

Primary Earth Science Outdoors - Teachers' Guide -

ACTIVITIES



Introduction

Why Outdoors? Why Earth Science? Curriculum for Excellence links



Suggested Activities

Activities based around five Big Questions
related to the landscape



Resources

Health & safety, getting help, books, maps and rock kits

The Scottish Earth Science Education Forum (SESEF) is an association of educators and scientists established to promote understanding of planet Earth in Scottish schools and colleges.

Membership of SESEF is free – visit www.sesef.org.uk for further information.

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About these activities

These activities are designed to encourage primary schools to use their school grounds and local neighbourhood to learn about earth sciences. This has a number of benefits:

- Children are learning more about the place they live and viewing it from a different perspective.
- Curriculum for Excellence experiences and outcomes, particularly in social studies, have many references to exploring and using the local environment as a place for learning.
- You can make several short visits to local places, visits that will have more impact than one big special trip outdoors.
- By walking places, children are being more physically active and learn that getting about by foot is a valid and sustainable form of transport.

The "Big Questions" and the activities that support each question are designed to be followed in a structured programme. You probably won't have time to do every activity, and they might not all be suitable for your local area, but you should aim to progress from exploring the local environment, to thinking about how the environment is changing now, to consider what Scotland looked like in the past and how what happened in the past has created today's Scotland.

This Teachers' Guide has been produced by the Earth Science Outdoors project, which is developing resources to encourage and support outdoor learning within the Curriculum for Excellence (CfE). All our resources are available free from our website, and teachers are welcome to use and adapt them.

The activities are designed to be undertaken outdoors, but some can be classroom activities and we've also included links and ideas for complementary classroom activities. We intend to develop this resource further, and we welcome feedback, suggestions and examples of how you have used the guide. Contact us through the SESEF website www.sesef.org.uk.

Before you go

Involve the children as much as possible in the planning and preparation required for each venture outside:

1. Follow the Scottish Outdoor Access Code . Scottish Natural Heritage have a pack called “Know the Code Before You Go”, with a range of activities that can be undertaken prior to any series of trips or visits off-site.
2. Undertake a risk-benefit assessment. This is a useful activity to undertake with children too, so that expectations around behaviour and safety can be discussed and agreed.
3. Explore the local neighbourhood by yourself first, to plan the best places to go: but be open to suggestions from pupils, who may know special local places you don't!
4. Follow your school's health and safety policy and guidance about undertaking activities off-site. Ensure you have enough adults to supervise the activities. There is a school grounds activity in each section, so that you can alternate groups going off-site if necessary.

Big Questions	Key CfE Outcomes ...	Activities ...
1: What does my local landscape look like?	SOC 0-07a I can explore and discover the interesting features of my local environment to develop an awareness of the world around me. SOC 1-07a I can describe and recreate the characteristics of my local environment by exploring the features of the landscape.	1: Explore the local area 2: Visualising and sketching the local landscape
2: What's beneath my feet?	SOC 1-14a Through activities in my local area, I have developed my mental map and sense of place. I can create and use maps of the area. SCN 2-17a Having explored the substances that make up Earth's surface, I can compare some of their characteristics and uses.	3: What's down that hole? 4: Finding a special pebble: "everybody needs a rock" 5: Which one's mine 6: Group sorting 7: A Rocky Scavenger Hunt
3: Why is the landscape shaped like this?	SOC 2-14a To extend my mental map and sense of place, I can interpret information from different types of maps and am beginning to locate key features within Scotland, UK, Europe or the wider world. SOC 2-07a I can describe the major characteristic features of Scotland's landscape and explain how these were formed.	8: How tough is your rock?
4: Where can we find active processes that show change is happening now?	SOC 1-07a I can describe and recreate the characteristics of my local environment by exploring the features of the landscape. SOC 2-07a I can describe the major characteristic features of Scotland's landscape and explain how these were formed.	9: Weathering Detectives 10: Erosion and Deposition
5: Has Scotland always been like this?	SOC 2-02a I can interpret historical evidence from a range of periods to help to build a picture of Scotland's heritage and my sense of chronology. SOC 2-07a I can describe the major characteristic features of Scotland's landscape and explain how these were formed. SCN 2-17a Having explored the substances that make up Earth's surface, I can compare some of their characteristics and uses.	11: Geological Timeline: Scotland's story 12: Stories from the past – what did your area used to look like?

Big Question 1: What does my local landscape look like?

The activities associated with this Big Question take you out of the school to explore the local landscape. By experiencing the shape of the land directly, you can discover the high ground (where there might be good views) and the low ground (where there might be ponds, rivers or the sea). As you explore you should also start to think about what lies *beneath* the landscape and look for further opportunities to explore this.

Activity 1: Explore the local area within walking distance of your school

Learning intention:	I am learning to explore an area
Success criteria:	I can use a map to help me I can identify at least 3 different natural features of my local area I know and can recognize the difference between natural and man-made features
Equipment:	Digital cameras – at least one per group Clipboards (A3 size good for younger children and those with motor difficulties) Pencils and paper (use masking tape if needed to add additional security in windy weather or for young children) Maps – see <i>Primary Earth Science Outdoors - Resources</i> for more information on sources of maps

In class preparation:

- 1) Explore maps of the local area with the children before going outside. These could be a mixture of street maps, Ordnance Survey maps (the bigger the scale the better), online maps and satellite views. Identify local natural features on the maps, such as slopes, rivers, beaches, cliffs, hills.
- 2) Consider what you will be looking for when you go outside. Distinguish between natural and man-made features. But point out that man-made features such as steps and bridges often tell us about the shape of the land below. Look at pictures of typical landscape features (e.g. Figure 1 - these are available as separate image files from the SESEF website www.sesef.org.uk so that you can print or display on screen; we welcome further contributions to our web images showing examples from your local area).
- 3) Plan what you are going to do when you go outside. Consider what is possible in terms of exploration and where the children are interested in going: try to visit at least 3 or 4 natural features. Can you split the class into smaller groups each covering a different area, to allow each group to record and present their findings to others? Four groups could set off in a different compass direction, or you could choose parts of a defined area (e.g. 1 km square) around the school, or you could set off uphill to the nearest high point in the landscape or downhill to the nearest low point.

The activity:

Each group walks the agreed route, looking for, discussing, photographing and sketching features of the local landscape. With older or more able children, they could work out a grid reference for each feature (or see *Primary Earth Science Outdoors - Resources* for ideas on using portable digital devices to track your route).

Encourage the children to work out where they are on a map as you go along their route, using landscape features to help them. The adults with each group can encourage exploration by dividing the group into two or three teams and award points to the first team to spot a particular feature.

