

Introduction to the Geodiversity of Perth:

A Self-Guided Tour of Rocks on Display at the Crystal Palace, Tay Basin, Perth, Ontario

The relationship between the people who settled this area and the local geology tells a compelling story of how this community evolved.

This booklet offers a self-guided tour of this story, which is beautifully demonstrated by the landscape of the outdoor museum located at the Crystal Palace and Tay Basin in downtown Perth, Ontario. Start learning about Perth's geoheritage here, then continue exploring the town and other local attractions to learn even more!

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on the folded foliation (visible on the side to the right of the lens cap) are parallel to the fold axis. This block is in the treed strip adjacent to Colbourne Street.



18 The folds in this metamorphic rock are inferred to have been formed by compression during recrystallization of a mafic volcanic rock. The pen indicates the surface trace of one fold axis. The pale patch and streaks are cross-cutting calcite-rich veins.



19 The split face of this boulder of Grenville marble was metamorphosed from limestone. It is located beneath spruce trees adjacent to the pathway along the smaller canal, north of Colbourne Street. The



original clastic texture has been transformed to a crystalline texture due to regrowth of the carbonate grains into an interlocking mosaic of calcite crystals. The irregular banding may represent original bedding distorted during plastic deformation. Marble and calcite mining continues north of Perth. Rock from a large calcium carbonate deposit mined in Lanark Highlands is processed at a plant in Tay Valley Township west of Perth to make products such as toothpaste, paint, cleaners, construction materials and much more.

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As much as Perth and its surrounding townships are defined by the people who settled here and the traditions from their homelands, so too are they defined by the relationship between these settlers and the contrasting geology of this area. Geology has played an integral role in the development of the community.

When pioneers cleared the forests in areas underlain by the Canadian Shield, they found soil so thin it was barely adequate for farming and peppered with rocky outcrops and boulders. The Shield was a curse for farmers at first, but when it was later embraced by a boom of prospecting and mining it became a new source of income for many. In addition, the layers of rock closer to the surface yielded abundant, easily quarried building stone that is both durable and attractive. One look around the heritage Town of Perth and you can see how the local geology formed the basis for beautiful architecture, which has garnered national attention. With iron-rich deposits located near Perth, there was an expectation in the 1880s that an iron-smelting operation could be located here which, along with the potential for phosphate mining, was one of the catalysts for attracting public funding to rebuild the Tay Canal. To this day, local quarries and mines continue to play an economic role here, particularly in the manufacturing and construction sectors.

This booklet takes you on a journey through a microcosm of geological history. Civitan Court and areas near the Crystal Palace in downtown Perth offer an excellent opportunity to gain an understanding of the region's bedrock. Sandstone, limestone and dolostone blocks quarried from the underlying layers, or strata, that formed 250 to 540 million years ago during the Paleozoic era, make up the walls of many nearby buildings. Much was locally extracted and crafted by Scottish stonemasons who settled here after building the Rideau Canal in the early 1830s.

Many large blocks of rock aesthetically displayed beside the Crystal Palace were extracted from nearby exposures of the Canadian Shield. This outdoor museum showcases many rock types from the earliest geological era – Precambrian – that peek through glacial deposits as distinctive outcrops throughout 70 per cent of Canada. These “basement rocks” lie beneath Paleozoic and younger sedimentary strata exposed almost everywhere else across the country. The geological history of the area is all around us.

scoured to form glacial pavement can be seen between the bronze sculpture and black railing near the southwest corner of the Crystal Palace 12, and on top of the retaining wall 13 behind the Crystal Palace. Today, banded (layered) gneiss is often used as a decorative stone because of its tendency to break into large, flat plates ideal for flagstones in patios and walkways. Banded gneiss fieldstones were commonly favoured for use in old rubble foundations because of this flat, layered structure, which made it a natural building stone.

