Escarpment Geology: Another part of our Living Landscape

By Beth Gilhespy

Photo: Brian Duke

It's a crisp fall day on the Bruce Trail and I'm deep in a valley, about to start my ascent of the Niagara Escarpment. As the path steepens and I begin to lean into the hillside, I notice patches of bright red mud beneath the brown forest soil of the path. Continuing up the slope, the path steepens even more and thin layers of rock slide from under my feet. I thankfully reach a more gentle slope and continue my climb, eventually reaching the base of the prominent grey-white rock face. The Trail takes me up through a crevice and, having passed over boulders and rock fall, I finally reach my destination - the very top of the Niagara Escarpment.

My ascent of the Escarpment hasn't just been a workout – it's been a journey through 30 million years of the earth's history. I started at the late Ordovician Period 450 million years ago (that's the bright red Queenston Shale that muddies my boots and makes the path treacherous in rain) moving on to the early Silurian Period with its mixed beds of sandstone, dolostone and shale, and arrived at the climactic heights of the Amabel Dolostone, formed during the middle Silurian Period 420 million years ago.

It's hard to grasp the time gap between the formation of the Escarpment's sedimentary rock layers and the feature we know and love today. When the rocks were being formed, the earth's continents as we know them were scattered about the globe, a mountain range higher than the Himalayas dominated our own continent which in turn straddled the equator, and our very planet was spinning faster, giving us 21-hour days. We may think of geology as the element of our landscape that remains constant, but it's our inability to comprehend the magnitude of geological time that limits us from seeing it as part of a *living* landscape – not just the plants and animals, but the long, slow but inexorable changes to the Escarpment's hills, valleys and shorelines.

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During the late Ordovician Period, approximately 450 million years ago, a large, shallow sea filled an area now inhabited by the Great Lakes, called the Michigan Basin. The climate was tropical, and although the shallow sea was teaming with life, plants and animals had not yet been established on land.

All map references are 28th Edition Bruce Trail Reference.


Photo: Beth Gillespy
Queenston Shale at Gravelly Point, Peninsula.

Southeast of the Michigan Basin (roughly where the Appalachians are now) a mountain range was rising from the collision of the North American and European/African plates. The rocks of these mountains were rich in iron, and rivers flowing down the mountains picked up the red, iron-rich sediment and transported it to the basin to form a mighty delta of red mud and sand.

In time, the sea occupying the Michigan Basin deepened and cleared, coral reefs formed, and other sediments were deposited on top of the red delta. Compaction of successive layers of sediments formed the shale, sandstone and dolostone that make up the Niagara Escarpment.

Dolostone is limestone that has been altered by the addition of magnesium that was present in the seawater.

For the last 250 million years since the seas of the Michigan Basin dried up, soft layers of shale have continually been eroding away, undercutting the harder sandstone and dolostone rock layers on top and causing them to break off, creating the steep face of the Escarpment. Although most evident at waterfalls where erosion is accelerated, this process of undercutting is responsible for the gradual erosion of the entire Escarpment over the past 250 million years.

More recently – a blink of the eye in geological time – glaciers that left this region 12,000 years ago have modified the Escarpment's features. Glacial meltwater laden with hard boulders and cobbles from the Canadian Shield – called erratics – scoured broad valleys and its swirling action created potholes. Those same boulders and cobbles were left behind as moraines, drumlins and eskers, and cover the Escarpment bedrock in much of the Caledon Hills and Dufferin Hi-Land sections of the Bruce Trail. Crevices formed along the Escarpment's edge due to the effects of frost wedging. Higher lake levels carved shoreline caves and flowerpots.

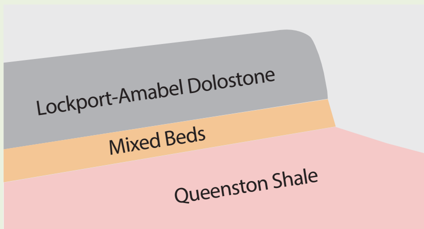
The geology of the Escarpment is expansive, and there's a lot to learn about the ground beneath our feet. This field guide provides just a snapshot of some of the major rock layers and geological features that make up the Niagara Escarpment. There's so much more to tell! Consider joining a geology hike (see page 30 of this magazine) or coming out to the Fossil Glen event on May 3 (see the back cover) to learn more about the geology of our beautiful Niagara Escarpment.

