ARGUING THE CAUSES OF FAULTS AND FOLDS

Using Sponge and Silly Putty™ models

http://www.iris.edu/hq/inclass/lesson/29

Version 2.0 (10/30/17)

www.iris.edu/earthquake

Incorporated Research Institutions for Seismology

Thank you to Robert Butler, University of Portland for further developing the models

Beginner

1 hour

Materials

Whole Class

Demo

OVERVIEW

Students examine images of faults and folds, then experiment with two models to collect evidence to determine how the structures formed. The activity begins by using Silly Putty™ to identify how different stresses can act on rocks, then examines the relationship between stress type and strain. This lays the foundation for students to understand that the structure (strain) we see in rocks provides evidence for the type of stress that caused it. Students are encouraged to develop the critical thinking skills related to explanation and argumentation in science (Appendix A).

Students summarize their ideas and evidence for each image in a short written paragraph or in alternative presentation format. These models are useful because students not only visualize deformation in 3-D, but they interact physically with the materials to consider the forces that created these features.

Figure 1: *Instructor demonstrating an extensional fault using large foam blocks. Smaller sponge blocks work well in the classroom.*

Sponge models can be constructed using inexpensive materials obtained from most grocery, dollar, or home-improvement stores.

OBJECTIVES

Students will be able to:

- Use sponge models to demonstrate the forces and relative motions of a block of rock to form anticlines and synclines.
- Use sponge models to demonstrate the forces and relative motions acting on blocks of rock to form normal, reverse and strike-slip faults.
- Use evidence to support or refute the claim made in an argument.

TABLE OF CONTENTS

MATERIALS

- Silly Putty™ – 1 egg for every two or three students plus several extras for the instructor. Alternatively, there are "Make your own Silly Putty" options available on the internet.
- Student worksheet
- Sponge fault and fold models. See box right for parts, and Construction instructions on page 3.

PRIOR KNOWLEDGE

Students will have already been introduced to the following concepts: Stress, strain, deformation (e.g. ductile, brittle, and elastic), and the Elastic Rebound Theory (See Vocabulary, Appendix B.)

TEACHER PREPARATION

- Construct sponge models several days ahead of time
- Watch a demonstration of the Sponge Faults model:
  www.iris.edu/hq/inclass/video/54
- How can rock be brittle and ductile? This demonstration is an excellent introduction to folding and faulting. Watch the video demo 'Brittle Vs. Ductile: Big Hunk as a Model for Earth's Crust & Mantle;:
  www.iris.edu/hq/inclass/video/65
- Watch a Silly Putty video demo modeling the asthenosphere:
  www.iris.edu/hq/inclass/video/102

MAKE THE MODEL

Materials for Sponge Fault model:

- *6 Long, narrow sponges in 2 different colors to make one fault demo and one fold demo (3 sponges each). Automatic mop refills removed from the plastic backing work well. Consider making extra sets for class manipulation.*
- *Manila folder(s)*

Tools

- Glue. A variety of kinds will work but *Gorilla*® brand *Super Glue* works well and minimizes drying time. Or glue gun.
- Ruler
- Scissors
- Markers
- Bread knife
- Cutting board
- Several heavy objects such as books.

SAFETY TIP

Use caution when cutting sponges

CONSTRUCTION OF FAULT MODELS

Step 1: Building up the sponge blocks

In this step we create 3-layer block models by gluing three 9" sponges together (Figure 2, Picture A). Make one block each for the fold and fault model. Extra models for students to work with is recommended.

- Place your first sponge on the table and cover the top with a layer of craft glue.
- Place a second sponge of alternating color on top of glue. Repeat with third sponge (Picture A).
- You may wish to lay a light-weight object such as a large scissors on the sponge stack to help provide a better glued contact. Be careful not to collapse the sponges driving the glue into the foam.
- Once dry, your Anticline/Syncline fold model is now finished (Picture B).

Step 2: Cutting the Normal/Reverse and Strike-Slip faults

In this step we will cut one of the sponge blocks (Picture A) for both the Normal/Reverse and Strike-slip fault models.

