The chemical element gold, atomic number 79, symbol Au (from the Latin ‘aurum’), is a soft, lustrous yellow, malleable metal and is one of the transition metals.

Its atomic weight is 196,967 and belongs to group 11 in the periodic table, along with copper and silver.

Although the Earth's crust averages a mere 0,004 grams of gold per ton, commercial concentrations of gold are found in areas distributed widely around the globe. The metal occurs in association with ores of copper and lead, in quartz veins, in the gravel of stream beds, and with pyrites (iron sulfide). Seawater contains astonishing quantities of gold, but the process of recovery is not economical.

The distribution of gold seems to validate the theory that it was carried toward the Earth's surface from great depths by geologic activity, perhaps with other metals as a solid solution within molten rock. After this solid solution cooled, its gold content was spread through such a great volume of rock that large fragments were unusual; this theory explains why much of the world's gold is in small, often microscopic particles. The theory also explains why small amounts of gold are widespread in all igneous rocks; they are rarely chemically combined and seldom in quantities rich enough to be called an ore. Because of its poor chemical reactivity, gold was one of the first two or three metals (along with copper and silver) used by humans in these metals' elemental states. Because it is relatively unreactive, it was found uncombined and required no previously developed knowledge of refining. Gold was probably used in decorative arts before 9000 BC. Even civilizations that developed little or no use of other metals prized gold for its beauty.

Did you know

Pyrite is referred to as "fools gold", since many a prospector brought home the shiny iron sulfide, and staked claims on their "gold’ deposit, which turned out to be pyrite. All that glitters is not gold.

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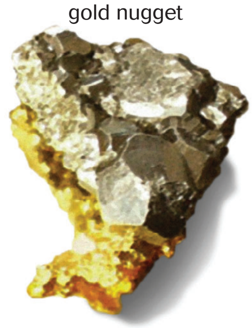
Gold ore

Pyrite on top of gold nugget



10 Facts About Gold

1. **Most of the world's gold comes from Africa.** Africa is home to two-thirds of all the gold ever mined.
2. **Gold never rusts, corrodes or tarnishes.** This is why so many ancient gold artifacts remain intact to this day.
3. **Gold can be hammered into a very thin sheet.** It can be flattened until it’s so thin, it's semi-transparent!
4. **The deepest gold mines in the world are located in South Africa.** South Africa's deepest operating mine is AngloGold Ashanti’s mine TauTona, in Carltonville, which is 3,5 kilometres deep.
5. **Africans have been goldsmithing for thousands of years.** The deep-level gold in the South African Witwatersrand Basin area was only discovered about one hundred years ago. The oldest gold artifacts are Egyptian, some dating from 1352 BC.
6. **It is safe to eat gold.** In some societies, eating gold is common, as the metal has no negative

effect on the human body. In fact, this is the reason that gold can be used for tooth fillings.

7. **West Africa was once the world's leading supplier of gold.** Between the 11th and 17th centuries, West Africa was the leading supplier of gold in the world. In the later Middle Ages, this region supplied almost two-thirds of the world's gold production.

8. **Gold is used in everyday technology.** It is used in very small microchips in computers, telephone exchanges and many other industrial applications.

9. **Gold is used by astronauts in outer space.** Astronauts who walk in space are attached to the spaceship by a cord covered in gold to protect it from the heat of the sun. Parts of spaceships are also covered in blankets made of gold to keep the heat out.

10. **Gold can be used with glass to make windows.** Gold can be electroplated with glass to help keep buildings cool by keeping the sunlight out.

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Frequently Asked Questions

1. What is gold?

It is a rare, yellow metal that occurs naturally in many different places around the world. It can be found in its pure form or mixed with other minerals.

2. Where is gold found?

All around the world. The major gold-producing countries include South Africa, Canada, the United States and Australia.

3. Why is Au the chemical symbol of gold?

Au is an abbreviation of the Latin name for gold, aurum, which means 'rising dawn.'

4. Where does the English word 'gold' come from?

The Old English word for gold, 'geolu', which means yellow.

5. What is a carat?

The unit measures the purity of an item of gold. Carats are expressed as fractions of 24. Pure gold is 24 carat, while 12 carat gold means there are 12 parts pure gold and 12 parts other metals.

6. How stretchy is gold?

It is the most malleable of all metals. One ounce, about 30 grams, can be hammered into a sheet more than 30 metres across on each side. It can be hammered so thin that it becomes transparent and light can pass through it.

7. Can base metals be turned into gold?

No. Alchemists have tried and failed throughout history to change other substances into the precious yellow metal.

8. What is an acid test?

This is a method used to determine the purity of gold by subjecting the metal to various acids like nitric acid and hydrochloric acid. If the gold is pure, it will remain its natural colour and texture. If it has been mixed with copper or another substance, the metal will turn blue!

Tutankhamun's gold death mask

Frequently Asked Questions (continued)

9. What is an alloy of gold?

This is a mixture of gold with such metals as copper, silver, zinc and platinum.

10. What is 'fool's gold'?

Fool's gold is the popular name for iron pyrite. This metallic-looking sulfur mineral is sometimes mistaken for gold, but it is hard and brittle, whereas gold is soft and malleable.

11. What is the 'gold standard'?

The gold standard was historically used as a monetary system whereby a country backed its paper currency with gold and agreed with other countries on a fixed price at which to buy and sell gold. The gold standard is no longer used by any nation.

12. What is the 'gold fix'?

Twice per day, the London gold pool (five members of the London Bullion Market Association) sets the price of gold based on basic economics of supply and demand. These prices are then transmitted throughout the world.

13. What is a gold nugget?

A gold nugget is a mass of gold that has been washed from the rock that contained it and deposited in a riverbed. Gold nuggets usually range in mass from about 30 grams to 50 kilograms. The heaviest nugget ever recorded was called the 'Welcome Stranger'. It was found in Australia in 1869 and weighed 70,9 kilograms or 200 lbs.

14. What is gold leaf?

Beating of gold into very thin sheets, or leaf, is an ancient craft. Skilled goldsmiths can hammer gold so thin that it would take 250 000 sheets of it to make a layer an inch high. Gold leaf is used to decorate things like buildings, picture frames and ornaments.

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Gold mining in South Africa. From extraction to 99% pure gold.

South African gold mines are deep-level mines reaching depths of over three kilometres.

1. **Going Underground**

   Miners go underground in shaft cages and then walk or take trains to the workface. When sinking a new shaft they descend in buckets, called kibbles.

2. **Safety Equipment**

   All miners wear hard hats, boots and carry battery lights and, when appropriate, use personal protective equipment like earplugs, goggles and respirators.

3. **Stoping**

   Miners work in teams in low, narrow workplaces called stopes. Their first task is to ensure the stope is safe by barring down loose rocks and installing support structures. Then they begin to drill.

4. **Ore Extraction**

   Holes are drilled in the gold-bearing reef using a pneumatic rock drill. These holes are filled with explosives and timed with igniter cord and fuses to ensure a pre-determined sequence of blasts. The area is blasted in order to free the gold-bearing rock from the face. This rock is then scraped away from the stope into box holes, where it is drawn off into hoppers, or small railway cars, hauled by locomotives.

5. **Ore Transport**

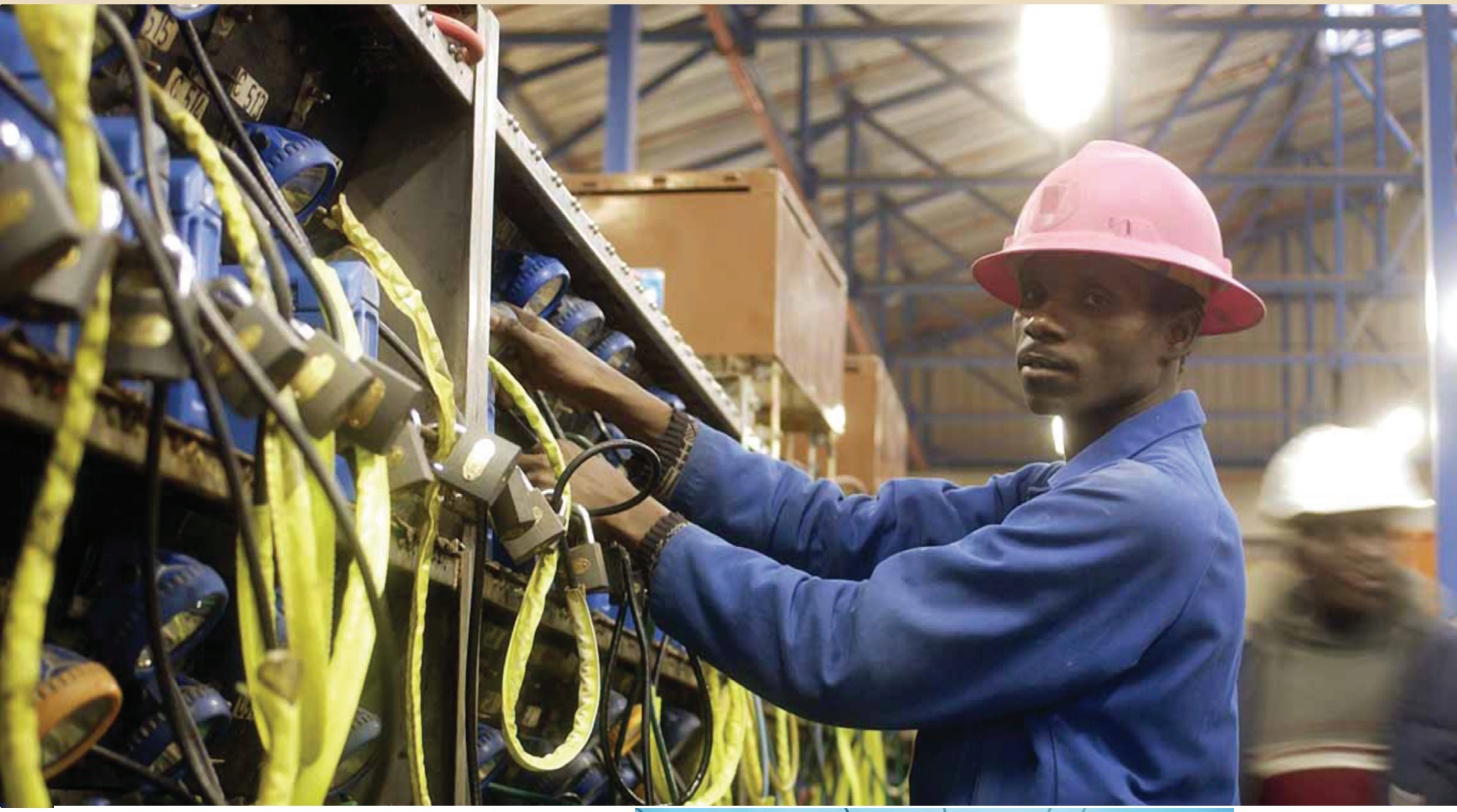
   Ore is hoisted from the lowest underground level of the mine in skips and then transported to the gold plant by rail hoppers or conveyor belts.

6. **Crushing and Milling**

   Ore is crushed and then milled to a fine powder.

7. **Leaching and Carbon-in-Pulp**

   Gold is leached from slurry by means of a diluted cyanide solution. Carbon is used to absorb gold from the solution. This is called 'carbon-in-pulp' process.



8. Gold Recovery Process

The carbon particles are screened from the pulp and chemically treated to produce a pure solution for electrowinning.

9. Smelting of Gold

The cathode sludge is dried and smelted in an electric furnace to produce gold bars of $99^{+}\%$ purity.

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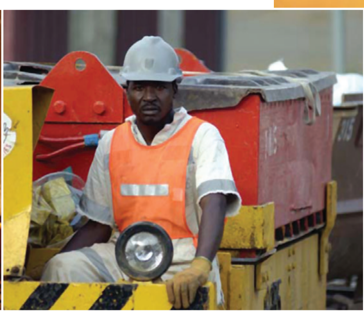


Eternally fascinating gold. Historians believe that gold was the first metal known to man, possibly as long ago as 6000 years. It was love at first sight.

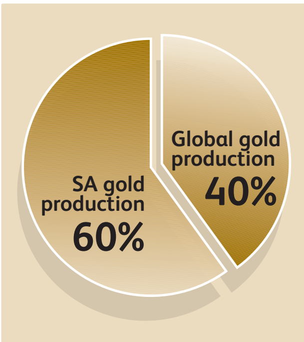
Ever since, man has desired gold for its sheer beauty, and for the ease with which he can make it into beautiful objects.

Because they have survived in situations where objects made of other materials have perished, gold artefacts are a source of much information about ancient civilisations. In such civilisations, gold was not used only in jewellery. It gradually became a major symbol of wealth and power. It even became a standard of value, hence the expression 'as good as gold'.

Over the centuries, gold has been used as money and in modern times, it has come to be used in industry such as dentistry, computers, electronic circuits, and even in the aero-space industry.

The Story of Gold in South Africa

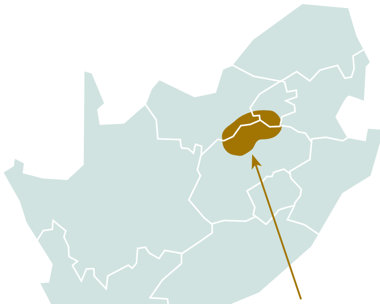
South Africa, with a production of about 60% of the gold mined in the world today, is the world's largest producer (2006). Many South Africans depend on gold, which is the country's main export and the nation's largest single industry and second largest employer (after the agricultural sector), for their livelihood.



Brief Overview

The first significant discoveries of gold in South Africa were made in the then Eastern Transvaal (now Mpumalanga) in the 1870s. They gave rise to 'gold rushes', particularly to the Pilgrim's Rest and Barberton areas. Although gold is still mined near Barberton today, the deposits of the metal in these two areas ultimately proved small in relation to those of the gold-bearing Witwatersrand reefs.

An outcrop of these was first discovered in 1885 by an Australian handyman/prospector, George Harrison, on the Oosthuizen farm, 'Langlaagte', on what are the western outskirts of present day Johannesburg.



The full extent of these reefs has emerged only gradually over the years. At present they are being mined over an arc which is about 500 kilometres in length and extends from beyond Virginia in the Free State, through Klerksdorp in North West, Carletonville, Krugersdorp and Johannesburg (Gauteng) to Kinross in Mpumalanga. They constitute by far the largest known deposits of gold in the world and are still the source of considerably more than half of the annual world production of newly-mined gold.

The most productive mines are situated in the 'West Wits' and Free State sections of the arc (the 'shoreline' of the Witwatersrand Basin), where there are a number of mines each producing more than 20 ton of gold per annum.

The Witwatersrand Basin

Experts believe that about 250 million years ago a great inland sea existed in what is now the Highveld (parts of North West and Gauteng) and the Free State plains. Successive layers of conglomerate containing pebbles and gold were washed down into the sea and spread over the bottom by wave action. The gold particles subsequently settled in successive layers of pebbles along the shoreline of this sea, which later silted up. Forced into rock formations by the buckling of the Earth's crust in past ages, the gold-bearing pebble layers, in turn, formed the golden reefs of the Gold Fields Limited.

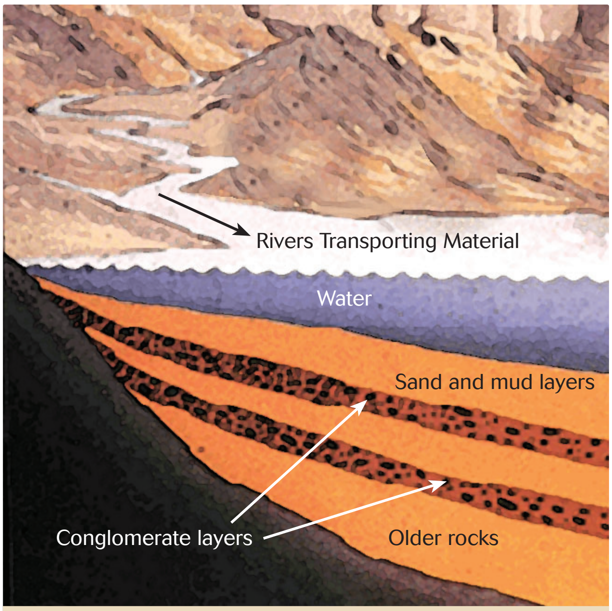
A Brief History of Gold

2

How Gold is Mined in South Africa

Modern prospecting culminates in the boring (drilling) of holes into the Earth at selected spots in order to locate the gold reef precisely. These holes (boreholes) may be no more than centimetres in diameter and extend to depths of many thousands of metres.

