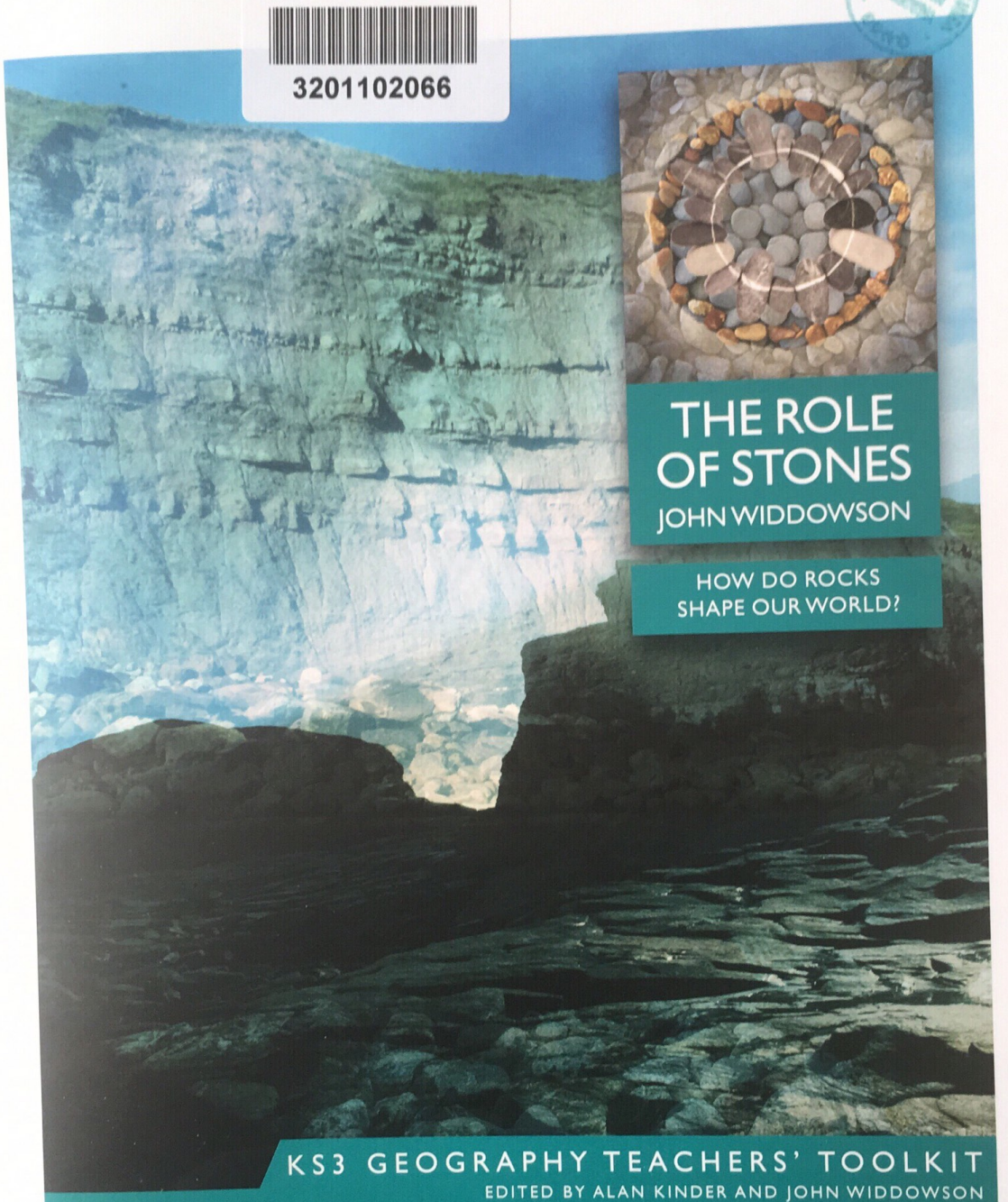

THE ROLE OF STONES

JOHN WIDDOWSON

HOW DO ROCKS SHAPE OUR WORLD?

KS3 GEOGRAPHY TEACHERS' TOOLKIT

EDITED BY ALAN KINDER AND JOHN WIDDOWSON

Geographical Association

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EDITORS' PREFACE

The *Key Stage 3 Geography Teachers' Toolkit* series is designed to help teachers create an exciting and challenging curriculum for their students by building geographical knowledge, ideas and skills into the exploration of important places, themes and issues around the world. The series provides guidance to teachers of geography to help them manage each new curriculum challenge with confidence.

We are delighted to be undertaking a major expansion of this award-winning series. The world around us is ever-changing; so too are the demands of the geography curriculum! The first new additions to the series explore the emerging economies of Asia, delve deep into the geology of Britain, visit remote and extreme glacial environments and enquire into the way in which human use of resources places an increasing strain on our planet.

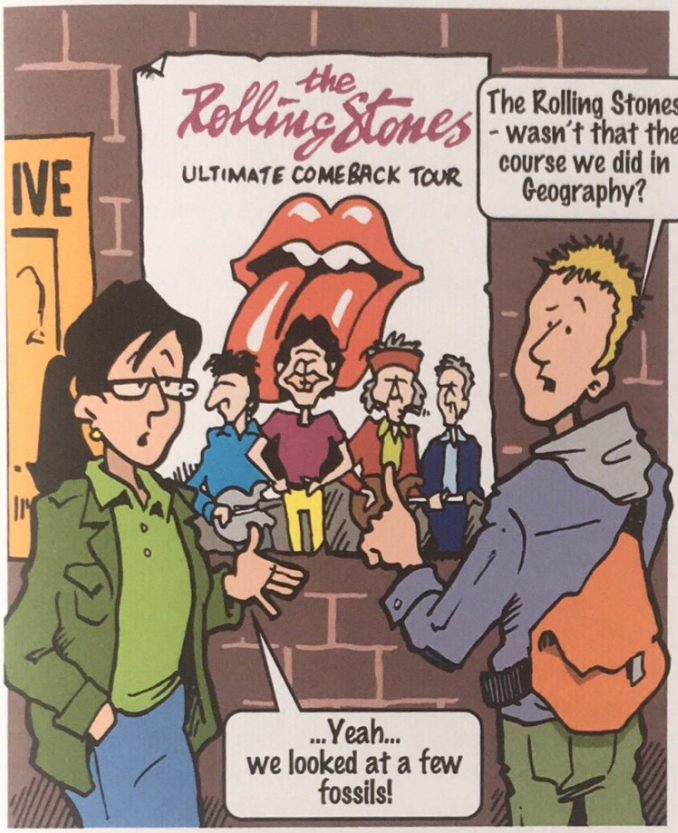
Each title in the series, written by outstanding teachers of geography, provides a complete unit of work: a bank of ready-made lesson plans with downloadable activities and resources to bring the real world into your classroom.

For busy teachers of geography, each *Toolkit* provides material for immediate and direct use with students with minimal preparation. Materials can also be adapted and extended. Each book explains how teaching strategies have been applied to a particular curriculum context, providing a rich source of teacher-to-teacher advice. Links to further resources and reading encourages even the highest-attaining students to be challenged.

The series also provides a template for writing new curriculum materials. Unit summaries, curriculum maps linked to geographical knowledge, processes and skills, assessment frameworks, glossaries, lesson plans and other materials are included as exemplars of rigorous curriculum planning. By using tools from the kit, we hope all teachers will gain the confidence to develop ideas and shape a curriculum to meet the needs and interests of their own students.

Alan Kinder and John Widdowson, 2014.

WHY TEACH ABOUT ROCKS?



To say that rocks are a solid foundation for geography would be a bit trite – but there is also a lot of truth in it. Geology provides a secure framework for much of the physical geography we teach which, in turn, is the context for human geography.

In physical geography, there are obvious connections between rock type and landscape, yet often the latter is taught without students knowing much about rocks. The action of rivers, oceans and ice on the landscape can all be better understood if students already have an understanding of geology. The study of tectonics is really a modern branch of geology. Certainly, earthquakes and volcanoes make more sense when taught alongside other aspects of geology.

There are also direct links between geology and human geography. The built environment is made of rock, or materials derived from rock. Farming and other primary activities such as mining, drilling and quarrying all depend on a good understanding of rocks. Soils, vegetation and ecosystems are also intimately connected with geology. Our lives are bound up in so many ways with geology – hence the key question that underpins this book, 'How do rocks shape our world?'

Traditionally, there has been rivalry between science and geography in the school curriculum to cover geology. Science's claim is strengthened by geology's alternative label, 'earth science'. However, geography also has strong claims through its literal translation, 'earth writing'. There is a good argument to be put for teaching about rocks in the context of both science and geography. Students don't always make connections between school subjects, so to see geology taught in both contexts, hopefully with different emphases, will underline its importance.

Over many years, there has been a gradual shift in schools away from physical geography towards human geography. The inclusion of geology in the curriculum is part of a 'rebalancing' of school geography. The problem is that many teachers are either out of practice at, or may never have taught, geology. This book should equip all teachers to teach geology to key stage 3 students with confidence.

Integrated geography

Geographers have a tendency to put themselves in one camp or the other – either physical or human. Of course, teaching programmes that separate physical and human geography encourage this dichotomy. I prefer to see myself simply as a geographer.

I have to confess that my personal bias has always been towards human geography. But, as the years have passed, I find myself becoming more and more interested in geology. The problem was, I think, I bought into this notion of geography being a subject of two halves. Rocks seemed particularly remote – being buried underground, they were not part of my world.

We owe it to our students to teach a rounded, more integrated geography. If they are to understand the world they live in, we need to make the connections between physical and human geography. Then they may begin to see the relevance of rocks. It may also help them to rethink the way they see themselves as geographers and to shape their future study and career choices.

Rocks around us

The key question this book addresses – 'How do rocks shape our world?' – could simply refer to the physical landscape around us; but it could also refer to our world in a human sense, encompassing the community and economy in which we live. Hopefully, the book does both. This is important if geography is to be seen as an integrated subject (see above). However, it is also good educational practice to relate the geography we teach to the real world our students inhabit.

The unit starts with students investigating rocks in their own town. There is no better place to begin our study of geology than in the place we are most familiar with. Obviously, this book can't provide information on the local geology of each school, but it is highly recommended that you use every opportunity for local fieldwork. Fieldwork helps to connect students' [illegible] Again, it will help to link geology with a map and places that students may already know.

Visualising rocks

Out of sight, out of mind! That may be one of the reasons geology has not had much coverage in the geography curriculum hitherto. There is no doubt that it is hard for students to visualise rocks buried deep underground, so to aid students' understanding we need to make teaching about rocks as visual as possible.

Normally, we can bring geography to life in the classroom with photos and videos of places, but rocks don't make the most exciting photographic subject and they don't move! Therefore, every attempt needs to be made to make geology visual in other ways. Rock samples can be used, wherever possible, to let students get up close and personal with rocks and to touch them. The rock cycle can be illustrated as a flow diagram (see page 8) and, even better, by getting students to move around the classroom. Sedimentary rock layers can be visualised by making 3D models and then showing how these can be turned into geological maps. The process of weathering can be turned into animations. Even oil exploration, which normally relies on seismic surveys and sound, can be made visual in the form of a game.

Make it relevant

Most of Britain's energy supply still comes from fossil fuels – found in rocks! The most recently discovered source of energy, frequently in the news, is shale gas. Shale gas, like other fossil fuels, has lain under the ground for millions of years, but is now being proclaimed as a way out of our energy crisis and a possible route to economic prosperity.

There is talk of 'fracking' for shale gas becoming the new coal mining of the 21st century. It could release valuable reserves of gas; however, fracking also entails harmful environmental consequences that make it, as coal once was, a controversial new source of energy. All of this

HOW TO TEACH ABOUT ROCKS

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Later, the focus widens to consider the geology of Britain. Students should be familiar with an atlas map of Britain and may have visited other places in the country. Again, it will help to link geology with a map and places that students may already know.

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Of course, there is a danger that relevance can be al froth and little substance. Relevance is not a replacement for rigour. It would not be possible to about drilling for shale gas unless students already

How do rocks shape our world? Photo © David Prasad.

learnt about sedimentary rocks and the formation of fossil fuels (any more than they could learn about climate change without understanding climate). However, such issues do help to engage students and help them to see the relevance of geography.

Summary

This unit is a broad overview of geology within a UK context. It also links rocks with weathering and soils. It aims to relate geology to students' previous geographical experience, including their local area, a map of Britain and Ordnance Survey (OS) maps.

The unit takes an enquiry-based approach to geology, asking the big question, 'How do rocks shape our world?' Each lesson starts with its own key questions, ideally the sort of questions that students themselves would want to ask. However, through the unit, they should keep returning to the big question and, by the end, they should be able to answer it.

Through this unit students will develop:

- location knowledge of physical features and geology within the UK
- place knowledge of the UK, including the Peak District
- understanding of physical geography, especially processes in rocks, weathering and soils
- understanding of human geography, mainly primary economic activities
- geographical skills, including use of atlas maps, interpretation of OS maps and fieldwork.

