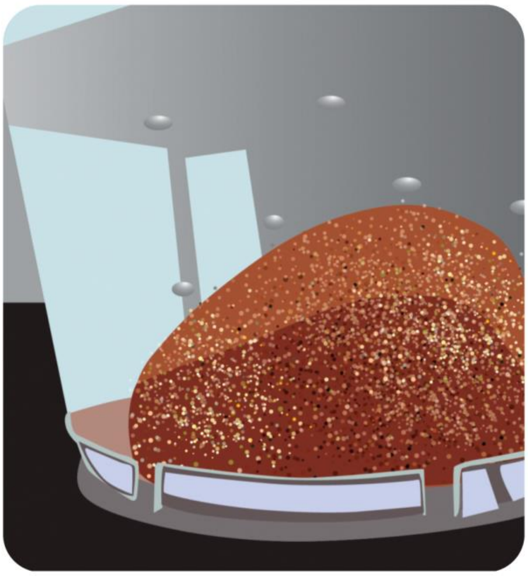
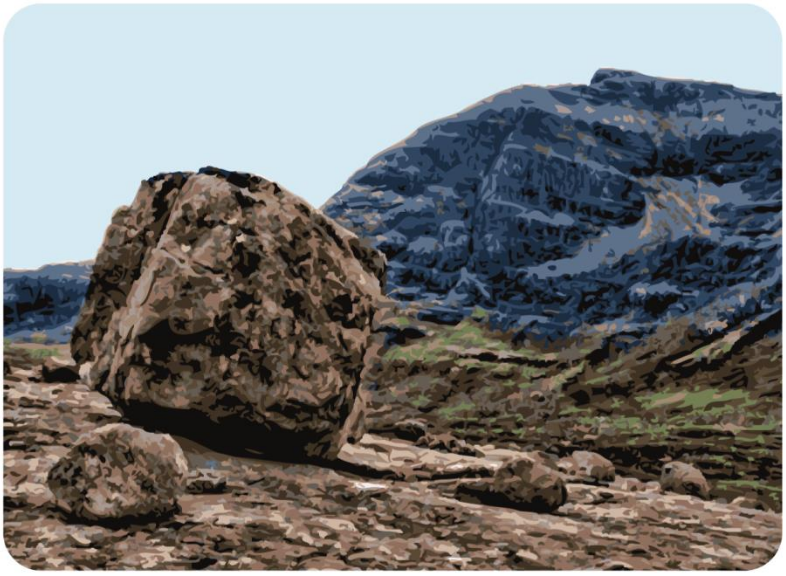
Teaching the Dynamic Earth

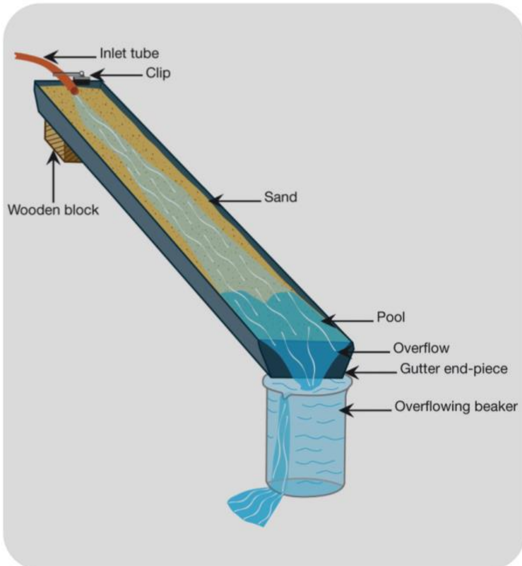
Earth's surface activity - quick to very very slow

ESEU KS3 geography workshop material



Earth science for KS3





EARTH SCIENCE EDUCATION UNIT

With the support of:

Oil & Gas UK
the voice of the offshore industry

Edited by: Chris King with contributions by Bernadette Callan and Suzy Allen

If you have any difficulty with the readability of this document, please contact The Earth Science Education Unit for further help.

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ESEU Secondary Workshops

Earth's surface activity – from quick to very, very slow
Earth science for KS3 geography

Contents

Summary

Try a series of 'hands-on' activities to investigate key processes in physical geography relating to geological timescales; rocks and weathering; glaciation and hydrology. The activities promote discussion about important Earth-processes practical, investigative ways.

Earth Science Education Unit workshops

These workshops have been devised for teachers and trainee teachers. They are intended to provide participants with a range of activities that can be used in the classroom, whilst helping them to develop the skills for using the activities in an engaging and motivating way that will enthuse and educate their pupils, whilst developing their critical thinking skills. The workshops should also develop the background Earth science knowledge and understanding of the teachers involved.

The workshop format may be transposed directly into a classroom, but often this is not appropriate. Similarly, individual activities, and the worksheets on which these are based, may be transferable directly into a classroom situation, but will often require modification for the classes and situations in which they are used, during which suitable risk assessments are undertaken.

Workshop outcomes

The workshop and its activities provide the following outcomes:

- Insights into ways of distinguishing and identifying different rocks based on their properties.
- Demonstrations of how rock properties affect landscape formation.
- Focus on the key processes of weathering, erosion, transportation and deposition by both water and ice.
- Different approaches to considering geological time and the rate of geological processes.
- Discussions and demonstrations about the state (solid/liquid) of the layers.
- Means of addressing common Earth science misconceptions.
- Links to the geography and science of Earth processes.
- Guidance on how the elements of Earth science in the curriculum can be taught most effectively.

Starter: 'Teacher - What's the difference between weathering and erosion?'

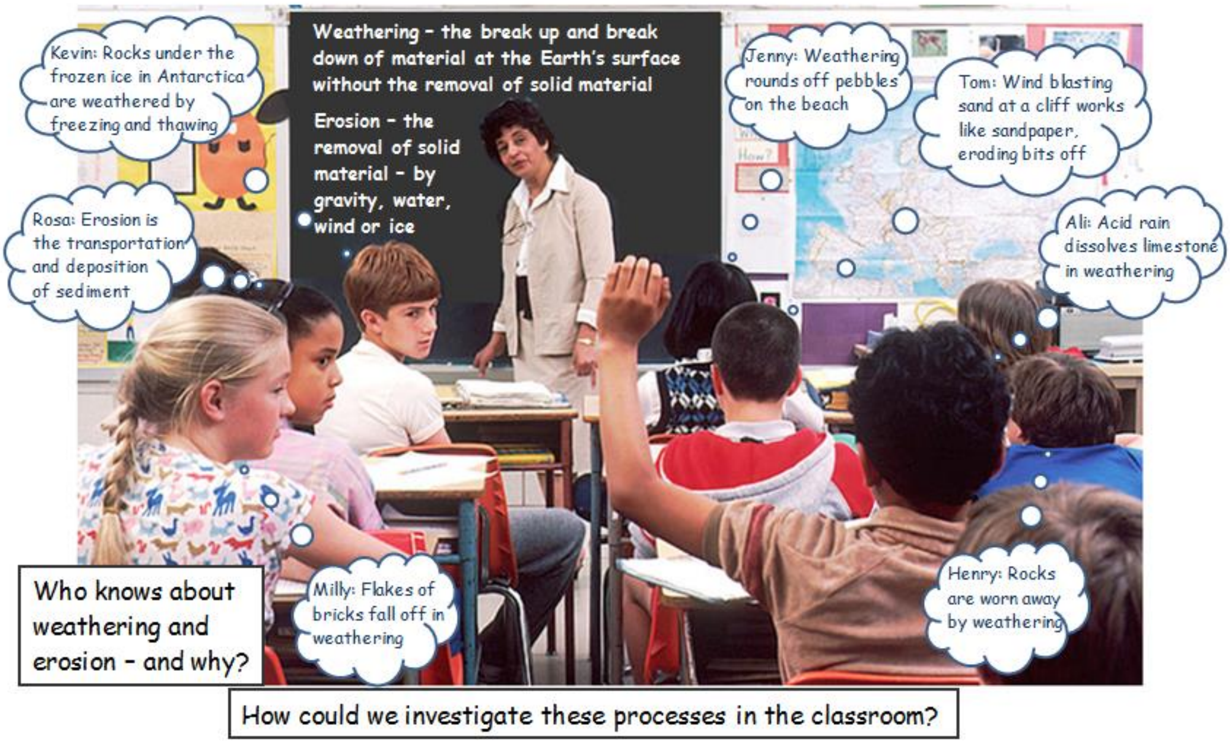
Topic: Using a 'contrasting ideas' to address common misconceptions about weathering and erosion.

Activity:
How can you address misconceptions about weathering and erosion like those below – which were found in a recent survey of science education textbooks?

Quote Sedimentary rocks are formed from the rock fragments that are made when a rock is weathered.
Quote The rocks are weathered – they are worn away where they stand
Quote Physical weathering. In a gale, grit and sand grains carried in the wind rub and scratch the surface of the rock as they blow against it.
Quote In cold weather the water freezes and expands. The forces generated by the ice cause pieces of rock to snap off.
Quote Erosion. Any process that wears away rocks is called erosion. Rainwater is slightly acidic … Some rocks are easily dissolved, eg. limestone.
Quote A diagram with the label 'weather breaks bits off the hills'

Try using a 'contrasting ideas' approach by showing your students the picture below and asking:
1. Who knows about weathering, and why?
2. How could we investigate these processes in the classroom?

If they find this difficult – ask them to note the definitions of weathering and erosion given on the blackboard in the picture.



Annotations by Chris King. Image in public domain

Pupil learning outcomes: Pupils can:
- describe the processes of weathering and erosion;
- distinguish between examples of weathering and erosion;
- discuss how the processes can be simulated in the classroom.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science **KS3** **Working scientifically** **Scientific attitudes** • pay attention to objectivity and concern for accuracy, precision, repeatability and reproducibility **Chemistry** **Earth and atmosphere** • the rock cycle and the formation of igneous, sedimentary and metamorphic rocks **Geography** **KS3** **Human and physical geography** understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: • physical geography relating to: … rocks, weathering and soils; **GCSE subject content and assessment objectives** **Physical geography: processes and change** *Geomorphic processes and landscape* – How geomorphic processes (e.g. weathering, slope movement and erosion by water, wind and ice) have influenced and continue to influence the landscapes of the UK and the interaction of those processes with human activity.	**Sciences** **Experiences and outcomes** • develop skills in the accurate use of scientific language **Planet Earth** **Processes of the planet** Through connections with collaborative studies of landscape, weather and climate in social studies they build up an integrated picture of the dynamic nature of Earth. **Materials** **Earth's materials** **Third** Through evaluation of a range of data, I can describe the formation, characteristics and uses of soils, minerals and basic types of rocks. SCN 3-17a **Social studies** **Second** **People, place and environment** I can describe the major characteristic features of Scotland's landscape and explain how these were formed. SOC 2-07a By comparing my local area with a contrasting area outside Britain, I can investigate the main features of weather and climate, discussing the impact on living things. SOC 2-12a **Third** I can investigate the climate, physical features and living things of a natural environment different from my own and explain their interrelationship. SOC 3-10a **Fourth** **People, past events and societies** I can explain how the interaction of physical systems shaped and continue to shape the Earth's surface by assessing their impact on contrasting landscape types. SOC 4-07a	**Science** **KS3** **The sustainable Earth** • the differences between physical and chemical changes using some common examples **Geography** **KS3** • the physical world: the processes and landforms of coasts or rivers	**Science** **KS3** **Earth and Universe** The environment and human influences **Geography** **KS3** • physical processes of landscape development; • the dynamic nature of physical and human environments

Age range of pupils: 8 – 18 years

Time needed to complete activity: 15 minutes

The story for teachers:

Textbook surveys have shown that misconceptions between weathering and erosion are common, when the scientific consensus is clear:

- Weathering is the break up and break down (physical break up and chemical breakdown) of rocks at the Earth's surface without the removal of solid material (although material can be removed in solution)
- Erosion is the removal of solid material, by gravity, water, wind or ice (as the start of transportation).

Some responses to the statements in the picture are given in the table below:

Pupil	Statement	Correct/incorrect + comment	Possible practical activity in the classroom
Ali	Acid rain dissolves limestone in weathering	Correct: the acid rain removes the limestone by dissolving it and carrying the solute away in solution – so this is weathering.	Add vinegar, limescale remover or other acid to a cleanly-broken piece of limestone to show the reaction. In the reaction a soluble substance is produced which is then dissolved.
Henry	Rocks are worn away by weathering.	Incorrect: rocks are worn away by erosion, by gravity, wind, water or ice although they may have previously been weakened by weathering.	Putting rock samples into a plastic container and shaking – to demonstrate <u>erosion</u>

Rosa	Erosion is the transportation and deposition of sediment.	Incorrect: erosion is the initial removal of sediment – which may then be transported and deposited; it can be the start of transportation.	Adding water to a sand-filled gutter – after the sediment is eroded at the top, it is transported along the gutter and deposited in the pool at the bottom – through three distinct processes.
Milly	Flakes of bricks fall off in weathering.	Incorrect: the removal of solid material is erosion, in this case, by gravity; the flakes may have been previously weakened by weathering though.	Look for flakes of brick beneath old brick school walls – these, having been weakened by weathering, have been removed by erosion through gravity.
Tom	Wind blasting sand against a cliff works like sandpaper, eroding bits off.	Correct: when solid material is removed by wind – this is erosion (even though it is being done by the weather in this case).	Sand blasting can be demonstrated by a powerful electric fan directed at a pile of dry sand – but it can be very messy and anybody in the way should wear safety glasses.
Jenny	Weathering rounds off pebbles on the beach.	Incorrect: beach pebbles are rounded by erosion, not weathering – the pebbles are thrown against one another in storms, abrading one another – a process called attrition.	Putting rock samples into a plastic container and shaking – to demonstrate erosion.
Kevin	Rocks under the frozen ice sheets in Antarctica are weathered by freezing and thawing.	Incorrect: the physical break up of rock by ice requires many cycles of freezing and thawing; rocks beneath the Antarctic ice sheets remain frozen.	Put a similar selection of fragments of different rocks (including some permeable ones) into two different plastic boxes (e.g. lunch boxes) and add enough water to cover the fragments. Leave one on the table as a control. Put the other into a freezer or the freezing compartment of a fridge until it is frozen and then take it out and allow it to thaw. Examine it after this first cycle (not much will have happened). Repeat this for several cycles until the permeable rocks break up through the 9% expansion of water as it becomes ice. Then the contrast with the control is clear.

When the textbook errors below were found, corrections were written using a similar number of words and a similar level of language and these were sent to the publishers of the textbooks in question. The corrections written for the quotes in the activity are given below.

Quote Sedimentary rocks are formed from the rock fragments that are made when a rock is weathered.

Correction Rock fragments that form sedimentary rocks have been formed by erosion. [Note: The unusual sedimentary rock laterite is formed by the weathering of rock fragments under sub-tropical conditions.]

Quote The rocks are weathered – they are worn away where they stand.

Correction Wearing away of rocks is erosion.

Quote Physical weathering. In a gale, grit and sand grains carried in the wind rub and scratch the surface of the rock as they blow against it.

Correction Erosion. In a gale, grit and sand grains carried in the wind rub and scratch the surface of the rock as they blow against it.

Quote In cold weather the water freezes and expands. The forces generated by the ice cause pieces of rock to snap off.

Correction When it is cold the water freezes and expands, when it is warmer, it melts again. The freezing and thawing weakens the rock until it snaps off. [Note. Rocks are not broken by one freezing episode].

Quote Erosion. Any process that wears away rocks is called erosion. Rainwater is slightly acidic … Some rocks are easily dissolved, e.g. limestone.

Correction	*The dissolution of limestone is weathering, not erosion.*
Quote	Diagram with the label 'weather breaks bits off the hills'
Correction	*Bits are broken off, not by the weather but in erosion by water, wind, ice or gravity - weather only loosens the material during weathering.*

Through using the 'contrasting ideas' approach, pupils have to think about their own mental construction of the terms 'weathering' and 'erosion' and test these against potentially wrong ideas through cognitive conflict.

Lead in ideas:
Ask pupils for their own ideas about weathering and erosion and where and how these take place.

Following up the activity:
Pupils could check their own textbooks for misconceptions like these.
They could also search for other misconceptions about weathering and erosion on the internet by using the terms, 'weathering erosion misconception'.

Source: Devised by Chris King of the Earthlearningidea Team, based on the 'Concept Cartoon' idea developed by Brenda Keogh and Stuart Naylor, see: http://www.conceptcartoons.com

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Preparation and set-up time: None

Resource list:
- the picture, preferably reproduced at A4 size and laminated

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Teacher – what's the difference between weathering and erosion?	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

Teacher - What's the difference between weathering and erosion?'

Using a 'contrasting ideas' to address common misconceptions about weathering and erosion.

How can you address misconceptions about weathering and erosion like those below – which were found in a recent survey of science education textbooks?

