The Earth's Crust

More about the Earth's crust

There are two types of crust. The **oceanic crust** is a thin layer that covers the Earth's surface and forms the ocean bed. The **continental crust** sits on top of it and forms the continents.

The continental crust is mainly **granite**. It is thicker than the oceanic crust.

The ocean floor is flat in parts but it also has mountains, deep valleys or **trenches**, and many underwater volcanoes.

volcano

land

ocean

ridge of underwater volcanoes

underwater mountains

ocean trench

granite

The oceanic crust is made of **basalt**. It is heavier than continental crust.

The crust and upper mantle are hard. Together they form the **lithosphere**.

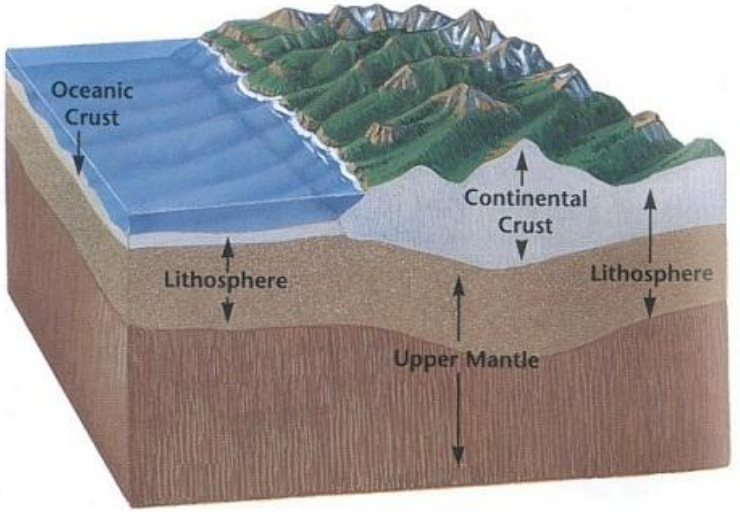
upper mantle

basalt

currents of hot rock

The rock below the lithosphere is hot, soft – and moving. Currents of hot rock rise very slowly, cool and sink again.

These heat-carrying currents or **convection currents** are so powerful that they are changing the face of the Earth. Find out how in the next two units!



How Are the Earth's Rocks Recycled?

The three major types of rocks found in the earth's crust

- *Sedimentary*
- *Igneous*
- *Metamorphic*

They are recycled very slowly by the process of erosion, melting, and metamorphism.

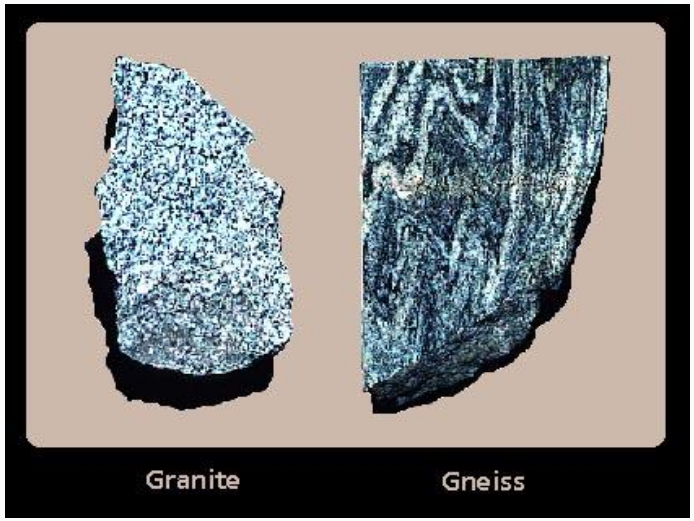
There Are Three Major Types of Rocks (1)

- Earth's crust
  - Composed of **minerals** and **rocks**
- Three broad classes of rocks, based on formation
  1. **Sedimentary (made of sediments- clastic -cemented and compacted and chemical- made from dissolved minerals like limestone and rock salt)**
     - **Sandstone and shale (compacted sediments)**
     - **Dolomite and limestone (compacted shells and skeletons)**
     - **Lignite and bituminous coal (compacted plant remains)**

