



**Introduction:**

Within a few kilometers of the Manor Park Elementary School, one can see many interesting examples of the geological development in this region of Canada. W.K. Fyson, a professor of geology at the University of Ottawa and a long time resident of Manor Park, has provided us with these informative notes.

He gives an insight into the events which led to the various formations. He then describes them for us. Maps, pictures and explanations of geological terms and processes help the non-geologist to go to places where they can be observed and to understand the features.

**Manor Park Geology:**

Notes to accompany Geological Map, Manor Park and nearby Ottawa

These notes describe geological features in the vicinity of Manor Park with reference to the accompanying map (Map 1), which indicates the areal extent of geological units and localities of good exposure. Photographs (1 to 16) and accompanying sketches illustrate some of the features. Aspects that reflect geological processes are discussed, with technical terms explained for the non-geologist.

**Two groups of sedimentary deposits are present:**

A. Sediments that were laid down in a shallow sea during the middle to upper part of the 495 to 445 million year old Ordovician Period, which followed the Cambrian Period, the oldest within the Paleozoic Era of the geological time scale (Table 1). The sediments have since been consolidated to form rock. With respect to later deposits this is termed bedrock.

B. Unconsolidated sediments that were deposited on the Ordovician bedrock much later during the Quaternary Period, which extends from 1.8 million years ago to the present (Table 1). The Quaternary includes the 1.8 million to approximately 10,000 year old Pleistocene Epoch that is characterized by times of widespread glaciation known as the ice ages. About 20,000 to 12,000 year old glacial deposits from the last ice age are preserved in the Ottawa area.

Symbols for sedimentary units in the map legend are in boxes arranged vertically in order of age of deposition, with the oldest (1) at the base. The arrangement represents a simplified vertical cross-section or geological column where all units are present, all are of the same thickness, and all are flat-lying, an arrangement not true for any single locality.

Missing from the lower part of the column are earlier Ordovician or Cambrian sedimentary rocks that are not exposed in this part of Ottawa. Examples include the Nepean sandstone, the principle building stone on Parliament Hill. The sandstone is underlain by much older Precambrian crystalline rocks, which in the Manor Park area are about 200-300 metres below ground level, whereas elsewhere, such as in the Gatineau Hills, these rocks are at the surface.

Within a broad region that encompasses Ottawa, the Precambrian rocks are older than 1 billion years. Included are granites and similar igneous or intrusive rocks that crystallized and solidified from a molten state. Also included are sedimentary and other rocks that when deep in the crust were metamorphosed (changed) by high

temperatures and pressure, resulting in the growth of metamorphic minerals, for example micas. Later, during and after uplift to the surface, these rocks were weathered and eroded, accompanied by transport and the break-up of fragments by streams, waves, and probably sandstorms in a desert-like landscape (land plants were absent until after the Ordovician Period). The various processes provided the clastic (broken) grains of quartz that are the main constituents of the Nepean sandstone. Quartz grains are also important components of later sandstones, notably those within the Rockcliffe Formation.

Not included on the accompanying map are faults that displace the Ordovician rocks but generally are overlain and masked by Quaternary deposits, which post-date most fault movement. Exposed small-scale faults, such as shown in Photo 14, are considered in the text. In the following account the rocks and features of interest are described according to geological units in order of decreasing age (1 to 7).

### **Rockcliffe Formation (unit 1)**

Shales and fine-grained sandstones of the Rockcliffe Formation are best exposed in cliffs along escarpments. Many of the sandstones contain, in addition to quartz grains, mica flakes that provide surfaces of parting parallel to the layering (which is also termed bedding or strata). The sandstones are thus readily split and have been used as flag stones for garden paths in Manor Park.

