

LAYER CAKE GEOLOGY

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Level: Grades 4 - 6 Can be modified for use with Grades 2 - 3.

Estimated Time Required: 50 - 60 minutes

Anticipated Learning Outcomes

- Students will understand the mechanisms by which folds and faults occur within the earth's crust.
- Students will recognize the difference in behavior between brittle and ductile rocks.
- Students will predict the structure likely to result from application of various forces to layered rocks.
- Students will interpret "core samples" to determine rock structures beneath the land surface.
- Students will learn the meaning of the following geologic terms: fold, fault, brittle, ductile, fracture, and core samples.

Background

No prior knowledge of geology is required. However, the teacher should introduce the two basic concepts of layered rock: superposition (oldest layer at bottom, youngest at top) and original horizontality (sediments deposited in horizontal layers until some force changes their tilt or orientation).

Materials

- Multiple-layer cake prepared according to the following instructions:
 1. Use moist pound cake (or other dense, coherent cake) mix. (One mix is sufficient for whole class activity if layers are made thin enough.)
 2. Bake four to six thin cakes, (each between 0.5 and 2.0 cm thick), each a different color (mix in food coloring before baking). Use square or rectangular pans.
 3. Stack the cakes in any order. Apply icing (of any kind) between the layers but not on the top or sides of the cake.
- Knife for cutting cake
- Three transparent plastic tubes (diameter between 1 and 2 centimeters) at least as long as the cake is high. Clear drinking straws could be used, but tubes of wider diameter produce better results.

Procedures

1. Display the cake in a central location so all students have a clear view. Explain to the class that the cake represents a portion of the earth's crust with the top of the cake representing the surface of the earth. Each different color layer (including icing layers) represents a separate layer of sedimentary rock within the earth's crust. Ask the following questions and have student volunteers answer them by using the cake:
 - What does the cake look like from the side?
 - Where on the earth would you expect to see rock layers having this orientation?
 - Which "geologic" layers are the oldest? Have any of the geologic layers been tilted?
 - Predict what the inside of the cake looks like away from the edges (sides)? On what did you base your prediction?
 - How might you test your prediction? What tools or "equipment" would you need?
 - Is your test procedure practical for use on the real earth? What real tools or equipment would you need?
 - Try out your test procedure on the cake. Were the results what you expected?
 - How many times would you have to repeat your test procedure to be sure your results applied to the entire cake?
2. If the cake is large enough (or if multiple cakes are available), cut two slices of cake for each group of up to four students. Each slice should be no more than 5 cm wide and should be as long as possible. Each group of students should follow the instructions listed below, answer the questions, and record their results on a separate piece of paper. [Or the teacher may do this as a demonstration.]

Place a slice of cake on a sheet of paper on a desk or table. How many ways can you think of to change either the shape of your cake slice or the orientation of individual layers within? Do not try out any of these ideas yet, but write them all down to share with the class. Predict the visible changes which would be seen in the cake layers because of each of these ideas. Which ones are possible on the real earth? What forces might cause such shape changes in the real earth? Is there a difference in behavior of the cake layers versus the icing layers? Why or why not?

Assign each group two of the suggested ideas to try out so that every idea is tested by at least one group. Each group should record observable changes in visible structure and make special note of any differences in behavior between the icing layers and the cake layers.

3. Compile the results of all groups. Assign results to one of two categories:

FOLD = layers have different orientation but are still in contact with each other and in same sequence as before.

FAULT = layers have broken and moved apart relative to each other.

Ask if there are any cases where some of the layers showed fault characteristics and others did not. Can you think of a reason why this might have occurred? What

characteristics of layers do you think are most responsible for whether folds or faults result from applied forces (stress)? Can you imagine a real world example where different types of rocks would behave differently under the same conditions of force?

Results & Discussion

1. Students will normally conclude that the same flat sequence of layers exists at every location for a given cake. The rationale may vary but should include reference to all visible sides having the same sequence. Students may want to cut open the cake to look at the center. Such a test will work but has the disadvantage of destroying the structural integrity of the cake. The value of road cuts, railroad cuts, and natural canyons to geologists can be mentioned, but in general we do not have the option of "slicing open" sections of the earth to view the inside (especially when dealing with a very flat land surface). Hopefully, students will come up with the alternative idea of taking a small core out of the center of the cake to view its cross-section. Student volunteers can test their prediction by taking and comparing three (or more) random core samples of the cake using the transparent plastic tubes. Actually, no specific number of samples is sufficient to "prove" that the layered sequence is the same everywhere, but the more samples taken, the stronger the likelihood of that statement being true. The procedure of drilling holes into the earth to collect core samples is a very practical way of determining what lies below and is used extensively in such diverse fields as oil exploration, mineral exploration, and ground water monitoring for pollution.
2. Students will probably think up at least a dozen ways to alter the cake structure. Some common methods of alteration along with possible forces within the earth which produce them are listed below.

