Mining & Mineral Processing

RESOURCE PACK

Teacher's Guide

AngloAmerican

UNIVERSITY OF CAPE TOWN
IDYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

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Index

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Introduction

Dear Science-teaching colleague

This resource pack was prepared by the Schools Project Team of the Department of Chemical Engineering at the University of Cape Town. The project was initiated by the introduction of the FET school syllabus in 2006. With the inclusion of mining and mineral processing in the Grade 11 syllabus we decided to compile a resource pack to assist teachers in teaching this new topic. Our links with industry, specifically the mining industry, created the opportunity to secure funding for such a project.

We have been fortunate to have had the financial support of Anglo American, Anglo Platinum, Kumba Iron Ore and Anglo Coal. Without their support, this project would not have been possible.

Although we have tried to make this resource pack such that a variety of schools from different contexts would find it useful, we realise that no one resource will be a one-size-fits-all. This is therefore not the ultimate resource, but hopefully a document that would give teachers a starting point in the teaching of a new topic and developing their own content.

This resource pack consists of a teacher's guide, a learner information section, a set of posters and a DVD. In the teacher's guide you will find a variety of activities that can be used in the classroom. The intention is not that you use all the activities, but rather that you choose the ones that are most appropriate for your class.

On the first few pages of the teacher's guide you will find a suggested sequence of lessons to take you through Grade 11 Chemical Systems in 3–4 weeks. The aim of these lessons is to give you ONE option of how to incorporate the pack into your teaching. Again this is not the only way to use the material, but only one suggestion. Every school will have different times allocated to teaching this section and we therefore leave it up to the teacher to decide what they would like to use.

During the development of the resource pack we conducted trials in a variety of schools. During the trial of the school research project we have found that many learners were struggling to find relevant information on the mining industry in local libraries or even on the Internet. To assist learners in completing their research projects we have included four learner information sections, one on each of the mining industries. Each section comprises twelve information sheets (twelve A3 sheets printed back-to-back). They aim to provide learners with broad but relevant information on each mining industry. The idea is that the learners use the information sheets for their projects as if they had found the content on the Internet or in a library. We advise that you use these sheets, but if you feel that your learners have enough resources available you may of course choose not to use them in this way. The rubrics were designed assuming that the learners had the information sheets available.

This teacher's guide is written under a copyright restriction (unless where specified otherwise) that allows you to make changes to the content and print copies of this revised content for non-commercial use in your school. Please refer to the copyright information on page 51 of this guide. Please note that the information included in the learner information sheets as well as the videos on the accompanying DVD can be reproduced, but may not be changed in any way.

We would like to know if you have found an activity useful and would appreciate your feedback. We have included an evaluation form at the end of the resource pack. Please complete it and either fax or e-mail it to us. You are also welcome to send us your modified version of an activity as this will help us improve any later versions of this resource pack.

UCT Chemical Engineering Schools Project Team
15 January 2009

Getting Started

Below you will find a suggested sequence of lessons which will take you through the resource pack and assist you in teaching Grade 11 Chemical Systems. About 3–4 weeks are usually allocated for this section and therefore we are suggesting a minimum of 15 lessons as described below. Additional lessons are also included if the research project (pages 21–25) is done. The lessons are only a guide and should be adapted to suit the needs of your class.

Lesson 1: Mining in my World

Mining forms an integral part of our lives. Almost everything around us can be linked to some mining activity. The activity 'A Classroom Full of Resources' (page 4) can be used during this introductory lesson to show your learners how important mining is in their lives. You can use the picture provided, or let the learners use your classroom. Remember the general rule that if it is not grown, it is most likely mined.

The purpose of this lesson is to introduce mining and the lithosphere to your learners. You could start your lesson by asking questions like 'What are rocks and where do they come from?', 'What are minerals and where do we find them?', 'How do we get them out of the ground?', 'Do you think mining is important?' These questions should lead to a discussion around what minerals are and where they come from, how they got into the ground, how we get them out of the ground and why they are important. Information Sheet 1 in the phosphate learner pack will provide you with useful information to lead this discussion.

If you have examples of rocks and minerals available they can be shown to the learners during this lesson. Your Geography department might also have samples of rocks that you can show your class.

Alternative activities/handouts:

- Your House Comes from a Mine (page 5)
- How Many Minerals do you Need to Make a Light Bulb? (page 6)
- The MII Baby (page 7)

Lesson 2: The Meaning of Mining

For this lesson you will need a television and DVD player. We have included two suggested videos for this lesson (see resource pack DVD).

1. Mindset Lesson 1.
   This video consolidates what was discussed during Lesson 1. Please also refer to pages 40–47 for notes on this lesson.
2. The Meaning of Mining. An essay-writing activity is included on page 10.

Lesson 3: Handing out the Research Project

If you choose to use our research project (page 21–25) you need to hand out the guideline and discuss the project with your learners during this lesson. Pages 21 and 22 are guidelines for the teacher and pages 23–25 should be handed out and discussed with the learners.

Lesson 4 & 5: Gold Mining

The following resources can be used in preparation of the lessons on gold mining:

- Mindset Lesson 2 (on the resource pack DVD)
- Pages 40–47 in this document for Mindset lesson notes
- Learner information sheets on gold mining. Although these sheets are meant for the learners they can provide you with useful background information to prepare your lessons.

The practical activity 'Extracting Copper from its Ore' on page 13 can be done as a classroom demonstration or in small groups.

Lesson 6 & 7: Iron Mining

The following resources can be used in preparation of the lessons on iron mining:

- Mindset Lesson 3 (on resource pack DVD)
- Pages 40–47 in this document for Mindset lesson notes
- Kumba Iron Ore video footage on the resource pack DVD
- Learner information sheets on iron mining
  The practical activity 'Separating Minerals' on page 15 can be done by the learners in class. This is an optional activity that can be done if you have time.

Lesson 8: Research Project Progress and Handing in of Initial Planning

This lesson should take place about a week after Lesson 3. During this lesson the learners must hand in their research project planning. Give the learners the opportunity to work on their research projects in class while you spend some time with each group discussing their progress. This is an opportunity to guide and assist your learners if they are experiencing any difficulties. If you have access to computers/a library at your school, use this lesson to allow learners to make use of these resources.

Lesson 9 & 10: Phosphate Mining

The following resources can be used in preparation for the lessons on phosphate mining:

- Mindset Lesson 3 (on resource pack DVD)
- Pages 40–47 in this document for Mindset lesson notes
- Learner information sheets on phosphate mining

The practical activity 'Separating Peanuts and Raisins' on page 17 can be done as a demonstration in class. It is quick to prepare and fun to watch. Phosphate mining uses flotation as a separation method.

Lesson 11 & 12: Coal Mining and Energy Resources

The following resources can be used in preparation for the lessons on coal mining:

- Mindset Lessons 4 & 6 (on resource pack DVD)
- Pages 40–47 in this document for Mindset lesson notes
- The Anglo Coal video footage on the resource pack DVD
- Learner information sheets on coal mining

The practical activity 'Make Your Own Rock' on page 19 can be done in groups in class. This is an optional activity that can be done if you have time.

Lesson 13: Classroom Discussion of Research Project

During this lesson the learners will have the opportunity to work on their research projects in class. If you have access to computers/a library at your school, use this lesson to allow learners to make use of these resources. This will also give you the opportunity to assist any groups that are still struggling. You could also discuss how to write a research report at this stage as their reports are due in a week's time.

Lesson 14 & 15: The Impact of Mining on South Africa

The impact of each mining industry on South Africa should be mentioned when the specific industry is discussed, but one or two lessons might be necessary to consolidate what was said. During these lessons, give ample opportunity for the learners to express their opinions. The following resources can be used in preparation of the lessons on the impact of mining:

- Mindset Lesson 5 (on resource pack DVD)
- Pages 40–47 in this document for Mindset lesson notes
- All four learner information sheets on the mining industries

Optional lesson 16: Can Mining Make a Greener World?

A comprehension/class discussion activity is included on page 8. In the article the relationship between mining and the environment is highlighted and the question around the importance of mining activities is raised. This activity can be done in the classroom or given for homework.

Additional Lessons (if you have done the research project)

- **Research project hand in**

  The research reports need to be handed in on the due date as specified by you when the research project was handed out.

- **Consolidation activity**

  Depending on which consolidation activity you have chosen, you will need additional lessons to do the debate or role play, or to let the learners present their research. As these discussions/presentations form part of teaching the section, we recommend that you complete them before moving on to a new section.

A Classroom Full of Resources

A Few Facts

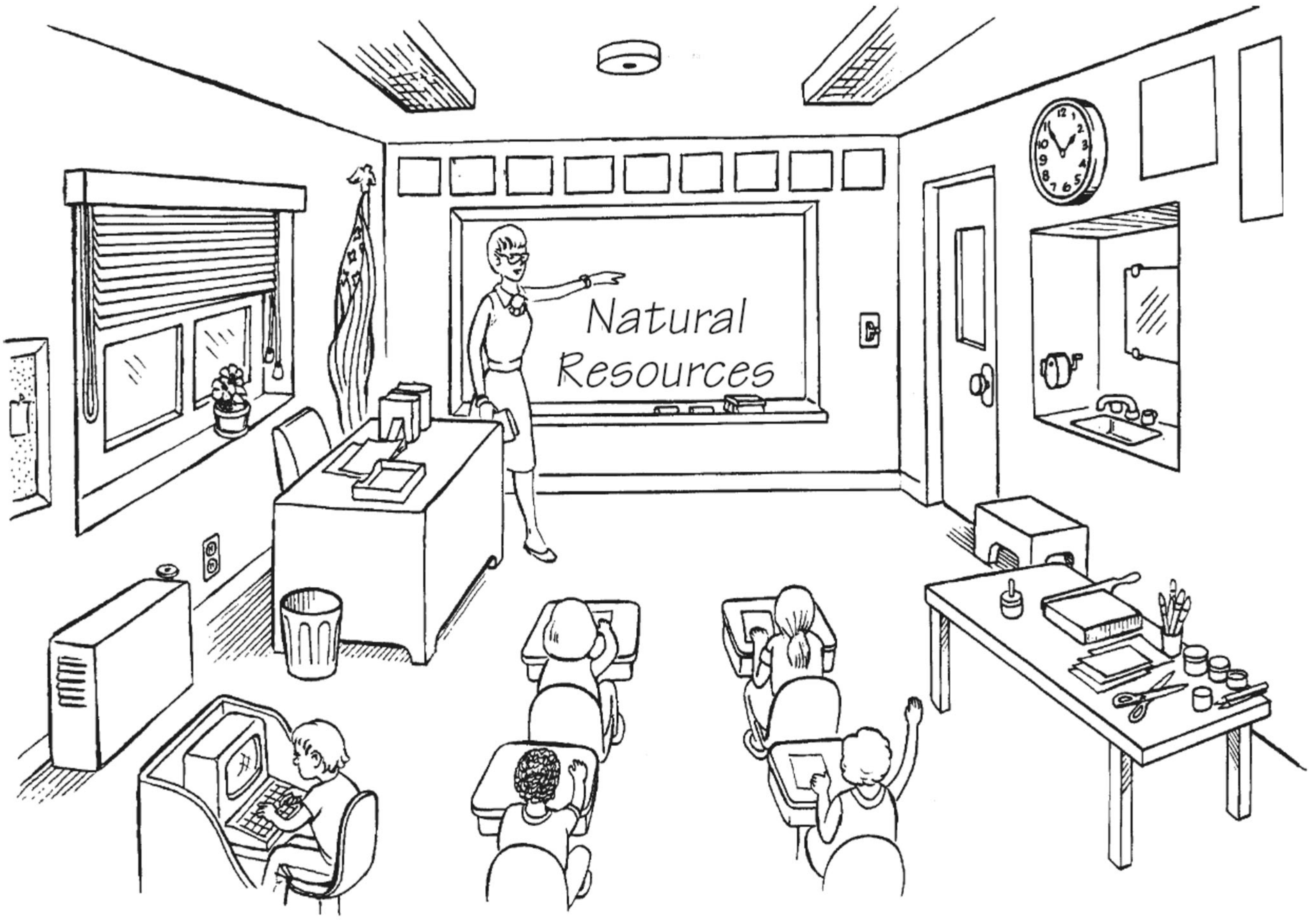
Natural resources are substances we obtain from the land, water and air around us, providing our food, shelter and amenities of life, for example cars, bicycles and tennis rackets, all are made from our natural resources. Look around the room you are in. The odds are very high that the majority of what you see is made from mineral products. In schools, unless it is a hardwood floor, it will be made of various rocks and minerals. Walls will almost always be brick or concrete block, sometimes drywall (gypsum) or wallpaper (almost always a vinyl). Wood is usually a major part of most desks and tables, and doors. There can be a lot of variety in the ceiling materials, but rest assured that they were either grown or mined.

Classroom Activity

Label as many resources as possible that are found in the classroom. Divide learners into several teams. Assign an area of the classroom (or wherever you choose) to each team and provide each group with peel-off sticky labels. Ask the students to label all of the natural resources in their designated areas and to list each item they label. They can then cooperatively sort the list into common components, such as wood, metals (steel or aluminum), minerals (brick & concrete blocks), or synthetics. Explain their decisions.

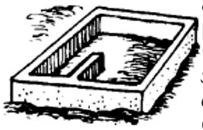
Suggest they do the same at home and discuss the different materials in each student's home, for example, brick vs. wood, carpet vs. wood or cement floors, metal vs. wooden window and door frames, etc.

Source: Mineral Information Institute, www.mii.org



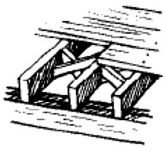
Can you find the different natural resources that were used to build your classroom? Remember, if it wasn't grown, it had to be mined.

Your House Comes From a Mine



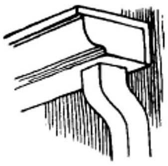
The **foundation** and sidewalk are probably concrete (*limestone, clay, shale, gypsum and aggregate*) and the **driveway –** concrete or asphalt (*petroleum and aggregate*).

The **exterior walls** may be of *concrete block, brick* (*clay*), *stone or aluminium siding*, all provided by mining.



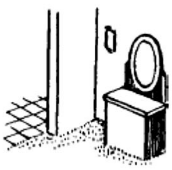
The **lumber in the walls, roof** and **floor** will be fastened together with nails and screws (*iron ore and zinc*).

The **roof** may be covered with asphalt shingles (*petroleum* and a variety of *coloured silicates*), *fibreglass (silica sand), clay* or *corrugated iron*.

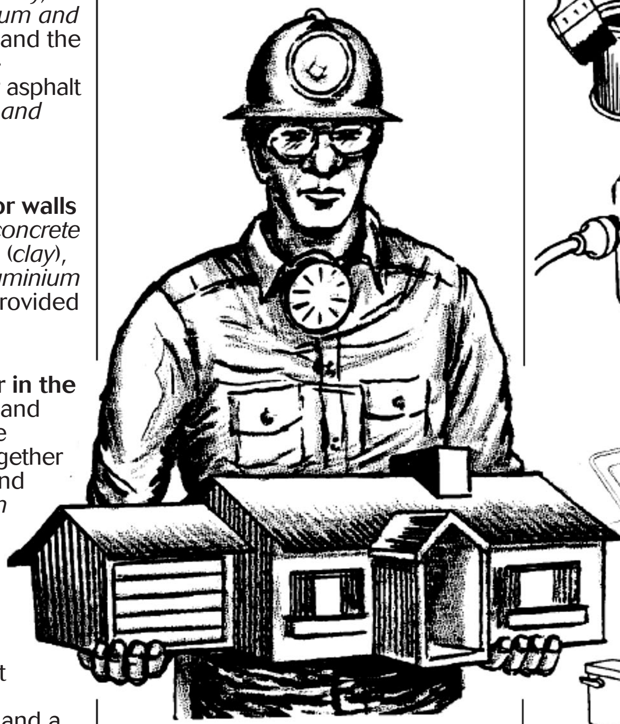


The **gutters** can be made of *galvanized steel (iron and zinc), aluminium (bauxite)*, or *plastic (petroleum)*.

