Geology Background

Ever since our Earth formed ~4.5 billion years ago, it has been slowly and constantly changing. Very early in its history it was completely molten, allowing heavy elements to sink to the core while light elements rose toward the surface. The Earth cooled and solidified; the outermost rock layer is the crust.

Plate Tectonics

- The outer ~60 mile layer of the Earth (the lithosphere) is cold and rigid.
- This layer is broken into ~12 major 'plates' that move relative to one another at ~2-10 " per year.
- Some plates contain continents, others do not.
- Plates can converge or diverge or slide by one another.

Every Rock Tells a Story

The 3 major rock types and their features preserve a partial record of Earth's history.

Sedimentary rocks

- form by burial & cementation of loose particles (mud, sand, pebbles) deposited at the Earth's surface
- preserve a record of past surface conditions (flat vs. mountainous; desert vs. swamp)

Igneous rocks

- form by crystallization of molten magma at plate boundaries
- magma may be injected to the surface and erupt in volcanoes, creating rocks like basalt
- some magma crystallizes at ~3-6 miles below the surface, creating coarse-grained granite

Metamorphic rocks

- form when sedimentary or igneous rocks are buried to ~12-40 km below the surface
- higher temperature & pressure at depth cause changes in the rock's texture and minerals
- they also make rocks plastic so they can change their shape

- At the NBS, you will see ~300 milllion year old sedimentary rocks (conglomerate and sandstone) which have been metamorphosed and deformed when an ancient plate collision formed the super-continent of Pangaea and created the Appalachian Mountains.
- You will see younger, ~200 million year old, igneous rock called diabase that was injected to the surface when Pangaea broke up.
- You will see evidence of a geologically recent ice sheet that covered RI ~15,000 years ago!

Frequently Asked Questions

Why does Hanging Rock ridge have a steep cliff on its southern end?

- Due to presence of E-W vertical fractures
- Expansion fractures formed when the weight of the overlying rocks was removed as the Appalachians gradually eroded
- Sea level was briefly higher when the last ice sheet melted, allowing wave action to enlarge a fracture and remove material to the south

Why doesn't the Red Fox Trail ridge have a similar steep drop-off?

- This ridge is also cut by vertical fractures
- But diabase rock here is more rapidly weathered than quartzite conglomerate
- Therefore, wave action eroded a gradual slope

How does the geology at NBS compare with that at Purgatory Chasm?

- The same layer of folded conglomerate occurs at Purgatory
- There are exposures of deformed (N-S elongated) pebbles

How does the geology at NBS compare to that at Sachuest Point?

- The Sachuest Point Wildlife Preserve to the east has rocks of different age and composition
- Older metamorphosed volcanic ash is present
- The older rocks were uplifted along a fault

More Resources

Want to learn more about the geology of NBS and Rhode Island?

- Stop into the Welcome Center to talk with a staff naturalist.
- Or email education@normanbirdsanctuary.org

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Geology of the Norman Bird Sanctuary

Hanging Rock, viewed to the East

Stretched pebble conglomerate rock

- first life (single cells)
- beginning of plate tectonics

Rodinia splits
forms ocean between proto-Africa and proto-North America

Collision of microcontinent
Avalonia with North America forming rocks of E and W RI

Pangaea supercontinent forms
- Collision of Africa and North America
- Appalachian Mountains form (as tall as present Himalayas)

Pleistocene Ice Age
- 20 advances and retreats of the Laurentide ice sheet from N Canada as far S as Long Island
- 12,000 years ago, RI was covered in ice >.6 miles thick
  - Ice flow caused smoothing and N-S scratches on the bedrock
  - Ice melting & retreat left sediments of all sizes, including large boulders

Initially molten, then cools and crystallizes

4.56 billion years (Ga)

The supercontinent **Rodinia forms**

~1.2 Ga

Tectonic plates reverse direction
- proto Atlantic-ocean starts to close
- first land plants

~450 Ma

Sediment deposition
become the NBS rocks

~325-300 Ma

Rifting of Pangaea
- Atlantic ocean basin starts to open
- Igneous rocks intrude
- Appalachian Mountains slowly erode

