'Round & round we go and up and down and around we go!'

QUARRY PRODUCTS ASSOCIATION

K.S 3: QCA Science - Unit 8H: The Rock Cycle

The Unit will encourage pupils to:

- Develop their skills of scientific enquiry
- Investigate the relationship between crystal size and method of emplacement for igneous rocks
- Relate particle size to method of transport for clastic sedimentary rocks
- Appreciate that not all carbonate rocks contain fossils
- Use modern examples to aid understanding of processes that have taken place throughout geological time

Teacher introduction and overview

This unit plan provides a number of lessons which can be used as part of the overall scheme of work for Unit 8H, The Rock Cycle. 5 hour long lesson outlines have been provided as part of a unit scheme allocated 7.5 hours. If all of the in class activities outlined are attempted however teachers will need more than 5 lessons. The lesson plans provide a range of ideas for introducing complex ideas to students through the use of visual aids and the rock samples recommended by the Quarry Products Association.

An introduction to the formation of extrusive and intrusive igneous rocks is followed by investigation of the forces at work in the processes of weathering, erosion, transportation and deposition.

The final stage of the journey from sediment to rock, burial and lithification introduces the concept of the Rock Cycle. Finally an exploration of the way in which changes in temperature and pressure can alter rock in its solid state to form metamorphic rock completes the cycle.

The basic structure is:

Lesson One

- Where do igneous rocks come from?
- The 1980 eruption of Mt St Helens will be used as the main example of extrusive volcanic processes. Lava flows on Hawaii will be used to show the variations in viscosity and therefore flow and type of eruption. Images of granites both as hand specimens and as physical features on Dartmoor will be used to illustrate intrusive processes.
- A volcanic eruption is created in a test tube.

Homework

- www.nhm.ac.uk/kids-only/fun-games/volcano/build-a-volcano.html Students use this interactive site to determine the influence of viscosity on volcanic eruptions.

Lesson Two

- How is sedimentary rock formed?
- Physical and chemical weathering

Homework: Freeze thaw weathering experiment. This takes class time to set up properly.

Lesson Three

- Erosion, transportation and deposition
- Practical examination of movement of sands and gravels in water and air

- Practical examination of the role of velocity in erosion, transportation and depositional processes
- Practical to examine the rate of erosion on a variety of rock types

Homework: Freeze thaw weathering experiment.

Lesson Four

- Lithification: turning loose sediments into rock.
- Results of freeze thaw experiments
- Mixing sands and gravels to observe deposition in action
- Practical to decide which rock types are more susceptible to weathering

Homework: use the Internet to find images of cross bedding, ripple marks, desiccation. How do these process occur, where do they occur?

Lesson Five

- ❖ Formation of carbonate rocks
- ❖ Chemical and physical weathering
- ❖ Porosity practical
- ❖ Rock guide for aliens

Homework: Use the Internet to find images of fossil footprints, well preserved fossil shells, broken fossil shells. How do these processes occur, in what sort of depositional environment would they occur?

Lesson Six

- Metamorphic rocks
- The Rock Cycle
- Limestones and marbles, mudstones and slates

- The greatest recycling act on Earth– the Rock Cycle!

Homework: A storyboard to show the rock cycle. Go to

http://www.oum.ox.ac.uk/children/rocks/cychome1.htm for ideas.

Round & Round we go!’
Unit 8H The rock cycle

Science
Year 8

About the unit

In this unit pupils:
- learn about the major rock-forming processes
- learn how rock-forming processes are linked by the rock cycle
- use the concept of rock texture as one of the key characteristics of igneous, sedimentary and metamorphic rocks
- relate processes observed in other contexts, *eg crystallisation,* to processes involved in the rock cycle
- consider processes operating on different timescales

In scientific enquiry pupils:
- model rock-forming processes
- investigate a technique for comparing the composition of limestones, evaluating different approaches
- investigate differences between igneous rocks using both first-hand and secondary data

This unit is expected to take approximately 7.5 hours.

Where the unit fits in

This unit builds on unit 8G ‘Rocks and weathering’ and work on the particle model in unit 7G ‘Particle model of solids, liquids and gases’ and in unit 8I ‘Heating and cooling’. Work on carbonates relates to work on acids and carbonates in unit 7F ‘Simple chemical reactions’. Rocks as mixtures are considered in unit 8F ‘Compounds and mixtures’. There are also connections with work on fossil fuels in unit 7I ‘Energy resources’.

This unit relates to work in unit 2 ‘The restless earth – earthquakes and volcanoes’, unit 13 ‘Limestone landscapes of England’ and unit 21 ‘Virtual volcanoes and internet earthquakes’ in the geography scheme of work.

This unit, together with unit 8G ‘Rocks and weathering’, provides the foundation for work in key stage 4 on rock formation and deformation and processes involving tectonic plates.

Expectations

At the end of this unit

in terms of scientific enquiry

most pupils will: suggest how they could investigate the carbonate content of a limestone rock; interpret data from secondary sources and their own observations of rocks and about differences between volcanoes and relate this to processes of formation; draw conclusions from their data and describe how their own conclusions are consistent with the evidence obtained

some pupils will not have made so much progress and will: describe the results of their investigation; use data from secondary sources and identify differences between different rocks

some pupils will have progressed further and will: evaluate data obtained, indicating how confident they are in their conclusions

in terms of materials and their properties

most pupils will: describe and explain how sediment becomes sedimentary rock; describe the conditions under which metamorphic rock is formed and how igneous rocks crystallise from magma; relate crystal size to rate of cooling; describe some distinctive features of igneous, sedimentary and metamorphic rocks and use these to distinguish between the rock types

some pupils will not have made so much progress and will: name the three types of rock and give some examples of each; describe some characteristics of each rock type; explain that high temperature and pressure can change existing rocks into different types of rocks

some pupils will have progressed further and will: explain in terms of the particle model how different rates of cooling lead to different crystal sizes; bring together physical and chemical processes to explain the formation of different rock types and the rock cycle; relate composition to the process of formation

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 of rocks and describe their textures
- can describe weathering processes and explain how sediment is formed
- know that solids, liquids and gases are made of particles and about the differences between the way particles are arranged in solids and liquids

