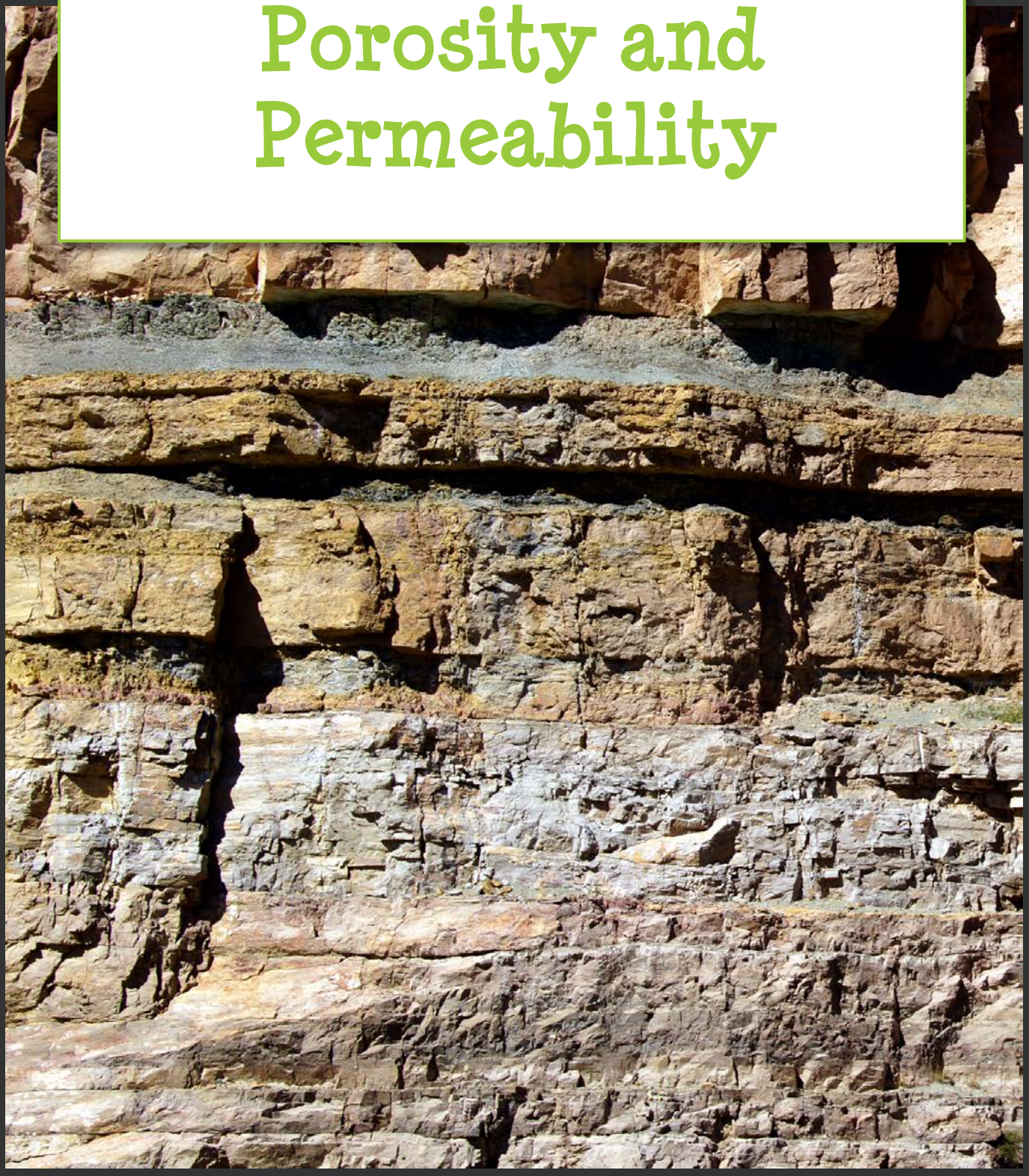
Porosity and Permeability



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AUSTRALIAN EARTH SCIENCE EDUCATION

Porosity and Permeability – Teacher Resource

Powering Careers in Energy Link:

Unit 2: Demonstrate an understanding of the importance of science in LNG operations.

Background Information:

As source rock, containing kerogen, is buried temperatures and pressures increase. Over time hydrocarbons (oil and gas) are formed, droplet by droplet. As these materials are of relatively low density they will migrate upwards, eventually accumulating to form a reservoir (if sealed and trapped). They cannot migrate through all rocks. For oil and gas to pass through a rock it needs to be both porous and permeable. Porosity is a measure of the volume made up of spaces and pores within a material. Permeability is a measure of how well pore spaces are connected up, and hence how easy it is for fluids to flow through the material.

Therefore, an essential component in the formation of an oil and gas reservoir is porous and permeable rocks. Some rocks suit these criteria more than others. Typically igneous and metamorphic rocks have little to no porosity and permeability (note: they may be fractured though). Sedimentary rocks may be porous and permeable or not. Sandstones are generally both porous and highly permeable. Other rocks, like chalk, limestone, and shale may vary in their porosity and permeability, according to factors such as; grain size, grain shape, cement type and percentage of cement to clasts (materials that stick it together to broken rock material). Further sedimentary rocks tend to have a low porosity and/or permeability, such as mudstone and (often) shale.

Aim

To determine the rocks that could make good migratory pathways and hosts for oil and gas.

