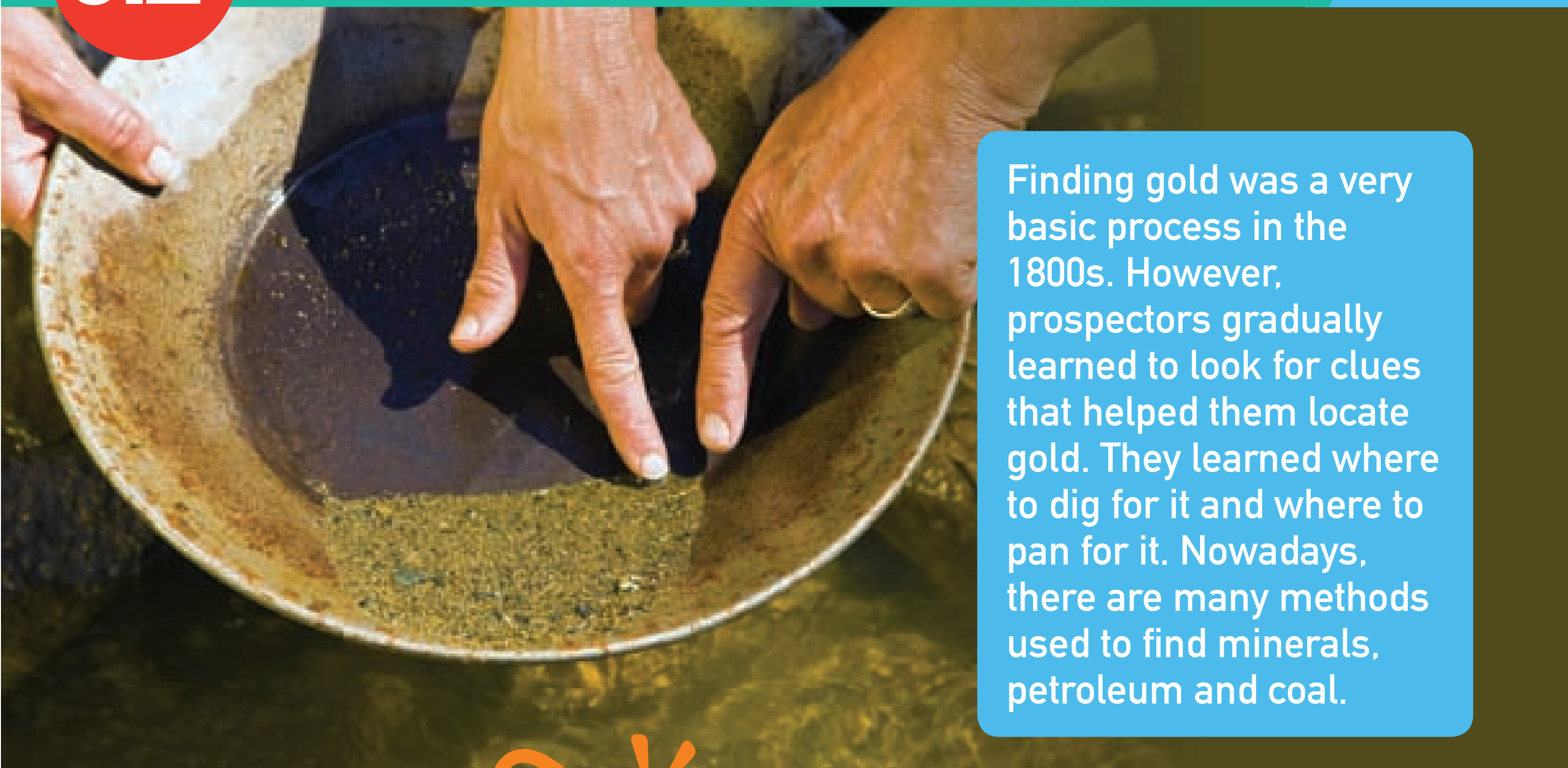
9.2 Exploration



Finding gold was a very basic process in the 1800s. However, prospectors gradually learned to look for clues that helped them locate gold. They learned where to dig for it and where to pan for it. Nowadays, there are many methods used to find minerals, petroleum and coal.

INQUIRY science 4 fun

Magnetic field

No

Can you show a magnetic field?

Collect this …

- 1 sheet of thin cardboard
- magnet
- iron filings in a pepper shaker

Do this …

1. Place the magnet under the cardboard in the centre.
2. Sprinkle the iron filings over the cardboard until a clear series of lines appears.
3. Keep adding more near the centre of the cardboard so they stick upwards.

Record this …

Describe what happened.

Explain why you think this happened.

Many methods are used to explore for minerals. Some of the most common are:

- aerial methods—magnetic, gravity and electromagnetic surveys
- on-site methods—seismic and geochemical surveys
- satellite images.

Aerial methods

Aerial methods of surveying are done from aircraft or helicopters. A great advantage of aerial surveying is that it can cover vast areas fairly quickly.

Magnetic surveys

Earth has a magnetic field running between its north and south poles. Minerals containing iron, nickel or cobalt change the magnetic field around them. Sensitive instruments called **magnetometers** detect this change and show the effect as a disruption to the normal field or 'magnetic anomaly'. Figure 9.2.1 shows an aircraft equipped for magnetic surveys.

Figure 9.2.1 This aircraft is fitted with a magnetic system to detect magnetic anomalies in Earth's north–south field.

The magnetic data from the magnetometer is fed into a computer and a coloured map can then be constructed. Colours are used to indicate areas of interest. For example, a highly magnetic area may be coloured red, while an area of low magnetism may be coloured blue. This will show patterns that could indicate possible mine sites. Figure 9.2.2 shows an example of a magnetic anomaly in Mt Oscar in the Pilbara region of Western Australia. Drilling showed the mountain to be made of a magnetic iron ore called magnetite.

1 p332

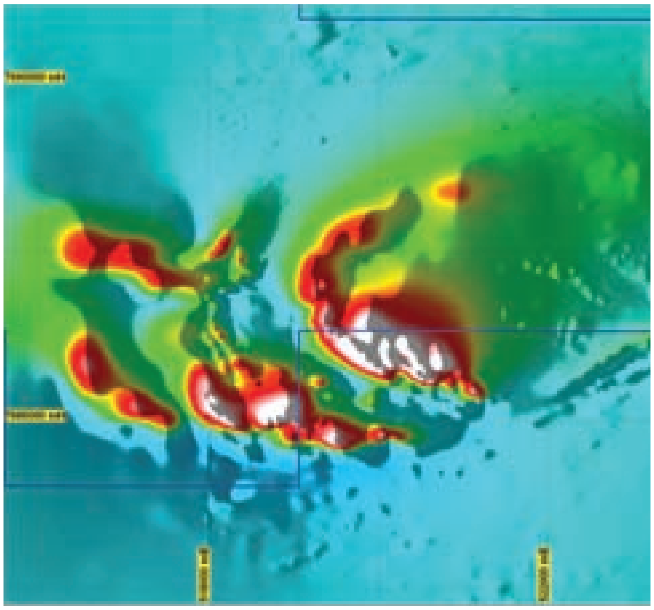


Figure 9.2.2 This map of magnetic anomalies near Mt Oscar in the Pilbara region of Western Australia helped in discovering a site of magnetite iron ore. White and red areas are more magnetic than the other colours.

SciFile

North goes north-west

The magnetic field of the Earth is changing. The position of the magnetic north pole is moving north-west at a rate of about 40 km/year. Some scientists have predicted that the poles may reverse within a few hundred years. Then the current north-seeking end of a compass will point south.

Gravity surveys

Small differences in the gravitational pull of the Earth can be detected by very sensitive instruments called **gravimeters**. These can be attached to an aircraft. Dense rocks and minerals affect the gravitational pull on the aircraft and gravimeters can detect this. Variations in gravitational pull are then shown on a map using colour to show differences. Such maps can give geologists clues about where particular minerals may be found. In Figure 9.2.3 you can see the image from a gravimetric survey in South Australia.

