exceeds the frictional strength of the tabs that are in contact. Sometimes, only small segments of the fault zone (one or two tabs) will slip, representing a small earthquake. At other times, a larger segment of the fault will slip, representing a larger earthquake. Note that although the plate motions are slow and continuous, the slip along the fault is rapid (in the Earth, taking place in a fraction of a second to a few seconds) and discontinuous. The motions and processes illustrated by the foam model effectively demonstrates the processes which occur in actual fault zones and the concept of the elastic rebound theory (Bolt, 1993). A brief segment during the beginning of the video “Earthquake Country” illustrates a similar “stick-slip” motion using a model made of rubber strips.



**Figure 2:** Foam pieces used to demonstrate strike-slip faulting, elastic rebound theory, and slipping along the fault plane during earthquakes. Cut out slits with razor blade knife and straight-edge.

## Extensions, Connections, Enrichment:

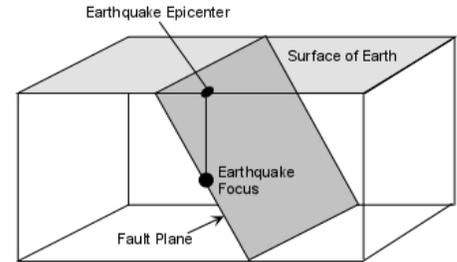
1. Good preparatory lessons for these activities are studies of elasticity (a spring and masses can be used to demonstrate the two fundamental characteristics of elasticity - the stretching is proportional to the force (suspended mass) and the existence of the “restoring force” (elastic energy is stored) in that the spring returns to its original length as the force (mass) is removed), and seismic waves which are generated as the fault slips.
2. The stick-slip process is well illustrated in a segment of the NOVA video “Killer Quake” in which USGS geophysicist Dr. Ross Stein demonstrates this process using a brick which is pulled over a rough surface (sandpaper) using an elastic cord (bungee cord). An experiment using this same procedure is described in “Seismic Sleuths” (AGU/FEMA).
3. Additional information on plate tectonics is available in Bolt (1993), Ernst (1991), Simkin et al. (1994), the TASA CD “Plate Tectonics,” “This Dynamic Earth,” and nearly any secondary school or college level geology textbook. Elastic rebound is well illustrated in Lutgens and Tarbuck (1996), Bolt (1993) and the TASA CD. An excellent description of plate tectonics can be found at: <http://pubs.usgs.gov/publications/text/understanding.html>.
4. An additional plate tectonic activity is the EPIcenter lesson plan “Voyage Through Time - A Plate Tectonics Flip Book” in which continental drift during the past 190 million years - a consequence of plate tectonics - is effectively illustrated; and Plate Puzzle which uses the “This Dynamic Planet” map.
5. Additional plate tectonic activities, especially for younger students, are contained in “Tremor Troop” (NSTA/FEMA).
6. A leading theory explaining why the Earth’s plates move is convection currents in the Earth’s mantle. The interior structure of the Earth is described in Bolt (1993) and is the subject of the EPIcenter activity “Earth’s Interior Structure.” Good activities illustrating convection are contained in the GEMS guide “Convection - A Current Event” (Gould, 1988), or “Tremor Troop” (NSTA/FEMA).

## References:

- Bolt, B.A., *Earthquakes and Geological Discovery*, Scientific American Library, W.H. Freeman, New York, 229 pp., 1993.
- Braile, L.W., “Earth’s Interior Structure” - <http://web.ics.purdue.edu/~braile/educindex/educindex.htm>.
- Braile, L.W. and S.J. Braile, “Voyage Through Time - A Plate Tectonics Flip Book” - <http://web.ics.purdue.edu/~braile/educindex/educindex.htm>.
- Braile, L.W. and S.J. Braile, “Plate Puzzle” - <http://web.ics.purdue.edu/~braile/educindex/educindex.htm>.
- Ernst, W.G., *The Dynamic Planet*, Columbia University Press, New York, 281 pp., 1990.
- FEMA/AGU, *Seismic Sleuths - Earthquakes - A Teachers Package on Earthquakes for Grades 7-12*, American Geophysical Union, Washington, D.C., 367 pp., 1994. (FEMA 253, for free copy, write on school letterhead to: FEMA, PO Box 70274, Washington, DC 20024).
- Gould, A., *Convection - A Current Event*, GEMS, Lawrence Hall of Science, Berkeley, California, 47 pp., 1998.
- IRIS, Western US Seismicity and Topography Poster, [www.iris.edu](http://www.iris.edu).
- Lutgens, F.K., and E.J. Tarbuck, *Foundations of Earth Science*, Prentice-Hall, Upper Saddle River, New Jersey, 482 pp., 1996.
- NSTA/FEMA, *Tremor Troop - Earthquakes: A teacher’s package for K-6 grades*, NSTA Publications, Washington, DC, 169 pp., 1990. (This book contains a reasonably complete curriculum for teaching earthquake and related Earth science topics; FEMA 159, for free copy, write on school letterhead to: FEMA, PO Box 70274, Wash., DC 20024).
- Simkin et al., *This Dynamic Planet*, map, USGS, 1:30,000,000 scale (\$7 + \$5 shipping), 1994, also at: <http://pubs.usgs.gov/pdf/planet.html>; 1-888-ASK-USGS.
- TASA “Plate Tectonics” CD-Rom - Plate tectonics, earthquakes, faults, (\$59 or \$155 for site license), (800-293-2725) <http://www.tasagraphicarts.com>, Mac or Windows.
- U.S. Geological Survey, *This Dynamic Earth: The Story of Plate Tectonics*, available from: U.S. Geological Survey, Map Distribution, Federal Center, PO Box 25286, Denver, CO 80225, \$6, (800 USA MAPS). Also available (full text and figures) for viewing at: <http://pubs.usgs.gov/publications/text/dynamic.html>.
- Videos (NOVA “Killer Quake,” and “Earthquake Country”) - information available in “Seismology-Resources for Teachers” online at: <http://web.ics.purdue.edu/~braile/edumod/seisres/seisresweb.htm>.

