ROCK CYCLE IN CHOCOLATE LAB – INSTRUCTORS NOTES AND TIPS

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The up sides to this lab are that students really have a lot of fun with it, they are exposed to simple experimental design and techniques, and most importantly they learn a lot through this process. There are a few down sides, however. Because this lab is somewhat labor intensive and can be a bit messy, it is difficult to run this lab back-to-back for multiple lab sections. It also requires a lot of equipment (see the equipment list below) and a collection of rocks. I designed this lab around materials I had available, so you may need to modify the lab to fit your collection.

Ideally, each student group will have their own setup. If you are low on equipment, you can have three or four groups work independently on a single rock cycle setup. In this design, each group would start at a different station (melting, crystallizing, sedimentary, metamorphic), and the groups would follow each other through the cycle. If you are going to do this, double check the lab questions for reference back to previous steps.

I strongly recommend running through the lab before you spring it on the students. Each stage of the cycle has its own quirks, and you can head off a lot of confusion and poor results with a few well-timed recommendations to students. Here are some comments for each of the steps:

Melting:

This is pretty straight forward. Keep the different types of chocolate separate to observe the different melting temperatures and rheologies (the white chocolate will be thicker due to the higher cocoa butter content). Mix them together at the end to give yourself enough mass to make it through all the remaining steps.

Crystallizing:

You need two different rates of cooling. Pouring the molten chocolate into very cold water quenches the chocolate nicely, but the resulting chocolate is somewhat water-logged and melts really easily when touched. For a plutonic texture, I suggest using a chunk of granite or gabbro countertop that is at or slightly below room temperature to allow slow cooling, but if the rock is too warm, cooling will take too long.

The plutonic texture is difficult to see, even with a hand lens, so I have students feel the difference by grinding a small sample of it in their teeth. That seems to work best.

Erosion:

I had a hard time trying to simulate erosion due to the consistency of the “igneous” chocolate – it melts too easy to facilitate grinding or grating. So, I cheat and us the edge of a knife to cut some chocolate shavings off of some dark chocolate I keep held in reserve. Once you get past that step, it is pretty straightforward to compress the sediment into a rock (section 3.2-3.6), and bounce angular block of chocolate in a jar to wear away the jagged edges (this is section 3.7)

Lithification:

Using small Plexiglas sheets helps this process quite a bit, but sandwiching the sample between a textbook and a table can work just as well.

In question 3.2, I use a large piece of sandstone to get students to think about burial of sediment by newer sediment.

Metamorphism:

This step takes more pressure than the weight of a hand sample, so I used some clamps. It is easy to over-squeeze the envelope and break the wax paper. It is important to use wax paper for this, as aluminum foil won't stand up to the pressure.

As with the lithification, if you don't have Plexiglas, you could use a textbook or something similar. If you do have Plexiglas, you might also consider getting a hair dryer to add heat the to system while metamorphosing it. This is the point of questions 4.8 and 4.9

Materials (for each group):

Chocolate (dark and white)
Aluminum foil
Wax paper
Hot plate
Knife (doesn't need to be sharp)
Piece of plutonic rock countertop (granite, gabbro, diorite, etc)
Glass beaker with cold water (ideally sitting in an ice bath)
Hand lens
Small glass jar with lid
Two Plexiglas sheets
Clamp (for metamorphism)

ROCK SAMPLE LIST:

A – Banded pumice or xenolithic rock
B – Aphyric basalt and/or vesicular basalt
C – Coarse-grained granite with obvious quartz crystals and other minerals (Qtz is important)
D – Medium-grained quartz sandstone (Qtz is important)
E – Quartzite (Qtz is important)
F – Folded gneiss or folded metamorphic rock (the fold is important)
G – Conglomerate with many lithologies (ideally all three major rock types)

Rock cycle in chocolate lab

Pete Stelling , Western Washington University

Summary

This lab activity simulates the rock cycle with a piece of chocolate instead of actual rock. Students melt, crystallize, erode, lithify and metamorphose a single small block of chocolate. Along the way students complete questions and compare the products of each step with actual rocks.

Context

Audience
High school or undergraduate introductory Physical Geology lab students with little previous exposure to geology.