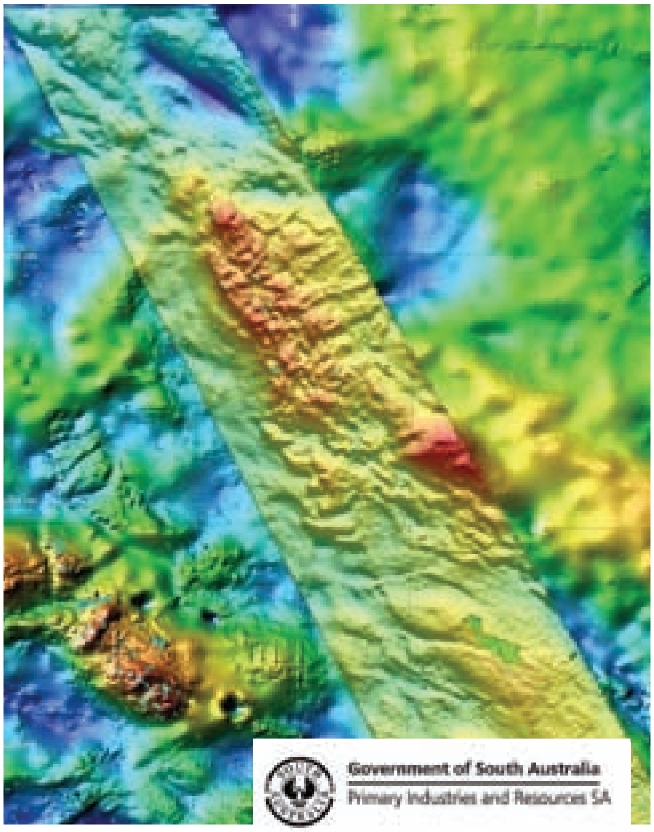


Figure 9.2.3 This is a gravity map of the land between Olympic Dam and Oodnadatta in South Australia. Red indicates the highest gravity (indicating the densest rocks) and blue indicates the lowest.

Electromagnetic surveys

Electromagnetic (EM) surveys detect ore bodies that are good electrical conductors. A magnetic field is sent from a transmitter on an aircraft or helicopter like the one in Figure 9.2.4. The magnetic field creates tiny electrical currents (called eddy currents) in minerals in the Earth. These currents create their own magnetic field (called the secondary field), which is detected by a receiver. You can see this in Figure 9.2.5. This method is very good for detecting metal sulfides such as copper sulfide, lead sulfide and zinc sulfide, and also for detecting gold and silver.

Figure 9.2.4

This helicopter is towing an electromagnetic device that combines a transmitter and a receiver.

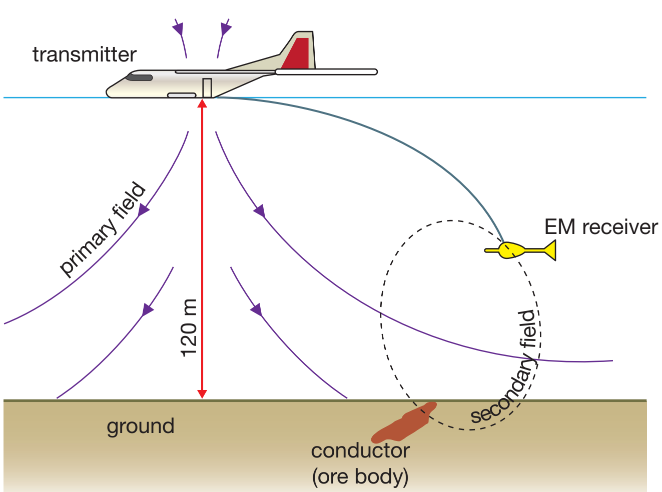


Figure 9.2.5

Airborne electromagnetic methods apply a magnetic field to the Earth and detect the secondary field created by the eddy currents in the ore body.

2 p333

On-site methods

Aerial methods give a quick overview of large areas. More specific data can come from on-site methods.

Seismic surveys

A **seismic survey** involves sending a shock wave into the ground surface, and recording the reflected sound waves. Different rocks layers reflect the sound waves in different ways and a 3D picture can be created from the reflections. Explosives can be used, but mechanical vibrators give a better picture and can go deeper. Detectors called geophones detect the reflected sound waves. The maps made from the sound waves help geologists predict likely areas where minerals can be found.

INQUIRY science 4 fun

Echoes

Can you hear a reflected sound?

Collect this …

2 flat pieces of wooden board about 30 cm long and 5 cm wide

Do this …

1. Walk outside to a place where there is a large area of flat brick or concrete wall.
2. Stand about 10 metres (roughly 10 large paces) from the wall and hit the large flat surfaces of the boards together loudly. Listen for an echo. You should not hear one.
3. Step away from the wall a further 10 paces so that you are about 20 metres from the wall. Hit the boards together and listen for an echo. You may hear one but it may be very hard to be sure.
4. Step a further 10 paces away, use the boards and listen for an echo. You should definitely hear one here.

Record this …

Describe what happened.

Explain how this is like a seismic survey.

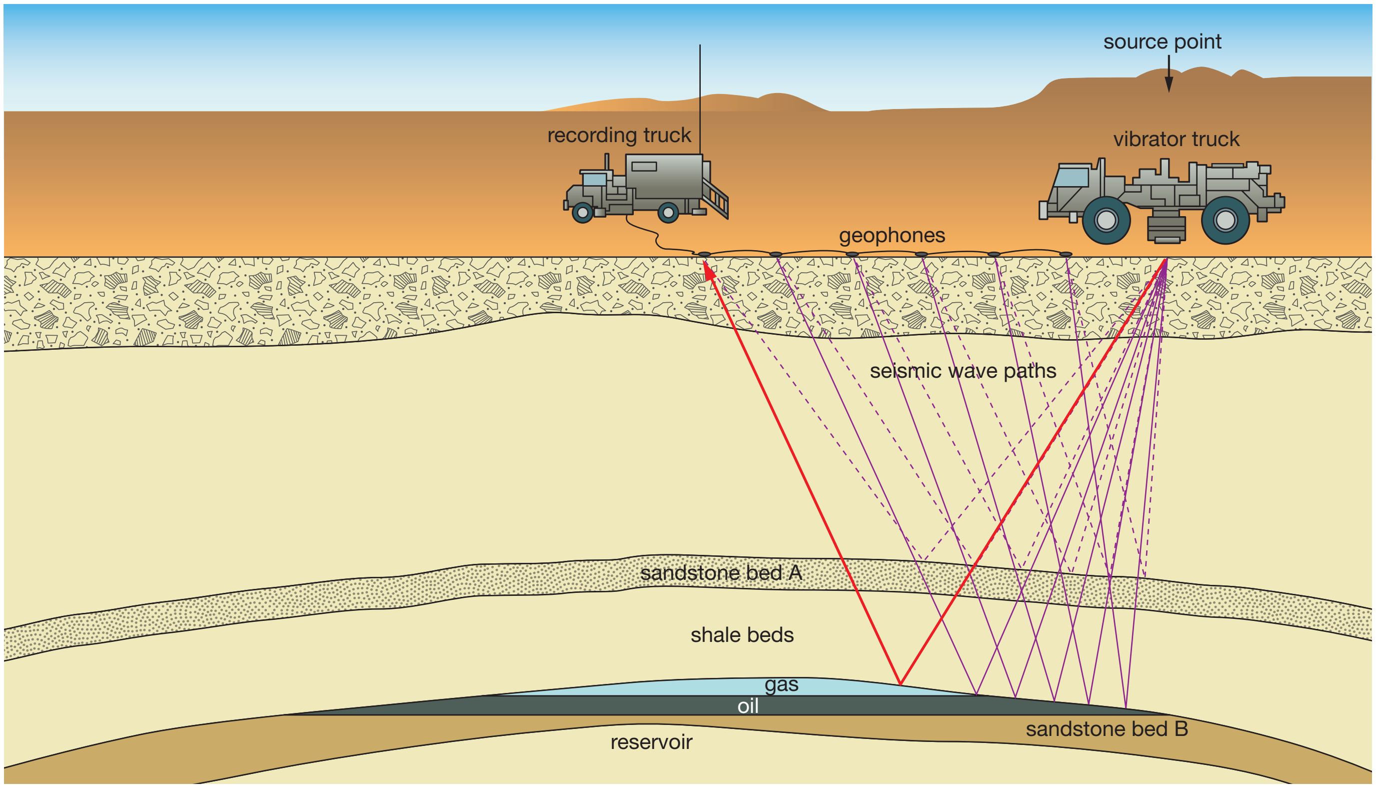


Figure 9.2.6 A seismic survey sends sound waves through the Earth and detects reflected sound waves to create a picture of the rock layers.