There Are Three Major Types of Rocks (2)

2. **Igneous** – forms the bulk of earth's crust
   - Granite (formed underground)
   - Pumice
   - Obsidian
   - Basalt

3. **Metamorphic** –formed by heat and pressure
   - Anthracite from coal
   - Slate from shale
   - Marble from limestone
   - Gneiss from granite



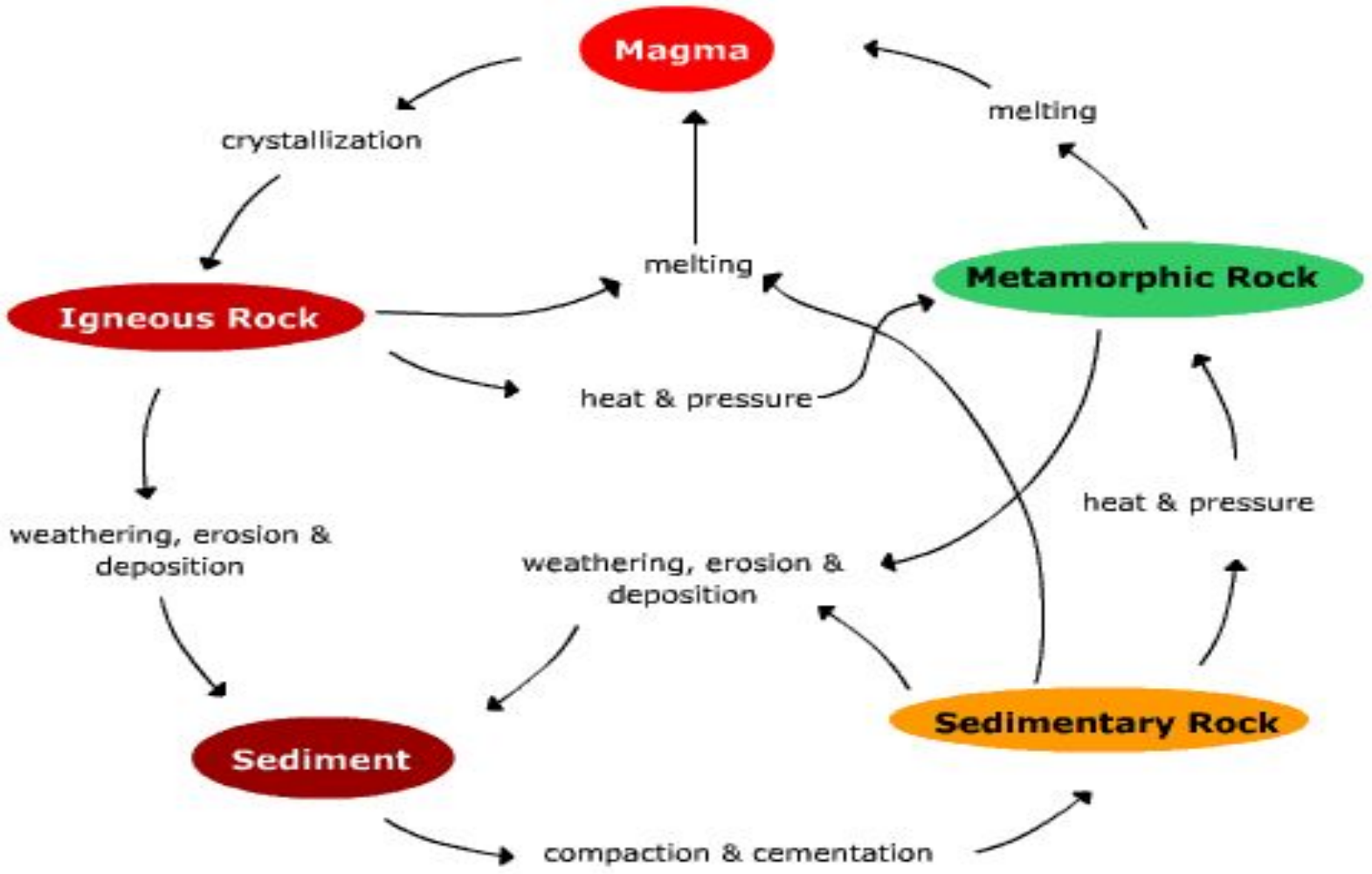
The Earth's Rocks Are Recycled Very Slowly

