Karstic scenery - in 60 seconds
Modelling the chemical weathering of limestone

Show pupils photos of limestone scenery like the two shown below.

Fig. 1 Yorkshire Dales *Photo: Julia Kay*

Fig. 2 Limestone pavement at Austwick, Yorkshire Dales
Photo: Peter Kennett

The rock shown is a hard limestone (of Carboniferous age). It is fine-grained and is highly permeable because of the natural fractures. It has a very low porosity, *(refer to Underlying principles, page 3).* Ask the pupils what they think has caused the limestone to look like this.

Now place a block of sugar cubes (e.g.3x3x3) on a clean tray. Pour a little (about 50ml) cold water over them and watch. **Ask the pupils:**

- what they think has caused the sugar cubes to look like this;
- how is the water which flows from the bottom of the sugar cubes different from the water which was poured on top.

Show the pupils diagrams of karstic scenery, similar to the ones shown in Figs. 5 and 6, on the next page. Ask them if they can see any of the features shown on the diagrams in the sugar cubes? How good is the model?

Fig. 3 Sugar cubes begin to dissolve and collapse after about 60s
Photos: Elizabeth Devon

The activity can be varied by using different amounts of sugar cubes (as shown below) and by dripping water (e.g. with a pipette) on to the surface instead of pouring it. Warm water speeds up the process still further.

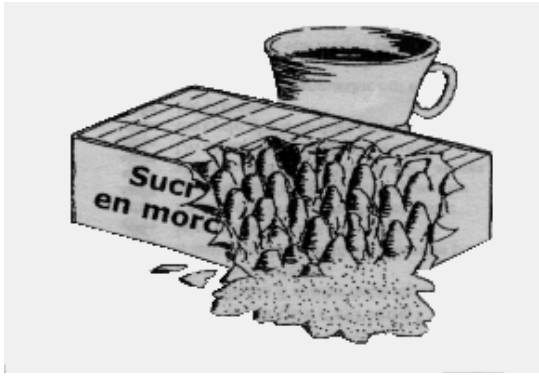

Fig. 4 Diagram from French workshops: Goûtez la Gèologie
Les Ecologistes de l'Euzière

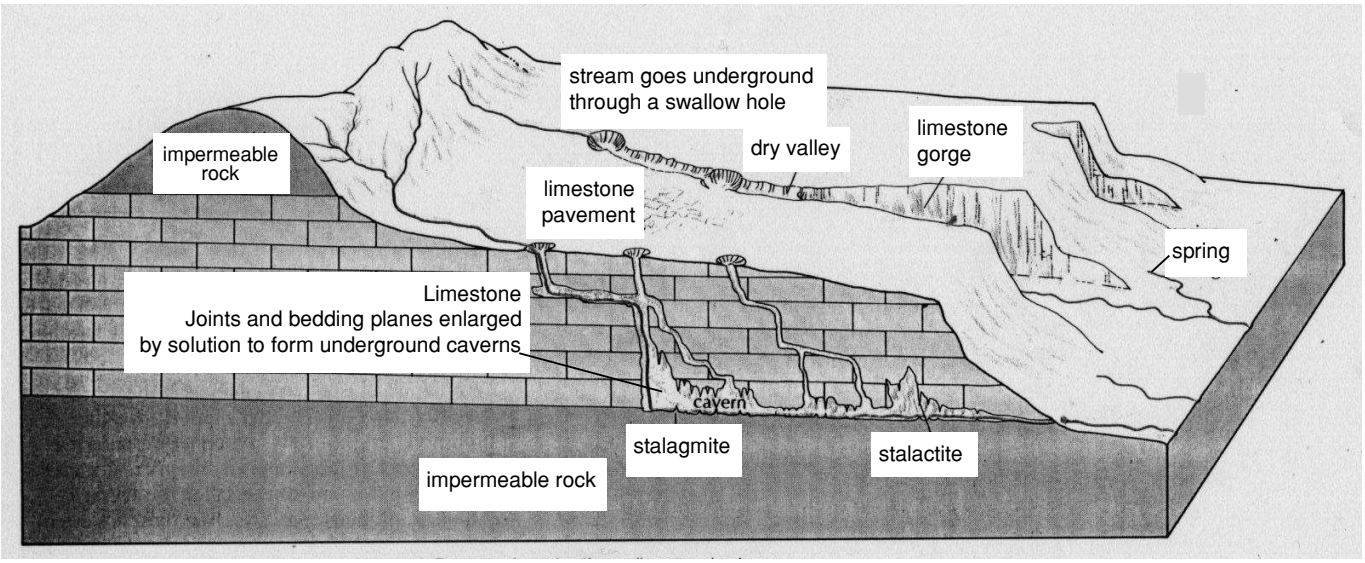

Fig. 5 Diagram to show the main features of limestone or karstic scenery *Source unknown*