**Location 1-a.** Vertical cliff along Rockcliffe Parkway where it curves up escarpment west of the Ottawa-New Edinborough tennis courts: Cross-beds are inclined at low angles to the main, near-horizontal bedding to form wedges that are visible from the pathway across the road (Photo 1). As with inclined layers on the steeper, downwind, lea side of a sand dune, the cross-beds are inclined in the direction of water flow during transport and deposition of the sandy material. Inclinations eastward, which are clear at an upper level in the cliff, and westward, less clear at lower levels, indicate that the flow direction changed.

Folded laminations within a flat-lying, fine-grained sandstone bed at the base of the cliff (Photo 2) indicate that there was internal deformation within the bed when the sand was water saturated and unconsolidated. This soft-sediment deformation suggests local slumpage shortly after deposition of the sandstone. (N.B. The folds are only visible close-up, a dangerous place beside the road !)

**Location 1-b.** Low cliff along base of escarpment south of the tennis courts: In a succession similar to that in location 1-a, thick (> 1 m), homogeneous, fine sandstone underlies more thinly bedded sandstones and shales. Irregular fractures curve across the sandstone, but folded laminations are not obvious. This and the other near-vertical cliff faces follow joints, which are fractures that generally form near-perpendicular to the gently inclined bedding, thereby displaying a view in cross-section.

**Location 1-c.** Upper bank of Rockcliffe Gardens: A current lineation, which is defined by fine parallel lines, and irregular trending current ripples are apparent on the top surfaces of laminated, fine-grained sandstone beds; best seen on steps in a small pathway cut into the rock. The lineation indicates the local path of the current but not the sense of water flow during deposition of the Ordovician sediments. Exposure at several levels and passage into the rock indicate that the lineation is not a Quaternary glacial striation, which would be superficial.

**Location 1-d.** East about 1 km from the Aviation Museum where the Rockcliffe Parkway is closest to cliffs along an escarpment. A track from the road leads to the base of a cliff that is used by geology students to measure features on vertical joints and gently inclined bedding planes. About a 20 meter cross section of the strata is exposed, the most complete section for the Rockcliffe Formation. Sandstone beds with

thinner intervening shales predominate in the basal 4 m. Between 2 and 3.5 m above the base, tubular features, < 0.5 cm in width, extend up to 12 cm across and along the bedding. These are sandstone-filled burrows of organisms (ancient worms?), burrows known as trace fossils, some of the few fossils preserved in the Rockcliffe Formation.

Rocks about 4 to 8 m above the base differ from those below in that they are mainly mudstones or shales interspersed with a few thinner sandstone beds. Above the mudstones, a 0.5 m thick sandstone bed is horizontally laminated parallel to the bedding, except within an internal zone, about 10 cm thick, where the laminations are contorted and folded. The contortions indicate deformation when the sediments were water-logged and soft, possibly while on the sea floor before deposition of the overlying, undisturbed sand (see also Photo 2, location 1a). An earthquake could have shaken and deformed the soft sediment in conjunction with upward escape of water, which locally formed small mushroom-shape structures.

Above the laminated sandstone unit there are shales and limestones that elsewhere grade up into limestones of the Ottawa Group.

### **Ottawa Group (unit 2)**

Limestones with thinner beds of shale predominate throughout most of the Ottawa Group, which includes the St Martin, Ottawa and Eastview formations of Wilson (1938 map). The limestones are partly exposed along escarpments. Near Manor Park they are best seen in road-side cuts and quarry walls (Locations 2a to 2g).

In common with similar rocks beyond the map area, the limestones were deposited in a shallow (mainly < 10 m) sea on a continental shelf, or within an intracontinental basin. The limestones vary from fine-grained to coarsely crystalline and include accumulations of shell or skeletal fragments broken by wave action and marine currents. The rocks composed of shell or skeleton fragments are bioclastic rocks that exhibit features of transport and deposition, for example cross-bedding (Photo 3) similar to that in the quartz sandstones of the Rockcliffe Formation. However, post-depositional calcareous cement commonly obscures the arrangement of the fragments.

