The Science of Mining

Queensland Government
Natural Resources, Mines and Energy

QUEENSLAND resources COUNCIL

Acknowledgements

Authors

Althea Gallaway
Nicolette Palmer

Concept, curriculum and editing

Kathleen Gordon, Education, Training and Curriculum Services

Project managers

Robert Wilson, Queensland Resources Council
Cheryl Petith, Department of Natural Resources, Mines and Energy
Linda Dobe, Department of Natural Resources, Mines and Energy
Claire Greer-Wilson, Department of Natural Resources, Mines and Energy

Editor

Tony Barker, Wordsmith Editorial Services

With thanks

David Carmichael, Department of Natural Resources, Mines and Energy
Marcin Ziemski, University of Queensland
Jim Beeston, Department of Natural Resources, Mines and Energy
John McKellar, Department of Natural Resources, Mines and Energy
Bernie Stockill, Department of Natural Resources, Mines and Energy
Francis Hayter, Queensland Resources Council
Caroline Morrissey, Queensland Resources Council
Andrew Mutton, GeoDiscovery Group Pty Ltd
Chris Towsey, Citigold Corporation Ltd

Design and printing

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Queensland Resources Council

The Queensland Resources Council (QRC), through its education program, aims to give teachers and students a balanced and informed understanding of our State's mineral and energy resources industries.

The QRC is strongly committed to developing and providing educational resources about our industry in Queensland and has produced teaching materials in the Key Learning Areas of Science, Studies of Society and the Environment and Technology.

The QRC offers free in-school presentations to primary (years 5–7) and secondary (years 8–12) students in south-east Queensland, the Darling Downs, Rockhampton, Townsville, Charters Towers and Cairns. Our Education Officers also visit regional centres throughout the year. To make a booking, contact the Education Manager.

Free professional development opportunities for teachers are offered, including seminars, workshops and geoscience short courses.

For further information, contact:
Education Manager
Queensland Resources Council
Level 13
133 Mary Street
BRISBANE QLD 4000

Telephone: (07) 3295 9560
Facsimile: (07) 3295 9570
E-mail: education@qrc.org.au
Web: www.qrc.org.au

The Department of Natural Resources, Mines and Energy

The Department of Natural Resources, Mines and Energy (NRM&E) works with the community and industry to manage and appropriately develop Queensland's natural resources. It is the department's role to mange our land, water, vegetation, energy and mineral and petroleum assets and foster sustainable environmental, economic and social returns from these resources.

Mining has been vital to the development of Queensland with the establishment of inland towns and cities as well as jobs and providing billions of dollars in export earnings. The department has played a central role in the industry by providing a number of services. These include promoting the State's potential, assisting in land access negotiations, developing geological data, managing safety and health standards and encouraging environmental best practice. NRM&E also manages leasing, permits and royalties, assists with investment opportunities and improves safety through scientific research.

For further information, contact:
Manager
Strategic Networks, Information and Liaison
Natural Resources, Mines and Energy
Level 3, Mineral House
41 George Street

Telephone: (07) 3237 1435
Facsimile: (07) 3229 7770
E-mail: mines@nrm.qld.gov.au
Web: www.nrm.qld.gov.au

Contents

Overview

The Science of Mining gives secondary science students opportunities to explore earth science in the context of mining activities in Queensland. The material is organised around outcomes from the Queensland Science Syllabus and is written for students operating at levels four, five and six.

The Science of Mining is divided into four sections, each focusing on a key question asked by students about rocks, minerals and mining.

- How are rocks and minerals formed?
- How are minerals found and mined?
- How does mining affect communities?
- How are minerals and oil processed and used?

Each section has teaching notes and resource sheets. The teaching notes advise how to carry out the activities. The resource sheets include fact sheets, work sheets, practicals and demonstrations.

The following icons are used in this book to help quickly identify activities:

Factsheets Worksheet Demonstrations Practicals

A table of useful contacts will help teachers to locate and obtain additional resources.

Outcomes

The material provides teaching and learning activities that address 17 science outcomes. These outcomes are drawn from three of the five science strands. The table lists the outcomes and the sections where they are addressed.

Science strand	Science outcomes	Outcomes are addressed in these sections
Science and Society (SS)	**4.3** Students present analyses of the short- and long-term effects of some of the ways in which science is used.	How are minerals found and mined? How does mining affect communities?
	5.2 Students refine investigations after evaluating variations and inconsistencies in experimental findings.	How are minerals found and mined?
	5.3 Students analyse the relationship between social attitudes and decisions about the applications of science.	How does mining affect communities?
	6.3 Students use scientific concepts to evaluate the costs and benefits of applications of science (including agricultural and industrial practices).	How are minerals found and mined?
Earth and Beyond (EB)	**4.1** Students recognise and analyse some interactions (including the weather) between systems of Earth and beyond.	How are rocks and minerals formed?
	4.3 Students summarise information to compare ways in which different communities use resources from the Earth and beyond.	How does mining affect communities?
	5.1 Students explain how present-day features and events can be used to make inferences about past events and changes in Earth and beyond.	How are rocks and minerals formed? How are minerals found and mined?
	5.2 Students infer from data that the events that occur on Earth and the solar system can have effects at other times and in other places.	How are rocks and minerals formed?
	5.3 Students prepare scenarios about the use of renewable and non-renewable resources of the Earth and beyond.	How are minerals found and mined? How does mining affect communities?
	6.1 Students use scientific ideas and theories about interactions within and between systems of the Earth and beyond to explain past and present features and events.	How are rocks and minerals formed?
	6.3 Students argue a position regarding stewardship of the Earth and beyond, and consider the implications of using renewable and non-renewable resources.	How are minerals found and mined? How does mining affect communities?

Natural and Processed Materials (NPM)	**4.1** Students collect information and propose ideas to explain the properties of materials in terms of each material's underlying structure.	How are minerals found and mined? How are minerals and oil processed and used?
	4.3 Students examine and assess ways that materials can be changed to make them more useful.	How are rocks and minerals formed? How are minerals and oil processed and used?
	5.1 Students present information in a variety of ways to explain the structure and behaviour of matter, in terms of the particles of which it is made.	How are minerals and oil processed and used?
	5.3 Students devise tests and interpret data to show that the properties and interactions of materials influence their use.	How are minerals and oil processed and used?
	6.1 Students explain the structure and properties of matter, using models of atoms and molecules.	How are minerals and oil processed and used?
	6.3 Students collect and present information about the relationship between the commercial production of industrial, agricultural and fuel products and their properties.	How are minerals and oil processed and used?

Assessment

Each chapter contains worksheets, practicals and assignment tasks that can be included in student portfolios.

In the assignment tasks, students are invited to:

- create a representation of the formation of a chosen type of rock and present it in a format of the student's choice
- review mining methods and present the positive and negative features of their use
- simulate a community forum about whether to mine the school oval after the discovery of a significant gold deposit
- research the production of an object by tracking the minerals used in its manufacture and then presenting this information in a format of the student's choice.

The practicals contained in this resource are listed below.

Practical	**Page no.**
Identifying some common rocks and minerals	xx
Investigating the properties of some common minerals	
Investigating how temperature affects crystal size	
Investigating sedimentation	
Investigating the properties of rocks before and after metamorphism	
Investigating the rock cycle	
Searching for an iron nail	
Percussion air drilling	
Biscuit mining	
Measuring and comparing steepness and wall height in an open cut mine	
Preventing cave-ins in underground mines	
Leach mining in Queensland	
Ice-cream container mining and rehabilitation	
Surveying and mapping of local vegetation	
Managing oil spills	
Investigating ceramics	
Working a metal: the effects of hammering and bending	
Heat treatment: the effects of annealing, quenching, tempering	
Investigating reactivity	
Obtaining metals: lead by smelting and copper by electrolysis	
Investigating some products of crude oil	

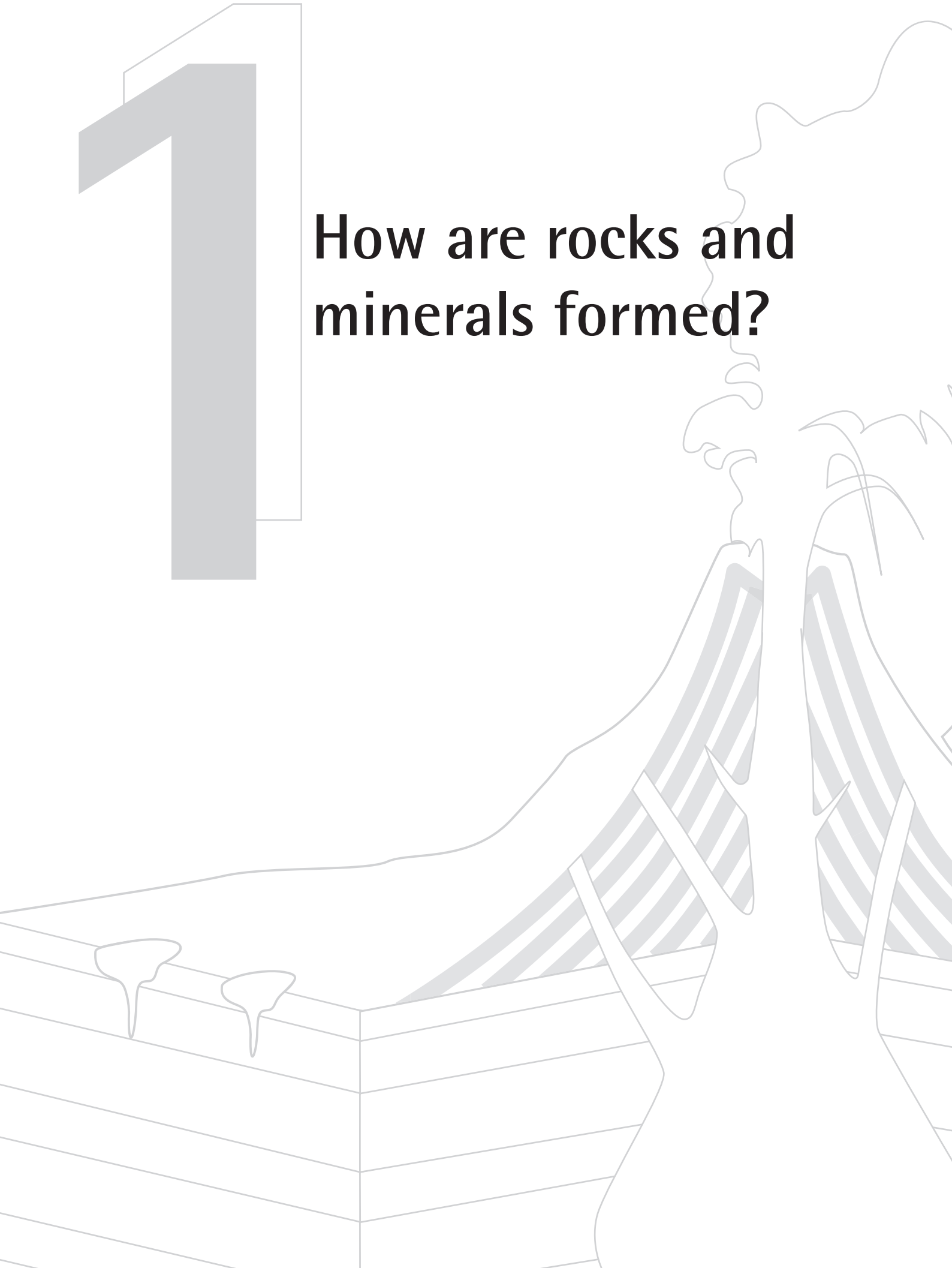
Student portfolios can contain:
- observation notes and recorded data from practicals and demonstrations
- written responses to consolidation questions
- completed worksheets
- students' reflective writing.

Teachers are encouraged to start with students' prior knowledge, and then negotiate assessment with students, use criteria sheets for assignments and use checklists, anecdotal records and observation notes to record student participation, concept development and demonstration of skills.

Contacts

Organisation/company	Contact details	What do they have?
Australian Petroleum Production Exploration Association	GPO Box 2201, Canberra, ACT 2601 Telephone: (02) 6247 0960 Facsimile: (02) 6247 0548 E-mail: appea@appea.com.au Website: **www.appea.com.au**	CD-ROM Discovery Explore the World of Oil and Gas.
Bayside Chemicals	PO Box 167, Mt Gravatt, Qld 4122 Telephone: (07) 3889 7022 Facsimile: (07) 3889 7033	Scientific materials and equipment.
Crown Scientific	PO Box 134, Newstead, Qld 4006 Telephone: (07) 3252 1066 Facsimile: (07) 3252 5664	Scientific materials and equipment.
Department of Natural Resources, Mines and Energy (Bureau of Mining and Petroleum)	Level 3, 41 George Street, Brisbane, Qld 4000 Telephone: (07) 3237 1435 E-mail: mines@nrm.qld.gov.au Website: **www.nrm.qld.gov.au**	Fact sheets, maps, general mining questions.
Geological Specimen Supplies	PO Box 542, Archerfield, Qld 4108 Telephone: (07) 3345 4253 Facsimile: (07) 3344 1582	Rock and mineral specimens.
Geoscience Australia	Websites: **www.ga.gov.au** **www.nationalminesatlas.gov.au**	Fact sheets, maps, geological information.
Queensland Resources Council	Level 13, 133 Mary Street, Brisbane, Qld 4000 Telephone: (07) 3295 9560 Facsimile: (07) 3295 9570 E-mail: education@qrc.org.au Website: **www.qrc.org.au**	Fact sheets, teaching materials, school visits.
Wardrop Laboratory Supplies	2/2 Pinacle St, Brendale, Qld 4500 Telephone: (07) 3881 3755 Facsimile: (07) 3881 3870	Scientific materials and equipment.

1 How are rocks and minerals formed?



How are rocks and minerals formed?

Outcomes

Science strand	Level 4 outcomes			Level 5 outcomes			Level 6 outcomes		
Earth and Beyond	4.1			5.1	5.2		6.1		
Natural and Processed Materials	4.1			5.1					

Teaching and learning activities

Focus areas	Resource sheets
Introduction—our Earth	1. As the Earth moves 2. Acrostic vocabulary activity 3. Tectonic plate activities
The link between rocks and minerals	4. What's in a rock? 5. Identifying minerals 6. Minerals 7. Identifying some common rocks and minerals 8. Investigating the properties of some common minerals
The formation of igneous rocks	9. Formation of igneous rocks 10. Investigating how temperature affects crystal size
The formation of sedimentary rocks	11. Formation of sedimentary rocks 12. Sedimentary rocks 13. Investigating sedimentation
The formation of metamorphic rocks	14. Formation of metamorphic rocks 15. Investigating the properties of rocks before and after metamorphism
Putting it all together—the rock cycle	16. The rock cycle 17. Investigating the rock cycle 18. Rock star

Teaching notes

Introduction—our Earth

Outcomes: Working towards EB 5.2 and 6.1.
Assessment ideas: Inclusion of worksheets in portfolio.

1. As the Earth moves

Invite students to brainstorm what they know about the Earth's structure. Then use this fact sheet to introduce them to the idea of Earth as a changing rather than static planet.

2. Acrostic vocabulary activity

To stimulate students or informally assess their understanding, use this work sheet either in conjunction with their reading, or after they have read, Resource 1: 'As the Earth moves'. For more capable students, you may wish to remove the wordlist provided.

3. Tectonic plate activities

This work sheet gives students another opportunity to consider the Earth as a changing planet. Enlarge the first map to A3 for students to work on in small groups and discuss their ideas. The second map could be given to students to complete on their own. This task can be used to demonstrate outcomes EB 5.2 and 6.1.

The link between rocks and minerals

Outcomes: Working towards EB 5.1, NPM 4.1.
Assessment ideas: Inclusion of work sheets and practical notes in portfolio.

Resource note. Rock and mineral kits can be bought from Geological Specimen Supplies (see contacts, page xx). Supplies can also be sourced from stonemasons.

4. What's in a rock?

Invite students, working in small groups, to list as many substances as they can think of that come from rocks and minerals before giving them this fact sheet to read.

5. Identifying minerals

This activity could be used to identify the differences between minerals or as an identification exercise. In the latter, the minerals would need to be numbered. Students would then match their descriptions against those supplied in the kit.

6. Minerals

This activity enables students to consolidate their knowledge of minerals. It can be used before or after Activity 7.

7. Identifying some common rocks and minerals

This practical can be completed each time a mineral/rock group is studied, making it four times in total. On each occasion, students complete the appropriate table on the record sheet, building upon their knowledge, before completing the identification quizzes and final test.

Before the practical

- Organise a class discussion of prior knowledge, including a review of physical features. Brainstorm a list of characteristics that could be used in the practical; for example, flaky, smooth, black or shiny.
- Model the activity.
- Invite students to form small groups and examine one sample at a time. Have students complete the first and second column of the table.
- Encourage students, in their groups, to contribute memory-jogger ideas.

After completing the practical

- Review the physical features of each sample.
- Consolidate students' work by giving revision quizzes, building up to the identification test given at the end of this chapter. As students proceed through each rock group, add to the list of names on the board until they have all 24 samples named. Quiz students, for five minutes, at the start or end of each lesson, gradually reducing the amount of scaffolding over a few weeks. An example is set out below.
  - Start with a list of mineral/rock names on the board and ask students to identify the ones you hold up. They can give oral answers only and can use their record tables to help.
  - Repeat without record tables.
  - Next, use a list of mineral/rock names (labelled A-X). When a sample is shown, students record the corresponding letter as their answer.
  - Finally, give the students a practice of the identification test.

Identification test

At the end of this unit give students a mineral/rock identification test. Place samples of all the rocks and minerals under numbered pieces of paper randomly around the room. Under test conditions students must identify them and record their work on the test sheet (page xx). For example, start each student at a different number and instruct the student when to move from sample to sample.

8. Investigating the properties of some common minerals

This task can be used to demonstrate outcome NPM 4.1.

Before the practical

- Organise a class discussion of the properties of minerals, in particular Mohs' scale of hardness (see Resource 5).
- Advise students to make <u>one</u> attempt only at scratching with each combination of minerals or materials. The scratching test is destructive, and specimens can be damaged or destroyed if they are scratched too often.
- Have students complete the table.

After completing the practical

- Organise a class discussion about the results, and discuss consolidation questions.

Answers to consolidation questions

1. Answers include density, solubility, odour, streak and hardness.
2. No. You would have to perform the other tests to confirm if they were the same or different.

The formation of igneous rocks

Outcomes: Working towards EB 5.1 and NPM 5.1.
Assessment ideas: Inclusion of practical notes in portfolio.

9. Formation of igneous rocks

After students have read this fact sheet, they complete the igneous rock section on Resource 7: 'Identifying some common rocks and minerals'.

10. Investigating how temperature affects crystal size

This task can be used to demonstrate outcome NPM 5.1.

Before the practical

- Prepare a hot concentrated solution of potassium permanganate, have some slides already in the fridge to cool and have warm water ready.
- Recap the difference in the size of crystals formed, the speed of their formation and the site of their formation.
- Recap the use of the microscope, and stress the need to keep slides dry so as to avoid splashing any of the solution on the objective lenses; for example, focus away from the slide.
- Focus students' attention on:
  - what they are actually looking for (formation of crystals)
  - what results are to be recorded (the rate at which the crystals form; for example fast, slow or intermediate)
  - drawing the crystals under the low power of the microscope to show relative size and shape.

Safety alert

Advise students that they must be extremely careful when using the potassium permanganate. Avoid inhalation, contact with skin and eyes, and ingestion. The table below details symptoms and treatment. It is extracted from the Material Safety Data Sheets (MDMS).

Exposure	Symptoms	Treatment
Inhalation	Burning sensation, sore throat, shortness of breath, laboured breathing (symptoms might be delayed).	Refer for medical attention, fresh air, rest, half-upright position, artificial respiration may be needed.
Contact with skin	Redness, pain, burns.	Refer for medical attention, rinse with plenty of water, remove contaminated clothes and rinse again.
Contact with eyes	Redness, pain, severe deep burns.	Refer for medical attention, rinse with plenty of water for several minutes (remove contact lenses, if easily done), take to a doctor.
Ingestion	Burning sensation, abdominal pain, diarrhoea, nausea, vomiting, shock or collapse (do not drink or eat while working with potassium permanganate).	Refer for medical attention, rinse mouth, give plenty of water, do NOT induce vomiting.

After completing the practical

- In a class discussion, reinforce the relationship between the cooling rate and the size of crystals formed.
- Invite students to complete consolidation questions.

Answers to consolidation questions

1. As molten rock cools, the atoms within it join to make crystals. When cooled slowly, large crystals are formed. When cooled quickly, small crystals are formed.
2. The slower cooling rate produces larger, interlocking crystals.
3. smallest crystals — cold
   room temperature
   largest crystals — warm
4. Cold (cools quickly)—basalt, obsididian, pumice, tuff; room temperature (moderate rate of cooling) — andesite, trachyte; warm (cools slowly) — granite, gabbro, porphyry.

The formation of sedimentary rocks

Outcomes: Working towards EB 4.1 and 5.1.
Assessment ideas: Inclusion of practical notes and work sheet in portfolio.

11. Formation of sedimentary rocks

After students have read this fact sheet, they complete the sedimentary rocks section on Resource 7: 'Identifying some common rocks and minerals'.

12. Sedimentary rocks

After Activity 11, invite students to complete this work sheet to consolidate their understanding of sedimentary rocks.

13. Investigating sedimentation

This task can be used to demonstrate outcome NPM 5.1.

- Discuss with students how to make a hypothesis.
- Discuss and provide examples of how to record observations visually by drawing diagrams scientifically.

After completing the practical

- Organise a class discussion about student observations.
- Discuss the consolidation questions, before inviting students to answer them individually.

Answers to consolidation questions

1. The largest sediments had settled before the picture was drawn. The smallest sediments took the longest to settle.
2. Small sediments are generally light and, therefore, do not settle as quickly.
3. Students' answers will vary, depending on their hypotheses. Most students will have predicted that the largest sediments will be on the bottom and that the layers of sediments will contain smaller grains as you go up the jar. This will be correct for the first observation; but once the jars have been left for some time, the smallest sediments will fall through the gaps and fill up some of the spaces between the largest sediments.
4. The smaller the sediment, the longer it takes to settle.

The formation of metamorphic rocks

Outcomes: Working towards EB 4.1 and 5.1.
Assessment ideas: Inclusion of practical notes in portfolio.

14. Formation of metamorphic rocks

After students have read this fact sheet, they complete the metamorphic rocks section on Resource 7: 'Identifying some common rocks and minerals'.

15. Investigating the properties of rocks before and after metamorphism

This task can be used to demonstrate outcome EB 5.1.

Before the practical

- Students should have read and understood Resource 14.
- The chosen rock samples need to clearly show the characteristics of each rock group, for students to successfully be able to pair them up.

- A class discussion could take place about what physical features students will examine to pair up the rocks; for example, colour, type of grain/crystal and presence of layers.

After completing the practical
- Organise a class discussion about results.

The expected results

Parent rock	Metamorphic rock	Similarities	Differences	Main cause of metamorphism
Shale	slate			pressure
Shale	schist			heat + pressure
Granite	gneiss			pressure + heat
Sandstone	quartzite			heat
Limestone	marble			heat

- Discuss the consolidation questions, before inviting students to answer them individually.

Answers to consolidation questions
1. Igneous and sedimentary.
2. Increased temperature and pressure.
3. Great pressure, as a result of being buried under the huge weight of the rocks.
4. As a result of contact with high temperature or hot magma.
5. Marble is formed from limestone. The marble can be considered to be the new generation of the original limestone.
6. Marble is formed from limestone. Limestone is made from the deposits of sea organisms such as shells and corals. Therefore, the area had to be under the sea for the original limestone to form before it was metamorphosed into marble.

Answer to extension question
1. A rock that is formed from molten rock is classified as an igneous rock.

Putting it all together—the rock cycle

Outcomes: Working towards EB 5.1.
Assessment ideas: Inclusion of practical notes in portfolio and assignment presentation about the formation of rock.

16. The rock cycle

This information could be used to either introduce or conclude this section. Used at the beginning, it introduces the process to students before they explore parts of the process in detail. Used at the end, the diagram could be given to students with the written text blanked out. This could be provided separately and students invited to label the diagram.

17. Investigating the rock cycle

This practical can be tricky. If students do not heat the limestone chip sufficiently in Step 1, then all other steps will be unsuccessful. Results are better if the bunsen burner is held by the base and the blue flame is directed onto the limestone. It still takes at least 15 minutes for the limestone to reach and maintain a sufficiently hot temperature. Alternatly this could be a demonstration.

Before the practical

- Recap the formation of limestone and its chemical composition.
- If doing this experiment as a whole-class practical, discuss the observations for which students will be looking; for example, changes in colour, form (such as solid, powder), change in temperature, gases given off, precipitate (solid) formed.

Safety alert Equipment will become exceptionally hot so revise guidelines to avoid burns and what action to take if this should happen.

After completing the practical

- Organise a class discussion about student observations.

The expected results

Reaction	Observations
Reaction 1	Limestone chip glows red, changes colour and becomes grey.
Reaction 2	Chip breaks into smaller pieces, becomes very hot, gas given off.
Reaction 3	White precipitate forms in the water.

- Discuss the consolidation questions before inviting students to answer them individually.

Answers to consolidation questions

1. Reaction 1—change in colour
   Reaction 2—heat given off, gas given off
   Reaction 3—formation of a new substance (precipitate)
2. Reaction 1—lime
   Reaction 2—aquafication
   Reaction 3—deposition
3. Start and finish with the same substance, which has been changed along the way.
4. Reaction 1—extreme heat = metamorphism
   Reaction 2—weathering to produce sediments
   Reaction 3—deposition of sediments

Answers to extension questions

Word equations

Reaction 1—limestone → lime
Reaction 2—lime → limewater
Reaction 3—limewater → limestone

Formula equations

Reaction 1—$CaCO_{3(s)}$ → $CaO_{(s)} + CO_{2(g)}$
Reaction 2—$CaO_{(s)} + H_2O_{(l)}$ → $CaO_{(aq)}$
Reaction 3—$CaO_{(aq)} + CO_{2(g)}$ → $CaCO_{3(s)}$

18. Rock star

This task can be used to demonstrate outcome EB 5.1.

This assessment task caters for diverse learning styles and abilities. It enables students to choose how they develop and present the concepts they have learned in this section. Students could be encouraged to choose rocks found in their local area or elsewhere in Queensland.

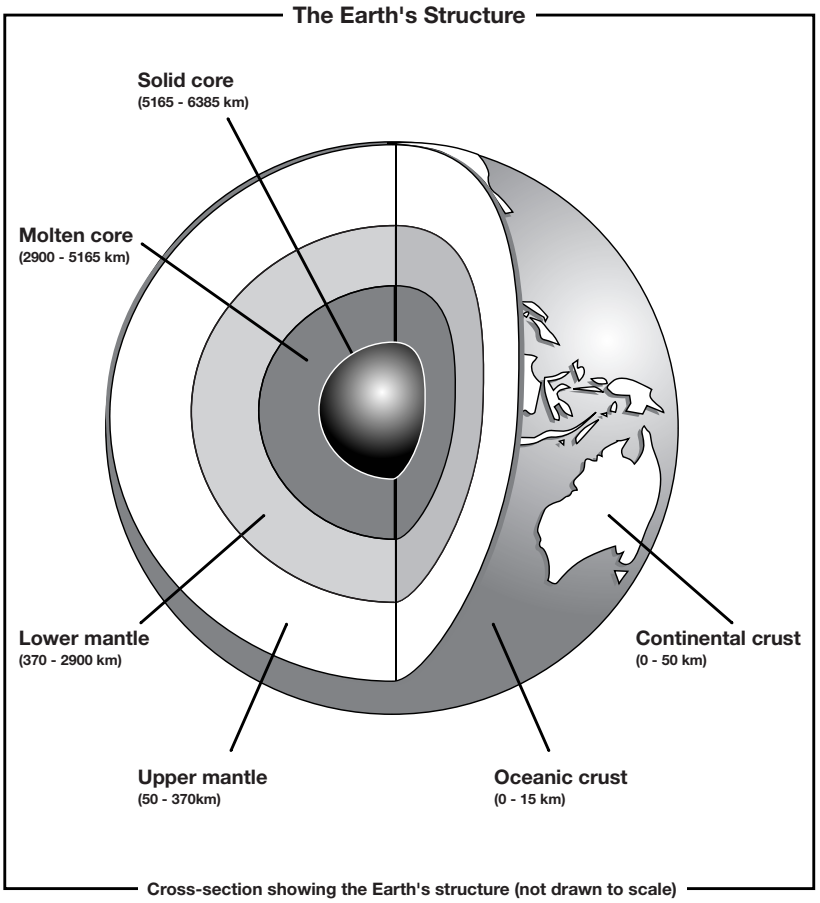
Resource 1: As the Earth moves

Sit very still for a few seconds and try to detect any motion or movement around you. You probably do not feel a thing, unless an aeroplane is passing overhead or your stereo is thumping out extra-loud vibrations.

Nevertheless, scientists know that the Earth's surface is divided into plates, and these plates are in constant motion. So, why can you not feel the motion? The average movement of the plates is about the same as the rate at which your fingernails grow. Since you cannot feel your fingernails in motion, it makes sense that you cannot feel the plates of the Earth in motion.

The study of the formation and movement of these plates is called plate tectonics (it was originally called continental drift). Some plates are moving apart (diverging); some are moving together (converging); and some are colliding and sliding under and past each other. Why are they moving? What provides the power to push them along? To answer these questions, you must know about the Earth's structure.

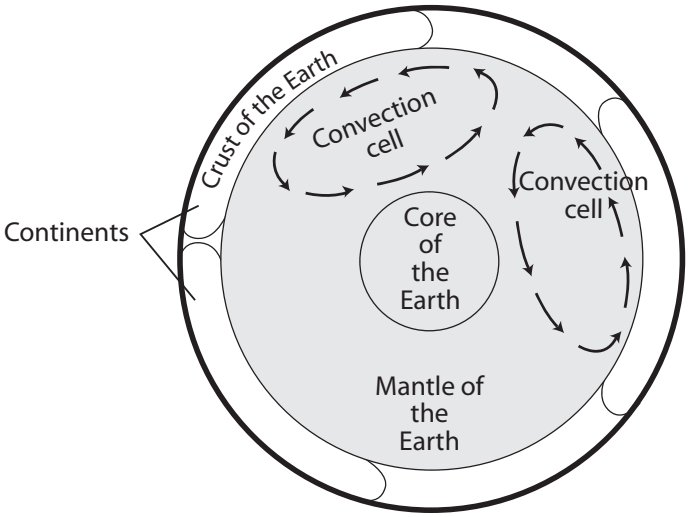
The Earth is divided into three basic layers: the crust, the mantle and the core.



Source: Department of Mines and Energy South Australia 1996, *Resources: working for the right balance*, Adelaide Institute of TAFE.

The crust is the solid part, made of soil and rocks. The mantle is a semisolid layer, made of molten rocks that flow and move about under the crust. The core is the innermost layer made of solid and molten iron.

There is also the lithosphere comprising the crust and the mantle's upper part. This is a rigid, although brittle, layer, and is the part that is broken into plates. The lithosphere sits on top of the asthenosphere, which is a zone of partial melting in the upper mantle that permits movement of the lithospheric plates. The asthenosphere is the uppermost part of mantle below the lithosphere. Plate movement occurs because of lateral thermal gradients and gravitational forces.

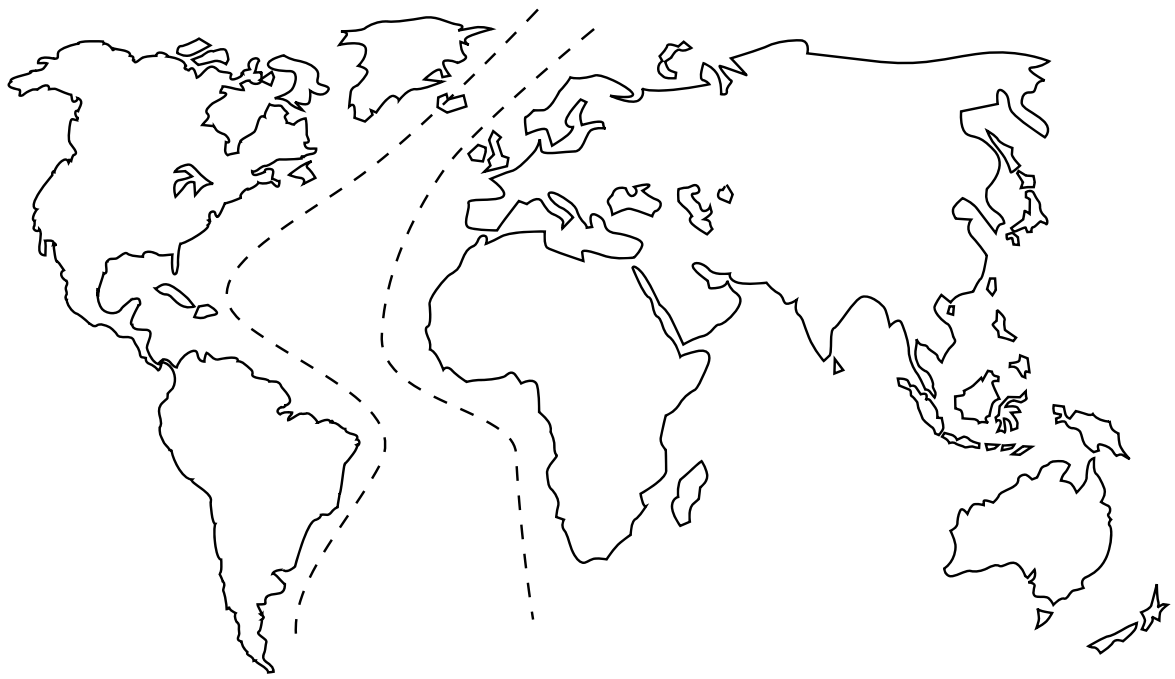


Source: Walker, P. and Wood, E., 1994, *Hands on General Science Activities*, Centre for Applied Research in Education, New Jersey

Convection currents within the Earth are created when heated material rises, and then cools and sinks back down. These currents cause lava to move up from within the Earth and form new rocks and push older material aside.

What is the proof to support the idea of plate tectonics?

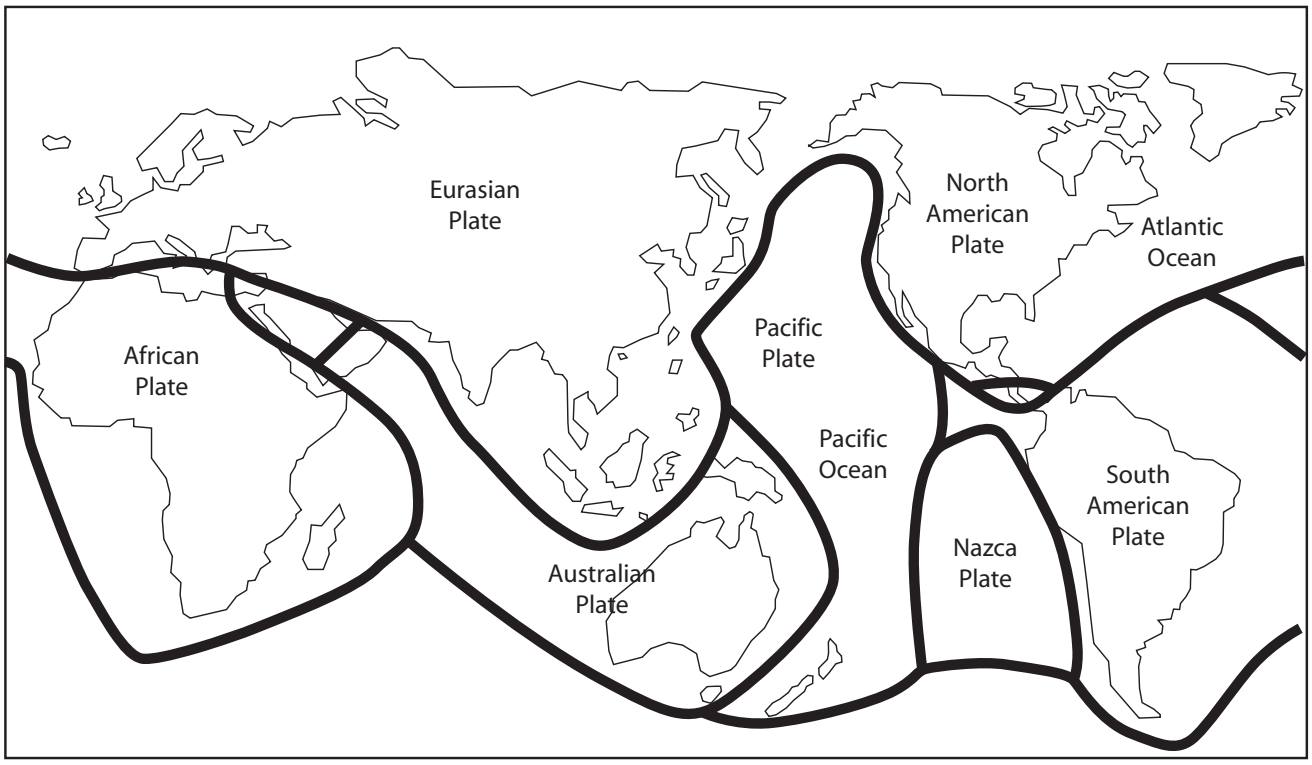
1. If you look at the shapes of the different continents, the borders seem to fit together like a jigsaw puzzle. Scientists have shown that the continents once formed a super continent called Pangaea (meaning all lands). The northern landmass component is termed Laurasia, and the southern component, Gondwana. During the middle of the Jurassic Period, rifting caused Pangaea to start breaking up. Since then, its fragments have drifted apart to form the world as we know it today.



The East & West Coast lines of the Atlantic Ocean seem to fit together.

2. Fossils of the same plant and animal species have been found in separate present-day continents, broadly suggesting that these continents might have once been joined.

The theory of plate tectonics explains the formation of mountains, the occurrence and distribution of most volcanoes, and most earthquakes. Earthquakes and volcanoes do not just occur anywhere on the Earth's surface. They are generally found in specific areas (or belts) that mark the boundaries where the plates meet each other. The largest belt is around the Pacific Ocean plate. About 90 per cent of all earthquakes occur in these zones.



Source: Walker, P. and Wood, E., 1994, Hands on General Science Activities, Centre for Applied Research in Education, New Jersey

Faults exist along the boundaries of lithospheric plates. When a plate moves along a boundary, earthquakes occur. When one plate plunges beneath another, in a process known as subduction, volcanoes can occur. When plates collide, the collision can cause material at the boundary to be pushed upwards, and mountains are formed.

Resource 2: Acrostic vocabulary activity

Directions

- After reading Resource 1 'As the Earth moves', answer the questions.
- Enter your answers vertically in the blanks.
- The numbers are written across the top of the puzzle.
- When you finish, you will form a two-word message horizontally in the boxes in the puzzle.

Clues

1. Breaks or cracks in the lithospheric plates that might result in earthquakes, as the plates slide by each other, are known as _____.
2. Specific locations at the boundaries of the plates that mark the location of the volcanic and earthquake activity are called _____.
3. A _____ can be caused by subduction of plates. Hot molten rock then moves upward towards the Earth's surface.
4. Scientists believe that the Earth has spreading centres where _____ wells up from within the Earth to form new rocks and push older material aside.
5. The partially melted layer of the mantle that is able to flow owing to convection currents and to carry the plates along with it is the _____ .
6. The crust and the upper portion of the mantle that is rigid in consistency is the _____.
7. When plates converge or collide, the lithosphere may be pushed upward at the boundary into the formation of _____.
8. Over the last 4 million years, the Earth's _____poles have been reversed.
9. The appearance of _____ in both Africa and South America, but nowhere else in the world, supports the plate tectonic theory.
10. The _____ is the semi-solid layer beneath the crust but above the core.
11. Convection currents within the Earth bring new materials to its surface and _____ older material aside.
12. The _____ Ocean has the majority of volcanic activity.
13. Plate _____ is the study of formation and movement of the Earth's plates.
14. Plate tectonics was previously called continental _____.
15. Cooler convection currents in the mantle are _____ and the hot currents rise.

