

Weathering and erosion: simulating rock attack in the lab: teacher's notes

Level

This activity is designed for students aged 11-14.

Topic

This topic examines the ways in which water can **weather** rocks, by solution and by **freeze-thaw**. Simulations of **erosion** by running water and by wind are also provided.

Description

This material consists of a circus of class practical and demonstration activities that simulate some of the processes occurring in **weathering** and **erosion**.

Activity 1 looks at the effect of pouring water onto brown sugar to simulate the effect of water on soluble rock.

Activity 2 looks at the residue left after water samples have evaporated to show that water can dissolve minerals.

Activity 3 shows that water expands on freezing by placing a sealed jar of water in the freezer overnight and looks at the effect of freezing on a water-soaked sample of porous rock.

Activity 4 simulates the effect of water impact on rocks by pouring water on sand.

Activity 5 uses a hair dryer to simulate wind erosion by 'sandblasting' copper sulfate crystals from a cylinder of Blu-Tack®.

Context

These activities introduce the ideas of **weathering** and **erosion** and lead onto work about the formation of sedimentary rocks.

Teaching points

Start with a discussion on how rocks can be broken down into smaller pieces (for example how a sandy beach forms from a cliff), before leading on to a series of activities to illustrate the various different types of weathering and erosion caused by water and wind. The activities can be arranged as some combination of demonstrations, class practicals or as a circus depending on resources

Points to bring out

Stress that although these simulations take a few minutes, the processes that they model usually take place over a much longer timescale.

Encourage correct use of the terms **weathering**, **erosion** and **transport**.

Weathering can take place in three ways – **physical weathering**, *eg* water collecting in cracks in rocks and breaking them when it expands on freezing; **chemical weathering**, *eg* reaction (dissolution) of rock such as limestone in slightly acidic rainwater; **biological weathering**, *eg* the roots of plants opening up cracks in rocks.

Erosion is the wearing away of exposed surfaces by agents such as wind, moving water and ice. These agents usually contain weathered rock debris. Rock fall under gravity is also erosion.

Transport begins as erosion and is the movement of rocks under gravity, or by moving water, by wind or by ice (in glaciers, for example).

Timing

Each activity takes between about 5 and 10 minutes to carry out. Activities 2 and 3 require the experiment to be left for a day or more in order for the results to be observed.

The activities could be fitted into one or two teaching periods, each of about 50 minutes, depending on how many activities are tackled as class practicals, how many as demonstrations and also how much time is allowed for introduction, write-up and discussion of results.

Activity 1

Apparatus

Each student or group will need

- Eye protection
- Shallow tray (a baking tray is ideal)
- Wooden blocks
- 100 cm³ beaker
- Dropping pipette
- Access to sink

Chemicals

Each student or group will need

- Brown sugar (or other cheap, coloured, soluble substance)

Safety notes

- Wear eye protection
- Ensure that students do not taste the sugar
- It is the responsibility of the teacher to carry out an appropriate risk assessment

The activity

Place a tray so that one edge hangs over the sink and place a wooden block under the other end so that the tray slopes down towards the sink. Arrange a small mound of brown sugar in the middle of the tray to represent a rock. Fill a beaker with water and use a dropping pipette to add water gently to the top of the mound, see Figure 1. This is an example of a model of water dissolving rock. The coloured solute is particularly useful, as students can see the coloured solution being washed away into the sink.

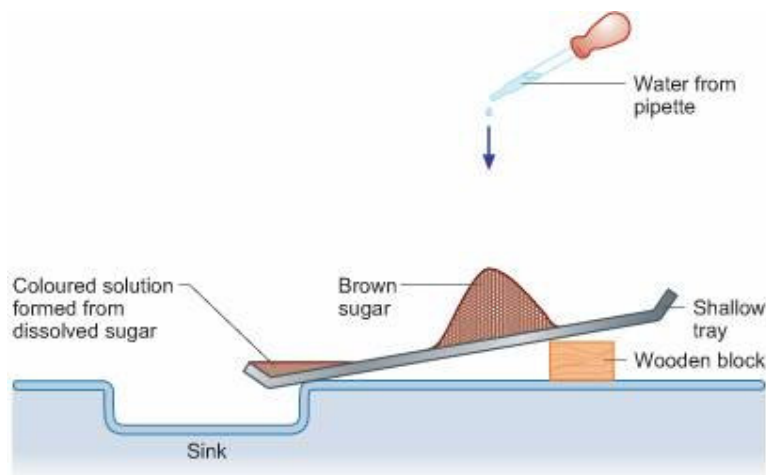


Figure 1 The setup for Activity 1

Activity 2

Apparatus

Each student or group will need

- Eye protection
- 3 evaporating basins

Chemicals

Each student or group will need

- Mineral water (still mineral water from a supermarket). It will be useful to leave the label on the bottle particularly if this has a description of the source of the water and / or an analysis of the water
- Distilled / deionised water

Safety notes

- Wear eye protection
- Ensure that students do not taste the mineral water
- It is the responsibility of the teacher to carry out an appropriate risk assessment.

