ROCKS ARE ELASTIC!! Seeing is Believing:

Demonstration & student worksheets

www.iris.edu/hq/inclass/lesson/28

Version 2.0 (October 2017)

IRIS
www.iris.edu/earthquake

Incorporated Research Institutions for Seismology recognizes the inspiration of John Lahr, and gives thanks to Rod Allen, science teacher at the DaVinci Academy, for development and testing.

OVERVIEW

How rocks respond to stress is a fundamental concept, critical to forming explanatory models in the geosciences (e.g., elastic rebound theory). Whereas students in your class are likely to have lots of experience with rocks, few will have directly experienced them behaving elastically. As a result of this "missed experience", most students in your classroom conceptualize rocks as rigid solids; a concept which generally serves students well in everyday life but impedes learning about particular geologic concepts.

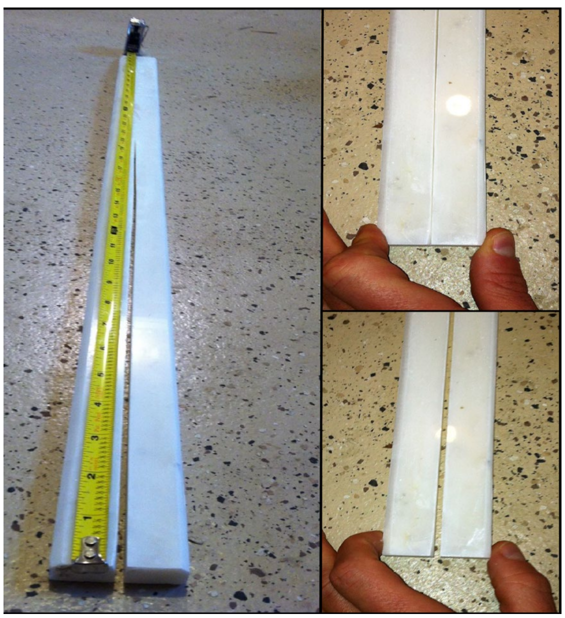


Figure 1. Marble tongs are notched lengthwise (a), providing students with an opportunity to see and feel the elastic deformation of rocks when stress is applied to the cut end (b). When stress is removed, it springs back as the stored energy is released (c).

Despite common awareness of rocks as rigid solids, it is possible to bend rocks and minerals to demonstrate their elastic property. For most students this concept is discrepant because our experience indicates that rocks are rigid and inflexible.

In this activity, a long, narrow slat of marble threshold is notched along ¾ of its length, like a springless clothes pin. Pinching and releasing the notched end allows students to directly "see and feel" that rocks do deform and return to their original position, providing a direct experience that solid rock can deform elastically, consequently challenging and changing their preconceptions.

Beginner

15 min → 45 min

Demo

Whole Class

Significant Prep

See this activity as part of a learning sequence:

www.iris.edu/hq/inclass/sequences

Overview 1
Materials List 2
Construction 2
Lesson Development 3
Vocabulary 3
Teacher Background 6
Student Worksheets SW1
Worksheet Answer Key 13

OBJECTIVES

Students will be able to:

- Explain at least one way to demonstrate that solids, like rocks, can deform elastically.
- Describe how the elasticity of rocks is fundamental to the earthquake cycle.

MATERIALS

- 2 or 3 Marble thresholds (2"X36") for the tongs. Purchase and construction details below.
- Class set of student handouts (Pages SW-1 and SW-2)
- (1) Earthquake Machine model (instructions available from: http://www.iris.edu/hq/inclass/lesson/15)
- Optional: Camera connected to a projection system may be useful to allow large groups of students see the demonstration.
- Optional: pieces of spaghetti to experiment with elastic rebound and brittle fracture

TIPS

- Fine-grained samples will tolerate more use than samples with larger mineral grains, and/or other heterogeneities. Despite this, having several on hand is strongly recommended as the tongs will eventually wear out and fracture unexpectedly.
- Most marble thresholds, or even scraps from countertops will have smooth edges and polished surfaces. The presence of these man-made alterations has been shown to lead younger students to believe that marble is manmade rather than naturally occurring. To overcome this, hammer the edge of the hand samples to expose the "raw" inside edges before passing them around.