To create the fault model

- Draw cut lines on top of the block with felt-tip pen parallel to the ends, ~ 3" from each end. (Picture C)
- Mark the base of the block about 4" from each end on front and back sides. Now turn the stacked-sponge block on its side to draw diagonal lines from the top lines to the base lines (Picture D) on both sides of the glued block. These will be your cutting lines.
- Use a sharp bread knife to gently saw through the sponge block along these cutting guides.
- To make the model easier to use in class, we will add a smooth surface to the fault interface. Measure and cut out pieces of manila folder to glue each side of all six fault surfaces. (Picture E)
- Your sponge models are now finished. You have both a dip-slip model for normal and reverse faults shown in Picture E, and a strike-slip fault by using the flat ends of blocks 1 and 2 shown in Picture F.

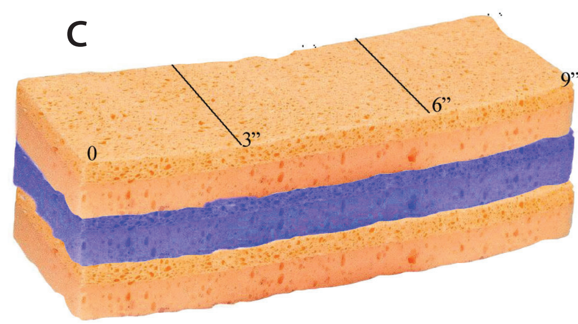
Glue 1 or more sets for folds

A

B

And 1 set (or more) for all of the faults

C



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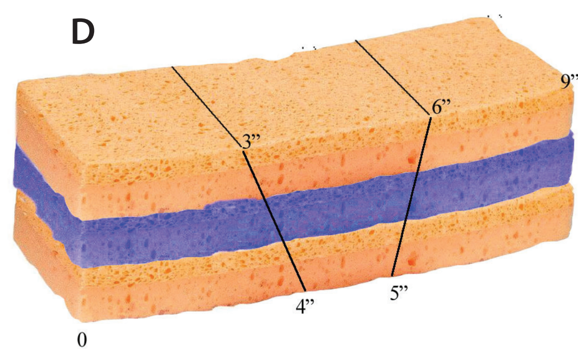

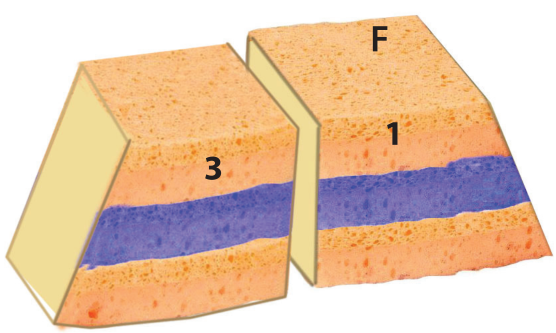

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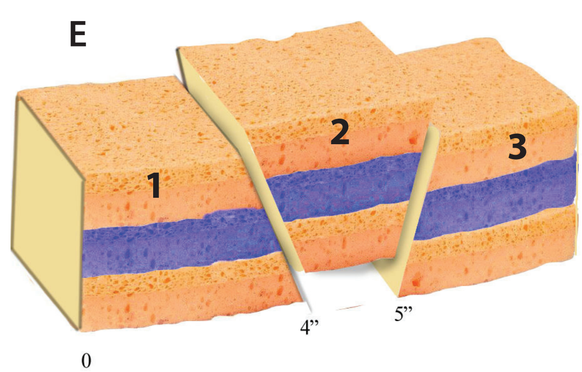


Figure 2*: Steps A-F for constructing and using foathe sponge fault model.*

LESSON DEVELOPMENT

This activity is structured using the "**OPERA**" system (Appendix C) and additionally offers leveled questions that will move your students from evaluating their knowledge to synthesizing new information.

