EBS 425 – MINERAL PERINDUSTRIAN

What are industrial minerals?

Industrial minerals, as used here, are non-fossil fuel rocks, minerals, and sediments that have an industrial use. We subdivide them into two broad groups, bulk rocks, and ore minerals. Bulk rocks are those that are used as aggregate, or for the production of lime, ceramics, Portland cement, or as a product used in coal-fired electricity-generating plants for the removal of sulphur. These bulk rocks or sediments include limestone, dolostone, clay, shale, sandstone, sand, and gravel. The ore minerals are mineral concentrations found in veins or in uncommon sedimentary rocks. Ore minerals that have been produced in Malaysia include calcite, barite, feldspar-bearing pegmatite, casseterite (tin), titanium oxide (ilmenite and rutile), , and various iron minerals (hematite). Other mineral occurrences, such as REE rich tailing sands (xenotime and zircon), may have commercial potential.

Other definition of industrial minerals is Nonmetallic materials/ minerals necessary to industry, such as salts, fertilizer components, sulfur, asbestos, abrasive minerals, and so forth.

Other thought, Industrial minerals are include all non-metallic and non-fuel minerals. This group includes gemstones and excludes construction aggregates (structural materials). They comprise rocks, minerals and other naturally occurring substances or mineral waste streams, of economic value.

Without a market, a deposit is merely a geologic curiosity ……

Peter Harben

INDUSTRIAL MINERALS CATAGORIES

UNTREATED ROCK PRODUCTS

Building stone

Cut (dimension) stone

Ashlar

Monumental stone

Flagstone

Roofing Slate

Terrazzo

Some commonly used rocks
Granite (includes “black granite”=gabbro, larvikite
Sandstone
Limestone

Marble (recrystallized and metamorphosed limestones)
Serpentinite
Slate

Crushed rock
Used for construction, aggregate
Hard, inert not reactive with cement – maninly limestone, granite, traprock(volcanic lavas), sandstone

Sand and Gravel
Aggregate. Alluvial fans, glacial deposts, occasionally beaches. Some submarine deposits

TREATED ROCK PRODUCTS

Cement

Mortar – mixed with sand to produce binding agent for masonry
Concrete – mixed with sand and gravel – a kind of artificial rock.

Original made by Romans by calcining limestone ($CaCO_3$) to make lime(CaO), mixed with volcanic ash and water

Modern cement – Portland Cement - Limestone and clay ground together and then heated to 1500^0C to produce clinker. Clinker then crushed and mixed with some gypsum ($CaSO_4$. $2H_2O$)

Plaster

Calcining gypsum – water driven off to form plaster of Paris ($CaSO_4$. $0.5H_2O$). Mixed with water for use, rehydrates to gypsum. Glue and starch can be added to reduce setting time.

Gypsum widely distributed in Malaysia – largest producer and consumer.

Brick and ceramics

Produced from clays (silicates). Plastic when wet so can be moulded. When fired, water given off and mixture partially melts and fuses

China clay (kaolinite) - fine porcelain also filler for paper

Ball clay (mainly kaolinite) –electrical insulators

Glass

Made from silica sand mixed with Soda (Na2O from sodium carbonate or sodium nitrate or rock salt) to reduce melting temperature. Calcium (limestone) and alumina (Al_2O_3)added to improve chemical stability.

OTHER INDUSTRIAL MINERALS

Asbestos

Group of minerals that form fibrous masses: Chrysotile, crocidolite, amosite, anthophyllite, tremolite, actinolite. Can be spun, woven or embedded in other materials. Heat resistant, electrical insulators and high tensile strength

Brake linings, clutch plates, cement products

Found in altered ultramafic rocks – opiolite complexes

Safe when firmly encapsulated in matrix material. Dangerous when in air. Latter can occur when materials get old and break down.

Abrasives

Diamond, garnet, corundum

GEMSTONES

INTRODUCTION TO NON-FUEL MINERAL RESOURCES

Mineral resources can be considered "stock" rather than renewable, but the amount available and the amount used in the future are still wrapped in serious uncertainties that make predictions about their depletion (whether dire or not) less than reliable. Even then several analysts were skeptical of rapid depletion claims.

There are several subtleties to be considered here.

- First, **"Reserves"** means different things. The text uses this definition: "mineral sources currently identified and profitable or at least minimally profitable to extract with existing technologies."
- **Resources** are "reserves" plus: (1) known mineral sources that are "sub-economic" (not profitable to extract with current technology), and "hypothetical" sources, based on expert opinion and extrapolation of geological knowledge of known and potential minerals around the world. Simply put, we have not yet looked everywhere, and we cannot easily estimate the economic or social constraints on development of resource snot currently extracted. For example, enhanced recovery technologies might let us get more tin, say, out of exiting ore bodies (tin ore) in Tapah, Perak than we can at the present. But, we may also find it difficult socially or politically to get more copper out of Tapah, Perak (say if nearby residents protect expanding of a mine, or say out of the Peru or any other country with known deposits.

