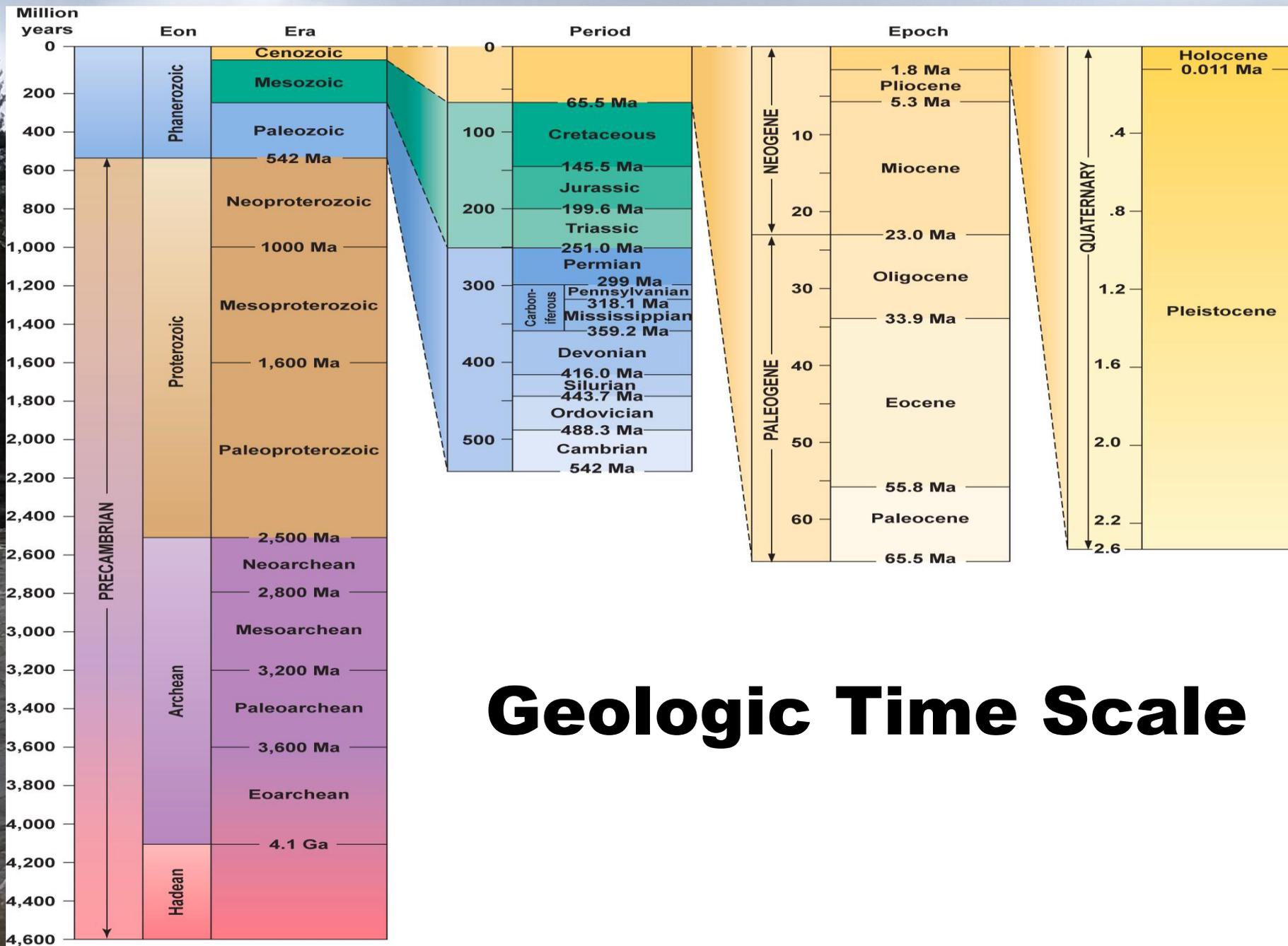


Geologic History of the Black River Watershed

Chris Ebey, PhD

Ninth Annual Black River Watershed Conference

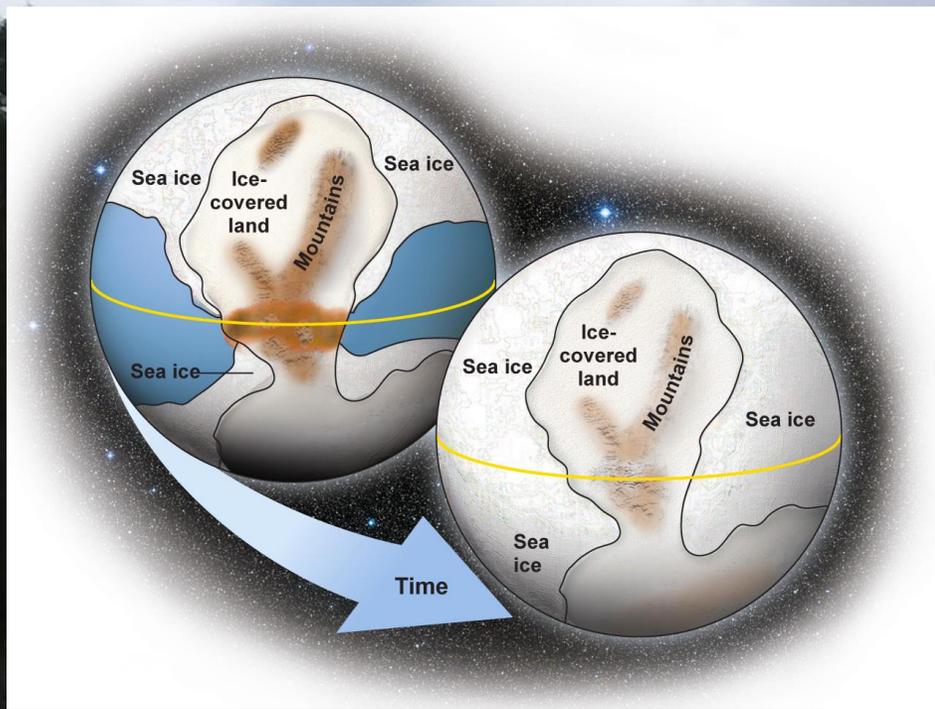
June 4, 2019



Geologic Time Scale

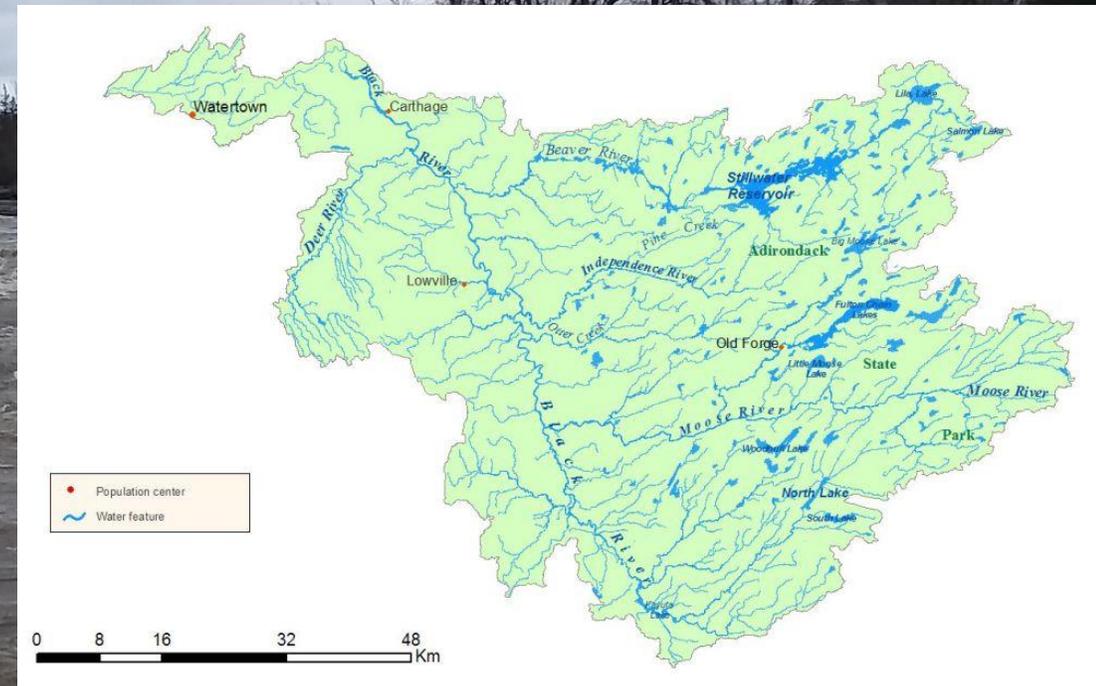
Earth Has a Story

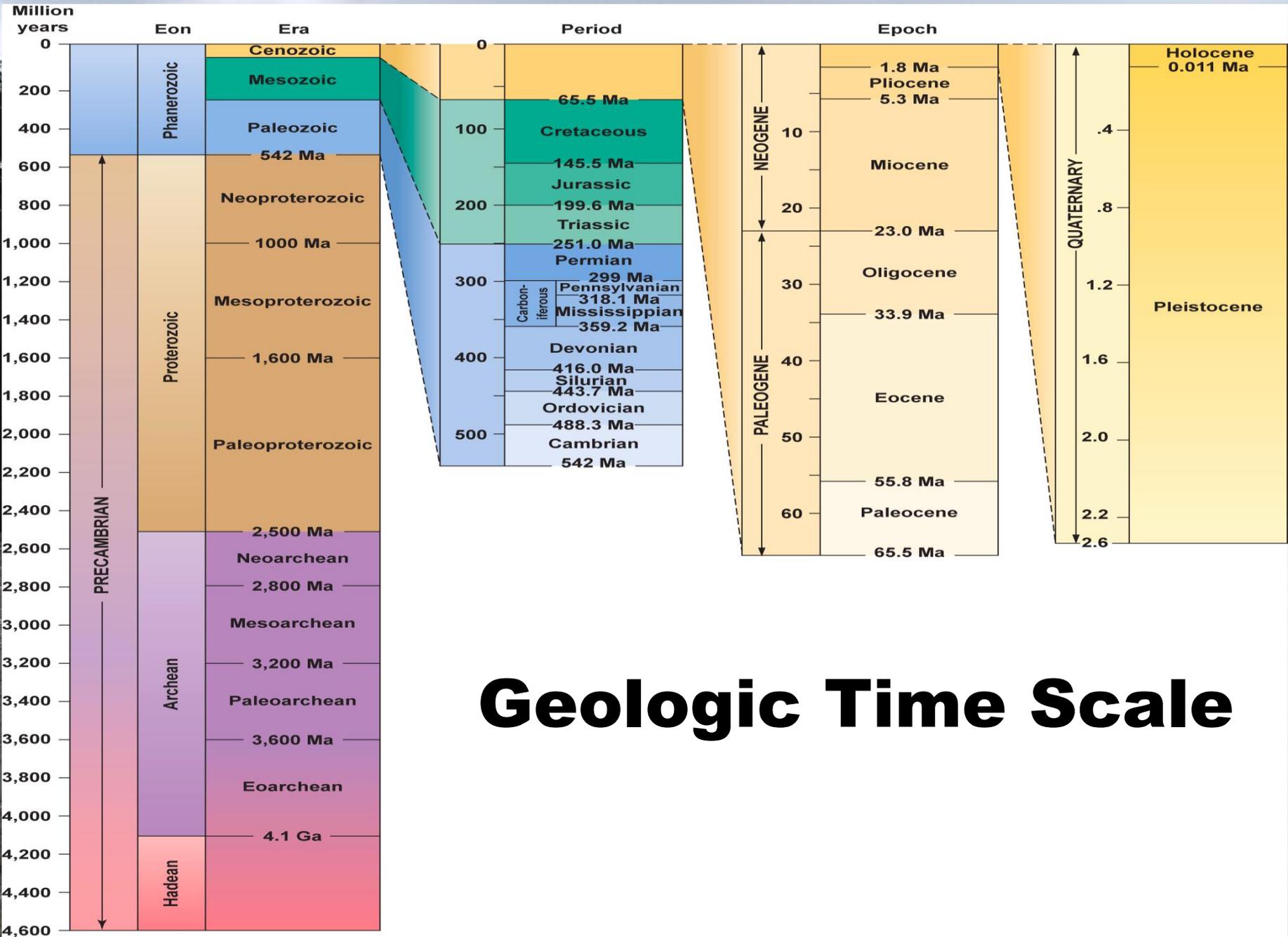
- Earth has gone through tremendous change in its 4.5 billion year history
 - Formation and breakup of continents; creation and destruction of oceans
 - Rise, diversification, and extinction of life
 - Rise of oxygen and changes in the oceanic and atmospheric chemistry
 - Greenhouses, ice ages, and Snowball Earth



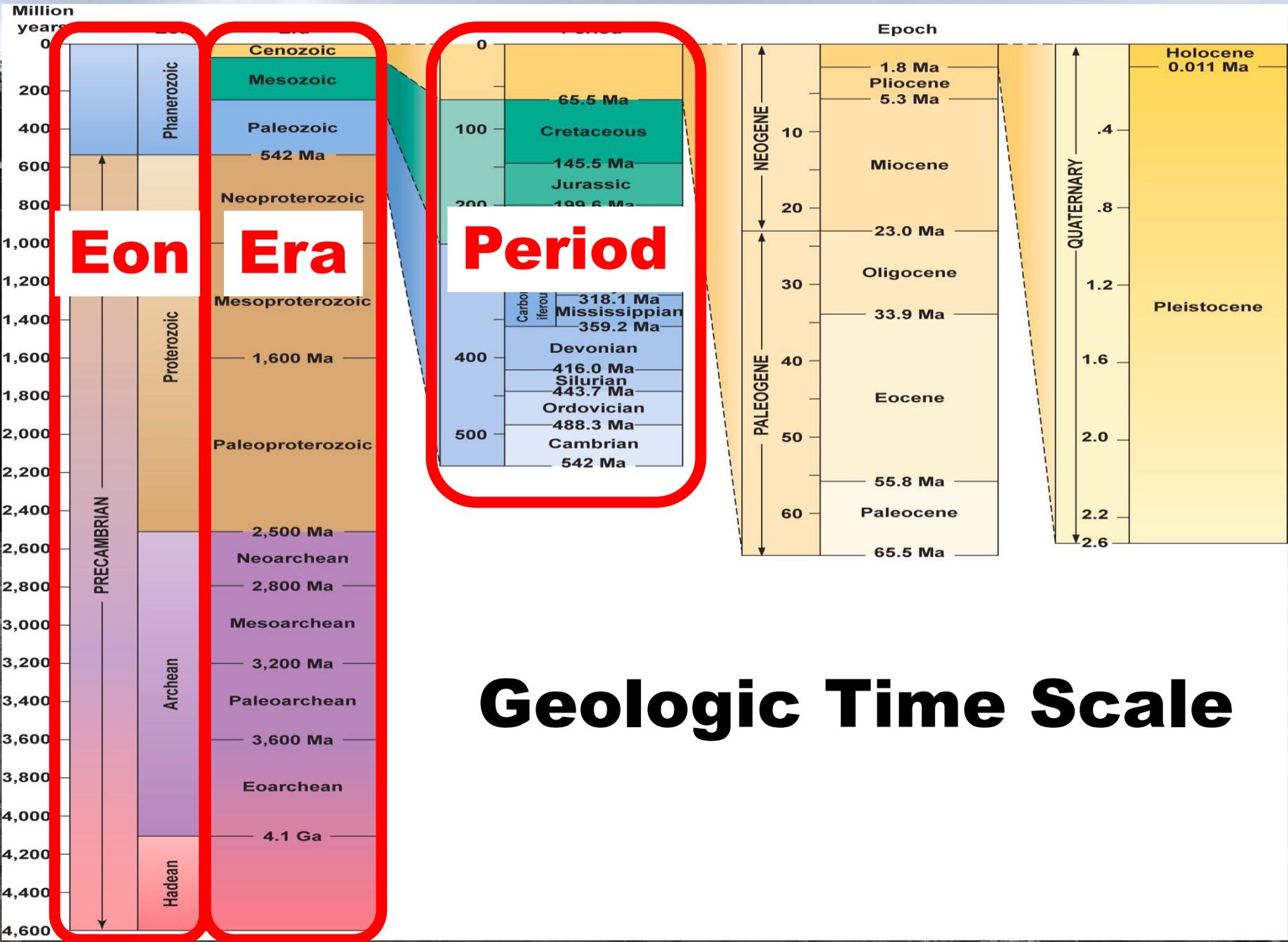
This Talk

- Evidence for many of the most important events in Earth's history are found in the Black River basin
- Events from more than one billion years ago through to today have shaped the watershed we know