> **TIP**
>
> Verbal prompts such as:
>
> *"What makes you think so?"*
>
> *"What do you mean by…..?"*
>
> *"Does that evidence support or refute your claim?"*
>
> can be extremely useful to encourage students to provide evidence-based explanations.

1) Open

a) Distribute Silly Putty™. Allow students to "play" freely with the silly putty for a few minutes to get a "sense" of the material.

2) Prior Knowledge

a) Hold up a sample of a rock in your hand. Squeeze it.

?? Ask students, "*Is this rock stressed? What evidence supports your claim?*"

ANSWER: Since the rock is being squeezed the rock is stressed. Stress is the amount of force applied across the area of an object.

b) Squeeze the rock again for all to see.

?? Ask students… Is this rock is strained? What evidence supports your claim?

ANSWER: Strain is the change in size, shape, or volume of an object due to stress. Although the rock is stressed from the squeezing, it has not changed size, shape or volume, thus it is unlikely to be strained.

3) Explore/Explain

a) Instruct students to experiment and identify ways they can cause their Silly Putty™ to deform.

b) Write list of students' ideas on the board and ask them to look for patterns. Lead students to see that all their suggestions fall into three stress categories (Figure 3):

Tensional (pulling apart)
Compressional (pushing together)
Shear (sliding horizontally past)

Use this as an opportunity to introduce these terms in the context of causing the Silly Putty™ to deform.

c) Show students a blob of Silly Putty™ that you have previously deformed without their seeing.

?? Ask students. "*Which type of stress had been applied to cause the deformation?*"
Be sure to require students to support their claims (an assertion or conclusion that attempts to answer the original question) with evidence (observations or measurements that supports the legitimacy of the claim).
This can be written on the board as follows:

?? *What type of stress was applied to the Silly Putty™?*

Claim:

Evidence:

ANSWER: Lead students to see that faults and folds provide evidence of past stresses and the state of the rock when it experienced stress.
NOTE: You might refer back to the *Brittle vs. Ductile Rocks* demo referred to in "**Teacher Preparation**."

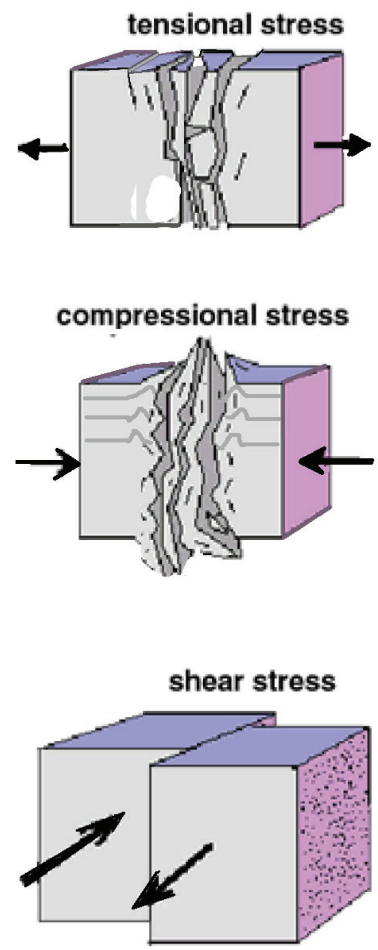


Figure 3. Rocks are subjected to three types of stress. (Image modified from Michael Kimberly, North Carolina State University)

We determined that brittle rocks are likely to fault (e.g. cold Big Hunk™ candy bar) while ductile rocks are likely to fold (e.g. warm Big Hunk™ candy bar).

d) Develop arguments about the causes of the faults and folds on the Student Worksheet. Model the process together as a class using the anticline/syncline example provided on Page 1 of the student worksheet.

e) Assign students to complete the Claim and Evidence portions of their worksheets for Questions 1 to 3. For each image students should:

i) Examine the image for evidence that addresses the question

ii) Develop a tentative claim in response to the question

iii) Identify evidence that supports their claim

f) Discuss students' claims and evidence for questions 1 to 3 on the student worksheet.

