A Short Geological History of Lanark County

by MVFN member Neil Carleton

This short history was inspired by the field trip on October 28, 2007, when members of the Eastern Ontario Certified Forest Owners / Eastern Ontario Model Forest explored the geology of Lanark County with Professors Allan Donaldson (Carleton University) and Donald Hogarth (University of Ottawa). It was a remarkable day that took us from the heights of Lanark Highlands, near Flower Station to the west, to the shores of the Mississippi River, at Almonte to the east. Along the way, we drove over and walked on a landscape that has been billions of years in the making.

To understand the rocks that form the familiar landscape of Lanark County, imagination is needed for a journey far back in time to ocean depths, erupting volcanoes, colliding and splitting continents, and a landscape locked in ice.

I like to imagine the Earth like an onion with concentric layers. Up here on the outermost layer, the Earth's crust, the story of our planet is about brittle continental plates that move by gliding across the softer mantle layer below. For about 3 billion years, the movement of continental plates has created a continuous rearrangement of continents and oceans on our planet. This remarkable process, known as plate tectonics, is fuelled by heat deep within the planet created by radioactive decay. Driven by convection currents, the continents move about like rafts.

2.5 Billion Years Ago

Arctica is the name given to the earliest recognizable North American continent. It now forms the stable central part of present North America. Arctica started to form about 2.5 billion years ago, and grew in size by the colliding and welding together of much older landmasses. In Ontario, Arctica is represented by rocks north of Lakes Huron and Superior.

Between about 1.9 and 1.6 billion years ago, Arctica grew into a larger continent by the addition of much older landmasses that now form part of Antarctica, Siberia, and Europe. This new continent was named Nena (Northern europe north america). Southern Ontario, including the area of present day Lanark County, didn't exist yet.

1.3 Billion Years Ago

The story of Lanark County starts more than a billion years ago, before the formation of southern Ontario, along the eastern edge of Nena. Off the coast, to the east, were microcontinents of volcanic islands with intervening seas and sedimentary basins. A modern example might be Indonesia with its many volcanic islands.

Between 1.3 and 1.2 billion years ago, the westward moving microcontinents collided with Nena, one after the other. The repeated collisions thrust the volcanic and

sedimentary rocks up and over the continental edge. The thrust sheets of the separate landmasses were pushed together, folded, buckled, invaded by magma, and pushed skyward to form the Grenville Mountains along the eastern coast of the continent. A modern example is the Himalayan Mountains formed by India colliding with Asia.

Deep within the roots of the Grenville Mountains, the volcanic and sedimentary rocks of the microcontinents were transformed by high pressure and temperature into metamorphic rocks. Limestone was changed to marble. Muds and gravels were deformed to schist and metaconglomerate. Amphibolite was formed from volcanic basalt. The rocks at depths of 25 to 30 km, with temperatures as high as 750 C, were changed to metamorphic gneiss far below the Grenville Mountains. Gneiss also partially melted to form granitic magma that moved through the surrounding rock.

Through repeated collisions, the landmasses of the microcontinents arriving from the east were thrust up and onto Nena, and welded together, to create a much larger continent called Rodinia.

The Precambrian age rocks of the Canadian Shield we take for granted under our feet, as we hike or drive around the western areas of Lanark County, were once buried deep in the roots of the ancient Grenville Mountain chain. It took about 200 million years of erosion to reduce the towering mountains to rolling hills.

550 Million Years Ago

About 550 million years ago Rodinia was torn apart by convection currents in the mantle. A new ocean, the Iapetus, was formed between the separating landmasses of ancestral North America, called Laurentia, and Europe, named Baltica. For the next 200 million years or so, much of the interior of North America was under water, and shallow seas lapped across southern Ontario. The sediments that accumulated in this marine environment form the Ordovician age sandstone, dolomite, and fossil rich limestone rocks we find in eastern Lanark County.

During the break up of Rodinia, the supercontinent was almost torn apart along the present Ottawa valley. As the Earth's crust was stretched and fractured in this zone, large blocks moved down between the faults. A modern example is the rift valley of Africa.

440 To 150 Million Years Ago

During the next phases of continent building, Africa and South America (part of the supercontinent Gondwana) and Baltica (ancestral Europe) collided with North America. The Iapetus Ocean closed, new coastal mountain ranges (Taconic and Acadian) were created, and the supercontinent Pangea was formed. Volcanoes towered above the east coast and blasted great amounts of ash northwards. Large inland seas were created, tropical reefs formed, and thick deposits of salt formed when the seas evaporated. The geological record of this time period can be found in the bedrock of southwestern

Ontario. If Lanark County was once covered by similar volcanic and sedimentary deposits of the Silurian and Devonian periods, all evidence has been eroded away.

