The Briefcase book of daily use minerals

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3D Briefcase of mineral applications

FOREWORD

Dear readers!

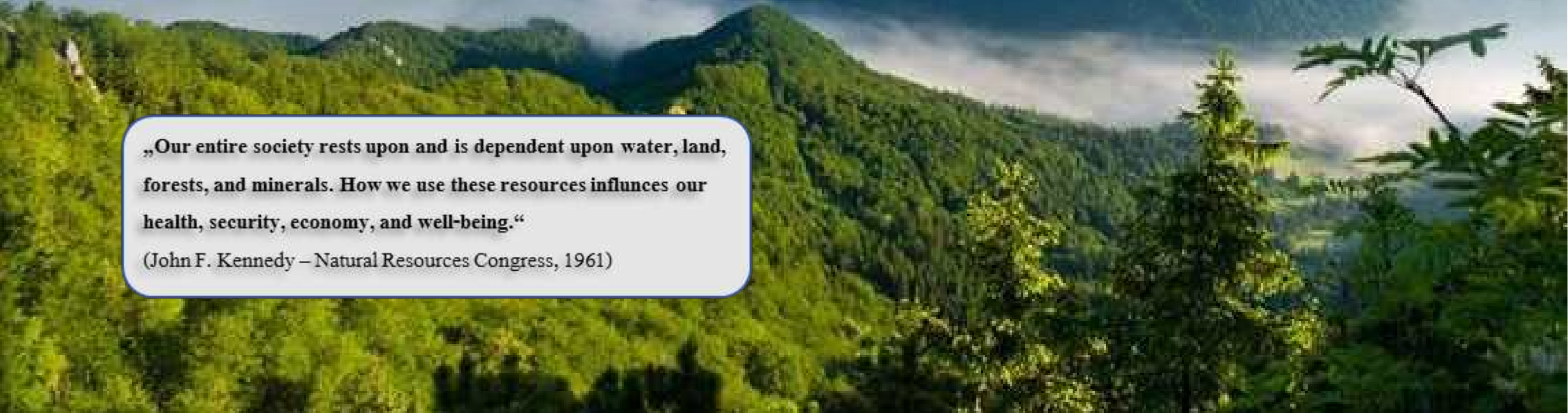
We are pleased to share with you this interactive book which uses modern digital tools.

"The Briefcase book of daily use minerals" is one of the products of the 3D Briefcase project and a teaching tool at the same time. It is intended to be used for teaching geoscience disciplines in schools as well as informing the public about the importance of mining and minerals in our daily lives.

When we look far back in history, prehistoric peoples sought out stones to make various tools to cut, dig, hammer, and hunt. They mainly used silicites – hard rocks with a high silicon content, such as flint, chert and radiolarite, as well as high-quality materials like obsidian, jasper and opal. Stone was used in the production of stone vessels and later ceramics (clay). It was also used in the production of glass, moulds (sandstone), jewellery (opal, chalcedony and crystal) and in the construction of dwellings. With the gradual development and growth of the population and the expansion of dwellings, our ancestors discovered other raw materials. In later prehistory, some metals, including copper, gold and silver, and then alloys such as electrum (Au + Ag), bronze (Cu + Sn) and brass (Cu + Zn) came into use. The discovery of iron ore was significant to human development. Humans invented a method to extract metal from ore by smelting (the origin of metallurgy) and began to mine rocks and minerals not only on the surface but also underground (the emergence of mining). Then, new manufacturing sectors emerged (blacksmiths), trade developed, and early coinages began.

Our current lifestyle also depends on mineral resources. Minerals are everywhere around us. When you drink a coffee from your favourite cup in the morning, look out of the window, get into your car, switch on a computer, call your friends from your smartphone, ... all these things contain mineral resources.

We hope you have fun with our interactive book and learn a lot of interesting things about minerals!



„Our entire society rests upon and is dependent upon water, land, forests, and minerals. How we use these resources influnces our health, security, economy, and well-being."

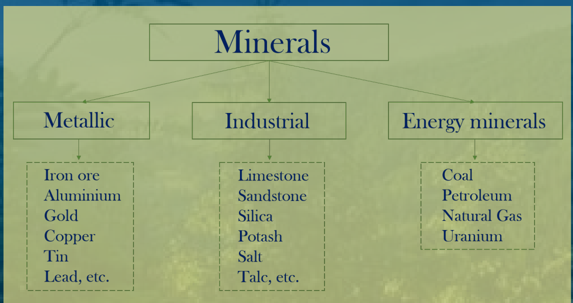
(John F. Kennedy – Natural Resources Congress, 1961)

INTRODUCTION

First, we explain key terms to help you to understand the information on mineral resources in this book. What is a mineral, rock, raw material? What is the difference between them?

Minerals are homogeneous (uniform), mostly solid crystalline natural "products" formed during various geological processes. They have the same physical and chemical properties in each part. They can be elements or compounds of elements and can be expressed by chemical formulae. Their origin is mostly inorganic, but they can also originate from organic processes, as is the case with amber (solidified tree resin).

Rocks are heterogeneous (non-uniform) natural "products" composed of several minerals. However, some rocks consist of one type of mineral or organic matter or contain natural substances other than minerals. Rocks are formed in the Earth's crust or mantle and form large geological bodies.



Classification of minerals

Picture showing the difference between rock and mineral

A **mineral raw material** can be an element, mineral or rock (in various phases), which is part of the Earth's crust. It can serve to meet the needs of society directly or through technological modification. In other words, mineral raw materials are those minerals or rocks that are used to obtain useful elements or compounds. This means that not every rock or mineral is raw material. Mineral raw materials are generally divided into three groups: ore (metallic minerals), non-ore (non-metallic, industrial minerals), and energy minerals (caustobiolites).

Metallic minerals are minerals that contain one or more metallic elements. They usually have high specific gravity and metallic lustre, e.g. tin, lead, iron, gold. The raw metals are obtained from the metallic base materials, known as the ores. Products like iron or aluminium are made from their ores by applying specific techniques.

Industrial minerals are rocks, minerals or other naturally occurring materials of economic value such as limestone, dolomite, talc, silica, and many others. Metals, energy minerals and precious stones are not considered in this group. However, an industrial mineral may contain metal elements, such as magnesite containing magnesium oxide. Its property, refractory (appropriate for clinker manufacturing), makes it an industrial mineral.

3D photo of Polymetallic Pb-Zn-Fe ore (galena, sphalerite, siderite)

A **mineral deposit** represents a unique natural accumulation of raw material in the Earth's crust or on its surface, with a definable material and financial value (size of reserves versus economic value). It is a part of the Earth's crust where, without human intervention and due to geological factors and time, raw materials have accumulated in suitable mining and geological conditions as well as quantity and quality for use now or in the future.

