Ore Processing

Ore processing is the art of separating valuable minerals from waste rock and minerals. Mineral processing can be divided into the following three phases: (1) Comminution (Crushing and Grinding), (2) Beneficiation (Separation and Concentration), and (3) Smelting and Refining.

Crushing and Grinding deals with grinding the ore down to a fine particle size to make follow up processing easy (Figure 5). Following this, ore Separation and Concentration processes are performed (Figure 5) and there are a number of methods that can be used depending on the minerals being processed. Basically for metals, two separate fundamental processes can be performed – one for precious metals and the other for base metals.

Smelting and Refining is the process of reducing mineral ores and concentrates (processed ores that contain higher concentrations of the target mineral(s)) to metals. Mineral concentrates are dried up and sold to be smelted and refined. Most methods involve heating the ore/concentrates with carbon to effect reduction with additional refining to produce metal in a high state of purity ready for sale.

Figure 5. A simplified diagram showing a mineral processing method excluding Smelting and Refining.

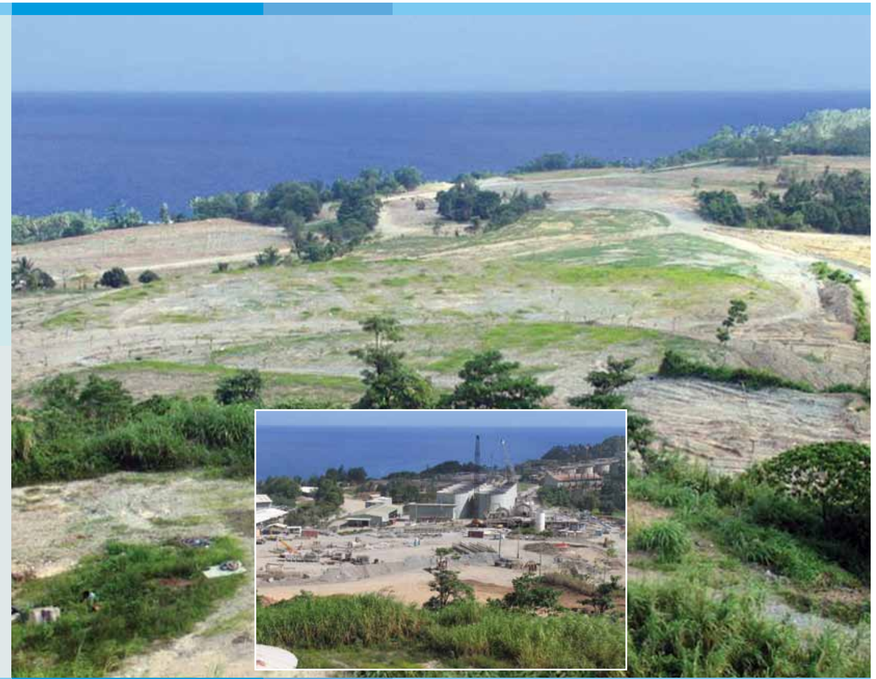
Mine Site Rehabilitation

Mine site rehabilitation is a requirement under most modern mining legislation and regulations and is an ongoing process. After mining finishes, the mine area must undergo rehabilitation to minimize the effects of mining or avoid further damage on the environment. The type and scale of the recovery program that needs to be used on any mine site depend on numerous factors including the extent of surface disturbance, waste disposal method and type and scale of mining. Open pit mining involves movement of significant volumes of mine waste (rock and tailings) hence any rehabilitation program would require a lot of effort with significant associated costs. Mine tailings can be defined as large piles of crushed rock that are left over after the metals of interest have been extracted from the ore materials.

If the waste materials (rock and tailings) contain sulphides, they are usually covered with soil to prevent access of rain and oxygen from the air and prevent the sulphides turning to sulphuric acid and contaminating nearby soil and water. Landfills are usually covered with topsoil, and vegetation is planted to help bind the loose material. Waste dumps are contoured to stabilise them against erosion, and then fenced off to prevent livestock from eating any subsequent vegetation since it could be poisonous. Open pits, which normally fill up with groundwater, are also fenced off to prevent access.

Figure 6. Mine rehabilitation, Misima Gold Mines, PNG[2].

[2] Petueli R and others. 2006. Mine Closure: Misima Mines Case Study.



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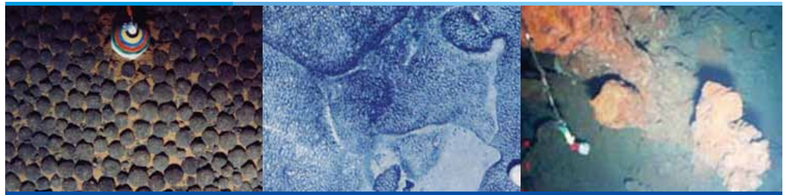

Information Brochure 2
Minerals and Mining Process

Minerals and mineral products are important for the development of any nation. Every segment of society uses minerals and mineral products everyday. The roads we ride or drive on and the buildings we live learn and work in all contain minerals.

