ROCKS, MINERALS & THEIR USES

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Rocks, Minerals & Their Uses

What is a mineral?
A mineral is a naturally occurring, inorganic substance with a specific chemical composition and a crystal structure. Everything that is not living or derived from living organisms can be considered of mineral origin. Elements are the building blocks for minerals, rocks, and ores. There are 92 elements which occur naturally and combine to form all of the earth’s minerals. About 4000 different minerals occur in the earth’s crust. Of those minerals, approximately 200 are so useful to us that we mine and transform them into products. Most minerals occur in association with other mineral rocks.

Metals
Metals are elements such as gold, copper, or zinc. These occur in their elemental state in nature and are classified as minerals. Metallic elements may also combine with other elements to form minerals.

What is a rock?
A rock is an aggregate of one or more minerals. For example, granite is a rock composed primarily of the minerals quartz, potassium feldspar, and muscovite, a mica mineral. Limestone is a rock whose primary constituent is the mineral calcite. Rocks and the minerals that comprise them form the earth’s crust. There are three types of rocks, classified according to how and where they were formed. These types, described below are igneous, sedimentary and metamorphic.

Igneous Rocks
When molten lava cools and solidifies, we call it an igneous rock. The lava can erupt through cracks or openings of the earth’s surface and cool when exposed to the air. Also, it can be trapped underground where it would cool more slowly. The chemical composition of the lava and the rate at which it cools determine the various types of igneous rocks. Some of the common igneous rocks are granite, rhyolite, andesite, basalt, obsidian, and pumice.
**Sedimentary Rocks**

Many sedimentary rocks start as dust, sand grains, and mud, and due to other rocks, these particles witness weathering and erosion. When a thick pile of sediment accumulates, the particles near the bottom are compacted due to the weight of the materials on the top. Over time, they become cemented together to form a solid sedimentary rock. Other sedimentary rocks are formed by precipitation of minerals from a drying lake or sea. Sedimentary rocks are the most commonly formed at the bottom of oceans, lakes, and rivers. Layers of sedimentary rocks form a structure called bedding. The formation of the bedding can be seen in the evolution of a mountain. As the mountain evolves the bedding layer moves up as new sediment forms underneath. These layers can often be seen exposed on mountain sides, in the walls of canyons, or in man-made cuts along highways. Some common sedimentary rocks are sandstone, shale, and limestone.

**Metamorphic Rocks**

Metamorphic rocks are rocks that have been changed from their original form by the application of pressure or heat. When rocks metamorphosize, as a result, their physical properties change. For example, limestone becomes marble. This can occur when the rocks, which form continental plates, collide and grind against each other, or as hot magma/lava comes into contact with cooler crustal rocks, or during deep burial of layers of sedimentary rocks. Further, hot water or gasses that flow deep in the earth can also change the chemistry of igneous or sedimentary rocks. As a result, new textures and new mineral assemblages may develop. Some common metamorphic rocks are slate, schist, gneiss, marble and quartzite.

**Rock Cycle**

The rock cycle illustrates the relationship among all of the rock types. Within our dynamic planet rocks are constantly being reformed by the motions of the crustal plates. Rocks may change from one type into another by being subjected to various forces within the earth or at the surface.

**Why are Rocks Important?**

Rocks are the source of the raw materials that we use in our everyday lives. Rocks are used to build our homes and pave our streets. Minerals in the rocks are the source of materials to make electrical wire, steel, cars, appliances, computers, medicines, energy to light and heat our homes, and fuel our gas tanks. They are everywhere but we usually don’t recognize them because the process of manufacturing disguises the minerals. Everything we use in our society is a product of either agriculture or mining. The selection of samples provided here will give you an idea of some of the many uses of our mineral resources.
and waste. Mining companies use a variety of processing techniques to recover the valuable minerals and reject the waste. Some processes, such as crushing and grinding, reduce the size of the ore and free up the valuable minerals from the waste rock. Then separation processes such as flotation, gravity separation, magnetic separation, leaching, and solvent extraction are used to increase the concentration of valuable material.

Ore minerals are produced from both underground and surface (open pit) mines. Once the ore has been removed from the earth, mining companies reclaim the land. A large percentage of land which was once mined has been restored as wildlife habitats, public parks, and housing developments. Only 0.3% of the United States has ever been disturbed by mining and more than 50% of that disturbed land has been reclaimed.

Our nation consumes immense amounts of rocks and minerals, about 20 tons per year for every person. This is about 3,000,000 pounds during a lifetime. By mining useful, essential minerals and transforming them into the comforts and necessities of life, we are following a long history of living well off the resources of the planet.