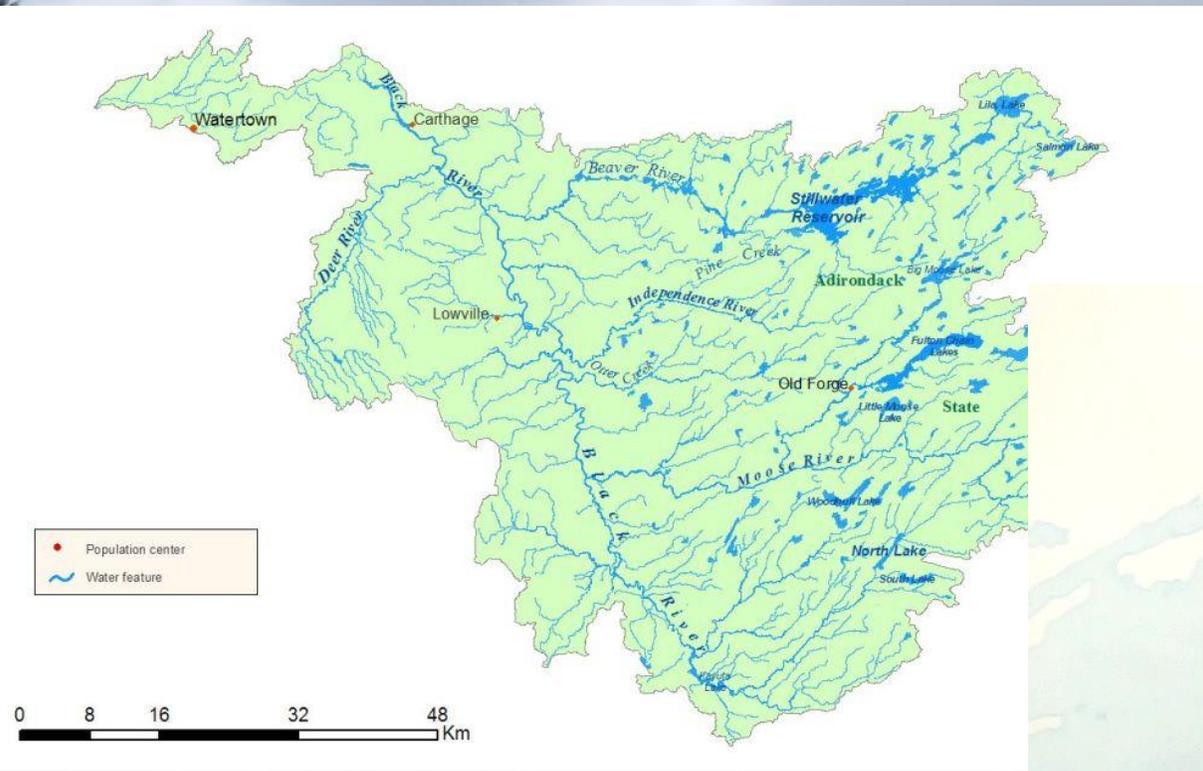
Geologic Time Scale

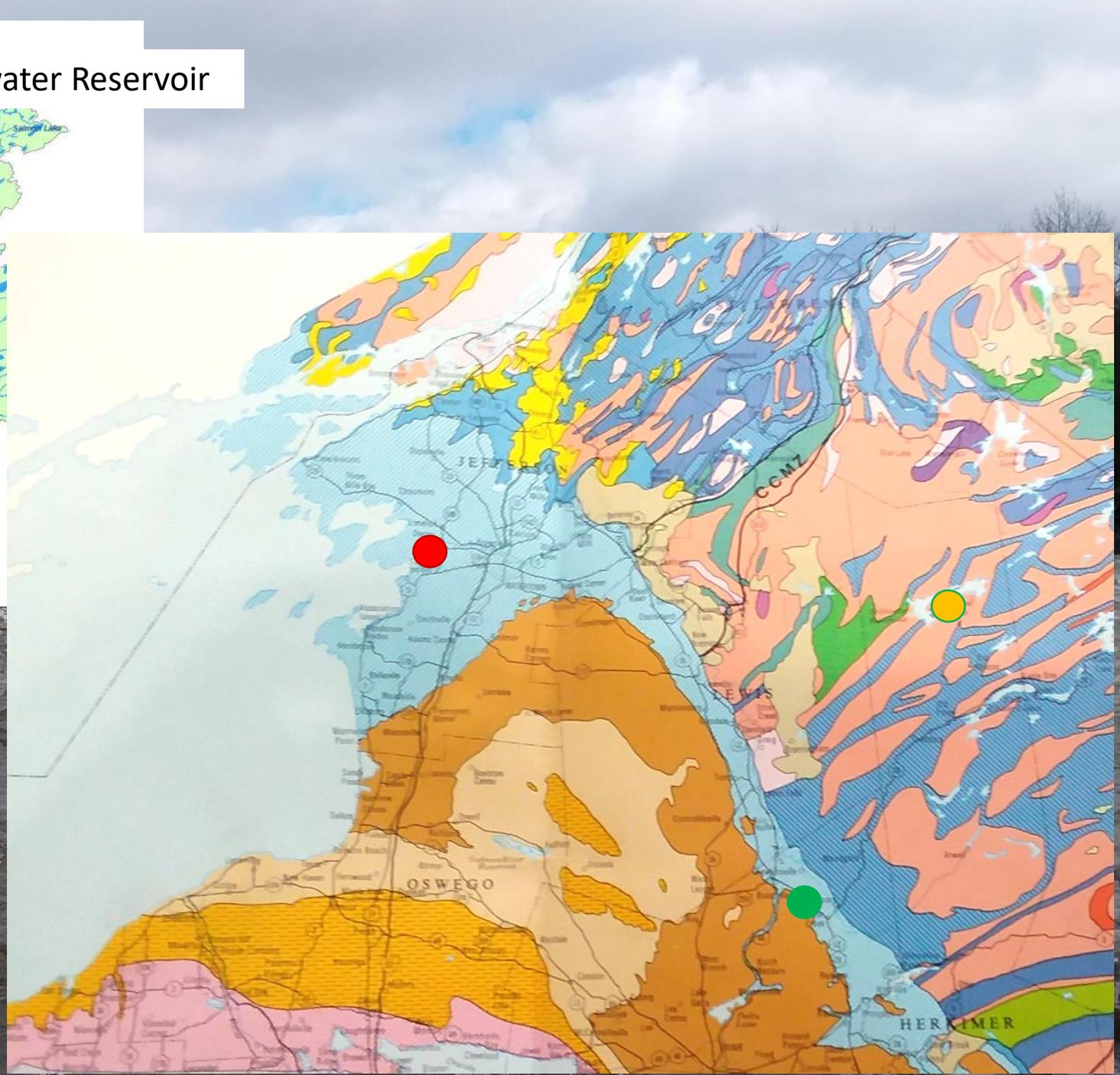
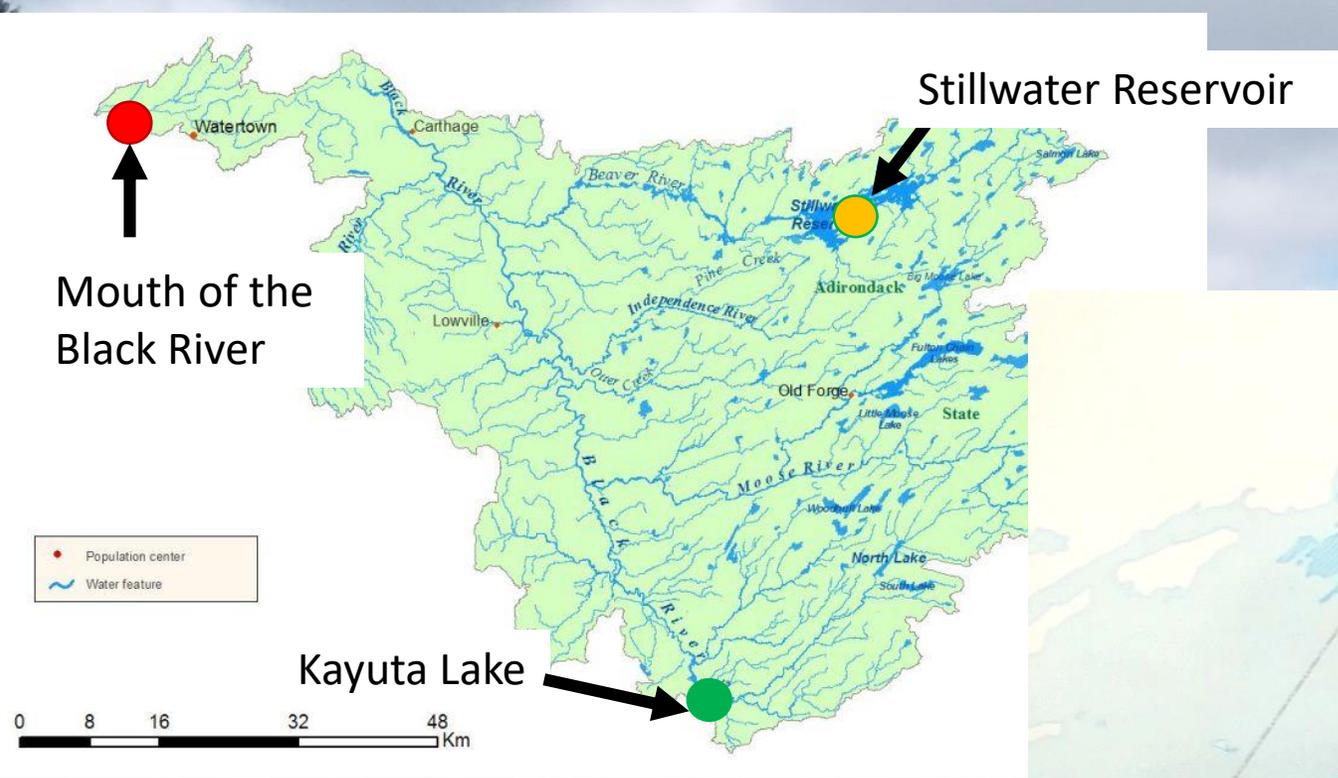


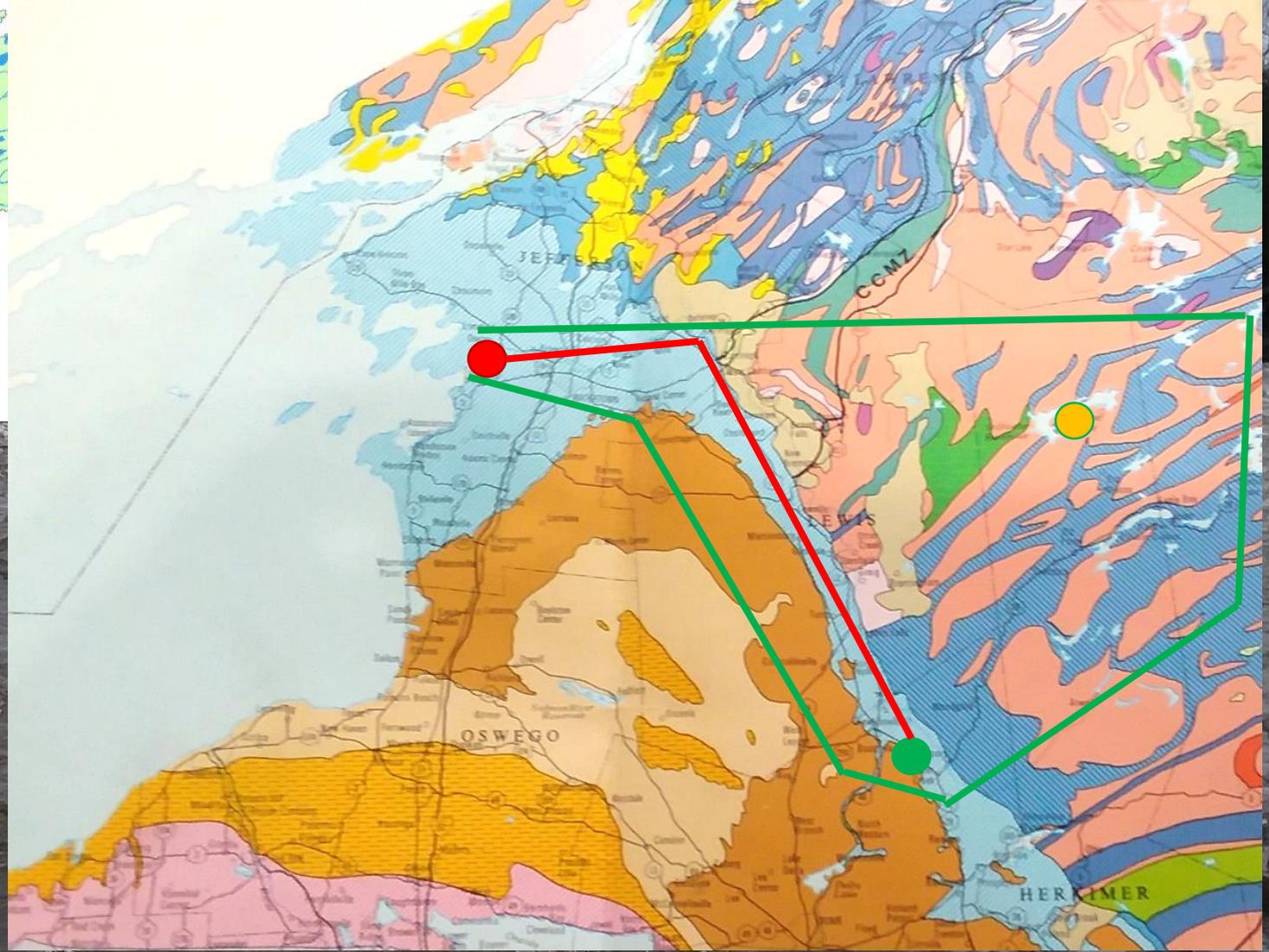
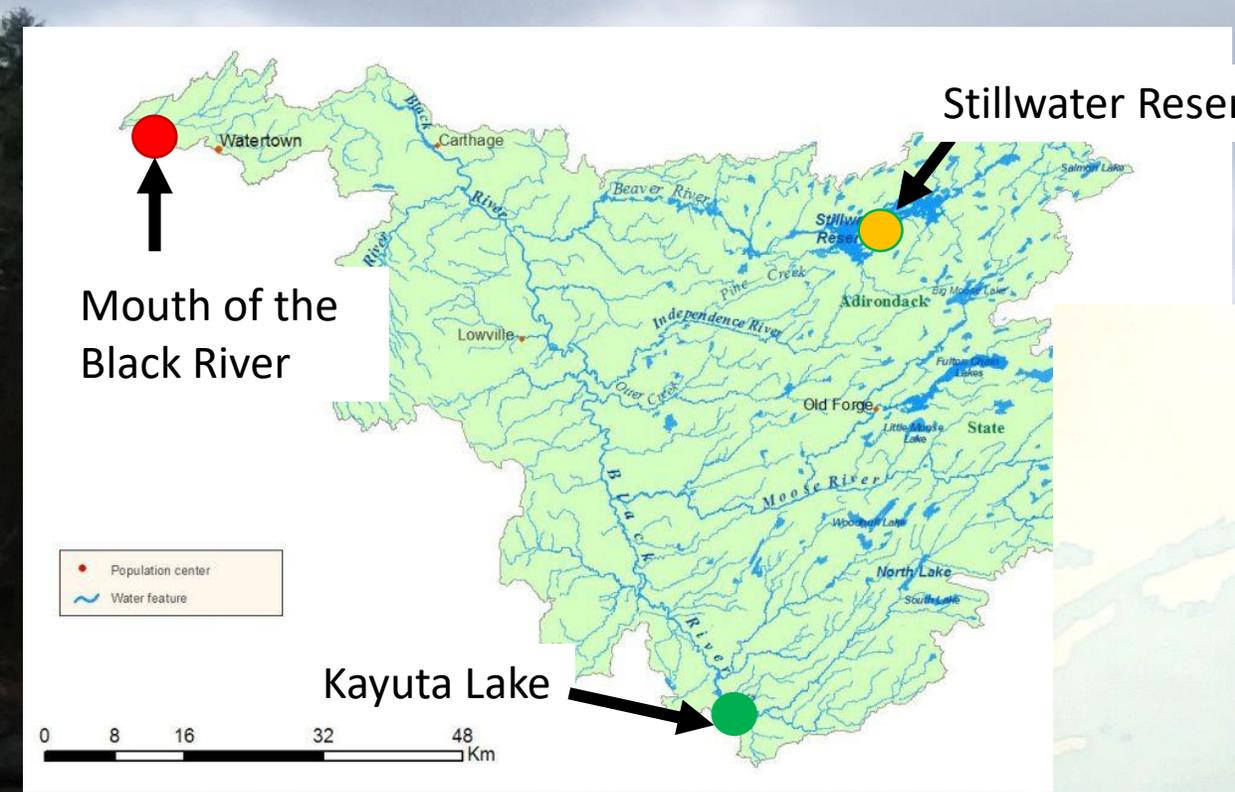
Geologic Time Scale

