**Resources:**
Mineral resources

**Reading:**
Today: Ch 12 (to p306)

**QUESTION**

**Composition of the crust**

**Table 3.4: Average Composition of the Continental Crust**

<table>
<thead>
<tr>
<th>Element</th>
<th>Weight % of Crust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>46.6%</td>
</tr>
<tr>
<td>Silicon</td>
<td>27.7%</td>
</tr>
<tr>
<td>Aluminum</td>
<td>8%</td>
</tr>
<tr>
<td>Iron</td>
<td>6%</td>
</tr>
<tr>
<td>Calcium</td>
<td>3.5%</td>
</tr>
<tr>
<td>Sodium</td>
<td>2.8%</td>
</tr>
<tr>
<td>Potassium</td>
<td>1.5%</td>
</tr>
<tr>
<td>Magnesium</td>
<td>1.8%</td>
</tr>
<tr>
<td>Others</td>
<td>15.9%</td>
</tr>
</tbody>
</table>

**(a) Mass by weight of 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

**Ore distribution**

- Iron ore
- Aluminum (bauxite) (U.S. — negligible)
- Copper
- Gold

...by definition ore is rare

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

Igneous rocks

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

Plate boundary location

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

Placer deposits

Minerals are sorted by fluvial processes increasing the concentrations.

Fossil placer deposits such as this gold deposit
Supply and demand

Aluminum Consumption Per Capita

<table>
<thead>
<tr>
<th>Average per year</th>
<th>1981-83</th>
<th>1984-86</th>
<th>1987-89</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981-83</td>
<td>1984-86</td>
<td>1987-89</td>
<td></td>
</tr>
<tr>
<td>20100</td>
<td>21800</td>
<td>22200</td>
<td></td>
</tr>
</tbody>
</table>

Change in projected lifetime by 1999 (see Table 12.2 in your textbook)

World production and reserves

<table>
<thead>
<tr>
<th>Material</th>
<th>Projected lifetime (years)</th>
<th>Projected reserves (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>21.5</td>
<td>63,800,000</td>
</tr>
<tr>
<td>Uranium</td>
<td>19.0</td>
<td>1,600,000</td>
</tr>
<tr>
<td>Copper</td>
<td>19.1</td>
<td>3,000,000</td>
</tr>
<tr>
<td>Coal</td>
<td>19.0</td>
<td>105,000,000</td>
</tr>
<tr>
<td>Natural gas</td>
<td>20.0</td>
<td>15,000,000</td>
</tr>
</tbody>
</table>

Change in projected lifetime by 1999

Environmental Geology – Mineral resources

U.S. production and reserves

Table 12.3: Projected lifetime of U.S. Mineral resources (compared with Table 12.3 in your textbook)

<table>
<thead>
<tr>
<th>Material</th>
<th>Reserves</th>
<th>Projected lifetime (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>7,000,000</td>
<td>20</td>
</tr>
<tr>
<td>Uranium</td>
<td>7,000,000</td>
<td>10</td>
</tr>
<tr>
<td>Copper</td>
<td>1,000,000</td>
<td>5</td>
</tr>
<tr>
<td>Coal</td>
<td>1,000,000</td>
<td>10</td>
</tr>
<tr>
<td>Natural gas</td>
<td>5,000,000</td>
<td>20</td>
</tr>
</tbody>
</table>

Compare with updated estimates

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Minerals for the future:

Reducing consumption?...no way!

...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

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Minerals for the future:

Marine mineral resources

1. Placer deposits on continental margins

The result of reduced sea level during the last ice age

2. Hydrothermal deposits at mid-ocean ridges

Juan de Fuca ridge off Oregon and Washington

3. Manganese nodules

Location of nodules

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

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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

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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).

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Underground mines

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

But, can later collapse

Subsidence pits above abandoned coal mine

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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.

Environmental Geology – Mineral resources
Impacts of mining activities:

Reclamation