Health and safety

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

- plan and carry out their own investigations into the composition of limestone and into the differences between igneous rocks

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:

- names of rock types, *eg igneous, metamorphic, sedimentary*
- names of rocks, *eg granite, pumice, shale*
- words and phrases describing properties of rocks, *eg relative density, iron rich, crystals, aligned, porous*
- names of materials and processes associated with volcanic processes, *eg magma, lava, volcanic ash, erupt*

Through the activities pupils could:

- describe and evaluate how work was undertaken and what led to the conclusions

Resources

Resources include:

- a collection of rocks, either one available commercially or one compiled by the department, *eg conglomerates, 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
- data showing relative density and composition of igneous rocks, *eg basalt, pumice, obsidian*
- data showing where volcanoes of different kinds are found
- cards/labels showing processes and examples of products of the rock cycle

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, including feature films, about the Earth, which help them understand how rocks are formed
- visit science museums to see displays about the Earth and its rocks and simulations, which will help them to imagine the effects of earthquakes and the forces involved
- visit other museums and art galleries, garden centres and builders' yards, 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
How is sedimentary rock formed?			
• that sedimentary rock can be formed by pressure from layers of sediment resulting in the compaction and cementation of grains • about some characteristics of sedimentary rocks	• Review what pupils know about different rocks, weathering and sedimentation by asking them a series of questions related to photographs and specimens. Establish key points, *eg the physical and chemical causes of weathering, that rocks consist of grains which fit together, and that over time layers of sediment accumulate*. • Introduce the idea of compacting grains by showing pupils the effect of squashing wet sand and asking them to observe the loss of water; show them pictures of deep layers of sedimentary rock and ask them to think about the pressure at the bottom of a cliff. Ask pupils to look at some damp sand and some sandstone with a hand lens, or under the microscope, and look for clues about what is holding the grains together. Remind pupils that rocks are mixtures and establish that the 'glue' comes from minerals in the sediment that have dissolved and been left as the water evaporated. Show pupils samples of other sedimentary rocks, *eg chalk, limestone, shale,* and identify some common characteristics.	• name some sedimentary rocks, *eg sandstone, chalk* • describe characteristics of sedimentary rocks, *eg non-interlocking textures, porous, contain fossils* • explain that the pressure exerted by deep strata will be very great • explain that sedimentary rock is formed as the grains are compacted and glued together	• If this half unit is taught directly after unit 8G 'Rocks and weathering', a similar activity will just have been carried out. • Pupils will not need to recall the details of compaction and cementation but will need to be aware that it occurs. • Extension: pupils could investigate compaction and cementation by making pellets of sand mixed with water, clay and plaster of Paris in a syringe with the end cut off, and compare the results.

Are all limestones different?

• to use preliminary work to find out whether a possible approach is practicable • to describe and evaluate how the work was undertaken and what led to the conclusions • that rocks are mixtures of varying composition • that the composition of a limestone is related to the process of formation	• Show pupils some examples of different limestone, *eg brown limestone*; ask them to describe some differences between them, *eg appearance, porosity*. Explain that they are going to find a way of investigating differences in composition. • Establish that limestones are carbonate-rich rocks, but may contain other components. Remind pupils of how carbonates react with acids and help them to plan a way of comparing the carbonate content of two samples, *eg by weighing samples before and after reacting with acid, measuring the volume of acid required to completely react with the carbonate*. Ask pupils to think about what they are planning to do and perhaps try out some ideas. Ask groups of pupils to explain and evaluate their methods and what they found out, *eg using a flip chart or overhead projector (OHP)*. Where appropriate, extend the work by providing pupils with data about the carbonate content of different limestones and information about how they were formed, e*g accumulation of fossil fragments, by chemical precipitation,* and why, *eg mud-free lagoon, reef*. Ask pupils to use the data to make generalisations about composition and formation.	• describe some observable differences between limestones • suggest an approach to the problem and try it out, identifying difficulties, *eg you have to dry the limestone before you weigh it again, it's better if you crush it up so that the acid reaches all of it* • describe and evaluate their approaches indicating problems they encounter • generalise that rocks are mixtures and vary in composition • relate the composition of limestone to the process of formation	• Pupils will have explored the effect of acids on carbonates in unit 7F 'Simple chemical reactions'. This will be revisited in unit 9E 'Reactions of metals and metal compounds' and in unit 9G 'Environmental chemistry'. • In unit 7I 'Energy resources' pupils will have had opportunities to use a balance. In unit 8F 'Compounds and mixtures' pupils will have considered differences between pure compounds and mixtures. • All limestones contain carbonates and are at least 50% calcium carbonate. **Safety** – eye protection will be needed when acids are used. Teachers will need to check pupils' plans for health and safety before practical work starts. Use acids in concentrations that present as low a hazard as possible, *eg hydrochloric acid is low hazard below 2 mol* dm^{-3}, *sulphuric acid below 0.5 mol* dm^{-3}, *nitric acid below 0.1 mol* dm^{-3}

What is different about metamorphic rocks?

• that increasing temperature and pressure can cause some rocks to change in the solid state • that metamorphic rocks are formed from pre-existing rocks during metamorphism, as a result of high pressure and/or high temperature	• Explain, with illustrations, theories about the formation of metamorphic rocks, and ask pupils to examine samples of metamorphic rock and compare them with the sedimentary rocks from which they were formed, *eg limestone and chalk with marble, sandstone with quartzite, shale with slate*. Using slides or photographs, show pupils illustrations of the alignment of grains, *eg in slate*. Ask pupils to choose one pair of sedimentary and metamorphic rocks, describe the differences between them and explain how the metamorphic rock was formed.	• name some metamorphic rocks • describe how metamorphic rocks differ from sedimentary rocks, *eg the crystals may be aligned, they may be less porous, fossils may or may not be distorted, no grains may be visible, the rock may be harder* • describe the processes by which a particular metamorphic rock is formed	• Pupils may not be aware that metamorphism means 'changing form'. • It may be helpful for some pupils if the processes and types of rock are presented on a series of cards or using ICT and pupils are asked to arrange them. • Metamorphic rocks can be formed from igneous, sedimentary or metamorphic rock, but the changes from sedimentary to metamorphic are most easily seen. Sedimentary rocks that contain 'platey' minerals, *eg shale*, may change to show alignment of crystals, as in slate. Other metamorphic rocks, *eg marble and quartzite,* leave a 'sugary' texture because the minerals from which they were formed resist pressure equally in all directions.