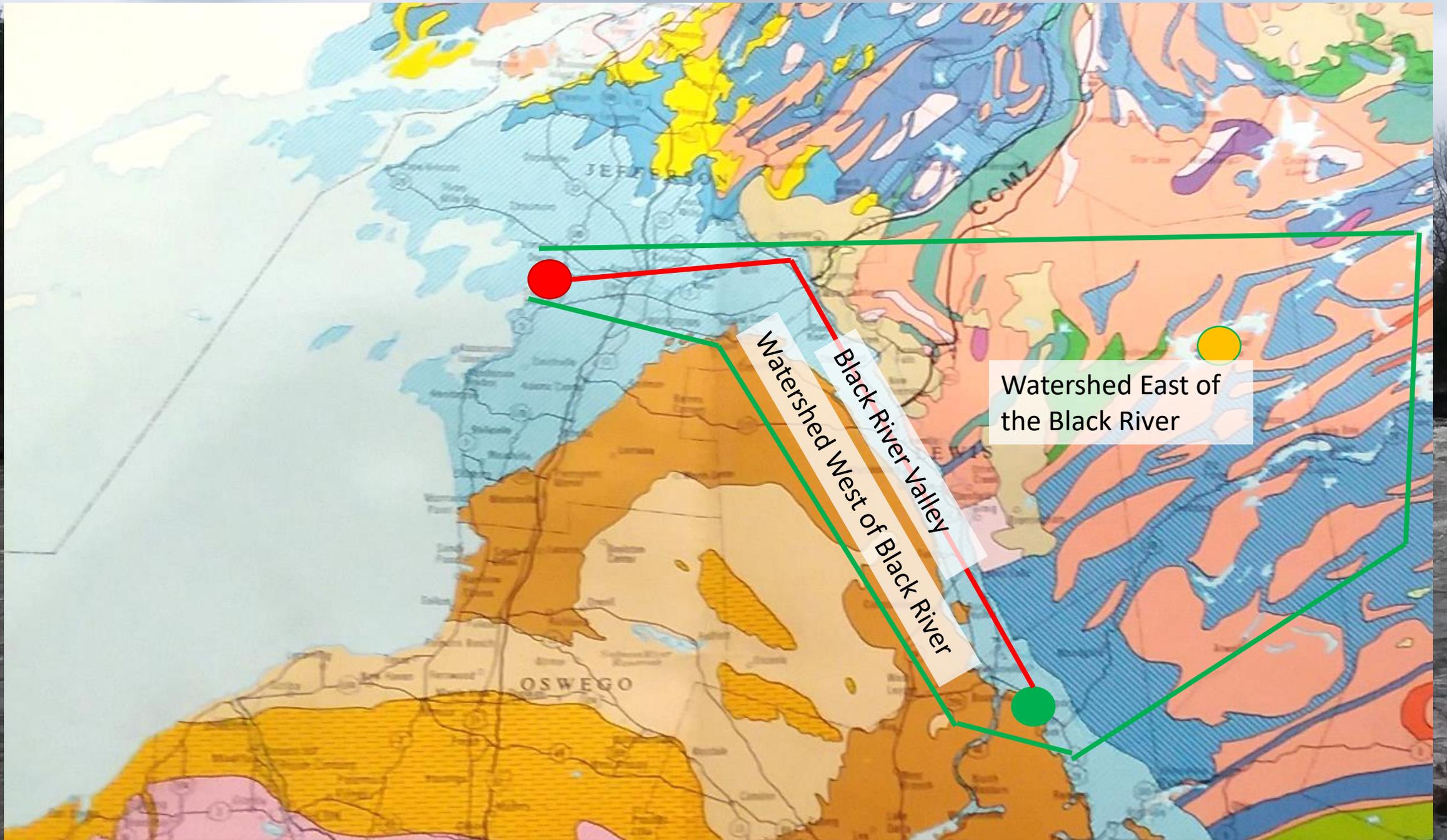


Where we'll be hanging out today 😊









JEFFERSON

CCMZ

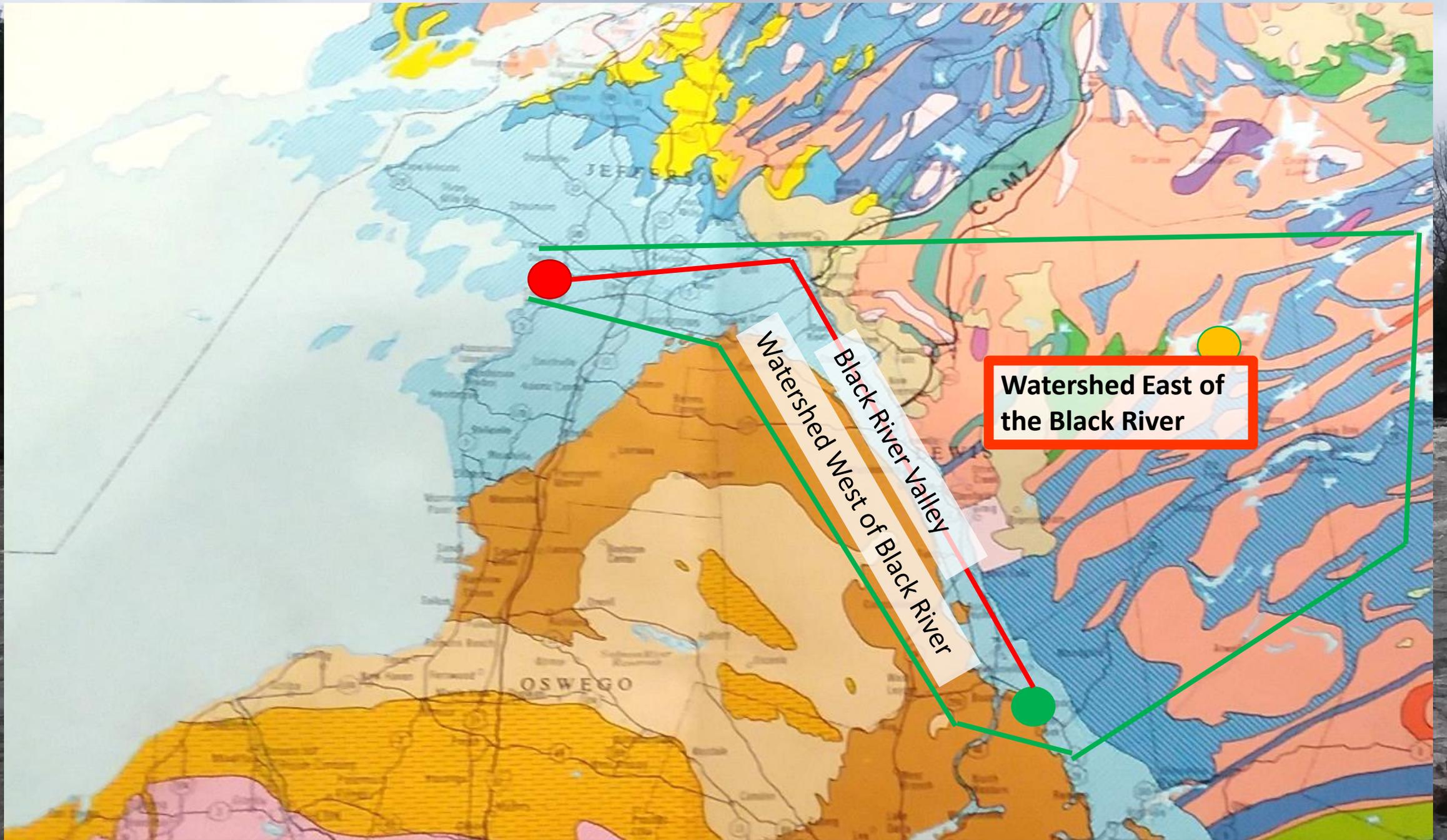


Black River Valley
Watershed West of Black River

Watershed East of
the Black River



OSWEGO



**Watershed East of
the Black River**

Black River Valley
Watershed West of Black River

Watershed East of the Black River

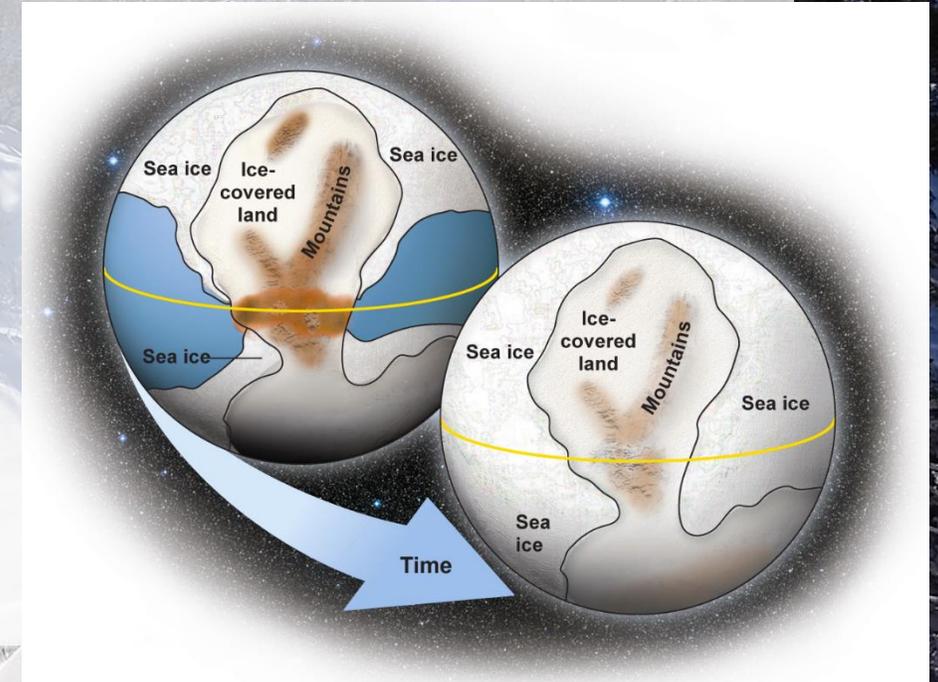


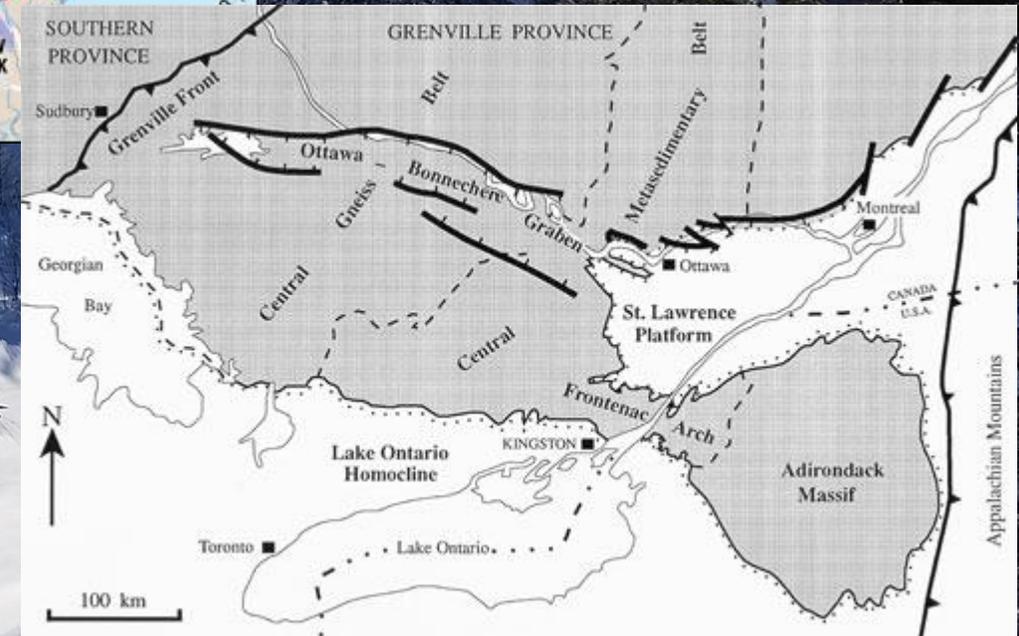
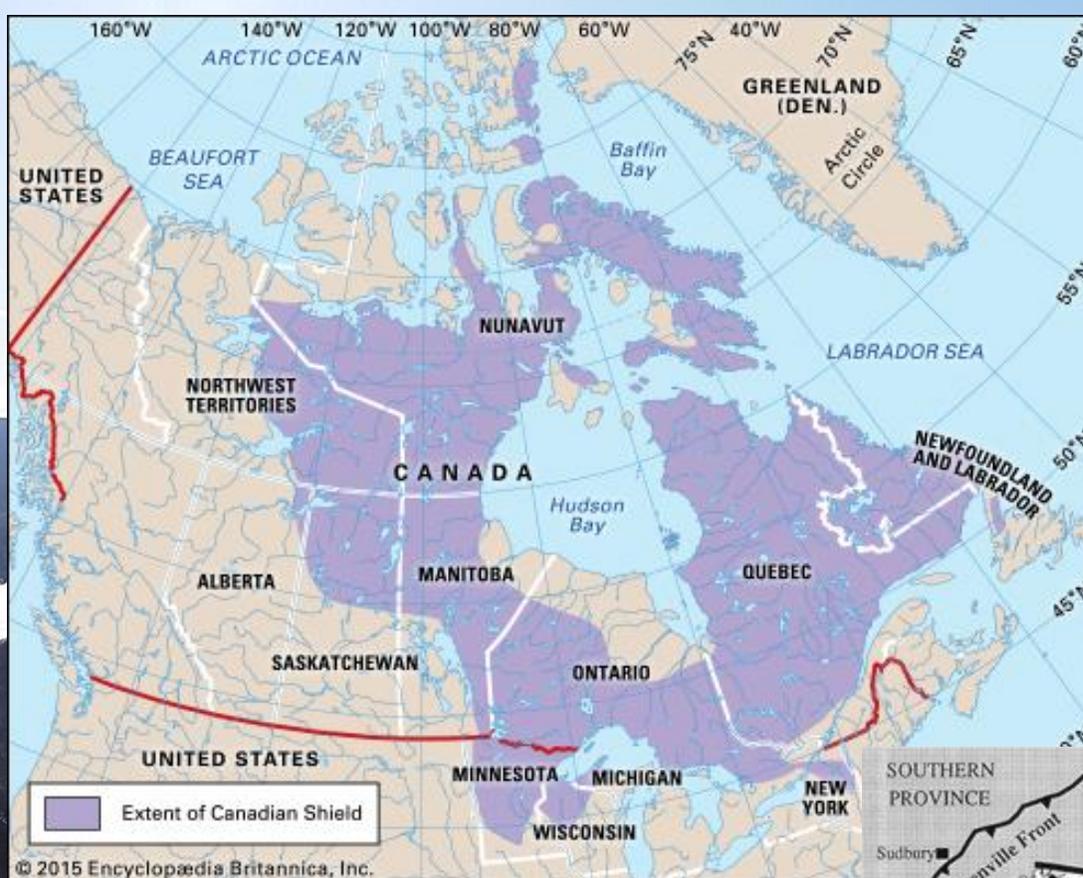
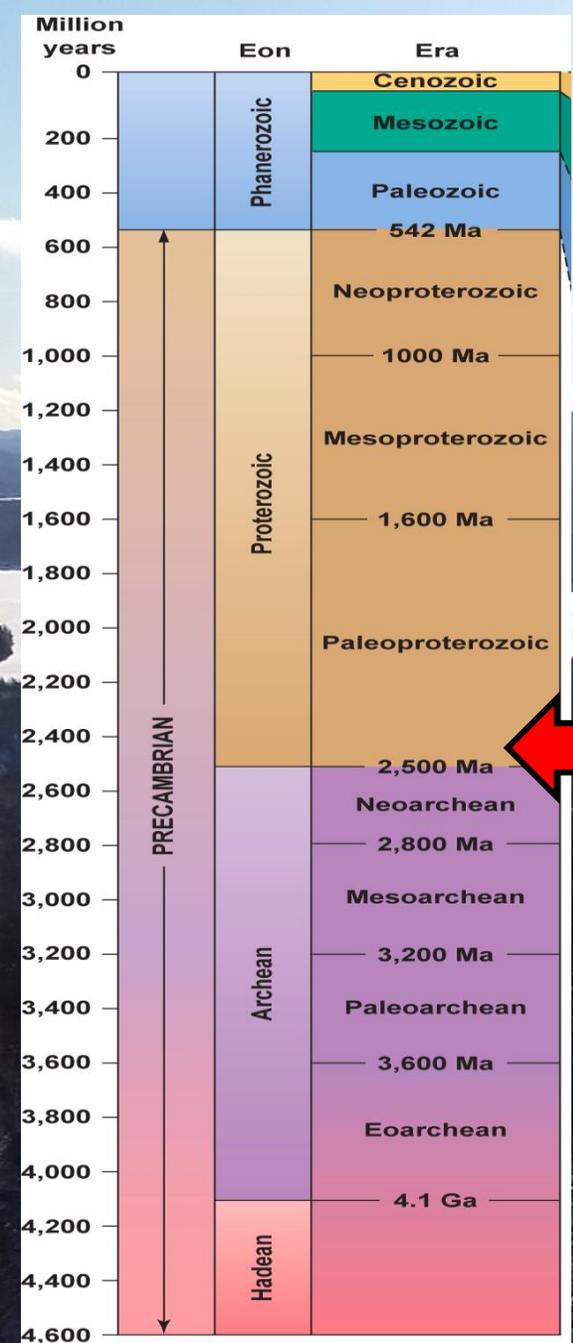
Watershed East of the Black River

