RED WORD LIST AND TEACHER SUPPORT NOTES

THE IMPORTANCE OF MINERALS AND MINING

To access relevant information in the TEACHER SUPPORT NOTES click on a word in the RED WORD LIST

At the end of the notes there is a brief section relating to class experiences and teaching tips. The main sources for the notes are www.wikipedia.org for general information and www.usgs.org for commodity information. For further information on minerals go to https://MineralsEducationCoalition.org/Minerals.

Further information on highlighted items or any unfamiliar terms in the notes can be found on the web.

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TEACHER SUPPORT NOTES

COPPER

The element Copper (Cu) is one of the few elements that occur in metallic form. It has been used since prehistoric times and was the basis for the "Copper Age" which covered about one thousand years from 7 to 6 thousand years ago. In ancient times it was mined in Cyprus and had the name "cyprium" from which we get the Latin "cuprum" and modern "copper". The Bronze Age followed after the discovery of Bronze, an alloy of copper and tin that is much harder than pure copper. Copper was thus a major material in the development of human civilization. It is still one of the most important metals, being third after steel and aluminum. It has very high thermal and electrical conductivity and its main modern use is for electrical transmission and the manufacture of electrical and electronic products. It is also used extensively for water pipes. In 2018 Chile was the dominant producer with 28% of world production, followed by Peru 11.7%, China 8.1%, USA 6.0%, Congo 5.2%, Australia 4.1%, Zambia 3.8% and Mexico 3.5% (back to List)

COPPER MINE

There are two types of mine, Underground and Open Pit. Underground mines extract rock from ore deposits that are some considerable distance below the surface. Access to underground mines is generally by a shaft with hoisting equipment for raising and lowering personnel, equipment and for bringing up ore. For deposits in a hill, access is sometimes by a horizontal tunnel called an adit. Open pit mines are surface mines. The slide shows the Kennecott Copper Bingham Canyon mine, one of the largest open pit mines in the world. Note the 320 ton haulage truck in the bottom right corner and the long train just visible in the lower levels of the pit. The primary purpose of a mine is to break the ore rock into pieces of an appropriate size for transport to a processing plant. (back to List)

COPPER SULFIDE

There are two basic types of Copper minerals, sulfides and oxides. Copper sulfides are minerals that contain both copper and sulfur. They may also contain other elements, particularly iron, cobalt and nickel. Examples of copper sulfide minerals are: Chalcocite (Cu_2S), Covellite (CuS), Bornite (Cu_5FeS_4), Chalcopyrite ($CuFeS_2$) and Carrolite ($Cu(Co,Ni)_2S_4$). Examples of copper oxide minerals are: Malachite ($Cu_2(CO_3)(OH)_2$), Azurite ($Cu(CO_3)_2$), Atacamite ($Cu_2Cl(OH)$ and Chrysocolla ($((Cu,Al)_2H_2Si_2O_5(OH)_4.nH_2O$). (back to List)

MINERALS

A mineral is a naturally occurring solid formed through geological processes that has a characteristic chemical composition, a highly ordered atomic structure, and specific physical properties. A rock, by comparison, is an aggregate of minerals and/or mineraloids and need not have a specific chemical composition. Minerals range in composition from pure elements and simple salts to very complex silicates with thousands of known forms. The study of minerals is called mineralogy. (back to List)

HAUL TRUCKS

Haul trucks are rigid trucks that are used in open pit mining to carry loads ranging from 50 to 450 tons. They are generally used in the larger operations mining copper, gold, iron ore, coal, or oil sands. The largest trucks cost about $3.5 million. The largest tires are about 14ft in diameter, cost over $65,000 and due to the extremely tough working conditions rarely last more than one year. In recent years more and more women have been trained to drive the large trucks and have established an excellent work record. (back to List)

BALL MILLS

A Ball Mill is a cylindrical drum which rotates about a horizontal axis and which is partially filled with the material to be ground and hard balls to do the work. The rotational action causes the contents to rise up, fall free from the drum wall and cascade down to the bottom, causing both impact breakage and attrition grinding. Ball mills are used in a wide range of industries where brittle materials need to be ground down to a fine size. They can be very small for hobby activities or very large in the mining industry where ball mills can be over 26 ft in diameter.
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FLOTATION CELLS

Hydrophobic solids do not like to mix with water. A slurry is a mixture of water and finely ground minerals. If some of the minerals are hydrophobic and bubbles are passed into the slurry the hydrophobic minerals attach themselves to the bubbles and rise to the surface where they can be skimmed off as a concentrate. Valuable minerals can be naturally hydrophobic or made so by the addition of chemicals. This process is called Flotation and is used extensively in the mineral industry. It is carried out in Flotation Cells which are large tanks made in a wide range of shapes and sizes. A common form is a rectangular tank with a central impeller for stirring the slurry and inducing air to make the bubbles. (back to List)

CONCENTRATOR and CONCENTRATE

A Concentrator is a large building which houses machines needed to grind ore to the size required to liberate the valuable minerals from the waste rock and to separate the valuable minerals into a Concentrate suitable for market or for the next step in processing. For metal bearing minerals the next step on the way to the metal product is generally either in a Smelter at high temperature (Pyrometallurgy) or by liquid phase chemical processes (Hydrometallurgy). (back to List)

SULFUR

Sulfur is a yellow nonmetallic element that occurs naturally around volcanoes, hot springs and in underground sulfur domes. Current production is mainly from the recovery of sulfur from oil and natural gas processing plants. About 90% of US sulfur consumption is in the form of sulfuric acid, the major industrial acid. Sulfuric acid is also obtained as a by-product from metal sulfide mine smelters. Important sulfide minerals are Pyrite (FeS_2, Iron Sulfide), Galena (PbS, Lead Sulfide), Covellite and Chalcocite (CuS and Cu_2S, Copper Sulfides), Sphalerite (ZnS, Zinc Sulfide) and many more. The largest use is for fertilizers where for example sulfuric acid is used to convert phosphate rock into phosphate fertilizers. In 2018 US consumption of sulfur was 10.0 million tons of which about 29% was imported. The number one producer was China with 21.7% of World production followed by USA, 12.0%, Russia, 8.9%, Saudi Arabia, 7.5%, and Canada, 6.8%. (back to List)