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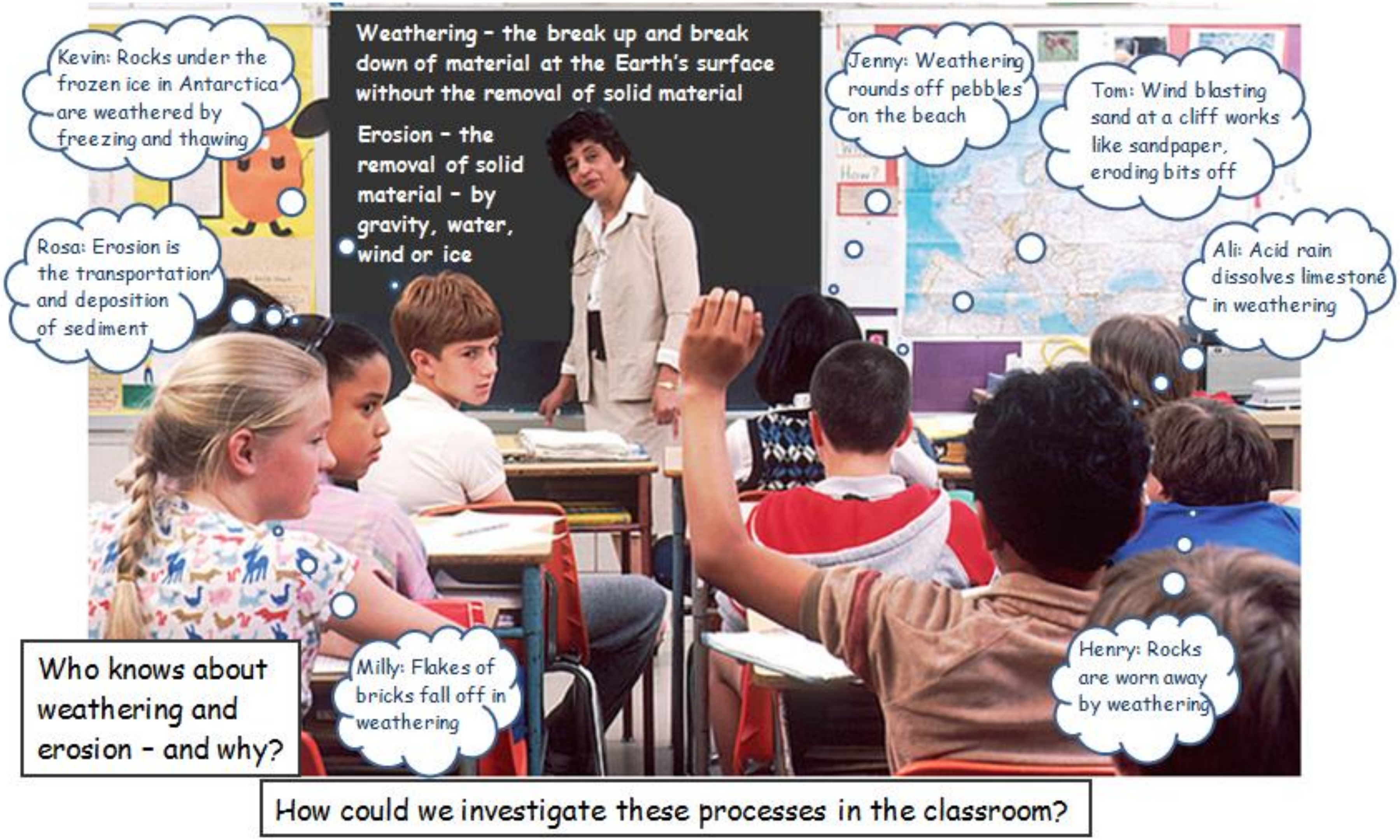

Annotations by Chris King. Image in public domain

Circus activity 1: A rocky look, touch and tell

Topic: This activity encourages rock identification based on rock appearance and texture.

Activity:

A What are the rocks like?

- You have been given two samples of rock. *Note. The two rocks provided are a sedimentary rock, e.g. sandstone, and an igneous rock, e.g. granite.*
- Pick up one sample and describe it to the rest of the group. Then do the same for the other.
  Possible answer(s): The words that often appear are: bits, colour, rough/smooth.
  Give the scientific word for 'bits' = grains.

B What are the 'grains' like?

- Now use a magnifier or hand lens to look at the grains in the rock.
- Pick up one sample and describe the grains to the rest of the group. Then do the same for the other.
  Possible answer(s): The words usually used are: shape, size, colour and shininess.

Looking closely at a rock with a magnifier (*Hazel Benson*)

C Rock scratch test

Use a piece of metal such as a spoon to try the 'rock scratch test' on the two rocks. How are the rocks different?
Possible answer(s): Grains will be scraped off the sandstone very much more easily than from the granite.

D Sorting out the rocks

- Rocks that are made of grains that are stuck together and can easily be scratched off are usually sedimentary rocks.
- Rocks that are made of interlocking grains that are very hard to scratch off are usually crystalline rocks (made of crystals).
  Possible answer(s): Sandstone, shelly limestone and chalk are sedimentary rocks, whilst granite, slate and marble are rocks formed of crystals (crystalline rocks).

Pupils use these definitions to sort all the rocks they have been given into two groups.
They can be given these definitions on cards, (see page 14).

Note: Further subdivision into igneous and metamorphic rocks is possible, as described in the 'Following up the activity' section on page 13.

Pupil learning outcomes

Pupils can:

- say that all rocks are made of bits or grains;
- observe that some of these grains are small and round and others are shiny and different shapes;
- say that some rocks are made up of lots of different coloured grains and in others, the grains are only one colour;
- say that some rocks are harder than others;
- show that some rocks have fossil shells in them;
- describe some rocks as sedimentary and others as made of crystals (crystalline).

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: Lower KS2 **Years 3 and 4** **Working scientifically** • asking relevant questions and using different types of scientific enquiries to answer them • setting up simple practical enquiries • making systematic and careful observations • using results to draw simple conclusions, • using straightforward scientific evidence to answer questions or to support their findings **Year 3** **Rocks** • compare and group together different kinds of rocks on the basis of their appearance and simple physical properties Linked with work in geography, pupils should explore different kinds of rocks, including those in the local environment Pupils might work scientifically by: observing rocks, including those used in buildings and gravestones, and exploring how and why they might have changed over time; using a hand lens or microscope to help them to identify and classify rocks according to whether they have grains or crystals, and whether they have fossils in them. **Geography** **KS3** **Human and physical geography** understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: • physical geography relating to: … rocks	**Sciences** **Early** **Biological systems** I can identify my senses and use them to explore the world around me. SCN 0-12a **Earth's materials** **Second** Having explored the substances that make up Earth's surface, I can compare some of their characteristics and uses. SCN 2-17a **Third** Through evaluation of a range of data, I can describe the formation, characteristics and uses of soils, minerals and basic types of rocks. SCN 3-17a **Social studies** **First** **People, place and environment** I can describe and recreate the characteristics of my local environment by exploring the features of the landscape. SOC 1-07a	**Science** **KS2** **The sustainable Earth** • a comparison of the features and properties of some natural and made materials • how some materials are formed or produced	**The world around us** **Foundation stage** **Strand 3: Place** **KS1** **Features of the immediate world and comparisons between places;** • about materials in the natural and built environment (G); (H); • about the properties of everyday materials and their uses (S&T); • the similarities and differences between buildings features and landscape in their locality and the wider world (G) **KS2** **Ways in which people, plants and animals depend on the features and materials in places and how** **they adapt to their environment;** • about the origins of materials (S&T)

Age range of pupils: 7 – 18 years

Time needed to complete activity: 20 minutes

The story for teachers:

There is often confusion between minerals and rocks. Minerals are naturally formed chemical compounds (eg. quartz). Rocks are generally formed of a mixture of minerals (eg. granite), but sometimes rocks are made of only one mineral (eg. limestone made of the mineral calcite).

Granite is an igneous rock formed of minerals that crystallised with random arrangement as it cooled from a liquid. Slate is a metamorphic rock that was formed under great lateral pressure, so the minerals formed in layers, allowing the slate to be split into sheets. Marble is a metamorphic rock formed from limestone under heat and pressure, and so is a crystalline rock made of just one material. (This is the scientific definition of marble; the term 'marble' is also used as a trade name for a variety of polished rocks.)

The activity helps pupils identify rocks in their local buildings and surroundings; it is a useful fieldwork skill.

Pattern is involved in classifying the rock types. Cognitive conflict is caused when rocks do not seem to fit easily into one category, e.g. slate is apparently quite soft when scratched and is so fine-grained as to not appear crystalline. However, it is waterproof and splits easily into layers and is a metamorphic rock.

Lead in ideas:
- Ask pupils to bring in small samples of rocks they have found and discuss their similarities and differences.
- Try the 'Found in the ground' ESEU activity.
- Talk about the rocks the pupils have seen e.g. cliffs, quarries, road cuttings.
- Ask if they realise that rocks are hidden from view under the soil beneath their houses and school.

Following up the activity:
The crystalline rocks can be subdivided using these descriptions:
- crystalline rocks made of different minerals scattered through them are usually igneous rocks;
- crystalline rocks with minerals in layers or bands or made of just one mineral are usually metamorphic rocks.

Ask pupils to try to sort out the crystalline rocks using these definitions – which they could be given on cards (see next page).

Pupils could also try:
- 'Will my rock hold water' ESEU activity.
- If appropriate, take the pupils outside to try to identify some rocks e.g. shelly limestone, sandstone etc.
- Ask pupils to think about how rocks might have been made, e.g. a sandstone (made by the sand that might be found in a river, beach or dune being cemented together)
- Ask pupils how the underlying rocks might be related to hills/valleys or cliffs/beaches, eliciting that harder rocks are likely to make hills/cliffs, etc.
- Pupils could link the rocks to where they might be found in the local area or in the UK. Use a geological map for this, if available.

Source: Based on 'Spot that rock', an ESEU workshop, visit www.earthscienceeducation.com for further details.
Adapted from an original workshop by Duncan Hawley.

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Preparation and set-up time
15 minutes maximum.

Resource list
- samples of granite, permeable sandstone and other samples such as: shelly limestone, chalk, slate, marble; specimens should be 2cm in diameter, or larger
- magnifier
- metal teaspoon
- definition cards

Note: If pupil groups are doing this activity, it is useful for them to have enough sets so they can work in groups of three.

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Rocky, Look, Touch and Tell	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

Definition cards (A rocky look, touch and tell: sorting out the rocks)

Sedimentary rocks are usually made of grains that are stuck together and can often easily be scratched off	**Crystalline rocks** are usually made of interlocking grains that are very hard to scratch off
Igneous rocks are crystalline rocks made of different minerals scattered through them	**Metamorphic rocks** are crystalline rocks with minerals in layers or bands or made of just one material

ESEU activity guide sheet:

A rocky look, touch and tell

This activity encourages rock identification based on rock appearance and texture.

A What are the rocks like?

- You have been given two samples of rock.
- Pick up one sample and describe it to the rest of the group. Then do the same for the other.

Give the scientific word for 'bits' = grains.

B What are the 'grains' like?

- Now use a magnifier or hand lens to look at the grains in the rock.
- Pick up one sample and describe the grains to the rest of the group. Then do the same for the other.

Looking closely at a rock with a magnifier. (*Hazel Benson*)

C Rock scratch test

Use a piece of metal such as a spoon to try the 'rock scratch test' on the two rocks. How are the rocks different?

D Sorting out the rocks

- Rocks that are made of grains that are stuck together and can easily be scratched off are usually sedimentary rocks.
- Rocks that are made of interlocking grains that are very hard to scratch off are usually crystalline rocks (made of crystals).

Pupils use these definitions to sort all the rocks they have been given into two groups.
They can be given these definitions on cards.
Note: Further subdivision into igneous and metamorphic rocks is possible

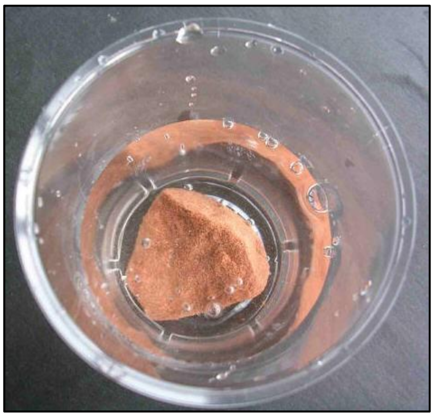
Circus activity 2: Will my rock hold water?

Topic: This activity investigates the porosity/permeability of rocks.

Activity:

A Bubbling rocks

- Take one sample of a permeable sedimentary rock (eg sandstone) and one of an igneous rock (eg. granite) both with clearly visible grains.
- Watch for bubbles as you put both of these into a container of water at the same time.
- Watch closely to see where the bubbles come from on each of the samples.
- Describe what you have seen.




(top view) (side view)

Sandstone 'bubbling' in a plastic beaker (*Peter Kennett*)


(top view) (side view)

Granite not 'bubbling' in a plastic beaker (*Peter Kennett*)

B Sorting the rocks

Put the rest of the rock samples into a container of water at the same time and watch for bubbles.

- What is the order of the rocks, from the most to the least 'bubbly'?
- Ask questions, e.g. How do we use a 'bubbly' (permeable) rock like sandstone?
- How do we use a non-'bubbly' (impermeable, waterproof) rock like slate?

Pupil learning outcomes

Pupils can:

- test to see whether a rock is permeable or not;
- test rock permeability and sort out rocks according to their permeability;
- know that some rocks can contain air or water and others cannot;
- apply their knowledge to real world situations.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: Lower KS2 **Years 3 and 4** **Working scientifically** • asking relevant questions and using different types of scientific enquiries to answer them • setting up simple practical enquiries • making systematic and careful observations • using results to draw simple conclusions, • using straightforward scientific evidence to answer questions or to support their findings **Year 3** **Rocks** • compare and group together different kinds of rocks on the basis of their appearance and simple physical properties Linked with work in geography, pupils should explore different kinds of rocks, including those in the local environment Pupils might work scientifically by: observing rocks, including those used in buildings and gravestones, and exploring how and why they might have changed over time; using a hand lens or microscope to help them to identify and classify rocks according to whether they have grains or crystals, and whether they have fossils in them. **Geography** **KS3** **Human and physical geography** understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: • physical geography relating to: … rocks	**Sciences** **Early** **Biological systems** I can identify my senses and use them to explore the world around me. SCN 0-12a **Earth's materials** **Second** Having explored the substances that make up Earth's surface, I can compare some of their characteristics and uses. SCN 2-17a **Third** Through evaluation of a range of data, I can describe the formation, characteristics and uses of soils, minerals and basic types of rocks. SCN 3-17a **Social studies** **First** **People, place and environment** I can describe and recreate the characteristics of my local environment by exploring the features of the landscape. SOC 1-07a	**Science** **KS2** **The sustainable Earth** • a comparison of the features and properties of some natural and made materials • how some materials are formed or produced	**The world around us** **Foundation stage** **Strand 3: Place** **KS1** **Features of the immediate world and comparisons between places;** • about materials in the natural and built environment (G); (H); • about the properties of everyday materials and their uses (S&T); • the similarities and differences between buildings features and landscape in their locality and the wider world (G) **KS2** **Ways in which people, plants and animals depend on the features and materials in places and how they adapt to their environment;** • about the origins of materials (S&T)

Age range of pupils: 7 - 18 years

Time needed to complete activity: 20 minutes

The story for teachers:
The bubbly rocks have spaces between the grains that can hold air and water and that air and water can flow through – so they are porous (they have spaces between the grains) and permeable (liquids and gases can flow through them). This activity shows which rocks are porous/permeable and which rocks don't allow air and water to flow through and so are impermeable.

The scientific definitions:
porosity - percentage of pore space in a rock
permeability - the rate of flow of a fluid through a rock

In the porous/permeable rocks, bubbles rise from the top. This is because the air 'hidden' in the pore spaces in the rock is less dense than the water and so rises through the connected pores. Atmospheric pressure on the surface of the water then pushes water into the spaces left behind – so water flows into the bottom of these rock samples as air rises from the top.

In the 'non-bubbly' (non-porous, impermeable) rocks, bubbles can sometimes be seen on the surface that come from trapped air in near surface cracks – but the bubbles do not grow or rise as they do in the 'bubbly' rocks with interconnected pore spaces.

The porosity/permeability of the rock samples is likely to be:
- porous/permeable - sandstone, chalk;
- impermeable – clay, slate, marble, granite.

This may vary according to the samples, e.g. some sandstones may have a mixture of grain sizes and may have poor permeability. Some sedimentary rocks that were once permeable but have become well cemented (natural cement has filled the pore spaces between the grains 'gluing' the rock together) may now be impermeable. Fine-grained sedimentary rocks, like clay, although having gaps between the grains (and so being porous), have gaps that are so small that water can't flow through, so they are impermeable.

