UNIVERSITY OF SOUTH ALABAMA

GY 112: Earth History

The Proterozoic Part 1

Lectures 18/19: Tectonics

Instructor: Dr. Douglas W. Haywick

Last Time

1) The Early Atmosphere
2) The Oceans and Hydrosphere
3) The Change

Earth's Early Atmosphere

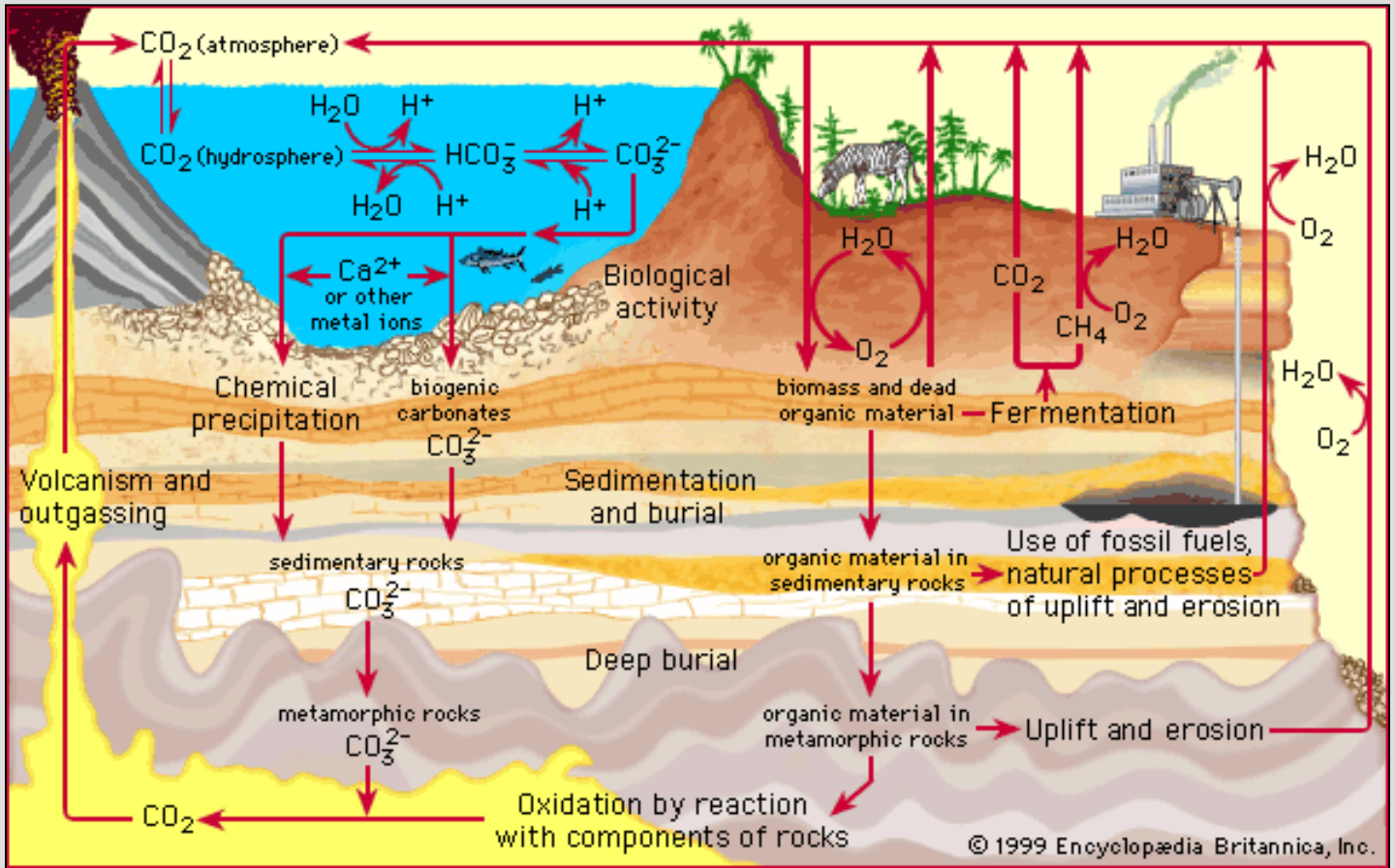
4.1 GA:

N_2; HCl; SO_2; CO_2; CH_4; NH_3; NO_2; H_2O

No…. O_2

Earth's Hydrosphere

- All water on, in and over the Earth is recycled via the hydrologic cycle



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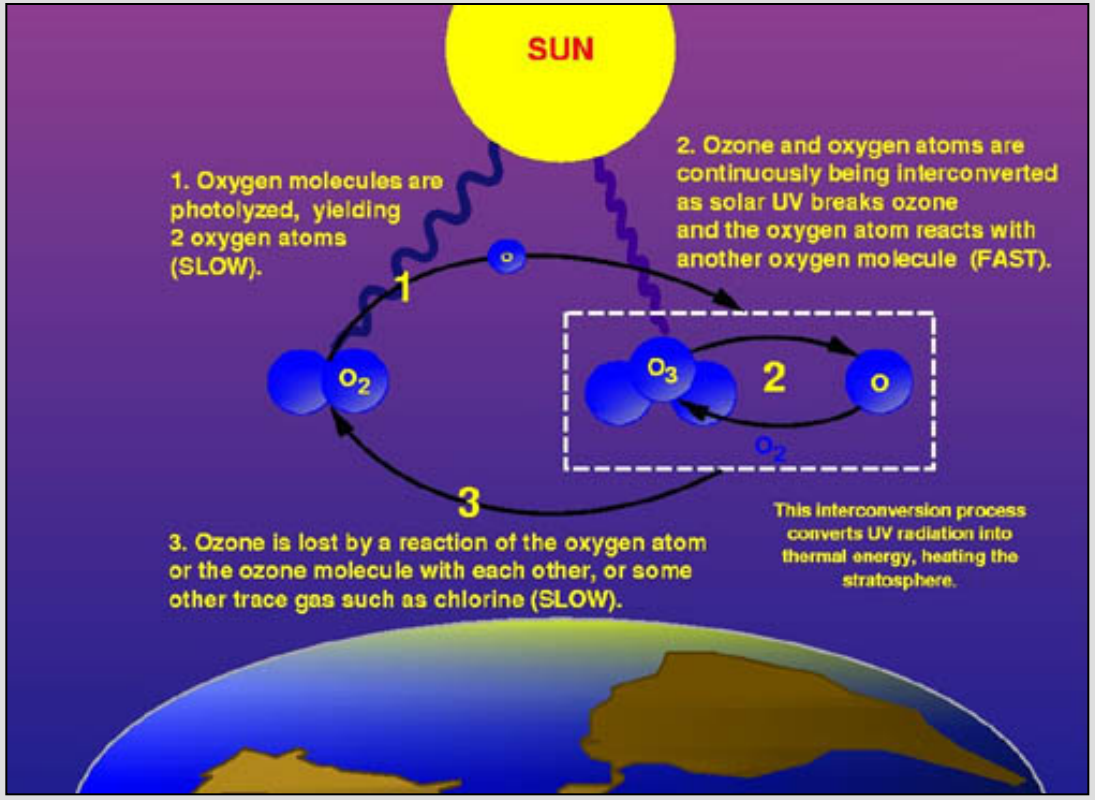
Ozone

UV radiation in the upper atmosphere makes ozone

$$2H_2O + UV \rightarrow H_2 + O_2$$

$$2O_2 + UV \rightarrow O_3 + O$$



Oxygen

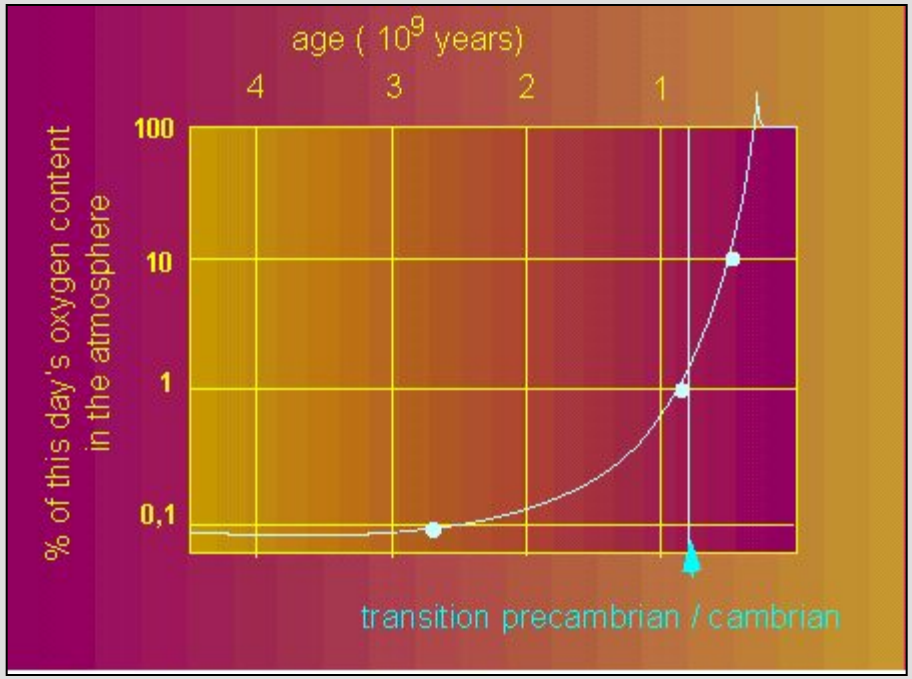
Cyanobacteria (e.g., the microorganisms comprising stromatolites)
and photosynthesis made oxygen starting at least 3.865 GA ago..

Photosynthesis

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 \text{ (“sugar”)} + 6O_2$$

Oxygen

The atmosphere became oxidizing by 1.8 GA and reached near current levels by the Ordovician.



http://www.biologie.uni-hamburg.de/b-online/ge42/01.jpg

Today's Agenda

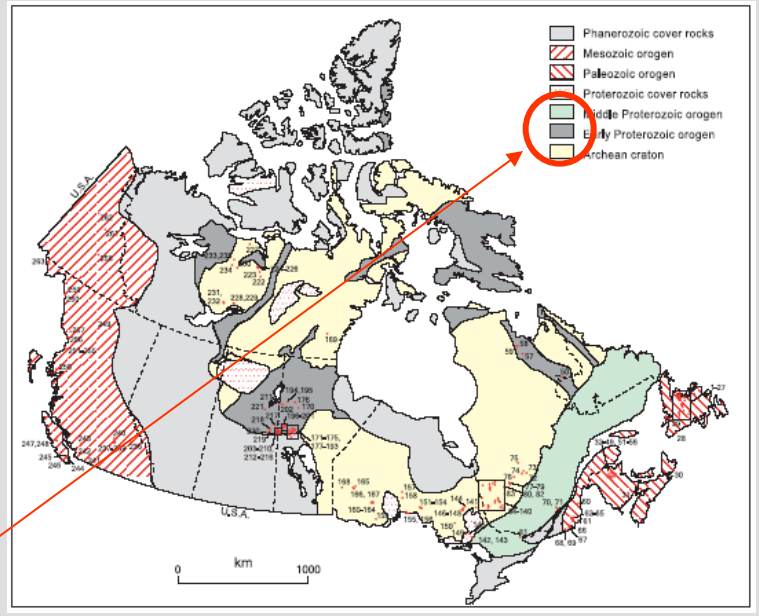
Proterozoic Part 1: Tectonics

1) The Proterozoic time frame
2) Paleogeography
3) Tectonics (Wopmay Orogeny)
4) The Wilson cycle
5) The Trans-Hudson Orogenic Belt
6) The Grenville Orogeny

(Web Lectures 18 and 19)

The Proterozoic Eon

Eon	Time
Phanerozoic	550 MA to 0 MA
Proterozoic	2.5 GA to 550 MA
Archean	4.1 GA to 2.5 GA
Hadean	4.6 GA to 4.1 GA



http://mmsd1.mms.nrcan.gc.ca/efab/images/slide1canMap_e.gif

Platform: younger (550 MA-2.5 GA) sedimentary rocks

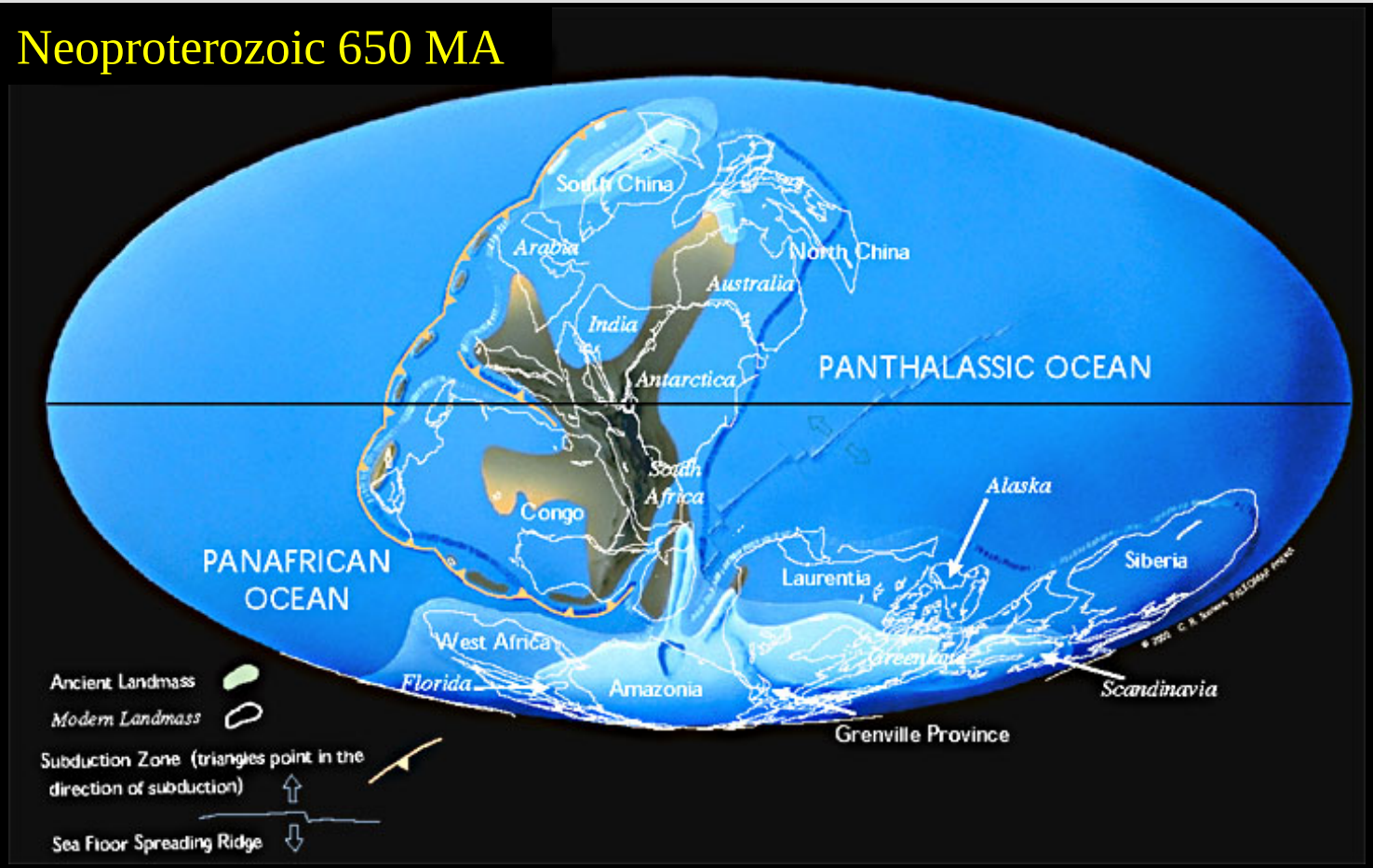
The Proterozoic Eon

Eon	Time
Phanerozoic	550 MA to 0 MA
Proterozoic	2.5 GA to 550 MA
Archean	4.1 GA to 2.5 GA
Hadean	4.6 GA to 4.1 GA

Division (ERA)	*Age*
Neoproterozoic	900 MA to 550 MA
Mesoproterozoic	1.6 GA to 900 MA
Paleoproterozoic	2.5 GA to 1.6 GA

