UK Critical Minerals Intelligence Centre

CRITICAL MINERALS

KS3 lesson 1 teacher's notes: minerals in everyday life

British Geological Survey

Department for Business & Trade

Minerals in everyday life

Curriculum Links:

Wales	England
Science & Technology • Being curious and searching for answers is essential to understanding and predicting phenomena • Matter and the way it behaves defines our universe and shapes our lives Humanities • Our natural world is diverse and dynamic, influenced by processes and human actions • Human societies are complex and diverse, and shaped by human actions and beliefs	Science • Working scientifically Chemistry • Materials • Earth and atmosphere Geography • Locational knowledge • Place knowledge • Human and physical geography • Geographical skills and fieldwork

Overview

- What is a rock? What is a mineral?
- Minerals in everyday life
- Critical minerals and the UK strategy
- Critical mineral potential in the UK
- Formation and use of some critical minerals
- Critical minerals in an electric vehicle battery

Introduction to minerals

[See Powerpoint slides 2 and 3]

[Play video 'Minerals in everyday life' from start to 0:40; pause and discuss]

What is a mineral?

- Scientific definition: minerals are naturally occurring, inorganic solids with a definite chemical composition and an ordered atomic arrangement
- Simplified version: minerals are composed of elements and have a defined chemical composition and atomic structure

What is the difference between a rock and a mineral?

- Rocks are aggregates or combinations of one or more minerals. Some rocks, for example marble, contain only one mineral (calcite), but most consist of more than one.

Additional questions that may arise from class discussion

- What is geology?
  Geology, also known as 'geoscience' or 'earth science', is the study of the structure, evolution and dynamics of the Earth and its natural resources. Geology investigates the processes that have shaped the Earth through its 4500 million (approximate!) year history and uses the rock record to unravel that history. It is concerned with the real world beyond the laboratory and has direct relevance to the needs of society.
- Where do we get minerals from?
  Minerals can be found throughout the world in the Earth's crust but usually in such small amounts that they are not worth extracting. Minerals are only concentrated into economically viable deposits with the help of certain geological processes and the deposits can only be extracted where they are found. Mineral deposits come in many shapes and sizes depending on where and how the mineral was formed or concentrated. Minerals are concentrated by igneous, sedimentary and metamorphic processes.
- How do we find minerals?
  Mineral exploration is undertaken to find mineral deposits that are suitable for commercial exploitation. A variety of methods may be used, including remote sensing (aerial photography and satellite images) and geochemical surveys (looking for chemicals that indicate certain minerals are present in soil and water).
  Once a mineral deposit has been found, it has to be extracted from the ground. This can be done by opencast quarrying or underground mining. Certain minerals can also be extracted by pumping, such as salt. The salt is dissolved in water and pumped out from underground. Almost all oil and gas is extracted by pumping.
  After minerals have been extracted from the ground, they are converted to a form that is useful to us. This usually involves removing any unwanted impurities and further processing to increase the concentration of the economic mineral. Metallic minerals may be smelted or refined close to the mine to produce metal, or the concentrate may be transported to another site for further processing. Oil and gas are also further refined before use. Finally, the mineral is transported to the consumer by rail, road, sea and pipelines.
- What is an economic mineral?
  The term 'economic minerals' includes minerals, metals, rocks and solid and liquid hydrocarbons (coal, oil and gas) that are extracted from the earth by mining, quarrying and pumping.
- What are economic minerals used for?
  Economic minerals are used in a wide range of applications related to construction, manufacturing, agriculture and energy supply. Economic minerals include:

  - energy minerals: minerals that are used to produce electricity, fuel for transportation, heating for homes and offices and in the manufacture of plastics:
    - coal
    - oil
    - natural gas
    - uranium
  - metals:
    - iron (as steel) used in cars or for frames of buildings
    - copper used in electrical wiring
    - lithium in rechargeable batteries
    - aluminium in aircraft parts and drinks cans
    - precious metals used in jewellery and mobile phones