Seismic surveys can also give information about the structure of the Earth's crust from 35 to 60 km deep. This helps geologists to better understand how minerals form. Figure 9.2.6 shows how a seismic survey is done.

Geochemical surveys

Geochemistry uses chemistry to show what minerals are present in the area surveyed. Rock and soil samples from the surface may be used, but generally holes are drilled into the rocks to check the amount of mineral in them. The rock that is removed is called a **core sample**. Some core samples are shown in Figure 9.2.7. Sometimes the presence of one particular mineral gives geologists clues to what other minerals could also be in the rock. For example, uranium, arsenic and antimony are associated with gold deposits.

Water from the surface or below ground can also be used as an indicator of minerals in the rocks or soil. Groundwater dissolves minerals in buried rocks and is especially useful in detecting metals. Copper, gold, uranium, nickel, zinc and diamonds can be located in this way. Many sulfides of metals are detected by water sampling. However, surface water is not always a good indicator of what lies below ground, especially if the water has flowed there from somewhere else or has been there only a short while.

Figure 9.2.7 Core samples of rock from holes drilled into a potential ore body are tested chemically for minerals of interest.

Satellite images

Satellites have long been used to take photographs of the Earth below. However, satellites also enable geologists to create images using forms of light rays that the human eye cannot see. The sensors in satellites detect radiation called near-infrared, shortwave-infrared and thermal-infrared. The **satellite images** produced often help geologists see features in the landscape that they cannot see in normal satellite photos produced with visible light. These features often contain particular minerals. Typical satellite images can be seen in Figure 9.2.8.

9.3

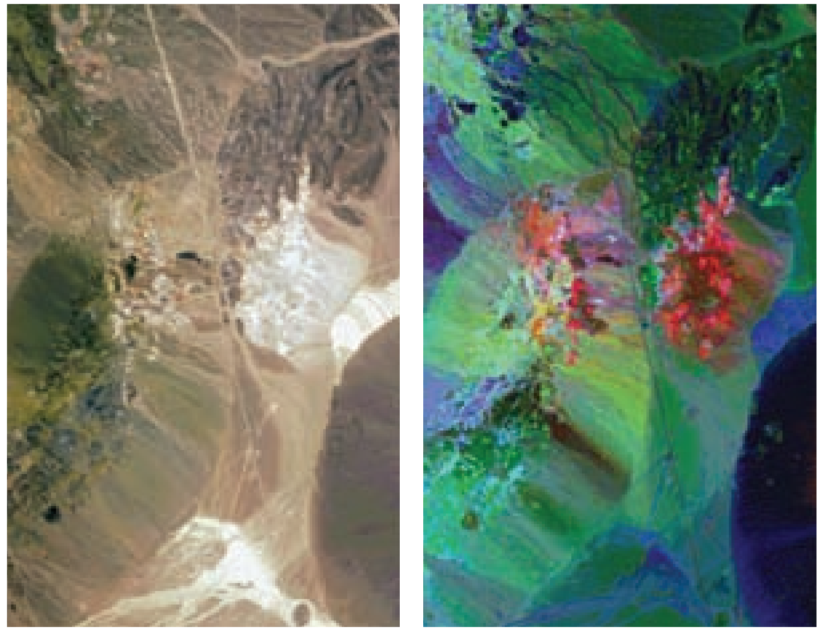


Figure 9.2.8

These two satellite images show the same area, in natural and infrared light. The red parts indicate deposits of azurite (an ore of copper).

Geological maps

Geologists use aerial methods, on-site methods and satellite images to construct different kinds of maps (such as those in Figures 9.2.2 and 9.2.3 on page 327) to show likely mining areas. However, other maps may be needed to show the underground rock formations before geologists can work out the best way to mine the deposits.

It is useful to draw **geological maps** that show the appearance of the ore bodies from above and from the side. The side view is called a **cross-section**. Cross-sections are very useful because they help to give a 3D picture of how the ore bodies look. Then geologists can decide how best to mine the ore. You can see a geological map in Figure 9.2.9.

9.4

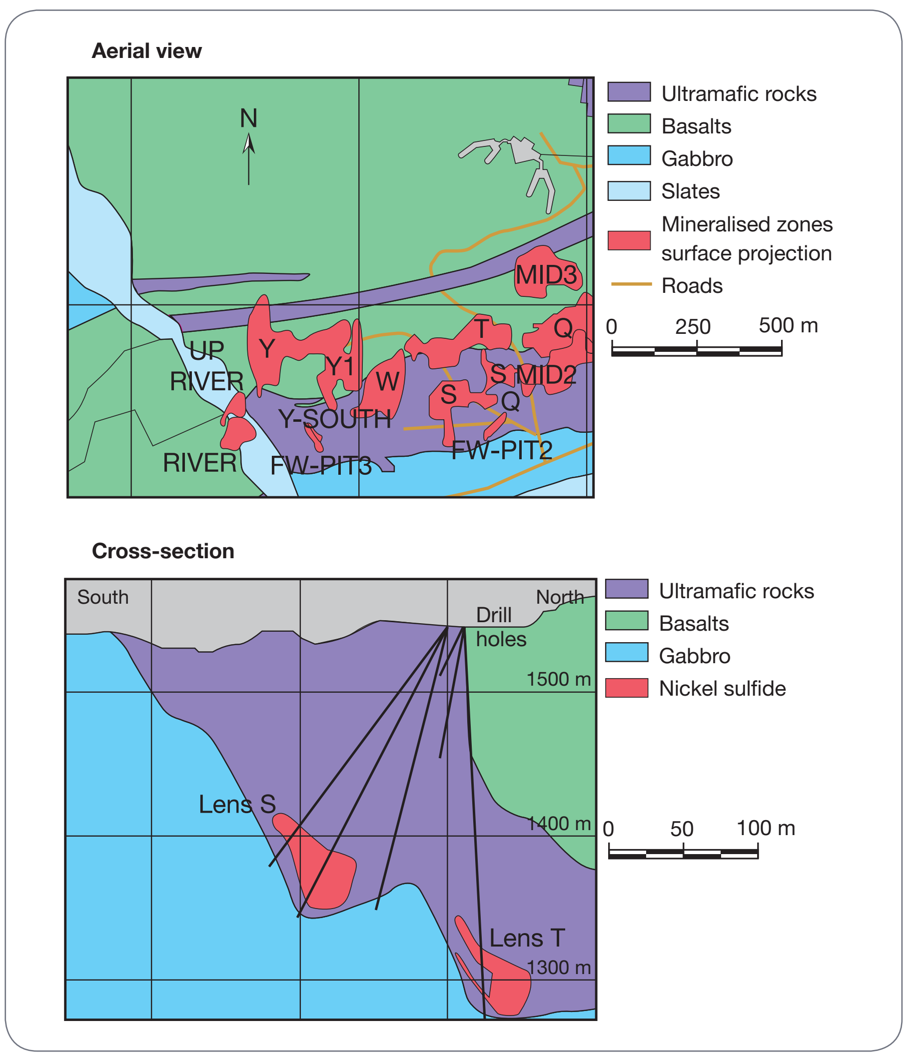


Figure 9.2.9

These geological maps show nickel sulfide ore bodies (red) from above and in cross-section. Each ore body has been given a different letter or name.

9.2 Unit review

Remembering

1 **List** three aerial methods of exploration.

2 **List** two on-site methods of exploration.

3 **List** the type of invisible rays that are used by satellite sensors to construct images.

Understanding

4 **Explain** what the following instruments do.
  a magnetometer
  b gravimeter

5 **Explain** the advantage of aerial methods of exploration.

6 **Explain** how aerial magnetic surveys can be used to create a map of the geology of an area.

7 **Outline** the uses of satellites in mineral exploration.

8 **Explain** how seismic surveying works.

9 **Explain** why geological maps are created.

Applying

10 **Identify** the best places to mine in the area shown in Figure 9.2.2 on page 327.

11 a **Explain** what an eddy current is.
  b **Identify** where the eddy current would occur in Figure 9.2.10.

