

Fieldwork sites in Weardale, County Durham



- **Science and geology**
Westgate: Getting to grips with minerals and mining
Stanhope Rocks!
Harehope Quarry: Fossils and cycles
- **Geography and Landscape**
Settlement and rural development in Weardale
Limestone quarrying and reclamation at Broadwood Quarry, Frosterley
- **Signposting of places of interest and information in Weardale**

Science and Geology





ORGANISATIONAL DETAILS

Aim of fieldwork

- To describe and identify rocks on the basis of their characteristics, including appearance, texture, colour and occurrence.
- To understand geological processes that can alter rocks and create economic minerals.
- To understand how geologists use the landscape to interpret the underlying geology and how mining can alter the landscape.

Target Group

Key Stage 3 and 4 science and geography. However, the exercise could easily be delivered to an advanced Key Stage 2 group.

Location

This fieldwork is based at West Rigg Quarry, Westgate and can be combined with many other geological activities in this education pack. All sites are located in the vicinity of West Rigg Quarry. It is suggested that half a day is suitable for completion of the exercise.

Practical Details

- Parking – easy access and parking for a coach along the road signposted to Rookhope called Scutterhill Bank. Parking available prior to steep incline in road.
- Useful map – Ordnance Survey 1:25 000 Explorer OL31 North Pennines Teesdale and Weardale

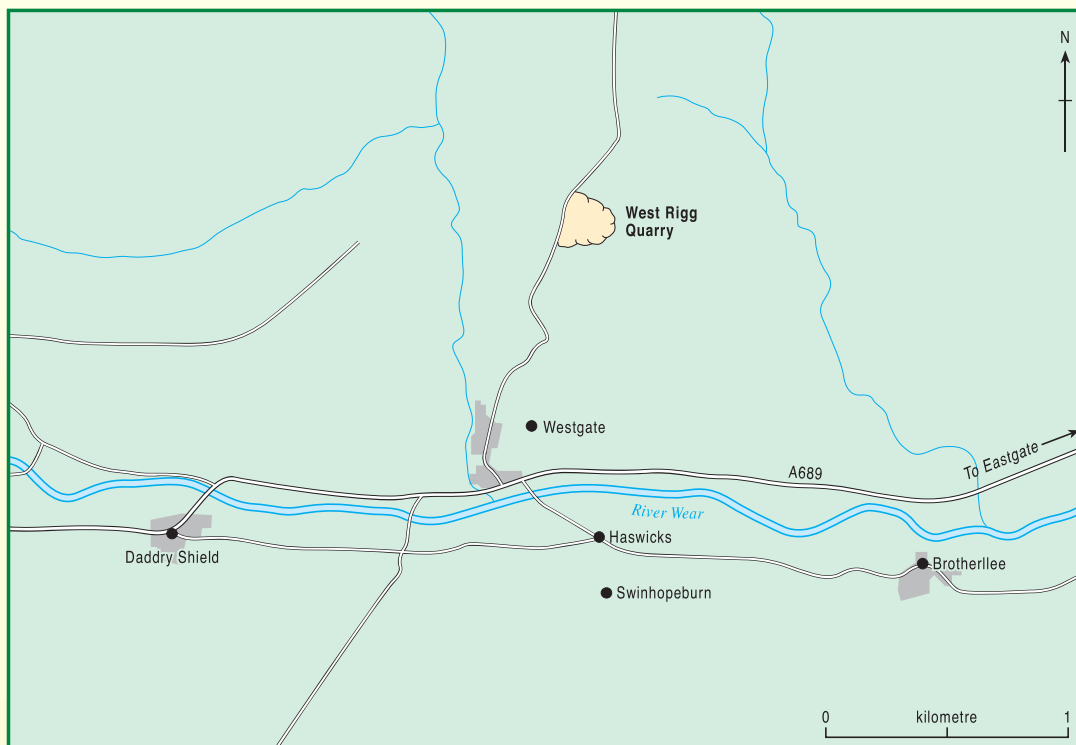
Materials Required

- Grain size cards if possible (available from the Rock Boxes)
- Hand lenses if possible (available from the Rock Boxes)
- Copper coins (1p or 2p) and blunted long steel nails
- Small plastic pipettes and a supply of bottled water
- Map of locations from Westgate to West Rigg Quarry

Safety Issues

- The parking in Westgate is off the main road but caution is needed when disembarking the coach or minibus.
- Refer to the Hazard Identification Sheet

Westrigg: Getting to Grips with Minerals and Mining Fieldwork Outline - Teacher Resource Sheet 1



HAZARDS IDENTIFICATION SHEET

The following notes will help teachers conduct their own risk assessments. This is not a risk assessment and teachers should follow guidelines from the Department of Children, Schools and Families.

Hazard Identified	Risk and to whom	Control measures
Getting on and off the coach or minibus	Caution needed when getting off the coach or minibus along the country lane. All students and staff.	Supervise students getting off the coach or minibus and gather in a safe place.
Weather	Road conditions along the A689 in Weardale can be highly changeable. Also as the activities take you up on to more exposed land it can become very cold and windy. All students and staff.	Check weather forecast and make sure driving conditions are suitable. Wear suitable warm clothing and footwear for the weather conditions.
West Rigg Quarry	Keep to path and away from all old mine workings. Some steep rock faces are unstable with loose boulders. All students and staff.	Supervise students and accordingly warn the students of the hazards. Hard hats to be worn at all times while in the quarry.
Uneven paths	Paths are uneven and may be slippery in wet weather. Students may slip and fall. All students and staff.	Warn about conditions.

Plan of activities

- Look at the carboniferous sedimentary rocks at Stop 1 in a small quarry (~40-60 minutes)
- Head from the quarry to Stop 2 at top of hill overlooking Middlehope Moor and next to notice board explaining West Rigg Quarry (~ 5 mins)
- Look at the landscape of Middlehope Moor and west towards Slitt Wood. Comment upon the artefacts of previous mining in the landscape (~10 mins)
- Examine the rock types and minerals at Stop 3 around the Slitt Vein in West Rigg Quarry. (~30-40 mins)
- Examine the effects the mineralization had upon the surrounding rock types along the edge of the quarry and especially at Stop 4. (~30-40 mins)
- Summary of sedimentary rock types, minerals and geological processes. (~20 mins)

BACKGROUND INFORMATION

1. General Geology

The landscape we see today reflects tens to hundreds of million years of natural occurring processes involving the underlying rocks and the important mineral deposits they contain. Superimposed on the landscape are the results of centuries of mining activities that have given rise to several industries which were vital for the prosperity of the North Pennines but especially so for Weardale.

Weardale was once the focus for lead mining forming part of the North Pennines Orefield with a remarkable array of lead, zinc and iron ores and fluorite and barium minerals. The ores and other minerals occur together in deposits known to miners as veins and flats. Veins are sheet like bodies of minerals that occupy more or less vertical fissures in the surrounding rocks. Most of these fissures are called Faults where the rocks on either side have been displaced through movement in the Earth over millions of years. Flats in contrast are roughly horizontal bodies of minerals, which may extend for several metres from the side of a vein. Flats occur in limestones and represent replacement of the limestone by minerals such as galena, fluorite and siderite.

2. Minerals and mining

Everywhere you look in the North Pennines you see a mining legacy, which dates from a time when mining dominated the landscape and the lives of local people. For many hundreds of years much of the North Pennines, especially Weardale and Allendale, were important centres of lead and fluorite mining.

The earliest mining was almost certainly opencast diggings based on local knowledge where some minerals may have been found and then worked along a vein. Eventually it was necessary to sink shafts into a vein or along side, in order to gain access to deeper

deposits. The extraction and processing has left its mark on the landscape. In places the mine buildings still survive, but often the spoil heaps are all that is left. Most importantly the minerals extracted were at the heart of many of the communities, and, though the industry was in decline from the beginning of the Twentieth Century, the last mine only closed in 1999.

The lead ore (galena, PbS) and other principal minerals were extracted from the rocks from what miners called veins and flats. **Veins** are sheet-like mineral occurrences that occupy more or less vertical cracks, fissures or faults in the rocks. Most veins are a few



Weardale Fluorite with its green colour (sample in Rock Box)



Classic purple coloured fluorite crystals from Fraser's Hush-Groverake Mine Complex, Rookhope. It forms perfect cubic crystals that are often found interlocking with others. Much of the fluorite was crushed but several specimens can be found in museums.



Galena, lead sulphide (PbS), is a dense, silver-grey metallic mineral. This is the main ore that was worked in much of the North Pennines. It was sometimes associated with silver (sample in Rock Box)

millimetres to tens of metres in width and typically consist of crude bands of minerals more or less parallel with the sides of the vein. A range of minerals made up the veins, some such as fluorite (CaF_2), were initially classified as 'gangue' or unwanted products, but later formed an important commodity in the economic prosperity and longevity of many mines. **Flats** are roughly horizontal occurrences of minerals that can extend for many metres away from a near vertical vein. Flats only occur in limestone, where large-scale mineral replacement has taken place. It was recognised early on in the geological development of the mines that flats were important locations for rich accumulations of lead and iron ores. Two of the regions largest and most productive lead mines, Allendales, Allendale and Boltsburn, Weardale, mined the ore from flats and the associated veins are called the Red and Boltsburn veins respectively.

During the later years of mining in Weardale and Allendale, fluorite became the most sought after mineral, with lead only being extracted as a by-product. The last mine to close in Weardale was Fraser's Hush-Groverake Mine Complex, Rookhope, which mined fluorite until its closure in 1999.

Use of mined ores

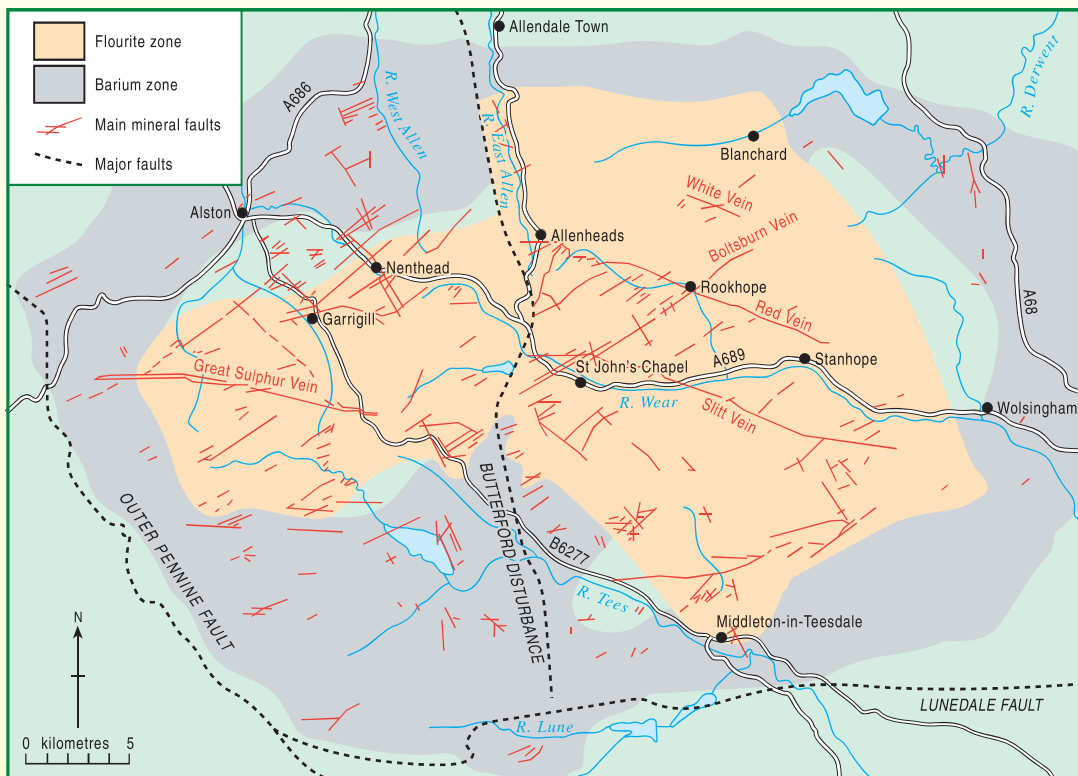
Galena (lead sulphide PbS): This metal is very soft and easily workable. It has been widely used for water pipes by plumbers and by builders for roofing

(commonly seen on churches). A less obvious use for lead is as a chemical additive in paints, petrol and batteries.

Fluorite (Calcium fluoride, CaF_2): The word fluorite derives from the Latin word 'fluere' meaning 'to flow because of the minerals use as flux in iron and aluminium smelting. Some of the last operators of mines in Weardale and Allendale were British Steel. It was originally referred to as fluorspar by miners and this is still its commercial name today. Fluorite is also used as a source of fluorine for hydrofluoric acid and fluorinated water. The element fluorine also gets its name from fluorite, fluorine's only common mineral. Other uses of fluorite include an uncommon use as a gemstone (low hardness and good cleavage reduce its desirability as a gemstone), ornamental carvings (in which it is sometimes misleadingly called Green Quartz) and special optical uses.

Galena, lead sulphide (PbS), is a dense, grey metallic mineral. This is the main ore that was worked in much of the North Pennines (sample in Rock Box).