Each deposit contains a finite amount of raw material, which represents the reserves of the deposit. These reserves are reduced by the extraction of the minerals and the extractive operation eventually comes to an end. Therefore, mineral deposits are classified as non-renewable natural resources and require specific conditions for their use and protection. The extraction of non-renewable raw materials must take into account their uniqueness, rarity and non-renewability, and must respect the level of technology and the availability of alternative resources.

This book presents examples of ores and minerals used as raw materials in the 3D Briefcase project consortium countries:

Metallic minerals – ores of iron, lithium, aluminium, zinc, tungsten, mercury, copper, tin, gold

Industrial minerals - magnesite, talc, quartz

Each mineral raw material is presented with interesting photographs and the following information: description of the mineral raw material; physical properties of the mineral and chemical formula; methods of mining and processing; mineral deposits and common applications.

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IRON

Metallic or native iron is rarely found on the Earth's surface. The source of its chemical symbol Fe is the Latin word ferrum. Iron is a relatively dense metal with distinctive magnetic properties. It is the fourth most abundant element of the Earth's crust after oxygen, silicon and aluminium. When exposed to air and water it quickly rusts. It melts at a temperature of 1538 °C. Pure metal is malleable and can be easily shaped by hammering. Iron is usually found in the form of iron ores represented by followed minerals: magnetite (72,4 % Fe), hematite (69,9 % Fe), goethite (62,9 % Fe), limonite (55 % Fe) and siderite (48,2 % Fe). Iron ores are one of the main raw materials to make steel, which is iron-carbon alloy.

HEMATITE

Chemical formula Fe_2O_3

Physical properties

Classification	Oxides
Crystal system	trigonal
Colour	steel grey to black, rust-red
Habit	blocky, tabular
Hardness	5 - 6 Mohs scale
Cleavage	none observed
Fracture	irregular, conchoidal
Lustre	metallic, sub-metallic, earthy
Streak	reddish brown
Density	5,26 g/cm^3
Transparency	opaque

Use in life

Nearly 98% of iron is used to manufacture steel. Steel is the most important engineering material because of its high strength and low cost. It is used for the construction of machinery and tools, rails, automobiles, ship hulls, concrete reinforcing bars and structural elements of buildings. Stainless steel is used for making cutlery, food service appliances and hospital equipment.

Method of mining and processing

Usually, iron ore is extracted through surface mining in open pits, but some underground mines do exist. After drilling and blasting, the next step of ore production is crushing. After that, the material is processed in one of two ways, depending on the quality. High-quality ores (more than 30% Fe content) are screened, washed and sorted using a sensor. The lower quality ores are processed by using a dense media separation and then the ore is crushed again to become fine grained.

Deposits

Iron ores occur in every type of rock – igneous, metamorphic or sedimentary, and in a variety of geologic environments. The most widely distributed iron-bearing minerals are oxides (hematite, magnetite, limonite). Deposits with less than 30 percent iron concentration are commercially unattractive.

The biggest producers of iron ore in the world are China, Brazil, Australia, Russia and Ukraine. Iron producing countries in Europe include Sweden, Turkey, Austria and Germany.

Styrian ore mountain (Erzberg)

Iron ores in Austria

In Austria, iron ore is mined at the Erzberg, Styrian. The Erzberg is the biggest and most modern open-cast mine in Central Europe and features the largest siderite deposit in the world. Open-pit mining has been operating at the Erzberg since 1820. Because the mining was done in benches from 1890 the mountain today looks like a pyramid.

Micaceous iron ore from the Waldenstein mine is used in the production of corrosion- resistant paints, which are used worldwide.


Massive siderite

Interesting facts:

Iron is an abundant element on earth and is a biologically essential component of every living organism. It is an essential element for blood production. Iron is found in red blood cells as haemoglobin which is crucial for transporting oxygen in your blood, and as myoglobin which transports and releases oxygen in muscle cells. Iron deficiency or overconsumption has noticeable effects on human health. When your body does not have enough iron, the level of haemoglobin in red blood cells decreases which causes anaemia. Overconsumption can lead to tissue damage and the iron concentration in body tissues must be strictly regulated.

LITHIUM

Lithium is a chemical element with the symbol Li. It is a soft alkali metal of silvery-white colour and is lightest of the solid elements. It is highly reactive and flammable element. It does not occur freely in nature, but it is found in brine deposits and pegmatite ores, such as spodumene, lepidolite, amblygonite and petalite.

LEPIDOLITE

Chemical formula

$KLi_2AlSi_4O_{10}F(OH)$

Physical properties

Classification	Silicates
Crystal system	monoclinic
Colour	pink, light purple, rose
Habit	foliated, platy, massive
Hardness	2,5 – 3,5 Mohs scale
Cleavage	perfect
Fracture	micaceous
Lustre	sub-vitreous, greasy, pearly
Streak	white
Density	2,83 g/cm^3
Transparency	transparent, translucent

Spodumene - var. hiddenite - Li-mineral used as a gemstone in jewellery

Use in life

Lithium is used in ceramic and glass production, the metallurgy of aluminium and the manufacture of synthetic rubber and lubricants. Well known applications of lithium range from batteries to lithium bromide manufacturing. It is used in the pharmaceutical industry for the treatment of depression, where it is presented in the form of lithium carbonate.

Method of mining and processing

Lithium is often recovered from brine (so-called salars). The production of lithium begins by pumping the brine into evaporative ponds. The concentration of the brine increases through solar evaporation and when lithium chloride reaches optimum concentration, the liquid is pumped to a recovery plant and treated with soda ash, precipitating lithium carbonate, which is then filtrated, dried and shipped. Lithium from ores is usually mined by open-pit mines. In this case, the method of mining involves stripping away the overburden, exposing the pegmatite veins which are then selectively removed and processed.

The Cinovec-Zinnwald deposit in Czech Republic

The Cinovec-Zinnwald deposit is situated on the border of Czech Republic and Saxony (Germany), in the Krušne hory (Erzgebirge) region. It is one of the most important deposits of the Bohemian Massif and is the type locality of the Li-mica mineral Zinnwaldite. The first historic record of mining activity in the Cinovec-Zinnwald area comes from 1378. Since this time, more or less intensive exploitation of the deposit lasted until 1990. The deposit was mined by underground methods from several historic shafts. Nowadays, several geological explorations are in progress in the Cinovec area for lithium extraction from tailing ponds, and as well as exploration for potential lithium, tin and tungsten mining.

Quartz - zinnwaldite vein from Cinovec deposit

Zinnwaldite mineral

Deposits

Lithium deposits are found in brine deposits and as salts in mineral springs or they are found in pegmatite ores. Lithiniferous pegmatite bodies outcrop in metasedimentary rocks and granitoids.

The world's largest suppliers of lithium are Australia and Chile. One of the largest lithium deposits in Europe is located on the Iberian Peninsula. The major producer is Portugal. Other European deposits are situated in Spain, the Czech Republic and Serbia.

Interesting facts:

One of the latest uses of lithium is in electro-optical ceramics. These are transparent materials whose optical properties change with electrical voltage. Lithium niobate and lithium tantalate are used in switches and modulators for high-speed data transmission via optical fibres.