TEACHER BACKGROUND

- **TEACHER BACKGROUND:** Appendix A, page 6.
- **WATCH A DEMO** of this marble-tong activity, as well as the Earthquake Machine, in John Lahr's explanation of elastic rebound: www.iris.edu/hq/inclass/video/67 The Earthquake Machine Lesson offers a logical lead in to this activity. See Appendix B for a set of questions that lead into this marble-tong demonstration.
- See EXTENSION in box on page 4 for classroom demos that complement this lesson.

.

CONSTRUCTION

Marble tongs need to be fabricated *prior to* instruction

- Homogenous and fine-grained natural stone like marble (or a silestone product that is similar to natural stone) can be found in the flooring or bath sections of most "big box" home improvement stores. Sold as a threshold, this marble is an off-the-shelf item and sold in sections that are 36" long by 2–4"wide. At the time of this writing a marble threshold could be obtained for less than $10.
- Many "big box" home improvement stores have the equipment to cut tile in-house and will do several cuts for free. However, if this is not the case in your area, a counter top shop should be able to make the cut for you for a small fee.
- Start by cutting four 2" long pieces off one end of the threshold as illustrated in Figure 2 (a through d). These pieces will become "hand samples" to pass around the class.
- Next, cut a lengthwise slot, 22" long in the threshold (Figure 2e). This will leave will leave several inches of uncut material at the end. Your "Marble Tongs" are now finished! While only one set of Marble Tongs is necessary for the demonstration, having several on hand is recommended as the tongs will eventually wear out and fracture unexpectedly.

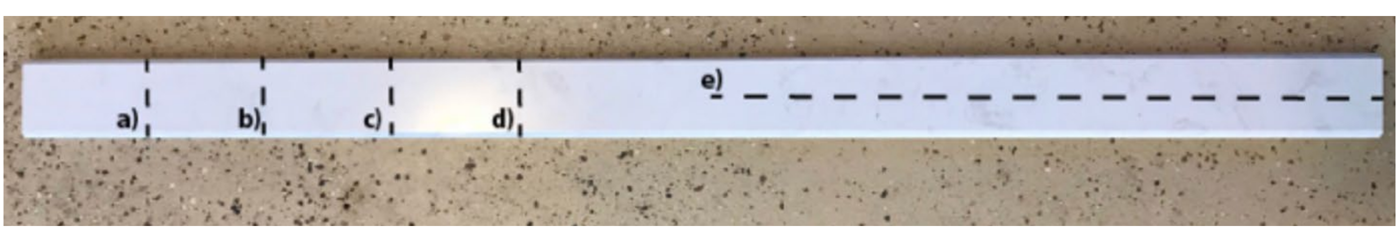


Figure 2. *Cutting guide for the Marble Tongs demonstration. Dashed lines (a) through (d) indicate cuts to create hand samples to pass around the room. Cut (e) is made lengthwise to notch the threshold like a spring-less clothespin.*

LESSON DEVELOPMENT

This activity is structured using the "**OPERA**" learning cycle ([Appendix C](#)).

Because students' conceptions of rocks will initially be different from the scientifically accepted view we would like them to have post instruction, conceptual change is an appropriate pedagogical approach.

1) Open/Prior knowledge

a) Begin by holding up a small hand sample of marble. Ask the students what it is, and lead them to conclude it is a rock. The purpose of this assessment probe is to elicit students' ideas about rocks. Next, ask students if they think you could deform a piece of marble with your fingers only and have it spring back to its original shape when you let go.

b) Be sure to ask student to explain why they believe what they do. Making student's current experiences with rocks explicit is an important step in the process.
?? "*What happens when you bend a rock?*" Answers will vary. If you bend a slab of soft rock, it will fracture.

?? Ask: "*Can <u>you</u> bend a rock?*"

2) Explore/Explain

a) Pass around the small handsamples. Tell them, "*Before I show you that I can can bend rock with just these two fingers, I want you to try.*"

?? *What does it feel like*? Answers will vary.

b) Next, introduce the marble tongs to the students and indicate that they are made from the same, or similar rock. Walk around the room with the tongs, allowing students to feel the *<u>unnotched</u>* end so all students can see and physically feel that the material is similar to the rocks they just experienced.

c) Next, flex and release the marble tongs elastically in class for students to see. Better yet, circulate the marble tongs around the room to allow students to pinch the tongs closed and watch it spring back to its original position when they let go. In this way, you are filling in an experience with rocks that most students do not normally have. When the tongs are pinched there is a maximum deformation that can occur as the tongs close. Not so for prying them open. Make it clear that they may only squeeze the tongs, not expand the tongs outward. The unnecessary stress on it will break the tongs.

d) Discuss the demo with students. When you pinch the tongs you apply stress, a force/unit area**,** to the tongs. In this case the stress is compressional stress as you squeeze the open end together. In response to the stress, the tongs deform or change shape. Energy is also stored in the tongs as potential energy. When you release the ends of the tongs, you remove the stress and the deformation is reversed as the ends return to their original position. In this process the

VOCABULARY

Brittle deformation: Strain where a material fractures.