ANODES

Copper anodes are large impure copper plates which are used in an electrolytic process to produce high purity refined copper. In electrolysis an electric current passes from the anode to the cathode through a conducting solution. The copper dissolves from the anode, moves through the solution and deposits onto the cathode. The impurities, which include silver and gold, fall to the bottom of the tank and are recovered as by-products.
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POWER PLANT

A Power Plant is a large industrial facility for the generation of electricity. The slide shows a coal fired power plant. Prior to 2008 coal accounted for about one half of US electric power generation. In 2018 the three major fuels for power generation were Natural Gas (35.1%) coal (27.4%), and Nuclear (19.3%). Renewable energy sources contributed 11.2% and Hydro 7%. In a coal fired power plant chemical energy in the coal is converted to heat by burning (oxidation), the heat is used to boil water and the steam converts the heat energy into mechanical energy in a steam turbine. The steam turbine is connected to a generator where the mechanical energy is converted to electrical energy (electricity). The overall efficiency of this process in a coal fired power plant is less than 40% yet this is the major method in the world for generating electricity. (back to List)

COAL

Coal is a readily combustible sedimentary rock containing more than 50 percent by weight of carbonaceous material formed from plant material accumulated as peat in ancient swamps and bogs. The peat was buried by sediments and with heat, pressure, and time became the rock coal. Coal is a solid hydrocarbon comprised of carbon, hydrogen, and oxygen, with minor amounts of sulfur and other elements. USA Coal production of about 775 million short tons/year is mined in 265 states with the main producers, in order, being Wyoming, West Virginia, Kentucky, Pennsylvania and Texas. Over 90% is used to generate electricity but the use of coal for power generation is decreasing as power generation by natural gas increases. Another important use for coal is to make Coke (see COKE below) for use in Blast Furnaces for the production of iron. (back to List)

OPEN PIT

An Open Pit Mine is a mine on the surface as opposed to an Underground Mine. The term is generally used for metallic mines extracting for example, ores of Copper, Gold, Nickel, Cobalt and Uranium. Surface mines extracting building materials are more often referred to as Quarries. Much Coal is mined at the surface and is termed Open-Cast mining or Strip Mining. (back to List)

UNIT TRAINS

A Unit Train is a long train dedicated to the transport of a single commodity from a single source (e.g. a mine) to a single destination (e.g. a dock or a power plant). Products commonly transported by unit trains include taconite, coal, grain and crushed rock aggregate. Unit trains typically have 100 cars or more and in some cases have the capability to be loaded and unloaded while moving. (back to List)

STRUCTURAL STEEL

Steel is an alloy which is mainly iron (Fe), with small amounts of carbon (C). Iron and steel comprise about 95% of all metal produced in the world and are by far the cheapest. In 2011 China was the largest producer with about 38% of the world production of 1.36 billion tons followed by Japan (9%) and USA (6.9%). In 2018 this had changed to a total of 1.8 billion tons with China producing 49.4%, Japan and India, 6.1% and USA 4.8%. Steel has a very wide range of applications and in USA about 43% is used for construction. Structural steel is literally the backbone of modern civilization being the structural skeleton of all high rise buildings and most low profile commercial and industrial structures. Structural steel is made in many grades and many structural shapes.
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IRON ORE

An ore is a naturally occurring rock from which a mineral or minerals of economic value can be profitably extracted. The principal minerals in iron ores are Hematite (Fe_2O_3) containing 70% iron and Magnetite (Fe_3O_4) containing 72.3% iron. In 2008 the world production of iron ore was 2.2 billion tons with major producers being China 35%, Brazil 18% and Australia 15%. US production was 2.5%. In 2018 world production was 2.5 billion tons with Australia 36.0%, Brazil 17.0%. China 13.6%. US production was 2.0%%. (back to List)

TACONITE

Taconite is a low grade sedimentary rock in a class known as banded iron formations which were deposited in the Precambrian era between 1.8 and 2.5 billion years ago. They are characterized by thin alternating bands of iron rich minerals, mainly Magnetite (Fe_3O_4), and Chert a microcrystalline form of Silica (SiO_2). Taconite is very hard and a great deal of energy is required to reduce the rock to the very fine size required to liberate the fine grained magnetite.. Taconite is the primary iron ore used in the US Steel industry with Minnesota (75%) and Michigan (23%) supplying 98% of US domestic production of over 50 million tons/year. (back to List)

PELLET PLANT

In a Taconite Pellet Plant the fine magnetite particles are separated from the waste rock by strong magnets. The concentrate is mixed with binders, rolled into balls and fired in furnaces at 2400ºF. The hot pellets are cooled and the final product is hard taconite pellets about 1cm diameter. (back to List)

TACONITE PELLETS

Taconite pellets are produced in a Pellet Plant and transported to the Steel Mills. The hard pellets are strong enough to resist breakage during shipment and the spherical shape improves the gas flow and hence the efficiency of the blast furnace. (back to List)

STEEL MILLS

A steel mill is an industrial plant for the manufacture of steel, which is an alloy of iron and carbon. In the United States there are two fundamentally different approaches to steelmaking. Integrated Mills use ore and blast furnaces while Mini Mills use scrap and electric arc furnaces. In 2008 US steel production was 93 million tons with Integrated Steel mill Blast Furnaces accounting for 58% and Mini Mills accounting for 42%. By 2018 these numbers had changed to 103 million tons with BF 33% and Mini Mills 67%. (back to List)

BLAST FURNACE

A blast furnace is a very large furnace for smelting metallic ores and is the primary producer of molten iron in an Integrated Steel Mill. Iron ore, coke and limestone are continuously fed into the top of the furnace and oxygen and/or air are blown in at the bottom. Temperatures at the bottom are over 3000ºF. As the solids descend the iron ore is reduced (Oxygen removed) and molten iron and molten slag are removed at the bottom. Hot gases under pressure exit from the top and contain mainly nitrogen with about 20% each of carbon dioxide (CO_2) and carbon monoxide (CO). The pressure, heat and the energy from combustion of the CO are recovered in a variety of recovery systems. The largest blast furnace in the world is in South Korea and was started up in 2016. It has a working volume of 6,000 m^3, equal to nearly 1.6 million gallons or 2.4 Olympic swimming pools. It is designed to produce 15,500 tons of iron per day, a little over 5.6 million tons a year. (back to List)