Materials

Per student –

- Paper towel
- Small plastic cup (or shot glass) (~30mL)
- Chocolate milk (~25mL)
- 1 x chocolate finger biscuit
- 1 x square of Aero chocolate
- 1 x small square of fudge (or Jersey Caramel)
- 1 x toffee crunch biscuit

Safety Notes

Students may have food allergies. Please alert them to the foods they will be working with and ask them to not consume anything that may trigger an allergy for them. This activity should not be conducted in a Science laboratory, a classroom or suitable outdoor area would be best.

Method

Students should collect all equipment and consider what each represents. Chocolate milk = oil, chocolate finger biscuit = sandstone, Aero = pumice, fudge = mudstone and toffee crunch biscuit = limestone. If you have these rocks available to you it is a wonderful opportunity for students to handle each before making these associations (ensure they wash their hands after handling the rocks and before conducting the experiment).
Student should then see if they can pass 'oil' through each of these. First they should remove anything that doesn't match the rock – for example they should nibble the chocolate off the ends/corners of the biscuits and Aero. One exposed end of the biscuit/chocolate/fudge should be placed in the milk the other in the student's mouth and they should try to use it as a straw. Once they have completed this test for one of these they should repeat for the others.

Students will likely be able to describe why different materials would allow the milk to pass through whilst others did not in their own words. Discuss the concepts of porosity and permeability to allow them to use this important terminology in their discussion and evaluation sections.

Results

The oil (milk) should pass through the sandstone (chocolate finger biscuit), it won't pass through the pumice (Aero) or the mudstone (fudge). A small amount may pass through the limestone (toffee crunch biscuit).

Discussion

1. Which food/s would allow the milk (oil) to pass through?
   Chocolate finger biscuit (sandstone) and possibly toffee crunch biscuit (limestone)
2. Why was this possible?
   The materials were both porous and permeable allowing the milk to pass through.
3. Which food/s would not allow the milk (oil) to pass through?
   Aero (pumice), fudge (mudstone) and possibly toffee crunch biscuit (limestone)
4. Why was this the case?
   The Aero (pumice) is porous but not permeable (little to no connectivity between the pores) and mudstone is not particularly porous and not permeable.
5. Which food/s would allow only a small amount of milk (oil) through or at a slow flow? (if any).
   (hopefully) toffee crunch
6. Why was this the case?
   It was slightly porous and permeable (in the biscuit portion only).

Evaluation

From your investigations, which rocks (represented by foods) would make the best migratory pathways and hosts for oil and gas?
Sandstone (chocolate finger biscuits)

Why is this possible?
It is porous and permeable (has good pore space connectivity)

Are these common rocks in a region containing an oil and gas reservoir?

Yes, these are sedimentary basins = a common rock

Was there a rock that could be a migratory pathway and host rock, depending on the circumstances? Explain your answer.

Limestone (toffee crunch biscuits). It depends on how much cement (toffee and filler) is present. If there is a lot it reduces porosity and permeability.

Extension:

Students could identify other rocks that may be present in an area that hosts an oil and gas reservoir. They could choose different biscuits/chocolate/confectionary to represent each, detailing why they are a fair representation.

Worksheet: Porosity and Permeability

Aim

To determine the rocks that could make good migratory pathways and hosts for oil and gas.

Materials

Per student

- Paper towel
- Small cup (~30mL)
- Chocolate milk (~25mL)
- 1 x chocolate finger biscuit
- 1 x square of Aero chocolate
- 1 x small square of fudge (or Jersey Caramel)
- 1 x toffee crunch biscuit

Safety Notes:

If you have any food allergies please take the time to learn the ingredients of the foods being consumed today and don't consume any that may trigger a reaction or you have any doubts about.

Method:

1. Collect the listed materials.
2. Identify what each food represents, from the list of rocks below, and note it down in the table below.
    - Pumice
    - Mudstone
    - Sandstone
    - Limestone

3. Check if you can pass 'oil' through each by doing the following;
    a. Take a small bite out of each end of the chocolate finger biscuit, to remove the chocolate, place one end in the milk and the other in your mouth, try to use it as a straw.
    b. Take a small bite from diagonal corners of the square of Aero, to remove the chocolate, place one corner in the milk and the other in your mouth, try to use it as a straw.
    c. Place one corner of the fudge in the milk and the corner on the diagonal in your mouth, try to use it as a straw.
    d. Break the toffee crunch biscuit in half (to fit the cup), bite the chocolate off each end, place one end in the milk and the other in your mouth, try to use it as a straw.
4. Note down your observations in the provided results table.

Results:

	Chocolate finger biscuit	Aero	Fudge	Toffee crunch biscuit
Rock represented by this food material				
'Oil' (chocolate milk) will/will not pass through it				
Notes				

Discussion:

1. Which food/s would allow the milk (oil) to pass through?

_____

2. Why was this possible?

_____

_____

3. Which food/s would not allow the milk (oil) to pass through?

_____

4. Why was this the case?

_____

_____

5. Which food/s would allow only a small amount of milk (oil) through or at a slow flow? (if any).

_____

6. Why was this the case?

_____

_____

Evaluation:

From your investigations, which rocks (represented by foods) would make the best migratory pathways and hosts for oil and gas?

_____

_____

Why is this possible?

_____

_____

Are these common rocks in a region containing an oil and gas reservoir?

_____

_____

Was there a rock that could be a migratory pathway and host rock, depending on the circumstances? Explain your answer.

_____

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