Resources:
Mineral resources

Reading:
Today: Ch 12 (to p306)

Composition of the crust

<table>
<thead>
<tr>
<th>TABLE 3.4</th>
<th>Average Composition of the Continental Crust</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oxygen (O)</strong></td>
<td>45.2%</td>
</tr>
<tr>
<td><strong>Silicon (Si)</strong></td>
<td>27.7%</td>
</tr>
<tr>
<td><strong>Potassium (K)</strong></td>
<td>3.3%</td>
</tr>
<tr>
<td><strong>Aluminum (Al)</strong></td>
<td>8.6%</td>
</tr>
<tr>
<td><strong>Calcium (Ca)</strong></td>
<td>5.6%</td>
</tr>
<tr>
<td><strong>Iron (Fe)</strong></td>
<td>5.7%</td>
</tr>
<tr>
<td><strong>Magnesium (Mg)</strong></td>
<td>2.7%</td>
</tr>
</tbody>
</table>

A. Percent by weight of the chemical elements
B. Percent by volume of the chemical elements
Ore deposits

A rock containing a useful metal in a useable concentration

**Concentration factor =** \( \frac{\text{concentration in ore}}{\text{average crustal concentration}} \)

- Fe 6% of crust Only need 4-5 times concentration
- Al 8% of crust

Copper needs 100 times concentration
Mercury needs 25,000 times concentration

Ease of extraction: relative mineral densities strength of compound bonds

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Ore distribution

...by definition ore is rare

**Iron ore**
(Aluminum (bauxite) (U.S. — negligible)

**Copper**

**Gold**

The U.S. must import many of the mineral resources it needs.

Al: U.S. uses one third of world supply but produces none ➔ strategic supply
Igneous and hydrothermal deposits

Pegmatite: very large crystals up to 10 m

Also, kimberlites...diamonds
Magma chambers

Gravitational settling of crystals

Chromite layers (black)

Hydrothermal resources

Black smokers produce rich mineral deposits
...at 2.5 km depth
**Hydrothermal resources**

Deposits include: copper, lead, zinc, gold, silver, platinum, uranium and others.

- Both igneous and hydrothermal processes are found at plate boundaries. Therefore this is where most ore deposits are found.
- Also look for paleo-plate boundaries.
Sedimentary deposits

**Banded iron formation**

Evaporites

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Placer deposits

Minerals are sorted by fluvial processes increasing the concentrations.

Fossil placer deposits such as this gold deposit
Supply and demand

World production and reserves

Table 12.2  World Production and Reserve Statistics, 1999*

<table>
<thead>
<tr>
<th>Material</th>
<th>Production</th>
<th>Reserves</th>
<th>Projected lifetime of reserves (years)</th>
<th>Estimated reserves</th>
</tr>
</thead>
<tbody>
<tr>
<td>aluminum</td>
<td>101,000</td>
<td>25,600,000</td>
<td>311 4%</td>
<td>55,600,000-75,600,000</td>
</tr>
<tr>
<td>iron</td>
<td>11,600</td>
<td>3,600,000</td>
<td>349 -19%</td>
<td>11,000,000</td>
</tr>
<tr>
<td>nickel</td>
<td>13,133</td>
<td>4,900</td>
<td>292 -22%</td>
<td>11,000</td>
</tr>
<tr>
<td>lead</td>
<td>9,600</td>
<td>340,000</td>
<td>32 -15%</td>
<td>2,500,000</td>
</tr>
<tr>
<td>magnesium</td>
<td>2,800</td>
<td>68,000</td>
<td>24 -13%</td>
<td>1,500,000</td>
</tr>
<tr>
<td>nickel</td>
<td>7,600</td>
<td>480,000</td>
<td>52 +8%</td>
<td>30,000</td>
</tr>
<tr>
<td>zinc</td>
<td>300</td>
<td>7,000</td>
<td>51 -20%</td>
<td>18,000</td>
</tr>
<tr>
<td>platinum group</td>
<td>230</td>
<td>56,000</td>
<td>243 +6%</td>
<td>180,000</td>
</tr>
<tr>
<td>gypsum</td>
<td>10,000</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>phosphate</td>
<td>157,000</td>
<td>11,000,000</td>
<td>80 +9%</td>
<td>2,400,000</td>
</tr>
<tr>
<td>sulfur</td>
<td>26,000</td>
<td>1,400,000</td>
<td>320 +4%</td>
<td>2,500,000</td>
</tr>
<tr>
<td>copper</td>
<td>1,500,000</td>
<td>9,000,000</td>
<td>32 +5%</td>
<td>3,000,000</td>
</tr>
</tbody>
</table>

*Includes 6% billion ton copper estimated to occur in manganese nodules. Reserves of uranium also projected to occur in these nodules.

