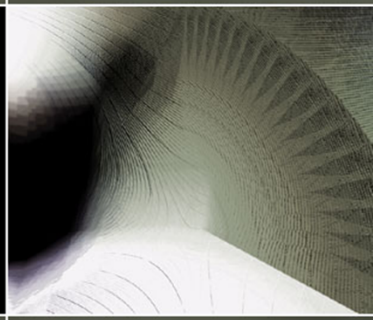
Mining



1. MINERAL RESOURCES

Introduction

Picture by User H, from Wikimedia Commons, CC license.

- **Minerals are natural materials with a characteristic composition, for example fluorite (shown) is mainly calcium fluoride (CaF_2).**
- **Since they often represent concentrated sources of particular elements or organic molecules, they provide the original raw materials (metals, acids, oil, etc.) for nearly all of manufactured products.**
- **They are extracted by mining.**

Mineral resources and human development

Bronze Age weapons. Picture courtesy of the Romanian govt. Public domain.

- **Human development has often been defined by the material resources being used – e.g., the Stone Age, Bronze Age, Iron Age.**
- **Even today, our world might be defined as the "Petroleum Age."**

The three Rs

- ***Reserve(s)*** **represent the "mineral resources that can now be economically and legally extracted."**
- **The *Reserve Base* has a reasonable potential for becoming economic within planning horizons.**
- ***Resources*** **(in this context) are natural concentrations of materials, for which extraction is economically feasible.**

Based on definitions found in Craig, Vaughn & Skinner

Abundant metals

Pictures from Metallium, Inc

- **Typically constitute >0.1% of the Earth's crust.**
- **Include iron, aluminum, silicon, manganese, magnesium and titanium.**
- **These metals are plentiful enough that the World's resources are still vast compared to human usage.**