- construction minerals: used to manufacture concrete, bricks and pipes and for building houses and roads:
  - sand and gravel
  - brick clay
  - crushed rock aggregates
- industrial minerals: otherwise known as non-metallic minerals, industrial minerals are used in a range of industrial applications including the manufacture of chemicals, glass, fertilisers and fillers in pharmaceuticals, plastics and paper:
  - salt
  - clay
  - graphite
  - limestone
  - silica sand
  - phosphate rock
  - talc
  - mica

Activity 1: everyday minerals

[See Powerpoint slides 5 to 8]

[Play video 'Minerals in everyday life' from 00:40 to 01:20]

This activity is best printed off and cut into cards as a matching game. In small groups, pupils will match the photos to the statement provided. As an extension, pupils can also try to match the photo to the mineral name. Full answers are provided in the teacher's notes on page 3.

You could use some actual items for visual purposes (some feature in the accompanying video clip).

Item	Statement	Mineral
Salt	Sodium chloride comes from the mineral halite	Halite
Toothpaste	Fluoride helps to reduce tooth decay	Fluorite
Brass padlock	Copper and zinc combined make the alloy brass	Chalcopyrite (copper) and sphalerite (zinc)
Aluminium foil	Aluminium is a very light metal	Bauxite
Drill bits	Tungsten and steel (iron) are added to improve hardness	Wolframite (tungsten) and haematite (iron)
Water pipe	Copper is used to make pipes	Chalcopyrite
Car battery	Lead and zinc are used as electrodes inside batteries	Galena (lead) and sphalerite (zinc)
Toilet	Porcelain is a ceramic material processed through high levels of heat	Kaolinite
Pencil	Graphite is mixed with clay to form the pencil 'lead'	Graphite
Wristwatch	Quartz is used in the electronics to keep it accurate	Quartz
Cement	Limestone and clay are the main components of this product	Calcite (calcium carbonate) and kaolinite (clay)
Glass	This is made from silica, which is composed of small grains of quartz crystals, commonly known as sand	Quartz
Talcum powder	Talc is one of the softest minerals	Talc
Kitchen utensils	Steel (iron), nickel and chromium are combined to make an alloy that is used to make eating utensils	Haematite (iron), pentlandite (nickel) and chromite (chromium)

Additional teacher information

- Quartz in a watch may need additional explanation. A slice of quartz crystal, which has been specially grown in a factory, is in the chip that controls the accuracy of the electronics in the watch
- A mineral is referred to as an ore if it contains one or more elements, usually metal, in sufficient concentration to be economically viable
- Metals extracted from minerals are often mixed with other metals to improve their physical properties, for example the hardness or strength; these mixes are called alloys

Activity 2: critical minerals

[See Powerpoint slides 10 and 11]

This section introduces pupils to ‘critical minerals’. A list of these has been defined by the Government in the UK Critical Minerals Strategy. There is also a ‘watchlist’ of minerals that are close to being on the critical list.

Part 1

[Play video ‘Minerals in everyday life’ from 01:20 to 03:45]

Pupils answer the following questions in their workbooks. Pupils may include some of this information in their answers.

