'I'm in bits and pieces!'

QUARRY PRODUCTS ASSOCIATION

QCA Science - Unit 8G: Rocks and Weathering

To explore the role played by water in the breakdown, transportation and eventual deposition of sediments.

The range of weathering processes that can attack rocks will be explored by focusing on the way in which the dominance of either chemical or physical weathering is determined not only by the availability of water but also by temperature fluctuations.

Teacher introduction and overview.

Key Theme: To explore the role played by water in the breakdown, transportation and eventual deposition of sediments

The range of weathering processes that can attack rocks will be explored by focusing on:

- the way in which the dominance of either chemical or physical weathering is determined not only by the availability of water but also by temperature fluctuations.

To encourage students to use first hand observations to aid prediction students will:

- examine a range of rock specimens investigating texture and the relationship that has to porosity.

They will then predict:

- whether water will soak easily into certain rock types
- what impact porosity has on the weathering process
- what impact porosity has on the usefulness of certain rock types as building stone

The breakdown of Cornish granite will be used as an example and the 3 main minerals found in granite, quartz, feldspar and mica followed on their journey from crystalline rock to sediments deposited at the mouth of an estuary.

A Case Study showing the formation and uses of China Clay (weathering product of Cornish granite) is included. An alternative Case Study considers the uses made of sand and gravel and some of the issues surrounding quarrying today.

To find out about the formation of sedimentary rocks with a biological origin (limestones) teachers should access the Quarry Products Unit Limestones in the Landscape or Lesson 5 in Unit 8G, The Rock Cycle.

The basic structure is:

Lesson One: What are rocks made of?

- Rocks formed from magma, investigation of crystal size in relation to cooling conditions.
- Sedimentary rocks – clastic or biological?
- What is metamorphism?
- Using hand specimens of the 3 rock types students will be shown how to differentiate between a crystalline and a clastic rock.

Homework: On prepared worksheets students will be asked to label the following structures: Crust Mantle Magma chamber Volcano

Lesson Two: What role does water play in the weathering process?

- Making predictions about porosity
- Physical and chemical weathering processes
- Experiment using effervescent tablets (such as Alka Seltzer) to determine the importance of surface area and/or pH in the chemical weathering process
- Optional field study in a local cemetery

Homework: the role of climate in the weathering process. Preparation for next lesson using Internet to gather information on quartz, feldspar and mica.

Lesson Three: How important is water, as a fluid or a solid, in the transportation and deposition of weathered material?

- What happens to weathered pieces of rock as they travel in water?
- Mohs scale of mineral hardness
- Using granite as an example, and information form the homework task ,the breakdown of rock and its transportation in water is discussed
- Demonstration of rounding
- Saltation, suspension and solution

Homework: Create a rhyme or a hip hop or rap tune which tells the story of a quartz mineral being transported in a river. The journey begins as a piece of weathered rock falls from a granite cliff face into a mountain stream.

Lesson Four: Can the weathering process be useful?

- Case Study: China Clay, St. Austell.
- Recap chemical weathering
- Quarrying, sustainability and biodiversity

Homework: Many species of plants and animals in the United Kingdom are in decline because of the spread of housing. Write an article for a newspaper explaining the role both working and restored quarries are playing in providing habitats for threatened species.

OR

- Case Study: river sands and gravels
- Recap physical weathering, link to Ice Age melt waters
- Aggregates – what are they, how are they quarried, what do we use them for, are there alternatives?
- Activity: debate: Little Paxton Quarry, Planning for a Sustainable Future.
- Homework: synopsis of the debate

I'm in Bits & Pieces!'
Unit 8G Rocks and weathering

Science
Year 8

About the unit

In this unit pupils:

- learn about rock texture as one of the key characteristics of different rock types
- model rock texture
- learn about the processes of weathering, erosion, transportation and sedimentation
- relate processes, *eg evaporation and dissolving,* involved in rock formation to processes observed in other contexts
- consider processes operating on different timescales

In scientific enquiry pupils:

- consider how evidence from sedimentary layers and from fossils has led to changes in ideas about the development of the Earth
- frame questions to be investigated
- make qualitative observations, including using time-lapse photography to record gradual changes, evaluating methods used
- present data in an appropriate way
- use scientific knowledge and understanding to explain observations
- investigate a question about sedimentation

This unit is expected to take approximately 7.5 hours.

Where the unit fits in

This unit builds on unit 3D 'Rocks and soils' in the key stage 2 scheme of work.

The two units about Earth science draw on work about pH in unit 7E 'Acids and alkalis', work on evaporation in unit 7H 'Solutions', work on mixtures in unit 8F 'Compounds and mixtures' and work on changes of state in unit 8I 'Heating and cooling'.

This unit relates to unit 2 'The restless earth – earthquakes and volcanoes', unit 7 'Rivers – a fieldwork approach' and unit 8 'Coastal environments' in the geography scheme of work.

The unit provides a foundation for work on the rock cycle in unit 8H 'The rock cycle'. Ideas about weathering are revisited in unit 9G 'Environmental chemistry'. Together with unit 8H 'The rock cycle', this unit lays the foundation for work in key stage 4 on rock formation and deformation and on processes involving tectonic plates.