When payable deposits are found, a mine is developed. After headgear and other equipment have been installed, a shaft is sunk to reach the areas of gold-bearing rock. Tunnels (called 'cross-cuts' are then driven at various levels from this shaft, until they strike the inclined plane of the gold bearing reef. These 'cross-cuts' are excavated by drilling patterns of holes at various angles into the 'face' of the tunnel.



The great inland sea which it is estimated was formed about 250 million years ago, showing how successive layers of conglomerate were laid down over the millennia.

These holes are then filled with explosives and the rock is blasted out.

When the cross-cuts reach the reef (the gold bearing conglomerate), other tunnels are developed along the plane of the reef. This is called 'reef development' and exposes the payable ore for mining. The reef is mined by a process of drilling and blasting known as 'stoping'. Barren rock and reef are transported to tipping stations, dropped down a rock chute (ore pass), and hoisted up the shaft. The barren rock is sent to waste dumps and the gold-bearing ore is sent to the reduction works for processing and the recovery of gold.

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Gold in Our Daily Lives

Gold has been with man since the dawn of time and has always been highly prized. In the past, this was chiefly for its beauty but in recent years, gold has become more and more extensively used. Today there is almost no one in the western world, and few in the developing world, whose lives are not somehow touched by gold each and every day.

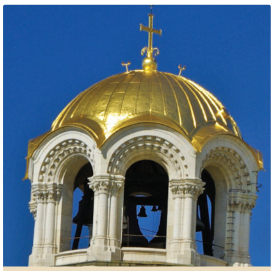
Characteristics of Gold

Durability: The foremost characteristic of gold is its durability. Unlike other metals, it does not tarnish or corrode under normal circumstances. That is why ancient gold, like that found in tombs, and gold coins recovered from the sea bottom, gleam as brilliantly today as on the day they were made. Heat does not

Characteristics of Gold (continued)

corrode or oxidise gold so it therefore can be used over and over. In fact, it is not unlikely that some of the gold in the gold jewellery worn today could have come from ancient Egypt or the land of the Incas!

Malleable and ductile: The second important characteristic of gold is that it is the most malleable and ductile of all metals. It can be beaten into gold leaf so thin that one ounce of it will cover 16 square metres. The domes of the Kremlin and other Moscow buildings are adorned with such gold leaf, as is the famous Mosque of Omar in Jerusalem from which Mohammed is said to have ascended to heaven.



Neo-Byzantium style cathedral dome covered

Gold can be drawn into such fine wire that a gold thread drawn from one ton of gold would stretch the distance to the moon and back. Its versatility makes gold an ideal component of such diverse items as decorative items and umbilical cords for space walkers.

A good conductor: A third property of gold is that it is an exceedingly good conductor of electricity and heat. Only silver is a better electrical conductor, but it lacks gold's resistance to tarnish and corrosion. This accounts for the widespread use of fine gold wire and thin gold films in transistors, minute computer circuits, telephone exchanges, etc. Many hundred million metres of fine gold wire are used each year in the production of micro-circuitry.

An efficient heat reflector: A fourth characteristic of gold is its ability to reflect heat rays efficiently. This is what makes it so valuable as a heat protector in space suits and vehicles. Thus films of gold so thin that they are translucent are applied to the glass of windows in both hot and cold climates. Under hot conditions, the gold eliminates glare, reflects heat from the sun and thus reduces cooling costs. Conversely, the film reflects back heat radiating from within the buildings and so reduces heating costs. Both ways are important in helping to conserve our precious energy resources.

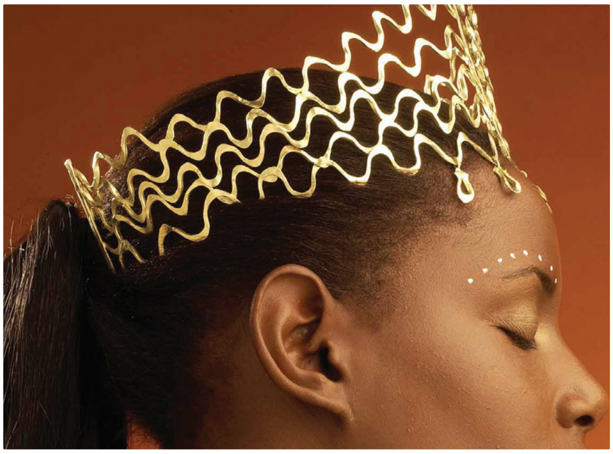
The colour: A fifth significant property of gold is its colour. It is one of the very few metals (copper is another) which is coloured and this is another reason, in addition to its resistance to tarnish and its malleability, for its extensive use in jewellery.

A good mixer: Gold readily mixes with a wide range of other metals to form alloys. Many of these have exciting properties which are very useful throughout industry. For example, gold alloys form the perforated plates through which many of the synthetic fibres for fabrics and clothing are extruded. Again, many of the instruments used in research and for industrial control use gold alloys. Gold alloys are used in the temperature recorders of jet engines.

Nevertheless, the most important alloys of gold are those used in jewellery and dentistry.

Gold in Jewellery

Gold in its pure state is soft and easily deformed, and therefore unsuitable for use in jewellery without some modification of its properties. Such modification can be achieved by mixing or alloying it with other



metals. The extent to which pure gold is alloyed or mixed with other metals is controlled, in most countries by tradition, but by law in others. For this purpose, the gold content of gold alloys is expressed in terms of either caratage or fineness.

Caratage indicates the number of parts of gold present in each 24 parts of alloy; the fineness indicates

the number of parts of gold present in each 1 000 parts of alloy.

As to the relative merits of the different caratages, here is a rule of thumb comparison:

- 22 carat alloys are not as strong as 18 or 14 carat alloys and are used for items of fairly solid construction like wedding rings.
- 18 carat alloys contain 75 percent of gold are used for high quality jewellery although their properties may be matched in some instances by 14 carat alloys containing 58,33% gold.
- Alloys of lower caratages, whose content of gold is less than their content of other metals, are really not gold alloys. Their content of gold is insufficient to prevent them from tarnishing under many conditions, and they are not suited for use in high quality jewellery.

The metals mixed with pure gold in the making of carat gold jewellery alloys are copper, silver, nickel, palladium and zinc. The proportions in which they are added to the gold determine both the properties and the colours of the final alloys.

Gold in Dentistry

Gold was used at least 2000 years ago in historical dental practice; the Etruscans used to wire loose teeth together with strips of gold, and the ancient Greeks and Romans used gold in their crude prostheses.

The properties which make high quality gold alloys

so popular for dental work are their non-tarnishing and non-corrosive qualities. They have no injurious effect on gums and other tissues. They take a high polish, are malleable and can easily be shaped without breaking.

Gold usage in dentistry is almost as old as its usage in jewellery, with the result that there is a long experience of the performance and bio-compatibility of gold alloys in dentistry. This is not the case with many of the base-metal alloys which have been introduced into dentistry in recent years.

Gold and Money

Gold, that lustrous metal of kings, has not always been available to the common man. Somewhere around 700 BC, however, kings began to stamp gold into coins, and in that form they became more widely acceptable. Gold coins became available to the soldier, the merchant and to families who had never possessed a gold bracelet or necklace. They were zealously hoarded against bad times.

Assets and Coins

Because gold is regarded as a valuable asset throughout the world, it enjoys international confidence as a store of value and in many places, people hold at least part of their wealth in gold rather than other investments. This is particularly true of the Middle and Far East where gold jewellery and coins constitute a major medium of investment.

In the western world too, many investors are putting a portion of their wealth into gold. Gold coins are a popular modern means of investment and perhaps the best-known gold coin of all is the Krugerrand, which has a fascinating story of its own.

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Six Basic Processes of Gold Recovery

1. Gravity/Separation

2. Flotation

3. Cyanidation

This is the method of choice- in this process there are a further four options.

- **3.1 Agitated tank leaching**
- **3.2 Heap leaching**
- **3.3 Carbon adsorption recovery** There are a further three options.
  - **3.3.1 Carbon-in-pulp (CIP)**
  - **3.3.2 Carbon-in-leach (CIL)**
  - **3.3.3 Carbon-in-column (CIC)**
- **3.4 Zinc precipitation recovery**

4. Refractory ore processing – this method is used to treat ore where the cyanidation process is not effective. The cyanidation process follows it.

5. Alternative lixiviants – cyanide is most commonly used as lixiviant to extract gold, but other liquid media can also be used. Alternative lixiviants include bromides, chlorides, thiourrea and thiosulfate.

6. Amalgamation – one of the oldest processes available. It relies upon the contact of ore with mercury to form a gold-mercury amalgam. This process is strongly out of favour with the major mining companies, because mercury is so toxic and the process is inferior, when compared to the available alternatives.

Gravity Separation

Gravity concentration processes rely on the principal that gold contained within an ore body is higher in specific gravity than the host rocks that contain the gold. Elemental gold has a specific gravity of 19,3, and typical ore has a specific gravity of about 2,6. All gravity concentration devices create movement between the gold and host rock particles to separate the heavy pieces from the lighter pieces of material.

The prospector's gold pan is the most familiar gravity concentration device. To function properly, the ore must be broken down into particles small enough to provide a significant specific gravity difference among the particles.

Placer mining has generally been where gravity concentrates have been most widely applied. In a placer deposit, there has generally been a pre-concentration of gold made naturally by gravity concentration due to ore particles being transported by water. Mechanical concentration is used to continue the process until sufficient concentration is obtained.


Panning for gold

Gravity concentration works when gold is in a free elemental state in particles large enough to allow mechanical concentration to occur.

The number of types of gravity concentration devised are numerous. Some of the more popular ones are:

1. Sluice boxes
2. Rocker boxes
3. Jigs
4. Spirals
5. Shaking tables
6. Centrifugal concentrators
7. Dry washers

In addition to specific gravity differences, the performance of gravity concentration is also affected by particle shape, as can be imagined by comparing a falling leaf to a falling twig through the air.

Flotation

The flotation process consists of producing a mineral concentrate with the use of chemical conditioning agents followed by intense agitation and air sparging of the agitated ore slurry, to produce a mineral-rich foam concentrate.

Specific chemicals are added to either float (foam off) specific minerals or to depress the flotation of other minerals. Several stages of processing are generally involved, with rough bulk flotation products being subjected to additional flotation steps to increase product purity.

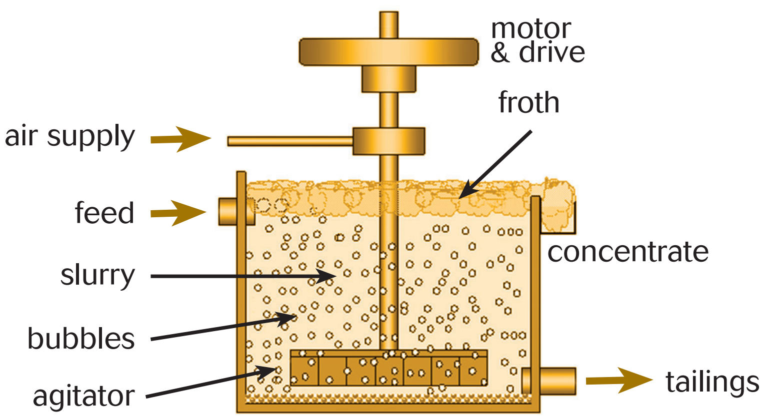
The flotation process in general does not float free gold particles, but is particularly effective when gold is associated with sulfide minerals such as pyrites. In a typical pyrytic gold ore, the gold is encapsulated within an iron sulfide crystal structure. Highly oxidized ores generally do not respond well to flotation.

Advantages of the flotation process are that gold values are generally liberated at a fairly coarse particle size (28 mesh), which means that ore grinding costs are minimized. The reagents used for flotation are generally not toxic, which means that tailings disposal costs are low.

Flotation will frequently be used when gold is recovered in conjunction with other metals such as copper, lead or zinc. Flotation concentrates are usually sent to an off-site smelting facility for recovery of gold and base metals.

Cyanide leaching is frequently used in conjunction with flotation. Cyanidation of flotation concentrates or flotation tailings is done depending upon the specific mineralogy and flow sheet economics.

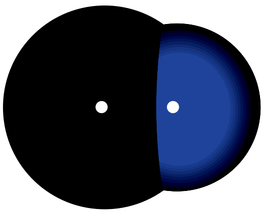
Flotation Cell



Cyanidation

Cyanide leaching is the standard method used for recovering most of the gold throughout the world today. The process originated around 1890 and quickly replaced all competing technologies. The reason was strictly economical in nature. Where amalgamation plants could recover about 60% of the gold present, cyanide could recover about 90%. Because of the improved recovery, many of the old tailings piles from other processes have been economically reprocessed by cyanide leaching. Cyanide is as close to a 'universal solvent' for gold as has been developed. Other leaching reagents will only work on very specific types of ore.

Cyanide CN^-



$(:C \equiv N:)^-$

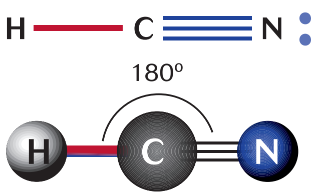
The standard cyanide leach process consists of grinding the ore to about 80% (200 mesh), mixing the ore/water grinding slurry with sodium cyanide and enough quicklime to keep the pH of the solution at about 11,0. At a slurry concentration of 50% solids, the slurry passes through a series of agitated mixing tanks with a residence time of 24 hours. The gold bearing liquid is then separated from the leached solids in thickener tanks or vacuum filters, and the tailings are washed to remove gold and cyanide prior to disposal. The separation and washing take place in a series of units by a process referred to as counter current decantation (CCD). Gold is then recovered from the pregnant solution by zinc precipitation and the solution is recycled for reuse in leaching and grinding.

Merrill-Crowe Recovery: Zinc Precipitation

The traditional method for gold recovery from pregnant cyanide solutions is zinc precipitation. Originally, solutions were passed through boxes containing zinc metal shavings. Gold and silver would precipitate out of solution by a simple replacement reaction procedure. Around 1920, zinc shaving precipitation was replaced by the Merrill-Crowe method of zinc precipitation.

The Merrill-Crowe process starts with the filtration of pregnant solution in media filters. Filter types used include pressure leaf filters, filter presses, and vacuum leaf filters. Generally, a precoat of diatomaceous Earth is used to produce a sparkling clear solution.

Hydrogen Cyanide



The clarified solution is then passed through a vacuum de-aeration tower where oxygen is removed from the solution. Zinc powder is then added to the solution with a dry chemical feeder and a zinc emulsification cone. The reaction of the special fine powder zinc with the solution is almost instantaneous.

Precipitated gold is then typically recovered in a recessed plate or plate and frame filter press.

Carbon Adsorption Recovery

Granular coconut shell activated carbon is widely used for recovery of gold from cyanide solutions. The process can be applied to clean solutions through fluidized bed adsorption columns, or directly to leached ore slurries, by the addition of carbon to agitated slurry tanks. This is followed by separation of the carbon from the slurry by coarse screening methods.

Gold cyanide is adsorbed into the pores of activated carbon, resulting in a process solution that is devoid of gold. The loaded carbon is heated by a strong solution of hot caustic and cyanide to reverse the adsorption process and strip the carbon of gold. Gold is then removed from the solution by electrowinning. Stripped carbon is returned to adsorption for reuse.

advantage of carbon-in-pulp recovery over Merrill-Crowe recovery is the elimination of the leached ore solids and liquid separation unit operation. The separation step typically involves a series of expensive gravity separation thickeners or continuous filters arranged for countercurrent washing or filtration of the solids. For ores exhibiting slow settling or filtration rates, such as ores with high clay content, the countercurrent decantation (CCD) step can become cost prohibitive.

Ores with high silver content will generally suggest that Merrill-Crowe recovery should be used. This is because of the very large carbon stripping and electrowinning systems required for processing large quantities of silver. The typical rule of thumb is that economic silver to gold ratios of greater than 4 to 1, will favor installation of a Merrill-Crowe system, but this decision can be altered if the ore exhibits very slow settling rates.