Weardale green fluorite (sample in Rock box) Classic purple coloured fluorite crystals from Fraser's Hush-Groverake Mine Complex, Rookhope. It forms perfect cubic crystals that are often found interlocking with others. Much of the fluorite was crushed but many spectacular specimens can be found in museums.



Map showing the distribution of mineral veins and mineral zones in the North Pennines. This is a simplified map, but still shows hundreds of mineral veins found by the miners



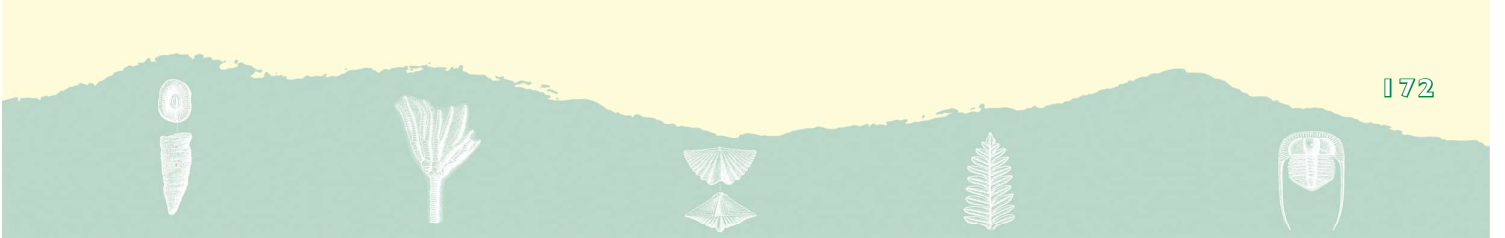
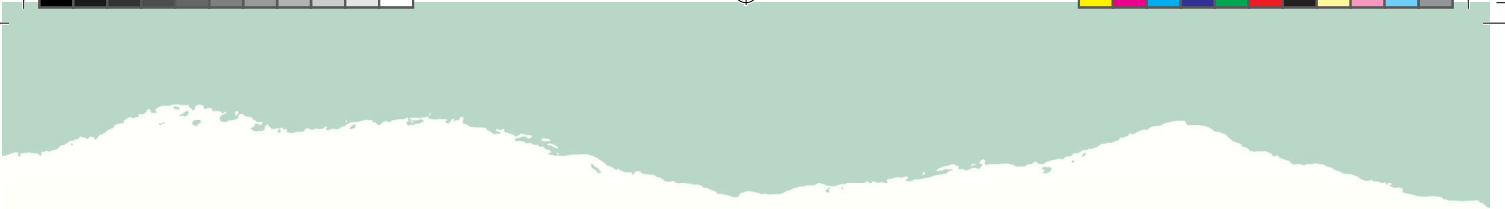
3. How were the veins and flats formed?

The possibility of a large mass of granite beneath the Pennines and especially Weardale eventually led to a deep borehole being drilled at Rookhope in 1960-61 and at the depth of 390.5 metres the Weardale Granite was reached. The Weardale Granite is thought to have played a vital role in generating the area's mineral deposits, as within all granites small amounts of radioactive minerals decay and generate heat. The thick sequence of sediments that were deposited during the Carboniferous acted like a blanket over the granite. As the heat was generated by radioactive mineral decay it was trapped, creating a large circulation cell with a convective motion of fluids causing hot saline waters to rise upwards and draw in cooler fluids from beneath and the sides.

The hot saline fluids were capable of dissolving minute traces of a great variety of chemical elements found in the rocks including, lead, iron, zinc and copper. The main pathways for these hot fluids enriched in minerals were along cracks, fissures and faults in the rocks. As the hot fluids rose into the overlying Carboniferous sediments they began to cool and the dissolved minerals started to crystallise building up the mineral veins we see today.

West Rigg Quarry is one of the few places in Weardale where it is easy to see a mineral vein and the associated mineralised flats. What is exceptional about West Rigg is the preservation of the mineral vein (Slitt Vein) as it is largely made up of worthless quartz. However, either side of the Slitt Vein has been quarried away along the flats due to the enriched occurrence of ironstone. This enables students to examine first hand what the lead miners would have encountered over 100 years ago.



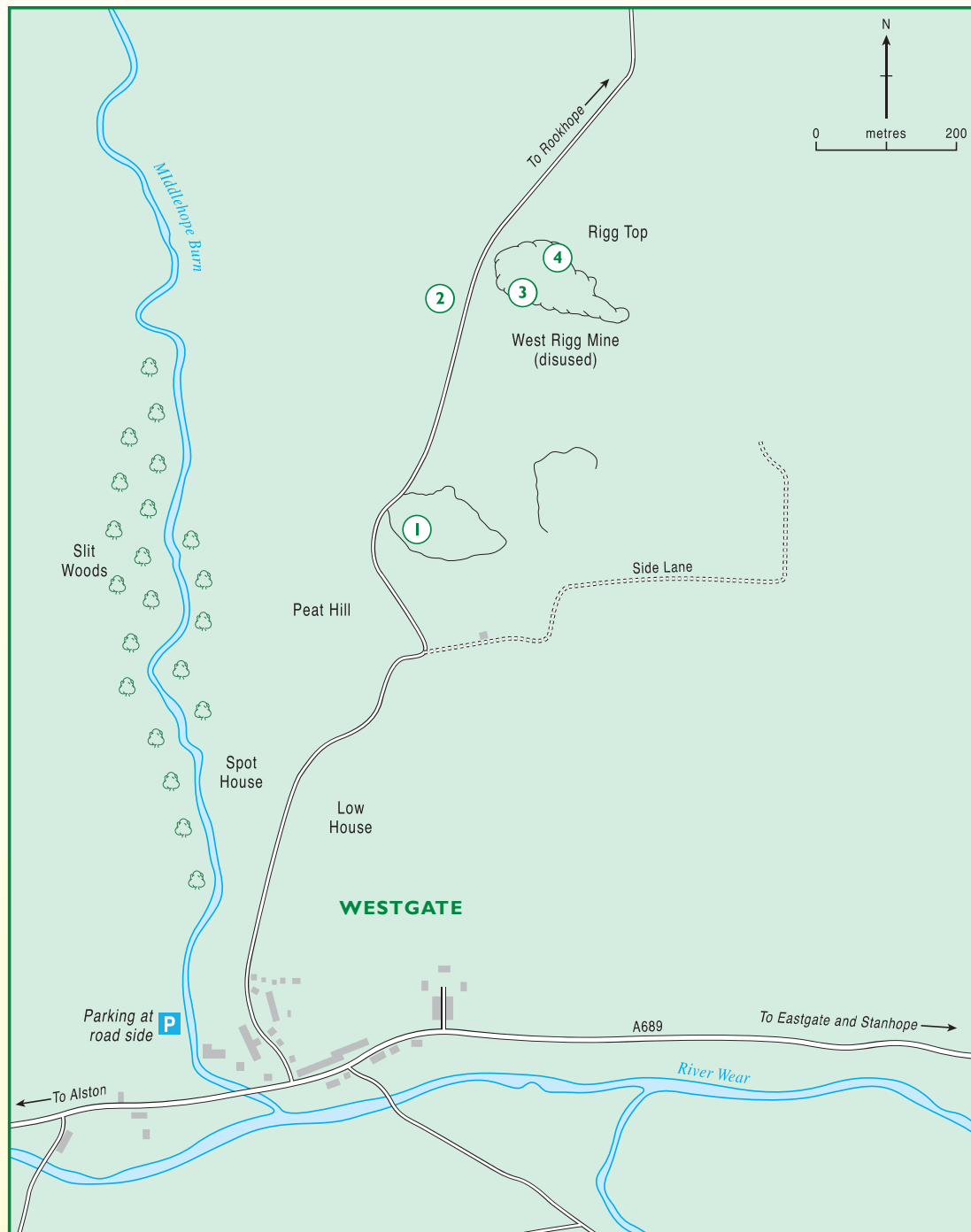




Westrigg: Getting to Grips with Minerals and Mining

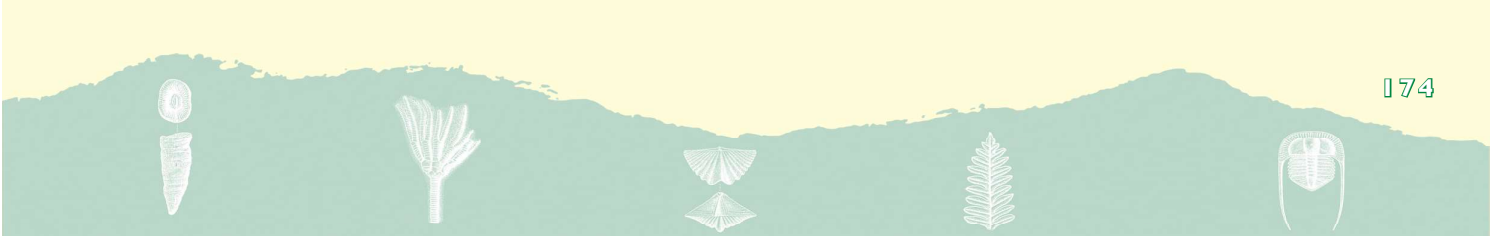
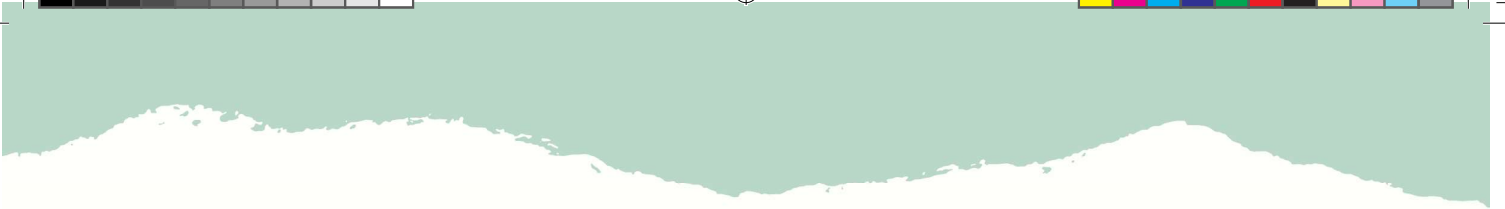
Student Resource Sheet 1

GETTING TO GRIPS WITH MINERALS AND MINING



Map of Westgate to West Rigg Quarry illustrating the different sites for the exercises (Peat Hill is not passable with a coach)







Westrigg: Getting to Grips with Minerals and Mining

Student Resource Sheet 2

GETTING TO GRIPS WITH MINERALS AND MINING

Welcome to Westgate!! The exercises that you will do here will help you to learn the following things:

- 1) The properties and importance of sedimentary rocks
- 2) How minerals that make up rocks can be concentrated and mined
- 3) Tests that can be carried out to identify sedimentary rocks and minerals

Study the map of Westgate to West Rigg Quarry and make your way to Stop 1

STOP 1. Quarry at Peat Hill

For about five minutes look around the quarry and collect three or four different rocks. These may have different colours, have different textures or even contain some fossils. Then carry out the following Rock Tests on each rock sample. Use the Rock Data Table below to record your results.

After completing your observations about the rocks in Peat Hill Quarry, turn right and continue up the hill along the road to Stop 2.

ROCK TESTS

Rock Test 1 - What does the rock look like?

Use a hand lens to observe the rock carefully.

- What colour is it?
- Is it rough or smooth
- Is it shiny or dull?
- Can you see any crystals or grains?
- Are there any fossils?

Rock test 2 - Is the rock hard?

Try to scratch the rock.

Rocks which can be scratched by a fingernail are called **very soft**.

Rocks which can be scratched by a copper coin are called **soft**.

Rocks which can be scratched by a nail are called **hard**.

Rocks which cannot be scratched by a nail are called **very hard**.

Rock test 3 - Does the rock soak up water?

Use a plastic pipette to drop a small quantity of water onto the rock sample.

What happens to the water?

Rocks that soak up water are called **permeable**

Rocks that do not soak up water are called **impermeable**

Rock test 4 - Does the rock react with dilute hydrochloric acid HCl?

Use a plastic pipette to drop a small quantity of dilute HCl onto the rock sample

Does the rock react with the dilute HCl?

If the rock does react with dilute HCl, why do you think this happens?

This is a very reliable test to identify the sedimentary rock called **Limestone**

Other information

Make any additional comments about the different rocks you have collected. You could make comments about their colour, shape. Do they contain any fossils?

You will be able to recognise if some of the samples have grains that fit well together. They have an **interlocking texture**. But in some rocks the grains do not fit so well. We say that they have a **non-interlocking texture**.





Rock Name

Attempt to name the rock samples you collected based upon the tests and your own observations. You could start by grouping the rocks into **Igneous**, **Metamorphic** or **Sedimentary**.