Porous/permeable sandstone underground can store water (or oil and gas).

Impermeable slate can be used on roofs of buildings to keep the water out. Impermeable rocks can also be used as facing stones on buildings or gravestones, and nice-looking ones (eg. granite) are used for kitchen work surfaces.

The activity can be used in any teaching scheme about the different properties of rocks. Pupils can devise their own ways of making a porosity/permeability chart.

Cognitive conflict occurs when two different sandstones for example, behave differently when put into water. One may be much more 'bubbly' than the other. Applying their knowledge of porosity and permeability of rocks to the uses of rocks around them is a bridging skill.

Lead in ideas:
The 'Found in the ground' and 'Look, touch and tell' ESEU KS2 Years 3 and 4 activities – sorting, describing and grouping rocks according to their appearance and texture.

Following up the activity:
- Investigate the natural building materials around the school – are they permeable or impermeable?
- Where are rocks found locally? – are they permeable or impermeable?
- List several uses for each of the rock samples, e.g:
    - sandstone – sand from sandstone is used in the building industry; sandstone is an underground reservoir rock because it is porous and permeable and so can hold water, oil or gas; tough sandstones are often good building stones;
    - clay is impermeable and can be used to line reservoirs to stop the water leaking away; clay is also used in pottery and paper making;
    - chalk is used in farming to make fields more fertile (it neutralises acid soils) and is used in cement-making. It is also a porous and permeable rock that can hold underground water supplies;
    - slates are used on roofs to keep water out because slate is impermeable;
    - marble and granite are both decorative stones used for buildings, sculpture.

Some of the more able may be able to time for how long a rock 'bubbling' continues. These results could then be recorded on a simple graph.

The rocks could be weighed when dry and then again after they have been immersed in water. Experimentation is necessary here, as some may need to be submerged overnight/weekend to make a significant difference. They also may need to be left on a window sill or radiator to dry out to ensure they are dry for next time.

Source: Earthlearningidea 'Modelling for rocks. What's hidden inside – and why?' http://www.earthlearningidea.com.

…………………

Preparation and set-up time
5 minutes.

Resource list
- samples of granite, permeable sandstone and others such as: shelly limestone, chalk, slate, marble; samples should be 2cm in diameter, or larger
- plastic container/beaker of water to put the rocks in, preferably transparent

If pupil groups are doing this activity, it is useful for them to have enough sets so they can work in groups of three

Risk assessment

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Will my Rock hold Water?	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

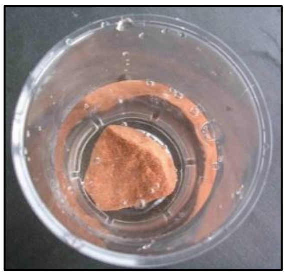
Will my rock hold water?

This activity investigates the porosity/permeability of rocks.

A Bubbling rocks

- Take one sample of a permeable sedimentary rock (eg sandstone) and one of an igneous rock (eg. granite) both with clearly visible grains.
- Watch for bubbles as you put both of these into a container of water at the same time.
- Watch closely to see where the bubbles come from on each of the samples.
- Describe what you have seen.

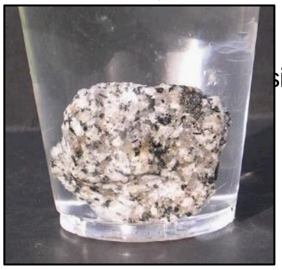
(top view)



ide view)

Sandstone 'bubbling' in a plastic beaker (*Peter Kennett*)

(top view)



ide view)

Granite not 'bubbling' in a plastic beaker (*Peter Kennett*)

B Sorting the rocks

Put the rest of the rock samples into a container of water at the same time and watch for bubbles.

- What is the order of the rocks, from the most to the least 'bubbly'?
- Ask questions, e.g. How do we use a 'bubbly' (permeable) rock like sandstone?
- How do we use a non-'bubbly' (impermeable, waterproof) rock like slate?

Circus activity 3: Ice power – freezing water in a syringe to measure the expansion

Topic: A simple demonstration, using a 10 or 20 ml syringe, of the power of water to expand when it freezes.

Activity:
Most pupils are aware that water expands when it freezes, but by how much? Demonstrate as follows. Fill a 10ml or 20ml syringe with cold water, sealing the nozzle end (with Blu Tac™ or clay). The result is clearer if the water is coloured slightly with food colouring, as shown in the photographs. Measure the length of the water column in millimetres. Place it in a freezer in between lessons. Measure the length of the ice column in millimetres, and calculate the percentage expansion as water turned to ice as (length of ice-length of water)/(length of water) x100%.

The syringe filled to the 9 ml mark with water.

The syringe after freezing (*Peter Kennett*)

Show pupils photographs of "frost damage", but point out that it is the successive freezing and thawing that eventually weathers rocks down, rather than one single episode of freezing.

The effects of freeze/thaw weathering in a porous limestone. (*Peter Kennett)*

Rocks shattered by freeze-thaw weathering on Glyder Fawr, Wales. (*P007204, BGS. Contains public sector information licensed under the Open Government Licence v2.0*)

Ask pupils where on Earth freeze-thaw weathering is likely to be most active:
a) beneath polar ice sheets;
b) on mountain tops;
c) in cold arid deserts;
d) in hot arid deserts.
A. On mountain tops where there is frequent freezing and thawing; under polar ice sheets it is frozen most of the time, in cold arid deserts there is not enough water, as also in hot deserts, where it usually does not become cold enough either.

Pupil learning outcomes: Pupils can:
- make an accurate estimate of the percentage expansion of water when it freezes;
- apply their lab observations to natural occurrences of freeze/thaw weathering.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science **KS3** **Chemistry** **Earth and atmosphere** • the rock cycle and the formation of igneous, sedimentary and metamorphic rocks **Geography** **KS3** **Human and physical geography** understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: • physical geography relating to: … rocks, weathering and soils **GCSE subject content and assessment objectives** **Physical geography: processes and change** *Geomorphic processes and landscape* – How geomorphic processes (e.g. weathering, slope movement and erosion by water, wind and ice) have influenced and continue to influence the landscapes of the UK and the interaction of those processes with human activity	**Sciences** **Planet Earth** **Processes of the planet** Through connections with collaborative studies of landscape, weather and climate in social studies they build up an integrated picture of the dynamic nature of Earth. **Materials** **Earth's materials** **Third** Through evaluation of a range of data, I can describe the formation, characteristics and uses of soils, minerals and basic types of rocks. SCN 3-17a **Social studies** **Second** **People, place and environment** I can describe the major characteristic features of Scotland's landscape and explain how these were formed. SOC 2-07a By comparing my local area with a contrasting area outside Britain, I can investigate the main features of weather and climate, discussing the impact on living things. SOC 2-12a **Third** I can investigate the climate, physical features and living things of a natural environment different from my own and explain their interrelationship. SOC 3-10a **Fourth** **People, past events and societies** I can explain how the interaction of physical systems shaped and continue to shape the Earth's surface by assessing their impact on contrasting landscape types. SOC 4-07a	**Science** **KS3** **The sustainable Earth** • the differences between physical and chemical changes using some common examples **Geography** **KS3** • the physical world: the processes and landforms of coasts or rivers	**Science** **KS3** **Earth and Universe** The environment and human influences **Geography** **KS3** • physical processes of landscape development; • the dynamic nature of physical and human environments

Age range of pupils: 10 – 16 years

Time needed to complete activity:
A few minutes to set up in one lesson and a few minutes to investigate the outcome in the next lesson.

The story for teachers:
This activity may be used in either science or geography lessons on weathering. It can also be used in discussions of molecular theory and changes of state. For the most accurate measurements use pure (distilled or de-ionised) water at as near to 4ºC as possible.

Note that:
- Water is one of very few liquids which expand, rather than contract, on freezing.
- Pupils are likely to find that water expands by about 9% on freezing, using the simple method described.
- Water is the only non-metallic substance on Earth whose density in solid form is less than its density in liquid form (Water Structure and science. M Chaplin 2015 http://www1.lsbu.ac.uk/water/density_anomalies.html).
- Ice made from pure water at 0ºC has a relative density of 0.917. This is less dense than pure liquid water, which has a maximum density at 4ºC defined as relative density = 1.000. Thus between 0º and 4ºC water is about 8.3% denser than ice.
- The volume of water is equal to the area of the tube of the syringe (A) x the length of the water column ($A = \pi r^2$ where r is the radius, ie half the diameter). The volume of ice is equal to A x the length of the ice column. The expansion is equal to the difference between the measurements, and the coefficient of expansion is the expansion divided by the original length.
- If the water is measured above or below 4ºC the expansion on change of state will be slightly under-estimated.

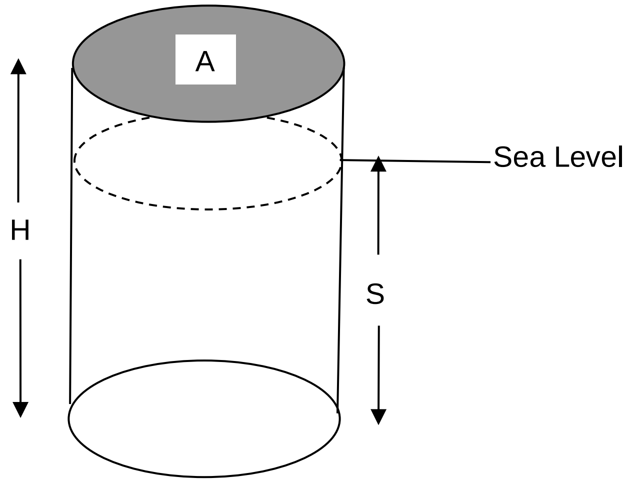
Thought processes of construction are involved when observing the outcomes of the demonstration. Bridging skills are needed to relate the observations to the real world.

Lead in ideas:
Tell pupils that if you put a glass bottle of liquid into a freezer, it would burst. Ask them why this might be. (If you actually try this activity, put the bottle into a sealed plastic bag first, to avoid flooding the freezer and sharp shards of glass).

Following up the activity:
Pupils could:
- look for evidence of freeze/thaw damage after a few frosty nights near their homes;
- measure the density of ice, compared to that of water (Weigh the syringe empty and weigh again with the water in it, to find the mass of water alone; weigh it again with the ice (it should be the same). Density = mass/volume in g per ml (cc). The volume will be different after the water has turned to ice and expanded.
- calculate what percentage of an iceberg lies below the water surface taking the average relative density of seawater as 1.025.

Icebergs near the Antarctic Peninsula. (*Peter Kennett*)

The iceberg problem can be worked out as follows – by calculating it as a vertical cylinder.



Iceberg

The total mass of the iceberg is height (H) x area (A) x density = H x A x 0.917

By Archimedes' Principle the mass of seawater displaced by the <u>submerged</u> part of the iceberg is equal to the mass of the iceberg.

The mass of seawater displaced by the submerged part is submerged length (S) x area (A) x density = S x A x 1.025

H x A x 0.917 = S x A x 1.025 giving S/H = 0.917/1.025 = 0.898: i.e. 89.8% of the iceberg is submerged (nine tenths)

Source: Written by Peter Kennett of the Earthlearningidea Team, with acknowledgements to Martin Devon for assistance with the iceberg calculations. The original idea was published by P. Williams in *Geology Teaching* 9.1, March 1984.

…………………

Preparation and set-up time:
A couple of minutes to fill the syringe with coloured water, seal the end and put in in a freezer. This needs to be given time to freeze before being viewed again.

Resource list:
- 10 or 20 ml plastic syringe
- Blu tak™, clay, Plasticine™ or similar substance to block the nozzle of the syringe
- pure (distilled or de-ionised) water (optional)
- access to a freezer or freezer compartment of a fridge

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Ice power – freezing water in a syringe to measure the expansion	No significant hazard	-	-	-	No
Lead in activity – leaving a glass bottle of liquid in a freezer to burst	Experimenter	2	1	2	Place bottle in a sealed plastic bag to avoid shards of glass and floods of water

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

Ice power – freezing water in a syringe to measure the expansion

A simple demonstration, using a 10 or 20 ml syringe, of the power of water to expand when it freezes.

Most pupils are aware that water expands when it freezes, but by how much? Demonstrate as follows. Fill a 10ml or 20ml syringe with cold water, sealing the nozzle end (with Blu Tac™ or clay). The result is clearer if the water is coloured slightly with food colouring, as shown in the photographs. Measure the length of the water column in millimetres. Place it in a freezer in between lessons. Measure the length of the ice column in millimetres, and calculate the percentage expansion as water turned to ice as (length of ice-length of water)/(length of water) x100%.

The syringe filled to the 9 ml mark with water.

The syringe after freezing. (*Peter Kennett*)

Show pupils photographs of "frost damage", but point out that it is the successive freezing and thawing that eventually weathers rocks down, rather than one single episode of freezing.

The effects of freeze/thaw weathering in a porous limestone. (*Peter Kennett)*

Rocks shattered by freeze-thaw weathering on Glyder Fawr, Wales. (*P007204, BGS. Contains public sector information licensed under the Open Government Licence v2.0*)

Ask pupils where on Earth freeze-thaw weathering is likely to be most active:

e) beneath polar ice sheets;
f) on mountain tops;
g) in cold arid deserts;
h) in hot arid deserts.

A. On mountain tops where there is frequent freezing and thawing; under polar ice sheets it is frozen most of the time, in cold arid deserts there is not enough water, as also in hot deserts, where it usually does not become cold enough either.

Circus activity 4: Rock, rattle and roll – erosion

Topic: Investigating the resistance of different rocks to erosion, by shaking them vigorously in a plastic container.

Activity:
Investigate rock resistance to find out how rocks erode at different rates and use this to explain the formation of uplands and coastal headlands by the more resistant rock types.

There are many different ways in which rocks are eroded in the natural world. It is not always possible to imitate these different ways in the laboratory. We do not have nearly so much time available either! However, we can try.

Carry out a risk assessment (see below).

Before each group does these investigations, encourage them to think how they can improve them from these outlines to get the most useful information. For example, how can some sort of control can be set up, so that they can compare the results with the original rock samples.

Investigation A: They should test how much each rock is affected by being bashed against rocks of the same type and other rocks. Use a plastic container. Warn pupils not to inhale the dust when the lid of the container is removed

.

(*Peter Kennett*)

Investigation B: They should test how much each rock can resist being worn away, using a file and/or emery paper.

Notes: These activities are done 'dry', to speed up the process and reduce mess. Use three or four different types of rock such as crumbly sandstone, limestone, granite, slate. Some specimens may be destroyed by the activity. The noisy container shaking need take only 10 seconds. The debris produced by each rock is easier to compare if each type of rock is shaken in a separate container. The provision of a balance allows quantitative comparisons to be made. By using rocks from the local area you can gain insight into the development of the landscape in your home region.

Note that rates of erosion range from seconds to hundreds of years.

Questions:	*Answers:*
Which rocks did you find were the most resistant?	*Those with interlocking crystals, igneous and metamorphic.*
Where on Earth might these processes be occurring naturally?	*In fast-flowing rivers or on wave-pounded beaches.*
How could these simulations of natural processes be made more realistic?	*Add water.*
Which rocks are most likely to form hills or headlands in coastal areas?	*The toughest ones.*

Pupil learning outcomes: Pupils can:

- appreciate the need for a consistent approach to the investigation, e.g. shaking for the same time and trying to keep a uniform vigour of shaking with each set of rock fragments;
- observe differences in rounding of a range of materials after erosion;
- place results in rank order, based on visual inspection, or weighing;
- account for variation in relief (height) of the land where, as in most cases, this depends on the response of different rock types to erosion;
- account for coastline variation, where the tougher rocks tend to form headlands and the weaker rocks bays.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science **Upper KS2** **Working scientifically** • taking measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate • recording data and results of increasing complexity • using test results to make predictions to set up further comparative and fair tests • reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations • identifying scientific evidence that has been used to support or refute ideas or arguments Pupils should use their science experiences to: explore ideas and raise different kinds of questions; They should use their results to identify when further tests and observations might be needed; recognise which secondary sources will be most useful to research their ideas and begin to separate opinion from fact. **Year 5** **Properties and changes of Materials** • compare and group together everyday materials on the basis of their properties, including their hardness, • give reasons, based on evidence from comparative and fair tests, for the particular uses of everyday materials • explain that some changes result in the formation of new materials, and that this kind of change is not usually reversible **KS3** **Chemistry** **Earth and atmosphere** • the rock cycle and the formation of igneous, sedimentary and metamorphic rocks **Geography** **KS3** **Human and physical geography** understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: • physical geography relating to: … rocks, weathering and soils **GCSE subject content and assessment objectives** **Physical geography: processes and change** *Geomorphic processes and landscape* – How geomorphic processes (e.g. weathering, slope movement and erosion by water, wind and ice) have influenced and continue to influence the landscapes of the UK and the interaction of those processes with human activity.	**Sciences** **Planet Earth** **Processes of the planet** Through connections with collaborative studies of landscape, weather and climate in social studies they build up an integrated picture of the dynamic nature of Earth. **Materials** **Earth's materials** **Third** Through evaluation of a range of data, I can describe the formation, characteristics and uses of soils, minerals and basic types of rocks. SCN 3-17a **Social studies** **People, place and environment** **Early** I explore and discover the interesting features of my local environment to develop an awareness of the world around me. SOC 0-07a **Second** I can describe the major characteristic features of Scotland's landscape and explain how these were formed. SOC 2-07a By comparing my local area with a contrasting area outside Britain, I can investigate the main features of weather and climate, discussing the impact on living things. SOC 2-12a **Third** I can investigate the climate, physical features and living things of a natural environment different from my own and explain their interrelationship. SOC 3-10a **Fourth** **People, past events and societies** I can explain how the interaction of physical systems shaped and continue to shape the Earth's surface by assessing their impact on contrasting landscape types. SOC 4-07a	**Science** **KS3** **The sustainable Earth** • the differences between physical and chemical changes using some common examples **Geography** **KS2** **Investigating** Pupils should be given opportunities to: • measure, collect and record data through carrying out practical investigations and fieldwork **KS3** • the physical world: the processes and landforms of coasts or rivers	**The world around us** **KS2** **Change over time in places** • how natural and human events / disasters can cause changes to the landscape and environment (G) **Science** **KS3** **Earth and Universe** The environment and human influences **Geography** **KS3** • physical processes of landscape development; • the dynamic nature of physical and human environments

Age range of pupils: 7 – 16 years

Time needed to complete activity: 30 minutes

The story for teachers:
Erosion means "wearing away" (from the Latin erodere = to gnaw away).