The limestones contain shelly and skeletal fossils including fragments of brachiopods, bryozoans, corals, crinoids, ostracods, gastropods, bivalves, cephalopods and trilobites. Fragments that are most readily identified locally are those of segmented stems of crinoids (sea lilies); some hollow segments about 2 mm across resemble tiny doughnuts (Photo 4). Less obvious are gastropods (sea snails), and brachiopods that have two shells of unequal size and ribs that converge towards a straight hinge line. Scattered colonial corals are identified by groups of tube-like corallites, which on bedding planes are a few millimeters across and up to 5cm in length (Photos 7 and 8). Horn-shaped solitary rugose corals are locally common on bedding and other surfaces; cross-sections display septa radial from the centre, a characteristic feature (Photo 13). Parts of the straight orthocone of an extinct nautiloid cephalopod in Langs Quarry (location 2-g) are those of the largest fossil animal in the limestones (cones of unknown original length in Ordovician rocks measure up to 7 cm across). These creatures were mobile. Resembling the curled nautilus, a modern cephalopod, they swam by squirting water through a funnel, the earliest known example of jet propulsion.

Fossils clearly displayed only in Langs Road quarry include Stromatolites, which are curved laminations in the limestone, typically convex upward (Photo 15). Modern analogues indicate that these are growth shapes of successive mats formed by communities of micro-organisms and trapped sediments. Stromatolites are also present in Precambrian limestones, many examples older than 2 billion years. They are the most readily recognizable evidence for early life on earth.

Also well exposed in Langs Road quarry are stromatoporoids. These are horizontal laminations and vertical pillars built by unknown organisms, possibly including sponges. Stromatoporoids are restricted to limited zones in Ordovician rocks, whereas they are major components of later, large limestone reefs, including some that are significant oil reservoirs, for example the Devonian reefs of Alberta.

Irregular shaped nodules and lenses of hard, black chert are prominent in a few limestones (Photos 5 and 6). Margins are commonly white and calcareous. The nodules and lenses are siliceous concretions of very finely crystalline quartz, some possibly nucleated around fossils. The silica in solution could have come from nearby shale interbeds or from siliceous parts of some fossils. Of interest and concerning the much later Quaternary Period and history of human settlement, spear points were chipped from similar chert and other hard material by the Fluted Point people about 11,500 to 10,200 ago. The spear points are the earliest indisputable evidence for the presence of humans south of the ice sheet that at its maximum during the last glacial period covered most of Canada.

Rock solution in the limestones is indicated by stylolites, which are irregular wavy surfaces, many with short, grooved columns extending up and downward. In cross section, as seen on joint faces, stylolites form wiggly lines suggesting marks by a stylus. Stylolites in the local impure limestones are marked by thin irregular films of dark shaly or carbon-rich material, the residue of variable solution of the calcium carbonate in the limestone. In overall orientation the stylolitic surfaces are mainly parallel to bedding, including where it is horizontal. This suggests that the solution was due to the vertical pressure of a thick pile of overlying rock, which is now mainly eroded.

**Location 2-a.** Roadside cliff close to the cemetery entrance off Beechwood Avenue: A fence restricts close inspection but the outcrop of limestones is probably that most frequently seen by residents of the Manor Park area. Beds are tilted (dip) southward near an unexposed fault.

**Location 2-b.** Northern cliff and wall beside steps up to an apartment on Brittany Drive opposite Talbot Street: Upper weathered part of thinly bedded, bioclastic limestone clearly shows cross-bedding (Photo 3); opposing senses in successive units indicate changes in local current direction. Here, and in nearby wall, crinoids (Photo 4) and other fossil fragments are common. Irregular shaped chert nodules are prominent in an adjacent wall block (Photo 5).

v Southern low cliff at steps down to pond: Chert lenses follow a layer within laminated limestone (Photo 6). Laminations within the chert parallel to those in the limestone indicate that the silica that forms the chert permeated and replaced the calcium carbonate of the limestone without physical disruption of the structures within the limestone.