Skills and concepts that students must have mastered
Few; ideally students will have experience with the rock cycle, but this lab also serves as a comprehensive introduction.

How the activity is situated in the course
This is a stand-alone lab exercise designed to be completed in two hours. Some students will take a little more time to complete the final write up on the last page.

Goals

Content/concepts goals for this activity

The rock cycle, and many components thereof:

- melting temperatures vs. composition
- melting and magma mixing
- plutonic vs. volcanic textures
- erosion
- lithification
- metamorphism
- distinguishing between igneous, metamorphic and sedimentary rocks

Higher order thinking skills goals for this activity

Formulation and testing of hypotheses
Synthesis of ideas and concepts

Other skills goals for this activity

Working in groups

Setting up experiments
Evaluating experimental limitations

Description of the activity/assignment

In this lab students receive two small blocks (1 cm^3) of chocolate (white and dark), and follow it through the entire rock cycle. The chocolate blocks are melted on a hot plate, with different melting temperatures and rheologies due to compositional differences. The "magma" is then cooled either slowly or quickly, and the resulting textures are examined and compared to granite and basalt hand samples. The "igneous" chocolate is then ground and abraded to show erosion, and the eroded material is pressure-lithified to form "sedimentary" chocolate. The sedimentary chocolate then undergoes greater pressure to mimic metamorphism, and additional heat re-melts the chocolate back into magma. Students compare the chocolate "rocks" in each of these stages with real rock samples. The final assignment is to describe the "life story" of complex conglomerate rock sample. The lab is a bit messy and takes a bit of preparation, but students come away with a significantly better understanding of the rock cycle as a whole and each of its component parts.

Determining whether students have met the goals

The lab has been written with a series of questions, some of which are fairly simple (drawing, observations, etc.) and others are open-ended for students to explain their understanding of each step. The final question, the discussion of the "life story" of a conglomerate, is an easy way to determine if students understand the rock cycle relationships as an overall concept.

More information about assessment tools and techniques.

Download teaching materials and tips

- Activity Description/Assignment (Acrobat (PDF) 38kB May19 08)
- Instructors Notes (Acrobat (PDF) 14kB May5 08)
- Solution Set (Acrobat (PDF) 33kB May5 08)

Other Materials

A Professional Development Day for Teachers at Olivet Nazarene University

Rock Cycle in Chocolate

Developed by Dr. Pete Stelling, Western Washington University
http://serc.carleton.edu/NAGTWorkshops/intro/activities/23590.html

Learning about rocks can be boring to some - but everybody loves chocolate! This workshop presents a lab activity that can be used to introduce students to the rock cycle that uses chocolate as a surrogate for rocks and minerals. Students will melt, crystallize, erode, lithify, and metamorphose a small sample of chocolate to simulate rock cycle processes and results.

Your Facilitators

Dr. Kevin Brewer – Professor of Physical Sciences, ONU.

Lucas Madding, Natalie Arnold, Rebecca Compton – Teaching Assistants.

Illinois Learning Standards

12.E.2a Identify and explain natural cycles of the Earth's land, water and atmospheric systems (ex. rock cycle, water cycle, weather patterns)

12.E.4a Explain how external and internal energy sources drive Earth processes (ex. solar energy drives weather patterns, internal heat drives plate tectonics)

Our Workshop

Normally this lab takes two hours, with students working through the procedure step-by-step. The lab process is set up so while the students wait for their processes to finish, they are busy looking at real rocks and answering questions.

Since we have much less time than two hours, we will not go through some of the steps.

What we will do	What we won't do
Melting	
Crystalization	
Weathering (Erosion)	
	Transport (Rounding)
	Lithification
Metamorphism (if time)	