# Types of Faults

A **fault** is a fracture or zone of fractures between two blocks of rock. Blocks move relative to each other along the fault plane. This movement may occur rapidly, in the form of an **earthquake** or may occur slowly, in the form of creep. Faults may range in length from a few millimeters to thousands of kilometers. Most faults produce repeated displacements (movement) over geologic time. During an earthquake, the rock on one side of the fault suddenly moves with respect to the other. The fault surface can be **horizontal**, **vertical** or **oblique** (horizontal and vertical displacement).



## Strike-Slip Faults

**Strike-slip faults** develop when rocks are subjected to shear stress. In strike-slip faults, the movement is purely horizontal, with no up-and-down displacement. We classify strike-slip faults as either right lateral or left lateral. Imagine yourself standing on one side of a strike-slip fault, so that you are facing the fault. If the block on the other side is displaced to your right, the fault is a right lateral strike-slip fault (Figure 1). If the block on the other side of the fault is displaced to your left, the fault is a left lateral strike-slip fault.

Notice that pure strike-slip faults do not produce fault scarps. There are other tell-tale changes in the landscape that signal strike-slip faulting. The zigzag effect (offset) of the creek channel is the result of movement along the fault (Figure 1). As you might guess, where the two massive blocks on either side of a strike-slip fault grind against each other, rock is weakened. Streams flowing across strike-slip faults are often diverted to flow along this weakened zone.

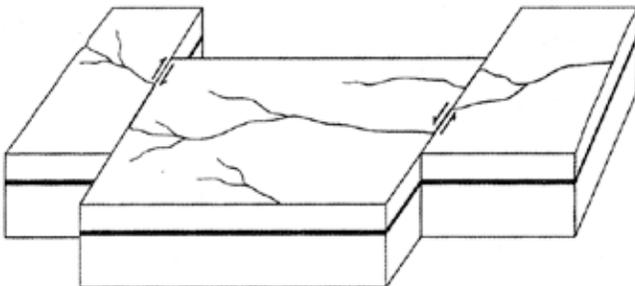


Figure 1. Right and left-lateral strike-slip faults.

## Dip-Slip Faults

When distinguishing between the types of **dip slip faults**, we define the block of rock above the fault plane as the **hanging wall** block and the block of rock below the fault plane as the **footwall** block (Fig.2). The terms "hanging wall" and "footwall" are old mining terms. The hanging wall block was the block of rock where miners would hang their lanterns; the footwall block was where miners would walk. It is easy to determine which side of the fault is the hanging wall if you imagine a miner standing on the fault plane. The hanging wall will be the block above the miner's head; the footwall will be the block below the miner's feet. Strike-slip faults are vertical and thus do not have hanging walls or footwalls.



If rocks break under tensional stress, the hanging wall will move down relative to the footwall and a **normal fault** forms (Figure 2). In this situation, the crust actually extends and lengthens.

When rocks break under compressional stress, the hanging wall moves up relative to the footwall, and a **reverse fault** forms (Figure 3). In a reverse, the crust is shortened. **Thrust faults** (Figure 4) are simply reverse faults in which the angle formed by the fault plane and the surface is quite shallow.

Commonly, the fault plane itself can become grooved and polished as one block of rock scrapes against the other. The scratches on the fault plane surface are called **slickensides**. Slickensides may record the slip orientation of the fault plane, and may even feel smoother in the direction of slip.

There is another relationship between rocks on either side of the fault plane that can be used in distinguishing normal and reverse faults and are seen in Figures 2 and 3. If the rocks are right side up then the normal fault brings down younger rocks over older rocks. Under the same conditions the reverse fault moves older rocks over younger rocks.

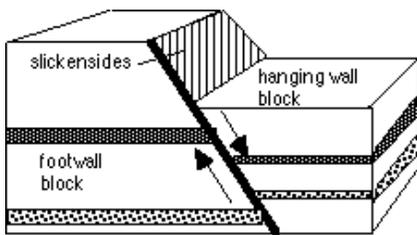


Figure 2. Normal Fault

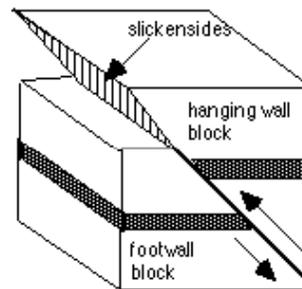


Figure 3. Reverse Fault

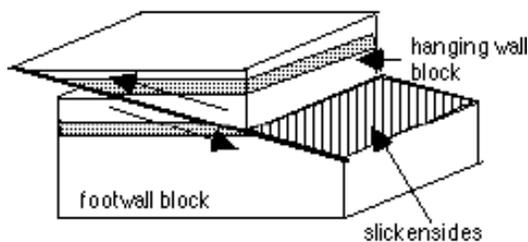


Figure 4. Thrust Fault

## Model of Three Faults

### Procedures

1. Color the fault model that is included according to the color key provided.
2. Cut out the fault model and fold each side down to form a box with the drawn features on top.
3. Tape or glue the corners together. This box is a three-dimensional model of the top layers of the Earth's crust.
4. **The dashed lines on your model represent a fault.** Carefully cut along the dashed lines. You will end up with two pieces.