Eastern outcrop. Low bluff of limestone at entrance to parking lot, north side of Quarry Road off Brittany Drive: Corallites of colonial coral on a bedding surface are randomly oriented (Photo 7), suggesting breakage and movement by currents.

**Location 2-c.** Cliff beside drive eastward into apartment garage, east side St. Laurent Blvd.

Thick homogeneous limestone unit with bedding-parallel stylolites overlies finer grained, partly laminated unit with shale interbeds, chert layers, and nodules.

**Drive entrance:** Corallites on bedding surface between the units are randomly oriented (Photo 8) as in location 2-b east (Photo 7).

Cliff along drive (Photos 9 and 10): East ~ 12 m. Washout channel, 1.5 m wide, in

lower unit is filled with coarse fragments (Photo 9), an arrangement indicating storm activity.

East ~ 20 m. In contrast to near-horizontal external bedding, curved beds within a washout channel are steeply inclined (Photo 10), suggesting soft-sediment slumpage into the channel before deposition of the overlying beds.

Location 2-d. Aviation Parkway road-cut, about 200-300 m south of Hemlock Road overpass.

West side: Fine to coarsely grained limestone with rock and fossil fragments is interbedded with thin black shales. Thin nodular beds in southern part contain many fossils, including crinoids and molluscs. The rock is broken and displaced by small, steeply inclined faults of variable orientation. Slickensides (polished surfaces) on calcite films along the faults display striations (Photo 11), which are scratch marks in the direction of fault movement. Striations on the faults vary in inclination from steeply down the dip to horizontal, indicating that the movements were complex.

East side at northern end of small outcrop: Stylolites lie approximately parallel to bedding. Crinoids and solitary corals are exposed on top and side surfaces of the outcrop. The beds dip moderately westward; slickenside striations are aligned approximately down the dip, possibly indicating downward movement of overlying rocks.

**Location 2-e.** Road-cuts on western side of Aviation Parkway, about 100-200 m north of Montreal Road. Bedding is generally inclined southward. Thus following the outcrops southward along the near-horizontal parkway is progressing upward in the succession of strata. Nodular limestones with shaly partings in northern outcrops grade further south up into limestones interbedded with black shales, some 0.5 m thick (Photo 12). Similar mixed rocks in other parts of the Ottawa area pass upward into black shales that predominate in the Billings Formation (Unit 3). The contact between the limestones and unit 3 shales is shown on the accompanying map as in subsurface south of Montreal Road. The shales are fine-grained debris derived from an eastern mountain belt that rose in the late Ordovician. The debris overwhelmed the limestone-producing organisms, which for growth needed clear water and light.

**Location 2-f.** East side of Aviation Parkway near Hospital. Crinoids and solitary rugose corals are well exposed on limestone bedding surfaces at top of northern exposure (Photo 13). Minor vertical fault beneath the bedding in Photo 13. Calcite films along the fault display slickenside surfaces that are offset horizontally in a consistent sense by small ~1 mm steps (Photo 14); this is in accord with left-lateral fault movement. In moving across the steps, the fault surface feels smoother in one direction than the other, a feature useful for determining the relative movement of rocks along this and other faults.

**Location 2-g.** Langs Road old quarry. Good exposure of about 10 m of medium to coarsely crystalline, bioclastic limestone interbedded with fine-grained limestone and shaly partings.

Low northern face, partly obscured by bushes: Weathered joint surfaces clearly display cross-beds with changes in the sense of inclination indicating varying directions of marine currents (see also Photo 3, location 2-b). Fragments that are finer upward reflect a decrease in current velocity. Scoured-out small troughs filled by coarse material suggest storm activity such as indicated by the larger channels at location 2-c (Photos 9 and 10).