Erosion is **not** the same thing as weathering, Weathering involves the breakdown of rock material in place by atmospheric agencies, plant or animal action, and does not involve the removal of the resulting solid debris.

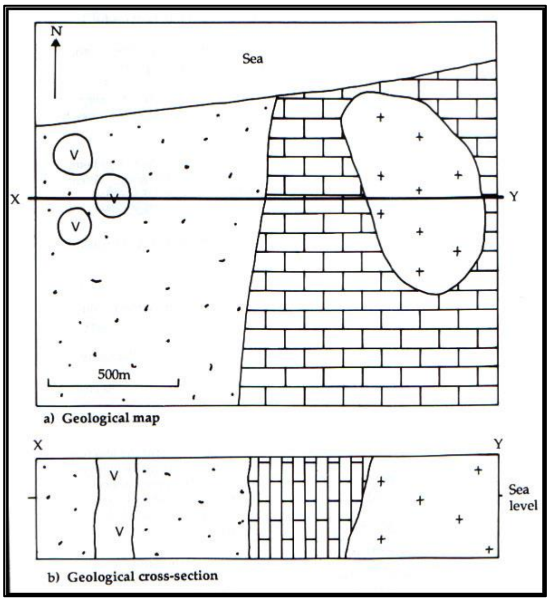
As rock fragments are transported by water, ice, or wind, the fragments themselves are rounded by being knocked against each other. They also abrade the solid rocks beneath them as they are moved. Both such processes are part of erosion.
The resistance to erosion of a rock fragment is controlled by the resistance of its constituent minerals; how the crystals of crystalline rocks interlock; the strength of any cement holding sedimentary rock particles together and any preferred orientation within the rock, such as planes of bedding or of cleavage.

Relating the results of the shaker activity to the landscape around them demands bridging skills in pupils' thinking.

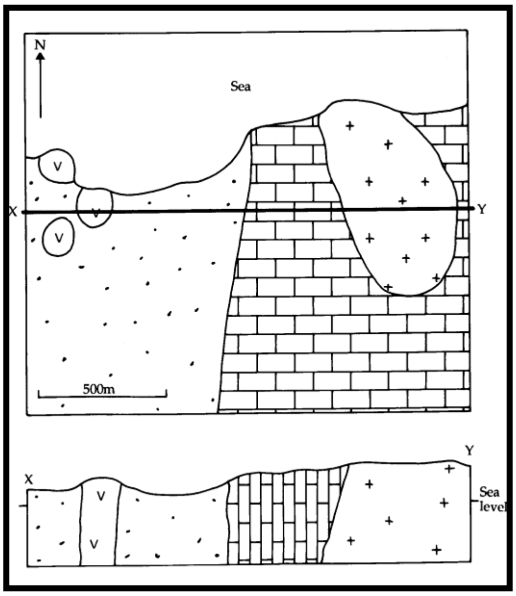
Lead in ideas:
Ask pupils why they think that some areas are hilly and others are low lying and why coastlines are rarely straight. Such differences are often caused by the relative resistance to erosion of the rocks that make up these areas – more resistant rocks usually form higher areas and headlands. You may be able to achieve this by encouraging the class to gaze out of the window, for a change!

Following up the activity:
EITHER
For pupils familiar with maps and cross sections, use a geological map/cross section of a mythical area seen with a straight coastline and a flat land surface before erosion, and with headlands/bays, hills/valleys after erosion (e.g. 10,000 years later). See following maps.

Repeat the activity using rocks from the local area. Relate the resistance of each rock type to the local relief (hills and valleys: headlands and bays).

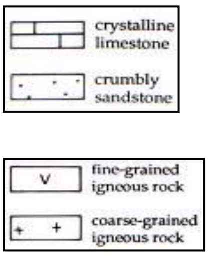


Today



c. 10,000 years ago

Key



OR
For pupils unfamiliar with maps, ask them to sort these pictures into those showing things made of weak rocks and those showing things made of strong rocks.

Note: Either, give sets of photographs to groups of pupils to sort, also providing the two 'Rock group description cards' to help them, or show them the photos on PowerPoint and use them for class discussion.

You may also wish to add your own pictures – particularly of the local area.

Building made of rock blocks - South side Glasgow Tenement (Shawlands) © George Rob

Mochram Village from Motte © AM Hurrell

Garden path © Elizabeth Devon

Buachaille Etive Mor © MJ Mac

St Abbs Head © Mick Knapton

Tiree, Balephuil © Irvine Smith

Carn Mor Dearg arête © Ben Hanson

Kitchen worktop © Elizabeth Devon

Rock group description cards:

Pictures of things made of strong rocks	**Pictures of things made of weak rocks**

It is possible to carry out the investigation with the container half-full of water, to imitate a river or the sea, (although it is difficult to measure the amount of eroded material, and it can be messy!).

A field visit to a local river or beach would enable pupils to investigate the degree to which different fragments of rock are rounded by having been knocked together during transport.

Source: This activity is based on ESTA's "Moulding Earth's Surface – Landshaping" in "The Science of the Earth 11-14" series

Preparation and set-up: 15 minutes

Resource list: Per group of pupils:
Expendable rock specimens e.g.
- 4 X 25g (approx.) crumbly sandstone (sedimentary)
- 4 X 25g (approx.) limestone (sedimentary)
- 4 X 25g (approx.) granite (igneous)
- 4 X 25g (approx.) slate (metamorphic)

- expendable specimens of rocks of variable resistance, as appropriate to the local area (optional)
- two plastic containers with wide necks and secure lids (e.g. screw-on)
- mechanic's file
- emery paper
- eye protection
- electronic balance, e.g. to 200g, accuracy to 0.1g or better (optional)
- tray

Risk assessment

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Rock, rattle and roll – erosion	Shaking rock specimens in plastic container – when lid is removed there is a potential dust inhalation problem. Asthmatics beware.	1	1	1	Instruct participants to open the top well away from the nose and not inhale dust.

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

Rock, rattle and roll – erosion

Investigating the resistance of different rocks to erosion, by shaking them vigorously in a plastic container.

Investigate rock resistance to find out how rocks erode at different rates and use this to explain the formation of uplands and coastal headlands by the more resistant rock types.

There are many different ways in which rocks are eroded in the natural world. It is not always possible to imitate these different ways in the laboratory. We do not have nearly so much time available either! However, we can try.

Carry out a risk assessment.

Before each group does these investigations, encourage them to think how they can improve them from these outlines to get the most useful information. For example, how can some sort of control can be set up, so that they can compare the results with the original rock samples.

Investigation A: They should test how much each rock is affected by being bashed against rocks of the same type and other rocks. Use a plastic container. Warn pupils not to inhale the dust when the lid of the container is removed.

(*Peter Kennett*)

Investigation B: Test how much each rock can resist being worn away, using a file and/or emery paper.

Notes: These activities are done 'dry', to speed up the process and reduce mess. Use three or four different types of rock such as crumbly sandstone, limestone, granite, slate. Some specimens may be destroyed by the activity. The noisy container shaking need take only 10 seconds. The debris produced by each rock is easier to compare if each type of rock is shaken in a separate container. The provision of a balance allows quantitative comparisons to be made. By using rocks from the local area you can gain insight into the development of the landscape in your home region.

Note that rates of erosion range from seconds to hundreds of years.

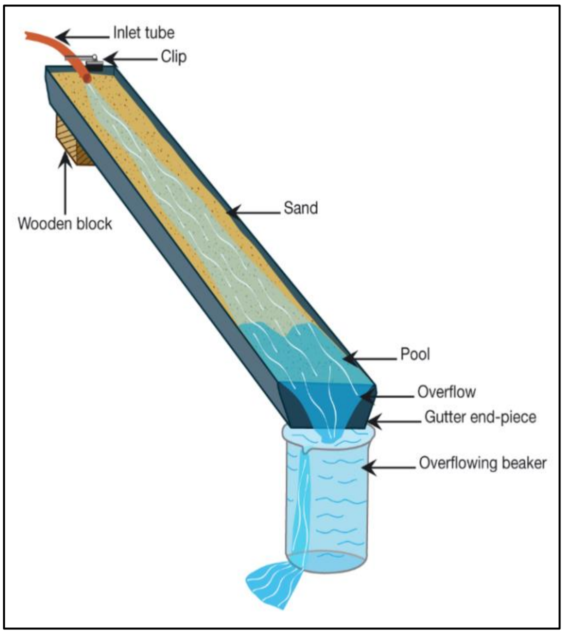
Questions:	***Answers:***
Which rocks did you find were the most resistant?	*Those with interlocking crystals, igneous and metamorphic.*
Where on Earth might these processes be occurring naturally?	*In fast-flowing rivers or on wave-pounded beaches.*
How could these simulations of natural processes be made more realistic?	*Add water.*
Which rocks are most likely to form hills or headlands in coastal areas?	*The toughest ones.*

Circus activity 5: Flowing water – moving sand

Topic: Running water over a sand-filled gutter or cut-away plastic bottle to investigate processes of erosion, transportation and deposition and to model river processes.

Activity:
Investigating sedimentation
Investigate the processes by which sediment grains are eroded, transported and deposited by flowing water, in the lab.

If you have guttering, a water supply and a sink available, fill the gutter with washed sand (to within around 2 cm of the top). Put one end of the gutter over a sink (or bucket) to catch the overflow (and put a container in the sink to stop sand going down the plughole). Put the other end of the gutter on a wooden block so that the gutter is tilting down towards the sink/bucket, as shown in the diagram. Turn on the tap gently.



Redraw ESEU

Observing the gutter. *(Photo: Peter Kennett)*

The 2 litre plastic bottle in action *(Peter Kennett)*

If you have no guttering available, cut a 2 litre plastic bottle as in the photo and set it up as shown. Try to get the pop bottle about 1cm over the edge of the table, place a bowl underneath on a chair. Use Blu Tac™ to secure the bottle to the desk as it may slip off the desk when filling with water. Keep the lid on the bottle (otherwise the water may run out the hole if the tilt is not enough or if the water is water poured too fast). Pour water from a jug or watering can slowly into the top end of the bottle. The water will run over the end of the bottle and down underneath the desk but only for a short way before falling into the bowl.

A class of pupils can use several of these bottles, reducing overcrowding.

Sedimentation observations and questions:

- If you are the first to use the apparatus, notice what happens to the water as it fills up the gutter/ bottle.
- Once it is running uniformly, look carefully for places where *erosion* is taking place. How is the sand being moved at these spots?
- Study where the sand is being moved along the bed. This is known as "*transportation*" of the sediment. Exactly *how* is it being moved?
- Find places where *deposition* is taking place. Are the newly formed layers of sediment horizontal or inclined? How do they build out into the pool at the end of the gutter?
- Try changing the flow rate and discuss any differences you spot.
- Try adding a few pieces of gravel and study the flow around them.

When you have finished, try to match the gutter work to modern sedimentary environments and rock specimens. Would your investigations enable you to say which way former currents flowed?

Be ready to tell the rest of the group about the investigation and your results.

Simulating larger-scale processes

As well as showing how sediment grains move, the apparatus can be used to simulate larger-scale processes too. Ask the pupils point out:

- a channel, like river channels rivers;
- the bed of the channel, like a river bed;
- the bank of the channel, like a river bank;
- a plunge pool, as found under a waterfall;
- a micro-delta, like deltas such as the Nile and Mississippi deltas.

Pupil learning outcomes Pupils can:

- describe how erosion takes place where water has the highest energy, transportation occurs under middle energy conditions and the sediment is deposited when energy is low;
- realise that if the velocity of the water is increased, more sand grains will be eroded, transported and deposited;
- realise that fine grains are moved first but increasingly larger grains are picked up and transported as the volume of water increases;
- spot the similarities between the features of the apparatus and rivers, plunge pools and delta.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: Upper KS2 **Years 5 and 6** **Working scientifically** • planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary • using test results to make predictions to set up further comparative and fair tests • reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations • identifying scientific evidence that has been used to support or refute ideas or arguments. Pupils should use their science experiences to: explore ideas and raise different kinds of questions; select and plan the most appropriate type of scientific enquiry to use to answer scientific questions; They should make their own decisions about what observations to make. They should use relevant scientific language and illustrations to discuss, communicate and justify their scientific ideas. **Geography: KS2** **Locational knowledge** • name and locate counties and cities of the United Kingdom, geographical regions and their identifying human and physical characteristics, key topographical features (including hills, mountains, coasts and rivers).	**Sciences:** **Materials** **Second** Having explored the substances that make up Earth's surface, I can compare some of their characteristics and uses. SCN 2-17a **Third** Through evaluation of a range of data, I can describe the formation, characteristics and uses of soils, minerals and basic types of rocks. SCN 3-17a **Social studies:** **People, place and environment** **First** I can describe and recreate the characteristics of my local environment by exploring the features of the landscape. SOC 1-07a	**Science KS2** **The sustainable Earth** • how some materials are formed or produced **Geography KS3** • the physical world: the processes and landforms of coasts or rivers	**The world around us** **Strand 3: place** **Features of and variations in places, including physical, human, climatic, vegetation and animal life;** • that the landscape locally differs from that elsewhere (G) **Change over time in places** • how natural and human events / disasters can cause changes to the landscape and environment (G)

Human and Physical Geography • physical geography, , including: climate zones, biomes and vegetation belts, rivers, mountains, volcanoes and earthquakes, and the water cycle. **Science: KS3** **Working scientifically** • ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience • use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety **Chemistry** **Earth and atmosphere** • the rock cycle and the formation of igneous, sedimentary and metamorphic rocks **Geography: KS3** • understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: physical geography relating to: hydrology • understand how human and physical processes interact to influence, and change landscapes	**Second** I can describe the major characteristic features of Scotland's landscape and explain how these were formed. SOC 2-07a **Third** Having investigated processes which form and shape landscapes, I can explain their impact on selected landscapes in Scotland, Europe and beyond. SOC 3-07a **Fourth** I can explain how the interaction of physical systems shaped and continue to shape the Earth's surface by assessing their impact on contrasting landscape types. SOC 4-07a		**Geography KS3** develop an understanding of: • physical processes of landscape development

Age range of pupils: 7 – 18 years

Time needed to complete the activity: 10 minutes.

The story for teachers:
Having plunged into the plunge pool at the top, the water flows over the sand forming channels that will develop into a braided pattern. As the water flows into the pool at the bottom, it slows down and sand is deposited to form the micro-delta.

Rivers have two characteristic forms; they can be braided rivers, with curved channels that intertwine, such as the River Ganges, or meandering rivers, with wide meander bends, such as the Mississippi River. This gutter/bottle demonstration models a braided river. Meandering processes cannot properly be shown in models of this scale. Even if an artificial meandering channel is made, it will soon revert to a braided state.

The fine grains are moved along first but if the water volume is increased larger grains will be picked up. They are either held in suspension or roll/slide along the channel bed but if the flow is increased, they can sometimes be seen to move in a jerky fashion as they bounce (a process called saltation).

This activity fits any teaching scheme which involves the study of erosion, transportation and deposition.

Applying the model to the real world requires bridging skills.