14 This foliated mafic rock was metamorphosed from a conglomerate: a sedimentary rock consisting of a variety of pebbles set in a fine-grained sandy matrix. The pebbles have been stretched parallel to a near-vertical lineation. It is located beneath a spruce tree at the west end of the treed strip adjacent to Colborne Street.



15 This faintly foliated grey igneous rock in front of the patio of the Stone Cellar Restaurant has been cut by a dyke of pink pegmatite (large crystals predominate). Dykes and veins are formed by injections of magma into fractures. Faulting occurred after this dyke solidified, as indicated by the offset along the fracture. The upper triangular-shaped part has slid upward along



Paleozoic Rocks on Display Near the Crystal Palace



The Crystal Palace is located at the Tay Basin, which is a leg of the Rideau Canal Waterway, a UNESCO World Heritage Site extending between Ottawa and Kingston. This is a fitting location for a tribute to the area's geoheritage because in the heyday of small-scale mining in the area, the Rideau Canal was an important transportation corridor for barges carrying minerals to far-off markets. This site now showcases many blocks of Canadian Shield Precambrian rock, both igneous and metamorphic, as well as examples of sedimentary rock from the Paleozoic era.

1 Here, looking southward, examples have been arrayed around this centre of activity. The cream-coloured walkway consists of slabs of sedimentary layers made of limestone and dolostone. These sedimentary rocks were quarried with surfaces that correspond to the original bedding in the sediments that formed them. These surfaces display trace fossils (indirect evidence of life, such as tracks, trails and burrows), ripple marks, mud cracks and cavities called vugs that are lined with crystals of white and pink calcite. The red brick surface to the left 2 is "artificial" metamorphic rock. Shale, sand and clay grains were heated to a temperature high enough to cause them to bond tightly together, as a result of mineral recrystallization, without significant melting.

Sedimentary rocks can be identified in a number of ways. One is by observing "clastic textures," such as recognizable sand grains rounded

Precambrian Rocks on Display Near the Crystal Palace

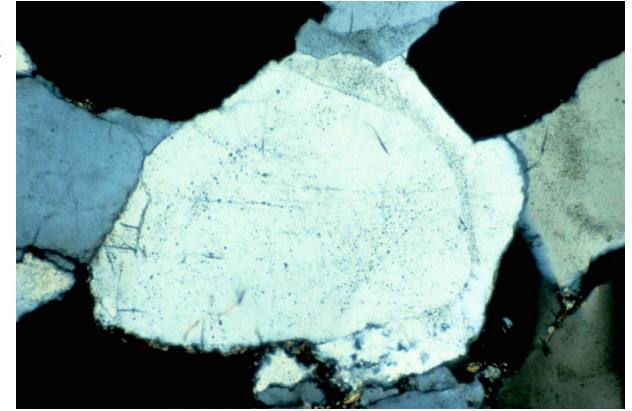
More than 100 large blocks of Precambrian rock representative of the Canadian Shield and artistically distributed around the Crystal Palace provide an excellent venue for becoming acquainted with “crystalline” rocks (composed of interlocking mineral crystals). If such rocks developed by the cooling of molten rock (magma), they are igneous. If they were formed by recrystallization in the solid state of a pre-existing rock under high temperature and/or pressure, they are metamorphic. Igneous rocks usually have a uniform texture, while metamorphic rocks generally display distinctive layering (foliation) and/or the mineral grains are elongated and appear in a linear alignment (lineation). If flat, flaky crystals (platy minerals, such as mica) are abundant and distributed in similar orientations, allowing the rock to split in thin, parallel layers, the rock is a schist. If the layers consist of different-coloured minerals and the rock does not tend to split along the layers, it is a gneiss. These types of rock are well represented in the small-scale mining industry that peaked in the area during the late 1800s and early 1900s.

