Thermal Convection Currents

A Carolina Essentials™ Demonstration

Overview

Many diagrams of convection currents show only one convection cell, drawn in one plane, with the heat source absent. It's a very simplistic model for a far more complex phenomenon. On Earth, thermal convection currents drive our weather, ocean currents, and tectonic plate movement. In this demonstration, students get a less simplistic but a more visual model of thermal convections currents in three dimensions. The model can be altered by changing the location of the heat source to explain atmospheric, oceanic, and mantle convection currents. The accompanying student sheet examines mantle convection currents.

Earth and Space Science
Grades: 9–12

Phenomenon

Students observe the natural phenomenon of a system of convection currents and propose a model for the location of mantle thermal convection currents to explain a current tectonic plate map.

Essential Question

How is matter cycled and energy transferred through the oceans, atmosphere, and mantle?

Activity Objectives

1. Develop a model of thermal convection currents in Earth's mantle.
2. Apply the model to explain current tectonic plate motion.

Next Generation Science Standards* (NGSS)

PE HS-ESS2-3. Develop a model based on evidence of the Earth's interior to describe the cycling of matter by thermal convection.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**ESS2.A: Earth Materials and Systems** •Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.	**Energy and Matter** • Energy drives the cycling of matter within and between systems.

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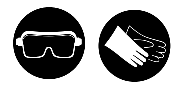
TIME REQUIREMENTS

PREP 15 min | **DEMONSTRATIONS** 20-30 min

Teacher Prep: 15 min
Demonstrations: 20-30 min

SAFETY REQUIREMENTS



MATERIALS

Plate Tectonics

Pyrex baking dish or other colorless, heat resistant dish, 13” × 9” × 2”

Hot plate

Carolina Convection Fluid, 1 bottle

5–6 wooden splints or coffee stirrers

Document camera or overhead projector

Food coloring (optional)

Ocean Currents

Pyrex baking dish or other colorless, heat resistant dish, 13” × 9” × 2”

Heat lamp or 100-W incandescent bulb in a utility lamp

Waterproof tape, 1/2” wide

Carolina Convection Fluid, 1 bottle

2–3 heavy barriers

Document camera or overhead projector

Food coloring (optional)

Atmospheric Currents

Pyrex baking dish or other colorless, heat-resistant dish, 13” × 9” × 2”

Heat lamp or 100-W incandescent bulb in a utility lamp

Waterproof tape, 1/2” wide

Carolina Convection Fluid, 1 bottle

Document camera or overhead projector

Food coloring (optional)

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Safety Procedures and Precautions

The glass dish will get hot. Handle with heat resistant gloves. Wear safety glasses.

Teacher Preparation and Disposal

Mantle convection currents

1. Preheat the hot plate.
2. Add food coloring to the convection fluid, if desired.
3. Cut wood coffee stirrers or wood splints into 1/4 to 1/2” pieces.

Ocean convection currents

1. To represent the equator, place a 13” × 1/2” piece of black tape across the center-bottom interior of the 13” × 9” × 2” glass baking dish.
2. Measure a 23° angle with respect to the equator to position a heat lamp or incandescent bulb.
3. Place 2 or 3 barriers of different sizes that will not float in the baking dish.

Atmospheric convection currents

1. To represent the equator, place a 13” × 1/2” piece of black tape across the center-bottom interior of the 13” × 9” × 2” Pyrex baking dish.
2. Measure a 23° angle with respect to the equator to position a heat lamp or incandescent bulb.

Disposal

The convection fluid can be reused. Wash the baking dish with hot water and detergent.

Procedure

Mantle convection currents

1. Preheat the hot plate to between 90°–110° C.
2. Add food coloring to the convection fluid in the bottle (if desired) and mix well.
3. Cut the wood coffee stirrers or wood splints into 1/4” to 1/2” pieces.
4. Position the document camera directly above the hot plate, and turn the camera on.
5. Place the glass dish on the hot plate, and pour in the entire bottle of Carolina Convection Fluid. Let the fluid come to rest.
6. After 4–5 minutes of heating, ask students to draw what they observe. ***There will be many convection currents emanating from the heat source and expanding in several directions.***
7. Add the wood splint pieces in a line, directly above the heat source and visible through the document camera.
8. After 3–4 minutes, ask students to draw what they observe. ***The wood splints will move in several directions, always away from the heat source. They may pile up at the sides of the dish.***
9. Have students complete the modeling exercise and discuss student models.

HELPFUL LINKS

[Plate Tectonics Activity](#)

[Plate Tectonics: Evidence of Plate Movement](#)

REFERENCE KITS

[Plate Tectonics and Island Formation](#)

[Seafloor Spreading and Age of Crustal Rocks](#)

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Analysis

1. Observe the convection currents in the glass dish with the convection fluid. Draw what you observe.
2. Observe the motion of the wood splints in the glass dish with the convection fluid. Draw what you observe.
3. What do the wood splints represent? What does the convection fluid represent?
   The splints represent the continents, and the fluid represents the Earth's mantle.
4. Use your observations to propose a model for tectonic plate movement. You may illustrate or explain your model.
   Wood splints move away from the heat source "riding" on top of the convection current in the fluid (divergent plate boundary). When they reach a rigid barrier like the side of the dish, they bunch up and collide (convergent boundary). Plates move out in all directions.
5. Apply your model to the map of tectonic plate movement below by adding thermal convection currents to explain plate movements. Identify where you hypothesize the heat source(s) may be for the convection currents.
   Students may notice that movement starts at divergent plate boundaries and moves away from the boundary. They may illustrate the convection current beginning with an uprise at a divergent plate boundary, traveling in a direction, and then sinking at a convergent boundary. They should show several convections currents moving in a variety of directions.

Reference Map

Named Tectonic Plates and Their Motion

Image from Wikimedia Commons.

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