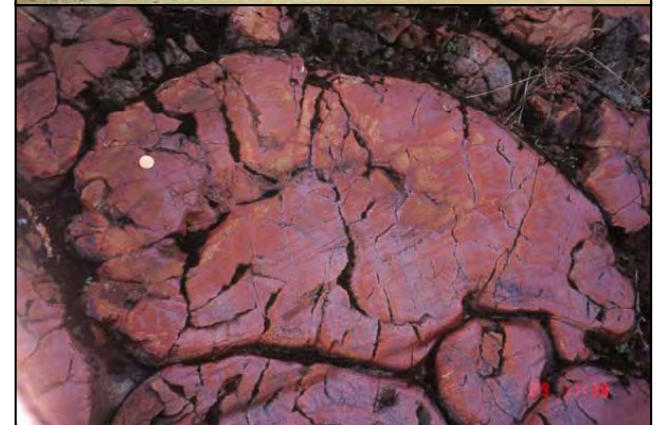


Introduction to Manitoba Geology

A journey through geological time

Presentation to:
Mining Matters 2010
By: Jim Bamburak
Industrial Minerals
Geologist

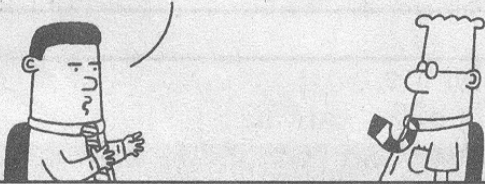
Prepared by: Ric Syme
Director
Manitoba Geological Survey



DILBERT

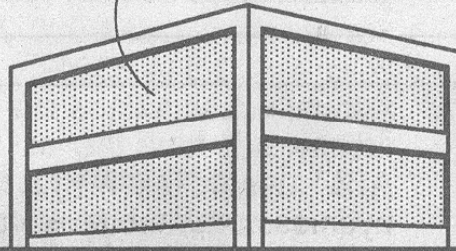
THE MAN WHO COULD NOT SUMMARIZE

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



Dilbert.com DilbertCartoonist@gmail.com

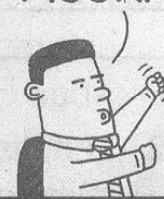
I HOPE YOU DON'T MIND IF I SKIP OVER THE PART WHERE THE EARTH FORMED BY ACCRETION FROM THE SOLAR NEBULA.



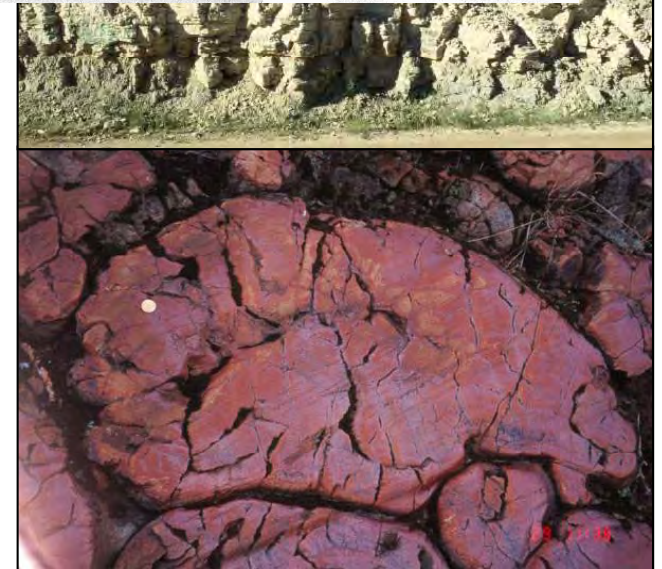
11-17-10 © 2010 Scott Adams, Inc./Dist. by UFS, Inc.

HOURS LATER

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



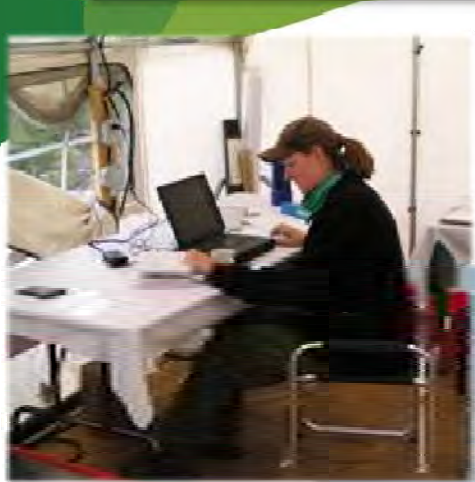
MAYBE I'LL JUST ASK SOMEONE ELSE WHAT TIME IT IS.



Manitoba 

Manitoba Geological Survey

50 staff; 26 geologists



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

50 staff; 26 geologists

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



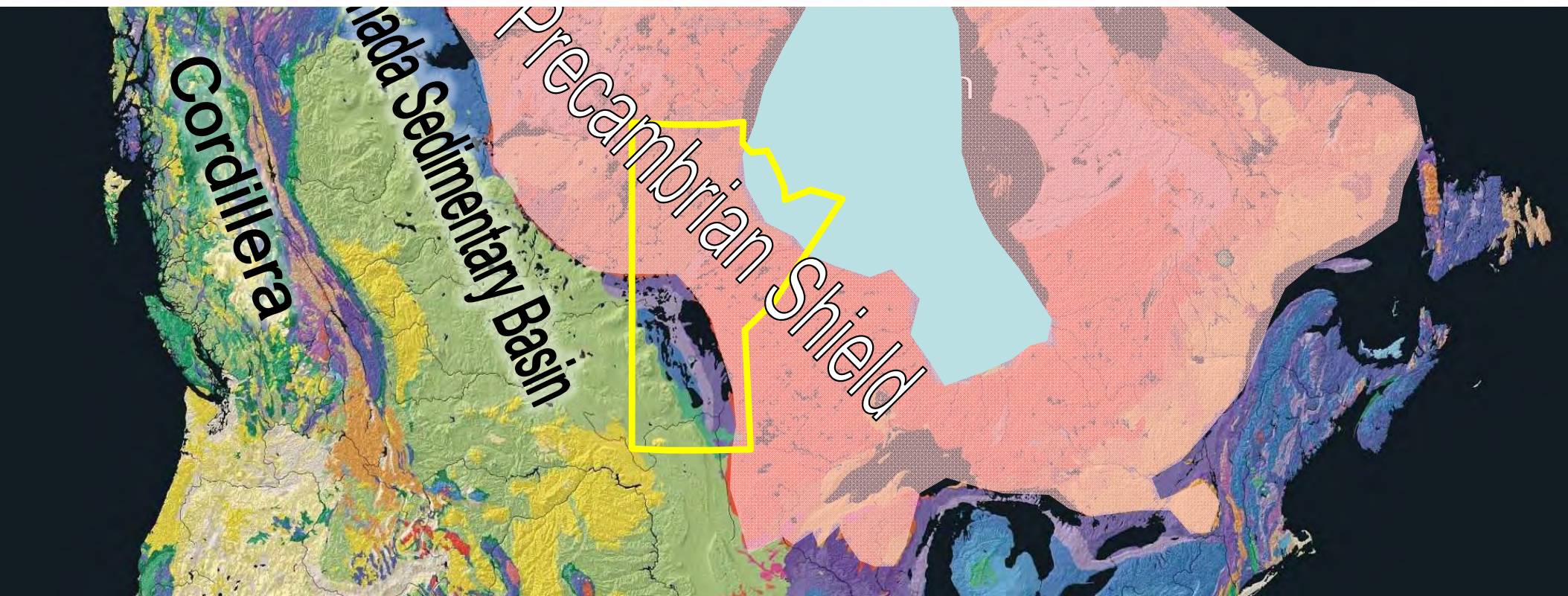
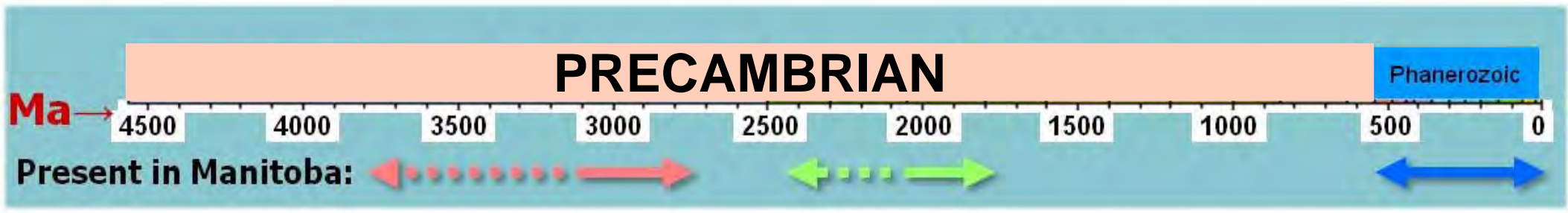
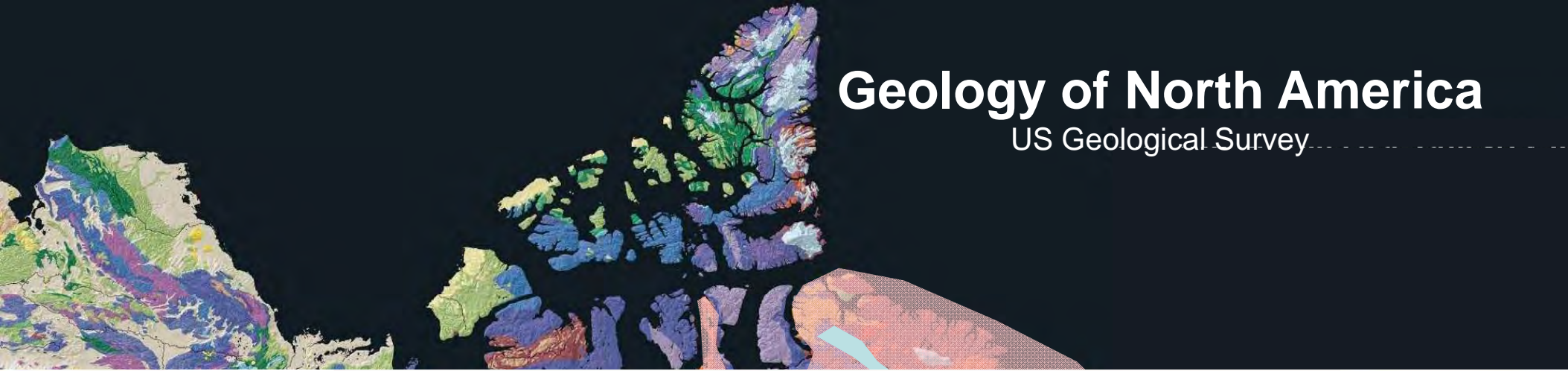
Mapping in southern Manitoba