NICKEL

Characteristics:
Bright apple green, or pale green nearly white, amorphous, soft and friable

Occurrence:
Hydrothermal metamorphism of igneous rocks rich in Ni-Fe-Mg

Uses:
Batteries, alloys in steel production, coins

Nickel

Nickel (Ni) is a transition element that exhibits a mixture of ferrous and nonferrous metal properties. The bulk of the nickel mined comes from two types of ore deposits:

Laterite deposits in which the principal ore minerals are garnierite (a hydrous nickel silicate) and, nickeliferous limonite [(Fe, Ni)O(OH)]

Nickel sulfide deposits in which the principal ore is pentlandite [(Ni, Fe)9S8]

Nickel sulfide deposits are generally associated with iron and magnesium-
rich igneous rocks called ultramafics. Many of the sulfide deposits occur at great depth. Laterite deposits are formed by the weathering of ultramafic rocks and are a near-surface phenomenon. Most of the nickel on earth is believed to be concentrated in the planets core. Nickel is primarily sold for first use as a refined metal (cathode, powder, and briquette) or ferronickel. About 65% of the nickel consumed in the Western World is used to make stainless steel. Another 12% goes into super alloys or nonferrous alloys which are widely used because of their corrosion resistance. The aerospace industry is a leading consumer of nickel-based super alloys. Turbine blades, discs and other critical parts of jet engines are fabricated from super alloys. Nickel-based super alloys are also used in combustion turbines, such as those found at electric power generation stations. The remaining 23% of consumption is divided between alloy steels, rechargeable batteries, catalysts and other chemicals, coinage, foundry products, and plating. The principal commercial chemicals are the carbonate (NiCO3), chloride (NiCl2), and sulfate (NiSO4).

**Coal**

Technically, coal is not really a mineral. It should be considered a black or brownish-black rock of organic origin. It is a “fossil-fuel”, just like petroleum and natural gas. It was created from the remains of trees, ferns, and other plants that existed and died in tropical-like forests between 1 and 400 million years ago. Coal in many locations is older than the dinosaurs! Coal that formed in swamps covered by sea water contains a higher sulfur content; low sulfur coal was generally formed under freshwater conditions. Coal is a mixture of the elements carbon, hydrogen, oxygen, nitrogen, and trace amounts of aluminum, zirconium, and other minerals. There are four principal types of coal. Listed in order of lowest to highest heating value, they are: sub-bituminous coal, bituminous coal, anthracite, and lignite.

Lignite is an important source of energy production in Texas, North Dakota, Montana, and Louisiana. Sub-bituminous coal burns hotter than lignite. It is used for both generating electricity and for space heating. Key producing states include Montana, Wyoming, Colorado, New Mexico, Washington, and Alaska. Bituminous coal is the most commonly used coal for electricity generation in this country. It is mined chiefly in Appalachia and the Midwest. Anthracite is found primarily in the Appalachian region of Pennsylvania. It has the highest energy content of all coals, and is used for space heating and electricity generation.

Coal is a source material for an amazing array of products, from things like ink and roofing shingles to medicines and synthetic fabrics such as polyesters,nylons, and rayons. It is also what plastics are made from, and shows up in many “personal products” and cosmetics in the form of petroleum jelly.
Diatomite

Diatomite is a siliceous product organically produced by diatoms. A diatom is a single-celled organism found in fresh and salt water that under ideal conditions can divide every eight hours. In thirty days, a single diatom may produce ten billion descendents. The external skeletons of these creatures are made of silica. The shell is microscopic in size and full of tiny holes and passages. Some deposits of diatomaceous earth are over 1,500 feet thick and extend over thousands of acres. World resources of crude diatomite are adequate for the foreseeable future, but the need for diatomite to be near markets encourages development of new sources for the material.

The U.S. is the largest producer and consumer of diatomite and exports processed diatomite to 75 countries, primarily for filtration use. In the years 1995-96, the U.S. produced between 687,000-700,000 metric tons of diatomite. California and Nevada are the principal producing states.

A layer of diatomite tends to mat like straw or felt. A thick mat of this material is almost uncompressible although minute voids in the individual skeleton form 75-90% of the mat. Because it is essentially inert, it makes an excellent filtering medium. New applications are continuously being found for this material in the fields of biotechnology, particularly in pharmaceutical applications, in toxic liquid waste thickening, and other environmental cleanup technologies. You might see diatomite in filters for pools, hot tubs, or aquariums. It also has agricultural applications such as keeping slugs and snails away from plants. Other uses include thermal insulation.

Talc

The mineral talc is a hydrous magnesium silicate. Industrial talc of various kinds is employed where certain of the following properties are desired: extreme whiteness, a high degree of softness and smoothness, fibrous or flaky forms of component with large surface areas in relation to their mass, excellent coverage, absorption, good luster, or sheen, high “slip” or lubricating powder, chemical inertness, high fusion point, low shrinkage, low electrical and thermal conductivity, a good retention as fillers, high specific heat, and resistance to heat shock.