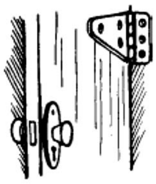
The **insulation** in the walls may be glass wool *(silica, feldspar, trona)* or expanded *vermiculite* (available from mining).



The **interior walls** are usually wallboard made of *gypsum*.



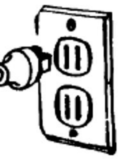
Your **windows** are made of glass *(trona, silica, sand and feldspar)*.



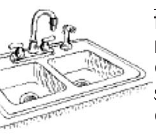
Your **door knobs, locks** and **hinges** are brass or steel *(copper, zinc, iron ore & alloys)*.

Your **fireplace** may be made of rock or brick or you may have wood/coal burning stove *(steel, iron, alloys, etc.)*. Your **furnace** is made of steel (iron and alloys).

If your home is painted, **paint** is manufactured with *mineral fillers* and *pigments*.

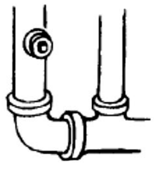


Your **electrical wiring** is of copper or aluminium (*bauxite*).



Your **plumbing fixtures** my be made of brass (*copper & zinc*) or stainless steel (*iron, nickel & chrome*)

Your **toilets, sinks and bathtubs** are made of porcelain (*clay*) over iron, or plastic (*petroleum*).



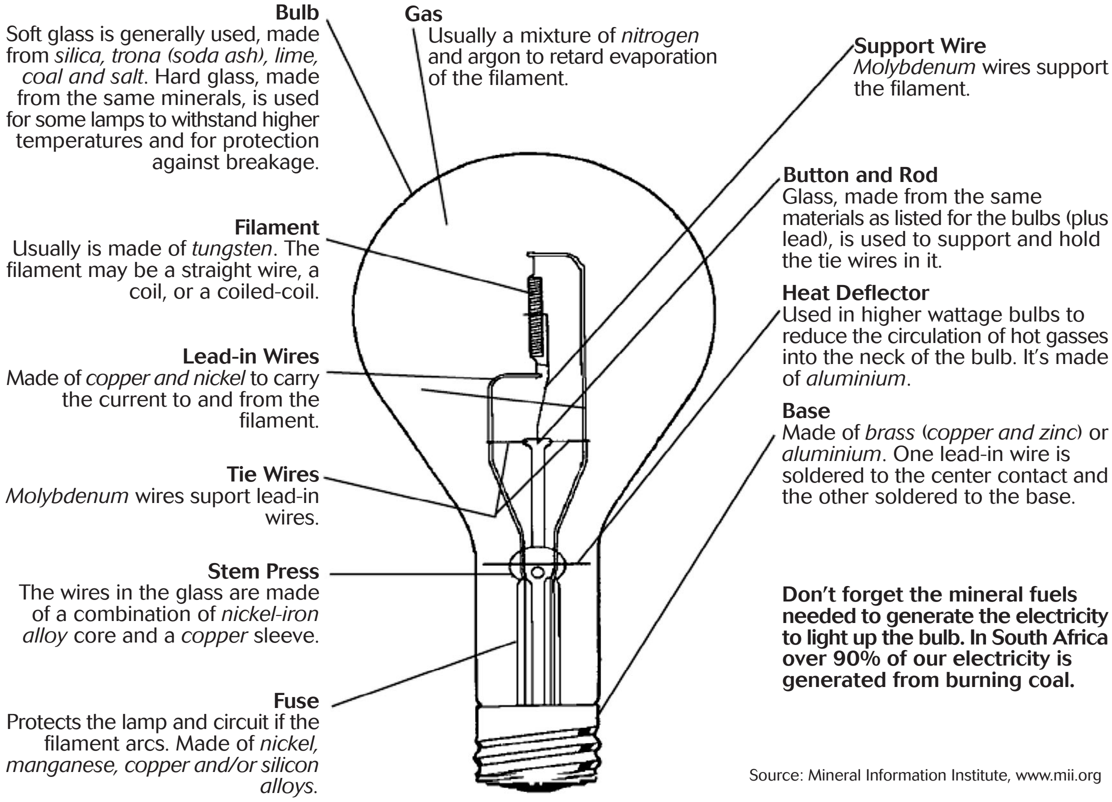
Your **sewer system** is made of clay or iron pipe (plastic pipes are made from *petroleum*); if you have a **septic tank** it is concrete and the leach field is filled with *sand and gravel*.

The carpet in your home is made from synthetic fibers (*petroleum*). The back is filled with *limestone*, even if your carpet is made of wool.

And finally, your **mortgage or rental contract** is written on paper made from *wood or cloth* fibers. The fibers are filled with *clay* and *other minerals* to determine its colour and texture.

Source: Mineral Information Institute, www.mii.org

How Many Minerals do you Need to Make a Light Bulb?



Source: Mineral Information Institute, www.mii.org

Did you know?

It takes more than 33 elements and minerals to make a computer.

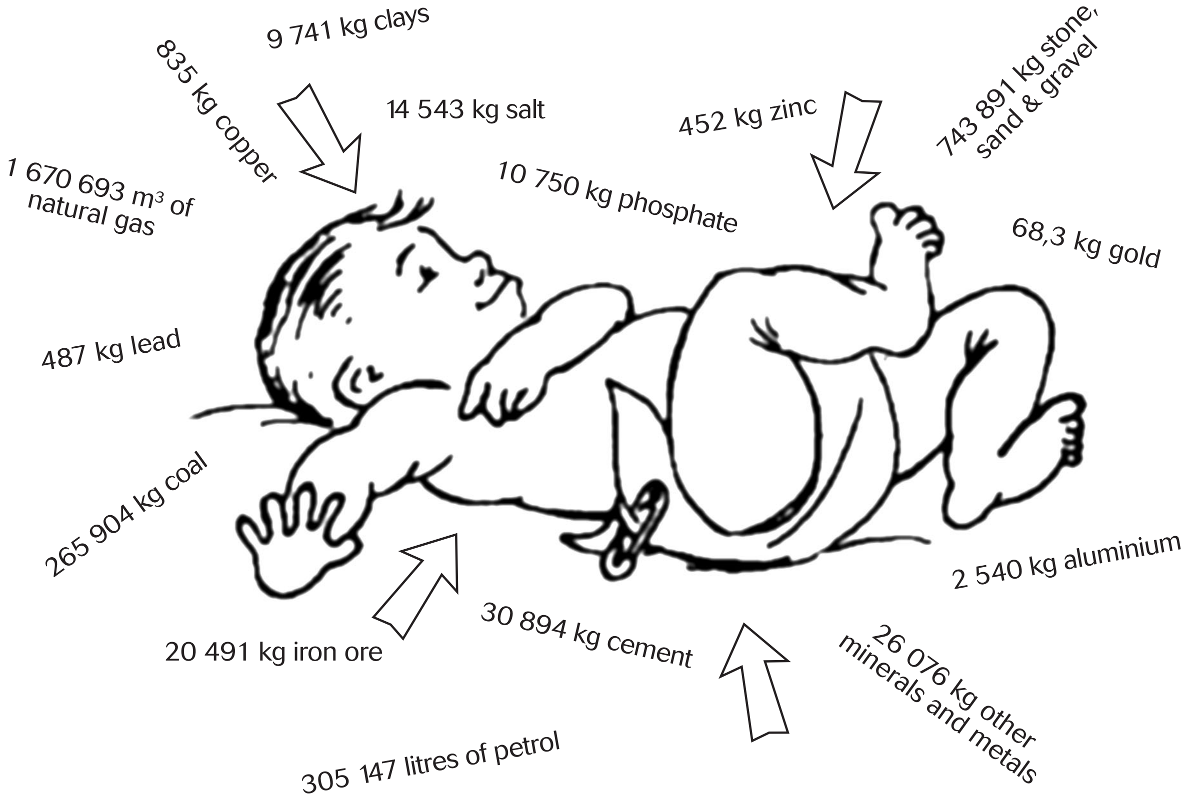
Those vital computer ingrediants consist of: aluminium, antimony, barite, beryllium, cobalt, columbium, copper, gallium, germanium, gold, indium, iron, lanthanides, lithium, manganese, mercury, mica, molybdenum, nickel, platinum, quartz crystals, rhenium, selenium, silicon, silver, strontium, tantalum, tellurium, tin, tungsten, vanadium, yttrium, zinc and zirconium.

And we can't forget the petroleum industry's role in the computer. All the components noted above are housed in plastic.

Source: Mineral Information Institute, www.mii.org

The MII baby

Every American born will need:



1,68 million kg of minerals, metals and fuels in his/her lifetime

Source: Mineral Information Institute, www.mii.org

Can Mining Make a Greener World?

Read the article "Can Mining Make a Greener World?" and answer the following questions.

1. Summarise the argument of the article in your own words.
2. Which metals, according to the article, will be in high demand in the future? Why would these metals be in high demand?
3. What is the relationship between mining activities and global warming?
4. Do you think that we will be able to manage global warming? Justify your opinion in 200–400 words (1/2–1 page)

Can Mining Make a Greener World?

Written by David Zgodzinski
Published: Thursday, June 19 2008; The Montreal Gazette
http://www.canada.com/montrealgazette/news/story.html
(Accessed on 7 October 2008)

Clashes between environmental lobby groups and international mining companies especially over global warming could soon be history. The attraction is not apparent to many of them yet, but miners and tree-huggers will likely find each other increasingly good looking if the party heats up.

Most environmentalists agree that the overriding environmental imperative, trumping other concerns, is to reduce greenhouse gas emissions. But converting from a hydrocarbon burning society to one that runs on cleanly generated electricity will not be simple or painless. And the switch will demand metals – lots of metals. Those metals have to be mined.

According to a study by British merchant bankers, the Fortis Group, over 1 000 tonnes of silver will be used in 2008 to manufacture solar panels. That's twice the amount of silver that was used in 2002 by the solar industry.

Silver is the most conductive of metals and that quality makes it a necessary element in solar equipment. More and more silver will be mined for the solar energy ramp up in coming years.

Robert Friedland, the executive chairman of Ivanhoe Mines likes to point out that hybrid cars require twice the amount of copper as regular gas guzzlers. Friedland's company is sitting on a mountain of copper at Oyu Tolgoi in Mongolia, and the significance of this increasing use of copper in vehicles isn't lost on him. Open pits will be blasted to provide copper for greener cars.

Current hybrid models also use an estimated 14 to 20 kilograms of nickel per vehicle in nickel-hydride batteries and electronic systems. While two-thirds of the world's nickel production is now used in stainless steel, the popularity of hybrid cars has helped to boost the overall demand for nickel and then also the bottom line for companies like CVRD and Xstrata.

Non-hybrid vehicles also use metals to help keep the air clean. The principal demand for platinum is not in fancy jewellery, but in pollution control. One-third of platinum mined every year goes into the catalytic converters that control emissions from cars and trucks.

Wind turbines and smart electricity grids need metals. Electric vehicles, advanced batteries, and solar arrays need metals. Metals are integral to the effort to reduce greenhouse gases.

Eventually, environmentalists will be forced to reconcile the need for metals with the concerns they have about mining. The realization that metals are cool when it comes to cutting carbon could eventually win over their hearts.

Patrick Moore was a co-founder of Greenpeace and the group's leader for a number of years. In 2006, he turned around his attitude about nuclear power 180 degrees. Moore became a spokesman for nuclear energy, sponsored by a lobby group called the Nuclear Energy Institute. He now sees uranium as part of the solution to global warming. The conversion of Moore from anti-nuclear demonstrator to pro-nuclear advocate may be a harbinger of things to come.

Not every environmentalist will have the kind of epiphany Moore must have had. But environmentalists may soften their attitude toward mining companies. Could a new accommodative attitude be reciprocated by the miners?

Audio-visual Material and Accompanying Worksheets

The mining industries have produced a range of audiovisual materials to help educate the public about their activities. We have highlighted here four of these videos which can be useful in the teaching of this section and provide accompanying activities which you can use in your class. The videos are included on the accompanying resource pack DVD.

1. The Meaning of Mining 12:53 min

This video was produced on behalf of The Chamber of Mines in the late 80s. It highlights the importance of mining in South Africa and gives a good overview of mining, ideal for an introductory lesson. An essay-writing exercise that accompanies this video is included on page 10. This activity can be done in collaboration with the English department.

2. Powering South Africa the Anglo Coal Way 14:18 min

This video was produced by Medialab on behalf of Anglo Coal in 2008 and gives a very good overview of coal mining in South Africa. It includes how coal is formed, the different mining techniques used, safety aspects in mining, mine rehabilitation and sustainable development. This video can be used to give your learners a good basic understanding of coal mining. A classroom discussion activity of this video is included on page 11.

3. Kumba Iron Ore Quality Assurance and Quality Control 21:23 min

This video was produced by Kumba Iron Ore and highlights the rigorous quality checks that are in place in the mining of iron ore. The various steps in the mining process, from exploration through drilling, excavation, beneficiation and blending, to dispatch are shown. This video can be used to give your learners a very good overview of processes involved in mining iron ore and the scale of these mining activities. A classroom discussion activity of this video is included on page 11.

4. Anglo Platinum Corporate Video 2007 11:25 min

This video was produced by Anglo Platinum in 2007 and gives an overview of the platinum industry and its importance in South Africa. Although the processes are focused on the platinum industry (which is currently not in the FET Physical Sciences curriculum), many of them are used in other mining industries. The scale of mining equipment and the extent of a processing plant are also highlighted. This video can be used as extension material after teaching this section. A classroom discussion activity of this video is included on page 11.

The Meaning of Mining

Writing an Essay

In this activity you will watch a video and write an essay about the 'meaning of mining'. The video will provide you with some ideas, but you must also include your *own opinion*.

Option 1 (individual work)

- Each learner will work on his/her own.
- Watch the video. Remember to make notes while you watch as you will be writing an essay about the meaning of mining.
- If time allows it, watch the video again.
- Choose a title for your essay. Here are some examples, or choose a title of your own:

  The real meaning of mining

  Is mining really that important?

  Mining – what it really means for me in … (add the name of your town here)

- Plan and write your essay.
  Your teacher will inform you about the length/number of words for your essay.

Option 2 (group and individual work)

- Divide the class into small groups of about three learners each.
- Watch the video. Remember to make notes while you watch.
- Discuss what you have learned with the rest of your group.
- If time allows it, watch the video again.
- Each person must write his/her own essay. Choose a title for your essay. Here are some examples, or choose a title of your own:

  The real meaning of mining

  Is mining really that important?

  Mining – what it really means for me in … (add the name of your town here)

- Plan and write your essay.
  Your teacher will inform you about the length/number of words for your essay.