Prior learning

In key stage 2, students should have developed their locational knowledge of regions within the UK and their physical characteristics. They should have described and understood key aspects of physical geography, including mountains, earthquakes and volcanoes. They should have used atlas and OS maps and done local fieldwork. In key stage 2 science, students should have observed rocks, including those in their local area, identified and classified rocks and explored how fossils and soils are formed.

Future learning

By the end of the unit, students should have a secure knowledge and understanding of basic geology in a UK context. This will provide a useful foundation for development at GCSE level of their place knowledge of the UK, how geomorphic processes have influenced the landscape of the UK and the interaction of those processes with human activity.

Key learning outcomes

Most students will be able to:

- know the three main types of rock, how they are linked together in the rock cycle and how rocks are weathered to form soil
- identify some common rocks and recognise their associated landscape features
- interpret atlas maps and OS maps to link landscape and geology
- appreciate the role of rocks in the local environment and in human activities
- carry out local fieldwork to collect evidence and draw conclusions about rocks.

Some students will not have made so much progress and will be able to:

- know the three main types of rock and processes in the formation of rocks and soil
- distinguish two common rocks and their associated landscape features
- interpret atlas maps and OS maps
- appreciate the role of rocks in some human activities
- carry out local fieldwork to collect evidence about rocks.

Some students will have progressed further and will be able to:

- know the three main types of rock, with named examples, the processes that link them together in the rock cycle and how rocks are weathered to form soil
- identify some common rocks and their associated landscape features, explaining how the features are related to rock characteristics
- interpret atlas maps and OS maps to explain links between landscape and geology
- appreciate and explain the role of rocks in the local environment and in human activities
- carry out local fieldwork independently to collect evidence and draw conclusions about rocks.

THE GEOGRAPHY BEHIND ROCKS

Get up to speed on rocks

Many teachers using this book will not be geography specialists. Even if you are a geographer, you may never have taught geology to key stage 3 students or, if you have, it might have been a long time ago. The purpose of this section is to cover the basics of geology to put you at least one step ahead of your students! The key ideas below are extracted from the information sheets linked to the book. For more information, refer to the sheets themselves.

The rock cycle

There are three main types of rock:

- Igneous rock is made of crystals, formed when molten rock, or magma, cools down at the Earth's surface.
- Sedimentary rock is made from sediment – bits of rock, organic remains or chemical deposits that sink to the bottom of the sea, river or lake – compressed into layers.
- Metamorphic rock is formed from igneous or sedimentary rock that is changed by heat or pressure deep in the Earth.

All rocks are linked together in the rock cycle (Figure 1). Slowly, over millions of years, old rock gets worn away by weathering and erosion. Eventually, the rock melts as it is pushed back down into the magma and the whole cycle starts again.

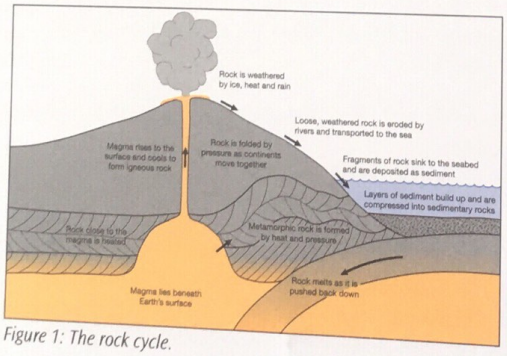


Figure 1: The rock cycle.

Weathering

Weathering is the decay and disintegration of rock by the action of sun, rain, ice, wind and living things. There are three main types of weathering;

- physical weathering, caused by changes in temperature and pressure
- chemical weathering, caused by the action of water and chemicals
- biological weathering, caused by the physical and/or chemical actions of plants or animals.

Weathering and erosion often get confused. Weathering is the decay and disintegration of rock, while erosion is the removal of the weathered remains from the surface. The combined effect of weathering and erosion is denudation.

Soil

Soil is composed of a number of different materials. It sits on a layer of slowly weathering bedrock and contains a mixture of tiny particles of rock and humus (the remains of dead plants). It also contains water and air. Most soil has three main layers, as shown in Figure 2: humus, soil and bedrock.

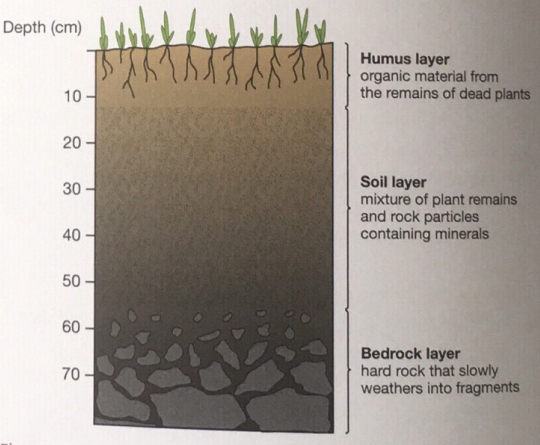


Figure 2: Soil profile.

A geological map of Britain

The geological map of Britain (Figure 3) shows the types of rock that occur in each part of the country, together with the geological period in which the rocks were formed. There is potential for confusion here, because the same types of rock, e.g. sandstone, were formed in different geological periods, e.g. Cretaceous and Jurassic. At key stage 3 it is only required that students know some types of rock and are aware of the geological timescale. They would not be expected to relate each rock to specific geological periods on the timescale.

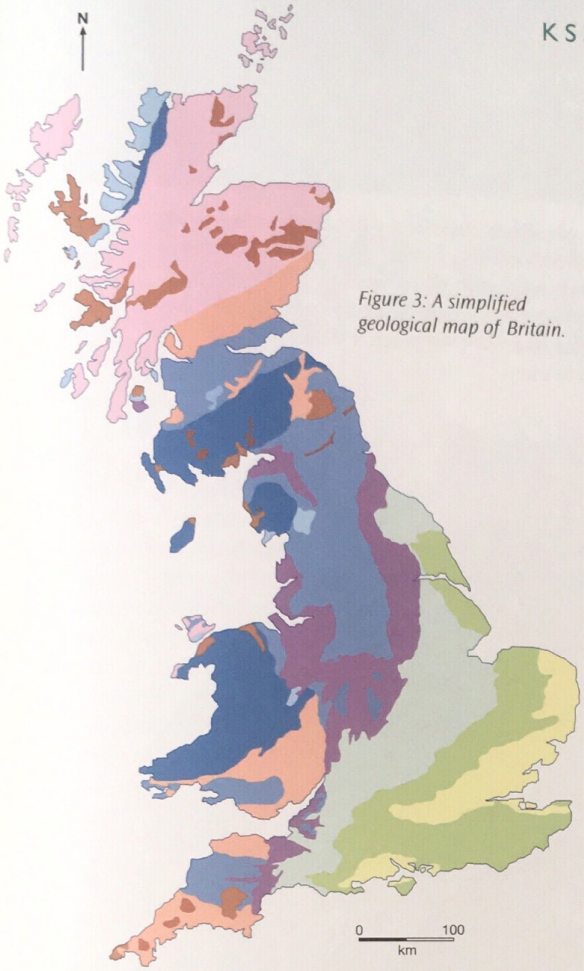


Figure 3: A simplified geological map of Britain.

Key	Geological period	Start of period (millions of years ago)	Rock type
	Caenozoic: Quaternary, Neogene and Palaeogene	66	Sedimentary: gravel, sand, silt and clay
	Cretaceous	145	Sedimentary: chalk, sandstone, clay and mudstone
	Jurassic	200	Sedimentary: mudstone, sandstone, limestone and siltstone
	Triassic and Permian	299	Sedimentary: mudstone, sandstone and limestone
	Carboniferous	359	Sedimentary: limestone, gritstone, shale, sandstone and coal
	Devonian	416	Sedimentary: sandstone and siltstone
	Silurian - Cambrian	542	Sedimentary: sandstone, slate, gritstone and limestone
	Precambrian	4600	Sedimentary: sandstone and shale
	Various		Metamorphic rocks
	Various		Igneous rocks

How oil and gas were formed

Tiny sea plants and animals died and sank to the ocean floor. They were covered by sediment and, over millions of years, were buried deeper and deeper under layers of sedimentary rock. Immense heat and pressure turned them into oil and natural gas. Today, it is possible to drill down through the layers of rock to reach the oil and gas deposits (Figure 4).

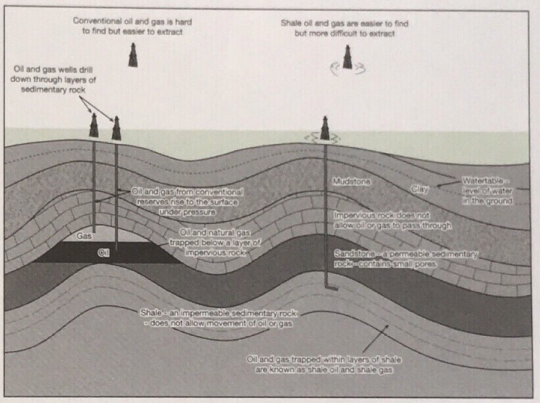


Figure 4: Cross-section of sedimentary rock showing conventional oil and gas reserves and shale gas.

Shale gas and fracking

Shale is a sedimentary rock made from mud containing many fossils. In many cases, it also contains gas from the decomposition of plants. Shales containing gas are found across much of Britain but the richest reserves are under northern England.

The problem with shale gas is that it is difficult to extract. Shale is a densely compacted rock, which means that the gas is trapped in tiny pockets. In order to extract gas the shale first has to be fractured, or broken.

Hydraulic fracturing, or fracking, is the method used to obtain shale gas. Boreholes are drilled down to the shale deep underground. When the shale is reached, horizontal shafts are drilled and pipes inserted. High-pressure water, sand and chemicals are blasted into the rock to break it apart. The gas is then sucked out of the rock, together with the waste water.

CONCEPTS AND CURRICULUM LINKS

n key stage 3 geography students should be taught ocational knowledge, place knowledge, human and physical geography (including how human and physical processes interact on the environment) plus geographical skills and fieldwork.

We have used these areas of geography to create a curriculum map for this book. The map lists the key questions used as the basis of enquiry in all the lessons.

As you might expect in a book on rocks the balance is tipped towards physical geography, but there are also many links with place, human geography and environment. Creating a curriculum map (see Figure 5) helps to ensure we teach a broad and balanced curriculum.

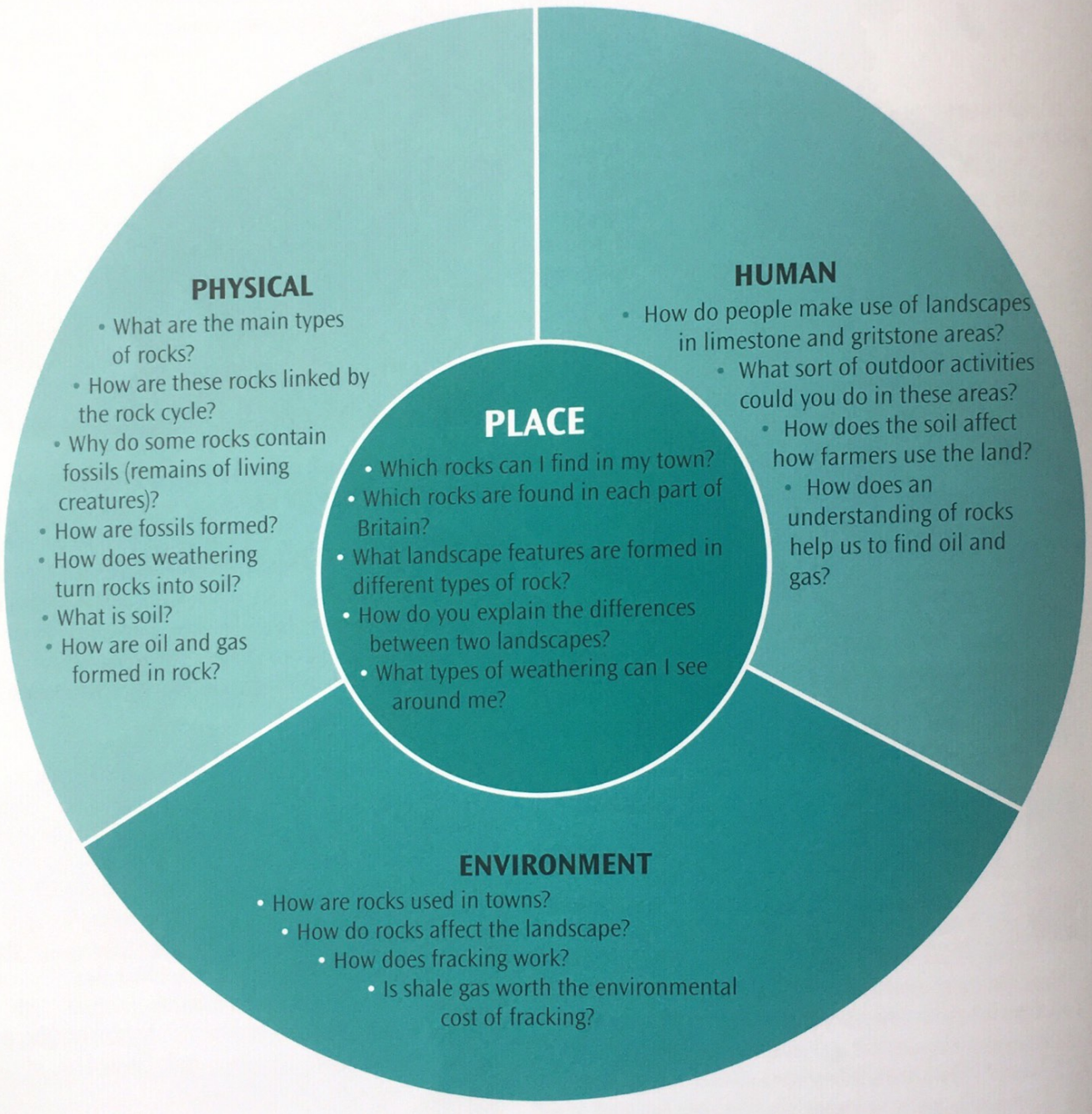


Figure 5: Plotting your broad and balanced geography curriculum in map form.