Since the beginning of civilization minerals have been extracted from onland sources and used in various development sectors. With the discovery of manganese nodules on the seabed more than a century ago, the potential of deep sea mineral deposits have not been realised until recent success in exploration efforts that trigger growing interests for commercial mining. Potential seabed mineral deposits are composed largely of metallic minerals and some are considered strategic metals due to their specific uses. It is therefore crucial to describe minerals and understand the process of extracting them in simplified terms.

What are minerals?

A mineral is a naturally occurring solid substance that is formed through processes where rocks are formed and/or transformed. It has characteristic appearance, behaviour and composition. Minerals are neither animal nor plant and they are inorganic. At present, about 2,000 minerals have been found on earth.

A mineral is composed of an element or more than one element (i.e. compounds) combined through various natural mineral-forming processes. Examples of mineral elements and compounds are given below.

Minerals				
Element		Compound		
Mineral Name	Chemical Symbol	Mineral Name	Major Element Present	Chemical Symbol
Gold	Au	Calaverite	gold, tellurium	$AuTe_2$
Silver	Ag	Petzite	silver, gold & tellurium	Ag_3AuTe_2
Iron	Fe	Pyrite	iron, sulphur	FeS_2
Manganese	Mn	Cuprite	copper, oxygen	Cu_2O
Copper	Cu	Chalcopyrite	copper, iron & sulphur	$CuFeS_2$

Minerals are the building blocks of rocks. A rock is a mixture of one or several minerals in different proportions.

Types of Minerals

Minerals are broadly classified into two categories: Silicate and non-Silicate minerals. Silicate minerals are the most commonly found group of mineral on Earth and they constitute approximately 90% of the Earth's crust. Almost all silicate minerals have silicon and oxygen as their primary components and examples are: Fayalite (Fe_2SiO_4), Zircon ($ZrSiO_4$), Enstatite ($MgSiO_3$), and Ferrosilite ($FeSiO_3$).

Non-silicate minerals can be further classified into many different groups. Four common examples are: elements (E.g. diamond, gold, silver), oxides (Magnesium oxide, Copper oxide, Iron oxide), carbonates (Iron Carbonate, Calcium Carbonate) sulphates (Gypsum, and Barite). Many more non-silicate minerals are not commonly found naturally.

Minerals can also be divided into these three main categories based on their appearance, behaviour and use: Metalliferous minerals, Non-metalliferous minerals and Industrial minerals.

Metalliferous minerals are naturally occurring minerals that contain a high concentration of metallic elements. This can further be subdivided into Precious, Base and Rare Earth Metals.

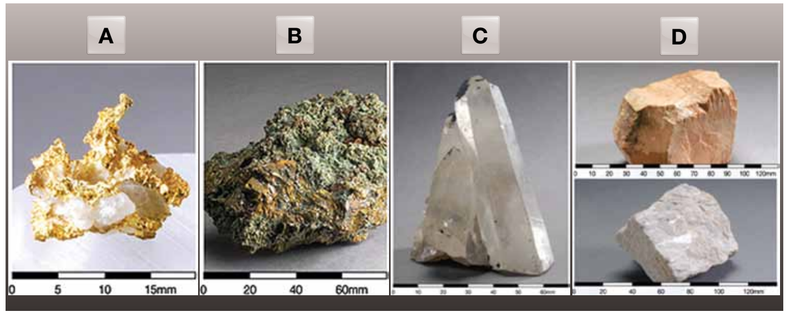

Figure 1. Examples of mineral specimen: Metalliferous minerals (A) Gold and (B) Chalcopyrite (a copper ore); Non-metalliferous minerals (C) Quartz and (D) Feldspars.

(http://hkss.cedd.gov.hk/hkss/eng/education/GS/eng/hkg/chapter8.htm).

A precious metal is a naturally occurring metallic element of high economic value. E.g. Gold (Figure 1A), Silver and Platinum. On the other hand, a base metal is a metal that oxidizes or corrodes relatively easily. E.g. Iron, Copper (Figure 1B), Lead and Zinc. A rare earth metal is a rare naturally occurring metallic element. Rare earth metals comprised 17 elements that are used in high tech applications such as laser guided weapons and hybrid car batteries. E.g. Scandium, Yttrium, Lanthanum and Neodymium.

Non-metalliferous minerals are defined as naturally occurring minerals that contain high concentration of non-metallic elements. E.g. Carbon, quartz (Figure 1C), mica and feldspar (Figure 1D).