There are several variations to the carbon adsorption process including:

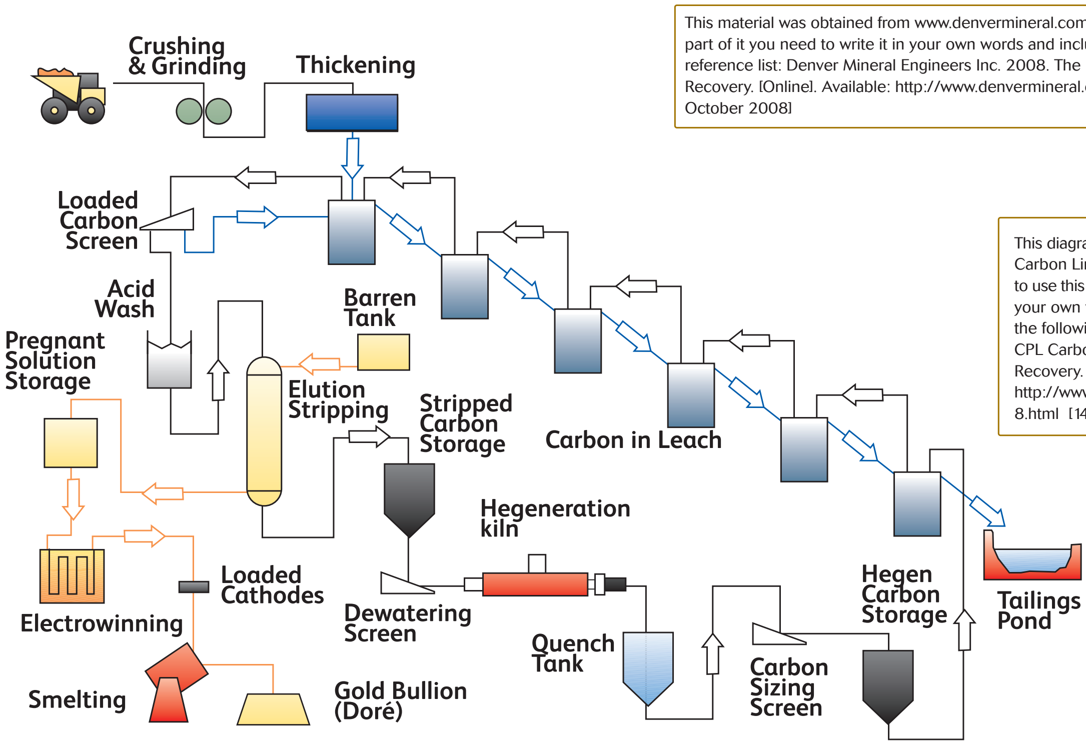
1. **Carbon-In-Column (CIC):** With carbon-in-column operation, solution flows through a series of fluidized bed columns in an up flow direction. Columns are most frequently open-topped, but closed-top pressurized columns are occasionally used. Carbon columns are most commonly used to recover gold and silver from heap leach solutions. The major advantage of fluidized bed carbon columns is their ability to process solutions that contain as much as 2 to 3% solids. Heap leach solutions are frequently high in solids due to fine particle washing from heaps. Down flow carbon columns are rarely used for gold recovery, because they act like sand filters and are subsequently subject to frequent plugging.
2. **Carbon-In-Pulp (CIP):** Carbon-in-pulp operation is a variation of the conventional cyanidation process. Ore is crushed, finely ground, and cyanide leached in a series of agitated tanks to solubilise the gold values. Instead of separating solids from the pregnant solution, as in the traditional cyanidation process, granular activated carbon is added to the leached slurry.

   The carbon adsorbs the gold from the slurry solution and is removed from the slurry by coarse screening. In practice, this is accomplished by a series of five or six agitating tanks where carbon and ore slurry are contacted in a staged countercurrent manner.

   This greatly increases the possible gold loading onto the carbon while maintaining a high recovery percentage. Carbon is retained within the individual CIP tanks by CIP tank screens. The opening size of the CIP tank screens is such that the finely ground ore particles will pass through the screens, but the coarse carbon will not. Almost every imaginable type of screen has been tried for this application, with some types being much more successful than others.
3. **Carbon-In-Leach (CIL):** The carbon-in-leach process integrates leaching and carbon-in-pulp into a single unit process operation. Leach tanks are fitted with carbon retention screens and the CIP tanks are eliminated. Carbon is added in leach so that the gold is adsorbed onto carbon almost as soon as it is dissolved by the cyanide solution. The CIL process is frequently used when native carbon is present in the gold ore. This native carbon will adsorb the leached gold and prevent its recovery. This phenomenon is referred to commonly as 'preg-robbing'. The carbon added in CIL is more active than native carbon, so the gold will be preferentially adsorbed by carbon that can be recovered for stripping. The CIL process will frequently be used in small cyanide mills to reduce the complexity and cost of the circuit.

   There are several disadvantages to CIL compared with CIP. Carbon loading will be 20 to 30% less than with CIP, which means more carbon has to be stripped. (This disadvantage may be overcome by a hybrid circuit, incorporating a cross between CIL and CIP.) The CIL process requires a larger carbon inventory in the circuit, which results in a larger in-process tie up of gold. The larger carbon inventory can also result in higher carbon (and gold) losses through carbon attrition.

This material was obtained from www.denvermineral.com. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Denver Mineral Engineers Inc. 2008. The Basic Processes of Gold Recovery. [Online]. Available: http://www.denvermineral.com/basicp~1.html [14 October 2008]



This diagram was obtained from CPL Carbon Link. Learners - if you want to use this diagram you need to draw your own version of it and include the following in your reference list: CPL Carbon Link. 2008. Gold Recovery. [Online]. Available: http://www.activated-carbon.com/3-8.html [14 October 2008]

Gold Mining – the Process

The following flow diagram can be used as a starting point to explain the processes involved in gold mining. Not all the details are included. Add your own findings to this diagram.

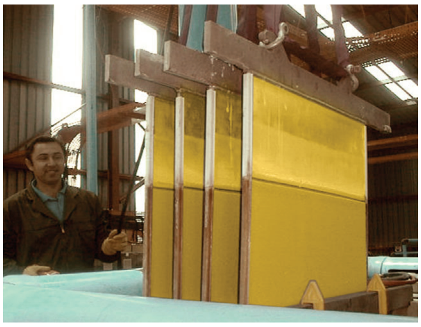
Underground mining

↓

Comminution

↓

Processing



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Refining

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Pictures courtesy of Anglo American

Gold Ore Processing

Throughout the centuries, gold has been recovered from its ores in many ways. These range from the rocker or long tom of the California Forty-Niner and the noisy stamp mill of the 19th century to modern methods of leaching with cyanide.

Any method of treating gold ores must take advantage of the natural characteristics of the metal. Cyanide solution, unlike most other liquids, is able to dissolve gold and is therefore used in the processing of gold ore. When in solution (and in the presence of oxygen), cyanide slowly attacks fine particles of gold and ultimately dissolves them. It is strange, but fortunate (because cyanide is extremely toxic), that a weak cyanide solution attacks the gold particles faster than a strong solution.

For the cyanide to attack the gold particles, it is necessary that the gold first be liberated from the worthless gangue rock which surrounds it because cyanide will not attack or dissolve most other minerals.

Overall, the cyanide process is very efficient. A gold ore containing less than one gram of gold per ton can, in some cases (and depending on the gold price), be profitably treated. A modern cyanide mill recovers or extracts 95% to 98% of the gold in the ore.

In a cyanide mill, lime and cyanide are added to the ore pulp in the grinding circuit. The lime has several functions: it protects the cyanide from being destroyed by naturally occurring chemicals called cyanicides, and improves the settlement rate of the pulp in the thickening stage.

Cyanidation (the actual dissolution of the gold) begins in the grinding step. Cyanide and lime solutions are introduced here, where the grinding is constantly polishing newly liberated gold particles and the solutions are heated by the friction. Depending on the ore and fineness of grind, from 30% to 70% of the gold may be dissolved during the grinding process.

Additional time is required to place the balance of the liberated gold into solution. This is done by pumping the gold-bearing pulp to a number of mixing tanks, known as agitators. Here the pulp is aerated either mechanically or by compressed air, or by a combination of both, for a predetermined period of time. This varies anywhere from 24 to 48 hours.

The 1980s saw a rapid expansion in gold production from low-grade oxide deposits around the world. That expansion could not have occurred without the development of a new, low-cost method of recovering the gold, which is called heap leaching.

Heap leaching avoids most of the above steps, and does not even require that a mill be built, making it a very low-cost method of processing ore. Here, broken ore is heaped onto a thick polyethylene sheet, called a liner, and then dilute cyanide solution is sprinkled on top of the heap. As the solution trickles down through the ore, the gold is dissolved. Before the heap is constructed, the polyethylene liner is specifically laid down so that the cyanide solution will drain to a central point. From here the gold-laden solution is channeled into a man-made pond.

One downside of heap leaching is lower recovery — just 65% to 85% of the gold in the ore ends up in the gold bars a heap-leach mine produces.

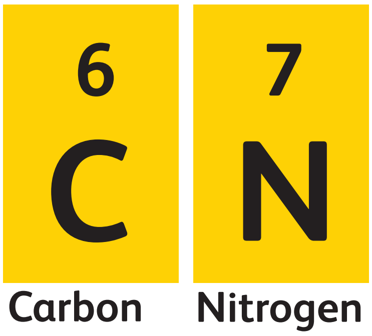
Extracting Gold Out of Solution

Traditionally, separating the gold-laden, or pregnant, solution from the barren solids present and then precipitating the gold achieved recovering the gold from the cyanide solution.

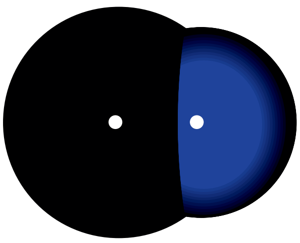
The traditional approach is called the Merrill-Crowe method. The first step is to move the pulp from the agitators to one or more thickeners — large, shallow tanks. The solution flows over the top of the tank and is collected in a launder around the tank's perimeter, while the worthless rock particles sink to the bottom and are slowly raked to the center by mechanical arms which operate continuously. The material is discharged through a pipe at the bottom of the tank but it contains too much valuable material to be discarded, so is filtered to recover additional gold.

This material was obtained from www.miningbasics.com.
Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Miningbasics.com. 2008. Gold Ore Processing. [Online]. Available:
http://www.miningbasics.com/html/gold_ore_processing_method_t.php
[14 October 2008]

Gold Mining – the Process

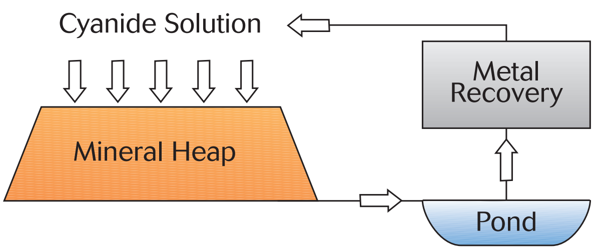


Cyanide CN^-



$(:C\equiv N:)^-$

Heap Leaching



Heap Leaching

The heap leaching process involves placing ore in a stationary heap and a solvent (cyanide) percolates through the solid. The primary benefit of heap leaching is that it can be done with little reduction and hence significant cost savings.

Generally, ore of selected rock size is placed on a leach pad, which is saturated with a weak cyanide solution. The pads are constructed by laying impermeable plastic sheeting over a gently inclined, compacted graded soil. Before stacking the ore onto the leach pads, a thin, protective layer of sand is placed on the plastic as in insulator. The gold (and other metals) is then leached from the stack where it is gathered in a recovery pond for subsequent processing.

For single-stage leaching, two steps are involved:

– contact of solid and solvent for transfer of solute to solvent

– separation of resulting solution from the residual solid.

The extract is the solvent phase and the raffinate is the solid material and its adhering solution. The solute in the raffinate is in both dissolved and undissolved forms.

Heap leaching is not widely used in South Africa because of the nature of the ore bodies. A derived process for refractory ores involves bacterial leaching to oxidize sulfide minerals.

Activated Carbon (Carbon-in-pulp)

The application of activated carbons to gold recovery has its origins in the patented use of wood charcoal for the recovery of gold from chlorination leach liquors in 1880. However, its use in precious metal recovery is a small element of activated carbon's potential and existing applications in any number of fields.

Gold Mining – the Process

The carbon-in-pulp (CIP) process, which was developed to its present form in South Africa during the 1970s, is considered to be the most significant advance in gold recovery technology in recent years. The CIP method is increasingly widely used. By 1995, there were 42 CIP circuits installed in South Africa. CIP makes use of the tremendous physical affinity 'activated' carbon has for gold (it can attract 7% of its weight in gold), which it readily attracts to its surface in cyanide solution. The finely ground ore (typically about 75 μm particle size), and the slurry of fine ore and water (the 'pulp') are treated with cyanide in large tanks that are stirred mechanically or by air agitation. Activated carbon is used to adsorb the gold directly from the cyanided pulp which flows continually from the first vessel to the last in the series. The carbon is transferred intermittently by pumping in the opposite (countercurrent) direction. The gold value of the pulp decreases downstream, and the gold loading on the carbon increases upstream, with the highest value in the first tank.

The CIP process consists of three essential stages: adsorption, in which the dissolved gold in the pulp is loaded on to aerated carbon: elution, in which the gold is removed from the carbon into an alkaline cyanide solution, and electrowinning, in which the gold is removed by an electrical process from the alkaline cyanide solution and deposited on steel wool electrodes. The carbon is then treated with acid to remove contaminants, after which the acid itself is treated. Both are then re-circulated into the adsorption-elution circuit. When the leach and adsorption circuits are combined, the process is described as carbon-in-leach.

Pyrometallurgy

The final stage of recovery is the conversion of gold concentrate to bullion. Generally, South African mine doré contains about 10% silver and 2 to 3% of copper, iron and other base metals. The removal of the non-gold metals is achieved in refineries. As a result, smelting in mine metallurgy plants is restricted to producing suitable quality bullion that can be accurately sampled and assayed.

This material was obtained from the Chamber of Mines website www.bullion.org.za. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Wood, T. 1996. The science of gold extraction. [Online]. Available: http://www.bullion.org.za/
[14 October 2008]

Gold Recovery

Leaching Gold With Cyanide

Since the 1890s, cyanide has been used to recover gold from gold bearing ores. And today, over 115 years later, most of the world's gold is recovered with cyanide playing a large part in the beneficiation of the yellow precious metal. Chemically, it is a rather simple reaction:

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

The equation presumes that the only elements are the gold, sodium cyanide and water. However, as any geologist will tell you, no two ores are the same, and their chemical composition will vary greatly throughout the ore body. These 'extra' elements in the mineral compounds will often play havoc with a chemical reaction.

Copper is definitely worth mentioning, since copper minerals will dissolve in cyanide solutions, and cause an increased use of cyanide, the copper-cyanide complexes formed by the dissolution will tend to inhibit the dissolution of gold in the cyanide solution. Zinc, the element used to precipitate gold from solution, if present in the ore, will bond with the cyanide to form a zinc cyanide compound. Another element that plays with the cyanide chemistry is nickel. Nickel, however does not interfere with the gold going into solution, but rather the precipitation of the gold from the cyanide solution.

The use of alkali such as calcium oxide, will prevent the decomposition of cyanide in solution to form hydrogen cyanide gas. It reduces the volume of cyanide required to leach the gold or silver. In addition, hydrogen cyanide is highly toxic to people. So, the small amount of money spent on adding a cheap calcium oxide to the ore or solution prior to leaching is worth the money spent. Most cyanide leaching is carried out at an alkaline pH of between 10 and 11, depending upon lab testing of individual ores and the optimum leaching/chemical use rates.

The cyanide solution strength is also important in leaching gold, with the typical range of solution being 0,02 - 0,05% NaCN. The gold particle size has a tremendous effect on the time required for dissolution in a cyanide solution. Generally, the finer the gold, the quicker it will dissolve. A 45micron particle of gold would dissolve in 10 to 13 hours, while a 150 micron particle might take from 20 to 44 hours to dissolve in the same solution.

Oxygen plays an important role in the leaching of gold in a cyanide solution. It has been proven that the rate of dissolution of gold in cyanide solution is directly proportional to the amount of oxygen present. Normal water will have 8 to 9 ppm dissolved oxygen present in it. If this oxygen is used up by other reactions, it may be necessary to aerate the solution, inducing oxygen into it, to speed up the reaction. With cost being always the determining factor (except in safety), the decision to aerate and speed up the reaction will be made based upon economics and laboratory testing.

Once the gold has been dissolved in the cyanide, and the ore body has been reasonably depleted of its gold, there are two main processes for recovering the gold from the pregnant cyanide solution. One is the Merrill-Crowe zinc precipitation process and the other is the adsorption of the gold onto activated carbon. The oldest method, Merrill-Crowe, involves


Steel cathode plates with gold plated on them

first removing the oxygen from the solution, then mixing a fine zinc powder with it (<200 mesh), and recovering the very fine gold precipitate on a precoat filter, since the gold precipitate is very fine, ranging from a few microns to 50 or so microns. The zinc reacts with the cyanide:

$$2Au(CN)_2^- + Zn \rightarrow 2Au + Zn(CN)_4^{2-}$$

Other chemicals have been used to leach gold, and they include bromine, chlorine, and thiourea. There has also been a lot of experimentation with various biological media for recovering gold from ores, but no one has come up with a more cost effective and productive method than leaching with cyanide. In some special circumstances, some of the other methods may show promise, but for a good oxide gold ore, CN leaching is usually the best of the leach methods.