ROCKS IN THE NEWS

UK SHALE GAS RESOURCES 'GREATER THAN THOUGHT'

Fracking is the controversial process of freeing trapped gas by drilling and pumping in a mixture of water, sand and chemicals. Photo © www_ukberri_net.

UK shale gas resources may be far greater than previously thought, a report for the government says. The British Geological Survey estimates there may be 1300 trillion cubic feet of shale gas present in the north of England – double previous estimates. Meanwhile the government has announced measures to enable shale gas drilling as part of its infrastructure plans. Energy Minister Michael Fallon described shale gas as 'an exciting new energy resource'.

The BGS said its estimate for shale gas resources in the Bowland Basin region, which stretches from Cheshire to Yorkshire, represented potential resources, but 'not the gas that might be possible to extract'. 'Shale gas clearly has potential in Britain but it will require geological and engineering expertise, investment and protection of the environment,' it said. Drilling companies have previously estimated that they may be able to extract around 10% of this gas – equivalent to around 130 trillion cubic feet.

If the estimates are proved correct, that would still suggest recoverable reserves of shale gas far in excess of the three trillion cubic feet of gas currently consumed in the UK each year. Shale gas is extracted through 'fracking' – the controversial process of freeing trapped gas by pumping in a mixture of water, sand and chemicals. The process has helped boost the domestic energy industry in the US in recent years, where oil production has risen and gas prices have plummeted.

In a statement, the Department of Energy and Climate Change said: 'Though it is early days for shale in the UK, it has the potential to contribute to the UK's energy security, increase inward investment and growth'.

The government has unveiled a package of reforms to encourage development in the industry. They include new planning guidelines to make the process of approving new drilling sites more streamlined, and a consultation on tax incentives to encourage exploration. Communities affected by shale gas drilling are also expected to receive £100,000 in 'community benefits' and 1% of production revenues, should sites start producing gas. 'Shale gas represents an exciting new potential energy resource for the UK, and could play an important part in our energy mix,' said Energy Minister Michael Fallon.

'Development must be done in partnership with local people. We welcome the commitments from industry on community benefits. This will provide a welcome boost for communities who will host shale exploration and production as well as offering strong assurances that operators will engage with them and work to the highest health, safety and environmental standards'. He said communities hosting shale gas drilling could benefit from cheaper bills, regeneration schemes and new community facilities like playgrounds and sports halls. The incentives are designed to overcome significant scepticism surrounding the process of fracking, which has generated environmental concerns.

Critics argue that it can cause earth tremors and pollute water supplies, and that shale gas wells could blight the countryside and affect house prices. They also want investment in green energy sources, rather than fossil fuels.

Source: BBC News, 27 June 2013.

MEDIUM-TERM PLAN

Lesson	Key questions	Learning objectives	Teaching and learning	Resources	Assessment opportunities
1. Rock around the block!	Which rocks can I find in my town? How are rocks used in towns?	To recognise some common rocks and to identify them in local buildings To know how different rocks are used in a town	**Starter**: Plan an urban geology trail around the local town centre **Main**: Students follow the trail to find examples of rocks. They try to identify them using an ID chart. They note how rocks are being used **Plenary**: Students report back on findings. They make connections between the rocks and local geology	*Cambridge Geology Trail* (optional) Information Sheet 1: Rocks in towns Local area map Photo Set 1: Rock ID chart	Students identify rocks used in local buildings and draw or photograph them Students describe the different ways in which rocks are used in a town
2. Rock story	What are the main types of rock? How are these rocks linked by the rock cycle?	To know what igneous, sedimentary and metamorphic rocks are To understand the processes that form rocks within the rock cycle	**Starter**: Students look at samples or photos of three types of rock for clues to how they were formed **Main**: Students play the rock cycle game and use the experience to complete their own flow diagram **Plenary**: Student match photos of landscape with types of rock and processes in the rock cycle	Activity Sheet 1: Rock cycle labels Activity Sheet 2: The rock cycle game Dice Information Sheet 2: The rock cycle Photo Set 1: Rock ID chart or rock samples Photo Set 2: Rocky landscapes	Students complete a flow diagram to show how the rock cycle works Students identify landscapes formed from igneous, sedimentary or metamorphic rocks, using photographic evidence
3. The fossil mystery	Where do you find fossils and where did they come from? How are fossils formed?	To understand why fossils are found in rocks and how they were formed To create a model to demonstrate the formation of fossils and sedimentary rock	**Starter**: Show the students a fossil (or photo of a fossil) and ask them what it is and where it might have come from **Main**: Students sort sentences to describe how a fossil is formed. They work in groups to create a model to represent sedimentary rock layers. They include a 'fossil' in their layers **Plenary**: Students describe how they made their model and compare with the formation of sedimentary rock	Activity Sheet 3: The fossil mystery Activity Sheet 4: Sedimentary rock recipe A real fossil or Photo Set 3 Materials to create a model of fossil and sedimentary rock formation Scissors and glue Water and mixing containers	Students create a model to demonstrate how sedimentary rock and fossils are formed Students compare their model with the formation of real sedimentary rock

Lesson	Key questions	Learning objectives	Teaching and learning	Resources	Assessment opportunities
4. The map that rocks!	Which rocks are found in each part of Britain? How do rocks affect the landscape?	To interpret a geological map to find where different rocks are found in Britain To recognise the relationship between geology and physical landscape	**Starter**: Show students a geological map of Britain and how to read it, using the sedimentary rock model **Main**: Students interpret a geological map of Britain. They identify the rocks found in different places and list the rocks from oldest to youngest along a line from northwest to southeast. They compare an atlas map of Britain with the geological map **Plenary**: Students use rock samples to try to explain the link between geology and landscape	Activity Sheet 5: The geology of Britain Atlas – physical map of Britain Information Sheet 3: Geological map of Britain and timescale, or iGeology app Model of sedimentary rock from Lesson 3 Photo Set 4: British landscapes Rock samples or Photo Set 1	Students interpret a geological map of Britain to find rocks in different regions Students identify relationships between geology and physical landscapes
5. Rocks and landscapes	What landscape features are formed in areas of different rock types? How can we explain the differences between two landscapes?	To interpret OS maps and photos of limestone and gritstone landscapes To understand why differences between the two landscapes occur	**Starter**: Students look at two photos of the Peak District to find clues about the underlying rocks **Main**: Students interpret two OS maps and photos from the Peak District to describe limestone and gritstone landscapes. They read about the rocks to explain the features **Plenary**: Students suggest in which landscape they would be most likely to have different experiences	Activity Sheet 6: The Peak District Information Sheet 4: Limestone and gritstone Photo Set 5: Limestone and gritstone landscapes Limestone and gritstone rock samples, if available	Students interpret OS maps and photos to describe limestone and gritstone landscapes Students explain the differences between the two landscapes
6. Exploring landscapes	How do people make use of landscapes in limestone and gritstone areas? What sort of outdoor activities could you do in these areas?	To understand how human features are related to the geology of an area To use OS maps to plan an adventure trail	**Starter**: Students distinguish human and natural features in limestone and gritstone areas on maps and photos **Main**: Students explain why some human activities occur in limestone and gritstone areas. They choose one area for an adventure trail. They plan a trail and complete a table locating each activity using co-ordinates **Plenary**: Students report back to class	Activity Sheet 7: Human or physical? Activity Sheet 8: Plan an adventure trail Information Sheet 5: Using limestone and gritstone	Students identify human features in a landscape and explain how they relate to geology Students use an OS map to plan an adventure trail in a limestone or gritstone area

MEDIUM-TERM PLAN continued

Lesson	Key questions	Learning objectives	Teaching and learning	Resources	Assessment opportunities
			to persuade them their landscape is the best choice for an adventure trail	Photo Set 5: Limestone and grit-stone landscapes	
7. From rock to soil	How does weathering turn rock into soil? What types of weathering can I see around me?	To understand how different types of weathering can break up rock To identify different types of weathering in the local environment	**Starter**: Students look at photos of rocks and list the features of weathering **Main**: Students play a game to match types of weathering with photos. They create animations of processes from cartoon drawings and match drawings and captions. They draw their own animation of biological weathering **Plenary**: Students investigate their school or local buildings for examples of weathering	Activity Sheet 9: Weathering match Activity Sheet 10: Weathering animations Information Sheet 6: Physical, chemical and biological weathering Information Sheet 7: Weathering match answers Mobile phones/ cameras Online weathering animations Photo Set 6: Weathering Scissors and glue	Students create animations to describe the processes in different types of weathering Students identify and take photos of different types of weathering in the local environment
8. What in Earth?	What is soil and how is it formed? How does the soil affect how farmers use the land?	To know what soil is and understand how it is formed To decide the best way for a farmer to use the land on different types of soil	**Starter**: Ask the students how they would turn the ingredients into soil. They examine a soil sample and make soil doughnuts **Main**: Students read about soil formation. They use a simple GIS of a farm to decide where the farmer should grow crops, grass and trees. They give reasons **Plenary**: Students share their decisions, then compare with the farmer's decision using Google Earth	Activity Sheet 11: Penrhiw Farm Disposable gloves Google Earth Information Sheet 8: Soil formation Ingredients to make soil: a rock, water, a plant and a jar of air Soil sample *Soil doughnuts*	Students compare the soils at three locations on a farm and explain the differences between them Students decide on the best way to use the land at each location

Lesson	Key questions	Learning objectives	Teaching and learning	Resources	Assessment opportunities
9. Oil strike!	How are oil and gas formed in rock? How does an understanding of rocks help us to find oil and gas?	To understand how oil and gas have formed To be able to predict where oil and gas could be found from a geological map	**Starter**: Show students a *YouTube* clip of water from a tap burning. Ask them to try to explain it with the help of a geological cross-section **Main**: Students work in pairs to play the oil and gas exploration game. They each have a geological map with a grid. They take turns to drill for oil and gas and keep a record of their findings **Plenary**: Students evaluate how successful they were at finding oil and gas	Activity Sheet 12: Oil and gas exploration game Activity Sheet 13: Conventional oil and gas answers Activity Sheet 14: Shale oil and gas answers Information Sheet 9: Oil and gas formation Video clip 'Can you do this with your tap water?'	Students explain the mystery of burning tap water Students evaluate their success in finding oil and gas
10. Rocks to riches	How does fracking work? Is shale gas worth the environmental cost of fracking?	To understand how fracking works To weigh the economic benefits of shale gas against the environmental costs	**Starter**: Students list all the ways we depend on oil and gas. They share their ideas with the class and begin to suggest alternatives **Main**: Students read about fracking. They prepare for a debate on fracking in Britain, playing different roles. At the end of the debate they vote on whether fracking should go ahead **Plenary**: Students think back over ten lessons to complete an assessment of what they have learnt. They discuss the question, 'How do rocks shape our world?'	Activity Sheet 15: The shale gas debate Activity Sheet 16: The case for fracking Activity Sheet 17: Assessment sheet Information Sheet 10: Shale gas and fracking	Students prepare questions and take part in a debate on fracking Students evaluate the importance of rocks in shaping our world

LESSON 1:
Rock around the block!

Key questions
- Which rocks can I find in my town?
- How are rocks used in towns?

Learning objectives
- To recognise some common rocks and to identify them in local buildings
- To know how different rocks are used in a town

Key words
- composition
- geologist
- geology
- rock
- texture

Resources
- Cambridge Geology Trail: *www.sedgwickmuseum.org/about/news/FINAL_CGT_08022011-1.pdf*
- Information Sheet 1: Rocks in towns
- Local area map
- Photo Set 1: Rock identification chart

Assessment opportunities
- Students identify rocks used in local buildings and draw or photograph them
- Students describe the different ways in which rocks are used in a town

Starter
Plan a geology trail around your town or local area. Every area has rocks for students to find, even if it is granite kerbstones, a few old gravestones and bricks (made of clay!).