A Journey Through the Rock Layers

We'll start at the base of the Niagara Escarpment with the Queenston Shale, and work our way up through the layers to the caprock of the Escarpment, the Lockport-Amabel Dolostone. Rather than cover each and every layer we'll focus on the more visible rock layers encountered along the Bruce Trail.

Navigating the Rock Layers

It's easy to become muddled when trying to sort out the different rock layers of the Niagara Escarpment. Here's a hint to keep it in context.



Lockport-Amabel Dolostone caprock at the top.

Thinner layers of sandstone, shale, limestone and dolostone in the middle.

Queenston Shale at the bottom.

Think of the Escarpment as three main layers. The bottom layer is the Queenston Shale, while the top is the Lockport-Amabel Dolostone, and these two layers are fairly constant throughout the length of the Escarpment. It's the middle layers that can vary widely, and the layer you encounter will depend on where you are along the Bruce Trail. From Niagara to Hamilton, closest to the Appalachian Mountains (the source of the sediments), there are many middle layers – shale, dolostone, sandstone and even some limestone. From Hamilton north there are fewer of the middle layers, reflecting a more stable marine environment.

Queenston Shale

The Queenston Shale is one of the more familiar layers of the Niagara Escarpment. It can be found at the Niagara River near the start of the Bruce Trail, and continues as far north as Cabot Head, where it appears just off shore and washes up as red mud during storms.

The Queenston Shale is the remnant of a large, muddy delta that was building into the shallow continental sea to the northwest of the precursor to the Appalachian mountains about 450 million years ago. Its red colour is due to the presence of iron (hematite) in the mud.

While the Cheltenham Badlands is perhaps the best known exposure of Queenston Shale, its existence is certainly evident elsewhere on the Escarpment. In Hamilton, Milton and in the Brampton area, Queenston Shale was (and continues to be, in some places) quarried for brick-making. Along most of the Escarpment the Queenston Shale is covered by vegetation (grasses in some areas, thick forests in others) that masks but at the same time protects and stabilizes the shale. Farther north near Mono Cliffs, in the Hockley Valley, and along the waterline at Colpoy's Bay, erosion of steep banks of Queenston Shale means that vegetation can't take hold, and the characteristic rich red clay and grey-green stripes are exposed.

Where to see it:

- Along the banks of lower Grindstone Creek, especially where the Trail crosses the river on a splendid bridge built by volunteers (Iroquoia km 69.2)
- On portions of the main Bruce Trail at the Cheltenham Badlands (Caledon Hills Section between km 0.0 and 1.3 with views from the Olde Baseline Side Trail)
- Just west of Gravelly Point at the shoreline (Peninsula Section – Gravelly Point Side Trail)

Whirlpool Sandstone

From Niagara to the Pretty River Valley area of the Blue Mountains, the Queenston Shale is directly overlain by the Whirlpool Sandstone. The thickest layers of Whirlpool Sandstone are to the southeast, and gradually thin in a wedge shape towards the northwest. This reflects the source of the sand, which came off the rising pre-Appalachian Mountains.

Photo: Alison Watt

Whirlpool Sandstone overhang at Grindstone Creek, Iroquoia

The contact between the Queenston Shale and the Whirlpool Sandstone represents a significant time in geological history. The Queenston Shale was deposited at the very end of the Ordovician Period, while rocks overlying it mark the start of the Silurian Period. The boundary between these two periods marks a major extinction event that began in the late Ordovician, 444 million years ago, when 60 percent of the planet's species were wiped out. Scientists believe that this extinction was due to a 500,000 year period of glaciation. The end of the extinction and the beginning of species recovery marks the start of the Silurian Period.

Where to see it:

- Overhang at Grindstone Creek (Iroquoia km 70.2)
- In the walls of the base of the stack at the Hoffman Ring Kiln lime kiln (Caledon Hills Ring Kiln Side Trail, accessed from main Bruce Trail at km 8.2)
- In the beds of numerous streams in the Niagara section

Photo: Inti Ali

Cut blocks of Whirlpool Sandstone in the Hoffman Lime Kiln stack, Forks of the Credit, Caledon Hills

Manitoulin Dolostone

The Manitoulin Dolostone can be found on the Escarpment from Hamilton north to Manitoulin Island. From Hamilton to the Blue Mountains it immediately overlies the Whirlpool Sandstone as that formation gradually thins in a wedge shape to the northwest. From the Blue Mountains north the Manitoulin Dolostone directly overlies the Queenston Shale, and forms the lowermost Silurian Bed.