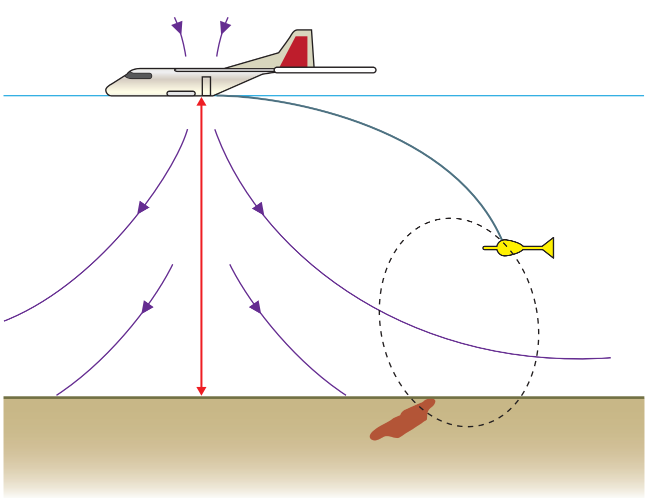


Figure 9.2.10

12 **Use** Figure 9.2.9 to **explain** how drill cores and geochemistry help create geological maps.

13 **Identify** approximately where the cross-section was done on the first diagram in Figure 9.2.9.

Analysing

14 **Compare** geochemical surveys with satellite surveys.

15 **Compare** aerial magnetic surveys with aerial gravity surveys.

16 **Contrast** electromagnetic surveys with magnetic surveys.

Evaluating

17 An aerial survey gave an extremely strong electromagnetic reading in an area. A gold mining company decided to do a ground survey of the area. They bored some holes in the soil and sampled the water. A laboratory test on the water they collected was negative for gold. However, a drill core of rock when analysed gave quite a high reading for gold. **Propose** why the water readings contradicted the drill core readings.

Creating

18 **Construct** a table summarising the use of each of the methods of exploration mentioned in this unit.

Inquiring

1 Research a company that uses one of the aerial survey methods for exploring. Research which method they are using, where they are exploring, what mineral they are searching for and what results they have had so far.

2 Research uranium exploration in Australia. Describe what uranium is used for, how much of the world's uranium deposits are thought to be in Australia and what exploration methods are used.

9.2 Practical activities

1 Detecting magnetic minerals

Purpose

To model a magnetic survey to detect minerals.

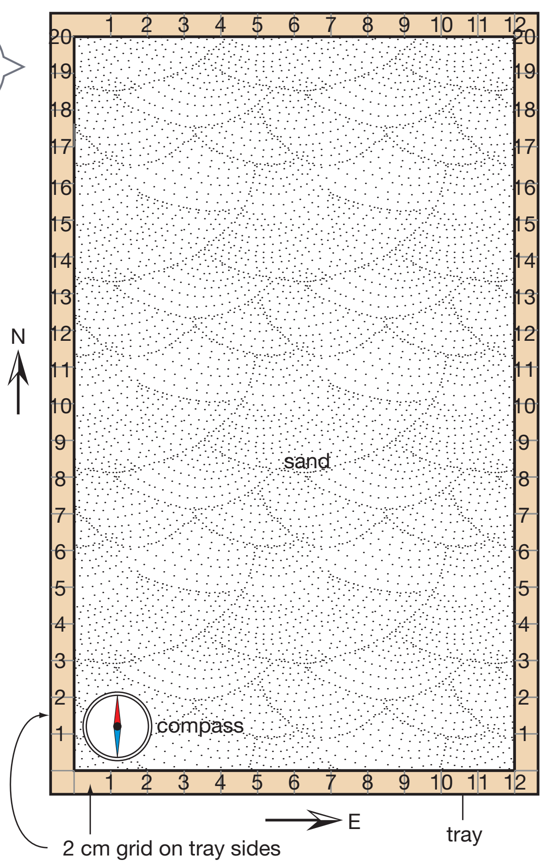
Materials

- tray
- clean sand
- magnetic compass
- marking pen (non-permanent)
- 3 or 4 pieces of iron/steel (the 'mineral')

Procedure

1 Fill your tray with sand and draw a 2 cm search grid along two sides. Call one side of the tray 'north' and the other 'east'. Use the compass to arrange the tray so that these sides point north and east. Number each square from 1 to as many as needed to cover the tray (see Figure 9.2.11).

Figure 9.2.11



2 One student (the experimenter) is to hide the pieces of iron or steel in the sand and the other (the surveyor) is to conduct the survey. The metal pieces are the 'mineral' the surveyor is trying to locate. The surveyor must not see where the experimenter hides the metal pieces or how many are hidden.

3 On a piece of A4 graph paper, the experimenter marks a grid representing the grid on the tray. This is your record sheet.

4 The surveyor now holds the magnetic compass a few centimetres above the sand in the first grid square: 1 North 1 East (1N1E). The experimenter must draw on the record sheet the direction in which the compass is pointing.

5 The surveyor must now decide what search pattern to use to find the 'minerals'.

6 Move the compass to the next square and show the direction of the compass needle on the record sheet. Continue until you think you have enough information.

7 The surveyor now uses the record sheet to try to determine where the ore body is located. When located, dig up the ore.

Discussion

1 **Explain** why the compass needle detects the mineral.

2 In a real magnetic survey, **name** the devices that take the place of the compass.

3 **Describe** how you predicted the location of each ore body.

4 **Evaluate** your performance in detecting the ore bodies.

2 Electromagnetic surveys

Purpose

To model an electromagnetic survey to detect minerals.

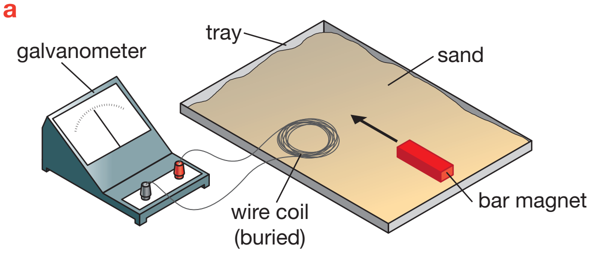
Materials

- laboratory tray
- clean sand
- good-quality magnetic compass
- strong bar magnet
- copper coil (ore body)—varnished
- galvanometer
- 4V power supply (or battery)
- 3 electrical leads with alligator clips
- switch

Procedure

1. Fill the tray with sand and bury the coil just below the surface about 10 cm in from one edge and near the centre of the side. Leave the two ends of the coil sticking above the sand and over the edge of the tray.
2. Connect the two wires from the coil to the galvanometer. A galvanometer is an instrument that detects very small electric currents. Your set-up should look like Figure 9.2.12a.
3. Pick up the magnet and imagine it to be on an aircraft with an electromagnetic (EM) survey system. Start at the end away from the coil. 'Fly' the magnet a few centimetres above the sand and towards the coil (your 'ore body') and watch the galvanometer. You may have to do it a few times to notice any effect.
4. Try 'flying' faster or slower, and higher or lower. Record the readings on the galvanometer each time. Construct a table to record your observations.
5. Disconnect the galvanometer from the coil and connect the coil to DC terminals of the power supply (or battery) with a switch. The power supply represents the eddy currents created in the ore body. Turn the knob on the power supply to 4V. Your set-up should look like Figure 9.2.12b.
6. Pick up the compass and imagine it to be on an aircraft with an EM system. The compass is modelling the detector on the aircraft. Hold the compass flat and start at the end away from the coil.
7. 'Fly' the compass just above the sand and towards the coil. Close the switch a few seconds before the compass 'flies' over the coil. Watch the response of the compass. Turn off the switch as soon as the compass passes the coil. You may have to do it a few times to notice any effect. Try 'flying' faster or slower, and higher or lower.

a



b

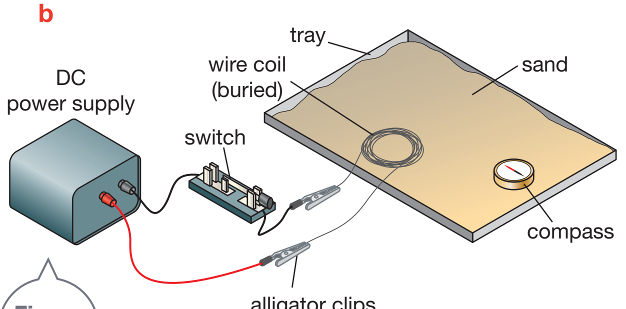


Figure 9.2.12

Results

1. Record your observations of the effect on the compass.
2. Predict what would happen to the compass direction if you turned the coil over in the sand and repeated step 7. Try this and record any observations.