- **Rock cycle**

The slowest of the earth's cyclic processes

Dolomite (see the shells) and a cave of limestone

The rock cycle



What Are Mineral Resources, and what are their Environmental Effects?

- ***Concept:*** *Some naturally occurring materials in the earth's crust can be extracted and made into useful products in processes that provide economic benefits and jobs.*

- ***Concept:*** *Extracting and using mineral resources can disturb the land, erode soils, produce large amounts of solid waste, and pollute the air, water, and soil.*

We Use a Variety of Nonrenewable Mineral Resources

- **Mineral resource (concentration of a naturally occurring material)**
  - Fossil fuels (coal)
  - Metallic minerals (Al, Fe, Cu)
  - Nonmetallic minerals (sand, gravel)
- **Ore – contains enough of the mineral to be profitable to mine**
  - **High-grade ore**
  - **Low-grade ore**

Mineral Categories

1) **Rock-forming minerals**

   Most common minerals in the Earth's crust, e.g. olivine, pyroxene, mica, feldspar, quartz, calcite and dolomite.

2) **Accessory minerals**

   Minerals that are common but usually are found only in small amounts, e.g. chlorite, garnet, hematite, limonite, magnetite, and pyrite.

3) **Gems**

   A mineral that is prized primarily for its beauty. (Although some gems, like diamonds are also used industrially), e.g. diamond, emerald, ruby, and sapphire.

Mineral Categories (cont.)

4) **Ore minerals**

Minerals from which metals or other elements can be profitably recovered, e.g. native gold, native silver, chalcopyrite, galena, and sphalerite.

5) **Industrial minerals**

Minerals are industrially important, but are mined for purposes other than the extraction of metals, e.g. halite for table salt.

QUARTZ –SiO_2

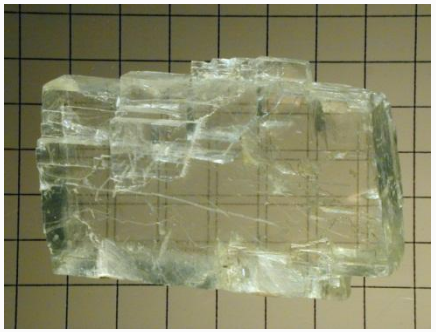
- Quartz is the most common mineral on Earth. It is found in nearly every geological environment and is at least a component of almost every rock type. It is also the most varied in terms of varieties, colors and forms.

Uses: silica for glass, electrical components, optical lenses, abrasives, gemstones, ornamental stone, building stone, etc.

Mineral tests and observations

- **Color** is as variable as the spectrum, but clear quartz is by far the most common color
- **Luster** is vitreous (glassy)
- **Reflection of light:** Crystals are transparent to translucent
- **Cleavage** -none
- **Fracture** is conchoidal.
- **Hardness** is **7**
- **Specific Gravity** is **2.65**
- **Streak** is white.
- A metalloid and semiconductor

(calcite with rhombohedral cleavage)



(Conchoidal fracture of quartz)

fireworks, computers, transistors, pottery, contacts, breast implants, solar cells, glass,

Mineral Use Has Advantages and Disadvantages

- Advantages of the processes of mining and converting minerals into useful products

Generates income, provides revenue for states and employment

- Disadvantages – energy intensive and can disturb the land, erode soil and produce solid waste and pollution