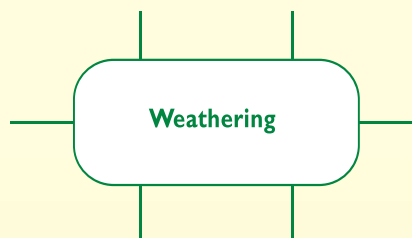
Rock Data Table				
Sample number	1	2	3	4
Rock Test 1				
Rock Test 2				
Rock Test 3				
Rock Test 4				
Other information				
Rock name				

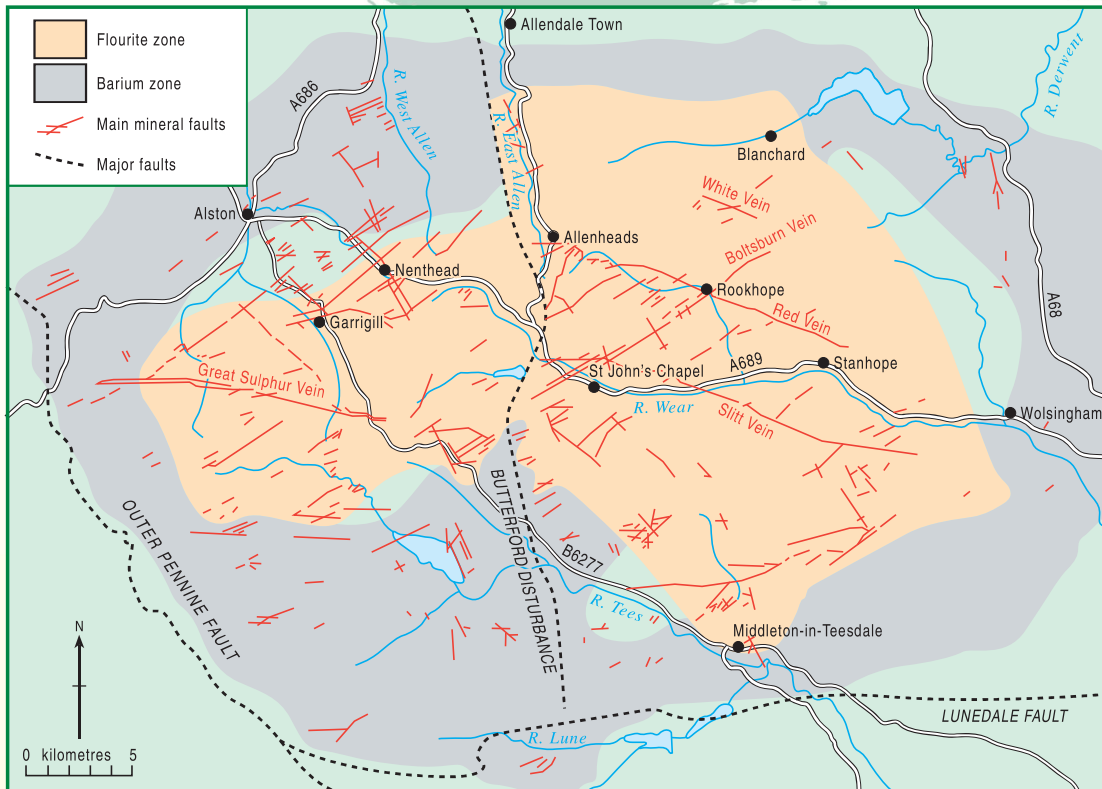
STOP 2 Top of hill overlooking Middlehope Moor and West Rigg Quarry

At the top of Peat Hill is a very important place. This is one of the few places in Weardale that it is easy to see a mineral vein in and to visualise the human impact of lead mining on the landscape across Middlehope Moor and west towards Slitt Wood. The Slitt vein is one of the longest mineral veins in the North Pennines and proved to be one of the most productive.

Geologists often use the landscape to understand more about rocks. The weathering of the rocks gives rise to the landscape we see.

What causes weathering? Annotate the spider diagram below.





Unfortunately not all we see of the landscape in Weardale is natural.

What features in the landscape can you recognise as being caused by lead mining and human impact.

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.....

.....

Now enter West Rigg Quarry where the mineral vein runs through the centre of the quarry.

STOP 3 Slitt Vein in West Rigg Quarry

Mineral veins in Weardale were once very important. They formed the focus of a huge lead mining industry for many hundreds of years. Read the following text and then answer the questions.

What are mineral veins?

Veins are sheet-like bodies of minerals that occupy vertical cracks or fissures in the surrounding rocks. Veins can vary in thickness from a few millimetres to over 10 metres in width, though most are around a metre wide.

How did veins form?

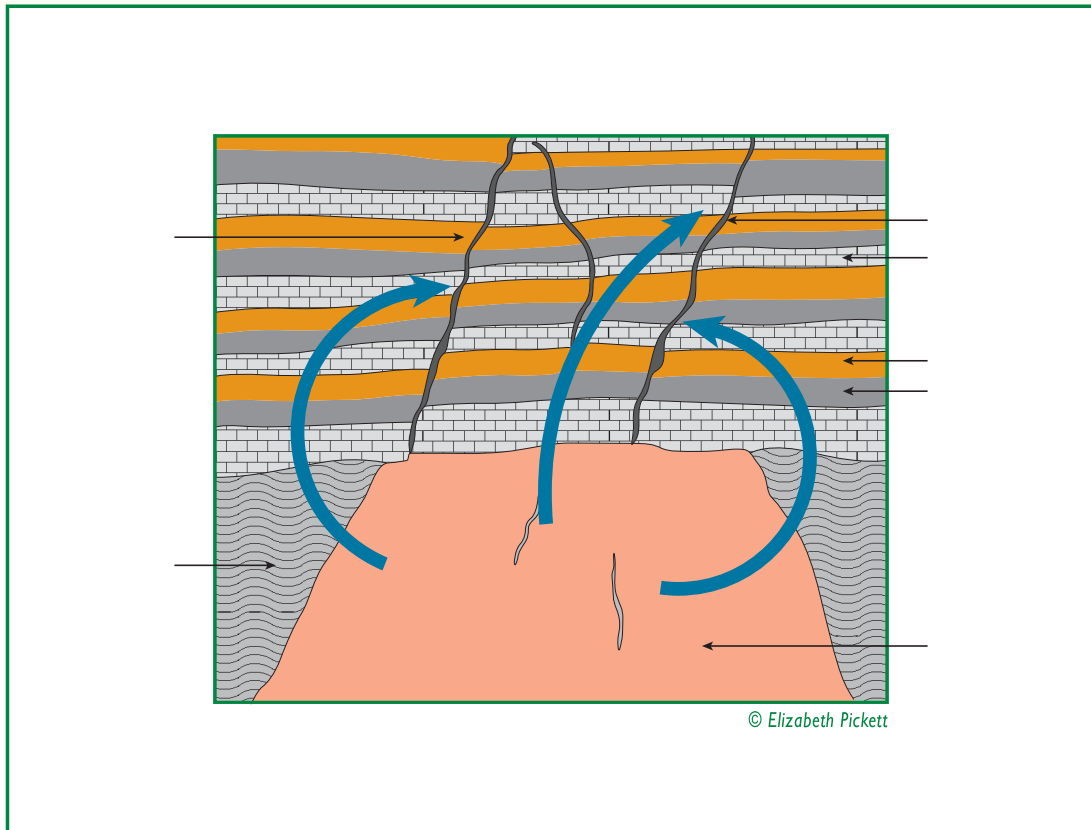
Deep in the Earth, rocks become saturated with water. This is a powerful solvent, capable of dissolving a variety of chemical elements including lead and zinc that occur throughout rocks. Beneath the North Pennines lies the Weardale Granite that is thought to have acted as a heat source for warming the waters and fluids. This caused the fluids to be circulated through fractures and fissures dissolving minerals and enriching the fluids. As the fluids gradually cooled, the dissolved minerals crystallised on the walls of the fractures and fissures in the rocks building up mineral veins. This is thought to have happened around 290 million years ago.





Look at the sketch of the formation of mineral veins in the North Pennines.
Choose the correct labels from below and label the sketch.

- Mineral Vein Fissure Granite Sedimentary Rocks
- Mineral Enriched Fluids Igneous rock Limestone



What is exceptional about West Rigg Quarry is that the miners have not mined away the complete mineral vein as they normally did to extract the economic minerals.

Why has most of the vein been left standing in the centre of the quarry?

.....

.....

.....

Now look around the quarry and see if you can collect any minerals. The main mineral that was mined was called Galena. Galena is a lead mineral but many other minerals are present in the quarry

Use the Mineral Dial to identify at least three different minerals and record their characteristics in the table below. One of the common minerals found at West Rigg Quarry and its characteristics has been completed for you to get you started.

Now walk to the far side of West Rigg Quarry and stop 4 as indicated on the map.





Mineral Name / Identifier	Hardness	Specific gravity	Colour	Habit	Lustre
Flourite	4	3	Blue/purple/green	Cubic	Vitreous-gassy

STOP 4 Mineralisation of the 'Flats'

The hot mineralised fluids not only created mineral veins as seen at Stop 3, but also reacted with the surrounding rocks. At West Rigg Quarry the fluids reacted with the sedimentary rocks called limestones.

The alteration of the limestones produced a new rock type called an **Ironstone**.

The areas of mineralization/alteration either side of a vein are called **Flats**.

Complete the missing words in the following sentences

The process where rocks are altered by heat or pressure is known as.....

Metamorphic rocks can be created from, or other metamorphic rocks.

The high temperatures of the mineralised fluids can change the structure of the rock.

Examples of metamorphic rocks include....., slate and.....

Ironstone!

The ironstones that form the flats were once mined for their iron ore for steel making. It is a valuable iron mineral, since it is 48% iron and contains no sulphur or phosphorus.

The ironstone seen in the quarry today was originally a crystalline mineral called **Siderite** (FeCO_3), but due to oxidation and weathering at the Earth's surface it has been altered to a iron oxide called Limonite ($\text{FeO}(\text{OH}) \cdot n\text{H}_2\text{O}$).

Using the descriptions and photographs of siderite and limonite see if you can identify these minerals in the quarry. They can be quite difficult to recognize.

Why is it important that the iron ore contains no sulphur or phosphorus for steel making?

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What's changed?

The sedimentary rocks have been altered by the hot fluids to create ironstones. Using your own field observations compare and contrast the ironstone with the grey limestone seen at Stop 1.

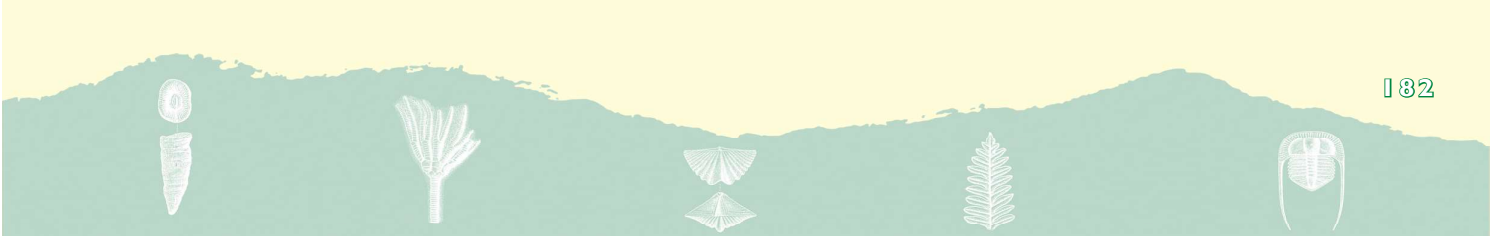
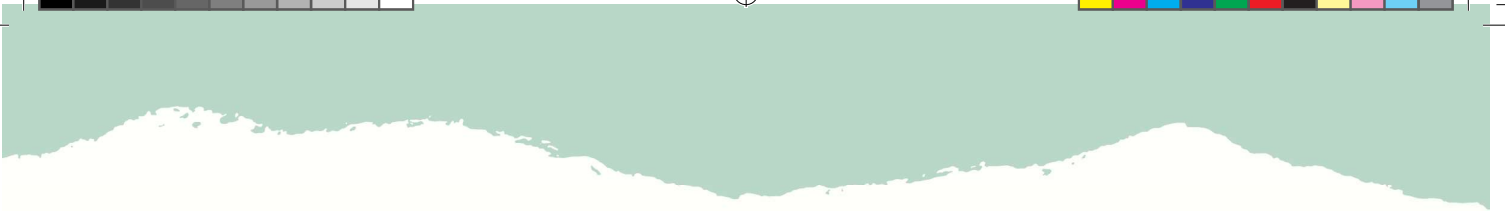




	Siderite	Limonite
Hardness	3.5	4-5.5
Specific gravity	3.8	3.5
Colour	Brown-yellow	Shades of yellow-brown
Lustre	Vitreous-pearly	Vitreous
Crystal shape	Rhombohedral	No crystals - amorphous-powdery
Photograph		

Limestone (Stop 1)	Ironstone (Stop 2)





Westrigg: Getting to Grips with Minerals and Mining

Follow-up Activity 1

ORE GRADE

Purpose

To calculate the percentage of galena in a piece of ore containing only calcite and galena and to work out the grade of the ore. A sample of galena and calcite are both available in the rock boxes along with other ore minerals once mined in the Geopark.

