Peak Everything
Running Out of Commodities
in a Crowded World

Gary McMurtry
Peak Minerals

Bingham Canyon Copper Mine, Utah
1904 - 2020?

Pit is 2.5 miles wide and over 0.5 miles deep

Owned & operated by Kennecott Copper Co.
Peak Minerals

- **Hg (Mercury)**
  - **Major Use:** Electrical, Instruments, Chlorine Production

- **Pb (Lead)**
  - **Major Use:** Pb-acid Batteries, Solder

- **Zr (Zirconium)**
  - **Major Use:** Nuclear Power, Superconductor

- **Se (Selenium)**
  - **Major Use:** Photovoltaic, Rectifiers, Glass-Rubber Production

Source: Ugo Bardi and Marco Pagani; http://www.theoildrum.com/node/3086
Peak Minerals (cont.)

**Gallium (Ga)**
- Major Use: Solar PV, Lasers, LEDs

**Iron (Fe)**
- Major Use: Steel

**Copper (Cu)**
- Major Use: Electrical Wiring

Source: Ugo Bardi and Marco Pagani; http://www.theoildrum.com/node/3086
# Peak Minerals (cont.)

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Peak year (logistic)</th>
<th>URR (tons) from logistic fitting</th>
<th>URR (tons) from USGS: reserves + cumulative production up to 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>1962</td>
<td>$(5.8 \pm 0.4) \cdot 10^5$</td>
<td>$5.9 \cdot 10^5$</td>
</tr>
<tr>
<td>Tellurium</td>
<td>1984</td>
<td>$(1.0 \pm 0.4) \cdot 10^4$</td>
<td>$2.8 \cdot 10^4$</td>
</tr>
<tr>
<td>Lead</td>
<td>1986</td>
<td>$(3.3 \pm 0.2) \cdot 10^8$</td>
<td>$2.9 \cdot 10^8$</td>
</tr>
<tr>
<td>Cadmium</td>
<td>1989</td>
<td>$(1.33 \pm 0.09) \cdot 10^6$</td>
<td>$1.5 \cdot 10^6$</td>
</tr>
<tr>
<td>Potash</td>
<td>1989</td>
<td>$(1.54 \pm 0.09) \cdot 10^9$</td>
<td>$9.5 \cdot 10^9$</td>
</tr>
<tr>
<td>Phosphate rock</td>
<td>1989</td>
<td>$(8.1 \pm 0.4) \cdot 10^9$</td>
<td>$2.4 \cdot 10^{10}$</td>
</tr>
<tr>
<td>Thallium</td>
<td>1995</td>
<td>$(4.7 \pm 0.3) \cdot 10^2$</td>
<td>$7.6 \cdot 10^2$</td>
</tr>
<tr>
<td>Selenium</td>
<td>1994</td>
<td>$(1.1 \pm 0.14) \cdot 10^5$</td>
<td>$1.6 \cdot 10^5$</td>
</tr>
<tr>
<td>Zirconium minerals concentrates</td>
<td>1994</td>
<td>$(3.9 \pm 0.25) \cdot 10^7$</td>
<td>$6.7 \cdot 10^7$</td>
</tr>
<tr>
<td>Rhenium</td>
<td>1998</td>
<td>$(1.0 \pm 0.3) \cdot 10^3$</td>
<td>$3.3 \cdot 10^3$</td>
</tr>
<tr>
<td>Gallium</td>
<td>2002</td>
<td>$(2.5 \pm 0.5) \cdot 10^3$</td>
<td>$1.65 \cdot 10^4$ (?</td>
</tr>
</tbody>
</table>

Source: *Ugo Bardi and Marco Pagani*; [http://www.theoildrum.com/node/3086](http://www.theoildrum.com/node/3086)
World Uranium Production

Uranium demand according to IEA scenarios and possible supply from known resources

Supply deficit 2006-2020:
180 – 260 kt Uranium
Uranium Stocks:
appr. 200 kt Uranium

WEO 2006-Alternative Policy Scenario

WEO 2006 Reference Scenario

Constant Capacity as of 2005

Fuel demand of reactors

RAR< 130 $/kg: 3,236 ktU
RAR+IR< 130 $/kg: 4,743 ktU

Reasonably Assured Resources (RAR) < 40 $/kg: 1,947 ktU

1950 2000 2050 2100
Year

Source: Miquel Torres;
http://www.theoildrum.com/node/2379
Who’s Got the Uranium?

2007 Uranium Mining

- Canada: 23%
- Australia: 21%
- Kazakhstan: 16%
- Russia (est): 8%
- Niger: 8%
- Namibia: 7%
- Uzbekistan: 6%
- USA: 4%
- Ukraine (est): 2%
- South Africa: 1%
- Other: 3%
- China (est): 2%
World Oil & Phosphate Production versus World Population

From: http://www.theoildrum.com/node/2882 (Patrick Déry and Bart Anderson)
Why is Phosphorous So Important?