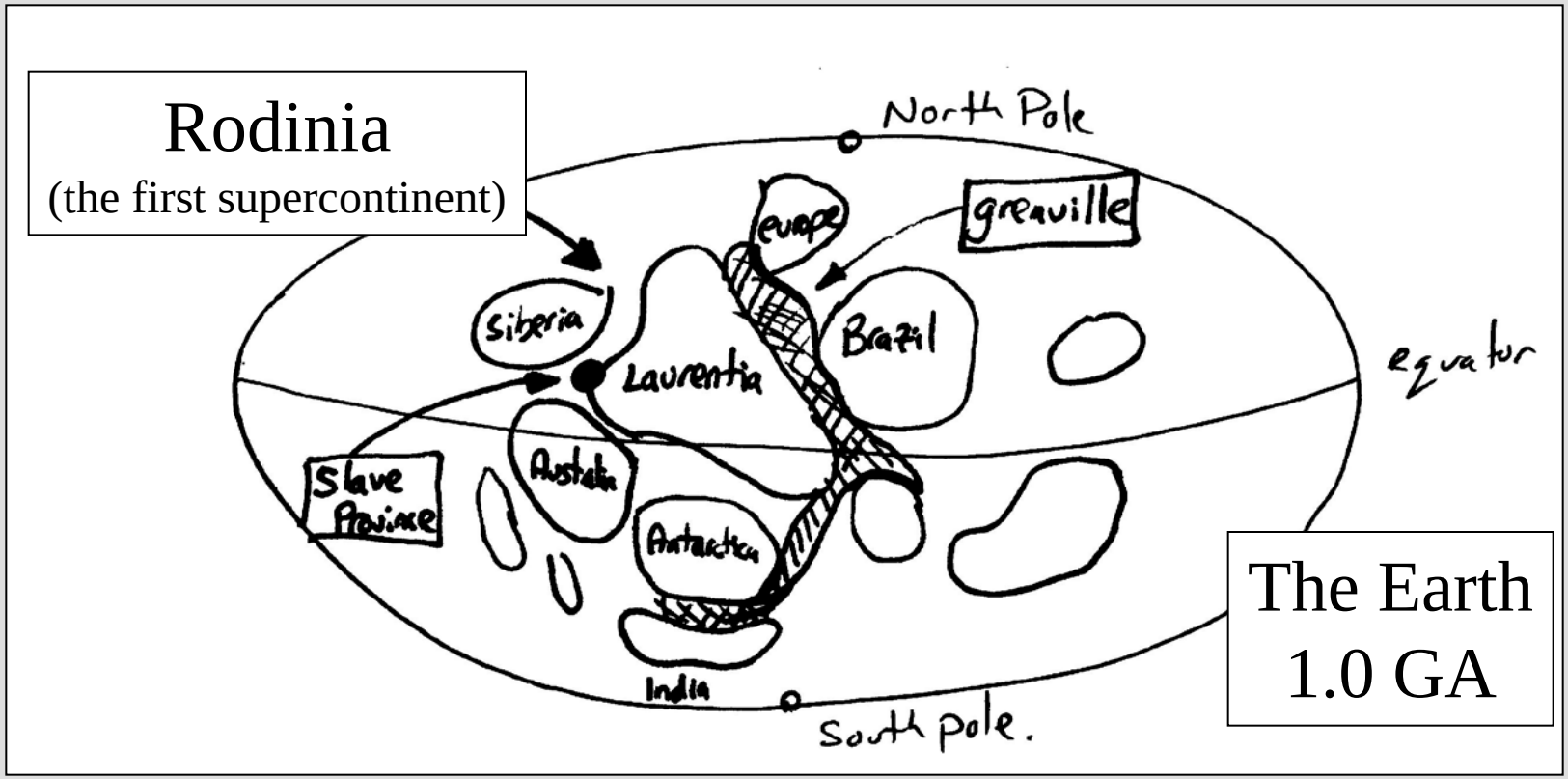
- Paleo- old
- Meso-middle
- Neo-new

Proterozoic Paleogeography



- This is about as far back as we can go with detailed paleogeography

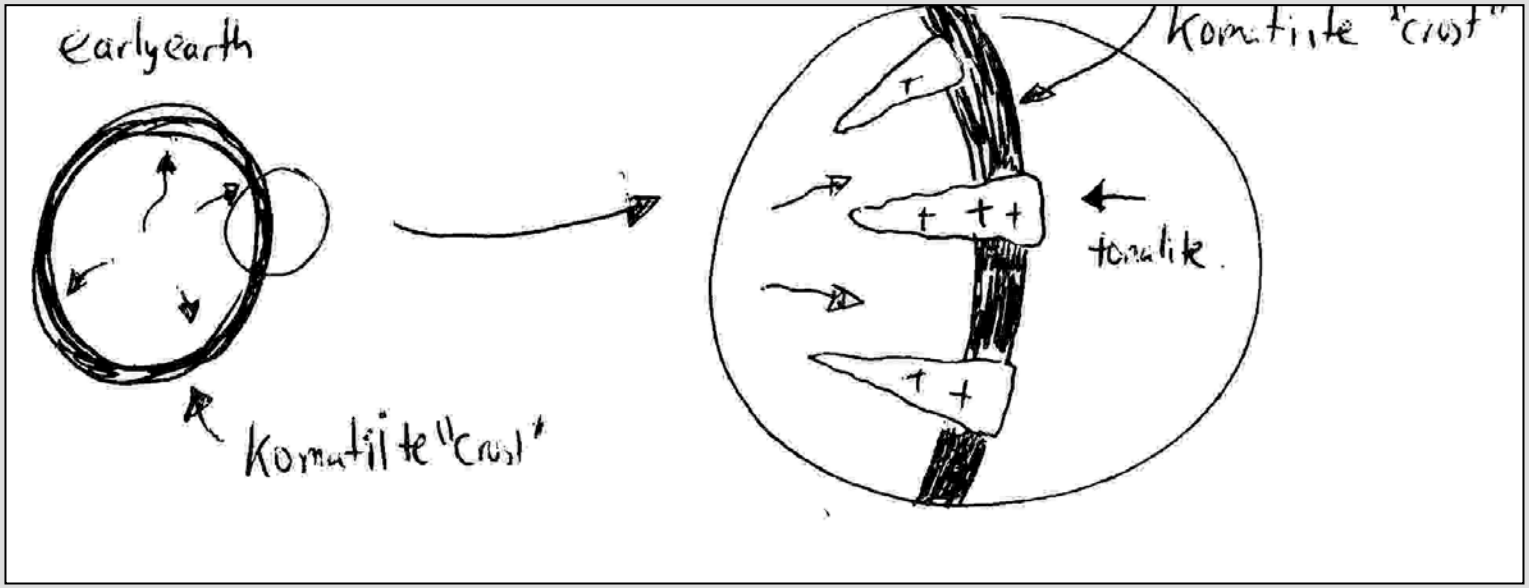
Proterozoic Paleogeography



- But we can “guestimate” back to about 1 GA

Archean Tectonics

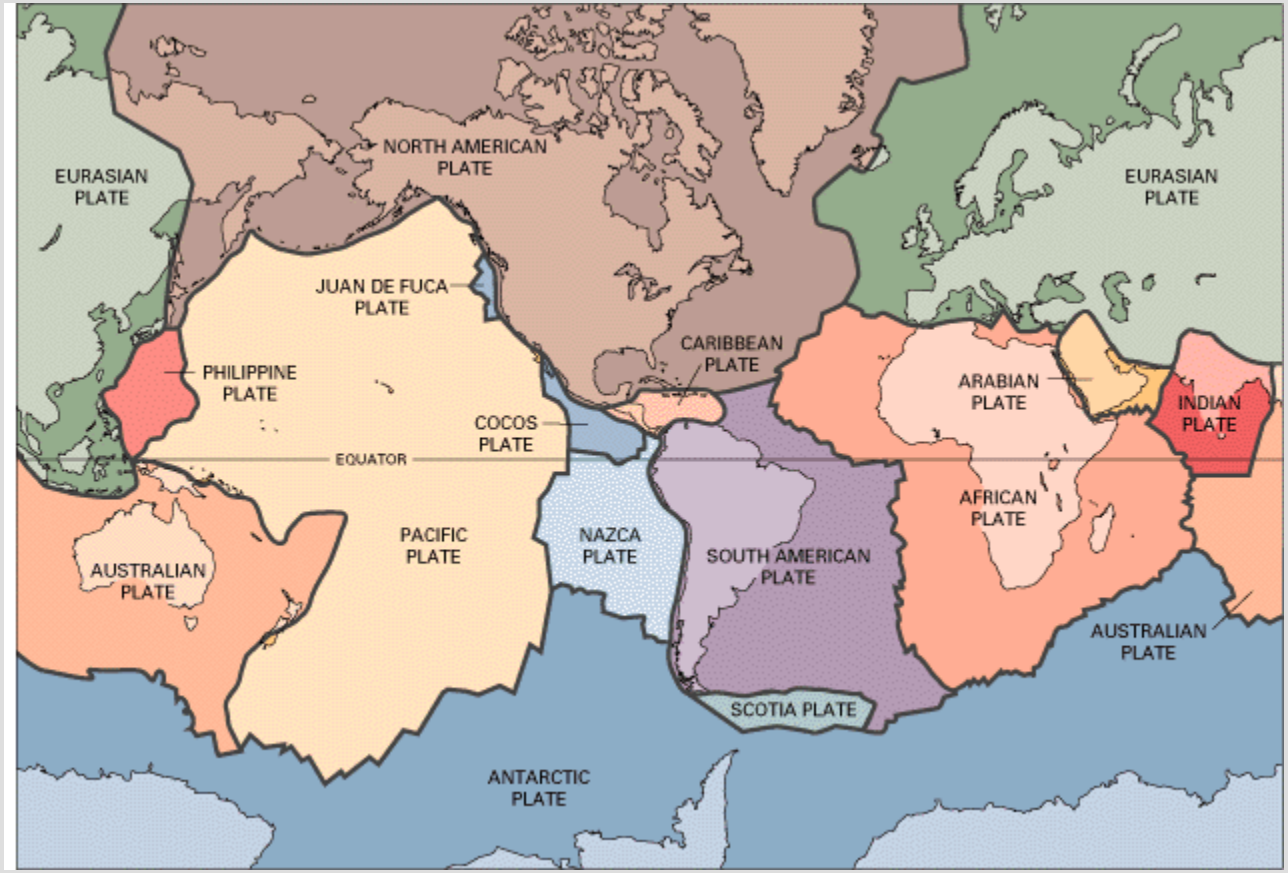
Recall: Archean Tectonics involved differentiation of the Earth's crust. Volcanoes, plutons and stretching of the crust, but possibly limited to no "rifting"



- Translation: As far as we can tell, there was no modern plate tectonics during the Archean.

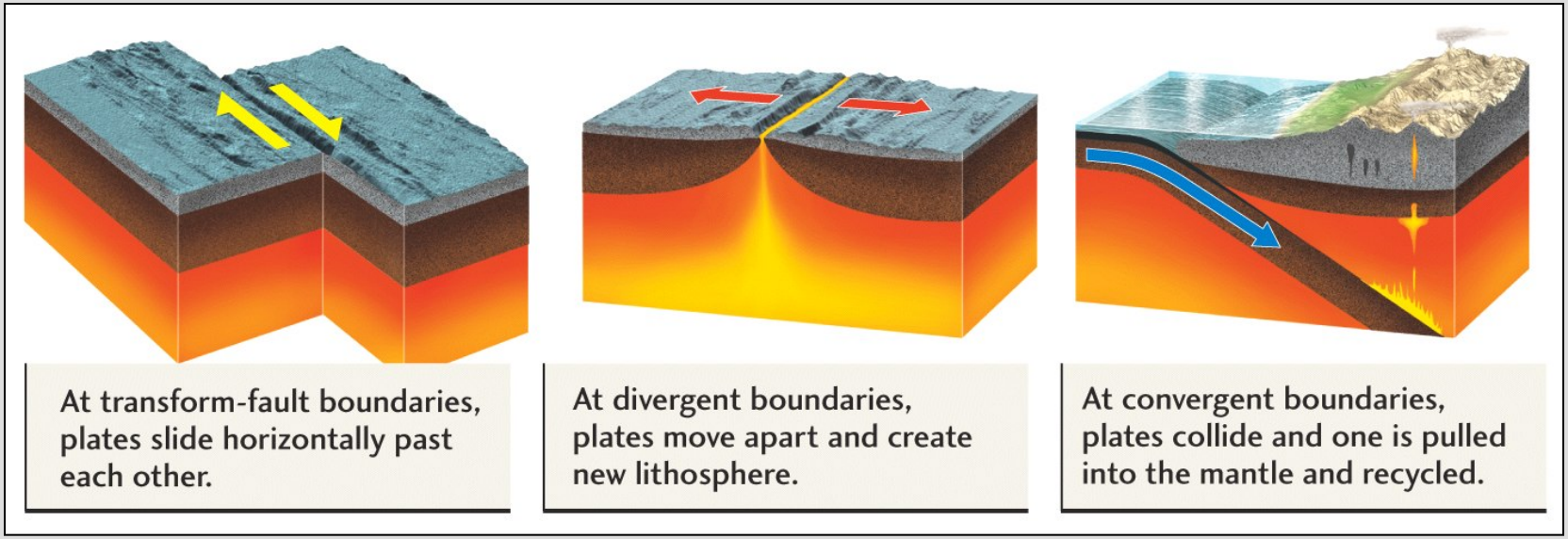
Modern Plate Tectonics

- 7 major lithospheric plates



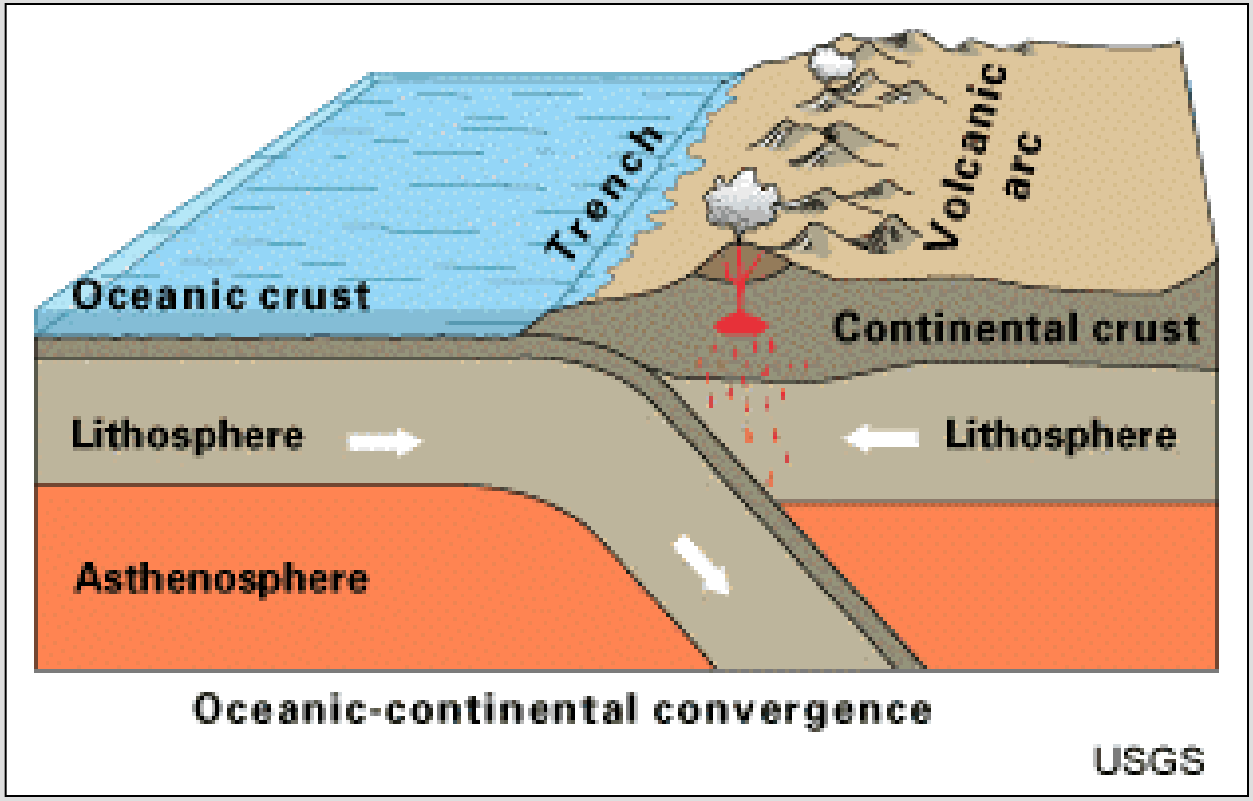
Modern Plate Tectonics

- Rigid lithospheric plates “float” atop ductile asthenosphere



Modern Plate Tectonics

- Where they make contact, you get serious geology (earthquakes, volcanoes, mountain building)