Activity

1. Work out the density of calcite using the piece of calcite provided. First weigh the calcite.
2. Then place the beaker of water on the balance and press the tare button. Read the balance with the calcite suspended in the water. The last reading gives the volume of the sample.
3. Calculate the density. Density = weight/volume
4. Work out the density of galena in the same way..
5. Weigh the piece of ore and then calculate its density.
6. Make a graph to enable you to calculate the percentage of galena in any sample which is a mixture of only calcite and galena. Plot percentage of calcite along the y axis from 0% to 100%. Plot the density on the x axis starting at the origin with the density of calcite and increasing to the density of galena . Draw a diagonal line from 100% to the density of galena.
7. Use your graph to work out the percentage of galena in your sample.
8. Check your result by using the following equation to calculate the percentage by weight of galena in the sample.
$$D_s = P_g \times D_g + (1 - P_g) \times D_c$$

D_s = density of sample D_c = density of calcite
 D_g = density of galena P_g = proportion of galena as a fraction
9. Now try to calculate the percentage of lead in the ore. This would be its grade. Galena is PbS and lead has an atomic weight of 207 and sulphur 32. Therefore the grade = $207 / (207 + 32) \times \% \text{galena}$ in ore.



TEACHER SECTION

Requirements

Pieces of pure calcite and pure galena about 5cm by 5cm by 5cm.

A piece of mixed ore about the same size. Each sample should have a nylon (fishing line) loop about 15cm long attached to it with araldite.

A beaker or coffee jar large enough to fit each sample. Balance with tare facility if possible otherwise ordinary balance.

Notes

Make sure your samples do not contain any barite or fluorite.

Measuring the density can be done with a normal balance without the tare facility by weighing in air and water or with a displacement can.

Time

Lab work 15minutes, calculations and write up 1 hour.





ORGANISATIONAL DETAILS

Aim of fieldwork

To demonstrate how Earth science (geology) principles can be illustrated out of doors, in a simple and safe way. It can be used to engage pupils in discussions about Earth processes and products.

Target Group

Key Stage 4 science and geography. However, the exercise could be easily delivered at Key Stage 3 and adapted for advanced Key Stage 2

Location

Stanhope town centre, Weardale, County Durham

Logistics

This fieldwork is based at Stanhope and can be combined with many other geological activities in this education pack. All sites are located in Stanhope town centre with the Durham Dales Centre and St. Thomas' Church the focus of the activities. It is suggested that half a day is suitable for completion of the exercise.

Practical Details

- Parking - easy access and parking for a coach and minibus at the Durham Dales Centre or in the centre of Stanhope Town
- Useful maps - Ordnance Survey outdoor Leisure / Explorer OL31 North Pennines

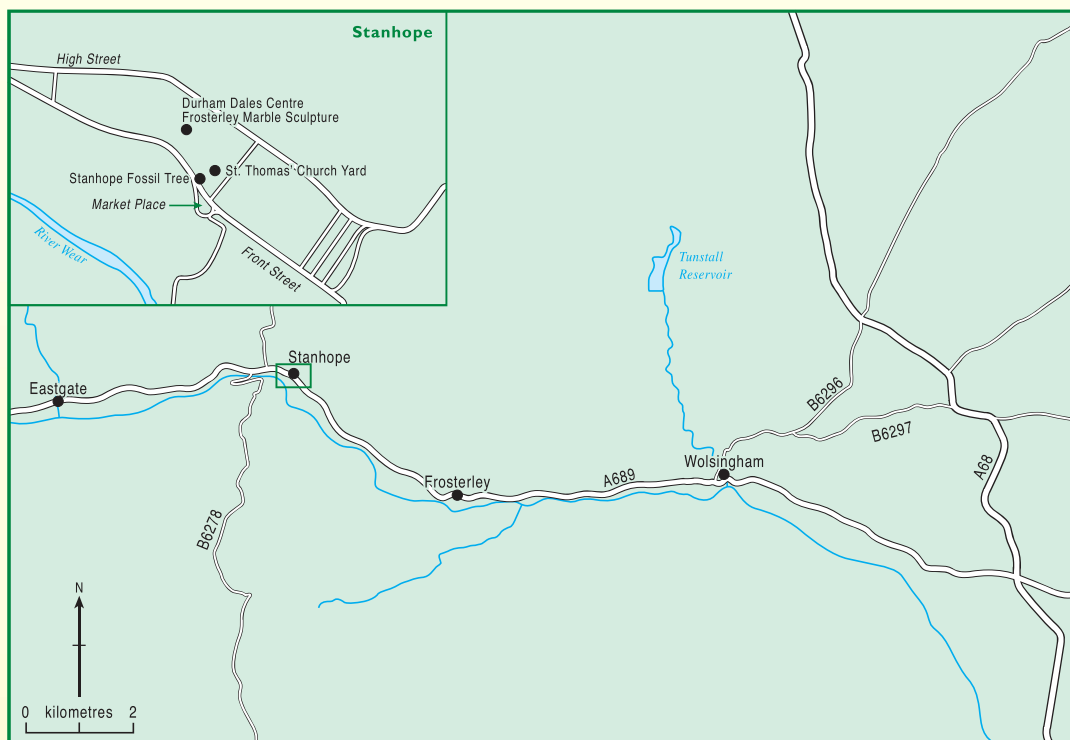
Materials Required

- Clipboard
- Pencil
- Hand lens (available from the Rock Boxes)
- Grain size cards (available from the Rock Boxes)

Safety Issues

- The Durham Dales Centre car park is off the main road but caution needed when disembarking the coach / minibus in the car park
- The A689 is a busy main road through Weardale and students should be supervised at all times especially when walking from the Durham Dales Centre to St. Thomas' Church
- Refer to the Hazards Identification sheet

Getting to Grips with the rocks in Stanhope Fieldwork Outline - Teacher Resource Sheet



HAZARDS IDENTIFICATION SHEET

The following notes will help teachers conduct their own risk assessments. This is not a risk assessment and teachers should follow guidelines from the Department of Children, Schools and Families.

Hazard Identified	Risk and to whom	Control measures
Getting on and off the coach or minibus	Caution needed when getting off the coach or minibus in the car park All students and staff	Supervise students getting off the coach or minibus and gather in a safe place
Weather	Although Stanhope is relatively sheltered the road conditions to the town along the A689 can be highly changeable. Also it can be cold and windy in Weardale All students and staff	Check weather forecast and make sure driving conditions are suitable Wear suitable clothing and footwear for the weather conditions
Grave stones (St. Thomas' Church)	Many of the gravestones are very old and can be unstable. Do not climb or push any of the gravestones All students and staff	Supervise students at all times
Uneven paths	Paths are uneven and may be slippery in wet weather. Students may slip and fall All students and staff	Warn about conditions

Plan of activities

- Look at the sculpture at the Durham Dales Centre. Identify the rock type and come up with a theory for its formation (~15 mins)
- Head from the Durham Dales Centre to St. Thomas' church (~5 mins)
- Look at the fossil tree in St. Thomas' churchyard. (~5 mins)
- Examine the rock types of the graveyard near St. Thomas' church. (~10 mins)
- Look for patterns in the weathering of the gravestones (~10 mins)
- See how rock types used for gravestones have changed through time. (~20 mins)

BACKGROUND INFORMATION

The rocks of Weardale form part of the back bone of England and have significantly influenced the landscape and man's activities within the region. The rocks of Stanhope and the surrounding dales have provided many natural resources over the centuries and perhaps most significantly lead mining that has left a lasting mark on the landscape.

Most of the rocks found in Weardale are sedimentary rocks that were deposited between 350 and 300 million years ago when the UK landmass was positioned over the equator. The North Pennines, during this geological time period known as the Carboniferous was periodically covered by large rainforests, vast river deltas and warm tropical seas that hosted an abundant fauna.



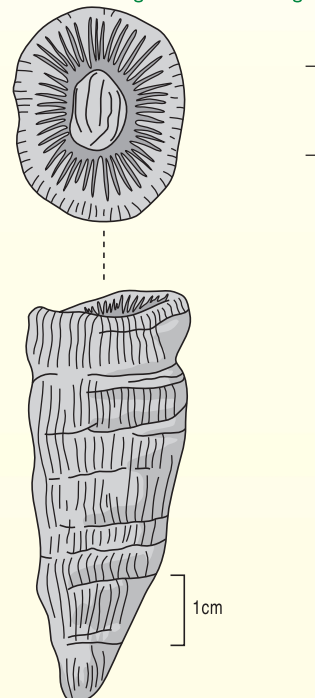
The sedimentary rocks that form the Weardale landscape were deposited in cycles. A typical cycle begins with limestone, which in turn is overlain by mudstone, sandstone and often coal. Such cycles are called cyclothems (see activity at Bowlees, Teesdale). The limestones are particularly resistant to weathering and tend to form prominent ledges in the landscape. One of the thickest limestones in Weardale at approximately 20 m is called the Great Limestone. It is within the upper part of the Great Limestone that the famous Frosterley Marble can be found. The Frosterley Marble has long been used as an ornamental stone and is commonly found in Churches in Weardale (e.g. St Thomas', Stanhope) as well as in Durham Cathedral and York Minister.

Frosterley Marble is a dull grey limestone, with well-preserved fossils of a solitary coral called *Dibunophyllum bipartitum*. These corals were horn-shaped with tentacles that filtered out organic particles from the sea water. When they died they became preserved in limey mud that has now hardened to form the dark grey limestone. The excellent preservation allowed intricate details of the fossils to be preserved and is often best seen in polished sections (e.g. sculpture at the Durham

Dales Centre). *Dibunophyllum* belongs to a group of corals called **Rugose** corals and this group of corals became extinct at the end of the Permian Period (approximately 250 million years ago).

Confusingly, the name Frosterley Marble is not geologically correct, as it is not a true marble, but a name given by quarrymen because of its hardness and use as an ornamental stone. Marble is the name reserved for limestone that has been altered and heated through the geological process known as metamorphism in the Earth's crust. Frosterley Marble has not been affected in this way and would be better called a 'Fossiliferous Limestone'.

The hot and humid climate during the Carboniferous provided the ideal setting for thick vegetation



Sketch reconstruction of what the solitary Rugose corals called *Dibunophyllum* would have looked like when they were living on the sea floor some 325 million years ago

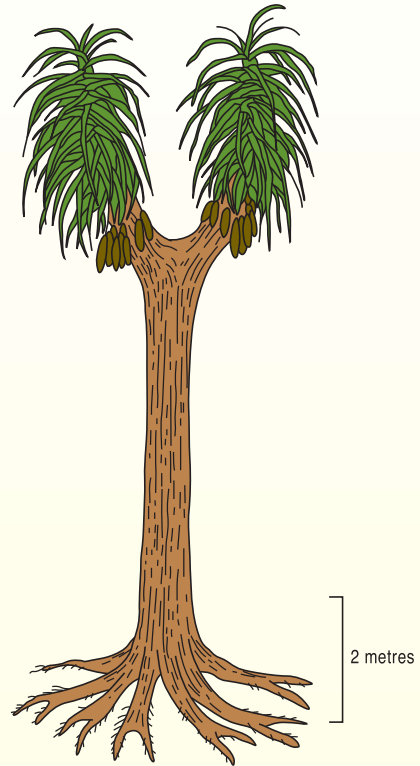
similar to a modern tropical swamp. These were associated with huge river deltas that deposited much of the sandstones and mudstones in Weardale. The Carboniferous tropical swamps and forests contained some of the earliest large land plants. Huge *Lepidodendron* and *Sigillaria* trees grew to tens of metres high and are unrelated to modern trees. Giant ferns and horsetails were abundant, growing to several metres high. Flowering plants had not yet evolved and Earth would have been a very different place. Much of the plant debris and plant remains became preserved as fossils, some examples are available in the rock boxes (e.g. *Lepidodendron* tree bark; *Alethopteris* seed

fern) but the most spectacular is the Stanhope Tree. The Stanhope Tree is the base of a *Sigillaria* found in a local sandstone quarry in 1915 and moved to its present position at St Thomas' Church in 1964. *Sigillaria* is an early ancestor of modern clubmosses and would have been a giant of Carboniferous plants easily growing to 30 metres tall

FACT: Modern day club mosses are small, creeping, terrestrial, vascular plants, which lack flowers and reproduce sexually by spores. The sporophyte consists of true roots, an aerial stem and scale-like leaves which are called microphylls. These are small and spirally arranged on an elongated stem. It is difficult to believe these are related to the giant Carboniferous species, *Sigillaria*.



