

EPSC240: GEOLOGY IN THE FIELD

# (SOME OF THE) GEOLOGY OF QUÉBEC

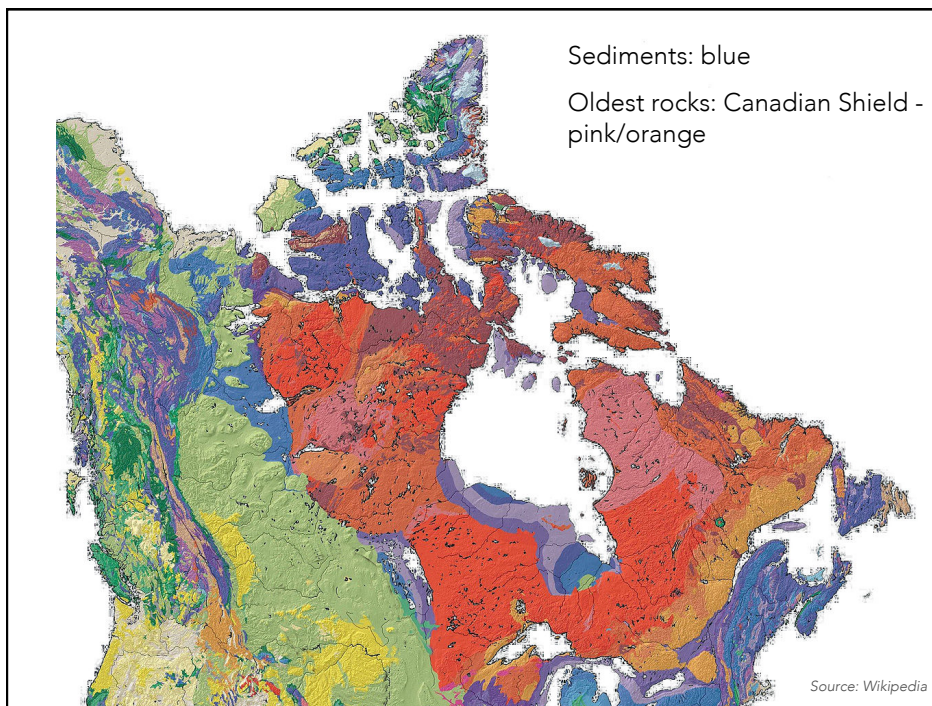


## WEDNESDAY

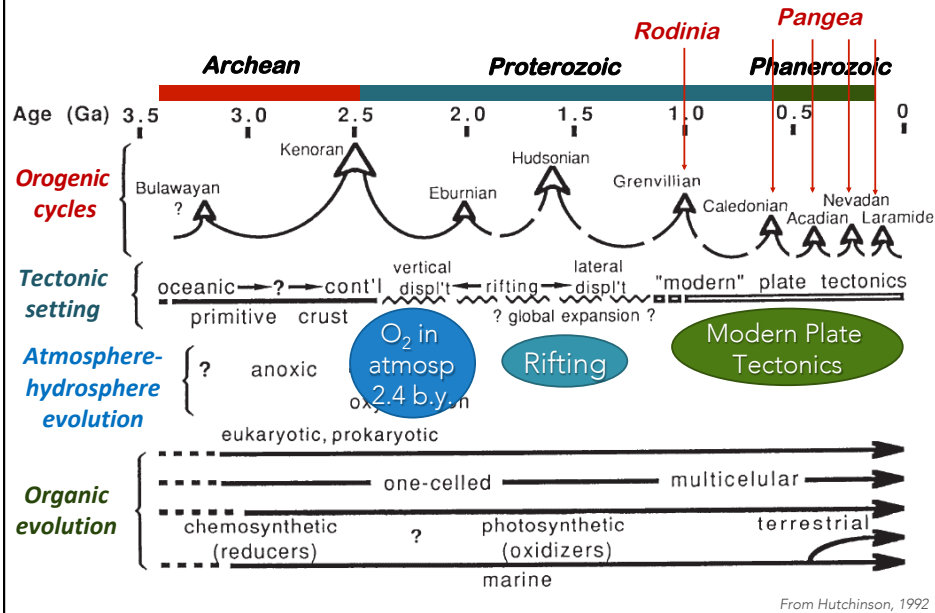
- Return mineral ID kits (for non-Mineralogy students)
- Google Earth/Mars lab due – at start of class
- Presentations