# Types of Faults

Name:

Per:

Date:

1. Referring to Figure 1, does it make any difference which side of the fault you stand on in naming the right-lateral or left lateral strike-slip fault? Explain.



Figure 1

2. Compare and contrast a reverse fault and a thrust fault.
3. Explain how slickensides are used to determine the slip orientation of the fault plane.

## Model of Three Faults

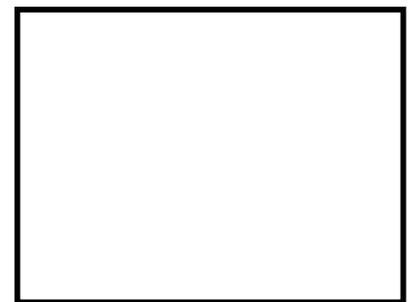
### Normal Fault

Locate points A and B on your model. Move point B so that it is next to Point A. Observe your model from the side (its cross-section).

Draw the normal fault as represented by the model you have just constructed.

### Questions

1. Which way did point B move relative to point A?
2. What happened to rock layers X, Y and Z?
3. Are the rock layers still continuous?
4. What likely happened to the road? The railroad tracks?
5. Is this type of fault caused by tension, compression or shearing? Explain.
6. On the drawing label the hanging wall and the footwall.



Normal Fault

*Many normal faults are found in Nevada. This is because Nevada is located in a region called the Basin and Range Province where the lithosphere is stretching.*

## Reverse Fault

Locate points C and D on your model. Move Point C next to point D. Observe the cross-section of your model.

Draw the reverse fault as represented by the model you have just constructed.

### Questions

1. Which way did point D move relative to point C?
2. What happened to rock layers X, Y and Z?
3. Are the rock layers still continuous?
4. What likely happened to the river?
5. Is this type of fault caused by tension, compression or shearing? Explain.
6. On the drawing label the hanging wall and the footwall.



**Reverse Fault**

Faults are important in mineral and petroleum exploration as they may either seal and act as a barrier to fluid flow (e.g., due to smearing of mud or shale along them), or may be important conduits for the migration of petroleum or mineralizing fluids. Many mineral deposits are fault and fracture controlled. Recognition of faults is also important in hydrogeological studies as fracturing along faults may produce hard-rock aquifers.

***An example of a thrust fault is the fault in which the Northridge earthquake occurred. The thrusting movement raised the mountains in the area by as much as 70 cm.***

# Strike-Slip Fault

Locate points F and G on your model. Move the pieces of the model so that point F is next to point G.

Draw an **overhead** view of the surface as it looks after movement along the fault.

## Strike-slip Questions:

1. If you were standing at point F and looking across the fault, which way did the block on the opposite side move?
2. What happened to rock layers X, Y, and Z?
3. Are the rock layers still continuous?
4. What likely happened to the river?
5. If the scale used in this model is 1 mm = 2 m, how many meters did the earth move when the strike-slip fault caused point F to move alongside point G?  
**(Show all calculations for full credit)**



**Strike-slip Fault**

(Note that this scale would make an unlikely size for the railroad track!) If there were a sudden horizontal shift of this magnitude it would be about five times the shift that occurred in the 1906 San Andreas fault as a result of the San Francisco earthquake.

6. Is this type of fault caused by tension, compression or shearing? Explain.
7. Is the strike-slip fault a right or left – lateral movement? Explain.

***A strike-slip fault can be described as having right or left-lateral movement. If you look directly across the fault, the direction that the opposite side moved defines whether the movement is left-lateral or right-lateral. The San Andreas Fault in California is a right-lateral strike-slip fault.***