Ductile (plastic) deformation: Irreversible strain. When the stress is removed the deformation remains.

Elastic deformation: Reversible strain. When stress is removed the material will return to its original position or shape.

Fracture: Irreversible strain when the material separates into two or more pieces due to stress.

Kinetic Energy - The energy of an object due to its motion.

Mineral: a naturally occurring, inorganic, homogeneous solid with a crystalline structure.

Potential Energy: Stored energy of an object due to its position or condition.

Rock: a naturally occurring, solid, comprised of a combination of one or more minerals.

Solid: Anything that retains a fixed volume and shape.

Strain: Changes in size, shape, or volume of an object due to stress.

Stress: The amount of force applied across the area of an object.

stored energy converts potential energy to kinetic energy, and moves the tongs back to their original position.

e) Finally, build on students' new experience with rocks. Begin by introducing the concept of elastic response to stress as a name for the rock's behavior. Most students will be familiar with the concept of elasticity and will be able give examples (e.g. rubber bands or balls), but ultimately hold non-scientific understandings of the concept that are most similar to ductile behavior.

f) Ask students to complete Questions #s 1–4 on their worksheets.

3) Reflect

a) Ask students, "*Is seeing always believing?*"

ANSWER: Seeing does not necessarily mean it should be believed. Examples of situations where this is the case include optical illusions/magic tricks. Here logic must also be applied to what we see (e.g. can things simply disappear? What possible alternative explanations exist?).

b) Ask students, "*Would rocks always behave in this manner? What might make a rock break rather than deform elastically?*"

ANSWER: All rocks are elastic, though their degree of elasticity will vary depending on the type of rock and the bonding between particles. For example, a poorly cemented sedimentary rock is more likely to have an earlier elastic limit than the marble tongs used in the demo.

c) If time allows, you might also expand the discussion to include ductile and brittle responses to stress. Again, it will be important to use a spectrum of objects as examples and illustrate how the same objects can experience all three responses. While this demonstration has a number of strengths, you will also want to be mindful of its limitations as well (Table 1) and address those explicitly with students. From here, students' new experiences with rocks, and their understanding of elastic response to stress can be applied to geologic applications as an explanatory model. For example, it can help students make sense of Global Positioning System data.

4) Apply/Assess

a) Question #5, #6 and #7 on student handout.

b) A discussion of Question #7 will help students realize that the rocks eventually must break or overcome the forces that are keeping the fault locked resulting in energy release. Make sure that students also realize that there are other types of rock deformation, such as ductile deformation (folding).

TIP

To avoid generating misconceptions when working with models, create a list such as Table 1 to emphasize BOTH like and unlike features, as well as strengths and limitations, of the model and reality.

EXTENSION

Below are videos of simple effective demos that complement this lesson by showing how different materials respond to stress, giving analogies for the Earth.

WATCH:

Arguing the Causes of Faults & Folds:
www.iris.edu/hq/inclass/lesson/29

Elastic Rebound Demo Using a Yardstick:
www.iris.edu/hq/inclass/video/64

Brittle Vs. Ductile: Big Hunk as a Model for Earth's Crust & Mantle
www.iris.edu/hq/inclass/video/65

***Table 1**. Strengths and Limitations of the Marble Tongs demonstration*

Strengths	Limitations
Provides a direct experience with marble deforming elastically.	The demonstration is limited to only one type of rock.
Various types of stress can be demonstrated (e.g. tension by pulling the tongs apart, and compression by squeezing them together).	The scale of this demonstration is much smaller than the 10s to 100s of kilometers of elastic deformation that occurs along faults.
The marble tongs can fail brittlely like rocks in Earth. When this occurs, stored potential energy is suddenly released as one side of the fault (break rock along which the sides have moved) moves past the other. The scale is just much smaller.	Marble thresholds have smooth edges and polished surfaces which has been shown to lead some students to believe it is manmade rather than naturally occurring.
	While the marble is elastic, it can eventually wear out and fail brittlely so keep a backup pair handy.