Ways of recording each feature can be more than sketching or photographing. Children can record their thoughts about a feature through words, e.g. a kennings poem (a 'kenning' is a two-word metaphor), noting three adjectives that describe the feature, a simile to describe the feature.

Back in the classroom:

Children can share their work with the other groups. They might write poetry, create a Powerpoint presentation, make a personalized book about the features seen, create a journey line, or come up with their own ways of sharing their local landscape.



A: Flat parkland



B: Gentle grassy slope



C: Cliff



D: Steps up a steep slope



E: Bridge over a small river



F: Building made of stone



G: River and valley



H: River estuary at low tide

Figure 1: Some landscape features you might find in your local area

Bring together the different routes you have explored to build a picture of the shape of the local landscape. You could work together to make a large 3D model of the local area, or each pupil could draw their own local map. Keep the focus on the shape of the land, although you might want to add features such as their walk to school to help them visualise what the map means in real life.

If you have found a local stream or river, follow it on a map to trace its route across the landscape. You can then widen the perspective to consider other rivers in Scotland and the general shape of the land.

Activity 2: Visualising and sketching the local landscape

In Activity 1 you have discovered the general shape of the local landscape. Now encourage the pupils to choose, as a group, a good spot to return to and explore the shape of the landscape in more detail. This needs to be a place where it will be enjoyable (and safe) to spend a bit of time and where there is a good view. Ideally there will be a range of landscape features visible e.g. slopes, low ground, high ground, perhaps with a view of mountains or hills in the distance.

Activity 2a: Camera

Learning intention:	I am learning to observe my surroundings
Success criteria:	I can notice details in close up objects I can observe key features when looking at the wider landscape I can observe objects and features from a variety of different positions and angles
Equipment:	None

This activity is described in Joseph Cornell's book *Sharing Nature with Children*, Volume 2 and was adapted for the TeachingSpace website <http://www.snh.org.uk/TeachingSpace/whattodo/landscape/camera.asp>.

It is a good introductory activity to get children of all ages thinking about either close up objects or more distant landscape. It is easy to do in a school ground, it works well with children who are less used to working outside, and makes a good lead-in to the more detailed Activity 2b where you will spend time sketching outdoors.

The Activity:

Choose a site where the players can view the surrounding landscape and make choices about which way they can look. The children work in pairs. In each pair, one player takes the role of photographer, and the other plays the camera. The photographer guides the 'camera', who keeps his/her eyes closed, on a search for beautiful and interesting views. When the photographer sees something he/she likes, he points the camera's lens (eyes) at it, framing the object he wants to 'shoot'. Then he presses the 'shutter button' to open the 'lens'. Shutter button opening and closing can be done by the photographer tapping her/ his partner's shoulder. For the first picture, it may help for each photographer to say "Open" with the first tap, and "Close" with the second.

It's important that the 'camera' keeps his/her eyes tightly closed between pictures, so that the 3- to 5-second 'exposure' will have the impact of surprise. Encourage the photographers to be creative in choosing and framing pictures. When viewing the landscape, encourage them to take a wide view. But you could also ask for an ant's eye view of the landscape, to encourage them to look at the detail – for example a close-up of tree bark, or from an unusual angle. The preferred 'exposure time' (i.e. eyes open time) is 3 to 5 seconds, to maintain the camera player's concentration.

Suggest photographers take a certain number of pictures, e.g. five, then trade places with their partners.

After everyone has played both roles, give each player a 3 x 5 index card and tell them, "Remember one of the pictures you took when you played camera. Develop it by drawing it, and give it to the photographer." Alternatively, they could take a permanent record with a digital camera, for follow-up back at school.

Why sketch? Some background information and ideas

Sketching is an important fieldwork skill. Digital equipment has added much value to ways of capturing and recording what we see around us, but should never replace drawing altogether.

Sketching and drawing are valuable science skills to help us think, invent and communicate - regardless of our age or ability. It provides an alternative to language for recording and describing and leads to understanding and explanation.

Spending time making a sketch of the landscape helps children to:

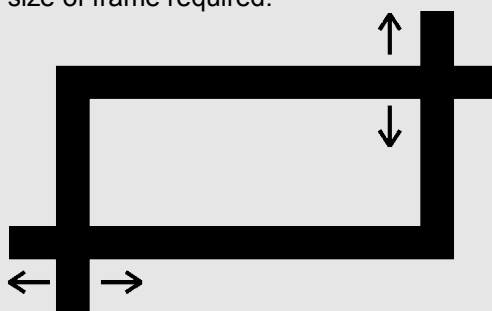
- Connect with their local environment
- Understand how it is shaped and managed
- Respond to the world around them in a personal and emotional way that is important for developing a sense of place and belonging
- Identify environmental issues and become aware of the need for change and improvement
- Improve their observational skills as objects or landscapes are studied for longer periods of time
- Be still and calm outside. This helps children reflect upon what they see and gives them time to formulate ideas and questions that help them make sense of what they experience.

Some tips to help sketching:

- A3 size clipboards work best for small children or those with motor difficulties as the elbows and forearms can rest more easily on the board.
- If it's windy, use masking tape and ensure children stick their paper onto the clipboard before going out.
- Take spare paper and masking tape on your trip with you.
- Always have a few extra drawing challenges ready for those children who finish quickly (see below)
- The younger the children the less time they will be able to spend on sketching as a general rule.
- The children will get cold if they sit for long periods of time. Keep the sketching sessions short and get children moving around before and afterwards. If you are in the school grounds, blankets and sleeping bags can be taken outside to keep children warm.
- Have portable seating mats so it is comfy and warm when sitting.
- Regardless of age, children should carry their all own equipment in their own bags and take responsibility for bringing it all back to school. This develops their independence.
- A view frame can help children to frame the landscape or object to be drawn (Figure 2). You can make a simple frame by cutting a rectangle out of a sheet of A4 card. Or give each pupil two L-shaped pieces so that they can decide on the size of frame required.



Simple frame from A4 card



Frame made of 2 L-shaped pieces can be adjusted

Figure 2: different types of view frame

- There is a wide choice of materials to use for sketching. Lead pencils are fine and good for sketching. Acetate sheets and whiteboard marker pens are fine in dry weather.
- Sketching outdoors can be followed up with many arts related indoor work that presents scientific concepts in a creative way.

Activity 2b: Sketching the local landscape

Learning intention:	I am learning to sketch what I can see
Success criteria:	I can make an accurate drawing of the feature and/or landscape I can annotate my sketch highlighting natural and man-made features I can work quietly and independently on my sketch
Equipment:	Clipboards, paper, masking tape, pencils, view frames

To sketch a landscape, the best place is to find somewhere with a view. This is usually on or at the top of a hill. However sometimes a gap between buildings or a break in a forest can work well too.