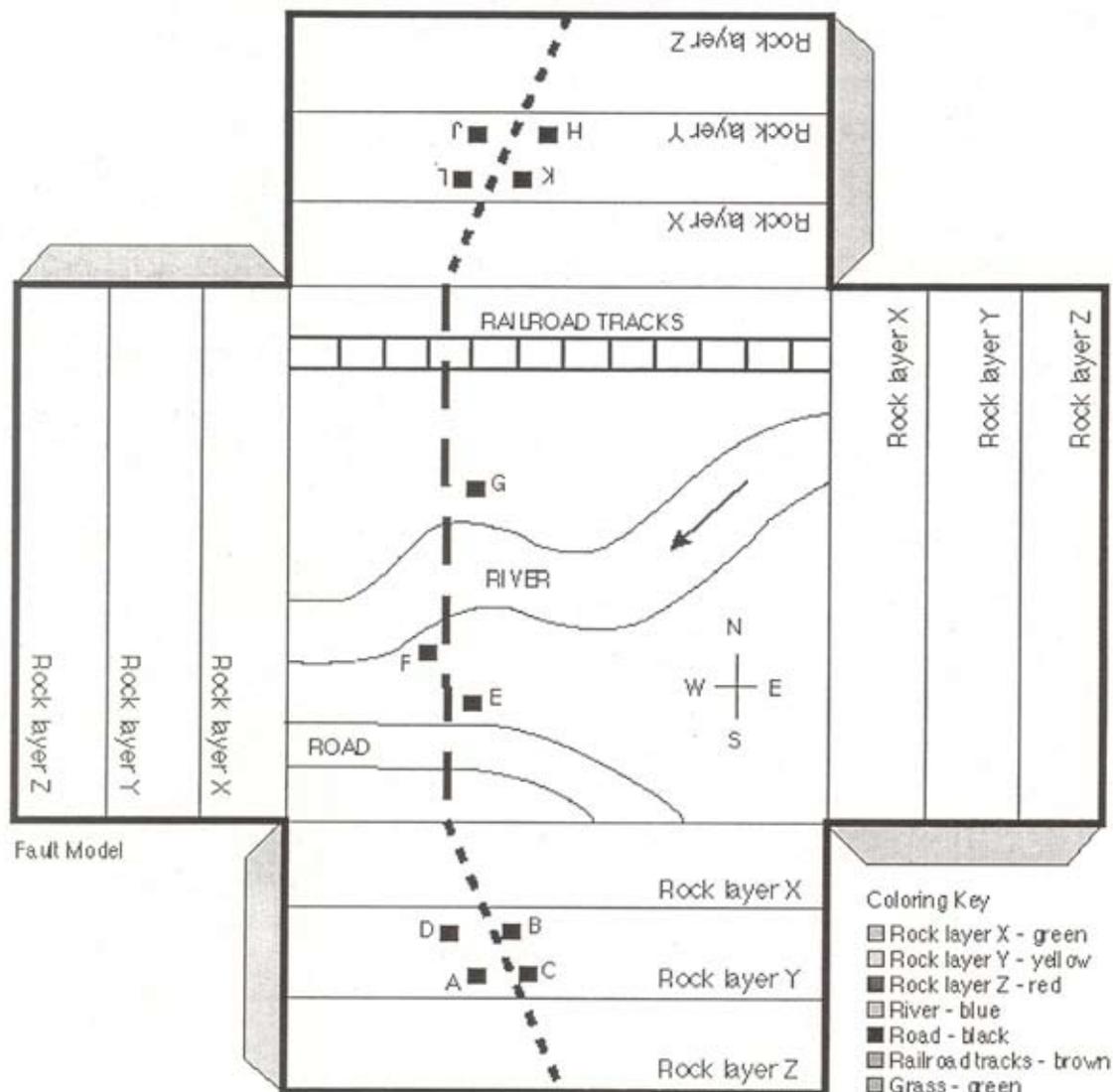
## Reinforcement

1. Explain the miner's method of naming faults. Use a simple diagram showing the shaft, fault line, hanging wall, and footwall for normal and reverse faults. How did the walls get their names?
2. Name and describe the types of faults and folds that form in convergent margins. Use a simple diagram to illustrate your answer.
3. Name and describe the types of faults that form in a rift valley/mid-ocean ridge. Explain why normal faults form at divergent boundaries. Use simple diagrams to illustrate both answers.
4. Name and describe the types of faults that form along a transform boundary. Use a simple diagram to illustrate your answer.

## Extra Credit

**Research and classify two of the faults below. Be sure to cite the internet URL.**

- Portland Hills Fault
- Molalla Canby Fault
- Burns Fault



# Faults: Types of Faulting

Name:

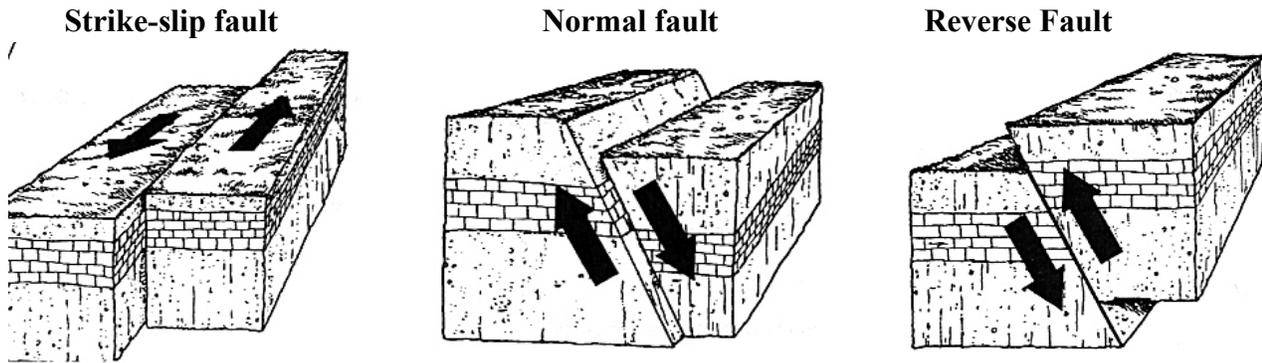
Due:

Per: Date:

## How Do Earthquakes Happen Along Plate Boundaries and Faults?

Earthquakes occur when there is a sudden movement on the Earth's crust. Most movement on the Earth's crust takes place along plate boundaries. There are three main types of plate boundaries; they include converging (moving together), diverging (moving apart), and sliding or transform plate boundaries. **There is a direct correlation between the plate boundary and the type of fault associated with an earthquake.**

