

# Part 3 Earthquakes

Name: \_\_\_\_\_

## Part 3 Lesson 1 Faults and Folds

Deformation: When a \_\_\_\_\_ gets bent, twisted, or breaks.

Movement of tectonic plates against each other cause the plates to f\_\_\_\_\_ and f\_\_\_\_\_.

Which picture is a fault? And which is a fold?

Answer=



Answer=

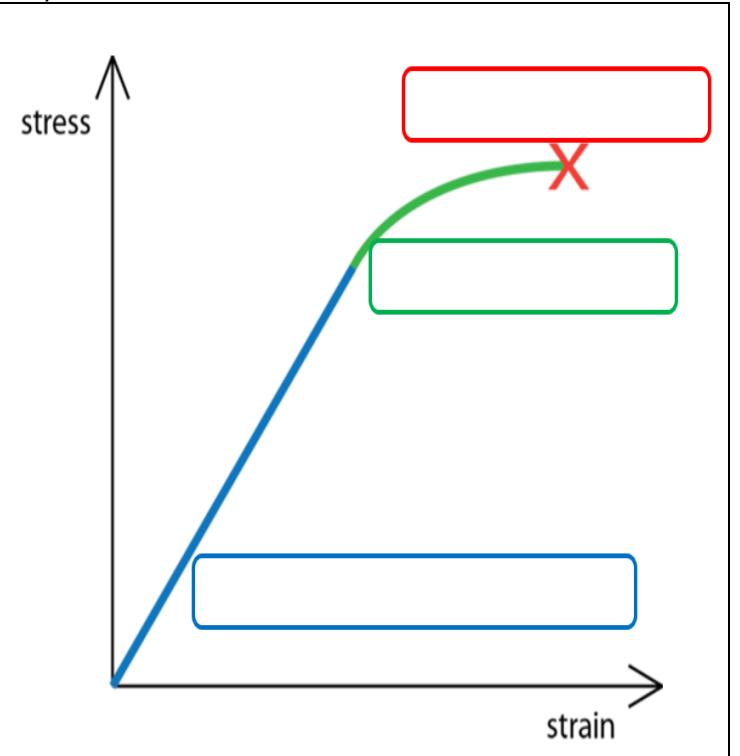


What are the three types of deformation in rocks. Word Bank: Elastic Deformation, Ductile /Plastic Deformation, Fracture Deformation (Brittle)

\_\_\_\_\_ A temporary shape change that is self-reversing after the force is removed, so that the object returns to its original shape.

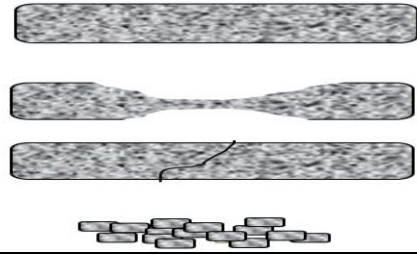
\_\_\_\_\_ This refers to the breaking of rock that creates fractures and faults. The rock is brittle/cold.

\_\_\_\_\_ The permanent distortion that occurs when a material is subjected to tensile, compressive, bending, or torsion stresses that exceed its yield strength and cause it to elongate, compress, buckle, bend, or twist. Irreversible



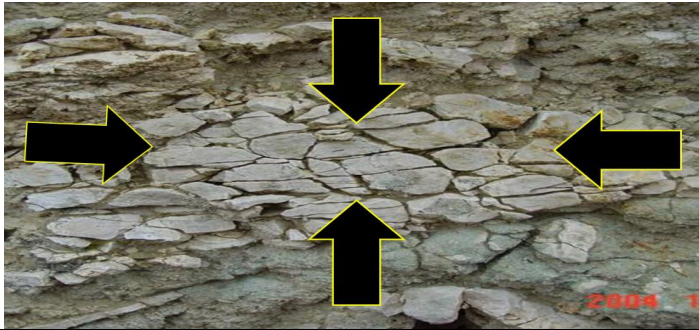
Stress on a rock can be...

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- Confining / \_\_\_\_\_



Stress on a rock can be... Word Bank, Compression, Tension, Shearing, Uniform/Confining,

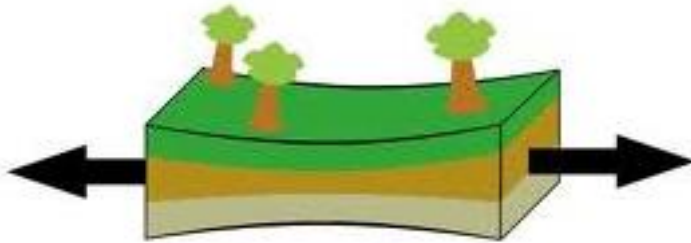
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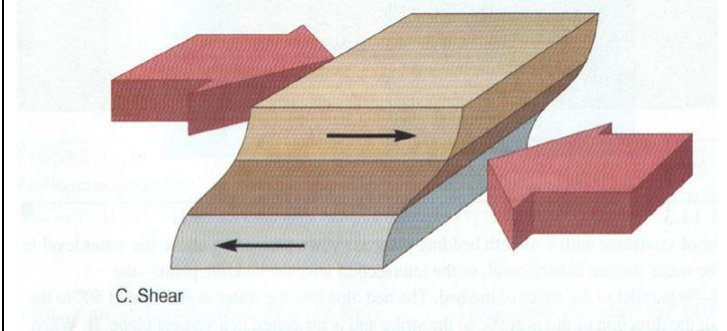
Answer=



Answer=



Answer=



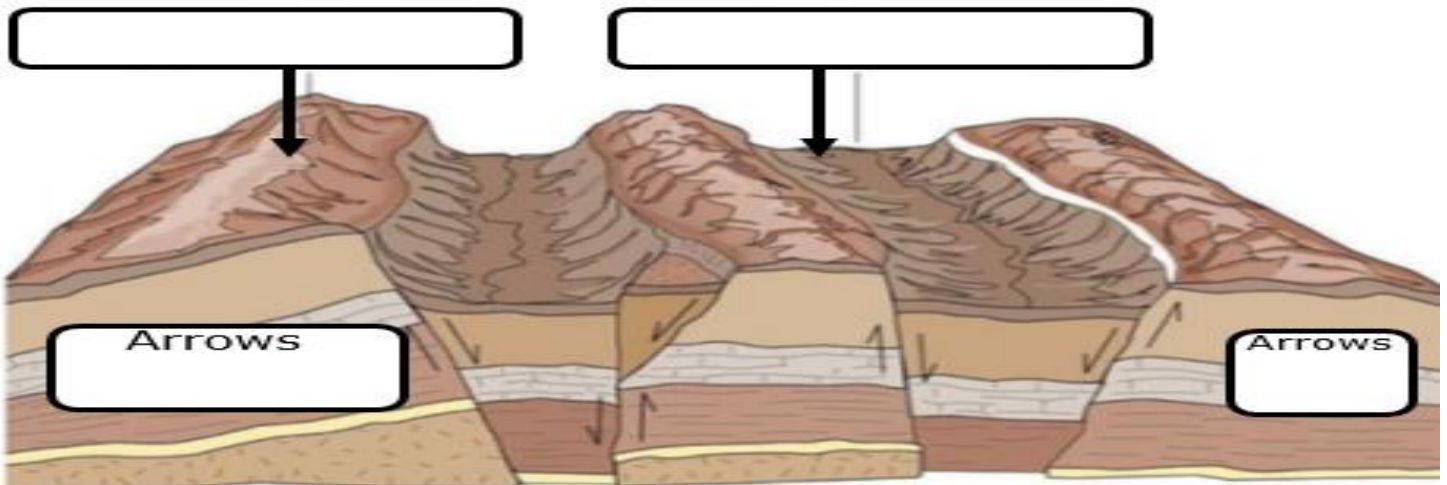
Part 3 Lesson 2&3 Types of Faults

Normal Fault: Pulling apart t\_\_\_\_\_ causes crust to drop down. <- / ->

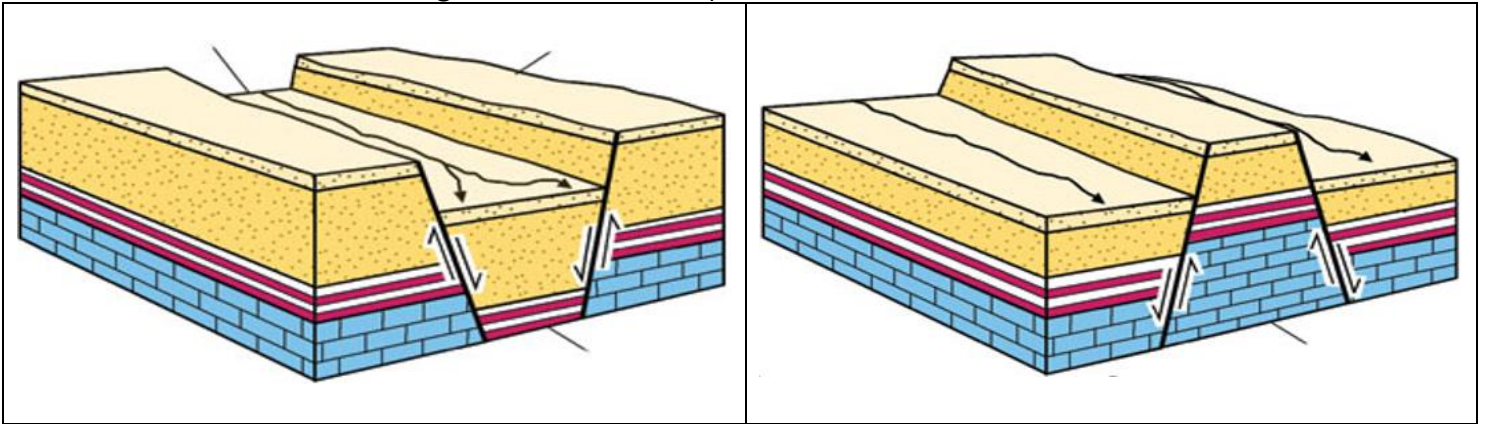
Which is a Horst? And which is a graben?

Graben: The block has dropped down along two, inward-dipping normal faults

Horst: The block has moved up along two outward-dipping normal faults.



Label all of the horst's and graben's in these pictures. There's 3 each for a total of 6.



Reverse Fault: Compression forces cause crust to move up.

- Thrust Fault: A type of reverse fault with a shallow angle of the fault plane, less than 45°

Strike-slip Fault: Crust moves alongside each other in opposite directions. Shear Force

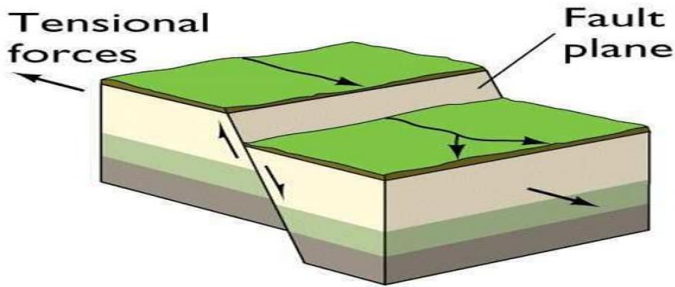
- A right-lateral strike-slip fault is one on which the displacement of the far block is to the right when viewed from either side.
- A left-lateral strike-slip fault is one on which the displacement of the far block is to the left when viewed from either side.

Please research this important fault. Name the fault Describe the type of fault, provide arrows that show the movements, and provide some information about it in the writing space.

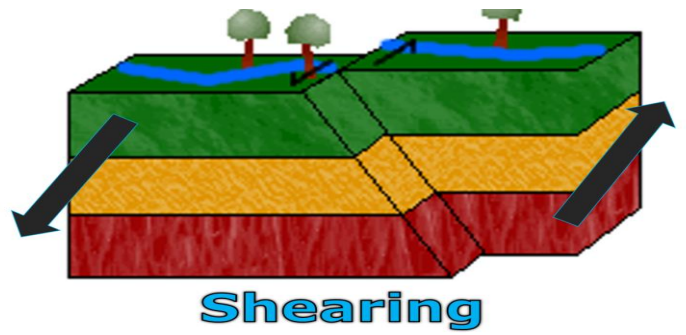
Please name the fault below.

Answer=

Which is the hanging and Footwall?

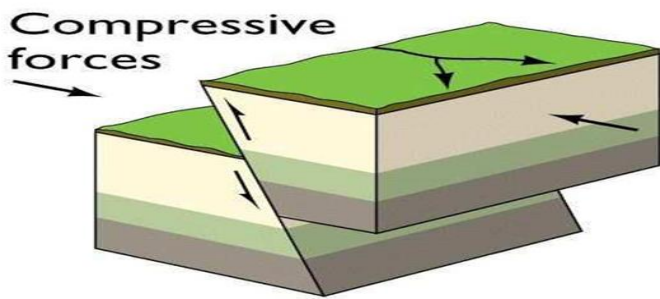


Answer=



Answer=

Which is the hanging and Footwall



Name the Fold=



Name the fault and type of stress?

A: Type of Fault=

Can you label the HW & FW?

B: Stress on rock is =

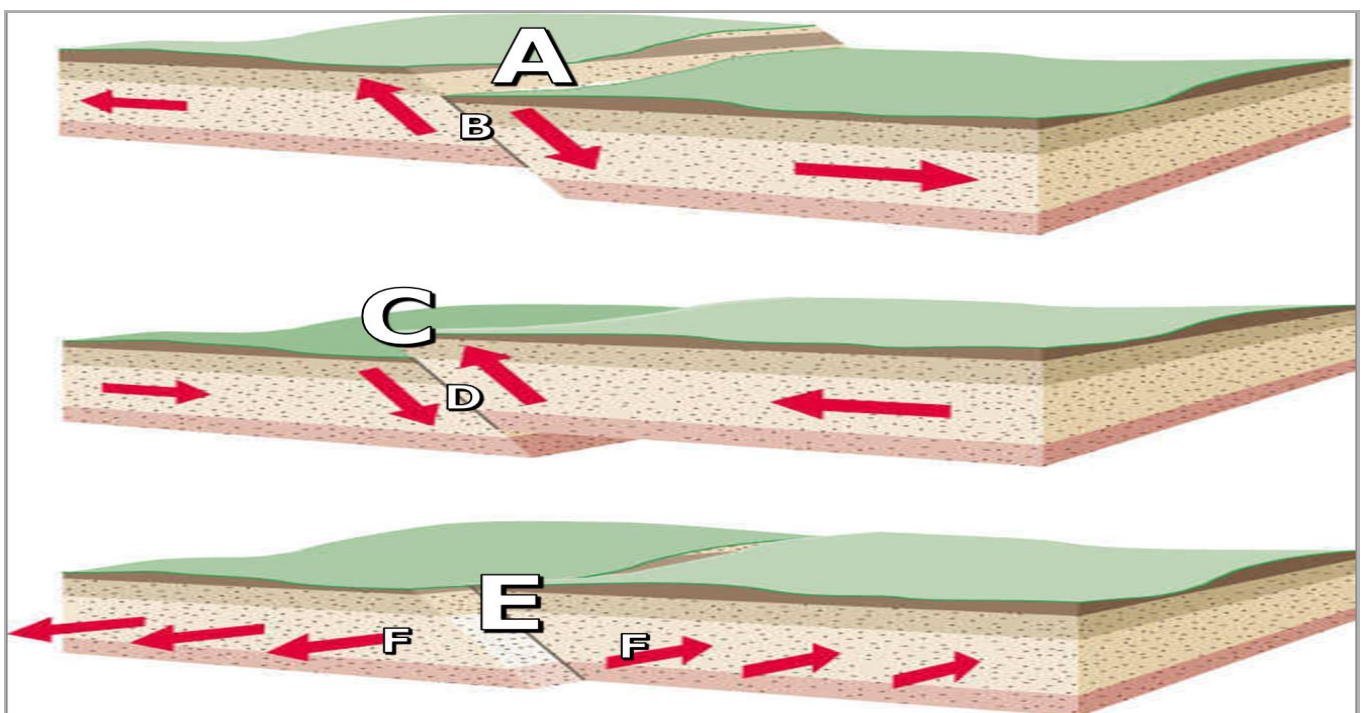
C: Type of Fault=

Can you label the HW & FW?