Discussion

1. **Describe** the effect on the galvanometer of passing a magnetic field through the coil.
2. **Explain** what the changing magnetic field must have done to the coil.
3. **Describe** what the electric current in the coil did to the compass.
4. **Explain** why the electric current in the coil affected the compass.
5. **Compare** this model with a real electromagnetic survey.

9.3 Mines and wells

A mine or an oil well is not just a simple hole in the ground. Oil below the sea floor may require a massive drilling platform resting on the sea bottom. Gold may need a hole several kilometres deep with miners working in tunnels. Designing, building and operating mines and wells requires many skilled workers, from geologists and engineers to drillers and mechanics.

Mining methods

There are many different mining methods. Some methods are specific to a particular mineral or a specific type of coal. The method of mining chosen depends on three main factors:

- the type of mineral
- the geology of the area
- the cost and how much the mineral is worth.

Some of the more common mining methods are surface, underground, dredging and leach mining. Other methods exist as well. Figure 9.3.1 summarises some of these methods.

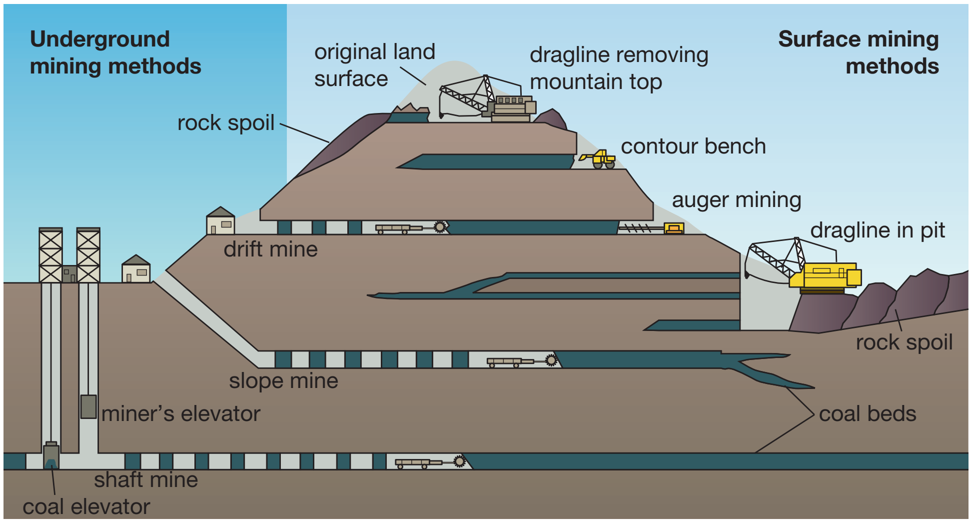
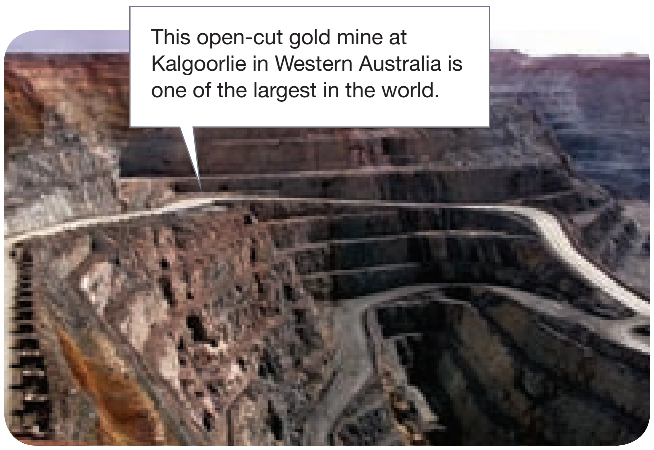


Figure 9.3.1 Many of the coal mining methods shown here are also used to mine other minerals.

Surface mining

When the ore body is near the surface, the cheapest option for mining may be to remove the soil and rocks covering it to get to the ore. A large, open working surface is created, often by drilling and blasting the rock with explosives. Removal of this rock creates a large pit or **open-cut** mine. The pit is usually designed with roads around its walls so that trucks and other machinery can be driven down to the working surface and the mined ore can be driven back up to the surface. The ore can be removed in various ways, such as by machines with large shovels, giant drills called augers and drag lines. A good example is the Kalgoorlie gold mine called the 'Super pit', shown in Figure 9.3.2.



Open-cut mines are suitable for low-grade ores. These are ores with a low concentration of the mineral present. Open-cut mines are also useful for ores that are spread out over a large area. The brown coal reserves of the Latrobe Valley in Victoria are widespread and are found relatively close to the surface. This makes open cut the easiest and cheapest way to mine the coal.

9.5

Figure 9.3.2 Three images of an open-cut gold mine in Kalgoorlie, Western Australia

SciFile

Big pit

The deepest open–pit mine in the world is Bingham Canyon Mine in Utah, USA. It is 1.2 km deep, about twice as deep as the Kalgoorlie super pit. It would take a rock about 15 seconds to fall to the bottom!

Underground mining

If the ore body is deep, fairly concentrated and confined to a small space or in narrow veins, then it may be too costly to remove the overlying rock. In these cases, underground mining is more suitable. Figure 9.3.3 shows one of the methods used.

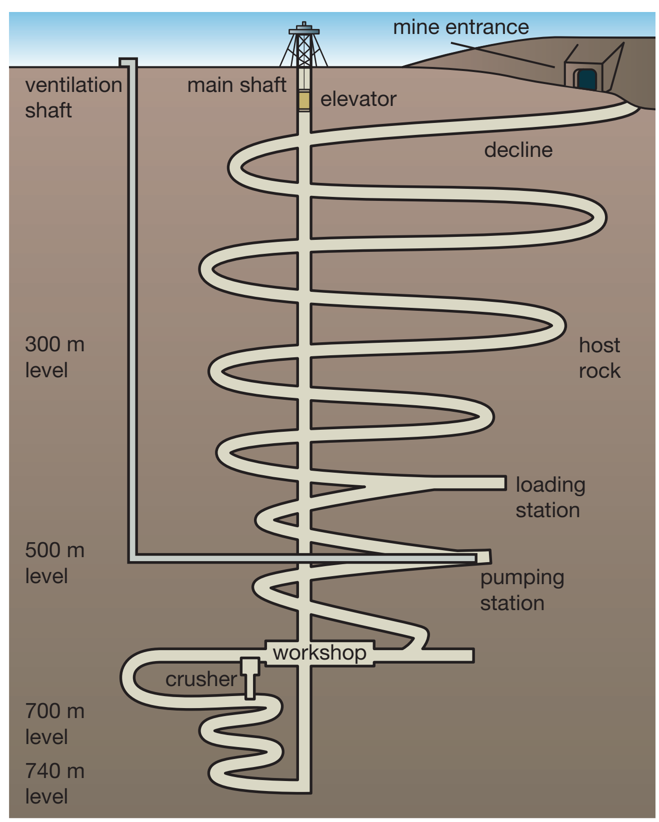


Figure 9.3.3 Underground mining using a decline enables trucks to drive down to pick up crushed ore and carry it to the surface.

One method uses **vertical shafts** down to the level of the ore body. Horizontal shafts are then dug out into the ore body itself. A hoist connected to a head frame lifts the mined ore to the surface.

> **SciFile**
>
> **Down deep**
>
> The deepest underground mine in the world at present is the TauTona Mine in Carletonville, South Africa. It is 3.9 km deep. Without its air-conditioning system, the temperature at the bottom would be about 60°C!

Another approach is to use a steady slope (called a **decline**) and drive the ore out by vehicle. The slopes of the tunnels are about 15 degrees.

If the ore body is inside a mountain, it can be reached by horizontal tunnels through the mountainside. These are called **adits**.

Dredging

Sand mining uses **dredging** to remove minerals from sand. A large pit is dug and filled with water to create a small lake. Then a dredging boat is floated on the surface. As you can see in Figure 9.3.4, the boat then uses large hoses to suck up the sand. The minerals are heavier than sand and so are easily separated from it when in water. The sand and the water are then pumped back into the lake.

Figure 9.3.4 This boat is dredging for mineral sands at the Gingko Mine, Pooncarie, 220 km south of Broken Hill in New South Wales

Leach mining

Some materials can be mined by dissolving them in a fluid that is injected into the ore body. The process begins by drilling bore holes into the ore deposit. A solution that will dissolve the ore, called a **leach solution**, is pumped into the ore. The dissolved ore in solution is then pumped to the surface through a second bore hole. You can see this in Figure 9.3.5.

