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

- **Eon**
  - Hadean
  - Archean
  - Proterozoic
  - Neoproterozoic
- **Era**
  - Paleoproterozoic
  - Neoproterozoic
  - Mesoproterozoic
  - Proterozoic
  - Paleozoic
  - Mesozoic
  - Cenozoic
- **Period**
  - Eocambrian
  - Ordovician
  - Silurian
  - Devonian
  - Carboniferous
  - Permian
  - Triassic
  - Jurassic
  - Cretaceous
  - Cenozoic
  - Holocene

- **Epoch**
  - Miocene
  - Pliocene
  - Pleistocene
  - Holocene

- **Time Units**
  - Million years (Ma)
  - Ga (Giga- years)

- **Key Events**
  - 4.1 Ga: Hadean Eon
  - 3.55 Ga: Archean Eon
  - 2.5 Ga: Proterozoic Era
  - 1.8 Ga: Neoarchean
  - 2.8 Ga: Mesoarchean
  - 3.2 Ga: Palearchean
  - 3.6 Ga: Eoarchean
  - 65.5 Ma: Mesozoic Era
  - 145.5 Ma: Jurassic Period
  - 199.6 Ma: Cretaceous Period
  - 542 Ma: Paleozoic Era
  - 145.5 Ma: Devonian Period
  - 416.0 Ma: Silurian Period
  - 443.7 Ma: Ordovician Period
  - 488.3 Ma: Cambrian Period
  - 65.5 Ma: Cenozoic Era
  - 1.8 Ma: Pliocene Epoch
  - 5.3 Ma: Miocene Epoch
  - 23.0 Ma: Oligocene Epoch
  - 33.9 Ma: Miocene Epoch
  - 65.8 Ma: Paleocene Epoch

- **Scale**
  - Million years (Ma)
  - Ga (Giga- years)
  - Quaternary
  - Holocene (0.011 Ma)

- **Notable Periods**
  - Paleoproterozoic
  - Proterozoic
  - Paleozoic
  - Mesozoic
  - Cenozoic
  - Quaternary
  - Holocene
Where we’ll be hanging out today 😊
Kayuta Lake

Stillwater Reservoir

Mouth of the Black River
Watershed East of the 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!
Proterozoic Eon
Proterozoic Eon

Great Oxygenation Event

2.5 Ga

0.5 Ga

0% O₂

15% O₂

30% O₂
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. 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
When the rocks that form the Adirondacks were formed

HALF A BILLION YEARS!!!
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

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  • 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

Yang et al, American Geophysical Union, 2018
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

Formation of ice sheet in Antarctica
Formation of Isthmus of Panama

• 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 Wood's 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
Milankovitch cycles
Earth’s position relative to the sun changes in cycles of 1,000-100,000 years.

(a) Earth’s orbit varies from nearly a circle (left) to an eclipse (right) and back again in about 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
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
• 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)
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
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.