Figure 1: Types of Faults

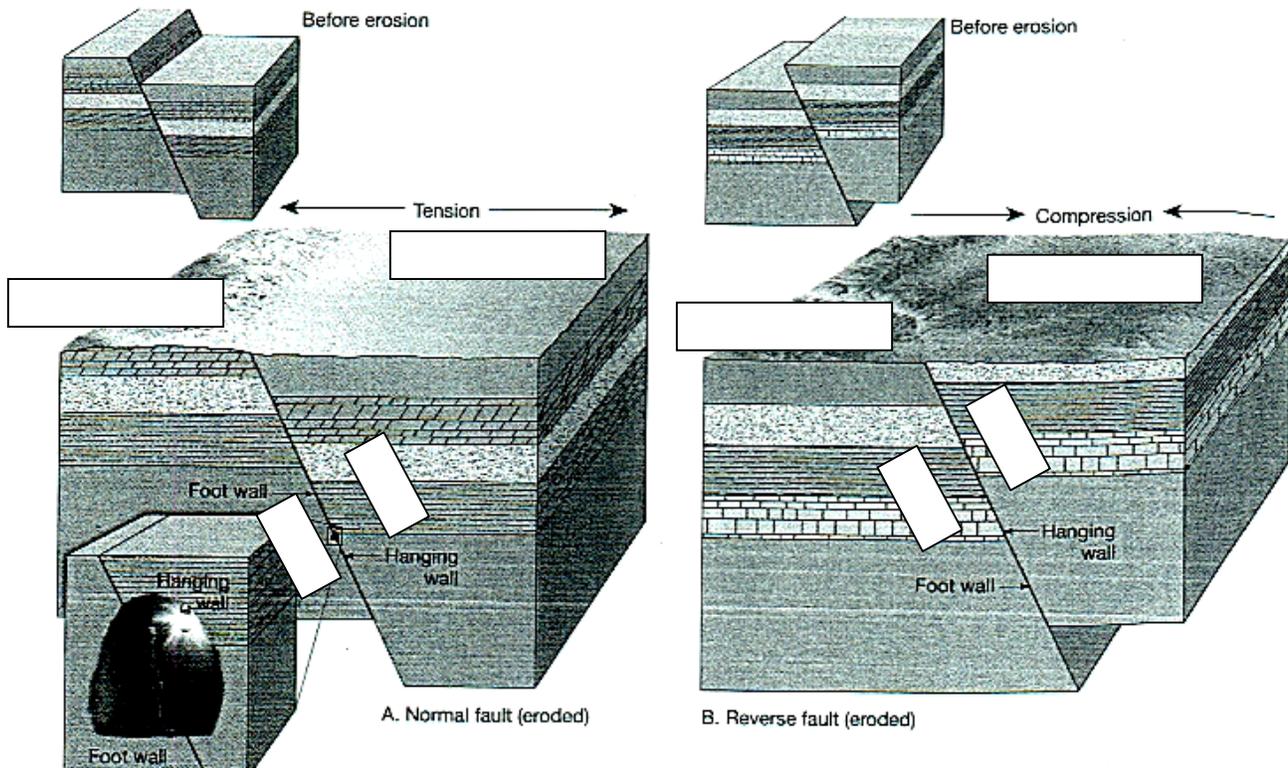


1. Complete the chart below to distinguish between each of the three main types of faults.

Type of Fault	Type of Force ( <i>compression, tension, or shearing</i> )	Vertical or horizontal motion	Type of plate boundary	Types of Earthquakes ( <i>shallow, intermediate, deep, or all</i> )
Strike-slip				<i>Shallow</i>
Normal				<i>Shallow and intermediate</i>
Reverse				<i>All types</i>

## Application of the Concepts

The block diagrams below illustrate a simplified version of a normal and reverse fault. The arrows by each fault show the relative motions of the blocks on both sides of the fault.



1. Draw an arrow on each side of the fault on BOTH diagrams to illustrate the movement along the faults.  
 Check here if complete
2. Indicate in BOTH diagrams which side has younger rocks and which has older rocks **at the surface**?  
 Check here if complete
3. What is the difference between the hanging wall and the footwall?
4. On an eroded normal fault, are the rocks **at the surface** on hanging wall side the youngest or oldest surface rocks? Describe fully.
5. On an eroded reverse fault, are the rocks **at the surface** on the hanging wall side the youngest or oldest surface rocks? Describe fully.

## ANSWER KEY FOR TEACHERS

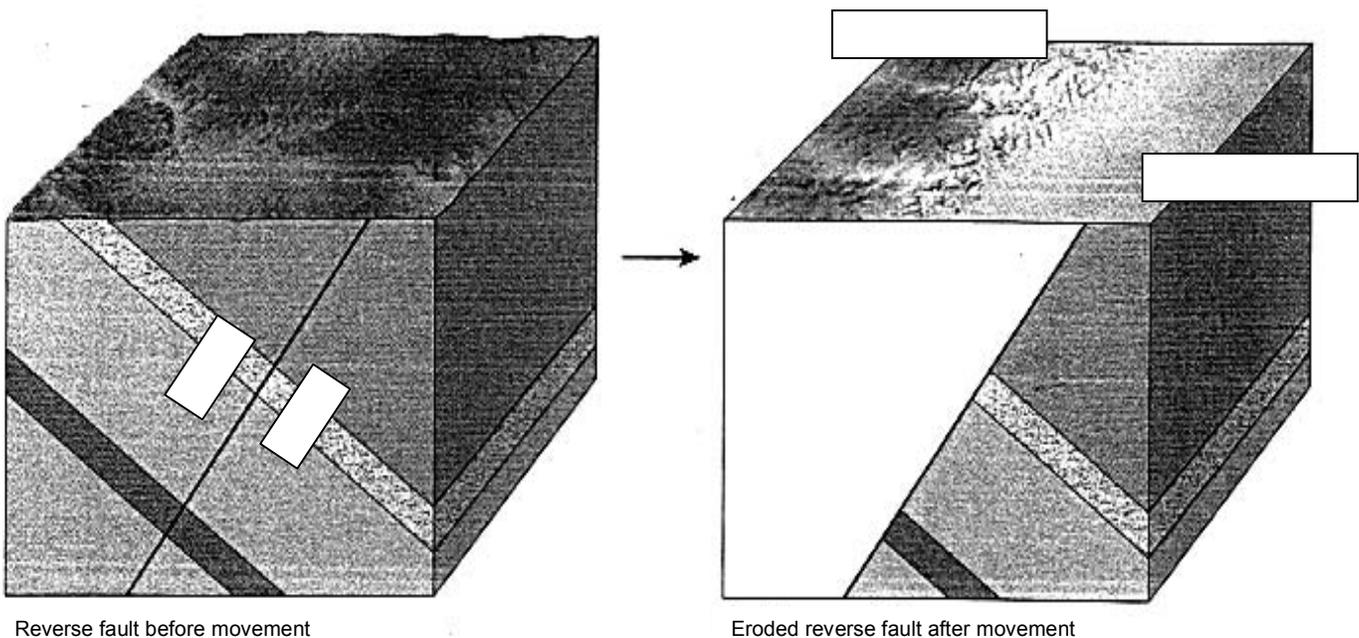
The diagrams below illustrate an eroded **REVERSE** fault at two ages. On the **left-hand** side of the diagram, the fault has not moved. On the **right-hand** diagram the fault has moved to produce mountains on surface to left side of the drawing.