## WEDNESDAY

Time	Topic	Presenter(s)
1:45 pm	Abitibi gold (Archean)	Mathilde
2:00	Abitibi gold	Magda, Elisabeth
2:15	Appalachian foreland ophiolites (Paleozoic)	Émilie S
2:30	Manicouagan impact structure (Triassic)	Émilie L
2:45	Monteregian Hills (Cretaceous)	Giovanni, Coralie
3:00	Monteregian Hills	Emily P
3:15	Cookie time	
3:45	Monteregian Hills	Lois
4:00	Monteregian Hills	Deneyn, Audrey
4:15	Fossils of the Laval Formation	Joshua
4:30	St Lawrence Lowlands (Paleozoic)	Maya
4:45	St Lawrence Lowlands	Maude
5:00	Hudson Bay Lowlands (glacial-modern)	Rachel

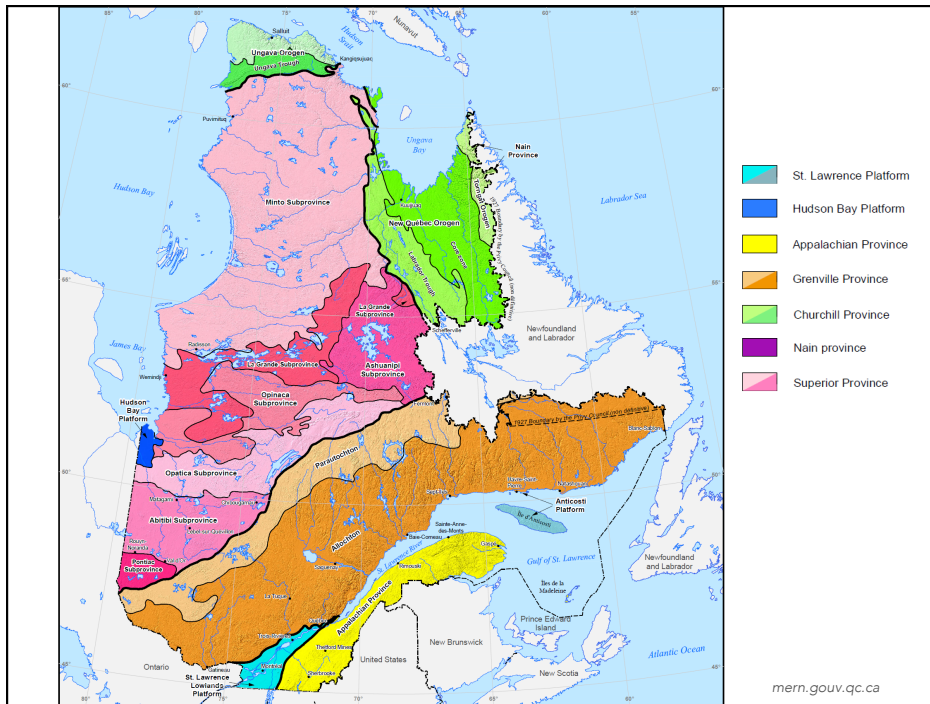


## MAJOR EVENTS IN EARTH HISTORY



## GEOLOGIC PROVINCES

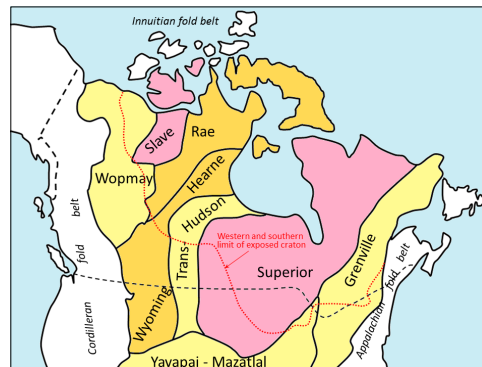
- Groups or areas of rocks which share some history
- Examples:
  - Rocks of similar age
  - Rocks of similar origin
- Divided from other provinces by faults or unconformities
- **Terranes are fault-bounded, smaller-scale regions with distinct tectonic history**



## LAURENTIA: THE CANADIAN SHIELD

opentextbc.ca

- Part of the supercontinent Rodinia (1100-700 Ma)
- ➔ Superior, Churchill, Grenville Provinces
- Outer areas covered by sediments during Ordovician, Silurian, Devonian
- ➔ Hudson Bay & St Lawrence Platforms



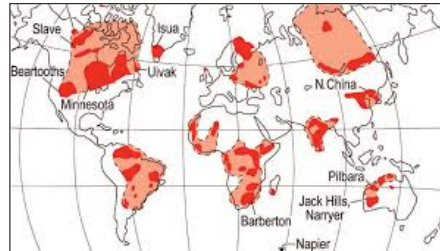
Main provinces of Laurentia. Pink = oldest; light yellow = youngest. Areas S & W of dotted red line are now covered with younger rocks (not part of Canadian Shield). White areas = rocks that were added to North America since 700 Ma.

