Convection Currents in Magma

Topic
Differences in density can create convection currents in liquids.

Introduction
Movement of hot, molten rock in the Earth’s mantle causes changes in the positions of tectonic plates of the crust. Molten rock moves because its density varies from one area of the mantle to another. Differences in density can be due to differences in composition or differences in temperature. As the mantle shifts, tectonic plates floating on it are pulled along for the ride. On the surface of the Earth, humans experience these movements as volcanic or earthquake activity.

Some areas of lava are hotter than others. Just as warm water rises above cool water to create convection currents, areas of hot lava are less dense than areas of lava that are not as hot. The less-dense, hotter materials migrate to the upper surfaces, setting up convection currents in the mantle.

Inside the Earth, materials of different compositions have different densities. These materials will move up and down until they have arranged themselves with the densest material on the bottom and the least-dense material on top.

Time Required
40 minutes

Materials: Part A
- small glass jar with lid (like a baby food or pimento jar)
- can opener (the kind that punches holes in lids)
Materials: Part A

- food coloring
- 30 milliliters (30 ml) of very hot water
- 1 to 3 liters of cool water
- large glass bowl or small aquarium (2- to 5-liter capacity)
- science notebook

Materials: Part B

- large test tube with stopper or cap
- food coloring
- 20 ml water
- 10 ml corn syrup
- 10 ml mineral oil
- 50-ml beaker
- stirring rod

Safety Note

Please review and follow the safety guidelines.
Take care when using the puncture-style can opener and when working with very hot water.

Procedure: Part A, Differences in Temperature

Causes Variations in Density of a Liquid

1. Pour cool water into the bowl or aquarium until it is about full.
2. Put the lid on the glass jar. Use the can opener to punch two holes in the lid, one on each side.
3. Remove the lid, put 2 or 3 drops of food coloring in the jar, then fill the jar with very hot water. Replace the lid.
4. Carefully lift the jar and set it in the bowl or aquarium of cool water, as shown in Figure 1.
5. Observe what happens. Describe in your science notebook what you see.
Procedure: Part B, Differences in Composition Cause Variation in Density of a Liquid

1. Pour corn syrup into the test tube until it is about 1/3 full.
2. Add 2 drops of food coloring to the 50-ml beaker. Fill the beaker about 1/3 full with water and stir.
3. Pour enough colored water on top of the corn syrup to fill the tube to 2/3 full.
4. Add enough mineral oil to finish filling the test tube (Figure 2). Cap the tube.
5. Observe the test tube of fluids. In your science notebook, describe the appearance of the liquids in the tube.
6. Invert the test tube and observe for 2 to 3 minutes. Describe in your science notebook what happens.
Analysis

1. Suggest an explanation for your results in Part A.
2. Predict what will happen when the warm water in the jar and the cool water in the bowl reach the same temperature.
3. Suggest an explanation for your results in Part B.
4. What happened when you inverted the tube? Why?

What’s Going On?: Part A

Cold water is denser than warm water. Cold water sank into the holes in the lid, forcing the warm, less-dense water out. As the warm water rose, it put the water in the aquarium in motion, setting up a convection current.
What’s Going On?: Part B

Materials that have different compositions have different densities. In this experiment, corn syrup is the densest fluid, water the second most dense, and mineral oil the least dense. Therefore, three distinct layers form in the tube. When the tube was inverted, the fluids rearranged themselves so that the densest was again on the bottom.

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CONVECTION CURRENTS IN MAGMA

Analysis

1. Warm, colored water from the jar rose through the cool water in the aquarium.

2. Answers will vary. When the aquarium water and water in the jar reach the same temperature, the colored water from the jar and cool water in the aquarium will slowly diffuse together.

3. Answers will vary; corn syrup forms the bottom layer, water the middle layer, and oil the top layer, because corn syrup is denser than oil or water, and water is denser than oil.

4. When the tube is inverted, the liquids exchange places so that corn syrup forms the bottom layer, water the middle layer, and oil the top layer, because liquids arrange themselves according to their densities.
SAFETY PRECAUTIONS
Review Before Starting Any Experiment

Each experiment includes special safety precautions that are relevant to that particular project. These do not include all the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is necessary that you read and remain mindful of the General Safety Precautions that follow. Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly while you are performing an experiment. Materials can spill, break, or even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following the basic safety guidelines during the entire experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. For one reason, we want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical.

Read the safety precautions here and at the beginning of each experiment before performing each activity. It is difficult to remember a long set of general rules. By rereading these general precautions every time you set up an experiment, you will be reminding yourself that lab safety is critically important. In addition, use your good judgment and pay close attention when performing potentially dangerous procedures. Just because the text does not say “be careful with hot liquids” or “don’t cut yourself with a knife” does not mean that you can be careless when boiling water or punching holes in plastic bottles. Notes in the text are special precautions to which you must pay special attention.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking an unnecessary risk can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the individual experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone. When you are working off site, keep in
groups with a minimum of three students per group, and follow school rules and state legal requirements for the number of supervisors required. Ask an adult supervisor with basic training in first aid to carry a small first-aid kit. Make sure everyone knows where this person will be during the experiment.

**PREPARING**
- Clear all surfaces before beginning experiments.
- Read the instructions before you start.
- Know the hazards of the experiments and anticipate dangers.

**PROTECTING YOURSELF**
- Follow the directions step-by-step.
- Do only one experiment at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure there is adequate ventilation.
- Do not horseplay.
- Keep floor and workspace neat, clean, and dry.
- Clean up spills immediately.
- If glassware breaks, do not clean it up; ask for teacher assistance.
- Tie back long hair.
- Never eat, drink, or smoke in the laboratory or workspace.
- Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult.

**USING EQUIPMENT WITH CARE**
- Set up apparatus far from the edge of the desk.
- Use knives or other sharp-pointed instruments with care.
- Pull plugs, not cords, when removing electrical plugs.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
• Clean up broken glassware immediately.
• Do not use reflected sunlight to illuminate your microscope.
• Do not touch metal conductors.
• Use alcohol-filled thermometers, not mercury-filled thermometers.

USING CHEMICALS
• Never taste or inhale chemicals
• Label all bottles and apparatus containing chemicals
• Read labels carefully.
• Avoid chemical contact with skin and eyes (wear safety glasses, lab apron, and gloves).
• Do not touch chemical solutions.
• Wash hands before and after using solutions.
• Wipe up spills thoroughly.

HEATING SUBSTANCES
• Wear safety glasses, apron, and gloves when boiling water.
• Keep your face away from test tubes and beakers.
• Use test tubes, beakers, and other glassware made of Pyrex™ glass.
• Never leave apparatus unattended.
• Use safety tongs and heat-resistant gloves.
• If your laboratory does not have heat-proof workbenches, put your Bunsen burner on a heat-proof mat before lighting it.
• Take care when lighting your Bunsen burner; light it with the airhole closed, and use a Bunsen burner lighter in preference to wooden matches.
• Turn off hot plates, Bunsen burners, and gas when you are done.
• Keep flammable substances away from flames and other sources of heat.
• Have a fire extinguisher on hand.
FINISHING UP

- Thoroughly clean your work area and any glassware used.
- Wash your hands.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Do not dispose of materials in the sink unless instructed to do so.
- Clean up all residues and put them in proper containers for disposal.
- Dispose of all chemicals according to all local, state, and federal laws.

BE SAFETY CONSCIOUS AT ALL TIMES!