Powering South Africa the Anglo Coal Way

Classroom Discussion Activity

Work in small groups to discuss the impact of coal mining on:

1. The South African economy.
2. The energy crisis in our country.
3. The environment, global warming and climate change.

Report back to the class in a class discussion on your topic.

Kumba Iron Ore Quality Assurance and Quality Control

Classroom Discussion Activity

Work in pairs for this activity.
Answer the following questions once you have watched the video:

1. What was the most interesting part of the video?
   Why do you say so?
2. Identify the different steps, in the correct order, used in the mining of iron ore.
3. What is 'quality assurance' and 'quality control'?
   Do you think this is important in mining operations?
4. Do you think that the mining of iron ore is important for South Africa?
   Why do you say so?

Anglo Platinum Corporate Video 2007

Classroom Discussion Activity

Work in groups of 3 or 4 and answer the following questions once you have watched the video:

1. What was the most interesting part of the video? Why do you say so?
2. How has this video changed your thoughts about mining in general?
3. Do you think mining is important in South Africa? Why do you say so?

Practical Activities

The following activities can be used in the classroom when teaching Chemical Systems in Grade 11. Some activities are also suited for other topics and/or grades as mentioned below. You have permission to modify the activities to suit the needs of your specific class. If you do so, please add the following onto the modified version: Adapted from the Mining and Mineral Processing Resource Pack, 2009. University of Cape Town.

1. Extracting Copper from its Ore

This experiment demonstrates the method of extracting copper from a mixture of sand and copper oxide through displacement and redox reactions. This extraction is similar to the cyanidation method and zinc precipitation used for gold extraction.

This activity can be done in small groups or used as a class demonstration. It can also be used to demonstrate the reaction between acids and metal oxides as well as redox reactions.

2. Separating Minerals

This activity can be used to learn about, or revise, different separation methods for solid particles. It has application in other topics and grades, for example Grade 10 Matter and Materials (separation methods).

3. Flotation Demonstration

This is an easy and short demonstration to explain the principles of flotation, a method that is extensively used in mineral processing. This demonstration can also be used to explain concepts like density (floating and sinking) or surface phenomena (adhesion forces).

4. Make Your Own Rock

This activity can be used to demonstrate how minerals end up in rock formations. Learners can do the activity in groups or it can be used as a class demonstration. It is recommended that you do the activity beforehand.

Extracting Copper from its Ore
Notes to the Teacher

In this experiment an insoluble metal oxide is reacted with a dilute acid to form a soluble salt. Copper(II) oxide, a black solid (powder), and colourless dilute sulfuric acid react to produce copper(II) sulfate, giving a characteristic blue colour to the solution. The copper ions are then displaced by the more reactive zinc metal to form metallic copper.

The reaction equations are:

$CuO_{(s)} + H_2SO_{4(aq)} \longrightarrow CuSO_{4(aq)} + H_2O_{(\ell)}$

Metal oxide + acid $\longrightarrow$ salt + water

$Zn_{(s)} + CuSO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + Cu_{(s)}$

Zinc is oxidised: $Zn \longrightarrow Zn^{2+} + 2e^-$

Copper is reduced: $Cu^{2+} + 2e^- \longrightarrow Cu$

Spectator ion: SO_4^{2-}

Or in ionic form:

$CuO_{(s)} + 2H^+_{(aq)} + SO_4^{2-}{}_{(aq)} \longrightarrow Cu^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} + H_2O_{(\ell)}$

$Zn_{(s)} + Cu^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} + Cu_{(s)}$

Notes:

In part 1, learners should be able to observe the colour change from colourless to blue, at the same time as the black powder disappears. The blue colour intensifies as more black powder is used.

In parts 2 and 3, learners should be able to use their previous experience of blue solutions to recognise the familiar colour of Cu^{2+} ions in solution. This reaction can then be used as the starting point for teaching acid-base reactions: acid + metal oxide $\longrightarrow$ salt + water.

Learners already familiar with acid-base reactions should be able to predict the identity of the compound formed, using the colour change as confirmation of that prediction.

The symbol equation for the reaction is:

$CuO_{(s)} + H_2SO_{4(aq)}\ CuSO_{4(aq)} \longrightarrow + H_2O_{(\ell)}$

<u>The analogy with gold is as follows:</u>

Gold (Au) is present as metallic gold in gold ore. To extract it from the ore, Au is dissolved with sodium cyanide (NaCN) or potassium cyanide (KCN). Au forms a stable complex ion $Au(CN)^{2-}$ in solution. The solution containing the gold complex ion can now be filtered from the unwanted rock. Zinc powder is added to precipitate the gold similar to the copper precipitation. Solid gold can now be filtered from the solution.

$4Au + 8NaCN + O_2 + 2H_2O \longrightarrow 4NaAu(CN)_2 + 4NaOH$

$Zn + 2NaAu(CN)_2 \longrightarrow 2Au + Zn(CN)_2 + 2NaCN$

Na^+ is a spectator. If the spectator is left out, the reaction equation is:

$Zn_{(s)} + 2Au(CN)^-_{2(aq)} \longrightarrow 2Au_{(s)} + Zn^{2+}_{(aq)} + 4CN^-_{(aq)}$

Lesson Planning

This activity should take about 30–45 minutes if done in groups and about 20 minutes for a class demonstration.

Apparatus and Chemicals

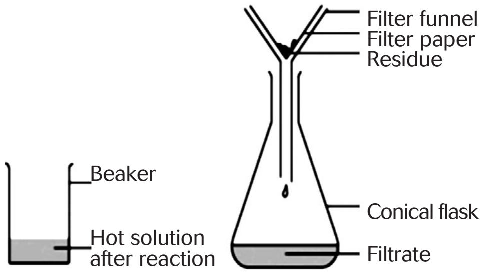
Each group will require:

- Small glass beaker (100 cm^3)
- 2 conical flasks (150 or 250 cm^3)
  (If conical flasks are not available, two glass beakers can aslo be used.)
- Spatula
- Filter funnel and 2 filter papers
- 20 cm^3 dilute sulfuric acid (1:50 dilution)
- About 2 g zinc powder
- About 5 g copper ore sample (mixture of about 0,5 g CuO and 4,5 g clean sand)

Extracting Copper From Its Ore
Learner Worksheet

Aim: To extract copper metal from a copper ore sample

Method



Part 1

1. Add the ore sample to the small beaker.
2. Add 20 cm^3 of the dilute sulfuric acid to the beaker.
3. Swirl the mixture regularly to ensure thorough mixing.

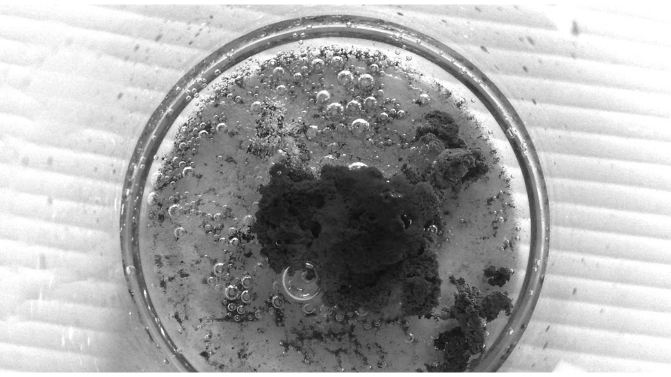
Part 2

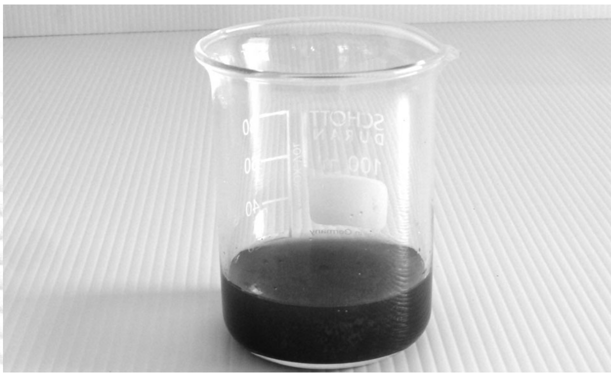
4. Place the filter funnel in the neck of the conical flask.
5. Fold the filter paper to fit the filter funnel, and put it in the funnel.
6. Pour the mixture into the filter funnel and allow it to filter through.
7. A clear blue solution should collect in the flask. If the solution is not clear, and black powder remains in it, you will need to repeat the filtration.

Part 3

8. Add one spatula tip of zinc powder to the blue solution. A precipitate should be observed.
9. Leave the reaction mixture until the reaction is complete (the solution is colourless). It might be necessary to add more zinc.
10. Fit a new piece of filter paper to the filter funnel and filter this mixture. Collect the filtrate in the second conical flask. The filtrate should be clear and your recovered copper will be left behind on the filter paper.

Source: Adapted from http://www.practicalchemistry.org/experiments/reacting-copperii-oxide-with-sulfuric-acid,23,EX.html [accessed on 1 October 2008].





Your Task

This process is similar to the process used in extracting gold from its ore. Study the gold extraction process and write a paragraph (including reaction equations for gold) to explain how gold is extracted from its ore. Include a flow diagram of the gold extraction process in your write-up.

Separating Minerals
Notes to the Teacher

Each Group Will Need:

- Container with a variety of beads of different shapes, sizes, densities and magnetic properties
- Paint tray (separation tray)
- Plastic cup and plastic mesh (sieve)
- Optional: additional containers for storage
- Optional: Sheet of A4 paper for planning
- Optional: water (for density separation)

Discussion Prior to Activity

The learners are required to draw a flow diagram. If they are not familiar with drawing flow diagrams you would need to explain the concept to them. Remind them that it is possible to swap methods around or to repeat methods for better separation. You will not get 100% separation in the first attempt. Real life is also like this where minerals are never separated 100% from gangue rock in one step. A series of steps and a combination of methods are necessary and even with this you do not get 100% separation.

Inform the learners that they are not allowed to use hand sorting as a separation technique.

When Buying the Beads

Ensure that there is enough of each type of bead. Rather supply a smaller variety, but more of each type. Ensure that, for at least one type of bead, you have identical beads but of different colours. The idea is that the learners will be unable to find a method of separation, allowing you the opportunity to discuss making use of the chemical properties of minerals to separate them.

Choosing the High Value Mineral

Choose one of the identical beads (of two different colours) to represent the high value mineral for the classroom activity.

Discussion

The following physical properties should be identified and used to decide on the best separation method:

- **Size –** the small beads will go through the holes of a sieve where the larger ones will stay behind.
- **Shape –** some beads are flat and will stick, others are round and will roll.
- **Density –** some beads will float in water and others will sink.
- **Magnetic properties –** some beads will be attracted to a magnet and others won't.
  (Real example – iron is found in magnetite rock. Magnetite can be separated from other rocks by magnetic attraction. This is done on large scale in iron mining.)

Chemical Properties

At some point the learners will need to separate identical beads of different colours. Hand sorting will seemingly be the only option. Suggest to them that hand sorting is very time consuming and very expensive in industry and therefore almost never done (except in the diamond industry).
Another method needs to be found. This is where chemical properties play a role: suggest to the learners that the one colour reacts with acid and the other does not. Let the learners discuss how they would separate the two colours knowing this fact. (Real example: silver reacts with chlorine and gold does not. Chlorine, however, is toxic and usage should be avoided, or limited to the very last step and only if absolutely necessary. Strict environmental controls are necessary when this method is used. Silver is the very last impurity to be removed from gold and only if the customer requires it. At a refinery, gold is purified from 99,9% to 99,99+% for the jewellry industry on a small scale. All other gold is accepted at the 99,9% purity level (the 0,1% is mainly silver).

Separating Minerals
Learner Worksheet

You are working at the mineral processing plant of a mining company. Your job is to find a method to separate the valuable mineral from a sample of ore in the cheapest possible way.

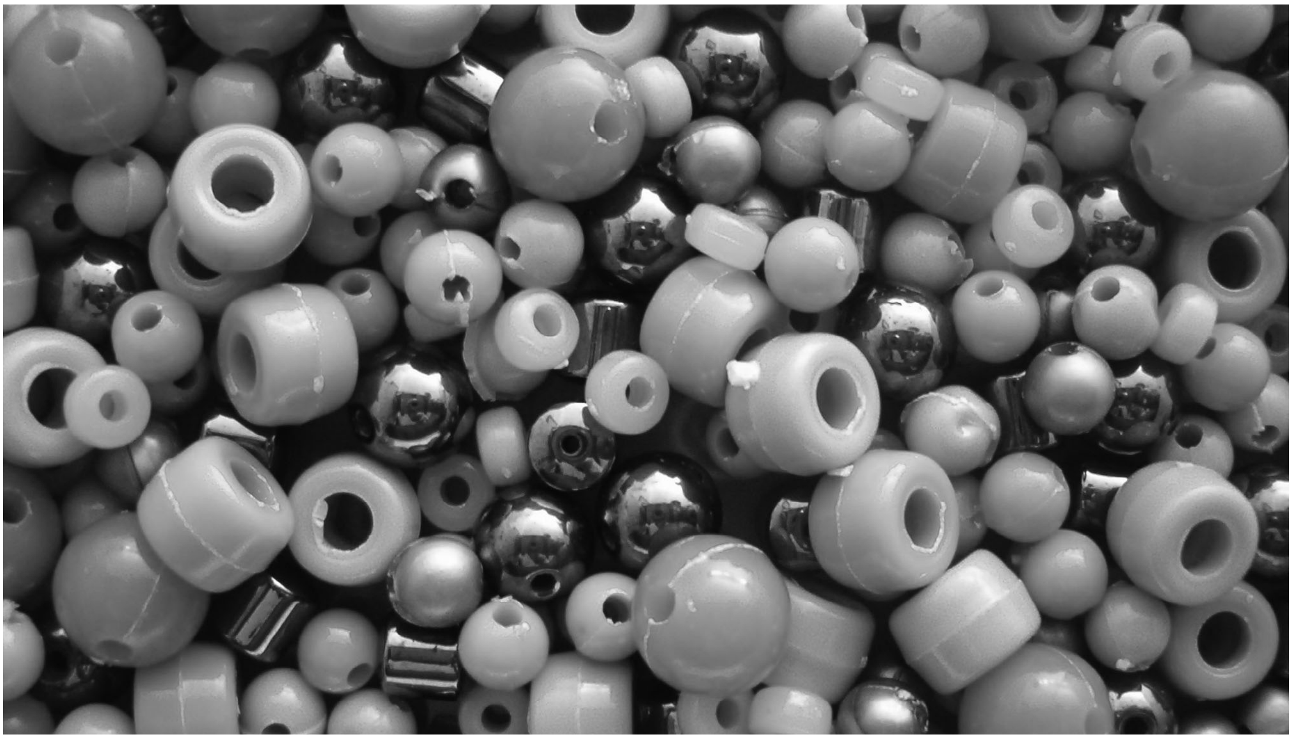
You will be supplied with an ore sample (beads of different shapes, sizes and densities and magnetic properties) and apparatus to use in your separation (plastic cup, separation tray, piece of carpet, plastic sieve). Your teacher will inform you which bead represents the high value mineral.

Your task

Work in your group and find a method to separate your high value mineral from the waste rock and draw a flow diagram to illustrate your combination of separation methods.

