Metamorphic aureole – instructions for the virtual experiment

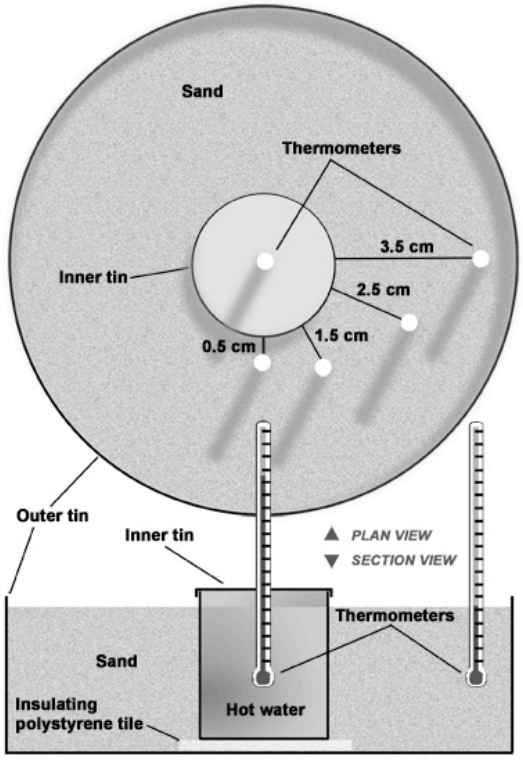
This document tells you how to use the virtual experiment, and is in four parts:

1. Overview of the real-life experiment
2. Preparation for the virtual experiment
3. How to run the virtual experiment
4. Interpreting your results

1. Overview of the real-life experiment

The experiment is a table-top simulation of the transfer of heat from an igneous intrusion into the surrounding 'country' rock. The apparatus consists of a large container – here a sweet tin – containing sand, with a smaller tin in the centre containing hot water. The sand represents the country rock and the inner tin with the hot water the intrusion. The inner tin sits on a polystyrene tile which prevents heat escaping downwards. The thermometer measuring the temperature of the water in the inner tin is held in place by a rubber bung or disc.

Above: Photograph of the experimental apparatus,with a digital timer



Left: Diagrammatic plan- and section- views

2. Preparation for the virtual experiment

2.1 Variables and constants

In this experiment the only variables will be the temperature, the position of the thermometers and the size of the inner tin. What other factors need to be kept constant for this to be a fair test?

2.2 Safety

If this were a real experiment would there be any hazards? If you think there would be list them otherwise, say there are no significant hazards.

2.3 Reading the thermometers

Why are the thermometers read every two minutes and not every minute or every 5 minutes?
Why is it important to read the thermometers before the hot water is added to the inner tin?

2.4 Number of measurements

If this was a real experiment one might record the cooling of each size of inner tin several times and one would expect to get slightly different results each time. In this virtual experiment you will get the same figures each time. Therefore you will only need to record the cooling for each tin size once.

2.5 Equipment

The equipment used in this experiment, chocolate and paint tins, sand, thermometers and timer, are all readily available or easy to obtain. How could you improve the experiment if lots of money was available?

2.6 Some initial questions

Before starting the virtual experiment can you predict the answers to the following questions and give reasons for your answers?

a) How will the temperature of the sand change with distance away from the inner tin?
Sketch a graph of temperature (y axis) against distance (x axis).

b) How will the size of the inner tin affect the size of the area of sand heated up?
Add a line for a smaller tin on your graph.

c) How will the size of the inner tin affect the thermal gradient?

d) How will the temperature of the sand at any one place change with time?
Sketch a graph of temperature against time for one of the thermometers.

e) Which will cool fastest - a large inner tin or a small one?
Sketch cooling curves (temperature against time) for a large tin of water and for a small one on the same paper.

f) Given sufficient time what determines the lowest temperature the water and sand can cool to?

3. How to run the virtual experiment

You are now ready to start the virtual experiment. Before starting the experiment, you will need to print a copy the worksheet with the two data tables.

1. Choose the size of your igneous intrusion. There are four sizes of inner tin, with diameters of 78mm, 85mm, 92mm and 107mm. Selecting one of these will open the animation, and you will see a schematic diagram of the apparatus, with the inner tin and the sand with the thermometers (the left hand side of the outer tin is not shown).

2. There is a timer display at the top left, and then two rows of data windows that display temperatures. The top row of values shows the maximum temperature reached by each thermometer so far. The lower row shows the current temperature of each thermometer.

3. Record the initial temperature of all five thermometers.

4. Press the start button to start the experiment animation. The experiment runs at four times normal speed, so that one ‘virtual’ minute lasts for 15 ‘real’ seconds.

5. Now record the temperature of all five thermometers every two minutes using the timer on the screen. For fifteen ‘virtual’ seconds before the two minutes are up, the timer window will change colour to amber to warn you that it is almost time to record the next set of data. For thirty ‘virtual’ seconds (about 8 real seconds) after the two minutes, the timer window and the five current temperature windows change colour to green, indicating that you should record the temperatures on your worksheet. For the rest of the time, the timer window has a red background, indicating that you should not be recording. However, if you haven’t finished recording temperatures in the green period, don’t stop when the timer goes back to red.

6. Continue until the timer reads 90 minutes. The animation will stop automatically.

4. Interpreting your results

Close the animation. Describe and explain your results and relate them to your predictions.

Plot you data on one piece of graph paper (if you are using A4 graph paper you may find it best to join two pieces together end on). Use a different a different colour for each thermometer. Use the paper in landscape orientation. Plot the temperature on the vertical axis and the time on the horizontal axis. Alternatively, enter your data into the spreadsheet and use it to plot the graphs.

You can either press ‘Back’ and choose a different tin size and repeat the experiment, or obtain the data for the other tin sizes from other students.

Fill in Table 2 using the data from all four tin sizes. Take the time of maximum temperature as being half way between the first and last times for that temperature.