ALUMINIUM

Aluminium is rarely found in the elemental state because of its strong affinity for oxygen. The only important ore of aluminium (Al) is bauxite. Bauxite is not a mineral, but a sedimentary rock that has no defined composition and contains Al-hydroxides, namely gibbsite ($AlOH_3$), boehmite ($AlO(OH)$) and diaspore ($AlO(OH)$), Fe-oxides (hematite and goethite) and other minerals such as quartz, anatase, rutile, kaolin and ilmenite.

Aluminium is relatively cheap, highly conductive, has a low density and resists corrosion. Aluminium is normally alloyed to improve its mechanical properties. The main alloying agents are copper, zinc, magnesium, manganese and silicon.

DIASPORE

Chemical formula $AlO(OH)$

Physical properties

Classification	Oxides, Hydroxides
Crystal system	orthorhombic
Colour	white, brown, colourless, pale yellow, greyish, lilac, pinkish
Habit	platy, tabular
Hardness	6,5 – 7 Mohs scale
Cleavage	perfect
Fracture	conchoidal
Lustre	vitreous, pearly
Streak	white
Density	3,38 g/cm^3
Transparency	transparent, translucent

Bauxite

Use in life

The main use of aluminium is in the transport industry due to its low density: automobiles, aircraft, railway cars, bicycles, etc. Aluminium is widely used for packaging (cans, foil, frames). It is also used in building, construction and electrical applications such as conductor alloys, motors, generators and transformers as well as in a wide range of household items, from cooking utensils to furniture.

Method of mining and processing

Open cast mining is mostly used as bauxite is found near the surface. The remaining overburden is removed and caprock is broken by blasting, scrapping or excavating. Bauxite loading takes place, being transported to crushing facilities. Crushed bauxite passes through a vibrating screen, which classifies the finest material. Subsequently, the screened bauxite is further downsized to approximately 7.5 cm grain size. After sorting, washing and beneficiation are done if needed. The crushed bauxite is transferred to refineries where „Bayer process“ is commonly used. The final stage of Bayer process is the calcination of aluminum trihydrate crystals at 1100 °C, producing anhydrous Al_2O_3. This anhydrous alumina is the final product. In most cases, alumina refineries are located near bauxite mines, where 2-3 tonnes of bauxite produce 1 tonne of alumina (Al_2O_3).

Aluminium

Alumina

Aluminium from Greece

Greece is a major bauxite producing country in Europe. The most important Greek bauxite deposits ('karst' type) are located in the mountainous Helikon, Parnassus and Giona zones. Greek bauxites are of the diasporic type.

Deposits

Bauxite is formed by the weathering of many different rocks. Major deposits of bauxite occur in the tropics, where mostly the lateritic bauxites, which were formed by lateritization of various silicate rocks, can be found. Other types are carbonate bauxites or karst bauxite ores, which were formed by lateritic weathering and the residual accumulation of clay layers.
The world's largest aluminium producers are Australia, China, Brazil and India. In Europe, aluminium ores have been extensively mined in France, Italy and Greece.

karst type bauxite

Interesting facts:

Aluminium is a valuable metal and has significant positive impacts on the environment and economy when recycled. Aluminium production from recycled metal (secondary aluminium) saves more than 90 % of the energy needed for primary production. Also, the increased use of secondary aluminium reduces the use of natural resources to make primary aluminium.

ZINC

Zinc is a metal widely found in nature but very rarely found as a native element mineral. It can be found in zinc minerals and especially in blende (also named sphalerite or zinc sulphide, ZnS), which is the most important zinc ore. Other ores are, for example, smithsonite ($ZnCO_3$) and zincite (ZnO). When pure, with little or no iron, sphalerite forms clear crystals with colours ranging from pale yellow to orange. If iron content increases it forms dark, opaque crystals. Zinc is an essential component of some alloys like brass that are used to produce many commonly used objects.

SPHALERITE

Chemical formula **ZnS**

Physical properties

Classification	Sulphides
Crystal system	isometric
Colour	yellow, brown, black, red-brown
Habit	colloform, euhedral crystals
Hardness	3,5 - 4 Mohs scale
Cleavage	perfect
Fracture	conchoidal
Lustre	adamantine, resinous
Streak	brownish white
Density	4 g/cm^3
Transparency	transparent, translucent

Sphalerite

Use in life

Zinc is used in metallurgy as an anti-corrosion agent through a process called galvanisation, which consists of applying a coating of zinc to metallic materials, mostly iron and steel, to give the manufactured product a greater strength, protecting it from deterioration. Zinc is a component of some types of batteries, like conventional batteries, and is increasingly used in new-generation technologies related to the storage of energy from renewable sources. The advantage of zinc for battery producers is mainly in the low cost of the production process as zinc does not require special treatments in the way that lithium does. Zinc oxide, also known as white zinc due to its colour, has wide-ranging applications: it is present in some kinds of ceramic tiles and enamels as it improves durability and brightness; it can be used as a strengthening agent in rubber and as a pigment in paints, where it contributes to preserving the colour as well as providing significant fungicidal properties; it is also found in agriculture, as a nutrient in fertilizers and feed mixtures. In recent years, an interest in zinc oxide has been increasing in electrical engineering, especially in the production of optoelectronics like LEDs, lasers and photodetectors.

Method of mining and processing

Zinc ores are extracted using different mining techniques. Oxidised ore bodies, located close to the Earth's surface, are recovered through open-pit mining. Underground methods are used for the more deeply located sulphide ores.

Zinc minerals are usually associated with lead minerals, present a low metal content and contain impurities like iron and cadmium, so they need to be concentrated and smelted to be transformed into the corresponding metal. The most common zinc recovery process, which provides over 80% of production, is the hydrometallurgical process: zinc concentrate from the mine is roasted (at 600 °C) and transformed into oxide (ZnO), which is then dissolved in dilute sulfuric acid. The solution, which contains the zinc sulphate, is purified and subjected to electrolysis which causes the metallic zinc to deposit at the cathodes from which it is then recovered by fusion.

Deposits

Zinc deposits principally occur as sulphide orebodies but they may occur as a carbonate. Deposits containing zinc from hot hydrothermal fluids may flow along sub-surface fractures and zinc minerals may precipitate to make vein deposits. Where carbonate rocks occur, the fluids flow through cavities and form rich deposits. Another type of zinc deposit are volcanogenic deposits.

Major zinc producing countries are China, Australia, the USA and India. In Europe, mining activities suffered a slowdown in recent decades and are currently concentrated in Ireland and Sweden, which provide almost 70% of the total production in Europe.