PROCESS	RESULT	FORCE RESPONSIBLE
turn cake on edge	vertical layers	tectonic uplift & tilt
turn cake upside down	overturned layers	tectonic uplift & tilt
compress cake vertically by squeezing layers from above	thinner layers	gravity loading (weight)
compress cake horizontally by squeezing cake sideways	folds	tectonic plate collision
pull ends of cake apart creating break	fault	tectonic rift zones

push ends of cake sideways in opposite directions	fault	tectonic transform fault
push top of cake sideways relative to bottom of cake	sliding layers	weakness allows sliding
push up on center from underside of cake	dome (fold)	igneous intrusion

The biggest differences in behavior of cake and icing layers should be observed during vertical and horizontal compression and in the sliding of layers over each other. The icing layers are much more flexible and will "flow" without any noticeable fracturing, but they do not show noticeable change in thickness. The cake layers, on the other hand, tend to break in places under stress, but are easily compressed from thick to thin layers. Sliding tends to occur within the icing layers and not the cake layers.

- Results will vary depending on exactly how much force (stress) was put on the cake. In general, only "pulling apart" or "pushing laterally in opposite directions" will produce faults. Simple compression is likely to produce folding, while tilting or overturning tends to leave layers pretty much in their original relative condition. Several methods may show differential behavior between icing layers and cake layers, depending on the level of force (stress) applied. By comparing several examples from the class data, it should be possible to point out that faults (breaking) are the end result of forces (stresses) that exceed the ability of the material to bend. Some materials reach that critical point at lower force (stress) levels than do other materials. As a simple geologic example, sandstones are more rigid than shales. Under similar stress conditions, sandstone may crack in several places while shale layers appear undisturbed.

Conclusions

- Multiple core samples provide information about layered structures beneath the surface.
- Core sample data can be collected from several locations to determine structure over a wide area.
- Increasing the force (stress) on layers can cause folding at first, then eventually faulting as layers break apart.
- The type and direction of stress applied to layers determine the structures that result.
- Brittle layers break sooner than more ductile layers affected by the same force (stress).
- Sliding of layers is more likely to occur within a ductile layer.

Additional Activities

With advanced students, the effect of rock structure and erosion on topography can be modeled and investigated by creating folds in the cake and then cutting off (eroding) parts of the cake which are higher in elevation (see reference below). Sketches can be made of the "geologic map

view" of the top of the cake after erosion takes place. "Stream channels" can likewise be cut into the cake surface with a knife to illustrate geologic map patterns in an area dissected by streams.

Layer Cake Geology can also be used as a teaching tool for younger students. To adjust this activity for grades 2 - 3 use only Procedure #1, and make following changes:

- In procedure 1, inject (with an icing gun?) a big glob of icing somewhere in the center area of the cake, but underneath the surface so it cannot be seen. [Be sure that one of the transparent tubes hits this area during the "core sampling" process. This will reinforce the idea that even when geologists think they know what rock structure underlies an area, there can still be surprises.]
- Results & Discussion: A balance should be presented regarding making generalizations based on limited facts versus the chance that new data can change those generalizations. Oil companies, mining operations, and engineering geologists commonly make decisions based on generalizations from rock cores. Usually their conclusions are correct, but occasionally the unexpected will occur.
- Conclusions: Use only the first two statements regarding core samples.
- Related Activities: Students may be asked why all layered rocks in the world are not horizontal (most are not). Pictures of rock exposures in mountains showing folding may be used. Students can be asked what they would have to do to the cake to make it look like the folded rock in the pictures. In this way, the concept of external force as a requirement to cause folding of rock may be introduced. Students may compress the cake to produce similar results within the cake layers.

Reference

WAGNER, J.R., 1987. Using Layer-Cake Geology to Illustrate Structural-Topographic Relationships, *Journal of Geological Education*, v. 35, p. 33-36.