

ENVIRONMENTAL GEOLOGY- A DYNAMIC PLANET

A Layered Sphere

- Core: interior of the earth, composed of hot metal (mostly iron), solid center, semi fluid outer, 2,900-5,000 km in diameter.
- Mantel: surrounds core, much less dense, high concentration of light elements (O₂, Fe, Si, and Mg), 2,900 km in depth.
- Crust: cool, lightweight brittle rock that floats on the mantle (oceanic crust is like the mantle but has more Si while the continents are thicker, lighter regions of crust rich in Ca, Na, K, and Al).

Plate Tectonics

- Originally called Continental Drift,
- Tectonic Plates: large pieces of land are broken and moved by huge convection currents on the soft upper layer of the mantle.
- Plates were once all connected in a single land mass called Pangaea
- Magma: molten rock underground, Lava: molten rock on the Earth's surface

Divergent plate boundaries- when plates separate.

- Magma that gets pushed up from the mantle through cracks in the oceanic crust pile underwater to create ocean ridges. Huge underwater volcanoes are formed, greater than anything on the continents. ex. Mid-ocean ridge
- Divergent boundaries can occur on land too causing a rift valley ex. Kenya, Africa

Convergent plate boundaries- when plates collide

- land-land collisions- non-volcanic mountain ranges are pushed up. ex. Himalya Mtns.
- ocean-land collisions- ocean plate is subducted and volcanic mountain chains are formed on the side of the land adjacent to the ocean. ex. Andes Mtns.
- ocean-ocean collisions- one of the ocean plates are subducted causing a chain of volcanic islands are formed called an island arc ex. Japan or Indonesia. NOT Hawaii- it is caused by a hot spot: a single plume of pulsing magma creates an island chain as the plates move over it.

Earthquakes are caused by grinding and jerking as plates slide past each other.

"Ring of Fire" is the area surrounding the Pacific ocean rich in earthquakes and volcanoes!

ROCKS AND MINERALS:

Mineral: a naturally occurring, inorganic solid element or compound with a unique chemical

composition and a regular internal crystal structure.

Rock: a solid, cohesive, aggregate of one or more minerals.

Rock Types and How They Were Formed

Rock Cycle: any rock can turn into any other rock type. Knowing this cycle can explain the origin and characteristics of rocks and how they are shaped, worn away, transported, deposited, and altered by geologic forces.

Igneous Rocks: made by the melting and subsequent cooling of molten rock. Magma that reaches the earth's surface cools quickly into basalt or rhyolite. These rocks have fine grains. Magma that is cooled in subsurface chambers has coarser, intergrown crystals and forms granite and gabbro.

Sedimentary Rock: made three different ways

- Clastic rocks- are formed when weathered sediments are cemented together ex. conglomerate
- Chemical sedimentary rocks (evaporites)- form when a solid rock is precipitated from solution ex. rock salt
- Organic sedimentary rocks- are made of or organic matter ex. coal

Weathering: exposure to air, changing temps and chemical reactions cause the breakdown of even durable rocks. (Mechanical weathering -physical breakup of rocks into smaller particles w/o a change in chemical composition. Chemical weathering- selective removal or alteration of specific components that leads to the weakening and disintegration of rocks ex. oxidation and hydrolysis. The products of chemical weathering are very susceptible to mechanical weathering and dissolving in water).

Metamorphic Rocks: preexisting rocks that have been modified by heat, pressure. They can form from contact metamorphism (proximity to magma) or regional metamorphism (burial deep in the crust). These rocks often hold the most economically important minerals such as talc, graphite and gemstones.

Geologic History

Geologic time is broken up into eras, periods and eons in increasingly smaller time units. Each segment is divided based on the predominant fossils living in that time period. Famous eras include the Paleozoic (age of fish), Mesozoic (age of reptiles) and Cenozoic (age of mammals). Mass extinctions punctuate the end of each era... hmm, I wonder if we are moving into a new era right now and don't realize it...

ECONOMIC GEOLOGY AND MINERALOGY

Economic Mineralogy: the study of minerals that are valuable for manufacturing and are important parts of domestic and international commerce. Metal bearing ores are the most economic

minerals.

- The most valuable crystal resources are everywhere but concentrated and in places of easy access is what is needed.

Metals

- The metals consumed in greatest quantity by world industry include iron, aluminum, manganese, copper, chromium and nickel.

Nonmetal Mineral Resources

- Include gemstones, mica, talc, asbestos, sand, gravel, salts, limestone, and soils.
- Sand and gravel have the highest economic value of nonmetals and metals for their use in making roads and cement.
- Evaporites: are materials deposited by evaporation of chemical solutions. They are mined for halite, gypsum, and potash. Often found at 97% purity. Halite is used for water softeners and as road salt and refined as table salt. Gypsum is used for wallboard and potash is used for fertilizers.

Strategic Metals and Minerals

- World industry depends on about 80 minerals and metals, some of which exist in plentiful supplies others do not like gold, silver and lead.
- Strategic metals and minerals: resources a country uses but cannot produce itself. A government usually will consider these materials as capable of crippling its economy or military strength if unstable global economics or politics were cut off to supplies.
- Usually less developed countries sacrifice the environment to mine and become producers of resources other countries need. This emphasis on a single export is not a stable foundation for an entire economy to be built since stable international markets are not a reality.