COKE

Coke is produced from a mixture of coals crushed and ground into fine powder. The powder is heated for 18 to 24 hours in a coke oven to drive off volatile matter such as oil and tar. The coke product is removed from the oven, cooled and screened into pieces ranging from one to four inches. The resulting coke is porous but very strong, contains 90 to 93% carbon and is ideal for providing the chemistry and physical characteristics necessary in the blast furnace. (back to List)

LIMESTONE

Limestone is a sedimentary rock composed mostly of the mineral Calcite ($CaCO_3$, Calcium Carbonate). About 15% of the Earth's sedimentary crust is limestone. Dolomitic limestone is mainly Calcite but also contains Dolomite ($Ca.Mg(CO_3)_2$, Calcium Magnesium Carbonate). Uses are numerous. Limestone is a basic building block of the construction industry and the chief raw material from which aggregate, cement, lime, and building stone are made. 71% of all crushed stone produced in the U.S. is either limestone or dolomite. When calcined (burnt at high temperature), Carbon Dioxide (CO_2) is driven off and lime (CaO) is produced. Lime is used in many industries including paper, plastics, glass, paint, steel, cement, carpets, used in water treatment and purification plants, and in the processing of various foods and household items (including medicines). (back to List)

BASIC OXYGEN FURNACE

Molten iron is converted into refined steel in the Basic Oxygen Furnace. High purity oxygen is blown through the molten bath to lower the carbon, silicon, manganese, and phosphorous content of the iron, while various fluxes are used to reduce the sulfur and phosphorous levels. The impurities and a small amount of oxidized iron are carried off in the molten slag that floats on the surface of the hot metal. (back to List)

INTEGRATED STEEL MILLS

Integrated steel mill are very large industrial complexes that have all the functions required for primary steel production. These include coke making in coke ovens, iron making by smelting iron ore with limestone and coke in a blast furnace to make molten pig iron, steelmaking in a basic oxygen furnace to convert pig iron into liquid steel, casters to solidify the molten steel into basic shapes and various hot and cold rolling mills to progressively reduce the size of the cast blocks and ingots to final product specifications. Integrated mills typically produce from 2 to5 million tons per year of steel. (back to List)

REBAR

Rebar is the short name for Reinforcing Bar. Concrete is strong in compression but week in tension so rebar is used in reinforced concrete and masonry structures to provide tensile strength. It is made of long steel rods with ridges to provide strong anchoring to the concrete. Sometimes the rebar is coated to resist rusting which can be caused by salt penetration of the concrete in cold regions where salt is used for ice control. Rebar comes in many sizes ranging from 3/8” to over 2” diameter. (back to List)

SCRAP IRON

Scrap Iron is iron and steel collected for recycling and is a vital raw material for the production of new steel and cast-iron products. The steel industry has been recycling steel scrap for more than 150 years. Prompt, or Home scrap is scrap produced in steel mills and factories making finished products. Old scrap is material recycled from items that have been used and discarded. In 2018 about 51 million tons of steel was consumed in USA and 18

million tons were exported. More than 15 million tons came from automobiles, with a recycle rate of over 95%. Other major sources were appliances, cans and the construction industry. Scrap recycling is important for conserving raw materials and for conserving energy since re-melting scrap consumes much less energy than the production of iron and steel from iron ore. (back to List)

MINI MILLS

The development of Mini Mills began in the 1970s and the industry quickly grew to the point of producing as much steel as the Integrated Steel Mills. Raw material is mainly from scrap iron but direct reduced iron, a specialty iron product which does not come from blast furnaces, is also used in many plants to blend with the scrap iron. The molten iron from the electric arc furnace is converted to steel in a separate furnace and then solidified in a continuous caster. Some of the largest Mini Mills can produce up to 3 million tons per year but these are the exception. Most Mini Mills have capacities in the range 200,000 to 500,000 tons per year. In 2018 mini mills accounted for 67% of US steel production. (back to List)

CONCRETE

More Concrete is used in the world than any other man-made material. It is made by mixing cement with aggregate and sand and adding water to make a smooth paste. The wet concrete can be poured horizontally to make structures such as roads, pavements and foundations or poured into formers to make vertical sections such as walls or columns or more complex shapes like large concrete pipes or pre stressed concrete structural beams. Most concrete structures are reinforced with steel reinforcing rods (rebar). Chemical reactions cause the cement to harden and make the familiar stone like product. The slide shows concrete being poured for a building floor and the grid formed by the reinforcing bar (rebar) can be seen. (back to List)

SAND

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles (or grains) in the size range from 0.0625 mm (62.5 micrometers) to 2 millimeters. Gravel is coarser than sand with size range from 2 mm up to 64 mm while silt is finer than sand. Sand feels gritty when rubbed between the fingers while Silt feels smooth like flour. Sand is a product of the weathering of rocks and can have many different compositions depending on the type of rock. By far the most common sand is silica sand (SiO_2) usually in the form of quartz. Silica sands are used in glassmaking, in foundries, as abrasive, for hydraulic fracturing (frac sand) applications, and for many other industrial applications. The specifications for each use vary, but silica resources for most uses are abundant. In almost all cases, silica mining uses open pit or dredging mining methods with standard mining equipment. About 44% is used for making concrete. Frac sand demand increased dramatically with the growth of oil and gas production from shale formations by the use of horizontal drilling. (back to List)

SAND PITS

Sand is transported by wind and water and is deposited in the form of beaches, dunes, sand spits, sand bars and related features. In time these deposits can be covered by other sediments or soil. All states recover sand for construction from local deposits called sand pits or sand mines that are generally close to the surface and located close to population centers. Frac Sand, used by the oil and gas industry, must have special shape and strength properties. Production surged in recent years with the increase in natural gas production from shale deposits. The number of these mines in Wisconsin increased from 5 in 2010 to over 100 in 2014. In 2016 there were 92 active facilities. (back to List)