- What are critical minerals?
  A critical mineral is a metallic or non-metallic element that is essential for modern technologies, economies or national security, and has a supply chain at risk of disruption. Some minerals are more important than others, especially for developing new clean technologies for the future, and these are referred to as critical minerals
- Name some of the critical minerals of the past and some of the modern-day critical minerals.
  During the Industrial Revolution, iron and steel were critical minerals. Before that, flint was a critical mineral used by Stone Age humans to make tools. Nowadays, it is minerals such as cobalt, lithium, graphite, tin and rare earth metals (see Part 2) that are the critical minerals.
- Why are critical minerals so important today?
  As technology evolves faster than ever, we become more and more reliant on a new range of minerals. We are moving into a world powered by critical minerals: we need lithium, cobalt and graphite to make batteries for electric cars; silicon and tin for our electronics, and rare earth elements for electric cars and wind turbines. Modern society is quite literally built on rocks!
  Almost every part of modern daily life relies on minerals, often mined thousands of miles away. Critical minerals will become even more important as the world is expected to need four times as much critical minerals for clean energy technologies in 2040 as it does today.
- What problems exist with the supply chain for critical minerals?
  Critical mineral supply chains are complex, the market is volatile and distorted, and China is the dominant player. This creates a situation where UK jobs and industries rely on minerals vulnerable to market shocks and political events, at a time when global demand for these minerals is rising faster than ever.
  It is vital that we make our supply chains stronger and more diverse to support UK industries in the future, to meet our environmental commitments and protect our national security.

The UK Government’s critical minerals strategy

The UK Government has produced a ‘critical minerals strategy’, which could help to make critical mineral supply chains more secure, create new jobs and help solve global challenges around critical minerals.

There are areas rich in minerals across the UK, from Shetland to the tip of Cornwall. Due to its long history of mining minerals, dating back to the Bronze Age, it has also lots of experts in refining and manufacturing. The new strategy will boost what the UK produces through mining, refining, manufacturing and recycling in a way that creates jobs and protects the natural environment. It will also encourage people to work with their colleagues in other countries and lead the new, so-called ‘green’ Industrial Revolution.

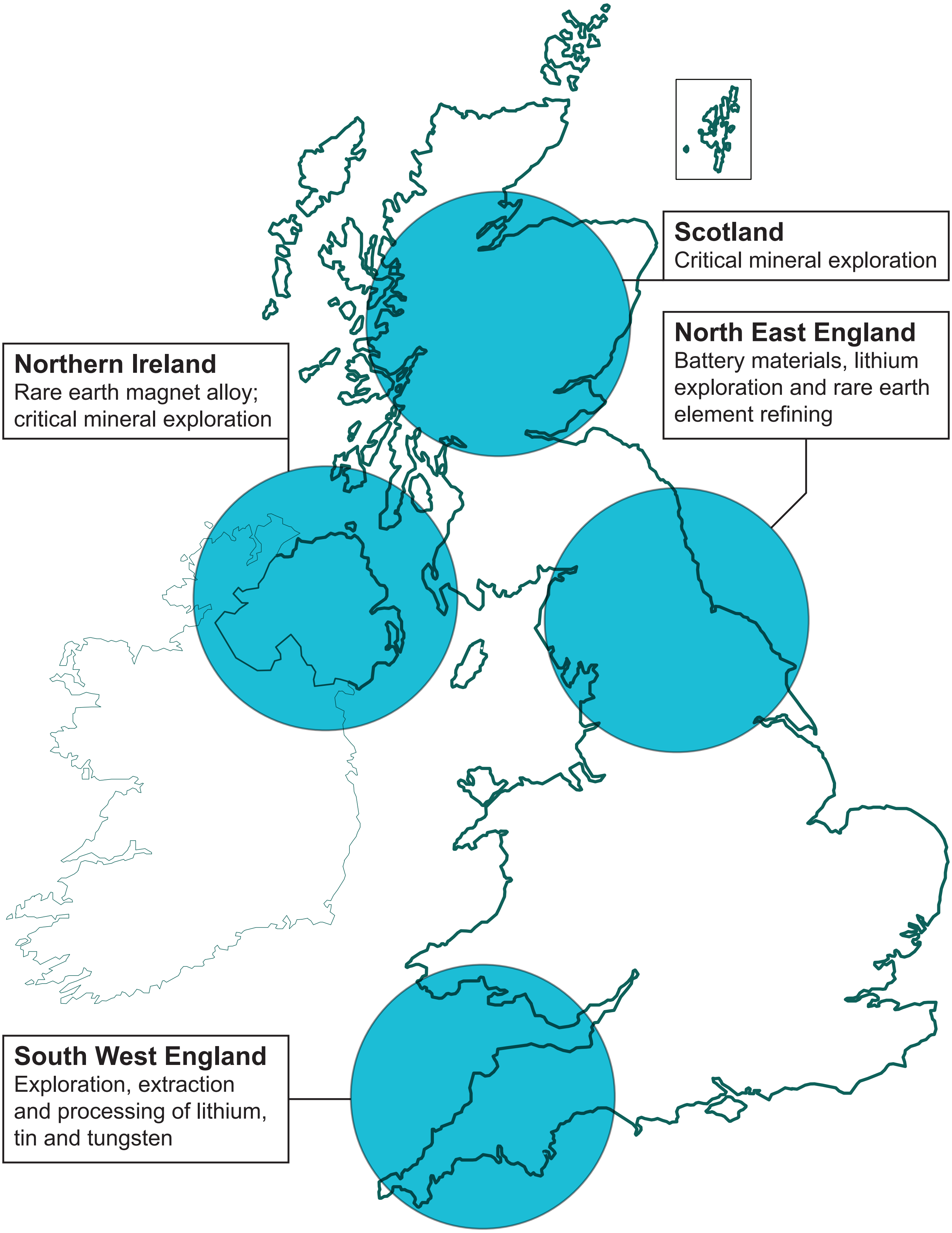
Part 2: critical mineral potential in the UK