Lead in ideas:
Ask which processes occur in the gutters on the edges of roofs or pavements in and around the school during a rain storm. *A. Sediment grains are picked up (eroded), carried along (transported) and laid down (deposited) depending upon the strength of the water flow.*

Look at photographs of the two different sorts of rivers, braided and meandering. Ask which of these two types is most common in their area. In lowland UK, meandering rivers are usually more common. Braided rivers are characteristic of mountain and desert regions, but can also be seen in upland UK areas and on beaches.

Following up the activity
The riverbed mix could be varied – grittier/muddier.

Model 'houses' could be put on the sand and left as the system develops over several minutes, to test what happens to houses built in active river areas.

Source: Developed from an activity published by the Earth Science Teachers' Association in *'Science of the Earth'*, *Secondhand rocks – introducing sedimentary processes'* booklet.

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Preparation and set-up time:
5 minutes, if the gutter/ bottles are ready prepared (once prepared, it/they can be re-used year by year.)

Resource list
EITHER
- 1m length of guttering (square section guttering is preferred) with two end pieces
- wooden block (about 5cm high)

OR
- 2 litre bottle with the top part cut away (as shown in the photo)
- a cloth (as a support for bottle)
- Blu Tac™ (to secure underneath end of bottle at the edge of the desk)

EITHER
- rubber tubing to connect to a lab tap
- clip (to fix the tubing to the gutter)
- container such as a large beaker to put in the sink to catch any sediment washed over the end of the gutter – preventing it from blocking the sink

OR
- a watering can or jug to pour water
- a bucket or washbowl to catch the overflow

- washed sand to fill the gutter/bottle to within 2cm of the top
- small pieces of gravel (approx. 50g)
- a cloth (to wipe up spillages)

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Flowing water – moving sand	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

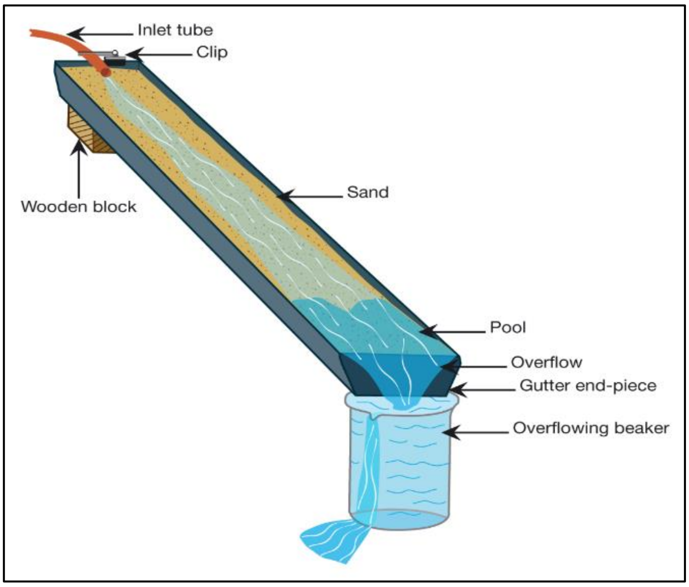
Flowing water – moving sand

Running water over a sand-filled gutter or cut-away plastic bottle to investigate processes of erosion, transportation and deposition and to model river processes.

Investigating sedimentation

Investigate the processes by which sediment grains are eroded, transported and deposited by flowing water, in the lab.

If you have guttering, a water supply and a sink available, fill the gutter with washed sand (to within around 2 cm of the top). Put one end of the gutter over a sink (or bucket) to catch the overflow (and put a container in the sink to stop sand going down the plughole). Put the other end of the gutter on a wooden block so that the gutter is tilting down towards the sink/bucket, as shown in the diagram. Turn on the tap gently.



Redraw ESEU

Observing the gutter. *(Photo: Peter Kennett)*

If you have no guttering available, cut a 2 litre plastic bottle as in the photo and set it up as shown. Try to get the pop bottle about 1cm over the edge of the table, place a bowl underneath on a chair. Use Blu Tac™ to secure the bottle to the desk as it may slip off the desk when filling with water.

The 2 litre plastic bottle in action. *(Peter Kennett)*

Keep the lid on the bottle (otherwise the water may run out the hole if the tilt is not enough or if the water is water poured too fast).
Pour water from a jug or watering can slowly into the top end of the bottle. The water will run over the end of the bottle and down underneath the desk but only for a short way before falling into the bowl.
A class of pupils can use several of these bottles, reducing overcrowding.

Sedimentation observations and questions:

- If you are the first to use the apparatus, notice what happens to the water as it fills up the gutter/ bottle.
- Once it is running uniformly, look carefully for places where *erosion* is taking place. How is the sand being moved at these spots?
- Study where the sand is being moved along the bed. This is known as "*transportation*" of the sediment. Exactly *how* is it being moved?
- Find places where *deposition* is taking place. Are the newly formed layers of sediment horizontal or inclined? How do they build out into the pool at the end of the gutter?
- Try changing the flow rate and discuss any differences you spot.
- Try adding a few pieces of gravel and study the flow around them.

When you have finished, try to match the gutter work to modern sedimentary environments and rock specimens. Would your investigations enable you to say which way former currents flowed?

Be ready to tell the rest of the group about the investigation and your results.

Simulating larger-scale processes

As well as showing how sediment grains move, the apparatus can be used to simulate larger-scale processes too. Ask the pupils point out:

- a channel, like river channels rivers;
- the bed of the channel, like a river bed;
- the bank of the channel, like a river bank;
- a plunge pool, as found under a waterfall;
- a micro-delta, like deltas such as the Nile and Mississippi deltas.

Circus activity 6: Ice – grinding, gouging and depositing

Topic: An activity that can be included in teaching the rock cycle, wearing away of rocks, erosion by ice.

Activity:
Demonstrate how ice, a very soft substance, can grind rocks away by rubbing ice cubes over painted wood. Then show them the Britice animation of how glaciation has affected the UK in the recent geological past.

Ask the pupils:
- what will happen when they rub a clean ice cube on the piece of painted wood?
- what will happen when they rub a sand-covered ice cube on the piece of painted wood?

Ice, sand and painted wood.

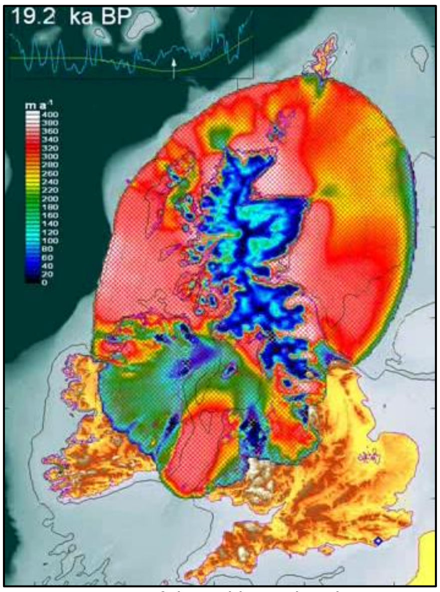
Carry out the activity by asking the pupils to rub a clean ice cube over the wood, pressing down as hard as possible. Next, ask them to press an ice cube on to some loose sand in a dish for about 15 seconds and then rub this over the wood. Are the results as predicted?

Ask the pupils:
- why are there scratch marks on the rock in the photo taken in Glacier National Park?
- how can the direction of the scratch marks be explained?
- the U-shaped valley in Moffatt Hills in the Scottish Southern Uplands was carved by ice. How could this possibly have happened?
- how could the large boulder on Allt Coire Roill (overleaf) have been deposited there?

Glacial striations, Glacier National Park, Montana, USA. (*US Geological Survey*).

U-shaped valley near the Grey Mare's Tail nature reserve, Moffatt Hills in Scotland.
(Ailith Stewart, creative commons 2.0)

Glacial erratic, Allt Coire Roill. Beinn Damh in the background, North West Scotland © Chris Eilbeck



Part of the Britice animation.
(*with permission of the Centre for Glaciology, Aberystwyth University*. 'Dynamic cycles, ice streams and their impact on the extent, chronology and deglaciation of the British–Irish ice sheet'. A Hubbard, T Bradwell, N Golledge, A Hall, H Patton, D Sugden & Stoker, M. 2009. Quaternary Science Reviews 28 (7), 758-776.

Watch the Britice animation with pupils and ask them to try to imagine what it was like when your area was covered by ice sheets like those shown in the animation.

Pupil learning outcomes: Pupils can:
Pupils can:
- explain that ice alone will not scratch rock;
- demonstrate that ice carrying sediment will scratch rock;
- realise that ice will scrape any soil and weathered, loose material from the surface of the underlying rock;
- work out the possible direction of ice movement;
- show that other evidence is needed to determine the actual direction of ice movement;
- explain how a valley glacier could erode a deep, U-shaped valley, given enough time
- explain how large boulders (glacial erratics) can be moved by ice and deposited when the ice melts.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Geography **KS2** **Locational knowledge** • name and locate counties and cities of the United Kingdom, geographical regions and their identifying human and physical characteristics, key topographical features (including hills, mountains, coasts and rivers). **Human and Physical Geography** • physical geography, , including: climate zones, biomes and vegetation belts, rivers, mountains, volcanoes and earthquakes, and the water cycle. **Science: KS3** **Working scientifically** • ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience • use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety	**Sciences:** **Materials** **Second** Having explored the substances that make up Earth's surface, I can compare some of their characteristics and uses. SCN 2-17a **Third** Through evaluation of a range of data, I can describe the formation, characteristics and uses of soils, minerals and basic types of rocks. SCN 3-17a **Social studies:** **People, place and environment** **First** I can describe and recreate the characteristics of my local environment by exploring the features of the landscape. SOC 1-07a **Second**	**Science** **KS2** **The sustainable Earth** • how some materials are formed or produced **Geography** **KS3** • the physical world: the processes and landforms of coasts or rivers	**The world around us** **Strand 3: place Features of and variations in places, including physical, human, climatic, vegetation and animal life;** • that the landscape locally differs from that elsewhere (G) **Change over time in places** • how natural and human events / disasters can cause changes to the

Chemistry **Earth and atmosphere** • the rock cycle and the formation of igneous, sedimentary and metamorphic rocks **Geography: KS3** • understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: physical geography relating to: glaciation • understand how human and physical processes interact to influence, and change landscapes	I can describe the major characteristic features of Scotland's landscape and explain how these were formed. SOC 2-07a **Third** Having investigated processes which form and shape landscapes, I can explain their impact on selected landscapes in Scotland, Europe and beyond. SOC 3-07a **Fourth** I can explain how the interaction of physical systems shaped and continue to shape the Earth's surface by assessing their impact on contrasting landscape types. SOC 4-07a		landscape and environment (G) **Geography KS3** develop an understanding of: • physical processes of landscape development

Age range of pupils: 7 – 14 years

Time needed to complete activity: 20 minutes

The story for teachers:
Responses to the questions posed above are given below.

- What happens when a clean ice cube is rubbed on a piece of painted wood?
  A. Ice alone will not scratch the paint.

- What happens when a sandy ice cube is rubbed on a piece of painted wood?
  A. The paint will be scratched off fairly easily.

- Why are there scratch marks on the rock in the photo?
  A. Moving ice (a glacier) erodes material of all shapes and sizes from the valley floor as it moves downhill. The moving glacier acts rather like a bulldozer, stripping away anything that is loose above the underlying rock. Some of the eroded material becomes embedded in the bottom of the glacier and so scrapes along the newly-exposed rock beneath the ice and leaves behind line-shaped scratch marks, often called glacial striations.

- How can the direction of the scratch marks be explained?
  A. The direction of the scratch marks gives an indication of the trend of flow of the glacier (it could have flowed in either direction, in this photo, either up or down the picture). If you wanted to know which of the two directions it flowed in, you would need to look for other evidence, such as the general slope direction of the valley or the direction in which erratic boulders have been moved from their source.

- How was the U-shaped valley in the photo carved by ice?
  A. A valley glacier armoured with boulders and sand, carved this valley as it ground its way over the rock beneath. Since valley glaciers erode both the sides and base of the valleys they flow through, glacier-carved valleys have typical U-shapes, like the one in the photo. In contrast, river-eroded valleys have V-shapes (since most of the erosion takes place at the base of the 'V').

- How could the large boulder (glacial erratic) have been deposited?
  A. Moving ice sheets and glaciers transport debris of all sizes from boulders to clay; when the ice melts, all the sediment is deposited, including boulders like this one. Glacial erratics can be carried far away from their original source rocks.

Lead in ideas:
Ask pupils why some valleys on Earth might be 'U'-shaped whilst others are 'V'-shaped.

Following up the activity:
Pupils could try using mixed sediment, sand and gravel, beneath their ice cube to scratch the paint. They can demonstrate that gravel will make deeper scratch marks than sand.

Pupils could also consider what would happen to the debris being carried by the ice when it melts. They can simulate this by freezing ice cubes of sandy/muddy water, then leaving them to melt and observing the results.

Source:
From an Earthlearningidea (at www.earthlearningidea.com) called '*Grinding and gouging: how moving ice can grind away rocks'*, originally adapted from an idea by Peter Kennett, of the Earthlearningidea team, for Key Stage 3 National Strategy 'Strengthening teaching and learning of geological changes in KS3 science', 2004. The Britice animation was produced by the Centre for Glaciology at Aberystwyth University and is based on the following academic paper: A. Hubbard, T. Bradwell, N. Golledge, A. Hall, H. Patton, D. Sugden & Stoker, M.(2009) Dynamic cycles, ice streams and their impact on the extent, chronology and deglaciation of the British–Irish ice sheet. *Quaternary Science Reviews* 28 (7), 758-776.

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Preparation and set-up time:
Ice cubes should be made in the freezer beforehand, otherwise, little time.

Resource list:
- clean ice cubes
- some pieces of painted wood (or hardboard with one smooth side)
- some sand in a dish
- photographs of glacial striations and a U-shaped valley
- ice cubes made from sandy/muddy water (for extension)
- Britice animation downloadable from: https://www.aber.ac.uk/en/iges/research-groups/centre-glaciology/research-intro/britice-model/
- computer on which to play the animation

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Ice – grinding, gouging and depositing	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

Ice – grinding, gouging and depositing

An activity that can be included in teaching the rock cycle, wearing away of rocks, erosion by ice.

Demonstrate how ice, a very soft substance, can grind rocks away by rubbing ice cubes over painted wood. Then show them the Britice animation of how glaciation has affected the UK in the recent geological past.

Ask the pupils:

- what will happen when they rub a clean ice cube on the piece of painted wood?
- what will happen when they rub a sand-covered ice cube on the piece of painted wood?

Ice, sand and painted wood.

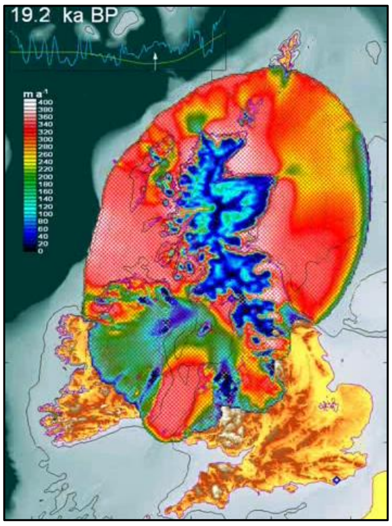
Carry out the activity by asking the pupils to rub a clean ice cube over the wood, pressing down as hard as possible. Next, ask them to press an ice cube on to some loose sand in a dish for about 15 seconds and then rub this over the wood. Are the results as predicted?

Ask the pupils:
- why are there scratch marks on the rock in the photo taken in Glacier National Park?
- how can the direction of the scratch marks be explained?
- the U-shaped valley in Moffatt Hills in the Scottish Southern Uplands was carved by ice. How could this possibly have happened?
- how could the large boulder on Allt Coire Roill have been deposited there?

Glacial striations, Glacier National Park, Montana, USA. (*US Geological Survey*).

U-shaped valley near the Grey Mare's Tail nature reserve, Moffatt Hills in Scotland (Ailith Stewart, creative commons 2.0)

Glacial erratic, Allt Coire Roill. Beinn Damh in the background, North West Scotland © Chris Eilbeck



Part of the Britice animation. (*with permission of the Centre for Glaciology, Aberystwyth University.* 'Dynamic cycles, ice streams and their impact on the extent, chronology and deglaciation of the British–Irish ice sheet'. A Hubbard, T Bradwell, N Golledge, A Hall, H Patton, D Sugden & Stoker, M. 2009. Quaternary Science Reviews 28 (7), 758-776

Watch the Britice animation with pupils and ask them to try to imagine what it was like when your area was covered by ice sheets like those shown in the animation.

Circus activity 7: The washing line of time

Topic: Exploring the pattern of evolution since the origin of the Earth.

Activity:
You are provided with a set of cards representing various organisms that have appeared on the Earth or become extinct throughout geological time, plus an 'Origin of the Earth' card.