g) Introduce the sponge model to students as a way to test their claims and collect additional evidence that could not have been collected by the images alone. Discuss how the model can be representative of the rock images. Also, discuss ways the model differs from the rocks depicted in the images. See Table 1 below for similarities and differences.

h) Select one of the student's claims to focus on as you create the fault using the model. Test one of the student's claims using the model. As you create the fault emphasize both the stress causing the fault (e.g. compression, tension, etc) as well as the relative motion of the fault. Having volunteers re-create the fault is also very useful as the kinesthetic process helps students gain physical experience with the fault mechanics.

i) Students should record additional evidence collected from experimentation with the model on their worksheets. Both words and sketches are helpful.

TIP

While discussing each image and the model, your students will quickly find it necessary to develop a vocabulary to make group discussions of the models easier. Thus, it is an excellent time to introduce terms as they come up (e.g., footwall, hanging wall, fault plane, etc.). See Appendix B.

Table 1. *Whereas the Fault Model has many features that are* LIKE REALITY, *it also has a number of features that are UNLIKE REALITY that also must be made explicit to students.*

LIKE REALITY	UNLIKE REALITY
• Comprised of layers laid down horizontally in order from oldest on bottom to newest on top. • Has the features of a fault including a footwall, hanging wall, fault plain, etc. • At a large scale, the models deform in a way that is consistent with the phenomena they represent (e.g., compression forms a reverse fault).	• Sponge models are not connected to anything below them. Thus, students can easily perceive that extreme vertical motion is normal possible. • The scale is obviously much smaller than the real thing. The sponge model may represent an area from less than one, to tens of miles long. • Sponge models are highly elastic compared to rocks. Therefore their behavior will not be identical to that of rocks. Nor will they respond to heat and pressure they way that rocks do.

4) Reflect

In small groups of three or four, assign students to examine all evidence collected (both from the image and the model) and make decisions about what is relevant and what is not. Groups should also revisit the tentative claims they made individually with the goal of creating a common conclusion (final claim).

5) Apply/Assess

Students should develop an explanation for each of the three images on the student worksheet. This is the formal presentation of their conclusion (final assertion). This should synthesize previously held knowledge (assumptions) with newly acquired knowledge (evidence) and connect it to the assertion. This could be an individual written assignment or individuals/groups could present their explanations in alternative formats e.g. posters, slide presentations, etc.

A rubric for assessing students' arguments is available at
www.nsta.org/highschool/connections/201007SampsonRubric.pdf

6) Optional

?? *Which of the following diagrams (Figure 4) represents a normal fault?*

?? *What is your evidence?*

ANSWER: The diagram on the left shows a fault as there is an indication of motion. Meanwhile the diagram on the right does not show any evidence of movement. Therefore it shows a fracture.

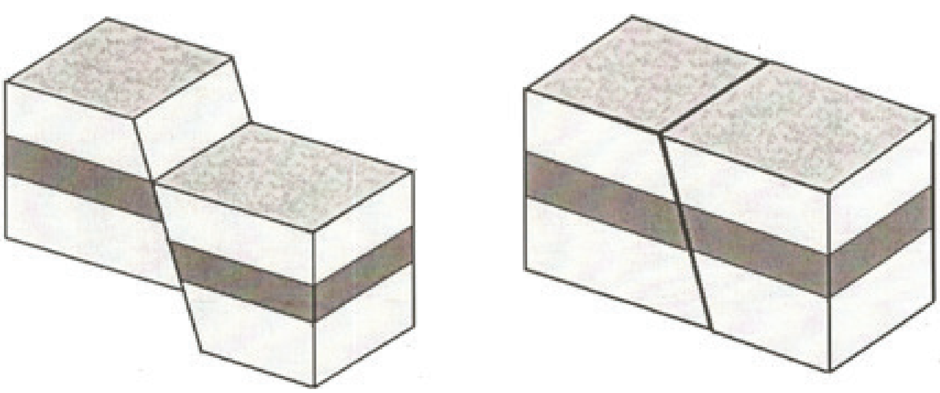


Figure 4. Diagram of Normal Fault (left), and a fractured rock with no offset (right).