Things to consider:

- Complete separation does not take place during the first try. Repeat the same method a number of times to improve the separation.
- Consider changing the order of separation methods to see if a more efficient process can be obtained.
- Hand sorting is a very accurate way to separate beads, but is very time consuming, highly labour intensive and in most cases not possible as the particles are too small to see. Do not use hand sorting as a separation method.



Acknowledgements: Dr Jochen Petersen and Mr. Craig Sweet, UCT Chemical Engineering

Separating Peanuts And Raisins
Notes to the Teacher

Aim: To demonstrate flotation as a separation method.

What is Flotation and how does it Work?

Flotation is a separation method used to separate hydrophilic and hydrophobic particles by bubbling air through the solution. Hydrophobic particles will more likely attach themselves to air bubbles than hydrophilic particles. If air bubbles are pumped through a solution the hydrophobic particles will adhere to the air bubbles. As the bubbles rise, they carry the hydrophobic particles with them to the top of the solution where they can be removed from the mixture.

Where is it Used?

Flotation is used in the mining industry to separate valuable minerals from unwanted material. Chemicals are added to change the properties of the mineral so that the mineral adheres to air bubbles, rises with the bubbles and accumulates in the froth that forms. The minerals can now be separated from the waste materials. Platinum, gold, copper, iron, zinc and phosphates are some examples of the minerals that can be separated by means of flotation.

What do you Need?

- Peanuts and raisins
- Soda water
- Tap water
- Two tall glasses or beakers

Method

1. Pour tap water into the first glass ($3/4$ full).
2. Add a handful of the peanuts and raisin mixture to the water and note what happens.
3. Pour soda water into the second glass ($3/4$ full).
4. Add a handful of the peanuts and raisin mixture to the soda water.
5. Write down your observations.
6. Explain why this happens.

Acknowledgement: Personal communication: Dee Bradshaw and Roger Leighton, UCT Department of Chemical Engineering

Separating Peanuts And Raisins
Notes to the Teacher

How Flotation Works: The Mechanics

The essential mechanism of flotation is that mineral particles be attached to air bubbles so that those particles are carried to the surface of the ore pulp, where they can be removed. The process includes the following steps:

1. Grinding the ore fine enough so the valuable mineral particles are separated from those of the adhering gangue (worthless rock). Grinding the ore has an important influence on the flotation process. For optimum flotation results, valuable minerals should be separated completely from the waste rock (gangue) and from each other in the grinding step.

2. Creating a rising current of air bubbles in the ore pulp. This can be done by a flotation machine that produces bubbles through the mechanical agitation of the ore pulp, by the direct introduction of air under pressure, or both. These operations are 'mechanical' add-ons of the flotation process.

3. Making conditions favourable for adhering (attaching) the desired mineral to air bubbles. To get the desired mineral particles to 'stick' to the air bubbles, and to form a mineral-laden froth on the surface of the ore pulp, a hydrophobic (does not like water) surface must be formed on the particles to be floated, and a hydrophilic (water loving) film on all others. Materials called 'collectors' and 'modifiers' do this and selecting the proper combination of reagents for each particular ore is a principal responsibility of the ore dressing metallurgist.

4. Forming a mineral-laden froth on the surface of the ore pulp. The bubbles will collect on the surface and form a layer that can easily be removed.

5. Removing the mineral-laden froth. The froth layer can be removed by scraping it off and collecting it in a separate container.

Source: www.miningbasics.com. 1994. Flotation. [Online] Available: http://www.miningbasics.com/html/how_flotation_works__the_mecha.php [20 October 2008]

Make Your Own Rock
Notes to the Teacher

Make Your Own Rock – Investigating How Loose Sediment May Be Stuck Together to Form a 'Rock'

Ask a learner to take a handful of sand and see if it is possible to make a 'rock' by squeezing it as hard as possible. (It isn't!)

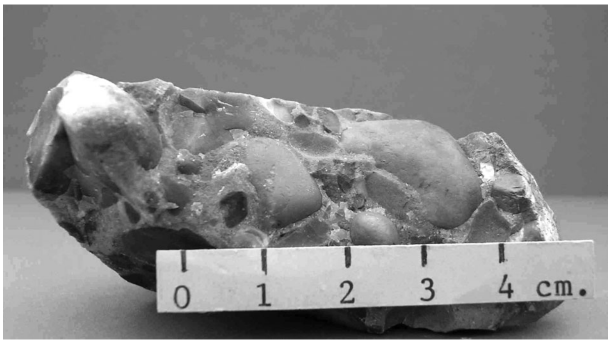
To become hard rocks, most sediments need to be cemented together. This idea can be tested with a variety of 'cements'. Before carrying out each part of the activity, ask learners to predict how strong they think each 'rock' will be when it has dried.

Dampen some sand with water and pack it tightly into the bottom of an old plastic cup or small pot. Cut away the plastic carefully and leave the sand pellet to dry.

Repeat this several times, but mix the sand beforehand with any suitable 'cements' that come to hand. Use a ratio of about one part of 'cement' to four parts of damp sand. The 'cements' could include salt, sugar, plaster of Paris, etc. Builder's cement powder can be used, but note that it is hazardous if inhaled, or in contact with the skin or eyes – use eye protection and do not touch with the hands.

Note: If an old 20 ml syringe is available, the nozzle end can be cut off with a hacksaw and the syringe used several times to make a more uniform series of 'rock' pellets than can be achieved with the plastic cups described above.

Ask the learners to devise a fair way to test the strength of their rocks after they have hardened. When the 'rocks' have become hard (which may take a day or so), pupils can then be invited to test them to destruction, to see which were made with the strongest cements. If possible, give them a piece of real sandstone to test as well. If they plan a series of tests, they should try the least destructive one first! Many sedimentary rocks were once loose sediments that were cemented by natural cements in a very similar way. Fluids flowing through the spaces between the grains deposited natural cements.



Pupil Learning Outcomes:

Pupils can:

- Demonstrate how 'rocks' are made by compacting and cementing loose sand.
- Devise a fair way of testing the strength of their 'rocks' and a fair way of testing the strength of their 'rocks'.
- Explain that the strength of a rock may depend as much on the cement that holds the particles together as it does on the composition of the particles themselves.

Context:

The activity could form part of a lesson dealing with sedimentary rocks and how they are formed. It may have applications to local building materials.

Following up the activity:

Pupils can be asked to test the strength of any real rocks that may be available. If the sample has a flat surface, one simple test is to drop a ball bearing onto it from a height of, say 2 m, and record how high it bounces back. The more resistant the rock, the higher the rebound.

Underlying principles:

- Many basic textbooks claim (wrongly) that sediments become hard rocks simply by compacting them.
- This normally applies only to fine grained sediments, such as clays, where electrostatic attraction helps to hold the particles together.
- With sands and coarser grained sediments, some sort of natural 'cement' is needed to bind the particles together.
- The chemicals to form such cement come from groundwater, which is present in most sediments.
- In practice, the cementing agent is usually either silica (SiO_2), calcium carbonate ($CaCO_3$) or various compounds of iron.
- Most naturally-occurring rocks are more strongly cemented than those that can be made in a school classroom.

Thinking skill development

A pattern is established that the tougher the cement is, then the tougher the rock will be. Relating the findings from artificial cements in the classroom to real sedimentary rocks is a bridging concept.

Resource list:

- Sand
- Expendable small plastic cups or pots
- If available – old 20 ml syringes with the nozzle end cut off with a hacksaw
- Water
- A range of 'cements', e.g. salt, sugar, plaster of Paris, builder's cement powder (cement powder is a hazard – protection needed)
- Stirring sticks
- Scissors, for cutting up the plastic cups
- Large ball bearing, or similar item, for testing the strength of the 'rocks' by dropping on to them

Source: Earth Science Teachers' Association (1991) Science of the Earth 11 – 14 Secondhand rocks – introducing sedimentary processes Sheffield: Geo Supplies Ltd.
http://education.usgs.gov/schoolyard/RockSedimentary.html

Grade 11 Research Project
Notes to the Teacher

Divide the class into groups of four. Each group is assigned a different mining industry (gold, coal, iron or phosphate). You can have more than one group investigating the same industry. Try not to have groups larger than four as this is the optimum number for group participation for this activity.

Hand out pages 23–25 (Research Project: Learner Guidelines and Marking Rubrics).

Read the instructions on pages 23–24 to the learners and allow some time so that they can discuss the project in their groups. Answer any questions that they might have. Also provide them with the deadlines for handing in their planning and research report.

Draw their attention to the rubrics – what they need to do to achieve a good result. Note that some marks are allocated for individual work and some marks for group work. Each learner should receive his/her own copy of the rubric. This should be handed in with the report so that each learner's marks can be indicated on his/her own rubric.

The project is out of 100 marks made up of the following:

Planning	5 marks
Research report	65 marks
Consolidation activity	30 marks

The purpose of the planning is to get the learners to focus and force them to start the project. It is up to the teacher to specify what should be handed in and in what format. We suggest a timeline of events, ideas for resources and who is responsible for what. The 'Planning' rubric is used to mark this.

Choose one of the following consolidation activities. More activities can be done in the classroom, but only one needs to be for formal assessment. The aim of the consolidation activity is to provide learners with the opportunity to 'talk science' in the classroom and to incorporate LO3. A suggested rubric (30 marks) for each activity is included. Inform your learners of the deadline for this activity.

- Class presentation – page 31
- Role play – page 33
- Debate – page 36

Timeline:			
End of Week 1	Week 2	End of Week 3	Week 4
Planning is handed in and discussed in class.	Learners work on their projects. Informal discussion to find out whether they are on track. Provide assistance if needed.	Research project is handed in and assessed. Results are discussed to give the learners direction to prepare for the consolidation activity.	Consolidation activity: presentations, debate or role play is done in class and assessed.

Other useful information that can be handed out includes:

- A list of useful websites (page 26)
- How to write a reference list (pages 27–28)

Learner Information Sheets

What are they?
Four sets of learner information sheets are included in the resource pack, one on each of the mining industries prescribed by the syllabus. They are a collection of relevant sections of information on each industry and mostly sourced from the internet. The sheets can be seen as a 'mobile Internet' that provides learners with information in cases where access to updated and relevant information is limited.

Why are they included?
We have found during 18 months of testing the material that this research project requires learners to do research on a topic for which information is not widely available. In an attempt to address the situation, we have collected information from the Internet, repackaged it, and have included it in this format.

How can I use them?
Although the main purpose of the information sheets is to provide a resource for learners, it can also be used by teachers to gain knowledge about a new topic in the Grade 11 syllabus. You could therefore also use the sheets to prepare your lessons.

If you feel that your learners have sufficient access to information to complete the research project, you do not have to use the sheets at all. However, if you do decide to use the sheets, we strongly recommend that you hand out copies of it and keep the originals for future years. Please note that even if your learners use the packs, they can still go to libraries or search the Internet for additional information. The packs will provide them with the basic information, but it does not mean that information should not be added. They should be encouraged to find their own definitions for words they do not understand.

There is too much to read…
Many learners struggle when they are required to read a lot of information. Unfortunately this is a skill that needs to be developed and also something that is required to complete this task. We have deliberately included too much information. Even if we provide them with the information they are still required to make sense of it and decide what is important and what is not. They still have to do the research! Remind your learners that they should not report back on everything that they have read, but only on what they feel is most important.

Should the research project not have more practical experiments?
Research in the real world often involves practical investigations in addition to sourcing existing information on the topic. Here we are focusing on the latter as a result of observations during our trials indicating that many learners struggle with making sense of information. To expect them to also include an investigative/practical approach in this project might pose an unmanageable challenge. In an attempt to familiarise learners with doing research, we suggest a step-by-step approach where learners do a simple project in Grade 10, in Grade 11 this more extensive project, which focuses on the information and presentation side of research and only then incorporate an investigative/practical component in Grade 12. In this way one can progressively address issues like finding and analysing information, synthesising information, presentation skills and report writing.

Grade 11 Research Project: Learner Guidelines

NAME: .... **CLASS:** ....

THE RESEARCH QUESTION:
What is the impact of mining on South Africa and its people?

You will be working in a group as well as on your own to find an answer to the research question. You need to write up your findings in a research report. You will be divided into groups of four and each group will be assigned a mining industry: gold, iron, coal or phosphates.

How to approach your task

As a group, think about and discuss the following:

- South Africa has been involved in mining for centuries and is still mining today.
  Do you think mining is important for South Africa?
- Who do you think is doing the mining?
- How do you think they are mining? Do they need equipment? How do they know where to mine?
- Do all countries mine the same minerals?
- During mining operations, rock is are taken from the ground and brought to the surface. What do you think happens to the rock once it gets to the surface?
- How do you think the landscape has changed due to mining operations?
- How do you think mining has influenced the environment?
- How does mining affect you/people in general/people working on a mine?
- Do you think mining will ever stop? Why do you say so?

Keeping all these questions in mind you need to investigate the mining industry that was allocated to you and try and answer all these questions. You also need to answer the research question at the top of this page. Below you will find some suggested topics that you can use as a starting point. Please add your own topics to this list. We suggest that each group member chooses at least one technical topic and one socio-political issue; however it is up to the group to decide how to tackle this project. Keep in mind that your report must not be a collection of individual efforts, but should be a product of the group's effort.

Technical content

- The history of the industry
- The properties and uses of the mineral
- How and where the mineral is mined
- Processing of the mineral (it would be a good idea to include a flow diagram of the process here)
- Refining of the mineral

Socio-political issues

- The impact of the industry on the South African economy (past, present and future)
- The impact of the industry on the environment (global warming, pollution, etc.)
- The impact of the industry on the community and the health sector (AIDS, TB, STI's, etc.)
- Safety in mining
- The impact of the industry on agriculture (phosphate mining only)
- Eutrophication and land degradation (phosphate mining only)

Choose a group coordinator and decide who will be doing what. You will have about three weeks to do the research on your topics. After one week you need to hand in your planning in the form of a timeline. The timeline should include the plan of action for your group and some initial ideas for the project.

Marks:

Planning	5 marks
Research report	65 marks
Consolidation activity (your teacher will choose this activity)	30 marks
Total	100 marks

Deadlines (your teacher will give you these dates)

Planning: ....

Report: ....

Consolidation activity: ....

What is a Research Project?

According to the Subject Assessment Guidelines document (SAG, January 2008) a research project is defined as follows:

> *"A research project involves a collection of data and/or information to solve a problem or to understand a particular set of circumstances and/or phenomena. While the problem that focuses the research task is well defined, the nature of the data collected will determine the solution to the problem."*

This means that you need to collect data/information to enable you to solve a problem, or answer a research question. You will not know what the answer to the question is, until you have collected, interpreted and applied the information that you have collected. You must therefore give your own opinion based on your findings.

How to write the research report

- One report must be done per group.
- Understand what is being asked of you.
- Remember that you have to interpret and analyse the information.
- Collect the data/information. Make use of as many resources as possible. This could include books, the internet, newspapers, magazines, interviews and results from research done by others on the same topic. Your teacher might provide you with some additional information.
- Study the information and present it in a logical, scientific manner. Present your findings in a group research report of 12–15 pages.
- DO NOT COPY information directly from your sources (like the Internet). This is PLAGIARISM and is NOT ALLOWED! If you use a direct quote you need to use quotation marks and include the details of the author, date and page number in brackets. Otherwise you need to write the information in your own words and you still need to list the reference in your reference list.
- Interpret the findings and state conclusions. Form an opinion of your own. Marks will be awarded if it is clear that you have interpreted the information. Provide an answer to the research question in your conclusion.
- Your report should consist of the following:
  - Title page (include the research question, your mining sector and the names of the group members)
  - Introduction
  - Content (1–2 pages per topic)
  - Conclusion (100–150 words)
  - Reference list
  - Acknowledgements
  - Glossary (list of all new terms and concepts with explanations)
- For each topic/section, include the name of the group member(s) who investigated it below the heading so that your teacher knows who was responsible for which part.