LEARNING OBJECTIVES PUPILS SHOULD LEARN	POSSIBLE TEACHING ACTIVITIES	LEARNING OUTCOMES PUPILS	POINTS TO NOTE
Where do igneous rocks come from?			
• that igneous rocks crystallise from magma • that the rate of cooling and crystallisation determines the grain size in an igneous rock • to explain observations in terms of the particle model • to draw conclusions from observations of rock samples	• Show pupils a video clip of a volcanic eruption, asking them to observe that magma can flow out as lava or be blasted out as ash, and compare the resulting rocks. Ask them to suggest the origin of the magma. Remind pupils that they have considered two kinds of rock, sedimentary and metamorphic. Explain that there is a third type, igneous rock. • Ask pupils to find out how they can make larger or smaller crystals from melted salol to illustrate the behaviour of cooling magma. Establish the link between cooling rates and size of crystals produced. • Model the effects of cooling rates on crystal size, with pupils representing atoms free to move around in an open space, as in a melt. On cooling, indicated by a signal, pupils stick together to begin forming crystals. The longer this goes on, the larger and fewer the crystals will become. Ask pupils to relate differences in crystal size (number of pupils bonded) and number of crystals (number of groups of pupils) to cooling time and to explain in terms of the particle model of matter. • Provide pupils with a variety of rock samples and ask them to classify them into types of rock, *eg igneous and non-igneous,* and then to subdivide them into rapid- and slow-cooling types, and/or suggesting where they were formed, *eg* – *obsidian (glasslike, very fast cooling on surface)* – *pumice (gas bubbles, fast cooling on surface)* – *basalt (small crystals, moderate cooling near surface)* – *gabbro/granite (large crystals, slow cooling in the Earth)*	• name some igneous rocks • describe how hot liquid magma can flow out of volcanoes as lava and solidify or be blown out as ash which settles • describe how some rocks are formed when magma solidifies and these are called igneous rocks • relate speed of cooling to crystal size and explain this in terms of the particle model • relate the size of grain to where the crystal was formed, *eg it has small crystals, so it cooled fast and was probably formed near the Earth's surface*	• The relationship between the three types of rock will be dealt with at the end of this unit. • Pupils could access website references for currently active volcanoes, *eg www.geo.mtu.edu/volcanoes/world.html or www.volcano.und.nodak.edu* • Particle explanations of changes of state are covered in unit 8I 'Heating and cooling'. • Extension: pupils could simulate the cooling of magmas in the Earth's crust and on the surface by datalogging the cooling curves of a beaker of boiling water surrounded by sand and a tray of boiling water. Ask pupils to explain the differences in the cooling curves and relate them to differences between different samples of rock and where these were found. **Safety** – salol is low hazard, but eye protection should be worn

Where do igneous rocks come from? (Cont.)			
• to use first-hand and secondary sources of data to investigate differences between igneous rocks	• Present samples of granite and gabbro to pupils and ask them to suggest evidence for their origin as igneous rocks. • Show pupils how to find the relative densities of the two rock samples using displacement and ask pupils what could cause the difference in their densities. Ask pupils to investigate the relative densities of other igneous rocks, *eg obsidian, basalt*, and to use what they know about the difference in relative density to decide whether they are more like granite or gabbro. • Where appropriate, present pupils with data about the relative density, mineral composition and chemical composition of gabbro and granite and help them to use the data to show that granite rocks are relatively silica rich and gabbroic rocks are relatively iron rich.	• use data to assign igneous rocks to one of two main groups, dense iron-rich or less dense silica-rich • show how relative density relates to composition of igneous rocks • evaluate how well their data supports their conclusions	• Data about location and type of volcano can be found on the internet at, *eg www.geo.mtu.edu/volcanoes /world.html or www.volcano.und.nodak.edu* • Extension: pupils could be asked to find out about specific volcanic eruptions and their effects on the local population and environment. Teachers will be aware that sensitivity is needed where pupils have relatives or friends living in volcanic areas. • Extension: pupils could be asked to use secondary sources to locate where volcanoes with silica-rich rocks (continents) and volcanoes with iron-rich rocks (oceans) are found. They could then identify the location of explosive volcanoes (with violent and generally unpredictable eruptions producing ash and pumice, not lava), *eg Montserrat* and moderate volcanoes (with streaming lava flows and frequent eruptions producing basalt lavas, sometimes with gas bubbles), *eg Hawaii*. Discuss how strongly the evidence supports the link between the chemical composition of magma and the types of volcanic activity.

What is the rock cycle?			
• that the rock cycle links together the processes of rock formation • how the rock cycle provides a continuous supply and transformation of Earth materials	• Review pupils' knowledge of the three kinds of rock through asking questions about processes and asking pupils to match descriptions with rock types. Remind them of how sedimentary rocks are formed and how these can be changed into metamorphic rock. Pose a question about where igneous rock comes from and describe the process whereby existing rocks melt under high pressure and at high temperature to form magma. • Lay out labels of the products of the rock cycle, *eg sediments, metamorphic rocks, magma, rocks at the Earth's surface,* and ask pupils to place labels for processes, *eg deposition, metamorphism, melting,* and examples of the products, *eg sand, limestone, slate, a photograph of a volcano, a photograph of a mountain*, in the right places.	• describe the evidence for rocks melting • identify and link the rock-forming processes	• As an alternative, pupils could be presented with an outline flow diagram of the rock cycle, together with phrases describing processes and rock types, to insert at appropriate places on the diagram. Ask pupils to work in groups to fit the phrases in the correct places in the diagram. Discuss with pupils, asking questions to test their understanding.
Reviewing work			
• to relate key ideas about geological changes to each other	• Ask pupils to produce and present, on overhead transparencies (OHTs), an interpretation of the rock cycle, *eg through a cartoon, story of the life of a rock (or two or three).*	• describe the continuous process of the rock cycle	• As an alternative, pupils could be asked to indicate on a diagram, or other illustration of the rock cycle, which of the processes are biological, *eg soil production, formation of fossils*, which may be chemical, *eg weathering*, and which may be physical, *eg transportation, metamorphism, melting*.