> **TIP**
>
> Textbook diagrams commonly indicate displacement on faults. As a result many students infer that the forces acting on faults are purely vertical. Sketching relative displacement and the forces acting on a fault on separate diagrams can help students overcome this confusion.

APPENDIX A

TEACHER BACKGROUND

Facilitating Argumentation

The National Science Education Standards describe scientific inquiry as a process of both "exploration and experiment" and "explanation and argumentation." Although many activities exist that allow students to explore and experiment, there are significantly fewer examples that provide a structure for students to develop the critical thinking skills related to explanation and argumentation in science. Towards this end, this activity is structured around the *Generating an Argument* instructional model of Sampson & Grooms (2010). Here students gain experience in knowledge generation and validation through the development of an argument, or an explanation based on available data and existing scientific theories or concepts.

An argument is comprised of several key components.

Assumptions - statements that use prior knowledge about natural phenomena. These can be used to construct a possible or tentative solution to the question under study.

Assertion - conclusion, also called the claim. This attempts to answer the original inquiry.

Evidence - data in the form of observations and measurements that support the legitimacy of the assertion.

Explanation - synthesizes previously held knowledge (assumptions) with newly acquired knowledge (evidence) and connects it to the assertion.

In the first step of the process students identify the question under investigation and relevant assumptions. Here students seek to answer the question "How did a structure, illustrated on their worksheets, form?" The conceptual framework related to this question is presented for students in the introductory segment of the worksheet. If your students have significant experience with argumentation then this could be removed and replaced with a space for students to develop their own assumptions.

Students then examine the data presented, in this case imagery of faults and folds, in light of the assumptions presented in step 1. From this evidence they develop a tentative claim and an explanation (reasoning that connects the claim and the evidence).

Next, students are introduced to a mechanical model to test their initial claim and gather further evidence that can't be collected through the image alone. To simplify instruction and save time, the teacher uses the models as whole-class exploration. However, if multiple models are available, this could become a hands-on experiment for small groups of students.

Following this, small groups of students revisit their initial claims and make decisions about the relevance and implications of the all the evidence they have collected (both from the image and the models). During this processes students explore the merit, relevance and limitations of the evidence collected. Competing claims are evaluated and vetted.

Finally, students individually construct an explanation that addresses the initial question. This is the formal presentation of their conclusion (final claim), evidence, and rationale (reasoning that connects the claim and the evidence). Writing in this step is important because it encourages metacognition and helps students develop the ability to present their thinking in a clear and concise manner.

The science of the model – The faults and folds that we see in rocks provide evidence that 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 2). 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.

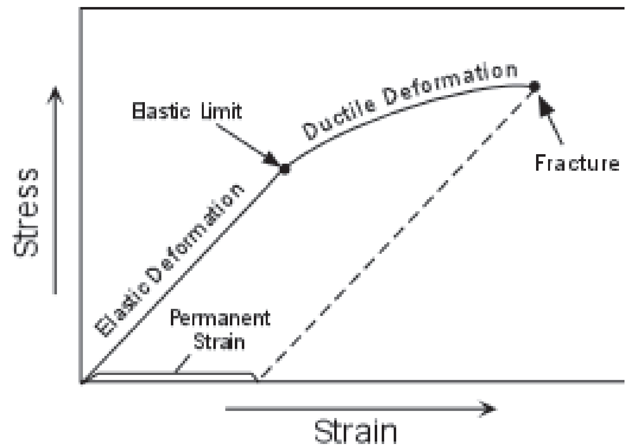


Figure 5. Rock passes through 3 successive stages of deformation as it is subjected to increasing stress.

Figure 5 shows how 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 undergoes when you pull on it. Once this stress is removed, the rubber band returns to its original shape.

As rocks pass their elastic limits they undergo ductile deformation. Ductile deformation is irreversible or permanent. 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.