Change in projected lifetime by 1999

(see Table 12.2 in your textbook)
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U.S. production and reserves

Table 12.3: Projected Lifetimes of U.S. Mineral Reserves (assuming complete reliance on domestic reserves)*

<table>
<thead>
<tr>
<th>Material</th>
<th>Reserves</th>
<th>Projected lifetime (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>bauxite</td>
<td>20,000</td>
<td>5</td>
</tr>
<tr>
<td>chromite</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>coal</td>
<td>40,000</td>
<td>9</td>
</tr>
<tr>
<td>copper</td>
<td>30,000,000</td>
<td>17.6</td>
</tr>
<tr>
<td>iron ore</td>
<td>2,000,000</td>
<td>200</td>
</tr>
<tr>
<td>lead</td>
<td>8,000</td>
<td>5.5</td>
</tr>
<tr>
<td>manganese</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>nickel</td>
<td>25</td>
<td>0.1</td>
</tr>
<tr>
<td>tin</td>
<td>20</td>
<td>0.4</td>
</tr>
<tr>
<td>zinc</td>
<td>16,000</td>
<td>11</td>
</tr>
<tr>
<td>gold</td>
<td>5,000</td>
<td>79</td>
</tr>
<tr>
<td>silver</td>
<td>51,000</td>
<td>**</td>
</tr>
<tr>
<td>platinum group</td>
<td>250</td>
<td>**</td>
</tr>
<tr>
<td>gypsum</td>
<td>780,000</td>
<td>27</td>
</tr>
<tr>
<td>phosphate</td>
<td>1,280,000</td>
<td>27</td>
</tr>
<tr>
<td>peat</td>
<td>74,000</td>
<td>13.4</td>
</tr>
<tr>
<td>sulfur</td>
<td>140,000</td>
<td>10</td>
</tr>
</tbody>
</table>

*Reserves in thousands of metric tons except for gold, silver, and platinum group metals for which figures are in metric tons.
*Not all commodities are available.
*Note that bauxite consumption is only a partial measure of total aluminium consumption; additional characteristics are consumed as refined aluminium metal, of which there are no reserves.

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Compared with updated estimates (Table 12.3 in your textbook)

- not much change

The shorter lifetimes mean the US must rely on imports.
Is this a problem?

Minerals for the future:
Reducing consumption? ...

...no way!

U.S. Material Consumption Trends

...and in developing nations

QUESTION
Minerals for the future:
New methods of mineral exploration

Can we find more resources?
Geophysical methods: Gravity, magnetics, radioactivity
Geochemical prospecting: Chemistry of soils
Remote sensing: Airborne and satellite imaging

Landsat imaging:
Sensitive to red and green wavelength, image plants, soils and rock types

dry
wet

Minerals for the future:
Marine mineral resources

1. Placer deposits on continental margins
   The result of reduced sea level during the last ice age

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Minerals for the future:

Marine mineral resources

2. Hydrothermal deposits at mid-ocean ridges
   - Juan de Fuca ridge off Oregon and Washington

3. Manganese nodules
   - Location of nodules:
     - Location 1
     - Location 2

International Resources Law:
3rd U.N. Conference on the Law of the Sea

Territorial limits were traditionally 3 miles
After eight years of negotiation:
- Territorial waters extended to 12 miles
- Exclusive Economic Zones extend 200 miles from coast

U.S. did not sign the treaty (141 did, 4 did not)
- U.S. has abided by the treaty
- Reagan unilaterally claimed the 200 km zone for the U.S. anyway
Minerals for the future:

Recycling

Also reduces waste and the need to open new mines

Good for recycling: metals used in big pieces, mixed elements, alloys are a problem

Some minerals are not recoverable: potash in fertilizer, road salt

<table>
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<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>aluminum</td>
<td>11</td>
<td>22</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>chromium</td>
<td>21</td>
<td>21</td>
<td>26</td>
<td>23</td>
</tr>
<tr>
<td>cobalt</td>
<td>15</td>
<td>14</td>
<td>25</td>
<td>22</td>
</tr>
<tr>
<td>copper</td>
<td>22</td>
<td>25</td>
<td>42</td>
<td>39</td>
</tr>
<tr>
<td>lead</td>
<td>30</td>
<td>60</td>
<td>62</td>
<td>67</td>
</tr>
<tr>
<td>manganese</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>nickel</td>
<td>21</td>
<td>24</td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>zinc</td>
<td>7</td>
<td>10</td>
<td>29</td>
<td>25</td>
</tr>
</tbody>
</table>


Impacts of mining activities

Mining occurs throughout the U.S.

Mining is one of the most dangerous professions: 43 deaths per 100,000 per yr (agriculture and construction are next).
**Impacts of mining activities:**

**Underground mines**

- Small surface exposure
- Usually little waste
- Seal shaft after use

But, can later collapse

**Surface mines**

**Strip mines:**
Extraction of horizontal layers usually near the surface eg coal mines

**Open-pit mines:**
Extraction of large 3D ore bodies near the surface

Both cause permanent change to topography. Weathering can change the chemistry of ground water.
Impacts of mining activities:

Reclamation