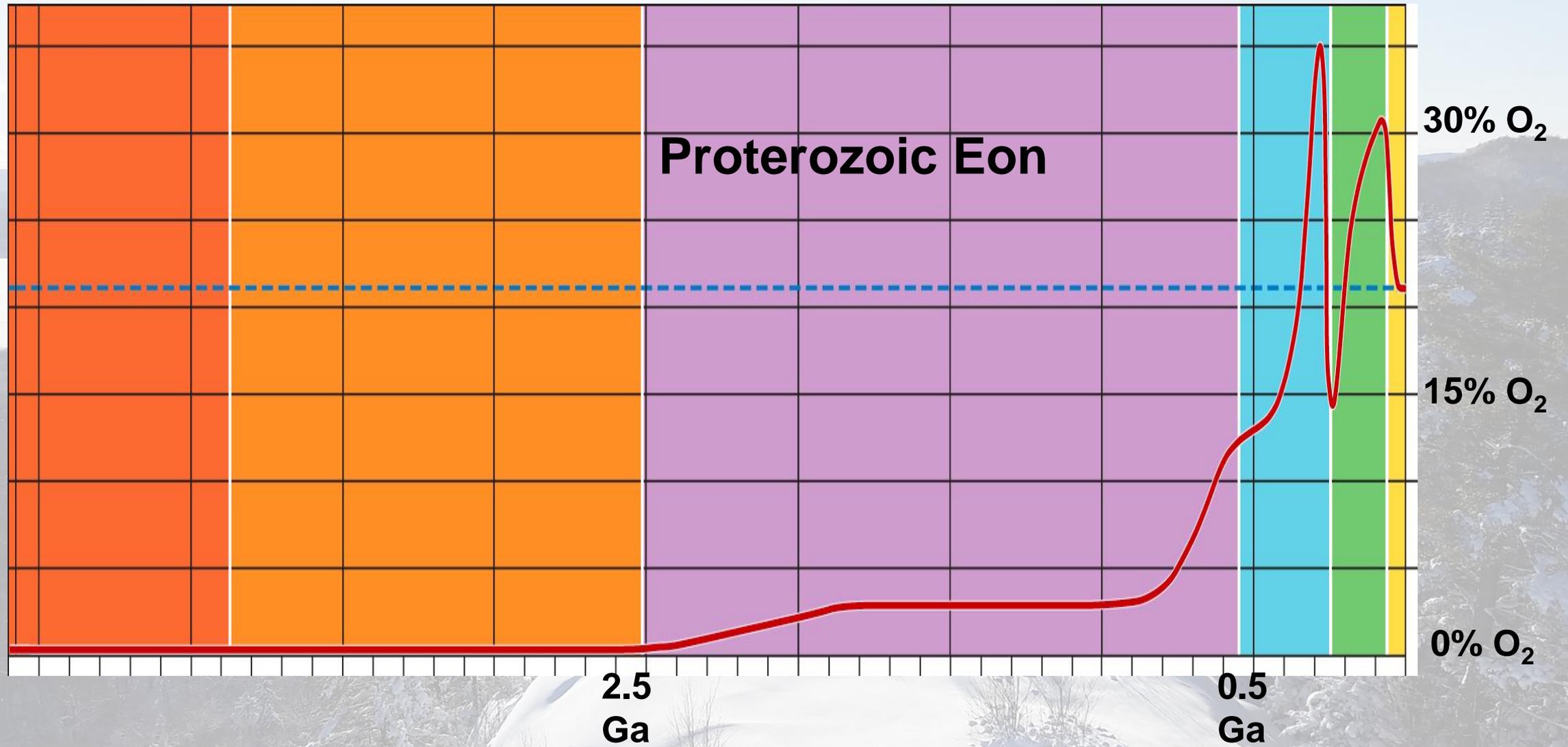
- **Much of the geology is shaped by Proterozoic events (2.5 billion to 540 million years ago)**
- **Later, Proterozoic events became visible during the relatively recent (10 to 5 million years ago) formation of the Adirondack dome**
- **Almost all the events we see in the Adirondack region are present in all parts of the watershed**
 - **Buried under more recent rock**

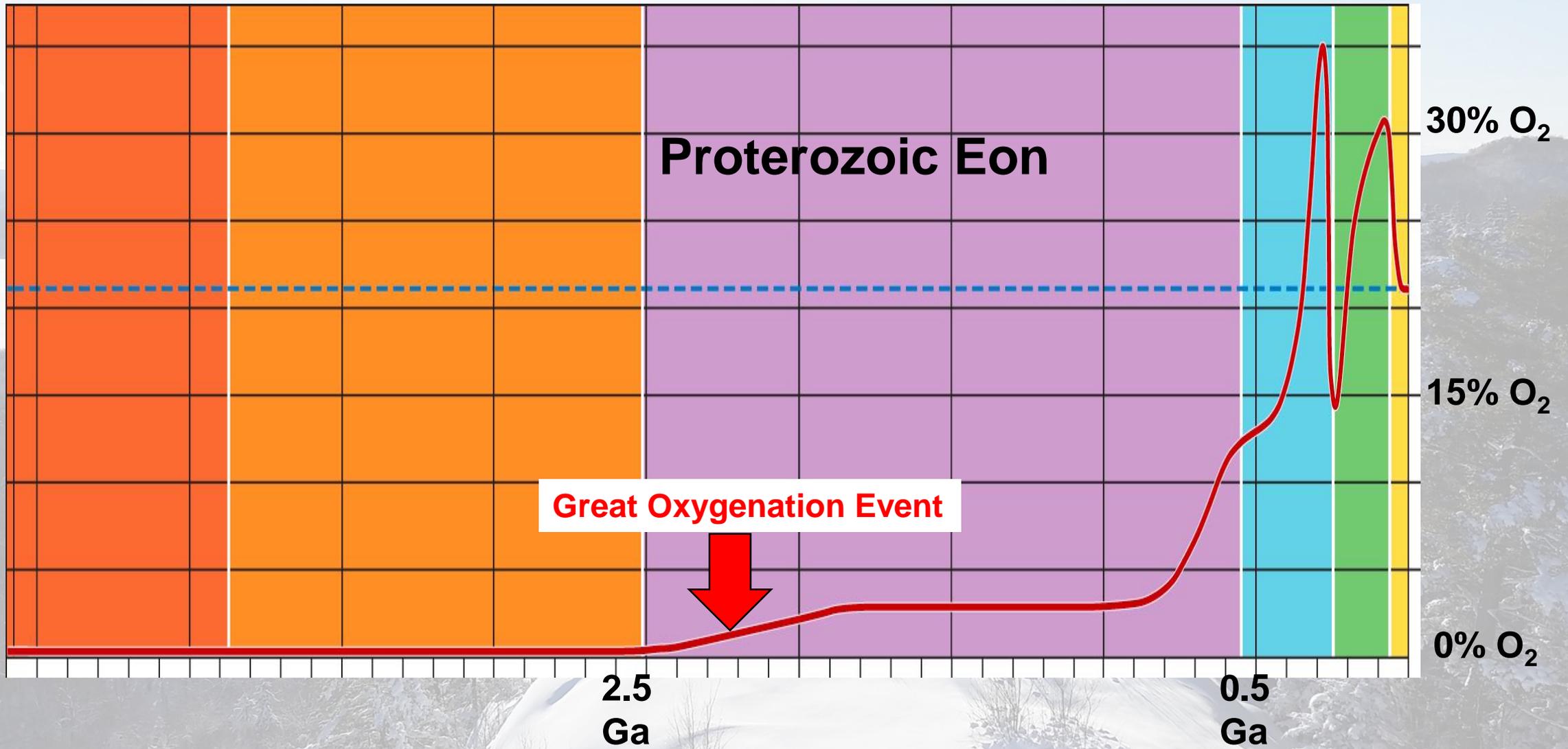
Proterozoic

- **Proterozoic = early life.**
 - **Around 2.5 Ga to 542 Ma.**
- **Continental crust finished forming**
- **Atmospheric oxygen rose**
 - **From ~0% to ~12%**
- **Snowball Earth**
- **A lot of Proterozoic history in the Adirondacks!**

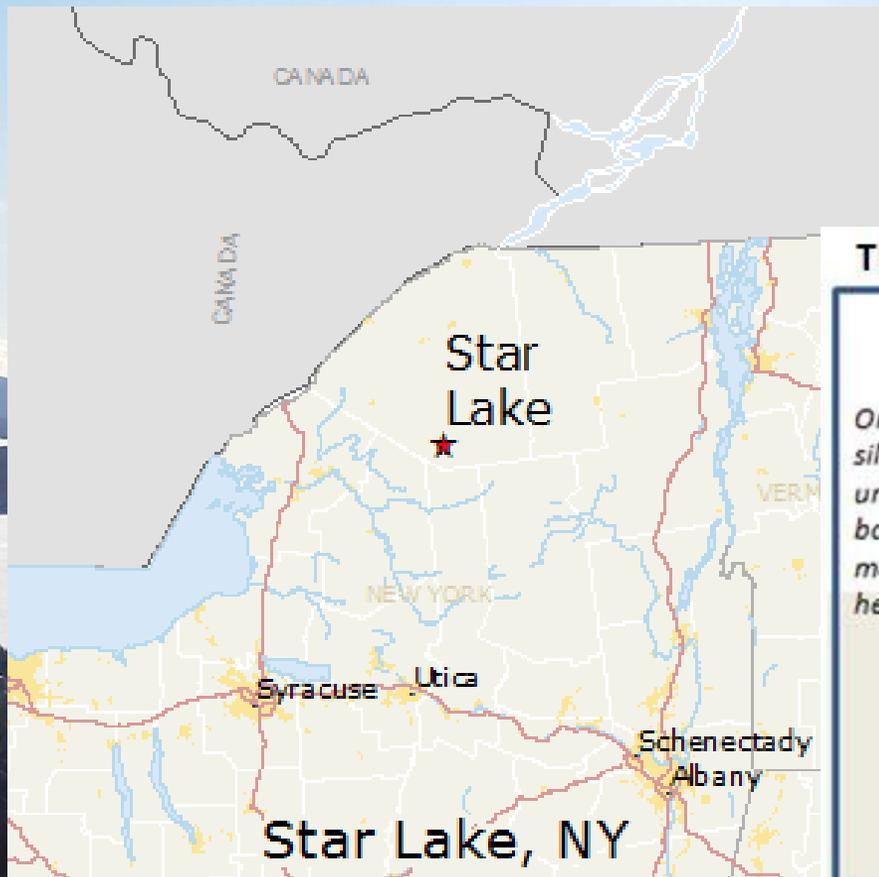












Three “map” views of the Benson Mine open pit near Star Lake, NY

Ore grade garnet and sillimanite gneiss units are shaded based on grade and magnetite vs hematite

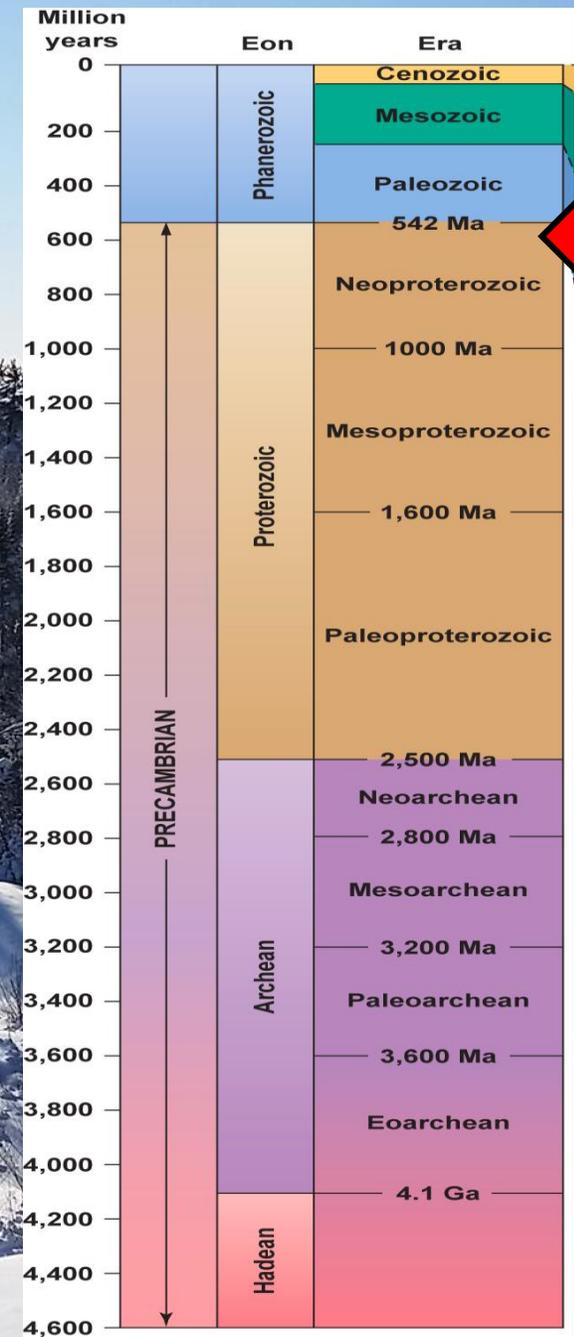
Geologic map of Benson Mine open pit: modified from Crump and Beutner, 1968

Topographic map of Benson Mine open pit. Note Route 3 near bottom of map. Star Lake is 1 mile west.

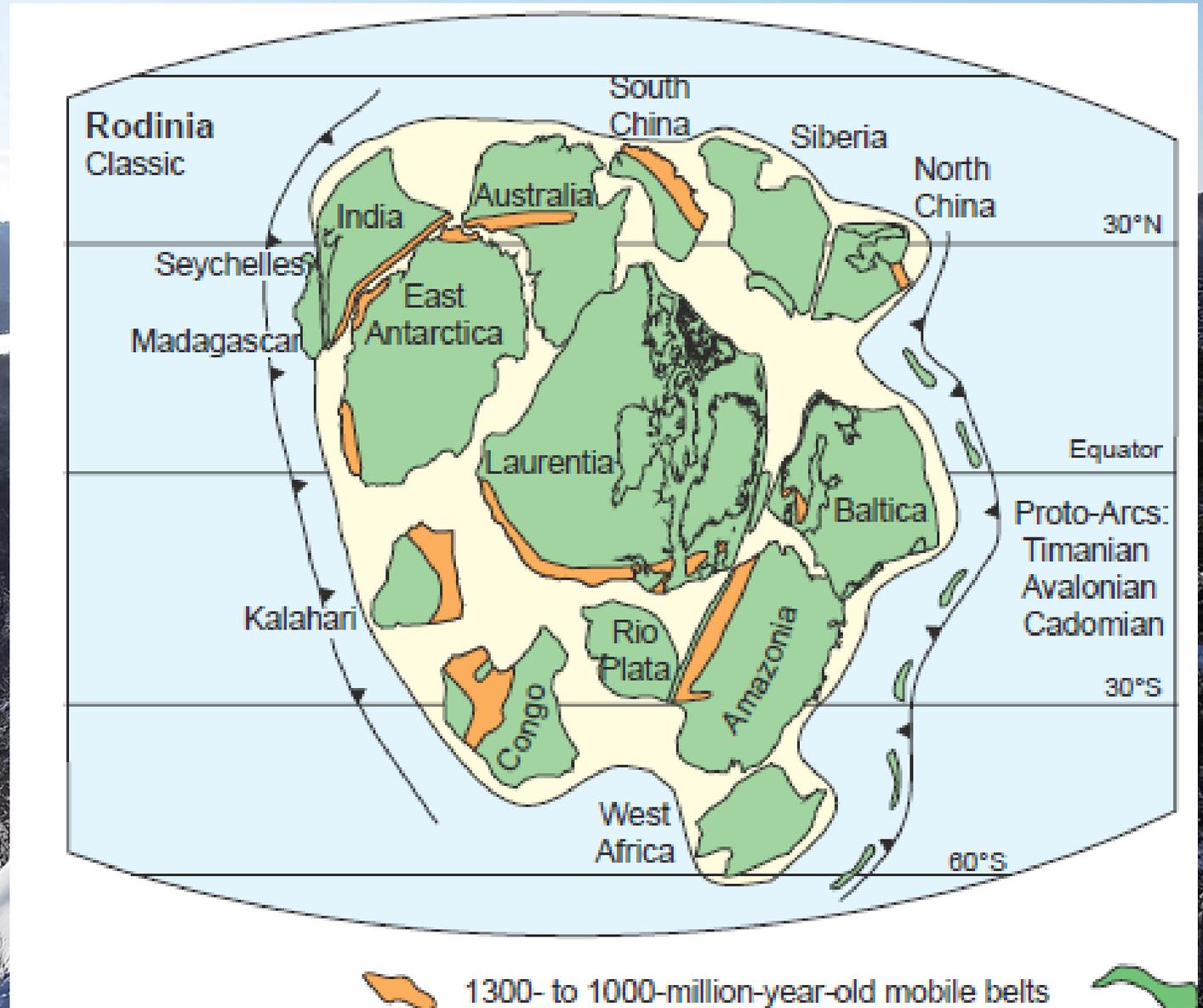
Satellite view of Benson Mine open pit filled with water. Lake is 4 km long.



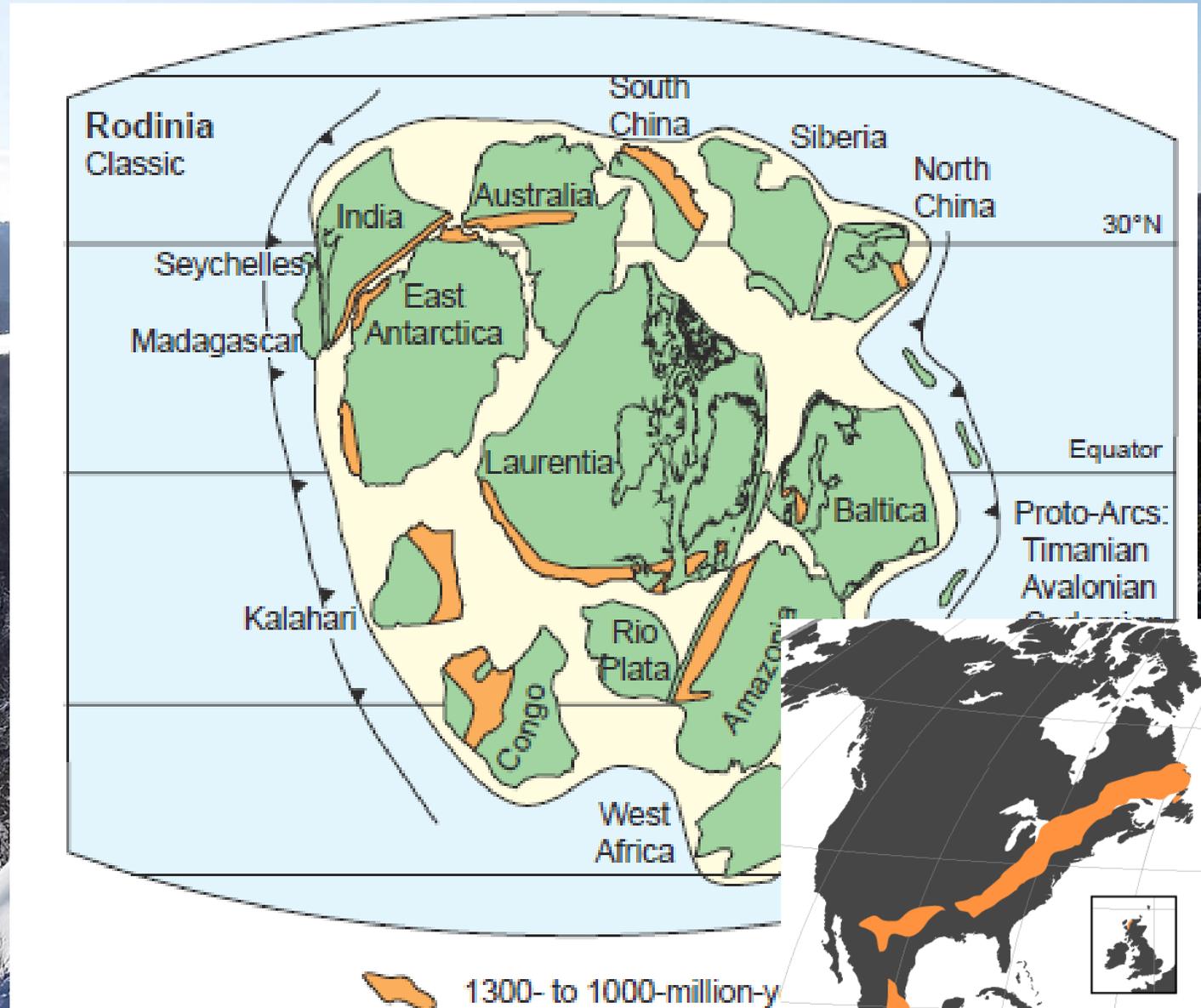
At the end of the Proterozoic, the Earth becomes a very busy and exciting place...