Figures 6a and 6b illustrate examples of ductile deformation in rocks. The fold in a rock can either be up or down. An upward-curving (convex) fold in rock that resembles an arch is called an anticline. When eroded, the central part contains the oldest section of rock. A downward-curving (concave) fold in rock is called a syncline. After erosion, the youngest beds are exposed in the central core of the fold. Both anticlines and synclines can be easily modeled by compressing the ends of the Sponge Model (Figure 2b).

Finally, if the stress becomes too great the rock may fracture or undergo irreversible strain. Here, 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 bends and then breaks. If the two sides of the fracture have been displaced relative to each other we call this a *fault* and the planar (flat) surface along which there is slip, the *fault plane*.

Different types of stress cause different types of faults to form (see Figure 7 for examples and forces). For example, a *Normal Fault* is formed by tensional stress. Here the crust extends and the rock layers above the fault plane (*"hanging wall"*) drop down relative to the rock layers on the other side of the fault plane (*"foot wall"*). If the fault is formed by compressional stress, a *Reverse Fault* is formed.

a

b

c

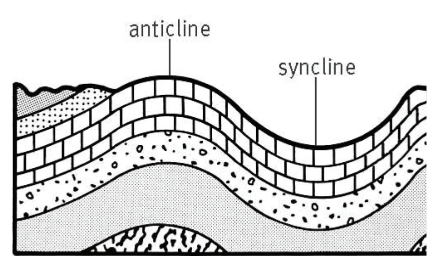


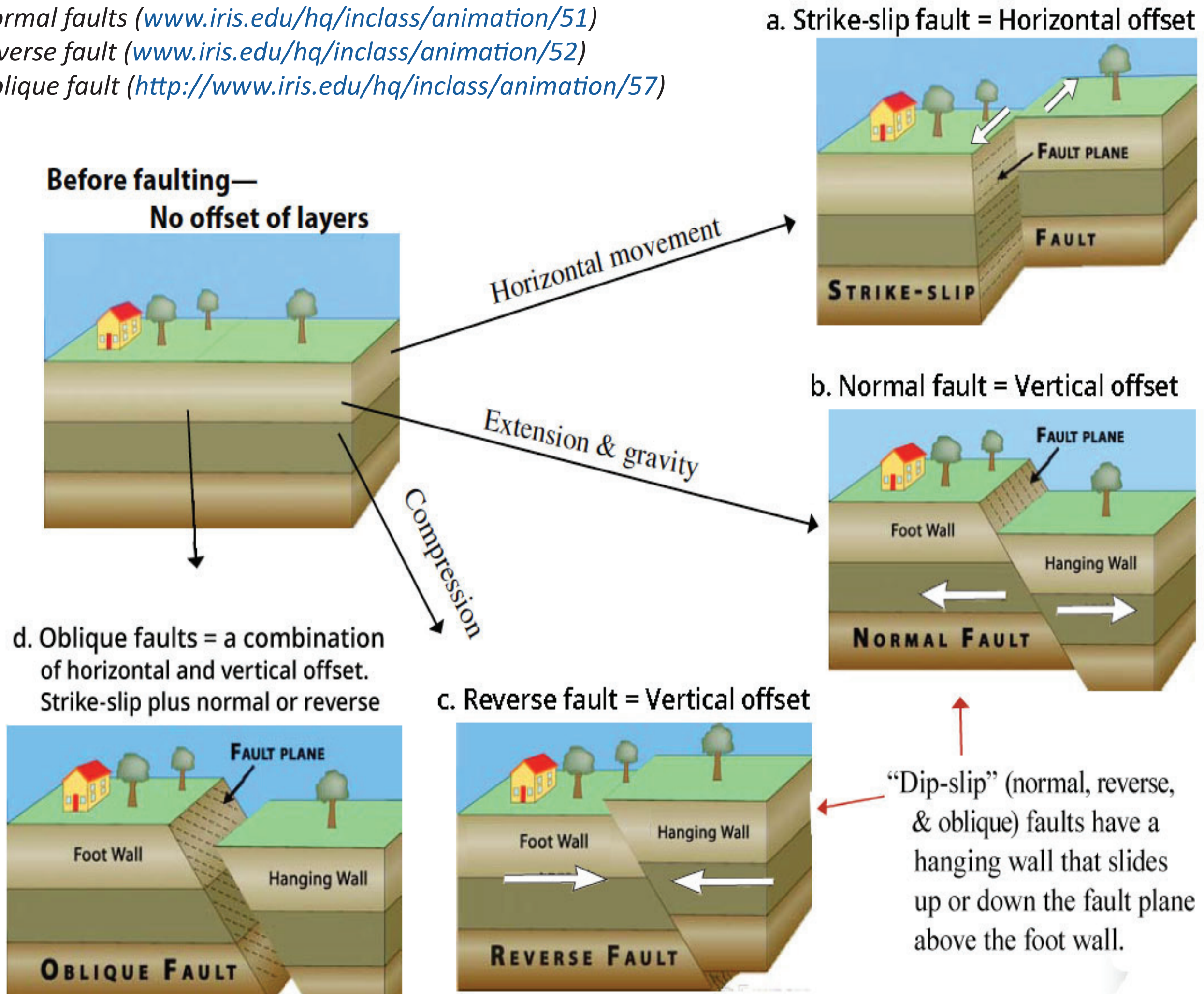
Figure 6. (a) Folded rock layers in this road cut indicates prolonged ductile deformation. Person for scale.
(b) Hand sample of a folded rock.
(c) Example of anticline and syncline shapes.