Original Source: Igneous Apatite
\[ \text{Ca}_5(\text{PO}_4)_3(\text{OH, F}) \]

The ATP Cycle

- Light (photosynthesis) or compounds with high potential energy (respiration)
- Adenosine triphosphate (ATP)
- Active region
- Adenosine diphosphate (ADP) + inorganic phosphate (P_i)
- Energy
- Synthesis of cellular macromolecules (DNA, RNA, proteins, polysaccharides)
- Synthesis of other cellular constituents (such as membrane phospholipids and certain required metabolites)
- Cellular movements, including muscle contraction, crawling movements of entire cells, and movement of chromosomes during mitosis
- Transport of molecules against a concentration gradient
- Generation of an electric potential across a membrane (important for nerve function)

Heat
Land Phosphate Resources: US lower-48

Appearance of Marine Phosphorites

- Phosphatized limestone, basalt-clast conglomerate, Hawaiian EEZ seamounts

- Phosphatic nodules, East Pacific

(Butt et al., 1987)

(McMurtry, 2001)
Global Marine Phosphorite Distribution

US MMS (1983)

Cronan (1980)
Peak Phosphorous: Island of Nauru

Ancient Seabirds’ Island Nesting => Guano
(Marine version of Ancient Bats’ Cave Nesting => Guano)
Peak Phosphorous: Island of Nauru

Use of Hubbert Linearization (HL) to Estimate Ultimate Recoverable Reserves (URR)

P = Annual Production (mass units)
Q = Total Production to Date

http://www.theoildrum.com/node/2882
(Patrick Déry and Bart Anderson)
Peak Phosphorous: USA

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Peak Phosphorous: USA

http://www.theoildrum.com/node/2882

(Patrick Déry and Bart Anderson)
Phosphate Rock--Years of Extraction Left Based Upon Present Reserves and 2% Annual Increase

Data source: USGS
From: EcoSanRes (2005)
Peak Phosphorous: World*

* Excluding offshore deposits.

http://www.theoildrum.com/node/2882

(Patrick Déry and Bart Anderson)
Global reserve estimates of phosphate rock (thousands of metric tons)

Data source: USGS
From: EcoSanRes (2005)
Peak Phosphorous: World*

* Excluding offshore deposits.

http://www.theoildrum.com/node/2882 (Patrick Déry and Bart Anderson)
US Energy & Minerals Policy?
Deer Caught in the Headlights?

“May you live in interesting times”…

Old Chinese blessing or curse?
Future of Hawaii

**Burdens**
- >1.2 million people living thousands of miles from the nearest land
- ‘Standing crop’ of >0.1 million tourists, >0.1 million military
- Small land area, with limited water resources
- Surrounding ocean waters are oligotrophic (biological desert)

**Advantages**
- Equitable climate, inspiring natural landscape & educated, cosmopolitan culture
- History of self-sustainability and export agriculture
- Geothermal, wind, biomass and OTEC/cold-water agriculture potential on Hawaii Island

**Disadvantages**
- Current reliance on all things imported, including most food, goods & energy
- AC high-rises, suburban sprawl & outmoded land transportation system
- Economic reliance on tourism, military & soon-to-be-extinct cheap airline industry
- Active volcanoes?
Conclusions

Peak Everything is not The End, but is certainly a warning “shot across the bow”.

We already live in a post-peak world for many commodities, e.g., mercury, gold, etc. These are scarce and expensive (valued), and heavily recycled.

Living with the effects of Peak Oil may be different, but only because we have foolishly allowed it and the other fossil fuels to heavily permeate our culture.

Besides not checking our general population growth, perhaps one of mankind’s greatest mistakes has been implementation of the “green revolution”, whereby we have unwittingly used fossil fuels to grow human populations well past the Earth’s finite carrying capacity. We are now in Overshoot (bad!).

Going forward, we will have to recycle, close open cycles, and learn to live within our means once again. We must “make other living arrangements”, and soon.

Peak Everything, Climate Change, and the Anthropocene Mass Extinction Event are all part of the same problem: Human Overpopulation & Over-Consumption
Hey, It’s a Finite Planet!
Recommended Reading

The Party's Over (2003, 2005) by Richard Heinberg
Power Down (2005) by Richard Heinberg
Peak Everything (2007) by Richard Heinberg
Hubbert's Peak (2001) by Kenneth Deffeyes
Beyond Oil (2005) by Kenneth Deffeyes
Out of Gas (2004) by David Goodstein
Twilight in the Desert (2005) by Matthew Simmons
Big Coal (2006) by Jeff Goodell

Related:
Overshoot: The Ecological Basis of Revolutionary Change (1980) by William R. Catton
Collapse: How Societies Choose to Fail or Succeed (2005) by Jared Diamond
The Long Emergency (2005) by James H. Kunstler