Modern day clubmoss



Fossil clubmoss tree



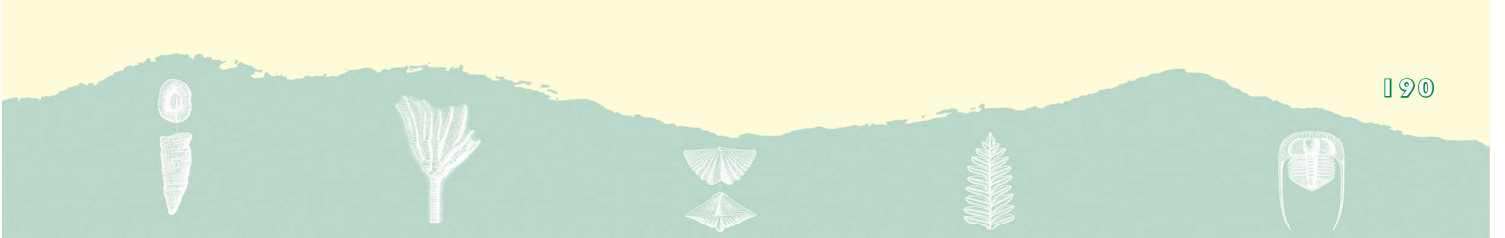
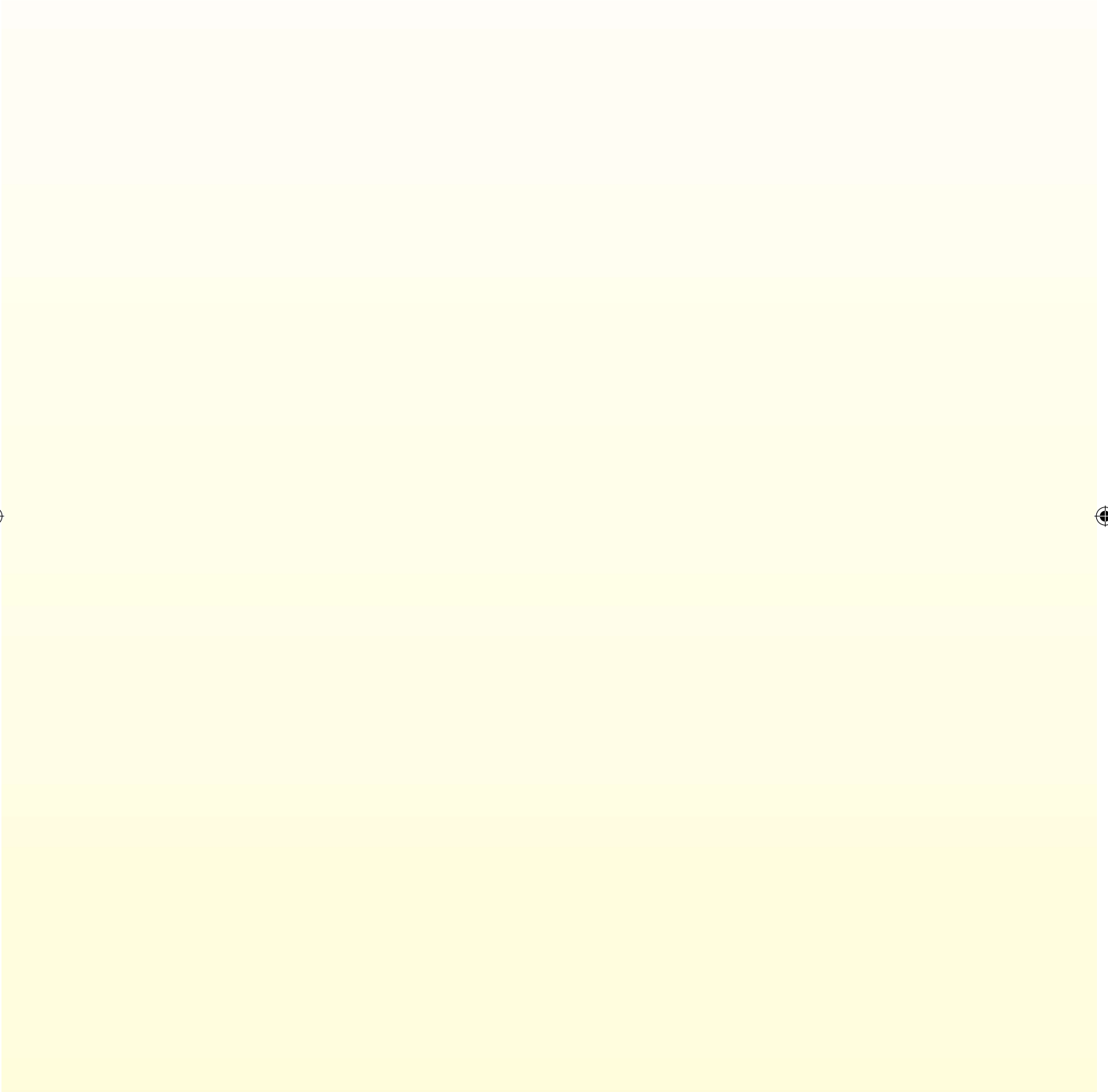
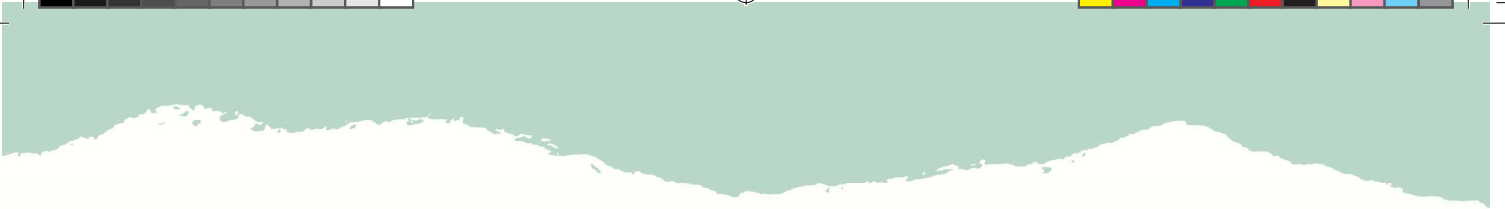
Getting to Grips with the rocks in Stanhope

Pupil Information Sheet



Map of Stanhope town centre





Getting to Grips with the rocks in Stanhope

Student Resource Sheet 1

STANHOPE ROCKS

Welcome to Stanhope! The exercises that you will do here will help you learn the following things:

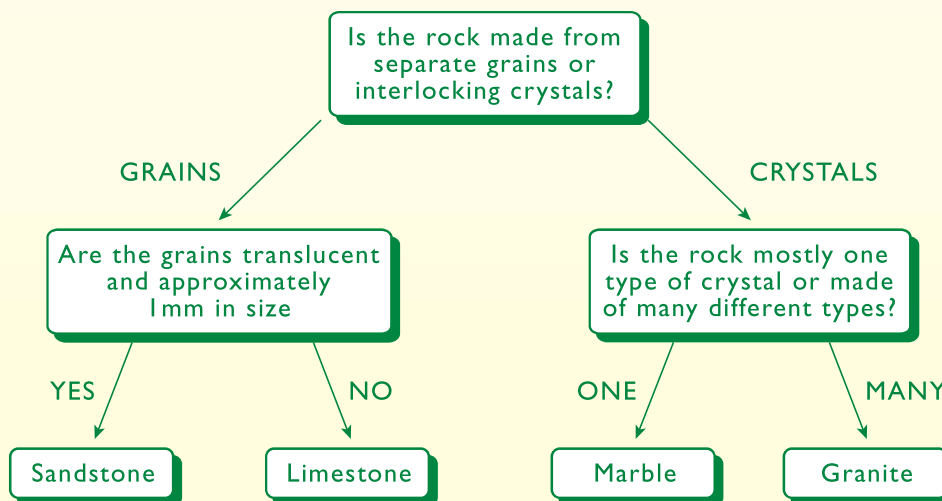
- 1) How to explain what you see scientifically. (Hypothesising)
- 2) Understand how changes in science and technology effect how people live.
- 3) The properties of 4 types of rock: sandstone, limestone, marble and granite.

You begin at the Durham Dales Centre. Examine the sculpture behind the main building. This is made of an important local rock.



Exercise 1

Use the key below to identify what type of rock the sculpture is made from:



Answer _____



Exercise 2

Note down key observations you would use to identify this type of rock if you see it again:

.....
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Exercise 3

Based on your observations, what sort of environment do you think this rock was laid down in, when it was formed 325 million years ago?

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After looking at the sculpture leave the Durham Dales Centre and turn left. Carry along the street until you reach St. Thomas's church. The church has a large fossil tree stump outside.

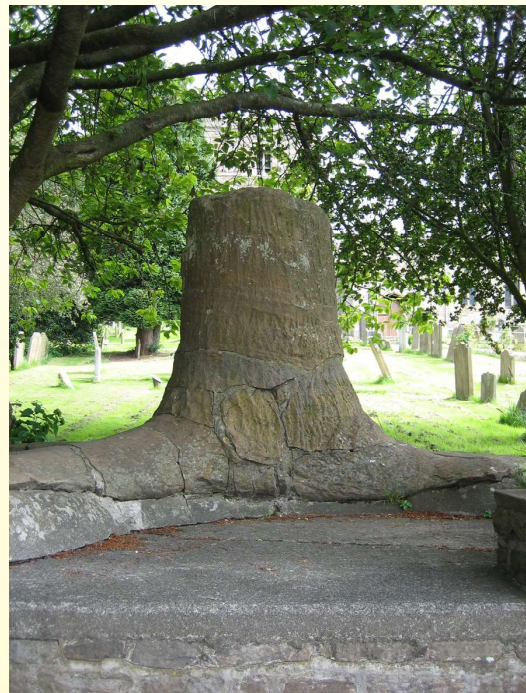
Exercise 4

Use the key from exercise 1 to figure out what material the tree is made from now.

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The tree became fossilised when the original stump was buried in layers of sediment. The wood of the tree rotted away, leaving an imprint that has the shape of the original stump. The imprint is then filled by more sediment, forming the fossil cast of the tree. Some detail is lost in the process, but patterns of bark can be seen on this fossil.

Graveyards are good places to look at how communities use the rocks around them and how this changes over time. Unlike most rocks gravestones have dates on them!



Exercise 5

Using the key from Exercise 1, find examples of graves made from sandstone, marble and granite.

Exercise 6

Record the observations you would use to identify these three rock types if you saw them again.

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Exercise 7

Many of the gravestones have been weathered. Some examples of this are shown below:



Look at several gravestones in the graveyard. Can you see any patterns in how much weathering they have undergone?

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Gravestones made of granite are more resistant to weathering than sandstone gravestones.



Exercise 8

Why do you think most of the gravestones are made of sandstone instead of granite?

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The map below shows how the rocks around Stanhope are distributed:

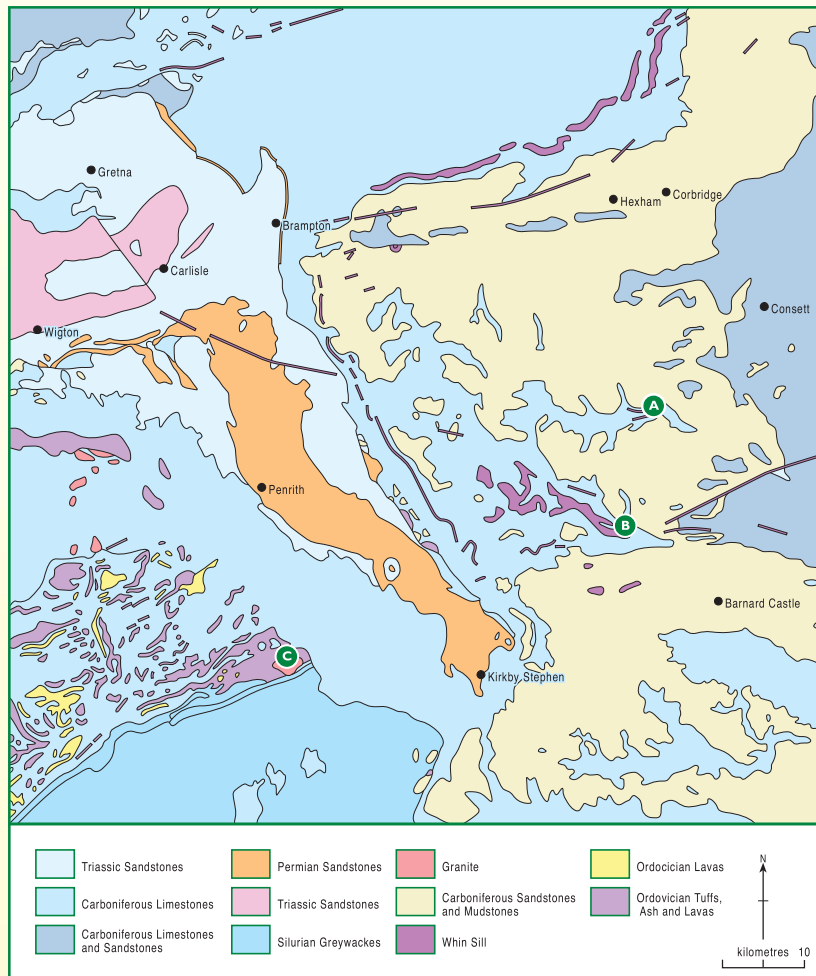
A is the location of Stanhope.

B is the nearest source of the marble used in the gravestones you have seen. It is called sugar 'limestone' and has been made by normal limestone getting heated by molten rock that pushed into the middle of all the sedimentary rock. The molten rock has cooled and is now known as the Whin Sill. This is the purple patches seen on the map.

C is the location of the nearest source of granite.

The rock represented by the large grey area is a type of sandstone.

Geological maps show us how the rocks are arranged. Combined with the dates from the gravestones we can figure how peoples' uses of these rocks have changed over time.



