Chapter 21 Economic Geology

Minerals and Mining

Mining brings in billions to the NL economy every year. Over 80% comes from two mines, the IOC Iron mine in Labrador City and the Vale Inco Nickel mine near Nain, also in Labrador. Oil and gas brings in billions as well, depending on the price of oil. The entire fishery of NL brings in approx. 1 billion a year.

The value of these resources depends on three factors:

1. **Production**: Obviously the more we produce, the more money we make.

2. **Global Commodity Prices**: These can fluctuate wildly with supply and demand. Since 2005 metal prices skyrocketed, then crashed in 2015. One reason for this was the practice in China of building Ghost Cities in order to meet GDP growth numbers. This required massive amounts of raw materials, which drove up prices. Oil and gas prices plummeted in 2015 because there is now more oil being produced than the world consumes.

3. **Canadian dollar**: Commodities are priced in US Dollars. If the CDN dollar is low, this actually helps the resource sector because we get more Canadian dollars when we sell our resources to the world. This chapter will focus on the formation of ore minerals, locating them, processing them, and their uses.

There are four main ways of **Mineral Formation**:

1. **Magmatic Segregation** (Gravitational Settling) Settling of metallic compounds in a magma body. Nickel, Copper, Iron etc Sulfide minerals

2. **Hydrothermal Deposits** Hot water near magma chambers dissolves metals and concentrates them in veins. Gold, Silver, Platinum, Copper...
(3) **Placers** Running water concentrates dense minerals in sand bars or beaches. Gold, Platinum, Diamonds.

(4) **Weathering** Chemical weathering concentrates minerals. Usually in the tropics. Aluminum, Iron, Copper. . .

I. Magmatic Segregation: Nickel and Copper

- **I. Magmatic Segregation** aka Gravitational Settling:
  - Magma bodies contain some economic metals
  - These tend to crystallize early and sink to the base of the magma chamber.
  - When cooled, the top part is silicate rock, the base is metal ore rich.
  - Over time, erosion and isostatic lifting remove the top and the former base is revealed at the surface.
  - This is how the Voiseys Bay nickel-copper sulfide ore formed in Labrador 2 billion years ago.
  - Erosion has been lifted to the surface as the rock above it eroded away.
  - The two guys who discovered it got 500 million from Inco (in 1990s dollars)
Nickel (Voisey’s Bay)

I. Nickel sulfide deposits
   • Magmatic Segregation
     (Gravitational Settlement) (Gravity Separation)
   • Stage 1: Metal-rich magma
     dense metal sulfides sink
     as magma cools, metallic compounds form
     crystals of nickel sulfide (and others) sink to the bottom, making the base of the magma chamber metal-rich

Stage 2: Erosion & Uplift
   • The base of the pluton is several km below surface.
   • Over billions of years, the surface erodes, removing weight. The crust rises up in response.
   • Eventually the ovoid-shaped metallic ore deposit is exposed at the surface.
   • Discovery of Voisey’s Bay by Chislett & Verbiski
     30 billion dollars worth of nickel

Erosion

Nickel sulfide ovoid

Uplift

1 billion dollars per year of Nickel
II. Hydrothermal Deposits: Gold, Silver

- Superhot water dissolves mucho minerals
- Flows into cracks, cools, minerals precipitate, filling the cracks = Veins
- Usually Quartz, sometimes Gold, Silver, etc.

Ore Veins

- Rock is fractured
- Need magma body
- Water in rocks heats up to 900°C
- Stays liquid!
III. Placer Deposits: Gold, Diamonds

Earth Systems: Gold

Hydrothermal Deposits

Placer Deposits:

• form in rivers
• heavy minerals are concentrated by moving water.
  (basalt, sand, gold, platinum, diamonds)
• you "pan" for the minerals.

• this gold must have eroded from somewhere

The Mother Lode

• the source of river gold
• look for quartz veins in the mtns. These are hydrothermal deposits.
• magma superheats water which dissolves minerals from rocks, find cracks, minerals precipitate in the cracks forming veins.

Quartz, gold, silver, platinum.
3. Placer Deposits

- When moving water “places” dense minerals in river banks, stream beds, beaches.
- Gold, silver, diamonds all very dense.
- If you can trace the source of the placer sediment to its source, you will find the Mother Lode!

Note: All gold was created in the supernova that preceded our solar system.
- It is concentrated by superhot fluids in folded mountain chains.
IV. Weathering: Iron

Banded Iron Formations
The story of iron ore is linked to the evolution of complex life in the Pre cambrian.