Proterozoic Tectonics

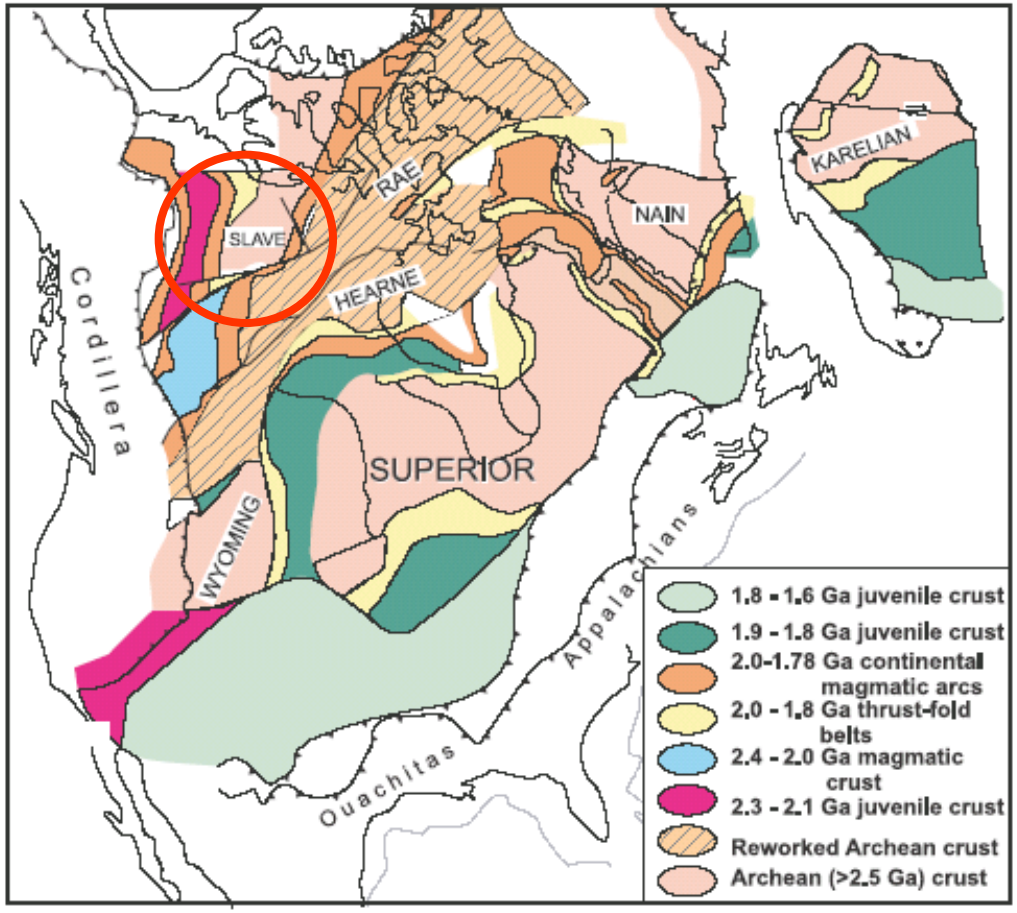
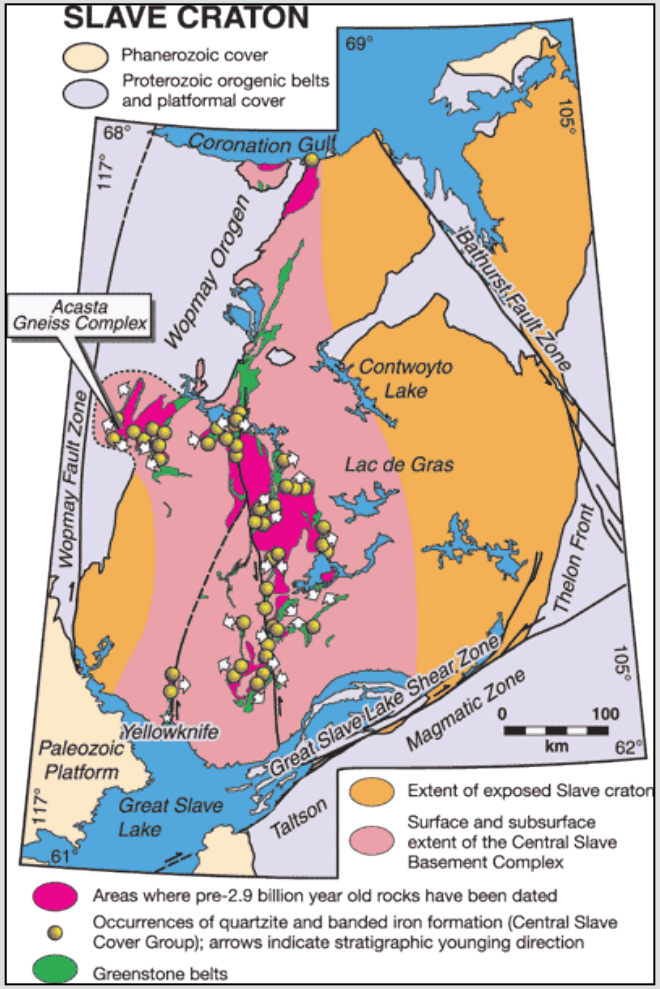


Fig. 1: Tectonic map of North America, showing location of the Archean Superior Province at the core of the Canadian Shield (after Hoffman, 1989).

- But this type of tectonics may not have always occurred
- The first evidence of divergent and convergent plate tectonics was during the Paleoproterozoic (2.1 GA) in the Slave Province of the Canadian Shield

Proterozoic Tectonics



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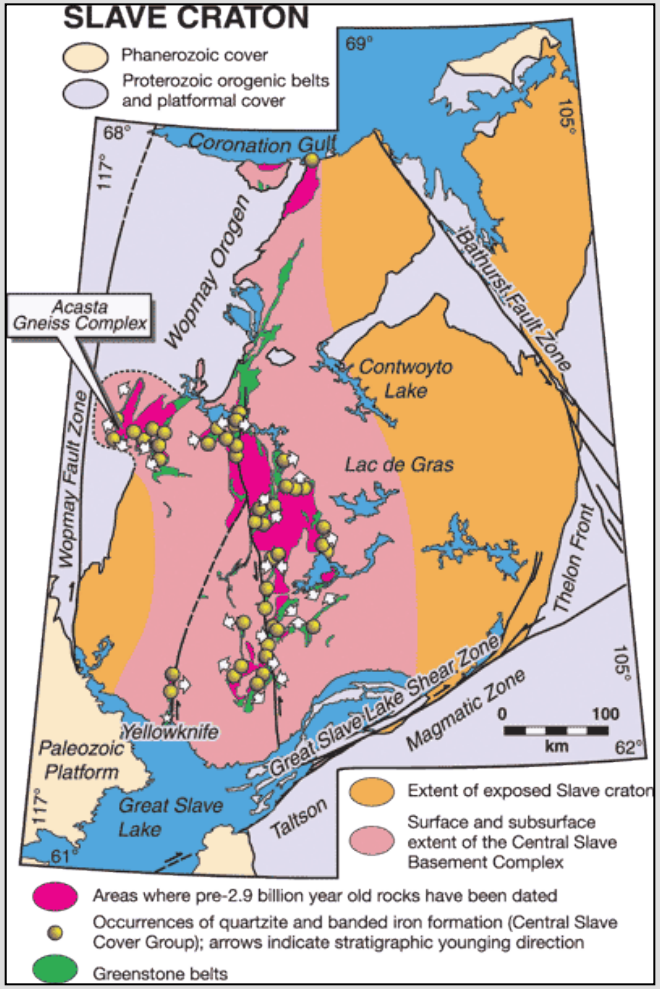
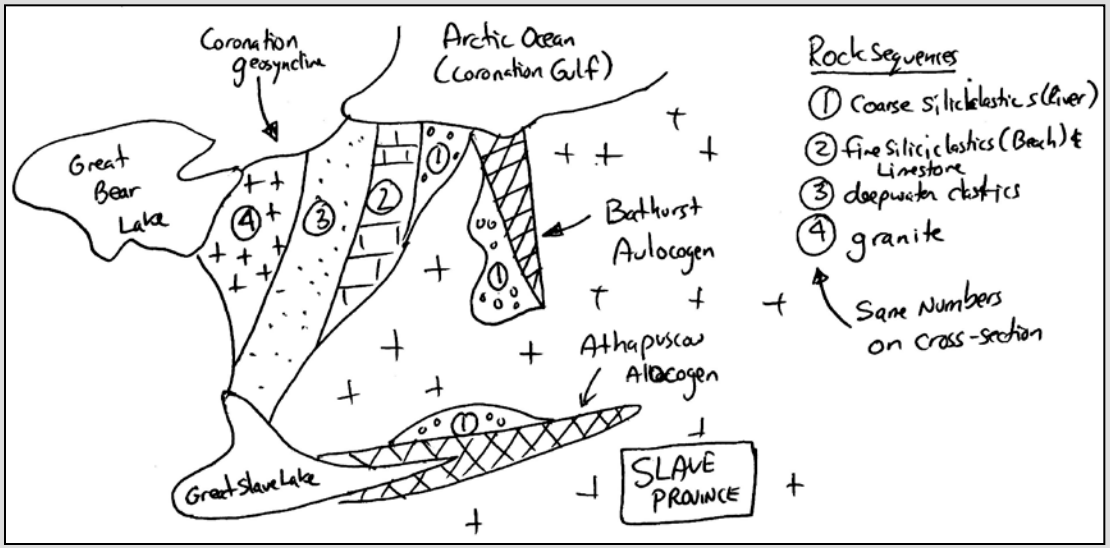
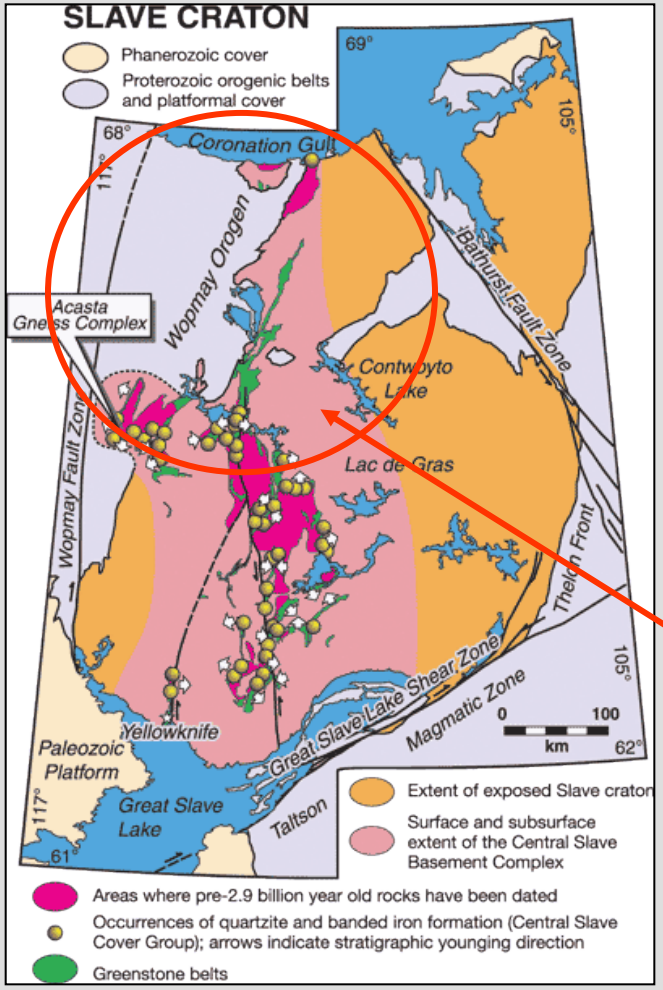
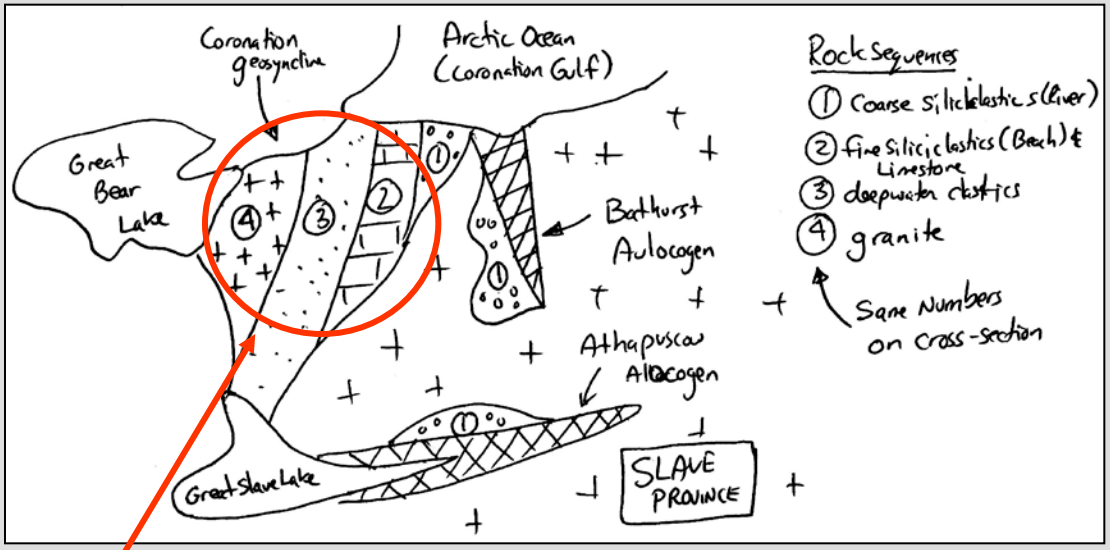
Proterozoic Tectonics