Exercise 9

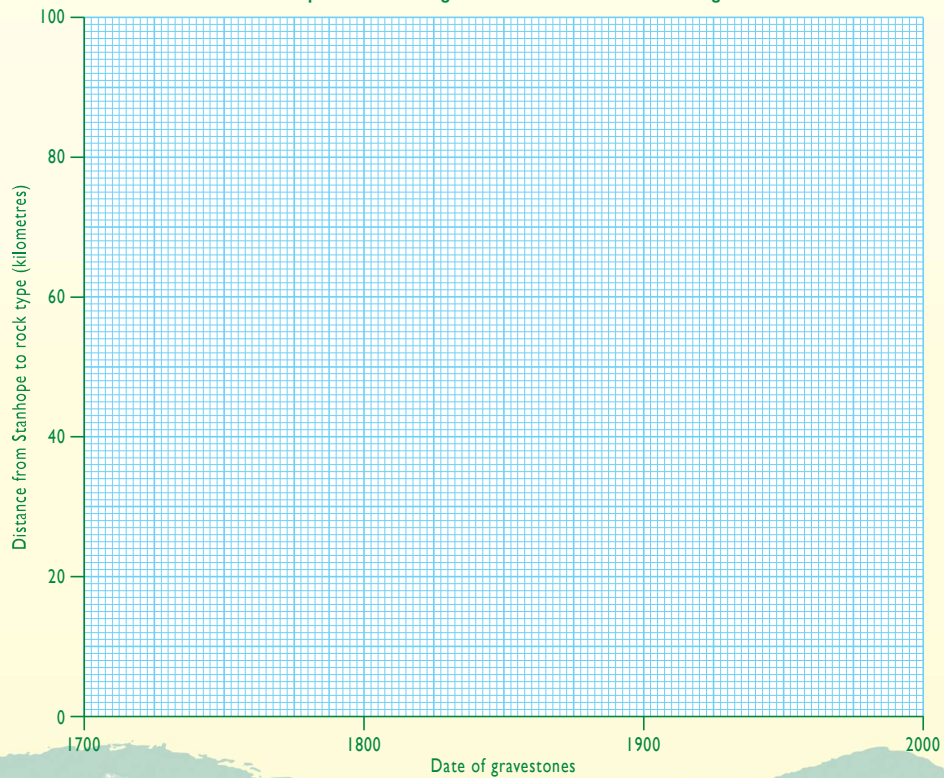
Collect data from the gravestones and the map to fill in the following table:

Year put up	Rock type	Shortest distance between Stanhope and that rock type

Exercise 10

Look for any patterns in the data. It may help if you plot your results onto the graph below:

Graph to show change in source rock distance with age





Getting to Grips with the rocks in Stanhope

Follow-up Activity 1

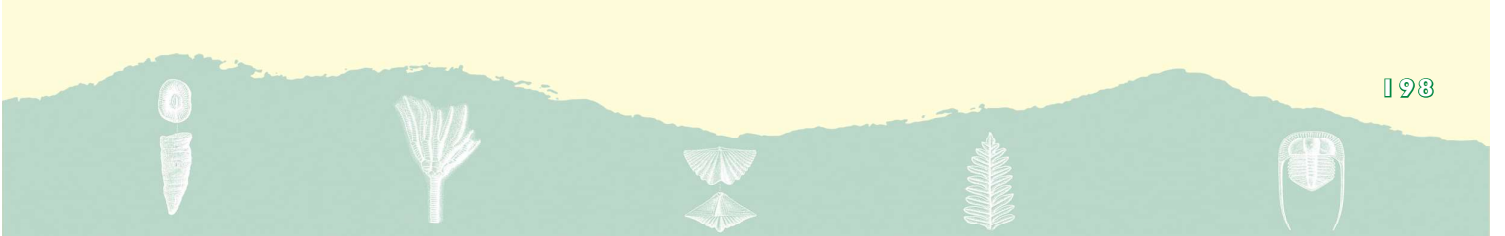
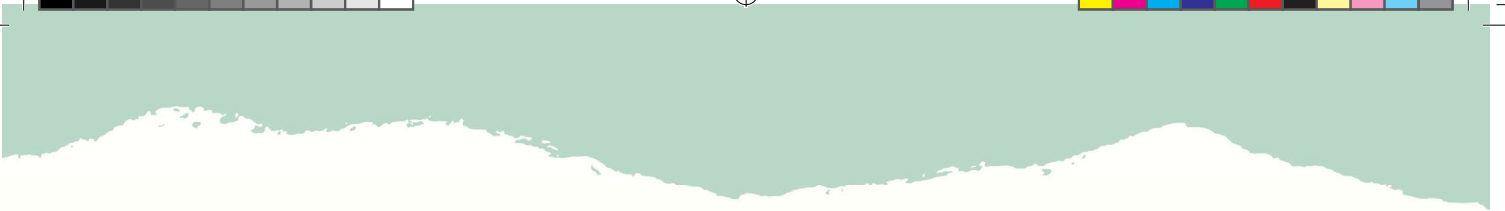
FOLLOW UP ACTIVITIES

Selection of activities for classroom experiments

This excursion could be usefully followed by sessions on weathering mechanisms. Practical experiments that can be tried are:

- Filling a glass bottle with water and then freezing it, to demonstrate freeze-thaw weathering.
- Demonstrate the reaction between dilute hydrochloric acid and marble chips to demonstrate chemical weathering.
- Rounding and breaking up of grains as they are transported before deposition can be demonstrated by putting bits of wax, or firelighters, in a sealed container and shaking it vigorously.
- Small pieces of rock (granite is one of the best types) can be heated in a Bunsen and then cooled rapidly in water to show shattering caused by head expansion/contraction.







ORGANISATIONAL DETAILS

Aim of fieldwork

- To investigate how geologists divide the past up into geological time
- To describe and identify rocks on the basis of their characteristics, including appearance, texture, colour and occurrence;
- To identify different fossils and how they can be used to reconstruct ancient environments hundreds of millions of years old
- To draw graphic logs and recognise the repeating sequences seen in the Carboniferous called cyclothem

Target Group

Key Stage 3 geology, science and geography. However, the exercise could be easily adapted for key stage 4.

Location

Harehope Quarry, Frosterley, Weardale, County Durham

Practical Details

This fieldwork day is based at Harehope Quarry, Weardale. It will start from the car park next to the Eco-classroom in the quarry and will involve a walk of approximately 2 km to complete all the stops (allow

3 hours). The walk will take in various geological stops and will culminate at the viewing circle next to Bollihope Burn. If travelling by coach it is advised for the coach to drop you off and collect from the car park at the entrance to the quarry.

Materials Required

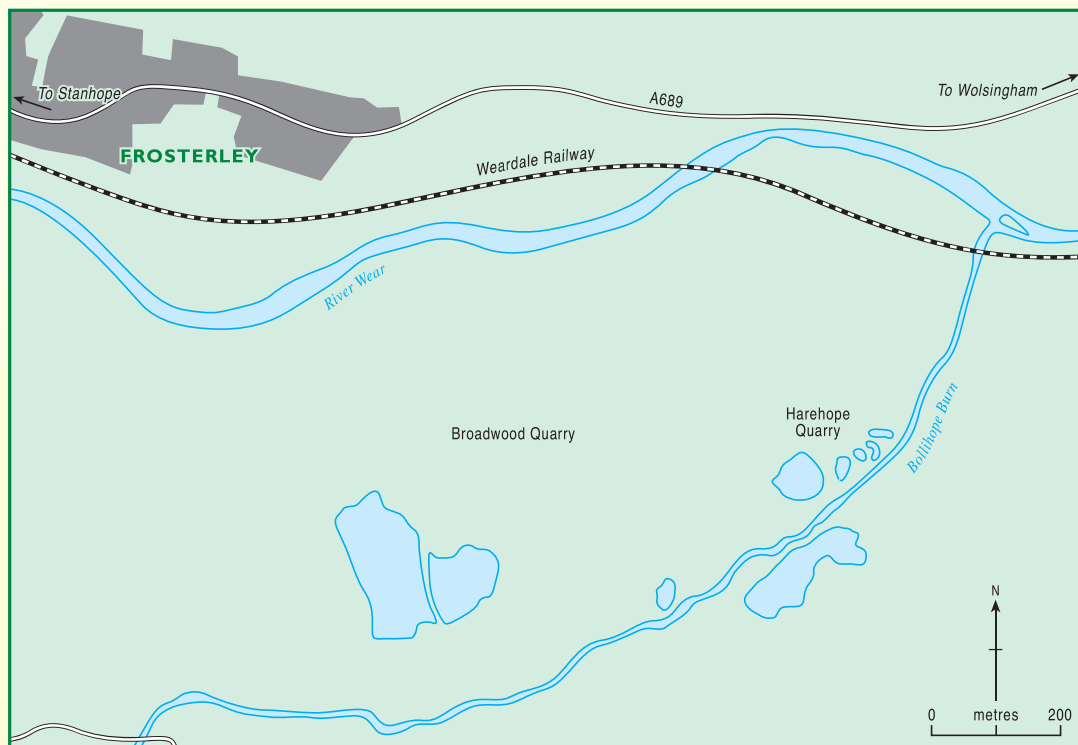
- Grain size cards if possible (available from the Rock Boxes)
- Hand lenses if possible (available from the Rock Boxes)
- Extending tape measures (one between two)
- Use of rock dials (optional)
- Fossil photograph identification sheet
- Map of locations around Harehope Quarry

Safety Issues

- Weardale, like much of the North Pennines, can experience bad weather and the surrounding area can experience bad weather. Staff and students should be prepared for extreme weather conditions and all need to wear suitable warm clothing and footwear.
- In some places old mine workings and caves are present and these may be unstable. Do not attempt to enter any of these old workings and only keep to the designated paths
- Refer to the Hazard Identification Sheet.

Harehope Quarry: Fossils and Cycles

Fieldwork Outline - Teacher Resource Sheet



HAZARDS IDENTIFICATION SHEET

The following notes will help teachers conduct their own risk assessments. This is not a risk assessment and teachers should follow guidelines from the Department of Children, Schools and Families.

Hazard Identified	Risk and to whom	Control measures
Vehicles in the car park	Caution needed when getting off the coach or minibus in the car park as other vehicles may be passing. All students and staff.	Supervise students getting off the coach or minibus and gather in a safe place.
Uneven paths	Paths are uneven and may be slippery in wet weather. Students may slip and fall. All students and staff.	Warn about conditions.
Disused quarry	The route passes through a now disused quarry and contains several steep cliff faces and sheer drops. Some areas may be unstable. All students and staff.	Warn about steep rock faces and sheer drops. To keep to the designated paths at all times.
Bollihope Burn	Falling or sliding down the bank into the Burn. All students and staff.	Keep to wooden bridge to cross the Burn and do not stray from the path.
Lakes in Harehope Quarry	The lakes contain deep water that is very cold, even in summer. All students and staff.	To supervise all students and to keep away from the edge of the reservoir, the dam and sluice gates.

Plan of activities

- Look at the Carboniferous sedimentary rocks and fossils at **STOP 1** behind the Eco Classroom (~30-40 mins)
- Go back around the Eco classroom to the bottom of the gravel ramp and take the left fork crossing over the stream. You will arrive at the Geology Garden - **STOP 2** (~ 40-50 mins)
- In completing the geological time line by walking back through time you will reach a road. Walk up the hill until you come to a stile on the right. Walk along the path above the main quarry face around the perimeter following the map of the quarry. There are many good viewing points along the edge of the quarry. Look at the landscape and comment upon the artefacts of quarrying in the landscape – **STOP 3** (~20 mins)
- At the far end of the quarry, you will descend several steps and come to a circular viewing platform. Examine the rock types in the wall of the viewing circle and note the names of beds given by local quarrymen and miners carved into the rock – **STOP 4** (~20 mins)
- Following the map now examine the cyclicity exhibited by the sediments in the quarry by sketching a graphic log of the cliff section - **STOP 5** (~40-50 mins). To undertake Stop 5 you must ask for permission from the landowner.
- Continue back along path and over the Bollihope Burn using the wooden bridge. You will see spectacular examples of Frosterley Marble in the stream bed that has been polished by the flowing water. On the far side of the bridge is a large block of polished Frosterley Marble to look at in detail and provide a summary of sedimentary rock types and geological processes - **STOP 6** (~20 mins)

BACKGROUND INFORMATION

1. General Geology

The rocks of Weardale form part of the back bone of England and have significantly influenced the natural landscape and man's activities within the region. The rocks of Frosterley have provided many natural resources over the centuries but it is quarrying that has left a lasting mark on the landscape.

Most of the rocks found in Weardale are sedimentary rocks that were deposited between 350 and 300 million years ago when the UK landmass was positioned over the equator. The North Pennines, during this geological time period known as the Carboniferous was periodically covered by large rainforests, vast river deltas and warm tropical seas that hosted an abundant fauna.

The sedimentary rocks that form the Weardale landscape were deposited in cycles. A typical cycle begins with limestone, which in turn is overlain by mudstone, sandstone and often coal. Such cycles are called cyclothems. The limestones are particularly resistant to weathering and tend to form prominent ledges in the landscape. One of the thickest limestones in Weardale, at approximately 20 m, is called the Great Limestone. It is within the upper part of the Great Limestone that the famous Frosterley Marble can be found. Frosterley Marble has long been used as an ornamental stone and is commonly found in Churches in Weardale (e.g. St Thomas', Stanhope) as well as in Durham Cathedral and York Minister.

