'Limestone Landscapes of England.'

K.S 3: QCA Geography - Unit 13: Limestone Landscapes of England

This unit concentrates on the massive limestone deposits of the Midlands and Northern England. Students will be introduced to:

- The geomorphological features found in limestone deposits in the Midlands and the North of England.
- The need to appreciate the fragile nature of certain geological features
- The debates surrounding quarrying in National Parks and Areas of Outstanding Natural Beauty

Teacher introduction and overview

This scheme concentrates on the massive limestone deposits of the Midlands and Northern England. Students will be introduced to:

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- The debates surrounding quarrying in National Parks and Areas of Outstanding Natural Beauty

Problem solving and observational skills:

- Using clues left in the landscape to determine events requires a methodical approach to problem solving, a useful skill in a rage of subjects and situations.

Interpretative and discursive skills.

- The use of maps and photographs of the various areas under discussion encourage group work, particularly in response to questions dealing with the responsible use of primary resources.
- A role play activity will encourage students to share ideas, listen and draw conclusions from evidence presented.

The basic structure is:

Lesson One

How was the limestone formed?

- Chemical reaction for the precipitation of calcite
- Preservation of fossils

Homework: Students compile their own scrapbook about fossils.

Lesson Two:

Above and below ground - what features are typical of limestone landscapes?

- Virtual walking tour of Lathkill Dale using a guide available from English Nature and Ordnance Survey and Geological maps
- Alternative tour for Malham outlined briefly

Homework: Students prepare a brief for a quarry company planning to restore an area of limestone.

Lesson Three:

What features are typical of limestone landscapes?

- The Ice Age in Britain.
- The formation of limestone pavements
- Why protect them?

Homework: Using the National Snow and Ice Data Center (USA) website students create a storyboard to illustrate the formation of limestone pavements.

Lesson Four:

Why is limestone quarried?

- This lesson will consider quarrying in the Yorkshire Dales, an area with extensive Carboniferous limestone deposits.
- Using information available from various Internet resources students plan a role play exercise to consider the wide ranging debate surrounding quarrying in National Parks. Presentation of the roleplay will take place in the following lesson.

- Homework: Preparation for the roleplay presentations.

As an alternative students could plan the roleplay in class and then write up their roles as a homework exercise.

Lesson Five:

Roleplay presentations.

Homework: Who got the vote?

Unit 13 Limestone landscapes of England

Geography Year 8

About the unit

This unit develops pupils' knowledge and understanding of the patterns and processes associated with massive limestone landscapes (rather than softer limestones such as oolitic limestone and chalk). Pupils are involved in two problem-solving activities: one that asks them to consider the impact of quarrying on the local community; the other to consider sustainable development as the way forward.

This unit focuses on specific landforms above and below ground in the Yorkshire Dales National Park, although other areas could be substituted.

Throughout the unit pupils are encouraged to work collaboratively, to discuss issues and solve problems. There are also numerous opportunities for pupils to develop literacy skills.

This unit is expected to take 8–11 hours.

Key aspects

Geographical enquiry and skills

Pupils will:
- ask geographical questions
- suggest investigation sequences
- collect/record/present evidence
- analyse evidence and draw conclusions
- appreciate values and attitudes
- communicate appropriately
- use extended geographical vocabulary
- use atlases/globes/maps
- use secondary evidence
- draw maps, plans and graphs

Knowledge and understanding of places

Pupils will:
- locate places and environments
- describe scale contexts
- describe and explain physical features

Knowledge and understanding of patterns and processes

Explored through:
- geomorphological processes

Knowledge and understanding of environmental change and sustainable development

Pupils will study:
- environmental change and management
- sustainable development

Expectations

At the end of this unit

most pupils will: know about the different types of limestone landscapes and where they are to be found in England; describe and begin to explain how physical processes interact to form massive limestone landscapes and a selected limestone landform (above/below ground) and their formation; recognise how conflicting demands on an environment may arise because of the need for an important industrial resource; appreciate that different values and attitudes result in different approaches for managing such an environment sustainably, and that these may have different effects on the environment and people living there; begin to suggest relevant geographical questions and a sequence of investigation into limestone landforms and related issues; select and use appropriate skills and sources of evidence; suggest plausible conclusions and present their findings both graphically and in writing

some pupils will not have made so much progress and will: know about some of the different types of limestone landscapes and where they are to be found in England; recognise and describe how physical processes create a selected limestone feature (above/below ground); begin to understand ways in which a human activity/process like quarrying causes changes to a limestone environment, how it can affect the lives and activities of people living there, and the different views people hold about it; recognise how people try to manage such an environment sustainably; suggest suitable geographical questions and sequences of investigation; use a range of skills and sources of evidence and communicate their findings using appropriate vocabulary

some pupils will have progressed further and will: distinguish between the different types of limestone landscapes, where they are to be found in England and why they are there; describe and explain the physical processes which create massive limestone landscapes and selected limestone landforms (above/below ground); understand that many factors, including people's values and attitudes, influence decisions about extraction of a valuable industrial resource in such an area and how people who live there may be affected; appreciate the need for considerations of sustainable development in the planning and management of similar environments in the future; suggest relevant geographical questions and sequences for investigation into landform formation and environmental issues; select and use effectively a range of skills and sources of evidence; begin to evaluate critically sources of evidence, present well-argued reports and begin to reach substantiated conclusions

Prior learning

It is helpful if pupils have:

- used thematic maps in an atlas
- sent and received e-mail messages
- used OS maps at 1:10,000 scale
- surfed the internet

Language for learning

Through the activities in this unit pupils will be able to understand, use and spell correctly:

- words relating to rock formation, *eg sedimentary, limestone, Karst, clints, grikes, stalagmites, stalactites, pervious, permeable/impermeable, chemical weathering, swallow holes, joints, bedding planes, caves, caverns, calcium carbonate*
- other separate vocabulary:
  - evaporate, minerals, crystallise, waterfall, moor, springs

