Does my rock hold water and will water flow through it?
Investigating the differences between porosity and permeability

Explain to the pupils the differences between porosity and permeability.
Porosity is the volume of pore space between the grains. Permeability measures the ability of fluids such as water or oil to flow through a rock. It reflects how well pores are connected.
This can be demonstrated in a variety of ways; here we have used chocolate and Lego™. Either or both could be used, depending on the age of the pupils and the time available.

(1) Divide the pupils into groups. Provide each group with one chocolate biscuit, e.g. Penguin™ and one chocolate bar which has holes in it, e.g. Aero™. Cut the ends off both the biscuit and the chocolate bar. Ask the pupils to look at both and to predict whether or not they are porous and/or permeable or neither. To find out, one member of each group puts one end of the chocolate into a container of milk (or water) and blows gently into the chocolate.

Photo 1
The chocolate biscuit

Photo 2
The bubble-rich chocolate

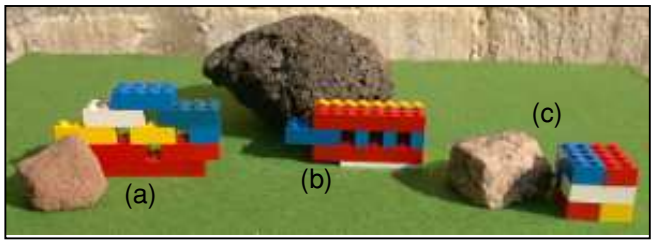
(Elizabeth Devon)

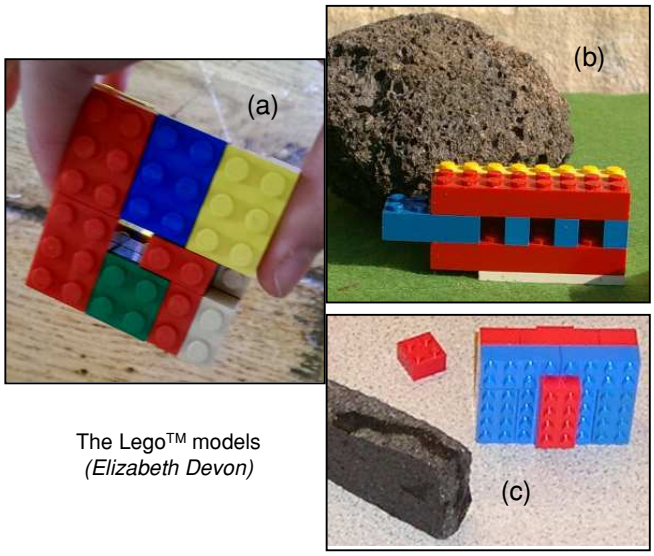
Ask the pupils to observe what happens.
Photo 1 - Blowing through the chocolate biscuit has created bubbles in the milk so the biscuit must be both porous and permeable.
Photo 2 - Blowing through the bubbly chocolate has no effect on the milk so the bubbles in the chocolate are not connected. It is impermeable, even though it has pore spaces (is porous).

(2) Divide the class into small groups and, using Lego™ building blocks, ask the pupils to do the following:-
a. Construct a small block of bricks with some pore spaces that are freely connected.
b. Construct a small block of bricks in which pore spaces are isolated i.e. not connected.
c. Construct a small block of bricks which has no pore spaces, (apart from the spaces inside the bricks).

Ask them to:-
- relate their models to rock samples and to describe the properties of each model and rock in terms of porosity and permeability;
- suggest how you could find out which rocks are capable of holding fluid natural resources, e.g. water, oil and gas. Suitable rocks need to be both porous (contain common pores) and permeable (the pores are well connected and allow fluid to move through them).

Models to demonstrate the differences between porosity and permeability, Wiltshire Museum, Devizes





The Lego™ models
(Elizabeth Devon)

The back up:

Title: Does my rock hold water and will water flow through it?

Subtitle: Investigating the differences between porosity and permeability

Topic: This activity can be used in any science or geography lesson where the ability of rocks to hold water or hydrocarbons is being discussed.

Age range of pupils: 9 - 14 years

Time needed to complete activity: 30 minutes

Pupil learning outcomes: Pupils can:
- distinguish between porosity and permeability;
- explain that porous and permeable rocks can be reservoir rocks for water or hydrocarbons;
- explain that some porous rocks may be impermeable because the connections between the pores are very tiny;
- explain that rocks made of interlocking crystals are neither porous nor permeable.

Context: With reference to the Lego™ building bricks:-
a. Construct a small block of bricks with some pore spaces that are freely connected.
This models a porous and permeable rock, e.g. in an aquifer or hydrocarbon reservoir in which pore spaces are filled with water or hydrocarbons which could be extracted.

b. Construct a small block of bricks in which pore spaces are isolated i.e. not connected.
This models a porous and impermeable rock such as chalk (a very fine-grained limestone in which the connections between one pore and the next are so small, less than one µm, that the fluid cannot flow through).
However, in the North Sea, there are several chalk reservoirs, but in each case, movement of underlying salt has caused doming and fracturing of the chalk, thus changing an impermeable rock into a permeable one.
Oil shale or shale gas occur within porous, equally fine-grained mudrocks which have very low permeability due to the extremely small (micron-sized) connections between the tiny pores. The hydrocarbons can only be extracted by widening some of the pore spaces through hydraulic fracturing (fracking) which widens the pore connectors.
c. Construct a small block of bricks which has no pore spaces.
This models non-porous and impermeable rock; a non-reservoir rock such as granite, with its interlocking, crystalline texture.

Following up the activity:
Pupils could use a search engine on the internet to carry out research into the various reservoir rocks. Which rocks hold most of the country's water/oil/gas? Why do some areas have no natural resources like these?

Underlying principles:
- Porosity is defined as the volume of pore space in a material such as a sediment or rock, and is expressed as a percentage.
- Permeability measures the ease with which fluids are able to move through a material such as a sediment or rock. It reflects how well pore spaces in the rock are connected and how large are these connectors. An impermeable rock has virtually no connectivity.

Thinking skill development:
Cognitive conflict occurs when pupils realise that rocks may be porous but are not necessarily permeable. Discussion about the properties requires metacognition and applying the Lego™ models to actual rocks requires bridging skills.

Resource list:
- chocolate biscuits e.g. Penguin™ and bubbly chocolate bars e.g. Aero™
- plentiful supply of Lego™ building blocks
- variety of rock samples including sandstone, chalk, shale, granite

Useful links:
Water cycle and permeability - https://www.youtube.com/watch?v=8uRtKOrJqx0X
Chocolate rocks - porosity and permeability - https://www.youtube.com/watch?v=j_Vns8uZ1G0X
Geobus activity
http://www.geobus.org.uk

Source: Developed by Elizabeth Devon from an idea by Dr. Fiona Hyden