Before children undertake a landscape sketch, it is helpful if they know some relevant terms appropriate to their age and ability: slope (concave and convex), foreground, vegetation, farm, boundary, horizon, back ground, etc.

Demonstrate what you are looking for from the children in terms of drawing and annotating and the purpose of the exercise. Having a prepared example helps. Also when outside, be prepared to demonstrate how to use a view frame.

There are 3 main parts to sketching:

1. Decide upon the view. Are the children focusing on a specific feature or a general landscape? Use a view frame to assist. Children generally prefer some choice, and different people will see and focus on different features.
2. Draw the view or feature. You will need to provide guidance and feedback here.
3. Annotate the sketch. Label what has been drawn. Remember to use a compass to note down which direction you are facing.

Get the children to look at the key shapes or forms. Look for hills and valleys, slopes, curves, running or standing water, etc.

What signs of human activity can you see? How has this been affected by the landforms?

What rock is present and where? Natural forms, e.g. rock outcrops, stones at the side of a path or put there by humans, e.g. buildings, walls, etc. Look for evidence in the foreground, mid and background.

Is the scale of the landscape large (e.g. distant views/mountains/seascape, broad river valleys) or small and intimate (close up features such as trees/plants/bushes/ponds/buildings)?

Activities to support sketching

Children will finish their sketches at different times. For those that finish first you can extend the activity by:

- If the children have been sketching distant views, get them to do another sketch of an object close at hand. The view frame can be laid on a patch of ground or around an object, e.g. a flower or tree stump.
- Hand out mirrors or Fresnel lenses and ask the children to draw what they see through these.
- Make a 3D landscape on the ground. Ask children to scrape out a rectangular frame on some earth or create a frame out of stones or sticks. Using natural materials, they can create the landscape they see in front of them. It can be flat or model-like.

Big Question 2: What's beneath my feet

The Story for Teachers

Scotland's natural landscape reflects the rocks beneath. Everywhere underneath Scotland – buried under soil, streets, buildings, parks – there is solid rock, the 'bedrock'. It is a big imaginative leap for children to start considering what is beneath their feet, beneath the bottom of the loch or the bottom of the sea. It is also quite unusual to see what is beneath all these things. We need to help children to explore (safely) what is beneath the surface and understand that, wherever in Scotland they dig, they will eventually find some kind of solid rock. This rock plays a very important role in the shape of our landscapes and many other aspects of our lives.

But what is rock? It's worth exploring this. Is a piece of brick a rock? A piece of glass? A shell? Broken crockery? A sapphire? It's not always easy to say. But pupils will (hopefully!) agree that a piece of wood is not a rock. Why? We tend to think of rock as something which is solid and, well, not obviously anything else. There is no easy definition. It is OK to allow pupils just to explore the idea, perhaps agreeing that rock is solid (at the temperatures of the Earth's surface) and natural, not human-made (though it might be used by humans) and not a dead organism (though coal and limestone contain the remains of dead organisms). There are important literacy and science messages here about the inadequacies of the English language, and probably most languages, to fully express what we want to say about some 'obvious' things.

There are many different types of rock; later Big Questions get more into the detail of classifying rocks according to how they were formed (main categories are igneous, sedimentary and metamorphic, see below). In the activities in this Big Question we explore rocks based on first-hand observations about how rocks look and feel. That is a piece of science that pupils can do. The 'heaviness', colour, patterns, feel (rough/smooth) are all observable characteristics, and a plastic hand-lens or magnifying glass would reveal even more. Pupils will come up with different classification schemes, which is important because science is a process of enquiry and is not always about 'finding the right answer.' Any classification scheme is 'right' as long as it works. The reason we all use the same classification is not because it is the best but because we need to agree on something in order to communicate with each other about it.

Activity 3: What's down that hole?

This activity takes us from thinking about *what* the landscape looks like to asking *why* the landscape looks like this? Crucial to this is an appreciation that the shape of landscape is closely linked to the rocks beneath.

Activity 3a (outdoors): Dig a hole, or find a hole

Learning intention:	I am learning about the earth beneath my feet
Success criteria:	I can recognize that there are different layers of soil I can self-assess the risks around digging and being in a hole I know and can describe a variety of places where holes exist and why.
Equipment:	Spades, trowels etc if there is a place pupils are allowed to dig.

Anywhere in Scotland, if you dig a hole you will eventually reach bedrock, although practical considerations will limit what can safely be achieved by pupils. **This activity is a good opportunity to reinforce common-sense safety messages about dangers of entering construction sites or digging holes and tunnels (occasionally a child is killed in the UK while digging in sand dunes – e.g. <http://news.bbc.co.uk/1/hi/wales/7540089.stm>).**

If you have a gardening area within the school grounds, perhaps some or all of the pupils could dig a hole. They should find that the soil changes as they dig (Figure 3 shows a typical soil profile) and it becomes harder to dig as the soil becomes more compacted with depth. You can discuss questions such as: How deep is the soil? Can you see the soil changing as you dig deeper? What's beneath the soil? Could I dig a hole like this on a beach? On top of a local hill? On top of Ben Nevis?

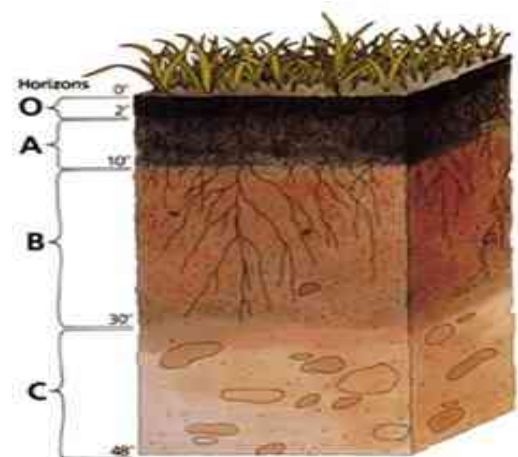


Figure 3: typical soil profile, showing soil and sub-soil (B) overlying a rocky layer (C) derived from bedrock.

Pupils may have previous experience of digging holes and they might have an idea that in some places the soil is thin and bedrock is visible, and in other places the soil is much thicker. Most built-up areas in Scotland are in relatively flat terrain where there is a thick carpet of sand, gravel and soil covering the bedrock.

Next, are there places nearby where you can see what's beneath the surface, either in a artificial hole or a natural exposure? Pupils are likely to have seen holes being dug for road or utility repairs or new buildings. In most cases these holes won't reach bedrock. However you may see clues that there is rock beneath the surface, and it can be seen in stream and river banks, along the coast (Figure 4b) and in places where cuttings have been made for roads and railways.



