

Resources

- “Resources are like air - of no great importance until you are not getting any”
– Anonymous

<http://wings.buffalo.edu/ubgreen/index.htm>

How do you define Resource ?

- Your textbook defines a resource as the following “In economic terms, anything with potential use in creating wealth or giving satisfaction”
- Murck & Skinner (another intro book) basically define a resource as “useful things that we get from the Earth.” pg. 470

- Resources. The total means available for economic and political development, such as mineral wealth, labor force, and armaments.
- b. The total means available to a company for increasing production or profit, including plant, labor, and raw material; assets.
- c. Such means considered individually

Limited Source ? Potential Profitable ?

–Renewable resource

- “can be replenished over a relatively short time span - days, months, years, decades”

–Non-renewable resource

- “A resource that cannot be replenished on the scale of several human lifetimes”
- the processes that create them are so slow that they can be considered finite

–Renewable resource

- Wind & water power, solar energy, food and natural fibers

–Non-renewable resource

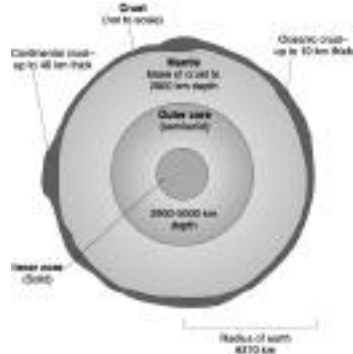
- Fossil fuels, soil, gold, diamonds and other gemstones

Some resources fall into both categories - groundwater, trees ...

- Geologists are usually thought of in conjunction with mineral and fossil fuel resources.



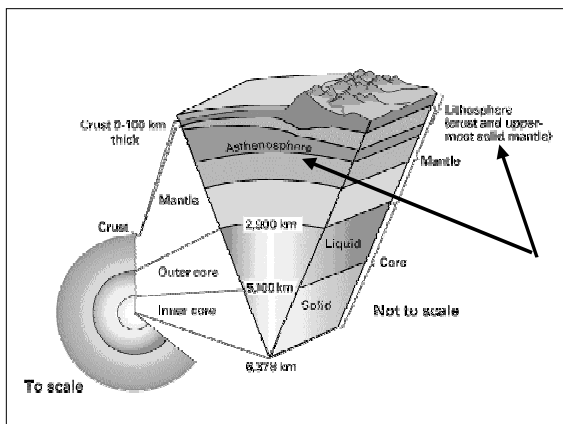
How are resources distributed ?



- Inner core - with a thickness of ~1300km, believed to be composed mostly of iron (~90% by weight) with minor amount of nickel
- Outer core - with a thickness of about 2000km, a highly viscous liquid with a composition similar to that of the inner core
- Average density of the core is 10.7g/cm³

- Mantle - almost 3000km thick, mostly solid with an average density of 4.5 g/cm³. Primarily rich in iron and magnesium silicates
- Mohorovicic discontinuity - the boundary between the crust and the mantle.
- Crust - very silica rich with an average density of only 2.8 g/cm³

- The crust varies greatly in thickness, up to 10 km thick in the ocean basins and up to 40 km thick in the continental plates.
- The near surface Earth is also divided another way -



- The strong, cold, brittle outermost layer of the Earth is called the **lithosphere**. This is the layer that is broken in to mobile “plates” (the crust and uppermost mantle)
- Beneath the lithosphere is the **asthenosphere**, a hot, slowly flowing layer of relative weak rock (mantle rock) on which the “plates” float.

- The lithosphere varies from near 0 km thickness at the mid ocean ridges to ~120 km thick under the old ocean floor
- The lithosphere varies from about 20 to over 400km thick under the continents.

- The distribution of elements within the Earth is dependant on two key factors
 - density of the element (Fe verses O)
 - chemical affinities (which other elements will it readily form compounds with ?)

- This leads to yet another way of dividing up the layers of the Earth - based on their average chemical composition
 - **Siderophile** Elements normally found in combination with iron and nickel (Fe, Ni, Mg). The name derives from the Greek "sideros" (iron) and "philein" (to love).
 - Siderophile Elements, such as Os, Au, Pt, Ni, Co, Pd, and Ir, are Rare Earth Elements
 - Their only terrestrial abundance is in the core of the Earth
 - Their surficial source is mostly extra-terrestrial

- Chalcophile elements having a strong affinity for sulfur (S), and therefore tending to be more abundant in sulfide minerals and ores than in other types of rock. Examples are Zn, Cd, Cr, Mn, Ag, and Se.
- Lithophile (rock loving) Elements: These elements tend to concentrate in silicate (Si) materials (igneous rocks). Some examples are, Na, K, Ca, Mg, and Cl.

- Atmosphile (gas loving) Elements: These tend to be found in our atmosphere such as H, He, C, N and Ar.

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Composition of earth and crust

TABLE 11.1 Eight Most Common Chemical Elements (Percent) in Whole Earth and Crust			
WHOLE EARTH		CRUST	
Iron	33.3	Oxygen	45.2
Oxygen	29.8	Silicon	27.2
Silicon	15.6	Aluminum	8.2
Magnesium	13.9	Iron	5.8
Nickel	2.0	Calcium	5.1
Calcium	1.8	Magnesium	2.8
Aluminum	1.5	Sodium	2.3
Sodium	0.2	Potassium	1.7

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Mineral

- “a naturally occurring, inorganic **solid** with a definite chemical composition and a specific crystal lattice structure.”