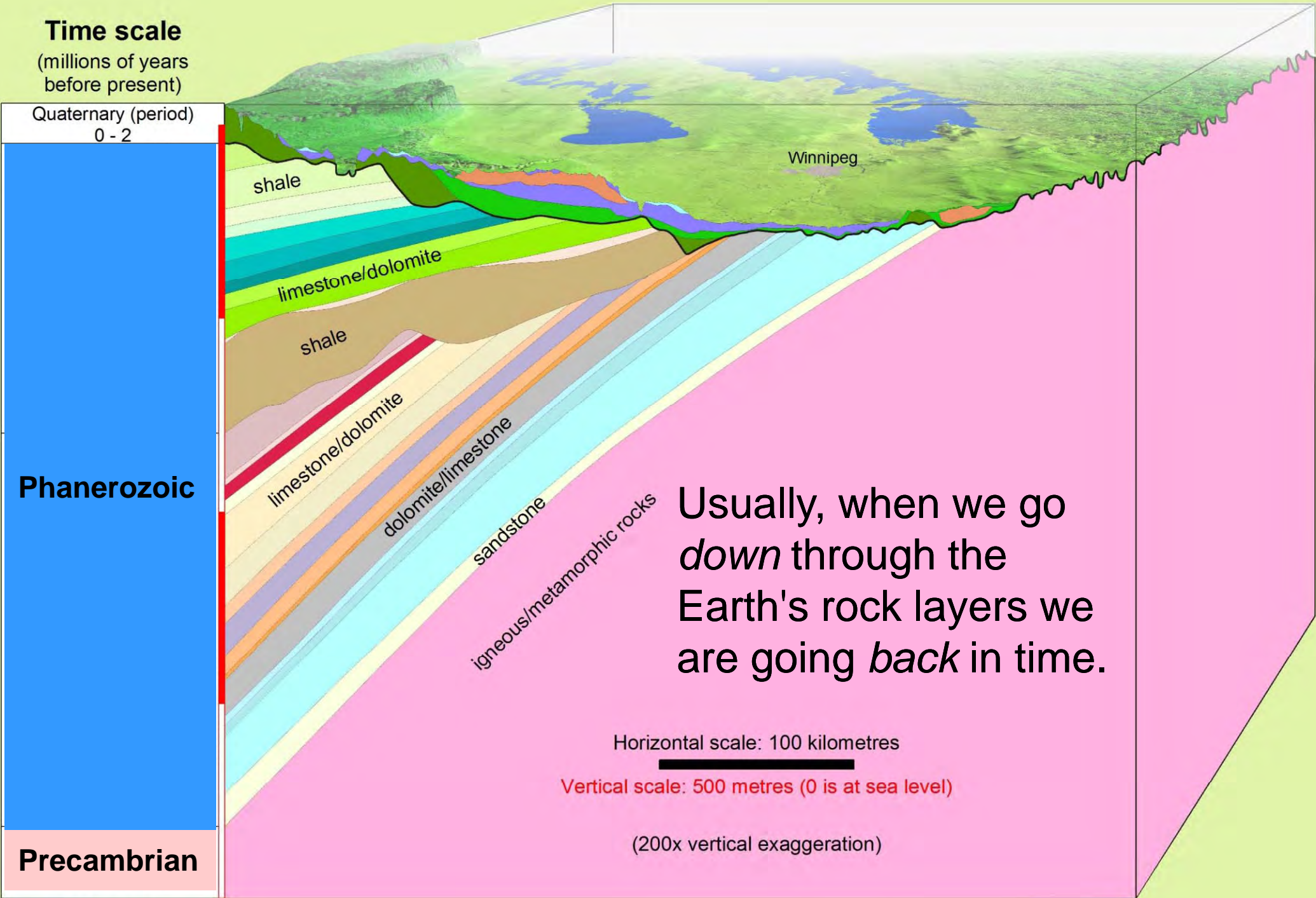
Working with First Nations

Geology of North America

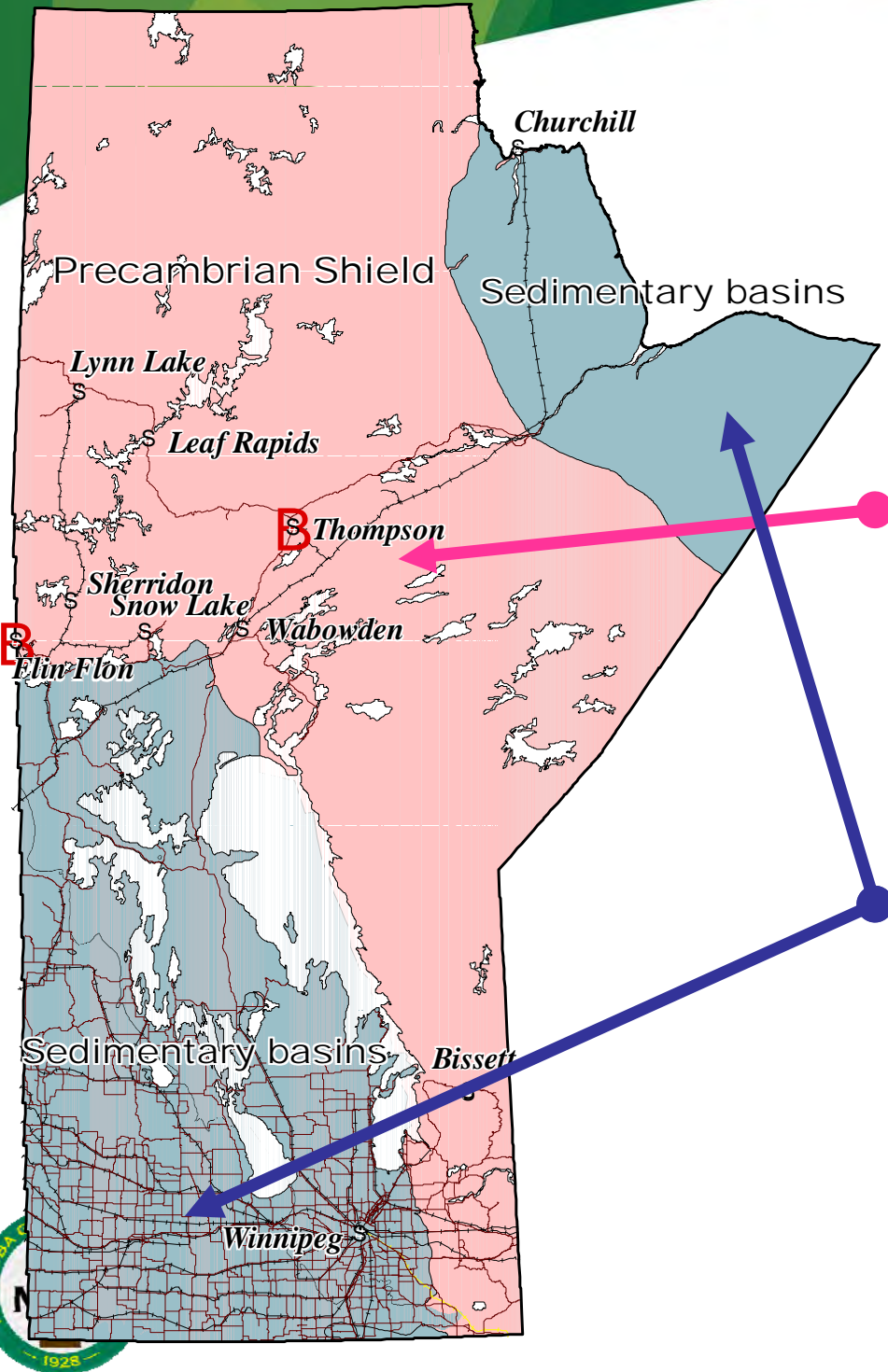
US Geological Survey



The third dimension



Manitoba geology



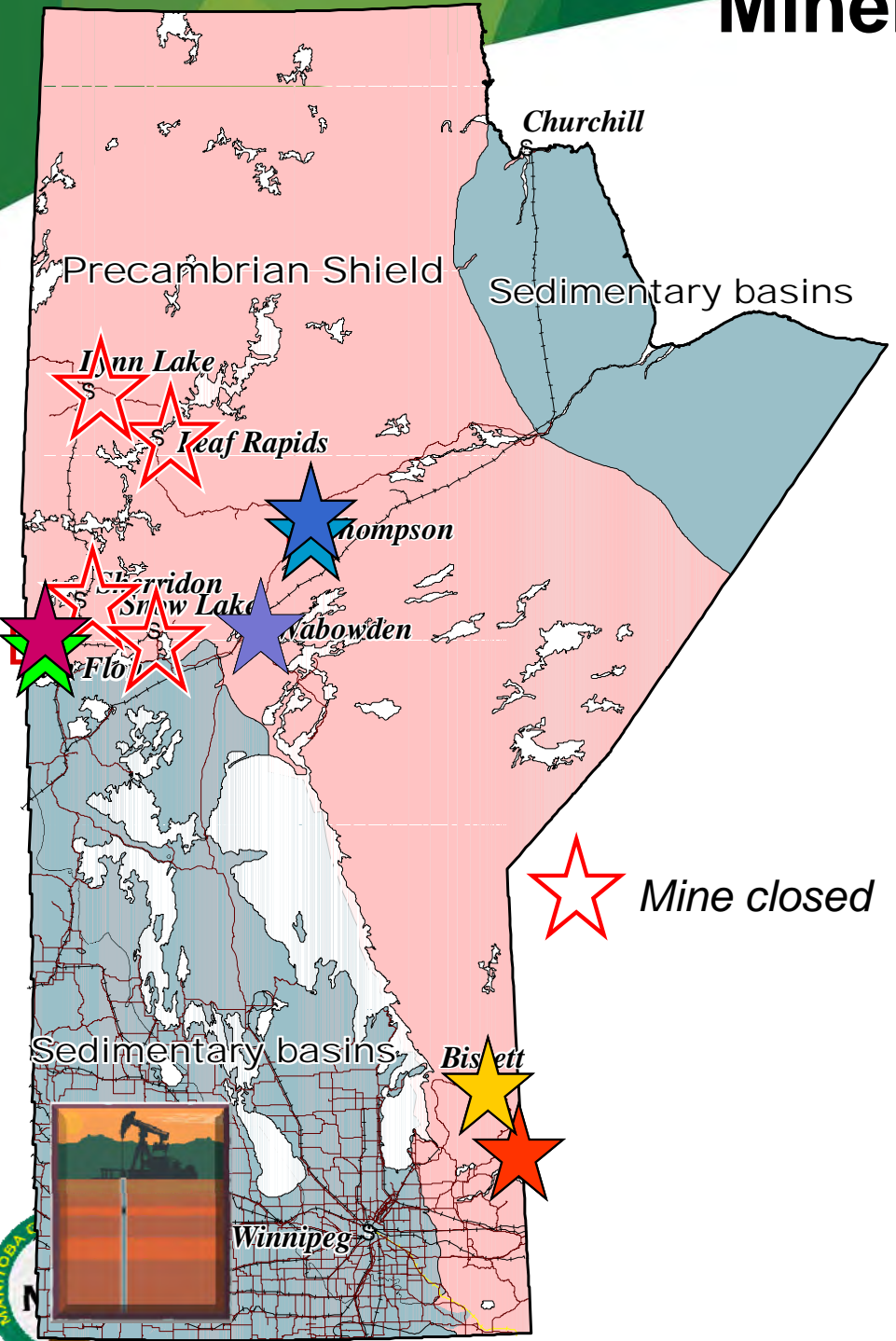
Precambrian Shield

- 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.)

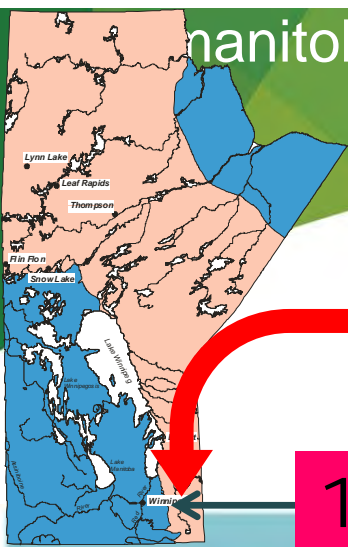
-  Tanco Mine

Gold (San Gold Corporation)

-  Rice Lake Gold Mine

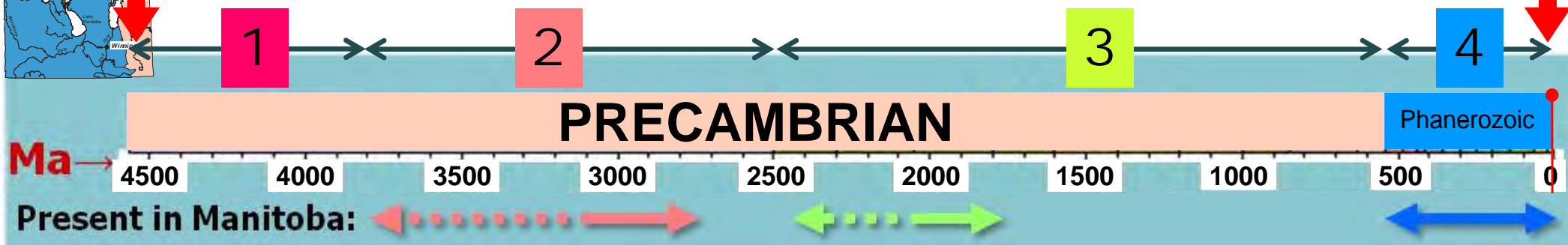


Manitoba through geological time



Formation of the Earth

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

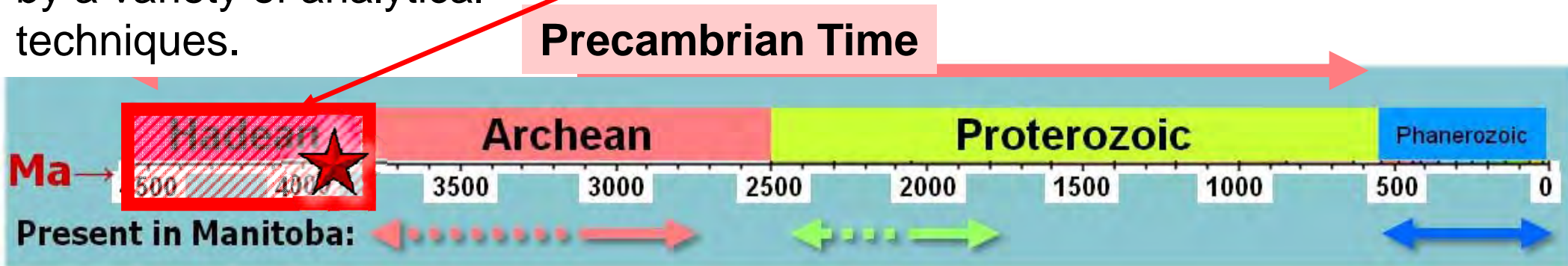
(e.g., 1500 Ma = 1.5 billion)



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.

Hadean Eon: Formation of Earth

4600 – 3800 Ma



Assean Lake



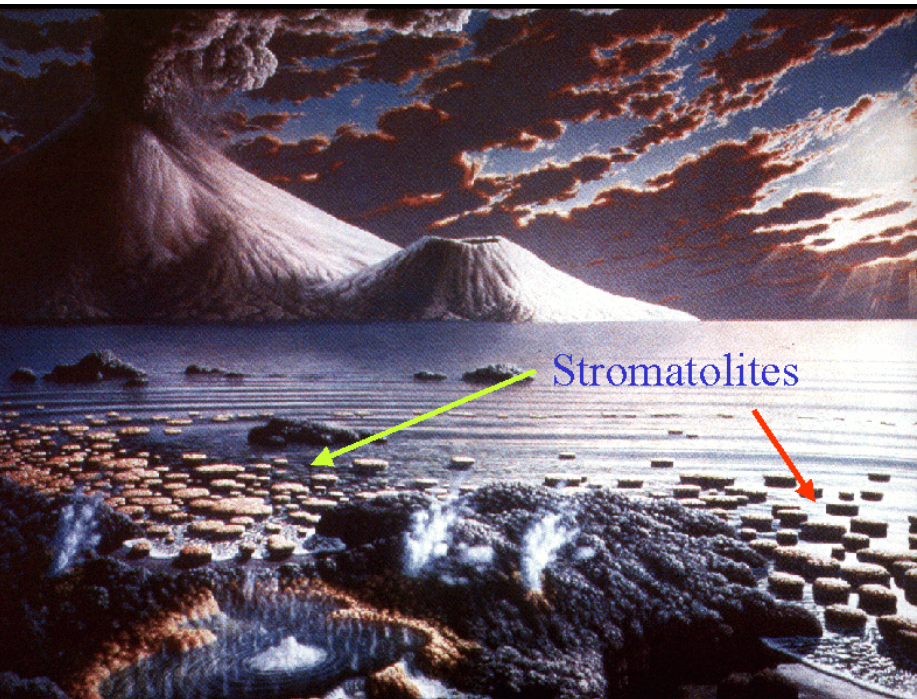
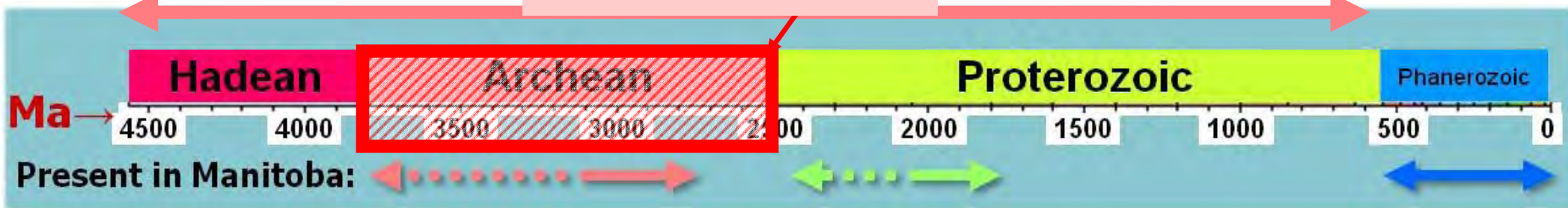
- The Earth formed as a solid planet
- Earth's interior organized into layers
- Early crust formed but was largely recycled or destroyed by rapid convection and numerous meteorite impacts



Archean Eon: Formation of Crust

3800 – 2500 Ma

Precambrian Time

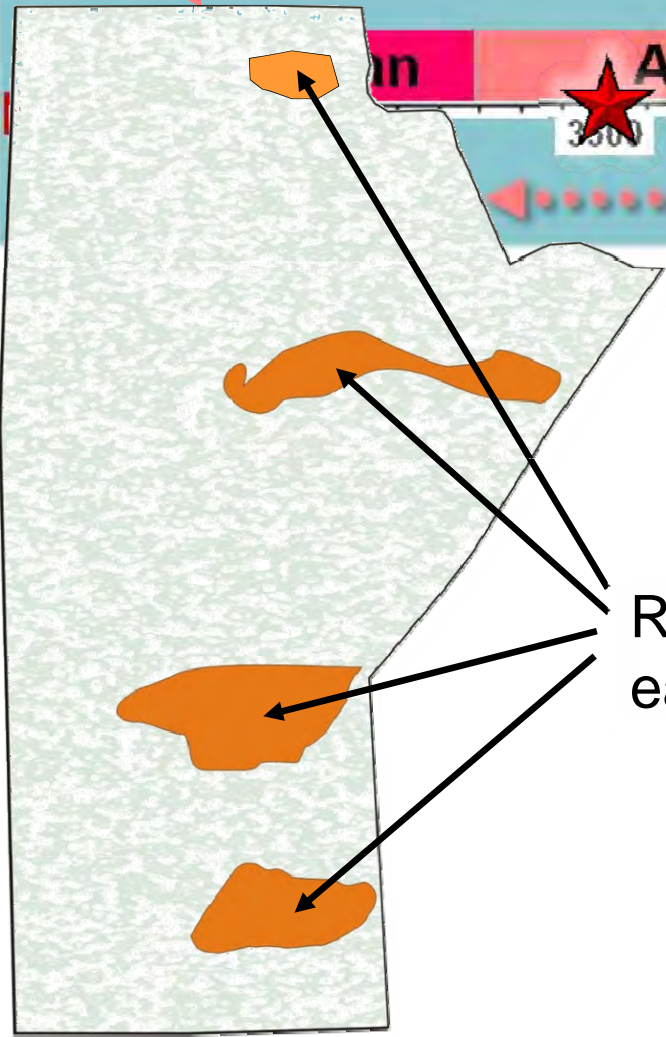


- Earth's permanent crust was formed
- First large continents formed
- Earliest life forms began
- The oceans and atmosphere resulted from volcanic out-gassing

Archean Eon in Manitoba

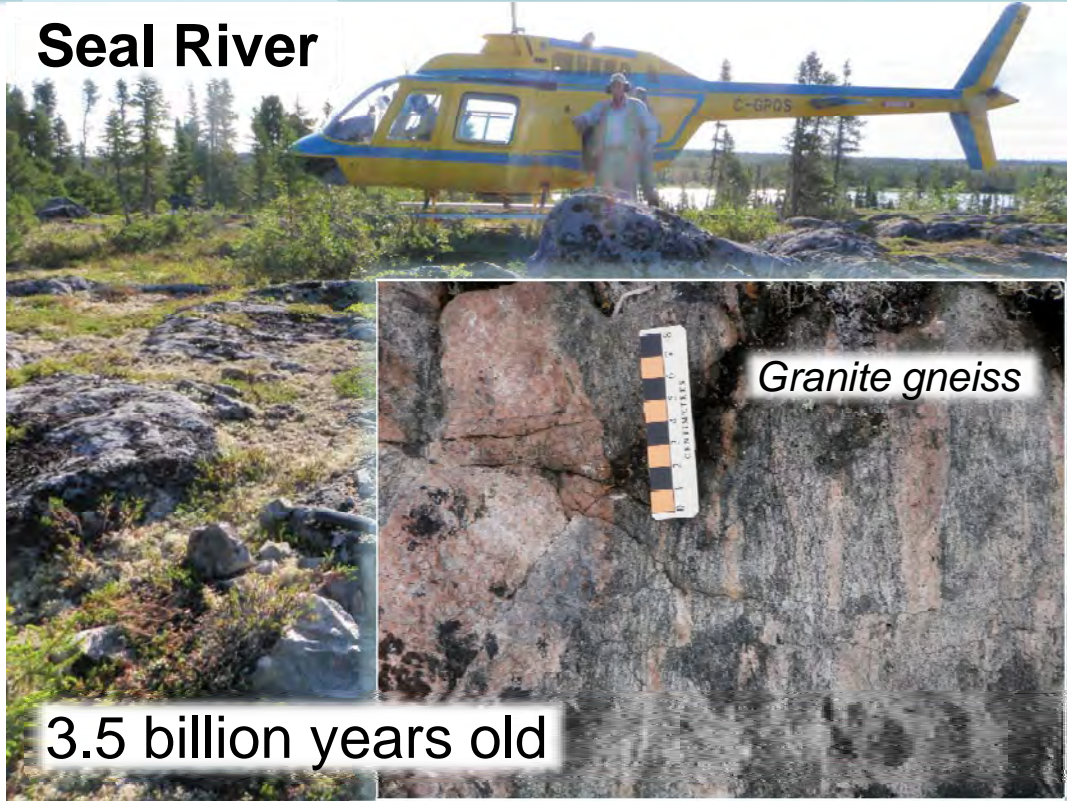
- Very early crust formed (3500 Ma). Locally contains indications of very old rocks (3900 Ma)

Precambrian Time



Remnants of early crust

Seal River



Granite gneiss

3.5 billion years old

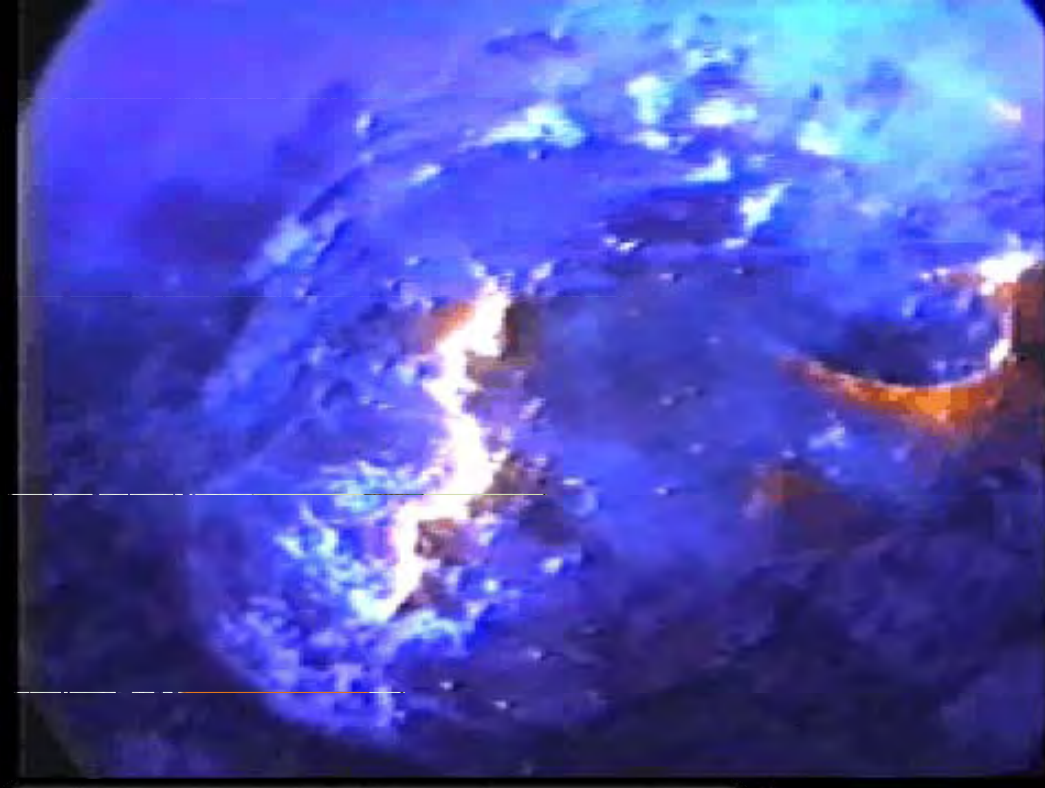
Archean pillow lava, Cross Lake



Modern pillow lava on the sea floor



Archean Eon in Manitoba



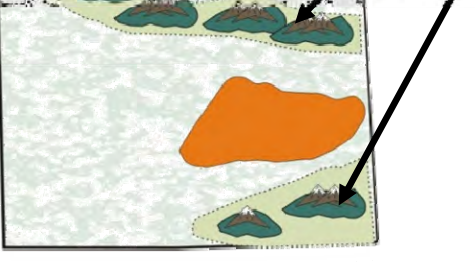
Shield volcanism (3000-2720 Ma)