1. Try to place the cards on the bench in the order in which you think each organism first appeared on Earth (so far as we can tell from the fossil record); then add the 'extinction' cards.
2. Fix up a piece of string 4.6m long, to represent the 4600 million years since the Earth was formed (i.e. 1 metre to 1000 million years).
3. Peg the 'Origin of the Earth' card at one end of the string.
4. Then peg the picture cards where you think they belong on the line.

The washing line of time. (*Peter Kennett*)

The table below provides dates and distances for a 4.6 metre washing line (1 million years = 1 mm).

Event	Millions of years ago (Ma)	Distance from 'present day' (cm)
First humans (genus Homo)	2	0.2
First grasses	55	5.5
K-T boundary mass extinction	65	6.5
First flowering plants	130	13
First birds	150	15
First mammals	220	22
First dinosaurs	225	22.5
The 'Great Dying' mass extinction	251	25.1
First reptiles	325	32.5
First plants with seeds	360	36
First amphibians	360	36
First plants on land	501	51
First animals with hard parts	545	54.5
First multicellular organisms	1200	120
First eukaryotes	2000	200
First bacteria	3500	350
The origin of the Earth	4567	460

Pupil learning outcomes:
Pupils will be able to:
- describe, in general terms, the history of life on Earth;
- explain the enormity of the timescale in which evolution operates;
- recall that humans appear only very recently in geological terms.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: KS2 Year 6 **Working scientifically** • recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs • using test results to make predictions to set up further comparative and fair tests **Evolution and inheritance** • recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago • recognise that living things produce offspring of the same kind, but normally offspring vary and are not identical to their parents • identify how animals and plants are adapted to suit their environment in different ways and that adaptation may lead to evolution. **Geography** **KS3** **Human and physical geography** understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: • physical geography relating to: geological timescales **Science** **KS4** **Evolution, inheritance and variation** • the evidence for evolution	**Sciences: Biological systems: inheritance First** By comparing generations of families of humans, plants and animals, I can begin to understand how characteristics are inherited. SCN 1-14a	**Science KS4** Variation within species can lead to evolutionary changes and similarities and differences between species can be measured and classified.	No specific references

Age range of pupils: 7 – 18 years.

Time needed to complete activity:
20 minutes.

The story for teachers:
Indirect evidence for early life can be considered to be very old (more than 3700 million years - Ma) in carbon-rich rocks from Greenland. Bio-geochemists argue about the significance of their carbon isotope composition.

Later, in the geological record microfossils filaments and spheres are preserved in chert (microcrystalline silica). The oldest of these 'archaebacteria' are around 3500 Ma from Western Australia and South Africa.

By 2700 Ma, shallow seas were populated by similar organisms that produced build-ups of limestone. These were considered to be photosynthetic and contributed oxygen to the hydrosphere and eventually the atmosphere. Geochemical analysis is consistent with this story. By about 2000 Ma the first oxidised –'rusty' sediments are found. This date coincides with the molecular clock calculations for the origin of the first eukaryotes (organisms with cells containing nuclei), although the first fossil evidence for them is some half a million years later.

As oxygen built up in the hydrosphere, biotic diversity increased to the point some 600 Ma when animals developed the ability to grow armed limbs for predation and exoskeletons for defence. This led to the Cambrian explosion of diversity. This increase in variety was set back by a major cull or extinction event at the end of the Cambrian, around 480 Ma. The rest of the Phanerozoic (geological time since then) – when fossil remnants are big enough to be seen by the naked eye - is characterised by these expansions of biotic diversity, followed by mass extinctions. The most dramatic of these occurred at about 250 Ma when 60% of life forms became extinct. Following that, new organisms exploited vacant ecological niches and evolution accelerated.

An important mass extinction occurred at 65 Ma when the dinosaurs were finally killed off.
Mammals exploited the vacated habitats, and eventually we – *Homo sapiens* - evolved.

There is much debate about the causes of extinctions, but impacts by extra-terrestrial bodies, and/or sudden climate change associated with major volcanic activity seem to be favoured causes.
At about 450 Ma, plants migrated from their watery existence and invaded the land, soon followed my mites and insects, and then higher organisms. Primitive vascular plants eventually evolved into complex flowering plants.

Lead in ideas:
There are many ways to introduce the concept of 'deep time' (the geological timescale), for example, using marked up rolls of wallpaper, the 24 hours of the day, or even a toilet roll.

Following up the activity:
Ask Pupils to consider:
- Which events were difficult to place on the timeline?
- What can they say about the order in which the events occurred? Is it surprising?
- Humans have existed for 2 million years, while bacteria have been around for 3500 million years. Will either still be around 3500 million years from now?
- The evidence from the fossil record used in this activity can be compared to the dating for events provided by 'molecular clocks' when DNA sequences are compared. Why might the date for the first eukaryote in the fossil record be much later than the date calculated using DNA sequences? *A. The fossil record is incomplete - and small organisms without hard parts are the least likely to be preserved – so it extremely unlikely that we will ever find the very first fossil of anything. Alternatively, the molecular clock used may be wrong.*

Source: ESEU '*Dead and buried?: teaching KS4 biology through an Earth context'* workshop booklet.

Source of images:
- First bacteria, scanning electron micrograph of *Escherichia coli* – by NAIAD, this image is in the public domain
- First eukaryotes, *Sacharomyces cerevisiae* cells in DIC microscopy - by Masur, this image is in the public domain
- First multicellular organisms, *Naraoia compacta fossil* – © Apokryltaros, Creative Commons
- First animals with hard parts, 2 *Kainops invius* specimens - © Moussa Direct Ltd.
- First plants on land, *Cooksonia pertoni* - © Smith609
- First amphibians, model of *Ichthyostega* - © Dr. Günter Bechly
- First plants with seeds, fruiting twig of *Ginkgo biloba* - © IMC
- First reptiles, *Hylonomus lyelli* - © ArthurWeasley, Nobu Tamura (http://www.palaeocritti.com)
- First dinosaurs, *Coelophysis* animatronics model – photo created by Ballista – image edited by Firsfron
- The 'Great Dying' mass extinction, top image is an *Archaeothyris* - © ArthurWeasley, bottom image is an *Aenigmatoceras rhipaeum* - © Apokryltaros
- First mammals, *Adelobasileus cromptoni* - © Nobu Tamura (http://www.palaeocritti.com)
- First bird, *Iberomesornis romerali* - by Locutus Borg, this image is in the public domain
- First flowering plants *Amborella trichopoda* - © Scott Zona
- K/T boundary mass extinction, top image is a *Douvilleiceras mammilatum* - © Apokryltaros, bottom image is a *Styracosaurus - by* LadyofHats, this image is in the public domain
- First grasses, - by D.Herman, this image is in the public domain
- First humans - © Gunkarta Gunawan Kartapranata

....

Preparation and set-up time:
5-10 minutes to set up the 4.6 metre long 'washing line'

Resource list:
- pictures of organisms, each representing an important event in the history of life (see following)
- 5 metre length of string (allows 0.4m for fixing at each end)
- metre ruler or tape measure
- 13 clothes pegs or clips to attach pictures to the washing line
- drawing pins/clips to attach the string to the wall

Risk assessment:

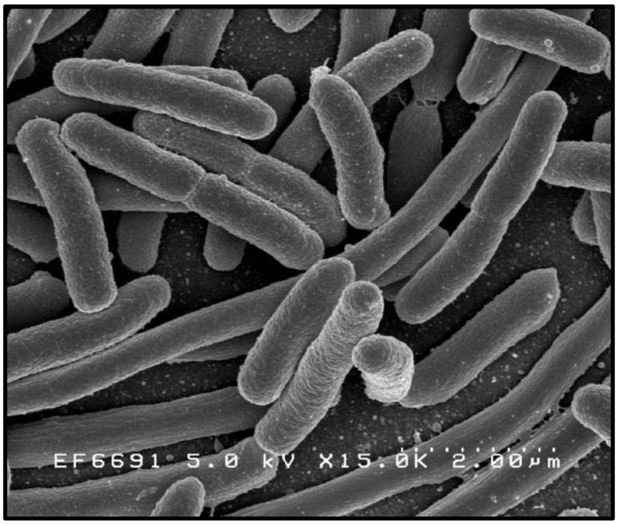
Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Washing line of time	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

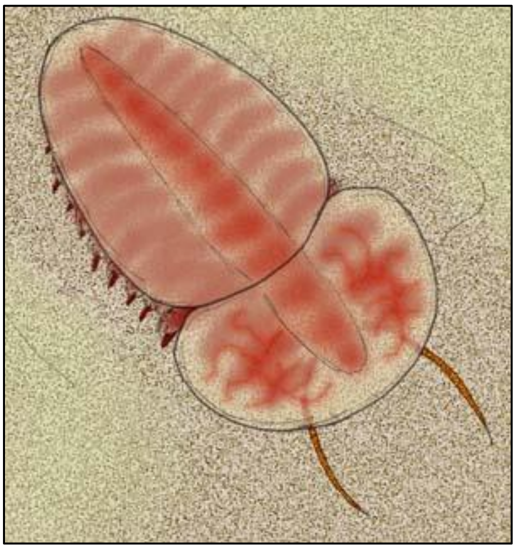
Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

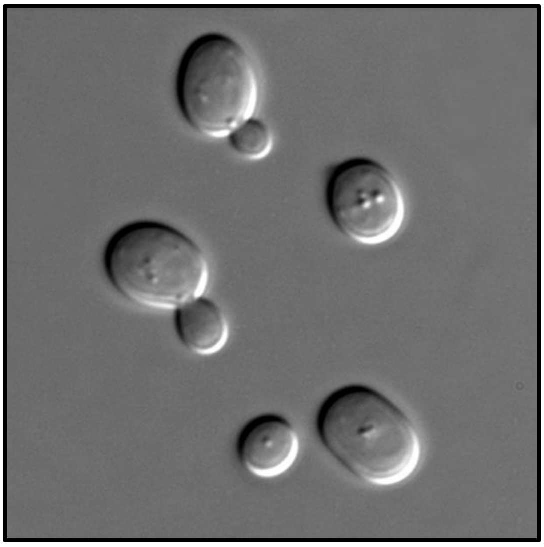
Origin of the Earth



First bacteria (cells without a nucleus)

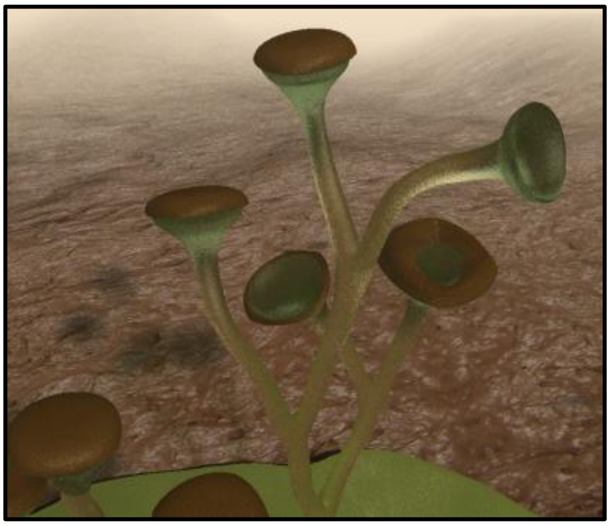


First multicellular organisms

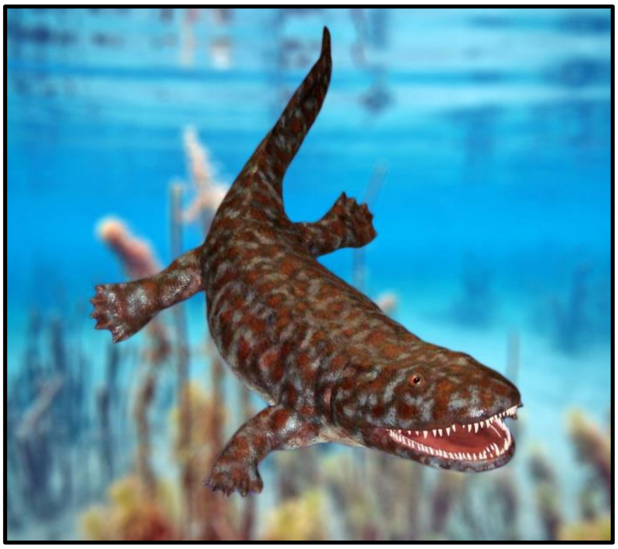


First eukaryotes (cells with a nucleus)

First animals with hard parts

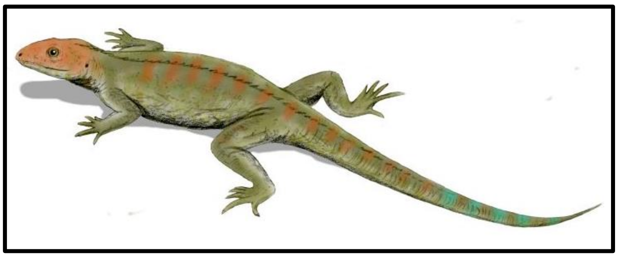


First plants on land

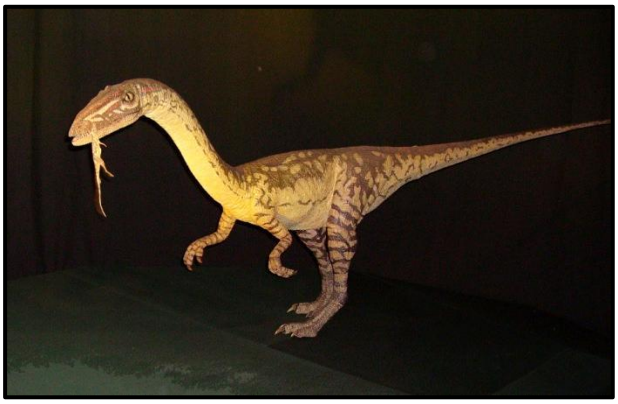


First amphibians

First plants with seeds



First reptiles



First dinosaurs

The 'Great Dying' mass extinction

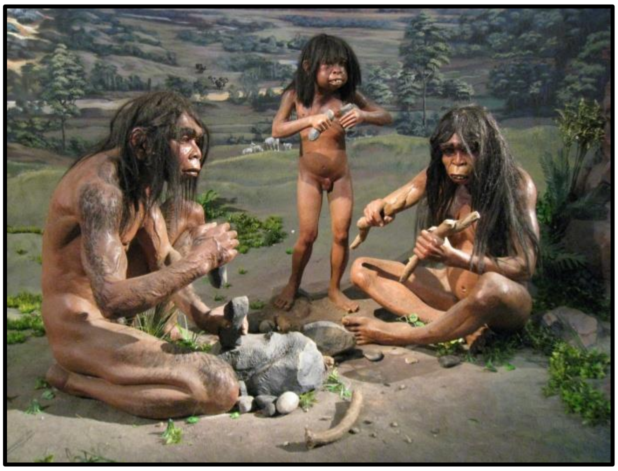
First mammals

First birds

First flowering plants

K/T boundary mass extinction

First grasses



First human

ESEU activity guide sheet:

The washing line of time

Exploring the pattern of evolution since the origin of the Earth.

You are provided with a set of cards representing various organisms that have appeared on the Earth or become extinct throughout geological time, plus an 'Origin of the Earth' card.

1. Try to place the cards on the bench in the order in which you think each organism first appeared on Earth (so far as we can tell from the fossil record); then add the 'extinction' cards.

2. Fix up a piece of string 4.6m long, to represent the 4600 million years since the Earth was formed (i.e. 1 metre to 1000 million years).

3. Peg the 'Origin of the Earth' card at one end of the string.

4. Then peg the picture cards where you think they belong on the line.

The washing line of time. (*Peter Kennett*)

The table below provides dates and distances for a 4.6 metre washing line (1 million years = 1 mm).

Event	**Millions of years ago (Ma)**	**Distance from 'present day' (cm)**
First humans (genus Homo)	2	0.2
First grasses	55	5.5
K-T boundary mass extinction	65	6.5
First flowering plants	130	13
First birds	150	15
First mammals	220	22
First dinosaurs	225	22.5
The 'Great Dying' mass extinction	251	25.1
First reptiles	325	32.5
First plants with seeds	360	36
First amphibians	360	36
First plants on land	420	42
First animals with hard parts	545	54.5
First multicellular organisms	1200	120
First eukaryotes	2000	200
First bacteria	3500	350
The origin of the Earth	4567	460

Very quick
From seconds to minutes
↕
From minutes to weeks
↕
From weeks to years
↕
From years to thousands of years
↕
From thousands of years to millions of years
↕
From millions of years to thousands of millions (billions) of years
Very, very, very slow

Circus activity 8: How long does it take? – quick to very, very, very slow

Topic: Discussing the rates of Earth processes.

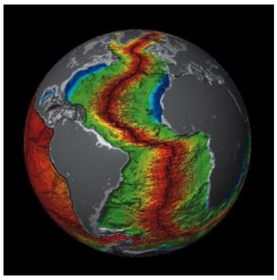
Activity: Sorting out Earth events according to the time they take

Some Earth processes are dangerously quick – but some are extremely slow. Help your pupils to understand how the rates of Earth processes differ by cutting out the cards on page 58 and the scale to the left, and fitting the cards in the best places on the scale.