Marking Rubrics

NAME: ....

Planning	2 marks	1 mark	0 marks
The timeline is realistic and the important aspects are included.	—	Acceptable	Not acceptable
Resources or suggestions for resources are appropriate and are good variety.	—	Acceptable	Not acceptable
Some initial ideas for the project are included and appropriate.	Yes	Not really	No
The timeline is neat and easy to understand.	—	Yes	No
		Total	**/5**

Research Report							
Research (individual) (30 marks)	**Not achieved 0–29%**		**Moderate 30–49%**	**Adequate/ Substantial 50–69%**		**Outstanding 70–100%**	
• Use of available resources	0	1	2	3	4	5	6
• Accuracy of interpretation of information	0 1	2 3	4 5	6 7 8		9 10	11 12
• Coverage of the topic	0	1	2	3	4	5	6
• Quality of writing	0	1	2	3	4	5	6
Research (group) (25 marks)	**Not achieved 0–29%**		**Moderate 30–49%**	**Adequate/ Substantial 50–69%**		**Outstanding 70–100%**	
• The research question was addressed through an introduction and conclusion	0	1	2	3		4	5
• Content is coherent and reads well	0	2	4	6		8	10
• Group members worked together to produce the report	0	1	2	3		4	5
• Creative approach to topic, write-up and/or presentation of report. Project stands out from the rest.	0	1	2	3		4	5
The report (10 marks)	**Not achieved**			**Acceptable**		**Good**	
• The format of the report is correct according to the instructions given	0			1		2	
• Reference list is included and shows a variety of sources	0			1		2	
• Source are referenced correctly	0			1		2	
• Acknowledgements are included and appropriate	0			1		2	
• Glossary is extensive and definitions are correct	0			1		2	
				Total		**/65**	

List of Useful Websites

1. www.angloamerican.co.za
2. www.angloplatinum.co.za
3. www.kumba.co.za
4. www.anglocoal.com.au
5. www.anglogoldashanti.co.za
6. www.activated-carbon.com
7. www.bullion.org.za
8. www.coaleducation.org
9. www.denvermineral.com
10. www.dme.gov.za
11. www.earthscienceeducation.com
12. www.e-goldprospecting.com
13. www.enviroliteracy.org
14. www.environment.gov.za
15. www.foskor.co.za
16. www.fssa.org.za
17. www.goldinsouthafrica.co.za
18. www.goldworld.com
19. www.ifpri.org
20. www.ironminers.com
21. www.keatonenergy.com
22. www.mbendi.co.za
23. www.mii.org
24. www.mine-engineer.com
25. www.minerals.net
26. www.miningbasics.com
27. www.miningreview.com
28. www.miningweb.co.za
29. www.miningweekly.com
30. www.mintek.co.za
31. www.randrefinery.co.za
32. www.steeluniversity.org
33. www.teachcoal.org
34. www.usgs.gov
35. www.worldcoal.org
36. www.worldsteel.org
37. http://fipr1.state.fl.us/PhosphatePrimer
38. http://nora.nerc.ac.uk/
39. http://www.gcis.gov.za/docs/publications/yearbook/
40. http://www.saimm.co.za/publications/downloads/v089n05p129.pdf
41. http://www.uoguelph.ca/~geology/rocks_for_crops/

The following websites are general search engines where you need to search for information using key words, like iron mining, refining of gold, types of coal and gold price.

42. www.about.com
43. www.howstuffworks.com
44. www.kitco.com
45. www.madehow.com
46. http://commons.wikimedia.org (for images)
47. http://en.wikipedia.org

How to Write a Reference List

Books

When you use a book as a source, you need to include the following in your reference list:

Surname and initials of the author(s). Year of publication of the book. Title of the book. Place of publication: Name of the publisher.

Notes

* If there are two or more authors you use 'Blogg, J. A., Moodie, S. & Zulu, M. M.'.
* If the author of the book is a company it is called a corporate author and the name of the company is used as the author. See second example below.

Examples

Blogg, J. A. 2009. Mining and mineral processing. Cape Town: First Publishers.

Anglo American. 2007. Annual Report: 2007. Johannesburg: Anglo American.

Encyclopedia

When you use an encyclopedia you need to include the following in your reference list:

Author. Date. Title of the article. Title of the encyclopedia, volume of encyclopedia: page reference.

Example

Lessing, B.P. 1985. Nuclear energy. McGraw-Hill encyclopedia of Science and Technology, 12:127-129. Encyclopaedia - Author not indicated

When you use an encyclopedia where the author is not known, you need to include the following in your reference list:

Anon. Date. Title article. Title of encyclopedia, volume of encyclopedia, page reference.

Example

Anon. 1983. Medieval manuscripts. Encyclopedia Americana, 14:346-–347.

Government publications

When you use a government publication you need to include the following in your reference list:

Correct name of the country. Name of the department. Date of publication. Title. Place of publication: Publisher.

Example

South Africa. Department of Home Affairs. 1980. Guidelines for chairmen of publications committees. Pretoria: Government Printer.

Videos

When you use a video you need to include the following in your reference list:

Title of the video. Date of publication. Place of publication: Publisher [format of the video recording]

Example

Anglo Platinum Corporate Video. 2007. Johannesburg: Anglo Platinum [DVD]

Articles in books

When you use an article in a book you need to include the following in your reference list:

Surname and initials of the author. Year of publication. Name of the chapter or article in the book. Name of the book . Name of the editor/s of the book. City of publication: Name of the publisher.

Example

Blogg, J. A. 2009. Mining education in secondary schools. Science in schools, Smith, J., Ed. Cape Town: First Publishers.

Articles in journals

When you use an article in a journal, you have to include the following in your reference list:
Surname and initials of the author. Year of publication. Name of the journal article. Name of the journal. Volume (issue number): Page numbers of the article.

Some journals do not have an issue number, in which case you just write the volume number.

Example

Blogg, J. A. 2009. Science in the classroom. Science Journal. 25(3): 120-123.

Internet sites

When you use and Internet site, you need to include the following in your reference list:
Surname and initials of the author. Year of publication. Title of article in italics. [Online]. Available: Full URL address. [Date on which you visited the site]

Example

Kubach, C. 1994. Gold. [Online]. Available: http://www.mine-engineer.com/mining/mineral/gold.htm [14 October 2008]

Paraphrase

When you refer to a source in your report you need to include the year of publication and the page number where you have found the information next to the name of the author.

Example

Blogg (2008:12) claims that the mining industry still plays an important role in the South African economy.

Direct quote

When you use a direct quote in your report you need to include the name of the author, the date of the publication of the text and the page number you are referring to. If you are citing from an Internet site you still need to include the author and the date.

Example

Blogg asks in the mining resource pack: "What is the real meaning of mining?" (Blogg 2009:25). **Source: Adapted from http://www.lib.uct.ac.za/infolit/bibharvard.htm [Accessed 28 November 2008]**

Analysis of the Research Project

Name of school:		**Lesson Plan no:**
PHYSICAL SCIENCE		**GRADE 11**
Total time:	Start date:	End date:
Knowledge area: Chemical Systems		**Theme:** Mining and mineral processing
CORE CONCEPTS		**CONTEXT**
Using our natural resources (the lithosphere)		Mining in South Africa
The impact of science on the environment		Global warming and climate change
Chemical reactions (oxidation-reduction, acid-base, precipitation)		Mineral processing

LEARNING OUTCOMES AND ASSESSMENT STANDARDS			
LO1	**AS 1.1**	Conducting investigations	
	AS 1.2	Interpreting data to conclude	✓
	AS 1.3	Solving problems	
	AS 1.4	Communicating and presenting information and scientific arguments	✓
LO2	**AS 2.1**	Recalling and stating scientific concepts and facts	✓
	AS 2.2	Indicating and explaining relationships	✓
	AS 2.3	Applying scientific knowledge	✓
LO3	**AS 3.1**	Evaluating knowledge claims and science's inability to stand in isolation from other fields	✓
	AS 3.2	Evaluating the impact of science on human development	✓
	AS 3.3	Evaluating science's impact on the environment and sustainable development	✓

RECOGNITION OF PRIOR LEARNING
Grade 10 Global Systems
Grade 10 Chemical Change
Grade 10 Matter and Material (mixtures)
Grade 9 Geography

INTEGRATION		**SKILLS**		**VALUES & ATTITUDES**	
Mathematics/Maths Literacy	✓	Classifying and communicating	✓	Teamwork	✓
Life Orientation	✓	Critical thinking and problem solving	✓	Appreciation	✓
Geography	✓	Predicting	✓	Cooperation	✓
Life Sciences	✓	Extracting relevant information	✓	Responsibility	✓
Economics	✓	Presenting information in a logical manner	✓	Accountability	✓
History	✓	Communicating in a scientific language	✓	Self esteem	✓
		Drawing conclusions	✓	Endurance	✓
		Evaluating conclusions	✓		

Consolidation Activities
Notes to the Teacher

The following activities are available to use in the classroom to consolidate the information that was presented by the learners in their research reports. The focus of these activities should be on getting the learners to communicate with each other in a scientific language (get them to talk science) and to incorporate Learning Outcome 3 in teaching this section. It is up to the teacher to decide which activity will be done. It could also be left up to the individual groups to choose the activity they would prefer.

1. Class presentation page 31
2. Role play page 33
3. Debate page 36

Why do we ask learners to present their work verbally in the classroom?

In an ordinary school day learners are given very little opportunity to practise 'speaking' science in the classroom. Due to the large volume and complexity of the content to be covered in Physical Science, learners spend most of their time writing down facts and solving problems on paper. However, science is a language and the only way to learn a new language is to practise speaking it. The learners' fluency in the language of science is not as important in the beginning as simply getting the learners to try conversing scientifically on a regular basis. As with most languages, the more one speaks in a particular language the more comfortable, fluent and confident one becomes.

Real understanding of a subject is only achieved when learners are forced to process the information that they have read and present the material in their own words – the language of an oral presentation of content is quite different from that of the written language.

What does this mean in terms of the research project?

By including an oral presentation section to the research project, the learners are given the opportunity to practice the skill of communicating science. Learners therefore need to be reminded that this is not an English oral but rather a process in which they communicate orally what they have learned during their research to their peers – it is more like teaching than a speech.

It is also important that, during evaluation, the teacher does not evaluate the ability of the learner to talk/present well, but rather the ability to communicate science. When the presentations are assessed, the teacher should focus on what the learner says rather than how it is said.

Class Presentation
Learner Instructions

In this activity you will present the findings of your research project to the rest of the class. Your presentation should not be longer than 20 minutes (including question time). You will be working in the same group as for the research project. You will NOT be doing a language oral, but instead you will be teaching the class what you have learnt during your research.

You need to:

- Work as a group in preparing your presentation – this is not an individual task and your group will be assessed as a whole on the flow of the presentation.
- Decide who will be presenting what. As a group you need to decide which content is most important to cover in your presentation – you cannot cover all the topics in 15–20 minutes.
  You do not have to present the section you did the research on, but could help present another topic.
- Choose someone to do the introduction and the conclusion.
- Be aware of **time constraints.** Your presentation will be a total of 20 minutes, of which 15 minutes consists of the group presenting the content and the remaining 5 minutes consisting of a **question and answer session.**
- Know and understand your content. You need to understand and explain new scientific terms in your own words, for example 'comminution' or 'leaching'. If you don't know the meaning of a word the chances are that your peers won't know it either.
- Find creative ways to captivate the attention of your audience. Be enthusiastic.
  Make the presentation interesting by using **posters, models, diagrams, examples and pictures.**
- Speak clearly and with confidence, making eye contact with the audience.
- Use appropriate language. **Do not read** off notes. **Do not recite** a prepared speech.
  Talk to the class about what you have found and what you have learned as if you are **teaching** the material.
  This is not an English oral but rather a presentation of what you have learned.

A poster is a good visual aid to use.
When designing your poster, keep the following in mind:

- The poster should summarize your findings (answer the research question) and NOT be a replica of the research report.
- Make your poster eye-catching and interesting.
  You want others to stop and read about what you did.
  Use colour to attract attention.
- It must be legible from a distance of two metres.
- Information must be laid out in a logical order.
  Your presentation must be neat and well thought through.
- Use large, clear headings that tell the reader what the project is about.
- Show the most important aspects of your work. Use flow diagrams, maps or graphs where applicable.
- Be creative! Be original!

Class Presentation: Marking Rubrics

Your name: ....

Names of other group members: **1.** ....

2. ....

3. ....

Class presentation (Group mark)	Not achieved 0–29%	Moderate 30–49%	Adequate/ Substantial 50–69%	Outstanding 70–100%
• The content was presented in a logical and well-organized way.	0	1	2	3
• The most important and relevant content was presented.	0	1	2	3
• The visual aids were effective, appropriate and supported the presentation.	0	1	2	3
• The socio-political issues were addressed by the group and own opinions were presented.	0	1	2	3
• Appropriate conclusions were drawn.	0	1	2	3
Class presentation (Individual mark)				
• A highly enthusiastic learner; the presentation is interesting, capturing the attention.	0	1	2	3
• Accurate information was presented. It is clear that the learner has mastered the content.	0	1	2	3
• The learner is able to answer questions knowledgeably.	0	1	2	3
• The learner is able to converse in a scientific language.	0	1–2	3–4	5–6
			Total:	**/30**

Role Play: "A Town Meeting" Notes to the Teacher

A role play is a combination of drama and science. Learners are asked to think about and research a position in a situation and then speak up in a discussion and talk about their opinions. During the discussion, learners take on a role, such as a town's mayor or a local doctor or a miner. This is a role which they may not agree with or have ever thought about before. They then use that platform to talk about the situation that is presented to them.

There are two scenarios below. In Scenario A, the mine in Westgold is closing down. In Scenario B, SAMC wants to open a mine in Richtown. For large classes, split the class into two 'towns' so that everyone can have a chance to speak.

This is best done with two teachers in the room if possible – one to moderate the discussion and one to assess the role play. However, you can nominate a strong learner to be the moderator.

Scenario A

In the small town of Westgold in the North West Province, there is an old mine which has been very successful in the past, but is currently just breaking even. There is a large expense to keep the mine running due to the small amount of gold being dug out of the ground. The mining conglomerate which runs the mine – SAMC (South African Mining Conglomerate) – wants to close the mine as there is another project at the coast which may make more money. The mayor of Westgold has decided to call a town meeting to discuss the way forward with the mine and the town's future.

Interest groups:

Group 1: Town Council – Mayor Mtimukulu and staff

As mayor, you are concerned with the future of your community. You want the people to be safe, but you want the economy to grow. You are also concerned about the elections taking place in five months' time. The people of the community are looking to see if you can continue to make positive changes in this community.

Group 2: National Union of Mineworkers – Thandeka Njobe and other representatives

You are representing the thousands of mine workers who depend on the mining industry for their livelihood. You are concerned about the people losing their jobs when the mines close down and the affect it will have on their families.