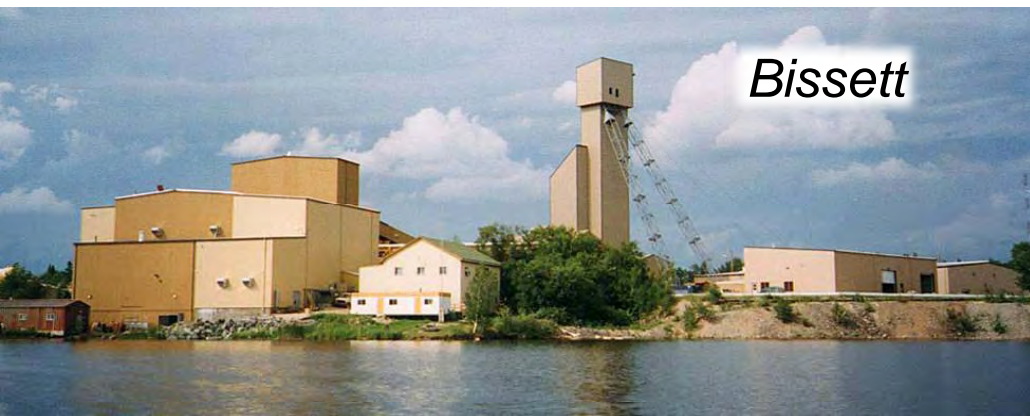
"Belts" –

Volcanic eruption under the sea



NOAA, courtesy of Richard Pyle at Lava Video Productions

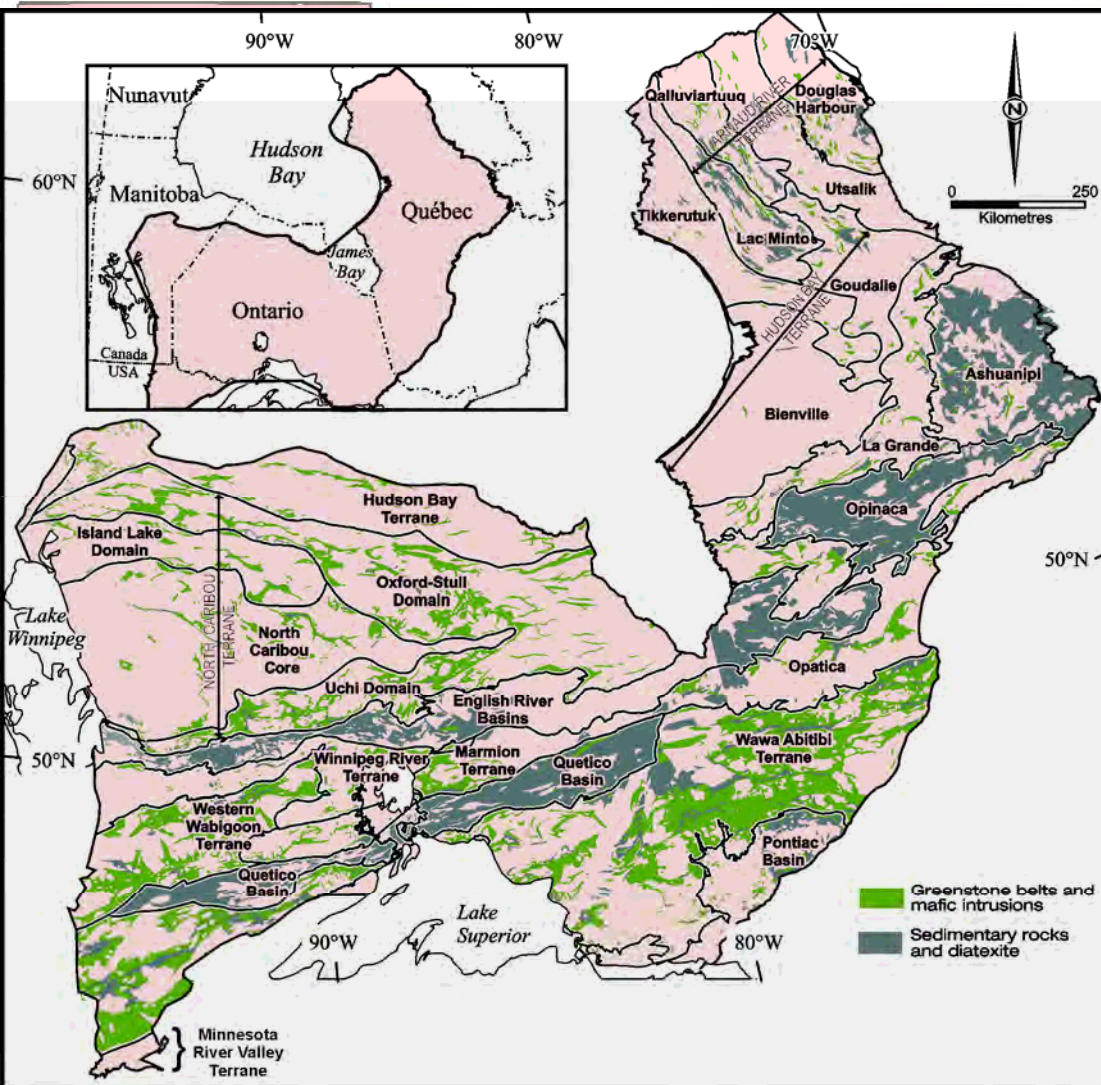




Bissett



Archean Eon in Manitoba



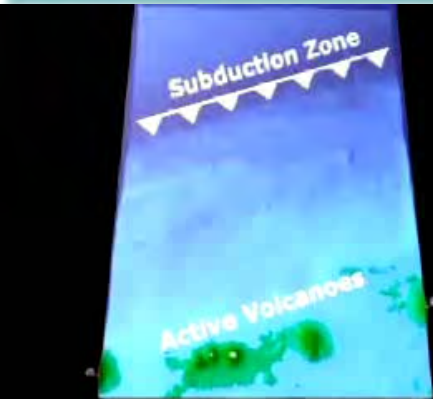
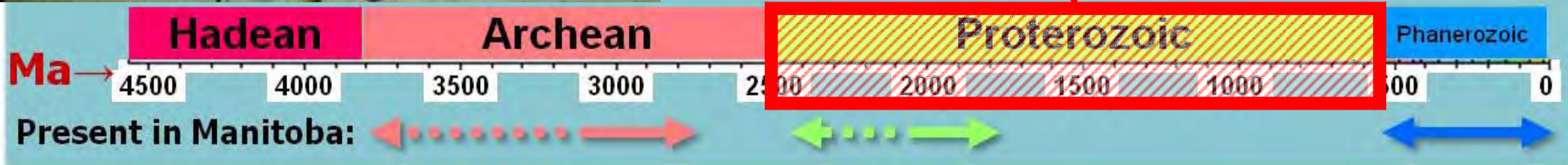
- Laurentian *orogeny* (mountain building) (2730-2700 Ma)
- Granite plutonism and assembly of a large Archean continent (Superior “craton”)
- Many large gold deposits formed (e.g., Rice Lake mine in Bissett)



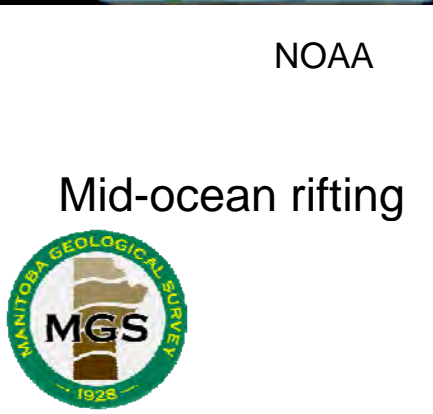
Proterozoic Eon: Modern Earth Processes Begin

2500 – 542 Ma

National Museum of Natural History



Subduction and island arc volcanoes



- 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)

NOAA



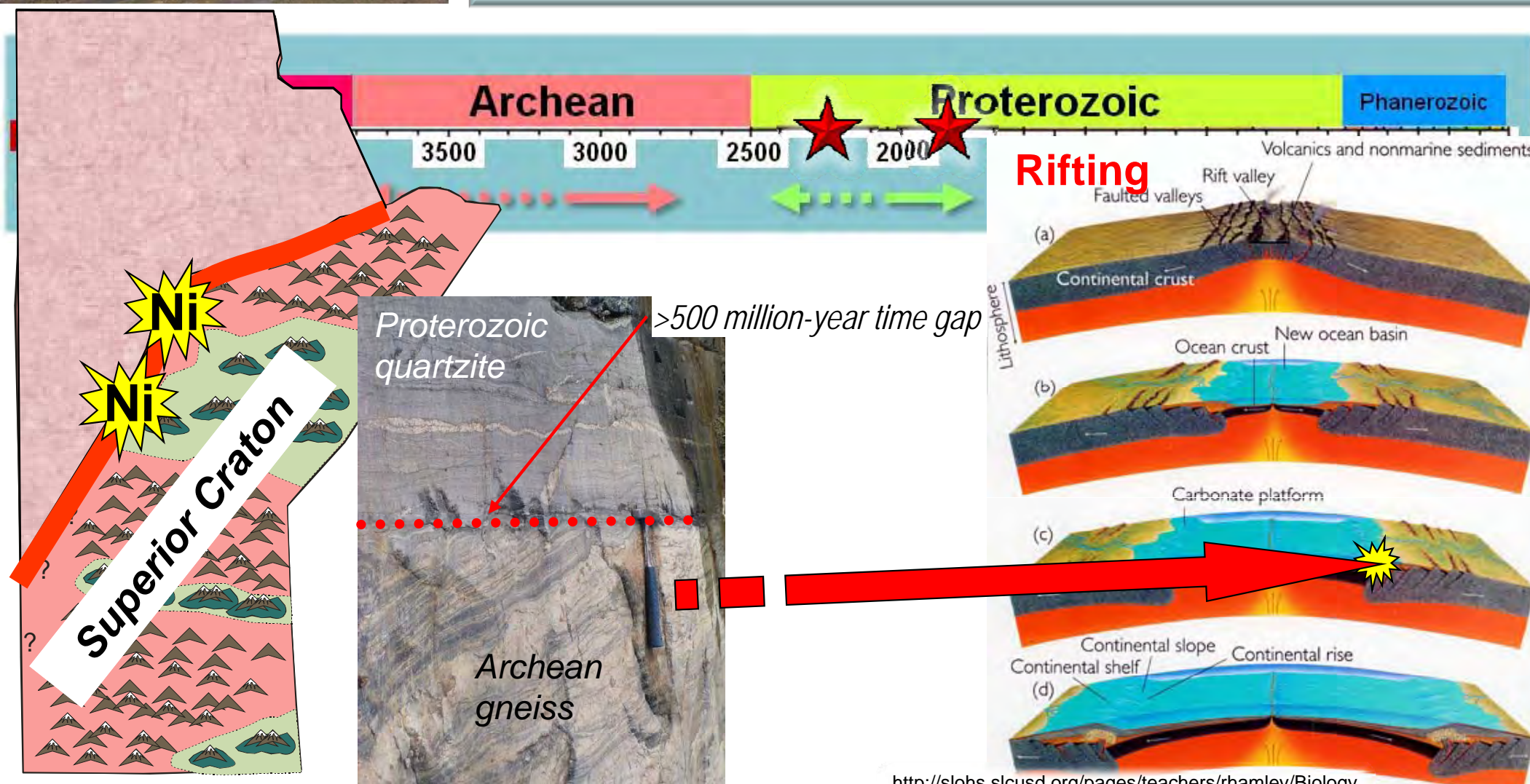


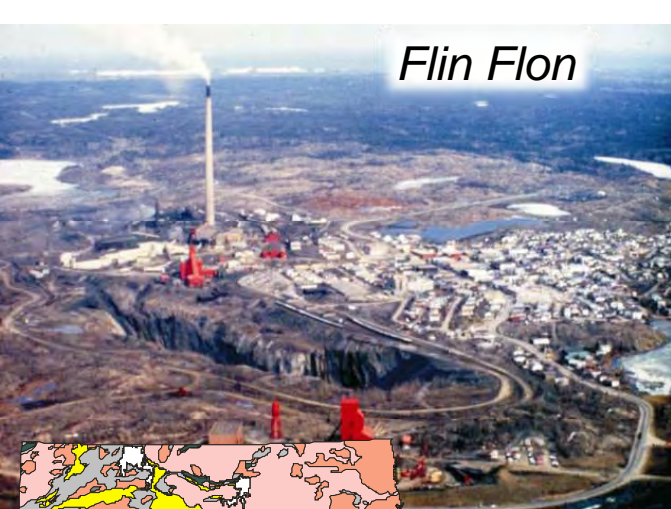
Thompson

erals

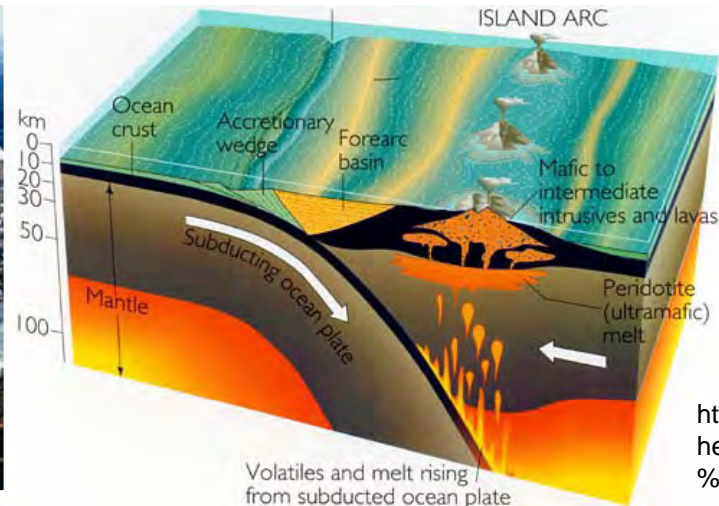
Proterozoic Eon in Manitoba

- subsequent (1885 Ma) emplacement of nickel deposits
- ocean basin
- tectonics laid



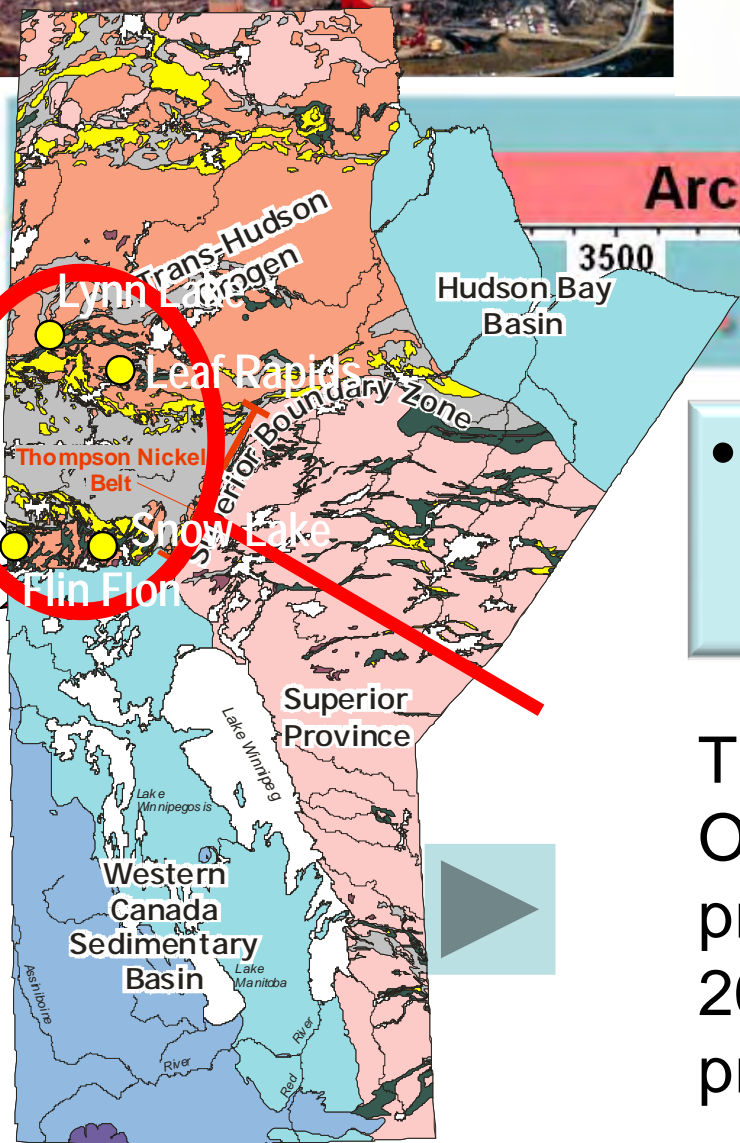


Flin Flon



Proterozoic Eon in Manitoba

<http://slohs.slucsd.org/pages/teachers/rhamley/Biology/Continental%20Drift/Tectonics.html>

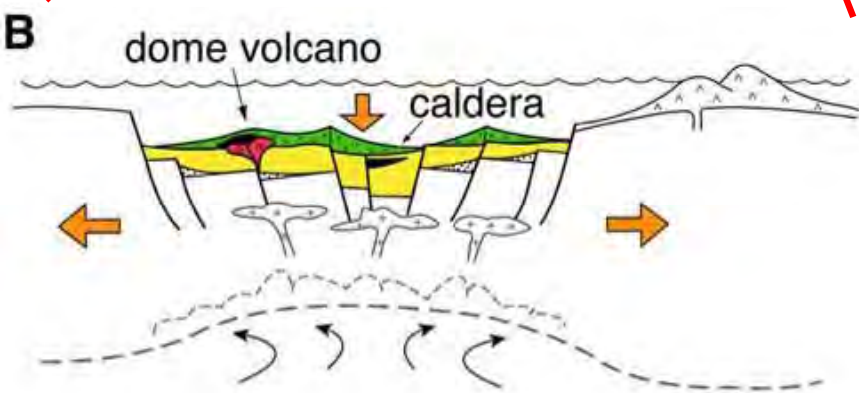
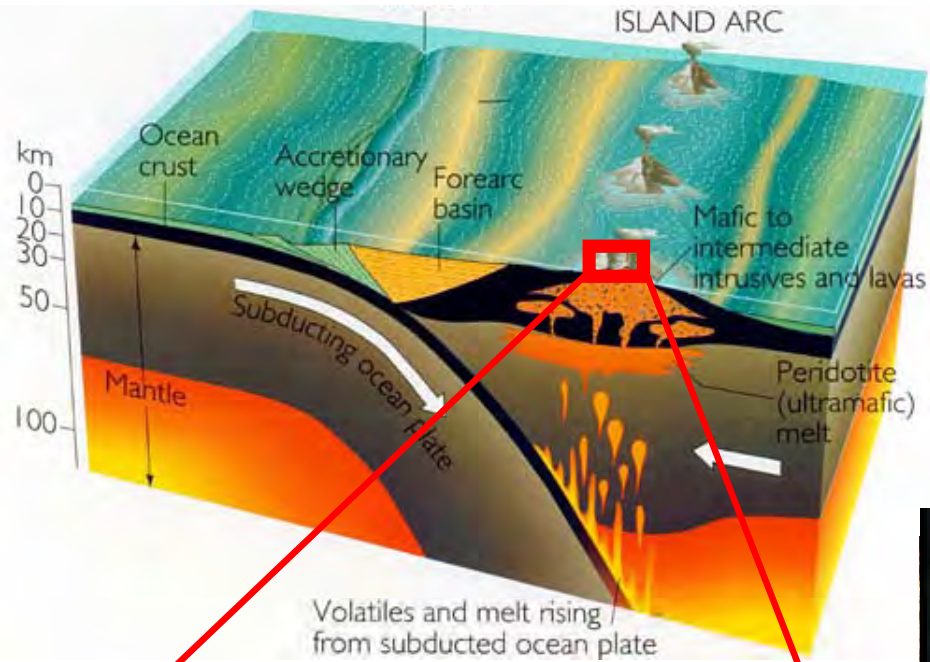


- 1910-1830 Ma active volcanism and deposition of copper-zinc deposits (e.g., Flin Flon, Lynn Lake)

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.