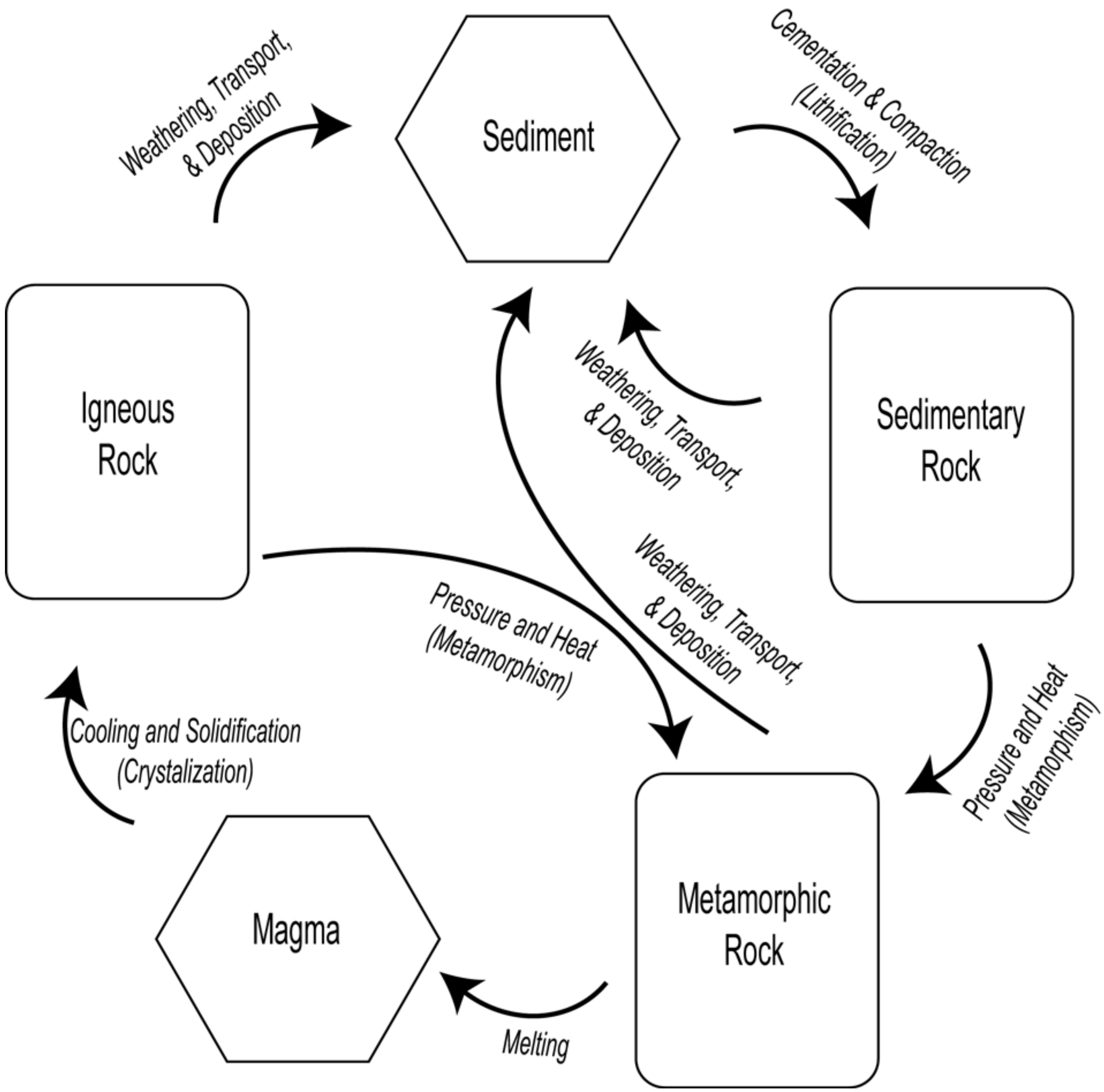
Packet Contents

Workshop Sheet

(The rest of the packet is available for free at the website address given above.)

Lab Overview Sheet
Instructor's Notes and Tips Sheet
Solution Set
Student Procedure and Worksheet

The Rock Cycle



NAME ___________________________________

ROCK CYCLE IN CHOCOLATE LAB - SOLUTIONS

Materials (for each group):

- Chocolate (dark and white?)
- Aluminum foil
- Wax paper
- Hot plate
- Knife (doesn't need to be sharp)
- Piece of plutonic rock countertop (granite, gabbro, diorite, etc)
- Hand lens
- Small glass jar with lid
- Two Plexiglas sheets
- Clamp (for metamorphism)