High eastern face that follows vertical joints: Nodular layers in the lower part contain coarse fragments of fossils (identification is needed). Stylolites are parallel to

laminated layers in the upper part. A distinctive ~50 cm zone near the top displays curved Stromatolite laminations (Photo 15). Intermixed are solitary corals and coarse bioclastic limestone, presumably the result of storm waves and currents. Overlying beds contain gastropods and fragments of the straight orthocone of a nautiloid cephalopod.

#### **Glacial Deposits (unit 4)**

Glacial deposits in the map area are mainly compacted sand and silt, an example of till, which is material deposited beneath a glacier as the ice moved. Moving ice with entrained rock debris scraped and plucked fragments from the underlying bedrock. As the ice and debris tumbled along, the fragments were mechanically reduced in size to sand and silt grains. Down the stream of ice, the material was accreted or plastered on to bedrock, resulting in lodgement till. Other grains may have settled from water beneath the glacier. In contrast to the fabric of sediments transported and deposited in water, the grains in most tills are not sorted according to size, and layering is generally absent.

During the last period of maximum glaciation, the eastern and southern margin of the vast Laurentide ice sheet extended from the New England coastline to south of the present-day Great Lakes. In the Ottawa region, 400 to more than 500 kilometres from the margin, the ice was probably over 2000 m thick. The great weight of the ice depressed the bedrock at least 200 metres and compressed and compacted the till. Consequently in some places the till has resisted erosion by later streams and occupies relatively high ground, for example in Rockcliffe and in the Beechwood Cemetery. Large areas are underlain by till, but the deposits are not well exposed because of plant cover.

Discontinuous sand, gravel, and boulders overlying the till were derived from glacial debris as the ice melted and the glacial sheet thinned and contracted northward. Boulders of granitic and metamorphic rock scattered in Rockcliffe Park and elsewhere were evidently derived from Precambrian rocks, such as those north of the present Ottawa River. From the large size of the boulders, which indicates that long-distant transport by river water is unlikely, it is assumed that they were moved by ice. Similar large boulders were recently excavated from within marine clay (unit 5) underlying Birch Avenue (Photo 16, location 5-a). The boulders are known as erratics in that they differ markedly in character from the surrounding deposits. In this case the erratics were transported to a site where marine clay was deposited. The ice margin had then retreated to the northern boundary of the Champlain Sea, which was north of the Ottawa valley. Most likely the boulders were ferried on rafts of ice that calved from the glacial margin and floated southward across the sea.

#### **Champlain Sea Deposits (unit 5)**

Following glacial retreat and removal of the ice overburden there was a lag in the time of crustal rebound and uplift. Consequently the Ottawa valley remained depressed at least 200 metres, which is below sea level, and about 12,000 years ago it was inundated by the Champlain sea.

Clays, the most extensive of the marine sediments, were deposited offshore away from the beaches fringing the inland sea. Glacial movement and streams brought coarse to fine-grained material to the shoreline where waves reworked the debris and winnowed out the fine fractions, principally ground-up rock flour with particles less than 0.02 mm across. The rock flour was carried in suspension offshore then slowly deposited to form a clay locally known as Leda clay. The clay underlies most of Manor Park, including beneath a thin cover of river sand (unit 6).

The Leda clay reflects a succession of glacial, marine and fresh water conditions that make it mechanically unstable. Marine salts that initially stuck the particles of rock flour together were slowly replaced by fresh water, leaving a delicate honeycomb

structure of particles. If shaken or vibrated, the moist clay acts like jelly, as witnessed by residents of houses near the Birch Road reconstruction. Vibrations may also break apart the internal structure so that the clay becomes semiliquid like quicksand. This has led to landslides, some fatal, down sloping river terraces and banks. An old landslide lies east of the Aviation Parkway where Hemlock Road climbs a slope; slump ridges are obscured by grass. Sands on each side of the slide area form a thin veneer on the clay.