EXTENSION—If the tongs break during the demonstration

There is a possibility that the marble tongs will break during the demonstration. If they do, that is also a teachable moment due to the element of surprise.

If the tongs don't break, and you don't foresee needing them for a future demo, this could be a great way to actually demonstrate an earthquake occurring. For example, if you were to place an iphone on one end with an accelerometer app running you would certainly record the seismic waves from the break. Maybe we could make it an optional activity for those who want to go further with things? What do you think abort that? Based on this question I added a few sentences about this to the bending a rock article.

APPENDIX A

Instructor Background

The rocks that make up Earth's outer shell are continually subjected to stresses. Stress is the amount of force applied across the area of an object. There are three types of stress affecting rocks. Rocks can be squeezed by compressional stress, stretched by tensional stress, or sheared by shear stress (Figure 3). In response to the ongoing stress, rocks are said to strain or change in their size, shape or volume. As the stress increases rocks respond by passing through three successive stages of deformation.

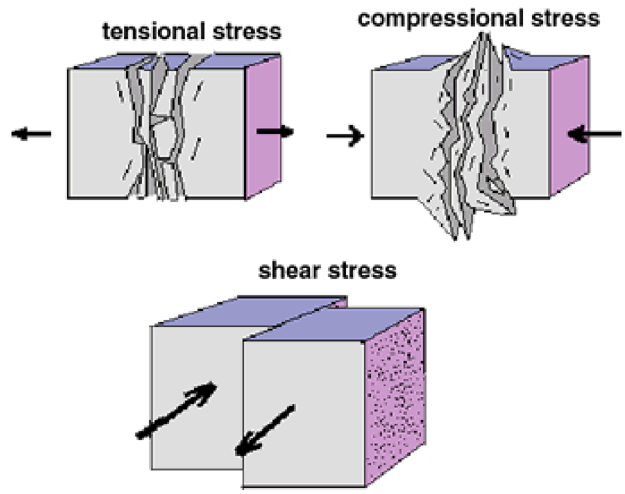


Figure 3. Rocks are subjected to three types of stress. (Image courtesy of Michael Kimberly, North Carolina State Univ.)

As illustrated in the table below, rocks respond to stress in three ways (strain). Initially rocks respond elastically. Elastic deformation is reversible. This means that when the stress is removed the material will return to its original position. A common example of elastic deformation is the change in shape a rubber band experiences when you pull on it. Once this stress is removed, the rubber band returns to its original shape.

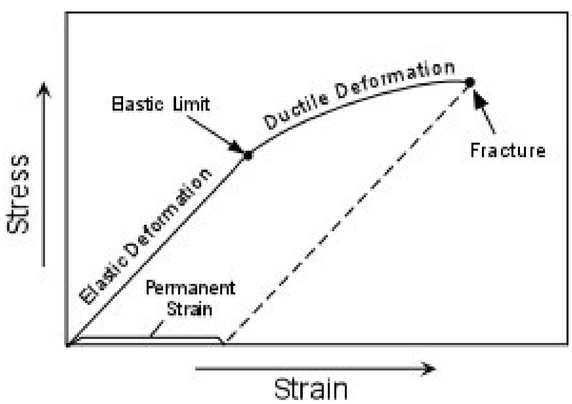


Figure 4. Rock passes through 3 successive stages of deformation as it is subjected to increasing stress.

As rocks pass their elastic limits they experience ductile deformation. Ductile deformation is irreversible. This means that when the stress is removed the deformation remains. A common example of this is applying stress to a copper wire. As stress is applied the wire's shape is changed as it bends. When the stress is removed the wire remains bent. Finally, a rock experiences fracture or irreversible strain were the material is separated into two or more pieces. A common example is a piece of uncooked spaghetti. When enough stress is applied, the strain becomes so great that the spaghetti breaks into two or more pieces.

This elastic behavior of rocks is a fundamental concept for studying earthquakes and Earth's structure. As illustrated with the Earthquake Machine model, an earthquake occurs when potential energy, that was stored elastically in the rocks, is suddenly converted to kinetic energy as the rock fractures and moves to a position with less strain. The slow accumulation of strain is spread over many, many miles on opposite sides of the fault, but friction on the fault "locks" each side and prevents it from slipping. Eventually the accumulated stresses are more than the fault can endure, and the fault slips in an earthquake. This process, first describe by H.F. Reid in 1906 is known as the Elastic Rebound Theory of earthquakes (Figure 5).