[See Powerpoint slides 13 to 16]

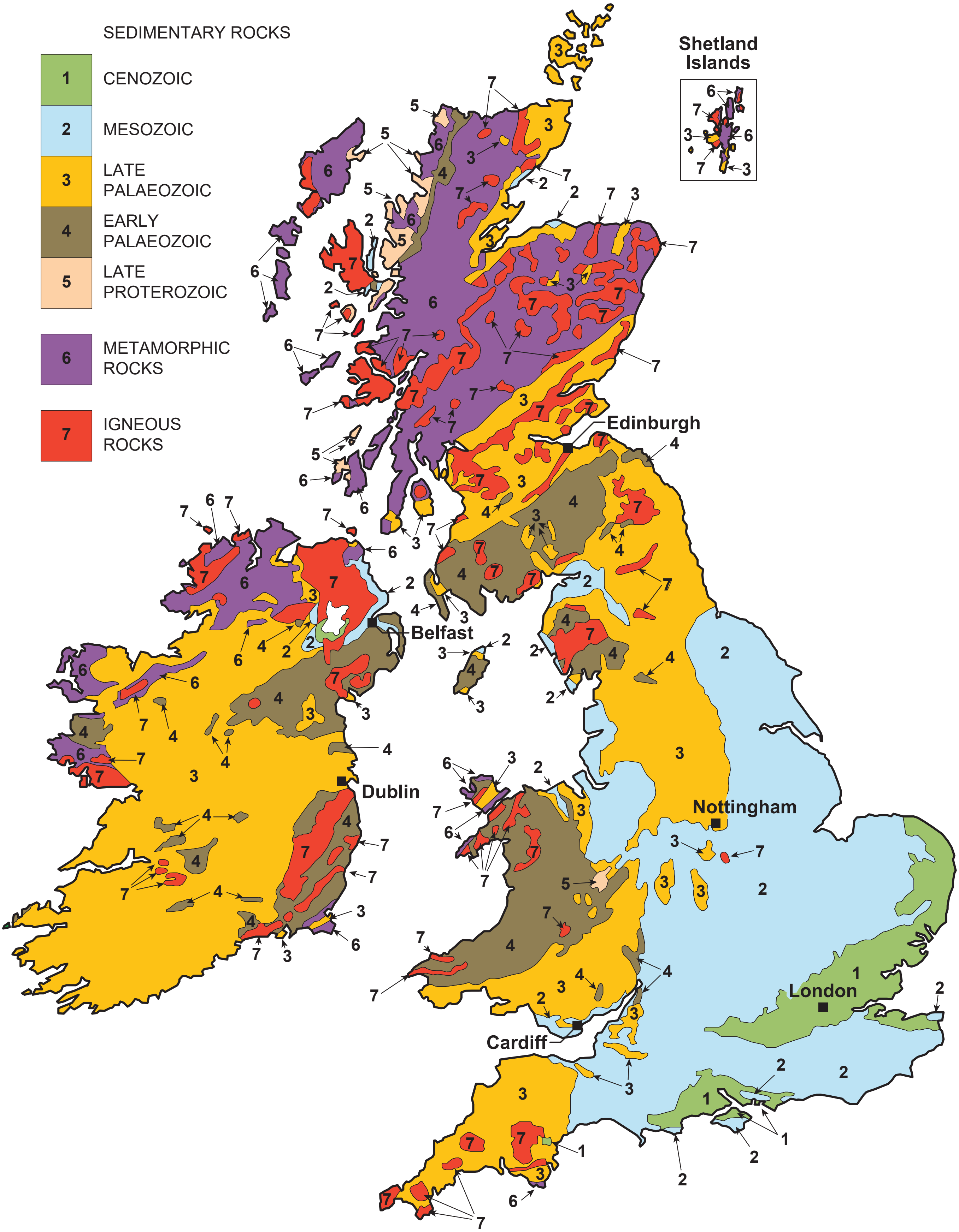
Begin by introducing the three rock groups: igneous, metamorphic and sedimentary. The teacher slide shows example images of each of these how they differ.