On the **left-hand** diagram illustrate the movement of this fault by drawing:

- Arrows in the spaces provided indicating the relative movement on each side of the fault.

On the **right-hand** diagram illustrate the movement of this fault by:

- Labeling the **oldest** and **youngest** rocks on the surface.
- Sketching in the relative position of the rock layers in the blank part of the diagram.



### Conclusion:

Write four to six complete sentences explaining the relationship between faults, earthquakes and plate boundaries. Feel free to use the back page if necessary.

# ANSWER KEY FOR TEACHERS

## Types of Faults

Name:

Per:

Date:

1. Referring to Figure 1, does it make any difference which side of the fault you stand on in naming the right-lateral or left lateral strike-slip fault? Explain.

*Right lateral. Imagine yourself standing on one side of a strike-slip fault, so that you are facing the fault. If the block on the other side is displaced to your right, the fault is a right lateral strike-slip fault (Figure 1). If the block on the other side of the fault is displaced to your left, the fault is a left lateral strike-slip fault*



Figure 1

2. Compare and contrast a reverse fault and a thrust fault.

*Thrust faults are simply reverse faults in which the angle formed by the fault plane and the surface is quite shallow.*

3. Explain how slickensides are used to determine the slip orientation of the fault plane.

*The scratches on the fault plane surface are called **slickensides**. Slickensides may record the slip orientation of the fault plane, and may even feel smoother in the direction of slip*

## Model of Three Faults

### Normal Fault

Locate points A and B on your model. Move point B so that it is next to Point A. Observe your model from the side (its cross-section).

Draw the normal fault as represented by the model you have just constructed.

### Questions

1. Which way did point B move relative to point A?

*It moves closer to A*

2. What happened to rock layers X, Y and Z?

*They get offset by the fault*

3. Are the rock layers still continuous?

*No – they are now broken by the fault*

4. What likely happened to the road? The railroad tracks?

*The were likely offset vertically. During that process they will be potentially broken.*

See figure 2 above

5. Is this type of fault caused by tension, compression or shearing? Explain.

*This is caused by tension. Normal faults are formed by tensional forces.*

6. On the drawing label the hanging wall and the footwall.

*The hanging wall moves down relative to the footwall in a normal fault.*

### Normal Fault

*Many normal faults are found in Nevada. This is because Nevada is located in a region called the Basin and Range Province where the lithosphere is stretching.*

# ANSWER KEY FOR TEACHERS

## Reverse Fault

Locate points C and D on your model. Move Point C next to point D. Observe the cross-section of your model.

Draw the reverse fault as represented by the model you have just constructed.

### Questions

1. Which way did point D move relative to point C?

*It moves closer to point C*

2. What happened to rock layers X, Y and Z?

*They get offset by the fault.*

3. Are the rock layers still continuous?

*They are no longer continuous.*

4. What likely happened to the river?

*Perhaps a waterfall could have been formed by the rising hanging wall.*

5. Is this type of fault caused by tension, compression or shearing? Explain.

*This is caused by compression. Reverse faults are formed by compressional forces.*

6. On the drawing label the hanging wall and the footwall.

*The hanging wall moves up relative to the footwall in a reverse fault.*

See figure 3 or 4 above

**Reverse Fault**

Faults are important in mineral and petroleum exploration as they may either seal and act as a barrier to fluid flow (e.g., due to smearing of mud or shale along them), or may be important conduits for the migration of petroleum or mineralizing fluids. Many mineral deposits are fault and fracture controlled. Recognition of faults is also important in hydrogeological studies as fracturing along faults may produce hard-rock aquifers.

***An example of a thrust fault is the fault in which the Northridge earthquake occurred. The thrusting movement raised the mountains in the area by as much as 70 cm.***

## ANSWER KEY FOR TEACHERS

### Strike-Slip Fault

Locate points F and G on your model. Move the pieces of the model so that point F is next to point G.

Draw an **overhead** view of the surface as it looks after movement along the fault.