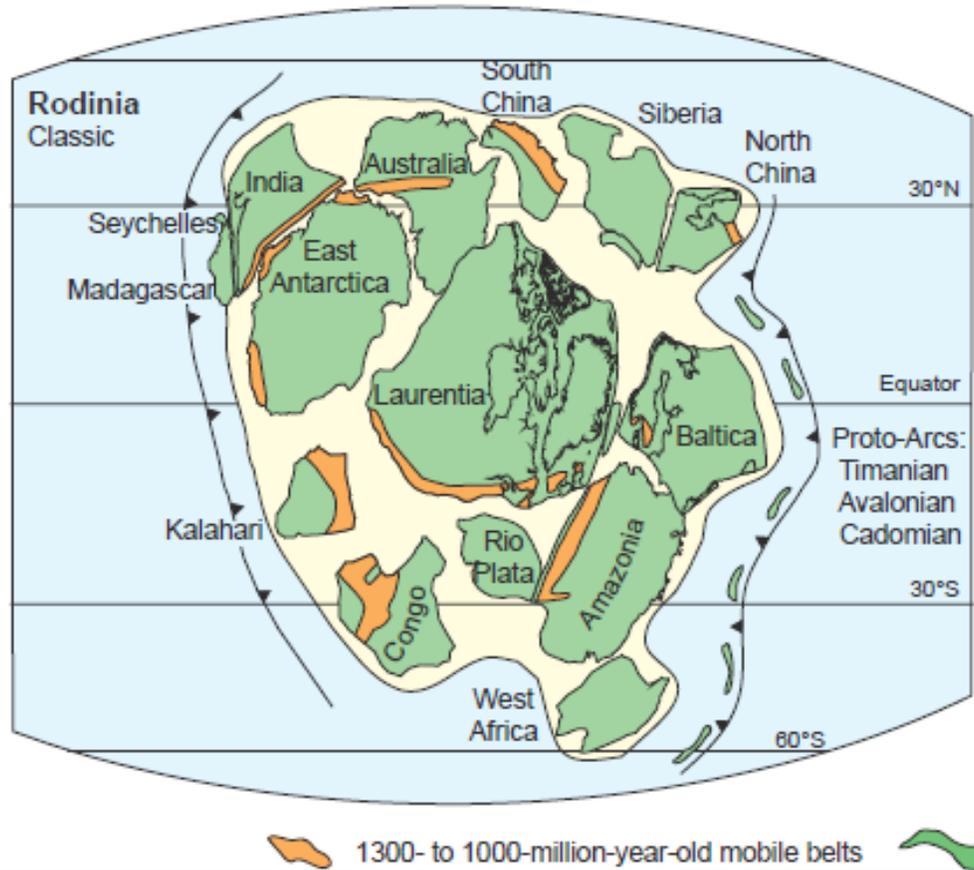
Welcome to beautiful, sunny Rodinia

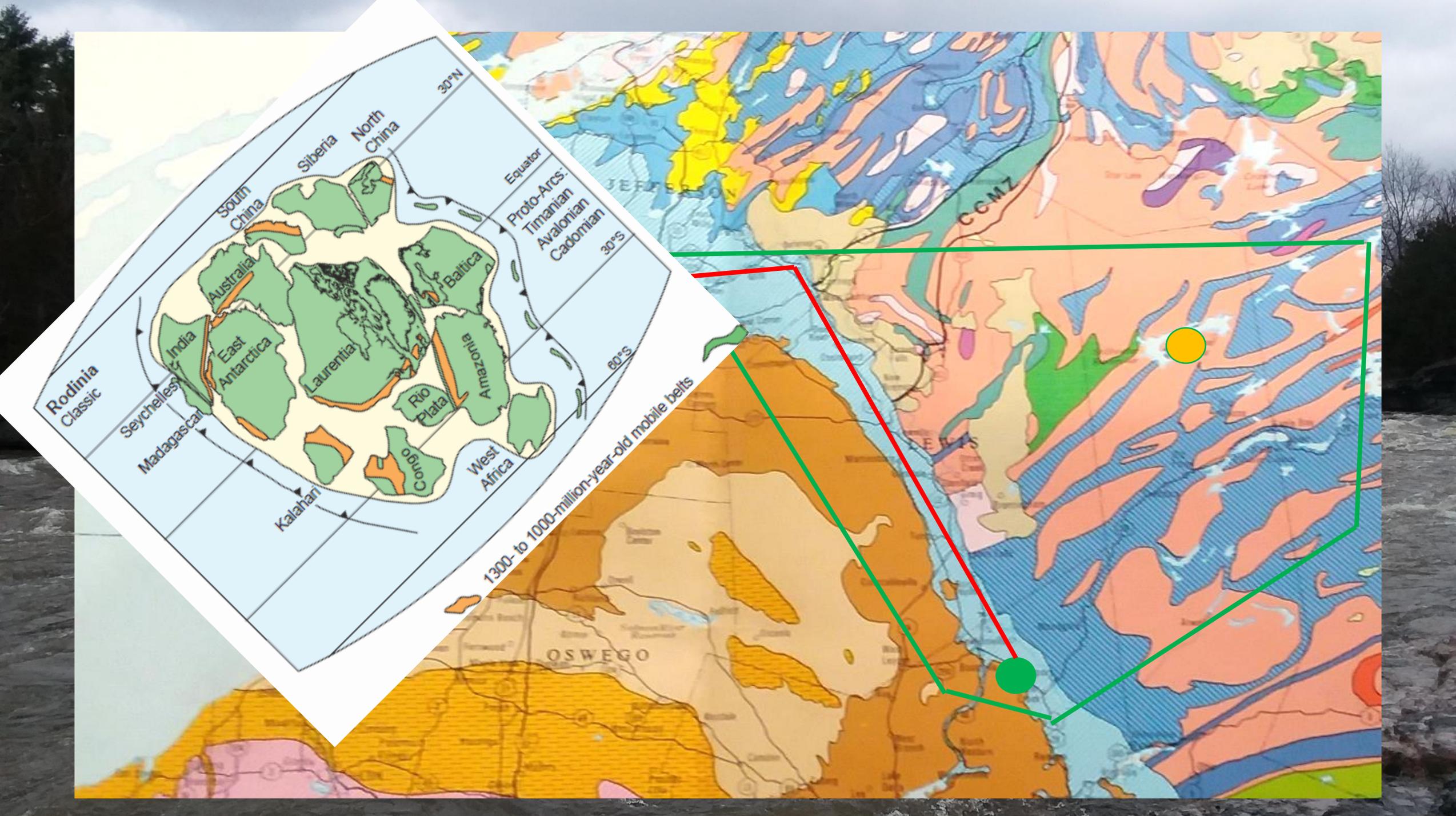


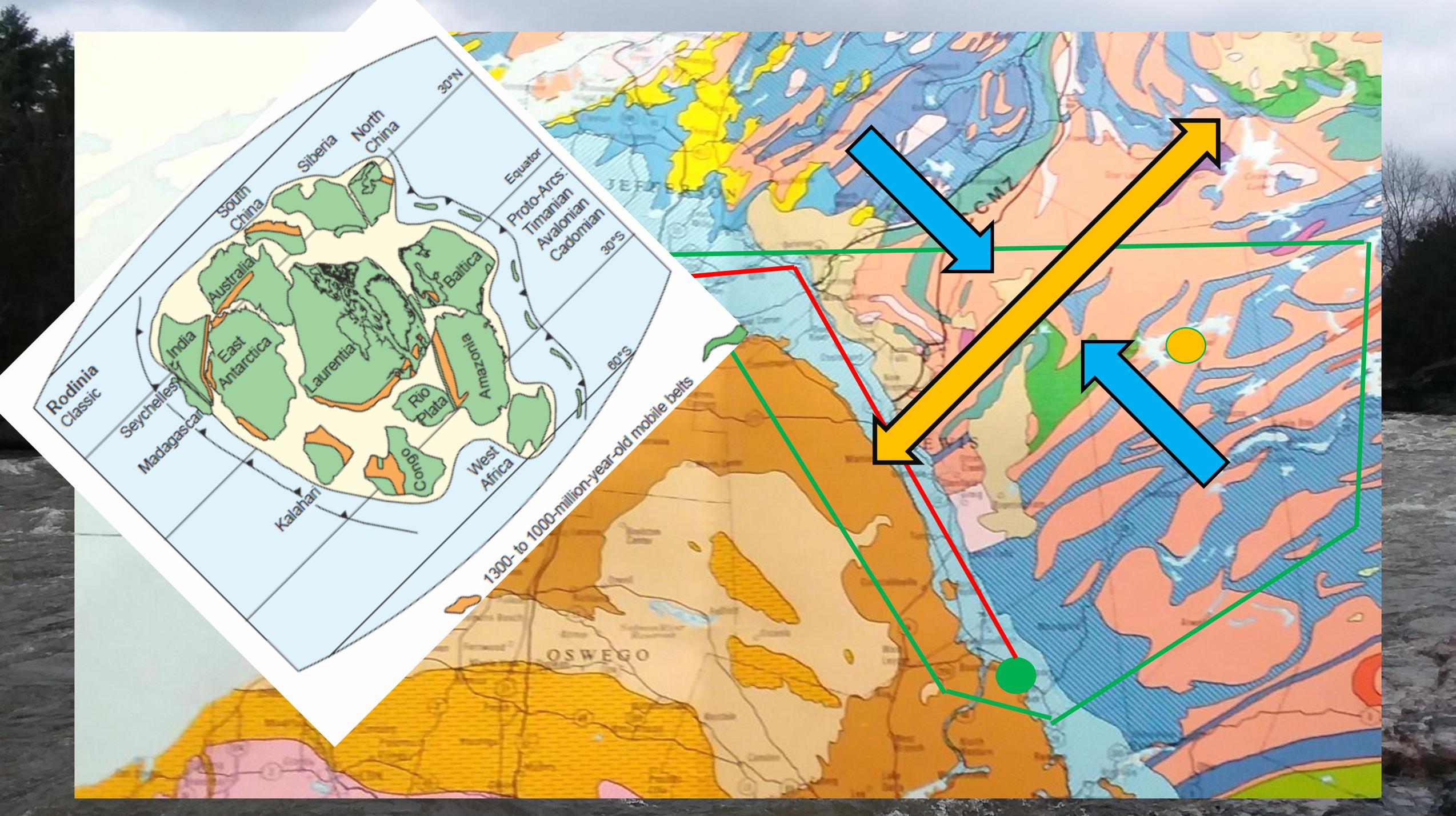
Welcome to beautiful, sunny Rodinia

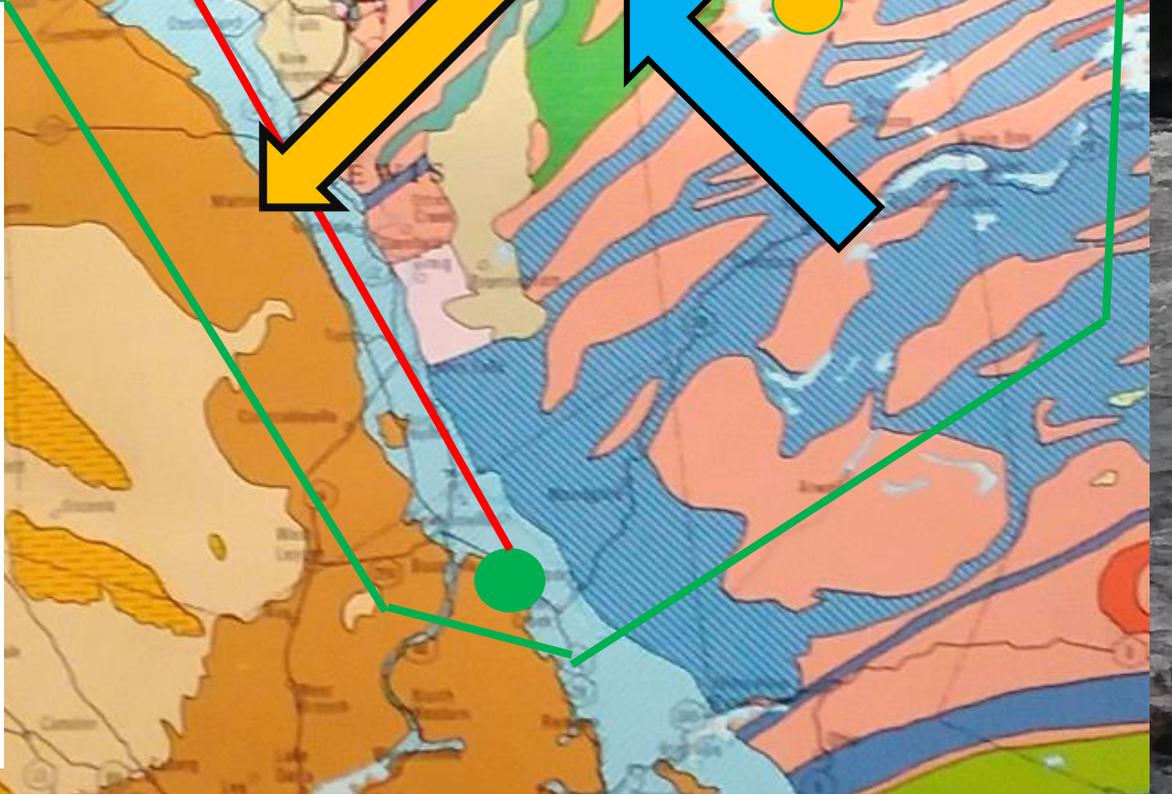
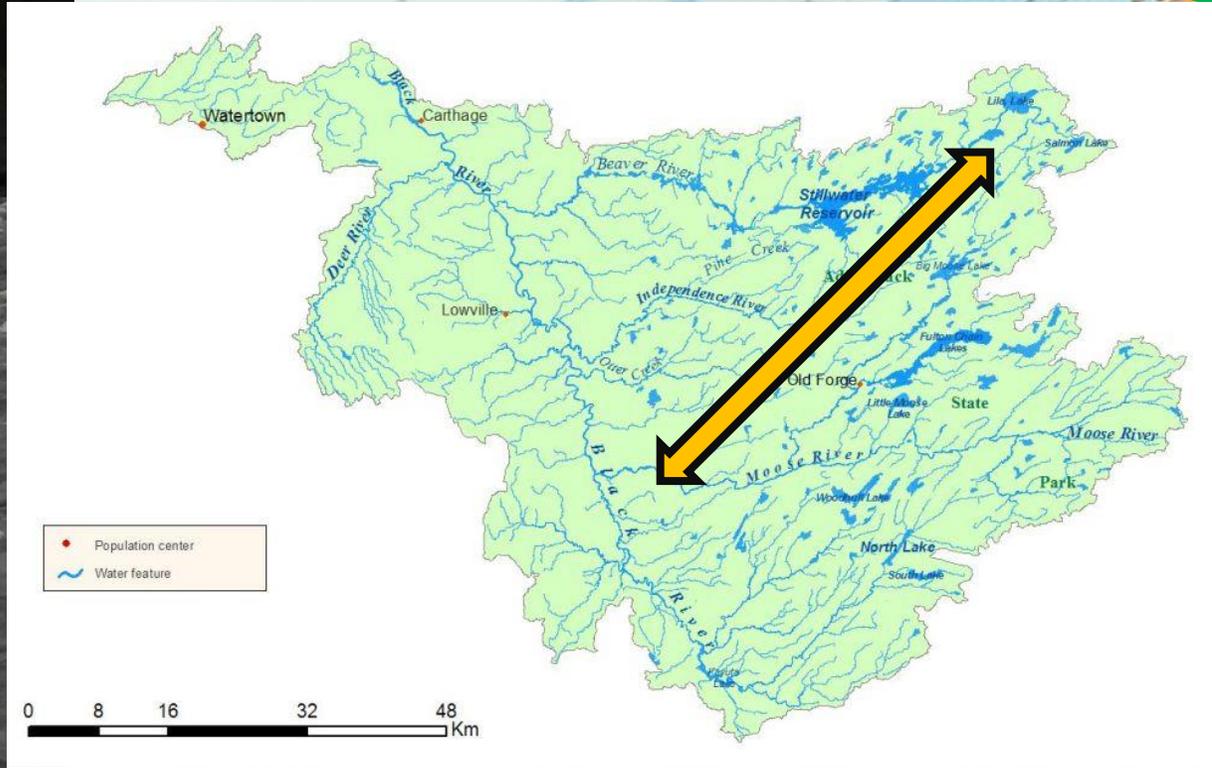
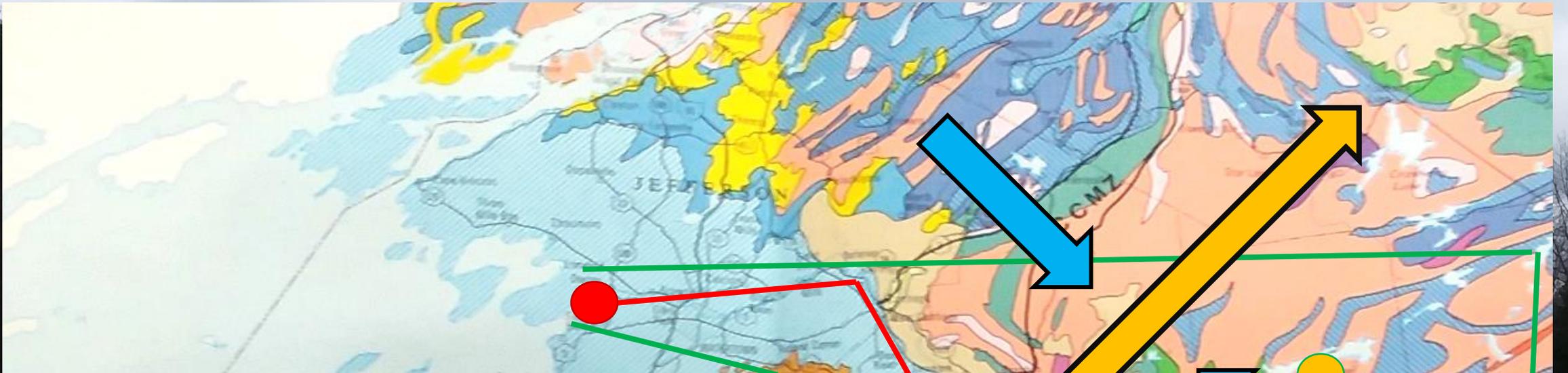