~200 Ma

2 Ma

Earth Formed

~3.8 Ga

~700 million years (Ma)

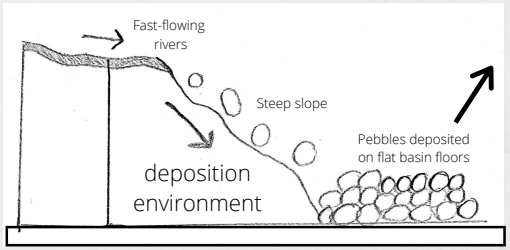
~375 Ma

~275 Ma

Today

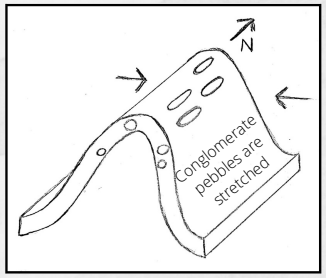
Conglomerate rock formation

The dominant rock at NBS is a sedimentary rock called a conglomerate, deposited in a basin near the equator ~300 Ma. Thick layers of white quartzite pebbles and thinner layers of sand were deposited in a basin and then buried.

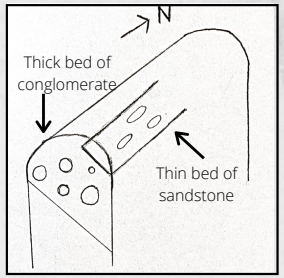


sediments were buried to ~3-5 miles and cemented into solid rock

*Layers of sand deposited when the river flowed less fast



Soon after sedimentary layers were deposited, they were caught in the E-W collision between Africa and N America and folded.



Long erosion has left a ridge of conglomerate; the inclined sandstone layers preserve evidence of the folding.

Deformation of the Rocks

- Sedimentary rock layers were buried deeper (to ~7.5 miles) and shortened by folding --> Evidence from tilted sand layers
- Higher temperature allowed the pebbles to be deformed from spheres into ellipsoids
- The fold hinges and stretched pebbles trend N-S (parallel to the trend of the Appalachian mountain chain)

Igneous Rock Formation

The rock that makes up the Red Fox Trail ridge is an igneous rock called diabase (basalt), which formed when Pangaea rifted and N America and Africa drifted apart E-W.

- Diabase is a fine-grained and hard rock, thus forms a ridge
- It undergoes greater surface weathering than conglomerate, thus is covered in moss

Time Travel on the Trails

Points of Interest

Red Fox Trail

- This trail follows the top of a ridge made of diabase, a fine-grained igneous rock.
- Reddish-brown stains are due to oxidation of iron-bearing minerals.
- The diabase was injected into a vertical N-S trending fracture when Pangaea began rifting.
- Later, after erosional unloading, it developed vertical E-W trending expansion fractures just like Hanging Rock.

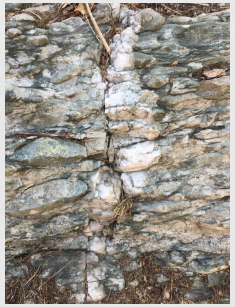
Can you find the moss and lichen on this trail? They are more common on diabase due to the minerals present.

Hanging Rock Trail

- Find the rounded pebbles; which direction are they stretched?
- Note the size; why is fast-flowing water required to transport large pebbles?
- There are layers of sandstone (1-2 ft thick); how did the river velocity change in order to deposit the smaller particles?
- Which direction are the sandstone layers tilted? Can you visualize how this reflects the folding that resulted from continental collision?
- Find one of the vertical E-W fractures cutting across the ridge; they formed when overlying rocks were eroded away.
- Note the smooth surface of the ridge; it is due to 'sandpapering' action by the ice sheet.

Quartz Rock Trail

Huge boulders of conglomerate have been moved and deposited by the ice sheet.



- Look for white quartz veins that cut across some of the boulders.
- You can also find quartz veins on the Hanging Rock Trail.

Valley Trail

This trail mostly goes through woods, where the bedrock is covered by sediments from the ice sheet and recent streams.

- Evidence of glaciers can be found on all the trails; can you find glacial smoothing and striations?