This microscopic view of a slice of igneous rock, cut and polished thin enough to transmit polarized light, shows the jigsaw-puzzle-like texture typical of crystalline rocks. This is a mafic rock, which means it is rich in iron and magnesium minerals (coloured and black grains) that fill all spaces within a mesh of first-crystallized, randomly oriented elongate grains of plagioclase feldspar (white and grey grains). The field of view is 2 mm wide.



Feldspar is the most abundant mineral in rocks of the Earth’s crust. There are two types of feldspar: orthoclase (typically pink blocky crystals) and plagioclase (typically white elongate crystals showing fine parallel lines called striations). Quartz is generally white or transparent, and its fractured surfaces are conchoidal (irregular, like broken glass).

This is a microscopic view of a slice of clastic sedimentary rock cut and polished thin enough to transmit polarized light. The framework consists entirely of quartz grains cemented by quartz. Because the quartz grains are randomly oriented, some appear opaque and others grey in the polarized light. This section is cut perpendicular to the long axis of the central grain, so it appears white and its original rounded outline is apparent within the binding overgrowth of quartz cement. (Field of view is 2 mm wide.)



3 In this close-up view of sandstone blocks in one of the two columns that flank the Tay Street entranceway, the colour differences accentuate the bedding. The rectangular blocks show various degrees of disruption of bedding by trace fossils. Many buildings in the area feature this locally quarried, cream-coloured sandstone. A series of successful limestone and sandstone quarries operated near Perth. The Hughes Quarry, for example, was worked in the late 1800s and early 1900s, and supplied stone for new buildings. Nearby clay deposits provided materials for mortar. The Hughes Quarry was known for supplying a dressed stone with distinctive purple outlines of trace fossils running through the bedding planes. Smiths Falls architect George Thomas Martin appears to have preferred this stone, which can be seen in the Code’s Mill complex on Herriott Street downtown, as well as St. John’s Convent on Wilson Street East and the Perth Community Care Centre on Christie Lake Road, for example.



4 The slab of dolostone on the west side of the Crystal Palace displays mud cracks on the bedding. This polygonal-shaped primary structure shows the result of extreme drying of wet clay-rich mud (bluish areas) on a tidal flat or margin of a shallow pond, followed by infilling of the cracks by mud containing calcium carbonate. The Matheson House Museum courtyard has patio stones that show grooves caused by glaciers, as well as ripple marks, trace fossils and other examples of the primary and secondary features described for sandstones and dolostones around the Crystal Palace.



5 These blocks of interbedded dolostone and mudstone in front of the southwest corner of the Crystal Palace show distinct purple streaks perpendicular to the bedding in the central slab, which represents Liesegang banding.

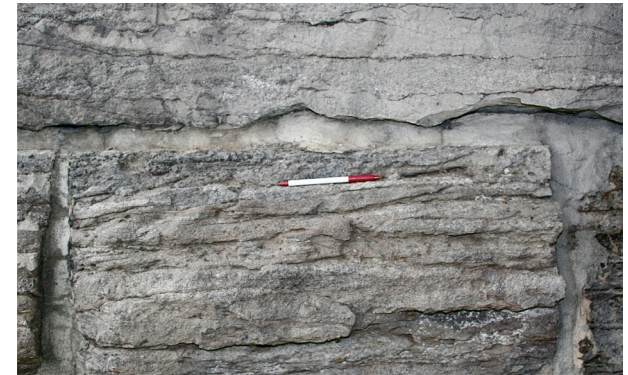


6 Most of these blocks of sandstone and limestone (see next page) that form the retaining wall behind the Crystal Palace display abundant stylolites. The tops of several capstones show many parallel striae, indicating that they came from a glacial pavement. The wall was built in the late 1800s when the area was heavily used for commercial purposes,



taking advantage of the link to the Rideau Canal. After a failed first attempt by the private sector, a second publicly funded Tay Canal was built between 1882 and 1891. It was considered a priority in light of expected development around phosphate mining and iron smelting, which would need a feeder to the main Rideau Canal. The project included the building of the Tay Turning Basin for commercial purposes, as well as bridge supports (see below) at Craig, Beckwith and Drummond streets. While not a success commercially, the canal and basin have beautified the area and enhanced recreation.