D: Stress on rock is =

E: Type of Fault=

F: Stress of rock is =



Part 3 Lesson 4 Folds

Folding: This occurs when tectonic processes put stress on a rock, and rock \_\_\_\_\_, instead of breaking / fault. This creates a variety of landforms as the surfaces of the folded rocks are eroded and exposed.

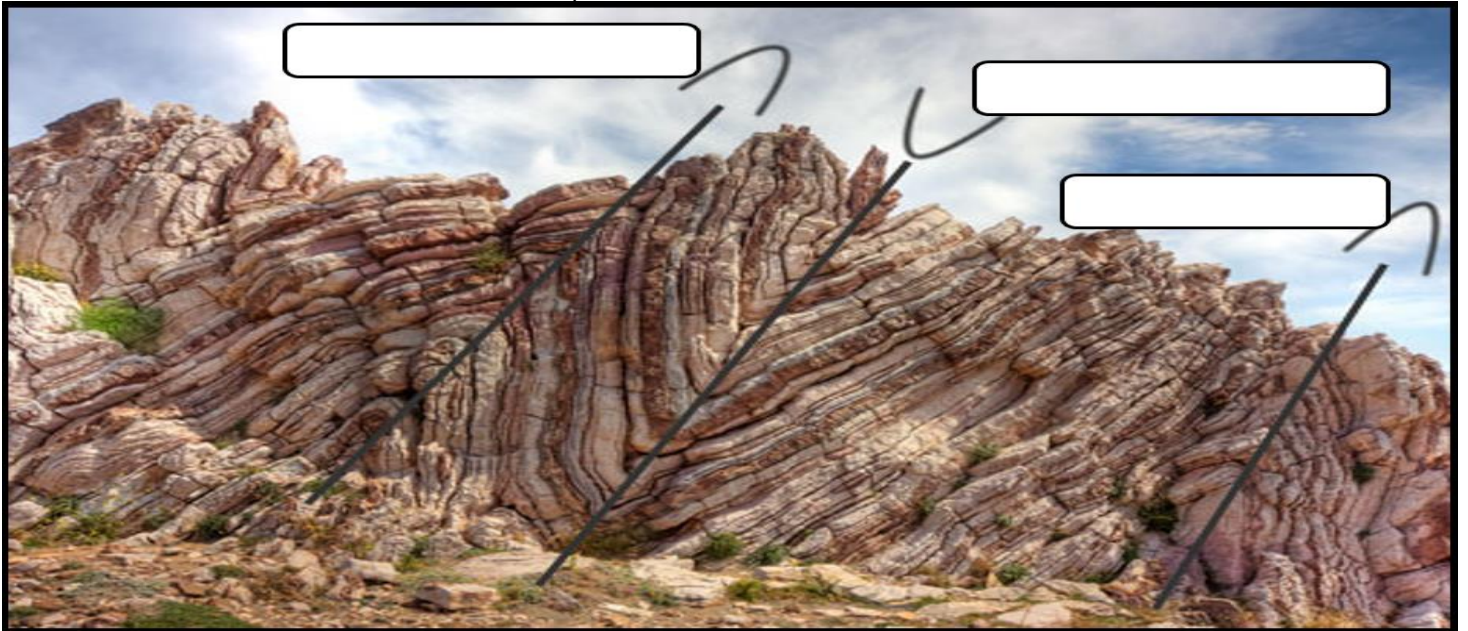
Compression Folds

Anticlines ☹ \_\_\_\_\_ layer at core. Folds shaped like an arch

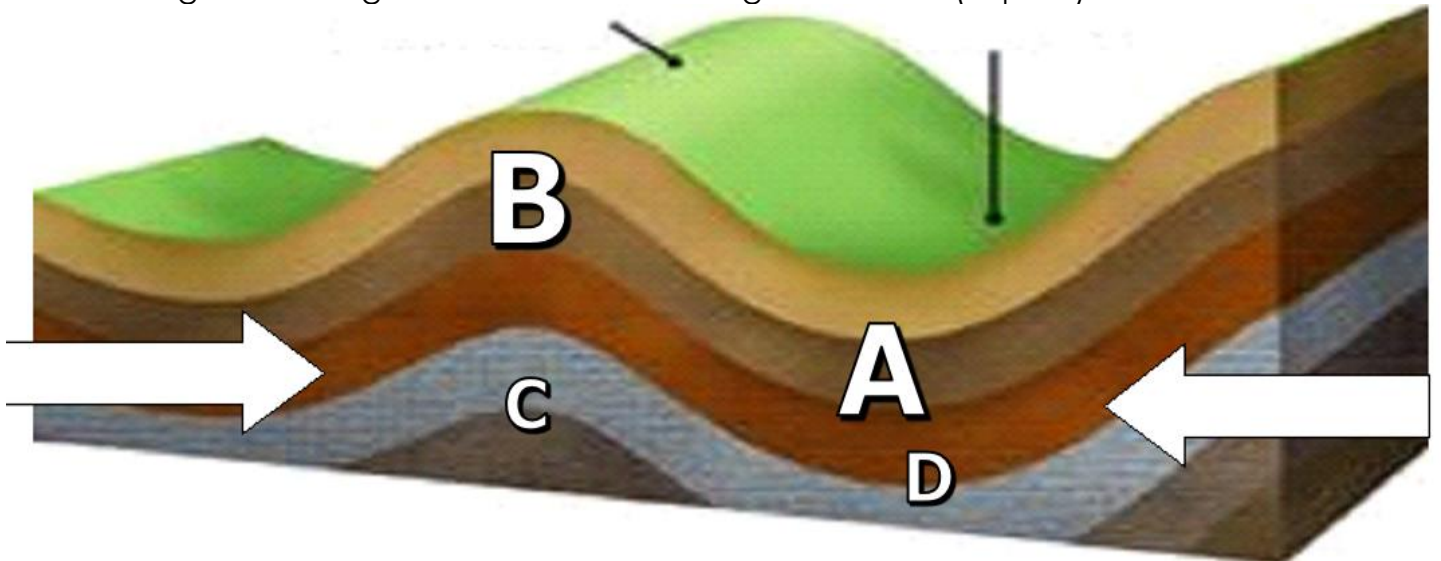
Synclines ☺ \_\_\_\_\_ layer at core. Folds shaped like the letter 'U'.

◇ Is this fold caused by compression, tension, or shearing? \_\_\_\_\_

◇ Please label the anticline and the syncline?



◇ Where might we find gas and oil? How about groundwater (aquifer)



A=	B=
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C=Oil and Gas or Water?  	D= Oil and Gas or Water?  
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Quiz Wiz 1-10. Name that fault or fold.

- Normal (Tension), Reverse (Compression), Slip-strike (Shearing)
- Compression Fold is a Anticline / Syncline showing or both.

1)	2)	3)
4)	5)	6)
7)	8)	9)
10)	*11)	

**Part 3 Lesson 5 Mechanical/Energy Waves**

Earthquake: Shaking of the earth's crust from a sudden release of e\_\_\_\_\_.

B\_\_\_\_\_ Waves

P Wave: P\_\_\_\_\_ wave. Moves lateral (faster-Arrives First)

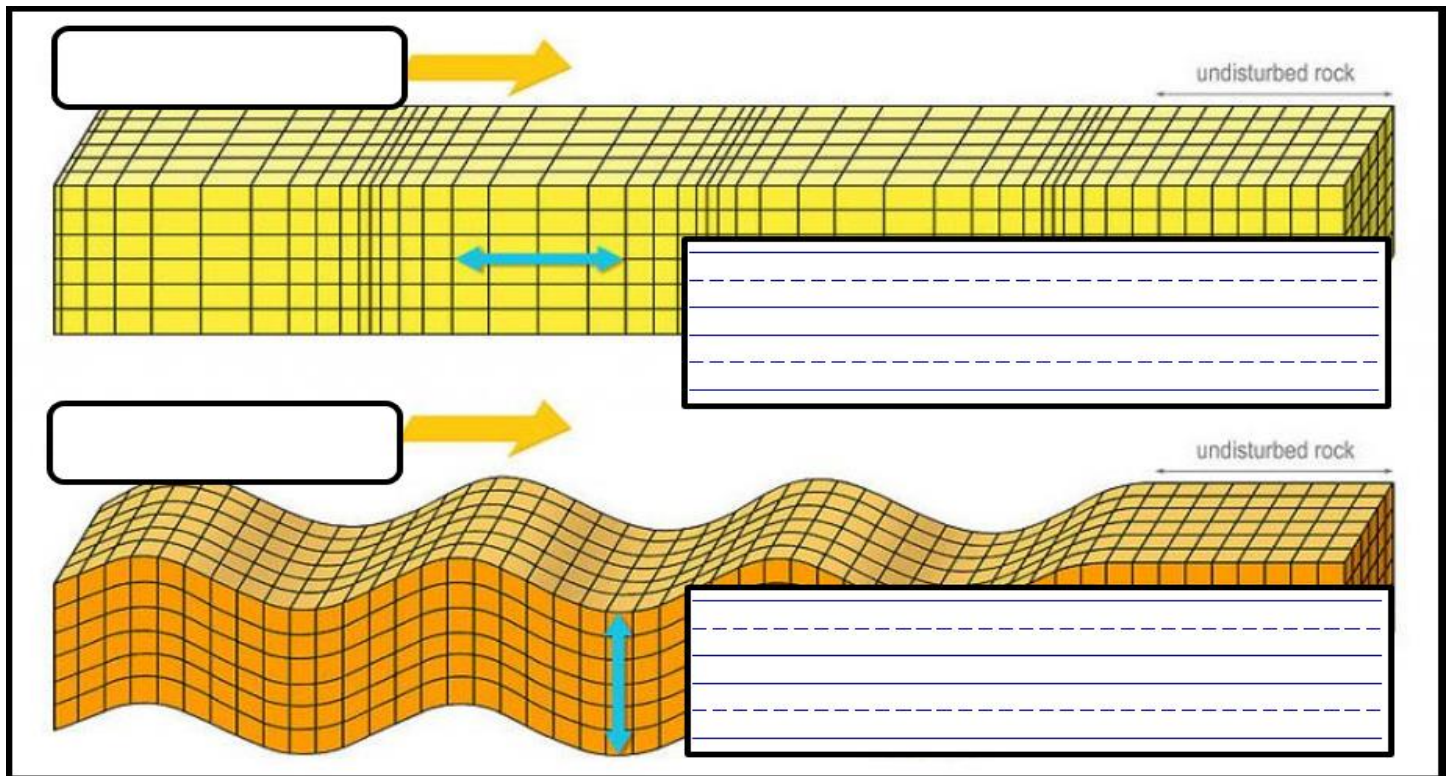
S Wave: S\_\_\_\_\_ waves. Moves back and forth. (Slower, but stronger)

S\_\_\_\_\_ Waves

-R\_\_\_\_\_ wave is a seismic surface wave causing the ground to shake in an elliptical motion, with no transverse, or perpendicular, motion.

-A L\_\_\_\_\_ wave is a surface wave having a horizontal motion that is transverse (or perpendicular) to the direction the wave is traveling.

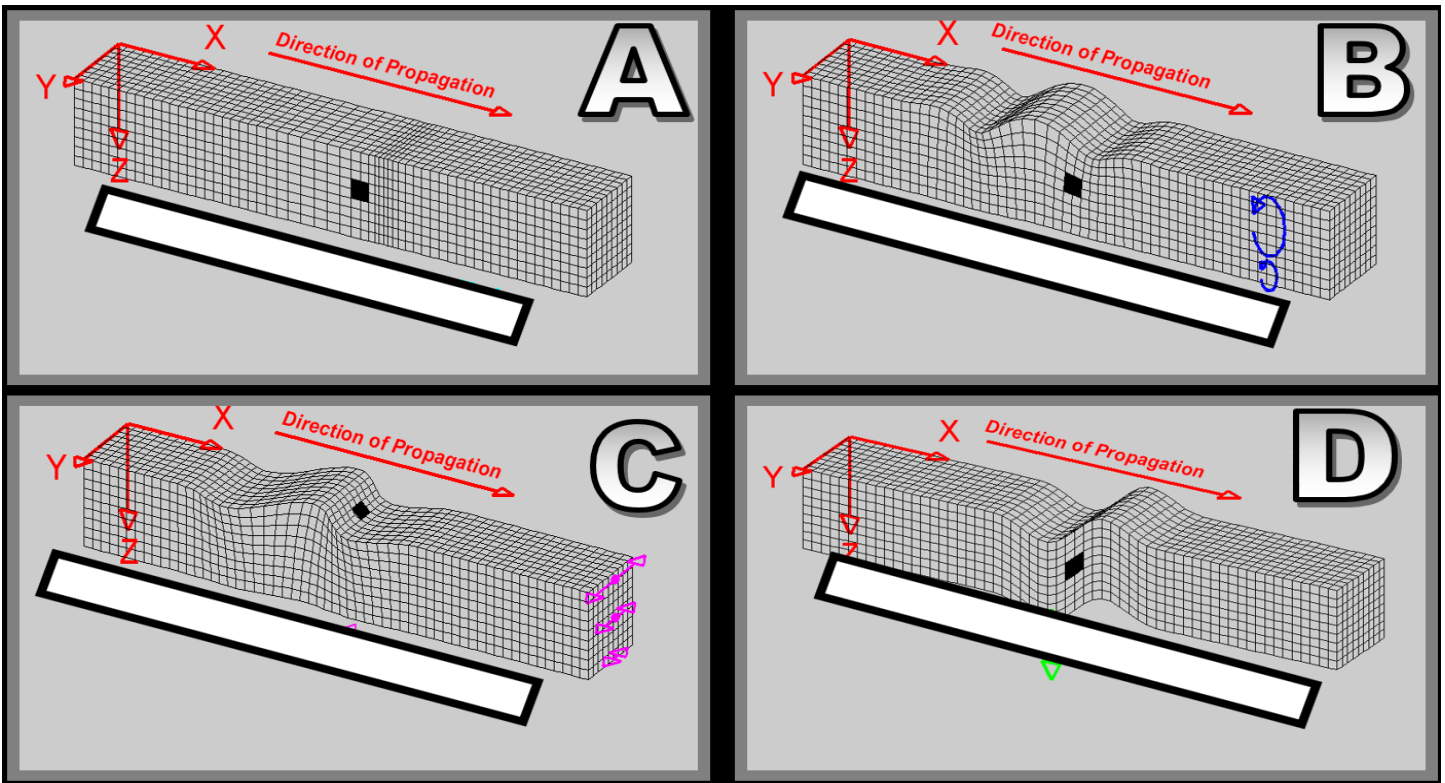
Mechanical waves can be longitudinal or transverse. Which one below is a longitudinal P Wave, and which is a transverse S-Wave? Add any additional info on the lines.



Which one of the waves above causes the most damage \_\_\_\_\_? Which one will arrive first \_\_\_\_\_?

Name each wave below. Word Bank: Primary Wave, Secondary Wave, Rayleigh Wave, Love Wave

Which two are body waves?	Which two are surface waves?	Which ones are transverse?	Which one is longitudinal only?
Which two cause the most destruction?	Which is the fastest wave?	Is the S-Wave or P-wave more powerful?	How are you doing?



**Part 3 Lesson 6 Earthquakes**

Seismograph: An instrument used to measure the s \_\_\_\_\_ caused by an earthquake.

Seismometer: The internal part of the seismograph, which may be a pendulum or a mass mounted on a spring.