Expectations

At the end of this unit

in terms of scientific enquiry

most pupils will: describe evidence for a sequence of geological events; suggest a question to be investigated about the movement of sediment and, with help, identify an appropriate approach; use ICT to make and record observations and explain these using scientific knowledge and understanding

some pupils will not have made so much progress and will: describe changes in rocks or rock fragments over time; with help, identify a question about movement of sediment to be investigated and use ICT to make and record observations related to the question

some pupils will have progressed further and will: use evidence from several sources to describe a sequence of geological events

in terms of materials and their properties

most pupils will: describe rock specimens in terms of texture and relate this to properties such as porosity; describe the physical and chemical processes by which rocks are weathered and transported and relate these to features of the environment; describe and explain the processes by which layers of sediments are produced

some pupils will not have made so much progress and will: describe rock specimens and recognise that different rocks have different textures; describe some effects of weathering and recognise sedimentary layers

some pupils will have progressed further and will: relate processes of chemical weathering to the reactions of particular grains with acids; relate sedimentary layers to the processes by which they were produced

Prior learning

It is helpful if pupils:

- know that there are rocks under the surface of the Earth and that soils come from rocks
- can name some examples and uses of rocks
- know that solids, liquids and gases are made of particles and about differences between the way particles are arranged in solids and liquids
- have experience of determining the pH of a solution and relating this to acidity or alkalinity
- know that dissolved solids are left behind when water evaporates

Health and safety

Risk assessments are required for any hazardous activity. In this unit pupils:

- plan and carry out an investigation into sedimentation

Model risk assessments used by most employers for normal science activities can be found in the publications listed in the *Teacher's guide*. Teachers need to follow these as indicated in the guidance notes for the activities, and consider what modifications are needed for individual classroom situations.

Language for learning

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

- words and phrases for physical processes associated with rock formation, *eg chemical weathering, abrasion, sedimentation*
- words and phrases for timescales over which change occurs, *eg millions of years, millennia*
- names for specific rocks, *eg granite, limestone, sandstone*
- words and phrases relating to geological features, *eg sedimentary layers, porosity*
- words and phrases relating to scientific enquiry, *eg time-lapse photography, sequence of events*

Resources

Resources include:

- a collection of rocks, either one available commercially or one compiled by the department, *eg conglomerate, sandstone, limestone, chalk, mudstone, shale, slate, marble, quartz, granite, gabbro, basalt, pumice, obsidian*, some of which are typical of their type and some of which have unusual features
- access to pictures, CD-ROMs, internet sites showing geological landscapes and events, *eg volcanic eruptions, both explosive and lava,* and simulations of geological events which occur over many millennia
- examples of fossils or fossilised materials
- materials for modelling rivers
- digital camera for recording changes over a period of time
- secondary sources illustrating the work of Mary Anning

Out-of-school learning

Pupils could:

- read books about the Earth and its history and newspaper articles about weather conditions (floods and high winds) or volcanic eruptions
- watch television programmes or videos about the Earth, which will help them understand how rocks are formed
- visit science museums to see displays about the Earth and its rocks as well as simulations which will help them to imagine the effects of earthquakes and the forces involved
- visit other museums and art galleries to see how rocks are used
- read science fiction texts about earlier geological ages
- visit the seashore to observe shingle, sand, river estuaries and cliffs, or hills to observe peat and rock formations, *eg limestone pavements*

LEARNING OBJECTIVES PUPILS SHOULD LEARN	POSSIBLE TEACHING ACTIVITIES	LEARNING OUTCOMES PUPILS	POINTS TO NOTE
What are rocks made of?			
• that rocks are usually made up of a mixture of mineral grains • that two main textures can be recognised • how to use experimental evidence and models to explain the texture of different rocks	• Show pupils samples of rocks and ask them to sort them into groups. Ask them to explain the basis for their groups, prompting if necessary by asking questions, *eg What makes the rock shiny? What can you see in the rock? Is the rock all the same colour?* Ask pupils to record key responses. Discuss with them the words/observations that occurred most frequently. • Provide pupils with samples of granite and sandstone and ask them to explore their textures, *eg by close observation using a magnifier and by immersion in water*. Ask pupils to explain why one rock produces bubbles in water and the other does not. Investigate the absorption of water by weighing samples before and after immersion to illustrate porosity. Model interlocking and non-interlocking textures, *eg using a three-dimensional block puzzle and marbles,* and relate observations to interlocking and non-interlocking textures. Ask pupils to record and explain their findings using annotated drawings and diagrams. Establish the idea that rocks are almost always mixtures of materials.	• describe rocks as containing different grains which fit together • explain that some grain shapes are interlocking and some are not, *eg some grains fit together and others do not; when the grains don't fit there are spaces and the water goes into these* • relate evidence about porosity to the way in which grains fit together	• Rocks need to be chosen so that pupils will see easily that they are a mixture of different grains. The word most commonly used in their explanations/ descriptions may be 'bits'. • Some pupils may not realise that the term 'rock' as used by geologists includes unconsolidated material, such as sand, clay and peat, as well as harder materials. • Differences between mixtures and chemical compounds are considered in unit 8F 'Compounds and mixtures'. • It may be helpful to illustrate porosity using sponges of different kinds.

How does rain cause rocks to weather?			
• that rocks at the Earth's surface disintegrate through exposure to water in the environment, which causes chemical reactions • how to record results over a period of time • to use knowledge and understanding of the composition of igneous rocks to explain results of changes over time	• Take pupils to observe rock materials out of doors, *eg in a cemetery or on a high street*, or show them pictures, video clips of rocks/building materials in the locality of the school. • Ask pupils to compare older surfaces with new or chipped surfaces to record evidence of discoloration and/or crumbling. Ask them to speculate about possible causes. Note the effects of weathering under trees or adjacent to soil and ask pupils to suggest reasons for this. • Remind pupils about earlier work on acids and alkalis and show that samples of rainwater are slightly acidic. • Ask pupils to compare fresh granite with weathered granite to observe any changes to minerals. Simulate wet, oxygen-rich, acidic conditions using dilute hydrochloric acid and hydrogen peroxide in a 50:50 mixture. Place a sample of granite in the solution and capture the changes daily for up to two weeks using a digital camera to create a time-lapse sequence. Ask pupils to examine, describe and explain the changes using a computer-generated slide show. Discuss with them why this is an effective way of recording results.	• describe changes in rocks and building materials over time • identify acidic rain as a cause of chemical weathering • describe and evaluate the use of time-lapse photography to record gradual changes • describe changes in granite exposed to acid and relate these to changes in particular grains that are dissolved by acids	• Weathering of rocks and the formation of sedimentary rocks are considered before the formation of igneous rocks, as these processes are likely to be more familiar to pupils. • The formation of acid rain is covered in more detail in unit 9G 'Environmental chemistry'. • A set of photographs of weathered materials in other environments may be useful. See suitable internet sites, *eg* *www.geo.duke.edu/sched/geopages/geo41/wea.htm* *www.geo.duke.edu/sched/geopages/geo41/wea2.htm* *http://athena.wednet.edu/curric/land/landform* • Extension: present pupils with a map showing rainfall and temperature and ask them to suggest regions where extensive weathering might occur. **Safety** – use acid solutions in concentrations less than 0.4 mol dm^{-3} as these are low hazard