7 These sandy limestone blocks used to support the bridge beneath Drummond Street show abundant black stylolite seams and small-scale concave-up channels (one right below pen). The pen marks the base of an example of cross bedding, where



thin inclined laminations show the transport of loose sand that cascaded over the advancing front of a small-scale dune that was moving leftward when the sediment accumulated for that bed. The cross bedding in the uppermost block is bounded top and bottom by stylolites and contains thin inclined crossbed layers showing that the depositing current flowed to the right. The construction of stone bridges across the Tay in the 1800s was a key factor in the commercial growth of the town.

by wind and water. They can also include primary structures such as bedding (see 1), crossbedding (when some layers lie at an angle to the main ones, usually a sign of changing wind or water currents), channels, ripple marks and mud cracks. Sedimentary rocks commonly contain body fossils and/or trace fossils.

Trace fossils are especially abundant in specific beds of the local sandstone. One variety believed to have been made by a marine worm is *Scolithus*, which consists of closely packed tubular structures perpendicular to bedding. Another, *Climactichnites*, is a tire-like trail up to 30 cm wide made by an unknown invertebrate, possibly a gigantic snail, as it crawled over intertidal sand flats before burial and cementation to form sandstone. The first examples of these trails were discovered near Perth in 1860 by physician/amateur geologist James Wilson. One of his specimens of this distinctive trace fossil is on display a few blocks away in Matheson House Museum (11 Gore St. E.), as are other specimens collected by Wilson. Perthite, a distinctive intergrowth of two varieties of the mineral feldspar, was also discovered by Wilson south of Perth, in Tay Valley Township.

Sandstones are clastic rocks composed of a framework of mineral and rock particles of sand size. Some of these particles may be surrounded by what is called a “matrix” of even finer grains. They are compacted by “intergranular cement,” which is typically quartz or calcite, or as a result of the framework and matrix grains binding together by mineral recrystallization. Most sandstone in the Perth area is composed of a framework of quartz grains bound by quartz cement.

Most limestones and dolostones of the region are also clastic. They are made up of carbonate minerals (calcite and dolomite) that have been reworked by erosion and then redeposited after initially being deposited by precipitation in shallow seas.

After sediments are deposited, secondary structures may form during their transformation to sedimentary rocks. A common one is stylolites, which appear as irregular seams. Usually they are almost parallel to bedding and are created when insoluble minerals (mostly hydrocarbons and clay) accumulate during burial compaction. Liesegang banding is an unusual secondary structure formed when pulses of solutions containing minerals migrate through layers as they are being compacted, depositing coloured bands that typically cut across the bedding.

Granite is an intrusive igneous rock, meaning it was formed from magma that was squeezed into cracks in older rocks. It consists mostly of orthoclase and lesser amounts of quartz. Syenite is similar to granite, but contains less than 10 per cent quartz. Both of these rocks are well represented in front of the Crystal Palace. 8

Diorite is another intrusive igneous rock similar to granite, but the principal feldspar is plagioclase instead of orthoclase. It is the pale grey rock used for the inscribed blocks in the four entranceway pillars and inset in the walkways around the Crystal Palace. 9

Amphibole and pyroxene are the two most abundant minerals in mafic (iron-magnesium-rich) igneous and metamorphic rocks. Amphibole generally forms elongate crystals and is more prevalent in metamorphic rocks, whereas pyroxene tends to occur as blocky crystals and is more common in igneous rocks.

The array of blocks in front of the Studio Theatre 10 is a mix of igneous and metamorphic rocks, mostly felsic, which contain only small amounts of dark minerals. These are interrupted by several sets of steps composed of sandstone and limestone, some of which display trace fossils on bedding. Trace fossils are also on display in the Wilson collection at the Matheson House Museum, and on the bedding surfaces of many sedimentary slabs in the patio beside the museum.