Lesson One

Where do igneous rocks come from?

The word igneous comes from the Latin ignis, which means fire. The term igneous describes rock formed from magma, melted rock that forms in the mantle and to a much lesser degree within the crust itself. There are two categories of igneous rock, intrusive rock formed within the Earth's crust and extrusive rock formed at the surface of the Earth. People have always associated volcanic eruptions with fire and brimstone, death and destruction. This is still true when volcanoes erupt violently and without warning but igneous rock, which has formed within the Earth, provides us with a hard, resistant rock, which is used by all sectors of the construction industry.

Students should know that:

- The Earth is made up of different layers; the crust is the thin, cold and brittle solid layer that we live on. This sits on the mantle; the core of the Earth is divided in to two sections, the outer and the inner core. The outer core is liquid, the inner core solid.

Students will be introduced to the formation of intrusive and extrusive igneous rocks through a series of images downloaded from the Internet for use on an Interactive Whiteboard or for use as a Powerpoint display.

Extrusive igneous rocks

The 1980 eruption of Mt St Helens will be used as the main example of extrusive volcanic processes. Lava flows on Hawaii will be used to show the variations in viscosity and therefore flow and type of eruption. Images of granites both as hand specimens and as physical features on Dartmoor will be used to illustrate intrusive processes.

Go to
http://vulcan.wr.usgs.gov/volcanoes/MSH/Images/MSH80/framework.html

Select an image from the section: Prior to the 1980 eruption.

Then select the following 7 images from the section showing the impact of the eruption. There are brief notes alongside each thumbnail image.

- Devastation
- Debris avalanche helicopter
- Blast area spirit lake
- Debris avalanche looking downstream
- Volcanic ash with helicopter
- Reid Blackburn car
- Blowdown Smith creek

The 7 images show the eruption and consequence damage to the surrounding area, the image of the helicopter flying into the ash fall gives students some idea of the scale of the eruption and the image of the car virtually buried by ash continues this theme.

Teacher input

The origins of Mt St Helens can be found 100 to 330 kilometres below the Earth's surface. Here in the Earth's mantle it is so hot rock melts and a thick flowing magma is formed. Magma is more buoyant than the rock surrounding it and it begins to rise towards the Earth's surface. Some of the magma will fill in the spaces between the rock in the Earth's crust to form large reservoirs of magma. These are known as magma chambers. Gradually the rising magma will reach the Earth's surface. The magma contains gases which until no have been held under pressure in the magma but now as the pressure from above is decreasing the gases begin to expand. The expanding gases push the magma upwards and it erupts through openings in the Earth's surface - this is a volcanic eruption. Once the magma has erupted onto the Earth's surface it is called lava. How explosive an eruption is depends on the viscosity of the magma. If it is thin and runny the gases escape easily, if thick like treacle the gases are trapped in the magma until the pressure of the expanding gas becomes so great that there is a violent explosion. This explosion throws ash and lava high up into the air. The eruption of Mt St Helens in 1980 was just such a violent explosion.

If the magna reaching the surface is thin and runny then a different type of volcanic eruption will take place.

Go to
http://vulcan.wr.usgs.gov/Imgs/Jpg/Hawaii/puu_oo_lava_flow.jpg

and

http://vulcan.wr.usgs.gov/Imgs.Jpg/Hawaii/puu_oo_lava_flows2.jpg

for images of slow gentle eruptions and pahoehoe flows. Pahoehoe lava flows smoothly looking like coiled rope, the Hawaiian word pahoehoe means rope like.

Go to

http://seis.natsci.csulb.edu/basicgeo/EXTRUSIVE/volcanic_pahoehoe.jpg
for an image of pahoehoe lava

Go to

Go to

http://seis.natsci.asulb.edu/basicgeo/EXTRUSIVE/volcanic_a-a.jpg

for an image of another lava flow on Hawaii. This lava is called aa. aa lava is formed from a more viscous lava flow, as it cools it forms a rough, sharp and jagged surface. Maybe the name aa reflects what people walking over the lava flow cried out!

http://hvo.wr.usgs.gov/cam/

for a live panorama of Pu'uOo vent , Kilauea Volcano, Hawaii.

The image is updated every 5 minutes and shows pahoehoe flows in front of January vent with small amount of lava to the front of the image.

Scientists have measured the temperatures of the lava erupting from Kilauea and Mt St Helens to see whether heat has any bearing on the type of eruption.

The lava escaping from Mt St Helens in 1980 had a recorded temperature of between 750 degrees C and 850 degrees C. The lava erupting today on Kilauea has a recorded temperature of 1, 160 degrees centigrade.

- Do students think temperature can be related to type of flow and if so why.

Explosive eruptions cause death and destruction as they happen very rapidly and the ash and lava travel as a rolling, billowing cloud away from the vent. It is not only people in the immediate area who suffer. In April 1815 Tambora Volcano in Indonesia erupted. This is the most powerful explosion recorded since records began. So much ash was thrown high into the atmosphere that it soon circled the Earth. The dust pollution blocked much of the Sun's energy from reaching the Earth; we know this as in Europe records show 1816 as "the year without summer". There is evidence of crop failure and famine.

Another famous explosive volcanic event that students will have heard of is the eruption of Vesuvius in AD79, ash and red-hot lava droplets burying the town of Pompeii.

Not all magma that forms reaches the surface to create extrusive igneous rock. Some magma will remain in the earth's crust where it will slowly cool and crystallise. The igneous rocks that form bodies within the crust are known as intrusive igneous rocks.

Go to

http://geologyonline.museum.state.il.us/geogallery/record_basic.php?table=rocks&catalog_number=304990

This is an image of granite, and intrusive igneous rock. Use the zoom to look at the minerals in the rock. The minerals are pink feldspars, glassy quartz and silvery mica.

Got to

http://geologyonline.museum.state.il.us/geogallery/media/images/large/304990.jpg

for an expanded image of the rock.

- Ask students to comment on the size of the crystals. Why do they think the crystals are large?