Divide into groups of 2-5 (depending on how many set-ups for which you have materials). Each group will need materials to work through

1. melting
2. crystallizing
3. erosion / weathering / sediment production / lithification
4. metamorphism
5. Short-circuiting the cycle
6. Comprehension

ROCK SAMPLE LIST:
A – Banded pumice or xenolithic rock
B – Aphyric basalt and/or vesicular basalt
C – Coarse-grained granite with obvious quartz crystals and other minerals
D – Medium-grained quartz sandstone
E – Quartzite
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G – Conglomerate with many lithologies

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STAGE 1: MAKING CHOCOLATE **MAGMA**

1.1 Make a hypothesis. We are going to be putting white and dark chocolate on the hot plate. Do you think the two types of chocolate will melt in the same manner? Describe what you think will happen:

1.2 Test your hypothesis. Cover the surface of the hot plate with aluminum foil and turn the hotplate to ~2 (no hotter!). Place a small chunk (1 cm^3) of dark chocolate and a similar sized piece of white chocolate next to each other. You will need to use a stick or knife to smear the chocolate on the foil to help the entire chunk melt. **BE CAREFUL NOT TO TEAR THE FOIL WITH THE STICK** – we don't want to spill chocolate on the hot plate. Try to keep the white and dark chocolate separate. Remember to treat both samples the same (same amount of heat, smearing, time on the hot plate, etc).

1.3 Describe the results of your experiment. What happened to the chocolate? Describe how both types of chocolate melted. Did both types of chocolate melt the same? Be sure to include **viscosity** ("thickness" or "stickiness") and how much heat was required to melt each sample type.

WHITE CH. WILL BE MORE VISCOUS THAN DARK CH. AT THE SAME TEMPERATURE (DIFFERENT COMPOSITION; WAY MORE COCOA BUTTER)

1.4 Expand your conclusions. What does this experiment tell you about how substances melt? Can you extrapolate the information you just gathered to other systems (especially rocks)?

YES, DIFFERENT COMPOSITIONS WILL MELT AT DIFFERENT TEMPERATURES

Before moving on to the next step, mix the white and dark chocolate together. As you are mixing these together, look at rock sample "A" in your tray. This is the result of two magmas mixing before they solidified, just like you are doing with your chocolate.

ROCK "A" IS A BANDED PUMICE

NAME ___________________________________

STAGE 2: MAKING **<u>IGNEOUS</u>** CHOCOLATE

Turn off the burner and

2.1 Now that we have made chocolate "magma," it must cool to become an igneous "rock." We will cool the magma in two ways, fast and slow. What do you think will happen? What differences do you think will result?

2.2 Bring out the polished rock slab (countertop) or tile and the beaker of ice water. Pour a small amount (~ ¼ of your total sample) on the polished rock slab or tile. Take the rest of your sample and pour it into the ice water. Which will cool faster? Why?

ICE WATER SAMPLE COOLS FASTER; GREATER TEMPERATURE CONTRAST, AND WATER CAN MOVE (CONVECT)

2.3 While your samples are cooling, answer the following questions:

a. What geologic environment would allow magma to cool slowly? What environment would cause magma to quench (cool rapidly)?

SLOW COOLING HAPPENS DEEP UNDERGROUND, WHEN MAGMA IS SURROUNDED BY INSULATING ROCK

FAST COOLING (QUENCHING) HAPPENS IN THE AIR OR IN WATER

b. Look at the slab of countertop on which your smaller sample is cooling. Then look at rock sample "B" in your tray. Describe the differences between these two igneous rocks. You can use the hand lens to look up close at each sample.

GRANITE SLAB IS COARSE GRAINED
ROCK B IS A BASALT, WITH VERY FEW, VERY SMALL CRYSTALS SITTING IN A GROUNDMASS OF ROCK (ACTUALLY, THE GROUNDMASS IS MADE OF MICROSCOPIC CRYSTALS, WHICH IS WHY IT IS OPAQUE)

c. Which of these two rocks (the cooling slab or rock B) do you think cooled faster? What clues in the rock give it away?