Proterozoic Eon: copper-zinc-gold deposits

<http://slohs.slcsd.org/pages/teachers/rhamley/Biology/Continental%20Drift/Tectonics.html>



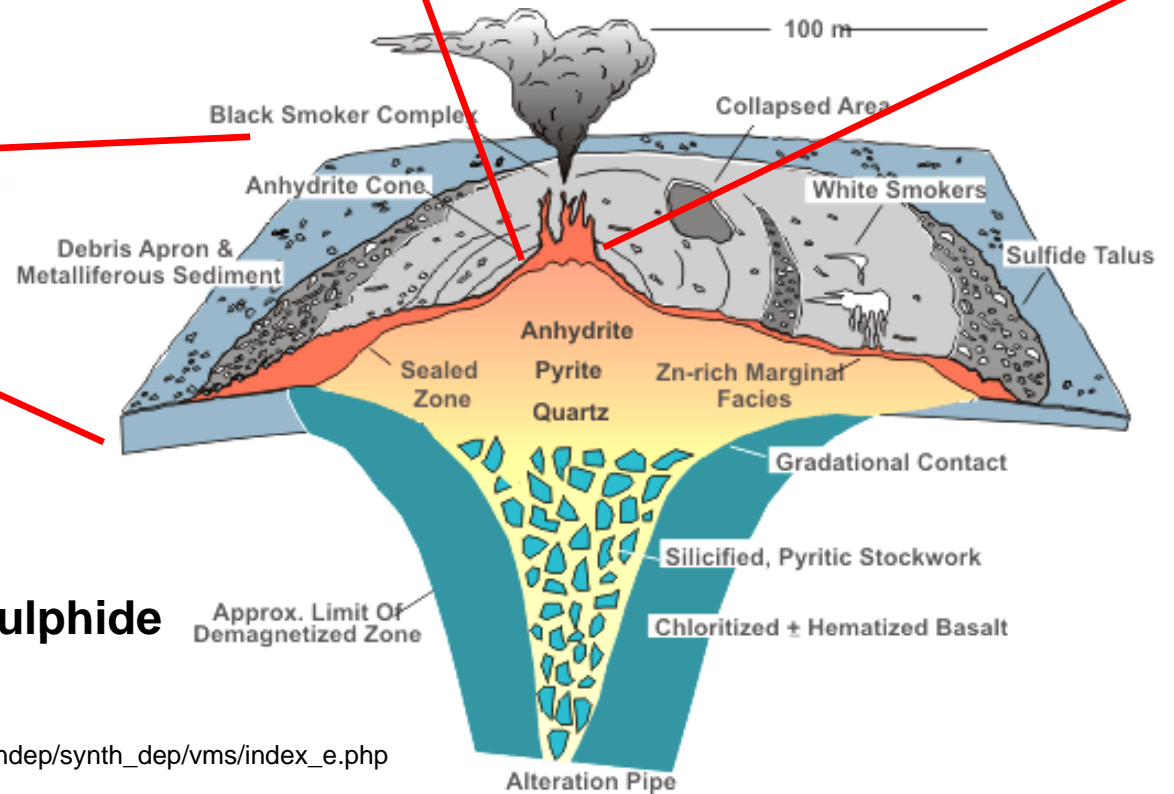
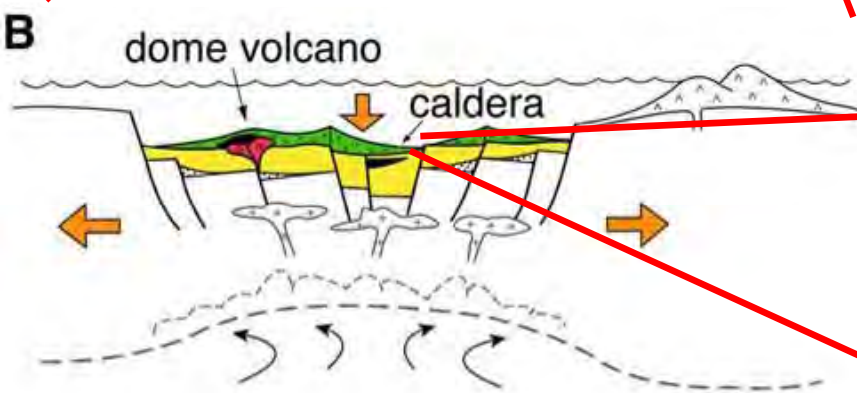
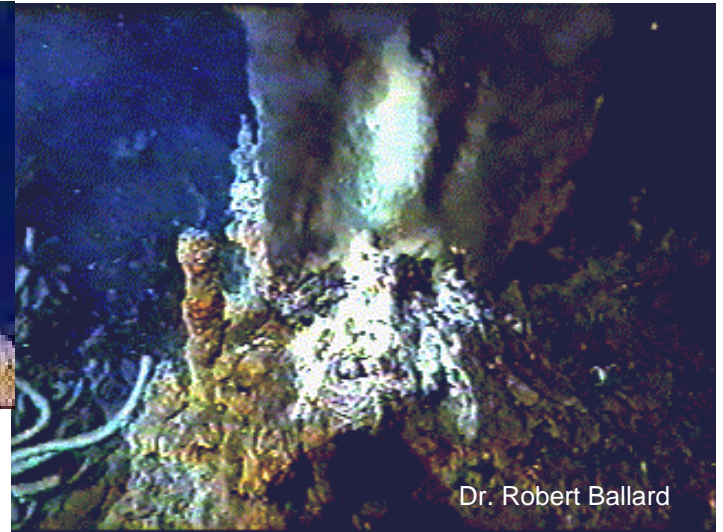
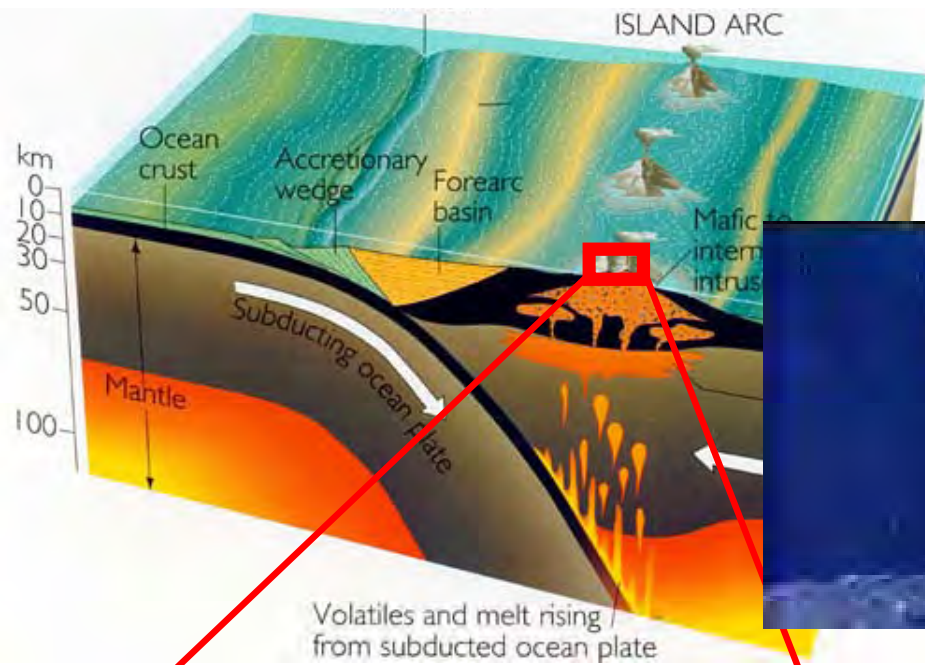
NOAA



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



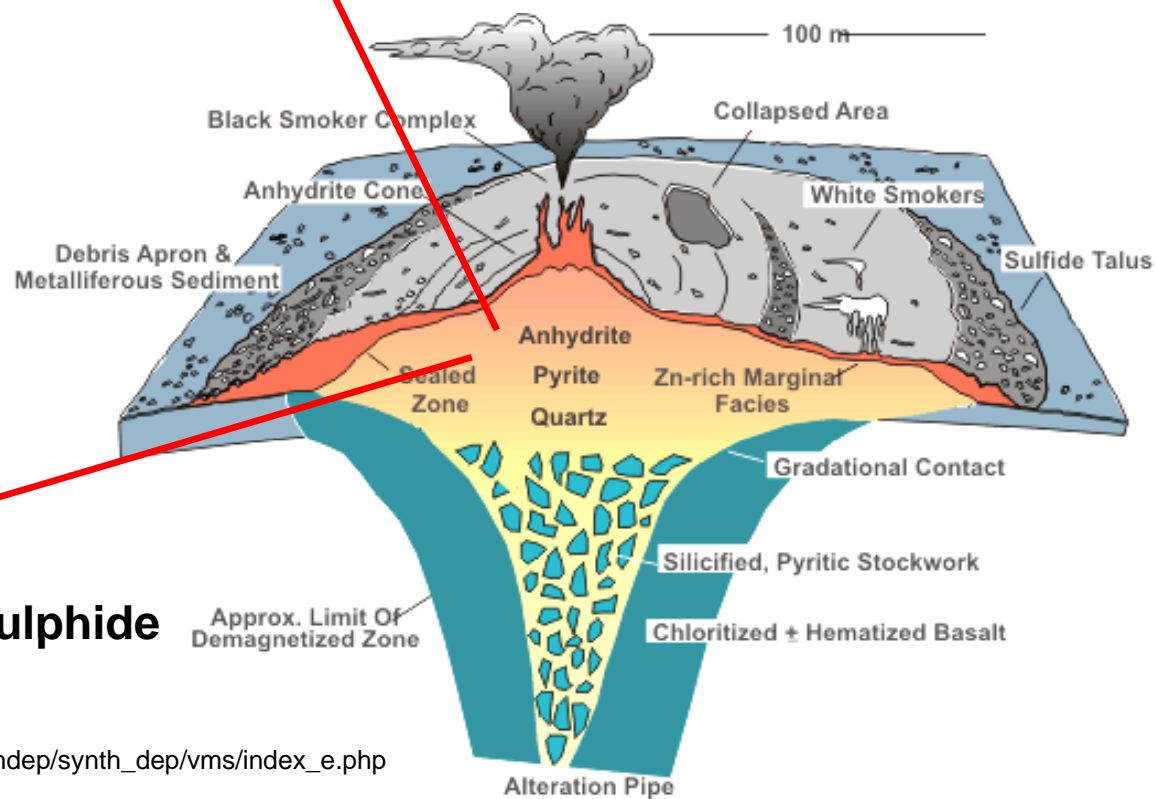
Proterozoic Eon: copper-zinc-gold deposits



Zinc ore, Snow Lake



Copper ore, Flin Flon



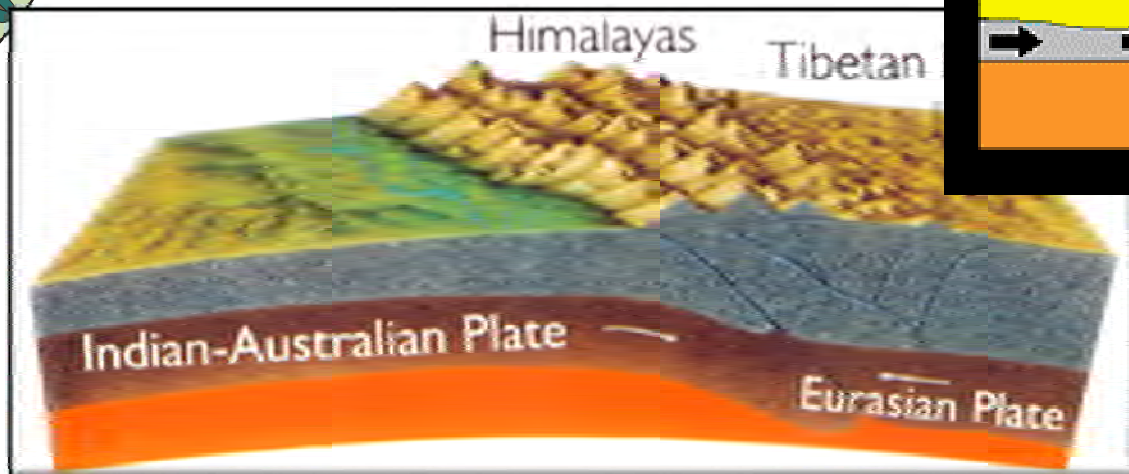
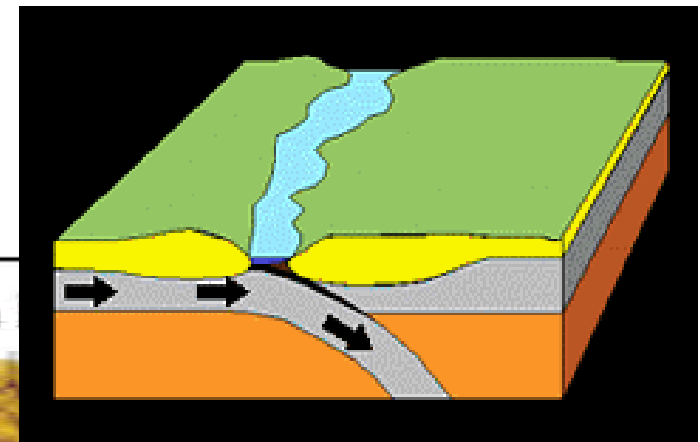
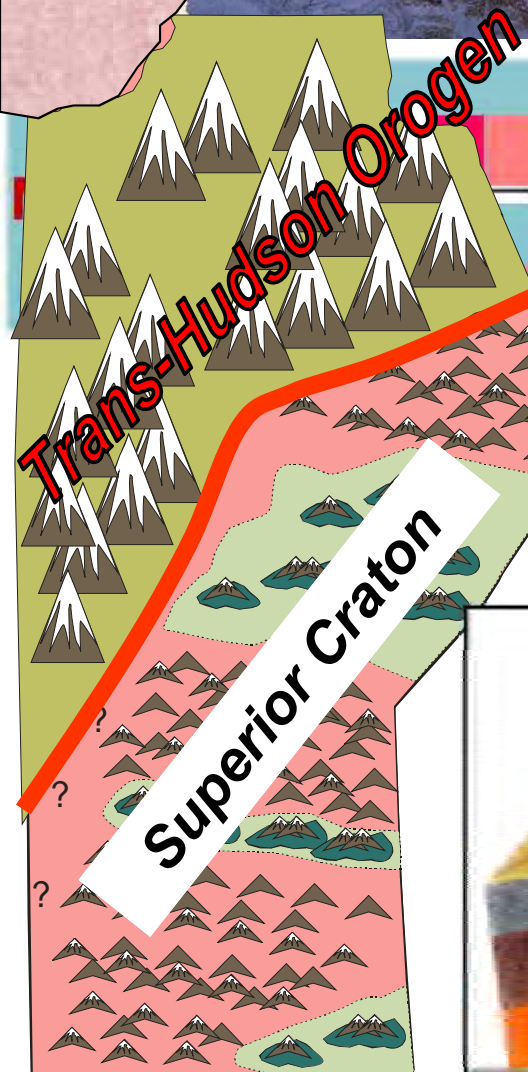
Massive sulphide mound

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)