## ARCHEAN : 4300 - 2500 MA

- Unique assemblages of rocks - not formed on earth today
- Local evidence of bacteria, but no O<sub>2</sub> in atmosphere
- Archean crust is very rarely preserved - only in the central core of the oldest continents

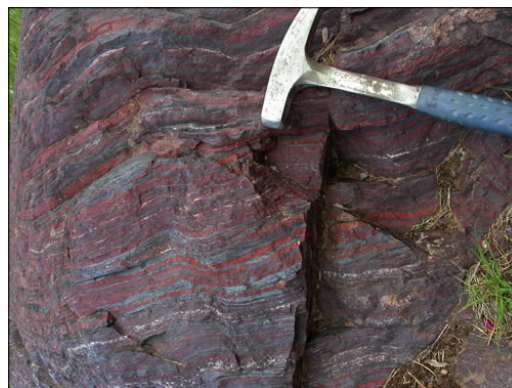


komatiite with spinifex texture



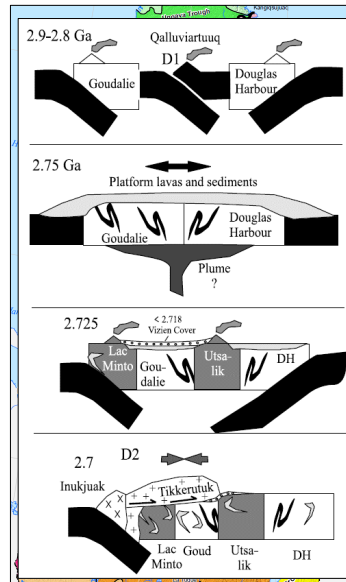
## ARCHEAN CANADA

- Roots of continents (mantle) beneath Archean crust are very old/cold, contain diamonds
- Only the volcanic pipes that go through Archean continental roots bring diamonds to surface
- Some of the oldest rocks found on earth (3.8 Ga):  
Porpoise Cove/  
Nuvvuagittuq  
Greenstone Belt, QC
- Canadian Shield -  
greenstone belts,  
gneisses
- Gold, iron, base metals



# SUPERIOR PROVINCE

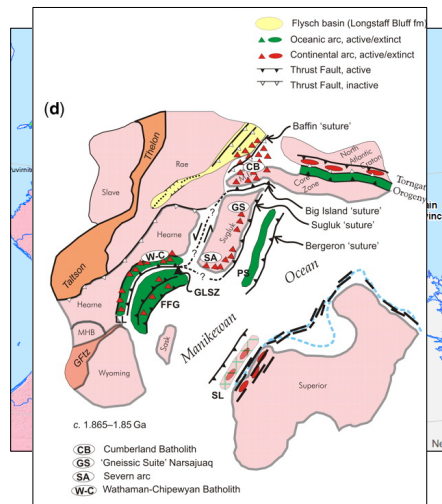
- Archean (4.3 - 2.5 Ga)
- Divided into multiple subprovinces with complex accretional history
- e.g., Minto Block (right) → subduction, rifting, subduction
- Abitibi greenstone belt:
  - Volcano-sedimentary belt with gold, copper, zinc, silver



Bedard et al. (2003)

# CHURCHILL PROVINCE

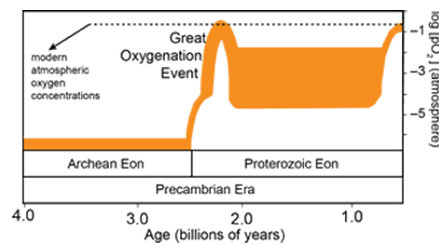
- Archean-Mesoproterozoic (2.9-1.1 Ga)
- Collided with the Superior Province at about 1.9–1.8 Ga in the Trans-Hudson orogeny
- Accretion of micro-continents, arc terranes
- Highly reworked, metamorphosed fold-and-thrust belts