ROCK B COOL FASTER, SINCE THERE ARE FEWER CRYSTALS AND THEY ARE SMALLER THAN IN THE GRANITE

2.4 Now look at your experimental samples. AVOID TOUCHING THE SAMPLES WITH YOUR FINGERS as our newly-formed chocolate will melt much faster than it did originally (this is why it is hard to make good chocolate). Using the knife or scoop, retrieve the sample from the ice water and place it on the slab next to the other sample. Using the knife, cut each of the samples in half.

NAME ___________________________________

a. Using a hand lens, look closely at the textures of the two samples. Are there any differences?

DIFFERENCES ARE A BIT HARD TO SEE, BUT THE SLOW-COOLING SAMPLE WILL HAVE SOME SUGAR CRYSTALS FORMING.

b. Now the fun part. The texture differences can be pretty minor in these samples. It is easier to tell the differences using your teeth. Carefully grind a small piece of each sample in your teeth. Can you detect any differences now? Describe them.

THE SLOW-COOLING SAMPLE IS GRITTY, AND THE QUENCHED SAMPLE IS SMOOTH

2.5 Now look back at the countertop slab and rock sample B. What do you think caused the differences in texture between these two rocks?

DIFFERENCES IN THE COOLING RATE. GRANITE COOLED SLOWER, BASALT COOLED FASTER

2.6 The texture differences between the two rock samples are significantly greater than the chocolate samples. How do you explain this?

ROCKS COOLING UNDERGROUND COOL FOR A MUCH LONGER TIME (UP TO 100,000 YEARS), SO CRYSTALS CAN BECOME MUCH LARGER, EVEN THOUGH FORMING MINERAL CRYSTALS IS MUCH SLOWER THAN IN CHOCOLATE

STAGE 3: MAKING CHOCOLATE **SEDIMENT**

At this stage, we're going to have to cheat a little because these processes are hard to duplicate in the lab (in fact, reproducing natural conditions in the lab is often one of the hardest parts of doing experiments!)

The formation of sediment requires processes that turn a few big objects into a lot of little objects. Use the knife to cut your igneous chocolate samples into small chunks. Use the knife to scrape flakes and chips of chocolate from the original block to increase the volume of your sample (see your TA for more chocolate if you don't already have some).

3.1 You now have a pile of a various types and compositions of material. In geology this is called sediment. What will it take to turn this pile of chocolate sediment into a cohesive mass (a rock)?

A SMALL AMOUNT OF PRESSURE. IDEALLY, IT WOULD ALSO TAKE SOMETHING TO BOND IT ALL TOGETHER (CEMENT) BUT THE CHOCOLATE FRAGMENTS WILL MELT SLIGHTLY AT THE EDGES, ACTING AS CEMENT

NAME ___________________________________

3.2 Place all the sediment on a piece of aluminum foil and wrap the sediment in the foil. Place the foil envelope between the two pieces of Plexiglas and put the heaviest rock available on top of the Plexiglas. Why put the rock on top of the sample? What geologic process does this represent?

THE ROCK REPRESENTS NEW SEDIMENT THAT BURIES THE ORIGINAL SEDIMENT PILE. IT IS THE WEIGHT OF THIS OVERBURDEN THAT LITHIFIES THE SEDIMENT INTO ROCK.

3.3 While the chocolate sample is sitting under a rock, use the hand lens (magnifying glass) to look up close at sample D. This is a sedimentary rock that formed from sediment produced from rocks like sample C. Describe the differences between rocks C and D.

ROCK C IS A COARSE GRANITE WITH LOTS OF QUARTZ. ROCK D IS A MEDIUM GRAINED QUARTZ SANDSTONE. IN THE SANDSTONE, THE CRYSTALS ARE ROUNDED, AND MORE OF IT IS QUARTZ

3.4 The light-gray, almost transparent grains in rock C are quartz. Can you identify quartz in rock D? How is the quartz different in rocks C and D?

QUARTZ IN ROCK C (GRANITE) IS TRANSLUSCENT WITH SHARP EDGES QUARTZ IN ROCK D (SANDSTONE) IS OPAQUE BECAUSE THE FACES HAVE SMALL GROOVES IN THEM CAUSED BY ABRASION

3.5 Estimate the percentage of sample C that is quartz. Do the same for sample D. Are there any other minerals present in either sample? Describe (or name) them. Assuming that sample D is formed the sediment from sample C, is anything missing in sample D? What happened to that material?