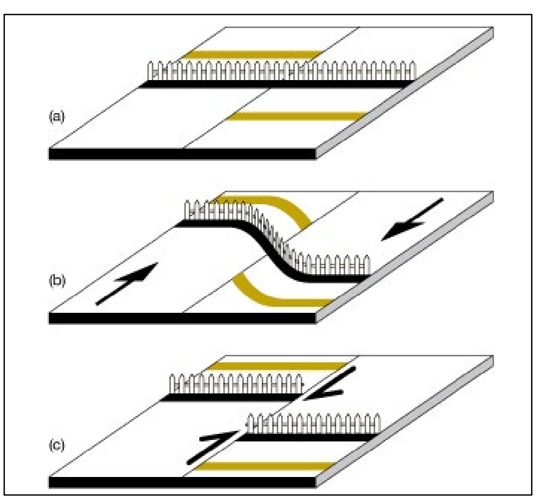


Figure 5. Motion of a fence crossing a fault before and during an earthquake illustrates the gradual accumulation and sudden release of stress and strain.

This disturbance along the fault carries energy and propagates outwards in all directions. The propagation of energy, as seismic waves, is only possible because Earth materials are elastic. As the particles of Earth materials are deformed elastically, each applies stress to it's neighboring particles before returning to their original position. In response to this stress the neighboring particles also deform and the process continues. As a result, seismologists study seismic waves to gain information about both their sources and the materials through which they have traveled.

What is "Elastic Rebound Theory"?

Elastic rebound is what happens to the crustal material on either side of a fault during an earthquake (Figure 6). The idea is that a fault, stuck by friction, undergoes immense pressure and stress while strain accumulates. The rock distorts, or bends (strain) under applied stress until friction is overcome, at which point the rock snaps to an un-strained position, releasing energy in an earthquake that produces seismic waves over the duration of the seismic event. (https://earthquake.usgs.gov/learn/animations/elasticrebound.php)

Most earthquakes are the result of the sudden elastic rebound of previously stored energy. In Great earthquakes the first large earthquake, released during elastic rebound, initiates a rupture along a vast fault surface. This triggers continued earthquakes due to successive tearing in a domino effect that results in ground shaking over several minutes, rather than seconds. Because the initial seismic signal recorded the beginning of the rupture, scientists have to recalculate the larger magnitude based on the size of the rupture as well as the energy released during the event. Elastic rebound is like releasing a spring, causing ground shaking until the stress is relieved.

This picture, taken near Bolinas in Marin County by G.K. Gilbert, shows a fence that was offset about 8.5 feet along the trace of the fault (from Steinbrugge Collection of the UC Berkeley Earthquake Engineering Research Center

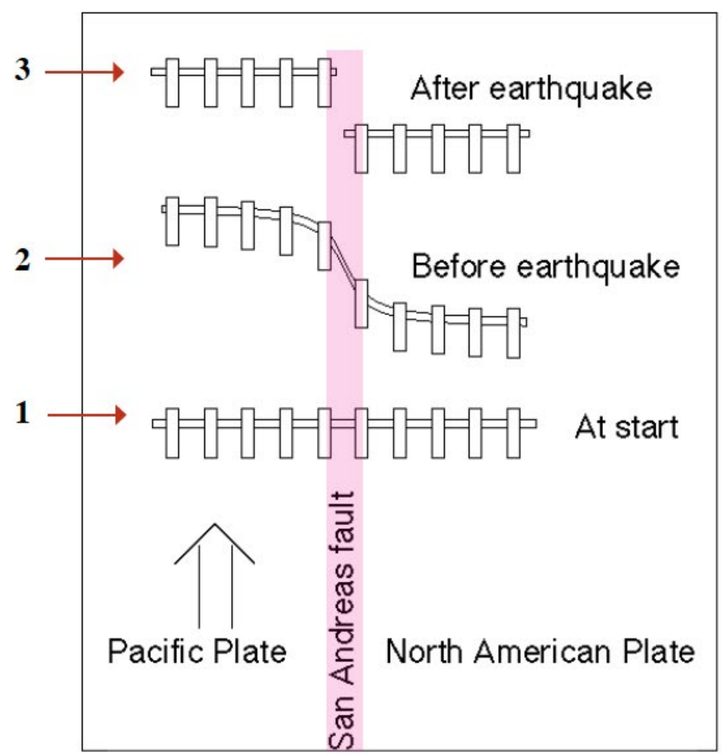


Figure 6: Image and text from: https://earthquake.usgs.gov/earthquakes/events/1906calif/18april/reid.php

