Lecture 1: Introduction to Mining Geology

- Mining geology study is a specialized area of applied geological sciences that historically evolved as a support for operating mines and for evaluating mining projects.
- The main objective of mining geology is to provide detailed geological information, and undertake technical and economic studies to evaluate a mining project.
- Modern mining geology represents an interface between different disciplines, including structural geology, petrography, stratigraphy, geochemistry, mining geophysics, sampling theory, mathematical statistics, geostatistics, mining engineering, rock mechanics, mineral economics and computer sciences.
- The main goal of this course is to be a practical manual for geologists working at the mines or studying and developing mining projects therefore the course gives a fundamental information about mining kinds and a description of the various techniques and practical recommendations of effectively using them.

Basic Terminology

Mine: an excavation made in the earth to extract minerals.

Mining: It is the process of extracting metal and mineral ores from the Earth.

Mining Geology: the practice of applying engineering principles to the development, planning, operation, closure, and reclamation of mines

Economic geology involves the theories of formation, the physical and chemical characteristics, and environments favorable for formation, and different methods and techniques for discovery of potentially economic mineral deposits. It involves a familiarization with mining and metallurgical technology, and the economics of the mineral industries.

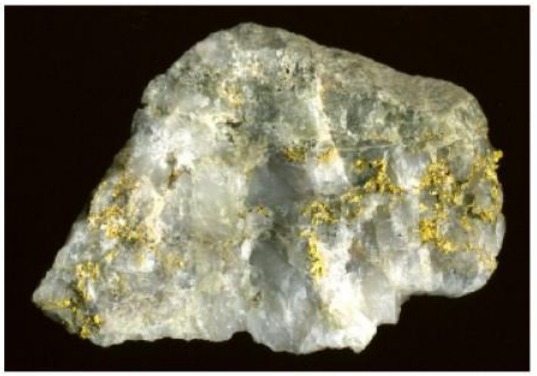
Basic Terminology

Ore: a mineral deposit that has sufficient utility and value to be mined at a PROFIT. (A distinction must be made between **Ore** and **Ore-minerals**. A deposit of ore minerals in geological terms is not always an ore deposit.)

Gangue: the valueless mineral particles within an ore deposit that must be discarded.

Waste: the material associated with an ore deposit that must be mined to get at the ore and must then be discarded. Gangue is a particular type of waste.

Cut-Off: Many factors: cost of mining and metallurgical treatment, percentage of recovery of metal values during treatment, deleterious elements present, cost of transport and marketing, metal or mineral pricing, taxes and royalties, etc. all influence the ore/waste transition. The transition from ore to waste is known as the **CUT-OFF**.



Basic Terminology

Metallic ores: those ores of the ferrous metals (iron, manganese, molybdenum, and tungsten), the base metals (copper, lead, zinc, and tin),the precious metals (gold, silver, the platinum group metals),and the radioactive minerals (uranium, thorium, and radium).

Nonmetallic minerals (also known as industrial minerals): the nonfuel mineral ores that are not associated with the production of metals. These include phosphate, potash, halite, trona, sand, gravel, limestone, sulfur, and many others.

Fossil fuels (also known as mineral fuels): the organic mineral substances that can be utilized as fuels, such as coal, petroleum, natural gas, coalbed methane, gilsonite, and tar sands. It should be noted that the mining engineer is associated with the extraction of nearly all these mineral resources. In addition to the production of oil and gas