Tell the students they are going to follow a geology trail around their local town. Explain that the raw materials from which towns are built are mostly obtained from rocks and they are going to be geologists to try to identify the rocks. Give the students a rock identification chart (Photo Set 1) to use on the trail. Ask them to read about rocks in towns (Information Sheet 1) to prepare them for what to look for. If it is not possible to visit a town, they could do a shorter trail around the school, or they could use a virtual trail such as the Cambridge Geology Trail.

Main teaching phase
Provide the students with a local area map with your geology trail route marked on it. You could add numbers to the map to locate the sites where you expect students to identify the rocks and, to make it easier, a list of rocks they have to match with the sites.

Start the trail with the whole class, modelling for students how to identify rocks from the chart, looking for features such as grain shape, grain size and how the grains fit together. Students can sketch or take photographs of the rocks they find. They describe how the rocks are being used. They mark and locate where they found each rock on the map.

If students are familiar with the local environment, and you are sure it is safe, they could continue the geology trail independently, working in smaller groups. Encourage them to be observant and to look out for other examples of rocks not on the identification chart. If they take photographs, they could try to identify these later in the classroom, using a more comprehensive identification chart.

Plenary
Students report back on the rocks they have been able to find and identify and any they were unable to identify. You may be able to help them with identification, or they could try a more comprehensive identification chart such as *Building Stones* (see page 38). They also report how the rocks were being used. If the students worked independently in groups they can share information with each other.

Ask the students what they know about the geology of the area surrounding the town. If they don't know, you could tell them. How has the local geology influenced the town? What local rocks have been used in building? Is there any evidence that this is changing with new building materials and techniques?

Clay brick. Photo © Lars Thomsen.

Flint. Photo © David J Coombes.

Gabbro. Photo © Quin Dombrowski.

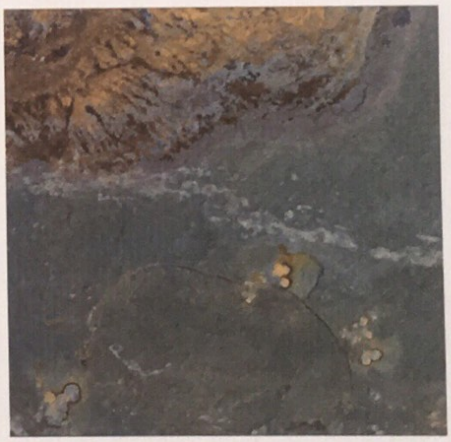
Gneiss. Photo © euphro.

Granite. Photo © Charles de Mille-Isles.

Limestone. Photo © Friends of San Jacinto.

Marble. Photo © Luke McGuff.

Sandstone. Photo © Peter Harris.



Slate. Photo © quicksilver_ice.

Teaching tips

Nothing beats getting students out of the classroom and into the real world to enhance their geographical understanding. Geographers call this fieldwork. Sometimes, with so many administrative and logistical obstacles, it may seem easier to stay in the classroom. Once you overcome the obstacles, you'll find fieldwork is worth the effort. Take every opportunity you can to use your local area for fieldwork.

Before attempting a geology trail, or any other fieldwork, it is vital that you have researched the proposed location(s) yourself. Ensure the route you plan for the geology trail has plenty of examples of rocks for students to identify and don't forget the risk assessment! Make sure the route is safe, without dangerous roads to cross. Decide whether it will be safe to allow the students to work independently in small groups.

LESSON 2:
Rock story

Key questions

What are the main types of rock?
How are these rocks linked by the rock cycle?

Learning objectives

- To know what igneous, sedimentary and metamorphic rocks are
- To understand the processes that form rocks within the rock cycle

Key words

- deposition
- erosion
- igneous rock
- magma
- metamorphic rock
- rock cycle
- sediment
- sedimentary rock
- weathering

Resources

- Activity Sheet 1: Rock cycle labels (to be located around the classroom)
- Activity Sheet 2: The rock cycle game
- Dice
- Information Sheet 2: The rock cycle
- Photo Set 1 or a selection of rock samples, including igneous, sedimentary and metamorphic rock, if available
- Photo Set 2: Rocky landscapes

Assessment opportunities

- Students complete a flow diagram to show how the rock cycle works
- Students identify landscapes formed from igneous, sedimentary or metamorphic rocks, using photographic evidence

Volcanic rock landscape. Photo © Yinghai.

Starter

Print out the five labels from Activity Sheet 1 and place each in a different area of the classroom. Show the students three rock samples, including an igneous, sedimentary and metamorphic rock, or photos of these. Good examples to choose would be granite, sandstone and slate where crystals, particles or layers are clearly visible. If you don't have samples, use the photos in Photo Set 1, or even photos taken by the students on the geology trail. Ask the students to examine the rocks carefully. Can they see any clues that might explain how each rock was formed?

Tell the students that geology is dynamic – new rocks are continually being formed, while old rocks get worn away. The processes that form new rocks and wear away old rocks are linked together in the rock cycle. Students read about the rock cycle on Information Sheet 2. If students have not come across the processes in the rock cycle

Sedimentary rock landscape. Photo © J. Brew.

Metamorphic rock landscape. Photo © David Prasad.

Cliff erosion. Photo © Martin.

before, it is worth taking a few minutes to introduce them prior to starting the game. They will learn more about sedimentary rock in Lesson 3 and weathering in Lesson 7.

Main teaching phase

Students read the instructions for the rock cycle game on Activity Sheet 2. They draw a large copy of the rock cycle diagram in their book or on a sheet of paper. Working in pairs or small groups, they position themselves around the classroom in one of five labelled areas, then move around the room to represent the processes in the rock cycle. The photos on the labels will act as a visual aid to students of where they are in the rock cycle.

Each time, before they move, they roll a dice to choose the direction. As they move they write labels on their copy of the rock cycle to describe the processes. Stop the game every few minutes and freeze the groups in their position. Check students' understanding by asking them where they are in the rock cycle and what process is happening now. Encourage them to connect the processes with the properties of the rocks they saw in Lesson 1, e.g. cooling with crystalline rocks.

The groups continue to move around the classroom until they have visited all five areas and experienced each process. Students then complete the flow diagram to describe all the processes in the rock cycle.

Plenary

Students look at photos of landscapes formed from igneous, sedimentary or metamorphic rock (Photo Set 2). Using photographic evidence, such as new lava flows, sedimentary layers or folded strata, they identify the type of rock that forms each landscape. They might also be able to identify processes such as weathering, erosion or deposition.

Teaching tips

Getting students to physically move around the classroom helps to secure the processes in the rock cycle in their minds. This is particularly true for kinaesthetic learners – those who learn best through physical activity. Representing the rock cycle in the form of a flow diagram also helps visual learners.

It is often good to stop students in mid-activity to check their understanding. Pausing may help to iron out any misunderstandings before they get embedded in the student's mind. Pausing an activity also helps students to reflect on the geographical meaning of the activity. There is a danger when playing a game, for example, that the game takes over and they forget what the point is.

LESSON 3:
The fossil mystery

Key question
- Where do you find fossils and where did they come from?
- How are fossils formed?

Learning objectives
- To understand why fossils are found in rocks and how they were formed
- To create a model to demonstrate the formation of fossils and sedimentary rock

Key words
- continental drift
- fossil
- sediment
- sedimentary rock

Resources
- Activity Sheet 3: The fossil mystery
- Activity Sheet 4: Sedimentary rock recipe
- A classroom with a water tap and mixing containers
- A real fossil, e.g. an ammonite, or Photo Set 3
- Materials to create a model of fossil and sedimentary rock formation. These should include particles of different types of 'sediment', e.g. cornflakes, bread crumbs, biscuit crumbs; a 'cement' to hold the particles together, e.g. filler and water, and 'fossils', e.g. jelly babies.
- Scissors and glue

Assessment opportunities
- Students create a model to demonstrate how sedimentary rock and fossils are formed
- Students compare their model with the formation of real sedimentary rock

Starter
Show the students either a real fossil, such as an ammonite, or a photo from Photo Set 3. Don't tell them what it is. You could pretend you found/saw it on holiday while climbing in mountains and you don't know yourself what it is. Try to build up a sense of mystery around the fossil. If you have access to a real fossil it is much better as students can pass it around, touch and examine it to try to work out what it is.

Some students may already know about fossils and may recognise it. Having established it is a fossil, ask them where you find fossils and where they came from originally. If, for example, you show them an ammonite, they may recognise it as a sea creature, which raises the question of how it ended up as a fossil at the top of a mountain.

Main teaching phase
Students read a series of muddled up sentences about the stages in fossil formation (Activity Sheet 3). They put the sentences into order in a paragraph to describe how fossils are formed. The best way to do this is to cut out the sentences and place them in the right order. To make the task more challenging for some students, omit one or more sentences for them to work out the missing stages.

Ammonite. Photo © Smabs Sputzer.

Leaf. Photo © Sabrina Setaro.

Ask the students to take turns to read a sentence to the rest of the class. Each student chooses the best sentence to follow the previous one. Discuss with the class what the best order should be. The order is not totally clear-cut since some stages would happen concurrently. Once they are satisfied with the order they have students stick their sentences into their book.

Next, working in groups, students create a model to demonstrate the formation of layers of sedimentary rock containing fossils. The best space to do this would be in a classroom with a water tap and mixing containers. The ideal solution would be to make an arrangement with the Design and Technology department to use a kitchen!

Each group is given materials to create their model. Encourage the students to think for themselves about how they will use the materials, without giving too much advice. You could refer them back to what they learned about the formation of sedimentary rock in Lesson 2. When they have created their models it will take a few minutes for the filler to harden. While they are waiting for this to happen, students write a description of the method they used to create their model, comparing it with the real process of sedimentary rock formation (Activity Sheet 4).

Shell. Photo © Jan Helebrant.

Trilobite. Photo © Joanna Bourne.

Plenary

Ask the students about analogies between their model and real sedimentary rocks. They could mention that materials come from a variety of sources, formed in layers and were laid down in a particular order. However, there are also differences. Obviously, the timescale is different, as are the location and conditions under which the rocks were formed.

When the models have hardened you could have a ceremonial cutting of the sedimentary layers to reveal the fossils within. Keep the models until Lesson 4 when students will find out how layers of sedimentary rock are represented on a geological map of Britain.

Teaching tips

Making models is a practical activity that will really help to deepen students' understanding of geographical processes. It will encourage students with practical skills to shine. The result should be a better description of the processes involved in the formation of fossils and sedimentary rock than if students were to merely regurgitate the information from a textbook.

Comparative writing is a particular writing skill with which students may need help. A writing frame can offer this support. However, comparative writing can also shine greater light on the things being compared. In this case, it will make students think more carefully about the processes, timescale, location and conditions under which fossils and sedimentary rocks are formed.

LESSON 4:
The map that rocks!

Key questions
- Which rocks are found in each part of Britain?
- How do rocks affect the landscape?

Learning objectives
- To interpret a geological map to find where different rocks are found in Britain
- To recognise the relationship between geology and physical landscape

Key words
- geological map
- geological period
- geological timescale

Resources
- Activity Sheet 5: The geology of Britain
- Atlas – physical map of Britain
- Information Sheet 3: Geological map of Britain and timescale, or iGeology app
- Model of layers of sedimentary rock (from Lesson 3)
- Photo Set 4: British landscapes
- Rock samples, including some common British rocks, e.g. granite, limestone, chalk (or Photo Set 1)

Assessment opportunities
- Students interpret a geological map of Britain to find rocks in different regions
- Students identify relationships between geology and physical landscapes

Starter
Show the students a geological map of Britain (Information Sheet 3). You could also do this using the iGeology app. The timescale to the map shows the names of the geological periods alongside the main rock types laid down during each period. Do they recognise the names of any of the rocks? Some of them may be familiar from their geology trail in Lesson 1. What is the underlying rock in the place they live?

Tell the students that you are going to show them how to read a geological map. They should notice that most of the rocks in England are found in bands on the map. These are sedimentary rocks. Use a model of sedimentary rock layers from Lesson 3 to demonstrate how these bands have formed.

