Introduction to Manitoba Geology
A journey through geological time

Presentation to:
Mining Matters 2010
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THE MAN WHO COULD NOT SUMMARIZE

IT ALL STARTED 4.53 BILLION YEARS AGO DURING THE HADEAN EON.

I HOPE YOU DON’T MIND IF I SKIP OVER THE PART WHERE THE EARTH FORMED BY ACCRETION FROM THE SOLAR NEBULA.

HOURS LATER

AND THAT FORMED WHAT WE CALL THE MOON.

... AND THAT FORMED WHAT WE CALL THE MOON.

MAYBE I’LL JUST ASK SOMEONE ELSE WHAT TIME IT IS.
Manitoba Geological Survey

50 staff; 26 geologists

Visit us on the Internet (www.manitoba.ca/minerals)
Manitoba Geological Survey

1. Regional and detailed geological investigations to support mineral and hydrocarbon exploration in the province

2. Geoscience information for decision-making (e.g., land use planning, protected areas)

3. Outreach and education

Mapping in northern Manitoba

Mapping in southern Manitoba

Working with First Nations
Geology of North America
US Geological Survey

PRECAMBRIAN

Ma
Present in Manitoba:

Cordillera
Nada Sedimentary Basin
Precambrian Shield
Usually, when we go down through the Earth's rock layers we are going back in time.

Horizontal scale: 100 kilometres
Vertical scale: 500 metres (0 is at sea level)
(200x vertical exaggeration)
**Precambrian Shield**
- Crystalline rocks >1.5 billion years old
- Host of Manitoba’s metallic mineral deposits

**Phanerozoic**
- Sedimentary basins <500 million years old
- Host of Manitoba’s petroleum resources, aggregate and industrial minerals
Mineral production in Manitoba

**Nickel/Cobalt** (Vale, Crowflight)
- Thompson Mine
- Birchtree Mine
- Bucko Mine
  - 24% of Canadian Ni production
  - 16% of Canadian Co production

**Copper/Zinc** (HudBay Minerals Inc.)
- Callinan and 777 mines
- Trout Lake Mine
  - 10% of Canadian Cu production
  - 11% of Canadian Zn production

**Tantalum/Cesium** (Tantalum Mining Corp. of Canada Ltd.)
- Tango Mine

**Gold** (San Gold Corporation)
- Rice Lake Gold Mine
Formation of the Earth

- **Precambrian**
  - Hadean
  - Archean
  - Proterozoic
  - Phanerozoic

- **Present in Manitoba:**
  - Present day

**4,600,000,000** years of earth history

- 4 periods or **Eons**
- Manitoba geology records significant portions of this extensive history
- Each Eon has a distinct mineral endowment

**Ma = million years (ago)**

1000 million years = 1 billion years

(e.g., 1500 Ma = 1.5 billion)
Zircons are tiny mineral crystals that occur in many rocks. Zircon contains trace amounts of uranium and thorium and can be dated by a variety of analytical techniques.

Precambrian Time

- The Earth formed as a solid planet
- Earth’s interior organized into layers
- Early crust formed but was largely recycled or destroyed by rapid convection and numerous meteorite impacts
Archean Eon: Formation of Crust
3800 – 2500 Ma

- Earth's permanent crust was formed
- First large continents formed
- Earliest life forms began
- The oceans and atmosphere resulted from volcanic out-gassing
• Very early crust formed (3500 Ma). Locally contains indications of very old rocks (3900 Ma)

Remnants of early crust

Seal River

Granite gneiss

3.5 billion years old
Archean pillow lava, Cross Lake

Modern pillow lava on the sea floor

Archean Eon in Manitoba

Formation of pillow lava

"Greenstone belts" – widespread volcanism (3000-2720 Ma)

Volcanic eruption under the sea

NOAA, courtesy of Richard Pyle at Lava Video Productions
Archean Eon in Manitoba

- Laurentian orogeny (mountain building) (2730-2700 Ma)
- Granite plutonism and assembly of a large Archean continent (Superior “craton”)
- Many large gold deposits formed (e.g., Rice Lake mine in Bissett)
Proterozoic Eon: Modern Earth Processes Begin

