Activity 14: A Simulated Metamorphic Process

Maine Geological Survey

Objectives:

Using an analogous process, students will investigate one aspect of metamorphic activity and will realize how directed pressure can align mineral grains during metamorphism.

Time:

This activity is designed to last one class period.

Background:

Metamorphism is a complex process with a number of simultaneously interacting and related components. Heat, pressure, degree and composition of reacting fluids, and chemical composition, all play a role in the metamorphic process.

A number of mineral species and families, especially the micas, the subsilicate group minerals (kyanite, andalusite, etc.), and the amphiboles respond significantly to directed pressure by reorienting themselves into flattened, plate-like aggregates which are perpendicular to the direction of greatest applied pressure. This results in the cleavage patterns of some fine-grained metamorphic rocks such as slate. It also produces the more common textural attribute of schistosity seen in a number of metamorphic rocks.

This activity allows students to see the results of ONE agent of metamorphism, pressure, on a simulated rock material, in this case a granola bar.

Materials:

Students should work in groups of 3; each group will need the following items:

- One granola bar, preferably of the softer variety with raisins (Kudos bars work well)
- Two pieces of plywood 5.5 by 8 by 5/8 inches in size
- Three large C clamps with at least a 4 inch opening (these can usually be borrowed from a physics teacher)
- Two 5 by 8 inch pieces of waxed paper
- Single-edged razor blade
- Pens, and notebooks

The class as a whole will need access to a balance for weighing the bar.

Procedure:

Students examine the bar "before metamorphism" by cutting off one end of the bar and describing the noted grain orientation. The bar is then placed between the sheets of waxed paper on one of the pieces of plywood. The second sheet of plywood is placed on top of the first, clamps are applied at three points, see Figure 1, and pressure is applied evenly by turning each clamp a turn at a time until they cannot be turned BY HAND any further. At this point the clamps are removed and the bar reexamined.

Special Safety Precautions:

Care should be exercised in the use of the single edged razor blade.

Follow-Up:

Other types of materials can be tested such as cooked oat meal, cream of wheat, vermiculite, "hard" cookies, nut fudge, and so on. Students will note that some materials are more apt to show grain deformation than others. This can lead to a good

discussion regarding why metamorphic rocks have such a wide range of textures. You may wish to display samples of quartzite, schist, gneiss, slate, and marble at this point.

Show several slides (photographic slides such as Ward's Metamorphic Rock Sections set, 173 E 0639, $55 for 20 slides with guide) of thin sections of metamorphic rocks. Note the grain deformations that indicate directed pressure. Compare the macroscopic deformation such as that observed in a schist with the microscopic deformation seen in individual mineral grains.

If time allows, you may wish to get into a discussion of specific TYPES of mineral grain deformations such as kinking (the students love this one), bending, gliding, twinning, and polygonization. See Alan Spry's Metamorphic Textures (Pergammon Press, New York, 1970) for diagrams and details. With a little effort and some thin sections (see Wards) you can set up a series of microscope stations for students to look at individual grains. A good selection of slides is as follows (Ward's catalog numbers):

Rock Type	**Catalog #**	**Typical Deformation**
Quartzite	44 E 7495	Polygonization
Marble	44 E 7488	Twinning
Garnetiferous mica schist	44 E 7499	Bending/gliding
Biotite gneiss	44 E 7391	Kinking/transport
Biotite granite	44 E 7301	None

References:

Activity developed by Duane L. Leavitt.

Name_____

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Student Sheet

Purpose:

To investigate directed pressure as an agent of metamorphism. This activity will help you understand ONE of the things that happens to the minerals in a rock when that rock is metamorphosed; that is when the form of the rock (and sometimes the composition) is changed by intense heat and pressure.

Materials:

You should work in groups of three, each group will need the following materials - a granola bar, two pieces of plywood which measure 5 by 8 by 5/8 inches, three large C clamps, two pieces of waxed paper, a single edged razor blade, pens, and notebooks. The class as a whole will need access to a balance.