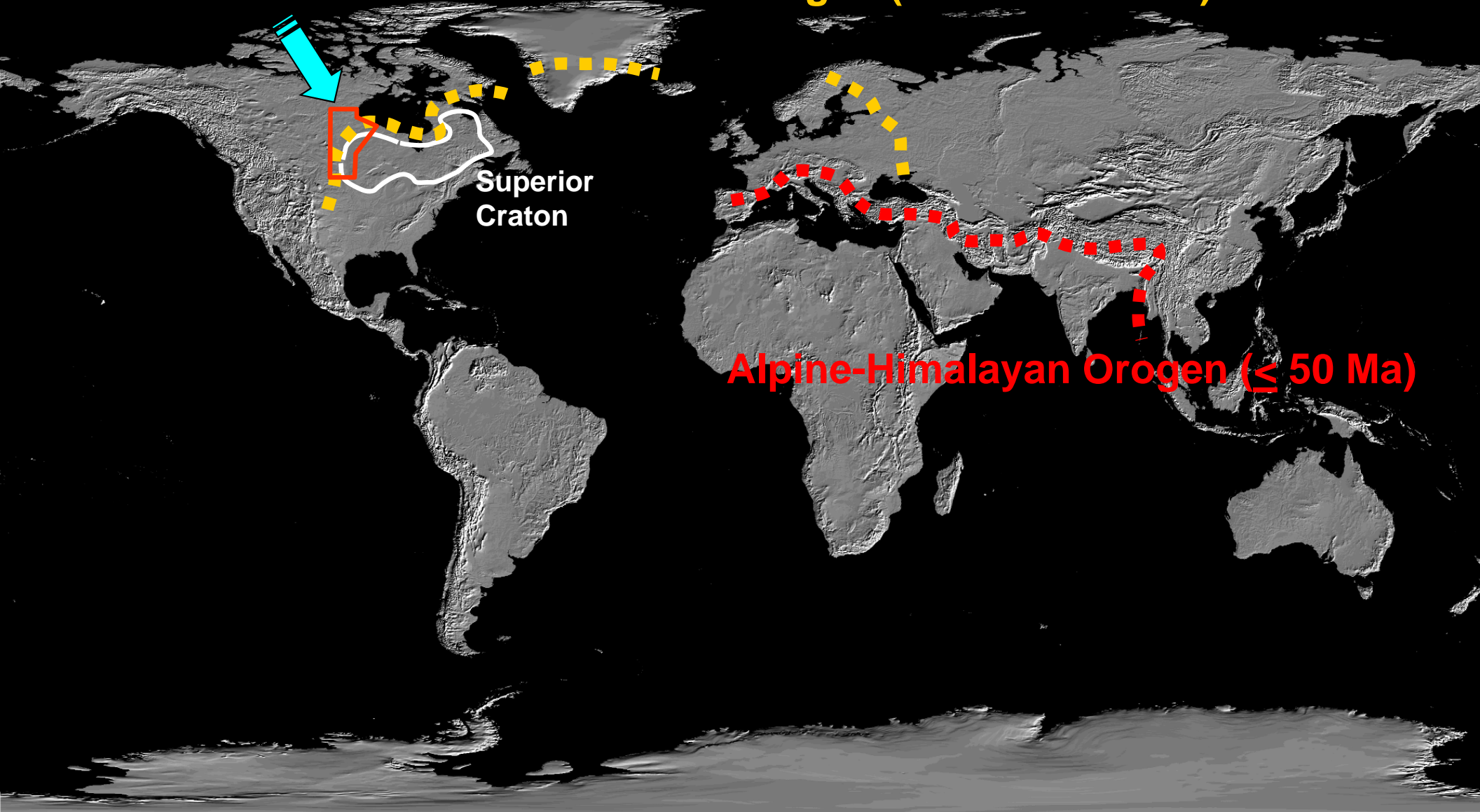


<http://mafecarr.blogspot.com/>

Comparison of the Trans-Hudson Orogen with a modern orogen (mountain belt)

Manitoba

Trans-Hudson Orogen (1830 – 1800 Ma)



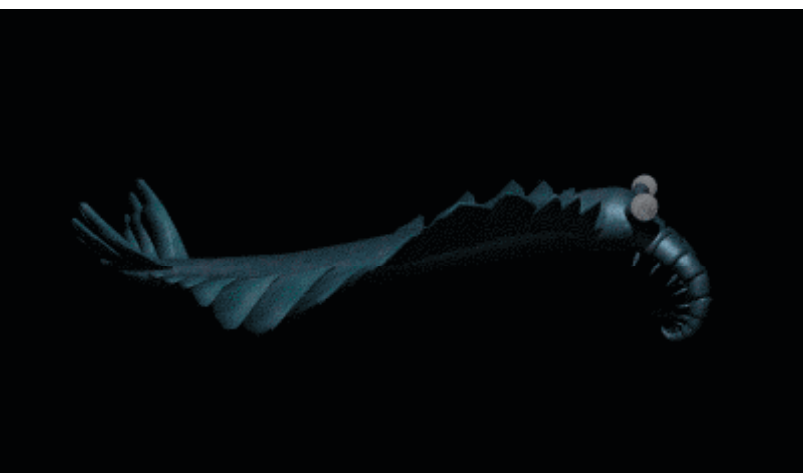
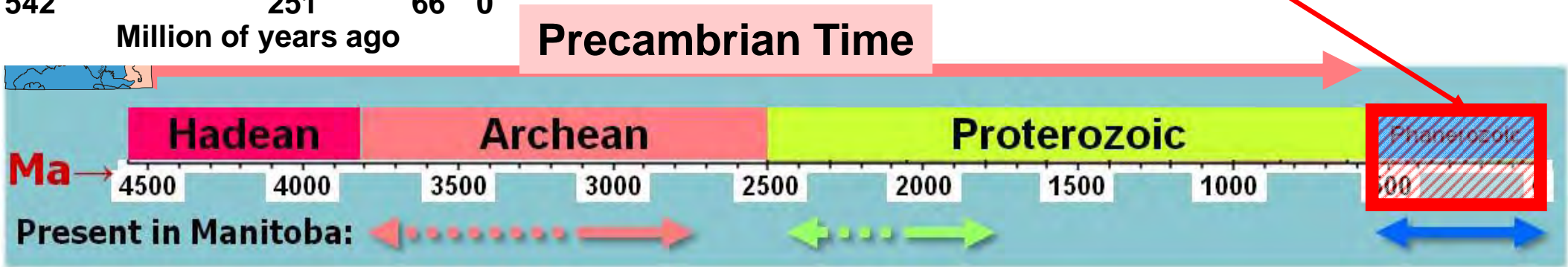
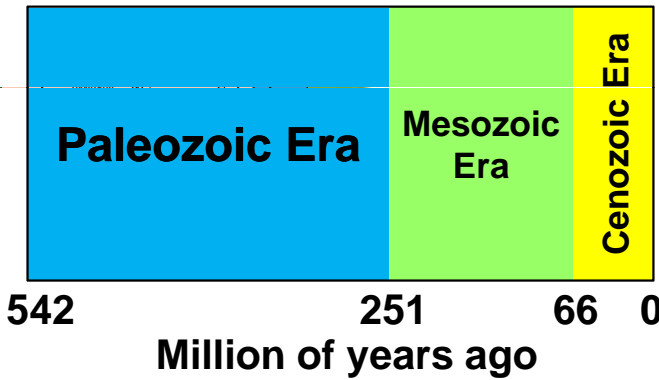
Superior
Craton

Alpine-Himalayan Orogen (≤ 50 Ma)

Phanerozoic Eon

Phanerozoic Eon:

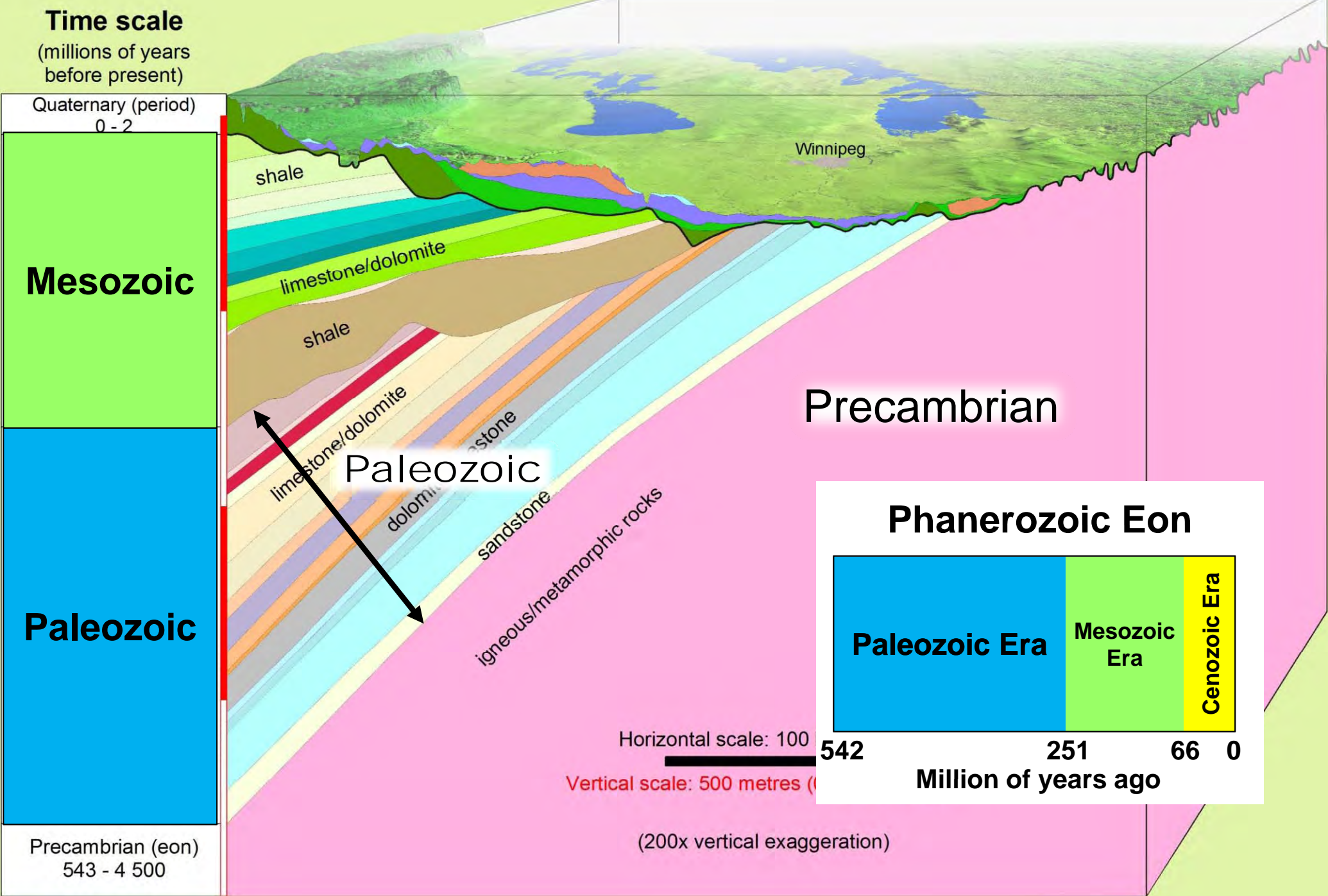
Modern Earth and Life Forms Evolve



- 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.



The Phanerozoic



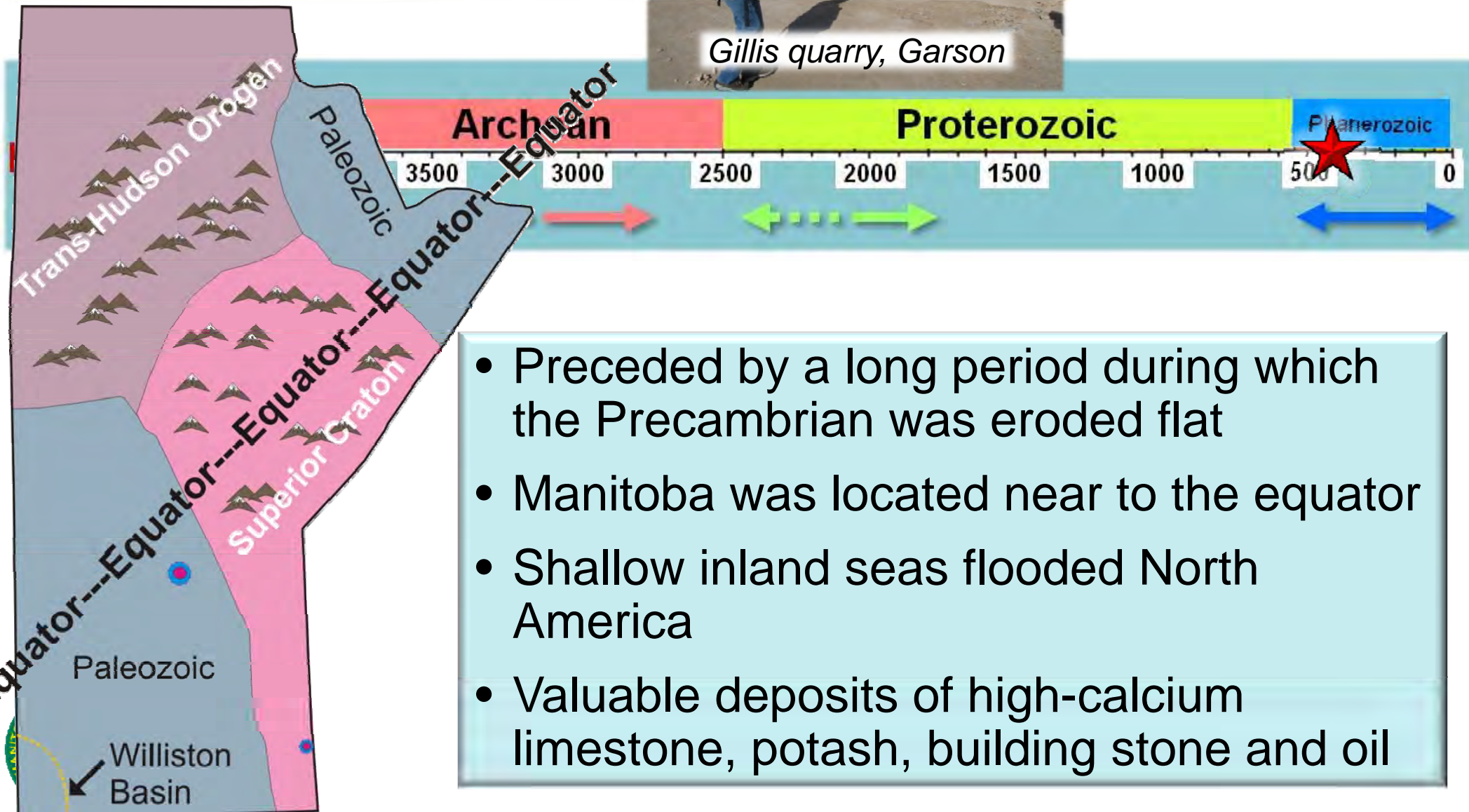
Crushed rock

Tyndall Stone

Paleozoic Era in Manitoba

542 – 251 Ma

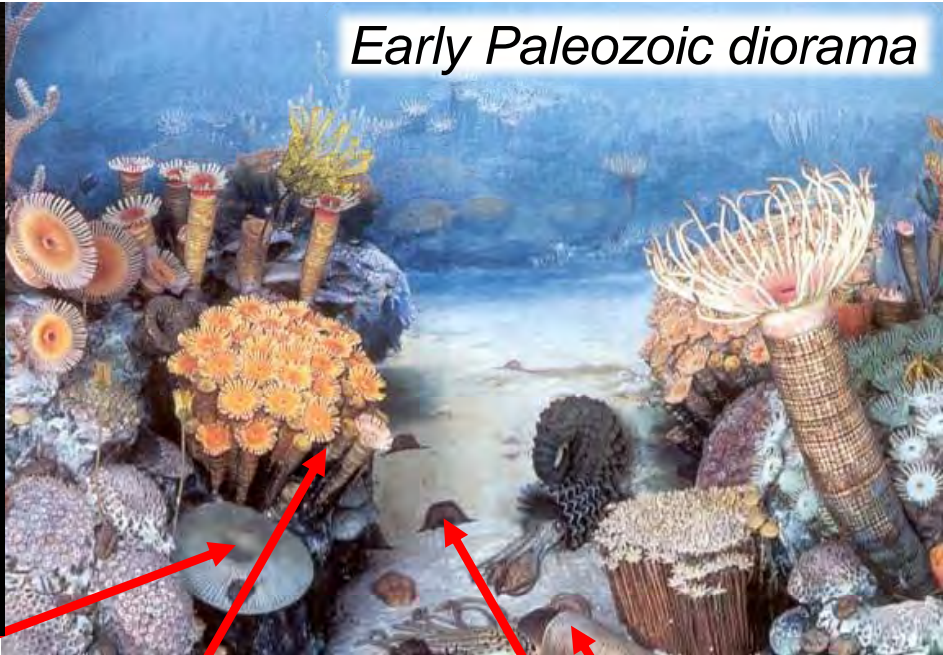
Gillis quarry, Garson



- 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



Maclurites (gastropod)



Early Paleozoic diorama



(trilobite)



Graham Young

World's largest trilobite
from Churchill



Argyrioides (brachiopod)