APPENDIX B

Linking: the *"Earthquake Machine"* **(**www.iris.edu/hq/inclass/lesson/15**)** as logical "prequel" to *Rocks Are Elastic!*

If the class has already done the Earthquake Machine activity, the following questions can guide thinking to whether rock in the Earth is elastic.

1) <u>O</u>pen & <u>P</u>rior Knowledge

a) Demonstrate the stick/slip earthquake cycle using the Earthquake Machine Lite activity.

b) Ask students, "*How does the model illustrate the definition of an earthquake?*" (www.iris.edu/hq/inclass/video/67)

ANSWER: The stick-slip behavior of the block is similar to the earthquake cycle where Earth materials store energy elastically (potential energy) as stress is applied over a period of time. When a deformation threshold is reached, the Earth materials fracture and the potential energy is suddenly converted to kinetic energy as the Earth materials move to a position with less stress (an earthquake). This causes seismic waves to propagate outward in all directions like the sound waves that radiate away from the sandpaper. This explanation for earthquakes is known as the Elastic Rebound Theory.

c) Ask students, *"How could you modify the model so that earthquakes no longer occur?"*

ANSWERS—Among others:

Option 1: Don't pull the rubber band. In Earth, this would be analogous to cooling Earth's interior thereby removing the driving force on the plates

Option 2: Eliminate the friction between the block and the sandpaper base. In Earth, this would be analogous to removing the locking forces (friction, pressure, etc) at a plate boundary or fault.

Option 3: Remove the rubber band or replace it with string. In Earth, this would be analogous to making rocks and other Earth materials inelastic and unable to store the potential energy for an earthquake.

d) Ask students, *"How could you modify the model to make bigger quakes?*

ANSWERS—Among others:

Option 1: Add to the mass on the block. This increases the locking friction between the block and sliding surface. As a result, more potential energy builds before the block slips. If potential energy gets larger, the block may slip further once it starts to move.

Option 2: Use a weaker (more elastic) rubber band.

Option 3: Use coarser grit sandpaper.

e) Ask "*What is elastic in the Earth that could store energy?*"

ANSWER: Explore all possible answers with students but lead the discussion to rocks. Emphasize that the Earthquake Machine model suggests that without the elastic properties of rock to store potential energy, earthquakes would not occur.

APPENDIX C

OPERA Learning Cycle

A learning cycle is a model of instruction based on scientific inquiry or learning from experience. Learning cycles have been shown to be effective at enhancing learning because by providing students with opportunities to develop their own understanding of a scientific concept, explore and deepen that understanding, and then apply the concept to new situations. A number of different learning cycles have been developed. However, all are closely related to one another conceptually, and differ primarily in how many steps the cycle is broken into. The "flavor" of learning cycle that you choose is primarily up to what works best for you, just pick one or two and use it as the basic formula for all your instruction.

This lesson is designed around a learning cycle that can be remembered as O-P-E-R-A. OPERA is convenient when designing lesson-level instruction because one can generally incorporate all the major components into the single experience. Each phase of the OPERA cycle is briefly outlined below.

	Instructional Stage
Open	**Open** the lesson with something that captures students' attention. This could be through demonstrations, videos, or thought-provoking ideas. In this case you will tell them that you have the power to bend rock.
Prior knowledge	Assess students' **Prior Knowledge** and employ strategies that make this prior knowledge explicit to both the instructor and the learner
Explore	Plan and implement a minds-on experience for students to **Explor**e the content
Reflect	**Reflect** on the concepts the students have been exploring. Students verbalize their conceptual understanding or demonstrate new skills and behaviors. Teachers introduce formal terms, definitions, and explanations for concepts, processes, skills, or behaviors.
Apply	Practice concepts, skills and behaviors by **Applying** the knowledge gained in a novel situation to extend students' conceptual understanding.