Word list

mountains	lithosphere	lava	fossils	drift
tectonics	asthenosphere	faults	sinking	belts
magnetic	volcano	push	mantle	Pacific

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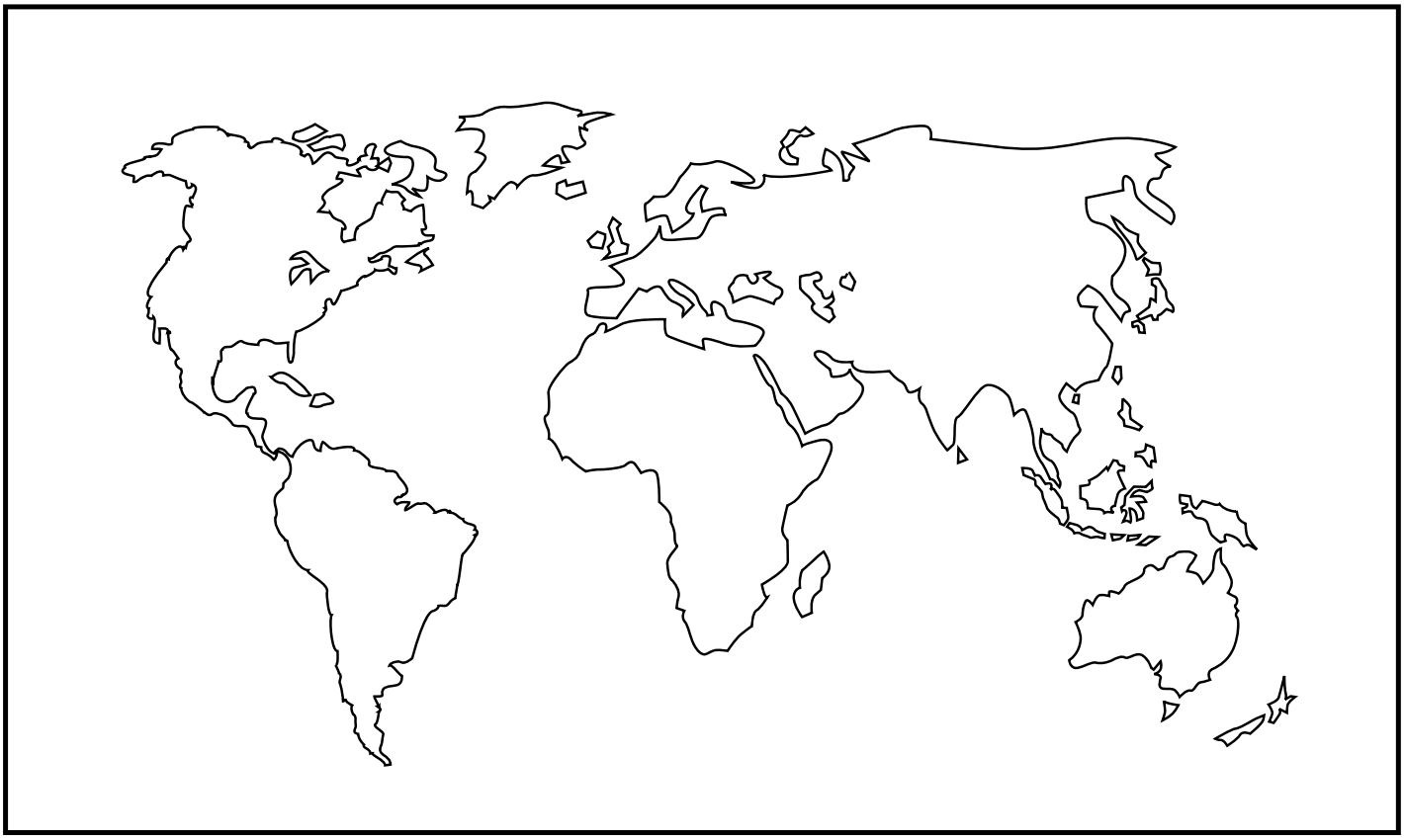
Source: Walker, P. and Wood, E., 1994, *Hands on General Science Activities,* Centre for Applied Research in Education, New Jersey

Resource 3: Tectonic plate activities

Demonstrating outcomes
EB 5.2 and 6.1

A. How the continents might once have fitted together

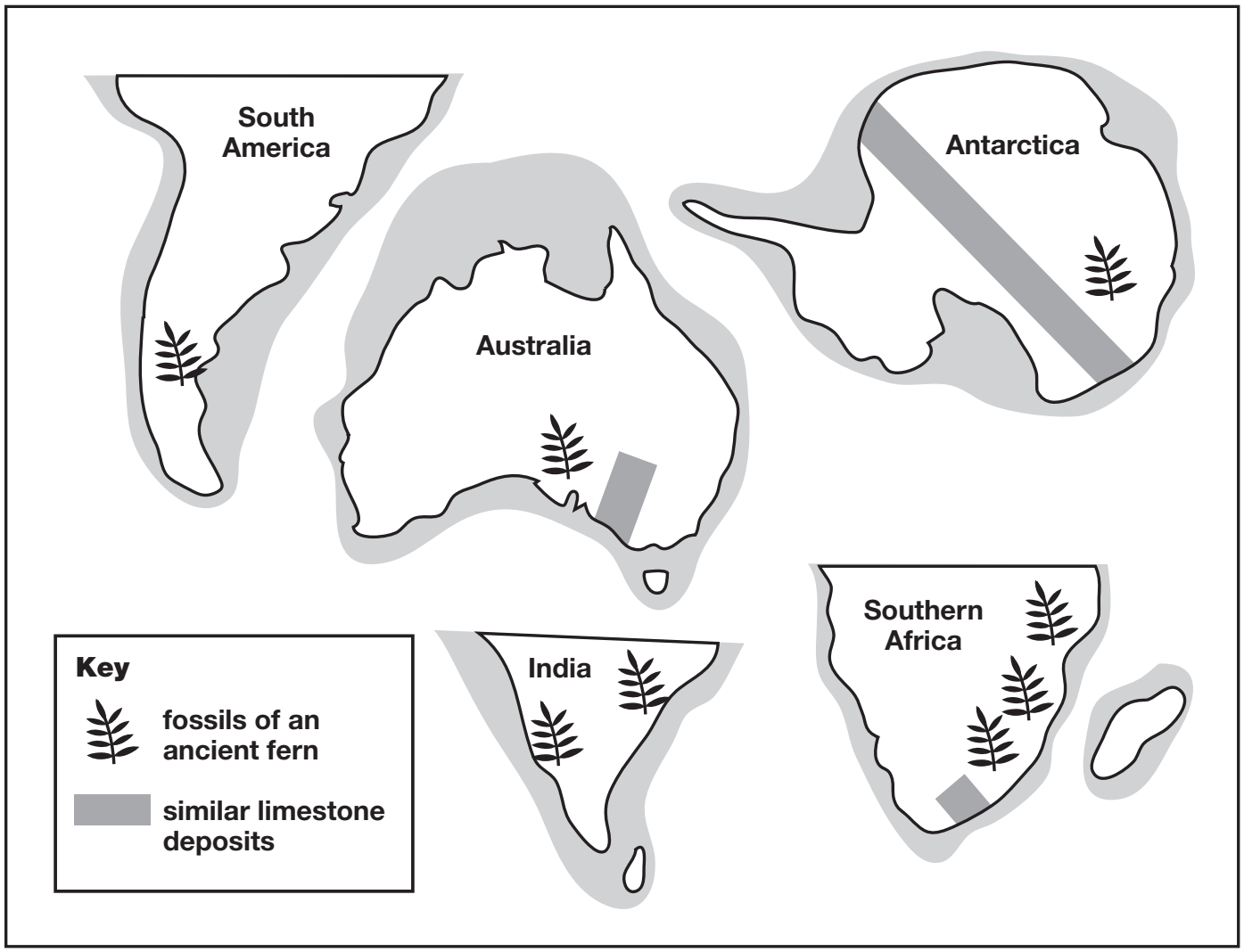
1. Look at the map of the world below and compare these coastal shapes:
   - The west coast of Africa and the east coast of South America
   - The north coast of Africa and southern Europe
   - The south coast of New Guinea and the north coast of Australia
   - The west coast of Japan and the east coast of China.



In your workbook:

2. Explain, in words and sketches, what you have noticed.
3. Are there any other places in the world that seem to have related coastal shapes? Explain.

B. Making Gondwana



Source: Ash, M., Lofts, G. and Evergreen, M. J., 1999 Jacaranda Science 2, Jacaranda Wiley, Brisbane. © John Wiley & Sons Australia

1. Cut around the shaded area near the edges of the continents.
2. Attempt to fit the pieces together, matching up shapes, rock types and fossilised remains, to make Gondwana. They will not fit exactly, but make your pieces fit as closely as possible.
3. Glue the result in your workbook.
4. In your workbook, write a paragraph that explains how this jigsaw supports the theory of plate tectonics. Mention evidence that scientists use to support the idea of plate tectonics. Use Resource 1: 'As the Earth moves' to help you.
5. Explain why you think the rocks in Western Australia are similar to those found in Africa.

Did you know that Australia is moving north at about the same rate your fingernails grow? So, each time you cut your fingernails, you can measure how far Australia has travelled!

Resource 4: What's in a rock?

Rocks tell us many things. Depending on the type of rock, they tell us about the Earth's history; about extinct animals and plants whose fossils lie preserved within them; about explosive volcanoes; about earthquakes; about rivers that washed them away to be deposited elsewhere; and about what it is like inside the Earth.

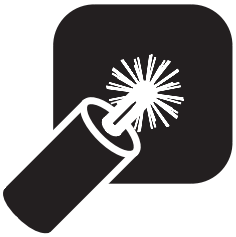
Some of the particles that make rocks are called minerals. A mineral is a naturally occurring compound with a fixed composition and internal atomic structure. For example, quartz is a mineral with a chemical composition of $Si0_2$.

Rocks are mixtures of minerals called aggregates. For example, sandstone is composed of minerals such as quartz and feldspar.

Some minerals are useful or valuable. Commonly used metals like iron, copper, aluminium and zinc are contained within certain minerals. For example, copper (Cu) occurs in the mineral chalcopyrite ($CuFeS_2$), which is mined at Mount Isa.

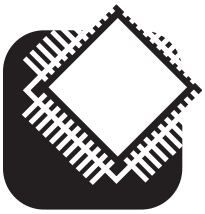
Industrial minerals are commonly used in industry for building and construction. These include limestone, gypsum, sandstone, greywacke, slate and marble.

Minerals are all around us. However, they occur rarely in ore deposits. An ore deposit is an economic term used to describe high concentrations of minerals and can be mined profitably.

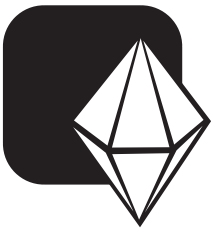


The fuels used in fireworks and explosives include **aluminium, magnesium** and **titanium.**

The 'lead' found in most pencils is not actually made from lead. It is made from **graphite.**



Computer chips contain **silica.** The wiring is made from **copper** and the solder from **lead.**



Gemstones, gold, silver and **copper** are all used to make jewellery.

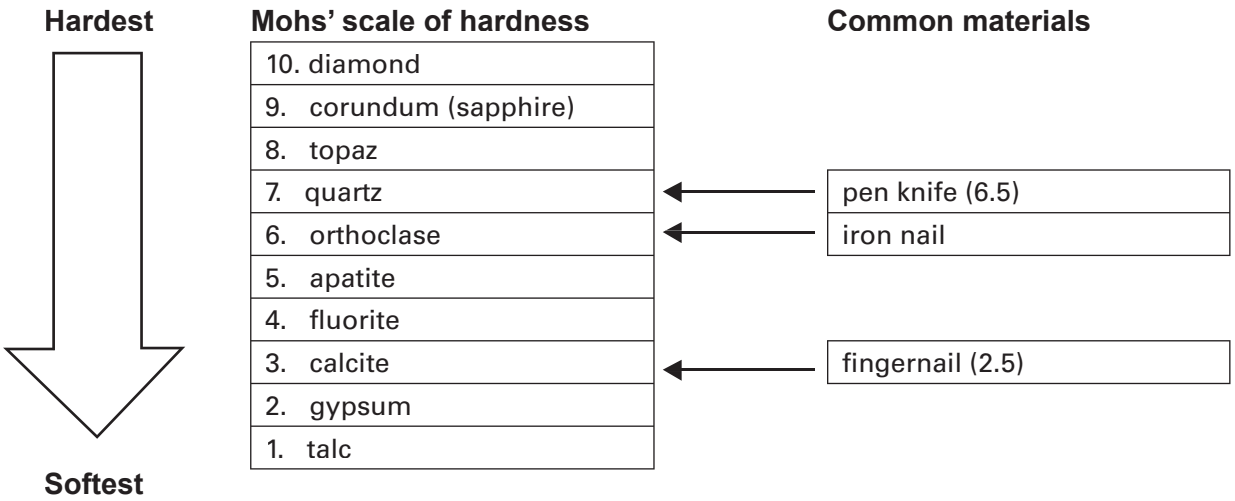
- Queensland is one of the world's leading mineral-producing areas.
- It is among the world's major producers of coal, copper, silver, lead, zinc, bauxite (aluminium).
- Some other industrial minerals produced in Queensland include gypsum, limestone, magnetite and marble.
- Gemstone production includes garnet, opal, sapphire, topaz and agate.

Resource 5: Identifying minerals

Minerals have several different physical properties, which can be used to help identify them.

1. **Colour**. This is unreliable because many minerals have similar colours, or the same mineral can have several different colours; for example, quartz can be pink, violet, black, yellow, white or green.
2. **Lustre**. This is the shininess of a mineral's surface. Lustre can be described in many ways; for example, dull, pearly, waxy, metallic, glassy or brilliant.
3. **Streak**. This is the colour of the powdery mark left when a mineral is scraped across a hard surface such as an unglazed white tile.
4. **Hardness**. This can be found by trying to scratch one mineral with another. The harder mineral leaves a scratch on the softer mineral. Mohs' scale is used to determine a mineral's hardness. For example, a mineral that can be scratched by topaz, but not by quartz, has a hardness of between seven and eight.

   Friedrich Mohs developed a scale of hardness in which 10 minerals were ranked in order of hardness. The higher numbers correspond to harder minerals. The diagram below shows Mohs' scale. Common materials can be used in their place to determine a mineral's hardness.



5. **Crystal shape.** When minerals form, the atoms that join to make them often make up regular geometric shapes. For example, quartz crystals are hexagonal.

Resource 6: Minerals

Remember

Read and answer the questions below; then use Resources 4 and 5 to check your memory.

1. What is a mineral?
2. What is an ore?
3. What are at least five properties that would help you identify a mineral?
4. What is the approximate hardness on Mohs' scale (to the nearest whole number) of a mineral that a pen knife can scratch, but an iron nail can't?

Think

Apply the information in Resources 4 and 5 to help you answer these questions.

1. What is the difference between a rock and a mineral?
2. You have a sample of two minerals, but no other equipment to test them for hardness. How can you tell which mineral is harder?
3. A mineral can be scratched by a pen knife but not by a fingernail. You know that the mineral is one of quartz or fluorite. Which mineral is it?
4. Why is colour not a good property to use when trying to identify a mineral?
5. Which of these pairs of minerals is the harder?
   calcite and talc
   gypsum and apatite
   quartz and fluorite
   quartz and topaz

Research

Use these websites to answer the questions below:
www.nrm.qld.gov.au
www.qrc.org.au
www.nationalminesatlas.gov.au
www.minerals.org.au

1. What are three uses for each industrial mineral listed on Resource 4?

2. What is the value of production of five of these commodities produced in Queensland?

bauxite	coal
gemstones	lead concentrate
magnetite	copper concentrate
silica	zinc concentrate
limestone	gold bullion

3. Each of these minerals contains an important metal mined in Queensland. What does each contain:
   galena
   chalcopyrite
   phalerite.

Create

Imagine that you are a rock lying by the side of a newly made road and imagine you were magically given the ability to walk and talk. Write a speech that you could deliver to your class about your life—from your formation to the present time.

Resource 7: Identifying some common rocks and minerals

Purpose

To identify common mineral and rock samples.

Materials and equipment

- Samples of:
  - Minerals: calcite, quartz, hematite, chalcopyrite, galena, muscovite mica and biotite mica
  - Igneous rocks: pumice, obsidian, tuff, granite, gabbro, basalt, porphyry
  - Sedimentary rocks: coal, limestone, sandstone, conglomerate, shale
  - Metamorphic rocks: slate, schist, gneiss, marble, quartzite
- hand lens
- scales

Method

Use Resources 5 and 6 to help you.

1. Collect a sample of one of the mineral or rock groups being studied.
2. Look closely at the sample and record its physical features; for example, colour(s), weight, crystals in the rock or shape of crystals.
3. Record these observations in the appropriate table on the record sheet.
4. Create an easy way to identify the rock by its physical features. This is your memory jogger; for example, tuff—looks like tough cement.
5. Record your ideas in the appropriate table on the record sheet. See the example below.
6. Repeat for all the samples in the group being studied.

Identifying some common rocks and minerals: record sheets

Minerals

Name	Description	Memory jogger

Igneous rocks

Name	Description	Memory jogger

Sedimentary rocks

Name	Description	Memory jogger

Metamorphic rocks

Name	Description	Memory jogger

Identifying some common rocks and minerals: test

Name: _____

Word list: muscovite mica, haematite, chalcopyrite, galena, quartz, biotite mica, calcite, pumice, obsidian, tuff, granite, gabbro, basalt, porphyry, coal, limestone, sandstone, conglomerate, shale, slate, schist, gneiss, marble, quartzite

1. _____	7. _____	13. _____	19. _____
2. _____	8. _____	14. _____	20. _____
3. _____	9. _____	15. _____	21. _____
4. _____	10. _____	16. _____	22. _____
5. _____	11. _____	17. _____	23. _____
6. _____	12. _____	18. _____	24. _____

Resource 8: Investigating the properties of some common minerals

Demonstrating outcome NPM 4.1

Purpose

To find the properties of a range of minerals.

Materials and equipment

- Collection of mineral samples
- Common materials to substitute for unavailable Mohs' scale minerals
- Magnifying glass
- White ceramic tile.

Method

In your workbook, draw the table below and record your observations as you work through the steps for each mineral.

1. Describe the colour and lustre of the mineral sample.
2. Use the magnifying glass to look closely at the mineral and describe the shape of its crystals.
3. Scrape the mineral across the unglazed side of the white ceramic tile. Record the colour of the streak.
4. Rate the hardness of the mineral according to Mohs' scale by attempting to scratch the mineral against the other samples. Only an approximate range only is required; for example 5-6.

Mineral	Colour	Lustre	Crystal shape	Streak	Hardness

Consolidation

1. Other than those already described, what other properties can you think of that could be used to identify minerals?
2. If two unlabelled mineral samples had the same colour and lustre, can you be sure that they are the same mineral? Explain how you would find out.

Resource 9: Formation of igneous rocks

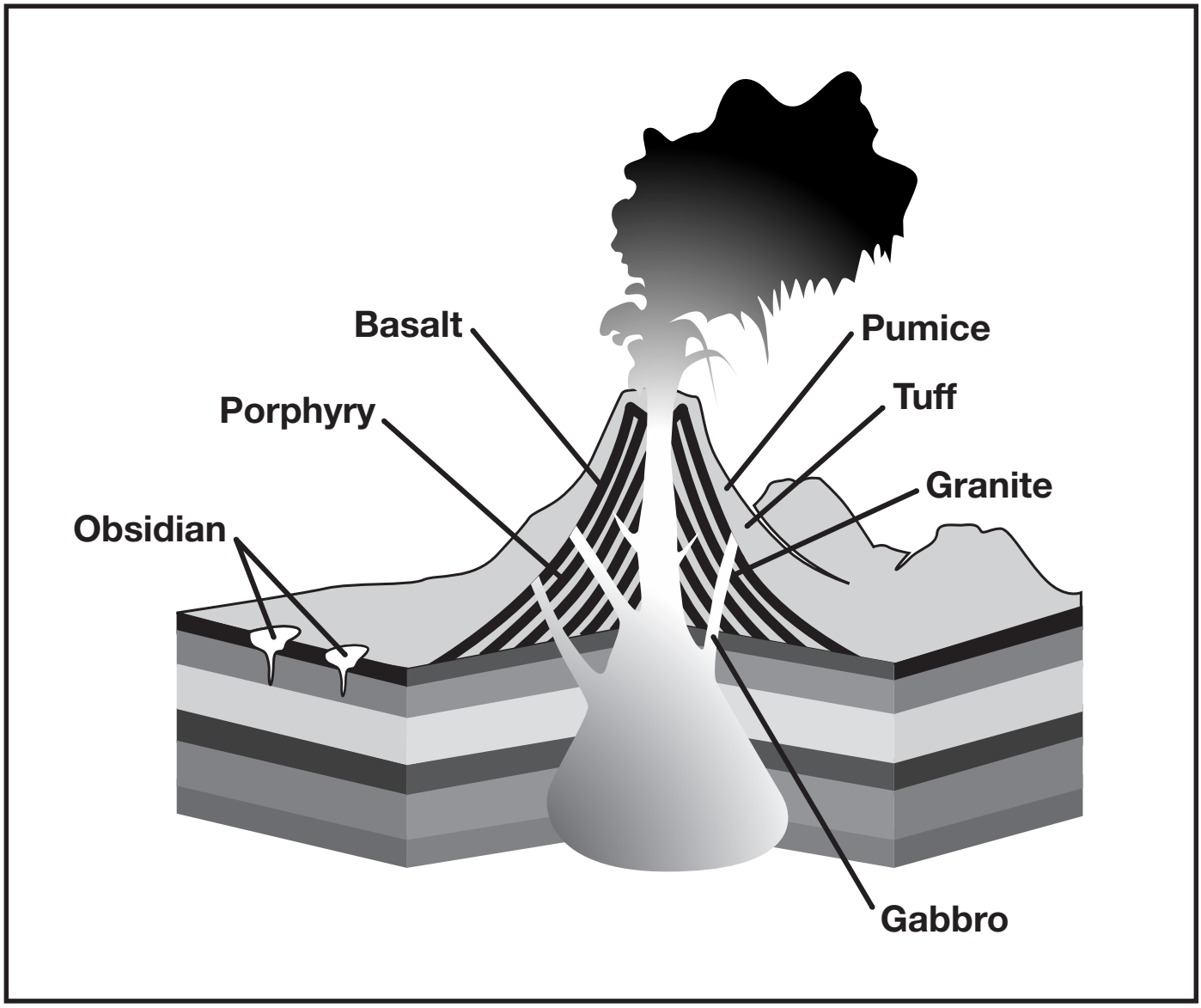
Igneous rocks are formed by the solidification of magmas or lavas. Molten rock is called magma, when it is below the Earth's surface, and lava, when it is above the surface after a volcanic eruption. As molten rock cools, the atoms within it join to make regular crystalline shapes within the rocks.

These crystalline shapes can tell you:

- whether the igneous rocks have formed above or below the Earth's surface
- whether they formed quickly or slowly.

Basalt and obsidian (volcanic glass) form when volcanic lava cools quickly on the ground or under the ocean, and large crystals have insufficient time to form. Tuff is formed from volcanic ash and pumice is formed from froth. These rocks are called volcanic igneous rocks and have small crystals.

Granite, porphyry and gabbros are formed when magma cools more gradually under the ground. These rocks are called plutonic igneous rocks and have large crystals. For example, the large crystals of quartz, feldspar and mica, of which granite is made, can easily be identified. Rocks with medium-sized crystals such as andesite and trachyte are formed from a moderate rate of cooling of the magma.



Resource 10: Investigating how temperature affects crystal size

Demonstrating outcome NPM 5.1

Purpose

To investigate how crystal size is affected by different rates of cooling.

Materials and equipment

- Microscope
- Cavity slides
- Cover slip
- Small beaker
- Dropper
- Bunsen burner
- Tongs
- Hot concentrated solution of potassium permanganate.

Safety alert Potassium permanganate is a potentially dangerous substance. Avoid inhalation, contact with skin and eyes, and ingestion. Tell your teacher immediately, if inhalation, contact or ingestion occurs. Take care when using hot solutions and glassware.

Method

1. Draw a table similar to the one below in your workbook and use it to record your results for this practical.
2. Place a drop of the hot potassium permanganate solution onto a cavity slide. Add a cover slip and immediately observe the solution under the low power of the microscope. Note the shape and size of the crystals.
3. Repeat Step 2, using the warm slide to slow cooling. To do this, gently heat a cavity slide by placing it in hot water. Note how quickly any crystals start to form and their size.
4. Using a slide that has been in the fridge, repeat Step 2 again.

Recording results

Record the relative speed of formation of the crystals, using the terms, 'slow', 'intermediate' and 'fast'. Draw the relative size and shape of the crystals in the last column.

Temperature of slide	Speed of formation	Drawing of crystals
Room temperature		
Hot		
Cold		

Consolidation

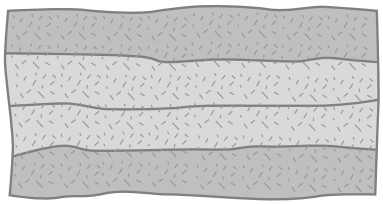
1. How is this similar to the cooling of hot molten rock?
2. How does the slower cooling rate affect the development of crystals?
3. Rank the temperatures according to the size of the crystals formed, from smallest to largest crystals.
4. Give an example of an igneous rock that would have been formed under each of these conditions.

Resource 11: Formation of sedimentary rocks

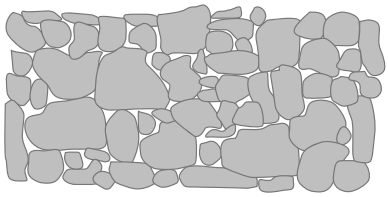
Rocks on or near the Earth's surface are exposed to physical, chemical and/or biological breakdown. The action of water, ice, wind and temperature changes and living organisms such as plants and bacteria are important in this process, which is known as weathering.

Rocks, apart from those such as limestone, which can be dissolved in water, are broken down into smaller and smaller pieces. These pieces, carried away by erosion involving transport by ice, water or wind, are eventually deposited as a sediment in a river or on its flood plain, in a lake, or in the ocean. Sediment carried by wind can be deposited anywhere, as we well know from the dust storms that sometimes disturb our every-day life.

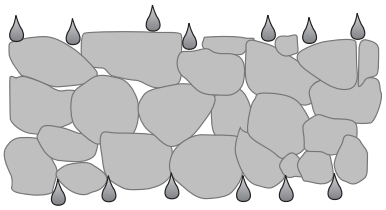
After sediments have formed, the grains comprising them can slowly become cemented to form sedimentary rocks. Rocks of this type are commonly highlighted by the contrasting layers (strata), which are formed when different sediments are deposited on top of one another.



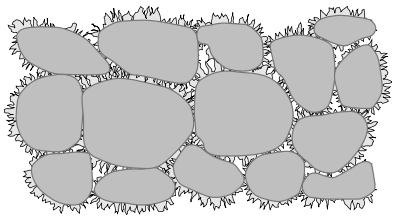
Sediments are laid down by ice, wind or water, in horizontal layers called beds.



Within each bed, the sediment grains are squashed together so that they are in close contact.



Water seeps in between the grains, bringing with it many dissolved chemicals.



When the water evaporates, these chemicals are left behind as crystals around the edges of the grains. These crystals cement the grains of sediment together to form rock.

Source: Ash, M., Lofts, G., and Evergreen, M. J., 1999, Jacaranda Science 2, Jacaranda Wiley Ltd, Brisbane. © John Wiley & Sons Australia

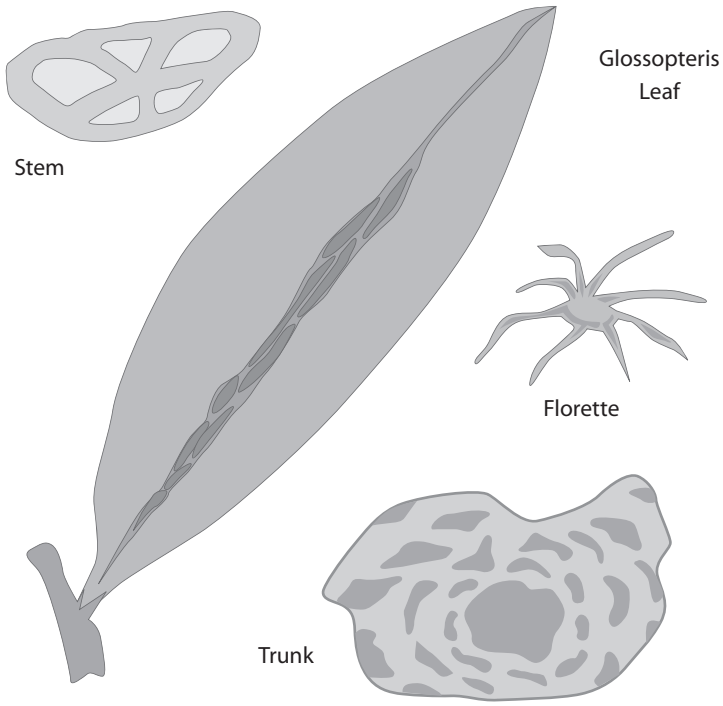
Examples of sedimentary rocks

Name of sedimentary rock	Sediments it is made from
Sandstone	Grains of sand
Shale	Fine grains of mud
Mudstone	Fine grains of mud
Conglomerate	Mud, sand and pebbles of rock of varying sizes
Limestone	Mostly remains of dead sea organisms
Coal	Remains of dead plants

Limestone and coal are commercially valuable sedimentary rocks. They are both mined in Queensland and contribute many millions of dollars to the State's economy each year.

Limestone is formed mainly from deposits of the remains of sea organisms such as shellfish and corals, which are often evident in such rocks. The hard parts of these animals contain a chemical called calcium carbonate ($CaCO_3$).

Coal is formed when plant material is buried quickly before it is changed very much by decay. This happens when sediment is deposited and covers the plant debris. The sediment excludes oxygen and prevents the plant material from decaying. Over millions of years, the weight of overlying sediment squashes the plant debris and squeezes out contained water, with increased temperatures from depth of burial helping to convert the plant material into coal. The longer the time involved and the greater the pressure, the higher is the energy value of the coal produced. This process of plant material being turned into coal is called coalification.



Glossopteris leaf. Leaf fossils of this genus, which is known to be associated with extinct seed ferns that were confined to the Permian Period, are generally found in the black coal of the Sydney Basin, in New South Wales, and the Bowen Basin, in Queensland.

Source: Cook. B., 2003 *ITAM Coal*, Osmond Earth Sciences, Adelaide

Coal deposits are usually found in sequences (layers) of sedimentary rocks. The coal bed often occurs between beds of shales, siltstones and fine sandstones. The bed of coal may also be referred to as a coal seam. Some coal deposits might consist of thick seams of almost pure coal. Others might have many thinner coal seams separated by layers of shale.

Sequences of sedimentary rocks containing coal seams occur in basins. The basins might be elongated or rounded with their deepest parts near the centre. The coal lying at the centre of the basin has usually been subjected to the greatest pressure from overlying sediments and is therefore of higher grade. Nearer the basin's edges, the coal might be of lower grade, not having been subjected to the same degree of pressure.

After the basins have been uplifted and eroded, the best-quality coals can stick out or outcrop at the surface. Sometimes, this is what coal explorers look for.

Resource 12: Sedimentary rocks

Remember

Read and answer the questions below, then use Resource 11 to check your memory.

1. What is a sediment?
2. Where do sediments come from?
3. What is coalification?
4. How does the formation of coal differ from the formation of limestone?
5. During the formation of coal, the plant material becomes covered by other sediments which prevent the plants from rotting completely. What element, which would usually cause the plants to rot, is being blocked from reaching them?

Think

Apply the information in Resource 11 to help you answer these questions.

1. Sometimes you can see layers of sedimentary rocks in the walls of road cuttings. Would you expect these layers to be horizontal? Why/why not?
2. Why are limestone and coal sometimes referred to as biological rocks?
3. Limestone is mostly formed on the ocean floor. Explain how Riversleigh in northern Queensland, a very dry area, came to be riddled with limestone caves and fossils of sea organisms.
4. Read about the formation of coal again using Resource 11. Produce a flow chart to summarise the process.
5. In 1669, Nicolaus Steno stated that the layers of sediments on the sea floor will form rocks. Why would the youngest layers of rock be formed at the top of the sediments?

Extension

1. In 1895, William Sollas estimated that it takes 300 years to form one metre of sedimentary rock. The Grand Canyon in the United States is 1600 metres deep and is formed from sedimentary rock. Calculate the approximate age of the rocks on the bottom of the Grand Canyon, according to William Sollas.

Research

1. What do peat, brown coal and black coal have in common? How do they differ from each other?
2. Limestone is broken up to produce a chemical called lime, which has many uses. Find at least four different uses of lime.
3. What is the main use of coal?
4. What is the name of the major basin in Queensland from which coal is mined? Where is it located?
5. Find the value of the limestone and coal mined in Queensland for the last year.

Resource 13: Investigating sedimentation

Demonstrating outcome NPM 5.1

Purpose

To investigate the affect of particle size on the rate of sedimentation.

Materials and equipment

- Mixture of garden soil
- Gravel
- Sand
- Clay
- Large jar with lid
- Watch or clock.

Method

Before starting this experiment, form your own hypothesis about the order in which the different types of particles in the mixture will settle. Give reasons for your hypothesis.

1. Quarter fill a large jar with a mixture of garden soil, gravel, sand and clay.
2. Add water to three-quarters fill the jar and place the lid on firmly. Shake the jar vigorously.
3. Put the jar down and watch carefully as particles begin to settle. Note the time taken for each layer of sediment to settle completely.
4. Record your observations of:
   - the type of sediment that settled first
   - where other particles of sediment are, while the first layers are settling.
5. Draw a labelled diagram showing clearly any layers that form. Identify the layers if you can.
6. Leave the jar for a day or two.
7. Draw another labelled diagram showing clearly any layers that form. Identify the layers if you can.
8. Compare your diagrams of the jar on day one and day two. Note any similarities/differences that you observe.

Consolidation

1. Which sediments settled after the diagram was drawn?
2. Why have the last sediments taken so long to settle?
3. Was your hypothesis supported by your observations? Explain.
4. What is the relationship between the size of sediment particles and the time taken to settle?

Extension

1. Make a map of a section of a local creek and record the grain sizes of the sediments found in different parts; for example, on the edges, in the middle, on bends.
2. What does this tell you about the flow rate of the water in these different parts of the creek?
3. Gold is a heavy material. If you were prospecting for gold in this creek, where would you look and why?

Resource 14: Formation of metamorphic rocks

Igneous, sedimentary and metamorphic rocks can become buried below the Earth's surface, owing to the movements of the Earth's plates. They are subject to forces from the huge weight of soil, sediments and other rocks above them. They are also subjected to very high temperatures, although not quite hot enough to melt the rock.

This heat and pressure can change the composition and appearance of the minerals in these rocks. This change is called metamorphism and the rocks that are formed this way are called metamorphic rocks.

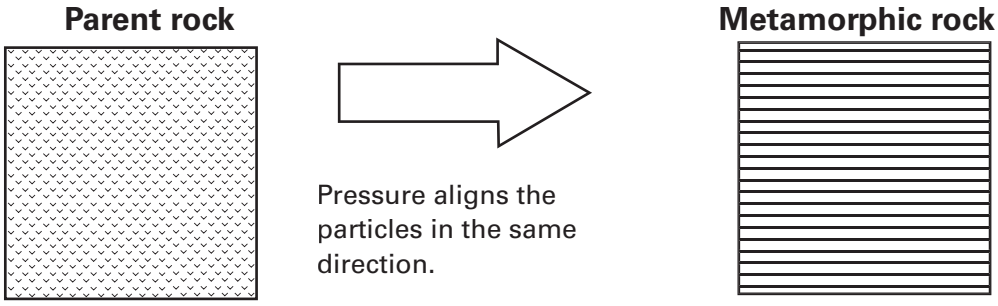
The changes that occur during the formation of metamorphic rocks depend on these factors:

- the type of original rock
- the amount of heat to which the rock is exposed
- the amount of pressure caused by the weight of the rocks above
- the time it takes the change to happen.

Examples of the formation of some metamorphic rocks.

Original rock		Metamorphic rock
Shale	mainly pressure →	slate
Shale	heat + pressure →	schist
Granite	pressure + heat →	gneiss
Sandstone	mainly heat →	quartzite
Limestone	mainly heat →	marble

The new metamorphic rocks are generally hard and spotty or layered in appearance, owing to new minerals being formed in them. The pressure can change the position of the particles, aligning them in the same direction. This gives many metamorphic rocks a layered or banded appearance.



Metamorphic rocks themselves can be reburied and remetamorphosed. This can make identifying the original 'parent' rock difficult.

Resource 15: Investigating the properties of rocks before and after metamorphism

Demonstrating outcome EB 5.1

Purpose

To identify similarities between rocks before and after metamorphism.

Materials and equipment

- Labelled samples of:
  - granite
  - gneiss
  - limestone
  - marble
  - sandstone
  - quartzite
  - shale
  - slate
- hand lens.

Method

1. Try to sort the rocks into pairs of parent rock and corresponding metamorphic rock. (If you have trouble, refer to Resource 14.)
2. Examine each pair with a hand lens.
3. Copy and complete the table below by noting similarities and differences between the parent and metamorphic rock of each pair.

'Parent' rock	Metamorphic rock	Similarities	Differences	Main cause of metamorphism
Shale				
	schist			
	gneiss			
Sandstone				
	marble			

4. Use the last column of your table to suggest whether the main cause of metamorphism was heat or pressure.

Consolidation questions

1. Rocks are classified into three groups. Metamorphic makes up one of these. What are the names of the other two rock groups from which metamorphic rocks are formed?
2. What can cause rocks to change form and become metamorphic rocks?
3. What causes granite to be transformed into gneiss?
4. How is sandstone transformed into quartzite?
5. Why is limestone referred to as the parent rock of marble?
6. Metamorphic rocks are generally formed deep below the Earth's surface. However, they are often found above the ground. Why would the presence of marble high in a mountain range suggest that the area was once under the sea?

Extension

1. If an igneous or sedimentary rock gets so hot that it melts completely, it does not become a metamorphic rock. Explain why.

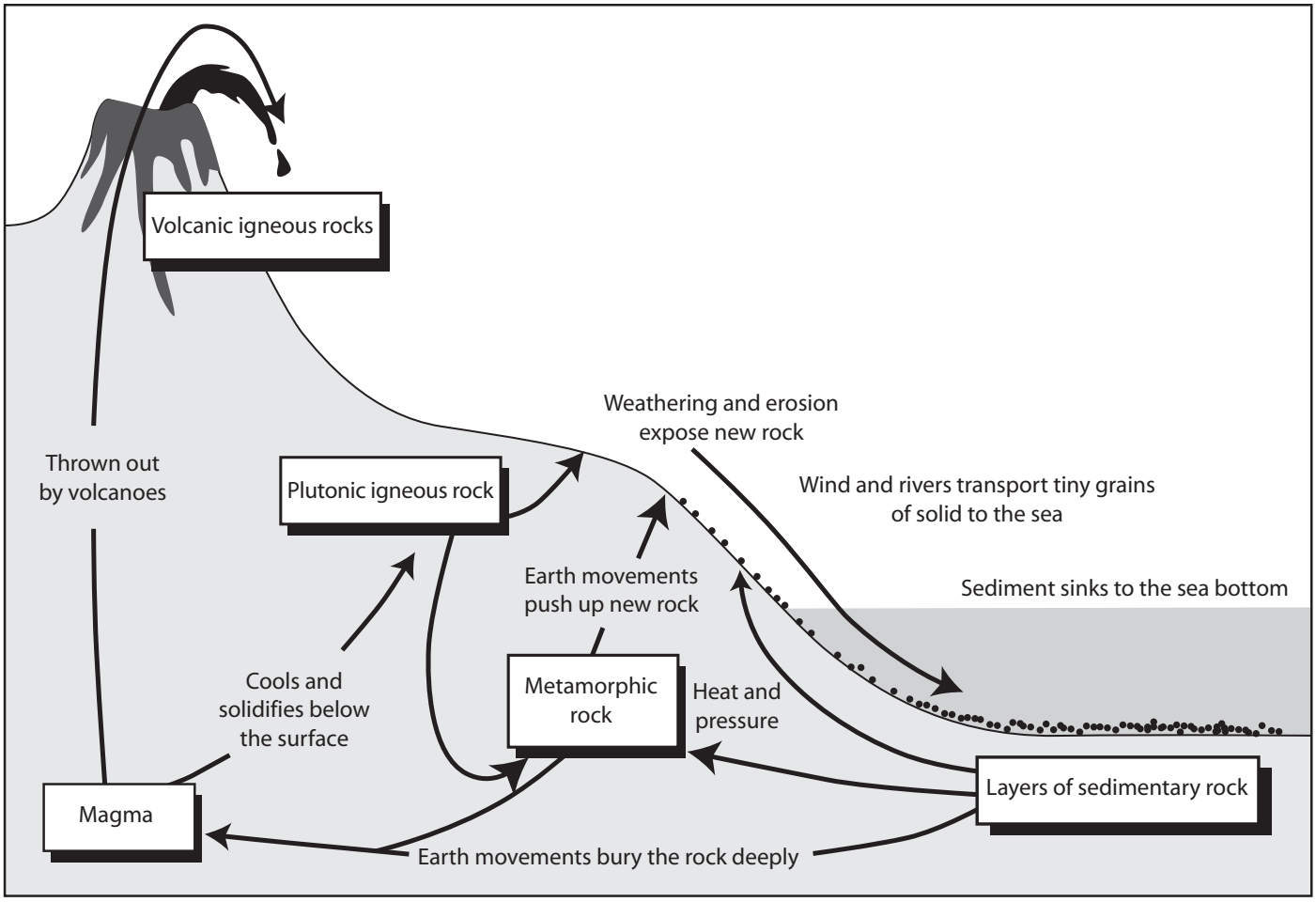
Source: Ash, M., Lofts, G and Evergreen, M. J., 1999 *Jacaranda Science 2*, Jacaranda Wiley, Brisbane.