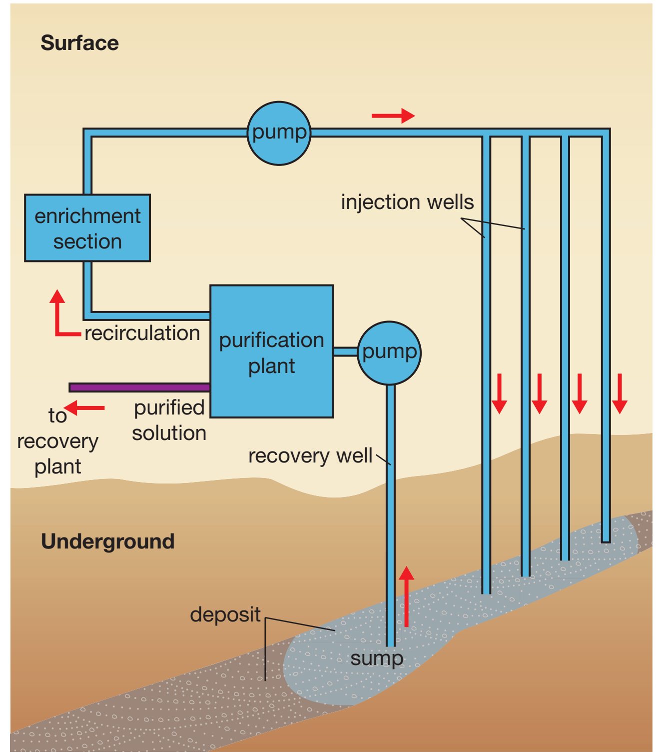


Figure 9.3.5 Leach mining involves injecting a solution to dissolve the ore underground and then pumping it back up to the surface.

The type of leach solution used varies according to the ore deposit. It simply could be water for some salt deposits. For copper ore, acids are generally needed. Copper carbonate ores such as malachite and azurite are recovered in this way. For uranium ores, the leach solution may be acid or sodium hydrogen carbonate.

1 p341

Petroleum wells

Removing from the ground requires a different method from mining for minerals. **Petroleum** occurs as both a liquid (oil) and a gas, and is usually found trapped within sedimentary rock layers.

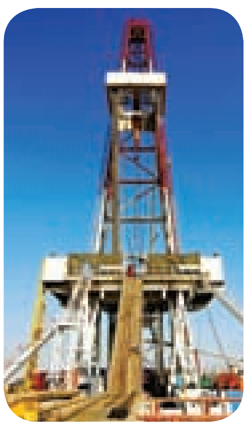
Petroleum is recovered by boring narrow holes down into the rock. A steel tower called a derrick is built to support the drilling equipment. This is shown in Figure 9.3.6. A hole is drilled deep into the earth until oil or gas is found, or the company gives up and starts drilling in a new area.

The drill usually has a rotating 'bit' that cuts into the rock. The bit is attached to a length of hollow drill pipe.

As the bit cuts deeper, more pipe is added. A mixture of clay, chemicals and water is continuously pumped through the drill pipe. This cools the drill bit and carries crushed rock to the surface.

When oil or gas is found, the drill pipe and bit are pulled from the **petroleum well**, and a metal casing (a hollow tube) is lowered into the hole and cemented in place. At the upper end of the casing is a system of pipes and valves called a wellhead. This allows the oil or gas to rise up to the surface and into separation and storage tanks.

Sometimes the natural pressure of the oil or gas drops and cannot force the oil to the surface. Then pumps may be used. In some cases, water, steam or gas may be injected into the well to increase the pressure or make the oil flow more freely.



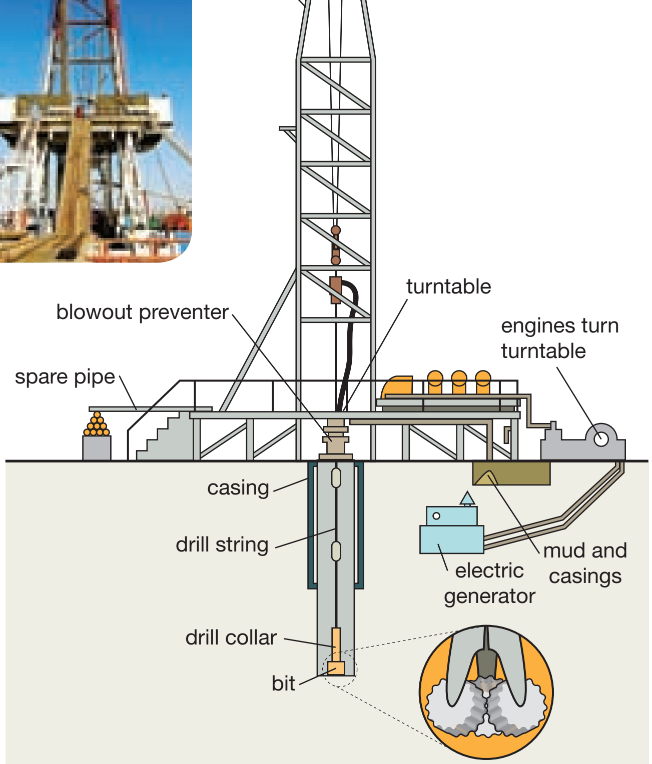


Figure 9.3.6 An oil derrick is a steel tower that supports the drilling equipment needed to drill an oil well.

Oil bugs

If oil does not flow easily out of an oil well, geologists have a trick. They pump in bacteria that like eating oil. The bacteria break down the oil molecules into smaller ones that flow more easily out of the rock.

SciFile

Oil and gas rigs in the ocean have a variety of designs. Some, like the one in Figure 9.3.7, rest on the ocean floor. Others are floating platforms tied to the ocean floor by wires. Some are ships that can move from place to place. The oil and gas can be pumped through pipelines on the sea floor to production factories on land. There are also floating ships that can link up to the well and collect the oil and gas for treatment and storage on board.

Oil and gas are flammable and the risk of disaster is high. Oil spills devastate the environment and strict laws exist to make sure that explosions (like the one in Figure 9.3.8) never occur.

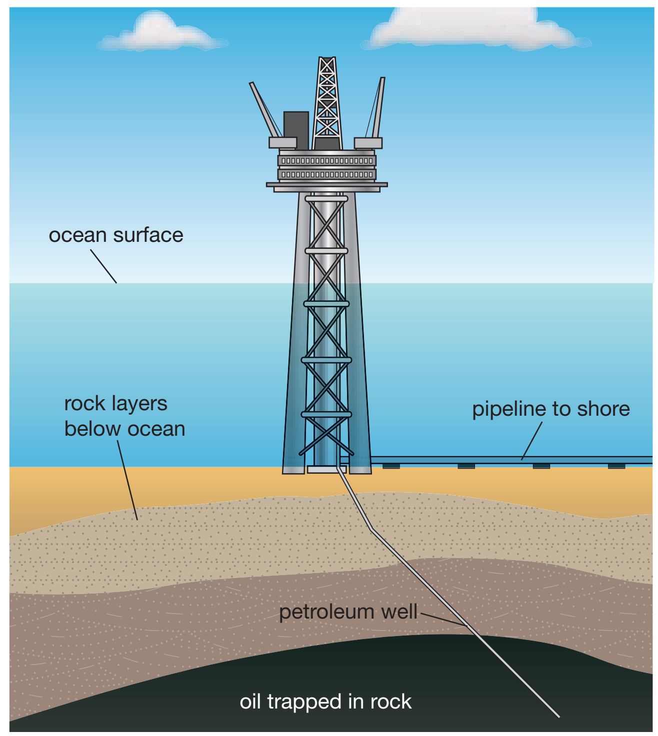


Figure 9.3.7 An offshore gas platform on the North West Shelf of Western Australia

Figure 9.3.8 Safety is vital on oil rigs. Accidents such as fires and oil spills can occur.

ENDEAVOUR

SCIENCE AS A HUMAN ENDEAVOUR

Use and influence of science

Environmental effects of mining

Figure 9.3.9 Water sprayed over gold ore to reduce dust during loading of a mining truck

Mining and oil exploration provide great benefits to our society. However, without proper laws, monitoring and protection procedures, damage to the environment can occur. Environmental damage can include erosion, subsidence of land, poisoning of soil and water, dust and loss of biodiversity.