Figure 4a: excavations show what lies beneath the surface



Figure 4b: natural exposure of soil above bedrock

Activity 3b (indoors): make a model of soil layers

Learning intention:	I am learning about soil and what it is made from
Success criteria:	I can use materials to construct a soil profile I can explain the differences between my model and a real soil profile
Equipment:	Sand, gravel, bits of stone, shells; a small, empty plastic bottle for each pupil

The activity:

This activity can be done indoors. Give each pupil a small plastic bottle with the top cut off, and ask them to build a model of a soil profile using different materials. If you use clean play sand and wash the other materials before use, you can avoid the risks involved in handling soil. Encourage the children to think about how the layers vary from bottom to top, based on what you have observed in part 1.

You could add shells or leaves to the upper layers to mimic the presence of biological material in soil.

Once the soil profile is made, you can experiment with dropping water into the top of the bottle and observing what happens. How long does it take the water to get to the bottom of the bottle? How does the water travel through the 'soil'. What does this tell us about water underground?



Figure 5: model of a soil profile in a bottle.

Activity 4: Finding a special pebble: "everybody needs a rock"

This activity begins the search for your own special pocket-sized pebble (a search that might last a lifetime), and the appreciation that there are lots of different kinds of rock in Scotland.

Learning intention:	I am learning about the variety of rocks that exist in a small area
Success criteria:	I can recognize my rock when it sits amongst other rocks I can describe characteristics of my rock such as size, shape, colour, hardness, etc.
Equipment:	It's worth giving children a range of magnifiers and mirrors to help them explore and find rocks. Younger children need bigger magnifying glasses or Fresnel sheet lenses, whereas older pupils can manage with small yet powerful hand lenses that can fit in a pocket.

The activity:

This activity can be done anywhere, but the more natural a setting the better. Pebbly beaches and river banks are great places to find a selection of local stones or different types and sizes. If you can't go to the beach, bring the beach to the children – collect a couple of boxes of pebbles from nearby and scatter them in the playground!

Once you get to the place where your kinds of rocks are to be found, start looking. It takes time, maybe half an hour or more of just looking, before you even begin to see what's there. Suddenly you will see the first object for your collection. This amazing moment of discovery is repeated for every new addition to your collection. This is sometimes called 'getting your eye in'.

This activity is based upon the book "Everybody Needs a Rock" by Byrd Baylor ISBN 978-1416953975. It is about beginning a lifelong quest for the perfect rock. The book covers 10 basic rules and is a super starting point to searching for a pet rock. If you can't get a copy, try using these ideas and rules based upon the book:

1. Do not tell anyone what is special about your rock and don't let anyone choose your rock for you.
2. Any place will do to start searching.
3. Don't worry – it's the worst thing you can do when you are rock hunting.
4. Was everything quiet when you found your rock?
5. How closely did you look at your rock? Check it out with a magnifying glass.
6. Is your rock the perfect size? Can you close your fingers over it? Does it jump about in your pocket when you run?
7. Is your rock the perfect colour? How do you know?
8. Put your rock in the middle of other rocks. Then stand it on its own. Does it look good and special in both instances?
9. What does your rock smell like? Which part of the earth did it come from?
10. What game can you play that involves just you and your rock?

Once everyone has found a special rock (some may need eventually to simply find any old rock!) you can follow on to the next activities.

Activity 5: Which one's mine?

This is a quick and simple activity which helps children to focus on basic properties of rocks and their variety.

Learning intention:	I am learning about the variety and characteristics of different rocks
Success criteria:	I can recognize my rock by how it feels I can work with my group to complete the activity
Equipment:	One rock per person. It might be best <i>not</i> to use the special ones found in Activity 3: there is a danger of a child not getting the right rock back or squabbles developing between children with similar rocks. We speak from experience!

The Activity:

Each person spends a short time exploring the qualities of their rock: look at it, feel it, smell it and get to know its distinctive features. The group then sit in a close circle with their rock behind their backs (or everyone can be blindfold). On the count of three, everyone passes their rock clockwise to the next person and receives a new rock to feel. They keep the new rock behind their back and continue passing around the specimens so that they can be felt but not seen. The challenge is to work out when you have your own rock back!

Activity 6: Group sorting

Start to explore some of the properties of rocks and how to describe them.

Learning intention:	I am learning to classify objects
Success criteria:	I can choose different criteria for sorting rocks I can sort a selection of rocks according to their properties/characteristics
Equipment:	Measuring tapes, a nail, perhaps a rough file (a tile file works well), magnifying glasses If your school grounds or local area does not have rocks and stones which can be gathered, then have a basket of rocks from which children can choose one. This "Describing Rocks" sheet can be helpful: http://www.knockan-crag.co.uk/downloads/Rock%20identification%20-%20describing.pdf

The Activity:

First, give the children an opportunity to find a rock, or use their "special rock" found in the activity above.

Then, ask the children to sort themselves into a line according to a specific criteria about their rock. e.g.

- The biggest to the smallest. The child with the biggest rock at one end. The child with the smallest rock at the other end. Everyone else in their correct place going from biggest to smallest.
- The hardest to the softest rock.
- The smoothest to the roughest rock.
- The rounded to the most angular or jagged edged rock.
- The darkest to the lightest colour of rock.

It is important to let the children talk whilst doing this activity. It is the discussions around whether a rock is bigger in length or width or circumference or discussions about specimens with a variety of shades which aids understanding. It could be that the children decide that the criteria need to be more specific, ie "largest to smallest length" rather than "biggest to smallest" rock.

Do this activity several times using different criteria. Let the children use any equipment listed above to help them decide the line order and close observations of their specimens.

Finally you can get the children to sort themselves into groups of similar rocks and get them to justify their decisions. These can be illustrated as a geological Venn diagram on the ground using chalk to group similar rocks.

Activity 7: A Rocky Scavenger Hunt

Another approach to focusing on properties of rocks and the variety you find when you start to look.

Learning intention:	I am learning to recognise the variety and characteristics of different rocks
Success criteria:	I can find rocks that match the criteria/description given I can explain the reasons for my choice of rocks
Equipment:	A list of rocks to be collected (for young children this can be held by the adult).

The Activity:

This activity can be done on the beach, in a park or even in a school ground. If you are short of stones in your school grounds, then you can import them and scatter them carefully around different places. The list can be shortened or made more challenging to adapt to your local circumstances. If you don't want a huge collection of rocks, get the children to work in groups or pairs to find each rock. Alternatively the children bring their rock to show an adult and then put it back before getting the next rock. Try to find a:

- Sharp rock (don't cut yourself!)
- Rock with only one colour (is this possible?)
- Stripy rock
- Interesting rock – explain why
- Speckled rock
- Rough rock
- Rock which makes you smile
- Smooth rock which rolls
- Rock which can keep a secret
- Shiny rock, or one which glitters
- Dull rock that feels cool on your cheek
- Soft rock which crumbles
- Hard rock bigger than your pinkie
- Flat rock which doesn't move
- Rock that can be thrown far
- Two rocks that look alike
- Bumpy rock that is smaller than your thumb

Big Question 3: Why is the landscape shaped like this?