2. Frosterley marble



Frosterley Marble is a dull grey limestone, with well-preserved fossils of a solitary coral called *Dibunophyllum bipartitum*. These corals were horn-shaped with tentacles that filtered out organic particles from the sea water. When they died they became preserved in limey mud that has now hardened to form the dark grey limestone. The excellent preservation allowed intricate details of the fossils to be preserved and is best seen in polished

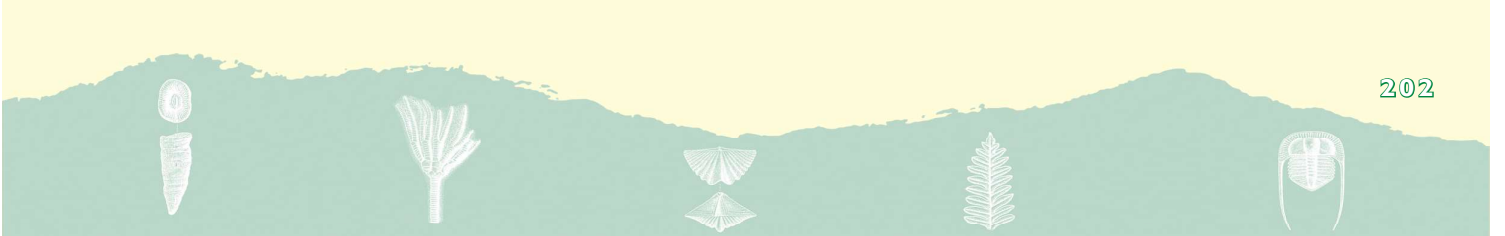
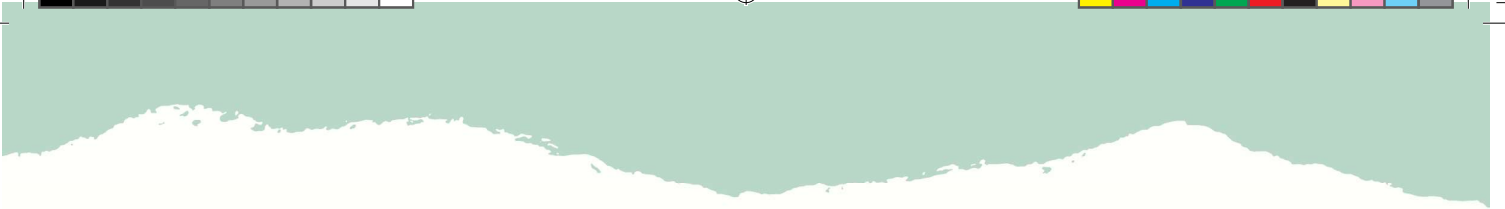
sections (slab of Frosterley Marble, Wise Eel Bridge, Harehope Quarry). *Dibunophyllum* belongs to a group of corals called **Rugose** corals and this group of corals became extinct at the end of the Permian Period (approximately 250 million years ago).

Confusingly, the name Frosterley Marble is not geologically correct, as it is not a true marble, but a name given by quarrymen because of its hardness and use as an ornamental stone. Marble is the name reserved for limestone that has been altered and heated through the geological process known as metamorphism in the Earth's crust. The Frosterley Marble has not been affected in this way and would be more appropriately described as a 'Fossiliferous Limestone'.

3. Harehope Quarry

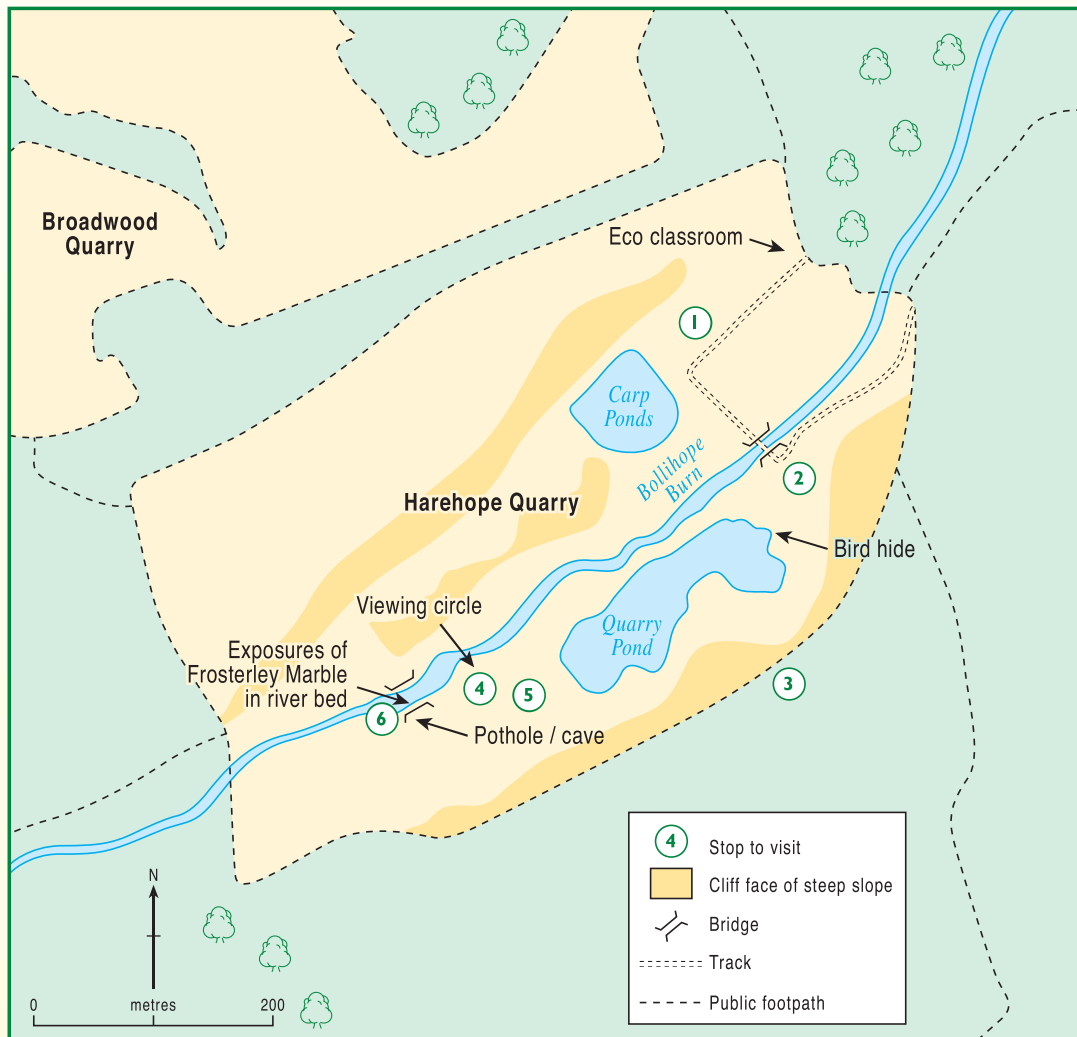
Harehope Quarry is one of the best places to see the spectacular Frosterley Marble and is thought to have been the source of much of this decorative rock. The quarry still contains many large blocks that can be easily examined. The quarry also provides an excellent site to gain insight into the ancient Carboniferous environment of tropical seas and large river deltas. The quarry will form the focus of the exercises for this field excursion.





Harehope Quarry: Fossils and Cycles

Student Information Sheet 1



Map of Harehope Quarry illustrating the different stops for the exercises



204





Harehope Quarry: Fossils and Cycles

Student Resource Sheet 1

FOSSILS AND CYCLES

Welcome to Harehope Quarry! The exercises that you will do here will help you to:

- 1) Learn about the importance of fossils in sedimentary rocks
- 2) Understand about geological time
- 3) Recognise ancient environments from an understanding of the rocks

Study the map of Harehope Quarry and make your way to Stop 1.

STOP 1. Frosterley Marble – Is it all Change!

Spend about 5 minutes looking at the loose fallen rocks of Frosterley Marble.

Now answer the following questions about the rocks at Stop 1:

The pressure from Earth movements and high temperatures cause rocks to change. Rocks formed by changing existing rocks are called

.....

Limestones are made from calcium carbonate. If a limestone is heated and compressed, the limestone turns into a metamorphic rock called Marble. Marble consists of interlocking crystals, which make it harder than the limestone from which it formed. Most marbles do not contain any fossils.

Do you think the Frosterley Marble is really a Marble? Give a reason for your answer.

.....

Fossils found in rocks can tell us what living organisms were like in the past. A fossil is any part of something that once lived, and is now preserved in rock.

Only rarely is the fossil a whole body or plant.

Sometimes fossils can be just a single bone, part of a shell, or even a footprint

Circle the rock type you have the best chance of finding fossils in

Igneous

Sedimentary

Metamorphic

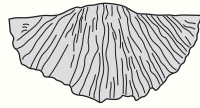
The Frosterley Marble is about 325 million years old and belongs to the Carboniferous Period. It contains well-preserved fossils of a solitary coral called *Dibunophyllum bipartitum*. *Dibunophyllum* belongs to a group of corals called Rugose corals and this group of corals became extinct at the end of the Permian Period (approximately 250 million years ago).

After the corals, the next most common group of fossils found in the Carboniferous are the brachiopods. Brachiopods are a phylum of benthic invertebrates. This group of fossils, which can rarely be seen today, was much more common in the past. *Gigantoproductus* is the largest found in the limestones of Harehope Quarry and grew up to 30 cms, but most are around 2 to 6 cms wide.

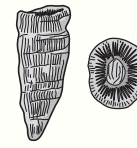




Gigantoproductus



Dibunophyllum



Look for examples of Dibunophyllum and Gigantoproductus in Harehope Quarry and make a sketch of one you find. You will have other opportunities at later Stops to see other examples of these fossils (Stops 2, 5 & 6).

Sketch a fossil found in Harehope Quarry. Limestones are full of fossils but not always obvious. Remember to include a scale on your sketch to show the size of the fossil.


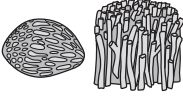

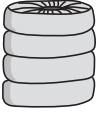

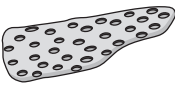

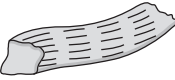
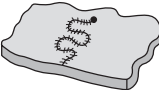
What ancient environment do you think the fossils Dibunophyllum and Gigantoproductus lived in?

	Dibunophyllum	Gigantoproductus
Ancient environment		

At each stop see if you can recognise any other fossils using the fossil identification sheet. Tick them off if found.





Type of fossil	Name	Description	Sketch	Found
FOSSILS FOUND IN LIMESTONES				
Coral - solitary	<i>Dibunophyllum</i>	Corals live on own		
Coral - colonial	<i>Lithostrotion</i>	Corals live together		
Brachiopods	<i>Gigantoproductus</i>	Two shells of different sizes		
Crinoids	Crinoid ossicles and stems	Fossilised 'Sea Lillies'. Ossicle are disc shaped segments that make up stalks		
FOSSILS FOUND IN SANDSTONES AND MUDSTONES				
Brachiopods	<i>Gigantoproductus</i>	Two shells of different sizes		
Fossil plant	<i>Stigmaria</i>	The fossil root of the giant clubmoss tree		
Fossil plant	<i>Lepidodendron</i>	The fossil stem / bark of the giant clubmoss tree		
Fossil plant	<i>Calamites</i>	A fossil horsetail		
Trace fossil	Worm or snail trace	Trace left by a worm or snail on the sediment		



Following the map make your way to Stop 2 in the Geological Garden.

STOP 2 Geological Time Line

Near to the start of the geological time wall you will see a cross section through the North Pennines made from each of the local rock types. These rock types include igneous, metamorphic and sedimentary rocks.

Study the geological cross section. Try to identify each type of rock as igneous, metamorphic or sedimentary and complete the table below (one rock has already been identified to help you):

Rock Name	Igneous	Metamorphic	Sedimentary
Weardale Granite	✓		

Following the path past the Time Wall, walk back in time from the present day to when the Earth was formed four thousand six hundred million years ago (4600 Million Years). Note the large block of Frosterley Marble at the start of the wall.



Using the Time wall and the geological time sheet complete the following paragraphs by filling in the missing words from the list:

Carboniferous	Trilobites	Insects	Fishes	P-T mass extinction
Dinosaurs	Triassic	Homonid	Jurassic	Angiosperms
88%	Pangaea	Ordovician	Cambrian Explosion	Crinoids

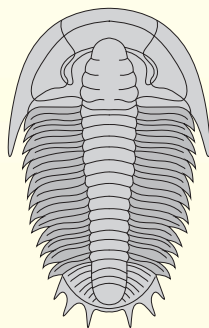
Australopithecus, the oldest fossil from Africa is 4 Myrs old.

At the end of the Cretaceous became extinct, but the Cretaceous is also important for the evolution of (flowering plants). The oldest bird, *Archeopteryx* from the Solenhofen Limestone of Germany is of age. Birds are thought to have evolved from dinosaurs. The oldest known dinosaur, *Eoraptor* is 228 Myrs old and is.....in age.

The Permian sees the formation of a supercontinent called, that stretched nearly from the North to South Pole. This is the only time in Earth's history that all the tectonic plates were joined as one. The End-Permian, is also called the..... This was the greatest mass extinction of all time. More than 90% percent of all life became



extinct. Giant lava flows poured out of what is now Siberia and continental collisions destroyed many shallow marine areas.



During the, corals andare common fossils. Giant clubmoss trees grew to heights of over 30 m and it is thought to be the first occurrence of flying

The Devonian is often called the age of the It is when the first started to venture on to land.