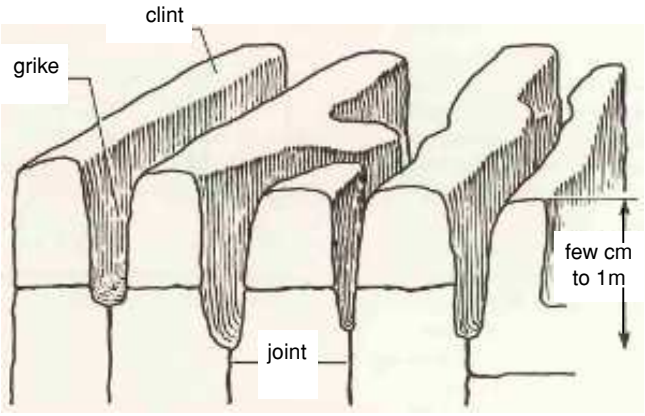

Fig. 6 Details of a limestone pavement where the joints in the rock have been enlarged by solution
From 'Physical Geography in Diagrams, Bunnett, 1965

The back up

Title: Karstic scenery - in 60 seconds

Subtitle: Modelling the chemical weathering of limestone

Topic: This activity can be used in any science or geography lesson.

Age range of pupils: 8 - 14 years

Time needed to complete activity: 20 minutes

Pupil learning outcomes: Pupils can:
- see that the sugar cubes dissolve in water, removing the solid sugar and forming a sugar-rich solution;
- relate the solution of the sugar cubes to the solution of limestone;
- explain that rain water is dilute carbonic acid and will react with the limestone so dissolving it;
- relate some of the features shown in the diagrams and photographs of limestone scenery to the dissolved sugar cubes;
- explain that, although chemical weathering is important in producing the characteristic features of this karstic scenery, physical weathering, such as freeze-thaw, could also take place;
- discuss the value of this model.

Context:
Rainwater, which is very dilute carbonic acid, reacts with the calcium carbonate of limestone, dissolving it and removing calcium hydrogen carbonate in solution.

$H_2CO_3 + CaCO_3 \rightarrow Ca(HCO_3)_2$

As Fig. 5 shows, streams, derived from rain water, flow over the impermeable rock, which lies above the limestone. Once they flow on to the permeable limestone, however, the rain water dissolves the rock, enlarging its natural joints, and disappearing underground down gaps that widen into swallow holes. Once underground, the rain water continues to dissolve the rock along its joints and bedding planes, creating caves and caverns in which stalactites and stalagmites form from dripping water saturated in calcium hydrogen carbonate. The streams emerge at the base of the limestone where there is often another impermeable rock.

The enlarging of the gaps between the sugar cubes models the solution that results from this chemical weathering process. Fig. 6 shows a limestone pavement where the joints have enlarged and are known as grikes, separated by upstanding clints.

Following up the activity:
The pupils could search for evidence of chemical weathering in the rocks and building stones of their area. The photograph, Fig. 7, shows the chemical weathering of alabaster. Alabaster (gypsum, calcium sulfate) dissolves in rain water. The slab in the photograph was quite smooth when it was placed outside the Cathedral 40 years before.

Fig. 7 Alabaster tomb, outside Sheffield Cathedral
Photo: Peter Kennett

Underlying principles:
- Carbon dioxide is removed from the atmosphere by combining with falling rain water to form dilute carbonic acid (H_2CO_3). This becomes more acidic as it passes through soil and vegetation.
- Limestone (calcium carbonate) slowly dissolves in rainwater (dilute carbonic acid).
- Calcium hydrogen carbonate is soluble and is removed in solution.
- Joints in limestone are enlarged by the dissolving and removal of the limestone (dissolution).
- Karstic scenery is produced as a result of this chemical weathering.
- Some physical weathering, e.g. freeze-thaw, also may aid the breakdown of the rock.
- Porosity is the amount of space within a rock (given as a percentage space); permeability is a measure of the rate of fluid flow through a rock.
- Porosity can be primary porosity, in the spaces between the grains as the rock formed, or secondary porosity, formed later in cracks and crannies.
- The limestone that develops karst features usually has a low primary porosity and permeability (no bubbles come out when put in water) but, due to the fracturing and widening of the fractures, has a much higher secondary porosity and therefore permeability.

Thinking skill development:
Bridging skills are required to compare the dissolution of the sugar cubes with karstic scenery. The model does not represents all features of karstic scenery, e.g. caves and caverns do not form; this causes cognitive conflict. Metacognition is involved in the discussion about the value of the model.

Resource list:
• sugar cubes
• water
• clean tray (so that the sugar can be used later)
• pipettes (optional)
• photos of limestone scenery
• a copy of a diagram of limestone scenery.

Useful links:
The following Earthlearningideas -
http://www.earthlearningidea.com
Building stones 1 - a resource
Building stones 3 - sedimentary rocks
Geological postcards 2 - sandstone and limestone
Weathering - rocks breaking up and breaking down

Source:
Written by Elizabeth Devon from an idea demonstrated by Ros Todhunter at a meeting of the Earth Science Education Unit, Keele University. It was originally published by Les Ecologistes de l'Euzière http://www.euziere.org