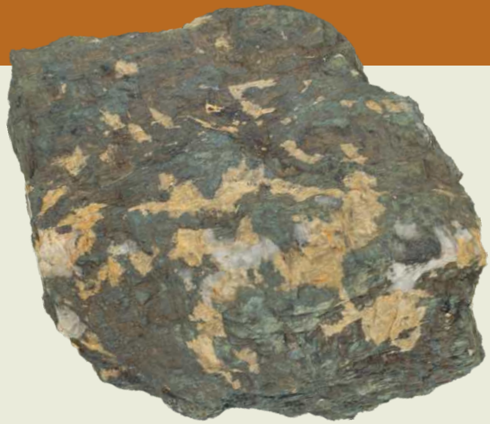
Zinc mining in Italy

In the past, zinc ores were mined in Italy. After a series of closures in the past, Italy is beginning to undertake a new phase of development: in recent years the authorisation to re-start mining activity at the Gorno site in the Bergamo area (Lombardia region) has been approved. The Gorno deposit is a Pb-Zn-Ag deposit.

Interesting facts:

Zinc is also found in the human body, in animal and vegetable tissues. Although it is only present in traces, it is of crucial importance, for example, in helping with the transcription of the genetic code. It is essential for the proper functioning of our bodies due to important properties that help to fight cellular ageing and improve tissue repair and the operation of the reproductive system. Therefore, it is largely used in cosmetics and pharmaceuticals, usually in the form of zinc oxide: in food supplements and emollient, anti-redness and anti-inflammatory creams, especially for skin disorders like acne.

COPPER



Copper is a chemical element with the symbol Cu on the periodic table. In its native mineral form, it is a soft metal with a pinkish – orange – brown colour when fresh. When oxidised, it becomes greenish blue colour. It is ductile and malleable metal with very high thermal and electrical conductivity. The name comes from the Greek "Kyprios", meaning Cyprus, where copper was exploited in the Roman era. It is one of the few metals occurring in nature as a pure native element. The most frequent copper ores are sulphides (chalcopyrite, chalcocite, bornite and covellite), oxides (cuprite) and carbonates (azurite and to a lesser extent, malachite).

CHALCOPYRITE

Chemical formula $CuFeS_2$

Physical properties

Classification	Sulphides
Crystal system	tetragonal
Colour	brass yellow
Habit	druse, striated, euhedral crystals
Hardness	3,5 – 4 Mohs scale
Cleavage	poor, indistinct
Fracture	irregular, uneven
Luster	metallic
Streak	greenish black
Density	4,18 g/cm^3
Transparency	opaque

Native cooper

Use in life

Copper is used mostly as a pure metal, but when greater hardness is required, it is made into alloys such as brass (Cu + Zn) and bronze (Cu + Sn). It is very useful because of inherent and beneficial properties, such as high electrical conductivity, tensile strength, ductility, deformation resistance, corrosion resistance, low thermal expansion, high thermal conductivity, malleability, ease of soldering and ease of installation. Copper is a very effective electrical conductor and is used in the production of electrical wires and cable conductors. It is usually used for roofing, plumbing, making industrial machinery and jewellery. It is also used in integrated circuits in electronics, magnetrons in microwave ovens and electric motors. Copper alloys have become important materials in the medical and aquaculture industries because they are antimicrobial and prevent biofouling.

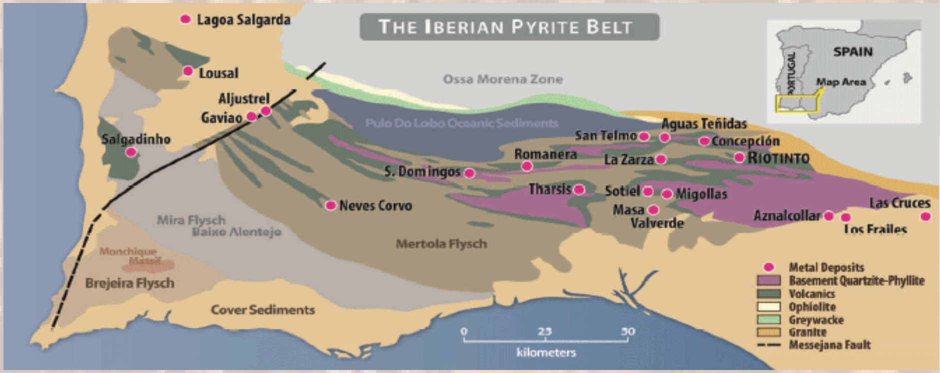
Method of mining and processing

Underground mining is relatively expensive and is generally limited to rich ores. Copper ores are more frequently extracted from large open-pit mines, especially when the orebodies are extensive, low grade and relatively near the surface, where they can be quarried after the removal of overburden.

The pyrometallurgical route for copper beneficiation from ores begins with the size reduction, which is followed by concentration by flotation. The copper concentrate is then sent to a smelter where it is melted, refined and cast in anodes. The anodes turn into 99.99% Cu cathodes by electrorefining. The hydrometallurgical route also begins with size reduction, but followed by leaching, purification and then electrowinning to produce 99.999% Cu cathodes..

Copper in Spain

Spain has some of the most mineralised territories in Western Europe, such as the volcanic-hosted massive sulphide (VMS) deposits of the Iberian Pyrite Belt (IPB) of southern Spain, where copper mining activity is located. This area represents a significant concentration of massive sulphides, that extends throughout much of the southern part of the Iberian Peninsula where more than 80 large sulphide deposits and more than 300 mines are located. This area is approximately 250 km long and 30 to 50 km wide, from Alcácer do Sal (Portugal) in the northwest to the province of Seville (Spain) in the southeast. The Río Tinto mining district is one of eight substantial sulphide deposits in the Iberian Pyrite Belt and has perhaps the highest concentration of sulphides in the Earth's crust.



Deposits

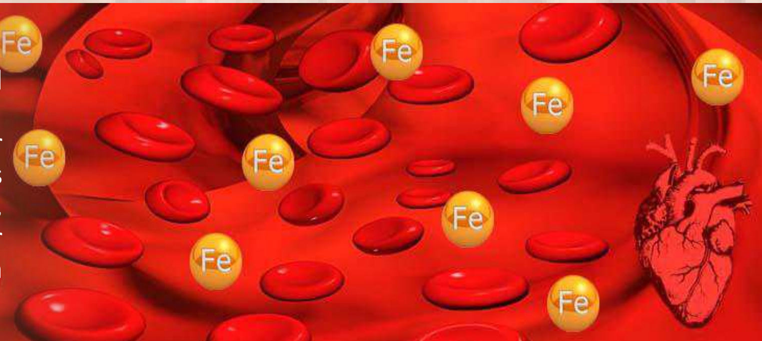
Copper minerals occur in deposits which can be classified as porphyry copper deposits, strata – bound deposits and massive sulphide deposits, according to the lithology and geologic environment. For commercial exploitation, copper deposits generally need to be over 0.5% copper, preferably over 2%. The known reserves of higher-grade ore in the world amount to nearly 1 billion tons of copper.

The main copper producing countries are Chile, Peru and China. EU countries producing copper are (alphabetically): Bulgaria, Cyprus, Finland, Poland, Portugal, Romania, Serbia, Spain and Sweden.