Here the crust is shortened and the rock layers above the fault plane (*hanging wall*) move upward relative to the rock layers on the other side of the fault plane (*foot wall*) A strike-slip fault is formed by shearing stress. Here the main sense of movement on the hanging wall is horizontal.

Modeling the faults – Faults can be modeled with the sponge models. This not only allows students to see the relative motion of the footwall and the hanging wall in each fault but they can also experience the stress required to create each fault type. For example, students frequently confuse normal and reverse faults. This can be addressed instructionally by giving students a chance to manipulate the model. With the model in hand, students quickly realize that you cannot form a normal fault by compressing the sponge blocks. Likewise, tension must cause the hanging wall to drop.

The way rocks respond to stress depends primarily on the temperature and confining pressures of the rock when the stress is applied. For example, rocks near the surface experience relatively low temperatures and pressures. Under these conditions, fracturing is much more likely. Meanwhile, rocks deeper in Earth undergo much higher temperatures and pressures that allow ductile deformation thus inhibit fracturing. Other factors such as the strain rate and the composition of the rocks may also influence whether rocks fracture or undergo ductile deformation.

Figure 7: *Screen grabs of faults showing the forces and sense of offset for the four main fault types. Animations of each can be downloaded here:*
a. Strike slip fault (www.iris.edu/hq/inclass/animation/53)
b. Normal faults (www.iris.edu/hq/inclass/animation/51)
c. Reverse fault (www.iris.edu/hq/inclass/animation/52)
d. Oblique fault (http://www.iris.edu/hq/inclass/animation/57)



APPENDIX B

Vocabulary I: Basic physics concepts

Vocabulary II: Physical features

VOCABULARY I

Deformation—process where rocks are folded, faulted, sheared or compressed by Earth stresses.

Brittle Deformation—irreversible strain where the material (rock) fractures/ breaks response to stress.

Ductile Deformation —When rocks bend or flow, like clay.

Elastic Properties—the measure of an objects ability to change shape when a force is applied to it, and return to its original shape when the force on it is released.

Elastic Rebound—an object's ability to return to its original shape after strain is overcome, and the sides move apart.

Elastic Strain— a form of strain that, when the deforming force is removed, the distorted body returns to its original shape and size. Earthquakes are caused by the sudden release of energy as strain is overcome and the sides of the fault move past each other. This form of energy release is the only kind that can be stored in sufficient quantity to be regionally damaging.