Common Ore & Gangue Minerals

COMMON ORE MINERALS

Metal	Ore Mineral	Composition	Percent Metal
Gold	Native gold	Au	100
	Calaverite	$AuTe_2$	39
	Sylvanite	$(Au,Ag)Te_2$	
Silver	Native Silver	Ag	100
	Argentite	Ag_2S	87
	Cerargyrite	$AgCl$	75
Iron	Magnetite	$FeO \cdot Fe_2O_3$	72
	Hematite	Fe_2O_3	70
	Limonite	$Fe_2O_3 \cdot H_2O$	60
	Siderite	$FeCO_3$	48
Copper	Native copper	Cu	100
	Bornite	Cu_5FeS_4	63
	Brochantite	$CuSO_4 \cdot 3Cu(OH)_2$	62
	Chalcocite	Cu_2S	80
	Chalcopyrite	$CuFeS_2$	34
	Covellite	CuS	66
	Cuprite	Cu_2O	89
	Enargite	$3Cu_2S \cdot As_2S_5$	48
	Malachite	$CuCO_3 \cdot Cu(OH)_2$	57
	Azurite	$2CuCO_3 \cdot 2H_2O$	55
	Chrysocolla	$CuSiO_3 \cdot 2H_2O$	36
Lead	Galena	Pbs	86
	Cerussite	$PbCO_3$	77
	Anglesite	$PbSO_4$	68
Zinc	Sphalerite	ZnS	67
	Smithsonite	$ZnCO_3$	52
	Calamine	$H_2Zn_2SiO_5$	54
	Zincite	ZnO	80
Tin	Cassiterite	SnO_2	78
	Stannite	$Cu_2S \cdot FeS \cdot SnS_2$	27
Nickel	Pentlandite	$(Fe,Ni)S$	22
	Garnierite	$H_2(Ni,Mg)SiO_3 \cdot H_2O$	
Chromium	Chromite	$FeO \cdot Cr_2O_3$	68
Manganese	Pyrolusite	MnO_2	63
	Psilomelane	$Mn_2O_3 \cdot xH_2O$	45
	Braunite	$3Mn_2O_3 \cdot MnSiO_3$	69
	Manganite	$Mn_2O_3 \cdot H_2O$	62
Aluminum	Bauxite	$Al_2O_3 \cdot 2H_2O$	39
Antimony	Stibnite	Sb_2S_3	71
Bismuth	Bismuthinite	Bi_2S_3	81
Cobalt	Smaltite	$CoAs_2$	28
	Cobaltite	$CoAsS$	35
Mercury	Cinnabar	HgS	86
Molybdenum	Molybdenite	MoS_2	60
	Wulfenite	$PbMoO_4$	39
Tungsten	Wolframite	$(Fe,Mn)WO_4$	76

COMMON GANGUE MATERIALS

Class	Name	Composition
Oxides	Quartz	SiO_2
	Other silica	SiO_2
	Bauxite, etc	$Al_2O_3 \cdot 2H_2O$
	Limonite	$Fe_2O_3 \cdot H_2O$
Carbonates	Calcite	$CaCO_3$
	Dolomite	$(Ca,Mg)CO_3$
	Siderite	$FeCO_3$
	Rhodochrosite	$MnCO_3$
Sulfates	Barite	$BaSO_4$
	Gypsum	$CaSO_4 + 2H_2O$
Silicates	Feldspar	
	Garnet	
	Rhodonite	$MnSiO_3$
	Chlorite	
	Clay minerals	
Miscellaneous	Rock matter (sic)	
	Fluorite	CaF_2
	Apatite	$(CaF)Ca_4(PO_4)_3$
	Pyrite	FeS_2
	Marcasite	FeS_2
	Pyrrhotite	Fe_7S_8
	Arsenopyrite	FeAsS

Source of Data: January 1961, *Field Manual for Mineral Engineers*, U.S. Dept. of the Interior, Bureau of Land Management

Check this: https://www.mineralminers.com/

Grouping of Minerals according to Established Classification Systems

GROUPING OF MINERALS ACCORDING TO ESTABLISHED CLASSIFICATION SYSTEMS

A. Industrial Classification of Metals

1. Ferrous Metals

Iron

2. Ferro-alloy Metals
(sometimes included in the ferrous classification)

Manganese
Chromium
Nickel
Molybdenum
Cobalt
Tungsten
Vanadium
Columbium

3. Light Metals

Aluminum
Magnesium
Titanium
Zirconium

4. Non-Ferrous Base Metals

Copper
Lead
Zinc
Tin
Antimony
Cadium
Bismuth

5. Nuclear Elements

Uranium
Thorium
*Beryllium

6. Precious Metals

Gold
Silver
Platinum

B. Non-Metallic Minerals (also termed industrial minerals and rocks)

Potash
Sodium Carbonate (Trona)
Sodium Sulfate
Salt
Borax and Borates
Gypsum
Lithium minerals
Strontium minerals
Barite
Phosphate
Flourite
Limestone
Dolomite
Magnesite
Chalk
Diatomite
Clay
Sandstone, Quartzite
Shale
Bentonite
Perlite
Graphite
Mica
Asbestos
Talc and Soapstone
Vermiculite
Pyrophyllite
Slate
Sillimanite Group (topaz, kyanite, andalusite, sillimanite, dumortierite)
Garnet
Crushed Stone
Sand and Gravel
Dimension Stone
Sulfur
Diamonds
Bauxite

