Table 3. Uses of Some Non-Metallic Minerals

Asbestos	Fireproof fabrics, paper, brake linings.
Barite	Oil-well drilling muds, glass, paint.
Borates	Flux, glass, detergents, chemicals.
Clays	Bricks, tiles, pottery, fillers for paint, rubber and paper, decolourisers.
Diamond	Drills, abrasives, gems.
Feldspar	Flux for glass manufacture, porcelain, enamel, tile glazes, abrasives, toothpaste.
Fluorite	Glass, enamel.
Garnet	Abrasives, gems, watches, jewels.
Graphite	Pencils, batteries, foundry facings, crucibles, lubricants.
Gypsum	Wall board, plaster, soil improvement, retarder in portland cement.
Halite (salt)	Food, Chlorine for water treatment, sodium hydroxide for soap.
Magnesia	Cements, rubber, foundries, refractory brick,
Mica	Electronics, radio tubes, electrical insulation, cement, paint.
Olivine	Refractories, gems.
Quartz	Broadcast frequency control, silica glass.
Sulphur	Fertiliser, sulphuric acid, paper making, bleaches.
Talc	Toiletries, ceramics, paint, paper.
Vermiculite	Sound insulation in plaster and loose fill, plastics.

Table 4. Minerals Used in a School Room

Blackboard	Made of wood covered with paint containing abrasive minerals such as ground pumice. Duster made of synthetic fibre.
Cement	Made from clays, shale, limestone, bauxite, hematite, gypsum.
Chalk	Dried and moulded paste of calcium carbonate and gypsum.
Desks	Frames of steel painted or galvanized with zinc.
Glass	Made from silica sand, limestone, borate salts, soda ash and feldspar minerals.
Paper	Filled or coated with industrial minerals like kaolin, calcium carbonate and talc.
Pens & pencils	Graphite and clays in pencils. Ballpoint pens use brass, tungsten and plastic. Ink uses calcium carbonate and fillers.
Walls	Wallboard of gypsum joined by cement with gypsum, mica, clays and calcium carbonate.
Wood	Saws and planes made from steel are used to cut wood. Wood is sanded with sand paper embedded with emery, corundum and garnet powders.

Table 5. Minerals Used in Bathroom

Cistern	PVC and plastics from petrochemicals and components or brass.
Cleaners	Sterilants and bleaches made with chlorine and halite. Scouring and cleaning liquids and soap made from soda ash, borax, limestone, halite, sulphur, clays, diatomite, pumice and petrochemicals.
Cosmetics	Talc in powder, magnesium carbonate and silica help flow and fragrance. Lipsticks use talc and calcium carbonate.
Countertops	Marble and granite or ceramic.
Hand basin and bath	Porcelain made using silica, limestone, borate salts, soda ash and titanium minerals.
Shampoo	Clays used as thickeners.
Tap fittings	Brass, steel or aluminum with plastic components. Chrome uses chromium, cadmium, sulphur.
Tiles	Ceramics are made from kaolin, silica, feldspar, talc. Manganese, cobalt, antimony and iron oxides give colour. Putty uses limestone and gypsum.
Toilet paper	Pulp is processed with sulphur, soda ash, limestone, clay, talc and titanium minerals.
Toothpaste	Calcium carbonate, zeolites, sodium carbonate and clays. Gels use silica.

Table 6. Minerals used in Sporting Equipment

Bicycles	Frame, wheels and gearing are of steel, aluminum, chromium and titanium minerals. The plastic seat and helmet are from petrochemicals. The tyres made using sulphur and petrochemicals.
Skate-board	Iron, chromium, nickel, petrochemicals, aluminum. Pads and helmet use copper, zinc, petrochemicals and iron.
Sneakers	Plastics, dyes, synthetic fibres and printing ink for the tough fabric come from petrochemicals. Petrochemicals and sulphur used in the rubber soles.
Sun creams	Made with zinc compounds and titanium oxides.
Sunglass	Lenses of glass or plastics from petrochemicals. Frames of chromium, brass and gold.
Roller blades	The plastics, nylon and synthetic fibres from petrochemicals, while the metal parts are aluminum, steel or brass.