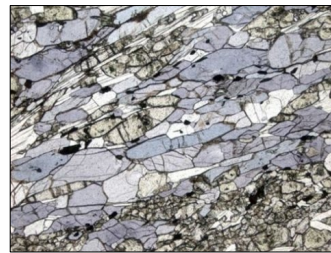
Corrigan et al. (2009)

## PROTEROZOIC : 2500 - 540 MA

- Great Oxidation Event: Rise of oxygen at 2.45 Ga - from ~1% of atmosphere to >12% (modern level: 21%)
- Onset of subduction (?): Oldest high pressure-low temperature rocks (blueschists & eclogites = direct evidence of subduction)



thecollege.syr.edu



Oldest blueschists ~700-800 Ma.  
Blue mineral: glaucophane.  
sciencedaily.com

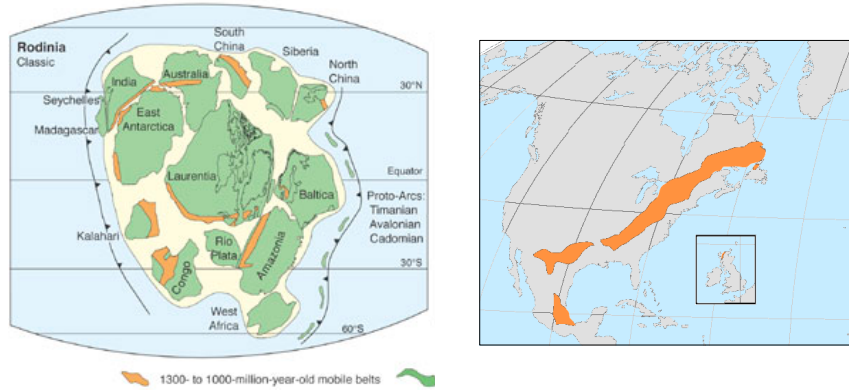
## PROTEROZOIC CANADA

- Global time of hot orogens - 1200-900 Ma: left huge belts of very melty rocks!
- Proterozoic collision between Archean blocks of continental crust built core of N America



www.geol.ucsb.edu

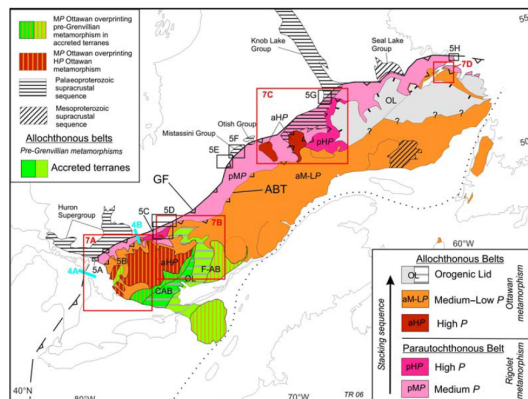
# GRENVILLE PROVINCE



- Consists of Archean (Superior) rocks, plus accreted arc terranes (2-1.2 Ga), plus orogenic belt (~1 Ga)

# GRENVILLE PROVINCE

- Product of long-lived collisional (Grenville) orogeny during assembly of Rodinia:
- 1) Parautochthon (2 to 1.2 Ga)
    - Accreted arc terranes, supracrustal & plutonic rocks
  - 2) Allochthon (~1 Ga)
    - Fold & thrust belt of metasediments & gneisses.



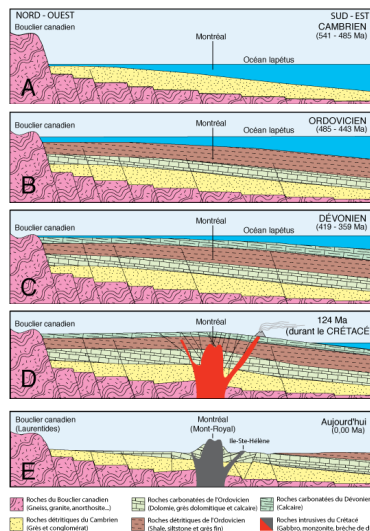


# PHANEROZOIC: 540 MA - NOW

- Cambrian Explosion (540 Ma): Photosynthesizing cyanobacteria, appearance of multi-cellular life
- Shells - predation
- Burrowing - changed sediments forever!
- Modern tectonics
- Similar to modern climates



# PHANEROZOIC QUÉBEC



Cambrian: sand & gravel sedimentation (Iapetus Ocean)

Ordovician: limestone & mud deposition (tropical sea environment)