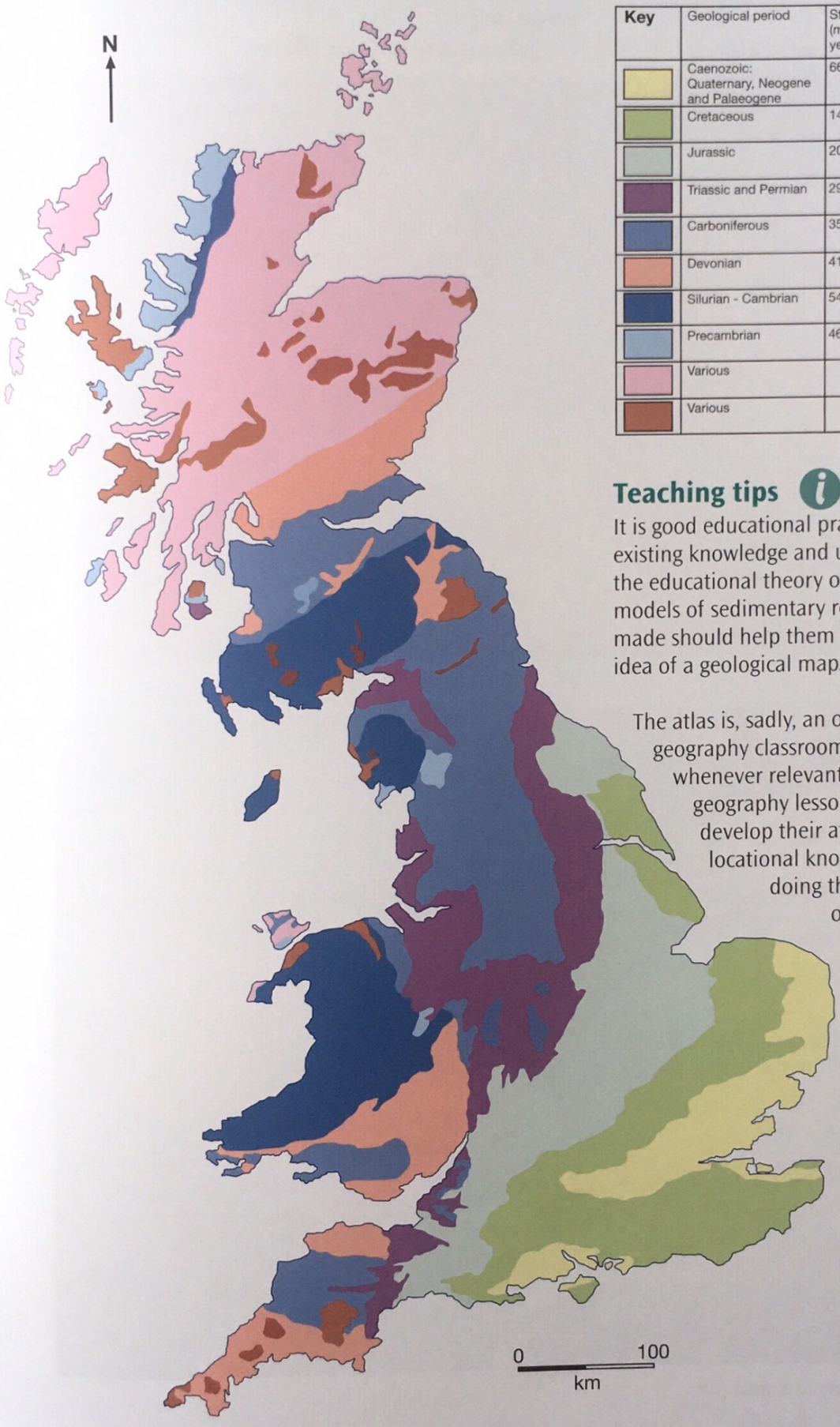
Tilt the model, explaining that sedimentary layers have been tilted by periods of mountain building in the past. As you tilt the model, show the students what it would look like from above. By tilting the model down to the right, you are replicating the pattern found on a geological map of England. They will notice bands of rock where the layers of sedimentary rock meet the surface. The order of the sedimentary layers on the map shows the order in which the rocks were laid down.

Main teaching phase
Students compare the rocks on the geological map of Britain with the timescale beside the map (Information Sheet 3). They should notice that, in general, the oldest rocks are to the northwest of Britain and the youngest are to the southeast. They interpret the map, listing the rocks from oldest to youngest along a line from northwest to southeast (Activity Sheet 5). They should become familiar with the names of some of the main geological periods on the timescale, e.g. Jurassic, Carboniferous, though students of this age would not be expected to remember all the names or the order in which they occur.

Students compare the geological map with a physical map of Britain in an atlas. They identify rocks found in upland and lowland areas of Britain (Activity Sheet 5). From this they should be able to deduce the type of landscape associated with each rock. Students look at the photos in Photo Set 4 to reinforce this idea. They use the maps to work out which rock underlies each landscape. They describe the landscapes and suggest what they tell them about the different rocks.

Plenary
Ask the students to share their ideas about the landscapes associated with different types of rock. They might be able to talk about the landscape in their own area and the underlying rock. How do rocks affect the physical landscape? For example, why are some areas much hillier than others?

Show the students samples of some common British rocks, ideally ones represented in the landscape photos they have seen. Pass the rocks around the class and encourage them to feel the rocks. Which is the most durable rock and which is weathered and eroded most easily? What effect could this have on the landscape?



Key	Geological period	Start of period (millions of years ago)	Rock type
	Caenozoic: Quaternary, Neogene and Palaeogene	66	Sedimentary: gravel, sand, silt and clay
	Cretaceous	145	Sedimentary: chalk, sandstone, clay and mudstone
	Jurassic	200	Sedimentary: mudstone, sandstone, limestone and siltstone
	Triassic and Permian	299	Sedimentary: mudstone, sandstone and limestone
	Carboniferous	359	Sedimentary: limestone, gritstone, shale, sandstone and coal
	Devonian	416	Sedimentary: sandstone and siltstone
	Silurian - Cambrian	542	Sedimentary: sandstone, slate, gritstone and limestone
	Precambrian	4600	Sedimentary: sandstone and shale
	Various		Metamorphic rocks
	Various		Igneous rocks

Teaching tips

It is good educational practice to build on students' existing knowledge and understanding. This is based on the educational theory of constructivism. Using the models of sedimentary rock that students themselves made should help them to grasp the relatively complex idea of a geological map.

The atlas is, sadly, an oft-neglected resource in the geography classroom. We should be using atlases, whenever relevant, in the context of our geography lessons. In this way students will develop their atlas skills and improve their locational knowledge naturally, rather than doing this artificially in isolation from other geography lessons.

LESSON 5:
Rocks and landscapes

Key question
- What landscape features are formed in areas of different rock types?
- How can we explain the differences between two landscapes?

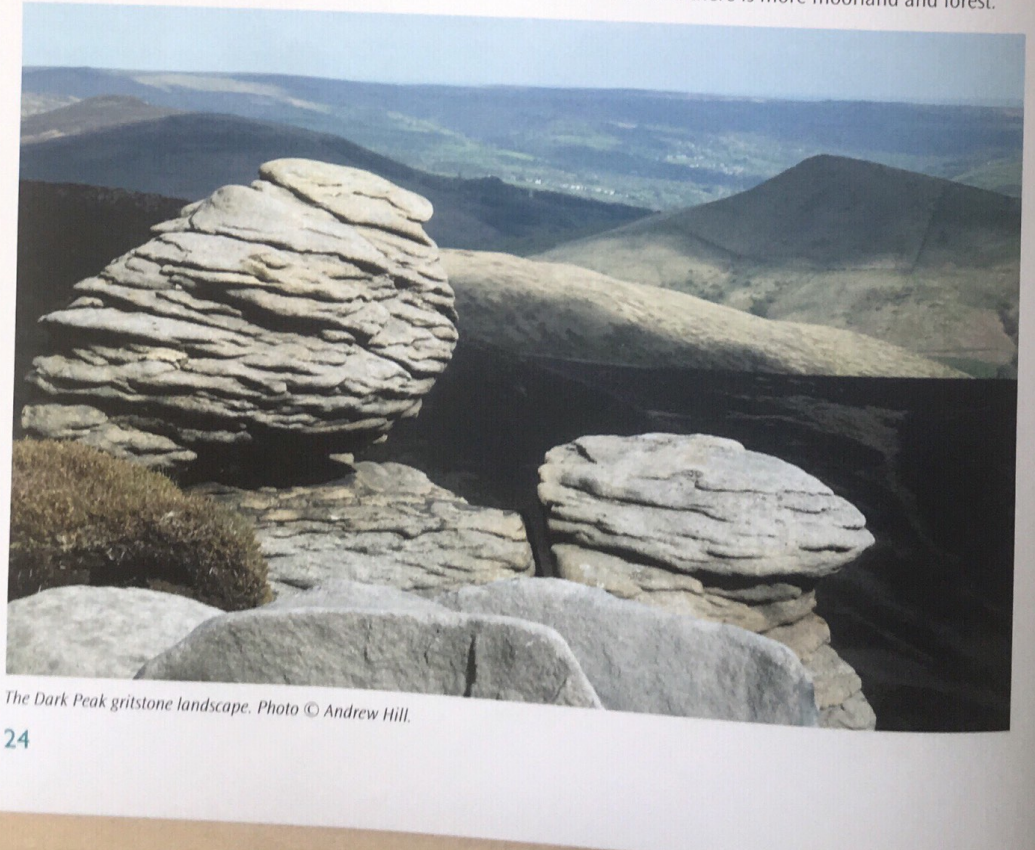
Learning objectives
- To interpret OS maps and photos of limestone and gritstone landscapes
- To understand why differences between the two landscapes occur

Key words
- cave
- dry valley
- gritstone
- impermeable rock
- limestone
- permeable rock
- tor

Resources
- Activity Sheet 6: The Peak District
- Information Sheet 4: Limestone and gritstone
- Photo Set 5: Limestone and gritstone landscapes
- Limestone and gritstone rock samples, if available

Assessment opportunities
- Students interpret OS maps and photos to describe limestone and gritstone landscapes
- Students explain the differences between the two landscapes

Starter
Show the students two photos of the Peak District – one of a limestone landscape in the White Peak, the other of a gritstone landscape in the Dark Peak (Photo Set 5). Ask the students to describe the two landscapes and compare them. They might notice that the White Peak is less undulating, has no surface water and there is more farmland. By contrast, the Dark Peak is more rugged, has surface water and there is more moorland and forest.



The Dark Peak gritstone landscape. Photo © Andrew Hill.

The White Peak limestone landscape. Photo © Tristan Ferne.

Ask the students what clues the landscapes might contain about the underlying rocks. Why is the terrain different in the two areas? Why is there more surface water in one area? And, why are the two areas being used in different ways?

Main teaching phase

Students study two map extracts from the Peak District: one from the White Peak and one from the Dark Peak (Activity Sheet 6). They look at more photos of the two landscapes in Photo Set 5 and examine the two map extracts in more detail to describe the two landscapes.

Student read about limestone and gritstone (Information Sheet 4) to help them to explain some of the differences between the two landscapes. They should mention the differences caused by the texture, permeability and mineral content of the rocks, which give rise to different relief, surface water, soil and vegetation in the two landscapes. Students' understanding of the differences between the two rocks and related landscapes would be further enhanced if you can show them real samples of limestone and gritstone.

Plenary

Ask the students in which of the two landscapes they would be most likely to experience the following;

- getting stuck in a bog
- meeting a flock of sheep
- finding an old millstone
- getting lost in a forest.

In each case, ask them to give reasons for their choice. You can make up more of these scenarios to further test their understanding.

Teaching tips

Like atlases, OS maps are best used routinely in geography lessons in the context of other geographical learning. Regular use of maps is far more likely to result in the development of students' map skills than the occasional isolated lesson about maps.

'Thinking skills' activities, such as 'Where would you be most likely to…' encourage students to think and apply their knowledge. This particular activity works best when there are two options for students to choose between, such as a limestone and a gritstone landscape.

LESSON 6: Exploring landscapes

Key questions

- How do people make use of landscapes in limestone and gritstone areas?
- What sort of outdoor activities could you do in these areas?

Learning objectives

- To understand how human features are related to the geology of an area
- To use OS maps to plan an adventure trail

Key words

- forestry
- livestock farming
- mining
- quarry
- reservoir

Resources

- Activity Sheet 7: Human or physical?
- Activity Sheet 8: Plan an adventure trail
- Information Sheet 5: Using limestone and gritstone
- Photo Set 5: Limestone and gritstone landscapes (repeat)

Assessment opportunities

- Students identify human features in a landscape and explain how they relate to the geology
- Students use an OS map to plan an adventure trail in a limestone or gritstone area

Starter

Students use the OS map extracts and photos of the Peak District (Activity Sheet 7 and Photo Set 5) to distinguish human and natural features in limestone and gritstone areas. The students work through the list of features to find them on the maps and decide whether they are human or natural. Not all of these are straightforward and might lead to an interesting discussion of human impact on landscape, now and in the past. For example, much of the moorland in Britain has been created by past clearance of natural forest, while much present-day forest in Britain has been planted.

Main teaching phase

Students read about the main human activities in limestone and gritstone areas (Information Sheet 5). They explain why certain activities are found most commonly in limestone (e.g. farming) or gritstone (e.g. reservoirs) landscapes and why others are found in both landscapes. Students can also refer back to the information they read about limestone and gritstone in Lesson 5 (Information Sheet 4).

Tell the students they are going to work in pairs to plan an adventure trail in one of the two landscapes (Activity Sheet 8). First, they must choose which landscape – limestone or gritstone. They could choose the one they find most interesting, or the one where they could do the most activities. Students look at a selection of outdoor activities and what landscape requirements each has.

Students plan an adventure trail in their chosen landscape, including as many outdoor activities as they can find suitable locations for. They complete a table to locate each activity on the map, giving grid references, distances and directions and listing any equipment they would need.