- Magma contains the building blocks for minerals, which begin to grow out of the hot fluid when the temperature is right. The temperature at which a particular mineral crystal will begin to grow is called its freezing point. Use the analogue of water turning into ice as the temperature drops to illustrate how a liquid becomes solid. When magma erupts at the Earth's surface cooling will be rapid, heat is lost to the air or to water and to the rock over which the lava is flowing. That means the mineral crystals will grow rapidly and will be small. Most mineral crystals in extrusive igneous rock are too small to be seen by the naked eye. This is not the case when magma cools in the Earth; heat loss is slow and so mineral crystals have time to grow large. Intrusive igneous rocks have crystals large enough to be identified by eye.

Go to

http://geologyonline.museum.state.il.us/geogallery/media/images/large/304244.jpg

This is muscovite mica, the mineral that looked silvery in the image of the hand specimen. It is a platy mineral, which is easily split into thin layers.

Go to

http://geologyonline.museum.state.il.us/geogallery/record_basic.php?table=minerals&catalog_number=304244

for the opportunity to zoom in and look closely at the mineral. Mica will be used to help explain the breakdown of minerals during transport so it is worth spending a few minutes now helping students to appreciate the properties of the mineral.

Another of the common minerals in igneous rocks, quartz, can be viewed by going to

http://geologyonline.museum.state.il.us/geogallery/media/images/large/306783.jpg

Granites often form extremely large formations; much of Devon and Cornwall for example is granite. The rock, which formed in the Earth has been forced up to the surface, by looking at these rock structures geologists are able to learn about the igneous processes taking place in the Earth.

Go to

http://www.richkni.co.uk/dartmoor/pix/mister/mister.jpg

Excellent image of Great Mis Tor (grid reference SX563770)

http://www.nchi.co.uk/dartmoor/pix/ugbo/DCP_5850.JPG

Image of Hangershell Rock (grid reference SX655594)

- These images will be used again in the lesson plan for weathering processes.

Not all intrusive emplacements are so large, sometimes the magma cuts through existing rock to form small intrusions.

This is an image of a dyke

http://seis.natsci.csulb.edu/basicgeo/GABBRO/labelled_mafic_dike.jpg

be ready for the howls of laughter over the hat!

Not all intrusive rocks look the same colour, each magma is different and so the minerals that grow from it will be different. We have looked at images of granites containing pink minerals but here is an image of Cornish granite. The size of the crystals tells us the rock is intrusive and the colour of the rock tells us it is granite but there are no pink crystals to be seen. The “ingredients” needed to make the mineral pink feldspar weren’t available.

Go to

http://seis.natsci.csulb.edu/basicgeo/INTRUSIVE/Granite_handspec_phanerit.jpg

The chemical composition of magma, the minerals that make up the rock also influence the texture of the rock. Rock which is high in silica minerals i.e. quartz (65% +) are light coloured. These are the granites that form the bulk of intrusive igneous rocks. Those that are low in silica (45/55%) are dark coloured, basalt the rock which forms on the ocean floor is an example of this.

- Ask students where they think they have seen examples of igneous rocks low in silica in the images viewed. The Hawaiian lavas were dark in colour. What properties did these lavas have? They flowed easily – so what deductions can students draw about the relationship between silica % and viscosity?

Complete the slide show by reloading a few images which enable you to recap, ask questions, and reinforce students understanding of the processes involved in the formation of intrusive and extrusive igneous rock.

The images can also be printed to use as handouts or as a display.

- Session could end in a messy way if students create their own volcanic eruption.

- In a test tube place half a teaspoonful of bicarbonate of soda
- In a separate container add 2 drops of red or orange food colouring to 3 teaspoonfuls of malt vinegar
- Quickly tip the vinegar mixture onto the bicarbonate of soda and stand back!

- The eruption should be fairly slow as this sort of mixture produces a thick viscous "magma" similar to that erupted from Mt St Helen's. The Earth Science Teachers Association will provide you will details for a much more explosive experiment should you wish!

The chemical reaction that takes place between the vinegar and the bicarbonate creates carbon dioxide a gas present in many volcanic eruptions.

Homework

Visit the web site

www.nhm.ac.uk/kids-only/fun-games/volcano/build-a-volcano.html

This is an animated site. Wait until the site has fully loaded before you start. Create as many volcanoes as you can using the choices available. Draw a series of diagrams to show how each volcano is formed. What difference does the amount of water in the magma make to the type of eruption? Why do you think this is?

- Students should be able to mix and match to create a Strato, Cinder Cone, Plug Dome and Shield volcano.   It is important they wait till the site is fully loaded or the animation sequence showing the build up of the volcano will be missed.

Lesson Two

<u>How is sedimentary rock formed?</u>

<u>Weathering</u>

Students should know that:

- Igneous rocks have formed from molten rock.
- Igneous rocks are intrusive, formed in the Earth, or extrusive, formed on the Earth's surface.
- They can use crystal size as a tool to aid identification of igneous rock type.

Hands on activity to recap on Lesson 1

Students are given a number of igneous rock samples to look at - can they identify the extrusive and the intrusive rocks.

Weathering

The intrusive igneous rock granite is used as an example to explain physical weathering processes.

Students need to know that:

- The process by which rocks and minerals begin to break down at the Earth's surface is called **weathering**
- Weathering is a process that takes place when the rock is *in situ* (literally means in place).
- Granite often forms hills and mountains and so is found at high altitudes
- At high altitudes the day and night temperatures are cold, in winter the temperature is often below freezing
- When water freezes it expands by 9%
- If the water is in a joint or a crack in the rock as it freezes and expands it puts pressure on the rock
- This can cause hairline fractures to appear in the rock
- When the temperature rises above zero the ice melts and the water trickles into the newly formed cracks
- Next time the temperature drops below freezing the water in the new cracks will also freeze and expand causing new hairline fractures to appear
- Gradually the rock is broken apart
- This process is known as freeze thaw weathering
- It is a physical process.

Ensure students recognise the need for the temperature to fluctuate around zero in order for water to freeze and thaw. They should recognise that this process operates only very, very slowly indeed in Polar regions where there is limited thaw.

Students need to know that:
Weathering can also take place because of chemical changes.