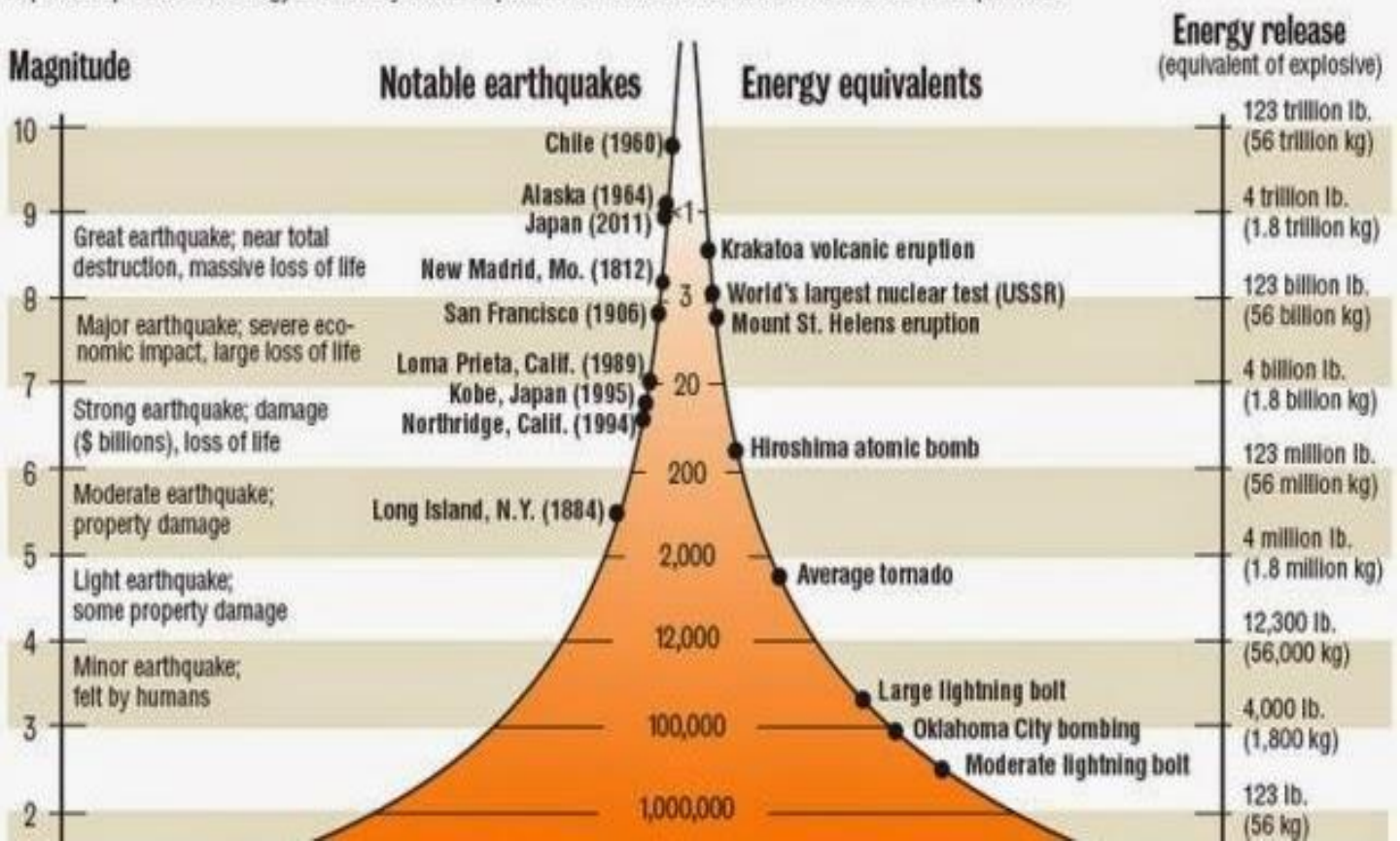
Richter Scale - Scale for measuring earthquake m \_\_\_\_\_. Being phased out.

A magnitude 7.0 earthquake generates \_\_\_\_ times larger amplitude waves than those of a magnitude 6.0.

The moment magnitude scale, abbreviated \_\_\_\_\_, is preferred because it works over a wider range of earthquake sizes and is applicable globally.

The moment magnitude scale is based on the total moment release of the earthquake.

Use the graphic representation of the Moment Magnitude Scale to answer the questions below.



<p>Where and when was the largest earthquake ever recorded? What was the magnitude and energy released?</p>	<hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>
<p>Will a 3.0 on the Moment Magnitude Scale cause serious damage? Explain</p>	<hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>
<p>What magnitude earthquakes will cause severe \$ damage and large loss of life?</p>	<hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>
<p>A 7.0 earthquake is how many times larger than and 6.0?</p>	<hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>



Research one earthquake and record some information below. No copy and paste. Please cite your source.

Where? When? How strong / Damage and Death Toll? What type of fault line was it?

Handwriting practice lines consisting of solid blue top and bottom lines with a dashed blue middle line for a cursive-style writing guide.

Author's name

Date of publication

Title of page

Name of the website

Lund, N. (2015). How to begin birding. Retrieved from National Audubon Society website:

<http://www.audubon.org/news/how-begin-birding> URL

Answer in the spaces below.

- ◇ What is the name of this device?
- ◇ What does it measure?
- ◇ How does it work?
- ◇ Can you point out the arrival of the first P-wave, S-Wave, and Surface Waves?

The diagram illustrates a seismograph. A blue L-shaped frame supports a vertical spring labeled "Spring". A grey rectangular "Weight" is suspended from the bottom of the spring. A red "Pen" is attached to the side of the weight, pointing towards a large cylindrical "Rotating Drum". The drum is shown with a horizontal line and a wavy line representing seismic waves. To the right of the drum are several sets of horizontal lines for writing, including dashed midlines. Below the drum, the text "Rotating Drum" is partially visible.

Answer in the spaces below.

- ◇ What is the name of this device?
- ◇ What does it measure?
- ◇ How does it work?
- ◇ Can you point out when the earthquake occurred below?

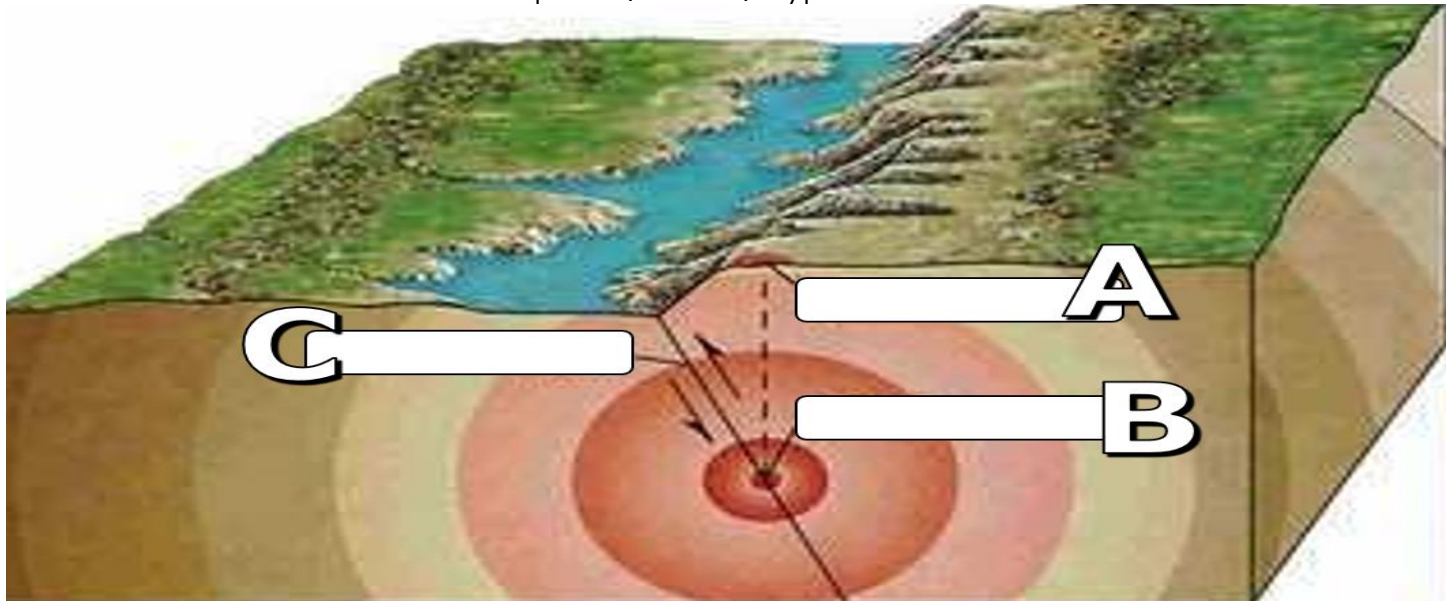
What was this earthquake on the Mercalli Intensity Scale? Answer= \_\_\_\_\_

Modified Mercalli Intensity Scale			
I	Instrumental: detected only by instruments	VII	Very strong: noticed by people in autos Damage to poor construction
II	Very feeble: noticed only by people at rest	VIII	Destructive: chimneys fall, much damage in substantial buildings, heavy furniture overturned
III	Slight: felt by people at rest Like passing of a truck	IX	Ruinous: great damage to substantial structures Ground cracked, pipes broken
IV	Moderate: generally perceptible by people in motion Loose objects disturbed	X	Disastrous: many buildings destroyed
V	Rather strong: dishes broken, bells rung, pendulum clocks stopped People awakened	XI	Very disastrous: few structures left standing
VI	Strong: felt by all, some people frightened Damage slight, some plaster cracked	XII	Catastrophic: total destruction



Part 3 Lesson 7 Epicenter

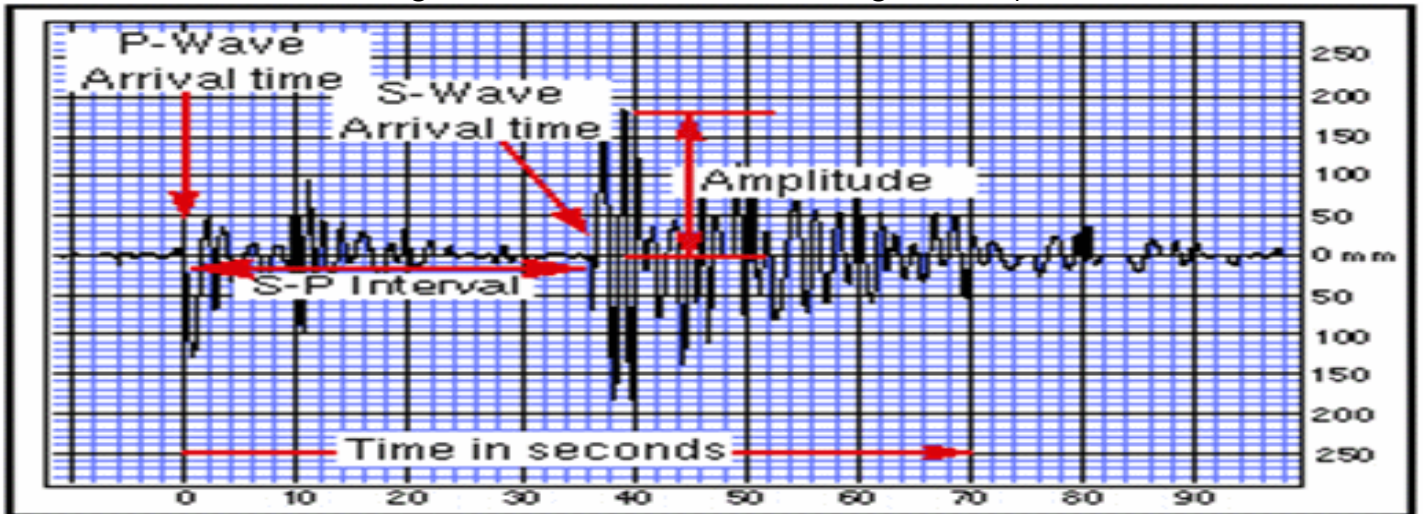
Epicenter: The point on the earth's surface that is directly a \_\_\_\_\_ the hypocenter or focus.  
 Just above the earthquake / focus / hypocenter



An earthquake requires three monitoring stations to determine its location.

P and S waves travel at known v \_\_\_\_\_ through the earth. \_\_\_ waves are slower than \_\_\_ waves by a known amount. Therefore, the farther a s \_\_\_\_\_ recording station is from the earthquake e \_\_\_\_\_ the greater the d \_\_\_\_\_ in time of arrival between the P and S wave.

S waves are indicated by an abrupt change in wave amplitude. Below, the S wave arrived about how many \_\_\_\_\_ seconds after the P wave? The time difference is the called the S-P interval and the lag time between the first P wave and arrival of first S wave. Can you show with a line were the shaking "Surface Waves" had the highest amplitude.




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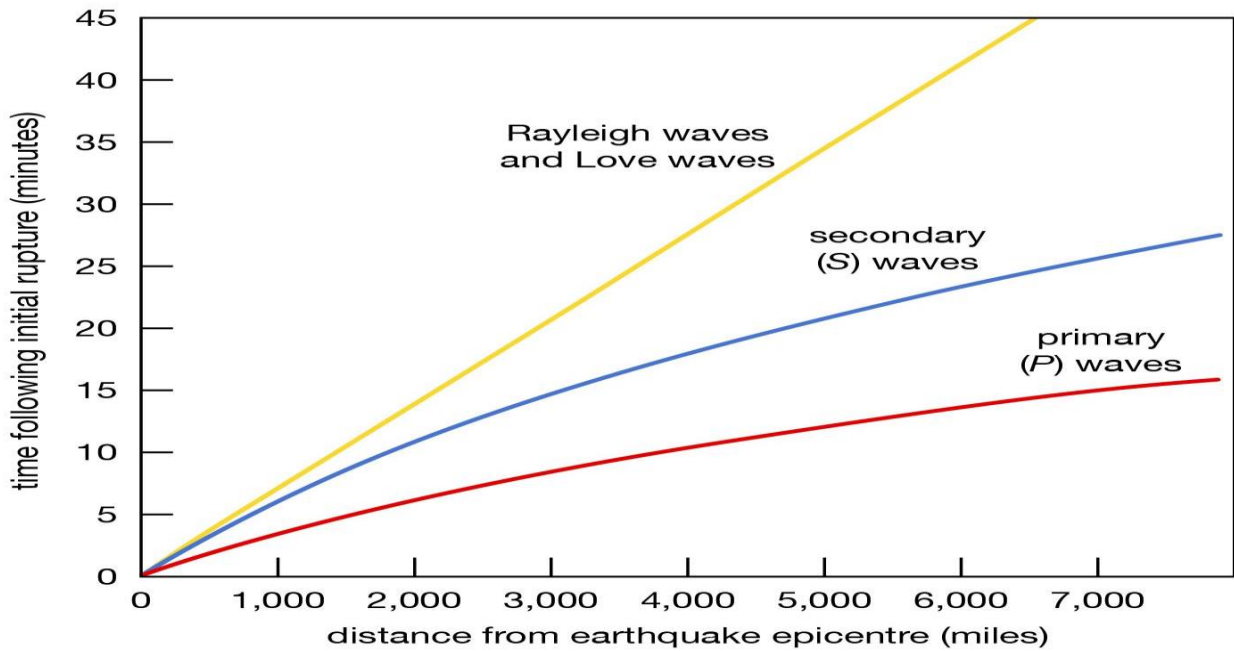
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Use the graph to answer some question below.

**Generalized travel-time curve for seismic waves**

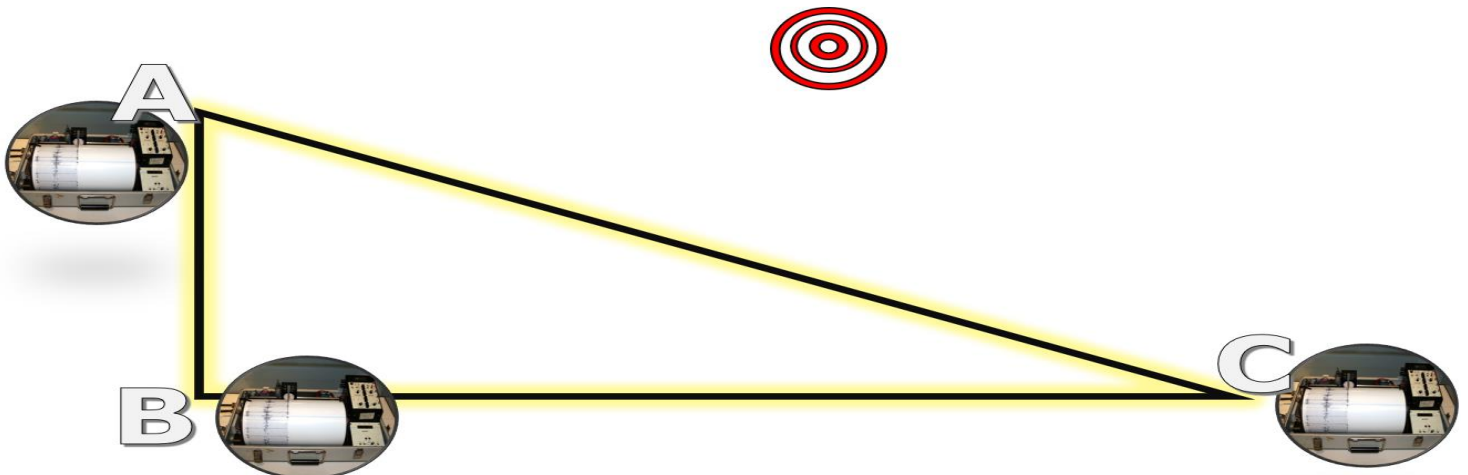


Source: Incorporated Research Institutions for Seismology (IRIS), "Travel Time Curves" (2014).