The activity

This activity may be most suitable for demonstration purposes as it needs to be set up and left for at least a couple of days.

This demonstration can be used as further evidence to satisfy those students who are not convinced by the first activity. Place a few cubic centimetres of tap water into an evaporating basin, place a similar amount of distilled or deionised water into a second basin and a similar amount of mineral water in a third basin. Label the basins appropriately, then place them somewhere warm for a few days for the water to evaporate. (This could be speeded up by placing them in an oven.) Explain the origin of the three water samples, paying particular attention to the fact that mineral water is filtered through rocks and therefore has come into intimate contact with rock. The label on the bottle will probably reinforce this, and there may be an analysis of the water which may lead to discussion. (If the analysis is given in terms of ions, this can

lead to further discussion, especially with older students.) After evaporation, show the basins to students – the one that contained distilled or deionised water should be still clean, the one that contained tap water may be clean (this depends on the hardness of the water in your area), but the mineral water basin should have some mineral deposits present, indicating that the deposits were, in fact, dissolved by the water when passing through the filtering rocks.

Activity 3

Apparatus

Each student or group will need

- Eye protection
- Coffee jar with screw top
- Dropping pipette
- 100 cm³ beaker
- Access to a freezer

Chemicals

Each student or group will need

- A sample of porous rock, typically a shale, siltstone, chalk or sandstone. Suitable material can be obtained from a geological supplier if none is available locally. Click here for details of some suppliers <http://www.earthscienceeducation.com/suppliers>.

Safety notes

- Wear eye protection
- There may be sharp fragments of glass from the broken coffee jar
- It is the responsibility of the teacher to carry out an appropriate risk assessment

The activity

It is very difficult to show freeze-thaw damage in one lesson, so it is likely that this activity will need to be set up and left to be inspected until next lesson.

Fill a coffee jar completely with water, making sure that there are no air bubbles, and screw the lid firmly onto the jar (care is needed, remember water cannot be compressed!) and place it in a container such as a plastic bowl in the freezer.

Take a small sample of porous rock (it is sometimes useful to have previously dried the rock slowly in an oven for a few days), place in a beaker and, using a dropping pipette, carefully drip water onto the rock. Add the water slowly, stopping when no more water appears to have been absorbed. Alternatively, use a sample that has previously been soaked in water overnight. Place the sample in a plastic bowl in the freezer.

In the following lesson, remove the samples from the freezer. The expansion of water on freezing will have cracked the glass jar. As the rock sample thaws out, particles of rock may fall from the main sample. Be warned, this does not always work and some trial and error prior to the lesson may be needed to select a suitable sample of rock that does show this effect – porosity is the main factor. The best types of rock to try are shale, siltstone, chalk and sandstone – porous red sandstones have been found to be most effective.

It may be necessary to carry out more than one freeze-thaw cycle to produce fragmentation. This can be done by the teacher or lab technician between the lesson in which the activity is set up and the one in which the results are examined. Note that natural freeze-thaw weathering requires many cycles of freezing and thawing, rocks are not broken by freezing alone.

The expansion of water on freezing is unusual. It occurs because in ice the water molecules form an open hexagonal structure held together by hydrogen bonds. On average the water molecules are further apart in ice than in liquid water. So ice has a lower density than water and floats on top of it. This effect means that ice forms an insulating blanket on top of liquid water and is important for the survival of aquatic life in cold climates.

Activity 4

Apparatus

Each student or group will need

- Eye protection
- Shallow tray (a baking tray is ideal)
- Sand
- 100 cm³ beaker
- Dropping pipette
- Washing up bowl or similar
- Access to sink

Safety notes

- Wear eye protection
- It is the responsibility of the teacher to carry out an appropriate risk assessment.

The activity

Set up the tray as described in Activity 1. Place a small mound of dry sand on the tray. Carefully, drip water onto the sand using the dropping pipette, see Figure 2. Students should be able to see grains of sand being washed down the mound. Repeat the process, this time, pouring water directly from the beaker (to simulate a torrential downpour of rain). A washing up bowl placed in the sink is used to catch the sandy water and prevent sink blockages.

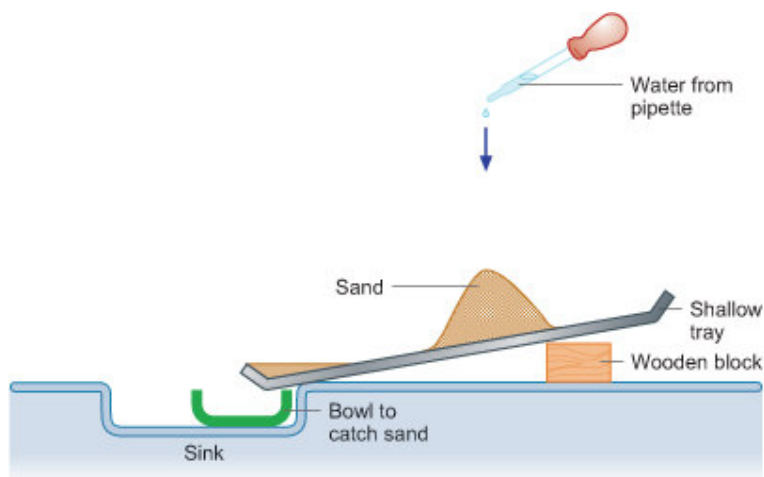


Figure 2 The setup for Activity 4

Repeat the above procedure again, this time using a heap of wet sand. The grains of wet sand tend to stick together more than dry sand and so this simulates the action of water on a harder rock. In this way, the students can see the effects of water impact on rocks and, although someone will undoubtedly point out that very few rocks would crumble quite so easily, this can be countered by explaining that the process they have just simulated usually takes many years.