#### Strike-slip Questions:

1. If you were standing at point F and looking across the fault, which way did the block on the opposite side move?

*To the right*

2. What happened to rock layers X, Y, and Z?

*They are not offset in a vertical manner, only a horizontal manner.*

3. Are the rock layers still continuous?

*Yes they are.*

4. What likely happened to the river?

*It likely was offset to the right (south).*



**Strike-slip Fault**

5. If the scale used in this model is 1 mm = 2 m, how many meters did the earth move when the strike-slip fault caused point F to move alongside point G?

**(Show all calculations for full credit)**

*Approximately 46 meters*

*1 mm = 2 m; 23 mm x 2 = 46 m*

(Note that this scale would make an unlikely size for the railroad track!) If there were a sudden horizontal shift of this magnitude it would be about five times the shift that occurred in the 1906 San Andreas fault as a result of the San Francisco earthquake.

6. Is this type of fault caused by tension, compression or shearing? Explain.

*Shearing – two blocks moving past one another with little vertical motion*

7. Is the strike-slip fault a right or left – lateral movement? Explain.

*Right lateral – the east side of the fault moves so the south.*

***A strike-slip fault can be described as having right or left-lateral movement. If you look directly across the fault, the direction that the opposite side moved defines whether the movement is left-lateral or right-lateral. The San Andreas Fault in California is a right-lateral strike-slip fault.***

## ANSWER KEY FOR TEACHERS

### Reinforcement

1. Explain the miner's method of naming faults. Use a simple diagram showing the shaft, fault line, hanging wall, and footwall for normal and reverse faults. How did the walls get their names?

*See figures 2 and 3 on page 2.*

*The terms "hanging wall" and "footwall" are old mining terms. The hanging wall block was the block of rock where miners would hang their lanterns; the footwall block was where miners would walk. It is easy to determine which side of the fault is the hanging wall if you imagine a miner standing on the fault plane. The hanging wall will be the block above the miner's head; the footwall will be the block below the miner's feet.*

2. Name and describe the types of faults and folds that form in convergent margins. Use a simple diagram to illustrate your answer.

*Convergent margins result in compressional stresses so reverse and thrust faults would be expected along with folds. Pictures will vary.*

3. Name and describe the types of faults that form in a rift valley/mid-ocean ridge. Explain why normal faults form at divergent boundaries. Use simple diagrams to illustrate both answers.

*Divergent boundaries result in tensional stresses therefore they would be found at rift valley/mid-ocean ridge settings. See Figure 2 on page 1.*

4. Name and describe the types of faults that form along a transform boundary. Use a simple diagram to illustrate your answer.

*Transform boundaries result in shearing stresses that result in strike-slip faults. See figure 1 on page 1*

### Extra Credit

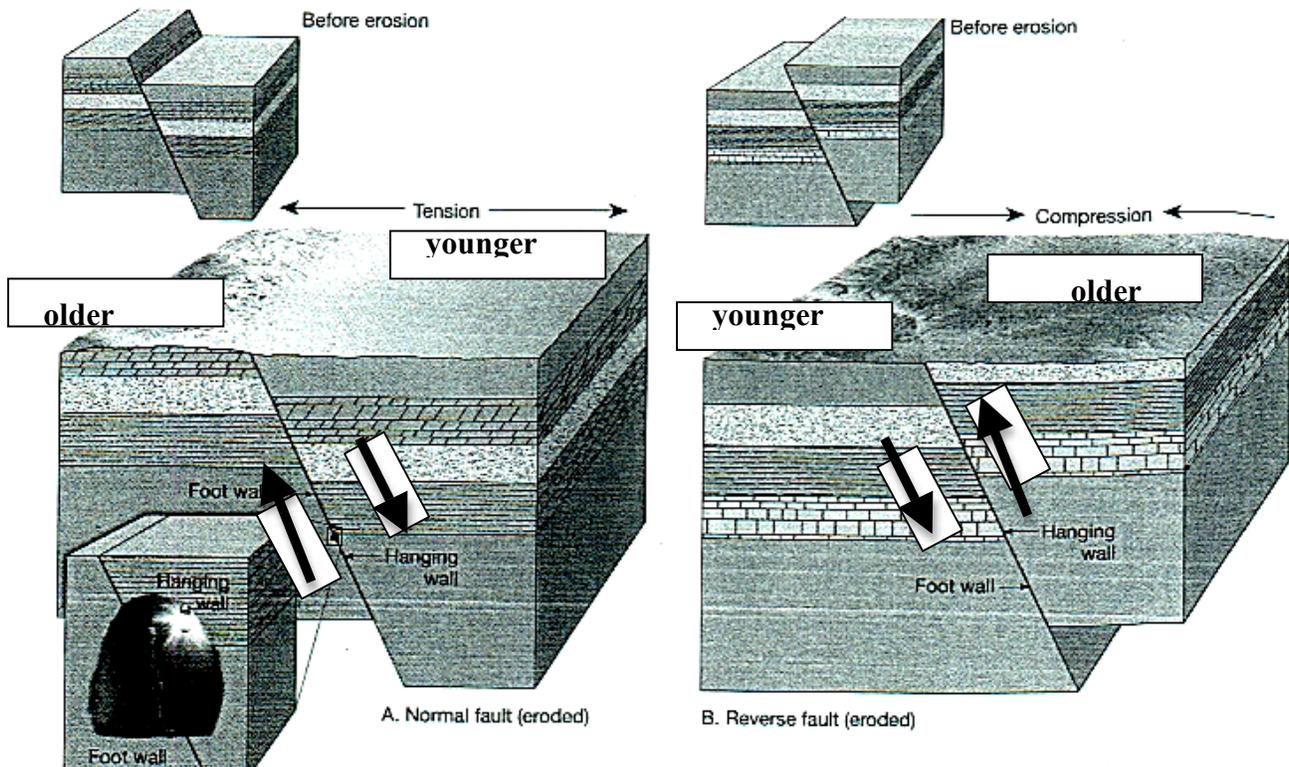
**Research and classify two of the faults below. Be sure to cite the internet URL.**

- Portland Hills Fault
- Molalla Canby Fault
- Burns Fault

# ANSWER KEY FOR TEACHERS

## Application of the Concepts

The block diagrams below illustrate a simplified version of a normal and reverse fault. The arrows by each fault show the relative motions of the blocks on both sides of the fault.