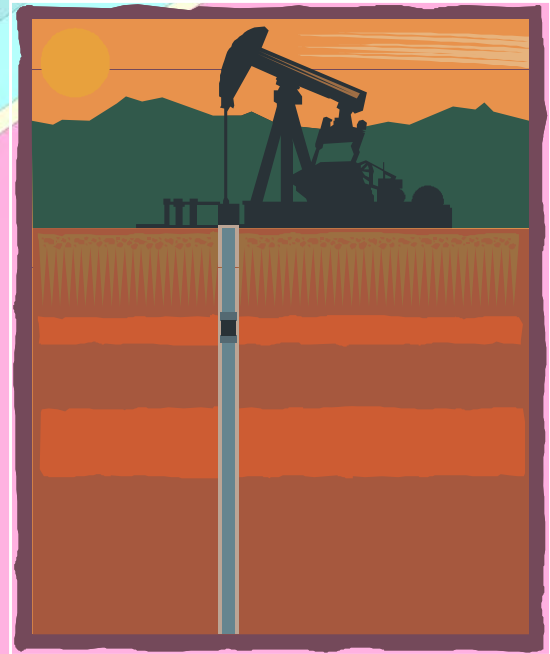
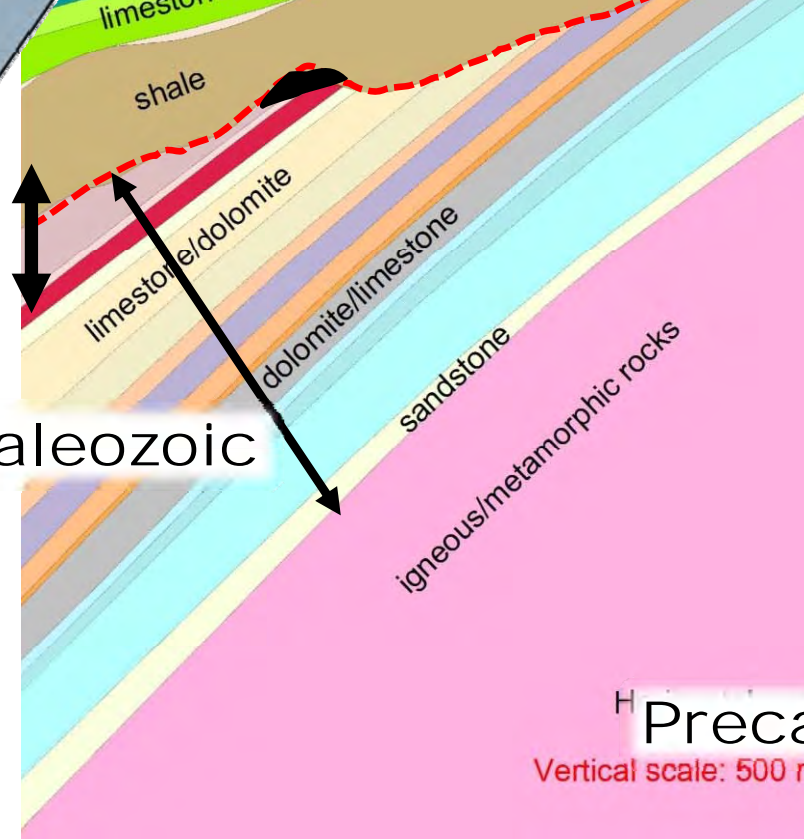
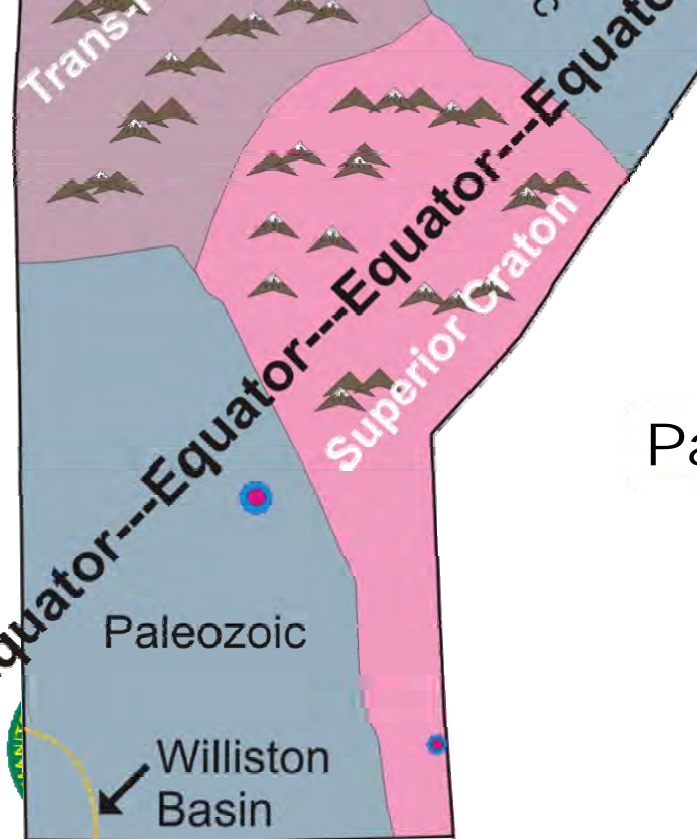


Paleozoic Era in Manitoba

Upper Devonian reef diorama



<http://www.chasestudio.com/rtmp/large/images/Upper-Devonian-Diorama.jpg>



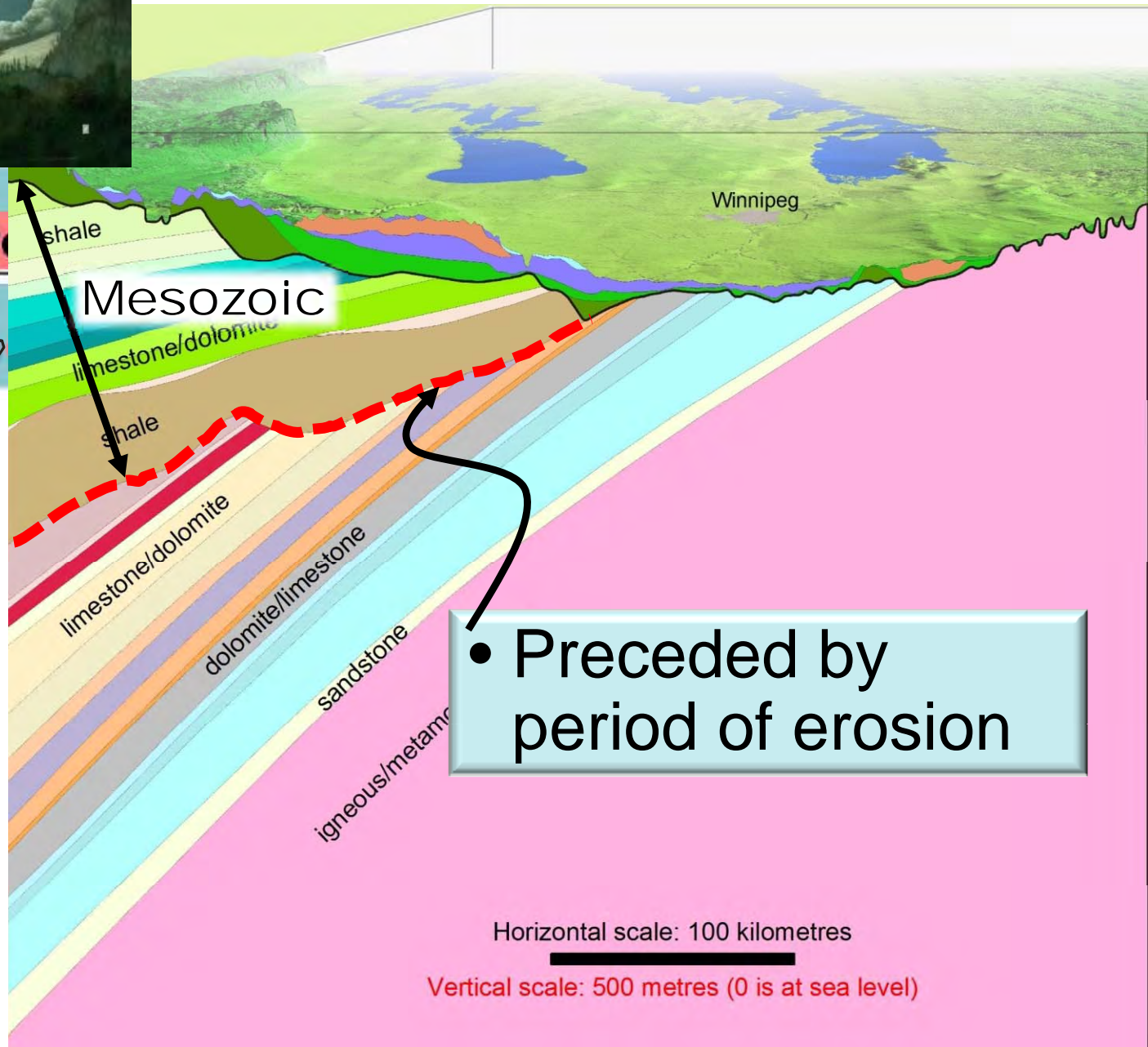
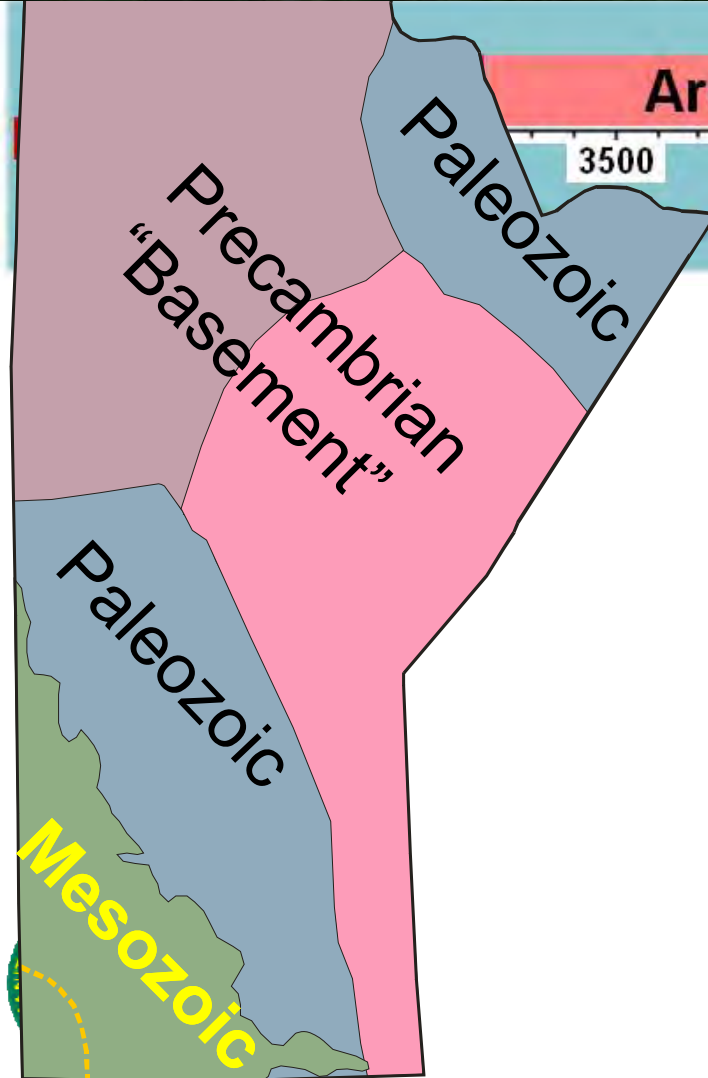
Precambrian

Vertical scale: 500 metres (0 is at sea level)



251 – 66 Ma

Mesozoic Era in Manitoba

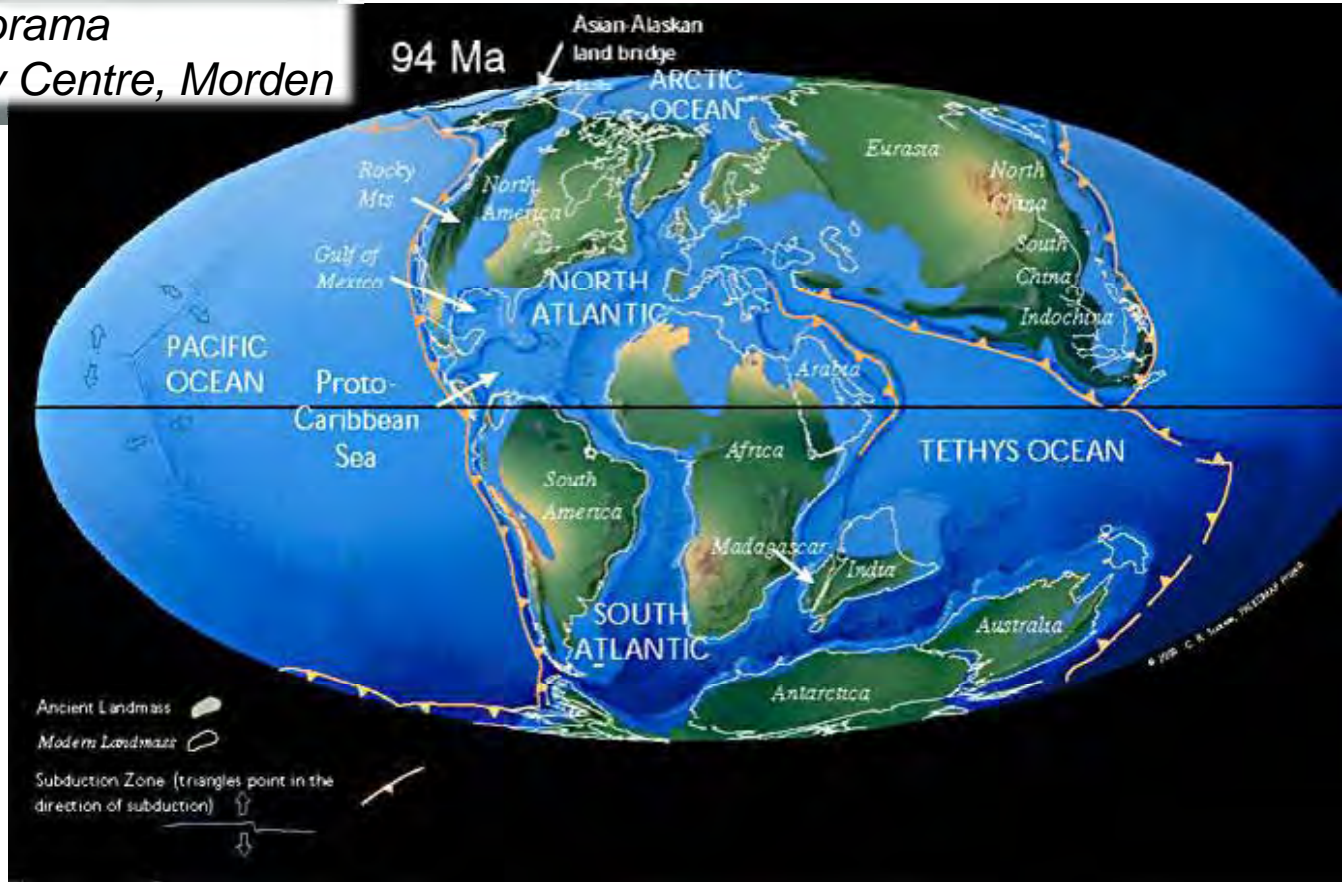
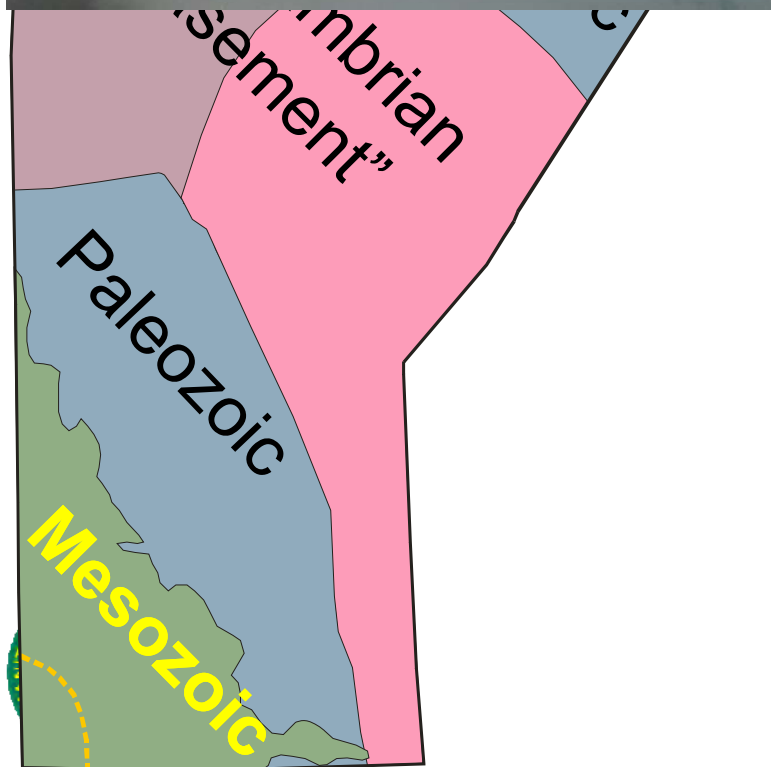


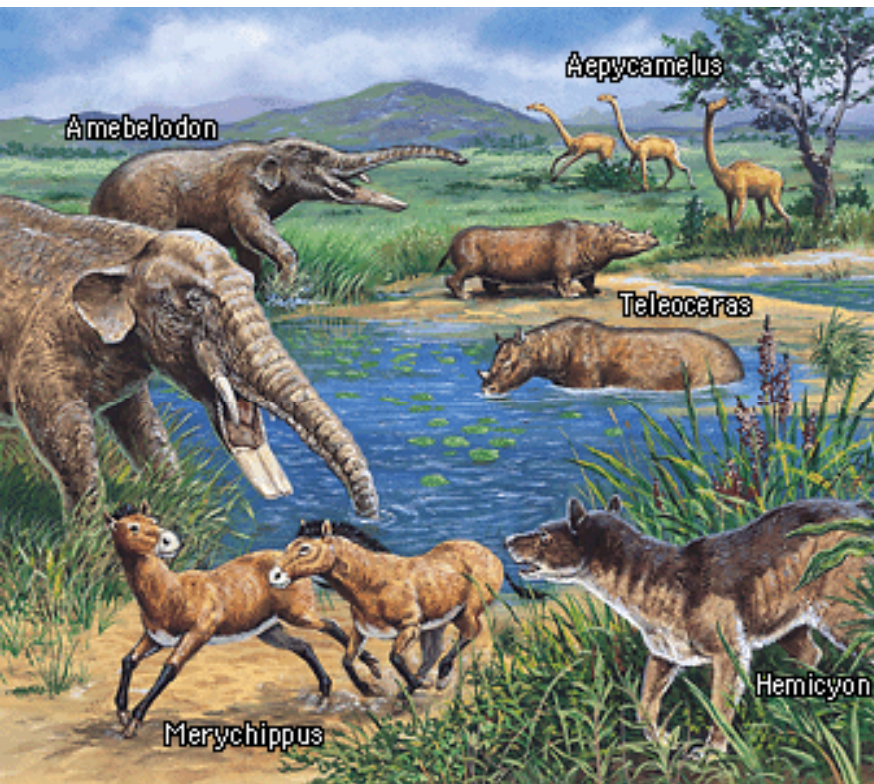
Mesozoic Era in Manitoba

- Periodically flooded by shallow inland seas
- Ended by a meteoric impact and major extinction event