Surface mining → Metal ore → Separation of ore from gangue → Smelting → Melting metal → Conversion to product → Discarding of product

Recycling

NATURAL CAPITAL DEGRADATION

Extracting, Processing, and Using Nonrenewable Mineral and Energy Resources

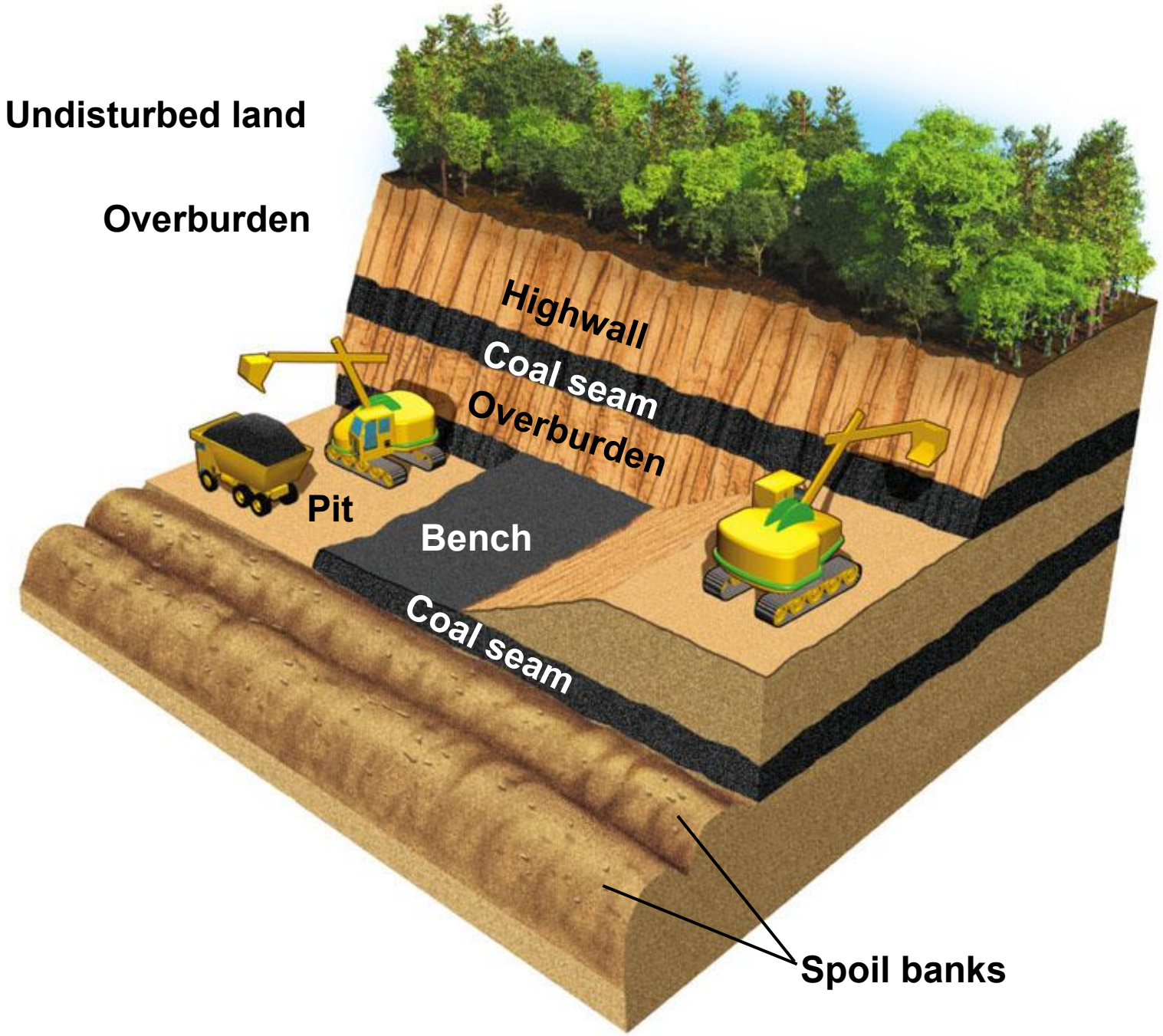
Steps		Environmental Effects
Mining Exploration, extraction	 	Disturbed land; mining accidents; health hazards; mine waste dumping; oil spills and blowouts; noise; ugliness; heat
Processing Transportation, purification, manufacturing	 	Solid wastes; radioactive material; air, water, and soil pollution; noise; safety and health hazards; ugliness; heat
Use Transportation or transmission to individual user, eventual use, and discarding	 	Noise; ugliness; thermal water pollution; pollution of air, water, and soil; solid and radioactive wastes; safety and health hazards; heat

