Danger – quicksands!

Why do some rocks give way when it rains hard?

Show pupils the photographs of a major landslide, on Mam Tor, in Derbyshire, England. Ask them what they think might have caused the rocks to slide down and for the road to have broken up. (*They may talk about "weak rocks", or "rainwater lubricating rock masses").* Alternatively, show them photos of buildings that sank into the ground due to the liquefaction of the underlying sediment during an earthquake.

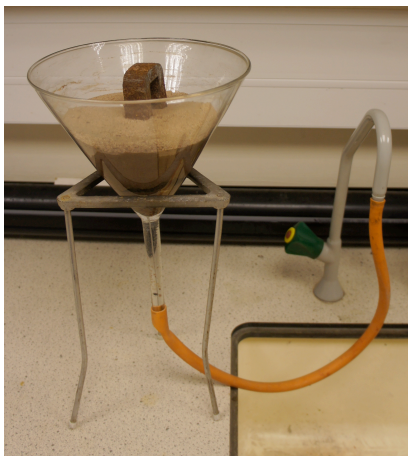
Mam Tor, Derbyshire. The land in the middle distance has slipped down from the summit of the mountain

Mam Tor – the old road, now badly broken by landslide, and impassable since 1977. (*Photos: Peter Kennett*)

Demonstrate the role of water pressure in forcing grains apart, so that that the strength of the rock/sediment is lessened and failure occurs, as follows:

- Set up either of the sets of the apparatus as shown in the photographs and described in the Resources List below.
  Either
  - with the basic version, turn on the lab tap.

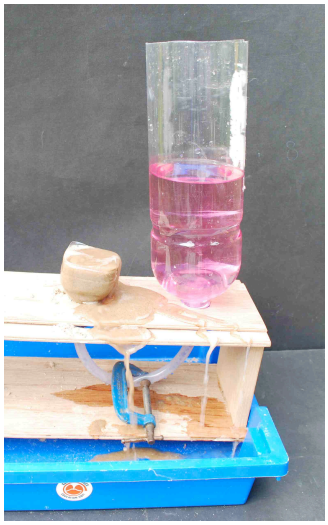
  Or
  - with the more elaborate version, screw the clamp shut, and add a heavy object (e.g. a steel bolt) to the top of the sand.
  - Add water to the right-hand container until its level is about three times that of the thickness of the sand.
  - Loosen the clamp and watch what happens. (*The heavy mass usually topples over, or is swallowed up in the sand, as water pushes the grains apart. Sometimes the water oozes out slowly; on other occasions it gushes)*.



A very basic set up for testing the effects of pore water pressure on the strength of sediment (*Photo: Chris King*)

A more elaborate home-made apparatus, ready to close the clamp and fill the right-hand bottle

Just before the clamp was loosened



A few seconds later, after the clamp was loosened, the 'building' has sunk, as the pore water pressure of the sand increased. (*Photos: Peter Kennett*)

The back up

Title: Danger – quicksands!

Subtitle: Why do some rocks give way when it rains hard?

Topic: Investigating pore water pressure in a sediment and demonstrating how raised pore water pressure can weaken apparently strong rocks/sediments, causing subsidence in buildings or landslides.

Age range of pupils: 14 -1 8 years

Time needed to complete activity: 15 minutes, assuming that the apparatus has been made up and set up in advance.

Pupil learning outcomes: Pupils can:
- explain that apparently stable rocks/sediments can be weakened by water pushing the grains apart;
- show that a head of water is needed to produce sufficient pore water pressure for this to happen;
- understand that raised pore water pressure can cause liquefaction of sediments;
- appreciate that such events happening on slopes can cause landslides;
- appreciate that liquefaction can also occur during earthquake-shaking, allowing buildings to topple over or subside.

Context: This activity could be used to illustrate hazards of a geological nature, in a science or geography lesson.

Following up the activity: Repeat the investigation, changing the grain size of the sand in the receptacle, up to granule size (2mm to 4mm); or use a range of sizes for the heavy mass.

Underlying principles:
- Many sediments and rocks (sedimentary rocks in particular), contain pore spaces between the grains.
- If a head of water builds up in the rock/sediment, the pressure of the groundwater within the pore spaces can increase, until it exceeds the strength of the material.
- When failure takes place due to increased pore water pressure, buildings may subside. Landslides may occur on slopes.
- Heavy rain may lead to a rapid increase in pore water pressure, so failure may be sudden enough to cause a human disaster.
- Rocks are affected by increased pore water pressure after heavy rain and not by simple 'lubrication'.
- In the case of Mam Tor, the landslide has been active for centuries, but the road moved sufficiently after a few nights of heavy rain in 1977 for it to be closed completely.
- Liquefaction of underlying materials can also occur during earthquakes – as was shown in the Christchurch earthquake in New Zealand, in 2011 when large amounts of water flooded out of cracks in the ground.

Thinking skill development:
Pupils establish a pattern of events by watching several demonstrations with the apparatus, under varying conditions. Relating the demonstration to a landslide or to subsided buildings is a bridging skill.

Resource list:
Whichever method is used, you will need:
- rubber tubing
- small heavy mass, e.g. a bolt, a metal block or a piece of lead pipe
- washed sand
- water
- fine mesh or wire wool for a filter
- a means of supporting the apparatus - clamp stands, bosses and clamps; or a home-made structure
- tray for overflowing water

Using the lab tap:
- glass funnel, with some mesh in the neck and then ¾ filled with washed sand. Then, see page 1.

Using home made equipment:
- 2 cut-down plastic drinks bottles, with a hole drilled in each cap to fit snugly round the tubing. PTFE tape or mastic will help to control leaks
- tubing clamp, or small G clamp

Place some mesh in the neck of the home-made plastic funnel, to stop sand slipping through and then completely fill the funnel with washed sand. With the clamp open, add water to the sand until it is completely saturated, and the top surface of the water in both receptacles is level. Then, see Page 1.

Useful links: Earthlearningidea activities: 'Quake shake – will my home collapse?'; 'Landslide through the window – what would you see, what would you feel?' 'The space within – the porosity of rocks';

Source: Based on an original activity in 'Moving Ground', written for the 'Science of the Earth' series by Simon Elsy, Earth Science Teachers' Association, 1988.