GRAVEL

Gravel (also called Aggregate) is loose rock fragments that range in size from 2mm to large boulders. One cubic yard weighs about 3000 pounds (one cubic meter weighs about 1,800 kilograms). Gravel is an important commercial product, with several applications. Roads in rural areas with little traffic are often surfaced with gravel. Globally there are more gravel roads than concrete or tarmac roads. A major use is for the manufacture of concrete, made by mixing sand, aggregate and cement with water. The size of the aggregate used depend on the thickness of the concrete product. Generally the size of the largest gravel should be less than one third that of the concrete slab. For a 4" concrete slab the gravel would typically be less than 1¼" size. Gravel deposits are formed as a result of the weathering and erosion of

rocks. Subsequent transportation by rivers and glaciers can result in large deposits. If natural gravel deposits are insufficient for local needs, crushed rock aggregates are produced by quarrying and crushing hard-wearing rocks, such as sandstone, limestone, or basalt. (back to List)

AGGREGATES

The terms Aggregate, Aggregates or Construction Aggregate are used in the construction industry for any solid product used in the making of concrete (particularly sand, gravel and crushed rock), used as a compacted base material for roads, foundations and railroads or for a variety of drainage purposes. In recent times US crushed rock production decreased from a peak of 1.72 billion tons in 2006 to 1.26 billion tons in 2014 with about 69% being limestone or dolomite. In 2018 US production was1.4 billion tons. (back to List)

ROCK QUARRY

Rock Quarries exist close to most population centers to satisfy construction needs. Surface overburden is removed by earthmoving equipment and the rock is drilled and blasted. The large rock fragments are conveyed to crushers where they are broken down and then screened to make various product sizes.(back to List)

CEMENT

Cement is made by heating limestone with small quantities of other materials (such as clay) to 1450°C in a kiln, in a process known as calcination. The product, called 'clinker', is cooled and then ground with a small amount of gypsum into a very fine powder to make 'Ordinary Portland Cement' (OPC). OPC is the most commonly used type of cement and is a basic ingredient of concrete, mortar and most non-specialty grout. The most common use for Portland cement is in the production of concrete. There are many different blends of cement for special applications including colored cement for decorative purposes. In recent times US cement production decreased from a peak of 99.3 million tons in 2005 to 67.7 million tons in 2011, but then increased to 87.8 million tons in 2018.

The sidewalk is a concrete sidewalk, not a cement sidewalk. (back to List)

CEMENT PLANT

A Cement Plant is an industrial facility that contains all the equipment necessary for the manufacture of cement. It may be located alongside a limestone quarry or have a receiving area for limestone transported from a remote quarry. Raw materials are mixed in the correct proportions then ground to a powder. After passing through a preheating tower they are fed into the kiln and calcined at 1450°C. The clinker is cooled and ground to a fine powder for bagging and shipping. In 20 the world production of hydraulic cement was 4.1 billion metric tons. The top three producers were China 57.8%), India (7.1%) and USA (2.2%), the world's three most populous nations. On a per capita basis production in tons per person was China (1.71) India (0.22) and USA (0.26). The US output of 87.8 million tons was produced in 98 Cement Plants in 34 states. (back to List)

CEMENT KILN

A Cement Kiln is a rotary kiln consisting of a long cylindrical shell made from steel plate, and lined with firebrick. The kiln slopes slightly (1–4°) and slowly rotates on its axis at between a half and 4 revolutions per minute. Kilns can be provided in varying sizes depending on throughput requirements and can range from 100ft long by 9ft diameter to over 300ft long by 20ft diameter. Raw blended mix is fed in at the upper end and gradually moves downhill to the other end of the kiln where fuel, in the form of gas, oil, or pulverized solid fuel, is blown in through a "burner pipe". As material moves under the large concentric flame in the lower part of the kiln it reaches its peak temperature around 1450°C before dropping out of the kiln into a cooler. Combustion air passes through the cooler and is preheated by the cooling clinker to 400 to 800 °C before entering the burner pipe. This conserves energy and causes intense and rapid combustion of the fuel. (back to List)

LIMESTONE QUARRY

A limestone quarry is a quarry (see ROCK QUARRY above) for the production of Limestone (see LIMESTONE above). (back to List)

COPPER PIPES

A pipe is a tube or hollow cylinder used to convey materials or employed as a structural component. The terms pipe and tube are interchangeable conceptually but pipes are generally specified by the internal diameter (ID) whereas tubes are usually defined by the outside diameter (OD). Many industrial and government standards exist for the production of pipe and tubing. Copper pipes are used extensively in buildings to transport drinking water and in heating and cooling systems to benefit both from copper's high thermal conductivity and its malleability (ability to be bent and shaped). (back to List)

WATER TREATMENT PLANT

Water Treatment Plants receive surface water from rivers, lakes and reservoirs or groundwater pumped from underground aquifers, and must remove all undesirable contaminants to meet state and federal standards for drinking water. Substances to be removed include sediments, dissolved minerals, man-made pollutants such as industrial chemicals or fertilizers, and organic material such as algae, bacteria and viruses. Water Treatment Plants producing municipal drinking water use a combination of processes including sedimentation or filtration to remove coarse sediments, pre-chlorination for algae and biological growth control, aeration for precipitation of dissolved iron and manganese, carbon treatment to remove dissolved organics, coagulation to consolidate the fine precipitated particles into flocs, sedimentation to remove the majority of the flocs and filtration for final clarification. Before leaving the plant the water is provided with a disinfectant to protect against bacterial contamination during its journey to the final faucet. The quality of all natural waters varies widely depending on the particular source and surface waters also vary seasonally. There is no standard plant and treatment plants have to be designed for each particular water source. (back to List)

STEEL PIPES

Steel pipes are used in many areas, particularly for large diameter applications including pipelines for water, oil, gas and mineral slurries. They are also used in the construction industry as structural members. (back to List)