How do changes in temperature cause rocks to weather?			
• that rocks are broken down by forces that result from stresses generated when water in cracks and fissures expands on freezing • that rocks at the Earth's surface are broken down by forces that result from stresses generated when rocks expand and contract on heating and cooling	• Show pupils pictures or a video clip as a stimulus and ask them to suggest why mountaineers climbing in high mountains, *eg the Alps or Himalayas*, start early in the morning and try to complete their climbing on mountain faces before midday. • Demonstrate the magnitude of the forces arising from expansion or contraction of a solid, *eg by repeatedly heating a corner of a chip of granite to red heat then quenching it in cold water or by using a breaking-bar experiment*. Establish with pupils that these forces are large enough to cause pieces of rock to break off and are most significant where there are large temperature ranges. • Present pupils with a rock sample containing cracks and soak in water. Explain that this is to be used to model what happens when water freezes and thaws. Ask them to suggest how this might be done and how to record the results. Use a digital camera to create a time-lapse sequence showing the number of freeze–thaw cycles on the rock sample and ask pupils to examine the changes, particularly the width of cracks and the shape and size of fragments, using a computer-generated slide show. Discuss how the angular fragments are formed. Ask pupils to re-evaluate their suggestions about mountaineers and explain why rockfalls can be a major hazard to climbing.	• explain how water absorbed by rocks expands on freezing and fragments the rock • describe how changes in temperature can result in rock fragmentation • describe conditions when fragmentation is likely to occur • explain that the forces arising from expansion and contraction are great enough to break off pieces of rock • relate expansion and contraction to the particle model of matter	• If pupils do not know that water expands when it freezes, a demonstration using a plastic bottle filled with water frozen in a freezer would be helpful. • Extension: ask pupils to use a hand lens to look at a sample of highly porous rock that has been soaked in a saturated salt solution, *eg sodium sulphate solution,* and then dried, and to note the presence of crystals occupying the pore spaces. Discuss how the salt can be leached in solution from the rock and then crystallised on nearing the surface of the rock. • Extension: use a digital camera to create a time-lapse sequence showing a number of saturation–drying cycles on the rock sample. Ask pupils to examine the changes using a computer-generated slide show and to record the size and shape of the fragments that are formed. Ask pupils to explain how the growth of salt crystals breaks down the rock. **Safety** – eye protection should be worn when heating granite

Checking progress			
• to relate a landscape to a process of weathering	• Show pupils photographs of natural scree slopes, *eg Wast Water in the Lake District*, and ask them to suggest how rock ended up as fragments in a pile at the bottom of the cliff and what the scree slope tells us about past conditions. Ask pupils what characteristics would lead to rocks being weathered easily.	• identify conditions under which rocks fragment • explain the formation of the scree slope in terms of these conditions	• Pupils would not be expected to recall terms such as 'scree slope'. • Extension: to test their ideas, pupils could investigate rock resistance by shaking several small specimens of different rock types in a plastic container and recording changes of size after different time intervals.
What happens to weathered pieces of rock?			
• that rock fragments become sediment grains which can be transported by water currents and deposited when the energy is dissipated • to make predictions about where sediment is deposited	• Review work on weathering and fragmentation of rocks. Find out pupils' ideas about how rock fragments are transported and changed by asking them to sequence a set of statements/drawings and to explain their sequence. Help pupils to investigate water flow in a channel and its overflow by using square guttering that channels water into a large trough. Use a dye, *eg ink,* to track what happens to the current along the gutter and in the trough. Discuss the spreading out of the dye and ask pupils to describe and record where water is moving quickly, and where it is moving slowly, and to use the results to predict where large and small fragments will be deposited.	• state that rock fragments can be transported by flowing water • use the results of their investigation to predict where different sizes of sediment might be moved or deposited in a river flowing into a lake or sea	• Pupils' understanding of how different grains behave can be reinforced by adding a cupful of mixed-sized grains of sediment to a jar of water and swirling it around. Ask pupils to observe which grains roll, which bounce and which 'fly', *eg in suspension*. **Safety** – take care that floors do not become wet and slippery
• how to frame a question that can be investigated • to decide whether evidence supports predictions • that larger grains are not taken as far, as it requires more energy to move them • that sediment grains of similar size are deposited together	• Ask pupils to suggest how water flow might affect the movement of different-sized grains of sediment and to plan how to investigate a specific question using gravel, sand and muddy soil. As part of their investigation, ask pupils to observe and record the distribution of sediment grain size along the gutter and to explain the relationship with volume and speed of water flowing. Bring together the outcomes of all investigations, asking pupils to describe what they did, what problems they encountered and how they overcame them.	• suggest a question that can be investigated, *eg Is sand carried as far as gravel? Does the distance sand travels depend on the width of the channel?* • relate the outcomes of their investigation to the grain size and/or volume and speed of water • conclude that grains of similar size are deposited together	**Safety** – teachers will need to check pupils' plans for health and safety before practical work begins