Table 7. Minerals Used in Furniture, Fittings and other Equipment

Aircraft	Made of aluminum, cobalt, chromium, cobalt, tantalum, and titanium.
Carpets	Wool is cleaned with clays, soda ash, zeolite or petrochemicals. Synthetic fibres and dyes come from petrochemicals.
Chairs	Frame made of steel painted or galvanized with zinc. Coverings of vinyl and synthetic fibres derived from petrochemicals.
Computers and electronics	More than 33 minerals and elements ranging from aluminum to zirconium. The silicon chip is made from silica or quartz.
Curtains	Made of natural or synthetic fibres. Tracks are of aluminum or steel.
Door Handles	Made from steel or brass (alloy of copper and zinc).
Door stopper and other rubber items	Made from petrochemicals, sulphur, limestone and clays.
Fireworks	Sulphur; colours from mineral mixtures like iron fillings and charcoal (gold sparks), strontium and sodium (orange), barium (green), strontium (red), copper (blue), sodium (yellow), and others. Fine aluminum powder is used for
Floors	Concrete uses light weight aggregates such as perlite, vermiculite, zeolite or expanded shales. Floors covered with ceramic, marble or granite tiles.
Light bulbs, fluorescent tubes	Made from glass. Metal fittings of steel, copper and lead. Elements of tungsten and rare earth metals.
Light switches	Made of steel, copper and brass, with plastic components from petrochemicals.
Linoleum	Made from petrochemicals, and also contain clays, limestone and wollastonite.
Medicine	Contains minerals like kaolin, iodine, and many others.
Metallic window frames	Made of steel and aluminum.
Telephones	A telephone handset uses 42 different minerals.
Paints	Most are made from petrochemicals, but contain minerals such as calcium carbonates (from limestone), clays, hematite, talc, mica, petrochemicals, and colouring pigments from titanium minerals.
Whiteboard	Steel or aluminum frame covered with plastic sheeting from petrochemicals.
Windows	Sheeting made by floating glass on molten tin.

NECESSITY OF MINERALS

Today, mineral resources play a role second in importance only to that of agriculture, and there are thousands of uses for the various materials of the Earth. There isn't much that one can think of that doesn't come from some sort of mining process and it can honestly be said that:

"If it's not grown, it's mined"!

Virtually no aspect of our lifestyle could be sustained without minerals. Minerals are used in every facet of our daily living from food production and processing, building, providing shelter/housing to transport, communications, medicine and leisure activities.

EXPLORATION AND MINING

Exploration is the search for mineral deposits containing sufficient ore to be economically mined. Geologists use all available geological and geophysical tools to assist exploration. Ore minerals are extracted from the Earth's surface and from underground by mining. The ore is then milled, (crushed), processed and refined to produce the metal or non-metallic product.

FIJI'S MINERAL WEALTH

Fiji's mineral wealth includes gold which is mined at Vatukoula. There are plans to commence exploration at Mt Kasi in south-west Vanua Levu and commencement of mining at Tuvatu near Nadi. Advanced exploration is also currently underway at Namosi for copper-gold and in other parts of Fiji for gold. In addition, there is quarrying of rock and sand for road material, concrete aggregate and landfill and of coral sand for cement manufacture. Clay is used by many villagers to make pottery.

SUGGESTIONS FOR FURTHER READING

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MINISTRY OF LANDS AND MINERAL RESOURCES

MINERALS

MINERAL RESOURCES DEPARTMENT

MINERALS

WHAT ARE MINERALS?

The rocks which form the Earth, the Moon and the planets are made up of **minerals**. Minerals are chemical elements or compounds which occur naturally within the crust of the Earth. They are the discrete crystalline particles of which nearly all rocks are made. Minerals are solid substances made up of atoms with an orderly and regular arrangement, which is the basis of their crystalline state. Because of their orderly atomic arrangement it is also possible to express the composition of a mineral as a chemical formula.

Minerals are **Inorganic substances** (not derived from living things) composed of elements such as silica, oxygen, aluminum, iron, etc. *Fossil fuels* such as coal, oil and natural gas are organic (formed from once-living matter) and hence are not minerals in the strict sense.

Minerals provide the elements essential to life, the metals of industry and the materials for building (Tables 2-7). The calcium and phosphorus in bones and the iron in blood are made available to the body through plants which extract these elements from minerals in the soil.

Mineralogists (geologists who study minerals) have identified nearly 3000 minerals. About 100 of these are regarded as common minerals and less than 20 can be found everywhere.