Mining and processing of minerals produce large amounts of waste, called tailings. These are often toxic as they may contain acids or poisonous chemicals, such as cyanide from gold mining. Tailings are usually dumped into ponds surrounded by earth walls. Leaks in these ponds are common, with up to five major spills occurring every year worldwide.

In Hungary in 2010, a toxic sludge from a burst pond at an aluminium processing plant (Figure 9.3.10) swept through a village and killed eight people and injured another 150. It also polluted one of Europe's major rivers, the Danube.

In Australia, laws require mining companies to comply with strict procedures. Environmental scientists design and monitor pollution control measures. Dust levels are controlled by spraying water on roads, stockpiles and conveyor transfer points and fitting drills with dust collectors. Often there is an area of vacant land left between the mine and surrounding areas that may be affected by dust.

Figure 9.3.10 This spill at an aluminium processing plant in Hungary in 2010 killed eight people.

Water pollution is controlled by treating it chemically and leaving it to settle out in tailings dams. Clean run-off can be discharged (released) into surrounding watercourses, while other water is treated and re-used for reducing dust.

With underground mines, the surface area can still be used for other purposes such as farming, water reservoirs or urban development. This is obviously not possible with open-cut mines. They have to be rehabilitated (repaired) before they can be used for some other purpose. Rehabilitation may be done while mining is proceeding. In one part of the mine, there may be mining while in another part the area is being repaired. In general, the original top soils that were removed to create the open cut mine are replaced. Figure 9.3.11 shows the same mining site before and after rehabilitation.

The rehabilitation begins by carefully considering the water drainage of the area, so soil erosion can be reduced. This is achieved by ensuring that the slope of the land is not too steep and that vegetation can be planted to bind the soil together. Earthmoving is carried out using diggers to shape the surface to allow for this drainage. Sometimes a dam may be built to serve as a permanent source of water. Then the original topsoil that was kept from before the mining is replaced. The area is fertilised and replanted with plants native to the area. If pollution levels are safe, such areas may become suitable for parks or as refuges for wildlife such as waterbirds.

Figure 9.3.11 These photos show a bauxite mine site in Western Australia before and after the site was rehabilitated.

9.3 Unit review

Remembering

1 **State** the three main factors that determine what type of mining method is chosen.

2 **Name** four methods of mining.

3 **List** five methods of mining coal.

4 **List** five ways in which mining may cause environmental damage.

5 **Name** an example showing that mining can cause environmental damage.

Understanding

6 **Outline** the process of open-cut mining.

7 **Explain** why a mining company would choose open-cut rather than underground mining.

8 **Outline** the process of dredging mineral sands.

9 **Describe** the process of solution mining of copper ore.

10 **Explain** how petroleum can be removed by drilling a hole.

11 **Explain** how erosion problems may be prevented when designing the rehabilitation of a mine.

Applying

12 **Identify** the type of mining method you could choose if the ore body was:

- a gold at the surface
- b gold deep below the ground
- c coal in a mountainside
- d coal just below the surface
- e salt deep underground
- f uranium or malachite deep below ground.

13 The flow of oil from a well slows down after it has been in use for a while. **Identify** a method by which the flow may be increased again.

14 **Demonstrate** your knowledge of oil drilling by explaining the function of four key parts in Figure 9.3.6 on page 337.

15 **Demonstrate** your knowledge of mining methods by choosing a mining method shown in Figure 9.3.1 on page 334 and explaining what sort of ore body it would be used for mining.

Analysing

16 **Compare** adits, vertical shafts and declines as methods of underground mining.

17 **Compare** the leach liquids used in solution mining of salts and copper ore.

18 **Compare** removal of petroleum from the Earth with solution mining of uranium.

Evaluating

19 Gold miners in the past used shaft mines whereas modern mines on the same sites are open-cut. **Propose** what type of gold deposit the two mines located.

20 **Propose** why drilling rigs used in the ocean are sometimes mounted on board a ship rather than on a platform that is fixed to the ocean bottom.

Creating

21 **Construct** a diagram of an ore body in the ground that would probably be recovered using:

- a solution mining
- b underground mining
- c surface mining.

Inquiring

1 Research the advantages and disadvantages of open cut and underground mining methods. Present evidence for both their suitability as mining methods and the environmental effects.

2 Research an important mining or petroleum operation in your state or territory. Discuss the location, mineral or resource being recovered, and any benefits you think it gives your local community.

3 Research three sites where environmental damage has been caused by mining. Some sites you could start with are the Ok Tedi Mine in New Guinea, the Sukinda Valley in India and Kabwe in Zambia.

4 Research the environmental dangers of offshore oil rigs and find at least two examples of disasters.

9.3 Practical activities

1 Leach mining

Purpose

To model the process of leach mining.

SAFETY
Sulfuric acid is corrosive.

Materials

- 500 mL beaker
- 250 mL beaker
- test-tube and rack
- 400 mL fine crushed rock (not soil)
- 2 g copper carbonate
- 5 mL syringe and plastic tube
- 2 × 10 cm plastic tubes, each containing a pencil (for wells)
- filter funnel (plastic)
- retort stand, bosshead and clamp
- 100 mL 0.2 M sulfuric acid
- spoon
- iron nail

Procedure

1 Place 2 g of copper carbonate (your mineral) in the large beaker.

2 Fill the beaker with the fine crushed rock to a few centimetres below the top.

3 Make sure the pencil is not a tight fit in the plastic tube and can be removed easily. Drill a hole down to the copper ore using the plastic tube containing the pencil. This is the injection well. Try to reach the bottom of the beaker. Remove the pencil.

4 Place the filter funnel in a retort stand. Connect the end of the filter funnel to the plastic tube in the beaker. Make sure the lower end of the plastic tube is about half a centimetre off the bottom of the beaker as shown in Figure 9.3.12.

5 Carefully pour about 100 mL of sulfuric acid into the filter funnel, making sure it does not spill over the top of the funnel. Leave to stand for about 2 minutes.

6 Drill another hole down into the beaker using the other plastic tube containing the pencil. Make sure it is about half a centimetre off the bottom of the beaker. Remove the pencil. This is the recovery well.

7 Pass the other end of the plastic tube on the syringe down into the recovery well.

8 Carefully pull the plunger out on the syringe. When you recover some liquid, squirt it into the test-tube. Keep removing liquid until you have about 20 mL. (If you cannot remove any liquid, push the plastic tube of the recovery well down to the bottom of the beaker and try again with the syringe.)

9 Add an iron nail to the test-tube of recovered mineral and observe it for several minutes.

Results

Record your observations.

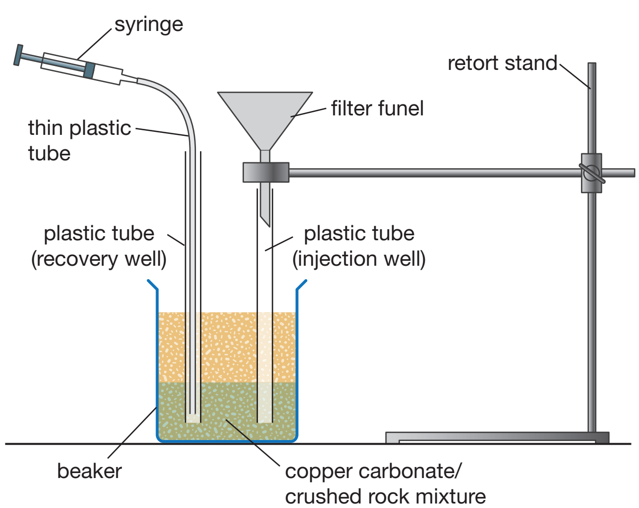


Figure 9.3.12

Discussion

1 **State** the part of this model that represents the:
   a ore body
   b mineral
   c injection well
   d recovery well
   e leach solution
   f pump.

2 **Describe** how this model showed the process of solution mining using a leach solution.

3 From your observations on this simulation, **propose** what would need to be done to the leach solution after it is pumped out of the recovery well in a real leach mine.

4 **Describe** what happened when the iron nail was placed in the blue solution.

5 **Propose** what substance was formed on the iron nail.

9 Chapter review

Remembering

1 **List** some reasons why mining is important to Australia.

2 **List** ten minerals that are important to Australia.

3 **List** five exploration methods used to locate minerals, coal or oil.