*Cretaceous in Manitoba diorama
Canadian Fossil Discovery Centre, Morden*



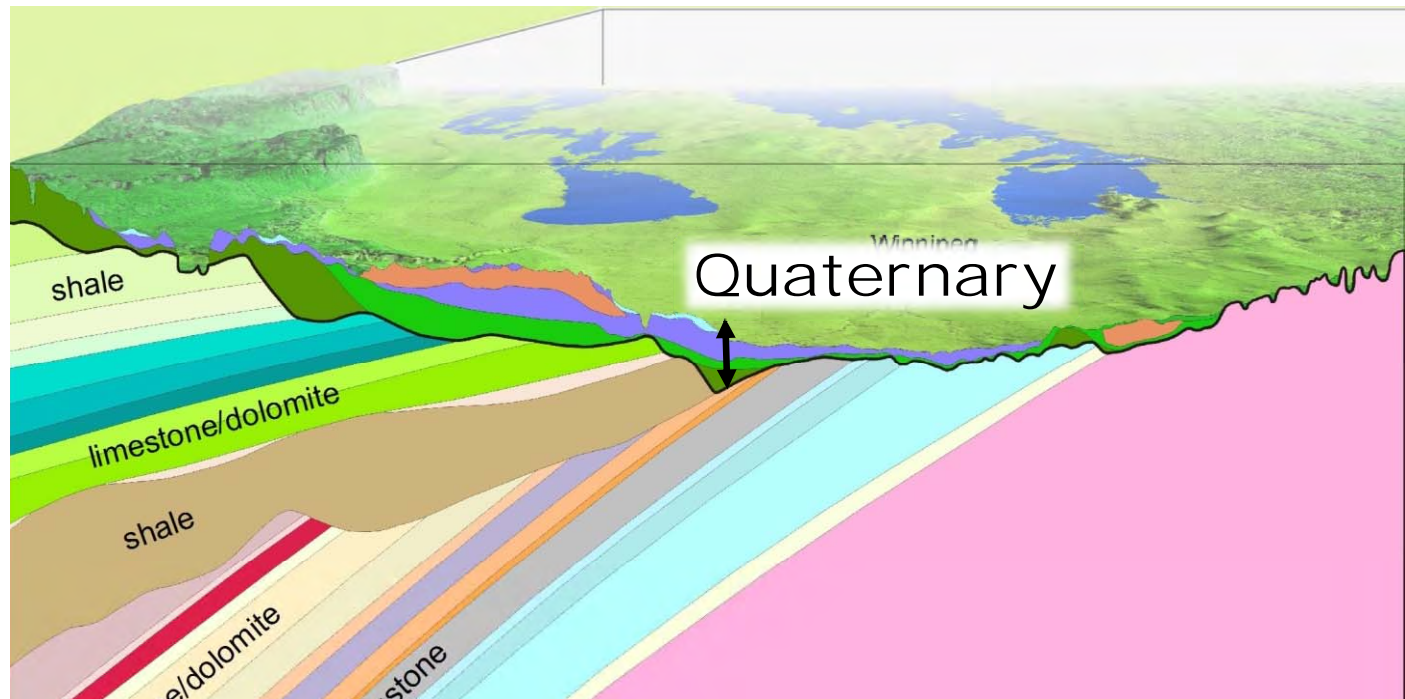
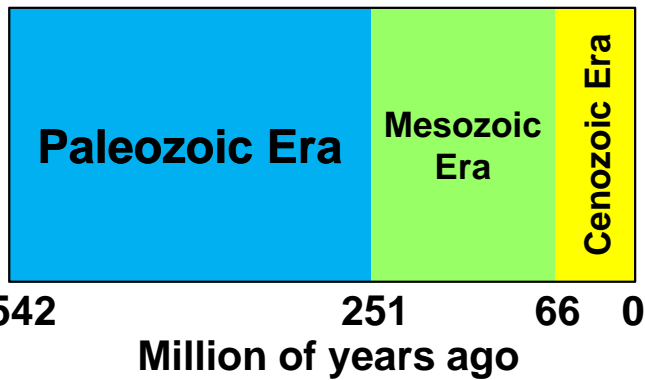


Cenozoic Era

66 – 0 Ma



Phanerozoic Eon



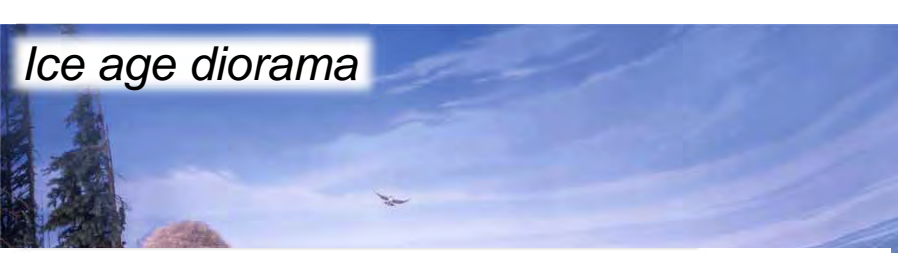
Cenozoic Era

66 – 0 Ma

Dr. Ron Blakey, NAU Geology - <http://jan.ucc.nau.edu/~rcb7/>



Ice age diorama



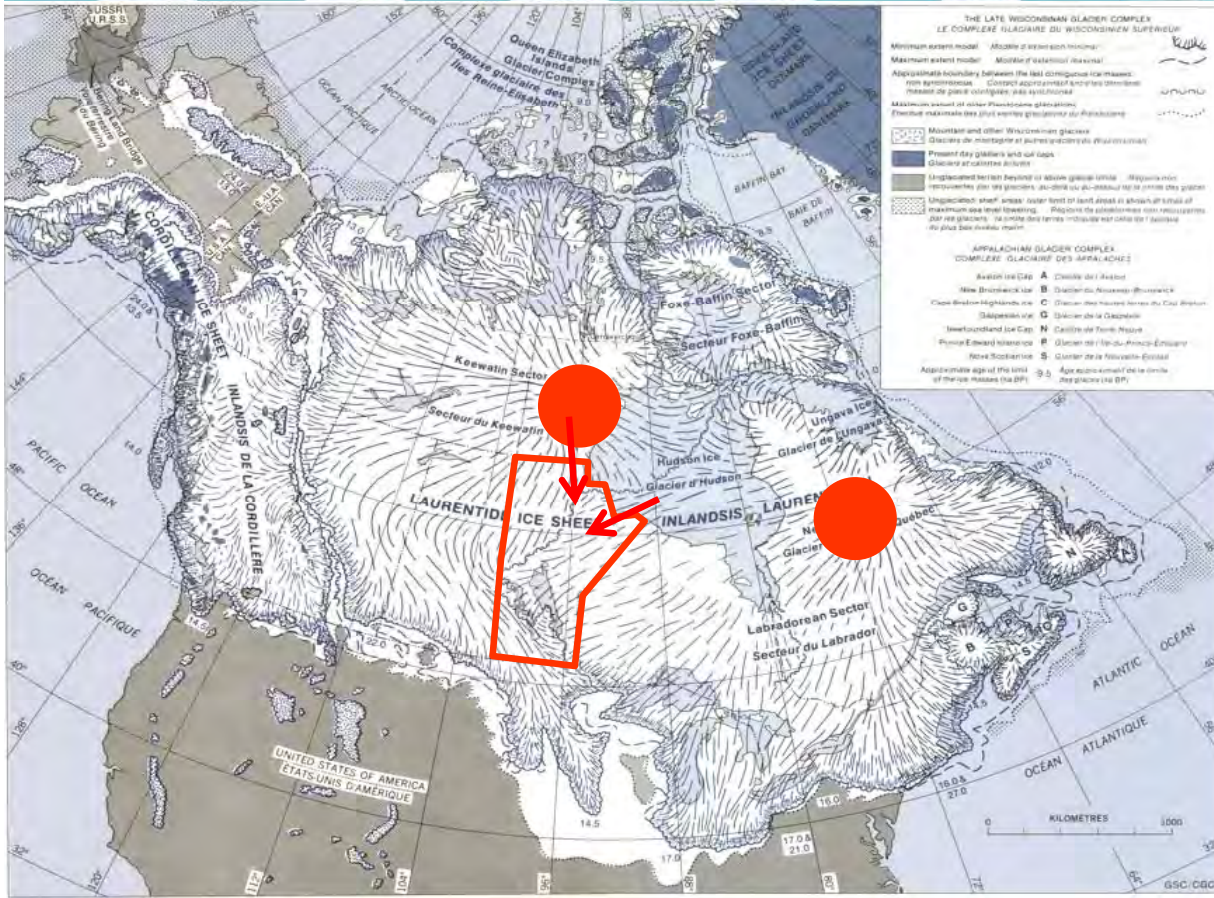
Paleogeographic reconstruction during deglaciation



- pre-Lake Agassiz 11 700 BP
- 11 500 BP
- 11 200 BP
- 11 100 BP
- 10 900 BP
- Lake Agassiz 10 400 BP
- 9900 BP
- 9300 BP
- 8200 BP
- 8000 BP
- 7800 BP
- 7700 BP
- Tyrrell Sea 7600 BP

Modified from: Thornefsen, 1996

Cenozoic Era The Ice Age(s)



THE LATE WISCONSINAN GLACIER COMPLEX
LE COMPLEXE GLACIERE DU WISCONSINAN SUPERIEUR

Minimum extent model: Modèle d'extension minimale
 Maximum extent model: Modèle d'extension maximale
 Approximate boundary between the last deglaciation and maximum extent of glacial coverage: Approximate limite entre la dernière déglaciation et l'extension maximale des plus récents glaciers sur l'Amérique du Nord

Mountain and other Wisconsinan glaciares: Glaciers de montagne et autres glaciares du Wisconsinan
 Present day glaciers and outcrops: Glaciers actuels et rochers

Unglaciated terrain beyond or above glacial limits: Terrain non recouvert par les glaciers, au-delà ou au-dessus de la limite des glaciers
 Unglaciated shelf areas: Shelf areas not shown at limit of maximum sea level lowering: Zones non recouvertes par les glaciers, au-delà des terres recouvertes au cours de l'abaissement du plus bas niveau marin

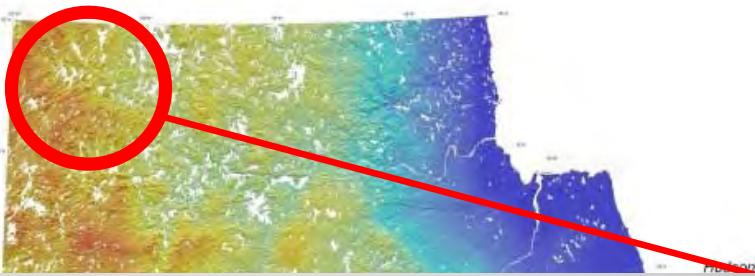
APPALACHIAN GLACIER COMPLEX
COMPLEXE GLACIERE DES APPALACHES

Keokuk Ice Cap: A
 New England Ice Cap: B
 New York Ice Cap: C
 New England Ice Cap: D
 New England Ice Cap: E
 New England Ice Cap: F
 New England Ice Cap: G
 New England Ice Cap: H
 New England Ice Cap: I
 New England Ice Cap: J
 New England Ice Cap: K
 New England Ice Cap: L
 New England Ice Cap: M
 New England Ice Cap: N
 New England Ice Cap: O
 New England Ice Cap: P
 New England Ice Cap: Q
 New England Ice Cap: R
 New England Ice Cap: S
 New England Ice Cap: T
 New England Ice Cap: U
 New England Ice Cap: V
 New England Ice Cap: W
 New England Ice Cap: X
 New England Ice Cap: Y
 New England Ice Cap: Z

Approximate age of the limit of the ice masses (in BP): Age approximatif de la limite des glaciers (en BP)