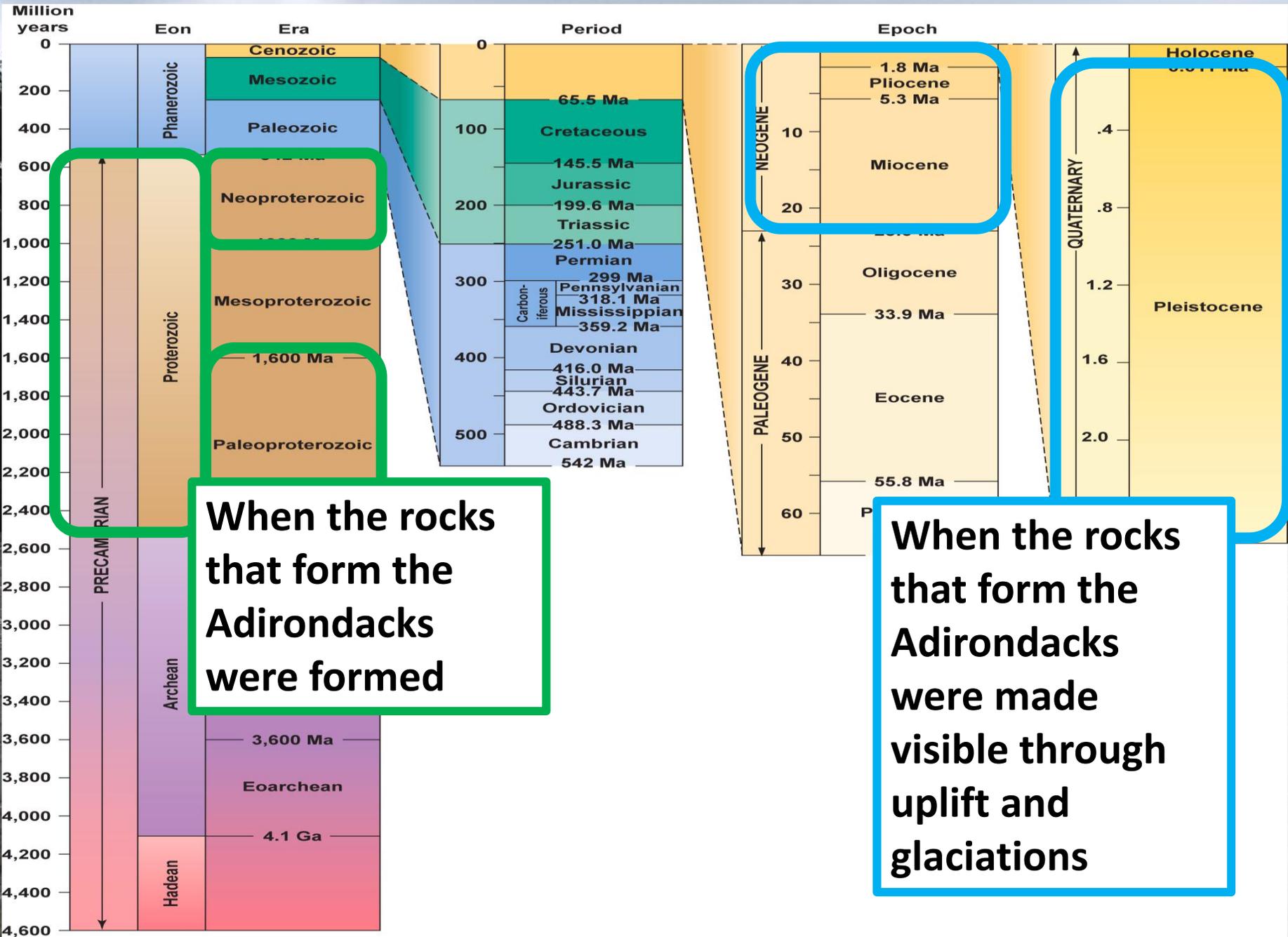








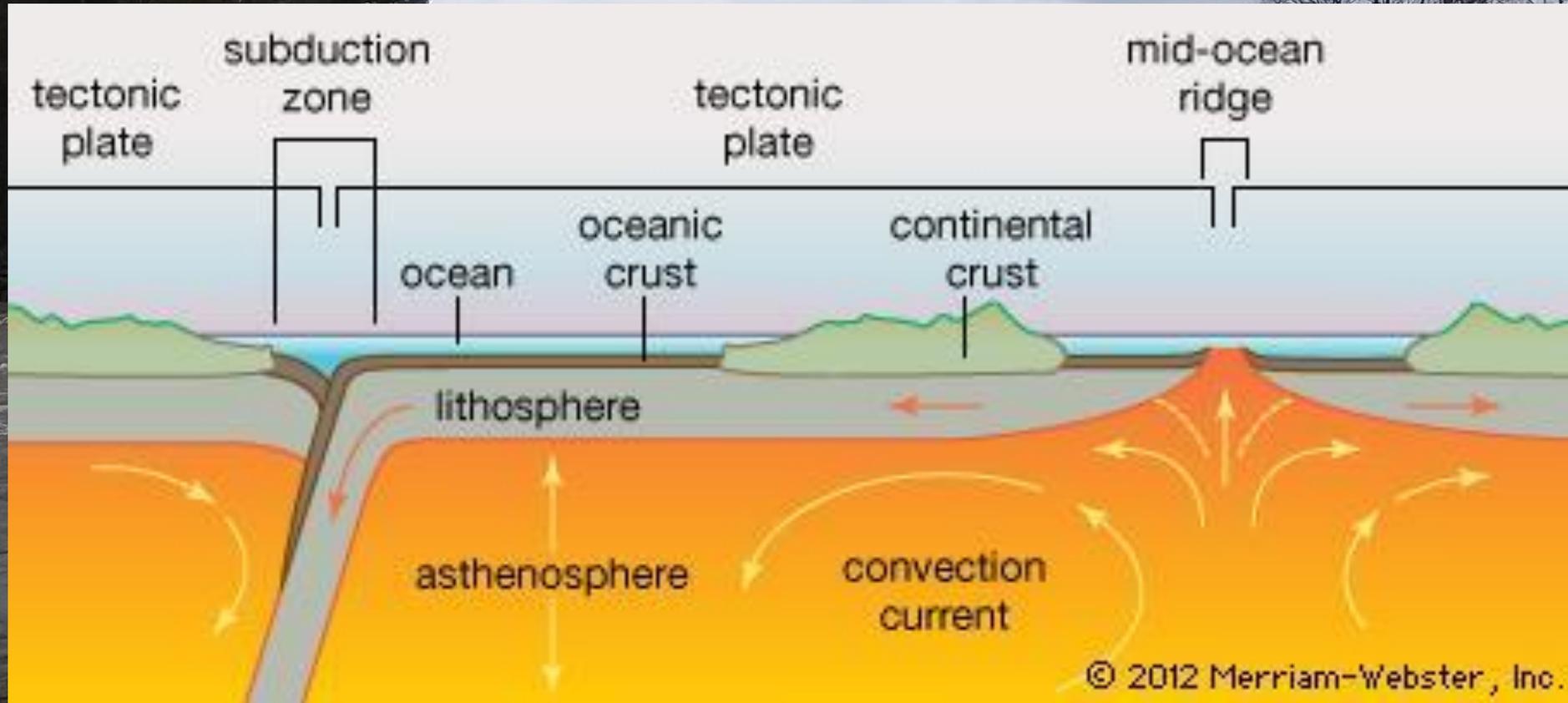




When the rocks that form the Adirondacks were formed

When the rocks that form the Adirondacks were made visible through uplift and glaciations

Geology – Quick 101 Review



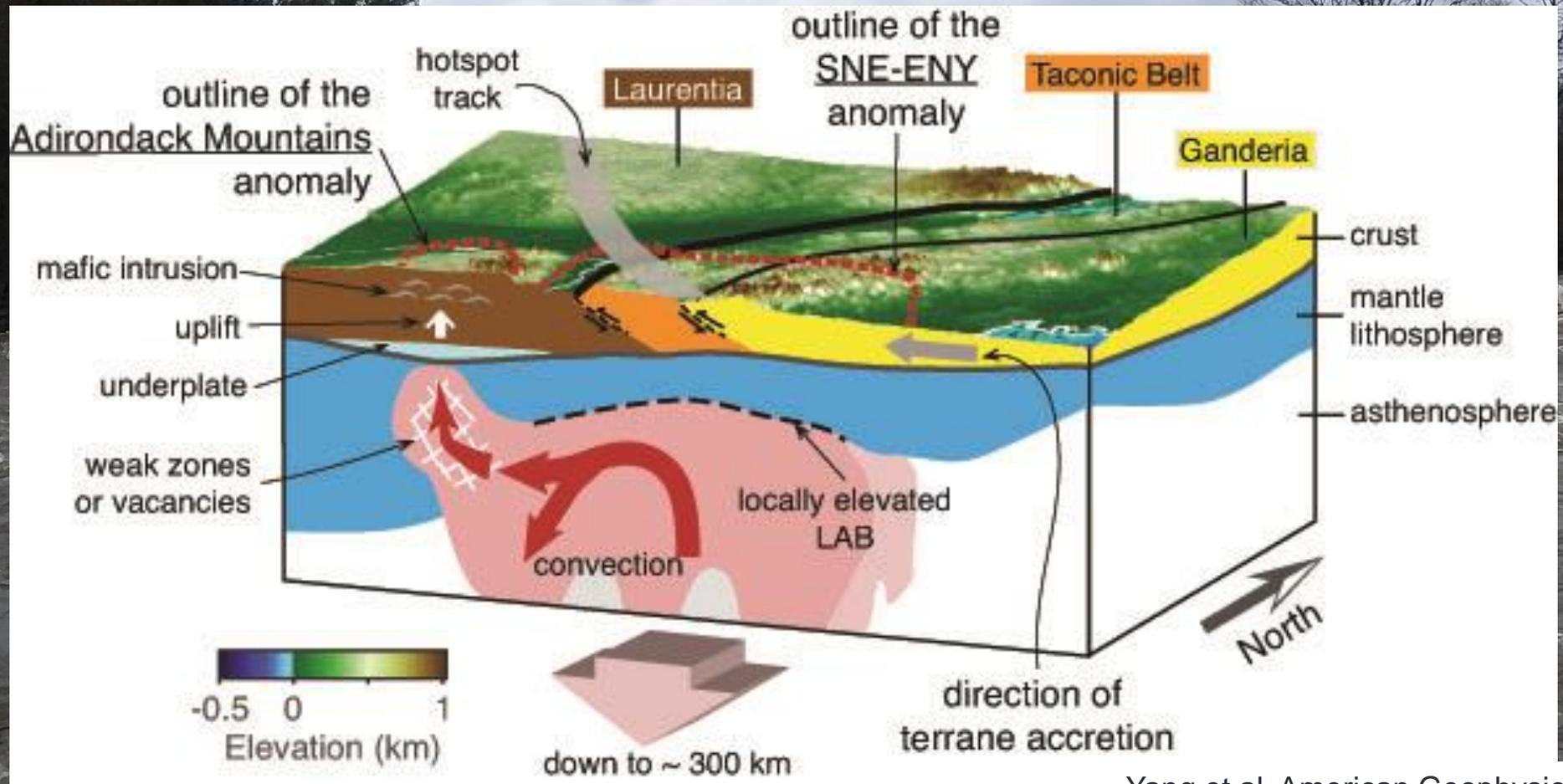
Formation of the Adirondack Dome

- Many details poorly understood
- What we know:
 - Adirondacks is a very different type of mountain range from Appalachians, Rockies, Alps, Himalayas, etc.
 - Adirondacks are NOT from continental collision
 - A type of phenomenon called a “hot spot”
- **Adirondacks have more in common with Hawaii than the Appalachians (at least geologically! 😊)**