Devonian: deposition of more limestone & eventual disappearance of Iapetus

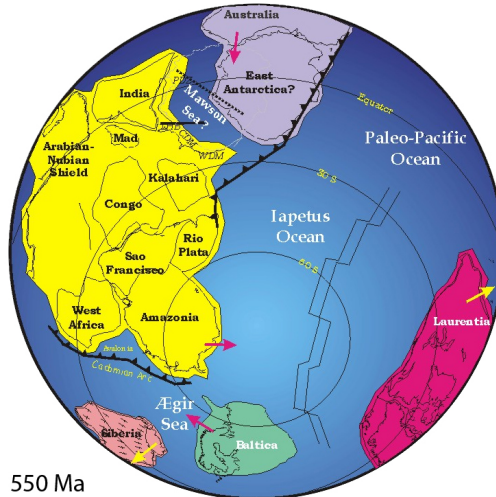
Cretaceous: ascension of magma from the earth's mantle

Today: glacial erosion has removed some sediments & the intrusive rocks are visible. They resisted erosion, creating Mt Royal.

From [www.pierrebedard.uqam.ca/mont-Royal/excursion\\_mt-royal.html](http://www.pierrebedard.uqam.ca/mont-Royal/excursion_mt-royal.html)

## PALEOZOIC SUPERCONTINENTS

- Opening of Iapetus Ocean between Gondwana and Laurentia
- Appalachians
- Deposition of marine sediments (St Lawrence Platform)



Wikipedia

## PALEOZOIC QUÉBEC: APPALACHIAN PROVINCE

- At ~350 Ma, western Gondwana collided with E coast of Canada
- Arc-arc and arc-continent collisions during closure of Iapetus Ocean
- Accreted arcs & sediments became Appalachian fold belt
- Would have been as high as the Himalayas before erosion!

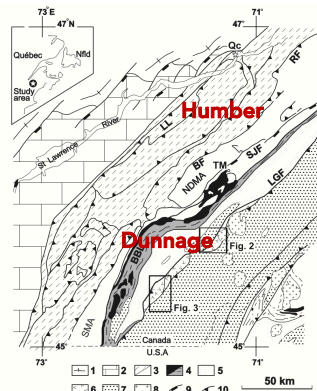


Figure 1. Geologic map of the southern Québec Appalachians. Modified from Castonguay et al. (1997). 1—Grenvillian rocks; 2—Cambrian-Ordovician rocks of the autochthonous domain; 3—fault-inhherited continental margin rocks (external domain is dashed); 4—ophiolite rocks (in black) and melange units; 5—syn-Iaconian flysch deposits (Magog Group); 6—Ascot Complex volcanic rocks; 7—Silurian-Devonian rocks of the Gaspé Belt; 8—syn- to post-Acadian intrusive rocks; 9—normal faults; 10—thrust faults. LGF—La Guadeloupe fault; LL—Logan's line; RF—Richardson fault; SJF—St-Joseph fault; BBL—Baie Verte—Brompton line; Qc—Québec city; TM—Theford Mines; SMA—Sutton Mountains anticlinorium; BF—Bennett fault; Nfd—Newfoundland; NDMA—Notre Dame Mountains anticlinorium. See inset for location.

## PALEOZOIC QUÉBEC: APPALACHIAN PROVINCE

- Humber Zone: Remnants of a passive margin, developed on Laurentia during Cambrian-Ordovician
  - Marine sediments
- Dunnage Zone: Subduction zone rocks developed in laptus during Cambrian-Ordovician
  - Island arcs, ophiolites

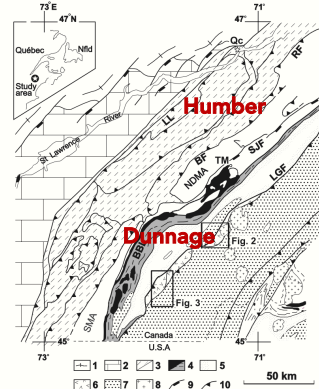
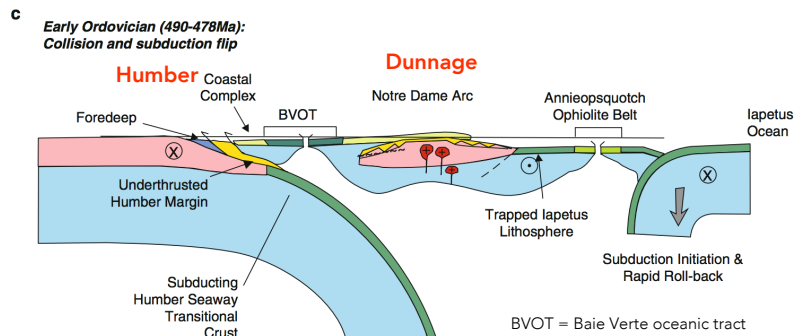