Most talc and soapstone deposits of commercial importance occur in ultrabasic igneous rocks and metamorphosed dolomitic limestone. Rocks of these types, with contained talc deposits are characteristic of metamorphic terranes of various ages in many parts of the world.

Talc mining is largely a grinding operation accompanied by air separation. Most industrial talc is dry-ground. Talc has a wide variety of uses and markets for which tests and specifications of grain size, shape, color, chemical and mineral composition, oil absorption, weight per unit volume, and hardness are employed. Talc is commonly used in the ceramic and paint industries, roofing industries, cosmetics and pharmaceutical as fillers, and in the manufacturing of food products as a polish or as an absorbent.
Copper

Most copper ore bodies are mined from minerals created by weathering of the primary copper ore mineral chalcopyrite. Minerals in the enriched zone include chalcocite, bornite, djurleite. Minerals in the oxidized zones include malachite, azurite, chrysocolla, cuprite, tenorite, native copper and brochantite. There are two distinct types of copper ore, the sulfide ore and the oxide ore. The sulfide ores are beneficiated in flotation cells, while the oxide ores are generally leached.

First, the copper ore from an open pit mine is blasted and then transported to a crusher where the ore is crushed and screened with the fine sulfide ore going to froth flotation cells for the recovery of copper. The coarser ore goes to heap leach, where the copper is subject to a process called solvent extraction where a diluted sulfuric acid solution is dispensed over the ore. Copper is dissolved and flows to a pond at the bottom of the leach pad. The leached solution is pumped to the solvent extraction circuit, which looks like a series of agitation tanks or cells. The fine sulfide ore is sent to froth flotation cells for recovery by chemically attaching the copper to a chemical bubble and overflowing the froth (bubbles with copper). The concentrates are then sent to the smelter for processing to a copper plate.

Copper is used by many different industries to produce many products that are used daily. Copper is often used as a conductor of electricity where almost all electrical devices rely on copper wiring because copper is inexpensive and highly conductive. The conductivity of copper is second only to silver. Copper is often used in currency as the American penny was 95% copper from 1909 to 1982. In 1982 the penny’s core was switched to zinc and coated with copper. Two radioactive isotopes of copper, copper-64 and copper-67 are used in medicine. Copper-64 is used to study brain function and to detect Wilson’s disease. Copper-67 treat cancer when the isotope is injected into the body it goes to cells that are cancerous and gives off radiation that can kill the cancerous cells.

Iron

Iron (Fe) is a metallic element that encompasses about 5% of the Earth’s crust. When pure it is a dark, silvery-gray metal. It is a very reactive element and oxidizes (rusts) very easily. The reds, oranges and yellows seen in some soils and on rocks are probably iron oxides. The inner core of the Earth is believed to be a solid iron-nickel alloy. Iron-nickel meteorites are believed to represent the earliest material formed at the beginning of the universe. Studies show that there is considerable iron in the stars and terrestrial planets: Mars, the “Red Planet,” is red due to the iron oxides in its crust.

Iron is one of the three naturally magnetic elements; the others are cobalt and nickel. Iron is the most magnetic of the three. The mineral magnetite (Fe3O4) is a naturally occurring metallic mineral that is occasionally found in sufficient quantities to be an ore of iron.
The principle ores of iron are Hematite, (70% iron) and Magnetite, (72% iron). Taconite is a low-grade iron ore, containing up to 30% Magnetite and Hematite.

Hematite is iron oxide (Fe₂O₃). The amount of hematite needed in any deposit to make it profitable to mine must be in the tens of millions of tons. Hematite deposits are mostly sedimentary in origin, such as the banded iron formations (BIFs). BIFs consist of alternating layers of chert (a variety of the mineral quartz), hematite and magnetite. They are found throughout the world and are the most important iron ore in the world today. Their formation is not fully understood, though it is known that they formed by the chemical precipitation of iron from shallow seas about 1.8-1.6 billion years ago, during the Proterozoic Eon.

Taconite is a silica-rich iron ore that is considered to be a low-grade deposit. However, the iron-rich components of such deposits can be processed to produce a concentrate that is about 65% iron, which means that some of the most important iron ore deposits around the world were derived from taconite. Taconite is mined in the United States, Canada, and China.

Iron is essential to animal life and necessary for the health of plants. The human body is 0.006% iron, the majority of which is in the blood. Blood cells rich in iron carry oxygen from the lungs to all parts of the body. Lack of iron also lowers a person’s resistance to infection.

Our thanks to the following companies for supplying samples for this kit and helping to fund our display:

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