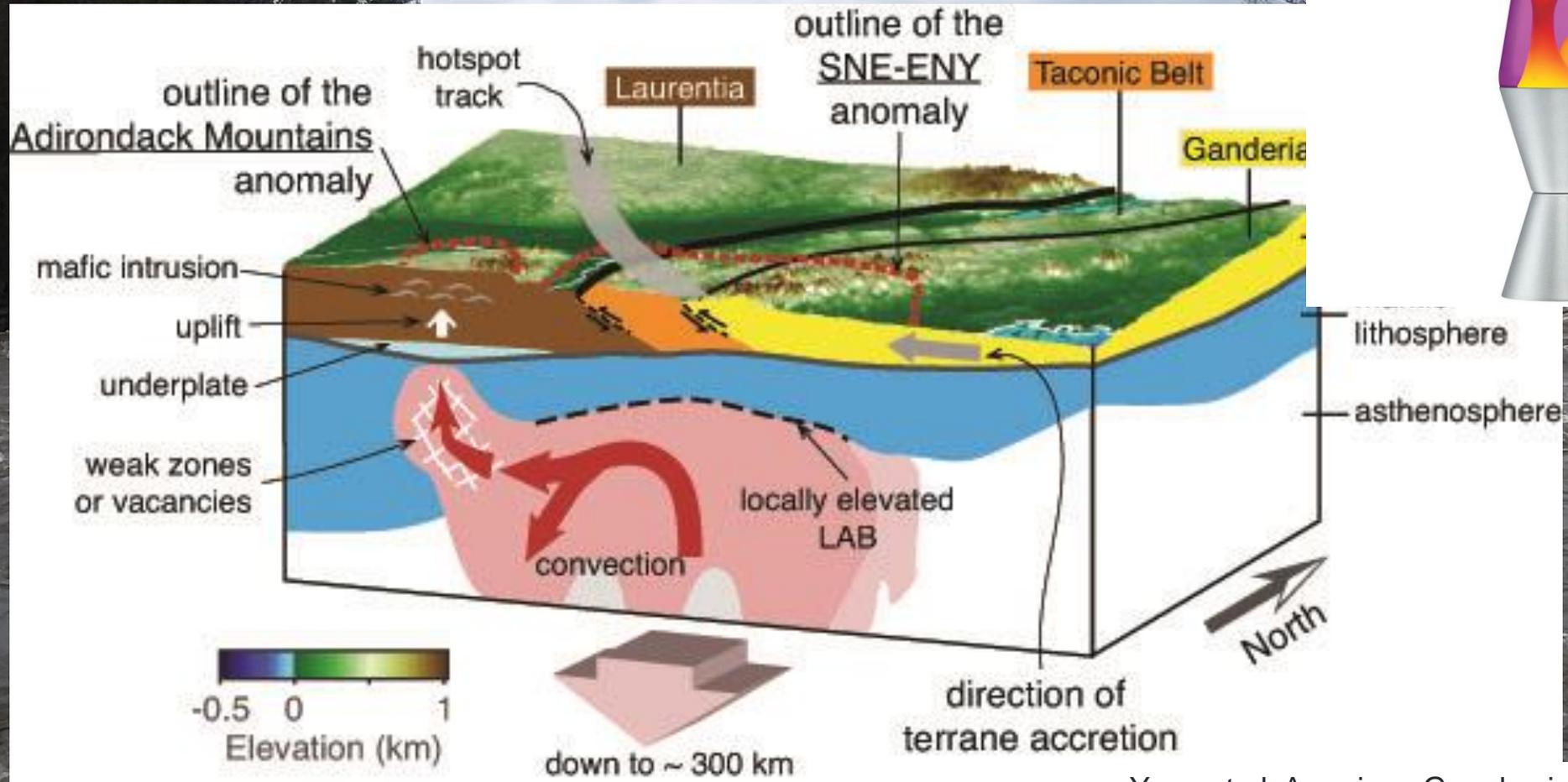
Formation of the Adirondack Dome

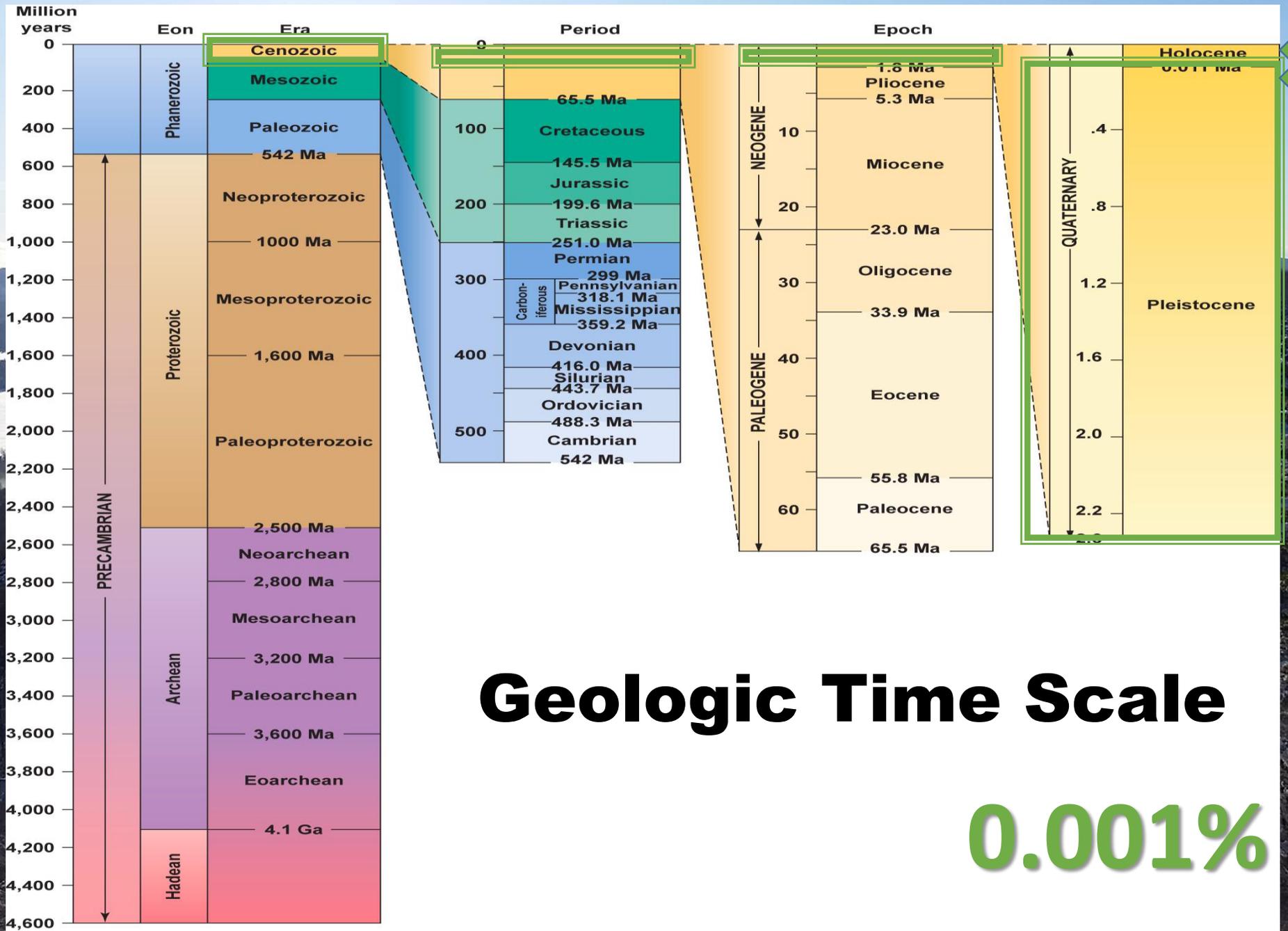
- Many details poorly understood
- What we know:
 - Adirondacks is a very different type of mountain range from Appalachians, Rockies, Alps, Himalayas, etc.
 - Adirondacks are NOT from continental collision
 - A type of phenomenon called a “hot spot”
 - Rising about 1-3 mm per year
 - **The Adirondack Mountains have more in common with Hawaii than the Appalachians (at least geologically! 😊)**

Formation of the Adirondack Dome



Formation of the Adirondack Dome





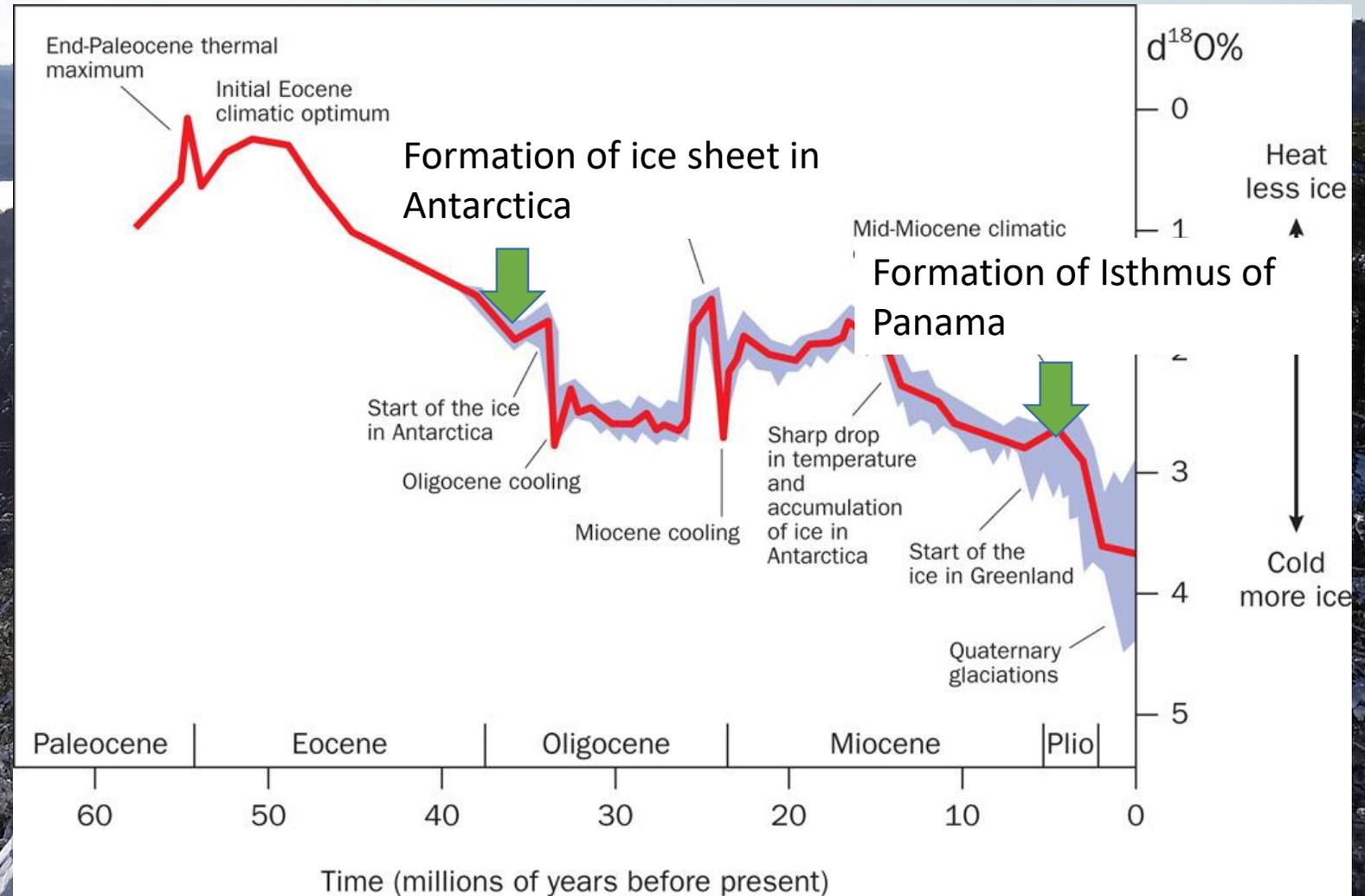
Geologic Time Scale

0.001%

Earth's Cenozoic Climate (65 million years ago to today)

Prelude to the Big Chill

- Climate for the last 65 million years has been complex but trend was cooling



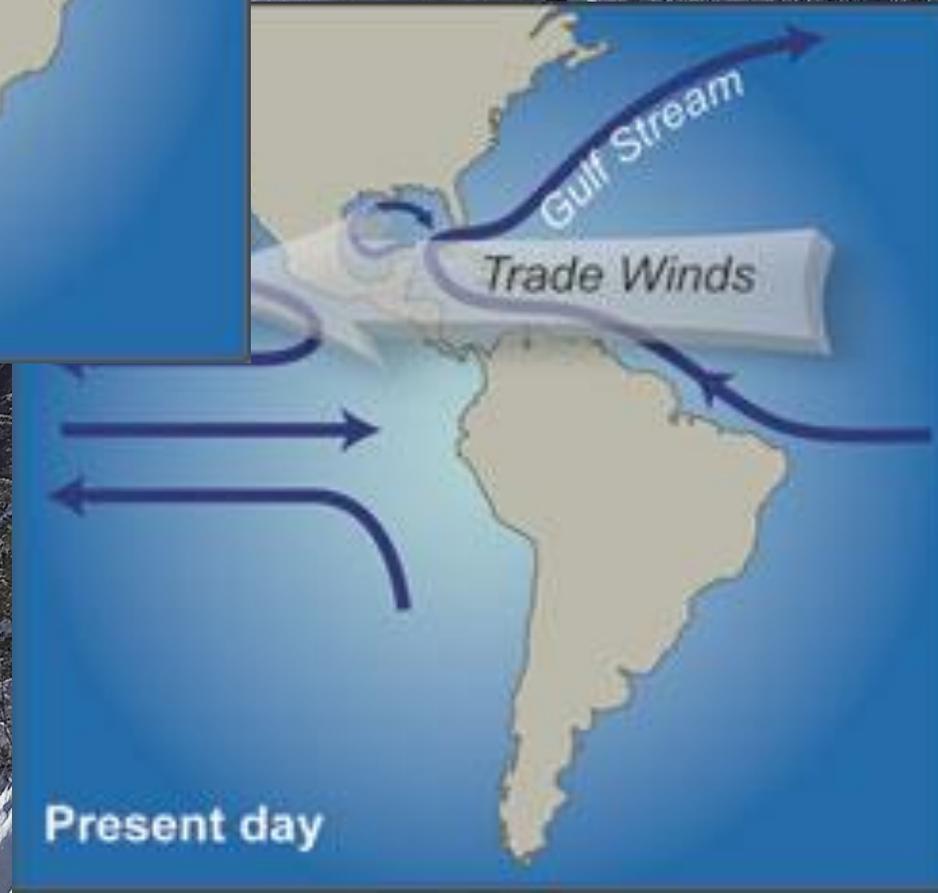


- Antarctica broke off from the southern tip of South America about 34 million years ago
- Created the Drake Passage
- Antarctica was now completely surrounded by ocean
- The Antarctic Circumpolar Current formed, isolating Antarctica from the warmth of the global oceans

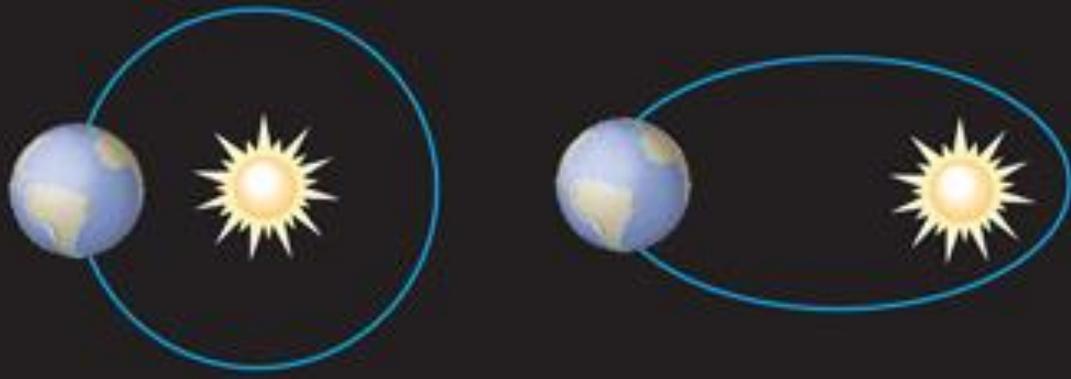
Diagrams from Woods Hole Oceanographic Institute

Panama changed global ocean currents

Delivered water to the glaciers forming in the Northern Hemisphere



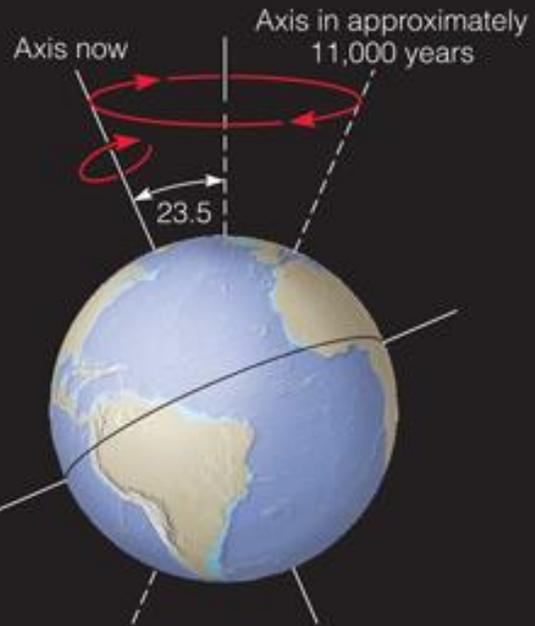
- Before the closing of the Isthmus, the Gulf Stream was weak or did not exist
- After the closing, the Gulf Stream brought humid air to Europe, providing water for glaciers to form



(a) Earth's orbit varies from nearly a circle (*left*) to an ellipse (*right*) and back again in about 100,000 years.

Milankovitch cycles

Earth's position relative to the sun changes in cycles of 1,000-100,000 years



(b) Earth moves around its orbit while rotating on its axis, which is tilted to the plane of its orbit around the Sun at 23.5 degrees and points to the North Star. Earth's axis, or rotation, slowly moves and traces out a cone in space.



(c) At present, Earth is closest to the Sun in January (*top*), when the Northern Hemisphere experiences winter. In about 11,000 years, however, as a result of precession, Earth will be closer to the Sun in July (*bottom*), when summer occurs in the Northern Hemisphere.





Ice Reflects Sunlight

Speeds up and stabilizes cooling

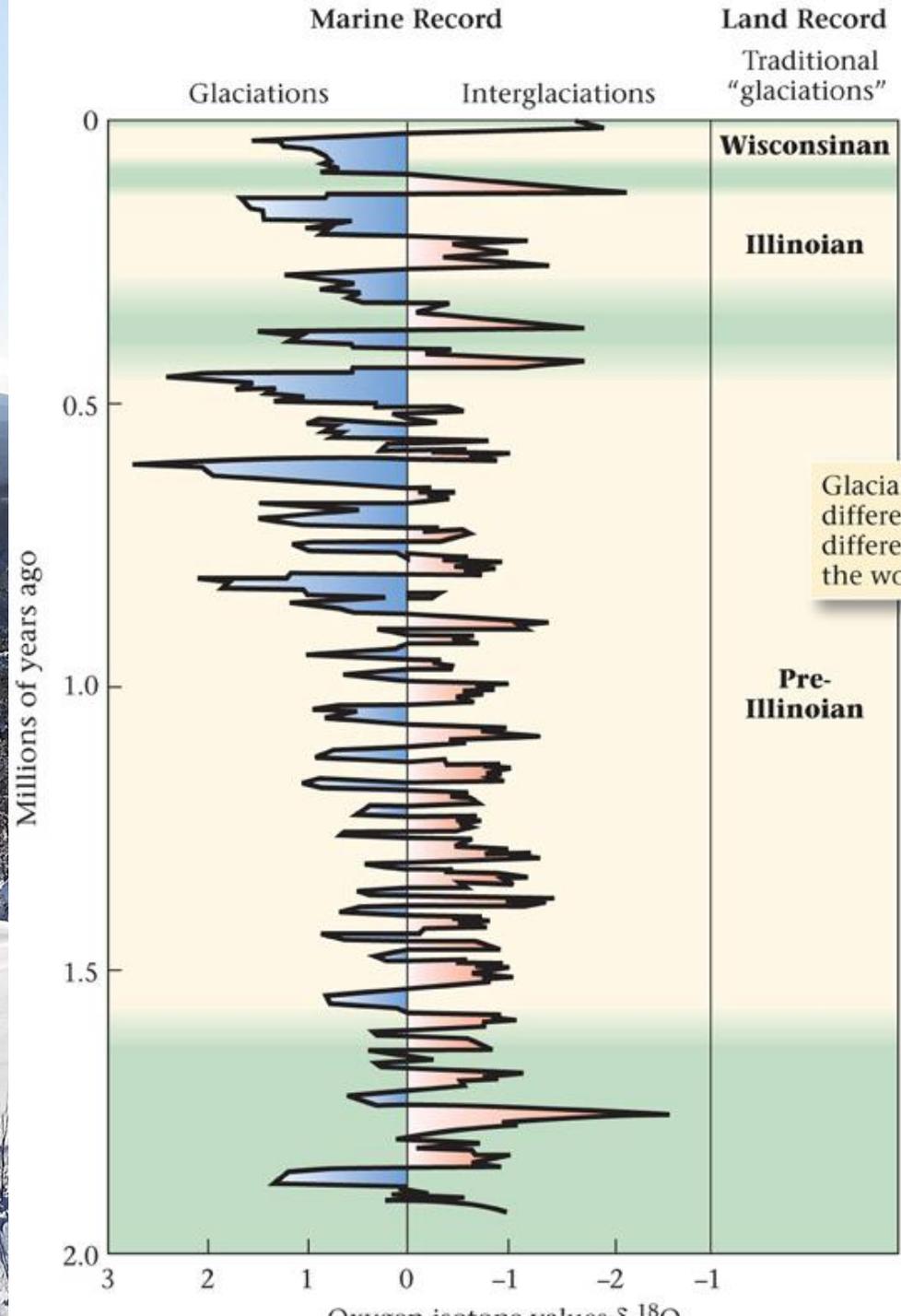
Diagrams from NASA's
Conceptual Image
Laboratory and Goddard
Institute for Space
Studies