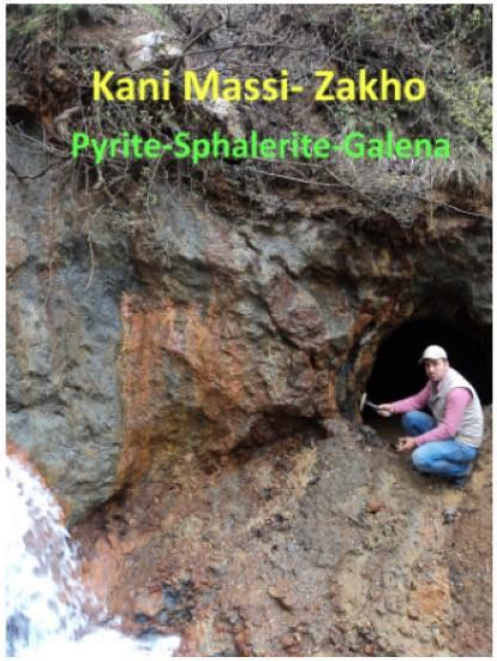
*Beryllium is also a common ferrous and non-ferrous alloying metal.

Types of Ore Deposit

There are several types of ore deposits:

- Magmatic: crystallization of minerals within a body. of magma
- Hydrothermal: hot fluids released as magma cools, minerals precipitate from fluids.
- Sedimentary: precipitation of minerals from a lake or ocean water
- Placer deposits: deposition of metals in a river or stream (causing people to pan for them).
- Residual: concentrations of minerals produced by weathering and chemical reactions with oxygen and water.

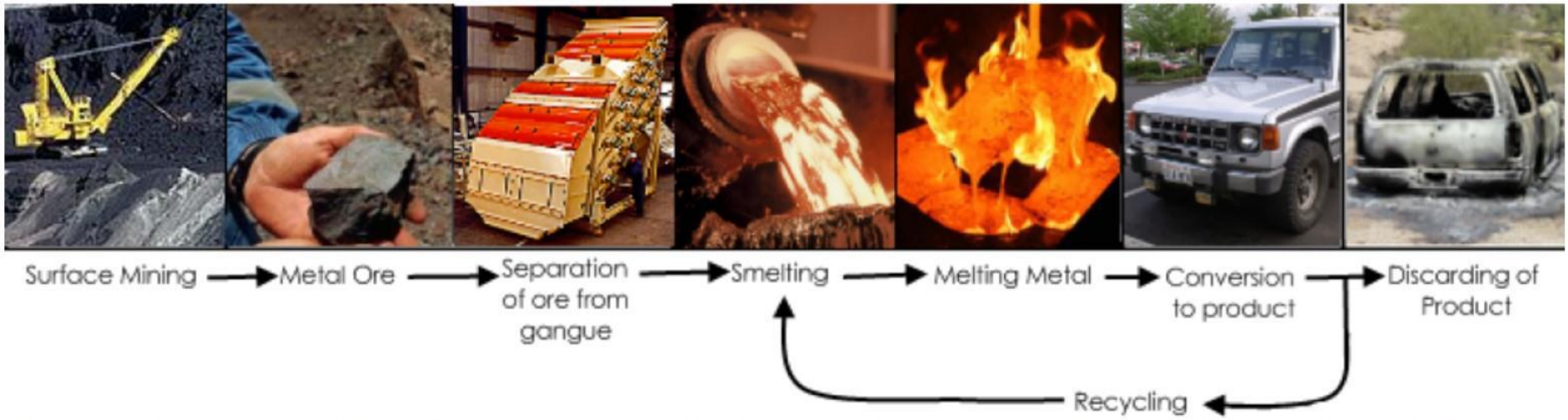
This is a very broad classification. There are many sub-types and even more types -nature provides much complexity.



Hydrothermal Ore deposit
Kurdistan- Iraq

Life Cycle of a Metal Resource

A metal resource goes through a life cycle all its own, though whether it lasts long or is cut short is entirely up to the consumer. I have constructed a helpful diagram of this cycle



The earth is mined for its resources, which are extracted and separated into usable and unusable components. These usable components are melted down and shaped into the products that people buy, and from there are either recycled or disposed.