The Manitoulin Dolostone began forming in a shallow tropical sea roughly 444 million years ago. The formation is thinly bedded, and contains small fossils and iron inclusions.

Where to see it:

- Along the shoreline at Rush Cove (Peninsula km 55.8 to 56.4)
- Rocky outcrops all along the high ridge at Loree Forest (Georgian Peaks)
- Flat layer sitting atop the Whirlpool Sandstone layer at Grindstone Creek (Iroquoia km 70.2)

Photo: Ethan Meleg

Manitoulin Dolostone beach at Rush Cove, Peninsula

Cabot Head Shale

The Cabot Head Shale can be found from the Hamilton area north through to Cabot Head at the northeast tip of the Bruce Peninsula. The formation is a mix of iron-rich red shale layers (similar to the much older Queenston Shale at the base of the Escarpment), and grey-green shale layers, interspersed with thin grey dolostone layers.

The Cabot Head Shale was laid down in a nearshore, muddy environment, which was not conducive to sustaining sea life. Occasional rises in the water levels created deeper, clearer water, where the thin dolostone layers formed.

Where to see it:

- Behind the viewing platform at Cataract (Caledon Hills km 12.5) and along the path for the next 100 to 200 m.
- Inglis Falls road (just north of Sydenham km 91.7 – take care when walking on this narrow and busy road)

Cabot Head Shale and spring on the road at Inglis Falls, Sydenham

Photo: Beth Gilhespy

Fossil Hill Dolostone

The Fossil Hill Dolostone is a thinly bedded dolostone that formed in a warm, shallow tropical sea about 430 million years ago. It directly overlies the Cabot Head Shale, and can be seen from the Beaver Valley area northwards to Manitoulin Island and beyond. As hinted by its name, the Fossil Hill Dolostone is rich in fossils, including brachiopods (pentamerids), corals (rugose and tabulate) and sea sponges; bryozoans, cephalopods and others may also be found.

Where to find it:

- Woodford (Sydenham km 43.0 to 43.8)
- Near The Glen (Sydenham km 115.2 to 115.5) and at the BTC's new Fossil Glen Nature Reserve (see the back cover of this magazine)
- Coveney Hill (Peninsula km 17.5 to 21.5)

Photo: Beth Gilhespy

Fossil Hill Dolostone at Fossil Glen, Sydenham

COMMON FOSSILS IN THE FOSSIL HILL FORMATION

Rugose ("Horn") Coral

Rugose corals are extinct corals with a distinctive cone-shaped chamber.


Rugose Coral

Photo: Ron Savage

Tabulate Corals

Tabulate corals are an extinct form of colonial coral that thrived in the shallow, warm waters of the Ordovician and Silurian. Common tabulate corals in the Fossil Hill Formation are halysites, favosites and syringopora.

Halysite ("Chain") Coral

Halysite colonies ranged from less than one to tens of centimeters in diameter. They fed upon plankton.


Halysite Coral

Photo: Ron Savage

Favosite ("Honeycomb") Coral

Favosite had hexagonal segments packed closely together; pores in the walls allowed for the transfer of nutrients between the segments.


Favosite Coral

Photo: Sheryl Johnston

Syringopora ("Organ Pipe") Coral

Syringopora grew as individuals rather than in colonies, with numerous interconnecting tubes.


Syringopora Coral

Photo: Beth Gilhespy

Stromatoporoids

Stromatoporoids – sea sponges – were important reef builders during the Silurian. Most fossils on the Niagara Escarpment are calcite-based; stromatoporoids were comprised of silica. In many places on the Escarpment the silica is sufficiently dense such that chert has formed. First Nations peoples used Escarpment chert to make arrowheads that were traded throughout the Great Lakes.