Next, it is difficult to project future demand, estimated lifetimes of mineral reserves (depletion rates). Mineral reserve and demand estimation often based on current rates of use, trend and nature of application for a period of time by assuming global population and rate of consumes today in a specific country.

This is an extreme scenario, and unlikely. Among the uncertainties:

How big a human population will there be in the future?

? How much will they consume (e.g., at what rate, which depends on their affluence; can everyone achieve consumption rates of the current, middle-class industrial nation citizen?).

? What technologies might make consumption more or less efficient?

? Might increasing price cause substitutes, conservation, and recycling to kick in somewhere down the depletion curve?

The mineral resource production and use cycle: Source to Sink

The process diagram is pretty simple and self-explanatory, so let's focus again on problems and uncertainties. Key problems mentioned in the text are:

? Externalities: the cost of production and ultimate disposal may not be fully reflected in market costs and prices. There may be significant externalities if, for example, the public is left to clean up after a mining company finishes use of an ore body. The example I used in class is Summitville gold mine near Alamosa, CO (USA). developed by the transnational firm that went bankrupt and left the clean-up to government. In this case the costs are paid by state and federal government, some from a fund extracted from companies ("Super Fund") and some from general tax revenues (our tax charge).

? Geo-political uncertainties: Some mineral resources may become less or more accessible due to geo-political changes. Harper notes that most industrial countries are not self-sufficient in many key mineral resources (e.g., they must import them, from less developed countries) and thus their supply is subject to geo-political changes and tensions.

? Problems of the "extractive economies": one of the political-economic issues harks back to our discussion of globalization. World Systems and Dependency theory both would posit that industrial countries have a vested interest in maintaining access to cheap mineral extraction from developing countries. But suppliers of raw materials (in almost all types, from the minerals we are discussing now to agricultural products, though maybe not most energy resources) find themselves receiving less and less return per unit of extracted resource. The "value added" and larger economic returns come not from producing the raw resource, but from processing it into industrial and consumer products and selling those products. This problem of "extractive economies" even applies to some areas of the US which produce raw resources, like the mining areas of the Rockies or the agricultural regions of the Great Plains—they receive only limited economic returns compared to processors further up the chain of production and consumption, and thus suffer depressed economies.

EXAMPLES OF INDUSTRIAL MINERALS AND ROCKS

Definitions (adapted from AGI's, "Glossary of Geology")

Rock : Any naturally formed material composed of one or more minerals having some degree of chemical and mineralogic constancy.

Mineral: A naturally formed chemical element or compound having a definite chemical composition and, usually, a characteristic crystal form.

Sediment: Solid fragmental material, or a mass of such material, that originates from weathering of rocks and is transported by, suspended in, or deposited by air, water, or ice, or that is accumulated by other natural agents, such as chemical precipitation from solution or secretion by organisms, and that forms in layers on the Earth's (or other planet's) surface in a loose, unconsolidated form; e.g., sand, gravel, silt, mud.

Limestone: A sedimentary rock consisting chiefly of the chemical calcium carbonate, primarily in the form of the mineral calcite (more rarely, aragonite).

Dolostone: A carbonate sedimentary rock consisting chiefly of the chemical calcium-magnesium carbonate, primarily in the form of the mineral dolomite, or approximating the mineral dolomite in composition, or a variety of limestone or marble rich in magnesium carbonate.

Clay: (a) A rock or mineral fragment or a detrital particle of any composition (often a crystalline fragment of a clay mineral), smaller than a very fine silt grain, having a diameter less than 1/256 mm. (b) A loose, earthy, extremely fine-grained, natural sediment or soft rock composed primarily of clay-size or colloidal particles and containing a considerable amount of clay minerals (hydrous aluminum silicates).

Shale: A fine-grained, indurated, sedimentary rock formed by the consolidation of clay, silt, or mud, and characterized by very thin layers, and by a composition with an appreciable content of clay minerals, and commonly with a high content of quartz sediment.

Sandstone: A medium-grained sedimentary rock composed of abundant fragments of sand size, more or less firmly united by a cementing agent; the consolidated equivalent of sand, intermediate in texture between conglomerate and shale.

Sand: (a) A rock fragment or particle smaller than a granule and larger than a coarse silt grain, having a diameter in the range of 1/16 to 2 mm. (b) A loose aggregate of unconsolidated mineral or rock particles of sand size.