CONCRETE CONDUITS

A Concrete Conduit is a large diameter reinforced concrete pipe generally constructed in preformed sections but which may also be made by lining tunnels with concrete. The main purpose of concrete conduits is for the transport of water. The world's largest municipal water transport project is the New York City Water Tunnel No. 3 project begun in 1970 and which is not due for completion until after 2020. Tunnel diameters are up to 24ft. Concrete conduits have also been manufactured for road tunnels. (back to List)

RESERVOIR

A reservoir is an artificial lake used to store water and is created by building a sturdy dam across a river or stream. Once the dam is completed the river or stream will fill the reservoir over a period of time. The water level rises with the inflow rate and falls as a result of withdrawals and evaporation. Lake Volta in the West African nation of Ghana is the largest reservoir in the world. It was formed in 1965 by the construction of the Akosombo Dam and now covers an area of 8,502sqkm (3283sq miles). Lake Mead is the largest reservoir in the United States and was formed by water impounded by the Hoover Dam (see DAM below). It extends 112 miles (180 km) behind the dam, holding approximately 28.5 million acre feet (35 km^3) of water. The water held in Lake Mead is used to generate electricity and is also transported via aqueducts for agricultural purposes and community uses in Southern California and Nevada. The term is also applied to underground formations where fluids collect e.g. oil reservoir. (back to List)

DAM

A dam is a natural or man-made barrier made of concrete, earth, rock, or a combination of these built across a river or stream in order to retain water. Intended purposes include providing water for: agricultural irrigation, town or city water supplies, improving navigation, industrial uses, generating hydroelectric power, creating recreation areas, providing habitat for fish and wildlife, and retaining wet season flow to minimize downstream flood risk. Some dams can also serve as pedestrian or vehicular bridges across the river. When used in conjunction with intermittent power sources such as wind or solar, the reservoir can serve as pumped water storage to augment base load demand in the power grid. Few dams serve all of these purposes but some multipurpose dams serve more than one. Tailings dams are also built to contain effluent from industrial sites such as mines, industrial complexes

or coal fired power plants. The Hoover Dam is a concrete arch-gravity dam in the Black Canyon of the Colorado River and is located 30 miles (48 km) southeast of Las Vegas, Nevada, on the border between Arizona and Nevada. When completed in 1936, it was both the world's largest electric-power generating station and the world's largest concrete structure. In 1945 it was surpassed by the Grand Coulee Dam which is almost a mile long at 5223 feet (1586 m) and required 11,975,521 yd^3 (9,155,942 m^3) of concrete. The Grand Coolee Dam is the largest concrete dam and concrete structure in North America. The height of the dam from bedrock is 550 feet which is taller than the Great Pyramid of Giza. All the pyramids at Giza could fit within its base. The Largest dam in the World is the Three Gorges dam in China, 1.3 miles wide and over 600 ft high. (back to List)

TURBINE

A turbine is a rotary mechanical device that extracts energy from a flowing fluid and converts it into useful work.. It has at least one moving part called a rotor assembly, which is a shaft or drum with blades attached. Moving fluid acts on the blades and imparts rotational energy to the rotor. Windmills and water wheels are early examples of turbines where the rotor assembly is not enclosed. Modern gas, steam or water turbines have enclosed rotors and operate at high temperature and/or pressure. Turbines are the primary source of energy for modern electric power generation. (back to List)

HYDROPOWER

Hydro is a prefix relating to water, hence hydropower is power derived from the flow of water. Since ancient times, hydropower has been used for irrigation and various mechanical devices, such as watermills and sawmills etc. In modern times the word is generally used to describe hydro-electric power. About 7% of current US electric power is generated by Hydropower. (back to List)

CERAMIC

A ceramic is an inorganic, non-metallic solid made by heating clay in a furnace or kiln followed by controlled cooling. Pottery, the making of ceramic objects, is one of the oldest human technologies and art-forms and the study of ancient pottery relics gives archeologists revealing insights into early human cultures. Apart from pottery for artistic purposes the modern ceramic industry falls into four main categories. “Structural” products such as bricks, pipes, and floor and roof tiles, “Refractories” for lining furnaces and crucibles, “Whiteware” for domestic purposes such as tableware, wall tiles, pottery products, and sanitary ware and “Technical” products covering a wide range of advanced items including materials used in the space program, bioengineering and the electronics industry. (back to List)

CLAY

Clay is a naturally occurring moldable material typically formed over long periods of time by the gradual chemical weathering of rocks. It is composed primarily of very fine-grained minerals which can be hardened when dried and/or fired. Water is trapped in the clay by the surface characteristics of the very fine particles and as a result, clay can contain up to 50% water without appearing wet. (back to List)

CLAY PIT

A Clay Pit is a surface mine from which clay is excavated. Clay deposits can be formed in place but thick deposits are usually formed as the result of secondary sedimentary deposition processes after they have been eroded and transported by water from their site of origin. Clay deposits are typically formed at the mouths of rivers as they enter lakes or seas. (back to List)

CAST IRON

Cast iron is name given to a range of iron alloys containing between 2-4% carbon and 1-3% silicon. Cast iron is very different from steel, being hard and brittle. It has a melting point lower than pure iron and is easy to cast. Due to its excellent machinability, resistance to deformation, and wear resistance it has a wide range of engineering applications including pipes, machinery and automotive industry parts. It is resistant to destruction and weakening by oxidation (rust). (back to List)

SEWER PIPES

Sewer pipes range from 4 inch cast iron or PVC plastic pipes collecting bathroom waste water to 12 ft diameter reinforced concrete pipes taking the combined waste from a city to a treatment plant. Each house in a street is connected to a sewer pipe below the road and these in turn connect to larger and larger diameter pipes until they reach the waste water or sewage treatment plant. Most modern installations use plastic pipes up to 5 ft diameter and reinforced concrete for larger diameters. (back to List)