Stromatoporoid

Photo: Ron Savage

Pentamerid Brachiopods

Brachiopods have a very long history of life on Earth (at least 550 million years). The most abundant brachiopod in the Fossil Hill Formation is Pentamerus Oblongus. Communities of pentamerids thrived in depths of 30 to 60 metres, close enough to the surface for sunlight but protected from the waves.


Pentamerid Brachiopod

Photo: Walter Brewer

Photo: Sheryl Johnston

Lockport-Amabel Dolostone

The caprock of the Niagara Escarpment is the Lockport Dolostone (from Niagara to Hamilton) and the Amabel Dolostone (from Hamilton to High Dump). The two layers grade into each other, and are collectively called the Lockport-Amabel Dolostone. The rock is quarried for building stone, crushed stone, flux stone and dolomitic lime products. The Lockport-Amabel Dolostone formed roughly 420 million years ago in a warm, shallow, salt sea. Limestone created by the accumulation of calcium-rich body parts of corals and sea creatures including Crinoids (anemome-like animals that ate plankton, also called "Sea Lillies" because of their flower-like appearance) gradually altered to dolostone through addition of magnesium.


Amabel Dolostone at Lion's Head, Peninsula

Photo: Beth Gilhespy

Where to find it:

- The Amabel Dolostone is one of the more iconic features of the Niagara Escarpment, and forms prominent cliff outcrops including Mount Nemo (Iroquoia Map 10), Rattlesnake Point (Iroquoia Map 11), Old Baldy (Beaver Valley Map 26), Skinner's Bluff (Sydenham Map 34), Malcolm Bluff (Peninsula3 Map 36), Lion's Head (Peninsula Map 38), and White Bluff/Smokey Head (Peninsula Map 28). Though less prominent, its counterpart the Lockport Dolostone is a strong feature at Beamer's Falls high above Grimsby (Niagara/Iroquoia Map 5), and forms the caprock of the Escarpment from Niagara to Hamilton.
- To get "inside" this magnificent caprock layer, try the crevices at Cave Springs (Niagara km 63 to 64), Mount Nemo (Iroquoia km 89.5), Metcalf Rock (Beaver Valley km 27.5), and at Williams' Caves at Lion's Head (Peninsula km 82.2).
- To see crinoid fossils, try the walls of the passage at Splitrock Narrows (Dufferin Hi-Land Splitrock Narrows Side Trail, Map 19) or in the rock at the Canada Goose Side Trail (just north of Toronto km 16.1).


Crinoids in Amabel Dolostone
Photo: Beth Gilhespy


Photo: Beth Gilhespy


Williams' Caves, Peninsula
Photo: Beth Gilhespy

When exploring the geology along the Bruce Trail, please remember: No gathering of rocks or fossils, no stepping on sensitive vegetation, and no removal of sensitive vegetation (especially mosses and ferns) to better see the rock, fossil or other feature. Leave our natural history in place for others to enjoy.

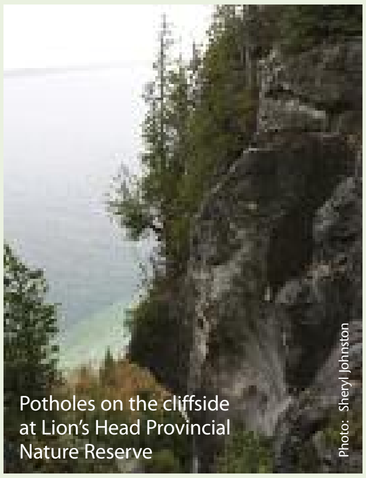
Information sources and other geology resources:

- *Geology and Landforms of Grey & Bruce Counties* (2004), Owen Sound Field Naturalists
- *Guide to the Geology of the Niagara Escarpment* (1992), Walter M. Tovell
- Ministry of Northern Development and Mines reports at http://www.geologyontario.mndm.gov.on.ca
- Province of Ontario's Natural Heritage Information Centre database at https://www.ontario.ca/environment-and-energy/natural-heritage-information-centre

EXPLORING OTHER LANDSCAPE FEATURES

Potholes form from the swirling of boulder-laden glacial meltwater.