- How many minutes does it take a P-wave to travel 5,000 miles?
- How many minutes does it take an S-Wave to travel 5,000 miles?
- How many minutes does it take a Surface Wave to travel 5,000 miles?
- What is the time gap in minutes between the P-Wave and S-Wave at 2,000 miles?
- What is the time gap in minutes between the P-Wave and S-Wave at 7,000 miles?
- If you were 2,000 miles from the earthquake. How long would it be before you felt your first surface wave with a seismograph? \_\_\_\_\_ How about a P-wave? \_\_\_\_\_

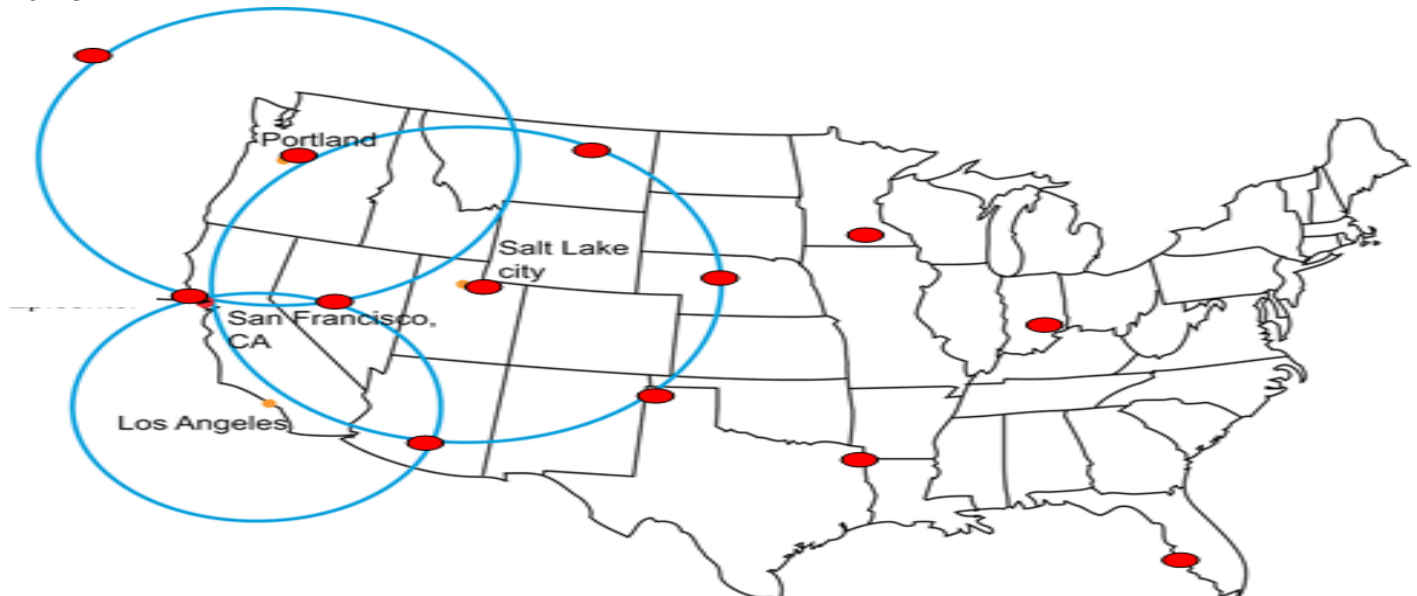
What the time P and S interval at the three seismic stations during the activity with the fast walker (P-wave) and slow walker (S-wave).

Seismic Station #1	Seismic Station #2	Seismic Station #3
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Where was the earthquakes epicenter?

Answer=



### Part 3 Lesson 8 Earthquake Design

Liquefaction: A process where sand or landfill will often change from a wet solid into a dense \_\_\_\_\_, which further amplifies shaking.

Damping: Buildings in general d\_\_\_\_\_ vibration by absorbing it. Damping is a rate at which natural vibration is absorbed.

Torsion: Objects and buildings have a center of \_\_\_\_\_, a point by which the object (building) can be balanced without rotation occurring.

Building Configuration: Size and Shape. It determines the way seismic forces are d\_\_\_\_\_ within the structure.

R\_\_\_\_\_ Configuration (Better Design) buildings have... Low Height to Base Ratios, Equal Floor Heights, Symmetrical Plans, Uniform Sections and Elevations, Maximum Torsional Resistance, Short Spans and Redundancy, Direct Load Paths.

Irregular Configuration *buildings are those that differ from the "Regular" definition and have \_\_\_\_\_ concentrations and torsion.*

Ductility: Ductility is the characteristic of a material to b\_\_\_\_\_, flex, or move. Non-ductile materials (such as poorly reinforced concrete and bricks) \_\_\_\_\_ abruptly by crumbling.

Strength and Stiffness: Strength is a property of a material to r\_\_\_\_\_ and bear applied forces within a safe limit. \_\_\_\_\_ are better than squares.

Sketch Out a design below for an earthquake resistant structure. The structure must fit on an 8' by 11" sheet of paper.

You'll have roughly \$100,000 dollars of materials.

Spaghetti / skewers -\$1000, Gumdrops / marshmallows -\$2,000

What is the total cost of your structure? Price out your materials.

Describe your design in the space below and provide a follow-up about how it did on the shake table. What worked well, and what part of your design could use improvement?

Handwriting practice lines consisting of a solid top line, a dashed middle line, and a solid bottom line, repeated multiple times for text entry.

## Smart Libs Earthquake Design Challenge Presentation

Good afternoon \_\_\_\_\_ and \_\_\_\_\_. We are part of the \_\_\_\_\_ design team and are here to present \_\_\_\_\_ towers. Our motto is \_\_\_\_\_

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Earthquakes are an inevitable part of our \_\_\_\_\_ planet and evidence to the dynamic forces that are \_\_\_\_\_. At some point, plate movement beneath \_\_\_\_\_ will cause the plates to \_\_\_\_\_ violently, releasing \_\_\_\_\_ amounts of energy along fault lines. We feel that our structure will be able to withstand a \_\_\_ on the Movement Magnitude Scale with little structural damage.

Remember, \_\_\_\_\_

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The concept for our design was \_\_\_\_\_

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\_\_\_\_\_. The configuration of the building was \_\_\_\_\_. This type of configuration was used as it \_\_\_\_\_. Torsion was avoided by \_\_\_\_\_

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\_\_\_\_\_. Damping devices were/weren't used in this model. The materials used in this design were extremely \_\_\_\_\_ in that they were able to flex and bend without breaking. The following seismic test will show the \_\_\_\_\_ and \_\_\_\_\_ of our design. We feel that this test will showcase how \_\_\_\_\_ and \_\_\_\_\_ along with \_\_\_\_\_ construction can plan for the next big earthquake. This model has been designed with \_\_\_\_\_ and \_\_\_\_\_. Remember... \_\_\_\_\_

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Thank you for your \_\_\_\_\_ and after the test we will be \_\_\_\_\_ to answer any questions you may have.

Questions! Answer 3 of the 6 Below.

- 1.) What happened to your building? Explain with specifics in your design.
- 2.) What would you do differently next time?
- 3.) How did you work as a team? Be specific.
- 4.) Did you create a design using some already proven earthquake design technology? Explain.
- 5.) Is this an important topic to study? Why or why not?
- 6.) If you decide to move into a building, what type of building should it be? It's your future.

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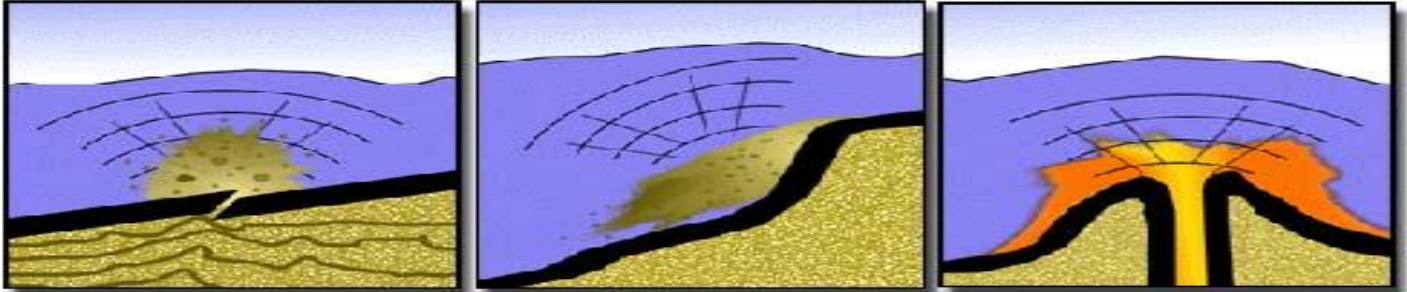


Part 3 Lesson 9 Tsunami

Tsunami: An ocean \_\_\_\_\_ generated by a submarine earthquake, volcano or landslide.

- A tsunami can travel across whole oceans.

Please describe the three causes of a tsunami beneath each picture.



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Please case study the 2004 Indian Ocean earthquake and tsunami and use the space below to describe this horrible event.

Please case study the 2011 Tohoku Earthquake and tsunami and use the space below to describe this horrible event.

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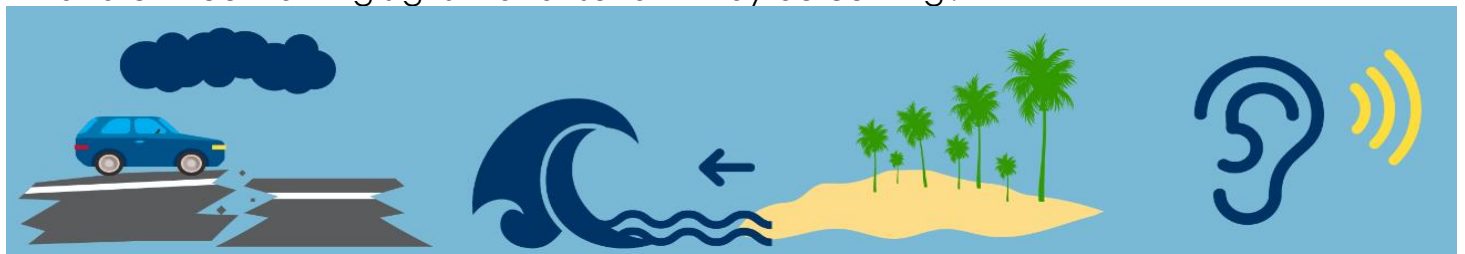
\_\_\_\_\_

\_\_\_\_\_

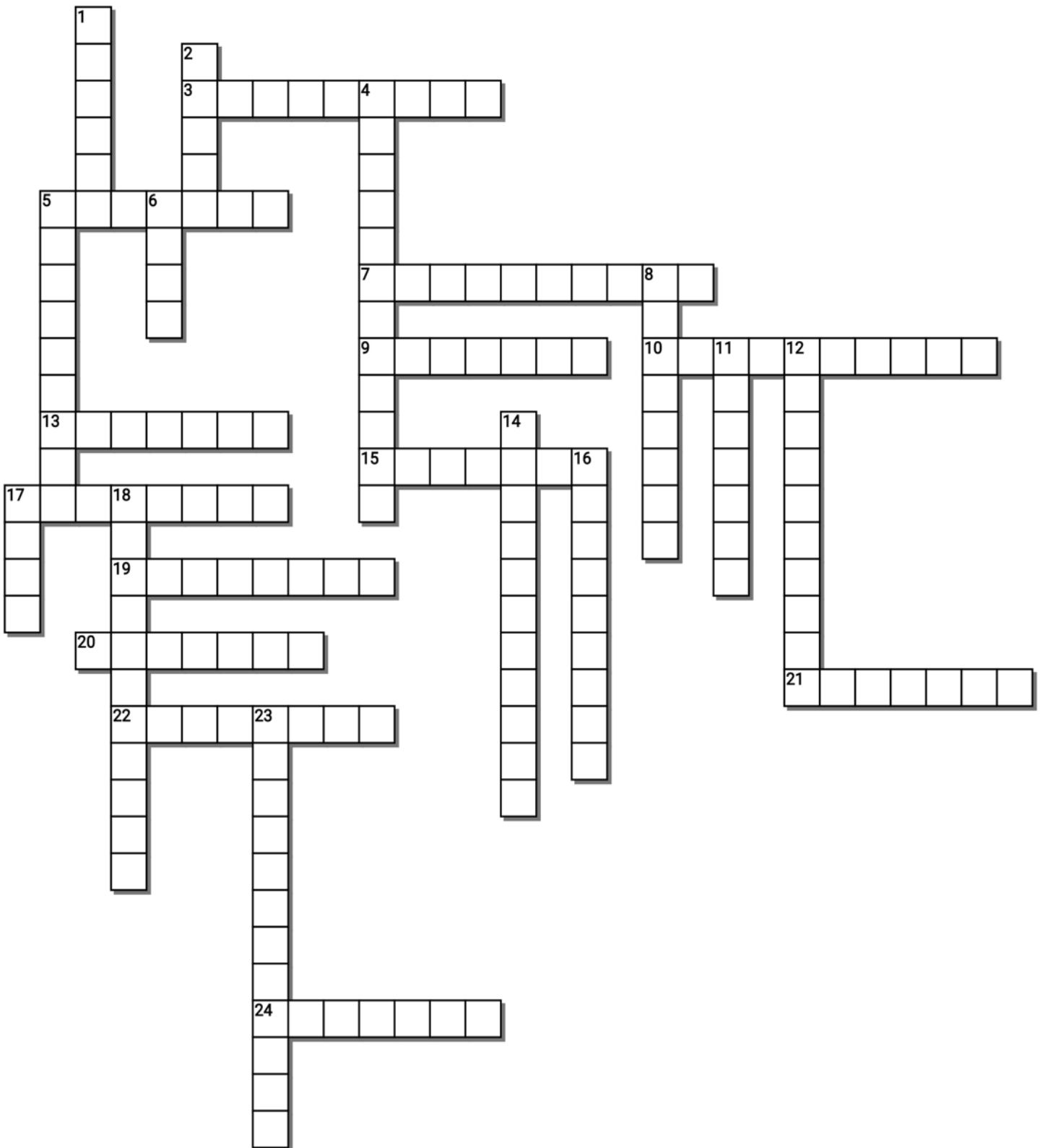
\_\_\_\_\_

\_\_\_\_\_

What are three warning signs that a tsunami may be coming?



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-----teacher can remove word bank to make puzzle more challenging-----

**Possible Answers**

ANDREAS, ANTICLINE, COMPRESSION, DUCTILE, EARTHQUAKE, ELASTIC , EPICENTER, FAULT, FOLD, FRACTURE, HYPOCENTER, LIQUEFACTION, LONGITUDINAL , MOVEMENT, NORMAL, PRIMARY, REVERSE, RICHTER, SECONDARY, SEISMOGRAPH, SHEARING, SLIP, SYNCLINE, TENSION, TRANSVERSE, TSUNAMI

**Across**

3. Fold where the Oldest layer at core.
5. \_\_\_\_\_ Deformation: A temporary shape change that is self-reversing after the force is removed, so that the object returns to its original shape.
7. \_\_\_\_\_ Waves: The particle displacement is perpendicular to the direction of wave propagation
9. \_\_\_\_\_ or Plastic Deformation: The permanent distortion that occurs when a material is subjected to tensile, compressive, bending, or torsion stresses that exceed its yield strength and cause it to elongate, compress, buckle, bend, or twist. Irreversible
10. Shaking of the earth's crust from a sudden release of energy.
13. The stress which occurs when rock pulls apart or gets longer.
15. The San \_\_\_\_\_ Fault
17. \_\_\_\_\_ Deformation: This refers to the breaking of rock that creates fractures and faults. The rock is brittle/cold.
19. \_\_\_\_\_ of tectonic plates against each other cause the plates to fault and fold.
20. P Wave: \_\_\_\_\_ wave. Moves lateral
21. Scale for measuring earthquake magnitude.
22. Fold where the youngest layer at core.
24. An ocean wave generated by a submarine earthquake, volcano or landslide.

