Uses for Uranium

Historic Uses

Coloring agent (glass)

Research on radioactivity (pitchblende)

• Led to discovery of Po, Ra

• Half-lives

• Atomic structure

– Protons, Neutrons, Electrons

• Theories on nuclear energy

– Electricity

– Weapons
The Uranium Industry

• The Manhattan Project
  – Germany was pursuing nuclear weapons
  – FDR authorized the Project with cooperation between:
    • Government
    • Military
    • Academia
    • Private Industry
  – Results:
    • End of WW II
    • Basics of infrastructure for nuclear power industry
Valuable properties of Uranium

• Radioactive
  – Isotopes:
    • $^{238}\text{U}$ – 99.275 % of naturally-occurring U
    • $^{235}\text{U}$ – 0.720 %
    • $^{234}\text{U}$ – 0.005 %
  – Spontaneous fission Ė neutrons & gamma radiation
    • Chain reactions Ė nuclear-powered electricity

• Dense metal
Uses for Uranium

• Radioactivity-based applications:
  – Nuclear weapons
  – Nuclear power for naval vessels
    • Technology for nuclear-powered civilian electricity
  – Medicine
    • TEM
    • Staining viruses, organelles & macromolecules
  – Geochronology

• Density-based applications:
  – Shielding
    • Armor
    • Radioactivity containment (depleted uranium)
  – Projectiles
    • Armor-piercing bullets, etc.
  – Ballast
History of Uranium discoveries in Wyoming

• ~1918 Radium ore (research) – Silver Cliff Mine, Lusk, WY
• 1930: Minnie McCormick found a yellow mineral in the Lost Creek area north of Wamsutter (Schröeckingerite)
• 1949: North of Sundance, WY, in Cretaceous sandstones
• 1951: Uranium found in Tertiary sandstone at Pumpkin Buttes (J.D. Love)
• 1953: Uranium discovered in Tertiary sandstone at Gas Hills, Wind River Basin (Neil McNeice)
• 1953: Crooks Gap
• 1955: Uranium discovered in Shirley Basin by Teton Exploration
• 1956: Little Mountain, northern Bighorn Range
Uranium
(*Physics and Radioactivity*)

- Radiation –
  - Transfer of energy as waves or particles

- Radioactivity –
  - Measurement of radiation
  - Radioactive decay

- Nuclear Radiation –
  - Produced by radioactive decay
Nuclear Radiation

- $\alpha$ – Alpha (particle)
  - 2 protons
  - 2 neutrons
    - Can be stopped by sheet of paper or plastic wrap

- $\beta$ – Beta (particle)
  - 1 electron
    - Relatively low energy
    - Can penetrate ~ 1” of wood (very low mass)

- $\gamma$ – Gamma (wave)
  - Electromagnetic radiation, similar to X-rays
    - High energy (v. small wavelength)
    - Can penetrate ¼” of lead or 3’ of concrete
Nuclear Radiation

• Fission of Uranium releases:
  – Particles
  – Gamma radiation

• @ Critical mass of $^{235}\text{U}$
  – Chain reaction – one fission releases particles which then initiate more fission
  – Controlled Chain Reaction creates the energy to fuel nuclear power plants
    • $\geq 3\%$ $^{235}\text{U}$ in nuclear fuel rods
    • ($\geq 85\%$ $^{235}\text{U}$ in nuclear weapons)
Geology of Uranium Deposits

Concentration Of Uranium

Mantle

Granite

2nd generation melt

Fractionation

Basalt

Fractionation

Mantle

Melting

Time
Geology of Uranium Deposits

- Uranium Deposits
  - Breccia Deposits
- Recent
- Paleozoic
- Mesozoic
- Lower Proterozoic
- Middle Proterozoic
- Volcanic-hosted Deposits
- Vein Deposits
- Granite Intrusion
- Metamorphic Rocks
- Archean
- Conglomerate Deposits (paleoplacer)
- Unconformity Deposits
- Sandstone Deposits
- Quartz Pebbles
- Pyrite
- Uraninite
- High-Grade Ore
- Disseminated Ore
- Limit of Altered Rock
- Graphite
- Reduced
- Oxidized
- Iron oxide
- Pyrite
- Roll Front
- Humate Type
Conglomerate Deposits (paleoplacers)

- Concentrations of heavier sediments in an oxygen-free environment
- Most are derived from Archaean & Paleoproterozoic granitic orogenies
- Sediments transported from highlands to alluvial fans, stream beds, basins
- Examples:
  - Elliot Lake, Blind River, Ontario
  - Witwatersrand, S.Africa
Unconformity Deposits

- Highest grade
- Occur at boundary between basin sediments and underlying basement rocks
- 3 main deposition events
  - $\sim 1350 - 1050$ Ma
  - $\sim 890 - 820$ Ma
  - $\sim 380$ Ma
- Examples
  - Athabaska Basin (Rabbit Lake, McArthur River, Cigar Lake, etc., etc., etc., Saskatchewan/Alberta, Canada)
  - Aligator River, Jabiluka, etc., N.T., Australia
Sandstone-hosted Uranium Deposits

• Very high tonnage but lower grade (compared to unconformity type)

• U transported by ground water

• U deposited as water encounters a reducing environment (organic matter or gas, sulfide minerals)

• Drop in pH results in precipitation of U minerals in pore spaces.
Prerequisites for a Sandstone U Deposit

1) Source of U
   - Precambrian basement rocks?
   - Tertiary volcanic ashes and tuffs?
   - Combination?

2) Coarse sands with good porosity and permeability

3) Ground water flow (naturally oxygenated) – ideally channelized, high rate of flow

4) Reduction zone – heavy mins., organic matter
Uranium Deposit host Rocks
Wasatch Formation - PRB
Wind River Formation, Puddle Springs Member – Gas Hills
Wind River Formation
Shirley Basin
Battle Spring Formation
Great Divide Basin
Roll Front Ore Deposit Development

- Oxidized (high pH) $\text{H}_2\text{O} + \text{Uranium}$
- Reducing Environment (low pH)
- Altered (oxidized) rock
- Unaltered Uranium-Mineralized rock
- Impermeable Shale
- Groundwater
- Time
Geography of U Deposits - globally
Geography of U Deposits – USA

- States with mineable resources
- States currently producing $\text{U}_3\text{O}_8$
Geography of major U Deposits – USA
Wyoming Uranium Districts
Wyoming Uranium Deposits (historic production)
Possible Future Production
(in various stages of permitting)
Uranium Mining Methods

1. Surface Pit
2. Underground
3. In-situ Recovery (ISR)
ISR – Header House

INJECTION
($H_2O + CO_2, O_2$)

PRODUCTION
($H_2O + U$)

To ion exchange facility and mill
ISR – yellowcake processing

- Ion exchange columns (+ soda ash)
- Resin recharge (+ salt)
- Elution tanks (add acids, hyd perox)
- Precipitation (adjust pH to precip)
ISR – yellowcake processing

Settling tank

Filter press

Dryer

Loaded barrels ~ 700 lb
Thank You