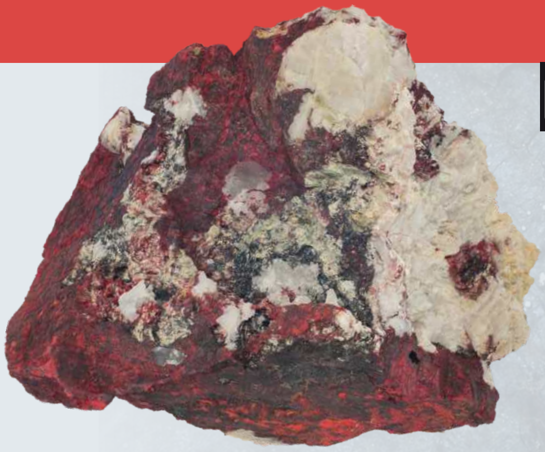
Interesting facts:

Copper can be recycled without losing its quality and is the third most recycled metal after iron and aluminium.

Copper is an essential nutrient for the human body. Together with iron, it enables the body to form red blood cells. Copper is present in the human body including in the liver, brain, heart, kidneys and skeletal muscle. An excess or shortage of copper can affect brain function, and an imbalance in copper has been linked to Alzheimer's disease.



MERCURY



Mercury is a naturally occurring chemical element found in rocks in the earth's crust, including in deposits of coal. On the periodic table, it has the symbol Hg. The element was named after the Roman god, Mercury, known for his speed and mobility. Mercury is commonly known as quicksilver and was formerly named hydrargyrum. It is a heavy, silvery element and is the only metallic element that is liquid in ordinary temperature and pressure conditions. It is found either as a native metal (which is rare) or in cinnabar, metacinnabar, corderoite, livingstonite and other minerals. It occurs in deposits throughout the world mostly as cinnabar (mercuric sulphide).

CINNABAR

Chemical formula HgS

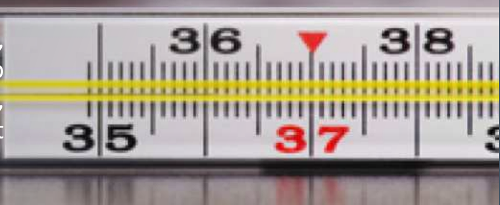
Physical properties

Classification	Sulphides
Crystal system	trigonal
Colour	tint or shade of red
Habit	druse, massive
Hardness	2 – 2,5 Mohs scale
Cleavage	perfect
Fracture	irregular, uneven
Lustre	metallic
Streak	red brown to scarlet
Density	8,2 g/cm^3
Transparency	transparent, translucent

Native mercury

Use in life

Mercury is highly toxic, and therefore its use and production are prohibited in most countries!
A few years ago, mercury was used in electric batteries (replaced today by zinc, lithium or nickel). Due to the fact that mercury expands as the temperature rises, it was used in thermometers, barometers or manometers for a long time. It is also used in fluorescent lighting. Electricity passed through mercury vapour in a fluorescent lamp produces short-wave ultraviolet light, which then causes the phosphor in the tube to fluoresce, making visible light. Mercury is used in amalgam for dental restoration. However, dental clinics have to install high-performance filters, which significantly reduce mercury releases into water.
Now it is clear that mercury is highly toxic for the environment, animals and people. Therefore, in 2013, a treaty signed by almost all countries was designed to protect our health and to stop the production and usage of mercury. The EU banned mercury-containing batteries, thermometers, barometers and blood pressure monitors. It is also no longer allowed in most switches and relays found in electronic equipment.



Method of mining and processing

The most common method of ore recovery is underground mining, with conventional drillig and blasting followed by scarping or mechanical loading into ore cars.

A common method for separating mercury from cinnabar is to crush the ore and then heat it in a furnace to vaporise the mercury. This vapour is then condensed into liquid mercury.

Antony gallery (Antonijev rov)

Deposits

Most of the world's mercury supply comes from China, Kyrgyzstan and Chile.

Large commercial mercury deposits in Europe include Almadén (Spain), Idrija (Slovenia) and Monte Amiata (Italy).

Mercury in Slovenia

Between the 16th century and the end of 20th century, Slovenian mines were important suppliers of metal ores on the European level (especially Hg, Pb and Zn). The only large mercury mine in Slovenia is in Idrija. The Idrija ore deposit was formed by a volcano-sedimentary process. The mineral paragenesis of the deposit is almost monometallic and consists of cinnabar, metacinnabar, native mercury, sporadic iron sulphides and gangue minerals calcite and quartz. The richest vein is Antonijev rov with a maximum depth of 385 m. Antonijev rov was excavated in the 1500s and is the oldest preserved entrance to a mine in Europe. Despite rich deposits and high consumption of mercury around the world, the decision was made to close the mercury mines for commercial, geological, and ecological reasons in 1986. Today, the Antonijev rov and the Hg smelter are of particular interest to tourists.

Interesting facts:

Cinnabar powder has been used as a vermilion pigment since ancient times. Synthetic (less toxic) substitutes are now used.

Mercury was ideal for the production of thermometers, because it changes volume significantly with very small temperature changes.

TIN

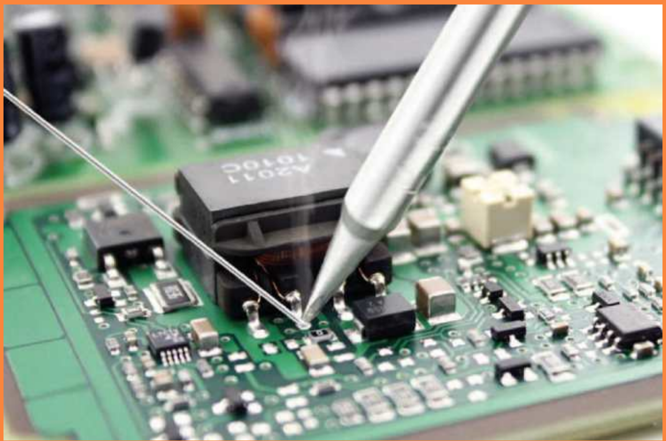
Tin is a chemical element, known for its resistance to corrosion and its ability to coat other metals. In the periodic table, it is shown with the symbol Sn, an abbreviation of the Latin word for tin, stannum, and atomic number 50. Tin is a soft, silvery-white metal with a bluish shade. It can occur as native metal in grains but is mainly found as stannic oxide, SnO_2, in the ore cassiterite.

