Weathering limestone – with my own breath!
A classroom demonstration of how limestone is weathered

Carry out a laboratory demonstration of the first stages in the chemical weathering of limestone. Quarter-fill a small glass beaker or a boiling tube, with some water of neutral pH and add some Universal indicator. Ask what will happen if a pupil blows steadily into the water through a straw (it pays to choose the most talkative pupil to do this!). Watch what happens as the exhaling continues, and see if the water will turn acid – indicated by the colour changing from green to yellow, to orange or even to pink. Ask pupils to explain why this has happened (*Along with nitrogen and oxygen, the exhaled breath contains carbon dioxide which has dissolved in the water producing the weak acid, carbonic acid, in the tube*).

A conference delegate produces carbonic acid by blowing into water
(Photo: *Peter Kennett*)

Ask if pupils can think of a situation where naturally produced acids might have an effect on rocks at the Earth's surface. (*The most likely answer is in the chemical weathering of limestone*).
See if limestone is affected by adding a small spoonful of powdered limestone to the "breath acid" in the boiling tube and agitate the tube for a few seconds. Although the acid is weak, it is usually concentrated enough to react with the powdered limestone, and to be neutralised by it, turning the indicator back to green, or even slightly blue. The solution is also cloudy because of the limestone powder in suspension.

The same tube a few seconds after adding powdered limestone.
(Photo: *Peter Kennett*)

Set up a similar boiling tube with water and Universal indicator and make more carbonic acid by exhaling into it. This time, ask pupils what will be the outcome of adding a small chip of limestone, of about the same mass as the powdered limestone used earlier. Will it react and dissolve, too? If so, will it take the same time, or more or less time? (*The limestone may produce little reaction during the time of the lesson, because it has considerably less surface area than in the powdered form. If you wish to keep it until the next lesson, seal the tube with a bung, to prevent the carbon dioxide in the air from keeping the water acid*).

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The back up

Title: Weathering limestone – with my own breath!

Subtitle: A classroom demonstration of how limestone is weathered

Topic: A pupil activity, or a demonstration, involving blowing into neutral water to produce a weak acid. Powdered limestone is added to neutralise the acid, as a quick-acting laboratory example of how limestone is weathered in the natural world.

Age range of pupils: 11-18 years

Time needed to complete activity: 5 minutes, plus discussion

Pupil learning outcomes: Pupils can:

- explain how rainfall may become acid as it falls through the atmosphere;
- describe the colour change of Universal indicator when it is made more acid or more alkaline;
- explain that exhaled air contains carbon dioxide, which will produce a weak acid when blown into water;
- explain that limestone (calcium carbonate), can neutralise carbonic acid when added to it;
- explain why powdered limestone reacts more quickly than a single large limestone fragment;
- explain how chemical weathering of limestone may occur.

Context: This activity may be used in Geography or Science lessons. Features of limestone weathering are commonly taught from photographs or fieldwork. Follow this activity up with other examples of limestone weathering (see suggestions below).

Following up the activity:

- Take pupils to a local building where limestone features are showing signs of weathering, e.g. carvings on old churches or gravestones made of limestone, and ask them to suggest what is causing the decay (*weathering as described above, caused by natural carbonic acid; the weathering may have been accelerated by the extra acids derived from vehicle exhaust and other pollutants ("acid rain"); also, possible lichen or plant action).*

A weathered Roman sculpture, in Bath limestone, from the West of England (Photo: *Elizabeth Devon)*

- Ask pupils to look out for examples of such chemical weathering on their journeys around the town.
- Use Earthlearningidea activities 'Karstic scenery - in 60 seconds: Modelling the chemical weathering of limestone' and 'Weathering - rocks breaking up and breaking down: matching pictures and descriptions of weathered rocks with the processes of weathering that formed them'.

Underlying principles:

- Carbon dioxide from the atmosphere combines with falling rain water to form carbonic acid.
  ($H_2O + CO_2 \rightarrow H_2CO_3$).
  The water becomes more acidic as it passes through soil and vegetation.
- Limestone (calcium carbonate) reacts with acidic rainwater (carbonic acid, H_2CO_3), to form calcium hydrogen carbonate.
  ($H_2CO_3 + CaCO_3 \rightarrow Ca(HCO_3)_2$.
- Calcium hydrogen carbonate is soluble and is removed in solution.
- Weathering is the decay and disintegration of rock *in situ* at the Earth's surface, without the removal of solid rock fragments.
- Material carried away in solution is regarded as an aspect of weathering, rather than erosion.
- Marble also consists of $CaCO_3$, and responds to weathering in the same way as limestone, so marble gravestones may be examined for evidence of weathering too.

Thinking skill development:
Metacognition is involved in discussing the outcomes of the activity. Bridging skills are need when relating the laboratory work to the natural world.

Resource list:

- 2 small beakers (eg. 100 or 250 ml) or 2 glass boiling tubes
- Universal indicator solution
- unused drinking straws
- spatula
- ground limestone or powdered chalk [horticultural ground limestone is ideal, but do ensure that it is calcium carbonate ,$CaCO_3$, and not slaked lime, $Ca(OH)_2$]
- a small limestone chip (a few mm diameter)
- water. Use distilled or deionised water if available. If not, tap water may be used, although it has frequently been made alkaline, in order to reduce corrosion of pipes, and it may not be possible to lower the pH of the carbonic acid to the pink tone.

NB. Eye protection may be advisable to safeguard against splashes of water with indicator. Pupils should be told to blow into the water and not to suck any up into their mouths.

Useful links: www.earthlearningidea.com
'Geological postcards 2 – sandstone and limestone: Picture postcard puzzles'

Source: This activity was originally devised by Peter Kennett for the Earth Science Education Unit.