Speaking and listening – through the activities pupils could:

- discuss and respond to initial ideas and information, carry out tasks and refine ideas

Reading – through the activities pupils could:

- undertake independent research using knowledge of how texts, databases, etc, are organised and of appropriate reading strategies

Resources

Resources include:

- useful websites, *eg*
  - *www.holdenhurst.co.uk/mothershipton/index.htm (information about Mother Shipton's Cave and the Petrifying Well)*
  - *www.education.leeds.ac.uk/~edu/technology/yorkshire/a9.htm (information about Gaping Gill)*
  - *www.yorkshirenet.co.uk/ydales/index.html (information about the Yorkshire Dales)*
- OS maps of this area at a variety of scales
- atlases
- supporting video programmes:
  - *Geographical eye over Europe, series 3: Yorkshire – Limestone Landscapes* (Channel 4 Education)
  - *Geography in animation* series (BBC), programme 9 on ground water hydrology, *The secret of Mother Shipton's Well*, provides additional case study material, including limestone features formation, Gaping Gill and the Petrifying Well, as do the teacher's notes that accompany this series. The teacher's notes also contain a 1:10,000 OS map extract of the Gaping Gill area

Future learning

These studies may lead on to studies of other areas of massive limestone, within or outside England. Equally, another type of limestone, *eg chalk,* could be explored and pupils' understanding deepened by comparing and contrasting the features. Considering people's interaction with the environment lays the foundation for more detailed work on sustainable development and the complex issues of how to balance the need for a resource with conservation for the future – see unit 14, 'Can the earth cope?', unit 19 'Tourism – good or bad?' and unit 23, 'Local action, global effects'.

Links

The activities in this unit link with:

- other geography units – unit 14 ‘Can the earth cope?’, unit 19 ‘Tourism – good or bad?’, unit 23 ‘Local action, global effects’
- mathematics – interpreting maps and scales
- ICT – using a presentation package, using internet search engines
- key skills – problem solving, working with others
- science – work on rock cycles, geological changes, chemical changes
- English – creative writing

LEARNING OBJECTIVES PUPILS SHOULD LEARN	POSSIBLE TEACHING ACTIVITIES	LEARNING OUTCOMES PUPILS	POINTS TO NOTE
What do I already know about the relief of England?			
• to use an extended vocabulary • to use atlas maps to describe physical features	• Using an atlas, ask pupils to consider a relief map of England. Divide them into pairs and give them a series of true/false statements (between 10–15), *eg There is no land above 300 metres, All low-lying land, below 50 metres, is in the east.* Ask pupils to note true statements and correct false statements. Ask pupils, either in pairs or individually, to write a summary paragraph to describe the relief of England at a national scale. A glossary of key vocabulary may be helpful to support weaker pupils, who may also benefit from more structured guidance to write the paragraph, *eg using the cards as prompts.*	• classify information correctly based on map evidence • describe the general relief pattern of England	
Where are some of the areas of higher land?			
• to use atlas maps to obtain information and locate environments	• Ask pupils, working in pairs, to find the areas of higher ground in the north, south-west and south-east of England and locate and name these on an outline map which already has them outlined. Ask them to add a suitable key to distinguish height range. • Provide pupils with a simple geology map of England and, using the key, draw out the link between relative height and geology in the various parts of England. A brief explanation of geological time will help pupils to group rocks into older/younger. Then, by moving to rock types, help pupils to identify the rocks which stand out as the higher ground. Eventually narrow this down to types of limestone (massive and softer) and, if possible, show examples and test reaction with acid. Finally focus on the higher areas of massive limestone.	• use atlas maps to name and locate relief features correctly	• The teacher may wish to consider carefully the pairings for this activity to facilitate some peer tutoring. • Key skills: links with problem solving, where a problem is posed and there are options for a solution, of which a suggested activity is one, and which involves pupils in confirming their understanding of the problem, identifying ways to solve it, planning and implementing the option, and reviewing how to improve their approach. • Science: links with materials and their properties – rock formations **Safety** – use of acid and other issues: consult with the science department

LEARNING OBJECTIVES PUPILS SHOULD LEARN	POSSIBLE TEACHING ACTIVITIES	LEARNING OUTCOMES PUPILS	POINTS TO NOTE
What is special about areas of massive limestone?			
• to identify the processes responsible for the development of a particular landscape • how one type of landform is formed	• Use a brainstorming activity to find out what pupils know about massive limestone. • Using resources, *eg videos, photographs, text,* discuss with pupils key limestone features and how they are formed. Include features found above and below ground. Then ask pupils to work in groups of three or four to select one landform feature and to list its characteristics on cards, which they present to the rest of the class. Give pupils the choice of medium of presentation, *eg video, presentation software, poster, overhead transparency (OHT).* The presentations need to be shared with the whole class, either orally or by display. Alternatively, pupils can extract the information from texts, following guidelines they are given.	• describe the characteristics of a selected feature in a presentation and explain how it was formed	• ICT: this activity provides pupils with the opportunity to use a package for mixed-media presentations. • Language for learning: this activity provides pupils with the opportunity to discuss and respond to initial ideas and information, carry out the task and then review and refine ideas. • Key skills: links with working with others, where pupils work on a one-to-one or group basis and plan with others what needs to be done, confirm their understanding of the objectives, their responsibilities and working arrangements, carry out tasks and review progress.
What features are typical of areas of massive limestone?			
• to select and use appropriate graphical techniques to present evidence • to identify the processes responsible for the development of selected limestone features	• Give pupils a series of factcards about massive limestone, and ask them to produce a factual poster about this rock type. Pupils must choose five cards from those offered. They have 10 minutes to choose the information and prepare a poster. After eight minutes, give pupils two more factcards; they have to decide which, if either, of the new cards to select and which to reject. Factcards may include the following information, *eg 'carboniferous limestone is made up largely of calcium carbonate', 'chemical weathering is especially effective on limestone', 'the calcium carbonate is slowly being dissolved', 'a limestone pavement of clints and grikes is a surface feature of limestone areas', 'carboniferous limestone is pervious, allowing water to pass through its joints rather than the rock itself'.* It may be helpful to explain to pupils the difference between porous, pervious and permeable and for this to be noted, *eg in glossaries.* The posters may be used to form a classroom wall display.	• describe and explain the main characteristics of massive limestone	• Language for learning: this activity provides pupils with an opportunity to learn about word derivation. • Science: links with work in science on pollution and chemical weathering.