CASSITERITE

Chemical formula SnO_2

Physical properties

Classification	Oxides
Crystal system	tetragonal
Colour	black, yellow, brown, red
Habit	prismatic, massive
Hardness	6 - 7 Mohs scale
Cleavage	imperfect
Fracture	irregular
Lustre	adamantine, sub-metallic
Streak	brownish-white, white
Density	7 g/cm^3
Transparency	transparent, translucent, opaque



Use in life

Nearly half of produced tin is used in solder. The rest is used for tin plating, tin chemicals, brass and bronze alloys. Tin has long been used in alloys with lead as solder for joining pipes or electric circuits. Tin is also used for coating lead, zinc and steel to prevent corrosion. Tin-plated containers are widely used for food preservation. The oxides of indium and tin are electrically conductive and transparent, so they are used in optoelectronics devices such as liquid crystal displays. Pierced tin or punched tin-plated steel is a technique for creating housewares that are both functional and decorative.

Method of mining and processing

Tin is mined in different ways, depending on the genesis and location of the deposits. When it occurs in alluvial deposits, the dredging technique (detritus extraction) is suitable, especially in a previously exploited and flooded area. When the deposits are of the skarn type, open-pit or underground mining techniques are applied.

Once the tin ore is extracted, the gangue is separated from the ore by physical or chemical processes to concentrate the tin. Physical processes, including grinding, screening, hydraulic classification, separation on vibrating tables, magnetic separation, jigs and centrifugal equipment, and sometimes flotation with foams, are used to produce a concentrate containing up to 70-77% tin through thickening and filtering.

When the required concentration of tin has been achieved (55 to 75% SnO_2), the tin concentrate goes to smelting. It is heated in a furnace along with carbon in the form of coal or oil to about 1400°C. The carbon reacts with the carbon dioxide in the furnace to form carbon monoxide, and the carbon monoxide reacts with cassiterite in the tin concentrate to form crude tin and carbon dioxide. A residual slag formed by this process often contains tin and is reheated to recover crude tin.


South Crofty mine

Tin mining in Cornwall (England)

Tin has been mined in Cornwall, south west England, since 2,300 BC, and large-scale operations started in the 1600s. South Crofty was one of the most famous mines in Cornwall and is located in Pool, the Central Mining District of Cornwall. The initial assessment of the economic viability of re-opening the mine was completed in 2017. The South Crofty project has been fully permitted, and test drilling began in June 2020.

Deposits

Cassiterite, the primary ore of tin, is found in hydrothermal veins and pegmatites associated with granite intrusions. It is also often found concentrated in alluvial placer deposits.

The leading world producer of tin is China. Other top producers are Indonesia, Peru and Bolivia. The oldest tin mines in Europe were located in Cornwall (England) and Spain.

Interesting facts:

Tinplate canisters for preserving food (Am. “cans”) was first manufactured in London in 1812. Many copper pans are lined with tin since the combination of acidic foods with copper can be toxic.

TUNGSTEN

There are two different names for this metal: tungsten and wolfram. This is why tungsten is listed in the periodic table under the letter “W”. Both names emerged at the same time. “Wolfram” originated from the German language and “tungsten” originated from the Swedish language. Tungsten can be found in minerals such as wolframite, an iron manganese tungstate (Fe, Mn)WO_4, or scheelite, a calcium tungstate mineral $CaWO_4$, and is economically important. Tungsten in its raw form is a hard steel-grey metal and one of the heaviest metals with a density of 19,25 g/cm3.

WOLFRAMITE

Chemical formula

$(Fe, Mn)WO_4$

Physical properties

Classification	Tungstates
Crystal system	monoclinic
Colour	greyish-black
Habit	tabular, short prismatic
Hardness	4 – 4,5 Mohs scale
Cleavage	perfect
Fracture	brittle
Lustre	sub-metallic
Streak	reddish brown
Density	7,3 g/cm^3
Transparency	opaque

Scheelite

Use in life

Tungsten is mainly consumed in the production of hard materials – tungsten carbide. Its hardness is close to the hardness of diamond. It is an efficient electrical conductor. It is used to make cutting tools such as knives, drills and circular saws as well as milling and turning tools for metalworking, woodworking, mining and construction industries. Tungsten is added to different alloys for numerous applications, including incandescent light bulb filaments and X-ray tubes. It is a suitable material for military applications in projectiles because of its hardness and high density. The jewellery industry makes rings out of sintered tungsten carbide.

Method of mining and processing

Tungsten ores are mined from an open-pit mine or underground mine. The processing of scheelite and wolframite ores consists of crushing and grinding, pre-concentration, roughing, cleaning and purification in the final stages. Gravity concentration and flotation are applied to scheelite ores. Gravity or magnetic separation is applied to wolframite ores. The final stage is to convert the ores to tungsten trioxide (WO_3) by heating them with hydrogen or carbon to produce powdered tungsten. Then, the powder is mixed with small amounts of powdered nickel or other metals, and sintered. During the sintering process, the nickel or the other metal diffuses into the tungsten to produce an alloy.

Processing plant

Tungsten in Portugal

In Portugal, several tungsten mines were exploited during the 20th century and mainly in the Second World War period. Presently, wolframite is exploited in Panasqueira Mine in Portugal, a very important historical mine recognised for having one of the purest forms of wolframite in the world. It is mined using underground methods.

Panasqueira mine

Deposits

Both minerals (wolframite and scheelite) result from the mineralisation processes in hydrothermal geological environments. There are several types of deposits where we can find tungsten, but the most relevant ones are mineralisations in granite, greisen and pegmatite deposits, and vein type deposits, where the hydrothermal fluid percolated into already existing fractures in pre-existing rocks, and skarn deposits, which occur when hydrothermal fluid invades carbonate rocks with calcium, like limestone. Wolframite appears more significantly in vein type deposits and scheelite in skarn deposits, where calcium is also available.

Tungsten resources are geographically widespread. Between 2017 and 2018, about 80% of the global market came from the United States, Austria, Bolivia, China, Portugal, Russia, Rwanda, Spain, the United Kingdom and Vietnam. China ranks first in the world in terms of tungsten resources and reserves and has some of the largest deposits of scheelite. The Mittersill mine in Austria hosts the largest tungsten deposit in Europe. The deposit consists of two parts, an open-pit mine and an underground mine.

Interesting facts:

Tungsten has the highest melting point (3422 °C) and the highest tensile strength of all metals in pure form. It is the most non-reactive element – it does not react with water, oxygen or air at room temperature and is resistant to most acids and bases.

GOLD

Gold is a native element and precious metal. It has long been prized for its beauty, resistance to chemical attack and workability. It has a relatively low melting point (1063 degrees Celsius) and is malleable. It is a good electrical conductor. Gold often occurs in its elemental native form, as nuggets, grains, veins, etc. Pure gold is slightly reddish-yellow, but it can be produced in a white colour by alloying with silver or in a red colour by alloying with copper. The alloy of gold and silver is known as electrum.

NATIVE GOLD

Chemical formula **Au**

Physical properties

Classification	Native Elements
Crystal system	isometric
Colour	gold yellow
Habit	arborescent, granular, platy
Hardness	2,5 - 3 Mohs scale
Cleavage	none
Fracture	hackly
Lustre	metallic
Streak	yellow
Density	19,3 g/cm^3
Transparency	opaque

Use in life

Gold as a precious metal has been used for coinage, jewellery and other arts throughout history. Because of its resistance to corrosion and most other chemical reactions and its conductivity to electricity, gold is used in electrical connectors in all types of computerised devices. Gold elements have long been used for medicinal purposes. Some gold salts do have anti-inflammatory properties and are used as pharmaceuticals. Gold alloys are used in restorative dentistry.