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

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

VOCABULARY II

Anticline - *A upward-curving (convex) fold in rock that resembles an arch. When eroded, the central part contains the oldest section of rock (Figure 6). See "Syncline."*

Fault - *A fracture or zone of fractures in rock along which the two sides have been displaced relative to each other.*

Fault plane - *The planar (flat) surface along which there is slip during an earthquake (Figure 7).*

Fold - *A bend or flexure in a rock that is a result of permanent deformation.*

Footwall - *The underlying side of a fault (Figure 7).*

Hanging Wall - *Occurs above the fault plane (Figure 7).*

Normal Fault - *A fault, formed by extension, where the main sense of movement on the hanging wall is down (Figure 7).*

Reverse Fault - *A fault, formed by compression, where the main sense of movement on the hanging wall is up (Figure 7).*

Strike-slip Fault - *A fault, formed by shearing, where the main sense of movement on the hanging wall is horizontal. These can be classified as left lateral (see image next page) or right lateral, where the block opposite to the one you are standing on is moving right, relative to where you are (Figure 7).*

Syncline - *A downward-curving (concave) fold in rock. After erosion, the youngest beds are exposed in the central core of the fold (Figure 6). See "Anticline."*

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 is an invitation for learning and leaves students wanting to know more.
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.

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.

Earth's Systems

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
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.	**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.	**Scale, Proportion, and Quantity** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

HS-ESS2-1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. http://ngss.nsta.org/DisplayStandard.aspx?view=pe&id=183

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.	**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.

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NAME: ______________________________

PERIOD: ________ DATE: ______________

SPONGE MODELS WORKSHEET

Initial Understandings

- Existing structures provide evidence of past deformation
- Many rock layers are deposited in a time sequence, with the oldest on the bottom and the youngest on the top.
- Many rock layers are deposited in a horizontal orientation and remain that way unless acted upon by an outside force.
- The rocks that make up Earth's outer shell are continually subjected to stresses.

QUESTION: How did this structure form?

Example 1:

Photo by Roy W. Schlische

a) Your Claim:

b) Your Evidence:

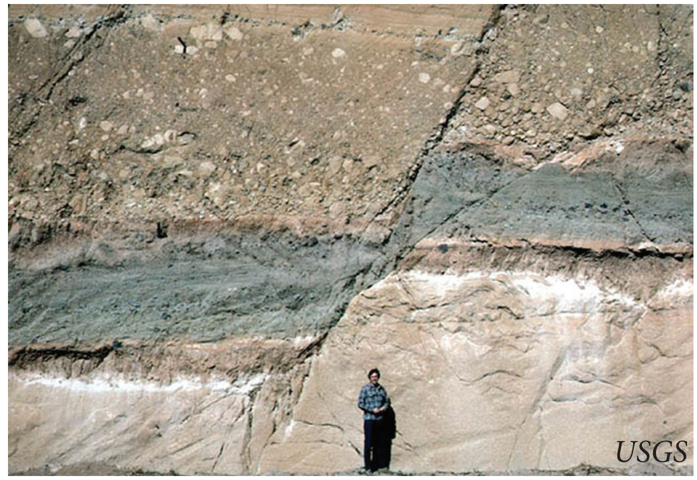
c) Additional Evidence (from the model)

d) Your Explanation. Use these bulleted points for the next two pages:

- State the conclusion you are trying to support.
- Present the evidence and the reasoning that connects the evidence to the conclusion in a logical format.
- Make sure writing has an easy flow.
- Review for grammar, punctuation and spelling errors.

QUESTION: How did this structure form?

Example 2:



a) Your Claim:

b) Your Evidence:

c) Additional Evidence (from the model)

d) Your Explanation (See bulleted points on previous page):

QUESTION: How did this structure form?

Example 3:

a) Your Claim:

b) Your Evidence:

c) Additional Evidence (from the model)

d) Your Explanation:

QUESTION: How did this structure form?

a) Your Claim:

b) Your Evidence:

c) Additional Evidence (from the model)

d) Your Explanation:

Example 4:

Photographer unknown

Incorporated Research Institutions for Seismology

IRIS

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.

NSF