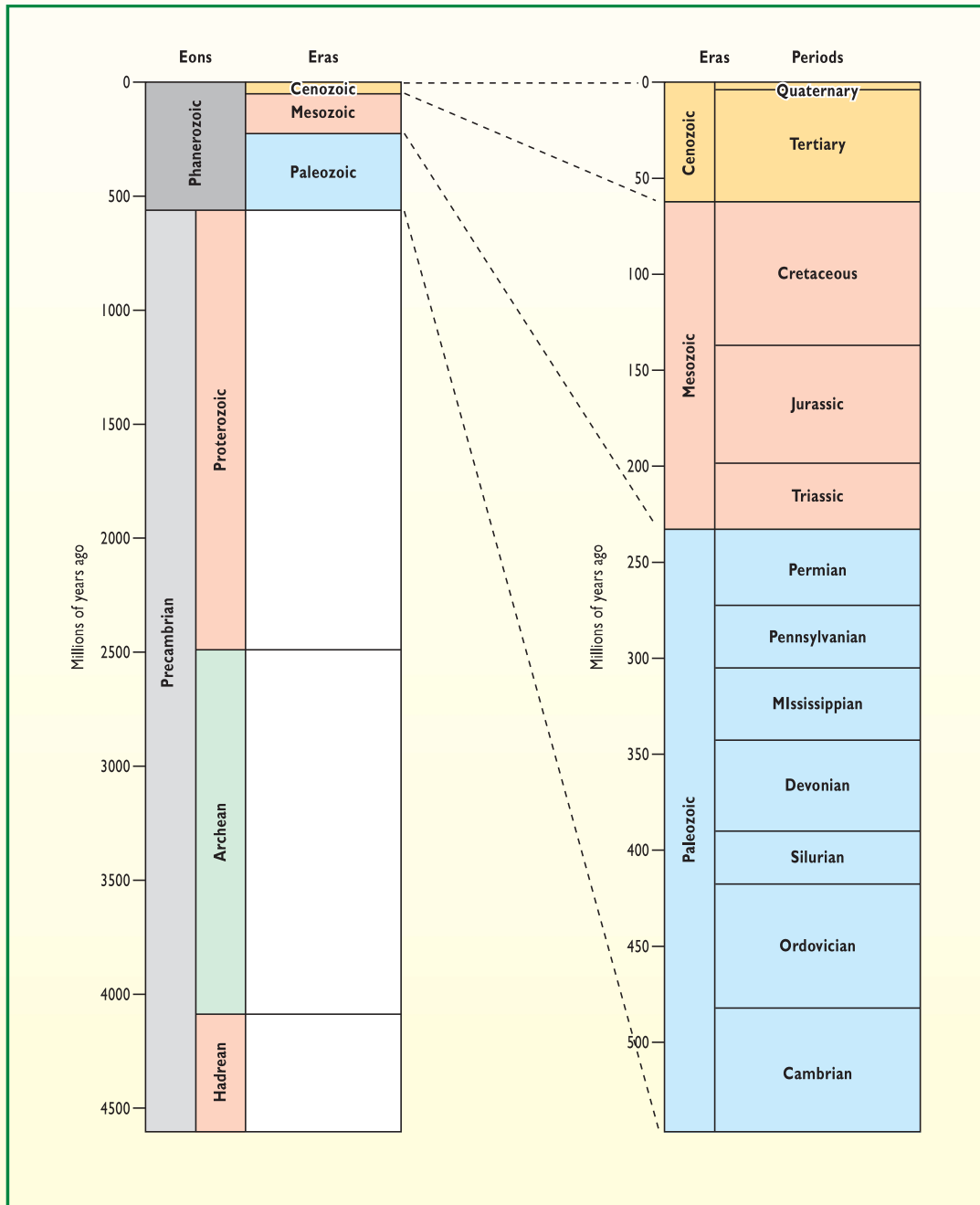
The oldest fossil evidence of land plants is found 470 million years ago in theperiod. The first plants looked like lichen.

The Cambrian sees an abundance of invertebrate life preserved as fossils throughout the world This is termed the "....." because of the sudden appearance of a diverse range of fossils in rocks of this age. Brachiopods, corals, sea snails, and many types of arthropods, including were common.

The approximate percentage of geological time that the Precambrian comprises is

Fact

If you were to write a history of the Earth's past, allowing just one page per year, your book would be 4,600,000,000 pages long. That's a very thick book — 145 miles to be exact.



Geological Time



At the end of the time line you will reach a road. Turn right and walk up the hill until you come to a stile on the right. Walk along the path above the main quarry face around the perimeter following the map of the quarry.

STOP 3 View of Harehope Quarry

Look across the landscape and discuss what impact quarrying has had on the landscape and the local community.

What are the benefits and problems of quarrying in this area of Weardale. Write your answers in the table below:

Benefits of quarrying	Problems of quarrying

Continue along the path to the far end of the quarry descend some steps, and you will see the circular viewing area.

STOP 4 Circular viewing Area

Look carefully at the rocks that make up the stone circle (excluding the cream capping stones).

These are sedimentary rocks

Now use your magnifying glass to observe the rocks carefully and complete the following table and related questions (this is what geologists regularly do in the field).

Geological rock tests	Observation
What colour is it?	
Is it rough or smooth?	
Is it shiny or dull?	
Can you see interlocking crystals?	
Can you see grains?	
Does the rock break?	
Does it contain any fossils?	
Is the rock Sandstone or Limestone?	



The dark grey rocks that makes up the lower and middle sections of the quarry (as seen at stop 1) are called the **Great Limestone**. The Frosterley Marble is one of the more important beds in the Great Limestone. The Great Limestone can be found through out the whole of Weardale and the North Pennines.

Now look at the cream coloured capping to the stone circle. You will see many names carved into the capping stones.

During the 1800's quarrymen and miners use to name the individual beds of the Great limestone according to how they looked, how hard they were and where the beds were found.

STOP 5 Cycles in rocks!

(To undertake **STOP 5** you need to ask for permission from the landowner)

The sedimentary rocks that form the Weardale landscape and Harehope Quarry were deposited in cycles. A typical cycle begins with limestone, which in turn is overlain by mudstone, sandstone and often coal. Such cycles are called cyclothem.

The best way to recognise cyclothem is to draw a graphic log of the cliff section. A graphic log is a geologist's shorthand for the full description of the rocks they see, including thicknesses of beds, structures they can see in the rocks and any fossils found.

Below is a sketch graphic log of the section as seen at Stop 5. Study the log and fill in the blank spaces in the adjoining table [You may need your grain size cards and hand lens].

Graphic log of a cyclothem and associated features –to fill in blank spaces
Would the oldest rocks be at the top or bottom of the cliff section? Explain your answer.

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.....

Some of the sedimentary rocks in the cliff section are harder than others –why?

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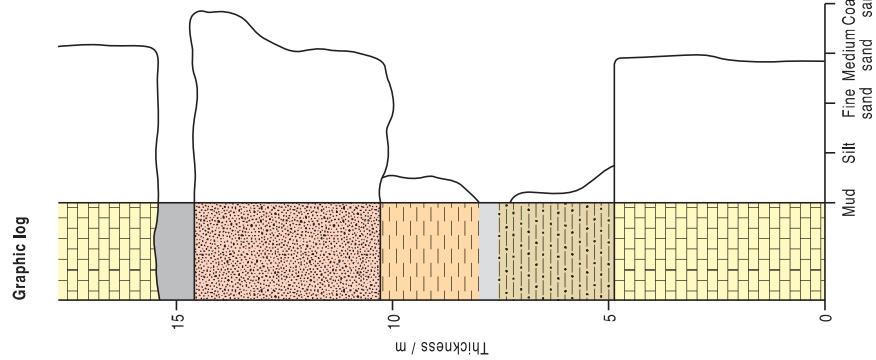
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Continue back along the path until you come to the wooden Bridge over Bollihope Burn.





Colour	Hardness	Sea level		Description of rock types	Ancient environments	Fossils commonly present
		High	Low			
					Shallow tropical sea	Coral, brachiopods and crinoids
Black	V. soft				Delta top swamps	
					Large river deltas Layers of mud and sand settled onto the sea floor, burying the marine life	
	V. hard					Coral, brachiopods and crinoids



Observe the different rock types at Stop 5 and complete the table





STOP 6 Polished Marble?

Directly beneath the bridge is the Frosterley Marble bed.

Now answer the following questions.

Provide a hypothesis as to why you think the Frosterley Marble contains only a single species of now extinct solitary coral (*Dibunophyllum*).

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Finally, why do you think it is important to study the Earth and our landscape?
Give as many different reasons as you can.

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Harehope Quarry: Fossils and Cycles

Follow-up Activity 1

PURITY OF LIMESTONES

Purpose

To determine whether there is a relationship between the colour of a limestone and the amount of impurities it contains.

Limestone has more uses than any other rock and for many of those uses (for example cement and toothpaste) it is important to know how pure it is.

(This experiment will only catch those impurities that are insoluble in 2M HCl. Other carbonates and some sulphides and oxides will be dissolved.)

Instructions

- 1 Take one bag of limestone chips and remove the large piece of limestone. Note its number and match its colour against the rock colour chart if there is one.
- 2 Weigh out accurately a quantity of limestone, about 10 grams.
- 3 Write your name and sample number on the beaker.
- 4 Place the chips in the beaker and add 50ml of acid.
- 5 Write your name and sample number on the edge of the filter paper and weigh it.
- 6 When the sample has stopped fizzing add a further 20ml of acid. If no further fizzing occurs then the CaCO_3 has all been dissolved.
- 7 Now filter the contents of the beaker and carefully wash all the contents on to the filter paper.
- 8 Once all the water has passed through the filter paper carefully take it out of the funnel, fold it so no sediment can escape and place it to dry.
- 9 When it has dried weigh the filter paper again and calculate the percentage of impurities.

$$\frac{\text{Weight of paper + solids} - \text{weight of paper} \times 100}{\text{Weight of limestone}}$$

- 10 Compare your results with other members of the class and draw your conclusions.





TEACHER SECTION

Requirements

You will need a variety of limestones of different colours: white, cream and several shades of grey. You should have one large piece say 5cm by 5cm plus several small chips.

A 100ml beaker and small funnel, retort stand to hold funnel, filter paper, wash bottle of distilled water, 2 molar hydrochloric acid.

Access to balance which will measure to 0.1g.

Oven (optional).

Rock colour chart (optional).

Notes

The limestones can be chipped in a crusher or by hammering them inside a piece of cloth.

If you do not have a rock colour chart then a paint colour chart will do, or else put them in order of increasing darkness.

Filter papers are best dried in an oven, but can be dried on a radiator or window sill.

Results

Generally the darker the limestone the more impure it is.

Time

30 minutes.





Harehope Quarry: Fossils and Cycles

Follow-up Activity 2

CHEMICAL WEATHERING OF LIMESTONE: MY BREATH AND ROCK CHIPPINGS FROM THE CAR PARK

Introduction

Loose limestone (largely calcium carbonate) fragments are often used as the surface of drives and car parks as well as in making roads. In this activity you can discover how the limestone fragments collected from Harehope Quarry or locally are attacked by the weather.

What you will need

- Eye protection
- 250 cm³ beaker
- drinking straw
- deionised water/distilled water
- Universal indicator solution in a small dropping bottle
- White paper
- Several limestone fragments

Safety notes

Always wear your eye protection throughout the experiment.

What to do

Pour a 2 cm depth of distilled/deionised water into the beaker. Add enough drops of Universal indicator to colour the water. Stand the beaker on the white sheet of paper and carry out the tests as itemised in activities in Table 1. Write your answers in the spaces in the table. You should attempt to make predictions before attempting any experiment.

Number	Activity - answer the questions in the box opposite	Indicator colour	Reason - why is the indicator this colour?	Try out the activity	Were you right? Was your prediction correct? If not, what actually happened?	Where on earth might this sort of thing be happening?
1	What colour is the indicator in the water at the start?	Green	The solution is neutral	—	—	—
2	What do you think will happen to the colour of the water when you blow into it through the straw for some time?			Blow into the water		
3	If you drop some pieces of limestone into then water you blew into, what do you think will happen to the colour of the water immediately?			Carefully drop some limestone pieces into the water		
4	What do you think will happen to the colour of the water some time after?			See what has happened some time later		



Use your results to answer the following questions.

Questions

1. If you had something that was precious made of limestone, how could you make sure it wasn't attacked by natural chemicals?
2. As water trickles through the soil, it picks up much more carbon dioxide than it does in the atmosphere. How might soil water affect limestone?
3. As well as carbon dioxide, rain can contain dissolved sulphur dioxide and nitrogen oxides. How might these chemicals effect limestone?

TEACHER SECTION

Requirements

You will need a variety of limestone pieces for the whole class. These can be collected from Harehope Quarry or from a local known limestone site.

Notes

The limestones can be chipped in a crusher or by hammering them inside a piece of cloth.

Results

Generally the darker the limestone the more impure it is and it may not always give the expected test results. This can give some interesting results for discussion. For a dramatic effect, dropping some dilute HCl onto the limestone chippings can provide a good demonstration experiment at the start of the exercise and this can then be followed up with a discussion at the end bringing all together.

Time

30 minutes.