Method of mining and processing

The nature of a gold deposit determines the mining and mineral processing techniques applied. Alluvial deposits are either dredged from pond and river bottoms or sluiced from banks and floodplains with high-pressure hydraulic hoses. Then a slurry is passed over grooved or ridged tables which separate the denser gold particles from sands and gravels.

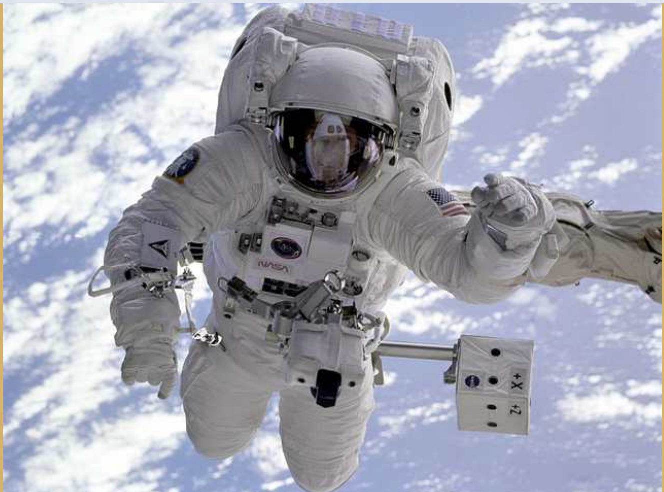
Elemental gold of endogenetic deposits is frequently disseminated within a base metal sulphide mineral. These deposits are mined, crushed and ground, and then concentrated by gravity separation to recover coarse particles of native gold before being subjected to froth flotation. Elemental gold is soluble in mercury, and when particles of gold brought into contact with fresh mercury they are wetted and dissolved, forming an alloy called amalgam. This process is used to recover and concentrate gold. Gold extracted by amalgamation contains a variety of impurities and two methods are commonly employed for purification: the Miller process and the Wohlwill process.

Deposits

Gold occurs in significant amounts in three main types of deposits: in hydrothermal quartz veins and related deposits in metamorphic and igneous rocks; in volcanic-exhalative sulphide deposits; and in consolidated to unconsolidated placer deposits.

The best-known exogenetic ore is alluvial gold which refers to gold found in riverbeds, streambeds and floodplains. These deposits are formed through the weathering actions of wind, rain and temperature change on rocks containing gold. Endogenetic gold ores include vein deposits of elemental gold in quartzite or its mixture with various iron sulphide minerals, particularly pyrite and pyrhotite.

The world's largest gold producers are China, Australia and Russia. The EU leaders in gold production are Bulgaria, Finland, Sweden and it is also produced in Slovakia, Serbia, Poland, Romania and the United Kingdom.



Interesting facts:

Thin layers of gold reflect 98% of incident infrared radiation. Therefore, they are used in the thermal protection of satellites and in the manufacture of spacesuits for astronauts.

TALC

Talc is a hydrous magnesium silicate mineral, which is the softest mineral and is usually of pale green, white or grey-white. It can be recognised because it is greasy to the touch and can be scratched by a fingernail. It occurs as foliated mass and exceptionally in a rare crystal form. It originates from the hydrothermal alteration of non-aluminous magnesia silicates.

TALC

Chemical formula

$Mg_3Si_4O_{10}(OH)_2$

Physical properties

Classification	Silicates
Crystal system	triclinic
Colour	colourless, white, pale green
Habit	foliated, massive
Hardness	1 Mohs scale
Cleavage	perfect
Fracture	fibrous, micaceous
Lustre	vitreous, pearly
Streak	white
Density	2,78 g/cm^3
Transparency	transparent, translucent

Use in life

Talc has a wide application in many industrial sectors and in production of every-day products. It is used in the cosmetic industry for the manufacture of soaps, toothpaste, powders, creams and make-up like eye shadow or lipstick. In the paper industry, talc is used as the filler for paper and in the textile industry as an impregnation of fabric. Talc is applied in the manufacture of acid and alkali-resisting vessels and in the chemical industry for producing paints, synthetic fertilisers and polishing pastes. Pure talc is used as the filler for pills and medicines in the pharmaceuticals industry and in the production of electrical porcelain in the ceramics industry.

Method of mining and processing

Most talc is produced from open pit and underground mining. Rocks are drilled, blasted, and partially crushed. Partially crushed rocks are taken from the mine to a mill, where a further reduction in particle size takes place. Impurities are removed by froth flotation or mechanical processing.

Deposits

Talc is often found in the metamorphic rocks of convergent plate boundaries. Most large talc deposits are formed when heated waters carrying dissolved magnesium and silica reacted with dolomitic marbles. Talc can also occur due to the alteration caused by heat and the contact with chemically active fluids such as serpentinite.

The leading talc producing countries are China, India, Brazil and the United States. The known EU producers of talc are Finland, France, Austria, Italy and Slovakia.

Talc from Gemerska Poloma (Slovakia)

The talc deposit in Gemerska Poloma in Slovakia is one of the largest talc deposits in the world. It was discovered in the 1980s. It is located in the environment of metamorphic sedimentary rocks and of granite complex. The talc magnesite body is lenticular in shape and is located at a depth of approximately 215 – 760 m below the surface. It is 3 km long and about 408 m thick. In addition to magnesite and talc, it consists of quartz, dolomite and chlorite.

Interesting facts:

There are other names given to talc. Compact aggregates of talc and other rock-forming minerals are called soapstone (for its soapy or greasy feel). The famous Christ the Redeemer statue in Rio de Janeiro (Brazil) is made of soapstone. Dense aggregates of high-purity talc are called steatite.

MAGNESITE

Magnesite is the most important mineral source of magnesium. It is named from a Greek word, “magnesia lithos”, a kind of ore from Magnesia, coastal district of ancient Thessaly, Greece, and also after its chemical composition. It usually occurs as a translucent, colourless or white or grey mineral. It can contain some impurities such as silica, iron and calcium. Magnesite deposits are found in rocks rich in magnesium – dolomites and serpentinites. It is formed by the alteration of ultramafic rocks in the presence of water and carbon dioxide at elevated temperatures and high pressures.

MAGNESITE

Chemical formula $MgCO_3$

Physical properties

Classification	Carbonates
Crystal system	trigonal
Colour	colourless, white, greyish-white
Habit	massive
Hardness	3,5 – 4,5 Mohs scale
Cleavage	perfect
Fracture	brittle
Lustre	vitreous
Streak	white
Density	3,01 g/cm^3
Transparency	transparent, translucent

Magnesite

Use in life

Magnesium oxide (MgO – periclase) is an important refractory material used as a lining in blast furnaces, kilns and incinerators. Magnesite can be used as a binder in flooring material (magnesite screed). It is also used as a catalyst and filler in the production of synthetic rubber and the preparation of magnesium chemicals and fertilisers. Magnesite is used in jewellery-making in the form of polished beads. In addition, it is used in paper, paint, ink and in the pharmaceutical industry.