Group 3: Local Doctors – Dr. David Newton and Associates

You represent the families affected by losing loved ones to mining accidents. You and your associates have all lost family members, such as a brother or a father, in the mines and know how this affected your family life. You are also seeing increased cases of diseases in the town, like asthma, AIDS and TB. You are very concerned about the health of the people here.

Group 4: Department of Environmental Affairs – Minister Naidoo and staff

Gold mining in South Africa has, over the last century, contributed significantly to water, air, noise and light pollution and still plays a significant role in the production of greenhouse gases. Mine dumps have changed the landscape in many areas. You have watched this town change from rolling hills with grass to large industry and holes in the ground. You believe that closing this mine will greatly benefit the environment.

Group 5: CEO of GoGold Mining (Pty) Ltd – Siphokazi Tatedi and staff

You are representing a gold mining company. Your company will close down if SAMC chooses to pull out of Westgold and close the mine. All your employees will lose their jobs.

Group 6: Department of Minerals and Energy – Minister Mhlope and staff

You are concerned about the future of South Africa as mining plays a very important role in the South African economy. Closing down a complete mining operation will affect other industries such as manufacturing and food. The country must be able to maintain the amount of gold that is being mined.

Scenario B

In the small coastal village of Richtown, SAMC has approached the local municipality about opening a mine in the town. Since the vehicle manufacturing plant closed down in the 1980s, there has been a large gap in the economy of the town. Many young people continue to move to the larger cities like Cape Town and Johannesburg because work is very scarce in Richtown. The mayor of the town has decided to call a town meeting to discuss the way forward with the mine and the town's future.

Interest groups:

Group 1: Town Council – Mayor Botha and staff

As mayor, you are concerned with the future of your community. You want the people to be safe, but you want the economy to grow. You are also concerned that elections will be in five months' time. The people of the community are looking to see if you can continue to make positive changes in this community.

Group 2: National Union of Mineworkers – Thandeka Njobe and other representatives

You are representing the thousands of mine workers who depend on the mining industry for their livelihood. You are concerned about the people's jobs. They must be safe and well-paid. They will also have to relocate to this new area as there are not enough people here to sustain a large operation yet. However, a new industry is welcome as this means more jobs for more people.

Group 3: Local Doctors – Dr. Sally Smith and Associates

You are concerned with the safety of the miners and their families. In your research, you've read about the diseases that spread due to mining, and this is of concern to you. You believe that it is important to have a healthy community.

Group 4: Department of Environmental Affairs – Minister Naidoo and staff

Gold mining in South Africa has, over the last century, contributed significantly to water, air, noise, and light pollution and still plays a significant role in the production of greenhouse gases. Mine dumps have changed the landscape in many areas. This town is a quiet, small coastal town. Opening a mine here would drastically change the landscape.

Group 5: CEO of Let's Dig Mining Company – Alfred Mhambi and staff

You are representing a gold mining company. Your company will benefit from this mine opening. It is a fantastic opportunity and lots of jobs will be created and money made.

Group 6: Department of Minerals and Energy – Minster Mhlope and staff

You are concerned about the future of South Africa as mining plays a very important role in the South African economy. Opening a new mine will affect other industries such as manufacturing and food. The country must be able to maintain the amount of gold that is being mined.

Instructions

1. Divide the class into 6 interest groups according to the information provided in each scenario.
2. Each interest group should consist of 3–4 learners, depending on class size.
3. Each learner will be required to speak during the town meeting.
4. Each interest group needs to prepare a 1 minute (max) statement on the scenario. Address the following questions in your statement.
   a. Do you think that this is a good or a bad idea?
   b. Why do you think that this idea will help or hurt your town?
   c. What suggestions do you have to change the idea?
5. After each interest group has spoken (presented their one minute statement), individuals can comment on each other's statements and a general discussion can continue.
6. At the end of the meeting, there can be a vote to determine the outcome of the discussion.

NOTE: These instructions and scenarios have been given in English; however, it would be best to allow the town meeting to happen in the common language of the learners in the classroom.

Notes for marking

1. During the town meeting, listen to the arguments. Make notes on what is said in general.
2. Using a class list, make a note when a learner speaks. This is to ensure that every learner in the group speaks.
3. Use the rubric on the next page to evaluate the learners.

Acknowledgement: Nickie Wallace St Cyprian's School

Role Play: Marking Rubric

Name of learner: ....

Class: ....

LO1:		**0**	**1**	**2**	**3**	**4**
Practical scientific inquiry and problem-solving skills	Interpretation of information from research findings					
	Communicating and presenting information and scientific arguments					
LO2:		**0**	**1**	**2**	**3**	**4**
Constructing and applying scientific knowledge	Scientific accuracy of content					
	Relevant application of scientific knowledge to the issue that is being addressed					
LO3:	Learners were able to address the following:	**0**	**1**	**2**	**3**	**4**
The nature of science and its interrelation ship to technology, society and the environment	Impact of science and technology on socio-economic development					
	Impact of science and technology on human development					
	Impact of science and technology on the environment					
Participation		**0**		**2**		
	Learner participated in the role play	**No**		**Yes**		
			Total:		**/30**	

Additional Task:

After the town meeting, have each of the learners write a short summary of their position as well as their view of how the town meeting went. It is possible that their opinions changed during the town meeting due to arguments that they heard. Let them include what they felt about the outcome of the meeting (the vote). This piece of writing (no longer than one page, hand-written) can be used alongside the rubric for more accurate marking. It also gives the learner a chance to reflect on the exercise.

Debate
Notes to the Teacher

What is argumentation?

The definition of argumentation is a discussion aimed at solving a specified controversy/problem. But how does this relate to the science classroom setting? And why would you want to include this form of teaching in your classroom when you are already pressed for time to complete a heavy curriculum and your learners already learn debating skills in their English lessons? What follows will hopefully answer these questions and put forward an easy way of implementing argumentation in your classroom – an answer to Learning Outcome 3, which encourages learners to think critically for themselves and become responsible, thoughtful young adults.

Form of debate/structure of an argument

Argumentation in the classroom would involve a reflective discussion of a scientific issue which has relevance to your learners' lives in the 'real world'. Here the learners need to express their opinion and put forward reasons that support their claims. Their peers/classmates are then open to challenge these perspectives, express doubts regarding the authenticity of their claims and present alternative solutions to the problem under consideration. Once the various opinions have been put forward, the learners need to decide on a solution to the social issue as a class. This solution may involve compromise from both sides. You may find that learners are not able to articulate an argument at this stage, but by just expressing their views they have taken the first step forward to thinking about issues that impact on their lives.

Skills developed through argumentation

Learners have to think about the issues surrounding the socio-political problem under debate if they are to arrive at a consistent, acceptable position which they can defend persuasively in class. Besides taking their own point of view/side/position into account, they also need to consider the counter argument in preparing for the debate. This process develops intellectual independence and critical thinking – both of which lie at the heart of scientific thinking/reasoning. In developing their argument, the learners have to be open to other opinions. This makes learners aware that real life problems are complex and may not have one 'correct', clear-cut solution.

Why should we include it in our classrooms?

Learners' identities as scientists

The first reason links to developing learners' identities as prospective scientists and equipping them with the language of science and it tools. As a science teacher you have the unique ability to not only introduce learners to scientific concepts but also to equip learners with the new language of science and spark their identity as new members of the scientific community rather than leaving them feeling as outsiders or observers. We all know that the best way to learn a new language is to use it. Thus, learners need opportunities to practise using scientific language and ideas for themselves. In this way learners become active participants rather than passive observers and become confident in their own ability to reason through difficult socio-political issues.

Scientific literacy amongst learners

The second reason links to enhancing public understanding of science and improving scientific literacy amongst young people (which links directly to LO3 in the curriculum). In our contemporary, democratic society, it is critical that your learners receive an education that helps them to both construct and analyse arguments relating to the social applications and implications of science. They are at an age where they tend to question and challenge society's norms any way. Using argumentation in your classroom enables you to empower your learners question society and the world around them in a constructive fashion. This topic in the Grade 11 curriculum provides space and time, in a crowded year, to foster critical scientific thinking which is so essential to producing thinking and scientifically literate citizens. Argumentation, as a tool, provides learners with the opportunity to think through the issues surrounding the impact of science on society and develop their own understanding of its impact on their lives.

How can it be implemented effectively?

Argumentation can be implemented in your classroom in the form of a debate where a number of socio-political topics, such as those outlined on the next page relating to the mining industry, are assigned to a group of four learners according to the industry that they explored during their research project. The group divides into two pairs – two learners are assigned/choose to argue for and two learners argue against the statement in an attempt to understand the issue more clearly.

Learners need to construct their arguments based on what they have learnt during their research project as well as their own, informed opinions. Each learner in the pair needs to come up with their own argument which supports the case being put forward by the pair.

Once learners have drawn up their arguments (at home), the opposing members in the group present their arguments to the class for discussion and evaluation. To begin with, learners talk through what they have learnt during their research projects and raise matters for discussion. The next stage involves each pair presenting their opinion (negotiation and persuasion) before moving into a series of counter-arguments and rebuttals between the pairs. Once the two pairs have had an opportunity to defend their statements, the teacher opens the discussion to the rest of the class. Learners are asked to present either their own opinion or ask questions of the presenters. When the presenters have been given an opportunity to respond to the questions and statements, the teacher opens the topic up to a vote. Here the class as a whole is able to make a judgement of the socio-political issue in light of the arguments presented. Learners need to be encouraged to observe that different perspectives still exist and that the judgement made may differ in light of new evidence at a later stage. Learners are evaluated (see marking rubric on page 39) on their thinking and ability to present their opinions in a clear manner and not on whether they have won the argument or not.

Important points of clarification:

- Learners may not be able to articulate an argument at this stage but by just expressing their views they have taken the first step forward. Encourage the learners to express what they have learned openly – before they can argue they have to have a sound basis of what they understand and the project should have provided this for them. This activity provides them with the opportunity to think through the issues surrounding the impact of science on society and develop their own understanding of the mining industry and its impact on their lives.
- Impress on learners that it doesn't matter if what they think is perceived as 'wrong', but they need to substantiate their claims with informed views and argue their case.
- Choose the groups carefully, taking learners personalities into account and monitor their progress to ensure successful interactions.
- Encourage learners to explore different perspectives to the problem and the possible reasons for these.

Debate
Learner Instructions

You will be working in a group as well as on your own to put forward an opinion on a socio-political issue linked to the mining industry based on what you have learned during your research project. You will be divided into groups of four. You need to do the following:

Choose a topic and a side

Within your group of four you need to split into two pairs. The one pair needs to propose the statement and the other pair needs to oppose the statement. The topic will depend on which mining industry you covered during your research project. The three topics to be covered are:

Topic 1: Gold mining

'The benefits of gold mining in South Africa outweigh the costs.'

Discuss this statement in light of the evidence uncovered during your research. In your argument you should take into account what you have learned about the industry's impact on the health sector (e.g. AIDS), economic sector, industrial sector (industrial applications of gold & industrial growth due to mining industry), environmental sector (waste production, sustainable development, etc.) and social sector (e.g. displaced communities and migrant workers).

Topic 2: Iron & Coal industry

'South Africa is a developing nation and therefore should not be held accountable to the same extent for its pollution and contribution to global warming as the USA and Europe.'

In debating this issue, look into climate change and carbon trading and consider its impact on African countries, the Kyoto agreement, considering our industrial history, as well as that of developed nations, such as USA and UK. Al Gore's movie 'An inconvenient truth' might be a useful resource for some of this background. Suggest viable alternatives to energy production in South Africa.

Topic 3: Phosphate industry

'All food should be produced organically and fertilisers should be banned since they contribute to the impending water crisis through eutrophication.'

Weigh up the benefits and costs of using phosphates as fertilisers in light of nutritional benefits that they add to the farming industry as well as eutrophication & the impending water crisis.

Construct your argument

- State the problem in your own words.
- Think about the problem in light of your literature search and research – form an opinion/choose a side; weigh up the evidence for your opinion.
- Offer your opinion and reasons for your position – make sure you rely on accurate, reliable & multiple justifications – attempt to persuade or convince your friends of your opinion.
- Consider: Your friend disagrees with you. Define his/her position and offer reasons for that position. How will you answer your friend? Explain (this would be your rebuttal and counterargument).
- Are there flaws in your opinion? How would you defend your position in light of these flaws?

Remember: There is an important distinction between knowledge & values. You all share the same knowledge base. However, each one of you may make your own independent value decisions. You need to respect alternative points of views. Try not to make your argument personal. Use rational and scientific facts to justify your opinions and to oppose your friend's opinion. Be aware that there may not be one solution to a problem, it may be more complex than this – real life problems are not clear cut. Often we need to take all points of view into account in order to make the best possible decision at the time based on the available information to us at the time.

Remember good arguments include accurate, reliable & multiple justifications. They also refer to alternative arguments & rebut them.

Debate: Marking Rubric

Name: ....

Names of other group members:
1. ....
2. ....
3. ....

LO1:		**0**	**1**	**2**	**3**	**4**
Practical scientific inquiry and problem-solving skills	Interpretation of information from research findings					
	Communicating and presenting information and scientific arguments					
LO2:		**0**	**1**	**2**	**3**	**4**
Constructing and applying scientific knowledge	Scientific accuracy of content					
	Relevant application of scientific knowledge to the issue that is being addressed					
LO3:	Learners were able to address the following:	**0**	**1**	**2**	**3**	**4**
The nature of science and its interrelation ship to technology, society and the environment	Impact of science and technology on socio-economic development					
	Impact of science and technology on human development					
	Impact of science and technology on the environment					
Participation		**0**		**2**		
	Learner participated in the debate	**No**		**Yes**		
			Total:		**/30**	

Mindset Lessons: Resources of the Lithosphere Additional Information for the Teacher

Six lessons of approximately 20 minutes each are included on the DVD. The lessons are meant for the teacher and can be used to broaden your knowledge about the industry and to equip you to teach this section with confidence. Due to space restrictions, only the low resolution versions of these lessons are supplied. The high resolution versions can be obtained from Mindset.

Summary of the Lessons

Lesson 1: Mineral Resources of the Lithosphere

In the first lesson learners are introduced to the Earth's crust and its composition. They find out that mineral compounds combine to form different types of rock and that these minerals are unevenly distributed within rock.

Minerals are defined as inorganic substances with a definite chemical composition. The learners discover that by observing a sample of rock, its components can be analysed to give insight into how it was formed. The lesson also investigates the history of our ability to extract metals from ore; this is closely related to our capacity to harness fire. Learners are briefly exposed to the social and environmental impact of mining.

Lesson 2: Gold

The second lesson is focused on gold mining and extraction processes used to produce gold. An expert begins by explaining how the Witwatersrand basin was formed – gold granules were deposited amongst pebbles in an ancient seabed, then covered with silt and exposed to conditions that created conglomerate which is embedded with gold. This enables learners to observe and identify the type of conglomerate that bears gold. They experience, with the presenter, what it is like to be a miner and travel down a mineshaft into the working tunnels i.e. cross-cuts, drives and raises. They discover that the chemical extraction of gold is quite complex and makes use of 'activated carbon' technology. The carbon granules have many, many small pores giving each granule an extremely large surface area. This makes the new technology far more efficient in the adsorption of potassium gold cyanide if compared to the old method of precipitating gold using zinc. Gold precipitation with zinc is an example of a redox reaction and can be used when teaching Chemical Change.