1. The Archaean
   - 4.0 by – 3.0 by ago
   - bacterial life evolves in the oceans
   - there is no oxygen in the atmosphere or oceans.
   - life couldn’t live in the presence of oxygen.
   - the oceans were full of dissolved iron, coming from undersea volcanoes.

2. The Proterozoic
   - 3.0 by – 2.0 by
   - photosynthetic bacteria evolve. They create their own food & release oxygen gas as a by-product.
   - huge colonies of cyanobacteria live in the shallow waters of continental shelves.
   - as they release oxygen, it reacts with iron producing iron oxide which settles out on the sea floor.
   - by 2.0 years, most of the iron is gone, forming Banded Iron sediment.
   - oxygen begins to build up in the oceans & atmosphere allowing complex life to evolve & creating an ozone layer against UV radiation.

This is where the huge iron ore deposits of Labrador & Australia (4 others) came from.
Weathering: Iron (continued)

May 17 GABCD
Industrial Metals:
I. Banded Iron Formations

- p. 593-594
- all formed \( \approx 3-2 \) billion yrs ago in shallow sea sediments.
- iron oxides (hematite) has a biological origin.

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Lab City / Wabush
- huge iron ore deposit

3 BY ago, life was bacterial, no \( O_2 \) in oceans or atmosphere.
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Then photosynthetic bacteria evolve

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\begin{align*}
\text{CO}_2 + \text{H}_2\text{O} & \rightarrow \text{O}_2 \\
& \rightarrow \text{sugars}
\end{align*}
\]
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- combined with iron dissolved in oceans \( \Rightarrow \) iron oxide
- layers of iron oxide.
- after this period, \( O_2 \) begins to fill the oceans & atmosphere.
- complex organisms evolve
- ozone layer forms, \( O_3 \) protects us from UV Radiation.

“Battle of the Bands”
Thurs. May 17th.
Get Tickets!
Weathering: Aluminum

Aluminum Ore - Bauxite Al(OH)₃ "aluminum hydroxide"

- the world's most common metal
- formation & refinement
  I. Secondary Enrichment
  - occurs in the tropics where soil is thick & high temp & rainfall leads to high rates of chemical weathering.
    - either: valuable minerals are dissolved (leached) to lower levels and deposited
    - or: jink is leached away leaving good stuff behind ⇒ aluminum

- Refining, any process that purifies the metal once it's extracted from the ore.
  - Heap leaching allowing acid to run thru ground up metal ore. The acid leaches out the metal for collection.
  - Floatation metals stick to bubbles in a chemical bath.
V. Kimberlite Pipes: Diamonds

May the fifth be with you
Day 7 CD E FG Tuesday

Diamonds (C)

I. Formation
- hundreds of km down, heat & pressure recrystallizes graphite (Carbon) into diamonds
- all diamonds are billions of years old

II. Ore Formation
- super-fluid magma transports diamonds in volcanos
- the eroded volcanic necks are made of

Kimberlite which is a carrot-shaped igneous rock
- mines are circular & deep

III. Placer Deposits
- over billions of years, erosion transports diamonds to river sediment or glacial sediment
- diamonds are dense crystals

IV. Exploration
- by tracking the paths of glaciers or rivers which deposited diamonds, it's possible to find the Mother Lode, the source Kimberlite Pipe
- almost always in ancient shield rock
- NWT, Australia, South Africa
- eroding for billions of years
VI: Copper Smelting

Earth Systems
"Iceman of the Alps"

1) Radio carbon dating
   - using C14 in organic remains, comparing to living things, to calculate years since death.

2) Flint tools
   - sedimentary rock of compressed silica shells, it's basically Quartz.

3) Agriculture
   - began ~ 10,000 yrs ago
   - spread to Europe from the Middle East ~ 9500 yrs ago.

4) Smelting
   - process of separating metals from the mineral ores they're found in.
     - Native copper was first metal used for tools.
     - "Malachite" copper Carbonate CuCO3 first ore smelted on Earth.
     - temps > 1100°C decompose CuCO3 into copper & gases.
     - 4000 B.C. "Copper Age"
Day 4 BCDEF
Monday June 2

- Smelting any process that separates metal from ore into its
  heat, chemicals, electricity.
- Copper forms in hydrothermal veins (like quartz)
  resists rusting in salt water.
  anti-microbial resists growth of algae, fungus & barnacles.

- Found as a Native Element in veins.
- First metal used in tools & weapons.
- 3500 B.C. addition to get Bronze (an alloy, mixture of metals)
- Refining purifying the metal
- Heap leaching letting acid run thru ore to dissolve the metal into a solution.
- Floatation a chemical soup causes copper to stick to bubbles, which is scooped off.
- Electrefining using electricity of acid solutions.