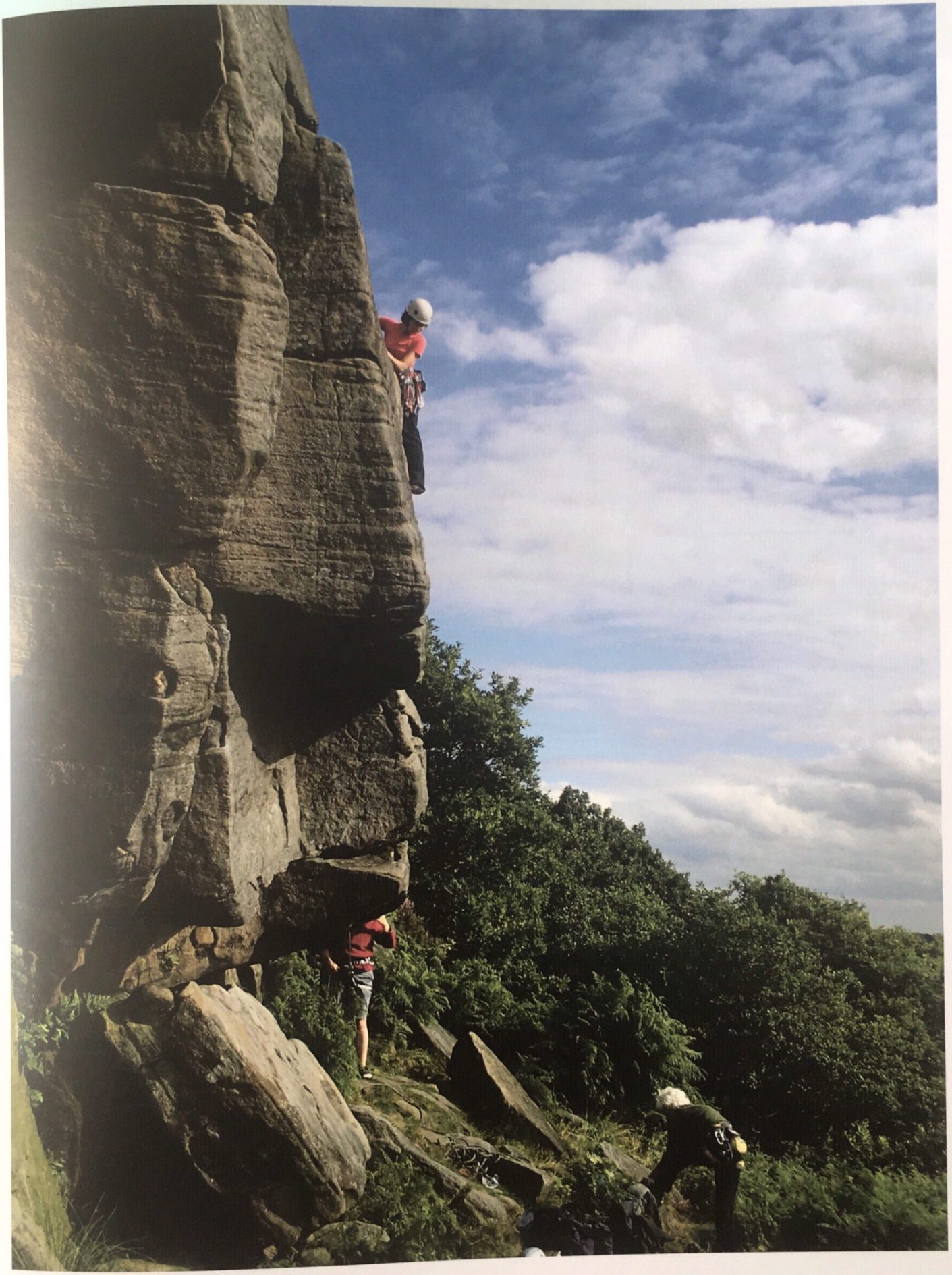
Plenary

Students report back to the whole class on their plans for an adventure trail. They have to persuade the class that their landscape would be the best one to visit, giving reasons for their choice. They listen to each other's ideas. At the end, the class votes on which landscape they would most like to visit for a weekend. Better still if this could be turned into a real visit to make the task and vote even more significant!

Teaching tips

Some students may already do outdoor activities. It is good to make connections between activities they already do and the geography they study in school. However, there will also be students who have never done any outdoor activities. One aim of geography is to excite students about the world around them. Who knows, this lesson may even encourage students to get out there and experience landscapes for real!

Giving students choice helps them to have more control over their learning and, arguably, makes them think a little bit harder. In choosing a landscape to plan their adventure trail, students will be making a personal response to landscape photos. Even if it is not possible to make a field visit, students should be encouraged to engage with landscapes at a personal level.



Leisure and landscape. Photo © Masa Sakano.

LESSON 7: From rock to soil

Key questions

- How does weathering turn rock into soil?
- What types of weathering can I see around me?

Learning objectives

- To understand how different types of weathering can break up rock
- To identify different types of weathering in the local environment

Key words

- biological weathering
- chemical weathering
- freeze-thaw
- lichen
- physical weathering
- soil
- solution

Resources

- Activity Sheet 9: Weathering match
- Activity Sheet 10: Weathering animations
- Information Sheet 6: Physical, chemical and biological weathering
- Information Sheet 7: Weathering match answers
- Mobile phones/cameras
- Online weathering animations, e.g. BBC GCSE Bitesize *www.bbc.co.uk/schools/gcsebitesize/geography/rock_landscapes/processes_rev1.shtml*
- Photo Set 6: Weathering
- Scissors and glue

Assessment opportunities

- Students create animations to describe the processes in different types of weathering
- Students identify and take photos of different types of weathering in the local environment

Starter

Show the students photos of rock weathering (Photo Set 6). Ask them to describe in as much detail as they can what they think is happening in the photos. They should notice there are cracks in the rock or much of the rock is covered in moss and lichen; in some places soil has formed and larger plants are growing. Explain that these features are all stages in the process of weathering. Make a class list of all the features they have described. Finally, ask students what each place might look like in hundreds of years' time.

Main teaching phase

Students read about physical, chemical and biological weathering (Information Sheet 6). They play Weathering match (Activity Sheet 9) to match the six processes they read about with the photos of weathering in Photo Set 6. They write the names of each type of weathering in their cards, cut out the photos from page two and match them. When they have completed the card, they are to shout 'Stones!'. Check their answers (see Information Sheet 7). The first student to get each one correct will win.

Discuss with the students how they can spot a process in a photo. Is it possible to 'see' weathering? What evidence that weathering has occurred would you look for?

Ask the students to create their own animations of physical and chemical weathering, using the cartoon drawings on Activity Sheet 10. You could show them an online weathering animation, such as BBC GCSE Bitesize, to give them an idea of what they are aiming for. Finally, they draw their own cartoons and write captions to create an animation of biological weathering.

Plenary

Remind the students about Lesson 1, when they identified rocks in their town. If rocks are all around us, it should be possible to find examples of weathering nearby too. Ask the students to explore the exterior of their school building to identify examples of weathering and take photos of them. Give them a time limit to do this. If necessary, suggest a few locations to visit. If it is a new school and there are no examples of weathering, you could ask the students to do this as a homework exercise further from the school. Again, suggest some locations (graveyards are good!).

When they return to the classroom, ask them to share their photos and to say what types of weathering they think they are. Peeling paintwork and crumbling cement are common features around some schools. Discuss with the students whether these are examples of weathering and, if so, which type. Does everyone agree? What are the main requirements for each type of weathering to occur?

Teaching tips

Too often, photos are used superficially, simply as illustration or to fill a space in a textbook. Here is an opportunity to really interrogate a photo. At first sight it may not look too promising – a rock covered in moss! However, careful scrutiny reveals the many stages in the weathering of the rock. Photos can be used creatively in the classroom in a variety of ways; in this case to sketch, annotate and sequence the weathering processes.

Sequencing is a way to develop students' understanding of geographical processes. Sometimes there may be doubt about the correct order, but doubt can be used positively to encourage students to think more carefully than if the order was clear-cut. A further level of challenge for students can be added by asking 'what happens next?'

LESSON 8: What in Earth?

Key questions

- What is soil and how is it formed?
- How does the soil affect how farmers use the land?

Learning objectives

- To know what soil is and understand how it is formed
- To decide the best way for a farmer to use the land on different types of soil

Key words

- bedrock
- clay
- fertility
- humus
- loam
- mineral
- organic material
- sand
- water table

Resources

- Activity Sheet 11: Penrhiw Farm
- Disposable gloves
- Google Earth – Penrhiw Farm location, 52 3'7.07'N 4 16'49.20'W
- Information Sheet 8: Soil formation
- Ingredients to make soil: a rock, water, a plant and air
- Soil
- Soil doughnuts (*http://earthlearningidea.com/PDF/153_Soil_doughnuts.pdf*)

Assessment opportunities

- Students compare the soils at three locations on a farm and explain the differences between them
- Students decide on the best way to use the land at each location

Starter

Show the students the basic ingredients of soil – a rock, water, a plant and air (in a jam jar). Set them a two-minute challenge to work out how to turn these ingredients into soil. If they need a clue, you could remind them of the process of weathering from Lesson 7. They share their ideas with the whole class.

Then show the students some soil. You could allow them to feel it wearing disposable gloves. They could use *Soil Doughnuts* to try to create doughnuts to find out how much sand, loam or clay is in the soil. If you have more than one soil sample, they could compare them. Ask them to guess the proportions of mineral particles, organic matter, water and air in the soil. In a typical soil the proportions are 45%, 5%, 25% and 25% respectively. Explain to the students why each of these ingredients is important.

Main teaching phase

Tell the students that they are going to play the role of a farmer, to decide how to use the land on their farm. First, they need to know more about soil. They read about soil formation on Information Sheet 8. The type of soil that is formed depends on a number of factors. Even within a relatively small area, like a farm, there is likely to be variation in the type of soil that forms.

Provide students with a simple GIS for Penrhiw (pronounced pen-roo) Farm in Wales (Activity Sheet 11), showing contours and field boundaries. If students have not used a contour map before, you may need to help them to interpret the contours. They compare the soils at three locations on the farm – hilltop, valley side and valley bottom – and explain the differences from the topography.

Now, they have to decide on the best way to use the land at each location. They can choose to grow arable crops, trees or grass. They will need to consider soil fertility, soil depth and the risk of flooding. They give reasons for their decisions.