LEARNING OBJECTIVES PUPILS SHOULD LEARN	POSSIBLE TEACHING ACTIVITIES	LEARNING OUTCOMES PUPILS	POINTS TO NOTE
What is distinctive about the Yorkshire Dales?			
• to follow the geographical route of enquiry • how to distinguish between national and regional scales and how a region may be identified • how to locate other regions with similar features, using an atlas • how to compare the geographical contexts of two regions	• Ask pupils to consider what makes a distinctive massive limestone area or region. Discuss with them how a region may be defined. Ask pupils to carry out an investigation of surface limestone features. Ask them to imagine that they have received an e-mail request from some pupils in the Karst area of Croatia, which is also an area of limestone scenery. Pupils use their atlas to locate it. The teacher in Croatia has asked them to find out about another region in Europe with similar features. Can the pupils in this class help? Ask them to work in groups of three or four to find information from a variety of sources, including video, print, the internet and CD-ROM. The choice of medium of presentation may be left up to the pupils. Encourage them to make their own judgements as they work.	• examine a variety of sources to gather information for a particular purpose • research and select information independently of the teacher • describe and explain selected physical features of one region of England to exemplify landforms typical of massive limestone • accurately describe the national and international contexts of regions studied	• In this worked example the Yorkshire Dales have been chosen. Any limestone region would be appropriate, depending on the resources available to the teacher. Resources for the Yorkshire Dales are provided in the Resources section. • ICT: this activity provides pupils with an opportunity to use the internet to access resources. • Language for learning: the activity provides the opportunity for pupils to undertake independent research using knowledge of how texts, databases, etc, are organised and of appropriate reading techniques. Pupils may need reminding of efficient approaches for selecting and recording what they find.

LEARNING OBJECTIVES PUPILS SHOULD LEARN	POSSIBLE TEACHING ACTIVITIES	LEARNING OUTCOMES PUPILS	POINTS TO NOTE
What can an area of carboniferous limestone look like underground?			
• to use OS maps at a range of scales • to select and use appropriate graphical techniques to present evidence on maps and diagrams • to identify the processes responsible for the development of underground limestone features	• Give pupils an OS map (preferably 1:10,000) of an area within the Yorkshire Dales, *eg the Ingleborough area, around Gaping Gill.* Ask pupils to produce a sketch map to show where Fell Beck disappears underground and where it reappears as Clapham Beck, and to illustrate in a separate annotated diagram what happens to it. (At Gaping Gill, Fell Beck drops 100 metres from the moor, forming England's largest cavern, and the fall of the Beck into the swallow hole is the highest unbroken waterfall in England.) Ask pupils to annotate the diagram with the names of features, *eg caves, caverns, joints,* and labels explaining the processes. Encourage them to refer back to their earlier investigation of limestone features to ensure accuracy. Some pupils may benefit from the support of a factsheet outlining features and processes, to use as stickers to add to their own sketches.	• interpret an OS map of a massive limestone area • use geographical skills and techniques to present the information • use correctly specialist vocabulary • describe and explain the processes responsible for the formation of a specific massive limestone feature	• The most appropriate map scale is 1:10,000, although other scales may be used. This scale encourages pupils to be detailed in their analysis and to think about a small area for local study. • Key skills: links with problem solving where a problem is posed and pupils are given options for a solution. This could involve pupils confirming their understanding of the problem, identifying, planning and implementing solutions. • Mathematics: interpret maps and scales.

LEARNING OBJECTIVES PUPILS SHOULD LEARN	POSSIBLE TEACHING ACTIVITIES	LEARNING OUTCOMES PUPILS	POINTS TO NOTE
How is the landscape being changed?			
• to appreciate how people's values and attitudes affect environmental issues • to communicate in ways appropriate to task and audience • to consider how conflicting demands on an environment arise and may lead to change • to explore the idea of sustainable development and its implications	• Ask pupils to undertake a local case study, *eg the Petrifying Well by the River Nidd, near Knaresborough, in Yorkshire.* (For centuries, this well gave rise to great superstition. Leaves, birds and small animals which fell into it were coated with a hard layer of rock, spreading rumours of witchcraft. In fact, the water springs from an underground lake. Its high mineral content means that everything porous left long enough in the water is turned to stone.) Ask pupils to solve the mystery *How can a teddy bear left by this river turn into stone?* Ask them to offer an explanation to the owner of the teddy bear. Suggest they do this by examining either video or website evidence or to go to any other source they might think helpful. • Follow this with a more substantial investigation into the sorts of conflicts of land use that occur in some areas of natural beauty. An appropriate conflict to study may be the value of limestone as an industrial resource and the impact of quarrying on a community, through a real *(eg limestone quarry near Hope in the Castleton Valley in Derbyshire)* or fictional case study. Divide the class into two groups, one which supports quarrying and one which wants to preserve the landscape for today's and future generations. Ask each group to present its views in the form of a debate, during which pupils make their own notes. Ask pupils to write up a report including both viewpoints. Ask pupils to make and justify a decision on whether the quarry should go ahead or not. There is opportunity here to explore the concept of sustainable development as a possible way forward.	• apply problem-solving strategies to solve a given problem • follow the investigative sequence to plan, follow and report on a specific issue • describe and explain how people's different values and attitudes about development may affect an environment which contains an industrial resource	• Language for learning: this activity provides pupils with the opportunity to learn about word derivation. • Language for learning: this activity provides opportunity for pupils to discuss in groups and respond to initial ideas and information, carry out tasks and refine ideas. • Key skills: links with problem solving, where pupils confirm their understanding of the problem, identify ways of solving it, plan and implement the option, and formulate a review for improving their approach. • Citizenship: this activity provides pupils with the opportunity to justify orally and in writing a personal opinion about such issues, problems or events.
What do I like/dislike about massive limestone scenery?			
• to express substantiated views about geographical features • to use geographical vocabulary correctly	• As an alternative to the last suggested activity, ask pupils to produce a 'shape poem' about limestone, using the shape of a limestone feature, *eg a stalagmite, stalactite or cavern,* as an outline. The writing could be a descriptive piece of prose or a poem, with pupils using some geographical vocabulary to say what they like and/or dislike about that particular feature or limestone features in general.	• produce a shape poem which describes their feelings about the landscape	• English: this activity provides pupils with an opportunity to write creatively.