Lesson 3: Iron and Phosphates

The third lesson explores the history of iron extraction and how iron has been used in Europe and the Far East; you also listen to the life experiences of an African expert in this field. The terms 'wrought iron' and 'cast iron' are defined. This lesson also explains the opencast mining of both iron and phosphate and explores the environmental impact of this mining method. The extraction of iron in the blast furnace involves carbon dioxide reacting with coke to produce carbon monoxide. In the next step it reacts with iron ore to form iron. At this point the learners may find it useful if you review what has been discussed or if the video is replayed to grasp the full extent of the chemical reactions. A pause button also appears to facilitate a discussion about the redox reaction of carbon monoxide and Fe^{3+}. A flow chart helps learners to visualise the sequence of extracting phosphates. The environmental impact of fertilizers is also discussed.

Lesson 4: Fossil Fuels

In this lesson an expert shares the information about South Africa's huge reserves of coal and how they were formed – dead plant material was pressurised at high temperatures for a long period of time. Coal is a very useful fossil fuel because it burns very well in air, producing energy in the form of heat. It is mined using an opencast method or the board-and-pillar method. This lesson also explores crude oil, another kind of fossil fuel.

The learners discover that crude oil is formed in a similar way to coal and is extracted from a well drilled into the ground. An expert explains that it consists of many different organic molecules which have a different number of carbon atoms bonded together. These different molecules are separated out by fractional distillation; the learners find out what each fraction is used for. Some of the longer chains are broken apart in a process called 'cracking'. The two resulting pieces are used in the plastic industry and for petrol.

Lesson 5: Environmental Impact of Mining

In this lesson an expert informs the learners of the destruction caused by gold and coal mining to the environment. For example, the Earth's crust is weakened and miners can be hurt or even killed.

Water can be contaminated by the leaching of the slime dumps. The increase in heavy metals and nutrients such as phosphates and nitrates also causes eutrophication and the destruction of life in rivers and dams.

Mine dumps pollute the atmosphere with fine, radioactive dust and gases that cause respiratory diseases. This lesson therefore helps learners to discover that the wealth from mining comes with a cost to our environment and us. We therefore need to promote and take responsibility for the rehabilitation of the environment. They find out that the government is taking a stronger stand on these issues and forcing mining houses to abide by environmental laws.

Lesson 6: Energy Resources

This lesson gives learners insight into where South Africa's energy comes from and how some of it is turned into electricity. They are then able to recognise why it is disturbing that most of our energy is harnessed from fossil fuel. The pause button provides a good opportunity to generate class discussion around the problems of relying on fossil fuel for our energy supply. An expert also discusses the pros and cons of alternative renewable energy resources for South Africa.

Lesson Notes

Notes on Lesson 1

The Earth's crust consists of large plates that 'float' independently on the mantle. The molten rock of the mantle is a mixture of various elements. The elements combine to form specific kinds of mineral compounds in the crust. The rocks that form due to the cooling of mantle material are called igneous rock. The rock cycle begins when igneous rock is broken down. Sedimentary rock then forms from the broken down igneous rock and then eventually becomes part of the mantle again.

Minerals are defined as inorganic substances with a definite chemical composition. The atoms of each element are arranged in a particular pattern in different minerals. There are many different minerals found in the crust, each with its own chemical composition and with crystals of different shape, size and colour. The particular combination of minerals gives different rocks their physical and chemical properties. Different rocks are found in different places and the mineral resources they contain are unevenly spread over the Earth. The minerals contained in rock have an impact on the value of the rock. For example, kimberlite rock contains diamonds that formed as the molten material in a volcanic pipe cooled and hardened. Pebbly sedimentary rock, called conglomerate, has rich deposits of gold within it.

When people learnt to control fire this had a revolutionary impact on the way they lived. Fire provided heat for cooking and keeping warm. Importantly, fire enabled people to extract metals from certain ores. These skills, especially those of metal extraction, brought about a new period referred to as the Bronze or Iron Age. Copper and tin were the next metals to be discovered. People discovered that heat could be used to separate copper and tin from the rock in which they were found. This process is called smelting. Eventually they started to mix copper and tin together to make bronze. A mixture of metals is called an alloy. Bronze was better than tin or copper as it was stronger than the individual metals used to make it. Technology progressed further with the smelting of iron. Iron has a higher melting point and is harder and stronger than copper and tin. Even though it involved effort, the objects made of iron were more useful – weapons, jewellry, implements and tools for farming. Today our modern technology and lifestyle depends on a large range of minerals that have to be extracted from the rock in which they are found. Usually the rock containing minerals has to be dug out of the ground, often with the help of explosives. South Africa is very fortunate in having some of the best reserves of minerals in the world. These rich deposits of valuable minerals are a great boost to a country's economy. Mining and mineral processing create jobs, provide resources for industry within the country, earn foreign money through export and can be strategically important for foreign relations.

Notes on Lesson 2

Gold

Gold has metallic properties and is ductile and malleable. It also conducts electricity better than copper and is therefore used on solar panels on spacecraft. Gold has unique properties for example it has a very specific colour. This quality is partly because gold is also inert, meaning it does not combine with other elements to form compounds very easily. It does not therefore react with oxygen in the air and tarnish.

Gold is found in the Witwatersrand basin, originally a very large shallow sea surrounded by large mountains. Some of the rock in these mountains contained gold and over time rivers carried eroded rock and gold into the sea. The denser gold sank in the water and collected between the pebbles of the seabed. The seabed was then covered with layers of silt and sand and lava from volcanic activity. The pebble layer containing the gold hardened to form the rock called conglomerate. The gold rich pebble beds are called reefs. These reefs can be thin or thick, close to the surface, or much deeper in the earth.

A gold mine consists of an intricate web of tunnels called shafts, cross-cuts, raises and drives. The work surface where the ore is drilled and blasted is called the stope. The work area is narrow and hot and has to be cooled and ventilated by air pumps. Miners have a physically demanding and lonely job.

Gold bearing ore is crushed to a powder during a process called milling. A suspension or slurry is formed by adding water to the powdered solid. The slurry is pumped into large tanks. Here potassium cyanide is added and oxygen is bubbled through the slurry. Although usually inert, gold reacts in an aqueous solution of potassium cyanide and oxygen to form potassium gold cyanide and potassium hydroxide.

This process of dissolving gold out of the powered rock is called leaching. The powder has a greater surface area allowing extraction to be more efficient. After leaching the mixture is filtered. The insoluble crushed rock, or gangue, is left on the filter as a residue. It is scraped off and pumped into waste dumps. The filtrate contains potassium gold cyanide in solution. This filtrate is passed through vessels containing charcoal that is used to extract the gold ions. Charcoal has a very large surface area, allowing the gold cyanide complex to be adsorbed from the solution. Adsorption is the process by which one substance accumulates on the surface of another substance. The highly concentrated gold cyanide complex is then washed off the charcoal in a process called elution using a solution of sodium hydroxide and potassium cyanide. Electricity is used to recover the elemental gold from the gold cyanide solution in a process called electrowinning. The gold is cast into bars (called bullion) that are 85% pure gold. Gold from all the gold mines is sent for purification to the Rand Refinery in Germiston.

$$4Au_{(s)} + 8KCN_{(aq)} + 2H_2O_{(\ell)} + O_{2(g)} \longrightarrow KAu(CN)_{2(aq)} + 4KOH_{(aq)}$$

Notes on Lesson 3

Iron

South Africa has the sixth-largest reserves of iron in the world. It is mined in the Northern Cape at Sishen, then the ore is transported far via rail 800 km to Saldanha Bay, and from here it is mostly exported. High-grade deposits of haematite are mined at Thabazimbi. In the past iron was generally melted and poured into a mould that gave the iron object its shape – this is known as cast iron. Wrought iron was also produced by repeatedly heating and hammering it. Today most iron is obtained through open pit mining on the surface of the ground over a very large area. Huge machines are necessary to remove the earth and expose the ore. This type of mining removes the soil and completely destroys the vegetation and the environment unless the pits are filled and the vegetation replaced once the mining operations are complete. The ore obtained through these processes is blasted out using explosives then crushed and sorted into grades. The best grades of ore contain more than 60% iron and require less treatment while lower grades require more refining.

After mining, the iron needs to be extracting from the rock that has been brought to the surface. Clay and sand is washed out of the crushed ore and magnets are used to further separate it from unwanted substances.

$$C + O_2 \longrightarrow CO_2$$

$$C + CO_2 \longrightarrow 2CO$$

$$Fe_2O_3 + CO \longrightarrow Fe + CO_2$$

The iron ore is formed into pellets and sent to a blast furnace for sintering. A blast furnace is a huge, tower-shaped structure, made of steel and lined with heat resistant bricks. The iron ore is fed into the top, along with lime (calcium carbonate) and coke (almost pure carbon). Hot air is blown into the furnace to exothermically oxidise the carbon to form carbon dioxide. The resulting heat energy increases the temperature to over 1 000 ºC, so that carbon dioxide reacts with coke to form carbon monoxide, an important gas. This gas removes the oxygen from the iron oxide, reducing it from Fe^{3+} to Fe. Iron oxide is reduced while carbon monoxide is oxidized. At such high temperatures the iron is molten, and flows to the bottom of the blast furnace.

The iron ore contains mineral impurities such as silica that consists of silicon dioxide. Silicon dioxide reacts with the calcium carbonate to form a molten slag of calcium silicon oxide and carbon dioxide.

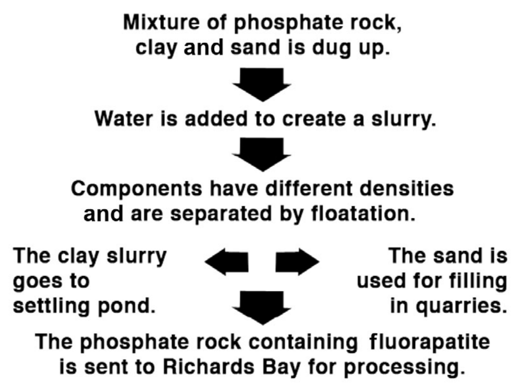
$$CaCO_3 + SiO_2 \longrightarrow CaSiO_3 + CO$$

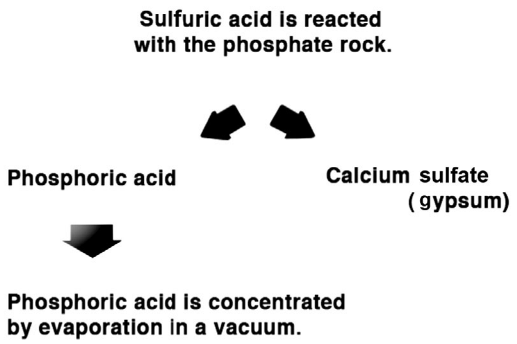
The molten slag is less dense than the molten iron. Each layer is drained separately from the furnace. The iron is cast into pig iron ingots. The pig iron can be further refined in a furnace and converted into steel alloys. The waste products from the extraction process include slag that is used to fill quarries and lay roads.

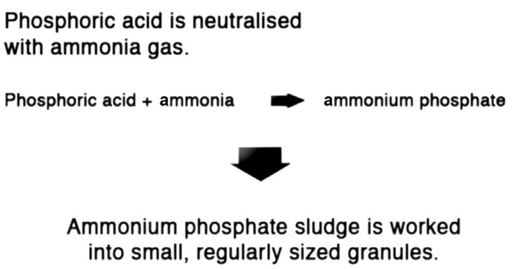
Phosphate

Phosphate is obtained from phosphate-bearing rock which contains fluorapatite. It is mined using the open pit method near Phalaborwa in Limpopo Province. Heavy machinery called draglines scoop up the overburden and dump it in spoil piles on the side of the pit. A mixture of phosphate rock, clay and sand is then dug out and combined with water to create slurry. These components have different densities and are separated by flotation. The clay slurry component is pumped into a settling pond and the sand is removed and used for filling in quarries. The phosphate rock is sent by rail to Richards Bay 800km away for chemical processing into fertiliser.

In the chemical processing, sulfuric acid is reacted with the phosphate rock and this produces phosphoric acid and calcium sulfate (gypsum), they are separated by filtration. The gypsum is discharged while phosphoric acid is concentrated by evaporation in a vacuum. Concentrated phosphoric acid is sold to fertilizer producers in South Africa and overseas. In a fertilizer plant phosphoric acid is neutralised in a reactor with ammonia gas. The resulting sludge contains ammonium phosphate and is pumped into a drum granulator. Here binging and coating agents are added and the sludge is worked into small, regularly sized spheres. The granules are finally dried and bagged. There is debate about how beneficial phosphate based fertilizers are – they can lead to the pollution of rivers and excessive algae growth in lakes and dams.



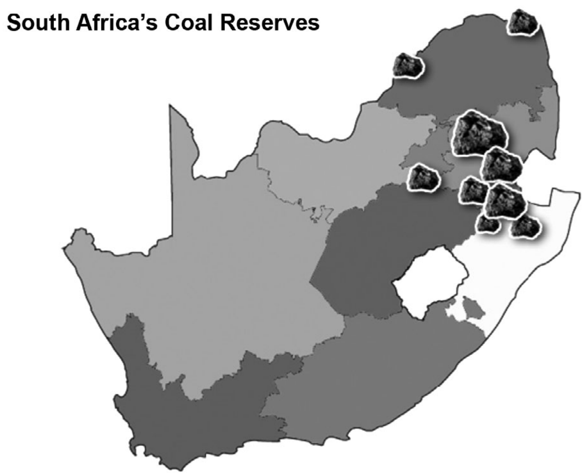




Notes on Lesson 4

Coal

Coal is a hard, black solid that consists of elemental carbon, it is South Africa's most important energy resource. Coal reserves are spread over this country but the Witbank area in Mpumalanga is the most productive.



Coal was formed 200 million years ago. Trees in the large, hot swampy forests of the Karoo basin absorbed energy from the Sun, as well as water and carbon dioxide. Through the process of photosynthesis they produced oxygen and sugars. The sugar molecules, called carbohydrates, were stored in the form of chemical potential energy and this energy is trapped within the bonds of the coal, natural gas and crude oil. In the case of coal, the trees died and were buried under layers of sand and water. Along with other dead plant material, they were compressed and changed into coal over millions of years.

Crude oil and natural gas were formed in a similar way; these energy sources are however made up of animals and plants that lived in tropical seas. When fossil fuels are burnt in oxygen they release their trapped chemical potential powerfully in the form of heat. This makes these substances unique and very useful.

$$\text{Fossil fuel} + O_2 \longrightarrow CO_2 + H_2O + \text{energy}$$

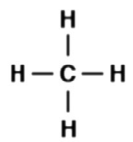
Coal requires pressure, temperature and time to form. The greater the pressure and temperature exerted on the plant material, the more matured the coal becomes. Coal matures from peat to lignite, to bituminous, to anthracite – it is more effective as a fuel if it is harder. South Africa's coal was laid down over a period of about 55 million years and is nearly all bituminous. It is of low quality and has a high ash and low sulfur content. South Africa is the world leader in the use of low quality coal. Opencast operations are used to extract coal from thick, shallow seams from a few metres to 300 m deep). Alternatively if the coal seams are lying less than 70 m below, the board-and-pillar method of extraction can also be used. Opencast coal mining involves excavating long, narrow, parallel trenches. The overburden rock and soil is blasted and scraped out of one trench and tipped into the previously mined-out trench. This is carried out by walking draglines that hold a bucket attached to a boom-like arm. The exposed coal seams are drilled and blasted and the coal is transported away from the pit by heavy-duty trucks. Once all the visible coal has been removed, the pit is filled in with the overburden from the next parallel trench. The overburden is flattened, the stored topsoil is spread over it, and indigenous grasses are seeded.