What happens to weathered pieces of rock? (Cont.)			
• that as transportation times and distances increase, sediment grains become more rounded and are also sorted into similar sizes • to present data in an appropriate form	• Show pupils that the change in sediment shape and size during transportation can be simulated by shaking plaster cubes in a cylindrical container. Ask them to investigate what happens over several cycles of tumbling in terms of, *eg number, average, mass or shape of fragments after each cycle*. Ask pupils to show the results as line graphs or appropriate drawings, and to explain what has caused the changes and what happens to the 'lost' mass. Bring together the class results with the pupils, and help them to make generalisations about fragmentation.	• identify changes in fragments as time and distance of transportation increase, *eg become smaller, smoother, rounder* • display their results, *eg line graph for average mass of fragments, drawings for shape of fragments*	
Checking progress			
• about fragmentation and transportation	• Show pupils photographs, video clips of rivers full after a storm and in normal state and ask them a series of questions, *eg* – *Why does the river appear dirty?* – *Where has the dirt come from?* – *What happens when the water level drops?* – *Why does the river become clearer?* • Help pupils to generate key points about transportation and formation of sediment grains from their responses and the responses of others.	• identify the source of 'dirt' in rivers in flood • make generalisations about transport and formation of sediment grains, *eg larger grains don't get carried so far*	
Why do sediments form layers?			
• that sedimentary layers are the result of distinct episodes of sedimentation over a variety of timescales • to suggest explanations for observations they make	• Show pupils photographs or video clips of cliffs with sedimentary strata and ask them to suggest, *eg in drawings or annotated diagrams*, how the layers were formed. • Ask pupils to investigate how quickly sediment settles using grains of different sizes, *eg clay, sand, gravel*, in a jar of water. • Ask pupils to observe if the layers have sharp boundaries or grade into each other and to relate this to the conditions under which the layers were formed. Ask pupils to speculate about what controls the thickness of layers and to explain their ideas to others.	• describe how sediments settle to form layers • identify in drawing or annotation that different layers were formed at different times • relate observations about sedimentary layers to factors, *eg particle size*	• Sharp boundaries are formed when there is a time interval between the deposition of the layers.

LEARNING OBJECTIVES PUPILS SHOULD LEARN	POSSIBLE TEACHING ACTIVITIES	LEARNING OUTCOMES PUPILS	POINTS TO NOTE
Why do sediments form layers? (Cont.)			
• that sedimentary layers can be formed by the evaporation of waters containing dissolved salts • that the remains of dead organisms and their shelly material can accumulate to form sediments • to use evidence in rock layers to suggest a sequence of events over time • about the use of fossils as evidence	• Ask pupils whether water in rivers, lakes, seas has solids dissolved in it. Remind them of earlier work on different types of water. Ask them to explain the origin of the salts. Use a flow diagram to explain how salts become concentrated in seas or lakes. Ask pupils to suggest what would happen if the seawater evaporated and how to test their ideas. Modify the flow diagram to discuss how seas and lakes can dry up. • Explore with pupils how a sequence of sediments can be built up by covering the residue from evaporated sea water with a layer of clay and shells to represent the remains of dead organisms, adding more seawater and allowing it to evaporate. Extend to the formation of oil, *eg by using video clips*. • Give pupils a simplified diagram showing different strata and ask them to tell the story of how the layers were formed and why fossils are often found in sedimentary layers. • Extend by asking pupils to use secondary sources to find out about Mary Anning and the fossil specimens she collected.	• describe how dissolved solids are left behind when water evaporates • describe a possible sequence of events leading to a pattern of sedimentary strata • justify their sequence using the evidence from the layers	• Pupils are likely to have investigated different types of water at key stage 2 to find out whether they contain dissolved solids. • The use of fossil fuels is included in unit 7I 'Energy resources'. • Extension: pupils could be asked to find out about how evidence in rock strata, *eg fossils, coal layers*, has been used to develop other ideas about changes in the Earth over time, *eg continental drift, climate changes*. • Teachers will be aware of the need to be sensitive to different religious beliefs. **Safety** – care is needed if the seawater is evaporated by heating. Eye protection should be worn
Reviewing work			
• to relate key ideas about geological changes to each other	• Provide pupils with a series of photographs/diagrams/drawings and brief descriptions, *eg a muddy river estuary – grains of mud and sand deposited at the edges of rivers; a pile of rocks at the bottom of a scree – water that gets into cracks and expands as it freezes*, and ask them to match them. Where pupils have matched images and descriptions in different ways, ask them to justify their choices to each other.	• match a description of a geological process to an illustration of it • relate the processes involved in weathering, transport and sedimentation	

Lesson One

What are rocks made of?

Identifying the 3 rock types

Students will be presented with a selection of igneous, sedimentary and metamorphic rock. Your local quarry will be able to supply you with samples of the rock extracted there or local stonemasons or companies providing rock to bathroom or kitchenware manufacturers may be happy to provide off cuts for you to use.

Set out groups of rocks and, depending on the number of samples available, pupils work in pairs or fours to observe and record the textures and properties of the various samples.

Students need to know that:

- Igneous rocks form from molten material
- The molten material is known as magma when it is in the Earth and lava when it has reached the surface of the Earth
- As the magma/lava cools crystals form
- The size of the crystals is determined by the rate of cooling
- Fast cooling = small crystals not visible to the naked eye, this means the lava has cooled in the air or in water
- Slow cooling = large crystals visible to the naked eye, this means the magma has cooled in the Earth

Students need to know that:

- Sedimentary rocks are formed from bits of other rocks
- The bits are called clasts and these rocks are known as clastic rocks
- The clasts are 'glued' together to form a rock
- The glue is called cement
- Some sedimentary rocks are made from biological remains known as fossils
- These rocks formed in the sea
- The fossils are usually held together by lime muds
- These rocks are known as bioclastic rocks

Students need to know that:

- Metamorphic rocks have formed from pre existing rocks
- The rocks were subjected to heat and/or pressure
- This caused the texture of the rock to change

- Sometimes the change is only slight and it is possible to guess what the original rock was (mudstones/slate for example)
- Sometimes the change is much greater (limestone/marble is a good example at this stage – just where have all the fossils gone?)
- The most important thing is that the original rocks did not get so hot that they melted – if they had they would have become magma

The website http://earthsci.org/rockmin/rockmin.html provides an animated series of images looking at the formation of the fundamental rock types

Homework
Worksheet showing the structure of the Earth.

Students add the following labels to their sheet:
Crust
Mantle
Magma chamber
Volcano

Extension task: Students write a few lines about each of the areas identified.