Activity 5

Apparatus

Each student or group will need

- Eye protection
- Plastic bin liner
- Hair drier
- Retort stand, boss and clamp
- Access to fume cupboard
- Blu-Tack® or Plasticine
- A few copper(II) sulfate crystals (harmful)
- Access to fume cupboard

Safety notes

- Wear eye protection
- It is the responsibility of the teacher to carry out an appropriate risk assessment

The activity

This activity is most suitable as a demonstration.

Work in a fume cupboard which should be switched off. Line the floor and walls of the fume cupboard with a bin liner. Make a cylinder of Blu-Tack® around a glass rod and coat it with copper(II) sulfate crystals, just enough to get a thin layer. This can be done by rolling the cylinder in a tray of the crystals. Place the cylinder on the bin liner as shown in Figure 3. Set up the hair drier (using the stand, clamp and boss) so that it is at the same height as the coated cylinder of Blu-Tack® and pointing towards it.

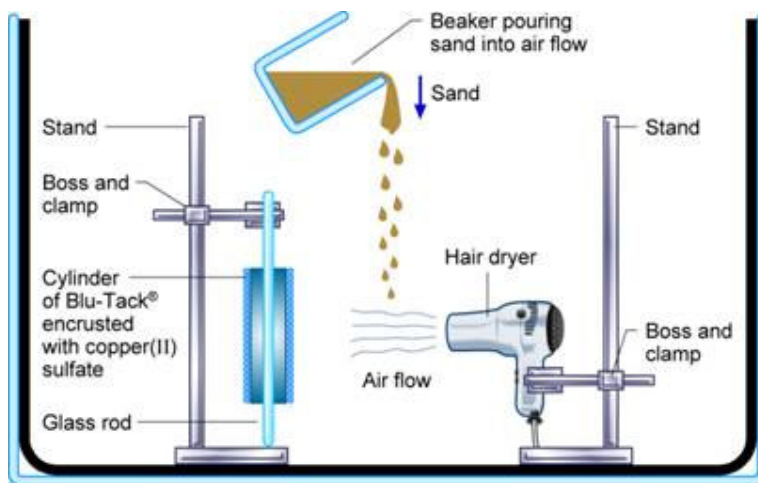


Figure 3 The setup for Activity 5

Switch on the hair drier and gently pour a stream of sand into the turbulent air flow, so that the sand is blown onto the cylinder. (This part of the activity does need to be practised beforehand to get the correct distances *etc.*) After a few minutes of this bombardment, stop the sand and air flow and examine the contents of the bin liner. There should be some blue crystals of copper(II) sulfate which have been ‘sandblasted’ from the coated Blu-Tack®

Answers to questions

The answers given here are for the guidance of the teacher. Other answers may be equally acceptable.

Activity 1

- Q 1. It has dissolved some of the sugar.
- Q 2. It has been dissolved away.
- Q 3. Most water has things dissolved in it as shown by the presence of deposits when the water evaporates away. Other acceptable answers might include the formation of stalagmites / stalactites, the formation of caves in limestone and the formation of mineral water.
- Q 4. Acceptable answers include that it may reappear if the water evaporates (as in the formation of stalagmites / stalactites), or it is washed into the sea.
- Q 5. Mineral water and tap water.

Activity 2

- Q 1. Tap water has fallen as rain and soaked through parts of the Earth’s surface before being collected for use, so it may contain dissolved material depending on the type of rock it has soaked through. Distilled water has been boiled and the steam condensed so that it contains no dissolved material. Mineral water has soaked through rock and dissolved some of its mineral content. Many students will probably give less-detailed answers.
- Q 2. The deposits on the evaporating basins were originally dissolved in the water / the solids on the dish must have come from the water.
- Q 3. Depending on the brand of water, there may be a description of its origin and / or an analysis of its mineral content.

Activity 3

- Q 1. It increases (*ie* the water expands).
- Q 2. Water can soak into porous rock and, when it freezes, it expands and this can break off bits of the rock.

Activity 4

- Q 1. It contains sand that has been washed away from the pile.
- Q 2. Sand has been removed from it.
- Q 3. Sediments in the estuaries of rivers or deltas, pebbles and sand below sea cliffs *etc.*
- Q 4. They may be worn away more quickly.
- Q 5. Softer rock and more soluble rock may be worn away more quickly.
- Q 6. The sand represents insoluble rock and the sugar soluble rock.

Activity 5

- Q 1. They were knocked off by impacts from grains of sand in the air stream.