

Mineral Resources

Knowing something about the distribution of the earth's elements, and the geological processes which can produce useful concentrations of minerals, geologists can focus their search for these valuable substances. To give the layman an idea of how important minerals are, consider that 35 chemical elements are required to manufacture your car, 66 elements are needed to make a telephone, and about 40 elements to make a average house.

1. Reserves vs. Resources
 - a. Reserves
 - i. Natural resources that have been discovered & can be exploited profitably with existing technology
 - ii. Oil – 700 billion barrels
 - b. Resources
 - i. Deposits that we know or believe to exist, but that are not exploitable today because of technological, economical, or political reasons
 - ii. Oil – 2 trillion barrels
2. Geochemically Abundant Elements (GAE)
 - a. Elements comprise > 0.1% (by weight) of the crust
 - b. Form as principal component in minerals within common rocks – i.e. iron (Fe) Fe_2O_3
 - c. Form very large deposits
 - d. Form rock deposits
3. Geochemically Scarce Elements (GSE)
 - a. Elements that comprise < 0.1% (by weight) of the crust
 - b. Do not form as principal component in minerals within common rocks, usually occur as a substitute in rock forming minerals
 - c. Form small deposits
 - d. Ore minerals include sulfides, native elements, etc.
4. Mineral Deposits
 - a. Elements need to be concentrated in order to be mined
 - b. Minimum Grade - minimum amount of element necessary to economically mine element
 - c. Minimum Concentration Factor (MCF) – Minimum Grade divided by the Crustal Abundance
 - i. GAE have $\text{MCF} < 100$
 - ii. GSE have $\text{MCF} > 100$
5. Process that concentrate elements
 - a. Igneous Processes
 - i. Hydrothermal Processes
 1. Precipitation of metallic ions from hot, ion-rich fluid
 2. Fluid could be
 - a. Magmatic
 - b. Groundwater
 - c. Oceanic water
 3. Magmas heat up the water

4. Water flows into fractures, faults, joints, etc. where it cools and precipitates (deposits) the metals
 - ii. Magmatic Processes
 1. Gravity Settling
 - a. Dense, early-crystallizing minerals sink to the bottom of the magma chamber
 2. Filter Pressing
 - a. Tectonic force compress a magma chamber and force the still-liquid portion into fractures, creating large crystals
 3. These processes have produced large bodies of iron, chromium, titanium, and nickel
6. Sedimentary Processes
 - a. Clastic
 - i. Weathering of rock also weathers out elements of interest
 - ii. Generally, the elements are heavy and are deposited when a streams competence is low.
 - iii. Placer deposits, i.e. gold
 - b. Chemical Precipitates
 - i. Water with high concentrations of elements is evaporated
 - ii. Evaporation of water leaves the elements
 - iii. Ex. Salts, Iron, etc.
7. Metamorphism
 - a. Alteration of rock concentrates the elements
 - b. The heat and pressure force out the GSE (“impurities”)
8. Weathering
 - a. Chemical weathering removes soluble material.
 - b. Ore material (element of interest) is left behind in a concentrated residue.
9. Groundwater
 - a. Secondary enrichment
 - i. Groundwater dissolves and carries elements in solution
 - ii. Chemical conditions change and the elements are precipitated (deposited) out.
 - iii. Ex. Lead
 - b. Chemical Leaching
 - i. Groundwater dissolves and carries insignificant elements in solution
 - ii. Insoluble elements of interest remain.
 - iii. Ex. Aluminum
10. Ore Mineral
 - a. Ability to separate and readily process the metal (element) from the ore material.
 - b. Need to look at
 - i. The energy to process the material
 - ii. The cost to process the material
 - iii. The value of the metal

c. Basically, is it profitable to mine the metal?