The Story for Teachers

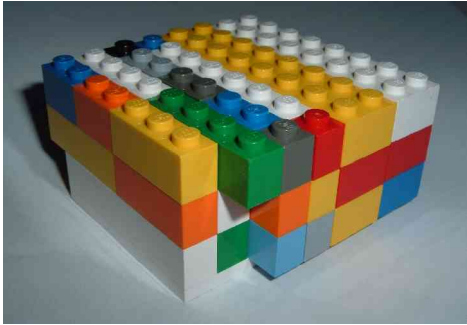
Different rocks are found beneath the surface in different places all over Scotland and the world. Take a look at the poster-sized "Simplified Geological Map of Scotland" (Figure 6) available from SESEF (see *Primary Earth Science Outdoors - Resources*) to find out about your local rocks.

The activities associated with Big Questions 1-3 take you out to explore the shape of the local landscape and find some local rocks. The shape of the landscape depends on several factors:

- **the kind of rock** Some rocks are crystalline and hard to wear away. Others are made of bits cemented together, and break up easily.
- **the shape and size of the rock body** Big, solid rock bodies with no layers or fractures survive erosion better than rocks that have lots of layers which allow the weather and water to get in.
- **how the rock has been eroded** Most parts of Scotland have been wearing away for tens or even hundreds of millions of years. So natural processes have had plenty of time to seek out weaknesses and preferentially erode the less resistant rock. The biggest shaper of the landscape has been the ice ages, when several times in the last million years Scotland has been covered by thick sheets of moving ice.
- **how humans have used the landscape** In the last few thousand years, and particularly in the last few centuries, people have used and changed the landscape. We have extracted rock for buildings, roads and fuel and we have made cuttings for railways, roads and buildings.



Figure 6: Simplified Geological Map of Scotland

Sedimentary rocks ...	Igneous rocks ...	Metamorphic rocks ...
are created from loose sediment (e.g. pebbles, sand, mud) that accumulates at the surface and gets buried. They usually have layers and get eroded quite easily	form from magma that comes from deep beneath the surface. The liquid magma cools and crystallises to make tough rocks.	start off as either sedimentary or igneous, and get changed by heat or pressure to make new rocks. This happens when continents collide, for example. Metamorphic rocks are crystalline and tough, and sometimes layered.
		
Figure 7: Simple 3-D models of rocks. Left: In sedimentary rocks individual grains are weakly cemented to their neighbours. Right: Crystalline igneous and metamorphic rock, with interlocking crystals making tough rocks that are resistant to erosion.		

Scotland's four main rock types and the landscapes they create

There are hundreds of different rock types in Scotland! But there are a few that are very common and are responsible for much of Scotland's scenery.

HIGHLAND

Schist – metamorphic

Schist is formed from the alteration (metamorphism) of sedimentary and igneous rocks and usually contains distorted layers. It has been deformed and changed and ends up being tougher than equivalent sedimentary rocks. White quartz bands are common. Schist forms mountains, with weaker bands (or areas with lots of fractures) often being worn away.



Figure 8a: Schist in Lochaber

Granite – igneous

Granite forms underground when magma cools slowly, giving time for large crystals to grow. As the rock cools it contracts, so that granite often has lots of cracks. Granite is one of Scotland's toughest rocks, forming large mountain masses such as the Cairngorms.



Figure 8b: Granite at Lochnagar

LOWLAND

Sandstone – sedimentary

Sandstone forms from layers of sand that have been deposited by wind or water. Over time the individual grains of sand get cemented to their neighbours. Sandstone is a relatively soft rock, because the cement is weak, easy to dissolve or break. It is great for carving to use as a building stone.



Figure 8c: Layered sedimentary rocks, Edinburgh quarry

Basalt - igneous

Basalt forms when volcanoes erupt and the lava spreads out, cools and crystallises. This happens so quickly that the crystals tend to be microscopic. These crystals interlock to create a tough rock.



Figure 8d: Basalt lava flows on the island of Staffa

Activity 8: How tough is your rock?

Explore samples of your local rocks to find out how good they are at “resisting erosion”, and make the link between rock type and the shape of the surrounding landscape.

Learning intention:	I am learning to undertake a scientific experiment
Success criteria:	I can understand vocabulary linked to this experiment such as resistance and erosion I can design and carry out an experiment which enables me to put the rocks in order of resistance. I can explain how the landscape is shaped by the resistance of rocks
Equipment:	• selection of local rocks (ideally ones that the pupils have collected themselves) • tough, plastic container with a wide neck and screw-on top • a tough file (e.g. a tile file) • emery paper • geological map of Scotland and if possible of the local area • similar maps showing hills / contours

The Activity:

Revisit the rocks that you have found in the local area. How could we choose the best rock for a particular purpose, e.g. to build houses or a sea wall to prevent flooding during a storm?

How could we predict which rock might be from mountains and which from low-lying areas? Note that the presence of equipment like files and emery paper will prompt answers so you may want to conceal/reveal this depending on how open a discussion you have time for. Try to use the words ‘resistant to erosion’ rather than ‘hard’ which is likely to be used by pupils. Consider the risks, for example to eyes, of filing / shaking rocks and producing rock dust.

Ask your pupils to design and carry out a short investigation/activity which might allow them to put the rocks they have in order of resistance. This might involve visual examination, scratching the rocks with a metal nail, filing them or rubbing with emery paper. They might consider shaking the rock samples in a closed plastic container (individually or together) and looking at the shapes of the fragments before and after shaking, or by judging the amount of powder produced. If a sensitive balance is available, accurate measurements of the loss of weight of each rock type could be made. The debris produced by each rock is easier to compare if each type of rock is shaken in a separate container, or if the rocks are of different colours.



Figure 9a: sandstone scraped with a file



Figure 9b: small pieces of sandstone shaken in a container

Concluding Discussion:

- Which rocks did you find were the most resistant? How do your findings compare with the rest of the class?
- Why? Explore what rocks are made of – it is the properties of rocks at a small scale that largely determines what happens when they are eroded. You might like to discuss the simple models in Figure 7 or devise your own models to explain your results.
- Which rocks are most likely to form hills or headlands in coastal areas? The more resistant rocks form hills, islands and headlands.

- Use a geological map of Scotland to explore the relationships between high (e.g. the Highlands) and low ground, and different types of rock. Most of the Highlands are underlain by tough metamorphic and igneous rocks that resist erosion better than the sedimentary rocks of the Lowlands.
- Can the underlying geology explain the landscape of your local area? Yes, but it is sometimes complicated! For example, the presence of a valley does not necessarily mean that it is underlain by a different rock. It may be that a glacier gouged it out, perhaps guided by a fault which made the rock locally less resistant.