This material was obtained from the website www.mine-engineer.com. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list:
Kubach, C. 1994. Gold Recovery: Leaching Gold with Cyanide. [Online]. Available: http://mine-engineer.com/mining/minproc/cyanide_leach.htm [14 October 2008]

Electrowinning of Gold

Gold can be recovered from solution by electrolysis, a process that is known in the extractive metallurgy industry as electrowinning. When two electrodes (cathode and anode) are placed in a solution containing metal ions and an electric current is passed between them, the metal can be deposited on the negative electrode. In the recovery of most metals, oxygen is evolved from water at the positive electrode. An electrolyte, and a current density, is generally chosen that gives dense, compact electrodeposits, and some additives could be included in the electrolyte to further improve product quality. All electrowinning cells with pervious, packed bed cathodes can be divided into two groups, those that operate with flow of the electrolyte at a right angle to the current flow, and those that operate with parallel solution and current flows. Usually cathodes are of steel wool and anodes of stainless steel. It's possible for 2 kg of gold to be deposited onto 0,5 kg of steel wool in each cathode compartment before the cell's current efficiency drops or the cathode becomes blocked by the gold deposit. The loaded cathodes are calcined at 700 °C for 20 hours. The calcine mixed with 40% borax, 30% sodium carbonate, and 25% silica is melted at 1 300 °C. Electrowinning of gold from cyanide solutions onto steel wool cathodes has become a very strong competitor of zinc precipitation, and is the standard procedure of gold recovery for plants employing a CIP process. The gold-laden cathodes are washed, dried, and smelted or treated with acid to remove the excess of iron and then smelted. Hence, iron slag with a high gold content is ground and gravity enriched, and the gravity tails are recycled into the mill.

This material was obtained from the website www.e-goldprospecting.com. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: www.e-goldprospecting.com. 2008. Electrowinning of Gold. [Online]. Available:
http://www.e-goldprospecting.com/html/electrowinning_of_gold.html
[14 October 2008]

Gold Recovery

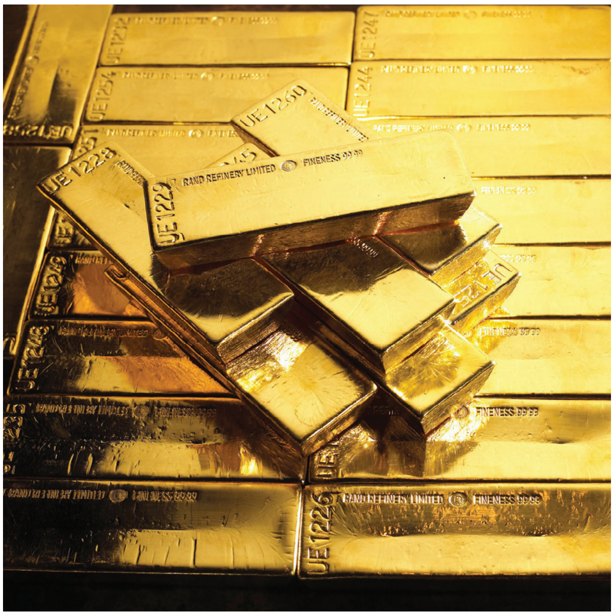
The Gold Refining Process

Primary refining in South Africa has employed two very different gold refining processes, both of which are described in brief below. The Miller Chlorination Process is one of the most widely-used processes in the large-scale refining of gold internationally and is usually employed in conjunction with Wohlwill Electrolysis, in order to produce gold of purity greater than 99,5%.

The Minataur process was developed in South Africa by Mintek and, prior to the closure of this refinery, was pioneered by Musuku Beneficiation Systems at its refinery in Virginia.

The Miller Chlorination Process

Dr F B Miller at the Sydney Mint first developed the Miller Chlorination Process. It is a pyrometallurgical process whereby gold doré, partially refined gold received from the mines, is heated in furnace crucibles. The process is able to separate gold from impurities by using chlorine gas, which is added to the crucibles once the gold is molten. Chlorine gas does not react with gold, but will combine with silver and base metals to form chlorides. Once the chlorides have formed, they float to the surface as slag or escape as volatile gases. The surface melt and the fumes containing impurities are collected and further refined to extract the gold and silver. The Miller Chlorination Process, which takes up to 90 minutes, produces gold that is at least 99,5% pure, with silver being the main remaining component. This gold can be cast into bars, as 99,5% gold purity meets the minimum 'London Good Delivery' requirements of the London bullion markets.



Wohlwill Electrolysis

Some customers such as jewellers and other industrial end users require gold that is almost 100% pure, so further refining is necessary. In this case, gold using the Miller process is cast into anodes, which are then sent to an electrolytic plant. The final product is a 99,99% pure gold sponge that can then be melted to produce various end products suited to the needs of customers.

The electrolytic method of gold refining was first developed by Dr. Emil Wohlwill in 1874. Wohlwill's process is widely used in major gold refineries and in conjunction with the Miller Chlorination process. The Wohlwill process is based on the solubility of gold and insolubility of silver in an electrolyte solution of gold chloride in hydrochloric acid.

The impure gold is cast into anodes which are suspended in cells, while the cathodes are thin strips of pure gold. By passing an electric current from anode to cathode through the electrolyte solution, the anodes are gradually dissolved and the gold is deposited on the cathodes. Any silver, which is insoluble in the electrolyte, and any platinum group

Learner Information Sheet

Gold Recovery

5

metals are precipitated to the bottom of the cells. The sequence takes about two days, following which the gold-coated cathodes are removed, melted and cast into bars. The initial process can produce gold of purity of up to 999,5 parts per thousand, with further treatment bringing it up to 999,9 parts per thousand.

The disadvantage of the Wohlwill process is that it is time consuming. Consequently, most gold is refined using the quicker Miller Chlorination Process. Where gold of 999 or 999,9 parts per thousand is required, electrolytic facilities at many refineries have been added.

The Minataur Process

Mintek developed the Minataur Process. In this process the gold-bearing feed is leached in a chloride solution. The resultant material is then subjected to selective solvent extraction to reject impurities and stripped to produce a purified, concentrated gold solution, from which high-purity gold powder is precipitated by reduction.

The gold content of the feed can range from about 20% to 90%. Suitable feeds include silver-refining anode slimes, gold-electrowinning cathode sludge, zinc precipitation filtrates, doré bullion and jewellery scrap. Materials with variable gold content can be handled.

The Minataur Process allows miners to refine their own high-purity gold on site. The refined product is formed into 99,99 percent or higher purity gold granules. The first Minataur plant was constructed in 1997 for Harmony, Virginia, Free State. Subsequently, turnkey plants have been built and supplied to customers in Mexico, the United Arab Emirates and Algeria. The plant in the United Arab Emirates is the largest of these, with capacity up to 150 tonnes per annum. Plants in Algeria and Mexico are smaller, with a capacity of 1 to 3 tonnes per annum.

This material was obtained from the publication 'Gold in SA 2007' which was found on the website www.goldinsouthafrica.co.za. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Short, R. & Radebe, B. February 2008. Gold in SA 2007. [Online]. Available: http://www.goldinsouthafrica.co.za/goldinsa_2007.htm [14 October 2008]

Mining in the Witwatersrand

Gold was discovered in the Witwatersrand in 1886, and it soon became evident that the area covered the world's largest and richest gold deposit. Despite the mining of over 50 000 tonnes of gold, approximately one-third of the gold in existence on the world's surface, reserves remaining in the Witwatersrand area are estimated to be some 40 000 tonnes, of which between 8 000 tonnes and 10 000 tonnes are thought to be economically recoverable, depending on the gold price and cost scenarios applied.

To this day opinions are divided on the identity of the man who first discovered gold in the Witwatersrand. The only fact on which experts agree is that gold was discovered by one of three men, all with the name George. The men were George Walker, George Harrison and George Honeyball. The men are said to have signed a lease with Gerhardus Cornelius Oosthuizen, who granted them the right to prospect for gold on his own portion of Langlaagte. The Australian George Harrison, however, is the member of the trio who is most widely credited with the discovery.

The development of gold mining on the Witwatersrand led to burgeoning economic activity in the area and the establishment of institutions to support the new industry. The Chamber of Mines was founded in

December 1887 to disseminate authoritative statistical information about the Transvaal Gold Fields Limited and to validate prospectuses. The original founding members were the Corner House (later Rand Mines and Randgold and Exploration Limited), Consolidated Gold Fields (later Gold Fields Limited), the Robinson Group and the Johannesburg Consolidated Investment Company (now JCI Limited). Their representatives met in the Central Hotel in Johannesburg prior to the establishment of the modern Chamber of Mines in 1989.

Other objectives of the Chamber included the promotion and protection of mining interests, the promotion of public discussion on mining industry issues, the promotion of favourable legislative measures and the exchange of information with other public and private mining bodies within and outside of South Africa. Today the Chamber of Mines focuses on the advocacy of major policy positions endorsed by mining employers to government. It provides strategic support and advisory input to its members and facilitates interaction among mine employers to examine policy issues and other matters of mutual concern and define industry-level stances. Consultation and co-operation within the Chamber system occur on a voluntary basis without encroaching on the managerial powers or prerogatives of individual member mines and mining groups.

The Development of Gold

The discovery of gold in the Witwatersrand changed the face of mining in South Africa. No longer could gold be recovered by simple panning, as the gold was embedded in deep level rock and high-level technology was needed to be able to extract and recover it. This meant that mining gold required huge sums of capital, and only large-scale mining companies could continue mining under these conditions.

Accordingly, the establishment of the Johannesburg Stock Exchange followed swiftly after the discovery of the Witwatersrand gold deposits. The JSE was founded by Benjamin Woollan in 1887 and subsequently became the largest stock exchange on the African continent.

South Africa has since become the largest gold exporter worldwide. Despite declining production volumes, the gold mining sector still contributes over 8% of the country's export earnings and 1,1% of GDP. Gold mining has played a major role in the establishment of infrastructure in South Africa, on foreign exchange and on employment and has led to the establishment of metropolitan centres such as Johannesburg, Welkom, Orkney, Springs, Benoni, Witbank and Klerksdorp.

Gold Mining

Key Findings

- Production of gold in South Africa as a share of global output has been declining consistently for a decade (Figure 1).
- According to the Chamber of Mines, South African mines produced 275,1 tonnes of fine gold in 2006 and 297,3 tonnes of gold in 2005.
- Mining accounts for the largest proportion of employees (95,31% in 2005 and 95,05% in 2006) employing 160,634 people in 2005 and 159 984 people in 2006 earning R12,6 billion in wages.

Production Data

South Africa has dominated the global gold mining industry for over 120 years. From 1884, when records of production were first collected, to 2006, the gold mining sector produced 50 627 tonnes of gold, which accounts for 32% of all gold estimated to be above the world's surface. However, the gold mining industry in South Africa is reaching a mature stage and new areas of competitive production have emerged in China, Russia, Indonesia, Uzbekistan, Peru, Papua New Guinea, Mali and Tanzania. Production peaked at 1000 tonnes in 1970 and has declined since.

South Africa's share of global gold output has decreased consistently over the last decade, declining on average by 5,6% per year (see Figure 1). In 2006 South Africa accounted for 11,8% of new global mine supply compared to over 20% a decade ago and approximately 70% in 1970.

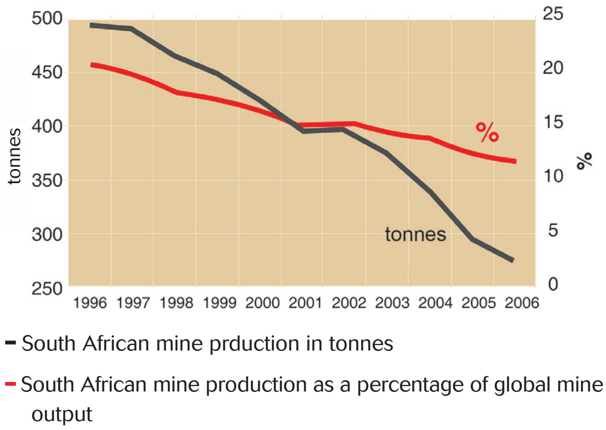


Figure 1: South Africa mining production from 1996 to 2006
Source: Chamber of mines, GFMS

In 2005, South Africa produced 2973 tonnes of fine gold, which declined to 2751 tonnes in 2006 – the lowest level of production in 84 years. The non-gold mining sector also experienced a decline (0,3%) in production volume in 2006. Factors that have led to the scaling down of production in the last two years include increasing mine depth and declining grades, as well as higher material input costs. Under normal circumstances an increasing dollar gold price would mitigate these trends and enable more projects to be brought on line, and this is now taking place as the strong gold price is prompting deepening projects which will reduce the rate of decline in production. Nonetheless, the gold mining industry continues to be an important player in the South African economy. Gold is South Africa's second largest export after platinum group metals, accounting for 8,4% of the country's export earnings and 1,1% of GDP (3% if indirect multipliers are added). 159 984 people were employed in the industry in 2006, and were paid some R12,6 billion in wages.

Mining in the Witwatersrand

Structure of the Secor

Production in 2005 and 2006 was dominated by five publicly listed gold mining entities, namely AngloGold Ashanti, Gold Fields, Harmony, DRDGOLD and Western Areas (Tables 1 and 2).

In 2006, these large public gold mining companies accounted for 89,45% of gold produced. The balance came from companies producing gold as a by-product of other mining activity (2,8%), from other smaller-scale miners and from the treatment of existing mine dumps (7,7%) (Figure 2). In 2005, the breakdown was similar, with the primary gold mining companies accounting for 89,1% of the gold produced, companies producing gold as a byproduct 2,51% and 8,36% of production originating from other smaller-scale miners and the treatment of existing mine dumps.

Informal gold mining also occurs in South Africa. Informal sector miners tend to be one-man operations seeking out a living from abandoned dumps and mine sites. It is not known how many miners operate informally – by nature they are unregistered and transitory. However, this review estimates that collectively these miners produce less than 1 tonnes of gold annually.

Company	2005 Production (tonnes)	2006 Production (tonnes)	**2006** Numbers employed
AngloGold Ashanti	83,22	79,43	35 968
Gold Fields	85,30	80,62	48 467
Harmony Gold	72,43	65,58	48 570
DRD Gold	13,59	11,06	7 693
Western Areas	14,34	9,42	5 636
Totals	**268,88**	**246,11**	**146 334**

Table 1: Production of main gold mining houses in South Africa for 2005 and 2006

Source: Chamber of Mines, company annual reports, interviews

Company	2005 % of total production	2006 % of total production	% of total numbers employed
AngloGold Ashanti	27,99%	28,87%	24,58%
Gold Fields	28,69%	29,30%	33,12%
Harmony Gold	24,36%	23,84%	33,19%
DRD Gold	4,57%	4,02%	5,26%
Western Areas	4,82%	3,42%	3,85%
Totals	**90,43%**	**89,45%**	**100%**

Table 2: Share of production of main gold mining houses in South Africa for 2005 and 2006

Source: Chamber of Mines, company annual reports, interviews

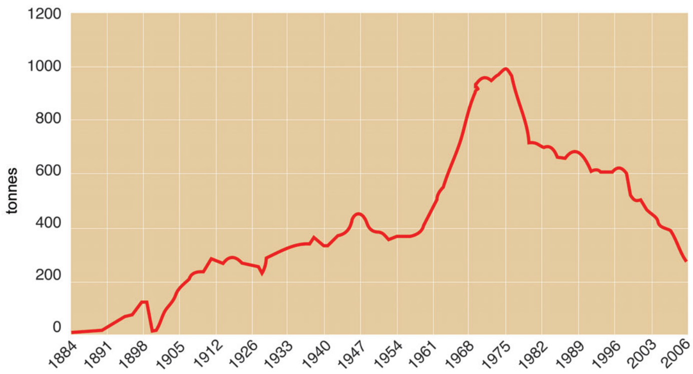


Figure 2 : South African gold mining production from 1884 to 2006

Source: Chamber of Mines

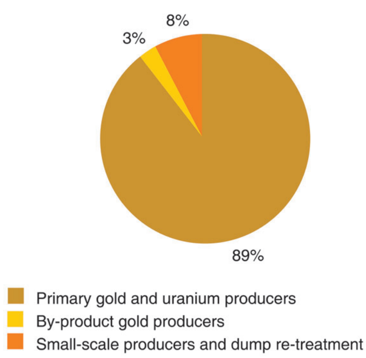


Figure 3 : Sources of gold in South Africa for 2006

Source: Chamber of Mines

Employment

The South African gold mining industry employs substantially more people than in other gold mining countries because it is engaged in deep-level, hard rock, underground mining which is labour intensive. Even so, there have been considerable job losses in mining as a result of mine closures and changing work patterns in the sector. In the last five years, numbers employed in the gold mining industry fell by around 8% per year on average. Job losses have been specific to gold mining and have not occurred to the same extent in other extractive mineral industries.