Students need to know that:

- Rain water commonly has a pH of 5.6
- This means it is acidic
- Acid rain reacts with some minerals, particularly feldspar found in igneous rocks
- Chemical weathering operates more quickly in warm climates

Physical and chemical weathering can both operate on the same rock outcrop at the same time. If temperatures are low freeze thaw weathering will be the dominant force but when the thaw occurs the acidic water will cause some chemical weathering. In hot and humid regions chemical weathering will be the dominant force but some physical weathering will take place, perhaps as a result of trees growing on the decaying rock their roots forcing the rock to shatter.

- As well as temperature and rainfall the surface area that can be attacked is also important in determining the rate at which the weathering processes take place.

- o What do students think will happen if the freeze and thaw process continues over time?

- ❖ The surface area will increase allowing an ever-increasing area to be attacked by both the physical (freeze thaw process) and the chemical (reactions between minerals and acidic water) weathering processes to take place. It is important students realise that this is process that takes time but eventually these processes can break down mountains.

Set up the Task for Homework

How does freeze thaw weathering affect different rock types.

An experiment to conduct at home over 7 days.

Each student is provided with a ziplock plastic bag and an indelible marker. They will also be provided with a few pieces of **one** of the following rock types:

Granite
Basalt
Sandstone
Chalk
Limestone

Students draw around each of their pieces of rock. They will use this information to compare the size of their rock pieces each day for the following week. They look carefully at the rock and predict whether they think it will break up easily if subjected to the freeze thaw weathering pattern they have just learnt about. Students predict how easily they think their rock pieces will break up. They will learn something about each of the rock types in the coming lessons so for the moment all they need to do is look and feel the samples they have. Does the rock feel soft, if two pieces of rock are rubbed together do loose pieces fall off easily, does the rock feel soft? Write the names of the rock type on the bag. Place the small pieces of rock inside the bag and **at home** add enough water to cover the rock pieces.

The bags will need to be frozen to simulate the freeze part of the process.
Take the bag out of the freezer each day and allow it to thaw on a plate. Take out the pieces of rock and draw the shape of your pieces, are there more pieces each day? Return the pieces to the bag, add the water and refreeze each day for 7 days.

- Students will compare their results in lesson time and consider why certain rocks broke up more easily than others.

Lesson Three

<u>Erosion, Transportation and Deposition. Let's make a clastic sedimentary rock!</u>

Students need to know that:

- The term **erosion** refers to the continued wearing away of rock material away from its place of origin.

- The pieces of granite that have broken off the rock face during the weathering process will be moved away from the original site.
- The process of movement is known as **transportation.**

- Pieces of rock and loose minerals can be moved by water, wind or ice.
- In the United Kingdom the most common fluid involved in the movement of weathered rock materials is water; in deserts the main mode of transport will be wind.

Task

Using sands and gravel obtained form your local quarry or builders merchant it is possible to observe the effects of transportation and erosion.

Students devise an experiment to determine the largest size of particle that can be moved by wind.

Provide students with:

A handful of sand
A handful of gravel
A tray
A grain size card – or ruler – to measure the grains accurately
A stop watch
Drinking straws

Students record their results and then answer the following question:

1. What is the biggest particle size that could be found in a sand dune

Movement by water.

- It is the velocity of the water in a river channel that determines how much sediment and what size of sediment can be moved.
- When the river carrying the sediments begins to meander across low lying land or enters an estuary the velocity of the water will decrease. At this point the water will be unable to move sediments of a certain size ad these will be **deposited** (dropped) and left behind.
- This process continues as the velocity continues to fall and finer and finer material will gradually be deposited.

- Ask students if they have seen an estuary or even the muddy water at the edge of a river, the velocity here is very slow and so even very low-density material will be deposited.

An experiment to determine the role of energy in the processes of erosion, transportation and deposition.

A small child's garden slide makes an ideal surface on which to mix sands and gravels and water. Elevate one end of the slide and ensure the other end is over a receptacle, bucket, bowl or sink depending on the amount of water to be used. Place a mixture of sand and gravel at the top of the slide and pour water onto it. Pour the water slowly in the first instance.

Record what happens as the water flows over the sands and gravels. Where are the areas of erosion, transportation and deposition.

Increase the speed of flow.

Record what happens, what differences are there between the observations made now and the first practical session? Can the students make links between the energy levels of the water flow and the processes taking place? What differences are there in areas of sand, gravel or mixed sand and gravel? Why is it important for people to understand these processes? One of the suggested impacts of continuing climate change is an increase in floods, modelling water flow in river channels will help planners to identify areas at risk from erosion.

Ensure students recognise that:

- **It is the velocity of the transporting fluid that keeps the sediment moving.**

Ask students to consider what is happening to the pieces of rock being moved by the water.

Task

Wearing away rocks by erosion

Rock Smashers! This practical experiment was published in the early 1990's by the Earth Science Teachers Association but seems to have been adopted by everyone from the Smithsonian to Australian Science Teachers groups. It is great but very noisy!

Provide students with a small plastic bottle with a wide neck and a screw top lid. Provide a few pieces of some of the following

Granite
Basalt
Sandstone
Chalk
Limestone

Students look at their pieces of rock, and as in the previous lesson predict which will be broken down most easily this time if tumbled in a fast flowing river.

Put the pieces of rock in the bottle, screw on the lid tightly and shake the bottle hard for 1 minute.

Empty out the rock pieces onto a piece of clean paper, look for changes.

Us the paper to make a funnel to aid return of the pieces to the bottle, put the lid back on firmly and shake hard again for another minute. Repeat for up to 5 minutes. Check to see if the students' predictions were correct.

Homework

Students continue to monitor their freeze thaw experiment, results needed for the next lesson.

Lesson Four

Turning sediments into rock.

Students know that:

- Chemical weathering and breakdown during transportation takes place in tandem with the physical processes of weathering and erosion

Students provide the results of their freeze thaw experiment.

- Which pieces of rock broke down the most?
- Why do students think that was?
- Did their results match their predictions?

Students need to be clear about:

- The processes of weathering, erosion and transportation.
- Students should appreciate the links between the movement of different particle sizes and the velocity of the transporting medium.
- Rocks exposed at the Earth's surface will weather; the broken pieces of rock (clasts) are then transported and deposited.
- The clasts form a sediment; this is a loose unconsolidated material.