Resource 16: The rock cycle

The geological processes that form rocks work in cycles. Igneous rocks can be eroded and form sedimentary rocks. These can again be eroded to form new sedimentary rocks.

The sedimentary rocks may be pushed down into the Earth and form metamorphic rocks or mix with magma and form igneous rocks. Metamorphic rocks can also be eroded to form sedimentary rocks.

In the rock cycle, any rock type may be changed into another rock or a different rock of the same type, as shown in the diagram, depending on the conditions.



Source: Chandler, N., 2001 *Queensland Science 2*, Pearson Education, Melbourne.

Resource 17: Investigating the rock cycle

Purpose

To demonstrate the rock cycle.

Materials and equipment

- Limestone chips
- Filter funnel and paper
- Tongs
- Bunsen burner
- Heatproof mat and tripod
- Straw
- Conical flask
- Gauze mat
- Dropper
- Measuring cylinder.

Safety alert The equipment will get extremely hot. Safety glasses must be worn.

Method

Chemical reaction 1:

1. Heat the limestone piece on a wire gauze. You will need to heat it enough so it glows red hot for several minutes.

Chemical reaction 2:

2. Leave the rock to cool. This rock is called lime.
3. Put it in a glass beaker. Add several drops of water one at a time. Listen carefully.
4. Touch the bottom of the beaker carefully.

Chemical reaction 3:

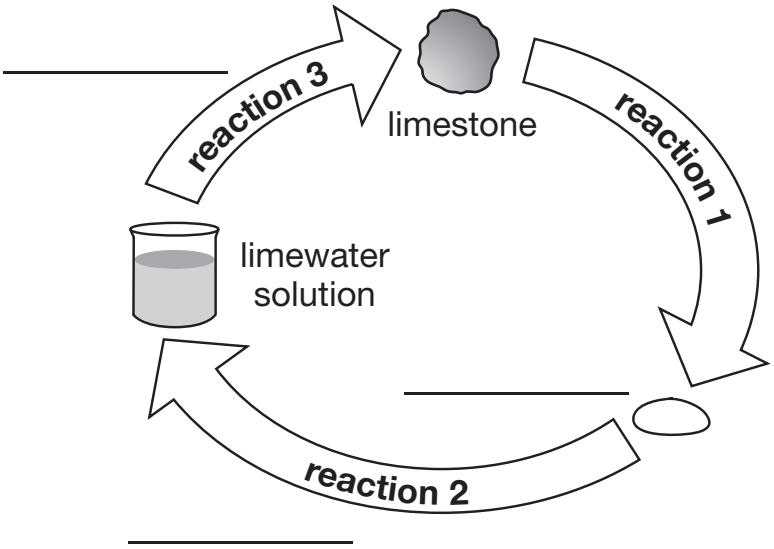
5. Add 20 ml of water to the lime solution from reaction 2.
6. Filter the solution into a flask. The solution is called limewater.
7. Blow into the solution through a straw to make bubbles. Watch carefully.
8. The carbon dioxide in your breath reacts with the limewater. This forms calcium carbonate.

Record your observations for each reaction in the table below.

Reaction	Observations
Reaction 1	
Reaction 2	
Reaction 3	

Consolidation

1. For each reaction explain how you knew that a chemical reaction was happening.
2. Copy and complete the diagram below stating what product or what reaction has occurred. Use it to explain why this is a chemical circle.



Source: Boyd, J., Whitelaw, W., and Warren, P., 1991, Understanding Science Book 1, John Murray Ltd, London

3. Explain how this practical can be used to demonstrate the rock cycle.

Extension

1. Write word equations and/or formula equations for the reactions that were occurring in each stage of this practical.

Resource 18: Assignment – Rock star

Demonstrating outcome EB 5.1

Core learning outcome

Earth and Beyond 5.1: Students explain how present-day features and events can be used to make inferences about past events and changes in the Earth and beyond

The task

Use what you have learnt so far to write a story about how a rock is formed. Your story is to describe what happens to a rock as it changes from one type of rock to another. Make your story interesting and scientifically accurate. Use the ideas below, if you wish. You can change the sequence of events and you do not have to keep to the outline provided.

1. Igneous rocks
You begin as magma. Are you near the surface or below? How does this affect the cooling rate? Is it fast or slow? What size crystals are you made of? What, then, is your appearance? What type of igneous rock are you?

2. Sedimentary rocks
You are broken down and carried away. What has caused this? What name applies to this process? What agent is carrying you away? Where do you end up? What size fragments make up your rock? What other fragments surround you? How do you form into a sedimentary rock? What is your appearance? What type of sedimentary rock are you?

3. Metamorphic rocks
What process must occur to change you into a metamorphic rock? Where is this occurring? How did you come to be in these conditions? What is your appearance now? What type of metamorphic rock are you? What type of rock were you originally?

Presentation

You may present your story in any of these formats:

- poster (no larger than A3)
- flow chart
- cartoon strip
- power-point presentation (hard copies of each slide need to be provided)
- oral presentation (a script with your information on it needs to be provided)
- a rap song or poem.

2 How are minerals found and mined?

How are minerals found and mined?

Outcomes

Science strand	Level 4 outcomes			Level 5 outcomes			Level 6 outcomes		
Earth and Beyond			4.3	5.1		5.3			6.3
Science and Society					5.2				

Teaching and learning activities

Focus areas	Resource sheets
Introduction to exploration	1. What do you know about mineral exploration in Queensland? 2. Cloze passage—exploration
Geochemistry	3. Geochemical surveys 4. Flame test 5. Stream sediment sampling
Geophysics	6. Geophysical surveys 7. Searching for an iron nail
Drilling	8. Exploration by drilling 9. Percussion air drilling
Computer modelling	10. Computer modelling in exploration
Introduction to mining activities	11. What do you know? 12. Biscuit mining
Open-cut mining	13. Open-cut mining in Queensland 14. Measuring and comparing steepness and height of a wall in an open-cut mine
Underground mining	15. Underground mining in Queensland 16. Preventing cave-ins in underground mines
Dredge mining	17. Dredge mining in Queensland
Leach mining	18. Leach mining in Queensland
Putting it all together—an overview of mining in Queensland	19. Mine safety 20. Reviewing mining methods 21. Mining methods

Teaching notes

Introduction to exploration

1. What do you know about mineral exploration in Queensland?

This concept map activity can introduce or conclude a unit on exploring for minerals. It gives students opportunities to reflect on their prior knowledge before starting the unit or to consolidate what they have learnt at the end.

2. Cloze passage—exploration

Use this activity to introduce or conclude a unit on exploring for minerals.

Answers

Exploration teams **search** for mineral deposits by **observing** rocks, maps, photos and satellite images. Higher-than-normal concentrations of metals, and/or the other elements, often **exist** in soils and rocks near mineral deposits. Geochemistry is the scientific process of locating zones of elevated chemical concentrations by **sampling** and **chemical analysis** of rocks, soils, water or vegetation.

Mineral deposits often have physical properties that differ from those of the surrounding rocks. Geophysicists look for physical **differences** in rocks, including density, magnetic properties, electrical **conductivity**, natural radioactivity and the speed that sound can **travel** through them.

Geochemical and geophysical exploration shows the possible **presence** of a mineral deposit, but cannot **confirm** the location. The only way to test for an underground mineral deposit is to gather data from **beneath** the surface by drilling. Drill samples are studied to find the composition and **depth** of a mineral deposit, if it exists.

Exploration teams must carefully manage the natural **environment**. They must **rehabilitate** any disturbed land, including planting seeds to replace vegetation and covering any drill holes.

Geochemistry

Outcomes: Working towards EB 5.1.
Assessment ideas: Inclusion of student observations of demonstration, work sheet and reflective writing in student portfolio.

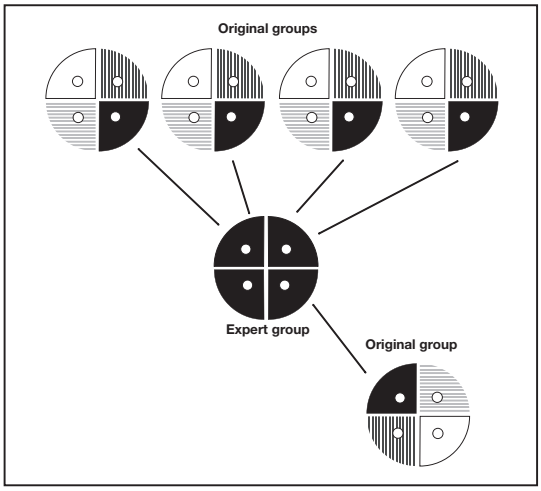
3. Geochemical surveys

To engage students in reading this fact sheet and Resource 6, 8, 13, 15 and 17, use a peer teaching strategy called 'expert jigsaw'. Students read only a part of the fact sheet and teach that information to their peers, thereby becoming an 'expert' in their area.

Procedure

- Before you start decide how you will divide up the text on the fact sheet as this will determine group size. For example, the text in Resource 3: 'Geochemical surveys' is divided into seven sections of varying length and complexity. You could use these sections and have seven in a group, or combine some sections and divide the material and the groups into three or four. Groups of three or four are usually more productive. Before you start photocopy and cut the sheets into the desired sections.
- Invite students to form groups (of the number you have decided on) and assign each group member a section of the fact sheet.
- Next ask students to meet with the members of other groups who have been assigned the same section, forming a new group. This new group learns together and becomes an expert on its portion of the assigned

material by talking it through and asking the teacher any clarifying questions. The group then plans how to teach the material to the members of their original groups.
- Students return to their original groups and teach the members about their area of expertise.



This strategy, which can be used in many contexts, can build depth of knowledge and conceptual understanding; disclose a student's understanding and resolve misunderstanding; and develop teamwork and cooperative working skills.

4. Flame test

This demonstration is an exciting way of showing the class how different elements show their fingerprint colour in a flame. When the atoms become heated, their electrons gain energy and move from one electron shell to another. As they move between shells, they give an emission of colour. Full procedural detail is provided in Resource 4: 'Flame test'.

Safety alert Take special care using the concentrated hydrochloric acid.

5. Stream sediment sampling

This activity can be used to demonstrate outcome EB 5.1.

In this activity, students use information from geochemical surveys (stream sediment and soil samples) to predict the location of a mineral deposit.

- Provide students with a copy of the work sheet and read through the task together. Students may complete the task individually or in groups of two.
- Discuss student findings after the work sheet is completed.

Background
- By collecting and analysing sediment samples from creeks and rivers geoscientists can track down any minerals and the location of the source rocks. A series of samples are taken working upstream along a creek bed. Once the source rocks have been passed the concentration of metal in the sediment drops sharply. This is because particles released by weathering will not find their way upstream.
- Advise students that, before undertaking exploration activities, an 'exploration permit' must be granted by the Department of Natural Resources, Mines and Energy and an 'environmental authority' granted by the Environmental Protection Agency (EPA). This may take from 3 to 12 months. If they want to do any work requiring access to private land they must contact the land owners 21 days in advance. If they happen to discover a mineral deposit and want to mine itz they would have to be granted a mining lease.

Answers to worksheet questions

Part A
1. Copper will be present only in areas downstream from the mineral deposit. Because no copper is at C and D, the copper deposit must be located to the north-east of B.
2. Concentrations in the water are too low and can be inconsistent.
3. The minerals tend to be heavier than other sediments in the creek; so samples are usually collected on the inside bends of creeks where the heavier sediments settle out. This happens because the flow velocity decreases here, making the suspended heavy minerals drop out of suspension or stop being rolled along the creek bed, while the finer/lighter material is carried further downstream.

Part B
3. About 800 square metres.
4. D4, E4.5, F6. Drill in the section that has the highest copper concentrations.
5. Magnetic survey, gravity survey, computer modelling, more drilling.

Geophysics

Outcomes: Working towards SS 5.2.
Assessment ideas: Inclusion of reflective writing and work sheets in portfolio.

6. Geophysical surveys

To engage students in reading this fact sheet, use a peer teaching strategy called 'expert jigsaw'. See Activity 3 on page xx for the procedure.

Note. The CD-ROM resource, *Discovery Explore the World of Oil and Gas*, available from the Australian Petroleum Production Exploration Association (APPEA), is an excellent interactive resource for students. It has an excellent section for students to view seismic profiles. For details go to **www.apea.com.au**.

7. Searching for an iron nail

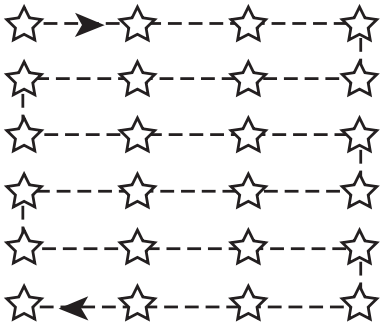
This activity can be used to demonstrate outcome SS 5.1.

Students use the magnetic properties of iron nails to search for them in a tray of sand.
- Before starting, ensure iron nails are magnetic enough. If the field is too weak, students can magnetise nails by rubbing them on a permanent magnet. Paperclips or small magnets could also be included to give a range of magnetic field strengths.

Extension
This practical can be extended easily to include the use of the items below and by testing a wider range of materials.
Conductivity kit—detects whether electricity goes through an object.
Stud finder—measures changes in density.
Metal detector—senses substances that can turn the magnetism of the search head into electricity. A metal detector will do same job as a conductivity kit.

Answers to consolidation questions

1. Magnetism.
2. Ore deposits containing magnetic minerals contain iron; for example, magnetite and pyrrhotite.
3. Advantages: a wide area can be covered using a plane or satellite. Disadvantages: not all deposits contain useful amounts of magnetic minerals; not all magnetic anomalies contain ore-bearing minerals; expensive; still need to drill to confirm ore is present.
4. Use a plane carrying a magnometer to take measurements of the magnetic field. The plane will fly over the area, in the direction shown in the diagram, about 500 metres apart. The diagram shows the most efficient direction. You travel less distance, and the measurements are taken in an ordered method.



Drilling

Outcomes: Working towards EB 5.1.
Assessment ideas: Inclusion of answers to consolidation questions and as before.

8. Exploration by drilling

Use a peer teaching strategy called 'expert jigsaw' to engage students in reading this fact sheet. See Activity 3 on page xx for the procedure.

9. Percussion air drilling

In this practical, students make a working model of a percussion air drill.

Teacher preparation

- Prepare a number of tall, clear plastic bottles filled with layers of as many different coloured sands as you can find. Layer thickness should not be less than two centimetres. Wrap paper around the outside of each bottle so that students cannot see the sand patterns until they have finished their interpretation from the log sheet.
- Make a model of the percussion air drill.

Before practical

- Invite students to form small groups and give each group a bottle of sand and a copy of Resource 9: 'Percussion air drilling', including the log sheet.
- Outline the method with students. Provide a model of the percussion air drill and demonstrate its use.

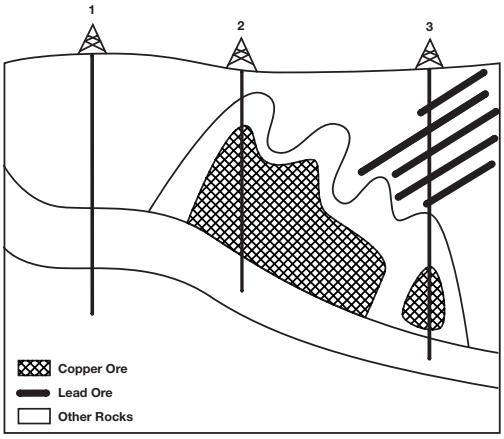
Extension activity

Students could be given a larger tray or box containing dipping layers of sand, including a black layer to simulate coal. Each group drills one spot on a grid so that a class display can reveal the three dimensional shape of the model and, in particular, the size and shape of the coal seam. Then change the shape of the deposit and see how the drilling pattern might need to change to find the deposit. This method is used in coal exploration.

Background
Drilling with air is used to retrieve rock chips, caused by the action of the drilling bit, from the bottom of the drill hole. Samples of these chips are studied to tell us the sequence of rocks that exists in the area and what geological events have happened in the past. Samples may also be tested for mineral composition.

While the drills used in exploration and mining have steel teeth on the ends to break through the rock, the model can only drill through sand. However, samples from the bottom of the drill hole are brought to the surface, using the same principle as the returning air or water used by real drilling rigs.

Answers to consolidation questions
1. To collect samples of rock at depth.
2. Individual responses.
3. Individual responses.
4. Individual responses.
5.
   - First—shows no mineral deposit; second—shows a large lead ore deposit; third—copper and lead ore.
   - Drilling is expensive and is undertaken only when other surveys show that it is likely that a mineral deposit is there. Usually, explorers start with a large area and narrow down their activities to areas most likely to contain minerals. Drilling then occurs in these areas.



Computer modelling

10. Computer modelling in exploration

This resource page lists websites with excellent images and innovations in computer modelling used in mineral exploration. As extension work, students, working in small groups or on individual research projects, could review sites and report their findings to the class.

Background
Computer technologies are used extensively to model and record information gathered in exploration. The images produced are an excellent visual aid for geologists. This area has many innovations, and Australia is a world leader in this technology. Many mining and exploration companies around the world use Australian-developed software. The CSIRO site has a student section that includes the question of the month and a huge amount of information on exploration and mining innovations.

Introduction to mining activities

11. What do you know?

Use this concept map activity to introduce or conclude a unit on mining. It gives students opportunities to reflect on their prior knowledge before starting the unit or to consolidate what they have learnt at the end.

12. Biscuit mining

Students use a variety of biscuits and extract the minerals using any method they choose. Students examine the impact of their method in relation to costs, benefits and impacts on the environment.

Open-cut mining

Outcomes: Working towards SS 5.2 and EB 4.3, 5.3, 6.3.
Assessment ideas: Inclusion of practical data and answers to consolidation questions in portfolio.

13. Open-cut mining in Queensland

To engage students in reading this fact sheet, use a peer teaching strategy called 'expert jigsaw'. See Activity 3 on page xx for the procedure.

14. Measuring and comparing steepness and height of a wall in an open-cut mine

This activity can be used to demonstrate outcome SS 5.2.

Students can experiment with an open-cut mining pit using sand to see how steep the mine wall can be before it slides into the pit. They should use a depth of 25 to 30 centimetres of sand and compare the wall steepness and stability with height and with changing moisture content in the sand. Use dry sand first, then damp, then wet and finally saturated.

The steepness and height of the wall in an open-cut mine determine the size of the pit needed to mine the ore body. This has ramifications for costs, environmental disturbances and rehabilitation strategies.

The experiment is best done in a sand pit. If one is not available, use a plastic tray or tub filled with sand.

Extension
You may wish to place a given number of marbles under, for example, 20 centimetres of sand and repeat the experiment. This time, weigh the sand which is removed. Comparing the weight of the overburden to the weight of marbles mined will help to emphasise a major cost and effort frequently associated with this type of mining.

Answers to consolidation questions
1. Dampening the sand makes the wall more stable. Too much water will make the wall unstable.
2. The deeper the mine, the wider the mine rim needs to be to maintain stability.
3. (a) Increase cost. (b) The mine wall will need to be stable to ensure miners are safe. (c) The larger the mine rim, the more dirt and rock that will need to be extracted. This will make mine rehabilitation more difficult.

Underground mining

Outcomes: Working towards EB 4.3, 5.3, 6.3.
Assessment ideas: Inclusion of answers to consolidation questions in portfolio.

15. Underground mining in Queensland

Use a peer teaching strategy called 'expert jigsaw' to engage students in reading this fact sheet. See Activity 3 on page xx for the procedure.

16. Preventing cave-ins in underground mines

Students investigate how the cross-section shape of support beams affects their load-bearing strength. The exercise may work better if students prepare the girder shapes ahead of the lesson.

Dredge mining

17. Dredge mining in Queensland

Use a peer teaching strategy called 'expert jigsaw' to engage students in reading this fact sheet. See Activity 3 on page xx for the procedure.

Leach mining

Outcomes: Working towards EB 4.3, 5.3, 6.3.
Assessment ideas: Inclusion of work practical data and answers to consolidation questions in portfolio.

18. Leach mining in Queensland

Students can do either the salt or copper practicals. Put the sand and salt, or the sand and copper sulphate mixture in a solid open container covered with a plastic sheet or in a zip-lock plastic bag. This container of salt-sand mixture is to be buried in a bucket under at least 20 centimetres of sand.

If you give students the weight of salt in the sand and salt mixture, they can calculate the efficiency of their recovery operation.

Extension

The techniques that can be used may be left entirely to the students to devise. In their planning, ask students to include the materials they will need to carry out the project and diagrams of the processes involved. They must include how to recover the solid salt from the leach water (for example, by evaporation) and compare this method with underground mining in terms of costs, time, environmental impact, percentage of salt recovered and time involved.

Answers to consolidation questions

4. Low impact on the environment.

Putting it all together – an overview of mining in Queensland

Outcomes: Working towards EB 4.3, 5.3, 6.3.
Assessment ideas: Inclusion of worksheet in portfolio.

19. Mine safety

Invite students to read this fact sheet and represent the key ideas graphically.

20. Reviewing mining methods

Once students have read the fact sheets on open cut, underground and dredge mining and completed the practical on leach mining, invite them to complete the questions.

Answers to questions

1. Rock that contains economic amounts of minerals.
2. It is stockpiled and, once mining has finished, is used to fill in the mine or is landscaped elsewhere.
3. Where the ore body is too deep or where the use of the land on the surface is such that surface mining is not appropriate.
4. The dredge moves slowly through the water and draws up material, mostly sand, from the bottom. Once on the dredge, the heavier minerals are easily separated from the lighter sand grains.
5. Safety, more complex machinery, greater risk of cave-ins.
6. It is cheaper and safer.
7. Leach mining. Drill bores into the ore body. Leachates are sent down drill holes to the deposit. The solution dissolves the minerals and is then pumped back up to the surface. At the surface, the mineral is removed from the leachate. Once the mineral has been extracted, the leachate is circulated through the ore body again, repeating the process, until no more of the mineral can be removed.

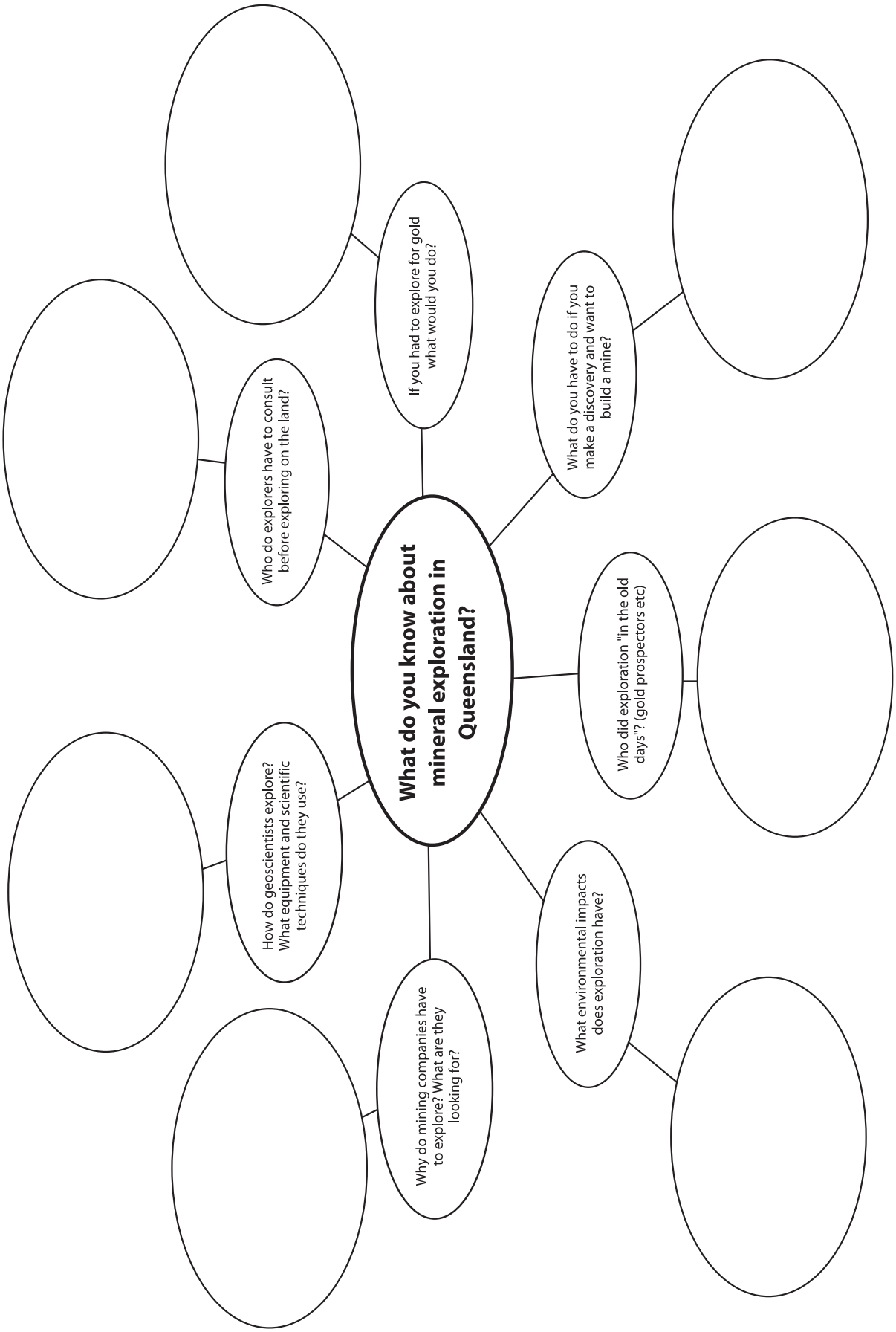
21. Mining methods part A and B

This activity can be used to demonstrate outcomes EB 4.3, 5.3, 6.3.

These activities are based on the work students have completed throughout this section. The tasks at Levels 5 and 6 build on earlier levels. Some scaffolding is provided in the form of a graphic organiser and a persuasive argument planner. Create clear guidelines and criteria so that everyone has a shared understanding.

Resource 1: What do you know about mineral exploration in Queensland?

Brainstorm as many ideas as you can for each question.



Resource 2: Cloze passage—exploration

Read the passage below and insert the missing words, using the words from the word box below.

Exploration teams _____ for mineral deposits by _____ rocks, maps, photos and satellite images. Higher-than-normal concentrations of metals, and/or the other elements, often _____in soils and rocks near mineral deposits. Geochemistry is the scientific process of locating zones of elevated chemical concentrations by _____ and _____ of rocks, soils, water or vegetation.

Mineral deposits often possess physical properties that differ from those of the surrounding rocks. Geophysicists look for physical _____ in rocks and these include density, magnetic properties, electrical _____, natural radioactivity and the speed that sound can _____ through them.

Geochemical and geophysical exploration is used to show the possible_____ of a mineral deposit, but cannot _____ the location. The only way to test for an underground mineral deposit is to gather data from _____ the surface by drilling. Drill samples are studied to find the composition and _____ of a mineral deposit, if it exists.

Exploration teams must carefully manage the natural _____. They must _____ any disturbed land, including planting seeds to replace vegetation and covering any drill holes.

Word box

chemical analysis	differences	confirm	travel
conductivity	rehabilitate	exist	depth
environment	search	sampling	
beneath	presence	observing	

Resource 3: Geochemical surveys

Introduction

In the soil and rocks near a mineral deposit, higher-than-normal concentrations of metals and other elements often exist. These are known as geochemical haloes or anomalies and are more extensive than the actual ore deposit. This makes them much easier to target and locate.

Geochemistry is the scientific process of locating these geochemical haloes by sampling and chemical analysis of rocks, soils, water or vegetation. Geochemical analysis can determine whether the level of an element found in a particular area is at background levels or at higher levels, which could mean that economic mineral concentrations are nearby. Geochemical techniques are also used by environmental scientists to determine levels of toxic metals in soils.

Stream sediment surveys

This involves collecting 500 grams of stream sediment samples from creek beds. In rugged areas, explorers use high-quality aerial photos, satellite-based global positioning systems and experienced ground crews to find the exact location of the samples. The number of stream sediment samples taken varies, but is usually one to four samples for each square kilometre.

Rock sampling

Explorers use a geological pick to break small pieces of rock from an outcrop to send to a laboratory for chemical analysis.

Soil sampling

Two hundred grams of soil samples are collected below the grass roots. Geochemical soil sampling is usually conducted over a relatively small area. Soil samples are typically collected by hand from a small hole dug to a depth of about 10 centimetres.

Innovations in geochemical sampling

Mineral deposits can emit gases that leak to the surface. These can accumulate in soils or be emitted to the atmosphere in extremely low concentrations. Attempts have been made to collect and analyse these gases, both with ground and airborne collection systems. Results to date have been variable.

Certain plant species are capable of taking up metals from the soil through their root systems and concentrating them in leaves and bark. Geo-botanical surveys, based on direct sampling of plants or ground litter, have been undertaken with some success around the world. These surveys are often used when it is difficult to get access to the ground to obtain samples.

- Only 1 in 1000 exploration prospects where mineralisation has been discovered get developed into mines.
- About 265 exploration permits were granted in Queensland in 2003.
- All disturbed areas resulting from exploration activities must be rehabilitated to the Environmental Protection Agency's satisfaction, before they can be relinquished.

How geochemistry was used to discover the Century mine

In September 1987, CRA Exploration was granted two exploration permits covering most of the old Burketown Mineral Field. Because it was too late in the season (approaching monsoon) to undertake any field work in 1987, exploration activities were delayed until March 1988.

Initial field work comprised geological mapping, geochemical soil sampling, and magnetic and gravimetric traverses at 100-metre reading intervals along traverse lines across the permits. The theory was should any deposit crop out at the surface, it would be seen in the geological mapping.

If the deposit was covered by soils, the geochemical samples would be anomalous in zinc-silver-lead values. If a magnetic ore body or a dense ore body was present close to the surface, then the magnetic and gravity readings would show anomalous values. CRA conducted surveys on two traverses, north-east – south-west and north-west – south-east.

Anomalous zinc and lead values were found in the geochemical samples from the NE-SW traverse.

The area of anomalous zinc-lead response was investigated in the field for signs of mineralisation. However, no evidence of a weathered zinc or lead deposit was visible, and no secondary zinc or lead minerals could be identified.

Reconnaissance drill testing of the primary anomalous target began in October 1989, 18 months after the initial field work had started. Again the wet season delayed drilling, and eventually three holes were drilled at the primary anomalous target in April 1990.

Inside the large soil anomaly, a small 19th century prospector's pit was noted as important to the discovery. The rock was sampled and returned high silver concentrations.

Drill holes LH4 and LH6 showed evidence of mineralisation. Although overall grades from these holes were not economic, another nine holes were planned from May 1990. Seven of these later holes returned economic grades at depth, and it was at this stage the discovery of a major zinc-lead deposit was confirmed. The mineralised zone could be traced back to the surface outcrop, now called Discovery Hill.

The discovery of the ore body at the Century mine was mainly due to the geochemical soil survey and drilling.

This is how one of the world's largest zinc, silver and lead deposits was discovered in one of the remotest parts of Australia.

The ore from the Century mine is transported to Europe, where zinc, silver and lead metals are extracted and made into useful products.

Resource 4: Flame test

Theory

When the atoms become heated, their electrons gain energy and move from one electron shell to another. As they move between shells they give an emission of colour.

Purpose

Identifying metal elements is an exciting way of showing to the class how different metals have their 'fingerprint' colour in a flame.

Materials and equipment

- Bunsen burner
- Nichrome wire (it is unreactive)
- Concentrated hydrochloric acid
- Heatproof mat and safety glasses
- Minerals and chemicals: strontium, barium, lithium, copper, calcium, potassium
- Copper carbonate or malachite (sample x)
- Cobalt chloride (sample y)
- Sodium chloride or table salt (sample z).

Safety alert Take special care using the concentrated hydrochloric acid and wear heat proof gloves.

Method

1. Wet the end of the nichrome wire in concentrated hydrochloric acid to clean it.
2. Heat the wire until it is red hot.
3. When there is no colour added to the flame, dip the wire in the compound and heat again.
4. Have students record their observations. (Can students suggest why you are using the hydrochloric acid for these demonstrations? 'To clean the wire.')
5. Repeat the process for each of your minerals.
6. **Hint.** Do the sodium chloride last, because it can easily contaminate other tests.
7. Tell the students what each sample is except for samples x, y and z. Ask students to identify whether or not these unknown samples contain copper.

Extension

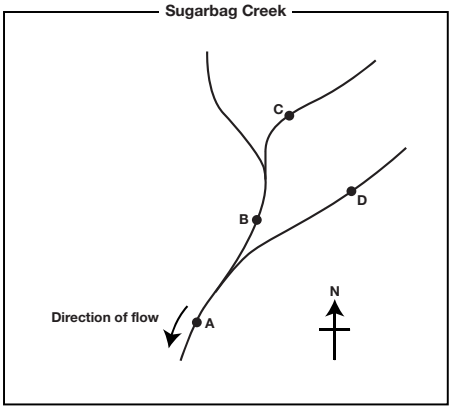
1. You could extend the collection of known samples and make a catalogue of your results. When you can match a range of minerals to the colours they emit in a flame test, you could then test soils or creek sediments.
2. What is the significance of this for mineral explanation? (Rocks break up naturally (or 'weather') over long periods, owing to the action of sunlight, water and gases in the air. This process releases minerals into the sediments of creeks, which then carry them downstream. Generally, the concentration of a mineral decreases the further we go from the source rocks.)

Expected results

calcium	brick red
copper	emerald green
sodium	bright yellow
lithium	deep crimson
potassium	violet
barium	yellow green
strontium	crimson

Resource 5: Stream sediment sampling

Geologists suspect that in Sugarbag Creek in the Many Peaks area an ore body contains copper. Stream sediments samples from the four points on the map were analysed. The samples from A and B showed traces of copper, but C and D did not.

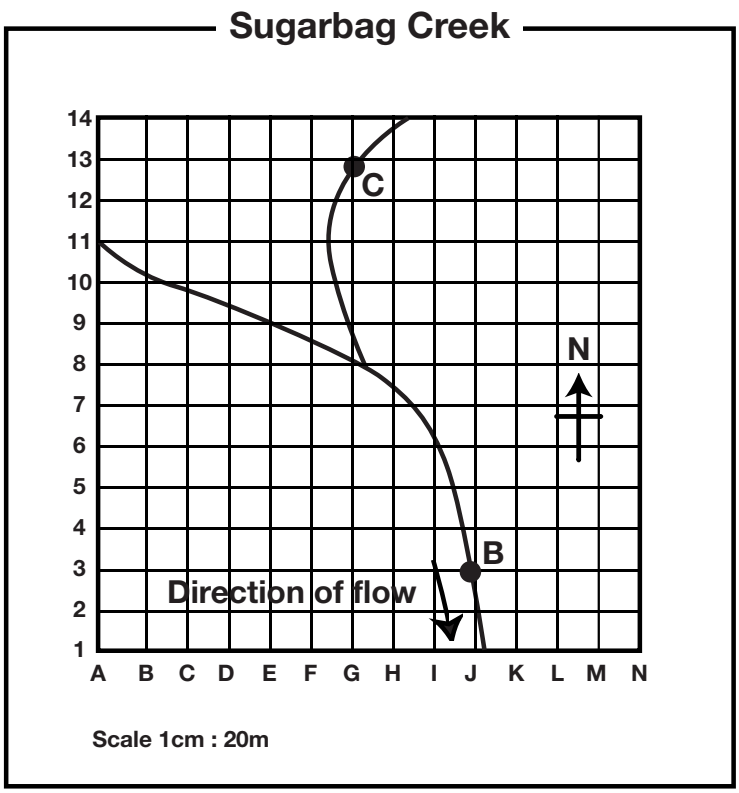


1. Write a paragraph explaining where you think the ore body is likely to be.
2. Why do you think the geochemist will take a sediment sample from the stream instead of sampling the water?
3. Which section of creek would the geochemist take sample from; middle, bank or bend.

The search was narrowed to the north area of Sugarbag Creek. Stream sediment samples were taken at each point on a grid marked on a map of the area thought most likely to contain the ore. The table below gives the map references of locations where medium, high and very high concentrations of copper were found.

Copper concentration	Locations
Medium	C3 C5 D3 D6 E3 E6 F7 G4 G7 H5 H7 I6 I7 I8 I9 J7 K8 K10 L9 L11
High	C4 D5 F4 F6 G5 G6 H6 J8 J9 K9 L10 M10
Very high	D4 E4 E5 F5

1. Use different coloured pens or pencils to plot the locations where medium, high and very high concentrations of copper were found.
2. Use different coloured pencil to shade in the ore body to represent medium, high and very high copper concentrations.
3. What is the approximate size of the ore body on the surface? Use the scale 1 cm = 20 m.
4. The next step in exploration is to drill and collect samples for analysis. Your budget allows only three holes. Give the map references of the three places you would drill, and explain your choice.
5. What else would you do to locate the ore body, and to find its size, depth and shape?



Resource 6: Geophysical surveys

Introduction

Mineral deposits usually possess physical properties that differ from those of the surrounding rocks. Geophysical methods are used to measure the physical properties of rocks at or below the Earth's surface.

Geophysicists look for differences in the density, magnetic properties and electrical conductivity of rocks. The levels of natural radioactivity and the speed with which sound can travel through rocks are also measured.

Types of surveys

Geophysicists collect information using ultra-modern equipment on the ground and from aircraft to measure the make-up of rocks found both on and under the surface. Ground geophysical surveys can be expensive and are generally undertaken only over relatively small areas of particular interest. Surveys are mainly conducted from the air using fixed-wing aircraft or helicopter normally flying 60 to 200 metres above the surface.

Ground magnetics

The Earth acts as a giant magnet and influences mineral deposits that are magnetic or may be magnetised particularly objects containing iron. Magnetometers measure the magnetic field. Magnetic surveys may be undertaken from the air or on the ground. The data can be presented as a magnetic map using computer technology.