THIS DEPENDS ON YOUR SPECIFIC SAMPLES, BUT CHANCES ARE THAT ANY MICAS AND MAFIC MINERALS ARE LARGELY ABSENT FROM THE SANDSTONE. THESE MINERALS ARE SOFTER AND HAVE BEEN BEATEN AND DISSOLVED AWAY.

3.6 We've cheated here by manually creating sediment by breaking down the large piece of chocolate into shavings and chunks. How do you think this happens in nature with rocks? What processes do you think might be involved?

ABRASION FROM ROLLING DOWN A RIVER, ROCKS FALLS, FREEZE/THAW, ETC.

3.7 Take the knife and cut a few more shards of chocolate from the original piece. On the left side below (under "before"), draw one or two of the shards. Now put the shards in the small bottle and close the lid. Shake the jar vigorously for 1 minute. Look at the shards again. What has happened to them? Draw what the shards look like now on the right (under the word "after").

BEFORE	AFTER
	THIS DRAWING SHOULD REFLECT MORE ROUNDED EDGES, MAYBE MORE ROUNDED CLASTS

NAME ___________________________________

What would happen if you shook the jar for 5 minutes? An hour?
THE ROUNDING WOULD BE MORE DRAMATIC, AND THE CLAST WOULD GET SMALLER AND SMALLER

a. Compare the crystals in sample C and D. Do you see the results of this process in sample D? What geologic process causes this effect? Comparing the shape of the crystals in C and D, and considering that quartz is much harder than chocolate, estimate how long this process might have gone on.

YES, THERE IS EVIDENCE OF THIS PROCESS; IT IS ABRASION. THIS PROCESS WOULD TAKE HUNDREDS TO THOUSANDS OF YEARS

3.8 Now remove the rock from the sample and unwrap the foil envelope. What has happened to the sediment? Is it hard? Is it soft? What are **<u>two</u>** things that would make this "rock" more cohesive?

MORE PRESSURE, AND SOME SORT OF CEMENT

In geology, this process is called **<u>lithification</u>**. This is how sediment is converted to sedimentary rock, and is an essential process in the formation of much of the Earth's crust and most of the rocks you see around you.

<u>**NOTE**: set aside a small portion of your sedimentary chocolate "rock" for later comparison</u>

STAGE 4: MAKING **<u>METAMORPHIC</u>** CHOCOLATE

Take the sedimentary rock you've just created and put it on <u>wax paper</u>. The rock may come off in pieces, so just stack the pieces on top of one another. Scrape or break some more chocolate on the sedimentary rock to increase the volume of your sample, and be sure to use different colors. <u>Wrap the chocolate in the wax paper to create as small and tight an envelope as you can.</u>

4.1 In order to make a sedimentary rock we used the weight of a rock on top of the sample. Predict what will happen if we apply more pressure. Consider what will happen on the scale of each grain and on the scale of the sample as a whole.

Place the envelope between the Plexiglas sheets and, using the clamp, squeeze the sample as tightly as you can. While it is pressing, answer the following questions:

NAME ___________________________________

4.2 Why are we using a clamp now, rather than just adding another rock to the sedimentary apparatus? What does this say about the differences between the sedimentary and metamorphic environments?

METAMORPHIC ENVIRONMENTS HAVE SIGNIFICANTLY HIGHER PRESSURE (AND TEMPERATURE)

4.3 Look at samples D and E. These rocks are composed of the same material and have the same composition. Using your hand lens, examine the details of rocks D and E. Describe the difference between them. Be sure to include the differences in the shape of the grains and how the grains contact one another.

ROCK D IS A QUARTZ SANDSTONE, ROCK E IS A QUARTZITE. IN ROCK E, INDIVIDUAL QUARTZ GRAINS ARE HARD TO DISTINQUISH

a. Rock E is the metamorphosed version of rock D. What does that mean? Does this fit in with your hypothesis you described in question 4.1? Specifically, what matches your hypothesis? What doesn't?