Employment in the gold mining sector declined from 180 039 employees in 2004, to 160 634 in 2005, and then to 159 984 in 2006 (Figure 4). This is in comparison with a high of 530 622 reached in 1987. Despite the declining employment levels, gold mining still accounts for the largest proportion of employees by far in the gold value chain (95,33%).

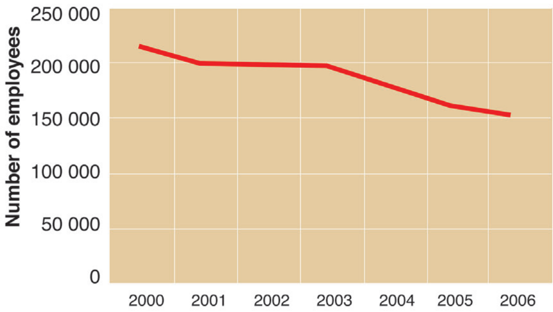
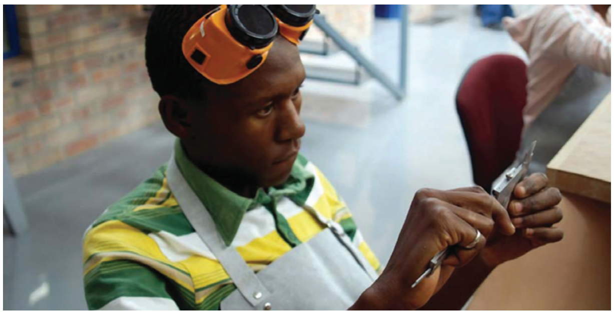


Figure 4 : Employment in gold mining in South Africa from 2000 to 2006

Source: Chamber of Mines, DME



Employment Along the Gold Value Chain

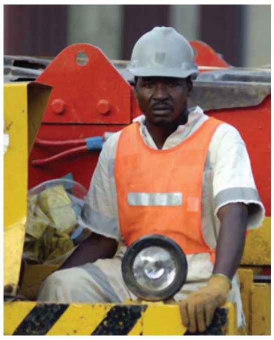
An estimated 168 547 people were employed in the gold value chain in 2005, and in 2006 (Table 3). The greatest number of job losses occurred in the mining sector, partly as a result of downscaling in production but also due to changes in work patterns.

Sector	2004 Persons employed	2005 Persons employed	2006 Persons employed
Gold mining	187 039	160 634	159 984
Gold refining and recycling	532	526	492
Gold jewellery manufacturing	2 680	2 782	2 833
Gold jewellery wholesaling and retailing	2 800	4 305	4 346
Gold coin manufacturing and retailing	82	100	101
Other*	500	200	200
Totals	**193 633**	**168 547**	**167 956**

Table 3: Persons employed in the gold value chain from 2004 to 2006

Source: Chamber of Mines, interviews, annual reports

* *'Other' is an estimate of employment in dental and industrial uses, investment, and gold industry suppliers. Some data was not gathered in 2004.*



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Social Responsibility

Thibela TB Research Programme

About 3,300 AngloGold Ashanti employees at the TauTona and Great Noligwa mines have consented to participate in the largest TB research programme undertaken in the South African mining industry. Two other AngloGold Ashanti mines are acting as controls in the programme.

The Thibela TB programme, which was launched towards the end of 2005, is being funded by the South African Mine Health and Safety Council and the international Consortium to Respond Effectively to the AIDS/TB Epidemic (CREATE). The programme is being conducted and overseen by South African medical research organisation, Aurum Institute for Health Research, a member of CREATE and formerly AngloGold Ashanti Health's internal research initiative.

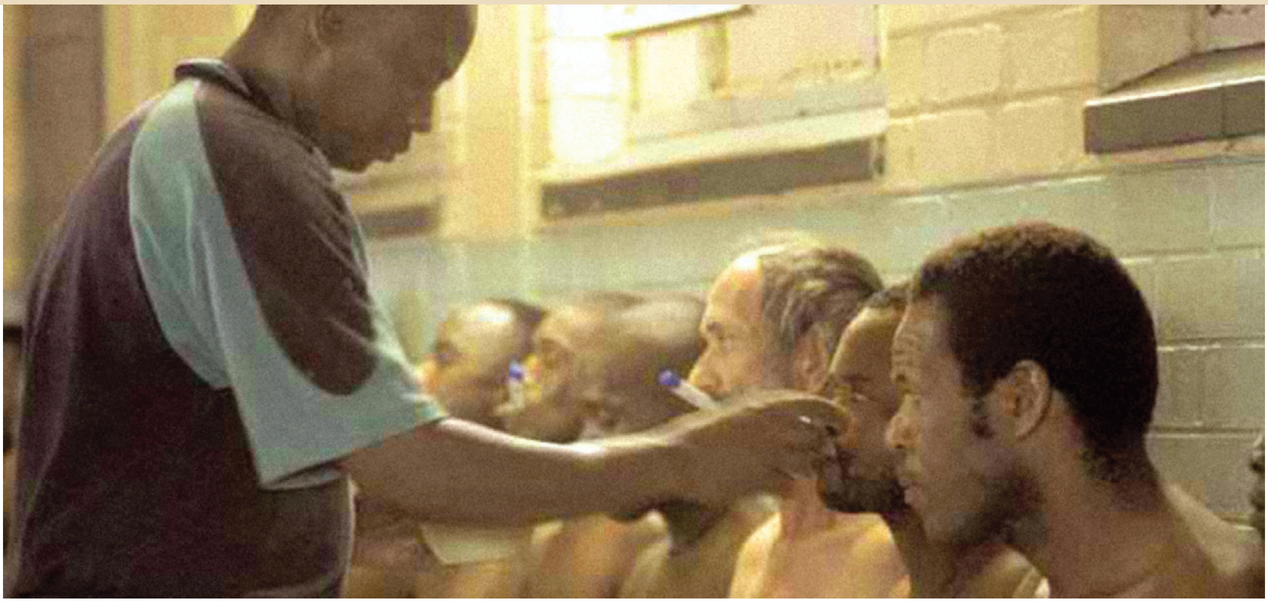
The overall aim of the programme is to establish whether administering community-wide TB preventive therapy in addition to standard TB control is more effective than the standard TB control alone. The programme includes targeted TB preventive therapy to individuals at high risk of developing TB, as is the case with underground gold miners working in dusty environments. If successful, such a programme would radically reduce TB transmission between people, which would lead to fewer TB cases occurring later, thus resulting in improved control of the disease. Specifically, the aim of the programme is to demonstrate that community-wide preventive therapy, used in addition to standard TB control measures, is effective in reducing both the incidence of TB and its consequences, and that it can improve the control of TB in high-risk environments, particularly where there is a high prevalence of HIV/AIDS and silicosis. Silicosis is a disabling, non-reversible and sometimes fatal lung disease caused by breathing in crystalline silica over a period of time. Silica is the second most common mineral in the Earth's crust and is a major component of sand, rock, and mineral ores.

The Thibela TB research programme is being undertaken in collaboration with several South African gold mining companies, and labour unions and associations. The study has the support of various government departments, including labour, health and minerals and energy.

The process of enrolling consenting individuals onto TB preventive therapy began in July 2006 and may take as long as 24 months to complete. The enrolment process is currently under way at TauTona and Great Noligwa and at the end of 2006, 3 300 individuals had consented to participate in the programme.

In all, around 65 000 miners will be involved in the study. The programme is progressing well but as the study could take five years to complete, it is too soon to report any preliminary results. Currently, funding is available for four and a half years.

The Thibela TB programme is part of a global research programme to find a solution, in the face of an escalating rate of infection, to reducing the incidence of TB, particularly as TB control in the South African gold mining industry is proving increasingly difficult, despite the implementation of control programmes exceeding World Health Organization standards. This is largely attributable to silicosis and the escalating HIV/AIDS epidemic, which compounds the incidence of TB. Similar studies are being conducted by CREATE



in high-risk communities in Zambia and Brazil.

According to Professor Gavin Churchyard, CEO of the Aurum Institute for Health Research and principal investigator for the study, "If successful, this study will demonstrate that it is possible to control TB in settings where HIV is prevalent and will serve as a model to control TB in other settings with high rates of TB transmission and HIV."

TB has a high social and economic cost, both for the individual concerned and the industry as a whole.

The onset of the AIDS epidemic in South Africa coincided with a four-fold increase in the rates of TB, which has serious implications both for the country and the gold mining industry. Historically, because of the increased risk of TB in silica-exposed gold miners, TB is considered an occupational disease in South Africa. Improved employee health would lead to an improved quality of life, improved productivity and much reduced healthcare costs.

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Land Stewardship: Reversing the Legacy of Mine Closure

The legacy of mine closure was in the past often one of environmental degradation and high unemployment. To avoid this, planners currently work from feasibility stage to minimise environmental damage and to create rolling rehabilitation that reduces costs at a time when the mine is less financially viable. Creative ways are sought to avoid the development of totally dependent communities and to stimulate direct and indirect economic activity. Community development activities around operating mines are increasingly geared to building the capacity of the community to maintain an acceptable standard of living after closure. This is, however, relatively new thinking and practical solutions are still being sought for old problems. We are currently providing $652 million against future closure liability, of which $493 million is for restoration and rehabilitation and the balance for decommissioning. As part of our approach to land stewardship, a Group land management policy has been drafted and is expected to be finalised and disseminated this year. It will provide the framework for drawing together the management of diverse legal and environmental risks.

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Social Responsibility

Environment and Society

Throughout history humans have both affected, and been affected by, the natural world. While a good deal has been lost due to human actions, much of what is valued about the environment has been preserved and protected through human action. While many uncertainties remain, there is a realization that environmental problems are becoming more and more complex, especially as issues arise on a more global level, such as that of atmospheric pollution or global warming. Interactions between human society and the environment are constantly changing. The environment, while highly valued by

most, is used and altered by a wide variety of people with many different interests and values. Difficulties remain on how best to ensure the protection of our environment and natural resources. There will always be trade-offs and, many times, unanticipated or unintended consequences. However, a well-managed environment can provide goods and services that are both essential for our well being as well as for continued economic prosperity. The environment has become one of the most important issues of our time and will continue to be well into the future. The challenge is to find approaches to environmental management that give people the quality of life they seek while protecting the environmental systems that are also the foundations of our well being. In order to face these challenges, students today will need more than superficial knowledge or awareness of disconnected environmental issues. A multidisciplinary approach to learning can build upon the strengths of a wide range of fields of study, providing a deeper understanding of the technological, political, and social options and strategies for both studying and managing the relationship between our society and the environment.

> This material was obtained from the Environmental Literacy Council's website www.enviroliteracy.org. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list:
> Environment & Society. [Online]. Available:
> http://www.enviroliteracy.org/category.php/5.html [14 October 2008]

Mine Environmental Management

Mine environmental management, which forms an integral part of the management of mineral and petroleum resources, focuses on:

- Strengthening enforcement to prevent mining legacies from occurring. This relates to the effective implementation of the MPRDA, 2002 and other short- and long-term strategies to strengthen environmental enforcement.
- Identifying mine-pollution 'hot spots' and implementing regional closure strategies to direct operational mines in addressing and managing pollution and mining waste within these areas.
- Rehabilitating abandoned and ownerless mines in accordance with a priority ranking system and a dedicated database.

Considering the extent of environmental damage caused by mining in South Africa, the department has entered into a five-year agreement with the Council for Scientific and Industrial Research (CSIR), the Council for Geoscience and Mintek to find solutions for long-term rehabilitation and environmental management.

The need for a national strategy dealing with derelict and ownerless mines is evident in the more than 8 000 entries on the database for such mines in South Africa. A ranking system has been developed to prioritise the rehabilitation of these mines and a dedicated geographic information system and an environmental auditing system have been finalised to strengthen environmental decision-making and the enforcement of environmental regulations. These systems will be integrated with the existing national mining promotion system.

Mining outcomes of the World Summit on Sustainable Development (WSSD)

Representatives from nearly 200 countries assembled at the WSSD in Johannesburg in September 2002 to reaffirm their commitment to sustainable development.

As a follow-up to the WSSD outcomes for mining, the Department of Minerals and Energy finalised a strategy with specific programmes, plans and time frames to achieve the objectives and priorities regarding the implementation of the Johannesburg Plan of Implementation (JPI).

The WSSD outcomes for mining include:

- poverty eradication
- changing unsustainable patterns of consumption and production
- protecting and managing the natural resource base for economic and social development
- globalisation
- initiatives for sustainable development in Africa.

International processes and structures such as the African Mining Partnership (AMP) have been established to champion, among other things, the mining and mineral-related initiatives of the New Partnership for Africa's Development (Nepad). The Global Mining Dialogue was also established to promote WSSD mining outcomes in the international arena.

The fourth AMP plenary, held in Pretoria in February 2007, further advanced collective efforts by African mining ministers to find the best ways to alleviate poverty in Africa via mining. Specific small-scale projects were identified so that their feasibility could be evaluated. During the AMP's plenary, the Association of African Geological Surveys (AAGS) was launched. Its members expected to publish the Council for Geoscience geological map for the Southern African Development Community (SADC) in 2007/08, which AAGS members created.

South Africa's Cabinet agrees that African countries have to develop and adopt a common position on environmental matters that highlights the links between eradicating poverty, sustainable development and maintaining the long-term integrity of natural resources. The Department of Environmental Affairs and Tourism is taking the lead in developing South Africa's position, including addressing issues covered by the Kyoto Protocol and targets set at the WSSD.

The dialogue was instrumental in establishing the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development. The 15th session of the United Nations (UN) Commission on Sustainable Development (CSD), met in New York from 30 April to 11 May 2007. The CSD's mandate is to follow-up, monitor and report on the JPI.

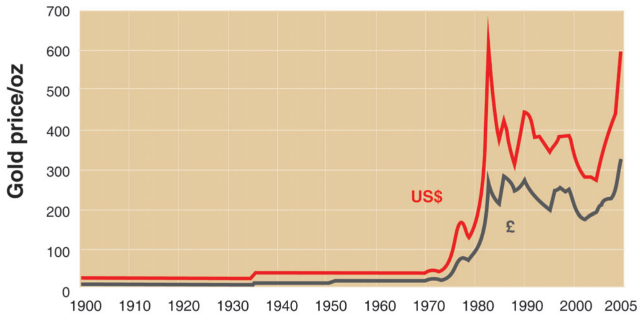
This material was obtained from the South Africa Yearbook 2007/08. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Government Communication and Information System. 2008. The South Africa Yearbook 2007/08. 2008. [Online]. Available: http://www.gcis.gov.za/docs/publications/yearbook/index.html [14 October 2008]

The Gold Price Fix

Representatives of five major banks, the gold fixing members of the London Bullion Market Association (the LBMA), meet together twice daily to determine the gold price fix. At the time of this publication, the banks involved in this process were the Bank of Nova Scotia-Scotia Mocatta, Barclays Bank Plc, Deutsche Bank AG, HSBC Bank USA NA and Société Générale. Gold fixing is conducted twice a day, at approximately 10 am and 3 pm London time.

The dealing unit is a Good Delivery Bar, which must contain between 350 and 430 oz of gold and must conform to the specifications for Good Delivery Bars laid down by the LBMA. The minimum required level of purity of a Good Delivery Bar is 99,5%. Only certain refineries are recognised as producers of Good Delivery Bars by the LBMA and qualification standards are rigorous.

In practice, the process of fixing the gold price works as follows: The chairman of the gold fixing team (a function which rotates annually through the members) suggests an opening price, which is reported by the representatives by phone to their dealing rooms; the chairman then invites clients to place orders with the dealing rooms of fixing members, who nets all orders before communicating their interest to their representative at the fixing. The metal price is adjusted to reflect whether there are more buyers or sellers at a given price until such time as supply and demand are seen to be balanced. Throughout the proceedings customers may change their orders, at which point the fixing member will raise a small flag to convey visually to the other members that they are changing their order. The price will not be fixed until all flags are down.