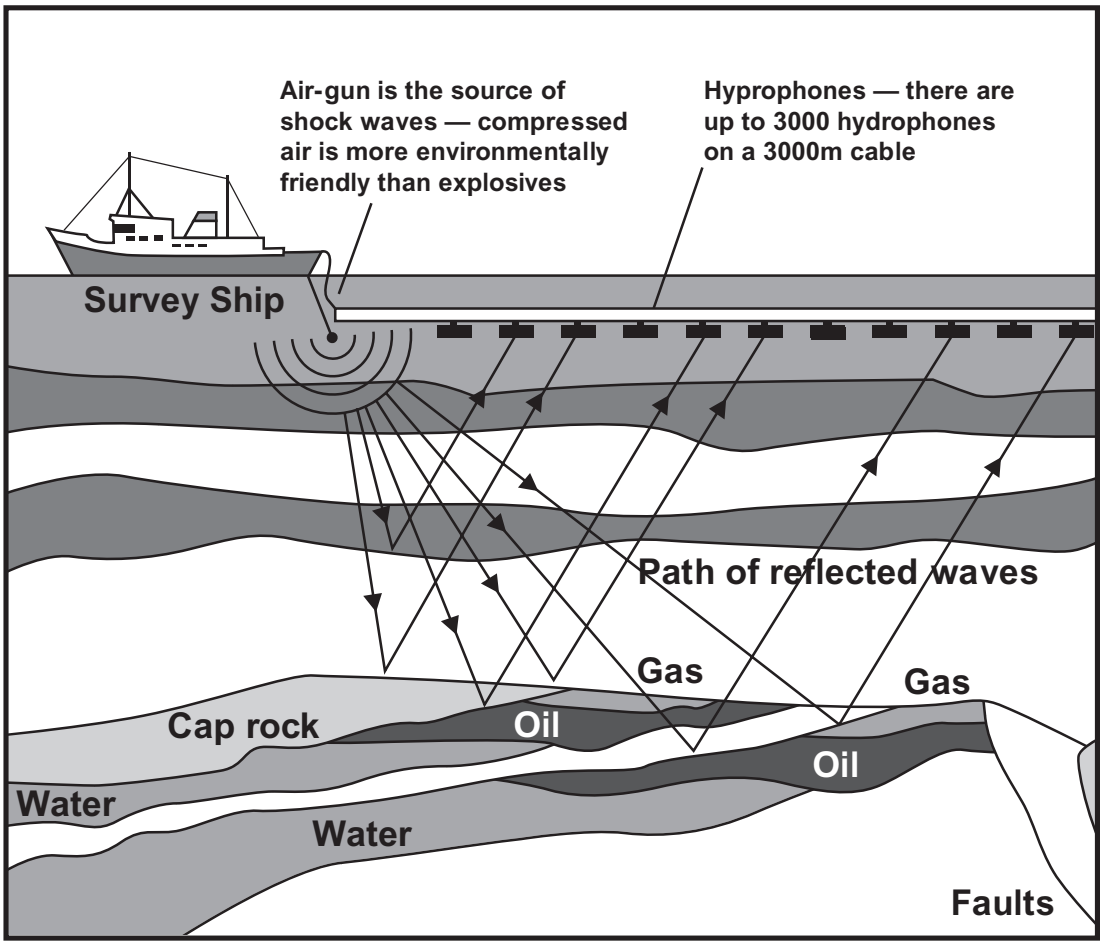
Electrical properties

Mineral deposits have a wide variety of electrical properties, including its electrical conductivity and capacity to hold an electric charge. These properties are measured by inserting electrodes into small holes dug in the ground, connecting them to a generator and running an electric current through the ground. Other methods include electro-magnetics, which can be measured on the ground, down drill holes or from aircraft.

Seismic methods

Seismic surveys measure the speed sound travels through rock under the surface. It shows changes in porosity and permeability density. The diagram shows how the sound waves are reflected at the surface of the denser rock.

Different rock types and geological structures affect these seismic waves in specific ways; and by studying the results obtained, the shape and structure of layers under the Earth's surface can be predicted. Seismic methods are commonly used in exploring for oil and coal.



Source: APPEA Essentially oil and gas (p18)

Radiometric surveys

Many rocks and minerals are naturally radioactive. In fact, almost everything has some level of radioactivity—even us! This is due to small concentrations of radioactive elements like potassium and uranium. Radiometric surveys measure variations in the natural radioactivity of the Earth's surface. Modern spectrometers enable radioactivity to be detected at very low levels not previously detectable. These surveys are normally done from the air, the ground and down all holes.

Geophysical surveys at Cannington Mine

Cannington is about 800 kilometres west-south-west of Townsville and about 250 kilometres south-south-east of Mt Isa. In 1989 a detailed aerial magnetic survey was carried out over the area and interpretation of the results defined a series of magnetic anomalies which lead to the discovery of a significant deposit of silver, lead, zinc and a magnetic mineral called magnetite.

- Some geophysical exploration techniques (for example, magnetics) originated from military technology used to search for submarines underwater.
- In 2003, 265 exploration permits were granted in Queensland.

Resource 7: Searching for an iron nail

Background

The Earth acts as a giant magnet and influences minerals that are magnetic or may be magnetised, particularly objects containing iron. Magnetometers measure changes in the magnitude of a magnetic field. Magnetic surveys may be undertaken from the air or on the ground. The data are presented as a magnetic map using computer technology.

Purpose

To search for buried nails without disturbing the land.

Materials and equipment

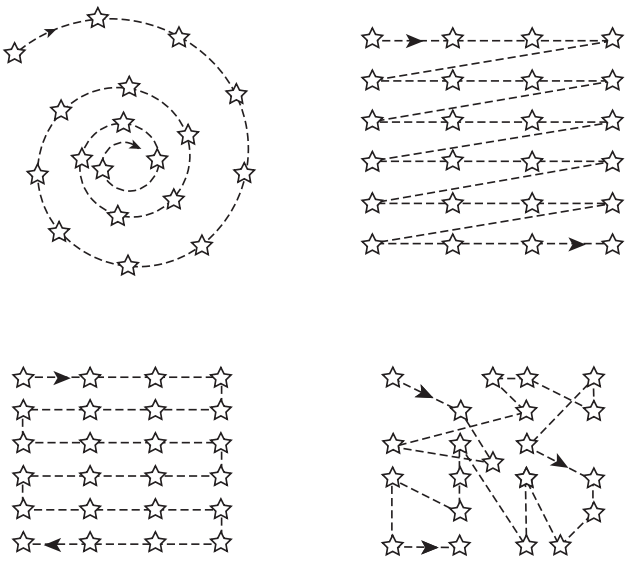
- Tray of sand (preferably square)
- Five 75 millimetre iron nails
- Compass
- Two copies of grid maps
- Ruler
- Permanent magnet.

Method

1. Check the magnetism of the nails using the compass to ensure their magnetic field is strong enough. If not, magnetise the nails by rubbing them along a permanent magnet.
2. Without showing your partner, hide the five nails in the tray of sand between two and three centimetres deep. Mark the location of the nails on your map.
3. When the surface is flat, mark north in the sand.
4. Your partner's task is to locate the five nails using the compass and without disturbing the sand. Mark the positions and directions on the map.
5. Check your predictions of the locations with a pencil.
6. After checking, restore the sand to its initial condition.
7. Swap roles and repeat the steps above.

Consolidation

1. What property of the nails was being used to allow them to be located?
2. What sort of mineral deposits can be explored this way?
3. What are some advantages and disadvantages of exploring for underground mineral deposits in this manner?
4. On the right are some patterns a survey could follow. Each place at which a measurement is taken is marked with a ☆. Which pattern do you think is the most efficient way to conduct the survey?
5. Write a paragraph to describe how you would use this technique to explore 100 square kilometres for a zinc deposit which you predict has the magnetic mineral pyrrhotite in it. Include the direction of your search pattern and how many readings you would take.



Source: Department of Mines and Energy South Australia, 1996, *Resources: Working for the Right Balance*, Adelaide Institute of TAFE

Conclusion

What did your results show? What worked well? What didn't work well? Suggest changes to the experiment.

Recording results—map of exploration area

	A	B	C	D	E	F	G	H	I	J
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

N

Resource 8: Exploration by drilling

Geochemical and geophysical exploration is used to locate the possible presence of a mineral deposit but cannot confirm its existence. The data are collected, plotted on maps using sophisticated computers, and then interpreted by geoscientists. The only way to test for an underground mineral deposit is to gather data from beneath the surface. This is usually done by drilling. Samples are studied to find the composition and depth of a mineral deposit.

Auger drilling

An auger rig may be used if non-core samples are required from relatively shallow depths soils or soft rocks. The auger may be truck or tractor mounted, similar to a farm posthole drill. An auger drill is like a large-scale corkscrew, with relatively loose rock and soil being bought to the surface.

Reverse circulation air drilling

As the drill goes into the ground, it uses pressurised air and a hammer to break the solid rock into small rock chips. These are continuously blown to the surface by compressed air and collected at regular intervals by the crew for the geoscientists to examine. These drill holes can be several hundred metres deep.

Core or diamond drilling

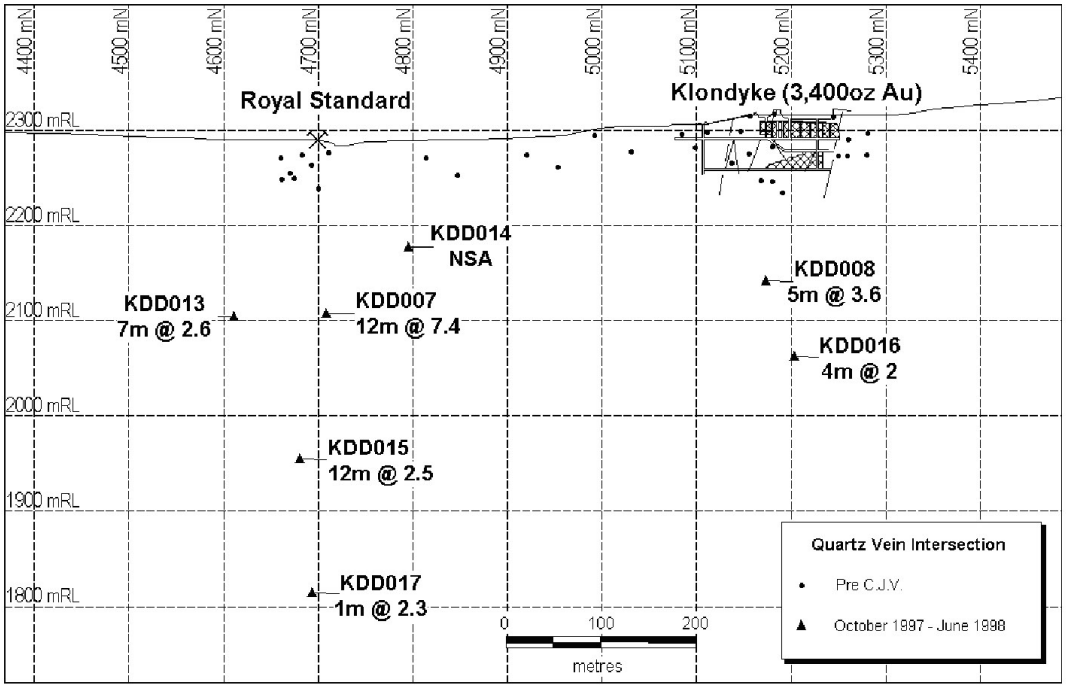
Samples are obtained by rotating a string of drill rods into the ground under hydraulic or mechanical pressure. The drill bit, which is usually faced with a small diamond, cuts a cylindrical core of solid rock that continuously passes up into the drill rods as they penetrate deeper. Although drill holes can be several kilometres deep, they are usually only a few hundred metres. This is the most expensive form of drilling.

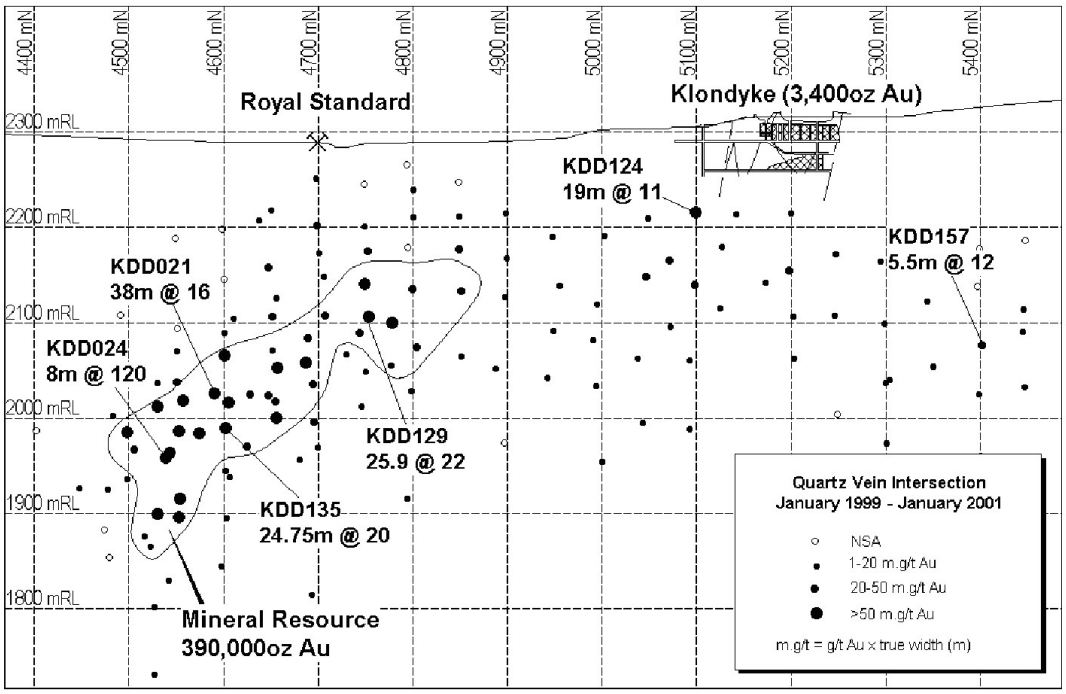
Cracow exploration drilling

Gold was first reported at Cracow, 100 km south-west of Biloela, in 1875. Since then, 825 000 ounces of gold have been mined. In 1996, exploration began for high-grade epithermal vein-style mineralisation in the Cracow Goldfield. The gold mineralisation is located in andesitic rocks that, in most areas, are covered by sedimentary rocks, hiding any surface features in the andesites. The gold mineralisation occurs at depths to about 600 metres and was located and sampled using drilling.

The exploration strategy involved looking for extensions from known ore bodies and testing new targets. The targets were located using geological mapping and surface geochemical sampling. The Crown Shoot mineral resource was found from 42 drill holes comprising 40 core drill holes and two reverse-circulation drill holes. The drill-hole samples were tested for gold and silver. The successful exploration program identified a total resource of 790 000 ounces of gold, and the feasibility study recommended development. The mine is proceeding to an underground operation.

The diagram is of a long-section showing progressive drilling phases. A mining long section is a vertical slice through the length of the deposit. Each dot represents a drill-hole intersection. The bigger the dot, the more gold.


4400 mN
4500 mN
4600 mN
4700 mN
4800 mN
4900 mN
5000 mN
5100 mN
5200 mN
5300 mN
5400 mN
2300 mRL
2200 mRL
2100 mRL
2000 mRL
1900 mRL
1800 mRL
Royal Standard
Klondyke (3,400oz Au)
KDD014
NSA
KDD008
5m @ 3.6
KDD013
7m @ 2.6
KDD007
12m @ 7.4
KDD016
4m @ 2
KDD015
12m @ 2.5
KDD017
1m @ 2.3
0
100
200
metres
Quartz Vein Intersection
Pre C.J.V.
October 1997 - June 1998


4400 mN
4500 mN
4600 mN
4700 mN
4800 mN
4900 mN
5000 mN
5100 mN
5200 mN
5300 mN
5400 mN
2300 mRL
2200 mRL
2100 mRL
2000 mRL
1900 mRL
1800 mRL
Royal Standard
Klondyke (3,400oz Au)
KDD124
19m @ 11
KDD157
5.5m @ 12
KDD021
38m @ 16
KDD024
8m @ 120
KDD129
25.9 @ 22
KDD135
24.75m @ 20
Mineral Resource
390,000oz Au
Quartz Vein Intersection
January 1999 - January 2001
NSA
1-20 m.g/t Au
20-50 m.g/t Au
>50 m.g/t Au
m.g/t = g/t Au x true width (m)

Resource 9: Percussion air drilling

Background

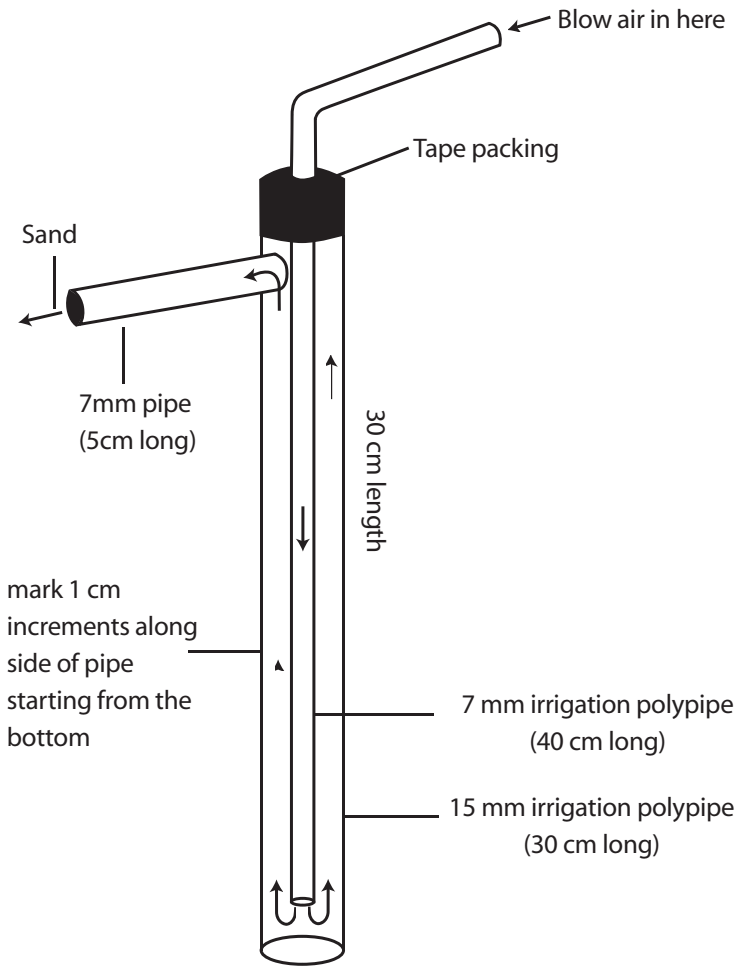
As the drill goes into the ground, it uses pressurised air and a hammer to break the solid rock into small rock chips. These are continuously blown to the surface by compressed air and collected at regular intervals by the crew for the geoscientists to examine. These drill holes can be several hundred metres deep.

Purpose

To demonstrate how samples of rock chips are brought to the surface using the same principle as the returning air or water used by real drilling rigs. To use the data collected to predict the composition of the ground.

Materials and equipment

- 30 cm length of 15 mm black poly pipe
- 40 cm length of 7 mm black poly pipe
- Extra 5 cm length of 7 mm black poly pipe for exhaust hole
- 10 cm of masking tape to wrap 30 cm from one end of the 7 mm pipe so that it will fit tightly into the 15 mm pipe, as in the diagram
- A pair of scissors or a Stanley knife to cut an exhaust hole in the big irrigation pipe 3 cm from the top end
- A bottle of sand to drill into
- A drill-hole log sheet
- Glue to stick sand samples.



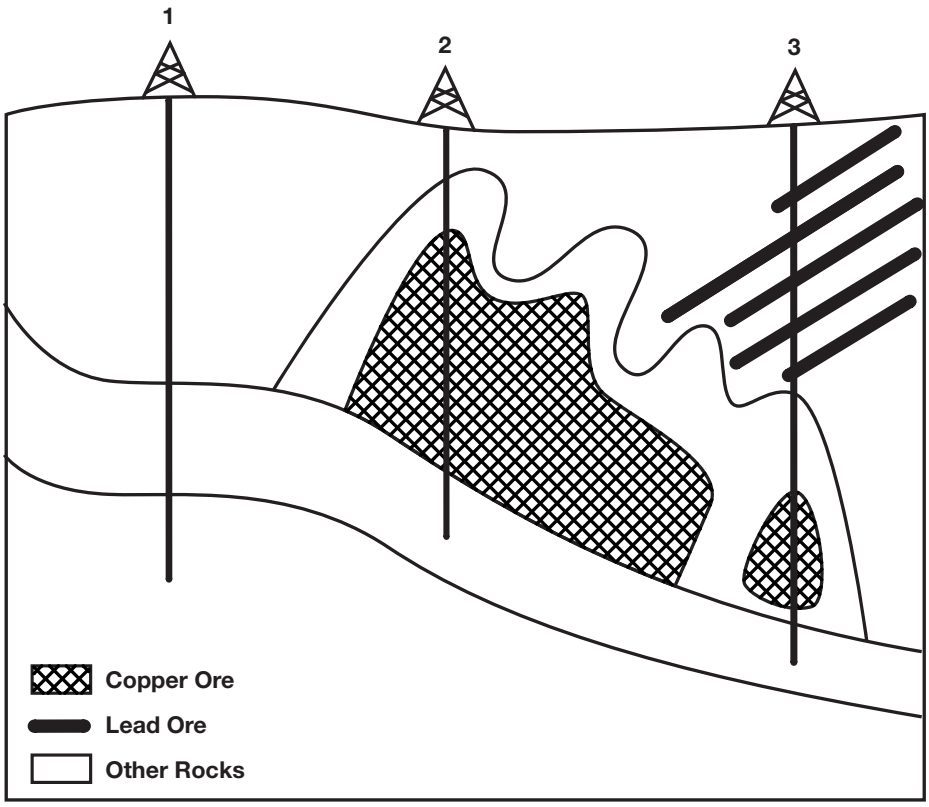
Source: Department of Mines and Energy South Australia, 1996, *Resources: Working for the Right Balance*, Adelaide Institute of TAFE

Method

1. Construct the percussion air drill as shown in the diagram.
2. Place the end of the drill tube on the sand to be drilled and blow down the narrow tube. **Hint:** Don't blow too hard. You will see the sand from the bottom of the hole lifted up and out of the exhaust hole. This is where samples are taken. With firm downward pressure of your fingers, guide the drill down in one centimetre increments.
3. Take sand samples every one centimetre as you drill through to the bottom of the container and glue these on the drill hole log sheet.
4. Once you have completed the consolidation questions, remove the paper wrapping from around the bottle of sand and compare your sand layer sequence from the log with that in the bottle. Is the sequence the same or does it differ? If it differs, explain why.

Consolidation

1. Why do explorers drill?
2. How deep was the total hole length?
3. How many layers of sand were there?
4. How thick is each layer?
5. The diagram below shows a cross-section of an ore body.
   - If you were a geologist, what would you infer after the first exploratory drill hole? After the second? And so on?
   - Why do you think drilling is often the last step in exploration?



Conclusion

What did your results show? What worked well? What didn't work well? Suggest changes to the experiment.

Recording results

Glue sample	Depth (in cm)	Description (colour, grain size, texture)
	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	
	11	
	12	
	13	
	14	
	15	
	16	
	17	
	18	
	19	
	20	

Resource 10: Computer modelling in exploration

Computer technologies are used extensively to model and record information gathered in exploration. The images produced form an excellent visual aid for geologists. Innovations in this area are many. Websites with current information on computer modelling and innovations are listed below.

Australia is the world leader in this technology, and most mining and exploration companies in the world use software developed in Australia. In some cases, this technology has been adopted and used by other industries. For example, underground mine surveying and modelling techniques were used for the filming of the movie, *The Matrix*, in Sydney.

As a group, choose one website and present the information you have learned to the class using PowerPoint, a poster or other forms.

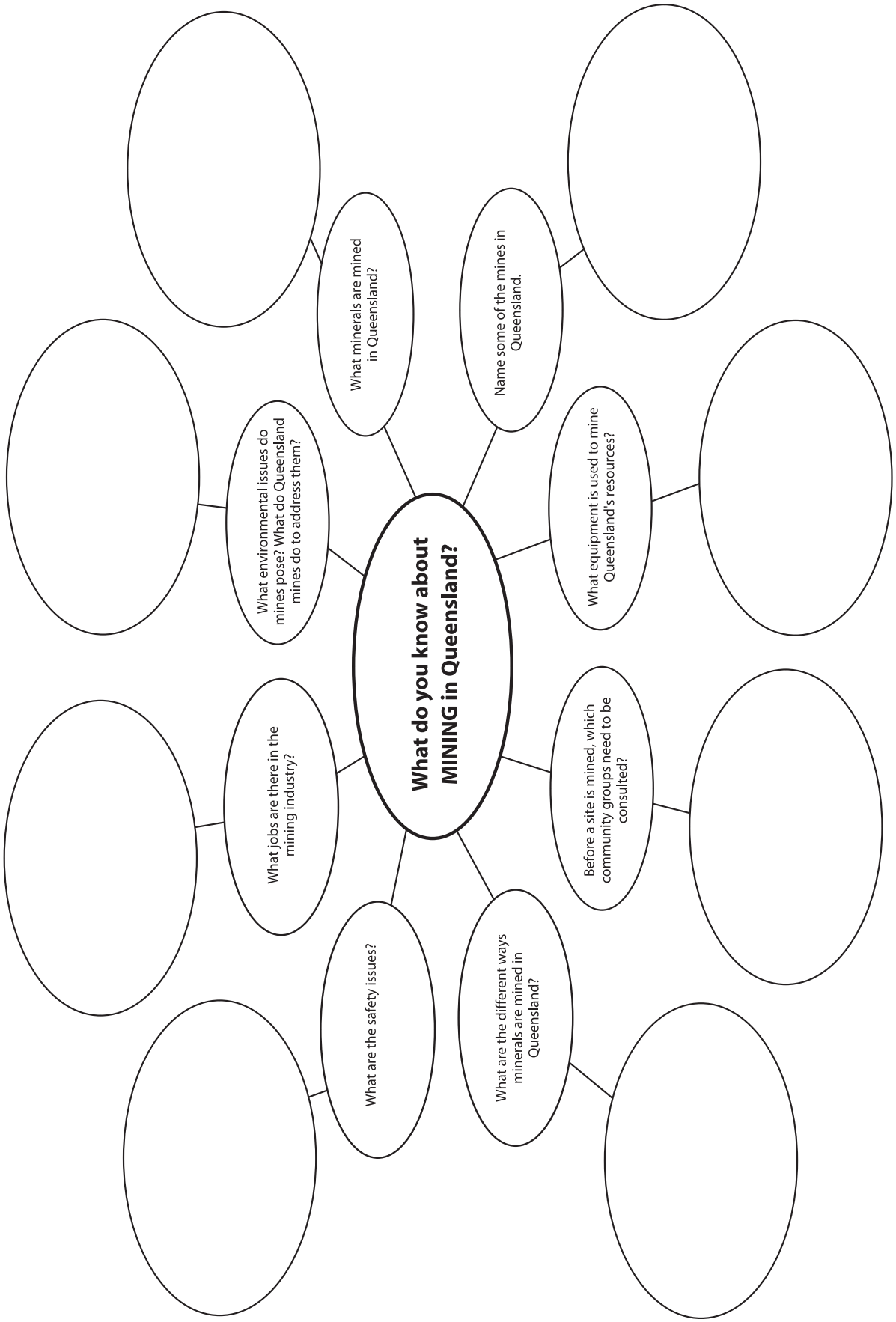
- CSIRO **http://www.dem.csiro.au/**
- CSIRO Glass Earth Project **http://www.dem.csiro.au/em/majorresearchinitiatives/index.html**
- Predictive mineral discovery Cooperative Research Centre **http://www.pmdcrc.com.au/**

Company websites

- Geosoft **http://www.geosoft.com**
- Encom Technology **http://www.encom.com.au/**
- Surpac Minex **http://www.surpac.com.au/index.asp**
- Fractal Technologies **http://www.fractaltechnologies.com/**
- Mincom **http://www.mincom.com/solutions/mining/default.asp**
- Micromine **http://www.micromine.com.au/home.htm**
- Vulcan **http://www.vulcan3d.com/case_studies.html**

Resource 11: What do you know?

Brainstorm as many ideas as you can for each question.



Resource 12: Biscuit mining

Background

Open-cut mining is usually carried out when the ore body is economically accessible using surface mining methods. The open-cut mine is dug downwards, in benches or steps, which slope in towards the centre of the pit.

Underground mining is used when an ore body is deep beneath the Earth's surface or where the use of the land on the surface is such that surface mining is not appropriate. Access to these underground deposits is by vertical shafts or by sloping tunnels.

Leach mining is used when ore contains minerals that can be dissolved in solution (leachates) and when rocks are impermeable or highly fractured. Firstly, bores are drilled into the ore body, then leachates dissolve the valuable minerals, which are pumped back to the surface through drill holes.

Dredge mining — Some minerals are mined using a dredge, which floats on the top of a large body of water.

Purpose

To use a variety of biscuit types and extract the minerals using any of the above methods, then examine the impact of your method in relation to costs, benefits and impacts on the environment.

Equipment

- Samples of chocolate chip, tim tams and fruit pillow biscuits
- Variety of mining tools including scissors, paddle pop sticks, drawing compasses, toothpicks, small spatulas, beakers, containers
- Scales.

Method

1. Before you start, discuss with your group members which mining method you will use (leach, open cut, strip, underground) to extract the minerals from each biscuit. Remember that, before mining companies begin to mine, they choose appropriate mining methods and plan how to manage their impact on the environment. Record this in the table and briefly describe your process.
2. Extract the ore using the tools provided.
   - The biscuit must remain flat on the table at all times.
   - You are unable to lift or turn the biscuit.
3. Sort the ore into separate piles.
4. Weigh the ore and record the results.
5. Put the biscuit back together to rehabilitate your mine site.
6. Repeat the experiment.

Consolidation

1. For each biscuit type, which method of mining produced the most ore?
2. For each biscuit type, which method would be most profitable?
3. What environmental management issues might there be with different methods of mining?
4. How might mining companies attempt to address these issues?

Recording results

Trial 1				
Biscuit type	**Mining method**	**Environmental management**	**Original weight of biscuit**	**Amount of ore produced**
Trial 2				
Biscuit type	**Mining method**	**Environmental management**	**Original weight of biscuit**	**Amount of ore produced**

Resource 13: Open-cut mining in Queensland

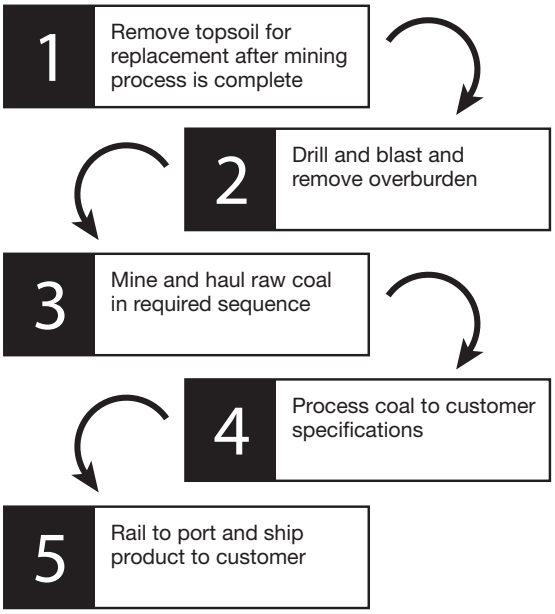
Open-cut mining is usually carried out when the ore body is accessible by surface mining methods. The open-cut mine is dug downwards, in benches or steps, which slope in towards the centre of the pit.

Ore and the surrounding waste rock are mined at the same time and later separated. Explosives are used to break up the ore, which is then scooped up by front-end loaders or large electric shovels, loaded into giant trucks and taken to a crusher. Waste material is placed in large piles and later covered with soil and revegetated.

Mining continues until the pit becomes too deep and, therefore, too expensive or too difficult to mine by this method. In Queensland, zinc, copper and coal are often mined this way.

Open-cut mining at Goonyella Riverside

Goonyella Riverside is a coal mine located 190 kilometres, west of Mackay. Export coal terminals are located at Hay Point and Dalrymple Bay. In 2002, Goonyella Riverside produced 11 million tonnes of prime coking coal. The diagram outlines the mining process at Goonyella Riverside coal mine.

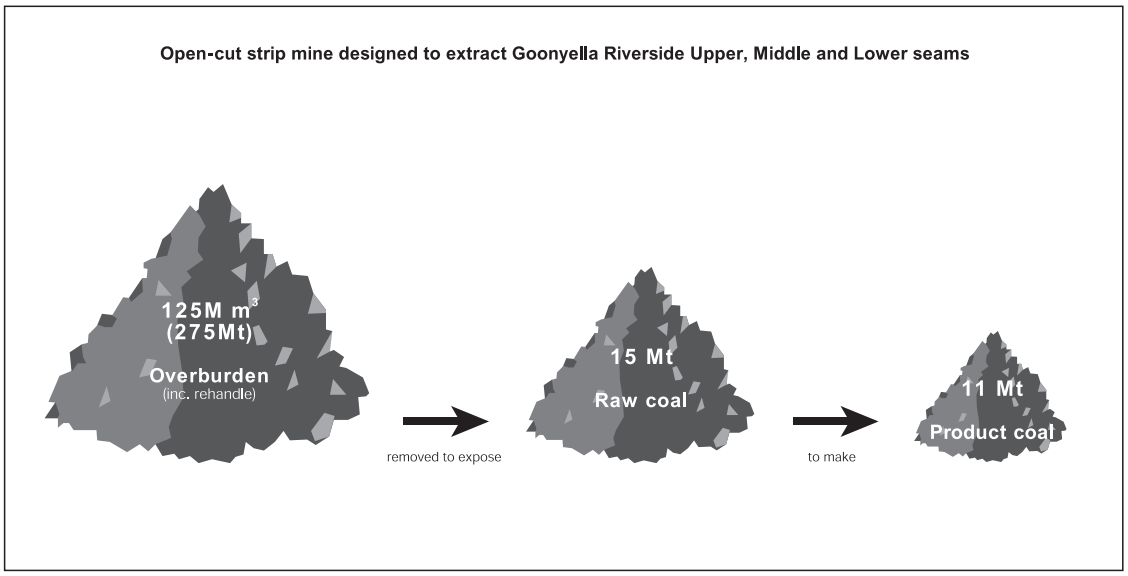


What does the future hold for Goonyella Riverside?

Goonyella Riverside has extensive reserves of coal, which will enable production to continue well into the future (at least 60 years of mine life at current output).

The major issue facing Goonyella Riverside is the increasing depth of the coal seams. This is being addressed by:

- upgrading equipment to increase efficiency
- optimising mine plans, including development of an airstrip pit and the feasibility of double-seam extension
- implementing a continuous improvement program (Operating Excellence) to increase mine efficiencies and reduce costs
- undertaking an underground mining feasibility study.



Environment issues

The main objectives of Goonyella Riverside's environmental management program are to leave an approved post-mining landform, preserve downstream water quality, effectively manage waste and minimise greenhouse gas emissions.

Working with the Goonyella Riverside community

The Goonyella Riverside coal mine provides:

- traineeships and apprenticeships for more than 20 young Moranbah people and four university scholarships each year
- matching grants for the volunteer efforts of each employee to $1000 each year to community organisations for which the volunteer work is undertaken.
- a fulltime computer technician to maintain the 200 computers in Moranbah's schools
- an annual health and wellbeing calendar produced from the posters of the local students providing a fundraiser for the local schools
- sponsorship of TriQ, an organisation providing and finding employment for youth in need
- a feedlot program, operated in cooperation with Goonyella Riverside's closest neighbour, which produces topsoil for the mine and fattened cattle for sale.

Careers

Mining engineers are employed at Goonyella Riverside to oversee the entire mine's operation. Their responsibilities include:

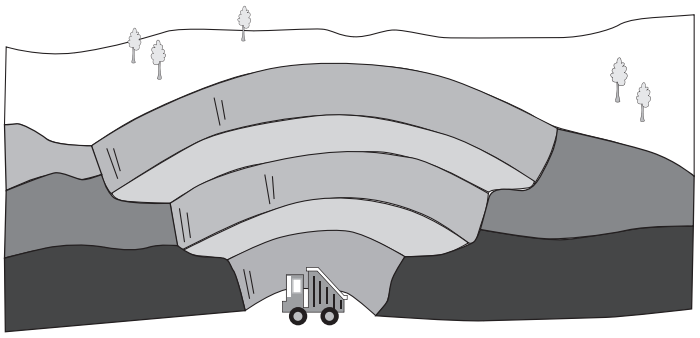
- conducting investigations and evaluations of mineral deposits to determine mining profitability
- determining the most suitable method of mining for the site
- preparing plans for mining operations
- preparing the layout of mining operation and development
- planning and coordinating how staff and equipment will be deployed
- consulting with geologists and other engineers on design, selection and provision of machines, facilities and systems for the mine
- ensuring mining regulations are observed.

Queensland coal is shipped to 33 countries. Major export customers are Japan, Korea, India, Taiwan and the United Kingdom.

Resource 14: Measuring and comparing steepness and height of a wall in an open-cut mine

Purpose

Open-cut mines are used to mine mineral deposits that are close to the Earth's surface. In this experiment, you will see how steep and how deep you can make the wall of an open-cut mine before it collapses into the pit.



Materials and equipment

- Sand to a depth of 25 centimetres
- Ruler to measure depth, water
- Ten marbles to represent the mineral ore body.

Method

1. Bury 10 marbles together at the bottom of dry sand at a depth of 25 centimetres.
2. Dig a hole in the dry sand to the marbles, making the sides of the hole as steep as possible.
3. Put the sand you have removed into another container. When the sand has stopped sliding back into the hole, mine the marbles out.
4. Measure the depth and diameter of the mine. Record all your measurements.
5. Repeat steps 1 to 4 after making the sand damp, then wet and finally saturated.

Results

	Diameter	Depth
Dry sand (Trial 1)		
Dry sand (Trial 2)		
Damp sand (Trial 1)		
Damp sand (Trial 2)		
Wet sand (Trial 1)		
Wet sand (Trial 2)		
Saturated sand (Trial 1)		
Saturated sand (Trial 2)		

Consolidation

1. Describe what effect dampening the sand has on the stability of the wall and on how steep it can be. Is there a limit to the amount of water you can add before the stability is lost?
2. How is the diameter of the mine rim related to stability?
3. How does mine wall stability affect:
   - the cost of mining a mineral deposit?
   - safety for the miners in the mine pit?
   - the amount of environmental disturbance and the way rehabilitation is carried out?

Resource 15: Underground mining in Queensland

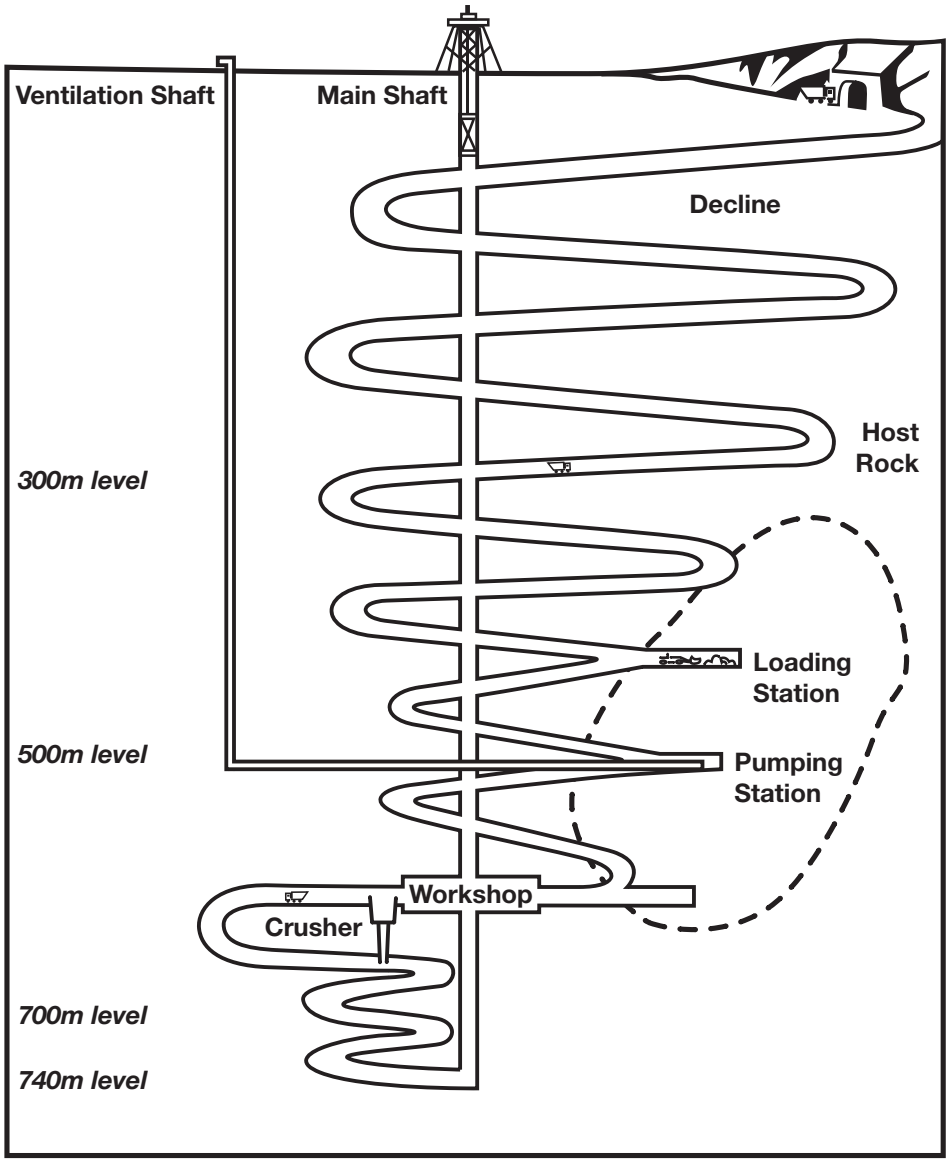
Underground mining is used when an ore body is too deep beneath the Earth's surface or where land use makes surface mining inappropriate. Access to underground deposits is by vertical shafts or by a sloping tunnel called a decline. Large machinery is often taken underground in pieces and assembled in the work area. All underground mines have ventilation systems, which continually circulate fresh air for the workers.