Environmental Effect on Research Extraction:

Physical processes of mining and physical or chemical properties of separating minerals, metals, and other geological resources from ores or other materials.

Ore: A rock in which valuable or useful metal occurs at a concentration high enough to make mining it economically attractive.

- Copper: economically viable concentration is close to 1 percent.
- Gold and other precious metals: desirable concentration is close to 0.0001 percent.

Methods of Mining:

- Placer Mining: process in which native metals deposited in the gravel of stream beds are washed out hydraulically. Stream beds and aquatic life are destroyed.
- Strip mining and open-pit mining: Materials are removed from large, deep surface mines by big equipment.
-nearly a million acres of US land have been destroyed by strip mining- land is left barren and water is polluted, 50% US coal is strip mined
- Heap-leach extraction- gold is separated from ores using alkaline-cyanide solution which is

- extremely toxic to the environment in the inevitable leaks into the groundwater
- Underground tunnels- used to reach the deepest deposits.
- Mountaintop removal mining: mountain is removed from coal which devastates ecosystems.

Mining Hazards:

- tunnels collapse or natural gas in coal mines can cause explosions
- acidic and toxic waste runoff is caused by surface waste deposits called tailings
 - tailings from uranium can cause wind scattering of radioactive dust
 - rain and ground water dissolves metals and toxic materials which causes pollution in drinking water
 - 19,000 km of rivers and streams in US are contaminated by mine drainage
- Long exposed ridges called spoil banks are susceptible to erosion and chemical weathering.
- soil is destroyed which prevents vegetation

Controlling Mining:

- 1977 federal Surface Mining Control and Reclamation Act requires better restoration of strip-mined lands, especially farmlands
 - expense of reclamation is high, approximately \$1,000 per acre

Processing:

- Metals are released from ores by heating or treatment with chemical solvents
- Smelting: roasting ore to release metals is a major source of air pollution
- Ducktown Tennessee: mid-1800s mining companies extracted copper with huge open-air wood fires which acidified soil and poisoned vegetation
- 1907: sulfur emissions from Ducktown were reduced when Supreme Court ruled to stop interstate transport of air pollution
- 1930s: Tennessee Valley Authority began treating soil and replanting trees
- two-thirds of areas is now considered adequately covered
- heap-leach extraction: technique used to separate gold from low-grade ores. It has a high potential for water pollution.
- Cyanide spills have occurred in Summitville mine near Alamosa, Colorado and in a gold operating mine near Baia Mare in Romania.

Conserving Geological Resources:

Recycling:

- advantages of recycling: less waste, less land lost to mining, less consumption of money, energy and water resources
- recycling aluminum consumes one-twentieth of the energy of extracting new aluminum (bauxite). Aluminum is used in construction, transportation, packaging and electronics.
- 1/2 of aluminum cans will be made into another can in 1 to 2 months
- platinum is recycled for used cars
- commonly recycled metals are gold, silver, copper, lead, iron, aluminum and steel.
- recycled metals are used for copper pipes, lead batteries, and steel and iron auto parts.

Steel and Iron Recycling:

- Minimills: remelt and reshape scrap iron and steel

- produce half of US steel production
- use less energy than integrated mills
- Minimills produce steel at between \$225 and \$480 per metric tons
- Integrated mills produce steel at \$1,425 to \$2250 per metric tons

Substituting New Materials for Old:

- plastic pipes have decreased our consumption of copper, lead and steel pipes
- in automobile industry, steel is being replaced by polymers (long-chain organic molecules similar to plastics) , aluminum, ceramics, and high-technology alloys
- new materials reduce vehicle weight and cost, and increase fuel efficiency
- Electronics and communication technology use glass cables to transmit light pulses instead of copper and aluminum wires

Geological Hazards:

Earthquakes:

- sudden movements in the earth's crust that occur along faults where one rock mass slides under another.
- Kobe, Japan and Mexico cities are built on soft landfills and they suffer the greatest damage from earthquakes
- contractors plan to build heavily reinforced structures, strategically placed on weak spots in buildings, to absorb vibrations from earthquakes.
- tsunami: giant seismic sea swells that can move at 1,000 km/hr or faster from the center of an earthquake
- 1883 Indonesian volcano Krakatoa created a tsunami that killed 30,000 people.

Volcanoes:

- source of most of the earth's crust and associated with most of the plate boundaries of the world
- fertile soils are weathered volcanic materials
- Nuees ardentes (glowing clouds) are denser-than-air mixtures of hot gases that move faster than 100 km/hour and destroys towns such as St. Pierre on the Caribbean island of Martinique
- Mudslide associated with volcanoes have devastated Armero and Chinchina in Columbia
- volcanic eruptions release large volumes of ash and dust into air which blocks sunlight
- 1991: Mt Pinatubo in Philipines emitted 20 million tons of sulfur dioxide producing sulfuric acid

Landslides:

- rapid downslope movement of soil or rock
- In US, \$ 1 billion in property damage is done every year by landslides and related mass wasting
- threats: road construction, forest clearing, agricultural cultivation, and building on steep slopes