150 Million Years Ago

About 150 million years ago, during the late Jurassic period, convection currents in the mantle broke up supercontinent Pangea along large faults. As North America pulled away from Europe to form the Atlantic Ocean, Ontario was stretched, cracked and slowly uplifted. It's estimated that as much as 7 kilometres of rock was stripped away by erosion. Dinosaurs may have roamed Lanark County, but we'll never know for sure because any rocks that contained their fossils were eroded away.

As Ontario was stretched and slowly uplifted, the Ottawa valley rift system was reactivated and widened. The Earth's crust was cracked in other parts of Ontario too along north-west to south-east fault lines that parallel the Ottawa valley to the west. Many faults in the Earth's crust are evident in the bedrock of Lanark County.

20, 000 Years Ago

Glaciation is the latest and briefest phase of the geological history of Lanark County. The picture of global climate change over the past 2 million years is long periods of glaciation (some lasting 90 000 years) and brief, warm periods (some were 15 000 years long).

The last ice sheet to cover Canada reached its maximum thickness and size about 20 000 years ago. Southern Ontario was buried by ice about 1 kilometre thick, that originated in Quebec and Labrador, until about 12 000 years ago. The tremendous weight of the ice pushed the Earth's crust down some 400 metres.

As the ice sheet melted, great volumes of water rushed to the sea. The level of the Atlantic Ocean rose and salt water flowed up the St. Lawrence and Ottawa valleys, and over the eastern part of Lanark County about 11 000 years ago. The whale skeleton found near Pakenham, when a farm well was being dug, is evidence that marine animals once lived here in the arm of the Atlantic Ocean called the Champlain Sea. The surface of this glacier fed arctic sea would have been at a level just above the present day tip of the flagpole on the Peace Tower of the Parliament Buildings.

The western shoreline of the Champlain Sea can be traced across eastern Lanark County by the sediments that were deposited in this unique marine environment. Extending from the base of Mount Pakenham, in the north, to Innisville and Ferguson's Falls on the present day Mississippi, and almost to Lanark in the west, the ancient shoreline can be followed south to near the southwest shore of Mississippi Lake. The shells of several kinds of arctic clams that lived in the marine sediments of the Champlain Sea can be found in sand and gravel deposits in Lanark County.

The ice sheet was always moving, grinding and smoothing the landscape underneath, and burying it in sediment. The glacier left scratches on the smooth rock surfaces of Lanark County where pebbles had been dragged or pushed along under great pressure beneath the ice. Many lakes in Lanark County fill basins that were carved out of the bedrock by the last glacier.

Silty to gravelly till (Scottish word meaning 'stony ground') was deposited in Lanark County by the dumping or pushing of sediment along the front of the ice sheet. This rocky till forms a thin and discontinuous cover over much of Lanark County.

Thicker sand and gravel were deposited in the area by streams and rivers running through the glacier, and as outwash from the melting ice sheet. When you walk along a beach or other sand deposit in Lanark County, imagine ice cold water rushing from a melting glacier in the distance that towered about a kilometre above the rocky landscape.

Still On The Move

The continent beneath our feet is still moving. It's headed west at about a centimetre a year. As it moves, stresses can build up in the bedrock along fault zones, or along boundaries between different rock types or zones. Rocks can withstand high stresses and, like the plastic rulers the students in my class use, can deform to the point where they break and release energy. We feel the released energy as an earthquake.

Here in Lanark County, we were reminded that North America is still on the move by the earthquake on January 9, 2006, that was centred about 23 kilometres west of Carleton Place. A listing of recent significant earthquakes in Ontario is available at the web site of Earthquakes Canada, at <http://earthquakescanada.nrcan.gc.ca>.

Local Rocks

In the western part of Lanark County, extending from the northeast to southwest corners, the landscape is dominated by metamorphic and igneous rocks formed about a billion years ago deep in the roots of the towering Grenville Mountains chain. Under great pressure and heat, for example, sedimentary limestone that had formed at ocean depths was changed to marble, and sandstone was metamorphosed to gneiss.

Ancient volcanic rocks that formed from underwater lava flows, or were deposited as layers of airfall ash, were altered over time by high temperature and pressure beneath the mountains to form new metamorphic rocks rich in amphibole minerals, such as hornblende. Igneous intrusions of granitic magma that formed deep within the mountains, flowed through cracks in the surrounding bedrock, or moved upwards towards the surface as giant plutons (Mount Pakenham).

Over millions of years, the towering mountains were eroded to expose the ancient roots we see today at the Earth's surface. These are the rocks we notice with sparkling white,

grey, pink, black, and even green minerals as we hike and drive across the western part of Lanark County.

In the eastern section of Lanark County, the landscape is defined by flat lying, sedimentary rocks of Ordovician age, some 450 million years old. The sandstones, dolomites, and limestones were formed from sediments deposited in tropical seas that once covered our part of the world. Look for fossils in the limestone that tell the story of a marine environment rich in life, including corals and bivalve brachiopods on the sea floor, and giant squid-like cephalopods with conical shells that roamed the tropical seas.