WASTE WATER TREATMENT PLANT

A Waste Water Treatment plant, also called a Sewage Plant, receives waste water discharges from homes, hospitals, commercial buildings and industry. In some cases storm water is also collected in the sewer system but this practice is avoided where possible since sudden dilution of the sewage stream make processing more difficult. The purpose of the treatment plant is to remove physical, chemical and biological contaminants to levels that permit safe disposal of the resulting sludge and treated water. Processing steps include pretreatment to remove coarse solids and trash, primary treatment in large settling tanks to produce a sludge and a homogeneous liquid suitable for biological treatment, secondary treatment designed to degrade the biological components of the sewage such as are derived from human waste, food waste, soaps and detergent using a variety of aerobic biological processes and tertiary treatment to ensure that the water finally discharged into a river or lake meets state and federal standards. The sludge stream must also be processed before disposal and the most common treatment options include anaerobic digestion, aerobic digestion, and composting. Incineration is also used in some plants, including the Twin Cities waste water treatment plant at Pigs Eye on the Mississippi River just south of the cities. (back to List)

VITAMINS AND MINERALS

A vitamin is an organic compound required as a nutrient in tiny amounts by all living things. If the diet does not provide essential vitamins it is necessary to take vitamin supplements to maintain good health. Vitamin tablets usually include minerals which are inorganic compounds containing trace elements that are also critical for good health. There are many different vitamins and associated deficiency diseases such as Vitamin C and Scurvy or Vitamin D and Rickets. The human body needs several essential trace elements including the metals Manganese (Mn), Iron (Fe), Cobalt (Co), Nickel (Ni), Copper (Cu), Zinc (Zn) and Molybdenum (Mo) and non-metallic Iodine (I). These trace elements are commonly referred to in supplements as “Minerals”, but are simple inorganic compounds and not the minerals of geology. (back to List)

FLOUR

Flour is a powder made from cereal grains or roots. It is the main ingredient of bread, a staple food for many civilizations, making the availability of adequate supplies of flour a major economic and political issue at various times throughout history. Wheat flour is one of the most important foods in Europe and North America, being the predominant ingredient in most European styles of breads and pastries. Maize flour has been important in Mesoamerican cuisine since ancient times, and remains a staple in much of Latin American cuisine. Flour contains a high proportion of starches, which are complex carbohydrates also known as polysaccharides. Leavening agents are used with some flours, especially those with significant gluten content, to produce lighter and softer baked products by embedding small gas bubbles. (back to List)

FLOUR MILLS

A Flour Mill also called Corn Mill or generically a Grist Mill is a building in which grain is ground into flour. The term also applies to the grinding mechanism itself. Flour Mills have a long history with the earliest recorded water powered gristmill dating from the mid first century BC. As population grew so did the number of mills with the Domesday Book survey in 1086 in England recording 5624 mills or about one for every 300 inhabitants. Until the industrial revolution (1750 – 1850) the grinding wheels were made of stone. Modern mills are large industrial facilities using electricity or fossil fuel for power and specialty steel for rollers. (back to List)

COMBINE HARVESTERS

The combine harvester, or simply combine, is a machine designed to harvest grain crops. The objective is to complete three processes, which used to be distinct, in one pass of the machine over a particular part of the field. The first is cutting, the second is removing the straw and the third is threshing to separate the product from chaff

and weed seeds. Among the crops harvested with a combine are wheat, oats, rye, barley, corn (maize), soybeans, and flax (linseed). The waste straw comprised of the dried stems and leaves of the crop is either chopped and spread on the field or baled for feed and bedding for livestock, but there is an increasing interest in using it for the production of bio fuel. The combine is a large complex machine made from many materials derived from minerals including steel, copper, aluminum, alloying elements such as chromium, cobalt and nickel, glass, paint, rubber and plastics. (back to List)

FERTILIZERS

Fertilizers are chemical compounds applied to promote plant and fruit growth. Fertilizers are usually applied either through the soil for uptake by plant roots or by spraying for uptake through leaves. Fertilizers can be organic (compost or manure) or inorganic (minerals or manufactured chemical compounds). Organic fertilizers can improve the health and productivity of soil and plants by provide different essential nutrients to encourage plant growth. Organic nutrients increase the abundance of soil organisms by providing organic matter and micronutrients for organisms such as fungal mycorrhizia, which aid plants in absorbing nutrients. The three principle elements in chemical fertilizers are Nitrogen (N), Phosphorous (P) and Potassium (K). Fertilizers with all three elements are common and known as N-P-K fertilizers. The proportions of the three elements differ for different applications. Although chemical fertilizers play an important role in obtaining good crop yields they may have long-term adverse impacts on organisms living in the soil and a detrimental long term effects on soil productivity. Fertilizer chemical run off can also have negative impacts on environmental water quality. The use of chemical fertilizers needs to be carefully monitored. (back to List)

NITROGEN

Nitrogen (N) is a chemical element which is a colorless, odorless, tasteless and mostly inert diatomic gas (N_2). The Earth's atmosphere contains 78% nitrogen by volume. Many industrially important compounds, such as ammonia, nitric acid, organic nitrates (propellants and explosives), and cyanides, contain nitrogen. The element nitrogen was discovered by Daniel Rutherford, a Scottish physician, in 1772. Nitrogen occurs in all living organisms. It is a constituent element of amino acids and thus of proteins, and of nucleic acids (DNA and RNA). It resides in the chemical structure of almost all neurotransmitters, and is a defining component of alkaloids, biological molecules produced by many organisms. Nitrogen is an important element in chemical fertilizers for agriculture. (back to List)

LIQUID AMMONIA

Over 80% of ammonia (NH_3) is used as fertilizers either in the liquid form, as its salts or as solutions. Ammonia is made from atmospheric nitrogen and hydrogen derived from natural gas. The process requires a large energy input and consumes more than 1% of all man-made power thereby being a significant component of the world energy budget. The photo shows a liquid ammonia tanker and direct injection into the soil. (back to List)