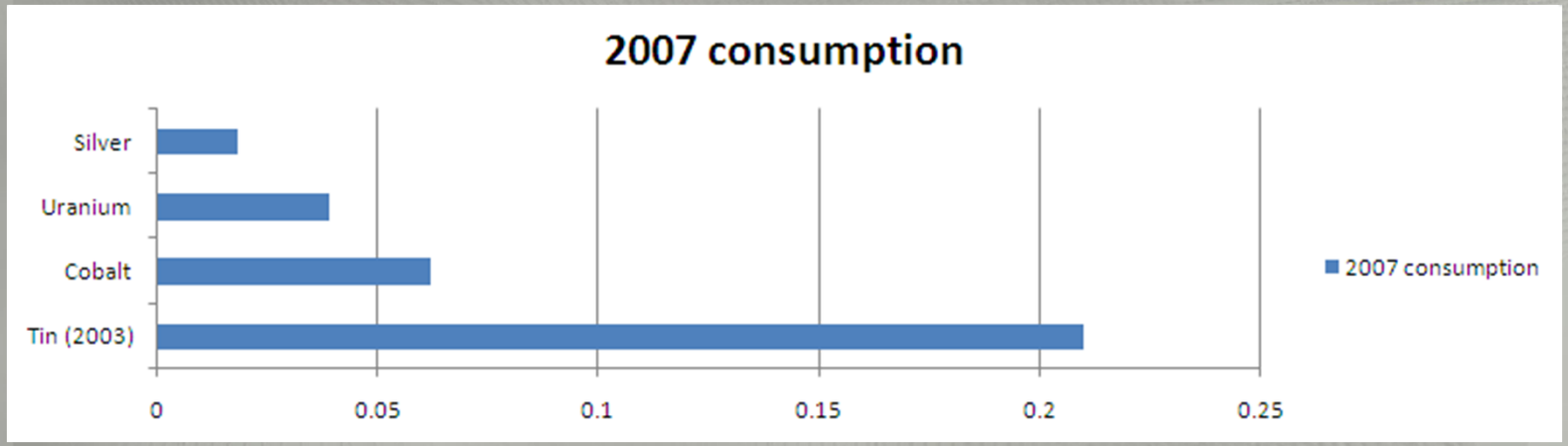
Scarce metals

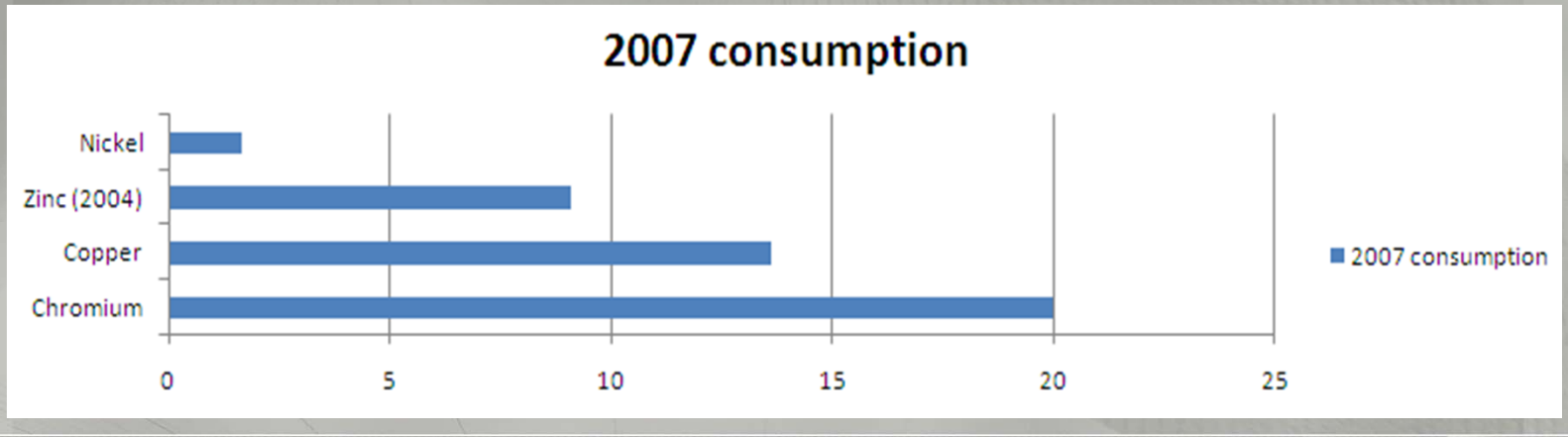
Pictures from Metallium, Inc

- Less than 0.1% of Earth's crust.
- Examples include copper, nickel, silver, molybdenum, lead, zinc, tin.
- It is possible for such metals that we could exhaust our current supply. This would most likely lead to a massive rise in price, as low-grade minerals become economic.

How fast are we using up our scarce metal resources?

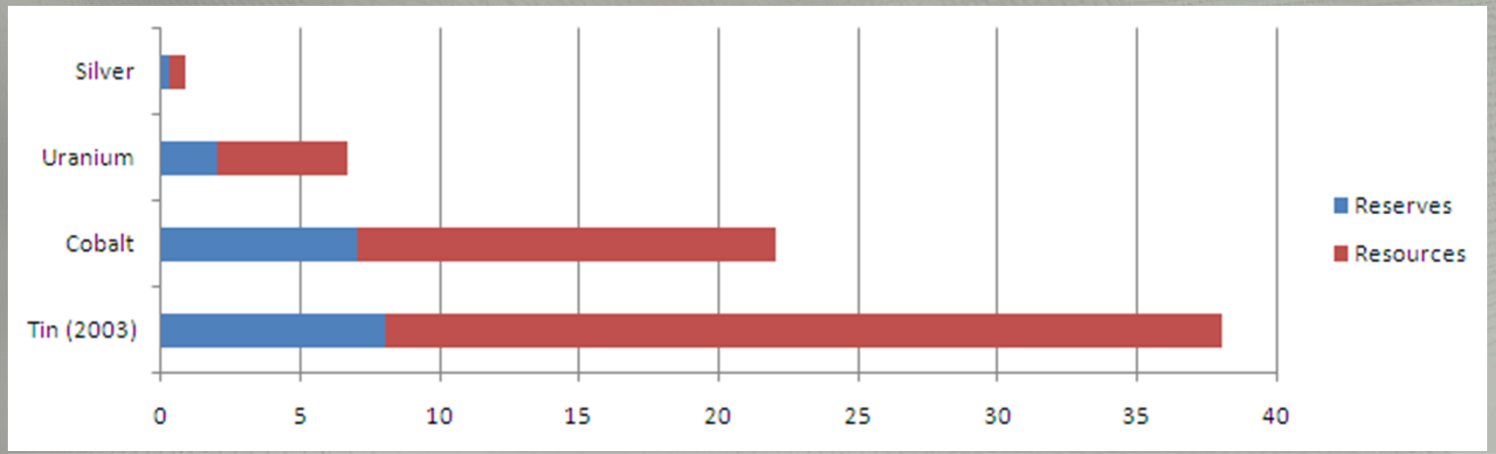
For eight typical scarce metals. Figures are in millions of tonnes/year.