Earth's Systems

MS-ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. http://ngss.nsta.org/DisplayStandard.aspx?view=pe&id=223

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s)	**ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **ESS2.B: Plate Tectonics and Large-Scale System Interactions**	**Stability and Change** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

MS-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. http://ngss.nsta.org/DisplayStandard.aspx?view=pe&id=224

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.	**ESS2.A:: Earth Materials and Systems** The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.	**Patterns** Patterns in rates of change and other numerical relationships can provide information about natural systems.

Motion and Stability: Forces and Interactions

MS-PS2-2 Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. http://ngss.nsta.org/DisplayStandard.aspx?view=pe&id=149

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.	**PS2.A: Forces and Motion** The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.	**Stability and Change** Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Name:

Period:

Date:

STUDENT WORKSHEET - ARE ROCKS ELASTIC?

1.) Use arrows to indicate the stress applied to the tongs.

a) What type of stress is this?

b) What type of energy are you applying to the tongs?

2.) Below, sketch how the tongs deform in response to the stress.

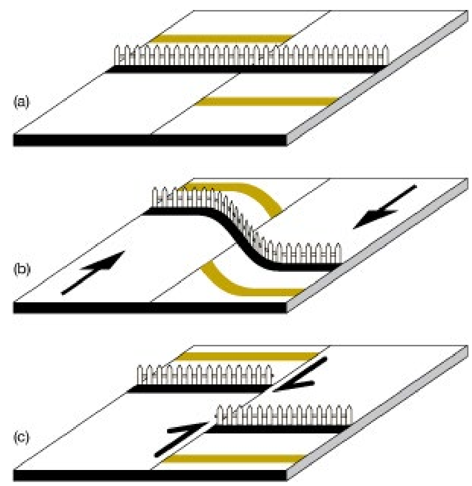
3.) Below, sketch how the tongs respond when the stress is released.

a) What forces the tongs to return to their original position?

b) What type of energy is being used?

4.) Describe how a common, everyday material, might show a similar response to stress and its removal.

5.) Examine the illustrations shown on the right. Use the Earthquake Machine Lite (specifically the stretching rubber band and moving block) to explain Diagrams a, b and c. Be sure to note which illustration shows the buildup of elastic deformation in the rocks.
NOTE*: In Diagram b, solid arrows show the direction of forces; in Diagram c, the barbs show direction of relative movement of the fault immediately following an earthquake.*



6.) Then use the marble tong example (pinching and breaking) to explain Diagrams a, b and c.

7.) Describe how you would modify th marble tong model to represent larger earthquakes.

INSTRUCTOR ANSWER KEY

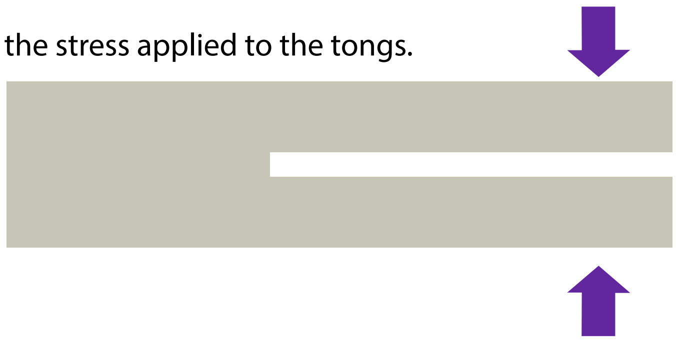
Name:

Period:

Date:

STUDENT WORKSHEET - ARE ROCKS ELASTIC?

1.) Use arrows to indicate the stress applied to the tongs.



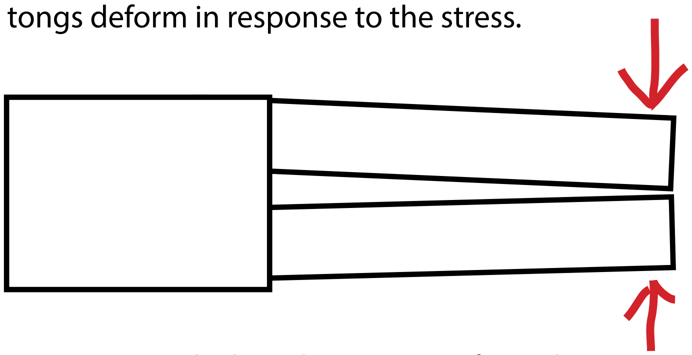
a) What type of stress is this?