1. Draw an arrow on each side of the fault on BOTH diagrams to illustrate the movement along the faults.  
 Check here if complete
2. Indicate in BOTH diagrams which side has younger rocks and which has older rocks **at the surface**?  
 Check here if complete

**3. What is the difference between the hanging wall and the footwall?**

*The terms "hanging wall" and "footwall" are old mining terms. The hanging wall block was the block of rock where miners would hang their lanterns; the footwall block was where miners would walk. It is easy to determine which side of the fault is the hanging wall if you imagine a miner standing on the fault plane. The hanging wall will be the block above the miner's head; the footwall will be the block below the miner's feet.*

**4. On an eroded normal fault, are the rocks at the surface on hanging wall side the youngest or oldest surface rocks? Describe fully.**

*Youngest surface rocks – younger rocks are forming on top of "young" rocks as younger rocks move downward relative to footwall.*

**5. On an eroded reverse fault, are the rocks at the surface on the hanging wall side the youngest or oldest surface rocks? Describe fully.**

*Oldest surface rocks – older rocks exposed as younger rocks are eroded away.*

## ANSWER KEY FOR TEACHERS

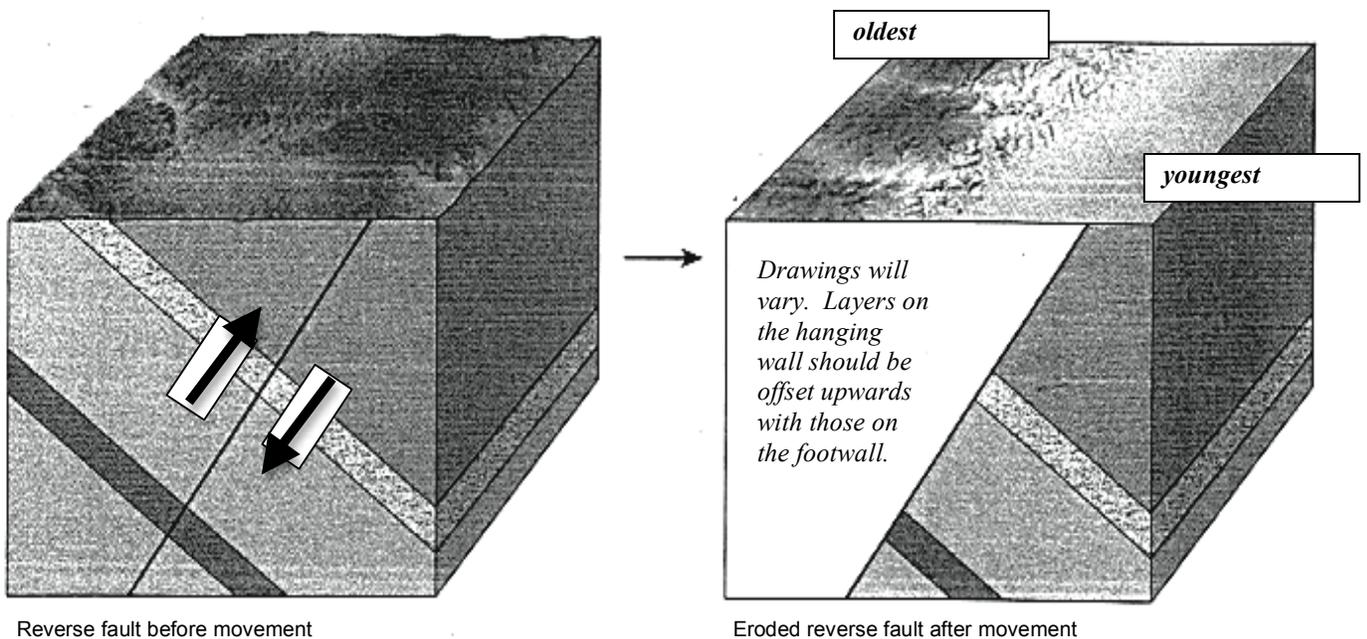
The diagrams below illustrate an eroded **REVERSE** fault at two ages. On the **left-hand** side of the diagram, the fault has not moved. On the **right-hand** diagram the fault has moved to produce mountains on surface to left side of the drawing.

On the **left-hand** diagram illustrate the movement of this fault by drawing:

- Arrows in the spaces provided indicating the relative movement on each side of the fault.

On the **right-hand** diagram illustrate the movement of this fault by:

- Labeling the **oldest** and **youngest** rocks on the surface.
- Sketching in the relative position of the rock layers in the blank part of the diagram.



### Conclusion:

Write four to six complete sentences explaining the relationship between faults, earthquakes and plate boundaries. Feel free to use the back page if necessary.

*Answers will vary. Plate boundaries have the highest concentrations of faults. Earthquakes occur along faults. Therefore, earthquakes occur along plate boundaries.*