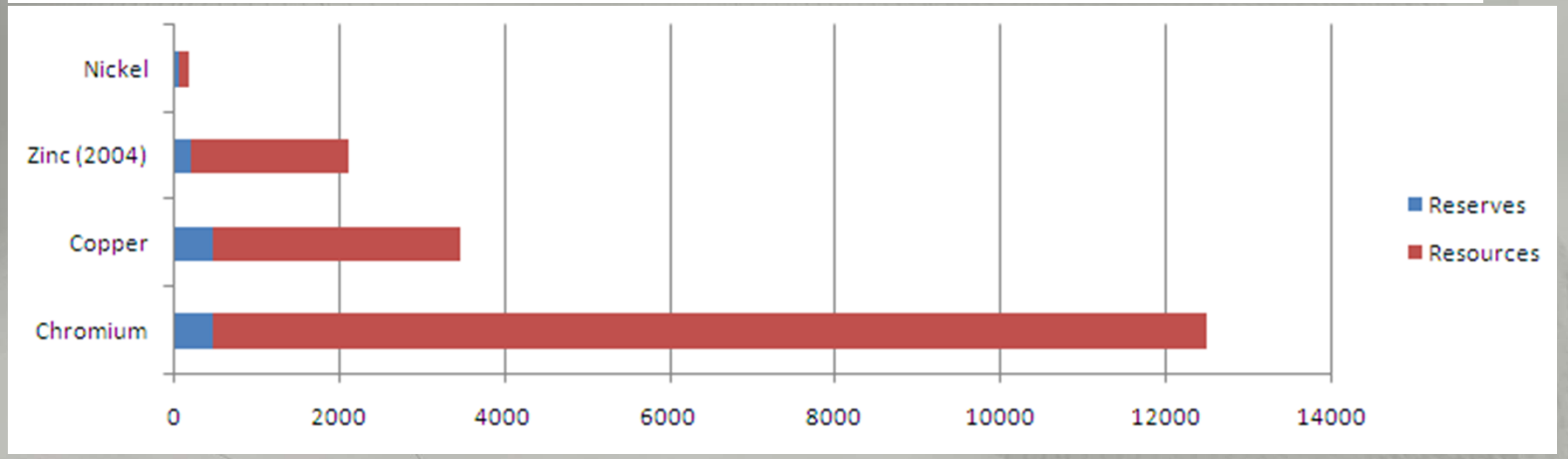




Scarce metals: Reserves and resources

Figures are in millions of tonnes

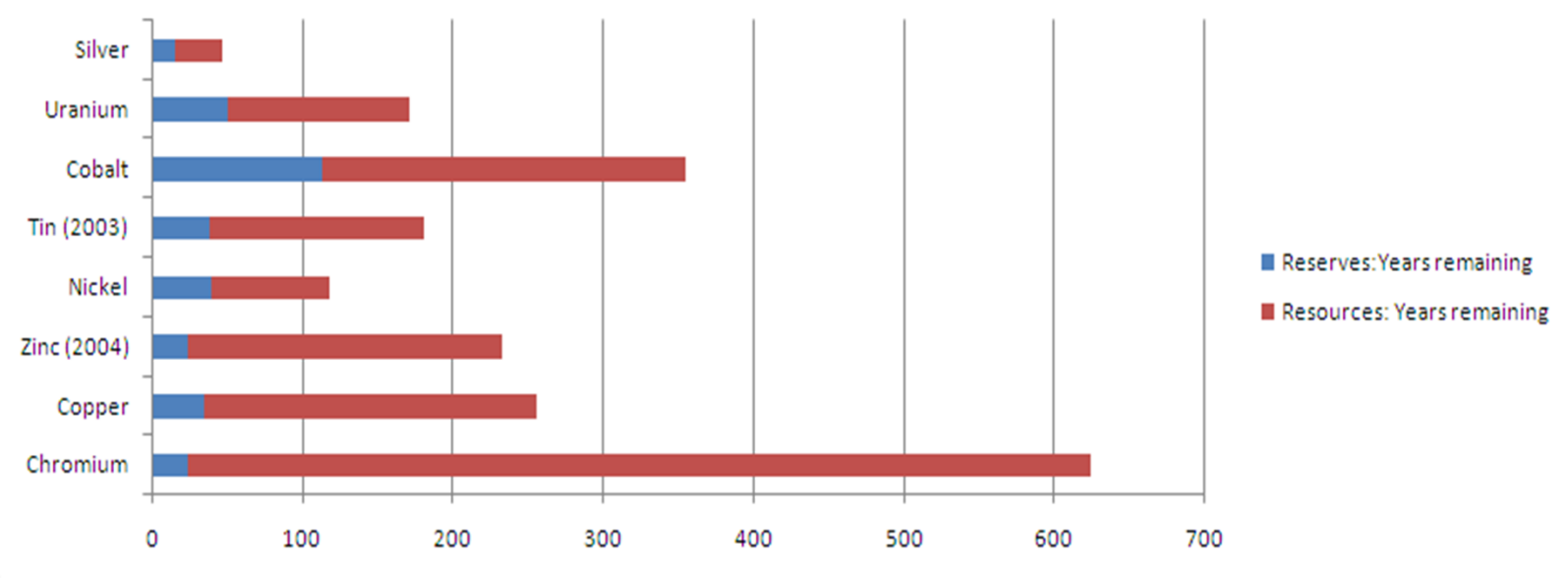




Graphs by Martin Walker, based mainly on USGS data

How long will these resources last?

- **Based on current consumption rates, there are adequate resources for most metals (except silver). However, if demand for certain metals rises dramatically, we could be in trouble…..!**



Graphs by Martin Walker, based mainly on USGS data

Petroleum, coal & natural gas

This "nodding donkey" is used to extract petroleum. Picture by US Dept. Energy.

- **Very important minerals, which we discussed earlier under "energy" in Unit 7.**
- **These are principally made up of carbon and organic compounds, principally hydrocarbons, so there is no metal to be isolated.**
- **Refined at oil refineries or chemical plants. Ultimately used as fuels, or as feedstock for chemicals & plastics. Coke is used in making steel.**

Alluvial deposits

A gravel pit in Rokitki, Poland.
Picture by Taw, GFDL license.

- **Sand and gravel are produced on a massive scale representing (for example) around two-thirds (by mass) of all mined materials in Canada.**
- **Typically produced by surface mining, they have lower waste than rock minerals, thought particulates can be an air pollution hazard.**

2. MINING

The life cycle of a mine

- ***Exploration*** **will involve use of geochemical/physical methods to locate ores, followed by drilling.**
- ***Development*****: Preparing the minesite.**
- ***Extraction*** **occurs at the mine.**
- ***Benificiation*** **occurs nearby, the bulk of the waste material ("gangue") is removed.**
- ***Refining*** **is often done elsewhere, to produce the pure metal or material.**
- ***Decommissioning*** **once the mine is exhausted.**

Extraction methods

- **Underground mining produces less waste rock than surface mining, but minerals are less accessible, and workers are at more risk.**
- **Non-entry mining methods are safer for workers, and may be used to reduce waste and surface disturbance, but they are only applicable in certain cases such as oil extraction or mining of sulfur.**