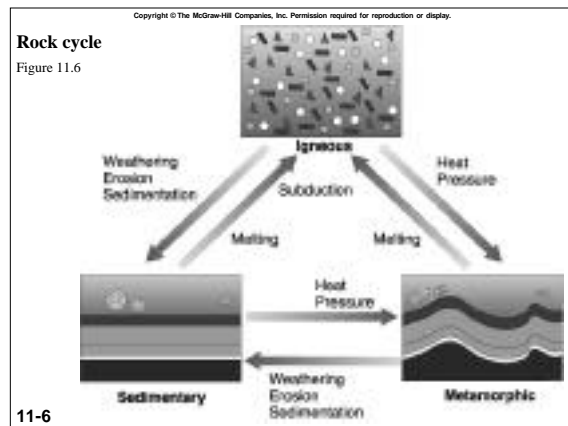
Rock

- your book specifies that a rock is an aggregate of one or more minerals

Ore

- a mineral deposit from which one or more valuable substances can be extracted economically.

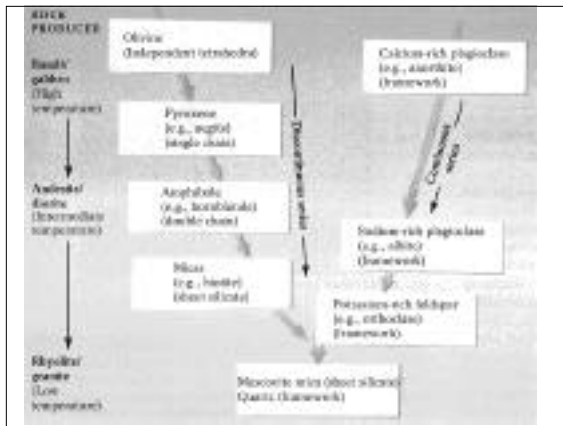
- The origin of most ore deposits is related to fundamental geologic processes
- 4 major groups of processes
 - Igneous
 - Metamorphic
 - Sedimentary
 - Weathering and Groundwater



Igneous Processes

- Magmas have higher concentrations of some elements than most other rocks and depending on the cooling processes affecting the magma, very high concentrations of certain elements can occur.

- Basic transport -
 - diamonds are carried to the surface/near surface by exotic ultramafic volcanic rocks from a source deep in the mantle
- Magmatic Segregation - different minerals cool at different rates and the dense solid grain rain down to the bottom of the magma, accumulating in layers near the base of an igneous body.



- Magmatic Segregation - dependant on cooling rate and chemical composition of the parent magma
 - deposits of chrome, nickel, vanadium, copper and platinum form this way
- Late stage segregation also occurs isolating elements which occur at only a few ppm but do not fit readily into the crystalline structure of the forming minerals.
 - beryllium, lithium, uranium, and tantalum
 - gemstones are also found here (topaz, beryl, tourmaline)

- Hydrothermal deposits - hot solutions which flow through the boundaries of the heated magma carrying away soluble materials and create deposits with much higher concentrations
 - Ex. veins of gold, silver, copper, lead, zinc, molybdenum, and other elements are formed this way.
 - Can also form large deposits of low-grade ore when the fluids flow along the grain boundaries of the cooling plutonic mass.

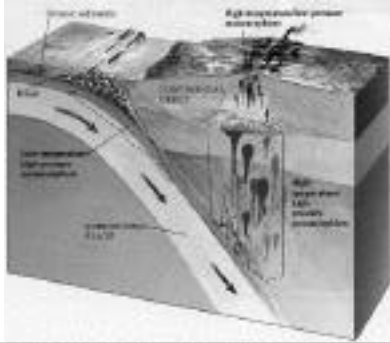
- Porphyry copper - these deposits are formed by hydrothermal activity and currently account for more than 50% of the worlds copper supply.



- Other igneous materials are also mined and used as industrial minerals
 - building stone (granite, diorite, etc.)
 - road aggregate

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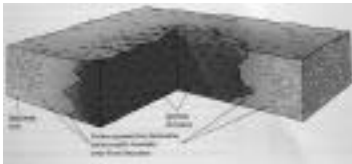
Metamorphic Processes



Metamorphic Processes

- Regional Metamorphism - important deposits of industrial minerals such as asbestos, talc, and graphite, are formed by regional metamorphism
- So is marble and serpentine (used as building materials)
- Corundum (Al_2O_3) and garnet are important abrasives and both are gems (corundum forms rubies and sapphires, and garnet is semi-precious)

- Contact Metamorphism - metamorphism along the contact between an igneous intrusion and the surrounding rocks.
- typically works in association with hydrothermal solutions related to the intrusion to form ore deposits – tungsten, and tin



- Seafloor hydrothermal vents / seafloor metamorphism - hot hydrothermal fluids circulating thru the fractured zones near the MORs leach metals like iron, magnesium, copper, zinc and lead) and sulfur from the crust and carry them to hydrothermal vents where the minerals precipitate out when the water cools, forming mounds of sulfide ores.



Sedimentary Processes

- Concentrations of sand and gravel are mined (largest mining industry not associated with fossil fuels) for construction and glass-making.
- Placer deposits - concentrations of gold, diamonds, silver etc. which are transported by streams - because these minerals are denser than silicate minerals then fall out of the streams where the current is weak.

- Chemical Precipitation
 - banded iron formations (PreCambrian)
 - Evaporates
 - sodium, potassium, and magnesium salts
 - gypsum

Weathering Processes

- concentrate minerals by breaking down chemical bonds
 - bauxites (Aluminum ore) left as a residue
- Soil formation