Lesson One

How was limestone formed?

Students need to know that:

- Limestone is a sedimentary rock
- That means it is made up of different grains cemented together
- The grains are made mainly of calcium carbonate in the form of the mineral calcite

Students should understand that:

- Oxygen and carbon dioxide moves from the atmosphere into the water at the sea-air interface.

- The organisms living in the water use these gases to help them live and some organisms use them to help build their shells

- Carbon dioxide is removed from the atmosphere by dissolving in ocean water and forming carbonic acid

$CO2\ (g) + H2O\ (l) \leftrightarrow H2O\ CO3\ (aq)$ (carbonic acid)

- Once dissolved into sea water carbon dioxide is converted into bicarbonate ions or carbonate ions.
- Certain forms of sea life biologically fix bicarbonate with calcium to produce calcium carbonate ($CaCO3$)

Demonstration

Some students may have difficulty imagining gases being held in solution in seawater, an easy way of demonstrating this is to use a bottle of carbonated water. With the cap on it is impossible to "see" the dissolved carbonate but as soon as the cap is realised the pressure holding the gas in solution is lowered and the gas escapes with a fizzing action clearly seen and heard.

Students might like to know that:

- Many organisms have shells made of calcium carbonate from the millions of microscopic plankton that inhabit the oceans to larger bi-valved organisms.

- Shells help protect the organism from predators

- The shells vary from species to species

- Some shells are smooth to enable the organism to burrow easily into the soft sediments on the ocean floor
- Some shells are heavy to protect an organism that lives its life sitting on the ocean floor.

Students could be introduced to the idea that:

- The build up of shelly material in order for rock to form is a slow process. Preservation of the shells is not an easy task, creatures need to live long enough to make their shells and then the shell needs to be buried and incorporated into a rock.

Diagram – could be produced on whiteboard, interactive whiteboard or PowerPoint

Let's imagine we have 10 shelly creatures living in the ocean

2 will be eaten alive!
When they die the other 8 will begin to sink gently towards the seabed.
Other creatures, known as scavengers will eat 2 of the dead creatures as they float past.
The other 6 reach the seabed.
Another scavenger comes along and eats 1.
Now there are 5!
A great storm builds up and the shells are tumbled and tossed by the currents.
2 of the thinner shells are broken into minute pieces and carried away by the current; these pieces may eventually land on a beach.
1 shell remains on the seabed and the other 2 are quickly buried by sands and lime mud, which forms on the seabed.
The shell left on the surface is broken down by chemical reactions until eventually there is nothing left – the calcium carbonate has completely dissolved.
So out of 10 original creatures only 2 are left to form part of the sedimentary rock known as limestone.

The lime mud forms the cement holding the shells together; gradually the lime mud hardens and becomes rock. The rock becomes part of the rock cycle.

Students should now know that:

- Limestone is a sedimentary rock
- It is made up of calcium carbonate either in the form of fossil remains, as the mineral calcite or the lime mud that forms the matrix of the rock
- Calcium carbonate reacts with dilute acid giving of carbon dioxide as a gas.

Practical
Students are given a range of rocks and asked to identify the carbonate rock. They should be provided with a dripper bottle of dilute acid and images of common fossils. The selection of rocks should include other sedimentary rocks such as sandstone and mudstone and igneous rocks such as granite and basalt.

Homework
In order for students to gain some understanding of the diversity of organisms, which eventually form carbonate rocks students could use the Internet to build up their own reference catalogue of common fossils. Students could produce a scrapbook, which has images and short pieces of text about the fossils they have found. To give the task direct relevance to the study of limestone in the Midlands and the North of England a list of fossils from the Carboniferous period could be given. In the following list fossils from the Carboniferous are identified by (C).

Examples

Trilobites (examples *Calymene* and *Griffithides*)

Goniatites (C)

Ceratites

Ammonites (example *Dactylioceras* or from the Jurassic *Titaintes giganteus*)

Brachiopods (examples *Spirifer* (C) and *Productus (C))*

Bivalves (examples *Mya* and *Pinna* (C) and *Gryphaea*)

Crinoids (sometimes known as sea lilies (C)

Corals (examples *Favia* and *Lithostrotion* (C))

Sea Urchins (example *Hemicidaris* and *Clypeaster)*

Virtual Quarry
There are a range of fossil images available on the Virtual Quarry Tour in the 'Geologist's Office'.

Lesson Two

Above and below ground - what features are typical of limestone landscapes?

A useful way to introduce some of the interesting geological formations found in areas where the bedrock is limestone would be take a Virtual Tour using a published guide and a geological map of the area.