Benificiation

Spinning ore crushers from a gold mine In Alaska. Picture by Nick Bonzey, CC license

- Removal of other rock, near the mining site, is a key part of the process.
- Flotation is the widely-used method. This uses vast amounts of water, though much of this is recycled.
- Large amounts of waste (gangue) are produced, and sometimes these may be toxic.
- Waste heaps etc. may also be a safety hazard (e.g., the Aberfan disaster, which killed 145).

Refining

Molten steel at the Allegheny Ludlum Steel plant in PA, 1944. Picture from Lib. Congress.

- **Many processes involve pyrometallurgy – the metal is isolated using high temperatures.**
- **Much waste is produced in the form of solids (slag) or gases (which may be acidic gases or greenhouse gases).**
- **Other common methods such as hydrometallurgy (using water) also produce much waste (“tailings”).**
- **Many processes require consume much energy.**

Decommissioning

- The ore body will become exhausted – sometimes after >100 years, sometimes <10 years.
- Often it is impossible to return the site to its original condition.
- Slope stability and subsidence are a problem long after the mine has closed.
- There may be high concentrations of toxic materials remaining, preventing a simple return to use for agriculture or housing.

Conclusion

- **Mining and refining are an essential part of human civilization, providing all the materials we use every day.**
- **However, these industries also have a massive environmental impact in terms of land damage and waste. Often this is ignored, because few people see these industries regularly.**
- **Much can be done to reduce the environmental impact, by**
  - **Using full cost accounting methods to factor in the true costs of waste.**
  - **Promoting use of "green" technologies.**

Bibliography

- ***Resources of the Earth*, by James R. Craig, David J. Vaughan, Brian J. Skinner. Prentice Hall, 1988.**
- **Environmental Effects of Mining, by Earle A. Ripley, Robert E. Redmann, Adele A. Crowder. St. Lucie Press, Delray Beach, FL, 1996.**