4.4 Remove the clamp from your experimental sample and unwrap the wax paper envelope. What has happened to the sample? Compare this sample to the sedimentary sample you set aside, using **both words and a drawing**.

THE SAMPLE WILL BE A LIMP BUT COMPACT WAFER OF MARBLED CHOCOLATE. IT WILL BE MUCH STRONGER THAN THE SEDIMENTARY VERSION

4.5 Now wrap up the sample in the *very small and tight* wax paper envelope again. This time *set the envelope on its side* between the Plexiglas sheets and apply <u>ONLY MODERATE PRESSURE</u> with the clamp (if you squeeze it too hard it will ruin the experiment). Predict what the resulting sample will look like.

a. What geologic process are we trying to replicate in this part of the experiment? Where (or in what context) might this type of event occur?

THIS REPRESENTS A FOLDING EVENT, SUCH AS MOUNTAIN BUILDING

4.6 Release the clamp and carefully unwrap the envelope. What changes have occurred? Compare this sample to the first metamorphic sample you created (refer back to question 4.4 for your description of the first sample). **Use words and a drawing**.

NOW THE SAMPLE SHOULD LOOK SIMILAR BUT BE FOLDED.

NAME ___________________________________

4.7 Look at rock F, another metamorphic rock. Consider how much additional pressure was required to form the metamorphic sample you just created over that required to create a sedimentary sample. With respect to depth, where do you think a rock like F might form?

ROCK F IS A METAMORPHIC ROCK WITH AN OBVIOUS FOLD IN IT. THIS WOULD REQUIRE A SIGNIFICANT AMOUNT OF PRESSURE. ROCKS LIKE THIS COMMONLY FORM 5-20 KM BELOW THE SURFACE

4.8 We have used pressure to metamorphose this sample. Is there another tool we could use to change the shape and texture of the sample? What is it? How could we include that in our experimental design?

HEAT – WE COULD USE A HAIR DRYER ON THE PRESSURIZED SAMPLE.

4.9 What do you think would happen if we added even more pressure to this sample? What if we used the tool you discussed in question 4.8? What would eventually happen?

EVENTUALLY THE "METAMORPHIC" CHOCOLATE WILL MELT AGAIN, AND THE ENTIRE PROCESS WOULD START OVER.

STAGE 5: SHORT-CIRCUITING THE ROCK CYCLE

5.1 Imagine taking the metamorphic sample you just created and cutting it into small pieces (like you did with the igneous sample) and compress it with the weight of a rock. What type of rock would this represent?

ANOTHER SEDIMENTARY ROCK, BUT WITH METAMORPHIC CLASTS IN IT RATHER THAN IGNEOUS

a. Thinking geologically, how could this happen? What would need to occur in order for the metamorphic sample to be turned into sediment? Considering your response to question 4.7, and given that the rate of many geologic movements are in cm per year, how long do you think it might take for this to occur (give a rough estimate)?

UPLIFT AND EROSION OF OVERLYING ROCK. THIS COULD TAKE MILLIONS OF YEARS

5.2 What would happen if you took the igneous sample you created and squeezed it with the clamp? What type of "rock" would result? Would it look the same as the sample you created in the experiment?

**A METAMORPHIC ROCK, BUT WITH IGNEOUS MATERIALS.
NO, IT WOULDN'T HAVE AS MANY LITTLE PIECES STUCK TOGETHER.**

NAME ___________________________________

STAGE 6: THE STORY OF THE ROCKS

Examine rock G. In a concise paragraph (with proper sentences and grammar) write the "life story" of this rock in the context of the rock cycle. Ask your TA if you have trouble identifying parts of the rock.

ROCK G IS A CONGLOMERATE WITH MANY DIFFERENT LITHOLOGIES. THE STORY SHOULD INCLUDE A DESCRIPTION OF HOW EACH OF THE ROCKS REPRESENTED BY THE CLASTS CAME TO BE FORMED, HOW ALL THOSE ROCKS WERE TURNED INTO CLASTS AND DEPOSITED IN THE SAME LOCATION, AND HOW ALL THE CLASTS WERE LITHIFIED INTO A SINGLE ROCK.

THIS IS ESPECIALLY TRICKY IF ANY OF THE CLASTS ARE SEDIMENTARY