  ❖ Your local builders merchant may supply you with small quantities of sands and gravels so students can see a range of different sized sediment.

Task

Sediments will gradually accumulate in areas of low velocity, whether they are being moved by water, wind or ice. The sediments will build up over time and form horizontal layers.

Different coloured sands can be used to build up layers in a clear carbonated drinks bottle or glass measuring beaker to illustrate this process. If the plastic container is used a handful of sands and gravels can be added along with the water and then, with the lid on, the mixture shaken for a minute to mix it. Watch as the different sediments are deposited, what is happening? Large particles settle more quickly, any clay in the mix has turned the water reddy brown: any odd pieces of organic material are floating on the surface.
Alternatively the process can be explained on the board as follows.

Working together in class answer the following questions so a series of diagrams can be created on the board to show how sediments are turned into rock.

1. How are sediments moved away from their point of origin?
2. What is meant by deposition? What changes must occur before deposition can take place. Where might it take place?
3. The sediments are laid down horizontally. Why?

All students will need the following information

4. The sediments build up over time, they can build up to 1 km thick. What will happen to the sediments at the bottom of the pile as more and more weight is placed on top of them?
5. At the bottom of the pile things are hotting up, the water still trapped in the sediments is being heated. What might happen to the minerals this heated water comes into contact with?

Answers

1. Sediments are moved by water, ice or wind away from their place of origin. The velocity of the medium in which they are travelling will determine how far they move from that source before they are deposited.
2. Deposition can take place in rivers, lakes, on beaches or in shallow near shore environments. The velocity of the transporting fluid must drop in order for sediments to be deposited.
3. The sediments will build up in layers over time in the order in which they were deposited i.e. one layer on top of another. This is the burial stage.

4. As sediments build up those at the bottom of the pile are compressed and compacted. Some of the spaces between the grains will be eliminated, those remaining are known as pore spaces. Some of the water trapped in the sediments will be expelled.

5. At a depth of about 1 km any water left in the sediments will have become hot. The hot fluid dissolves some of the minerals in the sediments. The fluid flows into the pore spaces. Eventually the fluid becomes supersaturated, it is unable to hold any more of the dissolving minerals and so expels some of the dissolved mineral it is already holding. The mineral precipitates on the clasts and acts as cement binding the clasts together.

6. The loose sediments at the bottom of the pile have now become rock, this final stage of the process is known as lithification. This type of rock is described as a clastic sedimentary rock, sandstones and mudstones are both clastic sedimentary rocks.

Task

For this session you will need a range of clastic sedimentary rocks, rocks formed from the weathered remains of other rocks.

<u>Task:</u>

Work with a partner to investigate the <u>properties</u> of each rock sample. Geologists always talk to each other about what they have found and share their ideas; you should do this as well.

Prediction

Poorly cemented clastic sedimentary rocks will weather quickly

To test the prediction:

Place a piece of white paper or card on the table in front of you. Take one of your sedimentary hand samples and rub it very hard for about 20/30 seconds with a piece of wood whilst holding it over the paper. Count the grains that have fallen onto the paper and record this number next to a description of the rock sample on a recording sheet. Do the same with another two samples. It is important that you rub each piece of rock equally hard and for the same length of time otherwise you will not have a 'fair test'.

Which piece of rock do you think will weather quickly? Why? Do you think these rocks will weather more quickly that the igneous rocks you have learnt about? Why?

- Student feedback should enable a table to be drawn up on the board/OHP to show the most easily weathered rock through to the most resistant rock. They should be able to identify the importance of strong cement in providing some resistance to weathering.

- When attempting to determine if clastic sedimentary rocks will weather more quickly than igneous rocks students may need reminding that igneous rocks are formed from crystals, which are interlocking. This is a much stronger structured than cemented grains regardless of the strength of the cement.

- What do students think happens to the weathered particles from their sedimentary rocks? Introduce the idea of recycling, nature is constantly recycling materials, in this instance weathered particles will be eroded, transported and deposited and the process of making a new clastic sedimentary rock will begin.

- Why is it important for us to understand the way in which rocks weather? Links to building stones, materials used for bridges, houses, stone walls etc.

Homework

Use the internet to find out about the following structures which are found in sedimentary rocks. Use drawings to show how the structures were formed. What do the structures tell us about the way in which the sediments were laid down? What can the structures tell us about where the sediments were laid down?

- Cross bedding
- Ripple marks
- Dessication cracks

Lesson Five

Limestones and chalks.

Students need to know that:

- Limestone is a sedimentary rock
- That means it is made up of different grains cemented together
- The grains are made mainly of calcium carbonate in the form of the mineral calcite
- The mineral calcite reacts with dilute carbonic acid (acid rain) and releases carbon dioxide to the atmosphere

- Chalk is a sedimentary rock
- The grains are made mainly of calcium carbonate in the form of calcite
- The mineral calcite reacts with dilute carbonic acid (acid rain) and releases carbon dioxide to the atmosphere

Students should understand that:

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

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

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

CO_2 (g) + H_2O (l) $\leftrightarrow$ H_2O CO_3 (aq) (carbonic acid)

- Once dissolved into sea water carbon dioxide is converted into bicarbonate ions or carbonate ions.

- Certain forms of sea life biologically fix bicarbonate with calcium to produce calcium carbonate ($CaCO_3$)

Demonstration

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

Students could be introduced to the idea that:

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

- Lime mud, which builds up on the ocean floor forms the cement holding the shells together; gradually the lime mud hardens and becomes rock. The rock becomes part of the rock cycle.

- Many limestones contain fossil remains
- Chalk is also made of fossil remains but the creatures, called coccoliths, are too small to be seen without the help of a microscope.

Practical

This practical session asks students to become a rock detective. Which rock is the carbonate rock?

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

Weathering

Physical weathering processes can break down carbonate rocks, in many limestone areas screes can be seen. These angular pieces of rock have been broken off the rock face by freeze thaw weathering processes but this is not the dominant type of weathering.

Limestone and other carbonate rocks are susceptible to chemical weathering regardless of where they are found. Rainwater is slightly acidic and so whenever it is raining carbonate rocks are under attack. The chemical reaction that takes pace between the rock and the rainwater means that the rock is literally carried away in solution.