**Down**

1. \_\_\_\_\_ Fault: Pulling apart tension causes crust to drop down.
2. A \_\_\_\_\_ is a fracture or zone of fractures between two blocks of rock. Faults allow the blocks to move relative to each other. This movement may occur rapidly, in the form of an earthquake
4. A wave that is propagated in the same direction as the displacement of the transmitting medium
5. The point on the earth's surface that is directly above the hypocenter or focus.
6. Strike-\_\_\_\_\_ Fault: Crust moves alongside each other in opposite directions.
8. Stress which occurs when tectonic plates move past each other causing rock to twist or change shape.
11. \_\_\_\_\_ Fault: Compression forces cause crust to move up.
12. Area just above the earthquake / focus
14. An instrument used to measure the shaking caused by an earthquake.
16. S Wave: \_\_\_\_\_ waves. Stronger and moves back and forth
17. \_\_\_\_: Collision of crust bends rock layers. "Stress"
18. \_\_\_\_\_ stress is when a rock is pressed together into itself, like when crust movements cause two rocks to squeeze another one between them.
23. A process where sand or landfill will often change from a wet solid into a dense liquid, which further amplifies shaking.

# Earthquakes

Name: \_\_\_\_\_

Score \_\_\_\_ / 100

1-20 = 5 pts

Part 3 Lesson 10

\*20-\*25 \* = Bonus + 1 pt,

(Secretly write owl in correct space +1 pt)

Final Question = 5 pt wager

IT's NOT YOUR FAULT	KNOW WHEN TO FOLD EM	WAVY GRAVY	IT BURNS	ON FIRE Bonus round 1 pt each
1)	6)	11)	16)	*21)
2)	7)	12)	17)	*22)
3)	8)	13)	18)	*23)
4)	9)	14)	19)	*24)
5)	10)	15)	20)	*25)

Final Question Wager \_\_\_\_/5 Answer \_\_\_\_\_

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# Part 3 Earthquakes

Name: \_\_\_\_\_

## Part 3 Lesson 1 Faults and Folds

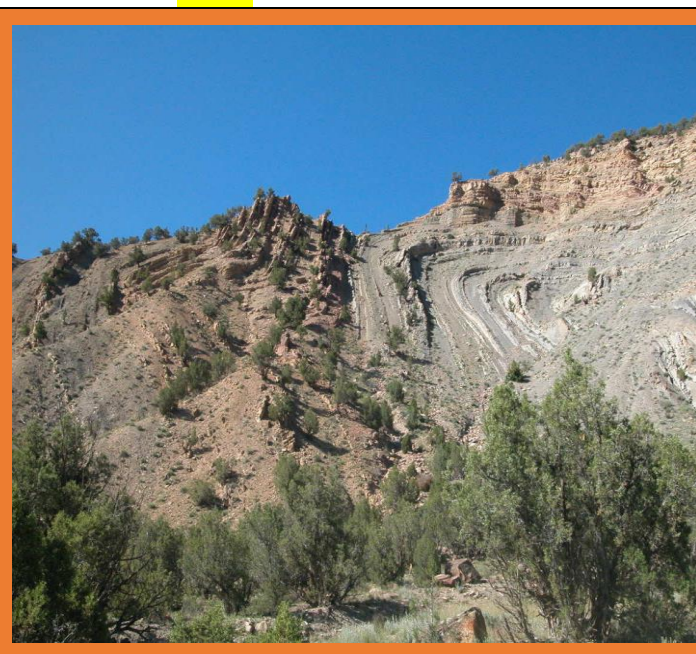
Deformation: When a rock gets bent, twisted, or breaks.

Movement of tectonic plates against each other cause the plates to **fault** and **fold**.

Which picture is a fault? And which is a fold?

Answer= **Fault**

Answer=**Fold**

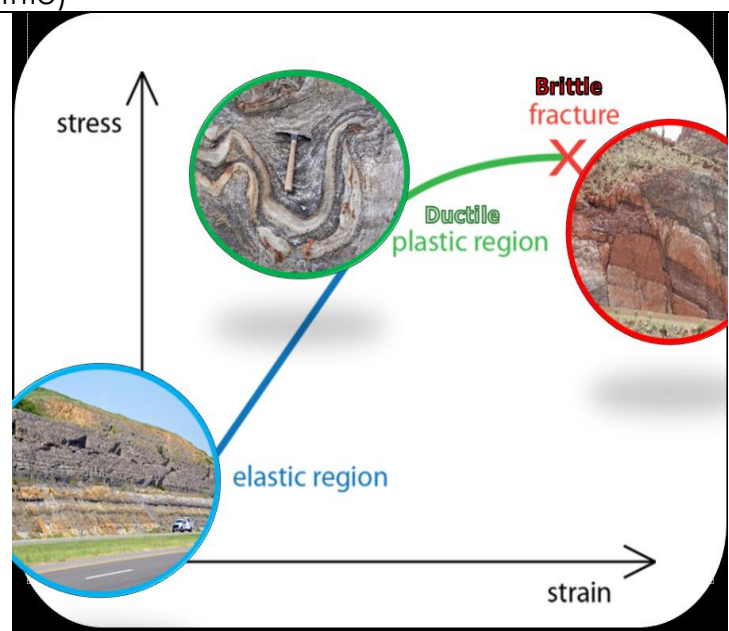


What are the three types of deformation in rocks. Word Bank: Elastic Deformation, Ductile /Plastic Deformation, Fracture Deformation (Brittle)

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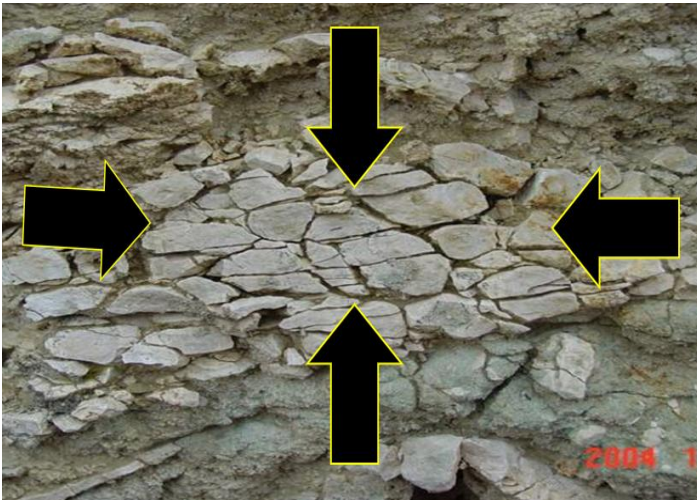
**Fracture Deformation:** This refers to the breaking of rock that creates fractures and faults. The rock is brittle/cold.

**Ductile or Plastic Deformation:** The permanent distortion that occurs when a material is subjected to tensile, compressive, bending, or torsion stresses that exceed its yield strength and cause it to elongate, compress, buckle, bend, or twist. Irreversible

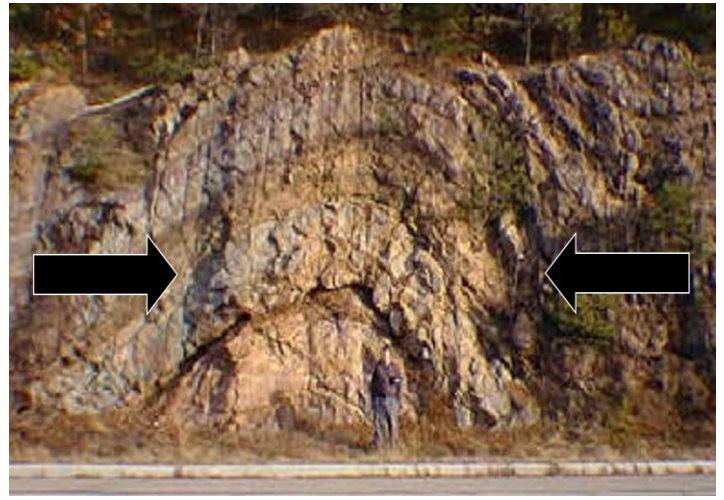


Stress on a rock can be...

Answer=Confining/Uniform

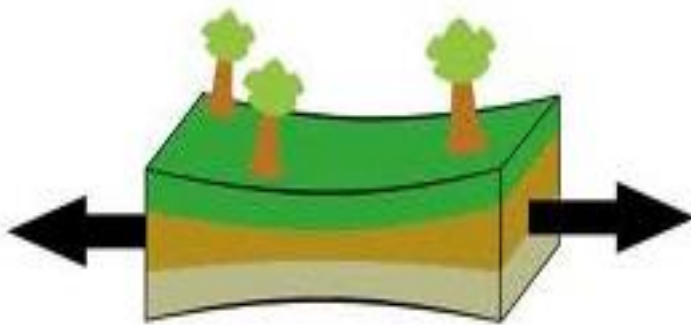


Answer=Compression



Stress on a rock can be...

Answer=Tension

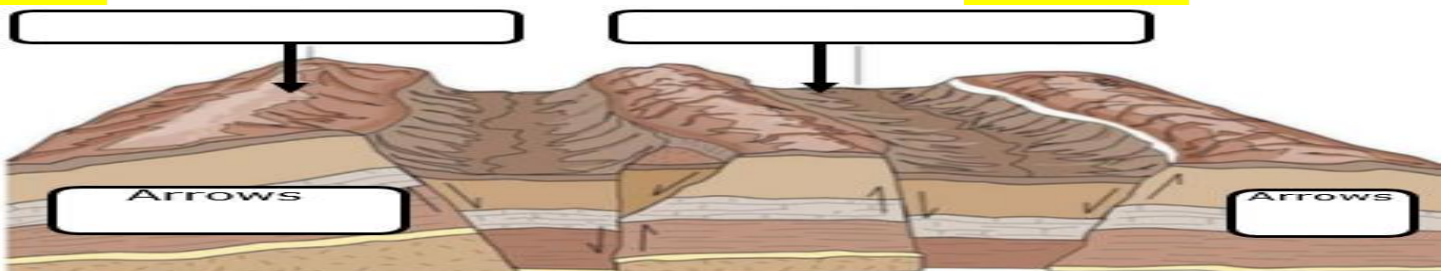


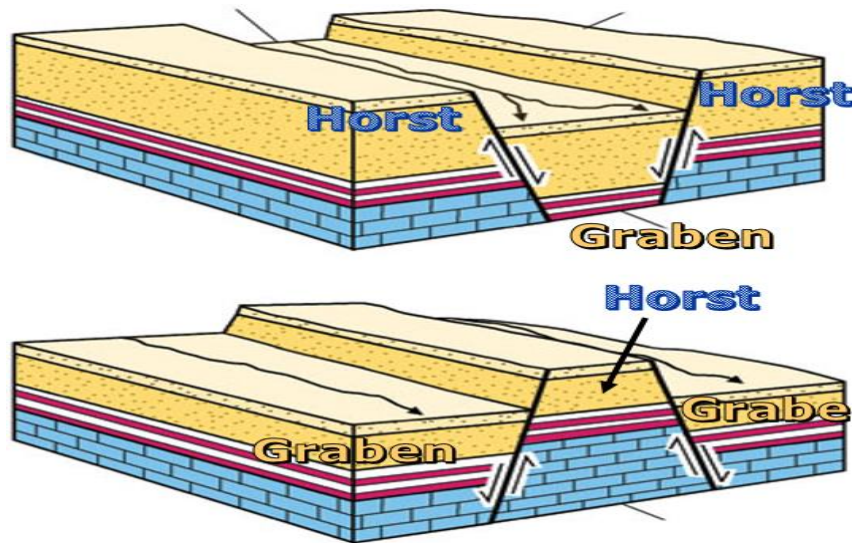
Answer= Shearing



Horst

Graben

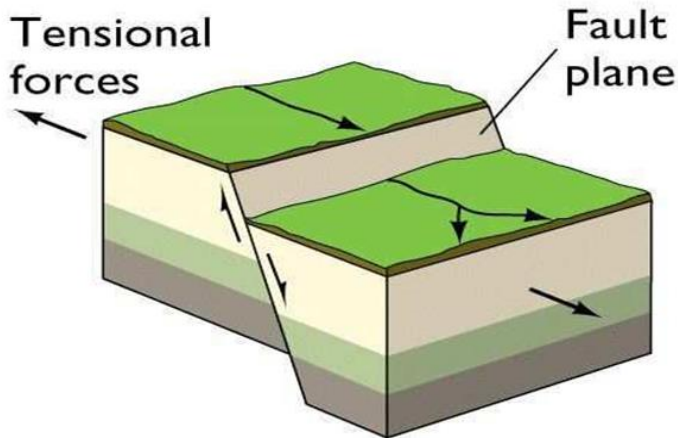




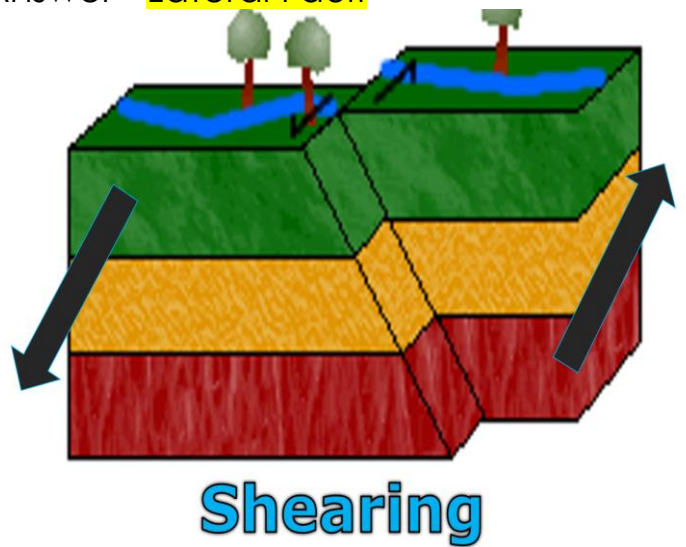
Part 3 Lesson 2&3 Types of Faults

Please name the fault below.

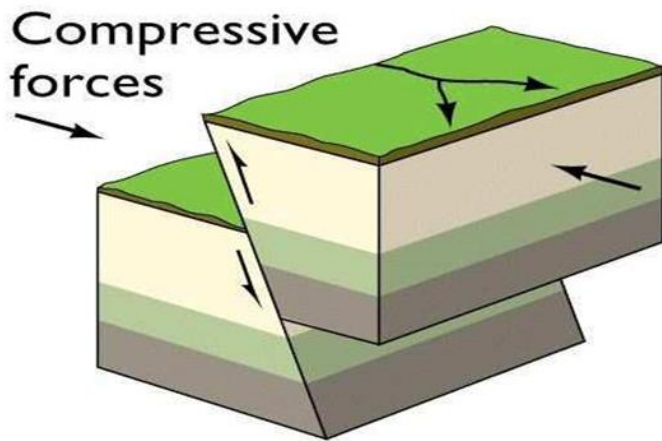
Answer= Normal Fault



Answer= Lateral Fault



Answer= Reverse/Thrust



Name the Fold= Chevron Fold



Reverse Fault: **Compression** forces cause crust to move up.