2500 – 542 Ma

- Modern plate tectonics started
- Large mountain chains formed as the Archean continents collided
- Photosynthesis lead to oxygenated atmosphere around 2200 Ma
- Soft-bodied life forms proliferated (no skeletons)

Ediacaran Fauna (600-545 Ma)

Present in Manitoba:
- Subduction and island arc volcanoes

Mid-ocean rifting

NOAA
Proterozoic Eon in Manitoba

- 2500-2000 Ma: opening of a large ocean basin with basin-margin "shoreline" sediments laid down
- Subsequent (1885 Ma) emplacement of nickel deposits

Rifting

>500 million-year time gap

Proterozoic quartzite

The greenstone belts in the Trans-Hudson Orogen of Manitoba and Saskatchewan have produced more than $60 billion in metals (at 2010 prices) - making them some of the most productive greenstone belts in Canada.
Underwater eruptions produce distinctive volcanic deposits that can be recognized in ancient greenstone belts.
Proterozoic Eon: copper-zinc-gold deposits

Massive sulphide mound

http://gsc.nrcan.gc.ca/mindep/synth_dep/vms/index_e.php
Proterozoic Eon: copper-zinc-gold deposits

Massive sulphide mound

Zinc ore, Snow Lake

Copper ore, Flin Flon

http://gsc.nrcan.gc.ca/mindep/synth_dep/vms/index_e.php
Proterozoic Eon in Manitoba

- 1830-1780 Ma closing of ocean basin and formation of the Trans-Hudson Orogen (mountain belt)

http://mafecarr.blogspot.com/
Comparison of the Trans-Hudson Orogen with a modern orogen (mountain belt)

Manitoba

Trans-Hudson Orogen (1830 – 1800 Ma)

Superior Craton

Alpine-Himalayan Orogen (< 50 Ma)
Phanerozoic Eon:
Modern Earth and Life Forms Evolve

- Life forms with skeletons proliferate
- 8 major life extinction events
- Continents separated and then collided again to form more mountain chains
- North America and Manitoba as we know it were formed.
Paleozoic Era in Manitoba
542 – 251 Ma

- Preceded by a long period during which the Precambrian was eroded flat
- Manitoba was located near to the equator
- Shallow inland seas flooded North America
- Valuable deposits of high-calcium limestone, potash, building stone and oil
Paleozoic Era in Manitoba

Maclurites (gastropod)

Early Paleozoic diorama

Receptaculites

Maclurites (gastropod)

Gastropods and cephalopods

World's largest trilobite – from Churchill

Graham Young
Paleozoic Era in Manitoba

Upper Devonian reef diorama

Mesozoic Era in Manitoba

251 – 66 Ma

- Preceded by period of erosion

Horizontal scale: 100 kilometres

Vertical scale: 500 metres (0 is at sea level)
Mesozoic Era in Manitoba

- Periodically flooded by shallow inland seas
- Ended by a meteoric impact and major extinction event
Cenozoic Era
66 – 0 Ma

Phanerozoic Eon

Paleozoic Era
Mesozoic Era
Cenozoic Era

542 251 66 0
Million of years ago

Glacial retreat
In N America

Quaternary
Cenozoic Era

66 – 0 Ma

Dr. Ron Blakey, NAU Geology - http://jan.ucc.nau.edu/~rcb7/
Cenozoic Era
The Ice Age(s)

Paleogeographic reconstruction during deglaciation

Ice age diorama
The last glacial period resulted in the deposition or modification of the landscape features we see today.
Cenozoic Era

The modern landscape

Figure 4. Subglacial delta model, after Alley et al. (1989).
Cenozoic Era

The modern landscape

- In the Red River Valley, it is still possible to see the scars left in the former lake bottom of Glacial Lake Agassiz.
Conclusion

- Geological processes have shaped (and reshaped) Manitoba over nearly 4 billion years of Earth history
- Our geological heritage impacts our daily life
  - Resources we use (e.g., metals, oil, aggregate, groundwater)
  - Landscape we live in
Contact us

• The Manitoba Geological Survey is a public resource, available for anyone to use
• We can answer questions about rocks, minerals, how landscapes developed, and what exploration activity is going on in the province
• Call us at: 1-800-223-5215
• Or e-mail: minesinfo@gov.mb.ca