Gravel: An unconsolidated, natural accumulation of rock fragments resulting from erosion, consisting predominantly of particles larger than sand (diameter greater than 2 mm), such as boulders, cobbles, pebbles, granules, or any combination of these.

Calcite: The most common crystalline or mineral form of calcium carbonate; a common rock-forming mineral.

Barite: The crystalline or mineral form of barium sulphate.

Gypsum: A widely, distributed mineral consisting of hydrous calcium sulphate; it is the most common sulphate mineral.

Fluorspar (fluorite): The crystalline or mineral form of calcium fluoride.

Sphalerite: A crystalline or mineral form of zinc-iron sulphide.

Galena: A crystalline or mineral form of lead sulphide.

Saltpeter: Naturally occurring potassium nitrate.

USES

Limestone: Limestone is used as construction aggregate, for building stones, and for agricultural uses. Limestones of high chemical quality are used as sulfur sorbents to control acid mine drainage. Limestones with low silica content are used as rock dust in underground coal mines. Lime, which is a derivative product of limestone, is used as a sulfur sorbent in utility and power plant flue-gas desulfurization.

Clay: The chemical quality of a particular clay determines its use. Clays are used in the manufacture of bricks, tile, chinaware, kitty litter, and other absorptive products, and as fillers and extenders. Malaysia has several plants that produce brick and clay tiles. Bentonitic clays are used as oil drilling fluids or in other products in which their expansive properties are desired for water sealing or retention.

Sand and gravel: Sand and gravel are used as construction aggregates, and silica sands are used in various glasswares.

Others: Iron and titanium are used in steel, and phosphates for fertilizer. Fluorite is the source of fluorine, which is used mainly as flux in the making of steel and for the preparation of hydrofluoric acid. Barite is used as a drilling fluid in oil fields, galena is a source of lead, and the zinc in sphalerite is used as a galvanizing agent.

Mineralogy

The vein minerals consist of fluorite, barite/celestite, sphalerite, galena, calcite, and secondary alteration/oxidation minerals such as smithsonite, hemimorphite, cerussite, anglesite, pyromorphite, gypsum, and anhydrite. Hematite, limonite, and goethite are the dominant minerals found in iron ore.

Rutile and ilmenite are titanium minerals, and a cryptocrystalline variety of apatite is an example of a phosphate.

The igneous rocks occurring which is called peridotites, often consist of minerals such as olivene, garnet, magnetite, ilmenite, and chromite. Other kind of peridotite is a special type of igneous rock called kimberlite, which is the type of rock in which diamonds occur.

Uses

Iron ore was used for various steel products. Titanium can be used as a high-strength alloy in aircraft and ship building. Phosphates are used as fertilizer. Vein minerals such as fluorite and barite are used in the steel and oil-field industries, respectively. Sphalerite and galena are metallic minerals used in automobiles, electronics, and radiation protection.

INDUSTRIAL MINERAL AND APPLICATIONS

CONSTRUCTION		
END USER INDUSTRY	**PRODUCT/ FUNCTION**	**MINERALS**
Building materials	Aggregate	Crushed granite, gabbro, basalt, diorite, syenite, dolomite, limestone, coral, shell, chert, sandstone, greywacke, quartzite Sand & gravel
	Brickmaking	Clay (common) Manganese Silica
	Lightweight aggregate	Clay (expanded) Perlite Pumice Shale (expanded) Vermiculite
	Dimension stone	Granite Marble Slate Limestone Travertine Sandstone
Cement	Basic ingredient	Limestone
	Additives	Bauxite & alumina Clay (common) Gypsum Iron oxide Pumice Silica sand Vermiculite
Insulation materials	Insulator	Asbestos Diatomite Perlite Pumice Vermiculite Wollastonite Zeolites
Wallboard & plaster	Basic ingredient	Gypsum
	Additives	Asbestos Lime Mica Vermiculite
METALLURGICAL PROCESSING & MANUFACTURING		
END USER INDUSTRY	**PRODUCT/ FUNCTION**	**MINERALS**
Raw material feedstock & alloying agents	Feedstock	Antimony oxide Beryllium Bauxite Chromite Iron oxide Manganese Silica/quartz Sulfur Titanium minerals (ilmenite/rutile) Zircon
Refractories	Refractories	Asbestos Bauxite & alumina Chromite Clays (refractory clays) Dolomite Graphite Kyanite Magnesite & magnesia Olivine Pyrophyllite Silica/quartz