Longwall coal mining

One efficient way of mining coal underground is by longwall mining. Mechanised shearers advance along the face of a block or seam of coal, which can be up to 250 metres wide. The shearers cut off the coal in slices. Conveyor belts transport the coal to the surface. The roof over the area where the coal is being removed is held up by hydraulic-powered supports that automatically move along as the coal is removed. As the equipment moves forward, the roof of the mined area is then allowed to collapse.

Traditional underground metal mining

Another method of underground mining involves blasting hard rock and ore from large openings known as stopes. The mined material is brought to the surface in trucks or hoisted up a shaft in large containers called skips. To protect workers from cave-ins, the roofs and walls of these underground workings are supported by various methods, including rock bolts, cable dowels, steel straps and steel mesh. Minerals that contain metals are often mined this way.



Source: 'Mineral Magic' Resource Book, p15, Australian Mining Industry Council

Underground gold mining in Queensland

Gympie was originally settled as a consequence of a gold rush. In 1867, James Nash was prospecting in the area and in six days found 2.7 kilograms of gold. Nash's discovery began a gold rush, which quickly led to Gympie's development. Historical production has yielded more than four million ounces of gold.

The town of Gympie is built over a complex series of underground mine shafts. Modern geophysical surveys have indicated that the major ore-bearing structure continues further in both directions than previously thought. A large area of the Gympie goldfield is intended to be mined using tunnels that can easily be extended in various directions.

- Gold is a dense metal. A gold bar or ingot the size of an average house brick weighs about 25 kilograms.
- Gold is a soft metal and can be beaten out to form paper-thin gold leaf. In some parts of the world, gold leaf is actually eaten as part of a special dish.
- Discovered in Gympie, the famous Curtis Nugget, which weighed 37 kilograms, was the largest single nugget found in Queensland.

Resource 16: Preventing cave-ins in underground mines

Background

Underground mining is used to get to minerals, which are deep below the surface. It is more expensive than open-cut mining and more dangerous for many reasons including possible cave ins. Several methods are used to stop tunnels in mines from caving in, including rock bolts and the use of girders, which are usually long pieces of steel made into frames.

Purpose

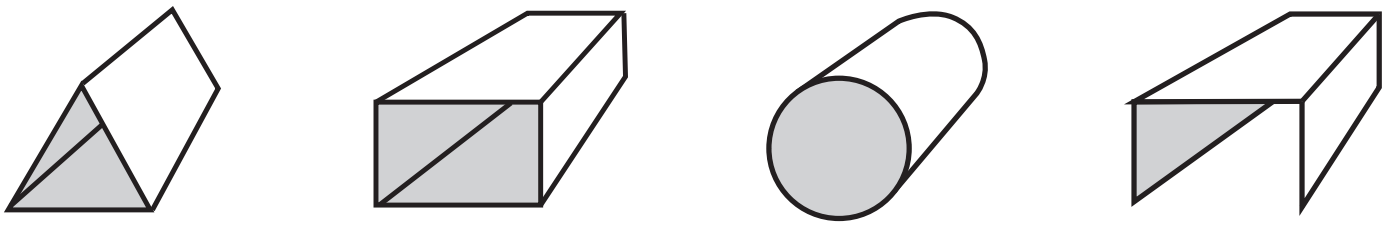
To investigate the strength of a number of different-shaped girders.

Materials and equipment

- Half a bucket of sand or weights
- Scoop for the sand
- Two cardboard sheets of girder templates
- Tape, glue, scissors
- Small container.

Prediction and justification

Which of these girders do you think will be able to support the greatest weight or sand?
Why?



Source: Department of Mines and Energy South Australia, 1996, *Resources: Working for the Right Balance*, Adelaide Institute of TAFE

Method

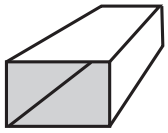
1. Make two sets of girders using the templates on the following page and allow the glue to dry.
2. Place the girder across a gap between two desks, hang a small container from the middle of the girder and add weights or sand until the girder fails
3. Add up the total weight or measure the depth of sand and record the results.
4. Empty the weights or sand, straighten out the girders, and test them again. What do you find about their strength now?

Consolidation

1. Which shape was able to support the most weight or sand?
2. Which shape supported the least weight or smallest amount of sand?
3. How do your findings compare with the results of other students?
4. Did you find that there was a difference in the strength of two girders of the same shape? If so, how could you design the experiment for more reliable results?
5. What improvements could you make in the design of this experiment to achieve more reliable results?

Templates

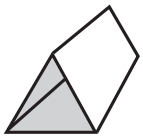
A



Rectangular Girder

glue to Tab A

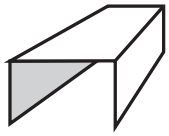
A



Triangular Girder

glue to Tab A

A



'N' Girder

glue to Tab A

A

Cylindrical Girder

glue to Tab A

Source: Department of Mines and Energy South Australia, 1996, *Resources: Working for the Right Balance*, Adelaide Institute of TAFE

Resource 17: Dredge mining in Queensland

Some minerals are mined using a dredge that floats on the top of a large body of water. This type of mining is carried out along some of the beach and sand-dune systems of Queensland's coastline, where heavy mineral sands are found.

The dredge moves slowly through the water and draws up material, mostly sand, from the bottom. Once on the dredge, the heavier minerals are easily separated from the lighter sand grains (quartz). The heavy minerals, which comprise about one per cent of the sand mass, are pumped ashore, where they are separated from each other, while the lighter sand (the remaining 99 per cent), is pumped straight back onto the beach or dune system.

The sand is shaped to match the way it was before being mined. It is then covered with topsoil and revegetated. Ilmenite, rutile, zircon and monazite are the heavy minerals mined this way.

Dredge mining on Stradbroke Island

Since 1966, Stradbroke Island has been mined for ilmenite and rutile used to make titanium metal and titanium dioxide pigment, and for zircon used in the manufacture of ceramics.

Working with the Stradbroke community

The dredge-mining operation on Stradbroke Island employs 150 island residents. The major operating costs comprise labour, electricity, maintenance and rehabilitation of mined areas. Schools, medical services, roads, electricity, water supplies and communication links have been established on the island with the mining company's assistance.

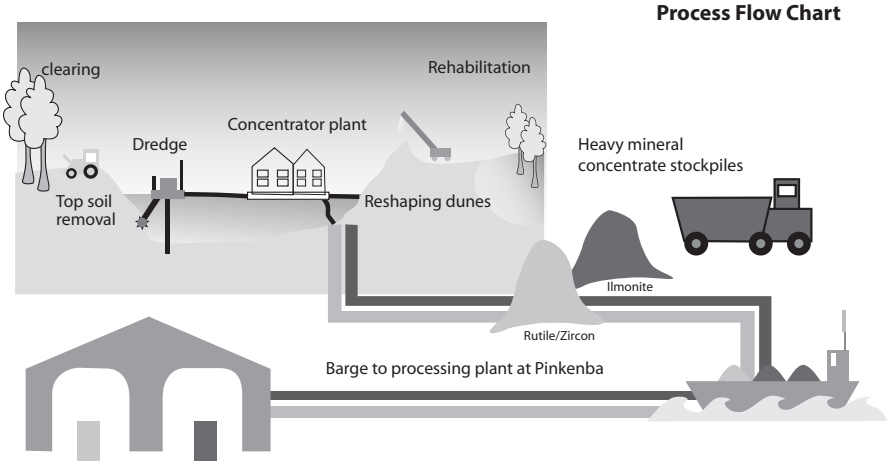
Environmental issues

As part of the rehabilitation of the mining operation, the heavy mineral sands company on North Stradbroke Island is committed to re-establishing the native flora and fauna that existed in the area before mining.

In 2002, 124 hectares were stabilised and revegetated. Rehabilitation of the site is generally completed in this sequence:

1. landform re-construction and contouring
2. topsoil spreading
3. direct seeding and fertilising
4. surface stabilisation
5. plant out of nursery stock
6. transplant grasstrees.

Process Flow Chart



Source: http://www.consrutile.com.au/minprocess/flowchart.htm

Zircon, as well as being a coating on tiles, is used as a coating for television and computer screens.

Resource 18: Leach mining in Queensland

Background

Leach mining is a method of extracting materials without actually extracting the rock. It is used when valuable minerals can be dissolved when a solution is pumped through drill holes to the ore body.

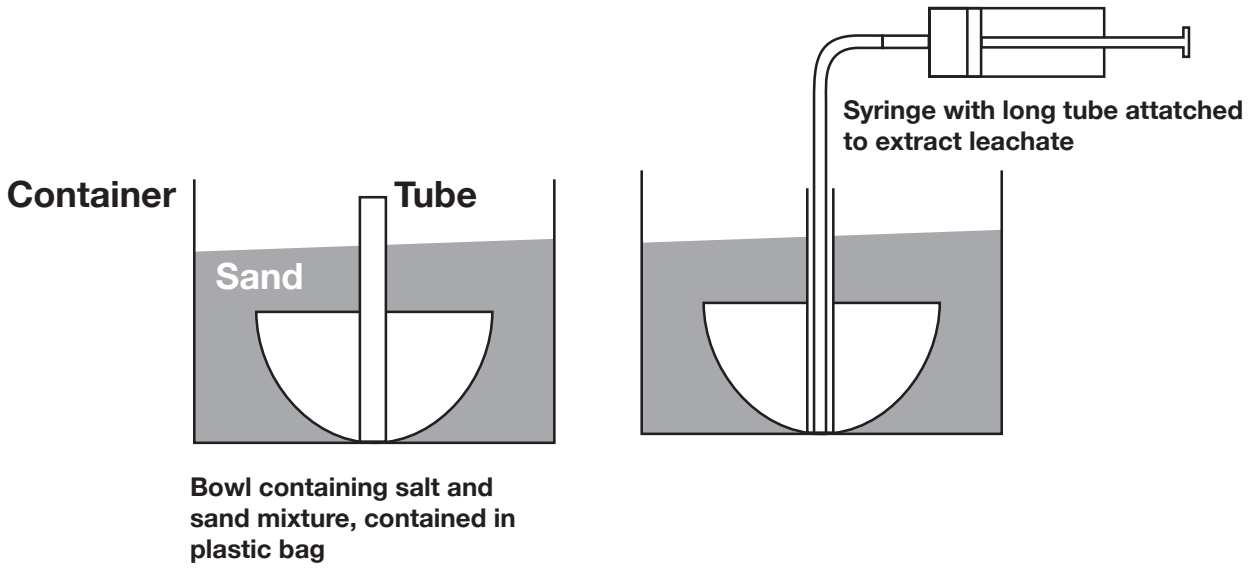
The solution containing the dissolved minerals is then pumped back to the surface and the valuable elements, such as metals, are extracted. The Mount Gordon mine, located 125 kilometres north of Mount Isa, uses this method to extract copper.

Purpose

To investigate how to extract a deposit of salt and copper sulphate from underground, using leach mining.

Materials and equipment

- Sand
- salt
- tube (for drill hole)
- syringe
- tube (to attach to syringe)
- filter paper
- beaker
- copper sulphate
- ribbon zinc.



Source: Mt Gordon website

Method (salt extraction)

1. Drill through the overburden sand using a tube.
2. Penetrate the covering plastic bag; then continue drilling to the bottom of the bowl.
3. Leave the tube in the hole.
4. Funnel in hot water to act as the leaching agent to dissolve the salt. Make sure the water level reaches the surface of the ground in the tube or is at least high enough for you to see. The bowl of sand and salt must be full. Filling it this high means some leakage will occur.

5. Use a syringe, with a long, thin plastic tube attached, to retrieve the salt solution after it has had enough time to dissolve. Make sure it has a long-enough tube to reach the bottom of the deposit. It may be necessary to wrap a gauze filter at the base of the syringe to stop it clogging with sand.
6. Filter the solution to remove any solids.
7. Build an evaporation pond to get the salt from the solution. Place the solution in a shallow bowl and leave it in a warm, well-ventilated area until the salt evaporates.
8. Measure the mass of the dry salt.

Method (copper extraction)

1. Repeat the experiment, this time mixing copper sulphate with the sand.
2. Use water to dissolve the copper sulphate from the mixture.
3. Once you have removed the copper sulphate solution, filter the mixture to remove any contaminants.
4. Polish a small strip of zinc and add it to your solution.
5. Label your beaker and leave it over night.
6. Filter the liquid and allow the filter paper containing the solid copper to dry.
7. Measure the mass of the dry copper.

Recording results

	Amount of mineral in original deposit	Amount of mineral mined
Salt		
Copper		

Consolidation

1. What weight of salt/copper were you able to extract from the deposits?
2. How well were you able to do all the processes?
3. Can you make any improvements?
4. What are the main advantages of leach mining?

Resource 19: Mine safety

Queensland mining operations maintain high health and safety standards. Mines regularly conduct crisis and recovery exercises, similar to a fire drill, to enhance response to a genuine workplace emergency. Data are kept on types and severity of accidents. Queensland has a very good safety record, and workers work hard to prevent mining tragedies.

Emergency exercises

Mining companies regularly hold emergency exercises, similar to a fire drill at school. This exercise tests the operation of the mine's refuge chambers, self-escape, fire fighting knowledge, use of electronic and manual devices to guide miners when visibility is severely reduced, decision-making, and communication systems. Through such realistic exercises, the mine workers gain insight into the effectiveness of their systems and procedures at all levels.

Technological advances

The 'hi-tech canary' developed by CSIRO is capable of predicting mine collapse or the release of deadly gases into a mine. This technology has the potential to save lives in mining accidents. The technique, which has been trialled at underground coal mines in Queensland, is called microseismic analysis. It measures the small seismic waves generated in rock under stress from mining. It has sophisticated instruments, data processing and visualisation tools to analyse the seismic waves, which can be conducted up to 700 metres from the mining area.

Arrays of geophones pick up the seismic waves. Inserted into the ground surface, geophones are devices with a wire coil inside a magnetic field. Seismic waves cause the coil to move in the field generating a voltage. Signals from the geophones pass through a cable to the data acquisition system, where they are amplified and recorded. Microseismic monitoring also provides estimates of the size of the fracture and the energy of the seismic waves generated. For further information, go to **http://www.csiro.au/**

Safety robot

A five-kilogram robot that can detect potentially hazardous gases in coal mines after a fire or explosion and send crucial information to safety and rescue personnel on the surface is being evaluated for use in Queensland coal mines.

The $54 000 robot, which looks much like a toy bulldozer, is small enough to fit down a 20 centimetre borehole leading into a mine. The robot is equipped with a digital low-light camera and a basic gas monitoring package, which will be able to detect oxygen and methane in the mine atmosphere. Queensland's robot is similar to ones used by the United States Navy in Afghanistan and Iraq to check out caves and other underground areas.

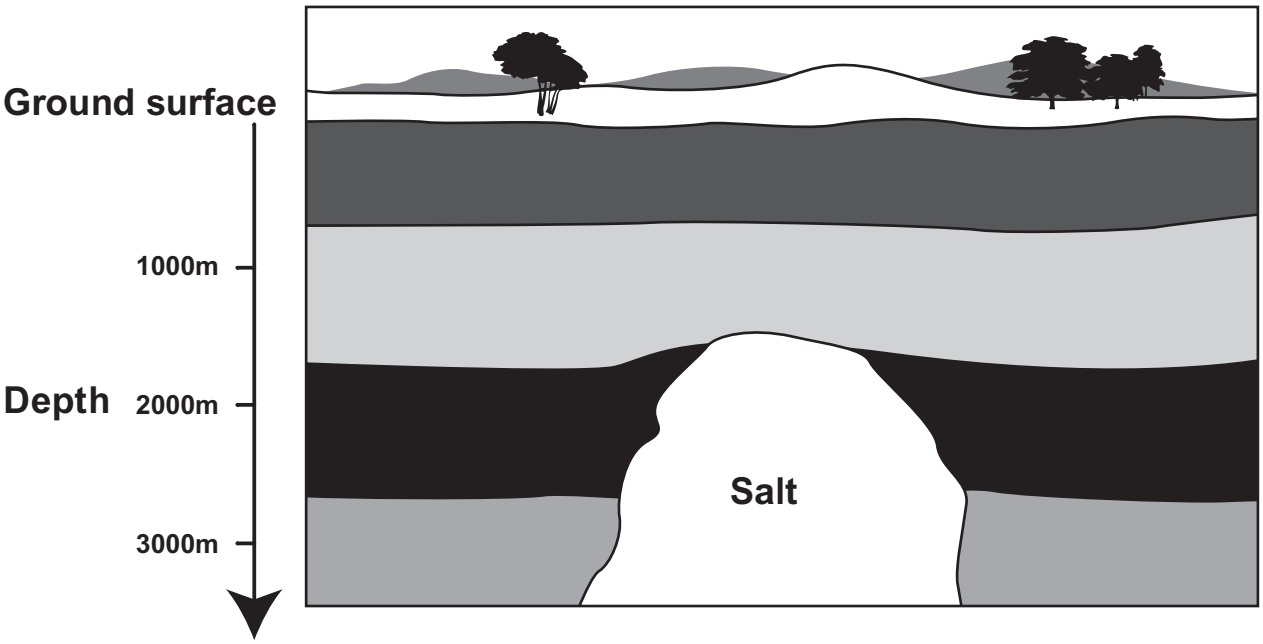
Source: Minetalk, Vol. 11, July 2003

Resource 20: Reviewing mining methods

Answer the questions below.

1. What is a mineral ore?
2. What happens to the overburden and topsoil that is removed to expose the ore body during open-cut mining?
3. Underground mining is more expensive than open-cut mining. Under what conditions is underground mining undertaken in preference to open-cut mining?
4. What is meant by the term 'dredge mining'?
5. Suggest why underground mining is more expensive than open-cut mining.
6. What are the advantages of open-cut mining compared with underground mining?
7. Study the situation shown in the diagram below and design a way of mining the salt without disturbing large areas of land.

Salt dome



Source: Department of Mines and Energy South Australia, 1996, *Resources: Working for the Right Balance,* Adelaide Institute of TAFE

Resource 21: Assignment—Mining methods Part A

Demonstrating outcome EB 4.3

Core learning outcome

Earth and beyond 4.3: Students summarise information to compare ways in which different communities use resources from the Earth and beyond.

Your task

Complete this table by reviewing what you have learnt from Resources 13–19.

Type of mining	Where is it used?	Minerals mined this way	Explanation of process
Open-cut mining			
Dredge mining			
Underground mining			
Leach mining			

Resource 21: Assignment—Mining methods Part B

Core learning outcome

Earth and beyond 5.3: Students prepare scenarios about the use of renewable and non-renewable resources of the Earth and beyond.

Core learning outcome

Earth and beyond 6.3: Students argue a position about stewardship of the Earth and beyond, and consider the implications of using renewable and non-renewable resources.

Your task—level 5

1. Open cut, dredge, underground and leach mining methods are used in Queensland. Choose one and identify and record the key ecological, economic and social factors that arise when this mining method is used. To complete this task, review Resources 13–19 and at least two other sources of information. Use the attached graphic organiser to record your notes.

2. Write a report about the use of your chosen mining method. You may include the positives and negatives of this method, the implications for using or not using this method, possible alternatives, and ideas that may improve the method or reduce/increase its use.

Your task—level 6

1. Open cut, dredge, underground and leach mining methods are used in Queensland. Choose one and identify and record the key ecological, economic and social factors that arise when this mining method is used. To complete this task, review Resources 13–19 and at least two other sources of information. Use the graphic organiser to record your notes.

2. Prepare a written or oral argument outlining the implications for using this mining method with a view to reducing any negative impacts this method has on the natural environment. Include the responsibilities that producers, consumers and regulatory bodies should exercise in this process. Before you begin writing, plan your report by mapping out your key arguments.

Graphic organiser

Ecological factors

Economic factors

Use of

_____

mining

Social factors

Sources:

1. _____

2. _____

Suggested format to plan a persuasive argument

Use the information on your retrieval chart to form your arguments and supply details to support them. Write these ideas on this plan before writing your essay.

Introduction

Issue _____

_____

Your position _____

_____

Preview of arguments _____

_____

Body

Argument 1

Topic sentence _____

_____

Supporting evidence _____

_____

Argument 2

Topic sentence _____

_____

Supporting evidence _____

_____

Argument 3

Topic sentence _____

_____

Supporting evidence _____

_____

Conclusion

Call for action (optional) _____

_____

Restate your position _____

_____

3 How does mining affect communities?

How does mining affect communities?

Outcomes

Science strand	Level 4 outcomes			Level 5 outcomes			Level 6 outcomes		
Earth and Beyond			4.3			5.3			6.3
Science and Society			4.3			5.3			6.3

Teaching and learning activities

Focus areas	Resource sheets
Sustainability and the future of mines	1. Sustainable quarrying 2. Sustainable quarrying industry 3. Sustainability game 4. Sustainable use of resources
To mine or not to mine—social impacts	5. Who needs to have a say? 6. Factors that determine if a mineral deposit will be mined
Environmental impacts	7. Environmental management 8. Ice-cream container mining and rehabilitation 9. Water conservation 10. Surveying and mapping of local vegetation 11. Managing oil spills
Economic impacts	12. The value of minerals produced in Queensland 13. Careers in the mining industry 14. Interviews with scientists working in the mining industry
Putting it all together—what would your community do?	15. Would you mine the school oval?

Teaching notes

Sustainability and the future of mines

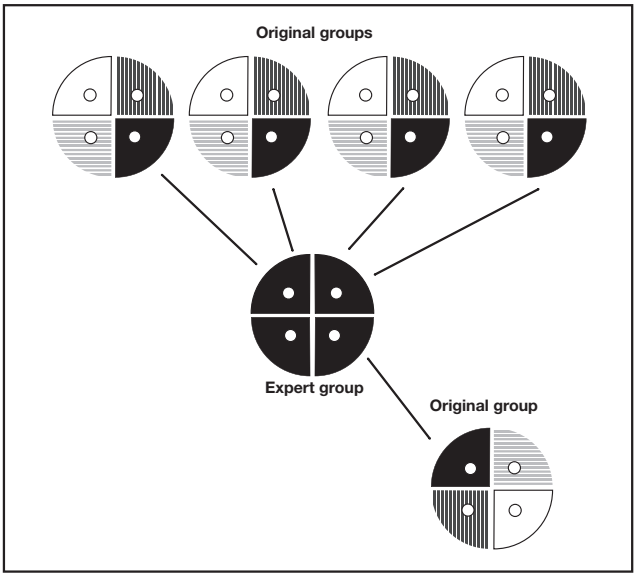
Outcomes: Working towards EB 4.3, 5.3 and SS 4.3.
Assessment ideas: Inclusion of worksheets and practical data in portfolio.

1. Sustainable quarrying

To engage students in reading this fact sheet and also Resource 7, use a peer teaching strategy called 'expert jigsaw'. Students read only part of the fact sheet and teach that information to their peers, thereby becoming 'experts' in their area.

Procedure

- Before you start, decide how you will divide the text on the fact sheet as this will determine group size. For example, the text in Resource 1: 'Sustainable quarrying' is divided into seven sections of varying length and complexity. You could use these sections and have seven in a group or combine some sections and divide the material and the groups into three or four. Groups of three or four are usually more productive. Before you start photocopy and cut the sheets into the desired sections.
- Invite students to form groups (of the number you have decided on) and assign each group member a section of the fact sheet.
- Next ask students to meet with the members of other groups who have been assigned the same section, forming a new group. This new group learns together and becomes an expert on its portion of the assigned material by discussing it and asking the teacher any clarifying questions. The group then plans how to teach the material to the members of their original groups.
- Students return to their original groups and teach the members about their area of expertise.



This strategy, which can be used in many contexts, can build depth of knowledge and conceptual understanding; disclose a student's understanding and resolve misunderstanding and develop teamwork and cooperative working skills.

2. Sustainable quarrying industry

Students complete the table in Resource 2 by listing ways in which the quarrying industry can work towards sustainability.

3. Sustainability game

Students use disks or marbles to represent the amount of a resource available. A full explanation of the game is provided on Resource 3. Below are some examples.

Round	No. taken out	No. left	No. added	No. in bowl
1	6	14	3	17
2	5	12	3	15
3	4	11	2	13
4	3	10	2	12
5	2	10	2	12
6	2	10	2	12
7	2	10	2	12
8	2	10	2	12
Total mined	26	**Total resource left**		12

Round	No. taken out	No. left	No. added	No. in bowl
1	4	16	4	20
2	4	16	4	20
3	4	16	4	20
4	4	16	4	20
5	4	16	4	20
6	4	16	4	20
7	4	16	4	20
8	4	16	4	20
Total mined	32	**Total resource left**		20

Answers to consolidation question

1. Four disks taken out every year will mean the amount of the resource is steady.

4. Sustainable use of resources Part A

This task can be used to demonstrate outcome EB 4.3.
Students determine the renewability or non-renewability of resources and list positive and negative attributes of each resource.

Sustainable use of resources Part B

Answers to questions

1. **True**. The primary animal in a food chain is always an eater of plants.
2. **True**. They are formed from the compression of vegetable matter and tiny marine organisms over millions of years.
3. **False**. The kinetic energy of the falling water is converted to electricity.
4. **True**. Solar energy was required to grow plants and animals that turned into fossil fuel; it is vital to the water cycle and wind patterns.
5. **True**. Fossil fuels are formed from the compression of vegetable matter and tiny marine organisms over millions of years.
6. **True**. They are formed from the compression of vegetable matter and tiny marine organisms over millions of years.
7. **False**. Energy in an animal's body comes from protein and carbohydrates. Plants convert solar energy into protein.
8. **True**. Fossil fuels are a non-renewable resource.
9. **False**. Energy is lost turning turbines and heat is lost.
10. **True**. Radiation from the sun is converted into electricity.
11. **False**. Minerals in economic quantities are finite.
12. **False**. Every person consumes 10 tonnes of quarry rock, sand and gravel.

To mine or not to mine – social impacts

Outcomes: Working towards SS 4.3, 5.3 and EB 4.3, 6.3.
Assessment ideas: Inclusion of worksheets in portfolio.

5. Who needs to have a say? Part A

This activity can be used to demonstrate SS 5.3.

The purpose of this exercise is for students to understand some of the issues affecting each group below.

Mining company	**Local council**
• Wants to find out about the size and value of mineral deposits. • Anxious to gain community support and government approval for mining. • Keen to address all legal requirements.	• Wants to know what new infrastructure will be required. • Concerned about noise and extra traffic. • Interested in the potential for jobs to be created and boost for the local economy.
Local residents	**Local chamber of commerce**
• Mixed feelings. • Concerned about air quality; do not want existing quality of life to deteriorate. • Interested in the potential for jobs and boost to the local economy. • Concerned about safety and working conditions.	• Believes the development will offer new jobs and provide a much-needed boost to the local economy. • Has some concerns about the impact of the development on the environment.
Traditional owners of the land	**State department of mines**
• Have spiritual and traditional links with the land. • Concerned about the impact of the development on the existing landscape, on their cultural heritage and on their traditional way of life.	• Grants exploration permit and mining lease. • Wants extensive community consultation to take place before the project begins. • Concerned that legal requirements are followed.
State department of environment	**State water board**
• Concerned about the impact on native flora and fauna. • Wants extensive community consultation before project begins. • Concerned that environmental guidelines are followed. • Approves Environmental Authority.	• Concerned about the impact of any development on quality water. • Concerned about the long-term availability of the water. • Wants extensive community consultation.
Local conservation group	**Local farmers**
• Concerned about the impact on the natural environment. • Has concerns about the impact on existing wildlife species, some of which are already rare. • Concerned about land clearing.	• Concerned about impact on the existing dairy industry. • Concerned about access to their properties. • Worried about potential land-use changes. • Interested in the potential for jobs to be created and a boost for the local economy.
Regional heritage society	
• Concerned about the preservation of regional heritage. • Does not want the existing quality of life and relaxed lifestyle to change.	

Who needs to have a say? Part B

Discuss the background with students. The students then complete the work sheet by examining the views of the people who are affected by a mine starting operation.

Background

The nature of environmental management is now more complex than at any stage in the past; for example, larger population, greater consumer demand, greater range of consumer goods and services, urban and regional growth, conflicting demands for resources, greater capacity for modern technology to do environmental damage, greater range of viewpoints tolerated, increased concern for the environment because of resource depletion and increased legislative requirements.

Most human activities require use of the environment in some way. Nearly all the resources within the environment have a range of possible uses or applications. For example, mining is only one use for the land. A particular site can have many other uses before, after, or instead of mining; for example, crops, housing, natural areas, pastoral activities, parks and tourism. Obviously, each group of stakeholders listed on the work sheet will have a variety of perspectives within it. Some stereotyping is necessary for the purpose of the activity.

6. Factors that determine if a mineral deposit will be mined

Students complete a word search.

Answers to missing word sentences

1. The **size** and **quality** of the deposit.
2. Its **geographical** location; for example, how easy it is to access, how close it is to the nearest town and port, and the cost of **transporting** the minerals.
3. The **depth** at which the deposit is located and the cost of **developing** a mine.
4. The demand for the **mineral** and the price for which it could be sold.
5. The impact on the surrounding **environment**.
6. Whether an agreement can be negotiated with **landowners** to establish a mine.
7. Government **requirements** and community **consultation**.

Environmental impacts

Outcomes: Working towards SS 4.3, 6.3 and EB 4.3, 5.3.
Assessment ideas: Inclusion of work sheets and practical data, reflective writing and answers to consolidation questions in portfolio.

7. Environmental management

Use a peer teaching strategy called 'expert jigsaw' to engage students in reading this fact sheet. See Activity 1 on page xx for the procedure.

8. Ice-cream container mining and rehabilitation

Students grow wheat in a container containing layers of gravel, sand and topsoil. They remove the layer of gravel and rehabilitate the mine site. Students record their results and report their findings. Students will need to grow their wheat seeds before the practical.

9. Water conservation

Students investigate the impact mining has on the water cycle and how it can be minimised.

Before beginning this activity, students may need a review of the water cycle.

10. Surveying and mapping of local vegetation

Answers to consolidation questions

1. Accurate records of native flora and fauna are kept so the mine site can be rehabilitated after mining and to protect biodiversity.
2. Seeds would be collected from native plants and grown. These will be replanted in the same area.
3. Advantages: accurate records for rehabilitation, mining companies collect a lot of information in remote areas that would not be collected otherwise. Disadvantage: flora and fauna may be seasonal, so were not present at time of survey.
4. Animals will hide when students walk in the vicinity. Some animals will be seen only at certain times of the day.

11. Managing oil spills

Students use a variety of methods to reduce the impact of an oil spill. The experiment can also be undertaken using a drop of oil and a drop of kerosene. The kerosene will dilute the oil, making it easier for the agents to react or absorb it.

Answers to consolidation questions

1. The oil does not dissolve and floats on top of the water.
2. Oil and water do not mix. Oil floats on the top of water because it is less dense and blocks oxygen and light entering the water.
3. Killing of animals and plants.

Economic impacts

12. The value of minerals produced in Queensland

Cut the dot points in into strips. Enlarge the table and make an overhead transparency (OHT). Give each strip to a different student and invite them to read it to the class. Display the OHT and ask students if they have any questions about the information or whether they were surprised by any of the information.

13. Careers in the mining industry

Make four copies of Resource 13 and give each student a copy of one of the jobs featured to read. Invite students to pair up with someone who has a different job card. When students are in pairs, ask them to swap cards and read the new card. Ask each pair to write four questions that could be answered by both students using the information on their cards.

14. Interviews with scientists working in the mining industry

Invite students to form groups of three. Give each group a copy of Resource 14 and ask each student to read one of the interviews. Give students an opportunity to discuss with their group what they have read. Ask groups to record some of these items on the graphic organiser.

Students could conduct their own interviews by sending questions to scientists working locally or further afield. For a list of Queensland mines, see page xx. Students could use the same questions or prepare their own. If students live in a mining community they may be able to interview a friend or family member. If they are contacting a mining company or government department, they should consider the points below.

- With your students, negotiate who will be contacted and who will do the contacting.
- Before sending written questions, make telephone contact. This ensures that the questions will be welcome and that they will be directed to the right person.

Putting it all together—what would your community do?

Outcomes: Working towards EB 5.3, 6.3.
Assessment ideas: Assignment involving a community consultation exercise and a simulated or actual community forum.

15. Would you mine the school oval?

This task can be used to demonstrate EB 5.3 and 6.3.

This activity builds on the work students have completed in Resource 5 '*Who needs to have a say?*' However, this time the issue is in their backyard.

After a brief discussion to introduce the issue, students should be able to complete task one independently. Once completed, invite students to share their ideas with the class. After discussion based around the four dot points in task two, students can undertake the task. Both tasks are aimed at Level 5.

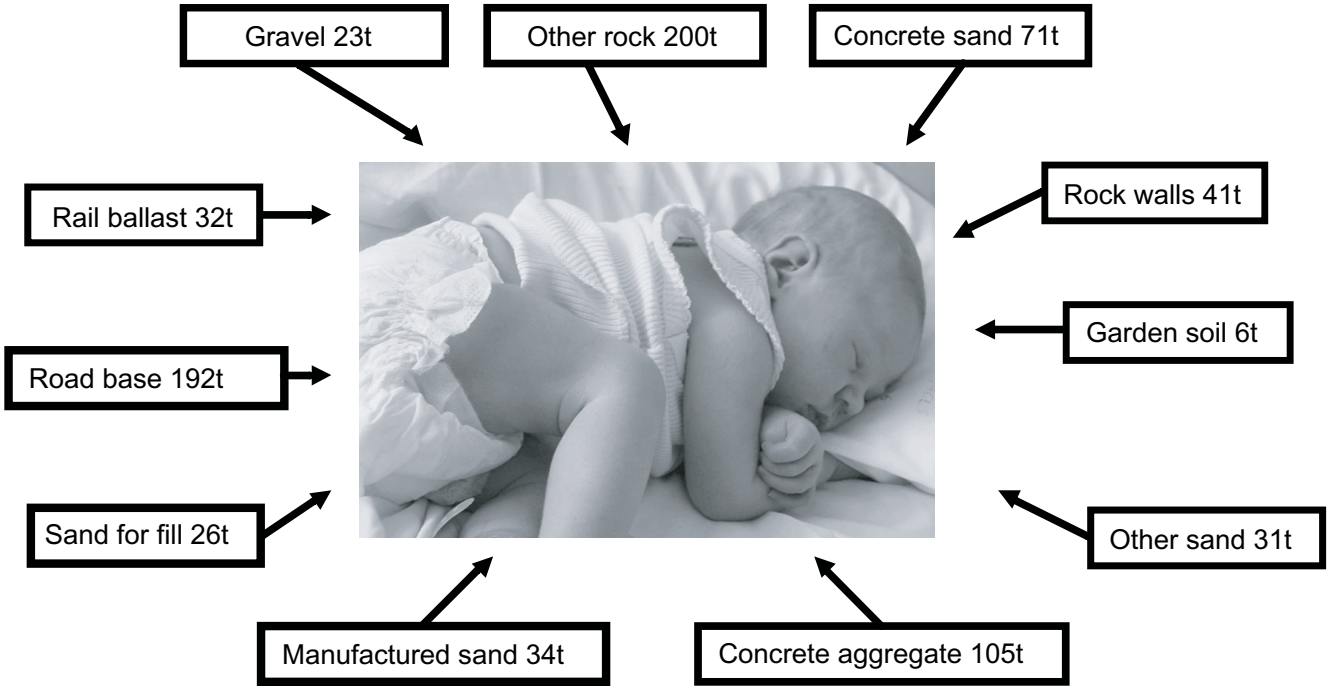
Building on the two previous tasks and aimed at Level six, the third task is more complex and requires more time to complete. With students, negotiate the process and product outcomes, and develop clear guidelines and criteria so that everyone has a shared understanding before students begin.

Resource 1: Sustainable quarrying

South-east Queensland's rapidly increasing population, residential developments and new infrastructure are resulting in a much higher demand for construction aggregates such as quarry rock, sand and gravel. Construction aggregates are the basic raw materials needed to build and maintain highways, roads, rail lines, homes, schools, factories and other buildings. Aggregates are mined from several quarries in south-east Queensland, which is one of the fastest-growing regions in Australia. High population growth is creating severe difficulties for the quarrying industry's ability to supply these construction materials.

To address this, the quarrying industry is working towards a sustainable approach to the industry. This means that the industry can continue to operate profitably, people can continue to use products and facilities made with quarried materials and any negative impacts on the environment will be minimised.

In her lifetime, this baby will use these construction aggregates.



Increases in resource requirements

During the past 20 years, the production of construction aggregates in south-east Queensland has risen from 10 to 24 million tonnes a year. In many areas, the quarry rock reserves approved for development will last only 15 to 20 years at present rates of usage. The future supply of sand is even more uncertain, with the industry in transition after the closure of dredging in the tidal reaches of the Brisbane River in 1998. The total total remaining sand resources approved for extraction in all of south-east Queensland is about 50 million tonnes, which will last only 13 to15 years at current usage rates.

Fifty years from now, south-east Queensland's population is estimated to be about 4.6 million people, and construction aggregate demand could rise from 24 to about 59 million tonnes every year. Over the next 50 years, the total consumption that will need to be discovered and approved for development is estimated at 2.3 billion tonnes.

Effect of residential development

Residential development has encroached on existing quarries, established transport routes and known future resources. This situation has led to increased costs to quarry operators in reducing impacts on new residents. The community perceives the quarrying industry as unsustainable and undesirable, even though usage continues to increase.

Environmental management

This rapid spread of urban development in south-east Queensland has consumed large areas of vegetated land. As a result, improved environmental planning is needed, particularly in relation to the early identification of environmental constraints and a need for improved management of quarrying activities.

Rehabilitation of sites is also needed. In south-east Queensland, there is particular concern with the potential for sediment runoff from sand and gravel operations to adjacent natural waterways, lack of adequate permit conditions, non-compliance with permit conditions and lack of site rehabilitation.

Transport of products through urban areas

The transport of construction aggregates in large trucks is a sensitive issue for the community. The main concerns are noise and vibration, exhaust emissions, dust, safety, property values and visual amenity. Owing to increasing demand for construction aggregates and the spread of urbanisation, truck traffic through some residential areas is likely to increase in the future.

A sustainable quarry industry

Sustainability is a concept that has become the guiding principle of many natural resource and economic debates worldwide. So that future generations are not disadvantaged, development needs to balance ecological, economic and social aspects.

The industry is working towards a sustainable future by:

- maximising the economic value of resources
- minimising wastage of resources
- maximising recycling
- supporting and developing alternative construction techniques
- minimising environmental impacts of operations
- maximising after-use of quarried land.

On average, every person consumes 10 tonnes of quarry rock, sand and gravel every year. These resources are the basic raw materials needed to build and maintain highways, roads, rail lines, houses, schools, factories and other buildings.

Resource 2: Sustainable quarrying industry

South-east Queensland's rapidly increasing population has led to a much higher demand for quarry rock, sand and gravel. The table lists some of the actions the quarrying industry is taking to make the industry more sustainable.

How would you implement each of the quarrying industry's goals and what factors need to be taken into account? Suggest ways the industry can work towards its goals, by completing the table.

The industry is working towards a sustainability by:	**List three ways the industry could achieve each of these.**
Maximising the economic value of resources	
Minimising wastage of resources	
Maximising recycling	
Supporting and developing alternative construction techniques	
Minimising environmental impacts of operations	
Maximising after-use of quarried land	

Resource 3: Sustainability game

Background

Sustainability is a concept that has become the guiding principle of many environmental and economic debates worldwide. There is a need for development towards an ecologically, economically and socially sustainable future.

Purpose

To demonstrate how to use the Earth's resources wisely.

Equipment

Shallow bowl containing 20 plastic disks (or marbles).