11 This block is “felsic” gneiss, which means it has a low content of iron/magnesium-rich minerals. This specimen was intruded by granite. The upper surface displays parallel glacial striae, indicating the block came from a bedrock surface (glacial pavement) over which the continental ice sheet moved during the last ice age. A slab of dolostone similarly



Geological Time Scale

The Canadian Shield is a vast geological complex that underlies most of eastern and central Canada, extending north into the Arctic and south into the northern U.S. It is mostly composed of igneous rocks (formed by the solidification of magma at depths of tens of kilometres) and metamorphic rocks (formed by plastic deformation under extreme pressure at similar depths). The Shield consists of seven principal geological subdivisions; the southernmost is called the Grenville Province.

Perth is on the northern side of what is known as the Frontenac Axis, a southeasterly trending extension of the Grenville Province that crosses the St. Lawrence River and ends in the Adirondack Mountains. Although rocks 4 billion years old (currently the oldest known in the world) can be found in the northern provinces of the Shield, most in the Grenville Province are about 1 billion years old. Outcrops of Grenville rocks can be seen in Stewart Park, immediately west of Gore Street. These ancient rocks provided a basement for deposition of flat-lying layers of sediments during the Paleozoic era, which started more than half a billion years ago. These sediments were lithified (either naturally cemented or compacted under pressure) to form solid rock retaining the distinctive stratification or layering that is the hallmark of sedimentary rock. Paleozoic sedimentary rocks probably once covered the Frontenac Axis, but have been removed by subsequent erosion.

The geological time scale below shows that vast segments of Earth's history are unrecorded in the Perth region, but by meshing records from all the continents, we can learn the amazing story of our geoheritage.

TIME BP	SIMPLIFIED GEOLOGICAL COLUMN FOR THE PERTH REGION			
65 MY	CENOZOIC	HOLOCENE	LEDA CLAY	Age of mammals, including humans and other primates; ice ages occur
		PLEISTOCENE	OUTWASH GLACIAL TILL	
250 MY	MESOZOIC	No local Cenozoic record before Pleistocene Glaciation		Age of reptiles, dinosaurs, birds evolve
		No Mesozoic record in the Perth region		
		No post-Ordovician Paleozoic record in the Perth region		
540 MY	PALEOZOIC	ORDOVICIAN	Limestone, Dolostone	Spiders, plants, amphibians and early reptiles
		CAMBRIAN	Sandstone	Early fish evolve
		Molluscs emerge and early vertebrates		
540 MY	PRECAMBRIAN	BASEMENT ROCKS OF THE GRENVILLE SUPERGROUP		Primitive fossils: algae, bacteria
		No pre-Grenville Precambrian rocks in Perth region		

the fracture relative to the lower part. Pegmatites are characterized by relatively large, concentrated grains of their constituent minerals (commonly mica, quartz and feldspar). Exceptionally large, coarse-grained granite pegmatites are fairly common in the Perth area, spawning a thriving feldspar mining industry in the early 1920s. The second-largest producer in the province was the local Bathurst Quarry, which operated from 1926 to 1951. High-grade feldspar was referred to as “dental spar” for its use in ceramic dental appliances. The mineral nepheline has replaced feldspar as the principal source of alumina in modern industry, so while historic producers are now inactive, these large pegmatites are still of particular interest to mineral collectors and lapidaries (artists who cut and polish stone) because of their concentrated mineralization and large crystal size.