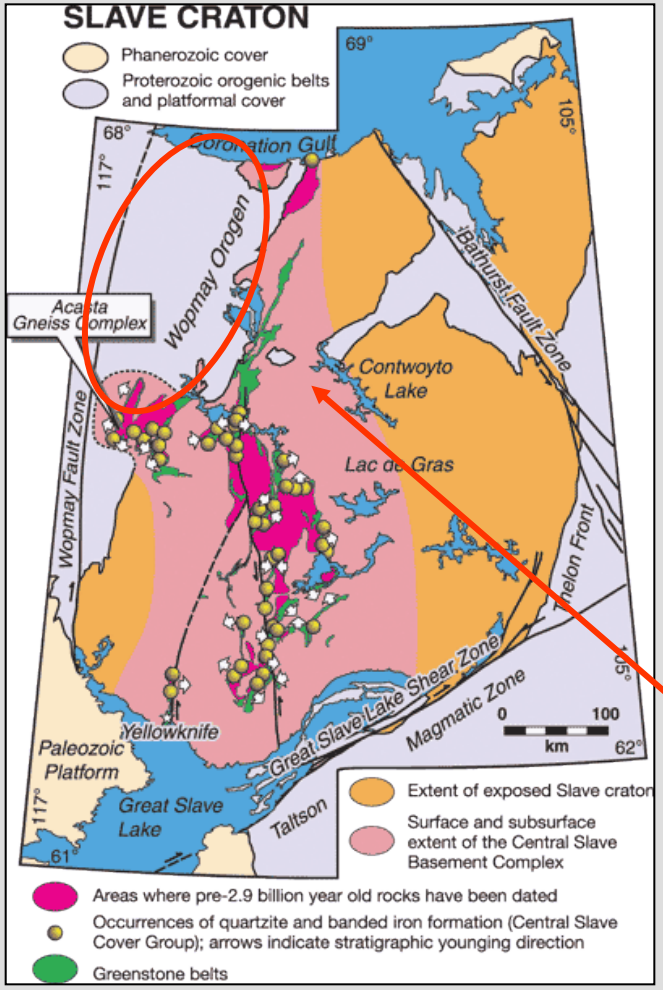
Proterozoic Tectonics

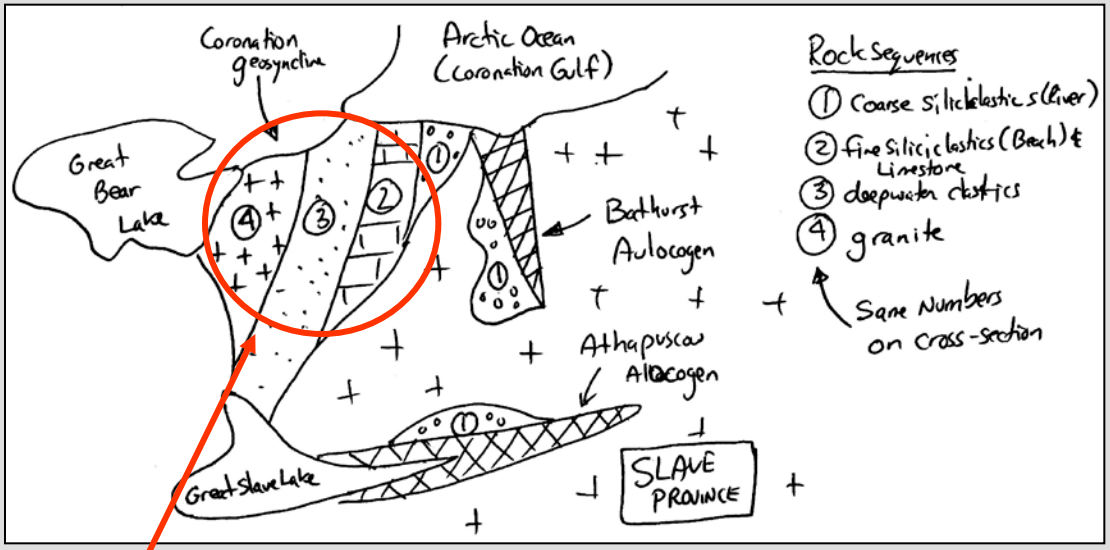




Coronation Geosyncline

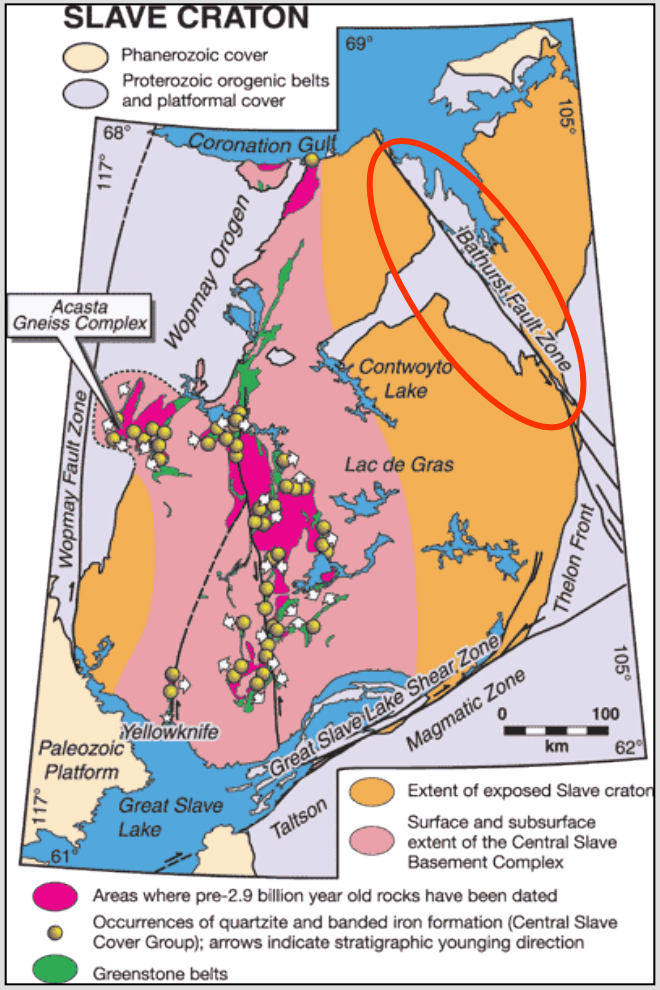
Proterozoic Tectonics

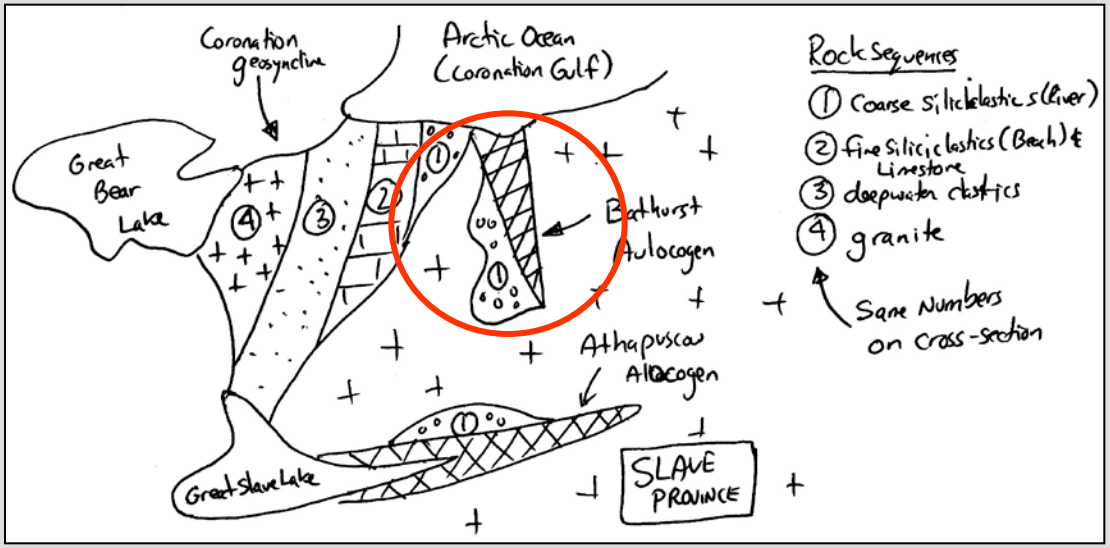




- Coronation Geosyncline
- Wopmay Orogen

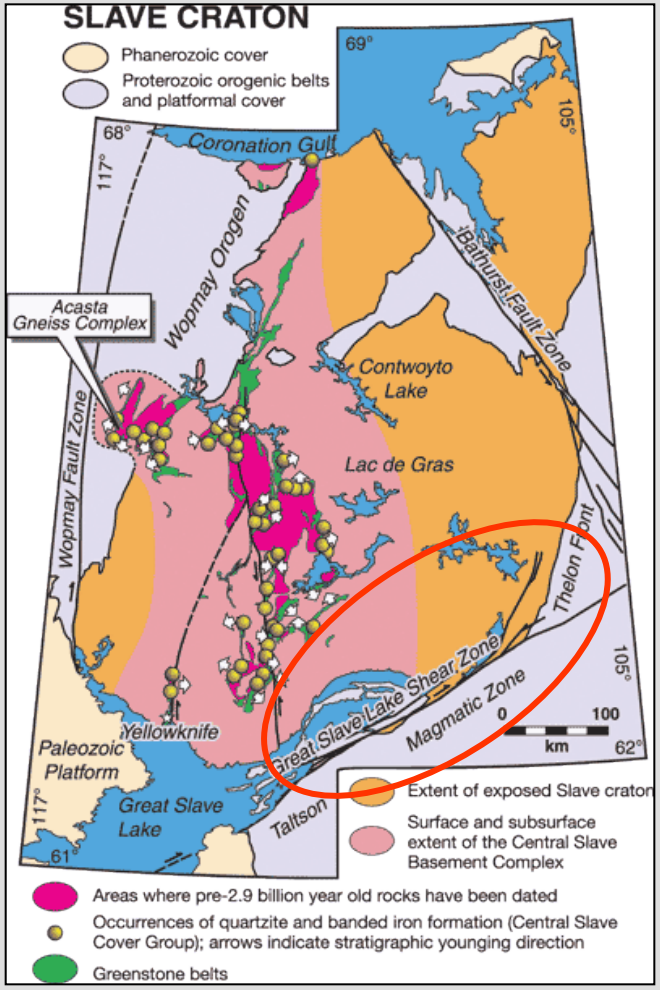
Proterozoic Tectonics

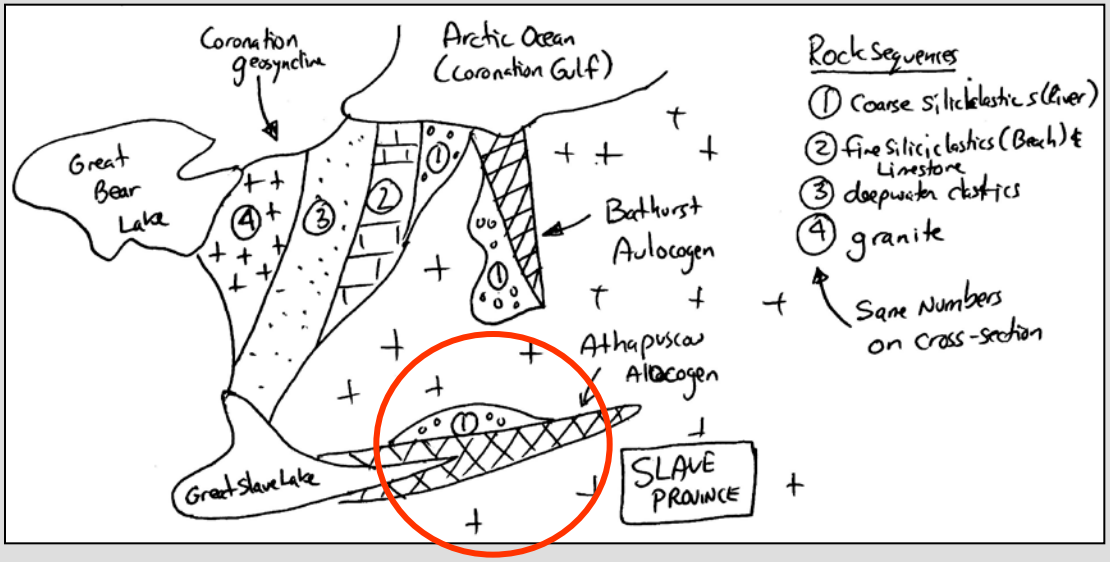




- Coronation Geosyncline
- Wopmay Orogen
- Bathurst Aulocogen

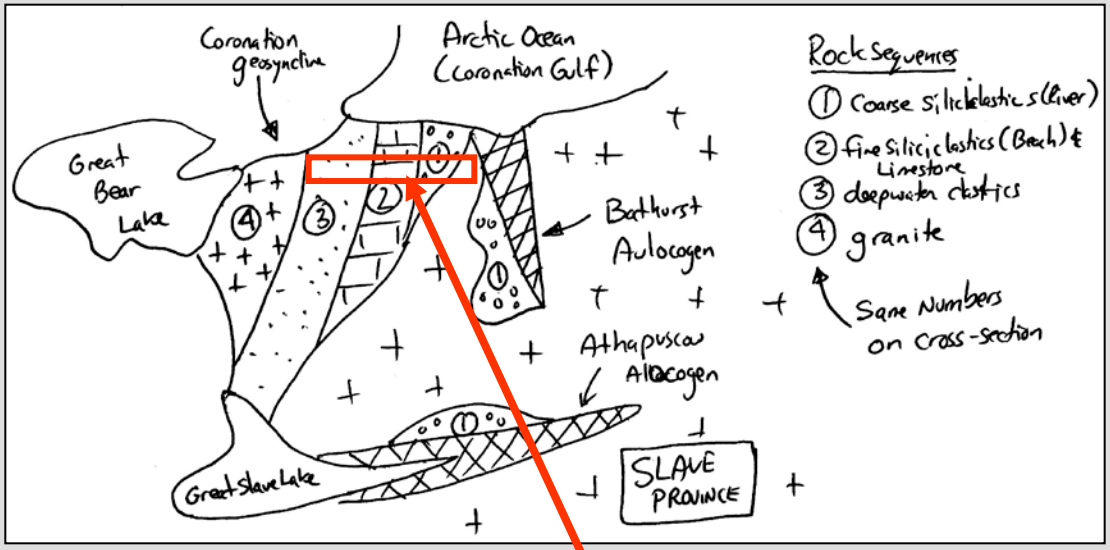
Proterozoic Tectonics



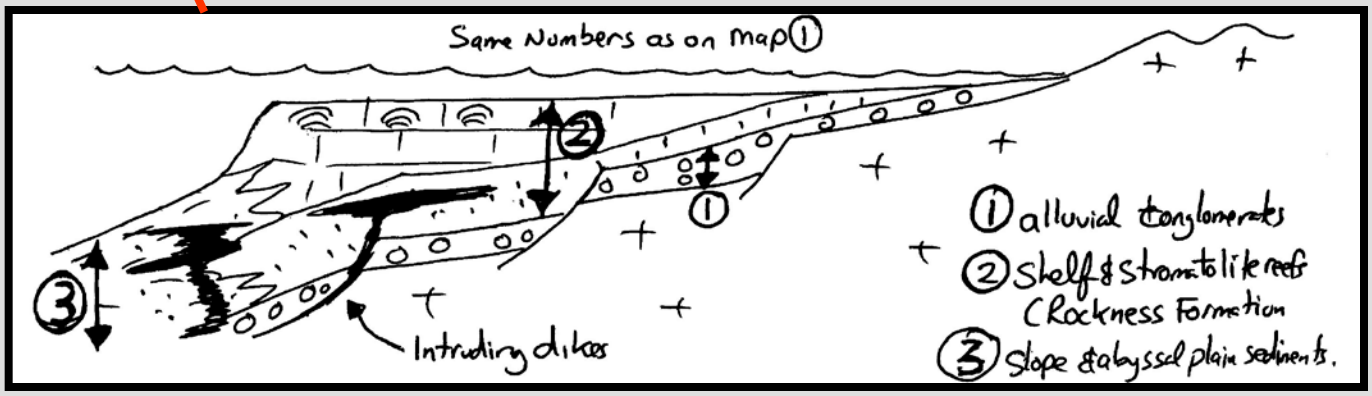


- Coronation Geosyncline
- Wopmay Orogen
- Bathurst Aulocogen
- Athapuscow Aulocogen

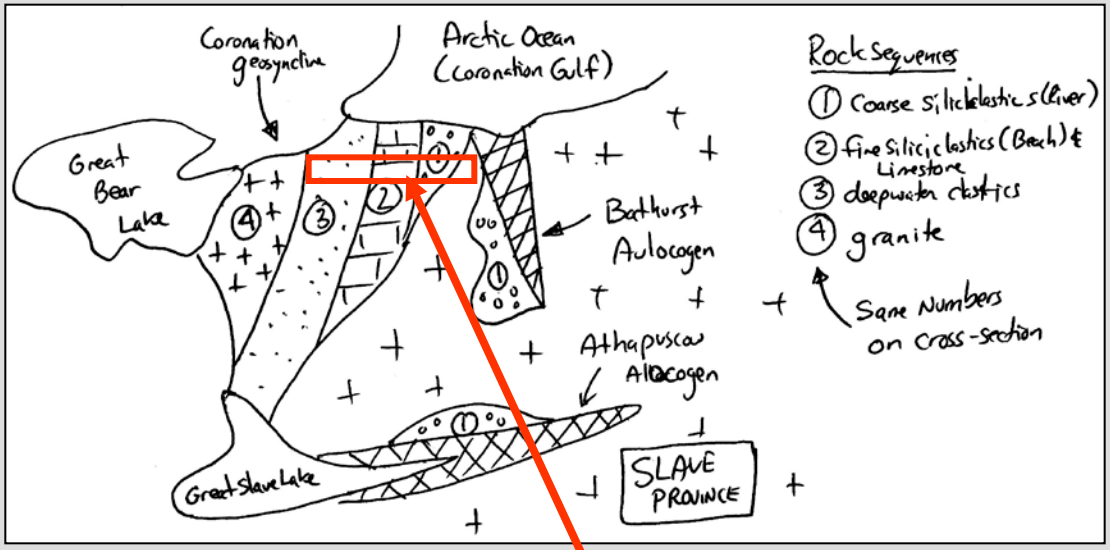
Proterozoic Tectonics



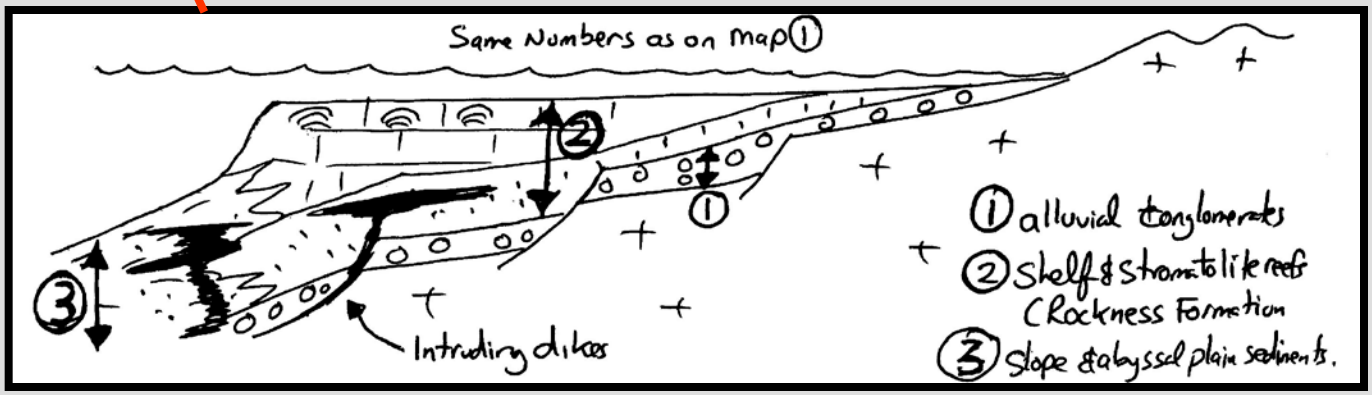
- A paleogeographic reconstruction of the Coronation Geosyncline 2.1 GA would look like this:



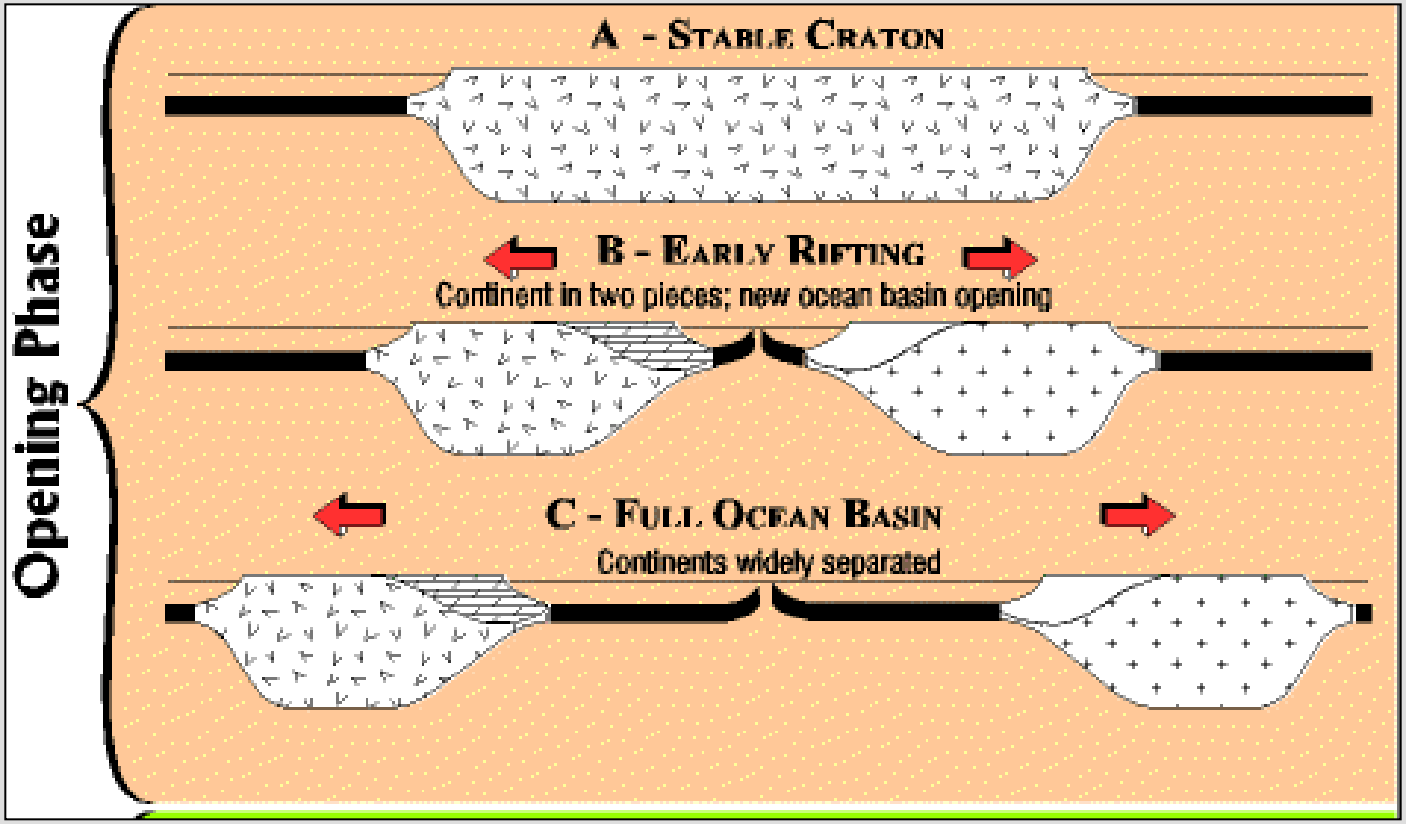
Proterozoic Tectonics



- Which indicates that the Earth's crust "rifted", flooded with seawater and deepened over time