Figure 10: The Ochil Fault near Stirling illustrates the contrasting resistance to erosion of igneous rocks (lava flows on the left) and sedimentary rocks (underlying the low, flat ground in the foreground).

Ideas for follow-on outdoor activities that use rocks and pebbles:

- Chalk is a particularly soft rock (you could show photos of the white cliffs of Dover, which are made of chalk that is rapidly wearing away). Make pavement pictures, or chalk poems about rocks outside on the ground. Take photos before rain or feet wash away the results. Have an outdoor gallery!
- Inuksuk are stone landmarks built by native peoples of the Arctic region of North America. They may have been used for navigation or to mark hunting grounds. You can make your own Inuksuk at key points around your school grounds to guide people to interesting landscape or focal points. For more information, buy the book *Make your own Inuksuk* by Mary Wallace or see http://www.creativekidsathome.com/activities/activity_30.html#How%20to%20make%20an%20Inuksuk
- Teach children how to play chuckies with pebbles. This can be played alone, in pairs or as a small group. There are many variations of the game; this is one simple version: Each child takes it in turn to throw a pebble into the air and pick up one (or more pebbles) before catching the first one. He stores the pebbles he catches and plays again. When he lets a pebble drop, he loses his turn. The person collecting the most pebbles wins.
- Create miniature worlds using rocks and pebbles. To keep it really on theme, make it the “Land Before Time” and have a few dinosaurs ready (see Activity 12). These can be completed in nooks and crannies or on trays which can then be stored inside if necessary. But the activity is best done outside, with mud and clay at hand to create volcanoes, mountains, etc. Have ferns or other plants to add interest too.



Figure 11: An Inuksuk at English Bay, Vancouver
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Ideas for follow-on activities for younger children:

- Make trails to follow around the school grounds.
- Make rock pets by painting and decorating.
- Use decorated pebbles to invent stories.
- Put rocks into a transparent container, fill with water and observe the differences.
- Draw and mark using stones on rocks or tarmac.
- In the digging area, dig the deepest hole. This may be a project that lasts several days. The challenge includes finding rock and other treasures in the soil and reaching the subsoil below.
- Play hide ‘n’ seek with rocks.
- Carefully drop different rocks onto a hard surface outside. Listen to the different sounds they make.
- Build cairns or piles of rocks. See how high you can get.
- Rocks can be valuable treasures in imaginative role play.
- In the outdoor sandpit provide a selection of rocks of different sizes and some rakes. The children can make their own Zen Gardens. Have photos of actual Zen Gardens for inspiration. The iPhone has a

Zen Garden app which can complement this activity.

- Provide different sized containers. How many stones can you fit into each container? Which container has more / less? How many stones do we need to put into this container so that both containers have the same amount?
- Many children love throwing stones. Teach them to do this *safely*. This will help them judge distances between themselves and other objects in space. Let them take turns to throw stones into a bucket of water, a puddle or large body of water. Ensure there is plenty of distance between the child and other people, buildings, windows, cars, etc.

Big Question 4: Where can we find active processes that show change is happening now?

The Story for Teachers

The activities associated with this Big Question help pupils appreciate that the Earth is a dynamic planet and the present landscape is a result of the action of natural processes over a long period of time. By going out and finding examples of where change is happening now, they can begin to appreciate the long story of change that has resulted in the present landscape.

Weathering is the physical breakdown and chemical decomposition of rocks over time. Some of the products of weathering are dissolved and removed in water. The rest are just loosened bits of solid rock, which might then be affected by **erosion** – the removal of this loose material. There are several main ‘agents’ of erosion. They include gravity, wind, waves, rivers and glaciers. In most cases, air and water don’t do much erosion on their own. They work on the landscape by moving already weathered bits of rock against rock surfaces. It is this ‘rock on rock’ contact with the landscape which causes it to erode. Most of our own efforts at erosion work the same way: we supply the movement of sandpaper, but it is the solid material stuck to the paper that does the sanding. When we use high-pressure sandblasting to remove paint, we are using air to fire solid particles at the surface and these do the eroding.

**WEATHERING =
breaking rocks up**

**EROSION =
transport of loose
material**

Weathering and erosion are key geological processes. This is what moves mountains and these processes are responsible for the shape of the surrounding landscape. Finding small local examples of change can lead pupils along the path of imagining how Scotland has changed over millions of years, and what these slow processes will do to Scotland's walls, playgrounds, buildings and mountains in the future.

Activity 9: Weathering Detectives

Find examples of small-scale change in the local environment caused by natural forces.

Learning intention:	I am learning about weathering processes
Success criteria:	I can find examples of small-scale change caused by the agents of erosion I can discuss the impact of weathering on human activity and the landscape
Equipment:	Digital cameras, maps for each group.

The Activity:

Weathering processes are the key to finding examples that show change is happening all around. By looking for this evidence in the local neighbourhood, children can identify the types of weathering and its impact. It is often small scale.

Physical weathering:

- Cracked or uneven paving stones.
- Loose or missing roof slates.
- Bricks and stones on buildings crumbling when rubbed.
- Fine sand and silt gathering near a drain.
- Rock fall at the bottom of a cliff.
- Ice in cracks in rocks.



Figure 12a: Physical weathering of the edge of a path. Many of the kerbstones have been removed by 'erosion'.



Figure 12b: Physical & chemical weathering of a gravestone



Figure 12c: Physical weathering of a sandstone cliff



Figure 12d: Different building stones weather at different rates: granite is more robust than sandstone



Figure 12e: Physical weathering of a school wall, plus chemical weathering of a railing



Figure 12f: Biological weathering by moss growing in cracks



Figure 12g: Biological weathering by trees: roots opening up a crack in a rock and trunks pushing against a wall.



Figure 12h: Chemical weathering of the rock above creates stalactites in a cave roof

Figure 12: examples of different kinds of weathering

Biological weathering:

- Weeds growing in cracks, breaking up the stones and soil.
- Roots of trees breaking up the surrounding pavement.
- Growing trees causing walls to bulge and crack.

Chemical weathering:

- Rusting of railings, metal, etc
- Stained and rusty concrete structures
- Stalactites under bridges

Each group should choose a different area of the local neighbourhood to look for signs of weathering and plot them on a map. A trial run can be undertaken in the school grounds, or this can be a focus for one or two groups.

Get the children take photographs of the weathering along their pre-selected route. Note down the place name of each photograph or an aid to remembering where it was taken. For each sign of weathering take a close up photo and a shot from further away which gives an observer an idea of where the weathering is taking place.