Method

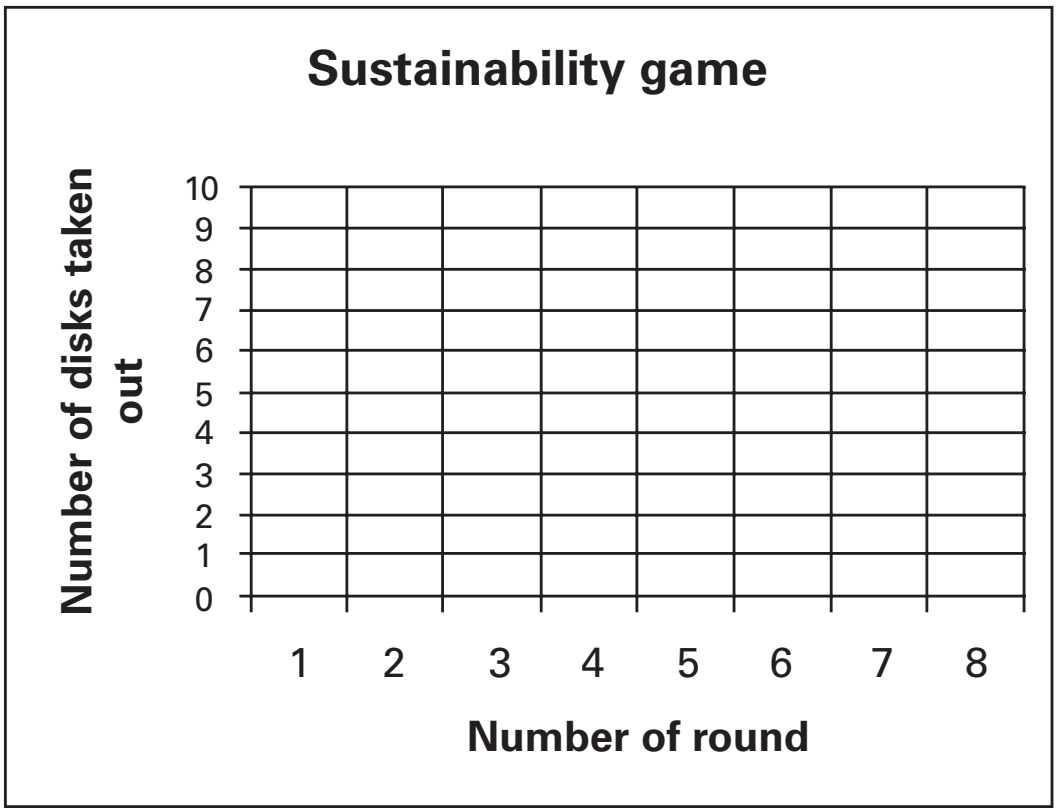
1. The idea is to take as many disks from the bowl as possible over eight rounds.
   - The number of disks you take out in a round can vary by only one from the previous round. (For example, if you take out five in one round, in the next you can take out four, five or six.)
   - At the end of each round, one disk will be added for every four left in the bowl.
   - If you take all the disks out of the bowl you are out of the game.

No. Left	Add
0-3	0
4-7	1
8-11	2
12-15	3
16-19	4
20-23	5

2. Fill in the table with your results, continuing until you run out of disks or complete eight rounds.
3. Find the total number of disks you have taken, and how many you have left.
4. Compare your results with what happened in other groups. Which group took the most disks after eight rounds?
5. Represent your results on a graph, with the number of disks taken each round on the vertical axis and rounds (years) on the horizontal axis.
6. You might like to play the game again to see how different approaches (or different rules) work.

Recording results

Round	No. taken out	No. left	No. added	No. in bowl
1				
2				
3				
4				
5				
6				
7				
8				
Total taken		Total resource left		



Consolidation

1. What are the most disks you can take out of the bowl year after year and still have disks left?
2. On your graph, draw a line that you think represents sustainable development.

Resource 4: Sustainable use of resources – Part A

Demonstrating outcome EB 4.3

Determine the renewability or non-renewability of each of the resources described. In the last two columns, list the positive and negative attributes of each resource.

Resource	Description	Renewable or non-renewable	Positive	Negative
Coal	Formed from the burial and compression of vegetable matter over millions of years.			
Oil	Formed from tiny marine organisms and plant matter subjected to raised temperatures and compression during burial over millions of years.			
Natural gas	Formed from tiny marine organisms and plant matter subjected to raised temperatures and compression during burial over millions of years.			
Solar energy	Radiation from the sun is converted into other energy forms.			

Resource	Description	Renewable or non-renewable	Positive	Negative
Nuclear energy	Radioactive substances, including uranium, are used to produce heat energy, which is then converted to other energy forms.			
Geothermal energy	Underground heat is used as a means of generating electricity.			
Biomass generation	Solar radiation is used in photosynthesis to create plant biomass and later animal biomass.			
Wind power	The kinetic energy of the wind is converted to other forms of energy; for example, electricity.			

Resource 4: Sustainable use of resources—Part B

Determine whether these statements are true or false. Give a reason to justify your answer.

1. Animals get their energy by eating plants (or eating other animals that have eaten plants).
2. Fossil fuels are made from the buried remains of ancient organisms.
3. Hydro-electricity is a non-renewable energy source.
4. The sun is responsible for most energy forms on the Earth.
5. It takes millions of years for fossil fuels to be made.
6. Both coal and oil were formed as a result of great pressure.
7. Solar energy is converted into chemical energy in an animal's body.
8. Eventually fossil fuels will run out.
9. Power stations are 100 per cent efficient.
10. Solar energy is a form of renewable energy.
11. Mineral resources are unlimited.
12. Every person consumes three tonnes of quarry rock, sand and gravel every year for houses, roads and bridge building.

Resource 5: Who needs to have a say?

The table shows the needs and concerns of various groups when a new mine starts operations. The groups are listed below the table.

Read through the points in the boxes and match the names of the groups with their box by writing the group name in the space above each box.

• Wants to find out about the size and value of mineral deposits. • Anxious to gain community support and government approval for mining. • Keen to address all legal requirements.	• Wants to know what new infrastructure will be required. • Concerned about noise and extra traffic. • Interested in the potential for jobs to be created and boost for the local economy.
• Mixed feelings. • Concerned about air quality; do not want existing quality of life to deteriorate. • Interested in the potential for jobs and boost to the local economy. • Concerned about safety and working conditions.	• Believes the development will offer new jobs and provide a much-needed boost to the local economy. • Has some concerns about the impact of the development on the environment.
• Have spiritual and traditional links with the land. • Concerned about the impact of the development on the existing landscape, on their cultural heritage and on their traditional way of life.	• Grants exploration permit and mining lease. • Wants extensive community consultation to take place before the project begins. • Concerned that legal requirements are followed.
• Concerned about the impact on native flora and fauna. • Wants extensive community consultation before project begins. • Concerned that environmental guidelines are followed. • Approves Environmental Authority.	• Concerned about the impact of any development on quality water. • Concerned about the long-term availability of the water. • Wants extensive community consultation.
• Concerned about the impact on the natural environment. • Has concerns about the impact on existing wildlife species, some of which are already rare. • Concerned about land clearing.	• Concerned about impact on the existing dairy industry. • Concerned about access to their properties. • Worried about potential land use changes. • Interested in the potential for jobs to be created and a boost for the local economy.
• Concerned about the preservation of regional heritage. • Does not want the existing quality of life and relaxed lifestyle to change.	

Group list		
Local council	Local farmers	Traditional owners of the land
State water board	Local residents	State department of mines
Local conservation group	Regional heritage society	Mining company
State department of environment	Local chamber of commerce	

Who needs to have a say? Part B

Demonstrating outcome SS 5.3

Planning for land use and resource management should involve considering the views of all those who are affected by the planning and decision-making processes.

Imagine you want to start a mining operation on a piece of land. List some of the concerns that each of the local interest groups below might have and what guarantees they might seek from the mining company.

Interest group	Concerns	Guarantees
Environmentalists		
Farmers		
Local chamber of commerce		
Local council		
Local residents		
Tour operators		
Traditional owners of the land		
State government		

Resource 6: Factors that determine if a mineral deposit will be mined

Name _____

Word Search

J	H	T	M	X	I	U	T	O	N	N	I	R	N	J	Q	U	Q	M	L	U
B	D	G	B	Y	H	A	H	H	E	T	M	L	S	S	W	F	S	L	A	K
K	Q	N	Z	B	B	P	O	J	D	V	X	Z	G	I	U	I	T	A	N	N
Q	P	Z	Z	K	C	O	L	J	J	S	X	A	S	Z	I	C	D	C	D	U
U	N	K	E	G	G	B	I	F	C	L	G	O	G	E	F	T	A	I	O	U
U	V	R	W	C	O	N	S	U	L	T	A	T	I	O	N	R	X	H	W	K
C	A	C	Z	M	E	I	D	E	J	X	Y	O	R	V	C	A	U	P	N	U
Q	P	S	B	W	W	F	J	N	L	Q	P	O	P	H	C	N	U	A	E	B
X	I	H	T	I	U	X	S	U	W	I	C	V	W	W	X	S	T	R	R	M
Z	G	T	T	N	E	M	N	O	R	I	V	N	E	H	Q	P	L	G	S	G
B	H	P	E	G	Q	E	J	N	W	C	T	D	K	S	U	O	D	O	T	N
O	Z	E	X	C	N	S	I	D	T	Q	K	W	Q	V	A	R	A	E	N	I
N	O	D	R	M	Q	R	Z	L	A	R	E	N	I	M	L	T	D	G	E	P
L	K	T	A	V	C	J	T	H	B	W	Y	R	V	L	I	I	V	G	M	O
Y	B	Q	K	K	H	P	U	M	U	M	P	F	I	V	T	N	D	A	E	L
S	L	H	U	A	O	D	U	O	H	P	O	F	K	O	Y	G	D	A	R	E
N	P	V	L	W	Y	M	P	F	A	Y	L	R	R	W	D	W	R	T	I	V
E	Z	J	S	Z	S	M	K	K	F	X	S	K	C	T	U	P	J	G	U	E
C	Q	J	D	N	D	K	N	R	G	J	J	L	W	L	S	F	M	G	Q	D
H	G	G	O	D	B	R	X	V	B	Z	U	H	L	Y	P	G	O	Q	E	K
U	G	O	I	Y	T	N	M	J	T	B	M	A	E	G	I	X	E	W	R	Z

Find the missing words in the word find

When deciding if a mineral deposit will be mined, a number of factors are considered. Some of these are listed below.

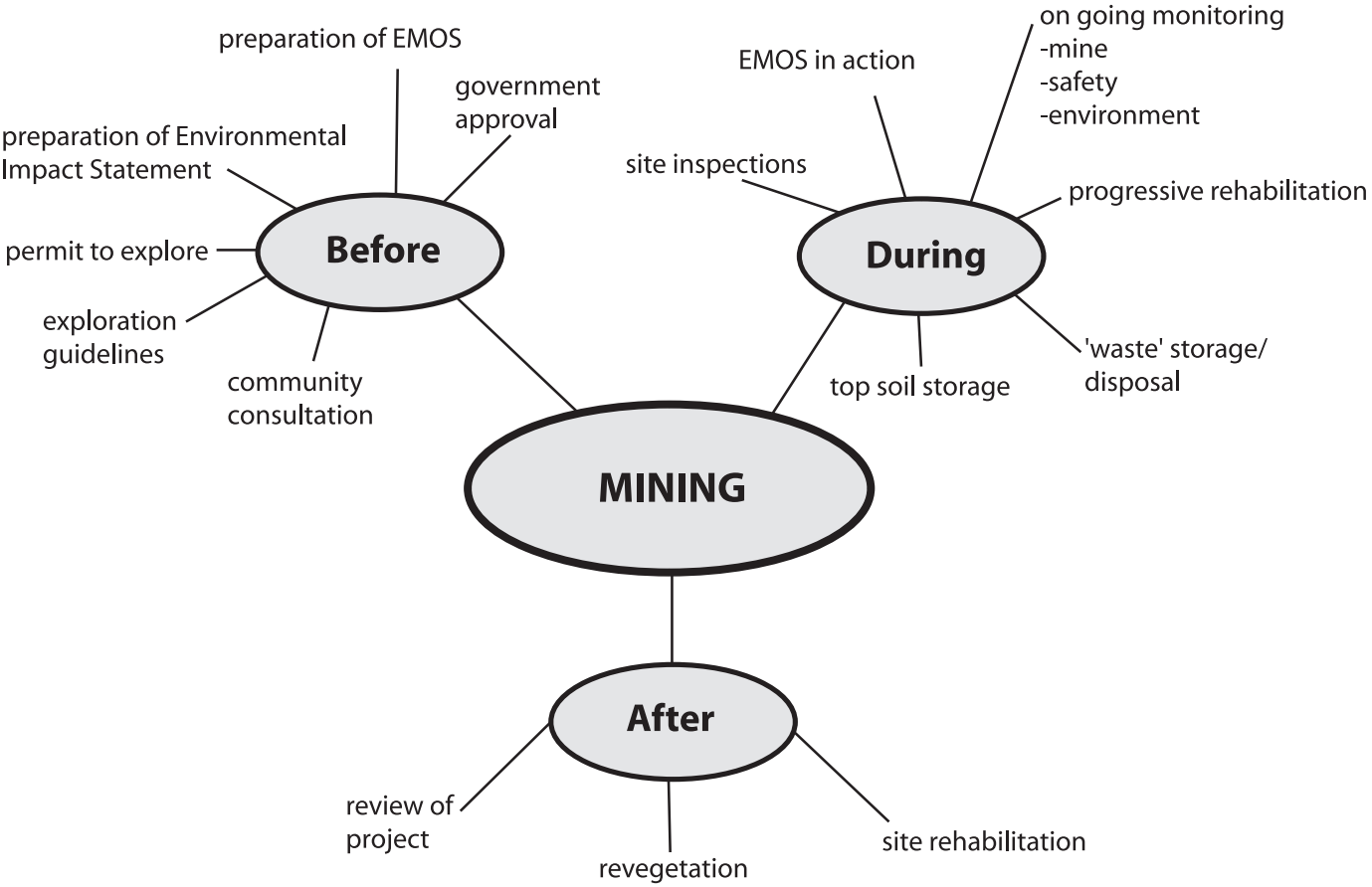
1. The _____ and _____ of the deposit.
2. Its _____ location i.e. how easy it is to access, how close it is to the nearest town and port and the cost of _____the minerals.
3. The _____ at which the deposit is located and the cost of _____ a mine.
4. The demand for the _____ and the price for which it could be sold.
5. The impact on the surrounding _____.
6. Whether an agreement can be negotiated with _____ to establish a mine.
7. Government _____ and community _____.

Word list	transporting	landowners	consultation
environment	depth	geographical	requirements
size	developing	quality	mineral

Resource 7: Environmental management

To obtain minerals from the ground, removal of large amounts of rock and soil is usually necessary. Although the total area of land disturbed by mining operations is small, a mine's operating requirements include rehabiliting the land after mining. The sites must be returned to the land use agreed to in the mine's Environmental Management Overview Strategy (EMOS), which is a whole-of-mine-life planning document.

In addition, the EMOS is used as the basis for the conditions of the mine's Environmental Authority (EA), which is the environmental licence issued by the Queensland Government. Because of its experience in rehabilitating land areas and re-establishing ecosystems, the Queensland minerals industry is a leader in the field of practical environmental management.



Source: Department of Mines and Energy South Australia, 1996, *Resources: Working for the Right Balance*, Adelaide Institute of TAFE

Conservation and protection of biodiversity

Environmental officers undertake detailed animal habitat and plant studies before, during and after mining operations. The aim is to minimise the impact of mining on the habitats of local species and care is taken to prevent introducing weeds or feral animals that could damage native species. This work also adds to our scientific knowledge of native animals and plants.

Rehabilitation of mine sites

In Queensland, all mine sites must be rehabilitated to their agreed final land use. These rehabilitation requirements form part of the conditions of the company's Environmental Authority. Often, the agreed final land use is a result of community consultation. Mined areas can either be rehabilitated to their pre-mining land use or for other uses, such as recreation, farming or native vegetation.

During open-cut mining, the over-burden (the material removed to expose the mineral ore or coal) can be used to fill holes left from earlier stages of the mining operation. Fresh top-soil is used to cover the over-burden to ensure that new vegetation will grow. The soil surface is re-shaped to fit in with the surroundings and ensure landform stability. It is then fertilised and planted with native seedlings grown from seeds collected on the site before mining began.

Before the mining operation can surrender its mining lease, a Final Rehabilitation Report needs to be approved by the Queensland Government.

Pollution controls

Mining companies have management plans that establish processes and systems for minimising the pollution of air, land and water, and include monitoring requirements to ensure that control measures are effective.

Dust control

Mining activities, such as use of heavy vehicles on haul roads and explosives that loosen dirt, can create dust that would cause problems for the nearby community and ecosystems. One mitigation measure is to use recycled water to spray on roads and stockpiles to suppress dust. Mining equipment is fitted with dust collection devices, and covers may also be used over stockpiles. Land not needed by the actual mining operation can be used to provide a buffer zone around the operational area.

Mine wastes

Sometimes a large amount of rock is removed to reach the ore. Any rock that does not have useful minerals is returned underground or stored on the site as waste rock piles. During minesite rehabilitation, these waste rock piles are usually shaped to blend in with the surroundings and then covered with soil and replanted with native vegetation.

Tailings are the crushed rock, water and sometimes chemicals that remain after the minerals are separated from the ore. They are pumped to specially built and sealed areas on a mine site where they are spread out to dry. Problems can arise if tailings storage areas are not properly managed. The area must be sealed to prevent seepage to the surrounding environment. When mining has finished, the hardened and dry tailings are covered with soil and replanted with native vegetation.

Water

It can take a significant amount of water to process minerals from ore. Water must be used carefully. Mining operations practise water conservation and recycle water. Generally, the Environmental Authority requires monitoring of any water allowed to leave the site to ensure its quality is sufficient to minimise impacts on the environment.

Mount Morgan mine site rehabilitation

In 1882, mining began at the Mount Morgan mine site to recover gold and considerable quantities of silver and copper. After many years of mining, large quantities of tailings, overburden and other waste material covered the site. Acid mine drainage has affected water quality in the adjacent Dee River. This type of example is usually described as a ‘legacy issue’ and results from the mining operation’s longevity and the fact that, when mining started, little consideration was given to environmental management requirements.

The Department of Natural Resources, Mines and Energy (NRM&E) is part of a 10-year plan to rehabilitate the Mount Morgan mine site. The main aim is to reduce the contaminants entering the Dee River. Rehabilitation planning started in 2000 when the NRM&E produced a conceptual rehabilitation plan to deal with the acid mine drainage, pollution of the Dee River, revegetation, land management and cultural heritage issues. Reprocessing of waste rock and tailings to extract residual gold resources was also considered. Evaluation of this process as an option commenced.

While the focus of the rehabilitation strategy is on environmental and safety issues, other important aspects of the mine site include cultural heritage conservation and interpretation, and economic development through tourism. When mining has finished in a town, often the community looks to tourism to provide future economic growth and jobs for the town.

The most important message from Mount Morgan is that this situation will never again be allowed to occur—both because the industry recognises that, to maintain its licence to operate, it must undertake sound environmental practices, and because government regulations set conditions that would not accept this poor performance.

Further information and a mine site rehabilitation tour can be found at
www.nrm.qld.gov.au/mines/environment/mt_morgan/index.html

- Mining disturbs less than 0.03 per cent of Queensland's land area.
- As part of its rehabilitation program for that land, the mining industry plants more than three million trees every year.

Resource 8: Ice-cream container mining and rehabilitation

Purpose

To investigate mining methods and environmental rehabilitation.

Materials and equipment

- Large ice-cream container
- Sand
- Gravel
- Potting mix
- Wheat seeds
- Teaspoon.

Method

1. Make a model of a mineral deposit that is flat and shallow. In a large ice-cream container place a layer of sand 5 centimetres deep followed by a layer of gravel 2 centimetres thick, and cover with another layer of sand 2 centimetres deep. Over this, place a layer of potting mix one centimetre thick.
2. Take 100 wheat seeds and plant them, evenly spaced over 75 per cent of the full area. They should be watered and let grow to 2 centimetres in height before you start any mining.
3. Your task is to mine the gravel, using a teaspoon as an excavator, and to do it with minimal environmental impact; that is, at the end of the mine's life, a full 100 wheat plants or more should be growing on a land surface, which has been graded back to its original form.
4. Transplanting and reseeding are allowed. You will be given an additional 20 unplanted wheat seeds.
5. Everything must be done within the confines of the container. Overburden dumps must be in the container area.

Recording results

Write up the stages of your development plan for the mine and your strategy for rehabilitating the land surface. You should include a map of the stages.

Conclusion

Report on how well the plans worked and include any ideas for improving your project next time.

Resource 9: Water conservation

Water covers about 70 per cent of the Earth. That water has been around for millions of years. The same water is recycled over and over again, as part of a natural process called the water cycle. For further information, refer to **http://www.watercorporation.com.au/business/students_topics_water_cycle.cfm**

1. Read the table of mining activities that use water.
2. Think how the stated activities could affect the water cycle. Consider from where the water used comes (for example river, dam, bores); how much is used; how it is changed; and what happens to it after it is used.
3. What do/could mining operations do to minimise these impacts?

Mining activities	**How they could affect water quality and quantity**	**Ways to minimise impacts**
Most mine sites have large dirt roads called haul roads. Big trucks using the roads stir up dust. In these places, water trucks spray water onto dirt roads to reduce the amount of dust in the air.		
Some minerals (for example, coal) are washed to remove dirt before being loaded onto trains.		
Water and chemicals are added to crushed rocks that contain copper. The copper floats in bubbles on top of the water and the waste rock sinks. The bubbles containing copper are collected.		
When rocks are drilled, water is sometimes used to bring the crushed rock material to the surface.		
When crushed ore is transported in a pipeline, water is added to make a slurry, enabling it to flow.		

Resource 10: Surveying and mapping of local vegetation

Purpose

To survey the flora and fauna in a local area.

Materials and equipment

- Ruler
- Paper
- Pens
- String
- Pegs
- Measuring tape
- Magnetic compass.

Method

1. Choose a local area that contains a variety of plants and animals. An area up to 5 x 5 metres square for each group should be available.
2. Measure the area and divide it into one-metre squares, using the string to mark out the area.
3. Draw a map, with the one-metre divisions and mark in north.
4. For each square, list the number of different plants and animals that can be seen.
5. If possible, take seeds or cuttings that you can grow in the lab, for transplanting when mining has finished.

Recording results

Draw up a matrix that lists the plants and animals in each one-metre section.

Consolidation

1. Why is surveying the native flora and fauna an important step before starting to mine an area?
2. How would the information from the survey be used to rehabilitate the site?
3. What are some of the advantages and disadvantages of flora and fauna surveys?
4. How difficult was it to count the animals in the area? Why?

Resource 11: Managing oil spills

Background

Oil spills not only devastate the plants and animals of the oceans but also coastal communities and their habitats.

Purpose

To investigate methods that can be used to manage oil spills when they occur.

Materials and equipment

- Cooking oil
- Water
- Small flat containers (for example, Petri dish)
- Pipette or eye dropper;
- Some or all of these:
  - Corks beaded on string
  - Detergent
  - Engine degreaser
  - Beanbag beans
  - Sawdust
  - Spoon
  - Kitty litter.

Method

1. Place one drop of oil from a pipette on to water in a bowl. Does the oil dissolve? Where does the oil go? Blow on the surface of the water and describe where the oil goes.
2. Try each of the control methods below and see if, and how, they work to manage the spill, and which is most effective. Record your results. For each trial, use water with a drop of oil and kerosene. Ensure the container is clean with fresh water and oil each time.
   - A necklace of corks threaded onto cotton to see if it can contain the oil slick and stop it from spreading.
   - A drop of dishwashing detergent on the water.
   - A drop of engine degreaser on the water.
   - A few styrene foam beads from a bean bag.
   - A teaspoon of sawdust.
   - Try to scoop it off with a spoon.
   - A few grains of vermiculite or kitty litter.
   - Anything else you can find.

Recording results

Complete the table on the next page.

Consolidation

1. What happens to the oil on the water? Does the oil dissolve? Where does the oil go? What happened when you blew on the water?
2. What property of oil and water makes oil spills particularly disastrous to the environment?
3. List some of the environmental impacts of oil spills.
4. Of the methods used, which was the most effective and which was the least effective?
5. Draw a flow diagram of the process you would use to reduce the impact of an oil spill. Which method could you use for each step?

Recording results

Method	Describe the effect on the oil spill
Necklace of corks	
Dishwashing detergent	
Engine degreaser	
Beanbag beads	
Sawdust	
Spoon	

Resource 12: The value of minerals produced in Queensland

Did you know?

- About half of Queensland's export earnings come from mining and minerals processing.
- Queensland is among the world's major producers of copper, silver, lead, zinc, bauxite and mineral sands.
- The mining industry contributes more than $1.9 billion to State revenue each year.
- Queensland is the world's largest seaborne coal exporter, accounting for 20 per cent of the world's seaborne coal trade and 62 per cent of Australia's total coal exports in 2002-03.
- Queensland coal is shipped to 35 countries. Major export customers are Japan, Korea, India, Taiwan and the United Kingdom.
- Much of the wealth generated from mining finds it way back into the State economy, providing jobs and public facilities for all Queenslanders.
- The mining industry in Queensland employs about 19 000 people directly and some 65 000 indirectly.
- Every $1 million spent by mining companies supports 27 jobs in the State.
- One in 14 jobs in Queensland depends on mining and minerals processing.
- Queensland has 65 per cent of Australia's total silica sand exports.
- Queensland has 17 per cent of the world's known zinc resources.
- As a source of rural employment in Australia, mining is now almost as important as agriculture.

Value of minerals produced in Queensland 2002-03

Mineral	$million
Bauxite	212
Clay	16
Coal	7 442
Coal seam methane	61
Copper	1 366
Construction materials	358
Crude oil	79
Dimension stone	1
Gems and ornamental stones	4
Gold	294
Limestone	58
Magnesite	17
Silica sand	27
Titanium minerals	165
Zinc concentrate	826

In addition to the value of the minerals, the mining industry generates employment; pays royalties and rent to the State Government; attracts capital investment; and is the source of further processing and associated industries.

Resource 13: Careers in the mining industry

Job: Mining engineer

Job activities

- Works with geologists to survey mineral deposits and decide whether mining is viable.
- Decides the best way to mine at the site and plans the location and construction of the mine.
- Decides how and where drilling and blasting will occur.
- Works with other engineers to design, select and provide the right machines and other things needed to get the job done.
- Makes sure that the mine has the right people and equipment, and that things are done safely.
- Supervises the daily operations at the mine site. (This might involve an eight-hour shift underground working with mine workers blasting rock faces that have been wired up with explosives. On the surface, the mining engineer might plan the shape of underground working areas and decide how much explosives are needed for a particular job.)

Education/training: Bachelor of Mining Engineering at a university.

Job: Environmental scientist

Job activities

- Studies the area to be mined and suggests ways to minimise the impact of mining on the land, flora and fauna.
- Works with the community on environmental management issues.
- Checks air, dust and waste water at the mine site during mining and write reports for the company and the government.
- Rehabilitates the site once mining is complete.

Education/training: Bachelor of Science or Environmental Engineering at a university.

Job: Geologist

Job activities

- Searches for new mineral deposits using maps, satellite imagery and other data, including how and when landforms formed.
- Collects and studies samples—spending a lot of time looking at rocks.
- Works with managers, environmental scientists, engineers and operators, and talks with people in local communities, such as Indigenous people and land owners.
- Prepares reports and maps using photographs and survey information.

Education/training: Bachelor of Science at a university.

Job: Machine operator

Job activities

- Operates large, heavy earthmoving equipment at underground or open-cut mines. (This may involve working a 12-hour shift operating a truck, dozer, shovel or grader. A week on day shift could be followed by a week working night shift, followed by a week off.
- Works with engineers, geologists and other operators.

Education/training: On-the-job training, but needs to have good driving skills, an interest in mechanics and be able to get on with different sorts of people. TAFE qualifications are helpful.

Job: Electrical tradesperson

Job activities

- Repairs and maintains all electrical equipment and control instruments in a mine or processing plant.
- Looks after mining equipment, such as electrical motors, computer control systems, air-conditioning and lighting.
- When something breaks down, the fault has to be found and fixed quickly.
- Works with engineers and mine workers.

Education/training: Year 12, TAFE, apprenticeship (an interest in maths, physics, electronics, welding, mechanics and working with hand tools will help).

Job: Mineworker

Job activities

- Operates equipment to excavate, load and transport coal, ore and rock at an underground or open-cut mine.
- Checks and maintains fuel or power supplies.
- Lays cable and explosives.
- Reports and/or fixes equipment failure.
- Works with engineers and other operators.

Education/training: On-the-job training and TAFE qualifications.

Job: Safety superintendent

Job activities

- Develops safety standards for activities in the mine and makes sure they are carried out.
- Operates instruments to monitor and ensure a safe working environment.
- Works with and trains all groups in a mine, including managers, engineers, tradespeople and operators/workers.
- Develops plans for responding to different kinds of emergencies; investigates accidents; and trains rescue teams.

Education/training: Could have training in many areas, including university study. Advanced first-aid skills and good communication skills are important.

Resource 14: Interviews with scientists working in the mining industry

Interview 1: Meet Chris Towsey—geochemist

Q: Why did you become a geochemist?
A: I had a really interesting science teacher at high school, who was very enthusiastic about chemistry. I was also given a chemistry set at about Year 6 and had a lot of fun with that. At the end of high school, I joined the steel works at Port Kembla in NSW as a trainee chemist, but was very disappointed in the sort of work I had to do. So, I went to university not really knowing what I wanted to do, and enrolled in geology. At the time the nickel business was really taking off. I liked geology and became a geologist, and then responded to an advertisement for a geochemist, which enabled me to combine my two favourite subjects, geology and chemistry.

Q: How do you become a geochemist?
A: You need a university degree in science (Bachelor of Science), specialising in either chemistry or geology. You also need to study your non-specialist subject up to second year at least. It would be an advantage to do an honours degree and also a masters degree in applying chemistry to geology. Geochemists can work in the minerals industry (as I do), or in coal, oil and gas, industrial minerals, sand mining or university research areas.

Q: What does a geochemist do?
A: A geochemist studies the Earth's chemistry, usually for a specific purpose, such as detecting trace amounts of chemicals that will lead to a deposit of material (like copper, gold, oil or coal) and that can be mined or extracted. It usually involves a lot of work in the bush, collecting samples that will contain the indicator chemicals. The samples can be rock chips; sand and gravel from creeks, soil, creek or bore water; gases contained in soil, plant leaves and bark; or even animal and insect life, such as sampling termite mounds or the termites themselves. Geochemists even sample things like trout livers. These may contain heavy metal toxins such as lead, zinc, copper, uranium or mercury, which may have come from water flowing over, or draining from, an ore deposit. Geochemists also work in pure research, looking at trace elements in rocks to work out the pressure and temperatures at which the rocks formed or how they have been changed later by heat, pressure or fluids flowing through the rock.

Q: How do you collect information and how do you use it?
A: We collect samples in the bush, as mentioned above. The samples are taken back to a laboratory, which can be in a major city or town; or it can be a mobile laboratory located in a remote area or on board a ship. The samples are analysed by high-tech equipment, often down to very small amounts. The results are often graphed or analysed by statistics or plotted by sophisticated computer programs to produce contour maps or coloured images to show the way the chemicals are distributed. We then interpret the patterns to see where the chemicals might have come from.

Q: Can you explain a problem you had and how you solved it?
A: I was asked to look for a gold deposit in a part of central Queensland, but at minimum cost. I designed a method of sampling creek sands, sieving out the fine sand, analysing it for low levels of gold using a special chemical process that allowed us to take one sample every 10 square kilometres over an area of 300 square kilometres. We used a helicopter to cover the area quickly. From these wide-spaced samples, we worked out the normal or background gold levels and what was unusually high. We then followed up the high samples by much closer spaced samples (one per one square kilometre) to find small areas of high gold values. We then followed up on the ground collecting soil and rock chip samples and analysed them for gold. We used a known gold deposit, Mount Rawdon, as a test site to see how far away from it we still detected unusual levels of gold. This is how we decided on the 10 square kilometre spacing. We found seven gold deposits, which are currently being drilled to see if they are big enough to be mined. We took duplicate samples to ensure our methods were accurate and also put blank or zero gold samples (to check for contamination) and samples containing known amounts of gold (control samples) through the laboratory to ensure their analytical methods were accurate.

Q: Describe a place(s) you have worked and what it was like working there.
A: I have worked in 20 countries around the world. I enjoyed Taiwan, as the Chinese culture is very different to ours and very much older. The most exciting place was in the highlands of Irian Jaya (West New Guinea) at more than 4500 metres altitude working with Indonesian Muslim and West Papuan people—a very large mixture of different people and cultures working in very steep mountains with high rainfall and there was even a snow-covered glacier on top of the mountains in a tropical jungle. I also lived in Fiji for five years, working in an underground gold mine. It was fascinating to see how very similar people are, despite their different skin colours and religious beliefs, and how much fun they can have together when they share a common purpose.

Q: What do you think makes a good scientist?
A: Good attention to detail; careful observation and careful recording of results; testing conclusions by designing control tests; and always being prepared to change your theory or hypothesis, if the facts do not support it.

Interview 2: Meet Linda Dobe—geologist

Q: Why did you become a geologist?
A: I wanted to do science at university, but I didn't really know what subjects to do; so I did almost all of them! I really enjoyed first-year geology; so I continued with it. I really enjoyed the fieldwork component of geology—getting out into remote areas looking at rocks and trying to work out how they were formed.

Q: How do you become a geologist?
A: You do a science degree, majoring in geology at university.

Q: What does a geologist do?
A: A geologist examines rocks and geoscientific information obtained from field observations and geochemical and geophysical surveys, and tries to work out how the rocks have ended up with the chemistry and structure/shapes you now see. If you are a mineral, coal or petroleum exploration geologist, you also try and work out where economic concentrations of these commodities might be found in the earth. You really are a detective looking back in time, often with very few clues to help you.

Q: How do you collect and use information?
A: Information is collected by making visual observations of rock types and mineral composition, and recording them to compile a geological map. The orientation of rocks, including folding and faulting, are also measured to determine what events might have disrupted the geological profile from its original position. Soil and rock samples are collected, often from drill holes, and chemically analysed to determine concentrations of elements and/or minerals in the samples. Statistical analyses are then carried out on the chemical results to determine whether the chemical concentrations are higher than background levels; and, if they are, then more follow-up work is done. It is essential that objective quantitative data are collected; so a real picture can be created, not just one person's opinion.

Q: Can you explain a problem you had and how you solved it?
A: At a particular prospect, we were trying to determine if there was sufficient gold mineralisation for there to be an economic resource (ore body). I collected information on the composition and orientation of the rocks and quartz veins that contained the gold at the ground surface and did some three dimensional calculations to determine where the quartz veins might be located below the ground. I then calculated where the drillholes should be located to intersect these quartz veins at depth, as this would tells us whether the quartz veins still contained gold. The drill core samples were collected and analysed by a laboratory for concentrations of gold and other elements (the gold could not be seen with the naked eye; so we had to do chemical analyses). The drilling program determined that the gold in the quartz veins was insufficient for an economic mine to be developed.

Q: Describe a place(s) you have worked and what it was like working there.
A: I worked for a year as an exploration geologist in the Pilbara desert in Western Australia (where the movie 'Japanese Story' was filmed). We were exploring for gold in some of the oldest rocks on the planet—more than four billion years old. I lived in a canvas tent with work colleagues in the middle of absolutely nowhere. We had a caravan as an office and a tent as a kitchen. A water bore supplied water for washing up, and the shower and a generator supplied electricity. We had hot water from lighting a fire under a 44-gallon drum of water. It was an absolutely beautiful place and it was lots of fun living there. However, even though you made friends with those you worked with, you couldn't really get in touch with other friends or family very easily—it was half a day's drive to the nearest phone. (Today you would just use a satellite phone.) We were doing field trips of up to seven weeks away from Perth (working seven days a week); so you couldn't be in a sports team or a band, and it was hard on relationships, too. Your life really is all work. But I got the opportunity to live for a while in one of the most interesting and beautiful places in Australia.

Q: What do you think makes a good scientist?
A: A good scientist is someone who asks questions and can work out how to find out the answers; someone who not only can make observations and record them accurately but also notices what is 'out of the ordinary'; and someone who is interested in how the world works.

Interview 3: Meet Andrew Mutton—geophysicist

Q: Why did you become a geophysicist?
A: When I was at school, I liked doing subjects such as science and maths, and was very interested in how things worked. I also liked to learn about the Earth, the solar system, what the Earth and planets were made of, and how the Earth formed. So, I liked science subjects like physics, chemistry and geology. When I left school, I decided to do a general science course at university, because of my liking for the sciences. When I was there, I learned about geophysics, and how it is used to study the inside of the Earth. I decided then to become a geophysicist, as I believed that this was a good way of combining my interest in geology and physics. As well, there were some really interesting jobs being offered at the time that used geophysicists to find minerals underneath the Earth's surface.

Q: How do you become a geophysicist?
A: To become a geophysicist, you have to go to university and study science subjects, including geology, physics and maths. Once you complete your university studies, you can apply for a job as a geophysicist with a mining or oil company, or with the government.

Q: What does a geophysicist do?
A: A geophysicist studies the rocks and structure of the Earth, below the Earth's surface. To do this, the geophysicist not only uses measurements of the Earth's magnetism and gravity, but also measures how sound waves, set off by small explosions, move through the rocks. From these measurements, a geophysicist can predict what rocks are below the surface and if there are any deposits of minerals or oil that could be extracted.

Q: How do you collect information and how do you use it?
A: A geophysicist uses specialised scientific instruments to take measurements of the Earth's physical properties. These are generally measured at the Earth's surface, but can also be measured in aeroplanes flying over the land or sea. For example, a magnetometer is a special instrument used by geophysicists to measure the Earth's magnetic field. The magnetometer is often put in a small aeroplane that flies just above the surface of the land and records the measurements as it is flying. The geophysicist then processes the measurements in a computer and produces maps showing the variations in the magnetic field. From these maps, the geophysicist can predict what type of rocks occur below the surface, and if there are any deposits of minerals, such as copper, gold, diamonds or coal, in these rocks.

Q: Can you explain a problem you had and how you solved it?
A: I was asked to predict how deep a deposit of copper minerals, in a remote area of Western Australia, would be. I designed a magnetometer survey to collect the magnetic field results over this area, on the basis that I believed the minerals would show up in these results. From these results, I was able to determine that the minerals were about 250 metres below the surface. We tested this by drilling a narrow hole into the rock at the point that I had calculated from the results. The rock taken out of the drillhole showed that the copper minerals did occur at about the depth I predicted.

Q: Describe a place(s) you have worked at and what it was like working there.
A: Most of the work I have done has been in outback parts of Australia, usually where there are no towns and very few people. For example, I spent three months in charge of a magnetometer survey using an aeroplane to collect the results, over the remote western desert areas of the Northern Territory. We had to set up our own camp near a dirt airstrip to be able to do the work, because it was hundreds of kilometres from the nearest town. The camp consisted of tents to live in, a tent kitchen and office. It was a fantastic place to work, even though it was very remote.

Q: What do you think makes a good scientist?
A: A good scientist must, firstly, be able to clearly understand the problem or task that you are attempting to solve and decide what methods or techniques will help you solve the problem. You must then be able to collect good-quality data, which you have determined will help you solve the problem. Then you must be able to analyse the data in a way that produces solutions to the problem. Finally you must be able to present your results in a confident way to the people who asked you to solve the problem. This means either writing a scientific report or giving a presentation to an audience. The best scientists generally have a broad range of skills that incorporate all these steps.

Graphic organiser

After reading one of the interviews, choose five items of interest and write them in the boxes below.

Type of scientist

Resource 15: Assignment— Would you mine the school oval?

Demonstrating outcomes EB 5.3 and 6.3

Core learning outcome

Earth and beyond 5.3: Students prepare scenarios about the use of renewable and non-renewable resources of the Earth and beyond.

Core learning outcome

Earth and beyond 6.3: Students argue a position about stewardship of the Earth and beyond, and consider the implications of using renewable and non-renewable resources.

The issue

Geochemical and geophysical surveys have led to the discovery of a significant gold resource under your school oval. The value of the gold deposit would pay for the construction of another 10 schools. The school and local community are debating whether the deposit should be mined. As we explored in Resource 5: 'Who needs to have a say?', planning for land use and resource management should involve considering the views of all those affected by the planning and decision-making process.

Your task— Level 5

1. Refer to the table you completed in Resource 5 'Who needs to have a say? Part B' and draw up a similar table that lists the different groups in your local community (including your school), their concerns and the guarantees you think they may seek from the mining company, if the project proceeds.