- Thrust Fault: A type of reverse fault with a **low** angle of the fault plane, less than  $45^\circ$

Strike-slip Fault: Crust moves alongside each other in opposite directions. **Shearing** Force

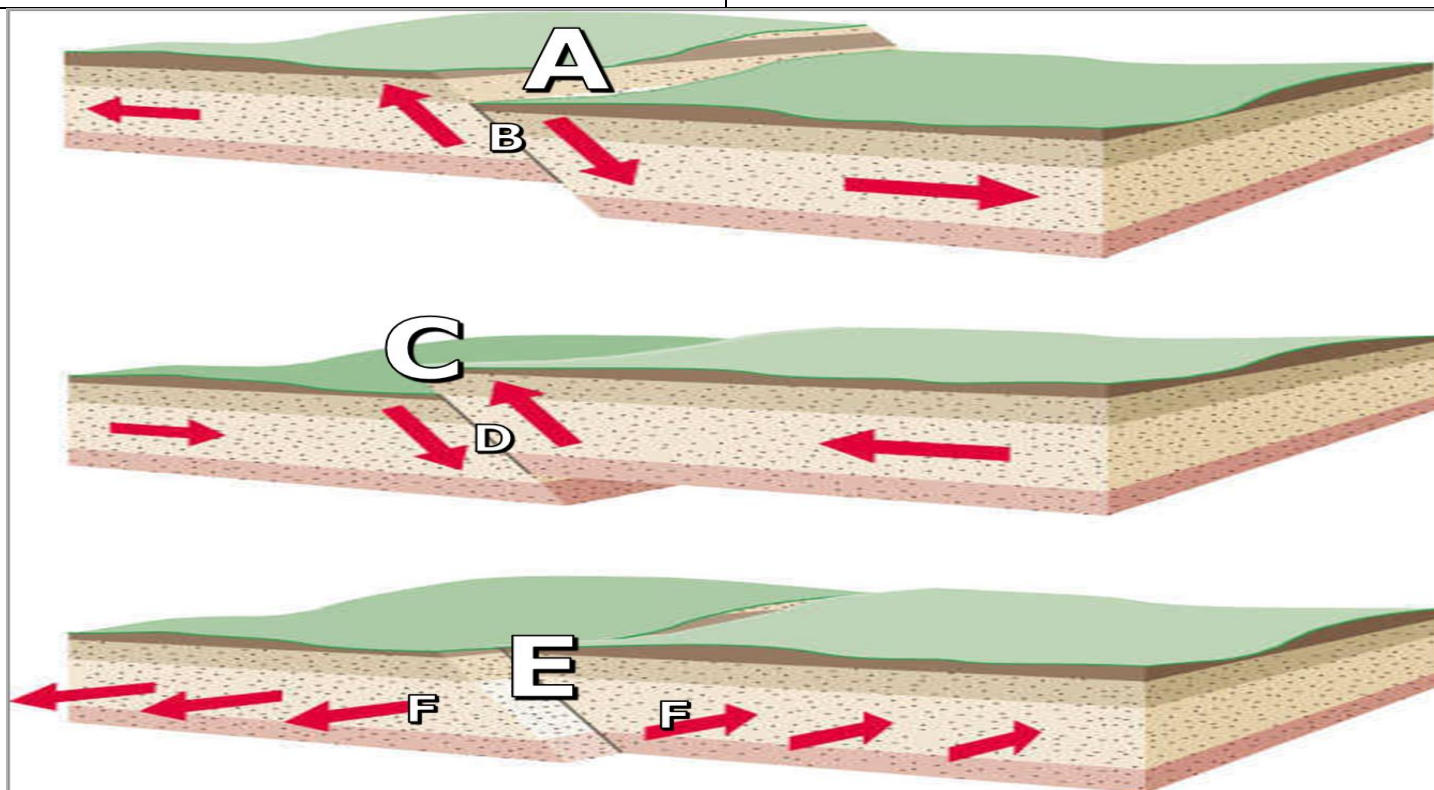
- A right-lateral strike-slip fault is one on which the displacement of the far block is to the right when viewed from either side.
- A left-lateral strike-slip fault is one on which the displacement of the far block is to the left when viewed from either side.

Please research this important fault. ◊Name the fault ◊Describe the type of fault, ◊provide arrows that show the movements, ◊ and provide some information about it in the writing space.

The San Andreas Fault is a continental transform fault that extends roughly 1,200 kilometers through California. It forms the tectonic boundary between the Pacific Plate and the North American Plate, and its motion is right-lateral strike-slip. This fault has been associated with large earthquakes originating near the surface along its path, including a disastrous quake in San Francisco in 1906, a less serious event in 1989, and a strong and destructive quake in a LA suburb of Northridge in 1994.

Name the fault and type of stress?

A= <b>Normal Fault</b>	B= <b>Tension</b>
C= <b>Reverse/Thrust Fault</b>	D= <b>Compression</b>
E= <b>Lateral / Strike-Slip Fault</b>	F= <b>Shearing</b>

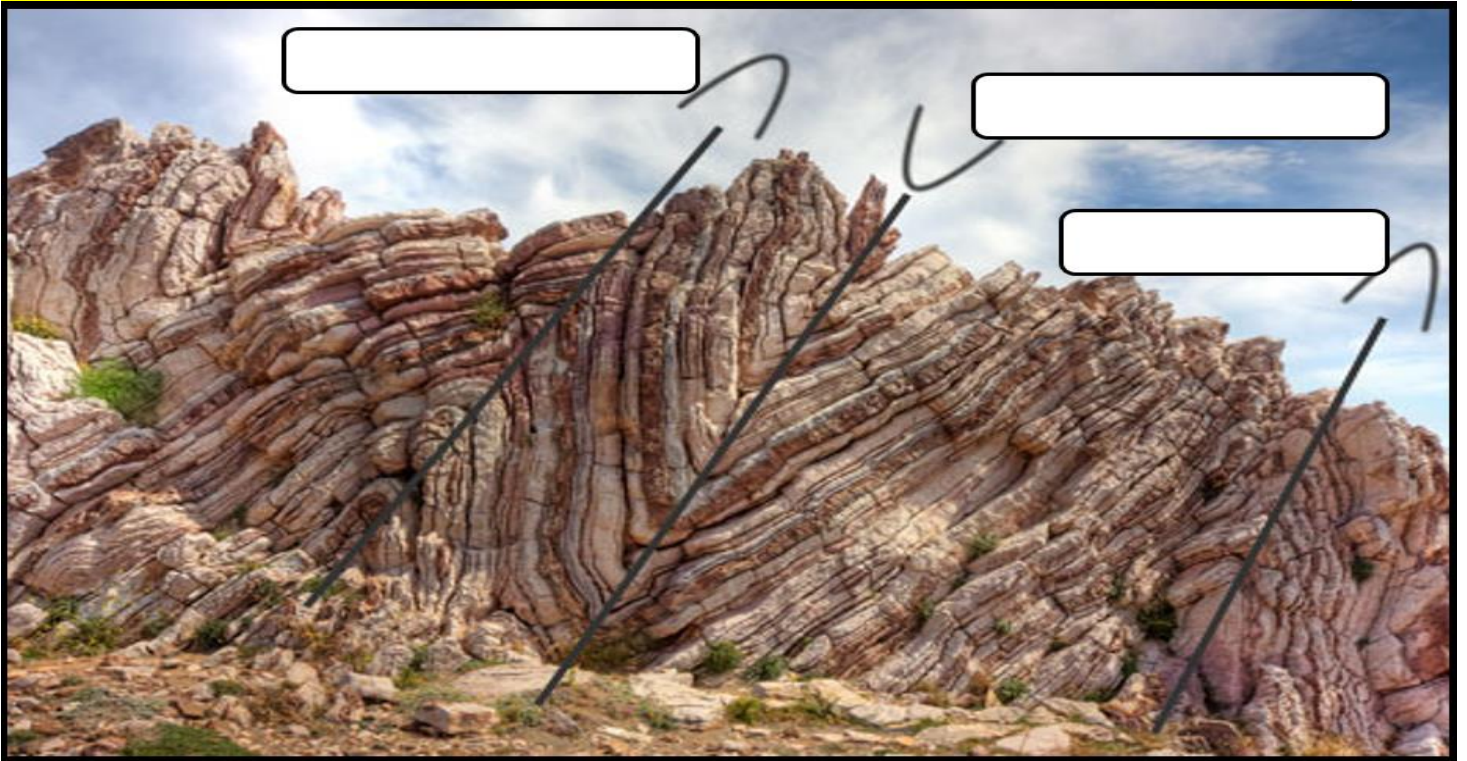




Part 3 Lesson 4 Folds

◇ Is this fold caused by compression, tension, or shearing? \_\_\_\_\_

Anticline, Syncline, Anticline

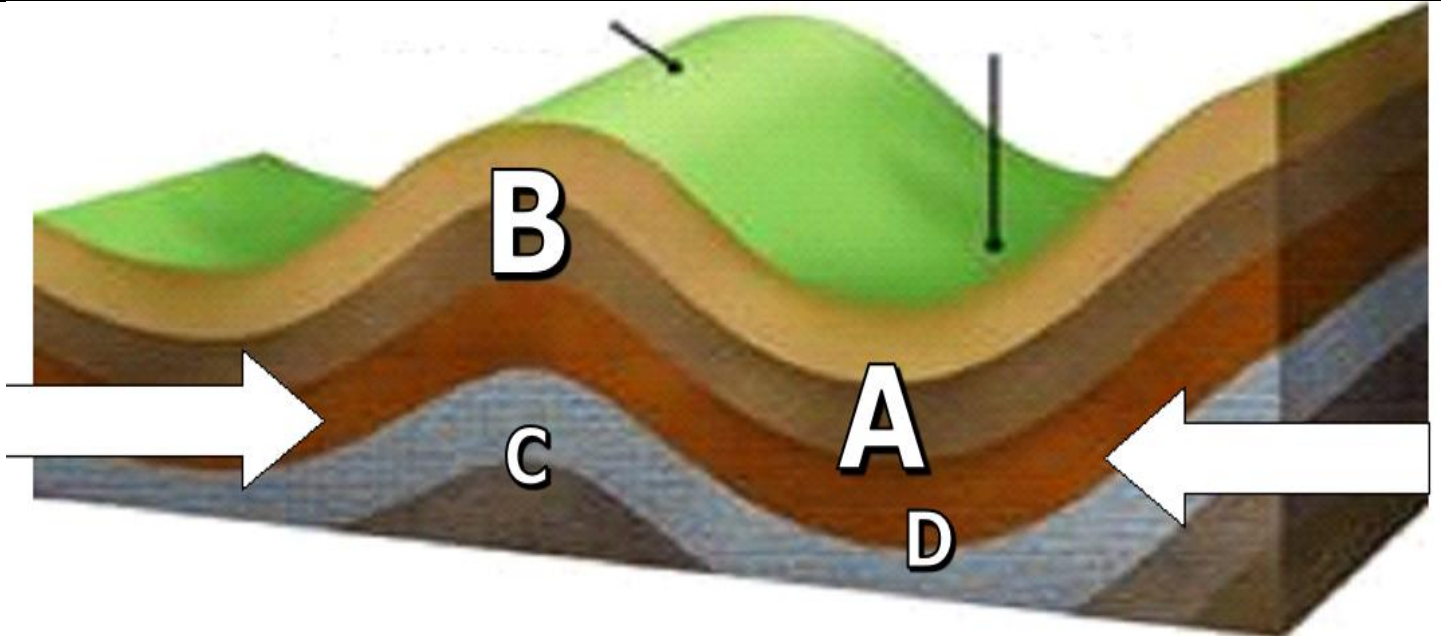


◇ Which box is the anticline and which is the syncline?

◇ Where might we find gas and oil? How about groundwater (aquifer)

A= Syncline

B= Anticline



C= Oil and Gas or Water?

D= Oil and Gas or Water?

Quiz Wiz 1-10. Name that fault or fold.

- Normal (Tension), Reverse / Thrust (Compression), Lateral / Slip-strike (Shearing)
  - Compression Fold
- Anticline / Syncline

1) Normal Fault / Tension <- ->	2) Reverse /Thrust Fault Compression-><-	3) Lateral/Strick-Slip Fault
4) Compression Fold	5) Lateral/Strike Slip, Shearing	6) Compression Fold
7) Reverse/Thrust Faults Compression	8) Normal Fault / Tension	9) Reverse/Thrust Fault Compression
10) Lateral/Strike Slip Fault Shearing	*11) Battle of the Bays Oakland A's vs San Fran Giants	

Part 3 Lesson 5 Mechanical/Energy Waves

Earthquake: Shaking of the earth's crust from a sudden release of energy.

Body Waves

P Wave: Primary wave. Moves lateral (faster-Arrives First)

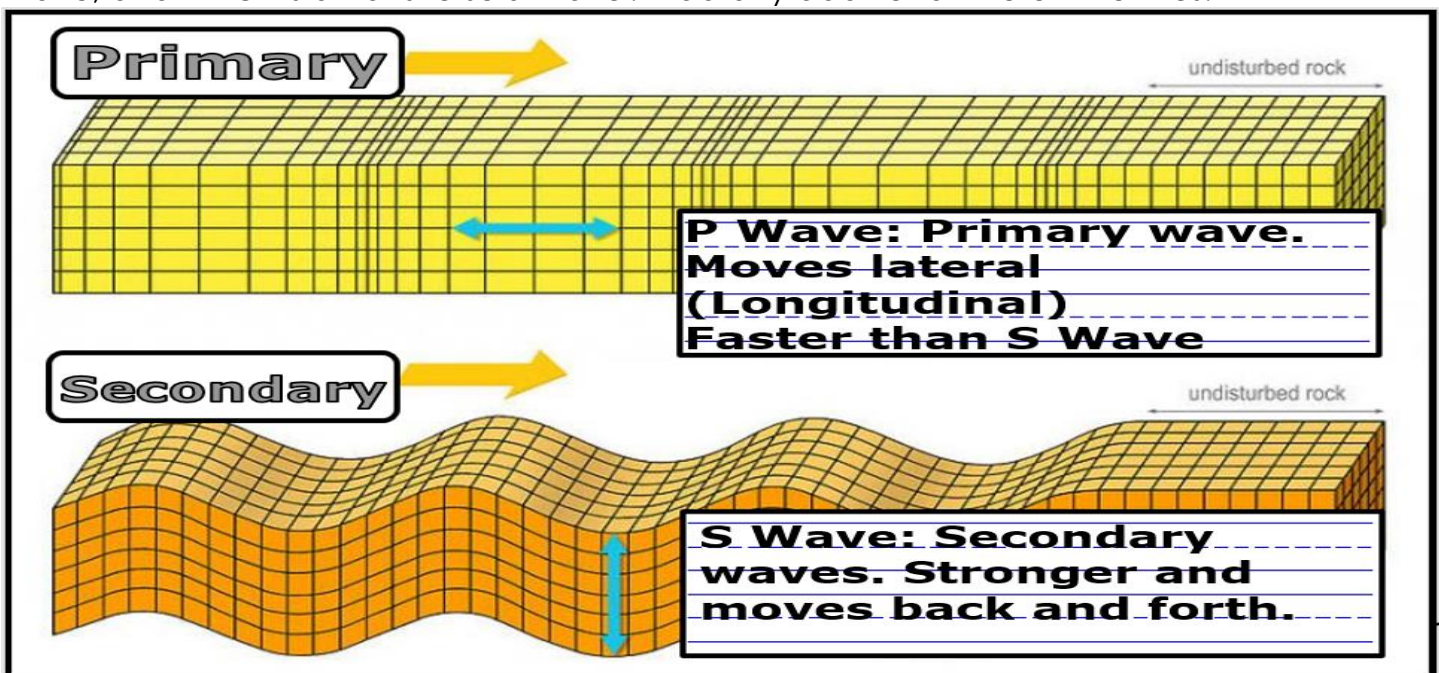
S Wave: Surface waves. Moves back and forth. (Slower, but stronger)

Surface Waves

-Rayleigh wave is a seismic surface wave causing the ground to shake in an elliptical motion, with no transverse, or perpendicular, motion.