UREA

Urea or carbamide is an organic compound, with the chemical formula $(NH_2)_2CO$, which plays an important role in the metabolism of nitrogen-containing compounds by animals. It is the main nitrogen-containing substance in the urine of mammals. Urea is widely used in fertilizers as a convenient source of nitrogen due to its basic properties, being solid, colorless, odorless, neither acidic nor alkaline, highly soluble in water, and relatively nontoxic. Urea is also an important raw material for the chemical industry. The synthesis of this organic compound by Friedrich Wöhler 1828 from an inorganic precursor was an important milestone in the development of the chemical industry. (back to List)

AMMONIUM SALTS

Ammonium salts used for fertilizers include Ammonium sulfate ($(NH3)_2SO_4$), Ammonium nitrate (NH_3NO_3), mixtures of the sulfate and nitrate and Ammonium chloride (NH_3Cl). They are usually applied in solution.
(back to List)

PHOSPHORUS

Phosphorus (P) is a nonmetallic element commonly found in inorganic phosphate rocks. Elemental phosphorus exists in two major forms - white phosphorus and red phosphorus. Although the term "phosphorescence", meaning

glow after illumination, derives from phosphorus, the glow of phosphorus originates from oxidation of white (but not red) phosphorus and strictly should be called chemiluminescence. Due to its high reactivity, phosphorus is never found as a free element in nature. Phosphorus is an essential element for all living cells, being a component of DNA, RNA, ATP and the phospholipids which form all cell membranes. The most important commercial use of phosphorus-based chemicals is the production of fertilizers. Phosphorus compounds are also widely used in explosives, nerve agents, friction matches, fireworks, pesticides, toothpaste and detergents. (back to List)

PHOSPHATE MINE

A Phosphate Mine is a mine that extracts phosphate rock from natural deposits. Phosphate rock minerals are the only significant global resources of phosphorus and are predominantly used to manufacture phosphate fertilizers. In 2018 China was the world's leading producer of phosphate rock with 51.9% of World production, followed by Morocco & Western Sahara with 18.5% and USA with 10%. In 2018 US consumption was 27.0 million tons of which more than 95% was destined for fertilizers and animal feed products. (back to List)

POTASSIUM

Potassium (K) is a soft silvery-white alkali metal element and is necessary for the function of all living cells. It is highly reactive, oxidizing in air and reacting violently with water generating sufficient heat to ignite the evolved hydrogen. The element was discovered in 1807 in England by Sir Humphry Davy, who was able to produce potassium from caustic potash (KOH), by electrolysis of the molten salt. Before the 18th century, no distinction was made between potassium and sodium. Potassium was the first metal to be isolated by electrolysis. Davy later extracted sodium by a similar technique, demonstrating the elements to be different. In nature Potassium occurs only in its ionic form. It is found dissolved in seawater, and as a component in many minerals. The potassium ion is a necessary component of life and is present in all plant and animal tissues. It is found in especially high concentrations in plant cells, and is most highly concentrated in fruits. Potassium and sodium are both alkali metals and although they have many similar chemical properties they have very different functions in organisms in general, and in animal cells in particular. Potassium, nitrogen and phosphorus are the three major elements in fertilizers. (back to List)

POTASH

Potassium (K) is an important component of fertilizers and 200 years ago was obtained as Potassium Carbonate (K_2CO_3) from the ashes of broadleaf trees, hence the name pot-ash. The term “Potash” now applies to mineral deposits that provide a source of soluble potassium salts. Current production is from salt deposits formed by the evaporation of ancient seas and lakes with the principle potassium salt being Potassium Chloride (KCl) occurring as the mineral Sylvite. The major component of Potash deposits is the mineral Halite which is Sodium Chloride (NaCl). In 2018 US potash consumption was 6.3 million tons with 0.5 million tons produced domestically. The majority of the imports come from Canada which is the largest producer in the world, producing over half of world production. About 85% of US consumption is used for fertilizers with the rest used in the chemical industry.
(back to List)

UNDERGROUND MINE

Mineral deposits occur at different depths. Those near the surface are extracted by surface mining techniques (see COPPER MINE and OPEN PIT above) while those at greater depths require access to the deposit and extraction by underground mining techniques. Access can be achieved through a decline, a vertical mine shaft or, for entry into a mountain, by a horizontal adit. The first phase of an underground mine is the development of the access and is in itself a major task with the removal of large quantities of waste rock. Once access to the ore deposit has been achieved production can begin. For hard rock mines the ore is broken by drilling and blasting and either crushed underground or transported to the surface for crushing and further processing in a concentrator. For softer rocks, instead of drilling and blasting, a variety of cutting machines are used to cut away the exposed surface of the deposit. The excavated material is then transported to the surface as in hard rock mines. Safety, haulage of personnel and materials, and ventilation are important factors in underground mining. The deepest underground mine is the TauTona gold mine in South Africa with a depth of 12,800 feet (2.42 miles). (back to List)