2. If the project does proceed, how do you think things would be different at school and in your local community? Create a written or visual representation that describes the major social, economic and environmental impacts. Include:
   - the changes that would take place,
   - the people who would be advantaged and disadvantaged by the changes,
   - who owns the gold (refer to **http://www.nrme.qld.gov.au/mines/royalties/mining_royalties.html** or Part 1, S8 of the Mineral Resources Act 1989 located at **www.legislation.qld.gov.au**
   - the rehabilitation required (refer to **http://www.epa.qld.gov.au/environmental_management/land/mining/codes_of_compliance** and the related fact sheet at **http://www.epa.qld.gov.au/publications/p00317aa.pdf/codes_of_environmental_compliance.pdf**).

Your task— Level 6

3. Negotiate with your peers and teachers before deciding on one of the options below; then participate in the chosen activity.

Option A: Simulating a community forum

This option involves students adopting the roles of people who represent various groups in the community, such as those listed in Resource 5: 'Who needs to have a say?'. Working in groups, you will develop positions based on that group's needs and concerns. Then, during a simulated forum, your group (in role) will present those concerns to the rest of the forum.

Option B: Organising a forum in your local community

This option involves students planning and facilitating a forum in your local community on the above mentioned issue. You will need to invite representatives of local groups to your school to work with a group of students and then participate in the forum in front of an audience of your peers, parents and interested community members.

4 How are minerals and oil processed and used?

How are minerals and oil processed and used?

Outcomes

Science strand	Level 4 outcomes			Level 5 outcomes			Level 6 outcomes		
Natural & processed materials	4.1		4.3	5.1		5.3	6.1		6.3

Teaching and learning activities

Focus areas	Resource sheets
Introduction to materials from minerals	1. What is a material? 2. Materials and their properties 3. Investigating ceramics
Altering properties	4. Physical and chemical properties of metals 5. Working a metal: the effects of hammering and bending 6. Heat treatment: the effects of annealing, quenching, tempering 7. What are alloys and where are they used?
Minerals to metal	8. Reactivity series of metals: aluminium and iron 9. Investigating reactivity 10. The reactivity of metals 11. Obtaining metals: lead by smelting and copper by electrolysis
Oil to petroleum—fuels	12. Crude oil and the fractionating tower 13. Investigating some products of crude oil
Oil to petroleum—plastics	14. Physical and chemical properties of plastics 15. Plastics and their properties
Putting it all together—from mineral to product	16. The top eight minerals mined in Queensland 17. Significant Queensland mines 18. Mining helps make many things 19: What's in your mobile phone? 20. What's in yours?

Teaching notes

Introduction to materials from minerals

Outcomes: Working towards NPM 4.1.
Assessment ideas: Inclusion of work sheet, practical data and consolidation questions in portfolio.

1. What is a material? and
2. Materials and their properties

This fact sheet and this work sheet could be used together to encourage students to consider materials and to make justified choices about the suitability of materials for particular purposes.

3. Investigating ceramics

Before practical

1. Discuss Mohs scale of hardness with the class. The higher numbers correspond to the harder minerals. Students must scratch each ceramic sample with the minerals. Students must find the two minerals next to each other in Mohs scale, one of which does not scratch the ceramic and one which does. The hardness of the ceramic will be between the rating of these two.

Mineral	Hardness rating	Mineral	Hardness rating
talc	1	orthoclase	6
gypsum	2	quartz	7
calcite	3	topaz	8
fluorite	4	corundum	9
apatite	5	diamond	10

2. Discuss with students what is meant by density. Density is the amount of mass a substance contains in a given space. It can be described as the concentration of mass. For example, one tonne of bricks and one tonne of feathers both have the same mass (one tonne). However, the tonne of bricks takes up much less space, because bricks are much denser than feathers.

After completing practical

3. Organise a class discussion about the results and the general properties of ceramics. The word ceramic is used to describe a wide variety of materials most of which have these properties:
   - resistance to heat and chemicals
   - low density compared to metals
   - a hard surface that resists wear.

4. Discuss the consolidation questions and then invite students to draft written responses to them in their workbooks.

Answers to consolidation questions

1. Ceramics have a low density compared to metals.
2. Each type of ceramic is made up of a different composition of minerals.
3. Low density and high hardness.

Altering properties

Outcomes: Working towards NPM 5.1, 4.3, 5.3.
Assessment ideas: Inclusion of worksheet, practical data and consolidation questions in portfolio.

4. Physical and chemical properties of metals

Introduce or revisit the periodic table with students drawing their attention to the 84 of the 106 elements that are metals. This fact sheet lists 12 of the most well known metals. The practical below can then be introduced, once students have read and understood the fact sheet.

5. Working a metal: the effects of hammering and bending

This task can be used to demonstrate NPM 5.3.

Before the practical

1. Organise a class discussion about the general structure of an atom and the structure of the metal lattice and associated physical properties.
2. Discuss the procedure with the class. The etching part (use of concentrated nitric acid) will need to be completed under strict supervision, with a water bath at hand for initial rinsing before students return to work stations.

Safety alert Advise students to take particular care when using strong acids. To avoid noxious nitrogen oxide gases, conduct this activity in a fume cupboard.

After completing the practical

1. Organise a class discussion about the results of the experiment.
2. Discuss the consolidation question with students; then invite them to write their understanding in their own words.

6. Heat treatment: the effects of annealing, quenching, tempering

This task can be used to demonstrate NPM 5.3.

Before the practical

1. Organise a class discussion about the use of a control.
2. Introduce definitions:
   - annealing—the extreme heating and slow cooling of metals
   - quenching—the extreme heating and rapid cooling of metals
   - tempering—the strong heating, quick cooling, strong heating and then slow cooling of a metal.
3. Discuss the procedure with the class.

Safety alert Advise students that hot metal can cause severe burns. Do not pick up the hairpins after heating. They will remain hot, even when they look normal.

After completing the practical

4. Organise a class discussion about the results of the experiment.
5. Discuss the consolidation questions with students then invite them to write summaries in their own words.

Answers to consolidation questions

1. Metal should be soft and malleable.
2. Metal should become strong but brittle.
3. Metal should become tough and springy.

Extension

1. Quenching will create a very hard, sharp blade.
2. Annealing will give the properties desirable of a wire.

7. What are alloys and where are they used?

Invite students to complete this worksheet to introduce them to the idea of alloys.

Answers to using data questions

	Answer	Explanation about appropriateness of properties				
		Electrical resistivity	Strength	Corrosion resistance	Corrosion resistance (when stressed)	Cost
Question 1	Alloy 6101 or 5083	irrelevant	very important	important	very important	low priority
Question 2	Alloy 1350	very important	low priority	important	low priority	medium importance
Question 3	Alloy 6101or 5083 Could use 2014 if painted	irrelevant	very important	important	important	irrelevant
Question 4	Alloy 3003	irrelevant	medium importance	needs to be fair	not high priority	very important

Minerals to metal

Outcomes: Working towards NPM 6.1.
Assessment ideas: Inclusion of worksheet, practical data and consolidation questions in portfolio.

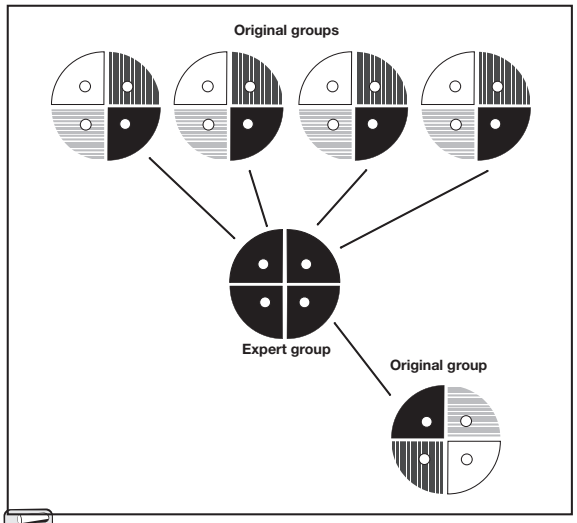
8. Reactivity series of metals: aluminium and iron

The length and complexity of this fact sheet lends itself to being broken into five segments. Using the peer teaching strategy 'expert jigsaw' is one way of introducing this information to the class. Students read only part of the fact sheet and teach that information to their peers.

Procedure

- Divide up the text on the fact sheet into five sections, based on the headings on the sheet. Photocopy and cut the sheets into the desired sections.
- Invite students to form groups of five and assign each group member a section of the fact sheet.
- Next, ask students to meet with the members of other groups who have been assigned the same section, forming a new group. This new group learns together and becomes an expert on its portion of the assigned material by talking it through and asking the teacher any clarifying questions. The group then plans how to

teach the material to the members of their original groups.
- Students return to their original groups and teach the group members about their area of expertise.
- Invite students to reflect on what they have learnt. This could be discussed or students could write a short response in their workbooks.



9. Investigating reactivity

Before practical

1. Organise a class discussion on reactivity and how to draw up and complete the data table.

Safety alert Revise procedures for using acids.

After completing the practical

2. Discuss the results and consolidation questions with students, particularly how to use the results to put the metals in order of reactivity.

Answers to consolidation question

1. Individual responses from results
2. Most reactive magnesium
   aluminium
   zinc
   iron
   tin
   lead
   copper
   Least reactive silver

Answers to extension questions

1. Copper metal. It will not react with the copper sulphate solution and is not expensive (silver) or poisonous (lead).
2. There is a reaction that produces hydrogen gas.
3. The rate of bubbling (reaction rate) would speed up. The higher concentration of acid means more acid molecules are available to react with the metal.
4. Each equation will form the metal chloride and hydrogen gas. For example:

Magnesium + Hydrochloric acid → Magnesium chloride + Hydrogen

$$Mg + HCl \rightarrow MgCl + H_2$$

10. The reactivity of metals

This work sheet is best used after Resource 8 and Resource 9. Posters designed in the 'create' section of the work sheet can be used as an assessment item.

11. Obtaining metals: lead by smelting and copper by electrolysis

Before the practical

Safety alert Lead oxide, lead and their various vapours are poisonous. Avoid skin contact and breathing fumes, and wash hands after using lead.

After completing the practical

1. Discuss the results and consolidation questions with students and then invite them to write their conclusions in their workbooks.

Answers to consolidation questions (lead by smelting)

1. Yes a chemical reaction has happened. The proof is that a new substance was formed.
2. Lead oxide + carbon $\longrightarrow$ lead + carbon monoxide.
3. The match is first dipped in water to attach lead oxide particles to the match.

Extension

1. $PbO_{(s)} + C_{(s)} \longrightarrow Pb_{(s)} + CO_{(g)}$

Answers to consolidation questions (copper by electrolysis)

1. Copper was deposited on the negative electrode (the cathode). The copper ion in the blue solution is positively charged—Cu^{2+}. Positive ions are attracted to negative electrodes and vice versa.
2. A gas was produced at the positive electrode.
3. Copper oxide + sulphuric acid $\longrightarrow$ copper sulphate

   ↓

   ELECTROLYSIS

   ↓

   copper

Extension

1. copper oxide + sulphuric acid $\longrightarrow$ copper sulphate + water$_{(l)}$

   $CuO + H_2SO_4 \longrightarrow CuSO_4 + H_2O$

   copper sulphate$_{(aq)}$ — electrolysis $\longrightarrow$ copper$_{(s)}$ + oxygen + sulphur dioxide

   $CuSO_4 \longrightarrow Cu + O_2 + SO_2$

Oil to petroleum—fuels

Outcomes: Working towards NPM 6.3.
Assessment ideas: Inclusion of worksheet, practical data and consolidation questions in portfolio.

12. Crude oil and the fractionating tower

Read through this fact sheet with students before they undertake the practical, Resource 13: 'Investigating some products of crude oil'.

13. Investigating some products of crude oil

This task can be used to demonstrate NPM 6.3.

Before the practical

1. Organise a class discussion of prior knowledge, including a review of the particle model, by asking such questions as written below.
   - What are the three states of matter?
   - What are their general properties? For example, do they have a fixed shape or a fixed volume?
   - How do the general properties relate to the forces of attraction (the intermolecular forces) between molecules in each state? For example: solids = very strong intermolecular forces; gases = very weak intermolecular forces.
   - What happens to the strength of intermolecular forces as a substance changes between states? For example: change from solid to liquid, liquid to gas—the intermolecular forces become weaker.
2. Review definitions of the properties of:
   - viscosity—a measure of how easily a liquid flows; for example, the higher the viscosity, the slower the flow as greater forces of attraction are holding molecules together;
   - flammability—a measure of how easily a substance burns; the weaker the forces of attraction, the greater the flammability.
3. Discuss the procedure and how to complete the table of results; for example, using ratings as described in the student method.

Safety alert Teacher to provide petrol samples.

After completing the practical

4. Organise a discussion of the results of the experiment with the class. Were the results expected?
5. Invite students to provide written responses to the consolidation questions in their workbooks.

Answers to consolidation questions

1. Intermolecular forces are the forces of attraction holding molecules together in any substance.
2. Candle wax has greater forces of attraction than paraffin wax. The proof is that candle wax is harder to ignite and is physically harder than paraffin.
3. Petrol has weaker forces of attraction than lubricating oil. The proof is that petrol has a lower viscosity and it is also easier to ignite.
4. Listed in decreasing forces of attraction: candle wax, paraffin wax, lubricating oil, petrol.
5. Candle wax = $C_{40} – C_{50}$
   Paraffin wax = $C_{40} – C_{50}$
   Lubricating oil = $C_{20} – C_{30}$
   Petrol = $C_4 – C_{10}$
6. The **longer** the hydrocarbon molecule, the **stronger** are the intermolecular forces of attraction, and vice versa.

Oil to petroleum—plastics

Outcomes: Working towards NPM 5.1.
Assessment ideas: Inclusion of work sheet, practical data and consolidation questions in portfolio.

14. Physical and chemical properties of plastics *and* 15. Plastics and their properties

The work sheet can be used to demonstrate NPM 5.1.

The fact sheet can be read in conjunction with the work sheet. Students can role play the formation of polymers from monomer units (by linking arms in a chain) for both forms of plastic and demonstrate how cross links give a fixed shape, once moulded. For additional classroom activities go to the American Plastics Council website at www.HandsOnPlastics.com.

Putting it all together—from mineral to product

Outcomes: Working towards NPM 6.3.
Assessment ideas: Research assignment on the production process of an object.

16. The top eight minerals mined in Queensland

Invite students to complete this Internet research task. Completion of the work sheet will help them with the assignment task, Resource 20: 'What's in yours?'

17. Significant Queensland mines *and* 18. Mining helps make many things

These fact sheets are provided to assist students to complete the table in Resource 16: 'The top eight minerals mined in Queensland'.

19. What's in your mobile phone?

This task can be used to demonstrate NPM 6.3.

Use this activity to model the process that could be used in the independent assessment task, Resource 20: 'What's in yours?' Resource sheets in Chapters 2, 3 and 4 will help students to complete this task.

Inferring why a mineral or material is suitable for use in the chosen product is the most challenging part of this activity, and students might require some modelling. It might be useful to prepare a table of the listed minerals and record what students have learnt about the properties of each. Then organise a class discussion about the suitability of using each mineral or material in a mobile phone. Though it is not a mineral, you could add crude oil to the list, because plastic is such an obvious component of mobile phones.

20. What's in yours?

This task can be used to demonstrate NPM 6.3.

This assessment task caters for diverse learning styles and abilities. It gives students opportunities to choose how they develop and present the concepts they have evolved in this section. They can also choose an object of interest to research.

Resource 1: What is a material?

We use many materials from the Earth; for example, stone, wood and metals. These are called **natural** materials. We can also make totally new materials, such as nylon, by chemical reactions. These new materials are called **synthetic** or processed materials.

Why do we make aircraft out of aluminium alloy instead of wood, glass, plastic or paper? Why are car bodies made of metal? Why are carpets not made of stainless steel? The answers to these questions lie in the fact that different materials have different properties.

The **properties** of a material are the qualities that make it different from other materials. The way in which a material is used depends upon its properties.

The need to make synthetic materials comes from the need to have materials with properties not displayed by those provided by nature. Most processed materials come from two natural materials—**oil** and **minerals.**

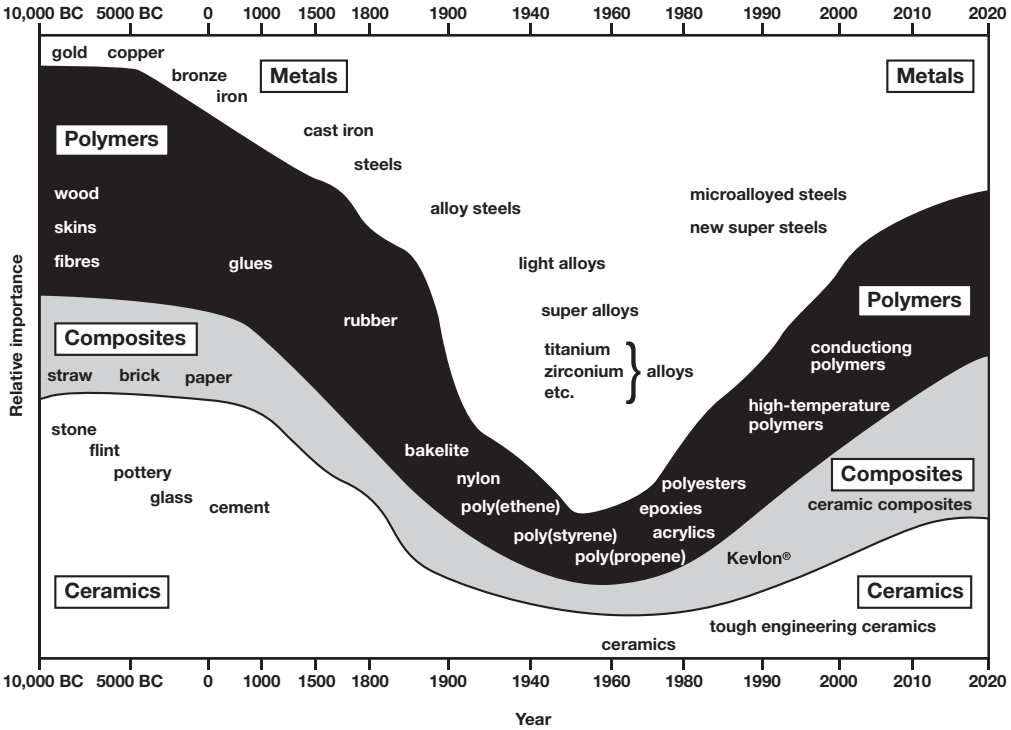
Some scientists have the important task of conducting tests to determine which material is best for a particular purpose. Such scientists are called **material scientists.** Material science is often connected with engineering, because the strength and durability of many structures in our society depend very much on the materials from which they are made. Imagine a bridge made out of cardboard for instance.

An accidental discovery

Safety glass was discovered by accident. In 1904, a French scientist called Edouard Benedictus dropped a bottle off his shelf onto the laboratory floor and noticed it cracked, but did not shatter. He examined the bottle and found the chemical inside it had evaporated leaving a thin film on the inside of the glass. This thin skin held the pieces together when the glass broke. Later developments by Benedictus led to the development of shatterproof glass.

Materials through time

Several groups of materials have been used by society throughout history. They are metals, polymers, ceramics and composites. The relative importance of each group has varied through time. New uses have been found for existing materials and new materials in each group have been discovered or synthesised.



Source: Ash, M., Lofts, G., Evergreen, M. J., and Buchanan, J., 1999, *Jacaranda Science 3*, Jacaranda Wiley Ltd, Brisbane © John Wiley & Sons Australia

Resource 2: Materials and their properties

Remember

1. What is meant by the properties of a material?
2. Why is it important to know the properties of a material?
3. What is the difference between a synthetic and a natural material?
4. Why do we need synthetic materials?

Think

1. Listed in the table below are the properties of six materials. Using this information, decide which material (A-F) would be the most suitable for making each of the items listed. Explain your choice of material, giving reasons for your answers.
   a. Gold ring
   b. Electrical wiring
   c. Table mats for hot saucepans
   d. Frying pans

Material	Flexibility	Ability to withstand breaking	Ability to conduct heat	Ability to conduct electricity	Melting point (°C)
A	good	low	poor	poor	not applicable —it ignites
B	satisfactory	moderate	good	good	1000
C	satisfactory	moderate	poor	poor	not applicable —it ignites
D	good	high	poor	poor	250
E	good	moderate	poor	poor	1800
F	good	high	good	good	1000

2. Gold has a number of useful properties. It is a soft metal that can be easily hammered into shapes. It is very dense. It is not reactive and is highly resistant to acids. Gold can occur as veins in quartz or as alluvial gold. Alluvial gold occurs in the gravel and sand of stream beds, or where streams once flowed. The 'Welcome Stranger' is the largest nugget found in Australia. It was found in Victoria in 1869 and contained 68.7 kilograms (2208.77 troy ounces) of gold.
   a. What property of gold makes it useful for jewellery and the protective coatings on laboratory equipment?
   b. Look up the price of gold in a newspaper and calculate the value of the 'Welcome Stranger' today.
   c. Suggest a theory for the presence of alluvial gold in streams.

Imagine

Imagine you are a member of the Parents' and Citizens' Association of your school and your job is to decide which fabric is the most suitable for making the shirts and blouses. You have a choice of cotton, polyester or poly-cotton. Natural fibres such as cotton are cooler to wear, but tend to crease easily and are easily worn-out. Synthetic fibres such as polyester tend to retain the heat, leaving the wearer feeling hot and clammy on a warm day, but do not crease so easily and are hard wearing. Which fabric would you select and why?

Using data and thinking skills

Using the graph of Materials through time from Resource 1: 'What is a material?', answer the questions below.

1. If the Industrial Revolution was based upon the manufacture and use of cast iron and steel, what time did it take place?
2. What could have accounted for the increased use of metals during the 1950s and 1960s?
3. What was the name of the first synthetic plastic polymer?
4. Which group of materials seems to be taking the place of metals in importance?
5. Besides composites, which group of materials is capable of providing new strong and tough materials?
6. What is a composite material?

Resource 3: Investigating ceramics

Purpose

To describe and compare the properties of ceramics.

Materials and equipment

- Samples of;
  - Pottery
  - Porcelain
  - Fired clay
  - Brick
  - Tile
- 100 ml measuring cylinder
- Dropping pipette
- 250 ml beaker
- 400 ml beaker
- Balance
- Mineral kit for hardness testing.

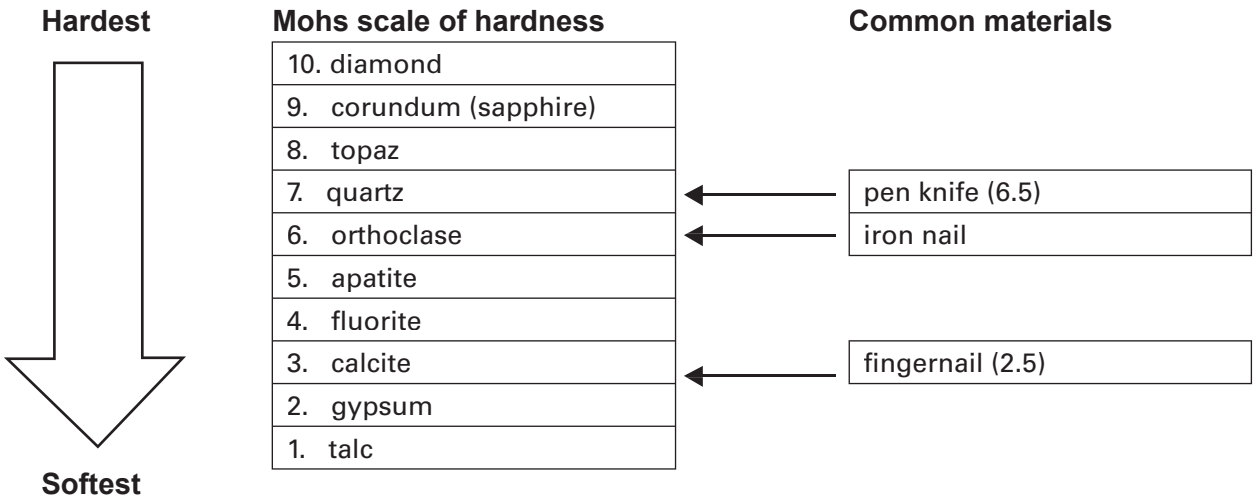
Method

Part A: To determine hardness

Draw the following table in your workbook and use it to record the results of each of the following tests.

Ceramic	Hardness	Mass (g)	Volume (ml)	Density (g/ml)
Pottery				

1. Try to scratch each of the ceramic materials with the minerals in the kit. Begin with the softest, according to Mohs scale, until you scratch the ceramic. When you make a scratch, record the hardness, using Mohs scale, in your table. For example, if a ceramic is scratched by calcite (3), but not gypsum (2), its rating will be between the two minerals—2.5.



Part B: To determine density

1. Measure the mass of each sample using the balance and record your results in the table.
2. Partly fill the 250 ml beaker with cold water and carefully place it inside the dry 400 ml beaker.
3. Using the dropping pipette, top up the 250 ml beaker carefully, until it holds as much water as possible.
4. Carefully add one of the ceramic samples to the beaker of water. Transfer the water that has overflowed into the large beaker into the 100 ml measuring cylinder.
5. Record the volume of the sample in the table. The amount of water that overflowed equals the volume of the sample. Repeat with other ceramics.
6. Calculate the density of each ceramic and record the results in your table.
   Density = mass ÷ volume

Consolidation

1. Iron has a density of 7.86 grams per millilitre. Copper has a density of 8.96 grams per millilitre. What statement can you make about the density of ceramics compared to the density of metals?
2. What explanations can you offer for the differing hardnesses of the ceramics tested?
3. Did the ceramics you tested have anything in common?

Extension

NASA's space shuttle is covered with ceramic tiles that protect the fuselage from high temperatures during re-entry into the Earth's atmosphere. Research what materials these tiles are made from and what properties they have that make them suitable for this function.

What do you use everyday that is made from ceramic materials?

Resource 4: Physical and chemical properties of metals

The periodic table lists all the elements currently known to scientists. Of these 106 elements, **84 are metals** and the rest are non-metals. Some of these metals are listed in the box.

Aluminium Al
Calcium Ca
Copper Cu
Gold Au
Iron Fe
Lead Pb
Magnesium Mg
Potassium K
Silver Ag
Sodium Na
Zinc Zn
Tin Sn

The properties of metals

1. They are **strong**. They can hold heavy loads without breaking.
2. They are **malleable**. They can be easily hammered into different shapes without breaking.
3. They are **ductile**. They can be made easily into wires.
4. They are **sonorous**. They make a ringing noise when you strike them.
5. They are **shiny**.
6. They are **good conductors** of heat and electricity.
7. They have **high melting** and **boiling points**. They are all solid at room temperature, except mercury.
8. They have **high densities**. That means they feel heavy.
9. They **react with oxygen** to form oxides.

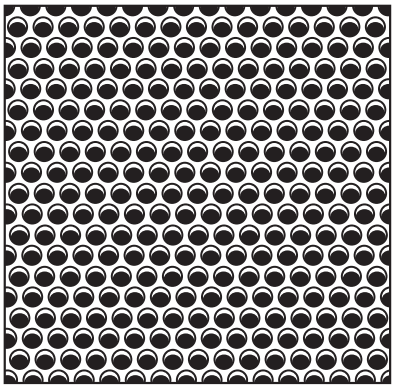
For example Metal + oxygen ⟶ metal oxide

Magnesium + oxygen ⟶ magnesium oxide

10. When metals form ions, **the ions** are **positive**; for example, in the reaction between magnesium and oxygen above, magnesium forms Mg2+ ions, and oxygen forms O2- ions.

The last two properties in the list above are called **chemical properties**, because they are about chemical changes in the metals. The other properties are **physical properties**.

In a pure metal, all the atoms are identical. The atoms exist in a regular pattern, called a **lattice**.



Each atom consists of a nucleus surrounded by electrons. The electrons form a sea throughout the lattice and are shared among all the atoms. This structure can be used to explain some of the physical properties of metals, including:

- good conductors—the metal atoms have a relatively loose hold on their electrons; so they are free to flow throughout the material
- high melting and boiling points—the forces holding the lattice together are very strong
- malleable and ductile—the nuclei can easily slide past each other without disrupting the lattice.

Pure metals are often of limited use because they do not have the properties needed for a specific function. For example, pure iron is of little use because it is too soft and stretches easily. When a little carbon is mixed with it however it becomes much harder and stronger. It is then called **steel** and can be used in buildings, bridges, ships and car bodies.

The properties of iron are changed by mixing other substances with it. These mixtures are called alloys. An alloy is a mixture of two or more metals. To make an alloy, you melt the main metal and dissolve the other substances in it.

Alloys have different properties from those of the metals from which they are made. These properties depend on the **proportions** of each metal used. There are thousands of different alloys. Some common alloys are listed in the table below.

Alloy	Made from	Special properties	Uses
Stainless steel	70% iron 20% chromium 10% nickel	does not rust	kitchen sinks, cutlery, car parts, artificial limbs
Nickel steel	95% iron 5% nickel	hard and strong	guns and axles
Duralumin	96% aluminium 4% copper	light and strong	aircraft parts
Brass	70% copper 30% zinc	shiny, hard and does not corrode	musical instruments, car radiators, ornaments
Bronze	95% copper 5% tin	harder than brass, does not corrode, takes a good polish	ships propellers, statues, ornaments, bells
Solder	60% tin 40% lead	soft, low melting point	joining wires, pipes
Cupro-nickel	75% copper 25% nickel	light, hard and does not corrode	‘silver’ coins

Metals are used for many different purposes. Two hundred years ago the town blacksmith produced nails, hammers, wheel rims, knives and horseshoes from the same basic metal. In some applications, a metal must be able to bend easily without breaking, whereas in other cases the metal must resist bending.

Today, metallurgists can produce these results by using different metals, alloying metals or by heat treating metals. The substitution of a different metal or using a special alloy is often costly because making alloys can be a complicated process. Therefore, heat treatment of a common metal is often the most cost-efficient method of producing a metal that has the properties required in a specific application.

Resource 5: Working a metal: the effects of hammering and bending

Purpose

To investigate the effects of hammering and bending on the properties and structure of a metal.

Materials and equipment

Copper rods, about 3 mm in diameter; hammer and anvil; newspaper (to put under the anvil); magnifying glass; sheet of lead foil, about 100 mm x 100 mm x 1.5 mm; metal tongs; etching solution (concentrated nitric acid); an etching bath (a metal tray about 20 cm x 20 cm x 5 cm); 250 ml beaker of boiling water; bunsen burner; tripod; gauze mat; heatproof mat; paper towel and/or hair dryer; tin snips or strong scissors; safety equipment, including glasses; lab coat/apron; and gloves.

Method

Part A: The effects of bending

1. Bend one of the copper rods backwards and forwards several times.
2. Describe what you can see and feel at the bending point.
3. Hammer the rod for about half a minute. Feel the rod. Bend it backwards and forwards as before.
4. Describe what you can see and feel at the bending point.

Part B: The effects of hammering on grains

Safety alert Care must be taken when using strong acids. To avoid noxious nitrogen oxide gases, conduct this activity in a fume cupboard.

1. With a pencil and ruler, draw a line down the centre of the lead sheet cross ways, to mark it into two parts.
2. Beat one half of the sheet with a hammer. Try to beat it in such a way that it stays as smooth as possible. Put a clear mark on the half that has been hammered.
3. Carefully pour the etching solution (acid) into the tray to a depth of about 0.5 centimetres.
4. Use tongs to immerse the lead sheet into the etching solution for about four minutes. Be careful to keep acid off your skin and clothes. Wear all safety gear.
5. Use tongs to hold the lead sheet under running water until all the etching solution has been washed off. Dry the sheet.
6. Examine the surface of the sheet with a hand lens.
7. Sketch the grains in each half of the sheet.
8. Cut the sheet in half length ways, so that each piece has one end that has been hammered and one end that has not.
9. Use the tongs to immerse one part in boiling water for about five minutes to raise its temperature.
10. Etch this treated half sheet as before (Steps 4 and 5)
11. Compare the grains in the heat-treated and untreated halves.

Consolidation

1. Describe the effects of each of the treatments on the physical properties of the metals.

Source: Ash, M., Lofts, G., Evergreen, M. J. and Buchanan, J., 1999 *Jacaranda Science 3*, Jacaranda Wiley, Brisbane. © John Wiley & Sons Australia

Resource 6: Heat treatment: the effects of annealing, quenching, tempering

Purpose

To investigate the effects of various heat treatments on the properties and structure of a metal.

Materials and equipment

- Metal hairpins with the plastic ends removed (paper clips will not work)
- Bunsen burner
- Tongs
- Beaker of cold water and/or ice
- Steel wool

Safety alert Take great care with hot objects.

Method

As a control, straighten the hairpin and determine the number of bends to break it in two. Record this in the table. Repeat two more times.

Part A: Annealing

1. Using tongs, heat one end of the hairpin in a hot burner flame until it is red hot. It must remain red hot for 30 seconds.
2. Very slowly move the hairpin up and out of the flame until it is about 30 centimetres out of the flame.
3. Let the hairpin cool gradually in the air for about 3 minutes.
4. When it has cooled, gently bend the treated arm of the hairpin until it breaks, and record the number of bends that it takes to break the metal.
5. Repeat two more times.

Part B: Quenching

1. Using tongs, heat one end of the hairpin in a hot burner flame until it is red hot.
2. Quickly immerse the heated arm in a beaker of cold water.
3. Bend the arm and record the number of bends needed to break the hairpin.
4. Repeat two more times.

Part C: Tempering

1. Using tongs, heat one end of the hairpin until it is red hot, and keep it in the flame for another 30 seconds.
2. Place it in a beaker of water.
3. Reheat the hairpin until it glows with a dull redness and remove it gradually from the flame, as you did in Part A.
4. When it has cooled, gently bend the arm and determine the number of bends needed to break the hairpin. Record in the data table.
5. Repeat two more times.

Consolidation

1. What are the effects of annealing?
2. What are the effects of quenching?
3. What are the effects of tempering?

Attempt	Control (untreated)	Annealed	Quenched	Tempered
1				
2				
3				
Average				

Extension

1. What type of treatment would be used in making a scalpel blade? Why?
2. What type of treatment would be used for making wire? Why?

Source: Ash, M., Lofts, G., Evergreen, M. J. and Buchanan, J., 1999 *Jacaranda Science 3*, Jacaranda Wiley, Brisbane. © John Wiley & Sons Australia

Resource 7: What are alloys and where are they used?

Remember

1. What are alloys? How are they made?
2. Why are alloys more commonly used than pure metals?
3. When making alloys, metallurgists often refer to the base metal. State what this means by using an example from the table on the fact sheet.
4. Why is iron more useful when it is mixed with a little carbon?

Using data

The table below contains some data on the properties of eight different aluminium alloys.

Alloy	Electrical resistivity*	Strength*	Corrosion resistance*	Corrosion resistance (when stressed)	Cost
6061	3.7	117	B	A	medium
6101	2.9	221	A	A	medium
1350	2.8	83	A	A	low
7001	5.6	255	C	C	high
5083	5.9	317	A	B	high
2014	5.1	421	D	C	high
3003	4.1	131	A	A	low
5005	3.3	200	A	A	medium

*Notes

Electrical resistivity—the higher the number, the less conductive (more resistive) the alloy becomes.
Strength—the higher the number, the stronger the alloy.
Corrosion resistance—on a scale from A (very good) to E (very poor)

Use the data in the table to choose the best alloy for each of the purposes below. Give reasons for your choices.

1. Underwater structure of a drilling rig.
2. Wires for electrical transformers.
3. Body of a jet fighter plane.
4. Low-cost prefabricated houses.

Imagine

Imagine a world without metals. Make a list of 10 items that could no longer be manufactured if there were no longer any metals available. Where possible, suggest which materials could be used to replace the metals used in these items.

Research

Construct a table (similar to that in Resource 4: 'Physical and chemical properties of metals") and list the main components, properties and uses of each of these alloys: solder, nichrome, amalgam, alnico, duralumin, carboloy, pewter, Wood's metal.

Resource 8: Reactivity series of metals: aluminium and iron

Have you ever wondered why gold, silver and platinum are used in jewellery and yet metals such as zinc and magnesium, are not? It is to do with their **reactivity.** Gold, silver and platinum are chemically very unreactive and retain their shiny appearance. Zinc and magnesium however react with the oxygen in the air and lose their shiny appearance—not a very useful property for jewellery!

The metal elements can be arranged in a list according to their reactivity; that is, how easily they react with other substances. The most reactive metals are at the top of the list and the least reactive at the bottom. This is called the **reactivity (**or **activity) series.**

Most reactive
Sodium Na
Calcium Ca
Magnesium Mg
Aluminium Al
Zinc Zn
Iron Fe
Tin Sn
Lead Pb
Copper Cu
Silver Ag
Gold Au
Least reactive

Things to remember about the reactivity series

1. The more reactive a metal, the more it forms compounds. So, only copper, gold and silver are ever found as elements in the Earth's crust. The other metals are always found as compounds.
2. The more reactive a metal, the more stable its compounds. **A stable compound is difficult to breakdown or decompose,** because the bonds holding it together are very strong.

This last property affects the decision on how a metal is obtained from its ore. The processing method depends on the reactivity of the metal, as shown in the table.

Metal			Method of processing		
Sodium Calcium Magnesium Aluminium	**Metals more reactive**	**Ores more difficult to decompose**	Electrolysis	**Method of processing more powerful**	**Method of processing more expensive**
Zinc Iron Tin* Lead*			Heating with carbon or carbon monoxide		
Copper*			Roasting in air		
Silver Gold			Occur naturally as elements		

Note.* Although copper, tin and lead are initially refined using other methods, electrolysis can be used for further purification of all three metals.

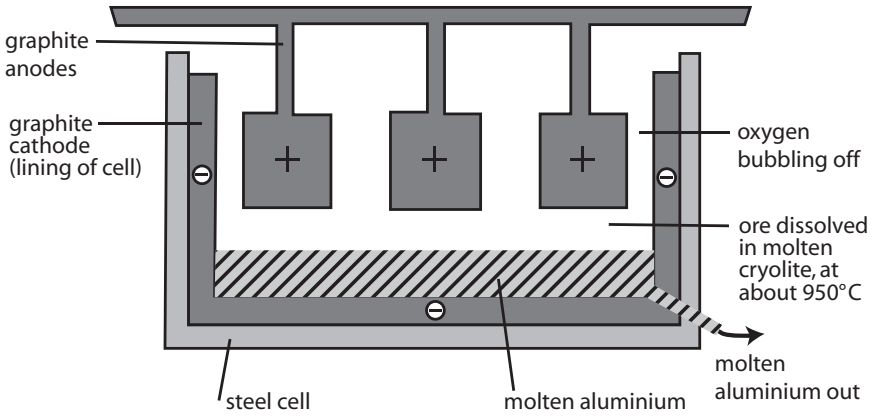
More about aluminium

Aluminium is the most abundant metal in the Earth's crust. Its main ore is bauxite, which is a general term for a rock composed of hydrated aluminium oxides together with impurities of iron oxides. These impurities make it reddish brown.

The steps in obtaining aluminium are listed below.

1. Geologists test bauxite to determine if aluminium content is high enough to warrant mining.
2. The bauxite is mined.
3. The bauxite is taken from the mine to the processing plant where it is treated to remove the impurities. The result is white aluminium oxide or alumina.
4. The alumina is taken to another plant for further processing by electrolysis. Aluminium is formed at the negative electrode. It drops to the bottom of the tank as molten metal. Oxygen gas is formed as a by product at the positive electrode.
5. The aluminium metal is made into sheets and blocks, and sold to other industries.
6. It is used to make soft drink cans, cooking foil, saucepans, television aerials, aeroplanes and even space rockets.

In Step 4, the aluminium is obtained by electrolysis. This is carried out in a huge steel tank, as shown below.



Pure alumina melts at 2045°C. It would be expensive and dangerous to keep the tank at this temperature. Instead, the alumina is dissolved in another aluminium compound, cryolite, with a much lower melting point.

In Queensland, a large bauxite mine is located near Weipa. Once the bauxite is mined and initially treated, it is taken to the alumina plant at Gladstone for refining. Bauxite mining contributes more than $250 million to Queensland's economy each year, and Queensland is responsible for nine per cent of the total world production of aluminium.