Back in the classroom, print out each photograph. Get the class to spread out maps of the route and work out, on the map, where each photograph was taken. Sticky labels or post-its could be used to mark the places on the map where a photograph was taken. For younger children the photo places could already be numbered on the maps, each group would then only need to work out which lettered photograph corresponded to which numbered point.

The photos of each sign of weathering can be displayed as a lift-the-flap card. The close up shot of the weathering is on the front, with a caption. Underneath, the photograph which shows the object or place of weathering. Other classes and groups can have fun guessing where each close up shot is taken.

Activity 10: Erosion and Deposition

Explore one of the Earth's key processes: erosion and deposition to form sedimentary rocks.

Learning intention:	I am learning about erosion and deposition
Success criteria:	I can recognize features of erosion and deposition I understand how these features can change according to the underlying rock and angle of the slope.
Equipment:	sand, mud, soil, plant material, small stones and sticks, guttering, watering cans

If your school has few natural erosion or deposition features nearby, then simulation experiments can be carried out in the school grounds using plastic guttering and watering cans bought from a DIY store. This is an ideal opportunity for children to invent or carry out their own investigations. Younger children will need time to explore the guttering and materials through free play.

Each group has a long length of guttering. Again using a variety of materials, miniature dams can be created and the children gently pour water down the guttering using a watering can. The movement of materials can be observed. The angle of slope can be varied. Children can consider:

- Which materials sink?
- Which materials float?
- Which materials are quickly eroded? Where does the material go?
- Does the angle of the slope make a difference?

A similar activity is to scatter soil containing a mixture of stones and other material (as opposed to finely sieved shop bought top soil) down the guttering. Pour water at the top out of a watering can and watch which parts of the soil are eroded and carried to the foot of the guttering. Ice cubes can also be left at the top of a piece of guttering and the melting and transporting process observed over a period of time.

If your school is fortunate to be located within walking distance of large features such as a meandering river, a gorge or waterfall, a beach or the sea, then it is easy to see the large scale impact of erosion and deposition. Make up a challenge sheet for children to complete in pairs or small groups, e.g.

Why are the pebbles on a beach rounded? Why are the rocks and stones at the foot of a cliff angular? What do you notice about the banks of the river at point X and Y.

If there is an unpolluted nearby stream, then children can have fun in groups damming the stream using different materials. Take care and only do this near streams that are easy to access safely. The children can look around the environment and decide which materials to test, e.g. Mud, sticks, stones, sand, dead plant material or different combinations of the above.

The power of the water will wash away some dams and children can observe the materials as they float or move downstream. Ask the children to consider:

- Which materials get stuck at the sides of the stream?
- Which materials sink?
- Which materials float?
- Which materials are quickly eroded? Where does the material go?

Look at the banks and sides of streams and see which banks are being eroded and where material is being deposited. Remember to leave the stream as you found it after you have finished the dam-building activity.

Big Question 5: Has Scotland always been like this?

The Story for Teachers

Scotland has many different types of rock, formed at different times by various natural processes in different environments. So, the rocks can tell us about Scotland in the past and the environments that existed when they were formed. The idea of “different environments” is an imaginative leap for children who tend to have a limited experience of environments. It is important to try and get them to realise that places with deserts, mountains, huge rivers, tropical forests, warm seas, active volcanoes, or places a few kilometres under the ground do exist and are all really different. That is one level of imaginative leap - a leap from place to place.

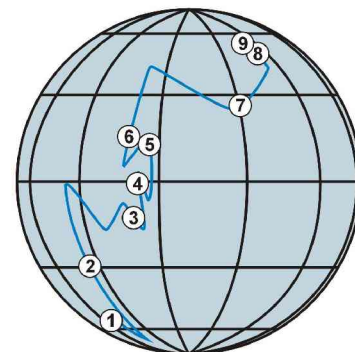
The next level is to imagine that at different times in the distant past, what is now Scotland used to be like these places – a leap from time to time, the idea of change. The many rocks of Scotland preserve a record of these different environments.

Scotland has moved around a lot, very slowly but over a long period of time. Over the last 600 million years, Scotland has journeyed from the Southern Hemisphere, over the Equator and the Tropics to where it is now (Figure 13). It is still moving (away from North America) at the rate that fingernails grow. In this long journey across the globe, Scotland has experienced changing environments, including deserts, tropical forests, warm seas and many others.

Also, some rocks that were formed deep underground (a very different environment) have now appeared at the surface because the rocks that were on top of them have been eroded away.

The activities associated with Big Question 4 helped pupils to discover processes of change that are happening now. These next activities expand the time scale and explore what's happened over millions of years.

Scotland's journey across planet Earth



- | | |
|----------------------|----------------------|
| 1. 600 million years | 6. 270 million years |
| 2. 525 million years | 7. 170 million years |
| 3. 430 million years | 8. 55 million years |
| 4. 365 million years | 9. Present day |
| 5. 300 million years | |

Figure 13: Scotland's Journey

Activity 11: Geological Timeline: Scotland's story

Based on an activity on SNH's website www.snh.gov.uk/teachingspace.

Learning intention:	I am learning about the geological history of the Earth and the relative times at which things happened.
Success criteria:	I can map the key geological time periods along the rope in scale I know the key features of the climate and evolving species in each time period
Equipment:	• 50m length of string or rope • Marker pen and insulating tape • A blindfold • 8 or more players

The Activity:

Scotland's oldest rocks, found in the Outer Hebrides and a thin strip along the west coast, were made an almost unimaginable 3 billion years ago. The standing stones at Callanish on Lewis are made of this ancient gneiss. How old is the Earth? The current best estimate is 4,566 million years (that is 4,566,000,000 years or 4.566 billion years). This estimate may be revised in the future, but is thought to be accurate to within a few million years.

There are many different ways of representing these time scales to allow people to appreciate not just the immensity of geological time, but the order of events (for example, most rocks in Scotland are older than the dinosaurs), and the relatively brief period in which humans have lived on Earth (modern humans appeared about 200,000 years ago). See *Earth Science Outdoors: Activities for all ages* document for more ideas.

There is good potential for numeracy links here, requiring measurements at different scales and calculations with lots of zeros, and revision of terms such as million and billion. In trying to appreciate the great span of geological time there are two common themes – represent geological time with reference to distance (e.g. 1 cm = 1 million years, see below) or by condensing the timescale, so that Earth's history is represented by one day, or one hour (77 minutes is better, with 1 second = 1 million years). Before proceeding with the timeline activity below it is worth exploring this with pupils, and making it as relevant as possible to them. For instance, if 1 cm = 1 year, pupils can draw on a piece of paper a line representing their age and e.g. the time since the second world war, and compare this to geological time that stretches the equivalent of 46,000 km, which is a bit more than the circumference of the Earth (40,000 km).