4 **List** the following steps in the correct order when extracting a metal from the Earth: enrichment, mining, exploration, mapping, extracting.

Understanding

5 **Explain** how iron ore, copper ore, gold and diamonds came to be where they are found.

6 **Explain** how coal and oil are formed.

7 **Describe** three aerial exploration methods used to locate ore deposits.

8 **Describe** how geologists represent ore bodies on a geological map.

9 **Outline** the process of environmental repair in the mining industry.

10 **Describe** five different jobs that enable us to use the resources of the Earth.

11 **Modify** the following definitions to make them correct.
- **a** A mineral is a naturally occurring substance in the Earth's crust.
- **b** A streak is the colour when the mineral is crushed to a powder.
- **c** An electromagnetic survey measures the effect of applying an electric current to the Earth.
- **d** A seismic survey sends a magnetic field into the ground surface and records the reflected waves.

Applying

12 Write a procedure to a prac that would **demonstrate** that gravity can separate heavy minerals from the rest of the ore.

13 Steel is harder than copper. Write a method that would **demonstrate** this.

14 Magnetite, cassiterite, tourmaline and haematite often look the same. They are all black minerals. However, one is magnetic. Testing the streak of the three remaining minerals gives one red streak and two white streaks. The two minerals with white streaks have very different densities. **Outline** the tests that would allow you to **identify** which mineral is which.

Analysing

15 **Compare** the suitability of open-cut mining with that of underground mining for an ore body that starts 20 metres below the surface and runs in narrow channels 2 km into the Earth.

Evaluating

16 **Propose** a suitable mining method if the ore body is:
- **a** iron ore at the surface and spread over a large area
- **b** gold at the surface in narrow veins
- **c** coal deep below ground
- **d** salt on the surface.

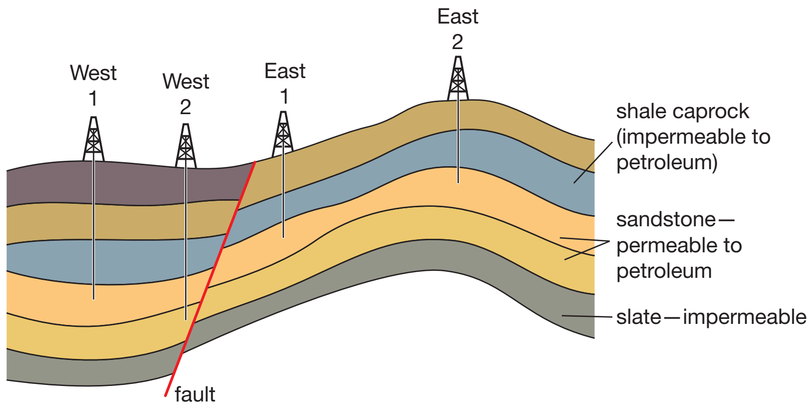
Creating

17 **Use** the following ten key terms to **construct** a visual summary of the information presented in this chapter.

mineral
hardness
coal
ore
petroleum
exploration
mine
open-cut
well
rehabilitation

Thinking scientifically

Q1 Petroleum is less dense than water and so tends to rise up through rock. Consider this diagram showing four possible sites to drill for petroleum.

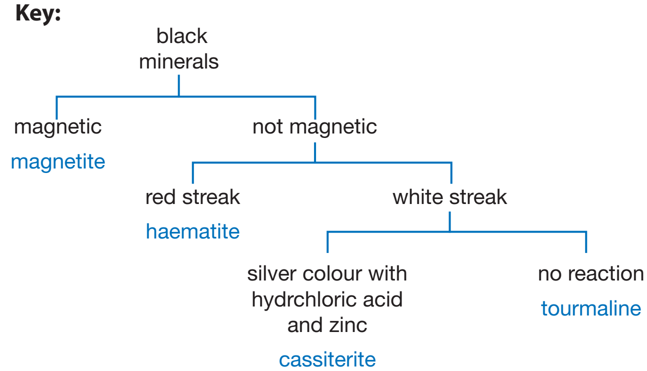


The best place to choose would be:

A West 1
B West 2
C East 1
D East 2.

Q2 Consider the key on the right, which shows how to distinguish between four black minerals.

Key:



Which of the following is correct?

A Cassiterite can only be distinguished from tourmaline by checking the streak.
B Haematite and tourmaline do not react with hydrochloric acid when in contact with zinc.
C Tourmaline cannot be distinguished from cassiterite by the streak test.
D Magnetite and tourmaline are magnetic.

Questions 3 and 4 refer to the table of mining methods on the right.

Name	Use	Description
Shaft	Deep ore body	Vertical tunnel
Decline	Deep ore body	Tunnel on a slope
Adit	Ore body in a mountain	Horizontal tunnel into mountainside
Open-cut	Ore body near surface spread over wide area	Large hole with series of steps down and roads around inside of the sloping walls. Working surface goes deeper as it is mined
Dredge	Ore body in soil	Hole flooded and slurry dredged up and separated usually by gravity
Strip mining	Shallow resource (e.g. coal) spread over long distance or area	Machine moves along, stripping the surface and gradually going deeper
Leach	Soluble ore body	Solution pumped in to dissolve ore and then pumped out again

Q3 A suitable mining method for mineral sands at a beach would be:

A shaft
B adits
C decline
D dredging.

Q4 The mining method that would probably not require crushing of the ore after mining would be:

A leach
B open-cut
C decline
D strip.

Glossary

Unit 9.1

Flame test: the colour a mineral glows when heated to a high temperature in a flame

Hardness: physical property based on ability to scratch particular minerals

Hydrothermal fluids: superheated liquids in the Earth's crust

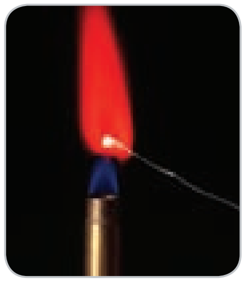
Lustre: how shiny a mineral is

Mineral: a naturally occurring liquid or solid in the Earth's crust but not including oil or coal

Ore: rocks containing minerals

Ore body: large deposit of ore

Streak: the colour of the mark left by scraping the mineral on a white unglazed tile



Flame test

Streak

Unit 9.2

Core sample: a drilled sample of rock

Cross-section: side view

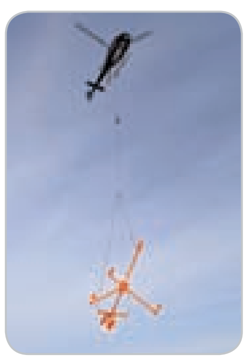
Electromagnetic (EM) survey: a survey that measures the effects of applying a magnetic field to the Earth

Geochemistry: the use of chemistry to show what minerals are present in an area

Geological map: map that shows the geology of an area, including the appearance of the ore bodies from above and from the side

Gravimeter: very sensitive instrument that measures small differences in the gravitational pull of the Earth

Magnetometer: device that measures magnetic field strength



EM survey

Satellite images: images created using data from satellites that detect electromagnetic radiation from Earth

Seismic survey: when a shock wave is sent into the ground surface, and the reflected sound waves are recorded

Satellite image

Unit 9.3

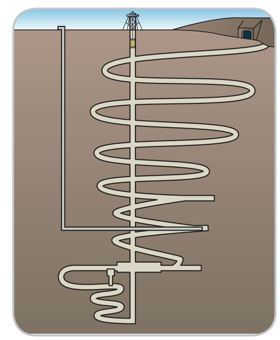
Adit: horizontal tunnel through a mountain

Decline: underground shaft that is on a slope, allowing vehicles to drive up and down

Dredging: process involving a floating platform that mixes water and rocks or soil to separate minerals

Leach solution: a solution pumped into the ground to dissolve minerals in the rocks

Petroleum: oil and gas occurring naturally in rocks

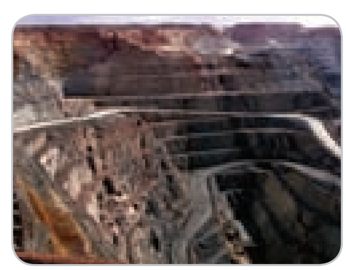


Decline

Petroleum well: narrow hole drilled into the rock, allowing oil and gas to escape to the surface

Open-cut mine: a large pit dug into the ground surface

Vertical shaft: a narrow tunnel dug vertically downwards into the Earth



Open-cut mine