- Igneous
  There are two types of igneous rock, extrusive and intrusive, distinguished from each other by how they are formed.
  Intrusive, or plutonic, igneous rock forms when magma is trapped deep inside the Earth. Great globs of molten rock rise toward the surface. Some of the magma may feed volcanoes on the Earth's surface, but most of it remains trapped underground, where it cools very slowly over many thousands or millions of years until it solidifies.
  Extrusive, or volcanic, igneous rock is produced when magma exits and cools above (or very near) the Earth's surface. These are the rocks that form at erupting volcanoes and oozing fissures. The magma, called lava when molten rock erupts on the surface, cools and solidifies almost instantly when it is exposed to the relatively cool temperature of the atmosphere.
- Sedimentary
  Sedimentary rocks are formed over millions of years, as sediments (broken remains of other rocks) compact on the Earth's surface and under seas, lakes and oceans. Different sedimentary rocks include sandstone, limestone, shale and chalk.
- Metamorphic
  Metamorphic rocks are formed when sedimentary and igneous rocks experience intense heat and pressure as a result of tectonic activity in the Earth's crust, which makes them change form (metamorphose). Because of this intense heat and pressure, metamorphic rocks rarely contain fossils as they are unlikely to survive.

Pupils add lines to the labels and colour in the relevant area to identify areas where critical minerals are explored, extracted and processed across the UK.



Pupils describe the links between the critical mineral areas on their map and geology map showing the three rock types.



Pupils should identify that igneous and metamorphic rocks are the rocks where most critical mineral exploration, extraction and processing takes place, so Scotland and Northern Ireland, parts of north-east and south-west England are important areas for them.

Suggestion

You could use the BGS Geology Viewer web resource. This lets you access detailed information about the geology all around you. Tapping the map reveals the bedrock and superficial geology (the soft layers on top of the solid bedrock) as well as explaining how certain features were formed.

Part 3: formation of critical minerals

[Play video 'Minerals in everyday life' from 03:45 to end]

[See Powerpoint slide 18]

Fill in the missing words (answers in **red**).