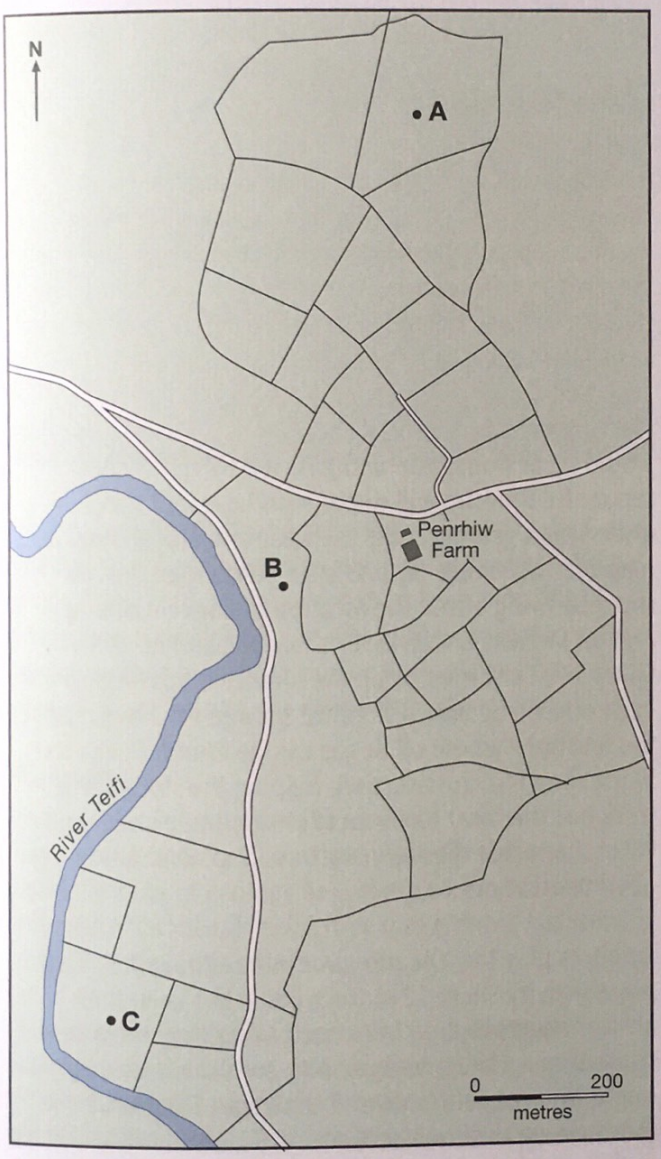
Plenary

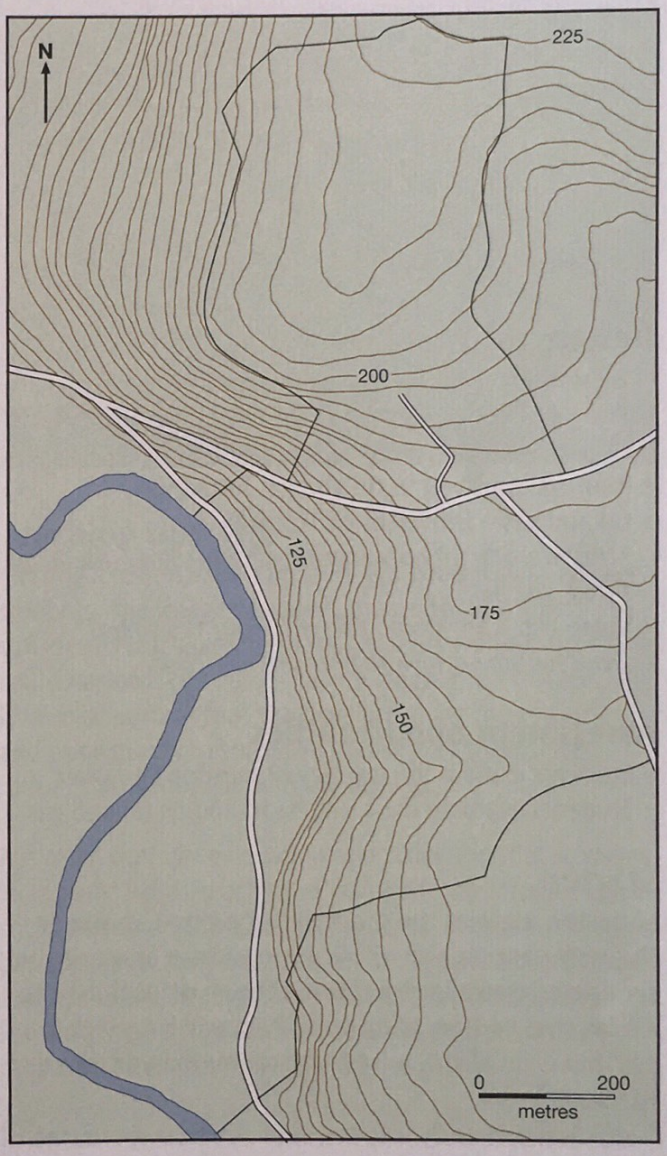
Students share their decisions with the whole class. Did they all come to the same decisions? Penrhiw Farm is a real farm in Ceredigion, west Wales. Using Google Earth they can check whether the farmer came to the same decision. When they locate Penrhiw, they will find arable crops are grown on the gently sloping hilltop, trees on the steep valley sides and grass on the flat valley bottom, close to the river.

Teaching tips

Soil is one of those topics in geography that teachers often avoid because it is considered a little dry, yet few topics could be more important, as we all depend on soil for our survival. The challenge is how to make soil exciting and relevant to our students. Actually handling the soil and turning it into soil doughnuts is not a bad start. Most students would be intrigued by this activity.

Using real case studies brings geography to life. Google Earth gives places an immediacy that helps to do that. Most students will be familiar with Google Earth, even if it is only to see their own home from the air (that's as far as most of us get!), but it has many other uses. In this case, students can actually see what is growing in the fields on the farm. If they look closely, they will even see the sheep grazing.





LESSON 9: Oil strike!

Key questions

- How are oil and gas formed in rock?
- How does an understanding of rocks help us to find oil and gas?

Learning objectives

- To understand how oil and gas have formed
- To be able to predict where oil and gas could be found from a geological map

Key words

- impervious rock
- natural gas
- oil
- porous rock
- shale
- shale gas
- shale oil

Resources

- Activity Sheet 12: Oil and gas exploration game
- Activity Sheet 13: Conventional oil and gas answers
- Activity Sheet 14: Shale oil and gas answers
- Information Sheet 9: Oil and gas formation
- Oil and gas – University of Tromsø: *http://ansatte.uit.no/webgeology/webgeology_files/english/oil_gas.swf*
- Video clip 'Can you do this with your tap water?': *www.youtube.com/watch?v=U01EK76Sy4A*

Assessment opportunities

- Students explain the mystery of burning tap water
- Students evaluate their success in finding oil and gas

Starter

Show the students the short YouTube clip, 'Can you do this with your tap water?', featuring a man appearing to set light to water from a tap. Ask the students if they can explain the mystery of how this happened. (In fact, it is gas that is set alight, mixed with rather than dissolved in the water.)

Students look at a geological cross-section showing oil and gas formation below ground (Information Sheet 9). Working in pairs, they use the cross-section to work out how the gas might have got into the water pipe. They should notice that oil and gas occur in sedimentary rock layers below ground, trapped beneath the top of the arch (or anticline) of a layer of impervious rock. Pipes bringing oil and gas to the surface pass through groundwater below the water table. Flammable gas could therefore leak into the water.

Ask the students to share their ideas with the whole class. Where does the oil and gas get trapped? Why here? Why are oil and gas able to rise through sandstone? Why do they get trapped in shale? Encourage the use of the vocabulary the students have already encountered, such as impervious rock. If needed, use the University of Tromsø website to help illustrate the explanation.

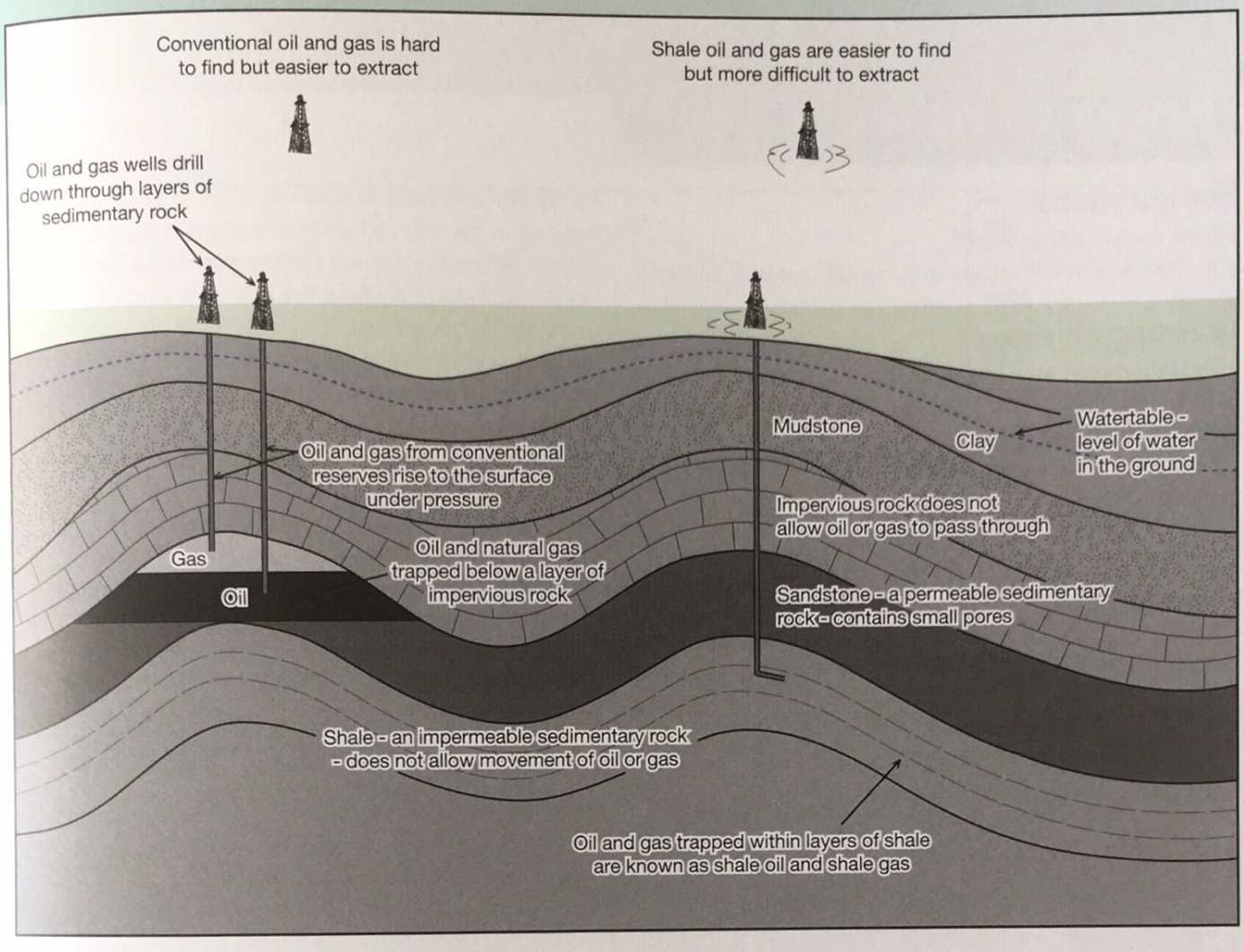
Main teaching phase

Explain to the students that, like the cross-section they looked at, sedimentary rocks underlying the UK and surrounding seas contain oil and gas. Much of the available oil and gas have already been exploited. For example, North Sea reserves are beginning to run out. However, new technology has enabled another form of gas – shale gas – to be exploited.

Working with a partner, students find out how good they would be at finding oil and gas. Tell them that how successful they are will depend on how well they understand geology. Give each pair a blank geological map (Activity Sheet 12) and each student an answer sheet showing either the location of conventional gas and oil (Activity Sheet 13) or shale gas and oil (Activity Sheet 14). They must keep the answer maps hidden from each other. The only difference between the two maps is the locations where oil or gas can be found. Below the blank map is a cross-section, helping the students to work out the most likely locations to find oil and gas. Warn them that they won't always find oil or gas in the obvious locations.

Students play the 'Oil and gas exploration game'. They place Activity Sheet 12 in the middle but keep their answer sheets hidden from each other. Together, the students use the cross-section to predict where they might find conventional and shale gas. They mark the locations on the cross-section.

Next, one student will explore for conventional oil and gas, the other will explore for shale oil and gas. They take turns to mark a square on the map where they would drill for oil or gas. They give the location of their chosen square to their partner using grid co-ordinates.



Their partner consults their answer sheet and tells them whether they have been successful in finding oil and gas or not. They mark the blank map to keep a record of where they have drilled and where they were successful. The game continues until one or both players have located all the oil and gas reserves on the map.

Plenary

Students answer questions to evaluate how successful they were in finding oil and gas. How did their understanding of geology help them to locate the oil and gas? What mistakes did they make? What did they learn from their mistakes?

They may notice, during the game, that shale gas is easier to find than conventional reserves of oil and gas. It covers a much larger area. However, the amount of gas drilled from shale is much less than the conventional reserves. Ask the students to suggest reasons for this. As they will find out in the next lesson, shale gas reserves in the UK are more extensive, but are more difficult to extract.

Teaching tips

Starting a lesson with a mystery is a good way to engage students. The image of water apparently burning is sufficiently intriguing to make students wonder how this could happen. Of course, having created the mystery, it is then important that students are given the resources and opportunity to solve the mystery for themselves, rather than simply be told the answer.

It is often through evaluation and reflection that students learn most from an activity. Playing the exploration game could be fun and should test students' understanding of basic geology. However, they are likely to make mistakes and it is often through these that the most important learning happens. Make sure to allow students time for reflection after they have played the game.

To encourage students to consider their decisions in the game more carefully, you could add a cost factor. Students could be given 100 credits at the start. Each time they drill to find oil or gas it costs 2 credits to drill for shale gas or 5 credits to drill for conventional oil and gas. However, finding conventional oil and gas brings greater reward than finding shale gas. Once they have used up their credits that game is over.

LESSON 10:
Rocks to riches

Key questions
- How does fracking work?
- Is shale gas worth the environmental cost of fracking?

Learning objectives
- To understand how fracking works
- To weigh the economic benefits of shale gas against the environmental costs

Key words
- horizontal drilling
- hydraulic fracturing (fracking)
- shale gas reserves

Resources
- Activity Sheet 15: The shale gas debate
- Activity Sheet 16: The case for fracking
- Activity Sheet 17: Assessment sheet
- Information Sheet 10: Shale gas and fracking

Assessment opportunities
- Students prepare questions and take part in a debate on fracking
- Students evaluate the importance of rocks in shaping our world

Starter
Ask the students, working in groups for one minute, to list all the ways in which we use oil and gas. Share the ideas as a class. You may need to supplement the list if any important ideas have been forgotten. For example, students may not realise the importance of oil in manufacturing things like plastic and fertilizers.

Now go through the list, asking students to suggest alternatives or substitutes for oil and gas. They should realise that our current lifestyle and economy depends on oil and gas. Furthermore, UK oil and gas reserves are dwindling and we are increasingly dependent on imports. Shale gas has the potential to increase our reserves and make us less dependent on imported energy.