Perhaps the most interesting fossils in the Leda clay are whale bones that have been recovered from up the Ottawa valley as far as Pembroke. A whale bone from a depth 91 m in the clay near the Ottawa airport is radiometrically determined as about 10,500 years in age. Evidently at this time before the end of clay deposition the sea was sufficiently deep and contained enough food for whales.

### **Post-Champlain Sea Deposits River sand (unit 6)**

With further retreat of glaciers and reduction of the overburden of ice, the Ottawa valley rose towards and above sea level and the Champlain sea was replaced by fresh water. Large volumes of fresh water from rapid melt of the ice flowed down a swollen Ottawa River, which in the north and west drained lakes much larger than the subsequent Great Lakes. A cataclysmic flood occurred when water from a lake ancestral to Lake Manitoba broke through an ice barrier and flowed via the upper Great Lakes to Mattawa and down the Ottawa River. The water in a wide river system eroded at various times terraces, escarpments, channels and hollows. A discontinuous blanket of stratified sand was deposited. Sand bars and spits, small-scale features not shown on the map, occupied flow channels that cross the marine clay and till as well as the river sand and part of the organic material of unit 7.

The arrangement of the channels reveals some of the complex flow. For example, channels across Montreal Road near the Rideau River indicate a reversal in flow direction, but the sequence is not obvious. Some channels indicate flow parallel to escarpments and others oblique, demonstrating an indirect relationship between current direction and the local topography. Convergence of channels northward to between escarpments east and west of Beechwood Avenue suggests constrictional, relatively fast flow, whereas further north towards the Mackay and Sand Pits Lakes, divergence could be linked to slower flow. The Sand Pits Lake or Pond is the site of a scoured out hollow in the underlying marine clay that was filled by unusually thick sand, possibly in response to relatively slow flow. Most of the sand has since been excavated for construction thereby providing a pond for swimming.

### **Organic muck and peat (unit 7).**

The Ottawa River shrank dramatically when outflow from ancestral Lake Winnipeg was diverted to the Mississippi River and when water from the upper Great Lakes started flowing through Lake Erie, Lake Ontario, and down the St. Lawrence River. In response to the reduction in water volume and to crustal uplift accompanying glacial retreat, the river eroded a successively narrower valley with terraces and escarpments that step down towards the present embankments.

Poorly drained marshes and lakes occupied valleys that were abandoned as the river system shrank. Plant debris accumulated to form peat and organic muck. Mer Bleue southeast of Blackburn Hamlet is the most extensive modern marshland in the Ottawa area. Organic material from depths near 70 m at two sites within the marsh have radiocarbon ages of approximately 7,600 and 6,700 years, demonstrating that this material was accumulating for a long period before the present.

Two small marshes lie within the neighborhood of Manor Park. Near the junction of Hemlock Road and St. Laurent Boulevard a narrow marshy zone fringes a stream flowing northeastward (stream not shown on map). The northern margin of McKay

Lake is marshy, but due to housing development and fill the marshland is more limited than illustrated. A thick deposit of organic muck beneath the lake may indicate that prehistorically it was also marshland. Muck from a depth of 34 m has a radiocarbon age of approximately 8,000 years, demonstrating, as at Mer Bleue, long-term accumulation of plant material. Climatic fluctuations that elsewhere are reflected by variations in the width and density of annual tree rings undoubtedly affected the accumulation. For example, high density wood indicates slow growth either during lower than normal summer temperatures<sup>1</sup> or during a period of drought when marshes and lakes like McKay Lake would dry up. Relevant information from the Ottawa area is sparse, and additional analysis of wood and other organic material from marshlands and lake bottoms is needed to document such climatic changes and their impact on the plant and wildlife habitats.

<sup>1</sup> A related cultural note. The wood of Italian spruce grown during the Little Ice Age of the late 16<sup>th</sup> and 17<sup>th</sup> centuries was unusually dense. It was used by Stradivarius and others to craft fine string instruments not since duplicated.

***W.K. Fyson January 2004***