Teachers' notes to support homework task:

The crust varies in thickness from 30-70 kms under the continents and mountain ranges on those continents to 5-7 km on the ocean floor. The crust is composed of cold, brittle rigid plates, which are being carried on the mantle, a layer of denser rock, which extends to a depth of approximately 3,000km. The molten material, which is generated mostly in the upper mantle, migrates towards the Earth's crust. It may form a magma chamber where large quantities of magma come together. As heat is lost from the magma to the surrounding rock crystals begin to grow, a useful analogue here is the formation of ice in the freezer.

- Water in ice trays is warmer than the freezer box it is placed in, heat is lost to the surrounding air and gradually, as the temperature of the water falls crystals begin to grow until eventually you have a solid, an ice cube. The minerals in magma also have their own freezing point at which they begin to turn into a solid, a crystal. It's just that their freezing temperature is measured in 000's of degrees!

Igneous rock formed in this way is known as intrusive igneous rock and has large crystals that are easily identified with the naked eye; they reflect the length of time taken for the magma to cool.

If magma reaches the Earth's surface it is known as lava. Lava cools quickly and the crystals formed are small, only visible with the aid of magnification.

Lesson Two

What role does water play in the weathering process?

Students will be presented with a number of rock samples and a small bottle with a drip feed containing water. The specimens should vary so that at least sandstone, limestone and granite are tested.

In groups of 2 or 4 they will be asked to devise a fair test to determine porosity.

Students will have to:

- Make predictions
- Recognise that both the number of drips of water and the time the water is left on the rock will have to be monitored if the test is to be fair
- Devise a recording sheet

Students can be asked to write their results on the board for the whole group to share. Ask pupils to group the rocks according to their type i.e. igneous or sedimentary when recording their results.

- Students can use IT skills to produce the whole class results as graphs.

Students need to know:

- The difference between the terms porosity and permeability.

  This can be demonstrated in class in the following way. Ask the students why they thought the water soaked into some rocks and not others – pore spaces between the grains in sedimentary rocks allowed the water to seep in, there are no pore spaces in crystalline rocks. Students sitting at their desks represent the pore spaces and the gaps between them the grains. Ask whether they think water will flow through the" rock " (the gaps between the students) easily. The answer should be no as there are no connections between the pore spaces. Now ask students to hold hands – the " rock" has now become permeable, there are links between the grains and the pore spaces.

Weathering

<u>Definition of weathering: breakdown of solid rock to form sediments</u>

Students will be introduced to the physical processes, which lead to the disintegration of rock. Weathering is usually broken down into two forms, physical or chemical. It is important that students recognise that neither process operates independently of the other, in a cold harsh climate physical weathering will be dominant and in a hot humid climate chemical weathering will be dominant but they will not be the only forces at work.

Physical/mechanical weathering

Use granite as an example of freeze thaw weathering showing clearly that although the rock type has not been identified as porous it often has 'joints' which allow water to permeate into it. Remind pupils this is a crystalline rock, which formed from molten material and is made up of different minerals.

Students will need to know that:

- Freeze thaw takes place in areas where the temperature fluctuates around zero
- That means it does not happen only in cold countries
- Even if the temperature fluctuates around zero if there is no water available the process cannot occur
- Other forms of mechanical weathering are exfoliation and thermal expansion, root pry or burrowing by animals.

Chemical weathering

Chemical weathering involves water. Carbon dioxide dissolved in rainwater leads to the formation of carbonic acid.

$H2O + CO2 \Rightarrow H2CO3$

This makes the rainwater acidic. Rainwater will react with calcium carbonate, the main "ingredient" of limestone or other carbonate rocks like chalk, dissolving the rock and carrying the residue away in solution, calcium hydrogen carbonate.

Stronger acids may be produced locally if water comes into contact with sulphide minerals the result will be

$H20 + SO2 \Rightarrow H2So4$

Another important chemical weathering process is hydrolysis, a reaction between a mineral and the hydrogen in rainwater. This process is associated with feldspars, which break down to form clays.

Acids produced by decaying plants can also influence chemical weathering rates as can the degree of oxygen available, use rusting as an example here.

Students will need to know that:

- In chemical weathering the amount of surface area available is very important. The larger the surface area the more rapid the chemical weathering process.
  Useful image of increasing surface area available at
  http://www.ux1.eiu.edu/~cfjps/1300/weathering.html

- The rate at which chemical weathering takes place is influenced by the climate, warmer and wetter climates increase the rate
- The rate at which chemical weathering takes place is influenced by the ph (acidity or alkalinity) of the water or the soil overlying bedrock
- Some minerals are particularly susceptible to chemical weathering (feldspar)

Experiment

Students can set up a simple experiment to test the effect of changes in surface area, temperature or pH on speed of breakdown.
Divide the class into groups of 4, for each group you will need the following:

Apparatus
4 x 50ml beakers
4 X 30ml water
4 X effervescent tablets (indigestion tablets for example, denture cleaning tablets are a good choice as they can be purchased very cheaply from the High Street chains of chemists)
Recording sheets
Stop watch

Method
- Keep one tablet whole
- Split one tablet in half
- Split one tablet into 8
- Crush one tablet.

Each student fills his or her beaker with 30ml of water at room temperature. When the student is ready to record the time they add their tablet (either whole, halved, crushed or split into 8) to the water and records the time taken for the tablet to dissolve (effervescence stops).

- The experiment can be repeated by altering one variable, either water temperature or pH of the water and the results recorded.
- Students share their results with the whole class.

What has the experiment shown? How do the results link to chemical weathering? Can they see the links between physical and chemical weathering?