There Are Several Ways to Remove Mineral Deposits (1)

- **Surface mining- 90% of nonmetal mineral/rock resources and 60% of coal (in USA)**
  - Shallow deposits removed- overburden, spoils, tailings(material dredged from streams)

  1. Open Pit
  2. Strip mining- (when the ore is in horizontal beds)
  3. Area strip mining- (flat land)
  4. Contour strip mining- (mostly used to mine coal from mountains)
  5. Mountain top removal (Appalachian Mts)- explosives
- **Subsurface mining**
  - Deep deposits removed

Natural Capital Degradation: Open-Pit Mine in Western Australia



Natural Capital Degradation: Mountaintop Coal Mining in West Virginia, U.S.

Mining Has Harmful Environmental Effects (1)

- Scarring and disruption of the land surface
  - E.g., **spoils banks**
- Loss of rivers and streams
- Subsidence
  - **road built over old mine shafts created a sinkhole**

Mining Has Harmful Environmental Effects (2)

- Major pollution of water and air
- Effect on aquatic life
- Large amounts of solid waste
- EPA cites that mining has polluted 40% of western watersheds.
- In US, mining produces more toxic emissions than any other industry

Banks of Waste or Spoils Created by Coal Area Strip Mining in Colorado, U.S.

Illegal Gold Mine

Ecological Restoration of a Mining Site in New Jersey, U.S.

Removing Metals from Ores Has Harmful Environmental Effects (1)