Where to find it:
- Hope Bay Forest Nature Reserve (Peninsula km 45.1)
- Lion's Head Provincial Nature Reserve (Peninsula between km 77.4 and 77.8)
- On the Lillie Pothole Side Trail (near Peninsula km 111.8)


Potholes on the cliffside at Lion's Head Provincial Nature Reserve
Photo: Sheryl Johnston

Sinkholes, underground streams and springs form when slightly acidic rain and groundwater wears away the alkaline dolostone rock.

Where to find it:
- Colpoy's Bay underground stream (Peninsula on Whicher Side Trail of km 6.8)
- Kimberley Springs (Beaver Valley km 80 at Bill's Creek)
- Driftwood Cove (on side trail near Peninsula km 152.8)


Kimberley Springs
Photo: Mike Mulvale

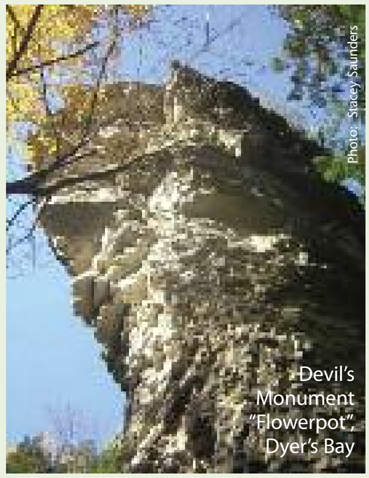
Erratics are boulders picked up by glacial ice from other parts of the continent and left behind as the glacier melted.

Where to find it:
- There are numerous erratics along the route of the Bruce Trail, with a spectacular one halfway along the Hart's Tongue Side Trail (north of Peninsula km 34.7), and at McKay's Harbour (Peninsula km 75)


Erratics at McKay's Harbour
Photo: Sheryl Johnston

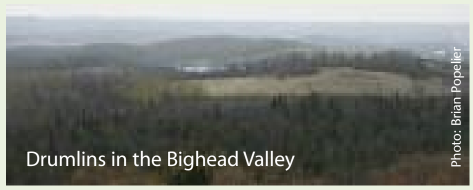
Flowerpots are stacks of rock left behind as wave action erodes the shoreline; many along the Bruce Trail were formed in the past 12,000 years when lake levels were higher.

Where to find it:
- Devil's Monument (Peninsula km 110.5)
- Georgian Peaks/Loree Forest (Beaver Valley km 4.2)


Devil's Monument "Flowerpot", Dyer's Bay
Photo: Stacey Saunders

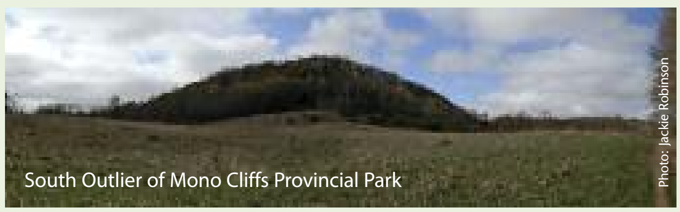
Drumlins are spoon-shaped hills shaped by glacial ice and meltwater.

Where to find it:
- Bighead Valley (views from Sydenham km 38.4)


Drumlins in the Bighead Valley
Photo: Brian Popelier

Outliers are large "islands" of Escarpment rock separated from the main Escarpment face by large rivers glacial meltwater.

Where to find it:
- Milton Outlier at Rattlesnake Point (viewed from Iroquoia km 108.0)
- Mono Cliffs Provincial Park (Dufferin Hi-Land km 1.0 and the South Outlier Side Trail)
- Black Bank (Dufferin Hi-Land km 48 to 49)


South Outlier of Mono Cliffs Provincial Park
Photo: Jackie Robinson

Crevice caves form due to frost wedging and movement of Escarpment rock over long periods of time.

Shore caves form from the pounding action of waves.

Where to find it:
- Crevice caves can be found throughout the length of the Escarpment, with fine examples at Mount Nemo (Iroquoia km 89.5), Rock Hill Corner (Dufferin Hi-Land km 29.5 and 30.0), and Metcalfe Rock (Beaver Valley km 27.5)
- Splendid shore caves are found at Bruce's Caves (Sydenham near km 160.6), Williams' Caves (Peninsula km 82.2), and at the Grotto at Bruce Peninsula National Park (Peninsula km 146.0)