There were at least 14 major glaciations and 14 interglacials

Glaciation: when glaciers grow and cover large areas of land mass

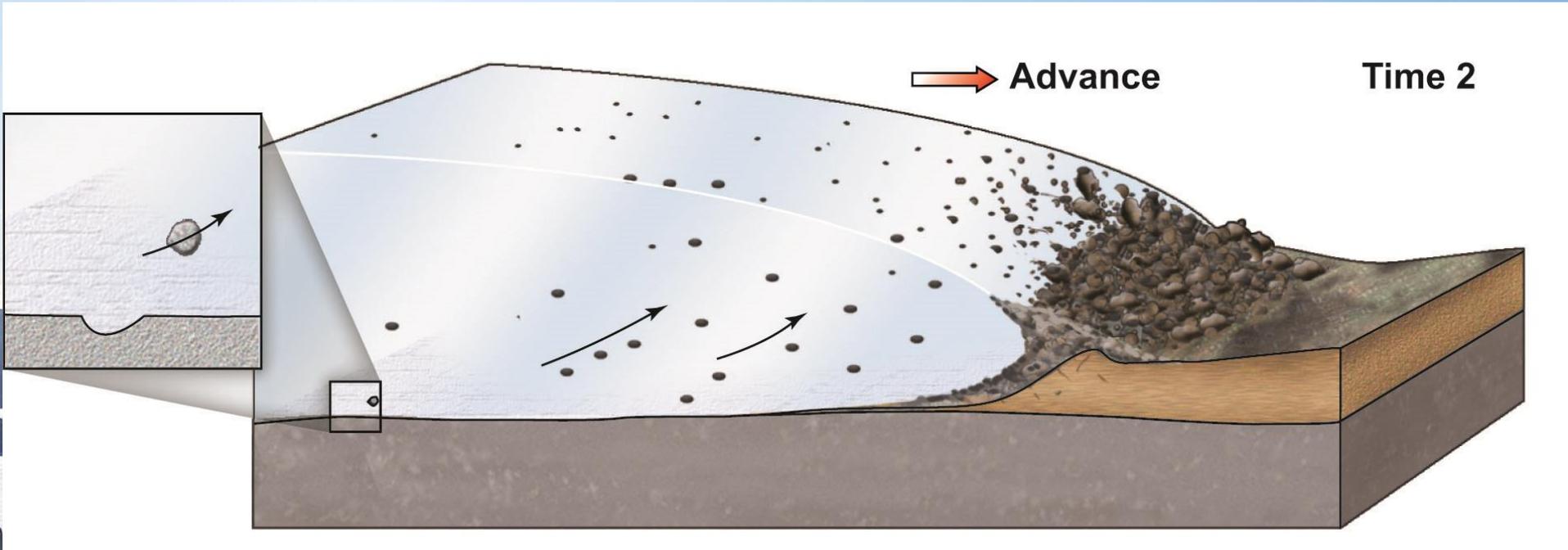
Interglacial: time between glaciations

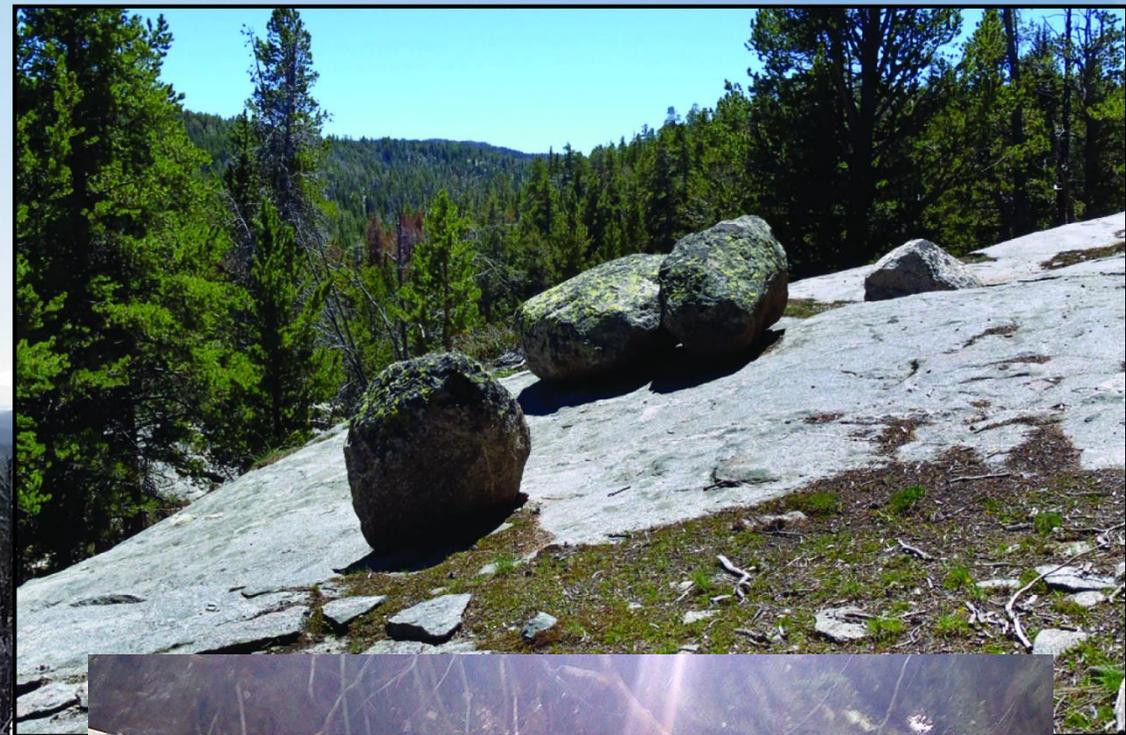




Source image:
UCSD





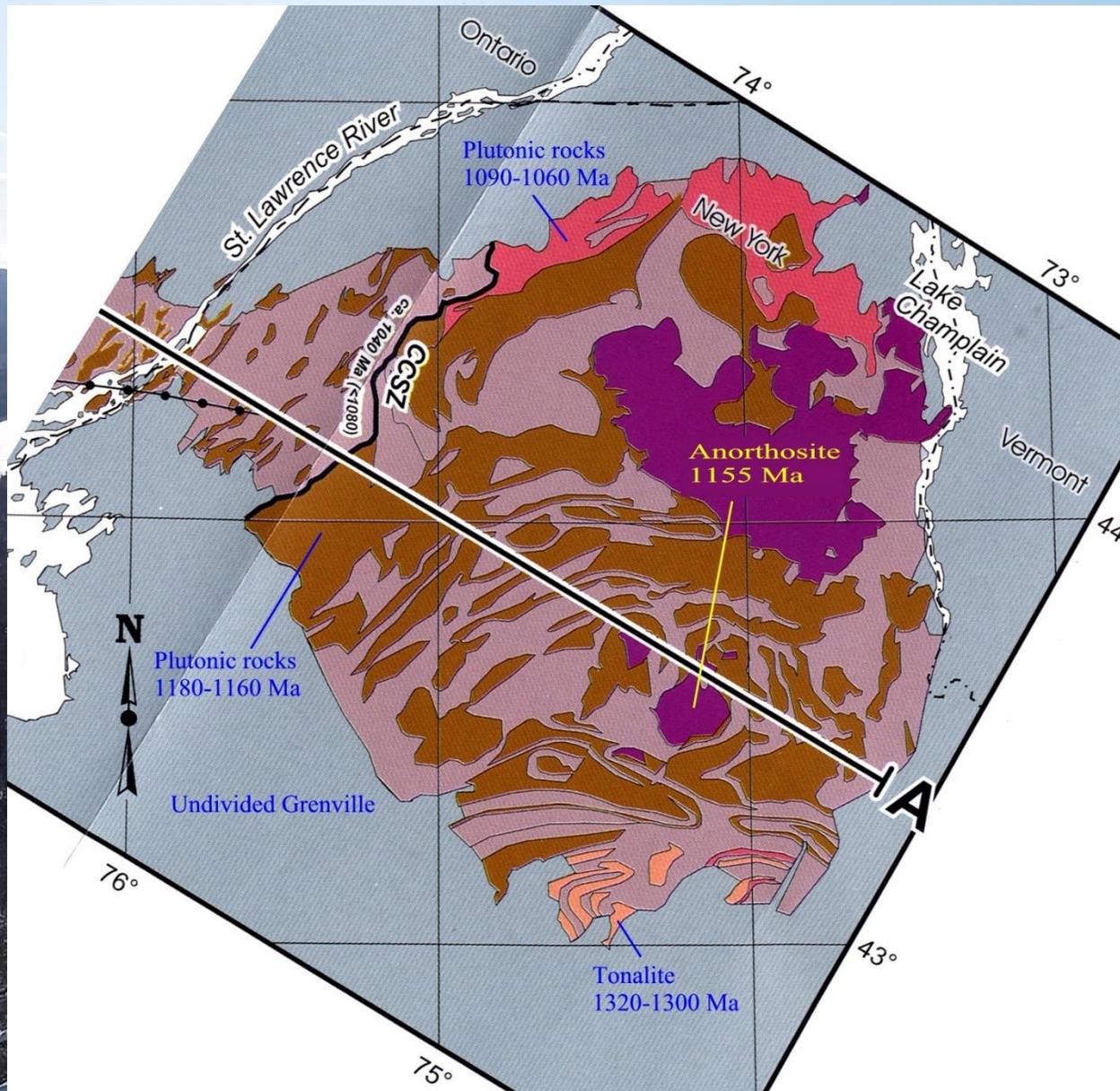


- Erratics: large rocks dropped by glaciers
- Glacial cobbles: larger than a pebble and smaller than a boulder dropped by glaciers

Maximum extent of Lake Iroquois (ca. 13,438–12,793 calendar years before present)

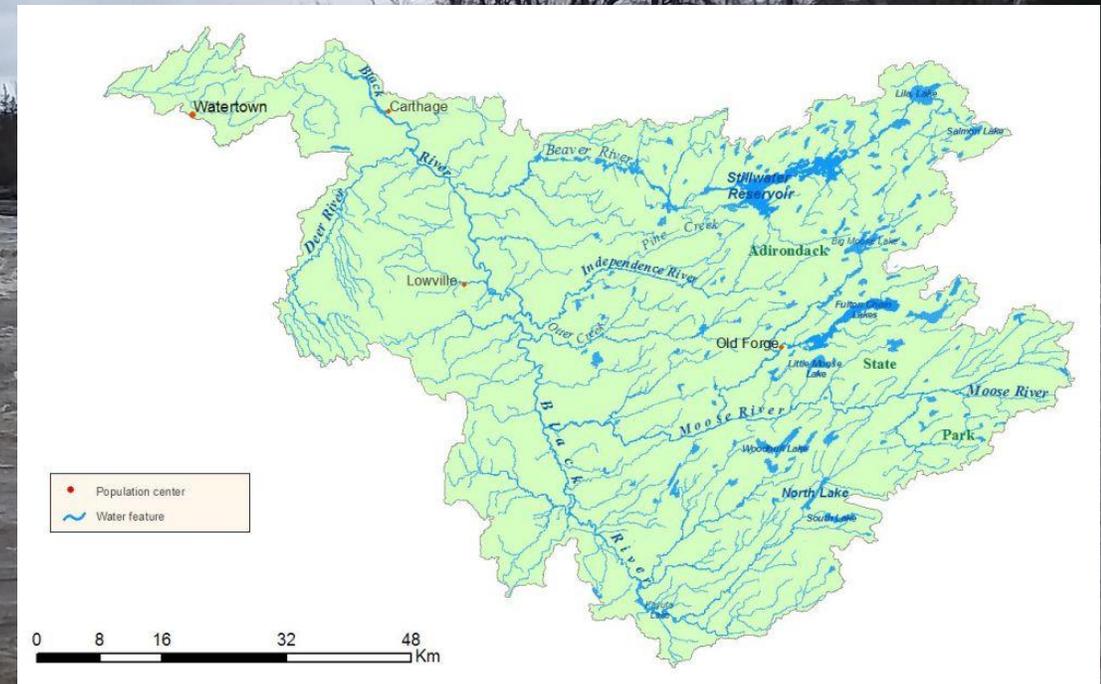


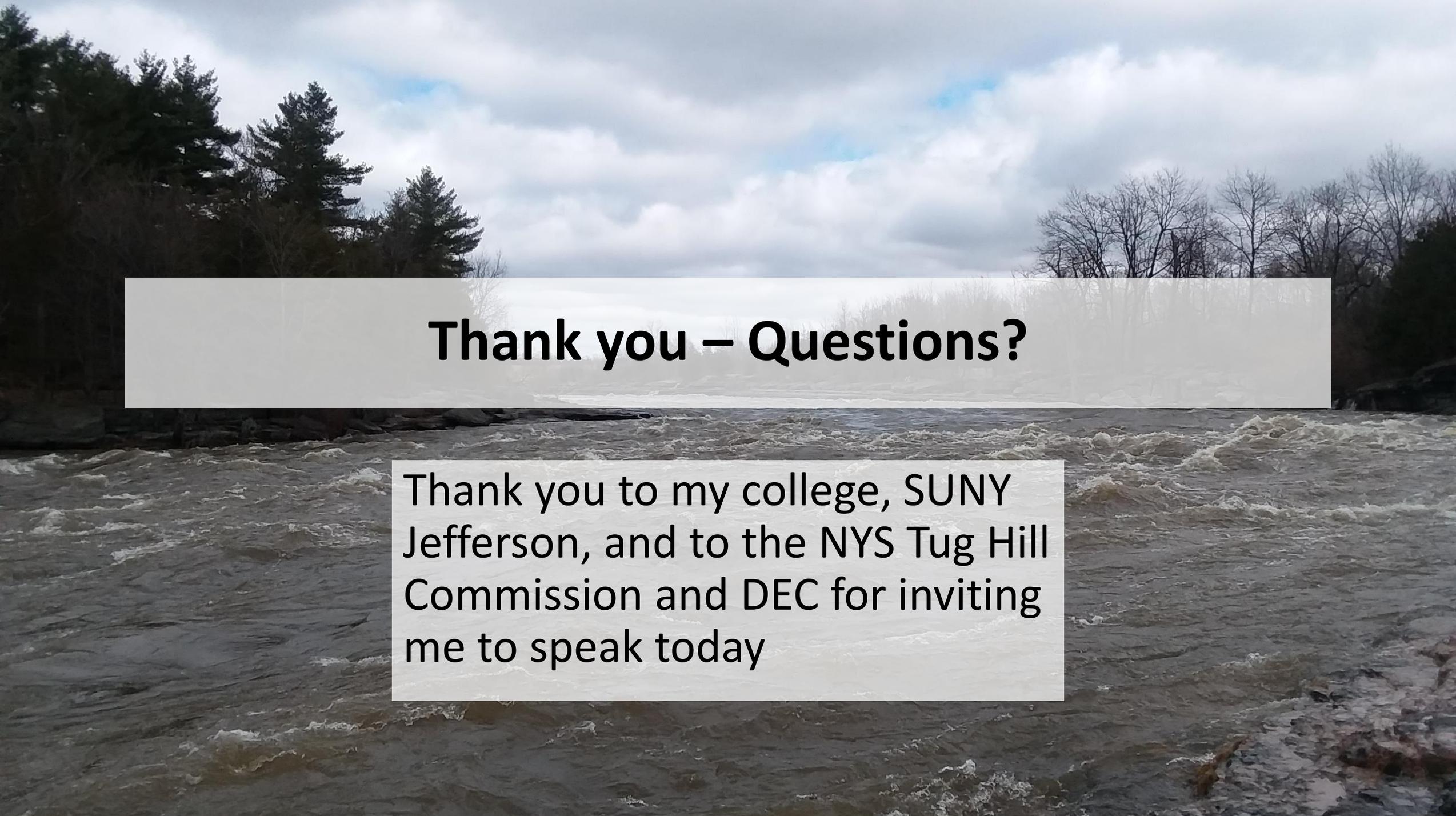
Source image: Carlton College Science Education Resource Center (SERC)



Summary

- Eastern Black River watershed dominated by Adirondack geology
- Rocks formed by continental formation and collision during Rodinia
- Uplift via a hotspot
- Glaciers exposed deeper bedrock, carved valleys



A scenic view of a river with rapids, surrounded by trees and a cloudy sky. The water is turbulent and white with foam. The sky is overcast with grey clouds, and there are some patches of blue. The trees on the left are dark green, while the trees on the right are bare and brown.

Thank you – Questions?

Thank you to my college, SUNY Jefferson, and to the NYS Tug Hill Commission and DEC for inviting me to speak today