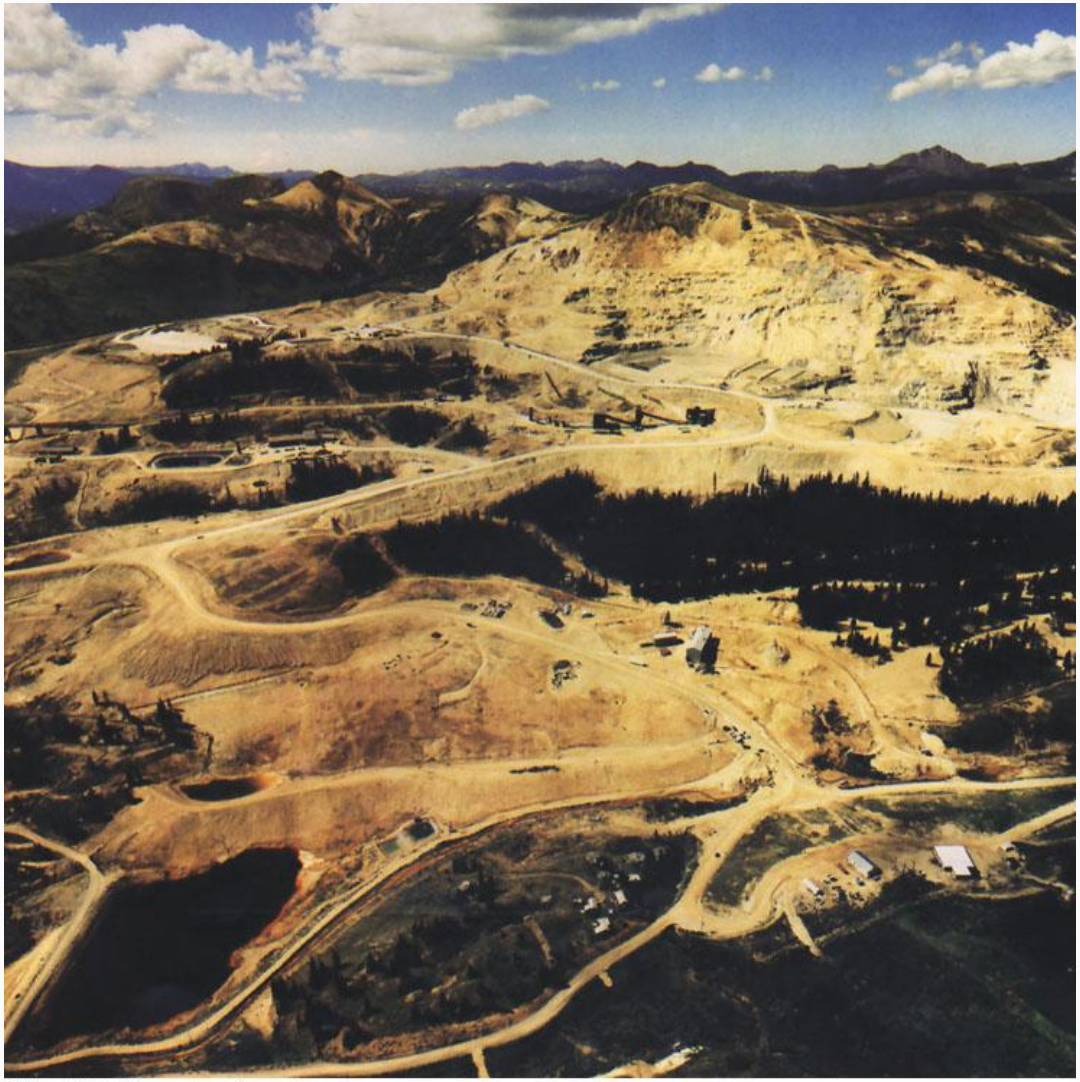
- Ore extracted by mining
  - **Ore mineral- a rock deposit that contains enough mineral to make it feasible to mine**
  - **Gangue- commercially worthless material that is mixed in with the ore**
  - **Smelting – obtaining ore by heating at high temperatures in an enclosed furnace**

- Water pollution- ARD (acid rock drainage)
  --when sulfur containing rocks are exposed to air and water and create sulfuric acid

Removing Meals from Ores Has Harmful Environmental Effects (2)

- Liquid and solid hazardous wastes produced
- Use of cyanide salt to extract gold from its ore
  - Summitville gold mine: Colorado, U.S.

Natural Capital Degradation: Summitville Gold Mining Site in Colorado, U.S.



How Long Will Supplies of Nonrenewable Mineral Resources Last?

- ***Concept:*** *All nonrenewable mineral resources exist in finite amounts, and as we get closer to depleting any mineral resource, the environmental impacts of extracting it generally become more harmful.*

- ***Concept:*** *An increase in the price of a scarce mineral resource can lead to increased supplies and more efficient use of the mineral, but there are limits to this effect.*

Mineral Resources Are Distributed Unevenly (1)

- Most of the nonrenewable mineral resources supplied by
  - United States
  - Canada
  - Russia
  - South Africa -Au, Cr, Pt
  - Australia

  - **US, Germany and Russia have 8% of world's population and consume about 75% of the most widely used metals**

Mineral Resources Are Distributed Unevenly (2)

- **Strategic metal resources- essential for the country's economy and military strength. The US has little of these metals and must import them.**
  - Manganese (Mn)
  - Cobalt (Co)
  - Chromium (Cr)
  - Platinum (Pt)