The example used is of Lathkill Dale in Derbyshire. Lathkill Dale is a National Nature Reserve managed by English Nature who have produced an excellent leaflet entitled: Lathkill Dale Geology Trail: a self guided trail to the formation and geology of the dale. This could be used in the classroom alongside an Ordnance Survey and Geology map of the area.

Students, working in pairs, use the maps and the trail guide provided to produce an illustrated and annotated wall display identifying and describing the various features typical of limestone areas identified on the Virtual Tour.

A base map on which students can add small sketches and text boxes explaining the various features characteristic of a limestone landscape identified along the trail is provided. When the task is complete the paper can be mounted onto A1 Daler board to be used as a wall display.

Teacher Information

If possible contact quarries in the White Peak in order to show students examples of the limestone being discussed.

In order to support teachers using hand specimens a brief introduction to the formation of limestone in the Derbyshire Dales and information on the most common fossils likely to be found in the rock is provided.

This is followed by material for classroom delivery on the impact of water on limestone landscapes and finally each of the features found along the trail is described briefly. The descriptions could be used as a handout to support teacher input or to support individual research.

Description of Derbyshire limestone

- Limestone found in the Derbyshire Dales formed in warm shallow seas approximately 360 million years ago when the landmass we call Britain was located near to the equator.
- The remains of shelly organisms found in those seas at that time have been fossilised and form part of the rock.

- There would have been many more creatures and plants in the warm seas but only a few of those with hard parts have been preserved.
- Brachiopods and crinoids are the most abundant fossils found in this limestone.
- Brachiopods were shellfish; a soft body was encased inside a shell, which consisted of two valves held together by a hinge. The valves would open just enough to allow the creature inside to feed by filtering food out of the water that flowed over it but they would close quickly if danger threatened.
- Crinoids are sometimes called sea lilies and were at one time thought to be plants. We now know they were creatures related to today's starfish. The soft body was attached to the sea floor by a "stalk" and the skeleton grew around it. The creature had five tentacles; these were used to catch their prey as it swam towards them through the water.

Students need to know that:

- The features seen in the landscape at Lathkill Dale reflect the impact water can have on limestone.

Students need to know that:

- Water contains dissolved carbon dioxide and may also contain dissolved sulphur dioxide or organic acids formed from decaying plants.
- This makes the water acidic.
- Carbonate rocks react with acid.
- The acid breaks the bonds holding the carbon and this reacts with oxygen to form carbon dioxide, which is released to the atmosphere.
- If this happens enough times the rock will eventually disappear, the carbon to the atmosphere, the remains of the rock washed away with the rainwater.
- Students should be provided with dilute hydrochloric acid and samples of carbonate rock to see the effect of cid rain on carbonate rocks.

In order to complete the wall display task students need to know about:

Dry Valleys

At the end of the last Ice Age vast quantities of water flooded across the land as the ice melted. To try and get some idea of the thickness of the ice at the height of the Ice Age it would have been possible, in Scotland, to walk straight across from one mountain peak to another. Even though the ice was melting the ground was still frozen and so there was little or no through flow (this is when water seeps into the soil and flows underground) just overland flow. In the Derbyshire Dales the water quickly cut down through the rock forming steep sided gorges. Very few of these valleys have rivers flowing through them today, hence they are known as dry valleys (an example of a dry valley can be seen along the Lathkill Trail at Mill Dale). There are some valleys, like Lathkill Dale itself, which have a river for only part of the year depending on the amount of rainfall in autumn and winter.

Springs

Rainwater, which sinks into the ground slowly will gradually fill up the open spaces, known as pore spaces, between the soil particles. Any water not held in the first few centimetres of soil, or used by plants, continues to seep downwards towards the bedrock. The water gradually fills up all the pore spaces in the soil and, as it infiltrates the bedrock, also fills the pore spaces and fractures in the rock. This water is called groundwater. The upper limit of the saturated zone – the zone where all pore spaces are full of water – is known as the water table. The zone above the water table is called the zone of aeration because the pore spaces there are mainly filled with air.

Students need to know:

- The difference between porosity and permeability and the effect this will have on groundwater movement. Porosity is a measure of the space between grains, permeability is the degree to which water can move through rock or soil.

- The water table is not level or static. The shape of the table reflects the landscape above it and the table falls or rises according to how much rain is falling and how quickly the water moves through the pore spaces.

In limestone regions rainfall quickly seeps down through the rock. The rock is often cracked or has been dissolved in places by the action of chemical weathering caused by acidic water. This allows water to move easily through it. If the permeable rock outcrops (appears at the Earth's surface) then the water will flow away. This is a spring.

In some parts of Derbyshire the groundwater travels to great depths where it becomes heated and, if it should rise back up to the surface, the water will emerge as a hot spring. In the Derbyshire towns of Buxton and Matlock a whole tourist industry grew up around these hot springs in late Victorian times when people came by train to swim in the warm spring waters pumped to bath houses as they were thought to help cure a range of aches and pains.

Caves

Groundwater gradually dissolves the limestone it flows through forming caves.

- Remember rainwater has a pH of 5.6 so is acidic
- Students could find out the chemical equation for the dissolution of limestone when it is in contact with acidic water and add this to their sketch.

    - $CaCO_3$ (limestone) + H_2CO_3 (carbonic acid) $\Rightarrow$ $Ca(HCO_3)_2$ (calcium hydrogen carbonate solution)

Sinkholes
Sinkholes may form gradually as the rock directly beneath the soil is slowly dissolved by the action of rainwater moving through it. A sinkhole formed in this way is usually a shallowly sloping gentle basin shape. Sinkholes can also be formed when the roof of a cave collapses under its own weight. This usually happens suddenly and without warning. The sinkholes formed in this way are steep sided and deep.