Remarkable Geological Heritage

The Precambrian age rocks of the Canadian Shield in the western part of Lanark County were formed deep in the roots of the ancient Grenville Mountains chain, about a billion years ago, when microcontinents from the east collided with Nena. The metamorphic and igneous rocks we now see at the Earth's surface in our area were once buried at depths of 25 to 30 kilometres.

Shallow, tropical seas, alive with primitive marine life, once lapped across eastern Lanark County during the Ordovician age, about 450 million years ago. We see the sedimentary evidence in the flat lying sandstone, dolomite, and fossiliferous limestone that characterize the landscape around Almonte, Carleton Place, and Smiths Falls.

Geological faults in the bedrock of Lanark County were created when supercontinent Pangea broke up, about 150 million years ago in the late Jurassic period, and North America pulled away from Europe to form the Atlantic Ocean.

The rolling hills of Lanark County were smoothed and sculpted by a massive glacier about a kilometre thick, originating in Quebec and Labrador, that only melted away about 12 000 years ago. Thin, silty to gravelly till, along with hills of thicker sand and gravel, were deposited during this most recent period of glaciation. As the ice sheet melted, an inland salt water sea covered the eastern portion of the County. Where farmland now exists, whales swam in arctic waters and marine clams thrived on the cold sea floor.

References

These are the references on my bookshelf that I used to prepare this short geological history of Lanark County. If you know of other suitable maps and publications, please send me the titles and descriptions so I can add them to the list.

Allan Donaldson and Donald Hogarth, 2007. Itinerary for EOCFO Field Trip, October 28/07, Geological Tour of Lanark County. Field trip notes for a geological tour that was conducted by Professors Donaldson (Carleton University) and Hogarth (University of Ottawa) for members and friends of the Eastern Ontario Certified Forest Owners - Eastern Ontario Model Forest.

Energy, Mines and Resources Canada, 1987. Surficial Geology and the Ice Age in the National Capital Region, ISBN 0-662-55092-7. Illustrated pamphlet with black and white photos and a surficial geological map (as far west as Carp), in colour, scale 1 : 125 000, based on Map 1425A of the Geological Survey of Canada.

Eyles, Nick. 2002. Ontario Rocks: Three Billion Years of Environmental Change, Fitzhenry & Whiteside. ISBN 1-55041-619-7. This is an easy to read reference book packed with many colour photos, maps, charts, and figures.

Geological Survey of Canada, 1961. Map 1089A, scale 1 : 63 360 (1 inch to 1 mile), Geology, Perth, Lanark and Leeds Counties, Ontario. Colour map of the bedrock geology from Smiths Falls, in the east, to Big Mud Lake on the Mississippi River, in the west, and from Crosby Lake, in the south, to 45 N latitude in the north, just above Drummond.

Geological Survey of Canada, 1973. Map 1362A, scale 1 : 50 000, Geology, Carleton Place, Ontario. Colour map of the bedrock geology from longitude 76 W (just east of Ashton), in the east, to Brightside in the west, and from just south of Lanark, in the south, to just north of Almonte, in the north.

Geological Survey of Canada, 1977. Map 1334A, scale 1 : 1 000 000, Riviere Gatineau, Quebec-Ontario. Colour map of the bedrock geology from longitude 72 W (about Magog, Quebec), in the east, to 80 W (Lake Nipissing, Ontario), in the west, and from latitude 44 N (about Newmarket, Ontario), in the south, to 48 N (upper reaches of the Ottawa River, Quebec), in the north.

Geological Survey of Canada, 1984. Map 1599A, scale 1 : 50 000, Surficial Geology, Arnprior, Ontario. Colour map of the surficial geology from longitude 76 W (just east of Carp), in the east, to the White Lake area, in the west, and from just north of Almonte, in the south, to the Arnprior area and Ottawa River, in the north.

Geological Survey of Canada, 1990. Map 1681A, scale 1 : 50 000, Surficial Geology, Carleton Place, Ontario. Colour map of the surficial geology from longitude 76 W (just east of Ashton), in the east, to just west of Watson's Corners, in the west, and from the south end of Mississippi Lake, in the south, to just north of Almonte, in the north.

Ontario Division of Mines, 1972. Map 2254, scale 1 : 1 013 760 (1 inch to 16 miles), Paleozoic Geology of Southern Ontario. Colour map of the bedrock geology of southern Ontario, from the Cornwall area, in the east, to Windsor, in the west, and from Pelee Island in Lake Erie, in the south, to Deep River on the Ottawa River, in the north.

Comments

Comments and suggestions for improvements are always welcome. Neil Carleton, P.O. Box 1644, Almonte, Ontario, K0A 1A0. <carle@magma.ca> 613-256-2018