- The crushed tablet will effervesce quickly
- The results show that greater surface area = rapid chemical breakdown
- The results should show the process is quickest in warm water
- Acidity affects the reaction time
- Crushing = physical weathering, so although chemical weathering can act on its own (the whole tablet) it is much quicker on "weathered" material

Useful images at
http://www.thewalkzone.co.uk A series of photographs associated with walks in, and views of, the Lake District, Morocco, Nepal, Spain. A range of tasks could be linked to the images, predicting what type of weathering is likely to occur for example.

http://www.au.au.com/cameras/images/devils-marbles.jpg Images of the spheroidal weathering of granite. This is a superb example of the way in which mechanical and chemical weathering processes work in tandem, the mechanical forces cracking the rock and the chemical reactions leading to removal of the flaked surface.

www.soton.ac.uk/~imw/portnew.htm#build
Excellent photographs of quarries on the Isle of Portland, students could debate the weathering processes going on in the quarries – mechanical removal acts like physical weathering exposing and weakening surfaces so that further physical and chemical weathering can take place.

Extension: Field Study in a local Cemetery

By examining changes to the surface of headstones in a cemetery deductions can be made about the degree of weathering that has taken place since the stone was erected. Predictions can be made regarding the speed with which a certain type of rock used for headstones in the same cemetery will weather. Students will need to develop a standard tool to allow them to measure the changes that have taken place in order to ensure a fair test takes place. Robert Inkpen, Department of Geography, University of Portsmouth suggests comparing the sharpness of the lettering; this could be linked to a percentage scale for example:

Lettering sharp and distinct = 0% weathering

Lettering still legible but all clean edges removed and writing difficult to distinguish form the gravestone's surface = 50% weathering

Unable to make out date on headstone = 100% weathering

The criteria could be made more complex depending on the time available for study but these 3 divisions will allow comparisons to be made between headstones of the same age, of the same or different rock type and deductions made about the speed at which certain rock types deteriorate. Teachers should note however that this approach gives the impression that weathering is a linear process when in fact rates of weathering may increase as the original surface is lost, position in the cemetery may also play a part and so it would be useful for students to draw a map and indicate the distribution of headstones examined and the direction the stone was facing. Students stand with their back to the face of the headstone, which has been inscribed, and take a compass reading from that point in order to determine which way the stone is facing. Have headstones of the same age and rock type weathered differently if they are facing in different directions?

Finally having completed the task ask your students which rock type they would want used for their own headstone!

Homework

Task One:
Students use the Internet to collect images of rocks weathered by the processes of exfoliation and thermal expansion.

Extension task: Students write a paragraph to accompany each of the images they have found to answer the question: What role does the climate play in these types of weathering processes?

Task Two:

Using the library and the Internet students collect information on the 3 main minerals found in granite, quartz, feldspar and mica. For each mineral they should answer the following questions:

- What shape is the mineral
- What colour is the mineral
- What is its hardness number

Teacher's notes to support homework task:

Hardness is a relative scale devised by the scientist Mohs in 1822 to show minerals resistance to abrasion. The scale ranges from 1 to 10, diamond is the hardest at 10, talc is the softest mineral at 1. A fingernail has a hardness of about 2.5, a steel penknife blade is 5.5 and any mineral that will scratch glass has a hardness of more than 6. Hardness reflects the way in which the atoms of a mineral are packed together; the more tightly they are packed the harder the mineral.

- **Mica**

  Hardness: 2.5
  Mica is flat and platy and splits easily along one plane. This is known as its cleavage and mica is described as having one perfect cleavage. It is very light and easily dispersed in wind but in water is often found in the mud deposited along the edges of slow moving rivers or in estuaries. Weathered from igneous rocks it is an important component in clastic sedimentary rocks.

- **Quartz**

  Hardness: 7
  Quartz crystals are usually 6 sided prisms which can be found in a range of colours from the white milk quartz to pink rose quartz to transparent. The crystal grows in such a way that it has no plane of weakness, it does not split easily in any one direction and so has no cleavage. This makes it resistant to erosion once it has been weathered from an igneous rock. Quartz is the main component of the clastic sedimentary rocks sandstones and gritstones. It also provides the "sand" for many of the beaches around the coast of the United Kingdom.

- **Feldspar**

  Hardness: 6
  Feldspars are very abundant minerals, which occur in igneous rocks, they may be pink or white. They exhibit 2 good cleavages. The alkali feldspars weather readily to the clay mineral kaolinite. Feldspars have an affinity with water and so are easily broken down by chemical weathering.

Lesson Three

How important is water, as a fluid or a solid, in the transportation and deposition of weathered material?

What happens to weathered pieces of rock as they travel in water?

Explain the difference between weathering and erosion.

- Weathering takes place in situ, erosion is a continuing process as the rock and mineral fragments are moved away from their site of origin.

Pupils will need to see examples of quartz, feldspar and mica in order to appreciate their particular qualities and varying hardness.

Images of granite, quartz, mica and feldspar can be found at
http://www.es.ucl.ac.uk/schools/Glossary/granite.htm

Pupils will need to know that:

- Minerals are ranked according to their hardness
- This is a relative scale which was set up by a scientist called Mohs
- He said that a diamond was the hardest mineral and gave this a numerical value of 10
- He then tested other minerals by seeing if they could scratch each other, the diamond could scratch every other mineral but talc couldn't scratch anything at all
- Talc was given the numerical number 1 as its hardness score, in other words the least hard mineral in the group

Task
Using information gathered by pupils for their homework activity construct the hardness scale for quartz, mica and feldspar

Transportation and erosion
Follow the journey of a weathered piece of granite as it rolls into a stream.

Students will need to know that:

- Physical weathering happens on high ground where there is little vegetation
- When the rainwater flows over the ground it picks up and moves pieces of weathered rock
- The size of the mineral transported depends on the velocity of the water
- The water will form a stream and eventually a river
- It takes a lot of energy to move a piece of rock initially but once it is moving it takes less energy to keep it rolling. This material is known as bedload.

Introduce terms **traction, sliding, rolling**

Experiment
Placing a few sugar cubes into a small tin with a lid and shaking the tin for about 30 seconds can demonstrate how pieces of rock break down as they are tumbled in the water. Students can observe that pieces break off the larger lump and the tumbling movement then erodes them further.

