Unit 8H The rock cycle

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 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}, *sulfuric acid below 0.5 mol* dm^{-3}, *nitric acid below 0.1 mol* dm^{-3}

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
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

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
• 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.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
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*.