The timeline activity can be done anywhere in the outdoors - on a beach, school playing fields or whilst visiting an interesting geological site. Place your 50 metre time line along the ground (46 metres represents time in the past and the final four metres represent the next 400 million years). Spread 7-12 people at intervals along the line, and allocate a geological time to each one.

The remaining participants take it in turns to walk slowly along the line wearing the blindfold. The players along the line whisper the stage of geological time that they are at. The walkers experience a sense of the planet evolving and the briefness of human existence.

Change roles so that all players have a turn at walking the timeline. Finally, ask the group to walk along the line into the future: what do they see?

Preparing the time line: Using 46 metres of rope to represent Earth's history gives 1 m for every 100 million years, 1 cm for 1 million years and 1 mm for 100,000 years. One end of the string represents the formation of the Earth; 46 m is the present day – and your 50 metre long time line continues 400 million years into the future! Prepare the time line by marking the stages onto the rope using 'flags' of insulating tape and labelling the flags with a permanent marker pen.

A 23 m rope might be more practical (able to be stretched around a classroom for example), with 50 cm representing 100 million years or 1 cm representing 2 million years.

Key stages during Earth's evolution:		
Time (million years ago)	Distance along 50 metre time string	What was the Earth like?
4,600	0 m	Earth & Solar System created
4,400	2 m	Creation of the moon
3,500	11 m	Earliest known life
2,900	17 m	Oldest rocks in Scotland
2,000	26 m	
400	42 m	Plants colonise land; the first land animals were similar to scorpions.
200	44 m	Dinosaurs and the first birds appeared.
65	45.35 m	Meteorite impact and extinction of the dinosaurs
0	46 m	Present day (200,000 years of modern humans equals 2 mm)
400 m.y. Into the future	50 m	What do you think? The continents will all be in different places, the Atlantic Ocean will have disappeared and Scotland will be at a different latitude. See the animation at http://www.scotese.com/futanima.htm

Activity 12: Stories from the past – what did this area used to look like?

Learning intention:	I am learning about Scotland's past environments
Success criteria:	I can create a model of Scotland in a different time period that reflects the landscape and climate I can use materials and resources available to make a model
Equipment:	Different kinds of local rocks. Pictures of different modern environments to help visualise what Scotland was like in the past. Art & craft materials to allow pupils to represent past environments.

The Activity:

Explore the stories of the rocks of your local area – what do they tell us about the past? Focus on perhaps 2 or 3 different kinds of rock that are found locally. For example, in the central belt you might choose sandstone, coal and lava, which have all formed in a different environment. In the Highlands, you might choose granite, schist and sandstone. Figure 14 shows some typical Scottish rocks along with examples of what the environment might have looked like when these rocks were forming.

Use geological maps (see *Primary Earth Science Outdoors - Resources* for sources) to find out what rocks are found in your local area and their approximate ages.

Work in groups or individually to prepare a series of images reflecting how your local area looked in the past. You might want to make some of these images outside, for example drawing with chalk in the playground, drawing in the sand on the beach, or making collages using natural materials. You might want to start with individual sketches that are inspired by looking at photos or artists' reconstructions of past environments.

You could follow on from images to three-dimensional models, or "rock gardens" including plastic animals, erupting volcanoes, etc.

Key stages in Scotland's story:	
Time (million years ago)	What was happening in Scotland?
630	Snowball Earth – Scotland near the South Pole
520	Most of Scotland under water
470	Continents colliding to form a large mountain range across Scotland – the Caledonian Mountain chain may have been the size of the modern Himalaya.
420	Big explosive volcanoes e.g. Glencoe.
340	Mountains in the north, eroding away with large rivers carrying sediment southwards. Volcanoes in the central belt e.g. Arthur's Seat. Coal swamps.
250	Desert conditions across Scotland. Early dinosaurs.
60	Volcanic eruptions along the west of Scotland – Arran, Mull, Skye. Dinosaurs had recently become extinct. North Atlantic Ocean starting to open.
1.5	Scotland covered in ice many times as ice ages came and went.
20,000 years ago	Peak in last ice age, the whole of Scotland under ice and the North Sea was mostly dry land. In the following few thousand years the ice started melting and sea level rose.

SCHIST
450 million years old



Colliding continents 500-400 million years ago helped create many of the metamorphic rocks of Scotland. The giant Caledonian mountain chain has been mostly worn away so that rocks formed deep beneath the surface are now exposed.



GRANITE
420 million years old



As the continents collided there was a lot of volcanic activity: the results are still visible in places like Glencoe and the Ochils; elsewhere all that is left is the granite formed where magma cooled underground.



OLD RED SANDSTONE
380 million years old



After the continental collision, Scotland was land-locked and located in the desert zone south of the equator. The mountains eroded fast, forming great piles of sedimentary rocks to the north and south.



Image by Mark Wilson, in the public domain

Figure 14: Examples of Scotland's rocks and the environments where they were formed (continues over)

BASALT
350 or 60 million years old



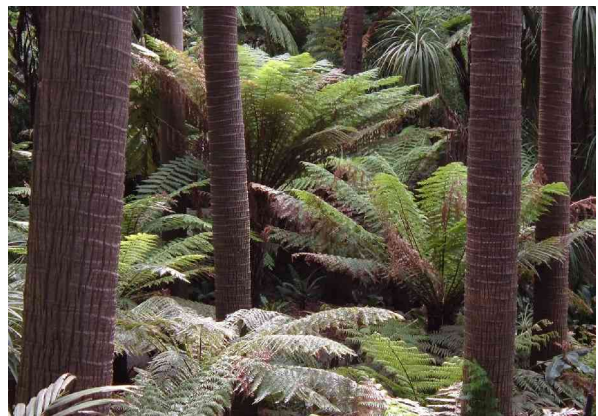
Scotland has experienced two intense periods of volcanic activity when red basalt lavas have poured across the landscape. Around 350 million years ago the volcanoes stretched from Fife to Ayrshire. Then later, 60 million years ago, there were volcanoes along Scotland's west coast.



COAL
300 million years old



Scotland was close to the equator in the Carboniferous Period, and the central belt was low-lying and occasionally flooded by the sea. Forest of tall trees grew in swamps, and the remains have been preserved as thin layers of coal.



NEW RED SANDSTONE
250 million years old



Scotland continued its northerly journey, leaving the equator behind and entering the northern desert zone, where the wind created giant sand dunes, now preserved in red sandstones in places like Dumfries.



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Figure 14: Examples of Scotland's rocks and the environments where they were formed (continued from previous page)

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Scottish Natural Heritage
All of nature for all of Scotland



THE UNIVERSITY of EDINBURGH



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