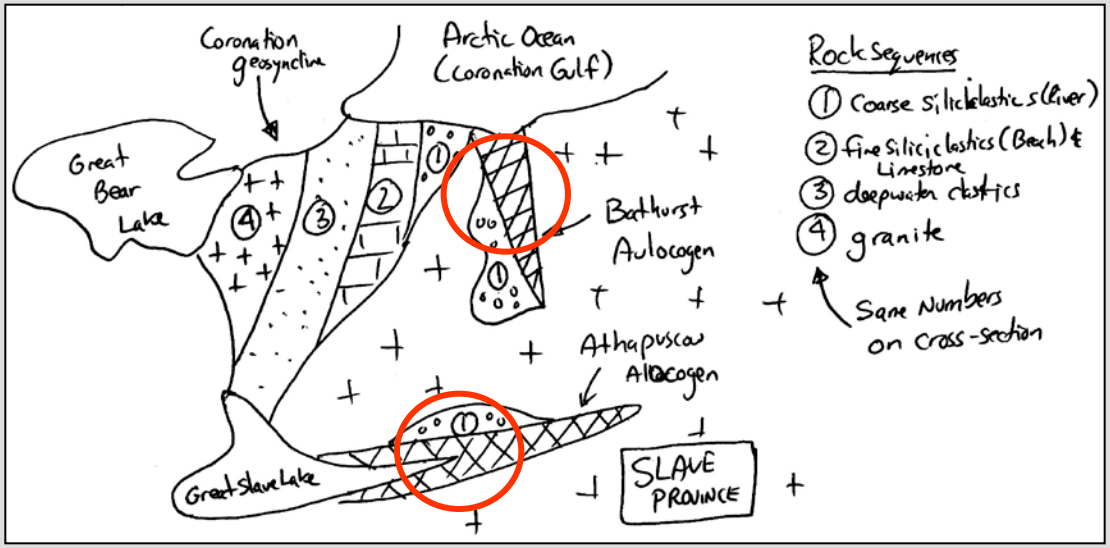


Proterozoic Tectonics



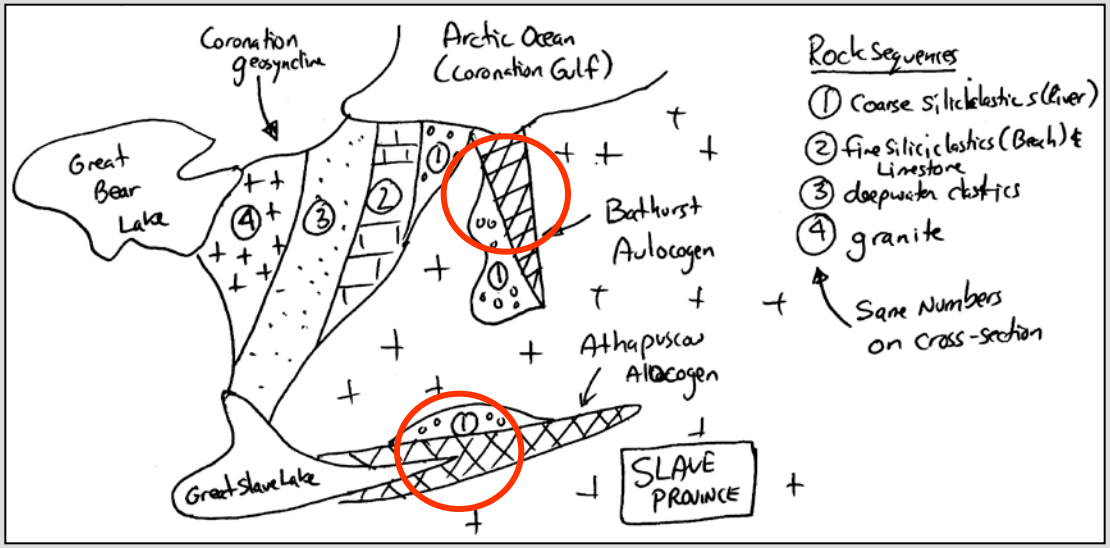
- The Coronation Geosyncline therefore represents the opening of an ocean basin (i.e., a new ocean formed). But…

Proterozoic Tectonics



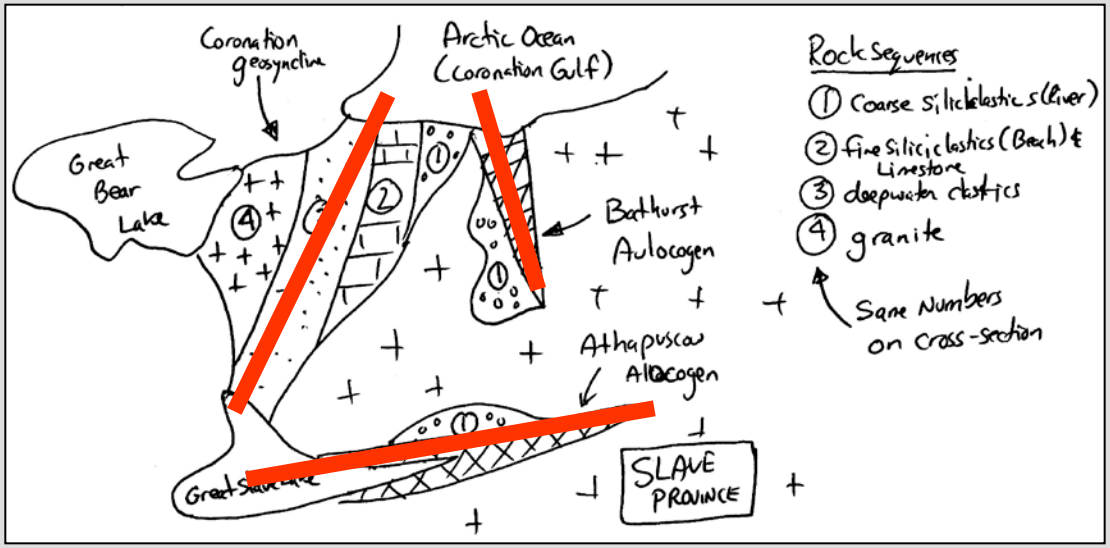
- Linear trenches also opened up.

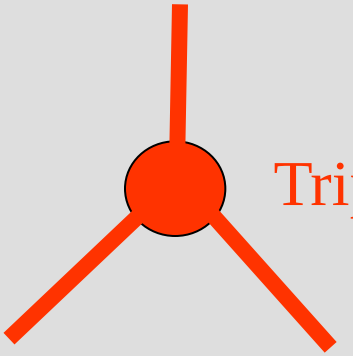
Proterozoic Tectonics



- Linear trenches also opened up.
- They were mostly filled with coarse gravel and breccia (phase 1 fill in the Coronation Geosyncline)

Proterozoic Tectonics



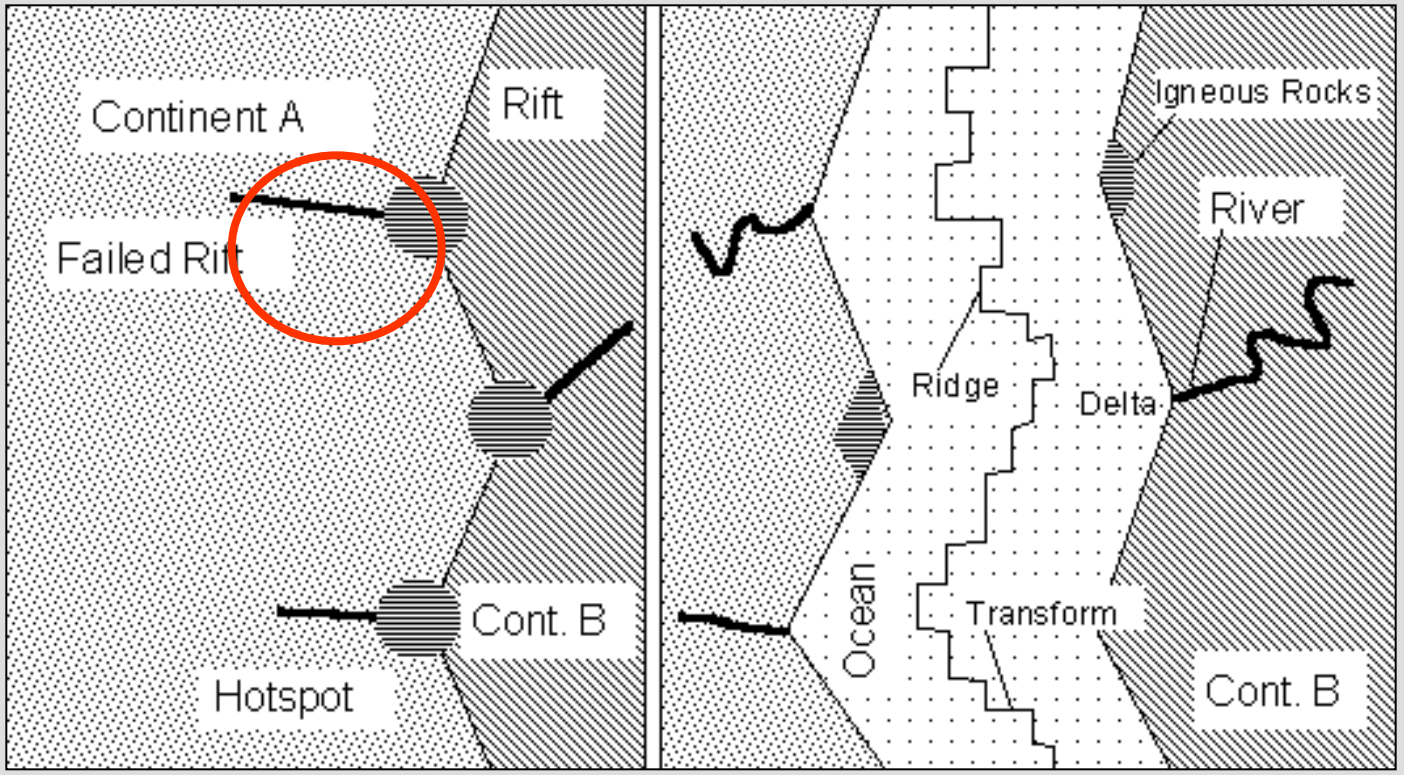


Triple Junction

- Linear trenches also opened up.
- They were mostly filled with coarse gravel and breccia (phase 1 fill in the Coronation Geosyncline)
- Ternary rifting patterns

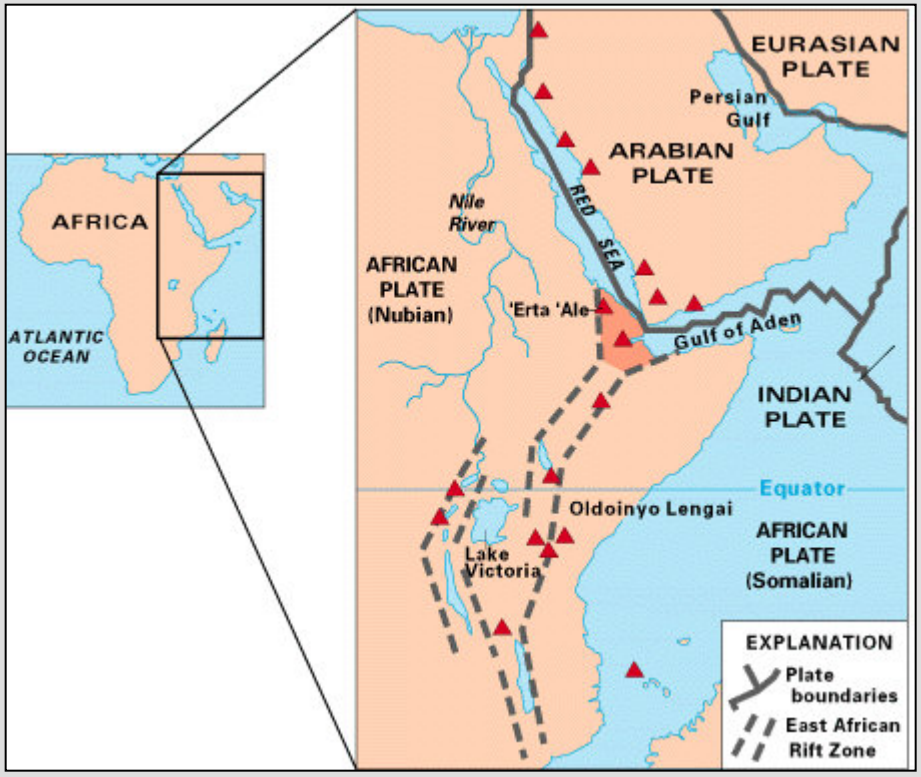
Chalk board

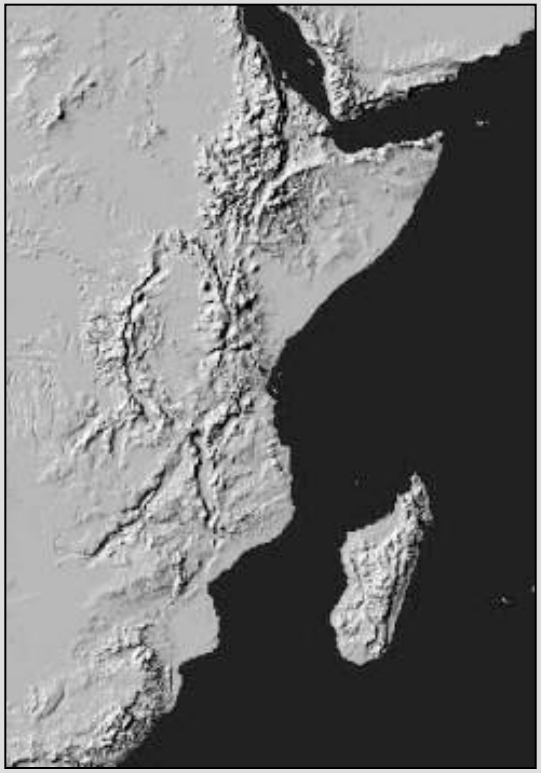
Proterozoic Tectonics



- In any triple junction, one of the “arms” will become a failed rift or an Aulcogen. Two will continue to spread into an ocean

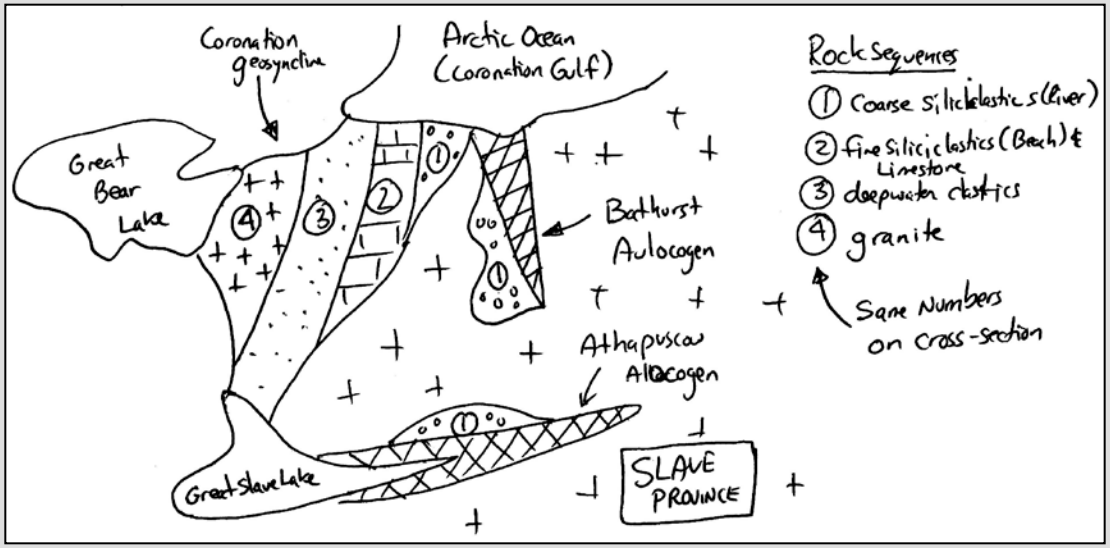
Proterozoic Tectonics





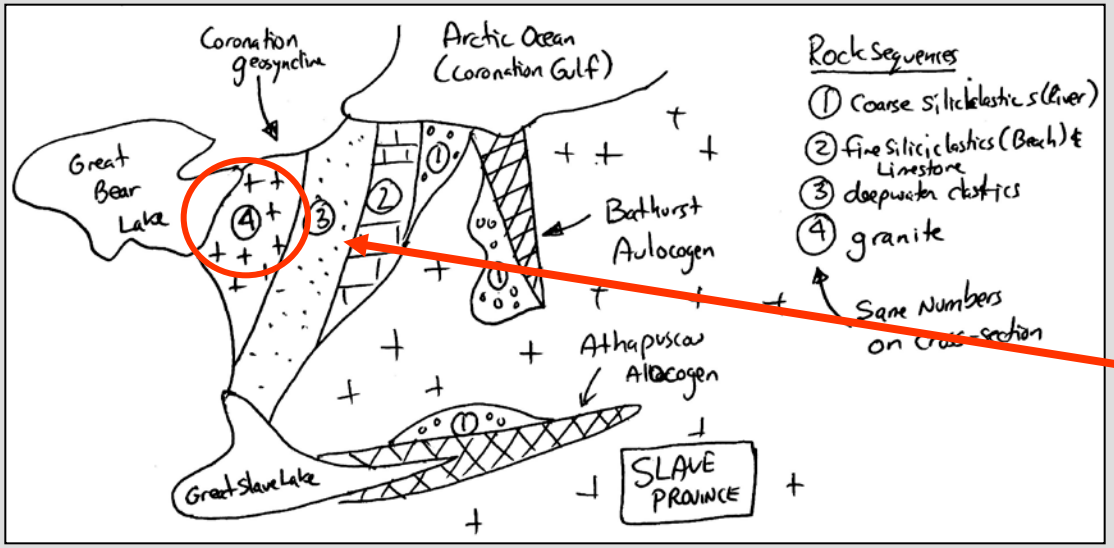
- The best modern example of a “failed arm” is the East African Rift