In the board-and-pillar method the seam is mined leaving columns or pillars of coal holding up the roof, provided that the pressure exerted by the overlying rock is low. About 90% of the coal can be recovered if timber hydraulic props and steel walls and supports are used to prop up the roof of the mine. Mechanical coal cutters with rotational steel picks carry out most of this mining.

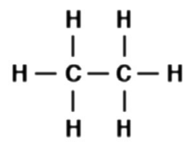
Crude Oil

In order to obtain crude oil a hole has to be drilled into the reservoir rocks that contain the oil. The oilrig is a superstructure that carries the load of the drill bit and the drill string. It also houses the machinery to rotate the drill bit and lengthen the string. After the hole has been drilled a metal casing is cemented into it. This is used as a passageway to drill deeper and install more casings. As the hole gets deeper the casings get smaller in width. The casing in contact with the oil reservoir has holes in it so that the oil can seep into the well. Acid is used to crack the rock and create pathways for the oil to move. Tubing is also packed into the casing to increase the speed of oil flow. The oil moves from a high pressure to a low pressure. If the difference in pressure is not great enough, a pump has to be used to help the oil to the surface.

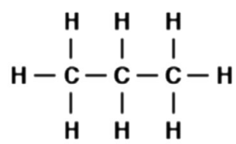
Crude oil consists of many different hydrocarbon compounds that are made up of carbon and hydrogen atoms only, each having a different number of carbon atoms in a chain.



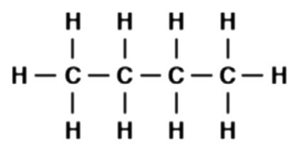
Methane (CH_4)



Ethane (C_2H_6)

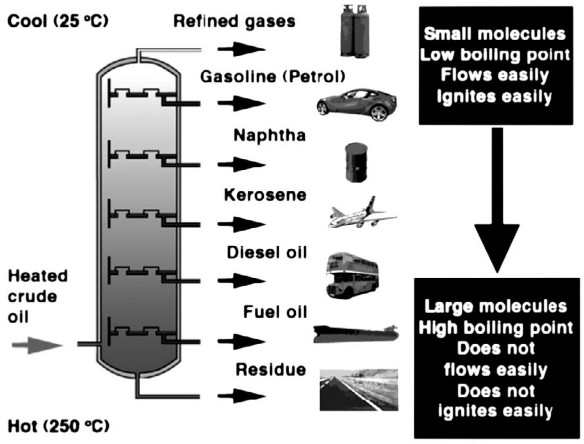


Propane (C_3H_8)



Butane (C_4H_{10})

Each hydrocarbon compound has unique properties such as boiling point, viscosity and reactivity. The crude oil mixture is separated into batches of compounds with similar properties – called fractions – by fractional distillation at a refinery. The technique of fractional distillation makes use of the unique boiling points of different hydrocarbons to separate the compounds. The crude oil is heated and when the temperature reaches the boiling point of the fraction with the lowest boiling point, it will change to a gas. The hot gas rises up the column and is taken away by huge pipes. It is then cooled and allowed to condense. As the temperature increases, subsequent fractions boil off.



The first fraction contains hydrocarbon molecules with less than four carbon atoms per molecule and is called refinery gas or liquid petroleum gas. The second fraction has between 5 and 10 carbons per molecule and is known as petrol or gasoline and naphtha. The third fraction between 10 and 16 carbon atoms per molecule is referred to as kerosene. The fourth fraction containing between 14 and 20 carbon atoms is brown diesel fuel. The dark brown residue left behind can be distilled further to produce lubricating oil, waxes and petroleum jelly. Bitumen is left over finally; it is black and is used for tarring roads. The carbon chains found in the residue fraction are very long, containing over 20 carbon atoms per molecule. These molecules are cracked or broken into smaller molecules by heating the molecules in the presence of a catalyst. The long molecules start to move faster, colliding with one another, and eventually they break apart. This produces smaller molecules such as octane that has eight carbon atoms, and ethene that has two carbon atoms and is used in the production of plastics. Octane is added to the petrol fraction to increase the volume of the petrol fraction.

Notes on Lesson 5

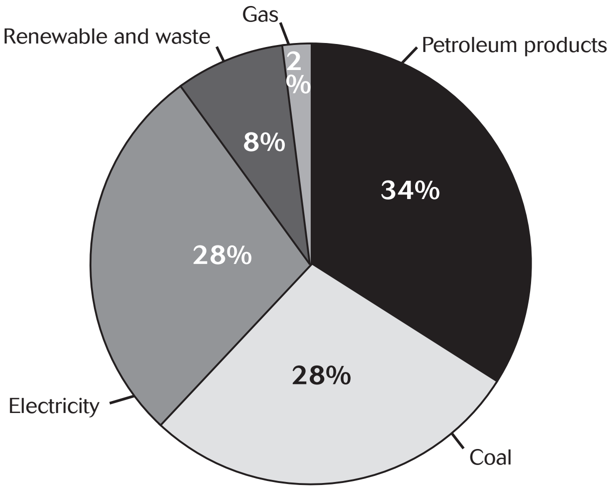
Mining and the processes used to extract minerals from ore damage our environment. Changes to the land itself are clear. For example, the crust can become unstable and result in small, localized earthquakes. Instability also results in underground rock falls that cause serious injury to miners. Pumping ground water from mines also lowers the water table leaving the overlying rock unsupported. These rocks collapse and open up huge holes called sinkholes. Mining industries produce different contaminants that are flushed away using water. This affects underground and surface water in streams, rivers, dams and wetlands and they become contaminated with salts and heavy metals like iron, cadmium, arsenic, copper, lead and zinc. During the metal extraction process, water is mixed with finely ground ore to create the slurry. After extraction the slurry is called slime and contains by products that are toxic such as zinc, copper sulfate, sodium cyanide and sodium dichromate. Sulfates are also contaminants as their ions react with water to form acidic solutions.

Slimes are pumped into dams and as the slime dries out the next batch of slime is poured on top. The dam therefore grows in height. Unfortunately slimes dams are not self-contained and the toxic waste is leached into the surrounding soil and ground water. High concentrations of calcium, magnesium and sulfate ions are found in waste-water from coal mines. Water collects in old mines and reacts with the minerals in the exposed rock forming acidic solutions of heavy metal ions. As this water is acidic, it is able to dissolve more compounds in the rock and this further increases the toxicity of the water. If this water is not pumped out, it may begin flowing out of dry springs and the mines themselves – this is called decanting. The high levels of sulfates and heavy metals in the water make it potentially harmful. Water from our mining industry needs stringent purification before being pumped into our water systems. The levels of sulfates, iron and uranium per litre far exceed the safety limits set by World Health Organisation. These toxins can cause vomiting and diarrhoea. Fish and animals die from acidic water filtering into dams and wetlands. An increase in nitrates, sulfates and phosphates encourages huge bursts of algae growth called eutrophication. The algae uses up the oxygen so fast that other aquatic and marine life is starved of oxygen. The ecosystems are completely knocked out of balance and many organisms die. The atmosphere is also affected by mine pollution. Even though some mine dumps are grassed, contaminated dust still blows off them. The contaminated dust from the gold slimes dams can both cause and aggravate sinusitis, asthma, bronchitis, burning eyes and headaches. Dumps can contain dangerous substances such as small quantities of radioactive material and asbestos fibres that cause an incurable form of lung cancer. Old coal mine dumps in Mpumalanga burn spontaneously releasing carbon dioxide into the air; a greenhouse gas which contributes to global warming.

Notes on Lesson 6

In South Africa, 91% of our energy demands are met by fossil fuels – coal, oil and gas. We have large reserves of coal that we burn directly to generate electricity, make petrol, coke and gas; one-third is exported. We use about 76% of the oil we need to power our vehicles and aeroplanes. The use of these fossil fuels is however destroying our environment. For example, coal mining scars the landscape. Also when we burn coal and oil they release carbon dioxide, nitrous oxide, sulfur dioxide and methane – all green house gases. Carbon dioxide, sulfur dioxide and oxides of nitrogen react with water in the air to form acid rain.

Energy Consumption in SA in 2005



Fossil fuels take millions of years to form. They are non-renewable resources because we use them up too fast to be replaced. The time will also come when there is no more coal and oil available. We need to import oil, so we are vulnerable to rising prices and there is also the possibility that supplies could be cut off for political reasons. Alternative energy sources are therefore urgently needed. There is a global effort to develop sustainable sources of energy that do not produce pollution and are renewable. Wood is a major source of energy in many households, especially in rural areas in South Africa.

Wood is renewable because more trees can be planted but it is not a pollution free energy source. Cow pats and mielie cobs are also burnt for cooking but they do not generate a lot of energy and could be more effectively returned to the Earth and used as a fertiliser. Hydrogen can be used to power cells in some cars. Methanol (derived from sugar cane) is also being used to fuel some motor cars, people are also investigating making diesel from sunflower oil.

The plant called jatropha is also a potential source of energy; it may however be invasive if grown in our environment.

Eskom, the national electricity utility, generates and supplies most of South Africa's electricity. Eskom has built huge coal-fired power stations for this purpose. Coal is used to heat water and generate steam; this steam turns turbines and then generators create electricity. There are twenty operational power stations in South Africa. They are usually found near coal mines so that the coal can be carried along conveyer belts to the station. These huge power stations have given us the cheapest electricity in the world, but many people are still not linked to the national electricity grid or cannot afford it. The government has allocated over R 200 million towards providing free basic electricity.

Koeberg supplies Cape Town with energy and produces about 6% of our total electricity. This nuclear power station splits uranium atoms in a reactor, releasing energy which is used to make steam for driving generators. Eskom is investigating the development of a new nuclear power unit called a Pebble Bed Modular Reactor.

Using nuclear energy is however a contentious issue and there is concern about its safety.

Also, because nuclear energy is derived from a mineral resource, it is not a renewable form of energy. A very small portion of power is derived from hydroelectric power in South Africa. Here the energy of falling water is used to drive turbines to generate electricity. We also make use of wind power, solar

energy and biological waste material (called biomass).

Various other options for alternate energy resources are being investigated:

- After the juice from sugar cane has been extracted it forms waste called bagasse. This can be used to create steam for heat and electricity generation.
- The rubbish in landfills can be burnt or changed into biogas containing methane. Methane can be used as a fuel to heat water or run gas turbines for electricity generation.
- Solar energy has high potential but at present it is mainly used to heat water in households to supplement electrical geysers. This reduces the amount of electricity needed but does not generate electricity. It can be used to make electricity using a photovoltaic cell; this is expensive equipment and needs to be renewed about every 20–25 years.
- We have good coastal conditions for wind and turbines on a few farms are used to generate DC current. Eskom has installed two wind turbines for research purposes at Klipheugwel in the Western Cape and there is also talk of a Darling Wind Farm. Besides being expensive, large areas of land must be claimed and a lot of noise pollution is generated.
- Further hydroelectric plants are not likely as we are a relatively dry country. The problem with alternative energy sources is the high cost, the large scale to which energy plants have to be built, and the environmental implications. We also therefore need to consider using electricity efficiently. This means using only what we need. For example, walk, use a bicycle or take public transport instead of a car, put a jersey on instead of a heater. Try not to waste, and switch lights off when leaving a room. It is important to choose low-energy options when they are available – like energy saver light bulbs and well-insulated hot boxes. Introduce energy friendly materials and designs such as insulation in the ceiling and buildings that face north and so catch the sun in winter but stay cool in summer, try to cook cleverly by putting more than one thing in the oven at a time and making sure that equipment is in good working order.

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Evaluation Form
Mining and Mineral Processing Resource Pack

Please complete the following evaluation form and return it to:

Attn: Mrs René Toerien
University of Cape Town
Department of Chemical Engineering
Private Bag
Rondebosch
7701

Fax: 021-6505501
Email: rene.toerien@uct.ac.za

Name of school: ---

Name of your subject advisor: ---

City / Town and Province: ---

School tel no: ---

School fax no: ---

Name(s) of physical science teacher(s): ---

Contact email address (if available): ---

Number of learners per class: ---
(if more than one class, then specify, e.g. 24 + 29)

Which activities did you use? (Please circle.)

		If yes, please specify which activity/video you have used
Getting started (pages 4–10)	Yes / No	
Audio visual material (pages 11–13)	Yes / No	
Practical activities (pages 14–22)	Yes / No	
Research Project (pages 23–31)	Yes / No	
Consolidation activities (pages 32–41)	Yes / No	
Mindset lessons (pages 42–50)	Yes / No	

Did your learners use the learner information sheets? ---

Which industries did you cover? Gold / Coal / Iron / Phosphate / All of them ---

General comments: ---

Evaluation Form
Mining and Mineral Processing Resource Pack

Please rate each of the following on a 0–5 sliding scale where:
0 = did not do the section   1 = poor   5 = excellent

Mining and Mineral Processing Resource Pack	0	1	2	3	4	5
Overall rating of the resource pack as a whole Comments:						
Overall rating of the audio-visual material Comments:						
Overall rating of the practical activities Comments:						
Overall rating of the consolidation activities (presentation, role play and debate) Comments:						
Overall rating of the Mindset lessons Comments:						
Overall rating of the learner information sheets Comments:						
Overall rating of the research project Comments:						
Did the learners enjoy doing the research project?						
Did the learners enjoy presenting the project?						
Did the learners enjoy working in groups?						
Did the learners impress you with the research project?						
In your opinion, are your learners able to 'talk science'/converse in a scientific language?						
Was marking the research project acceptable in terms of time spent on it and ease of marking?						
Would you recommend this project to your colleagues?						

Signed: ---------------------------------

Date: ------------------------------------

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Skool se inligting

Naam van skool: --

Telefoon (skool): --

Faks (skool): --

Hoeveel leerders in die skool (ongeveer)? --

Hoeveel leerders in Graad 11 Fisiese Wetenskappe? --

Onderwyser se inligting

Titel: ------------------------ Naam: --

Van: --

Selfoonnommer: --

Handtekening: --

Datum: --

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The People Behind this Resource Pack

- Mrs René Toerien, Department of Chemical Engineering, University of Cape Town, who was the project coordinator, compiled the materials, and coordinated trials, workshops, and rollout
- Dr Gillian Sheridan, Department of Chemical Engineering, University of Cape Town, who initiated the project in her postdoctoral work
- Associate Professor Jenni Case, Department of Chemical Engineering, University of Cape Town, who supervised the project
- Dr Jonathan Clark, Schools Development Unit, University of Cape Town, who gave valuable advice and comment
- Ms Nickie Wallace, St Cyprians School, who helped in the writing of the teacher's guide
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- The many Physical Science teachers who participated in the trials, offered help, shared ideas and gave encouraging comments

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Contact information

This resource pack was compiled by Mrs René Toerien. Her contact details are as follows:

Postal address:
Mrs René Toerien
University of Cape Town
Department of Chemical Engineering
Private Bag
Rondebosch
7701

Email: rene.toerien@uct.ac.za
Fax: 021 650 5501
Tel: 021 650 5527

AngloAmerican

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