Annual average gold price (US$ and £) from 1900 to 2006
Source: WGC, Global Insight

The gold fix has been used since 1919 to arrive at an internationally published benchmark for gold. It creates a convenient and transparent reference point for buyers or sellers trading in large amounts of the metal. Where gold is sold to end users as semi-fabricated goods, for example kilobars, granules or alloys for jewellery manufacture, the prices charged for these products are based on the gold price fix, plus a premium which varies according to the product and the market conditions.

In South Africa, prices published by Rand Refinery twice a day are used as a reference point for purchases of semi-fabricated products by jewellery manufacturers and other end users. Jewellery manufacturers can purchase gold either directly from Rand Refinery or one of the secondary recyclers or indirectly, via an agency trading in semi-fabricated products.

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Rand Refinery Limited is the world's largest single-site gold refining and smelting complex

As a fully-integrated precious metal management company, Rand Refinery Limited (RRL) offers a comprehensive package with its logistics, vault, treasury, refining and smelting services. The company also manufactures a range of value-added products for use in the jewellery and dental industries. In addition to the competitive refining fees it offers, RRL's alliances with major international bullion banks enable it to propose customised financial solutions tailored to suit client needs.

Situated in Germiston, in South Africa's Gauteng province, RRL is the world's largest single-site gold refining and smelting complex. The company has a reputation for quality, reliability and integrity built up over more than eight decades, and, to date, has refined more than 40 000 tonnes of gold, about one-third of all the gold ever mined.

While the company's roots lie firmly in South Africa's gold industry, its strategy has kept pace with changing dynamics, which have seen the company moving from a purely South African to a more international focus. RRL now processes gold doré and gold-bearing by-products from west, east and southern Africa, North America and the Far East.

In 2005, 40% of the doré processed was sourced from outside South Africa and 80% of Africa's gold production (excluding South Africa) was refined at RRL. RRL is the world's largest single-site gold refining and smelting complex.

RRL was awarded London Bullion Market Association (LBMA) Good Delivery Status – widely recognised as the quality standard for gold and silver bars – in 1921. The Good Delivery List currently includes 56 refineries worldwide. RRL's products are also accredited on the New York Mercantile Exchange (NYMEX), the Tokyo Commodity Exchange (TOCOM) and the Dubai Metals and Commodity Centre (DMCC). In 2006, RRL was admitted to the Dubai Good Delivery List of approved silver refiners.

In 2004, RRL consolidated its position as one of the world's premier refiners of precious metals through its appointment by the LBMA as an LBMA-approved Good Delivery Referee, one of only five such referees worldwide.

Since 1998, RRL has been responsible for the marketing and distribution of over 56 million bullion Krugerrand coins. The Krugerrand, which celebrated its 40th anniversary in 2007, has attained enduring success internationally. The coins have been manufactured at RRL since 1970.

Rand Refinery Limited

Safety, health and the environment are of primary importance to RRL, and the company is proud of its record in complying with relevant legislation and its international accreditation in this field. RRL has achieved certification in ISO9001 and 14001, and OHSAS18001, dealing with quality, environment and occupational health and safety respectively.

Our history – some milestones

- 1921: established by the Transvaal Chamber of Mines (now the Chamber of Mines of South Africa) to refine all gold mined in South Africa;
- 1993: becomes an independent company with its own board of directors appointed directly by its shareholders;
- 1998: establishes gold transit vault at O.R. Tambo Airport near Johannesburg;
- 1999: begins supply of semi-manufactured gold products to the jewellery manufacturing industry;
- 2004: accredited as an LBMA referee;
- 2005: becomes the world's first refinery to be admitted to the Dubai Good Delivery List of approved gold refiners.

Our business

Refining

RRL uses the Miller Chlorination process, first developed by Dr FB Miller at the Sydney Mint and widely used internationally. Through this process, gold doré is refined to at least 99,5% pure gold, which is the minimum 'good delivery' requirement for sale on world bullion markets.

Electrolytic refining

Some end-users require gold that is purified to a higher degree than the 99,5% produced by the Miller Chlorination process. The electrolytic method of gold refining, first developed by Dr E Wohlwill in 1874, produces gold of 99,99% purity.

Smelting

Approximately 2% of RRL's gold throughput originates from gold-bearing by-products – originally drawn from the gold mining process, but now also sourced from a wide range of computer and electronic scrap – that are treated in a high-security, custom-designed smelter plant. This facility recovers gold, silver and platinum group metals (PGMs) from approximately 4 000 tonnes per annum of low-grade materials.

Analytical services

The company's laboratory supplies an accredited analytical service to the international precious metals industry. An assaying service is also provided to the manufacturing jewellery industry.

Fabrication

RRL has a bulk manufacturing facility which allows it to produce a number of products to semi-manufactured stage, such as gold solder paste, gold plate, wire, washers, bangles and ferrules, thus relieving individual manufacturing jewellers of involvement in the costly initial jewellery manufacturing stage.

The fabrication unit at RRL also manufactures 1 kg, 500 g and 100 g gold bars, coin blanks and medallions.

Photos courtesy AngloGold Ashanti AuDITIONS www.goldauditions.com

Rand Refinery Limited

To increase its ability to meet the demand for gold bars the unit is installing robots that will allow it to improve on the current output of 1 000 kg per day by being able to operate on a continuous, 24 hour basis. The technology is used in the local motor industry for car manufacture and will represent the first worldwide use of robots for the manufacture of gold bars.

The unit is also considering extending the use of robotics to the production of coin blanks.

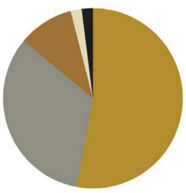
The Gold Zone, a joint initiative between RRL and its majority shareholder (AngloGold Ashanti) offers significant benefits to manufacturers. As part of its objectives, the project aims to create an internationally competitive South African gold jewellery manufacturing and export zone on land donated by RRL, which lies adjacent to the refinery's premises. This proximity carries with it a range of incentives, including eligibility for various concessions granted by the South African Department of Trade and Industry and for preferential export tariffs to the United States.

As part of its corporate social responsibility programme, RRL has supported the establishment of the Intsika Skills Beneficiation project. Housed within the Gold Zone, this project provides jewellery design and manufacturing training to formerly unemployed young people from the local community.

In the wider African context, RRL, in partnership with the Ghanaian mining industry, is investigating beneficiation opportunities in that country.

RRL has also participated, with AngloGold Ashanti and the World Gold Council, in the sponsorship of the AngloGold Ashanti AuDITIONS competition. The objectives of this competition are to promote excellence in jewellery design and enhance skills development in the international jewellery industry.

Our shareholders



- 53% AngloGold Ashanti Ltd
- 33% Gold Fields Ltd
- 10% DRDGOLD Ltd
- 2% Avgold Ltd
- 2% Western Areas Ltd

Russell and Associates 148/07

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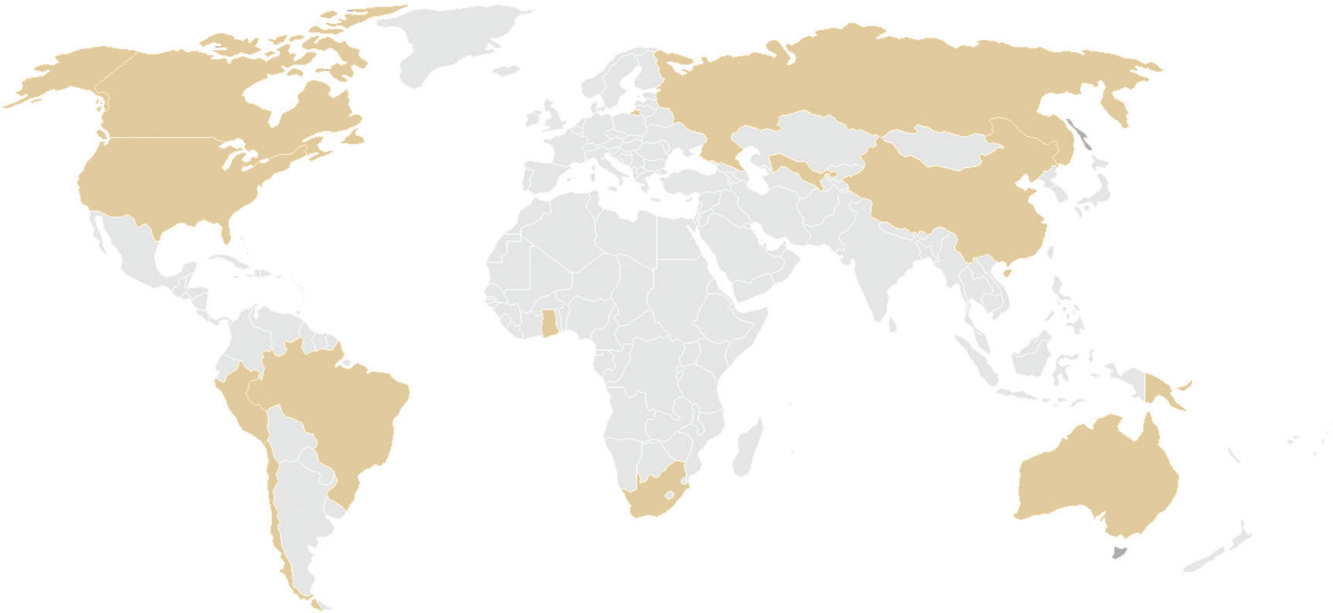
Gold Resources

Twelve countries are responsible for 66% of the worldwide gold extraction



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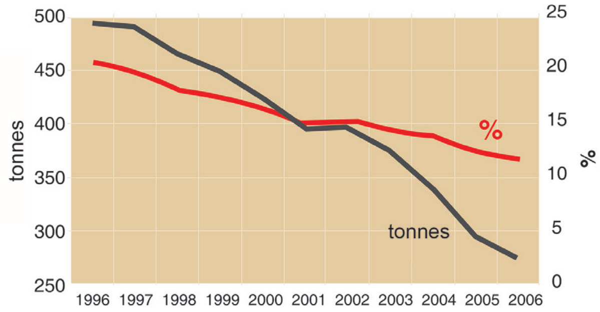
Mining

There are four legs to the gold value chain:

- Mining
- Refining and recycling
- Fabrication
- Retail

The following is a summary of the key findings, which have emerged from the research in each of these areas. South Africa remains the world's largest producer of gold although its share of global output has been declining consistently for a decade. In 2006, South Africa accounted for 11,8% of new global mine supply, compared to over 20% a decade ago (Figure 1).

From 2004 to 2006 there was a significant drop in mine output. According to the Chamber of Mines, South Africa produced 342 tonnes of fine gold in 2004, 297,31 tonnes in 2005 and 275,12 tonnes of fine gold in 2006, a total drop of 19,6% from 2004 to 2006. The scaling down of production can be attributed to increasing mine depth and declining grades, a relatively strong rand which has dampened the effects of an increasing dollar gold price, as well as higher material input costs, though the most recent surge in the gold price (Figure 2) has prompted deepening projects which should reduce the rate of decline.



— **South African mine production in tonnes**

— **South African mine production as a percentage of global mine output**

Figure 1: South African mining production from 1996 to 2006

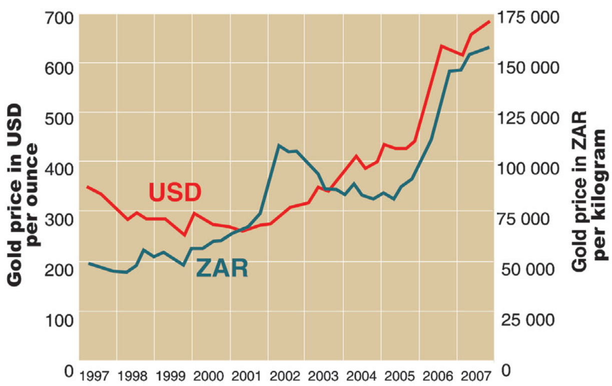
Source: Chamber of Mines, GFMS

	2005 % of total fine gold output	2006 % of total fine gold output
400 oz good delivery bars (export)	48,62%	56,2%
400 oz good delivery bars (export)	1,41%	0,9%
Kilobars and other bars	47,65%	40,58%
Coins (including krugerrand)	0,45%	0,39%
Jewellery semis	1,67%	1,39%
Dental products	0,13%	1,14%
Industrial products	0,02%	0,02%
Totals	**100%**	**100%**

Table 1 : Refining and recycling product output as a share of total output for 2005 and 2006

Source: Rand Refinery, Musuku, ABSA, recyclers

The figure for kilobars in 2006 (2005) does not include 1,25 tonnes (1,32 tonnes) of bars that went to local jewellery fabrication.



— US dollar price

— South African rand price

Figure 2: Gold price in US dollars and South African rand from 1997 to 2007.

Source: Chamber of Mines

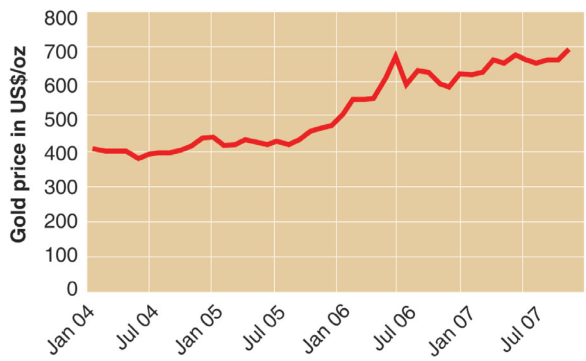


Figure 3: Gold price from 2004 to 2007

Source: Chamber of Mines

A high proportion of gold mined and refined in South Africa goes into the production of cast bars. In 2006, 418,54 tonnes (more than 97%) of total refined and recycled output was used in this way; in 2005 the figure was 442,75 tonnes. Most cast bars were exported to international bullion banks and federal reserves, with a small portion allocated to underwriting the local NewGold exchange traded fund (3,87 tonnes in 2006).

Volumes of fine gold consumed by local fabrication industries decreased from 11,24 tonnes in 2004 to 10,2 tonnes in 2005 and to 10,02 tonnes in 2006, a drop of 10,85% from 2004 to 2006. Of the 10,02 tonnes going to local fabrication in 2006, 7,18 tonnes went into jewellery manufacturing, 2,16 tonnes went into coin manufacturing, 0,6 tonnes into dental products and 0,08 tonnes into industrial products. A similar split applied in 2005.

Gold bars are either minted or cast. Cast bars are manufactured by the casting of molten gold into a mould, while minted bars are struck from blank templates in the same way that coins are struck, with precise dimensions. In the review period Rand Refinery and Musuku produced no minted bars; all were cast.

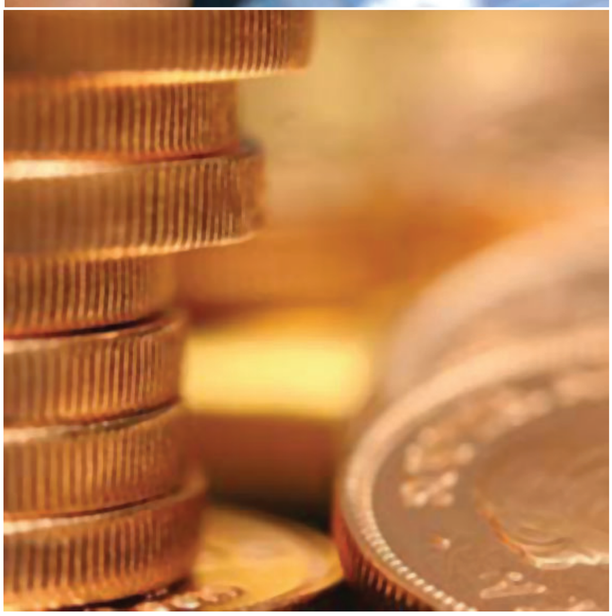
Gold Resources

Jewellery Fabrication

Jewellery fabrication is the largest gold fabrication industry in South Africa, as is the case worldwide. There are an estimated 500 gold jewellery manufacturers in the country. The vast majority of these are small enterprises using tiny amounts of gold. Sizeable usage is consolidated in only a dozen or so firms. In fact, in 2006, three firms accounted for 65% of fine gold consumed in jewellery manufacturing, while the top 13 firms accounted for 84%.

Coin Fabrication

The second largest fabrication industry after jewellery is coin fabrication. Like jewellery fabrication, this sector also saw a drop-off in gold consumed. Coin accounted for 2,93 tonnes of fine gold in 2004, 2,03 tonnes in 2005 and 2,16 tonnes in 2006 (a fall of 26,28% from 2004 to 2006).