		Zircon
Foundry products	Binder	Bentonite
	Foundry sand	Chromite Olivine Pyrophyllite Silica sand Zircon
	Heat control	Graphite Perlite Vermiculite
	Investment casting	Bauxite & alumina Clays (kaolin) Graphite Silica sand Zircon
Fluxes (soldering, welding, & smelting)	Fluxing agent	Borates Dolomite Fluorspar Limestone & lime Magnesite & magnesia Silica sand Titanium minerals (ilmenite, rutile) Wollastonite
Abrasives	Abrasive	Bauxite & alumina fused alumina) Corundum/emery Diamonds Diatomite Feldspar Garnet Iron oxide (magnetite) Nepheline syenite Olivine Perlite Pumice Silica (sand tripoli and silicon carbide) Titanium minerals (ilmenite)
Lubricants	Lubricant	Graphite Lithium Mica Talc
Friction materials	Friction material	Asbestos Bauxite & alumina Clays (attapulgite, sepiolite) Garnet Graphite Pyrophyllite Wollastonite Zircon
	Fillers	Barite Clay (kaolin) Gypsum Pumice Mica Silica Slate Zircon
Gems & jewelry	Feedstock	Bauxite & alumina Diamonds Garnet Iron oxide Rare earths Zircon
CHEMICALS		
END USER INDUSTRY	**PRODUCT/ FUNCTION**	**MINERALS**
Chemical manufacture	Feedstock	Antimony oxide Barite Bauxite & alumina Borates Bromine Celestite Chromite Dolomite Fluorspar Iodine Iron oxide Limestone Lithium minerals Magnesite Manganese Nitrates

		Phosphates Potash Rare earths Salt Silica/quartz Soda ash Sodium sulfate Sulfur Titanium minerals (ilmenite, rutile) Zircon
Explosives/pyrotechnics	Feedstock	Bauxite & alumina (aluminum chemicals) Celestite Limestone Nitrates Potash (potassium chemicals) Salt (sodium chemicals)
Dyes	Feedstock	Bauxite & alumina (alum) Borates Chromite Iodine Iron oxides Manganese Soda ash Sodium sulfate Sulfur
Fire retardants/wood preservatives	Feedstock	Bauxite & alumina (alumina trihydrate) Antimony oxide Asbestos Borates Bromine Chromite Diatomite Magnesite & magnesia Perlite Phosphates Pumice Vermiculite
Catalysts	Feedstock	Clays (kaolin, attapulgite) Iodine Lithium Pyrophyllite Rare earths Titanium minerals Zeolites, Zircon
Cleansers & detergents	Feedstock	Borates Phosphates Silica (sodium silicate) Soda ash Sodium sulfate Zeolites
HUMAN CONSUMPTION		
END USER INDUSTRY	**PRODUCT / FUNCTION**	**MINERALS**
Pharmaceuticals & drugs	Excipient	Clays (attapulgite, bentonite, kaolin, sepiolite) Dolomite Gypsum Iron oxide Limestone (calcium carbonate) Mica Talc Titanium minerals (TiO_2)
	Active minerals	Barite Bauxite & alumina (aluminum salts) Borates Bromine Iodine Limestone (calcium carbonate) Magnesite & magnesia Manganese Phosphates Salt Soda ash Sodium sulfate Sulfur
Cosmetics	Raw materials	Borates Bromine Clays (bentonite, kaolin) Gypsum

		Limestone (calcium carbonate) Magnesite & magnesia Mica Silica (flour, precipitated) Talc Titanium minerals (TiO2)
Food	Filler/pigments	Clays (bentonite and kaolin) Gypsum Limestone (calcium carbonate) Magnesite & magnesia Sulfur Talc Titanium minerals Zeolites
	Processing & refining	Clays (activated bentonite) Diatomite Fluorspar Perlite Nitrates Phosphates Potash Salt
FERTILIZER & AGRICULTURAL		
END USER INDUSTRY	**PRODUCT/ FUNCTION**	**MINERALS**
Fertilizer	Primary nutrients	Phosphates Potash Nitrates
	Secondary/ micronutrients	Borates Bromine Dolomite Gypsum Limestone Magnesite Manganese Salt Sodium sulfate Sulfur
Fertilizers, herbicides, and insecticides	Carriers	Clays (attapulgite, bentonite, kaolin, sepiolite) Diatomite Pyrophyllite Talc Zeolites
Soil amendments	Additives	Clays (bentonite/kaolin) Diatomite Gypsum Perlite Vermiculite Zeolites
Animal feed	Nutritional minerals	Dolomite Gypsum Iodine Iron oxide Limestone Magnesite Manganese Phosphates Salt Sulfur
	Carrier/digestive enhancer	Clays (bentonite, sepiolite) Perlite Talc Vermiculite Zeolites
GLASS & CERAMICS		
END USER INDUSTRY	**PRODUCT/ FUNCTION**	**MINERALS**
Glass	Batch raw materials	Borates Kaolin Feldspar/Aplite Limestone Nepheline syenite Silica/quartz Soda ash