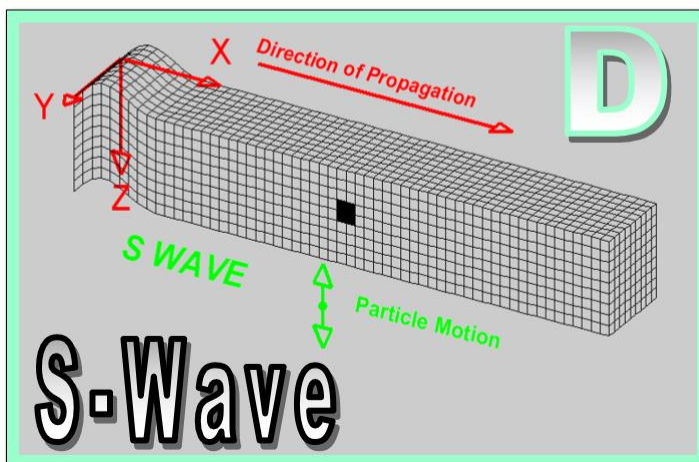
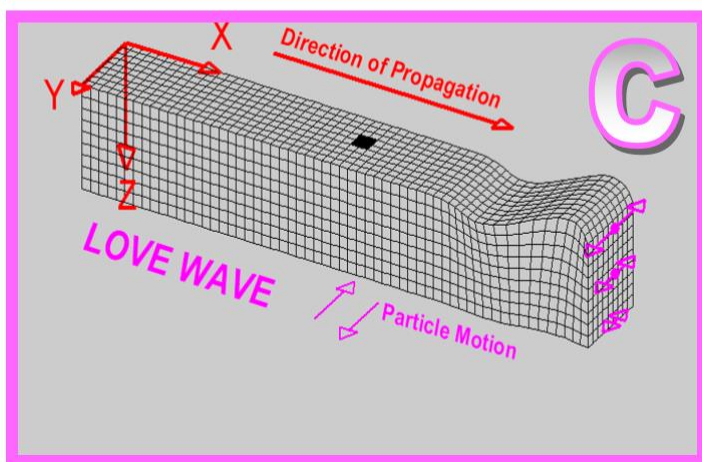
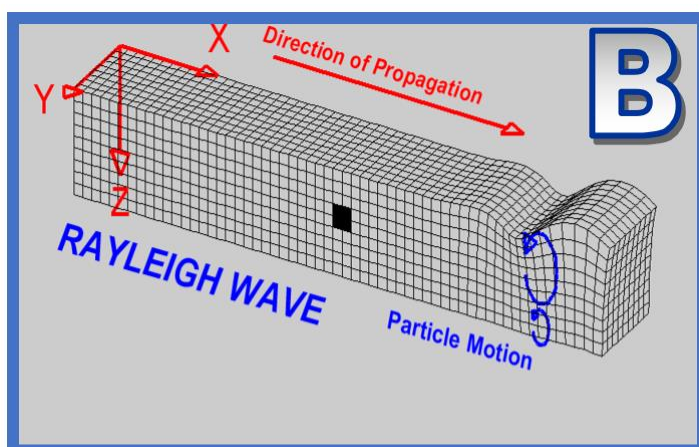
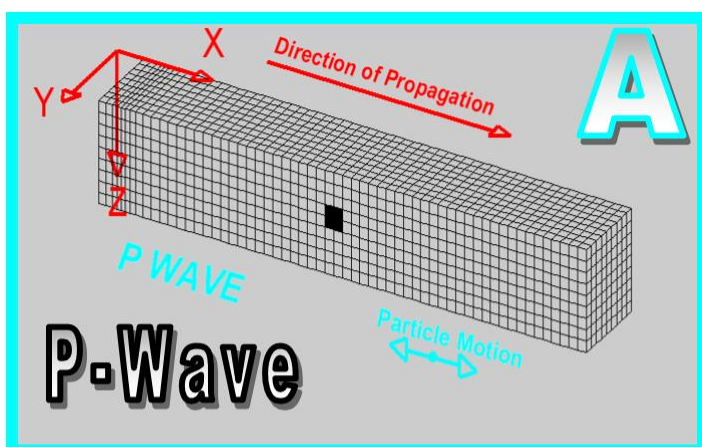
-A Love wave is a surface wave having a horizontal motion that is transverse (or perpendicular) to the direction the wave is traveling.

Mechanical waves can be longitudinal or transverse. Which one below is a longitudinal P Wave, and which is a transverse S-Wave? Add any additional info on the lines.



Name each wave below. Word Bank: Primary Wave, Secondary Wave, Rayleigh Wave, Love Wave

Which two are body waves? <b>S and P Waves (A and D)</b>	Which two are surface waves? <b>Love and Rayleigh Waves (B and C)</b>	Which ones are transverse? <b>B, C, D all but primary waves</b>	Which one is longitudinal only? <b>Primary Wave</b>
Which two cause the most destruction? <b>Surface Waves Love and Rayleigh (B and C)</b>	Which is the fastest wave? <b>Primary Wave</b>	Is the S-Wave or P-wave more powerful? <b>S-wave</b>	How are you doing? <b>Teachers need to take a break 😊</b>



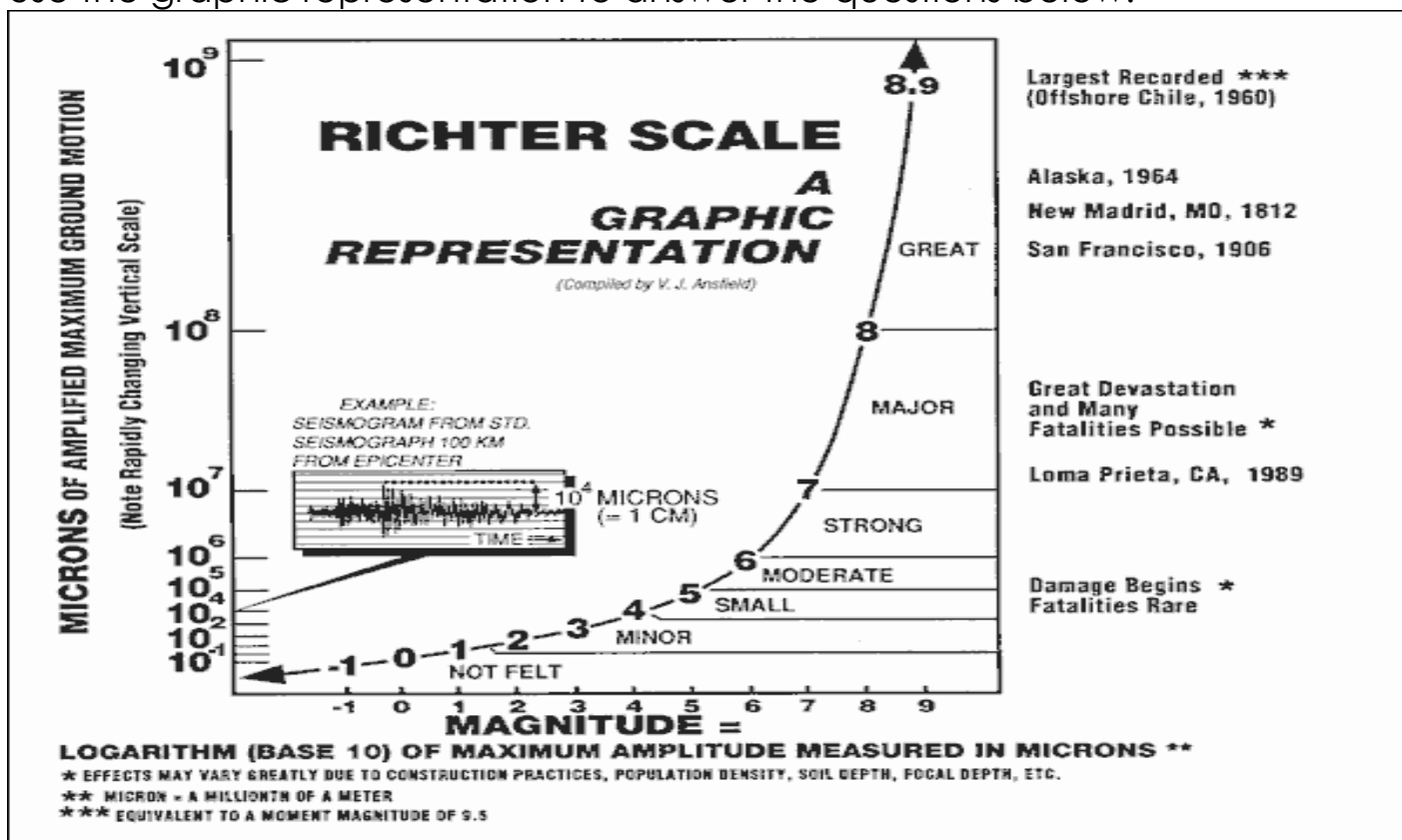
### Part 3 Lesson 6 Earthquakes

Seismograph: An instrument used to measure the **shaking** caused by an earthquake.

Richter Scale - Scale for measuring earthquake **magnitude**.

- A magnitude 7.0 earthquake generates **10** times larger amplitude waves than those of a magnitude 6.0.

Use the graphic representation to answer the questions below.



Where and when was the largest earthquake ever recorded?	Offshore of Chile in 1960
Will a 1.0 on the Richter Scale cause serious damage?	No, a 1.0 on the Richter Scale is usually not felt
What magnitude earthquakes start to cause damage and fatalities?	A 6.0 on the Richter Scale will cause moderate damage. A 7.0 will cause significant/Strong damage
A 7.0 earthquake is how many times larger than and 6.0?	The shaking amplitude of a 7.0 earthquake is 10 times that of a 6.0 earthquake

Research one earthquake and record some information below. No copy and paste. Please cite your source.

Where?, When? How strong / Damage and Death Toll? What type of fault line was it?

Answers will vary but here's the 2011 Earthquake in Japan

**The Great East Japan Earthquake**

Where: Off the North East Coast of the Tohoku region of Japan

When: March 11<sup>th</sup>, 2011

How Strong: A 9.0/9.1 on the Seafloor Megathrust Earthquake

Damage: Tsunami waves smashed the coast, causing massive damage and flooding. The Fukushima Daiichi Nuclear Power Plant cooling system which became damaged and lead to a level 7 meltdown.

Death Toll: 20,000 dead, 2,500 missing from the Tsunami, earthquake damage, and post disaster health conditions

Author's name  
 Date of publication  
 Title of page  
 Name of the website  
 URL

Lund, N. (2015). How to begin birding. Retrieved from National Audubon Society website:  
<http://www.audubon.org/news/how-begin-birding>

Answer in the spaces below.

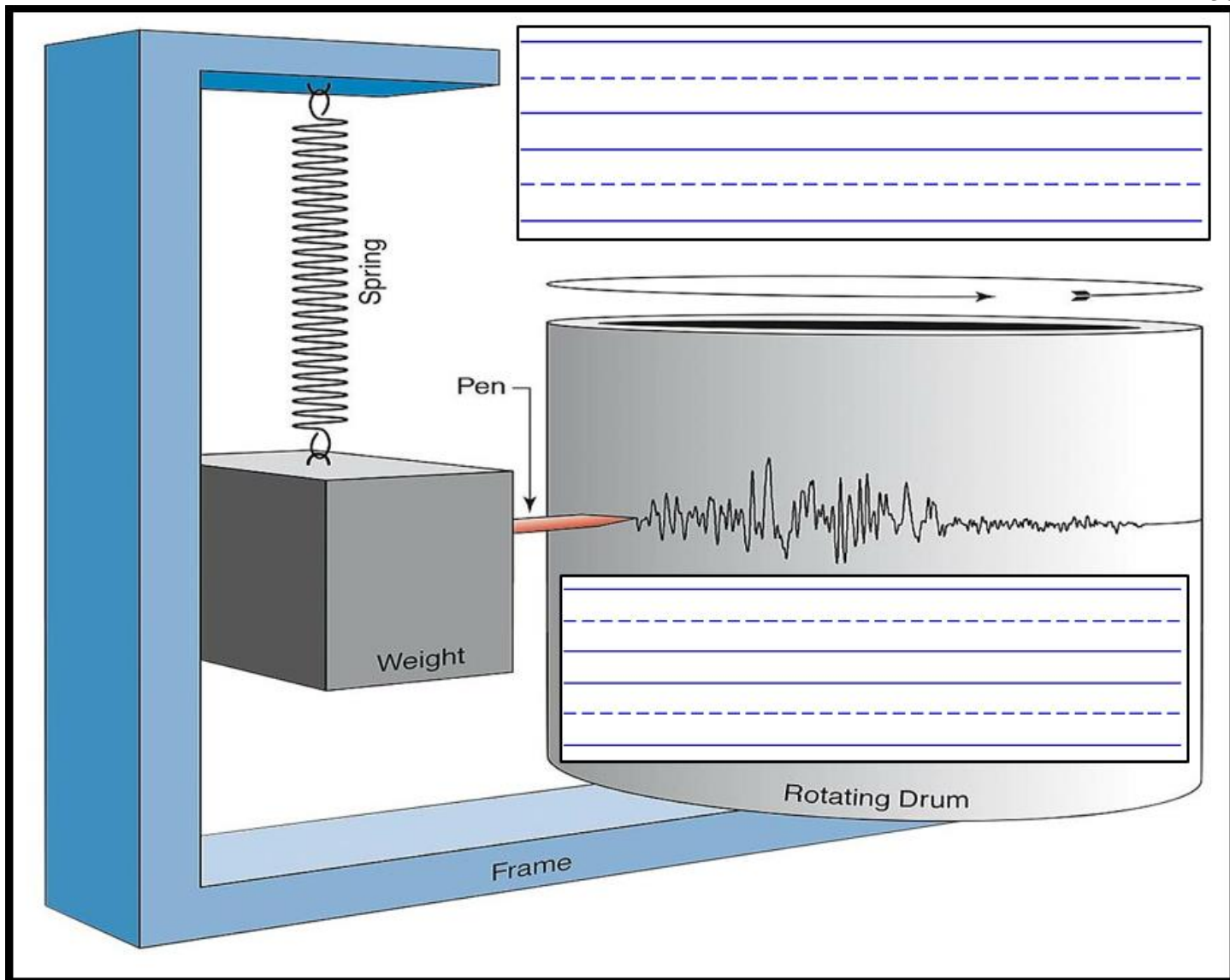
◇ What is the name of this device? Seismograph (Modern is a seismometer w/ seismogram)

◇ What does it measure? Motion of the ground in an earthquake

◇ How does it work? They contain a weight and a pen attached to a spring (below).

The seismograph is bolted to the ground so during an earthquake it moves with the ground, whilst the weight and pen remain still. The pen moves across a rotating paper roll recording the seismic waves. Seismometer

◇ Can you point out when the earthquake occurred below? When the first surface waves arrive



What was this earthquake on the Mercalli Intensity Scale? Answer=8 or 9 on Mercalli Scale

Modified Mercalli Intensity Scale			
I	Instrumental: detected only by instruments	VII	Very strong: noticed by people in autos Damage to poor construction
II	Very feeble: noticed only by people at rest	VIII	Destructive: chimneys fall, much damage in substantial buildings, heavy furniture overturned
III	Slight: felt by people at rest Like passing of a truck	IX	Ruinous: great damage to substantial structures Ground cracked, pipes broken
IV	Moderate: generally perceptible by people in motion Loose objects disturbed	X	Disastrous: many buildings destroyed
V	Rather strong: dishes broken, bells rung, pendulum clocks stopped People awakened	XI	Very disastrous: few structures left standing
VI	Strong: felt by all, some people frightened Damage slight, some plaster cracked	XII	Catastrophic: total destruction



### Part 3 Lesson 7 Epicenter

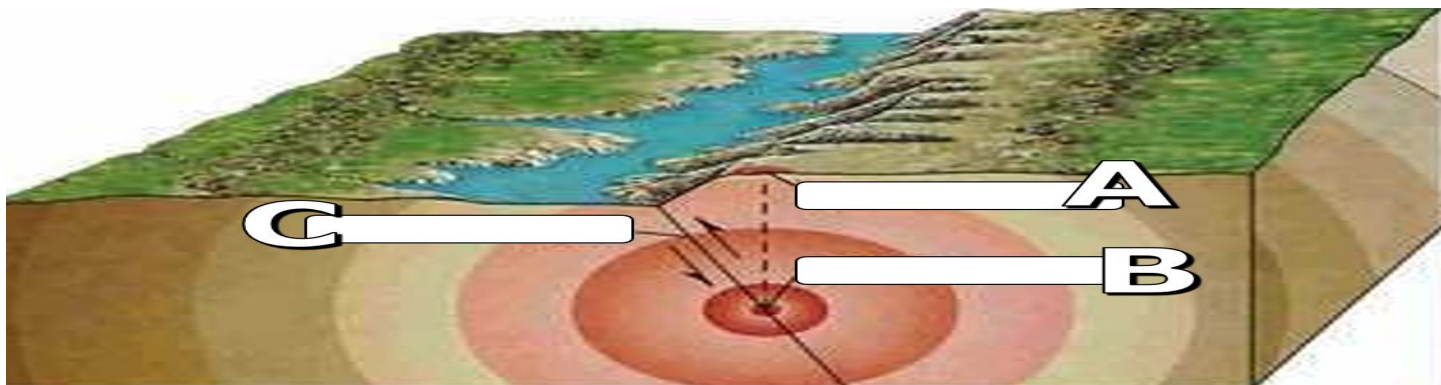
Epicenter: The point on the earth's surface that is directly above the hypocenter or focus.