This experiment can be used just as a demonstration or students can have their own tin/box and sugar cubes. At each stage of the journey down the river fewer and fewer students continue to shake their tin/box. Stretch out a long piece of ceiling lining paper and beginning with the students ho shook the tin for the least amount of time empty the sugar cubes on to the paper. Students will see the effects of long transportation in the differences between the size and shape of the grains.

This practical could be replaced with the much nosier practical outlined in Lesson 3 of Unit 8H, The Rock Cycle where rock fragments and pebbles are shaken vigorously in a plastic bottle. Advice from a teacher who uses the noisy version regularly – make sure a good cup of tea awaits you at break time!

Prediction
Pupils predict which of the 3 minerals, quartz, feldspar, mica, are likely to break down like the sugar cube. What do they think will happen to the minerals if they don't break down like this? Mica is light and platy and so will settle and become trapped in the slower moving water along the rivers edge. Feldspar will break into smaller pieces but if it stays in the water long enough it will go into solution (link to chemical weathering). Quartz is hard and so resists breaking down completely but becomes rounded as it is bumped along the river channel.

Students will need to know that:

- As the stream flows downhill it tumbles and erodes the pieces of rock and the minerals
- The way in which the rocks and minerals breakdown depends on their hardness, how long they are in the water, the chemistry of the water
- All the time the pieces are moving they are being eroded, worn away, and are gradually becoming rounder
- As the pieces become smaller the velocity of water needed to move them forward decreases and there will be enough energy in the moving water to lift the pieces into the water flow

Introduce the term **saltation** (the hopping movement of a piece of mineral lifted into the water column for a few moments before being dropped down to the river bed and then picked up again and so on).

- The pieces of rock and the loose minerals continue to wear away or to be changed by chemical weathering. Some minerals are now so small and fine they can be kept up in the water column all the time

Introduce the term **suspension**

- Some minerals like feldspar will be chemically weathered and eventually be incorporated into the water

Introduce the term **solution**

Homework
Create a rhyme or a hip hop or rap tune which tells the story of a quartz mineral being transported in a river. The journey begins as a piece of weathered rock falls from a granite cliff face into a mountain stream.

Lesson Four

Can the weathering process be useful?

<u>Rock products have commercial uses</u>

Two Case Studies examine the uses for weathered material, one examines the weathered granites of Devon and Cornwall and the way in which China Clay is recovered, the other the uses for sands and gravels recovered from river deposits. Students may be surprised at some of the uses for China Clay, it is for example used on paper to make a smooth finish - so that magazine they are reading has a direct connection to the China Clay industry.

Case Study One: China Clay

Pupils will need to examine samples of fresh and weathered granite; this can be obtained by contacting the quarries.

Pupils will need to know that:

- In hot and humid countries chemical weathering is the dominant type of weathering
- Chemical weathering refers to the decomposition of rocks through chemical reactions
- Chemical weathering occurs when the rock is in contact with water
- This can be soil or groundwater
- It occurs rapidly if the water is rich in dissolved carbon dioxide
- The process is known as hydrolysis and can be seen happening today in the humid climate of the S.E. United States of America

Chemical reaction

$2KAlSi_3O_8$	$+ 2(H^+ + HCO^-_3)$	$+ H_2O$	$\Rightarrow$
potassium feldspar	carbonic acid	water	

$Al_2Si_2O_5(OH)_4$	$+2K^+$	$+2HCO_3$	$+4SiO_2$
Kaolinite clay	potassium ions	bicarbonate ions	silica
(formed by weathering)	(these 3 dissolved in water)		

Orientation

Pupils study a geological map of Devon and Cornwall to discover the igneous outcrops. What can pupils say about the shape of the outcrops? Are these likely to be lava flows? If not how do they think the rock was formed?

- Students should use their homework from lesson 1 to help them consider the way in which igneous rocks are formed. If the outcrops in Devon and Cornwall were from lava flows students should expect to see linear outcrop patterns rather than the rounded shapes they see on the map, which are more representative of intrusive formations.

Case Study

- The granites of Devon and Cornwall were formed some 290 – 270 years ago. The formation runs through the South West of England from the Isles of Scilly to Dartmoor. The granites have a typical mineral mix of 30% quartz, 65% feldspars and 5% mica.

- On the moors tall granite 'pillars' can be seen, these are known as Tors. The granites that are exposed at the surface today have been heavily incised; they have been affected by chemical weathering processes. The deep weathering exhibited by the granites is the result of chemical weathering that took place in the Tertiary period (1.8.million years ago) when the climate of the landmass we know as England was very wet and warm.

- It is believed that superheated waters beneath the surface of the Earth caused chemical reactions to take place, which led to the alteration of feldspar to kaolinite.

- Kaolinite is a type of clay (silica and aluminia).

- Images of Tors available at:

http://www.richkni.co.uk/dartmoor

- **Quarrying:** The clays at St Austell have been quarried since the 1740's. William Cookworthy exploited the properties of the clay to make ceramics. The clay fires white and so was highly prized.

- Today kaolinite is used in a wide variety of products, paint, Coca-cola cans, plastic pipes, tennis balls, trainers, car hub caps, porcelain, white lines on the road and for coating the surface of high quality paper.

- 80% of kaolinite products are exported across the world.

- In the past there was little regard for the landscape and the way it was affected by the extraction of kaolinite but that is not the case today. Information on the restoration of china clay quarries can be obtained from the Dartmoor Society.

Students need to know that:

- The clays are removed from the weathered granite by high-pressure hoses.
- This works the loose material free and it is washed into a pit.
- From there it is pumped into a series of tanks and the quartz and mica are left to settle
- Once this has happened the clay is separated out and left to settle and dry.
- The process leaves large holes in the landscape and a great deal of waste.
- It is estimated that for every tonne of clay there will be 7 tonnes of waste.

Case Study cont.

- **Sustainability**: Spoil tips are being "mined" for secondary aggregates including china clay sand which is used in the manufacture of concrete. Quarries today take the issues of sustainability very seriously and are busy reducing the amount of material left as waste.