Proterozoic Tectonics



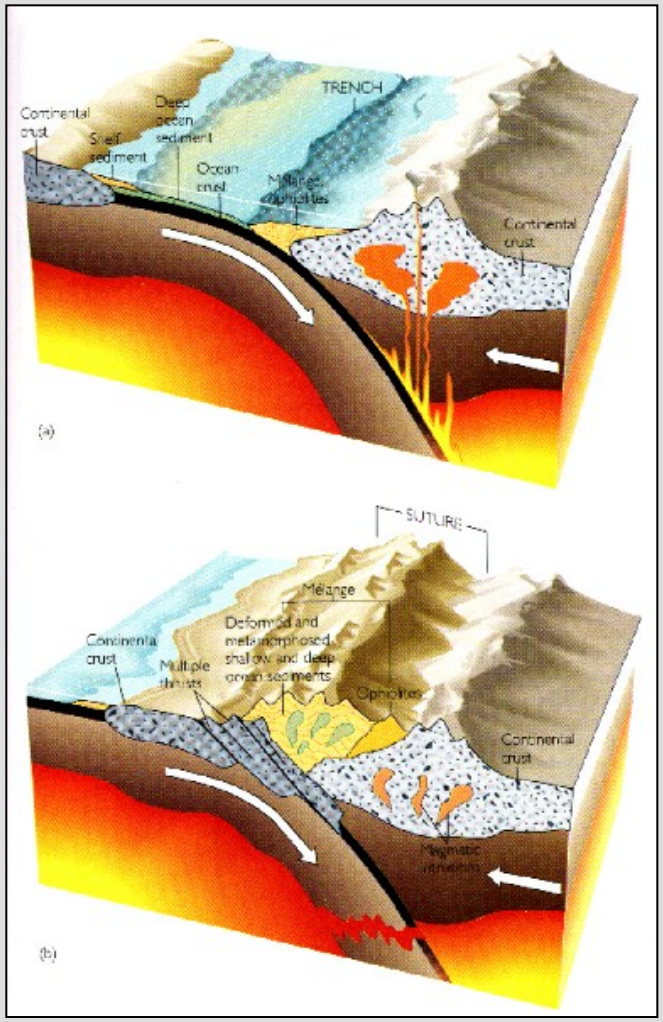
- But the Coronation Geosyncline ocean did not last a long time.

Proterozoic Tectonics



- But the Coronation Geosyncline ocean did not last a long time.
- Granite was emplaced along the western side around 1.8 GA…

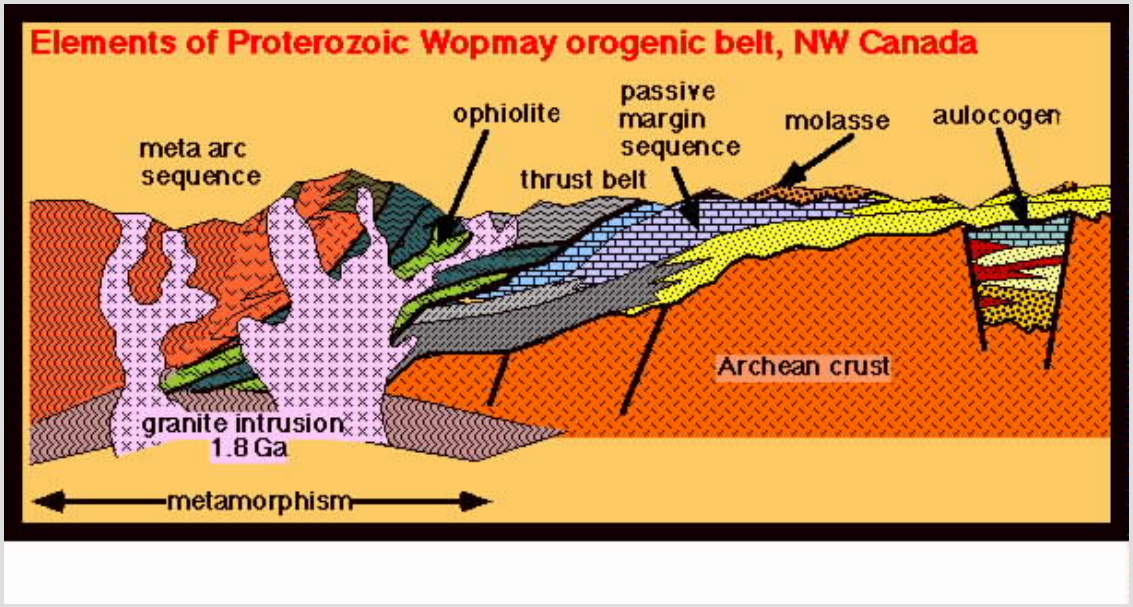
Proterozoic Tectonics



- But the Coronation Geosyncline ocean did not last a long time.
- Granite was emplaced along the western side around 1.8 GA…

…indicating a plate collision with another continent.

Proterozoic Tectonics



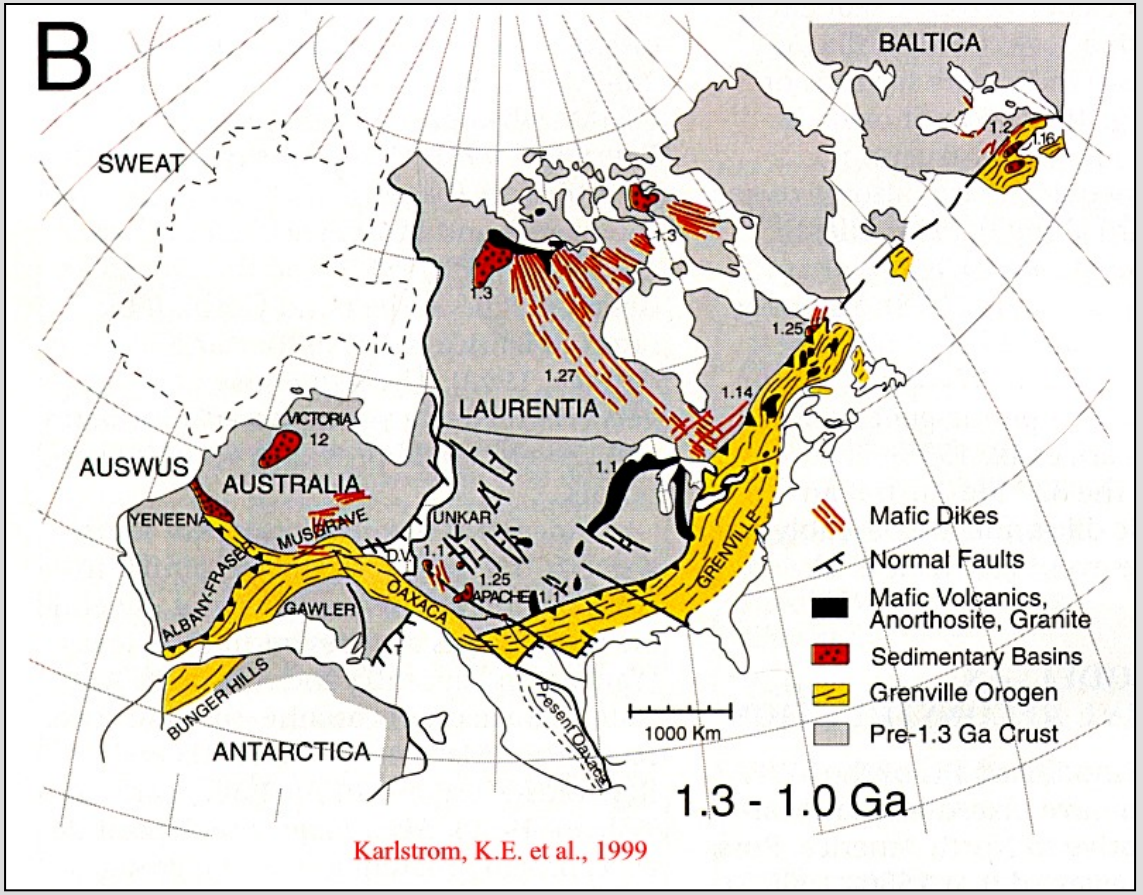
- This mountain-building event is called the Wopmay Orogeny

Proterozoic Tectonics

So what hit us?

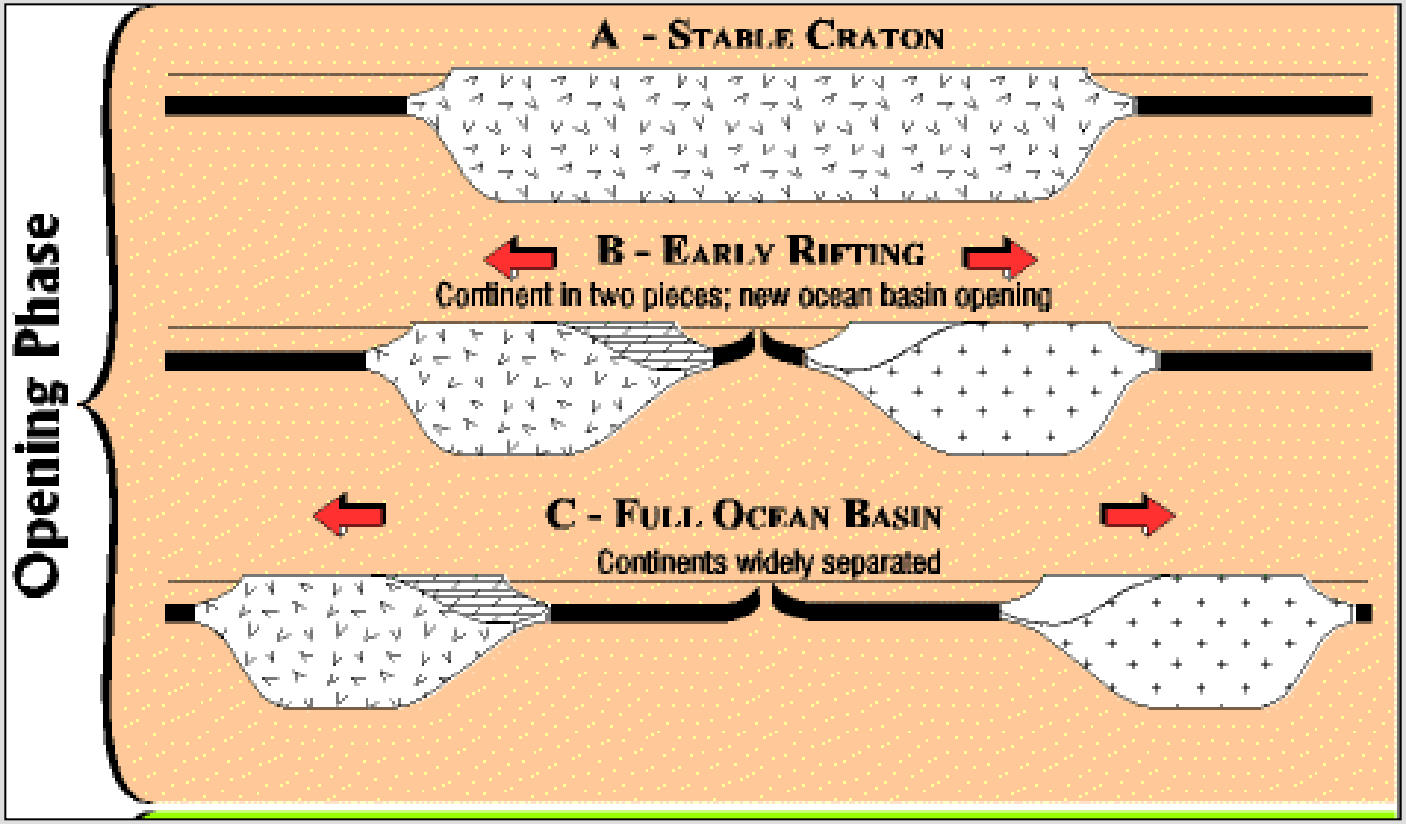
Proterozoic Tectonics

So what hit us?



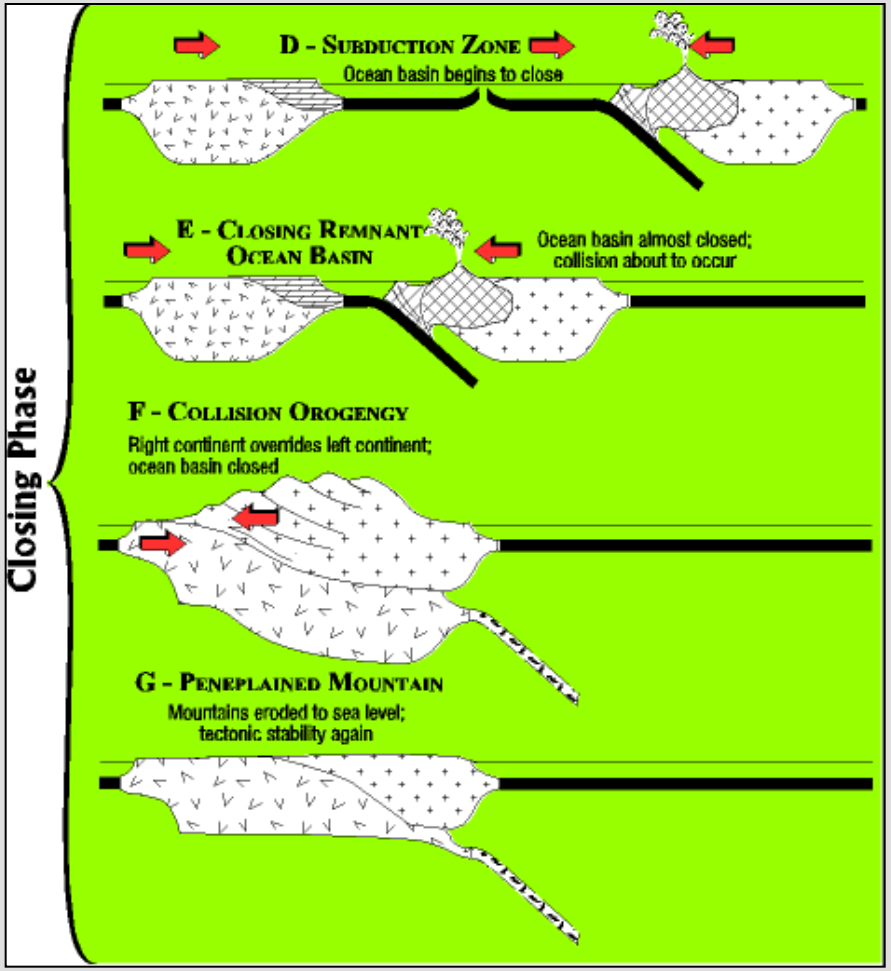
- The culprit was Australia seen here fleeing the scene of the accident about 500 MA after the incident

The Wilson Cycle



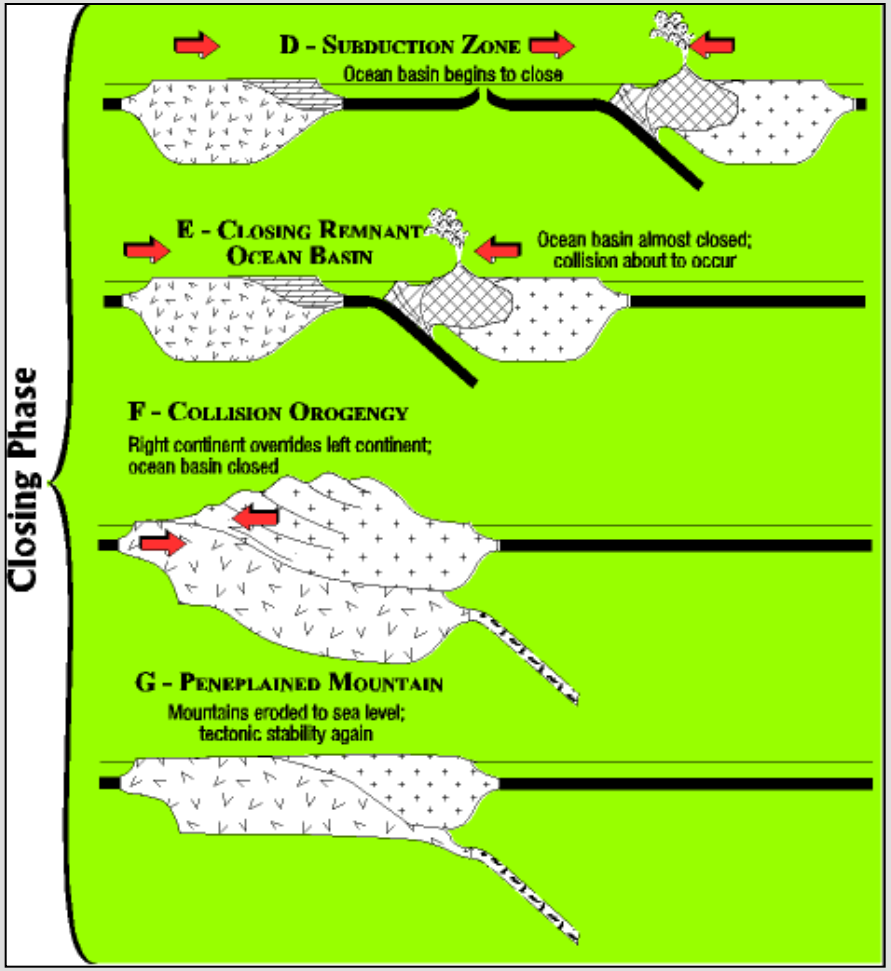
- Oceans are created when plate tectonics results in rifting