More about iron

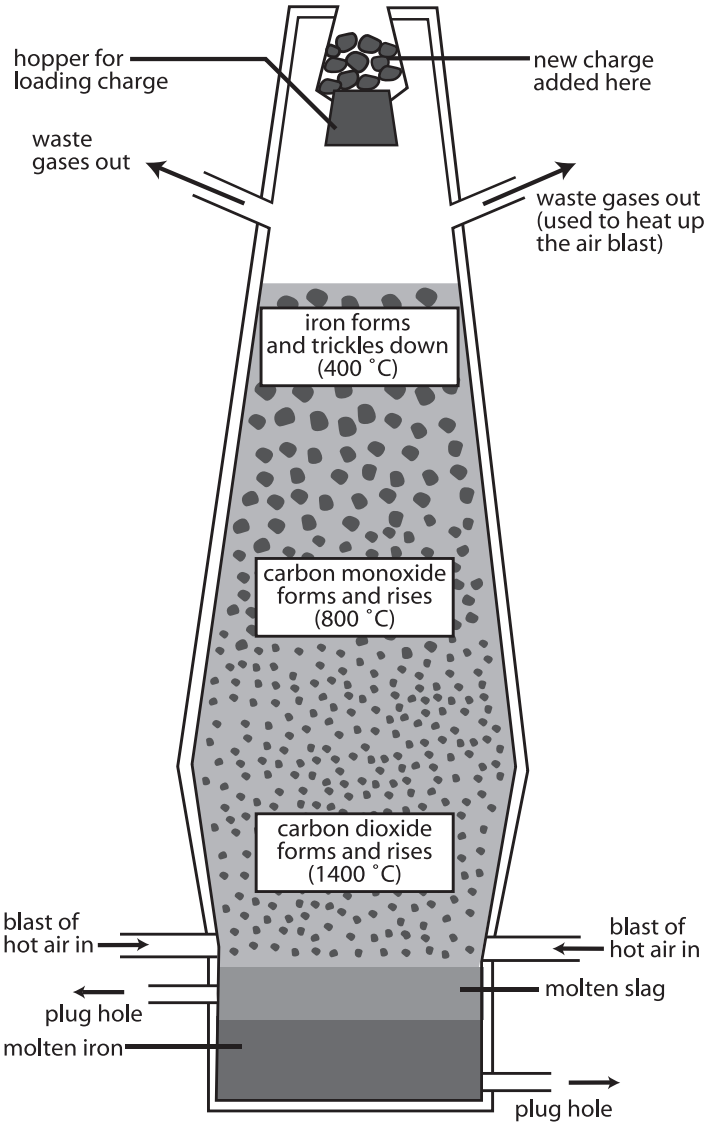
Iron is the second-most abundant metal in the Earth's crust. To process it, three substances are needed.

1. **Iron ore**. The chief ore is called haematite. It is mainly iron oxide, $Fe_2O_{3\,(s)}$ mixed with sand. Australia is one of the world's largest iron-ore producers.
2. **Limestone**. This is a relatively common rock. It is mainly calcium carbonate, $CaCO_{3\,(s)}$.
3. **Coke**. This is made from coal, and is nearly pure carbon, $C_{(s)}$.

These three substances are mixed together to give a mixture called **charge**. The charge is heated in a tall oven called a **blast furnace**. Several reactions take place and finally liquid iron is produced.

In the blast furnace

A blast furnace is like a giant chimney, at least 30 metres tall. It is made of steel and lined with fireproof bricks. The charge is added through the top and hot air is blasted through the bottom. This makes the charge glow white hot, and provides the energy for the reactions below to take place.



1. The coke reacts with oxygen in the hot air to produce carbon dioxide

$C_{(s)} + O_{2\,(g)} \longrightarrow CO_{2\,(g)}$

Coke + oxygen ⟶ carbon dioxide

2. The limestone breaks down to produce calcium oxide and carbon dioxide

$CaCO_{3\,(s)} \longrightarrow CaO_{(s)} + CO_{2\,(g)}$

Limestone ⟶ calcium oxide + carbon dioxide

3. The carbon dioxide reacts with more coke, giving carbon monoxide

$C_{(s)} + CO_{2\,(g)} \longrightarrow 2CO_{(g)}$

Coke + carbon dioxide ⟶ carbon monoxide

4. Carbon monoxide reacts with the iron oxide, giving liquid iron, which trickles to the bottom of the furnace

$3CO_{(g)} + Fe_2O_{3\,(s)} \longrightarrow 2Fe_{(l)} + 3CO_{2\,(g)}$

carbon monoxide + iron oxide ⟶ iron + carbon dioxide

5. Calcium oxide from Step 2, reacts with the sand in the iron ore to produce calcium silicate, or slag.

$CaO_{(s)} + SiO_{2\,(s)} \longrightarrow CaSiO_{3\,(l)}$

Calcium oxide + sand ⟶ calcium silicate

The slag runs down the furnace and floats on the iron.
The slag and the iron are drained from the bottom of the furnace.

The slag is left to solidify and is then sold, mostly for road building. Some of the iron is left to solidify in moulds, or casts. It is called **cast iron**. Containing impurities such as carbon, it is not only very hard but also very brittle, because it snaps under strain. It is used only for things like gas cylinders, railings and storage tanks that are not likely to get bent during use.

Most of the iron from the blast furnace is turned into steel, while still hot. Steel is an alloy of iron. There are many different types of steel. Below are just three of them.

Name	**Contains**	**Special property**	**Uses**
Mild steel	99.5% Fe, 0.5% C	Hard, but easy to work	Buildings, car bodies
Hard steel	99% Fe, 1% C	Very hard	Blades for cutting tools
Duriron	84% Fe, 1% C, 15% Si	Resistant to acids	Tanks and pipes in chemical factories

Resource 9: Investigating reactivity

Purpose

To test the chemical properties of some metals and arrange them in order of their chemical reactivity.

Materials and equipment

- Small samples of various metals:
  - Aluminium
  - Magnesium
  - Copper
  - Tin
  - Iron
  - Silver
  - Lead
  - Zinc
- Steel wool
- Dilute hydrochloric acid (2M)
- Test tubes and rack
- Saturated zinc sulphate solution
- Saturated copper sulphate solution

Safety alert Always use safety glasses when handling glassware and chemicals. If acid spills on your skin, wash it off immediately using lots of water and inform your teacher.

Method

Prepare a data table to record your observations for each part of this practical.
Hint. The name for each part of the experiment could be used for each column heading.

Part A: Appearance

1. Observe each of the metal samples. Which metals are tarnished (not shiny)?
2. Record your results in your data table.

Part B: Reactions with acid

3. Clean one piece of each metal sample with steel wool, and place into different test tubes.
4. Add hydrochloric acid to each test tube to a depth of about two centimetres.
5. Record the rate at which bubbles of gas are formed; for example, fast, medium, slow or no reaction, in your data table.
6. Clean out the test tubes, making sure to keep the remaining metals samples.
7. Wash the metal samples and keep them to use in the next part of the practical.

Part C: Reaction with zinc sulphate

8. Put zinc sulphate into each test tube to a depth of about one centimetre.
9. Add a different metal sample to each test tube, and leave for three to five minutes.
10. Carefully remove the metal samples and observe their appearance. A reaction will have occurred, if the metal now looks dark compared to its original appearance. If the metal is still shiny, you can infer no reaction has taken place.
11. Record your results in the data table (✓ for a reaction, ✕ for no reaction).

Part D: Reaction with copper sulphate

12. Clean the test tubes.
13. Repeat Steps 8–11 using copper sulphate solution.

Consolidation

Answer these questions using your results.

1. Which metals reacted with:
   a. all three test solutions (acid, zinc sulphate and copper sulphate)?
   b. two solutions only?
   c. one solution only?
   d. none of the solutions?
2. Try to put the metals in order, from the most reactive to the least reactive.

Extension

1. Suppose you wanted to make a metal tank to hold copper sulphate solution. Which would be the best metal to use? Why?
2. What usually happens when you add dilute hydrochloric acid to a metal?
3. What would happen to the rate of bubbling, if you used more concentrated hydrochloric acid? Why?
4. For those metals that reacted with hydrochloric acid, write a word equation to show the products and reactants of the reaction; for example,
   copper + hydrochloric acid $\longrightarrow$ copper chloride + hydrogen.

Source: Stannard, P. and Williamson, K., 1993, *Science Alive 3* Anteater Publications, Melbourne.

Resource 10: The reactivity of metals

Remember

1. Give an example of:
   a. an unreactive metal
   b. a reactive metal.
2. Using the reactivity series, place these metals in order, from most reactive to least reactive: copper, magnesium, sodium, zinc.

Think

1. Why is sodium never found uncombined in nature?
2. Which will break down more easily on heating: magnesium nitrate or silver nitrate? Explain.
3. An experiment was carried out to measure how long it took for equivalent amounts of different metals to react with 100 millilitres of hydrochloric acid. The results below were obtained.

Metal	**Time taken for metal to fully react (minutes)**
Iron	1.0
Magnesium	3.0
Tin	2.5
Aluminium	3.5
Nickel	2.0
Zinc	1.5

Unfortunately, the person recording the information accidentally changed the order of the metals recorded in the table. Using your knowledge of the reactivity series, redraw the table so that the correct metal is matched with the correct time.

Create

Information can be displayed in many ways. Posters can describe the results of practical investigations, using photographs, drawings and concise written summaries. Present the findings of your investigations in Resource 9: 'Investigating reactivity' as a poster display to your classroom.

Research

Design and carry out an experiment that investigates the reactivity of alloys such as stainless steel and brass. Compare the results with those obtained for the metal element.

Resource 11: Obtaining metals—lead by smelting

Purpose

To extract lead from lead oxide by smelting.

Materials and equipment

- Yellow lead oxide
- Piece of white paper
- Bunsen burner
- Matches
- Safety equipment, including glasses and lab coat/apron.

Safety alert Lead oxide, lead and their various vapours are poisonous. Avoid skin contact and breathing fumes; and wash your hands after using lead or any lead compound.

Method

1. Light the bunsen burner and adjust it so you have a very small flame.
2. Light a match and let it burn halfway. The black-charred end is mainly carbon.
3. Dip the charred end of the match into water and then into some lead oxide.
4. Place the match head in the burner flame and watch for the formation of any tiny drops of shiny grey molten lead.
5. Allow the match to cool. Then place it on a piece of white paper and look for any signs of lead. (You could use a hand lens.)
6. Record your observations.

Consolidation

1. Has there been a chemical reaction? How do you know?
2. Copy and complete the word equation for the reaction

   _____ + carbon ⟶ _____ + carbon monoxide
3. Suggest a reason for first dipping the match in water.

Extension

1. Write a balanced equation for Consolidation Question 2, using chemical formula and state symbols.

2. List 10 uses for lead.

Source: Stannard, P. and Williamson, K., 1993 *Science Alive 3*, Anteater Publications, Melbourne.

Resource 11: Obtaining metals—copper by electrolysis

Purpose

To extract copper from copper oxide by electrolysis.

Materials and equipment

- Conductivity kit
- Copper oxide
- 50 ml beaker
- Spatula
- Power pack
- Bunsen burner
- Tripod and gauze mat
- Dilute sulphuric acid (1M)
- Stirring rod
- Measuring cylinder

Method

1. Pour 20 ml of dilute sulphuric acid into a 100 ml beaker. Add a pea-sized amount of black copper oxide.
2. Set up the heating equipment. Carefully warm the beaker, while stirring, until the liquid turns blue. Turn off the burner and allow the beaker to cool before removing from the heating equipment.
3. Connect the conductivity kit to the power supply, set at 6 volts DC. Put the electrodes into the blue solution and turn on the electricity for two or three minutes.
4. Observe what is occurring in the beaker and record your observations.
5. Remove the electrodes from the solution and scrape off the copper deposit.

Consolidation

1. Was the copper deposited on the positive or negative electrode? Try to suggest a reason for this. (**Hint.** Are ions involved?)
2. Was anything produced at the other electrode?
3. Copy and complete the flowchart showing how copper is extracted from copper oxide.

Copper oxide + _____ → Copper sulphate

↓

Electrolysis

↓

_____

Extension

The electrolysis of copper oxide involves a two-step process. Try to write word equations for both parts of this process. Add chemical formula, where possible. (The chemical equations do not have to be balanced.)

Source: Stannard, P. and Williamson, K., 1993 *Science Alive 3*, Anteater Publications, Melbourne

Resource 12: Crude oil and the fractionating tower

Crude oil is formed underground from the remains of land plants and tiny marine organisms that lived millions of years ago.

Oil is a mixture of many compounds. They are mostly hydrocarbons and are very useful. Some compounds from oil are used as fuels. Some are used to make washing-up liquids, paints, drugs and cosmetics and others are made into nylon, polythene and other plastics.

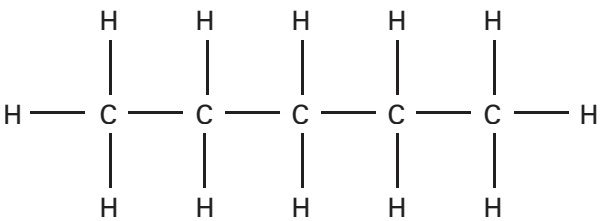
Getting oil from the Earth

Oil is usually found up to three to four kilometres below the ground. It is trapped in sedimentary rocks, like water in a sponge. To get to oil, a hole is bored using a drill mounted on a drilling platform. Next the hole is lined with steel and the oil is pumped through it to an oil refinery.

Refining the oil

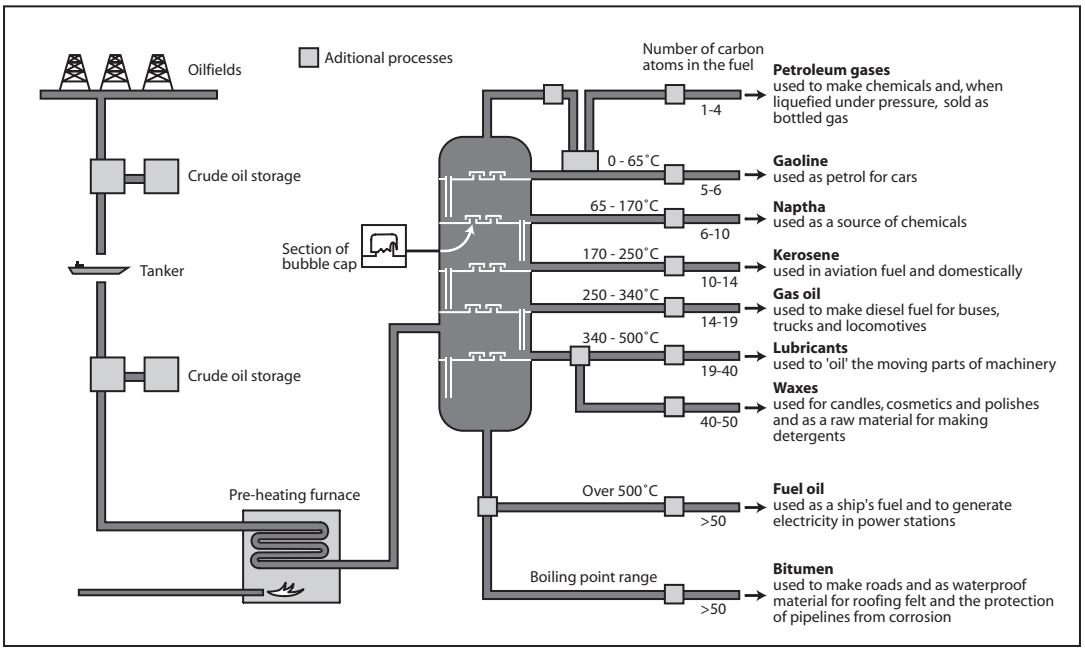
Oil is a mixture of hydrocarbons—chemicals made up of chains of carbon atoms, with hydrogen atoms attached. This mixture is called **crude oil**.

For example:



Some of the hydrocarbons in oil have only short carbon chains, but some have very long chains, up to 100 carbon atoms. To make the best use of oil, it is separated into groups of hydrocarbons that are close in chain length. This is called **refining** the oil, and is carried out by **fractional distillation**.

The distillation takes place in a tall tower called a **fractionating tower**. There the crude oil is heated. The hydrocarbons with short chains boil off first because they have the lowest boiling points. They rise to the top of the tower and are collected. The hydrocarbons with longer chains have higher boiling points and are collected lower down. The different groups of hydrocarbons are called **fractions**.



Resource 13: Investigating some products of crude oil

Demonstrating outcomes NPM 6.3

Purpose

To investigate the properties of some crude oil products and be able to relate these to the strengths of the forces of attraction (intermolecular forces) holding their molecules together.

Materials and equipment

Samples of lubricating oil, candle wax, paraffin wax and petrol; heatproof mat; crucible; short lengths of string; and matches.

Safety alert Do not collect the sample of petrol yourself. Your teacher will give it to you. Wear eye protection.

Method

1. Look at the products. Record in the table if each is a solid, liquid or gas at room temperature.
2. If the product is a liquid, give it a rating for viscosity; for example, if water is 1 and a solid is 10, what rating would it get between these numbers?
3. Record your results in the table.
4. To test flammability, place a small amount of your first product in the crucible (on the heatproof mat) and try to ignite it. If you have difficulty getting the product to burn, dip in a short length of string to act as a wick and try to ignite it again.
5. Observe how easily the product lights and how well it stays alight.
6. Repeat with other products.
7. Complete the table below using these statements for your observations:
   - lights easily/does not light easily
   - stays alight/goes out easily
   - does not light easily/stays alight.

Recording results

Properties	Lubricating oil	Candle wax	Paraffin wax	Petrol
State at room temperature				
Viscosity (if liquid)				
Flammability				

Consolidation

1. What is meant by intermolecular forces?
2. Compare the results for candle wax and paraffin wax. Which substance has the strongest intermolecular forces? How do you know this? (Use your results as proof of your answer.)
3. Compare the results for petrol and lubricating oil. Which substance has the weakest intermolecular forces? How do you know this? (Use your results as proof of your answer.)
4. Rank the four hydrocarbons in decreasing strength of intermolecular forces of attraction between their molecules.
5. Use the diagram of the fractional distillation tower in Resource 12: 'Crude oil and the fractionating tower' to find which fractions contain the four hydrocarbons used in this activity.
6. Copy and complete the sentence below by choosing the correct words:
   The **longer/shorter** the hydrocarbon molecule, the **stronger/weaker** are the intermolecular forces of attraction.

Source: Ash, M., Lofts, G., Evergreen, M. J. and Buchanan, J., 1999 *Jacaranda Science 3*, Jacaranda Wiley, Brisbane.

Resource 14: Physical and chemical properties of plastics

What is plastic?

Plastics are synthetic polymers made mainly from crude oil and natural gas. They are made by joining many small molecules, called monomers, together. Mono means 'one' and poly means 'many'. The chemical reaction in which the monomers join up to form polymers is called 'polymerisation'.

Many common plastics are made from hydrocarbon monomers. Polystyrene and polypropylene contain only carbon and hydrogen, but other elements are found in plastics, too. Polyester contains oxygen; PVC (polyvinyl chloride) contains chloride; Teflon contains fluorine; and nylon contains nitrogen.

Plastics are divided into two groups—thermoplastics and thermosets. Most plastics are thermoplastics, which mean that, once the plastic is formed it can be heated and reformed over and over again. This property makes them easy to process and recycle. Thermosets however cannot be remelted, reformed or recycled.

Although each plastic has different characteristics most are:
- resistant to chemicals
- thermal and electrical insulators
- usually light in weight
- able to be processed in different ways to make thin fibres or intricate parts.

Most plastics are blended with additives during processing into finished products. Some mineral additives include calcium, clay and magnesium. Additives alter the properties of plastics to make them suitable for specific purposes. Additives can:
- protect plastics from the degrading effects of light, heat or bacteria
- add colour
- increase flexibility.

Four main methods are used to process plastics.

- **Extrusion**. Molten plastic is forced through a small opening to shape the finished product. Plastic film and bags are made by extrusion processing.
- **Injection moulding**. Molten plastic is forced into a cooled, closed mould. Butter and yogurt containers are made using this process.
- **Blow moulding**. Using compressed air, a molten tube is blown into a chilled mould. Milk bottles are made this way.
- **Rotational moulding**. Plastic granules are placed inside a mould and heated. As the mould rotates, the molten plastic coats the inside of the mould evenly. This process is used to make hollow products like toys.

How and why was plastic it invented?

The first plastic was made by Alexander Parkes in England in 1862. It was made from cellulose, but did not go into production because investors thought it was too expensive to make. Four years later, in America, John Wesley Hyatt made a material called collodion as a substitute for ivory, which was being used to make billiard balls. It was too brittle, however, and the balls broke; so he added camphor and invented celluloid. Celluloid was used to make the first flexible photographic film for still and motion pictures.

In 1891, Louis Marie Hilaire Bernigigaut, from France, made rayon while trying to invent a man-made silk. Although, at first, the rayon made was highly flammable, another man, Charles Topham, later solved that problem. In 1907, Lee Baekeland, an American chemist, discovered the first completely synthetic plastic—bakelite. Six years later, a Swiss textile engineer, Jacques Edwin Brandenberger, was trying to find a way to stain-proof cloth. He added rayon to cloth and made cellophane, which became the first clear, flexible, water-proof packaging material.

In the 1920s, two important discoveries were made. German H. Staudinger recognised the structural nature of plastics. Later, Wallace Hume Carothers, an English chemist, demonstrated that, by putting different elements into the chemical chain, he could make new materials. PVC was discovered by mistake in the 1930s, when Waldo Semon, an organic chemist, was trying to bind rubber to metal. Teflon was discovered accidentally too. Roy Plunkett, a chemist, pumped Freon gas into a cylinder and left it in cold storage overnight. In the morning, the gas had dissipated into a solid white powder.

During World War II, significant changes occurred, because supplies of natural materials, such as latex, wool and silk, were in short supply. In the 1940s, nylon, acrylic, neoprene and polyethylene were used in the place of materials that were no longer available.

Since the 1950s, the number and types of plastics have grown tremendously. We use plastics so many times during a single day it is difficult to imagine living without it: bottles, bullet-proof vests, cables, CDs, home appliances, IV bags, packaging paints, pipes, prosthetic limbs, thermal underwear, toys, velcro and video cassettes—the list is a very long one.

What about recycling?

The very properties that make plastics so useful—strength, durability and convenience—are the same properties that have made plastics a waste problem. Only a small amount of the plastic produced each year is recycled. A large amount of plastic ends up in land fill, where it may take generations to break down. A lot of plastic also ends up as litter where it is a hazard to wildlife, particularly in rivers and oceans. We can all play a part in reducing this problem.

We can all reduce our use of plastics by using cloth shopping bags, reusing plastic containers and recycling plastic products when ever possible. Most local councils now operate kerb-side recycling programs. Look for the resin identification codes on plastic containers. These numbers tell you the type of recyclable plastic from which the container is made.

Resin identification code	Plastic type	Properties	Common uses
1	Polyethylene Terephthalate (PETE)	Barrier to moisture and gas Clarity Heat resistance Strength and toughness	Soft drink bottles Heatable pre-prepared food trays Fibre for clothing and carpet
2	High Density Polyethylene (HDPE)	Chemical resistance Ease of processing and forming Permeability to gas Stiffness and strength Toughness	Snack food packages Cereal box liners Milk bottles Grocery bags Detergent bottles Household chemical bottles
3	Polyvinyl Chloride (PVC)	Clarity Chemical, oil and grease resistance Ease of bending Toughness Versatility	Pipes Carpet backing Insulation Synthetic leather products Shower curtains Medical tubing and bags
4	Low Density Polyethylene (LDPE)	Barrier to moisture Ease of processing and sealing Flexible Strength and toughness	Produce bags Dry cleaning bags Flexible lids and bottles

5	Polypropylene (PP)	Barrier to moisture Heat, chemical, oil and grease resistance Strength and toughness Versatility	Large moulded auto parts Fibre for fabric and carpet Packaging Car battery casings
6	Polystyrene (PS) Expandable Polystyrene (EPS)	Clarity Easily formed Insulation	CD disk jackets Medical and food packaging Meat trays Hot food cups and containers

Because many plastic packages contain products that are consumed 'on the go', many containers are not making it into the recycling bin. When businesses, schools, and local and state governments place recycling bins in work spaces and public places, they encourage people to recycle when they are not at home.

Once collected, recyclable plastics are sorted into their different types and sent to a reclamation site. There they are chopped into flakes, washed to remove contaminants and sold to manufacturers to make new products such as bottles, containers, clothing and carpet.

Some companies have been researching the manufacture of biodegradable and photodegradable plastics to reduce the life of plastics that end up in landfill. Some of these plastics are being made from plants so that they degrade in compost. Others are being made from hydrocarbons. The idea is that, if the polymer chains are reduced in size, the plastic material should lose its strength, become brittle and eventually degrade into harmless products, such as carbon-dioxide and water. The development and use of more environmentally-friendly plastics is not progressing very quickly. The price of degradable plastics can be up to six times greater than the price of non-degradable plastics. The high price is due to research costs and uncertainty about demand for the product.

Resource15: The properties of plastics

Demonstrating outcome NPM 5.1

Remember

1. From what raw material are plastics made?
2. What is the relationship between a polymer and a monomer?
3. Which elements are found in most monomers and polymers?
4. Match the terms in the left-hand column with the definitions in the right-hand column.

Term
Synthetic
Extrusion
Monomer
Resin code

Definition
A number that indicates the type of plastic for recycling
Small molecule that repeats to form a polymer
A method of processing plastic
Manufactured, not natural

Think

1. Name the polymers formed from the these monomers:
   - styrene
   - propene
2. What is the difference between biodegradable and photodegradable plastics?

Imagine

Imagine if all the objects made from plastics suddenly disappeared. How would your life be changed? Write an imaginative piece describing this event. You may wish to talk to someone over the age of 60 about life before plastics were commonly used.

Research

- The town of Coles Bay in Tasmania has become Australia's first plastic bag free town. Find out how they did it and what action you can take to reduce and recycle plastic bags in your area.
  (Go to **www.planetark.com/index.cfm**. Scroll down to Planet Ark's Australian Campaigns and click on Plastic Bags.)
- Find out which plastics can be recycled through your local kerb-side recycling program and list examples.
- Some hospitals are now using laundry bags made from PVA, a water-soluble plastic. Find other applications of biodegradable and photodegradable plastics. When will they become available to consumers to buy? Are there any plans to make shopping bags degradable?

Create

Draw a time line showing when these plastics were discovered:
- celluloid
- polyvinyl chloride (PVC)
- bakelite
- perspex
- nylon.

Illustrate your timeline with sketches of some of the objects made from these different plastics.

Resource 16: The top eight minerals mined in Queensland

Use these websites to complete the table:

- **www.minerals.org.au** Follow the links to education program, then educational resources; then use either mineral fact sheets or rock files.
- **www.nationalminesatlas.com.au**

Mineral	Interesting facts	How is it formed?	With which other minerals does it exist?	Where in Queensland is it mined?	How is it mined?	What is it used for?
Black coal						
Aluminium						
Zinc						
Copper						

Mineral	Interesting facts	How is it formed?	With which other minerals does it exist?	Where in Queensland is it mined?	How is it mined?	What is it used for?
Lead						
Silver						
Gold						
Mineral sands rutile, ilmenite and zircon						

Resource 17: Major Queensland mines

Mineral mines

Mine Name	Commodity	Location	Mining Method
Aquamarina	Marble	8km south-south-east of Chillagoe	Open-cut
Bajool (Ulam)	Limestone	17.5km south of Bajool	Open-cut
Boral Brisbane	Brick Clay	Darra, Brisbane	Open-cut
Bowder	Brick clay	17km south-west of Bundaberg	Open-cut
Buckland	Limestone, Dolomite	12.2km west-north-west of Mount Surprise	Open-cut
Cannington	Silver, lead, zinc	140km south-south-east of Cloncurry	Underground
Cape Flattery	Silica sand	60km north of Cooktown	Surface
Cathedral Quarry	Sandstone	4km north-west of Helidon	Open-cut
Cedars	Bentonite	10km south-west of Yarraman	Open-cut
Cement Mills	Limestone	54km south-west of Warwick	Open-cut
Century	Zinc, lead, silver	150km south-west of Burketown	Open-cut
Charters Towers Limited	Gold, silver	0.9km east-south-east of Charters Towers	Underground & Open-cut
Claypave	Clay/brick, claytile	Ipswich	Open-cut
Christmas Creek	Limestone	150km west-north-west of Townsville	Open-cut
Comerford's Quarry	Sandstone	4km north-west of Helidon	Open-cut
Cork (Zinaback)	Gypsum	110km south-west of Winton	Open-cut
Cooroy	Brick clay	Cooroy	Open-cut
Coralime	Limestone	4.5km north-east of Mount Garnet	Open-cut
Curra	Limestone	13km north-west of Gympie	Open-cut
East End	Limestone, cement, clay	6km east of Bracewell, West of Gladstone	Open-cut
Eden Valley	Gypsum	175km south-west of Winton	Open-cut
Eidsvold	Siltstone	15km south-east of Eidsvold	Open-cut
Elbow Valley	Limestone	20km south-east of Warwick	Open-cut
Eloise	Copper, gold	60km south-east Cloncurry	Underground
Ernest Henry	Copper, gold	38km north-east of Cloncurry	Open-cut
Far Fanning	Gold	100km south-west of Townsville	Open-cut
Flinders	Earthy Lime and Dolomite	45km west of Brisbane	Open-cut
George Fisher	Zinc, lead, silver	19.2km north of Mount Isa	Underground
Great Australia	Copper	106km east of Mount Isa	Open-cut
Gro-Fast	Peat	8.7km west-south-west of Malanda, Atherton Tableland	Open-cut
Gumigil	Chrysoprase	15km south of Marlborough	Open-cut
Gurulmundi	Bentonite	30km north of Miles	Open-cut
Gympie Goldmine	Gold, silver	3.8km south-east of Gympie	Underground
Hadleigh Castle	Gold, silver	28.9km west of Ravenswood	Underground
Highway-Reward	Copper	33 km south-south-west of Charters Towers	Underground
Hillgrove Dolomite	Dolomite	74km north-west of Charters Towers	Open-cut
Hivesville Dolomite	Dolomite	20km north-west of Wondai	Open-cut
Hughenden	Gypsum	8km west of Hughenden	Open-cut
Ibis	Rutile, ilmenite, zircon	North Stradbroke Island	Dredge
IMT Bentonite Products	Bentonite	32km north of Miles	Open-cut
Ingham Lime	Limestone	24km south-east of Ewan	Open-cut
Inkerman Lime	Limestone	24 km south of Home Hill	Open-cut
Iveragh	Silica sand	2 km south-east of Tannum Sands	Open-cut
Jeebropilly	Bentonite	5 km south-east of Rosewood	Open-cut
Kirknie	Limestone	27km south of Home Hill	Open-cut
Kleinton	Brick clay	Toowoomba	Open-cut
Kunwarara	Magnesite	60km north-west of Rockhampton	Open-cut
Laroona	Dolomite	95km north-west of Charters Towers	Open-cut
Limevale	Limestone	10km north of Texas	Open-cut
Maidenwell	Diatomite	21km north-west of Yarraman	Open-cut
Marcotta	Clay tile	Maryborough	Open-cut
Marmor	Limestone	North of Marmor	Open-cut
Marule Lime	Limestone	21km north-north-west of Childers	Open-cut
Mayne River	Gypsum	165km south-west of Winton	Open-cut
Miles	Bentonite	5km south-west of Miles	Open-cut
Moffatdale	Limestone	6km south-east of Murgon	Open-cut
Montgomery's Quarry	Sandstone	6km north-west of Helidon	Open-cut
Moreton Dolomite	Dolomite	20km south of Ipswich	Open-cut
Mount Etna	Limestone	25km north of Rockhampton	Open-cut
Mount Cuthbert	Copper	13km north-west of Kajabbi	Open-cut
Mount Gordon	Copper	115km north of Mount Isa	Open-cut
Mount Isa	Copper, Silver, Lead, Zinc	1.3km west of Mount Isa	Underground
Mount Norma	Copper	30km south-west of Cloncurry	Open-cut
Mount Rawdon	Gold, silver	80km west-south-west of Bundaberg	Open-cut
Mount Sylvia	Diatomite	38km south of Gatton	Open-cut
Myora	Silica sand	2km north of Dunwich, North Stradbroke Island	Surface
New Hope Collieries	Brick clay	6km south-east of Ipswich	Open-cut
Numinbah Perlite	Perlite	McPherson Range, south-east of Beechmont	Open-cut
Nychum	Perlite	50km north-west of Chillagoe	Open-cut
Nyora	Kaolin	15km south of Kingaroy	Open-cut
Osborne	Copper, gold	109km south-east of Duchess	Underground
Oxley	Brick clay	Oxley, Brisbane	Open-cut
Pajingo Vera Nancy	Gold, silver	72km south of Charters Towers	Underground
Partridge	Limestone	50km south-west of Sarina	Open-cut
Phoenix Lime	Limestone	11km south-south-west of Almaden, west of Cairns	Open-cut
Phosphate Hill	Phosphate rock	150km south-east of Mount Isa	Open-cut
Port Alma	Salt	Port Alma	Evaporative salt pans
Ravensbourne	Kaolin	5km north-east of Ravensbourne	Open-cut
River of Gold Slate Mine	Slate, sandstone	62km north of Mount Carbine	Open-cut

Mine Name	Commodity	Location	Mining Method
Riverton	Limestone	19.3km east of Bonshaw	Open-cut
Rochedale	Brick clay	Rochedale/Redland Bay	Open-cut
Sarsfield	Gold, silver	1.4km south-east of Ravenswood	Open-cut
Schultz	Dolomite	87km north-west of Charters Towers	Open-cut
Scotsman's Folly	Sandstone	2km south-east of Stanwell	Open-cut
Skardon River	Kaolin	13.5km north-east of Mapoon Mission Station, north of Weipa	Open-cut
Southern Pacific Sands	Silica Sand	12km east of Caboolture	Open-cut
Stevenson Gypsum	Gypsum	125km west of Dirranbandi	Open-cut
Strathpine	Brick clay	Brendale, Brisbane	Open-cut
Stuart	Oil shale	11.2km north-west of Gladstone Power Station	Open-cut
Sugarlime	Limestone	95km south-west of Cairns	Open-cut
Sunstate Sands	Silica Sand	20km south of Bundaberg	Open-cut
Taragoola	Limestone	10.5km south-south-east of Calliope	Open-cut
Undilla	Limestone	140km north of Mount Isa	Open-cut
Wagner's Quarry	Sandstone	5km north-east of Helidon	Open-cut
Warbrick	Brick clay, shale	12km south-west of Warwick	Open-cut
Weipa	Bauxite	6km west-north-west of Weipa Airstrip	Open-cut
Whitehill	Earthy lime, Dolomite	19km north-west of Wondai	Open-cut
Wide Bay Pits	Brick clay	Bundaberg region	Open-cut
Willows	Zeolite	2km south of Willows, west of Emerald	Open-cut
Yarraman	Rutile, ilmenite, zircon	North Stradbroke Island	Dredge
Young Australian	Copper	117km south-east of Mt. Isa	Open-cut

Operating coal mines

Blackwater	Coking & thermal	24km south of Blackwater, and 195km west of Rockhampton	Open-cut
Blair Athol	Thermal Coal	20km north-west of Clermont, and 280km south west of Mackay	Open-cut
Burton	Coking & thermal	40km north-east Moranbah, 120km south-west of MacKay	Open-cut
Callide / Boundary Hill	Thermal Coal	15km north-east Biloela	Open-cut
Collinsville	Coking & thermal	4km west of Collinsville, 86 km south-west of Bowen	Open-cut
Commodore	Thermal	10km south of Millmerran, 180km south-west Brisbane	Open-cut
Cook	Coking & thermal	29km south of Blackwater,	Underground
Coppabella	Thermal coal	25km south-west of Nebo	Open-cut
Curragh	Coking & thermal	14km north Blackwater, 200km west of Rockhampton	Open-cut
Ensham	Thermal	40 north-ease of Emerald, 200km west of Rockhampton	Open-cut
Foxleigh	PCI	25km east of Middlemount, 200km north west of Rockhampton	Open-cut
German Creek	Coking	25km south-west of Middlemount, 200km west north west of Rockhampton	Open-cut
German Creek East	Coking	13km south south-west of Middlemount	Open-cut
Goonyella Riverside	Coking	25km north of Moranbah, 150km south-west Mackay	Open-cut
Gregory	Coking & thermal	62km north east of Emerald, 200km west of Rockhampton	Open-cut
Hail Creek	Coking	35km north-west of Nebo	Open-cut
Jeebropilly	Thermal	10-17km south west of Ipswich	Open-cut
Jellinbah East	PCI	20km north east of Blackwater	Open-cut
Kestrel	Coking & thermal	40km north-northeast of Emerald	Underground
Meandu	Thermal	30km south of Kingaroy	Open-cut
Moorvale	PCI thermal & coking	10km south of Coppabella Mine	Open-cut
Moranbah North	Coking	16km north of Moranbah	Underground
Moura	Coking & thermal	10km east of Moura	Open-cut
New Acland	Thermal	46km north west of Toowoomba	Open-cut
New Oakleigh	Thermal	24km west of Ipswich	Open-cut
Newlands	Thermal	32km north west of Glenden	Open-cut
North Goonyella	Coking	40km north of Moranbah	Underground
Norwich Park	Coking	25km south-east of Dysart	Open-cut
Oaky Creek	Coking	17km east of Tieri	Underground
Peak Downs	Coking	40km south east of Moranbah, 160km south west Mackay	Open-cut
Riverside	Coking	30km north of Moranbah	Open-cut
Saraji	Coking	22km north of Dysart	Open-cut
South Walker Creek	Thermal & PCI	35km west south west of Nebo	Open-cut
Wilkie Creek	Thermal	14km west of Macalister	Open-cut
Yarrabee	PCI	40km north east of Blackwater	Open-cut

Resource 18: Mining helps make many things

MINING HELPS MAKE ALMOST EVERYTHING

Magnesium is used to make lightweight carparts. Car batteries contain lead.

Telephone and electrical cables are made from copper. Most plastics are made from petroleum.

Silica sand is used to make glass. Magnesium and manganese are also used in glass making.

Aluminium is made from bauxite. It is used to make drink cans, cars, planes and bikes.

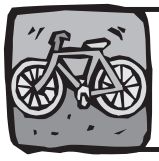
Make-up and skin care products contain minerals such as kaolin clay and petroleum.

The mineral sands rutile and ilmenite are used to make a white pigment used in paper making and paint.

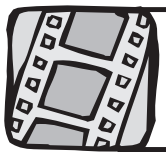
Clay is used to make bricks and pavers. Other clay products include tiles and pottery.

Computer chips contain silica. The wiring is made from copper and gold and the solder from lead.

Zinc and copper are used together to make brass for such products as taps, ornaments and door handles.



Bike frames can be made from aluminium or titanium. Magnesium is used to make rubber for tyres.



Silver is used to make photographic film and also developing paper.

Many musical instruments are made of brass, a metal made from copper and zinc.

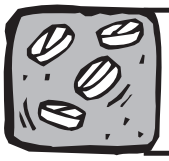
The fuels used in fireworks and explosives include aluminium, magnesium and titanium.

The lead found in most pencils is not actually made from lead. It is made from graphite.

Nickel, copper and silver are all used to make coins.

Gemstones, gold, silver and copper are all used to make jewellery.

Some of the metals used in dentistry and orthodontics include gold, nickel and titanium.



A number of minerals are used to make medicines and dietary supplements including iron.

Paint contains mineral fillers and pigments, including cobalt, titanium and magnesia.

Most of Queensland's electricity is made by burning coal.

Resource 19: What's in your mobile phone?

Demonstrating outcome NPM 6.3

A number of minerals are used in the production of mobile phones. Some of these are shown in the box. Using four of them, complete the flowchart below. Use the fact sheets and websites supplied by your teacher to help you complete the task.

Mineral	Percentage of mobile phone	Weight
Aluminium	8%	.011Kg
Copper	19%	.023Kg
Iron	8%	.010Kg
Nickel	1%	.001Kg
Silicon	4%	.005Kg
Tin	1%	.001Kg

Which minerals?				
Where found?				
How extracted?				
How processed?				
What properties make it suitable for use?				

Resource 20: Assignment—What's in yours?

Demonstrating outcome NPM 6.3

Core Learning Outcome

Natural and Processed Materials 6.3: Students collect and present information about the relationship between the commercial production of products and their properties.

Your task

1. Select a product (for example, X-box, computer, car, mountain bike, tooth paste, light bulb).

2. You are to describe how your product came to exist by answering the following questions:
   - What materials are in your product?
   - Where did they come from?
   - How were the raw materials extracted?
   - How were they processed?
   - What properties do the materials have that make them suitable for use in your product?

3. Your description must be scientifically accurate.

4. Present your research as a report, PowerPoint or oral presentation.

Notes

Notes