This has been devised as a group activity to promote discussion – so the quality of discussion is likely to be more important than the 'right 'answers.

Extend the activity by asking pupils to think of other Earth processes and discuss where on the scale they should fit.

How long for lava to crystallise and become solid? © public domain



How long for a new ocean to become 1000km wide? ©public domain

Pupil learning outcomes: Pupils can:
- determine the rates of Earth processes.
- explain how some Earth processes act very quickly, whilst others act very, very slowly.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Geography **KS2** **Locational knowledge** • name and locate counties and cities of the United Kingdom, geographical regions and their identifying human and physical characteristics, key topographical features (including hills, mountains, coasts and rivers). **Human and Physical Geography** • physical geography, , including: climate zones, biomes and vegetation belts, rivers, mountains, volcanoes and earthquakes, and the water cycle. **Science: KS3** **Working scientifically** • ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience **Chemistry** **Earth and atmosphere** • the rock cycle and the formation of igneous, sedimentary and metamorphic rocks	**Sciences: Materials** **Second** Having explored the substances that make up Earth's surface, I can compare some of their characteristics and uses. SCN 2-17a **Third** Through evaluation of a range of data, I can describe the formation, characteristics and uses of soils, minerals and basic types of rocks. SCN 3-17a **Social studies: People, place and environment** **First** I can describe and recreate the characteristics of my local environment by exploring the features of the landscape. SOC 1-07a **Second** I can describe the major characteristic features of Scotland's landscape and explain how these were formed. SOC 2-07a	**Science** **KS2** **The sustainable Earth** • how some materials are formed or produced **Geography** **KS3** the physical world: the processes and landforms of coasts or rivers	**The world around us** **Strand 3: place** **Features of and variations in places, including physical, human, climatic, vegetation and animal life;** • that the landscape locally differs from that elsewhere (G) **Change over time in places** • how natural and human events / disasters can cause changes to the landscape and environment (G)

Geography: KS3 • understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: physical geography relating to: : geological timescales and plate tectonics; rocks, weathering and soils; weather and climate, including the change in climate from the Ice Age to the present; and glaciation, hydrology and coasts • understand how human and physical processes interact to influence, and change landscapes	**Third** Having investigated processes which form and shape landscapes, I can explain their impact on selected landscapes in Scotland, Europe and beyond. SOC 3-07a **Fourth** I can explain how the interaction of physical systems shaped and continue to shape the Earth's surface by assessing their impact on contrasting landscape types. SOC 4-07a		**Geography KS3** develop an understanding of: physical processes of landscape development

Age range of pupils: 9 – 18 years

Time needed to complete activity:

The story for teachers:
Pupils are asked to subdivide Earth processes according to the time they take – answers likely to result from the discussions are given below.

Very quick	How long:
From seconds to minutes	• for an earthquake to happen? • for a landslide to happen? • for a pebble to be eroded from a river bed in a storm?
From minutes to weeks	• for mud cracks to form and be preserved? • for a flood deposit to be laid down?
From weeks to years	• for lava to crystallise and become solid?
From years to thousands of years	• for a glacial lake to fill with sediment? • for a monument to erode away
From thousands of years to millions of years	• for an intrusive igneous rock to crystallise? • do ice ages last? • does the Earth's magnetism stay in the same direction without reversal (the N magnetic pole staying near the N geographical pole)?
From millions of years to thousands of millions (billions) of years	• for a supercontinent to break up and reform • a new ocean to become 1000 km wide • for oceanic lithosphere to be recycled from spreading centre to subduction and up again?
Very, very, very slow	

This activity demonstrates the huge range of rates of Earth processes- from seconds to billions of years. It also tackles the misconception that earth processes, such as those in the rock cycle, are steady when, not only can the rates be very different, but also many rates of the same processes vary from quick to slow.

Pupils are asked to construct a pattern in the rates of Earth processes; processes with unknown rates will cause cognitive conflict.

Following up the activity:
Try adding cards with the processes below.

Very quick	How long for:
From seconds to minutes	• a tsunami to drown a coastline? • a lahar to flow down a volcano?
From minutes to weeks	• wave or current ripple marks to form?
From weeks to years	• gullies to be eroded in soil?
From years to thousands of years	• buildings to weather and erode away?
From thousands of years to millions of years	• a waterfall to erode back into a long gorge? • oil to be released from a source rock?
From millions of years to thousands of millions (billions) of years	• life to evolve? • the surface of the molten Earth to become solid?
Very, very, very slow	

Source: Devised by Chris King of the Earthlearningidea Team. Many thanks to Dave Rothery for his advice.

…………………

Preparation and set-up time:
A few minutes to cut out the cards – more if several seats are to be made and they are to be laminated.

Resource list:
- scissors to cut out the cards

Risk assessment:

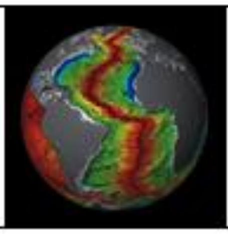
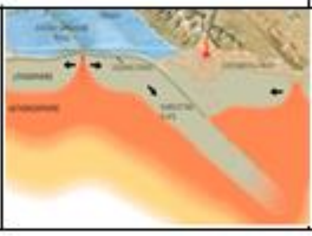
Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
How long does it take? – from quick to very, very slow	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

Quick to very, very slow – timing Earth event cards

How long for an earthquake to happen? *AGI Earth Science World Image Bank; h5ipp2; courtesy United States Geological Survey.*		How long for an intrusive igneous rock to crystallise? *Peter Kennett.*	
How long do ice ages last? *Peter Kennett.*		How long for a flood deposit to be laid down? *Peter Kennett.*	
How long for a new ocean to become 1000 km wide? *This image is in the public domain - it originally came from the U.S. National Oceanic and Atmospheric Administration.*		How long for lava to crystallise and become solid? *This image is in the public domain – it originally came from the United States Geological Survey.*	
How long for a monument to erode away? *I, Aram545, the copyright holder of this work, release this work into the public domain.*		How long for a glacial lake to fill with sediment? *This image is a work of the U.S. federal government, the image is in the public domain.*	
How long for a supercontinent to break up and reform? *Permission is granted by Kieff to publish this through the GNU Free Documentation License, Version 1.2.*		How long for a landslide to happen? *Peter Kennett.*	
How long for mud cracks to form and be preserved? *This image by Nicolai Bangsgaard is licensed under the Creative Commons Attribution-Share Alike 2.5 Generic license.*		How long does the Earth's magnetism stay in the same direction without reversal (the N magnetic pole staying near the N geographical pole)? *Peter Kennett.*	
How long for oceanic lithosphere to be recycled from spreading centre to subduction and up again? *Image in the public domain - from the United States Geological Survey*		How long for a pebble to be eroded from a river bed in a storm? *Peter Kennett*	

Very quick
From seconds to minutes
↕
From minutes to weeks
↕
From weeks to years
↕
From years to thousands of years
↕
From thousands of years to millions of years
↕
From millions of years to thousands of millions (billions) of years
Very, very, very slow

ESEU activity guide sheet:

How long does it take? – quick to very, very, very slow

Discussing the rates of Earth processes.

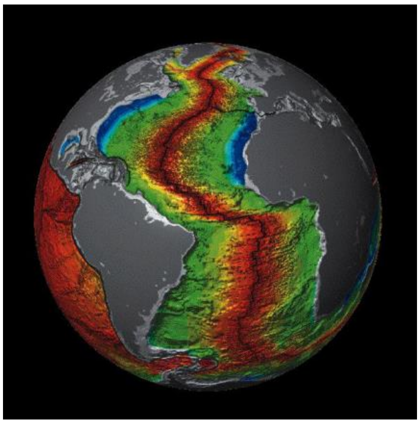
Sorting out Earth events according to the time they take

Some Earth processes are dangerously quick – but some are extremely slow. Help your pupils to understand how the rates of Earth processes differ by cutting out the cards on the next page and the scale to the left, and fitting the cards in the best places on the scale.

This has been devised as a group activity to promote discussion – so the quality of discussion is likely to be more important than the 'right 'answers.

Extend the activity by asking pupils to think of other Earth processes and discuss where on the scale they should fit.

How long for lava to crystallise and become solid?



How long for a new ocean to become 1000km wide? © public domain

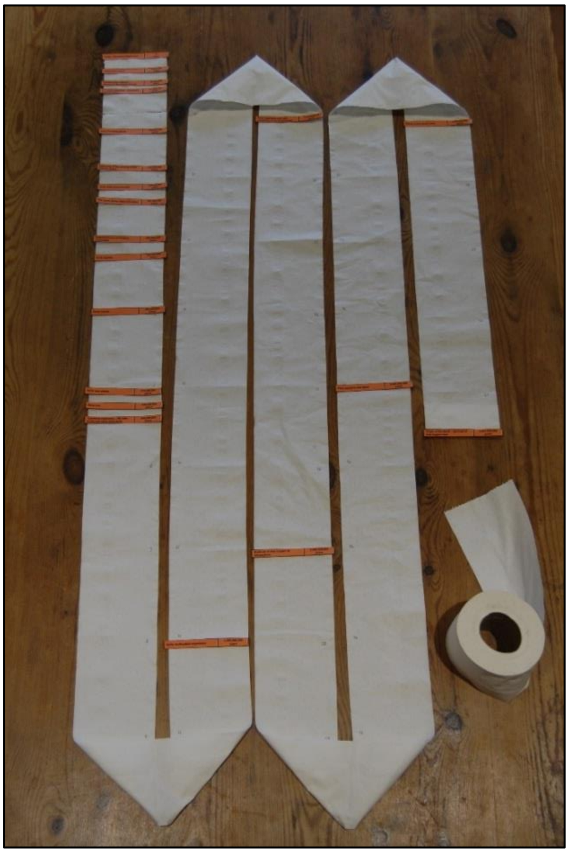
Circus activity 9: The toilet roll of time

Topic: A pupil activity to make a geological timeline to be taken home.

Activity:
Ask the pupils to make their own geological timeline, as follows:
- Each group should collect a strip of toilet paper exactly 46 sheets long.
- They should use a felt tipped pen to number each sheet from 0 to 45 with small numbers.
- They should mark the 46,000,000 point on the final sheet, and cut off or fold under the remaining paper.
- Meanwhile another member of the group should cut out the timeline markers for the table following, as individual strips:

Origin of the Earth – geological time begins here	**4,567,000,000 years**

- They should lay out the strip of toilet paper in a suitable space, preferably one where the strip can be laid out as one long length'
- Given that each perforated sheet of toilet paper is 100,000,000 (one hundred million) years, they should add the timeline markers in the correct places.
- It should be clear that most of the significant events in geological time have happened in the last 600 million years (last six sheets).
- They could glue or staple the timeline markers in place and take their toilet roll of time home to amaze their friends and family.



The toilet roll of time. (*Chris King)*

To emphasis the point that most of the 'action' on Earth happened relatively recently, show the pupils the 'Evolution of life in 60 seconds' video at: https://www.youtube.com/watch?v=YXSEyttblMI

Pupil learning outcomes: Pupils can:
- describe key events during geological time;
- put these in the correct order;
- give an idea of the extent of geological time and that key events happened mainly in the past 600 million years.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: KS2 Year 6 **Working scientifically** • recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs **Evolution and inheritance** • recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago **Geography** **KS3** **Human and physical geography** understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: • physical geography relating to: geological timescales **Science** **KS4** **Evolution, inheritance and variation** • the evidence for evolution	**Social sciences** **Third** Having investigated processes which form and shape landscapes, I can explain their impact on selected landscapes in Scotland, Europe and beyond. SOC 3-07a **Fourth** I can explain how the interaction of physical systems shaped and continue to shape the Earth's surface by assessing their impact on contrasting landscape types. SOC 4-07a Consideration of, for example, aspects of geological time, geology and atmosphere may help to clarify this relationship.	No specific references	No specific references

Age range of pupils: 9 – 16 years

Time needed to complete activity: 15 minutes, if the group works collaboratively.

The story for teachers:
This activity has been devised to address the common lack of knowledge about geological time. Research has shown that many people have no idea of the great length of geological time nor of the order of the key events during the geological history of the Earth.

You can find many more dates to add to the timeline on this website: http://www.nthelp.com/eer/HOAtimetp.html (although the activity described on the website uses a much longer toilet roll). Be wary of the dates in the list on the website though, as some have changed since this list was published. You can find the latest dates on the internet.

Lead in ideas:
Try to give the pupils an idea of how long a million years is by using the 'How many for a million' Earthlearningidea activity (http//:www.earthlearningidea.com).

Following up the activity:
Try using some of the other ESEU/Earthlearningidea geological time-related activities.

Source: Based on an idea by Pete Loader.

…………………

Preparation and set-up time: Time to purchase the toilet rolls.

Resource list: Per group:
- 47 sheets from a toilet roll
- the timeline marker sheet (see following)
- a felt-tip pen
- scissors
- a means of attaching the timeline markers to the toilet roll (e.g. glue, staples)

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
The toilet roll of time	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

Timeline markers

Event	Geological time (years ago)
Today – the future begins here	0 years
Oldest stone tools	2,600,000 years
India/Eurasia collision – Himalayan Mountains formed	50,000,000 years
K-T mass extinction – dinosaurs became extinct	65,000,000 years
Early flowering plants	130,000,000 years
Beginning of the opening of the Atlantic Ocean	190,000,000 years
Early birds and mammals	220,000,000 years
The 'great dying' mass extinction	251,000,000 years
Supercontinent of Pangaea assembled	300,000,000 years
Early reptiles	325,000,000 years
Early insects	400,000,000 years
Early land plants	510,000,000 years
Early fish	530,000,000 years
'Cambrian explosion – life with shells and other hard parts	545,000,000 years
Early multicelled organisms	1,200,000,000 years
Early organisms with cells containing nuclei (eukaryotes)	2,000,000,000 years
Build-up of free oxygen in atmosphere	2,700,000,000 years
Early bacteria and algae	3,500,000,000 years
Oldest known Earth rocks	4,000,000,000 years
Origin of the Earth – geological time begins here	4,567,000,000 years

ESEU activity guide sheet:

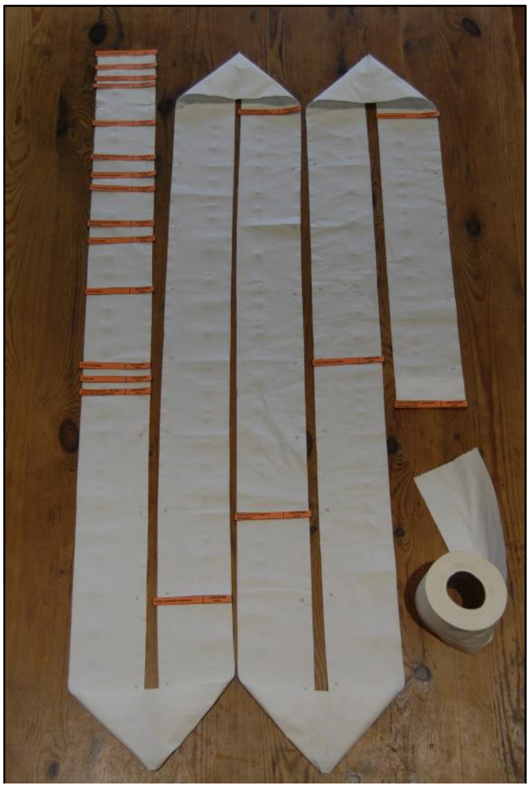
The toilet roll of time

A pupil activity to make a geological timeline to be taken home.

Ask the pupils to make their own geological timeline, as follows:
- Each group should collect a strip of toilet paper exactly 47 sheets long
- They should use a felt tipped pen to number each sheet from 1 to 47 with small numbers.
- Meanwhile another member of the group should cut out the timeline markers for the table following, as individual strips:

Origin of the Earth – geological time begins here	**4,567,000,000 years**

- They should lay out the strip of toilet paper in a suitable space, preferably one where the strip can be laid out as one long length'
- Given that each perforated sheet of toilet paper is 100,000,000 (one hundred million) years, they should add the timeline markers in the correct places.
- It should be clear that most of the significant events in geological time have happened in the last 600 million years (last six sheets).
- They could glue or staple the timeline markers in place and take their toilet roll of time home to amaze their friends and family.