The Wilson Cycle

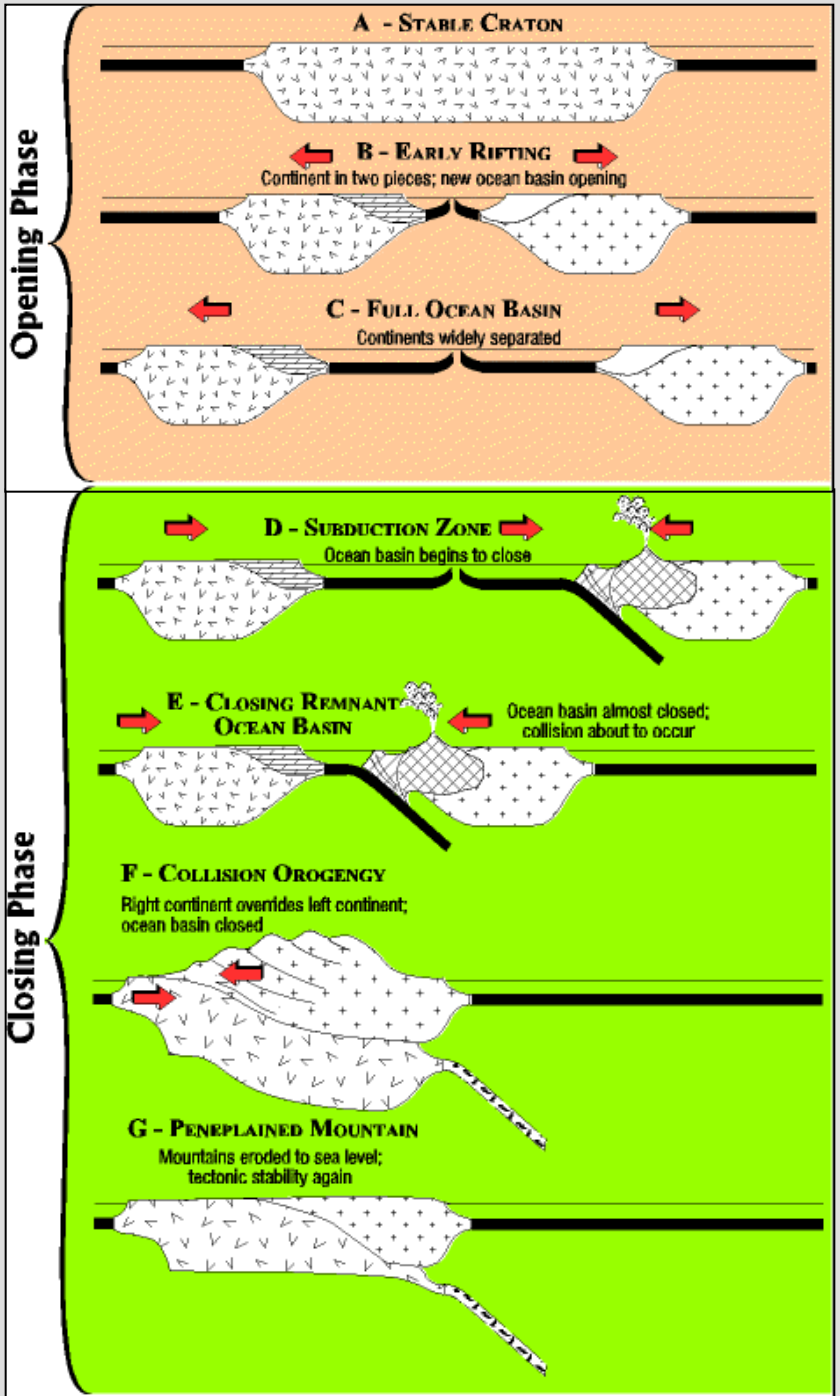


- But the Wopmay Orogeny demonstrates that not only do ocean open up, they can also close back up again (Subduction)

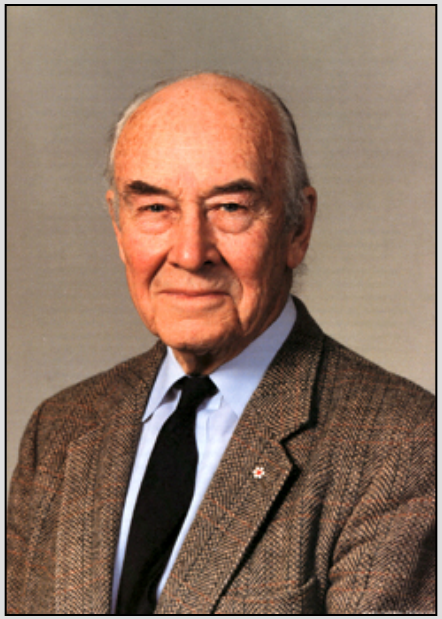
The Wilson Cycle



- And sometimes they repeat this cycle more than once (e.g., the Atlantic Ocean)



- This is now called the Wilson Cycle in honor of J. Tuzo Wilson who first suggested it for the Atlantic Ocean



Other Proterozoic Orogenies

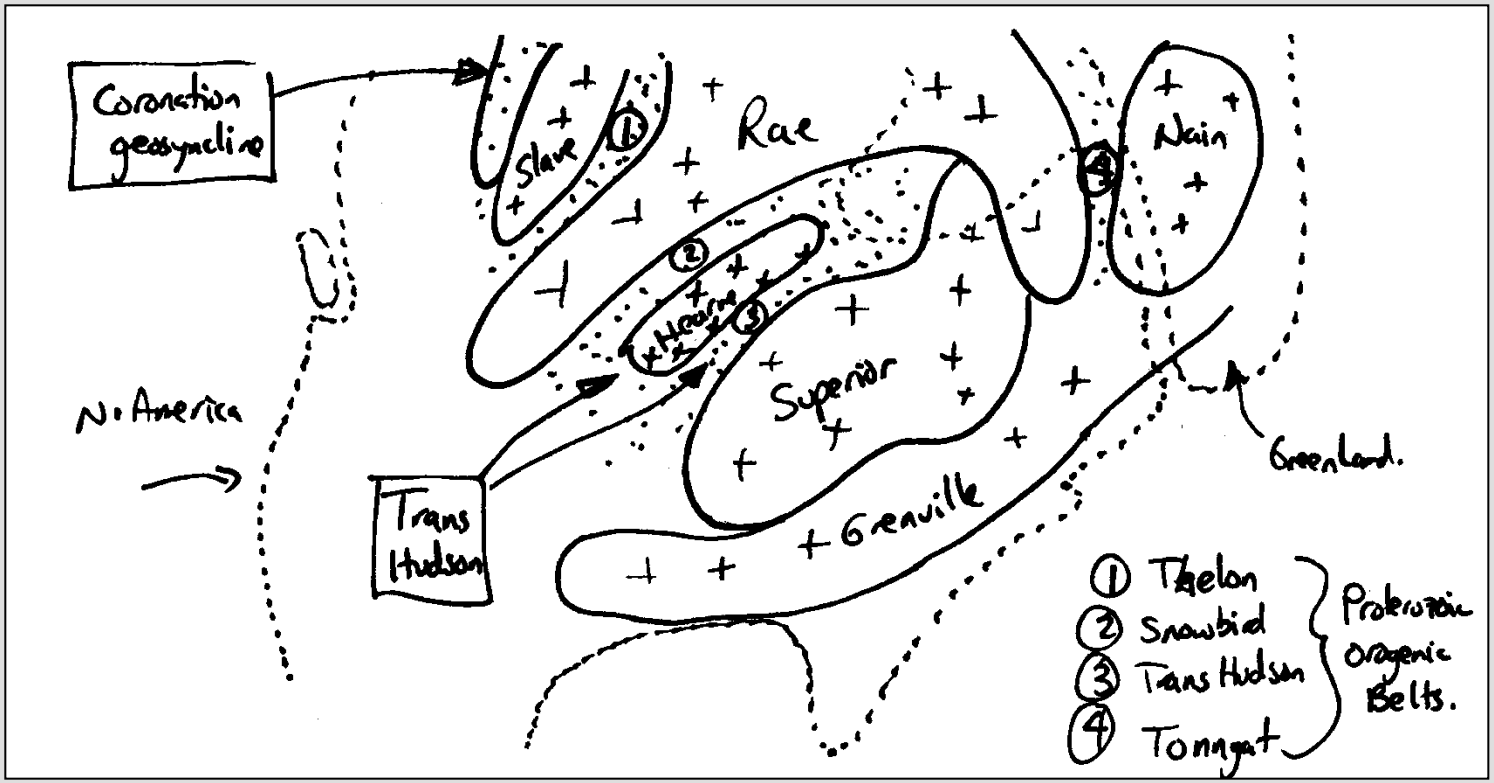
Orogeny: A mountain building event (mostly collision and subduction, occasionally transform motion, but doesn't require continent-continent collisions)

Note: Most mountain building episodes (regardless of the actual process are given specific names)

e.g.: the Wopmay Orogeny

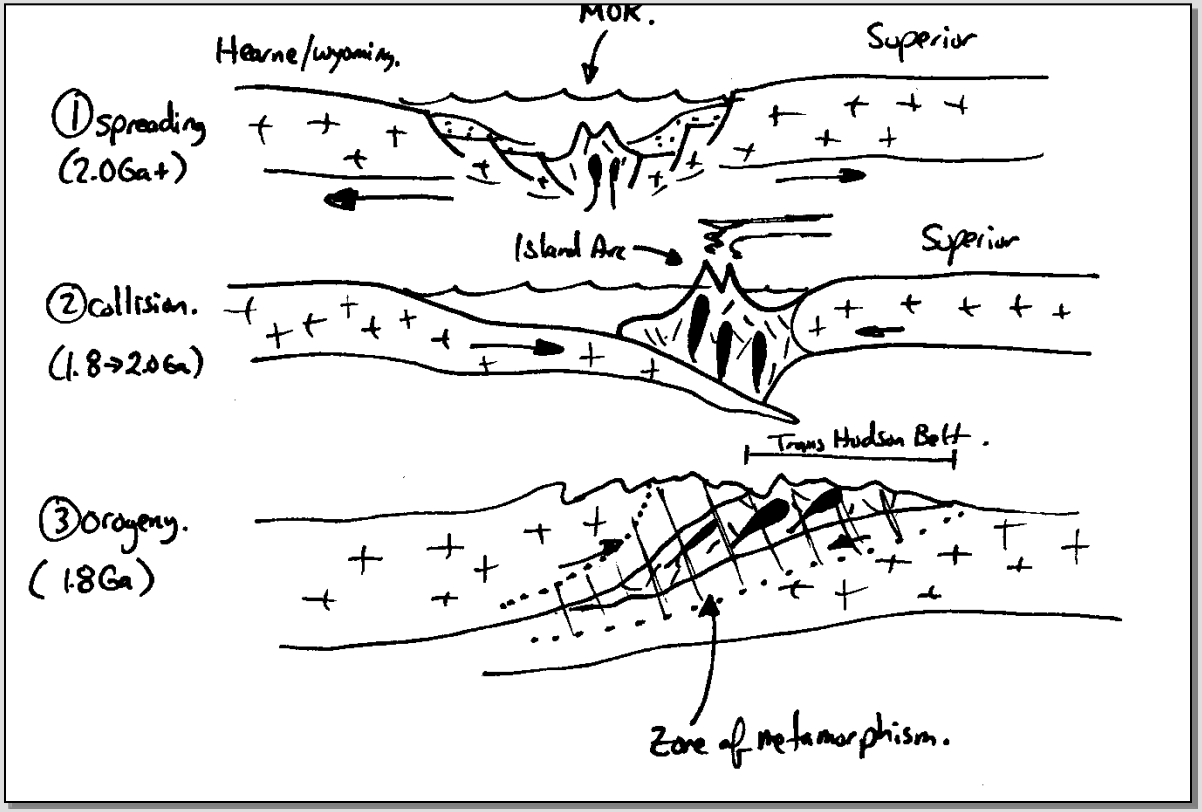
Other Proterozoic Orogenies

Starting in the Paleoproterzoic, orogenies became very common around the world.