HORSE POWER

It is important to understand the relationship between energy (E), work (W) and power (P). Power is the rate at which work is performed or energy is converted thus P = W/t or E/t where “t” is time. In mechanical terms work is done when an object is lifted from one level to a higher level. The work done depends on the weight of the object and the distance moved. A force has to be applied to move the object and the work done is the product of the force (F) times the distance (D). W=FxD. If a force F is moved a distance D in time t, then the power required is (FxD)/t = W/t = P. Energy is a broad term and covers mechanical, electrical and chemical systems. Human power is very small and one person can accomplish only a certain amount of work in one day. In pre historic times the only source of power was human power. The discovery of fire introduced a new source of energy which was used for heat and light. The use of rocks for domestic purposes (cutting, breaking and grinding) and for hunting purposes (knives, arrow heads and spear tips) allowed for more efficient use of human power and defined the Stone Age which covers time before 5000 BC. Obtaining the rocks required mining, which is consequently one of the earliest human industries. The stone age changed with the discovery of metallurgical processes where the application of heat energy permitted the extraction of copper from copper ores, (Copper Age, 5000 – 4000 BC), the alloying of tin with copper to produce bronze (Bronze Age, 4000 – 1200 BC) and subsequently the smelting of iron ores to produce iron (Iron Age, 1200 – about 500 BC). In the early stage of this evolution of human enterprise three other sources of energy were developed. Animals were domesticated and used for transportation (mules, horses and camels) and for work (oxen and horses). Wind energy was used for mills and transport on seas and lakes in sail boats, and water power was used for gristmills and sawing timber and stone. This situation continued for about 1700 years until a fundamental change in human civilization occurred in 1698 when Thomas Savery (1650-1715) patented the first crude steam engine which resulted from his efforts to solve the problem of pumping water out of coal mines. Thus the industrial revolution can trace its roots to mining. His machine consisted of a closed vessel filled with water into which steam under pressure was introduced, forcing water upwards and out of the mine shaft. A cold water sprinkler was then used to condense the steam to create a vacuum which sucked more water out of the mine shaft through a bottom valve. Thomas Newcomen (1663-1729) invented the atmospheric steam engine, an improvement over Slavery's design and in 1712 Newcomen together with John Calley built their first engine which was also used to pump water out of a mine. Later, in 1765, James Watt (1736-1819) while working for the University of Glasgow was assigned the task of repairing a Newcomen engine. That started the inventor to work on several improvements to Newcomen's design. Most notable was Watt's 1769 patent for a separate condenser connected to a cylinder by a valve. Unlike Newcomen's engine, Watt's design had a condenser that could be cool while the cylinder was hot. Watt's engine soon became the dominant design for all modern steam engines and helped bring about the Industrial Revolution, commonly dated at 1750 to 1850. Prior to steam engines the main source of power in Europe was the draft horse, used for pulling carts on roads and barges along canals. The work output of the new steam engines was compared to the work of a draft horse and an engine was rated as being equal to so many horses, hence horsepower. The official horsepower unit for mechanical work in precise physical units is 550 ft-lb per second. For electrical power the unit of power is named after James Watt and one Watt is equal to one volt times one amp. Electrical and mechanical power are interchangeable and one mechanical horsepower is equal to 745.7 Watts. (back to List)

FEEDBACK, COMMENTS AND TIPS

ON THE POWERPOINT PRESENTATION

THE IMPORTANCE OF MINERALS AND MINING

Background:

The PowerPoint is based on a slide show prepared for presentation to the Legislative Commission on Minnesota Resources (LCMR) in the early 1980s. It was digitized and updated in preparation for presentation to elementary school teachers at the 2009 Minnesota Mineral Educators Workshop (MMEW). However the workshop was canceled. In the meantime the Mineral Information Institute (Mii) expressed an interest and in December 2009 free access to the PowerPoint and teachers notes were provided on the web site www.mii.org (which is now www.MineralsEducationCoalition.org). In June 2011 SME reported 12,000 downloads per month which projects to approximately 360,000 by June 2012. It is presented annually at the MMEW and has consistently received very favorable teacher responses.

First School Presentation:

The first school presentation of "The Importance of Minerals and Mining" was in October 2009 to a group of 48 3rd grade students (two classes). After the presentation six large mineral specimens were shown and discussed followed by a general question and answer period. The total elapsed time was 45 minutes.

With minimal additional comment on the images the shortest time for the presentation is probably about 15 minutes. If student questions are allowed during the presentation the teacher notes are designed to give the teacher introductory background information. For higher grade classes students could be asked to select one of the red words, do a Google search and write a report.

Prior to the class one of the students had prepared a three-question questionnaire with the first question being "Did you like the Power Point?" The response to this first presentation was: Awesome 36, Good 9, OK 2 and Not Really 1 and provided encouragement to make the PowerPoint presentation available through the Mineral Information Institute. In 2015 googling "Importance of Mining" gave over 150,000,000 hits and the first three gave links to this PowerPoint presentation. (back to List)

Teacher Review: One of the class teachers reviewed the first presentation as follows:

Minerals and Mining Presentation Review
By Pam Olson – 3rd Grade Science Teacher

Helpful/Important Points in the PPT:

- Vocabulary words written in red – Visually helpful to students to remain on task. It could also serve to help students take notes. There were a few too many "red words" for grade 3 but I can see where it would be more applicable for the older grades. It might be helpful to have a slide at the end that specifically has all the red words on it to help remind students what they learned. (Done)

- Showing the process of how minerals are obtained from rock, then made into useful everyday materials was very well done. It was interesting to students to show some of the equipment used or steps done to process the materials.
- Donut Connection – always helpful to show something students are interested in (food☺) and how minerals affect our lives. I especially liked how you made an additional connection with their classroom desks to check for understanding – transferred learning.
- Pictures in the PPT were *very helpful* – especially the size of the mines and steps in the mineral gathering process.
- Very helpful to have actual minerals to show the students (your extensive collection).
- Length of presentation was just right☺!
- It was great to have time at the end of the presentation for questions and discussion.

Points to Possibly Clarify:

- At this age level, it might be helpful to explain the difference between Open Pits and Underground mines. I realize you don't necessarily want to get into the environmental issues involved in mining, but to briefly mention it along with weighing the positives/negatives of it might be worthwhile.
- This is a bit more in depth than what most 3rd graders can wrap their heads around but it is good for students who are ready for more than what our grade level expectations are. It was a good (and brief) overview of minerals and how we use them as a whole. Well done!

Thank you again for coming into our classroom to share your knowledge of minerals. It really makes a difference when students can see how what they are learning applies to the real world!

Comment: Teachers are encouraged to expand the message or add other viewpoints, e.g. environmental issues as appropriate. The primary objective of the presentation is to get students to understand that directly or indirectly everything depends on Minerals and Mining. (back to List)

Tips:

Be sure to point out the "tiny" load truck in the bottom right hand corner of the open pit copper mine slide. Then move on to the actual size on the next slide. The kids got quite a kick out of seeing how huge these vehicles are.

Spend some time on the donut for breakfast slide emphasizing that there are no rocks in donuts then go through the following slides to show the mineral connection for processing and transportation.

Ask the students to identify something in the room then discuss how it couldn't be there without minerals.

In the first class a wooden table was considered and the students were able to identify harvesting equipment, transportation to the saw mill, saw mill machinery, cabinet making machinery, sandpaper, screws and nails etc. (back to List)