    - There is more information on primary and secondary aggregates along with the sustainable use of aggregates with the second Case Study, Sands and Gravels.

- **Biodiversity:** Disused china clay works provide a habitat for rare plants. In the old quarry at West Penwith the Western Rustwort is growing freely. This plant is only found in West Cornwall and was thought to be in serious decline.

Homework
Many species of plants and animals in the United Kingdom are in decline because of the spread of housing. Write an article for a newspaper explaining the role both working and restored quarries are playing in providing habitats for threatened species.

Case Study Two: River Sands and Gravels

Pupils will need to examine samples of sand and gravel, which can be obtained by contacting local quarries or from local quarry products associates.

Students need to know that:

- Weathered rock is transported by water in streams, rivers and estuaries

- As the rock is moved in the water it is gradually broken down into smaller pieces
- As the transportation of the material continues the pieces become rounder
- Sediments can be moved in rivers or the melt water of glaciers or by wind. These are all fluids and the velocity at which they flow determines the size of the weathered material that can be moved and how far it can be moved.
- As the energy of the fluid decreases the weathered material will be deposited, the heaviest is dropped first and then with ever decreasing velocity so progressively finer material is deposited
- Boulders, cobbles, sands and gravels are the names given to those sediments by the quarrying industry
- A cobble is a different size to a boulder, sand a different size to gravel

Students can use the Internet to discover the size range for each of the materials mentioned.

Aggregates

Aggregates is a word used to cover lots of different types of material used by the construction industry. Sands and gravels, crushed rock even solid blocks of rock used on beaches as flood defences are aggregates.

Aggregates are divided into different groups.

Natural: Natural aggregates are sub divided into primary or secondary aggregates. Primary aggregates are sands, gravels and rocks quarried directly from the ground. Secondary aggregates are formed form the waste products of the primary extraction process.
Made/Manufactured: This group includes fly ash from coal fired power stations and the slag which forms as part of the steel making process
Recycled: When a building is demolished the bricks can be crushed to use as aggregate rather than being buried in a landfill site. Any concrete removed can be crushed and used in the same way. Other material can also be recycled and used as aggregates – tyres can be chipped or glass can be made into pellets to be used in road surfaces instead of using only primary aggregates.

Everyone relies on aggregates in their daily lives, for example it takes about 50 tonnes of aggregate to build a small family home, the United Kingdom as a whole uses about 100 million tonnes of aggregate every year. The quarrying industry is looking at ways to ensure they operate in a sustainable way.

Students need to know that:

- Sustainable operation means to conserve as much as possible of the United Kingdoms aggregate stock without using primary resources from other countries or using other natural resources as primary building materials.
- We should use more secondary or recycled aggregate.
- We should ensure we use the primary aggregates in the best possible way, for example not used crushed rock if a secondary aggregate would be suitable for the task.

Students need to think about:

- The properties of the materials used as aggregates
- Are they hard wearing and durable?
- How will they weather? Students need to understand that these processes do not stop just because the rock is being used in a building.
- How chemically reactive is the material?

Students should also consider:

- The impact of the quarrying itself n the surrounding area
- Sand and gravel quarries operate for about 10 years, rock quarries in excess of 40 years
- Employment in the industry
- www.qpa.org/quarry.htm provides an interactive map of the United Kingdom; students can click on regions to discover how much aggregate is quarried in that region and how many people are employed in the aggregate industry in each region. Students could consider the impact of quarrying in their own region or produce graphs to illustrate the amount of aggregate removed or the number of people employed by region

Activity and Homework

Little Paxton Quarry: Planning for a Sustainable Future.

Sands and gravels from the river terraces along the River Great Ouse in Cambridgeshire at Little Paxton have been used by people living in the area for over 4000 years in the construction of their settlements. By the nineteenth century gravel was being extracted on a commercial scale for the construction of houses and roads. When the Second World War began gravel from this area was used in the construction of runways for the Royal Air Force. Since then the area has provided gravel fro housing, by passes and other major construction projects.

The current owners of the site have permission to extract sand and gravel until 2006, in 2003 they submitted a planning application to extend the life of the quarry by a further 13 years in order to meet aggregate needs for the area.

Teachers may find it useful to read the Technical Summary (7 pages) prepared by Cambridgeshire County Council in advance of the planning decision.
http://www.cambridgeshire.gov.uk/NR/rdonlyres/3B7ED936-1530-4D31-BDIC-866D8B43B74B/O/little_paxton_NTS1.pdf

Two publications in particular should be used by the students.

Bardon Quarries have produced a leaflet entitled little Paxton Quarry: planning for a sustainable future. This can be downloaded from
http://www.paxton-pits.org.uk/quarry/AI_leaflet.pdf

There is also a leaflet outlining the history of gravel extraction in this area with links showing community and conservation awards won by te aggregates industry over the last 5 years
http://www.paxton-pits.org.uk/quarry/

The Friends of Paxton Pits have produced their own response to the request for extended working. This can be downloaded from
http://www.paxton-pits.org.uk/quarry/extension/
There are links from this site to other useful documents and maps.

Activity

Should the extension to the quarry be granted?

- Students should be divided into 2 groups, 1 group to represent the Quarry managers and 1 group The Friends of Paxton Pits.
- Students read all of the printed material available for students.
- Each large group is now divided into smaller sub sets
- Working on a large piece of paper each set has a storming session to identify points they think are really important for the group they are representing i.e. Friends or Quarry Owners
- The small sets come back together and share their ideas
- Using a large piece of paper pinned up on the wall each group sets out agreed points in their argument

Teacher input will be needed throughout to ensure students understand the task, remain focused, are able to discuss without resorting to argument! Students need to consider the UK's need for aggregates, local employment needs (employed by the Quarry or by the tourist industry), the use of alternatives, the after use of the site.

- Students imagine they are to give a short speech at an open meeting to decide if permission should be granted to extend the quarry.
- They remain in role i.e. Friend or Quarry Owners
- Students use the ideas gathered by the whole group to help them plan the speech
- Speech written up as homework activity