Procedure:

The granola bar is serving as a model of a rock material. While the granola bar is obviously not a rock, the particles in the bar will behave as some rock-forming minerals do. You will need to observe the bar closely before and after it has been "metamorphosed".

1. Unwrap the granola bar, measure and record the following:

Length_____

Width_____

Depth_____

Weight_____

2. Using the single edged razor blade, cut off one end of the bar and carefully observe and sketch the grain orientation (arrangement and position of the particles with respect to each other) of the granola bar. If your bar has a chocolate coating, note its thickness and degree of uniformity. Sketch what you see below.

3. Place a sheet of wax paper on one of the pieces of plywood, place the bar in the center of the waxed paper, cover it with the second sheet of waxed paper and place the second piece of plywood on top; be certain that the edges of the plywood are lined up so that one piece of plywood sits directly above the other.
4. Tighten the C clamps until the plywood/granola "sandwich" just fits between the jaws of the clamps. Place 2 clamps along one of the long sides of the plywood, one near each end. Place the third clamp on the opposite side an equal distance between the first two. Tighten each clamp just enough to hold the bar in place (see Figure 1 below).
5. Starting with one clamp, tighten each clamp in sequence, one turn at a time, until none of the clamps can be turned any tighter BY HAND. No not tighten the clamps beyond what you can do with your hands.

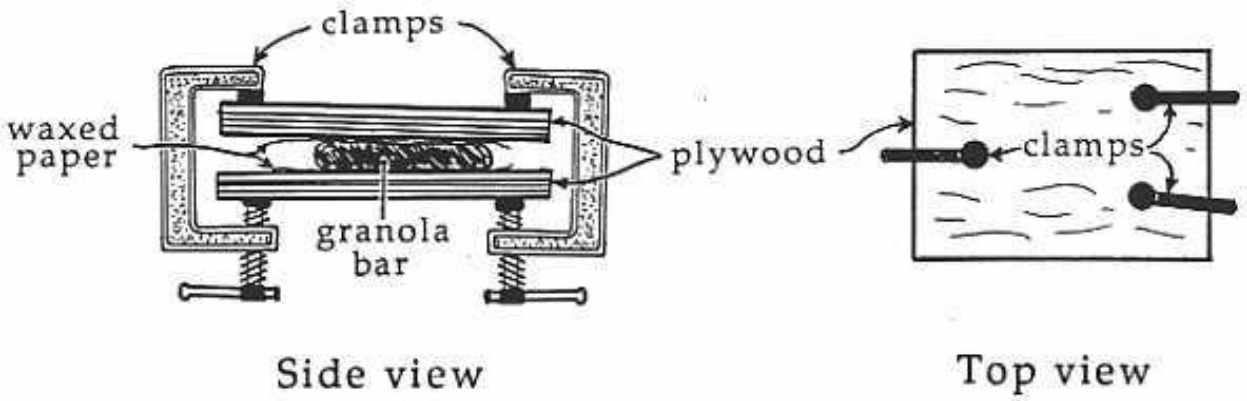

Figure 1. Simulated metamorphic process.

6. Loosen the clamps, remove the plywood and observe the granola bar. Measure and record the following:

Length_____

Width_____

Depth_____

Weight_____

7. Describe the shape and orientation of the grains in the granola bar. Sketch what you observe in the space below.

Questions:

1. What holds the particles of a granola bar together?

2. Summarize the CHANGES that occurred in the bar after it was metamorphosed.

3. After metamorphism was there a particular orientation of the granola particles? If so describe it.

4. What was the relationship between the direction of pressure and grain orientation?

5. What would happen to the rock directly beneath a large meteorite when it impacts the earth? Research the Meteor Crater in Arizona and see what you can find out.

6. Examine several of the metamorphic rocks in your classroom; do you see any evidence of mineral grains being flattened? If so, what minerals were exhibiting this flattening? Be specific.