Stalactites
Water moving through carbonate rocks collect dissolved carbon dioxide. If the water seeps into the roof of a cave filled with air some of the carbon dioxide will escape from the water and the mineral calcite begins to precipitate. The first sign that this is happening is the appearance of a ring around the edge of the water droplet. As one drop follows another a minute trace of calcite is left behind and a hollow limestone tube begins to form. The water now moves through the tube adding further tiny calcite deposits to the tube before falling to the floor.

Stalagmites
The drops of water, which fall to the floor of the cave from the stalactites or the roof of the cave, do not form a central tube of calcite in the same way as a stalactite. The calcite precipitates out of the water to form a column which grows upwards over time.

Stalactites and stalagmites can eventually meet, if this happens the structure is known as a column.

- Some students might realise that this is a new carbonate deposit being created albeit without the help of dead organisms!

Scree

Students should already know that:
- Rocks can be shattered by a form of mechanical/physical weathering known as freeze thaw
- Freeze thaw breaks the rock into small pieces

Screes form when water, which has seeped into the bedrock freezes and expands. This leads to fracturing of the rock and small pieces of broken limestone slide down the slope and collect at the bottom. Over time the scree builds up to form a rubbly mass on the slope. Some scree slopes are ancient, they formed at the end of the last Ice Age, and some are still forming today. An ancient scree slope can be easily identified as it will have stabilized and will have plants growing on it.

Quarries

Limestone has been an important material for building purposes for centuries. It has been used as an antiseptic (used as a lime wash to paint walls in houses for example or as quicklime sprinkled into graves) and as an ingredient in mortar. Today it is used amongst other things in the making of cement, for pharmaceuticals, in toothpaste, as a building material and by farmers to reduce the acidity of soil. Some of the landscape seen in the limestone regions of the United Kingdom that we consider to be "natural" is in fact a relic from quarrying activities. Remember that until the age of industrialisation rock would have been quarried by hand and so the scale of many quarries was quite small. Today quarries tend to be much bigger but right from the start the owners of limestone quarry sites have to think about what the site will look like when quarrying finishes. Computer technology is often used to show how the quarry can be worked in such a way that, when work finishes, it will resemble a natural scarp. Scarp is the word used to describe a cliff face in limestone landscapes.

An alternative to this exercise would be to visit
www.walkingbritain.co.uk/gallery/g2c.shtml

This link provides details of walks in the Malham area of the Yorkshire National Park along with a selection of images. Students could identify the area to be walked on both the Ordnance Survey and the Geological map of the area. They could produce their own map in exactly the same way as outlined for Lathkill Dale downloading images of specific features from the web site to add to their map and information boxes.

On the walk students might identify Watlowes Valley,a dry valley, Malham Beck, a spring which rises from a submerged cave and waterfalls at Thornton Force, Ingleborough where different rock types have been eroded to produce a steep drop. They may identify another series of caves at White Scar and in the wide glacial valley of Kingsdale where Yorda's Cave was a favourite haunt of Victorian visitors.

This exercise could be extended by visiting

http://www.multimap.com/multimap

Type in Malham, print the map and then click on aerial photographs to download and print and aerial photograph of the Malham area. These could form the basis of the student project, students identifying and labelling limestone features, or could supplement information given on their hand drawn map.

Homework: In planning a limestone quarry restoration scheme a quarrying company wants to leave the area as natural as possible. Write a brief report to the quarry company explaining which features they should plan to include, tell the company why these features are important.

Lesson Three

What features are typical of limestone landscapes?

Limestone Pavements

Students should know that:

- Limestone is a carbonate rock which formed in shallow warm waters
- Often there are the visible remains of fossils in the rock

In order to understand the way in which limestone pavements form students should know that:

- Carbonate sedimentary rock forms in beds. Each bed represents a period of deposition, a block of time during which shelly organisms collected in the lime mud on the floor of the ocean.
- The beds are separated by bedding planes.
- Bedding planes represent gaps in time as they form only when there is a period of non –deposition.
- The bedding planes are likely to form weaknesses in the solid rock when it forms.
- The rocks may remain hidden at depth for millions of years but some will eventually be seen at the Earth's surface when major Earth movements, such as earthquakes force them up to the surface.
- Over time a thin soil will develop on top of the limestone

Remind students of the way in which a soil forms. Tiny pieces of rock broken off by weathering processes are gradually covered by lichens and/or mosses, which continue the breakdown processes by chemical weathering. As the plants die they add organic matter to the mineral mixture formed by the broken pieces of rock. As more and more organic material collects larger plants will be able to grow, die and decay and add to the nutrient levels found in the newly forming soil. Air and water and eventually biological organisms such as worms combine with the minerals and the organic matter and a true soil is formed. This process can take hundreds or hundreds of thousands of years to be completed. In areas of limestone because so much of the rock is lost to solution as it is chemically weathered it takes a very long time to form just a thin soil.

Demonstration

In numbered beakers have:

- Leaf litter
- Sand/Crushed rock
- Clay
- Water

Ask students to give you the recipe for soil. What else do you need to make your soil complete?

- Air
- Soil fauna

Where has the sand and clay come from? *Weathering of rock*
Why would a soil on limestone take hundreds of years to form? *Dominant form of weathering is chemical weathering so little in the way of mineral matter to add bulk to the organic material.*

Students need to know that:

- During the Quaternary period of geological history glaciers up to 1km thick moved over the limestone landscape in Ireland and the North of England
- In some areas the soils were scraped off the limestone as the glaciers slowly moved over them
- The weight of the ice fractured the limestone along the bedding planes
- Some of the fractured rock was also stripped away by the ice
- About 15 thousand years ago the ice started to retreat (shrink) as the climate began to warm.
- As they did so thick layers of Till, a clayey deposit often containing boulders and broken rock pieces, was deposited on top of the limestone.
- When glaciers form sea level falls as the water that would usually flow in rivers from the land into the sea is locked up in the ice
- This means the sediments, sands and fine clays, which accumulate on the gently shelving edges of the oceans are exposed and the sediments dry out
- When the global climate begins to warm and glaciers retreat the winds blow these sediments from the edges of the oceans inland
- Sediments from the North Sea and the Irish Sea would have been blown inland and deposited on top of the Till
- Over time a soil formed
- Water percolated through the soil and attacked the cracks and fissures in the rock.