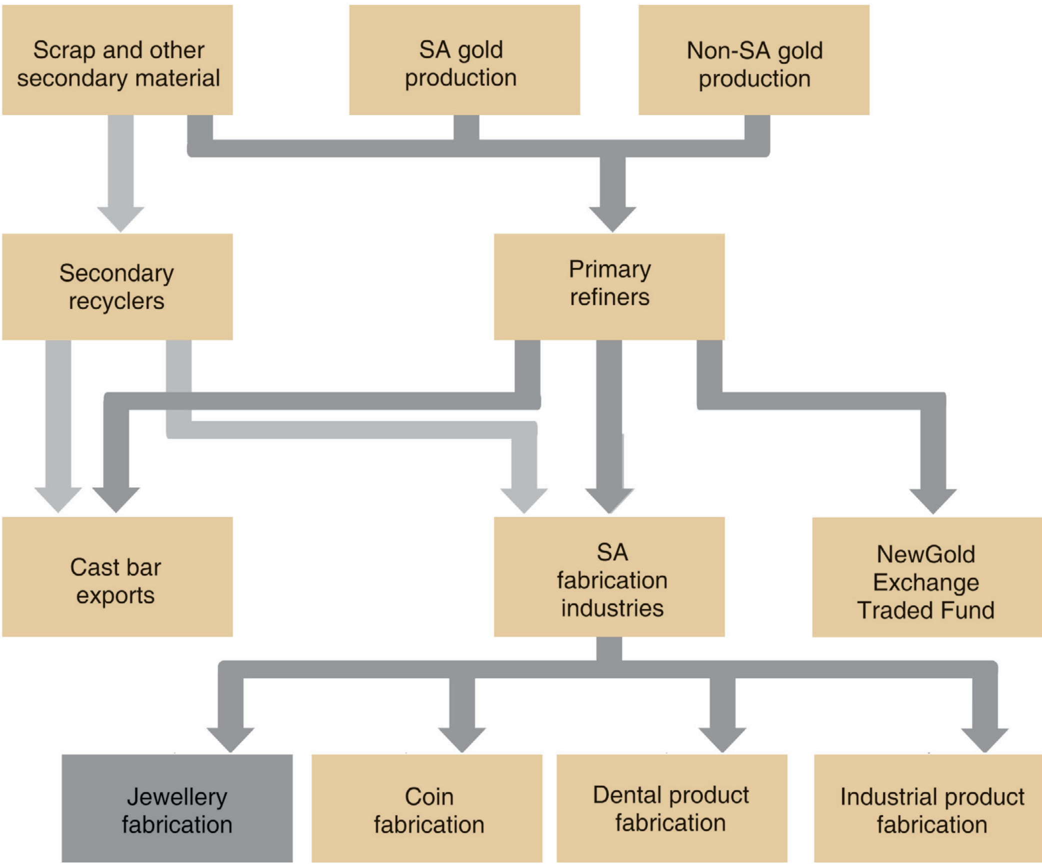
Dental-use Fabrication

The use of gold in dentistry remains limited. 0,58 tonnes of fine gold was used in 2005 in dental products and 0,6 tonnes in 2006. Dentistry is not regarded as a growth sector for gold use for two reasons: fashion is turning away from the use of gold in dentistry and local medical schemes do not, as a rule, cover the cost of gold in dental treatment.

Industrial-use Fabrication

Gold is used in a variety of industrial applications, though the quantities used are extremely small. No more than 0,09 tonnes of fine gold went into industrial end-use in each of 2005 and 2006. Interviews with circuit board manufacturers revealed they are using less gold and more copper in circuit board fabrication.

Flows of fine gold in the value chain for 2006



This material was obtained from the publication 'Gold in SA 2007' which was found on the website www.goldinsouthafrica.co.za. Learners – if you use any part of it you need to write it in you own words and include the following in your reference list: Short, R. & Radebe, B. February 2008. Gold in SA 2007. [Online]. Available: http://www.goldinsouthafrica.co.za/goldinsa_2007.htm [14 October 2008]

Case Study: Addressing Socio-economic Needs – the Nongoma Abalimi Phambili Project

In conjunction with the occupational health project being undertaken in a collaborative effort between the Chamber of Mines, the Department of Health and the National Union of Mineworkers, Teba Development has initiated the Abalimi Phambili Project at Nongoma in KwaZulu-Natal.

Modelled on the successful Abalimi Phambili Project that has been running in the Eastern Cape since 2002, the Nongoma-based project was initiated in August 2006. Owing to delays in start-up, it has been funded by Xstrata. Once the ODMWA project starts, it is envisaged that the Nongoma project will be the first pilot site and additional funding from the gold mining industry will be channelled into this project.

The Nongoma local municipal district was selected as a key target area for the broader mineworkers project as it is a major labour-sending area in the country. This too made it an ideal target for the socio-economic development project, added to the fact that agriculture is a primary source of income for the region and that the area has high and diverse agricultural potential.

Location of the Nongoma district

About the Nongoma region

The Nongoma district in KwaZulu-Natal has a population of around 26 000 people, of whom an estimated 71% are unemployed. The estimated dependency ratio (of 1:15), which is the ratio of the number of dependants to a breadwinner, is one of the highest in southern Africa. Nongoma is the home of the Zulu royal family and has 296 traditional wards and 19 municipal wards.

Says David Cooper, of Teba Development, 'The primary goal of the project is to stimulate the local economy by the provision of support services to around 800 farmers over a period of two years. Agriculture is a primary source of income in the area and it is vital that the high-potential agricultural resources are exploited and used successfully, efficiently and sustainably.'

Four key sub-objectives have been and remain:

The identification and implementation of projects. Interviews were conducted with local stakeholders to understand their needs and to develop a broader understanding of existing structures, resources, infrastructure and markets. A local project steering committee was established to oversee the project implementation process and to ensure alignment with local integrated development plans. The committee meets on a quarterly basis and is well attended by local stakeholders. Negotiations were concluded with agricultural input suppliers (feed, seed, nursery and fertiliser suppliers) to reduce delivery costs. Around 460 farmers have benefited from the programme, with around R2,7 million having been generated in revenue.

The creation of linkages with markets and support systems. Farmers are now selling their produce (mostly vegetables, livestock and poultry) on a large scale to the local community at a local market and additional markets are being identified.

Capacity building, technical training and management support at local level. Contracts are being put in place with more formal business sectors (hospitals, correctional services and local hospitality establishments). Training in basic business management skills, project management and financial record-keeping has been carried out. Eight school gardens have been established and teachers and learners have been trained in organic gardening practice and now produce food for vulnerable children. (These schools have a collective enrolment of 3 277 children, of whom 830 have been identified as orphans).

Extension of credit facilities to farmers in need. Technical training in poultry and vegetable farming has been provided to local farmers to assist them in increasing yields and hence sales plans are in place to establish a Revolving Credit Fund, which will provide farmers with a revolving credit facility to buy agricultural inputs and equipment.

Says David Cooper: 'We have set a number of key performance targets over the two-year period and I am pleased to report that we have made good progress in the first year. Apart from improving the livelihoods of over 460 individual farmers (and hence at their extended families), the programme has brought into production over 400 hectares of arable land, and has created valuable linkages with markets, supplier and support systems.'

This article was obtained from the AngloGold Ashanti Annual Report to Society 2007. Learners – if you use any part of it you need to write it in your own words and include the following in your reference list: AngloGold Ashanti. 2008. Annual Report to Society 2007. [Online].Available:http://www.anglogoldashanti.co.za/subwebs/InformationForInvestors/Reports07/ReportToSociety07/files/nongoma_social.pdf [27 January 2008]

A Human rights Approach to AIDS

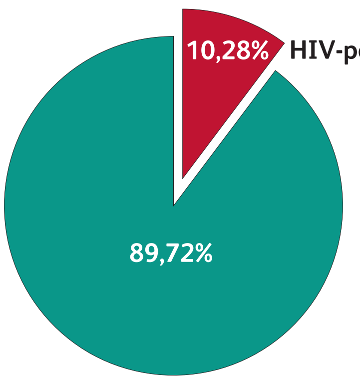
Anglo American's HIV and AIDS policy is built on a human rights foundation, and ensures that no employee will be discriminated against if they are infected with the virus.

So says Dr Brian Brink, Anglo's Senior Vice-President: Health, as the disease comes into the spotlight on World AIDS Day, 1 December 2007.

The great majority of HIV-infected employees in the Group are in South Africa, which explains the intensity of Anglo's response to the epidemic among our workforce in that country. A UNAIDS report published in November 2007 lists South Africa as having the largest number of HIV infections in the world.

According to its National Strategic Plan, the South African Government currently estimates that 5,5 million people, out of the country's population of 48 million, are living with the disease.

South African Population HIV Status 2007

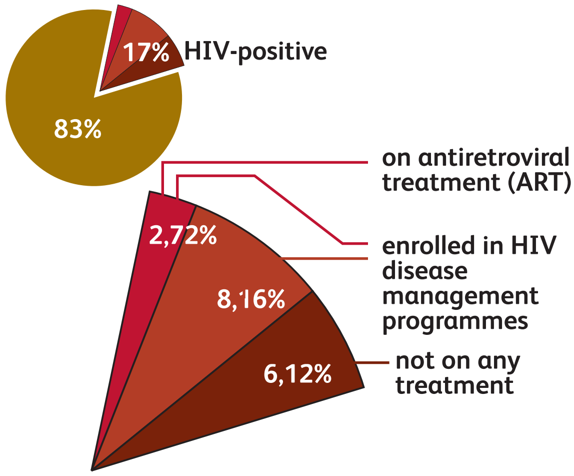


The UN report says that AIDS continues to be the leading cause of death in Africa, although there are indications that the number of new infections is decreasing in sub-Saharan Africa as a whole.

Although Anglo's South African workforce is worst affected by HIV and AIDS, the Anglo American Group HIV and AIDS Policy applies to all Anglo operations around the world.

Latest statistics suggest that out of our approximately 76 000 employees in southern Africa, an estimated 13 000 (or 17%) are HIV-positive. About 64% of those infected are enrolled in HIV disease management programmes, and about a quarter are on antiretroviral treatment (ART).

Anglo's Southern African Workforce HIV Status 2007



'Our focus is on testing as an entry point to a comprehensive response to AIDS,' says Brian. 'It's built on a human rights foundation, which means no discrimination, as well as confidentiality, eliminating the stigma and promoting gender equality.'

Prevention and Treatment

'A comprehensive and robust response to AIDS requires both prevention as well as access to care, support and treatment. Prevention on its own doesn't work – marrying the two aspects together is the only way to address the problem.'

Brian emphasises that the available treatment for the virus is 'extremely effective'. If an employee tests positive, he or she can be assured of a positive outlook, especially if diagnosed in the early stages of infection, before the onset of illness.

'Absenteeism can run up to 15 days a month without treatment,' says Brian, 'whereas you should never even have to lose a day if you are HIV positive.' With treatment, an employee living with the virus can continue to be healthy and productive, but far too many leave it too late for medication to be effective.

Godfrey Gomwe being tested

In addition to the humane aspect of providing employees with access to AIDS medication, it also has a positive impact on business. It has been estimated that if Anglo did not provide ART to affected employees, the annual cost to the Group of HIV would amount to just over 5% of payroll in South Africa.

'But even if an employee tests negative, we need to ensure they stay negative,' says Brian. 'Testing reinforces the prevention messages.'

Several southern African sites have embarked on vigorous voluntary counselling and testing (VCT) drives, and we are well on track to meet the target of 70% of employees heeding the call to be tested in 2007. Being tested for HIV is confidential, and the choice about whether to disclose one's status, and who to disclose it to, rests entirely with the individual. Anglo American respects the right to privacy of all its employees.

Removing the Stigma

However, Brian says that the more people that disclose their status, the better, so that the veil of secrecy surrounding the disease can be lifted. For example, during a recent visit by three British Members of Parliament to Anglo Coal South Africa operations, 10 employees publicly declared that they were HIV positive.

Anglo's strategic approach – in addition to prevention, testing and treatment – includes providing care and support to HIV-positive employees and their families, many of whom have limited access to healthcare facilities.

Community programmes in the vicinity of Anglo operations are aimed at providing access to HIV testing and treatment, creating awareness among the youth, and encouraging sexual and reproductive rights and health for young women and girls.

In line with Anglo's safety message of zero tolerance of accidental injury, our broader HIV and AIDS target for any given community is three zeroes: zero new HIV infections, zero people getting sick or dying from AIDS, and zero babies born HIV positive.

People who test HIV positive should seriously consider starting treatment once their CD4 blood cell count has dropped below 350. However, Brian says a big challenge is ensuring that patients adhere to their treatment regimen once they have started.

'Once you're on ART, treatment is life-long, and it is important to never miss a pill. Otherwise, you run the risk of developing viral resistance,' he says.

This material was published by Anglo American. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Anglo American. 30 November 2007. [Online]. Available: http://www.angloamerican.co.za/aa/media/releases [14 October 2008]

Mine Health and Safety

The MHSI, established in terms of the Mine Health and Safety Act (MHSA), 1996 (Act 29 of 1996), is responsible for protecting the health and safety of mineworkers or people affected by mining activities.

The activities of the MHSI focus on achieving a safer and healthier mining industry for all. The organisation works closely with industry and worker unions to reduce the incidence of mine accidents, with stakeholders committing themselves to continuously reducing fatalities by at least 20% a year. The inspectorate is also pursuing a strategy to eliminate silicosis and noise-induced hearing loss or occupational deafness by 2013, and to reduce the social costs of diseases and injuries to vulnerable communities, in particular.

Some 199 miners died in mine accidents in 2006 and about 4,000 people were injured. The mining sector failed to achieve the targets agreed to in 2003, of reducing the fatality rate by at least 20% a year. Further analysis shows that fatalities in the platinum sector dropped by 21%, but there is more room for improvement. The Mini-Indaba on Seismicity and Rockbursts was held in October 2007. The department continues to work with security forces to develop a strategy of combating illegal mining, which is one of the biggest threats to mineworkers' health and safety.

The biennial Mine Health and Safety Council Summit was held on 5 October 2007 in Johannesburg, where the status of occupational health and safety in mines was discussed, including the progress on achieving the milestones agreed to in 2003. South Africa is committed to combating the HIV and AIDS pandemic in the mining industry. The Mining Industry Tripartite HIV and AIDS Committee observed the 2007 World AIDS Day.

The Mine Health and Safety Council advises the Minister of Minerals and Energy on the continued development of a revised regulatory framework for the industry. Projects aimed at raising awareness on the prevention, treatment and care of HIV and AIDS in the mining industry include the:

- Powerbelt Project, which focuses on coal-mining areas
- Lesedi Project in Virginia, Free State
- Lechabile Project in Welkom, Free State
- Bambisanani Project in Lusikisiki, Eastern Cape
- Carletonville Home-Based Care Project, Gauteng.

The Chief Inspector of Mines also proposed a strategy for dealing with deaths associated with HIV and AIDS, following a non-life-threatening mine accident.

The Safety in Mines Research Advisory Committee has a programme to overcome barriers to improved occupational health and safety performance. The programme is comprised of:

- Cultural change
- Rock falls
- Rock bursts
- Explosions and fires
- Machinery and transport systems
- Airborne pollutants
- Physical hazards (noise, temperature, radiation, etc.)
- Occupational diseases (the effect of HIV and AIDS on tuberculosis and silicosis)
- Special projects (surveys for quantifying risk prevalence).

This material was obtained from the South Africa Yearbook 2007/08. Learners – if you use any part of it you need to write it in your own words and include the following in your reference list: Government Communication and Information System. 2008. The South Africa Yearbook 2007/08. 2008. [Online]. Available: http://www.gcis.gov.za/docs/publications/yearbook/ [14 October 2008]

Four miners die in three days

24/11/2007 22:49 – (SA)

Johannesburg - South Africa's National Union of Mineworkers (NUM) said on Saturday it was more determined to call a strike over safety, set for December 4, after four miners died in accidents in three days.

NUM spokesperson Lesiba Seshoka said two workers had been killed in mines belonging to the Gold Fields group west of Johannesburg on Friday and Saturday.

They had been respectively crushed by a rockfall at Westenaria's Kloof mine and run over by a train in Driefontein.

Also on Friday, a miner was buried in an underground landslip at Elandsrand, in the mine operated by Harmony Gold that had only just reopened since 3 200 workers were trapped deep underground for hours on October 4 by a faulty lift.

And on Thursday another death occurred at the Marula mine, belonging to the Implats group, in northern Limpopo province, Seshoka said.

"It is intolerable and unacceptable. It is strengthening us, it shows that there is a real need for us to take that type of action," he said, adding that upcoming talks with the independent agency that mediates between workers and their employers were just a "formality".

Seshoka said that the NUM, the industry's biggest union with more than 260 000 members, had never had a strike over safety, despite the yearly average of 200 deaths in South Africa's mines.