Science Focus: The Nanotechnology Revolution

- Nanotechnology, tiny tech- using science and technology to manipulate and create materials out of atoms and molecules at the ultra-small scale (1/100 the width of a human hair. 1 nanometer = $1x10^{-9}$ m)

- Nanomaterials are used in over 400 consumer products such as stain resistant coating on clothes, cosmetics and sunscreens

Supplies of Nonrenewable Mineral Resources Can Be Economically Depleted

- Future supply depends on
  - Actual or potential supply of the mineral
  - Rate at which it is used

- When it becomes **economically depleted**
  - Recycle or reuse existing supplies
  - Waste less
  - Use less
  - Find a substitute
  - Do without

Market Prices Affect Supplies of Nonrenewable Minerals

- Subsidies and tax breaks to mining companies keep mineral prices artificially low. This decreases recycling/reusing, increases mining waste/pollution and decreases incentives to find alternative minerals.

Case Study: The U.S. General Mining Law of 1872

- Encouraged mineral exploration and mining of **hard-rock minerals (Au, Cu, Zn, Ni, Ag, U)** on U.S. public lands
- Developed to encourage settling the West (1800s)
- Until 1995, land could be bought for 1872 prices

(Built golf courses, hotels, subdivisions and then sold to private companies. Much of this land contains mineral resources)

- Companies must pay for clean-up now

Is Mining Lower-Grade Ores the Answer?

- Factors that limit the mining of lower-grade ores
  - Increased cost of mining and processing larger volumes of ore
  - Availability of freshwater
  - Environmental impact
  - (EX: copper ore contained 5% Cu by weight in 1900, now only 0.5%)
- Improve mining technology
  - Use microorganisms, *in situ (in place)*
  - Slow process
  - What about genetic engineering of the microbes?

Can We Extend Supplies by Getting More Minerals from the Ocean? (1)

- Mineral resources dissolved in the ocean-low concentrations (Mg, Br, NaCl)

- Deposits of minerals in sediments along the shallow continental shelf and near shorelines (sand, gravel, phosphates, S, Sn, Cu, Fe...)

Can We Extend Supplies by Getting More Minerals from the Ocean? (2)

- Hydrothermal ore deposits – minerals dissolved in the hot water and then precipitate out around the vent after cooling. Too expensive to mine and who owns these deposits?

- Metals from the ocean floor: **manganese nodules**
  - Effect of mining on aquatic life
  - Environmental impact

WHAT DO YOU REMEMBER??????

- Making new materials by manipulating atoms and molecules is called _____.

NANOTECHNOLOGY

- What type of rock is the Earth's crust composed?

IGNEOUS

- Obtaining ore by heating at high temperatures in an enclosed furnace is the process of ____.

SMELTING

WHAT DO YOU REMEMBER??????

- Rocks formed by heat and pressure are ___.

METAMORPHIC

- Most mining is done by ____ mining.

SURFACE

- A rock that contains enough of a mineral to mine profitably is termed ___.

ORE

- Banks of waste (hills like waves of rubble) created by strip mining are called ____.

SPOIL BANKS

How Can We Use Mineral Resources More Sustainability?

- ***Concept:*** *We can try to find substitutes for scarce resources, reduce resource waste, and recycle and reuse minerals.*

We Can Find Substitutes for Some Scarce Mineral Resources (1)

- Materials revolution- silicon, plastics, ceramics and nanotechnology substitutions

Styrofoam blocks sprayed with (Grancrete) a ceramic spray is 2x stronger than structural concrete and doesn't leak or crack. Reduces house costs and saves trees

We Can Find Substitutes for Some Scarce Mineral Resources (2)

- Plastics have replaced copper steel and lead in much piping.
- Fiber optic glass cables are replacing Cu and Al wires in telephone cables
- High-strength plastics used in autos and aerospace industries are replacing metals and are less expensive

- Making plastics are energy intensive.

Solutions: Sustainable Use of Nonrenewable Minerals