The toilet roll of time. (*Chris King*)

To emphasis the point that most of the 'action' on Earth happened relatively recently, show the pupils the 'Evolution of life in 60 seconds' video at: https://www.youtube.com/watch?v=YXSEyttblMI

Plenary: From observation and testing to rock identification

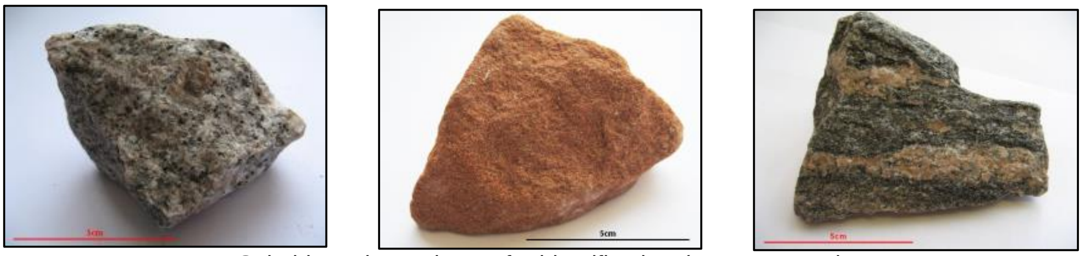
Topic: Using observation and testing methods to distinguish rocks.

Activity:
Give pupils a selection of rock specimens and ask them to use the methods from the ESEU workshop activities 'A rocky look touch and tell' and 'Will my rock hold water?' to sort the rocks into:

- Crystalline – made of interlocking grains and therefore usually impermeable and tough.
- Sedimentary – made of grains subjected to compression and compaction and therefore usually permeable and relatively weak.

Then ask them to further subdivide the crystalline rocks into:

- Igneous – crystalline rocks made of randomly orientated grains.
- Metamorphic – crystalline rocks usually made of aligned grains.



Suitable rock specimens for identification *(Peter Kennett)*

All these rock types can range from fine to coarse-grained. The pupils might find the rock type description cards, on page 66, useful in sorting out the rocks.

When they have completed this activity, check how accurate they have been.

Then use the 'Rock flash cards' to name the rocks. If the names are given at this stage, they will have more impact than if the rocks are named before the identification process has been undertaken.

Finally, ask them to use the 'Rock reference sheet' and the 'Names of common rocks' sheet to check their identification.

Pupil learning outcomes: Pupils can:
- apply rock observation and testing methods to the allocation of rocks to the three main rock groups;
- name rocks using rock reference sheets.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: Lower KS2 **Years 3 and 4** **Working scientifically** • asking relevant questions and using different types of scientific enquiries to answer them • setting up simple practical enquiries • making systematic and careful observations • using results to draw simple conclusions, • using straightforward scientific evidence to answer questions or to support their findings **Year 3** **Rocks** • compare and group together different kinds of rocks on the basis of their appearance and simple physical properties Linked with work in geography, pupils should explore different kinds of rocks, including those in the local environment	**Sciences** **Early** **Biological systems** I can identify my senses and use them to explore the world around me. SCN 0-12a **Earth's materials** **Second** Having explored the substances that make up Earth's surface, I can compare some of their characteristics and uses. SCN 2-17a **Third** Through evaluation of a range	**Science** **KS2** **The sustainable Earth** • a comparison of the features and properties of some natural and made materials • how some materials are formed or produced	**The world around us** **Foundation stage** **Strand 3: Place** **KS1** **Features of the immediate world and comparisons between places;** • about materials in the natural and built environment (G); (H); • about the properties of everyday materials and their uses (S&T); • the similarities and differences between buildings features and landscape in their

Pupils might work scientifically by: observing rocks, including those used in buildings and gravestones, and exploring how and why they might have changed over time; using a hand lens or microscope to help them to identify and classify rocks according to whether they have grains or crystals, and whether they have fossils in them. **Geography** **KS3** **Human and physical geography** understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: • physical geography relating to: … rocks	of data, I can describe the formation, characteristics and uses of soils, minerals and basic types of rocks. SCN 3-17a **Social studies** **First** **People, place and environment** I can describe and recreate the characteristics of my local environment by exploring the features of the landscape. SOC 1-07a		locality and the wider world (G) **KS2** **Ways in which people, plants and animals depend on the features and materials in places and how they adapt to their environment;** • about the origins of materials (S&T)

Age range of pupils: 9 – 16 years

Time needed to complete activity: 20 minutes

The story for teachers:
This method will enable pupils who use it carefully to divide perhaps 80% of rocks into the correct rock groups. However rock-formation processes are complex and they will find exceptions, such as those below:
- some sedimentary rocks are well cemented with a tough cement and so are not porous or weak – but are nevertheless formed of grains stuck together;
- some metamorphic rocks are not formed under pressure (but mainly by heat) and so have random grain orientation;
- some metamorphic rocks contain only one mineral, and so banding or layering cannot be seen;
- some igneous rocks can be weakened by gas bubbles or weathering and so can be fairly weak.

Lead in ideas:
Use the ESEU workshop activities 'A rocky look touch and tell' and 'Will my rock hold water?' to prepare pupils for this activity.

Following up the activity:
Pupils should be able to use the rock identification sheets and the methods described to sort out and name rocks that they find beyond the school.

Source:
Based on the Earth Science Education Unit's KS3 'Dynamic Rock Cycle' workshop.

Copyright: © Earth Science Education Unit
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Preparation, set-up: A few minutes

Resource list: For session leader:
One extra large reference set of rocks

Per group: (*groups of three are most effective*):
- selection of sedimentary rocks, e.g. conglomerate, sandstone, mudstone, shale, clay, limestone
- selection of igneous rocks, e.g. lava, granite, gabbro
- selection of metamorphic rocks, e.g. slate, schist, gneiss, marble, metaquartzite
- plastic container/beaker of water to put the rocks in, preferably transparent
- metal teaspoon or spatula
- magnifier or x10 hand lens
- 'Flash cards' of rock names
- 'Rock reference sheet'
- 'Names of common rocks' sheet

Risk assessment

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
From observation and testing to rock identification	No significant hazard	-	-	-	No

Hazard Rating (A):	**Likelihood of occurrence (B):**	**Risk Priority (AxB):**
1 = Insignificant effect	1 = Little or no likelihood	12-25 = High risk – take immediate action
2 = Minor Injury	2 = Unlikely	6-11 = Medium risk – take action as soon as possible
3 = Major Injury	3 = Occasional	Less than 6 = Low risk – plan future actions where required
4 = Severe Injury	4 = Probable	
5 = Death	5 = Inevitable	

Rock type description cards

Crystalline rocks **(made of interlocking grains and therefore usually impermeable and tough)**	**Sedimentary rocks** **(made of grains subjected to compression and compaction and therefore usually permeable and relatively weak)**
Igneous rocks **(crystalline rocks made of randomly orientated grains)**	**Metamorphic rocks** **(crystalline rocks usually made of aligned grains)**

Rock name 'flash cards'

gabbro (intrusive igneous rock)	**limestone** (sedimentary rock)
granite (intrusive igneous rock)	**mudstone** (sedimentary rock
slate (metamorphic rock)	**conglomerate** (sedimentary rock)
sandstone (sedimentary rock)	**schist** (metamorphic rock)
marble (metamorphic rock)	**gneiss** (metamorphic rock)
shale (sedimentary rock)	**metaquartzite** (metamorphic rock)
basalt (extrusive igneous rock)	**clay** (sedimentary rock)

Rock reference sheet © *Michele Bourne and Peter Kennett, ESEU*

Hand specimen	Close up
	

Conglomerate - pebble-sized grains cemented/ compressed together – a coarse-grained sedimentary rock.

Hand specimen	Close up
	

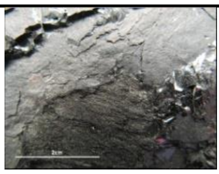
Sandstone – sand-sized grains cemented/compressed together, often with layers (bedding) – a medium-grained sedimentary rock.

Mudstone – mud-sized grains compressed together, often with fine layers (lamination) – a fine-grained sedimentary rock.

Limestone – lime grains cemented/compressed together; lime (calcium carbonate) reacts with dilute acid.

Coal – plant material compressed together – a black sedimentary rock.

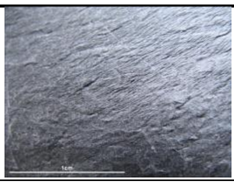
Basalt – dark-coloured, fine-grained (too small to be seen) interlocking crystals (dark-coloured crystals are usually rich in iron/magnesium) – a fine-grained, dark-coloured, iron/magnesium-rich igneous rock, often with gas holes.

Granite – pale-coloured, coarse-grained (clearly visible) interlocking crystals (pale-coloured crystals are usually rich in silicon) – a coarse-grained, pale-coloured, silicon-rich igneous rock

Peridotite – very dark-coloured, coarse-grained (clearly visible) interlocking crystals (dark-coloured crystals are usually rich in iron/magnesium) – a coarse-grained, very dark-coloured, very iron/magnesium-rich igneous rock

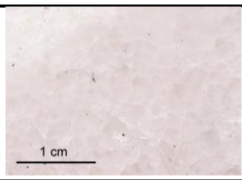
Slate – mud-sized (too small to be seen) interlocking crystals parallel with each other; can break into sheets (cleavage) – a fine-grained, low-grade metamorphic rock

Schist – clearly visible interlocking crystals parallel with each other – a medium-grade metamorphic rock

Gneiss – clearly visible interlocking crystals in bands – a high-grade metamorphic rock

Marble – clearly visible interlocking crystals – formed when limestone is metamorphosed; the calcium carbonate crystals react with dilute acid

Names of common rocks

Sedimentary

Sedimentary rock – made of deposited sediment

- conglomerate (cemented pebbles)
- sandstone (cemented sand)
- mudstone (compressed mud)
- shale (compressed mud in thin layers)
- clay (compressed mud, but still soft)
- limestone (made of calcium carbonate)

Metamorphic

Regional metamorphic rock – rock formed from other rock by heat and increased pressure during mountain-building episodes

- slate (low grade, from mudstone)
- schist (medium grade, from mudstone)
- gneiss (high grade, from mudstone)
- marble (low to high grade, from limestone)
- metaquartzite (low to high grade, from sandstone)

Thermal metamorphic rock – rock formed from other rock through baking by a nearby molten igneous rock (magma)

- hornfels (from mudstone)
- marble (from limestone)
- metaquartzite (from sandstone)

Igneous

Extrusive igneous rock – from magma extruded from the Earth's surface (flowing out or being blasted out)

- lava with gas holes (e.g. fine grained, dark coloured basalt)

Intrusive igneous rock – from magma intruded into the Earth's crust that cools slowly

- granite (coarse grained, pale coloured, rich in Si, poor in Fe, Mg)
- gabbro (coarse grained, dark coloured, rich in Fe, Mg, poor in Si)

From observation and testing to rock identification

Using observation and testing methods to distinguish rocks.

Give pupils a selection of rock specimens and ask them to use the methods from the ESEU workshop activities 'A rocky look touch and tell' and 'Will my rock hold water?' to sort the rocks into:

- Crystalline – made of interlocking grains and therefore usually impermeable and tough.
- Sedimentary – made of grains subjected to compression and compaction and therefore usually permeable and relatively weak.

Then ask them to further subdivide the crystalline rocks into:

- Igneous – crystalline rocks made of randomly orientated grains.
- Metamorphic – crystalline rocks usually made of aligned grains.



Suitable rock specimens for identification (*Peter Kennett*)

All these rock types can range from fine to coarse-grained. The pupils might find the rock type description cards useful in sorting out the rocks.

When they have completed this activity, check how accurate they have been.

Then use the 'Rock flash cards' to name the rocks. If the names are given at this stage, they will have more impact than if the rocks are named before the identification process has been undertaken.

Finally, ask them to use the 'Rock reference sheet' and the 'Names of common rocks' sheet to check their identification.

Resource list

Resource list: Starter: 'Teacher – What's the difference between weathering and erosion?	Supplied By: Facilitator	Supplied By: Institution
One set:		
• the picture of weathering/erosion misconceptions, preferably reproduced at A4 size and laminated	✓	

Resource list: Circus activity 1: A rock look, touch and tell	Supplied By: Facilitator	Supplied By: Institution
One set:		
• samples of granite, permeable sandstone and other samples such as: shelly limestone, chalk, slate, marble; specimens should be 2cm in diameter, or larger	✓	
• magnifier or x10 hand lens	✓	
• metal teaspoon	✓	
• definition cards	✓	

Resource list: Circus activity 2: Will my rock hold water?	Supplied By: Facilitator	Supplied By: Institution
One set:		
• samples of granite, permeable sandstone and others such as: shelly limestone, chalk, slate, marble; samples should be 2cm in diameter, or larger	✓	
• plastic container/beaker of water to put the rocks in, preferably transparent	✓	

Resource list: Circus activity 3: Ice power – freezing water in a syringe to measure expansion	Supplied By: Facilitator	Supplied By: Institution
One set:		
• 10 or 20 ml plastic syringe	✓	
• Blu tak™ , clay, Plasticine™ or similar substance to block the nozzle of the syringe	✓	
• pure (distilled or de-ionised) water (optional)	✓	
• access to a freezer or freezer compartment of a fridge		✓

Resource list: Circus activity 4: Rock, rattle and roll - erosion	Supplied By: Facilitator	Supplied By: Institution
One set:		
Expendable rock specimens e.g.		
• 4 X 25g (approx.) crumbly sandstone (sedimentary)	✓	
• 4 X 25g (approx.) limestone (sedimentary)	✓	
• 4 X 25g (approx.) granite (igneous)	✓	
• 4 X 25g (approx.) slate (metamorphic)	✓	
• expendable specimens of rocks of variable resistance, as appropriate to the local area (optional)	N/A	
• two plastic containers with wide necks and secure lids (e.g. screw-on)	✓	
• mechanic's file	✓	
• emery paper	✓	
• eye protection	✓	
• electronic balance, e.g. to 200g, accuracy to 0.1g or better (optional)	N/A	
• tray	✓	

Resource list: Circus activity 5: Flowing water – moving sand	**Supplied By**	
	Facilitator	**Institution**
One set:		
EITHER		
• 1m length of guttering (square section guttering is preferred) with two end pieces	✓	
• wooden block (about 5cm high)	✓	
• rubber tubing to connect to a lab tap	✓	
• clip (to fix the tubing to the gutter)	✓	
• container such as a large beaker to put in the sink to catch any sediment washed over the end of the gutter – preventing it from blocking the sink	✓	
OR		
• 2 litre bottle with the top part cut away (as shown in the photo)	✓	
• a cloth (as a support for bottle)	✓	
• Blu Tac™ (to secure underneath end of bottle at the edge of the desk)	✓	
• a watering can or jug to pour water	✓	
• a bucket or washbowl to catch the overflow	✓	
AND		
• washed sand to fill the gutter/bottle to within 2cm of the top	✓	
• small pieces of gravel (approx. 50g)	✓	
• a cloth (to wipe up spillages)	✓	

Resource list: Circus activity 6: Ice – grinding, gouging, depositing	**Supplied By**	
	Facilitator	**Institution**
One set:		
• clean ice cubes	✓	
• some pieces of painted wood (or hardboard with one smooth side)	✓	
• some sand in a dish	✓	
• photographs of glacial striations and a U-shaped valley	✓	
• ice cubes made from sandy/muddy water (for extension)	N/A	
• Britice animation downloadable from: https://www.aber.ac.uk/en/iges/research-groups/centre-glaciology/research-intro/britice-model/	✓	
• computer on which to play the animation		✓

Resource list: Circus activity 7: Washing line of time	**Supplied By**	
	Facilitator	**Institution**
One set:		
• pictures of organisms, each representing an important event in the history of life	✓	
• 5 metre length of string (allows 0.4m for fixing at each end)	✓	
• metre ruler or tape measure	✓	
• 13 clothes pegs or clips to attach pictures to the washing line	✓	
• drawing pins/clips to attach the string to the wall	✓	

Resource list: Circus activity 8: How long does it take – quick to very, very, very slow	**Supplied By**	
	Facilitator	**Institution**
One set:		
• scissors to cut out the cards	✓	

Resource list: Circus activity 9: The toilet roll of time	**Supplied By**	
	Facilitator	**Institution**
One set:		
• 47 sheets from a toilet roll	✓	
• the timeline marker sheet	✓	
• a felt-tip pen	✓	
• scissors	✓	
• a means of attaching the timeline markers to the toilet roll (e.g. glue, staples) (optional)	N/A	

Resource list: Plenary: From observation and testing to rock identification	**Supplied By**	
	Facilitator	**Institution**
For session leader:		
• one extra large reference set of rocks	✓	
Per group: (*groups of three are most effective*)		
• selection of sedimentary rocks, e.g. conglomerate, sandstone, mudstone, shale, clay, limestone	✓	
• selection of igneous rocks, e.g. lava, granite, gabbro	✓	
• selection of metamorphic rocks, e.g. slate, schist, gneiss, marble, metaquartzite	✓	
• plastic container/beaker of water to put the rocks in, preferably transparent		✓
• metal teaspoon or spatula		✓
• magnifier or x10 hand lens		✓
• 'Flash cards' of rock names	✓	
• 'Rock reference sheet'	✓	
• 'Names of common rocks' sheet	✓	