Security in the mines, among the world's largest producers of gold, diamond and platinum, is often an object of criticism. Following the Elandsrand incident in October, President Thabo Mbeki ordered a safety audit into all the nation's mines.

At the same time, the country's chamber of mines said it was seeking to reduce death rates by at least 20% a year by 2013.

"Mining is dangerous, but this is no excuse for harming people," the chamber's chief executive Zoli Diliza said in a report, acknowledging that South Africa's safety record fell way short of the benchmark countries of Australia, Canada and the United States.

This article was published on www.news24.com. Learners – if you use any part of it you need to write it in your own words and include the following in your reference list: www.news24.com. 24 November 2007. Four miners die in three days. [Online]. Available: http://www.news24.com/News24/South_Africa/News/0,,2-7-1442_2227135,00.html [14 October 2008]

Fifth West Rand mineworker dies

30/04/2008 17:03 – (SA)

Johannesburg - One of the three mineworkers injured during a ground fall at Driefontein mine on Tuesday, has died, bringing the death toll from recent mining accidents on the West Rand to five, a Gold Fields spokesperson said on Wednesday.

Andrew Davidson said the worker had been taken to a hospital in Carletonville to be stabilised, and was then transferred to the Krugersdorp Hospital, but later died. The remaining two injured miners were stable, he said.

There were two separate mining accidents on the West Rand on Tuesday.

Three workers died initially and two were injured after a seismic event caused a fall of ground at the Driefontein mine at 08:17 and at South Deep mine a driller's assistant died in a fall of ground at 10:30.

Investigations into the five deaths will be carried out.

This article was published on www.news24.com. Learners – if you use any part of it you need to write it in your own words and include the following in your reference list: www.news24.com. 30 April 2008. 5th West Rand mineworker dies. [Online]. Available: http://www.news24.com/News24/South_Africa/News/0,,2-7-1442_2314776,00.html [14 October 2008]

Gold Fields to shut down mines

01/05/2008 21:27 – (SA)

Johannesburg - Gold Fields will shut down all operations at its South Deep, Kloof, and Driefontein mines in order to conduct an inspection of the ropes on mine hoists, its chief executive Nick Holland said on Thursday.

"If we can't mine safely, we won't mine at all," he said.

This follows the deaths of nine workers, who plunged 58 metres down a shaft when a rope on their conveyance snapped at the Gold Fields South Deep mine near Randfontein on Thursday morning.

This article was published on www.news24.com. Learners – if you use any part of it you need to write it in your own words and include the following in your reference list: www.news24.com. 1 May 2008. Gold Fields to shut down mines. [Online]. Available: http://www.news24.com/News24/South_Africa/News/0,,2-7-1442_2315491,00.html [14 October 2008]

South African Gold Mining

Gold Production Falls 6,5%

Assisted by Canadian- and Australian-led projects that aim to add millions of ounces to world gold supply, China became the world's largest gold producer in 2007.
China produced 276 tonnes of gold last year, equal to about 9,7 million ounces. That's up 12% from 2006 and represented just over one-tenth of the world's supply.

The new ranking pushes the mighty gold producer South Africa into second place. And for the first time the gold giant has lost its top ranking since 1905.

South African Gold Mining

According to new figures from Statistics South Africa, total domestic mining production was 0,2% lower in 2007 compared with 2006. This 0,2% drop in annual mining production is followed by a 1,5% decline in 2006 and a 1,3% increase in 2005.

Significant contributors to the annual decrease include nickel, copper, and other non-metallic minerals such as diamonds. However, it was the gold industry in South Africa that really pitched in the most toward the annual production decrease.

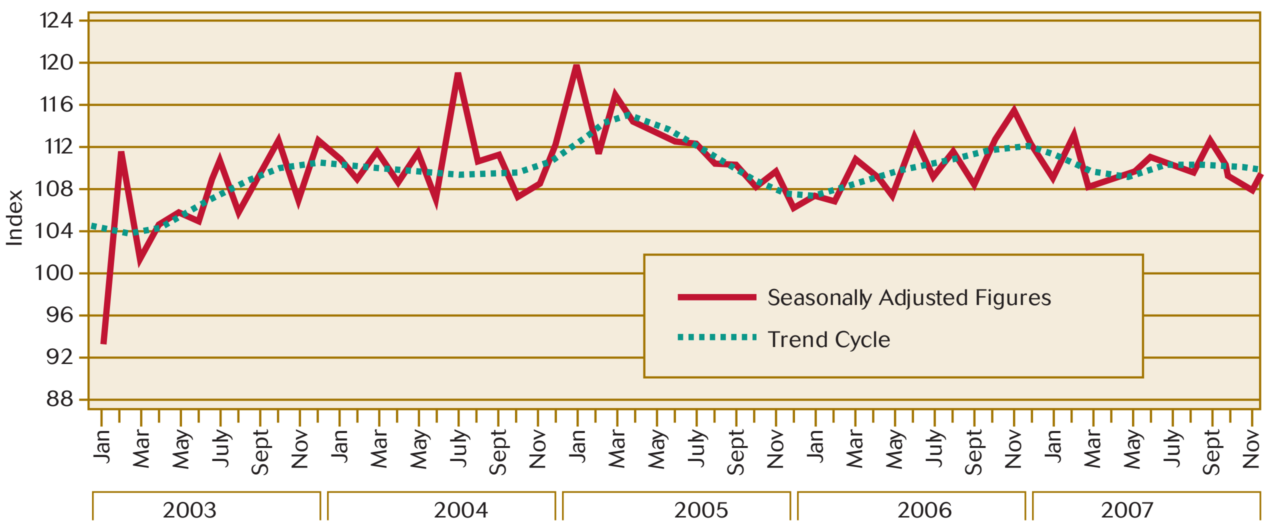
South African gold mining production fell by 6,5% in 2007 in volume terms against the previous year. Meanwhile production of the yellow metal fell 4,1% in December compared to December 2006 and a full 7,8% during 4Q 2007 over the previous year.

Overall mineral production has levelled off in the past three years. The chart below shows the seasonally adjusted figures and trend series for the index of mining production between January 2003 and December 2007.

The trend series rose from the beginning of 2003 until February 2004, but levelled off until November of the same year. The trend reached a peak in April 2005 and a trough in January 2006. From February 2006 the trend increased until November 2006 but started to decline thereafter.

This general levelling off of South African mine production may have dramatic effects on global mine

Actual estimates	Base: 2000 = 100			
	December 2007	% change between December 2006 and December 2007	% change between October 2006 to December 2006 and Octover 2007 to December 2007	% change between January 2006 to December 2006 and January 2007 to December 2007
Index of the physical volume of mining production				
Gold	56,4	-4,1	-7,8	-6,5
Non-gold	130,5	-1,1	-2,8	0,8
Total	111,5	-1,4	-3,5	-0,2



Learner Information Sheet

South African Gold Mining

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supply and prices in the short-term future because despite losing the title as world top gold producer to China, South Africa still produces a significant amount of the yellow metal.

New gold mines are always being developed, serving to replace the loss in current production. However, new mines can often taking up to 10 years to come on stream, mean mining output is relatively inelastic and unable to react quickly to a drop in new mine supply. So a significant drop in mine supply should result in a long-term rally of gold prices. The levelling out of South African gold mining is yet another compounding fundamental added to our bullish position for gold.

By Greg McCoach

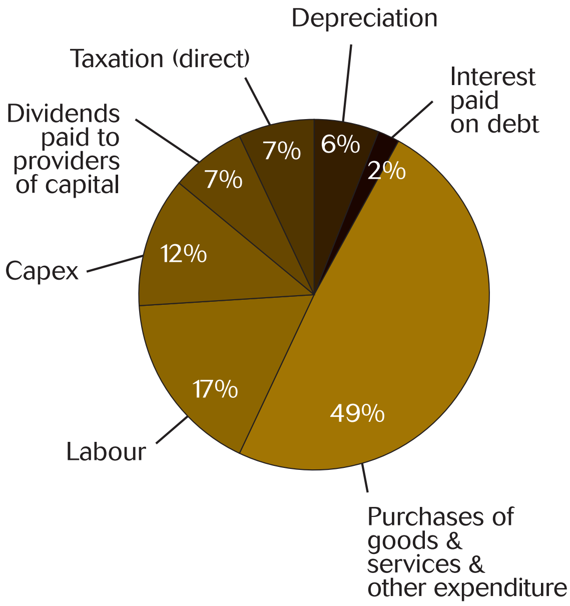
Wednesday, February 13th, 2008

This article was published on www.goldworld.com. Learners – if you use any part of it you need to write it in your own words and include the following in your reference list: McCoach, G. 13 February 2008. South African Gold Mining. [Online]. Available: http://www.goldworld.com/articles/south+african-gold-mining/221 [14 October 2008]

Income and Expenditure of the South African Mining Industry

In 2007 the total income of the South African mining sector was R310 billion, up by 27,4% on 2006 (StatsSA). Sales of minerals were R291 billion and other income sources included profits on equipment or investments sold or re-valued of R4,5 billion, interest received at R4,2 billion, dividends received R1,3 billion and income received from hiring mining equipment of R537 million. Most of the benefits of the income received by the mining companies was then reinvested or spent in South Africa. In 2007, the mining sectors total expenditure was R302 billion, comprising R143 billion spent on the procurement of goods and services, R50 billion went on salaries and wages, R37 billion went into capital investment in the sector, R22 billion was paid in the form of direct taxes to government, R22 billion was paid as reward to the providers of capital (shareholders), R19 billion was used for depreciation purposes and some R7 billion was paid as interest by the sector to the financial sector for loans to mining.

Expenditures of SA mining industry



This material is taken from the Chamber of Mines website www.bullion.org.za. Learners – if you use any part of it you need to write it in your own words and include the following in your reference list: The Chamber of Mines of South Africa. 2008. Income and expenditure of the South African mining industry. [Online]. Available: http://www.bullion.org.za/ [14 October 2008]

The **Golden** Timeline

4000 BC
Gold is first known to be used in parts of central and eastern Europe.

3000 BC
The Egyptians master the arts of beating gold into leaf and alloying gold with other metals to achieve variations in hardness and color. They also develop the ability to cast gold, using the lost-wax technique still used in today's jewellery industry. The Sumer civilization of southern Iraq uses gold to create a wide range of jewellery, often using sophisticated and varied styles still worn today.

1500 BC
The immense, gold-bearing regions of Nubia make Egypt a wealthy nation, as gold becomes the recognized standard medium of exchange for international trade. The Shekel, a coin originally weighing 11,3 grams of gold, is used as a standard unit of measure throughout the Middle East. The coin contained a naturally occurring alloy called electrum, which was approximately two-thirds gold and one-third silver.

1352 BC
The young Egyptian King Tutankhamen is interred in a tomb laden with gold.

1350 BC
The Babylonians begin to use fire assay to test the purity of gold.

1091 BC
Squares of gold are legalized in China as a form of money.

560 BC
The first coins made purely from gold are minted in Lydia, a kingdom of Asia Minor.

58 BC
Julius Caesar seizes enough gold in Gaul (France) to repay Rome's debts.

50 BC
The Romans issue a gold coin called the Aureus.

600 – 699 AD
The Byzantine Empire resumes gold mining in central Europe and France, for the first time since the fall of the Roman Empire. Artisans of the period produce intricate gold artefacts and icons.

1100
Venice secures its position as the world's leading gold bullion market due to its location astride the trade routes to the east.

1284
Venice introduces the gold Ducat, which soon becomes the most popular coin in the world, and remains so for more than five centuries. Great Britain issues its first major gold coin, the Florin, which is followed by the Noble, the Angel, the Crown, and the Guinea.

Learner Information Sheet

The Golden Timeline

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1511

King Ferdinand of Spain sends explorers to the Western Hemisphere with the command to 'get gold.'

1717

Isaac Newton, Master of the London Mint, sets price of gold that lasts for 200 years.

1787

First US gold coin is struck by Ephraim Brasher, a goldsmith.

1792

The Coinage Act places the young United States on a bimetallic silver/gold standard, defining the US dollar as equivalent to 24,75 grains of fine gold, and 371,25 grains of fine silver.

1803

North Carolina becomes the site of first US gold rush. The state supplies all the domestic gold coined for currency by the US Mint in Philadelphia until 1828.

1848

The California gold rush begins when James Marshall finds specks of gold in the water at John Sutter's sawmill near the junction of the American and Sacramento Rivers.

1850

Edward Hammond Hargraves, returning from California, predicts he will find gold in Australia within one week. He discovers gold in New South Wales a week after landing.

1859

The Comstock Lode of gold and silver is discovered in Nevada. As a result, Nevada is made a state five years later.

1886

George Harrison, while digging stones to build a house, discovers gold in South Africa.

1887

Glasgow doctors, Robert and William Forrest, and chemist John S. MacArthur patent the process for extracting gold from ore using cyanide.

1896

Two prospectors discover gold while fishing in the Klondike River in northern Canada and richer finds were rumoured farther south in Alaska's Yukon, spawning the Alaska Gold Rush in 1898 – the last gold rush of the century.

1900

US adopts the gold standard for its currency.

The Golden Timeline

1903

The Engelhard Corporation introduces an organic medium to print gold on surfaces. First used for decoration, the medium becomes the foundation for microcircuit printing technology.

1922

King Tutankhamun's tomb (1352 BC) opened to reveal the king's mummy lay within a nest of three coffins, the innermost of solid gold, the two outer ones of gold hammered over wooden frames. On the king's head was a magnificent golden portrait mask.

1933

President Franklin D. Roosevelt bans the export of gold, halts the convertibility of dollar bills into gold, orders US citizens to hand in all the gold they possess and establishes a daily price for gold.

1934

Roosevelt fixes price of gold at $35 per ounce.

1935

Western Electric Alloy #1 (69% gold, 25% silver and 6% platinum) finds universal use in all switching contacts for AT&T telecommunications equipment.

1944

The Bretton Woods agreement sets an international gold exchange standard and creates two new international organizations, the International Monetary Fund (IMF) and the World Bank. The new standard sets par values for currencies in terms of gold and obligates member countries to convert foreign official holdings of their currencies into gold at these par values.

1947

The first transistor, the building block for electronics, is assembled at AT&T Bell Laboratories. The device uses gold contacts pressed into a germanium surface.

1960

The laser is invented using gold-coated mirrors to maximize infrared reflection.

1961

Modern-day mining begins in Nevada's Carlin Trend, ultimately making Nevada the nation's largest gold-mining state.

1968

Intel introduces a microchip with 1 024 transistors connected by gold circuits. On March 15, Central Banks give up fixed price of gold at $35 per troy ounce and let it float free.

1969

Gold coated visors protect the astronauts' eyes from searing sunlight on the moon (Apollo II moon landing).

1970

The charged coupled device is invented, using gold to collect electrons generated by light and eventually used in hundreds of military and civilian devices, including video cameras.

The Golden Timeline

1971

The colloidal gold marker system is introduced by Amersham Corporation of Illinois. Tiny spheres of gold are used in health research laboratories worldwide to mark or tag specific proteins to reveal their function in the human body for the treatment of disease.

1973

The US dollar is removed from the gold standard, and gold prices are allowed to float free. By June, the market for gold in London reaches more than $ 120 per ounce.

1974

On December 31 the US government ends its ban on individual ownership of gold.

1976

The Gold Institute is established in Washington DC, to promote the common interests of the gold industry by providing statistical data and other relevant information to its members, the media, government, and the public.

1980

Gold reaches intra-day historic high price of $870 on 21 January in New York.

1986

Gold-coated compact discs are introduced.

1987

Airbags are introduced for cars, using gold contacts for reliability.

1996

The Mars Global Surveyor is launched with an on-board gold-coated parabolic telescope-mirror that is to generate a detailed map of the entire Martian surface over a two-year period.

1997

Congress passes the Taxpayers Relief Act, allowing US Individual Retirement Account holders to buy gold bullion coins and bars for their accounts as long as they are of a fineness equal to, or exceeding, 99,5 percent gold.

1999

The Euro, a pan-European currency, is introduced, backed by a new European Central Bank holding 15% of its reserves in gold.

2003

Astronomers at the Keck Observatory in Hawaii use the giant gold-coated mirrors of the observatory's twin telescopes to produce the most detailed images of Neptune and Uranus ever captured.

This material was obtained from the AngloGold Ashanti website www.anglogold.co.za. Learners – if you use any part of it you need to write it in your own words and include the following in your reference list: AngloGold Ashanti. 2008. Golden Timeline. [Online]. Available: http://www.anglogold.co.za/NR/rdonlyres/7BFBFAD3-14C6-4BB0-B1A1-AAF1D834ED0E/0/goldentimeline.pdf [14 October 2008]