Nearly all rocks are composed of minerals (some contain glass or organic matter) but it is rare to find good mineral specimens. These tend to occur in gaps, cavities and fractures within the rocks where the crystals have been unobstructed (have much free space) during their growth. Rocks can be formed from a combination of several different minerals or a single mineral can make up the bulk of a rock, for example, limestone or marble is mainly composed of the mineral calcite ($CaCO_3$).

GENERAL CHARACTERISTICS

Many minerals are found as beautiful **crystals.** Crystals are formed when minerals are free to grow without constraint. Crystal faces reflect the regular atomic arrangement of the mineral. The incredibly regular arrangement of crystals has been recognized for about 200 years but the internal structure of minerals has only been determined this century by the use of X-rays. The regularity of crystals is due to the angle between the same two faces of all crystals of the same mineral species being constant, even though the faces may look variable in size and shape. The crystal structure determines the physical properties of minerals. Crystals are symmetrical and can be grouped according to their symmetry into seven crystal systems. The study of crystals and crystal systems is called **crystallography.**

Minerals vary in colour and in the way they look and feel. Some minerals are hard and sparkle and shine like glass. Others are slippery and soft or hard and scratchy. The way minerals look depends on their interaction with light, and these **optical properties** can be used to classify and identify minerals. These include properties such as transparency, reflection and refraction, lustre, colour, streak (colour of the powdered mineral) and fluorescence.

Minerals can be classified according to their **hardness** as described by Moh's Hardness Scale (Table 1). In 1812, F. Mohs arranged ten minerals in order of hardness so that each mineral can be scratched by the one following it on the scale. Thus talc is the softest and diamond is the hardest.

Table 1. Moh's Scale of Hardness

Hardness	Mineral	Objects of Similar Hardness	Mnemonic
1	Talc	Dry Soap	*The*
2	Gypsum	Plaster of Paris	*Ground*
3	Calcite	Finger nail	*Can*
4	Fluorite	Copper Coin	*Form*
5	Apatite	Pen knife	*A*
6	Feldspar	Glass	*Fault*
7	Quartz	Hardened knife	*Quickly*
8	Topaz	Grinding wheel	*Terrifying*
9	Corundum	Garnet paper	*Cheerful*
10	Diamond	Diamond	*Dinosaurs*

Minerals also occur as **aggregates** of crystals that rarely show perfect crystal shape. The form of the aggregate can be useful for identification, i.e. whether they are fibrous, dendritic, lamellar or foliated, etc.

The **density or specific gravity** of a mineral depends on several factors including the kind of atoms in the structure and how closely they are packed. For example, the minerals tridymite and quartz are both silica (SiO_2) but quartz, the closely packed form, has a specific gravity of 2.65 at room temperature whereas tridymite, with a more open structure, has a specific gravity of 2.26 at room temperature.

Other properties that mineralogists use when identifying and classifying minerals are related to how they break i.e **cleavage** (breaks along a planar surface related to the structure and parallel to a possible crystal face) and **fracture** (broken surface is irregular), magnetic, electrical and radioactive properties.

The composition of a mineral can be expressed as a chemical formula which is a simple way of expressing mineral chemistry. The mineral chemistry can be used to further classify minerals. **Sillicate minerals** (combinations of silicon and oxygen with other elements) are the most abundant rock-forming minerals. Silicate minerals that commonly occur in the rocks of Fiji include feldspar, mica, olivine, pyroxene and amphibole. Quartz is simply a combination of oxygen and silicon, without other elements.

TYPES OF MINERALS

There are two types of minerals: metals and non-metals, and they have different properties as outlined below.

Metals

Strong, can support heavy loads without breaking.
Conduct heat and electricity.
Opaque - do not allow light to pass through.
Malleable - can be bent without breaking.
Ductile - can be stretched into wire.

Non-metals

Weak, shatter when hit with a hard object.
Most do not conduct heat and electricity.
Can be transparent, translucent or opaque.
Not malleable.
Not ductile.