ANSWER: *This is compressional stress.*

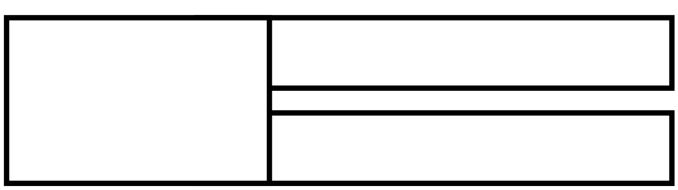
b) What type of energy are you applying to the tongs?

ANSWER: *Kinetic Energy is being applied to the tongs.*

2.) Below, sketch how the tongs deform in response to the stress.



3.) Below, sketch how the tongs respond when the stress is released.



a) What forces the tongs to return to their original position?

ANSWER: *The tongs are forced to return because once the stress is removed the inter-atomic forces push the molecules in the marble back to their original positions.*

b) What type of energy is being used?

ANSWER: *The potential energy stored elastically in the tongs.*

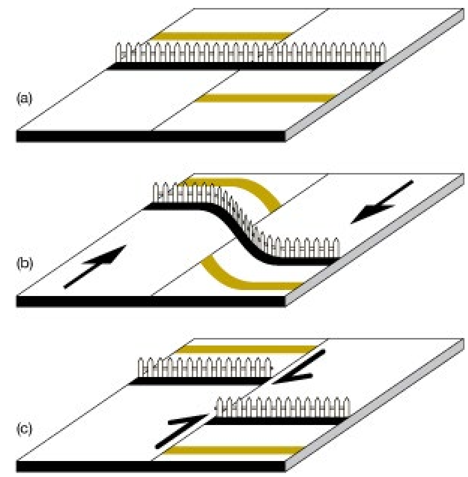
4.) Describe how a common, everyday material, might show a similar response to stress and its removal.

ANSWER: *A rubber band can be stretched. As long as the stress (tension in this case) is applied, it will be deformed but when the stress is removed it will return to its original shape.*

-OR-

ANSWER: *A piece of spaghetti can be bent. As long as the stress is applied, it will be deformed but when the stress is removed it will return to its original shape.*

5.) Examine the illustrations shown on the right. Use the Earthquake Machine Lite (specifically the stretching rubber band and moving block) to explain Diagrams a, b and c. Be sure to note which illustration shows the buildup of elastic deformation in the rocks.
***NOTE**: In Diagram b, solid arrows show the direction of forces; in Diagram c, the barbs show direction of relative movement of the fault immediately following an earthquake.*



ANSWER: *In illustration a) the system is at rest. In illustration b) stress is applied to the rocks. In response to the stress, the rocks are deformed. This is comparable to squeezing the marble tongs or pulling on the Earthquake Machine and stretching the rubber band. In illustration c) the stored elastic energy has been released as an earthquake when the stress becomes too great and the rocks slip and are no longer deformed (though they have moved as illustrated by the separated fence). This is comparable to when the block suddenly slips forward in the earthquake machine and the rubber band is no longer stretched. This process is not well illustrated by the marble tongs because the potential energy is released when the stress is no longer applied.*

6.) Then use the marble tong example (pinching and breaking) to explain Diagrams a, b and c.

ANSWER: *In Earth, the stored potential energy can suddenly be converted to kinetic energy when the stress become great enough to overcome the forces locking the fault closed or fracturing the rocks (diagram b). When this occurs the stored potential energy is converted back to kinetic energy as an earthquake (diagram c).*

7.) Describe how you would modify the marble tong model to represent larger earthquakes.

ANSWER: *Increase the potential energy by…*
1) Use different material that is more elastic and allows more strain accumulation. The resulting quake will be larger because more potential energy accumulated and released with elastic rebound.
2) Use bigger tongs (larger in three dimensions) and bigger notch. The increased size will increase the potential energy (for the same amount of displacement). The increased notch size will allow the tongs to be deform further before rupturing thereby increasing the potential energy as well .
3) Use material that is stronger and takes more stress to deform it.

Incorporated Research Institutions for Seismology

FACILITATE. COLLABORATE. EDUCATE.

Founded in 1984 with support from the National Science Foundation, IRIS is a consortium of over 100 US universities. In partnership with its Member Institutions and the scientific community, IRIS manages and operates comprehensive, high-quality geophysical facilities that enable exciting discoveries in seismology and the Earth sciences. IRIS programs contribute to scholarly research, education, earthquake hazard mitigation, and the verification of a Comprehensive Test Ban Treaty.