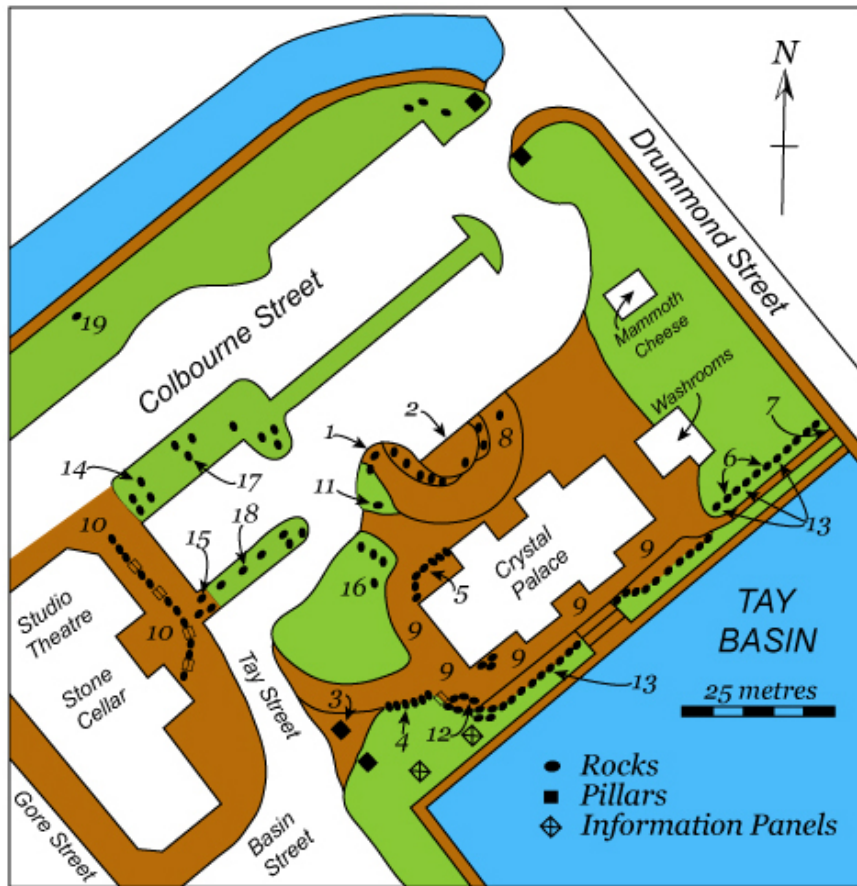
16 This greenish black- and pink-banded amphibole gneiss is a mafic metamorphic rock cut by a dyke of pink granite pegmatite, a coarse-grained felsic igneous rock. Both the gneiss and the pegmatite were subsequently fractured and intruded along these fractures by more felsic magma that cooled to form narrow, fine-grained felsic dykes of granitic aplite. This block is in the grassed area in front of the western wing of the Crystal Palace.



17 The fold in the grey gneiss on the next page is inferred to have been formed by metamorphism of a sedimentary rock. The bowl-shaped fold is accentuated by a white layer of calcite that runs parallel to the folded foliation, which mimics the original bedding. Steeply inclined lineations

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Overview

The area's geohistory has, quite literally, formed the foundation of this vibrant community of Perth. The Canadian Shield, its overlying Paleozoic strata and its cover of thin soils have provided a landscape that has been gently modified through several centuries. From the time of the early settlers until the present, the many generations of rock and overlying glacial deposits have continued to provide both beauty and immeasurable economic value. Continue to explore Perth's geoheritage by observing the nearby impressive stone architecture and the offerings, both cultural and geological, at the Matheson House Museum.

Special thanks to all the citizens and groups who contributed toward the creation of the rock display at the Crystal Palace in the Tay Basin. Of note are landscape architects Joe McFarlane and Gill Hyland, as well as the Perth Civitan Club, the Rotary Club of Perth, the Lions and Lioness Clubs of Perth, Eric Devlin, the Perth Courier, the Downtown Heritage Perth BIA, Algonquin College Heritage Institute, and many other businesses, institutions and individuals. The project was also made possible by the Town of Perth and an OSTAR Rural Economic Development grant.

This brochure was created by Allan Donaldson, retired Professor of Earth Sciences, Carleton University, and Chair of Friends of Canadian Geoheritage.

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