- Graphite
  Graphite occurs when **metamorphism** (increased heat and pressure from the Earth) happens to organic-rich **sedimentary** rocks, for example **coal**. The organic parts provide the carbon from which graphite forms. Graphite also occurs in igneous rocks and in meteorites.
  Graphite is used in making the cores of pencils, lubricants like **grease** as well as in paint as it is water-repellent, so provides a protective coating on surfaces. It is a common element used in the production of lithium-ion batteries as it is a good **conductor** of electricity. Finally, graphene sheets, which are made from graphite, are 100 times stronger and 10 times lighter than steel, making it useful in the **aerospace** industry.
- Lithium
  Lithium is found in ores from **igneous** rocks as well as salts in brine pools. The largest producer of **lithium** in the world is Chile. Lithium is important in the manufacture of personal technology devices and **electric** cars. It is highly reactive and easily conducts a current through batteries, allowing them to be recharged. It is also much **lighter** than other metals used in batteries, such as lead.
- Cobalt
  Cobalt is used in lithium-ion **batteries** and in the manufacture of high-strength magnetic alloys. Cobalt is found in **sedimentary** rocks and is often produced as a by-product from the production of **copper**, nickel, **silver**, gold, **lead** and zinc.
- Tungsten
  Tungsten is often extracted from **granite,** an igneous rock. Around half of the tungsten mined is used to produce **hard** materials (tungsten carbide), with the rest being used in alloys and steels. Its high **melting** point also makes tungsten suitable for aerospace and high temperature uses such as electrical, heating and **welding** applications.
- Rare earth elements
  The term 'rare earth elements' refers to a group of elements that are crucial to the manufacture of many **hi-tech** products. They are found mostly in igneous rocks such as granite but also in some sedimentary rocks such as clay. An example is neodymium, which is used to make powerful **magnets** used in loudspeakers and **computer** hard drives (hold up computer hard drive). Magnets containing **neodymium** are also used in green technologies such as the manufacture of wind turbines and hybrid **cars**.

Activity 3: critical minerals and electric cars

Background information

Lithium, graphite, nickel and cobalt are important critical minerals in electric vehicle batteries.

Rare earth elements (often called REEs) are critical minerals and a key part of many technologies nowadays including electric cars, but also renewable energies such as wind turbines, computers, aeroplanes and mobile phones. Neodymium is a REE and neodymium permanent magnets are used in electric vehicles for seat belts, brakes, speakers and the battery.