- Just above the earthquake / focus / hypocenter

A=Epicerter

B=Hypocenter

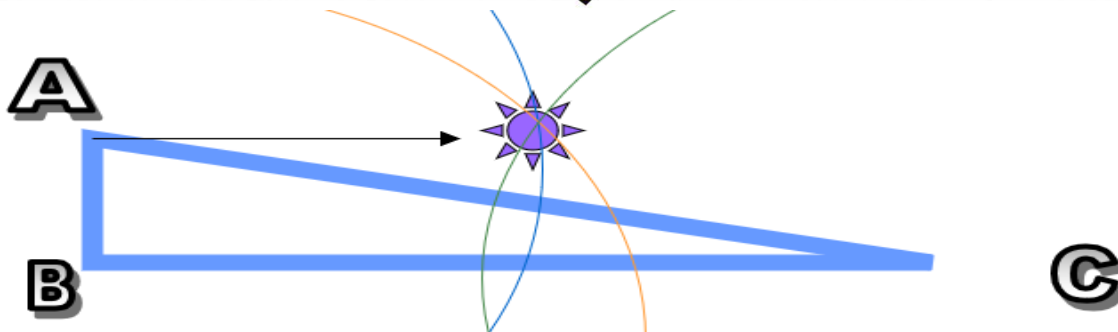
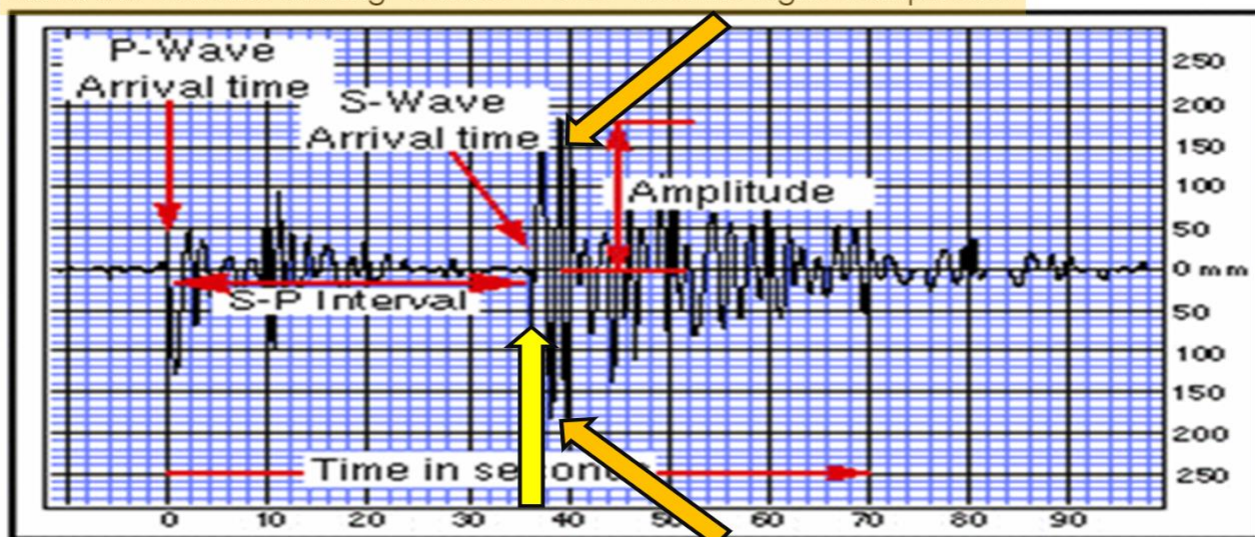
C=Fault Line

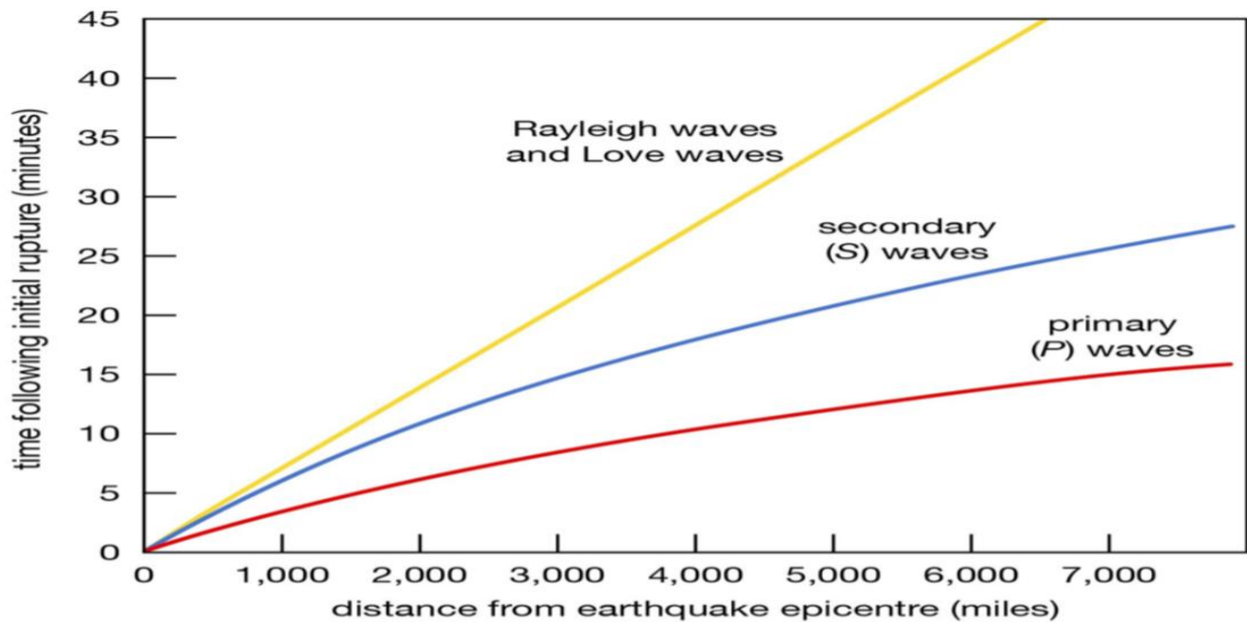


An earthquake requires three monitoring stations to determine its location.

P and S waves travel at known **velocities** through the earth. **S-** waves are slower than **P-** waves by a known amount. Therefore, the farther a **seismic** recording station is from the earthquake **epicenter** the greater the **distance** in time of arrival between the P and S wave.

S waves are indicated by an abrupt change in wave amplitude. Below, the S wave arrived about how many **34** seconds after the P wave? The time difference is called the S-P interval and the lag time between the first P wave and arrival of first S wave. **Can you show with a line were the shaking "Surface Waves" had the highest amplitude.**





Source: Incorporated Research Institutions for Seismology (IRIS), "Travel Time Curves" (2014).

How many minutes does it take a P-wave to travel 5,000 miles? **12 minutes**

How many minutes does it take an S-Wave to travel 5,000 miles? **20 minutes**

How many minutes does it take a Surface Wave to travel 5,000 miles? **35 minutes**

What is the time gap in minutes between the P-Wave and S-Wave at 2,000 miles? **5 min**

What is the time gap in minutes between the P-Wave and S-Wave at 7,000 miles? **10 min**

If you were 2,000 miles from the earthquake. How long would it be before you felt your first surface wave with a seismograph? **14 min** How about a P-wave? **5:30**

Where was the earthquakes epicenter?

Answer= **San Francisco California**





## Part 3 Lesson 9 Earthquake Design

Liquefaction: A process where sand or landfill will often change from a wet solid into a dense liquid, which further amplifies shaking.

Damping: Buildings in general dissipate vibration by absorbing it. Damping is a rate at which natural vibration is absorbed.

Torsion: Objects and buildings have a center of mass, a point by which the object (building) can be balanced without rotation occurring.

Building Configuration: Size and Shape. It determines the way seismic forces are distributed within the structure.

Regular Configuration (Better Design) buildings have... Low Height to Base Ratios, Equal Floor Heights, Symmetrical Plans, Uniform Sections and Elevations, Maximum Torsional Resistance, Short Spans and Redundancy, Direct Load Paths.

Irregular Configuration buildings are those that differ from the "Regular" definition and have problematic stress concentrations and torsion.

Ductility: Ductility is the characteristic of a material to bend, flex, or move. Non-ductile materials (such as poorly reinforced concrete and bricks) fail abruptly by crumbling.

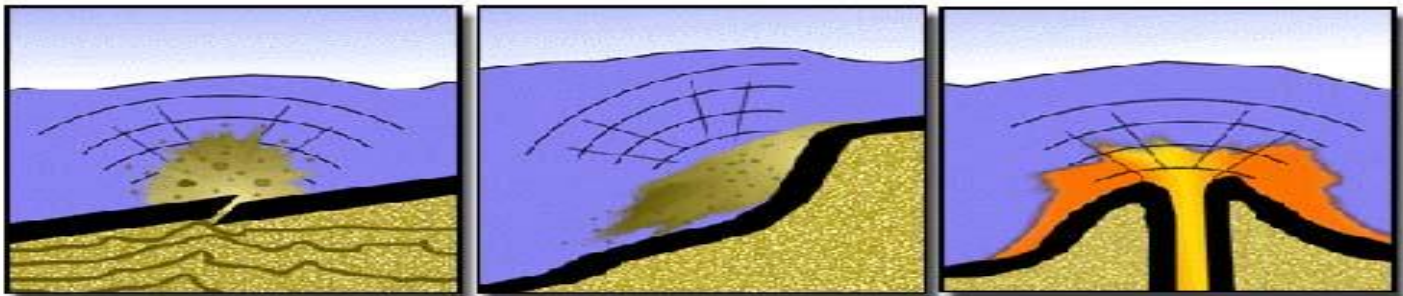
Strength and Stiffness: Strength is a property of a material to resist and bear applied forces within a safe limit. Triangles are better than squares.

## Part 3 Lesson 9 Tsunami

Tsunami: An ocean wave generated by a submarine earthquake, volcano or landslide.

- A tsunami can travel across whole oceans.

Please describe the three causes of a tsunami beneath each picture.



An underwater earthquake. Especially a reverse / thrust fault which can displace enormous amounts of water.

An underwater landslide can displace water and create a tsunami.

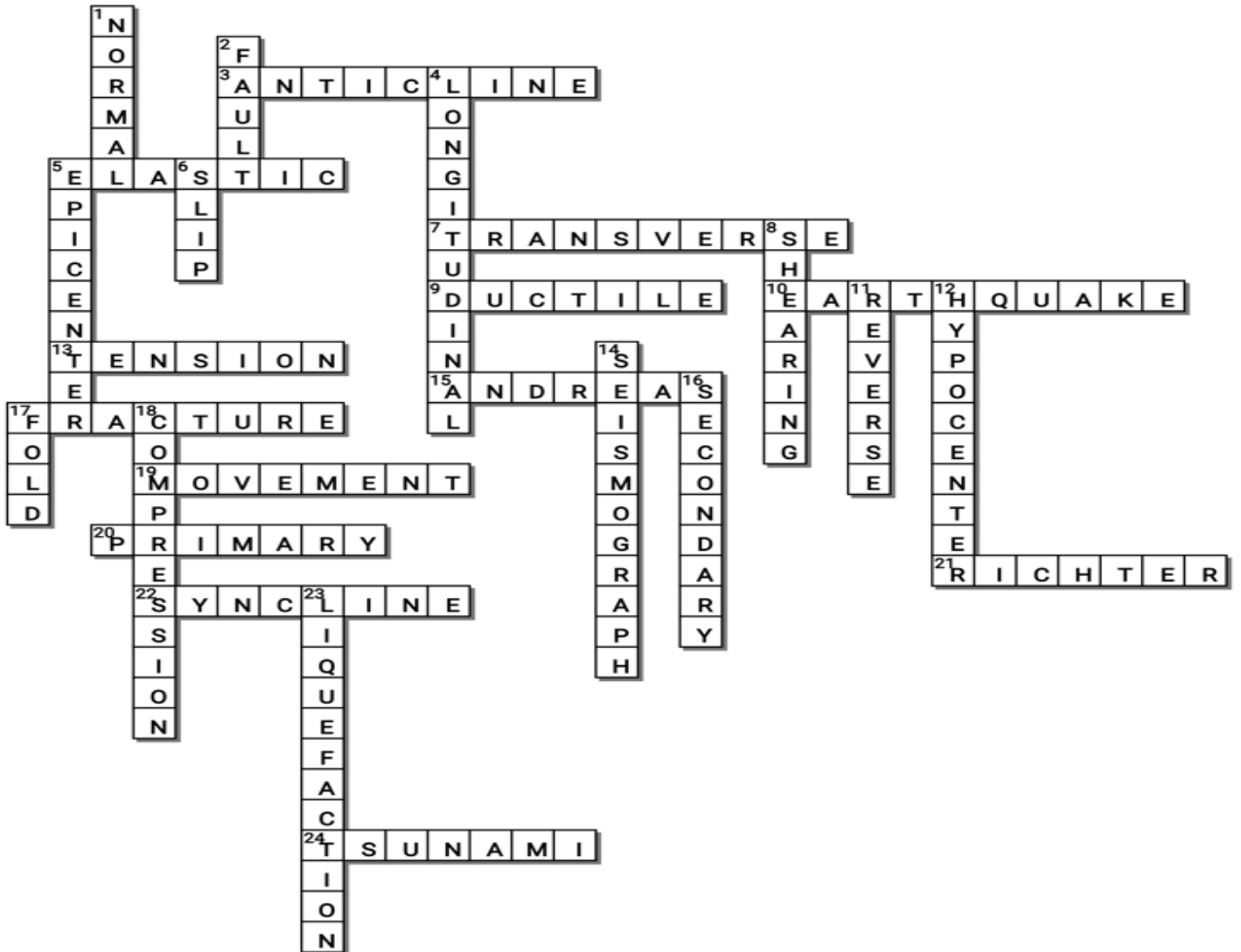
An underwater volcanic eruption.

What are three warning signs that a tsunami may be coming?

The bay may recede before a giant wave emerges.

An earthquake in your area.

Warnings on the news, warning sounds, phone alerts, get to high ground.



# Part 3 Lesson 11 Earthquakes

Name: \_\_\_\_\_

Score \_\_\_\_ / 100

1-20 = 5 pts

\*20-\*25 \* = Bonus + 1 pt,

(Secretly write owl in correct space +1 pt)

Final Question = 5 pt wager

IT'S NOT YOUR FAULT	KNOW WHEN TO FOLD EM	WAVY GRAVY	IT BURNS	ON FIRE Bonus round 1 pt each
1)  A=Fault B=Fold	6)  Lateral Fault Oblique Lateral Fault	11)  S-Waves P-Waves	16)  Epicenter Hypocenter	*21)  CRASH BANDICOOT
2)  REVERSE/THRUST FAULT	7)  B	12)  P-Wave is Faster	17)  Seismograph Seismometer	*22)  DIG DUG
3)  NORMAL FAULT TENSION	8)  Compression Fold Bonus Syncline Anticline	13)  Energy	18)  Richter Scale	*23)  TEMPLE RUN
4)  Lateral/Strike Slip Fault (Shearing Force)	9)  Body Waves Surface Waves	14)  B	19)  Tsunami	*24)  BOOK HOLES
5)  Confining/ Uniform	10)  Longitudinal Transverse	15)  Liquefaction	20)  The Mercalli Scale	*25)  MOVIE TREMORS

Final Question Wager \_\_\_\_ /5 Answer LETTER E is the Epicenter