		Sodium sulfate
Ceramic	Batch raw materials	Kaolin Feldspar/Aplite Limestone (calcium carbonate) Nepheline syenite Pyrophyllite Silica/quartz Soda ash Sodium sulfate Talc Wollastonite
Specialty additives including frits, glazes, enamels	Additives	Antimony oxide Barite Bauxite & alumina Beryllium Borates Celestite Dolomite Fluorspar Iron oxide Lithium minerals Magnesite Manganese Potash Rare earths Titanium minerals Zircon
Aerospace, optical glass & electronics	Raw materials	Bauxite & alumina Beryllium Borates Celestite Diamonds Graphite Rare earths Silica/Quartz Titanium minerals (rutile) Zircon
FILLERS, EXTENDERS, PIGMENTS		
END USER INDUSTRY	**PRODUCT/ FUNCTION**	**MINERALS**
Paper	Process chemicals	Bauxite & alumina (alum) Soda ash Sodium sulfate Sulfur
	Functional fillers	Barite Clays (kaolin, bentonite) Diatomite Gypsum Limestone (calcium carbonate) Silica/quartz Talc Zeolites
	Pigments	Titanium minerals (TiO_2)
Plastics	Functional fillers	Barite Bauxite & alumina (alumina trihydrate) Clays (kaolin) Diatomite Gypsum Feldspar Limestone (calcium carbonate) Mica Nepheline syenite Silica/quartz Talc Zeolites
	Pigments	Iron oxide Titanium minerals (TiO_2)
Paint, putty, caulk	Functional fillers	Barite Bauxite & alumina (alumina trihydrate) Clays (kaolin bentonite) Diatomite Gypsum Feldspar Limestone (calcium carbonate) Mica

		Nepheline syenite Pyrophyllite Silica/quartz Talc Zeolites
	Pigments	Iron oxide Titanium minerals (TiO_2)
Sealants & adhesives	Cement	Silica/quartz (sodium silicate) Sulfur Gypsum Limestone (calcium carbonate) Magnesite & magnesia
	Functional fillers (a.k.a. pigment)	Antimony oxide Asbestos Barite Bauxite & alumina (aluminum trihydrate) Clays (kaolin, bentonite) Diatomite Dolomite Limestone (calcium carbonate) Mica Pyrophyllite Silica/quartz (flour, precipitated, fumed) Slate (powder) Talc Vermiculite Wollastonite
	Pigment	Titanium minerals (TiO_2)
ENVIRONMENTAL, WATER TREATMENT, FILTRATION		
END USER INDUSTRY	**PRODUCT/ FUNCTION**	**MINERALS**
Waste & effluent treatment	Chemical additives	Bauxite & alumina (aluminum chemicals) Bentonite Dolomite Graphite (activated charcoal) Gypsum Iodine Limestone & lime Magnesite & magnesia Manganese Soda ash Sodium sulfate Sulfur Zeolites
	Filter media	Asbestos Diatomite Garnet Iron oxide (magnetite) Perlite Pumice Silica sand Titanium minerals (ilmenite)
	FGD	Dolomite Limestone & lime Magnesite & magnesia Soda ash Sodium sulfate Zeolites
Absorbents	Cat litter	Clays (attapulgite, bentonite, sepiolite) Diatomite (Moler) Gypsum
	Other	Clays (attapulgite, bentonite, kaolin, sepiolite) Diatomite (Moler) Gypsum Pyrophyllite Talc Zeolites

ENERGY		
END USER INDUSTRY	**PRODUCT / FUNCTION**	**MINERALS**
Oil and gas	Drilling muds	Asbestos Barite Bauxite & alumina Bromine Clays (attapulgite, bentonite, hectorite, sepiolite) Diamonds Diatomite Garnet Graphite Gypsum Limestone & lime Magnesite & magnesia Mica Salt Soda ash Titanium minerals (ilmenite) Vermiculite
	Refining & additives	Bauxite & alumina Bromine Clays (attapulgite) Diatomite Graphite Iodine Lithium minerals Pyrophyllite Rare earths Sulfur Talc Titanium minerals Zeolites
Batteries		Antimony oxide Graphite Lithium Manganese Rare earths Salt (chloralkalis) Sulfur
Nuclear		Graphite Rare earths Titanium minerals Zeolites Zircon