Task

Carbonate rocks are more porous than clastic sedimentary rocks

When a rock is porous there are spaces between the grains, which let water seep into the rock. Why do you think it is important to know about porosity?

- ❖ Increases the effects of physical and chemical weathering processes.

This practical session will identify which rocks are more likely to weather rapidly because of porosity.

Set out a selection of rocks, enough to ensure that each pair of students has a rock to work on. Give each rock a number so students can record their results. Give each pair of students a water dripper bottle and a stopwatch. Ask the students to devise a fair test to determine porosity.

- ❖ Same number of drops of water used on each sample. Same amount of time waited before recording results.

Students record what they see. Which rocks were most porous – were they surprised by the results? How does this experiment help students to explain what happened in the freeze thaw experiment? What use could be made of this information?

- ❖ Properties of building stone, granite more weather resistant than chalk
- ❖ Link to depositional environments, in areas of carbonate rock there is limited amount of physical rock debris being moved by water or air

As a whole class activity ask the students to give you three main points about each of the rock types they have met in the lessons so far. Imagine they had to describe our planet to an alien whose own planet didn't have any igneous or sedimentary rocks. What would the alien need to know to be able to distinguish between the rock types? Distribute hand specimens from the Quarry Products Association rock box to aid students recall.

Homework

Use the Internet to find out about the following structures, which are found in sedimentary rocks. Use drawings to show how the structures were formed.
What do the structures tell us about the way in which the sediments were laid down? What can the structures tell us about where the sediments were laid down?

- Fossil footprints
- Well preserved fossil shells
- Broken fossil shells

Lesson Six

Metamorphic Rocks and The Rock Cycle

Students should already know about:

- The formation of igneous and sedimentary rocks.
- The weathering processes that break down rocks over time.

Students need to know that:

- Rocks can be altered without being weathered or melted to form magma.
- Pre-existing rocks, whether they are igneous or sedimentary can all be changed if they are subjected to heat, pressure or a combination of the two.

  - ❖ Recap movement of magma from the mantle to the Earth's surface. What do students think will happen to the rock this extremely hot magma comes into contact with rocks in the Earth's crust.

- As the magma comes into contact with pre-existing rock, known as country rock, heat will be lost to the pre-existing rock.

  - ❖ Ask students to think about a hot water bottle placed into a cover, the cover warms up as heat is transferred from the hot water bottle to the surrounding material; this is exactly what happens with the heat from the magma. The idea of a thermal gradient could be introduced here, as it is useful for students to understand the way in which all of the Earth's processes are designed to achieve equilibrium. Heat transfer from hot to cold to achieve a temperature balance, minerals formed deep within the Earth where temperatures are high begin to break down at the Earth's surface in order to achieve a stable state (in equilibrium with the Earth's surface).

- The heat will 'bake' the pre existing rock, a process that is described as **Thermal Metamorphism**. <u>The rocks don't actually melt but they are changed.</u> They no longer look the same.

Task

Working in pairs.

Provide students with hand specimens of limestone and marble.
Students compare the 2 samples, what similarities are there, if any.

Wearing goggles students place a few drops of dilute hydrochloric acid on the limestone and note the reaction. The mineral calcite, which is present in limestone, reacts with acid to release the gas carbon dioxide. This is the" fizz" students can see.

Student place an equal number of drops of hydrochloric acid on the marble and record the results.

What can be deduced from this experiment?

Both rocks are made up of calcite yet they don't look the same. A limestone affected by heat will become a marble. The fossils and calcite crystals in the original limestone alter to become calcite crystals of the same size, which form an interlocking structure.

- A similar change occurs when quartz rich sandstones are subjected to heat. The rock becomes a mass of interlocking quartz crystals; the new rock is called quartzite.
- Thermally altered rocks are very strong which is why marble is so often used for carving sculptures. Quartzite is broken into lumps to use as the base on which to mount railway lines.

Students need to know that:

- When mountains are formed great forces are at work pushing up the solid rock.
- This process generates heat and also pressure, which affects the rocks.
- The rocks are uplifted to form the mountains and the area around them is affected by heat and pressure.
- Because these changes take place over such a wide area this type of metamorphism is known as **Regional Metamorphism.** The pre-existing rocks are changed but do not melt.

Task

Working in pairs.

Give students a selection of mudstones and slates to look at; the mudstones have been changed into the metamorphic rock slate due to the application of heat and pressure. One student describes the mudstone to their partner who takes notes. Roles are reversed and the other member of the pair describes the slate to their partner who takes notes. Students then consider their observations and make a list of the main differences between the two rock samples.

- Work with the whole class discuss the observations.

- Mudstones are soft, easily rubbed away with the finger. They are formed of layers but the layers are not easy to see. The slates are brittle, can be snapped (not recommended as a test but something that at least one student is bound to do!). The layers are easily identified; there are sparkly minerals along the layers (mica).

- Got to

http://geologyonline.museum.state.il.us/geogallery/media/images/large/304244.jpg

for the images of mica used in Lesson 1.

- When the original rock is subjected to pressure the flat platy mica minerals align themselves at right angles to the pressure, this makes it easy to split the rock along the boundaries between layers.

- Ask students to consider what would happen if the mudstone had been subjected to ongoing heat. The rock would melt and become magma – metamorphic rocks have been changed but not melted.

- Draw the session to a close by recapping on the way in which rocks are formed from a melt, weathered, reformed as a clastic sediment, are formed from organic sources (carbonate rocks) or are affected by heat and pressure and so changed.

- Draw the outline circle for the Rock Cycle on the board. Use student input to complete the diagram. Encourage students to consider a variety of pathways – sedimentary rock can be weathered to provide the sediments to make a new rock for example, ensure the students recognise that the Rock Cycle is a complex process not simply a circular process.

Homework: A storyboard illustrating the Rock Cycle. Your storyboard should be more than just pictures and should include written information about:
igneous rocks
weathering
erosion
transportation
deposition
lithification
sedimentary rocks

metamorphic rocks.

Oxford University Museum of Natural History has a great example of an interactive rock cycle, although designed for younger students it would provide a starting point for students own ideas.

Go to

http://www.oum.ox.ac.uk/children/rocks/cychome1.htm