Method of mining and processing

The extraction of magnesite from mines is followed by its separation from waste rocks. Magnesite ores are separated from impurity silica, iron and other compounds by crushing, grinding, screening and other physicochemical methods such as chemical leaching and flotation. The next step consists of qualitative separation. Magnesite can be burned in the presence of charcoal to produce MgO which is known as a periclase mineral.

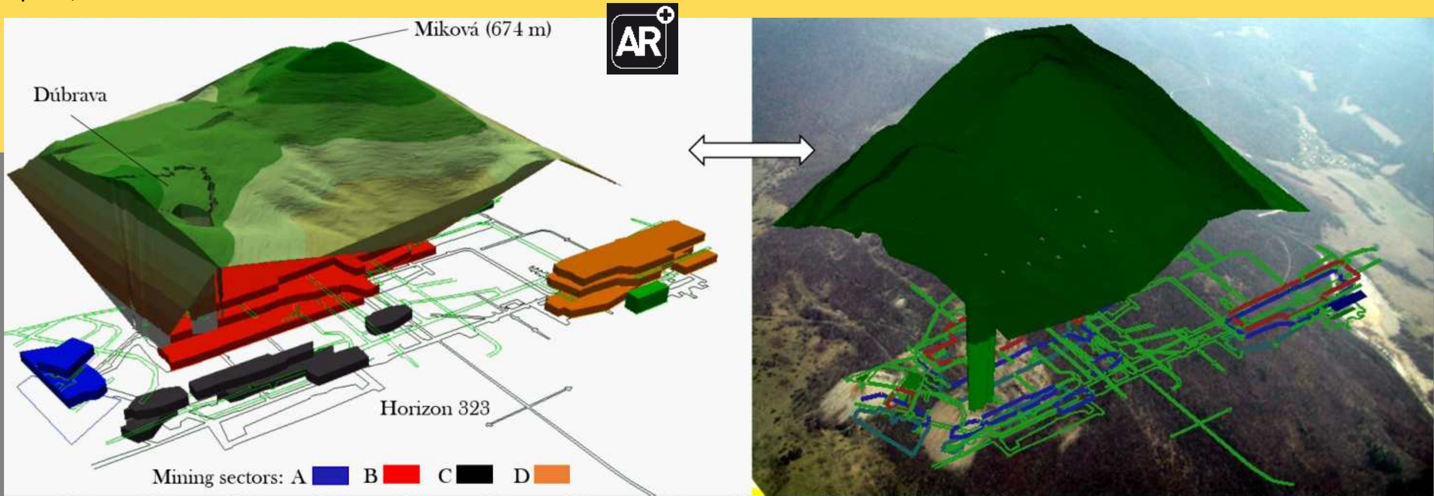
Deposits

Magnesite can be formed by several processes: the carbonation of magnesium-rich rocks such as serpentinite or peridotite during regional, contact, or hydrothermal metamorphism, the alteration of limestone or other carbonate-rich rocks by Mg-rich solutions during metamorphism, formation above weathering ultramafic rocks, or precipitation as a secondary mineral in veins and fractures in carbonate and ultramafic rocks.

Major magnesite producers in the world are China, Russia and Brazil. The significant EU producers are Turkey, Austria, Spain, Greece and Slovakia.

Magnesite from Slovakia

The magnesite deposit in Jelšava is the biggest mining and processing plant in Slovakia and also one of the biggest dead-burnt magnesia producers in the world. Magnesite in the Jelšava deposit is mined from underground using an overhead stopping method with inter-block pillars with backfilling. This method of mining increases the safety of the mining procedure. It enables the selective separation of mined magnesite and based on defined quality criteria, it also prevents the generation of dolomite waste rock piles. As for hauling equipment, electro-hydraulic drills, bucket hauliers and front scoop loaders are used. Magnesite concentrates are treated in rotary kilns. Calcinator and shaft furnaces produce clinker made of pressed fly ash. Clinkers are subsequently processed by crushing, classification based on grain size and magnetic separation, and are used for refractory components manufacturing or for the production of magnesite bricks with a wide range of applications.



Interesting facts: Magnesium imparts structural strength to alloys with aluminium, zinc or manganese. Therefore, magnesium alloy components are used in aerospace, mechanical engineering and the automotive industry, where strength and low weight are required. Magnesium is a very important mineral in human nutrition. Increased doses of magnesium help with high blood pressure and cardiovascular disease.

SILICA

Silica is the name given to a group of minerals composed of silicon and oxygen with the chemical formula SiO_2. The most common crystalline forms of silica are quartz, tridymite and cristobalite. Quartz is among the most common minerals in the Earth's crust. The melting point of silica is 1610 °C which is higher than iron, copper and aluminium, and for this reason silica is used to produce moulds and cores for the production of metal casting. Quartz is usually colourless or white but can be coloured by impurities. It is a hard mineral, relatively inert, and does not react with dilute acid, which are important qualities for various industrial uses.

QUARTZ

Chemical formula SiO_2

Physical properties

Classification	Tectosilicates
Crystal system	trigonal
Colour	colorless and various colour
Habit	crystalline, druse
Hardness	7 Mohs scale
Cleavage	none
Fracture	conchoidal
Lustre	vitreous
Streak	white
Density	2,62 g/cm^3
Transparency	transparent

Quartz sand

Use in life

Silica is a key raw material in industrial development, especially in the glass, foundry and ceramics industries. Quartz derivates are used in the chemical industry, such as in pesticides, fertilisers, and pharmaceuticals preparations. Silica in its finest form is used as a filler for paints, plastics and rubber. Silica sand is used in water filtration and agriculture.

Method of mining and processing

Silica is usually exploited by quarrying. The processing includes the cleaning of the quartz grains, the screening to produce the optimum size distribution of product depending upon final use and then the removal of impurities by gravity separation, froth flotation and magnetic separation.

Deposits

Silica sands may be produced from sandstones, quartzite or unconsolidated sand deposits. It is also found as several metre thick veins of quartz within other rocks.

Silica is produced by many European countries, including Belgium, the United Kingdom, France, Italy, Netherlands, Spain, Portugal and Slovenia.

Interesting facts:

Quartz crystals have piezoelectric properties. They develop an electric potential upon the application of mechanical stress. One of the most common piezoelectric uses of quartz is as a crystal oscillator. The oscillator works by distorting the quartz crystal with an electric field. By eliminating the electric field, the quartz generates an electric field with a precise frequency. This application is used in quartz watches, which use an electronic oscillator regulated by a quartz crystal to measure time.

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