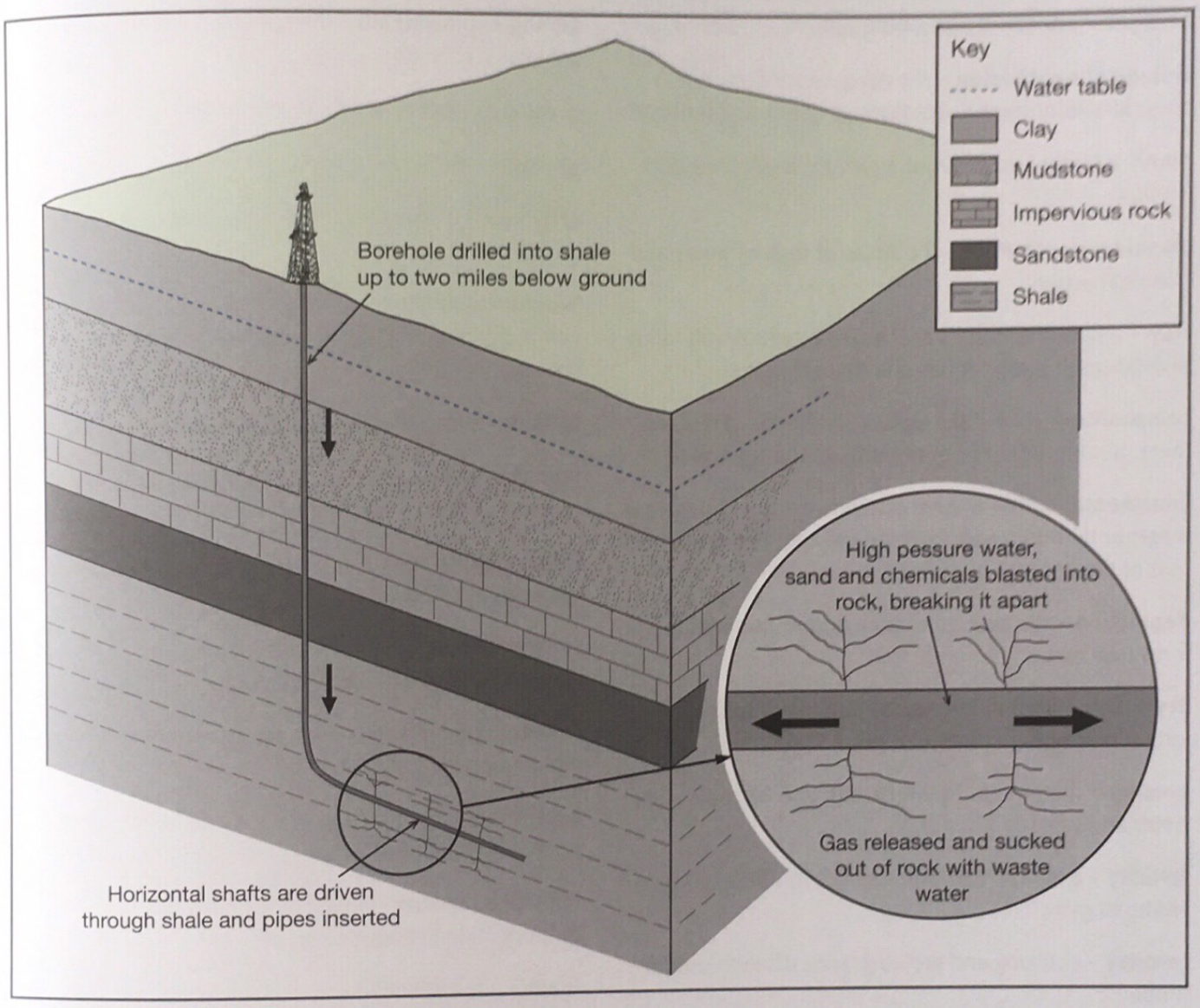
Main teaching phase
Students look at Information Sheet 10. They read how hydraulic fracturing, or fracking, could be used to extract shale gas and what the potential contribution could be to the UK's energy needs.

Ask students to take on different roles in the debate on fracking in the UK, including a resident, a tourist, a farmer, an environmental campaigner and a local businessperson. They read the role card for their character (Activity Sheet 15) and prepare questions about fracking in preparation for a public meeting. Designate a group of G+T students to represent a fracking company. They read about the case for fracking in preparation for the public meeting (Activity Sheet 16). They prepare an opening statement in favour of fracking. They should also try to anticipate the sort of questions that objectors to fracking might have and prepare their answers. Alternatively, you could take on the role of the fracking company representative yourself. Tell the students they are going to be assessed on their contributions to the debate. In particular, you will be looking for their understanding of the geology behind the debate on fracking.

Change the layout of the classroom for a public meeting with seats at the front for representatives of the fracking company. Ask students to submit their questions in writing before the start of the meeting. You could take the role of chairperson, selecting the questions that will be asked. Start the meeting with an opening statement from the company in favour of fracking. Allow time for questions related to the opening statement, then invite participants to ask their selected questions to representatives of the fracking company.

At the end of the meeting, you can take a vote. Should fracking go ahead in the UK; should it be delayed until certain conditions are met; or should it be totally banned?

Plenary
Ask the students to think back over the ten lessons about rocks and complete Activity Sheet 17. Encourage them to think back over the whole sequence of lessons, rather than be influenced just by the most recent ones. Finish with a discussion on the question, 'How do rocks shape our world?' Students may realise the question has more than a literal answer in relation to the physical landscape around us. Rocks also shape our lives in other ways, through the buildings we live in, the outdoor activities we do, the soils we farm and, most importantly, in providing the resources we need.



Teaching tips

Geography is a contemporary subject – arguably, this is one of its main attractions to students. Fracking is a contemporary issue and brings the topic of rocks bang up to date. It is important to keep up to date and direct students to the latest resources on the internet or elsewhere. Don't just rely on published resources – not even this one!

The sequence of lessons in this book is intended as an extended geographical enquiry – 'How do rocks shape our world?' It is worth asking students this question at the start and bringing them back to it each lesson. Certainly, you should return to the question at the end of the final lesson. How would students answer the question now? How has their answer changed since they started?

GLOSSARY

bedrock – hard rock underlying soil

biological weathering – the decay of rocks by the physical and/or chemical actions of plants or animals

cave – a hollow worn out of a rock by weathering and erosion

chemical weathering – the decay of rock by water and chemical action

clay – a fine-grained soil containing clay minerals along with traces of metal oxides and organic matter

composition – the make up or constitution of a given thing, a material made of more than one substance

Continental drift – a theory proposed in 1912 by Alfred Wegener that the continents are moving. This theory is a part of the concept of plate tectonics

deposition – the process of laying down material to form new rock

dry valley – a valley formed by past river erosion, no longer containing a river

erosion – the process by which rock gets worn away by water and wind

fertility – a measure of the minerals in soil helping plants to grow

forestry – planting and growing trees, often to produce timber

fossil – remains of a plant or animal preserved in rock

fracking – the method used to obtain shale gas by blasting water, sand and chemicals into the rock (also known as hydraulic fracturing)

freeze-thaw – physical weathering of rock by the action of ice

geological map – a map showing where underlying rocks are exposed at the surface

geological period – a time period, usually millions of years, when conditions led to formation of certain rock types

geological timescale – the sequence and duration of geological periods

geologist – a person who studies rocks

geology – the study of rocks

gritstone – a sedimentary rock made of course sand grains stuck together

horizontal drilling – drilling at an angle, rather than vertically, in order to better reach targets (oil/gas reserves)

humus – decayed organic (plant) material found in soil

igneous rock – rock made when molten rock, or magma, cools down at the Earth's surface

impermeable rock – a rock which is not porous and does not absorb water

impervious rock – a rock without joints or cracks, which does not allow water to pass through

lichen – small plants, which are a combination of fungi and algae, that grow on rock

limestone – a sedimentary rock made from fragments of sea shells stuck together

livestock farming – a type of farming that raises animals, grazing them on grass

loam – a fertile soil of clay and sand containing decayed organic matter

magma – molten rock beneath the Earth's surface

metamorphic rock – rock formed from heat or pressure deep in the Earth

mineral – a chemical component of rock which often forms crystals

mining – obtaining rocks and minerals from the ground

natural gas – a fossil fuel found in sedimentary rock formed from dead plant remains

oil – also known as petroleum, a liquid fuel created from the remains of plants and animals deep under the ground

organic – anything that was once liv
animals)

permeable rock – a rock which is p
water

physical weathering – the decay of
temperature or pressure

porous rock – a rock that absorbs w

quarry – an open mine where rock
surface

reservoir – an artificial lake to store
building a dam across a valley

rock – material that makes up the E
formed from minerals

rock cycle – the continual formatio
rocks at the Earth's surface over mill

sand – a naturally occurring materia
particles of rocks and minerals

sediment – rock fragments, organic
chemicals deposited in water

sedimentary rock – rock made fro
compressed and stuck together

shale – an impervious sedimentary
layers of compressed mud

shale gas – natural gas trapped in t
shale

shale oil – natural oil trapped in ti
shale

soil – a mixture of tiny particles of
humus, water and air

solution – a mixture in which the c
dissolved into a single substance

texture – the feel or appearance of
substance

tor – a large isolated rock that is re
and erosion

organic – anything that was once living (plants or animals)

permeable rock – a rock which is porous and absorbs water

physical weathering – the decay of rock by changes in temperature or pressure

porous rock – a rock that absorbs water

quarry – an open mine where rock is excavated at the surface

reservoir – an artificial lake to store water created by building a dam across a valley

rock – material that makes up the Earth's surface, formed from minerals

rock cycle – the continual formation and destruction of rocks at the Earth's surface over millions of years

sand – a naturally occurring material consisting of fine particles of rocks and minerals

sediment – rock fragments, organic remains or chemicals deposited in water

sedimentary rock – rock made from sediment, compressed and stuck together

shale – an impervious sedimentary rock made from layers of compressed mud

shale gas – natural gas trapped in tiny pockets within shale

shale oil – natural oil trapped in tiny pockets within shale

soil – a mixture of tiny particles of rock together with humus, water and air

solution – a mixture in which the component parts are dissolved into a single substance

texture – the feel or appearance of a surface or substance

tor – a large isolated rock that is resistant to weathering and erosion

water table – the level below which rock is saturated with water

weathering – the decay and disintegration of rock

FURTHER SOURCES FOR IDEAS

Earth Learning Idea

An independent, innovative website written by UK academic geologists with a wealth of earth-related teaching ideas, including some referred to in this book, e.g. 'Rock detective' and 'Soil doughnuts'.
www.earthlearningidea.com

Geology.com

US website with news and information about geology and earth science, including teaching ideas and galleries of useful photos of different types of rock.
www.geology.com

The Geological Society

The website of the Geological Society in the UK, providing resources on a range of topical geological issues, such as shale gas resources. There is a particularly useful section for KS3 students under the title of 'The Rock Cycle'.
www.geolsoc.org.uk

Oil On My Shoes

The website for petroleum geologists, including an introduction to what geologists do and an explanation of fracking for shale gas.
www.geomore.com

Scottish Geology

A very accessible site, covering the basics of Scottish geology, including geological timescale, map and some classic geological sites in Scotland.
www.scottishgeology.com

The Sedgwick Museum, Cambridge

This website contains a useful, virtual geological trail around Cambridge, which could be a model for your local trail or, even, a virtual alternative.
www.sedgwickmuseum.org

Photo © Alan Levine.

ASSESSMENT FRAMEWORK

Students should be expected to make progress throughout their KS3 geography programme. Within each unit of work progress should be made. Of course, the starting and finishing point for each student (what were previously described as 'levels' in the geography National Curriculum) will differ for each student. Rates of progress will also differ.

In the diagram below, student progression is measured in three broad bands – what might previously have been described as 'levels'. These bands are;

- most students at KS3 (previously levels 5-6)
- students who progress at a slower rate (previously levels 3-4)
- students who progress at a faster rate (previously levels 7-8)

The diagram describes the learning outcomes for students in each of the three bands.

Students who progress at a slower rate

- know the three main types of rock
- describe simply the processes in formation of rocks and soil
- distinguish two common rocks and their landscape features
- interpret atlas and OS maps to identify landscape features
- carry out local fieldwork to collect evidence about rocks
- appreciate the role of rocks in some human activities

Most students at KS3

- know the three main types of rock
- describe how rocks are linked together by processes in the rock cycle
- describe processes of weathering and soil formation
- identify some common rocks and associated landscape features
- interpret atlas and OS maps to make links between landscape and underlying geology
- carry out local fieldwork to collect evidence and draw conclusions about rocks
- appreciate the interaction between rock type and human activities

Students who progress at a faster rate

- know the three main types of rock with named examples
- describe in detail the processes that link rocks together in the rock cycle
- describe in detail processes of weathering and soil formation
- identify some common rocks and associated landscape features
- explain how landscape features are related to rock characteristics
- interpret atlas and OS maps to explain links between landscape and underlying geology
- carry out local fieldwork more independently, to collect evidence and draw conclusions about rocks
- appreciate how rock type and human activities interact to influence landscapes