Students should know that:

- Carbon dioxide dissolves in rainwater and forms a weak carbonic acid
- Decaying plant material may form organic acids, which will be picked up by the rainwater flowing over the land
- The rainwater seeping through the soil will attack weak areas of rock and, because limestone is a carbonate rock, the chemical reactions will lead to dissolution of the rock

Students need to know that:

- Over thousands of years a distinctive landscape has evolved where the water has attacked the rock

- Distinctive patterns began to form on the rock surface
- Horizontal gaps known as **grikes** are formed
- Some of the thin soil will be washed down into the grikes
- Over time the thin soils left on the flat rock surfaces will be eroded and the rock exposed
- The flat areas are known as **clints**
- The effect of both the weight of the ice and the action of the water has resulted in a structure known as a **limestone pavement**
- Limestone pavements are very special, unless the climate of the United Kingdom becomes so cold that another ice age begins then the conditions needed for their formation will not occur
- In years gone by pieces of limestone pavement have been used in gardens to form rockeries as they look very attractive, this was before geologists were able to explain how special these areas are. Garden centres are no longer allowed to sell limestone pavements and the areas of pavement are protected by special legislation

Task

You are a farmer who lives near an area of limestone pavement. You keep sheep that roam freely around your home and you have also converted three of your barns into holiday homes. Many of the people who stay on your farm have come to walk on the moors and to see the limestone pavement. There is a great deal of arguing amongst your neighbours about the best way to care for the limestone pavement now and in the future and they have asked you to a meeting to decide what to do. Everyone has been asked to bring 3 suggestions for protecting the limestone pavement to the meeting - what will your suggestions be?

Working in pairs, students use the following cards to help them decide how to care for the limestone pavement. Students should quickly realise that the farmer will be affected by any decisions made and gain some appreciation of the difficulties involved in reaching solutions about the care and protection of the environment.

- Limestone pavements are irreplaceable, as the climatic conditions in which they formed cannot be repeated.
- Plants and animals that live on limestone pavements are often not found anywhere else.
- People have collected limestone pavement to build rockeries and other features in their gardens.

- Only 3%, about 90 hectares of limestone pavement in the United Kingdom is undamaged.
- Animals grazing on the plants add nutrients (from their dung), which collects in the grykes enriching the thin soil.
- If the soil conditions change plants of more vigorous species will be able to grow and gradually the special plants of the limestone pavement will be lost.
- Animals grazing on the limestone pavement will scratch the surface with their teeth and hooves; this increases the surface area open to attack by acid rain.
- If there is no grazing small trees like ash, hawthorn and birch will begin to grow in the grykes. Over time the pavement gradually becomes woodland.
- People walking on the limestone pavement will, in time wear it away.
- Ramblers first reported the damage being done to the limestone pavement by the removal of large area of the rock.

Teacher information: Limestone pavements, which have formed in Carboniferous limestone can be found in Wales, Northern England and Northern Ireland but in total there is less than 3,000 ha. The largest amount is found in North Yorkshire and Cumbria. The United Kingdom has the largest proportion of the total limestone pavement found throughout the European Union. In 1975 research into the condition of the pavements found in the United Kingdom found that only 61% of the pavements could be classed as intact and out of that total only 3% were completely undamaged. Now a piece of legislation known as the Limestone Pavement Order makes it illegal to remove limestone pavement. Limestone pavements have been designated as Sites of Special Scientific Interest (SSSI), which also gives them some protection. Information about the United Kingdoms Biodiversity Action Plan with regard to the protection of limestone pavements can be found at http://www.UKbap.org.uk/UKPlans.aspx?ID=26

Web Link
Good images can be found at

http://www-biol.paisley.ac.uk/bioref/Habitats/LimestonePavement.html
Superb photograph

http://www.limstone-pavements.org.uk/geology.shtml

www.walking britain.co.uk/gallery/g2c.shtml
Images 051f, 239f. 239g. 208b

Useful information and images can be found at

www.english-nature.org.uk/special/nnr/nnr_details.asp?NNR_O=92

Scroll down to Limestone Walk or Ridge Route for information on limestone pavements.

Homework

Visit http://nsidc.org/glaciers/index.html the web site for the National Snow and Ice Data Center (American spelling!) in Boulder Colorado and follow the 'story of a glacier' links. Produce a storyboard to show the history of the limestone pavements in Yorkshire from the time the limestone formed to the exposure of the limestone pavements we see today.

Lesson Four

Why is limestone quarried?

This lesson will consider quarrying in the Yorkshire Dales, an area with extensive Carboniferous limestone deposits.

Students need to know that:

- The Pennines is often described as the backbone of Northern England. Students should identify the Pennines on a map.
- The Pennines run from Northumberland to Derbyshire, Carboniferous limestone is found extensively in the Yorkshire Dales and the White Peak of Derbyshire.
- Both the Yorkshire Dales and the Derbyshire Peak District are National Parks; they have been given this special designation because of their outstanding scenery, the wildlife found their and their history.
- The Yorkshire Dales cover 1769 square metres.
- Over 4 million tonnes of rock is quarried in the Yorkshire Dales each year; this is mostly limestone although there is some gritstone (a coarse sandstone) quarried as well.
- Limestone has a variety of uses.