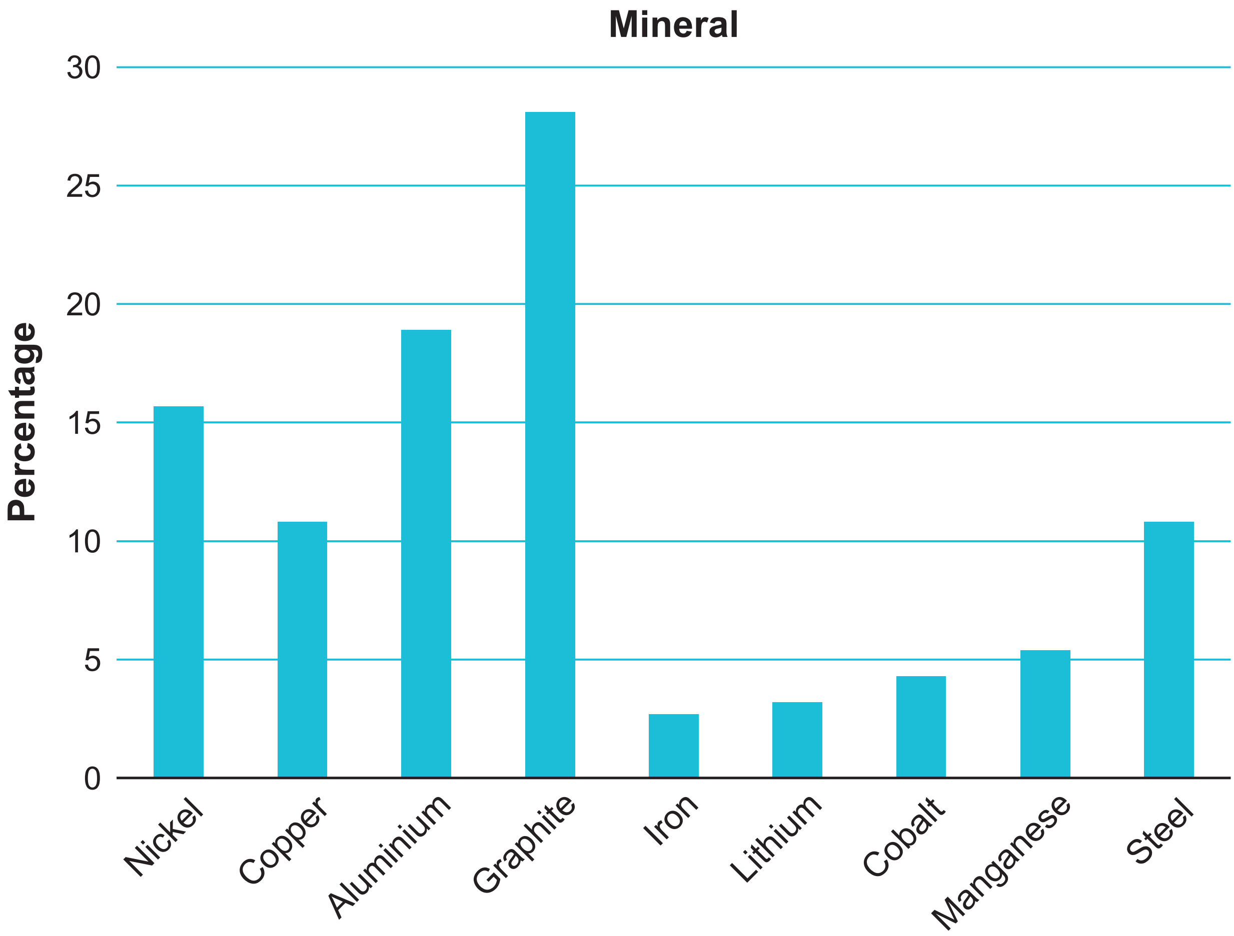
Extra information

- Engine
  Electric cars are plugged into a charging point and taking electricity from the grid. They store the electricity in rechargeable batteries that power an electric motor, which turns the wheels.
- Seat belts
  The presence of a magnetic field (like the one inside the seat belt tongue) means that, when the circuit isn't closed, the alarm system activates, resulting in that irritating (but effective) beep.
- Brakes
  Braking turns your car's kinetic energy into electricity to charge its battery and boost efficiency. The resulting friction works to slow the car down, generating heat and wearing away at the material on the brake pads and discs in the process.
- Car stereo speakers
  Magnets (neodymium-iron-boron magnets) allow for the vibration in the speakers to create the noise.

Pupils draw a bar graph using the table of data to show the percentage of key minerals in an electric vehicle battery.

Key Mineral in an electric vehicle battery	Percent
Nickel	15.7
Copper	10.8
Aluminium	18.9
Graphite	28.1
Iron	2.7
Lithium	3.2
Cobalt	4.3
Manganese	5.4
Steel	10.8

Completed graph



Key points

- Three out of the nine minerals in an electric car battery are critical minerals (cobalt, graphite and lithium) and one is on the watchlist (nickel)
- Graphite has a high % (28.1)

Homework/extension activity

Look for items at home and on your journey to and from school that are made from minerals and make a note or take pictures of them to report back to school. Have a class discussion on what they have found at the start of the next lesson. Use the slide on 'Minerals in the home' to supplement what the pupils have found themselves. This leads into Lesson 2 and critical minerals.

Loan kit box of minerals (if available)

As part of this project there is a loan kit available from BGS. Please email BGSengage@bgs.ac.uk to enquire about borrowing it. If you have this kit you can use the box set of ore minerals throughout this session to show examples. Beware of handling the minerals – wash your hands afterwards.