Cenozoic Era

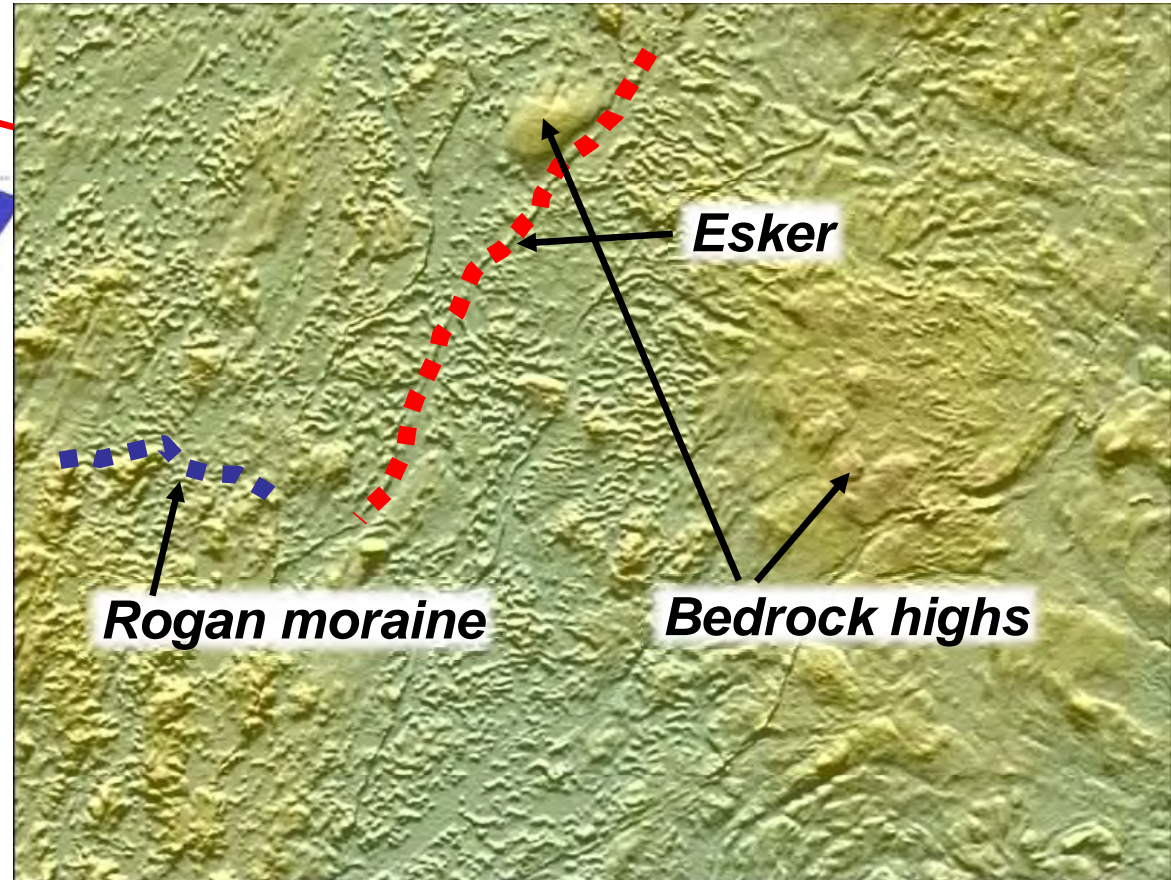
The modern landscape



Esker, NE Manitoba



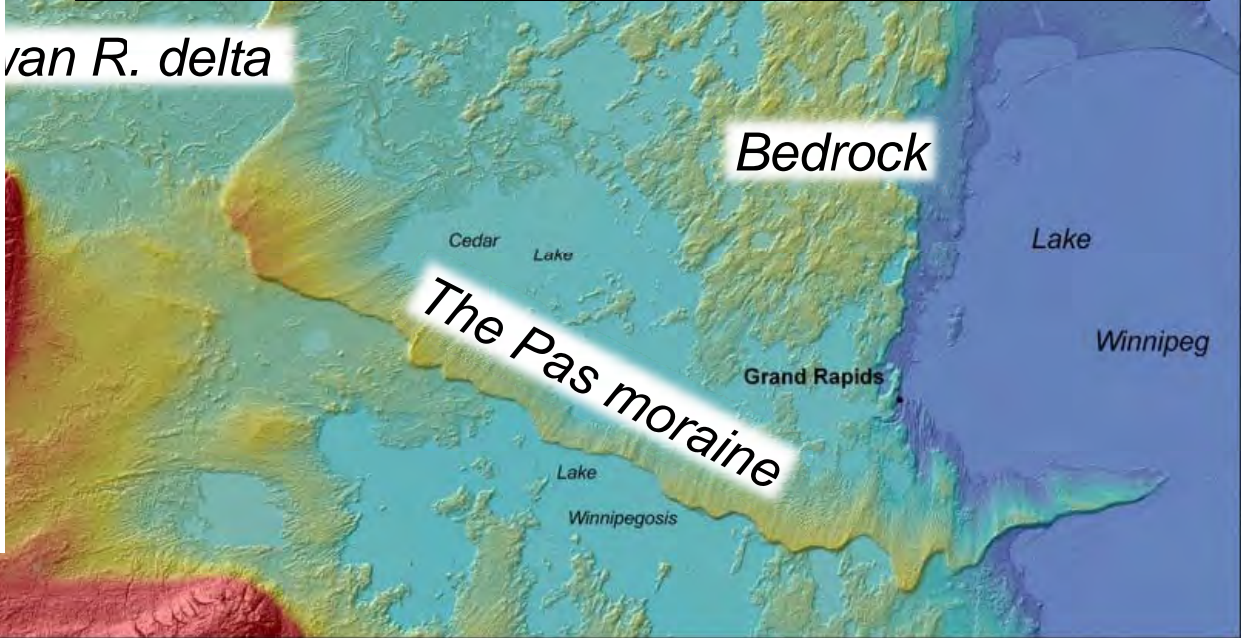
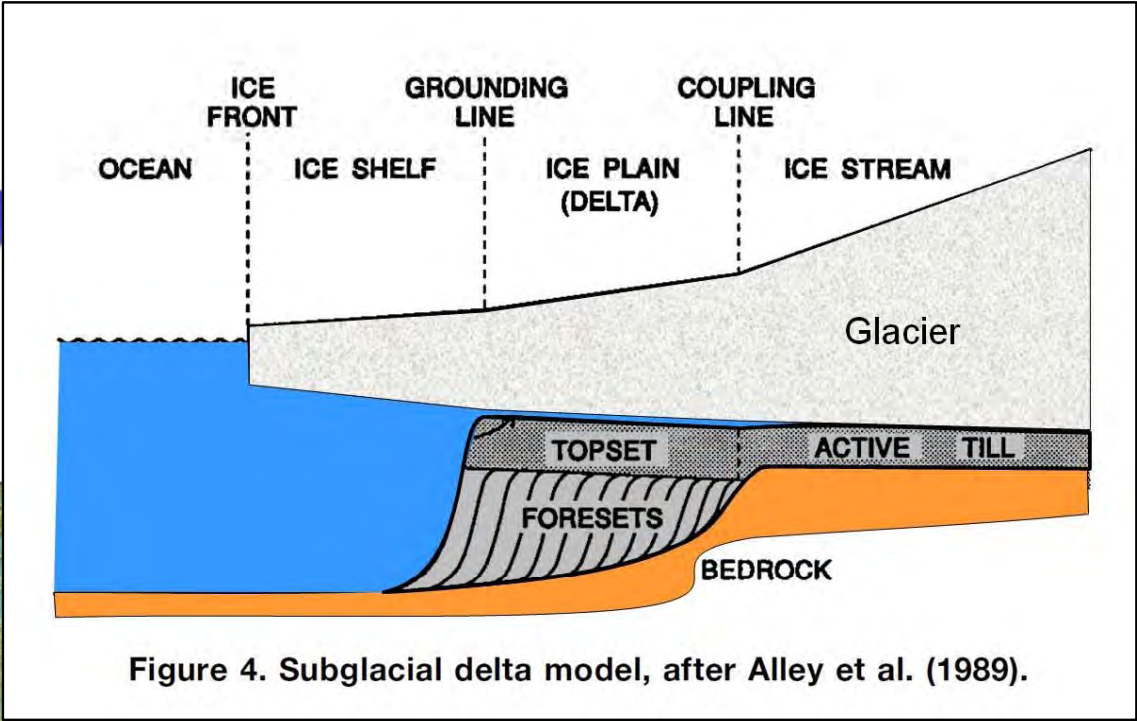
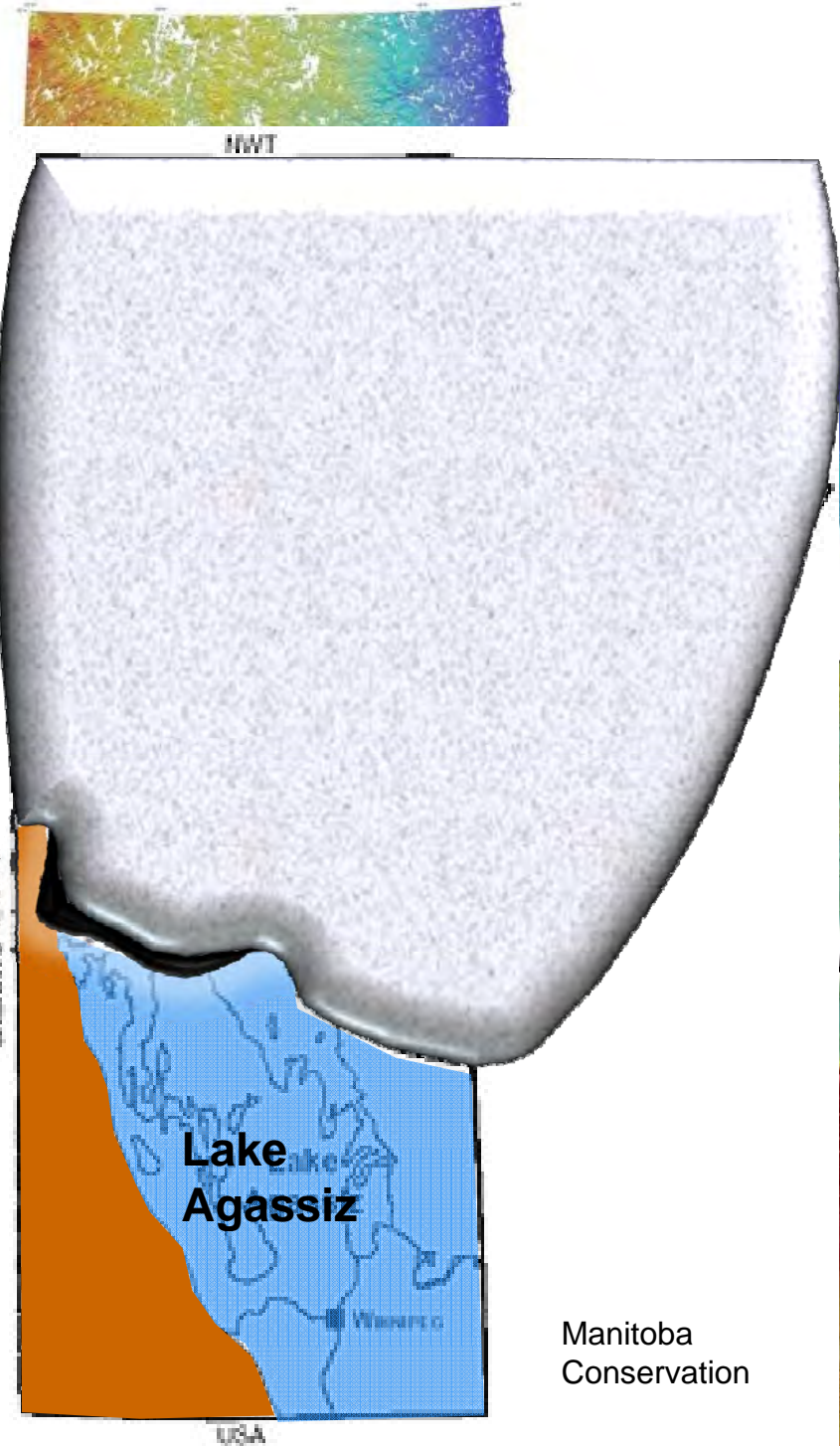
Rogan moraine, NE Manitoba



- The last glacial period resulted in the deposition or modification of the landscape features we see today.

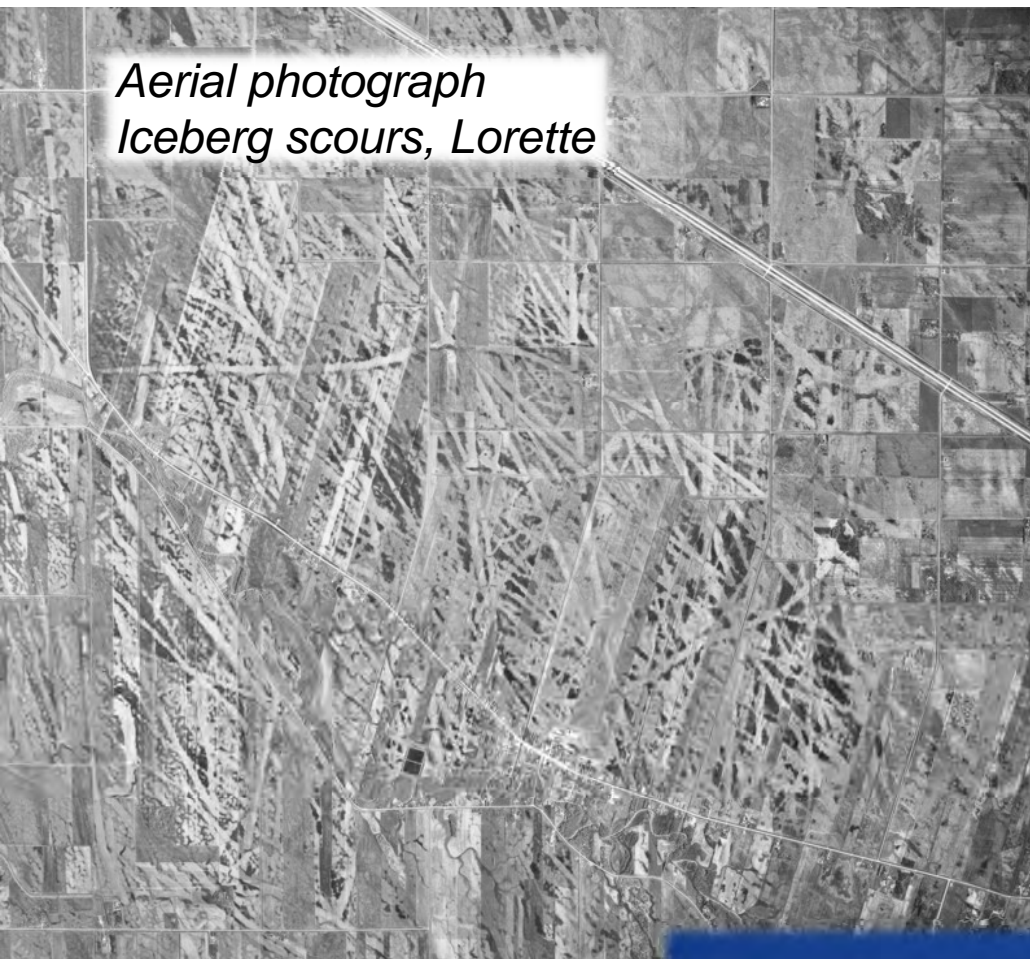
Cenozoic Era

The modern landscape



Digital Eleva

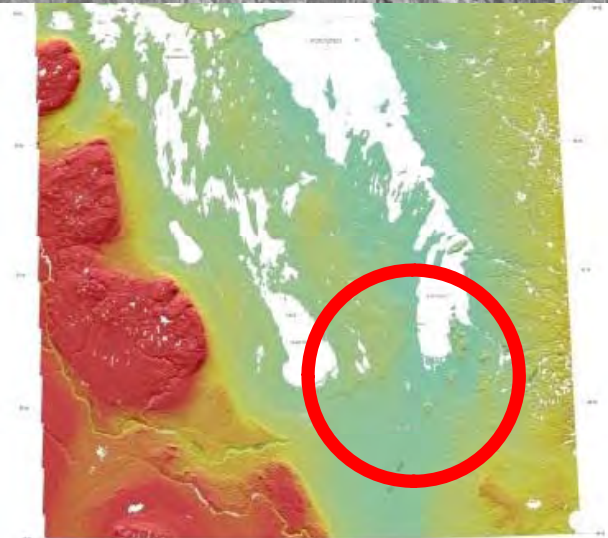
*Aerial photograph
Iceberg scours, Lorette*



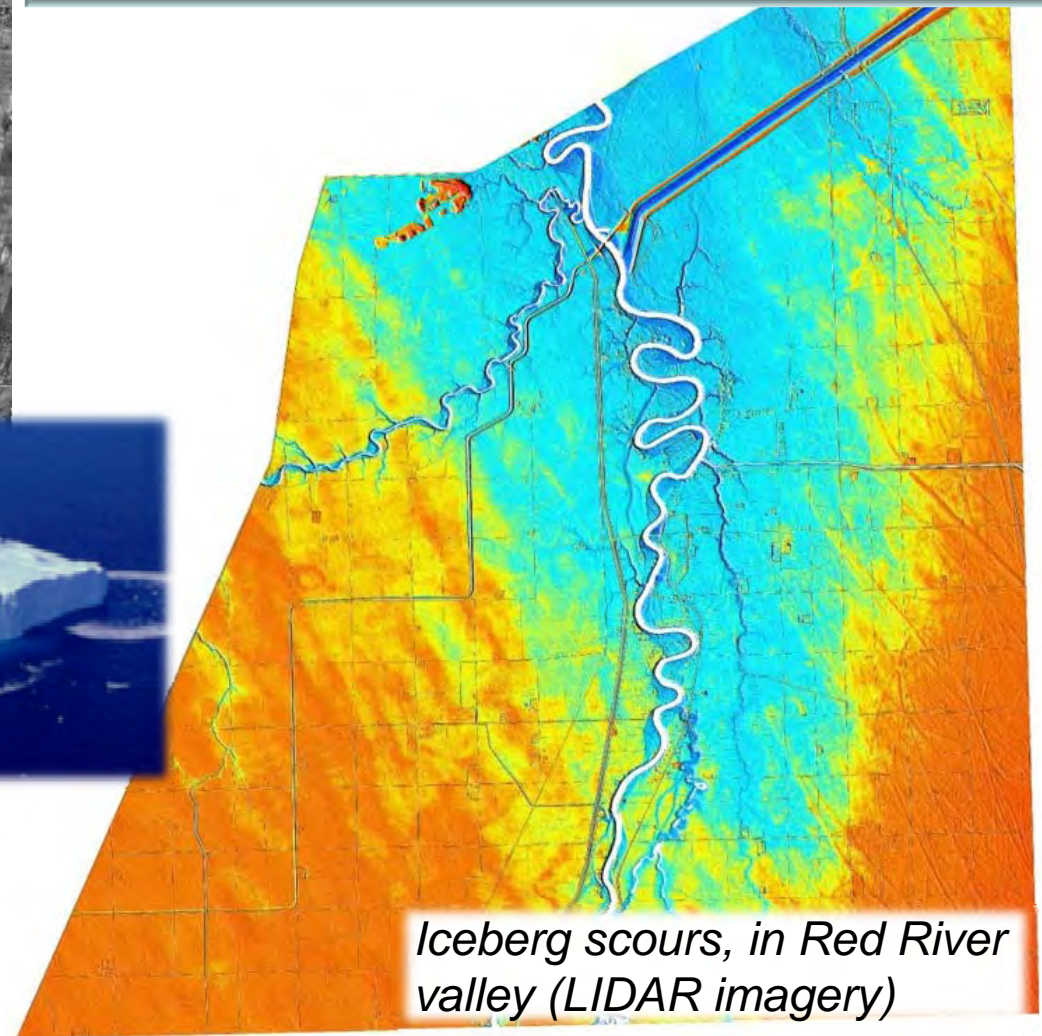
Cenozoic Era

The modern landscape

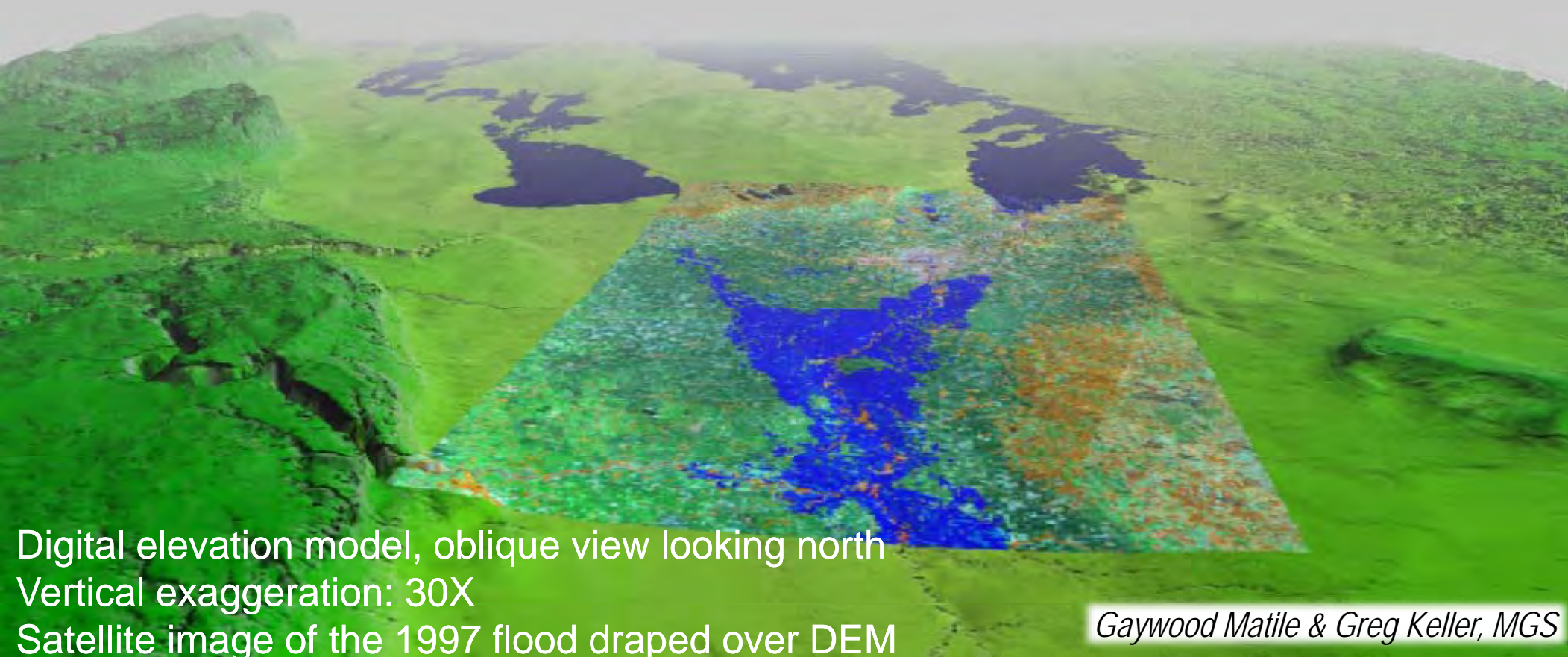
- In the Red River Valley, it is still possible to see the scars left in the former lake bottom of Glacial Lake Agassiz



Digital Elevation Model (NASA)

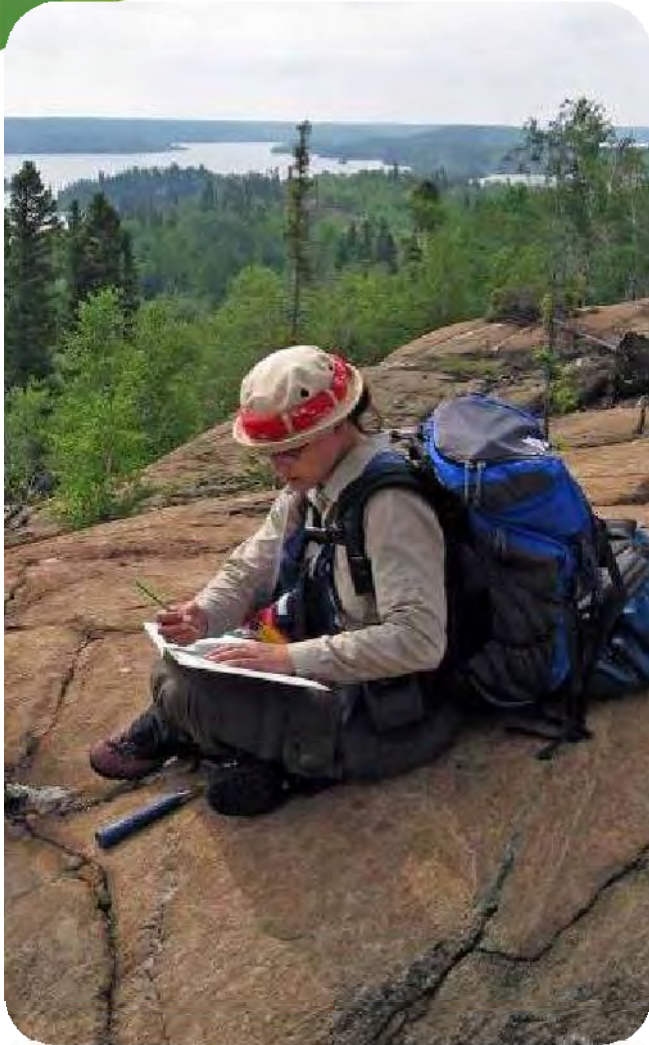


Iceberg scours, in Red River valley (LIDAR imagery)



- 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