Task

Ask students if they have seen or used any limestone at home or on their way to school. Students might suggest, depending on where in the country they live, building stone, fireplaces, in their bathrooms or kitchens as decorative work surfaces or tiles, in toothpaste, dry stone walls. Now using the Internet or the library ask students to find a range of industrial or agricultural applications for limestone. Examples may include flux for steel making, glassmaking, industrial lime, and agricultural lime. Other examples will be aggregates used in the construction and road making industries or limestone used in the making of cement and concrete. Can students suggest way limestone is so useful: answer is because of its high calcium carbonate content.

Students need to know that:

- In recent years, as the scale of quarrying has increased because of our demands for the products produced from limestone some people have become concerned about the effect the quarrying process has on the landscape and the surrounding countryside.

Task:

A roleplay exercise which explores the issues surrounding quarrying today, this task encourages creative thinking, problem solving and communication skills.

Students will consider the difficulties involved in making decisions in areas, such as quarrying, where people often have opposing views. The purpose of the role play will be to enable a group of people involved in the quarrying debate to put forward their views in a calm and reasoned manner. The audience will then be asked to make a decision based on the evidence they have heard, this is not a debate and so those involved in the roleplay will not be expected to argue with each other.

The exercise will have 3 stages.

Stage 1: Whole class activity to gather initial ideas on quarrying, the need for quarried materials, the impact on the local and the wider environment. Students should be given some guidance where necessary to see that one of the impacts will be economic and that many of the activities taking place in a quarry are governed by planning legislation or national legislation on noise and emission levels.

Stage 2: The class is divided into groups of 4. Each member of the group will take a particular role and research that role, gathering information, which will be presented verbally to the whole class.

In each group there will be

- A Quarry Manager
- A local resident
- A representative of the National Park Authority
- A young married man who lives in a neighbouring town with his wife and 2 small children

Each person will need to summarise the main points as they see it (in their role, not as themselves) in bullet form to help them in their verbal presentation.

The time each group is given to speak should not exceed 10 minutes to encourage each speaker to look at the main issues for their particular area. If your class is large you may want to confine the time to 5 minutes.

Stage 3: Following lesson:
Presentations of the roleplay exercise to the class. The remaining students will take the role of an audience at a public debate on the issue of quarrying in the National Park. As each presentation finishes they will need to decide which of the speakers would get their vote. This may not necessarily be for the same role each time as a well prepared speaker may well encourage them to pick a different stance each time. Students will be encouraged to consider their own standpoint through a homework task.

Information Sheet

Quarry Manager
You have worked in the quarry industry since leaving school. You think the quarry industry has worked very hard over the last 20 years to use the best technology to ensure they operate in a clean and environmentally sensitive way.

Local resident
You think the quarry is noisy and dirty. You are worried that the countryside around you will be quarried away.

A representative of the National Park Authority.
You have to balance the needs of the local community and the economy. In your region most of the employment opportunities are offered by the quarry industry the rest comes form farming or tourism. You realise that the landscape visitors come to see is the landscape that has been created by the quarrying industry.

Young family man
You know that the country needs the limestone removed from the limestone quarry for a variety of uses, which make the quality of life for everyone so much better. You are however worried about the sustainability of natural resources as you want your children to be able to have a good life in the future.

Web Links
A useful resource to provide background information on the debate is produced by the Yorkshire Dales Educational Service. It can be downloaded from http://www.yorkshiredales.org.uk/downloads/quarryin.pdf

This 4 page resource includes maps showing the distribution of quarries in the Dales and has interesting and informative comments from quarry operators Hanson and comments from local groups. Although in the opening paragraph it is suggested that quarrying activities must inevitably damage the landscape it does go on to show why we need aggregates and what quarry managers do to ensure the landscape is cared for. It looks at restoration and the move to more environmentally sustainable forms of transport. It shows why there is debate about quarrying.

www.daelnet.co.uk/news/weekend/weekend_18032005.cfm
Has information about prizes won by quarries in the dales for their environmental projects.

www.stoneroof.org.uk/cases.htm/
Information about grants being given by the National Park Authority to homeowners in conservation areas who use new stone slates from local quarries

www.english-nature.org.uk/special/nnr/nnr_details.asp?NNR_O=92
Scroll down and click on Ribblehead
Ribblehead Quarry Walk, Ingleborough National Nature Reserve
A walk through a landscape viewed by many as "natural" but which was in fact created as a result of quarrying

www.bbc.co.uk/scotland/education/int
Scroll down the main page to **upland limestone** link
Click on round table for ideas about roles and then follow the links to profiles of real people, listen to their thoughts

To inform the debate students will need to know that:

- Quarries only have a limited life, either the resource will be completely worked out or the limestone will not be of the same high quality throughout the quarry area and so quarrying will cease.
- Quarry operators have to apply for permission to extend a quarry or to continue to work an existing site beyond the original date they were given for working it.
- An example of this is Swindon Quarry near Cracoe, which has been granted permission to continue quarrying until 2020 when it must cease work and carry out planting, and restoration work, which will turn the "hole in the ground" into a nature reserve.
- Horton Quarry, in Ribblesdale is an example of a quarry with a long working life
- Hill Top quarry in Swaledale is an example of a quarry that produces a specialist product. Rock from this quarry is used to make stone roofing slates used to restore old buildings in the Dales in a sympathetic manner.

Homework

Preparation for the roleplay.

Lesson Five

Roleplay

Each group of students will present their roleplay to the class. Class members will be the audience at a public debate and will have to consider carefully which speaker in each group will get their vote. Students should consider the following points:

- Clarity of presentation
- How persuasive the speaker was

They may not necessarily vote for the same role in all presentations.

Homework: Who got the vote? A brief piece of writing to say why they voted as they did followed by a reflective piece of writing considering their own personal view based on what they have learnt by carrying out the roleplay.