An industrial mineral is any naturally-occurring rock or mineral of economic value, not including metallic ores, mineral fuels, and gemstones. Ore is a mineral or group of minerals that can be mined at a profit. Industrial minerals can be subdivided into two basic groups based on uses:

Fertilizer and Chemical Mineral:

Minerals in fertilizers are essential for growing food. E.g. potassium, nitrogen and phosphorus. Other minerals are used in many chemical applications E.g. salt, sulphur, boron, soda ash.

Construction and Manufacturing Minerals:

These are minerals and rocks that are used extensively in the construction industry, mostly in roads and buildings. E.g. Limestone, gypsum, sand and gravel.

Figure 2 demonstrates the various subdivisions of minerals, branching from the three main mineral categories, based on their appearance, behaviour and use.

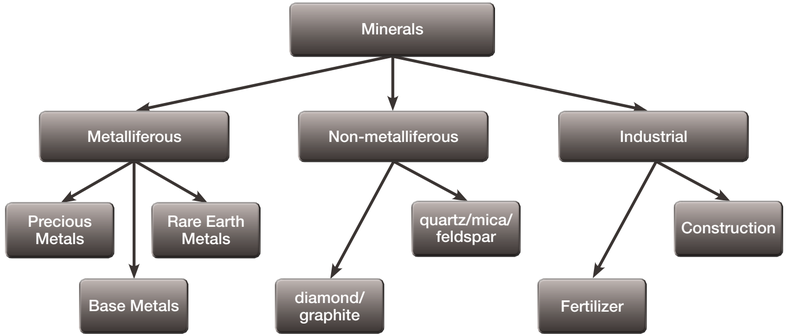

Figure 2. Various subdivisions of mineral types.

Uses of Minerals

Minerals have a wide variety of uses and are important to our health. They are ingredients in almost all of the products we use from fertilizer to plastics, from toothpaste to litter tray, from knives to plates. Minerals that are composed of metals (i.e. metallic minerals) have wide range and often vital uses in everyday life, including in industrial and manufacturing applications, medicine and dentistry and in the making of arts objects and jewellery.

Optical and scientific apparatus use minerals like quartz, fluorite, gypsum and mica for their optical properties. Plants require certain minerals such as phosphorus, potassium and nitrogen for growth and fertilizers provide these essential elements.

Minerals are needed by the human body in small amounts to help it function properly and stay strong. Iron, calcium, potassium, and sodium are some essential minerals. Humans need small amounts of about 14 minerals to maintain normal body function and good health. Almost all foods contribute to a varied intake of essential minerals and most of them are easy to obtain in quantities required by the body.

Mining Process

Mining is the removal of valuable minerals (ore) or other rock materials from the earth usually from an orebody. An orebody is a body of rock that contains mineral(s) that can be mined at a profit.

The process of mining commences from the discovery of an ore body through extraction of minerals and finally to mine site rehabilitation. This process consists of several different steps that can be summarised as mineral prospecting (discovery stage) and evaluation. Advanced evaluation (i.e. detailed assessment of issues relating to mining, rock and mineral behaviour, financial, and equipments) is carried out as the final step to determine the profitability of any mining operation.

Onland mining techniques can be divided into two common types: surface mining (open pit) (Figure 3) and sub-surface (underground) mining.

Figure 3. An aerial view of the Ok Tedi open-pit Mine in the highlands of PNG[1].

Once an evaluation determines that a given orebody can be mined at a profit, mine buildings and processing facilities are built. Additionally, necessary equipment is obtained prior to the beginning of mining. The operation of the mine to recover the wanted minerals begins and continues as long as the company operating the mine finds it profitable to do so.

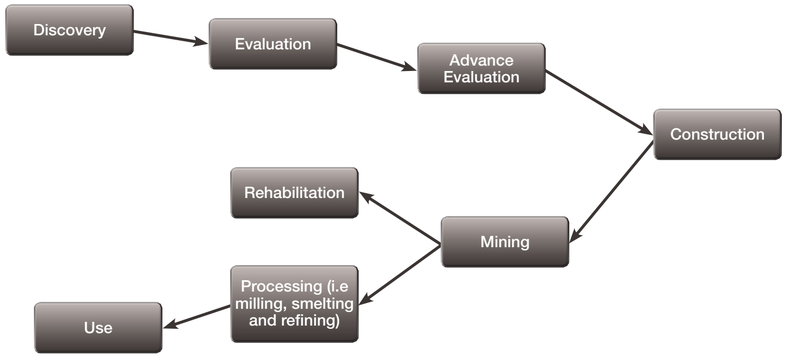

Figure 4. A flow chart summarising the mining process.

Once all the ore that the mine can produce profitably is recovered, the mine would close. A mining company must develop, implement and complete a site recovery program that makes the land and mine site suitable for future use. A flow chart illustrating the mining process is shown in Figure 4.

[1] http://www.oktedi.com/