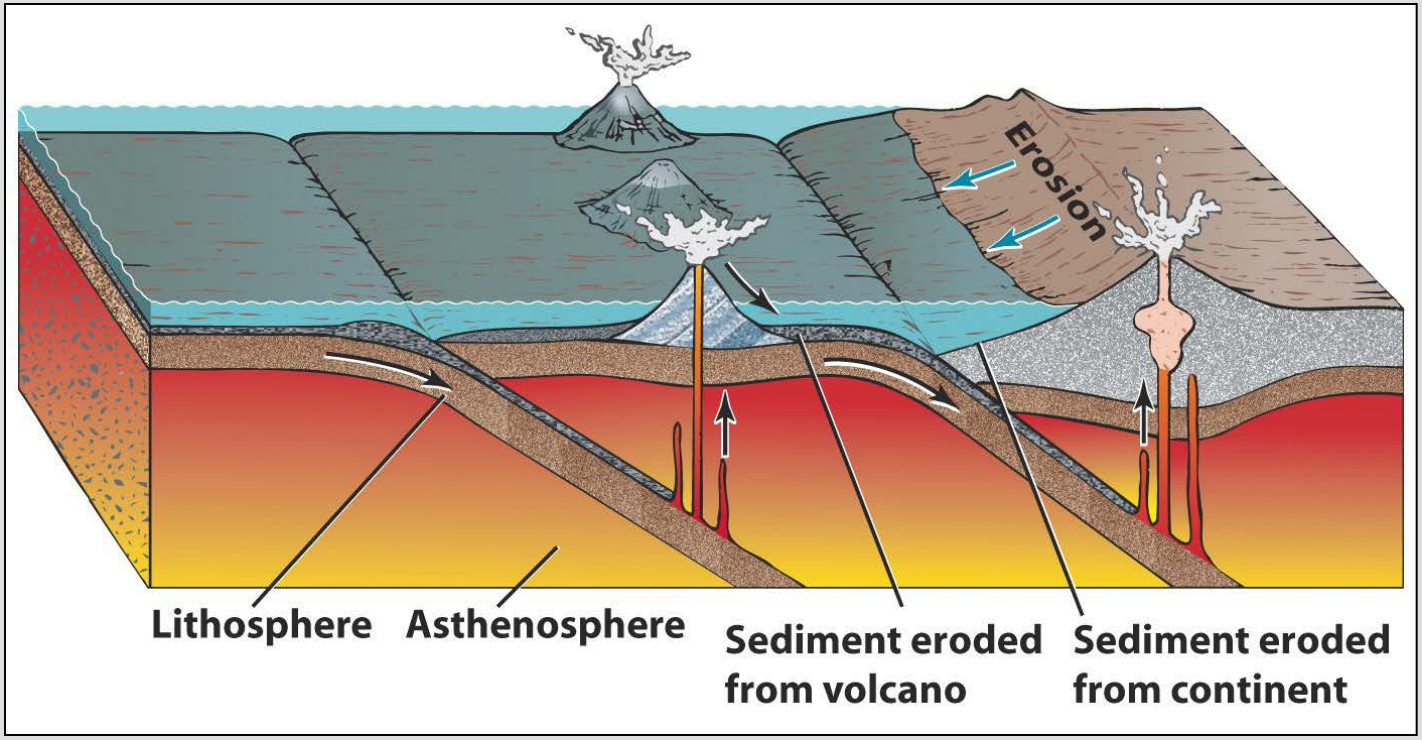
Trans-Hudson Orogeny

2.0-1.8 GA

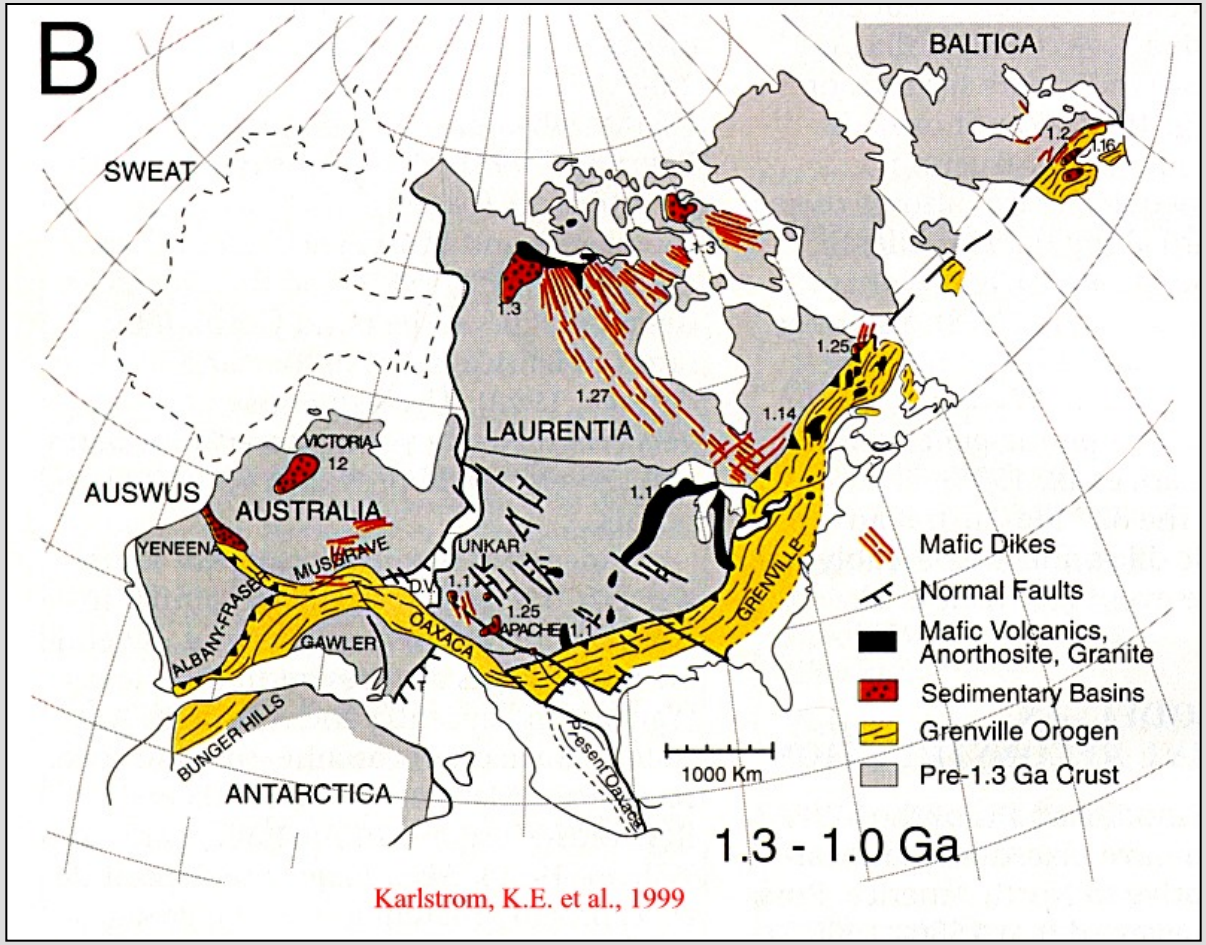


Trans-Hudson Orogeny

Modern Island Arcs

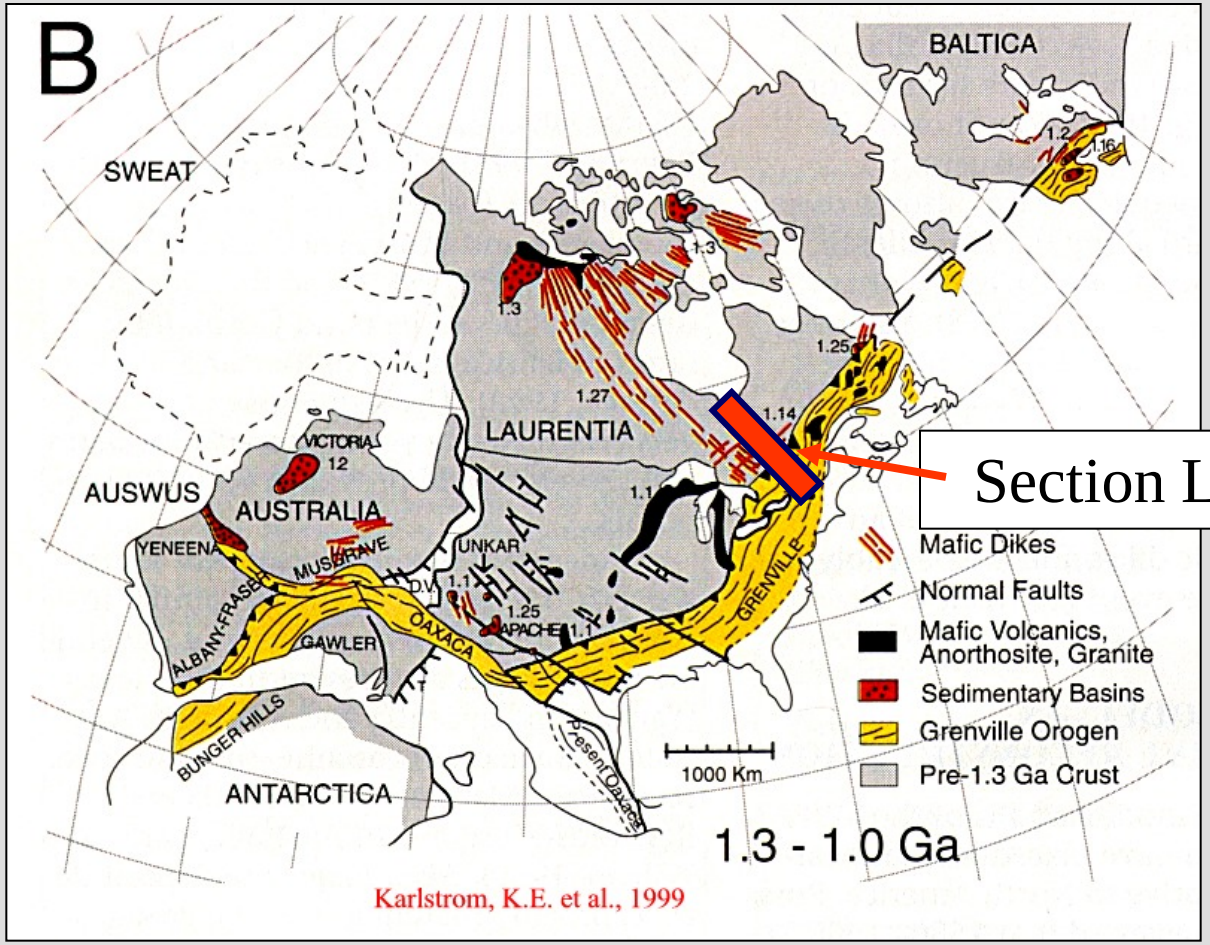


Grenville Orogeny



1.0 GA

Grenville Orogeny

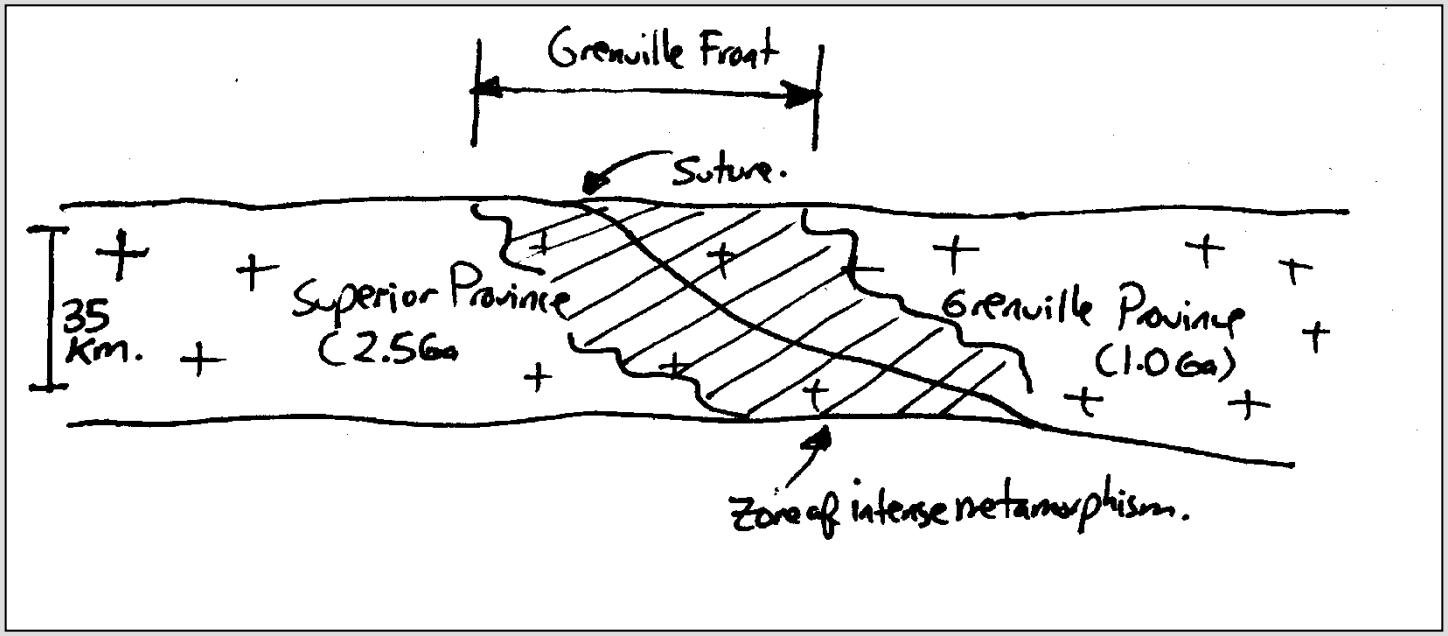


Section Line

1.0 GA

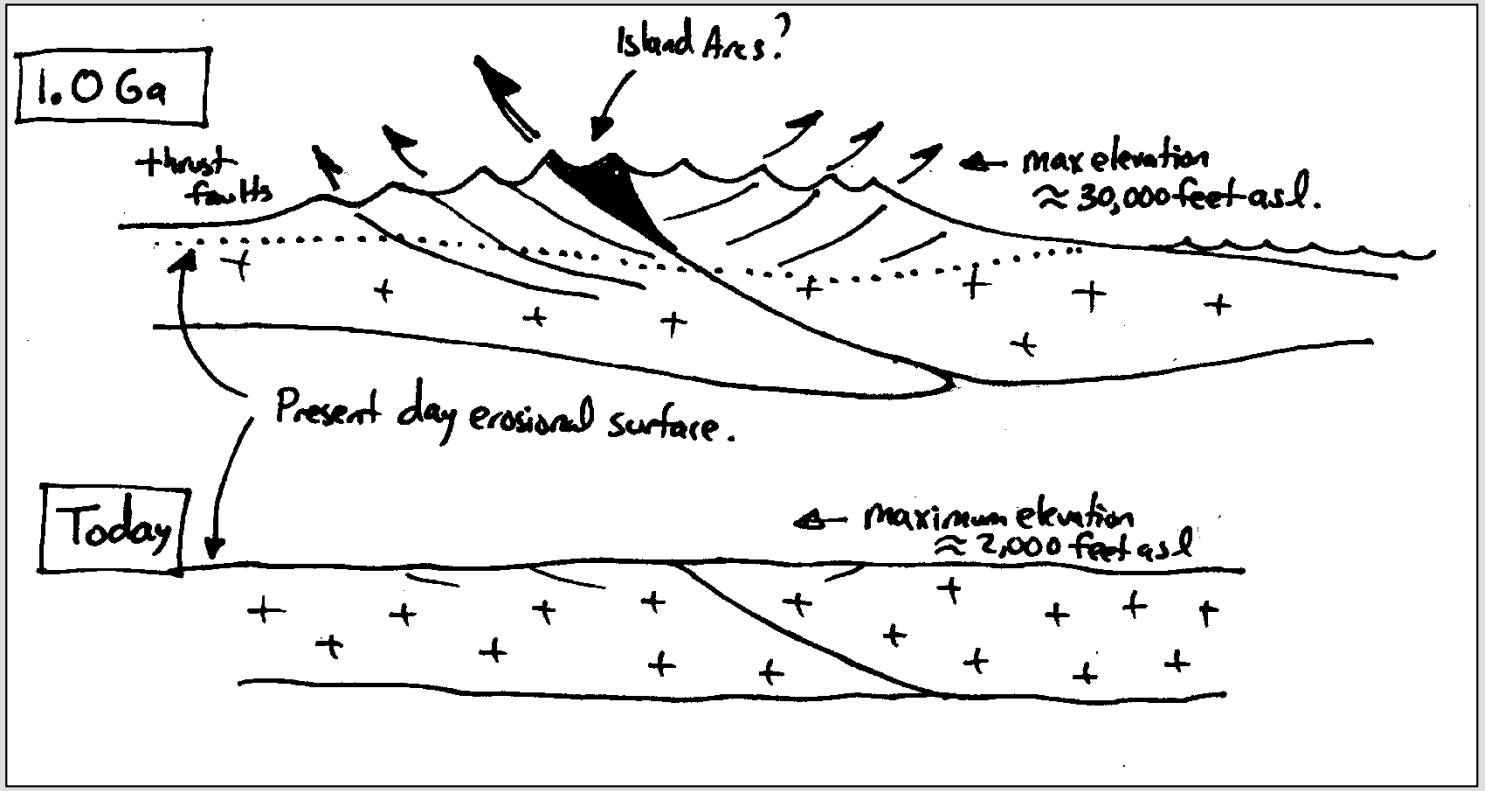
Grenville Orogeny

1.0 GA

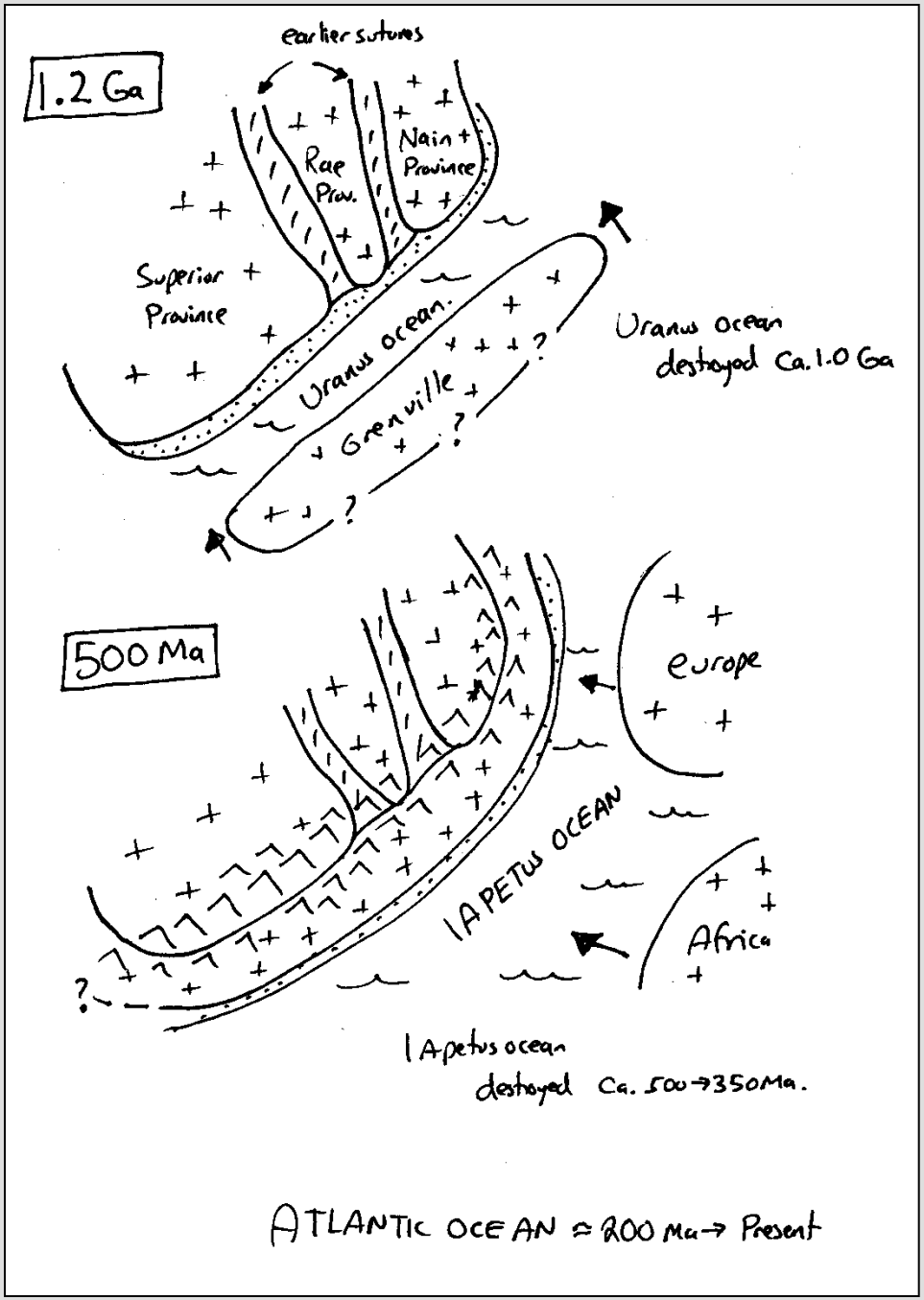


Grenville Orogeny

1.0 GA



Grenville Orogeny



Today's Homework

1. Time line version 1 due NOW
2. Study for Lecture test 2 (March 23, Tuesday after spring break)

Next Time

1. Proterozoic climate (a "cool" lecture)

GY 112: Earth History

Lectures 18/19: Proterozoic Tectonics

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