Figure 1. Geologic map of the southern Québec Appalachians. Modified from Castonguay et al. (1997). 1—Grenvillian rocks; 2—Cambrian-Ordovician rocks of the autochthonous domain; 3—fault-imblicated continental margin rocks (external domain is dashed); 4—ophiolitic rocks (in black) and melange units; 5—syn-Taconian flysch deposits (Magog Group); 6—Ascot Complex volcanic rocks; 7—Silurian-Devonian rocks of the Gaspé Belt; 8—syn- to post-Acadian intrusive rocks; 9—normal faults; 10—thrust faults. LGF—La Guadeloupe fault; LL—Logan's line; RF—Richardson fault; SJF—St. Joseph fault; BBL—Baie Verte-Brompton line; Qc—Québec city; TM—Theford Mines; SMA—Sutton Mountains anticlinorium; BF—Bennett fault; Nfd—Newfoundland; NDMA—Notre Dame Mountains anticlinorium. See inset for location.

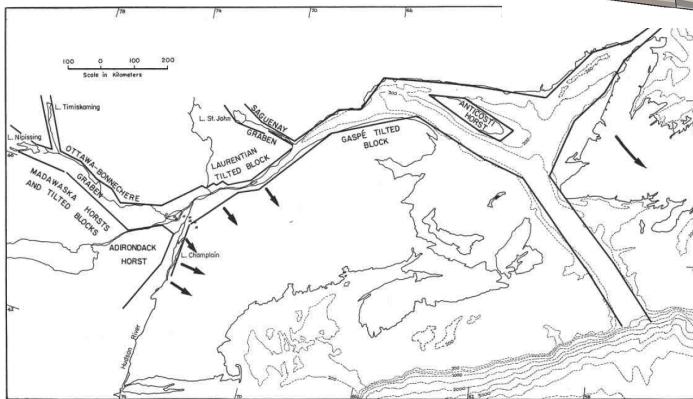
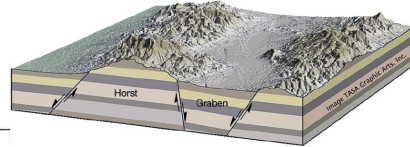
## PALEOZOIC QUÉBEC: APPALACHIAN PROVINCE



- Appalachians divided into distinct terranes based on rock history
- Above: Humber and Dunnage rocks in Ordovician time (Taconian orogeny)

## PALEOZOIC QUÉBEC: ST LAWRENCE PLATFORM

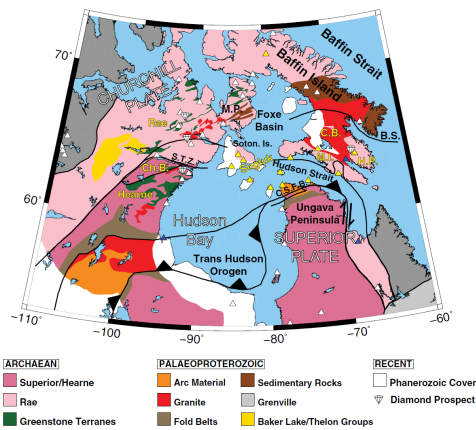
- Formed from St Lawrence rift as a horst-graben series (570 to 430 Ma)



Kumapareli & Saul (1966)

## PALEOZOIC QUÉBEC: HUDSON BAY PLATFORM

- Hudson Bay Basin overlies Canadian Shield
- Formed during late Cambrian by rising sea levels (marine transgression)
- Basin filled by Ordovician-Devonian carbonates, clastic sediments
- Extensive hydrocarbon potential
- Ongoing glacial rebound



Bastow et al. (2015)

## SUMMARY

- Quebec is made up of 7 geological provinces
  - Mostly Archean/Proterozoic Superior, Churchill, Grenville Provinces
  - Product of assembly and breakup of supercontinents
- Phanerozoic:
  - 600-300 Ma Appalachian Province - orogens
  - Cambrian-Devonian cover by St Lawrence/Hudson Bay Platform sediments
  - Cretaceous intrusion of Monteregian Hills

