Heat transfer

Activity

The Science

An important thermal property for geothermal reservoirs is the heat capacity of materials. Heat capacity is the amount of heat energy required to change the temperature of a material by one unit. Different materials require different amounts of heat to increase the temperature of the same amount of material.

As an example, imagine going to a park on a hot summer day. You see two benches side-by-side, one is made of iron, the other wood. You sit on the iron bench, but it is too hot and you quickly move to the wooden bench, which feels much cooler. The difference is not because the two benches received a different amount of heat, but because they are made of different materials. The metal bench needs a smaller amount of heat to increase its temperature, so it gets hot quicker than the wooden bench. WE say that the iron has a smaller heat capacity. Heat capacity can vary widely among materials.

The aim of this activity is to understand the relationship between thermal energy and heat capacity, and to differentiate between materials with low verses high heat capacity.

Scientists and engineers use their knowledge of heat capacity to determine the different applications of materials. It is essential for geothermal reservoir engineers to understand the heat capacity of rocks, fluids and other minerals that occur in the subsurface to determine how much heat energy the earth can hold. This also helps us understand how the temperature beneath the earth changes as we extract geothermal energy.

Materials

- Roasting/baking pan
- Kettle
- 2 glasses/cups
- 3 thermometers
- Measuring cup/beaker
- 200ml of sand
- Salt
- Ice
- Teaspoon
- 250ml of water at room temperature
- Timer or stopwatch

Instructions

1. Place a thermometer into each glass.
2. Measure 200ml of sand and pour into one of the glasses.
3. Measure 250ml of room temperature water and stir in 2 teaspoons of salt to make a saltwater solution. This is approximately the concentration of salt in the oceans.
4. Pour 200ml of the saltwater solution into the second glass.

5. Boil water in the kettle.
6. Carefully pour the hot water into the pan. Keep the water level about 2cm below the edge and put a thermometer in it.
7. Measure and record the initial temperature of the water, sand and saltwater solution.
8. Place the glasses containing the sand and saltwater into the pan and start the timer.
9. Measure and record the temperature of the water, sand and saltwater solution every minute for ten minutes.
10. Carefully remove the glasses containing the sand and saltwater and the thermometer from the pan and set aside.
11. Carefully discard the hot water. Pour ice into the pan and add warm tap water to melt the ice a bit.
12. Place the thermometer in the pan.
13. Record the starting temperatures of the icy water, sand and saltwater.
14. Place the glasses containing the sand and saltwater back into the pan and start the timer.
15. Measure and record the temperature of the water, sand and saltwater every minute for ten minutes.
16. Safely and responsibly discard the sand, saltwater and pan water.
17. Make a bar chart or line graph of the recordings of temperature versus time for both the hot and cold-water experiment.

Which material do you think has a lower heat capacity, sand or saltwater?

Hint: From the chart, which material loses heat faster, and which can store more heat (or lose heat slower)?

Further investigation

You can also experiment using different amounts of salt for the saltwater solution to investigate the effect of increasing or decreasing the salt concentration on heat capacity.

Are there other materials you could try? Soil, shredded paper, shredded Styrofoam, cloth, you just need 200 ml by volume to compare.

Note

You should note that a part of the heat in the hot water is lost to the room and not transferred to the material. In the lab, an equipment called a Calorimeter is used to measure the heat capacity of materials.

Caution

When using kettle to make warm water use care and have adult supervision.