ORIGINS OF MINERAL AND ROCKS

Most minerals crystallise from some sort of solution. Some of the ways mineral can form are from:

i. cooling of magma (complex solutions of molten rock materials within the earth) or lava (complex solutions of molten rock material that reach the Earth's surface);
ii. cooling of subsurface solutions involving hot water or hot gases, including steam, as in many mineral veins and metallic ore deposits;
iii. hot vapours condensing to form minerals, such as sublimates or sulphur near volcanic vents;
iv. chemical reactions with previous minerals, such as the hydrothermal alteration or feldspar to mica, or the oxidation of iron-bearing minerals in the zone of chemical weathering at the earth's surface;
v. replacement or substitution of an earlier-formed mineral;
vi. recrystallization of earlier-formed minerals to form new compounds under changed temperature and pressure conditions; or
vii. evaporation of water solutions.

ORE MINERALS

Many minerals are useful to us. A useful mineral from which a valuable element can be extracted is called an *ore mineral.* Ore is a rock that has enough concentration of one or more such minerals to make it profitable to mine it. Mineral ores are the source of all the metals and many other substances that we use every day (Table 5). To obtain these earth resources we have to take them out of the earth by mining and then change them into different substances. Ore also contains economically useless **gangue minerals** which have to be removed before the ore minerals can be concentrated.

USES OF MINERALS

Minerals have always been used by humans in almost every facet of daily living.Primitive people who use rocks to form weapons and other useful tools in the stone age. Then, as people discovered the methods of isolating metals from their mineral ores, "technology and civilization" advanced successively through the Copper,Bronze,Iron,Steel and Atomic Ages. At each step, minerals assumed progressively greater importance.

Tables 2-7 represent some of the common minerals and their many uses in our everyday lives.

Table 2. Uses of Some Common Metallic Minerals

METALLIC EXTRACTED			USES
Aluminum, Al	Bauxite	$Al_2O_3.2H_2O$	Beverage and food cans, furniture, buildings, electrical appliances, air conditioners, ships, motor vehicles, aircraft and other transport equipment, cooking utensils, aluminum foil, high voltage power transmission lines (with steel core).
Chromium, Cr	Chromite	$FeCr_2O_4$	Plating household appliances, motor cars, to harden and strengthen steels and cast iron, stainless steel for automotive, construction and chemical industries.
Copper, Cu	Native Copper Chalcopyrite Chalcocite Bornite	Cu $CuFeS_2$ Cu_2S Cu_5FeS_4	All electrical appliances, telephones cable, radios, TV sets, motor vehicle electrical systems, motors for all purposes, ornamental items made of brass and bronze, plumbing pipes and tanks, roofing.
Gold, Au	Gold	Au	Currency, jewelry, dentistry, electronic and space technology.
Iron, Fe and steel	Hematite Magnetite Limonite Siderite	Fe_2O_3 Fe_3O_4 $2FE_2O_3.3H_2O$ $FeCO_3$	Household appliances, motor vehicles, buildings, bridges, office equipment, beverage and food cans and other containers, tools, farm and factory machinery, transport equipment, building materials.
Lead, Pb	Galena Cerussite	PbS $PbCO_3$	Storage batteries, petrol additives, buildings, bridges, office equipment, beverage and food cans and other containers, tools, farm and factory machinery, transport equipment, building materials.
Nickel, Ni	Pentlandite Garnierite	$(FeNi)_9S_8$ $(Ni,Mg)SiO_3.n$ H_2O	Stainless steel, motor vehicles plating, aircraft, transport equipment, household appliances, electrical machinery, ships, coinage, numerous alloys particularly where corrosion resistance and hardeners are important requirements.
Silver, Ag	Native Silver Argentite	Ag Ag_2S	Photographic film and developing paper, silverware, jewelry, industrial refrigerators, coinage, batteries, electronic solder in aircraft.
Tin, Sn	Cassiterite	SnO_2	Tin plate solder, pewterware, in bronze, in electrical equipment, in pigments fro pints and plastics and in dry-cell batteries.
Titanium, Ti	Ilmenite Rutile	$FeTiO_3$ TiO_2	Ti metal for engines, Ti pigment for paints, paper, plastics, welding electrodes.
Uranium, U	Pitchblende or Uranite, Yellow-cake	UO_3 U_3O_8	Power generation, production of radioisotopes fro research, industry, agriculture and medicine.
Zinc, Zn	Sphalerite Smithsonite	ZnS $ZnCO_3$	Galvanised roofs, fences, car bodies, zinc die castings for carburetors, motor vehicle grills, household appliances, door handles, zinc oxides for tyres and paints, rolled zinc in dry-cell batteries.